2nd Edition

Project ARCADE

Build Your Own Arcade Machine

The definitive guide to home arcade machines

John St.Clair

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Second Edition

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This book is dedicated to my wife Kristi and my children Kayci, Isaac, and Sebastian, without whom my life would not be complete.

I'd also like to dedicate this book to my parents, Ed and Liliane, and brothers Don and Andy, who inspire me.

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About the Author

John St.Clair is a network engineer employed by a K-12 school district in a small county in Georgia. As network manager, John is responsible for the daily operation and stability of the networking infrastructure for the school system.

John has worked in the IT field since high school, approximately 25 years ago. He obtained a bachelor's degree in Computer Information Systems in 1995, and also holds MCSE and CNA networking certifications.

He started in the video gaming field like many children of the 80's, feeding most of his allowance into quarter-gobbling machines at the local arcade. His primary claim-to-fame in this subject matter is being the creator of the Build Your Own Arcade Controls (BYOAC) web site at `www.arcadecontrols.com`. This site has grown from a small hobbyist site to the de facto home of the hobby, with an average of 90,000 visitors monthly. Virtually every item of note in this hobby makes its way to the BYOAC web site, from product launch, to technique discussion, to presentation of yet another personal arcade cabinet project.

As if the above wasn't enough to occupy his time, John is also a martial artist, studying Jujitsu, Aikido, Hapkido, and Kyuki-Do.

John splits his personal time between being a web-master, tinkering with his arcade game collection, martial arts, and raising a family.

Acknowledgments

I'd like to thank my wife for her support and love while I wrote this second edition, and for doing the job of two parents *again* so that I could write this book. I can't imagine life without you by my side. I want to thank my kids, Kayci, Isaac, and Sebastian for their understanding and being willing to do without daddy while I was working on the project. I'd like to thank my father and brothers for their support and encouragement, and my in-laws Don "Cappy" and Jeannie Oakley for the same. I'd like to honor the memory of Earl Mead, a genuine WWII war hero to our country and personal hero to our family, who passed away just before this book was finished. "Grandad" was a father, grandfather, and great-grandfather, an inspiration to all of us, and will be sorely missed. Finally, I'd like to honor the memory of my mother, who passed away too soon between editions of this book. She instilled in me the firm belief that you can do anything you set your mind to, which attitude I hope is reflected well in the book you hold in your hands now.

I'd also like to thank my friends Mark and Michele for being rock solid friends in both the best and worst of times, and particularly Mark for his invaluable advice while building the cabinet. Thanks for being my "Dave Smallwood!"

I'd be remiss not to mention the folks who turn ideas into books — my editors Christopher Rivera and Scott Meyers, and the rest of the behind the scenes folks at Wiley Publishing. Their gentle urgings to mind the schedule made sure this book came out on time. To quote Douglas Adams, "I love deadlines. I like the whooshing sound they make as they fly by." Thanks everyone, I'm pretty sure I drove you nuts this time!

Special thanks go out to all the people who helped turn my Web site from a simple little one-page affair in late 1997 to the community it is today, which ultimately led to the book in your hands now. Jason "SirWoogie" Presnell in particular for doing so much to help keep things running behind the scenes, and Jay "PlanetJay" Wilkinson who had the job before him. Thanks also to Arthur "SirPeale" Peale, Michael "JustMichael" Horton, Kevin "SirPoonga" Jonas, and Matt "Nivo" Nivison for helping run the message forums.

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I'd also like to give a shout out to all the chat room, wiki, and message board regulars, whose contributions are too numerous to mention and are found throughout this book. Also a big kudos and thanks to everyone who has documented the construction of their own *Project Arcade* machines. Thanks for being part of everything ladies and gents!

Yes, it's a bit sappy, but I mean every word. Without everyone here, this book wouldn't be nearly as good as I hope you'll find it to be.

Contents at a Glance

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Introduction

Gotcha! As soon as you picked up this book, you started a journey toward a game-player's paradise! You might be a classic arcade-loving child of the 1980s, or perhaps a fan of more recent, modern arcades. Remember playing Pac-Man at the local convenience store, or Street Fighter at the mall's arcade? Whatever caused this book to catch your eye, I'm betting that somewhere along the line the thought of owning one of these machines has crossed your mind. Wouldn't it be great to have your favorite arcade machine in your own den or recreation room? Imagine your friends' reactions when they encounter this treasure from their past in your home. This is definitely off the scale on the "wow" factor!

The problem is, though, that it's just one game. Sooner or later the thrill wears off, and it starts to gather dust.

No problem — as an arcade enthusiast, you're probably also a game player at home. If you haven't found them on your own yet, you'll discover through this book the joy of playing near-perfect replicas of your favorite games on your computer. The first time you play Pac-Man on your computer, the "wow" factor is back. Between commercial and shareware re-creations of classic and modern arcade games, and thousands of unique games developed for the computer, there's a never-ending variety to suit everyone!

Sooner or later however, you'll realize that playing Pac-Man with the keyboard lacks something. It just isn't the same steering around the maze with the arrow keys as compared to using a genuine ball-topped arcade joystick.

So — you can own your own arcade machine at home (this book will give you some pointers on that), and you can play thousands of games on your computer (we'll get you started on that, too), but both fall short of that perfect arcade experience. Wouldn't it be great if you could combine the two? Wouldn't it be great if you could . . . build your own arcade machine? Imagine an arcade machine with that perfect combination of joysticks, buttons, and trackballs running all your favorite games. Picture it with an awesome paintjob, with your favorite video game characters decorating the sides and a lit marquee at the top saying "My Arcade!" Wouldn't that be awesome? This book will show you how. Congratulations — you've started down the road to game-playing paradise!

Some of you may be veterans of the first Project Arcade book. This edition has plenty in store for you as well! I've kept all the good parts from the first book, and updated or added what's new to the hobby. I'll be showing you a new cabinet design this time around, but if you prefer the "classic" design you'll find those plans and the original build chapters on the companion CD. There are also a bunch of new products to consider — the bar on adding "eye candy" to your cabinet has been raised considerably — and a greater emphasis on games you can play with your new machine. Welcome back — your second trip to paradise awaits!

About This Book

This book is a culmination of years of research into the subject of using genuine arcade controls with computer games. It is a polished and portable companion to the author's Web site, the Build Your Own Arcade Controls FAQ (BYOAC), located at `www.arcadecontrols.com`. Most of the research and information for this book came from the Web, and I'll refer to various sites throughout. Access to the Internet is useful and recommended; however, it is *not* required. Everything you need to get started is right here.

This book is meant to be read from start to finish, in order. I've kept the technical jargon and theory to a minimum, providing just enough background information to understand the direction we're heading when it comes time for the hands-on material. For those who are interested in a deeper understanding of the theory behind these projects, I've included pointers to more information where relevant.

This book will take you step by step through the process of designing and building your own arcade machine. You'll be able to begin immediately after the first chapter; you'll have the gratification of watching your design take shape as you proceed through the pages. In fact, one common pitfall of building your own arcade machine is getting to the point where the machine is playable before it's totally finished and getting lost in the game play. One day you'll realize it's been weeks since you've made any progress because you've spent all your time playing, even though it's held together with string and chewing gum! That's not a problem though: The book will be waiting for you when you're ready to pick it up again.

We'll take a couple of side trips along the way. I discuss building a standalone desktop arcade control panel (arcade controls minus the cabinet) for those who want the fun but don't want to dedicate the space. I also cover hooking up game console controllers to your computer, such as the Nintendo 64 or Playstation game pads, for those who feel that they provide the best game-playing experience. Finally, for those who think the building part is beyond them (it's not, by the way — I'd never built anything out of wood before starting in on this hobby), I'll point out and review some of the various commercial products you can buy. There is something in this book for everyone!

Assumptions

I'm assuming you have access to a computer. The majority of the computer-related material is PC-centric, but enough of it applies to Macintosh computers that Mac enthusiasts can successfully use this book to build an arcade machine as well. I'm not assuming you have any electronics or carpentry expertise. Depending on the path you take as you build your machine, you may gain those skills, but it's possible to build the entire thing with off-the-shelf parts. If you do decide to take the more advanced route (and I recommend it), I'm assuming you're willing to learn as you go. Most of all, I'm assuming you're ready to have fun!

Things You'll Need

- **Plans:** You'll need a set of plans to work from. Plans for upright arcade cabinets are included on the companion CD-ROM. You can use or modify them as suits you. I'll also show you where to find other plans on the Internet, and I'll give you suggestions should you choose to draw your own.
- **Computer:** A fairly modest computer will allow you a good classic arcade game experience. Depending on what you want to play, even an old Pentium-class machine can play a slew of great, albeit older, games. To play more recent games, you'll want a correspondingly recent computer to match. Specific requirements will depend on the software you want to play. Macintosh users will find that similar factors apply. Whatever you have available for this project will work fine to start with. You can always upgrade later if you discover you can't run the games you want to play.
- **Software:** The software that makes everything work comes from a variety of sources. Some of it can be had for free, and some of it has to be purchased. Where possible, the necessary software has been included on the

companion CD. The software behind this hobby is updated frequently, however, and you should consider downloading updated versions of whichever software you choose to use. Links are of course provided. Software will be covered in great detail in Chapters 13 and 14.

- **Tools:** Odds are, you already have many of the necessary basic set of tools. Screwdrivers and a drill will meet the need for those of you who want to build a cabinet from off-the-shelf parts, while woodworking tools will be required if you want to build it all from scratch. I'll discuss tools more in Chapter 2 when I cover the anatomy of an arcade cabinet. Unless you're planning a lot of woodworking in your future, this is a good time to find a friend or relative with a workshop that you can borrow.
- **Budget:** Budget requirements will vary depending on what you're trying to accomplish. Desktop arcade control projects will average $200 to $300, while full-sized arcade cabinet projects can run into thousands of dollars! The nice thing is that, with proper planning, you can start small and inexpensively and work your way up to bigger projects as your budget allows. For instance, you can start with a desktop arcade control panel that can later be incorporated into a full-sized arcade cabinet. Factors such as whether you need to purchase a computer and tools will obviously have a significant effect on your overall budget.
- **Space and Time:** No, this isn't a *Star Trek* reference. Space and time required for a project like this are often overlooked but are clearly worth some consideration. It is possible to complete a project like this in a weekend, but the more likely scenario is that you'll work on it in bits and pieces over the course of a couple of months. One truism is that a project like this is often never "finished" — there's always another tweak or upgrade to try. With this in mind, *where* you build your project becomes important. If you're going to tie up your garage for a month or two, you might want to check with your spouse first!

WARNING **Will it fit in my basement? Don't fall into the trap that one unfortunate fellow did. He spent months building an absolutely gorgeous custom arcade cabinet, only to discover it was too wide to fit through the doorway of his basement once completed. I'm not certain how that was resolved, but there's definitely a lesson to be learned there!**

How This Book Is Organized

In this book, you'll find chapters spread across five parts. Each part covers a different theme, and each chapter is broken down into sections covering the chapter's subject. The parts and chapters are laid out in a sequence designed to walk you through the process of building an arcade machine in a logical order. You'll probably be happiest browsing the contents of the entire book, and then diving in to Chapter 1.

Part I: Playing Your Games the Way They Are Meant to Be Played — with Arcade Controls

The two chapters in this part get you started on your project. You'll begin by exploring the different kinds of projects you can build. In Chapter 2 you'll pick a design and come up with a plan, and then you'll jump right into the actual construction.

Part II: Designing and Building Your Dream Arcade Control Panel

Part II is where it starts to get really fun. Chapters 3 through 5 cover the different kinds of joysticks, buttons, trackballs, and other arcade controls you can include in your arcade machine. Chapter 6 covers designing the control panel and installing the controls you've chosen. It's starting to look like a real arcade machine now!

Part III: Hooking Things Up Under the Hood — Time to Trick the Computer

Part III is the most "techie" part of the book. These four chapters describe how to make the computer think a joystick and trackball are really a keyboard and mouse. Chapter 7 briefly covers some theory, and Chapters 8 and 9 cover using keyboard and mouse interfaces, which is how the majority of these projects are done. The last chapter in this part, Chapter 10, discusses several other clever methods people have found to connect arcade controls to a computer.

Part IV: Putting Together the Final Pieces

Part IV is the capstone of the project. Chapters 11 and 12 discuss sound systems and monitor options, respectively. Chapters 13 and 14 go over software, configuring your system for the ultimate game-playing experience, and installing the computer in the arcade cabinet. Finally, Chapter 15 covers the miscellaneous odds and ends that will enable you to turn your creation into your idea of the perfect arcade machine: artwork, the marquee, and so on.

Part V: Like the Concept but Not Sure You Have It in You?

This part covers subjects for those of you who aren't quite sure you can or want to build an arcade machine. Chapter 16 points out troubleshooting tips and where you can go to get help when stuck. Chapter 17 covers the various products you can purchase, from arcade cabinet kits to outright arcade cabinets, and it includes several reviews. Chapter 17 also briefly covers using game console controllers (such as the Nintendo 64 or Sony Playstation) on your computer, with do-it-yourself information included on the companion CD-ROM. Finally, Chapter 18 will introduce you to a few arcade cabinet and controller projects to inspire you and show you places to go online for more information.

Appendices

Every good technical book has them, and this one is no exception! Handy information is gathered in this section, including where to find arcade parts for your project. There's also an interesting debate presented on whether to preserve or "MAME" an arcade machine. Feelings on this subject run deeper than you might think!

Conventions Used in This Book

Throughout the book, you'll find highlighted text where I point out cautions, cross-references, notes of interest, and helpful recommendations, as well as mention what's included on the book's companion CD-ROM. Specifically, five types of highlighted pointers appear:

WARNING **These give you valuable information that will help you avoid disaster (including some lessons I learned the painful way). Read all of these carefully!**

TIP **These are recommendations of best-practice methods and superior products or tools to use.**

NOTE **These pertain to items of interest related to the subject at hand. Although you can safely skip these, I recommend that you read them at your leisure. They'll help you to be a better arcade-machine builder!**

CROSS-REFERENCE **These refer you to valuable information, links, software, illustrations, and more that is included on the companion CD-ROM to this book. These are also pointers to other areas in the book or sites on the Internet where you can find more information on the subject at hand.**

Part

I

Playing Your Games the Way They Are Meant to Be Played — with Arcade Controls

In This Part

CHAPTER 1

Picking Your Path to Game-Playing Nirvana

IN THIS CHAPTER

- Where to Start? Finding Your Muse
- Choosing Your Goal
- Plan, Plan, and Then Plan Some More

I remember vividly the feeling I had when I realized I was really going to do this — that I was really going to build my own home arcade cabinet! I didn't have any idea how I was going to get there, but I knew that if others could do it, I could, too. All I needed was to pick my goal, plan out the steps, and buy a few things; then I'd have my own arcade cabinet. Nothing to it, right? Well, of course, there were a few minor details along the way, like actually building the thing. Still, after dreaming about it for well over a year, there I was, finally getting started! Now it's your turn. I'll walk you through the process from beginning to end, starting with goal setting and planning in this chapter. Are you ready? I almost envy you for just starting the book — for you, the magic is just beginning!

Where to Start? Finding Your Muse

The hardest part of any project is deciding where to start. It's tempting to jump right in and start hammering and sawing, but a bit of homework now will pay off in the end. Before you start on your own project, you should devote some time to browsing the work of those who have gone before you. There are thousands of examples of arcade projects on the Build Your Own Arcade Controls Web site and elsewhere for you to see.

TIP **Now is a good time to get out a notebook and start jotting down ideas as they come to you during this process. The number of possibilities in this kind of project can be overwhelming, so good organization from the start will help. Be sure to include the address of any project's Web site you make note of. When it's time to implement the ideas from your notes, you'll want to be able to find the site again quickly to check up on the finer details.**

Some projects are works of art, and some only a parent could love, but all have two things in common: Each was lovingly put together by its creator and might have a feature you wouldn't have thought of but won't be able to live without once you've seen it. The bar has been raised many times during the 11 years I've been involved in this hobby. It's unusual to have a month go by without some project inspiring me to bigger and better things in my own endeavors.

As meaningful as every project is to its owner, in every field there are examples that stand out from the rest. In Chapter 18, you'll find several arcade cabinet and desktop arcade control projects to inspire you. Although it's worthwhile to browse all the example projects available, doing so can literally take weeks! If you're looking to fast-track the inspiration process, skip ahead to Chapter 18 and read through those examples. The companion CD-ROM also has more examples and full-color photos.

CROSS-REFERENCE **It's a fact of life on the Internet that very little stays the same. By the time this book makes it into your hands, many of the project examples included on the CD-ROM will have been updated, and many more will have been added. Be sure to visit the Build Your Own Arcade Controls (also known as BYOAC) examples page and project announcements forum, located at `www.arcadecontrols.com`, for the latest and greatest!**

Choosing Your Goal

By now you're probably beginning to realize that there is more than just one model of what an arcade machine can look like. As you browse through other people's projects, you'll encounter upright arcade cabinets, sit-down cocktail cabinets, desktop arcade control panels, and contraptions that defy description. How do you decide where to begin? I'll describe each of these in the sections that follow and include pictures to help you make some decisions. Start by asking yourself the questions found in Table 1-1.

Table 1-1: Questions to Ask Yourself

QUESTION	POINT TO CONSIDER
Are you looking to recapture the full-sized arcade experience?	Nothing brings you back to the arcade like a full upright arcade cabinet.
Want the arcade experience but need a spouse's approval?	Consider a sit-down cocktail cabinet that doubles as piece of fine furniture. Okay, I admit calling it fine furniture may be a stretch, but a cocktail cabinet can blend into the decor nicely.
Do you have the time, skills, and patience to build a full cabinet?	If not, a desktop arcade control panel may be for you. They are comparatively small and not too difficult to make.
Do you want to start small and work your way up?	Start with a desktop control panel that can be incorporated into an upright cabinet later.
Is space at a premium?	With a little ingenuity, you can make a countertop arcade cabinet like those you'd find at a tavern.
Do you just want to plug in a game console controller and start blasting away?	For about $30, you can build or buy an interface that will allow you to hook up your favorite controller to your computer.

Take a few minutes to assess your personal situation. Do you have a limited amount of time to devote to the project, or are you in it for the long haul? Where will you put your creation when completed? Be thinking of issues such as these and the questions in Table 1-1 as you go over your project options.

Building a Desktop Arcade Controller

A desktop arcade controller takes the control panel from an arcade machine and adds a box around it to hold it and protect the insides (see Figure 1-1). The top panel holds the joysticks, buttons, and other arcade controls. Inside the box are the underside of the controls and the electronics needed to connect the controls to the computer. The back of the control panel has a hole (or holes) for the cables that hook into the computer.

What Are the Benefits of a Desktop Arcade Controller?

Building a desktop arcade controller is a good project for those with a more casual interest in game playing. You get the benefits of playing with real arcade controls without having to lose floor space in the house. I keep a small one-player unit on my desk for when I get the gaming bug, and I slide it out of the way when I want to work. Not only do desktop arcades save space, but you also do not have to dedicate an entire computer system for game playing. They are also portable for times when you visit arcade-deprived friends.

Photo courtesy of HanaHo, Northcoast Custom Arcades, and Xgaming, Inc., respectively.

Figure 1-1: Several commercial desktop arcade controllers.

WARNING **Visiting friends with your contraption or letting them play at your house can have one side effect: Shortly after playing, the question "How can I get one of these?" will come up. This is your cue to tell them where they can purchase a copy of this book. By no means should you allow them to borrow your copy. You will need it when you begin your next design, and the author has children to feed!**

Desktop arcades are also easier to build than full-sized arcade cabinets, but they still contain the same mixture of arcade controls. Although the design and layout work is the same, the woodworking is much simpler and you don't have to worry about the audio and video systems.

What Are the Drawbacks of a Desktop Arcade Controller?

Desktop arcade control setups have a couple of downsides. For one, you lose your desktop space. Wait — wasn't I just praising these units as a way to save space? Well, yes, but it's relative. You're not dedicating floor space, but you are giving up workspace. Even the smaller one-player units can measure a foot and a half wide by a foot deep, and the larger units can be two to three feet wide — that's a lot of desk space to give up!

After the initial thrill of playing wears off, the realization will set in that you're still in front of a computer screen. Playing a game with real arcade controls on your desktop is definitely fun, but it's not quite an arcade cabinet. If you're trying to recapture the feel of an arcade, you'll want the arcade cabinet atmosphere as well as the controls. Don't get me wrong — I think a desktop set is a project worth building, and I believe I'll always have one on my desk. It's just no substitute for the real thing!

NOTE **Some arcade game collectors will scoff at calling a home-built arcade cabinet *the real thing*. There's actually a bit of (mostly) good-natured argument on the subject, with valid points on both sides. You'll find more on this topic in Appendix B.**

Building an Arcade Cabinet

An arcade cabinet is essentially a box containing the monitor, speakers, arcade control panel, and miscellaneous electronics that make an arcade game work. In our case, the miscellaneous electronics include a computer that runs the whole operation. Many different types of arcade cabinets are available. The following descriptions cover the most popular (see Figure 1-2).

Photo courtesy of Jeffrey Allen, Oscar Controls, and Game Cabinets, Inc., respectively.

Figure 1-2: A variety of different arcade cabinets. From left: upright, countertop, and cocktail.

Upright Arcade Cabinets

You're probably most familiar with the stand-up, *upright* arcade cabinet seen in arcades and convenience stores everywhere. They usually stand about six feet high and have 19- or 25-inch monitors, though later models can have much bigger displays. These cabinets will support up to four players, depending on the design of your control panel. There is also a variation of the upright cabinet called a *mini*, which is a scaled-down version with a smaller monitor and cabinet that usually supports only one or two players. Roughly two-thirds of the build-your-own cabinets are uprights.

Cocktail Arcade Cabinets

You're likely to have seen the *cocktail* arcade cabinet also. They are popular in arcades, and for some reason pizza parlors tend to favor them as well. These units are about four feet by four feet square and about three feet high. The monitor rests face up in the middle of the cabinet with players looking down on it as they play. These cabinets are usually limited to two players sitting opposite each other and taking turns. About one-third of the build-your-own cabinets are cocktail cabinets.

Cockpit Arcade Cabinets

A *cockpit* arcade cabinet (not shown in Figure 1-2) is a full-sized enclosure with a seat as part of the cabinet. There are fewer of these than the other types of cabinets, presumably because of the sheer size. They typically take up the space of two or more upright arcade cabinets. These are usually one-player machines, though I have seen at least one two-player unit. I am aware of only a small number of cockpit cabinets that have been made by the build-your-own crowd.

Countertop Arcade Cabinets

The last main variation of the arcade cabinet is the *countertop*, or *bar-top*, model. These machines are not much bigger than a set of desktop arcade controls, primarily being taller and deeper to house a small monitor. You will often find these machines in taverns and bars, hence the name bar-top. They are most popular for trivia and puzzle games (such as Tetris). Again, only a handful of these cabinets are made by folks who try their hand at an arcade cabinet.

What Will You Gain by Building an Arcade Cabinet?

Building an arcade cabinet has to be the most rewarding variation of this hobby you can find. It's as close to the real thing as you can get without putting a full arcade in your basement. (See "The Game Room," in Chapter 18, for where this hobby can ultimately take you!) Depending on the type of cabinet you make, you can get a full-sized arcade control panel with genuine arcade controls custom-designed for the type of game play you're after. Add a monitor shrouded in darkness that minimizes distractions and a moderate sound system, and you can completely immerse yourself in the arcade experience. There's also plenty of space available to have such fancy things as removable steering wheels, sophisticated speaker systems, and four-player panels.

You can also customize your software setup to hide the fact that the brain behind your arcade cabinet is a computer. With a combination of a front-end menu system and an arcade-themed background and sounds, it's possible to disguise completely the non-arcade origins of your creation. Throw in a working coin door and you'll begin to believe you're standing in front of a real arcade machine — one that can play an unlimited number of games! I'll go through all of this in later chapters.

An arcade cabinet is also much easier to share with your friends, particularly if it has a two- or four-player control panel. Add music jukebox software (see Chapter 11) and your legally-obtained collection of music files, and you have an entertainment centerpiece for your next party that will be the envy of your friends. If you have the time and resources, building an arcade cabinet is definitely the way to go!

What Are the Drawbacks of an Arcade Cabinet?

Building arcade cabinets is more of an effort than building desktop arcade controllers. They can be more expensive, running anywhere from the $500 range for a small project to $1500 or more for the mother of all arcade machines. Arcade cabinets also tend to suffer from *feature creep* as they are being constructed, turning a simple project into a mammoth (and more expensive) one. This may not necessarily be a bad thing, but it does tend to wear on your family's patience.

Arcade cabinets also occupy a significant amount of floor space, and unlike desktop arcade controls, they cannot be put away when not in use. They also require dedicating a computer system solely for their use in most cases, although a couple of folks have managed to make do with external laptops or shared computers. Assuming you'll be dedicating a computer to the project, you'll need to factor in the cost of any computer components you need to buy for the cabinet.

TIP **If you own a computer, the odds are that you've upgraded at some point and have an older computer lying around. These computers make excellent starting points for arcade cabinet projects. They will limit you to somewhat older games because of hardware requirements, but there are still hundreds of games that are great additions to an arcade cabinet that will run fine on older hardware. Using an old computer also makes an excellent bargaining point when trying to convince a reluctant spouse. You can always upgrade computer parts once the cabinet is built.**

Buying Your Way to Gaming Nirvana

For every build-your-own project in this book, there's an already-made solution you can buy instead. Since I became involved in this hobby, a variety of vendors have cropped up who are eager to sell you what you're looking for. They range from small shops building products in their garage to large operations with full product lines. I present a look at various options in Chapter 17.

The smaller shops tend to come and go, although a few have stood the test of time. These vendors are usually much more willing to customize their products to your design than are the larger operations. They also tend to offer better customer support, because the person you contact for assistance may also be the person who built your product in the first place. They tend to have slower shipping times, however, due to the realities of being a smaller operation, and are often more expensive.

The larger operations have the benefit of mass production, financing, and a distribution infrastructure such that they can get their products to you faster than the smaller vendors. Their product lines are fixed, however, and they are less likely to be willing to customize a solution for you. At least one large vendor has been known to do customizations, so it never hurts to ask. Support from a larger company can be hit or miss, with some vendors providing faster and better support than others. Pricing should also be lower from a larger vendor.

What Do You Gain by Buying?

If you've got the money, but not the time or patience, to build your own, buying a pre-made product can be a great solution. You'll get a professionally made piece of gaming equipment that's attractive and comes with a warranty. If it stops working, there is someone you can go to who's responsible for getting you back in business. Depending on your access to tools, and factoring in what your time is worth, it may actually be cheaper, or close enough, so that you'll be happier purchasing rather than building your dream arcade machine.

What Do You Lose by Buying?

Although it *can* be less expensive to buy rather than build, that's usually not the case. If you already have access to the tools needed and have the available spare time, you will probably find it cheaper to build rather than buy. There's also the flexibility of being able to customize every facet of your design. Finally, there's a level of satisfaction with being able to say "I built it!" that you obviously won't get with a purchased product.

TIP **If you decide to buy rather than build, take some time to do a bit of research first. Log on to the Build Your Own Arcade Controls message forums (`forum.arcadecontrols.com`) and ask for opinions on any products you are considering. Also, pay by credit card if you can, and insist that your card not be charged until the product is shipped.**

Thinking Point

Take a moment to stop now and think about what I've covered so far. If you're planning to jump right in, you should try to make some decisions based on the preceding material and narrow the scope of what you're attempting to create. Do you know what type of project you want to undertake? Have you assessed the time and money you can devote to the project? Are you going to build or buy? As you begin to pick a plan, buy materials, and lay out your designs, you'll begin to limit the number of changes you can make midstream. By no means is change impossible, but it does become inconvenient in terms of time and expense. If you're planning to read this book first and then begin your project, you can safely postpone thinking at this point!

Plan, Plan, and Then Plan Some More

Where do you go from here? As a friend of mine is fond of saying, "Proper planning prevents poor performance!" You need to make a few decisions before you proceed. There's a bit of the chicken-and-egg syndrome coming up. It's hard to make planning decisions without knowing more about the various options available, but I've tried to gear this book toward your being able to jump right in without having to read it through first. In the next few paragraphs, I'll point you toward later chapters for additional information or inspiration for planning purposes.

However, if you'll trust me, there's already a plan in place over the course of the book. When all is said and done, you'll end up with a nice multi-player upright cabinet ready to play. If that's the route for you, you can skim over the next piece and then jump in to Chapter 2.

Deciding to Build or Buy

At this point, I hope you have a general concept in mind for the kind of arcade machine you want. This would be a good time to consider the build-or-buy decision. You may wish to skip ahead to Chapter 17 to browse through the various commercial offerings to see whether one of them will fit the bill. Don't forget to factor the costs of buying against the time and costs of building.

Planning for Controls and Interfaces

I'll go over the various controls and interfaces in detail in Chapters 3 through 10. Still, you should be able to make some preliminary choices now. How many players do you want your cabinet to support? If you're just starting out, a two-player cabinet is probably your best bet. However, if you have a favorite four-player game (and three friends who you know will come play), a four-player cabinet might be your goal. You don't really need to make any decisions regarding the interface just yet, other than planning to leave some space in your control panel for it. Figure about a four-inch by six-inch area inside the control panel for the interface.

CROSS-REFERENCE **An interface in this case consists of the electronics or other devices used to connect the arcade controls to the computer — something that translates the signal that the arcade controls generate to something the computer understands. This topic is covered in detail in Chapters 7 through 10.**

Picking Software

Most of this area can be left until much later in the building process. However, at this point, you should consider a few things that can make a difference in how you proceed. If you want to play a particular game, think about the kind of controls it may require. For instance, if the recently re-released Centipede is your cup of tea, you'll want to plan for a trackball. The majority of games will run fine with a couple of joysticks and a bunch of buttons, but consider any particular game favorites before you start building.

The second software consideration that may alter planning is the operating system choice. This will primarily affect your interface decisions. Almost every interface option will function in a Microsoft Windows or MS-DOS (or MS-DOS-compatible) environment. If you're planning to use Linux or a Mac, however, you'll need to investigate the interface's requirements before you proceed. Also bear in mind that more computer games are written for the Windows platform than any other. Arcade cabinets have been made with both Linux- and Macintosh-based systems, but unless you have a specific reason to do otherwise, running a Microsoft operating system will probably be your best (easiest) choice.

NOTE **My recommendations have nothing to do with the capabilities of Linux and Macintosh. I'm a big Linux fan, using it both personally and professionally. I also have a lot of respect for the Macintosh and its capabilities. Please don't flood me with e-mails pointing out the errors of my ways regarding my operating system choice. Constructive criticism is, of course, welcome!**

Figuring Your Budget

Now is the time to decide how much you're willing to spend on this project. This, as much as anything else, will determine what kind of project you're able to build. Planning for the mother of all arcade machines on a limited budget may be an exercise in frustration. However, with some careful thinking, you can lay the infrastructure for your dream machine and build it up slowly. A two-player panel can be swapped out for a four-player panel later, when you have the financing to buy all the required parts. A low-end computer can be upgraded to a high-end computer later. About the only choice that's not alterable is the physical construction of the cabinet. For instance, you might only be able to justify buying a 19-inch monitor at the start, but have a 25-inch monitor in mind down the road. In that case, be sure to build the cabinet wide enough to support the larger monitor later!

Putting It on Paper

A goal without a plan is but a dream. A plan is only as solid as the paper it's committed to. Now that you've hit the end of the chapter, take time to write down any thoughts and decisions you've made. Be sure to keep references noted as well, such as page numbers or Web site addresses, for later referral. This may save you frustration in the long run. Continue this habit as you proceed through construction.

As a side note, near and dear to my heart is the creation of arcade-related Web sites. If you know about creating Web sites, or even think you might want to learn, consider keeping a construction diary. Take plenty of pictures as you go and accurate notes. This will not only help you if you need to refer back for any reason, but if you put it up on a Web site, you just might be the inspiration for the next person who decides to build his or her own arcade machine!

TIP **Start a separate spreadsheet devoted to your budget. Keep track of every single expense so you can keep an eye on the bottom line. It's amazing how quickly those quick trips to the hardware store for a few screws can start to add up. Of course, if you'd rather not know what the grand total is, this step is *not* recommended!**

Summary

You have a lot of choices ahead of you, all of which lead to guaranteed fun! An upright, cocktail, or countertop arcade cabinet will make a great addition to a family room or game room. If space is at a premium, you might choose a desktop arcade controller. Whichever you decide upon, proper planning will help ensure success. Whether you choose to build an arcade cabinet or a desktop controller, or buy your way to gaming fun, this book will guide you along the way!

Speaking of plans, those are just a few of the things I cover in Chapter 2, where you get to jump right in and start building your arcade cabinet. The magic's starting, so keep going!

CHAPTER

2

Building Your Arcade Cabinet

IN THIS CHAPTER

- **Anatomy of a Cabinet**
- **Determining the Things You Need**
- **Getting Ready to Build Project Arcade**
- **Beginning Construction**

Wow, I built that! That's the first thought that ran through my head when I finished putting together the arcade cabinet I'm about to show you how to build (see Figure 2-1). After all the work, trips to the hardware store, and admittedly some amount of frustration, I could finally see the project taking shape before me. It's an awesome feeling getting there, and you're about to begin!

Although it may be tempting to jump right in, this is one chapter you should read once the whole way through before beginning to build. Pay close attention to the parts and tools needed — nothing is more frustrating than being on a roll and then having to interrupt what you're doing to run to the store. Take your time with this chapter. The work you put into it will be the foundation for the rest of your project.

Anatomy of a Cabinet

You'll find there are several different models of arcade cabinets, but they all have a set of characteristics in common. I'll cover the basic anatomy of an arcade cabinet, using an upright arcade machine as my example, but the explanation applies equally well to other types of cabinets. Refer to Figure 2-2 as you read through the descriptions.

Figure 2-1: Your goal — the completed arcade cabinet shell.

1. **Arcade cabinet shell**. The wooden shells that make up the cabinets come in a variety of shapes and sizes.
2. **Monitor**. Every cabinet has a monitor. Monitors are typically 19 or 25 inches in size, with later-model arcade cabinets having much bigger monitors.
3. **Speakers**. These are the sound system of the arcade cabinet.
4. **Coin door**. This is a metal door on the cabinet where players insert money or tokens to be able to play the game.
5. **Control panel**. This panel, where the various controls for the game are mounted, will be described in greater detail later.
6. **Control panel overlay**. This artwork covering the control panel is sometimes covered by a clear protective covering made from a variety of materials.
7. **PCBs**. The computer boards inside the cabinet make the game work. You'll be using a real computer in place of the PCBs.
8. **Marquee**. This is the sign at the top of an upright arcade cabinet, usually backlit.
9. **T-molding**. It is a strip of plastic (usually) that is mounted in a groove around the edges of an arcade cabinet. The T-molding is both decorative and protective.

10. **Side art**. This artwork decorates the sides of a cabinet. Sometimes side art is painted; other times it is a vinyl sticker.
11. **Bezel**. A bezel is a shroud around the monitor covering the gap between the sides of the monitor and the sides of the cabinet, intended to hide the insides of the arcade cabinet.

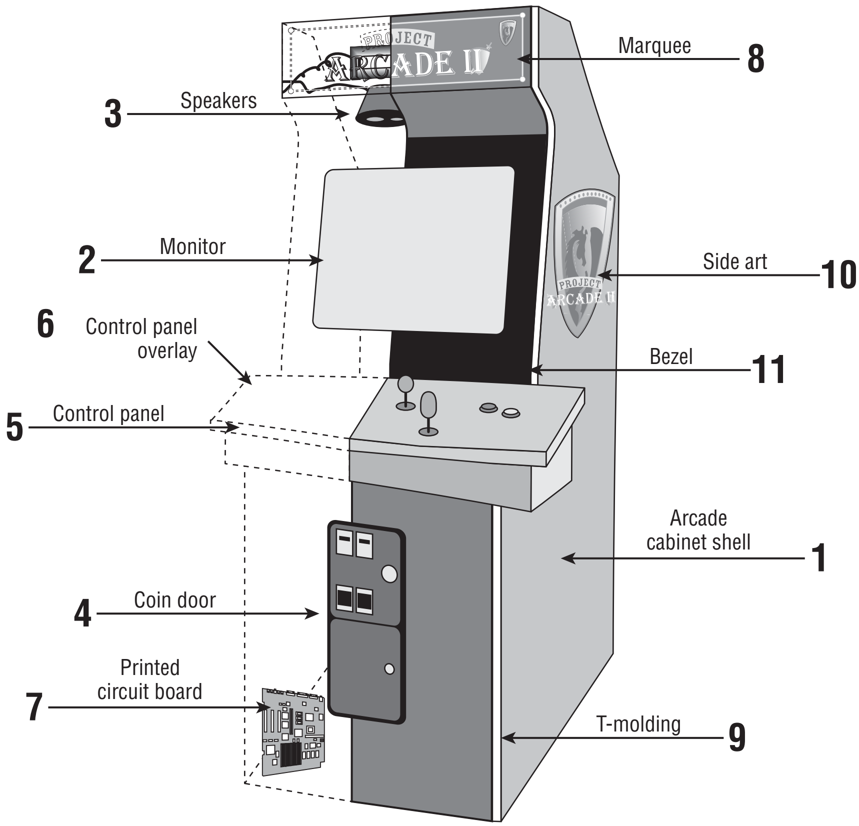


Figure 2-2: Anatomy of an arcade cabinet.

Determining the Things You Need

Before you can begin, you'll need to make a few quick decisions. Are your skills up to the task? What kind of wood are you going to use, and which plans will you follow? This section will help you answer those questions and get started.

Assessing Your Woodworking Skills

The good news is that you do not have to be a master carpenter to build an arcade cabinet. In fact, I won't make any *serious* effort to teach you proper woodworking skills at all! I can safely say that your woodworking skills are as good as, if not better than, mine, because I didn't have any when I started. I was about as far from a woodworking expert as you can be and still have opposable thumbs! Fortunately, if I can build an arcade cabinet, anyone can! (Yes, you too.)

If your woodworking skills are better than mine, you may very well find areas where you might want to do something a little differently from what I've shown. That's OK! As you work through the plans, you should feel free to make changes as you see fit. The important thing to remember is that as long as the construction is sturdy, your only goal here is to put together a cabinet that makes *you* happy. When all's said and done you'll have made a cabinet of your very own!

Choosing The Wood

Your first decision will be what kind of wood to use. You've got several options, and it's not feasible to cover them all here. However, most arcade cabinets are built from one of three varieties of wood: plywood, particleboard, and MDF. Each has its pluses and minuses. Your determining factors should be weight, suitability for the finish you're planning to use (laminate, painting, staining, other), and how difficult it is to work with.

Plywood

Plywood is manufactured by laminating thin sheets of wood together. They are laid together with the grain of the sheets at 90 degrees to each other, which provides the plywood with its strength. There are many different grades of plywood, rated by their strength and appearance. The various grades fall into two main categories: plywood intended for construction, and plywood intended for display. Obviously, plywood meant for display is the best kind for an arcade cabinet.

When you're working with 4 × 8 sheets of plywood, the wood is stronger along the axis that lies parallel to the grain of the top sheet of wood, typically along the 8-foot length. Use this to your advantage when using plywood in your cabinet. For example, if making a 2-foot by 3-foot base, making sure that the 3-foot section is cut from the 8-foot side will give you a slight strength advantage over orienting it the other way. It's not a major advantage, though, so it's OK to orient your pieces in different directions to take maximum advantage of the available wood.

When shopping for plywood for a cabinet project, you should consider the type of finish you're going to use. If you are planning to laminate the cabinet, then the finish of the plywood is not critical. If you intend to paint or stain the cabinet, then you should look for sanded plywood where one face has been prepared for painting or staining. Be sure the plywood you're using has totally dried before applying a finish, or the look of the finish may be altered as the wood continues to dry.

Plywood has the advantage that it's not as heavy as some of the other wood choices, and it has a nice grain pattern if you are considering staining. Damage during construction can be repaired with wood putty, although that makes staining difficult. The wood putty area will probably have a different appearance from the surrounding wood when stained. One issue with plywood is that the wood can warp (it's sometimes difficult to find plywood at lumber stores that's perfectly straight). If you are planning your cabinet to appear as a piece of furniture, this is a good choice. Many arcade cabinets have been built from plywood.

Particleboard

Particleboard is a wood product made by mixing sawdust with industrial glue. It is intended for furniture, countertop construction, and so on. The surface is rough and is best covered with a laminate of some kind. Painting or staining particleboard is not recommended. You *can* paint particleboard successfully, but it requires a significant effort to sand the surface smooth enough for a quality paint job.

Particleboard won't bow or warp like plywood, but it will absorb liquid and swell up if wet. Particleboard is often confused with OSB (oriented strand board), which is made of wood chips and glue. The difference is the size of the particles mixed with the glue to make the wood; however, the information here applies equally well to both. Problem areas during construction can be repaired with wood putty as for plywood, but because you'll be finishing with a laminate or painting, it's easy to hide.

Particleboard is strong enough for cabinet building, but due to its properties it is not well suited for the task. Few build-it-yourself arcade cabinets have been made from particleboard, and I do not recommend it.

Medium-density Fiberboard

MDF stands for medium-density fiberboard, which is similar to particleboard in that it's made from wood fibers and glue. However, the fibers in MDF are very small. This gives MDF a smoother texture than particleboard and plywood, and makes it easy to paint. Because it has no grain, you won't want to stain it. MDF is a very sturdy wood with a hefty weight, and is designed for furniture, shelving, cabinetry, and the like. These qualities make it perfect for a project such as an arcade cabinet. Like particleboard, however, it will swell up with water, so make sure you keep it dry until painted!

MDF is an easy wood choice with which to work and the most popular among arcade machine builders. It cuts, drills, and routs very easily, and it is fairly inexpensive. Like the other wood choices, problems are easily repaired with wood putty and will be invisible when painted. Its biggest disadvantages are the weight and the vulnerability to water. There's also some thought that the adhesive in the wood fibers can be tough on your tools. Finally, dust from MDF and similarly manufactured woods is particularly bad to breathe. Because of this, some wood shops won't cut MDF for you. Proper eye protection, breathing masks, and adequate ventilation are strongly recommended when you are working with MDF.

When cutting through MDF, you should go a little slower than you would go through other wood such as plywood. Because of its composition, MDF can gunk up your tools and you will start to burn the wood from friction instead of cutting it. Keeping your work area clean will help. Be sure to let the tool do the work and avoid the tendency to "help it" with pressure. In fact, during construction of the Project Arcade 1 cabinet, I broke one tool (a hole saw) by ignoring this advice!

MDF is more durable than particleboard and somewhat less durable than plywood. It's easier to work with than either, and easier to repair with wood putty when you need to do so. Most arcade cabinets, including the Project Arcade 1 cabinet, are built from MDF.

Medium-density Overlay (Signboard)

There is a hybrid wood called MDO (medium-density overlay) made from plywood with a thin sheet of MDF covering it. This gives it the strength and lighter weight of plywood with the smooth texture of MDF. The composition and materials used to make MDO give it resistance to moisture, so it's often used for outdoor signs. MDO is often referred to as "signboard" because of this.

Sheets of MDO are more expensive and difficult to find than the other types mentioned. None of the four different lumber yards near me carry it in stock, so it has to be special ordered. MDO is made in both single sided and dual sided versions — that is, the smooth MDF covering can be on one side or both. The dual sided version is more expensive than the single sided, but because many pieces of your cabinet will have both sides visible you should choose dual sided. Did I mention it was more expensive? I was quoted $90 per sheet for dual sided MDO — compare that to MDF sheets at about $25 to $30 per sheet!

Despite the higher cost, you'll be very happy choosing MDO for your cabinet. Working with MDO is easier than working with either plain plywood or MDF, and gives you the best features of both. Having used plywood, MDF, and MDO in various builds in the past, I will never again use anything but MDO, given the choice. In Figure 2-3 following, you'll see a comparison of different types of wood.

The Project Arcade 2 Wood Choice

Ultimately I chose to use MDO for the Project Arcade 2 cabinet. I did use plywood for the control panel as I wanted to try a couple of different wood types for the book, but if I were doing it again, I'd choose MDO for all of it.

Figure 2-3: A comparison of particle board, MDF, plywood, and MDO.

The Ultimate Arcade II plans included in the book, that are the foundation for the Project Arcade 2 cabinet, call for 5/8-inch wood. I found 5/8-inch wood difficult to locate at lumber yards in my area, and ended up using 3/4-inch wood instead. Either is fine, you'll just need to be aware of what you have during construction and make size adjustments as needed. The plans included on the CD are unaltered from the 5/8-inch specification. In the book I will specifically call out the alterations necessary for using 3/4-inch wood.

One thing to consider for your control panel is whether you'll put a protective cover over the top. I'll cover the details in Chapter 15, but in a nutshell, you may choose to put a 1/8-inch acrylic cover over the top of the control panel to protect the artwork. If you do that, you'll either want to use 5/8-inch wood for the control panel top to have a total 3/4-inch size (1/8 + 5/8 = 6/8 or 3/4), or make a deliberate choice that you don't care whether the top is something other than 3/4-inch. This is important because 3/4-inch is the most common size found for the edging (called t-molding) you'll likely be using around the edges of the control panel.

Choosing a Cabinet Plan

Many plans are available on the Internet for you to follow when building an arcade cabinet (see Table 2-1). You can use some for free, while others must be purchased. You can also easily roll your own by taking a tape measure to a friendly arcade and making notes. However, you'll have to make some educated guesses on the insides of the cabinet this way, and most arcade operators will not tolerate someone poking around their cabinets. Plans exist for upright arcade cabinets, cocktail table cabinets, countertop cabinets, and sit-down cockpits.

One of the most popular plans is the Ultimate Arcade II plan by NorthCoast Custom Arcades, also known as MAMERoom. Those plans normally have to be purchased, but are included on the companion CD and are the plans used for the Project Arcade 2 cabinet. If you are looking for a different style of cabinet, investigate the plans in Table 2-1.

NOTE **I consider the Ultimate Arcade II plans used in this chapter to be of moderate difficulty. They are certainly more complicated than the LuSiD plans used for the first edition of this book. There are more angled cuts and many more measurements to make in the Ultimate Arcade II cabinet. You'll get a more attractive cabinet in exchange for your efforts, however. Read this chapter and the plans carefully before you start cutting wood. You can, alternatively, choose to use the somewhat easier original Project Arcade 1 LuSiD design. If you'd like to do so, refer to Chapters 2 and 6 from the first edition, which we've included on the companion CD along with the original design plans. You can also purchase the Ultimate Arcade II cabinet in kit form from North Coast Custom Arcades at `www.mameroom.com`. There are both benefits and drawbacks to buying the kit instead of building your own from scratch — I'll cover them in Chapter 17. Having said all this, I strongly encourage you to build the Ultimate Arcade II cabinet from the plans in this chapter. I have very little wood working expertise, and if I can do it, you can do it!**

Table 2-1: Various Arcade Cabinet Plans

PLAN	LOCATION	DESCRIPTION
NorthCoast Custom Arcades' Ultimate Arcade II	`http://www.northcoast-arcades.com` and on the companion CD	A two-part upright arcade cabinet plan by NorthCoast Custom Arcades and used for the Project Arcade 2 cabinet.
LuSiD's Arcade Flashback	On the companion CD	An upright arcade cabinet suitable for a 25-inch monitor, and the basis for the first Project Arcade.
ArcadeParadise	`http://www.arcadeparadise.org/downloads.html` and on the companion CD	A set of 3 different upright arcade cabinets.
Frostillicus's plans	`http://arcade.tomvanhorn.com`	An upright arcade cabinet featuring a rotating control panel with multiple control sets.
Jeff's Ultimate	`http://mame.velociworks.com/plans.html`	An upright arcade cabinet.
1UP's Pac-MAMEA	`http://1uparcade.rmfx.com/arcade-const-plans.html` and on the companion CD	An upright arcade cabinet with rotating control panels featuring different control sets.
MAMEstation	`http://leafstation.com`	An upright arcade cabinet.

PLAN	LOCATION	DESCRIPTION
Massive MAME Project Plans	http://www.mameworld.net/massive/How-to/Cabinet_Plans/cabinet_plans.html	As of this writing, there are six plans for a variety of upright, cocktail, and cockpit cabinets.
MiniMAME	http://www.minimame.com	A half-sized upright arcade cabinet.
Oscar Controls Gotham Cabinet	http://mirrors.arcadecontrols.com/OscarControls/unnamed	An upright arcade cabinet, featuring separate upper and lower assemblies for easy transport.
Oscar Controls Happy Hour Bartop MAME	http://mirrors.arcadecontrols.com/www.skum.org/bartop/downloads.htm	A countertop mini arcade cabinet.
Supercade	http://cosmicjive.net/arcade/super/plans.shtml	An upright arcade cabinet with a unique two-level control panel.
Taz's Slim MAME cabinet	http://tazmame.com/building-and-design	A unique slim pedestal style design with a 26" LCD panel.
Thorn's Mortal Kombat cabinet	http://home.comcast.net/~sugg3d/MAME/CabinetSketch.html	An upright arcade cabinet patterned after the Mortal Kombat series of cabinets.

CROSS-REFERENCE **The links in the table and every other link in the book are also included on the companion CD-ROM so you don't have to type them!**

Making Your Own Plans

Got a yearning to roll your own? Designing your own cabinet can be fun and exciting, and I have a few suggestions if you'd like to try. First, look over other people's arcade cabinets, if you haven't done so yet. Take note of the features they have that you'd like to include in your cabinet. Do you want to incorporate a rotating control panel? Perhaps a custom-sized monitor is in order? Don't forget to plan for accessibility into the cabinet for later maintenance. As you pick the features you'd like for your cabinet, be sure to pay careful attention to stability. These cabinets are usually big and heavy, and they tend to take a small amount of abuse from enthusiastic play. It would be horrible to have a cabinet fall apart and possibly hurt someone during an otherwise fun-filled evening.

Once you have your basic design down on paper, run it by a few folks for opinions. The message boards at the Arcade Controls Web site (www.arcadecontrols.com) are an excellent resource for this. There are a lot of people there who will have the right kind of experience and enthusiasm for your project. Don't be surprised if you pick up a few good pointers and possibly requests for copies of your plans when finished! You did intend to share, didn't you?

Getting Ready to Build Project Arcade

Ready to begin? Great! If you'll be using the Ultimate Arcade II plans included on the CD-ROM, the rest of this chapter applies directly to you. If you've decided to use another set of plans, much of the following will still apply in general terms, such as the various construction tips. Either way, you should read through the rest of this chapter first, then put the book down and start making your masterpiece!

Setting Up Shop

The first thing you need to do is to decide where your mad-scientist laboratory will be. You should pick an area with adequate ventilation for dust and paint fumes, such as a garage or open basement. If you're lucky enough to have a workshop, so much the better! For the first edition of this book, since I was writing while building, I decided to set up shop in my study to avoid frequent trips back and forth to the garage. That was my first mistake! It worked very well for writing, but it took months to get the dust out of everything! This time I set up shop in my garage.

The place you choose should also have enough room to work in. The assembled cabinet is over 6 feet tall, and you'll need to be able to lay it down as well as stand it upright. Also, don't forget your cabinet's final destination. The final assembled cabinet will be in the neighborhood of 50 inches wide at the control panel. This is too wide to fit through some doors. You can plan for this eventuality, however, by not attaching the control panel until the cabinet has reached its final home. The width of the cabinet without the control panel will be approximately 28 inches wide, which should just fit through most doors.

Obtaining Tools And Supplies

The goal of this section is to get you everything you'll need with as few shopping trips as possible. You'll probably still have to run out for that "little extra something," but this will be a good start. This section concentrates only on what you'll need to do the woodworking and painting to build the cabinet. Materials needed for the rest of the project, such as joysticks and buttons, are presented later in the book.

I'll start with a look at the tools you'll most likely need. The tools in Table 2-2 are those I used to build the Project Arcade 2 cabinet, and are the tools most often used by people who build their own cabinets. If you are planning to build only one cabinet, you might want to consider borrowing or renting tools instead of purchasing them. Bear in mind however, that depending on the tool needed, decent quality can sometimes be purchased for about the same cost as renting.

Table 2-2: Tools You Will Need

TOOL	PURPOSE
Circular saw	You'll want a good circular saw to make the majority of your cuts as you cut out the pieces.
Jigsaw	You'll need a jigsaw to make some of the cuts and to cut out holes for speakers and a coin door (you could also use a router).
Table saw	Due to the number of angled cuts in this design, I highly recommend a table saw. If you're building a design with few angled cuts you can get away without using one.
Drill	A drill is a necessity. You'll use it to pre-drill your screw holes, and to make holes in your control panel to mount joysticks, buttons, and the like.
1 $^{1}/_{8}$-inch spade bit	Most arcade controls mount in a $^{1}/_{8}$-inch hole. Spade bits are a better choice than a hole saw for creating the holes in your wood when using MDF, because the hole saw can gum up and start to burn the wood.
1 $^{1}/_{8}$-inch forstner bit	A forstner bit is similar to a spade bit, but meets the wood at 90 degrees instead of at an angle like a spade bit. Forstner bits are somewhat slower to use than spade bits, but create perfect circles every time and work very well with Plexiglas. A forstner bit is *highly* recommended!
1 $^{1}/_{8}$-inch hole saw	Hole saws are good choices for working with Lexan or Plexiglas control panel covers.
Countersink bit	To get that nice, smooth finish to your wood, you'll use this bit to countersink your screws.
Power screwdriver	You'll be much happier with a separate power screwdriver or second drill than having to constantly switch bits on your primary drill. You can, of course, elect to use manual screwdrivers instead.
High-speed rotary tool	A high-speed rotary tool, such as a Dremel, is something you do not necessarily need but might find handy. They work well for grinding down and fixing small areas. I used mine a few times for fine-tuning my cabinet.
Router	You'll find the router to be one of your most versatile tools. You'll use it to rout out areas for mounting controls and to cut the groove in your edges for the T-molding.
Slot cutter bit	You'll need a slot cutter bit for your router to make the groove for the T-molding. Usually a $^{1}/_{16}$-inch or $^{3}/_{32}$-inch size will do, but size may vary depending on what T-molding you purchase.

Continued

Table 2-2 *(continued)*

TOOL	PURPOSE
Sander	An electric sander is another item you should consider but can do without in a pinch. If you're willing to trade elbow grease for electric power, you can sand by hand instead of with a sander. You're likely to end up doing a fair share of sanding, so a sander is recommended.
T-square	Perfect 90-degree angles are easier to achieve with a T-square.
Level	You'll want to make sure all the parts are level as you assemble them.
Straightedge	A good metal straightedge will help you make perfect cuts. Hardware stores sell them in varying lengths up to 8 feet.
Sawhorses/ workbenches	You'll need a couple of sawhorses or workbenches to hold your wood while you work on it.
Clamps	Unless you have more than two hands, you'll want to pick up at least four clamps to hold pieces still while you work on them. Look for clamps that have rubber shoes to protect the wood. I used as many as 8 clamps at one time.
Paint	A gallon of paint should suffice for painting your arcade cabinet.
Primer	To prepare the cabinet for painting.
Painting supplies	Drop cloth, two rollers, mixing sticks, and one or two paintbrushes.

You'll also want a good set of expendable supplies on hand as you build your cabinet (Table 2-3). A good rule of thumb is to pick up more than you think you'll need. There's nothing quite as annoying as having to interrupt a project in the middle because you're short on supplies.

Table 2-3: Supplies You Will Need

ITEM	PURPOSE
Wood	Three sheets of 4-foot by 8-foot wood in 5/8-inch or 3/4-inch thickness for the cabinet, a fourth sheet for the control panel. You may want a different thickness for the control panel top (read further on in this chapter).
Screws	An assortment of 1/2", 3/4", 1", and 1-3/8" (or 1-1/2" if you can't find 1-3/8") wood screws of the same thickness, #8 recommended.
L-brackets	Four 2-inch by 3-inch or 2-inch by 2-inch L-brackets.
Wood putty	One container of wood putty to fill countersink holes and repair blemishes.

ITEM	PURPOSE
Sandpaper	Sandpaper of various grits for different parts of the job. A rough grit will be good for sanding down imperfections, while a fine grit will be used when painting.
Miscellaneous	Pencils, good erasers, rulers, tape measures, and other common household items will come in handy during construction.
Protective gear	Pick up good-quality protective gear for your ears, eyes, and breathing. Be sure to include protective gear for your assistant as well if you have one.
Casters	Four casters with a wheel depth of 2–3 inches.

Beginning Construction

It's about time to fire up some power tools! I assume at this point that you've made your first shopping trip and have set up shop in an adequate area. You should have your protective gear available and your tools and supplies ready to go. Ready to start?

TIP **Are you planning to document your project as you go? Now's the time to start! Get that camera ready, and watch out for dust. As you work with the wood, fine particles of dust will go everywhere. Keep your camera inside a case or otherwise protected in between pictures.**

Drawing And Cutting Out The Plans

I'll get you started with drawing your construction plans on your sheets of wood. Take a good look at your wood before you begin to sketch the plans out. Is one edge in better shape than another? Check it with your T-square and level. Is the edge genuinely straight, or is it angled? Making sure now will help in the long run. If your first edge is not straight, and you base the rest of the edges and measurements on it, then the rest of your pieces may end up incorrectly proportioned, causing you problems as you begin to assemble.

WARNING **From here on out, always keep one eye out for safety. Building an arcade cabinet is a lot of fun — it would be a shame to ruin that by getting injured, or worse, in an accident. Working with power tools requires a certain amount of respect for the tool. Always follow the instructions included with the power tool for proper use and care. Routers can get away from you, power saws can kick back at you, improperly grounded tools can shock you. Better to be slow and safe than hasty and hurt!**

You need to decide on the width of your cabinet before you start drawing and cutting. This decision should be based on the size of the monitor you intend to put in it. If you already know which monitor you plan to use, you can adjust the dimensions of the plans to accommodate it. If you don't know, then a width of 26 inches is a good size for most needs, which will accommodate up to a 27-inch monitor (monitors are measured diagonally). Even if you know you intend to use a smaller display, such as a 19-inch, you should consider building a larger sized cabinet. This will allow you room to grow should you decide to upgrade to a larger display at a later time.

One thing you should think about as you begin is wood loss due to cutting and other imperfections. An average circular saw blade is $1/16$-inch wide. If you have two pieces drawn out back-to-back sharing a common edge, and you cut perfectly down the middle, then you are reducing both pieces by $1/32$-inch. As a practical matter, this small amount of loss will not matter. However, if you cut to one side of the line instead of down the middle, you've introduced a $1/16$-inch variance to one piece and not the other. If you compound this by sanding or by error, you begin to introduce a discrepancy in size that may be visibly apparent during construction. Take care as you lay out and cut your pieces to avoid these issues.

Fortunately, wood is a forgiving medium. If you carefully examine the pictures taken of Project Arcade 2 during construction, you may notice various edges that are slightly off. Sanding, wood filler, and the small amount of give that soft wood provides will take care of these things. When the project is finished, none of this will be noticeable. Don't let minor imperfections during construction discourage you. Remember, there are only two things you have to accomplish in this project. First, it has to be appealing to you (and perhaps a spouse). Second, it has to be safe and structurally sound. Other than that, beauty truly is in the eye of the beholder. That said, take your time and some care, and you'll create a work of art guaranteed to provide hours of fun!

There are a few tips to think about while laying out, cutting, and assembling your wood.

- Measure twice (or more!) and cut once. As my father-in-law often says, "No matter how many times I cut the wood, it's still too short!"
- When measuring distances for lines, use several tick marks. Two tick marks are all that's required to make a line, but three or more will help ensure that your line is straight instead of angled.
- This is a good time to call in favors with your buddies and get one to help you. Some of the construction can be heavy or awkward, and a helper can be invaluable. A lot of folks will build two cabinets at a time, one for them and one for their buddy.
- Have your helper double-check your measurements and lines. It's easy to overlook a problem with something you've been working on for a while, while someone with a fresh perspective might see it.

- Never assume that measurements from the store are accurate. Sometimes a 4-foot × 8-foot board isn't really 4 foot × 8 foot. In the case of Project Arcade 1, the MDF sheets purchased were actually 49 inches wide. There is some methodology in the wood industry where measurements aren't always as labeled. A stick of 2-inch × 2-inch wood is actually 1.5 × 1.5 inches, for instance. If in doubt, measure.
- As you draw out and cut the wood, label each piece. This will make it much easier to assemble the pieces later!
- When you have two pieces that are opposite sides of each other (such as the top side panels), clamp them together and make sure of a close match, sanding away minor differences.
- When choosing a saw blade, bear in mind that a finer-toothed blade will produce smoother cuts, although at a sacrifice in speed.
- Before you begin to cut, take an unused section of wood and do a test cut. This will let you make sure both your tools and you are working properly!
- When sawing, cut *through* the end of the wood. If you stop at the end, you might jerk the tool up, causing imperfections at the end of the cut. Continue your cut past the end of the wood to ensure a smooth cut all the way through.
- Check your cuts from a couple of angles. Sometimes cuts that aren't quite straight can be seen from one angle but not another.
- Use your straightedge and clamps for as many cuts as possible. Freehand only when you have to, otherwise take the guesswork out of the process when you can.
- When attempting to blow away sawdust, remove your mask first! Much productivity was lost to laughter when my father-in-law got this backwards!

Get Started!

You'll find three different sets of plans on the companion CD for the Project Arcade 2 cabinet. The first is the main set of plans (ultimatearcadeII_cabinet.pdf). If you haven't yet, print those out, because you'll need to use them as you build the cabinet. Before continuing on in this chapter, I strongly recommend you read the entire set of plans to familiarize yourself with them. For the rest of this chapter, I'll discuss the steps in the plans but I won't repeat the steps verbatim from the plans. As you build, I recommend you re-read each step in the plans then refer to the book for discussion on that step before you set to work. You may notice that I've deviated from the plans in a variety of areas. I'll cover that in a moment.

CROSS-REFERENCE The plans are in PDF format, which requires the free Adobe Acrobat Reader or a compatible alternative. You can get the reader software at `www.adobe.com`, clicking on the link that says "Get Adobe Reader."

The second set of plans you'll find is the details supplement (details_supplement .pdf). The measurements on the main set of plans for the various wood pieces are difficult to make out. Use the measurements in the supplement as you lay out the pieces on your wood sheets. In addition to the measurements, the supplement gives you a suggested layout for the various pieces on the three sheets of wood.

The third set of plans is the instructions for the control panel. I'll tackle that in Chapter 6.

Deviations From The Plan

These plans are the Ultimate Arcade II plans normally sold by North Coast Custom Arcades, and many people have happily built cabinets from them as is. However, I deviated from the plans in a few ways for a few different reasons. You can elect to follow my changes, or stick to the plans strictly. Either one will work fine. I'll mention some of the changes (and why I made them) as we go over the step-by-step build, but changes I made in general include:

- Tools required. Because of some of the other changes I made, the tools required vary slightly. If you decide to follow my changes, use the tool list presented in this chapter. If you decide to follow the plans strictly, use the tool list in the plans.
- Materials list. I modified the materials list as made sense for the other changes I made or for availability of the parts. For instance, the plans call for 1 3/8-inch wood screws, but I could not find them in my local hardware store. I used 1 1/2-inch wood screws instead. Make changes here as makes sense to you.
- Laminate. As more cabinet builders paint their cabinets than use any other finish, I elected not to use laminate on this cabinet. See "Paint vs. Laminate "later in this chapter to help decide how you want to proceed.
- Wood thickness. The plans call for 5/8-inch wood. I could not find MDO wood in 5/8-inch size, and went with 3/4-inch instead. This means several measurements on the details supplement need to be changed. I'll talk about that when we get to that section.
- Countersinking screws. I agree with the plans that all screws should be countersunk. However, instead of using a 3/8-inch drill bit and collar stop to countersink the screw holes, I used a countersink drill bit.

- Key lock. I decided I did not want a key lock in the front of the cabinet for the keyboard drawer. Aside from not buying the lock, that meant I did not have to make a hole for the lock in panels D and E as shown in the plans.

Paint vs. Laminate

Do you want to paint your cabinet or laminate it? Without a doubt you're likely to be happier with a laminate finish than a painted finish. When I asked arcade industry experts from HanaHo what kind of paint they normally used, they responded that paint as a rule hadn't been used on arcade machines since the early days. Most cabinets were laminated with a side-art sticker on top. This made sense — laminate is smoother and less susceptible to blemishes and generally looks nicer. For our purposes however, consider that laminate is harder to work with and can cost more, and that it's possible to get a beautiful paint finish with some time and patience.

Laminating

The two big drawbacks of using laminate are obtaining it and applying it. None of the hardware stores around me carried the laminate I might have used in stock (I did not want kitchen-counter stone fleck on the sides of my cabinet!), requiring a special order instead. It was also more expensive than I was happy with in comparison to paint.

Applying laminate can be tricky and generally follows these steps. Laminate comes in sheets, so first you cut it in the general shape of the piece of wood you're going to cover, making it somewhat larger so it overlaps on all edges. Next you apply the adhesive to both the wood and the laminate, and let it cure for a period of time as per the instructions. Then you put dowels or small sticks of wood on the piece to be laminated, and lay the laminate on top of the dowels. Carefully remove the first dowel and start to press the laminate to the wood piece, using a roller or similar tool to fix the laminate down. *Be careful here* — the adhesive is not forgiving at all! Once the laminate touches the wood it's permanently attached; you can't pick it up and reposition it. That's why you use dowels to keep it separated as you start to apply it. Work your way down the laminate, removing dowels as you go until you've pressed the entire laminate sheet down on the wood piece. Finally, you'll use a laminate trim bit in your router to cut the excess laminate from around the edges. Simple, no? Well, it's not really that complicated, but it's certainly a much less forgiving process than painting.

Painting

Painting is an easier and more forgiving process than laminating. If something goes wrong you can either sand it out and repaint, or just touch it up if possible. Be careful of your environment when you paint! I was painting outside, and being happy with my first coat of primer, I left it outside to dry. You can probably guess what I found when I came back out. My beautiful cabinet had bugs stuck to the drying primer! Ick! I rescued the bugs but I had to do more sanding than I originally intended to get rid of the bug impressions!

Your first choice to make when painting (other than color, of course) is oil based vs. water based (latex). Generally, an oil-based paint will make it easier to obtain a nice smooth finish than a latex paint. Oil based paints are slightly harder to work with however. You have to use mineral spirits to clean your brushes and rollers, and you'll need to have plenty of ventilation as it takes a long time for the smell from oil based paints to fade away. Latex-based paints clean up with soap and water, and the fumes are generally not an issue.

You will need to put a lot of time and elbow grease into your paint job if you want a really nice finish. It is possible to paint a cabinet quickly. However, what you'll end up with is a cabinet that looks like it was quickly painted. Doing it right is a long process of applying a coat of paint or primer, allowing it time to dry, sanding it smooth, and repeating.

Make sure your wood surface is smooth and clean before you begin painting. The MDO I used was very smooth to start with, but I still went over it with a fine-grit sandpaper before I began. Then I dusted it off, and used wet wipes to make sure I'd removed the dust. Only after that did I put down the first coat of primer. Be sure you do use primer before painting! You'll get poor results if you don't, possibly requiring you to sand all the way back down to the wood and start over.

TIP **I highly recommend using a power sander if you can. Elbow grease is fine, but you're going to be doing a *lot* of sanding if you want a great finish. Also, please be sure to wear proper respiratory protection! Some of the wood can have nasty chemicals in it, particularly the manufactured wood like MDF. You don't want to breathe that or the paint fumes.**

Let the first coat of primer dry completely; then sand it down to a smooth surface. Start with a rougher-grit sandpaper; then go over it again with a smoother grit. Don't be afraid to sand it so much that some of the wood starts to show through. For a great finish, you'll be using a lot of thin coats instead of a few thicker coats. Once it's smooth, dust it off then use a wet wipe or damp paper towel to make sure it's dust free. Throw on a second coat of primer, let it dry, and sand again. You'll probably only need a couple of coats of primer, but evaluate it now and decide whether you want a third before you move on to the paint.

You'll follow essentially the same process with your paint next, though you may want to use a finer grain of sandpaper than on the primer. The various grits of sandpaper should tell you what their intended uses are to help you decide what grit to use when. Remember that several thin coats will give you a nicer finish than globbing it on thick. Thin coats will also dry quicker, particularly in a humid climate. I've heard of some problems with cabinets being tacky (as in sticky, not appearance!) weeks after painting because the paint was laid on too thick.

TIP **I strongly recommend you talk to a paint expert in your area before you begin. They can help you select the best paint and tools to use for your specific situation and give you advice on curing times and finishing.**

Other Finishes

You can, of course, use other finishes as well. I've seen some beautiful cabinets done with a nice wood and then stained instead of painted or laminated. You have to have the right kind of wood for that of course — manufactured wood such as MDF doesn't have pretty grain patterns to highlight with stain.

Other people have elected to use a vinyl covering (often used in speaker construction among other things) for their cabinets. I wouldn't personally go that way for a couple of reasons. Most rolls of vinyl aren't wide enough to cover a cabinet side in one pass, meaning you have to line the edges up carefully so that you don't have a visible or crooked seam. Larger width vinyl is available but tends to cost a lot more. The other reason I wouldn't use vinyl is that it's not terribly forgiving when applying. The tiniest speck of dust can show as a blemish underneath vinyl, ruining the smooth look you're trying to achieve. Overcome these two hurdles however and vinyl can give you a nice finish.

Do The Math

You're about to measure and draw out your cabinet pieces on the sheets of wood. You need to know two things now — the width of the monitor area (hereafter referred to as WIDTH), and what deviations you have to make if you're not using $^5/_8$-inch sheets of wood. There's a bit of math involved for the next few steps, but if you bear in mind the overall concepts of why you're doing the math it'll help you avoid any mistakes as you make your various calculations.

For Project Arcade 2, I elected to declare the WIDTH to be 26 $^1/_4$-inches. This will accommodate the 25-inch monitor I'll use, and will also make some of the measurements easier. For instance, panel B should be cut to the width of the monitor area minus 1 $^1/_4$-inch, or WIDTH - 1 $^1/_4$-inch. In my case, with WIDTH set to 26 $^1/_4$-inches, that makes panel B 25-inches (26 $^1/_4$ - 1 $^1/_4$).

If you're not using $^5/_8$-inch thick sheets of wood, you'll need to adjust some of the measurements on the details supplement. I found it helpful to picture why the adjustments are needed. This cabinet is built in two sections — a lower base section, and an upper section that fits over the base. Take a look at Figure 2-4.

If you use a thicker wood, then the overall width of the base will be slightly greater. Why? There are two panels in the base that are vertical (each side piece), where the thickness of the wood is a factor. All the other pieces of wood in the base are horizontal, so their thickness won't affect the overall width of the cabinet.

However, the extra thickness of the two vertical side panels makes the overall cabinet base slightly wider. In my case, I used 3/4-inch wood for Project Arcade 2, 1/8-inch thicker than the plans expect. Since there are two vertical panels in the base where the width is a factor, that makes the overall width of the base 1/4-inch wider than the initial design. This is a problem because it means the base will be too wide to allow the upper section to fit over it as originally measured.

Figure 2-4: The Ultimate Arcade II design, upper section over lower section.

I had two choices to compensate — I could adjust the horizontal pieces in the base to be 1/4-inch narrower, making the overall base 1/4-inch narrower, or I could adjust the horizontal pieces in the upper section to be 1/4-inch wider, making the whole upper section 1/4-inch wider. I elected to make the upper section horizontal pieces wider because there are fewer pieces to adjust that way. If you are using something other than 5/8-inch thick wood, you will have to make similar adjustments to your own plans now.

If you're using a different thickness of wood and you elect to make the cabinet base narrower to compensate, you'll need to narrow the width of pieces A, B, C, D, E, G, H, I, J, and possibly F. I'll discuss F later in this chapter when it comes to installing it. Example: Panel B is WIDTH - 1 1/4-inch. Using my assignment of

WIDTH = 26 $^1/_4$-inches, panel B would be 25 inches. However, since I'm adjusting it, I need to narrow it by an additional $^1/_4$-inch. Final measurement for panel B is 24 $^3/_4$-inches. Remember your numbers may vary depending on the WIDTH you've chosen and the thickness of your wood.

If you're using a different thickness of wood and want to make the upper section wider to compensate, you'll need to increase the width of pieces K, L, M, N, P, and Q. Example: Panel K is WIDTH inches, or 26 $^1/_4$-inches. Since I'm adjusting it, I need to widen it by $^1/_4$-inch. Final measurement for panel K is 26 $^1/_2$-inches. Remember your numbers may vary, and you only need to adjust the upper section or the lower section, but not both!

TIP **This is a great time to take the supplement detail plans, make your calculations, and write your actual measurements on each piece on the plans. Also note any deviations, for instance if you're skipping the keyboard lock, don't drill the holes in panels D & E. It's easy to get caught up in the measuring and cutting of the wood, but if you have your specific changes noted on the plans it'll help keep you from making mistakes.**

Lay Out The Wood

Enough talking already, let's draw the pieces and fire up those power tools! If you look at the details supplement, it'll show you the dimensions of each piece (which you've hopefully adjusted as needed by now). The last couple of pages also show you a recommended layout for the various pieces on your sheets of wood. I won't walk you through cutting each piece, but I will give you some general tips and then some specific comments on various pieces.

Bear in mind the thickness of your saw blades. Note on the plans that each piece has space between it and its neighbors on the suggested sheet layout. You may be tempted to put pieces flush against each other to reduce the number of cuts you have to make. Don't forget to take into account the thickness of your saw blades as mentioned earlier. You can lose $^1/_{16}$-inch to $^1/_8$-inch with your cuts, even more if your pieces are flush against each other when cutting.

Be aware of how your various tools cut. For instance, a circular saw cut will extend further beneath the surface than what you see on the surface. This can be a problem for some cuts, for instance if you're cutting up to a turning point. Take a look at Figure 2-5 to see an example of where that caught me off-guard (fixed later with wood putty).

Many of the panels require angled cuts along one or more edges. The details supplement will show you the angle and direction of those cuts. I found it confusing sometimes as to exactly how the angled cut should go. If that happens to you, take a look at the cabinet details page on the main plans for where the piece goes to help decide how the angled cut should be made. I also found it helpful to hold adjoining pieces together before making the angled cuts to help me visualize what I was supposed to do.

Figure 2-5: Oops! The circular saw cut further into the wood than I wanted.

TIP **Once again, don't forget the width of your saw blades when making the angled cuts. You'll kick yourself if you carefully account for the saw blade when cutting your pieces out of the wood, for instance making sure a 10-inch width is really 10 inches when cut, only to lose 1/8-inch when you make the angled cut. If you're careful with your saw, you can make sure the angled cut starts at the outside edge of the wood so that the widest part of your wood is the proper width. If you forget, though, the widest part of your wood will be a bit short.**

I have a few more general suggestions. Use a straight edge to guide your saw for your cuts. Even with a steady hand, trying to make straight cuts free-hand will likely introduce small variations that will cause you grief during assembly. Use plenty of clamps while you work. Clamp your sheets of wood to the work benches you're using so they don't wobble on you during cuts. Clamp your straight edge securely as well. I also used clamps to help keep the already-cut side of a long cut together so that the wood didn't flex and bind the saw during long cuts (see Figure 2-6). Note on the details supplement the numbers inside brackets are measurements in millimeters if you prefer those over measurements in inches. Finally, label all your pieces while drawing them out before you cut. This will save you much confusion later on.

Upper Section Side Panels

Getting the slope and curve of the upper side section panels can be a bit tricky. Lay out all the straight and angled lines on your sheet of wood first except the two lines leading into the curve. The measurements on the details supplement show you the distance from one edge to the center of a 2-inch circle where the curve is (11 7/16-inch and 1-foot 10 5/16-inch respectively). Mark that point on your sheet of wood. Then take your 2-inch hole saw and place it so the center of the hole saw is on your mark. Draw a circle around the hole saw. Now connect the two corners that lead to the curve so that the lines connect to the circle as shown in Figure 2-7. When cutting, I found it easier to cut the circle with the hole saw first.

Figure 2-6: The near side of a long cut clamped to keep the wood from flexing.

Figure 2-7: A close-up of the straight lines coming into the circle for the curved cut.

Panel N

Panel N will be your speaker panel (note that I'm introducing panels in the order they appear on the details supplement). The two circles shown on the panel are cutouts for your speakers. Before you make those cutouts, you should have some idea of the size and shape of the speakers you're going to use. For instance, if you use the same speakers I chose for Project Arcade 2, your cutouts will end up rectangular instead of circular. If you don't know yet you can leave those cutouts for later, but it will be more difficult to make those cutouts after the panel is installed. If you're going to use the same speakers I chose, a cutout template is included on the companion CD. The speakers I chose are nice but a bit pricey, so consider that carefully before you cut!

NOTE **There's a bit of a chicken and egg dilemma here. It's better to cut out your speaker holes before mounting the panel, but it's not easy to visualize where the holes should go before the cabinet is assembled. Before you make the speaker cutouts, I strongly recommend reading at least the first part of Chapter 11.**

Panel C

Panel C has two angled cuts to make. Note carefully the direction of the cuts. The cuts should be somewhat parallel to each other as shown in the plans. Don't make the mistake I did, as seen in Figure 2-8!

Figure 2-8: Panel C — this is not how it is supposed to look!

Panel B

Panel B is the front "kickplate" panel and has a large cutout for a coin door. Coin doors come in different shapes and sizes, so before you cut it out make sure the hole matches the coin door you're getting. The coin door that matches the cutout on the plans is on the parts list and available from Happ Controls. Consider also that you may not want to include a coin door. They look nice but they're expensive and it's most likely illegal for you to charge to play your machine, so a coin door is mostly for show. If you don't want a coin door, you obviously won't need to cut out the hole.

If you do cut out the hole, you can use similar techniques as for the curve on the upper side panels. Use a 2-inch hole saw to help draw and cut the four corners.

Panel D

The slot in panel D is to accommodate the rear mechanism of the keyboard lock, usually a bar of metal that rotates 90 degrees behind the panel to prevent it from being able to pull forward. Examine your lock before you cut this slot to make sure it'll work properly, and of course if you're not using a keyboard drawer lock don't cut the slot. Panel D is the section your keyboard drawer will butt up against when closed, not part of the keyboard drawer that opens and closes.

Panel E

The hole in panel E is for the keyboard lock. Cut the hole to match the dimensions of your keyboard lock, and of course don't cut the hole if you're not going to use a lock.

Panel O

Don't miss the note on panel O that you make two of these.

Upper and Lower Side Panels

Once you have all the pieces cut out, take the two upper side panels and stand them next to each other on a level surface. Do they look exactly the same? Odds are you'll see some (hopefully) minor variances (for instance see Figure 2-9). If so, clamp the two matching pieces together and use sandpaper to smooth out the differences. If sandpaper won't cut it, you may want to use a pencil to mark the differences between the two and then use your woodworking tools to make adjustments. It doesn't have to be perfect, but you want it to be aesthetically pleasing and match up closely enough that your cabinet will be squared and won't be unbalanced or off-center. Do the same thing for the two lower side panels.

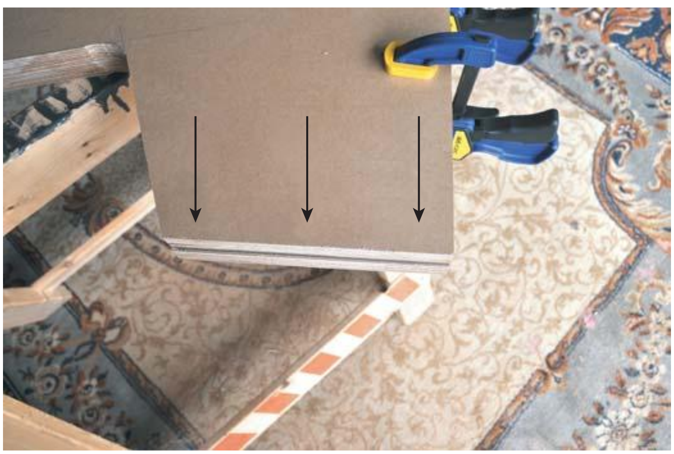


Figure 2-9: A close-up of front-top of my upper side panels, showing about a 1/8-inch variance.

Let's Build a Cabinet!

Now that you've got all of your pieces cut out and the angled cuts made, it's time to turn that pile of wood into something resembling an arcade cabinet (see

Figure 2-10)! We're going to go over this together step-by-step. Remember to read the step in the plans first; then refer to the book for more insight on each step. This is where all of your planning and preparation start to pay off, and you're on your way to arcade paradise. In fact, by cutting out the pieces, you've already completed step 1!

Figure 2-10: This pile of wood is going to become an arcade masterpiece!

Step 2 — Routing Slots for T-molding

It is much easier to route the slot for your t-molding before you assemble the cabinet. Unless you have a dust-catcher on your router, I highly recommend you do this step outside. This step produces an *incredible* amount of dust!

WARNING **If something goes wrong with a router, it can go wrong in a big way. Routers spin razor sharp bits at thousands of revolutions per minute. Be sure you're wearing good eye protection, as well as a good face mask and ear protection. A flying router bit can break flimsy eye protection and hurt you very badly. Also, the miniature dust particles are nasty to breathe. Don't skimp on your safety!**

You need a slot cutting bit for your router for the t-molding. A slot cutting bit is a sharp round disc that is fixed perpendicular to the shaft that goes into the router (see Figure 2-11). The router sits flush atop the wood piece about halfway over the edge, and the disc cuts into the edge of the wood, creating the slot (see Figure 2-11).

Figure 2-11: Left, a slot cutter bit. Right, a close-up of a router cutting a slot in a piece of wood.

Be sure to test cutting your t-molding slots on a piece of scrap wood first. It should require almost no effort at all to move the router in the wood — in fact, if you're not careful it just might get away from you! If it feels like you're having to muscle or fight the router, you're either going the wrong direction or something's wrong with the way you've set up the router. After you cut a sample slot in a piece of scrap wood, test fit your t-molding (Figure 2-12) to make sure the slot's the right size and centered properly. Once you're satisfied with your tests, cut your t-molding slots on the upper and lower side panels.

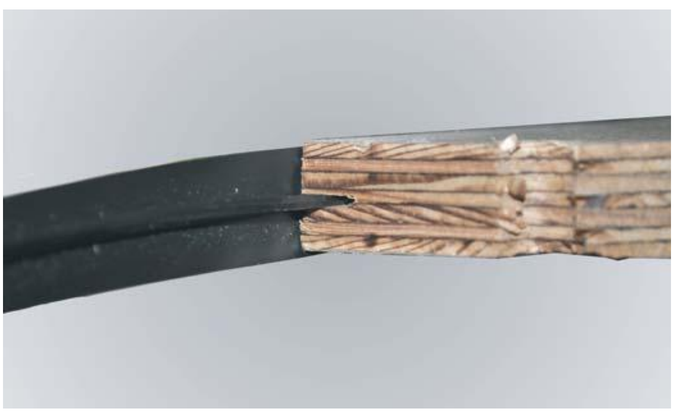


Figure 2-12: Test fitting the t-molding. Notice the slight bit of wood showing above the t-molding. The router height needs to be adjusted slightly upwards.

CROSS-REFERENCE **I'll talk about installing t-molding in Chapter 15. If you're installing it now, should skip ahead to that chapter to read about it; then come back to here.**

Step 3 — Cabinet Bottom Panel Assembly

Step 3, and many following steps, call for you to measure two lines on the edge of various panels: a starting line, in this case 1/2-inch from the outside edge, and a second parallel line 5/8-inch in from the first line (not from the outside edge). These two lines define the placement of a second panel piece that's about to be attached in some fashion to the first. If you're using a different thickness of wood from the 5/8-inch called for in the plan, adjust accordingly. In my case, my second parallel line is 3/4-inch from the first line.

Panel A is the floor of your cabinet and is going to be placed 1/2-inch up from the bottom of the two side panels, and recessed back from the front of the side panels. The amount of recess will depend on the thickness of the wood you're using. Panel B will sit vertically in front of panel A in the next step. In front of panel B you'll have 1/2-inch of empty space (i.e., panel B will not be flush with the front of the side panels). Therefore the amount of recess will be (thickness of wood + 1/2-inch) inches from the front edges of the side panels. In my case that meant a recess of 1 1/4-inch. Note that if you're using wood thicker than 5/8-inch this will mean that the rear panel, later on, will have less than the 1/2-inch recess called for from the back edge of the side panels. That's fine; this is purely a cosmetic consideration.

TIP **The plans call for you to make the two parallel lines for the placement of your panels on both the inside and outside of the adjoining panel. This is so you know where to place the panel on the inside, and where to drill the screw holes from the outside. Instead, I recommend you draw only the inside set of lines and then drill your pilot holes from the inside out. Your screws will be in the proper place, and you won't have to draw the extra set of lines. You'll see outside lines drawn in several of my photos as I didn't figure this out right away.**

This step might be easier with a partner to assist you. What I did was place the first side panel flat on my workbench, hanging slightly over the edge. I positioned panel A appropriately underneath it, using scrap wood to get it to the proper height (see Figure 2-13).

I used several clamps to fix the position of panel A to the side panel (see Figure 2-14), then drilled through my pilot holes in the side panel into the edge of panel A. Next came the screws, and panel A was attached to the first side panel. Then I flipped it over and did much the same to attach the second side panel.

The final part of step 3 (and some subsequent steps) calls for you to place a bead of adhesive along one edge in preparation for the next step. I would not do so until you have already drawn the lines for the next step, drilled your pilot holes, and test-fitted the piece to make sure it'll fit properly. If you get delayed or have to make an adjustment the adhesive will dry before you're ready, if you have done it too soon.

Figure 2-13: This Rube-Goldberg contraption worked like a charm!

Figure 2-14: Clamps on both sides help me keep this panel properly aligned while I drill and screw it into place.

Once you have both panels attached, carefully stand it upright and make sure everything looks square and level. This is the base of your cabinet; if it's off everything else will be off. If you have any problems fix them before proceeding, even if you have to re-cut a piece. If it looks right then congratulations, your cabinet has started!

Step 4 — Coin Door Panel Assembly

In this step you'll attach front coin door panel B to the base. When you're done it will look like Figure 2-15. Use similar techniques as before for drawing your lines, and clamps to position panel B in place. You probably won't be able to get clamps in place behind the panel, so position your clamps in front so that when panel B rests flush against them it's properly aligned according to the guide lines you've drawn. Note that the upper angled edge of panel B slopes from the back down to the front. That is, the lower edge of the top of panel B is in front.

Figure 2-15: Your end goal for step 4, looking from the rear of the cabinet.

For extra stability, I decided to glue panels A and B into place along with the screws. Attach one side completely with the screws, then flip the cabinet base onto its side with the completely attached side down. Remove all but one screw from the upper side panel, then loosen that remaining screw slightly so that the panel can swivel. Don't remove the last screw — it will help you quickly swivel the side panel back into place without fumbling for proper alignment while glue gets everywhere. Swivel the side panel out, and then place a bead of glue along the exposed edges of panels A and B (see Figure 2-16).

Be sure you are fully supporting the side panel so that no torque is placed on the one remaining screw! If it's not completely supported that screw will probably rip out of the wood. After you've placed a bead of glue on the edges, swivel the side panel back into place, put the screws back in, and let the glue dry. The glue is going to drip (Figure 2-17), so have some wet wipes or damp paper towels handy to mop up the excess glue. If you're using MDF, be careful of getting the wood too wet because it can absorb the water and the wood will expand. Check back a few times during the drying process because the glue will probably drip for some time.

Figure 2-16: Cabinet base side panel swiveled out to allow for gluing.

Figure 2-17: It's raining glue!

Step 5 — Angled Front Panel and Keyboard Drawer Back Plate

Panels C and D are next on the list. Panel C is straightforward. Draw your lines and use clamps to position the panel, then drill and screw into place. See Figure 2-18 for how I used clamps to assist placement.

Placing panel D will require a bit of thought and test placement. Panel D is the "backstop" for panel E, which is the vertical front panel of the keyboard drawer. Horizontal panel F of the keyboard drawer will ride above the top of panel D. Sneak a peek at step 6 on the plans to help make that clearer.

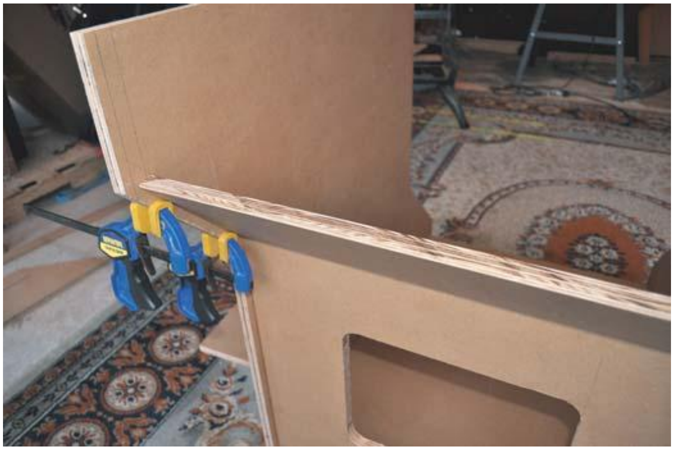


Figure 2-18: A close-up of panel C resting on the clamps.

You'll want to place panel D recessed far enough back from the front edge of the side panels so that when panel E is butted up against it, panel E is placed where you want it. You might want panel E to be flush with the edge of the side panels when the keyboard drawer is closed, or you might want panel E to be recessed slightly to match the rest of the front of the cabinet. The way I did this was to take panel E and rest it atop the lip of panel C, recessed as far from the front edge as I wanted it to be. Then I placed panel D flush behind panel E, and drew lines to mark where panel D should be placed. Don't forget if you don't have enough hands for all of this use those clamps! Panel D should rest on the lip of panel C, or, if recessed too far for that, should be mounted at the same height, as if it were resting on the lip of panel C. When done, it should look something like Figure 2-19.

Figure 2-19: Panels C and D in place. Left, looking at it from the rear. Right, looking at it from the front.

Step 6 – Keyboard Drawer Assembly

You'll use panels E and F to make the keyboard drawer assembly. Before you begin, you'll need to make sure panel F will fit properly once the keyboard rails are installed. Assemble the left and right pairs of keyboard rails and hold them to panel F as if they were permanently affixed. Tape may help you here. Then hold panel F with the attached rails in place between the base side panels. It should fit snugly. If it's too big, you'll need to trim panel F down a bit. If it's too narrow for the rails to meet the sides, that's OK. You can solve that problem by using washers between the rails and the side panels. Once you've determined that panel F will fit properly with whatever adjustments might be necessary, you can remove the keyboard rails for now.

The next step is to drill your two pilot holes into front panel E. What you need to do after that is drill through those pilot holes into the edge of panel F. This may be a bit difficult to do, as you need one hand to hold panel E, one to hold panel F, and a couple more hands to do the drilling. I don't have enough hands, and couldn't come up with a way to use clamps. An easy way to solve this is to drill your holes as shown in the plans in panel E. Then drive your screws into panel E until they stick out the other side a bit. Place panel F parallel to panel E, center panel F on panel E, then use the position of the screws to mark where your pilot holes should go on panel F (see Figure 2-20).

Figure 2-20: The screws make marking the position of your pilot holes easy.

Once you've marked and drilled your pilot holes in the edge of panel F, the rest of this step is easy enough. You might want to put a bead of glue along the edge of panel F before you install the screws. The last part of step 6 is to install the keyboard rails. Make sure the keyboard rails are flush with the back edges of panel F.

Step 7 — Keyboard Drawer Slide Installation

You may find step 7 to be a bit tricky. Installing the keyboard rails to the insides of the side panels isn't hard, but getting them lined up properly can be. What I did was to place the matched external rails on to the inside rails already attached to the keyboard drawer, position them so the back ends were flush, then tape the rails together firmly. Next hold the keyboard drawer in place in the cabinet, with a level on the drawer to make sure it doesn't lean to one side. Then draw a line around the edges of the keyboard rails onto the inside side panels, so you have a template for where the rails need to go. This is definitely a step that's easier with an assistant, but it's possible to do by yourself if needed.

Once you have the locations marked and have eyeballed it a few times to make sure everything's level, remove the tape and permanently affix the side rails to the side panels. Only use a couple of screws at first and then test the fit and level of your keyboard drawer, so you can make adjustments if necessary. Your end result should look like Figure 2-21.

Figure 2-21: The installed keyboard drawer. Left, open. Right, closed.

Step 8 — Rear Panel Assembly Part 1

Using the same techniques you've used in previous steps, placing panel G is straightforward. It should be inset 1/2-inch, or as much as panel A will allow if less than 1/2-inch. The bottom of panel G will be flush with the bottom of the side panels (see Figure 2-22).

Step 9 — Rear Panel Assembly Part 2

You'll put rear panel H into place in step 9. It will be easier if you place the cabinet base on one side, drill and install screws into panel H, then flip it over to do the other side (see Figure 2-23).

Step 10 — Monitor Shelf Assembly

The two panels marked I are the cross-supports for your monitor shelf that you'll place in step 11. The tricky part here is to make sure you get the pieces oriented the right way. The angled cut edges face up, with the slope of the cut matching the slope of the side panels you're attaching them to. Once again clamps are your friend (see Figure 2-24).

Figure 2-22: Rear panel G installed.

Figure 2-23: Rear panel H installed.

Precise placement front to back isn't critical, as the only purpose of these cross pieces is to give additional support to the monitor shelf in the next step. You do need to make sure they are flush with the top of the side panels so that the cross pieces support the shelf levelly. Use a piece of straight scrap wood to test across the side panels and cross supports, and if it isn't sitting flat make any necessary adjustments before screwing and gluing. The end result should look like Figure 2-25.

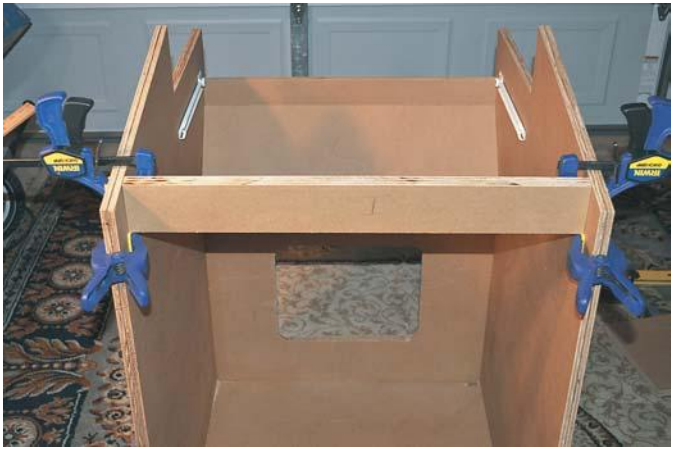


Figure 2-24: Positioning piece I with clamps.

Figure 2-25: Both cross pieces installed.

Step 11 — Monitor Shelf Assembly Part 2

Monitor shelf panel J sits atop the side panels and the two cross pieces installed in the last step. Test the fit to make sure the shelf doesn't extend over any edge and trim if necessary. Make sure the front edge of the shelf is flush with the front edges of the side panels, then glue and screw the shelf into place (see Figure 2-26).

Step 12 — Finishing the Assembled Base

You're on the last step of the base assembly! If you're using laminate on your cabinet, you'll want to install it now. Since Project Arcade 2 is painted instead of laminated, I obviously skipped this step. You also may want to install the t-molding now on the base section. I elected not to as I was concerned about damaging the t-molding during construction of the rest of the cabinet. This is not a major concern and damaged t-molding can be replaced, so you may be just as happy installing it now as later. Whichever you chose, wrap up this step and get ready to move on to the upper cabinet assembly!

Figure 2-26: Monitor shelf J in place.

Step 13 – Top Side Panel Assembly

You'll find this next step is a bit involved, so now is a good time to take a breather if you need one! This is also a good step with which to have an assistant help you. However, you can do it yourself with some care and ingenuity if no help is available. In this step, you will attach the two top side panels so they end up looking like Figure 2-27.

You should take some care with this step. Though not a major concern as far as the structural integrity of the cabinet goes, the two top side panels will greatly influence the overall appearance of your cabinet. If they are not evenly installed or are off in some other manner, it may show glaringly when the cabinet is complete. Your marquee may not sit properly, or the speaker shelf may not fit properly. Take this step slowly.

Start by laying both top side panels down, one atop another perfectly lined up and clamped, and mark your drill points as shown on the plans. I found it helpful to draw a grid based on the measurements. Drill your pilot holes through both pieces (see Figure 2-28). Do not counter-sink them yet.

The next step is to attach the first top side panel to the base cabinet assembly. You'll need to decide the best way for you to accomplish this based on the resources and help you have available, but I'll show you the way that worked for me.

Figure 2-27: Your end goal — two top side panels installed.

Figure 2-28: Top side panels clamped together with pilot hole grid laid out.

TIP **Now is a good time to look carefully at both top side panels. Either panel can go on the left or right, but one side of a panel may have a better finish than the other. The inside face of the panels will be mostly hidden by the monitor area, while the outside faces will be completely exposed. Choose which panels are left and right so that you put your best face(s) forward!**

Start by placing the base cabinet assembly on its side, with enough work room to be able to attach the top side panel. Place a saw horse or other platform further out from the base assembly, so that you can rest the top side panel on the base assembly and the other platform (from here out I'll just refer to a saw horse. Substitute whatever platform you're using in its place). Unless you are very lucky, it's unlikely that base cabinet assembly and your saw horse will be the same height. You need them to be the same height so that your top side panel rests levelly across them. I solved this by using leftover scrap wood underneath the base cabinet assembly to bring it up to the same height as the saw horse (see Figure 2-29).

Figure 2-29: Top side panel atop the base cabinet assembly and saw horse.

Position the top side panel on the base carefully. The front edge of the side panel should be flush with the edge of the base assembly and monitor shelf J. This affects how far forward the side panels will be when complete. Make sure it's flush — the back edge of the side panel will extend beyond the base cabinet assembly by several inches. When the side panel is standing upright, the back edge should be straight as measured with a level.

The corner of the side panel at the beginning of the angled cut should be just below the edge of the base cabinet. This will affect how high the side panels are when complete and upright. Some minor variance here is OK, so long as the pilot holes you drilled are low enough that they will go into the base cabinet assembly. When the side panel is standing upright, the top edge should be straight as measured with a level.

Once you have carefully positioned the side panel, clamp it into place and drill through your pilot holes into the base assembly (to extend the pilot holes into the base). Then counter-sink your holes, and screw the side panel into place (see Figure 2-30).

Figure 2-30: Panel positioned and clamped into place.

You're half-way through this step! It's still a bit tricky, and I highly recommend getting assistance. What you will do next is to flip the entire assembly over, and repeat the preceding steps for the other top side panel. Be careful! There are only 5 screws holding the first panel to the base assembly right now, and it will be very easy to rip the panel off the base by accident as you flip the assembly over. You're really better off having help when you do this.

There are two additional considerations for the second top side panel. First, your base assembly is now slightly thicker due to the addition of the first side panel. That means you'll need to adjust your supports so that the base assembly and the saw horse are the same height again. You'll also probably need additional supports, because you have to support the attached side panel as well as the base assembly now. You don't want to put any torque on the side panel! See Figure 2-31.

The second consideration is that while positioning the first panel was important, positioning the second panel is *really* important. You want it to match the positioning of the first panel as closely as possible. After you take all the steps to position the second panel, before you drill, use a long straight edge to verify all the edges of the panel are positioned the same as the other panel. I placed a yard stick across the same edge of both panels, and used a level to make sure they were as close as possible. Once you're satisfied they're as close as can be, clamp and drill and screw. Finally, stand the assembly up (using help!) and double-check your work. Congratulations, this was a tough step!

Figure 2-31: Additional scrap pieces of wood supporting the first side panel.

Step 14 – Top Panel Assembly

Install top panel K using the measurements from the plans. Bear in mind the space between the front edges of the top side panels, and the front edge of panel K, is where the marquee is going to go. Be sure you are careful with your measurements before you drill. I found it easier to lay the cabinet down when I installed this panel, and of course as always clamps are your friend (see Figure 2-32).

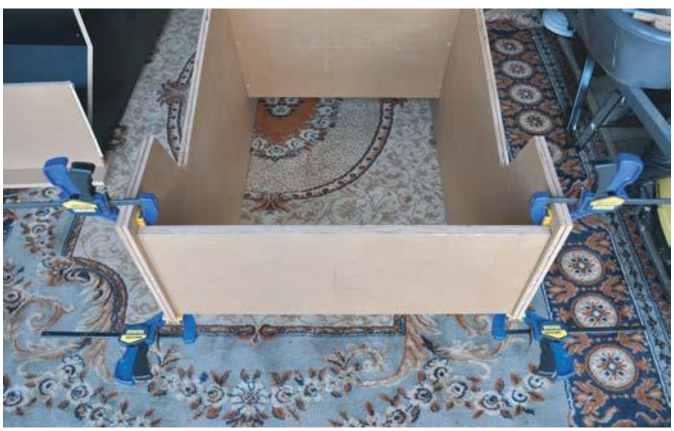


Figure 2-32: Top panel K clamped into place.

Bonus step — Install Cabinet Wheels (Optional)

This is a good time to install caster wheels on the cabinet if you choose to do so (read this entire step before proceeding). From here on out the cabinet will mostly stay upright, and is getting heavier with each piece of wood you attach. Lay the cabinet down on its back, and install the caster wheels inset approximately one inch from the corners by screwing them into the bottom panel (see Figure 2-33).

Figure 2-33: Caster wheels installed.

Some people prefer not to install wheels due to concerns with the cabinet moving during game play. This can be a problem if you are going to have your cabinet on a hard floor and anticipate vigorous game play, such as fighting games perhaps. You might consider locking wheels in that case. I have used wheels on every cabinet I've built without problem. Fully populated cabinets are **heavy** — combine that with placement on carpet and unwanted movement is not likely to be a problem. You will definitely appreciate the wheels anytime you need to move the cabinet to work on it however! Aside from being much easier on your back, dragging a cabinet across the floor without wheels can damage the wooden base of your cabinet. I highly recommend wheels — you can always remove them later if you don't like them.

Step 15 — Top Angled Panel Assembly

Install top angled panel L using the measurements from the plans. This panel is inset the same 1/2-inch as the rest, and the only really difficult part will be holding it in place while you drill and screw. I used clamps to support the back part of the panel, and rested the front part snugly against panel K installed in step 14. This held the panel in place while I outlined it in pencil. Then, I removed the panel and drilled my pilot holes (see Figure 2-34).

Figure 2-34: Side panels ready for top angled panel L.

Install panel L; then put a bead of glue between panels K and L. Be careful: if there are any gaps the glue will leak down the inside of the cabinet. If you have this problem, you can use wood putty to seal the gap instead of or before using wood glue. It's important that you not have any gaps here, or ambient light from the marquee will leak out the back and shine on your wall. I had this problem, and you can see daylight coming through the gap in Figure 2-35.

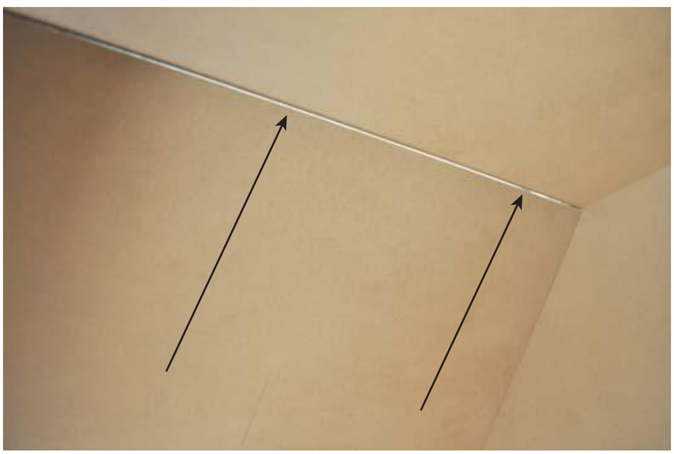


Figure 2-35: Light coming through before sealing.

Step 16 – Top Rear Panel Assembly

Top rear panel assembly M is another easy-to-install panel. Recess it 1/2-inch from the back and place it flush against panel L above it. I used clamps once again to hold it in place while I installed it (see Figure 2-36).

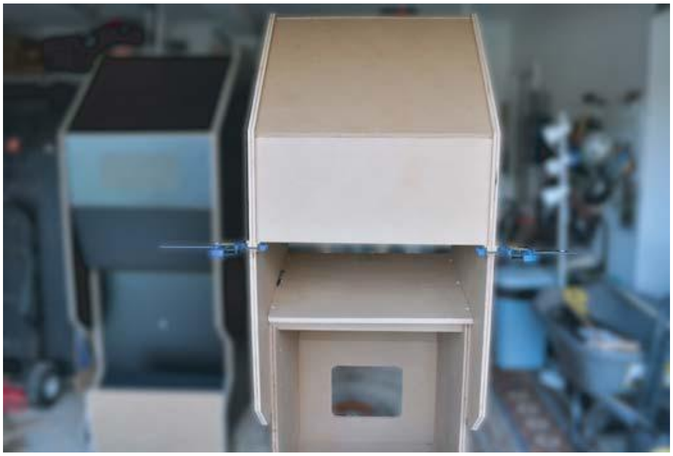


Figure 2-36: Panel M ready to install.

Step 17 – Speaker Panel Assembly

If you haven't determined how you will cut out the holes for your speakers, this is your last chance to do so easily. After this step the speaker panel will be installed and difficult to modify. Assuming you've cut your speaker holes, the only tricky part of installing speaker panel N is getting the angled edge lined up correctly. Test fit the panel before you drill any holes. The speaker panel will follow the line of the side panels down at an angle. You want the angled front edge of panel N to line up such that there is a flat and straight surface from it to the front edge of top panel K. These two edges will be the surface that the marquee rests against. You should be able to place a flat board levelly across panels K and N. Once again, inset the panel 1/2-inch from the lower edge of the side panel, using clamps to hold things in place (see Figure 2-37).

Figure 2-37: Installing speaker panel N.

Step 18 — Finishing the Assembled Cabinet

You're almost there! If you're using laminate, you should install it on the top side panels now. You can also install the t-molding now, if you like. However, like step 12, this can be done later, if you choose. If you're comfortable that the t-molding won't be damaged while you work on the rest of the cabinet, you can choose to install it now.

NOTE **You haven't missed anything, I've skipped step 19 from the plans for now. Step 19 covers installing the marquee, and I'll cover that in a later chapter. Likewise I'll cover steps 21 through 23 later in the book as well. These steps all merit more discussion before proceeding.**

Step 20 — Bezel Frame Assembly

You'll use the four remaining pieces O (x2), P, and Q for this step. Left and right pieces O are installed first, with pieces P and Q fitting snugly between them flush against the bottom and top respectively to form a square frame. This square frame is what your bezel (the glass in front of the monitor area) will rest against. You want to be very consistent about the amount you recess the pieces from the front edges of the cabinet, and make sure all four pieces of the frame are flush with one another. The top edge of panel O is the angled cut that should match the slope of panel N. It doesn't have to be precise, but if it's not a pretty good fit you should sand or re-cut the pieces to fix the problem.

Before you permanently affix anything, if you have the speaker grill covers you're going to use you should test fit them with all four bezel frame pieces in place. If the grill covers on panel N extend too far and conflict with the placement of the top piece of the bezel frame, you can slightly adjust the mounting depth of the entire frame to allow room for the grill covers. Don't forget, you'll have a piece of glass resting on the bezel frame so the distance between the grill covers and the bezel frame has to allow for that.

Once you're happy with how everything is going to fit, screw and glue the two O pieces into place, using clamps as your helper as always (see Figure 2-38).

Place piece P on the monitor shelf, and piece Q against the speaker panel, both snugly between the left and right O pieces. Screw, glue, and clamp them into place (see Figure 2-39).

Cabinet Assembly Completed

Congratulations! You're done with the cabinet assembly. It should look something like Figure 2-40. Now on to the control panel assembly!

Building the Control Panel

You'll read a lot more about laying out and assembling your control panel in Chapter 6, "Building the Control Panel." Right now however, you're going to build the control panel assembly — the box that will house your controls when you're ready to install them. To start, find the plans (ultimatearcadeII_control_panel.pdf) on the companion CD and print them out. Once again, I'll deviate from the plans to a degree. The plans on the CD take you from cutting the wood all the way to installing the controls. For now, we're just going to build the control panel body.

Figure 2-38: Left and right O pieces installed.

Figure 2-39: Bottom and top pieces P and Q in place.

Step 1 — Cutting Control Panel Pieces

Building the control panel will be fairly similar to building the cabinet. You need to lay out your pieces on the sheet of wood, cut them out, and then begin to assemble. Start by cutting out your pieces (see Figure 2-41).

Figure 2-40: A couple of views of the completed Project Arcade 2 cabinet.

Figure 2-41: The control panel pieces, ready to assemble.

There are a *lot* of angled cuts to make for the control panel. You can get a big picture view of what you need to do by laying the pieces out in the general shape they'll be in the final form (see Figure 2-42). There are two categories of angled cuts you'll make. First, the whole setup is sloped down gradually from the back to the front, so that the front edge of the control panel top will be lower than the back edge. The top edges of all the pieces that make up the box will be cut to an angle to facilitate that.

The second of the angled cuts will be so that the various pieces that make up the box base can fit together flush so the assembled shape of the base supports the control panel top. The matching edges of each pair of adjacent pieces are cut at an angle so that they fit together properly to give the base its overall shape.

Figure 2-42: The first set of pieces loosely positioned in place.

Step 2 – Assemble Side Panels

Once you've made all your angled cuts and verified everything fits together properly, you can begin to assemble the base side panels. Because of the angles you won't really be able to use clamps to hold pieces together. Instead, you glue the two pieces together, position them carefully so they will dry properly, and use painter's masking tape to hold them together until dry. Because wood glue takes a bit to set, you can glue and assemble the entire base at once (see Figure 2-43).

Figure 2-43: The control panel base, glued, taped, and drying.

Step 3 – Assemble Bottom Braces

The small narrow pieces cut in step 1 are the braces for the control panel bottom. The plans call for installing the braces inset $^5/_8$-inch from the bottom. However, this height has to match the thickness of your wood. If you're using $^3/_4$-inch wood for your control panel, inset the braces by $^3/_4$-inch instead (see Figure 2-44).

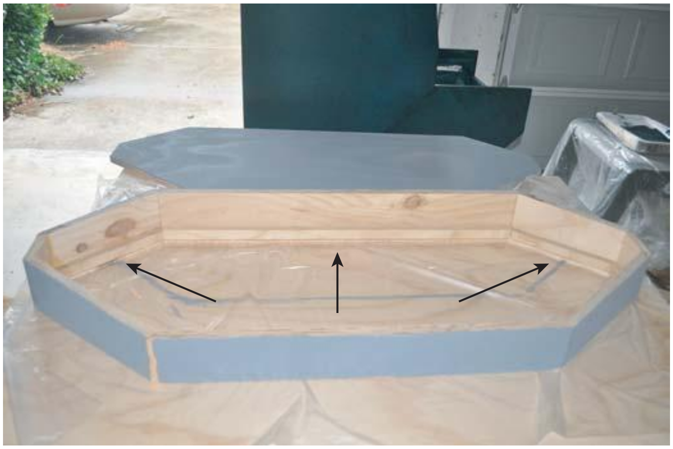


Figure 2-44: Control panel base with the braces installed.

STOP

Steps 4 through 7 of the included plans will be covered in Chapter 6. If you're going to be using laminate, hold off on installing it now. You haven't made the holes in the control panel top for the various controls, so you won't be able to trim the laminate at each control location. Trying to cut your holes through the wood and laminate will probably damage the laminate, so wait on that for now. If you're going to paint, now's a fine time to take that step (see the next section). You should also route the groove in the control panel top for the t-molding at this time.

So far you're doing great! You've built the cabinet, and have the control panel shell ready for the next steps. If you're laminating, you can skip ahead to the summary for this chapter. If you're painting, read on!

Time to Paint – Selecting Your Painting Tools

There are four different methods commonly used to paint cabinets. The first is simply to purchase a few cans of spray paint and have at it. As a rule, almost every person who does this regrets it. The quality of the paint job from spray paint is poor. It will do in a pinch, but you're not likely to be happy with it.

The next method used by a few folks to paint their cabinets is to use a paint sprayer. You can get very nice results quickly by using a paint sprayer. However, a paint sprayer can be an expensive tool if you're not going to use it again. Also, paint spray sometimes can get away from you. Your spouse will not be happy if the family car and the arcade cabinet become matching accessories! Unless you already have a paint sprayer, it's probably not worth going this route.

Several folks have used paintbrushes to paint their cabinet. This works, but tends to be more labor intensive than other methods. It is also harder to get a smooth finish with a paintbrush than it is with the next method.

The method you're most likely to be happy with is to paint the cabinet using rollers. Rollers will let you paint the cabinet quickly, and with overlapping strokes a smooth finish is easy to achieve. Spend a few extra dollars to invest in a high-quality foam roller. The cheap rollers you'll find at hardware stores tend to leave a textured finish behind, whereas the high-quality foam rollers give a smooth finish.

Preparing the Cabinet

Before you can start painting, you'll need to prepare the cabinet. Begin by filling in any screw holes and blemishes with wood putty. Let the putty dry, and then sand the excess away for a smooth finish (see Figure 2-45). Inspect the cabinet for any last blemishes or holes that need repairing. They may be hard to see now but will probably be glaringly obvious once painted. Take some time at this and have a second pair of eyes help you look it over.

Figure 2-45: Left, screw holes covered with wood putty. Right, sanded smooth and ready to paint.

Next, carefully clean the entire cabinet. It's been ground zero to a variety of dust clouds, and is assuredly covered in dust even if you can't see it. Use a damp rag to clean the cabinet, and then make sure to let the cabinet dry completely before you begin. Be careful that you don't overdo the liquid on the cabinet — remember that MDF will swell up if it absorbs water.

Painting the Cabinet

Make sure you are painting in an area with adequate ventilation and that you have proper breathing protection. Once the cabinet has completely dried, give it a coat of primer. You don't necessarily need to prime the entire insides of the cabinet, but some people recommend it to protect all the surfaces from the elements. Whether you do depends on the humidity of the area where you're going to keep the cabinet. If you're keeping it in a climate-controlled environment like a home, it's probably not necessary. You should, however, prime and paint a few inches into the surfaces that might show a bit of the inside, such as the monitor area and behind the gaps in the cabinet front. Let the first coat of primer dry according to the primer instructions, and then use a light-grit sandpaper to sand it down. Clean the cabinet again; let it dry; and then give it a second coat of primer, followed by a second sanding.

Once the primer is dry, switch rollers and give the cabinet its first coat of paint. Don't worry too much about the smoothness of this first coat. The object here is to cover the primer. Once the first coat is on, let it dry according to the manufacturer's instructions. For latex paint this is usually 4 hours, and for oil-based paint it can be as long as 24 hours. After the paint is dry, use a light-grit sandpaper to sand down the paint's rough spots until the side is smooth. This is where a power sander comes in handy — doing it by hand can be a lot of work. Be sure you are wearing your breathing mask; you do not want to inhale paint dust!

Once you've sanded down the paint, go over the cabinet again with a damp rag to remove the paint dust. Let it dry, and apply another coat of paint. Repeat the process of painting, sanding, and cleaning, each time using a finer grit of sandpaper. On the second and succeeding coats of paint, remember that a little paint will go a long way. Several thinner layers of paint will give you a better finish than a few thick layers. If you use these techniques, and vary the direction of your roller strokes, you'll soon have a beautifully smooth painted finish on your cabinet (Figure 2-46).

Figure 2-46: Project Arcade, ready for the next step!

You've now gone from a pile of wood and tools to a fully constructed and painted arcade cabinet. All it needs now is some arcade controls and a few electronics to bring it to life. I'll be going over that in the next few chapters. Congratulations! You are well on your way to having your very own arcade machine!

Summary

Wow, that was certainly a lot of work! You've managed to come a long way in just two chapters. From a pile of wood, you've put together the beginnings of your very own home arcade cabinet! Take some time now to go over the cabinet one last time before moving on. Check for stability, levelness, and paint finish. You can still make adjustments, but they'll get harder as time and your construction progresses. If everything's good, you're ready to move on.

Can you feel the excitement building? There's no doubt about it now — you're well on your way to arcade Nirvana! In the next few sections, you'll get to take a look at the various arcade components you can put into the cabinet. I'll start by introducing you to joysticks and pushbuttons next!

Part

II

Designing and Building Your Dream Arcade Control Panel

In This Part

CHAPTER

3

Pushing Your Buttons and the Joy of Joysticks

IN THIS CHAPTER

- Buttons, Buttons, Everywhere!
- Joysticks

What's your vision of the perfect arcade control panel? Does it have shiny red and blue pushbuttons? Bat-handled joysticks? Maybe you'd like a glowing trackball and polished silver spinner? Getting started is a fantastic feeling; you have a blank canvas (your empty control panel) in front of you, and you get to decide exactly what it's going to look like!

The possibilities are endless, and in the chapters to come I'll cover the majority of arcade controls you can use. Ultimately, everyone comes up with his or her own vision of what an ideal arcade machine should include. However, just about every control panel includes a good set of buttons and joysticks. That's what you'll get started with in this chapter. There's a lot more to it than you might think!

Buttons, Buttons, Everywhere!

Kapow! Jump! Flap! Kick! No matter how you try, you'll find very few games that can be played without buttons: buttons to shoot and buttons to jump, buttons for flight or buttons to fight. Most games need buttons. Even the games that don't use buttons to play usually will use buttons to coin up the game and select the number of players. Also, if you're planning to go for the most authentic arcade feel possible, you'll want to do away with the keyboard altogether. To do that, you'll need buttons to replace some of the keyboard's functions, such as a button to quit the game or a button to shut down the machine. In almost every kind of arcade machine, buttons play an important role. You can't start a game without a pushbutton. You can't jump, shoot, or punch without a pushbutton. Choosing the right kinds of buttons therefore is important. By the time you finish this section, you'll know more about buttons than you ever dreamed was possible!

Different Types of Pushbuttons

A look at one arcade parts vendor shows that it carries almost 40 kinds of buttons! Many of the differences are cosmetic — some buttons are round, some are square and so on. Some of the fancier buttons will light up. Others are intended for specific purposes, such as *bet* for a poker game. You have many different things to consider when choosing buttons for your arcade machine. Some of the different kinds of pushbuttons available are shown in Figure 3-1.

Figure 3-1: Many different pushbuttons.

NOTE **One of the most fun parts of building your own arcade cabinet is the brilliant colors you can choose. Photos in this book are printed in grayscale. However, full-color, high-resolution copies are included on the companion CD. I highly recommend taking a look at those while reading if you can!**

Leaf Switch or Microswitch?

The first decision you'll need to make when choosing buttons is what kind of switch you want your buttons to use. The switch sits at the bottom of the button and is pressed when the button is pushed down, making contact with it.

Pressing the switch activates the electronic signal telling the arcade machine a button has been pushed. Two main switch types are used in arcade machines, *leaf switches* and *microswitches*, with some recently introduced hybrids and variations to choose from.

Leaf Switch

A leaf switch consists of a small rectangular box of plastic through which two thin metal blades, or *leafs*, protrude. A short length of the metal lies on one side for connecting the wiring, while the main length of the metal lies on the other side underneath the button. The two leaf blades are usually a millimeter or two apart, with small nubs of metal facing each other beneath the button. When the button is pushed, the bottom of the button presses on the top leaf of metal, bending it down to make contact with the bottom leaf of metal, thus activating the switch. You'll find two types of traditional leaf switches. Some are standalone mechanisms screwed into the bottom of the button holder, and some are built into the button holder directly. See Figure 3-2 for a close-up of different leaf switches.

Used by permission of Groovy Game Gear.

Figure 3-2: Three different kinds of leaf switches.

The actual button for a traditional leaf switch consists of a narrow plastic tube with a wide top, with a spring-loaded center piece that you press. There's a small clip at the bottom of the center piece that stops it from springing back out of the tube. Figure 3-3 shows two leaf buttons, one assembled and one disassembled.

The only other consideration for a leaf switch is the size. They come in two lengths: a shorter length for mounting in a metal control panel and a longer length for mounting in a wooden control panel. There is no functional difference between buttons of different lengths.

TIP **Some leaf switch buttons are available in translucent colors. If that's your cup of tea, you can illuminate them from inside the control panel for a very cool retro effect! I'll cover that further in Chapter 15.**

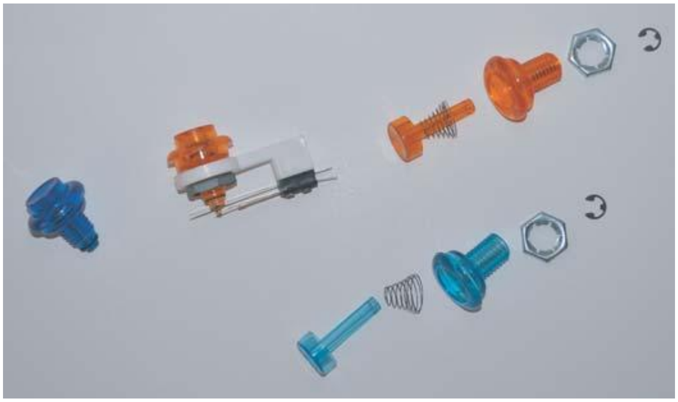


Figure 3-3: Assembled (left) and disassembled (right) leaf switch buttons.

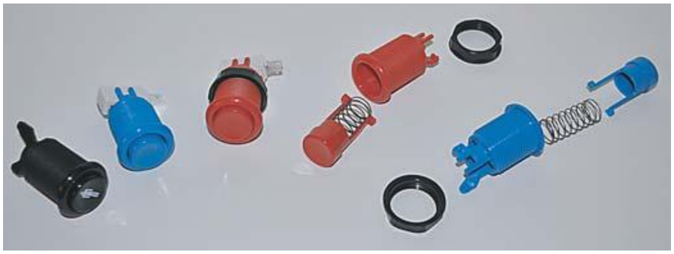
Microswitch

Microswitches work a bit differently from leaf switch pushbuttons. A microswitch pushbutton is a self-contained mechanism with three short blades of metal coming from the side and bottom and a tiny button on the top. The bottom blade is marked COM, and the two side blades are marked NC and NO. The finer details of wiring microswitch buttons will be covered in Chapter 7. For now, suffice to say that you'll be using the blades marked NO and COM, and not the blade marked NC. When the top of the arcade button is pushed, the bottom makes contact with the tiny button of the microswitch and presses it down, activating the switch. See Figure 3-4 for a look at a few microswitches.

NOTE **COM stands for Common, and this blade is always used. NO stands for Normally Open, and this blade is used when the button is up when not being used. NC stands for Normally Closed, and this blade is used when the button is pressed down when not being used. Arcade buttons are up when not in use; hence, you'll use the NO and COM blades when wiring.**

Figure 3-4: A close-up of a few microswitches.

The pushbutton for a microswitch is similar to that of a leaf switch, except that the plastic tube is wide-bodied instead of narrow. The center piece is also spring-loaded but is held in place by two tabs of plastic instead of a clip. There are two nubs at the bottom of the pushbutton that match the holes in the corner of the microswitch, and these hold the switch to the button. Figure 3-5 shows a few microswitch buttons, some assembled and some disassembled.



Used by permission of Happ Controls.

Figure 3-5: Microswitch pushbuttons: Assembled (left) and disassembled (right).

Choices

Whether to go with a leaf switch or a microswitch is a matter of preference and convenience. You can see a comparison of the two when idle at the top of Figure 3-6.

Used by permission of Happ Controls.

Figure 3-6: Assembled leaf and microswitch buttons when idle (top) and when pressed (bottom).

Many arcade fans prefer the leaf style of switch for two reasons. First, the leaf switch buttons are quiet when pressed, unlike most microswitches. Second, some people prefer the softer feel of a leaf switch button. Microswitch buttons make an audible click when pressed and typically do not have to be pressed down as far as a leaf switch button to make contact. Some people prefer the tactile feel of a microswitch, because you know when the button has activated by the click. The bottom of Figure 3-6 shows a comparison of assembled leaf switch and microswitch buttons when pressed.

Whether you choose to use a leaf or microswitch button is entirely a matter of personal preference, as both function equally well. However, the choice may be made for you as a matter of availability. Leaf switch buttons tend to be harder to find as most manufacturers are producing microswitch buttons. It is possible to find leaf switch buttons, but you have to be willing to do some looking. See Appendix A for information on where to find leaf switch buttons and other hard-to-find parts.

The Popular Choice: Microswitch Buttons

Because of availability, most people will use microswitches. Even if you do use leaf switch buttons, you'll likely use microswitch buttons for some of the administrative buttons, such as the *insert-coin* buttons and *player-1 start* button, saving the leaf switch buttons for game playing. Accordingly, there's still quite a bit more about microswitch based pushbuttons to tell you.

Pushbutton with Horizontal Microswitch

There are several styles of microswitch pushbuttons available. Those shown in the previous figures are the Pushbutton With Horizontal Microswitch from Happ Controls, although this style is available from other manufacturers as well. This is one of the most common pushbuttons to use for the action buttons of an arcade machine. These buttons are distinguished from other kinds of microswitch pushbuttons by their concave button surface, and the microswitch is mounted horizontally under the button. Most players seem to prefer the concave button surface, and, if you take a trip to an arcade, you'll find that it's the most prevalent style.

NOTE **I will often refer to a part by its name from the Happ Controls company. This is a matter of convenience as Happ is the biggest supplier of arcade parts in the United States. However, while building my own arcade machine during the writing of this book, I used parts from many manufacturers. I will note when a part is from a specific vendor.**

CROSS-REFERENCE **For a complete list of parts vendors, see Appendix A, "Where to Find Arcade Parts for Your Project."**

Competition Pushbutton

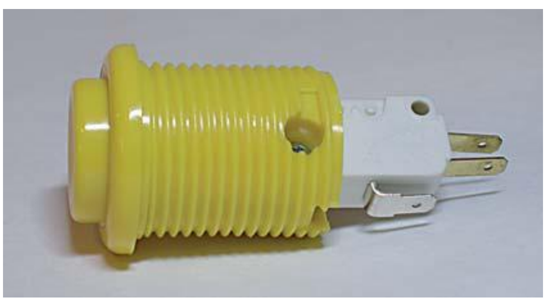
Another choice to consider is the Competition Pushbutton style shown in Figure 3-7. This is similar in construction to the Pushbutton With Horizontal Microswitch and has the microswitch mounted horizontally beneath it. The button surface is convex instead of concave, and hence has a slightly different feel. This is once again simply a matter of personal preference. Some people feel it has a better response, while others simply can't get used to it. Convex buttons are often popular with players who like fighting games.

Used by permission of Happ Controls.

Figure 3-7: The Competition Pushbutton with convex button surface.

Ultimate Pushbutton with Microswitch

The last pushbutton style most often considered for home arcade machines is the Ultimate Pushbuttons With Microswitch (see Figure 3-8). This is similar to the Pushbutton With Horizontal Microswitch with the difference that the microswitch is mounted vertically beneath the button. Instead of the bottom of the button making contact with the microswitch's button, the pushbutton slides against the microswitch vertically, pressing the microswitch's button as is slides by. Some people prefer this style of pushbutton, but the consensus is that this style is more prone to problems. If the part that slides against the microswitch wears away, or the button is not aligned correctly, you may experience intermittent *dead-button* syndrome. I do not know of anyone who has used this style button, but there may be situations (such as limited space for wiring) where this is the better option.



Used by permission of Happ Controls.

Figure 3-8: The Ultimate Pushbutton With Microswitch.

(Micro)switch Hitting

You have many additional choices of microswitches that weren't available when the first edition of this book was written. Catering to the build-your-own hobbyists, several vendors have come out with new styles to think about.

How Hard Can It Be to Push a Button?

The amount of effort (called actuation force) required to activate the switch in a microswitch is measured in grams. Typically, arcade buttons are supplied with 50 to 75 gram microswitches. They require a moderate amount of force and sound "clicky." Some arcade vendors have started selling a premium 20 gram microswitch. These require less force to press, and are quieter than standard microswitches. You can also get higher-gram microswitches which require more force. Other than perhaps for pinball flipper buttons, I can't imagine why you'd want them for your arcade cabinet.

Another consideration is the microswitch's *reset travel*, the distance you have to let the pushbutton travel back up before the microswitch resets and can be pressed again. Leaf switches don't have this issue, because as soon as you release the button the two metal leafs stop touching and are reset. The mechanics of a microswitch don't allow for that instant reset, and so you have to factor in their reset travel distance.

Some people prefer a microswitch with less reset travel. This makes it easier to rapid-fire a pushbutton, say, for a game such as Track and Field. In that game, the faster you push the faster your runner goes. With some practice, you can let the button rise just to the sweet spot at the top of the switch's reset travel and then press it again faster than if you let the button completely rise before pressing again. Shorter reset travel can be a two-edged sword however, as it makes it easier to double-press a pushbutton accidentally. This is bad in a game such as Donkey Kong, where one jump means you leap the barrel and live but an accidental double-jump means you slam your head into the next barrel and lose!

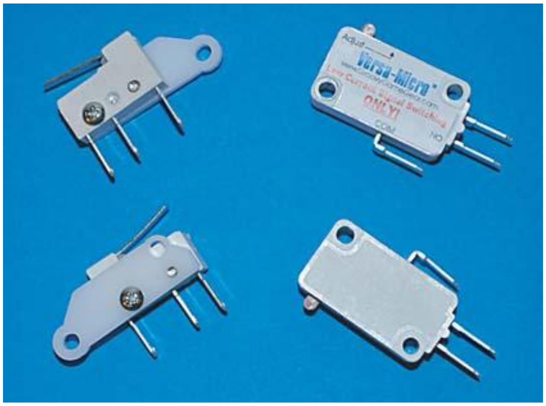
You're Not Out of The Microswitch Trenches Yet!

I'm going to tempt you with a few microswitch options. Groovy Game Gear (`www.groovygamegear.com`) sells two hybrid style microswitches that are specifically geared towards the build-your-own community.

First up is the Versa-Micro microswitch shown in Figure 3-9. This is an adjustable microswitch that allows you to adjust the switch's required actuation force and reset travel, making it quieter as a side effect as well. You can adjust it from standard reset travel and "clicky" settings all the way to an almost inaudible short-travel. In addition to its just being a nice microswitch to use, you might consider it if you're not certain yet what your reset travel preference is.

The MicroLeaf (also in Figure 3-9) is the other hybrid microswitch they sell, and it has received positive feedback from the build-your-own community. It is not a true leaf switch as described earlier in this chapter, but combines the feel and silence of a leaf switch with the form factor of a traditional microswitch.

You get an extremely quiet microswitch with a short reset travel that fits a standard pushbutton.



Used by permission of Groovy Game Gear.

Figure 3-9: The Versa-Micro microswitch on the left and MicroLeaf microswitch on the right.

Which Should You Choose?

Anything other than a standard microswitch inevitably costs more. You'll need to weigh the extra bang you get from a premium microswitch against the extra cost — at an extra dollar or two per button, and twenty to forty buttons per panel, that can rapidly add up!

If you have a specific genre in mind, such as racing games that require fast repetitive button presses, you might want to try some of the non standard microswitches. If you're building a general purpose control panel, however, for a variety of different game types, these microswitch differences are probably just splitting hairs, and more responsive buttons might actually be undesirable for some of the games you'll play.

My suggestion for most people is to not worry about the actuation force and reset travel of microswitches, unless you have the aforementioned favorite genre that dictates something different. If the clicking sound of a microswitch will drive you crazy, take a good look at the MicroLeaf. Ideally, if you have a few extra dollars to invest, you might consider buying a handful of the premium microswitches that interest you to go with your standard button assortment. A lot of builders will put premium microswitches in the primary one or two buttons for each player and will use standard microswitches in the remaining buttons on the control panel.

NOTE **Every arcade vendor will carry standard microswitches with their pushbuttons. As of this writing, you can find premium microswitches from Groovy Game Gear (`www.groovygamegear.com`) and Paradise Arcade (`www.paradisearcadeshop.com`), among others.**

Beware The Volcano!

You'll hear me use the term "holy grail" a few times in this book. A holy grail is an item that has high appeal and low availability in the build-your-own and arcade collecting communities. One of these holy grails is the volcano pushbutton.

Volcano pushbuttons refer to the shape of the button. These are small conical sleeves that come in black or silver, with either a black non-lit or a red lit button in the middle connected to a small microswitch underneath (see Figure 3-10). They were used in many classic arcade machines, but the original manufacturers stopped making them some time ago, so the buttons have been scarcely available for many years, fetching a premium price.

Used by permission of Ram Controls.

Figure 3-10: A variety of volcano style buttons from Ram Controls. The two buttons in front are original, and the rest are reproductions.

As a practical matter, they have no functional value that a standard pushbutton cannot supply. However, when you consider that you're building your own arcade machine, practicality is not always the highest consideration! These buttons are prized for their nostalgic and visual appeal. Many builders will use them for special functions, such as adding credits for players. They are not suitable for normal game play.

Because of their scarcity, few builders included them on their control panels. However, recently Ram Controls (`www.ramcontrols.com`) has reproduced the volcano cones and these are available again. They are still somewhat expensive (a set of two will run you over $40!), but if you're trying to recapture a particular piece of retro-gaming past, your cabinet won't be complete without them!

Light Them Up!

I've got one last set of button styles you might consider for your arcade contraption: illuminated buttons. Several hobbyists have experimented with creative ways to illuminate pushbuttons. A few vendors have brought off-the-shelf solutions to the market as well. You can have something as simple as static (always on) lit buttons, or something as complex as buttons that light up to show you which controls to use for a particular game or that beat in time to music! Before I get into that however, I need to talk about some other information, such as wiring and interfaces. I'll be doing so over the next few chapters, so the details of *how* to achieve the various lighting effects will be covered in Chapter 15. For the moment, I'll simply show you some of the off-the-shelf buttons you might choose to purchase.

NOTE **All the light-up buttons presented here use 5 volt (5v) or 12v sources of power. This is important because 5v and 12v sources are readily available from a computer. Light-up buttons that use other voltages are available, but they require slightly more complicated wiring than the 5v and 12v buttons. This will again be covered in more detail in Chapter 15.**

Groovy Game Gear Light-Up Buttons

Groovy Game Gear (`www.groovygamegear.com`) sells two different models of illuminable pushbuttons, the NovaGem, and the Electric ICE 2, both pictured in Figure 3-11.

Used by permission of Groovy Game Gear.

Figure 3-11: The NovaGems on top and the Electric ICE 2 buttons below.

The NovaGem has a tiny circuit board with an LED threaded into the base of the button, providing a single-color illumination. The buttons and LEDs are available in a variety of colors. You can see a disassembled and assembled NovaGem side by side in Figure 3-11.

The Electric ICE 2 is a more sophisticated illuminable pushbutton. The button itself is a plain white color, made of a plastic that is designed to diffuse light throughout the button. The button can be lit either through a single-color NovaGem style LED, or a 3-color LED module that can produce thousands of colors on the fly. Figure 3-11 shows a handful of Electric ICE 2 pushbuttons with different switches, including one button that's been disassembled.

Ultimarc and Paradise Arcade Light-Up Buttons

Ultimate Arcade Controls (known as Ultimarc, `www.ultimarc.com`) and Paradise Arcade (`www.paradisearcadeshop.com`) also sell a line of light-up buttons shown in Figure 3-12. The buttons have a flat top and are illuminated through an LED threaded into the shaft of the button. You can place printed inserts underneath the top to create unique illuminated buttons, such as "player 1 start."

Used by permission of Paradise Arcade and Ultimarc.

Figure 3-12: Paradise Arcade buttons above, Ultimarc buttons below. Be sure to view this one in color on the companion CD!

At first glance, the buttons look similar, but there are several differences under the hood. Ultimarc's buttons are available with 5v standard or super bright 12v LEDs, while Paradise Arcade's buttons come with a 12v standard LED. Ultimarc uses a more opaque diffuser (the disc at the top of the button that prevents the LED from shining straight up) and Sanwa microswitches. Paradise Arcade uses a more translucent diffuser with Zippy microswitches.

Should You Use Light-Up Buttons At All?

Be cautious when thinking about light-up buttons. A little can go a long way. At first blush the eye-candy glitter of a bunch of lit buttons can seem appealing, but remember that you are going to be standing directly over these buttons for long periods of time when you play. Bluntly, too much of a good thing will probably end up just being annoying; the 12v LEDs can be particularly hard on the eyes. However, with a combination of software and hardware, you can control *when* these buttons light up for a very pleasing effect. I'll cover that in Chapter 15.

Buttoning Up the Button Choice

Whew! That's a lot of discussion just for choosing a button! Although there are other kinds of buttons available out there, you'll probably be happiest sticking with something like those presented here that have been tried and tested by arcade cabinet builders for years.

When purchasing buttons, be aware of what you're getting. Some vendors will sell pushbuttons without the necessary microswitches or leaf switches. This is not necessarily a deceptive practice, as these pushbuttons are typically cheaper than whole assemblies and are useful for arcade operators who buy parts in bulk for repair. You don't need to pay for a button *and* a microswitch if you already have a box of microswitches. Also, some cheaper pushbutton bundles may come with higher actuation force (as much as 125 gram!) microswitches that you might not want. Just be sure that what you're purchasing is clearly spelled out; if it's not, ask.

Also be aware of the source of your buttons (and all arcade parts in general). Buttons from reputable arcade supply houses are generally all of good quality, but there are lower-quality look-alikes available. You may run into issues such as stiff springs and defects in the plastic, for instance. If in doubt, order a sample before placing a large order. Appendix A includes some (but not necessarily all) of the vendors known to provide quality products.

Joysticks

Did you think there were a lot of button choices? Take a look at how many joystick choices you have (see Figure 3-13)! I could fill pages and pages with information about different types of joysticks, and, well, because that's what you paid for, I'll do just that.

Types of Joysticks

You have more choices for joysticks than for any other kind of arcade control. Although there are 40 or more buttons available from one vendor, they all operate in essentially the same way, being some variant of a microswitch pushbutton. Joysticks, on the other hand, vary a great deal more from one model to the next. They vary by number of directions supported, type of switch used, type of interface supported, and shape. I'll introduce you to the more common choices in this section.

Used by permission of Groovy Game Gear, Happ Controls, and Ultimarc.

Figure 3-13: Some of the many joystick choices available.

Leaf vs. Microswitch vs. Magnetic vs. Optical

Joysticks have the same two options as pushbuttons: leaf switch and microswitch connections. There are also models that have different mechanisms from a physical switch, using magnetic or optical interfaces. There are two styles of optical joysticks. One simply uses optics to register where you've moved the joystick, but still uses the same interfaces as the leaf and microswitch models. You are essentially using *optical switches* instead of the other two kinds. The Happ Controls Perfect 360 (see the section "Happ Perfect 360 Electronic") is one such joystick. The other kind of optical joystick is one that's purely optical. It uses optical switches and also requires a special optical interface. The Happ Controls Optical Rotary joystick is one such model.

NOTE **What's an optical interface? An older style computer mouse is an example of a device that uses an optical interface. When you move the mouse on the surface, the ball in the bottom of the mouse turns two spoked wheels inside the mouse body. One spoke handles left-right movement and the other handles up-down movement. Optical sensors surround the spokes and register the change in the light as the mouse moves and the spokes turn — DARK-LIGHT-DARK-LIGHT. The speed and direction of the spokes tell the computer where and how fast you're trying to move the mouse. We'll take advantage of this concept in the next chapter.**

Which kind of switch type should you use? That's once again a personal preference. Choosing between the leaf switch and microswitch models involves the exact same considerations as choosing buttons. Magnetic or optical joysticks, such as the Happ Perfect 360, are favored by some people but usually cost more — they are typically three times the cost of the Happ Super joysticks.

Analog vs. Digital

Which type of joystick should you use? Analog? Digital? Both have their strengths. The majority of joysticks you'll encounter for this project will be digital. They use switches, and switches are either pressed or not, on or off. They require some kind of digital interface to connect (see Chapters 7 and 8). Other joysticks, such as older PC joysticks, are analog. Instead of switches, they normally use *potentiometers* to tell where you're moving the joystick. A potentiometer is a small device that varies the amount of current flowing through a circuit depending on how the shaft of the potentiometer is turned. As you move the joystick, potentiometers in the joystick are turned, telling the computer you've moved the joystick. I'll cover this in a lot more detail in Chapter 7. For now, though, see Figure 3-14 for a look at an analog PC joystick.

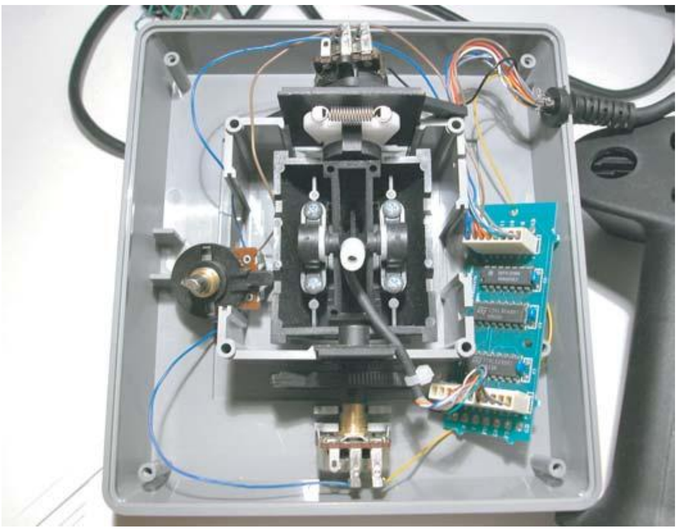


Figure 3-14: A look inside a very disassembled analog PC joystick. Notice the potentiometers. This joystick will probably never get put back together!.

Bats and Balls

No, we didn't slip a section about baseball into the book. One of the immediate (and usually only) differences among joysticks that a casual game-player will notice is the physical handle. They come in four main shapes: bat-shaped handles, ball-shaped handles, flight-grip handles, and flare-type handles. See Figure 3-15 for the most common shapes.

Figure 3-15: From left to right, bat-shaped, ball-shaped, flare-type, and trigger-grip handles.

The trigger-grip or flight-grip handles obviously are designed for specific types of games, such as flight simulators or *Zaxxon*. However, there is no functional difference between the ball- and bat-shaped handles. Once again, it is entirely a matter of personal preference. I prefer the ball-shaped handles, but opinions seem to be split down the middle as to which is the better handle to use. The flare-type handle is usually used in specific games, such as the crane games in which the player steers a claw and tries to get a prize out of the bin. Flare-type joysticks are occasionally used as substitutes for the trigger-grip because they are less expensive and have a fire button on the top. They'll do in a pinch, but they're no substitute for the real thing.

Number of Directions

Another way to distinguish joysticks from one another is by the number of directions they support. Most games are designed to be played with joysticks moving either in two, four, or eight directions (see Figure 3-16). Other types, such as 49-way joysticks, have been used, but typically the 2-way, 4-way, and 8-way joysticks will cover virtually anything you want to play. Several models of joysticks fall into the 2-, 4-, and 8-way categories.

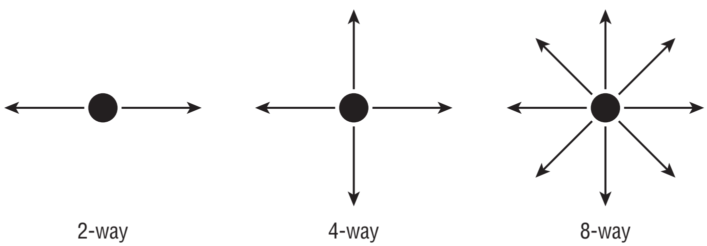


Figure 3-16: A 2-way, 4-way, and 8-way joystick layout.

Looking at Figure 3-16, you might think that you get the most versatility out of the 8-way joysticks, and for the most part you'd be right. If you have a joystick that can go UP, UP-RIGHT, and RIGHT, then it will work in a game that only needs UP and RIGHT, correct? Not always. Sometimes, a 4-way joystick is a better choice. For instance, consider *Donkey Kong*. In the game, you play Mario, a brave plumber running across horizontal girders (LEFT-RIGHT direction) and climbing ladders (UP-DOWN direction) in order to rescue the girl. Needing only LEFT-RIGHT-UP-DOWN directions, this game was sold with 4-way joysticks. Imagine playing with an 8-way joystick now. You are running as fast as your little pixilated legs can carry you from the flaming barrel on your left (Did I mention the barrels trying to run you over? You thought you had traffic problems!). Suddenly, you come upon salvation in the form of a ladder to your right. When you get to the ladder, you want to be able to switch from moving right to moving up without hesitation as the flaming barrel tries to make your acquaintance. With a 4-way joystick and good timing, this isn't hard. However, you have an 8-way joystick. Trying frantically to hit the UP direction, you move the joystick from the RIGHT to the UP-RIGHT diagonal direction instead of straight UP. This leaves poor Mario standing still beneath the ladder while the flaming barrel barbecues him. Alas, poor Mario, if only you'd had a 4-way joystick!

The same kind of reasoning applies with a 4-way joystick in an 8-way game. If you can only move UP-DOWN-LEFT-RIGHT, but you're flying a spaceship in a maze where you need to be able to go diagonally, sooner or later you'll smack into a wall and it's *game over*. As the saying goes, there's no substitute for using the right tool for the right job. Fortunately, in practice this doesn't seem to be as critical for 2-way games. Both 4-way and 8-way joysticks usually will suffice for 2-way games; though if you're trying to build a dedicated 2-way game machine, then, of course, you should try to find the right joysticks.

So what kind of joystick do you need to get for a multigame cabinet such as the one you're building now? The answer, of course, is both! I'll cover this in Chapter 6, "Building the Control Panel," but typically you'll end up with a couple of 8-way joysticks, and either a 4-way joystick for games that need it or one of the switchable joysticks in the next section.

Switchable Joysticks

To further complicate matters, several manufacturers make joysticks that can be switched or converted from an 8-way to a 4-way joystick. Some require tools to convert them, typically just pliers to remove the retaining clip on the bottom of the joystick shaft. Arcade operators who buy joysticks in bulk and don't know whether they'll be used in a 4-way or 8-way game typically use these. You might consider these if you are not totally sure whether you'll want 4-way or 8-way joysticks.

Other types of 4-way/8-way switchable joysticks can be switched without tools. Manufacturers have used a variety of methods to allow these joysticks to be switched on-the-fly — a lever or wheel on the base that can be moved by hand, an exposed lever above the top of the joystick base, or some method of pulling up and turning the shaft. Each method should be weighed against esthetic and convenience factors. A mechanism at the bottom of the joystick requires accessing the inside of your control panel to change, while a lever above can be seen.

There is an important consideration regarding joysticks that are switchable from 4-way to 8-way. Some methods, both commercial and homegrown, block the *functionality* of the diagonal directions but not the *physical* diagonal directions. One way they do this is with an actuator that fits over the end of the shaft. The bottom shaft of the joystick is too skinny to make contact with the switches. The actuator is a piece of plastic that fits over the shaft, thereby making it large enough to make contact with the switches when the joystick is moved. See Figure 3-17 for an example of an 8-way and a 4-way actuator.

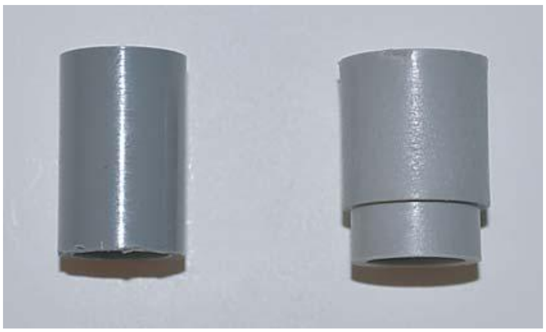


Figure 3-17: A 4-way actuator (left) and an 8-way actuator (right).

The bottoms of the actuators are the same size, but the top is larger on the 8-way actuator than the 4-way. When the larger 8-way actuator is installed, the bottom of the joystick shaft is big enough to press both the UP and RIGHT leaf switches far enough to make contact (see Figure 3-18).

However, when the smaller 4-way actuator is installed, the bottom of the joystick is only big enough to press either the UP or the RIGHT leaf switch, but not both at the same time, despite the fact that the shaft is pointed in the diagonal direction (see Figure 3-19). This means you could potentially find yourself with *dead-stick* syndrome when you attempt to hit the UP position but hit the UP-RIGHT position instead.

The more reliable design is to use a *restrictor plate*. A restrictor plate fits over the joystick and physically restricts the stick from being pushed in the diagonal directions. See the next section for more on restrictor plates.

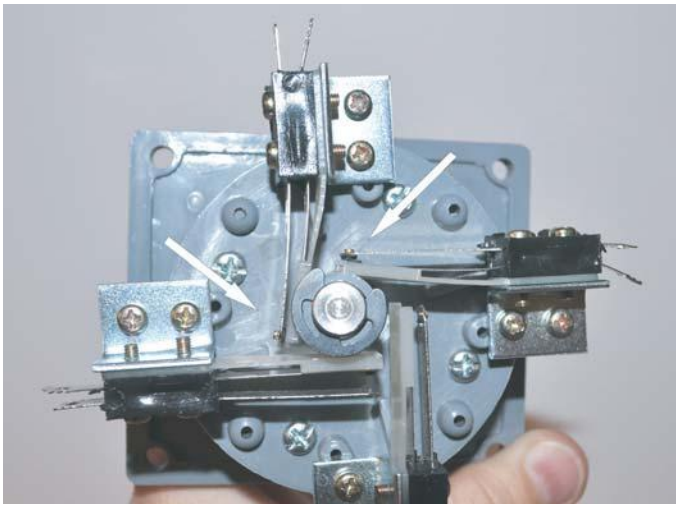


Figure 3-18: Joystick with 8-way actuator making full contact on the diagonal.

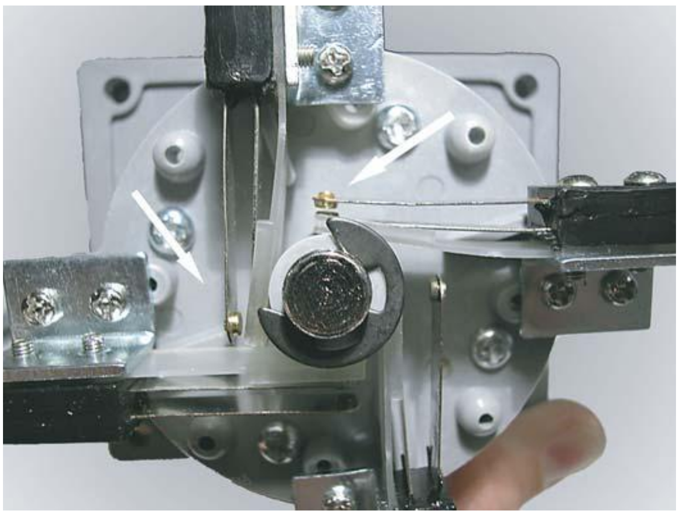
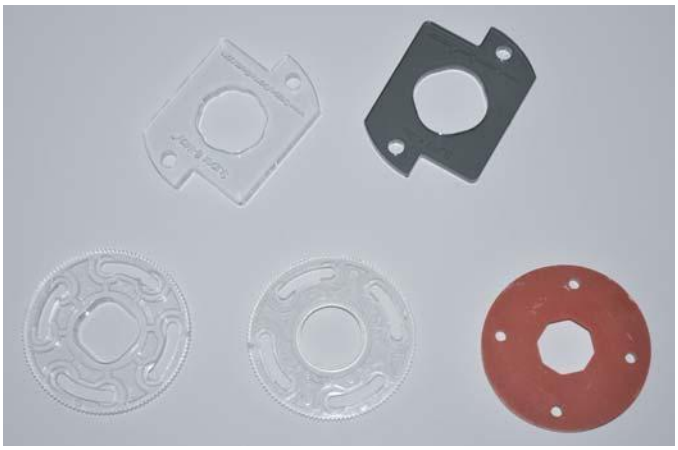


Figure 3-19: Same joystick with 4-way actuator failing to make full contact on the diagonal. Dead-stick syndrome!

The last switchable design I'll present here is a clever design sold by Ultimarc (listed in Appendix A). Ultimarc has a model called the E-Stik that is a 4-way joystick that can be rotated 45 degrees. The nice part is that you do not have to access the bottom of the joystick to do so; a simple twist of the cover plate will switch it back and forth. This makes it an ideal joystick to use for games such as Q*Bert that require a 45-degree mounted stick. There are so few games requiring a 45-degree angled 4-way stick that it's hard to justify dedicating a stick for them. The E-Stik is a handy solution to that dilemma. Happ Controls sells a similar joystick, the Universal.

Restrictor Plates

A restrictor plate is a device that fits over the shaft of a joystick with a center cutout that *physically* restricts the joystick from moving in certain directions. The angled shape of the cutout dictates which directions are accessible, such as restricting an 8-way joystick to 4-way motion. Some joysticks come with restrictor plates built in to the bottom of the joystick. Simply turn a gear or move a switch and the restrictor plate rotates between 8-way and 4-way movement. Separate restrictor plates are also sold by a variety of manufacturers to fit various joysticks. Restrictor plates are designed to work only with specific joysticks, so, if you are considering one, make sure you know a restrictor plate is available before you pick a joystick. You can see a few different restrictor plates in Figure 3-20.



Used by permission of Groovy Game Gear and Ultimarc.

Figure 3-20: Various restrictor plates. Notice the different shaped cutouts in the centers.

Joystick Throw

What is a joystick throw? It's the distance the top of the joystick can move before it stops. A short throw means a short distance before movement is registered and equals a quicker response. A longer throw means a longer distance and a slower response. Quicker response is not always preferred (for instance, when fine control is required, a longer throw may be the better choice). Joystick throw is also a very subjective thing. Some people prefer the feel of a short throw, while some can't stand it.

Rotary Joysticks

Rotary joysticks are like other joysticks in that they move in eight directions and work well in many situations. The extra trick of a rotary joystick is that the joystick handle will rotate clockwise and counterclockwise as well. There are a couple of games that use this feature, including Ikari Warriors. This feature makes it possible for you to aim your weapon one direction while moving another. A twist to the left while pressing forward, and your on-screen buddy aims to the left while going straight. These joysticks come in both optical and digital versions, requiring different interfaces. See below for a look at the Happ Controls Rotary joysticks.

A Look at Several Different Joysticks

Congratulations, you've made it through the many different ways joysticks differ from one another! Now in the next few pages I'll show you some of the joysticks that are available for your project. It is by no means an exhaustive list. I have limited the scope to those joysticks that are frequently chosen by the arcade machine–building community and that are readily available for sale. For instance, the original Wico brand leaf joysticks are wonderful additions to a control panel. However, since they are no longer made and are difficult to find, I have not included them in this discussion. Unless otherwise stated, the joysticks below all use microswitches.

Ultimarc Mag-Stik and Mag-Stik Plus

The Ultimarc Mag-Stik (see Figure 3-21) is a 4-way/8-way microswitch joystick with a short throw and bat-shaped handle. There is a small switch toward the bottom of the joystick that will rotate the built-in restrictor plate between 4-way and 8-way modes, allowing for tool-less conversion between modes. This makes the Mag-Stik a good choice if you want to be able to switch back and forth without opening your control panel, for instance through the coin-door.

Figure 3-21: The Ultimarc Mag-Stik Plus (left) and Mag-Stik (right).

The Mag-Stik Plus (also in Figure 3-21) adds the ability to switch between 4-way and 8-way modes without having to reach the bottom of the joystick at all. Pulling up on the joystick handle while rotating engages a mechanism that moves the switch, allowing you on-the-fly conversion. The Mag-Stik Plus is also available in a ball-top model.

Ultimarc E-Stik & Happ Controls Universal

The Ultimarc E-Stik and Happ Controls Universal are the same basic model made by Industrias Lorenzo, except Ultimarc customizes their E-Stik from the stock model. This ball-top model has two unique features. For installation, it has a plastic cover plate that eliminates the need for a control panel overlay to hide the screws and mounting bracket. Also, as mentioned previously, the joystick can be rotated 45 degrees by twisting the cover plate or bottom, making it an ideal joystick for games, such as Q*Bert, that require a diagonally mounted joystick. This does take some attention when mounting (see Chapter 6).

The 4-way/8-way rotating gear on the bottom of the Ultimarc model of this joystick makes for an easy change between modes (see Figure 3-22), although the switch is not as easy to perform by feel as it is with the Mag-Stik. The Happ Controls Universal must be unscrewed to be rotated between 4-way and 8-way. Because of the longer throw of this joystick, in 4-way mode there is still a slight amount of diagonal movement possible. However, there is not enough movement allowed to reach the switches and register the diagonal direction.

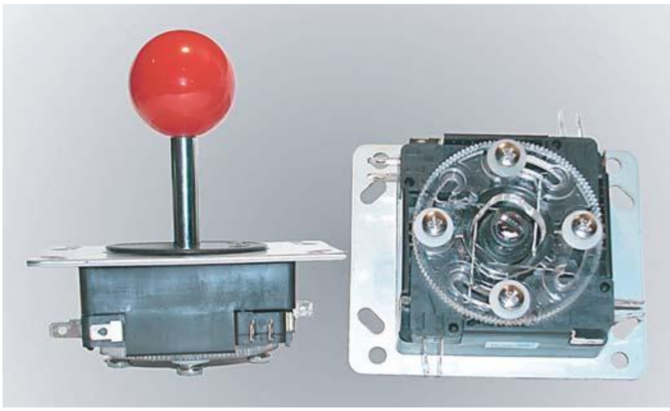
Used by permission of Ultimarc.

Figure 3-22: The Ultimarc E-Stik and its 4-way/8-way rotating gear.

Ultimarc J-Stik Ball-top and Oval-top

The Ultimarc J-Stik (see Figure 3-23), like the others, is 4-way/8-way switchable. This particular model is made and customized for Ultimarc by Sanwa, a highly respected Japanese arcade parts manufacturer. The J-Stik is available in either a ball-top or bat-shaped handle. It has a longer throw that has two settings, available by turning the restrictor plate over. The hole in the middle of the restrictor plate that the joystick shaft hits has angled edges. Flipped one way, the joystick shaft hits the top of the angled edge, making it stop slightly sooner than when flipped the other way, where it can be pressed all the way to the bottom edge of the restrictor plate.

The J-Stik uses the same rotating gear mechanism as the E-Stik and has the same considerations. It's easy to change between modes and, like the E-Stik, allows some travel in the diagonal directions before blocking contact with the switches diagonally. The joysticks are designed for metal control panels, but can easily be mounted to wooden control panels via a couple of methods (see Chapter 6).



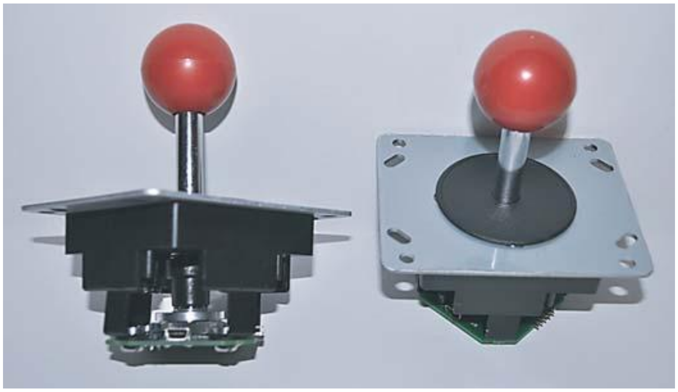
Used by permission of Ultimarc.

Figure 3-23: The Ultimarc J-Stik, side and bottom views.

Ultimarc UltraStik 360

The Ultimarc UltraStik 360 (see Figure 3-24) is the flagship model of the Ultimarc line, available in ball-top or bat-top handles. This is an analog joystick with an unlimited number of possible directions, hence the "360" name. The joystick has a number of remarkable features. For instance, it does not use either potentiometers or microswitches! Instead, control is achieved through magnetic sensors. When the joystick is moved in a particular direction, the sensors in that direction are triggered. The further in that direction the joystick is pressed, the stronger the magnetic field is, telling the joystick's controller both the direction and amount of travel.

By itself that is a unique enough design to distinguish the joystick, but the real genius lies in its embedded controller and software. Most joysticks need to be connected to an interface (which I cover in Chapter 8) that lets the joystick talk to the computer. The UltraStik 360 has a built-in USB interface that connects directly to the computer, eliminating the need for an extra interface. The joystick *can* connect to a separate interface if desired, in which case it functions as a standard 8-way joystick.



Used by permission of Ultimarc.

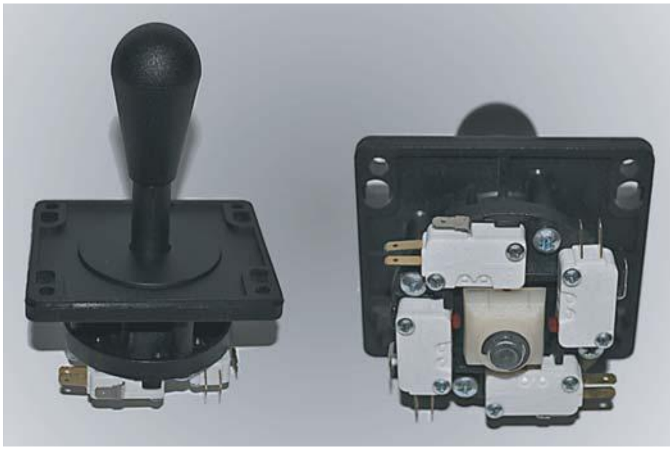
Figure 3-24: A pair of ball-topped UltraStik 360 joysticks.

The built-in interface allows the joystick to be programmed to act as any style joystick you prefer (2-way, 4-way, or 8-way) by downloading directional maps on the fly. Playing a game of Donkey Kong? Tell the joystick to limit itself to 4 directions. Playing Q-Bert? Tell it to allow only diagonals. With the right software (see Chapter 13) you can have these maps loaded when you choose your game, meaning no matter what type of game you play you automatically have the right joystick ready to use. No physical modifications are necessary. For those who prefer physical blocks on certain directions, restrictor plates are also available.

The UltraStik 360 is truly a remarkable joystick with more features to mention than space allows here. That comes at a premium however. I normally refrain from mentioning specific prices because they can change over the lifespan of this book, but the UltraStik 360 costs two to three times the rest of Ultimarc's product line. If you read the reviews, however, you'll find that people using them are almost universally happy with their choice.

Happ Competition

The Happ Controls Competition joystick (see Figure 3-25) is an 8-way microswitch joystick suitable for both wooden and metal control panels. The joystick has a square actuator, which makes it particularly easy to hit diagonals. This can be a blessing or a curse, as some users report accidentally hitting diagonals when they mean to go straight. This makes the Competition a poor choice for 4-way games. The Competition has a bat-shaped handle and a fairly long throw. It can be ordered with a heavier spring, which is recommended by some players to improve the tactile feel. The Competition joystick is one of the less popular choices for joysticks in the build-your-own community, and it is primarily used by people who plan to play a lot of fighter games.



Used by permission of Happ Controls.

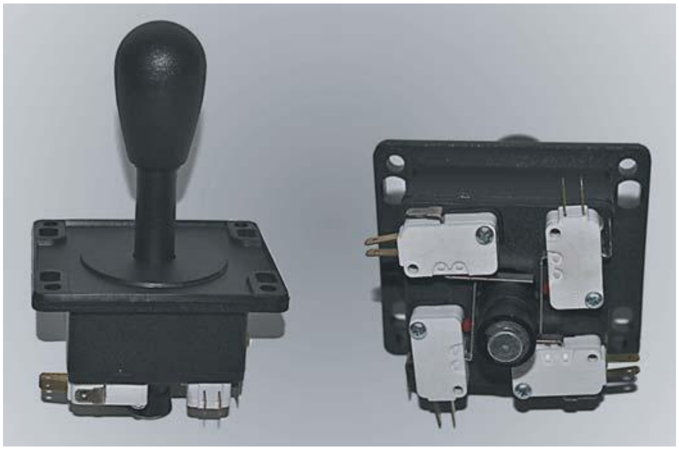
Figure 3-25: The Happ Controls Competition joystick.

Happ Super

The Happ Controls Super joystick is a 4-way/8-way switchable joystick with a modified bat handle. The bat portion of the handle is shorter than other bat-handled joysticks (see Figure 3-26). The joystick is converted from 4-way to 8-way by flipping the actuator over, a process that requires partially disassembling the joystick. This makes the Super a good choice as a joystick to keep in stock to suit a variety of purposes, but not a good candidate for a control panel in which you want a single stick to play both 4-way and 8-way games. In 4-way mode, the actuator prevents the microswitches from being pressed when the joystick is moved diagonally but does not prevent the physical diagonal movement itself. This can lead to dead-stick syndrome if you inadvertently hit a diagonal when attempting to go straight.

The microswitches on the Super joystick have metal levers that are pressed by the joystick actuator, which then activate the microswitch buttons (see Figure 3-26, bottom view). Some users have reported trouble hitting the diagonals on this joystick, a glitch that can be fixed by bending the metal levers outward slightly. Be careful not to bend them too much or you will find yourself hitting diagonals accidentally. These levers make the stick somewhat tweakable to suit your individual preferences.

Happ dubs the Super its strongest (most durable) joystick, and it is the most popular choice among both commercial arcade panel vendors and those who build their own arcade machines.



Used by permission of Happ Controls.

Figure 3-26: The Happ Controls Super joystick.

Happ Rotary and Optical Rotary

There are two models of the rotary style joystick from Happ Controls. These joysticks are 8-way microswitch-based with a bat-shaped handle. The extra feature of these joysticks is that the handle twists for games that require aiming, such as Ikari Warriors. The Rotary model (see Figure 3-27) does this via a mechanical 12-position switch, while the Optical Rotary does the same via an optical interface.

Used by permission of Happ Controls.

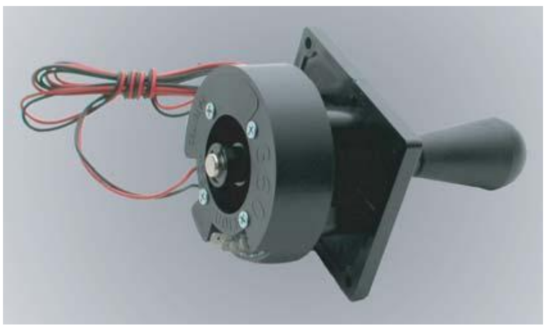
Figure 3-27: The Happ Controls Rotary (12-position mechanical) joystick.

Connecting these joysticks to your arcade machine requires a bit more work than other joysticks. The four microswitches connect in the same manner as other joysticks. The optical or 12-position switches require a different interface. Fortunately, a few methods for connecting these have been developed, some build-your-own and some ready to purchase off the shelf. See Chapters 8 and 9 for options for connecting rotary and optical rotary joysticks.

These joysticks have a limited but enthusiastic fan base. If you are a fan of a game that uses one of these joysticks, you'll be happy adding one to your project. Otherwise, they are probably not worth the extra steps and expense involved in connecting them.

Happ Perfect 360 Electronic

The Happ Perfect 360 joystick (see Figure 3-28) is considered the top of the crop of Happ Controls joysticks. It is similar to the Happ Competition and Super joysticks, with the bottom set of microswitches replaced with an optical sensor mechanism. The joystick is 4-way/8-way switchable by turning the actuator over. Like other actuator-based joysticks, the 4-way mode does not limit actual physical movement in that direction, allowing for dead-stick syndrome. However, the dead zone in 4-way mode is smaller in these joysticks than other 4-way/8-way sticks that use actuators instead of restrictor plates.



Used by permission of Happ Controls.

Figure 3-28: The Happ Controls Perfect 360.

The photoelectric mechanism used in place of microswitches provides for clickless game play and precise control in both 4-way and 8-way modes. In place of the normal connection to the microswitches, there's a 5-volt (+5v) connection and a ground, and four individual connections for each direction. The 5-volt connection is something to remember when designing your control panel. There are many options for obtaining the 5-volt connection. See Chapter 7 for more details.

Because of the switchless interface, the Perfect 360 joysticks have a smooth feel and very precise control. These joysticks tend to be favorites of those who try them, but are not as frequently used as the Super joysticks primarily due to the higher cost of the 360s. Fans of fighter games particularly favor them, and one popular hack of these joysticks is to replace the handle with a ball-top handle from old Wico leaf joysticks.

Groovy Game Gear Omni-Stik and Omni-Stik Prodigy

GroovyGameGear.com (`www.groovygamegear.com`) is another popular supplier to the build-your-own market with a line of joysticks customized for the hobby. Their answer to the 4-way/8-way convertible joysticks are the Omni-Stik and the Omni-Stik Prodigy shown in Figure 3-29.

Used by permission of Groovy Game Gear.

Figure 3-29: The Omni-Stik Basic on the left, the Omni-Stik Prodigy on the right.

The joystick shaft of the Omni-Stik line is an interesting cross between a bat-shaped handle and a ball-top handle. The shaft has a taper like a bat handle but ends in a ball top. The basic Omni-Stik is switchable between 2-way, 3-way, 4-way, 5-way, and 8-way modes. Switching modes requires physical access to the bottom of the joysticks. Switching between 4- and 8-way modes just requires turning the restrictor plate, and can be done by feel only (such as through an open coin door). Setting the joystick to 2-way, 3-way, or 5-way mode requires adjusting the pawls atop the restrictor plate with a screwdriver and hence isn't meant for on-the-fly adjustments. The ability to restrict it to 2-way as well as 4-way and 8-way make this a versatile joystick to have on hand if you don't know specifically what you'll need in the future.

The Prodigy line is a modification of the basic joystick, making it switchable between 4-way and 8-way from the top of the control panel. A small lever protrudes slightly above the mounting plate behind the shaft of the joystick. Rotating the lever left puts the joystick into 4-way mode; rotating it right puts the joystick into 8-way mode. The one feature this gives the joystick that no other 4-way/8-way switchable joystick has is that with the lever you can tell what mode the joystick is in. With other switchable joysticks there are no visual clues which could lead to starting games in the wrong mode before you realize it. The mounting plate that holds the joystick is a standard black-wrinkle surface with no screws showing, so it rests flush with the control panel top. The joysticks come in red, black, and blue models.

Groovy Game Gear SmoothStick

The SmoothStick (see Figure 3-30) is a modified Happ Controls 8-way Competition joystick. Groovy Game Gear has replaced the standard microswitches that come with the Competition with their Versa-Micro adjustable microswitches. The microswitches are pre-adjusted for nearly silent operation, and come with the adjustment tool if you want to tweak them.

Used by permission of Groovy Game Gear.

Figure 3-30: The SmoothStick 8-way joystick.

Juggling Joystick Decisions

Suffering from information overload? Don't worry; it's mostly downhill from here. Joystick choice is probably the most agonizing decision you'll have to make. Although there are plenty of options to choose from in the next few chapters, none are as overwhelming as joystick choices. If you can't make up your mind, here are a couple of suggestions:

- Hop onto the Build Your Own Arcade Controls (BYOAC) Web site at `www.arcadecontrols.com`, visit the message boards and chat room, and ask for opinions. Be prepared to discuss what your favorite games are and what kind of arcade machine you're trying to build.

- If you are a fan of fighting games, you may want to visit the Shoryuken forums at `www.shoryuken.com`, where joysticks optimal for fighting games are frequently discussed.
- If in doubt, choose a couple of 8-way joysticks (either the Ultimarc J-Stiks or the Happ Supers) or if your budget allows, a couple of Ultimarc UltraStik 360s. Complement those with either a joystick in 4-way mode (such as the Ultimarc E-Stik or Groovy Game Gear OmniStik Basic) or a top switchable 4-way/8-way joystick (such as the Ultimarc Mag-Stik Plus or the GroovyGameGear.com Omni-Stik Prodigy).

Bear in mind that once you've played with your arcade machine for a while, it's easy enough to swap joysticks.

Summary

Planning your control panel design can be a lot of fun. The biggest part of your control panel will be the buttons and joysticks. Buttons and joysticks distinguish themselves from one another by look, feel, and function and the types that you choose can have a real impact on how your arcade cabinet plays. Different buttons and joysticks lend themselves to different types of gaming (for instance, 4-way versus 8-way games), and there really is no single right answer as to which to choose. Ultimately, it comes down to personal preferences (you'll hear that quite a bit in this book).

There's more to most arcade cabinets than just buttons and joysticks, though. Many really great games use unique controls, such as spinners and trackballs. That's what I'll introduce in Chapter 4.

CHAPTER

4

Taking Your Game Out for a Spin — Spinners and Trackballs

IN THIS CHAPTER

- What Do Spinners and Trackballs Do?
- Spinner Choices
- Trackball Choices

Picture yourself twisting a spinner to fly your ship wildly around a geometric field as you shoot down spikes. Or perhaps you're madly spinning a trackball across the screen dodging laser beams. These are things you just can't do with a keyboard or even a joystick. These kinds of arcade antics require something more. In this case, the right tools for the job happen to be the second most popular controls for arcade cabinets: spinners and trackballs!

What Do Spinners and Trackballs Do?

Spinners and trackballs are essentially two peas from the same pod, with similar functionality and characteristics (see Figure 4-1). By twisting a spinner or rolling a trackball, you control the movement of your character or ship in an arcade game. Spinners move along a single axis, for instance left and right in the game Tempest, or up and down in Pong. Trackballs move freely along both the X and Y axes (360 degrees), for example in the game Missile Command.

In the case of a computer-based arcade cabinet, the spinner or trackball controls the mouse cursor on the computer. That translates to proper control when playing a game that uses a mouse for onscreen movement. You can even use a spinner (poorly) or trackball (better) to control your mouse in Windows!

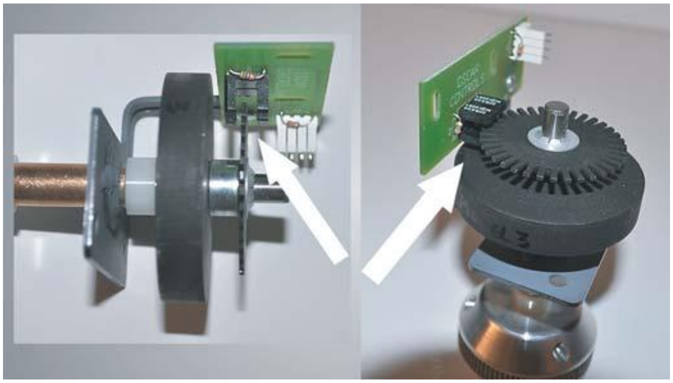
Used by permission of Apache Controls, Groovy Game Gear, Happ Controls, and Ultimarc.

Figure 4-1: Spinners and trackballs.

Spinners and trackballs are both optical devices. When the trackball is rolled or the spinner is spun, optical sensors detect the direction and speed of movement and send that information to their interface. Fortunately, computers already understand how to talk to optical devices. The mouse that you use on your computer is an optical device. This makes it very easy to connect arcade spinners and trackballs to a computer. Both typically connect to the computer in a similar fashion and to the computer both appear to be mice. All you need is an interface between the computer and the spinner or trackball to translate the spinner or trackball signal into a mouse signal. In a nutshell, there are two ways to do this. I'll go over interfacing spinners and trackballs in detail in Chapter 9.

Spinner Choices

You'll find that spinners, whether homemade or purchased, all share a common set of characteristics. Starting from the top, they have some kind of knob that is used to grab and twist the spinner. The knob is attached to a shaft, usually by a setscrew in the knob that holds it tight. The shaft penetrates the control panel and ends in an encoder wheel that is mounted perpendicular to the shaft. The encoder wheel has teeth around the outer edge. The toothed edge of the wheel rides between two halves of an optical sensor on the interface board. It's not as complicated as it might sound, as you can see in Figure 4-2. The optical sensor sees the teeth of the encoder wheel flash by as the spinner turns, light-dark-light-dark, telling the interface in which direction and how quickly the spinner is moving. I'll call each transition from light to dark or dark to light a pulse. Depending on the weight and size of the encoder wheel, an extra weight called a flywheel might be attached above or below it to provide extra heft and inertia to the spinner.



Used by permission of Oscar Controls.

Figure 4-2: The encoder wheel between the two halves of the optical sensor in an older model spinner. Left, side view. Right, top view.

There are variations on the basic spinner model, such as adding gears so that a single rotation of the knob causes the encoder wheel to rotate more than one time. Also, modern electronics allow for decoding the data from the optical sensors at a much higher rate of speed, so you can get the effect of a large encoder wheel in a smaller physical package. Nevertheless, the basic gist of how a spinner works remains the same, and I'll use that model in the remainder of this discussion.

One primary difference in the function of spinners is the free spin time. Some spinners are slow to move (in this case, slow means controlled, not unusable) and will quickly stop spinning when released. Others are extremely responsive and will spin for a long time when released. Which is better is another one of those almost religious debates. Some games were designed for fine controlled movement, while others were designed for high speed control. Even high speed spinners need to be controlled, however. It does you no good to move your spaceship quickly into position for a strike if it drifts out of position when you let go because the spinner is too sensitive. Other than the fact that a spinner does or doesn't have a free spin time, the length of free spin is really inconsequential. You won't give the spinner a twist and then watch it spin by itself. You only need the spinner to keep spinning while you let go and reposition your fingers on the knob.

Spinner Resolution and Sensitivity

I'm going to discuss spinner resolution and sensitivity. It's going to get a bit techie, but it's an important concept to understand because arcade games did not all use the same spinner design. The different designs used force us to consider resolution and sensitivity issues when choosing and using a spinner on our cabinets. I'll use two popular games, Arkanoid and Tempest, as my examples during this discussion. Arkanoid is a game where you control a paddle bouncing a ball into and destroying bricks at the top of the screen. Tempest is a game where you control a spaceship flying around the outside perimeter of the screen shooting objects that come at you from the center.

Think of a spinner's resolution as the number of apertures around the perimeter of its encoder wheel. Tempest, for instance, has an encoder wheel with 72 apertures around the wheel, so we'll call its resolution 72. Arkanoid has a geared encoder wheel with 486 effective apertures, so its resolution is 486.

NOTE **The Arkanoid spinner actually uses a 24 aperture encoder wheel. However, it has two gearing mechanisms that increase the number of times the encoder wheel makes a complete rotation with a single rotation of the knob. The gear ratios are 4.5 to 1. Multiply the 24 apertures * 4.5 * 4.5 (two staged gears) and you get the effective 486 aperture resolution of the Arkanoid spinner; one complete turn of the knob gives you 486 pulses. This can get complicated quickly, so unless explicitly stated otherwise, when I discuss resolution I will refer to the effective resolution even if the physical construction is different. Hence, I will refer to the Arkanoid spinner as a 486 aperture resolution spinner.**

CROSS-REFERENCE **You can find a list of arcade games and their associated spinner resolutions and physical makeup on the arcadecontrols.com Wiki at `http://wiki.arcadecontrols.com/wiki/Spinner_Turn_Count`.**

Another consideration is the spinner knob. A small knob requires less physical movement to make a complete rotation than a larger knob. Give a small knob an inch of travel, for example, and it might move a complete 360 degree rotation. Spin a large knob that same inch of travel and it might only rotate 90 degrees around. The Arkanoid knob only required a one-third rotation to move the paddle completely across the screen. Tempest, by contrast, moves the spaceship only part way around the screen with a full rotation of the knob.

I'm going to refer to the combined effect of the encoder wheel's resolution and the size of the spinner knob as the spinner's sensitivity. Arcade manufacturers factored in the spinner sensitivity when designing their games. A game like Arkanoid for instance called for a high degree of sensitivity. The player needed to be able to move their paddle a measured, controlled amount across the screen to meet the bouncing ball precisely. A small turn of the Arkanoid knob gives you a small amount of movement on the screen. Contrast that to a game like Tempest, where you fly madly around a geometric field firing at everything that comes your way. Tempest calls for a less sensitive spinner so that a small turn of the knob gives you rapid motion around the screen.

It's not quite as cut and dried as that, because in Arkanoid you still occasionally need to fly across the screen to catch a bad bounce, and in Tempest you sometimes need to be able to position your ship precisely to avoid spikes and enemy fire. Programmers programmed their games accordingly to take into account things such as the acceleration you put on the spinner as well as its velocity. Nevertheless, the principle remains that each game was designed around a spinner with a specific sensitivity.

For programmers designing a specific game, this did not represent a problem, as the spinner's sensitivity was a constant on which they could rely. For those of us building multi-game cabinets, however, it presents a challenge. If you swap the physical spinners between Arkanoid and Tempest, neither game will perform very well at all as the sensitivity of the spinner will no longer match the specifications for which the game was designed. This is a problem we need to overcome for our cabinets.

The solution on computer controlled multi-game cabinets is to adjust the game's *software sensitivity* settings to the spinner's *physical sensitivity* as defined by the spinner's resolution and knob size. To help understand how this works, put aside the games for a moment and just think about your computer and Windows. You can go into your Windows control panel and adjust the mouse sensitivity. Set it to low sensitivity and you have to use a lot of movement on your physical mouse to get the cursor to move across the screen. Set it to high sensitivity and just a small bump of the mouse can move it across the screen.

Now, let's look at the game system again. For better gameplay, you need to try to get the game software to restrict or enhance the physical spinner's sensitivity to what the game is expecting. For sake of discussion I'm going to distinguish two different spinner resolutions: standard and high. The reality is that there are as many different spinner resolutions as there are arcade games, but we'll lump them all into either standard or high resolution. If you are using a *standard* resolution spinner with a game that originally used a *high* resolution spinner, you'll want to adjust the software's sensitivity for that game to be higher. Conversely, if you're using a *high* resolution spinner with a game that originally used a *lower* resolution spinner, you adjust the software's sensitivity downward.

For instance, take a spinner with a resolution of 1200 (there are a couple of commercial models meeting this resolution presented in the following pages), and use it with the game Tempest. Tempest uses a spinner with a resolution of 72. Take Tempest's expected resolution and divide by the spinner resolution you actually have and you get 72/1200 = 0.06 or 6%. In your software, for the most accurate feel you should set the sensitivity of the game Tempest to be 6%.

You didn't know there'd be a math test involved did you? Fortunately, there are a couple of ways you can shortcut this if you would like. You can check the `www.arcadecontrols.com` message forums to see whether someone has already calculated the optimal sensitivity setting for a specific game, or alternatively you can simply use trial and error to adjust the sensitivity until it feels right to you.

You can adjust software sensitivity downward with few, if any, issues. Adjusting sensitivity upwards is problematic however.

First, let's look at setting your software to be less sensitive. If in a single second your spinner generates 4 pulses of light-dark transitions and you have the software sensitivity set downward to 50%, then the computer will respond to 2 of those 4 pulses. The remaining 2 pulses are discarded. There is no missing data; the software is simply choosing to use less of the data. The effect is that your on-screen character moves a little slower than the actual physical effort you put into turning the knob. This can help you achieve fine control.

Now, let's look at setting your software to be more sensitive. If in a single second your spinner generates 4 pulses of light-dark transitions, and you have the software sensitivity set upward to 200%, then the computer reacts to 8 pulses. However you only really have 4 pulses being sent to the computer. The software has to interpolate the additional 4 pulses. The problem is that even though you're effectively getting 8 pulses, you only physically moved the spinner through 4 pulses. This can give you visible jumping or skipping on the screen, resulting in less accurate control. The more you turn up the sensitivity, the more exacerbated this problem can become.

The problem with higher sensitivity settings is a real one (that is, there is no question that the jumping or skipping is in fact happening). However, there is some disagreement as to the severity and perceived impact of this issue. Some players will disregard the resolution issue because other features of the spinner are more important to them, or because they are not planning to play games that require high resolution spinners. To other gamers however, using the right spinner and fine tuning the spinner's sensitivity is as important as choosing to use real arcade controls instead of a keyboard! Nothing else feels right. It can mean the difference between being able to play a game and maybe getting through the first few levels, and mastering the game and beating it or setting the all time high score. You'll need to weigh a spinner's resolution and sensitivity against the other factors of the spinner and decide what's most important to you.

NOTE **An analogy I'll offer is movie watching. My family moved from a standard definition 33" television to a standard definition projector on a 100" screen then to a high definition projector on the same screen. For my wife, the appreciated difference was moving from a small television to the large screen. The difference between the standard definition and high definition did not mean much to her. To me the extra clarity and picture quality of the high definition projector was a night and day difference from the standard definition projector. While there clearly is a technical difference between the standard and high definition projectors, she and I had very different** *perceived* **experiences between the two projectors. I found a benefit in the higher definition projector while she did not.**

For simplicity's sake I haven't touched on every aspect of what makes a spinner work in this section. For instance I didn't discuss factoring in the effects of the Windows mouse driver and the spinner's interface electronics, and there are numerous (sometimes heated!) discussions on the message forums about spinner resolution and sensitivity. If you want to read more about this, log on to the `www.arcadecontrols.com` forums and search for "spinner resolution." Pack a lunch; you'll be there for a while!

If you build your own spinner, the resolution will depend on what components you hack to make it, of course. For the commercially available spinners, I'll mention for each whether it's considered a standard or high resolution model. How do you choose an off-the-shelf model? The best advice I can give you is to look at the features the spinner choices have (resolution, knobs, colors, size, extra features, and so on) and read reviews on the forums. What I will tell you is that all the commercial spinners presented in the following section have been out for some time and have many discussions on the forums. All the purchasable spinners below have received good reviews.

Building Your Own Spinner From Scratch

One of the neater hacks you'll encounter while building your arcade cabinet will come from the people who build their own spinner controllers. It's one thing to take a manufactured arcade control part and find a way to connect it to a computer (which is impressive), but to take a handful of parts and build a spinner from them is the utmost in ingenuity. There are several methods for building a spinner from scratch.

You should consider the worth of your time and money when considering a self-built spinner. At one time, purchasing a spinner and connecting it to a computer was an expensive proposition, and building your own spinner was the only economical way to get one. Now, however, commercially made spinners for home-built arcade machines are available starting at $70. When compared to today's commercial spinners, a build-your-own spinner is primarily an exercise in fun for those who enjoy a clever hack, rather than a way to save a lot of money.

Twisty-Grip Spinner

In 1998, a company called Retrosketch introduced a product line including a spinner under the name Twisty-Grip. The company has since abandoned production of spinners and made the instructions for building them freely available online. The spinner can be made for about $78 in parts, as listed in the instructions, but with some creativity you should be able to drop that cost. Building this spinner will require using the insides of a mouse.

The plans for building the Twisty-Grip spinner are very detailed, including more than 100 pictures, and come with a parts and price list.

CROSS-REFERENCE **The instructions for building the Twisty-Grip spinner, as well as the following hacks, are all included on the companion CD-ROM.**

The QuickSpin Arcade Spinner Project

The QuickSpin arcade spinner by Kendall Chun of Gearhead Labs is another build-from-scratch spinner. Designed for mounting directly into your control panel, it can be built for $30 to $40 in parts in a couple of hours. Instead of using mouse parts for its interface, the QuickSpin design connects to one of the several optical interfaces reviewed in Chapter 9.

Hard Drive Spinner Hacks

The last homemade spinner design I'll show you is one in which you scavenge a dead hard drive for parts (see Figure 4-3). Hard drives consist of round platters mounted on a center core spinning at 5,400 revolutions per minute or faster. Because of the high speed and precision at which hard drives operate, their parts are particularly well suited for this kind of hack. Old hard drives are easy to find, and most use similar technology, so this hack is not difficult to reproduce. Several visitors to the Build Your Own Arcade Controls (BYOAC) Web site (`www.arcadecontrols.com`) have made hard drive–based spinners and documented their projects online.

Used by permission of Doug Hansen.

Figure 4-3: The hard drive spinner hack.

CROSS-REFERENCE **One example of a spinner created with parts scavenged from a hard drive is featured on Doug Hansen's "Arcade Stupidity" project and is included on the companion CD-ROM, along with well-documented instructions and two QuickTime video clips of the spinner in action. Don't let the name fool you; Doug's arcade cabinet is a project to be proud of!**

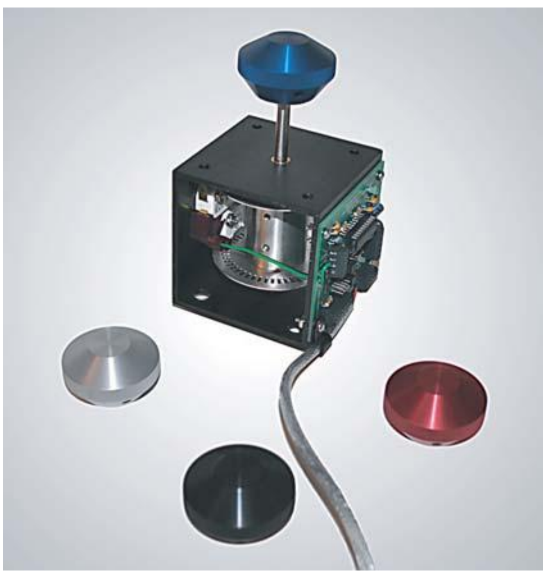
Purchasing An Arcade Spinner

You *could* build your own spinner, and doing so would certainly be within the spirit of this book. However, with so many other activities involved in creating your arcade cabinet, and the relatively low costs involved, you will probably be happier purchasing a spinner for your project. Among other reasons, all the commercially available spinners shown here come with a built-in USB interface, meaning you won't have to purchase a separate interface to use them. You have several choices.

Apache Controls Blackhawk Push/Pull Spinner

One of the holy grails of the of the build-your-own-arcade world is a push/pull spinner. This is a spinner that not only rotates along one axis but also lets you pull up and push down on the spinner knob. Doing either presses a microswitch and registers movement up or down. There are only a few arcade games that used a push/pull spinner. For instance, Discs of Tron used one to allow you to aim your disc up or down while the spinner let you run left and right across the game grid. Playing one of those games is very difficult without a push/pull spinner.

Apache Controls sells a push/pull spinner called the Blackhawk (see Figure 4-4). Being USB enabled means it doesn't need a separate interface, but it can also be connected to an Ultimarc Optic-Pac interface if desired. The spinner can be set to control the X, Y, or Z axis, and can have 5 pushbuttons. The pushbuttons act as mouse button inputs, and two of them are taken up for the push and pull buttons leaving three available for you. The built in interface also has available +5v and ground connections. Remember I mentioned 5v and 12v in the previous chapter? Here's one way you can tap into a 5v source! The built in interface can also be used to connect a second Blackhawk spinner.



Used by permission of Apache Controls.

Figure 4-4: The Blackhawk Push/Pull spinner and various control knobs.

TIP **XYZ? Mouse style inputs, such as trackballs and spinners, operate along axes (the plural of axis, not the wood chopper!). The X axis is horizontal along your screen. The Y axis is vertical along your screen. The Z axis normally controls the scroll bar in Windows, but for gameplay terms allows a third control to be used. For instance, if you wanted to use a trackball and a spinner on a single connection, the trackball would take the X and Y axes, and the spinner would use the Z axis. The Z axis is handled differently from the X and Y axes by Windows, so your software needs to adjust correspondingly or the response will be choppy. This can be a bit problematic, so check your specific game for support of the Z axis before using.**

Apache Controls gets a special mention for including complete assembly, installation, and troubleshooting documentation on their website. They get all the way down to the component level (every last screw, nut, and bolt) and you could completely disassemble and reassemble the spinner based on their documentation. I wish more vendors provided this level of documentation for their products.

The Blackhawk Push/Pull spinner takes up 3 inches squared beneath the control panel so you'll need to plan accordingly if you intend to use one. The spinner has a nice feel to it, with a moderate amount of free spin time. It is hefty enough that it shouldn't drift randomly. The shaft length is adjustable making this spinner suitable for mounting in control panels of any thickness. This is a standard resolution spinner.

Groovy Game Gear Turbo Twist 2 Spinner

Groovy Game Gear's Turbo Twist 2 spinner is a compact barrel spinner designed to be mounted from the top in a standard pushbutton mounting hole. Like a pushbutton, it's secured to the control panel via a nut threaded from below, so no screws or mounting plates are required (see Figure 4-5). This top mounting approach means it will always be the proper height without requiring adjustments due to control panel thickness.

As with the others listed here, the Turbo Twist 2 is USB enabled. You can also ask for a PS/2 interface instead. Both interfaces have support for 3 mouse buttons and can also act as the master for up to two additional spinners. The master spinner is always set to the X axis, while the secondary spinners can be set to X, Y, or Z.

The spinner has a relatively small amount of free spin when released. I'd like to emphasize once more that this isn't a drawback; the spinner is very responsive when manipulated and the small free spin is a design decision. An optional "energy storage cylinder" (also known as a weight, serving the same purpose as a flywheel) is available to add inertia and extended free spin time for those who want it.

Used by permission of Groovy Game Gear.

Figure 4-5: The Groovy Game Gear Turbo Twist 2 spinner.

Groovy Game Gear has a couple of unique options for their spinner that I'm not aware of any other vendor offering. First, in addition to a good selection of standard knobs to choose from, they offer an "inset" model that allows you to glue an industry-standard sized token to the top. You can see mine featuring a BYOAC token from Arcade Replay (`www.arcadereplay.com`) in one of my cabinets in Figure 4-6.

Used by permission of Groovy Game Gear, Arcade Replay, and Pixelhugger.

Figure 4-6: The Groovy Game Gear Turbo Twist 2 spinner with inset BYOAC token.

You can also convert a Turbo Twist 2 into a miniature steering wheel! Groovy Game Gear sells three different add-on mini steering wheels that are designed to connect to the Turbo Twist 2 spinner, turning it into driving gear. This is great for limited use when you don't want to commit the space to a dedicated wheel. For a full-time driving cabinet, you'll want to invest in a permanent steering wheel (see Chapter 5). The Turbo Twist 2 is a high resolution, 1200 pulse per rotation spinner.

Groovy Game Gear Turbo Twist High-Low Spinner

Groovy Game Gear's version of the holy grail push/pull spinner is the Turbo Twist High-Low model (see Figure 4-7). Pulling up on the spinner pushes a microswitch button, pushing down pushes another microswitch button. This is a compact top-mounted spinner with a mounting plate available in various colors, including translucent white matching the Electric Ice 2 pushbuttons for illumination. You also get a replica of the Discs Of Tron spinner knob with the High-Low spinner. The knob's mounting height can be adjusted for comfort.

Used by permission of Groovy Game Gear.

Figure 4-7: The Groovy Game Gear Turbo Twist High-Low spinner, front and back view with interface.

Like the TurboTwist 2, the High-Low can be configured as either USB or PS/2 and does not require an external interface. The included interface is the same as the TurboTwist 2 with the same feature set, with the primary spinner hard set to the X interface. The spinner's two buttons for push and pull activate the left and right mouse buttons respectively, and take up two of the three available buttons on the interface. Steering wheels are also available for this spinner, again recommended for limited use, particularly in light of the extra movement of the push/pull control. The High-Low is a high resolution, 1200 pulse per rotation spinner.

SlikStik Tornado Spinner

You'll be a fan of the SlikStik Tornado Spinner (see Figure 4-8) the moment you try one. In fact, when I first received the Tornado Spinner, I wondered whether

SlikStik had found a way to defy the laws of physics! Other spinners have free spin times (how long the spinner will spin with one good twist) measured in seconds. The Tornado Spinner's spin time is literally measured in minutes! Of course, a long spin time doesn't actually add anything to gameplay unless you want to fire the spinner off while you step out for a quick break. However, it is a clear indication of the workmanship and attention to detail that SlikStik put into their product and it just feels good!

Used by permission of Happ Controls.

Figure 4-8: The SlikStik Tornado Spinner with contoured knob.

The Tornado Spinner is a compact design using the industry-standard 1⁄4-inch shaft, with a small 2-inch diameter encoder wheel resting above a heavy barrel-shaped steel weight instead of a traditional flywheel design. The spinner mechanics are surrounded by a small bracket sized to the width of the components, making it a very compact unit. The Tornado Spinner needs only a 2-inch by 2-inch mounting space beneath the control panel, with a 2 1/2-inch mounting depth. Mounting the Tornado Spinner requires drilling a single hole for the shaft and four smaller holes for screwing the bracket to the control panel. The spinner comes with a dual USB and PS/2 interface controlling the X axis. This is a standard resolution spinner.

NOTE **The SlikStik company is no longer in business, at least as far as having a storefront on the Internet. However, the spinners are apparently still being made and can be purchased from a few online sources, such as Happ Controls (`www.happcontrols.com`) and DreamAuthentics (`www.dreamauthentics.com`).**

Ultimarc SpinTrak

Ultimarc's SpinTrak is their entry into the spinner market. Like the TurboTwist 2, this spinner is also a compact barrel design meant to be mounted from the top in a standard pushbutton mounting hole and secured with a nut threaded from below (see Figure 4-9). If you buy one of the optional flyweights you'll have to remove it before mounting it, as the flyweight is slightly bigger than the mounting hole. Without the flyweight the spinner will drop right in. Either way, once mounted you get a nice clean look without a mounting plate or visible screws.

Used by permission of Ultimarc.

Figure 4-9: The Ultimarc SpinTrak spinner with USB 2.0 interface.

The SpinTrak comes in two configurations, either USB 2.0 enabled or designed to hook to an Ultimarc interface (which I'll cover in Chapters 8 and 9). The USB interface includes the ability to connect up to three mouse buttons, and controls the X axis of the mouse cursor. Without the optional flyweight the spinner acts more as a paddle control, where it stops quickly the moment you let go of the knob. With the optional flyweight the spinner can continue to spin for a few seconds once you let go of the knob. The SpinTrak has a few different knob options, and is a nice solid feeling spinner. It is high resolution at 1200 pulses per rotation.

Picking a Spinner

All of the commercial spinners presented in this section are good choices; there are no lemons in the lot. When I tested them, all of them were automatically detected and installed by Windows on the X axis by default. Some of them include interfaces that support multiple spinners, meaning you only have to tie up a single USB or PS/2 port. Others require a dedicated port per spinner. I'll come back to that in Chapters 8 and 9.

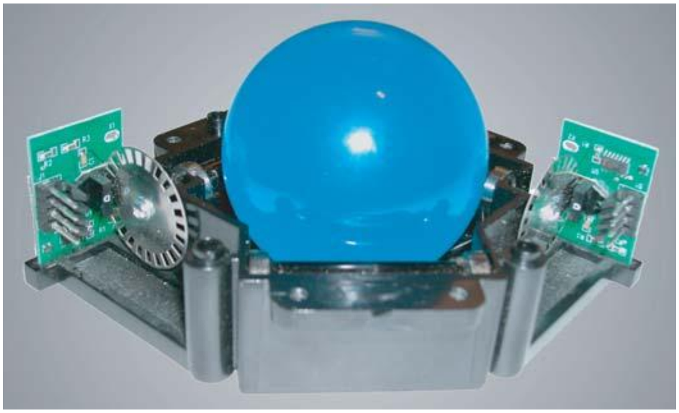
For versatility, one of the push/pull style spinners cannot be beat. If you are planning to play a game that requires such a controller, such as *Discs of Tron* or *Zwackery*, there simply is no substitute. If you're trying to put a spinner into your control panel on a tight budget, one of the non-push/pull spinners shown here will do the job nicely. Regardless of which of the available commercial spinners you choose, you are likely to be very happy with your choice.

Trackball Choices

As you look over the many arcade games available for your arcade cabinet project (see Chapter 14), you'll quickly realize that no control panel is truly complete without a trackball. Trying to play *Centipede* with a joystick just doesn't compare to the real thing! One of the best reasons to include a trackball in your arcade cabinet is cabinet control. Unless you are using an operating system that's not graphical, such as MS-DOS, you'll need some way to move your cursor. Having to pull out a mouse every time you want to select a game or turn off your computer really kills the arcade atmosphere you're trying to recreate. Since the trackball acts as a mouse, you get the best of both worlds. You can maintain the arcade look and feel while still being able to control your computer.

Although they differ in appearance, trackballs and spinners are near cousins to one another and operate under the same principles. Where a spinner has a single optical encoder and recognizes movement in one dimension along the X, Y, or Z axis, a trackball has two encoders and moves in two dimensions along both the X and Y axes. With a spinner you typically move left and right across the screen (sometimes up and down). With a trackball you move freely around the screen. Instead of using a knob and shaft to turn along one axis, trackballs typically have a solid ball resting on two rollers attached to encoder wheels oriented 90 degrees to one another. There may be a third roller providing support that is not connected to an encoder wheel. In Figure 4-10, you can see a partially disassembled 3-inch Happ Controls trackball. The ball sits in the center, surrounded on either side by the horizontal (X) and vertical (Y) axis encoder wheels. Moving straight along the X or Y axis turns one roller and encoder wheel, producing movement in one direction. Moving at any angle other than straight horizontal or vertical turns both rollers, producing movement in the appropriate direction. This works exactly like a mouse. In fact, if you turn a mouse on its back, you essentially have a trackball!

Trackballs have not received quite as much attention in the build-it-yourself field as spinners. There *are* modified computer trackball projects, but I'm not aware of any start-from-scratch designs. Some of the trackballs designed for personal computers might be adequate for arcade cabinets, but they are not as robust and lack that true arcade feel. Several commercial arcade trackballs are available that can be connected to your arcade cabinet, and I highly recommend choosing one. Factors to consider when choosing a trackball include the size of the ball, color/translucency, mounting requirements, and interface.



Used by permission of Happ Controls.

Figure 4-10: Happ Controls trackball with the cover off.

Trackballs come in a variety of sizes, ranging from small 1 1/2-inch models to large 4 1⁄2-inch models. The size you should consider depends on the amount of space you have available on your control panel and how often you intend to use the trackball. If your space is limited or you intend to play only a small number of trackball games, a small trackball may be the way to go. If you have the space, however, or if you are a fan of trackball games such as Golden Tee for the PC, then a big trackball is a must. The sweet spot for trackball size seems to be 3 inches, providing a good compromise in feel versus space required.

You can typically find trackballs in red, white, blue, yellow, green, and black varieties. A few are also available with an underlying light source to illuminate the trackball. A glowing trackball can really boost the *wow* factor!

Trackballs are easy to connect to your computer these days. In the past you either had to hack apart a mouse and use its electronics or purchase an expensive PC interface. Now, you have many off-the-shelf interface options, which I'll cover in depth in Chapter 9.

Computer Trackballs

I'll touch briefly on using computer trackballs on your arcade cabinet, but I really don't recommend them. Your only real benefit of doing so, that I can think of, is that they can be found somewhat cheaper than arcade trackballs. Some of the drawbacks of a computer trackball include feel and difficulty of installation. On the one hand, connecting a computer trackball to your computer is very easy because that's precisely what it's designed for. Plug the trackball into the appropriate port on your computer, perhaps install a driver, and it's ready to go. On the other hand, installation can be difficult when it comes to figuring out how to mount the trackball. Unlike an arcade trackball, which is meant to be placed in a control panel, a computer trackball is meant to sit on a desk. Take a look at Figure 4-11. The curved housing on the typical computer trackball shown in the top of the figure would make mounting it in a control panel difficult.

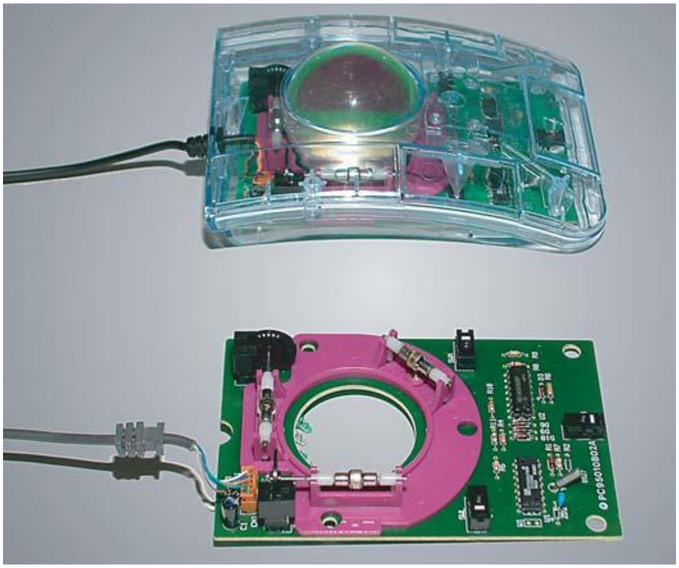


Figure 4-11: A typical computer trackball, assembled (top) and disassembled (bottom).

Fortunately, computer trackballs tend to be fairly simple devices and can be taken apart easily. You can see this same trackball removed from its housing in the bottom half of Figure 4-11. The circuit board is flat and has a couple of screw holes for mounting. Designing a wooden enclosure for this and mounting it to the underside of your control panel might not be difficult. Vendors such as Happ Controls sell mounting plates for various sized trackballs that could be used to make the installation look clean and professional.

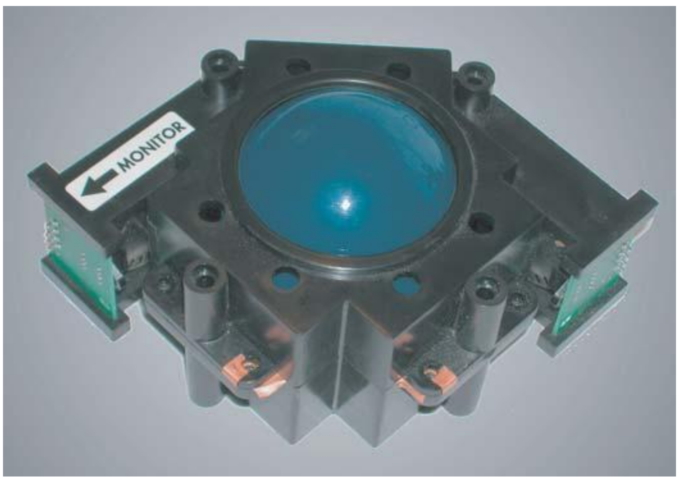
Trackballs such as the one pictured in Figure 4-11 can be found starting in the \$20 to \$25 range from a variety of online and brick-and-mortar stores. It is also possible to find high-quality computer trackballs for \$100 or more. You might hesitate to tear apart such an expensive item, however, particularly since an arcade trackball can be purchased starting in the \$60 range.

The most significant drawback to a computer trackball is the feel. Computer trackballs tend to have a lighter feel that is not well suited for game play. When you are playing Centipede, you want to be able to slam the trackball madly across the screen. Most computer trackballs will stop moving as soon as you let go of them and don't respond well to rapid movement. They're designed for fine mouse control, not game playing.

Arcade Trackballs

You'll find that a real arcade trackball complements an arcade cabinet very nicely and is highly recommended. Not only do you get the look and feel of a real arcade trackball, you also get all the benefits of mouse control. Arcade trackballs are available from a variety of vendors, and all typically use either the same arcade standard interface or a USB or PS/2 connector.

Arcade trackballs (see Figure 4-12) have a heft and feel obviously designed for game play. When you give one a mad spin, it continues to move briefly after you let go while a computer trackball will stop. The first time you play Centipede or Missile Command with a real arcade trackball instead of a mouse or computer trackball, you'll feel the difference and won't ever want to go back. The most popular trackball sizes used are the 2 1/4-inch and 3-inch models. The 2 1/4-inch trackballs use the same size ball as a standard pool ball, and several people have given their control panels a distinctive look by using an eight ball or other custom pool ball as their trackball. The translucent arcade trackballs are also a nice addition to a control panel and when illuminated give it a real *pop*!



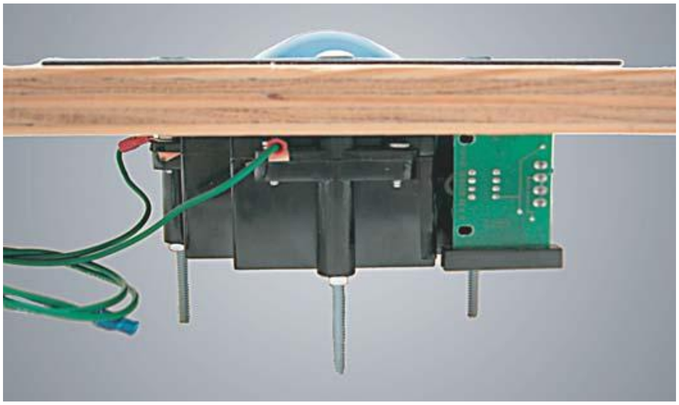
Used by permission of Happ Controls.

Figure 4-12: A Happ Controls 3-inch translucent trackball.

Connecting an arcade trackball to your computer is easy to do now. The hacker way involves disassembling a mouse and using its innards. The easier way involves simply purchasing one of several interfaces available for this purpose. As mentioned earlier, the specifics of interfacing trackballs and other components will be covered in Chapter 9. However, unless you really want to hack your own, you'll be happiest purchasing one of the dedicated trackball interfaces.

Putting in an arcade trackball will require some thought about space requirements. For instance, the 3-inch arcade trackball from Happ Controls (shown in

Figure 4-13) occupies roughly 2 1/2 inches above the control panel, and approximately 5 1/2 x 5 1/2 inches below. Adding a trackball is not something that can easily be done as an afterthought. Even if an arcade trackball is outside your immediate budget, you should consider leaving an adequate amount of space in your control panel to add one later.



Used by permission of Happ Controls.

Figure 4-13: An assembled 3-inch Happ Controls trackball, showing the 5 1/2-inch-squared space required.

You might think that mounting an arcade trackball involves only cutting the proper sized hole for the ball to extend through. However, trackball mounting is probably one of the more involved jobs when creating a control panel. Different trackball models have different needs, but you not only have to allow for the trackball itself to extend through the top of your panel, you also have to accommodate the large plastic housing in which the trackball sits. To complete a trackball installation, often you will add a trackball mounting plate. Happ Controls has two styles of mounting plates available, which fit their trackballs as well as those from several other vendors. There is one model in which the mounting hardware is hidden beneath the plate, presenting you with a smooth surface above, and one model in which the mounting bolts are exposed from the top. The smooth surface plate is only a few dollars more and gives the control panel a much nicer look (see Figure 4-14).

Commercially Available Arcade Trackballs

You have several choices when it comes to buying an arcade trackball. You can find trackballs from many arcade parts vendors or eBay. I'll take a look at the four most popular choices here.

Used by permission of Happ Controls.

Figure 4-14: A Happ Controls trackball mounted with a surface mounting plate.

Groovy Game Gear Electric Ice-T Deluxe

The Groovy Game Gear Electric Ice-T Deluxe RGB Trackball is a modified Betson Imperial (a well known arcade manufacturer) trackball that comes in 2 1/4-inch and 3-inch models. The standard encoder wheels have been replaced with higher resolution models for greater sensitivity and responsiveness during gameplay (see Figure 4-15).

Used by permission of Groovy Game Gear.

Figure 4-15: The Electric Ice-T Deluxe trackball, assembled on the left, showing the high resolution encoder wheels on the right.

The included interface is similar to that used with their spinner lines, available in USB and PS/2 models. The interface has support for three mouse buttons, and has one available 5v header (the other is taken up by the trackball).

You are most likely to consider this trackball for the eye-candy appeal of its lighting kit. The "RGB" portion of its name stands for the red-green-blue super-bright LED lighting unit that comes standard with the trackball, pictured in Figure 4-15. You can use any of the three colors or combine them to have up to seven different colors illuminate the trackball, or connect it to their optional LED lighting interface (which I'll cover in Chapter 15) to have pulsing and color changing effects. The ball in this unit is specially designed to capture and diffuse the light for a pleasing effect.

NOTE **Both the higher resolution encoder wheels and the RGB illumination unit are available as separate kits from Groovy Game Gear if you want to use them with a different trackball.**

Happ Controls and Betson Imperial

Happ Controls and Betson Imperial trackballs (available from many vendors) are industry standard arcade trackballs and come in many options. I will focus on the Happ Controls trackballs here as they have more options, but the Betson Imperial is a popular choice in the build-your-own crowd as well. The most popular Happ Controls choice is the 3-inch model you saw in Figures 4-12 and 4-13. They also have sizes ranging from 1 1/2-inch up to 4 1/2-inch, with balls available in various colors including some translucent models.

Some of the trackballs are available with either a standard arcade style interface, or with a USB or PS/2 interface. Others (such as the 1 1/2-inch model) only offer a USB or PS/2 option. You might choose the arcade style interface if you're planning to use a third party encoder or hack your own using a mouse (see Chapter 9) as the arcade style is two-thirds the cost of the USB or PS/2 style. The USB or PS/2 style models come wired for up to three mouse pushbuttons and are "plug and play" connectable to your computer.

Ultimarc U-Trak Flushmount

Ultimarc's entry into the trackball field is a 3-inch model custom designed for the wooden control panels most of us will use (see Figure 4-16). Its basic components are similar to the Happ Controls and Betson Imperial trackballs used elsewhere. The U-Trak uses arcade industry standard encoder wheels and connects to either a custom USB interface or to one of the separate encoder interfaces I cover in Chapter 9.

Where the U-Trak shines is the consideration made for mounting in wooden control panels. The trackball sits high in the plastic housing, with a high lip designed to bring the top of the trackball housing flush with the top of your control panel. The trackball is secured from below with no screws penetrating the top of the control panel. Unlike most other models, no routing (removal) of wood is required beneath the control panel to accommodate the trackball's plastic housing.

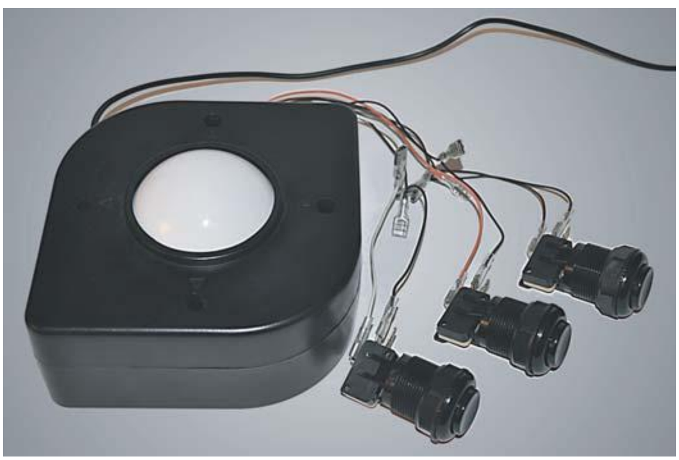
Used by permission of Ultimarc.

Figure 4-16: The Ultimarc U-Trak Flushmount trackball and optional RBG lighting kit.

You can add Ultimarc's optional RGB LED lighting kit and illuminate your trackball with one of seven different colors, or connect the kit to their optional lighting interface for more color options and lighting effects (see Chapter 15). Color choices for the ball are solid white, red, or "pearlescent" for use with the RGB LED kit.

X-Arcade

The X-Arcade trackball is a 3-inch modified Betson Imperial model with some enhancements. They use standard encoder wheels connected to Sharp Electronics optical gear with a USB and PS/2 dual interface (see Figure 4-17). Only a white color ball is available, but any standard 3-inch trackball will fit if you want to swap it out.



Used by permission of Xgaming.

Figure 4-17: The X-Arcade trackball.

Aside from being one of the lower-cost models available, X-Arcade has two notable features in this trackball. The built-in interface includes three mouse pushbuttons and comes pre-wired to connect to them. The unique feature they have is a fourth, horizontal cut-off button. There may be times (bowling or golf games) where you only want to be able to move vertically, but it's hard not to get a bit of left or right motion particularly with a good, hard spin. By pushing the fourth button, the horizontal encoder is electronically disabled so that only vertical motion is registered. That may or may not be cheating, but it's certainly not something I've seen in any other trackball models.

Trackball Roundup

When it comes to selecting your arcade trackball, it's hard to make a poor choice. Trackballs from the various vendors all tend to be of high quality and functionality. New trackballs from the arcade parts houses are more expensive, while used or refurbished trackballs can be found at a substantial discount. Because of the standard interfaces used, your selection can be based on pricing and cosmetic and tactile features. The general rule of thumb is the bigger and heavier the trackball, the better the play. Your best bet is to pick the size of trackball you want first and then shop different suppliers to find the one whose features you like the best.

Summary

Spinners and trackballs are almost must-haves for your arcade cabinet project. You can do without them, but you'll be missing out on a large selection of fun games if you do. If you've only got space or resources for one, go with a trackball. Having two axes, a trackball can substitute for a spinner in a pinch, but a spinner cannot substitute for a trackball since it only moves along one axis. Spinners and trackballs can be acquired from a range of sources, from the buy-it-off-the-shelf models to the hack-it-yourself variety. Unless you're looking to exercise your ingenuity or save some money, forego the hacked units in favor of the commercial products. The quality and convenience of the commercial models make them too good of a deal to pass up.

In Chapter 5 I'll introduce you to a few more arcade controls. You'll see them used less often, but no book on the subject is complete without them!

CHAPTER

5

Arcade Controls for Power Gamers

IN THIS CHAPTER

- **Steering Wheels and Pedals**
- **Flight Yokes**
- **Light Guns**
- **Dance Pads**

You've judged the joysticks, bought your buttons, selected a spinner, and tried a trackball. What's next? With this assortment of arcade controls, you've covered most of the game genres available, but what if you're seriously into racing or flying? What if target practice is more your speed? What if you have fast feet itching for a good dance game? This chapter is for you!

In this chapter, I'll introduce you to the remaining arcade controls covered in this book:

- Steering wheels and pedals
- Flight yokes
- Light guns
- Dance pads

All of these make great additions to an arcade cabinet, but few games require them. You'll need to decide whether adding them is worthwhile. Each control requires additional effort to install and interface and occupies space on the arcade cabinet. Space, as you probably are beginning to realize, is at a premium on most arcade cabinets. For each control in this chapter, you must weigh the games you want to be able to play against the resources required to install the needed control. I'll take a look at each of the controls in turn.

Steering Wheels and Pedals

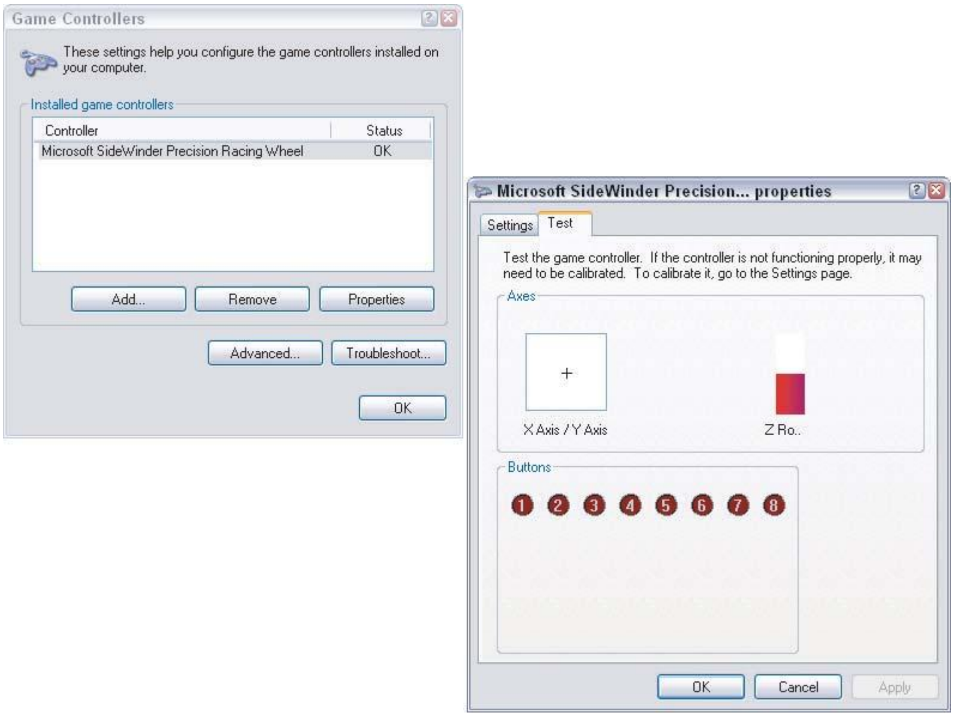
Picture yourself driving a classic Porsche convertible. You're cruising along the open road in the Swiss Alps with snow on the ground and sun in the sky. Passing a crystal-clear lake, you come upon a stretch of straight, open road. A catchy tune is playing on the radio that's got your blood pumping, and you decide to open up the speed and see what the car can do. Ready to shift gears and hit the gas, you eagerly reach for. . .a couple of pushbuttons? It doesn't quite work, does it? There are some really awesome driving simulations available for the PC (the one just described is Need For Speed: Porsche Unleashed by Electronic Arts, my all-time favorite), but they just aren't as satisfying without a steering wheel and pedals.

How Steering Wheels Work

Steering wheels — and pedals (assume pedals are included when I mention steering wheels) — usually appear to the computer as a 2-axis joystick. These are devices for which the computer registers how far and in which direction along the X and Y axes the control is pointing. Normally, the wheel part appears as the X axis, and the pedals appear as the Y axis. Figure 5-1 shows the Game Controllers Properties dialog box in Windows XP of a typical steering wheel. The crosshair in the X Axis/Y Axis box shows the position of the wheel and pedals. When the crosshair is in the middle of the box, neither the wheel nor the pedals are being used.

Steering the wheel left will move the crosshair to the left, and moving the wheel right will shift the crosshair to the right. That's basically intuitive. Slightly less intuitive is what happens with the pedals. Pressing down on the gas will move the crosshair upward along the Y axis whereas pressing the brake will move it downward, as you can see in Figure 5-2. In a game, movement up on the Y axis means accelerate, movement down means decelerate, and movement left or right on the X axis means steer left or right.

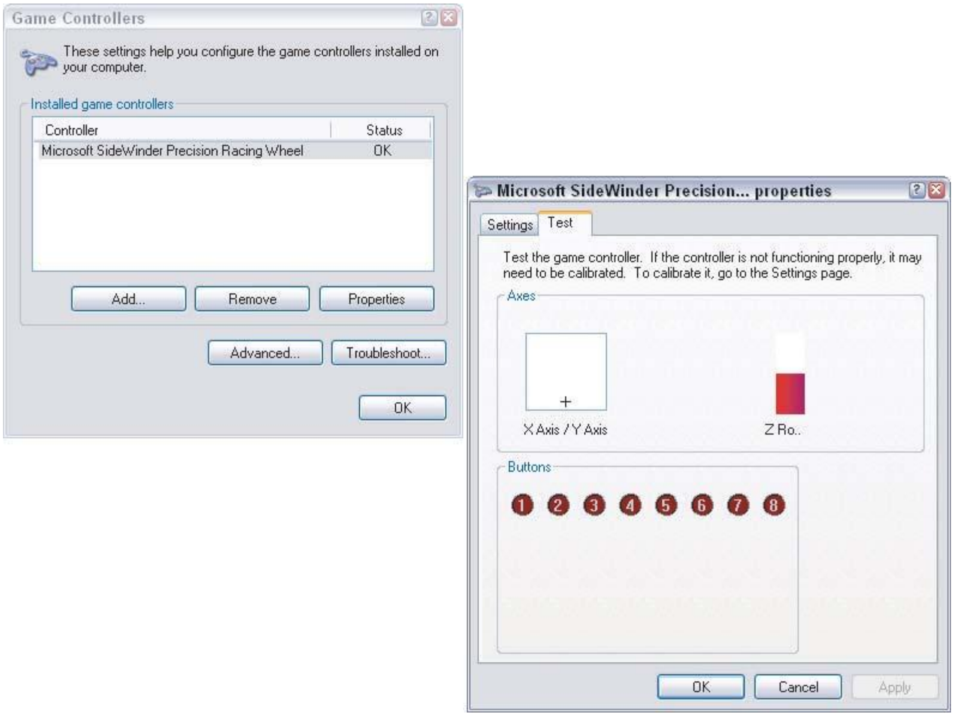
Sharing a single axis for the pedal and brake is referred to as a *single-axis setup.* Some steering wheels use a dual-axis mechanism for the gas and brake pedals. In this configuration, the steering wheel is on an axis, the gas pedal is on a second axis, and the brake pedal is on a third axis. In a single-axis pedal system, you can either brake or accelerate, but if you try to do both simultaneously, the commands cancel each other out, and the computer does not see either pedal as pressed. In a dual-axis configuration, you can press both the gas and brake pedals together, and the computer will see both inputs. This allows you to do things such as powering through a curve, which uses the gas to accelerate and the brakes to send the rear of the car into a controlled skid. Some games support a single-axis system; some support a dual-axis system. If you are building or hacking your own pedals to the game port, an easy modification can add a switch that will convert your pedals between single- and dual-axis mode. I'll cover this in Chapter 10. Using a switch in your pedals means you can have the best of both worlds.



Screen shot reprinted by permission of Microsoft Corporation.

Figure 5-1: Game Controllers Properties dialog box, which shows the steering wheel sitting idle.

Because form follows function, almost all steering wheels work under the same principle. Although the design may vary, the core mechanism is likely to be analog in nature, which means potentiometers. In Figure 5-3, you can see the inside of a typical set of pedals with the bottom removed (a lot of warranties were voided in the creation of this book). Two potentiometers sit in the middle back-to-back, turning when the pedals are pressed. In this case, the two potentiometers are electrically wired in series as one axis, which makes this a single-axis steering wheel. The steering wheel also has a potentiometer that is connected to the shaft of the wheel and turns as the wheel turns. Other wheels and pedals have similar mechanisms. This means whether you buy, build, or convert a steering wheel, you're likely to be able to get it to work with your arcade cabinet.



Screen shot reprinted by permission of Microsoft Corporation.

Figure 5-2: Game Controllers Properties dialog box, which shows the steering wheel idle while the brake pedal is pressed.

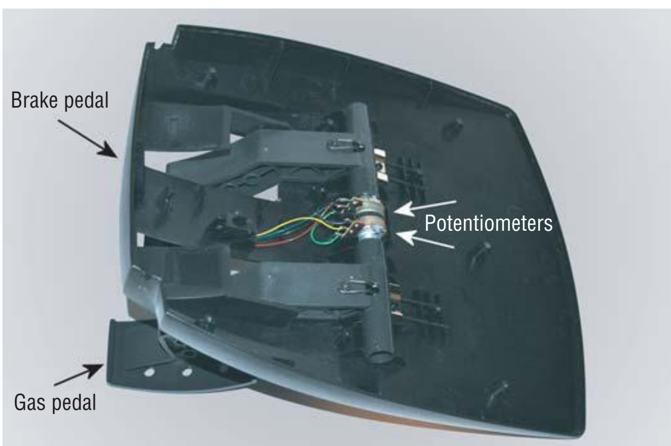


Figure 5-3: Inside view of a typical set of pedals.

Buying A Wheel

You will find many opinions on what types of steering wheels to purchase. Ultimately, they are just that — opinions. I cannot recommend one particular wheel — if for no other reason than that, by the time you read this, the available models are likely to have changed. Today's hot steering wheel choice may be unavailable or second fiddle to tomorrow's top contender. I *will* give you some guidelines to consider when making your choice.

Steering wheels by Logitech and Thrustmaster and discontinued products from Microsoft are among the popular choices though many others exist. When it comes to purchasing a steering wheel, you should spend some time researching your choices. The message forums at the Build Your Own Arcade Controls (BYOAC) Web site (`www.arcadecontrols.com`) and various news groups, such as rec.autos.simulators (`http://groups.google.com/group/rec.autos.simulators`), are excellent places to get opinions on available steering wheels. However, there is no substitute for heading down to your local computer store and trying the feel of the wheels for yourself. As you do, you should take into account the following concerns:

- How the steering wheel feels. There is nothing more important than how the steering wheel feels to you. Some things, such as reliability, are *as* important, but if you're planning to spend any amount of time using the wheel at all, it needs to be comfortable. For instance, a steering wheel that's too small for you will probably cause your arms to cramp with extended play, and a cheap plastic wheel won't feel as good as a deluxe model with a leather grip. Testing the feel may be difficult to do in the store because you're not likely to find steering wheels set up where you can sit and try them. Most displays are at eye level and can be tried only standing up. Give it a good "test drive" anyway. If someone looks at you funny, make a "beep-beep" sound, and wiggle your eyebrows. They'll go away quietly.
- Don't neglect the pedals. Pedals should provide some resistance so you don't end up instantly slamming them to the floor but not so much that you get fatigued. Also, the underside should have some mechanism to provide friction on the floor. Having your pedals slip away from you while you're powering through a U-turn at mach-5 is very annoying.
- The wheel's interface. Most will connect via the Universal Serial Bus (USB) port. Some older legacy wheels may connect using a game port. I'll cover these ports in Chapter 10, but newer computers usually don't have a game port so be sure you can use whatever wheel you're considering.
- Supported features. Some steering wheels, such as the Logitech MOMO series, have extra features supported in certain games. However, if you're not planning to play those games, the extra features do not help you

and may not be worth the extra cost. Also, make sure the steering wheel indicates it supports the operating system you're planning to use.

- Buyer beware. The rest of it is standard consumer shopping sense. Although PC steering wheels will sometimes go on sale, a good one will cost you between $50 and $150. You should probably steer clear of a wheel that sells for $25 or less. (Did I promise not to pun anymore?) Factors such as durability and warranty should obviously be considered as well.

Several years ago peripherals such as steering wheels were designed for only one particular system, such as the original Sony Playstation, and wouldn't work on others. A PC steering wheel wouldn't work on a Playstation, and a Playstation wheel wouldn't work on a PC without some trickery. With the popularity of USB as a standard interface, that is much less of an issue. You'll often find game controllers such as steering wheels that advertise compatibility with both modern game consoles and PCs.

You might have some luck finding an older steering wheel designed for an older model game console. You can take these wheels and connect them to a PC with a converter. Results will vary, but this can be an inexpensive way to add a steering wheel to a computer. Some extra effort will be involved in connecting the wheel and tweaking software settings to make everything work. Unless you have a compelling reason not to (such as cost), I would recommend purchasing a modern PC or multi-system steering wheel for your arcade cabinet instead of trying to convert an older wheel.

Building A Wheel

For the hard-core do-it-yourselfer, building is the only way to go, and some people like to build their own steering wheels from scratch. These wheels start life as a few pieces of wood and miscellaneous bits of hardware and end up as functional steering wheel masterpieces. There are as many steering wheel designs as there are arcade cabinet designs, but all build upon the common steering wheel principles introduced in the beginning of this section. Normally, a steering wheel includes these four parts:

- The wheel assembly
- The shaft, including a potentiometer
- The mounting platform
- Pedals

The steering wheel is assembled from a few layers of wood in a typical steering wheel shape. This assembly is attached to a shaft composed of various parts from a hardware store, which ends in a potentiometer. Next, this is attached to a platform of some kind, such as a mocked-up dashboard or, in our case, an arcade cabinet. Finally, pedals are made from wood and parts from hardware and automotive stores. The homemade wheels are attached via the game port (again, make sure you have one or can add one) to the computer and show up as generic driving controllers. Some of the results are very professional, with projects running the gamut from desktop steering wheels to fully enclosed racing cockpits.

Covering the details of building a steering wheel and cockpit would take far more than the allotted page limit of this book. However, I will point you in the right direction if you decide to go this route. Several excellent Web sites are available on the subject, which can be found by doing a Google search on "build racing cockpit." The following are a couple of the best:

- Lew's Wheels at `www.fortunecity.com/silverstone/thepits/195/lews` is one of the definitive Web sites on steering wheel construction. Lew will walk you through all the steps needed to build a steering wheel and pedals.
- SimRacingWorld has an eight-page article (`www.simracingworld.com content/36/`) detailing construction of a steering wheel setup.

You'll find other sites and steering wheel projects to look at that are linked from the preceding Web sites. Building steering wheels and cockpits is an entire hobby in itself, akin to building an arcade cabinet. Many fans of one hobby end up dabbling in the other as well.

Finally, Act-Labs (`www.act-labs.com`) sells a 3-in-1 USB adapter (see Figure 5-4) designed to let you connect a steering wheel, pedals, and shifter to the PC. You could buy their various products that fit those categories, but they also include information with the adapter to build your own instead.

Converting An Arcade Wheel

Somewhere between the simplicity (and expense) of buying a wheel and the complexity of building a wheel lies the relatively cheap and easy compromise of converting an arcade wheel. Arcade wheels are extremely sturdy and come in a variety of shapes and sizes. They can often be found for as little as $20 at auctions and online. Using an arcade steering wheel has one clear advantage: It's already designed to be installed in an arcade cabinet, so it should be easy to convert. Figure 5-5 shows an example of an upright racing cabinet.

Used by permission of Act Labs.

Figure 5-4: Act Labs 3-in-1 wheel/pedals/shifter USB adapter.

Figure 5-5: A three-player upright racing cabinet with wheels and pedals.

You'll run into one interesting issue with arcade steering wheels versus PC steering wheels. Many arcade games use a 360-degree steering wheel, which means it can be turned in a complete circle (for games that require it, such as a demolition derby). Most PC driving games use a 270-degree wheel, which means you can turn sharply left or sharply right but not completely around. A 360-degree wheel uses an optical encoder wheel and appears to the computer as a spinner or mouse control. A 270-degree wheel uses potentiometers and appears to the computer as an analog joystick, as discussed in the previous section on buying wheels. If you're planning to play only PC-based driving games, then a 270-degree steering wheel will work fine. If you're planning to play an arcade driving game, either through a PC-remake or emulation (see software choices in Chapter 14), then you might need to consider a 360-degree wheel.

Some classic arcade machine steering wheels have used 270-degree wheels. However, most of the older wheels that you're likely to find will be of the 360-degree variety. If you're thinking of choosing a 360-degree wheel, consider the following first: It is possible to play a 360-degree driving game with your spinner. In fact, certain models of the Groovy Game Gear spinners have optional steering wheels that can be attached.

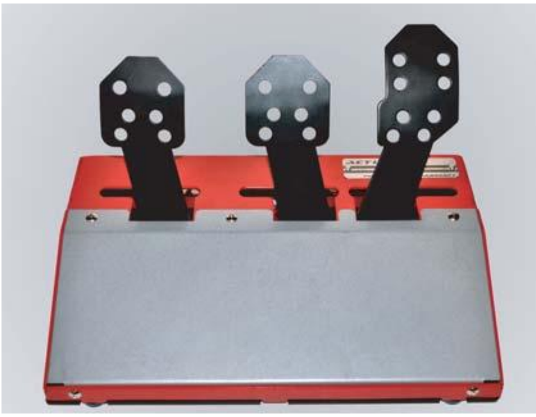
Add to that consideration the fact that there are a limited number of 360-degree driving games whereas the majority of PC driving games are geared toward 270-degree wheels. Driving a 360-degree game with a 270-degree wheel and vice versa are both fairly unsatisfactory. Ultimately, if you're planning only casual use of a steering wheel, you'll probably be happier buying a PC-based 270-degree wheel than using an arcade-based 360-degree wheel. Some driving enthusiasts have designed steering wheel panels with two wheels — one of each kind — to make sure they always have the right wheel for the game.

Converting an arcade steering wheel to a PC steering wheel is not very difficult. If it's a 360-degree wheel, you'll use a hack similar to that used for spinners and trackballs as covered in the previous chapter. If you'll be converting a 270-degree wheel, you'll need to take into account the potentiometers used. Arcade steering wheels typically use 5K potentiometers (also known as *pots*) whereas PCs typically use 100K pots. You have two options. You can swap the 5K pots with 100k pots and wire the wheel directly into the PC's game port if you have one available. Doing so is relatively easy. The only difficult part is finding a potentiometer that is physically the right size and mounting it. You can also use an analog-based game pad, such as the Microsoft Sidewinder Dual Strike, which essentially uses 5K pots and connects via the USB port. Because of the similar rating of the potentiometers in the Dual Strike, you can disconnect the Dual Strike's potentiometers from the PCB (Printed Circuit Board) and connect wires from the steering wheel's potentiometers to the PCB instead. This same technique can be used for a variety of analog/potentiometer-based arcade controls such as flight yokes and analog joysticks. I'll cover the details of this hack in Chapter 10. Beyond the interface hacking necessary to use an arcade steering wheel, the rest is just figuring out how to physically mount it, which will vary depending on which wheel you're using and where on your cabinet you wish to mount it.

Putting The Pedal Down

You probably can't find a commercial steering wheel without a matching set of pedals. Some of them leave a little to be desired though, and if you're converting an arcade wheel you might not have the pedals to go with it.

Aside from building your own pedals as referred to in the section on building your own wheel, you might also consider the RS Pedals made by Act Labs (`www.act-labs.com`) shown in Figure 5-6.



Used by permission of Act Labs.

Figure 5-6: Act Labs RS Pedals.

The RS pedals work with the 3-in-1 USB adapter and appear to the computer as X, Y, and Z axis devices. The pedal base is extremely heavy and won't easily shift around on you when played, something that can happen with some commercial wheel/pedal combinations. Mounting holes are built into the base to aid with permanent mounting into a racing cabinet. Out of all the various steering wheels I tested for this book, I found the Act Labs RS pedals were the most comfortable pedals to use.

Shifting Gears

You'll need to incorporate a way to shift gears in your steering wheel setup unless you plan to drive only automatic vehicles in games that support them. Most PC-based steering wheels come with a mechanism for shifting gears, either via onboard paddles or an attached gearstick. Standalone arcade shifters are also available in a variety of models. The immediate difficulty you'll run into is that different games incorporate shifters in different ways. There are three main styles:

- The first is a hi/lo shifter, wherein you're either going fast or slow. The hi/lo shifter usually has one microswitch, which is in low gear when the switch is not pressed, in high gear when it is, or vice versa. Occasionally, you will find a hi/lo arcade shifter that uses a potentiometer that varies from 0K at low to 5K at high. This is actually a throttle, not a shifter, and is not very useful for our purposes.

- The second is a shift-up/shift-down shifter. These are similar to hi/lo shifters in that they are two-positional. However, where a hi/lo shifter remains either in high or low gear, these shifters rest in neutral. Pushing into HI tells the computer to up-shift; pushing into LO tells the computer to down-shift. Once you shift up or down, the shifter returns to neutral. Most PC wheels include paddles with this functionality — one paddle for up-shifting and one for down-shifting.
- The third style of shifter you'll encounter is a more traditional multispeed shifter with first through fourth (or higher) gears and reverse. The multi-speed shifters typically have a series of switches — normally one switch for each gear — although other styles exist.

Which shifter suits your purposes depends on the types of games you wish to play. Most PC-based driving games will use the second style of shifter. Emulated arcade–style driving games might use any of the three styles listed. The draw-back to any of these is that, once you've chosen one of them, you have restricted the number of driving games you can play. The following paragraphs describe a few solutions to this dilemma.

Multiple Shifters

Declaring that "the right tool for the right job is not just a motto, they're words to live by!" some hard-core driving enthusiasts use multiple shifters on their cabinets. Usually, you'll only have room for these if you're making a dedicated driving cabinet that is free from non-driving controls or are using a swappable control panel scheme. One of the most creative projects I've seen is a sit-down racing cabinet made by Todd Rosen with horizontally rotating control panels (You'll get a look at this cabinet in Chapter 18). When you're ready to switch from one game to another, you simply rotate the control panel until the appropriate wheel and shifter combination are in place. This is quite a significant undertak-ing and is not for the casual driving enthusiast.

The Act-Labs RS Shifter

You'll appreciate the Act-Labs RS shifter the moment you lay eyes on it (see Figure 5-7). The sequel to their popular GPL model, the shifter is an excellent product — simple in design yet well thought out. It is a self-contained shifter apparatus with eight positions that connects to their 3-in-1 USB adapter and appears to the computer as an eight-button game controller with each gear cor-responding to a button. Overlay plates are available, which currently includes five-, six-, and seven-position models. These overlay plates limit how many of the eight positions of the gear stick can be reached, which determines the number of gears available in the game. In the multi-gear position settings, the shifter locks into each of the gears with a satisfyingly audible and tactile “snick-snick” and stays there until moved. When in gear, the button is pressed; when in neutral, no button is pressed.

The unit I received included extra overlay plates, allowing you to convert it from an eight-position shifter all the way down to a five-position model, or even to a simple hi/lo configuration. These plates are available separately and individually, or as a package in their ultimate bundle. Creating your own overlay plates out of sheet metal or wood using the original eight-position plate as a template would also be easy. With the hi/lo plate I have installed (see Figure 5-8), the shifter registers button 3 for high and button 4 for low. The shifter springs back to center instead of locking into place as the length of the cutouts in the overlay restricts travel, which prevents the gearstick from entering the locked position. You can control the locking versus return-to-neutral behavior in your own custom overlay plate by controlling the amount of travel the gearstick is allowed. With the use of custom overlay plates, you can emulate all three shifter styles listed at the beginning of this section, which provides an all-in-one solution!

Courtesy of Act-Labs Ltd.

Figure 5-7: The Act-Labs RS shifter in native eight-position mode.

Software support of the Act-Labs RS shifter is decent, with some 60-odd games supporting the shifter either directly, in “generic” mode, or with a custom game patch that you can download. Games that do not natively support the shifter generally support up-shifting and down-shifting. In these games, going from fifth gear to second gear requires cycling through fourth and third. Games that natively support the shifter allow you to drop from fifth to second gear without going through the intermediate gears, which allows the appropriate effect of a rapid downshift. The utility provided by Act-Labs mimics native mode support by rapidly cycling through the gears for you. When you physically drop the shifter from fifth to second gear, the utility cycles through fourth and third gears. Also, because the shifter appears to Windows as an eight-button game controller, any driving game that allows you to assign the controls should work. MAME falls into this category and works well with the Act-Labs RS shifter.

Figure 5-8: The same shifter with the hi/lo overlay plate installed.

Mounting the shifter is easy. It comes with dual mounting brackets built-in to the bottom of the shifter that can be used to mount or remove the shifter quickly. For permanent mounting, cutting a round hole that is just large enough for the shifter plate to be flush with the control panel and then attaching the mounting bracket to a supporting piece of wood works well. The bottom of the shifter is tucked away beneath the control panel, which leaves only the knob, shaft, and overlay plate extended above and provides a realistic look and feel.

Building A Shifter

Once more, the cry of "buying is the easy way out!" is heard. Like building a wheel, step-by-step details on building a shifter are beyond the scope of this book. However, also like building a wheel, resources are available online for building your own shifter. Homemade shifters tend to be built along the same lines as the Act-Labs RS shifter described in the previous section. In fact, many of them use the same utility software as the Act-Labs model to provide shifter functionality in racing programs. Building a shifter can be broken down into three parts: mechanical, electrical, and software. The mechanical portion deals with assembling a gearstick and knob, building the shifter housing, and physically assembling the parts. The electrical portion deals with connecting the switches and connecting the assembly to the computer. Finally, the software portion involves configuring the shifter for use on your PC and supporting the shifter in games, often using the Act Labs utility. Here are a few sites to visit for more details if you would like to build your own shifter:

- The Homemade Racing Controllers site at `www.massey.ac.nz/~jcmarsha/Wheel` has a very good write-up on building a shifter, including software drivers to get it to function in Windows.
- The Home Built USB H-Shifter site at `http://users.hfx.eastlink.ca/~mackaypenny/shifter.html` provides another look at building a shifter and includes several pictures.
- Zooomz Zu Zu Pedals at `http://users.eastlink.ca/~mikegiles/racin/home.html` provides pictures without accompanying text that are nonetheless worth viewing if you're going this route.
- Finally, you can find many individual writeups on building your own shifter by doing a Google search for "build your own H shifter."

Final Word About Steering Wheels

Steering wheels turn ordinary driving games from casual diversions to amazing simulations. Many a weekend has been spent at the St.Clair household playing head-to-head Need For Speed: Porsche Unleashed with our steering wheels. You'll need to consider the games you wish to play before you decide on a particular steering wheel configuration or let the steering wheel you've chosen dictate which games will work properly. If you're planning to stick to PC-based racing games, any PC steering wheel you purchase will essentially work although quality varies. If playing emulated arcade racing games is more your speed, you'll need to consider degrees of motion of the steering wheel and types of shifter. Choosing this route, you'll either need to come up with a compromise solution that handles most of the games you'd like to play or a multi-wheel configuration to try to support them all. A good force feedback PC steering wheel with the Act-Labs RS shifter and possibly the RS Pedals is probably the ideal setup for casual use.

Many classic arcade driving games were upright models. It may then surprise you to learn that I am not a fan of adding a steering wheel and pedals to an upright arcade cabinet. In my opinion, driving games are best played sitting down! You certainly can add a wheel and pedals to an upright arcade cabinet, but you may find it unsatisfying. Does this mean that you should abandon driving simulations altogether? Certainly not. For occasional driving, some people substitute a spinner for a steering wheel. However, you still need to drag out pedals for acceleration and braking or use buttons on the control panel. Either way, it's still not ideal. The best option is to start planning your second project, the sit-down driving cabinet! A driving cabinet with a real bucket seat, large screen, and surround sound speakers makes for one heck of an arcade experience!

NOTE **My recommendation to use steering wheels and pedals with sit-down driving cabinets only is obviously an opinion and not a matter of fact. There are people who use steering wheels quite happily on upright or even cocktail cabinets. If you'll pardon the pun, your mileage may vary.**

Flight Yokes

Flight yokes are similar to steering wheels in look and feel. There is usually a set of hand grips that turn like a wheel with optional accompanying pedals (see Figure 5-9). In fact, a good flight yoke can be substituted for a steering wheel for occasional play of driving games. The one significant difference is that steering wheels are designed to control vehicles that stay on a level surface and need to control movement only along the X (horizontal) and Y (forward/backward) axes. Flight adds another dimension of control required along the Z axis (up and down). This is accomplished by allowing the yoke to push in and out or sometimes tilt forward and back, as well as turning left and right. Normally, pushing forward will angle your vehicle down, and pulling backward will angle your vehicle up.

Photo courtesy of CH Products.

Figure 5-9: The CH Products LE Flight Yoke and optional pedals.

Buying A Flight Yoke

The commercial flight yoke field is dominated by the CH Products line of flight simulator controllers (`http://chproducts.com/retail/yokes.html`), which range in price from $130 to $175, and Saitek yokes for about $150. Yokes from other vendors continue to be in scarce supply with models coming and going quickly.

Only CH Products and Saitek seem to be actively developing, marketing, and supporting quality flight yokes. Reviews of the CH Products and Saitek flight yokes are overwhelmingly positive.

Building A Flight Yoke

As with racing enthusiasts, some serious flight simulator fans have built their own flight controls and cockpit simulators. This is another hobby that is akin to arcade cabinet building. Building a flight yoke follows a similar procedure as building a steering wheel. Projects range from something as simple as a desktop-mounted flight controller to fully enclosed flight cockpits complete with multiple displays and motion simulation. One of these undertakings is not for the casual fan! If you are interested in building your own flight controller or cockpit simulator, you will find many excellent online resources are available to guide you. I have gathered a set of resources to get you started.

- Your first stop should probably be the Cockpits Web ring at `www.webring.org/hub?ring=cockpits`. A Web ring is a collection of Web sites relating to the same topic. As of this writing, the Cockpits Web ring lists 24 sites.
- How to Build a Cockpit at `http://home.wanadoo.nl/norbert.bosch` includes details and pictures on yoke, throttle, and cockpit construction.
- SimPits International at `www.simpits.org` is a Web site community for flight simulator cockpit designers. It includes articles, links, and forums.
- Finally, Build Your Own Cockpit at `http://mypage.direct.ca/b/bsimpson/byoc~1a.html` includes many articles on flight controller construction.

The Star Wars Yoke

One flight yoke is the holy grail to arcade collectors and home arcade cabinet builders alike — the Star Wars flight yoke. Star Wars was a vector-based arcade game put out by Atari that put you at the controls of an X-Wing Fighter going up against the Death Star. The game was a runaway hit with both an upright cabinet and an absolutely stunning enclosed cockpit cabinet. The centerpiece of the system was the yoke controller, which is pictured in Figure 5-10. The yoke would turn left and right, and the handles would pivot forward and back. The yoke was analog-based, which means it had potentiometers for the X and Y axes. Firing buttons at the finger and thumb positions made rapid firing easy.

Like most classic arcade masterpieces, these controllers are no longer made by the original company. Collectors covet these yokes for Star Wars cabinet restorations while home arcade cabinet builders seek them for their projects. With a limited number of yokes available, this demand has often put collectors and home cabinet builders at odds. See Appendix B, "The Great Debate — Preserving vs. MAMEing the Past," for more on this topic. Fortunately, this is no longer an issue as commercial replicas of this yoke are available. Ram Controls (`www.ram-controls.com`), the same company that reproduced the coveted "volcano" style buttons covered in Chapter 3, has made a reproduction yoke that is for all intents and purposes identical to the original. The reproductions are hand-assembled, and availability tends to be scarce, so order early and be prepared to wait if you want one for your cabinet.

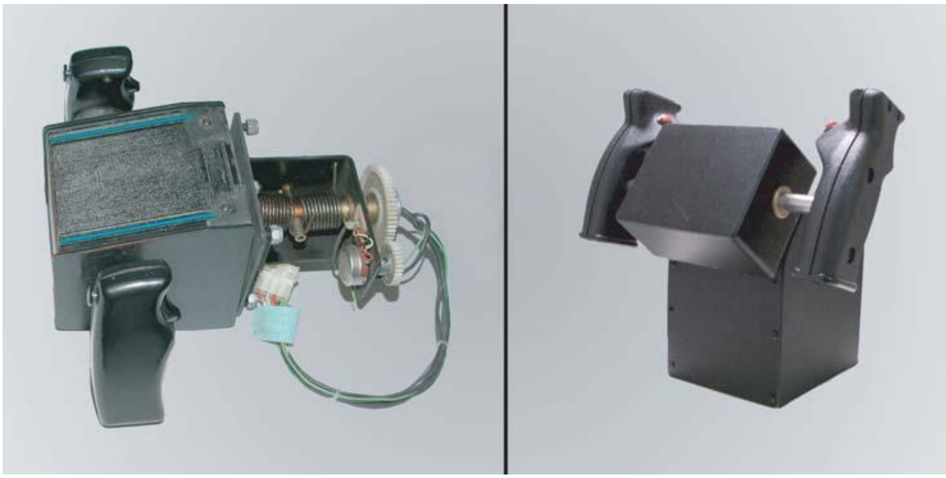


Photo courtesy of GameCab.com.

Figure 5-10: Left, original Star Wars yoke. Right, GameCab.com yoke.

Building A Star Wars Yoke

A number of stabs have been taken at building a Star Wars yoke controller. The examples listed here took different routes, and all came out looking great! Not only did they achieve the feel and functionality of the original Star Wars yoke, they also managed to re-create the look. Specific details of the construction of these projects are light, and they will probably prove difficult to re-create. However, if you have the skills and determination, these projects will prove inspirational.

- The first of the replica projects is Joey's Arcade Panel Project at `www.arcadecontrols.com/arcade_joey.htm`. Joey's project actually uses optical encoders, so is somewhat different from the original Star Wars yoke.

- The second replica belongs to Xiaou2's Matrix Arcade Controls at `xiaou2.arcadecontrols.com`. Xiaou2's yoke uses potentiometers and is designed to be connected to the gameport.
- The third replica was done by BYOAC forum member Menace, using children's toys among other parts! It can be found at `www.arcadecontrols.com/hosted/yoke`.

Another route to a Star Wars yoke was a design developed by the folks at Twisty-Grip. They created a plan to build a yoke with the feel and functionality of the original from cheaply available PVC parts. The Twisty-Grip group has shut down, but their yoke plans are available on the BYOAC website at `http://files.arcadecontrols.com/categories.php?cat_id=25`. The plans include a checklist of all parts needed, assembly instructions, and more than 120 detailed illustrations and photos. The yoke is made from PVC, which is available at any hardware store, and miscellaneous parts that should be available from local electronics stores or online. Building the yoke will require approximately four to six hours and will cost about $45. Reactions from people who have built a Twisty-Grip yoke have been very good, and they make an excellent addition to an arcade cabinet.

Converting A Star Wars Yoke

Most arcade cabinet builders who include a Star Wars yoke have opted to convert a real yoke for use with their project. Two pioneers paved the way in this type of conversion — Jude Kelly with his Star Wars Controller hack at `www.arcadecontrols.com/arcade_jude.shtml` and Rob Meyers (known as 1UP) with his PacMAMEa at `http://1uparcade.rmfx.com`. These hacks take advantage of the fact that the original Star Wars yoke used potentiometers. Jude's hack involves swapping the 5K arcade potentiometers with 100K PC gameport-compatible potentiometers whereas 1UP instead wires the existing potentiometers to a compatible USB game controller. Using either of these methods is very easy with the only remaining challenge being physically mounting the yoke to your cabinet. The mounting process will vary depending on the specifics of your cabinet, but the yoke comes with an easy-to-use mounting plate. This makes mounting mostly a matter of finding a good spot and making sure the weight is supported. See Figure 5-11 for a look at a Star Wars yoke hack.

CROSS-REFERENCE **Both Jude Kelly's Star Wars Controller hack and the PacMAMEa are included on the companion CD.**

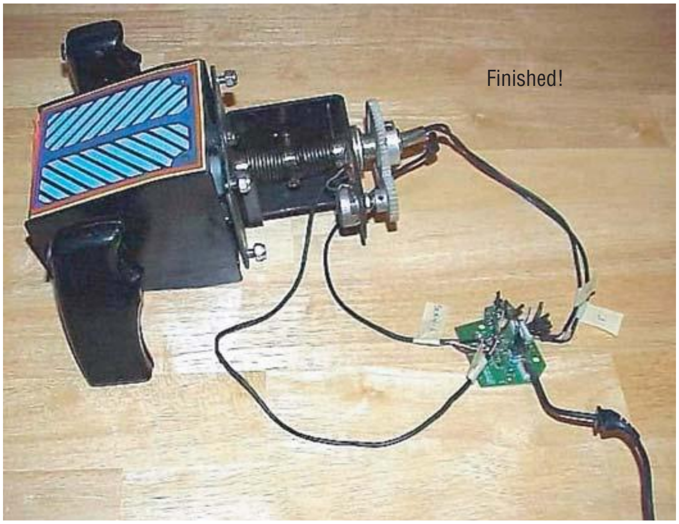


Photo courtesy of Oscar Controls.

Figure 5-11: Star Wars yoke hack.

Arcade Guns

Since the dawn of time, humankind has had the urge to go out and hunt dinosaurs, aliens, and undead zombies. Of course, you can't really do that without a good gun. When the first edition of this book came out, there were few choices for guns for your arcade cabinet project. Things have changed for the better since then, but this is one area that isn't quite "plug and play" yet. You'll need to do some work if gun games are on your wish list. Still, there are zombies out there that need blasting, so let's get to work!

Earlier arcade gun technologies included light guns and positional guns. Light guns work optically with your screen. They do not keep track of location on the screen until the gun is fired. When the gun is fired, the screen blanks for a moment, and the optics in the gun register where on the screen the gun is aimed. That information is sent to the computer, which registers the shot. Positional guns function much like joysticks, which maintain a known location on screen at all times as the gun moves and register the current location when fired. Figure 5-12 shows examples of both types of guns.

Newer technologies have introduced guns that are somewhat of a hybrid of the earlier technologies. Optics are used in the guns to determine where they are pointing, but positional information is kept at all times.

Figure 5-12: Fixed positional guns (left); light guns (right).

Positional Guns

A positional gun is mounted stationary on the arcade cabinet with the ability to aim left/right and up/down. There are no PC-based positional guns on the market. The only way to go this route is to convert an arcade positional gun for use with your cabinet. Fortunately, if you've read the steering wheel and Star Wars yoke conversion sections in this chapter, this is already well-traveled ground. Most positional arcade guns are analog-based (using potentiometers) and function as joysticks. Swiveling the gun left or right is equivalent to moving your joystick left or right, and aiming the gun up or down is the same as pushing the joystick up or down. Taking advantage of this design, these guns can be converted for PC use via either of the analog potentiometer hacks discussed earlier in this chapter. You can replace the gun's potentiometers with PC-compatible 100K potentiometers or connect the existing potentiometers to a suitable PC gamepad. Once again, the details on this type of hack will be covered in Chapter 10. The individual who performed the Star Wars yoke conversion discussed in the previous section, 1UP, also has done a positional gun conversion that is documented at `http://1uparcade.rmfx.com/projects-t2guns.html`.

CROSS-REFERENCE **Information on the positional gun conversion performed by 1UP (Rob Meyers) is included on the companion CD.**

Light Guns

Light guns are the most common for video game systems of any type. When purchasing a light gun for an arcade cabinet, you must first consider the type of monitor that will be used. A gun designed for a VGA CRT monitor cannot be used with an LCD monitor or TV, a TV-based light gun cannot be used with a non-TV monitor, and so on. People have had *some* success using a VGA light gun with an arcade monitor, which makes sense as both VGA and arcade monitors are CRT-based, but even then the success is hit or miss. In general, light guns are a headache for us and vendors alike. With people using CRT, LCD, projector, and other display devices, it is essentially impossible to come up with a one-size-fits-all light gun model.

NOTE **When discussing arcade monitors here and elsewhere, assume a raster type of monitor is meant unless specifically stated otherwise. Some arcade monitors are vector-based; most are raster-based. See Chapter 12 for definitions of raster and vector monitors.**

Configuration And Support

A light gun that supports multiple monitor resolutions will need to be calibrated for use. Calibration is the process in which the light gun and monitor are synchronized so the gun accurately follows your aim. Whenever you change resolution on your monitor, you will need to recalibrate your light gun. Bear in mind that starting a game will often automatically change the screen resolution. If you normally run in 800 × 600 mode (screen resolution), have the gun calibrated accordingly, and then start a game that runs in 640 × 480 mode, you'll need to calibrate again, or your shots will be off.

If shooting is your thing, there are numerous gun games available to you. Several are games that run natively on personal computers, a group of them run via a web browser, and finally there are many available in various emulators. The GunCon2PC driver page at `http://xoomer.virgilio.it/guncon2` maintains a list you can use as a starting point.

Act-Labs

Act-Labs (`www.act-labs.com`) makes the only light gun available for the PC at the time this book is being written (see Figure 5-13). Their light guns are such an established standard in the industry that they are specifically listed as compatible peripherals on some shooting games, such as House of the Dead 3. They have two models available, a PC USB model and a TV USB model. Both gun models work essentially the same, with the difference in the control box used to connect to the computer. The PC USB model should really be named VGA USB as it refers to using the gun with a standard CRT computer monitor and a VGA connection. The TV USB model is used to connect the gun to a PC when using a CRT television with an s-video or composite connection. These guns will only work with their intended, horizontally oriented, CRT monitor or TV. They will not work with any other orientation or display technology. This is a problem, because though the guns have been well regarded in the industry, CRT monitors are a dying breed (see the discussion on this in Chapter 12). If you have a CRT monitor however, these guns are an excellent choice.

Photo courtesy of Act-Labs.

Figure 5-13: A couple of Act-Labs light guns with a control box.

The guns are fairly simple devices — a trigger, a reload button, and a mode switch. The guns act as a mouse device, with the trigger generating a left-mouse-click. The reload button generates a right-mouse-click. You can also reload by shooting off-screen (a common reload method on various arcade games) which will also generate a right-mouse-click. You use the mode switch to set the gun to first player, second player, or calibrate mode. The light guns will work much better if you calibrate them once before using them. Two-player support was problematic when the first edition of this book was written, but now many gun games and emulators will support two gun controls. You will need to check the game you want to use specifically to verify if it has two-player support. Some games can be made to be two-player compatible with the addition of a patch found at `http://thetroubleshooter.home.mindspring.com`.

LED Sensor Guns

LED sensor guns are the most recent technology used for arcade guns on a computer or console. They are essentially a hybrid between a light gun and a positional gun. One or more LED sensor bars are mounted to the display, and an IR camera is mounted inside the gun housing. The sensor bar(s) and IR camera work in tandem to tell the computer where the gun is pointing.

The biggest advantage of using one of these guns is that they are agnostic of the monitor technology used. Because the positioning is based off of the sensor bars and not the actual screen, *any* display will work. The biggest drawback of using one of these guns is the visibility of the sensor bar. They do not function well, if at all, behind tinted glass. This means you cannot place the sensor bar behind a tinted glass bezel (see Chapter 15) or otherwise hide them from view. This is not a serious concern when playing on a TV or projector screen — there's no effort being made there to mimic an arcade cabinet. However, if you're trying to design a perfect arcade cabinet like those you used to play, a sensor bar sticking out makes it harder to suspend disbelief. They're not terribly big though, and the tradeoff of being able to work with any display makes these a good choice. As of this writing, three companies have LED sensor guns on the market.

EMS TopGun 2

EMS (`www.hkems.com`) makes a model called the TopGun 2 that works with the PC and several game consoles. These guns use two sensor bars instead of one, and have recoil capability. Getting these guns to work well involves tweaking your operating system, driver settings, and the game software as well. In fact there are two different driver sets out there — the manufacturer drivers, and third party drivers made by someone known as SMOG (`http://xoomer.virgilio.it/guncon2`). Many arcade cabinet builders have used TopGun 2 guns on their cabinet, with varying results. You should search the BYOAC message forums for any updates concerning using these guns if you are considering them, as they are not "plug and play" experiences.

XFPS Storm

You may be able to find another LED sensor–based gun called the XFPS Storm by a company called XCM (`www.xcm.cc`). At this time there is no real information available beyond a brief description on the XCM web site, and I know of no cabinet builders who have used these guns. However, by the time you read this that may have changed and it is probably worth a cursory look at these guns before making your final purchasing decision.

Ultimarc's AimTrak kit

You'll find the biggest buzz in the community surrounds the Ultimarc AimTrak gun kit. You should recognize the Ultimarc name from the previous few chapters as one of the vendors essentially dedicated to this hobby. The owner of Ultimarc first polled the build-your-own community as to what would make the ideal gun for an arcade cabinet, then set out to build exactly that. They have been out in the market for about a year as of the time this is written, but already many cabinet builders have purchased and are using these with a high degree of success, albeit with some initial setup effort required.

The AimTrak is not a ready-to-use gun, but is rather a kit that you can assemble into any gun shell that you may have or buy. The kit consists of a single small LED sensor bar that goes atop your display, and a small circuit board containing an IR camera that you install into the barrel of the gun (see Figure 5-14).

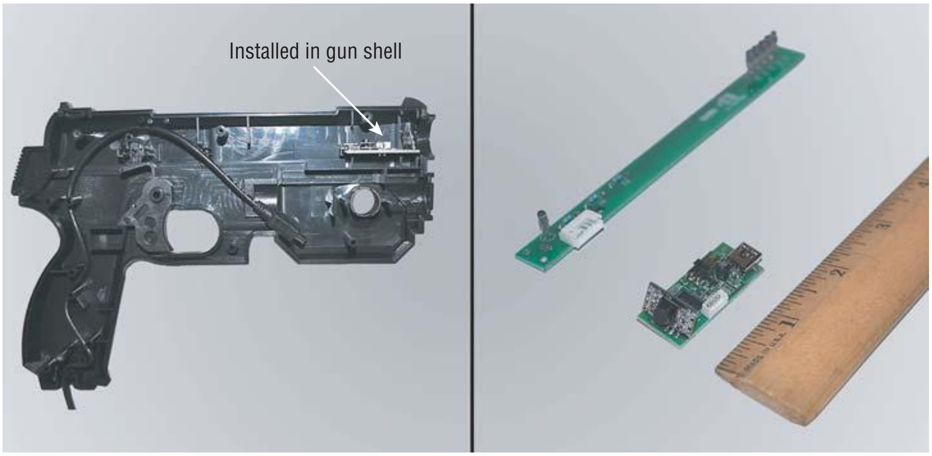


Photo courtesy of Ultimarc.

Figure 5-14: The Ultimarc AimTrak.

The gun kit emulates a mouse and does not require a special driver. Up to seven buttons can be attached to the kit and assigned to either gamepad or mouse button inputs. User response to the AimTrak has been generally very positive and vocal on the message forums. At least one firmware upgrade has been released for the gun kits based on feedback from the community, demonstrating the vendor's high level of support for their products. You will have to invest some effort into properly calibrating the gun for your setup, but this is common to all the guns presented in this section.

With the level of support and ongoing improvements, and with the AimTrak being a kit rather than a complete gun, whether you want an Army of Darkness shotgun, a futuristic ray gun, or an old fashioned pistol, the AimTrak will fit the bill.

Dance Pads

If you've stepped into an arcade recently, you've seen them. People of all ages and builds are in front of an arcade cabinet dancing away with a crowd of people behind them cheering or jeering. Welcome to one of the oddest crazes to hit the arcade — arcade dancing!

The premise of dance games is simple. While music plays on the arcade cabinet, instructions on the screen tell you which way to move your feet. Players stand on a dance pad that is divided into squares, which typically are marked by directional arrows. If the machine tells you to move left, you put your foot on the left arrow. If you can do it with some style, so much the better. Think of it as playing Twister to music without the usual contortions and spinal problems, with a bit of whack-a-mole thrown in for good measure. For such a simple concept, the game is strangely addictive and has acquired quite a following.

Buying A Dance Pad

The popularity of dancing games in the arcades soon led to the inevitable home versions. The company that arguably started the dancing simulation craze was Konami with its Dance Dance Revolution. Konami initially concentrated its efforts on the PlayStation console by selling both games and dance pads. Soon after a version of DDR was released for the PC, but, unfortunately, no dance pads for the PC were available.

Ah, but that's not a problem for the do-it-yourself crowd, right? Sure enough, a couple of solutions arose. The first took advantage of another trend in the home gaming arena — adapters that convert game controllers from one system to another. PlayStation to PC-USB (PSX-USB) converters are inexpensive, and DDR for the PC can be played with a commercially purchased PlayStation dance pad and a PSX-USB adapter. I was able to purchase the game, an adapter, and a dance pad for under $100. Unfortunately, not all PSX-USB adapters will work properly with dance pads. The adapters have to present the PlayStation controller as buttons and not axes. Certain moves in the game require hitting LEFT/RIGHT and UP/DOWN at the same time. You can't do that if the computer thinks you're using a joystick with axes (try hitting left and right with a joystick at the same time). The EMS USB2 adapter (`www.hkems.com`) is one that's known to work and recommended.

Since the first edition of this book was written, the dance game scene has exploded. Many dance pads are available for the PC now, and you can find a good breakdown of what's available at the Stepmania (another dancing game) Web site at `www.stepmania.com/wiki/Dance_Pads`.

Building A Dance Pad

You've probably realized by now that, when I use the phrase "commercially purchased" as I did in the previous paragraph, there is also a home-built solution. Most commercially available dance pads are plastic and hold up reasonably well under casual use. However, for the hard-core dance gamer, nothing short of an arcade-quality dance pad will do. With heavy use, the plastic dance pads have been known to deteriorate and begin to ignore or double-register your steps. Home-built dance pads use wooden frames and metal pads for improved durability and appearance. A growing number of dance game fans are building high-quality dance pads.

The basic concept behind a homemade dance pad is simple. As with most arcade controls, a signal is sent to the computer when two contacts touch. In this case, when you step on one of the squares on the dance pad, the square on top makes contact with a matching square underneath it, which activates the square. To connect it, you disassemble a PlayStation controller and divert the wires that originally went to the controller's buttons to the two parts of each dance-square instead. Building the dance pad is a matter of assembling the base and step spaces from wood (which makes the step squares), covering them in Lucite, and connecting a PlayStation controller. Simple, no? OK, a bit more detail is perhaps called for. Fortunately, several good step-by-step guides are available online (Google search: "build ddr pad").

CROSS-REFERENCE **One of the best step-by-step guides to building your own dance pad is included on the companion CD, courtesy of the author, ddrhomepad. The Arcade Style Dance Dance Revolution Metal Pad is very detailed and includes links to several other sites that focus on dance pad building.**

Dance pads are a great addition to an arcade cabinet. Two other dance programs are available in addition to Dance Dance Revolution. Stepmania as mentioned previously at `www.stepmania.com`, and Dance With Intensity (DWI) at `http://dwi.ddruk.com` are both popular dance programs available for download at no charge. If you're a member of the younger crowd, I'm sure you're already sold on the idea. If you're a member of the classic arcade generation but have kids who'll be playing your cabinet as well, consider adding one of these setups. Not only is it good fun, it's great exercise, too. Trust me, your kids will love it. In Figure 5-15, my daughter tests one of the several PlayStation dance pads playable on a PC-based arcade cabinet.

Figure 5-15: A PlayStation dance pad being played on a PC.

Summary

Steering wheels, flight yokes, guns, and dance pads are all special-purpose controls you might want to consider for your cabinet. The majority of games playable on your arcade cabinet will work fine with joysticks, buttons, spinners, and trackballs. However, for games that require one of the specialized controls covered in this chapter, playing without them will offer either a poor experience or will not be possible. The standard set of controls covered in the preceding two chapters will fit nicely on one standard control panel. Adding any of the controls from this chapter will involve an additional degree of complexity — both in physically finding space for them and in connecting them to your computer. You should consider which of these specialized controls you're likely to play enough to justify the effort and then decide if you're going to incorporate them into your original control panel or come up with an alternative plan, such as a second cabinet.

That's it for looking at the various controls that are available for your arcade cabinet project. Next, I'll begin to address some of the other issues involved in cabinet building, such as building the control panel, in Chapter 6!

CHAPTER

6

Building the Control Panel

IN THIS CHAPTER

- Laying Out Your Design
- Installing the Controls
- Mounting the Control Panel
- Standalone Control Panels
- Project Arcade Control Panel Design

Are you ready to dive into the really fun stuff? I hope you've found the book up to this point to be informative and the construction fun! So far, you've learned about the various things you can include in your dream machine, and you've built and painted your cabinet. That's all an excellent start, but now it's time to get your hands on some genuine arcade controls! As you continue to follow along, by the end of this chapter, you'll have picked exactly the controls you want for your arcade control panel, designed and tested your custom layout, purchased your controls, and installed them into the control panel. I recommend you read this chapter the entire way through once so you can decide on the parts you'll need to order, and then reread the pertinent parts once your supplies are on hand. This is where it starts to get really interesting! What are you waiting for? Jump in!

Laying Out Your Design

Before you pick up a drill or router, you should plan what you want to create. If you put some time and thought into what your ideal control panel should look like first, you'll be amply rewarded by the appearance and playability when you're finished. There's a world of difference between a well-crafted, multiplayer-friendly arcade control layout and a slab of wood with a bunch of controls strewn about. A well-crafted layout will let you enjoy the game play (which is, after all, the point of all this) instead of fighting with the controls, the same way a well-designed car lets you enjoy the drive instead of focusing on where the windshield wipers are. There are several elements to a good design, and I'll cover them in the next few sections.

TIP **A lot of cabinet builders end up designing a second control panel after a few months or more of actually playing with their first design. I'll discuss good design elements in the sections in this chapter, but sometimes there's just no substitute for time spent playing your first panel to decide what you really want in your final(?) product. Don't be afraid to experiment with this panel — a second panel is just some wood, paint, and time away!**

Choosing Your Controls

You should first decide on the controls you want to include in your control panel. The rest of the construction and design process will be affected by these choices. Things to consider include the types of games you want to play, availability of the controls, available space, and your budget. I'll take a look at space requirements in the next section. For the rest, I'll start by giving you a quick recap of the controls that have been covered in the preceding chapters (see Table 6-1).

Table 6-1: Control Choices

CONTROLS	AVAILABILITY	GAME TYPES
Pushbuttons — microswitch	High — multiple sources	All
Pushbuttons — leaf	Low — limited sources	All
Joysticks — microswitch	High — multiple sources	Most general game types
Joysticks — leaf	Low — limited sources	Most general game types
Joysticks — optical	High — limited sources	Most general game types
Spinners	High — multiple sources	Specific spinner games such as Breakout, Pong, Warlords

CONTROLS	AVAILABILITY	GAME TYPES
Trackballs	High — multiple sources	Specific trackball games such as Centipede, Golden Tee Golf, and a mouse substitute for OS control
Steering wheels	High — multiple sources	Driving games, boat games
Flight yokes	Limited — limited sources	Flying games, driving and boat games
Star Wars yoke	Rare — used market and one reproduction source	Star Wars, flying games, driving and boat games
Guns	High — limited sources	Shooting games
Dance pads	High — multiple sources	Dancing games

You'll almost certainly want to include pushbuttons and joysticks in your design. It would be virtually impossible to have a functional control panel without pushbuttons, and it's *usually* pointless without joysticks. Most games you'll play will use joysticks. However, you might build a panel without joysticks if you're working on a specific genre of games, such as a cabinet for playing driving games only. I'll assume for this discussion that you're building a multipurpose arcade cabinet. Whether to go with microswitch or leaf, and what types of joysticks to choose, should depend on the factors discussed in Chapter 3, "Pushing Your Buttons and the Joy of Joysticks." Functionally, all will work with your cabinet, so it is the considerations of appearance, feel, and game play that will help you decide what to buy.

Aside from pushbuttons and joysticks, I *highly* recommend including a spinner and trackball in your panel. Spinners take up relatively little room and can be tucked away almost anywhere on the panel without impacting the other controls. Trackballs do take up quite a bit of room, but because they perform dual duty as a mouse for desktop control as well as a game controller, I would not build a panel without one. Also, because of their low profile, trackballs will not interfere with other controls.

The rest of the controls are not as common on arcade cabinet projects as buttons, joysticks, spinners, and trackballs. Because they all serve specific genres of games, the first question to ask yourself is whether you want to be able to play those games on your cabinet. A steering wheel may get used for only one game out of several hundred on your cabinet, but if that game is the one you like to play every day, then by all means plan to include the steering wheel. Also consider your game-playing audience — you may not like dance games, but your kids might be nuts for them. For this second set of controls — namely steering wheels, flight yokes, guns, and dance pads — you might want to give them a pass unless you have a specific desire for them. If you *do* have a favorite game type that needs these controls, I would not hesitate to include them!

TIP **Take a moment now to jot down the controls you want to include in your arcade cabinet. Don't forget that you can always add or remodel later.**

Designing A Template

Now that you've decided which controls you are going to include, it's time to start sketching out a design. Visualizing what you're trying to create is invaluable, and few designs survive unaltered after this step. You may find, when putting a concept down on paper, that you do not have enough room for all your controls, or, conversely, that you do in fact have enough space to include that one extra item you originally left out. In the following sections I provide some tools and tips for laying out a design. There's a bit of material and things to consider, but I'll give you a sneak preview of the conclusion: After reading all about it, if you're not sure what you'd like to do, I've included a recommended layout for you at the end of this chapter!

Control Templates

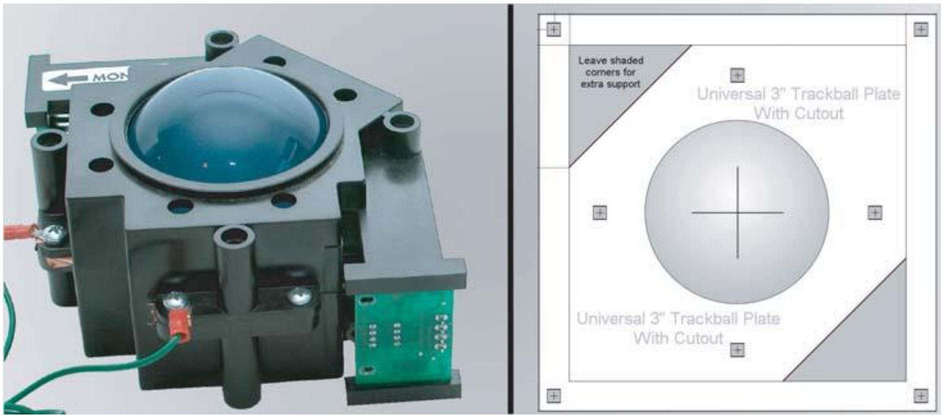
A control template is simply a layout of your control panel with the controls placed on it. You can create one digitally on a computer, moving parts around in a paint program and experimenting with design. You can also print out to-scale images of individual arcade controls and then test their placement on a mockup full-sized template.

CROSS-REFERENCE **On the companion CD, I have included JPEG (a picture format your computer likely understands) templates of many common arcade controls. When printed at 100 percent scaling, these templates are the exact size necessary for mounting the control in your control panel.**

You'll need to make sure that whatever program you're using to print them isn't altering the size when printing. Most of the templates have a sizing ruler. You can use the ruled template to verify proper size by comparing with a real ruler. If you don't have a graphics program on your computer, take a look at the "Design Tools" section in this chapter to read about the one I recommend. If nothing else, most operating systems come with a basic paint program that will work with JPEG images.

WARNING **These templates are meant for planning layouts and drilling holes. Although they are exactly sized, they are not exact replicas. Most controls use rounded corners on their mounting plates, although some templates have squared corners. This makes no difference for planning and drilling. However, do not use these templates to plan flush mounting of the mounting plates, as your corners will be different.**

If there's a control that you're planning to use for which I have not provided a specific template, then you can easily create your own. Almost every control you might add can be planned for with a circular, square, or rectangular template. Even the oddly shaped trackball housing (see Figure 6-1) can be planned for with a square template. Creating your own in a good paint program is not terribly difficult.



Used by permission of Happ Controls.

Figure 6-1: The Happ Controls 3-inch trackball on the left, and the mounting template on the right.

Control Spacing and Placement

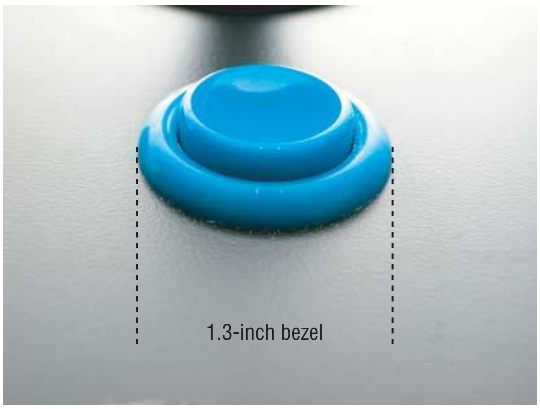
Proper spacing and placement of your control layout is extremely important. Good design with this aspect can make or break the enjoyment you'll get out of your arcade cabinet. The two concerns here are spacing between controls, and placement of controls in relationship to each other and the cabinet.

NOTE **The information in this chapter applies to 3/4-inch wooden control panels. Some control panels in original arcade machines were metal, and a few folks have followed suit in their own cabinets. Metal control panels are about 1/4-inch thick, while wooden panels are usually between 5/8-inch and 3/4-inch thick. Bear this in mind when you read about spacing.**

Spacing

Spacing is primarily a consideration of the physical size of the controls you're going to use, and the size of the hands that are going to be playing them. Take pushbuttons as an example. Physically, the largest part of the pushbutton is the bezel that rests on top of the control panel. In the case of the Happ Controls Pushbutton with Horizontal Microswitch, that bezel is 1.3 inches in diameter (see Figure 6-2).

With this diameter, you could install your pushbuttons to be placed every 1.3 inches as measured from center point to center point. When it came time to play, however, most people would find that too cramped for comfort. Control panels are usually designed with buttons 1 1⁄2-inch to 1 3⁄4-inch apart for buttons that are placed in a group, which is a comfortable distance for game play. Comfort is, of course, a subjective opinion. Someone with smaller hands might want tighter spacing on the buttons, while someone with larger hands might want extra space. Because of this variation, you need to go through the design process before you start installation, to make sure that what looks good as a concept actually feels right in practice.



Used by permission of Happ Controls.

Figure 6-2: A Happ Controls pushbutton installed in a panel.

You should also think about the spacing between different groups of controls, such as between player 1's buttons and joysticks. As you play, the part of your hand that's not using the control has to go somewhere. If there are buttons directly next to a joystick, then you'll end up resting your hand on the buttons. Doing so is uncomfortable and will cause button presses you don't want. As another example, be careful of the amount of space between two joysticks. If they are too close together, you'll bump one as you use the other. Don't forget to consider right-handed versus left-handed play also. The spacing may work for your particular style of play, but what about someone else who uses the other hand for the same control?

Even when you've provided for adequate spacing for your controls, an otherwise good attempt can be marred by poor control placement. For instance, you may be able to place a spinner in an empty space behind a joystick. However, using the spinner will mean having to angle your arm uncomfortably to get around the joystick. How much game play will spinner games get in this scenario? While it may be physically possible to cram many controls into a limited amount of space, it is not a good idea to do so. All the controls in the world will do you little good if you can't use them because of poor design. Take a look at Figure 6-3 for an example of poor control placement.

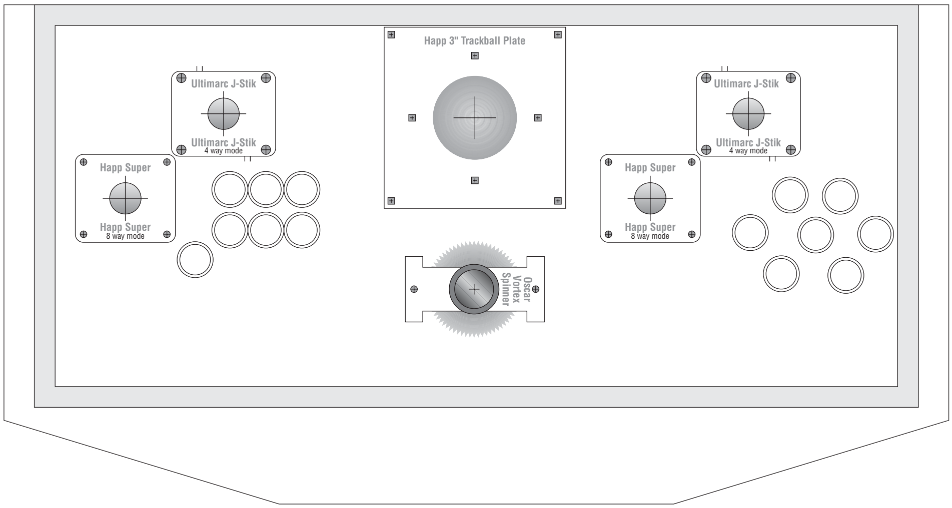


Figure 6-3: What's wrong with this control panel design?

Can you spot the several issues with the control panel in Figure 6-3? While the only control panel design that is "right" is the one you're happy with, there are several things in this control panel that are not conducive to game play. I hesitate to label them "wrong" because you may have a deliberate reason to place them in this fashion. However, the following are things in this design that I would not want on my personal panel:

- The trackball is at the back of the control panel. There's enough room for fine control, but some trackball games (like Golden Tee Golf) encourage you to slam your hand across the ball, rolling it madly. Try that with this setup and you'll smack your hand into the screen every time.
- The seven buttons grouped on the left are extremely close together. While this technically works, it isn't comfortable and is not necessary because there's plenty of room to space them out.
- The spinner is in front of the trackball. There's plenty of room to play spinner games, but you have to reach across or around the spinner to get to the trackball. Swapping the spinner and trackball and making sure there's a good 6 to 9 inches between them would be a good idea.

- The 4-way joysticks on both sides are very close to the 8-way joysticks. You're likely to bump into one joystick when you use the other.
- The buttons on the right are organized in a confusing fashion. It looks interesting, but probably isn't as useful as the button grouping on the left.

Using all the same controls except for one joystick, a better example of control panel design is shown in Figure 6-4. The issues with the previous design have all been addressed, and the panel is aesthetically pleasing. The trade-off of losing one joystick is well worth the enhanced playability of this new design.

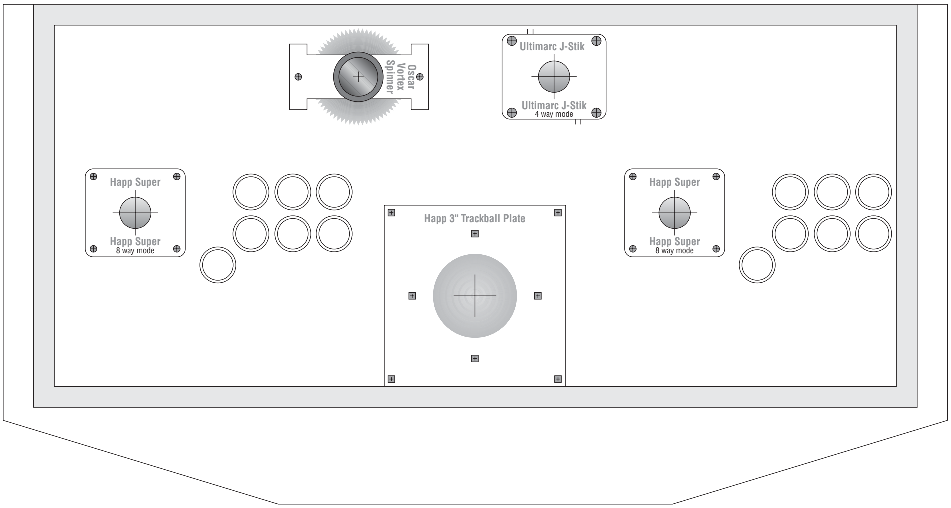


Figure 6-4: Redesigned control panel.

One last word on spacing out your controls: Bear in mind the space required below the control panel as well as above. Some controls require much more space below the surface than they do above, such as spinners and trackballs.

Design Tools

You can use a variety of tools to help you lay out your control panel. From expensive CAD (computer-aided design) programs to simple paper cutouts, any method can be used with good odds of success. I've included a few suggestions for you to consider in the following sections.

CAD and Paint Programs

Many people with access to them have used CAD programs to design their cabinets and control panels. CAD programs are designed for precisely this kind of work and allow precise design and control. The two drawbacks of these programs are the price and learning curve. CAD software tends to be very expensive, and because of the incredible range of functions, it's often difficult to learn. Mitigating these factors, however, are the resources available online. There are many trial, shareware, and free versions of CAD programs available on the Internet. You can also find excellent tutorials for using CAD software, and you should be able to use the templates included on the CD to give you a head start in the process. Visiting the Internet search engine Google (`www.google.com`) and searching for "free cad software" is the place to start if you're interested in this route.

Google itself has a free program called Google Sketchup (`sketchup.google.com`). Sketchup is a 3d modeling program that several cabinet builders have begun to use for their designs. You can get a head start with various arcade models already drawn out and uploaded to the Google Sketchup repository by searching for "arcade controls" on the Sketchup page (Figure 6-5).

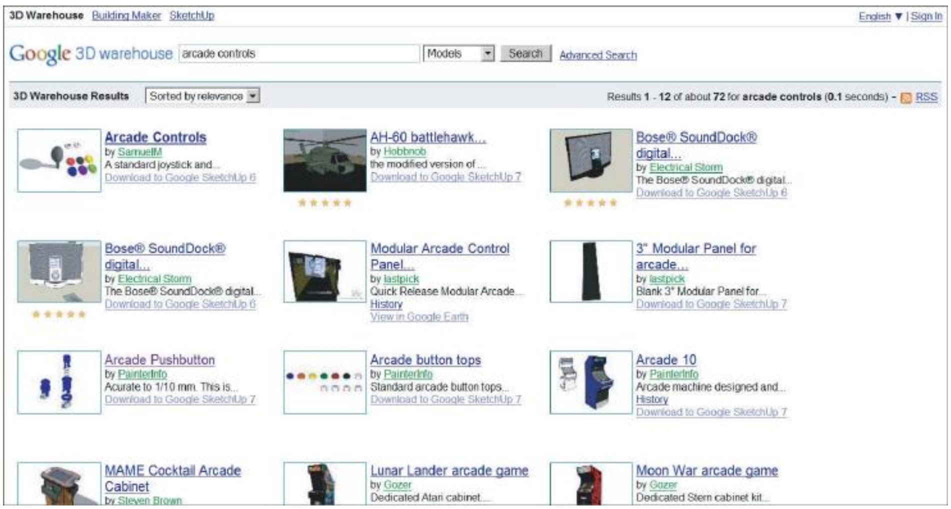
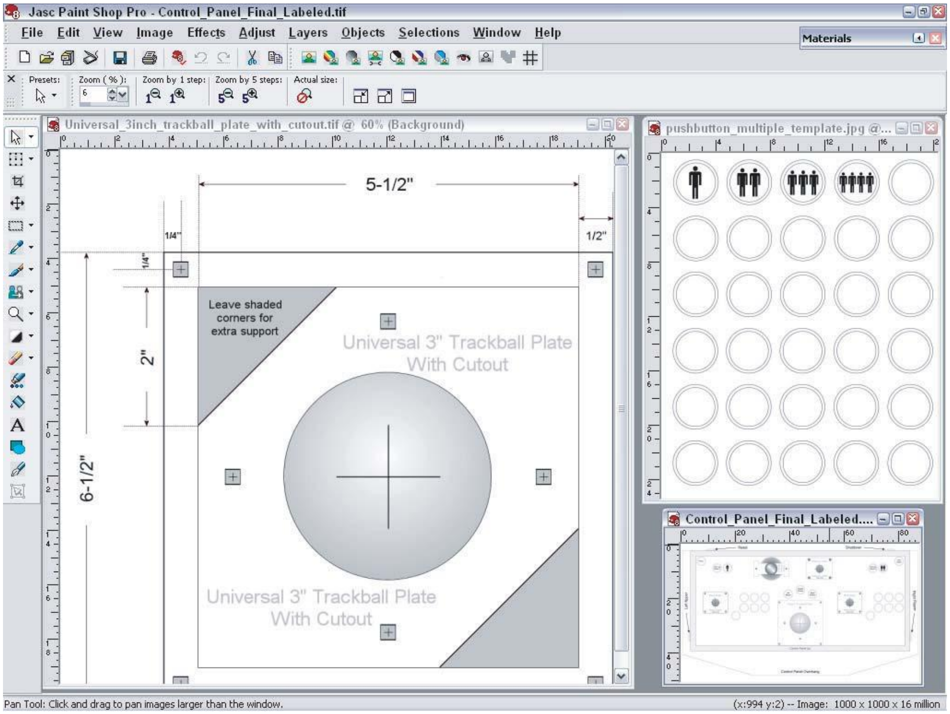


Figure 6-5: Google Sketchup "arcade controls" results.

Another tool used in control panel design is a good paint package. Adobe Photoshop, Adobe Illustrator, and (my personal favorite) Paint Shop Pro are some of the many quality paint packages available. A good paint package includes all the tools necessary to design a control panel layout, usually with a much gentler learning curve. All of the image work for this book, including the templates, was done using Paint Shop Pro. This program includes an excellent help system and tutorials. See Figure 6-6 for a sample screenshot.



Screen shot courtesy of Jasc Software.

Figure 6-6: Preparing templates using Paint Shop Pro.

The Simplicity of Cardboard

Don't overlook the simple idea of a cardboard mockup. A very effective way to experiment with control panel layouts is to cut a piece of cardboard into the exact shape and size of your control panel top. Then you can take to-scale template printouts of the controls you're working with and lay them out on the cardboard. Changes are quick and easy with this method. Remember to take into account space available below the control panel top. If your top has a lip that extends beyond the control panel box below it, you'll need to draw that on your cardboard template so that you don't end up putting a control where it simply hangs out into the open. Doing a full-scale mockup this way has several advantages. It's cheap, it's easy, and it's much easier to visualize the final product with a full-sized model in front of you.

Once you've come up with a plan for your panel, seek out some second opinions. Consider posting an image of your design on the message forums at the Build Your Own Arcade Controls (BYOAC) Web site (`www.arcadecontrols.com`) for other people to take a look at. The folks there aren't shy; they'll tell you both what they like and what they don't like about your design. It's almost always advice worth listening to, even if in the end you decide you don't agree. Just remember to be a bit thick-skinned; it's hard to hear criticism about something you've spent hours on. Bear in mind that it's meant to be helpful, and if you don't agree, there's nothing lost for having heard their opinions.

Design Philosophy

Now that you've got the technical bits under your belt, it's time to talk about design philosophy — the "art" of control panel design. You'll find quite a bit of discussion on this topic on the message forums at the Build Your Own Arcade Controls (BYOAC) Web site (`www.arcadecontrols.com`). I've highlighted the main points in the next three sections.

How Many Game Buttons Do You Need?

How many game buttons you choose to use will depend on the types of games you want to play. Most classic arcade games will work with between two and four buttons per player. If you're into more modern and fighter types of games, then six or seven buttons per player is about right. Four-player games tend to require fewer buttons than two-player games (mainly because there are few four-player fighting games), maxing out at four buttons per player. If you're building a two-player panel, I recommend seven buttons per player. For a four-player panel, I recommend seven buttons for players 1 and 2, and four buttons for players 3 and 4. These configurations will allow you maximum flexibility without appearing cluttered.

Aside from the main player buttons, there are other buttons to think about. You may want to add buttons near the trackball or spinner for games that use these, although many people simply use player 1's buttons for these games as well. Another set of buttons you might not immediately think about are pinball flipper buttons. Several good pinball simulations exist for the PC, and placing flipper buttons on the sides of your control panels adds a layer of fun to them. Finally, don't forget administrative buttons, as covered in the next section.

Administrative Controls

Unlike a real arcade machine, your arcade cabinet may need several *administrative* controls on the control panel, as you may want or need to do certain things on a home arcade machine that you wouldn't or couldn't do in an arcade. Take a look at Table 6-2 for a rundown of administrative buttons you might consider. Note that certain functions may not be applicable to all software. For instance, some games may not allow you to pause the action.

You'll notice that some of the buttons in the table are listed as *not recommended*. My rationale is that these functions are used only during the setting up and updating of your arcade cabinet. Based on the philosophy that you're trying to disguise the computer origins of your project as much as possible to mimic the arcade, you usually won't be doing setup activities during regular game play. Until the cabinet is finished (and during updates), you can drag out a keyboard or mouse for these functions. In normal use, you don't want your guests accidentally to bring up an "assign control keys menu" screen during the middle of a game of *PacMan*!

Table 6-2: Administrative Buttons to Consider

BUTTON	PURPOSE
Insert coin players 1 through 4	Inserts a virtual credit into the game. Some games require a separate coin-up for each player — hence four separate buttons. Use two buttons for two-player panels. *These buttons are recommended*.
Start game players 1 through 4	Starts the game for players 1 through 4. Use two buttons for two-player panels. *Recommended*.
Pause	Pauses the game during inconvenient phone calls or calls of nature! *Recommended*.
Exit	Quits the game. *Recommended*.
Reset game	Resets the game in play but not the computer. *Recommended, but hidden out of sight*.
Shutdown	Tells the computer to turn off. *Recommended but hidden*.
Mouse buttons 1 through 3	Function as left, middle, and right mouse buttons. Also function as trackball game buttons. *Recommended*.
Configure game	Used to enter game setup options. *Not recommended*.
Enter	Normally needed during setup. Also needed in many computer games. *Recommendation depends on personal preference*.
Shift	Used to modify control panel button functions to secondary functions. *Recommendation depends on interface and personal preference*.

The "reset game" button, which is listed as "recommended but hidden," is one that you will rarely use but might still need during the course of regular game play. For instance, emulator software attempts to recreate faithfully the operation of an original arcade machine, including any original quirks or bugs. Some arcade machines need to be reset the first time they are turned on to switch from startup to play mode. Accordingly, you'll want a reset button somewhere. However, since it will be used rarely and you don't want it accidentally hit during game play, I recommend hiding it somewhere. You might put it on the top or back of your arcade cabinet, in the coin door, or somewhere else easily reachable but unlikely to be accidentally pressed. The same rationale applies to the shutdown button. You'll want it once per game session, but you don't want it accidentally hit during play.

The enter button is a button you may or may not want to include. If you're just going to play classic arcade games, you aren't likely to need an enter button during game play. In that case I wouldn't include one. However, if you are going to play modern arcade games on your computer, particularly those meant to be played on a computer to start with, you may find an enter key needed. Many games are *almost* arcade cabinet friendly (see more on this in Chapter 14, "Choosing and Loading Software") and will work well with your arcade controls. However, they'll often require you to press enter to start or exit the game, or to complete entry of a high score before you can continue. If you anticipate playing any of these games, you might want to consider stashing an enter button somewhere around the control panel. You can also just elect to have a wireless keyboard nearby for the occasional need as well. This is completely a personal preference.

The shift button also needs some elaboration. Some interfaces (see Chapter 8, "Using the Keyboard Connector for Arcade Controls") support the use of a shift button, while others do not. This does not refer to the shift key on the keyboard, but it is similar. Like a shift or control key on a keyboard, a shift button is used to modify the purpose of a button on your control panel. For instance, you might have your player 1 start button function as a pause button when pressed along with the shift button. Some people like this function because it allows administrative controls to be included on the panel without extra space and clutter. Since not all interfaces support a shift button, you'll need to read Chapter 8 first and decide on an interface type if you're considering this.

Smorgasbord Or Simple?

Before you get too far into the process, you need to consider one more issue. The whole point of building an arcade cabinet is to bring home the experience of the arcade. So, what's the question? The problem is that you face something of a challenge. Machines in the arcade are designed to play only one game or a small set of games that use the same controls. You're trying to design a machine that will be able to play a large number of games, requiring many different controls. Trying to cover every angle leads to the smorgasbord syndrome. Include too many controls and you risk ending up with an unplayable mess. Include too few, and you limit the number of games you can play.

Oddly enough, this is occasionally a topic of heated debate. There are two camps on the issue. On one hand, you have folks who prefer to emphasize the aesthetics of a machine. To them, a control panel with too many controls is just short of an abomination (a "Frankenpanel"). On the other hand, there are the folks who want to maximize the playability of their cabinet. As long as it works, what's the big deal? The trick is to find that perfect balance between the "mother of all arcade machines" and the "arcade machine wannabe." The control panel design provided for you at the end of this section is a good compromise between the two extremes. Ultimately, however, the only opinion that matters is yours.

Putting What You've Learned Into Practice

Enough talking — time to get busy! Before you move on to the next section, you should put into practice what you've read. Decide on the controls you're going to use and then order them. While you're waiting for your parts to arrive, use whichever method you've chosen to lay out your design. Don't forget to run your design by a few other people for different opinions; this is almost always a useful step. If you're not confident in your design plans, you might want to reverse steps and finalize your layout before you order your controls. This helps to ensure that you get exactly the controls you need, but it does slow the process down a bit. If you've got some downtime while you wait for parts and opinions, you can sneak a peek at the next sections and do some practice work if you have spare wood. Remember, you can always elect to use the Project Arcade 2 control panel design at the end of this chapter as well.

TIP **You might notice I haven't covered where to purchase your controls. If you look at Appendix A, you'll find a list of locations to purchase them. Some parts are carried only by specific vendors, others by multiple vendors. All the vendors listed in Appendix A have a history of supplying the home arcade market.**

Installing the Controls

It's almost time to pick up your power tools again! Now that you've picked out your controls and decided on a design, you need to know how to install the controls in the control panel. The techniques listed here will be accurate for almost any arcade control you can find. However, do double-check the vendor's instructions before installing any particular control.

The tools you'll need for installation include a drill, jigsaw, and probably a router. The drill will be used to make holes for the buttons and joysticks. The jigsaw or router will be used if you need to make large openings, for instance, to mount a trackball. Finally, wood-working veterans sometimes prefer a router for making holes and cuts instead of a drill or jigsaw. You'll also use the router to flush mount or recess a control.

TIP **When drilling holes into wood, clamp a piece of scrap wood underneath and drill through both. This will avoid splintering the wood at the exit point on your control panel.**

Before you install the controls, you need to consider briefly whether you are going to be adding a Plexiglas cover to the control panel top. If you are, then you'll need to remove the controls to install it and then reinstall the controls. You might want to hold off installing the controls until I cover that in Chapter 15. However, I recommend proceeding as-is. Removing and reinstalling the controls is not that difficult.

Metal Versus Wooden Control Panels

Some controls are designed to be installed in metal control panels, some in wooden control panels, and some in either. The difference lies in how far the control will protrude above the control panel. A control designed for a wooden panel that's placed in a metal panel will extend higher than it is meant to, and a control meant for a metal panel that's placed in a wooden panel will end up shorter than intended. There's not much you can do about a control that extends too high other than altering the control (such as cutting a spinner shaft down to size) or using spacers of some kind beneath the panel.

Controls designed for metal panels will work nicely in a wooden panel, however, by having the control recessed into the panel from underneath. This is done with a router, with the recession depth depending on the control used and panel thickness. If you're using a 3⁄4-inch panel, then a depth of 1⁄4 inch is about right. With a shallower 5⁄8-inch panel, you probably will want to recess it only 1⁄8 inch deep. If you recess it too much, you run the risk of the wood breaking at that point. Leaving about 1⁄2 inch of wood in the panel will provide a sturdy surface. Take a look at Figure 6-7 for an example. In this particular 3⁄4-inch thick panel, the joysticks are recessed 1⁄4 inch.

Buttons

Most buttons, both leaf and microswitch, require a 1 1⁄8-inch hole for mounting. The buttons are passed through the hole, and a mounting nut is fastened on the underside. Figure 6-8 shows an example. If you're planning to use leaf-switch buttons in a 3⁄4-inch wooden panel, you'll need to rout out a space (1⁄4 inch will do) for them. Even though there are two lengths of leaf-switch buttons, the longer buttons are still a bit too short to allow attachment of the mounting nut through a 3⁄4-inch panel. If you are using microswitch buttons, a button wrench is a real time and knuckle saver. The mounting nuts on the buttons don't need to be too tight, but getting your hand into tight spaces can be a chore.

Used by permission of HanaHo Games.

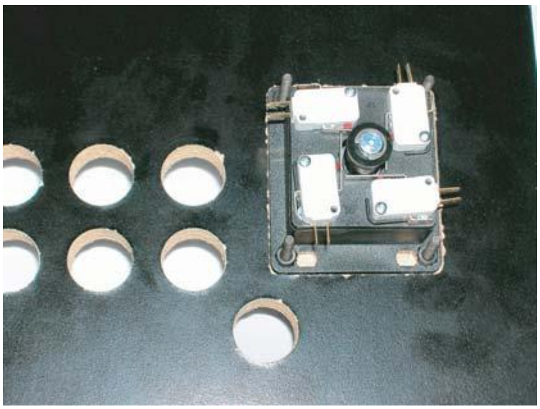
Figure 6-7: Underneath a HanaHo HotRod control panel.

Used by permission of HanaHo Games and Happ Controls.

Figure 6-8: Microswitch-type button (left) and leaf switch button (right) in an upside-down panel.

Joysticks

Joysticks will almost all mount in the same 1 1⁄8-inch hole used for buttons. Although the joystick shaft won't take up the entire hole, you need some room to move the stick around. For most joysticks, the mounting plate will attach to the underside of the control panel. You'll usually fasten it with carriage bolts from above, although some folks will install them with screws from underneath. Attaching them from underneath leaves you a smooth surface above, while using carriage bolts from above provides more stability. The joysticks will be taking quite a workout and could potentially fall in toward the panel, so if you are concerned, stick to the carriage bolts. Different models of joysticks have different mounting heights, and whether to recess them is a matter of functionality and personal preference. Most people will recess the joysticks; having a stick that's a little tall is okay, while a stick that's too short can hamper game play. You can always test-fit the joystick without recessing it first and then make up your mind. Take a look at Figure 6-9.



Used by permission of HanaHo Games.

Figure 6-9: A joystick recessed into the control panel.

Some joystick installations are done from above the control panel, with an area for the mounting plate routed on the top so as to flush-mount the joystick. Doing this requires a much bigger hole in the panel to accommodate the base of the joystick. Functionally, however, it is fine. If you go this route, you'll need to install a control panel overlay to cover the mounting plate.

NOTE **A control panel overlay is basically a large sticker with some appropriate design that you place over the entire control panel, hiding the installation holes and such. I'll cover that (no pun intended, honest!) in Chapter 15, "Buttoning Up the Odds and Ends."**

You might guess that there's not much that can go wrong with a dust cover, but most joystick installations get this part wrong. The dust cover is the washer that sits at the base of the joystick shaft, whose purpose it is to cover the hole in the control panel. It's really not in the least important where it goes, but if you're trying to get that perfect arcade look, then you might consider doing it the proper way. The correct way is to rout an impression in the top of the panel for the washer to rest in so that it's flush with the control panel top. Then you apply your control panel overlay on top of the control panel, sandwiching the washer between the overlay and the wood. It's a bit of effort that's probably not worth the results, and it particularly won't work if you aren't going to use a control panel overlay.

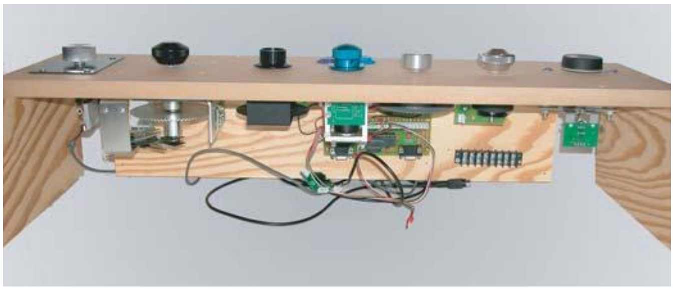
Installing the joystick involves removing the shaft from the base, which requires removing an e-ring from the shaft. An e-ring is a thin, flat semicircle of metal that fits snugly onto a notch in the joystick shaft, holding the entire mechanism securely in place. When you remove the shaft, various parts will come off as well — be sure to note where they go, or have the joystick assembly instructions available. Place the base of the joystick beneath the control panel, and thread the shaft through the control panel and into the joystick base, placing the various components in the same places they were removed from. Replace the e-ring and you're done. Beware! Those e-rings are pure evil and tricky to get on and off. Installing the e-ring requires one hand to hold the shaft, one hand to press down on the actuator on the bottom of the shaft to expose the e-ring groove, and one hand to install the e-ring. Were you counting? Yes, that's three hands! Because the metal e-ring has to be bent open slightly to snap onto the joystick shaft, it's essentially spring loaded. You haven't truly been initiated into the arcade cabinet–building community until you've crawled around on the floor muttering as you look for one of these e-rings after it went flying across the room when you tried to install or remove it! Some specific joystick models vary, so be sure to consult the vendor's instructions.

Spinners

Although the specifics of spinner installation will vary depending on which model you're using, all of them are similar. You'll need one hole for the spinner shaft, size depending on the model of spinner. Traditional spinners need a hole between 3⁄8 inch and 3⁄4 inch in diameter. You don't want a hole that's too big because there's no dust cover washer and the hole will show under the spinner knob. More recent innovations in spinner design (see Chapter 4) will allow you to install a spinner in a standard 1 1/8-inch hole just like a button. Either way, the spinner will mount to the underside of the control panel in a variety of methods, with none of the commercially available spinners needing to be recessed into the panel.

Above the panel the spinners all work the same. The knob mounts onto the shaft and is fastened with one or two tiny setscrews that are embedded in the knob. The knob will float above the control panel surface, hiding the shaft hole.

Installing the spinner is a matter of removing the knob, threading the shaft through the control panel hole, and reattaching the knob. It's very important that the shaft be straight and not touch the sides of the hole once installed, or the spinner may bind and not function properly. Fortunately, most of the spinner models currently available have well-designed mounting mechanisms, so this is not difficult to accomplish. Take a look at Figure 6-10 for a shot of the Project Arcade 2 test rig with various spinners installed. The spinners look very similar above, while having very different mounting mechanisms below.



Used by permission of Apache Controls, Groovy Game Gear, SlikStik and Ultimarc.

Figure 6-10: Test rig with spinners.

Trackballs

You'll find trackballs to be the most labor-intensive control to install. Most controls install into the control panel with a simple circular hole in the panel. Mounting a trackball requires a hole in the panel several inches in size. It can either be an irregularly shaped hole that matches the shape of the trackball casing, or a larger, square-shaped hole to make it easier. There are three styles of trackballs from different arcade vendors. Functionally and electronically they work the same, but the physical casings that hold the trackballs are slightly different in shape. Either way, accommodating the casing takes a bit more effort than simply drilling a hole.

CROSS-REFERENCE **The companion CD-ROM includes a one-size-fits-most trackball cutout template that will accommodate most of the trackballs available today.**

Trackballs are usually mounted with a mounting plate. The mounting plate can either rest on top of the control panel or be recessed into the top of the panel for a flush-mounted surface. There are two styles of mounting plates — one with holes to insert carriage bolts from the top, and one with a smooth surface. The one with the smooth surface has posts underneath that you attach to from beneath the control panel. Both plates have the same mounting pattern — four screws or bolts attach the trackball to the mounting plate, and another four screws or bolts attach the mounting plate to the control panel.

Installing the trackball is not difficult despite the extra effort involved. Begin by cutting the hole into which the trackball casing will fit. I recommend cutting a hole to fit the casing instead of the square hole, as that will leave more wood for the mounting plate to rest on, providing more support. The fitted hole will be six-sided, roughly in the shape of a football. Once you've cut the hole, drill four holes in the corners to mount the trackball plate to the control panel. Attach the trackball to the mounting plate, and then insert the trackball assembly into the control panel and fasten it into place. Figure 6-11 shows an example of a trackball mounted using the smooth-surface plate.

Used by permission of SlikStik.

Figure 6-11: A 3-inch trackball mounted inside a SlikStik control panel: underside (left) and surface (right).

Guns

Because there are no standards or conventions for arcade guns, you'll have to determine the best mounting method on your own. I have a couple of points for you to consider while you do so.

For light guns, the only part of the gun you'll be mounting to the cabinet is the end of the cord. The easiest way would be to route the cord through the coin door, and leave the guns in the cabinet when not in use — not terribly attractive and you have to open the door whenever you want to play. You can also purchase holsters for guns from arcade parts vendors and mount them somewhere on the cabinet — for instance, on the bottom-front beneath the control panel — where they'll be out of the way. However, you then have to have some way for the cords to enter the cabinet to connect to the computer. A grommet hole underneath the control panel box bottom would work nicely, keeping the cord entrance hidden.

If you're mounting permanently fixed positional guns to your cabinet, you'll want them positioned on the control panel far enough back that they won't hit the screen when rotated. Also be sure to leave enough clearance between guns so that players 1 and 2 can both aim inward without interfering with each other.

Steering Wheels And Yokes

Steering wheels and yokes are another set of controls that are difficult to give specific mounting instructions for — every model is somewhat different. Most steering wheel and flight yokes are meant to be set up on a desk, usually with some kind of clamping mechanism. If your control panel has an extended lip, then you can mount those wheels and yokes that use clamps to it. This is particularly a good way to do it if you intend to use the control only occasionally, with the ability to remove easily and put it away when not in use. If you're going to use this method, be sure to look at Chapter 13, "Installing the Computer," for an idea on surface-mounting USB ports on the cabinet.

If you're planning to mount a wheel or yoke permanently to your cabinet, you should think carefully about the angle of mounting. Clamping on to the overhang of the control panel is fine for casual use. However, because the control panel angles slightly downward, the wheel or yoke will also be angled slightly downward. This is not ideal for frequent use if you're going to be standing and will likely cause discomfort. Consider creating a mounting platform that will sit on or attach to the control panel. You'll find an excellent example of how to do this on the 1UPArcade Web site at `1uparcade.rmfx.com/projects-yokebase.html`.

CROSS-REFERENCE **Instructions on how to create a mounting platform that will sit on or attach to the control panel can be found on the companion CD-ROM.**

Dance Pads

Unless you're designing a permanent dance machine, you really won't be mounting the dance pad to the arcade cabinet. In that case, you'll just need to make sure you've left enough floor space in front of the cabinet for the dance pad once the cabinet has a permanent home. Once again, if you're going this route, look at the USB port–mounting idea in Chapter 13. If you *are* building a permanent dance machine with a wooden-framed dance pad, then you may want to consider semi-permanently fastening the dance pad to the cabinet. You probably don't want a fully permanent assembly, as the cabinet would be difficult if not impossible to move to another location.

Mounting the Control Panel

If you followed the instructions in Chapter 2, "Building Your Arcade Cabinet," then your control panel top already securely mounts to the control panel box with either screws or Velcro. If you haven't decided on screws or Velcro yet, now is the time to do so. With a closed-box design like the Project Arcade 2 control panel, Velcro is pretty much the only way to attach the top to the box securely while allowing for easy removal. In addition to providing access to the innards for maintenance, a removable control panel top also allows for a nice solution to the "smorgasbord or simple?" question raised earlier in this chapter, as explained in the next section.

Multiple Control Panels

Smorgasbord or simple? Why can't you have the best of both worlds? You can if you're willing to go through a little extra effort and expense. Many people have solved the problem of wanting extra controls without the clutter by using more than one control panel. To make this work, you have to use a modular wiring scheme, which I'll cover in the next chapter, "How it Works — Turning a Computer into the Brains of an Arcade Machine." This will allow you to unplug a control panel from the cabinet and plug in another one. There's usually a main control panel with a couple of standard joysticks, buttons, and probably a trackball and spinner. The bonus panels depend on what you're trying to achieve. One popular choice is to design a panel with a couple of trigger-grip joysticks for a particular set of flying and shooting games. You might create a panel with a limited set of controls to replicate faithfully a favorite game. Whichever panels you decide to create, once you get the wiring worked out, it's a fairly simple concept. Each control panel is designed to fit in the control panel box that stays on the cabinet. When it's time to swap panels, you pull the current one off, disconnect the wiring, plug in the replacement panel, and drop it into place. Voila! You have the equivalent of an entirely new arcade machine with about a minute's worth of work. The only trick is figuring out where to store the extra panels when not in use!

TIP **A removable control panel sounds good in theory. Experience has shown that in reality it can be a pain, particularly for guests who aren't familiar with your cabinet. Ultimately, if you have the resources and inclination, building a second cabinet with the alternate control panel you want is less hassle for playing and as a bonus you have two machines! However, if two machines are out of the picture and you're willing to deal with some inconvenience, then a removable control panel is a good way to go.**

You have one other option to consider for multiple control panels. A handful of very clever and dedicated people have come up with schemes for rotating control panels in their arcade cabinets. Like swappable panels, each one has a particular set of controls for a particular subset of games. Instead of removing the existing panel when you want to change, the control panel assembly is simply rotated into the cabinet and another panel rotated into place. This is an ingenious idea and nicely handles dealing with multiple control panels with a minimum of fuss — that is, once you've actually created the rotating panel mechanism!

Specific instructions on how to do this are beyond the scope of this book. There are a few good sites on the Internet you can go to for inspiration if you would like to give this a try (I'll show you a few in Chapter 18, "Online Places To Go"). In a nutshell, however, the control panel boxes are designed to allow the panels to rotate down into the cabinet when another panel is rotated up into place. Picture a set of three control panels arranged with the wide edges of each panel touching another panel, so that they form a triangle when looked at from the end. A lazy-susan mechanism of some kind is attached on each short end, and this entire assembly is mounted into the control panel box. Add a mechanism to fasten and release the control panel as needed, and you have the gist of a rotating control panel setup. An excellent example of a cabinet with a rotating control panel is 1UP's PacMAMEa at `1uparcade.rmfx.com/arcade-const-panels.html`.

CROSS-REFERENCE **1UP's PacMAMEa can also be found on the companion CD-ROM.**

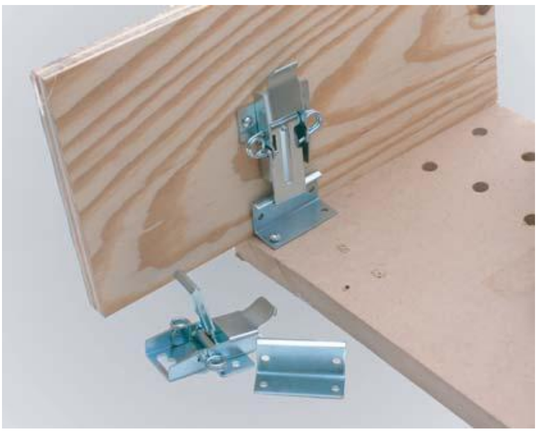
Attaching The Control Panel Box

Now that you have the control panel designed, built, and attached to the control panel box, it's time to attach the box to the cabinet. Recall that we deliberately did not attach it to the cabinet earlier to allow for ease of construction and the ability to fit the cabinet through doorways. If you haven't done so yet, now is the time to move the cabinet from the construction area to its permanent home.

WARNING **Up until now it's been possible (though not advised) to do things by yourself. Now, however, you should find a friend to help before trying to move the cabinet. With most of three sheets of wood assembled together, the cabinet is going to be bulky and heavy. Don't risk injury to the cabinet or yourself by trying to solo it, even with a moving dolly. Trust me on this one; Project Arcade 1 almost took a tumble down a flight of stairs before I was wise enough to ask for a hand (making this the book that almost wasn't!). Get someone to help; you'll be happy you did.**

Once you've done that, you have a choice to make. If you're convinced that you'll never need to move the cabinet back out the doorway, or if you have a doorway wide enough to accommodate it, you can elect to attach the control panel box to the cabinet permanently. There's nothing particularly complicated about doing it this way. Make sure the box is centered on the base of the cabinet, and use any of the construction methods from the beginning of this book (such as L-brackets or mounting strips) to attach it.

However, if you want to be able to fit the cabinet through standard-sized doorways and to be able to get into the cabinet for maintenance from the control panel area, you'll want to use a detachable mounting method for the control panel box. The best way to do that is with panel clamps available from various arcade parts vendors (see Figure 6-12).



Used by permission of Happ Controls.

Figure 6-12: Two sets of control panel mounting clamps.

Panel clamps come in two pieces. One piece has a lip on it and attaches to the control panel box. The other piece attaches to the cabinet and has a spring-loaded lever that clamps to the lip of the other piece. Close the lever and the clamp pulls down tight on the other piece, securing the control panel box into place. Raise the lever and the control panel box easily releases. With a panel clamp on the left and right sides, your control panel box will not be going anywhere! For added stability, you can attach a couple of 2×2 mounting strips to the control panel box underside to make sure the fit into the cabinet is snug. When the box is properly positioned on the cabinet, attach the mounting strips in the corners made by the box underside and the cabinet sides. Make sure you don't fasten the mounting strips to the cabinet as well!

Standalone Control Panels

It's time for a quick segue. Earlier on in the book, I mentioned building a standalone desktop set of arcade controls. You may not realize it, but if you've been building as you follow along in the book, then you've done just that! Rather than dedicating the time and space to a complete arcade cabinet, many people will build a control panel box and control panel and stop there. With a desktop arcade unit, you don't have to purchase all the materials for the cabinet, and you don't have to dedicate a computer and monitor. These make excellent semi-portable arcade units at a third or less of the cost of a dedicated arcade cabinet. They fit well on the top of a desk for casual game play and can be put away when not in use. They're also great responses to the inevitable requests you'll receive when people see your custom arcade cabinet. Build your family and friends desktop arcade units and they'll love you forever! OK, that may be pushing it. However, roughly a third of the projects submitted to the Build Your Own Arcade Controls (BYOAC) Web site are desktop arcade units. Building one is certainly something to consider.

Project Arcade Control Panel Design

Not sure yet what you'd like to do? If in doubt, try the Project Arcade 2 control panel as shown in Figure 6-13. This panel is fairly complete, designed to cover a wide range of game possibilities in a four-player configuration. It includes a spinner, trackball, and four joysticks. I did not use a dedicated 4-way joystick, so you will want to use one of the solutions discussed for a multi-functional joystick or add a dedicated 4-way to the mix. The panel uses 41 buttons, including 7 each for players 1 and 2, 4 each for players 3 and 4, 2 sets of 3 mouse buttons (for left handed or right handed use), 2 pinball flippers, and a handful of administrative buttons. The layout below does not include specific dimensions because it will depend on the size of your control panel and personal preferences for positioning. However, if you follow the general layout you will end up with a rock solid and fun to use arcade control panel!

You'll need the following controls (from any vendor) to build the Project Arcade 2 control panel:

- One 3-inch trackball and mounting plate
- One spinner
- Four joysticks with at least one being a switchable 4-way/8-way or use one of the other solutions for a 4-way joystick

- Four player (1/2/3/4) start buttons
- 37 unlabeled pushbuttons
- Assorted screws, nuts, and bolts depending on joystick, spinner, and trackball models (see specific vendor information for parts necessary)

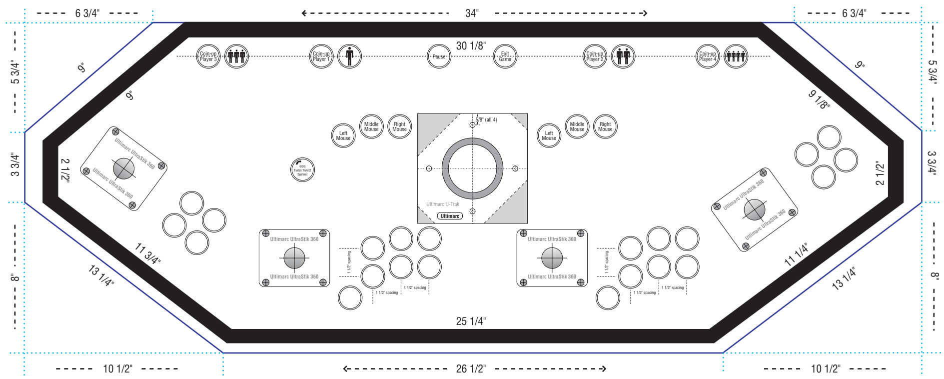


Figure 6-13: The Project Arcade control panel layout.

> **ON THE CD**
>
> **If you elected to build the original Project Arcade 1 cabinet by using the instructions from Chapter 2 on the CD, you'll want to refer to Chapter 6 on the CD now for the Project Arcade 1 control panel design.**

Getting Started With The Plans

To build the Project Arcade 2 control panel, you will follow the same kind of steps you did in Chapter 2 when building the cabinet. Start by printing out the control panel plans from the companion CD named "ultimatearcadeII_control_panel.pdf."

As with the cabinet itself, I deviated somewhat from the control panel plans. You can build an awesome control panel following the plans verbatim, or you can follow my deviations to get the equally awesome control panel shown to you in Figure 6-13. The deviations I made are:

- I used 3/4-inch plywood instead of 5/8-inch MDF or particle board.
- I did not use laminate.
- I used a different layout for the controls.

You can also, of course, elect to create a different layout altogether. Whichever you choose, I recommend reviewing the entire set of plans first before proceeding.

Cutting The Panel Pieces

Use the same general guidelines from when you cut and assembled the cabinet for the control panel, including all safety precautions. The entire panel can be cut from a single 4 x 8 sheet of wood. When you're done you should have a collection of pieces that looks something like Figure 6-14.

Figure 6-14: The control panel pieces.

The tricky part of cutting these pieces is getting all the angles correct. There are a lot of angled cuts in this part. It may help to envision what the assembled control panel box is going to look like while you measure and make the angled cuts. Take a look at Figure 6-15. I have placed the pieces in the general configuration they will have when permanently assembled. Note that the entire control panel box will slope downward from the rear to the front slightly. All the cuts on the pieces that make up the sides of the control panel box are angled so as to give the box its slope.

Take special care with left and right pieces "C" and "G." I had to remake those pieces twice because I kept neglecting to account properly for the material lost due to the width of the saw blade when making the angled cuts. To make sure all the pieces are sized properly, assemble the side pieces around the control panel box bottom part "I." If the side pieces cannot fit securely around bottom panel without gaps you will need to re-cut whichever piece is necessary. Note that small gaps can be plugged with wood putty, but any gaps big enough that two pieces fail to touch each other for most of their connecting sides will cause you structural problems.

Also, when you have cut all the angled pieces and test-assembled them, make sure you have a relatively smooth slope from the rear piece to the front. If you have any significant "stair-stepping" where the pieces do not match quite right, decide whether there is a big enough problem to warrant re-cutting some pieces. You can help make that determination by placing the control panel top piece "J" on the side pieces to see whether it sits properly.

Figure 6-15: Test fitting the pieces of the box.

Assembling The Control Panel Box

Once you're satisfied with the test fit, you can begin assembling the control panel box. The layout of the box does not easily lend itself to using clamps to hold things together. Instead, masking tape (I used painter's tape) makes a great temporary "clamp" while waiting for the wood glue to dry. Do not assemble the side pieces around the bottom panel because dripping glue may seal the bottom panel to the box, and you are not ready for that yet. Wood glue takes a few minutes to start to set, so you have enough time to assemble and glue all eight pieces that make up the control panel box sides. You can see my panel taped and waiting for the glue to dry in Figure 6-16.

Figure 6-16: Side pieces assembled, glued, and drying.

Once the side pieces have dried, you should be able to remove the tape and pick up the control panel box shell. It should feel fairly sturdy without any wiggle that would indicate a loose connection. Your next step will be to install the control panel box bottom support pieces as shown in Figure 6-17.

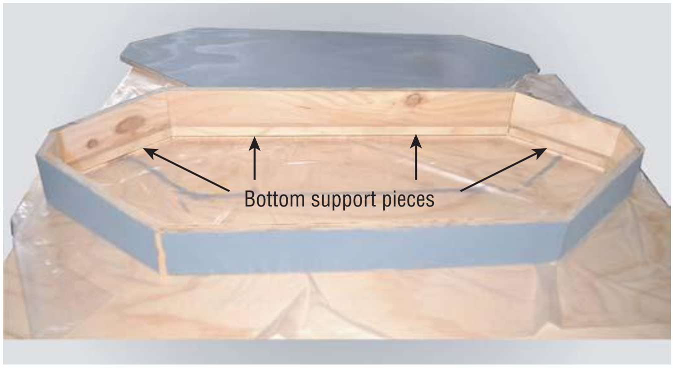


Figure 6-17: Control panel support pieces glued into place.

You *could* measure up from the bottom of the box side pieces 3/4-inch (or if you're using 5/8-inch wood measure that amount instead) to position the support pieces. However, I recommend instead actually placing the bottom panel "I" inside the control panel frame, then laying the support pieces atop it. Assuming everything is on a level surface, this will perfectly position the support pieces where they are needed. This will also allow you to test fit all the support pieces and make any adjustments necessary before you begin to fasten them into place. Be careful with your glue as this time it will not be possible to remove the bottom panel while the glue holding the support pieces dries, but you still do not want the panel bottom glued to the frame.

Once the support pieces are permanently fixed into place, you can secure the control panel bottom to the assembly with screws as shown in Figure 6-18.

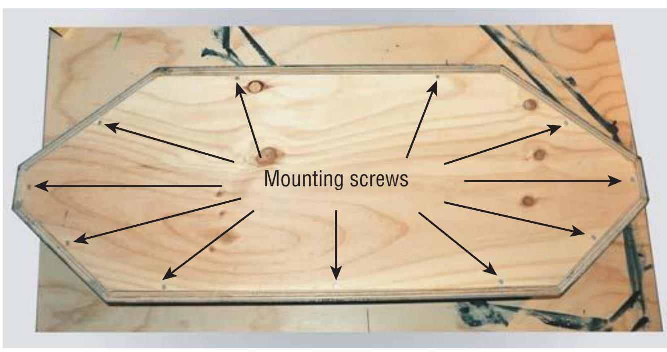


Figure 6-18: Panel I secured into place.

Laying Out The Controls

If you're going to use either the original Ultimate Arcade II control panel design, or the Project Arcade 2 design, you already have a layout ready to use. However, if you'd like to experiment with your own design then now is the time to do so. Before you begin your design, you need to consider what amount of real estate you have to work with on the control panel top. You do *not* have the entire surface to work with. You have to allow for the amount the control panel top overlaps the control panel box and the amount the sides take up. You can't have controls hanging out into space! The easy way to do this is to lay your control panel top on a flat surface, then place the control panel box upside down on the control panel top as shown in Figure 6-19.

Figure 6-19: The control panel box atop the control panel top.

Make sure you have the box centered from left to right, and flush against the rear. Remember the control panel top overhangs the box on the left, right, and front sides. It has to be flush on the rear so that the complete assembly can fit securely against the cabinet. Once you have it centered, use a pencil to draw a line against the inside sides of the control panel box. The enclosed area you draw is the space you have available for laying out your controls (see Figure 6-20).

Here comes the fun part! Print the to-scale templates of the various controls you are going to use from the companion CD and cut them out. Now you can place the templates on your control panel and experiment with your design. I suggest using scotch tape on the bottom to hold them loosely in place and test "playing" on the panel with your layout. Invite a second person to come play as well and give you their feedback. It also helps to have both of you testing at the same time to make sure you've left adequate space for multiple players to play comfortably at the same time.

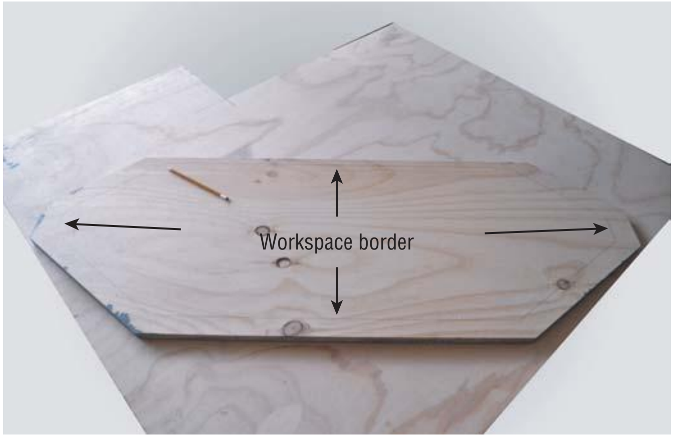


Figure 6-20: The working space for your control panel.

One thing to consider is the button layouts for each player. Different people have different preferences for the spacing and positioning of the buttons. On the CD I've included several different button layouts you can try. Make sure you're comfortable with the layouts before you start making holes in your panel! You can see the Project Arcade 2 in-progress layout in Figure 6-21.

Figure 6-21: The Project Arcade 2 semi-final layout.

Once you've perfected your design, take all the appropriate measurements and lay them out on a computer. This can be time consuming and a bit frustrating, so I suggest you start with the Project Arcade 2 control panel templates included on the companion CD. You can modify those easily in any paint program. I highly recommend printing the complete control panel template one final time and laying it atop your control panel to make sure you're happy with it. You can either have it printed at a print shop full sized, or print it in to-scale chunks and tape it together as I did in Figure 6-22.

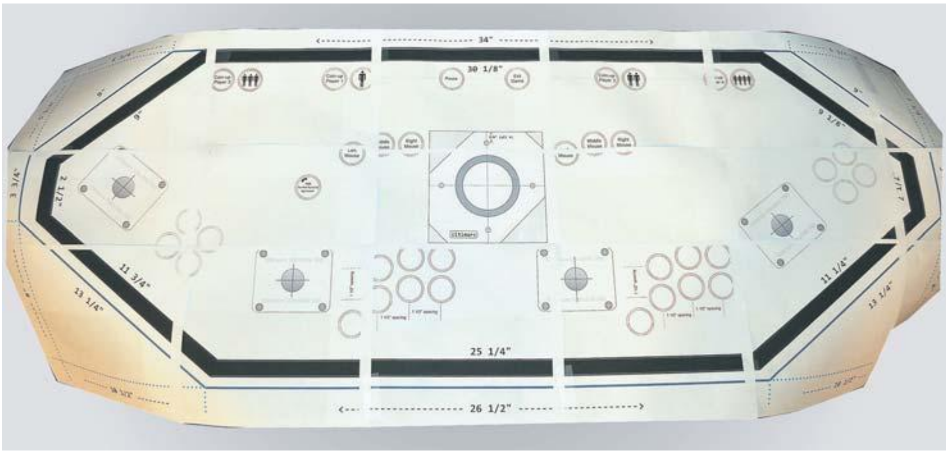


Figure 6-22: One last test of the Project Arcade 2 layout.

Drilling Holes? Not Quite Yet!

Now that you have the perfect layout for your control panel, the next step is to start drilling holes. Time for power tools again! However, you may wish to take a break from this chapter for now and proceed with the rest of the book, coming back to here after Chapter 15.

Chapter 15 covers artwork for your cabinet, including the control panel overlay. A control panel overlay is a large piece of artwork cut to fit your control panel top. If you are going to use one of these, you want to make sure the holes you drill in your control panel match the intended location of the holes on your artwork. It's extremely annoying to have a set of arrows indicating the directions the joysticks can point only to have the joystick itself offset so that it's not in the middle of the arrows due to a deviation in the artwork and the drilled holes.

If your artwork is not going to have specific locations for controls, or you're not going to have an overlay at all, you can proceed without worrying about mismatched holes. If you are going to have artwork where this is a concern however, you should wait until you have the artwork in hand (presumably after you've read Chapter 15) before you proceed with the rest of this chapter.

One thing you can do while you're waiting is to prime and paint your control panel box and top. If you're going to use a control panel overlay you can skip the paint on the top, but you should prime it at least once to give the control panel overlay a good surface on which to adhere. Primer and paint can "outgas" for a few days after application, so make sure you let the top dry for those few days before applying your artwork. If you do not, you may find bubbles forming underneath the overlay.

NOTE **You may be tempted to use your printed template to position and drill holes in your control panel top. I recommend resisting this urge. It's possible that the template and your artwork will match perfectly, but even minor deviations will be glaringly obvious. Far better to wait for your artwork and ensure an exact match!**

Definitely Time To Drill Holes!

Now that you have your artwork in hand (or have decided not to use or wait for artwork) it's definitely time to drill holes in your control panel! Start by laying your artwork (or template) on the control panel as shown in Figure 6-23. Once it's properly positioned, tape the overlay securely to the panel top to make sure it will not move once you begin working.

Figure 6-23: Above, positioning the artwork on the panel top. Below, the artwork secured in place.

You do not want to drill your holes through your control panel artwork into your control panel top. It is likely you will tear up your artwork no matter how carefully you proceed. A better method is to use the control panel artwork to mark the wooden control panel top underneath. Do so with a collection of nails. Position the nail where the joystick or button will go, and drive it gently through the overlay into the wood no more than 1/8-inch (see Figure 6-24). You want it just deep enough to dimple the wood.

Figure 6-24: Marking the control panel with nails.

Once you have the entire control panel marked, you can remove the nails and the overlay, and finally start drilling holes! Make sure you put a sacrifice piece of wood beneath the control panel to prevent splintering as you drill your holes. Once you've drilled all the holes for your controls, you're ready to move on to the next step. You can see the prepared Project Arcade 2 control panel top in Figure 6-25.

Figure 6-25: The Project Arcade 2 control panel top, ready to install controls.

Summary

In this chapter you were introduced to the concepts of good control panel design. If you've been building as you read, then by this point you've decided what controls are going to be a part of your arcade project. You've planned, purchased, and installed your controls into your control panel and attached it to the cabinet. If you're using the Project Arcade 2 design, then you've got a good four-player cabinet almost ready for friends to come play. If you're striking out on your own with your own custom design, then so much the better — your panel fits your unique style! This is the end of Part II, "Designing and Building Your Dream Arcade Control Panel." Take a moment and look back at what you've done so far.

Wow, you've come a long way in only a few chapters! From a pile of wood, hardware, and a few ideas, you've been able to create a full-sized arcade cabinet with a smoking control panel! But…it doesn't *do* anything yet, right? It's a bit like Dr. Frankenstein's monster in the movie, lying on the table covered by a sheet. Putting it together was almost certainly a fun and interesting process, but it won't impress your friends yet. In the opening chapters of Part III, "Hooking Things Up Under the Hood — Time to Trick the Computer," I'll show you how to get your controls to talk to the computer in a language it can understand. Ready to give your creation a jolt of lightning and bring it to life? Put on your lab coat, practice your mad scientist laugh, and read on!

Part

III

Hooking Things Up Under the Hood — Time to Trick the Computer

In This Part

CHAPTER

7

How It Works — Turning a Computer into the Brains of an Arcade Machine

IN THIS CHAPTER

- **Digital and Analog**
- **Arcade Cabinet Wiring 101**
- **How It All Works**

Congratulations! So far you have two steps down the road toward arcade paradise behind you. It's time for the next step! Think of this book as a fun, college-level science course. There's some lab work, some theory, and one whopping final exam. The first part of the book was the introduction to the course, and the second part was the hands-on lab work. That means you still have some theory and the final exam to go!

The theory portion starts in this chapter. Don't worry; you'll find it anything but boring! There are a lot of options available to you, and the next four chapters cover them all. You're going to get into how keyboards and mice work, perhaps take a few things apart (always fun), and generally play with ways to make a computer do things no one thought of a few years ago. I'll start things off with some behind-the-scenes information on the techniques that make this whole thing work. Oh, and the final exam? That's the look on your friends' faces when they come over and get to play with the results of your hard work! Ready to go? Then grab your wires and test tubes — it's time to bring your creation to life!

Digital and Analog

I'll start with a look at how computers talk to their various bits and parts. All the arcade controls that you connect to the computer need to talk to the computer somehow. That means the computer and the arcade controls will have to be able to speak the same language. Fortunately, the computer knows how to speak all the languages used by the arcade parts. Your task is to match the right language from the computer to the right arcade part. It's easy, when you get down to it, because there are really only two languages to worry about: digital and analog.

Digital Data

What is *digital data*? Entire books and courses are dedicated to that question. You could take years of study to master the subject. The following explanation is just a brief overview. It's really all you need to know for the purposes of this book and for building your arcade cabinet.

Simply put, digital data is a way of representing information by breaking it down into individual bits of 1s and 0s, or more appropriately for our purposes, the state of the bits being *on* or *off*. Consider a pushbutton, for instance. When the button is sitting in the control panel and no one is touching it, it's off (0). When someone presses the button, it's on (1). To the computer, there is no in-between state. What about when the button is pressed half-way down? The computer doesn't care, and in fact doesn't even know. The button is off until it is on. There's no other state for the pushbutton to be in.

Usually, the individual bits of 1s and 0s are grouped into bunches of 1s and 0s for easier sending and storing of the digital data. These *groupings* are still digital as far as we are concerned. However, as you will see in a moment, groups of 1s and 0s can also be used to represent analog data.

Analog Data

Analog data is a more traditional way of representing information. In the real physical world, almost everything is represented in analog terms. It allows for a range of values of information about the state of an item, such as the temperature outside. The temperature can vary over a range of values, some more specific than others (10 degrees, 32.5 degrees, warm, warmer, hot, and so on). In terms of a computer, instead of data about an item being represented in bits, it's represented in a way that presents the data as something more than simply being on or off. Consider a steering wheel as an example. A steering wheel is not simply turned or not turned. It can be turned a few degrees to the left, and the computer recognizes that as a gradual turn. The wheel can be turned many degrees to the right, and the computer recognizes that as a sharp turn to the right. You might think of analog as a way to qualify information about an item. *How* hot or cold is it? *How far* to the left is the wheel turned?

Mixing Them Together

Fortunately for those of us who are arcade cabinet builders, computers speak both digital and analog. In strict terms, computers of today are digital devices. At the core of the computer, the *central processing unit* (CPU) speaks only digital. However, part of the electronics that make up a computer include devices that convert between digital and analog. The game port is the only input connection on the computer that speaks analog natively (but most modern computers don't have this port anymore). All the other input connectors on the computer are digital in nature. There are a couple of analog outputs, such as the sound and video outputs, but only the one analog input. That isn't to say that the other input connectors can't have analog devices hooked up to them. In fact, it is quite common to do so. It just means that such devices have to perform an analog-to-digital conversion before they send the data to the computer. As noted in the "Digital Data" section, groups of digital bits can carry analog data, at least as far as our arcade machine and computer are concerned. A full understanding of how that works really would take a dedicated book or class. Suffice it to say that it works, which opens up many possibilities to us.

Can you identify which arcade controls are digital, and which are analog? A pushbutton is easy; it's either pushed or not pushed (digital). Steering wheels have been discussed — they're analog. What about spinners and trackballs? They might seem analog at first thought, but they speak digitally. They might send data saying "move 1 left" and the computer will move one left. They also might send "move 20 right and 3 up" to which the computer will respond as well.

Now consider a slightly more complicated question. Are there any controls that can be either digital or analog? What about a joystick? As it turns out, the answer is "yes." Not that there are joysticks that are both digital and analog at the same time, but joysticks come in both digital and analog models. A digital joystick is a simple device. It's basically a stick attached to four buttons underneath, one each for up/down/left/right. Press the joystick up and the up button is on (often referred to as *closed*). Release the joystick and the up button is now off (or *open*). That means the joystick is either pointing up or it's not — a digital situation. Analog joysticks, on the other hand, use *potentiometers* or more sophisticated electronics such as magnetic sensors to send positioning information to the computer. With an analog joystick, it's possible to be *degrees of distance* in one direction, for instance 50 percent of the way to the left. It's not a simple matter of pointing left or not pointing left; it's a matter of *how far* you are pointing to the left.

NOTE **You may have noticed that several terms mean the same thing when it comes to digital terminology. A digital switch that has been pressed can equally be referred to as 1, on, or closed. Likewise, a switch that has not been pressed can be expressed as 0, off, or open. Any one of the phrasings is okay.**

Different joysticks lend themselves to different situations. A digital joystick is good for games that don't require positional information to be sent to the computer. Take, for instance, the game of *Donkey Kong* and our poor friend Mario. Recall that when last we left him, brave Mario had narrowly escaped flaming death from a barrel. Once again, Mario needs to run right to avoid another barrel. You press your joystick to the right, telling the computer to send Mario scampering in that direction. You're not telling the computer to run right a certain distance; you're telling it to run right until you tell it to stop. You keep the joystick held right until you run out of the barrel's reach, and then release it. Mario stops running and lives to see another day. Huzzah, well done Mario!

Now picture a flight game that uses a joystick instead of a yoke, such as a jet-fighter simulation. You need to bank left 20 degrees, so you tilt your joystick part-way to the left. Oops, too much and you're banking 30 degrees. You ease the joystick slightly back toward the center until your plane is angled at 20 degrees. When you finish your turn, you bring the joystick back to the center and the plane levels off. This is an example of an analog joystick. This wouldn't work with a digital joystick. You would only be able to tell the computer to bank left, but not by how many degrees. If it worked at all, it would simply send you into a leftward barrel-roll until you let go of the joystick.

These limitations can be overcome with software; for instance the computer in the jet-fighter simulation might be programmed such that it translates how many seconds you hold a digital joystick to the left to a number of degrees, with the longer you hold it to the left the more it banks, but holding the joystick to the left for 3 seconds to achieve 30 degrees banking is a different feel altogether from fine tuning how far you move an analog joystick to the left to reach 30 degrees. This may seem much ado about nothing on paper, but comes near to a religious argument for many people. If the controls don't feel right, particularly when you're trying to recreate a favorite arcade machine, the game play just isn't as good!

This has been touched on earlier in the book but is worth one more look. For the purpose of this discussion, I'm going to focus on analog values as generated by potentiometers. Modern technology allows for other possibilities, such as the magnetic sensors used by the Ultimarc UltraStik 360. The basic principles are the same however, and you are more likely to be working with potentiometers than other analog technologies.

For arcade controls and computers, the potentiometer sends a *relative* position, such as 30 degrees to the right. Technically, what the potentiometer sends is a *resistance* value. A potentiometer works by varying the resistance as you turn its shaft (see Figure 7-1). Turned completely to one direction, the resistance is essentially zero. Turned completely to the other direction, the resistance is maximized (the value depending upon the rating of the potentiometer). Normally, the maximum value is 5K ohms (usually referred to as 5K) for arcade controls, and 100K for PC-based controls. The computer decides what the resistance value means. For instance, if there are 256 different positions along the *X* axis, a value of 0K would mean position 0 (far left), a value of 50K would mean position 127 (middle), and a value of 100K would mean position 255 (far right). It's also possible for the device to do its own conversion of the resistance to a digital value and send that to the computer. This lets you use an analog joystick, for instance, that has a *USB connector* (a digital input port).

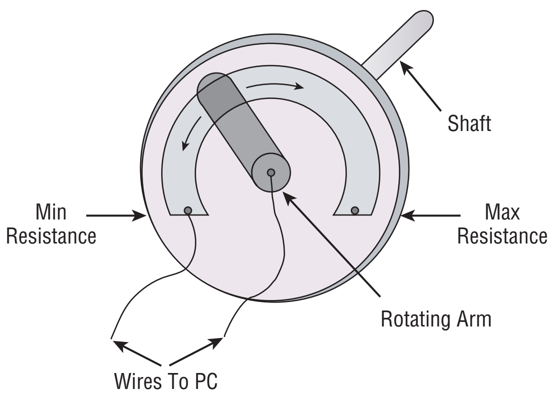
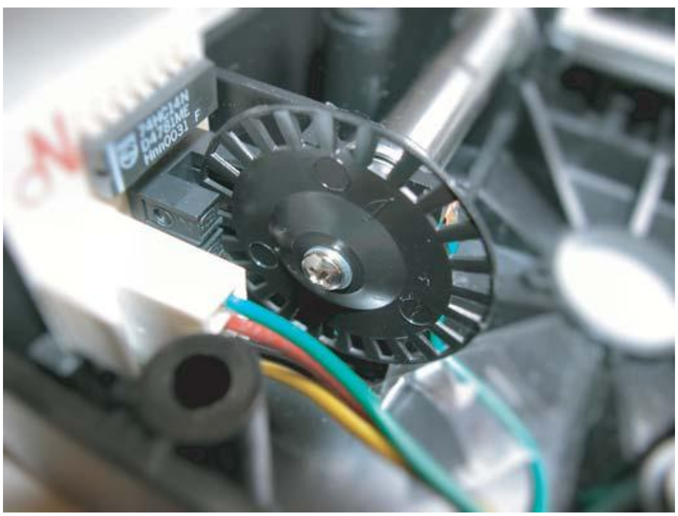


Figure 7-1: The resistance increases as the shaft is turned clockwise.

Digital values are generated by switches. The switches can take a variety of forms, but all generate a signal that is on or off, 1 or 0, closed or open. In the case of joysticks and buttons, that is usually either a *microswitch* or a *leaf switch*. When the tiny button on the microswitch is pressed down or the two leafs of the leaf switch are pressed together, the switch is closed and sends the appropriate signal. When they are not pressed, the switches are open and send no signal, normally. There is one exception to this, although technically it's really not an exception at all. Microswitches, as discussed earlier, have three contacts — *common* (COM), *normally open* (NO), and *normally closed* (NC). When you connect to the COM and NO contacts, you're using the switch in a situation where it's normally open (that is, not pressed). Only when it's pressed should the button send a signal to the computer. If you connect to the COM and NC contacts, then you're using the switch where it's normally closed (that is, constantly pressed). You want a signal sent only when the button is released. An example of using a button in this configuration might be a button that's used to monitor the back door of the arcade cabinet. When the door is shut, the button is pressed (normally closed), and all is well. If someone opens the door, the button is released or opened, and it sends a signal to the computer telling it that it's active. The computer then shuts the game down. This is called a *kill-switch* and is occasionally used for safety considerations. An unknown, defective kill-switch has been the bane of many an arcade repair technician who doesn't know to look for it! At any rate, this is entirely a matter of semantics because whether the button is normally open or normally closed, it still has only two possible states, and for all intents and purposes works the same. For the purposes of any discussion in this book, assume microswitches are normally open.

Another way that digital values are created and sent to the computer is by *optical encoders*. Mice, trackballs, and spinners use optical encoders. The encoder wheel (discussed while talking about spinners and trackballs in Chapter 4) rotates between two halves of the optical encoder, as shown in Figure 7-2. The disc has holes punched in it around the outer rim at regular intervals. The optical encoder sends a light beam from one half to the other half. When the disc is spun, the holes alternately block and let through the beam of light, which is translated into digital data. The faster you move the physical mouse, the faster the light-dark-light-dark pattern is generated. This corresponds to increased speed of the cursor on-screen. There are normally two wheels (one for the X axis, one for the Y) and two light beams per wheel, which allow the mouse electronics to determine not only how fast you're moving but also in which direction. Although the method of how they're created is different (physical button presses for switches, light beam patterns for optical encoders), the end results are the same. Digital data is generated and sent to the computer.



Used by permission of Happ Controls.

Figure 7-2: An encoder wheel between two halves of the optical encoders.

Arcade Cabinet Wiring 101

Now that you have a feel for the difference between digital and analog, it's a good time to talk about wiring your arcade cabinet project. Wiring is the *nerve system* of your cabinet: It allows the various parts to talk to one another. Getting the wiring right is a crucial part of creating your project. Fortunately, it's not a difficult task, and there are several options for wiring your cabinet.

NOTE **The information in this section applies to wiring arcade controls to your control panel. Wiring up lights and powering the cabinet are covered in Chapter 15.**

Traveling the Arcade Circuit

The principle behind how electricity flows through an arcade control is very simple. Every switch attached to a joystick, button, or other arcade control is used to complete a *circuit*. A circuit is basically a path for electricity to flow through. The electrons in the circuit flow from the source's negative side to the positive side, usually through one or more components (such as a button's microswitch). The source in this case is your arcade cabinet's *interface*, which is covered in detail in the next few chapters. If the path the electrons flow through is interrupted, then the circuit is broken and there's no electrical flow. If the path is complete, then the circuit functions and electricity flows.

WARNING **Although all the material in this chapter refers to low-voltage wiring in the 5- to 12-volt range, it is still electricity. It is unlikely that you would become injured, but it is possible to do damage to your computer components with improper wiring. Please use reasonable caution as you approach your wiring.**

The switches used in your arcade controls complete or break the circuit's path, depending on whether they are pressed or not pressed. Normally the switches are not pressed (normally open) and the circuit is broken. When you press the button or move the joystick, the circuit is completed and electricity flows (see Figure 7-3). This alerts whatever interface you're using that something has happened, and appropriate action is taken (for example, Mario jumps another barrel).

Shopping List

Let's start by looking at the essential components for wiring. You need a few tools, good wire, and miscellaneous consumable supplies. You can find these at any Radio Shack, electronics, or home improvement store.

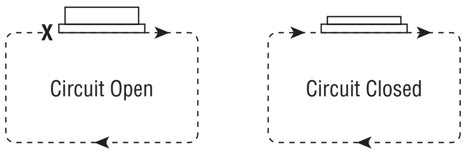


Figure 7-3: *Left*: A button not pressed (normally open), breaking the circuit's path. *Right*: A button pressed, closing the circuit and allowing the current to flow.

Tools

You need a handful of tools for the next few steps of your project. You can see a representative sampling in Figure 7-4.

Figure 7-4: Most of the tools you're likely to need for wiring. Clockwise from upper left: Soldering iron in soldering station, extra hands, soldering gun, screwdrivers, multimeter, solder-removal tool, and crimping tool.

TIP A word on tool quality: It's possible to get tools cheaply, and it's possible to get cheap tools. Those are not the same thing. A good tool is almost always worth the price paid for it, whereas a cheap tool may not be a bargain no matter what the discount. If you're going to do a project such as this more than once (and the fact that you're reading this book means it's quite possible), then consider investing in good quality tools. The amount of effort and frustration they'll save you will more than justify the extra cost in the long run.

- **Soldering iron.** A soldering iron is used to melt solder onto electrical components to make permanent wiring connections. Soldering irons come in different shapes and power ratings. Cheap soldering irons typically have lower temperatures and will take longer to melt the solder, causing no end of frustration. I was once convinced that mastering soldering was beyond me, which was infuriating, as I knew the skill was not complicated. Obtaining a good soldering iron and solder made all the difference.

- **Soldering station.** A soldering station comes in handy when working. A soldering iron gets very hot, and you need a safe place to store it while soldering. The damp sponge is used to clean the iron between soldering jobs.
- **Extra hands.** A solid base with alligator clips to help hold items while soldering solves the problem of needing three hands.
- **Soldering gun.** A soldering gun serves a similar purpose as a soldering iron with a different shape. Soldering guns heat up quicker than soldering irons but can be difficult to use for precise work.
- **Screwdrivers.** Screwdrivers are needed to attach wiring to screw-on connectors.
- **Multimeter.** Multimeters are used to test electrical connections and components. They have multiple settings to test various electrical properties. They are extremely useful in testing for breaks in wiring.
- **Solder removal tool.** Some of the techniques involve de-soldering a component so you can modify it. A solder removal tool is invaluable for these efforts.
- **Crimping tool.** A crimping tool is used to crimp wire onto wiring connectors, as well as other functions such as stripping and cutting wire.

Supplies

Likewise, you will need various consumable supplies to wire things up. A good rule of thumb for supplies is to buy more than you think you need. Sooner or later you almost always find out that you underestimated your needs. It's better to have some left over than to come up short and have to wait till you can get more before you can proceed. Figure 7-5 shows some of the supplies you're likely to need.

- **Solder.** The soft metal substance is melted onto two electrical components or wires to bond them together and allow for electrical connectivity.
- **Soldering braid.** Soldering braid is a spool of material used to absorb solder when de-soldering. It can be used instead of or in conjunction with a solder removal tool.
- **Wiring blocks.** Wiring blocks are long blocks of plastic with screws used for connecting wires together. It can be used instead of soldering or other types of connectors.

- **Electrical tape.** Used for temporary (and sometimes not-so-temporary) connecting of wire, electrical tape is insulative and will not conduct electricity.
- **Wiring disconnects.** Wiring disconnects are male and female spade-type connectors used to connect wiring. Connectors allow for quick removal and reattachment.
- **Connector plugs.** Connector plugs, such as the Molex style in the upper left of Figure 7-5 or the DB-25 style in the upper right (both unassembled), together with their opposite partners allow for quick connecting and disconnecting of multiple wires at once instead of one at a time.
- **Wire.** Obviously, to wire components together, you need wire. See the following section for a discussion on wire.
- **Cable ties.** Cable ties are used to bundle cable together, which will help to avoid *spaghetti* wiring.

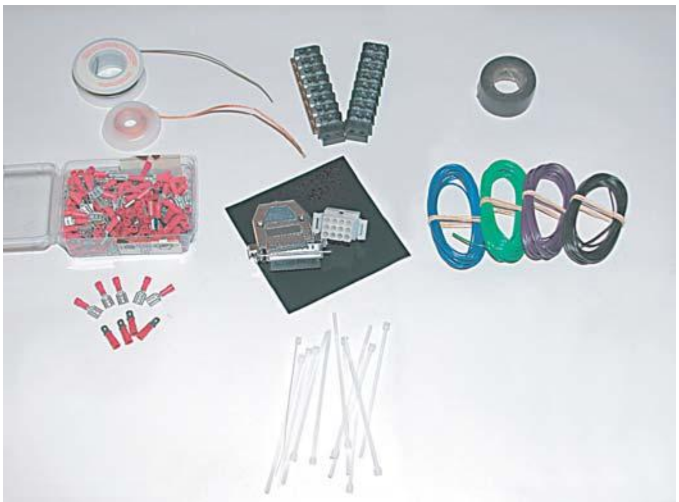


Figure 7-5: A well-rounded stock of supplies. *Top row*: Solder and soldering braid, wiring blocks, and electrical tape. *Middle row*: Wiring disconnects, DB-25 and Molex connector plugs, and wire. *Bottom row*: Cable ties.

Some vendors, such as Ultimate Arcade (`www.ultimarc.com`) and The Real Bob Roberts (`www.therealbobroberts.org`), sell wiring kits that have assembled some of the supplies and tools for you.

Wire

You have two goals when it comes to wiring your arcade cabinet project: You want it to work, and you want it to be safe. Neither goal is difficult to achieve as long as you put a little bit of thought into it beforehand. There are many different wire choices available to you. I'll discuss several options and make a recommendation in the following paragraphs.

Solid Core Versus Stranded Wire

Two different kinds of wire are used in electronic applications. *Solid core wire* is wire that's composed of one single metal strand of wire wrapped in a single run of insulating material. *Stranded wire* consists of multiple strands of wire run together in a single wrap of insulating material, effectively forming a single wire. Solid core wire is stiff and holds its shape when bent. It can break with repeated flexing; therefore, it is used in applications that are not likely to see a lot of movement, such as in-wall wiring. Stranded core wire is flexible and not likely to break with flexing. It is used in applications that are likely to see a lot of movement, such as extension cords. Stranded core wire is easier to work with and is usually preferred over solid core by arcade cabinet builders.

18 to 22 Gauge Wire

Typically, *18 to 22 gauge wire* is used in arcade cabinet construction. It's available in many solid colors, which is useful for keeping track of which wire goes to what control. Wire gauge is a measurement of the size of the wire. The higher the number, the smaller the wire — for example, 22 gauge wire is thinner than 18 gauge wire. Wire of 18 to 22 gauge is roughly a millimeter and a half in size. This wire is well suited for any connection method.

WARNING **Using an incorrectly sized wire gauge can lead to problems such as the wire heating up, which can be a dangerous fire hazard. For the low voltages used in the control panels, overheating is not likely to occur. However, be aware of the possibility of overheating and take care when wiring.**

Cat3 and Cat5 Cable

Cat3 and Cat5 cable is used in the cabling industry for voice and data networks. It has eight individually-wrapped wires contained in a single sheath. Each wire is color coded with a different color and is about 1 millimeter in size. Some people prefer to use this cable because the bundle of eight wires allows for quick and easy wiring. These wires are difficult to use with quick disconnects and are better suited for screw-down or soldered connections.

Phone Cable

Phone cable comes in a variety of shapes and wire counts. You can obtain rolls of phone cable in round sheaths (similar to Cat3 and Cat5 cable) and also in flat ribbons of wire. There will usually be four, six, or eight wires per cable. Other than the shape and wire count, the properties of phone cable are essentially the same as Cat3 and Cat5 cable.

Ribbon Cable

You've probably seen *ribbon cable* inside a computer connected to a CD-ROM or hard drive. It's a flat ribbon of cable with a varying number of small wires inside, usually a high count like 40 or so. The wires are approximately a millimeter or less in size. Some people like the high wire count for cabling purposes. However, all the wires look the same, so you have to identify them by their position in the ribbon and not by color. Doing so can be difficult. Wiring blocks or soldering will be necessary with this cable.

Recommendation

When in doubt, do what the professionals do. Those who know use good-quality stranded 18 to 22 gauge wire to wire arcade cabinets. Bob Roberts of The Real Bob Roberts Web site (`www.therealbobroberts.org`) recommends 18 gauge wire for power conductors, and 20 gauge for all the rest (22 gauge if you don't have 20). Wire of these sizes is big enough to be able to work with easily, yet still small enough to be neatly bundled for a professional appearance. A big spool of black wire for all the grounding (see the "Grounding" section in this chapter) and several smaller spools of different color for each control are ideal. It's difficult to advise how much wire to purchase, as that amount will be determined by the number of controls and distance between the controls and the interface used. A generous rule-of-thumb estimate is three feet of black wire and three feet of colored wire per switch. Remember that each button has a single switch, and that joysticks usually have four. Wire is cheap (you can find it for 5 cents per foot), so stock up.

NOTE **Don't forget to leave enough slack in your wiring path to be able to lift up the control panel for maintenance! It's extremely annoying to have to disconnect wiring or work in cramped space because you can't lift off the top of your control panel due to short wiring.**

Wiring Techniques

Wire is a way for electrical signals to travel from point A to point B. The method used to attach the wire to the end points depends on what their mounting requirements are. In arcade cabinet projects, the methods used fall into three broad categories: crimp-on connections, soldered connections, and straight connections.

Crimp-on Connections

Crimp-on connections involve attaching a terminal connector of some kind to the end of the wire. The top half of Figure 7-6 shows several different crimp-on connectors.

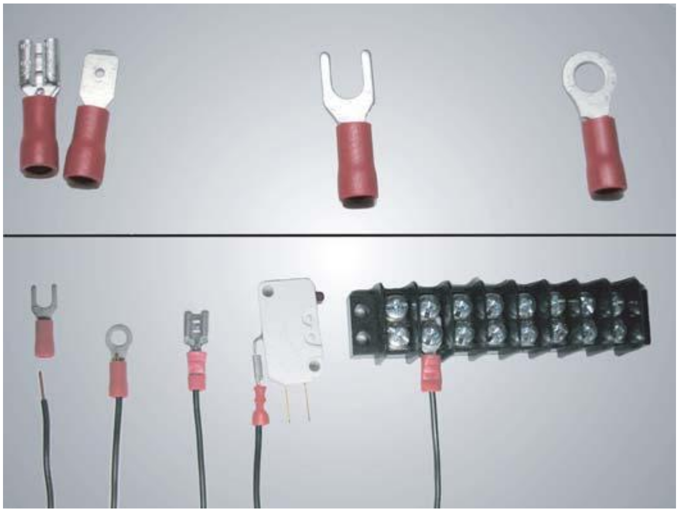


Figure 7-6: Blade terminals, spade terminals, and ring terminals.

Using your multipurpose crimping tool, strip off approximately 1⁄4 inch of the insulation from the wire. Insert the exposed copper into the terminal up to the point where the insulation begins, and then crimp the terminal down onto the wire (see Figure 7-6). Give it the tug-test to make sure the wire is properly seated in the terminal; it should not have any give to it. Make sure the terminals you use are of the proper type and size for the wire and component you're connecting. The terminal will have a rating for the wire gauge it supports and a size rating for the connector. For instance, most microswitches use a .187-inch male-blade connector, so your terminal would need to be a .187-inch female-blade connector with the appropriate gauge rating for your wire. Crimp-on connectors are often used in conjunction with wiring blocks.

Soldered Connections

Soldering a wire to a component or two components together is used when you want a permanent connection. It is possible to de-solder such a connection, but it's not something that can be done quickly, so consider this a permanent connection. You're most likely to want to solder connections when hacking arcade controls, such as replacing potentiometers in a yoke or steering wheel to make them compatible with a computer game port.

Good soldering technique is not difficult to learn. The core concept is simple: When you use an appropriate temperature soldering iron, the solder is heated to the point of melting, at which point it flows onto the components you're connecting. Remove the soldering iron and the solder quickly cools, attaching the two components together and forming a good electrical bond. However, there are some nuances to soldering that, if not grasped, will lead to frustration and bad solder joints. A bad solder joint will appear to be connected but in fact will not have a good electrical bond and can intermittently fail. I'll start by pointing you toward a good soldering tutorial and then give you a few pointers. Steve's MacMAME Arcade Experiment is a website which provides a good introduction to soldering (`www.starbase74.com/mame/solderframe.htm`, also included on the companion CD-ROM).

WARNING **Be careful when soldering! The soldering iron can reach temperatures over 800 degrees. You don't want to burn yourself or cause a fire through inattentiveness. Never leave a hot soldering iron unattended! Also, solder isn't pleasant to inhale (read the warnings on the package; it's nasty stuff). Make sure to have adequate ventilation when soldering. Use reasonable care, and you'll be fine.**

A Quick Step-by-Step Guide to Soldering

1. Assemble all your needed parts and tools, ensure adequate ventilation, and heat the iron for several minutes before using it. An iron that has not reached optimal temperature will not work well.
2. Tin the iron's tip by melting a bit of solder to it. The layer of solder will help promote heat transfer from the iron to the solder and components to be soldered. An un-tinned iron will not work as well.
3. Make sure the surfaces to be soldered are clean. This step is very important. Surfaces dirty with oxidation, oil, or grime will reject the solder, causing it to bead up instead of bond. Flux can be used to clean the surfaces if your solder doesn't have a flux core. If your solder does have a flux core, then you can clean the surface with an abrasive eraser, file, or similar tool. A final wipe with rubbing alcohol will clean the surface.

WARNING **Alcohol and a hot iron do not mix! Keep one well away from the other, and make sure the surface has dried off before getting the iron near it.**

4. Heat the components, not the solder. Solder flows toward the heat. To solder properly, apply the iron to both components to be soldered at the same time. Touch the solder to the components, not the iron. The heat will transfer from the components to the solder, causing the solder to flow onto the components. Resist the urge to heat the solder directly! See Figure 7-7.
5. Use the flat part of the iron's tip, and not the very point (see Figure 7-8). The more surface area of the iron you apply, the greater the heat transference.

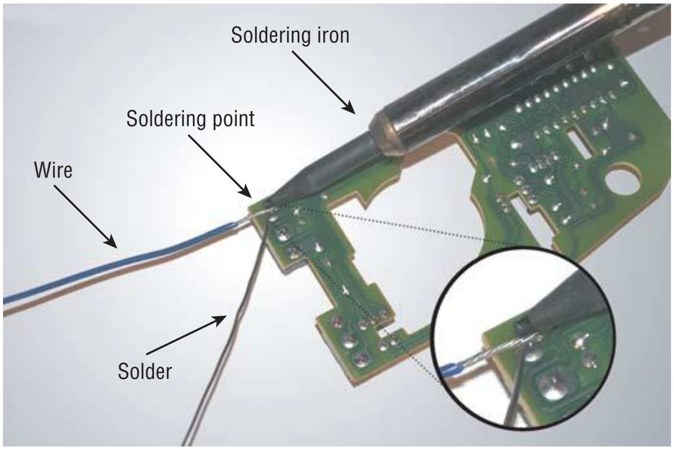


Figure 7-7: Properly applying heat to the components to be soldered.

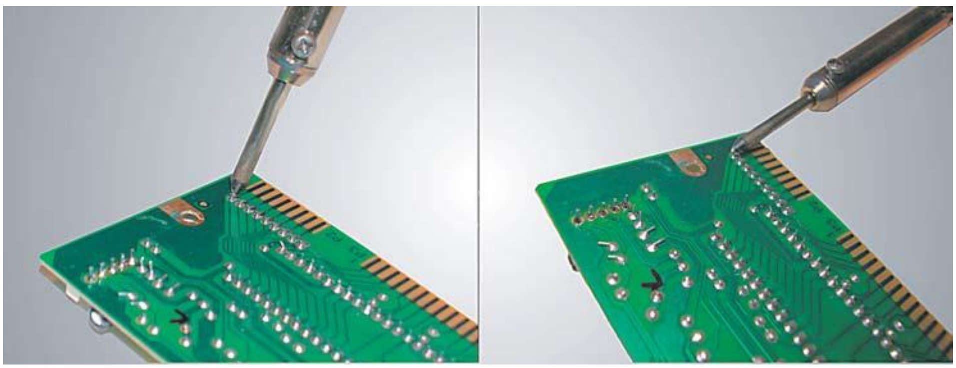


Figure 7-8: *Left*: Incorrect way to use the iron's tip. *Right*: The correct way.

6. Soldering should occur quickly. It should not take more than a few seconds for the solder to reach melting point and flow onto the components. Leaving heat on circuit boards for too long can damage the components; and if the solder hasn't melted after a few seconds then something is wrong. Check for cleanliness of the components and the iron.
7. Pre-tin wires by applying solder to them and then letting them cool, as shown in Figure 7-9. When it's time to attach the wire to the component, the pre-tinned wire will make it easier.
8. When you remove the iron from the solder joint, hold the components that have been soldered still for a couple of seconds until the solder has cooled completely. Allowing the components to move before the solder has fully set can cause *cold solder joints* that will not work properly.

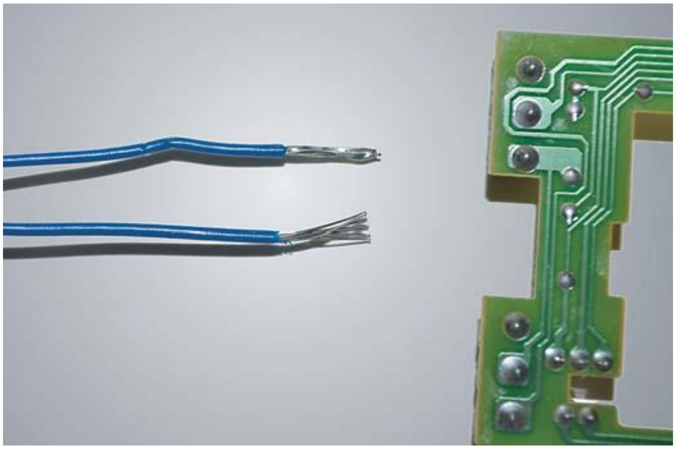


Figure 7-9: An un-tinned wire below, pre-tinned wire above.

9. Clean your iron between soldering tasks by wiping it on a cold damp sponge.
10. Practice soldering on scrap material a few times until you're comfortable with the technique before you work on the real components.

De-soldering is the process of removing solder from a previously joined connection. The process is similar to soldering up to the point where you have the solder melted. If you are using a solder-sucker such as a bulb or vacuum tube, then you simply use that to lift the solder off when it is melted. Alternatively, many professionals prefer the use of a de-soldering braid. This is a flexible wire mesh that you put between the solder and the iron, and then heat the braid. The solder melts and is absorbed into the braid. Either way will work, just be careful once again not to overheat the component you are de-soldering.

Straight Connections

A quick and easy way to attach wiring is with a *straight connection*. That means a connection where the wire is attached directly to the component without any extra parts required. For instance, many of the commercial interfaces have screw terminals for the wiring to attach to (see Figure 7-10). Simply strip about 1⁄4 inch of the wire and insert it into the screw terminal. Tighten the screw down onto the wire until snug and make sure it passes the tug-test. Another way to connect wire is to a wire block with screw terminals. Unlike the first kind, you actually wrap the wire around the screw and then tighten the screw down onto the wire. This kind of connection tends to get sloppy and is not recommended, if you can avoid it. The one disadvantage of both of these straight connects is that changing or removing things around involves unscrewing each wire, which takes longer than quick disconnects.

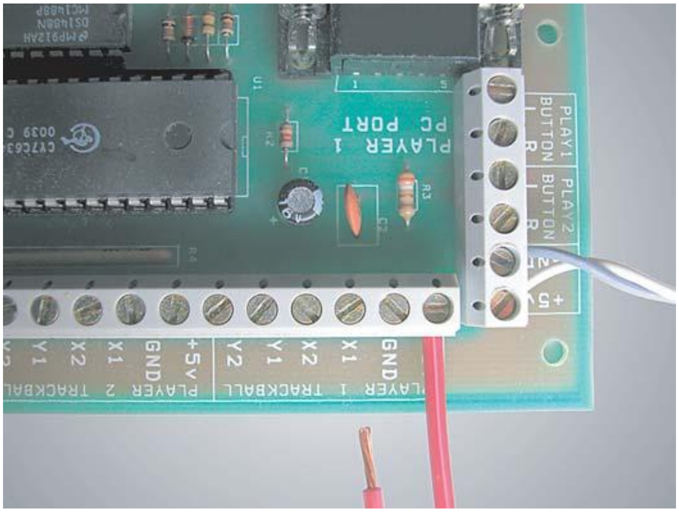


Figure 7-10: Attaching wires to the screw terminal block on an interface.

Wiring Blocks

Wiring blocks, sometimes referred to as *barrier strips*, are good ways to connect two components together when you don't want to wire directly between them. Neatness and ease of wiring are two reasons you might want to use wiring blocks.

Wiring blocks come in strips of varying sizes, with two columns of screw terminals. Each screw terminal is connected to its counterpart in the pair and will conduct electricity to the other side. Each pair is isolated from other pairs and will not conduct electricity to the other pairs. Wiring blocks can be attached to spade or ring terminals, or directly to the wire.

Grounding

Every switch in your arcade cabinet will have two wires coming from it. One will go to the positive side of the interface you've chosen, and one will go to the ground side. Each switch's positive connection will go to a unique terminal on your interface. The ground side, however, does not have to go to a unique terminal on the interface. In fact, most interfaces come with only one or two ground terminals, so you need a method to connect all the grounds to those few ground terminals. Bringing all the grounds to the same place is referred to as a *common ground*; you often hear people refer to a ground as a *common* instead. Recall that the microswitches discussed earlier in the book were labeled NO, NC, and COM (for common ground).

You have a couple of good choices for wiring all your grounds. One method that works well is to *daisy chain* the grounds together. Start by attaching a wire from the interface's ground terminal to the first switch's ground. Then attach a second wire from the switch's ground to the next switch. Repeat until each switch's ground is connected to another switch. Attach the last switch's ground to the ground on the interface, creating a giant loop of linked grounds. Every switch except for the two at each end of the chain will be connected to two other switches. The two switches at the end will be attached to the interface ground. The advantage of doing it this way is that you use much less wire than you would running a separate ground to the interface per switch, which results in a much neater wiring job. The fact that both ends of the chain are connected to the interface's ground means that even if one of the daisy-chained wires breaks or comes loose, all the controls will continue to function because they'll have a path to ground. Only if there are two breaks in the ground chain will some of the controls stop working.

TIP **Ultimarc (`www.ultimarc.com`) sells a pre-daisy-chained ground wiring harness with 144 connectors that you can cut down to size.**

The other method to ground multiple devices is to use a wiring block. Recall that every pair in a wiring block is isolated. The way to use a wiring block for common grounding is to connect the screw terminals in one column together, effectively making every screw terminal connect to all the others. You can do this by wiring between them or by using a strip made for this purpose (see Figure 7-11). Then attach one terminal to the ground terminal on the interface, and the rest of the terminals can be used for individual switches. There's a lot more wire involved doing it this way; daisy chaining the grounds is the better choice.

Sharing Controls

Sometimes, you may wish to have two separate controls appear to the arcade cabinet as one. For instance, you may have an eight-way joystick and a four-way joystick for player 1's side. Your game will recognize only one set of controls for player 1. What can you do? Fortunately, the solution is easy to accomplish. Simply connect the inputs from one joystick to the same place as the second joystick. That is, the positive side of the up switch on joystick 1 will connect to the same place as the positive side of the up switch on joystick 2, and so on. You can either do that by running wire from each switch to the same terminal on your interface or by daisy chaining the switch from one joystick to the switch on the other and running a single wire from there to the interface. Both solutions work equally well. The only thing to be aware of is that both joysticks are active at the same time. If you're trying to run the by-now exhausted Mario to the left on one joystick, and someone moves the other joystick to the right, Mario will stop running and have a nervous breakdown!

Figure 7-11: A wiring block with every terminal interconnected by a metal strip.

Tapping Into Power

Some of the things you want to have in an arcade cabinet may need power sources. Most of them do not, being simple passive devices. Most buttons and joysticks, for instance, simply open and close circuits when pressed and don't need any power by themselves. Some buttons and joysticks, however, do need a source of power that is a separate circuit from the open/close circuit that detects a button press. For example, the control may be illuminated and so the light or LED will need power. Other devices that use optics instead of physical switches will need a power source to run the optical encoders, such as spinners, trackballs, and the Happ Controls Perfect 360 joystick.

You can get power to these controls from a variety of sources. Some of the commercial interfaces you can purchase include +5v (5-volt) connections you can use. If you don't have +5v available from your interface, you can pick it up from a variety of locations. People have used +5v from the keyboard and mouse ports, USB ports, game ports, and directly from the PC power supply. Of all these, the only one I recommend is directly from the PC power supply.

WARNING **If something goes wrong in your wiring and there is a short, you can burn out whichever port you're pulling power from and possibly the motherboard. This is usually fatal to the computer, though you might get lucky if there's a replaceable fuse that blows. Unfortunately, you usually won't find a replaceable fuse. If something goes wrong and you're using power directly from the power supply, then you might blow out the power supply but the motherboard should be safe. Getting the power supply repaired or replacing it is almost always easier and cheaper than a fried motherboard.**

The power cables that come from the PC power supply contain 4 pins: +5v, +12v, ground, and ground. The +5v is usually red and the +12v is usually yellow, but measure with a multimeter to be sure. Tying into these is a simple matter of purchasing an extension or splitter cable, cutting off one end, and wiring that appropriately (see Figure 7-12). Be sure that you seal off any stray wires that you aren't using with electrical tape or wire nuts, or preferably remove them from the plug altogether. Then you can simply plug into the power cable from the power supply. You *could* cut the end off the power cable from the power supply directly, but that's a permanent alteration. Doing it with an extension cable allows you to change things around later.

WARNING **It should go without saying, but never work with the power supply until you've unplugged it! Don't just turn it off; make sure it's unplugged!**

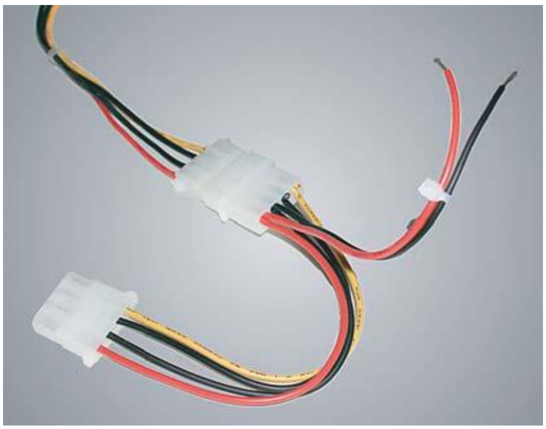


Figure 7-12: Tapping into a PC power supply.

Wiring the Happ Controls Perfect 360 joystick

The Happ Controls Perfect 360 joystick is a tad confusing to wire and deserves a bit of additional explanation. Recall that the joystick uses optical sensors instead of physical switches, so it needs a power source. The 360 has six contacts underneath it: one each for up/down/left/right, a +5v, and a ground (see Figure 7-13). If you are able to get +5v from the same interface to which you're attaching the directional contacts, then it's easy. Wire each direction to the appropriate connector on the interface, the +5v to the interface's +5v connector, and ground to ground.

What if you need to get power from a different source? Say you are getting power directly from the power supply. The four directional contacts will go to the interface as usual. The +5v contact on the 360 will go to the power cable from the power supply. Where does the ground go? Electricity flows only if you have a complete circuit, right? If you wire the ground to the power supply, then the optical encoders have a complete circuit, but what about the directional contacts? If you wire the ground to the interface, then haven't you created an incomplete circuit for the optical encoders? Fortunately, the answer is no. The interfaces all get their power from the same place. All the powered components that attach to the computer ultimately get their power, both positive and ground, from the same source — the PC power supply. By attaching the ground to either the interface or the power supply, you've created a complete circuit for all parts of the joystick. It's easiest to connect the ground to your interface or ground wiring block instead of to the power supply.

Used by permission of Happ Controls.

Figure 7-13: The labeled underside of a Happ Controls Perfect 360 joystick.

TIP **When you wire your joysticks, remember that up is down and left is right. Perfectly clear, right? When you press a joystick to the right, the bottom of the joystick under the control panel is pushing left. Therefore, the left-hand microswitch is the one that activates right, and vice versa. Keep this in mind. A lot of folks get this wrong. Happy wiring!**

How It All Works

The entire chapter to this point has been to give you the background for the magic that makes it possible to turn an ordinary personal computer into a laser-blasting, noise-making arcade machine. The core concept is that all the interaction between you and the computer takes place in an analog or digital fashion through the use of devices wired to the machine. It's a deceptively simple concept, but the fact that a circuit's a circuit no matter what hardware components are used is what makes everything work. Whether the circuit is a keyboard button being pressed or an arcade button, a mouse being moved or a trackball being spun, to the computer *it all looks the same*. We can connect to the keyboard interface on the computer and generate an F keystroke by pressing a shiny red arcade button! A spin of a lit-up blue trackball can move the mouse on the screen! I recall the first time I found this was possible that my jaw dropped as I realized the possibilities. All you need to complete the puzzle is an interface that sits between your arcade controls and the computer so that they can talk to each other. I cover that in the next few chapters.

Summary

Your computer is a digital device that interacts with the outside world through other digital and analog devices. Arcade controls are digital and analog devices. The two seemingly separate worlds can be induced to talk to one another, starting with wiring the arcade controls to your control panel in preparation for the next step. Good wiring is a core ingredient for a successful arcade cabinet project. Using the proper tools, materials, and wiring techniques will help you achieve this. It also happens to be a lot of fun!

The rest of the chapters in this section are devoted to making the computer think your arcade controls are in fact regular keyboard, mouse, game-port, and USB devices. First up in the next chapter is using the keyboard interface. Arcade paradise, here you come!

CHAPTER

8

Using the Keyboard Connector for Arcade Controls

IN THIS CHAPTER

- **Hacking a Real Keyboard**
- **Multiple Keyboard Connections**
- **Customized Keyboard Encoders**

You are more likely to connect your arcade controls to your computer through the keyboard port than any other way. Everyone who has a computer has a keyboard, but not everyone has a joystick or game pad. Software developers know this, so almost every game made for the computer includes the ability to control it with a keyboard. Even my favorite driving game, Need For Speed: Porsche Unleashed, can be played with a keyboard, though I don't recommend it.

Taking advantage of what you learned in the previous chapter, this chapter will show you how to use the keyboard port to connect your arcade controls. I'll start by introducing you to the various methods and products available. At that point, you'll know everything you need to know to be able to select an interface method and start connecting wires! If you're following along and building the Project Arcade 2 machine instead of your own design, I'll fill you in on the method chosen for the machine at the end of the chapter. You've come a long way, but, so far, all you have is something to look at. After this chapter, your mad-scientist creation will actually be able to *do* something!

Hacking a Real Keyboard

Remember, I said you might get to take something apart? I'm sure I heard someone laughing with glee when I mentioned that. Well, now's the time! Back in the beginning days of this hobby, the only way we knew to connect arcade controls to your computer was by hacking apart a keyboard. (Several keyboards were harmed during the creation of this chapter!) I'll start by taking a look at how keyboards work and then proceed into turning one into an arcade interface.

How Keyboards Work

What do keyboards do? In simple terms, a keyboard allows you to press a key, which closes a circuit associated with a particular keystroke. That closed circuit is detected by a mini-computer inside the keyboard called a *keyboard encoder*, which recognizes which key has been pressed. The keyboard encoder takes that information, encodes it in a digital form the main computer can understand, and passes it to the computer via the keyboard port.

The actual physical makeup of a keyboard can vary quite a bit. A typical design includes either a circuit board or a flimsy material (simply flimsy hereafter) that lies underneath the buttons on the keyboard. Laid out on the flimsy is a maze of circuits. Directly beneath each keyboard button on the flimsy are two halves of a circuit. The underside of the button has a conductive material of some kind. When the button is pressed, the conductive material comes into contact with the two halves of the circuit below, which completes the circuit. Variations on this design exist, but almost all are similar. Take a look at Figure 8-1 for an example.

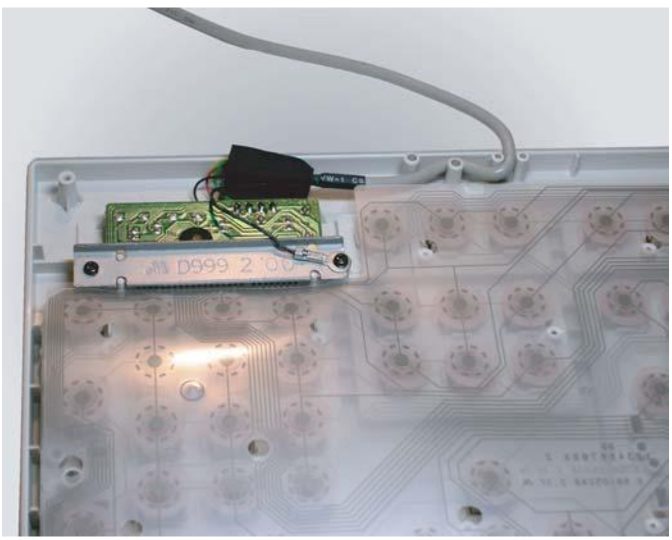


Figure 8-1: The circuit traces on the flimsy all come back to the keyboard encoder shown in the top left.

How the keyboard operates should sound very familiar. It's just like the arcade pushbutton coming down to press the microswitch button, which completes that circuit. The only piece that the keyboard has that is missing in the arcade pushbutton circuit is the keyboard encoder. Could we use the encoder from a real keyboard for our purposes? Take a look at the keyboard encoders shown in Figure 8-2.

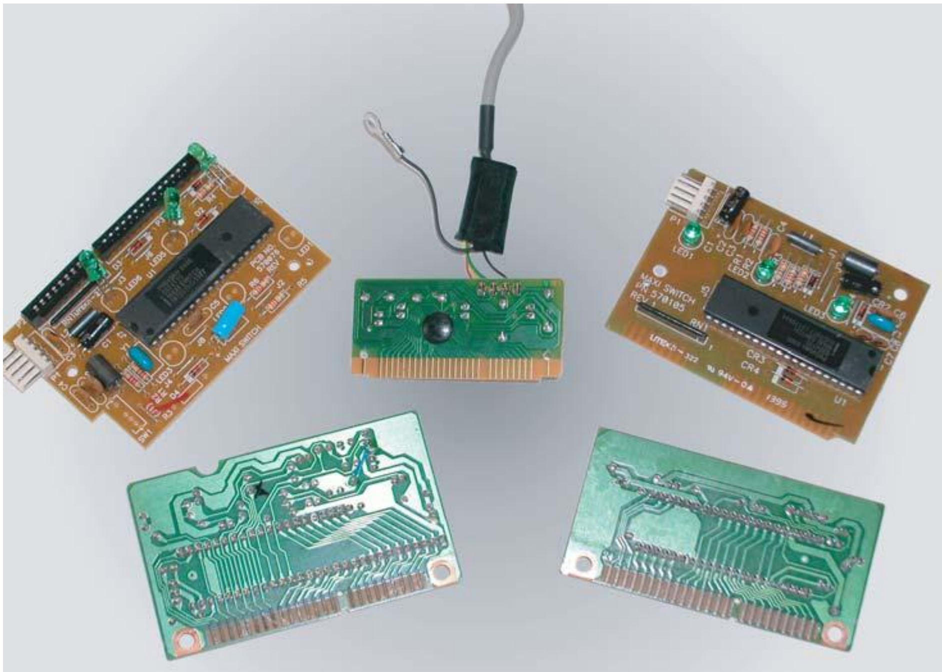


Figure 8-2: Some keyboard encoders removed from their keyboards.

Notice the connectors at the edge of the keyboard encoder boards. Those stripes are the contacts that the circuits on the flimsy come back to. If you start counting, you'll realize that there aren't nearly enough contacts to account for all the keys on the keyboard. Even if every key's circuit used a shared common ground, there are still not enough contacts to account for the 100 or so keys found on a typical keyboard. What's going on?

If a keyboard were configured to use *discrete contacts* (one contact per key), there would be over 100 contacts required and a keyboard encoder chip with the same number of pins on it! That would be big and expensive — something manufacturers always try to avoid. Instead, keyboard makers take advantage of a design technique called a *matrix*. No, Keanu Reeves is not going to show up suddenly in your arcade cabinet. A matrix is a method of using a small number of contacts to account for a larger number of inputs by arranging them into a grid. Take a closer look at the keyboard encoder in Figure 8-3. Notice the contacts separated into two groups. There are 14 contacts on the left and 8 on the right.

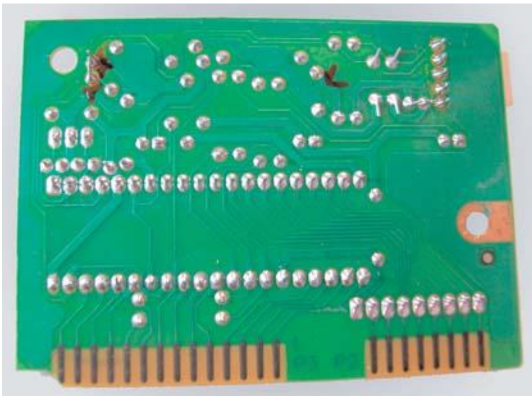


Figure 8-3: A close-up look at the contacts of a typical keyboard encoder.

If the keyboard were set up in discrete mode, there would only be 22 buttons possible on the encoder shown in Figure 8-3 because there are only 22 contacts. However, this encoder is configured in a grid of 14 × 8. This gives a total of 112 possible buttons (14 × 8 = 112) — more than enough for a standard 104-button keyboard. The way it works is that the keyboard encoder has a map of this matrix programmed in its memory. Take a look at the matrix in Figure 8-4. I'll refer to the 14-contact side of the matrix as the *X* side and the 8-contact side as the *Y* side.

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14
Y1	**A**	**I**	**Q**	**Y**	**·**	**·**	**·**	**·**	**·**	**·**	**·**	**·**	**·**	**·**
Y2	**B**	**J**	**R**	**Z**										
Y3	**C**	**K**	**S**	**1**										
Y4	**D**	**L**	**T**	**2**										
Y5	**E**	**M**												
Y6	**F**	**·**												
Y7	**G**	**·**												
Y8	**H**	**·**												

Figure 8-4: An example of a possible matrix using the keyboard encoder from Figure 8-3.

The A button is in the first spot on the matrix (X1-Y1). When the A button is pressed, the encoder sees the circuit that connects the first contact on the 14-contact side (X1) and the first contact on the 8-contact side (Y1) (see Figure 8-5). The encoder looks this up in its map and generates an A keystroke.

Determining which keyboard button has been pressed is a simple matter of the encoder doing a lookup in its table for the X and Y value that is generated by the key press. There is no set standard for how a matrix is designed and laid out. Another keyboard manufacturer might configure its matrix to be 13×9, which allows for 117 buttons, with the keystrokes occupying different spots on the grid.

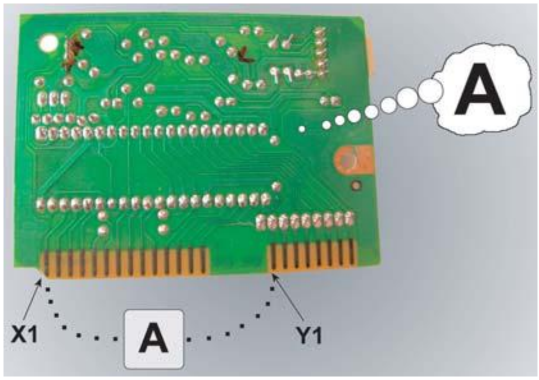


Figure 8-5: The A button pressed.

How To Hack A Keyboard

You may be thinking — based on the previous section's information about how keyboards work — that it should be possible to substitute arcade controls in place of keyboard buttons. In fact, it is, and many people have done just that. With the low cost of keyboards (sometimes with rebates you can even get them for free) and the high number of inputs available, a keyboard hack sounds ideal. It *is* possible to use a keyboard hack, but there are several obstacles to overcome first. Because of the potential drawbacks, I strongly recommend reading this section completely before beginning work. There are many alternatives available if you decide a keyboard hack is not for you, and in fact I highly recommend not doing a keyboard hack unless you want the challenge. Still, it's important to understand the concept of the keyboard hack even if you choose one of the alternatives, so do read on!

WARNING **The rest of the discussion on keyboard hacking can prove hazardous to the health of your computer! There is a +5v (five volt) presence on the encoder board while connected to the computer. If something goes wrong, it is possible to fry the keyboard port on the computer or the motherboard itself. With care, this can be avoided.**

Mapping The Matrix

Your first hurdle will be a time-consuming one. Because every keyboard is different, you will have to determine manually the matrix your keyboard uses. I'm assuming you've taken apart your sacrificial keyboard and disconnected the keyboard encoder board from the rest of it. The procedure is simple. First, you need a program on your computer that will tell you what keystrokes are being generated. It's easy to tell when letters and numbers are being pressed with any word processor or notepad application. However, those won't tell you whether you're pressing the left shift key, right control key, and so forth. On the "Download" section of the Build Your Own Arcade Controls Web site (`www.arcadecontrols.com`), there are several utilities that will do that. Download one of them, and fire it up.

NOTE Ghostkeys 1.1 (by John Dickson) is one of the programs that will tell you which keystroke is being generated, and it is included on the companion CD-ROM.

Start by laying out a grid on a piece of paper matching the X and Y contacts on your keyboard encoder. Next, take a length of wire, and strip off 1⁄4 inch from both ends. Hold (or attach with an alligator clamp) one end of the wire to the first X contact. Then, hold the other end of the wire to the first Y contact, and observe the keystroke that is generated on the computer. Record it on your grid, and move on to the second Y contact. When you're done with all the X1 combinations, move on to X2, and repeat. Continue until you have the entire matrix laid out. This can be quite time-consuming!

After mapping the matrix, you need to decide which keystrokes you're going to use for your control panel. You need to consider two factors. First, you need to determine which keystrokes are required by the software you decide to use. Many games are programmable; that is, they allow you to choose which keystrokes perform the in-game functions. However, some have hard-coded keystrokes for game control and do not allow changing them. For instance, the fire key in a particular game may be the F key. Even though all your other games use the left control key to fire, you have to use the F in this one. Second, you need to look at how your keyboard encoder's matrix is laid out. Certain keystroke combinations will be precluded from use simply due to where they are on the matrix. The next section, "Difficulties With Keyboard Hacks," will cover this.

After you map out your keyboard matrix and choose the keystrokes you need, you can begin to wire things up. Take another look at the keyboard encoder from our example in Figure 8-3. The contacts on the edge of the encoder cannot be soldered, and there's no easy other way to attach your wiring to them.

Follow the path of the circuits back a bit to see where they connect up to solder points. *That* is where you can solder your own wiring. The best way to proceed is to strip a small amount off both ends of the wire, pre-tin one tip with solder, and solder it to the contact point. Next, take the other end of the wire, crimp a connector on it, and attach it to a wiring block a few inches away, as shown in Figure 8-6. Repeat with the rest of the contacts. It is easiest to solder all the wires first and then attach them to the wiring block. The advantage of doing it this way is that any modifications are done to the wiring block and not to the wiring between the keyboard encoder and the block. This helps to ensure the wiring to the encoder is not damaged. You don't want to have to re-solder it!

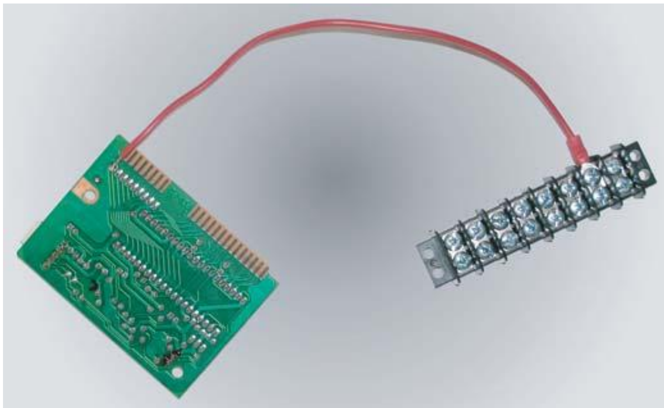


Figure 8-6: The first of 22 wires connected from the keyboard encoder to the wiring block.

Difficulties With Keyboard Hacks

I find the physical work of soldering the wiring to the keyboard encoder challenging, which is mostly due to the tight quarters. However, physical challenges aside, there are other issues with keyboard hacks. I'll cover each one of them briefly.

Ghosts In The Machine

Keyboard hacks can suffer from *ghosting* problems. Keyboards can be haunted? In this case, I am not referring to any nether-worldly spirits. Ghosting is a potential side affect of having a matrix design. What can occur in older keyboards is when three keys are pressed, a phantom fourth keypress is detected by the encoder even though no physical key was pressed. Figure 8-7 shows why this can happen. Recall that a keyboard encoder works by detecting completed circuits. When you press the A button, circuit X1-Y1 is completed. While pressing the A button, also press the B button to complete circuits X1-Y1 and X1-Y2. If you add the O button, something interesting happens. Not only have you added circuit X2-Y1, but, because the three keys — A, B, and O — involve all four terminal points, there are complete circuits between all combinations including X2-Y2 *even though no key was physically pressed at X2-Y2*. The encoder cannot tell that circuit X2-Y2 wasn't intended to be completed. So, it generates a phantom P keystroke.

	X1	X2	X3
Y1	A	O	3
Y2	B	P	4
Y3	C	Q	5

Figure 8-7: A portion of the keyboard encoder matrix.

This only occurs when three keys in the corners of a rectangular area of a matrix are pressed simultaneously. Typically, this does not occur when a keyboard is used for typing. However, this can occur very easily when used for arcade controls. Ghosting could be a problem if, for example, your "up-right" (diagonal movement involving two microswitches) and "jump" keys generated a ghost "quit" key. Picture poor Mario running his heart out, about to jump over one last barrel to save the damsel in distress, only to have the whole game suddenly exit — leaving Mario and his lady in lover's limbo forever. That would be enough to make any pixelated plumber pack up his bags and go into a less stressful line of work, such as gorilla dentistry.

Ghostbusting With Blocks, Design, And Diodes

Three solutions present themselves to the ghosting problem. The first is simply to purchase a new keyboard. Ghosting is a trait of old keyboards from a few years back. Newer keyboards usually have logic designed into the encoders to block ghost keys from appearing. Recognizing when two corner keystrokes of a rectangle in the matrix have been generated, the encoder will simply block the third corner keystroke from appearing. This is known as *keyboard blocking*, and it has its own drawbacks. There may be times when you *want* those three keystrokes to be able to function simultaneously. I'd recommend against it, but you may not have a choice depending on the encoder matrix and requirements of your software. No ready solution is available for keyboard blocking other than to try a different keystroke combination or different keyboard encoder.

The second solution is to select the keystrokes that you are going to use from the matrix such that three corner keystrokes from a rectangle in the matrix cannot be generated. Examine your matrix map, and make sure that no three keystrokes form a rectangle with a fourth keystroke that will cause you problems. This prevents both ghosting and blocking. This can be a problem if your software requires the use of three keystrokes that violates the above rule. However, software that does not allow changing its controls is fairly rare. Another possibility is to choose keystrokes that are impossible to have occur simultaneously. For instance, the keystrokes you choose for up, left, and right could safely be chosen even if they would normally be candidates for causing ghosting because it's impossible to move a joystick in all three directions at the same time. With careful planning, ghosting and blocking issues can be avoided.

The final solution brings up another electrical component — the *diode*. A diode is a device that, in simplest terms, only allows electricity to flow in one direction. A diode has two ends: a cathode (-) and an anode (+). Current can only flow from the anode to the cathode but not the other direction (see Figure 8-8).

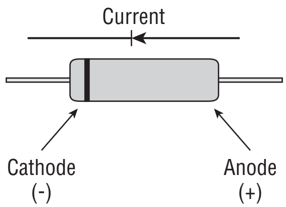


Figure 8-8: Current flow through a diode. The cathode end is marked with a band.

Ghosting is an electrical issue. With proper diode placement, you can prevent electricity from flowing the wrong way on the matrix, which prevents a ghosting situation. The following is paraphrased from information provided by the folks at Hagstrom Electronics (`www.hagstromelectronics.com`), a keyboard encoder vendor whose products are introduced later in this chapter.

While scanning the keyboard matrix for activity, a keyboard encoder will normally check columns in the matrix one at a time. When it activates a column, it will check each row to see whether any circuits are completed for the current active column. It then moves on to the next column. When three or more switches are pressed that share two columns and one row (or two rows and one column) then electrical ghosting occurs. In many early PC keyboards, you will find a diode in series with each button of the keyboard. On these keyboards, you may press every key on the keyboard at the same time, and the keyboard sends all that information to the PC. By placing a diode in series with each switch, ghosting is prevented. The cathode of the diode is connected to the column side of your matrix, the anode is connected to your switch, and the other contact on your switch connects to the row (see Figure 8-9). Using isolation diodes in a matrix to prevent ghosting is a technique that has been used in keyboards for many years — even preceding the personal computer. Cherry Corporation, a popular manufacturer of keyboard switches, even offers an option of built-in diodes on its switches.

Is your head spinning a bit? Don't worry about the theory. If you're suffering from ghosting problems, pick up some 1N4148 or equivalent diodes (a good electronics store will know what to substitute), and connect them up to the switches having problems. One of two things will happen. Your ghosting problem will go away, or the switch will stop working entirely. If it has stopped working altogether, your diode is in backwards. Reverse it, and all is well.

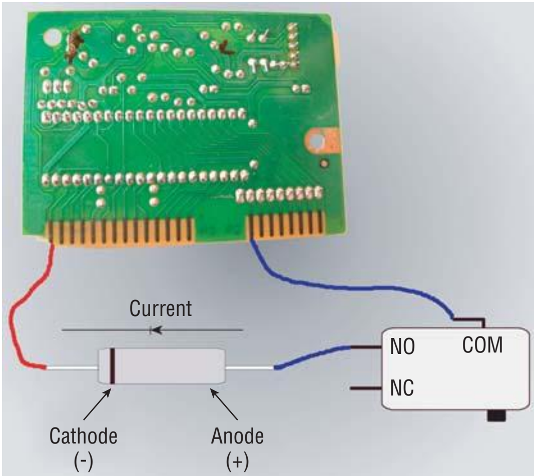


Figure 8-9: An example of a diode used to prevent ghosting.

USB Keyboard Limitations

Be careful about choosing a USB-based keyboard to hack. The USB keyboard interface is designed to limit the number of simultaneous possible keystrokes to six. This isn't a problem when used for games such as PacMan or Donkey Kong, which are unlikely to need more than two or three keystrokes at the same time. However, modern games such as fighting games can easily require many more than six simultaneous keystrokes, particularly if you are building a four-player control panel. PS/2 keyboard encoders often have a maximum simultaneous keypress limit as well, but it's typically between 10 to 20 or so and is unlikely to cause you issues unless you are building a four-player panel. One final possible drawback of USB keyboards is that DOS support for them is limited. Newer computers will probably work with USB keyboards in DOS, but older computers probably will not without finding and installing special drivers that are not guaranteed to work. It is extremely unlikely you're going to be using a computer old enough to have this problem, but bear this in mind just in case.

Keyboard Hack Recommendations

A keyboard hack is not terribly difficult, but it is fairly time-consuming. You should ask yourself what your time is worth to you. There is some sense of satisfaction for having accomplished a keyboard hack and having spent very little money on it, but with solderless commercial alternatives available starting at $34, a keyboard hack is probably not worth the effort. I do not recommend spending the time on one unless you are on an extremely tight budget. If you are going to pursue a keyboard hack, there is a good article on the Internet that I suggest consulting as an addendum to the material presented here. Marshall Brooks has created an excellent document (`www.mameworld.info/net/emuadvice/keyhack2.html`) expanding on the issues presented here as well as providing matrix maps for several keyboard models. Keyboard hacks are recommended only for those on a tight budget building two-player panels.

CROSS-REFERENCE **The keyboard hacking guide by Marshall Brooks (Tiger-Heli) is also included on the companion CD-ROM.**

Multiple Keyboard Connections

You may find there are times when you will want more than one keyboard device functional at the same time. Why would you want that? Take as an example a situation in which you've created a keyboard hack for your arcade controls, but you still need to be able to operate your computer for non-gaming functions. You *could* simply swap plugs, but you should not do that while the computer is on, and rebooting every time you want to change programs would grow tiresome quickly. Wouldn't it be better to have two keyboard devices plugged in at the same time? Your keyboard hack–based arcade controls would be ready to use whenever you wanted, and your un-hacked keyboard could sit inside the cabinet — ready to be used as needed.

You have a few options if you want to use more than one keyboard device at the same time. All of the solutions are good and use different approaches to the problem.

TIP **When I refer to using more than one keyboard device at a time, I mean two keyboard encoders with whatever is connected to them. Presumably, it would be a keyboard-based set of arcade controls as one device and a keyboard as the second. It could just as easily mean two sets of keyboard-based arcade controls. Just remember that the phrase "keyboard device" doesn't necessarily mean a keyboard.**

Keyboard Splitters

A keyboard splitter is not someone who has broken apart their keyboard in order to hack it. A keyboard splitter is a device that converts a single PS/2 keyboard port into two ports. You can find a circuit diagram to build your own on the Internet at `http://mirrors.arcadecontrols.com/stephan.hans/tricks.htm`, if you are so inclined. If you are not electronically inclined, purchasing a splitter is a better choice. P.I. Engineering sells the Y-key key Dual Keyboard Adapter (`www.ymouse.com/ymouse/whym04.php`) shown in Figure 8-10. This retails for around $60 and is plug-and-play. Simply plug in the adapter, plug in both keyboard devices, and turn on the computer. Both keyboard devices are fully functional, and the Y-key key is daisy-chainable; that is, it allows three or four keyboard devices to be connected simultaneously.

Courtesy of P.I. Engineering.

Figure 8-10: The Y-key key from P.I. Engineering.

USB Keyboards

A very easy way to have a second keyboard available on your arcade cabinet is to use a USB keyboard. Just make sure, if you use a USB keyboard, that it is your actual keyboard and not used for a hack, because of the six keystroke and operating system limitations discussed in the "USB Keyboard Limitations" section.

Keyboard Pass-Through

Probably the most elegant solution to the multiple keyboard question is available with many of the commercial keyboard encoders in the next section. They include a keyboard pass-through connector that allows a keyboard to be plugged into the back of the keyboard encoder device. Not every commercial encoder comes with a pass-through so you need to read the details on the ones you might be considering.

Customized Keyboard Encoders

You have many excellent alternatives to a keyboard hack available to you today. When I first became interested in this hobby years ago, keyboard hacks were the only way I knew of to use the keyboard port for arcade controls. In fact, there *were* other possible solutions, but no one had put them and arcade controls together at that time. Since then, not only have vendors with suitable products been discovered, but several cottage industries have sprung up solely to serve the home arcade cabinet industry! In the rest of this chapter, there are many keyboard port-based interfaces you can choose from. There's even one you can build yourself!

All of the following interfaces are custom keyboard encoders suitable for connecting arcade controls via the keyboard port. Each has a set of features addressing some or all of the problems associated with keyboard hacks. They appear to the computer to be a regular keyboard and are available in prices ranging from $27 up to $170, with the higher-priced models supporting extra features. The next few sections cover the highlights of each model.

NOTE **Even though this is the keyboard interface chapter, several of the chapters below have USB interfaces. Even though they physically have USB connectors, to the computer these interfaces all appear as a keyboard. It makes more sense to include them in this chapter accordingly.**

Poring over the next several sections covering multiple different keyboard encoders may prove a bit daunting. I suggest reviewing the comparison chart in Table 8-1 first and then reading the full details on those encoders that catch your eye. However, it's difficult to put all the important details into a single chart so I encourage you at least to skim the introduction to each encoder.

TIP **The chart and encoder descriptions that follow refer to *matrix mode* and *direct mode* inputs. Matrix mode refers to a keyboard matrix as described in previous sections. Direct mode indicates the encoder is using a single pin for each input with no matrix involved and hence no ghosting or blocking possibilities.**

Table 8-1: Keyboard Encoder Comparison Chart

NAME	COST	NUMBER OF INPUTS	PROGRAMMABLE	EXTRA FEATURES
ButtonBox	$35 – $50	Direct: 27 Matrix: 128	Yes	No
Groovy Game Gear Keywiz Eco, ST, and MAX	$26 – $39	Direct: 38 (max), 40 (Eco/ST)	Yes	Shazaaam key gives 32 extra "shifted" inputs
Hagstrom KE18 / KE18 MAME	$45	Direct: 18 Matrix: 81	No	No
Hagstrom LP24	$80	Direct: 23 Matrix: 144	Yes	No
Hagstrom KE24	$100	Direct: 24 Matrix: 144	Yes	Mixing direct and matrix modes

Continued

Table 8-1 *(continued)*

NAME	COST	NUMBER OF INPUTS	PROGRAMMABLE	EXTRA FEATURES
Hagstrom KE72 / KE72T	$120 – $140	Direct: 72	Yes	Spinner/ trackball interface add-on
InterfASD	$37	Direct: 27	Yes	Shift key for an additional 26 inputs
MAMI 24 / 48	$53 – $90	Direct: 24 / 48	No	No
Ultimarc I-PAC^2 / I-PAC^4 / Mini-PAC	$39 – $69	Direct: 32 / 56 / 32	Yes	Built-in programming; shift key; trackball/ spinner interface

The ButtonBox

The ButtonBox (`www.leien.info/buttonbox`) is a build-it-yourself keyboard encoder project designed specifically for connecting arcade controls. It was designed and made available online by an arcade cabinet enthusiast. It supports both direct mode and matrix mode configurations. It handles up to 27 inputs in direct mode and 128 inputs in matrix mode. Assuming you have the tools and depending on how you build it, building the ButtonBox will cost you between $35 and $50. It consists of two separate components: the main CPU card and the direct or matrix-mode daughter card.

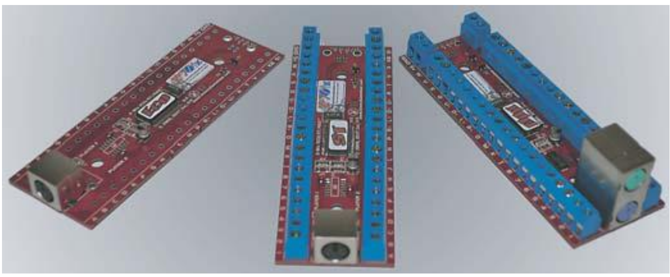
You will have to determine in advance how you want to configure the matrix or direct mode because you will physically construct the daughter card to match your needs. There is no one-size-fits-all daughter card in the design specifications. For instance, if you create an 8 × 8 matrix for 64 inputs and later decide you want an 8 × 16 matrix for 128 inputs, you will have to build a new daughter card. However, the design is a well thought out one. As far as wiring goes, follow the plans for the boards in order to end up with screw-down terminals to which it is easy to connect.

Programming the ButtonBox requires constructing a special parallel cable to connect to it and then running the programming software. Programming cannot be loaded or saved from disk, and it must be done interactively with the encoder. The programming software can be run within DOS or Windows.

The ButtonBox is an interesting home-brew device and has appeal to those who are building an arcade cabinet for the challenge of it. It is included here for those of you who fall into that category. However, the complexity of construction and the costs involved in gathering all the needed components make this impractical for most people.

Groovy Game Gear

Groovy Game Gear (www.groovygamegear.com) is arguably one of the two most innovative vendors in our hobby today. Relatively new on the scene when the first book was written, they have since dramatically expanded their product line. You've seen some of their creations in the various chapters on different arcade controls, and their expertise is not lacking when it comes to interfaces as well. They have three models of keyboard encoders (and several others you'll see in the following two chapters) in their KeyWiz line of encoders (see Figure 8-11).



Used by permission of Groovy Game Gear.

Figure 8-11: The Groovy Game Gear line of keyboard encoders — Eco, ST, and MAX models from left to right.

All three of their keyboard encoders share a core feature set with minor variations. The KeyWiz line supports 40 direct inputs (38 on the MAX version, which I'll explain momentarily) all in direct input mode. Since these are all direct input, there are no ghosting or blocking issues. Groovy Game Gear has done a lot of work "under the hood" on these encoders, with custom machine language programming on fast RISC based microcontrollers. I could go on with techno-babble, but what this means in a nutshell is the encoders just work, and work fast. When you press a button, it's instantly sent to the computer without delay.

All three of the encoders include a shift key dubbed the Shazaaam! key that allows 32 inputs to have a secondary function, for a total of 70 or 72 possible inputs. Press the button you've assigned to the Shazaaam! input, and hold it while you press any other button and you get the secondary function, just like using the shift key on the keyboard (but with programmable results). With the right adapter (basically just two diodes), you can use the Shazaaam! function with a single button press. The two wires essentially connect the Shazaaam and regular input both when you press the single button.

The KeyWiz shines when it comes to programming, with a full-featured programming utility. One unique feature is the ability to associate configuration profiles with certain games. You can create and store up to 15 different configurations in the programming software. When you press the button corresponding to a particular configuration, it not only loads the configuration, but it can also optionally launch the application! You can also switch between the default code set, and your programmed code set, on the fly by holding the Shazaaam! button while pushing the player 1 joystick to the left or right.

The Eco version of the encoder has no wiring block, so you have to solder your wires to the interface. It'll save you about $10, so if your soldering skills are up to it, that's a good option. The ST version adds screw-terminal wiring blocks so you don't have to solder. Neither the Eco nor ST versions have a keyboard pass-through, so if you want a keyboard while using these you'll need to add a USB keyboard, or look at the Max model.

The Max version includes the screw-terminal wiring blocks of the ST, but also adds a keyboard pass-through with an interesting twist. As much as you'd prefer never to see a keyboard on your arcade cabinet, sooner or later you'll probably need one. Either you'll be playing a computer game that requires entering a high score, or you'll need to configure something, or the like. Unfortunately, the problem with having a keyboard attached is that, if it gets touched at the wrong time, it can mess up your game. The Max solves this with a clever "switch" button — the keyboard is dead until you press the special button connected to the "switch" input on the encoder. Once you press that button, the keyboard works until you activate any of your arcade controls, at which point the keyboard is disabled again. Nice! This does take up 2 inputs on the encoder however, which is why the Max version has 2 fewer inputs than the other versions.

Hagstrom Electronics

Hagstrom Electronics (`www.hagstromelectronics.com`) has an entire suite of keyboard encoders suitable for use in arcade cabinet projects. Prices start at $45 for their entry-level model and range up to $170 for their top-of-the-line models. Hagstrom was in the keyboard encoder business when the home arcade cabinet hobby started taking off and was quick to embrace the community with both product customizations and excellent user support. As an example, with a majority of the arcade cabinet community using MAME (see Chapter 14), Hagstrom modified one of their encoders to support MAME better at no extra cost. I'll introduce you to some of the models they offer for keyboard interfaces in this section (Hagstrom appears in the next two chapters as well). Hagstrom frequently updates their product line, so be sure to check their Web site for any new interfaces.

KE18/KE18 MAME

Starting at $45, the KE18 is Hagstrom's entry-level keyboard encoder product (see Figure 8-12).

Copyright © 2003 Hagstrom Electronics, Inc., KE18 MAME.

Figure 8-12: The Hagstrom KE18 keyboard encoder.

It supports 18 direct inputs or a 9 × 9 matrix mode of 81 inputs. This unit is not programmable, which means that your software will have to be configurable to work with the keystrokes available to the encoder. However, Hagstrom sells an arcade cabinet–friendly, customized version of the KE18 dubbed the KE18 MAME. The key mappings are the same in matrix mode, but they are different in direct mode. Both sets of keystroke mappings are shown in Figure 8-13.

The KE18 can suffer from ghosting problems in matrix mode, so you need to plan your keystroke combinations carefully if you decide to use it in that mode. Obviously, there is no such problem in direct mode. The encoder includes a keyboard pass-through port, which is a nice feature on an entry-level model. It also includes the ability to enable/disable keyboard repeat (that is, a button held down can generate just one keystroke or repeat keystrokes). The wiring connector on the KE18 is of the standard IDE flat ribbon cable variety. You can either use your own IDE ribbon cable or add the optional screw-terminal board and cable header similar to that pictured in Figure 8-14. With that board, you connect the encoder to the terminal board with the cable and then connect your wiring to the screw terminals.

The KE18 is an entry-level keyboard encoder that is suitable for one- or two-player control panels. Its lack of programmability may limit its appeal to some users, but its cost and support of the native MAME command set make it an alternative for someone considering a keyboard hack.

KE18 Keycode Tables

The following tables list the keycodes that are sent to the computer by the KE18 in response to activation of an input.

KE18 Lookup Table (9 x 9 Matrix Mode) *

Header Row Pins (J–R) / *Header Column Pins* (A–I)

	J	K	L	M	N	O	P	Q	R
A	A	B	C	D	E	F	G	H	I
B	J	K	L	M	N	O	P	Q	R
C	S	T	U	V	W	X	Y	Z	Esc
D	: ;	" '	> .	< ,	? /	Space	Back-Space	{ [	}]
E	Ctrl	Alt	Shift	Insert	Delete	Home	End	Page Up	Page Down
F	/	*	-	+	F1	F2	F3	F4	F5
G	8 ↑	9 Pg Up	. Del	Enter	F6	F7	F8	F9	F10
H	4 ←	5	6 →	7 Home	_ -	| \	Caps Lock	Num Lock	Print Screen
I	0 Ins	1 End	2 ↓	3 Pg Dn	+ =	~ `	Tab	Pause	Scrol Lock

* - Keycodes to the computer are initiated in this mode by shorting one Row pin to one Column pin. Example: Row J to Column C would produce an "S" on the computer.

KE18 Lookup Table (18 Input Mode) **

KE18 Header Input Pins

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
Default	A	C	D	E	G	I	L	O	Q	R	S	X	? /	| \	F1	Space	Esc	Enter
MAME	5	6	1	2	Right	Left	Up	Down	CTRL	Alt	Space	Shift	G	D	R	F	A	S

** - In this mode, keycodes to the computer are initiated by shorting one Input pin to the provided Ground Connection. Example: Pin J to Ground would produce an "R" on the computer.

Copyright © 2003 Hagstrom Electronics, Inc., KE18 MAME documentation.

Figure 8-13: Default matrix key mappings along with default and MAME version direct key mappings.

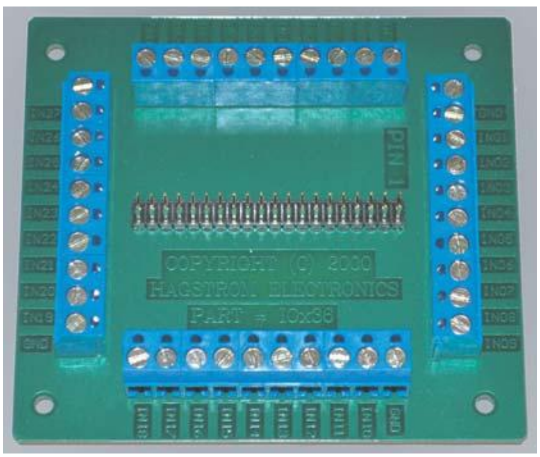


Figure 8-14: Hagstrom provides an optional screw-terminal board for the KE18 similar to this model.

LP24

Selling for $80, the LP24 is Hagstrom's next step up in the keyboard encoder field (see Figure 8-15). It is a 24-pin, programmable encoder module that is capable of up to 144 inputs in matrix mode or 23 inputs in pseudo-direct mode (see the following paragraph). Because it is programmable, you can determine exactly which keystroke is generated by any spot on the matrix. Technically, the encoder has 50 pins total in two rows of 25 pins each. Each pair of 25 pins is connected and functions like a single pin. The 25th pair is a ground pin used to erase the LP24's programming if programming errors render it unusable. Therefore, if you take into account the paired pins and discount the mostly unused 25th pair, you end up with 24 usable input pins, hence, the name of the unit being LP24, and my reference to it having 24 pins instead of 50.

Copyright © 2003 Hagstrom Electronics, Inc., LP24.

Figure 8-15: The Hagstrom LP24 programmable keyboard encoder.

Programming the LP24 requires an operating system capable of booting into true DOS mode. A DOS window will not work. This means you cannot program this encoder on a Windows XP machine, for instance, but Windows 98 will work. If you're interested in this encoder but have Windows XP, you could use another computer to program it and then bring it to your XP machine to use. Programming is accomplished via an interactive program through the keyboard cable. Once you've booted up in DOS mode and run the programming application, you're presented with a basic menu. First, you select the size of your matrix. To use it in direct mode, simply assign it to use a 1×23 matrix, which effectively makes it a 23-input direct mode encoder. The size of the matrix cannot exceed the number of pins available on the LP24 so the maximum matrix size is 12×12, or 144 possible inputs. Then, you fill in the keystrokes desired in the on-screen matrix grid, save the configuration to the encoder (and a backup to disk), and exit the program. Although you can save and load the configurations from disk, the programming application does not support a *batch mode* of operation so you cannot automate the process. Like the KE18, the LP24 can suffer from ghosting so you need to design your matrix carefully to avoid that.

Wiring the LP24 is similar to the KE18. However, because the LP24 has a total of 50 pins versus the KE18's 40, it will not work with an off-the-shelf IDE ribbon cable. Although the IDE ribbon cable is smaller and the pin spacing matches, the edges of the IDE ribbon cable connector will bend some of the unused pins on the LP24 if you try to use it. You can purchase a 12-inch wiring harness connector from Hagstrom to use with the LP24 or make your own with parts available at electronics stores. The encoder includes a keyboard pass-through and supports enabling/disabling keyboard repeat.

The added ability of the LP24 to program key configurations make this well suited for a two-player control panel. It will also work for a four-player control panel, but it will need to be in matrix mode with proper attention paid to the matrix configuration to avoid ghosting issues.

KE24

Retailing for $100, the KE24 is Hagstrom's distant cousin to the LP24 (see Figure 8-16). It has a 52-pin header on it with 24 pairs of input pins and 2 pairs of ground pins. Programmable like the LP24, the KE24 distinguishes itself by allowing any combination of matrix and direct mode configuration of the 24 available input pins, including true direct mode functionality. This means you could configure the encoder to have 24 direct inputs or up to a 12 × 12 matrix for 144 inputs. You could also elect to have a combination, such as a 10 × 10 matrix with four pins in direct mode. This would present you with 100 keystrokes possibly susceptible to ghosting and four keystrokes guaranteed not to have ghosting issues. This gives you a tremendous amount of flexibility as you design your keystroke inputs.

© 2003 Hagstrom Electronics, Inc., KE24.

Figure 8-16: The Hagstrom KE24 programmable keyboard encoder.

You may have noticed the extra serial port connector on the KE24. This has two functions. The KE24 is a multifunction device capable of sending input and output through the serial port as well as the keyboard ports. You could use a custom keyboard device to control a serial port–based robot, for instance, without having a PC involved at all. This is very flexible, but it is not particularly useful for our purposes. For arcade cabinet builders, the serial port on the KE24 will be used to program the encoder. Programming the encoder is similar to the LP24 except the KE24 can be programmed both in DOS and Windows. Once you load the programming application, you assign the various pins to be in matrix or direct mode and fill out the matrix map according to your preferences. The KE24 also supports the programming of macros (up to 16 key sequences) in the matrix so you could generate a series of moves with one button push. Save the configuration to the encoder (and a backup to disk), and you're ready to go. Like the LP24, you can save and load configurations for the KE24 from disk, but it cannot be automated.

Wiring the KE24 will require a homemade wiring harness because Hagstrom does not list one as an available accessory. These are not difficult to make with parts from an electronics store. A standard IDE flat ribbon cable will fit over some of the pins but will bend others at the ends unless modified. The KE24 includes a keyboard pass-through and the ability not only to enable/disable keyboard repeat, but also to configure the delay and speed of the repeat.

The unique flexibility of the programmable KE24 to have both matrix and direct mode configurations make this an intriguing candidate for an arcade cabinet. It is well-suited for either a two- or four-player control panel.

KE72/KE72T

The KE72/KE72T (see Figure 8-17) is the flagship of the Hagstrom keyboard encoder line. This model was designed specifically to be suitable for arcade cabinet builders after consultation with many members of the gaming community. Depending on configuration, the unit retails between $120 and $140. By adding support for industry-standard trackballs or spinners (KE72T model) as well, it is more than a keyboard encoder.

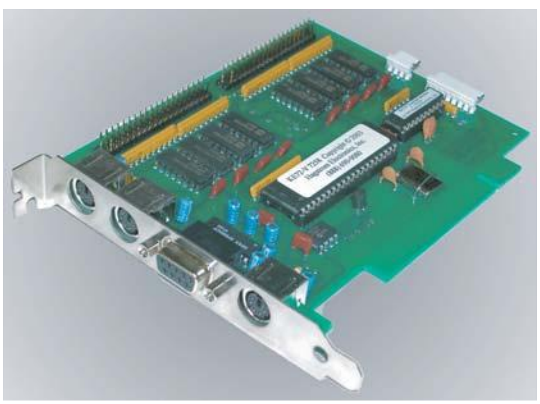


Figure 8-17: The Hagstrom KE72 programmable keyboard encoder with optional trackball interface chip installed.

The KE72 supports the highest number of direct inputs of any encoder currently available at 72 programmable inputs. It does not support a matrix mode. Programming the KE72 can be done through the keyboard cable or serial cable for Windows 98/95, and serial cable only for Windows 2000/XP. Hagstrom truly listened to the needs of the gaming community as the encoder can be programmed automatically through batch files. Programming is accomplished by running a command line programming utility that reads a configuration file and applies it to the encoder. If you need multiple configurations for different games, simply create a unique configuration file for each game and load it before running the game. Through the use of batch files, you can automate the entire process to load the proper configuration and run the game with a single click!

Because the encoder runs in direct mode only, ghosting is not an issue, and all 72 keystrokes can be generated simultaneously without key blocking occurring. The keystrokes generated can include any found on a standard keyboard, and also can include macros of up to 32 keystrokes with a single button press. Other features tailored to the gaming community include the trackball interface, which not only supports trackballs and spinners, but also has three mouse buttons as well. This requires using the PS/2 mouse port as well as the keyboard port. The KE72 includes a keyboard port pass-through. It also has soldering points for attaching Num-Lock, Caps-Lock, and Scroll-Lock LEDs to your control panel. Some games, mostly a few emulated by MAME, will light up the LEDs to correspond to coin inserts or in-game action. Upon request, Hagstrom will solder in a connector and include an appropriate cable for the LEDs so that you only need to purchase the LEDs themselves. They will charge a nominal fee for this service.

Wiring the KE72 can be done with two IDE flat ribbon cables, as the two wiring headers were designed specifically to fit the IDE standard. Combine this with the optional wiring break-out board shown earlier in Figure 8-13 for an easy wiring job. Although the KE72 physically looks like a PCI card, it is designed that way solely for mounting purposes. There are no electrical connections on the PCI-style mounting. You can either elect to mount the KE72 in a PCI slot or screw it to a spot on your control panel as with any other encoder.

Of all the encoders available from Hagstrom, the KE72T is the most ideal candidate to run a four-player control panel. The added ability to run a trackball or two spinners (but not both) along with 72 direct inputs, make it almost a one-size-fits-all solution!

InterfASD

The InterfASD carried by German based ArcadeShop (`www.arcadeshop.de`) is a 27-input direct mode keyboard encoder. It retails for approximately $37, but prices will vary as the dollar and Euro fluctuate. The encoder comes with a PS/2 keyboard interface and a keyboard pass-through (see Figure 8-18).

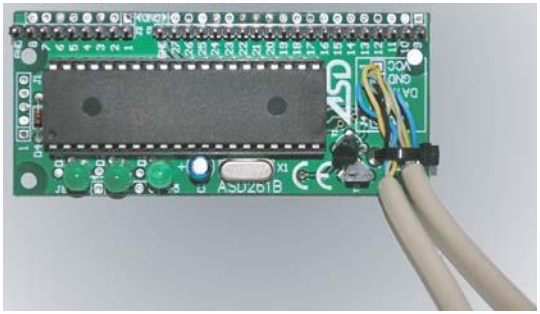


Figure 8-18: ArcadeShop.de's InterfASD keyboard encoder.

The InterfASD's shift button is a shared input on the encoder. The shift input activates when pressed, and if you press one of the other 26 inputs at the same time you get the shifted input. If you release the shift input without having hit any other buttons, then the normal function of that dual purpose input/shift button is activated instead.

The encoder has a default programming set, but can be programmed with a custom Windows programming interface much the same as other programmable encoders presented in this chapter.

ArcadeShop.de is a well known name in the hobby overseas — I expect to hear more and more from this company in the U.S. market as time passes. You'll see more from them in the following chapters as well.

MAMI 24/48

The Multiple Arcade Machine Interface (MAMI) line of products is the creation of 3Tronics Technical Services (`www.3tronics.com/index.html`). They have two products available with 24 and 48 direct input models available, respectively. The 24-input model ranges in price from $53 to $60, and the 48-input model ranges from $86 to $90, both depending on which variation of the model you purchase. You can purchase three different variations of each model: one with solder points to connect to, one with ribbon-cable connectors similar to traditional IDE ribbon cables (but of a different size), or standard screw-terminals. With the small price difference between the low end and high end of each model, it is probably worth purchasing the screw-terminal variations.

The MAMI products are not programmable, but can be ordered with customized key mappings. By default, they ship with a fairly standard MAME-compatible configuration. They are designed to support one joystick and up to eight buttons per player, with the MAMI 24 geared for two players and the MAMI 48 meant for four-player panels.

Wiring the MAMI encoder will depend on which variation you purchase. Either the ribbon cable or screw-terminal models will be easy to wire with material available from any electronics store. Wiring to the entry-level models will require some skill with soldering. All versions of the MAMI come with a keyboard pass-through standard.

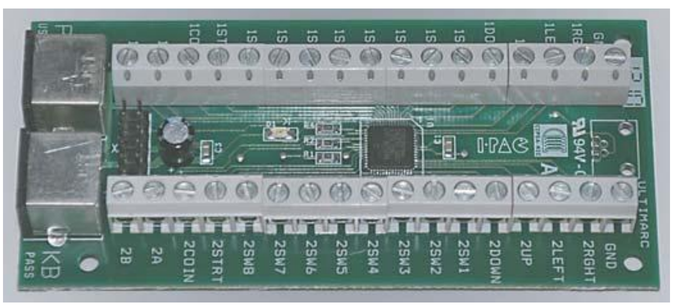
Ultimate Arcade Controls

Ultimate Arcade Controls (hereafter Ultimarc, `www.ultimarc.com`) is probably the first of the cottage industries to spring up in response to the needs of the arcade cabinet building community. They are the other vendor of the two most innovative vendors in the business I mentioned earlier in this chapter, and you'll see their name repeatedly throughout this book. Ultimarc is extremely well regarded, providing top-notch customer support, and has probably sold more encoders to the community than any other vendor. Following are their keyboard encoder products. A few of their other products appear in the next few chapters.

All of the Ultimarc keyboard encoders have gone through multiple revisions and upgrades through the years. Through sophisticated programming and design (once again I'll spare you the techno-babble), these encoders yield quick responses to button presses, whether connected via PS/2 or USB.

I-PAC^2

The I-PAC^2 (see Figure 8-19) is Ultimarc's entry-level product, offering 32 programmable direct mode inputs with shift-key functionality. This allows one (and only one) of the keys to double as a shift key similar to a shift key on a keyboard. When pressed by itself, the key generates a single keystroke. When pressed in conjunction with one of the other 31 buttons, it generates an alternate keystroke, effectively doubling your total inputs to 63. The I-PAC^2 is available for $39 with PS/2 cable, and $43 with USB cable. Through some sophisticated programming, Ultimarc has designed their product not to suffer from the six-simultaneous-keystroke limit that native USB keyboard interfaces have.



Used by permission of Ultimarc.

Figure 8-19: The Ultimarc I-PAC^2 programmable keyboard encoder.

You'll be pleasantly surprised by some of the sophisticated features available with the I-PAC^2 for the low costs involved. The encoder includes a keyboard pass-through, a pre-programmed MAME configuration that you can modify to your own configuration, and several programming options. With the pre-programmed MAME configuration, most users will be able to plug the encoder in and use it without having to program it at all.

Ultimarc has provided several methods to program the I-PAC². The first method involves running the I-PAC configuration application. Versions of the programming software are available for DOS, Windows, MAC, and Linux. The Windows version is pictured in Figure 8-20.

Used by permission of Ultimarc.

Figure 8-20: Programming the I-PAC² with the Windows application.

Programming is straightforward. It's an interactive panel designer where you lay out your controls to look like your control panel, click on the control you want to change, and then press the button you want assigned to it. The labels on the programming menu correspond to the labels on the wiring blocks on the I-PAC². Save the configuration to the encoder (and a backup to disk) and you're done. You can also program the unit on-the-fly by pressing a special keystroke combination (which requires a second keyboard plugged into the pass-through) that brings up a built-in configuration menu. It has all the functionality of the two programming applications except for loading and saving to disk. Finally, demonstrating an understanding of the needs of arcade cabinet builders, the programming applications can be used in command line mode to read in a configuration file, allowing for automated programming of the encoder.

Also, several front-end applications (see Chapter 13) have built-in support for the I-PAC, enabling programming to be changed within the game environment.

The I-PAC^2 can be daisy-chained to another I-PAC to give you even more inputs if needed. Also, there is an optional 32-inch LED harness that attaches to the encoder's board, emulating a keyboard's Num-Lock, Scroll-Lock, and Caps-Lock LEDs. The long harness and design of the LED mounting allow you to mount them to your control panel, adding colorful red, yellow, and green lights that will correspond to certain MAME functions.

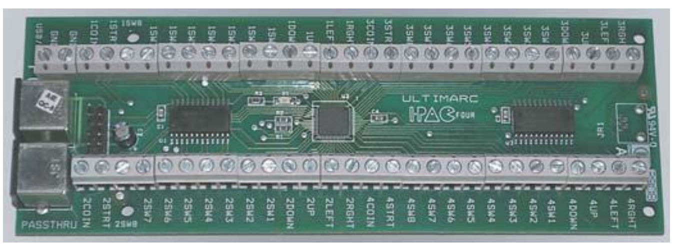
Wiring the I-PAC^2 is straightforward. The inputs use screw-down terminal blocks for attachment and include two ground terminals. By daisy chaining your grounds on your controls, all your wiring can come directly to the encoder board without requiring extra wiring blocks.

Ultimarc has made several firmware revisions over the years of supporting their encoders. The most recent one just before this chapter was sent off to the publisher adds several new functions not (yet) found on other encoders. Those include power, sleep, wake, volume up, and volume down. This means with a single button press you can turn your cabinet off, put it to sleep, wake it up, and control the volume. Currently only available for the I-Pac^2, by the time you read this it will probably be available on their entire keyboard encoder line.

The I-PAC^2 is tailor-made by Ultimarc to suit a two-player control panel. The impressive list of features and high quality of design have made it a favorite of arcade cabinet builders. The low cost of the encoder makes it an attractive choice.

I-PAC^4

The I-PAC^4 is Ultimarc's follow-up to the successful I-PAC^2. It is the big brother to its predecessor, having double the number of inputs. Essentially, it is two I-PAC^2 units installed on one board. The I-PAC^4 retails for \$65 with a PS/2 cable, and \$69 with a USB cable. See Figure 8-21.



Used by permission of Ultimarc.

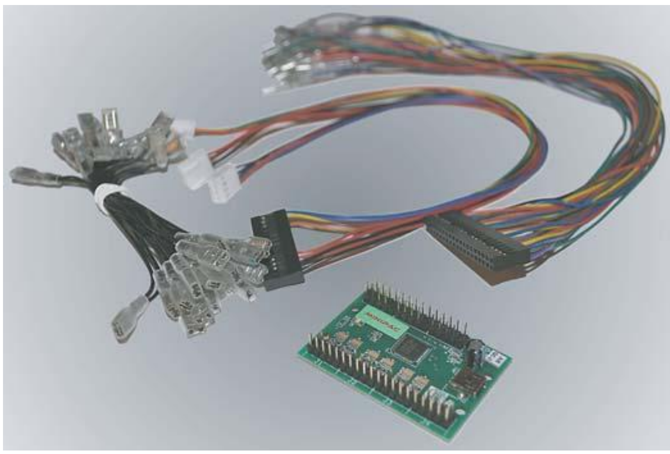
Figure 8-21: The Ultimarc I-PAC^4 four-player model.

Everything written about the I-PAC^2 holds true for the I-PAC^4 as well, except for the number of inputs. The I-PAC^4 has 56 inputs broken into two groups, each with a separate shift key. This allows for a total of 110 inputs. The rest of the feature set is the same, including the programmability, LED harness, and multi-operating system support.

The I-PAC^4 is effectively the same as purchasing two I-PAC^2 units, with a slight cost savings and the convenience of programming all inputs with one interface. Custom designed by Ultimarc for people building four-player control panels, it has quickly become a standard choice among the arcade cabinet building community.

Mini-PAC

Ultimarc's Mini-PAC is the final keyboard encoder in their line-up. This unit works identically to the I-PAC^2 and supports 32 inputs using either a PS/2 or USB connection. The 2 1⁄4-inch Mini-PAC can be seen in Figure 8-22.



Used by permission of Ultimarc.

Figure 8-22: The Ultimarc Mini-PAC with optional wiring harness.

The Mini-PAC adds trackball and spinner support to the I-PAC^2 functionality, requiring that the encoder be used in USB mode. The Mini-PAC is primarily targeted at OEM and frequent cabinet builders, with the available wiring harness, 32 encoder inputs, and trackball/spinner functionality designed to allow for quick hookup. In a nutshell it's the one-stop-shop of Ultimarc encoders. Prices for the Mini-PAC range from $29 for the encoder and PS/2 cable only up to $69 for the encoder, USB cable, trackball cable, and full wiring harness.

On The Horizon...

On the horizon is another encoder from vendor Legacy Engineering, known in the hobby for their replica Atari 2600 joysticks. Their new product is slated to be a keyboard/mouse/joystick encoder with inputs for all three interfaces with a USB connector. They weren't ready in time for this book, but check the companion Web site for more information.

Encoder Wrap-Up

You are likely to be happy with any of the encoder choices presented in this chapter. The economy models make excellent alternatives to keyboard hacks, providing the functionality of a keyboard hack with less effort involved. The higher priced encoder models justify their increased costs with extra features such as programmability, keyboard pass-throughs, and other miscellaneous features. Most of the vendors have been supportive of the arcade cabinet building community for quite some time, and will be happy to answer any questions about their products that you might have. My best advice to you when determining which model to choose is to analyze your current needs and thoughts for the future. Purchasing a budget model might help the bottom line now, but will limit your expansion possibilities. If you're constructing a limited purpose system, such as a PacMan clone for instance, a low-end encoder will work fine. I would recommend looking at the high-end models if you're planning a multipurpose arcade cabinet, however. With the difference between the bottom and top of the lines being approximately $100, you're better off buying the encoder with the best feature set to match your needs and not to economize on this point.

Summary

The keyboard port is your best choice for interfacing arcade controls to your computer. Almost every game playable on a personal computer allows for keyboard control. Keyboard hacks can be an extremely low-cost way to go, and can either be fun or infuriating to build depending on your temperament and soldering skill. Personally, if the luckless Mario depends on my soldering skills, then he'll never escape the barrels and rescue the princess! Most people will be happier with a commercial keyboard encoder.

Keyboard ports are a great way to connect your arcade controls, but they're not the only way. Put your mad-scientist coat back on, because in the next chapter you'll be dissecting some mice!

CHAPTER

9

Arcade Controls Using the Mouse Connector

IN THIS CHAPTER

- How Mice Work
- Hacking a Mouse
- Purchasing Optical Encoders
- Multiple Mice

Ready to experiment with some mice and their cousins? Don't worry; no actual mice were harmed in the creation of this book, though their computer-based brethren were not as lucky. Using mouse-based technology to connect arcade controls is quite popular and follows similar principles to using keyboard technology. What can you do with mouse-based connections? Quite a bit, as it turns out. You can play trackball and spinner games, hack a 360-degree arcade steering wheel, hook up the Happ Controls optical rotary joystick, or control your desktop with arcade controls!

Throughout this chapter, I will refer heavily to trackballs and spinners. However, the discussions apply equally well to other optical arcade controls. It's easier to say "trackballs and spinners" than it is to say "trackballs, spinners, rotary joysticks, 720-degree joysticks, 360-degree steering wheels, and so forth …" every time I want to refer to optical-based controls. Bear that in mind as you read.

How Mice Work

First, a promise: I will forgo any attempt at mouse humor in this section. The jokes are too easy and won't make it past my editors, who have threatened me with the bargain bin rack if I do not keep my pun-to-information ratio low. If at any point while reading this chapter an obvious joke occurs to you, please feel free to laugh out loud and assume I hid it there deliberately.

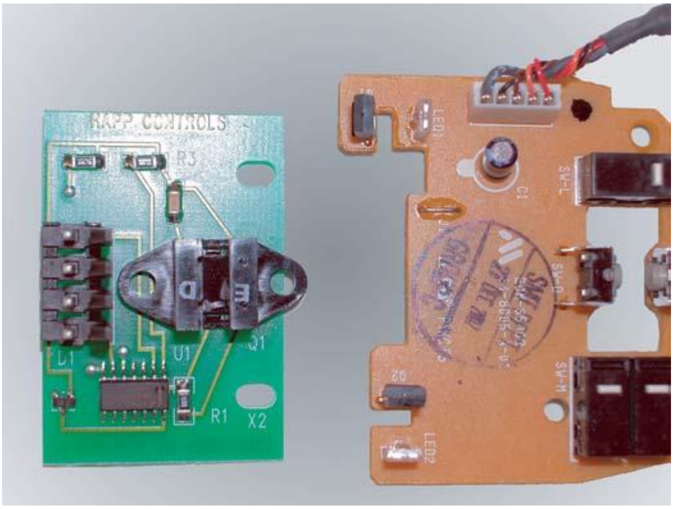
Mechanical Versus Optical

You can pick up two different kinds of mice at any computer store. The first is a mechanical mouse that contains a ball underneath the mouse that spins optical wheels inside the mouse body. These interact with optical encoders to generate mouse movement. The second is a purely optical mouse with no physical moving parts. A mini-camera in the mouse takes snapshots of the surface beneath the mouse at a rate of over 1,000 images per second. Any change in the surface beneath the mouse is detected by the mouse electronics and digital processor, which thereby determines speed and movement. Mechanical mice are getting harder to find as optical mice have become popular. To date, I am aware of no hacks of optical mice for arcade controls. They do not lend themselves to this purpose due to their lack of optical encoders. For the purposes of this chapter, any discussion that does not explicitly state otherwise refers to a traditional mechanical mouse. Figure 9-1 shows a mechanical mouse.

Figure 9-1: The inside of a mechanical mouse.

Optical Encoders

Because you will find an optical encoder in every device mentioned in this chapter, it would be a good idea to take a closer look at how they work. Examine Figure 9-2.



Used by permission of Happ Controls.

Figure 9-2: A close-up look at a couple of different optical encoders. A Happ Controls arcade version is on the left, and a disassembled mouse is on the right.

Recall from earlier in the book how these work. Optical encoders consist of three parts. There's an infrared LED and an infrared sensor facing each other, and a spoked wheel that spins between them. The LED is sometimes referred to as the emitter, and the sensor is referred to as the detector. When the ball of the mouse moves, it rotates the spoked wheels. As the spoked wheel spins, it breaks up the light from the emitter to the detector, which creates a light-dark-light pattern. The detector sends this pattern to the mouse electronics, which encodes it in a digital form for the computer.

Technically, the infrared sensor-and-detector combinations come in pairs. Sometimes, the pairs of detectors will be plainly seen as two separate components, but the two detectors will often be encased in one physical component. Both are equivalent. The pair of detectors let the mouse determine not only the speed of movement — based on the pace of the light-dark-light pattern — but also the direction of movement. There is one pair for the X axis and one pair for the Y axis. For the sake of discussion, I'll refer to each pair simply as a single unit, such as a detector instead of a pair of detectors.

Notice that the detector does the work of communicating to the electronics of the mouse. You'll use this to your advantage in the "Hacking a Mouse" section, later in this chapter.

Mouse Buttons

Mouse buttons work and look similar to microswitches in arcade buttons. The plastic button part of the mouse housing pushes down on the tiny button in the mouse microswitch. Take a look at Figure 9-3.

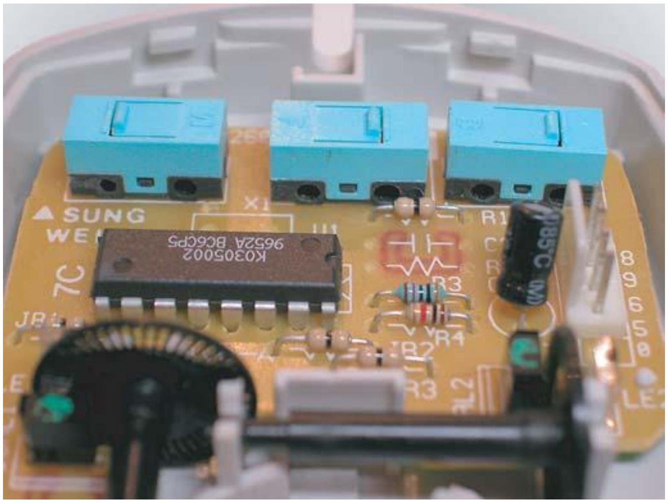


Figure 9-3: A close look at three microswitches on the mouse circuit board.

Though the actual physical plastic housing that presses on the microswitch will vary from mouse to mouse, the microswitches all look basically the same. Three pins connect the microswitch to the circuit board. Although they will probably not be labeled, they are NO, NC, and COM, just like an arcade microswitch. Because the button should do something only when pressed, the circuits are wired only to the NO and COM pins. In fact, some mouse boards won't even bother to solder the third pin, or, if it is soldered, the pin won't actually have any trace circuits connecting to the rest of the circuitry (see Figure 9-4).

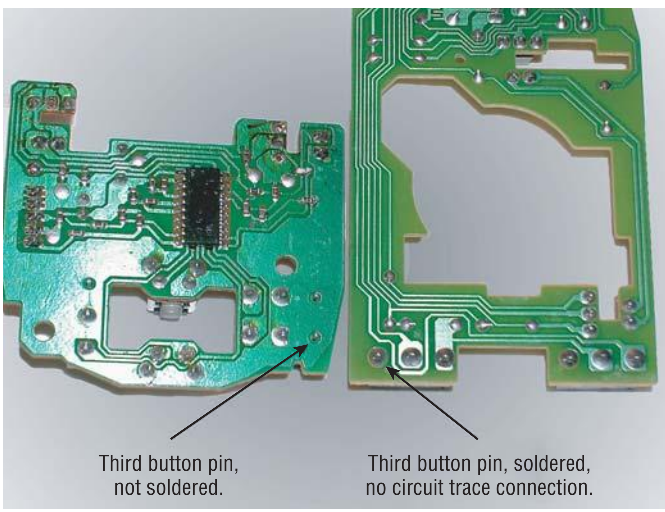


Figure 9-4: The mouse board on the left shows the third pin on the buttons, unsoldered. The board on the right shows that the traces do not connect.

Hacking a Mouse

Using what you learned in the previous sections, you can hack a mouse to use as an interface for your optical arcade controls. I'll be discussing trackballs and spinners, but the information applies equally as well to steering wheels, optical rotary joysticks, and other optical devices. You have two options for hacking a mouse device, as described in the following sections.

WARNING **The same concern that exists for keyboard hacks exists for mouse hacks. If something goes wrong, it is possible to damage your mouse port or motherboard. When using a mouse hack, test only on a spare computer if possible and certainly never on a computer with irreplaceable data. Do not attempt any of the hacks described while the mouse is plugged into the computer!**

Physical Hacks

Physical hacks involve connecting the circuit board (PCB) and optical sensors from a mouse to the encoder wheels of an arcade control device. The only hack involved is physically positioning the two separate devices so that the encoder wheel from the arcade control fits properly between the emitter and detector of the mouse PCB. When the arcade control spins its encoder wheel, the mouse's optical sensors detect the motion and respond accordingly. No standard method exists for doing this because it depends on the devices you're using and spatial requirements under your control panel.

Physical hacks are usually done for spinners only. It's relatively easy to mount a mouse PCB beneath a spinner so that the spinner's encoder wheel bisects the optical encoder. In fact, the first commercially available spinners used this method. Zip ties and hot glue guns are two favorites for fastening the mouse PCB in the proper position. Because trackballs use two sets of optical encoders set several inches apart, it's not possible to use a physical hack without modifying the mouse PCB. One possibility is to de-solder the emitter and detector sets from the mouse circuit board and mount them, appropriately spaced, onto two separate electronic breadboards. Next, connect wire from the parts on the breadboard to their former locations on the mouse PCB. By doing so, you've extended the electronics but have not altered the circuitry. Then, you can mount the breadboards in place at each encoder wheel of the trackball.

NOTE **A breadboard is a blank circuit board used to mount electrical components. Engineers use them to make prototypes of circuits while experimenting; hobbyists often use them to make permanent circuits. They're available at any electronics store.**

Depending on the mouse and software driver used, you may run into a problem. Because the arcade encoder wheel and the mouse optical encoders were not designed with each other in mind, the sensitivity may be off. Two remedies present themselves. You can adjust the sensitivity in the operating system and the game you're playing to see whether that fixes it. If not, replacing the encoder wheel with a bigger, spaced-out wheel may improve matters. Refer back to the "Spinner Resolution and Sensitivity" section of Chapter 4 for much more on this subject.

Finally, if you'd like to design a physical hack without using a mouse, such as building your own spinner from scratch, you can buy the same optical board used in commercial arcade spinners and trackballs from companies like Happ Controls (`www.happcontrols.com`). Because there is no extra circuitry or encoder chip, you'll also need an encoder board, such as one of those listed in the "Purchasing Optical Encoders" section later in this chapter. Being able to mix the optics, the encoder, and the physical components gives you a great deal of flexibility in designing a custom optical arcade control.

NOTE **You will occasionally notice two different things referred to as optical encoder boards. There is one part that contains the actual optical parts (the emitter and the detector) and another part that contains the circuitry and the chip that encodes the signals digitally for the computer. On a mouse, this is all combined in one PCB. Arcade controls, on the other hand, often have the two parts separated.**

Electrical Hacks

Electrical hacks are a much more elegant way to connect arcade controls to mice. These hacks take advantage of the fact that the detector halves of the mouse's optical sensors do the talking with the optical encoder chip on the mouse PCB. If you could intercept the point where the detector sends its signals to the encoder chip, could you send the signals from the arcade control's detector instead (see Figure 9-5)? As it turns out, the answer is yes — usually! Occasionally, you'll run into problems, as explained in the "When It Doesn't Work" section a bit later on.

How To Make It Work

You'll need to know a bit more about how optical sensors are wired to understand how an electrical hack works. The detector portion of the sensor sends two signals to the encoder chip, which requires two pins. The emitter and detector also need and share a power source, so each side has one pin for power. Remember that the detector side of the optical sensor is actually a pair of infrared receivers. If the detector side is split into two physical components, then each half of the detector will have one pin for signal and one pin for power. The power pin on one will be electrically tied to the power pin on the second half of the detector. Because the power pins are tied together, they effectively function as one pin. On a detector housed in one physical casing, the shared power is actually just one pin. This means that, whether you have a split or combined detector component, there are three pins to consider (see Figure 9-6).

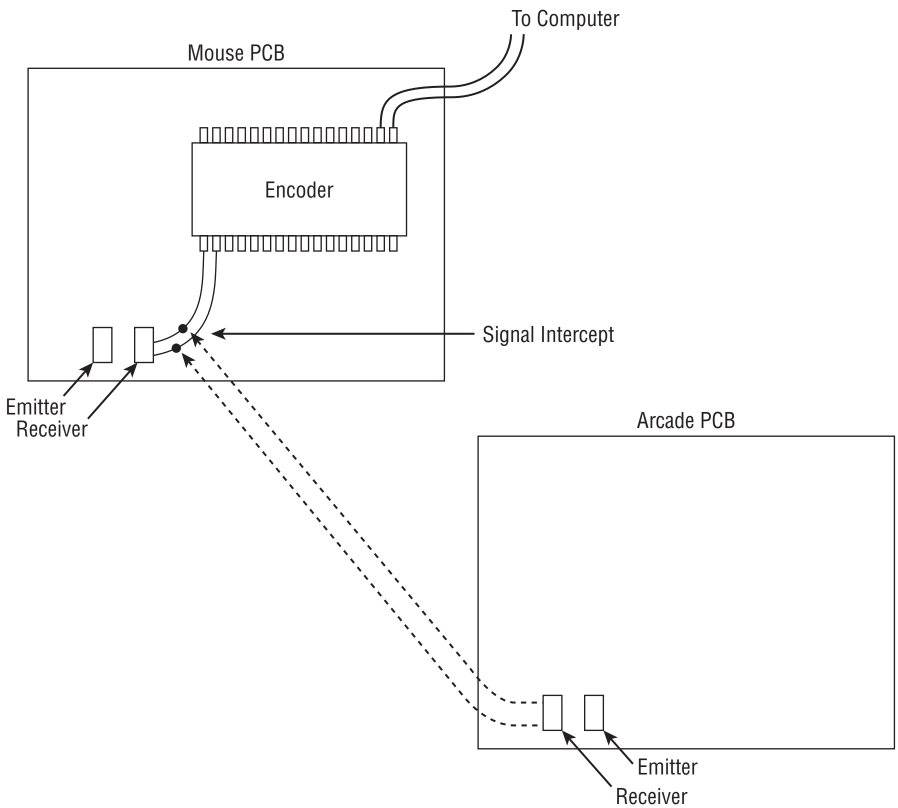


Figure 9-5: Replacing the mouse detector's signals with those from the arcade control.

Identifying The Pins

You'll need to identify which pin on the detector side is the power pin. *Usually*, this is the middle pin, but, because manufacturing methods differ, you should not take that for granted. You will not be using the power pin so it's important to find it. You can determine this by following the traces on the circuit board. This pin should trace back to the emitter opposite and to the other detector as well. You can also determine the power pin with a multimeter.

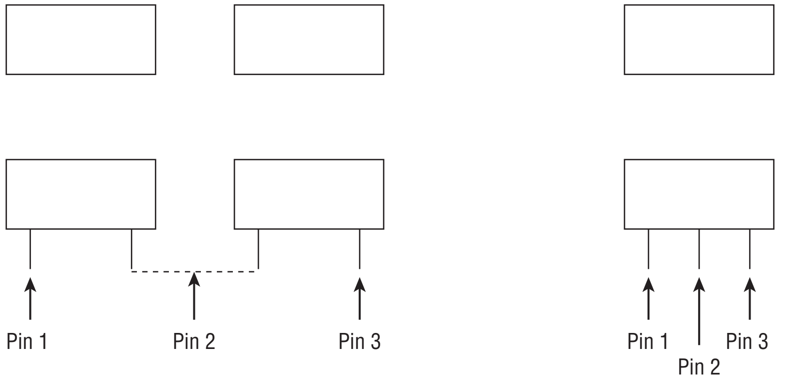


Figure 9-6: Separate components on the left; a combined unit on the right, all with three effective pins.

WARNING **This next piece involves disassembling the mouse, connecting the PCB of the mouse to the computer, and turning it on. I have one more warning. If something goes wrong here, it is possible — although unlikely — to cause damage to the mouse port or motherboard. If in doubt, don't do this. Alternatives are available in the "Purchasing Optical Encoders" section later in this chapter.**

There will usually be four pins in the mouse cable from the PC to the mouse PCB. One will be +5v, and one will be ground. If you're lucky, the pins will be labeled where they connect with the PCB. The +5v may be a red wire, and the ground may be black or sometimes white. Set your multimeter to DC voltage, plug the removed mouse PCB into the computer, and turn on the computer. Be very careful not to short out any pins. You should put something nonconductive, such as a static bag, underneath the mouse PCB.

Touch the positive lead of your multimeter to the likely +5v pin (the underside at the solder points is your best bet), and touch the negative lead to the likely ground pin. Your multimeter should read a positive five volts. If it reads negative five volts, you have the pins reversed. If it reads something else more than a tenth or so off, you have at least one wrong pin altogether.

Once you know where the ground pin is on the PCB, touch the negative lead to that, and touch the positive lead to one of the pins underneath the detector. The power pin will read +5v when you've found it. Verify that touching the other pins underneath the detector does not produce +5v. If it does, something is wrong. If it does not, you're in business. Repeat for the other detector. You have now isolated the power pins attached to the detectors.

Replacing The Detectors

Now that you know which pins are which, it's time to remove the detectors. This is where you get to exercise your soldering and desoldering skills. I found a desoldering braid easiest to use in this circumstance (see Figure 9-7). Using appropriate caution, de-solder the detectors from the mouse PCB. You can de-solder the emitters if you'd like as well, but it is not necessary. Some people like to remove them to save a small amount of power.

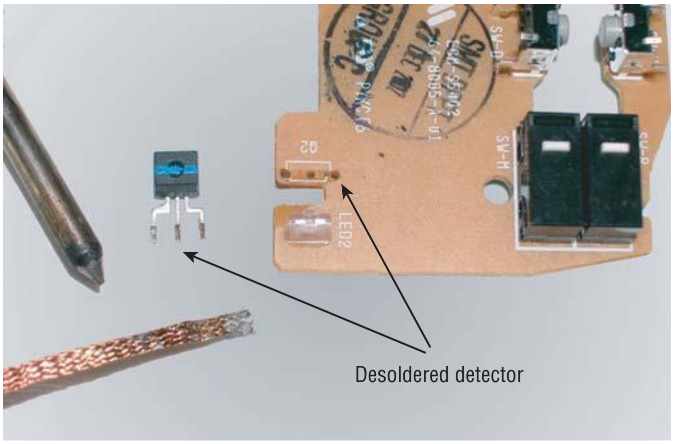


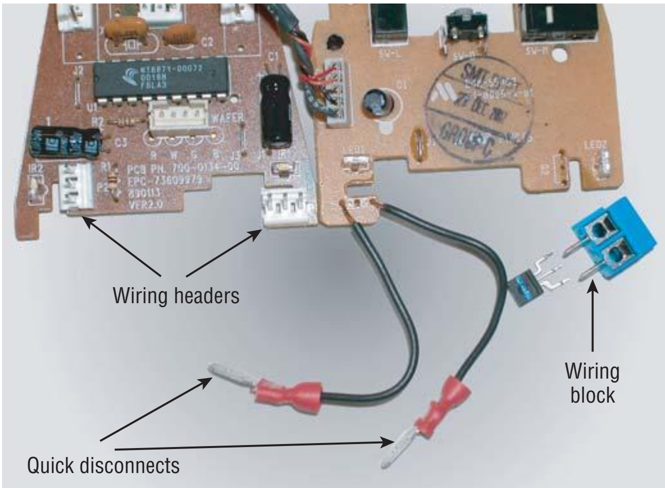
Figure 9-7: Showing the desoldered and removed detectors.

You now have a couple of options for replacing the detectors. You *could* solder wires directly into the holes left by the detectors and then run them back to your arcade control. I do not recommend it because that limits your flexibility. One suggestion is to connect short runs (two inches or so) of wire to the holes and crimp quick-disconnects on the other ends. Another possibility is to attach wiring headers or wiring blocks to the mouse PCB. In Figure 9-8, you can see a few examples. From the left, there are wiring headers on the Oscar Controls interface, wires with quick disconnects on one side of a mouse hack, and (unfortunately) a wiring block whose pins were too big to fit in the holes on the other side of the mouse hack. Any of these methods will allow you easily to connect and disconnect your mouse hack while working on the system. Make sure at this point that you do not permanently wire anything so you can troubleshoot if necessary.

Connecting Your Arcade Control

Here's where the really amazing part happens when, after all the theory and wiring, you get to plug something in and see it work! Read this section through before you begin. You should now have some method to connect up to the two signal circuit traces on the mouse PCB formerly occupied by the detectors for both the horizontal (X) and vertical (Y) axes. Examine your arcade control now. If you are connecting a trackball, there are two optical boards — one for each axis. If you are connecting a spinner, there will be only one optical board.

I will describe a trackball hack for the rest of this section. However, if you are attempting a spinner hack, the details are exactly the same except you will be connecting only one optical board instead of two. Instead of matching the X axis from the trackball to the X axis of the mouse PCB, you'll need to decide whether you want your spinner to control the X or Y axis on the mouse PCB. If in doubt or only using one spinner, connect to the X axis.

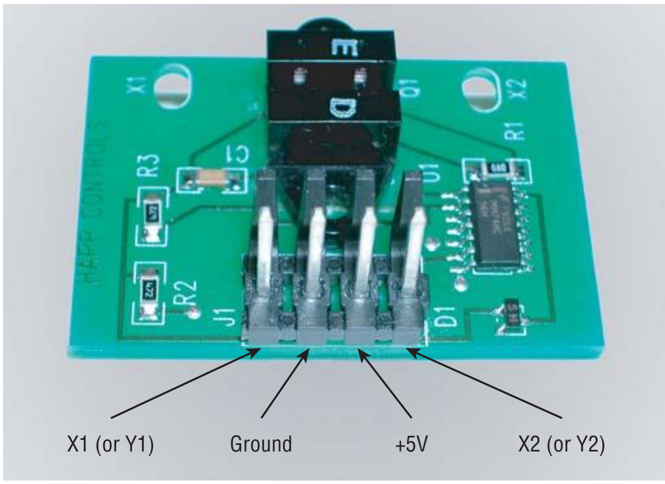


Used by permission of Oscar Controls.

Figure 9-8: Different methods of wiring detector replacements.

There are four pins coming off of each encoder interface board from the trackball. Two of them are signal pins, one is +5v power, and one is ground (see Figure 9-9). This should sound awfully familiar. Both the mouse detectors and the optic boards have two pins for signaling. By connecting the two signal pins from the trackball optic board to the matching two signal pins (now your wiring connectors instead of detector pins), you will be able to send the trackball's signals to the mouse encoder! Once again, I find this to be simply amazing! There are two potential wiring gotchas. First, you may accidentally connect the trackball's X axis to the mouse PCB's Y axis, or vice-versa. This will be evident when scrolling the trackball left and right moves the mouse cursor up and down. The second possibility is reversing the two signal pins on the axis, such that scrolling up moves you down, or vice versa. Both are easily corrected by swapping your wiring around until the proper pins are connected to the proper locations. Remember that you were strongly encouraged to use quick-disconnect wiring!

You're not quite finished yet. None of the wiring will work without power to the optical boards, but, I didn't tell you to wire anything to the power pin on the mouse PCB. How do you get power? Recall that, as long as the ultimate source is the PC's power supply, all power and ground is equivalent. My recommendation is to tap into one of the leads coming from the PC's power supply, although grabbing +5v and ground from another source in the computer will also work. If you are doing more than one hack, you should consider attaching two wiring blocks to your control panel, which dedicates one to +5v from the power supply and one to ground from the power supply. This will let you connect multiple devices to the power easily.



Used by permission of Happ Controls.

Figure 9-9: A standard arcade optical board with labeled pins.

Now that you know where the wires go conceptually, it's time to connect things up. You can either use the trackball's original wiring harness and devise an adapter wiring harness to connect to it, which modifies the trackball's wiring harness directly, or create a new wiring harness altogether. If you have the trackball's wiring harness, I recommend using it intact by creating an adapter. The harness will have six pins: one +5v power, one ground, two X-axis signals, and two Y-axis signals. The pins are labeled: pin one is ground, pin two is +5v, pins three and four are the Y axis, and pins five and six are the X axis. It's possible that your wire scheme will differ from these so you may need to do some detective work to be sure. The inner two pins on the optical boards should be +5v and ground with the outer two pins being signaling.

The connector block on the wiring harness is a standard, six-pin male Molex connector. The matching female Molex connector is available at any good electronics store. Connect six wires to the female connector, preferably using red and black only for the +5v and ground pins. Then, connect pin one to ground and pin two to +5v (presumably on the appropriate wiring blocks in your control panel unless you are obtaining power elsewhere). Connect pins three and four to the mouse PCB's Y axis, and connect pins five and six to the PCB's X axis. If you are not using the trackball's wiring harness, you'll need to create your own wiring harness using the techniques discussed previously in this book and parts available from any electronics store. As long as the wires ultimately connect to the same places as described here, the specific method used is unimportant.

Congratulations! If all has gone well, you have successfully connected your arcade control to the computer by using a mouse hack. Now is the time to plug everything in, turn it on, and see whether it worked! Spin your trackball or spinner, and the cursor should move on-screen. If it worked, great! If not, read on to the next section.

When It Doesn't Work

Argh! All of this effort and it doesn't work! Now what? Think you should have bought the "Project Basket Weaving" book instead? Don't panic. Many attempted hacks don't work on the first try. There are a few things you can look at to try to figure it out.

Wiring

First, go over your wiring one more time. Step back through your hack. Are all the wires connected to the right spots? Are all your solder joints good? One common problem is a solder joint that is too big and spills over to another circuit trace. The circuit traces on a mouse PCB are very small and close together. You can fix a problem like this with some judicious de-soldering and re-soldering.

The Highs And Lows

You may also be running afoul of the difference between a device that's considered active high versus one that's active low. Let me explain that briefly. (Strap on the seatbelt because this one gets a bit techie.) The optical sensor that the encoder wheel spins between is also referred to as a phototransistor, and you can think of that as a switch. Instead of physically pressing it off and on, the light-dark-light pattern turns the switch off and on. Remember that a switch sits in the middle of a circuit, which completes the circuit when the switch is closed and breaks the circuit when the switch is open. One end of the phototransistor switch is continuously connected to the circuit. The other end of the phototransistor switch is open (i.e., circuit is broken) when the encoder wheel is blocking the infrared light (dark) and the switch is closed (i.e., circuit is complete) when the wheel is allowing light through. You can therefore think of the light-dark-light pattern as closed-open-closed or "circuit-complete - circuit-broken - circuit-complete."

The side of the phototransistor switch that is continuously connected to the circuit is what determines whether it is considered active high or active low. Whether this side is attached to the +5v or ground side of the circuit determines whether the unit is labeled active high or active low. For instance, when a trackball is connected to an interface, the dark signal (i.e., the circuit is open) must be pulled either high or low electronically by a resistor. Whether the trackball's signal needs to be pulled high or low depends on the requirements of the interface. To confuse the matter a bit more, different vendors have not always used the terms "active high" and "active low" to mean precisely the same thing. Don't panic yet because the next paragraph brings this to a happier conclusion.

I did not mention this earlier because most devices are active low and compatible with most mouse hacks. However, some trackballs are known to be active-high devices. It doesn't really matter whether you use active-high or active-low devices, *as long as you're consistent*. Your mouse and your arcade control both need to use the same method. Confused? Don't worry, here's the important part. It may be possible to connect an active-low device to an active-high interface (like a mouse hack) by adding a 1K resistor between the power pin of the optical board and the +5v or ground (depending on what it's connected to in the first place) of the circuit. Several folks who have run into this problem have resolved it by adding the resistors as described. If you are running into this problem and need more assistance, hop on to the message forums at `www.arcadecontrols.com`, and describe your situation. Odds are that someone there will be able to assist.

Not All Mice Are The Same

Finally, if all else fails, you might need to try another mouse. It's possible that the mouse was damaged in the hack attempt or simply has electronics that are different enough that they won't work for this particular hack. Logitech mice, for instance, have been noted as being difficult to use for a hack. Cheap, hackable mice can be had for less than $10, so it's probably worth it to you to try another mouse.

Another Look

Several people have created and documented electrical hacks of this nature. If you're feeling a bit fuzzy about this, you may wish to look at their efforts to gain another perspective. This will also let you see the specific brands used in their hacks that you might want to consider. A few good examples include:

- Bob Akaye's Betson Imperial (Wico) 3-inch Trackball Mouse Hack at `http://www.members.shaw.ca/bakaye/tballhack.htm`.
- MAMEWAH's Hacking a Mouse to a Happ Trackball page at `http://mamewah.mameworld.info/mousehack.html`.
- 720 Circular Spinner Joystick mouse hack at `http://www.jstookey.com/arcade/720/720-arcadejoy.php`.
- The Massive MAME Project's Trackball Hack at `mameys.arcadecontrols.com/How-to/Trackball_Hack/trackball_hack.html`.
- ZeitGeist's Mouse to Trackball Hack page at `www.arcadecontrols.com/files/Miscellaneous/Mouse_to_Trackball_Instructions.pdf`.

Hacking Buttons

Hacking arcade pushbuttons to a mouse to enable left, middle, and right mouse click buttons is very easy. Recall from the "Mouse Buttons" section earlier in the chapter that mouse buttons are almost exactly the same as microswitches in arcade controls. Using the same techniques described earlier for an electronic mouse hack, de-solder, and remove the mouse button switches. Extend wiring from the vacated button spots on the mouse PCB to your microswitches for your pushbuttons (hopefully using some modular, quick-disconnect wiring method). Make sure you're using the NO and COM leads to wire to. Connect everything up, and you should have working mouse buttons using arcade pushbuttons. It's really as simple as that.

Purchasing Optical/Mouse Encoders

If you're thinking that a mouse hack is too much effort without a guarantee of results, then you're in luck. You can find commercial mouse/optical encoders with a range of prices and features that will accomplish the same thing with predictable results. All come from vendors you've already met in previous chapters. Start by looking at Table 9-1 for a side-by-side comparison. Note that when it states the number of axes (as in the plural of axis, not a sharp weapon!) that a spinner takes one axis, a trackball takes 2 axes, and other devices have their own requirements. You can also substitute "optical board" for "axis" so an encoder with 2 axes has 2 optical boards, and would support 1 trackball or 2 spinners. Alternatively, if you read "trackball" support think "2 axes" or "2 optical boards." The terms will be used interchangeably throughout.

Table 9-1: Optical Encoder Comparison Chart

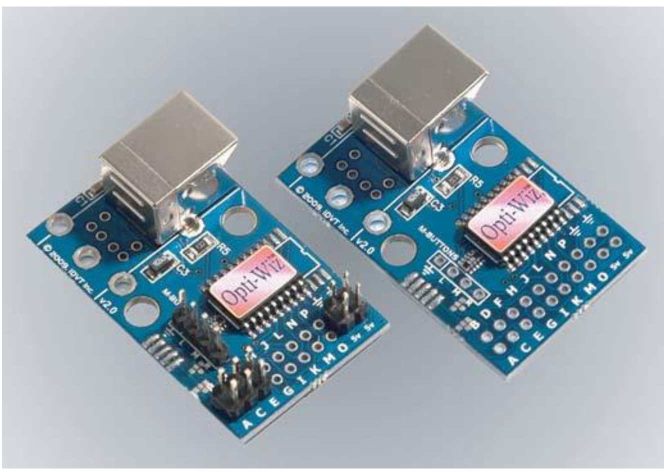
NUMBER OF NAME	COST	DEVICES SUPPORTED	INTERFACE TYPE
Groovy Game Gear OptiWiz	\$15/\$17	3 axes, 3 mouse buttons	PS/2 or USB
Happ Controls USB Trackball Interface Kit	\$49	2 axes, 3 mouse buttons	USB
Hagstrom Electronics KE72T	\$140	2 axes, 3 mouse buttons, and keyboard encoder functions	PS/2 mouse port
Hagstrom Electronics KE-USB36	\$80	2 axes, 3 mouse buttons, and keyboard encoder functions	USB

NUMBER OF NAME	COST	DEVICES SUPPORTED	INTERFACE TYPE
Hagstrom Electronics ME4	$35 ($50 with full cabling)	3 axes, 3 mouse buttons	PS/2 mouse port
Ultimarc Opti-Pac	$40	4 axes, 2 buttons per player for players 1 and 2	USB

NOTE **Unless specifically stated otherwise, the interfaces presented here are designed to work with active-low optical arcade controls, such as the Happ Controls trackball. It is possible that an active-high device, such as certain Suzo trackballs, will work with the addition of 1K pull-up resistors, as explained earlier in this chapter.**

Groovy Game Gear OptiWiz

The Groovy Game Gear OptiWiz (`www.groovygamegear.com`, $15) is a PS/2 or USB trackball and spinner interface with three axes and support for three mouse buttons. Both a solder and no-solder ($2 extra) version are available as shown in Figure 9-10.



Used by permission of Groovy Game Gear.

Figure 9-10: A standard arcade optical board with labeled pins.

The OptiWiz really makes a great alternative to trying to hack your own interface. The Z axis on this encoder has the same high resolution as the X and Y axes, something that's not the case if you hack a mouse (on a mouse the Z axis is the mouse wheel). The OptiWiz also has soldering points if you want to add optical switches (the emitter and detector pairs) to turn it into a complete optical encoder board for making your own controls. The interface also has a very small footprint, making it easy to tuck away in tight control panels. Combine the feature set with the low cost and the Groovy Game Gear OptiWiz is a great choice for an optical encoder for your project.

Happ Controls USB Trackball Interface Kit

Happ Controls (`www.happcontrols.com`) offers a USB model trackball interface kit for $49. The kit supports two axes, or one trackball and up to three mouse buttons. Alternatively, you could connect two spinners, steering wheels, or other optical devices instead of one trackball, though you would have to modify a wiring harness to fit. Being a USB device, the trackball will automatically install as a plug-and-play mouse in all modern operating systems. DOS-based systems will need a USB driver with no guaranteed results. The interface has a small footprint (2.5″ × 1.7″) and comes with appropriate wiring harnesses for the pushbuttons.

Because the interface comes with the wiring harness, connecting it is easy enough. Connect the pushbuttons and trackball, connect the USB cable, and then turn on the computer. There is no need to worry about power and ground connections because they are supplied by the USB cable.

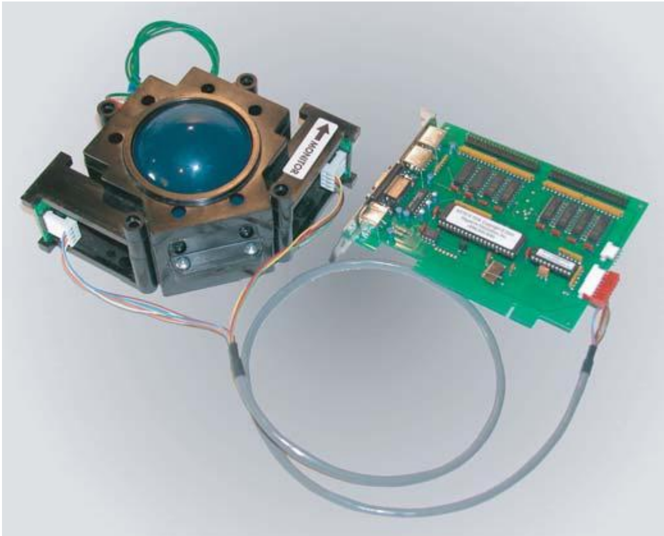
Hagstrom Electronics

Hagstrom Electronics (`www.hagstromelectronics.com`) has three interface models that provide optical device support. One is a dedicated unit, and two are multi-purpose units that range in price from $35 to $140. Like their keyboard encoder line, these interfaces have all been well received by the arcade cabinet community. Hagstrom has a strong reputation for customer support and service.

Hagstrom KE72T

The Hagstrom KE72T (`www.hagstromelectronics.com/ke72det.html`) was covered in the previous chapter so I'll provide only a brief summary here. The unit costs $140 with the trackball chip installed and will support 72 programmable keyboard inputs along with two axes and three mouse buttons. The interface will connect through the keyboard and PS/2 mouse ports. You will need either to create your own wiring harness or to purchase the trackball wiring harness for an additional $10 (see Figure 9-11).

As previously mentioned, the KE72T is one of the flagships of the Hagstrom line and has received excellent reviews from those who have used one. The combination of 72 keyboard inputs along with the trackball interface provides an extra layer of functionality and makes it an excellent candidate for a single-interface control panel.



Used by permission of Happ Controls and Hagstrom Electronics.

Figure 9-11: A Happ Controls trackball connected to the KE72T with the Hagstrom-supplied interface cable.

Hagstrom KE-USB36

Hagstrom's follow-up to the KE72T, the KE-USB36 (`www.hagstromelectronics.com/keusb36.html`) is also an amazingly flexible device (see Figure 9-12). At $80, the unit provides all the functionality of the KE72T and more even though it has a maximum of 36 programmable keyboard inputs. The interface connects via a single USB connection.

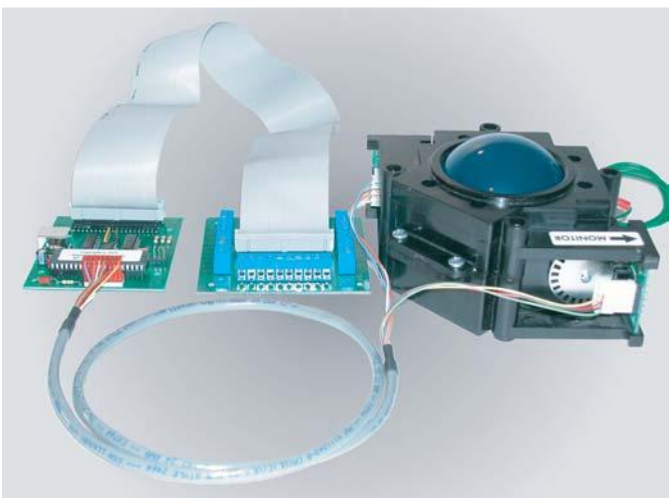
The KE-USB36's programmable inputs can be designated as either keyboard inputs or as one of the three mouse buttons. The programmable inputs are direct mode so there are no concerns about the ghosting that matrix solutions can suffer from. Fully populated with a trackball (or 2 spinners) and three mouse buttons, you are left with 33 available keyboard inputs. This is enough for two players with a joystick and seven buttons apiece with room left over for several administrative buttons. You could also configure it to support four players with a joystick and four buttons apiece with only one input left over.

Programming the KE-USB36 is done via a GUI interface in Windows through the USB cable. Each keystroke can be as-is or can be set as a combination keystroke with the Shift, Control, or Alt keystrokes.

Wiring the interface is similar to the KE72T with a standard IDE cable header on the board. You can either use an IDE cable or purchase the IOX36 breakout board ($16) mentioned in the previous chapter and attach your wiring to the screw-down blocks. The interface uses the same wiring connection for the trackball as the KE72T with the option to build your own wiring harness or purchase the one from Hagstrom for $10 (see Figure 9-13). One additional feature that MAME fans will appreciate is the connections for Caps Lock, Num Lock, and Scroll Lock LEDs. The board already has the necessary resistors built in so all that is required is to attach the LEDs via standard wiring. Because the unit gets its power through the USB interface, no additional power wiring is required.

Used by permission of Hagstrom Electronics.

Figure 9-12: The Hagstrom KE-USB36 encoder.



Used by permission of Hagstrom Electronics.

Figure 9-13: The KE-USB36 interface on the left attached to the IOX36 breakout board in the middle and a Happ Controls trackball on the right.

Hagstrom's KE-USB36 comes with an incredible range of features at an affordable price. Its USB interface means DOS users may wish to look elsewhere, but, for all other operating systems, purchasing this interface is a wise choice. The combination of keyboard and trackball inputs, along with the bonus LED connections, makes this one hard to beat.

Hagstrom ME4

Already have a keyboard encoder solution and just need a trackball or spinner interface? The Hagstrom ME4 (`www.hagstromelectronics.com/ME4.html`; see Figure 9-14) is a good candidate to consider. The ME4 supports one trackball, one spinner, and three mouse buttons for $35 ($50 with all required cables).

Used by permission of Hagstrom Electronics.

Figure 9-14: The Hagstrom ME4 optical encoder interface.

The ME4 uses a PS/2 mouse port connection and operates with standard mouse drivers. Both the trackball and spinner are functional at the same time and appear to the system as a single mouse device. There are two jumpers on the interface, which allows you to define the axis and direction of the spinner. If the spinner spins left when you think it should be spinning right, you can switch the jumper to correct it.

Wiring the interface can be done with your own custom-made harness with parts available from any electronics store. However, with all the interface cables necessary available from Hagstrom for $15, you'll probably be happier just purchasing them instead of making your own. The unit takes its power from the PS/2 interface so no external power hookups are necessary.

Since the original version came out, Hagstrom has updated the ME4 so that it supports both active-high and active-low devices natively. Supporting both a trackball and spinner along with three buttons in a single interface, the ME4 makes an excellent optical interface for those of you who already have a keyboard solution.

Ultimarc Opti-Pac

Wrapping up the lineup of optical encoders is the Ultimarc Opti-Pac (`www.ultimarc.com/optipac1.html`; see Figure 9-15), which is available for $40. The Opti-Pac is Ultimarc's counterpart to their highly successful I-PAC keyboard encoder. It supports a whopping two trackballs and four spinners (one trackball and two spinners per player) with up to two mouse buttons per player. No other interface supports as many simultaneous optical controls.

Used by permission of Ultimarc.

Figure 9-15: The Ultimarc Opti-Pac.

The Opti-Pac is full of features designed for the home arcade cabinet builder. It supports both active-high and active-low devices, so no matter what you connect it should work. The Opti-Pac comes with screw-down wiring block terminals that are clearly labeled for easy wiring.

Of all the optical encoders available, the Opti-Pac is the most versatile. The ability to support both active-high and active-low controls and the total number of controls supported make this the clear contender for control panels with multiple, optical-based arcade controls. Combine that with their strong presence in the arcade cabinet building community, along with their excellent support and customer service, and you've got a great product on your hands.

NOTE **Don't forget that the Ultimarc Mini-PAC in the previous chapter also supports a single trackball and spinner.**

Optical Encoder Wrap-Up

All of the commercial optical encoders in this chapter are good candidates for interfacing optical arcade controls. They come from vendors with a proven track record in creating devices of this type, and there is not a lemon in the bunch. You should match the feature set and pricing to your needs and choose accordingly with confidence. For those of you who are new to the hobby, the range of choices available is a marked departure from when it all started several years ago when few options existed. From the $15 dedicated Groovy Game Gear OptiWiz to the $140 full-featured Hagstrom KE72T, a solution is available for every budget.

Multiple Mice

As a rule of thumb, you can have two or three axes per mouse device. No matter how you interface your controls, the computer ultimately thinks your arcade controls are a single two or three axis mouse. Depending on your needs, you may want to have more than one mouse device available on the computer at a time. In one scenario, you might need two physical mouse devices that appear to the computer as a single mouse. In another scenario, you may prefer the computer to recognize that you have two distinctive mouse devices. The first situation allows you to have different mouse-based devices all controlling the same cursor, such as a trackball and spinner both controlling player 1's action. The second situation allows separate arcade controls, such as two players competing against one another in a trackball-based game.

Whether a second mouse device is treated by the computer as being the same device as the first or as a separate device depends on the connection method, the OS, and the software involved. By itself, Windows does not support the concept of separate mouse control. Windows will recognize two mice, but both will be configured to control the same cursor. From an operating system point of view that makes sense: why would you want to control two separate cursors on the screen? However, from a game-playing point of view, that's obviously a different story.

If two mouse devices (hereafter, I will refer to them as "mice" even though I mean trackballs, spinners, and other optical arcade controls) are physically or electronically connected to the same port, then they will appear to the computer as a single mouse no matter what software is used. If two or more mice are connected through separate ports, with the right software, the computer can be convinced that they control two separate mouse cursors. In the case of USB, two USB mice are considered to be in separate ports even though both are USB, due to the way USB is designed.

Multiple distinct mice are supported primarily in certain emulators (see Chapter 14). Multiple mice that appear as a single mouse are supported essentially in every application. This is usually done with a trackball and spinner combination that both control a single player's cursor or perhaps two spinners that each control one axis of a single mouse. In the case of two spinners on one mouse, the game software will know that the X axis represents one player and the Y axis represents the second player. The operating system will simply consider it one mouse.

Multiple Ports

The easiest way to have multiple mice is simply to use multiple ports. From Windows 95 and up, Windows has supported the use of dual-pointing devices controlling the same cursor. Mice can be connected via the PS/2 mouse port, serial port, and USB ports. It is possible to have PS/2 and serial port mice living side-by-side, two USB port mice working together, or any other combination thereof. By being connected to multiple ports, this configuration allows the possibility of distinct mice, which depends on the capabilities of the game software. The serial port is rapidly becoming extinct, and even the PS/2 port may be on the way out, so you're most likely to have multiple USB mice.

Mice Splitters

Splitters are also available for both the PS/2 mouse port and serial port. The splitter is a physical Y device that combines two individual mice into a single port. They are available from a variety of sources. By far, the most popular is the Y-mouse dual mouse adapter (see Figure 9-16) from PI-Engineering (`www.ymouse.com`). These retail for $50, and various versions, including a serial port model, are available. You can also find schematics for building your own splitter on the Internet, if you are so inclined.

Because splitters combine multiple units into a single electrical signal, it is not possible to control separate cursors this way. All mice connected via a splitter appear as a single mouse to the computer.

Switchable Mice

You may encounter a drawback with having more than one mouse-type arcade control connected at a single time. (That is, both devices are connected at the same time!) The possible drawback is having one control accidentally move the mouse cursor in one direction while you're trying to move another in another direction. This wasn't so much a concern with joysticks because they don't have any drift to them. However, spinners and trackballs can easily drift a bit if accidentally (or, in the case of a nefarious opponent, deliberately) brushed against.

Courtesy of P.I. Engineering.

Figure 9-16: The PS/2 mouse port Y-Mouse splitter from PI-Engineering.

That's probably not a major concern, but, if you'd like to prevent the possibility, there's an easy circuit you can make that will switch between your trackball and spinner, which deactivates one when activating the other. Essentially, you place a single switch between the mouse and trackball on the axis the spinner uses. If your spinner is on the X axis, the switch toggles between the trackball and mouse having the X axis functional. The circuit was designed by the now out of business Oscar Controls and was meant to be used with their USB mouse interface, but it is easily adaptable to other mice interfaces as well. The circuit is available online at `mirrors.arcadecontrols.com/OscarControls/DPDTswitch.shtml`.

CROSS-REFERENCE **The circuit is also included on the companion CD-ROM.**

Recommendation

You have so many excellent choices for connecting optical arcade controls that you may be feeling hard-pressed to choose the right one. Only you can determine what is right for your particular situation, but I can make some general recommendations. If you're trying to control a single trackball or spinner, or even a couple of them, pick one of the low cost optical interfaces such as the Groovy Game Gear OptiWiz. A mouse hack is an inexpensive way to go as well, but the minor amount you'll save isn't likely to be worth the hassle. If you'd like extra functionality, give some consideration to any of the other commercial optical encoders. If you're planning a panel with many optical arcade controls, the Ultimarc Opti-Pac is an excellent choice. If you're looking for a one-size-fits-all encoder for keyboard and mouse inputs, the KE72T or KE-USB36 from Hagstrom are your best bets, depending on the number of inputs you need.

Summary

In this chapter, you have been introduced to the many ways you can connect optical arcade controls, such as trackballs, spinners, and rotary joysticks, to your computer. Whether you choose to build or buy a solution at this point, you have enough information and options at your fingertips to connect things up. You can have a simple, single trackball connected or multiple devices such as a trackball and spinner. Now that all the decisions have been made, if you haven't yet, it's time to wire things up and see what happens. Got your lab coat on? Lighting storm going on outside? Have Igor stand by, attach the electrodes, and bring your creation to life! Congratulations! It's an arcade control panel!

You are a long way, if not all the way, to a completely functional Project Arcade system! If you are following the Project Arcade 2 design specifications, your control panel is essentially finished. If you're just building a control panel without a cabinet, you can jump straight to Chapter 14 to start playing games! If you're building a full-sized Project Arcade cabinet or want to explore some of the other creative things you can add to your project, you'll want to move on to Chapter 10. Either way, you're on the home stretch where things just continue to get more interesting and more fun. Keep going!

CHAPTER

10

Miscellaneous Bits of Arcade Trickery

IN THIS CHAPTER

- Gaming with the Gameport
- Using the USB Port
- Other Miscellaneous Tricks

In this chapter, you'll learn some of the more advanced tricks you can use to hack arcade controls to your arcade cabinet. Interested in attaching a genuine Star Wars-style Atari flight yoke to your arcade cabinet? Maybe you'd like to include a couple of stationary machine guns for defending the Earth from tyrannical cyborgs? These are some of the things you can do with the information in this chapter. Read on!

Gaming With the Gameport

I'll start by introducing you to the PC gameport. When IBM first came out with their version of a personal computer, they adopted a typical no-nonsense, IBM, business-oriented approach. Monochrome monitors, sound limited to beeps, and a limited number of connection ports designed for printers and modems made up the IBM-PC. People who purchase personal computers aren't interested in playing games, right? Well, the purchasing public quickly set them straight on that score, demanding color screens and ways to make their computers fun. The PC gameport was IBM's first nod to the fact that personal computers could be used for more than just business activities. It has evolved little since its initial design and has since been replaced by USB ports as the gaming interface of choice. Still, there are some things that can be done quite easily with the gameport, and so I'll spend a bit of time talking about it here.

NOTE **Game ports are a dying breed. Microsoft stopped supporting them as of Windows Vista, and most computers don't come with them connected anymore. However, you can still find sound cards with game ports, and many motherboards have a connector for the game port that you can enable by buying an inexpensive connector. If you are planning to use an operating system that supports game ports and can physically find one, the following hacks can work for you!**

How the Gameport Works

The gameport is a 15-pin port you'll usually find as part of your sound card or as a separate connector on the motherboard (see Figure 10-1).

Figure 10-1: A close-up look at a dedicated gameport card with two ports.

You can connect up to two joysticks to a single PC gameport as originally designed. The interface supports four digital and four analog connections. The four digital connections come in the form of buttons with switches, and the four analog connections come in the form of 100K potentiometers. In the early days of the personal computer, this allowed you one joystick with two potentiometers (X and Y axes) and four buttons, or two joysticks with two potentiometers and two buttons each. Using two joysticks requires the use of a Y-cable because the pins for all the inputs are contained in one single port. Later development produced gameport-based steering wheels, yokes, and pedals, but these are still potentiometer-based analog devices and appear to the computer as simple joysticks.

Gameport Pinouts

You will find the design of the gameport straightforward, based on what you've read so far. Throwing a curve into the mix, however, a second standard for the

PC gameport called the *gameport+MIDI* was introduced. This standard replaced two pins from the original gameport design and supported the use of MIDI (musical instrument digital interface) devices as well as joysticks. The pinouts are labeled in Figure 10-2.

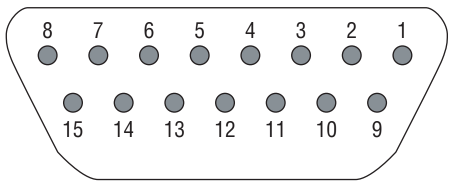


Figure 10-2: Looking into the gameport connector.

Table 10-1 shows the pinout specifications. Notice the differences in pins 12 and 15.

Table 10-1: PC Gameport and Gameport+MIDI Pinouts

PIN	GAMEPORT	GAMEPORT+MIDI
1	+5v	+5v
2	Button 1	Button 1
3	Joystick 1 — X axis	Joystick 1 — X axis
4	Ground	Ground
5	Ground	Ground
6	Joystick 1 — Y axis	Joystick 1 — Y axis
7	Button 2	Button 2
8	+5v	+5v
9	+5v	+5v
10	Button 4	Button 4
11	Joystick 2 — X axis	Joystick 2 — X axis
12	Ground	MIDI transmit
13	Joystick 2 — Y axis	Joystick 2 — Y axis
14	Button 3	Button 3
15	+5v	MIDI receive

The gameport was designed to be cheap and simple because even though IBM was wrong in their assumptions about playing games on the PC, still surely no one was going to spend a lot of money on it, right? This decision in hindsight was a poor choice that plagued the PC game industry as it progressed beyond the days of the original IBM-PC. Problems with timing and interface speed are among the challenges presented by gameports, which led to the growth of USB- and keyboard-based controllers. Still, advancements in programming and design have led to improvements in the use of the gameport, and it maintains some usefulness today. I expect by the time Project Arcade 3 rolls around gameports will be extinct. Until then, you can use the pinouts listed in Table 10-1 combined with what you've learned about connecting arcade controls to do some pretty interesting things.

Connecting Buttons And Joysticks

I'll start by taking a look at connecting pushbuttons to the gameport. You probably can guess how it will work. All you need to do to activate any of the four pushbuttons is to connect its pin to ground. Put an arcade pushbutton with its microswitch wired in between the button's pin and ground, and you've created a pushbutton circuit that will turn that button on and off. Not terribly complicated.

Connecting an analog joystick (remember this section applies to joysticks that use potentiometers, not digital joysticks) is also straightforward. A 100K potentiometer is connected between one axis pin and +5v pin for every axis you want to connect. For instance, you'll connect the center leg of the X axis and Y axis potentiometers of joystick 1 to +5v pins on the gameport. One of the outer legs of each axis's potentiometer is then connected to the appropriate axis pin of the gameport, as described in Table 10-1. You may be wondering why you need to connect only two legs of the potentiometer instead of three. Whether you use two or three legs depends on how the interface is designed. In this case, the gameport is measuring the resistance only between the center leg and one outer leg. Which leg you connect depends on the orientation of the potentiometer, toward or away from you. Once connected, if the joystick moves in the opposite direction than expected, move the wiring to the other outer leg to correct it. For the rest of this section, I'll assume you're looking at the top of the potentiometer and will be wiring to the center and left legs from that perspective. Take a look at Figure 10-3 for an example.

Compare the pinouts in Table 10-1 with the diagram shown in Figure 10-3. Pins 2 and 4 are tied together through the microswitch to generate button 1. Pins 7 and 4 make the circuit for button 2. The two potentiometers connect pins 1 and 3 for the X axis of joystick 1, and pins 6 and 9 for the Y axis of joystick 1. Using the information in Table 10-1, you could easily expand upon this wiring diagram to add buttons 3 and 4, as well as the axes for joystick 2.

NOTE **You'll find more than one type of potentiometer in electronics stores. You want linear potentiometers. Audio type potentiometers will not work properly for these kinds of connections.**

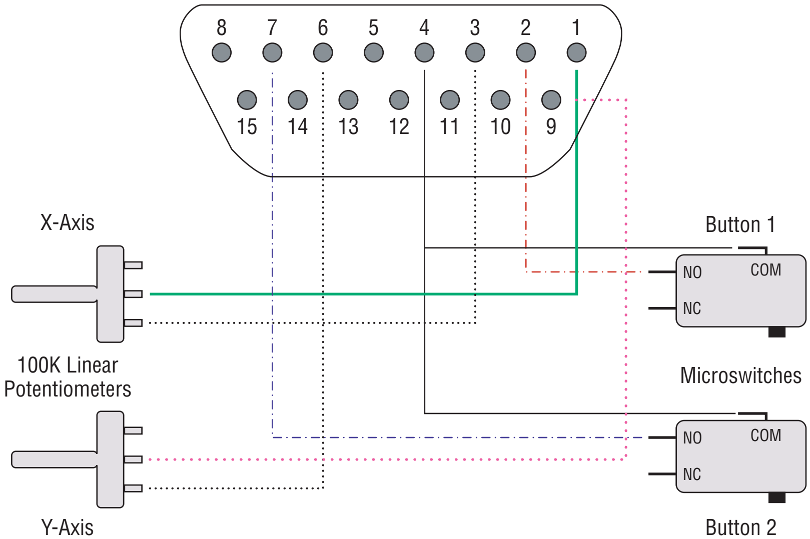


Figure 10-3: Wiring diagram for a simple two-button joystick.

Because the PC gameport supports up to four axes, just about any potentiometer-based analog arcade controller can be connected to this port. There are a couple of things to think about when converting an arcade controller to a PC. First, verify the rating of the potentiometers. With most arcade controls using 5K potentiometers, you'll need to remove them and replace them with PC-friendly 100K potentiometers. Second, if you are connecting something that uses an odd number of axes, you may run into problems. The PC normally expects to see both an X and Y axis under most drivers, although Windows XP does provide support for three-axis controllers. To be sure your controller will work if it has an odd number of axes, you should direct connect the final unused axis on the gameport. You can do this simply by connecting two pins. For instance, if you're using only the X axis of joystick 2, connect a wire from pin 13 to pin 1 or 9. Remember that for the X and Y axis pins, you connect to +5v and not to ground!

You can branch out from here to connecting wheels, flight yokes, and other devices to your computer through the gameport. The default drivers built into pre-Vista versions of Microsoft Windows (particularly Windows XP, though earlier versions also have some built-in drivers) support a wide range of possible combinations of gameport buttons and axes.

Just about every combination you might encounter, from flight yokes and steering wheels to joysticks and other devices, will be supported with default drivers in Windows. Other operating systems may need to install specific drivers, such as the Linux joystick driver available at `ftp://atrey.karlin.mff.cuni.cz/pub/linux/joystick`.

CROSS-REFERENCE **The Linux joystick driver is also included on the companion CD-ROM.**

Connecting Wheels And Flight Yokes

I talked quite a bit in Chapter 5, "Arcade Controls for Power Gamers," about connecting arcade steering wheels, pedals, flight yokes, and positional guns to your computer. Bear in mind that the one thing these all have in common is that they have potentiometers inside controlling their movement. Details on how to hack them to the computer should begin to fall into place now. I'll discuss wheels in the rest of this section, but the principles apply to the other controls as well.

Wiring a steering wheel is easy enough. Connect the center leg of the wheel's potentiometer to +5v on pin 1 of the gameport, and connect the left leg to pin 3 (joystick 1, X axis). So far this isn't any different from connecting a joystick, except that instead of a joystick moving left and right you have a wheel turning left and right. It gets a bit trickier when it comes to the pedals.

Warning: It's getting technical again! You might want to brace yourself with a cup of coffee before you proceed. Ready? OK, here goes. In Chapter 5, I referred to the difference between a single-axis and dual-axis mechanism for steering wheel pedals. On a single-axis pedal system, the gas and brake use two potentiometers connected in series that appear to the computer as a single axis. On a dual-axis pedal system, the brake and gas use two separate potentiometers that appear to the computer as separate axes. Wiring for both types is shown in Figure 10-4. Note that any buttons, such as those for shifting up and shifting down, are wired the same as in Figure 10-3 and are not shown.

As shown in Figure 10-4, the center leg of the gas pedal in a single-axis system connects to pin 9 (+5v), and the left leg of the brake pedal connects to pin 6 (joystick 1's Y axis). The left leg of the gas pedal connects to the center leg of the brake pedal, which puts the two potentiometers in series, making them appear as one unit to the computer. In a dual-axis system, both center legs connect to pin 9 (+5v). The left leg of the gas pedal connects to pin 11, and the left leg of the brake goes to pin 6. Also note that because there are a total of three axes configured, pin 13 is jumpered to pin 1 to ensure the computer sees four axes total (otherwise it might see only two of them).

Is your head spinning yet? Don't worry about the specific details; they're important only when you're actually wiring. The general concept to take away from this is that with one method of wiring you have the gas and brake pedal acting as a single unit, and with another method of wiring, the pedals act as separate units. Some games work with single-axis pedals only; some allow the flexibility of dual-axis. Wouldn't it be great if you could use one set of wheel and pedals for both game types instead of having to have two sets of wheels? You can! Notice that pins 6 and 9 are used in both situations, with pin 11 added in the dual-axis circuit. Using a *double-pole, dual-throw* (DPDT) switch available from any electronics store, you can convert between single-axis and dual-axis as needed.

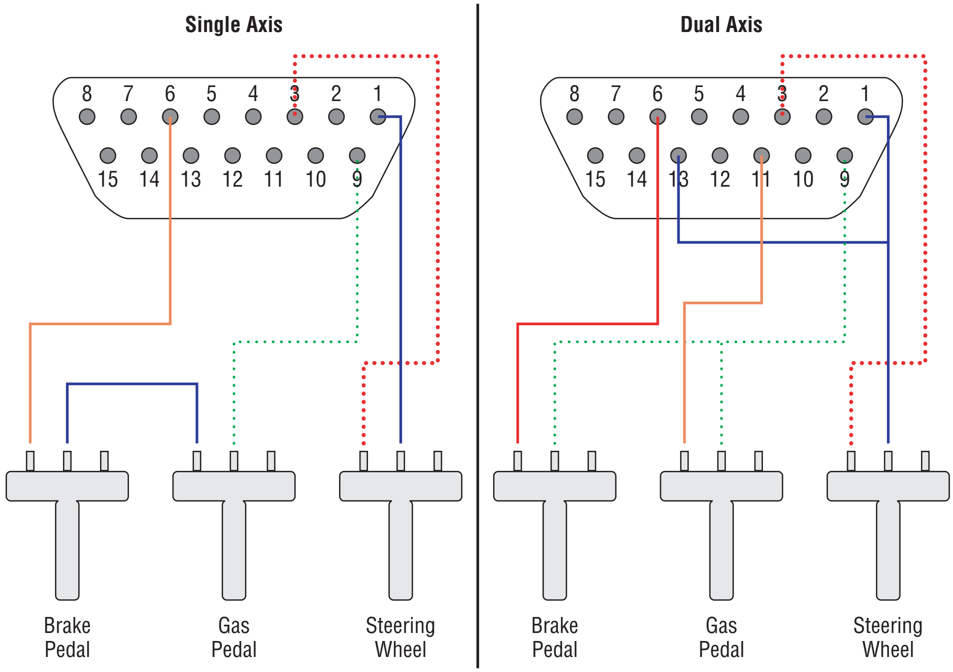


Figure 10-4: Wiring for a single-axis system (left) and a dual-axis system (right).

Credit for the switch design circuit goes to Lew's Wheels at `www.fortunecity.com/silverstone/thepits/195/lews/`. I won't attempt to describe the full details in text here; visit Lew's site for pictures and more info. Essentially, however, when you switch between settings, the connections between the potentiometer legs and the gameport pinouts are rearranged as required to convert between single- and dual-axis pedals.

Other Analog Controls

You'll find wiring other analog devices to the gameport fairly easy after reading about steering wheels and pedals. Pretty much the only other analog controls of importance not yet discussed are positional guns. Other analog controls probably exist, but they do not have a significant enough presence in the arcade world to merit a specific mention. The discussion of positional guns here applies to those devices as well.

Positional guns are really nothing more than oddly shaped joysticks. They mount to the top of the control panel and allow you to pan left and right and up and down. Sound familiar? Joysticks move left and right and up and down.

Other than the fact that they have built-in firing buttons and a different physical construction, inside they're all the same. One potentiometer controls movement along the X axis, and another controls movement along the Y axis. As long as you make sure the potentiometers are 100K rated, you can connect these devices to a gameport just like a joystick.

Game Pad Hacks

Directly wiring your arcade controls to the gameport is pretty fascinating and can give you a big sense of accomplishment. How many other people can take a handful of electronic components, mix them together, and make a joystick or steering wheel? It's a pretty small group to say the least! However, übergeek status aside, it's a lot of work that isn't necessarily required to get the results you want. So many inexpensive game pads and joysticks exist that it's easier to pick one up and hack your arcade controls to it rather than wiring directly to the gameport.

Hacking a computer gamepad (or joystick, steering wheel, etc. — hereafter I'll just refer to all computer gameport based controllers as gamepads) has a couple of advantages. The costs can be low with the use of used or generic gamepads. Even broken gamepads can often be salvaged for a project like this. Also, game developers usually included support for gamepads (although not as often as keyboard support) in their games. Finally, gamepad hacks are usually much easier than keyboard hacks and do not suffer from the ghosting and blocking problems that keyboards do. Your biggest hurdle in hacking a gameport gamepad will be in finding one! Due to the huge success and deployment of USB, most gamepads are now USB based. eBay (`www.ebay.com`) or large consumer electronics stores are your best bet for finding a good cheap gameport gamepad.

Hacking an arcade control to a gamepad is a lot like hacking a keyboard. Button presses or potentiometers sit in the middle of a circuit that sends a particular signal to the computer. Removing the physical mechanism of the gamepad and substituting your own button press or potentiometer to the gamepad's circuit board should sound familiar to you. Gamepad circuit boards typically have soldering points that you can connect wiring to, and they sometimes will even have wiring headers that you can use instead of soldering!

Digital Hacks

Digital hacks refer to hacking gamepads that use switches. This applies not only to the pushbuttons but also to the directional controls. Many gameport-based gamepads use a little 4-way direction pad (see Figure 10-5) for movement, similar to Nintendo controllers. Wait! Haven't I been saying that gameports use analog controls for movement? Four axes and four pushbuttons, right? Yes, but like many things in the PC world, programmers have worked around initial limitations to stretch the capabilities beyond the original design. Using a combination of hardware and software techniques, gamepad designers have been able to move beyond the original specifications of gameport joysticks. Gameport gamepads with a directional pad and six or more buttons are now common designs, although they are still using the original gameport specifications.

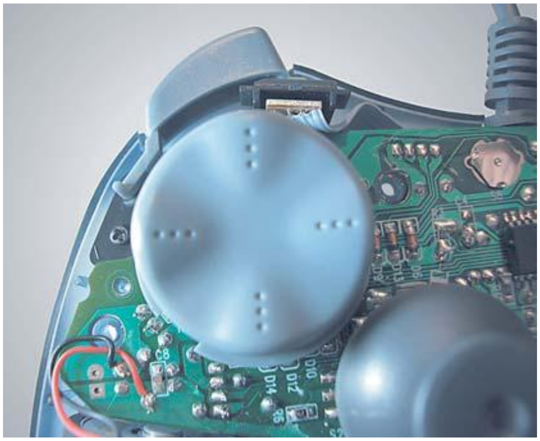


Figure 10-5: A partially disassembled gamepad showing the directional pad.

When you peel apart a gamepad, you'll find that the design is fairly simple. Any particular digital (pushbutton) control is usually a three-layer affair. There's a hard plastic button or pad that you directly press. Below that is a plastic membrane with conductive material on the underside. Directly beneath that lies the circuit board, with two halves of a circuit that the membrane makes contact with when pressed (see Figure 10-6). It's starting to sound an awful lot like a keyboard, isn't it?

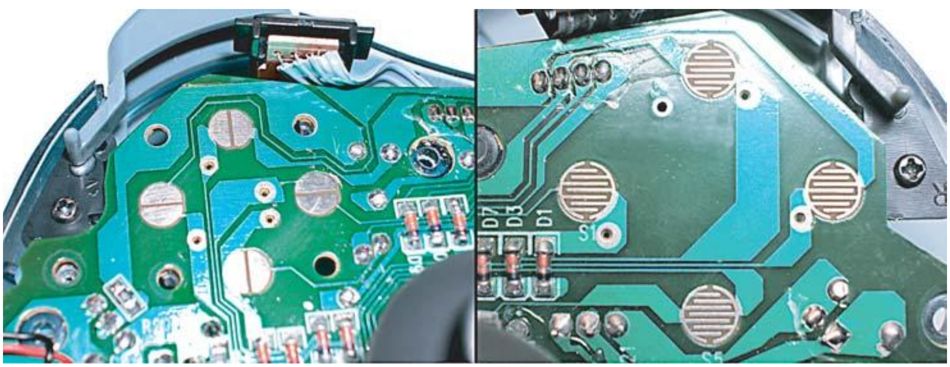


Figure 10-6: Peeling away all the layers reveals the circuit board. Two different styles of contacts are shown: Solid (left) and interweaved (right).

You should not solder directly to the button contacts on the gamepad. You may have success doing so, but the connection will probably be weak and likely to fail. If you'll look at Figure 10-7, you can see what happened after a test solder to the contacts on my gamepad. The contacts lifted right off the PCB! Presumably this is due to the heat applied during the soldering. However, do you notice the tiny holes on the circuit traces coming from the contacts? Soldering a wire there is much easier! Even though this particular contact is ruined, I can still use this board by wiring to the soldering points on the circuit traces. Most gamepads will have soldering points to which you can attach your wiring. You should look for the circuit traces that the various contacts have in common; that will be your ground. Solder a wire to the non-ground side of the contact (at the soldering point), and attach the other end to your pushbutton or joystick microswitch. Solder a single wire from the gamepad's ground to a wiring block and run the ground from your microswitches to this wiring block. There's no need to solder both sides of every contact. You can also daisy chain the grounds, as described in previous chapters.

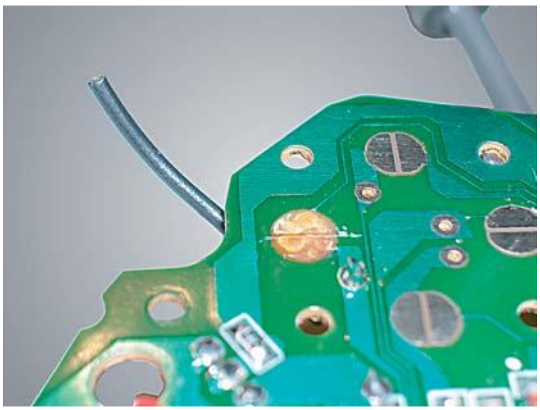


Figure 10-7: Showing the ruined contact. The solder point is to the bottom right, beneath the ruined contact, and has a wire soldered to it.

Analog Hacks

Analog hacks deal with hacking gamepads that use potentiometers for directional control. You may find it easier to use a true PC joystick to hack rather than a gamepad because the potentiometers are likely to be bigger and easier to get to. Once again, you have two possible ways to perform an analog hack. If the gamepad or joystick you're using as your interface uses the same rating of potentiometer as your arcade control, then all you need to do is to wire the outputs of the arcade control to the gamepad's circuitry. If they do not match, you'll need to replace the potentiometers in the arcade control with potentiometers rated the same as the gamepad and then wire the outputs of the arcade control to the gamepad's circuitry.

Recall that analog arcade controls typically use 5K potentiometers, whereas PCs normally use 100K. This means you are probably going to have to swap out the potentiometers. Before you do, however, be sure to read the Microsoft SideWinder Dual Strike hack in the "USB Gamepad Hacks" section in this chapter. Replacing potentiometers can be tedious, and finding one the right size isn't always easy.

Figure 10-8 shows a look at the inside of a driving-yoke controller. On the right-hand side, you can see a potentiometer with three wires coming out of it. Make sure you are orienting the replacement potentiometer in the same direction, and the hack is as simple as wiring the output legs of the arcade control's potentiometer to the same place that the PC gamepad's potentiometers are wired to. Obviously, you'll need to make sure the gamepad's potentiometers are disconnected first!

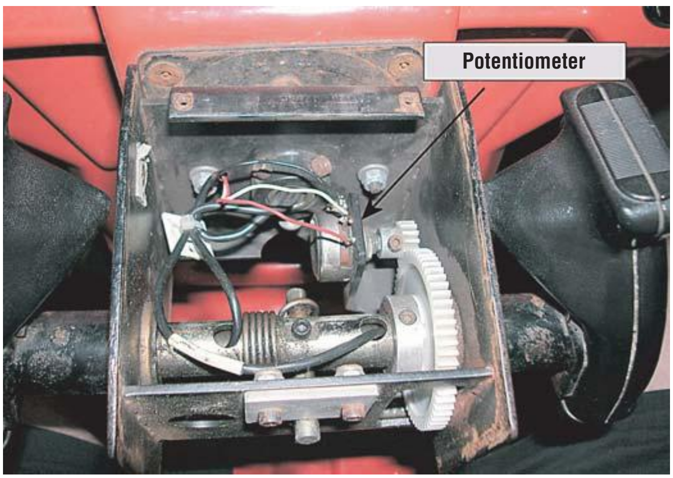


Figure 10-8: Inside the yoke, with the potentiometer controlling the Y axis exposed and pointing to the right.

Replacing this yoke's potentiometer would not be terribly difficult. The security bolt holding it in place would need to be removed and the wires clipped. (You won't be using them, so there's little point in de-soldering them.) Vendors tend to use off-the-shelf parts when they can, so finding a 100K potentiometer the right size should be possible, though you may have to resort to ordering online. Happ Controls sells a 100K potentiometer that should be a perfect fit for many arcade controls (part number 50-2032-00 at `www.happcontrols.com`). Remember that you want a linear potentiometer!

Wrapping Up The Gameport

Many excellent online resources were visited during research for this section. Two good places to read and learn more about the PC gameport are Tomi Engdal's joystick documents at `www.epanorama.net/documents/joystick/index.html` and the Control Center's joystick history essay at `www.joy-stick.net/articles/essay.htm`. More details about steering wheel connections specifically can be found at Lew's Wheels at `www.fortunecity.com/silverstone/thepits/195/lews`.

Using the USB Port

USB ports are a lot like the Borg from Star Trek. "We are USB. You will be assimilated. Resistance is futile!" Just about everything you can connect to a computer also has a USB version, if it hasn't done away with its original version altogether. Keyboards, mice, sound systems, networks, and yes, gamepads can all be found with USB connections today. There are many advantages to using USB. Plug-and-play almost always works properly with USB, devices can be plugged in and removed at will, and USB support can be found in several operating systems and computers. This means that a gamepad, for instance, can be manufactured that works with Windows, Linux, and Macintosh computers with little to no extra effort on the manufacturer's part. Add to this the fact that you can have well over 100 USB devices on a computer, and the possibilities of USB for an arcade cabinet become obvious!

USB Features

USB stands for *Universal Serial Bus*. It was developed as an answer to the limitations suffered by other ports and protocols used to connect devices to a computer. If you'd really like to dive into how the USB protocol and hardware works, visit the USB homepage at `www.usb.org`. Some of the features particularly of concern to arcade builders include:

- **Power** — USB cables have four wires. Two wires are used for data, one wire is for +5v power, and one is for ground. USB supplies up to 500 milliamps of +5v power to peripherals that need it. You can tap into this power for arcade hacks either directly (a bit tricky) or via a breakout cable of some sort. Groovy Game Gear (`www.groovygamegear.com`) sells a USB power tap cable for a few dollars.
- **Expandability** — The USB standard allows for up to 127 devices to be connected. Part of the standard includes USB hubs, which will expand a single port into many ports. Hubs can be powered or unpowered. If you have many devices that draw power through the USB cable, you should

consider a powered hub so that you don't try to draw more power than the computer is supplying. You won't hurt anything by doing so, but your USB devices may not work.

- **Hot-swapping** — USB was designed to allow for quick insertion and removal of peripherals into a computer. Being able to remove a peripheral without powering off the computer is referred to as *hot-swapping*. You can use this on your arcade cabinet, for example, to plug in a steering wheel for occasional use, removing it when done without turning off your cabinet.

There's more to USB, of course, but these are the main points of interest to us. You can use USB connections in some interesting ways in an arcade cabinet project. One I've already touched on, using an arcade control in a temporary situation when you don't want it permanently mounted on your cabinet. Because USB supports hot-swapping, you can plug in the control, play a game, and then unplug it without causing problems.

Another interesting way to take advantage of USB expandability and hot-swapping is to use it for extra players. Say that you've built a two-player arcade cabinet, and that's how it gets used most of the time. Occasionally, however, the gang comes over for a rousing arcade session. Take turns? Bah! Connect two more game controllers to the USB ports, and turn your two-player cabinet into a four-or-more-player cabinet. Arguments are avoided and a good time is had by all!

Most computers have many USB ports these days — some in back, some in front, some on the side. However, your computer is going to be buried inside the cabinet. How can you get to it for controls you want to have removable? The USB standard allows for cable lengths of up to 5 meters (about 16 feet). Take a USB extension cable, plug one end into the computer, and mount the other end somewhere accessible in the cabinet. Consider a hidden connection underneath the lip of the control panel, or perhaps two connections — one on each side of the cabinet for additional players on the left and right. Voila! You have a well concealed but easily accessible expansion port available for use!

Connecting to the USB Port

You really have only a couple of options for connecting to the USB port. You can purchase an arcade control or interface that natively supports USB (many do these days) or you can hack a USB gamepad.

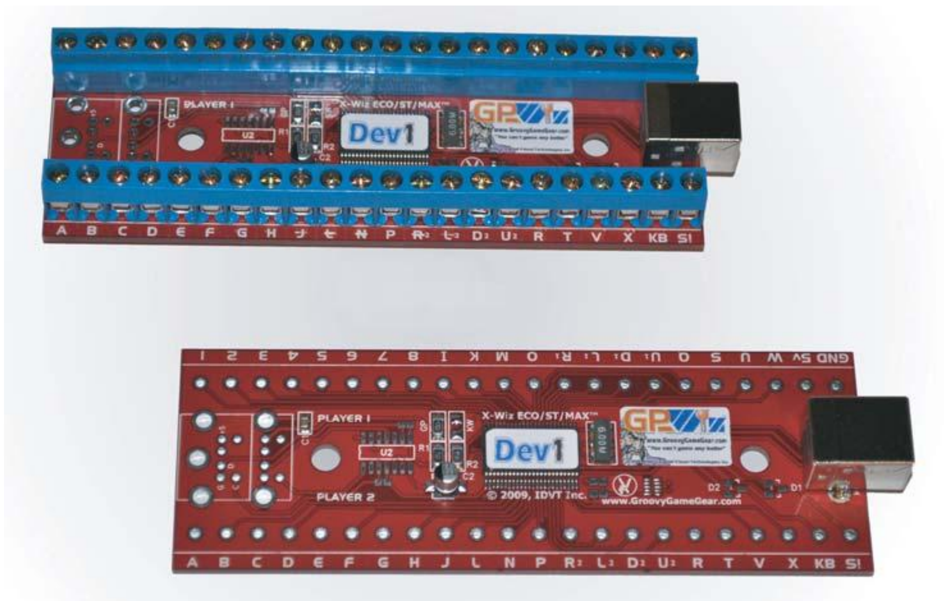
USB Interfaces

You've already seen many USB keyboard and optical interfaces in previous chapters from Groovy Game Gear, Hagstrom Electronics, and Ultimarc. There are also a variety of gamepad USB interfaces available. These are interfaces with

USB connections that appear to the computer as gamepad devices. Gamepad devices have a fixed input map and hence are not programmable. They do not need to be programmable however, as long as the game you're playing supports gamepads. Most do.

Groovy Game Gear USB Gamepad Interfaces

Groovy Game Gear has three interfaces that fall into this category. The first and second are the GP-Wiz40 MAX and ECO models of the same interface. The difference between the two is the MAX has screw-terminals to which you can connect wires, while the ECO requires you to solder to the board for a somewhat lower price (see Figure 10-9).



Used by permission of Groovy Game Gear.

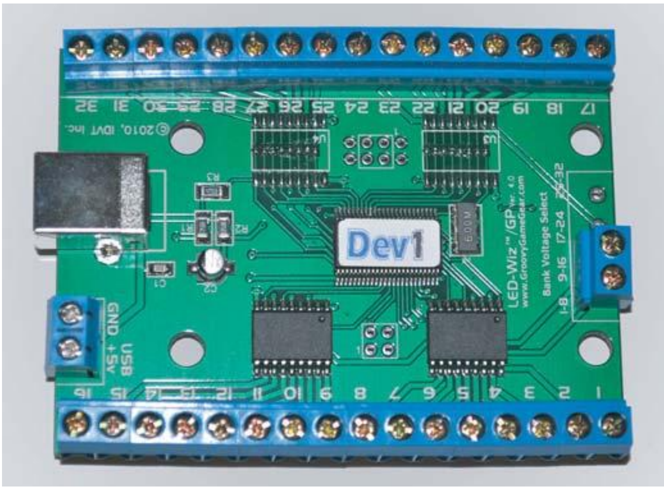
Figure 10-9: The Groovy Game Gear GP-Wiz40 MAX and ECO models.

These interfaces offer 40 inputs, 32 of which are gamepad buttons or joystick inputs, and eight of which are digital axes (player 1 U/D/L/R, player 2 U/D/L/R). These are not analog axes, so you cannot hook a potentiometer based device to them.

The "bonus" that these interfaces have is the Roto-X feature that allows you to use a mechanical rotary joystick. These are the digital rotary joysticks introduced in Chapter 3, which have handles that rotate clockwise and counter-clockwise. Some games used these for extra functions, such as changing where you're aiming your weapon while running in a different direction. For example, you could push the joystick up to move forward, while simultaneously rotating the handle to fire off to your left. Having Roto-X as part of the interface makes the GP-Wiz40 line a nice all-in-one encoder interface.

Groovy Game Gear LED-Wiz+GP

The LED-Wiz+GP is an interesting hybrid interface. One half of the interface functions as an LED output controller, while the other half functions as a gamepad interface (see Figure 10-10).



Used by permission of Groovy Game Gear.

Figure 10-10: The Groovy Game Gear LED-Wiz+GP.

I'll cover the LED functionality in Chapter 15, when I discuss this interface's 32-output big brother called the LED-Wiz. The LED portion works the same on both interfaces. The gamepad portion of the interface supports two digital axes (up/down and left/right) and 12 buttons. Combining the LED output control with the gamepad functionality makes this another nice all-in-one interface.

Happ Controls USB Interfaces

Happ Controls also has a line of USB interfaces for connecting arcade controls to your computer. There are four models available:

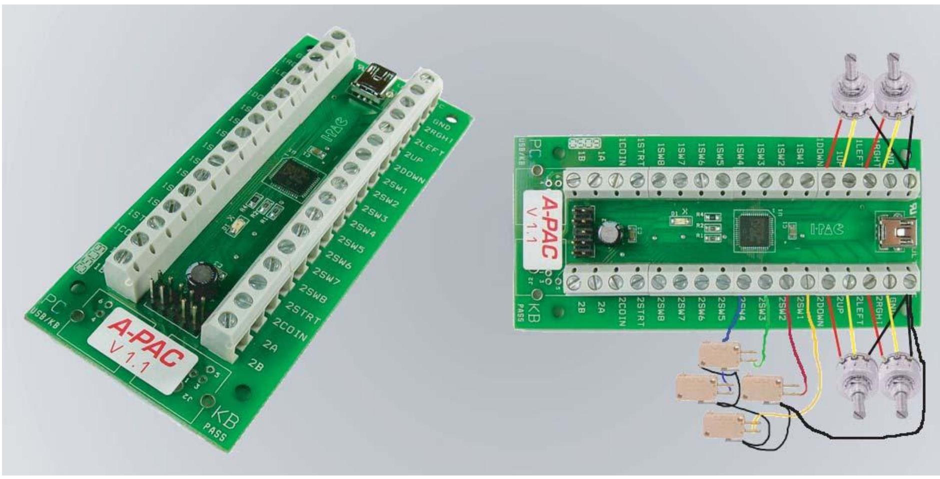
- **Driving USB UGCI** — Supports a steering wheel, brake, throttle, shifter, eight buttons, two coin-ups, and a trackball with three mouse buttons.
- **Flying USB UGCI** — Supports an analog joystick with POV hat, rudder pedal, throttle, two buttons, two coin-ups, and a trackball with three mouse buttons.
- **Fighting USB UGCI** — Supports two eight-position digital joysticks, six buttons per joystick, six buttons, two coin-ups, and a trackball with three mouse buttons.

- **USB Trackball Interface Kit** — Supports a trackball or steering wheel with up to three mouse buttons.

Prices on the Happ Controls USB interfaces range from $49 for the trackball kit to $185 for the other kits. However, prices occasionally vary so you should check their Web site for up-to-date pricing. A software development kit is available for the three UGCI models to allow keyboard mapping for the various attached controls.

Ultimarc A-Pac

The Ultimarc A-Pac is an analog and digital USB gamepad interface that reports to the computer as two gamepads (see Figure 10-11).



Used by permission of Ultimarc.

Figure 10-11: The Ultimarc A-Pac.

- The A-Pac supports up to 32 button inputs, and four analog axes. Each axis takes two button inputs, so you can have the following different configurations:
  - 0 axes, 32 buttons
  - 1 axis, 30 buttons
  - 2 axes, 28 buttons
  - 3 axes, 26 buttons
  - 4 axes, 24 buttons

One side of the interface functions as gamepad 1 to the computer, the other side as gamepad 2. The axes can be configured either digitally, connected to microswitches for each direction, or as analog, hooked up to potentiometers.

This means you can hook up steering wheels and pedals as well as joysticks. Being able to support digital and analog makes this an extremely versatile gamepad encoder, a good candidate for something like a flight-simulator as well as regular arcade controls.

USB Gamepad Hacks

Hacking a USB gamepad is virtually identical to hacking gameport gamepads. In fact, were it not for one particular item, I would not have anything to tell you here at all. However, this one item more than merits space in the book. Ready? Okay. Recall that though it's possible to wire a potentiometer directly to the PC's gameport, a USB port has only two wires for data. These two data signals are digital in nature and cannot directly communicate with potentiometers in any meaningful fashion. Therefore, any USB analog gamepad has to include electronics onboard to convert to a signal the computer can understand. Because the conversion is done on the gamepad and not by the computer, the gamepad is not constrained by the 100K requirement of the gameport. This is significant.

How does that help? The Microsoft SideWinder Dual Strike is a USB gamepad with analog controls that use 5K potentiometers! Technically, it uses 20K potentiometers that have a restricted range of motion, limiting them from 0K to 5K, but it amounts to the same thing. Remember analog arcade controls also use 5K potentiometers. With six programmable buttons, a shift button for a second round of programmable functions, and two 5K potentiometers, the Dual Strike is an arcade-control hacker's dream! Although Microsoft stopped making the Dual Strike (along with the entire SideWinder line) back when the first edition of this book came out, you can still find Dual Strike online. I was able to buy one new for $4.

1UP, the creative talent behind PacMAMEa, at `1uparcade.rmfx.com/`, used Dual-Strike hacks extensively in connecting an original Atari Star Wars flight yoke and positional guns to his incredible arcade cabinet. His instructions for performing the Dual-Strike hack are available online at `1uparcade.rmfx.com/projects-dualstrike.html`. Other USB gamepads may also use 5K potentiometers, but the Dual Strike is the only one I know of currently.

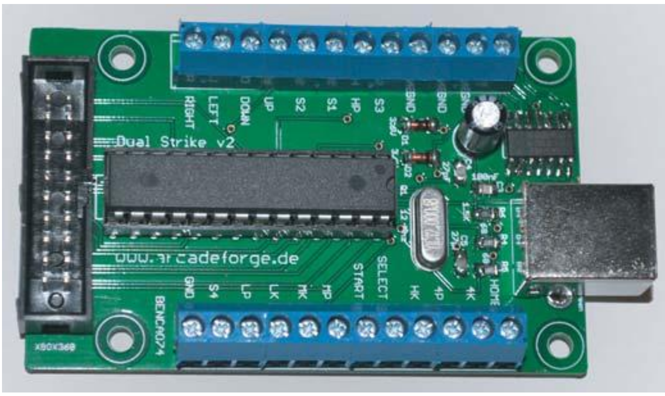
CROSS-REFERENCE **The instructions for the Dual-Strike hack are also included on the book's companion CD-ROM.**

Other Miscellaneous Tricks

I've got just a few more things to show you that defied easy categorization in the previous chapters. Let's take a look at these non-conformists!

Dual Strike V2 Interface

The Dual Strike V2 interface is an interesting contraption that defies easy explanation. It is made by Arcade Forge (`www.arcadeforge.de`) and sold by ArcadeShop.de (`www.arcadeshop.de`). It is an arcade controls interface (see Figure 10-12) that generates different outputs based on the system to which you have it connected and how you have it configured.



Used by permission of Arcadeshop.de.

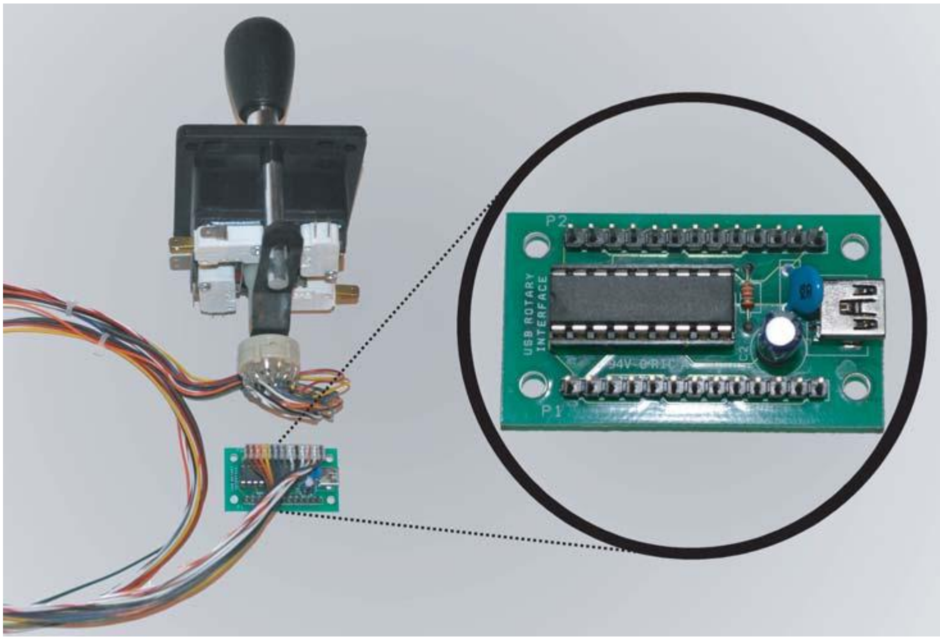
Figure 10-12: The Arcade Forge Dual Strike V2.

It supports being connected to personal computers (Microsoft, Mac, and Linux operating systems) as well as the PlayStation 3, Xbox, and Xbox-360 consoles. It can appear as a gamepad or MAME compatible keyboard encoder when connected to a PC, or as a system native gamepad when connected to one of the supported game consoles. The interface can be set to auto-detect what it's connected to, or to have a default configuration that you have to change manually.

The firmware for the device and all support files for the project are open-source, making it the only commercially available interface I'm aware of that you can modify! Being open source means the community can tinker with the functionality, and at least one additional function has been added to it since release. You can learn more about this unique interface at the Shoryuken forums (`http://shoryuken.com/f177/dual-strike-pcb-219484`), and on the project's documentation page which you'll find linked from the Arcade Forge homepage.

Ultimarc Rotary Joystick Interface

The Rotary Joystick Interface from Ultimarc is a standalone adapter for connecting mechanical (digital) rotary joysticks to your computer via USB (see Figure 10-13). This interface will support two rotary joysticks, and has pin headers that will allow you to plug the modular connector from the joystick straight into place. The interface reports to the computer as a keyboard, generating "[" and "]" keystrokes for player one, and "\" and "/" for player two. These keystrokes are not programmable so you have to make sure your software will support them. MAME (see Chapter 14) will support these keystrokes for rotary joysticks. Not every game is compatible with these keystrokes as of the time this is written, so check on the message forums (`http://forum.arcadecontrols.com`) if there is a specific game you have in mind.



Used by permission of Ultimarc and Happ Controls.

Figure 10-13: The Ultimarc Rotary Joystick Interface connected to a Happ Controls rotary joystick.

Game Console Controllers And Adapters

Are there any other ways to connect arcade controls to a computer? Well, there are a couple more that haven't been brought up yet. You can use the parallel port (and sometimes USB) to connect Nintendo, PlayStation, and other gaming-console controllers to your PC. It's also possible to connect arcade controls to the PC via the parallel port, but there is little compelling reason to do so. Any connections via the parallel port require special drivers and/or software support, and with much easier solutions available, it's not worth the effort. Due to space limitations (this book is already around 500 pages!) exploring these topics is left as an exercise to the reader. However, the `arcadecontrols.com` forums are an excellent place to start with a lot of information on the subjects!

Summary

In this chapter you learned about the PC gameport and how it can be used to connect arcade controls. Though the gameport is an old and simple interface, it is uniquely suited for easy analog-arcade-control connections. You also took another look at the USB interface and learned how the Microsoft SideWinder Dual Strike is particularly useful to arcade cabinet builders. You were introduced to a few USB gamepad interfaces, and finally some miscellaneous odds and ends that didn't easily fall into the other categories. Between these subjects and the past few chapters, you've picked up many different options for connecting arcade controls to your arcade cabinet.

In fact, you've now finished all the arcade control and interface selection information this book has to offer! You've successfully peeled back the veil of mystery surrounding how arcade controls work, and mastered the techniques necessary to design your own dream arcade-control system. Think back on how much you've learned! In the end, it's all pretty simple and boils down to one concept: An arcade control is simply a way of completing a circuit. It may be a discrete digital circuit that's either on or off (such as a pushbutton), or it may be an analog circuit that generates a varying degree of resistance (such as a steering wheel). Either way, the different designs and pretty colors all do the same thing in the end. Connecting an arcade control is a matter of choosing one of several possible interfaces and connecting your control circuits through them. This concludes Part III, "Hooking Things Up Under the Hood."

Coming up next is Part IV, "Putting Together the Final Pieces," in which I'll cover the remaining steps necessary to put an arcade cabinet together. Start with Chapter 11, "Audio — Silence Isn't Golden," where you'll learn about the various audio-related choices you have. There's more than you might think! Keep going, and in a few more chapters you'll be completely finished and the envy of all your friends!

Part

IV

Putting Together the Final Pieces

In This Part

CHAPTER

11

Audio — Silence Isn't Golden

IN THIS CHAPTER

- **Speaking of Speakers...**
- **Arcade Jukeboxes**

You and your pal Mario have dodged flaming barrels, risked life and limb climbing rickety ladders, and finally rescued the damsel in distress from a gorilla who's seen too many King Kong movies — only to have her and the gorilla run off together. Alas, poor Mario, left in a lurch! Bravely carrying on, Mario discovers a secret passage into the Land of Video Game Clichés. Successfully dodging countless crazed turtles and unspeakably vile villains (thanks to your masterful guidance with *real arcade controls*), Mario comes to a pivotal moment. Perched on a crumbling ledge with seconds to spare, a mob of flaming barrels building a pyramid to reach him from below, Mario must quickly choose between running left or right. In one direction lies certain painful death and video game obscurity (the bargain bin!). In the other lies video game–superstar Valhalla, where the gorillas serve cold drinks, the damsels in distress do their own rescuing, and barrels are used only as planters. Which way is which? Which way to go? Suddenly, Lara Croft swings down guns a-blazing and urgently whispers "Mario, you have only one chance at this! The path to safety lies *KAPOW!* *KAPOW!* . . . got it?" "Wait!" yells Mario as Lara does a swan dive into the pile of barrels, sending them scattering before running off into the darkness, "I couldn't hear you over the shooting! Which way; which way!?" If only your arcade cabinet had a good sound system, perhaps Mario might have been able to hear her!

OK, sound is probably not *that* important, but you (and Mario) still want a quality sound system in your arcade cabinet. Good sound can make the difference between a fun gaming session and one that leaves you in a heart-thumping adrenaline rush. There's a whole science (art?) dedicated to creating perfect sound. Enthusiasts build their own speakers, fine-tune each speaker's audio levels, and use meters to determine perfect placement in the room. I'm not going to subject you to any of that! That's appropriate for designing a home theater, but, for an arcade cabinet, the job isn't quite as hard. With some careful thought and planning, you'll have a sound system that will make Mario proud without breaking the budget!

Speaking of Speakers . . .

If you're planning only to play games on your arcade cabinet, speaker selection isn't quite as critical as if you're planning to use it as a multipurpose, multimedia station. Most arcade games had fairly basic speakers in them. After all, the players are right in front of the machine. Do you really want or need the sound to drown out the machine next to it? On the other hand, if you really dig the sound of thumping gorilla feet and laser beams, or if you're planning to use your machine for more than just games, then consider investing in a quality set of speakers. What else can you do with your arcade cabinet besides games? I'll cover that later in this chapter, but imagine your cabinet doubling as the household jukebox!

You should try to select a set of speakers you know you'll be happy with in the long run because replacing them later will be difficult. You'll be cutting a hole or holes in the speaker panel to match the shape of the speakers and fastening them into place. Replacing them later will limit you to using something that fits the already existing holes or finding some way to disguise the difference. You can avoid that with some extra consideration before you start.

A lot of folks toy with the idea of surround sound on their monster arcade cabinet. At first blush, that might seem like a good idea, but it may be overkill in this case. It depends quite a bit on what kind of gaming you intend for the cabinet. If you're planning to stick to emulated arcade classics, you should remember that almost all of them used only mono or stereo speakers. If you're thinking of playing a wider mix, including modern PC games, then surround sound makes more sense. Hearing the sounds of footsteps behind you while running around in a deadly maze adds an element of gaming not to be missed!

Choosing PC Speakers

You have a couple of options when it comes to choosing speakers for your cabinet. You can choose a set of PC speakers, or you can choose something else. How's that for vague? I should probably have said you can choose the simple way or the more involved way. PC speakers are obviously the simple way. (Note that PC speakers refer to external stereo speakers designed to work with a computer and not the tiny speaker built into the computer case.) Aside from physically mounting them, connecting PC speakers is simply a matter of plugging the cables in to your sound card. Depending on quality, they can be had for as little as a few dollars up to a few hundred dollars. My personal favorites are the Klipsch ProMedia 2.1 computer speakers (`www.klipsch.com`; see Figure 11-1). The sound quality is amazing, and they have a relocatable volume control pod that I'll discuss a bit later in this section. These speakers are available exclusively at Best Buy (`www.bestbuy.com`).

Photo courtesy of Klipsch Audio Technologies.

Figure 11-1: Klipsch ProMedia 2.1 stereo computer speakers.

Other Speaker Choices

Other speakers can be used in an arcade cabinet as well. Car stereo speakers, home audio bookshelf speakers, or projects speakers from electronics stores have all been used successfully in arcade cabinet projects. If you're planning to use non-PC speakers, there are a couple of things you'll need to consider.

Power

Like anything electronic, speakers need power (in the form of amplifiers, in this case). Most computer speakers have built-in amplifiers. Most other speakers, such as car stereo or arcade speakers, do not, so you'll need to supply one. Without an amplifier supplying power to the speakers, you will barely be able to hear anything, if they work at all. You can either purchase an external amplifier or kit (try Radio Shack or Parts Express at `www.partsexpress.com`) or hack an existing amplifier. Many people have successfully hacked a cheap PC speaker that has an amplifier and wired it to their non-PC speakers. Inside the PC speaker is a circuit board with the amplifier and associated electronics (Figure 11-2).

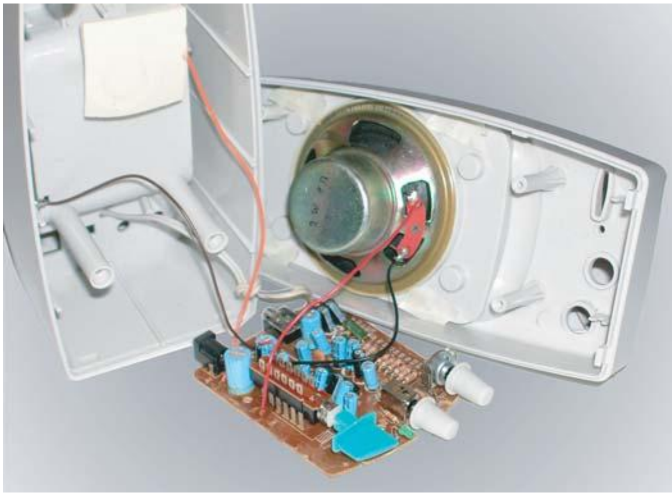


Figure 11-2: Amplifier from generic PC stereo speakers.

Using these amplifiers is quite easy. Disconnect the PC-speaker wires from the amplifier, and connect the wires from your speaker in their place. Repeat this for the other speaker. You can either clip the wires and use quick-disconnects, or you can solder them directly to the amplifier board. Quick-disconnects are much easier and are recommended. The second speaker is likely to plug into the amplifier through a 1⁄8-inch stereo plug so you may need to hack or build an appropriate cable. Voila! You have an instant, amplified, stereo-speaker set using higher quality arcade or car stereo speakers!

NOTE **If you're thinking of using a PC-speaker amplifier hack, take a look at Oscar Controls' tutorial on the companion CD.**

An audiophile would mention matching the impedance of the new speakers to those originally attached to the PC speaker's amp (speakers are usually rated at either 4 Ohms or 8 Ohms). Practically, mixing them up does not matter much for an arcade cabinet. You may slightly degrade the sound quality or shorten the lifespan of the speakers/amp — depending on whether your impedance is higher or lower than originally rated — but the odds are against this causing you a problem for the life of the cabinet.

As an alternative to hacking an amplifier, some older sound cards have an amplified speaker-out connection as well as a line-out connection. Self-powered/amplified speakers use the line-out jack whereas cheaper unpowered/unamplified speakers are connected to the speaker-out jack. If you have a sound card with speaker-out, you can wire unamplified speakers directly to the sound card's plug. One drawback is that volume control can be more difficult this way. Sound cards available today typically include only line-out connections, so this isn't an option for most people.

For those who truly want to shake the house, a PC speaker amplifier won't do it. If you're going to use car stereo speakers, why not use a car stereo amplifier to crank out the sound? It works, and people who have done it are quite happy with it. However, using a car stereo amplifier to power the speakers in your arcade cabinet is probably overkill. There's nothing wrong with it, but your time and effort are probably better spent elsewhere. Serious audio enthusiasts would argue with me on this point, so you may wish to experiment before you make a final choice. I have one word of caution. Car amplifiers require a lot of power and can easily overload a PC power supply that's also powering other components. Use a dedicated power supply if you plan to use a car stereo amplifier.

Magnetic Interference

Car stereo speakers and those from electronic project stores can work very well in a cabinet. Nevertheless, be careful if you chose to go this route. These speakers usually aren't magnetically shielded. Have you ever held a magnet up to a CRT video monitor? *Don't try it now*! You'll get a wavy picture with distorted colors straight out of the '70s. Distortion caused by strong or long-term exposure to magnets can be difficult — if not impossible — to fix. If you mount car stereo speakers to the speaker panel over your monitor, you may end up with unwanted (but sometimes pretty) distortions in your picture. It's unlikely to cause a permanent problem with brief exposure, so you can see whether magnetic interference is going to be an issue before you attempt to solve it.

You can combat this problem by attaching a set of bucking magnets to your speakers. A bucking magnet is a magnet between 1⁄2 to 3⁄4 the size of your speaker's magnet, which you attach to the speaker magnet in reverse polarity so that they try to repel each other (see Figure 11-3). Because they will repel each other, you'll need to use a good industrial-strength adhesive to attach them permanently. The sound quality is not affected, but the magnetic fields are muted, which allows you to place the speakers close to your monitor without adverse affect. You can find these at Parts Express (`www.partsexpress.com`) for less than $1.

You can also deal with magnetic interference by installing shielding. Thin sheets of metal designed for this purpose are available from a variety of online locations. However, shielding is harder to work with and more expensive than using bucking magnets, and I would not recommend it.

Car stereo and hobby speakers do have one advantage over PC speakers: They're designed to be mounted flat into a panel like the one in your arcade cabinet. Their low-profile design and mounting holes make them an easy addition to a cabinet. If you can counteract any magnetic interference to the monitor, these speakers can work out very well.

Photo courtesy of Oscar Controls.

Figure 11-3: A bucking magnet attached to a car stereo speaker.

Speaker Recommendations

If you have cheap or easy access to non-PC speakers, they can produce excellent sound quality and volume. Even a cheap pair of PC speakers can give you sound as good as or better than a 20-year-old arcade cabinet mono-speaker. They probably won't sound as good as car stereo or hobby speakers. However, for quality of sound and ease of installation, the best speaker choice for an arcade cabinet project is a set of moderately priced 2.1 or surround-sound PC speakers.

With non-PC or cheap PC speakers, you may not get a dedicated subwoofer. Good speakers are great for an arcade cabinet, but there's nothing quite like well-tuned, booming bass thumping in time to the firing of a laser beam to make you appreciate the desirability of a subwoofer. A 2.1 or surround-sound system with subwoofer is *highly recommended*!

Mounting Speakers

For the purposes of this section, I'm going to assume you're using a set of 2.1 PC speakers with a subwoofer, such as the Klipsch ProMedia 2.1 speakers recommended earlier, and that you're following the Project Arcade 2 plans. If you are using another solution, the specifics of mounting will vary, but the principles will remain the same.

Start by determining where you will mount the speakers. Most people will want to mount their speakers behind the marquee, facing down toward the monitor. Some may choose to mount them elsewhere, such as side mounts on the cabinet. Following the Project Arcade 2 plans, you'll be mounting them behind the marquee.

Speaker Covers

Consider what kind of covers you'll place over the speakers. Will you be cutting out slots in the panel for the sound to come through, as shown in Figure 11-4? This can be done with a router.

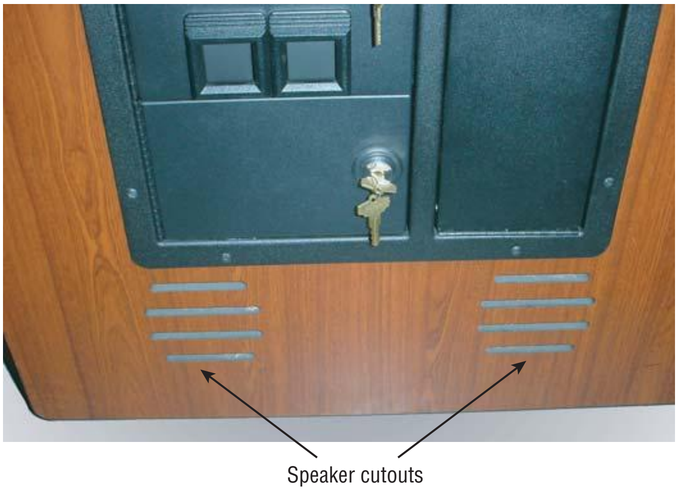


Photo courtesy of Oscar Controls.

Figure 11-4: Routed speaker cutouts on a cocktail cabinet.

Easier and more popular is the use of speaker grills to cover the speaker holes in the cabinet. However, you'll be amazed at how difficult it can be to find properly sized speaker grills for your cabinet. Those available at local retailers are usually the wrong shape or entirely too big. Fortunately, I've tracked down a few online resources for likely candidates. The speaker grills used in Project Arcade are available from Mike's Arcade (`www.mikesarcade.com`) as well as Arcadeshop Amusements (`www.arcadeshop.com`). Round speaker grills are available from Happ Controls (`www.happcontrols.com`). You also might consider using the speaker covers that come with the Klipsch speakers if you're using those.

Positioning Your Speakers

Whether you use grills or some other method, you'll need to position your speakers between the marquee retainer and the monitor-area glass. I'll be covering both a bit later on, but the marquee retainer is an L-shaped strip that attaches to the edge of the speaker panel and holds the marquee in place. The monitor-area glass is a glass or Plexiglas sheet that covers and protects the monitor area. The speakers will be placed so that they rest between the marquee retainer and the monitor cover. You should allow between 1⁄2 inch to 1 inch from the edge of the speaker shelf for the marquee retainer, at minimum. Exact placement of the speaker holes will depend on the placement of the speaker covers. If you're using the Klipsch 2.1 speakers and the Project Arcade 2 plans, the layout for this has already been done for you. If you're not, you'll want to bear in mind that the holes need to be placed so that they are centered inside the speaker covers.

You may also run into issues with light. Light? Isn't this the audio chapter? It is, but the speakers and marquee light share a common cabinet space. Because of this you'll want to be fairly accurate with your speaker hole cutouts. If your holes leave gaps once the speakers are mounted, light will shine through the speaker covers. You can also run into issues with the speakers casting shadows onto the marquee if the speakers are between the marquee light and the marquee. You can avoid this by placing the speakers further back, the marquee light further forward, or by using a shield of some kind such as a black posterboard covering over the speakers.

TIP **Unless you're using the Klipsch speakers recommended and the Project Arcade 2 plans, I can't advise you specifically where to place your speaker cutouts. I recommend test placing your speakers and marquee light to help determine where to cut your speaker holes.**

Attaching The Speakers

Mounting the Klipsch speakers onto the speaker shelf is easy enough once you've got the holes cut and the paint touched up. Start by removing the speaker stands and the volume control pod. The speaker stands unscrew from the bottom, and the volume control pod will slide forward with a bit of effort. Next remove the speaker grill in order to expose the speaker hardware and screw holes. The screws holding the speaker together are 3⁄4 inch long. You're going to remove those and use 1 1⁄2-inch screws to mount through the speaker shelf into the speaker, which holds it firmly into place. The screws are just a bit too short to hold well, so you'll want to counter-sink them about 1⁄4 inch. You could also try to find 1 3⁄4-inch screws instead. Take a look at Figure 11-5.

You'll want to mount the speakers with the wiring jack toward the outside walls. This will let you neatly route the speaker cable down the sides instead of dangling it down the middle. Be sure the screws are tight through the wood and into the speakers. If they're loose, the back of the speaker enclosure will fall off, which will probably break the speaker as it goes. Give the speaker a tug test to make sure it's secure. You want to make sure that the speaker won't fall when the cabinet is moved around. When the speakers are securely in place, cover them with the speaker grills, and you're done! Figure 11-6 shows what the installation will look like.

Used by permission of Klipsch Audio Technologies.

Figure 11-5: Klipsch ProMedia 2.1 speaker with cover and screws removed. Replacement screws are on the left; original screws are on the right.

Used by permission of Klipsch Audio Technologies and MikesArcade.com.

Figure 11-6: Left: grill-covered speaker. Right: securely mounted speaker.

The Subwoofer

Your last task is to mount the subwoofer somewhere. There are mixed camps on this. Some people contend you should mount the subwoofer outside the cabinet because they are designed to be placed in the open air and enclosing them can alter the acoustics. Other people think that there's enough open space inside the cabinet that it won't make a difference and, if anything, it will magnify the bass effects. As usual, it comes down to your personal preference. I suggest placing the subwoofer inside the cabinet and fine-tuning the output with a relatively "boomy" song or game playing. If you don't like it, just move the subwoofer outside the cabinet. Because you're likely to be working in the cabinet for some time yet, I recommend staking out a suitable spot for the subwoofer and then placing it aside until you're ready to unveil your creation.

The Final Word On Speaker Mounting

If you're planning to use surround-sound speakers, you have some additional challenges. The front and middle speakers are not terribly difficult to place. The middle speaker would fit ideally behind the marquee with the front speakers either behind the marquee also or possibly mounted directly on the sides of the cabinet. Placing the surround rear speakers is where you'll need to do some creative thinking. In my study, I have in-wall wiring with my surround-sound speakers mounted in the ceiling. I have an outlet in the wall behind my computer to which the wiring is connected. My rear-speaker outputs plug into this and give me surround-sound audio in my room. A similar concept can be used in your arcade cabinet project if you have the opportunity to run wiring in the walls. You can also follow the steps of a few audiophile cabinet builders who have used telescoping arms to mount the rear speakers to their cabinet. The arms mount to the back top of the cabinet and extend out past the player, which positions the rear speakers behind you.

NOTE **You might be considering dismantling the speaker or subwoofer enclosure to make it easier to mount. *Don't*! Speaker design consists of more than the electronics and physical parts. The enclosures are an important part of the overall sound quality. Removing the speaker/subwoofer enclosure changes the pressure and airflow and will have an adverse affect on the sound.**

Volume Control

Your last point of consideration with speakers is volume control. Sometimes, you may want your cabinet **loud**; sometimes, you may want it *quiet*. If you're using the Klipsch ProMedia 2.1 speakers or a similar set, you're in luck! The volume control pod connects to the subwoofer and has a long cable

(Figure 11-7), which allows you to place it just about anywhere that's convenient for you.

Photo courtesy of Klipsch Audio Technologies.

Figure 11-7: Klipsch ProMedia 2.1 volume control pod.

I recommend placing the control pod somewhere easily reachable but out of sight, such as on the inside-front panel, which is accessible through the coin door. If you have a similar speaker set or are using a hacked amplifier, you should be able to do something very similar.

If you don't have an easily re-locatable volume control knob, it's possible to make one. In a nutshell, what you do is split the speaker cable and wire an audio taper potentiometer in between. Note the difference in this potentiometer and the linear taper potentiometers used in analog controls! If you use a long enough run of cable, you will be able to install the volume control anywhere you wish. One nice perk of doing it this way is that you can drill a small hole in an appropriate spot on the cabinet, thread the potentiometer shaft through the hole, and mount a knob just like a real stereo volume control. Building a volume control will cost you somewhere between $15 and $20.

CROSS-REFERENCE **If you'd like to do this, I've included a step-by-step tutorial on the companion CD-ROM, courtesy, once again, of Oscar Controls.**

Volume controls that go between the amp and speakers are called "L-pads." If you'd like to use one but aren't interested in building it yourself, you can purchase an Arcade Cabinet Volume Control from 3Tronics (`www.3tronics.com/arcade_volume.htm`), makers of the MAMI keyboard encoders, for $35 plus shipping. L-pads are also available from Radio Shack and Parts Express (`www.partsexpress.com`).

You can also use a variety of software solutions to control volume on your cabinet. Cabvol (also on the companion CD) by BYOAC forum member ahofle is a program that allows you to use a "hotkey" button in combination with other buttons or a spinner or trackball to control volume up and down. Some front ends also have mechanisms for controlling volume, which I'll cover in Chapter 13. Also, the I-Pac keyboard encoder by Ultimarc includes built in volume control functionality assignable to the buttons of your choice.

Now that you've looked at all the considerations for speaker selection and installation, it's time to take a look at what you can do with your sound system. I'll take game playing for granted, but what else can you do with your creation?

Arcade Jukeboxes

How about an arcade jukebox! What's an arcade jukebox? Recognizing that their arcade cabinet project was going to be a centerpiece of their home game room, many people started thinking about other purposes for their arcade cabinets. When you think back to days spent in an arcade, what comes to mind besides playing games? Noise and music — arcades are loud! There's almost always someone playing music on a jukebox competing with the sounds of the arcade machines. Now, with compressed audio files and software, you can re-create that atmosphere at home!

NOTE **The rest of this section talks about playing compressed music files on your computer — usually in MP3 format — although others are possible. Like many things, it's possible to obtain MP3 music files both legally and illegally. Regardless of your opinion of the music industry and how it operates, the law is the law, and significant consequences are possible for copyright violations. Please, keep it legal!**

Building An Arcade Jukebox

First, I'll bring up a quick diversion. Instead of using your arcade cabinet as a jukebox (won't you be playing games on it?), why not have a dedicated jukebox? Aside from actually going out and purchasing a real jukebox, you have a couple of resources available if you'd like to build your own jukebox at home.

North Coast Custom Arcades (`www.northcoastarcades.com`), makers of the Ultimate Arcade II plans used in this book, have a wall-mounted jukebox plan for $28. The jukebox measures roughly 1 1/2 feet wide by 3 feet tall with a maximum depth of about a foot. It's designed to work with a 15-inch flat-panel LCD monitor.

Mountain Designs (`www.mountaindesigns.net`) sells a variety of countertop jukebox kits that are extremely popular as well. Prices range from $100 for a basic package to $750 for a completely assembled shiny jukebox kit.

Alternatively, you can pick up a real jukebox that's seen better days and convert it into a PC-controlled arcade jukebox. That's a bit outside the scope of this book, but if you visit the jukebox forum over at `www.arcadecontrols.com`, you'll find a variety of folks who've done just that!

Jukebox Software

If a fully dedicated jukebox isn't for you, but you'd still like to be able to play music on your cabinet, consider one of the many jukebox software programs designed to work with your arcade cabinet. They run the range from simple overlays for Winamp (software for playing MP3 format music files on your computer at `www.winamp.com`) to full music- and video-playing software packages designed to be controlled with an arcade joystick. There are *many* available; I'll highlight just a few of them and point you to the rest. Unless otherwise stated, all programs run under Windows.

Arcade Jukebox

Arcade Jukebox (`www.arcadejukebox.net`) is a simple MP3-playing jukebox application intended for use on arcade cabinets. It has not been in active development for several years but is still a worthwhile contender. All controls can be enabled with a joystick and four buttons, or a mouse/trackball can be used, which makes it very cabinet-friendly. Arcade Jukebox reads MP3 ID3 tags (part of the MP3 music format that identifies a song's artist, album, and other information) and can sort your music by title, artist, album, year, and genre. The database-driven program will automatically search for all your music tracks in the directory you specify, including subdirectories. The jukebox comes with a set of backgrounds, or you can add your own.

Virtual Music Jukebox

Virtual Music Jukebox (`www.virtualmusicjukebox.com`) is a full-featured jukebox program with support for arcade cabinets. It features random (radio) play mode, play by album, and other song-selection modes. It can play Windows video files (WMV format) as well as MP3 and Windows music files (WMA). Your music can be grouped into libraries, so you can choose, for instance, a classical library for quiet times, a rock library for parties, and so on. Virtual Music Jukebox supports album covers, lyrics display, and windowed and full-screen modes. The program is available in a demo version with a limited number of albums supported, and the full version costs $19.95.

DW Jukebox

DW Jukebox (`www.dwjukebox.com`) is one of the oldest arcade cabinet–friendly jukebox software packages still in development. It is also one of the only packages to still support DOS, making it an excellent choice for a low end salvaged computer. It's fully skinnable, with choices available that can make it look from anything like an old time soda-fountain jukebox to a Star Trek LCARS style interface. It has a full set of features, including random play, built in slideshow screensaver, and input from gamepads, joysticks, mice, and touch screens. DW Jukebox is free for non-commercial use.

UncleT's Jukebox

This is another jukebox developed by an arcade cabinet builder. UncleT's jukebox (`unclet.arcadecontrols.com/Jukebox`) is capable of playing video as well as audio files, supports dual monitors, and is arcade cabinet–friendly (meaning it works with your cabinet controls or a touch screen). Features include random playlist, search for songs, "party mode" to lock out controls, and many others. UncleT's Jukebox is free for non-commercial use.

Freebox Jukebox

Freebox Jukebox (`www.freeboxjukebox.com`) is another arcade cabinet–friendly, skinnable jukebox, under active development. It supports both audio and video files, dual screen, and even MP3+G (Karaoke) mode. Freebox is fairly popular in the BYOAC community and giving it a try is recommended.

MultiFE

MultiFE (`www.multife.com`) is a combination front-end game launcher and music jukebox. It supports gamepads, keyboard/arcade controls, mouse/spinner, and touch screen. Features include a built in screensaver, auto-shutdown after last song is played, radio mode, and others. This frontend/jukebox is under active development, and is free to use.

CROSS-REFERENCE **Several jukebox software packages are included on the companion CD for you to try!**

Other Jukeboxes

There are many more music-playing programs and jukeboxes you might want to consider for your arcade cabinet or jukebox cabinet. Some of them are designed to work on arcade cabinets with arcade controls, while others are designed to be used with a touch screen monitor (and so can go into any contraption you want to design). Others are just designed to be good MP3-playing programs. You can find a good listing of arcade cabinet–friendly jukebox software on the

BYOAC wiki page at `wiki.arcadecontrols.com/wiki/Jukebox_Software` and in the jukebox forum at BYOAC.

The arcade jukebox field has matured dramatically since the first edition of Project Arcade but is still an actively changing scene. Be sure to look online as much may have changed since this book was written. If you're looking to include a jukebox in your game room, you might be happiest dedicating a PC and full surround-sound speaker system to it. Otherwise, an arcade cabinet-friendly jukebox program makes a good compromise!

Summary

The sound system is often an overlooked part of an arcade cabinet project, but it is clearly as important as anything else. You obviously want to hear what you're playing, with the option to control the volume to suit the environment in which you're playing. A really good sound system with a subwoofer will add an element of gaming that can surpass that of the original arcade! If you add an optional jukebox program, you can really have a whole arcade in one cabinet.

So, you've paid attention to what you hear, but what about what you see? Coming up next, I'll take a look at the options you have for video!

CHAPTER

12

A Picture Is Worth a Thousand . . . Tokens?

IN THIS CHAPTER

- Electrical Warning
- A Basic Understanding of Monitors
- Monitor Types
- Mounting Monitors

You've put together a styling arcade cabinet, concocted a perfect blend of authentic arcade controls, and added in a Mario-saving sound system that lets you hear every zap and explosion. What about the monitor? All the rest may seem pretty silly if you don't have a great video system to go with it. A nice bright, big and bold, in-your-face monitor is the perfect complement to the attention to detail you've put into the rest of the cabinet so far. Fear not. I've shown you the way thus far, haven't I? You may be surprised to find out how many choices you have when selecting a monitor for your arcade cabinet. Computer monitors, arcade monitors, and televisions are possible paths to your dream arcade machine — each with their own strengths and weaknesses. Read on to see what's right for you!

Cathode Ray Tubes — The CRT

From the beginning of the very first arcade video game cabinet in 1971 (Computer Space) until the late 2000s, arcade machines used some variation of a monitor called a cathode ray tube, or a CRT. A little later in this chapter I'll talk about the successor to the CRT and what it means for this hobby, but with 30+ years of arcade machines and CRT monitors going hand in hand there's quite a bit to talk about first.

Electrical Warning

Warning! Danger! The information in this section can help you avoid hurting yourself — potentially fatally. Don't skip it! A few minutes here might save your life. If you do not read this section, then you should not proceed any further with a CRT monitor in your cabinet!

Wonder what I'm going on about? Throughout the book, I hope my sense of humor has come through. However, there's nothing funny about what I need to tell you here. CRT monitors can be dangerous. What you don't know can hurt you; what you know but don't respect can also hurt you. What can hurt you can also prove fatal. There's no joking here. This subject is serious.

WARNING **You may notice I'm really trying to get your attention on this one. Take the warnings in this chapter seriously. Improper handling of a CRT monitor can hurt you!**

NOTE **Until I get to the section on LCD monitors, any reference to a monitor in the following pages should be understood to mean a CRT monitor.**

A CRT monitor acts as a big capacitor or battery. When powered on, the monitor has a huge electrical charge in it. Here's the important part. Monitors can carry a huge electrical charge *even when turned off and unplugged*! They may have between 20,000 and 30,000 volts without a connected power source! Like a battery, that electrical charge is looking for somewhere to go. Complete a circuit between the two terminals of a battery with a light bulb, and the bulb glows. What do you think might happen if you touch the wrong part of the inside of a monitor? You may end up completing a circuit between the monitor and the ground, which places you in the role of the light bulb. Unfortunately, you don't glow — you just get hurt! If you're unlucky, in rare occasions, it can even prove fatal.

Now, any electrician reading this may be frowning. They'll tell you it's not voltage that does you in, it's current. You'll barely notice one milliamp of current. Current greater than 16 milliamps can force your muscles to contract, which makes you unable to let go of the electrical object that's hurting you. Twenty milliamps of current can cause paralysis to your respiratory muscles so you cannot breathe, and 100 milliamps of current running across your heart can make it stop pumping blood properly and simply quiver (fibrillation). As little as two amps can stop your heart outright and cause internal organ damage (Source: `www.cdc.gov/niosh/docs/98-131/prevention.html`). As a frame of reference, a standard household outlet normally provides at least 15 amps of current.

How much current will you expose yourself to if you touch the wrong part inside the monitor? It depends on the circumstances. The formula is voltage = current × resistance. Rephrased, current = voltage × resistance. That means the current varies as the resistance varies. If you accidentally touch the wrong part inside a monitor, which creates a circuit with you in the middle, your body provides the resistance. If your skin was very dry, the resistance would be high, and the current would be lower. If your skin was damp, for instance, if you were in a humid environment or were perspiring, the current would be higher — possibly high enough to do you harm. So, what is the answer to how much current you might be exposed to? The answer is, I don't know. It depends on your monitor's electronics, what you might be touching, and skin moisture. Are the odds in your favor that the current will be low enough not to hurt you? Frankly, the odds are against you getting seriously hurt or killed. However, do you want to play the odds when your life is at stake? Is it worth taking a chance with careless behavior? The answer is clearly an emphatic *no*.

What could happen if you are accidentally shocked by a monitor? As you've just read, you could have problems with your breathing, your heart beating, and internal organ damage. However, even if you only get a "mild" shock and don't suffer any of these immediate physical injuries, related injuries can occur. Involuntary muscle spasms can cause your limbs to jerk, causing them to slam into sharp metal objects inside the monitor frame or possibly encounter other electrical components. If you are carrying your monitor and drop it from the shock (or accidentally knock it off onto the floor), it can break. A monitor is a vacuum-filled container of thick glass. If it breaks suddenly, the force of the air rushing in to fill the vacuum can cause shards of glass to go flying, with you at ground zero!

I'm not trying to scare you, but I am trying to make you pause and consider before you get near the inside of a monitor. I probably don't need to elaborate on the danger any further. It can be summed up as follows. The inside of a monitor is potentially dangerous to you. Touching the wrong part inside a monitor can cause you immediate physical harm or death. Even a mild shock can cause you to react involuntarily, possibly causing you second-hand harm. Please, take this seriously, and treat your monitors with extra care. Wiley Publishing and I want you safe and healthy for our next book! Thanks!

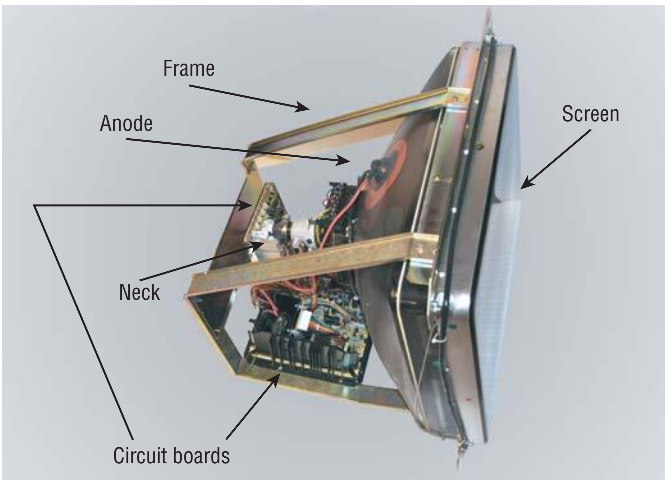
Does this mean you shouldn't handle a monitor? Of course not. With proper care and handling, you can safely choose, mount, and operate a monitor for your arcade cabinet. Which parts of the monitor should be safe to handle, and which parts are dangerous? The answer is simple. Never touch any part of a monitor other than the frame, interface cables, or screen. Other parts of the monitor should only be touched by trained professionals.

A Basic Understanding of CRT Monitors

Let's move on to a lighter topic — the parts of a monitor. Whether it's an older model television, computer monitor, or arcade monitor, if they are CRT based they all work essentially the same.

NOTE **Look out — it gets techie for a bit here! You should at least skim the next few sections and then read the last paragraph where I sum it up. Mastering the full details isn't necessary, but the gist will be important when it comes time to choose a monitor.**

CRT monitors have rectangular screens facing the viewer with a large body behind that tapers to a small neck as shown in Figure 12-1 (the labels in the figure will be discussed in the "Anatomy of a Monitor" section that follows).



Used by permission of Billabs.

Figure 12-1: A cathode ray tube exposed.

CRT technology is 60 to 100 years old. Of course, there have been many improvements in that time. However, the basic principles have stayed the same. In the neck of the monitor tube is an electron gun that fires a beam of electrons at the screen. The inside of the screen is coated with a layer of phosphor dots that glow briefly when struck by the electron beam. Monochrome monitors have only a single color of phosphor, whereas color monitors have three different-colored phosphor spots arranged in groups coating the entire screen. These colors are red, green, and blue, and this is where the term "RGB monitor" comes from. Different combinations and intensity levels of red, green, and blue produces the different colors we see on the screen (see the extreme close-up in Figure 12-2). You'll have to look at the picture on the companion CD-ROM to appreciate the full effect. However, do you notice the pattern of three spots in every grid? Those are the red, green, and blue spots of phosphor. You wouldn't know it by looking at it, but that is an extreme close-up of a bright white screen on a television!

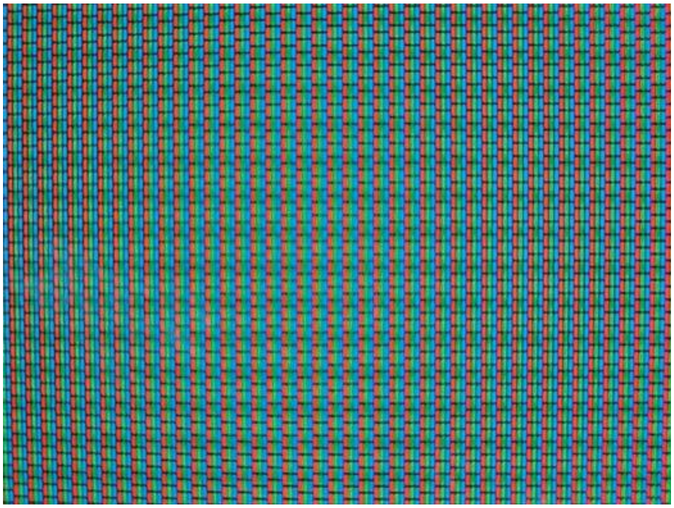


Figure 12-2: Close-up of a color television screen.

Color monitors actually have three electron guns — one for each color. If you look closely at a CRT, you can see the three different-colored dots covering the screen. Electronics in the monitor modify the direction and intensity of each electron beam so that it strikes the appropriate red, green, or blue phosphor dots, which combine to make the colors and images you see on the screen. This is accomplished by the deflection yoke, which applies a magnetic field that alters the path of the electron beam as required. Each electron gun has a corresponding deflection yoke. In practice, people often refer to the electron guns and the deflection yokes as single entities ("the electron gun" and "the deflection yoke").

After it is struck and glows, the phosphor begins immediately to fade and has to be hit with the electron beam again to refresh the glow. The rate at which the electron beam refreshes the phosphors is known, plainly enough, as the refresh rate. A higher refresh rate makes a smoother picture. A lower refresh rate can cause flicker. Different types of monitors are designed to work at different refresh rates. This is important because the input video signal (from the video card for a computer monitor, from the TV tuner in a television) has to send a signal at a refresh rate the monitor is capable of. A mismatch between the video signal's expected refresh rate and the monitor's capability can cause problems, from a loss of picture to actual damage to the monitor itself!

This is a very simple description of exactly what makes a monitor work, but it covers the highlights of what you need to know when building an arcade cabinet. There's much more to what makes a monitor tick. If you're interested in learning about it, read the "How Television Works" guide at `http://entertainment.howstuffworks.com/tv.htm`, the "TV and Monitor CRT (Picture Tube) Information FAQ" at `www.repairfaq.org/sam/crtfaq.htm`, and the PC Technology Guide at www.pctechguide.com/06crtmon.htm.

To sum up how a monitor works, beams of electrons are fired from guns in the neck of the monitor tube. Magnetic fields from components called *deflection yokes* help steer the path of the electron beams. The electrons hit phosphors on the inside of the screen, which causes them to glow. The speed at which this happens is referred to as the refresh rate. There you have it — an entire course in CRT monitor technology in only five lines. You should hear me explain economics!

Anatomy of a Monitor

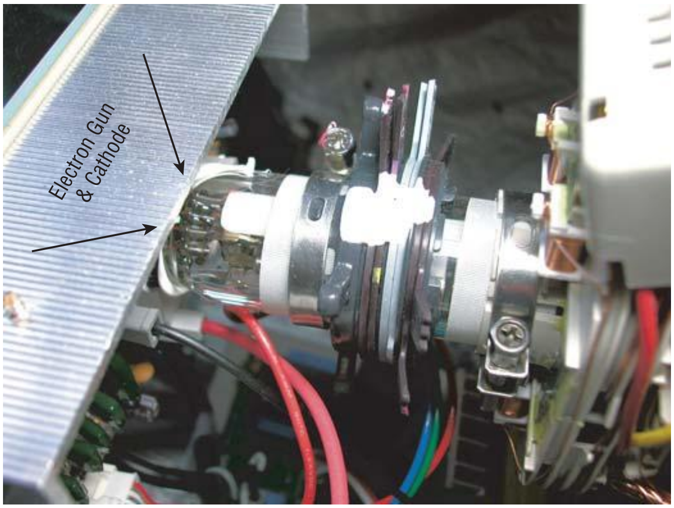
Before you handle a monitor, you need to be able to identify some of the important parts.

WARNING **This section in particular attempts to give you an overview of how a monitor works. It — in no fashion — should be considered a complete course in monitor theory and will not make you an expert in monitor safety! Always respect the hazards of a monitor, and do not touch the electronics.**

Anode and Cathode

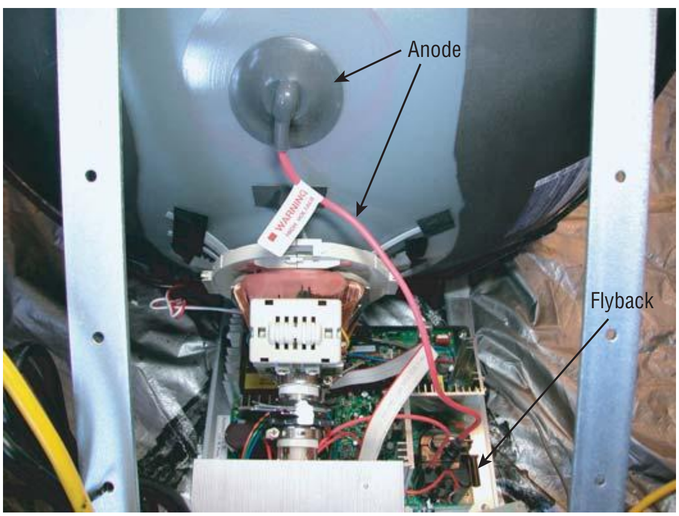
You can think of anodes and cathodes as the positive and negative ends of a circuit. The anode is the positive side of the circuit; the cathode is the negative side. It's a common misconception that electricity flows from the positive to the negative side. Actually, the opposite is true. Electrons flow from the negative to the positive or from the cathode to the anode. The cathode portion of the CRT is part of the electron gun in the neck of the tube (Figure 12-3). Even though you shouldn't be touching any part of the inside of a monitor, be particularly careful of the neck of the tube. It is the most fragile part of the tube. If it breaks (for instance, by something falling on it), then the monitor is dead.

Once an electron has struck the phosphor, which causes it to glow, it needs somewhere to return to. At the top of the tube is the anode (technically referred to as the "second anode"), a suction cup covering an electrode that enters an opening in the tube. It's really an indentation into the tube — not a hole — with the vacuum sealed beneath it. The suction cup has nothing to do with sealing the vacuum. The electrode is connected to a large wire that attaches to the flyback transformer on the circuit board. The flyback transformer generates the high voltages you'll find in a monitor. The electrons in the tube are attracted to the anode's positive charge and return through the wire to the circuit board. This anode is where the extremely high (20,000–30,000) voltage is! You cannot tell in the gray-scale picture (Figure 12-4), but the wire is usually a bright red to catch your attention.



Used by permission of Happ Controls.

Figure 12-3: Electron gun and cathode in the neck of the tube.



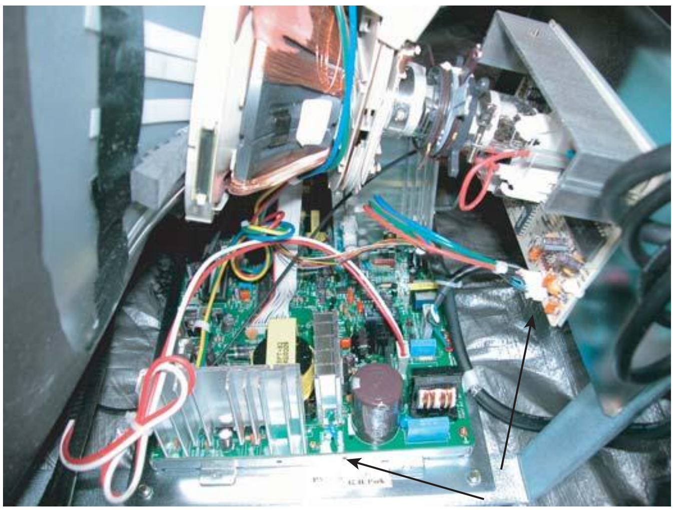
Used by permission of Happ Controls.

Figure 12-4: The anode and flyback transformer.

Notice the prominent warning tag on the anode wire — don't count on the insulation of the wire protecting you. Take extra care to stay away from the suction cup, wire, and anode component on the circuit board! It's important enough to repeat once more. The monitor can retain a charge even when it has been unplugged for a long period of time. Unless you know the monitor has been discharged, assume high voltage is present. See "Discharging a Monitor" later in this chapter for more information.

Circuit Boards

The circuit boards take the incoming video signal and convert it into information needed to control the electron guns and deflection yokes. Two circuit boards are usually in a monitor (see Figure 12-5).



Used by permission of Happ Controls.

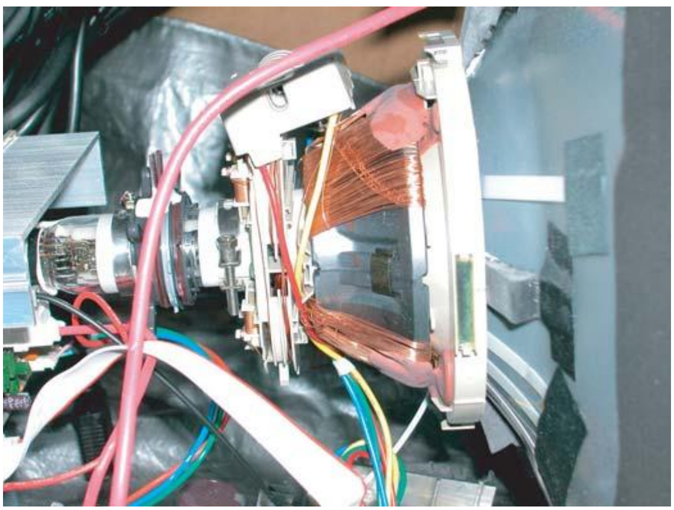
Figure 12-5: A typical arrangement of two circuit boards.

The first is the "main" board where the power and video signals are connected, which is shown underneath the deflection yoke in the figure. Attached to the base of the tube's neck is the second circuit board, which is often referred to as the neck board. This is the board that directly controls the electron guns and is connected to the main circuit board. The circuit boards are not any safer to touch than the rest of the monitor's insides and should be left alone. The only user-serviceable parts on most monitor circuit boards are fuses and monitor controls such as horizontal hold, vertical hold, and so on.

NOTE **Even though the fuse on the circuit board can be easily replaced, you should be asking why the fuse blew. It could have been a power surge in the household current, or it could be a symptom of something wrong with the monitor. You are probably safe replacing the fuse once, but, if it blows again, you certainly should consult an expert for repair. Remember the cardinal rule. Treat the inside of a monitor extremely carefully!**

Deflection Yoke

The deflection yokes sit at the base of the tube in front of the electron guns. As the electron beams pass through the yokes, the yokes generate the magnetic fields that alter the path of the beams. The yokes are electromagnets, which generate a magnetic field when current flows through them and generate no field when there is no current. Electromagnets are basically tightly wound coils of copper wire, as you can see in Figure 12-6. Remember the magnetic fields. They'll be important a bit later on in the chapter.



Used by permission of Happ Controls.

Figure 12-6: A close-up of a deflection yoke.

Isolation Transformers

An isolation transformer is a component that sits between the household electrical outlet and the monitor's electrical connection (see Figure 12-7). It takes the household electricity in and sends electricity right back out to the monitor. Does it seem kind of redundant? It performs a very important job by keeping both the monitor and *you* safe. Allow me to explain. In a household electrical outlet, you will find three prongs: hot, neutral, and ground. The circuit in whatever electrical appliance you use is between the hot and neutral prongs (I'll refer to them as wires from now on). The ground exists as a safety that ultimately should be connected to a metal rod buried in the earth (hence, the term "ground" or "grounded"). If you measure with a multimeter between the hot wire and neutral wire in a standard outlet, you'll find it reads about 110 volts in the USA. You'll find the same reading between the hot wire and the ground wire. The neutral wire is designed to be the return path for the current whereas the ground wire is designed to be a fail-safe in case something goes wrong. You might find an electrical outlet where the ground and neutral wire have been reversed. The outlet still supplies electricity, and you may not know anything's wrong, but your ground wire is no longer a safety measure. In fact, it's now the default return path for the current!

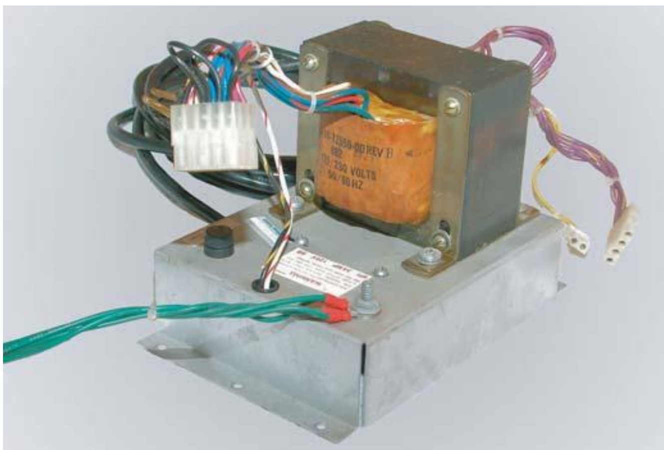


Figure 12-7: One of many different possible isolation transformers.

Assume for this discussion that the household electrical wiring is properly connected. (If in doubt, don't assume. Have it tested by an electrician!) If something goes wrong inside the appliance, the hot wire can come into contact with parts of the appliance that you might be able to touch. A principle of Ohm's law is that current will follow the path of least resistance. Human bodies make good conductors — we don't offer much electrical resistance. If the appliance frame becomes electrically hot (that is, becomes connected directly to the hot wire) because of a problem, and you touch it, you will probably make the easiest return path for the current. That means 110 volts at an unknown current (remember, your body's resistance will vary) will flow through you to ground.

Ouch! This is where the ground wire comes to your rescue. The ground wire is deliberately tied into the frame of the appliance. If something goes wrong, and the frame becomes electrically hot, the ground wiring normally has less resistance than the human body, and the current returns through the ground wire instead of through you!

The way many monitors are designed, the metal monitor frame is often (deliberately) tied into the neutral wire of the electrical system. The monitor frame is not tied directly to the household ground at all. I'm not sure why it's still done this way, but it's a throwback to the way televisions were made when the monitor chassis was "live" (electrically connected). Without an isolation transformer, everything has a common ground. The AC electrical system in your house and the wiring in the monitor both ultimately connect to the same ground. Touching the monitor frame would make you the easiest path back to ground for the current, which puts you in the middle of a high-voltage circuit. You're the easiest path back to ground because the monitor frame isn't tied into the third ground wire of the household electrical system. Once again, ouch!

This is where an isolation transformer comes into play. An isolation transformer electrically isolates the electrical flow into the transformer from the electrical output of the transformer that feeds the monitor. There's only a hot and neutral wire feeding the monitor. There is no third ground wire. If you touch the frame at that point, the household ground you're touching with your feet or other part of your body (such as a hand touching an electrical outlet while plugging in a cord) isn't part of the circuit feeding the monitor. By isolating the monitor's power from the building's power, you won't complete a circuit to ground by simply touching the monitor frame. No ouch this time! With the monitor safely powered by an isolation transformer, you can and should ground the frame to earth ground (the third prong on a power cord) at an appropriate location inside the cabinet.

Warning! An isolation transformer does not make the inside of a monitor safe to poke around in! The inside of the monitor still has hot and neutral electrical points. If you accidentally touch both a hot and neutral inside the monitor, then once again your low resistance makes you an easy circuit for the current to flow across, which gives you a nasty shock. What an isolation transformer *does* do for you is make the frame safe to touch, assuming everything is working properly.

WARNING **I have a sound piece of advice. Never assume anything when working with an exposed monitor! A problem with the monitor's wiring or the isolation transformer can mean that the safety measures designed into the monitor are not functioning.**

Some monitors require an isolation transformer for proper (safe) use, and some do not. Enclosed monitors, such as televisions or computer monitors, do not require an isolation transformer. The functionality of the isolation transformer is built into the internal workings of the monitor. Monitors whose inner workings are exposed, such as arcade monitors, often will require an isolation transformer. Newer arcade monitors most likely incorporate the workings of an isolation transformer and will not need a separate isolation transformer. How can you tell? The monitor may be explicitly labeled as not requiring an isolation transformer. I have heard of at least one example when a monitor was incorrectly labeled, so your safest bet is to consult the manual that comes with the monitor or contact the manufacturer. One school of thought says it is safer to use an isolation transformer even if it's not necessary than it is not to use one that's needed. There is one rule of thumb. If the monitor is an enclosed unit, such as a television or computer monitor, you do not need to be concerned about it. If the monitor is exposed, such as an arcade monitor or a monitor that was designed to be enclosed but has been opened, then you should be very concerned about whether an isolation transformer is required!

How To Handle A CRT Monitor Safely

Having done my best to impress upon you the dangers of monitors, I want to assure you now it *is* possible to handle and install a CRT monitor in your arcade cabinet safely. Observe the following safety guidelines as you do so, and you shouldn't have any problems.

General Guidelines

The first rule for handling monitors safely is that you should always have someone near you (but not right next to you) when you are handling your monitor. That person's job is to help you if you get in trouble. If you get shocked or injured, he or she should be able to provide first aid or call for medical help. If for some reason you *must* handle the monitor when it is still plugged in, then the person should be ready to help if you get hurt and cannot get away from the electrical current. You will need to make sure the person understands that he or she should never touch you in those circumstances! If electricity is flowing through your body, and the person touches you, he or she will also get shocked and will be unable to help himself or herself — much less you. Your helper should instead be prepared to unplug the power source from the wall and have a nonconductive long-reach object, such as a plastic broom handle, to separate you from the monitor. Other guidelines you should follow:

- Make sure the monitor is unplugged. The only reason for a nonprofessional to be tinkering with a monitor while it's plugged in is to adjust the user-adjustable settings, such as horizontal hold. At all other times, if you're going to move or handle the monitor for some reason, make sure it's been unplugged for at least a half hour to allow the various capacitors to discharge, and, even then, don't assume they have in fact done so.

- Do not attempt to discharge the charge inside the monitor unless you are professionally trained to do so. Unless the inside electronics of the monitor are being worked on (which you should not do if not professionally trained), the monitor does not need discharging for basic mounting procedures. *Do* take extra care that you do not touch the electronics inside the monitor at all times.
- Wear safety gear. You might consider wearing insulated gloves and safety goggles. You should certainly wear rubber-soled shoes or sneakers. This will insulate you from the ground. Remove any loose jewelry so it doesn't accidentally come into contact with something in the monitor.
- Watch your back. Monitors are heavy! A healthy adult can probably lift a 19-inch monitor without issue. If you have any kind of back issues or need to lift a monitor bigger than 19 inches, you should use the buddy system.
- Hold the monitor only by the frame. This keeps your hands away from the sharp or electronic components inside the monitor, which keeps you safe and avoids damage to the monitor as well. It bears repeating. *Do not touch the inside electronics of the monitor at any time*!
- Use two people or a mirror to adjust the picture. Some monitors have adjustments in front so you can see the results while you make adjustments. However, many have the controls in back so it is impossible to see what you're doing while you make adjustments. Resist the urge to try to reach around the back and make adjustments while you're in front. That's a good way to grab the wrong thing and get zapped. Have a friend assist you, or use a mirror to observe the screen while you make adjustments.

Discharging A Monitor

I'll start by stating that I will not attempt to tell you how to discharge a monitor. If you have been professionally trained in the field, then you know what to do to discharge a monitor safely. If you have not been trained professionally, then it would be irresponsible to try to show you how in this book. To attempt to do so would put you at an unnecessary risk of getting hurt. Instead, have the monitor professionally discharged by an arcade or television technician. Fortunately, a monitor rarely needs to be discharged. Once it's safely installed in your cabinet, there should be little reason to move or work on the monitor.

Discharging a monitor is the process of removing the built-up 20,000–30,000-volt electrical charge inside the tube. Most modern monitors have a circuit built into them that automatically discharges the tube when powered off. Older monitors are not likely to have this discharge circuit, and any monitor with the discharge circuit may have a malfunction such that the automatic discharge does not work. Never assume that a monitor has been discharged unless you know it has been directly discharged and has not left your sight since then.

Monitors can build up a secondary charge after being discharged once, so even after a discharge, treat it with caution. Professionals will discharge a monitor once, wait a few minutes, and then discharge again.

You can find instructions on the Internet on how to discharge a monitor. Some of them are good. Some of them are bad. Some of them are really bad. You shouldn't attempt to follow any of them unless you have been professionally trained. Some of the instructions will give you information that may lead to damage to the electronics in your cabinet, and some may prompt you to take actions that just are not safe and may cause you harm. Even the good and valid instructions may assume knowledge you do not have and skip mentioning an important step or concept. Please, if you don't already know what you're doing, do not attempt to discharge a monitor by yourself. Your safety is worth much more than the cost of a $75 service call by a trained technician.

CROSS-REFERENCE **If you're really interested in becoming trained on the subject, be sure to read Chapter 18 for information on an arcade training school.**

Proper Care And Feeding Of A CRT Monitor

You won't need to do very much to keep your monitor in good operating condition. New monitors should last a good five years or more before needing any electrical maintenance. Used monitors, or any monitor that's having various display issues, will probably benefit from a "cap-kit." Applying a cap-kit to a monitor means replacing the capacitors on the main circuit board with new capacitors. Over time, capacitors can dry out and lose their original electrical properties. For just about any monitor problem other than a totally dead monitor, the first solution is always to apply a cap-kit. The cost of a cap-kit is normally less than $10. However, applying a cap-kit involves discharging the monitor, removing the circuit board, desoldering, and soldering. Once again, unless you have been trained, leave that to a professional.

Other than a cap-kit, the only other electrical maintenance required might be an occasional degaussing or replacement fuse. Remember that, if you have to replace a fuse more than once, something is probably wrong, and the monitor should be inspected by a technician.

Degaussing is the process of demagnetizing the monitor. Keep in mind that the electron beams are guided by magnetic fields. That means they are sensitive to external magnetic fields as well. If an external magnetic force is strong enough, it can alter the path of the electron beam and distort the colors and picture on your monitor. You will commonly see this when unshielded speakers are placed too close to the monitor. However, even the earth's natural magnetic field can cause monitor distortion. Monitors are adjusted at the factory for the specific hemisphere the monitor is sold in and the orientation of the monitor. Modifying either factor, such as moving to the other hemisphere or taking an upright arcade machine's monitor and laying it on its back in a cocktail cabinet, can cause the monitor to interact differently with the earth's magnetic field, which causes distortion. Fortunately, it's easy enough to fix. Monitors have a built-in degaussing circuit that activates when you first turn the monitor on. That's the two clicks and brief wobbling you see when you press the power button.

Some monitors may not have a working degaussing coil. In that case, you can use an external degaussing coil to correct magnetic problems. Degaussing coils are available from arcade parts supply houses. Some people will substitute an appliance that generates its own magnetic field, such as a soldering gun that has a built-in transformer. To degauss, hold the coil in the center of the monitor and then turn on the coil. Wave the coil around the monitor using an increasing spiral motion to cover the whole screen, and, when you've extended your spiral beyond the sides of the monitor, turn it off. It's important to note that degaussing coils will burn out if you leave them on too long. Monitor degaussing circuits typically should be activated only after being off for 20 minutes or more.

You may think this last bit of maintenance advice goes without saying, but it is amazing how often it's overlooked. A clean monitor is a clear monitor, so clean your monitor! Only clean the front of the screen; don't clean the back of the tube or the monitor electronics. Also, don't use a regular spray cleaner on a monitor screen because it can eat away at the anti-glare coating many monitors have. Use a cleaning solution advertised for monitor screens or simply use a water-dampened rag. If you are cleaning a used monitor for the first time, you will be very surprised at how grimy it really is!

CRT Monitor Types

Now that you've taken a look at how monitors work and basic safety, it's time to get into the fun stuff! You have essentially three choices for a CRT monitor — arcade monitors, televisions, and computer monitors. Availability, degree of difficulty, cost, and arcade authenticity are all factors to consider when making a monitor choice. Different monitor types require different interface methods and levels of complexity. Arcade monitors and televisions are generally cheaper than the same-sized PC monitor. Finally, CRT arcade monitors and televisions will give you a more arcade-authentic picture whereas PC monitors will give you a clearer picture with more flexibility. I'll touch on these subjects as I describe each monitor choice in the next few sections.

Monitor Resolution and Refresh Rates

You'll need to understand the different monitor resolutions and refresh rates before you can pick the monitor type that's right for you. You're probably familiar with standard computer resolutions of 640 × 480, 800 × 600, and 1024 × 768. That means 640 pixels horizontally by 480 lines vertically, and so on. You may not know that some games, particularly emulated arcade games, can use resolutions as low as 320 × 200. As a rule, almost every monitor is capable of resolutions of 640 × 480. However, it gets murky from there. Not every monitor is capable of 800 × 600 or higher resolutions or the unique resolutions such as 320 × 200 used in arcade games. Computer monitors certainly can handle the full range of higher-standard resolutions, but they probably cannot run at the unique resolutions used by arcade games. Televisions and arcade monitors generally can handle the lower resolutions, but they often cannot support 800 × 600 and higher resolutions.

Fortunately, the software and hardware takes care of many of these issues for you. If you choose a computer VGA monitor, the lower-resolution arcade games can still run even though the monitor doesn't support the lower resolution. This works because the software and hardware in the computer adjust the picture to match the capabilities of the VGA monitor. However, even though you can get a lower-resolution picture to fit on a higher-resolution monitor, it doesn't work the other way around. Remember that televisions and arcade monitors can't usually support higher resolutions. That's fine for most arcade games that don't need higher resolutions. However, if you're also planning to run modern, high-end arcade games, you probably won't be happy at lower resolutions. That high-end video card capable of 60 frames per second at 1024 × 768 or higher resolution is a waste if your monitor cannot handle more than 640 × 480.

NOTE **Strap on your seatbelt. It's getting techie once more! It's important to have a basic understanding of this so grit your teeth and plow through it. You might skim through it once, read the rest of the chapter, and then come back to this section to fill in the gaps.**

Understanding refresh rates is a bit more complicated. The picture on your screen starts by creating a single horizontal line at the top from left to right. The signal is briefly turned off while the electron guns are refocused to the left again and drop one or more lines down. The time during which the electron beams are off and moving back to the left is called the horizontal retrace, or blanking, period. Then, the next horizontal line is drawn from left to right. This repeats until the entire screen is drawn at a speed so fast that it appears as a single picture to you. You should be aware of two refresh rates. The horizontal scan rate (or horizontal refresh rate) is the speed at which the monitor draws a single line on the screen from left to right. The vertical scan rate (or vertical refresh rate) is the speed at which the electron beams move from the top of the screen to the bottom. The horizontal scan rate is much higher than the vertical scan rate because the monitor has to draw an entire horizontal line before the vertical scan can move to the next line. Vertical refresh rates are measured in Hz (hertz, or cycles per second) whereas horizontal refresh rates are measured in kHz (kilohertz, or thousands of cycles per second).

If the horizontal scan rate is very fast, then the corresponding horizontal retrace period is also fast. This means there is less vertical progression before the guns turn back on and the next horizontal line is drawn. If the horizontal scan rate is slower, then there is more vertical progression during the horizontal retrace period. This means that, at slower horizontal scan rates, horizontal lines are skipped such that you have a line on, then a line off, then a line on, and so on. These skipped lines in between drawn lines are sometimes referred to as scan lines. On older arcade games or televisions, you can actually see the skipped lines. Your brain will normally tune these out, but, if you deliberately look for them, you can see them. Figure 12-8 shows a close-up of a television screen with a white area on top and a blue area beneath. Once again, you'll need to view the image on the CD-ROM to get the full color effect. However, even in gray-scale, you can see the dark horizontal lines. These are the lines that were skipped during the horizontal retrace.

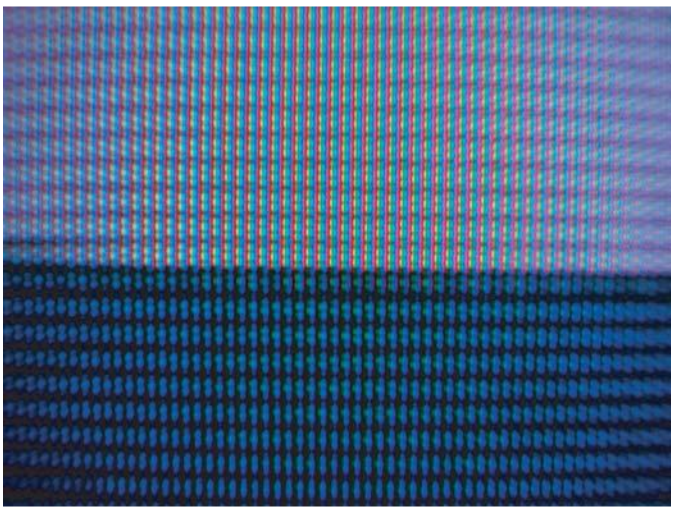


Figure 12-8: Extreme close-up of a television screen showing scan lines.

The combination of the vertical and horizontal scan rates dictates how many horizontal lines are drawn on the screen in one "frame." If you increase the horizontal scan rate, then more horizontal lines can be drawn on the screen in the same amount of vertical scan time, which produces a better picture. You could also achieve a similar increase in horizontal scan lines by reducing the vertical scan rate so that there is more time to draw horizontal lines before the vertical scan progresses. However, decreasing the vertical scan rate will produce flicker on the screen, which you will notice. Even vertical scan rates you can't consciously notice may still bother you. For instance, many people report eye fatigue or headaches after prolonged periods in front of a computer screen. Most arcade monitors and televisions use a 60 Hz vertical refresh rate. Most computer monitors support varying vertical refresh rates from 60 Hz to 100 Hz or higher.

When shopping for a CRT computer monitor, you will often see the vertical refresh rate mentioned. However, when discussing resolutions for arcade games, it is the horizontal refresh rate that is of interest. There are three standard monitor resolutions used in arcade machines:

- Standard — Horizontal refresh rate of 15.75 kHz
- Medium — Horizontal refresh rate of 25 kHz
- High — Horizontal refresh rate of 31.5 kHz

Here is where monitor resolution becomes important to you. Most video cards for computers are designed to work only with computer monitors, which are high resolution. That means most video cards are incapable of running at a refresh rate low enough to operate a medium- or standard-resolution monitor. I'll show you ways around this as I discuss each monitor type in the next few sections.

I've only given you a mid-level overview of monitor refresh rates and resolutions so far. There's more to understanding the subject that isn't necessary for the scope of this book. If you'd like to learn more about monitor refresh rates and resolutions, you can visit a couple of good Web sites: Arcade Monitors on the PC2 Jamma Web site at `http://pc2jamma.mameworld.info/monitors.html` and the Arcade Monitor FAQ on the Ultimarc Web site at `www.ultimarc.com/monfaq.html`. The Randy Fromm arcade school also has excellent material for learning more (see Chapter 18 for more information about Randy Fromm's arcade school).

Arcade Monitors

The original arcade monitors were simply modified televisions, which operated at standard resolution. Later on, monitors tailored to the arcade market were developed with medium and high resolutions. Most classic arcade games use standard-resolution monitors (15 kHz). Whatever the resolutions, these monitors all fit into a category called *raster* monitors. In simplest terms, the screen is drawn as a series of dots. Another type of monitor was occasionally used that drew pictures on screen as a series of lines, known as a *vector* monitors. Initially using raster monitors was more expensive than using vector monitors, but that quickly changed. Vector monitors were more difficult to maintain and more prone to failure. Once raster monitor prices dropped, vector monitors fell out of favor. Few vector games were ever produced.

Raster Monitors

Raster arcade monitors used to be one of the most economical choices you could find. Older, used monitors could be found anywhere at prices from free to $100. New arcade monitors started in the $200 to $250 range for 19-inch models and up from there for bigger models. Now that CRT monitors are no longer being made however, prices are likely to be much higher. Any remaining new stock will be sold at a premium, and there is probably going to be a big refurbished monitor market. This major upheaval in the CRT monitor market is happening right while this book is being published, so it's difficult to say exactly what will happen in this area.

Some people prefer to use an arcade monitor because of the authentic appearance. Graphics on these monitors will show scan lines and have that familiar pixely appearance you might remember from the arcade. Take a look at Figure 12-9 for an example. It shows a close-up of an image on my original Atari *Crystal Castles* game. The effect is exaggerated because of the viewing distance, but it shows what you can expect from an arcade monitor.

Figure 12-9: Close-up of an arcade monitor.

Mounting an arcade monitor is not difficult. They are designed with open frames meant to be fastened to an arcade cabinet in some fashion. All you will need to do is to adapt the mechanism used, such as by employing mounting brackets or bolting it to a shelf.

Connecting to an arcade monitor is a challenge. Arcade monitors will only work at their specified horizontal refresh frequency, which is normally 15.75 kHz for standard-resolution monitors. Attempting to drive them at a higher frequency will not work, and it may damage the monitor. How do you get around this problem? You have three possibilities.

VGA Hack

The first attempts at using arcade monitors involved directly connecting the VGA card to the monitor. That meant three challenges to overcome. First, arcade monitors do not have VGA-style connectors. Second, some method had to be used to get around the incompatible refresh rates. Finally, output voltages usually differ between arcade games and VGA cards.

Physical Connection Connecting the VGA card to the monitor is not terribly difficult. VGA connectors have 15 pins, as shown in Table 12-1:

Table 12-1: Standard VGA Pinouts

PIN	DESCRIPTION
1	Red video
2	Green video
3	Blue video
4	
5	Ground
6	Red ground
7	Green ground
8	Blue ground
9	(Optional: +5 volts)
10	Sync ground
11	
12	
13	Horizontal sync
14	Vertical sync
15	

The pins that are important in a VGA to arcade hack are 1, 2, 3, 5, 13, and 14. These will correspond to the same connections on the monitor. The monitor should have a Molex-style connector attached to the circuit board with the connections for red, blue, green, ground, and sync. You'll need a VGA extension cable to connect between the VGA card and the arcade monitor. Clip one end of the VGA cable, and expose the wires you need. Connect the six wires corresponding to the pins listed previously from the VGA cable to the corresponding pinouts on the arcade monitor's cable. You can either purchase a matching Molex connector for the wires from your VGA extension cable or clip the connector from the arcade monitor and use quick-disconnects to cable everything together. I do not recommend clipping the monitor's cable, if you can avoid it. The horizontal and vertical sync from the VGA cable should be twisted together and connected to the single sync pin on the arcade monitor. Some arcade monitors may have separate horizontal and vertical sync pins, and they can be connected directly instead of twisting the syncs together. *Do not turn anything on yet*!

WARNING **Remember your safety precautions! Handling the input connector to the monitor is safe. Touching the inside electronics of the monitor is not.**

A couple of good tutorials on the Web will walk you through this hack. If you'd like to see another perspective on it, visit the PC2Jamma page at `http://pc2jamma.mameworld.info`, and Rockman's tutorial at `www.arcadecontrols.com/arcade_pc2arcade.html`.

Driving The Refresh Rate Now that you've physically connected the cabling, you need to tackle the incompatible refresh rates. Doing so requires installing software on your computer that will program the VGA card to output the proper refresh rate signals. You have several options, all of which work with specific video cards and operating systems.

ArcadeOS ArcadeOS, which is available at the PC2Jamma page, is a DOS-based menu system that includes the ability to program a VGA card for arcade monitor use. ArcadeOS has two drawbacks. The first is that it works in DOS only. The second is that it obviously can protect your arcade monitor from receiving an incompatible signal only when it is running. That means that, from the time you turn your computer on until ArcadeOS is running, your VGA card is sending out an unmodified signal that can hurt the monitor. ArcadeOS is programmed to beep when it's loaded so leave the arcade monitor turned off until the beep and then turn it on.

Mon-ARC PLUS Another driver that works with older operating systems is Mon-ARC PLUS (also called Mon-ARC) that is available at `http://homepage.ntlworld.com/andrew.lewis5/arcade/monarc.htm`. Mon-ARC supports both DOS and Windows 98 and is a terminate-and-stay-resident driver you load in the autoexec.bat file. If that didn't make sense, don't worry. Instructions come with the driver at the above Web site. However, in simple terms, what it does is sit in memory and convert the VGA card's signal to one the arcade monitor can use. Like ArcadeOS, you have to wait for the driver to be loaded before turning on your monitor.

Soft-15KHz The most recent utility for running arcade monitors on a PC is Soft-15KHz (included on the companion CD) at `http://community.arcadeinfo.de/forumdisplay.php?f=142`. Soft-15KHz isn't a driver itself per-se, but rather modifies your existing driver to add arcade-monitor friendly resolutions to the driver's supported list. Soft-15KHz runs on Windows 98 through Windows XP, with support for Vista and Windows 7 in the works.

Powerstrip The last utility you might want to take a look at is Powerstrip (`www.entechtaiwan.com/util/ps.shtm`). Powerstrip works similarly to Soft-15KHz, but is designed for a broader audience than Soft-15KHz, for instance for use on high-definition televisions. Powerstrip can be harder to use than Soft-15KHz but may have support for video cards or drivers that Soft-15KHz does not. If you're going to go this route, you should try both utilities and see which one better matches your configuration and personal preferences.

Tweak The Video Signal's Voltage

The final issue is adjusting for different voltages. Arcade circuit boards usually send a 5-volt signal to the arcade monitor. VGA cards send out a 1-volt signal. A low-voltage signal from a VGA card will produce a darker picture on the arcade monitor if not corrected. Fortunately, it's easy to correct. Ultimarc (`www.ultimarc.com/vidamp.html`) sells a video amplifier for $15 that will adjust the voltages for you. Also, some arcade monitors have adjustments on them to switch between 1-volt and 5-volt input levels.

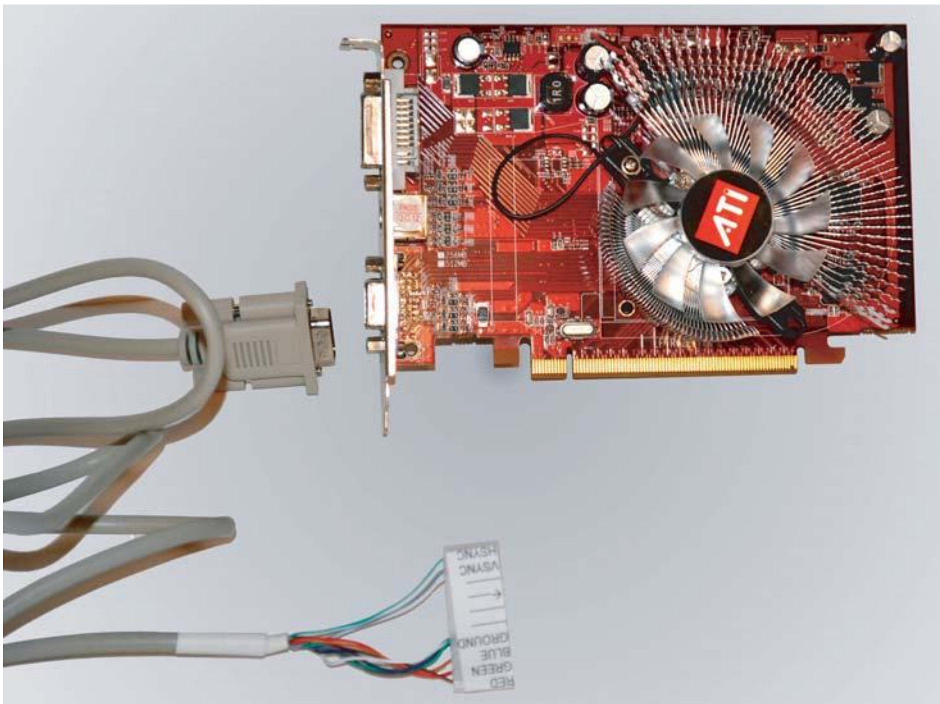
VGA hacks are relatively inexpensive because, with the possible exception of an inexpensive video amplifier, you don't have to purchase additional hardware to go between the video card and the monitor. Their limitations take away from the seamless re-creation of the arcade feeling, but those who use them feel the use of a real arcade monitor more than makes up for the minor inconveniences. Keep reading for alternatives.

Scan Converters

Scan converters have been around for some time and are primarily used to convert from a VGA card's output to a television's composite or S-Video input. Output quality varies with a correspondence between the quality and the cost of the converter. As of this writing, although a few people have tried, I know of no one who is actively using a scan converter in his or her arcade cabinet. I'm including scan converters here for completeness and to advise you that they probably aren't worth your time.

Ultimarc's ArcadeVGA

Ultimarc (whom you've encountered in previous chapters) has an ideal solution to the arcade monitor challenge. They market a line of ATI based VGA video cards called the ArcadeVGA 3000 (`www.ultimarc.com/avgainf.html`) that are designed to work with arcade monitors. It offers all the benefits of a VGA hack and overcomes all of the drawbacks. You will still need a cable to connect from the VGA card to the arcade monitor. You can hack your own as described in the previous section or purchase a pre-hacked cable from Ultimarc. The video card is available for $89, and the pre-hacked cable is available for an additional $12. Both are shown in Figure 12-10.



Used by permission of Ultimarc.

Figure 12-10: The ArcadeVGA 3000 and pre-hacked cable.

Some of the many features of the ArcadeVGA include:

- Designed to work with 15 kHz and 31 kHz arcade monitors.
- Will display in boot up, and Windows (XP and above). No need to wait before turning on your monitor.
- Special display modes designed to emulate various arcade games, such as 300 × 256 resolution.

- Support for rotating desktop in Windows to allow for vertical monitor mounting.
- Displays Windows resolutions of 640 × 480 and 800 × 600, including support for 3D-enabled games.

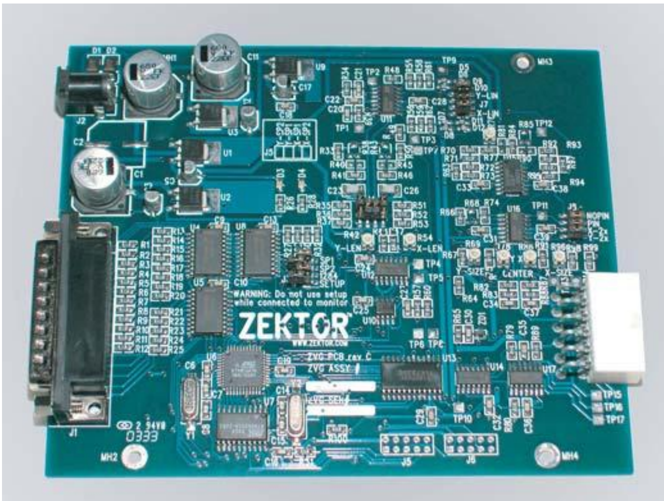
The ArcadeVGA uses modern video card chipsets, which makes it a powerful card for standard Windows games as well as emulated arcade games. Because the card natively outputs at 15 kHz, no extra drivers (beyond the video card's Windows drivers) are required. Like all Ultimarc products, the ArcadeVGA has received positive reviews from the arcade cabinet building community. If you intend to use an arcade monitor, you should take a good look at the ArcadeVGA card.

Vector Monitors

No VGA hacks are currently possible with vector monitors. The different technology used in vector monitors makes them incompatible with raster monitor connections, and, until recently, the only place you'd see a working vector monitor was inside a vector arcade game. Arcade emulators use software techniques to play vector-based games on raster monitors and do a remarkable job at it. However, a vector monitor enthusiast would quickly notice the difference. No matter the technique, an emulated vector game running on a raster monitor cannot compare with the vibrancy of running on a real vector monitor. There is something about seeing the glow of *Tempest* running in a dark room on a real vector monitor you have to see to experience.

Until recently, no alternative existed. You either purchased a real vector game or ran an emulated version on a raster monitor. A group of hard-core vector enthusiasts took up the challenge and produced the Zektor Vector Generator (ZVG). The ZVG is an interface card that connects to a standard PC through the parallel port and is capable of displaying video on a real vector monitor! The card costs is shown in Figure 12-11.

The ZVG is not currently in production and there are no known plans for future runs. However you can still find them occasionally on eBay or the newsgroups. Because of this and the limited number of games supported by the ZVG, it should be considered a niche product. However, it is one heck of a niche to fill, and it does it very well. Unlike raster monitors, various vector monitors were used for the 30 different games, and different vector monitors were not compatible with each other. Producing a card capable of running on any vector monitor was quite a feat of engineering. After building a general-purpose arcade cabinet, you might consider a dedicated vector game cabinet. Imagine how impressed your friends will be when they discover that not only do you have a monster arcade cabinet, but you also have a genuine vector monitor-based cabinet as well! OK, you may need to educate them on the difference. However, seeing is believing. Once they compare a vector game running on a raster monitor to the same game running on a real vector monitor, they'll be standing in line for their turn at the vector.



Used by permission of Zekktor, LLC.

Figure 12-11: The Zektor Vector Generator.

CRT Televisions

Using a CRT television for your arcade machine will give you similar results as using an arcade monitor. The picture quality may not be quite as good, but the interface techniques are easier. The main advantages of using a television are that they are readily available and relatively inexpensive compared to other monitor choices. You can't find new CRT televisions in most stores these days, so you will need to look at the used market if you want to try one. Figure 12-12 shows the same screen shot on a television that was taken from an arcade monitor in Figure 12-10.

The picture does not appear to the eye as blurry as it shows up on the camera, but it certainly is not as crisp as the original arcade monitor picture. However, it does produce the scan line effect you would find on a real arcade monitor. The quality of a television picture will vary depending on which method you use to connect to it and what video card is being used. NTSC televisions (the kind used in North America) typically will accept composite video and S-Video inputs as well as the traditional coax cable. Many video cards on the market include a video-out option with either S-Video or composite video outputs. The ATI All-In-Wonder cards have produced good results. If you are choosing this method and have the option, use the S-Video connection instead of composite video. The picture quality will be better with S-Video than it will be with composite.

Figure 12-12: Close-up television screen shot.

One final limited option is to use an RGB SCART connection. Connecting to a television via the RGB SCART connector is very close to connecting to an arcade monitor via a VGA hack. RGB SCART connectors are typically seen in European televisions and are normally not an option in American televisions. If you have a television with an RGB SCART connector, visit `http://members.optusnet.com.au/eviltim/scart.htm` or `http://www.alvarezeninternet.com/mamescart` for more details. Using the RGB SCART connector with the ArcadeVGA video card from Ultimarc essentially turns your television into an arcade monitor with a very nice arcade-quality picture.

Mounting a television can be a bit trickier than an arcade monitor. Because televisions come in enclosed cases, there's no mounting frame for you to use. You will need to place the television on the monitor shelf in the cabinet and use some method to fasten it into place. The shelf will hold the weight so you only need to find a way to prevent the television from shifting when the cabinet is moved. L-brackets might be a good choice, but you will only want to use them to wedge the television into place. Do not screw them into the case of the television and by no means should you remove the television's case! Some people have done just that to fit a bigger television into the available space, but doing so involves quite a bit of risk. Televisions are not meant to be exposed, and the metal frame may shock you even if you do not touch the anode or other electrical components!

Using a television will give you a bit more flexibility than using an arcade monitor. Because video cards that support video/television output handle all the necessary conversion, you can run Windows on a television. Depending on the capabilities of the video card, resolutions of 640 × 480 up to 1024 × 768 are possible. This makes a television an option to consider for those who want a near arcade-quality picture without giving up the ability to run Windows.

Computer Monitors

A computer monitor is by far the simplest solution for an arcade cabinet. Unfortunately, new CRT computer monitors are also impossible to find now. You should still be able to find them in used markets, and if you work at a decent sized company you might ask your IT department if they are getting rid of any older CRT monitors that you can have. If you *can* find a CRT computer monitor, the picture quality is excellent, as you are probably familiar with. However, it is obviously not as authentic as an arcade monitor with visible scan lines. Take a look at the by-now familiar *Crystal Castles* screen shot (Figure 12-13). This time, it was taken from a computer monitor.

Figure 12-13: Close-up of a screen shot from a computer monitor.

Notice that the picture quality is crystal clear. Although you can see the scan lines in this close-up photo, you don't see them with the naked eye. Computer monitors are capable of multiple resolutions with very high vertical refresh rates, which provide a picture that is easy on the eye. Obviously, with the multi-resolution capabilities of a computer monitor, you will be able to play any computer game you choose. Connecting a computer monitor is simply a matter of plugging in the VGA cable. Many people prefer to use computer monitors for the simplicity and flexibility. Mounting a computer monitor has the same considerations and warnings as a television. Please, do not open the case of a computer monitor. Use it as-is with the case. Because computer monitors usually do not have built-in speakers like a television, you do not lose a significant amount of space to the case.

You do lose that authentic arcade look and feel with a computer monitor. Enter the hybrid monitor. In the last few years, manufacturers came out with arcade-style CRT monitors with VGA connections. These are also a vanishing breed, and by the time a few years have gone by from the publishing date of this book you probably will not be able to find any, new.

The Billabs BL25C90T 24.8″ VGA monitor (`www.billabs.com/crts.htm`) is one such model. It is capable of 640 × 480, 640 × 400, 320 × 240, and 320 × 200 resolutions, and is made in the same open-frame manner as regular arcade monitors with similar picture quality. Take a look at the same screen shot on this monitor (Figure 12-14). Notice you can see some of the arcade monitor pixelization, but the overall quality is extremely clear.

Used by permission of Billabs.

Figure 12-14: Close-up of the Billabs VGA arcade monitor.

The BL25C90T is one of the last CRT arcade monitors made for the industry, with the final run of these models literally being put into production as this book is being written. After this run, no further units will be made. As the end of the line for this type of technology, this is a very nice incarnation of the breed. The picture is sharp and even running Microsoft Windows looks good — something I did not see in other products when the first edition of this book was written. The screen is flat instead of curved, and the control board (horizontal hold, vertical hold, brightness, and so on) is attached by a long cable bundle so you can mount it somewhere in front. This will let you make adjustments while facing the monitor instead of having to use a mirror or an assistant. As an example of the end of this type of technology, it's obvious a lot of good thought has gone into making this monitor.

As of the time of this writing, other arcade-VGA hybrid models can be found at Nieman Displays (`www.niemandisplays.com`), Happ Controls (`www.happcontrols.com`), and possibly a few others. Like the Billabs monitor, quantities at all vendors are likely to be limited and will not last long.

Because these monitors are designed with open frames like other arcade monitors, mounting them is easy enough. All of them come with universal mounting frames with holes in the frame you can use to bolt them to the cabinet. An easy way to do that in the Project Arcade 2 cabinet is to test-fit the monitor on the shelf and draw a pencil line where the monitor frame rests when you have the monitor positioned to your personal taste. Pull the monitor back out, and mount a small strip of wood about 1⁄8 inch behind the line. Make sure the strip is securely fastened to the shelf and then remount the monitor. You can then fasten the monitor to the mounting strip. Remember, the mounting strip is not meant to be weight bearing. Its job is to prevent the monitor from sliding around when you move the cabinet. The monitor is probably heavy enough that this will not be a problem, but the extra security is peace of mind.

These monitors can be expensive, but they offer the best of all worlds. You get authentic arcade look and feel, VGA compatibility, and the option of running in DOS or Windows with the ability to handle any game your computer can play. Next to the arcade controls, the monitor is the most important part of the cabinet. The enjoyment you will get out of a good-quality monitor will more than offset the price over the lifespan of the arcade cabinet.

LCD Monitors

If you're reading this book in the first couple of years after it is published, CRT monitors will be a relevant topic for you. Unfortunately for this hobby however, CRT monitors are a dying breed. More than a few years from the publishing date and you are likely to have a difficult time finding a CRT monitor to use.

Relatively recent technology advances have led to monitors that differ significantly from CRT technology, such as flat-panel plasma and LCD displays. The arcade industry appears to have chosen LCD monitors as the successor to the venerable CRT.

How Do LCD Monitors Work?

LCD monitors use a completely different technology from CRTs to display. LCD stands for Liquid Crystal Display, and it's the liquid crystal that makes the technology possible. Liquid crystal is a state of matter somewhere between a liquid and a solid, that has two important properties. The first is that it can be manipulated with an electrical current. The other important property of liquid crystal is that it can transmit and modify light.

LCD monitors use two sheets of glass with multiple layers of liquid crystal sandwiched between the glass. The two sheets of glass each have a polarized film applied with the first sheet's film at right angles to the second sheet's. The liquid crystal layers between the two sheets of glass are arranged so that they gradually rotate so that the layer closest to either sheet of glass matches the polarized orientation of the adjacent glass. Light that hits the first sheet of polarized glass rotates its orientation as it passes through the liquid crystal layers so that the light's polarized orientation matches that of the far side sheet of glass and can be transmitted through the glass (see Figure 12-15).

Applying an electrical current to the liquid crystal alters its orientation, so that the light that passes through it from the first sheet of glass is not oriented to match the polarization of the far sheet of glass. Because the light is not oriented the same as the polarization film on the far sheet of glass, the light cannot pass through and is blocked (see Figure 12-15).

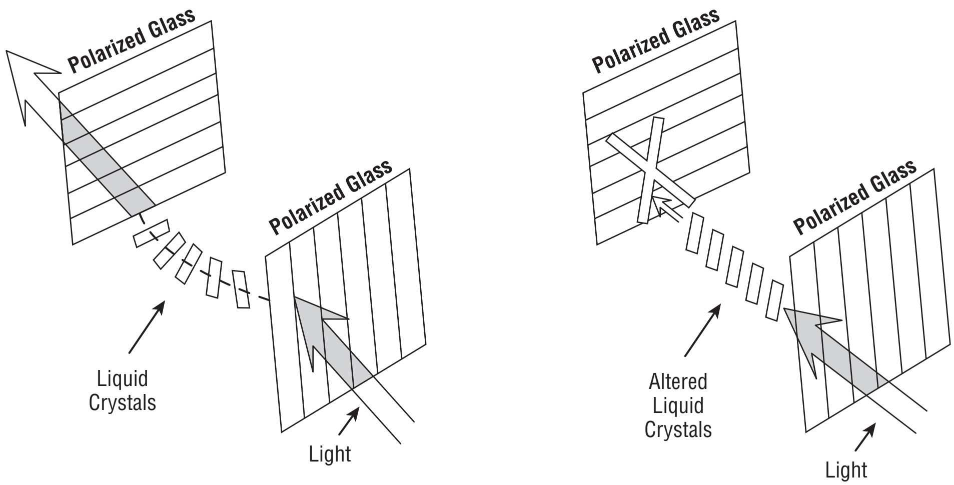


Figure 12-15: Left, light passes through the LCD. Right, the liquid crystals are altered so that the light is blocked.

You can probably see where this is going. An LCD monitor is arranged with a grid of pixels with transistors to control current to the pixels. Each pixel is made of three sub-pixels, one red, one green, and one blue (see Figure 12-16, and view the color image on the CD). By controlling current to the sub-pixels of a pixel, you determine whether that pixel will be red, green, blue, or a combination thereof. It's actually a bit more sophisticated in that it's possible to allow varying amounts of light to pass through a sub-pixel by varying the amount of current. Most LCD monitors allow for 256 degrees of light per sub-pixel. By combining varying intensities of red, green, and blue sub-pixels, you get a possible combination of almost 17 million colors per pixel.

The image you see on an LCD screen starts with a light shining in the back of the monitor. The light hits the first polarized glass layer, with each pixel filtering the light appropriately to produce the right color for the image being displayed. This may sound similar to the way a CRT uses three electron guns to illuminate red, green, and blue phosphors to produce an image, but it gets there in a completely different manner.

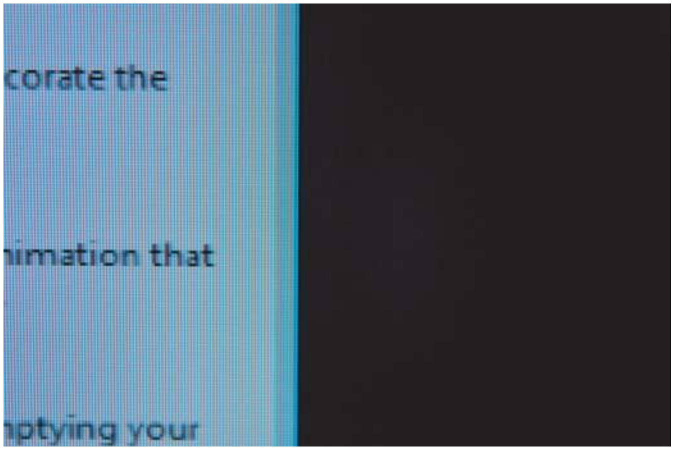


Figure 12-16: Close-up of the Billabs LCD monitor showing pixels.

LCD monitors don't really have a refresh rate like CRT monitors, though they'll report one for compatibility. CRT monitors work by a ray striking a phosphor and illuminating it, which then immediately begins to fade until it is struck again, or "refreshed." The light and current used to produce pixels on an LCD monitor are constant, so the concept of refreshing doesn't really apply. What LCD monitors do have is a *response rate*. This refers to how fast the liquid crystals in a pixel respond to changes in the current. If an LCD monitor has a slower response rate, you may see ghost trails when objects move across the screen as the pixels that initially showed the object are slow to change to whatever they should show next. This was a big problem in earlier LCD technology, which relegated them to the world of business and not gaming. Advances in LCD technologies however have mostly made this a thing of the past, but it's something you should be aware of if you're shopping for an LCD monitor. Generally a response time of 16ms or faster is enough for full motion video.

LCD Monitors And Your Arcade Cabinet

You are most likely going to be using an LCD monitor with your arcade cabinet, if for no other reason than availability. There are a few things you need to consider in contrast to using a CRT monitor.

Safety

Because LCD monitors are enclosed units they don't have the safety considerations that CRT monitors do. You still need to have a healthy respect for the electronics inside the monitor of course, but they don't act as capacitors and don't carry the 20,000 to 30,000 volts that CRTs do!

Aspect Ratios

One area I haven't touched on yet is the aspect ratio of a monitor. CRT monitors usually came with a screen in an almost square 4 × 3 horizontal to vertical ratio. They did make 16 × 9 ("widescreen") CRT monitors but they were not very common. Conversely, though they do make 4 × 3 LCD monitors, they are far less common than widescreen 16 × 9 models.

You need to be aware of this if you are considering using an LCD monitor in your cabinet. Most arcade games and computer games up until the last several years were designed for a 4 × 3 orientation. Using a widescreen monitor for these games will either involve stretching the game, or black bars on the left and right so as to maintain the proper aspect ratio. You've probably seen this effect in the other direction if you've watched a widescreen movie on a standard 4 × 3 television. Either the actors' proportions were somewhat distorted, or there were black bars at the top and bottom of the screen.

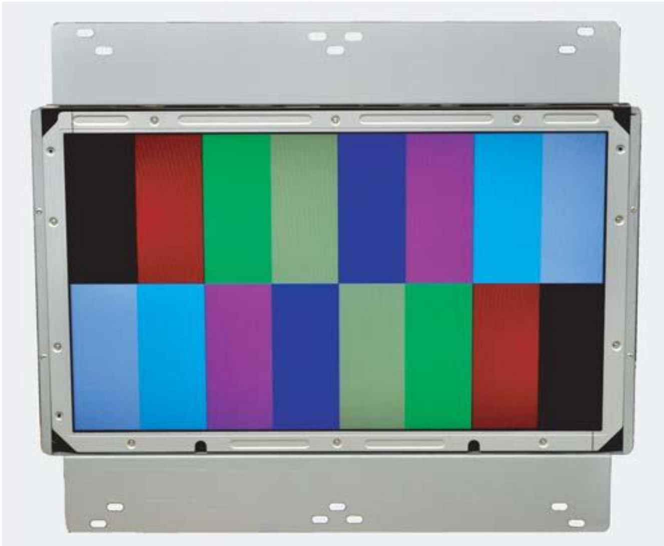
This is an aesthetic concern, not a functional one. Games will play just fine this way. It bothers some people though so it's something to remember.

Benefits Of An LCD Monitor

You'll reap many benefits by choosing an LCD monitor for your cabinet. They're much lighter and obviously thinner than a CRT which means they're easier to mount and will make moving your cabinet easier as well. They also draw less power and produce less heat, something that can be a concern depending on the air flow in your cabinet. The biggest benefit however is that LCD monitors are available and will continue to be available for years to come, while CRT monitors will soon be worth their weight in gold.

Most arcade monitor manufacturers have come out with LCD models designed to be drop-in replacements for older CRT monitors. They typically have similar mounting brackets but a different aspect ratio. For the Project Arcade 2 cabinet, I will be using a Billabs 26-inch LCD (model BL26LC3H) in this line (see Figure 12-17).

This monitor is designed to be a replacement for 27-inch CRT arcade monitors. It comes with a replacement bezel matching the 16 × 9 orientation and two pairs of mounting brackets for additional mounting flexibility. The picture is sharp and the monitor has on screen digital (OSD) controls to adjust various settings similar to what you'll find on a desktop computer LCD monitor.



Used by permission of Billabs.

Figure 12-17: The Billabs 26-inch LCD arcade monitor.

This monitor is a joy to use. It's a really nice all around monitor as far as picture quality and usability goes, but where this monitor really shines is in the proprietary technology invented by Billabs called Synxity Autosync. This is a method of having the monitor auto-sync to whatever resolution the computer or game system is displaying. Normally LCD monitors have to be pre-programmed at the factory to support whatever resolution you're going to use. If your LCD monitor wasn't pre-programmed with the resolution you intend to use (say, for instance, the 240 × 240 resolution that the original Burgertime used) it won't work. Billabs LCD monitors with Synxity Autosync will configure the LCD monitor on the fly to match the resolution being requested, even an oddball resolution like Burgertime's 240 × 240. Other manufacturers will likely be coming out with similar technology, but Billabs appears to be the first company to do so, and it works great! With the right game software and the Billabs monitor, I was able to choose between running a game in its original resolution or running the game stretched to full screen. I don't quite know how else to sum it up other than to say that the auto-sync technology added a layer of fun to the process, which is what this is all about after all!

Choosing A Monitor

Defining what makes a monitor the "right" monitor can almost be a religious argument for some. People whose goal is to recreate the classic arcade experience, complete with pixelized graphics, will not be happy with anything other than a CRT monitor that shows the scan lines. People who just want to play and who are interested in modern gaming as well as classic gaming will probably be happier with a modern LCD type of monitor. It's a bit like the comparison of LP vinyl records to compact discs. Many audiophiles will tell you that you get a richer sound from a record than you ever can from a CD. Some stereo buffs will tell you the same thing about vacuum tube stereo systems as compared to modern electronics. To each their own.

Therefore, as with everything else, choosing your monitor comes down to your personal preferences. You will need to balance your budget against your ultimate goal. Do you want an arcade-quality picture at a relatively low cost? If you can find one, consider a CRT arcade monitor with the Ultimarc ArcadeVGA card. Do you need to run Windows on your cabinet inexpensively? A used CRT television is your best bet if you want an arcade-like picture. If your budget is a bit more flexible, and you aren't concerned about a "classic" arcade pixelized picture, then an LCD monitor like the Billabs in the previous section is a great choice. If you have the budget for it and can get one while they're still available, an arcade-style VGA monitor is another terrific option. Take a look at Figure 12-18 for a comparison of all four choices. Clockwise from the upper left, you have an original arcade monitor, a television, an LCD monitor, and an arcade-VGA hybrid monitor.

Used by permission of Billabs.

Figure 12-18: Four different monitors showing the same screen.

For the Project Arcade 2 cabinets, I'll be using a Billabs LCD arcade monitor in the built-from-scratch cabinet, and a Billabs VGA arcade CRT in the NorthCoast Custom Arcades kit cabinet. You can see a side-by-side comparison of the Project Arcade 2 marquee artwork in the two monitors in Figure 12-19.

Used by permission of Billabs and Pixelhugger.

Figure 12-19: The Project Arcade 2 marquee on the Billabs CRT (top) and LCD (bottom) arcade monitors.

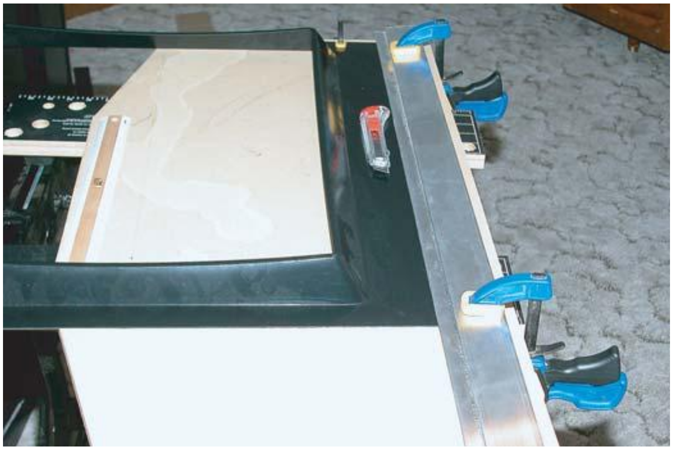
Monitor Mounting

Mounting a monitor in your arcade cabinet will vary depending on the specific model of monitor you have chosen. I've touched on mounting a bit in the previous sections, but here are a few more items to consider.

Bezels

No matter how you mount your monitor, you will probably want to hide the mounting mechanism. You'll never see mounting brackets or a monitor shelf in a real arcade cabinet, and you don't want to see one in yours either. Arcade manufacturers use bezels to hide the inner depths of the arcade machines. A bezel is a rectangular-shaped piece of material that surrounds the monitor and covers the gaps. You can make a bezel from foam board available at any good hobby store or purchase a pre-made bezel from arcade shops such as Happ Controls (`www.happcontrols.com/monitors/monitors.htm`).

I used a 25-inch plastic bezel from Happ Controls for Project Arcade 2. These fit the Billabs monitor perfectly, and they are oversized so that they can be tailor fit to your cabinet. Trimming the excess is easy with a sharp knife and a straight-edge. Start by measuring the amount of trim needed on all four sides and then marking appropriately on the bezel. Lay the straight-edge down on the bezel's backside against the marks you made, clamp them together, and then score the bezel three or four times (Figure 12-20).



Used by permission of Happ Controls.

Figure 12-20: Trimming the bezel.

You may end up cutting through it altogether or have a fine score on the backside. Fold the bezel trim away from the score, and it should snap cleanly off. I suggest erring on the side of being too big for your first cuts and then test fitting to see whether it needs trimming. Better to cut twice to perfection than to cut once and discover it's too small.

Monitor Orientation

One thing you might not have considered is the orientation of your monitor. Most people think of a monitor oriented in a horizontal position when they think of an arcade cabinet. Figure 12-21 shows an example of a monitor mounted horizontally.

A majority of modern arcade machines use horizontally mounted monitors. However, many older classics used monitors turned 90 degrees vertically. These were games such as Donkey Kong or Gyruss. Figure 12-22 shows an example.

What's the difference, and which method should you use? Emulators can rotate the screen to display any game at either orientation. To play a vertically oriented game on a horizontally oriented monitor, emulators will leave black vertical bars on the left and right sides to keep the aspect ratio of the game correct. This is fine on a 25-inch or larger monitor, but, on a smaller 19-inch monitor, the picture becomes pretty small. Some people handle this by having two arcade cabinets — one with a vertically mounted monitor and one with a horizontally mounted monitor. If you start to collect these beasts, then that's a pretty good idea. If you only want one ultimate arcade cabinet, an innovative solution exists for those of you with some woodworking skill and initiative — rotating monitors.

Figure 12-21: A typically mounted monitor.

Figure 12-22: A vertically mounted monitor.

Most rotating monitors are mounted by attaching a wooden circular frame around the monitor. The monitor frame rests on wheels mounted in the cabinet and is rotated either through a slit on the side or through access behind the cabinet. Some people have even gone so far as to use a motorized mount that rotates their monitor at the touch of a button! If you're interested in following any of these plans, visit these Web sites for more details:

- The Sturcade — `http://home.comcast.net/~bsturk/mame/monitor.html`
- Carlos' Centipede Extended — `www.retrospieler.de`
- Koz's rotating monitor — `http://206.113.145.82/mame`
- Dan's Cocktail Lounge — `http://dannygalaga.com/mame.htm`
- Search for "rotating monitor" on the arcadecontrols.com forums at `http://forum.arcadecontrols.com`.

You need to consider the effects of magnetism with a rotating CRT monitor. As a CRT monitor is rotated from one orientation to another, the different orientation to Earth's magnetic field may produce minor color distortion. You'll need to include some means of degaussing the monitor in your plans, whether with a built-in degaussing circuit or an external coil.

Rotating monitors are certainly very innovative. If you're going to use a smaller monitor, it's something to consider. However, if you're using a larger monitor, a rotating monitor is probably more trouble than it's worth. A vertical picture on a horizontally oriented 25-inch monitor will be the equivalent of a vertical 19-inch monitor, which is more than acceptable.

The angle at which you mount your monitor is your last consideration for monitor mounting. Most of the pictures shown so far are of monitors essentially parallel to the slope of the cabinet. If you're going to mount your monitor in an upright fashion like this, it should at least slope parallel to the cabinet. It will look better this way and will allow players to look down slightly. If the monitor was mounted with no angle, players would have to crook their neck to play, which would rapidly grow uncomfortable.

However, some games mounted their monitors at a steep angle — almost laying it down. Players look down as they play their games (see Figure 12-23).

Games that used a monitor in this orientation include some of the Pac-Man titles and the Nintendo VS series of arcade machines. Looking down at a monitor at this angle is comfortable and unlikely to cause neck aches during prolonged play. Mounting a monitor at this angle is more of a challenge. When a monitor is mounted on a shelf parallel to the cabinet's slope, the monitor shelf holds the weight. If the monitor is mounted at a steeper angle, then the force of gravity pulls the monitor down the slope. You'll need to use an appropriately strong method of mounting to accommodate a monitor at this angle.

Figure 12-23: A sharply angled monitor.

The Project Arcade Monitor

The Project Arcade 2 cabinet uses a 26-inch LCD arcade monitor from Billabs. The monitor is mounted horizontally and is angled parallel to the arcade cabinet's slope, as can be seen in Figure 12-24.

Used by permission of Billabs.

Figure 12-24: Project Arcade with mounted monitor.

Summary

Wow, there is certainly a lot more to monitors than you might think, at first! Above all, you should always have a healthy respect for the hazards inside a monitor. A bit of carelessness when working with an exposed monitor can have serious health consequences. Once you're past the basic theory and safety information surrounding monitors, you have four main choices. You can choose an arcade monitor, a television, an LCD monitor, or a hybrid arcade-computer monitor. Each type will dictate different interface and mounting requirements as well as provide different levels of arcade authenticity. Once you've chosen a monitor, your last decision will be the orientation and angle at which to mount the monitor.

You're so close to having a fully functional home arcade cabinet that you can probably see it in front of you now! In the next two chapters, I'll talk about installing and configuring your computer as well as finding and loading the game software that makes the cabinet work. Look out — Arcade Nirvana awaits!

CHAPTER

13

Installing the Computer

IN THIS CHAPTER

- **Configuring Your Computer for Total Arcade Immersion**
- **Installing the Computer into the Cabinet**

"Igor! Igor, where are you? Ah, good. There you are. What are you doing? Stop playing *Pac-Man* with that keyboard and come over here. It's time!"

"*Now, doctor*? *Are you sure*? *Is your creation really ready*? *I'm afraid, doctor. I'm afraid*!"

"Be still, Igor! There is nothing to fear and nothing to lose but the keyboard itself! We have worked long and hard for this moment, and it is time. We have long since assembled the cabinet body, and it is ready. Have we not installed the monitor for the eyes, the speakers for the ears? Did we not select an interface for the nervous system, and provide it genuine arcade controls to play with? No, Igor, be not afraid. It is time — time for the most essential part of all!"

"*Doctor*! *You can't mean your creation's ready for…for…*"

NOTE **At this point, maniacal laughter interrupts Igor, and thunder and lightning flashes in the background. Everyone in the audience gasps in horror and waits in breathless anticipation as the mad scientist (you) prepares for what comes next! Unfortunately, this is only a printed medium and our special effects budget is pretty low. You will need to supply the special effects and audience yourself. Please do so before continuing. Thanks! — Author.**

"Yes! Yes, Igor, bring me what is to be my creation's brain! It is time to bring my creation to life! Bring me...*the computer*!"

"But doctor — you haven't talked about the computer yet. The audience may get confused. You may get confused!"

"What? Oh yes, you're right. I forgot! Very well then, let us proceed. Bring me the first circuit board, my *Building Computers for Dummies* book, and a cup of hot cocoa! Oh, and bring my fuzzy bunny slippers, too — I have a long night of research ahead of me!"

"*Yes doctor...*"

In this chapter, I'll talk about installing the computer into your arcade cabinet, and configuring it to minimize the *computerness* of it while maximizing the arcade atmosphere. You can set up your computer so that from the moment it boots up to the time you're playing your first game, it looks as much as possible like a real arcade machine. There's some interesting stuff ahead. Read on!

Configuring Your Computer for Total Arcade Immersion

I'm assuming for this section that you have a working knowledge of computer terminology and how a computer works. If you do not, then some of this section may seem a bit foreign to you. I'll attempt to make it so you can follow along even if the terms and concepts aren't familiar to you. However, if you find that you'd like to know more, consider picking up a copy of *PCs For Dummies* by Dan Gookin and Wiley Publishing. I'll be concentrating on Windows-based computers, but similar concepts will apply to Linux and Macintosh users.

Picking A Computer

Just about any computer you pick for your cabinet will work, as long as you have an idea of what kind of games you will be able to play. The nice thing about re-creating a classic arcade cabinet is that many classic arcade games and emulators do not require high-end computers. Even an ancient 486 or low-end Pentium computer will work for a large number of great arcade classics. These games are also not terribly demanding in terms of memory and video requirements. Lower-end machines like these, however, will limit your ability to play more recent titles and emulators.

A good mid-level machine will do an excellent job of running almost all of the arcade emulators available on the Internet today. It will also run a good majority of the non-emulator games in the market, as well. Video and memory demands will be higher at this level. You'll want a decent video card and at least one or two gigs of RAM in the computer (depending on your operating system requirements) to be able to play modern video games on your cabinet.

To be able to play cutting-edge video games as well as to future-proof your cabinet for tomorrow's emulators, you should consider a relatively new computer. A workhorse with two to four gigs of RAM along with a high-end video card will let you play anything out there now and in the near future. Of course, this is always a losing game. In a year, the high-end computer you have now will be yesterday's news, and the newest video games will benefit from yet again higher amounts of RAM and newer video cards. This is one game you can keep up with, but won't ever win!

Along with the essentials such as a video card and RAM, you'll want to think about a few other things for your computer:

- **Sound card.** Any sound card will work, though, for really old games, you want one that's SoundBlaster compatible. Most computers have the sound system built into the motherboard, and that will work fine for most arcade cabinets. For really high powered gaming you might elect to put in one of the high-end sound cards that are available, but for arcade cabinet gaming that's really overkill. You might consider it though if your cabinet will double as a juke box.
- **DVD-ROM drive.** This is essentially a given, but all video games sold these days come on CDs or DVDs.
- **USB ports.** Many arcade controls can be made to connect through a USB port, and more are likely to be developed in the future. Even if you aren't using one now, you may want to in the future. I recommend having several available USB ports.
- **Network adapter.** A network adapter in the computer has two benefits. The first is that you can use it to provide maintenance access to your computer remotely via an in-house network, without having to open the cabinet. The second is that a network adapter will allow you to hook up your arcade cabinet for high-speed online or local network multi-player gaming action. Most computers have built in network adapters.

The good news is that it does not have to be that expensive to have a computer near the cutting edge of technology. Every year after Thanksgiving until New Year's, you can find computers on sale in the $200–$400 range with enough horsepower to run any classic arcade game, and probably enough oomph to run all but the most recent modern high-end video games. Granted, those kinds of deals are not the norm, but you should be able to pick up a decent computer system for your cabinet at prices ranging from $300 to $600 year round. Also, don't forget that the computer is the one part of your arcade cabinet that's easy to upgrade as time goes on. Don't bust your budget here — put in the most you can afford, even if that means using an old computer you have gathering dust, and upgrade it as your gaming demands and budget afford.

Setting Up Your Computer

I recommend performing the initial setup of your computer outside the cabinet. This lets you make sure everything works while it is easy to get to. Once you've got the operating system installed and the environment configured the way you like, you can install the computer into the cabinet. You're likely to be continually tweaking and updating the computer throughout the lifespan of your cabinet, so don't worry about having it 100% complete before you put it in.

Choosing An Operating System

You have several options when it comes to operating systems for your computer. Your easiest and most flexible choice is to use one of the Microsoft Windows operating systems. Almost every emulator and video game comes in a version that runs under Windows. If you have a licensed copy of Windows 98, and you intend to focus on older classic arcade games, then you may want to consider using it for your arcade cabinet. Up until Windows XP, Windows 98 was hands-down the best operating system for game playing that Microsoft made. Full details on why this is so would take many pages, but in short Windows 98 provided the most stable home-consumer (game)-oriented version of Windows available at the time. Windows XP continued this emphasis, providing the best of modern-day operating systems while maintaining the attention to the home-consumer market. Some older games do not run under Windows XP, though most will with a bit of configuration. I would not recommend Windows Vista, but Windows 7 is also worth considering. If you are planning to play modern games as well as arcade classics, be aware that several games (with more to come assuredly) will not run on operating systems older than Windows XP.

Other operating systems you might consider include DOS, Macintosh, and Linux. You will limit the number of commercial video games you can play by using one of these choices, but most of the arcade emulators have versions for these operating systems. You can run DOS by booting Windows 98 into DOS mode, using a version of MS-DOS if you have a license for it, or by obtaining a freeware version such as FreeDOS (`www.freedos.org`). You will need to go online for more information on Macintosh and Linux choices. Two good places to start are Richard Bannister's site (`www.bannister.org`) and `http://mameosx.sourceforge.net` for Macintosh emulators, and Arbee's WIP Emporium (`http://rbelmont.mameworld.info/?page_id=163`) for Linux.

My recommendation is that you choose Windows XP for your arcade cabinet. It will provide a maximum level of flexibility for your cabinet with a minimum amount of configuration issues.

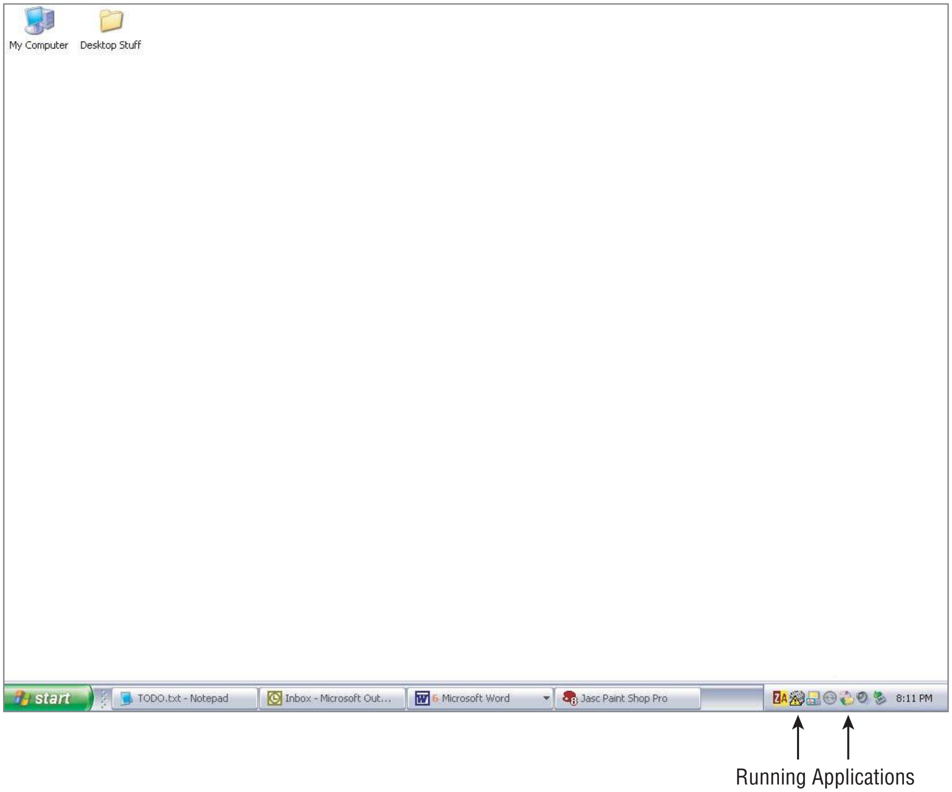
Basic Operating System Installation

Installing your operating system (OS) should be fairly straightforward using the instructions included with the OS. There isn't much I need to tell you about the basics of operating system installation, but I do have some guidelines for you to consider. Keep in mind the purpose of your computer when you're installing the operating system and applications. Unless you have other plans, the whole point of this computer is going to be to play games. Any options in the operating system that don't help with that point should be eliminated, if possible. When you're running the operating system installation, choose the custom install instead of default. Examine each option and decide whether it's absolutely necessary. Something like a paint program probably isn't necessary for your gaming system. However, it doesn't normally run until you manually select it, so is probably safe to leave. On the other hand, the Microsoft Messenger service does run constantly by default and probably doesn't add anything you want in a gaming system — take it out.

Be aware of things installed by software applications that sometimes sneak in by default. For instance, Microsoft Office and some other applications have a *quick-start* feature that loads part of the program in memory when the computer starts up, so that the application loads faster when you click it. That's great in a work computer, but once again takes up resources unnecessarily in a gaming computer. Either don't install the application at all (do you need to do word processing on your arcade cabinet?) or make sure they don't install extra things you don't want, such as quick-start. Look out for things installed by hardware installation drivers as well. Does your video card include a taskbar icon that lets you quickly change resolutions, record video, or watch TV? That's great, but it runs continuously and takes up memory and resources. Unless you're planning to use any of those features in your cabinet, take them out.

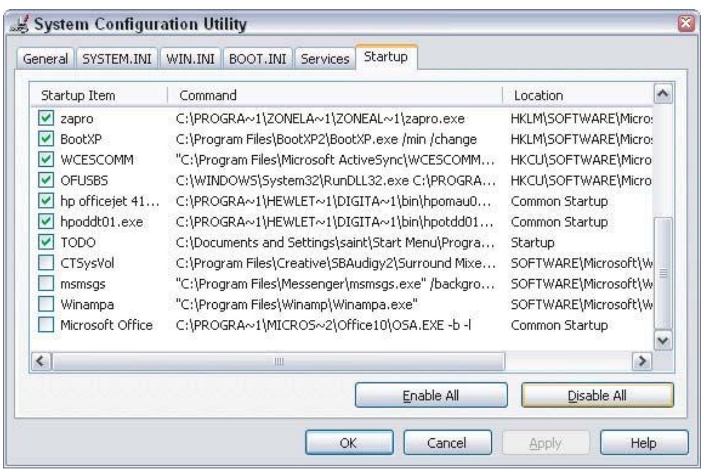
TIP **Look on the bottom right of your taskbar (see Figure 13-1). Any icon you see there is something running and taking up resources on your computer.**

If your computer came with the operating system and application pre-installed, which is likely for most commercially purchased computers, it is probably full of resource-stealing extras. Try this on a machine running any version of Windows after Windows 98: Click the Start button, then Run, and type **msconfig** in the dialog box. Click the Startup tab, and look at all the things that are set to run when you turn your computer on (see Figure 13-2). You may be surprised at all the things that are loaded before you ever start to use your computer!



Screen shot reprinted by permission from Microsoft Corporation.

Figure 13-1: Seven applications running on the taskbar.



Screen shot reprinted by permission from Microsoft Corporation.

Figure 13-2: A look at msconfig on a typical Windows XP computer.

Notice the checkbox next to each item. It's possible to turn an item off so it no longer starts when the computer starts. Some of the things that run are necessary for the computer to operate, however! You can examine each one to see whether its purpose is clear, and whether it looks safe to turn off. For instance, notice that I've turned off the Microsoft Office startup assistant (osa.exe) and Messenger service (msmsgs.exe). Deciding what to turn off and what to leave on can be a tricky affair. Some choices are obvious, some are obscure (what does regsvr32.exe do anyway?). You can turn off items one at a time and then reboot your computer to see the effect. If something stops working that needs to work, you can re-run msconfig to correct it. If the computer stops working so badly that you can't run msconfig, you can boot into safe mode. Do so by pressing the F8 key immediately after the computer starts to boot, and choose safe mode from the startup menu. Once Windows is running in safe mode, you can undo your changes.

WARNING **Performing the steps in the previous paragraph should be perfectly safe. However, the unlikely possibility exists that something may go wrong and corrupt your operating system or data. Do not do these steps on a computer that has the only copy of the family photos on it! Make sure you have a backup of anything important on the computer before you start tinkering.**

Another thing I highly recommend on a computer that came pre-installed or that has been in use for a while is scanning for spyware programs. Spyware refers to programs that install themselves on your computer for the purpose of gathering information (usually marketing information) and reporting it back to someplace on the Internet. Some may have been installed with your consent, while others may have snuck in without making it obvious to you. Either way, even if you're not connected to the Internet, these programs will take up system resources you'd rather use for gaming. A good spy-busting program is Spybot Search & Destroy available free from `www.safer-networking.org`. This program scans your computer for such programs, notifies you about what it finds, and gives you the option to remove them. Another excellent spy-buster is *Ad-aware* available from `www.lavasoftusa.com`.

Once you have your operating system installed or cleaned up, you should consider preventative security measures. No computer should be without a good measure of security to prevent problems and spy programs from occurring in the first place. Make sure you have a good anti-virus program (such as *AVG*, among other good choices) installed on your computer. If you are going to have the machine connected to the Internet, you should also have a personal firewall installed. Windows XP service pack 2 and later Windows versions have built-in firewalls. For older Windows operating systems, my favorite firewall is Zone Alarm (`www.zonelabs.com`), which has a free basic version, or a full-featured version (recommended) for $40.

Tweaking The Operating System

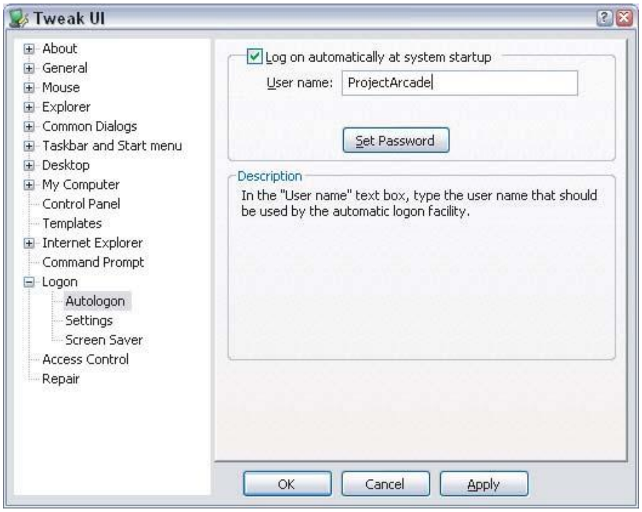
You can do a few more things to the basic operating system configuration to minimize the appearance of running a computer and make maintenance easier. For instance, Windows requires you to log on to the computer by default. You certainly don't want your arcade cabinet to boot up to a logon screen! Fortunately, getting rid of the logon screen is easy. Start by downloading a copy of *Tweak UI* from Microsoft if you're using Windows 98 or XP. *Tweak UI* is a user interface tweaking tool that Microsoft released in response to public demand, but does not support. It allows you to tweak and configure many different parts of your operating system safely. *Tweak UI* comes in one version for Windows 95 through Windows 2000, and another version for Windows XP. Microsoft frequently changes the locations of files, so I can't guarantee exactly where the utility will be. You can find it by visiting the Microsoft Web site (`www.microsoft.com`) and searching for either "*Tweak UI* Windows 98" or "*Tweak UI* Windows XP" depending on your need.

Windows XP was the last version of Windows for which Tweak UI was released. If you're using a version of Windows after Windows XP, download a copy of Ultimate Windows Tweaker from `www.thewindowsclub.com` instead.

Tweaking The Logon

For Windows XP and earlier, once you've installed the *Tweak UI* program, run it and browse through the various options. You'll see there are many things you can do with this handy utility. The Windows 98 version uses tabs; the Windows XP version uses a tree-like menu structure. I will refer to the XP version, but the same steps can essentially be taken on the 98 version. Click the logon-autologon menu (in Windows 98, just click the logon tab). Here you can check a box to tell Windows to log you on to the computer automatically when it starts, and you can tell it what username and password to use (see Figure 13-3). Enter the username and password you are using on the computer, click OK, and you will no longer have to log on to the computer when it starts.

NOTE **Windows 98 and Windows XP use user profiles to maintain separate settings from user to user. This lets one user select a background screen, for instance, and another user a totally different background screen. Each gets his or her own background screen when logging on without having to change it each time. This is handy for a computer that has multiple users with unique needs. For your gaming cabinet, however, you'll probably want everyone to use a single username, so they always get the same environment you've set up for the arcade cabinet. From here on out, make sure any changes you make occur while you're logged in using the same username you selected in the autologon section of *Tweak UI*.**



Screen shot used with permission from Microsoft.

Figure 13-3: Setting the logon under Windows XP *Tweak UI*.

For later versions of Windows, follow these steps:

1. Press the Windows key and the R key together. You should get a "run" dialog window.
2. Type in "control userpasswords2" and press the enter key.
3. The User Accounts window will open (see Figure 13-4). Uncheck the option at the top that says "Users must enter a user name and password to use this computer."
4. Click OK.
5. If you have a password set on the account, you will be prompted to enter it. If you have no password you will not be prompted.

After following these steps, you will no longer be prompted to logon when Windows starts. You're now one step closer to the arcade experience!

Clean Your Desk!

Another thing from which all versions of Windows suffer is a messy desktop. Icons for this, icons for that; icons here, icons there; icons, icons everywhere! On an arcade cabinet, all you want to see are games and perhaps jukebox programs. You certainly don't need to see a trash can! This is another area where some ingenuity and *Tweak UI* (for Windows 98/XP) can help. First, run *Tweak UI* and choose the Desktop menu (see Figure 13-5; Windows 98 version will vary slightly). Notice you can turn off several of the standard Windows desktop icons. That's a good start!

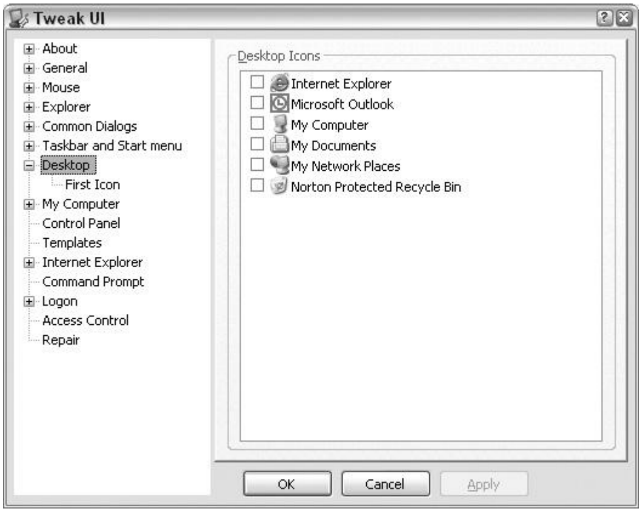
Screen shot used with permission from Microsoft.

Figure 13-4: Disabling the logon prompt under Windows Vista and Windows 7.

WARNING **Turning off the network neighborhood icon in Windows 98 disables networking. In Windows XP you can turn off the network icon without that problem. If you want your arcade cabinet networked and you're running Windows 98, the best you can do is to change the default network neighborhood icon and title to something else to disguise it, or investigate different user interfaces in the "Shell Games" section later in this chapter.**

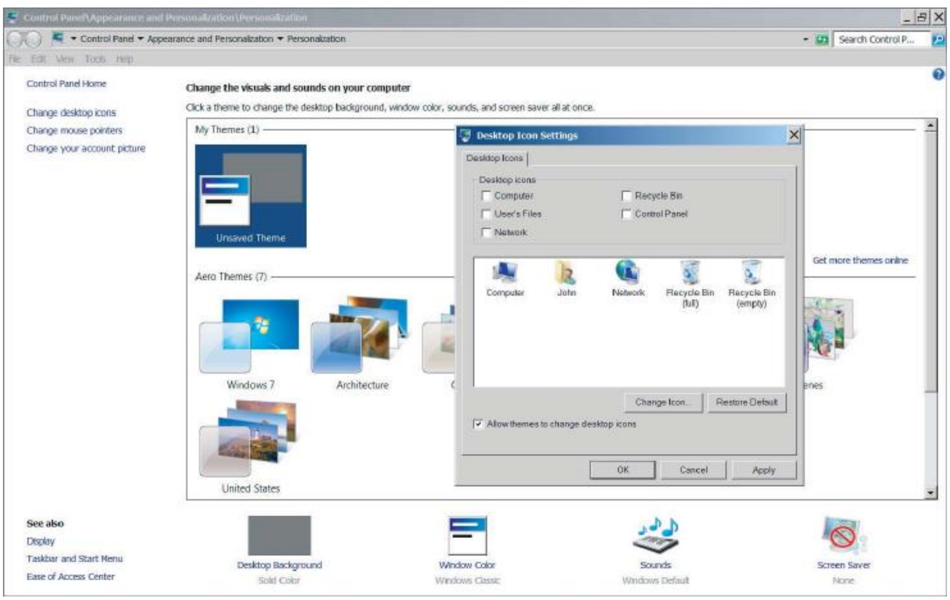
In Windows Vista and beyond, you can right-click the desktop and choose Personalize. Then you click "Change desktop icons" and turn off the icons you don't want on your desktop (see Figure 13-6).

Next (in all versions of Windows), make a new folder on the desktop called Desktop Stuff by right-clicking an empty spot on the desktop and choosing new folder. Select every remaining icon on the desktop that you do not want shown, and move them into the folder you just created. Make sure that your taskbar has the quick-launch toolbar showing on it (small icons you can activate with a single click). If it's not there, right-click the taskbar, choose Properties, and turn the quick-launch toolbar on. Now, right-click the Desktop Stuff folder and drag it to the quick-launch toolbar on the taskbar. Let go, and make sure you choose to move it instead of copying it. Voila! The desktop is now cleared of everything but what you want on it. You can gain access to the desktop icons by choosing the folder on the quick-launch toolbar, so you haven't lost access to anything.



Screen shot used with permission from Microsoft.

Figure 13-5: Desktop settings in *Tweak UI* for Windows XP.



Screen shot used with permission from Microsoft.

Figure 13-6: Desktop settings in Windows Vista and later versions.

The last thing you'll want to do is to go to the properties for the taskbar, and make sure auto-hide is turned off. This will stop the taskbar from popping up and down whenever the mouse is near it. Finally, grab the top of the taskbar (the cursor will turn into a double-headed arrow when you're in the right spot) and drag it down until it disappears. You'll still be able to get to the taskbar by dragging it back up when you need it later, but otherwise the only sign of anything computer oriented on your screen will be a small line at the very bottom of the screen. Figure 13-7 shows my Windows XP desktop with all the icons removed and the taskbar hidden. You can just barely see the double-headed mouse cursor sitting on top of the taskbar line. The desktop may look a bit plain right now, but you'll be jazzing it up in the "Sights, Sounds, and Themes" section later in the chapter. Still, notice that there's nothing computerish left. Your desktop cleanup is complete!

Figure 13-7: A fully functional but cleaned up Windows XP desktop.

Remote Control

You should think about one more thing before considering the basic operating system installation finished. How are you going to access and update the computer after it's in the cabinet? Getting to the computer in the cabinet won't be too difficult, but do you really want to have to do that every time you want to update or add a game? There is a better way. Remember the network adapter

I recommended earlier in the chapter? If your computer is available on your household network, accessing it for updates and maintenance is easy. Walking you through installing a home network is beyond the scope of this book, but it really is not difficult. You probably guessed it, but Wiley Publishing has a book that will help you. The book is called *Home Networking Do-It-Yourself For Dummies* and is written by Lawrence Miller.

If you have your arcade cabinet's computer on a network, you can use basic Windows networking to share files and copy updates to your arcade cabinet. The really neat part comes in when you remotely control your arcade cabinet from another computer in the house (or even across the Internet, though I don't recommend it for security reasons). Using some method to remotely control your arcade cabinet's computer, you can update or maintain it without ever having to open up your cabinet or crawl around in back!

Windows XP and later versions include a built-in application called *Remote Access* for this purpose. It works very well, but I do not recommend it because running it on the arcade cabinet's computer will involve setting it up and a bit of typing each time. Since the goal of the arcade cabinet is to be keyboard free, this presents a problem. There is an excellent freeware alternative called VNC (`www.tightvnc.com`). VNC is a remote-control program available for many operating systems, including all flavors of Windows. It can be installed on your arcade cabinet's computer and either configured to be running always, or to run with a simple double-click using your trackball and arcade buttons. Once it's running on the arcade cabinet's computer, you can run the viewer program on another computer on the network, and remotely take control of the arcade cabinet's computer. It's fast, takes up few resources on the host computer, and works great!

CROSS-REFERENCE **VNC is distributed under the GNU General Public License. This is a distribution license that maintains the original owner's copyright while allowing free distribution of the software. As required by the GNU license, both the VNC software (Windows version) and the source code are included on the companion CD-ROM.**

Sights, Sounds, And Themes

Now I'm going to talk to you about something that can be really fun — dressing up your computer with arcade sights and sounds to complete the illusion that you're playing a real arcade machine! This is often referred to as eye candy (and ear candy). Normally, it doesn't do anything for your computer in practical terms; it just looks and sounds pretty. However, because you're trying to recreate the arcade experience, dressing up the sights and sounds of your computer is almost a necessity!

Configurable Eye And Ear Candy

Let's start by taking a look at the parts of the operating system that can be configured with different sights and sounds. All versions of Windows support these configurations, with different ways to get there. Table 13-1 shows the items that can be controlled, along with the applet in the control panel (Windows 98/XP: click Start ➢ Settings ➢ Control Panel. Windows Vista/7: click Start ➢ Control Panel) used to configure them.

The Internet is full of different bits and pieces of graphics and sounds you can download and apply to the items in Table 13-1. Finding them is easy with a search on Google (`www.google.com`). Choosing them is an exercise that can easily take days as you stumble on one idea after the next. Imagine turning on your arcade cabinet and having it come up to a picture of the light cycles from Disney's *Tron* movie while the Master Control Program announces, "I'm going to have to put you in the game grid." Your friends will get goose bumps the first time they see and hear that — very cool!

Table 13-1: Configurable Sights and Sounds

ITEM	DESCRIPTION	WINDOWS 98/XP CONTROL PANEL	WINDOWS VISTA/7 CONTROL PANEL
Background	The wallpaper (the picture on your computer's desktop) and the background colors (if you have no wallpaper).	Display	Appearance and Personalization ➢ Change desktop background
Screensaver	The screen saver that runs when your computer has been idle.	Display	Appearance and Personalization ➢ Change screen saver
Mouse cursors	The various shapes your mouse cursor takes when in use (15 different cursors).	Mouse	Appearance and Personalization ➢ Change the theme
Icons	The icons used on the standard desktop, such as for My Computer.	Display	Appearance and Personalization ➢ Change the theme
Appearance	The various sizes, colors, and fonts for different windows and buttons on the desktop and in the Windows environment.	Display	Appearance and Personalization ➢ Display

ITEM	DESCRIPTION	WINDOWS 98/XP CONTROL PANEL	WINDOWS VISTA/7 CONTROL PANEL
Sounds	The .wav sound files that are played in association with certain events, such as starting or exiting Windows.	Sounds	Appearance and Personalization ➢ Change sound effects
Startup screens	The screen shown when Windows is starting up and when it's shutting down.	Special (see text following)	Special (see text following)

Desktop Themes

You have two choices for installing all but the startup screens in Table 13-1. I'll get to the startup screens in a moment. For all the rest of the items, you can manually edit each item by replacing the default with the icon, wallpaper, or sound you've downloaded from the Internet. This can be a lot of fun, but can take a lot of time. Once again, there's a better way. Microsoft groups all of these items as a theme. Once you've got it configured exactly the way you want, you can save all the customized settings as a theme file and share it with your friends. When your friends install the theme file, they'll get all the same cursors, icons, colors, fonts, wallpaper, sounds, and so on, that you have. The nice thing is that many (hundreds, if not thousands) of people have already made themes to share! Try a Google search and you'll be inundated with Web sites to browse. You'll find themes from old arcade classics all the way up to modern-day cutting-edge games.

Installing a theme is done in a slightly different but mostly similar way in different versions of Windows. In Windows 98, choose the Desktop Themes applet in the control panel. In Windows XP, choose the Themes tab on the Display applet in the Control Panel (see Figure 13-8). In Windows Vista and Windows 7, you get there through the Personalization applet in the Control Panel.

Before you do anything else, you should save the current configuration of your computer under your own personal theme. That way, if you don't like the results from testing different themes, you have your old standby to fall back on. Give it a name such as "mytheme.theme" so you'll always be able to find it when you need it.

Installing a theme is as simple as unpacking it if needed, then using the operating system's theme manager to select the theme. All the cursor, icon, wallpaper, sound, and other changes will be made automatically simply by choosing the theme. It couldn't be easier!

Screen shot used with permission from Microsoft.

Figure 13-8: Themes tab on the Display Properties dialog box, Windows XP.

As well as doing a search on Google, you can find video game themes on the Web sites or CDs of your favorite games and game developers. For instance, the Atari *Arcade Hits* CD (which I'll tell you more about in Chapter 14) includes a desktop theme for each of the games on the CD. Some other video game themes, wallpaper, or movies can be found on Sega's Flickr account at `www.flickr.com/photos/segaamerica/sets`, and Digital Leisure at `www.digitalleisure.com`.

For more desktop themes, try the search words "desktop themes video arcade game" on Google. Finally, stop by ezthemes.com (`www.ezthemes.com`) and click on the Games link for a huge collection. Careful, searching for and playing with themes can be addictive. Have fun!

Startup Screens

If you eliminate the logon screen and decorate your computer with a good arcade-oriented theme, you're most of the way to hiding the computer behind your arcade cabinet. You need to tweak one more thing, and then you'll have a computer that's as close to an original arcade cabinet as is possible. That last piece is the Windows startup screen. All versions of Windows display a Windows logo when booting up. In Windows 98/XP, changing the startup screen for something more appropriate (for instance a picture of Pac-Man or perhaps a nice logo like "Project Arcade") is easy to do. Unfortunately, this is not the case with Windows Vista or Windows 7, as I'll explain in the following sections.

Windows 98

If you're using Windows 98, you can actually replace three screens. The first is the startup screen, the second is the screen displayed as Windows is shutting down, and the third is the screen displayed when Windows has completed shutting down (if your computer doesn't just power off). Those files are C:\logo.sys, C:\windows\logow.sys, and C:\windows\logos.sys, respectively. These files are 256-color Windows bitmap files with dimensions of 320 × 400. You can use any compatible bitmap file by simply naming them appropriately and copying them over the other logo files. Be sure to make backup copies of your originals first! The C:\logo.sys file may not exist at first on your system — that's fine, just copy your own to the C:\ directory and Windows will pick it up.

It's also possible to have an animated startup logo for Windows 98! The image won't actually move, but the colors will cycle through a range of colors, giving the appearance of animation. Animated (as well as non-animated) logo screens can be found once again with a good Google search. For more information on creating animated Windows 98 logo screens, as well as a collection of screens to get you started, visit the XrX page at `www.xrx.ca/logoutils`.

Windows XP

The only logo screen you can replace on Windows XP is the startup screen. The startup image is a 640 × 480 picture with 16 colors and a small animated bar. Beyond the small bar of moving dots, Windows XP startup screens cannot be animated as they can with Windows 98 startup screens. Also, Microsoft made it a bit more difficult to get to the Windows XP startup screen by embedding it in a file that's part of the operating system. That file is ntoskrnl.exe, found in the C:\windows\system32 directory as well as other directories (the one in the system32 directory is the important one). Before you make any changes to this file, be sure to back it up. If this file gets corrupted, your operating system will stop working!

You should use a utility to replace the startup screen safely in the ntoskrnl.exe file. There are several good programs you can try. Two are commercial programs, both of which have trial versions you can use to see whether you like them before you buy them. The first is BootXP, available by searching for "BootXP 2.50" on Google. The second is Inno Logo, also available by searching on Google for "Inno Logo." They support automatic backups of your original ntoskrnl.exe file, previews of the boot screen before you apply it, and restoration of the original if you decide you don't want to use custom bootup screens. The other program you might want to try is LogonUIBootRandomizer (`http://userxp.belchfire.net`), a freeware program that will randomize your bootup screen quietly so that it's different every time you start the machine.

Windows Vista And Windows 7

Starting with Windows Vista, Microsoft began to make it harder to change the bootup screen. It seems primarily to be a security concern. Modifications to the bootup screen happen before the operating system has loaded various security measures such as antivirus and firewalls. To prevent possible exploits during this time, Microsoft has made it difficult to modify the bootup screen.

In Windows Vista, it was possible to modify the bootup screen when it was first released. However the method stopped working after service pack 1 was released. If you have a pre-service pack 1 version of Vista you can get more information at Development Dan's Blog (`http://dan.computa.co.uk`).

After Windows Vista service pack 1, and in all versions of Windows 7, changing the bootup screen involves various hacks of startup files with, so far, mixed results. There is no simple utility to change the screens, and with reports of operating systems being corrupted and having to be repaired or reloaded, I do not recommend trying at the time this book is being written. Things may change as time goes by, so if you're interested in changing your bootup screen I recommend doing a Google search to see whether the situation has improved.

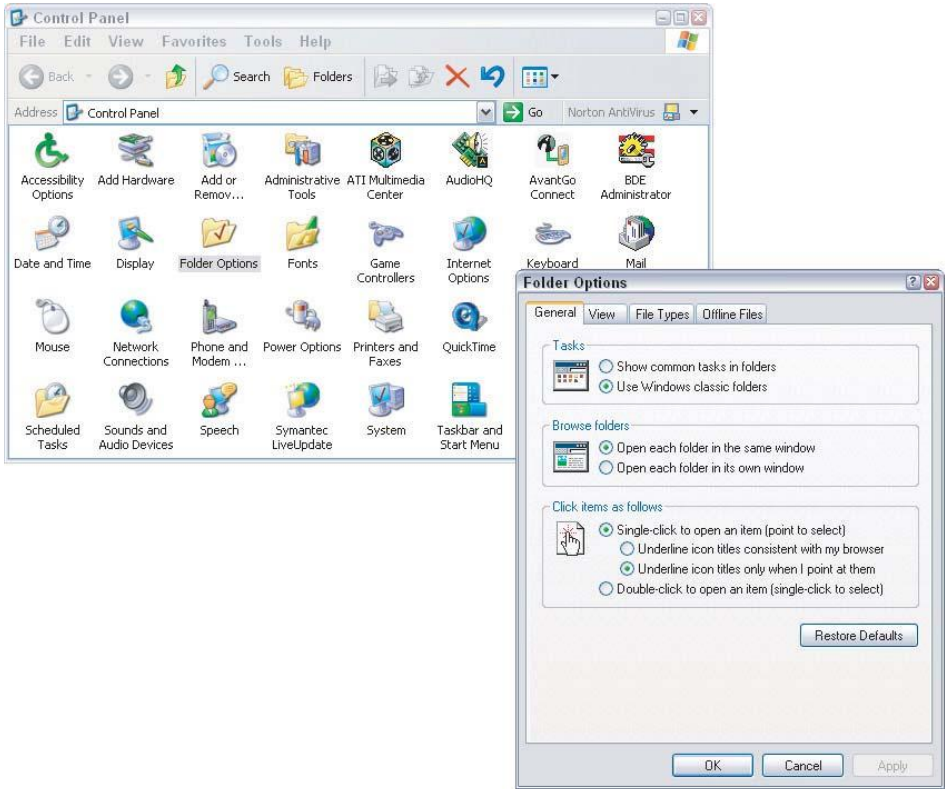
Launching Your Games

Now that you've installed the operating system and configured the look and feel, it's time to consider the games you're going to play. Specifically, how will you select and run a particular game? Booting your computer up with a custom arcade startup screen and arcade sounds makes it look like you're running a real arcade machine, but having to click Start ➢ Programs ➢ Mygame ➢ Rungame, and then opening the cabinet to insert the game CD can sure spoil the effect fast. Isn't there a better way? You're reading *Project Arcade 2* — of course there is!

One-Click Game Launching

The first thing you'll want to do away with is the concept of double-clicking with a mouse to run a game. Hopefully, you've installed a trackball to use in place of the mouse, and have pushbuttons configured as mouse buttons on the control panel. You can use these to move the cursor to a game you want to play, and then use the pushbutton to run it. You don't want to have to press the pushbutton twice to run the game — too computer-like. A single press of a pushbutton should launch whatever game you're selecting.

Fortunately, this is easy enough to do in Windows. In Windows 98, double-click the My Computer icon, drop down the View menu, and select Folder Options. Then click the Custom bullet, choose Settings, and set Windows to use a single click. On a Windows XP machine, the steps are slightly different. Open the control panel, and double-click the Folder Options icon. On the General tab, make sure the "Single-click to open an item" option is selected, as shown in Figure 13-9.



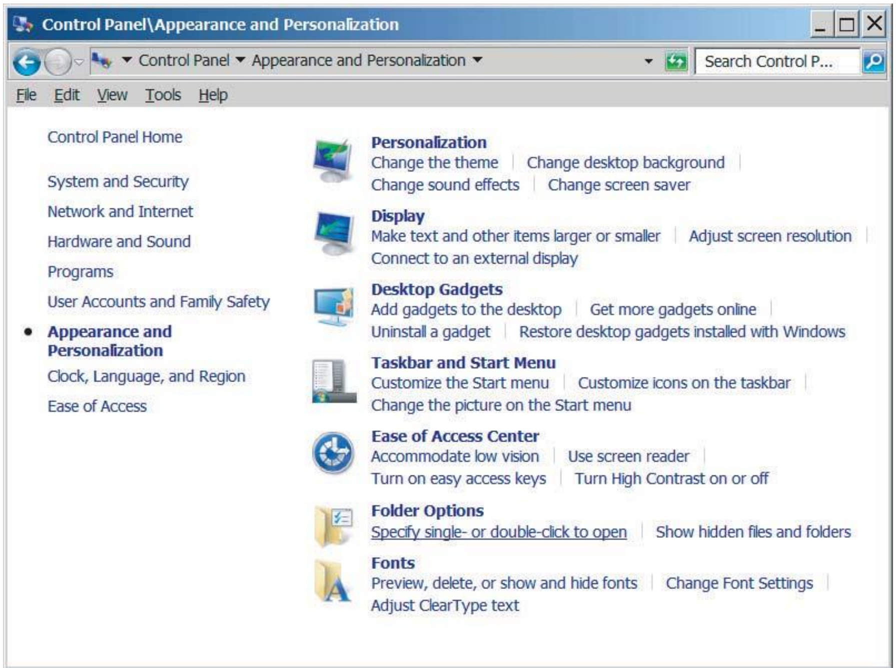
Screen shot used with permission from Microsoft.

Figure 13-9: Choosing single-click in Windows XP.

For Windows Vista and Windows 7, open the Appearance and Personalization applet in the control panel; then click the "Specify single- or double-click to open" under Folder Options (see Figure 13-10).

Front Ends

The single-click setting works great with single video games that launch directly into game play after you click. However, many of the arcade games you may play will be through emulators that run multiple arcade games. You don't run the game directly; you run the emulator. The emulator, in turn, starts the game. Many of these emulators have a common trend — they are not easy to use. Those with a menu system to choose the game are sometimes confusing or have to be configured. Some of them are command-line based, even though they run under Windows, and don't have a menu system. Running a particular arcade game requires typing the name of the emulator followed by the name of the game you're trying to play. Typing? That's not very arcade-like!



Screen shot used with permission from Microsoft.

Figure 13-10: Choosing single-click in Windows Vista/7.

The problem is that programming a computer to emulate an arcade machine's hardware and software can be very difficult. Emulators are almost always in a state of development to perfect game emulation. In fact, I do not believe I have ever seen an emulator that was declared completely finished! Making the game work properly is a significant technical achievement that requires a lot of time and talent on the part of the programmer. The rest of the details, such as designing an easy-to-use interface and menu system, do not always get enough attention. This makes many otherwise excellent arcade emulators difficult for novices to use. Once you're playing the game itself, the controls are arcade authentic and game play is intuitive. Getting to that point isn't always. The solution to this problem? Enter the front-end software program!

A front-end software program does the tedious bits of setting up a game for you. If an emulator requires typing to start, the front end will do that for you. If you have to set up some options such as screen size, the front end will do that, too. Essentially, a good front end turns a process that normally requires a keyboard and mouse into a simple trackball, joystick, and fire-button operation. Very slick! Some do this with a simple text display of available games, while others show you an image of the games. Many of the popular programs are *skinnable*, meaning that you can design (or download) your own look and feel for the front end, with custom wallpaper, game selection images, background noises, and more. One of my favorite front ends lets you walk through a virtual arcade full of cabinets to play, just like you were there in person!

NOTE **One of the best features of a front end is the way it looks, with a picture or screen shot of the game you're about to run. Unfortunately, space and copyright issues prevent showing you those here. You'll need to visit the front-end Web sites or download them to get the full effect!**

There are many (*many!*) front-end packages available. I'll start you off by directing you to the Build Your Own Arcade Controls Wiki, where you'll find a listing of front-end programs (`http://wiki.arcadecontrols.com/wiki/Front-Ends`). As of this writing, there are more than 25 listed! Choosing a front end is kind of like choosing a car — there's no one right answer for everyone. You should at least browse through the various front-end Web sites to see if you like a front end's look and features, and experiment with those that catch your eye. However, I'll highlight a few personal favorites here. The front-end arena is constantly in flux, with front ends being updated and new front ends being introduced. Be sure to visit the BYOAC message boards' software forum (`http://forum.arcadecontrols.com`) to see what's new! There's also a specific topic with a survey on front end popularity that's worth a visit at `http://forum.arcadecontrols.com/index.php?topic=84933`.

ArcadeOS

Available from `www.mameworld.info/pc2jamma/frontend.html`, ArcadeOS is a DOS-only front end that lists your games in text on the screen against an arcade background image. Some of the features of note are both horizontal and vertical modes, to best fit on your monitor no matter what orientation you're using. It's controllable by both trackball/mouse and joystick/keyboard, supports multiple emulators as programmed, and allows you to customize it to support even more emulators and games. Its most unique feature is built-in support for arcade monitors that require 15 kHz refresh rates. ArcadeOS is part of the PC2Jamma project (more information in Chapter 17). ArcadeOS will run right out of the box, so initial use is easy. Configuring and customizing ArcadeOS for emulators other than MAME is mildly complex, but there is a support forum at the MAMEWorld message forums (`www.mameworld.info`). It is open-source software, meaning the programming code for the front end is available for you to download, tweak, and possibly even to contribute your changes to the next version. ArcadeOS is no longer in development and is showing its age, but if you're going to use a DOS based cabinet it's one of your best bets. ArcadeOS is free software.

AdvanceMenu

AdvanceMenu (`http://advancemame.sourceforge.net`) is an emulator front end that runs under DOS, Windows, Linux, and Mac OS. Like ArcadeOS, AdvanceMenu has support for arcade monitors as well as other monitors. It supports both horizontal and vertical orientations with many different display modes for choosing games — full-screen snapshots, text lists with snapshots, tiled snapshots, icons, and more. AdvanceMenu is controlled by a joystick/keyboard. A unique feature of AdvanceMenu is support for customized sounds when navigating the menus, with the ability to assign a unique sound to each game. You can also have a background sound playing while in the front end. Another nice feature is a screensaver mode where it will cycle through arcade game screen shots when idle. AdvanceMenu supports multiple emulators, and is mildly complex to configure. It is also an open-source software program. AdvanceMenu is also no longer in active development, but is included here for those of you who may be using DOS or Linux. AdvanceMenu is free software.

NOTE **For the rest of the front ends, I will only mention mouse and keyboard support. Obviously, if it uses a mouse, your mouse-hacked trackball will work, and likewise for a keyboard-hacked joystick.**

Dragon King

Dragon King (`http://dragonking.arcadecontrols.com`) is a Windows-based multi-emulator front end with both keyboard and mouse support. It has several nice features that make it a good fit for an arcade cabinet. Dragon King supports customizable skins, screensavers and sounds, and an animated startup video among other features. The front end can be configured to support an arcade monitor as well as other monitors. Startup configuration for MAME support is easy with Dragon King walking you through the process. Configuring advanced features and additional emulators is of mild to medium complexity. Dragon King does not have a dedicated support forum, but the author is a regular member of the BYOAC (`www.arcadecontrols.com`) message forums and chat room. Dragon King is free software.

Emulaxian/FE-3Darcade

Emulaxian/FE-3Darcade (hereafter simply Emulaxian, `www.mameworld.info/3darcade`) is the front end that arguably has the "eye candy" category all but won. This is the front end where you can roam around a virtual arcade with real background noises and sounds, virtual players in the arcade, and cabinets that you can walk up to and play. When you select a cabinet, the front end loads the game and you run it full screen, returning to the virtual arcade when done. Many other options are available for the front end aside from the virtual arcade mode, such as a spinning wheel used to select games, a traditional text listing with screen shots, and others. Virtually everything in this front end is skinnable and customizable. You can choose to have the background arcade ambiance continue while you play your game, or to have it silent when you're in the game.

Probably the front end's neatest feature is the use of 3D arcade cabinet models, so that instead of generic boxy cabinets in your virtual arcade, you can design or download models that look like the real thing. Another nice feature is that this front end can shut down your computer when you exit, preserving the arcade illusions a little bit more. Very nice! I've only begun to touch on the potential of this amazing front end. This one should be high on your list to try! Emulaxian runs multiple emulators and games as well as MAME. It supports both horizontal and vertical orientation, keyboard and mouse control, and is easy to configure for basic operation through a menu-based configuration procedure. Advanced operation is mildly complex to configure. Support for this front end can be found in its message forums located at `http://echo.messageboard.nl/2243`. Emulaxian is free software.

GameEx

GameEx (`www.gameex.net`) is another popular front end in this community. You start with a professional standard Windows-type installer that walks you through the configuration process. A very nice touch here is that the installer will ask you whether you want it to download various components, such as emulators, large sound files, and other optional packages. This is much nicer than having to hunt down all the various components yourself. Once downloaded, it only took a few moments to install and start playing my first game with this front end.

GameEx makes a great candidate for a home theater system that includes gaming, such as a pedestal-based arcade control system used with a projector and screen. It ties into Windows Media Center for a seamless approach to multimedia fun, and its interface can be configured to look like it's part of Windows Media Center. This is nice if you're going to integrate it into a home theater system. In addition to keyboard and joystick support, GameEx also will work with a Windows Media Center remote.

If home theater integration isn't your goal, it is possible to configure GameEx to look much more like an arcade front end instead. Out of the box when I installed it I had flying space ships, animated screens, and background arcade noises, all with a minimum of configuration on my part. When I first fired it up and saw the sights and heard the sounds, it reminded me why I started in this hobby to begin with — much nostalgic fun!

GameEx has excellent support with an active user community and message forums. I have barely touched on the number of features the front end supports; I recommend you take a further look at their Web site for more details. I will be using this front end with a stand alone quad-player control panel that you'll see in Chapter 17. The program is shareware. You can use it as-is without paying, but for $25 you unlock a large set of premium features and remove the startup nag screen.

Hyperspin

Hyperspin (`http://hyperspin-fe.com`) is one of the hottest front ends in the community today and has rapidly grown to be the 300 pound juggernaut of the front end world. Like most modern front ends it is skinnable and supports multiple emulators and computer games. Hyperspin has excellent support with a dedicated community forum at `www.hyperspin-fe.com/forum`. This front end is also being actively developed and is likely to just keep getting better. Hyperspin supports keyboard, mouse, and joystick control.

Out of the box, it is visually and audibly stunning, with lots of animation and ear-candy. Some users have reported that configuration is a bit complex, but my experience was that setup was straightforward. It took only a couple of minutes to install the front end and play my first game, without reading any documentation at all. A configuration utility comes with the package, something not every front end has (requiring you instead to edit text files to configure the front end). The incredible visuals of Hyperspin come with a corresponding need for a decently powered computer system. This is probably not the front end for older hardware, though I encourage you to test it out to see for yourself. Though I try to maintain a bit of distance when presenting the options to you so as to introduce you to the broadest range of possibilities, I have to confess that I just plain like this front end! Hyperspin is free.

MaLa

MaLa (`www.malafe.net`) is arguably one of the work horses of the front end community. It is the second most popular front end in the aforementioned survey, and has been my regular front end for some time. MaLa is skinnable and has many layouts available for download. Initial configuration is easy enough, and once again I was able to install and start playing my first game in only a few minutes. However, configuration can get complex as you attempt to enable fancier features of the front end. Fortunately, MaLa has good support which can be found on the BYOAC Wiki at `http://wiki.arcadecontrols.com/wiki/Mala_Wiki`, and in the support forums at `http://forum.arcadecontrols.com` (English) and `www.arcadezentrum.com/forum` (German). MaLa supports keyboard, mouse, and joystick control.

An example of one of the many nice features is that MaLa is rotatable on the screen, so makes a good choice for a dual-headed cocktail cabinets. MaLa will detect when controls on one side of the cabinet are touched, and will rotate the screen to face that player. Nice! This would be an excellent solution to the Frankenpanel problem discussed in earlier chapters, giving you a way to use different controls on different faces of the cabinet. The front end also has built in support for many different hardware devices, such as the Ultimarc and Groovy Game Gear LED driver boards. Once you move beyond the basic "start a game" approach, MaLa is an amazingly full featured front end. It is another one of my favorite front ends, and is free.

Front-End Recommendations

It's really hard to point to a single front end and declare it the one you must try. Also due to space limitations I only highlighted a few in this chapter. You're better off taking a good look at all the front ends on the BYOAC Wiki and choosing the one that suits your particular wants and needs. Consider the operating system you'll be using, support for the games you want to run, degree of difficulty to install and use, extra features that might be important to you, and finally the look and feel. The short list of front ends provided here consists of the most popular among the arcade cabinet-building community members, but remember, there are many more out there you might want to try. Bear in mind you don't have to choose just one. You might run Emulaxian or Hyperspin for when you really want to wow someone, and MaLa when you want something more traditional. Experiment. Trying different front ends is part of the fun!

Shell Games

For those of you who *really* want to disguise the Windows engine behind your arcade cabinet, consider coming out of your shell — the Windows user interface shell, that is! Explorer (not to be confused with Internet Explorer, a different program) is the user interface that Windows presents you with when it starts up. It's the desktop, the icons, the start menu, and so on. One of the nice touches in Windows, however, is that you don't have to use Explorer as your shell. Any executable program can be used as a shell. For instance, you might choose to use a front-end program as your default Windows interface!

Changing the shell in Windows 98 is very easy. Edit the C:\windows\system.ini file (make a backup first!), and find the line that reads "shell=explorer.exe" near the top of the file. Change the explorer.exe to the name of your front end or other shell replacement, including the full path (such as C:\frontend\myfrontend.exe) if it's not in the C:\windows directory. Reboot the computer and you'll be running a brand-new user interface! If things go bad, reboot the computer and start it in command mode. Use the DOS edit command to modify the system.ini file and change it back to Explorer, reboot, and then try again.

Playing shell games in XP and later versions is more complex than Windows 98. Changing the shell requires making a few edits in the registry. If it's not done correctly, strange things can occur, like the Explorer shell opening up on top of your custom shell unexpectedly. On the other hand, several really good shell replacements exist to look at, and trying them out is once again a lot of fun. Here's one thing you might consider: Unlike Windows 98, Windows XP and later versions can support a different shell for each user. You can keep Explorer as your primary shell on your primary user account, and create new user accounts to try different shells. If things go wrong, just reboot the computer, log on as the primary account using Explorer, and fix it.

You can find full details on changing shells in Windows XP and later versions online. One good spot to start is the BYOAC Wiki page on shelling at `http://wiki.arcadecontrols.com/wiki/Hiding_Windows`. I recommend spending some time reading about it before deciding to put it into action. You can manually hack your Windows to use a different shell, but I suggest using a shell-swapping utility that will make the changes for you. One of the most popular is Instant Sheller by the creator of GameEx (`www.gameex.net/Community/InstantShellerandshellingguide.aspx`). Instant Sheller works with Windows XP service pack 2 and later versions of Windows. Not only will it let you change the default shell that Windows uses, it will also let you set auto-logon and change the bootup screen, though that's not available in Windows Vista or Windows 7. Instant Sheller is included on the companion CD.

Aside from using one of the previously discussed front ends for your shell, you might want to use one of the excellent full-fledged shell replacements available. Litestep (`www.litestep.net`) is very popular and extremely customizable. You can find hundreds of themes for Litestep, and if you can't find one to your liking, you can make your own. Would you like nothing but game icons on the desktop? Litestep can do that. Want everything arranged in menu bars against an arcade background? Litestep can do that, too. Another popular shell replacement is Aston (`www.astonshell.com`). Like Litestep, Aston allows you almost total freedom to design the perfect desktop, with many pre-packaged themes to try if you don't want to make your own. Litestep is free, while Aston is shareware for a very reasonable $30.

Be careful changing your shell; if something goes wrong, it can be difficult making your computer operational again. You should also make sure you have some way to turn off the computer properly if you change your shell, such as the ability to shut down Windows that some front ends have. Not every front end can do that, and if you use one of those as your shell, you'll end up with an arcade cabinet that can be turned on but cannot be properly shut down! The full shell replacements such as Litestep, of course, will not be a problem. Because changing the shell in Windows 98 is so easy, I wouldn't hesitate to try it if you're so inclined. If you're running Windows XP or later, it depends on how computer adept you're feeling. The minimalist approach would be to just run a front end in the startup folder and not change the shell. If you're feeling adventurous, then I suggest giving a few different shells a try!

WARNING **Make sure you have a backup of any important data and configuration files before you start playing with your shell. Normally you can reverse your steps if something goes wrong, but there's always the potential for a complete disaster requiring you to reload your computer. Better safe than sorry!**

Virtual CD-ROM Drives

I've got one final bit of advice for hiding the computer behind the scenes. Games and emulators that install themselves completely to the hard drive won't require any intervention when you want to play them. That's good. However, games that require inserting a CD (or DVD) anytime you want to play disrupt the arcade illusion. Finding a way to install those games fully on the hard drive would let you enjoy them without having to insert the CD. Fortunately, programs exist to allow you to do just that. These programs enable you to copy the contents of the CD to the hard drive, and create virtual CD-ROM/DVD-ROM drives on the hard drive. The computer is fooled into thinking a real CD is inserted and runs the software as if that were the case. Except for the fact that the CD exists as a virtual drive on the computer's hard drive instead of as a real physical medium, everything works the same. For instance, the CD has to be virtually inserted into the virtual CD drive before it can be used (which can be automated with a single click). Also, software that has to be installed off a real physical CD will still have to be installed off the virtual CD. In fact, you'll want to make sure that you install the game off the virtual CD instead of the real CD, in case the program expects to find the CD in the same drive every time it is run.

You'll encounter two possible drawbacks when using virtual CD drives. The first is that some CDs cannot be converted this way due to copy-protection schemes. The virtual CD programs are frequently updated to get around this, but not all CDs can be copied to the hard drive. The second drawback is a huge impact on space requirements. A typical CD holds 640 megs of data. A typical DVD holds 4.7 gigs of data. Copying the CD or DVD to the hard drive requires that same amount of space, although some virtual CD programs may compress that data on the drive. After you account for the space the virtual CD requires, installing the program off the virtual CD will then occupy still *more* space on the hard drive. One good game can take several gigabytes or more of space on your system! Fortunately, with hard drive prices plummeting, you should be able to find a good-sized drive inexpensively. Still, the extra drive space required is certainly something to balance against the inconvenience of having to swap CDs.

I recommend you take a look at two programs if you'd like to use virtual CD-ROM drives. The first is Virtual CloneDrive from `www.slysoft.com`, and the second is Virtual CD from `www.virtualcd-online.com`. Both have received praise from the computing industry for doing what they claim to very well. Virtual CloneDrive is freeware, while Virtual CD is $35 in a try-before-you-buy model. Some of the features you'll find in either program include DVD support, multiple virtual CDs active at one time, and the ability to have desktop shortcuts to the CD with auto-run enabled. This last feature means that once you've installed the virtual CD, you can run it with a single click on the desktop without navigating the virtual CD program's menus. Combined with the fact that you don't have to insert a physical CD, this makes running a CD-ROM game as easy and intuitive to the player as any other game on your arcade cabinet!

NOTE **It's not a secret that a virtual CD program can be used to make illegal copies of a game. In no way, shape, or form should anyone consider this section an endorsement of software piracy. It's illegal and immoral, and there's no legitimate justification for it. Please, use the software only for its intended purposes.**

Installing The Computer In The Cabinet

I really struggled when it came time to mount the computer in the cabinet. It wasn't that I had a hard time physically getting it into place. My problem was deciding whether I should place the PC in the cabinet as is, or dismantle the PC and install the separate components in the cabinet like a real arcade machine. PCs are designed to work assembled as a whole, so there's normally no reason not to leave it as is. However, stripping it down to the components and fitting them into place in the cabinet just has that *übergeek* coolness factor to it. Real classic arcade machines have circuit boards exposed when you look inside the cabinet; why not yours? In the end, pragmatism won out over impulsiveness. I simply had no good reason to take the PC apart other than the fact that I wanted to. You might consider it, so I'll go into when and how to do so.

Reasons To Take Your PC Apart

Besides "I want to," there are a couple of good reasons to consider disassembling your computer prior to placing it in the cabinet. The first is possible heat concerns. There's plenty of airflow in the Project Arcade 2 cabinet design, so heat should not be an issue. However, if you have used a different or altered plan, heat may be an issue. The faster computers get, the more they need good airflow for their fans to cycle the hot air out and cool air in. If your cabinet restricts airflow (for instance if it's essentially completely sealed), you might want to consider uncasing your computer. It's unlikely that this will be a problem, however. In fact, you may be better off leaving the computer assembled because of the design of the airflow inside the case. I recommend leaving it in the case first, and measuring the temperature when it's been on for an hour or two. If you do have a heat problem, you might also consider installing a fan in the back door of the cabinet like the one shown in Figure 13-11.

Used by permission of Happ Controls.

Figure 13-11: A heavy-duty cooling fan from Happ Controls.

Probably the most compelling reason to take your PC apart to mount it in the cabinet is a lack of space. If you're building a cocktail, countertop, or other oddly shaped cabinet that your computer won't fit in, then you have no choice. Some people in this situation have elected to have the computer sit next to or behind the arcade cabinet, but I would avoid that if you can — you lose some of the illusion that way. If you're building one of these space-limited cabinets, but haven't picked up your computer yet, search around for compact cases. Computer components have shrunk so much that manufacturers have been able to make extremely small packages for full-featured computers.

If none of the previous constraints apply to you, then I recommend leaving the computer in the case. The components will be protected from accidental damage, and the entire unit will be easier to remove for serious upgrades or replacement as compared to having to un-mount multiple components from the cabinet. Still, I can't help thinking about how authentic it would look . . .

How To Mount A Disassembled PC

You should consider accessibility and safety when it comes time to mount a disassembled PC into a cabinet. If your cabinet has an opening front panel, then accessibility is a given. If it does not, you need to think about how you're going to access the computer's parts when needed. For instance, sooner or later, you'll probably want to insert a CD into the CD-ROM drive. You'll need to do this if you're installing a new game, even if you have a virtual CD program (however, if you have a virtual CD program *and* network access, you can avoid using the cabinet's CD-ROM drive altogether). You could mount the CD-ROM drive near the back of the cabinet where the opening is (if you've followed the Project Arcade 2 plans), or at the front of the cabinet so the CD can be inserted by opening the coin door. Make sure you allow enough room for the CD tray to open fully!

The placement of your motherboard guides the placement of the rest of the computer components. Hard drives, floppy drives, and CD-ROM drives all connect to the motherboard via ribbon cables of a limited length. This means, for instance, that you probably cannot mount the motherboard against the back wall of the cabinet and then expect to mount the CD-ROM drive at the front. I recommend the use of stand-off feet (see Figure 13-12) to mount the motherboard to the cabinet rather than screwing the motherboard directly to the wood. This will allow some airflow beneath the motherboard, and avoid potentially shorting the motherboard out if something metallic (such as a quarter or exposed screw) is underneath. This will also leave enough room for the brackets of the cards in the computer, which descend below the edge of the motherboard and otherwise would have to be bent.

Used by permission of Happ Controls.

Figure 13-12: Circuit board mounting feet from Happ Controls.

I recommend mounting the motherboard vertically against the sides of the cabinet if possible instead of on the floor of the cabinet. That way, if something does fall, it's less likely to hit the computer parts and cause damage. The rest of the components can be mounted wherever they make sense, as they do not have exposed parts like the motherboard. All the various drives have mounting holes on the sides, and you can use their original mounting cages from the computer or angle brackets to mount them to the cabinet. Make sure to keep the underside of the drives raised off the wood for the same reasons as for the motherboard. Also, if you have a speaker or subwoofer in the cabinet, make sure to keep your hard drives away from it. Figure 13-13 shows a good example of mounting components in a cabinet.

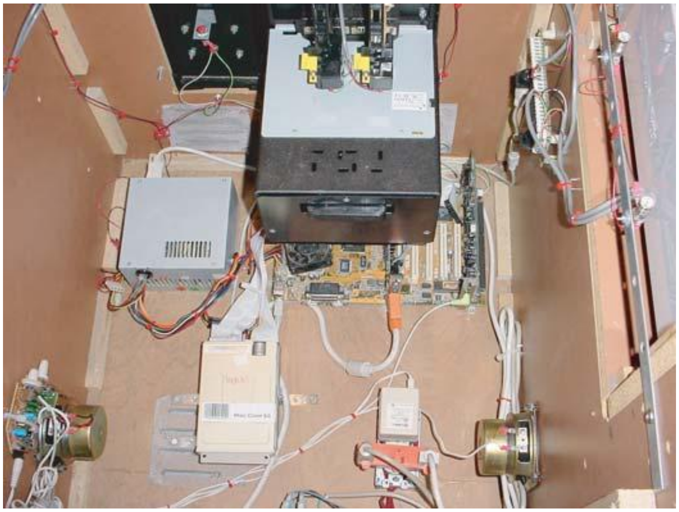


Photo courtesy of Oscar Controls.

Figure 13-13: Motherboard and components mounted directly inside a cocktail cabinet.

How To Mount A Complete PC

Mounting a complete PC inside a cabinet is easy enough. Put it in place and forget about it, right? Well, almost. You should consider some precautions against the PC falling during rough game play or moving of the cabinet. A couple of shelf brackets will secure the PC nicely. I picked up ornamental shelf brackets from a local hardware store, and then padded them with felt to protect the finish of the computer. After double checking that the computer was far enough forward to reach when needed, but far enough back that the CD-ROM door could open, I positioned my brackets (see Figure 13-14). Note that you only need to screw the brackets into the wood, not into the case of the computer!

Special Consideration — Mounting USB Ports

Remember when I talked about mounting external USB ports for things such as light guns or extra gamepads? This is a good time to tackle that. Now that you've got your PC secured in the cabinet, you can decide the best way to route the cables for your USB ports. The easiest way to do this is to take a pair of USB extension cables (with a type "A" plug and a type "A" receptacle), and route them from the computer to an easily accessible location. Some folks, for instance, run the extension cables behind the coin door. Plugging in extra devices into the USB ports then requires opening the coin door. If you're only going to use the USB ports rarely, then a simple solution like this is probably best.

Figure 13-14: PC secured in cabinet.

However, if you expect to get frequent use out of your USB ports, a permanently mounted solution is called for. This is the route taken with the Project Arcade 2 cabinet. A USB gender changer from arcadeshop.de does the trick here. The NAUSB-W-B is a 1 1/2-inch mountable USB A/B gender changer that mounts perfectly into the vertical face of the control panel (see Figure 3-15). Pick a convenient spot, drill a 7/8-inch hole, and insert the gender changer. Screw it into the panel for security and then run a USB A to B cable from your computer into the back of the gender changer. You now have a surface mounted USB port in your control panel! If you'd rather it not be seen you can pick any spot that's easily accessible but hard to see, such as the back of the control panel that extends beyond the cabinet.

Photo courtesy of arcadeshop.de.

Figure 13-15: Left, the NAUSB-W-B. Right, the NAUSB-W-B mounted.

Summary

"Igor! Igor, I'm ready now. Bring me the computer!"

"Sorry, doctor, I installed it while you were studying. See how nice a job I did? I'm particularly proud of the electrodes on the sides. I took them from that other project you were working on."

"But I'm the mad scientist. That was my job! I read all these books! I . . . . It does look very good, though. The electrodes are a nice touch. Oh, very well, Igor. How about a nice game of *Pac-Man*?"

Once again you've gone through a lot of material in this chapter. When all is said and done, you're almost able to disguise the fact completely that there's a computer running your arcade machine. Now, from the moment you start up to the moment you shut down, your arcade cabinet can look, sound, and feel like a real classic arcade machine!

Now that the cabinet has a computer in it, isn't it about time to install some games to play? I think so, and I'll tackle that in the next chapter!

CHAPTER

14

Choosing and Loading Software

IN THIS CHAPTER

- **All About Emulators**
- **Commercial Arcade Software**
- **Shareware and Other Great Games**

You now have all the parts you need to achieve gaming Nirvana, including a personal arcade cabinet, custom arcade controls, an audio and video system, and a computer to run it all. It's time to invite some old friends over — friends like Pac-Man, Frogger, and Centipede — to play a few games and bring back some memories! Your cabinet will also let you make new friends, such as Sonic the Hedgehog and Ryu from Street Fighter. Broadly speaking, games for your arcade cabinet can be broken into three categories: emulators, commercial games, and shareware titles. In this chapter you'll discover some of the many wonderful games you can play on your new arcade cabinet and where you can go to find still more. Are you ready to play? It's time to get rewarded for all your hard work!

All About Emulators

For me this is how it all began: A long time ago, in a place far, far away (with apologies to George Lucas). . . I was randomly surfing the Internet when I came across a reference to something called MAME. Here was a program that claimed to allow you to play a real arcade game on your PC! I'd played arcade re-creations on the computer before and had been disappointed. They were okay, but they didn't live up to the original and didn't hold my interest long. A bit skeptically, I decided to give this a try. I downloaded it, installed it, and fired it up.

Wow!

First the screen went black. Then the program made funny images on the screen while the "arcade machine" on my computer booted up. There were flashes of familiar looking arcade characters and strange symbols and letters. Next, a promising-looking title screen appeared! The program made a familiar noise when I eagerly inserted my virtual quarter, and it beeped at me when I pressed player 1. Suddenly, there it was!

It had the same background music I remembered from the arcade original. It made the same sounds when I moved and fired. The tricks and strategies I used to use worked the same way — the game played exactly the same as I remembered. I had no doubts; this was the same game I had poured quarter after quarter into years ago! It was like the feeling a child gets the first time he visits Disney World, and I felt just like a kid again. This was arcade magic, and it was on my very own computer! A whole new yet old world had just opened up to me, and I was hooked!

You are very likely to have become involved in this wonderful hobby because at some point you also learned about emulators. Emulators allow you to play your favorite video games on your computer instead of on the arcade machine or video game system the game originally was designed for. For the most part, using an emulator requires more effort than simply buying a game and installing it. There are also some legal considerations of which you should be aware so you don't run afoul of copyright laws. In the next few sections I'll talk about these issues and point you down the path toward emulator happiness.

How Does An Emulator Work?

Just about every video game, except the oldest, such as Pong, works under similar principles. At the heart of the system is a microchip, a cousin to the CPU at the heart of your computer today. Connected to this microchip are various bits of electronic circuitry and other chips that control the audio, video, and game controllers. All of this together can collectively be referred to as the *game hardware* (see Figure 14-1). Additional chips give instructions to the hardware — draw a maze here, move a ghost there, fire a laser and make a laser beam sound. These sets of instructions, even though they are contained in a physical chip, are considered the game software. The combination of hardware and software is housed in a cabinet and becomes the video game you know as Pac-Man or Asteroids.

The cheapest computer you can purchase today has hundreds of times the power of the hardware used in classic video games. Is it possible to put the software from those video games into the computer and play them? Without emulation, the answer is no. The hardware in your computer is different from the hardware in those video games. They aren't physically interchangeable and they don't speak the same language. Nevertheless, all microchips are basically the same at the very core, aren't they? Ones and zeros, executing instructions and producing results, right? Well, yes, essentially. That leads to some interesting possibilities. What if you could write a program on a computer that would teach it to speak the language used by the hardware in those video games? Would it be able to play the video game software then? Enter the emulator!

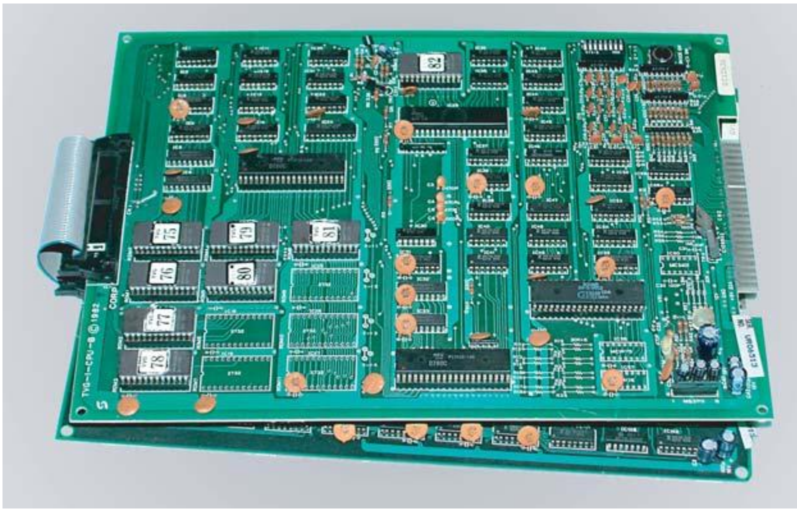


Figure 14-1: Typical hardware from a classic arcade game.

An emulator is a program written to emulate, or imitate, hardware from a different system. The emulator receives instructions from the software designed for the original hardware and translates it into instructions that the current computer's hardware understands. No matter what hardware the original instructions were designed for, once it's translated to the computer's native hardware the results are the same. An image on the screen that looks like the original video game's image, with the same sounds and movement, is just as good as the original, right? Well, an arcade collecting enthusiast might dispute that. Emulation is *hard*. Just because it looks and sounds the same doesn't mean it's exactly the same. For instance, different hardware runs at different speeds. Not only do emulation programmers have to interpret the instructions from the emulated system correctly, they have to get the timing right as well. It might be arcade perfect, but if the ghosts in Pac-Man move so fast that they're a blur on the screen then it's not much of a game. Emulation programmers are pretty good at getting it very close to the original, but an arcade collector would probably insist there are minor differences. To the average person, however, if it looks like a duck and sounds like a duck, it must be a real video game!

By themselves, emulators will do nothing for you. Remember, an emulator mimics the *hardware* portion of the video game. To actually play a game, you also need to have the *software* that was used in the games. Because the software was actually encoded onto microchips (not a CD or floppy disc), it is commonly referred to as a ROM. ROM stands for Read Only Memory and usually refers to a microchip that has data encoded on it that cannot be altered. Microchips that can have their contents altered do exist, and video game software can be found on all kinds of microchips. Collectively they're all referred to in the community as ROMs. Obtaining ROMs is a subject entirely unto itself, and I'll talk about it at length in the section entitled "Are Emulators Legal? The Ethics and Laws behind Obtaining ROMs." As a rule, no emulators come with ROMs.

Emulation is an old trick in the computing industry, and many different kinds of emulators exist. You can find emulators for just about every classic computer there is, from the venerable Apple II to the obscure X68000. You can also find emulators for game consoles such as those from Atari, Nintendo, and Sega. In this chapter I'll stick to discussing emulators for arcade machines. If you'd like to learn more about other types of emulation, visit some of these Web sites:

- Emu-HQ at `www.emuhq.com`
- Retrogames at `www.retrogames.com`
- Vintage Gaming Network at `www.vg-network.com`
- Zophar's Domain at `www.zophar.net`

WARNING **Emulation tends to attract people of all ages and backgrounds. Some of them have an *interesting* sense of humor. Most of what you'll find will be rated PG, but you are also likely to encounter some strong language. Also, like almost every other form of media, sex made its way into the arcades. Without warning, you may stumble into a screenshot of an emulated arcade game featuring nudity. For the most part, your Web surfing will be safe, but those who may be offended should take note that it's a wild, wild Internet out there and you may encounter anything.**

Emulators You Should Try

You'll find many, many emulators if you start to poke around the Internet. I'll save you some time and highlight a few you should start with. By no means is this an extensive list, however. You'll find many links at the Web sites listed in the previous section if you want to experiment with others.

MAME

Although it is not the first emulator, the Multiple Arcade Machine Emulator, otherwise known as MAME, is by far the best known and most popular. MAME is the brainchild of Nicola Salmoria, a talented programmer from Italy. Nicola had been working on a variety of standalone emulators that each emulated a single arcade game. Then, in early 1997 he released MAME version 0.1, which supported five games in one package. History was made that day, as MAME continued to grow from its humble origin to become the giant project that it is today. As of the time of this writing, MAME supports 8000+ arcade games and is developed by a team of more than 100 volunteers.

MAME is first and foremost a documentation project. As time goes by, classic arcade games suffer from the ravages of age and begin to disappear. It can be difficult to find older arcade games in working condition, and many can no longer be found in any condition at all! The people who develop MAME share a love and fascination for arcade games and learn all they can about a particular game or aspect of video game design. They then contribute what they know and are able to learn to the MAME program, so that this information is recorded and preserved for the future. This is an important distinction of which end users of MAME sometimes lose track. The point of MAME is not to play games; the point is to preserve the games. A game that worked in one version of MAME may not work in the next, as the developers discover that something in the game wasn't correctly emulated. It may have worked, but it wasn't faithful to the original and so needed to be fixed, even if fixing it made it unplayable for some reason (for instance, requiring a feature that hasn't been implemented yet). That may be frustrating to someone who simply wants to play the game, but rest assured the MAME developers will keep at it until the emulation is as perfect as they can get it and the game is working.

The obvious but very nice side effect of documenting the many arcade games in a program such as MAME is that it enables the average user to play those games. As mentioned previously, however, there are some very important legal considerations before you do so. I'll talk about that in the "Are Emulators Legal?" section as well. Playing games on MAME is simply amazing. Once a particular game's emulation has been perfected, the sights, sounds, and playability are virtually indistinguishable from the original. Often, the only things lacking are the real arcade controls and arcade cabinet, but since you're reading this book that won't be a problem for you! The list of games you can play in MAME is impossible to include here, but among the 8000+ games in the current version, just about any arcade game you remember can be found. What you won't find are recent games that are still in the arcades making money. The MAME developers are very sensitive to the impact that MAME might have on the arcade manufacturers. MAME's goal is to preserve and document arcade machines, not put arcade machine operators out of business.

Many versions of MAME are available. The official home of MAME is `www.mamedev.org`. There, you'll find the command line (no graphical interface) versions of MAME. These are the versions that require you to type the name of the game you're going to play on the command line — for instance "mame centipede" — and are best used with a front-end program on an emulation cabinet. MAME is another open-source program. Ports of the official version of MAME can be found for many different computers and operating systems, even versions that run on digital cameras and on cell phones! Along with ports to different hardware and software platforms, derivatives of MAME exist. These are modified versions of MAME that add extra features, such as versions with built-in graphical user interfaces (GUIs). MAME is updated constantly and is at version 0.139 at the time of this writing. The ports and derivatives are also updated often to reflect new changes in MAME but sometimes lag behind by several versions.

MAMEUI (`www.mameui.info`) is the version of MAME recommended for a quick and easy start. It runs under Windows and includes a GUI. The GUI allows you to display your game choice by title or icon and also displays a screen shot, marquee, flyer, title screen, or cabinet image of the game you're selecting (see Figure 14-2).

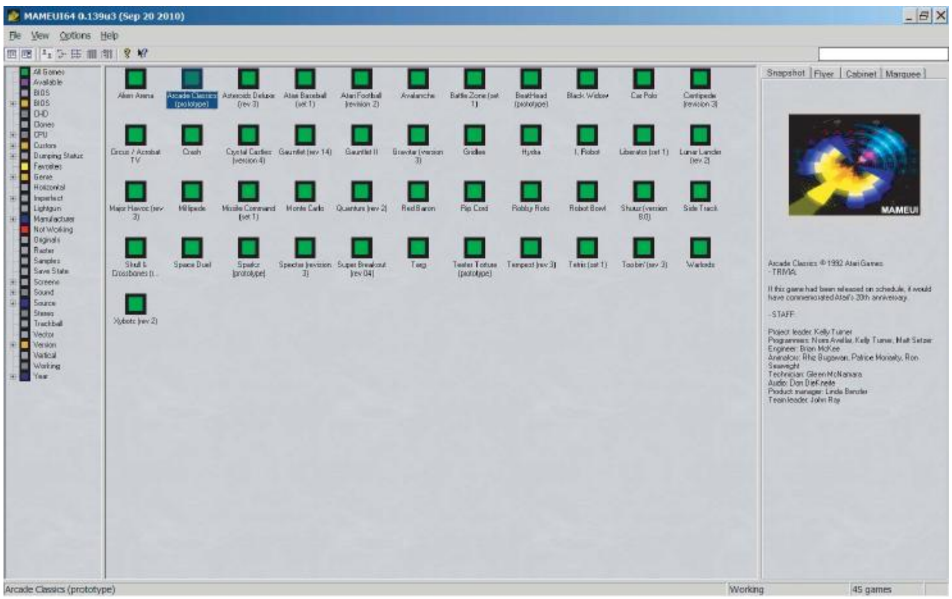


Figure 14-2: MAMEUI displaying games by icon.

MAMEUI's GUI is controllable by keyboard, joystick, or mouse/trackball. I recommend using a trackball if you have one on your cabinet, as it will be the easiest. The interface can be configured in a variety of ways, such as turning off the folder list and the screen shot list, leaving you with a simple window showing icons of your available games. You can also change the background to a custom image as well as change the fonts and colors.

MAMEUI allows you to categorize your game selection in some interesting ways, such as by genre, manufacturer, or by customized lists of favorite games. It also lets you configure the many options that MAME supports, such as configuring it to mimic the scanlines of an arcade monitor. Figure 14-3 shows you most of the options that can be configured easily with MAMEUI.

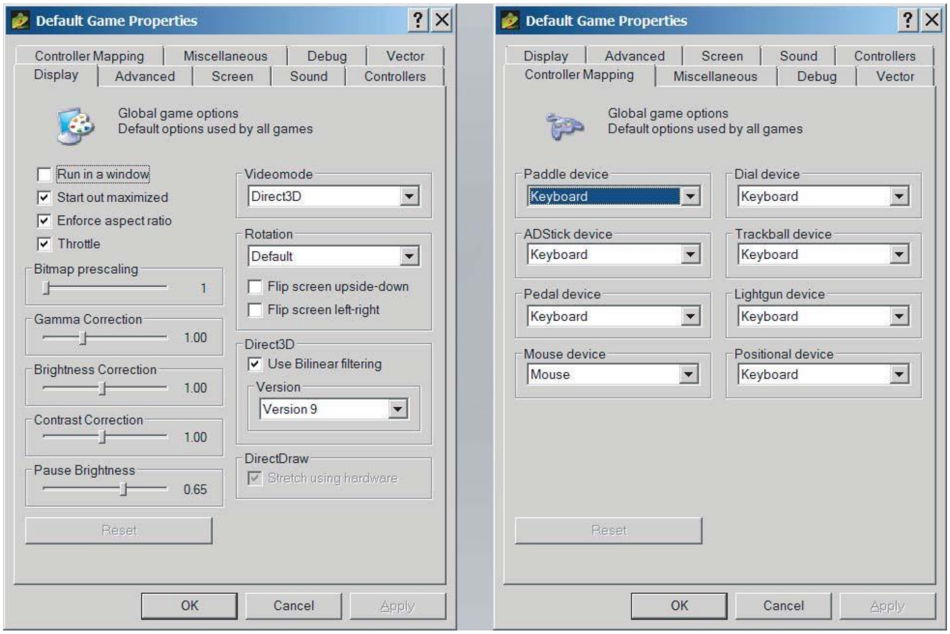


Figure 14-3: MAMEUI configuration screens.

Some of the other versions of MAME you might be interested in for your arcade cabinet include the following:

- AdvanceMAME, available from `http://advancemame.sourceforge.net`, is an unofficial version of MAME designed with extra support for television and arcade monitor displays. It is available for DOS, Windows, Linux, and MacOS among other operating systems. This version is not being updated and is several versions out of date. Even out of date however, the extra features may make it a contender for your cabinet.
- SDLMAME (`http://rbelmont.mameworld.info/?page_id=163`) is another version of MAME maintained by one of the MAME developers designed to run on Linux/Unix, MacOS, and other SDL supported operating systems. This derivative is kept up to date.

If you'd like to learn more about MAME (and I recommend it as I've barely touched the surface here), there are several excellent sites for you to visit. Start, of course, at the home of MAME at `www.mamedev.org`. Once you've explored there, stop off at MAMEWorld (`www.mameworld.info`), which is by far the biggest MAME resource on the Internet. If you need help getting MAME set up and running properly, visit the easyEmu site at `http://easyemu.mameworld.info` (hosted by MAMEWorld). Finally, for specific questions regarding MAME in an arcade cabinet, visit the software forum at BYOAC (`http://forum.arcadecontrols.com`).

Daphne

"Dragon's Lair — The fantasy adventure where you become a valiant knight . . ." Thus began a new chapter in arcade history and a new era of video gaming magic. Dragon's Lair was an *animated* laser disc–based video game in which you played the part of Dirk the Daring — a brave adventurer setting out to rescue princess Daphne from the clutches of the dragon's lair. It was a fully animated cartoon-style game that practically defined the term *eye candy*. Just reading the first sentence in this paragraph brings back the goosebumps I felt when I first saw this game in the arcade. Instead of pixelated graphics, you were treated to real animated movie sequences from the studios of Don Bluth, who is responsible for movies such as Anastasia and The Secrets of NIMH. This was the first of many popular laser disc–based video games that hit the arcades starting in the early 1980s.

Daphne (`www.daphne-emu.com`) is an emulator, named after everyone's favorite princess from Dragon's Lair, that specializes in emulating laser disc–based video games. No home arcade cabinet is complete without a copy of Daphne running on it. Daphne has some hefty requirements, and you'll need a reasonably fast computer with Windows XP or better for best results, although Windows 98 will work. Versions are also available for Linux and MacOS.

Daphne will emulate Dragon's Lair, Dragon's Lair II, Space Ace, Thayer's Quest, and a host of some 15 or so other laser-disc games. You will need to supply the laser-disc video files because they are copyrighted material and do not come with the emulator. You can obtain them either from the original laser discs from the video games (which will be difficult — check eBay at `www.ebay.com`) or from re-creations of the games sold by Digital Leisure (recommended — `www.digitalleisure.com`). If you're going to purchase them from Digital Leisure, be sure to purchase the DVD-Video version on the Dragon's Lair 20th Anniversary Box set (3 DVD set), not the CD-ROM version or the 20th Anniversary PC DVD-ROM. With these DVDs in hand to prove ownership, the Daphne emulator will download the necessary video files by agreement with Digital Leisure right to your computer, making setup easy. The video files will be copied to your hard disk to run with the emulator. Daphne can also be connected to a laser disc player from an original arcade cabinet and be played straight off the original laser discs!

NOTE **If you can obtain re-creations of the games for your PC, why would you want to run an emulator version instead? Two reasons come to mind. First, running them under the emulator will let you run multiple laser disc–based games under a single game interface. Second, having the video on your hard disk instead of the CD/DVD means you won't have to insert the CD/DVD each time you want to play.**

Obtaining the video files and configuring Daphne can be fairly complicated if you don't use the auto-download option, but is well within the abilities of anyone who has built their own arcade cabinet! If you're configuring Daphne manually, be prepared to do a bit of reading at the Daphne homepage before you can get it working. A good utility is available to help you — dvd2daph, available from `www.laserarchive.com/dvd2daph`. This utility will convert the video files from the DVD into the format required by Daphne as well as create the companion files needed. Daphne also comes with its own front-end program to try or can be launched from a command line, making it compatible with other front-end programs such as those introduced in Chapter 13.

Although it can be frustrating to get Daphne running properly, once you've done so the reward is well worth it. Laser disc games represent a unique genre in video game history, ranking up there with Pac-Man and Pong as defining the lure of the arcade. The first time you see one of those games running on your cabinet will be another of those jaw-dropping moments that occur when you build your own arcade cabinet. To quote Dragon's Lair, "Lead on adventurer — your quest awaits!"

Other Emulators To Try

MAME and Daphne cover most of the arcade games emulated to date. A few years ago there were many more emulators under active development, but most have been abandoned in favor of MAME. However, you might want to give some of the other emulators a try. Some of them may have interfaces that you might prefer over MAME, while others may be optimized for a select set of games that run faster than MAME. Remember that MAME is a documentation project designed to be portable to multiple platforms. Games drivers are programmed to be identical to the original and are programmed in C, which is very portable but not the fastest programming language. Other emulators do not operate under the constraints MAME places upon itself and so can use techniques that improve speed. For instance, they may be programmed in a language that is faster than that used in MAME but sacrifices portability, or they may program shortcuts that are not faithful to the original code but produce similar results. The following emulators are arcade cabinet friendly and support a good number of games:

- Nebula (`nebula.emulatronia.com`) is an emulator that runs Capcom and NeoGeo arcade games. It has a full screen GUI that looks like many standard front ends with screen shots on the right and a game list on the left. The background, colors, and sound are customizable as are the keys used to control the games, making it a good candidate for an arcade cabinet. Nebula runs games that are included in other emulators but has more modest system requirements. If your games are running slowly on your older computer, Nebula is a good emulator to try.

- Raine (`http://rainemu.swishparty.co.uk`) is an emulator that supports several hundred arcade games made in the late 1980s through the early 1990s. Raine is capable of running these games quite well on modest machines and will even run on older machines. Versions are available for DOS, Windows (with a graphical user interface), Linux, and MacOS. Installation is easy — simply uncompress the downloaded package and place the ROMs you've legally obtained into the appropriate folder. If you need assistance, there is a message board at the Raine homepage.
- Zinc (`www.emuhype.com`) is another good emulator for arcade cabinets with older PCs. It runs a handful of arcade games from Sony and Namco whose hardware is based somewhat on the Sony PlayStation. It is *not* a Sony PlayStation emulator. It is command line only but can be run with any customizable front end. Zinc supports customizing the keys used to control the games, making it easy to fit into your cabinet's controller scheme.

Visit EmuHQ (`www.emuhq.com`), Zophar's Domain (`www.zophar.net`), Retrogames (`www.retrogames.com`), or the Vintage Gaming Network (`www.vg-network.com`) for more resources and information about emulators.

Are Emulators Legal? The Ethics And Laws Behind Obtaining ROMs

You're now entering a very sticky area in the arcade cabinet-building and emulation scene — the question of whether this whole thing is legal. What? How could building a personal arcade cabinet be illegal? Obviously it's not, but the emulation scene is not quite so clear. The question hinges on copyright laws. A full treatise on copyright law would be impossible to include here. There are people who spend their entire professional careers in just this area of the law. However, the situation can be summed up as follows: Copyright laws grant the owner of a work, such as a video game, the right to control when, how, and where that work is copied until the copyright expires. Until the copyright expires, no one may reproduce or copy the work unless given explicit permission to do so by the copyright holder. Copyrights expire anywhere from 50 to 100+ years after they are granted, depending on when the work was created and under what circumstances it was created — for video games, the period is typically 75 years. The first arcade game, Computer Space, was released about 40 years ago in 1971, meaning every arcade game out there is clearly covered under a current copyright.

What does that mean to people interested in this hobby? It means you have to be careful about the software you install on your cabinet to make sure you are not in violation of copyright laws. Emulators seem to be okay. Unless they use copied portions of the programming code used in the original arcade machines, creating a program that acts the same as another program appears to be allowed. Notice I've used the words *seem* and *appears*. That's because there are some companies that claim that emulation is a violation of copyright laws. Nintendo, for instance, clearly states their position regarding emulation on their Web site's legal area (`www.nintendo.com/corp/legal.jsp`). In a nutshell, Nintendo's stance is that emulators are vehicles for piracy and are thus illegal. Sony is another company with a dim view of emulation. Two commercial emulators were created that mimicked the Sony PlayStation without Sony's permission. One was called Virtual Game Station by Connectix, and the other was called Bleem!. Sony took both companies to court for copyright and trademark violations. In both cases, Sony ultimately lost with the courts ruling that reverse engineering and emulation were fair and legitimate practices. Ultimately, market forces killed both of these emulators, with Connectix being purchased by Microsoft and the marketer of Bleem! simply shutting down operations.

Although some manufacturers believe unauthorized emulation is illegal, the courts have so far ruled otherwise. Since the Sony PlayStation cases a few years ago, I am not aware of any further legal action involving emulators. It is possible that this situation might change someday, and governments are taking a hard look at copyright and intellectual property issues these days. ROMs, however, are another matter. Unlike emulators, which are original works of programming, ROMs are copied directly from the video games. They are not reverse engineered, nor are they original works (usually); they are simply direct copies. That's clearly illegal, right? Not necessarily, and I'll explain the details in the next few sections.

NOTE **Keep in mind one thing: IANAL. IANAL is Internet-speak for "I am not a lawyer" and means that the information here should not be considered as legal advice. This section should only be taken as my personal understanding of copyright law. My opinion is based on several years of being involved in the retro gaming community and observations of the statements of gaming companies, along with the few legal actions that have occurred such as the Sony versus Bleem! case. I think my understanding is accurate, but bear in mind that it is only my opinion, and I Am Not A Lawyer!**

The White Area — When You're Clearly Legal

The only way you can be certain that you are obeying copyright laws is when you have obtained a ROM through a legally authorized source. This means the ability to obtain verifiably legal ROMs is severely limited. Although emulation and reverse engineering seem to have withstood legal challenges in court, most arcade manufacturers view emulators as competitive to their own products at best and illegal at worst. No matter what their viewpoint, it seemed no manufacturer sees any profit in allowing ROMs to be purchased alone.

Arcade manufacturers do see profit in the retro gaming craze, however. Several titles produced by the manufacturers for the PC market were actually based on emulation. Capcom for instance used to authorize a variety of arcade game packs. Emulation based titles were either sold by the copyright holders or by companies who had obtained licenses from the copyright holders to do so. People purchasing these games were purchasing the right to run those ROMs on their computers, *using the emulator sold by the copyright holder*. The important distinction to note is that although the copyright holders were selling the right to play the game as a whole, they were not selling ROMs to be used however purchasers saw fit, such as with MAME.

Although manufacturers have begun to realize the potential of selling arcade games to the PC market, very few are made available. Thousands of arcade games were made, and only a very small percentage have been translated and sold for the PC. Naturally, if there is a demand, a way will be found to fill it, and emulators filled the void left by arcade manufacturers. Unfortunately, although the emulators themselves were legal, for a long time there was almost no way for most people to obtain the ROMs legally to play in them. A handful of ROMs have been made legally available, as the copyright holders announced their support for MAME and granted the public the right to use the ROMs in MAME for noncommercial purposes. These ROMs can be found on the MAME Web site at `http://mamedev.org/roms`.

Other than those few ROMs, no other legal ROMs have been made freely available for a long time. Those running other ROMs on their emulators are most likely doing so without the consent of the copyright holder. The copyright holders are either unaware or do not believe pursuing the copyright violations is a good business practice. After all, these games were many years old (40 years in some cases) and have stopped making them money long ago. Those who are committing copyright violations by using these old ROMs are the same people who are buying their new PlayStation 3, X-Box 360, and PC game titles. Alienating them by pursuing legal action against them probably won't help and may hurt their bottom line.

Other manufacturers have vigorously protected their copyrights, primarily by sending cease and desist letters to Web sites making ROMs available for download and threatening legal action. Even though Pac-Man and Donkey Kong came out in the early 1980s, the Pac-Man and Donkey Kong franchises continue to thrive to this day, with new games in the series and retro re-releases coming out every few years. Protecting their copyrights appears to make good business sense to these manufacturers, and generally a letter is enough to make the copyright violations stop. To my knowledge, no one has been sued or prosecuted for distributing or possessing ROMs, because anyone who has received such a letter has complied with the company's legal right to protect their intellectual property and removed the ROMs in question. In general, the ROM situation is a murky mess.

For a brief while in 2003, a company called StarROMs set up shop. They negotiated the rights with Atari to sell some of Atari's ROMs for use with emulation. Suddenly, there was a legal source to purchase ROMs! StarROMs had 61 titles from Atari available at a price of around $2 each. This was exactly what the emulation community had been demanding for years! In the first edition of this book, I said "At the time of this writing, it's too early to tell if this will prove to be a viable business model for the industry." Sadly, it turned out not to be the case and StarROMs has closed up shop. I have high hopes that another company will step up with a similar operation some day. I think the success of ventures like Apple's iTunes shows that this is a viable money-making operation that would be a win-win for the copyright holders and the emulation community. Personally, I purchased every ROM available from StarROMs the day they opened. Those are the ROMs you see in the screen shot of MAMEUI earlier in this chapter.

That is the state of legally obtaining ROMs for use with emulators today — a few ROMs available for free, and no other source available for sale. Hopefully, other copyright holders will see the potential of this business model and allow sale of their arcade game ROMs. Time will tell.

NOTE **Does the situation sound bleak? It's not. There are hundreds if not thousands of great arcade games you can legally play on your cabinet. Keep reading for more!**

The Grey Area – ROMs You Own In Other Media

Aside from the white area in which clearly legal ROMs are available, there's a grey area in which ROMs *might* be legal for use on your emulators. The question is one that has not been tested in court and has not been clearly defined as it applies to ROMs and emulation: *If you have purchased the ROMs in some other format, do you then have the legal right to use them on your computer with an emulator*? The answer to this has broad implications for the emulation community. Many ROMs can be purchased in the form of packaged emulation-based games, such as the Capcom titles that used to be sold (and can still be found for purchase online). Does that give you the right to use those ROMs with MAME? What if you own an original arcade game, including the ROMs inside it? Can you use copies of those ROMs on your computer? What if you own just the circuit board from the game with nonworking ROMs from a cabinet that has been destroyed? Other interesting situations come to question, such as if you purchase an emulation-based program designed to run on a game console like the Sony PlayStation. The PlayStation disc has copies of the original ROMs from the arcade game on it. Does owning that disc allow you to have a copy of those ROMs on your computer even though it's for a totally different system? What about copying the video files off DVD-ROMs that you've purchased to use with the Daphne emulator? Unfortunately, I can't give you a definitive answer to most of these questions. Other than the negotiated arrangement between the programmers of the Daphne emulator and Digital Leisure, these questions haven't been tested anywhere that I am aware of. However, I can draw some parallels for you to consider.

I think that a very similar situation presented itself with the debut of cassette tapes and VCRs. Copyright holders objected that these devices would be used for piracy and would lead to the demise of their industries. Legal battles were waged, and the courts ruled otherwise. You are allowed to make a cassette tape copy of a CD you own for your own personal use, for instance to play in the car. You are allowed to record a television show on a VCR and play it back at a time more convenient for you (a concept known as time-shifting). A similar objection arose with the advent of recordable CDs and DVDs. Manufacturers were concerned once again about piracy. Consumers demanded the right to record their own material and make backups of their legally purchased software in case the original was destroyed. Once again it was determined that it was in the public's best interest to allow this use. You are allowed to make a single archival backup of digital material such as a CD-ROM game to keep for your own use in case the original is damaged. Could these court decisions legitimizing these rights to copy material legally be applied to ROMs? If I purchase a CD-ROM of music then I can use it in my car's cassette player. If I purchase a commercial emulation package or a circuit board with ROMs from an arcade game, can I use those ROMs on my computer with MAME? Nintendo for one clearly states on their legal page their opinion that the answer is no, owning their ROMs in one software package does not allow you to use it on another system. There is no court precedent that I'm aware of that answers the question definitively. (In recent years, a law arose that put emulators themselves into some legal question. More on that after we cover copy protection.)

NOTE **Far from bringing about the demise of those industries, cassette tapes and VCRs actually helped the industries profit. For instance, many movies made much more money from sales of VCR tapes and DVDs than from the theater releases.**

To be fair to the manufacturers, piracy is a big problem in this and many other countries. How much revenue is lost depends on who you ask, but there is no doubt that there is a significant amount of illegally copied material floating around out there. Some manufacturers came up with techniques to prevent copying of their software, methods that made copies useless. Techniques and products were then developed that circumvented those copy protection schemes. New copy protection schemes were then invented. This went on back and forth for many years. Then a law was passed called the DMCA, the Digital Millennium Copyright Act, which made it illegal to circumvent copy protection schemes built into digital material. This may have an impact on emulators. Many arcade game ROMs were encrypted (a form of copy protection) to prevent unscrupulous manufacturers from making bootleg copies of their arcade games. For instance, a bootleg version of Donkey Kong (which did not have encrypted ROMs) was created called Crazy Kong. Bootleg copies of arcade games became a serious problem in the arcade industry until encryption was used. The problem this made for emulators was that to run encrypted games, the programmers had to break the encryption used in those games. Breaking encryption is a method of circumventing copy protection, which now appeared to be against the law.

After some time had passed and some amount of public outcry, the restrictions enacted by the DMCA were relaxed as they pertained to video games that had become obsolete (for more information, go to `www.copyright.gov/1201`). These relaxed interpretations of the DMCA appeared to allow the techniques used in emulators because the video games appear to fit the definition of obsolete as described in the following reference.

> *2. Computer programs and video games distributed in formats that have become obsolete and that require the original media or hardware as a condition of access, when circumvention is accomplished for the purpose of preservation or archival reproduction of published digital works by a library or archive. A format shall be considered obsolete if the machine or system necessary to render perceptible a work stored in that format is no longer manufactured or is no longer reasonably available in the commercial marketplace.*

However, every few years, the Library of Congress revisits the DMCA and updates the exemption rules. In 2009, the above clause was removed from the exemption list. The exact impact of the DMCA and the current exemptions upon the emulation community is not clear, but it is certain that this is an area of copyright law that is in flux and will be subject to analysis and change for some time to come.

Is it legal for you to use ROMs you've obtained from other media on your computer with an emulator? Obviously, I cannot give you a definitive answer because the matter has not been addressed by the courts. I personally own a Crystal Castles arcade game made by Atari, but I also purchased the ROM from StarROMs when it became available.

Also, I must once again remind you that I am not a lawyer and this is not legal advice. It will be very interesting to see whether this ever does go to court. I suspect that the market demand will cause manufacturers to realize that there is profit to be made, and more vendors will follow the lead of Atari and Capcom — making the matter moot. It will be up to us to support them if and when they do so!

The Black Area – ROMs You Do Not Own

This brings up the final matter to consider in regard to ROMs — circumstances under which it is clearly illegal to obtain and use a copy of a ROM. Simply put, if it doesn't fit into either of the previous two scenarios, it's probably illegal. A common myth on the Internet is that you are allowed to download and play a ROM that you do not own, so long as you delete the ROM within 24 hours. This is a fallacy. There is no such provision for a 24-hour grace period within any copyright laws. If you don't own it and aren't purchasing it, you have no legal right to obtain it (with the obvious exception of ROMs whose copyright holders have given permission to do so).

This leaves the majority of arcade games unobtainable by legal means. There are several thousand arcade games that have been made. Even allowing for use of ROMs that are available in different media and those that can be legally obtained, the average consumer can hope to have a handful of legal ROMs at best. What about the rest of the games? A commonly stated opinion goes something like this: *The manufacturers no longer make money off this copyrighted material (the ROM) but are refusing to allow me a legal means to purchase it. Therefore, I am justified in illegally obtaining a copy of it for my own personal use so long as I do not profit from its use. If they gave me an alternative, I would use it, but they have not, so it is their fault*. The critical point to realize is that this is an invalid argument from a legal perspective. Should the manufacturers give you a means to use their copyrighted ROMs? Do the copyright laws extend too long? I have an opinion, but it really isn't pertinent. The law is clear that copying material under a copyright without the copyright holder's permission is not permitted. Using ROMs you have not legally obtained is a violation of copyright laws and should not be done on those grounds alone.

Commercial Arcade Software

Many people build an arcade cabinet strictly to run emulation software and overlook a wide selection of other great titles that should be considered. Any game that has an arcade theme and does not require typing is a likely candidate. There are some genres that simply won't work well in an arcade cabinet. First-person shooters such as Doom and strategy games such as Myst probably aren't the best choice. That still leaves many games to consider. Many of these games are older and may be difficult to find on store shelves. However, they are easily (and often cheaply) found online and at used game stores.

Microsoft's Arcade Series

Microsoft produced a series of hit arcade titles in cooperation with Atari and Namco that were among the first to bring an authentic arcade experience to PC users. The first title was Microsoft Arcade, which came with five Atari titles: Centipede, Asteroids, Missile Command, Tempest, and Battle Zone. The second was Revenge of Arcade, which included 5 Namco arcade titles: Motos, Ms. Pac-Man, Xevious, Rally-X, and Mappy. The last title, Return of Arcade Anniversary Edition, includes five Namco games: Pac-Man, Ms. Pac-Man, Dig Dug, Pole Position, and Galaxian. I found all of these titles on eBay for $10 to $30.

Games from all of these titles were big hits in the arcades and will make an excellent addition to your arcade cabinet. These titles all have extremely modest system requirements and are designed to run with keyboard controls, meaning they'll work well with keyboard-hacked arcade controls. Sound and game play are authentic, although the windowed mode may be a bit distracting.

Atari's Arcade Titles

Atari has taken a long, somewhat strange trip through the years. Virtually synonymous with the term *arcade*, the Atari company has been split, has been bought and sold many times, and has finally been purchased by Infogrames (`www.atari.com`). The company known as Atari today bears little resemblance to the classic Atari company that produced so many excellent arcade video games, but it remains committed to the home game playing market. As the company went through its changes they produced many titles for home use that are still available today. The first set of titles is that published under the Infogrames/Hasbro/Atari umbrella as shown in Figure 14-4.

Figure 14-4: A collection of Atari arcade titles.

Some of the titles are compilations that are re-creations of original games, and some are sequels to original titles with enhanced game play and graphics. Available titles include the following.

Atari Arcade Compilations

Atari produced several compilations of arcade titles for the PC. This includes *Atari Arcade Hits* Volume 1 and 2, with six games each, and the *Atari Anniversary Edition* comprising all the material from the previous two CDs. Games in these packages include Tempest, Missile Command, Super Breakout, Asteroids, Centipede, Pong, Asteroids Deluxe, Battlezone, Crystal Castles, Gravitar, Millipede, and Warlords. Gameplay on these titles is amazingly faithful to the original considering they were not emulation projects, but also includes an enhanced mode. For instance, you can choose to play Tempest, or the enhanced mode which gives you Tempest Tubes — the same game play with a new set of screens to conquer. The CDs come with a host of very nice extra features, including desktop themes, and features the Atari Archive. The archive has images from Atari history and video clips of interviews with Atari founder Nolan Bushnell. The extra material is what distinguishes this from running an emulated version of the game and makes good "eye candy" dressing for your cabinet's desktop and screen savers. The CD is packaged with a nice graphical interface (Figure 14-5), but the games and archive material are also individual applications, meaning you could launch them with your own front end. The Anniversary Edition version installs completely to the hard drive and does not require the CD, making it particularly arcade cabinet–friendly.

Figure 14-5: *Atari Anniversary Edition* — Volume 1 opening screen.

Atari Remakes

In addition to packaging reproductions of original Atari arcade classics, Atari/Infogrames also produced a series of remakes for their titles. These are games whose basic premises are the same as the originals but with enhanced 3D graphics bearing little resemblance to the originals. They also feature enhanced game play with new strategies, enemies, power-ups and the like, with new story lines to complement the new features. As a rule these games are all fun to play but are more complicated than the classics from which they derive. These titles are not designed with arcade cabinets in mind, and though they can be made to work, you will need to add support for extra keys (such as Enter and Esc). Players looking for the original titles will not find them here. Players looking for something new to try will find much to tempt them here. Atari, under the guise of Infogrames, also produced remakes of arcade classics from other manufacturers such as Namco and Konami. I have included all the arcade classic remakes under this section. They are all available online or in retail stores, though you may have to do some digging to find them.

- Asteroids — Asteroids is a remake of an Atari title created by Activision. Game play is faithful to the original, with enhanced graphics and sound being the most notable differences. Choices of different ships with different characteristics, new enemies, and new weapons round out the enhancements to this classic title.
- Break Out — Break Out is a sequel to the original popular game in which you paddle a ball against a stack of bricks, knocking the bricks off one by one until they are all gone. It's now a traditional tale of paddle meets girl, paddle loses girl to evil paddle and gets thrown in jail, paddle has to break out of jail and rescue girl. After spending a few minutes learning the controls (which are customizable), I gave it a test and quickly became addicted. I was pleasantly surprised at how much I enjoyed the game.
- Centipede — In classic mode, you play a somewhat familiar game of Centipede except the screen and graphics have been converted to 3D graphics mode. Game play is otherwise essentially the same as the classic. In adventure mode, you play out a story line in a 3D interactive world. Roaming through each level, your job is to shoot the invading centipedes and a whole host of new bugs while saving the houses and citizens of your world.
- Combat — Combat is an interesting adaptation. Originally, Combat was a two-player tank game for the Atari 2600 home game console. Every Atari 2600 shipped with Combat, and you're likely familiar with the name. This version has had the usual enhancements made, with 3D graphics and interactive worlds. Your tank is actually a hovercraft, and your object, as in the classic, is to shoot or be shot. The unusual thing about this CD is it comes with an unannounced Atari 2600 emulator called Stella and includes the Atari 2600 ROMs for Combat and Combat2.
- Dig Dug Deeper — This remake is particularly well done, enhancing the original with 3D graphics and extra eye candy while remaining remarkably faithful to the original. Unlike some of the others, game play is almost exactly the same as the original. As Dig Dug, you wander around new

worlds finding bad Pookas and Fygars and blowing them up (literally) with your inflating pump or dropping rocks on their heads. New power-ups and different types of rocks, such as those that explode, enhance game play and distinguish it from the classic without deviating so far as to make it an entirely different game.

- Frogger — The new Frogger and the sequel, Frogger 2, from Konami and Infogrames, are another set of sequels worthy of their originals. Basic game play is similar to the original, yet enhanced with many different levels and multiplayer fun. The controls are simple enough to function well with an arcade cabinet, although you will still need an Enter and Esc key.
- Galaga — The remake of Galaga starts out faithful to the original with enhanced graphics but quickly moves on to advanced levels with a heads-on display and 360 degrees of movement. Controls are more sophisticated than the original but are still within the capabilities of an arcade cabinet's control panel.
- Missile Command — Missile Command is another well-done enhancement of the original. The graphics are stunning, and game play is true to the spirit of the original. The first wave starts out at a moderate pace; then the game quickly advances to faster and harder levels that will leave you gasping for air. Controls are well suited for an arcade cabinet.
- Pac-Man series — Infogrames and Namco have released three titles in this series: Pac-Man All-Stars, Ms. Pac-Man Quest for the Golden Maze, and Pac-Man Adventures in Time. They can be purchased separately or in a combination pack. All three are delightful additions to the franchise, sporting updated 3D enhanced game play while sticking primarily to their original roots. Most of them can be played with a single joystick, with two additional buttons needed for Adventure in Time. The graphics are good, the game play is good, and these make fun additions to an arcade cabinet.
- Pong — Pong is a game you won't find emulated, as there are no microchips in the original Pong to emulate. Pong was designed with good old-fashioned electronic circuitry. This version is similar to the original in that you have a paddle knocking a ball toward an opponent, but the similarity ends there. The graphics are much enhanced from the original, the sound effects are fun, and it has penguins. How can you go wrong with a game that has penguins? Simple yet addictive game play and basic controls make this a good candidate for an arcade cabinet.
- Q*bert — This game is another extremely well done upgrade to the original. It features a classic mode that is obviously a re-creation and not emulation but is so close to the original that the minor differences do not detract at all. The enhanced playing modes include mazes that are much more geometrically disorienting, as they are rendered in 3D with depth instead of flat 2D, but that only adds to the fun of the game play. Simple controls make this a good choice for an arcade cabinet, but like the original you'll need a joystick mounted diagonally instead of square.

- Warlords — I have to confess that I was never a fan of Warlords in the arcade. Nonetheless, the game play in classic mode on this remake is faithful to that original and fans will be happy with it. The enhanced mode, however, made a believer out of me. Beautiful graphics, with flying dragons and fiery fireballs (is that redundant?) menacing you while ominous music plays in the background, make Warlords a good addition for anyone who has spinner controls on their arcade cabinet.

All of the Atari branded remakes are fun games to have and play. Some of them, such as Dig Dug, Q*bert, and Warlords, are very faithful to the original classics. Others such as Break Out and Pong are good games in their own right but not terribly close to the original. One title worth mentioning that isn't from Atari comes from an arcade company called Midway:

- Midway Presents Arcade's Greatest Hits 2 — Midway and GT Interactive collaborated to produce a collection of arcade authentic titles for the PC. Titles include Blaster, Joust 2, Splat, BurgerTime, Moon Patrol, Root Beer Tapper, and Spy Hunter. These titles are faithful re-creations of the originals, and the keys are configurable, making it a good addition to a cabinet. Unfortunately, this title is out of print, but you can still find it on eBay and used gaming stores. If you can find a copy, it's well worth your while to pick it up.

Digital Leisure's Laser Disc Arcade Games

One final genre of arcade classic remakes is brought to us by Digital Leisure (`www.digitalleisure.com`), a company you were introduced to earlier in this chapter. Digital Leisure specializes in PC ports of laser disc arcade games. All of them feature incredible graphics (see a shot from Dragon's Lair in Figure 14-6), with game play virtually identical to the original.

Photo courtesy of Digital Leisure, Inc.

Figure 14-6: Dirk hides from the dragon in Dragon's Lair.

Games available from Digital Leisure include the following:

- Dragon's Lair — The original classic from Don Bluth studios that set the bar for all laser disc games that followed. Take the part of Dirk the Daring as you try to rescue Princess Daphne from the clutches of the evil dragon Singe! If you pick up no other laser disc title for your cabinet, pick up this one.
- Dragon's Lair II — Happily ever after doesn't last long for Dirk and Daphne, as the evil wizard Mordroc kidnaps Daphne, leaving Dirk no choice but to rescue her again. This is an excellent follow-up to the first game.
- Space Ace — Following on the success of Dragon's Lair, Space Ace is another title from the creative forces of Don Bluth studios. In this title you play Ace, who must rescue his girlfriend Kimberley from the clutches of the evil commander Borf!
- Hologram Time Traveler — Originally a title in the arcades that used a new technology to display 3D images without requiring 3D glasses, this title has been ported to the PC by Digital Leisure (albeit requiring glasses this time). In this game, you play Marshall Gram, the daring adventurer who must travel through time to rescue Princess Kyi-La from the evil scientist Vulcor! Are you noticing a trend here? When do the princesses get to rescue the men? At any rate, this was another smash arcade hit that has been brought to the PC.
- Mad Dog McCree I and II — These titles are laser disc–based shooting games that were very popular in the arcades. Ported to the PC, these games are compatible with the Act-Labs USB light gun. Play the hero and rescue the town sheriff (yes, and his daughter too) from the wicked Mad Dog McCree. Do you have what it takes?

Other titles from Digital Leisure are also available, though the previous listed titles are the most popular arcade conversions. They carry several other shooting titles, all compatible with the Act-Labs light guns. The games often come in both CD-ROM and DVD-ROM formats, with fans typically preferring the DVD-ROM versions. Most arcade cabinet builders will pick up Dragon's Lair, Dragon's Lair II, and Space Ace as the most popular titles of the genre. Digital Leisure conveniently has a collection of these three games available.

Street Fighter IV

Capcom released Street Fighter IV, a continuation of the classic arcade series, for the PC among other systems. This is one of the quintessential series in the fighter genre. There is a post on the BYOAC forums (`http://forum.arcadecontrols.com/index.php?topic=96377.0`) with a patch for the game that enables full keyboard support for two players, which means of course that it can now be used in an arcade cabinet.

Shareware and Other Great Games

Gaming in modern day times centers around incredible 3D graphics and 3D interactive worlds. Many of these games are a lot of fun, but sometimes not enough attention is paid to good old-fashioned game play. Somewhere between the arcade classics of yesterday and the 3D immersive gaming worlds of today lies a collection of freeware and inexpensive shareware games with incredible game play produced by classic gaming fans. Many of these games will make great additions to your arcade cabinet! You can find these games at a variety of places on the Internet. I'll list some of the places you can look for such games as recommended by members of the Build Your Own Arcade Controls (BYOAC) Web site. You can always find the most up-to-date list on the arcade games page at `http://wiki.arcadecontrols.com/wiki/Cabfriendly_games`.

CROSS-REFERENCE **You'll find a clickable list of great shareware/freeware arcade cabinet–friendly games on the companion CD. As a bonus, several good games to get you started are included on the CD as well!**

Other places to try:

- **Epic Games** (`www.epicgames.com`) is the maker of games such as Jazz Jackrabbit currently available from Epic Classics (`www.epicclassics.com`). Jazz Jackrabbit is an old favorite that gets plenty of play time on the Project Arcade 2 cabinet. It's a game similar to Sonic the Hedgehog, where Jazz Jackrabbit runs lickety split around various worlds fighting evil turtles, jumping, shooting, and flying around.
- **3D Realms** (`www.3drealms.com/downloads.html`) has released freeware versions of many of their classic PC arcade hits such as Alien Carnage and Bio Menace, and has the shareware versions of great games such as Commander Keen and my all time favorite Duke Nukem.
- **PoMPoM Games** (`www.pompom.org.uk/index.htm`) has Mutant Storm, a title that is a popular hit among the arcade cabinet crowd, along with several others.
- **MegaGames** (`www.megagames.com`) lists a *huge* collection of freeware games to try.
- **Retro Remakes** (`www.retroremakes.com`) maintains a constantly growing list of popular freeware remakes of classic arcade, console, and computer games.

- Finally, don't forget the power of Google. A search for "freeware PC arcade games" will lead you to hours of possible games to try!

Many people will discount freeware or shareware games as not being worth the effort. Those people are *clearly* missing the mark. Some of the best game companies started out producing freeware and shareware games, and many talented programmers continue that tradition today. You can literally fill your arcade cabinet with hundreds of incredible games for hours and hours of fun. There are many gems waiting out there for you to find!

Summary

Emulation is probably the most compelling reason to have a personal arcade machine. There's nothing quite like playing a real arcade game inside a real arcade cabinet. Although there are thousands of possible games that can be played this way, at present legal issues only make playing a small percentage feasible. Other games fill the gap, including commercial arcade titles patterned after classic arcade games. Some of them are extremely well done, such as Dig Dug Deeper and Q*Bert, while others are fun but substantially different from the originals. Finally, often overlooked is the wealth of excellent games available as freeware or shareware titles.

Though it might not seem like it, you've reached a challenging point in the creation of your arcade cabinet. Many people get to the point where games are playable and stay there for months enjoying the fruits of their labor. That's okay, but you're not quite finished yet! Coming up in the next chapter, I'll talk about the various things you can do to dress up and finish off your cabinet. It's okay if you want to run another game of Pac-Man first, though; I'll wait!

CHAPTER

15

Buttoning Up the Odds and Ends

IN THIS CHAPTER

- **Decorating the Cabinet**
- **Lighting Effects**
- **Protecting the Cabinet**
- **Other Odds 'n' Ends**

In reaching this chapter you've come to a bit of a crossroads. If you've been following along, your cabinet or controller project is built and playable. You can stop here, and many people do just that. Some people stop temporarily to enjoy the fruit of their labors, and for some this is about as far as they'll go.

I really encourage you to keep at it, though. With just a few more steps, you can move from a good project to a great one, with lighting, artwork, protective covering, a working coin door — in short, all the things that make a real arcade machine! Those are some of the subjects I'll be covering in this chapter. I thoroughly enjoyed writing this chapter — this part is going to be fun!

Decorating the Cabinet

You can decorate your cabinet in many different ways, from the simple to the incredibly complex. Chapter 18 has some examples of cabinets with very nice artwork you may wish to look at while you read this chapter. In this section, I'll take a look at the various parts of the cabinet that are typically decorated and how you might go about decorating them.

Artwork Philosophies

You should take a moment to stop and think about the artwork you want for your cabinet. Is your cabinet going to have a specific theme, such as re-creating a particular classic arcade cabinet? Are you going for an overall montage look, reminding people of all the classics from the past and present? Maybe you'd be happy with a theme from a particular genre, such as a fighter-themed cabinet (a popular choice among fans of recent arcade titles). Or, perhaps you don't have a particular theme in mind at all and just want something that looks nice? Keep these thoughts in mind as you read the rest of this section.

Something to consider, no matter what theme (or lack thereof) you choose, is the cabinet as a whole, not just as individual sections. A color-coordinated cabinet with matching joystick and button colors can look very appealing. A cabinet with individual pieces that don't match probably won't have the impact you hope for. Consider a cabinet with a particular classic arcade machine theme. A marquee associated with the character's name (for example, "PacMAMEA"), related graphics on the side, and controls with a matching color theme will tie the cabinet together nicely. Would that cabinet be as appealing with unrelated artwork on the marquee, side, and control panel? You'll notice I'm not declaring anything right or wrong here — it's a personal opinion and yours is the only one that matters (unless you have to face the spouse test)!

Typically the best looking cabinets fall into one of two categories. For those in the first, a particular arcade theme is chosen and followed as the cabinet is decorated. Characters from the original games and their color schemes adorn the cabinet. The second set of cabinets tends to have a more abstract look, usually with minimal character graphics or no character graphics at all. Color choices for the controls, overlay, paint and t-molding tie the cabinet together. Both types of cabinets can look very nice.

Finding Artwork

Finding artwork for your cabinet is not difficult at all. There are many resources at a range of budgets available to you. From rolling your own to having something custom designed and printed for you, I'll cover the options in the next few sections.

The Forums

A great place for you to start is the artwork forum of the Build Your Own Arcade Controls (BYOAC) Web site at `www.arcadecontrols.com`. Whether you're creating your own and need technical assistance and feedback or you're looking for help getting artwork for your cabinet, this forum is a great place to visit.

For those of you who are creating your own artwork, you'll find valuable tips and helpful folks to aid you. I'm frequently amazed, not only at the caliber of talent that is exhibited on this forum, but also at the willingness of people to share their expertise with others. It's not unheard of for one person to post a message indicating they're looking for help making a particular kind of graphic for their cabinet, only to have someone else volunteer to make it for them shortly thereafter! Please do not enter the forum expecting someone to do that every time, however; such offers are gifts of time and talent and shouldn't be taken for granted. It's also fairly common to see someone present a work in progress and then receive constructive criticism that ultimately makes the work better.

You can also find people on the forum who are willing to take on custom work for you under a private arrangement such as for a fee or trade. Again, however, most people do so as a sideline, so patience and politeness are the keywords of the day. The artwork you'll see later in this chapter on the Project Arcade 2 cabinet was created by one such individual and turned out incredible! Whatever level of assistance you're looking for, the artwork forum is a good stop.

Making Your Own

Making your own artwork for your cabinet can be as fun and rewarding as building the rest of the cabinet itself. You can either start completely from scratch or find pre-existing artwork and modify it for your purposes. Both choices can turn out looking great! Success depends on knowing your ultimate goal before you begin and selecting your tools and settings appropriately.

Raster Versus Vector

Before you begin, you should understand the difference between *raster*-based graphics, and *vector*-based graphics. A raster-based graphic, such as the JPEG files included on the CD for all the photos in the book, is composed of tiny dots, or pixels. For instance, a simple square might consist of a ten-dot by ten-dot grid of red pixels that produces a red square. If a set of red and black alternating squares form a game board, it would consist of a large collection of different-colored pixels arranged in a manner to produce the game board.

A vector-based graphic on the other hand is composed of a series of mathematically described lines that form shapes. For instance, that simple ten-by-ten dot square might be described as follows: *Start here. Draw a line to the second corner, then the third, then the fourth, and finally back to the first corner. The shape created is colored red*. The specific mathematical formula used is likely different from the simple way I've described it here, of course, but the basic principle applies. Instead of laying the image out bit by bit, the image is described. The computer knows how to turn the image description into the square you see on the screen and displays the square for you. This square is a single shape in the image. For the game board, each square is an additional shape, so a simple two-by-two board would consist of four described shapes.

Why is the difference between raster and vector images important? Choosing one graphic type over the other makes a difference when it comes to *scaling*. Scaling is the process of making a graphic image bigger or smaller than the original. Scaling an image is problematic for raster graphics and is where vector graphics shine. When you make a raster image larger or smaller, you have to add or remove pixels to the image respectively. A 10-by-10 square that is expanded to a 20-by-20 square is now missing 10 pixels per row that have to be filled in. For a single-colored square that's easy enough, but what about an image with angles, curves, or different colors? How do you know which pixels to add or remove and in what color? The computer will make an educated guess for you based on what the nearby pixels look like. However, no matter how good the program is, when you expand a raster image you'll get noticeable jaggies, or pixelization. That's the effect you see when a straight line appears as a stair-step instead of a smooth surface. Vector-based graphics do not suffer from this problem, as the lines describe the same shape and relative position on the image no matter how big or small it's resized. The square is still described as proceeding from one corner to the next until the square is drawn; the corners are just farther apart. A complex vector-based image has many shapes in it, but the principle remains — the shapes are just made larger or smaller without any pixelization effects. You can see an example of the difference in Figure 15-1.

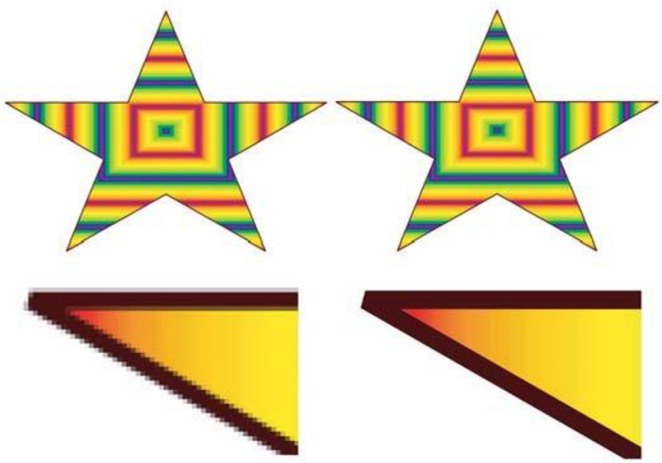


Figure 15-1: Left, raster star shape and blow-up. Right, vector star shape and blow-up.

In the top-left corner of the figure is a star drawn in raster mode using Paint Shop Pro. In the top-right corner is the exact same figure in the exact same dimensions drawn in vector mode. They look basically the same. Underneath each star is a small section that has been expanded 1800 percent for illustrative purposes. The raster side has noticeable jaggies, and the color gradation can be seen as a series of color changes instead of a smooth progression. The vector side looks just as smooth at 1800 percent as it does at its original size, with the color changes still progressing smoothly. You may wish to view this image on the CD to get the full effect (make sure you're viewing it at 100% zoom).

The same issues seen in the star example will be seen when resizing any raster image. Generally, you can resize a raster image downwards without too much noticeable effect (it's there, you just can't see it), while resizing upwards more than ten percent or so will produce noticeable defects. Graphics programs will perform some tricks to make it less visible, such as anti-aliasing, adding pixels of lighter color to smooth out the jaggies (visible in Figure 15-1). However, all the efforts made by the computer to render the new image will still not completely hide the defects. Ultimately, you do not want to work with raster graphics if you intend to resize them.

Unfortunately, unless you start from scratch, most of the artwork you'll find to use or modify for your cabinet will be in a raster format at a particular size. Does that mean you can't use it if you need the image at a different size? Not necessarily! There's a process of converting a raster to a vector image called, appropriately enough, *vectorizing*. That's the process of taking a raster image, identifying all the various shapes that make it up, and then tracing lines to match. Take a two-by-two checkerboard for instance. If you visualize it as a collection of four shapes (four squares), you can select the corners of the squares and trace lines for each square. Once you've traced over the whole raster image, the layer of lines and shapes you've created from your tracing is now in vector format! Most images aren't easy squares of course and converting a complex raster image into a vector image can be difficult, but it's possible, with patience, to convert any raster image into a vector. There are even programs that will automatically vectorize an image, but the consensus is that the quality is subpar and manual tracing is the best way to go.

As far as the output of raster versus vector graphics goes, there's no difference. Once your image is in its final form, converting it to a raster image, if necessary, will have no undesirable consequences, beyond that of a larger file size than the same vector-based image. Converting from a vector image to a raster image is as simple as telling the computer what file format to use and saving it. The file format you use for output will largely be dictated by where and how you get it outputted. For an on-screen image, a JPEG is a likely candidate, but a printed copy will depend on the needs of the people doing the printing for you.

The person who created the artwork for the first edition Project Arcade cabinet, Tom Van Horn, has produced an excellent tutorial (`www.arcadecontrols.com/files/Miscellaneous/VectorTutorial_v1_3.zip`) for people interested in getting started with vector graphics for their cabinets. It covers the basics of raster versus vector graphics, how to create and manipulate vector shapes, the process of converting raster graphics to vector, and how to get your artwork printed. Many people with no prior experience have picked up the tutorial and a raster graphic and, in a day or so, have turned out quality resizable vector graphics for their cabinets. I learned a lot from Tom's tutorial and highly recommend it!

Tools

Before you get started you'll need to pick your tools. My favorite (Paint Shop Pro) is a great package to use and is capable of working with both raster and vector-based images. A trial version can be downloaded from `www.corel.com`. Other packages used by members of the artwork forum include:

- **Adobe Illustrator** — This program, from graphics company powerhouse Adobe, appears to be the hands-down favorite for working with vector graphics. Adobe Illustrator is the program used in the tutorial mentioned in the previous section.
- **Adobe Photoshop** — A powerful graphics editing suite, Photoshop is the default tool of the majority of graphics artists and represents the raster side of the Adobe house. A popular process is to create vector graphics in Illustrator then import them into Photoshop at the appropriate size in order to use the powerful image-manipulation tools that Photoshop has available.
- **Corel Draw** — Another vector graphics program known for its powerful capabilities.
- **Inkscape** — Inkscape (`www.inkscape.org`) is an open-source vector graphics program for Unix/Linux and Windows.
- **The Gimp** — Gimp (`www.gimp.org`) stands for Gnu Image Manipulation Program and is a powerful open-source, raster-based graphics tool. Versions exist for Unix/Linux and Windows.

Graphics Tips

When you start working with graphics, there are a few tips that will help you produce nice results that are consistent from your screen to final output.

Start by considering color. How hard can using colors be — red is red, blue is blue, right? Not necessarily. There are different systems used to create color depending on the media for which it is intended. Monitors use a three-color RGB (red, green, blue) scheme. Most commercial printers use a four-color CMYK (cyan, magenta, yellow, black) scheme. A full description of color theory is beyond the scope of this book. However, what's important to know in a nutshell is that the appearance of an image described in RGB will probably vary somewhat from that of an image described in CMYK. RGB colors are additive — light shines through the colors to your eye, and colors are made by adding different intensities of red, green, and blue. CMYK works the opposite — light reflects off the colors to your eye, and colors are made by subtracting different intensities of cyan, yellow, magenta, and black.

The important point to grasp is that what you see on your screen is not necessarily what you'll see when it is printed out. It'll likely be close, but the shades of color may vary. There are fewer colors possible with CMYK than with RGB. Some paint packages will show you a preview of what you can expect when an image is printed. For instance, in Paint Shop Pro, choose File ➤ Preferences ➤ Color Management.

Some programs, such as Adobe Illustrator, allow you to work natively in CMYK. However, RGB color tends to be more vibrant and gives you a broader range of colors to work with. Conventional wisdom seems to be that you should work in RGB mode and convert to CMYK if needed. Do you *need* to convert to CMYK? That depends on where you're printing your image. If you're printing it on your own printer the answer is likely no. If you're taking it to a professional printer, consult with them and ask them what file formats and color model they prefer. Matching your format to their preferences is your best bet for accurate printing.

Another point to consider is the resolution of your image. DPI stands for "dots per inch" and literally means how many pixels there are for every inch of graphic. Fewer dots per inch result in a lower-quality image, while a higher DPI produces a better-quality image but with a corresponding increase in file size. The sweet spot for a balance between image quality and file size seems to be 300 DPI. Lower than that and there really isn't enough data in the image for great results. Good results are possible at a DPI lower than 300, but they probably won't be as good as a higher DPI. On the flip side, resolutions higher than 300 DPI are probably overkill and not worth the extra space required. I wouldn't recommend using more than 300 DPI unless your print shop specifically asks for it. At something like 600 DPI, a single graphic can take up an entire CD!

It is possible to convert from a lower to a higher DPI, but the results are suboptimal. The program you're using must add extra pixels that weren't there before and, no matter how good a guess it makes, the resultant image won't be as good as if the image were produced at a higher DPI to start with. Your best bet is to create your graphics at the higher resolution. If you're importing graphics from another source you don't always have that option, so the rule of thumb is simply to keep it as close to 300 DPI as you can and not worry about the numbers too much. Remember that these graphics are going on an arcade machine, not in the Louvre!

Another consideration is that you will be much happier working in your graphics program in layers. The way layers work in a graphics program is that each element in an image can be on a particular layer that can be turned on or off. In Tom's vectorizing tutorial, for instance, he recommends a separate layer for the hair, shirt, face, and so forth of the character being vectorized. With all layers turned on you can see the entire image. When you're concentrating on a particular feature, turning off the layers you don't need allows you to see only the one on which you're working. If you make a mistake, for instance a slip of the mouse that draws a line across the screen, you've only done something to that layer and the rest of the image is safely hidden away. Layers have a hierarchy where the top layer always shows, the second layer only shows where the first layer has no material, and so on. This makes it easy to create complex images a chunk at a time.

Finally, it's not a bad idea to have bleeding edges around your image. These "bleeders" allow for variances in print sizes that sometimes occur. If you need exactly a 10-inch-wide marquee and the name of your cabinet exactly fills those 10 inches, you won't be able to use the image if it comes out at 10 1⁄2 or 9 1⁄2 inches. However, if your 10-inch image with the name of your cabinet includes some black space around the text, then you'd be okay. If it's too big, you just trim off the black edging as needed. If it's too small, you have a nice black border. Of course, if there's too much variance, then it simply needs to be reprinted. Also, your graphic has to look good with a bleeder edge for this to work. Something with bright colors might look boxed in with a black border. You'll have to make that judgment as you design your graphics.

Printing

I'll give some specific tips on printing for each item in the sections below. There are some general pointers to bear in mind when it comes to getting your artwork printed professionally.

- The success of your printout depends in large part on the print shop's understanding of what you're trying to achieve. The more they know about your project, the better they will be able to help you decide on materials and printing techniques.
- If possible, take a proof of what the artwork should look like. If you are getting a large piece of *side art*, print a copy on a regular-sized sheet so that the printer knows the proportions and color tones that are expected.
- If you don't know what the printer needs, save multiple formats of the image on a CD. Better yet, contact the printer in advance, explain your project, and find out what file format they'd prefer. If you can't produce it in that format, ask them whether they can take another and whether there's a conversion fee.
- Ask about UV resistant inks. Ultraviolet light can cause ink to fade over time. UV resistant ink is designed to avoid that problem. Usually used on products that are expected to be outdoors, it can sometimes be used on other materials.
- Some printers will want to charge you an up-front setup fee in addition to regular printing costs. This isn't necessarily price-gouging. Setup

can include modifying your image's color tones so the final product from their CMYK print process matches the color of your RGB printed proof. If you're faced with a setup fee, ask them what it entails. Ask whether they can guarantee a close color match if they don't mention a setup process.

- Some printers, particularly large chains, may refuse to print well-known images to which you don't own the copyright, such as a picture of PacMan on your marquee. Print shops have encountered legal problems by ignoring copyrights and are rightfully cautious. If this happens to you, ask them specifically what portion of the graphic is a problem and what alterations are necessary to print the artwork. Bear in mind that they're not going to risk losing their business for one print job, so if you do not agree with the alterations you will not be able to get your material printed there.
- Take a tape measure and a copy of the proof with you when you go to pick up your product. Compare the colors and make sure it was printed at the right size and proportion before you walk out of the store. Mistakes, unfortunately, seem to be fairly common at some of the larger chains so make sure you're getting what you paid for.
- I strongly urge you to consider using one of the printers who are part of the arcade cabinet building community. You can find them on the artwork forum at BYOAC. Since they cater to this market they know the requirements and pitfalls of printing artwork for cabinets better than anyone.

Internet Resources

The Internet is a great place to find artwork that can be used on your cabinet project. Much of it is copyright protected, meaning you should consult the owner for permission to use it unless they've already explicitly given it. Many art sites have disclaimers along the lines of "free for personal use, commercial use requires a negotiated arrangement." Other images, such as those produced by publicly funded projects like NASA, are free for commercial or personal use. If in doubt, consult the terms of the Web site on which you find the artwork.

Some of the favorite sites for arcade cabinet builders seeking arcade-themed artwork include the BYOAC Web site (`www.arcadecontrols.com`), Oscar Controls' art gallery (`http://mirrors.arcadecontrols.com/OscarControls/gallery01.htm`), and VectorLib (`http://vectorlib.free.fr`) among many others. You can also find great artwork for cabinets at non-arcade-oriented Web sites, such as deviantArt.com and even eBay! Between both sets of sites, you should be able to find good artwork for side art, control panels, marquees, and desktop wallpaper. You can even find arcade-style fonts for creating your own logos.

CROSS-REFERENCE **You'll find clickable links to the previously mentioned Web sites and many others on the companion CD-ROM. You'll also find control panel artwork ready to use on the CD-ROM, courtesy of Oscar Controls.**

Commercial Vendors

Another excellent choice for artwork for your cabinet is commercial arcade shops. They sell a mixture of NOS and reproduction artwork for arcade cabinets that will work just as well on a home-built arcade machine as a real arcade machine that's being restored. Prices vary considerably, depending on whether a piece of artwork is original or reproduction and how scarce the material is. Expect to pay in the $20 to $40 range for marquees and up to as much as $200 or so for good side art, although it can sometimes be found for considerably less.

NOTE **NOS: Stands for "New Old Stock" and refers to material that is unused from the day it was made, that is, stock from several years ago. It is from the manufacturer, with the same colors and material used as the original machines. NOS artwork was usually either produced by the manufacturer as replacements for damaged artwork or as conversion kits for arcade operators (to turn a Donkey Kong into a Donkey Kong Jr. for instance). Reproduction artwork is art that has been re-created from the original. It attempts to reproduce the original faithfully, and for the most part, succeeds. Nevertheless, quality can vary depending on the materials used.**

Some shops will sell a piece of reproduction artwork that's been silk-screened while others may sell a similar print that is from an inkjet printer. Silk-screening is how original arcade artwork was produced and is generally of a higher quality and durability. Inkjet prints have been known to fade over time, although technological improvements have changed that for high-end printers. In some cases, an inkjet print may be the only available option. As a rule, if both options exist, purchase the silk-screened print. You'll be happier in the long run. Don't hesitate to purchase an inkjet print if no other option is available, however. Vendors selling artwork in this category include:

- `www.endkay.net`
- `www.gameongrafix.com`
- `www.thisoldgame.com`
- `www.phoenixarcade.com`
- `www.gamestencils.com`
- `www.arcadeshop.com`
- `www.quarterarcade.com`
- `www.arcadeoverlays.com`

Every effort was made to verify the merchandise and customer service reputations of the vendors listed. Other vendors may or may not be reputable. Before purchasing from them, you should seek opinions about the quality of their workmanship from the BYOAC artwork forum and the Killer List of Video Games forum (`http://forums.arcade-museum.com/index.php`) — caveat emptor!

The Marquee

Your cabinet's marquee is one of its most noticed features. Glowing from the light behind it, the marquee can attract attention from across the room. Having a nice marquee can really set your cabinet off and make it noticed!

Obtaining A Marquee

You have two options for obtaining a marquee — you can make one yourself or use one of the many ready-to-print marquees available on the Internet. Even if you wish to design your own, you might want to use one of the finished marquees on the Internet as clipart or as a starting point. Remember the graphics tips mentioned earlier in the chapter if you choose to create your own. Also bear in mind that a marquee, unlike the rest of the artwork on your cabinet, will be lit from behind. Dark and vibrant colors will work better than a marquee with a lot of white and light coloring.

Places you can find marquees to print or modify for your own include:

- The Build Your Own Arcade Controls (BYOAC) Web site, `www.arcadecontrols.com`, has marquees available for download in the artwork section. Also, many individuals who have made their own marquees are happy to share. You can find these by browsing the list of cabinets on the Web site (included on the CD-ROM) and by reading the artwork forum.
- Oscar Controls (`http://mirrors.arcadecontrols.com/OscarControls`) includes several marquees in their online galleries, some of which are included on the companion CD-ROM.
- The Classic Arcade Game Art archive at `www.arcadecollecting.com` includes a big collection of marquees from classic arcade games.
- Massive Mame at `www.mameworld.info/massive/Marquee2/marquee2.html` has a very nice collection of marquees that have been used by many home arcade cabinet builders.

Printing The Marquee

You have three options for printing your marquee. You can print your own, you can take it to a print shop, or you can have it done by an online shop specializing in printing marquees. Of the three, the online shops are highly recommended, although all three methods can be used successfully.

If you are going to print your own, be sure to use the best materials possible. A good photo-quality paper with photo-quality ink is your best bet (most of today's inkjet printers have these options). I was concerned at first that a piece of photo paper would be too opaque and not allow light through, but in test prints it actually worked fine. In fact, it allowed too much light through (which I'll show you how to solve in the next section). Once I solved that issue, I was pleasantly surprised with the results. However, unless you have the means to use large paper, you'll end up printing your marquee on more than one page and having to piece it together. No matter how careful you are, you'll see the seam when it's back-lit.

Retail print shops can print marquees for you as well. Print shops have printers and material that allow them to print your marquee full sized on a single sheet. If you choose this route, make sure your print shop has back-lit material available. This is a semi-opaque film-like material designed to be lit from behind. If you want to spend some money on your marquee, you can try to find a print shop that will screen print it onto Plexiglas for you. That is likely to be expensive, however. Either way, be sure to review the pointers in the printing section earlier in this chapter if you choose to use a retail print shop for your marquee.

My best recommendation is that you choose to use one of the online print shops that cater to arcade cabinet builders. At the time of this printing, there are two in operation:

- **EMDKAY** — EMDKAY Marquees (`www.emdkay.net`) is one of the best-known marquee shops in the home arcade cabinet community. As a rule, reviews of the marquees customers have received from them have all been positive. They offer a collection of MAME, personalized, and classic arcade game marquees. They will also help you design a marquee or accept a custom marquee from you for printing.
- **Game On Grafix** — Game On Grafix (`www.gameongrafix.com`) started out by printing marquees for home arcade cabinets, though they have long since branched into a complete arcade cabinet artwork service. They have many marquees available to choose from and will print your customized design as well. They have received very positive reviews on the BYOAC message forums.

Both of these online shops are clearly interested in the home arcade cabinet business. All have good customer feedback, a wide range of products, and a willingness to work with you for a custom design. Prices are approximately the same, and you are likely to be satisfied with choosing either of these sources. Emdkay.net printed the marquee for the first Project Arcade cabinet, while Game On Grafix printed the one for the Project Arcade 2 cabinet. Both turned out great!

Light Things Up

Of course, a marquee looks much more impressive when lit from behind. Part of the fun of having a great marquee is the glow it gives off. Lighting your marquee is a simple matter really. An inexpensive, regular white fluorescent light behind the marquee is one option. Be careful if you choose another type of lighting. Ultraviolet (black-light) can produce a very nice effect, but is likely to fade your artwork over time. You'll also occasionally see a real arcade machine with a regular light bulb illuminating the marquee, but heat becomes a serious concern. The light bulb will not spread the light across the marquee evenly so you'll have a center bright spot, and the heat from the bulb may discolor the marquee.

Is there a better way? Whenever that question is asked, one of the vendors in the community will soon answer "yes!" In this case, two of the community's vendors sell a marquee light specifically designed for arcade cabinet use. Groovy Game Gear's light is the NovaMatrix LINX™ LED Marquee Light, using high output, wide-angle, "cool white" LEDs. Ultimarc sells a cold-cathode tube marquee light. Both run off a 12 volt power source, which you can tap from your computer's power supply. Various cabinets around the St.Clair household use lights from both vendors and both look great. The nice thing about these lights, other than using the 12 volt power source, is that both are narrow fixtures and can fit into tight spaces that may be competing with the speakers in your cabinet.

You may run into a couple of problems lighting your marquee, particularly if there's a lot of lighter color. The light from behind may be too bright, washing out the colors of your marquee. You can solve this in a couple of ways. The first is simply to print two copies of the marquee and mount them together. The extra marquee will help diffuse the light so the colors show up darker and richer. If your marquee has areas that look good with bright light but also has black areas that appear grey due to excessive lighting, you can fix that as well with a second marquee. Instead of an exact duplicate of the first marquee, only print the dark areas on this second marquee, and leave the rest of it white. The light will pass through the white area without too much dimming, while the light passing through the two layers of dark area will be much more dimmed.

You can also sandwich a single marquee between two layers of Plexiglas/Lexan and leave the paper backing on the inside piece. This will diffuse the light nicely as well. If your Plexiglas doesn't have a white backing (the one purchased for Project Arcade 2 used a clear-blue plastic backing) then you can substitute an appropriately sized sheet of white paper behind the marquee. Also, mind where the light is mounted in relation to the speakers. Don't put the light behind the speakers, thereby casting shadows on the marquee.

Mounting The Marquee

Mounting your marquee involves two steps. The first step is finding a way to get the marquee to remain flat when placed on the cabinet. If you are fortunate enough to have a marquee that's been screen-printed onto glass or Plexiglas, then it's already rigid and you have this base covered. Most marquees, however, are printed on the back-lit material recommended in the previous sections. This is flexible like paper, so a way needs to be found to keep it rigid. The easy way to do this is to sandwich the marquee between two thin layers of Plexiglas and treat the three layers as a single marquee. No adhesive is necessary.

Once you have a rigid marquee, the next step is to find a way to mount it to the cabinet. Happ Controls (`www.happcontrols.com`) sells a PVC marquee retainer in ten foot lengths that you can cut to size and use. Alternatively you can find angled aluminum material in various sizes at any hardware store. Both are pictured in Figure 15-2.

Used by permission of Happ Controls.

Figure 15-2: Left, Happ Controls marquee retainer. Right, angled aluminum.

The Happ Controls marquee retainer is a U-shaped, curved affair that sticks out approximately 1⁄2 inch from where it rests against the marquee. It is easily cut with a hacksaw, is easy to drill holes in, and comes in black, which matches most cabinets. The angled aluminum material is a bit harder to work with but is preferred by some cabinet builders because it is lies flat against the marquee instead of the U-shape of the Happ Controls marquee. The aluminum cuts with a hacksaw and can be drilled with the proper bit. Unless you prefer the metal appearance, the aluminum will need to be painted. Use a primer designed for metal or lightly sand the aluminum with a fine grit to help the paint adhere to the metal.

If your cabinet top or speaker shelf is angled, like the speaker shelf on the Project Arcade 2 cabinet, then the angled aluminum may not work for you because it is rigid and will flex the marquee. Other options in that case include using a ceiling-grid retainer, which will be a bit more flexible, or the Happ Controls marquee retainer.

To mount the marquee, drill two or three holes in your marquee retainer of choice and the speaker shelf. I prefer to clamp the marquee retainer in place and drill through both retainer and wood at the same time to ensure the holes line up. Be careful! Don't place the holes so the marquee retainer is snug against the wood. That doesn't leave any room for the marquee! Place the marquee or a similar-sized piece of Plexiglas in the proper spot and then place the marquee retainers to ensure proper spacing. Repeat for the top marquee retainer and cabinet top. Voila, your marquee is mounted!

Project Arcade's Marquee

The Project Arcade 2 marquee was designed by BYOAC artist Pixelhugger, and printed by Game On Grafix. It's printed on laminated backlight material mounted directly to Plexiglas and held in place with a Happ Controls marquee retainer. The marquee is absolutely stunning as you can see in Figure 15-3 (be sure to see the color version on the companion CD-ROM), and is arguably one of the most attractive features of the cabinet!

Used by permission of Pixelhugger and Game On Grafix.

Figure 15-3: The Project Arcade 2 marquee, unlit above, lit below.

NOTE **Are you feeling artwork challenged? All of the artwork for the Project Arcade 2 cabinet was created by arcadecontrols.com forum member Pixelhugger. He is available for limited commissions if you're interested in having artwork designed for your cabinet! Other artists are as well, and you can make inquiries on the message forums at `forum.arcadecontrols.com`.**

Side Art

Next to your marquee, another item that really draws attention to your cabinet is the side art. The side art on the cabinet is your best opportunity to get creative because of the sheer volume of space with which you have to work. There are basically three camps when it comes to side art. Many people will simply place a center graphic somewhere in the two-feet-squared range in the middle of the cabinet. Others will use much more of the available space by using a banner-sized graphic, or, more rarely, something that fills the entire side. Others simply choose not to use any side art at all or to leave the decision for a later date. A cabinet really looks better with some sort of side art applied, so I wholeheartedly recommend you give it a whirl!

Haven't We Been Here Before?

Much of what you need to consider for side art is the same as what you've already read about for the marquee. The same considerations apply for the settings you use when creating the graphics, and you can find artwork and entire side art pieces at several of the same places. The vendors who cater to the home arcade cabinet business for marquees also sell side art with the same variety and quality available. Once again, Game On Grafix was chosen to print the side art for Project Arcade 2. Whichever vendor or method of printing you choose, there are a couple of differences between printing side art and printing marquees that you should bear in mind:

- **Lighting** — Unlike the marquee, the side art is not going to be lit from behind. This means you can use lighter colors without worrying about them being washed out.
- **Size** — Compared to the marquee or control panel overlay, there is a lot more area to work with. You may want to consider making your lettering and characters larger so they can be seen more easily from farther away.
- **Material** — Your best choice for material on which to print side art is adhesive-backed vinyl. Not all print shops carry adhesive-backed vinyl, so if you're printing your own you may need to go with a non-adhesive-backed vinyl. Other materials can be used but may not be as durable as the vinyl. See the next section, "Applying Side Art," for some ideas when using other materials.

Applying Side Art

The best advice I can offer you for applying your side art is to consult the place you have it printed. They should know the particulars of the material being used and the best method for applying it. However, if they do not have a recommendation for you, two popular methods are given here.

If you're using a vinyl that does not have an adhesive backing, you'll need to supply your own. The recommended method is to pick up a can of spray adhesive (3M Super 77 is the most popular choice), spray the back of the side art, and apply it using one of the methods in the following two sections.

If you're using a non-adhesive material other than vinyl, then you'll need to apply spray adhesive as well. In addition however, you should also protect the artwork in some fashion. Good results have been reported from spraying the artwork with a clear acrylic coat. Some people spray the artwork before it's applied, while others coat it after it's on the cabinet. Both methods seem to work equally well. Several coats are suggested for maximum protection of the artwork. A wise word of caution comes from Oscar Controls. Before spraying a clear coat, allow the adhesive to dry completely for a couple of days or so. Sometimes the adhesive can leak fumes through the artwork that aren't really noticeable to you but that can interact with the spray acrylic and cause bubbling. After waiting a couple of days that problem generally does not occur. Consult your printer before applying a clear coat to make sure they do not have any cautions against it.

Spray-Soak Application Method

This method of applying side art to a cabinet is very popular in the arcade-collecting community. The basic premise is to position the artwork with the adhesive exposed and slide the artwork around until it's perfect instead of trying to get the artwork perfectly positioned the first (and only) chance you have. The way you do this is by first spraying the side of the cabinet with mildly soapy water. This prevents the adhesive from sticking as you position the artwork. Carefully peel the backing off the artwork to avoid stretching it and place it on the cabinet. When you have it in position, carefully squeegee the water out (so as not to damage the side art), and the artwork then sticks. You should work from the center of the artwork out to the edges to make sure no bubbles develop. If you do develop a bubble (and that's common even with the most careful of installations), use a small pin at the base of the bubble (not in the middle) to pop the bubble gently. Then carefully press the air out. Squeegee the side art several times to make sure all the water is out. You may find it easier to use this method with the cabinet temporarily lying on its side. Don't lay it on its side with the monitor in it!

Hinge Application Method

The other popular method is the hinge process. The basic premise of the hinge method is that you place the graphic on the cabinet with the backing still attached, line it up perfectly, then place masking tape horizontally across the middle so the artwork is hinged from top to bottom. Gently pull the top part down and remove the section of backing from the top down to the hinge. To avoid damaging the graphic, I suggest cutting the backing off in the air when you have it pulled off (you'll need a helper) rather than trying to score the backing while still attached to the artwork. Carefully begin to lay the artwork back down on the cabinet, starting with the sticky part closest to the hinge. Use the squeegee method to work the artwork onto the cabinet, from the center out to the edges. This lets you work any bubbles out. If any bubbles persist, use the pin method to carefully pop them (at the base!) and work the air out. Once the top is attached to the cabinet, remove the masking tape, lift the bottom, and repeat the process with the bottom half.

In Figure 15-4 you can see the variant of the hinge method used on the Project Arcade 2 Cabinet. The general premise is the same, but instead of placing the hinge in the middle the hinge is placed at the top of the artwork. Then the entire backing is pulled off, and the artwork is gently rolled back onto the cabinet using a squeegee as described above.

Used by permission of Pixelhugger and Game On Grafix.

Figure 15-4: Applying the artwork.

Project Arcade 2 Side Art

The side art for Project Arcade was once again designed by graphics artist Pixelhugger. Game On Grafix (`www.gameongrafix.com`) printed the artwork and did an outstanding job. Installed, the side art looks great (Figure 15-5)!

Control Panel Artwork

Your control panel artwork is equally as important as the other artwork on your cabinet. Unlike the marquee and side art, however, the control panel artwork is seen up close and is what you'll spend the most time looking at other than your bezel. As usual, there are different opinions about what makes good control panel artwork. Some people prefer a minimalist approach, with a few discretely placed graphics, maybe an overall background graphic, and perhaps some labels and arrows around the controls. Others prefer a full-body graphic covering the entire panel, with arcade characters and a lot of action. The Project Arcade 2 CPO lies somewhere in the middle of these two.

Used by permission of Pixelhugger and Game On Grafix.

Figure 15-5: Project Arcade 2 cabinet with custom side art installed.

NOTE **Applying artwork to your control panel obviously needs to be done without any controls installed. If you followed the suggestion in Chapter 6 and held off installing controls or skipped ahead to this chapter, then you're in good shape now. If not, you'll need to spend a few minutes removing the controls from the control panel top now.**

We've Definitely Been Here Before!

The same general considerations for the graphics that apply to the marquee and side art also apply to the control panel artwork. There are a few points to mention however. Artwork for the control panel is usually referred to as the control panel overlay (CPO). CPOs can be found at many of the same vendors as mentioned previously. Control Panel Overlays are normally printed on the same adhesive-backed vinyl material as side art. If necessary, you can also use non-adhesive-backed vinyl with a spray adhesive to attach it to the control panel. You do not need to cover it with a spray acrylic if you use a durable vinyl material or if you intend to protect it with a Plexiglas covering as discussed in the next section, "Covering the Control Panel."

If you intend to place arrows and labels on your control panel artwork, you'll need to be very careful to make sure the graphics line up precisely with the template you used to drill your holes. Another easy method is to use a background graphic that doesn't have specific arrows and labels on it. Then, print the directional arrows and labels separately and place them on the control panel graphic in the appropriate place when the overlay is applied and the holes laid out. This only works if you're going to cover the control panel with Plexiglas to hold the graphics down.

Some people choose to use contact paper, or a plain Formica or vinyl overlay on their control panel. This is a simple solution that can look very nice, if somewhat plain. If you use contact paper you can get various patterns for a bit of pizzazz, but you'll need to cover it with Plexiglas because it isn't very durable.

I highly recommend putting some effort into an eye-catching control panel overlay. The Project Arcade 2 CPO designed by Pixelhugger is always one of the things praised by visitors to the St.Clair arcade (see Figure 15-6).

Used by permission of Pixelhugger and Game On Grafix.

Figure 15-6: The Project Arcade 2 control panel overlay.

Covering The Control Panel

Because your control panel gets the most contact with hands and drinks and such, you may want to protect the artwork from getting dirty or damaged. It may seem like this section is out of order as I haven't talked about applying the artwork on the panel yet, but you should work out the control panel protection before the artwork is applied. This is to protect the artwork from mishap while you're working on the protective covering.

Do You Want to Cover The Panel?

While looking at the classic arcade machines in my collection, I noted that the majority of them had nothing covering the control panel overlay. A couple of them were in nice condition, albeit fairly dirty from years of use. The majority of them, however, were ripped and damaged from heavy use in arcades. A few of the machines had a thin Plexiglas cover over the control panel, and those control panels still had nice conditioned artwork although the Plexiglas was a bit beat up.

So you need to decide how, if at all, you intend to protect the control panel overlay on your cabinet. If you're likely to have your arcade cabinet in a controlled environment with only friends and family playing it, you might be just as happy not bothering with a cover over your control panel. Regular cleaning and TLC may keep the control panel looking nice. On the other hand, you never know when accidents are going to happen no matter how careful you and your friends and family are with the cabinet. A layer of protection over the control panel is cheap insurance, particularly if the control panel artwork was difficult or expensive to produce. If your control panel has a simple and inexpensive covering on it without artwork, you're probably okay not doing anything special to protect it. At worst, you may need to replace it down the road. However, if your control panel overlay has artwork or was difficult or expensive to produce, then you might be happier with a layer of Plexiglas to protect it.

NOTE **I refer to Plexiglas and Lexan quite a bit in this book and in this chapter particularly. Those are brand names of sheets of acrylic plastic. In all cases I'm using the brand names as generic terms. Any quality acrylic plastic will do. Plexiglas is more durable than Lexan but cracks easier. Lexan is easier to work with without fear of cracking, but is more susceptible to scratches. Other brands exist as well — consult the shop you purchase it from about the properties of the material and the best way to work with it.**

Working with Plexiglas, Lexan, and Other Acrylic Plastic

Working with Plexiglas can be tricky. If you apply too much pressure or speed as you're drilling holes, the Plexiglas will probably crack. Murphy's Law says that the Plexiglas will not crack until you're drilling the very final hole! If you don't use the proper technique, cutting it to size can also be frustrating, causing chips and splinters at the edges that can hurt and look horrible (Figure 15-7).

WARNING **Working with Plexiglas can be messy, nasty work. Your drill will cause the Plexiglas to melt a bit, putting off acrylic fumes. You don't want to breathe this stuff more than you have to. Make sure you have plenty of ventilation and wear safety gear, including a mask!**

With proper techniques however, you can get good results without too much effort other than the time taken to do it right. There are basically three steps to working with Plexiglas: cutting it to shape, drilling holes, and smoothing edges.

Figure 15-7: This Plexiglas was improperly cut, causing a rough edge.

NOTE **Getting the hang of working with Plexiglas can take a few tries. I strongly suggest working with a scrap piece of Plexiglas to get the feel for it before you start cutting and drilling on the one you want to keep. Don't start working with your Plexiglas until you've read this entire section through once!**

With the right tools, cutting Plexiglas is easy. A fine-toothed circular saw or high-speed rotary tool can be used but may be overkill. To start, with the backing still affixed, place the control panel top over the Plexiglas and line it up so major edges are flush with one another. By lining up the big edges, you minimize the amount of cutting required. Clamp the Plexiglas to the top, and mark the Plexiglas where it will need to be cut. Remove your control panel top and put it aside.

Next, place the Plexiglas on a piece of scrap wood at least large enough to support the length to be cut, if not the entire sheet. Clamp a straight-edge along the first line to be cut with the bulk of the straight-edge covering the part of the Plexiglas you're going to use. This will protect it against slips. Make sure the wood backing, Plexiglas, and straight-edge are clamped firmly together in a sandwich (Figure 15-8).

Using a sharp utility knife (the place you bought the Plexiglas should have a knife designed for cutting acrylic), score the line to be cut several times. Go slowly but firmly — too fast and you risk slipping and fouling the straight line! You want to score the plastic about one-third of the way through. Then for good measure, I suggest flipping the Plexiglas over, clamping the straight edge back down on the same line, and scoring the back a few times. Not everyone does the scoring on the back, but I find it can make things easier. Flip the Plexiglas back over so the original side is up.

Now place the Plexiglas, with the deep cut side up, between two pieces of wood so the main piece is supported and the excess is hanging into the air. Clamp the two pieces of wood and Plexiglas together firmly — the scored cut should be precisely at the edge between the two pieces of wood (Figure 15-9). With a smooth, firm motion, place downward pressure on the excess Plexiglas. It should cleanly snap off where you scored it. For a big piece, work from one side to the other, snapping as you go. If things go properly, you have a nice, clean, smooth edge!

Figure 15-8: Straight-edge, Plexiglas, and wood sandwich.

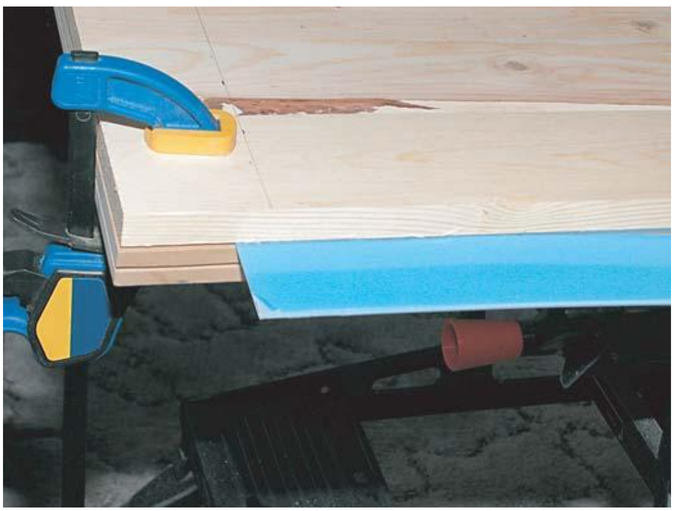


Figure 15-9: Lined up and ready to snap off.

Before you remove the clamps, carefully inspect the edge of the Plexiglas. If you find a spot that isn't smooth, you can easily sand it flush with the rest of the cut while it's still sandwiched. Take a fine-grit sandpaper and gently sand across the rough edge until it's smooth.

It may take a couple of tries before you get it right, but, once you have the knack of it, it's very easy to get smooth cuts with this method. The trick is to score it repeatedly and to go slowly. In Figure 15-10, you can see a comparison of a sheet that was scored only twice and then snapped without a top sandwich layer and a sheet that was cut following the method described.

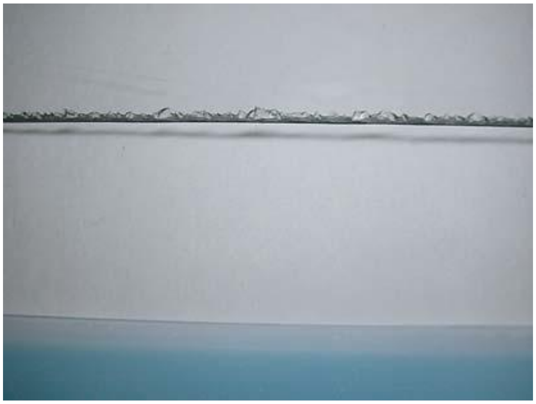


Figure 15-10: Top, improper method. Bottom, smoothly cut the right way.

Now that you've got the edges cut, you need to drill holes in the Plexiglas for the joysticks, buttons, trackball, and other controls. Drilling Plexiglas is prone to problems if it is done improperly. If it is done carefully, however, good results are easy to achieve. The key is the speed and pressure applied. If you place too much pressure or try to use a high speed, you are prone to crack the plastic. If you use a slow to medium speed, with only a moderate amount of pressure, drilling through Plexiglas isn't likely to cause cracks. Figure 15-11 shows two holes drilled in Plexiglas. One was drilled slowly and the other was drilled at full speed with firm pressure, causing a crack.

Figure 15-11: Below, slowly drilled hole. Above, cracked hole.

You may notice that the *good* hole in Figure 15-11 is fuzzy around the edges. That's because when you drill Plexiglas, you're melting it as much as you're drilling it. The fuzzy stuff around the edges is the plastic shavings that melted and then solidified again. They scrape off easily, leaving a clean hole behind. Drilling through Plexiglas is much easier with the right tools and techniques. A good forstner bit makes drilling button holes very easy. In fact, I was surprised at how easy making holes in Plexiglas was with my forstner bit (Figure 15-12). Thanks to Kendrick Childers for the tip on choosing a forstner bit! Special drill bits that are designed with a gentler point for drilling acrylic can also be purchased.

For the trackball, you should use a properly sized hole saw. Carefully drill the pilot hole until the hole saw touches the surface. Then put the drill in reverse and slowly apply *gentle* pressure. Your goal is to melt the hole away with the teeth on the hole saw working in reverse instead of biting into the plastic and possibly cracking it. You can also use this reverse-drilling technique with a regular bit if you don't have a forstner bit. Patience is the keyword here — this will take a while and you don't want to force it along. You may not need to reverse-drill with the hole saw depending on the particular properties of your acrylic. I recommend testing a scrap piece first. Pre-drill a pilot hole big enough to fit the hole saw's drill bit, then slowly start the hole saw in the proper direction to see whether the acrylic cracks. If it does not, you're in luck and can drill your Plexiglas panel the easy way, albeit very carefully!

Figure 15-12: A smoothly cut button hole next to the forstner bit.

For carriage bolt holes, you'll want to make the hole slightly bigger than the square block at the head of the bolt. Normally, in wood, you drill a hole the same size as the shaft of the bolt. When fastening the nut onto the bolt, the square block crunches into the wood holding it tight. You can't do that with Plexiglas, so you'll need to make your hole just big enough to accommodate the square block while still being hidden by the top head of the bolt. For a standard 1⁄4-inch carriage bolt, a 5⁄16-inch drill bit will work.

Now that you know how to cut and drill your Plexiglas, it's time to work on your real control panel cover. Begin by cutting your Plexiglas to the proper dimensions of the control panel top. Next, if you haven't predrilled the holes in your control panel top, you can do so using my favorite method. Place your control panel template, created back in Chapter 6, between the Plexiglas and scrap wood so the template lines up perfectly with the edges of the Plexiglas. If you're using the Project Arcade 2 template then now is a good time to print it out, if you haven't yet. Make sure you have it printed out to scale — if necessary, you can print it in sections and carefully tape them together. Clamp the wood, template, and Plexiglas together and double-check that all the edges line up properly. Now you can use the template that you see through the Plexiglas to drill your holes perfectly (Figure 15-13). Don't forget to drill the holes for any carriage bolts needed for joysticks and trackballs, and double check the required size of hole for any spinners or special controls. Remember that if you're using a trackball plate with no visible bolts, you don't need to drill bolt holes in the Plexiglas, only the wood!

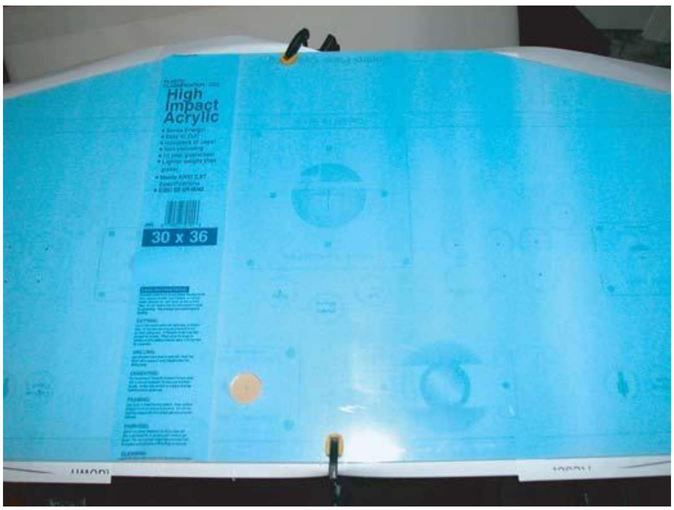


Figure 15-13: The first of many holes drilled.

Once you've drilled all your holes, you can discard the template. If you haven't drilled the holes in your control panel yet, your Plexiglas cover is now the perfect template for drilling holes in your control panel top! Clamp the template to the control panel and drill away, using regular wood-drilling techniques. Voila, a perfectly matched control panel and Plexiglas cover!

If you drilled the holes in your control panel top before anything else, then you can use a similar technique now. Place the Plexiglas between a piece of scrap wood and your control panel top. Make sure the Plexiglas and control panel top are oriented the same way they will be on the control panel box, that is, you don't want to drill one side of the Plexiglas then try to flip it over to place it on the control panel top — the holes won't match up. Firmly clamp everything together and then use the control panel top's holes as your template for drilling the Plexiglas. Once again, a perfectly matched control panel and Plexiglas cover!

NOTE **What about any extra holes to fasten the Plexiglas to the control panel top? In most cases, the joystick bolts and button lips should be enough to hold it firmly in place. If that is not the case, you can drill a couple of small holes for tiny screws as needed. I do not recommend doing so unless necessary.**

The last step is to go over all the cuts and drilled holes and to make sure they are smooth. You don't want jagged edges tearing your control panel overlay or injuring someone. Use a knife to trim away jaggies left from drilling and then gently sand sharp edges with a fine grit sandpaper. Remember to wear a mask when sanding — you don't want to breathe Plexiglas fibers!

Applying the Control Panel Overlay

Applying your control panel overlay is easy enough. Use the same technique as followed for applying side art. If you're using the wet technique, make sure you're not working over electronics. For example, if you've already drilled the holes in the control panel top and it's resting over your control panel box, the hinge technique may be easier.

Before you apply your overlay, I need to remind you to make sure your control panel has a flush surface if you plan to use a Plexiglas cover. Without a cover, your joystick dust covers can just rest above the graphic. With a Plexiglas cover, however, you need to rout out enough space so your dust covers lie beneath the graphic. Make sure you put them in before you lay down the vinyl. You also might consider having the dust cover on top to hide the hole in the Plexiglas, although real arcade machines all bury the dust cover beneath the graphic and leave the hole exposed. Either way, the one thing you can't do is have the dust cover between the Plexiglas and the graphic. Also, make sure your trackball plate is routed flush with the control panel surface before you apply the graphic. In a nutshell, your control panel top has to be smooth before you can apply a Plexiglas cover to it.

If your control panel overlay has graphics on it that have to line up with your controls, such as directional arrows around the joysticks, then you should verify that everything lines up properly before applying the overlay. You can use your Plexiglas cover as an easy way to do this. If everything lines up then you're in great shape — carefully apply the overlay using the method of your choice. If for some reason your overlay doesn't line up, you have a difficult choice to make. If it's not significant, you may choose to ignore the problem. Alternatively, you'll need to re-do the graphic or, in the worst case, re-drill your holes in your control panel top and Plexiglas.

If all has gone well, you now have your control panel overlay properly placed on the control panel top. All that remains is to pierce the control panel overlay at the holes in the control panel top and either trim away the overlay or fold the excess into the holes. If you're using a Plexiglas cover then go ahead and place it on top now. Congratulations! You've now got your control panel ready to install/reinstall the controls!

The Project Arcade 2 cabinet CPO was printed by Game On Grafix on an adhesive vinyl with polycarbonate laminate — a material designed for durability that doesn't necessarily need an acrylic covering (shown previously in Figure 15-6). However, the original Project Arcade 1 cabinet used a different material, and I did cover it with a layer of Plexiglas. You can see how that turned out with the covering in Figure 15-14.

Used by permission of Tom Van Horn.

Figure 15-14: The Project Arcade control panel.

Bezels

The bezel is the shroud or glass covering that goes over your monitor. Its purpose is to look attractive while hiding the insides of the monitor and cabinet that would show around the edges without it. Some bezels are part of the glass covering the monitor while others are plastic or foam inserts that rest between the front glass and the monitor.

In the "Protecting Your Cabinet" section that follows later in this chapter, I discuss placing a sheet of glass over the monitor area to protect the insides of the monitor and cabinet. You can create a bezel for your cabinet by placing artwork or black paint around the inside edge of the glass, thereby masking the parts of the cabinet around the monitor that you don't want people to see. You can also get a glass or Plexiglas screen printed with your artwork at some print shops. If you choose to do this, prepare to spend a bit of money and remember that you want the artwork on the inside of the glass to protect it. That means it has to be reverse printed (which your print shop will be able to handle). A lot of people simply get artwork printed on paper or vinyl and then sandwich the artwork between the monitor glass and another layer of something rigid behind, such as a sheet of Plexiglas or a stiff posterboard backing. I do not recommend gluing your artwork directly to the glass because it is easy to make a mistake and the adhesive may show on the glass. By the way, under the glass covering of the monitor is a great place to put instructions for your cabinet!

In addition to, or as an alternative to, using the monitor glass cover as a bezel, I highly recommend a bezel directly surrounding the monitor itself. Happ Controls makes an easy-to-use black plastic bezel in a variety of sizes that fits directly on the monitor (Figure 15-15). The center open area is sized to fit your monitor, while the plastic surrounding the opening is oversized so you can trim it to fit your cabinet's opening exactly.

Used by permission of Happ Controls.

Figure 15-15: A 25-inch bezel from Happ Controls.

Many people also choose to make their own bezel. Any dark, rigid material, such as poster board or cardboard, can be assembled into a bezel. Most homemade bezels are square, flat, and fit around the frame of the monitor. That works fine, but the Happ Controls bezel is flared out and rests on the outer edges of the monitor tube itself, providing a bit more coverage than a flat bezel. If you combine either of these monitor bezels with a smoked glass cover over the monitor area, players will not be able to see the cabinet's insides while still being able to see the monitor's picture (which is the ultimate goal).

You can find full-sized, pre-made bezel artwork at a couple of places on the Internet. The BYOAC (`www.arcadecontrols.com`) artwork page has one displaying MAME across the top that you can have printed or modify. Zakk's Massive MAME page (`www.mameworld.info/massive`) has an absolutely gorgeous bezel graphic along with some artwork you can use to create your own.

You can purchase bezels from many of the arcade parts shops listed in Appendix A, "Where to Find Arcade Parts for Your Project." They carry both generic black bezels and also NOS and reproduction bezels for many classic arcade games, in glass, Plexiglas, and cardboard. In addition, gameongrafix.com sells many bezels designed for home arcade cabinets. They also have a design-your-own kit where you choose the placement of graphics on the bezel and send it to them to print.

Instruction Cards

You may know where and how everything on your arcade cabinet works, but your guests won't have your detailed knowledge. You can help them out by creating and strategically placing an instruction card or two on the cabinet. The best place to put an instruction card is under the monitor glass on your bezel. Occasionally, some people will place an instruction banner along the top of their control panel. To each their own — if you decide to use an instruction card let the rest of the cabinet's appearance guide you when choosing where to place it.

Creating your instruction card is a matter of spending some time in a paint program such as Paint Shop Pro. Pick a font with a good arcade or video game theme (see the section "Internet Resources" earlier in this chapter) and go to town. With a nice border and a couple of arcade characters, some simple instructions can look very nice on the cabinet and be helpful to boot! You can find some instruction cards already made at many of the resources listed earlier in this chapter. However, because everyone's cabinet is a bit different, the instruction cards are not likely to be useful to you. They can, however, make great starting points and inspiration for your own.

Lighting Effects

Next to the artwork on your cabinet, the lighting effects can really grab attention and look great. The areas that people normally light up include the coin-door return buttons, trackball, pushbuttons, and marquee. You can, of course, get much fancier with lighting, including lining parts of the cabinet with glow-wire, using black-lights (but don't forget their possible fading effect on artwork), and other ideas. Those kinds of things are left as an exercise to the reader, but if you're interested in them you might want to do a Google search on "case mods," which will bring up links relating to modifying computer cases (try `www.coolight.com` as a starter).

I've already discussed lighting the marquee, and I'll cover lighting the coin-return buttons in the coin-door later in this chapter. The one thing I want to cover in this section is how to light up the various things on the control panel. If you have many things on the control panel you want to light up, you can elect to use the simple method of placing a small fluorescent light inside the control panel box. Even a small one will take up a lot of room, though, and may put light where you don't want it. You could use small light bulbs — that's often done underneath trackballs. In fact, most trackballs have a kit you can add to them that allows you to illuminate them by mounting a light bulb underneath. However, light bulbs generate unwanted heat that can warp your trackball and tend to burn out when you least want them to. Is there a better way? Certainly! The lighting method of choice in the arcade cabinet-building community is to use light-emitting diodes, or LEDs.

LED technology has come a long way in recent years, and a new class of LEDs has come out called super-bright LEDs. These generate a powerful but focused beam of light and make great illumination sources for arcade controls. Different LEDs require different voltages, so hooking them up becomes an issue to consider. Most off-the-shelf LEDs don't come in convenient 5- and 12-volt sizes, which means you can't just directly hook them up to the power available in the cabinet. Too much power will burn out the LED, while not enough will make it dim. Most LEDs use less than five volts, so by adding a resistor in line with the LED you can reduce the voltage to what's needed. LEDs will last for years and draw so little current that you can run dozens of them off a PC power supply without making it blink.

In addition to mounting LEDs under items that are normally illuminated, some cabinet builders are going so far as to hack their normally opaque pushbuttons with LEDs lighting them (another wonderful idea from PacMAMEA, `http://1uparcade.rmfx.com`). A small hole is drilled underneath the button, and an LED is inserted so it doesn't interfere with the mechanics of the button but still has the LED leads exposed so they can be wired. This allows even normal buttons to have a glow effect! You can also find illuminated pushbuttons (using light bulbs or optional 12-volt LEDs) at arcade supply houses, and occasionally on eBay you can find the coveted Atari-style, light-up cone buttons, although the latter are rare.

One other popular thing to do with LEDs is to hook them up to your keyboard encoder in place of the Caps-Lock, Num-Lock, and Scroll-Lock LEDs. The Hagstrom KE72, MK64, and I-PAC encoders all have hookups on them for the keyboard LEDs. MAME will flash these LEDs at certain times to mimic the behavior of real arcade games. For instance, several arcade games flash the one-player start button when a single quarter is inserted and both the one- and two-player start buttons when more quarters were inserted. For this reason, some cabinet builders like to place LEDs under their player 1 and player 2 start buttons or place the LEDs directly in the control panel just for appearance. File this under the "great eye candy" category!

CROSS-REFERENCE **Carsten Wessels (whom you'll meet again in the "Inspirational Projects to See" section in Chapter 18) has a tutorial on his Web site (`www.retrospieler.de/e-led-r.html`) explaining the electronics of hooking up LEDs and figuring resistor values. Oscar Controls' Web site also has a tutorial (`http://mirrors.arcadecontrols.com/OscarControls/led/index.shtml`) on connecting LEDs including using super-bright LEDs with the I-PAC, which natively only supports regular LEDs due to available power. Both have allowed us to include the tutorials on the companion CD-ROM!**

Recently, another category of super-bright LEDs has hit the market. These come in various colors (red, blue, green, white, and UV) and are designed to be connected straight into a PC power supply taking 12 volts. These are meant for the case modding community to light up the insides of their computer cases, but credit goes to Zakk from the Massive MAME Web site (`www.mameworld.info/massive`) for realizing their potential for arcade controls. Marketed under a variety of names, these come in kits ready to plug straight into a power supply and have mounting mechanisms that make it easy to point them precisely where they need to shine.

You can find super-bright LEDs at these locations among others:

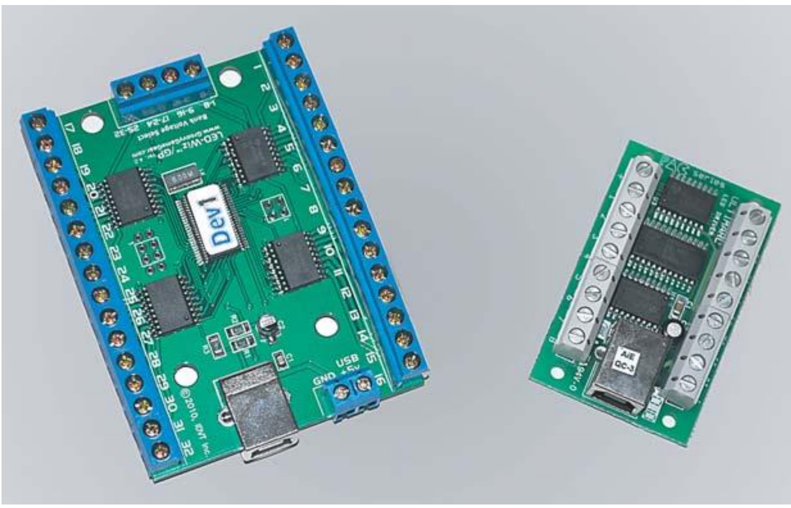
- `www.glowire.com`
- `www.coolight.com`
- `www.svcompucycle.com`
- `www.superbrightleds.com`

Designing lighting effects with your own LEDs can be fun, but there are commercial solutions available to you now that weren't available when the first edition of this book was written. Recall back in Chapter 3 I introduced you to illuminated pushbuttons available from Groovy Game Gear, Ultimarc, and Paradise Arcade. These all work great, illuminate nicely and can be connected straight to an appropriate 5- or 12-volt power source in your cabinet. That's fine, and static illuminated buttons may be all you're after, but what if you want a bit more "bling?"

Enter the LED driver boards and software! With a combination of hardware driver boards from Ultimarc or Groovy Game Gear, and software from the BYOAC community, you can add a variety of great lighting effects to your control panel. Imagine the specific buttons used for a particular game lighting up when you select the game so players know what buttons to use. Picture your trackball cycling through a rainbow of colors for a cool psychedelic effect! These kinds of effects and more are possible with the following products.

Groovy Game Gear has a product called the LED-Wiz shown in Figure 15-16. This is an LED lighting and output controller capable of driving individual outputs at up to 500 milliamps at 5 volts DC. Primarily used as a lighting controller, it could also be used for triggering other devices or relays that run off 5 volts. There's a 32 output model that just runs outputs, and the 16 output LED-Wiz + GP model introduced in Chapter 10 that functions as a gameport controller interface as well. Up to 16 boards can be used together on one system.

Ultimarc's controller is the PAC-Drive (see Figure 15-16), which supports 16 outputs of 500 milliamps at 5 volts DC. In addition to the software support in the following section, the PAC-Drive also has drivers for support in Linux. The PAC-Drive can be connected to devices requiring more than 5 volts or more than 500 milliamps by connecting it to an external power source. For instance, 12-volt LEDs could be used by connecting to at 12-volt power source inside the computer. Up to four boards can be used together as is, or more by special request from the vendor.



Used by permission of Groovy Game Gear and Ultimarc.

Figure 15-16: Left, Groovy Game Gear's LED-Wiz. Right, Ultimarc's PAC-Drive.

Several of the front ends introduced to you in the previous chapter have built in support for the LED-Wiz and PAC-Drive. For instance, MaLa will allow you to light individual buttons based on the game selected. In addition, you can setup an attract mode, where the buttons can flash in a predefined or random fashion. GameEx will allow you to configure light for individual buttons, and also will allow you to assign lights to events. For example, in several arcade games the "start" button would light up once a coin was inserted. GameEx will allow you to do that with the LED-Wiz or PAC-Drive. Other front ends may support these LED boards as well.

LEDBlinky (`www.dndw.com/ledblinky/ledblinky.htm`) is LED software that drives the LED-Wiz and PAC-Drive as well. It integrates with the previously mentioned front ends as a plug-in, but can also operate in stand-alone mode to operate with front-ends like HyperSpin and others. It can light up active/inactive controls in any of the front ends or in MAME directly, allows you to set features such as color and intensity for LEDs, set LEDs to blink and pulse in time to audio output, and other features as well. The feature set is long and highly configurable. If you're at all intrigued by the possibilities, visit their Web site and view the videos they have showing off what LEDBlinky can do.

Light effects add great eye candy value to an arcade cabinet, and can be useful to boot. You can do something as simple as illuminating various controls (see Figure 15-17) to adding glowing animations and special effects. Hardcore eye candy enthusiasts can do more, such as having illuminated ball-top joysticks. Things you can do with illumination are limited only by your imagination!

Used by permission of Happ Controls.

Figure 15-17: Happ Controls trackball with super-bright LED attached.

Protecting the Cabinet

You've put a lot of effort into building and decorating your cabinet so far. Now would be a good time to give some thought to ways you can protect the cabinet from damage. There are a few specific areas you'll want to protect, many of which have already been discussed but I'll recap here:

- **Control panel overlay** — An acrylic plastic cover over your control panel artwork will look nice and may add years to the life of your control panel artwork.
- **Side art** — Side art printed on durable material like vinyl probably does not need additional protection. Less durable material can be protected

with a spray acrylic so long as the printed material is compatible with the acrylic and won't bleed.

- **Cooling** — Cooling the cabinet is another item you probably don't have to worry about. If you notice that the temperature inside is climbing too high, then a fan or two like that shown in Chapter 13 should do the trick.
- **Monitor area** — Whether you have a decorated bezel of some kind, you should put a protective sheet of glass or Plexiglas over the monitor area to protect the insides and keep inquisitive fingers out. Smoked glass 1⁄4-inch thick looks particularly nice and will hold up very well. The glass can be mounted by placing small strips of wood appropriately around the monitor area for the glass to rest against. A small locking strip of wood or mechanism of some kind should be placed on the outside of the glass to prevent it from tipping out accidentally.

The bottom corners of your cabinet are another area you might want to consider protecting. Arcade supply houses like Happ Controls sell corner protectors designed to do just that. These are triangular plates of metal that attach to the corner with screws. If your cabinet is prone to frequent moving you may want to consider these, otherwise they are probably not necessary.

T-molding is the final protective item you will want to think about for your cabinet. Many people consider T-molding decorative, and it certainly is. In fact T-molding comes in many colors, just to match the overall artistic theme of your cabinet. However, T-molding also serves the important purpose of protecting the edges of your cabinet from being bumped and damaged.

Installing T-molding is easy if you've properly routed the groove for it (as discussed in Chapter 2). T-molding is called that because it looks exactly like a T when viewed straight on. The horizontal part of the T is what shows, and the vertical part is what fits into the grooves in the cabinet edges. The T-molding should fit into the grooves snugly; you may need a rubber mallet to gently tap it into place. If it requires a lot of effort then your grooves are too small (or, you got a bit frisky with the paint and need to clean out the grooves). If your grooves are too big for your T-molding, you can fix it into place with a bit of glue as you work it into place in the grooves. Of course, you'll have to hold it or clamp it while the glue sets.

The tricky part of T-molding is working around corners, where the T-molding has to bend. If you're bending the T-molding inwards towards the vertical piece, the vertical part of the T needs to be trimmed. Cut two or three small, triangular notches out of the vertical part of the T as shown in Figure 15-18. If you're bending the T-molding outwards away from the vertical piece, cut straight slits in the vertical part to allow the molding to bend (also in Figure 15-18). Once cut for either direction, work the T-molding around the corner. Be careful, T-molding plastic cuts easily, and it's very easy to slice through the face of the T-molding accidentally.

Used by permission of T-Molding.com.

Figure 15-18: Notching T-molding to go around a corner. Left, inward. Right, outward.

You can find T-molding in a variety of colors and sizes at most arcade parts shops and these specialty stores:

- www.t-molding.com
- www.groovygamegear.com
- www.arcadeemulator.net
- www.happcontrols.com
- www.outwatercatalogs.com

Other Odds 'n' Ends

Almost there! Here are just a couple more miscellaneous odds and ends to pay attention to when putting together your arcade cabinet.

The Coin Door

If you've decided to include a coin door in your arcade cabinet, now is as good a time as any to mount and hook it up. Adding the coin door adds a touch of arcade cabinet authenticity that looks great!

WARNING **A coin door looks great and can make a fun piggy bank to boot. However, the moment you charge someone to play a game on your machine you may be running afoul of local laws regarding running coin-operated machines without proper license to do so. Also, the license under which you've obtained software and arcade ROMs likely doesn't allow operating them for profit. A coin door is for looks and entertainment value only!**

Mounting the Door

Mounting the door into the hole you cut in the front of the coin-door panel is straightforward. Fit the coin door into the hole and then attach the mounting brackets to the screw holes in the door. As you tighten them down, the coin door will fit snugly against the outside of the panel. Don't over-tighten them or you'll start to bite into the wood. Figure 15-19 shows the coin door mounted into the Project Arcade 2 cabinet. Normally there's a metal container that mounts to the bottom of the coin door that holds your coin bucket. For a home arcade cabinet, I elected not to use a mounted container. I simply place the coin bucket on the bottom of the cabinet to catch any coins the kids throw in.

Used by permission of Happ Controls.

Figure 15-19: The Happ Controls multi-player coin door mounted.

Groovy Game Gear sells a faux-coin door if you want one for appearances but don't want to cut out the opening and mount a real door. The UNREAL CoinDoor™ is a 3D rendered, full-scale printed reproduction of an actual coin door you can apply to the front of your cabinet. It won't take coins or let you start a game that way, of course!

Lighting The Returns

The coin-return buttons have lights behind them, and lighting them up adds a very nice effect! If you are using the bulbs that came with the coin door you'll need to check their voltage rating. Some bulbs are rated at 5 volts, some at 6, and some at 12. If you have bulbs rated at 5 or 12 volts, you can power them directly from the PC power supply in your cabinet (using the wiring block to which you attached the voltage earlier in the book). If not, you'll need to provide the proper power, either with a separate transformer or by using resistors with the voltage available in the cabinet as described earlier for LEDs.

What a lot of people prefer to do is replace the bulbs with super-bright LEDs as introduced earlier in the chapter. However, Happ Controls makes this even easier with a drop-in replacement for the bulbs that ship with their coin doors. These replacements are either single or three-cluster LEDs that run off of 12 volts and come in a variety of colors. I chose to replace the regular light bulbs from the Project Arcade 2's coin door with the white cluster LEDs (Figure 15-20). They get power easily from the 12-volt supply in the cabinet and are very bright, making the coin return look great! Because they fit into the mounting sleeve that is designed to attach at the right spot on the coin door, they are easier to use than other LEDs that have to be fastened in place.

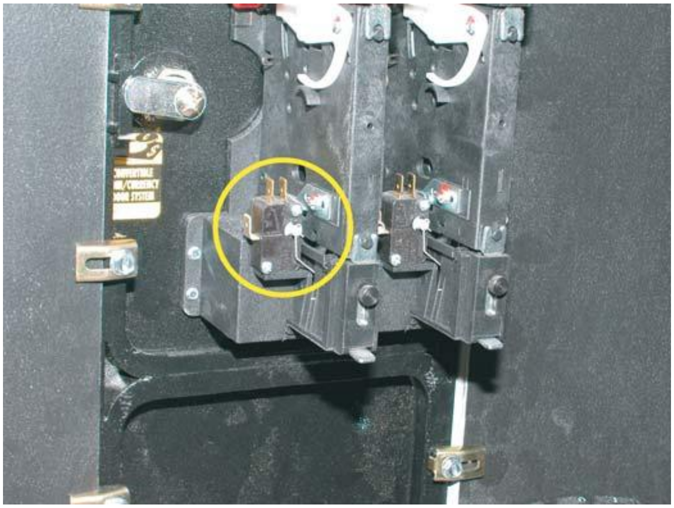
Used by permission of Happ Controls.

Figure 15-20: Regular light bulbs and the three LED super-bright cluster replacements.

Connecting the Coin-Ups

You can connect the coin mechanisms to your interface so that inserting a quarter into the cabinet really generates a coin-up in your emulator or game. Remember the earlier caution about charging people to play your games, though! If you'd like to hook them up (and for the fun of the realism I recommend it, just keep a bucket of quarters nearby for people to play) all you need to know is that they work with a familiar microswitch. The quarter (or token) rolls through the coin mechanism and is either rejected as an improper coin or is accepted and falls through the bottom of the mechanism into the coin bucket. At the last part of the coin mechanism, there's a wire that's pressed down as the coin rolls by.

When the wire is pressed down, it activates a microswitch (Figure 15-21). Simply connect the microswitch to the same place you have your coin-up buttons on your control panel to make both of them functional at the same time!



Used by permission of Happ Controls.

Figure 15-21: Close-up of the microswitch on the coin mechanism.

Groovy Game Gear has a companion to their faux coin door mentioned previously. Their NovaGemCDR™ Coin Drop Replacement Pushbuttons look like coin slots in a real coin door, but are really illuminated pushbuttons. You can use these with their faux coin door and have players push these coin-buttons to add credits. It's not quite the same as dropping a quarter in the machine to coin-up, but it's close and they look good (see Figure 15-22).

Used by permission of Groovy Game Gear.

Figure 15-22: NovaGemCDR™ Coin Drop Replacement Pushbuttons.

Powering The Cabinet

"Scottie, I need more power."

"I'm giving you all she's got sir!"

"Darn it Scottie, I *need* more power!"

Well, the *Enterprise* might have had power issues, but your cabinet won't! I've already covered the low-voltage power inside the cabinet, making 5 volts and 12 volts available for miscellaneous lights and such. What about powering the whole cabinet, however? You could just mount a power strip in the cabinet and turn everything on one by one, but where's the fun in that? This is an arcade cabinet, right? Don't they turn on with a single button?

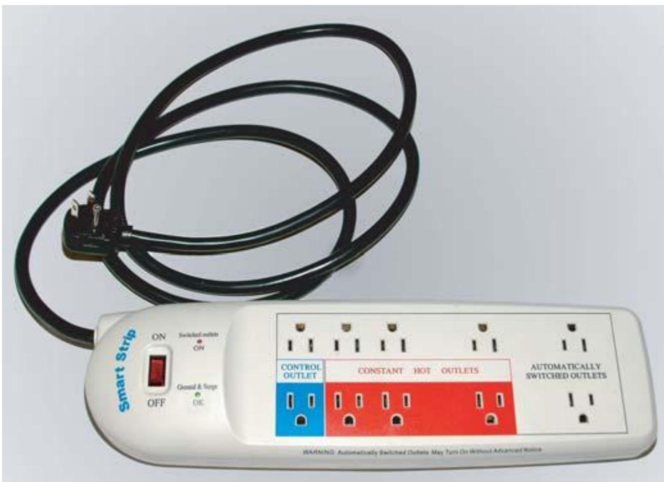
It used to be that if you wanted the single-button power-on effect you had to work with high-voltage wiring. People would hack power switches so they could extend them to a different location. I cannot at all recommend that as there are now commercial, off-the-shelf solutions that achieve the desired results. Leave working with high-voltage electricity to the electricians.

WARNING **Up until now, other than the monitor, everything discussed for your arcade cabinet has been low-voltage stuff. The main power to the cabinet, however, is high voltage. Once again, you need to be careful — do something incorrectly and you can be hurt or killed! The author and Wiley Publishing emphatically recommend that you *do not* do any high-voltage wiring hacking for your cabinet, and that, instead, you use the safe off-the-shelf solutions that are available.**

What home arcade cabinet builders need is a way to power up their entire arcade cabinet with a single button without having a bunch of power cords exiting the cabinet. This is easy enough with the Project Arcade plans because of the open back. Simply mount your power strip conveniently near the opening in back, plug all your equipment into it, and turn everything on with a flick of the strip's power button.

What if you don't have an open back, however, or don't want to have to reach in the back to turn it on? If your PC has the ability to power on with a keystroke (which many computers do; check the system setup on the PC), then you can power the entire cabinet up by pressing a single arcade pushbutton! What makes this work is a clever power strip (Figure 15-23) from a company called Bits Limited (`www.smartstrip.net`).

The Bits Limited power strip has three different kinds of outlets on it. The first is a control outlet. You plug your PC into that. The other outlets are relay outlets. Everything else goes into those. The last outlets are regular power outlets that you probably won't use. The control outlet senses when whatever is plugged into it is turned on. When it realizes something's been turned on, it turns power on to the devices in the relay outlets. Turn on your computer, and your monitor, speakers, and marquee all come powering on as well! All you need to do is include a button somewhere on the cabinet that's connected to your encoder and generates the right keystroke needed to power on your computer. Some computers will power on with the space bar, some with another keystroke or perhaps even a mouse button. Consult the documentation or the system settings on your computer to see whether this applies to you and what keystroke is needed. The power strip from Bits Limited works great and has an adjustable sensitivity for the different power requirements of control devices. Bits Limited acted in direct response to requests from the arcade cabinet community and added a model of their power strip that had a black power cord instead of the default white. They also offered free upgrades to their customers who had purchased earlier versions without the sensitivity adjustment capability. Clearly, a sign of a company eager to please their customers!



Used by permission of Bits Limited.

Figure 15-23: The power strip from Bits Limited.

Summary

Wow! For being a chapter involving odds and ends, there was a lot of material to cover! I hope you had as much fun working through this chapter as I had writing it. From having a functional but unadorned cabinet, you've now progressed through lighting it up, applying artwork, protecting the vulnerable parts, and powering everything up. Now, it not only plays games like a real arcade machine, it looks and acts like one too. You also got to play with power tools again! What a great chapter! What else could there be to talk about?

Well, if you've made it this far without anything going wrong, congratulations! Unfortunately, I had a stumbling block or two as I was putting everything together, and the odds are that you may have run into one somewhere along the line as well. In the next chapter, I'll take a look at where you can go for help and what to do if you get stuck. There are still many exciting things to look at in the rest of the book, so carry on to Chapter 16!

Part

V

Like the Concept but Not Sure You Have It in You?

In This Part

CHAPTER 16

Stuck? Frustrated? Out of Quarters?

IN THIS CHAPTER

- **Troubleshooting Tips**
- **Getting Help**
- **Giving Back**

It's inevitable. Like the way a younger relative puts you to shame on a game you thought you were the master of, sooner or later a problem may get the better of you. No matter how good your plan or how skilled you are, you're likely to come to a point in your cabinet building where you need some help. Even the mad scientist had Igor! Where can *you* go for help building your arcade cabinet? Right here! I'll start by pointing out a few troubleshooting tips for commonly encountered problems and then move on to places you can go for extra assistance if needed. Read on!

Troubleshooting Tips

Getting stuck can be incredibly frustrating. The most important thing to remember is not to panic. I had my share of problems when I put together Project Arcade 1 and 2, and everything turned out, not only well, but outstanding, in the end. Whatever challenge or hurdle is in front of you, it's likely that someone has dealt with it before. There's no way to predict exactly what issue you might run into. However, several problems seem to come up time and again, and I'll try to help you out with those. Start your way out of your problem with these basic troubleshooting tips. Some are common sense, and some are specific to issues that have come up before in these kinds of projects.

Cabinet-Building Conundrums

Most cabinet construction issues fall into the common sense category. It's important to spend some time here and get everything right. Computer, controls, and software issues can all be dealt with at any time. Your cabinet, however, will be difficult if not impossible to tweak once it's all put together. The following are some common pitfalls you may encounter and possible solutions.

Minor Wood Fitting And Placement Issues

This is a likely problem, particularly with angled cuts. If the problems are minor, a bit of cosmetic touchup is likely all that you'll need. I ran into this problem more when building Project Arcade 1 (before I had a table saw) but still had some issues with Project Arcade 2. My angles weren't all perfect, and I had a visible gap between two back pieces that should have been flush. Because this was the area that would house the marquee light, I couldn't just ignore it or you'd see light shining out of the back of the cabinet. Once I applied wood putty, the gap could not be seen (see Figure 16-1). While I was focused on that part of the project it was frustrating, but once I patched it and moved on to other areas I realized it didn't matter at all. I was stressing about something that no one but I was ever likely to see, much less notice that it was patched, even if they did see the back of my cabinet.

Lesson learned: *Don't let minor cosmetic issues bother you*.

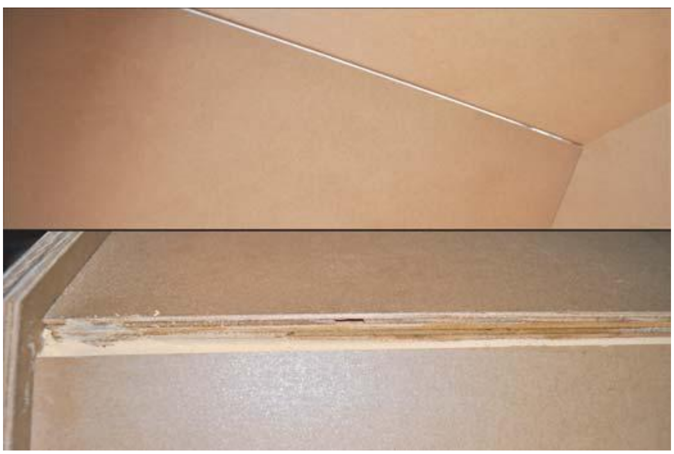


Figure 16-1: Top — front view of the gap with light shining through. Bottom — rear view with the gap sealed with wood putty.

Major Wood Fitting And Placement Issues

Hopefully you won't run into a major problem. If you do, however, you have several options. If the problem doesn't affect the structural soundness of the cabinet, you can disguise the problem. If it does affect the stability of the cabinet, you'll need to take steps to correct it, even if it means buying new wood and rebuilding a section. The base of my cabinet ended up about 1/8-inch narrower than I'd planned, and so I ended up trimming each horizontal piece to match as I went. Not a big deal. Panel C, however, I ended up cutting one of the angles facing the wrong direction (Figure 16-2). There was no way to fix that and so I had to re-cut the entire piece.

Lesson learned: *It's better to bite the bullet and do it over than to try to make do with a major defect*.

Figure 16-2: Panel C — there is absolutely no way to fix this one!

Painting Problems

Your paint job may or may not be a major issue to you. If you're going to have your cabinet in a dimly lit basement game room, you might not be terribly concerned about imperfections. If your project is going to be the centerpiece of a brightly lit family room, however, then a good paint job can make or break the appearance of the cabinet. If you're having problems getting it to look the way you want, double-check these tips:

- Make sure you're using the right paint and tools. Generally, a latex semi-gloss paint is a good choice for MDF or MDO based cabinets. Also, not all rollers/brushes are made alike. Make sure the tools you use are meant for the paint you're using and the finish you're after. A builder's grade paint roller will not give you the best results on your cabinet's surface! The folks at your paint store can help you out if you're not sure.

- Proper surface preparation is key. Make sure you've applied a layer or two of primer and that you're sanding the surface smooth between coats of primer and paint. If you're after a really smooth finish, don't be afraid to sand it almost down to the next layer with fine-grit sandpaper. Multiple thin coats of paint will yield better results than fewer and thicker layers. Don't overlook the appeal of a slightly textured surface, however. It can look just as nice as a mirror smooth surface and is much easier to achieve.
- Don't rush the painting. Use nice smooth strokes while you are painting and take your time. Then make sure you leave enough time for the surface to dry completely between coats of paint. Read the drying times for your paint and stick to them. Don't be afraid to take several days for the entire paint job.

Lesson learned: *Using the right material and tools and taking the time to do the job properly will yield much better results than trying to hurry this step along using the wrong material and tools.*

Problems Getting Tools To Cooperate

Trying to accomplish something when you don't have the right (or working) tool for the job is incredibly frustrating. It can even be dangerous. A good example of the wrong tool is attempting to cut the groove for t-molding without a slot cutter bit in Project Arcade 1. My buddy and I tried using a Dremel rotary tool, first. It was extremely slow and almost burned up the tool. Next, we tried a router with a straight cutting bit. It was fast enough but essentially impossible to guide in a straight line (due to the narrow edge of the wood, we weren't able to use a straight-edge guide). Finally, my slot-cutting bit arrived in the mail. Using it, I was able to cut perfectly straight grooves easily and accurately in very little time. I was literally able to work about ten times as fast with about one-quarter of the effort.

Even if you have an adequate tool, investing in another tool may be a good move. I had issues making angled cuts in Project Arcade 1 using my jig saw. My angles didn't end up very straight and the degree of the cut wasn't as accurate as I'd have liked. I used a lot of sanding, wood putty, and paint for those! The table saw I bought for Project Arcade 2 made a world of difference. Setting up accurate cuts only took a moment and they were straight as a ruler. The jig saw is certainly an acceptable tool for the job and a better woodworker probably wouldn't have the problems I had, but the table saw gave me professional results without professional skill.

Sometimes you have no choice and simply have to work with what's available. However, if you have the option then buy, rent, or borrow the proper tool for the job in front of you. There is simply no acceptable substitute for having the right tool for the right job.

Lesson learned: *Using the right tool for the right job isn't just a cliché*; *it will save you time and frustration in the long run*. *Trying to use the wrong tool can also be a safety hazard*!

Gain A Fresh Perspective

If all else fails, take a break and come back to it later. It frequently amazes me that what seemed insurmountable after a long and frustrating work session is easily solved when you look at it after taking a break. I've also regretted the times I've attempted to force something to do what I wanted when I was tired and frustrated, and ended up making things worse. Consider getting a second opinion from a buddy as well — a neutral perspective may be just what you need.

Lesson learned: *Building a cabinet shouldn't be a race*. *Taking a break and coming back with a fresh perspective is much easier than trying to brute-force a solution when you're frustrated*.

Software Snafus

Setting up your computer and games is likely to throw up an occasional stumbling block as well. Much of what you'll put into your arcade cabinet is pieced together from multiple sources and not from a single software solution. That means it's possible that you'll run into issues getting everything working together properly. Here are a few tips to help you stave off software snafus.

Identify The Culprit

The first step in resolving a software problem is identifying where the problem lies. A blank screen that appears when you launch a Multiple Arcade Machine Emulator (MAME) game through the MaLa front end could be a problem with the emulator, the front end, the ROMs being used, or something else entirely. Where do you start troubleshooting? Start with a process of elimination. The game should run straight from the emulator without the front end, so try that. If running it manually in MAME works, but running it with MaLa does not, then something has gone wrong with the front end. If it won't work in the emulator directly, there's no point in even looking at the front end until you have it working with the emulator. If you have another computer, try running the emulator and ROM on that system. If it works there, but not on your cabinet's computer, you probably have a configuration or driver issue. If it won't work on either computer, then the ROM may be corrupt or emulation of that game may not be working yet.

Lesson learned: *Identifying the root of the problem is the first step toward fixing it*. *Approach it methodically and work through the issue step by step*.

Check Your Paths

Probably the most common issue that comes up with emulators and front ends is using incorrect directories (also known as folders) or not specifying them properly. Emulators have to know where the ROMs are for the games you want to play, and front ends have to know that and where the emulator is as well. Most assume a standard set of defaults. For instance, the usual default for MAME is C:\MAME for the emulator and C:\MAME\ROMS for the ROMs. If you're using different directories, make sure you've configured the emulator and/or front end appropriately. Several front ends tested while writing this book assumed that they were installed in the same directory as MAME. I ran into this while testing because I used separate subdirectories for each front end to keep things cleaner. Obviously, those front ends that need to be in the same directory as MAME wouldn't work. It took me some head scratching and consultation on the message forums to figure that out because that requirement wasn't always clearly documented.

Lesson learned: *Pay attention to the directories used when installing your software, and make sure that what you have configured or what the software requires matches what you actually have.*

Just The FAQs, Ma'am

If you're having problems with a specific emulator or front end, see whether there's an appropriate FAQ or wiki. If there is one, it might have the answers you're looking for. MAME's FAQ can be located at `www.mame.net/mamefaq.html`. The BYOAC wiki has FAQs and guides for a variety of related subjects as well!

Lesson learned: *The problem you have may have already been addressed by the software developers or the community; take a look.*

NOTE FAQ stands for Frequently Asked Questions and usually refers to a document containing those questions and the answers. A wiki is a Web page that can be edited and updated by users, and wikis are often used these days in place of or as supplements to more traditional documentation.

Come Back To It Later

Sometimes with emulation and gaming software, giving up *temporarily* is the right thing to do. The problem may be one that's not solvable with the tools available to you at the time. Particularly with emulation software, remember that you're usually not purchasing an off-the-shelf commercially supported product. Emulating another hardware and software system is complex, and first efforts often come with bugs. In fact, those bugs may be known and documented at time of software release or shortly thereafter. For instance, the MAME Testers Web site (mametesters.org/) was created specifically to help identify bugs in MAME and to track their statuses. This is a good place to check if you're having a problem with a specific MAME game. If there's a known bug, you have two choices — wait for a new version to hopefully correct it or, in the case of open source software, you might consider looking at the code and helping to fix it. Either way, emulation software often gets updated with a host of bug fixes after its release. This also applies to front ends, operating systems, and hardware drivers.

Lesson learned: *Sometimes a problem with a particular piece of software simply can't be solved. With thousands of other games available, learn when a problem isn't worth further troubleshooting efforts and mark it for a return visit when the software's been updated.*

Update Everything

If you're having a problem you can't figure out, make sure every piece of software involved is up to date. A sound issue in an emulator could be a fault in the emulation or it *might* be a problem with older sound card drivers. Display problems? Make sure you have the latest version of your video drivers and Direct-X from Microsoft installed on your system. Making sure all your software and all hardware drivers are fully up to date can save you time troubleshooting. However, there is one instance where you might want to take the opposite advice: Because MAME is a documentation project first and foremost, later versions of MAME sometimes break (temporarily) games that worked in earlier versions. Reverting to an earlier version is sometimes the easiest way to resolve a particular game problem.

There's a potential downside to updating however. As emulators (particularly MAME) get updated, the hardware requirements often go up. It may be that the updated version of the software you need requires more horsepower than your computer can supply. Your choice then is to either do without, or to upgrade your hardware. It'll come down to how important the specific problem you're trying to solve is to you.

Lesson learned: *The problem you're facing may be solvable simply by updating (or in rare occasions, reverting to an earlier version of) the software you're using.*

Getting Help

If a bit of extra time and the previous troubleshooting tips didn't work, then it's time to ask for help. Fortunately, you have many resources available to you. There are many online resources dedicated to this crazy, wonderful hobby. I'll introduce you to some of the best places to get help in this section.

How To Get Help, And How Not To

By picking up this book and thinking about or actually building your own arcade cabinet, you've joined a select but growing group of retro-gaming enthusiasts. By conservative estimates, there are a few thousand home-built arcade machines out there, and more are being built every day. This means that, although you may have found a unique idea to try, for the most part the path you're traveling has been walked upon before. One of the signature marks of this hobby is the overwhelming number of people who donate time, effort, and money (by financing a product or hosting a Web site) to help others join the fun. These people have documented, photographed, and self-published via Web sites and message forums their contributions to the hobby for all to share.

These are all wonderful resources you can turn to for help. However, this also means a bit of effort is warranted on your part when you seek answers. Newcomers to the hobby are always welcomed enthusiastically, but it is important that you've taken advantage of the available resources to try to find your answer. For instance, a request such as this is likely to find many helpful answers: "*I've searched the Web site and message forums, but I am still unclear on this point. How do you mount the marquee at the top of the arcade cabinet without screwing holes into it*?" On the other hand, a request along the lines of this next one is more likely to get a curt reply to read the available documentation (or to be ignored) than anything else: "*Need someone to explain to me step by step how to build an arcade machine. E-mail it to me. Thanks.*" Almost every aspect of this hobby has been documented in some fashion, so take the time to read about it first. Not only are you likely to find your answer that way, but even if you aren't, you'll be able to ask more specific questions than a general cry for help.

If you do need to ask for help, use the public forums whenever possible as compared to e-mailing someone directly. There are several advantages to doing so. Instead of relying upon a single person to help you, by posting in a public forum you allow for the possibility of hundreds or thousands of people being able to assist you. Also, many people who have some public presence in this hobby (such as the first one to create a rotating control panel) can receive hundreds of e-mails weekly. Personally speaking, it sometimes takes me more than a week to respond to e-mails that come to my public e-mail addresses. By posting to a public forum you can often get an answer in minutes or hours instead of days. Finally, and probably the most compelling reason to ask for help publicly, is that the question you're asking is one that someone else is probably wondering about as well. By getting a good discussion going on the question and possible answers, that information will be available to the next person in the future. That's truly the strength of the Internet at work!

Helpful Web Sites

You can find many excellent Web sites relating to the emulation and arcade cabinet-building communities. Most of the sites are dedicated to a particular aspect or genre of the hobby. For instance, just about every emulator and front-end program has a home Web site, as referred to when introduced in this book.

CROSS-REFERENCE **You'll find a clickable list of these Web sites on the companion CD.**

You can also find a few Web sites that are broader in scope and should be on your list of places to go to for more information and assistance.

Project Arcade 2

Project Arcade 2 (`www.projectarcade2.com`) is the companion site for this book. Until the third edition of this book comes out (I can dream!), changes and updates from the time of this printing will make their way to the Web site. Any errata will also be posted here, and you'll also find the link to the support forum for this book. The companion Web site is probably your first stop on the Web when building your cabinet!

BYOAC

A great place to get help is the Web site that was the spark behind writing this book, the Build Your Own Arcade Controls FAQ at `www.arcadecontrols.com`. You'll find how-to instruction guides, hardware reviews, utilities and multimedia downloads, and a several-thousand-member active user community at BYOAC. BYOAC is also the home to the comprehensive examples database, listing and linking to more than a thousand arcade cabinet and joystick console projects at the time this book goes to press.

Unquestionably the most active sections of the BYOAC Web site are the message forums. This is where you can go to meet and discuss arcade cabinet-related issues with other like-minded folk. Message forums at BYOAC include the following:

- **Main forum** — This forum contains the bulk of the discussions at BYOAC. Anything that doesn't fit into a dedicated forum goes here. Frequent topics of conversation here occasionally spin off a dedicated forum. Help for anything from building arcade cabinets to discussing arcade controls to purchasing components can be found here.
- **Buy/Sell/Trade** — As the name suggests, this is a marketplace for people to buy, sell, or trade anything related to arcade cabinet building. Commercial vendors are welcomed here. Need help finding a rare part? This forum is for you.
- **Software** — This forum is primarily devoted to front-end programs, emulators, and other arcade cabinet–related software topics.
- **Monitor/Video** — This forum is for discussing all things related to monitors and video cards.

- **Audio/Jukebox/MP3** — This is a forum for the discussion of speakers, sound cards, juke boxes, MP3s (legal only please!), and all things audio related.
- **Project Announcements** — This forum is a place to announce new projects in the works, brag about your continued progress, and get feedback while you're still working on your project. This is also a great forum for finding inspiration for your project!
- **Artwork** — Looking for artwork for your cabinet or willing to provide it to others? Seeking comments on artwork you've created? Post about it here!
- **Consoles** — A forum for bringing arcade cabinet–building concepts to the world of game consoles such as the Xbox and PlayStation.

With more than 195,000 topics of discussion across 28 sub-forums as of the time of this writing, you're likely to find that just about any issue you're having problems with has already been discussed here. If not, feel free to start a new topic of discussion. Chances are it won't be long before you're on the way to solving your problem!

MAMEWorld

MAMEWorld (`www.mameworld.info`) dubs itself as the largest MAME resource on the net, and with good reason. Not only is it an absolutely wonderful emulation news site, it also hosts a plethora (and that's really the appropriate word here) of sections and specialty sites devoted to MAME. Have a question about MAME artwork? MAMEWorld has answer for you. Want news about what's happening in the world of MAME? MAMEWorld's your source. Granted, MAME is not the only thing you're able to play on your cabinet. However, almost every emulation cabinet out there does run MAME, so quality MAME help is good to find. MAMEWorld is *the* go-to site for MAME support on the net.

KLOV

KLOV (Killer List of Videogames), hosted by the International Arcade Museum (`www.arcade-museum.com`), is the home of the de facto authoritative database of coin operated video games. You'll find a page for almost every coin operated video game ever created, with pictures and details about the game. They also have an incredible message forum dedicated to the hobby. Where BYOAC is arguably the default home of the build-your-own crowd, KLOV is the default home of the coin-op collector crowd. There's inevitably overlap between the two hobbies, and KLOV is on my daily visit list — highly recommended.

Newsgroups

Usenet newsgroups are another wonderful Internet resource you can turn to for help. A newsgroup is a discussion forum that is not hosted in any one central location but instead is decentralized across the Internet. Messages in a particular newsgroup are copied from server to server, and to access them you simply need access to a server that carries the newsgroup you're interested in. It used to be that your Internet service provider had to carry the newsgroup you wanted to read or you were out of luck. However, these days you can access newsgroups online through Google Groups (`http://groups.google.com`). There are two groups of particular interest to arcade cabinet enthusiasts:

- RGVAC — Rec.Games.Video.Arcade.Collecting (`groups.google.com/group/rec.games.video.arcade.collecting`) is a newsgroup dedicated to discussions about real arcade machines and collecting them. It is *not* an appropriate place to discuss emulation-related topics and matters specific to home arcade cabinets. There is much overlap, however, between a home arcade cabinet and a real classic arcade cabinet. For instance, discussions on repairing arcade monitors or painting techniques for arcade cabinets are certainly on target.
- RGVAM — Rec.Games.Video.Arcade.Marketplace (`http://groups.google.com/group/rec.games.video.arcade.marketplace`) is a place to discuss buying, selling, and trading items related to arcade collecting. This is a good group to keep an eye on for arcade parts and the like. Topics are often cross-posted to RGVAC as well, but that should really be avoided to keep the noise level there down.

It's time to bring up the warning about the wild nature of the Internet again. You'll find the best and worst of people on the newsgroups. In addition to wonderfully on-topic discussions and useful information, you'll find occasional profane or hate-filled postings. Sadly, time has taken its toll and there's almost as much noise as useful information on the newsgroups these days. Filter it out and they're still an excellent resource — just be prepared to wade through some muck to get there.

Giving Back

Okay. So you've done your planning and gotten started. You've probably made mistakes, skinned your knuckles, or perhaps thought of something unique and brilliant. Hopefully this book or one of the many projects out there has inspired and helped you. Finally, you're faced with the results of your efforts, a beautiful home arcade cabinet! Are you done?

Maybe not — you might want to consider *one more thing* when it comes to your arcade cabinet project. Presumably the wonder you've created came about with the help and advice of others. Wouldn't it be great if you could give some of that back to the community now that you're an arcade veteran yourself? Wouldn't it be fun to brag about your creation to an appreciative audience? You can! Being a community, there are a few ways you can help out (or brag to) the next person trying to reach arcade cabinet happiness. Document what you've done, what you've learned, what you'd recommend, and what you'd avoid! Don't forget what it was like when you were just getting started. Someone else is just beginning, and they could use all the help you're able to give!

Build A Web Site

Start by considering a Web site. It doesn't have to be anything terribly fancy, although once you've mastered an arcade cabinet project putting together a nice Web page should be no challenge at all. If you took my advice in Chapter 1, you've already got the makings of a Web site in the construction diary you've been keeping. Even if you haven't kept track as you went along, reconstructing the basic steps probably won't prove too difficult. A Web page with some good photos of your project, along with a description of anything particularly complicated or unique about your cabinet, makes a great addition to the arcade cabinet–building community.

If you have an Internet connection, chances are your Internet service provider has given you some Web space on which you can host your arcade cabinet project. If not, you can find several Web hosting companies willing to host your site for free in exchange for placing ad banners on your site. You can also ask on the message forums; occasionally someone there is willing to host an ad-free site for you. If you're just looking for a place to host your arcade project, I'll be happy to host it for you on BYOAC at no cost!

Join The BYOAC Community

If a Web site is outside the scope of things you're up for, consider becoming an active member of the BYOAC community. Even if you do put up a Web site, we'd love to see you join us online. Becoming an active posting member of the message forums at `www.arcadecontrols.com` is sure to give you a great feeling, and helping someone with a problem is good karma! If you don't want to do a whole Web page but still want to share photos and tips, the Project Announcements forum of BYOAC is a great place for you to have your own personal build journal.

Aside from the regular message forum postings, there's a semi-regular group that meets in the BYOAC chat room. You'll find the chat room linked off the message forums at the BYOAC Web site.

Finally, you can help contribute to the BYOAC wiki. As compared to the main Web site, the BYOAC wiki is entirely created by the community with only a little input from the author. If you've solved a particular puzzle or have a great tip to share, along with the forums you can permanently document it in the wiki.

Joining the BYOAC community is not only a good way to get and give help; it's also a great group of like minded people to hang out with online. We hope to see you there!

Summary

Building an arcade cabinet and using emulation software on it is a bit of an adventure into the unknown. Although the hobby has matured greatly over the years, and has evolved from the sparsely documented beginning days, there's still new territory being covered. It's an interesting time to be involved in the hobby, but recall the curse "*May you live in interesting times*." Fortunately, if you run into uncharted waters there are several resources you can turn to for help. Web sites, newsgroups, and online discussion forums are great places to turn to when you run across a stumbling block. Do your homework first, and you'll find many people and places happy to help you along your journey to arcade paradise!

Building an arcade cabinet is the ultimate expression of this hobby. However, not everyone wants to go the full distance at first or put in all the time and effort. Some people are just interested in a better way to play games than the keyboard, and are looking to buy their way to arcade fun rather than build their own. If that's you, I've got something for you in the next chapter!

CHAPTER

17

Buying Your Way to Gaming Nirvana

IN THIS CHAPTER

- **Kits**
- **Arcade Controllers and Cabinets**
- **Game Console Controller Adapters**

Building an arcade control cabinet is an incredibly rewarding experience. It can also be a costly one — in terms of both time and money spent. Some people have built full-sized arcade cabinets for a few hundred dollars, but most will spend somewhere between $1,000 and $1,500 (some will spend more) when all is said and done. This includes the costs of tools, mistakes, and other "first-time" expenses. If you're planning to build more than one, the costs usually go down based on lessons learned and tools obtained for the first. If you're only planning to build one cabinet, for the same amount of money you might consider purchasing something in kit form that will take you a day to build instead of days and weeks. You have a lot of great choices if you'd like to go this route! Of course, you can also find preassembled cabinets in the $3,000-plus range if you want top of the line! I'll take a look at some of the offerings here and point you to the rest online. Check your wallet, and dig in!

Kits

Kits are a great compromise between building your own from scratch and buying an arcade cabinet fully assembled. Normally, I shy away from hardware reviews in a book format because the information gets dated so quickly. (Reviews can be found online at the Build Your Own Arcade Controls [BYOAC] Web site if you'd like to read more.) However, all the kits in this section were sent to us for a hands-on review, so I'll share my results here. The kits were placed into the hands of my buddy Mark. Mark is an arcade enthusiast who has never delved into building his own arcade controllers or cabinets before (other than a brief stint with the router while building Project Arcade) and, as such, made a perfect test case for the ease and completeness of these kits.

NOTE **The line between kit and full cabinet blurs a bit on the next few pages. Some of the kits I'll show you are also available fully assembled, and vice versa. I'll introduce them to you in the manner in which I received them or that I think you are most likely to want to buy.**

Some comments apply to all the kits in general. Any of these kits can be built within a few hours. If you have assembled any furniture in kit form before, such as bookshelves available at any department store, then these kits will look familiar. As a rule, all of the packages were heavy so arrange to have a buddy help you with the lifting. Quality varied from plain but serviceable furniture to top-of-the-line, "Wow I gotta have that!"

CROSS-REFERENCE **Space constraints only allow for one picture at most per kit or cabinet included here. On the companion CD-ROM, I've included several shots of each item, where available, so you can get a really good look at them.**

Arcade Depot Cocktail Kit

Arcade Depot (`www.arcadedepot.com`) sent a cocktail kit for review (see Figure 17-1). Initial impressions were in the "wow" category. The kit came in two, incredibly well-packed boxes. The cardboard boxes were framed inside with wood boards and contained plenty of packing material. The cocktail glass had no less than 25 rubber bumpers placed on it with packing material, and the box was clearly labeled not to lay it flat. Needless to say, everything arrived in perfect condition!

Assembling the kit went quickly. Printed instructions included many pictures, and instructions were detailed and complete. Tricky points along the way were anticipated and pointed out, which helped to avoid problems. The cabinet is constructed of plywood, dowel pins, and wood glue with a few screws and brackets thrown in for extra support. The control panels are a tad small as befits a cocktail cabinet, which normally houses games with a single joystick and a few buttons, but a third and larger control panel option is available for the side. The control panels are made of metal and are available as blanks with pre-drilled holes in a standard pattern or with customized pre-drilled holes, depending on your needs. We were very impressed with the quality of the kit. You will need a screwdriver and a variety of clamps for optimal construction.

Used by permission of Arcade Depot.

Figure 17-1: The Arcade Depot cocktail kit (assembled).

The only question left after constructing the cabinet is how to mount the monitor. The hinged door is meant for cabinet access only and will not support the weight of a monitor. You will have to determine your own method for installing the monitor, computer, and joysticks. This would be a good candidate for a light-weight LCD monitor. Depending on the options selected at time of purchase, prices for the kits range upward from $200.

This is a great little kit and is very reasonably priced. Arcade Depot also sells preassembled cocktail cabinets, including a replica Ms. Pac-Man cocktail cabinet complete with inside electronics and cabinet graphics.

HanaHo ArcadeWerX

HanaHo may not be a familiar name if you are new to the home arcade cabinet hobby, but, if you're an arcade veteran, then you're familiar with their work.

They have been building arcade cabinets for arcade manufacturers for 30 years, such as the Dragon's Lair cabinet, among many others. HanaHo *knows* arcade cabinet building, and it shows! They sent one of their ArcadeWerX mini cabinet kits for us to build (`www.arcadewerx.com`). It was packed extremely well and made it to us in great shape. The assembled cabinet is shown in Figure 17-2.

The instructions included for assembly are very well documented and include many construction pictures. There were no ambiguous points so mistakes were easily avoided. There are a lot of wrist-killing screws and bolts in this kit and use of a power screwdriver is highly recommended. The kit is constructed from 3⁄4-inch, melamine-laminated wood with a black finish and matching black t-molding. HanaHo includes several nice touches in their kit, such as the professionally made ArcadeWerX marquee, locking front panel (keys are taped to the back; remove before assembling!), and a Number 3 Phillips Bit. Everything in the kit spoke of the quality that comes from years of experience.

Used by permission of HanaHo Games.

Figure 17-2: The ArcadeWerX mini cabinet.

The cabinet does not come with a control panel. It is designed to work with the HotRod control panel from HanaHo (shown later in this chapter), or you can build your own to fit the space provided. This makes a great kids' cabinet (see Figure 17-3) or a sit-down cabinet. Adults will not want to play on it for long periods of time standing up because it will grow uncomfortable. However, HanaHo also sells an optional stand you can add that raises the cabinet by 10 inches.

The ArcadeWerX sells for $600. When you apply the included full-sized side art and light up the marquee, you have a great looking mini arcade cabinet! This cabinet is destined for the kids' playroom and is sure to be a favorite for years to come.

Used by permission of HanaHo Games.

Figure 17-3: My children look over their new ArcadeWerx cabinet.

North Coast Custom Arcades Bartop Kit

North Coast Custom Arcades has been in the home arcade community for many years. They got their start selling cabinet plans and soon after expanded to cabinet kits and complete controllers and cabinets. The first bit of gaming goodness I laid hands on from North Coast Custom Arcades was their Ultimate Bartop I kit shown assembled in Figure 17-4.

Like everything else I've received from them since, the Ultimate Bartop cabinet kit is a well-designed, sturdy piece of arcade gear. Although compact, there is enough room inside that I was able to install a full sized computer motherboard, power supply, keyboard encoder, and a 15-inch CRT monitor. Still, at 27 inches from front to back, it ended up being too big to fit on my bar counter. Instead, it has a dedicated spot on a small table up in my study. It actually gets as much play time as any of my other arcade machines because it's always right here near me when I need a break, though I often have to wait my turn because my kids are on it!

Used by permission of North Coast Custom Arcades, Game On Grafix, and Pixelhugger.

Figure 17-4: The North Coast Custom Arcades Bartop Kit with artwork from Game On Grafix.

North Coast Custom Arcades Ultimate Arcade II Kit

You should be intimately familiar with the look of the Ultimate Arcade II kit from North Coast Custom Arcades. This is the kit version of the Project Arcade 2 cabinet built for this book! The kit is virtually identical to the cabinet built from the plans with a few minor differences. You can see the kit cabinet next to the scratch-built cabinet in Figure 17-5. Can you tell which is which without looking at the caption?

Building the Ultimate Arcade II cabinet from the kit was an enjoyable and relatively quick experience. It was extremely well packed and came in multiple flat boxes. The kit has comprehensive assembly instructions. A variety of accessories are available, such as t-molding, Plexiglas, and control panel blanks among others. Take a look at the "before" picture of the unassembled kit in Figure 17-6.

Used by permission of North Coast Custom Arcades.

Figure 17-5: The North Coast Custom Arcades Ultimate Arcade II Kit on the right next to the in-progress Project Arcade 2 cabinet.

Used by permission of North Coast Custom Arcades.

Figure 17-6: The Ultimate Arcade II Kit — unassembled.

Although it may look like I had some work in front of me, the kit assembled quickly and easily enough and, once assembled, was rock solid. It differs from the Project Arcade 2 cabinet in that the kit includes back panels while the scratch-build cabinet leaves the computer area open. Other than minor differences in this vein the cabinets are identical, and, if you like the idea of the Project Arcade 2 cabinet but don't want to build it completely from scratch, this kit is a great option!

North Coast Custom Arcades holds the crown in the arcade kit race, offering no less than 12 different kits you can buy. Aside from the Ultimate Arcade II and bartop cabinet kits in this section, they also have multiple cocktail, pedestal, jukebox and controller kits along with a variety of control panel bases and stands. They have something for pretty much everyone, and all of their kits are well designed, documented, and easy to assemble.

Other Arcade And Jukebox Kits

Several other arcade cabinet and jukebox kits are available that we, unfortunately, were not able to review. If you're interested in any of these, you should read and ask questions about them on the various message forums. These kits include the following:

- Mike's Arcade (`www.mikesarcade.com`) is a familiar name to members of the arcade building community. Known more for his work in the emulation community and for selling arcade parts and repairs, he also sells replica Ms. Pac-Man and Galaga arcade cabinets. Designed for rebuilding actual Ms. Pac-Man and Galaga arcade machines, they can also easily be used as home arcade machines.
- Mountain Jukebox (`www.mountaindesigns.net`) sells a gorgeous bartop jukebox kit reminiscent of old time soda shops and classic rock and roll. I admit I have a problem. When it comes to this hobby, like Pokemon, I "gotta catch 'em all," but of all the cabinets and kits out there I really regret not laying my hands on one of these before the book published. By the time you read this I probably will have one. These kits started as a single jukebox built by the soon-to-be manufacturer as a gift for his father. When the BYOAC community saw what he had built, they all but *demanded* that he go into business selling them (and he did)! Emdkay.net sells a marquee custom designed to fit the jukebox's unique curved front marquee area. This kit is definitely worth a look!

Arcade Controllers And Cabinets

If building a kit isn't your cup of tea, you can purchase a ready-to-play setup from a variety of places instead. Both desktop arcade controllers and arcade cabinets are available.

CROSS-REFERENCE You can find pictures of many of the controllers and cabinets listed in the following sections on the companion CD-ROM.

Desktop Arcade Controllers

You can find a lot of people making and selling desktop arcade controllers. Many people make them one-at-a-time and customized to your specifications. A list of those would be impossible and out-of-date almost immediately, but, if you'd like to find them, you can look on the BYOAC (`http://forum.arcadecontrols.com`) and Shoryuken (`http://shoryuken.com/forum`) message forums. These can make great additions to a game room, and I would not hesitate to consider one just because they do not have a company behind them. However, the backing of a company usually means a certain level of support and speed so be aware of all the factors (ask) before you purchase.

You have several choices of businesses selling arcade controllers:

Dream Authentics / Retro Arcades

Retro Arcades is the controller/parts division of Dream Authentics (`www.retroarcadeslive.com`). They sell both blank and fully populated arcade control panels, and you can see the one we received in Figure 17-7.

Used by permission of Dream Authentics

Figure 17-7: The Dream Authentics / Retro Arcades Quad Arcade Control Panel.

Picture your author rubbing his hands with glee and cackling when he unboxed this contraption. I don't know that that is exactly what I did, but I do know that I made lots of "ooh" and "aah" sounds when I first gazed on my new control panel. It's big. It's huge. It's colorful and full of buttons and joysticks! OK, so many cabinets and control panels fit this description, but the Quad Arcade Control Panel from Dream Authentics is a stunningly nice example. It is powered by an Ultimarc IPAC keyboard encoder which means it is fully reprogrammable if needed but comes with a default MAME compatible layout. Along with the normal assortment of controls, you get a Tornado Spinner (introduced in Chapter 4) and have the option to add a flight stick. It also has a dedicated four-way joystick at the top for games that require one.

When ordering the control panel you also have a variety of customization options, including spinner knob style, flush mounting the trackball, optical and rotary joysticks, and my personal favorite, illumination effects. What made my eyes really pop was when I plugged the controller in and turned on my computer, and everything started to glow! There's just no way to get the effect across in a grayscale picture so be sure to take a look at the full color photo on the companion CD. This is the very definition of "eye candy!" Seeing the joysticks and trackball light up made me change my mind about whether illumination effects added anything to the game playing experience. They definitely add to the "back in the arcade" atmosphere and DreamAuthentics nailed it with this control panel!

I am fortunate in that I get to play with a lot of retro arcade toys running a Web site and writing a book about the subject. Most of them I will play for a while then they'll get put aside. A rare few become permanent additions to the St.Clair family arcade and gaming center (my house). This control panel is one of those few. It is going to have a new home in the home-theater room for multi-player game playing on the projector screen. Four-player Gauntlet (purchased legally from StarRoms!) gaming goodness awaits!

North Coast Custom Arcades Controllers

North Coast Custom Arcades (`www.northcoastarcades.com`) sells two models of their popular arcade control panels — the Classic two player and the Quad Controller four player shown in Figure 17-8.

Used by permission of North Coast Custom Arcades

Figure 17-8: The North Coast Custom Arcades Quad Controller.

This is another great product from North Coast Custom Arcades. Along with the usual assortment of joysticks and buttons, it includes a three-inch trackball, Tornado spinner, and dedicated four-way joystick. It also has side-mounted buttons for pinball. The controller is powered by an Ultimarc IPAC and so has the programmability and default MAME compatible layout you would expect. You can have a variety of color choices and control panel overlay customizations, or you can choose to go with basic black as we did in anticipation of designing your own overlay. Game On Grafix (www.gameongrafix.com) also sells a line of control panel overlays designed to fit a standard two-player or four-player North Coast Custom Arcades controller.

Other options include completely customizing the layout of your control panel via a software application you can download and run before buying, and a protective Plexiglas overlay that will be custom-cut and drilled to match your layout even if you customized it! You can also add an illumination kit to make your joysticks, trackball, and buttons all glow.

The Quad Controller makes a great companion to an Ultimate Arcade II cabinet, as you can see mounted on the kit cabinet in Figure 17-9.

Used by permission of North Coast Custom Arcades.

Figure 17-9: The North Coast Custom Arcades Quad Controller mounted.

Xgaming X-Arcade Controllers

Xgaming is another big presence in the home arcade market with their popular X-Arcade (www.x-arcade.com) line of arcade controllers. They make several models: A single-player unit, a two-player model, and their deluxe two-player with trackball called the Tankstick. You can see all three in Figure 17-10.

Used by permission of Xgaming.

Figure 17-10: The Xgaming X-Arcade line of controllers.

Xgaming was a relative newcomer when the first edition of this book was printed, but has since grown to become the 300 pound gorilla in the home arcade market. They are the only manufacturer of which I'm aware to sell their line of gaming products in retail stores as well as through the Internet.

The signature selling point of the X-Arcade units is their customized encoder interface. The X-Arcade is capable of connecting not only to a PC, but, with the right adapter sold by the company, it can also connect to any model PlayStation, Xbox, Xbox-360, GameCube, Wii, and Dreamcast systems. Xgaming has stated their commitment to continue to come out with adapters for new game consoles as they are introduced, making the one-time investment in the X-Arcade one that will continue to pay off. So far they have done exactly that, adding new adapters as the market dictates, such as the Xbox-360. The controllers are also programmable but come with a default MAME ready layout. The X-Arcades start at $100 for the solo model, and run up to $200 for the Tankstick. All come with one adapter, and extra adapters are available for $15. Like all Xgaming products, their controllers come with a lifetime warranty.

Other Arcade Control Panels

There are also several other companies doing business that make arcade controllers including the following:

- Custom Arcades (`www.customarcades.com`) sells two-player and four-player control panels for which you can customize the colors and some of the components.
- Game Cabinets, Inc. (`www.gamecabinetsinc.com`) sells a couple of arcade controllers called the Stinger and the Stinger Plus. The stinger is "just" an arcade controller, while the Stinger Plus includes an entire computer system inside the controller as well.
- HanaHo (`www.hanaho.com`) was the first company to get into the home arcade controller business. They sell a very popular arcade controller called the HotRod, which is a two-player controller with one stick and seven buttons per player.
- Mike's Arcade (`www.mikesarcade.com`) has a line of single and dual player arcade control panels available.
- Quasimoto Interactive (`www.quasimoto.com`) sells the QuasiCon line of one player control panels. One notable feature is special functionality designed for players with fine motor disorders (such as cerebral palsy), including easy-press buttons and joystick extensions adding height and a larger grip.

Complete Arcade Cabinets

Just like arcade controllers, there are many people who would be happy to build you a custom arcade cabinet. The same caveat mentioned before applies here. There's nothing wrong with buying from an individual as long as you realize you are buying from an individual and not a company. The BYOAC forums are a good place to find someone willing to build you a cabinet. Often, you can find someone local to your area and save a bit on shipping costs.

There are also many companies that would be happy to sell you an arcade cabinet. Be prepared for sticker shock; these cabinets are not usually cheap. Bear in mind you're not only paying for the materials, but you're also paying for the time and labor. Before buying, be sure to check current status, references, and feedback on the BYOAC forums.

Emdkay.net Bartop Cabinets

One of the fun parts of writing this book has been the wide variety of different toys with which I've been able to play. Emdkay.net sells a line of bartop cabinets in both pre-assembled and kit form. One of the things they have that caught my eye was a "mini" cabinet. The Emdkay.net mini is a small 12-inch wide, 20-inch high bartop cabinet that can accommodate up to a 10-inch wide and 7-inch high screen (see Figure 17-11).

Used by permission of Emdkay.net.

Figure 17-11: The Emdkay.net Mini Bartop Cabinet.

Emdkay.net sells the mini in both kit and complete form, as well as one player and two player full-sized bartop cabinets. I particularly like the mini for two reasons. First, its small size makes it portable. Imagine bringing this with you to the next get-together to which you're invited! Second, not every bar or countertop has a lot of room on it. My basement bar has a 15-inch countertop. I love my full sized bartop arcade cabinet, but it won't actually fit on my bar's bartop! The mini fits it perfectly.

The inside of the mini bartop cabinet will fit a micro-atx motherboard if you want to go the computer route, or a 12-inch or smaller game console. This might also be a perfect candidate for hacking one of those multi-game arcade joysticks that play five to ten games and sell for $30 or less around the holidays.

The "kit" version of the mini actually comes assembled, but you still have to supply your own accessories (for example, controls or t-molding). The fully assembled versions of the mini and other Emdkay.net cabinets include a monitor, Xbox game console, joystick, buttons, speakers, and other accessories. Both kit and assembled cabinets come with your choice of Emdkay.net marquees.

X-Arcade Machine Cabinet

Wow. I have seen many arcade cabinets and kits in my 12+ years in this hobby. I can truthfully say I have never seen a cabinet more suited for the home arcade hobby or as well put together as the X-Arcade Machine cabinet. Words and pictures are not going to do this cabinet justice, but I will try.

My pleasant experience with the X-Arcade Machine cabinet started before I could ever see the cabinet. Oh, I could see the silhouette of the machine, but it was buried under layers and layers of protective plastic wrap, thick cardboard, and packing foam and strapped atop a heavy duty pallet. Xgaming made very sure there would be no damage to their cabinets when shipped. I probably had to remove 20 pounds of shipping and packing protection before I could get to the cabinet!

Once I got it unwrapped the surprises kept coming. Xgaming advertises their joystick control consoles as being "built like a friggin' tank!" They should consider slapping that slogan atop their cabinets as well. Built of out laminated 7/8-inch particle board with a lifetime warranty, this is one solid machine (see Figure 17-12).

Xgaming really paid attention to the needs of the home arcade market when designing this cabinet. Classic arcade cabinets were not made to be easily accessible. Changing the marquee light involved unscrewing the retainers and any internal troubleshooting required removing the back door and working in somewhat tight quarters. Xgaming made their cabinets very accessible while still maintaining the look and feel of a classic arcade cabinet. The marquee area opens up with a gentle lift exposing the speaker and light area. The control panel hinges up to expose the inside. Doors and panels on the front and back open with a key to provide easy access to any portion of the inside of the cabinet. They get major props for this design (see Figure 17-13).

Used by permission of Xgaming.

Figure 17-12: The Xgaming X-Arcade Machine Cabinet.

Used by permission of Xgaming.

Figure 17-13: The Xgaming X-Arcade Machine Cabinet opened.

Some of the other features of the cabinet include a power strip with a power switch wired to the outside of the cabinet for single button power on and a cooling fan at the back bottom. The control panel area is designed to allow you to drop in an X-Arcade Tankstick controller, making this a nice upgrade for someone who started with just the Tankstick. The top opening includes rounded cutouts so that you can get your hands easily inside to hit the Tankstick's flipper buttons on the sides of the control panel. If you decide you want something different, it would be very easy to remove the top panel, attach your own blank panel to the hinges, and design your own control panel to fit.

They have two models available: The X-Arcade Mame Cabinet and the X-Arcade Machine Cabinet. They are the same basic model with various extras added to the more expensive Machine Cabinet. For example, the Machine Cabinet includes a sound system, marquee light, 27-inch monitor, and 200 licensed arcade games. The lower cost model is a good option if you want to use your own monitor and other various components. The higher end Machine Cabinet is a good choice if you want a turn-key system. Both include the X-Arcade Tankstick controller. If you already have a Tankstick you'll get an extra to play with or you may be able to ask Xgaming to sell you a cabinet without one for a discount.

I want to give a particular shout-out to the folks at Xgaming. I learned of someone trying to put together an arcade system for some of our troops stationed overseas. I fired an email off to Xgaming and asked whether they'd be willing to donate one of their Tankstick control panels to the cause. Less than two hours later I had response that said simply "Done deal, please give me an address." While opinions on politics and foreign policy are very personal and potentially contentious things, I hope everyone can agree that supporting our troops even in a small manner like this is admirable.

Other Cabinet Vendors

- ArcadeShopper.com (`www.arcadeshopper.com`) defies easy categorization. An online arcade business, they sell an eclectic collection of arcade cabinets and kits. See their Web site for current offerings and prices.
- Custom Arcades (`www.custom-arcade.com`) is an established company in the home arcade cabinet community. They have an exciting host of cabinets available, including a sit-down driving cabinet dubbed the Roadrage, and an amazing "must-see" contraption called Project Morph.
- Dream Arcades (`www.dreamarcades.com`) sells upright arcade cabinets, cocktail cabinets, and pedestal style arcade machines.
- Dream Authentics (`www.dreamauthentics.com`) sells a variety of attractive pre-built arcade cabinets from bartops up to sit-down racing cabinets (with optional cup holders!). Their cabinets are available with a range of options and eye candy — be sure to take a look at the Dream Authentics control panel introduced earlier in this chapter. These are nice, solid products!

- Game Cabinets, Inc. (`www.gamecabinetsinc.com`) sells pre-built cocktail cabinets, unique slim bartop machines, and upright arcade cabinets. They also sell a "you have to see it to believe it" translucent arcade cabinet that pulsates different colors with an internal lighting system.
- HanaHo (`www.hanaho.com`) sells pre-assembled arcade cabinets as well as the ArcadeWerx cabinet kit mentioned earlier in this chapter. They have a mini cabinet, full-sized deluxe, and cocktail model available. These cabinets use their popular line of HotRod controllers with extra options like a trackball and additional 4-way joystick. The ArcadePC and HotRod products have received great reviews. As pointed out in the ArcadeWerx review, building arcade cabinets has been HanaHo's business for 30 years — a pedigree no other cabinet vendor can boast.
- North Coast Custom Arcades (`www.northcoastarcades.com`) is assuredly a familiar name to you by this time! In addition to the plans and kits I've shown you so far in the book, they also sell a fully equipped upright arcade cabinet with all the trimmings. For those of you who like the Ultimate Arcade II cabinet but just don't want to build your own, North Coast Custom Arcades has got you covered. They'll customize it for you with lighting and other graphics and a variety of other options.
- Quasimoto Interactive (`www.quasimoto.com`) has a couple of upright arcade cabinets for the home arcade market. The Arcade Station EFX is a stained hardwood and veneer cabinet, while the Arcade Station EX is a traditional black melamine model.

Using An Arcade Machine

It has probably occurred to you that it might be simpler to convert a real arcade machine into a home arcade cabinet. Why hasn't anyone thought of that before? Well, the obvious answer is that they have. Roughly half of the home arcade cabinets submitted to the BYOAC database are converted. This can be a great way to go and can be done fairly inexpensively. There are a few things to know if you're considering going this route.

NOTE **Before you obtain and start to convert a real arcade machine into a home arcade cabinet, *please* read Appendix B, "The Great Debate — Preserving Versus MAMEing the Past." This is an emotional issue — believe it or not — and you should know what you're getting into before you leap. Many beautiful and irreplaceable arcade treasures are being destroyed by well-meaning but uninformed people. Read Appendix B, and avoid becoming one of them!**

Finding A Cabinet

You can find cabinets to use for a home arcade cabinet conversion at a variety of locations. The best place to find a cabinet to use is at an arcade auction. If you haven't been to an arcade auction yet, and one is near you, I heartily recommend you go. They're a lot of fun to experience at least once. You'll encounter a warehouse full of classic and modern arcade cabinets, a row or two of pinball machines, and a variety of other gadgetry from arcades and pubs like pool tables, air hockey tables, slot machines, and so forth. Sometimes, you'll get a machine that sells for a third of its value. Other times, you'll see a beat-up clunker go for more than twice what it should. You never know what will happen at an arcade auction!

Normally, at an auction, there's an area affectionately(?) referred to as "dead row." These are machines that have seen much better days. Some have damaged cabinets (steer clear), and others have all of their parts and artwork stripped but are otherwise structurally intact. These are the machines for you to keep your eye on. Often, they'll sell for as little as $1 because operators just want to get rid of them and would rather not have to haul them back home. With a structurally sound "throw-away" cabinet as a starting point, building your own arcade cabinet can be really easy!

A couple of well known arcade auction companies exist and hold auctions around the country every few months. You can check the following Web sites to see if an auction is coming near you!

- Super Auctions (`www.superauctions.com`)
- Auction Game Sales (`www.auctiongamesales.com`)

Other good options for finding arcade cabinets include Craigslist (`www.craigslist.org`) and eBay (`www.ebay.com`).

Converting A Cabinet

Converting a real arcade cabinet to a home arcade cabinet is not any different from the techniques already discussed in this book, with one exception that I'll get to in a moment. Having been in use in an arcade for its entire life, the cabinet is likely to need some minor repairs. A bit of wood putty, glue, and some new screws can do wonders for its stability. You'll want to clean the cabinet thoroughly at a minimum and probably will want to sand, prime, and paint it unless it has salvageable artwork on it. (You *did* read Appendix B, right?)

If there are any salvageable parts left in it that you don't want, post a message on the rec.games.video.arcade.collecting newsgroup to see whether anyone else needs them to restore a cabinet. You can either sell the part to them, or, in the true spirit of the collecting group, give it to them for the cost of shipping. Even if it looks damaged or unusable, post a message anyway. It might have that one small part on it that someone needs to bring an old friend back to life.

The one exception to a conversion being like building your own cabinet is if you are converting a cabinet that has a working game in it. Instead of hacking things apart inside the cabinet to make it talk to your computer, you can make the computer talk the arcade cabinet's language! There's a conventional standard used in many arcade cabinets called *JAMMA*. JAMMA stands for Japanese Amusement Machine Manufacturers' Association and has standard electrical hookups for monitors, speakers, and control panels. By taking advantage of the fact that JAMMA is a standard, an interface can be made that takes a computer's inputs and outputs and connects them to the JAMMA hookups in the arcade cabinet.

Because you've put an interface between the JAMMA hookups and the computer, you haven't had to modify the arcade cabinet in the slightest. You've simply unplugged the arcade cabinet's game circuit board and replaced it with your computer. You now have a home arcade cabinet with very little effort at all! If at any point in the future you want to sell the cabinet, all you have to do is plug back in the original circuit board, and it's back to its original condition. Of course, by choosing this route, you've elected to use the arcade cabinet as-is with the joysticks and buttons with which it came. You *could* add extra buttons and controls, but you're then back to the regular old method of hacking the cabinet.

You can follow this method in one of two ways. You can decide to build the interface yourself, make the wiring harness, and deal with the issues involved in using an arcade monitor as described in Chapter 12. There's a great Web site that pioneered this concept called the PC2JAMMA project at `http://pc2jamma.mameworld.info/pc2jamma.html`. Full details on how to build the PC2JAMMA interface are available there.

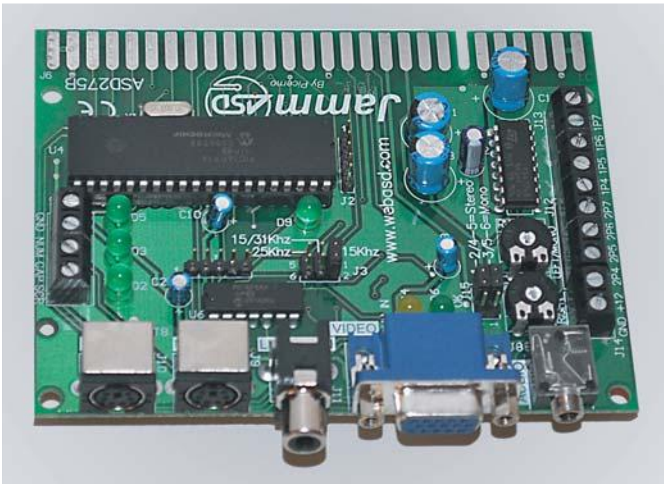
Building the PC2JAMMA interface can be a fun project, but, once again there are off-the-shelf products if you'd rather go that route. Ultimarc has an adapter available called the J-PAC (`www.ultimarc.com/jpac.html`) that has the same basic functionality of its popular I-PAC encoders, but it also adds the hookups for JAMMA cabinets, including circuitry designed to work properly with an arcade monitor.

ArcadeShop.de (`www.arcadeshop.de`) has a similar adapter called the JammaASD (see Figure 17-14). It incorporates a keyboard encoder and an audio and video amplifier.

With a functioning JAMMA arcade cabinet and a J-PAC or JammaASD, you can switch back and forth between a home arcade cabinet and a working real arcade cabinet in minutes!

NOTE **Do you like the idea of being able to switch back and forth? For the ultimate in switchable games, take a look at the MultiJAMMA kit from**

www.multigame.com. This kit allows you to plug several JAMMA arcade boards into a single JAMMA arcade cabinet and switch back and forth at the press of a button. Add your PC2JAMMA, J-PAC, or JammaASD enabled PC to the mix, and make your arcade cabinet into an über-arcade cabinet!



Used by permission of ArcadeShop.de.

Figure 17-14: ArcadeShop.de's JammaASD interface.

Game Console Controller Adapters

You have one more piece of arcade gaming fun to learn about. Entire generations have been brought up on video game consoles from the Super Nintendo, Sega Genesis, and Dreamcast up to the Xbox-360, Wii, and Playstation 3. Rather than an arcade cabinet with a joystick and buttons, to them, video gaming is best done with a handheld console controller with directional pad and mini buttons. There's a whole genre of games that works well with these types of controller that aren't really any better with a joystick than they are with a keyboard.

Do you have a favorite game console controller that you'd like to use with your computer gaming? Of course by now you realize that when I bring a subject like this up, it's because there's a way to get the best of both worlds! For some time now, clever game players have been building adapters and hacking game console controllers to work with personal computers. Like many things that start as home-brew hobbies, commercial adapters are now available that will connect many different controllers to your computer's USB port. You can find these adapters at many locations on the Internet, such as Play-Asia.com (www.play-asia.com). Do a Google search on "PC console controller adapter" to find more online stores.

CROSS-REFERENCE **Even though there are commercial adapters to do the work for you, some of you might be thinking of building your own console controller adapter. Space doesn't permit including it here, but the BYOAC Web site has information to get you started!**

Summary

Building a home arcade cabinet is an incredibly rewarding and fun experience. However, it can take more time, effort, and money than you may be willing or able to devote. If time and effort are not on your side, you have a wide range of arcade controllers and cabinets that you can purchase. Alternatively, if all you're after is something better than the keyboard without spending more than a few dollars, a game console controller adapter makes a great addition to a computer gaming setup.

For every field of endeavor, you can find those projects that stand out above the rest. In the next chapter, I'll introduce you to some of the most inspirational controller and cabinet projects that have come through the BYOAC project database so far. You've done a lot of reading and work in the last 17 chapters. The next one's just for fun!

CHAPTER

18

Online Places to Go

IN THIS CHAPTER

- Inspirational Projects to See
- Great Places to Get More Information
- The Project Arcade Finale

Now that you've got the bulk of the book behind you (unless you skipped ahead, which is okay), you should have a really clear understanding of how this all goes together. You may have a partially or completely finished project and be thinking of a second, or you might be reading the whole book before you plunge in. Either way, this is a great chapter to read next! I've gathered some incredibly inspirational projects for you to look at and some online resources for diving deeper into the hobby. Think you've seen it all? Think again, and dive in!

Inspirational Projects to See

Every Project Arcade creation is someone's dream. Most projects reach the point of having a playable home arcade machine, with more to do *later* on the horizon. You might have a complete cabinet, but might not have full artwork or a specific control, like a flight yoke, installed yet. That's the trap I mentioned earlier in the book, when work stalls because the machine is playable. There's absolutely nothing wrong with that; the whole point is to have fun with it. Any working home arcade machine or controller that you've built with your own hands is a great achievement! Still, some home arcade projects transcend the merely great to achieve awesomeness — projects that can truly be considered works of art. These are the projects that inspire us in our drive to create the *perfect* home arcade machine!

CROSS-REFERENCE **The grayscale pictures in the book cannot do these projects justice. Be sure to check the CD for the full-color, high-resolution photos including multiple shots!**

NOTE **Some figures may have been slightly altered for copyright reasons while still maintaining the integrity of the picture as a whole. You can see the original, unaltered images on the appropriate Web sites.**

1UP's PacMAMEA

The PacMAMEA arcade cabinet (`1uparcade.rmfx.com`) is one of the most acclaimed home arcade cabinet projects of all. The brainchild of Rob Meyers, known online as 1UP, PacMAMEA (see Figure 18-1) is both aesthetically pleasing and a marvel of engineering, with a simple Pac-Man yellow theme, rotating control panels, and almost every type of arcade control imaginable.

Used by permission of Rob Meyers.

Figure 18-1: 1UP's PacMAMEA arcade cabinet.

One of the design goals with the PacMAMEA cabinet was to create as authentic an arcade cabinet appearance as possible. It started with yellow laminate for the sides, producing a very nice arcade cabinet finish without the hassle of painting. Next, using Photoshop and high-resolution arcade artwork found on the Internet, 1UP created custom side art and control panel images. These were then printed at a local print shop on their large-scale printers. The side art was coated with spray acrylic to protect it, and the control panel overlays were covered with 1⁄8-inch Lexan. The marquee was printed on backlit film and sandwiched between two layers of Lexan. LED and glowire lighting (available at `www.glowire.com`, among other places) completes the effects used to create a classy yet eye-catching authentic arcade cabinet!

The rotating control panel setup used in PacMAMEA is probably its most distinctive feature. The cabinet sports three panels; one panel is active while the other two are rotated into the cabinet body. The three panels include a standard complement of joysticks and pushbuttons as well as a removable *Star Wars* flight yoke, removable force-feedback arcade guns, Tron style trigger-grip joysticks, a trackball, and a spinner. The controls are interfaced to an Ultimarc I-PAC, an Opti-PAC, and a Microsoft SideWinder Dual Strike game pad. 1UP was the first person to note that the Microsoft SideWinder Dual Strike game pads used 5K potentiometers and could be used to hack analog-style arcade controls.

The PacMAMEA Web site is fairly well detailed, and emphasis is placed on the special projects in the cabinet, including the flight yoke and gun hacks and removable modular base for the same. There is sufficient detail on the Web site to enable you to design your own version of the cabinet, and detailed plans are available for downloading.

NOTE **Prominent features of the PacMAMEA arcade cabinet: rotating control panels, analog control hacks, attractive artwork.**

Frosty's Arcade

Frosty's arcade cabinet (`www.arcade.tomvanhorn.com`) is yet another example of the lengths you can go to when creating a home arcade cabinet. Thomas Van Horn, a.k.a. Frostillicus or Frosty online, is the creative genius behind the original Project Arcade marquee and side-art graphics from the first edition. His talent shows in the quality of the cabinet he has created. Based on a modified version of the PacMAMEA project, this cabinet sports custom-designed graphics and a rotating control panel (see Figure 18-2).

The marquee and side art for this project were created in Adobe Illustrator by Tom, based largely on characters from fighter-style arcade games. Each of the three control panels has a different themed overlay inspired from different genres of arcade games. The quality of the graphics is one of the items that really set this cabinet apart from others. Tom has put together a popular tutorial on how to create quality arcade artwork available online at `arcadecontrols.com/files/Miscellaneous/VectorTutorial_v1_3.zip`. The cabinet itself is a two-piece design, meaning the top can be separated from the bottom for easy maintenance and moving!

Used by permission of Thomas Van Horn.

Figure 18-2: A look at Frosty's Arcade.

The three rotating control panels boast a collection of standard joysticks and buttons, a Tron trigger stick and spinner, a trackball, dual rotary joysticks, and Atari cone start buttons. The controls are interfaced to an Ultimarc I-PAC and Opti-PAC, and the rotary joysticks are connected to a rotary interface. Each panel is oriented toward a specific set of games, such as the trackball panel that includes Tron-inspired artwork, the trackball, and the trigger-grip joystick. The start buttons, the Tron joystick, and the translucent trackball are lit from beneath with LEDs, which adds to the eye-candy appeal of this cabinet.

Distinctive features of this cabinet include the rotating control panel, the custom-designed artwork, and the two-piece design. Plans are available for download for this cabinet and include details on how the top and bottom parts are connected.

NOTE **Prominent features of Frosty's Arcade: impressive artwork, rotating control panels, two-piece design.**

Knievel Kustoms

There's always that one guy — that one guy who sets the bar for everyone else (actually in this hobby we have several of those people!). In this case, that guy is Brad Smith, also known as Knievel on the message forums. Rather than highlight a specific project of his, in this case I'm going to point you to his Web site to take a look at *all* of his projects. Knievel's cabinets have been the inspiration for many of the projects that have been built since he came on the scene. His cabinets are all meticulously built works, sporting neon rings, plasma discs, other illumination, and matching artwork. You can see some of them in Figure 18-3.

Used by permission of Brad Smith.

Figure 18-3: Knievel Kustoms' cabinets.

His Metal Station full sized jukebox cabinet is a heavy metal themed work of art designed to match the bar built in his basement, sporting more neon and metal paneling than should be legal and LP record jackets on the sides. It runs commercial jukebox software with a touch screen interface. The various illuminations pulse in time to the music — even the volume knob glows!

The Woody is an elegant stained wood creation with tastefully muted black accents that would be right at home in a family living room. It's a thin cabinet profile with an LCD monitor instead of CRT. The Neon MAME cabinet is Knievel's crown jewel, combining visual elements like neon rings, glowing controls, and integrated artwork. Knievel truly has the Midas Touch when it comes to building arcade cabinets. Be sure to visit his Web site to see more of his creations.

NOTE **Prominent features of Knievel Kustoms cabinets: neon rings, plasma discs, LED illuminated controls, illuminated side art, LCD monitors, touch screen monitor.**

Supercade

Jeff Allen's Supercade (`cosmicjive.net/arcade/super/`) is one of those projects that, when seen, elicits statements along the lines of, "I wish I had built that!" Sporting an attractive appearance and a full complement of arcade controls, including a light gun, the Supercade stands out as one of the most often commented upon home arcade cabinets (see Figure 18-4).

Used by permission of Jeffrey Forester Allen.

Figure 18-4: The Supercade.

The Supercade has a really tasteful and distinctive theme. The cabinet is painted black with red t-molding and grey control panel overlays. Each player's controls are a different color scheme and the joystick and buttons match. Other than the marquee, there are no graphics anywhere on the cabinet. It's a perfect example of how a cabinet can look attractive without requiring any artwork. The marquee was modified from a design available for download from Massive MAME (`mameys.arcadecontrols.com`) and printed on backlit material at a local print shop.

The controls are where this cabinet really shines. Instead of rotating or swappable control panels, Supercade uses a double-decker control panel to accommodate all the different controls used on the cabinet. The lower panel has joysticks and buttons for four players and a single trackball in the middle. The upper panel includes a trigger-grip flight stick, a spinner, and an 8-way joystick. The 8-way joystick is used with restrictor plates to turn it into a 4-way-straight or 4-way-diagonal joystick. The controls are interfaced to KE-72 and ME-4 encoders from Hagstrom Electronics. An Act-Labs light gun with a holster inset into the front control panel rounds out the controls on this cabinet. Plans are available for this project, but the author notes that they are not exact measurements and should be used as guidelines instead of cookbook instructions.

NOTE **Prominent features of the Supercade: unique double-decker control panel, pleasant *graphics-free* design.**

Nº18 Arqadium

The Nº18 Arqadium (`forum.arcadecontrols.com/index.php?topic=88515.0`) is an absolute masterpiece of design. It is a combination of arcade controls meets steampunk meets furniture. If you're not familiar with steampunk, think of 19th century Victorian Britain with modern technology but driven by steam instead of electricity and with lots of brass gears and gadgets. This is the concept that hatched from the mind of BYOAC forum member Drventure one day. He took an antique buffet table, gutted it, and then filled it with a dual-level arcade control panel similar to the Supercade. He then went to work with antique brass gears, knobs, widgets, lamps, el wire, and fabric. The results are the impressive piece of work shown in Figure 18-5!

Used by permission of Darin Higgins.

Figure 18-5: The Nº18 Arqadium — ready to play.

It looks like one should wear curator's gloves when playing this machine. When not being played, the cabinet folds back into itself to reveal an elegant piece of furniture, shown in Figure 18-6. You can read the complete design build on his forum journal at the above link, including details on all the artwork and the matching custom-skinned MaLa frontend. This project gave me a serious case of mad-scientist envy. To top it all off, it was even struck by lightning (true story, you can read about it in the build journal)!

Used by permission of Darin Higgins.

Figure 18-6: The N°18 Arqadium — closed.

NOTE **Prominent features of the No18 Arqadium: double-decker control panel, transforms into furniture, incredible steampunk design.**

Aliens-Themed

The Aliens-themed cabinet (`forum.arcadecontrols.com/index.php?topic=96465.0`) by BYOAC member Epyx is another delicious piece of eye candy. It features a unique futuristic curved front and back outline, an Aliens inspired neon green and black color scheme, lit up controls and inset glowing discs in lieu of artwork on each side. One of the nice things about this (and some of the other examples here) project is that it came together with comments and feedback from the BYOAC forum. Epyx did all the work of course, but if you read his design journal there was clearly a collaborative process involved. The results (Figure 18-7) speak for themselves!

Epyx's build journal has a lot of detail on accomplishing the curves and the woodworking difficulties he had to overcome. It's more involved than you might think! With the custom marquee, illuminated side-discs, and glowing controls, this is one of the most eye-catching cabinet projects I've seen. Check out the build journal for tons of pictures and details!

Used by permission of Gordon Westbroek.

Figure 18-7: The Aliens-themed cabinet.

NOTE **Prominent features of the Aliens-themed cabinet: futuristic, curved style, illuminated controls, and illuminated side-discs.**

Mission Control

Mission Control (`forum.arcadecontrols.com/index.php?topic=13118.0`) is the brain child of Mitch Gardiner, also known as Pixelhugger, the artist who did the artwork for Project Arcade 2. This is another cabinet that is as much a piece of art as it is a functional arcade machine. The project was designed to evoke the same larger-than-life feel Mitch felt as a kid in the arcades, so it's 6.5 ft tall and wider at the top than the base. This gives it that same looming feel arcade cabinets had when we were kids (Figure 18-8).

Used by permission of Mitch Gardiner.

Figure 18-8: Mission Control.

Mission Control was made from 2-inch thick cherry wood with solid walnut accents — the sides of the cabinet are about 1 1/2-inch thick! The marquee is a space themed three sided design similar to the classic Dragon's Lair cabinet, and the side art is a solid aluminum cutout of a rocket ship. Other design elements include a mini-marquee beneath the three sided marquee, and an "administrative" navigation control panel above the playing control panel, both of which are done with space artwork to tie into the overall cabinet theme. Words cannot do it justice, be sure to look at the full color pictures on the companion CD and in the construction journal.

When you go to take a look at the construction journal, be prepared to sit for a while. Mission Control has the dubious honor of being one of the longest running projects in this hobby, spanning some seven years from start to completion! However, the construction journal is extremely detailed and an inspiring read.

NOTE **Prominent features of Mission Control: solid wood construction, unique side art, marquee, and other accents.**

Arcade Odyssey

Arcade Odyssey (`rdowney.com/arcadeodyssey`) by Robert Downey is a modified LuSiD design cabinet with a theme inspired by *2001, A Space Odyssey* (Figure 18-9). I particularly like the retro feel of the integrated artwork on the control panel, marquee, and side-disc. It reminds me very much of the exit tunnel from Space Mountain in Disney World and ties the various parts of the cabinet together nicely. The controls and side panels illuminate and there is an administrative control panel strip above the normal control panel.

Used by permission of Robert Downey.

Figure 18-9: Arcade Odyssey.

Some of the nicer touches are those you can't see on the cabinet — for instance it incorporates a unique, adjustable monitor glass retention system that pushes the glass against the front of the machine from the inside rather than having the glass lay on the front of the machine. Robert also kept a meticulous account of his expenses which may be an eye opener as you decide how fancy to get on your own project. You can learn more about the construction in his forum post (`forum.arcadecontrols.com/index.php?topic=89624.0`) and on his Web site.

NOTE **Prominent features of Arcade Odyssey: nicely done integrated art theme, unique monitor glass mechanism.**

Benderama

Benderama (`forum.arcadecontrols.com/index.php?topic=84113.0`) by Sean Beavers is an amazing example of thinking outside of the box, no pun intended. He started with a few design goals — portability, sturdiness, and laptop based — and then built a complete prototype before starting out on the final product. From there he went on to build the creation you see in Figure 18-10, complete with a top-fire joystick, full complement of buttons, a spinner, and a trackball!

Used by permission of Sean Beavers.

Figure 18-10: Benderama. Closed on the left, ready to play on the right.

As you might expect, the buttons, trackball, and marquee all light up. Sean incorporated a Groovy Game Gear LED-Wiz running LEDBlinky to control the button colors. Along with the usual complement of pictures, Sean gave us a video clip of the Benderama being opened and set up (on the companion CD). It's a neatly done piece of work, one I'm tempted to try my hand at!

NOTE **Prominent features of Benderama: ultra-portability, full range of control types in a small form factor, laptop based.**

MiniMAME

The MiniMAME cabinet (`www.minimame.com`) by Chris Cowherd looks at first glance like a nice but ordinary upright arcade cabinet similar to 1UP's PacMAMEA introduced earlier — that is, until you see the cabinet next to something else for perspective (see Figure 18-11).

Used by permission of Chris Cowherd.

Figure 18-11: The MiniMAME cabinet next to a car.

The MiniMAME cabinet is in fact patterned after the PacMAMEA cabinet, but it is scaled down to suit a child. The creator has two different versions shown on his Web site: one standing 40 inches tall, and one standing 48 inches. The cabinets are constructed from MDF sections, laminated a Pac-Man yellow, and trimmed with black t-molding. A small monitor or television is used for the display, and controls and interface are left as an exercise for the reader. The cabinet plans are available for download from the Web site, including full-sized templates for the side panels.

NOTE **Prominent feature of the MiniMAME: upright cabinet shrunk to suit a child.**

Bella's Arcade

Bella's Arcade (`bellasarcade.blogspot.com/`) is a cabinet built by forum member Javeryh for his young daughter. I absolutely love this cabinet. As a parent and arcade geek it resonates with something in my soul. Having my own arcade machine as a child would have been awesome enough, but having something hand designed for me with my name on it would have probably made my head pop.

Bella's Arcade is a simple, cleanly designed one-player cabinet themed in pink — pink sides, pink t-molding, pink controls, accented with a black interior. It even matches the color theme in his daughter's room! It's not overdone though: if you look at the picture (Figure 18-12) it works perfectly. The cabinet is an 80% sized Ms. Pac-Man style with a custom pink skinned MaLa theme. Bella is sure to be the envy of all her friends!

Used by permission of James H.

Figure 18-12: Bella's Arcade.

NOTE **Prominent features of the Bella's Arcade: child-sized, pink-themed to match room.**

Weecade

The Weecade (`www.koenigs.dk/mame/eng/stepweecade.htm`) is a compact bartop designed by Rasmus Sorensen. This is another one of those creations where the builder paid attention to every detail to tie everything together in a coordinated theme (Figure 18-13). The control panel overlay and marquee artwork pleasantly complement the neutral tone of the cabinet. The custom skin used in the Maximus Arcade frontend that he is running also matches. This is a good example of how a clean and elegant design can be just as nice as a cabinet dripping with eye candy.

You don't see many metal control panels built in this hobby due to the difficult of working with the metal, but Rasmus integrated a 2-player one into his creation. He also designed a custom back panel incorporating USB and audio connectors. This is nice because it allows connectivity to the computer that would be otherwise extremely difficult to get to due to the tight design of the cabinet. Another nice touch is the arcade pushbutton hacked in place of a standard computer power button.

NOTE **Prominent features of Weecade: Extremely compact design inside, custom connector back panel, metal control panel.**

Used by permission of Rasmus Sorensen.

Figure 18-13: The Weecade.

The Taxi Cab Bartop

The Taxi Cab (`www.got2getalife.com`) is another one of those all-around themed cabinets. Many cabinets are nicely done physical works, with pleasant artwork on the sides, marquee, and control panel, but somehow fail to capture that overall *gestalt* — that sense that the entire project is tied together into a cohesive whole. The Taxi Cab manages to capture that feeling easily (see Figure 8-14).

Used by permission of Dale Murray.

Figure 18-14: The Taxi Cab bartop.

If an arcade cabinet were to be made out of a real taxi cab, it would look like this one. The yellow and black theme with the subtle checkered pattern and marquee make me feel like I should be putting on a seat belt!

The cabinet has the usual assortment of features — joysticks, buttons, spinner, and so on. Things that make this cabinet stand out aside from the theme are the detachable control panels, and the use of a USB computer trackball in place of an arcade trackball. The cabinet also has a recessed administrative panel with access to USB ports, an external monitor port, and a DVD drive. All in all, this is a sporty little cabinet I could see being right at home on a bar top somewhere!

NOTE **Prominent features of the Taxi Cab: well-done theme, removable control panels, uses a computer trackball instead of an arcade trackball.**

Carlos's Centipede

Carlos's Centipede cabinet (`www.retrospieler.de`) is another blend of arcade beauty and technical innovation. The cabinet is a from-scratch-built replica of an Atari Centipede cabinet complete with reproduction artwork, swappable control panels, and a motorized rotating monitor (see Figure 18-15).

Used by permission of Carsten Wessels.

Figure 18-15: Carlos' Centipede cabinet.

The cabinet pieces were cut out on a professional CNC router, which produces very nice results. Reproduction Centipede artwork from Arcadeshop Amusements (`www.arcadeshop.com`) was applied to the white background, producing a look virtually identical to the original. The marquee was replicated from a scanned image and printed on backlit paper. If it were not for the custom controls, you would be hard pressed to tell the difference between this cabinet and a real Centipede arcade machine.

Demonstrating the principle that sometimes simpler is better, Carlos originally had an all-in-one control panel design but then switched to a classy-looking swappable control panel approach instead. Controls are interfaced to an Ultimarc I-PAC and Opti-PAC through an easily disconnected cable that allows quick control panel swapping. The first control panel has only a single joystick and four buttons, which suits the majority of classic arcade-style games that will be primarily played on the cabinet. The player 1 and 2 start buttons are lit with LEDs that will flash in some games in the Multiple Arcade Machine Emulator (MAME), replicating the behavior of the original machines. Carlos includes a nice tutorial on his Web site on how to connect the LEDs.

Although the artwork on the cabinet is very nicely done, the project's biggest claim to fame is probably the automatic motorized rotating monitor. Cannibalized from an actual production arcade machine, the rotating monitor mount will automatically rotate the monitor from horizontal to vertical and degauss the monitor when it does so. Carlos caps the project off with a custom-designed front end that will eventually tell the monitor mount to rotate when needed, making it truly 100 percent automated! Detailed measurements and plans are available on his Web site to help you if you'd like to re-create this cabinet, although finding another motorized rotating monitor mount will be a trick!

NOTE **Prominent features of Carlos' Centipede cabinet: impressive replica cabinet and artwork, automated rotating monitor.**

UncleT's Mom's Arcade

UncleT's Mom's Arcade by Todd Rosen is one of those Übergeek arcade cabinets that almost defies description. It's a sit-down arcade driving cabinet with multiple driving and flying controls (see Figure 18-16).

The cabinet features six control panels that rotate horizontally around the cabinet, featuring steering wheels, joystick controls, and even a coveted Star Wars–style flight yoke. The controls are interfaced through Microsoft SideWinder Dual Strike hacks as described earlier in the book. Todd tops the cabinet off with multiple gear shifters mounted on the right-hand side, adjustable driving pedals, and a rotating monitor that doubles as the family television. This cabinet is an incredible feat of engineering!

Used by permission of Todd Rosen.

Figure 18-16: UncleT's Mom's Arcade.

NOTE **Prominent features of Mom's Arcade: sit-down driving cabinet, horizontally rotating control panels.**

More on the CD

Space won't allow for including all the great inspirational projects that are out there, but you'll find a few more of my favorites on the companion CD!

Great Places to Get More Information

Still thirsty for more? Got an inspiration for something brand new? There are some excellent online resources you can visit to get more information and to help you on your way. This is an eclectic collection of places around the Internet with information relating to arcade collecting and home arcade cabinet construction. A lot of people migrate to collecting real arcade and pinball machines after constructing one or two home arcade cabinets (and vice versa). Both are fun and fascinating hobbies with a lot of overlap between the two. Even if you're only interested in one, you can still learn a lot from the other. I'll even sneak in a couple of game console links as well.

WARNING **Make sure you've had something to eat and have a drink nearby. The following collection of links can lead to a Web surfing coma — a condition where you suddenly realize you've been Web surfing for days without coming up for air and suddenly keel over comatose. Occasionally, interventions by a spouse or loved one may be necessary. Enjoy!**

- **Game Room Magazine** (`www.gameroommag.com`) — This is a favorite among arcade enthusiasts, covering the entire coin-op collecting scene including arcade machines, pinball, game room design, and even the home-built arcade hobby. Highly recommended!
- **Randy Fromm's arcade school** (`www.randyfromm.com`) — Randy Fromm is a video arcade machine technical expert and magazine writer and has numerous how-to repair articles to his credit. He runs the Randy Fromm arcade school where you can go for a five-day intensive education on repairing arcade machines. For those who cannot make it to a training session, video tapes and books are available on his Web site. These tapes and books are excellent resources for people who want to learn more about what makes video games tick and how to repair them!
- **The Real Bob Roberts** (`www.therealbobroberts.org`) — Bob Roberts' Web site is primarily known as a great place to get arcade parts inexpensively. Aside from that, however, his site has a big collection of technical and how-to articles that are recommended reading.
- **Arcade Gameroom Design Information** (`members.cox.net/jmccorm`) — Now that you've built a home arcade machine or two, what are you going to do next? No, a visit to Disney World isn't in order; it's time to build a real game room! This Web site is an attempt to walk you through things to consider when you put together a personal game room, and it makes a great visit.
- **Blacklight carpeting** — No game room is complete without blacklight reactive carpeting like that found in arcades and movie theaters. You can find this carpeting online at these Web sites:
  - `www.valuecarpetonline.com/carpet-black-light.htm`
  - `www.kidcarpet.com`
- **Newsgroups and mailing lists** — You've already been introduced to rec.games.video.arcade.collecting (RGVAC), alt.games.mame (AGM), and rec.games.video.arcade.marketplace (RGVAM) as good places to go to for help. They're also great groups to read just to learn more about the hobby (reachable at Google Groups, groups.google.com). Sadly, the wild Internet has caught up to these newsgroups and they're full of SPAM and foolishness as well as the good stuff. They're still worth a visit, but be warned that some messages may not be suitable for civilized people. Two other great resources are the Vectorlist and Rasterlist mailing lists for the discussion of vector-based and raster-based arcade machines, respectively. Signup information and past archives can be found at www.vectorlist.org.

- **Web forums** — There are three Web forums I highly recommend as well as the aforementioned newsgroups and mailing lists.
  - KLOV — The Killer List of Video Games forum at `forums.arcade-museum.com` is a wealth of arcade and pinball collecting information. Moderated at slightly more adult than PG-13.
  - Shoryuken — The Shoryuken forums at `www.shoryuken.com` are a great resource for arcade stick builders for fighting games such as Street Fighter. You'll find a lot of discussion and use of Japanese and Korean joysticks in particular. Moderated at slightly more adult than PG-13.
  - BYOAC — Finally, be sure to visit the Build Your Own Arcade Controls (BYOAC) forums at `forum.arcadecontrols.com`. This is the forum run by the author of this book. Stop in, say hi, and share your project with us! Moderated at about PG-13.
- **The Basement Arcade** (`www.basementarcade.com`) — This is one of the premier arcade collecting sites on the Web. Aside from a great arcade collection and technical info, it is home to one of the biggest collections of interesting arcade links on the Web.
- **Videotopia, "The Exhibit of the True History of Video Games"** (`www.videotopia.com`) — This is a traveling museum of classic arcade game history. The exhibit consists of between 60 and 85 arcade games from the original Computer Space to modern side-by-side racing games. The Web site has an online mini version of the exhibit you can visit.
- **Arcadecollecting.com** (`www.arcadecollecting.com`) — This site is not only a great place to find artwork, as introduced in Chapter 15, it's also a repository of technical information and tips!
- **The Arcade Restoration Workshop** (`www.arcaderestoration.com`) — This site is a must visit for anyone working on old arcade machines. It is absolutely chock full of tips, tricks, articles, photo tutorials, and links related to arcade machine collecting and repair. Highly recommended!
- **VAPS, The Video Arcade Preservation Society** (`www.vaps.org`) — This site is dedicated to organizing arcade collectors into a group. Post your collection in their database, and look for like-minded fellows in your area that are accepting visitors!
- **Al's Arcade** (`www.alsarcade.com`) — This is another good stop on the Web for arcade collecting information.
- **ePanorama.net** (`www.epanorama.net/documents/joystick`) — Tomi Engdal's collection of technical information about joysticks is an absolute must visit for those interested in joysticks from all manner of computer and game systems.

- **GameSX.com** (`www.gamesx.com`) — This site is one of my favorites on the Web. There isn't a game console or arcade contraption they're afraid of taking apart and documenting.
- **APPOLO's Arcade** (`www.appolo.com`) — This site is another regular stop on the Web for arcade collectors. Items of note include several arcade-related tutorials and a collection of paint codes for matching paint on classic arcade machines.

The Project Arcade 2 Finale

Still need that last bit of convincing that building an arcade cabinet is something you can or want to do? Consider the author of this book and the Project Arcade 2 cabinet. Before I started the first edition in 2004, I'd never built anything more complicated than a cheap screw-together bookshelf kit. I'd tinkered with arcade controls, put together the BYOAC Web site, and gathered all the information you hold in your hands now — but I'd never actually built a complete cabinet from scratch. I had a cabinet I was going to convert and knew that if others had done it then I could too, but I had been in the *getting started* mode for two years and hadn't made any progress. Then the opportunity to write this book came along, and over the course of a few months I was able to start from a pile of wood and create my own dream arcade machine.

Here's what I said after I built the first Project Arcade cabinet and wrote the first edition of this book:

It's my creation. I made it with my own two hands. The cabinet's big and shiny. The smoked glass over the monitor rests perfectly over the monitor area, protecting the huge 27-inch monitor and hiding the mysterious depths of the cabinet beneath. The blue t-molding sets off the custom marquee and side art perfectly. A collection of multicolored arcade controls lie in a custom-designed field of stars beneath a shiny protective overlay. My buddy's reaction when he sees the cabinet is the icing on the cake. It lights up, makes noise, and plays anything I put on it. There's not another arcade cabinet exactly like it anywhere in the world. Turn off the lights, put on some music from the 80s, turn on the cabinet, and you're instantly sent back to your teenage years, spending all your time and money at the local arcade. Finally, there's that magic moment — select a game, insert a credit, and start playing! Would I do this again? You bet!

And then I did. There's nothing else quite like the feeling of owning and playing your very own set of custom-built, home arcade machines. If I can do it, you can, too! It is with some amount of pride that I present to you the Project Arcade 2 cabinet (see Figure 18-17)!

Figure 18-17: The Project Arcade cabinet, ready to play!

Summary

Some very talented people have built many different types of arcade machines that are a cut above the ordinary. Some started with already existing skills, while others picked up tools for the very first time and dug in. The one thing they have in common is something you share as well — a dream and the desire to see it come to fruition. I hope the projects highlighted here have inspired you for your next (or first) project! Perhaps you'll see *your* project here in future revisions.

Congratulations are now in order — you've reached the end of the book! The appendices that follow include a few footnotes and details that are well worth reading, but for the most part you've seen all that I have to show you. I hope you've learned a thing or two and have successfully created your very own arcade machine! Creating the Project Arcade 2 cabinet as I wrote this book was an extremely rewarding experience personally, watching it unfold from a few lines on paper and a pile of wood to a fully functioning home video arcade machine.

Hopefully your experience has been just as good and you won't stop here. There's always room for a second (and third, and …) machine and personal arcade controllers make great gifts! This hobby continues to grow with creations and innovations undreamed of when it all started. The next few years are sure to get more exciting still — why not be part of it? Come join us at the Build Your Own Arcade Controls Web site at www.arcadecontrols.com. Hope to see you there!

Thank you for reading my book. I hope you enjoyed it!

APPENDIX

A

Where to Find Arcade Parts for Your Project

You can find good-quality arcade parts from many locations. Arcade parts vendors are broadly broken down into three categories: direct from manufacturer, purchases from resellers, and purchases from used markets. Like any shopping trip, price, quality, and availability should be your guides as to where to buy.

Direct from manufacturer is almost always guaranteed to be a satisfactory transaction but tends to be the most expensive option. They are usually more geared toward selling to large arcade shops and resellers than they are to individual customers. However, they'll often have sales and specials that can't be found anywhere else, so I would always check with the manufacturers before buying.

Resellers tend to be the easiest transactions at good prices. They are geared toward selling to individual customers and are usually active in the collecting community. Purchasing from them is a good way to find what you need and give something back to the community in a small way. Selection is sometimes smaller than the manufacturers can offer, however, service levels tend to be high.

The used and after markets are where you can find some incredible deals and out-of-production rare parts to use. However, every purchase in this market comes with a *caveat emptor* (buyer beware) attached. Check feedback for anyone with whom you're doing business in the used market before you purchase.

In the following section you'll find resources listed under category (direct, reseller, used). Sometimes the distinction between manufacturer and reseller is blurry, so I've placed them where they seem to fit best. You can find other vendors by searching online as well. Happy shopping!

Buying Direct

- **3tronics** — www.3tronics.com, manufacturer of Multiple Arcade Machine Interface (MAMI) keyboard encoders and external volume control for arcade cabinets.
- **Apache Controls** — www.apachecontrols.com, maker of the push/pull Blackhawk arcade spinner.
- **Betson Imperial** — www.betson.com/MainDept.asp, large manufacturer and distributor of arcade parts.
- **Groovy Game Gear** — www.groovygamegear.com, manufacturer of KeyWiz encoders and many arcade parts and joysticks designed for home arcade cabinet builders.
- **Hagstrom Electronics** — www.hagstromelectronics.com, manufacturer of keyboard encoders and optical encoders.
- **Happ Controls** — www.happcontrols.com, large manufacturer of arcade parts of all types and other arcade-related materials.
- **Ram Controls** — www.ramcontrols.com, manufacturer of reproduction arcade parts including the coveted Star Wars style flight yoke and volcano pushbuttons.
- **Ultimarc** — www.ultimarc.com, manufacturer of I-PAC keyboard, Optic-PAC optical encoders, and ArcadeVGA video card; also sells arcade parts and joysticks customized for home arcade cabinet builders.
- **Xgaming** — www.xgaming.com, manufacturer of X-Arcade keyboard encoder, reseller of multiple arcade parts.

Buying from Secondary Vendors

- **8Liners** — www.8liners.com, reseller of various arcade parts including hard-to-find monitors.
- **Arcadeshop Amusements** — www.arcadeshop.com, reseller of arcade parts and arcade artwork.
- **ArcadeShop.de** — www.arcadeshop.de, vendor of arcade parts including Ultimarc encoders and manufacturer of the E-Limitator motion filter encoder.
- **ArcadeEmulator.net** — www.arcadeemulator.net, reseller of Happ and Ultimarc arcade parts.
- **Centsible Amusements** — www.centsibleamusements.com, reseller of arcade parts and artwork, including leaf joysticks.

- **Coin-Op Yellow Pages** — `http://randyfromm.com/amusements/yellowpages`, a listing of arcade-related vendors hosted by Randy Fromm.
- **Game Cabinets, Inc.** — `www.gamecabinetsinc.com`, reseller of arcade parts and manufacturer of arcade cabinet plans and cocktail cabinets.
- **Lizard Lick Amusements** — `www.lizardlick.com`, reseller of arcade parts including Japanese and Korean manufacturers.
- **Mike's Arcade** — `www.mikesarcade.com`, reseller of arcade parts, artwork, and manufacturer of various arcade game kits as well as arcade circuit board repairs.
- **Paradise Arcade Shop** — `http://paradisearcadeshop.com`, vendor of arcade parts including illuminated pushbuttons and joysticks.
- **Retro Arcades** — `www.retroarcadeslive.com`, reseller of various arcade parts including rare illuminated joysticks and pushbuttons, and one of the only vendors to carry the Tornado spinner.
- **The Real Bob Roberts** — `www.therealbobroberts.org`, reseller of arcade parts; very popular choice among Build Your Own Arcade Controls (BYOAC) community members.

Buying from Used Markets

- **Auctions** — Real arcade auctions are a good place to look for arcade parts. A throw-away broken down arcade cabinet (*please* read Appendix B) can be a great place to get coin doors, joysticks, and buttons. Usually, they're picked over by the owner before being dumped, but often you can find great deals that someone else wouldn't look twice at if you're willing to put in the time to clean them up. Auction locations can be found online at Super Auctions (`www.superauctions.com`) and Auction Game Sales (`www.auctiongamesales.com`).
- **BYOAC forums** — The Bring Your Own Arcade Controls buy/sell/trade message forum (`http://forum.arcadecontrols.com`) is a great place to find arcade parts, including special runs of items designed for home arcade cabinets.
- **eBay** — `http://listings.ebay.com/listings/list/all/category13718`, eBay's coin-op arcade category is a great place to find rare or cheap arcade parts. Don't get caught up in a buying frenzy and pay too much though!
- **RGVAC/RGVAM** — The rec.games.video.arcade.collecting and rec.games.video.arcade.marketplace (`http://groups.google.com`) newsgroups are another good place to find arcade parts at a good price, although patience is required.

APPENDIX

B

The Great Debate — Preserving Versus MAMEing the Past

It seems like such a good idea, at first. Building a home arcade cabinet is a lot of fun, but it can be a good bit of work. Why not take an already existing arcade cabinet, strip out all the stuff you don't need, and turn it into your home arcade cabinet? It can be really cheap — throw-away cabinets go for a dollar at arcade auctions; nice cabinet shells with artwork and monitors can go for $100 to $150. It's easy — instead of building from scratch you simply have to clean it up and you're ready to go. What's not to like? What's the big fuss about?

Most likely you picked up this book due to happy memories of time spent in an arcade, feeding quarters into some machine that you were determined to beat or get a high score on. Maybe you missed the heyday of the arcades and would like to get a glimpse of it now. Either way, most of us are trying to re-create a part of the past that we can visit whenever we wish. That seems harmless enough. What's the great debate about then? The issue is this:

Please don't destroy that past as you attempt to re-create it!

Classic arcade cabinets — Tron, Star Wars, Galaxian, and so on, are a dying breed. They suffer from the ravages of time and conversion to other games. Some will sit in a leaky warehouse until the elements turn them into kindling. Other beautiful classic arcade cabinets will get converted into some mindless fighting game (with apologies to fighting game fans) when the original stops making money. The problem is that classic arcade cabinets represent a finite resource. The arcades of yesterday are just that — a thing of the past. Barring a scattering of reproduction projects, these classic cabinets cannot be replaced. As if these problems were not bad enough for classic arcade cabinet fans and collectors, suddenly home arcade cabinets (often referred to as Multiple Arcade Machine Emulator [MAME] cabinets for the emulator most often used on them) started popping up. No one begrudges someone building a personal cabinet from scratch. However, every time a classic arcade cabinet is converted to a home arcade machine, somewhere someone cringes, now that there's one fewer cabinet available to collectors.

To an arcade collector, modifying a classic arcade cabinet is akin to chopping down old growth redwood forests. The people doing so may have the legal right to their actions, but they are doing a disservice to humanity. Granted, the degree of the problem is certainly different! Hacking apart an old Robotron cabinet won't cause environmental problems or displace animals (except, perhaps, a family of mice). It will mean, however, that there's one less Robotron cabinet in the world. That same cabinet could be some collector's *holy grail* — the one item they're looking for to complete their collection. Even if the cabinet is in bad shape, someone probably has the parts and desire to rebuild it and restore it, if only they had the cabinet.

On the other hand, there are a bunch of not-so-classic cabinets, generic cabinets, and the aforementioned already-been-mutilated (converted) cabinets out there. Those are much better candidates for conversion to a home arcade cabinet than a nice classic cabinet. Yes, they usually mean more work for you than a cabinet that's in nice condition. That's a small price to pay for entering the classic arcade community. You don't *have* to destroy a classic arcade cabinet to get the convenience of using an already constructed cabinet for your project.

If you must use a classic arcade cabinet for your home machine (which is, after all, totally within your rights as owner of the cabinet), please consider a few limitations. Use a PC2JAMMA conversion, so that the original woodwork and artwork are kept intact. Restore what needs TLC instead of slapping black paint on it and putting up a customized logo. If you're going to remove parts, sell or give them away instead of junking them. That way, the classic cabinet still exists, and its parts can go to help another classic machine live again.

There's room for both home arcade cabinet builders and classic arcade collectors along the road to arcade nirvana. Many arcade cabinet builders end up becoming collectors as well. MAME led me to discover using real arcade controls, which in turn led me to my current collection of seven real arcade cabinets, two pinball machines, and an air hockey table! Many arcade collectors also end up adding an emulation (MAME) cabinet to their collection as well. A little consideration for both camps goes a long way. Enjoy your new hobby, and thank you for considering the impact of your choices on the arcade collecting community!

APPENDIX

C

What's on the CD?

This appendix provides you with information on the contents of the CD that accompanies this book. For the latest and greatest information, please refer to the ReadMe file located at the root of the CD. Here is what you will find in this appendix:

- System Requirements
- Using the CD
- What's on the CD
- Troubleshooting

System Requirements

Make sure that your computer meets the minimum system requirements listed in this section. If your computer doesn't match up to most of these requirements, you may have a problem using the contents of the CD. Most of the material on the CD consists of Web pages and color photos. Those will work on any computer and operating system. For best results with the rest of the CD's contents, make sure you meet the following requirements:

- PC running Windows XP, Windows Vista, Windows 7, or later
- An Internet connection

- At least 512MB of RAM
- A CD-ROM drive

Using the CD with Windows

To access the content from the CD, follow these steps.

1. Insert the CD into your computer's CD-ROM drive. The license agreement appears.

NOTE The interface won't launch if you have autorun disabled. In that case, click Start ➢ Run (for Windows XP) or Start ➢ All Programs ➢ Accessories ➢ Run (for Windows Vista and above). In the dialog box that appears, type D:\Start.exe. (Replace D with the proper letter if your CD drive uses a different letter. If you don't know the letter, see how your CD drive is listed under My Computer.) Click OK.

2. Read through the license agreement, and then click the Accept button if you want to use the CD.

   The CD interface appears.

What's on the CD

The following sections provide a summary of the software and other materials you'll find on the CD.

All Chapters

Color figures. Every chapter folder on the CD-ROM includes full-color versions of the figures used throughout the book.

Web links. This book many links to useful Web sites. The companion CD-ROM includes a Web-enabled listing of these links, organized by chapter. As you read the material in the book you can keep this listing up on your screen for handy access. No typing required!

Shareware programs are fully functional, trial versions of copyrighted programs. If you like particular programs, register with their authors for a nominal fee and receive licenses, enhanced versions, and technical support. *Freeware programs* are copyrighted games, applications, and utilities that are free for personal use. Unlike shareware, these programs do not require a fee or provide technical support. *GNU software* is governed by its own license, which is included inside the folder of the GNU product. See the GNU license for more details.

Trial, demo, or evaluation versions are usually limited either by time or functionality (for example, some will not allow you to save projects). Some trial versions are very sensitive to system date changes. If you alter your computer's date, the programs will "time out" and no longer be functional.

Chapter 1

Examples database. The examples database is a Web-enabled listing of many "Project Arcade" style projects. Clicking a link in the examples database will launch the home page on the Internet of the project in question.

Chapter 2

Project Arcade 2 Plans. These are the plans for the Project Arcade 2 cabinet built in this book, based on the Ultimate Arcade II plans from North Coast Custom Arcades.

Project Arcade 1 Plans. The design plans for the Project Arcade cabinet, based on the original design by Sean Hatfield (LuSiD).

Arcade Paradise 3 Plans. Plans for the Arcade Paradise 3 arcade cabinet from www.arcadeparadise.org.

1UP Arcade Plans. Plans for the 1UP Arcade cabinet with rotating control panels.

Project_Arcade_1-Chapter_2.PDF. A PDF of Chapter 2 from the first edition of *Project Arcade*, for those of you who elect to build the first Project Arcade cabinet model.

Chapter 3

No CD-ROM content is included beyond color figures for Chapter 3.

Chapter 4

Arcade Stupidity spinner plans. A Web-based guide to building your own spinner controller from old hard drive parts, including video clips.

Gearhead Labs QuickSpin spinner plans. Another Web-based guide to building a spinner from scratch.

Twisty Grip spinner plans. Yet another Web-based tutorial on constructing a spinner from parts available at any hardware store.

Chapter 5

PacMAMEa gun hack. How to hack a Microsoft Sidewinder Dual Strike game pad to connect arcade gun controllers to your computer.

PacMAMEa Star Wars hack. A guide on hacking the Microsoft Sidewinder Dual Strike game pad to an Atari Star Wars flight yoke controller.

DDR Homepad. Instructions on creating a Dance Dance Revolution style dance pad to connect to your computer.

Jude Kelly's Star Wars controller. A link to a Web site with instructions for hacking an Atari Star Wars flight yoke to your computer.

Chapter 6

Templates. Layout and mounting templates of different arcade controls you can use when creating your control panel.

Control Panel Templates. Full scale versions of the Project Arcade 2 control panel templates are also included.

Yoke mounting platform. Instructions from the PacMAMEa Web site on constructing a mounting platform for a Star Wars flight controller.

Project_Arcade_1-Chapter_6.PDF. A PDF of Chapter 6 from the first edition of *Project Arcade*, for those of you who elect to build the first Project Arcade control panel.

Chapter 7

Starbase 74 soldering tutorial. A Web-based tutorial demonstrating how to successfully solder and avoid problems.

Chapter 8

Keyboard hacking guide. How to hack a keyboard by Marshall Brooks (Tiger-Heli). Includes information on specific keyboards that have been successfully used in arcade cabinets.

Ghost Keys. A utility by John Dickson you can use to test keyboard hacks and keyboard encoder configurations.

Chapter 9

Oscar Controls DPDT switch tutorial. Instructions courtesy of Oscar Controls on how to connect a trackball and spinner to a single mouse hack using a dual-pole-dual-throw switch.

Chapter 10

Microsoft Sidewinder Dual Strike hack. Web-based instructions from PacMAMEa on how to hack the Microsoft Sidewinder Dual Strike game pad to analog arcade controls.

Linux Joystick Driver. A driver for using joysticks on Linux-based computers.

Chapter 11

Cabvol. A program enabling you to control the volume in your cabinet with arcade controls.

Klipsch speaker mounting templates. To-scale mounting templates for the Klipsch ProMedia 2.1 speakers.

Oscar Controls speaker amplifier hack. Instructions from Oscar Controls on how to use car or arcade speakers with PC-based speaker amplifiers.

Oscar Controls volume control hack. Information from Oscar Controls on how to build a remote volume control for your arcade cabinet.

Virtual Music Jukebox. A trial version of a jukebox-based MP3 music file player.

Chapter 12

Soft 15Khz. A utility allowing you to use certain video cards with arcade monitors.

Chapter 13

Tight-VNC. Freeware remote control software that enables you to control the computer in your arcade cabinet from another system.

Chapter 14

Games. A collection of freeware and shareware games that work great with arcade controls is included to get you started!

- ArkLight. A space ship shooting twist on Arkanoid.
- Bullet Candy Perfect. A space ship shooter with 50 levels.
- Darkside. A graphics-intensive space ship shooter.
- Hurrican. A space ship shooting twist on Arkanoid.
- Irukandji. A liquid physics–style space shooter.
- Jack'O'Roid. A Halloween-style Asteroids type of game.
- Omega Race. A remake of the classic arcade game Omega Race.
- Omega Race 2009. An updated take on the classic arcade game Omega Race.
- Quantasm. A visually stunning Tempest type of arcade game.
- RetroRoids. A colorful retro-remake of Asteroids.
- Rocket Bowl Plus. A trackball-friendly arcade bowling game.
- Scavenger. An arcade shooter.
- Space Fury. A remake of the vector classic arcade game.
- Star Monkey. A vertically scrolling arcade shooter.
- Zektor. A remake of the classic vector-based arcade game.

Chapter 15

Carsten's LED tutorial. A Web-based tutorial on how to connect LEDs to your arcade cabinet project.

Oscar Controls LED tutorial. Another Web-based tutorial on how to connect LEDs to your arcade cabinet project.

Oscar Controls joystick graphics. Artwork you can place around joysticks on an arcade control panel, courtesy of Oscar Controls.

Oscar Controls marquees. More artwork from Oscar Controls, this time meant for the marquee of your arcade cabinet project.

Links to artwork resources. A Web-enabled list of free resources for finding artwork for your arcade cabinet project.

Links to commercial artwork resources. Another Web-enabled list of commercially available arcade cabinet artwork.

Chapter 16

Helpful Web links. Web-enabled listing of emulation and arcade Web sites and newsgroups.

Chapter 17

Arcade Depot pictures. Photos of the cocktail cabinet kit from Arcade Depot.

DreamAuthentics Quad Arcade control panel photos. Pictures of the DreamAuthentics Quad Arcade control panel.

Emdkay.net Mini Bartop cabinet photos. Pictures of the Emdkay.net Mini Bartop cabinet "kit."

HanaHo ArcadeWerx pictures. Photos of the ArcadeWerx arcade cabinet kit from HanaHo.

HanaHo HotRod photos. Pictures of the HanaHo HotRod desktop arcade controller.

North Coast Custom Arcades bartop pictures. Photos of the North Coast Custom Arcades bartop cabinet.

North Coast Custom Arcades Quad Controller. Photos of the North Coast Custom Arcades Ultimate Quad Controller control panel.

North Coast Custom Arcades Ultimate Arcade II kit. Photos of the North Coast Custom Arcades Ultimate Arcade II kit.

Xgaming X-Arcade console pictures. Photos of the Xgaming X-Arcade desktop arcade controllers.

Xgaming X-Arcade Machine Cabinet photos. Pictures of the Xgaming X-Arcade Machine Cabinet.

Chapter 18

Project Arcade2 photos. Pictures of the Project Arcade 2 cabinet.

Example photos. Pictures of other arcade cabinet projects for inspiration.

Troubleshooting

If you have difficulty installing or using any of the materials on the companion CD, try the following solutions:

- **Reboot if necessary.** As with many troubleshooting situations, it may make sense to reboot your machine to reset any faults in your environment.
- **Turn off any anti-virus software that you may have running.** Installers sometimes mimic virus activity and can make your computer incorrectly believe that it is being infected by a virus. (Be sure to turn the anti-virus software back on later.)
- **Close all running programs.** The more programs you're running, the less memory is available to other programs. Installers also typically update files and programs; if you keep other programs running, installation may not work properly.
- **Reference the ReadMe:** Please refer to the ReadMe file located at the root of the CD-ROM for the latest product information at the time of publication.

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