

by Phil Combs

An Arcade-Quality Game Controller For Your Computer

How many hours of your time, and quarters, were spent on video games in the 1980's? Although most of those games are long gone, many people worldwide still want to play them. It's now possible with your PC, Macintosh, Unix, or Linux box, Amiga, and even a certain digital camera! This is done using a software program called an emulator that uses data from the original game ROM (read-only memory) chips.

Playing those old arcade games can be enjoyable, but using a computer keyboard as a controller takes away from the experience. I built my own arcade-quality input device to solve that problem. This is not a step-by-step article on how to exactly duplicate my controller. Like all input devices, a gamer's interface to the machine is a highly personal choice. I will give you enough information to see how mine went together, and will point you to the sources of the components you'll need to construct your own controller.

Background

There are many fine arcade game emulators available on the Internet today,

with names like MAME, MESS, Raine, and Impact. I consider MAME — or the Multiple Arcade Machine Emulator — the granddaddy of them all. MAME supports over 2,000 games and has dozens of people worldwide contributing to its ongoing development.

This emulator program was born in 1997, under the hands of Nicola Salmoria. He had written several arcade emulators that played specific games. Nicola decided to combine them using a common emulation engine, with drivers for different types of arcade hardware. As the number of supported games became too large for one person to maintain, other people stepped in to assist.

These programmers, known as the MAME

Team, support what is now officially called a 'documentation project.' The project's aim is to preserve the games and assist people who repair and maintain the original arcade game cabinets. A side benefit of these preservation efforts is a freely distributable program that allows game fans to play those classic games again.

What do you need to play the games in your home? I won't go into the details of copyright law here, as this info is clearly spelled out on the many Internet sites supplying ROM images. However, you should own the original arcade hardware, usually just the main processor board, of the games you wish to emulate before downloading their ROM images. Each



Photo 1. My arcade controller.



Photo 2. The front-panel layout is clean and uncluttered.

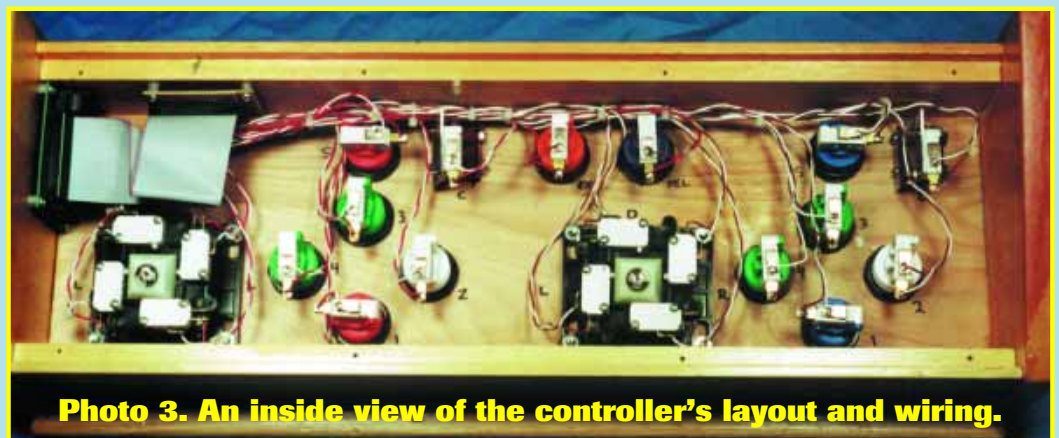


Photo 3. An inside view of the controller's layout and wiring.

front-end like Arcade @ Home. The Windows version — MAME32 — sacrifices some speed but integrates better with the operating system.

A Simple Controller

Most arcade games are controlled with joysticks, buttons, steering wheels, foot pedals, levers, trackballs, and spinner knobs. Emulators support a limited number of joystick types, but most all of them can use the computer's keyboard. The user customizes the emulator to define keystrokes for certain actions. For example, to go up, you might press the up-arrow key; to fire, you might press the 'F' key. Keyboards are not ideal controllers because of their fragility, but using the keyboard's interface circuitry allows for the creation of a custom controller.

Photos 1 through 3 are pictures of my project. It is built around a Hagstrom Electronics KE18 PC keyboard encoder module. This under-\$50.00 part emulates a PC keyboard and receives its power from the host PC. It provides two modes of operation. In one mode, a maximum of 18 different predefined key closures are defined, while matrix mode allows 81 different PC keys to be used.

Table 1 is a list of the keys I used and what functions they control. The KE18 also has a keyboard passthrough, allowing the controller to remain plugged in while you use the keyboard. Hagstrom also makes a version called the KE24, which is completely programmable using your PC's COM port. This makes the controller more usable with emulators that do not allow keyboard remapping, but cost twice as much. The joysticks and switches are genuine arcade-quality units from Happ Controls, a major arcade game parts supplier.

Interfacing the switches and joysticks to the KE18 required a junction board. This simple 2.5" x 2.5" piece of RadioShack solder-ringed hole perfboard duplicates the KE18's 40-pin header connector, and allows simple wire connection and troubleshooting. Photo 4 shows the KE18 and the junction board. The two boards connect with a short length of 40-pin ribbon cable.

Wiring the junction board is straightforward, and begins with the creation of a chart showing the keys you will use with your emulator. You may wish to use my example in Table 1 as-is or create your own. The KE18 supports Control, Shift, and Alt-keypresses like a PC keyboard, but you'll want to use "straight" key assignments for your controller's functions. Next, solder a pair of wires for each key you've defined in the chart across the proper header pins. Label each wire pair with either "Player 1" or "Player 2" and the key name.

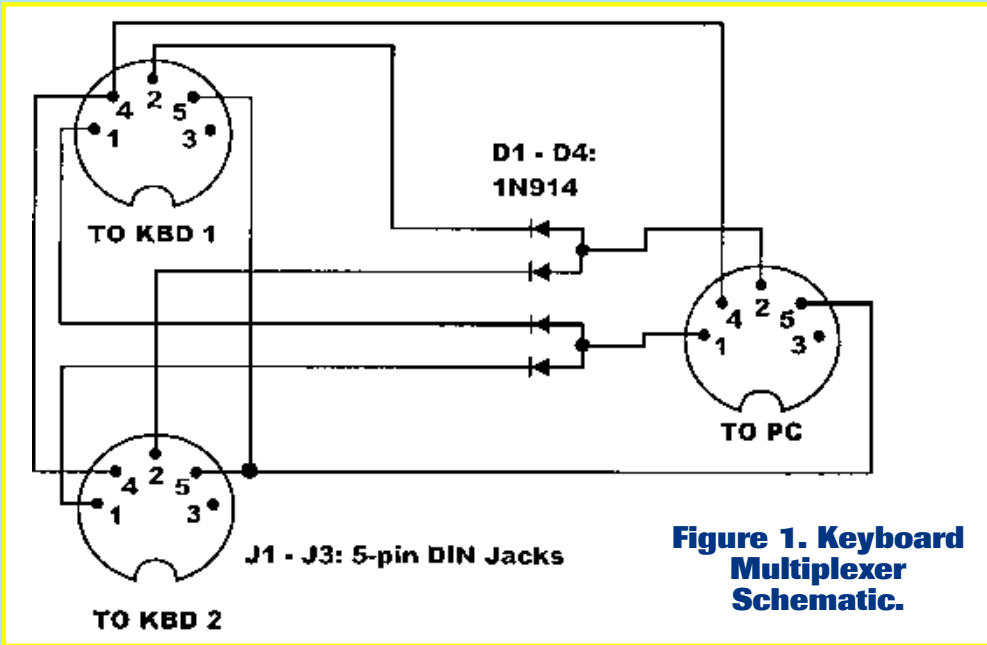


Figure 1. Keyboard Multiplexer Schematic.

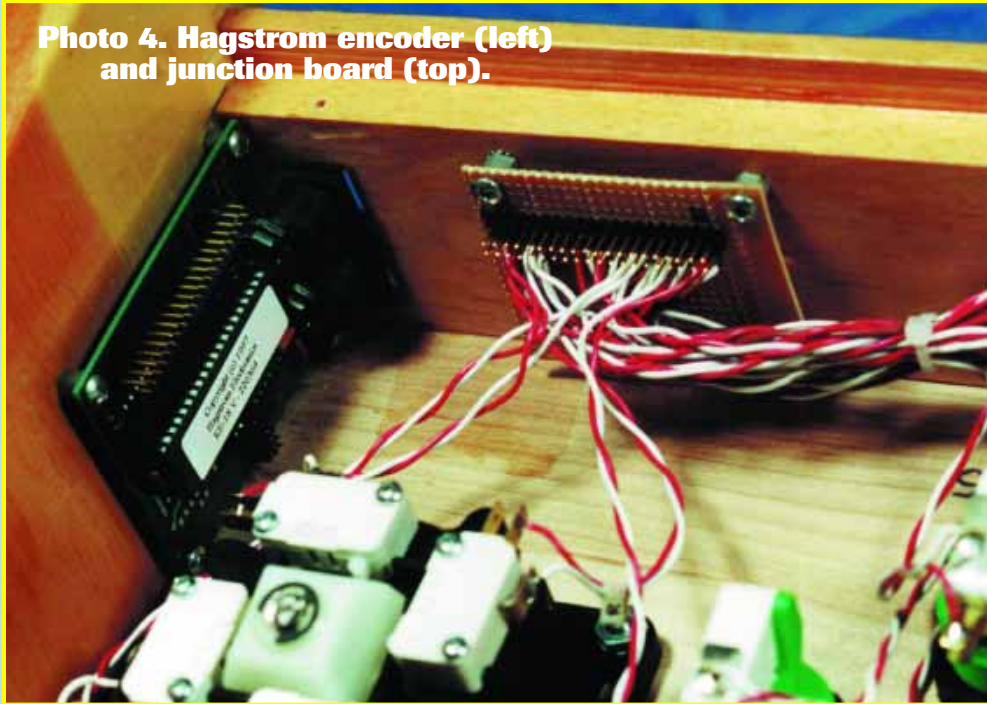


Photo 4. Hagstrom encoder (left) and junction board (top).

emulator's hardware requirements are usually spelled out in the documentation. For PC users, a Pentium 200MMX with 64 MB of RAM and a fast video card are sufficient for most of the older arcade games. You can

use less-capable hardware with DOS-based MAME, which is reputed to play games faster than other versions. Under Windows 95 and 98, you can use MAME DOS by booting the PC into DOS mode, or with a

Parts List

- Hagstrom KE18 Interface with keyboard cable
- Happ Ultimate Joystick (2)
- Happ Push Buttons and Horizontal Switches (14, various colors)
- Happ Coin Reject Buttons (2)
- Happ/Cherry Microswitches for Coin Reject Buttons (2)
- RadioShack #276-158 perfboard (1)
- RadioShack #RSU11323813 40-pin header strip (1)
- 40-conductor IDE PC hard drive cable (1)
- Scrap 18-gauge aluminum for Coin Button brackets
- 6/32 x 1-1/4" screws with nuts (4)
- 6/32 x 3/4" screws with nuts (4)
- 22-gauge stranded hookup wire
- Suitable case

Table 1. Key Function Definitions

Player 1 Controls			Player 2 Controls		
Function	Key	Pins	Function	Key	Pins
Start	1	I - K	Start	2	I - L
Coin	3	I - M	Coin	4	H - J
Up	R	B - R	Up	U	C - L
Down	C	A - L	Down	N	B - N
Left	D	A - M	Left	H	A - Q
Right	F	A - O	Right	J	B - J
Button 1	E	A - N	Button 1	Y	C - P
Button 2	T	C - K	Button 2	I	A - R
Button 3	X	C - O	Button 3	B	A - K
Button 4	V	C - M	Button 4	M	B - M

Common To Both Players		
Function	Key	Pins
Exit Game	ESCAPE	C - R
Select/Enter	G	M

Where do I find game ROMs?

ROM download sites can be found all over the Web. Enter any search engine, such as Altavista or Yahoo, and use terms like MAME, emulator, arcade, ROMs, or ROMZ. Add computer-specific names like Amiga and Mac or Macintosh to find emulators for those platforms. Be careful! Some sites may have explicit pornographic banners, and may open multiple instances of your browser that display these sites. It's an unfortunate fact of Internet life that these sites exist, and you're bound to encounter them sooner or later.

Make sure to visit the "Links" section of the sites you visit, as you will find many other resources there that won't appear in the search engines. Bookmark liberally. You'll set up a trail you can retrace later if you find something that catches your eye.

Be prepared to spend a lot of time downloading and updating ROMs. MAME supports over 2,000 different games and, as the program evolves, you may be required to re-download updated ROM sets, as well as new ones. Most classic arcade games are well under one megabyte, while most Neo-Geo games are larger than four megabytes. Some of these games are 30 to 40 megabytes each.

If you don't have an Internet Service Provider (ISP) and can't connect to the Web, stop whining and join the digital age! ISPs typically charge between \$15-\$30 a month for their service, and allow you to have email, as well as access another great resource called newsgroups. These are similar to the computer BBSes of years past. Groups such as alt.binaries.emulators.misc and comp.sys.emulators have ROM files available for downloading. If you can tolerate an on-screen ad banner, services like Free Altavista provide local, FREE dial-up access to the Internet (Web only, no newsgroups). The no-cost software can be found at altavista.com. Find a net-connected friend and have them download this single-floppy program for you.

Be mindful of the joystick's switch orientation when connecting wires, because directions are reversed when operating the joystick. When the stick is pushed up, or away from you, the switch closest to you is actually triggered. When the stick is pushed left, the right-hand switch is pressed. If your joystick does not take you in the proper on-screen direction, double-check your wiring. To help keep my wiring straight, I marked the switch functions on the case's

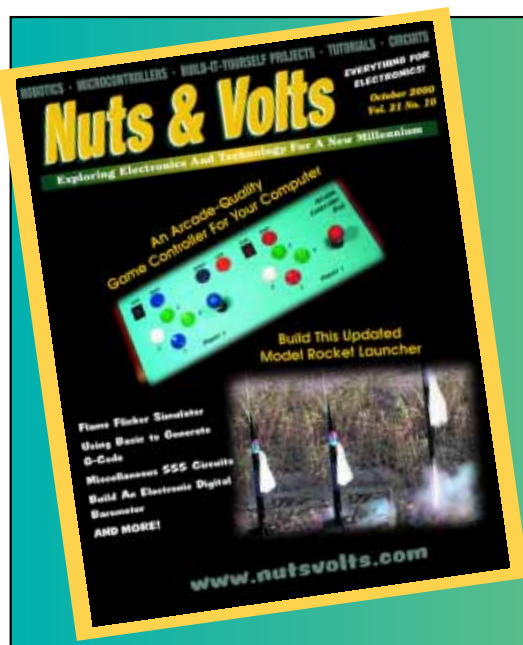
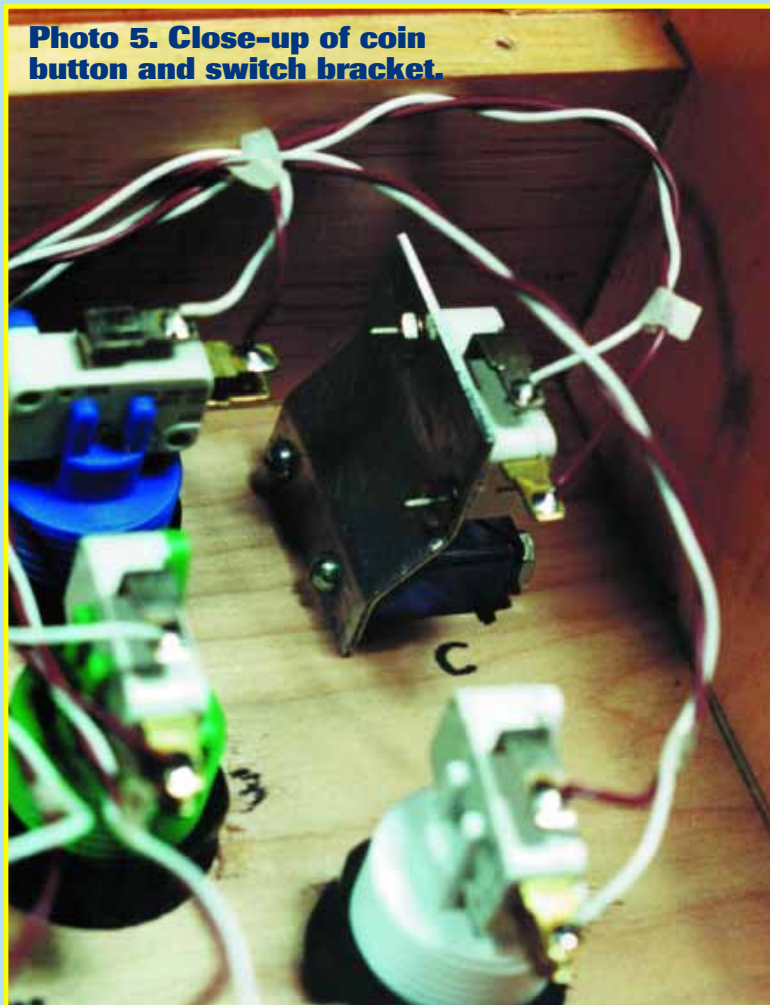
inside. This is visible in Photo 3.

One whimsical detail of my controller is shown in Photos 1 and 2. Rather than use standard push-button switches for the 'Coin' functions, I installed two Happ coin-reject buttons. These buttons do not have switches, as they trigger mechanical coin-reject mechanisms. I fabricated simple switch brackets using sturdy pieces of aluminum, and attached a Cherry microswitch to each bracket. Two holes were

drilled completely through each bracket and button, and long screws were then used to fasten the two pieces together. This is shown in Photo 5. The bracket also serves to hold the coin-reject button against the front panel. These buttons are not backlit, as the PC's keyboard port doesn't supply enough current for light bulbs.

The controller cabinet measures 23-1/2" wide by 9" deep. It stands 5-1/4" high in the

Photo 5. Close-up of coin button and switch bracket.



Shameless Plug

This article was reprinted from the October issue of *Nuts & Volts Magazine*. If you aren't familiar with *Nuts & Volts* and are interested in electronics, we invite you to stop by our website and see what it's all about. (Even if you have seen it, stop by anyway.)

Heck, we'll even send you a sample copy for free if you've never seen it before. And of course, you can also subscribe for only \$19.00. **What a deal!** The details are on our site.

www.nutsvolts.com



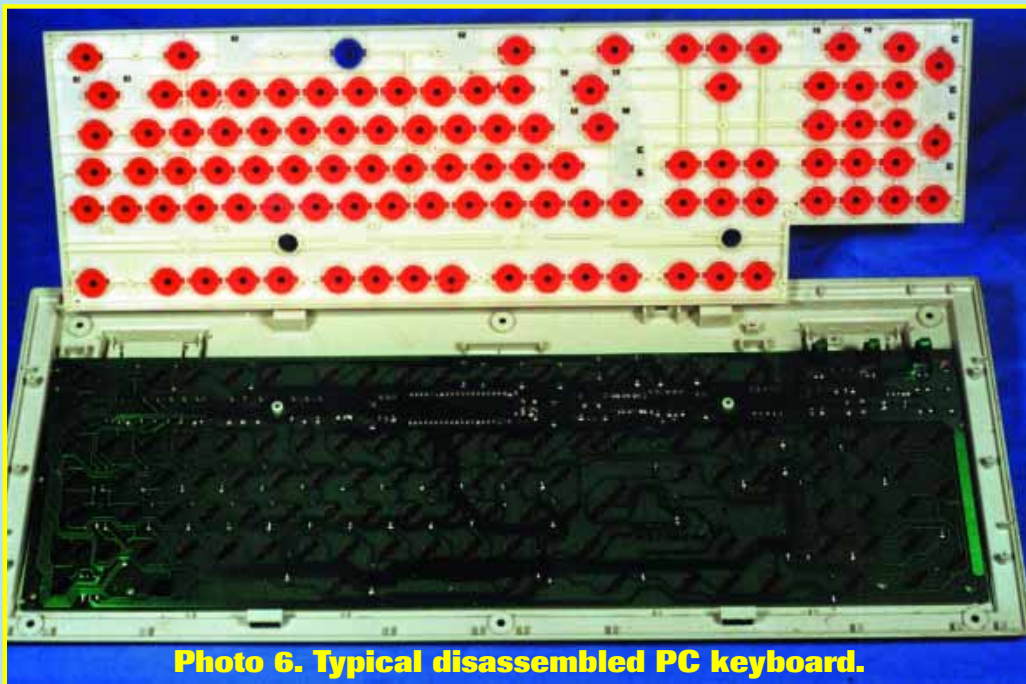


Photo 6. Typical disassembled PC keyboard.

back and slopes to 4-1/4" at the front edge. The slope is accomplished by cutting the bottom edges of the controller's end pieces on an angle, with the short side toward the player. The case was built from 1/4" scrap plywood and 1/2" pine boards, and finished with a honey oak stain/polyurethane. The front panel was sized to allow printing of the front panel legends on two 8.5" by 11" pieces of blue card stock, then taping them together.

The front panel and legends are protected by a sheet of 1/8" Plexiglas, with switch holes cut by a machinist friend using a Bridgeport mill. This is why it pays to have contacts with skilled people who can help you with the more difficult areas of your projects. You might also use dry-transfer lettering with several coats of clear enamel over your work.

Controller Alternatives

If you want to keep costs down, it is possible to gut an existing keyboard and use its controller instead of buying a dedicated controller. PC keyboards can be found at most swap meets for \$5.00 or less, or in special sales at your local computer store. Interfacing them to the necessary switches can be accomplished in several ways.

If you disassemble a typical keyboard, you'll see that the key mechanisms are mounted onto a frame that fits over a PC board. Photo 6 shows a disassembled keyboard. This PC board contains many pairs of etched-on contacts, which are shown more clearly in Photo 7. One of the rubber key domes is also

shown. When a key is pressed, a conductive pad inside the key dome shorts a pair of contacts on the PC board and makes a key closure.

If you have ample room in your controller case, you can keep the PC board intact and simply solder wires from each switch to each pair of key wires contacts that you will use. It will be necessary to remove the protective black coating on each set of pads by rubbing them gently with steel wool. After the wires are connected at both ends, you then mount the entire PC board into your controller case. Small-footprint, space saving keyboards work best for this approach.

If you wish to have a neater project, you can use a volt-ohmmeter to trace each key's contacts back to the keyboard encoder IC. Make a list of which pins are shorted when each key is pressed. Then use a bandsaw or jigsaw to carefully separate the keyboard encoder section from the rest of the PC board. Construct a junction board similar to mine, then make an umbilical cord that attaches the junction board to the encoder board.

This approach prevents the simultaneous hookup of a real keyboard; however, adding the simple circuit in Figure 1 should address that shortcoming for PC-based controllers. Gutting a keyboard is the only viable approach for the owners of Amigas and some pre-USB Macintoshes. Other owners of older Macs have another option that I'll discuss in the next section.

My controller works with most arcade games, but some games demand a trackball. For those occasions you can attach a PC trackball to your COM port. By carefully choosing the case style of your trackball, you can mount it directly inside your controller's case. Happ offers a genuine arcade trackball with serial and USB interfaces. While this option is more

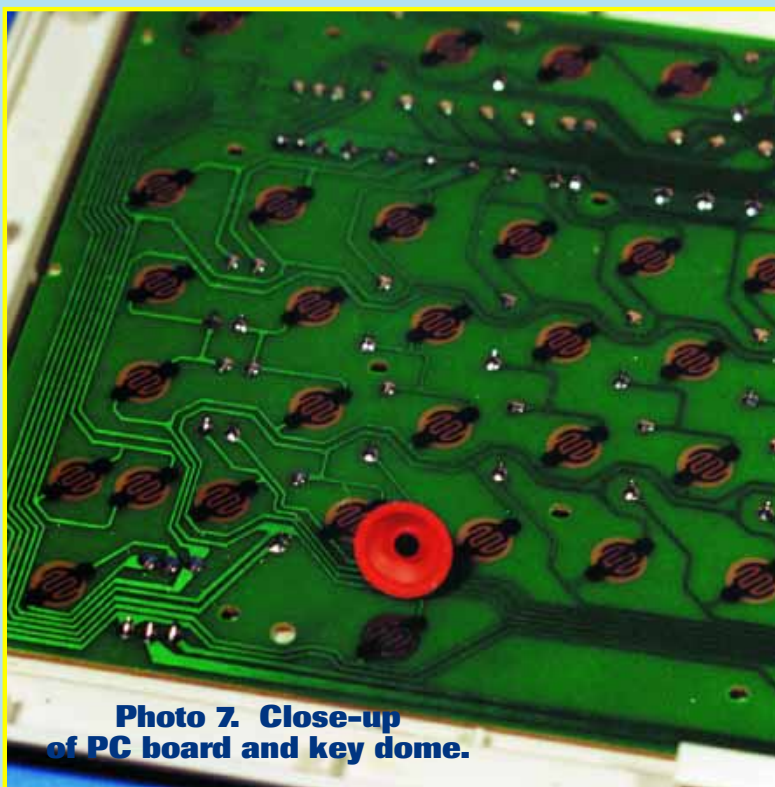


Photo 7. Close-up of PC board and key dome.

Companies Referenced

Hagstrom Electronics
Keyboard and USB encoders
2 Green Lantern Blvd.
Endicott, NY 13760
(607) 786-7523
www.hagstromelectronics.com

Wico
Arcade game parts and controllers.
7847 North Caldwell Ave., Building C
Niles, IL 60714-4508
1-800-367-9426 or (847) 583-1320
www.wicothesource.com

Happ Controls
Arcade game parts and controllers
106 Garlich Drive
Elk Grove, IL 60007
1-888-289-4277 or 1-847-593-6130
www.happcontrols.com

Fultra
This site offers arcade spinners
www.fultra.com/arcade/

MCM Electronics
Arcade game parts and other items to finish your project
650 Congress Park Drive
Centerville, Ohio 45459
1-800-543-4330
www.i-mcm.com

expensive, it will be easier to install in a custom case and will hold up well under hard use.

Some games like *Tempest* and *Asteroids* are best played with spinner knobs. Until recently, these were not easily obtained. A new company, Fultra, is making them available at a reasonable cost. These units are available with serial interfaces. If you want a USB version, I recommend buying just the mechanism from Fultra, then gutting a cheap USB mouse for its interface.

For games requiring light guns, you can use a console's game gun (such as a Super Nintendo) by constructing a simple parallel-port interface and installing a special DirectX Windows driver called DirectPad Pro.

Cross-Platform Controller Options

Did you know that you can use a Macintosh keyboard on your PC, and that a Windows-style keyboard can be used on a Macintosh? It's true — if you have a USB port in your computer and a USB keyboard. Using these keyboards to construct your custom controller will allow their use on either platform. There are some caveats.

The PC must have an option in its BIOS to allow "USB Legacy Support" (or other similarly worded phrase). This is necessary because operating systems older than Windows 98 don't recognize that USB keyboards or mice are connected. The USB support in Windows 95 was half-baked and didn't work reliably. Windows 98 is rock-solid in this area and other aspects of its performance. The best thing you can do for your system is to buy a copy of Windows 98 SE, wipe your hard drive, and perform a fresh installation.

You could get a USB-based keyboard

and use its controller. However, a stand-alone USB controller similar to the Hagstrom unit is available from a British web site. The I-PAC (Interface for PC to Arcade Controls) allows switch interfacing to your computer using the PC-AT (five-pin DIN), PS/2, or USB ports on your PC. Newer Mac users would use the USB port. Owners of older Macs may be able to add a USB controller card and software to use this type of controller. Check with a knowledgeable Mac dealer.

Who Says You Can't Live In The Past?

Emulators open up a world of fun previously unattainable on your computer. I can now run games from the arcades on my PC, as well as for popular consoles like the Super Nintendo, Sega Genesis, Atari 2600/5200/7800, Intellivision, Playstation, and even the Nintendo 64! The uses for game emulators are limited only by your imagination and wallet.

Have you always wanted an arcade console for your rec room, but didn't want to be stuck with one game forever? Buy a dead arcade machine, gut it, and install a PC with an arcade controller interface. Better yet, buy one of the "cocktail" cabinets that allow two players to sit face to face and use it as a living room coffee table. Have fun with your project! **NV**

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Web Emulation Resources (or, Where Do I Begin?)

The Vintage Gaming Network www.vintagegaming.com

A great source for gaming and computer emulation.

Arcade @ Home www.arcadeathome.com

This site offers gaming resources and the best Windows-based GUI for DOS MAME called Arcade @ Home.

RomCenter

www.emuhq.com/romcenter/

The home of the best ROM management utility I know of. You need this program to maintain your ROM collection.

Build Your Own Arcade Controller FAQ www.arcadecontrols.speedhost.com/arcade.htm

This site offers lots of info on building your own controller and retrofitting old arcade cabinets.

Andy's Arcade Site www.spaceinvaders.uk.com

This site features the IPAC interface, as well as instructions for integrating it into your project.

DirectPad Pro

www.ziplabel.com/dpadpro/index.html

You can download the DirectX console controller driver and interface details here. Look around — they may have some other software you never knew you needed!