



Make Your Own MAC

BY
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There's nothing really magical about assembling your own IBM PC compatible computer, in fact, nearly everyone has or will be doing it. Some experts feel that most electronics companies are now actively and aggressively producing IBM clones—even the off-shore companies that used to make CB radios. But that's something you probably already know. Besides, the topic of this article is how to build your own Macintosh®, so perhaps we should ponder the question: "Why aren't there any Macintosh clones as well?"

The answer to that question is one of legality, rather than technology. Apple Computers in their infinite wisdom designed and patented a rather unique product line—the Apple Computer, and more recently the Macintosh. While there have been several companies who have tried to "clone" or dupli-

*Macintosh is a registered trademark of Apple Corporation.

You can build an easily expandable Macintosh with some built-in frills for less than what a new no-frills unit would cost.

cate the Apple computer system, they have found themselves facing perhaps the industry's most aggressive and successful legal department. If you've followed the newspapers over the years, the marketplace is littered with the "bones" of firms who tried to duplicate or replicate Apple products but got legally burned.

You might now wonder, how then can a magazine as reputable as **Popular Electronics** even consider running an article on building your own Macintosh. The answer is quite simple: No step or procedure contained in this article will violate any of Apple Computer's legal

rights—you will be using original Apple parts, not illegal duplicates.

That may sound expensive, but it's really not because good used Macintosh motherboards can be purchased very cheaply. Unlike IBM clones, Macintosh computers don't have a bunch of expansion slots. So when a user wants to upgrade a Macintosh, say by adding a hard disk, the motherboard must be replaced. The old motherboards are usually consigned to the local landfill, or retained by a dealer as a source of spare parts. (If you are concerned about the environment, and want to save some landfill space, building your

own Macintosh is the way to go.) So distributors for used motherboards have sprung up, and you could buy your own legal Apple Macintosh motherboard at low cost. For example, we bought ours for \$45 from one of the sources we mention elsewhere in this article.

However, a motherboard does not a Macintosh make. Sure you could go out and by the original Macintosh case, power supply, CRT, etc., but what you'd have would be a somewhat crippled computer limited by whatever the motherboard's original configuration might have been. If it was an early model, you'd have about 128K RAM and be forced into using a low capacity space-eating 5.25-inch floppy drive—hardly a state-of-the-art system. But what if we told you that you could assemble a high performance, "infinitely" expandable Macintosh with only a few simple hand tools and at a price less than the original cost of an unadorned Macintosh? What if you could do it in less than two hours and in most cases without the need for a soldering iron? Would you be interested? If your answer is "yes," read on.

Enter the Convertible Kit. The idea of building a home-made Macintosh is an old one. However, up to now building a Macintosh was a project only for the full-blown hacker. You'd have to assemble components, solder and cut foil traces, and really get into the circuitry. Hopefully, the end result was a usable Macintosh. Frankly you had to be a real glutton for punishment to shop, modify, solder, shop some more, and then still not really have what you wanted.

What the less daring of us needed was a "Volkswagen" approach to building your own Macintosh. Something along the lines of an IBM clone, so anyone with a few screwdrivers and a moderate amount of skill could build one, and do so at a cost-effective price.

With the easy and legal availability of certain key components—namely the motherboards and BIOS ROM chips—for a reasonable cost, all we needed was for someone to figure out how to produce a kit platform that would allow the integration of these components with a decent-sized power supply, and to figure out how we could use a regular PC-compatible monitor to further limit the expense.

Well, there's a little company called ATS, Inc. (Atlanta Technical Services Inc.)

TABLE 1—ITEMIZED COST

Item	Approximate Cost
Motherboard 128K	\$ 45.00
128K ROM set	\$120.00
Memory Upgrade/SCSI Adapter	\$249.00
Mouse	\$ 69.00
256K Memory Modules (minimum of 4 needed)	\$ 25.00/ea
Monitor	\$149.00
SCSI 40MB Hard Drive	\$400.00
ATS Convertible Kit	\$375.00
Keyboard (Basic Mac)	\$ 99.00
Total:	\$1606.00
Note 1: Available from ATS (see box entitled "Accessory Sources" elsewhere in this article).	
Note 2: You'll also need a copy of the Macintosh Operating System from your local Apple dealer.	

that has produced a kit with almost all the features we'd hoped for. The ATS Convertible Kit, as the package is called, sells for less than \$400 and includes a small-footprint PC-like case, power supply, cables, video/power adapter, 800K 3.5-inch floppy drive, and a well written instruction manual. What remains is for you to do a bit of shopping on your own and acquire the "guts," namely a Macintosh motherboard and ROM. You'll also need a memory/SCSI adapter board (which ATS can also supply), a few hand tools, and a bit of time.

Shop 'Till You Drop. We've already identified some of the key components of our Macintosh system, and Table 1 gives you a run-down of what you need to acquire, and the actual costs we encountered while ordering the supplies. You might stop and wonder about the cost, considering there have been advertisements for Macintosh Plus computers for less than \$1000 in the media. However, the Macintosh advertised does not come with a hard drive, nor is it what I tend to refer to as a "platform," which can be expanded at will and in an almost infinite manner. Likewise, you will be getting a system with a full-sized power supply and a conventional PC monitor—a far cry and improvement over the minimal display which comes standard on the Macintosh Plus.

However, for the accountants or bean-counters in our readership, the total price shown is still less than the original Apple Macintosh computer pricing, and still represents a cost-effective savings over the actual or true cost (apples to apples minus the display) of a similarly configured Macintosh Plus with a 40-MB hard drive. If you are in the mood to be frugal, and don't

see a hard drive in your immediate future, you could instead add a second floppy drive to the system and reduce the cost by some \$200. Likewise, if you have a monitor that can easily be converted to reproduce the Apple/Macintosh/ATS video output, you can save another \$149—that is providing you can safely make the modifications (that topic will not be covered in this article.)

Ordering Information. Now that you've got an idea of what it will cost, you need to know where to buy your supplies, and how to get in touch with the sources. The boxed text entitled "Accessory Sources" lists sources as well as addresses and, in most cases, toll-free telephone numbers.

Before you order your motherboard or Convertible Kit, there's something you should know: For some unknown reason, Apple elected to use two different package styles for their CPU IC's. One type of chip, easily identified by its black-plastic body requires a connector called a "killy clip" in order to install the memory/SCSI adapter board. The Killy clip can be installed in a few moments with the use of just a screwdriver.

The other chip has a gray ceramic case and will require the use of a different connector called a "pin header." Installing the pin header requires the use of a small tip, low wattage soldering iron to make 64 connections. So, if at all possible (especially if you doubt your soldering skills) request a motherboard with a black-plastic 68000 CPU chip. You will also need to let the people at ATS know which type of CPU you have before ordering a Convertible Kit so they can ship you a kit with the proper connector.

On a different note, you might be

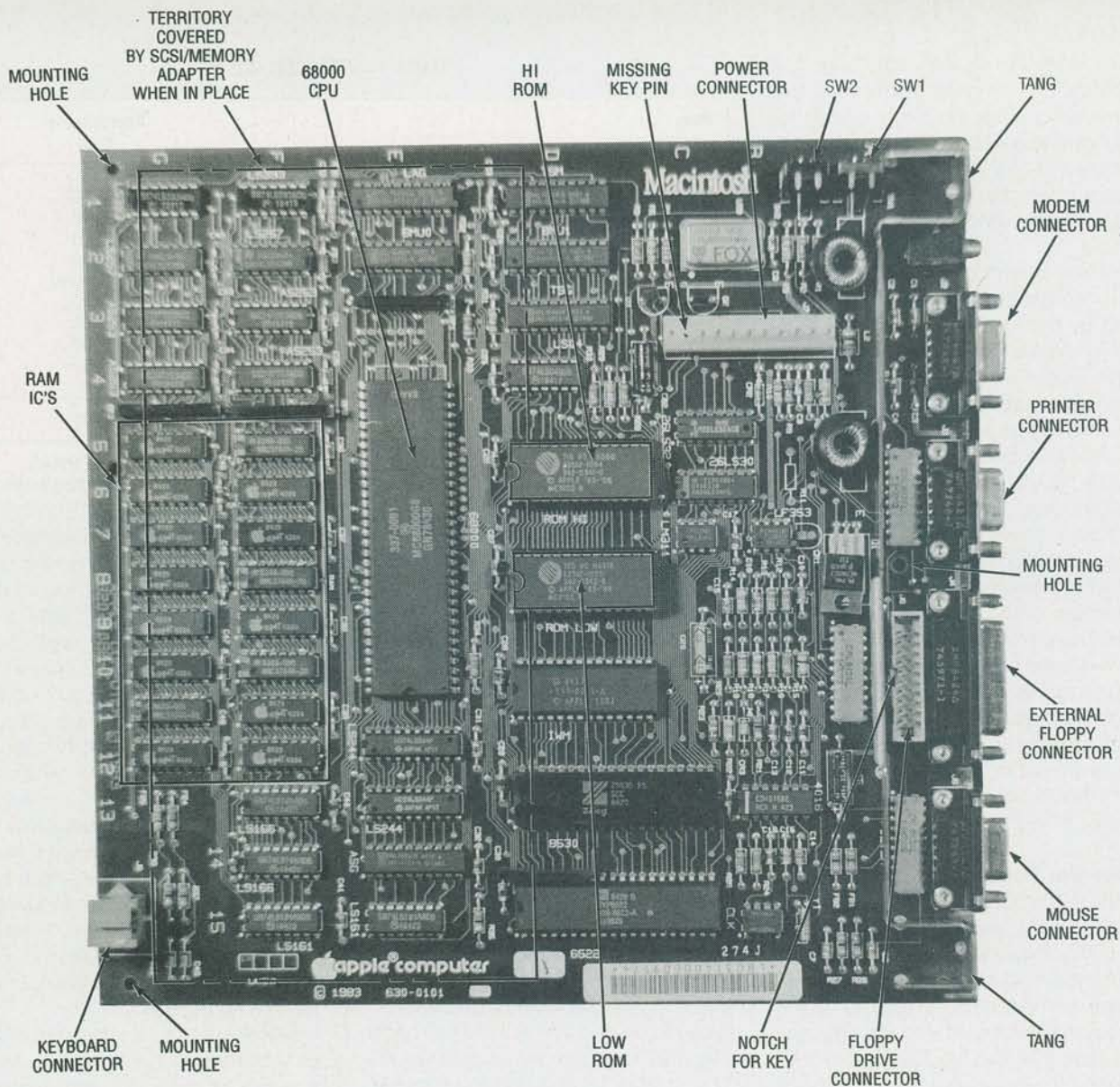


Fig. 1. This is a basic Macintosh motherboard. The most useful features shown here are the locations of the ROM chips and the area that will be covered up by the SCSI/memory adapter.

able to save some money if you know someone who has just added an additional 800K drive to their system, and won't be using their (supplied) BIOS ROM chips. **Under no circumstances should you attempt to copy or knowingly purchase copied/counterfeit Apple Macintosh BIOS ROM chips.** The author, **Popular Electronics**, Gernsback Publications, as well as the people at ATS Inc., caution you against potential violations of Apple's copyrights. Regardless of how much you might think you'll save, the potential legal hassles you could run into can be more costly. In short, don't do it!

Likewise, you could possibly acquire an as-is motherboard at a flea-market or swap meet. If you find one out of

commission, keep in mind that the under-rated power supply and CRT in the early Macintosh systems were more prone to failure than the motherboards, which is really what you'd be interested in anyway.

Assuming you've placed all your orders, you will still need a few common hand tools such as a Phillips-head screwdriver, a small flat-blade screwdriver, a 3/16-inch nut driver, a 7/32-inch nut driver, gas-joint pliers (common household pliers), long-nose pliers, and an anti-static grounding wrist strap. If you couldn't find a plastic-CPU motherboard, you'll also need a 15-25-watt soldering iron with a small tip, a supply of rosin-core solder, and some liquid flux.

Replacing the ROM Chips. Now that we have all of our components together, let's get underway. Our first step will be to replace the motherboard's 64K ROM chips with 128K units. There are two socketed chips (see Fig.1), clearly identified on the silk screening as "HI" and "LOW" ROM. They should bear the part numbers 342-0220 and 341-0221, respectively.

Wearing your anti-static wrist strap, remove each of the IC's by sliding a flat-blade screwdriver between the ROM and its socket. Rotate the screwdriver and gently pry the ROM free. Repeat this process for the remaining ROM chip. You can discard the two old chips as you won't be using them in your "new" Macintosh.

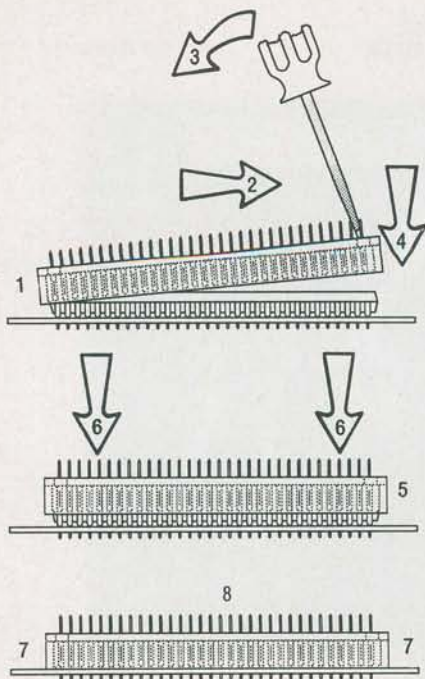


Fig. 2. This drawing shows the step-by-step installation for the Killy clip. You'll need to follow these steps if your motherboard has a plastic CPU.

Locate the new HI ROM chip (part number 342-0341) and examine it to be sure that the pins are all straight and exit the IC at right angles. If any pin (or leg) is bent, carefully straighten it using your long-nose pliers. One end of the ROM has a notch. Insert the ROM in the HI ROM socket, with the notched end pointing towards the CPU chip as shown in Fig. 1. In a similar manner, locate the new LO ROM chip (part number 342-0342) and carefully insert it into the LO ROM socket. The notch on the LO ROM should also point towards the CPU. Make sure that both ROM chips are firmly seated in their sockets.

Installing the Connectors. Now you can unpack your Convertible Kit (if you haven't already). You will find a low-profile case and an instruction manual. Use your Phillips screwdriver or a $\frac{7}{32}$ -inch nut driver to remove the four cover screws on the sides of the case, and carefully pry the cover up and towards you. Inside the case you will find the cables, hardware and battery pack as well as a package of four AA alkaline batteries. Remove the components and set them aside. At the same time, take out the 800K floppy drive by removing the four screws that secure the floppy drive plate and lifting the assembly, placing it aside; we will be reinstalling the floppy drive later in our procedure.

Because we have no way of knowing which of the two CPU's (black plastic or gray ceramic) your motherboard has, we will describe both the Killy clip and pin-header installation procedures. Throughout our discussion we will use numbers in the parenthesis to refer to special points in the figures. For either procedure be sure to wear your anti-static wrist strap and read the instructions at least once before beginning.

Let's start with the procedure for the black-plastic CPU using the Killy clip (illustrated in Fig 2), which should be somewhere among the hardware. Place the clip over the CPU chip with the flange on one end of the clip centered on the body of the CPU chip (1). **Do not** hook the flange under the CPU chip at this point. Holding the Killy clip firmly, push the clip towards the other end of the CPU (2). The end of the clip resting on the CPU will bend slightly outward. While maintaining pressure on the clip, insert the flat-blade screw-

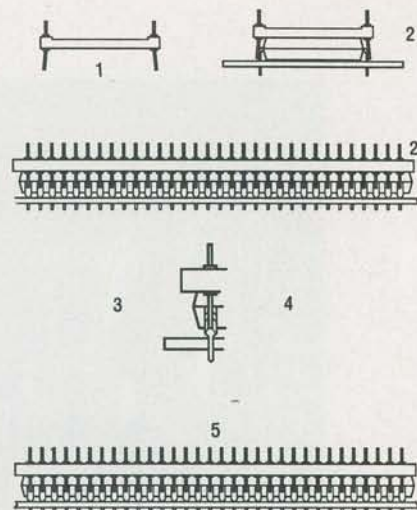


Fig. 3. Follow this guide to install the pin header on a ceramic CPU. Be sure to remove the spacers first.

driver into the slot on the free end of the clip. Use the screwdriver as a lever to gently bend the end wall of the clip away from the chip (3) while sliding the clip down over the CPU (4). Remove the screwdriver once the flange is resting on the body of the CPU chip (5). Now apply downward pressure to the Killy clip (6). The clip will first snap into position on one side of the CPU chip so it rests on the circuit board. Push down on the side that has not fallen into position. It may take considerable force to seat the clip, which will be indicated by an audible snap as the flanges fit under the CPU chip. When the clip has been installed properly, both sides of the Killy clip should touch the circuit board (7). Examine the clip, the pins should extend vertically from the top of the clip, if necessary, straighten any bent pins (8).

To install the pin header (see Fig. 3) instead, start by removing the U-shaped plastic spacers on the CPU if any are present on the motherboard. You should be able to push them off with your fingers or a small screwdriver.

Examine the pins of the CPU for corrosion. Clean the pin surfaces by rubbing them with a pencil eraser and remove any residue with a cloth dipped in common rubbing alcohol. You may wish to apply a light coating of liquid flux to the pins before beginning to solder. Bend the pins outward on one side of the pin header by approximately 10 degrees (1). That is necessary to fit the header over the pins of the CPU. Place the pin header over the CPU (2). Make sure that the pins of the header are aligned with the pins extending from the CPU chip. Push the header down as far as it will

ACCESSORY SOURCES

CONVERTIBLE KIT AND MONITOR:

ATS (Atlanta Technical Specialists), Inc.
3550 Clarkston Ind. Blvd.
Suite F
Clarkston, GA 30021
1-404-292-6655

USED MOTHERBOARDS:

Pre-Owned Electronics
30 Clematis Ave.
Waltham, MA 02154
1-800-274-5343

Shreve Systems
2421 Malcom St.
Shreveport, LA 71108
1-800-227-3971

128K ROM/UPGRADES:

Pre-Owned Electronics
30 Clematis Ave.
Waltham, MA 02154
1-800-274-5343

Peripheral Outlet
314 S. Broadway
Ada, OK 74820
1-800-332-6581

MacProducts USA
8303 Mopac Expressway Suite 218
Austin, TX 78759
1-800-622-3475

CMO
101 Reighard Ave.
Williamsport, PA 17701
1-800-233-8950

Shreve Systems
(See address under "Used Motherboards")

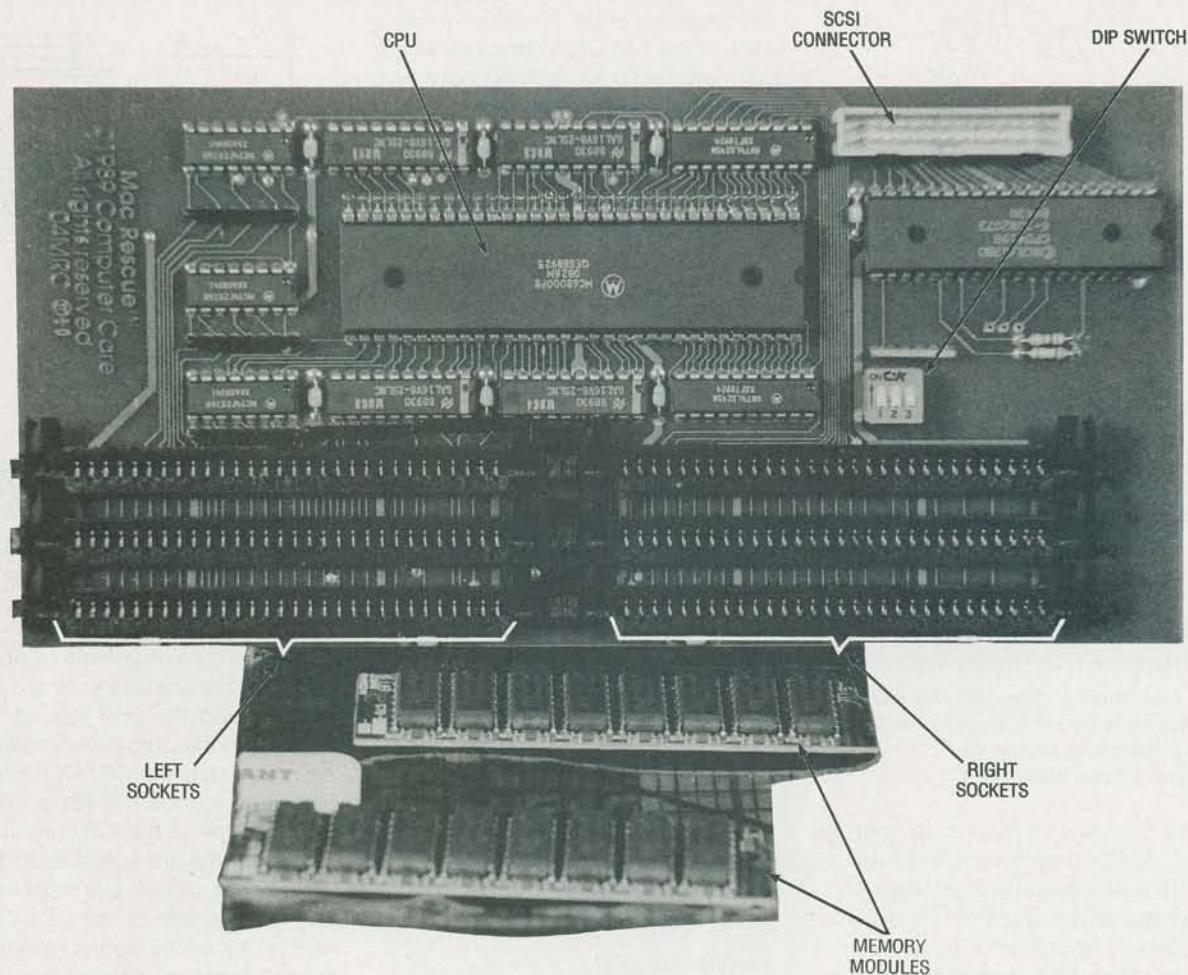


Fig. 4. This is the memory/SCSI adapter board with two SIMM's at the bottom. Note that each row of SIMM sockets requires two SIMM's.

go. There will be a slight gap between the body of the pin header and the body of the CPU.

You can now begin carefully soldering the pin header in place (3). Note that the ceramic chip can act as a very efficient heat sink, so you may need to use a higher temperature setting (if you have one) on your soldering iron in order to make good connections. First solder the four corner pins to hold the header stationary. Before soldering the remaining pins, make certain that the header is parallel to the motherboard.

Once you've soldered the header in place, it is impossible to reposition it.

Inspect your work. A good solder joint will be shiny (not grainy) in texture, and will have a fillet of solder between the contacts (4). Examine the pins on the pin header. They should extend vertically from the top of the header. If necessary, straighten any bent pins (5).

Memory Installation. We've now completed perhaps the most difficult part of our Macintosh assembly, and are ready to configure our memory/

SCSI adapter board (see Fig. 4). Table 2 shows how to configure the DIP switch located on the adapter board to suit the memory and motherboard's "base

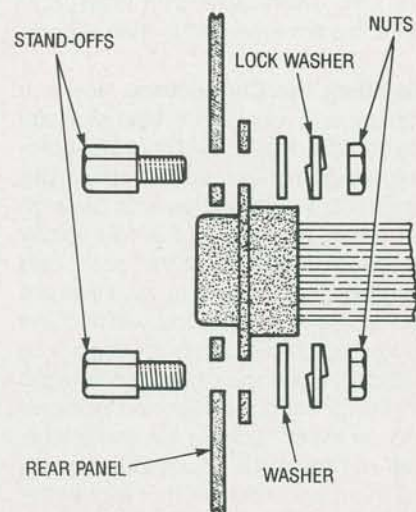


Fig. 5. Use these mounting details for the Video and SCSI connectors. It's a good idea to mount them onto the back panel before installing the motherboard.

TABLE 2—DIP-SWITCH CONFIGURATION

Motherboard Type	Total Memory	S1	S2	S3
128K	1MB	OFF	OFF	OFF
128K	2MB	OFF	OFF	ON
128K	4MB	OFF	ON	ON
512K	1MB	ON	OFF	OFF
512K	2MB	ON	OFF	ON
512K	2.5MB	ON	ON	OFF
512K	4MB	ON	ON	ON

memory size."

The information in Table 3 should allow you to properly arrange the memory modules (called SIMM's) in the slots on the adapter board to suit the motherboard and the amount of memory you desire. Note that each row on the adapter board has two sockets, a left one and a right one. Both must be filled with the specified SIMM to complete a row.

The SIMM's should be installed by inserting them at a 75° angle, then rotating them downward until they snap into place, causing both plastic locating tabs to engage. Once the memory is installed, and the DIP switches are configured, you are ready to connect the adapter board to the motherboard, either via the Killly clip or the pin header. If you are curious, look back at Fig. 1 to see the area that will be covered up by the adapter's circuit board.

Start by setting the motherboard on a flat surface and then orient the adapter board so that its six SIMM sockets are positioned over the RAM chips on the motherboard. Sight between the motherboard and the adapter board to ensure that all of the pins are aligned. Apply downward pressure to the CPU chip on the adapter board. Once installed, the pins of the Killly clip or pin header should be fully inserted into the socket on the underside of the SCSI/memory-adapter board. Now carefully set the motherboard/adapter board aside so you can proceed with

TABLE 3—SIMM CONFIGURATION

Motherboard	Memory	SIMM's For Row 1	SIMM's For Row 2	SIMM's For Row 3
128K	1MB	256K	256K	Empty
128K	2MB	1MB	Empty	Empty
128K	4MB	1MB	1MB	Empty
512K	1MB	256K	Empty	Empty
512K	2MB	256K	256K	256K
512K	2.5MB	1MB	Empty	Empty
512K	4MB	1MB	1MB	Empty

Note: Each row has a left and a right socket and both sockets must be filled with the designated SIMM.

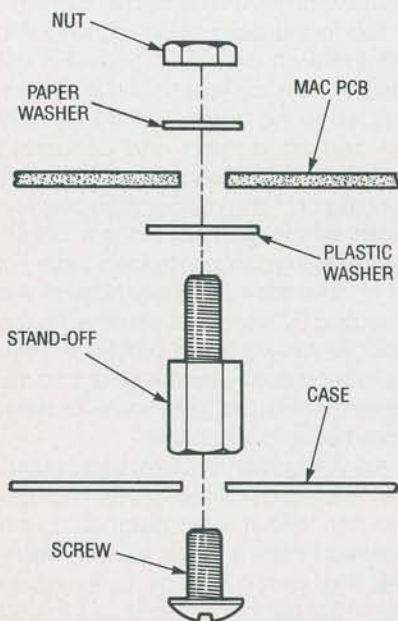


Fig. 6. Mount the circuit board standoffs using this figure as a guide. You should place the plastic washers between the PC board and the body of the standoffs.

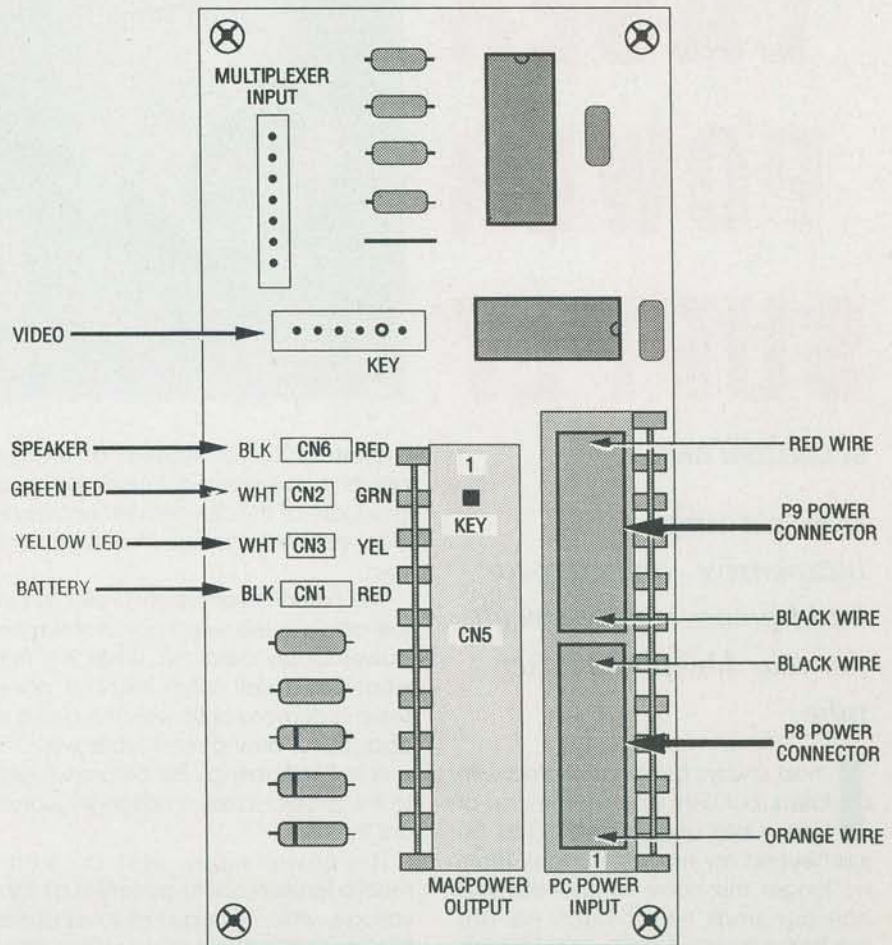


Fig. 7. This is a top view, of the power/video-adapter board. It's mainly responsible for performing the Converter Kits magic.

the assembly of the "home" for your Macintosh.

Final Assembly. The manual which comes with each ATS Convertible Kit is well illustrated and very detailed. For that reason, we will merely summarize the remaining assembly steps, adding illustrations, photographs, and some suggested changes in assembly order that we found to be of benefit.

Although the manual suggests mounting the SCSI and video connectors to the rear panel after installing the motherboard, that's not a good

idea. We found that the motherboard left little room for maneuvering the connectors into place, so you should install the connectors first.

In that vein, open the parts packages and select the SCSI and video-cable assemblies. Using your 3/16-inch nutdriver and long-nose pliers, mount the two connectors to the two vertical slots on the rear panel. The hardware assembly for this step is shown in Fig. 5. Flop the cables attached to the connectors over the rear of the case to move them out of the way for the next steps.

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When installing the motherboard, we found that the "tang" (identified back in Fig. 1) could get in the way. You might consider using your gas-joint pliers to bend the two tangs slightly to eliminate that problem.

The instruction manual tells you to mount three standoffs to the motherboard. A word of caution, while it might seem more logical to mount the standoffs first to the case, and then mount the motherboard on them, you are advised not to try it. Stick to the instructions in this respect.

The instructions call for "two paper washers" to mount each standoff to the motherboard. This was not exactly accurate. First, there are only three such washers supplied (you would need a total of six) and they are really made of fiber. However, there are three other washers supplied. They are black in color and seem like plastic. Figure 6 shows the assembly for mounting the standoff hardware. We placed the plastic-type washers on the foil or bottom side of the circuit board, and used the paper washers on the top or component side of the motherboard. All other steps and procedures remained the same.

The next phase of the installation concerns the on-board SCSI 3.5-inch disk drive. In our system, we decided to make use of an external drive, and were able to skip these steps. However, the instructions are clear, and accommodate virtually any Macintosh-compatible 3.5-inch SCSI drive.

The balance of the assembly process is purely mechanical with the manual clearly directing you to install and position the cables, etc. The key to a successful Macintosh clone lies with the connections of the various (clearly identified) cables to the ATS power supply and video adapter.

The single-board video adapter is the "magic" we alluded to earlier in this article. Customer engineered and built by ATS, this single board (see Fig. 7) is the difference between a project that "anyone" with a few common hand tools can complete and a project which should be attempted by only the most experienced and prolific "hacker." The instructions that are included with the kit clearly describe how to connect the remaining cables between this board, the power supply, the floppy drive, the SCSI and video con-

nectors, and the backup batteries to complete the job.

Start Your Engines. Assuming you've had no problem getting any parts and have followed the excellent manual to complete all the steps, it's time for the initial powerup. The manual assumes you will be using the ATS monitor and gives you a few simple steps for adjusting the image (horizontal and vertical). These steps call for the use of an insulated screwdriver, but our experience has indicated that the same small flat-blade screwdriver we used earlier can easily accomplish the task. If you have another monitor, naturally the set-up will be different. However, we strongly recommend that you acquire the ATS monitor or an exact equivalent.

All of the necessary instructions to configure and set-up your Macintosh clone are augmented with some additional information that might be of use should you have problems with your fixed- or hard-disk drive format, or in case of other problems.

We promised to show you how to build your own Macintosh, and have succeeded not only in demonstrating how to build a "street-legal" Mac, but one that even Apple hasn't considered. What we mean is an expandable Macintosh platform, with power for all of the possible accessories and adapters presently or soon to be available for the Macintosh computer family.

As we were going to press, we learned of yet another ATS Convertible Kit, this one based on the now-available Mac SE motherboard that will enable you to have more performance, more features, and at a lower cost, despite the increased cost of acquiring a Mac SE motherboard. You may want to look into one for yourself.

We'd like to acknowledge the assistance of ATS's president John Yaeger for his help and permission to reproduce line art from the Convertible's Manual. ■

