
# BUILD THIS IBM INCOMPATIBLE

*Build your own fully functional computer from discrete components.*

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Like the early settlers of this country, the pioneers of the personal-computer revolution built their own. Legendary machines like the Altair 8800 and the SWTPC 6800 were built, like settler's houses, from whatever materials were at hand. There was no going into the local Computerland and saying "Yea, I wanna buy a machine to do the bills and maybe play a few games—just for the kids, you know. . . ." If one of those pioneers wanted to balance his checkbook, he had to write a program to do it—and in assembly language at that!

Nowadays people say that that pioneering spirit is dead, and that no one in his right mind would attempt to build his own computer. Well we think differently. We think that you can learn an enormous amount about computers (and, possibly, about psychiatry) by building your own computer. In fact, we think that, for the engineering or technical student interested in digital design, there is no better way to learn than by building your own computer.

So, in this 463-part series, we are going to teach you everything you need to know—from the ground up—about building your own computer. With the information we'll provide, you'll be able to put together a fully functional version of anything from an Apple II to an IBM-PC to a Cray I. So stay tuned.

## Basic electricity

To begin our foray into the world of computers, let's discuss the basics of electricity. As everyone knows, there are two basic kinds of electricity, positive and negative. (See Fig. 1.) Due to the nature of the Earth's orientation with respect to the sun, electricity in the northern hemisphere is positive. If you're from "down unda," you have negative electricity. You can see for yourself how the two types of electricity differ by standing on the equator, extending your arms from your sides, and holding a large plastic pail in each hand. (See Fig. 2.) You must use a plastic pail, because a metal one would conduct electricity and allow it to leak out on the ground. Anyway, after a while, you'll find that the pail in the northern hemisphere is much heavier than the one in the southern hemisphere.

For our circuit examples we'll use positive electricity. Later on (in part 367) we'll show you a simple means of converting positive to negative (and negative to positive) electricity. But for now, if you live down unda, just reverse the orientation of all polarized components (diodes and capacitors), and substitute PNP for NPN transistors.

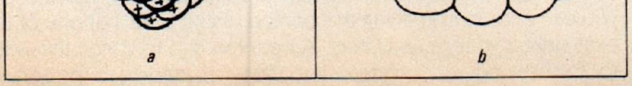
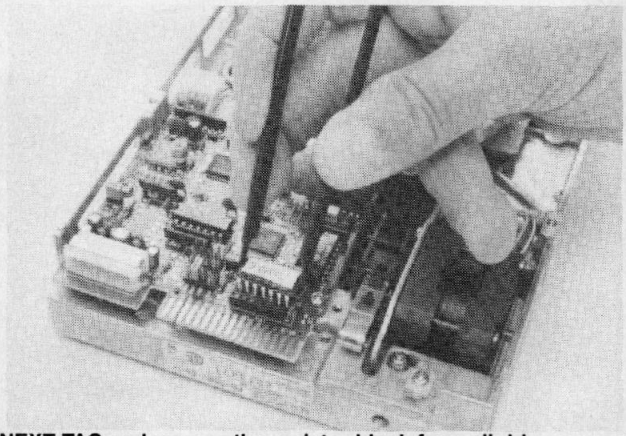
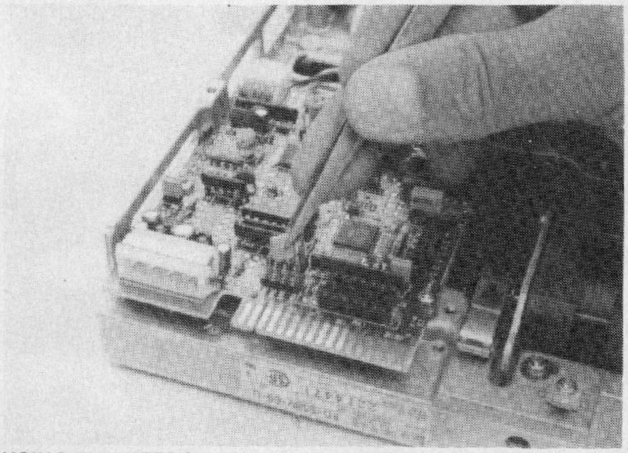


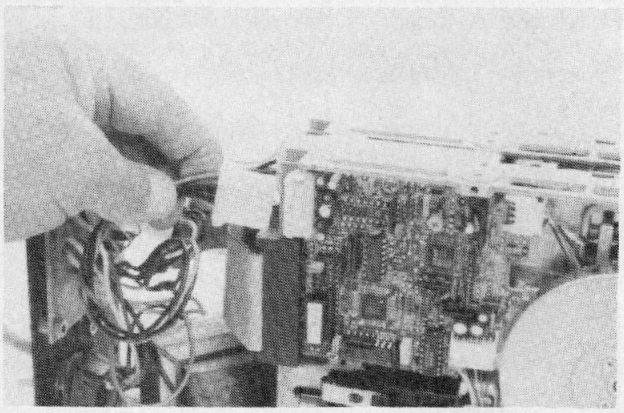

**FIG. 1—THE TWO MAJOR KINDS OF ELECTRICITY. Other less-common types are not shown.**



**NEXT TAG and remove the resistor block from all drives except the one that uses the last connector on the signal cable. Then mark the block.**



**USING TWEEZERS or needle-nose pliers, set each drive's DS *drive select* jumper to correspond to the jumper of the older drive being replaced, or to the required jumper pair if you're just adding an extra drive.**

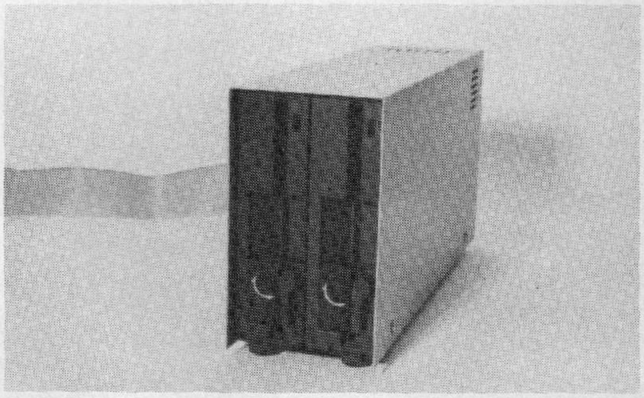


**INSTALL THE DRIVE(S) and the signal and power connections. Make sure that matching power connector terminals are spliced together. One or more drives will probably be damaged if you reverse the end wires of a single connector.**

## Power connections

You will need to install an extra power connector for the extra drive. Do not remove the power supply assembly and drill new holes in the printed circuit board for the extra power wires because you can end up damaging the printed circuit board or one of the heat-sinked voltage regulators. A better way is to splice the wires for the new power connector into the wires leading to the original power connector. Don't attempt to match colorcoded leads because there is no color standard for a disk drive's power connector: Every color in the rainbow has been used. Since the connector is polarized, orient the old and new connectors in the same direction and then match the individual connections. To splice in the new wires, scrape about ¾ inch of insulation off an original wire, wrap the new wire around the old, solder, and cover with tape. If you offset each splice about one inch there will be no possiblility of a short if a strand of wire slips out from under the tape.

Since it's almost impossible to program one of the half-heights when two are substituted for a full-height drive, make sure you program the drive before it's installed in the cabinet. Programming means setting the drive select jumper and possibly pulling a termination resistor block. Older drives programmed drive selection through pins shorted by a jumper plug. Also, most no longer have HS and HL head-loading programming, nor a MUX connection. If they exist they are factory set at other pin-jumper terminals—which should never be changed by the user. If you don't know what a jumper is for, don't touch it.



**SECURE THE CABINET COVER and you now have two drives that occupy the space of one, both using the original cabinet and power supply.**

The drive select programming for any 5-¼ inch disk drive is almost always located adjacent to the card-edge signal connections, which are easy to locate because they are labled DS0, DS1, DS2, and DS3. To program a half-height, look at your old drive and determine which one of the drive select jumpers isn't cut open. Then move the half-height's jumper to the same set of terminals, but keep in mind that the physical location might be different; on your old drive DS1 might be the third set of terminals, on the half-height it might be the first or second set of terminals. You are only interested in matching the DS connections, not their physical location. If your old drive also has HS, HL or MUX jumpers forget them. If your old drive has all DS jumpers set (Radio Shack does this for some computers because the selection is actually made by the pins of the signal cable's connector), you either must determine which is the one that's actually used, or short all DS pairs on the half-height drive.

Finally, there is the terminating resistor block. All drives are supplied with a terminating resistor, which resembles a socketed integrated circuit. It is generally located near the drive select jumpers. (If you can't locate the terminator block, phone the store that sold you the drive.) Only one drive per set of drives on a signal cable—usually the one at the end of the signal cable from the computer—can have the terminator; often, drives won't work if two or more drives are terminated. Pull the unwanted resistor block, but use an IC extractor tool so you don't damage the pins. You might need the block in the future. Not all resistor blocks are alike; a Brand X drive won't necessarily work with a resistor block from a Brand Y drive, so place a small label on each block before it's pulled so you know which block goes into which drive.

Basically, it takes longer to describe how to swap or retrofit half-height disk drives than it takes to do the job. The photographs show how easy it is to do a 2-for-1 half-height retrofit. If you plan your work carefully and solder neatly, soon you'll enjoy the convenience of dual disk storage.

FIG. 2—POSITIVE ELECTRICITY falls on the northern hemisphere; negative electricity falls on the southern hemisphere.

## Basic logic

Just as there are two basic kinds of electricity, there are two basic kinds of logic. Your choice of positive or negative logic, however, depends not on which hemisphere you live in, but on how obscure you want your circuit designs and programs to be. Due to the nature of the human mind, positive logic is inherently more comprehensible than negative logic. Positive logic is used more often than negative logic, but negative logic certainly has its uses. Sometimes, for example, if you're having trouble resolving a circuit into its proper logic elements, merely thinking about it in the opposite set of terms may suggest a solution. Or, if you're a student, you may be able to impress your professor by casting a circuit with negative logic elements. Or you may be able to confuse him so much that he'll have to admit you're a genius and place you on the dean's list. As we said, negative logic does have its uses.

There are three basic kinds of logic operations; it has been shown that many logic problems can be solved by combining them in various ways. The operations are the NOT, the AND, and the NAND. Their truth tables are shown in Fig. 3-*a*–Fig. 3-*c*.

NOT

| INPUT | OUTPUT |
|---|---|
| 1 | 0 |
| 0 | 1 |

*a*

AND

| INPUTS A | INPUTS B | OUTPUT |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

*b*

NAND

| INPUTS A | INPUTS B | OUTPUT |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

*c*

FIG. 3—TRUTH TABLES OF THE MAJOR LOGIC ELEMENTS. The NOT and the AND combine to form the NAND..

## The NOT gate

The operation of the NOT gate will be familiar to anyone who is married. For lack of anything better to do, couples often take up opposite sides of an argument. It doesn't matter which side each person takes; in fact, often, the partners may in fact agree, or each may actually believe in the point of view the other represents. The important point is that for every "yes" there is a corresponding "no," and for every "no" there is a corresponding "yes." That is the essence of the NOT gate.

## The AND gate

By contrast, the operation of the AND gate will be totally unfamiliar to anyone who is married. A two-input AND gate has the following property: for the output to be "yes," both inputs must be yes. Just as the two partners of a marriage almost never agree on the same thing at the same time, the AND gate is seldom used in practical circuits.

## The NAND gate

The operation of the NAND gate should be somewhat more familiar. It is a combination of a NOT gate and an AND gate. For the output of a NAND gate to be "no," both inputs must be "yes." However, the output will be "yes" if either input is "yes." That is a very useful property.

Let's consider an example: suppose you want to buy a new computer, and your wife says no. If you had signed a marriage

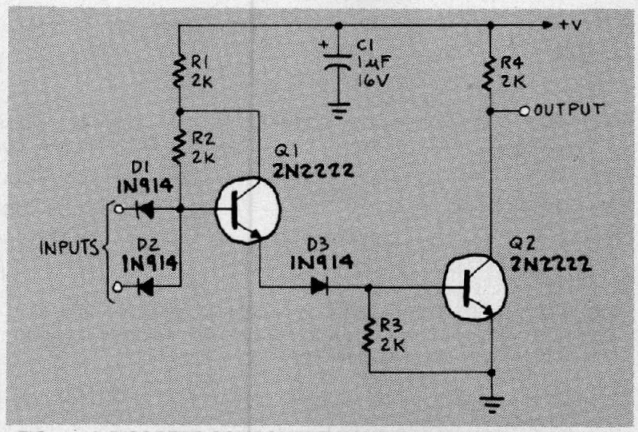



FIG. 4—A DISCRETE-COMPONENT NAND GATE. Build several hundred for next time.

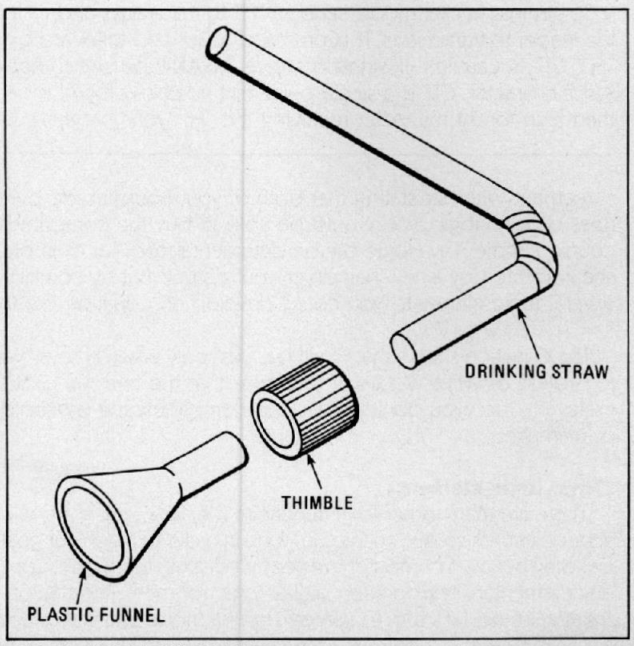



FIG. 5—POSITRON CATCHER. To decrease loss due to leakage, all components should be non-metallic. Use non-conductive epoxy to attach the parts together.