

Upgrading CoCo's Memory

By Martin H. Goodman, M.D.

Probably one of the simplest things CoCo owners can do to improve the utility and performance of their machines is adding more memory. All it takes is the right chips and tools and a few modifications to your computer. Usually memory upgrades can be done by CoCo owners with a little help from Tandy or a third-party vendor. This article discusses things to consider before upgrading memory, offers the general procedures for upgrading memory, and gives brief technical reviews of the various products on the market.

The Warranty

Some of the procedures I discuss involve opening your CoCo. Please note: Opening the computer can void the warranty, so if your machine is under warranty you may want to wait until that warranty has expired. More adventurous users may want to run their machines continuously for 72 hours. If no trouble arises, these hardy souls may assume with *some* degree of confidence that their warranties will not be needed and open their machines.

Martin H. Goodman, M.D., a physician trained in anesthesiology, is a longtime electronics tinkerer and outspoken commentator — sort of the Howard Cosell of the CoCo world. On Delphi, Marty is the SIGop of RAINBOW's CoCo SIG and database manager of OS-9 Online. His non-computer passions include running, mountaineering and outdoor photography. Marty lives in San Pablo, California.



Defining Directions

I often describe procedures for the CoCo circuit board. While some diagrams are provided, many procedures are just described. At all times I will be talking about the CoCo circuit board as if it were sitting in front of you in the CoCo case with the keyboard (or the space where the keyboard was) facing you — as if you were about to type on

an intact CoCo. When I say *front*, I mean “toward the keyboard,” and when I say *rear* or *back*, I mean “toward the back of the computer, where the power and reset switches, and joystick, cassette and serial port connectors are located.” Similarly, *right* means “toward the system bus (ROM pack) connector,” and *left* means “toward the power supply side of the circuit board.”

Opening the Machine

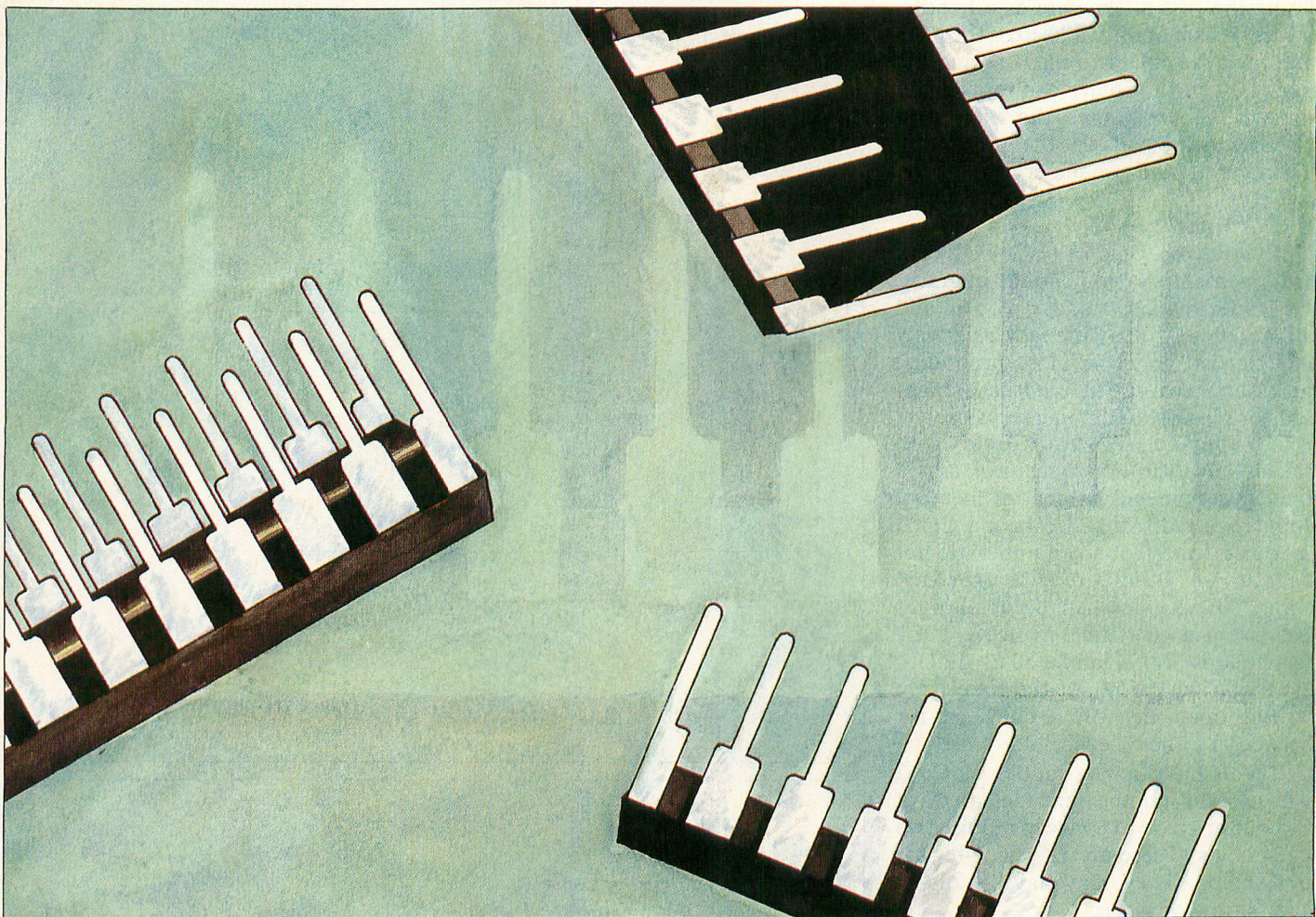
Upgrading memory on all CoCos requires opening up the machine. This is accomplished by removing the screws holding it together (accessed from the bottom of the case). In most cases it is necessary (or at least desirable) to remove the keyboard to gain better access to the circuit board. On all CoCos, beginning with the CoCo 1's “F board,” the keyboard is attached to the computer with a mylar ribbon cable that plugs into a connector on the CoCo motherboard. You can pull the mylar cable out of this connector and reinsert it later. Do not scratch or tear the mylar cable; it's rather delicate.

Turn the Power Off!

Let me remind you to *unplug* the machine before working on it. Trying to modify a CoCo with the power on could result in frying some or all of the chips in the computer and possibly getting you electrocuted in the process. Electrocution by 110 volts AC is a grisly way to go.

Put the Chips in the Right Way

Plugging in a chip upside down can destroy the chip, so plug in the chips



correctly. Chips are typically oriented using either a notch or a dot (or both) at one end of the chip. This mark should correspond to the notch on the socket for that chip, to the notch on the silk-screen or to the part of the socket that has one corner filed down. On *most* CoCo models, all chips point the same way. Use this information to guide your placement of new chips. However, this information cannot be used when putting a new ROM chip into models A and B of the CoCo 2. In that situation, pay attention to the marks on the chip and the socket in which it goes.

You will need a Phillips screwdriver to open up the CoCo's case. In addition, you need a soldering iron and solder for almost all CoCo 1 and 2 upgrades. A temperature-controlled or low-wattage (15 to 25 watts) pencil iron with a small tip is essential. Some upgrades require cutting pliers, and most of the upgrades need needle-nosed pliers and a short piece of wire.

ROM and RAM chips are sensitive to static electricity. They are usually shipped in anti-static tubes or on anti-

static foam pads. Make sure you and the foam surrounding the RAM chip have touched the ground plane on the CoCo before you handle or insert the chips. This will bring you, the CoCo and the chip to the same potential. Be careful in dry, cool environments, especially if you are on a thick rug. In such situations, it may be necessary for you to ground yourself to a water pipe via a conductive wrist band before working on the machine. Be sure the machine's ground and the foam-padded chips are brought to the water-pipe ground, too.

The best tool for removing memory chips from their sockets is a small screwdriver, which can be slipped between the chip's body and the socket and then rotated to gently pull up first one and then the other side of the chip. Occasionally a chip will be in a position not easily reached with a screwdriver. In this case, you may want an IC extractor tool. Radio Shack sells its extractor in combination with an IC inserter tool (Cat. No. 276-181, \$6.95); however, many electronic supply houses sell an extractor for \$2 or less. The extractor

is a U-shaped piece of resilient metal with little teeth at the end of the U. Slip the teeth under the IC at both ends and use a rocking motion to remove the chip. Caution: It is easy to misuse the tool — especially when attacking a “stuck” chip. Be careful.

When inserting chips in the sockets, first put the chip on its side and gently bend the pins a little inward. Brand-new chips are often supplied with the pins angled out a bit, which makes it difficult to insert them. When inserting the chip, make sure all pins go into the holes of the socket. It is easy to leave one pin sticking out or (worse) bend a pin under the chip.

Many of these upgrades call for you to solder wire across two adjacent solder pads on the motherboard of the CoCo. Often the wire should be an eighth of an inch long — or less. Handling such short pieces of wire can be quite difficult. I recommend you jumper such pads in the following manner: Strip a bit of the insulation off a piece of 24-, 26- or 30-gauge wire. Then bend it at its end, so the length you want to

use is bent in an L shape. Now *tin* that end of the wire, and put a little blob of solder on the two pads you need to join. Using the rest of the wire as a handle, lay the L part of the wire across the pads and melt the solder to the wire and the pads. When the solder has thoroughly melted, flowed over the wire and bonded to the pads, let the joints cool. Then cut off the remainder of the wire.

CoCos 1 and 2

If you own a CoCo 1 or CoCo 2 with 16K of memory, you should upgrade. Upgrades for late-model CoCo 1s and all models of CoCo 2 are easy, relatively inexpensive and (for most programs) necessary because 64K is now the standard for CoCo 1 and 2 memory.

The upgrade procedure will vary with the model CoCo 1 or 2 you have, as will the exact type and number of memory chips required. All CoCo 1s and CoCo 2s whose Tandy catalog numbers do not have an A or B suffix require eight 4164 chips. These chips can be as slow as 200 ns in access time. However, any faster chips of that kind (150 ns, 120 ns, etc.) will work fine. At the time I am writing this article, these chips sell for between \$1 and \$2 each.

If you have a late-model CoCo 2 whose serial number includes an A or B, your upgrade to 64K will require two 4464 chips. These are 18-pin, 4-bit-by-64K chips. They may have a 200-ns access time or faster.

CoCo 1 C-, D- or E-Board Computers

These large Color Computers came with a *chicklet* keyboard and a gray case. When opened, they have a keyboard connected to the motherboard at a 16-pin connector. At the front-right side of the computer, you will see a multidigit number followed by the letter C, D or E. C-board computers will also have a satellite board connected to the main board via a cable. For all but the most fanatic hackers, the C-board upgrade can be considered impossible. C-board computers are rare and should not be upgraded but considered museum pieces.

D- and E-board CoCos can be upgraded to 64K, but the procedure is tedious, especially for the D board. These upgrades were covered in past issues of THE RAINBOW (see "ROM-RAM Roundup," May 1984, Page 49) and space does not permit my rehashing those instructions. Problems arise because the D-board CoCo 1 was not designed to support any more than 16K of memory. The E-board CoCo 1 was

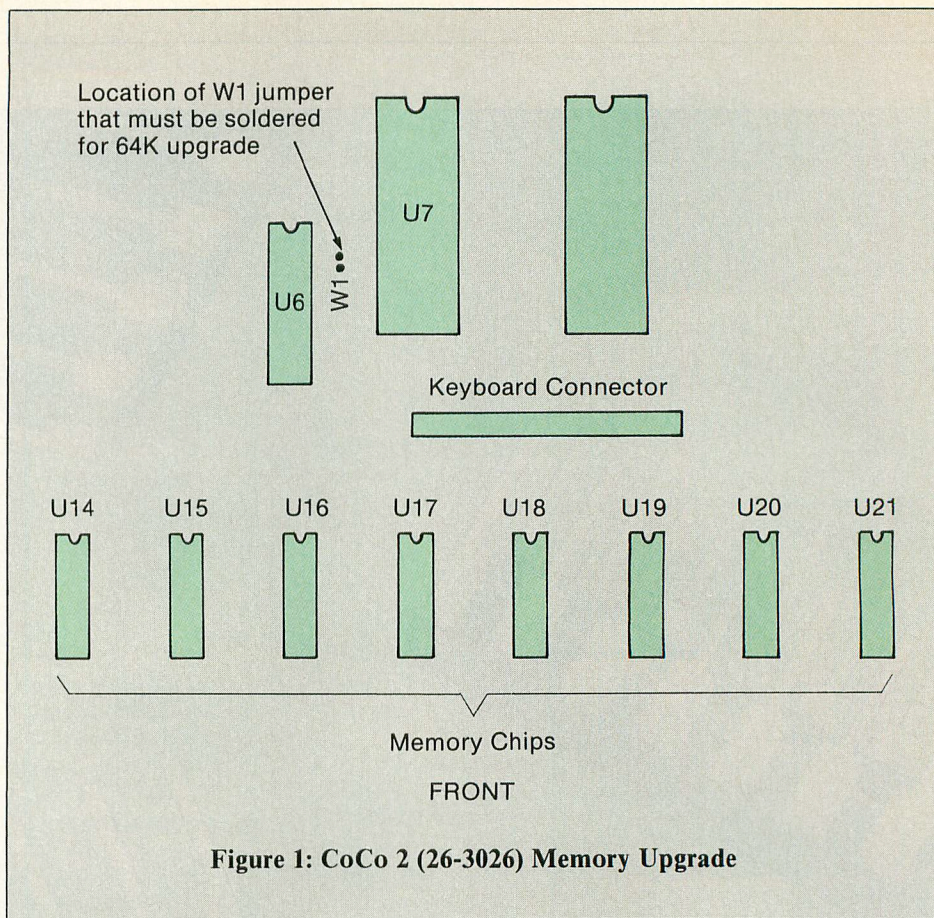


Figure 1: CoCo 2 (26-3026) Memory Upgrade

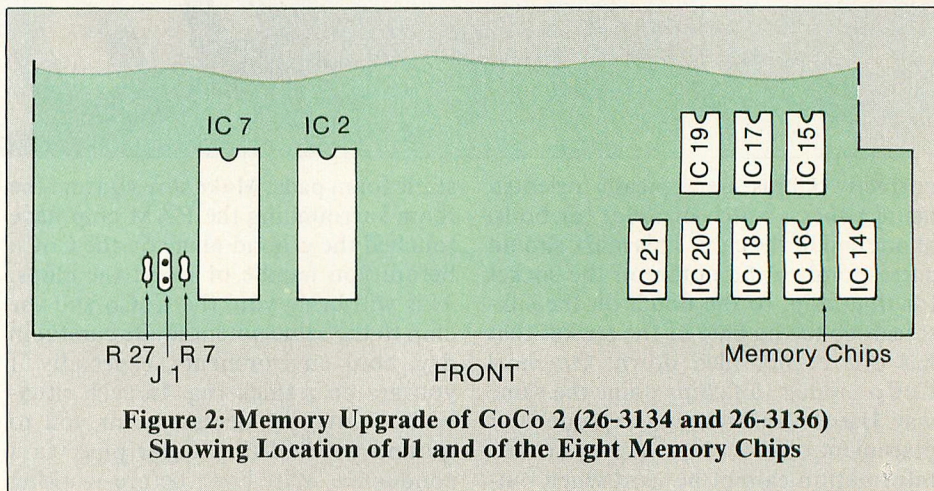


Figure 2: Memory Upgrade of CoCo 2 (26-3134 and 26-3136) Showing Location of J1 and of the Eight Memory Chips

designed to support 64K memory chips but was not designed to use more than 32K of those chips. Thus extensive modifications to the chip power supply and address lines and the addition of an extra logic gate in the memory circuitry is required to accomplish the upgrade of those machines. The E-board CoCo 1 was designed to accept half-bad (optimists call them half-good) 64K memory chips (sometimes mistakenly called 32K-RAM chips), which Tandy bought at a discount. The board even had a jumper, so Tandy could populate it with chips that had either their top or bottom halves intact.

The CoCo 1 F-board (Cat. Nos. 26-3002A, 26-3003A and 26-3004A) was the first Color Computer made by Tandy designed from the start to be upgraded to 64K of memory. The 3002A and 3003A models require memory upgrading. They are large computers, like the CoCo 1 C-, D- and E-board machines. The CoCo 1 F board did not actually have the letter *F* on its circuit board. Rather, it had either no letters at all, or the phrase *REV NC* was silk-screened on it. However, because it followed the CoCo C, D and E boards, CoCo owners refer to it as the F-board CoCo 1. The machine came in a beige

case with a keyboard somewhere between the old CoCo chicklet keyboards and the later keyboards. This was a low-profile keyboard, with keys that looked as if they had been melted down. Early F board units were also gray and had the chicklet keyboard. Tandy marketed the same machine in a square white case as the TDP 100 computer.

This computer's upgrade consists of removing the metal shield that hides the 74LS783 chip and the eight DRAM chips. This shield is attached with little tabs, some of which can be removed by moving your finger around under the circuit board. With most of the tabs unbent, the shield can be removed from above. You then remove the old 16K DRAMs (U21 through U28) and cut out capacitors C58, 60, 62, 64, 66, 68, 70 and 72. Insert the eight 4164 DRAMs in the sockets you just cleared. Two sets of three staking pins are located to the left of the DRAM chips. Each has a jumper that connects the middle pin to one of the two side pins. These jumpers should be moved from the 16K position to the 64K position. Another set of three pins is to the right of the DRAM chips. This set also needs to have its jumper moved from the 16K to the 64K position. (Note: If you fail to move all three of these jumpers, you will probably burn out your new DRAM chips.) A fourth jumper needs to be added (not

moved). This jumper must connect two pins labeled 64, found to the left of U17 (the 6821 chip). Serious hackers will remove the jumpers entirely and solder the appropriate pins together.

CoCo 2s

If you own an American-made, original CoCo 2 (Cat. No. 26-3026 or 3027) with 16K of memory, open the computer and remove all eight socketed 16K DRAM chips. These are located in the front of the computer in a single row of eight chips and are numbered U14 through U21. Replace them with 4164 chips. Now find U7, a 40-pin 6822 chip in the center of the board, toward the rear. Just to the left-front of U7 (bottom of the chip), you will find two adjacent solder pads labeled *W1* on the circuit board.

These two pads are close together and oriented front to back. Jumper these two pads together, using a tiny bit of wire and a soldering iron. When you have jumpered them, the jumper wire will run parallel to U6 and U7. That's all there is to it — your upgrade is complete. (See Figure 1 for details.)

If you own one of the first Korean-made CoCo 2s (Cat. No. 26-3134 or 26-3136), you need eight 4164 chips. Upgrade the memory on your computer in the following manner: Open your machine. You will find eight socketed 16-

pin 16K DRAM chips, which are in two rows (one of five and one of three chips). Remove those chips. Immediately to the left of IC-7, between R27 and R7, you will see two solder pads labeled *J1*. Solder a jumper between those two pads. This jumper will run front to back and join the two *J1* pads. That's all there is to this upgrade. (See Figure 2 for details.)

If you want to upgrade a 26-3134A, 26-3134B, 26-3136A, or 26-3136B model CoCo 2, the procedure is slightly different. You will need two 4464 DRAM chips. These chips are 4-bit-by-64K DRAMs and have 18 pins. These are the *same* chips used in 128K CoCo 3s. If you upgraded your CoCo 3 and saved the four 18-pin chips you removed from it during that upgrade, you own two sets of "upgrade kits" for these CoCo models. When you open these CoCo 2s, you will find two socketed 18-pin memory chips — 4416 chips. Remove these two chips and replace them with two 4464 chips. Now look on the left front of the circuit board. There you will find two solder pads labeled *RAM Size* and *64K*. The two pads are enclosed by a white silk-screen rectangle. Solder a jumper between those two pads. That's all there is to it. (See Figure 3 for details.)

On all these A and B models of CoCo 2 there are two white connectors that look like the white connectors for the memory upgrade board on the CoCo 3. You cannot use those connectors. They are there to support a plug-in board with eight 4164 chips, which Tandy used at one time to upgrade these machines. When Tandy designed those boards, the cost and availability of DRAMs was in a state of flux, and Tandy could not be sure which would be the most economic upgrade — two 4464 chips or eight 4164 chips. For this reason, the company designed the boards to allow use of two 4464 chips on the board, or eight 4164 chips via a plug-in memory upgrade board.

The CoCo 2 B models have both the white connectors and places on the main circuit board where Tandy could solder eight 4164 chips. Therefore, the B model boards can be upgraded to 64K in one of three ways: Two 4464 chips to replace the 4416 chips, a plug-in board with eight 4164 chips, or 4164 chips soldered directly to places provided on the motherboard. For both the A and B models of the CoCo 2, I recommend using the two 4464-chip approach. This approach is cleaner, simpler, and puts less power drain on the computer.

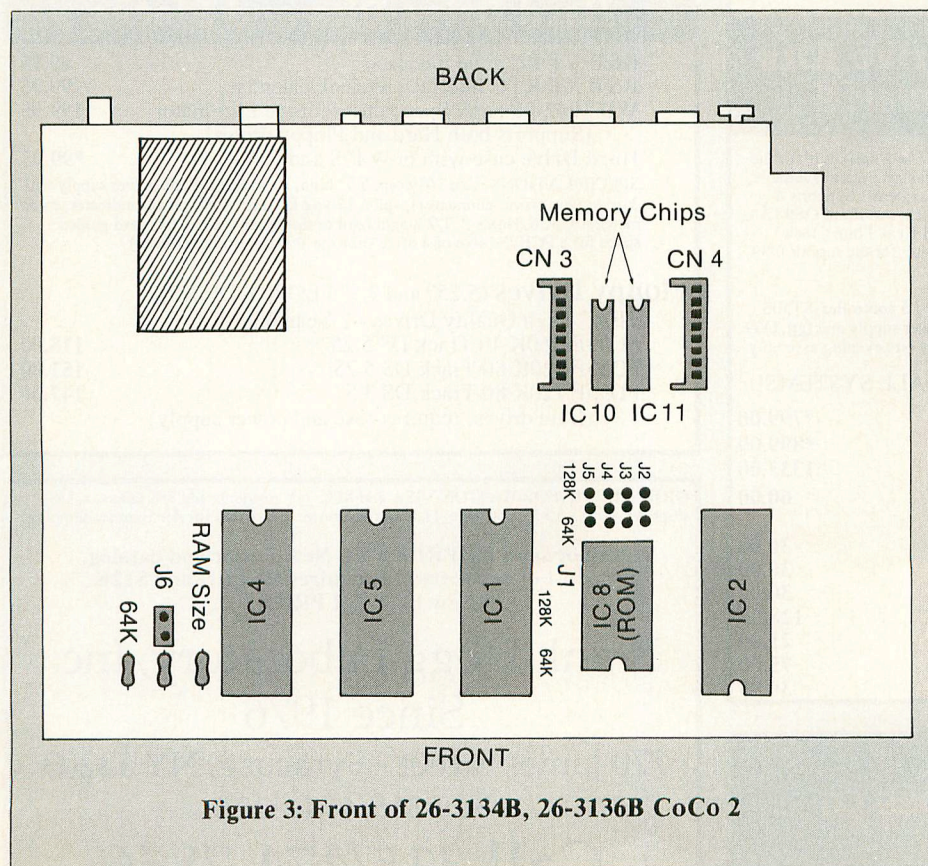


Figure 3: Front of 26-3134B, 26-3136B CoCo 2

Testing Memory

After upgrading your memory to 64K, you should get the Color BASIC or Extended Color BASIC copyright message when you turn on your CoCo. Entering PRINT MEM (or ?MEM) will give you the number 24871 if you have Extended Color BASIC or 31015 if you have Color BASIC. Even with a full 64K of memory, the CoCo is capable of using only the lower 32K of RAM under Color BASIC. This is true even for a 512K CoCo 3. The problem here is that the ROM software was never revised to work with more than 32K of RAM memory. To better test memory, try using one of a number of RAM-test programs published in past issues of RAINBOW or posted on Delphi.

ROM Upgrade

On some of the computers discussed, you may be hampered by a lack of both memory and Extended Color BASIC (ECB). With the CoCo 1 and 2, Tandy offered the machines in any of three options: 16K Color BASIC, 16K Extended BASIC and 64K Extended BASIC. Those with machines with only Color BASIC (not ECB) are missing a great deal. Such machines lack most of the graphics commands under BASIC and cannot be used with a disk controller — ECB is needed for the Disk Controller to work. If your machine does not have ECB, you can add it yourself.

There are two types of Extended BASIC upgrades for Color Computers 1 and 2. If you have only Color BASIC and own any CoCo 1 or CoCo 2 (Cat No. 26-3126 or 26-3134), you will need a 24-

There are two types of Extended BASIC upgrades for Color Computers 1 and 2. If you have only Color BASIC and own any CoCo 1 or CoCo 2 (Cat No. 26-3126 or 26-3134), you will need a 24-pin, 8K-by-8-bit Extended BASIC ROM. If you own a Cat No. 26-3134A or 26-3134B model CoCo 2, you will need a 28-pin 16K Extended Color BASIC ROM that has both Color BASIC 1.3 and Extended Color BASIC 1.1. Both these chips can be ordered from Microcom, Computer Plus, MicroWorld or Tandy National Parts. The cost should be under \$25.

Installing the 28-pin Extended BASIC ROM in an A- or B-model CoCo 2 is a bit trickier. Refer to Figure 3 for a diagram of the Model B CoCo 2. Remove the 24-pin Color BASIC ROM from the 28-pin socket, and locate the five ROM size jumpers near that socket. Four are behind it, and one is to the left

of the socket. These jumpers are labeled 64 on one side and 128K on the other. They are soldered in place. The 64K and 128K refer to the number of bits in the ROM chip and are not indicative of a 128K RAM memory upgrade for that machine. Clip all five jumpers where they touch the 64K solder pad. Then bend them over so they touch the 128K solder pad. Now solder them in that position. A fine pair of diagonal cutters and a fine-tipped soldering iron are helpful. You can remove the old jumpers and install new ones; however, I prefer the first method because it's faster. After moving the jumpers, insert the 28-pin ROM chip into the socket. The notch on the chip must point toward the *front* of the computer (i.e., it should be pointing in the direction opposite to IC chips 4, 5 and 1, which lie to its left, and point in the same direction as IC 2, to its right). You have now rewired the ROM socket to accept the pin of a 28-pin 16K-by-8 ROM.

Hacker's note: The 24-pin 8K DECB ROM is pin-compatible with a Motorola 68766 EPROM. This ROM is predominantly pin-compatible with a 27128 EPROM; however, you must short Pin 1 to Pin 28 of the EPROM after programming it to make sure it will work in a CoCo. Pin 1 of the ROM is not connected internally, whereas Pin 1 of a 27128 EPROM needs to be tied high to +5 volts. On some CoCo models, Pin 1 is left unconnected. In addition, while you can read the 28-pin ROM in most EPROM programmers, you cannot read the 24-pin ROM because it is a dynamic ROM, which requires its enable line to be pulsed each time a byte is read from it. The best way to extract data from that ROM is to read its contents using a working CoCo that has the ROM installed.

Why upgrade to 512K?

All OS-9 Level II users require 512K to make any reasonable use of OS-9 Level II's capabilities. At this time, few Disk BASIC programs make use of memory above 128K. *Word Power 3.1* from Microcom, *Vterm* from Gimmesoft, and *CoCo Max 3* and *Max 10* from Colorware are among the exceptions, using a significant amount of the memory available with a 512K CoCo 3. Microcom sells a disk duplicator implementing a complete RAM image of the disk to be copied if you have a 512K CoCo 3. SpectroSystems soon presents an ADOS enhancement providing a very Disk BASIC-compatible RAM disk feature.

The Tandy 512K Upgrade

The upgrade provided by Tandy's designers is in the form of a plug-in memory board populated with 16 one-bit-by-256K (41256) chips. For this upgrade, first remove the four 4464 chips from their sockets. Next make a minor alteration in the timing of the RAS and CAS lines by removing C65 (a timing "fudge-factor" capacitor on the RAS line). Finally, insert a populated memory-upgrade board into the three white connectors provided on the CoCo 3 motherboard. Most third-party upgrades are electrically identical to the Tandy upgrade, but these vendors often suggest different timing modifications.

The 256K DRAM Crisis

About a year ago, 256K DRAMs were cheap and plentiful. They were available to dealers at about \$2 a chip or less. Then U.S. chip makers — unable to compete with Japanese production — demanded limitations on memory-chip import. The government responded by pressuring Japan to cut back on this import. After this, all but one U.S. manufacturer (Micron Technologies) ceased production of 256K DRAMs, which they deemed unprofitable, and Japanese manufacturers began converting factories that had been making 256K DRAMs into plants to make 1-megabit chips. At this same time, there was an unforeseen increase in the demand for 256K DRAMs because desktop computers with standard memories of 640K or more were coming into their own. These computers required 256K chips.

The combination of these factors caused DRAM chip prices to skyrocket. Over a period of months, the price soared to a high of \$15. By July '88, the price leveled off, but it hasn't come down much. Dealers still pay between \$9 and \$13 per chip for memory chips on a 16-chip CoCo 3 upgrade board. Therefore, the cost of a fully populated CoCo 3 memory-upgrade board can be in excess of \$170. (Compare this to the \$100 or so that such upgrade boards were selling for before the DRAM crisis.) There is no end to this crisis in sight. Prices for 256K DRAMs are expected to remain high for an indefinite time. No matter who is to blame for the prices, we must deal with these high memory-chip prices.

Tandy was able to lock its supply of 256K DRAMs at a fixed price for a long time, so recently the Tandy upgrade, at \$130 to \$150, has been the most economical way to add 512K to your CoCo

3. However, I doubt Tandy can sell memory chips at that price for long.

Memory Chips

The CoCo's manner of addressing memory is a bit odd. The timing on the GIME chip for its memory access is not quite right, especially on older (1986) GIME chips. Users have been faced with an array of inconveniences: "Sparklies" occasionally appear on the screen; memory chips in the 512K upgrade run hot; and some particular brands of memory chip work better than others for subtle reasons. I have been told that the minimum access time for proper operation of a DRAM chip on a CoCo 3 running at 2 Mhz is around 142 nanoseconds. In theory, one really should use 120-ns access-time parts. In practice, however, most 150-ns parts will work fine. Although NEC memory chips are reported to work very well, I have used several brands of memory chips (including NEC, Motorola, TI, Hitachi, Fujitsu, Micron Technologies, and Samsung) with no problems.

Available Memory Upgrade Boards

With one exception, the various

CoCo 3 memory upgrade boards come with sockets for the DRAM chips and can be populated with any speed or brand of DRAM chip. With DRAMs so expensive these days, many sales of 512K upgrades are in the form of bare boards users will populate when they get good deals on memory chips.

Considerations in 512K upgrade-board design include the following:

- The quality of the chip sockets used
- The layout of the traces on the board
- The number and value of deglitching capacitors used
- The positioning of the deglitching cap traces

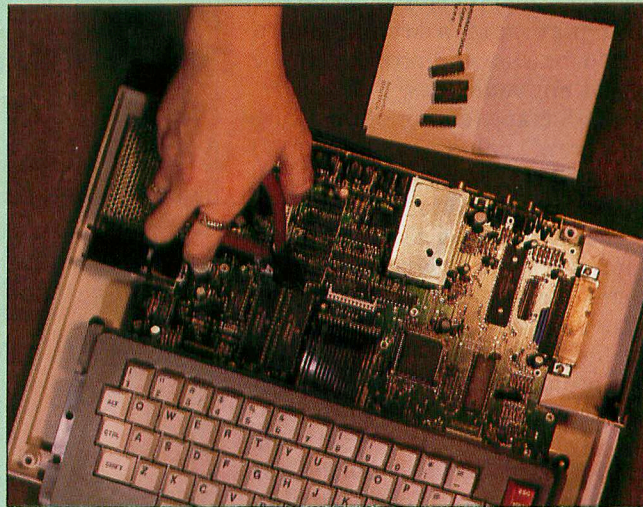
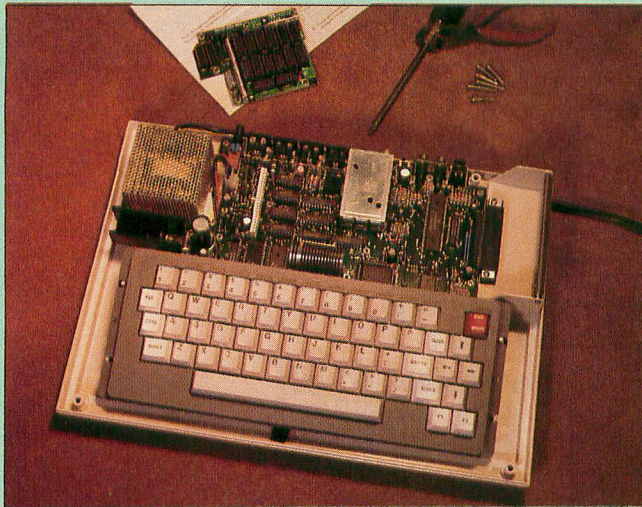
Sockets with gold plating are best but are too expensive for use in this market. Next to gold-plated sockets, double-wipe sockets would be best (i.e., sockets that contact each pin of the memory chips on two sides). Single-wipe sockets are least desirable, but they work adequately. A large fraction of CoCo 1s and 2s use single-wipe sockets for their memory chips, and the CoCo 3 uses single-wipe sockets for its 4464 chips. All these work reliably. Proper provi-

sion for wide ground plane traces will reduce noise on the power-supply lines and radio frequency interference.

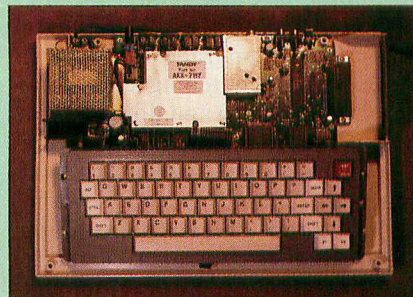
In theory, every DRAM chip should have a .33-mfd deglitching capacitor wired to its positive and ground pins. In practice, many board makers cannot include a cap for every memory chip, so some chips share the same deglitching cap. In addition, many manufacturers supply boards with .1-mfd deglitching caps, despite manufacturers' specifications, which often say the .33 mfd value is preferred. The shorter the length of wire or printed circuit board trace between the power supply pins of the DRAM chip and its associated deglitching cap, the better.

The Tandy 512K upgrade board is (or was) sold with DRAM chips by Tandy for between \$130 and \$150. Its price may increase as Tandy's supply of lower-priced DRAMs is exhausted. The Tandy board is unique because it is mounted upside down (i.e., the DRAM chips are facing the CoCo motherboard, and the solder side of the board is up). Tandy designed the board this way because it was easier to mass-produce. All components (including the

Tandy's 512K Upgrade



These photographs illustrate the steps involved in upgrading to 512K with the Tandy upgrade. *Above left:* The CoCo 3 with case top removed. The upgrade is shown behind the computer. *Above right:* The four 4464 RAM chips have been removed and capacitor C65 is being clipped with "dikes." While the keyboard has been left in the computer, it has been moved slightly forward. More working room can be gained by carefully removing the keyboard entirely. *Right:* The completed upgrade. Note how the ground plane is visible and the chips, which are underneath, cannot be seen.



pins that connect it to the motherboard) are soldered *on the same side* of the board, so the entire thing can be wave-soldered. By putting the solder side up, Tandy can add a foil-ground plane to reduce radio interference and comply with FCC regulations. Tandy has the only memory-upgrade board with such an added ground plane. Tandy's board uses roughly 12 deglitching caps for the 16 DRAM chips, and each are .1-mfd in value. All reports indicate that the Tandy board works adequately; however, when the DRAM chips get hot, their position beneath the board conserves that heat. Tandy uses single-wipe sockets in all of the Tandy 512K upgrade boards I have seen.

Although PBJ no longer makes products for the CoCo market, before it disappeared it ran off a large number of 512K memory-upgrade boards. This board is still sold by Computer Plus. The board comes with about a dozen .1-mfd deglitcher caps for its 16 memory chips. It is supplied with a variety of sockets — sometimes double-wipe, sometimes single-wipe. I used a PBJ upgrade board for nearly a year in one of my CoCo 3s, and it worked fine. One word of warning: PBJ's quality control seems a bit sloppy. I have seen three separate boards delivered to customers "dead on arrival." Naturally, a dealer will take back and replace a bad board, but you may need a second board present to be sure the problem is the board and not your chips.

Tony DiStefano (author of the "Turn of the Screw" column in RAINBOW) designed a 512K upgrade board sold by CRC. This is the smallest 512K upgrade board I have seen. Tony also uses .1-mfd caps. He says some production runs of the board use single-wipe sockets and others use double-wipe sockets. I used one of his boards for several months with no problems, nor have I heard of any problems with them. Prior to shipment of any bare board, it is tested using continuity checks to weed out boards with internal shorts. Tony's quality control should be quite good.

Performance Peripherals makes a high-quality 512K upgrade board using sixteen .33-mfd deglitching caps (one for each DRAM chip) and double-wipe IC sockets. Bare upgrade boards are tested in a CoCo 3 before shipping, and the boards are sent only when tested and burned in as good. This is a painstaking amount of quality control. I currently use one of its boards in my development system and have had no problems with it. Performance Peripherals is a small

company but worthy of serious consideration by CoCo 3 owners.

J&R makes another design of memory upgrade board. This board features an excellent ground plane on the PC board. The company uses double-wipe sockets and 16 caps (one per DRAM chip); however, it tends to use only .1-mfd instead of .33-mfd caps. I've never used this board, but I have examined one. It looks well-made and -designed, and I have heard of no problems from anyone using one. J&R is the only company to offer a board in kit form (without sockets on the board).

The Hemphill upgrade is the most unique memory upgrade of all. Instead of using dual-inline pin chips, Hemphill uses single-inline pin chips. This lets the company make a very small circuit board and include one capacitor per chip. The company uses .33-mfd caps. The memory chips are soldered to the board, making them less usable anywhere else but making the board reliable and trouble-free. Hemphill's upgrade has a reputation as one of the most reliable and trouble-free 512K upgrades. You must buy this board with the chips provided.

All 512K upgrade boards advertised in RAINBOW work fairly well. Although there are a number of theoretical reasons to prefer one to another, you will get reliable performance regardless of which one you purchase. (See Table 1.)

Timing Modifications

When you install a 512K upgrade board, make a timing modification to the computer, or it will not work. There are various modifications to the CoCo 3 recommended by different manufacturers. Tandy's service manual for the CoCo 3 specifies the removal of only C65 (the RAS timing fudge-factor capacitor). Many third-party upgrades specify removing both C65 and C66 (a CAS line timing fudge-factor cap). Hemphill Electronics suggests yet a third timing modification for installation of its upgrade. The company suggests leaving both C65 and C66 in place and soldering a 47-ohm resistor in parallel with R22 (a 120-ohm timing fudge-factor resistor on the RAS line). Some people who have tried the Hemphill modification say their memory chips run cooler with that modification than with the cap-removal mods. Some

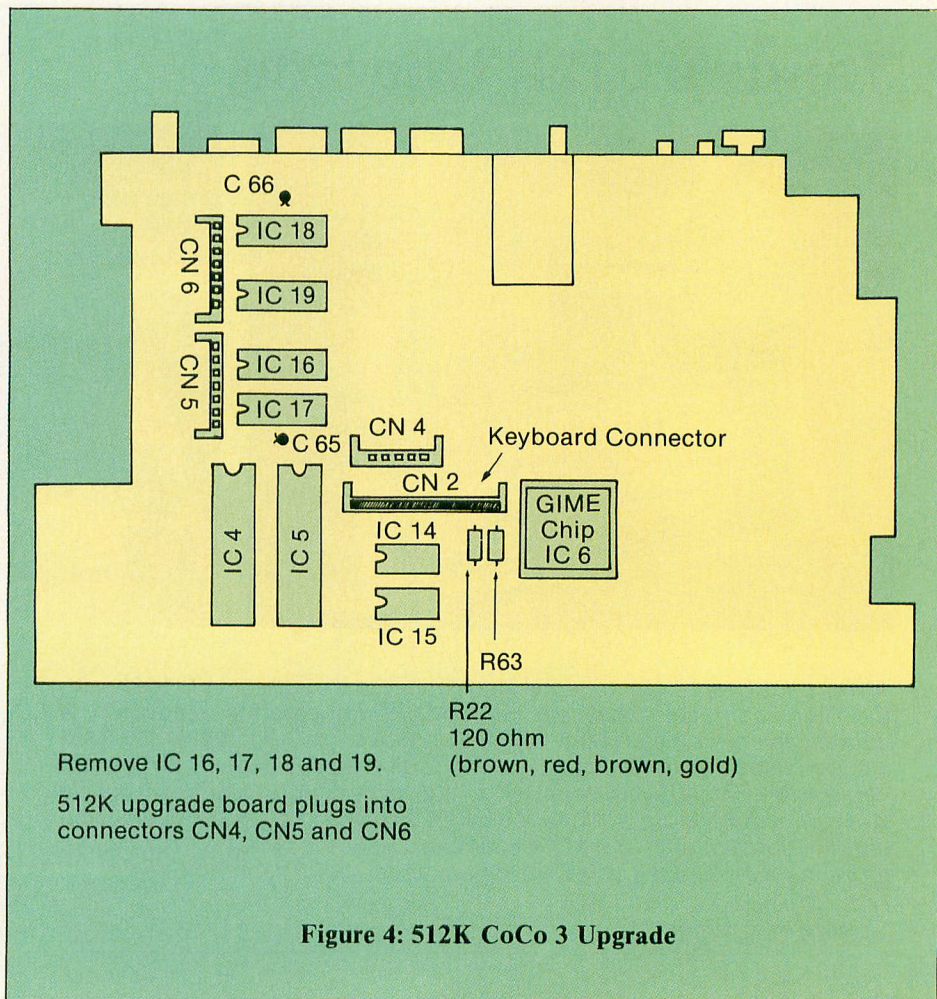


Figure 4: 512K CoCo 3 Upgrade

also claim the Hemphill method results in fewer or no sparklies on machines that previously had them.

Figure 4 shows the location of the various components referred to above. C65 and 66 are little green blobs, and R22 is a gray cylinder with brown, red, brown and gold stripes. If you destroy the capacitors in the act of removing them, you can find near replacements at Radio Shack. Radio Shack Part No. 272-121 is a 47-pf capacitor. Two of those in parallel will be 94-pf — close to the 82-pf value for C65. Two of those capacitors in series will yield a value of 23.5 pf — close enough to the 27-pf value for C66. If you try the Hemphill upgrade, Radio Shack sells a 47-ohm resistor (Cat. No. 271-009).

About Those 4464 Chips...

Memory on the CoCo 3 is addressed via the GIME chip, which is both a memory-manager chip and a video-display generator chip. The CoCo 3 comes supplied with 128K of memory in the form of four socketed 4-bit-by-64K 18-pin 4464 chips. This memory is wired so it presents 64K of 16-bit words to the GIME chip. Therefore, while the 6809 can address external memory along an 8-bit data path, the GIME chip can read the DRAMs 16 bits at a time. This allows the GIME chip to read memory faster to properly update the Hi-Res color graphics screens. Each of the four 64K-by-4 chips contributes one quarter of each 16-bit word read by the GIME chip.

The logical way to accomplish an upgrade to 512K on the CoCo 3 would be to substitute 4-bit-by-256K chips for the 4-bit-by-64K chips with which it came. After all, 44256 chips do exist; they sell for about \$45 each. But Tandy chose not to provide for this upgrade route. The 44256 chips are 20-pin chips, with a different pin out from the 4464 chip. Worse, the 44256 chips require a different refresh cycle because they are

Company	Product	Warranty	Bundled Software	Comments
Tandy/Radio Shack*	Tandy 512K	90-Day	None	Optional installation extra.
Computer Plus*	Tandy 512K Tandy 0K PBJ 512K PBJ 0K	90-Day One Year	None	Optional installation extra.
The Computer Center*	Disto 512K	90-Day	RAM Disk RAM Test	Optional installation extra.
Owl-Ware*	LR Tech 512K	One Year	RAM Disk RAM Test Printer spooler	Optional installation extra.
Performance Peripherals	Performance Peripherals 512K	One Year	RAM Disk RAM Test Printer spooler	
MicroWorld*	Tandy 512K	90-Day	None	Optional installation extra.
Microcom Software*	Performance Peripherals 512K	90-Day	RAM Disk RAM Test Printer spooler Backup utility OS-9 LII RAM Disk	Optional installation extra.
CRC/Disto	Disto 512K	90-Day	RAM Disk RAM Test Printer Spooler	Optional installation extra.
Arizona Small Computer Co.	Disto 512K	180-Day	RAM Disk RAM Test Printer Spooler	In-shop installation included.
J & R Electronics	J & R 512K J & R 0K J & R Kit		RAM Disk RAM Test Printer Spooler	Available in kit form.

*These advertisers also offer 64K upgrades for the CoCo 1 and 2.
Because of rapidly fluctuating chip costs, our advertisers request that you contact them for current pricing information.

Table 1: Sources for CoCo Memory Upgrades

internally more like the 1-bit-by-1-megabit chips than the 4-bit-by-64K chips. They require a 512-cycle refresh while the GIME chip provides a 256-cycle refresh. There is no way around this problem. The chips cannot be interfaced to the GIME chip.

Finally, hold onto those 4464 DRAMs you remove. If a problem develops in your upgrade, you will have an alternative of downgrading to 128K, or you may want to switch these chips with those in another board. There are not many machines around that use the 4464 DRAMs for memory upgrade, except the Tandy 3000 and some 10-

Mhz 8088 PC compatibles. If you are certain you have no use for your 4464 DRAMs, you can send them to me in care of RAINBOW magazine. I sometimes have projects that use them.

That's all there is to it. Follow the instructions found in this article carefully, and you will soon have the memory you and your computer need. Modifying your Color Computer takes time and patience. Look around; find the best merchandise for you. Then watch for the best prices on that equipment. Once you have your parts and your tools, be sure to take the time to do the work right. ☺

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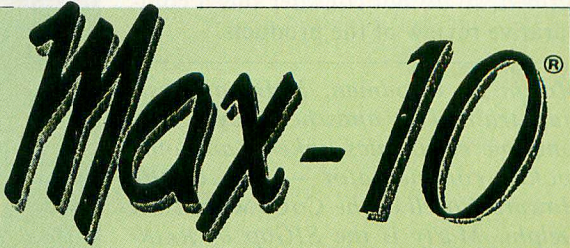
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