Ray Carlsen's
Technical Notes
for the
C128

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C128 CHIPS AND COMMON SYMPTOMS

1-1-98

U1 906108-02 (6526) VIA (interchanges with 8521)
unknown (8521) VIA later version C128
C64 startup screen normal, but no cursor. Will not start up in 128 mode. No keyboard, joyport, or cassette access. Partial failure: some keys or joystick positions don't work. Cartridge works. Swap U1 with U4 to check. See KEYBOARD.

U4 901108-02 (6526) VIA
Startup screens normal (64 & 128), but no serial or user port access. Drive resets on power up but "File not found" error when drive accessed. Cartridge works. Swap U4 with U1 to check. Check also buffer IC U30.

U5 906112-02 (6581) early 128 SID: 12 volt VDD
318013-01 (8580) late 128 SID: 9 volt VDD
No sound (check also transistor Q2), weak or bad sound of one or more voices. Proportional mouse or graphics tablet doesn't work, or mouse pointer frozen or jitters. If chip is shorted, will produce blank screen. Remove chip to check.

U6 315020-01 (8502) MPU (Microprocessor)
No bootup in any mode. Blank screen with no border. Cartridge don't work. If intermittent, screen freezes after warmup or running programs lock up.

U7 310389-01 (8722) MMU (Memory Management Unit)
No bootup in any mode. Blank screen with no border. Partial failure: CP/M inoperative.

U10 906150-02 (Z80B) CPU (Microprocessor)
No bootup in any mode. Blank screen with no border. Partial failure: CP/M inoperative.

U11 315012-01 (8721) PLA (Programmable Logic Array)
No bootup in any mode. In 40 columns: blank screen, white screen, light blue screen (no border), random checkerboard pattern or flashing "garbage" characters.

U18 390059-01 CHARACTER ROM
No characters. Startup has border, but "garbage" where characters belong. Entire area inside border just lines or blocks.

U19 generic SRAM (6116 - LC3517A) COLOR RAM 2K X 8
128 startup screen and colors normal. C64 screen characters & colors flash rapidly.

U21 315009-03 (8564) VIC (40 column screen)
Dead chip: Blank white screen in 40 columns and black screen in 80 columns. Partial failure: 80 column OK but weak or garbled 40 column video, no video or no color. Check also U28 and crystal Y2.

U22 315014-09 (8563) VDC for C128 80 column screen.
315092-01 (8568) VDC for C128D 80 column screen.
Blank screen in 80 column only. May not switch from 128 to 64 mode with reset switch. Check also crystal oscillator Y1. If one or more 80 column colors missing, check also U24.

U23 & U25 generic 4416 Video RAM (16K)
generic 4464 Video RAM (64K VRAM upgrade)
In 80 column mode only: blank screen or some characters garbled. Shorted chips will get hot.

U24 generic 74LS244 Buffer
One color (such as red) missing from 80 column screen.

U28 251527-09 (8701) Clock gen. (Master oscillator)
Dead chip: no bootup in any mode. Partial failure: diagonal lines on monitor or TV (horizontal sync bad), no color in 40 column mode, or "barber pole" colors. Check also crystal Y2.

U32 251913-01 C64 Kernal/Basic ROM.
Blank screen at startup in C64 mode only. Cartridge works.

U33 318018-02 C128 BASIC LO ROM
No BASIC startup screen in 128 mode only. Computer goes into "monitor" mode.

U34 318019-02 C128 BASIC HI ROM
Blank screen with border at 128 mode startup. Lines or "garbage" inside border.

U35 318020-03 C128 Kernal ROM
Comes up in C64 mode, but cartridge doesn't work. Partial failure: blank screen in 128 mode only.

U36 socket empty from factory... for "upgrades".

U38 THRU U53 16 RAM chips (4164)
4 RAM chips (4464) in later versions.
Blank screen, no border. Shorted chips will get hot. Will sometimes produce "garbage" screen, abnormal number of bytes free or "out of memory in 0" error on startup screen, and program crashes when loading (depending on what part of memory is bad)... repeatable, i.e. crashes in same place.

Y1 16 MHz Crystal Oscillator
Blank screen in 80 column only.

Y2 14.31818 MHz crystal (Master osc. reference)
See U21 VIC.

M1 251917-02 RF Modulator (tin can "module").
TV output only: no picture, no sound, snowy picture, no color, weak video or sound, interference, etc. Note: direct A/V outputs still work normally.

KEYBOARD: Stuck (shorted) keys will show up when another key is pressed... it either will not work, or both appear on screen. Character may repeat, depending on which key is bad. If keyboard is suspected, unplug it... the computer will start up normally without it. Check also U1 chip.

POWER SUPPLY: Most common problem is "dead" computer, but can produce many symptoms like blank screen (power LED on or off), screen freeze-up, "garbage screen", hum bars moving up screen, intermittent operation, etc.
For intermittent operation or "glitches" on screen, random characters, etc. check solder of power supply connector and power switch on motherboard. Also, reseat socketed chips: lift up slightly at each end (but do not remove) and press back down. Reseat suspected chips first for any problem, especially intermittents.
For in-depth troubleshooting, Sams Photofact (schematic and parts list) has flow charts and step by step diagnostics. It requires an oscilloscope and the necessary skills to interpret the readings. The Sams book for the C128 is CC18 and CSCS25 for the 128D. They are available at electronic parts distributors. Copies may be viewed at the main branch of the Public Library.

UPGRADING THE C128 FROM 16K TO 64K OF VIDEO RAM

06-06-06

There used to be an easy-to-install piggyback board made by Chip Level Designs (Lawrence Hiler) back in the 1980s. You would pull the VDC chip, install the board, then plug your chip into it. It had the upgraded video RAM chips on it and required no soldering. Unfortunately, that board has not been available for years. *[Editor's note: This board is now available again from Centsible on eBay.]* If you have the skills (or know someone who does), you may be able to make your own board using the info on my site. It shows the CLD PC board layout and photos of the parts used. It's at: http://staff.washington.edu/rrcc/uwweb/C128/C128VRAM

Upgrading the VRAM on your own involves unsoldering the two original 4416 (16K X 4) RAM chips (probably marked something like: MB81416-12) inside the tin can in the middle of the motherboard. The two chips are at board locations U23 and U25 and are very likely soldered in. It's tight in there and desoldering chips is a pain anyway, not to mention risky if you accidentally break a foil trace and don't repair it before installing the new chips. You end up covering up your mistake rather well. As a tech, I always desolder the original and put in a socket. That way, I have the option of putting the old ones back if the upgrade doesn't work for some reason. You never want to solder on the board more than once if you can help it. Sockets are cheap. An alternative to desoldering the whole chip is to cut off all the pins close to the body of the IC, then desolder each one and clean out the holes with wick or a solder sucker so the new chip (or socket) will fit. That's much easier on the board, but obviously destroys the chips. Not a big deal... they usually end up in the garbage anyway.

So, you'll need two 4464 (64K X 4) RAM chips. Jameco Electronics @ 1-800-831-4242 has them, but you'll need to add $5 for orders under $25, then shipping on top of that. They have a website: www.jameco.com. The Jameco part number for the chip is 41582 or 41574 or 41611. Those three numbers represent the same chip, but at different speeds, 120ns, 100ns, and 80ns respectively. All will work and cost less than $3 each. Jameco has the sockets too. Order # 38113 or 112230 socket (18 pin DIP single or double contact) for less than $0.25 each.

For desoldering, you'll want an iron of about 25 watts. Don't be tempted to use your 30-year-old soldering gun... it will eat that board. Make sure you mount the new chips exactly the way the old ones came out. There is a notch at one end so you shouldn't get them in backwards. Use a marking pen to indicate where the notch goes if necessary. After the new sockets/chips are installed, carefully inspect your work for solder splashes or bridges between traces, etc. If all is Well, put it all back together.

Power up the computer and observe the opening screen. You might notice that just -before- it comes up, the screen looks different than it used to. When the opening screen appears, it should look the same as before. One way to tell if you have the upgraded VRAM is with a little BASIC program typed in 80 column immediate mode:

```
POKE DEC("D600"),28:POKE DEC("D601"),63:SYS DEC("FF62"):SCNCLR
```

If the screen says: **READY** and looks normal, you have 64K of VRAM. If you have only 16K, the screen will fill up with zeros.

THE 1571 (and 1571 in the DCR) COMMON PROBLEMS AND SOLUTIONS

07-25-04

I TAP ON THE DISK, THEN IT WORKS...

This is such a common complaint, I put it here at the top of the list. Some users indicate that they must "tap on the disk after inserting it and closing the drive door" to get the drive to work properly. Some report that they can hear a "click" when they do that and then the drive works fine. This problem can be caused by: 1. a sticky lifter mechanism, (see HEAD LIFTER) or 2. the ejector mechanism is not latching properly (see DISK EJECTOR). DOOR LATCH: The twist down latch has a pin that eventually works loose and can fall out. That's what has happened if the latch flops around and will not move the mechanism. Hopefully, it's still in the drive (rattling around?) and can be recovered. If allowed to float around in there, it can short something out and cause damage. It's a round silver metal shaft, about 3/4" long and about 1/16" in diameter. If you can't find it after taking the drive apart, the correct sized nail can be cut to fit and installed as a replacement pin. The original, if still there, can be reinserted and secured with a dab of superglue or contact cement... just enough to keep it from sliding back out. It should be inserted just far enough to engage the white plastic part of the latch mechanism... too far forward, and it will scrape the metal part of the latch. Lube the metal-to-metal parts of the latch while you're at it.

HEAD WIRES:

The top head moves up and down when a disk is inserted and the door latch is turned. The 5 connecting wires on the top head must be free to move, but such movement will cause them to break eventually. Some drives will have a bit of epoxy where the wires are soldered to act as a strain relief. Note: wires can still break -inside- the insulation where it can't be seen. If you pull -gently- on each one with tweezers, the broken ones will be loose and pull apart easily. Looking down on the drive head, with the front of the drive facing you, the color code of the wires is as follows, from left to right: green, red, white, yellow, black. If any of these wires are broken, the drive will still work in the 1541 mode (bottom head only is used), but in 1571 mode, the top head will not function properly. If any wires are broken, you will need to trim off some insulation from each wire and resolder it. Because the repaired wires will be a bit shorter, you should cut the ties holding the cable to allow more freedom of movement for the remounted wires. Form a small loop in the wires for maximum flexibility. Add a dab of epoxy or silicon sealer to the wire ends to allow them to flex without breaking again. Loosely tie the cable back to the head assembly. Open and close the drive door with a disk inserted to see if the wires have enough slack to allow complete head motion. If the wires are too tight, the head will not come all the way down to the disk surface, and you will create intermittent read/write problems. Also, if there is not enough slack in the wires, they will break again in a short time. When you complete the repair to the wires, tie the cable bundle back to the head with thread or string and a dab of glue.

HEAD MOUNT:

In a 1541 disk drive, the disk is pressed against the single read-write head by a felt pad. That spring-loaded pad is lowered onto the disk when the door latch is pressed down. In the 1571, when you insert a disk and lower the door latch, a head lifter mechanism releases, and the spring-loaded top head is gently lowered down onto the disk. Both heads thereby remain in intimate contact with both sides of the disk. The top head is mounted by means of a thin flexible metal strip. This strip is rather fragile and can be damaged by rough handling. Notice that the head has only one "finger" (on the left side) to allow the lifter mechanism to keep it raised. If shipped without a transit card or disk in place, the head mount can be subjected to excessive twisting force because all the weight of the head is on the finger. A downward shock can twist the head mount and can possibly break it. The top head must sit straight and line up with the bottom head. If the mount is bent or torn, the head will not sit straight. You may notice that a spinning disk makes more noise than it should... that's the sound of the top head scratching it. Depending on the severity of the misalignment, the drive may not be able to read the top side of a disk (blocks over 664), the drive may not work even in 1541 mode, and/or disks may be damaged. If the head mount is only slightly bent, it should be possible to straighten it by -gently- bending it back into proper alignment.

Some users put weights (like a penny) on the top head, or increase the tension of the spring to provide more force. This is to be avoided... it will cause increased head and disk wear, and will not solve whatever problem it was meant to, but may cause further damage. Better to find out what is actually wrong, and fix that. See HEAD LIFTER

HEAD LIFTER:

This mechanism prevents the top head from lowering except: 1) when a disk is inserted, and 2) the door latch is down. It's there to keep the two heads from banging into each other. When a disk is inserted, it pushes a small lever with a brass cone-shaped end (at the left middle side of the drive) out from under the head lifter and allows the head to come all the way down and press on the disk. The brass cone should slide forward on the tab of the metal plate above it when a disk is inserted all the way, and should move completely out of the way when the door latch is closed.

If the cone does not move far enough or if the metal plate is sticky, the lifter will prevent the top head from being lowered all the way down to the disk. The result may be intermittent operation of the drive in all modes, but especially in the 1571 double-sided mode, when data is accessed on the top side of the disk. It may take longer to read disks (the drive will try several times until it gets a good read), or you may encounter errors on that side of the disk.

See if the cone-lever is sticking by pushing on it with a toothpick. It has a spring return and is hidden under the metal lifter plate when no disk is there. When you insert a disk and close the door slowly, see if the cone is pushed all the way back out of the way by the downward pressure of the plate. If not, see if that spring-loaded metal plate is free to move down by itself. Insert a disk, move the cone lever back out of the way and pull up on the plate, then gently release it. It should drop all the way and release the head. If not, the lifter plate probably needs lube (oil) on both ends of the shaft. The cone lever may need cleaning and/or lubrication if the lever itself

is sticky, or it needs lube at the contact point of the cone and the tab. I prefer Molytone grease, available at electronics supply houses. It stays where you put it, is -very- slippery, and it will not get gummy like oil or other greases. You should use only a small amount of grease on those parts.

If someone tried to "adjust" the cone lever or the plate, one or both may be bent, and bending may be necessary to straighten them again. The cone should be pointing straight up and should be shiny with no burrs on it. The tab above it should likewise be clean. Examine it's underside (the contact point for the brass cone) for burrs or rough spots. A pencil eraser works well as a polishing tool. If the drive has been "adjusted" by repair attempts, you may need to compare it to a working drive to see how everything -should- line up.

Before you even think about bending anything in an attempt to fix your drive, consider this: the drive worked for years from the factory the way it was designed. Find out why it doesn't work and repair it correctly. An easy way to tell if the head is hanging up on the lifter is to observe the black plastic "finger" on the left side of the top head. With a disk in the drive and the door closed, that finger should -not- be touching the lifter mechanism at all.

OPTICAL SENSORS:

The 1571 has three infra-red activated sensors. If these sensors becomes contaminated with dust or smoke residue, it can cause the drive to malfunction. The TRACK ZERO DETECTOR is located at the right rear of the drive head assembly. It is used during disk Formatting, Initialize, and whenever the drive seeks track zero. If out of adjustment, contaminated, or defective, it may cause the drive to "chatter" like a 1541 when the stepper hits the mechanical head stop. The INDEX DETECTOR (just to the left of the spindle collar) checks the disk for the index hole. Although not needed on a Commodore GCR drive, this sensor maintains compatibility with the MFM standard when the drive is used in that mode (the index hole coincides with sector 1). The WRITE-PROTECT SENSOR at the left front side of the drive senses disk change and write-protect status. It should be checked and/or cleaned if the drive will not format or write to a disk, but otherwise works normally. Don't forget to check for a write protect tab that may have fallen off a disk and got stuck at the sensor.

Sensors can be cleaned with compressed air (to remove dust) and/or a Q-tip moistened (not wet) with alcohol (to remove residue from cigarette smoke). Do not remove the mounting screws to gain access to the sensors... you will upset the alignment. The index and write protect sensors are accessible through the drive door area with the front cover removed from the drive. The zero stop sensor is a tight fit... remove about half the head from a Q-tip and it will work. You'll need to move the head forward to get to the sensor.

DISK EJECTOR:

This mechanism should automatically eject the disk when you open the drive door. Normally, when a disk is inserted, it pushes a spring-loaded slide plate back which locks in place. When the drive door is latched down, it triggers the release mechanism, but the plate remains fixed in place until the drive door is opened again. The slide plate then releases, the spring forces it backwards and it ejects the disk for the user to grasp. You can hear each one of these actions if you listen closely. If the drive does not automatically eject disks, check

for a bent, misadjusted or sticking slide lever, or a missing, broken, or dislodged spring.

Sometimes the lever releases prematurely when the drive door is closed. If that happens, you may hear a scraping sound as the spinning disk rubs the inside edge of the disk jacket. This problem can also cause a failure to read properly and can be "cured" by tapping on the disk after insertion and closing the door. You may hear the click of the ejector latching again. If the ejector is the problem, you can bend the slide plate down a bit at the spot where the tang on the slider engages the lower fixed plate. Don't bend it too far down or the slider will bind and disks will not eject at all.

CLEANING AND LUBRICATION:

The heads and stepper rails should be cleaned periodically, especially if the drive is running in a smoky or dusty atmosphere, or if old disks are used (shedding oxide onto the heads). Dust can be blown out with compressed air. Since the upper head is on a rather delicate swivel mount, a minimum of force should be used to clean it. Pull the top head up gently (it will not go very far before it hits the stop), just enough to get a Q-tip moistened with alcohol between the two heads. Rotate the Q-tip between your fingers to wipe the heads. The easiest access point is between the rails on the right hand side of the drive.

Alcohol works OK for heads, but a stronger solvent should be used on the stepper rails, especially if they are contaminated and/or sticky with old grease. I use paint thinner, but caution must be used not to get any such solvent on plastic parts as it may attack the surface. Swab down the rails and move the head assembly gently back and forth (drive turned off, of course) to reach further into the tight spots. Alternate between swabbing and moving the assembly several times until the rails are clean. You can't get everywhere, but with solvent on the rails, just moving the stepper back and forth will dislodge the dirt and old grease that can then be wiped off. Let the solvent dry thoroughly. Although it's really not necessary, you can relube the rails using a small amount of silicone or graphite lube, or just run them dry. Don't use oil... it will attract dirt and get sticky again. As an alternative to solvent, you can use WD-40 on a Q-tip as a cleaner. Contrary to popular belief, it's not a lubricant, but it works well as a solvent on old sticky grease.

ROM BUG:

If your stand-alone (not the 128DCR drive) 1571 takes a long time to access a 1541 formatted disk, suspect the early version drive ROM 3.0 (CBM # 310654-03) as the reason. The latest version from Commodore was V3.1 and was the one CMD used to formulate their JiffyDOS ROM. If you're on the fence regarding adding JiffyDOS to your system, here is one more reason. If you have access to a burner, a ROM image for the upgraded CBM version 3.0 (CBM # 310654-05) is available at ftp.funet.fi.

POWER SUPPLY:

The power pack inside the 1571 uses a switching type of supply. It runs cool and rarely fails. If it does malfunction, it can be replaced easily (one plug-in connector) or repaired by a competent technician. If you disconnect the power supply, make sure you note how the connector is oriented. If it is installed backwards, it will cause severe damage to the supply and/or the drive electronics package. The

four-pin plug of the supply goes to a motherboard socket: CN1. Pin # 1 is marked on the board. The correct orientation of the PS plug is: pin 1 = black, pin 2 = brown, pin 3 = black, pin 4 = red. It's wise to somehow mark any connectors you remove to prevent mistakes when you put them back.

OTHER PROBLEMS:

Because it runs cooler than a 1541, the 1571 rarely fails because of chip problems. In the rare event of a malfunction, one thing you can try is reseating the only socketed chip in the drive: the DOS ROM, a 310654-03 at board location U3 on the drive controller board (under the power supply). The power supply (metal can) can be moved out of the way (four screws) without disconnecting it. It will just fold up and over the drive mechanics, but be mindful that the power connector may be unplugged when you do that. Make sure you know how it goes back... don't get it backwards! If any other chips are socketed (perhaps because the drive was repaired before), try reseating them too. Make sure the connections between the drive and motherboard are properly seated when you're finished. Remove and reinsert them to clean the contacts. The mechanism for the stand-alone 1571 and for the internal drive in the 128D are the same, although I've heard that some will require cutting a bit of the cabinet at the drive latch because it rubs on the latch shaft. Drives can be interchanged if necessary as a diagnostic or to salvage a working mechanism from a bad drive.

Added notes for the 1571D (drive inside the C128DCR):

The socketed DOS ROM in the 128DCR is under the drive mechanism on the motherboard at location U102. It's different than the one in the stand-alone 1571 and therefore should not be interchanged.

If there is a problem with the drive in the C128DCR, you may get "dumped" into the built-in monitor at boot time (when it tries to autoboot). If that happens, the screen will show something like: U1:13 0 01 00. If you are having problems with internal drive access, as a diagnostic, or to use an external drive as device 8, you can disable the internal drive by disconnecting the ATN line, pin 1 of IC U113 (74LS14). That will make the internal drive "invisible" to the computer. That chip is under the drive near the right front edge of the computer. If you cut the IC pin, leave enough so that you can solder it back if necessary (cut it close to the motherboard).

C64/128 Control (joystick) Ports
Diagnostics and Repair

4-13-07

When a mouse or joystick doesn't work, it's not always obvious where the problem lies... in the device or the computer. Unless you have several input devices to cross-check, it's difficult to determine, but with a few simple tests, a small BASIC program and your VOM (volt-ohmmeter), you can run diagnostic tests yourself. It's helpful to know how a device functions when it's working normally, so that's where I'll begin with this article. Later, I'll explain how to test the joystick, proportional mouse, graphics tablet, and game paddles. But first, let's examine the computers control ports...

The two control ports on the right side of a C64/C128 are 9 pin male D subminiature connectors. They contain two separate sets of inputs, five digital or switch inputs and two analog or variable voltage inputs. One pin is +5 volts from the power supply and one pin is ground. Each device uses different input lines. The ports, as viewed facing the computer connectors, look like this:



1 joy 0 (UP)
2 joy 1 (DOWN)
3 joy 2 (LEFT)
4 joy 3 (RIGHT)
5 POT X (proportional mouse or graphics tablet UP-DOWN, paddle input)
6 joystick fire button, left mouse button or light pen (port 1 only)
7 +5VDC from computer power supply
8 ground or negative
9 POT Y (proportional mouse or graphics tablet LEFT-RIGHT, paddle input)

Pins 1 through 4 and pin 6 go directly to one of the CIA chips and share data lines with the keyboard. Therefore, a problem with one, such as a shorted switch or stuck key, can interfere with the other. That information is useful when trying to determine if a problem is in the computer or not. The keyboard is a matrix (pulses pass through it when a key is pressed) and doesn't ground data lines like a joystick does. One exception is the RESTORE key on the C64.

Signals from the two analog input pins 5 and 9 go through a "switch" IC and on to the SID chip POT inputs where they are converted to digital signals. The name POT refers to one way those inputs can be used, namely with potentiometers (mechanically adjustable resistors) found in game paddles. Potentiometers were commonly used for such things as the volume control in TV and radio before microprocessor controlled circuits eliminated the need for them.

Since there are two ports and two analog inputs per port, that's a total of four inputs, but there is only one SID chip with its two POT lines. To allow for four inputs, the two ports are "time shared" (switched back and forth) by the computer via the 4066 analog switch IC, U28 in the C64 and U2 in the C128.

Pin 6 of control port 1 can also be used as an input for a light pen. It is a device with a sensor in its tip that is placed against the TV or monitor screen to detect when the electron beam passes under it. With the proper software, the pen can be used for computer control using the screen as a "touch panel". That obviously requires holding your arm up to the screen... perhaps the reason light pens never really caught on. Some games used a "pistol" to capture the light from the TV screen as input.

CONTROL PORT TEST PROGRAMS

The following C64 BASIC program can be used to test the joystick inputs of the two control ports. It first clears the screen, then repeatedly PEEKs two memory locations that represent the two ports and prints the results on the screen. The two numbers that appear reflect which function is activated by a joystick in both ports. I have included the port input pins driven and corresponding keyboard keys that should produce the same numbers on the screen. The dual entries (example: Commodore key & F3) indicate two simultaneous keypresses.

```
 10 PRINTCHR$(147)
 20 PRINT"PORT 1:"PEEK(56321),"PORT 2:"PEEK(56320)CHR$(19):GOTO20
```

PIN	FUNCTION	CONTROL PORT 1	CONTROL PORT 2
	NONE	255	127
1	UP	254 (1)	126 (C= & F3)
2	DOWN	253 (LEFT ARROW)	125 (C= & S)
3	LEFT	251 (CTRL)	123 (C= & F)
4	RIGHT	247 (2)	119 (C= & H)
6	FIRE	239 (SPACEBAR)	111 (C= & K)

A more complex machine language program is needed to check the POT inputs, and BASIC is not recommended because it's inaccurate. However, since we only want to verify whether they work or not, I chose BASIC for troubleshooting purposes. The following program tests all inputs of the two control ports and prints the results on the screen. It works on the C64 and the C128 in 64 mode...

```
 10 PRINTCHR$(147):REM CTRL PORT TEST PGM
 20 PRINT"JOYSTICK PORT 1:"PEEK(56321)
 30 PRINT"JOYSTICK PORT 2:"PEEK(56320)
 40 PRINT:POKE56333,127:POKE56320,64
 50 PRINT"PORT 1 POT X:"PEEK(54298)
 60 PRINT"PORT 1 POT Y:"PEEK(54297)
 70 POKE56320,128
 80 PRINT"PORT 2 POT X:"PEEK(54298)
 90 PRINT"PORT 2 POT Y:"PEEK(54297)
100 POKE56333,129:PRINTCHR$(19):GOTO20
```

The first line clears the screen. Then, as in the first program, two memory locations (joystick) are PEEKed and printed to the screen. The keyboard is turned off in line 40 so it doesn't interfere with the POT lines, the next poke switches the POT lines to read from control port 1, then those memory locations are PEEKed. Line 70 is used to switch to control port 2 so those POT lines can be PEEKed. Line 100 reactivates the keyboard, shifts the cursor back to the top of the screen, then the program loops and re-reads all the lines. The screen

should look like this with the program running and nothing plugged into the ports...

```
JOYSTICK PORT 1: 255
JOYSTICK PORT 2: 127

PORT 1 POT X: 255
PORT 1 POT Y: 255
PORT 2 POT X: 255
PORT 2 POT Y: 255
```

For those wishing to test the 3 voices of the SID chip, I'll include a BASIC program to do that:

```
 5 REM C64 SID 3-VOICE TEST PROGRAM
10 FORL=54272TO54296:POKEL,0:NEXT:POKE54296,15:GOSUB60
20 POKEW,17:POKEA,9:POKEHF,15:POKELF,35:POKES,128:GOSUB50:GOSUB70
30 POKEW,17:POKEA,9:POKEHF,20:POKELF,40:POKES,128:GOSUB50:GOSUB80
40 POKEW,17:POKEA,9:POKEHF,25:POKELF,50:POKES,128:GOSUB50:GOTO10
50 FORX=1TO2000:NEXTX:RETURN
60 W=54276:A=54277:HF=54273:LF=54272:S=54278:RETURN
70 W=54283:A=54284:HF=54280:LF=54279:S=54285:RETURN
80 W=54290:A=54291:HF=54287:LF=54286:S=54292:RETURN
```

Line 10 resets the SID and POKEs maximum volume to the three voices.
Line 20 POKEs values to voice 1 and plays a note for a few seconds.
Line 30 adds voice two and plays a note mixed with voice 1 for a few seconds.
Line 40 adds the third voice to the first two for a few seconds, then the program loops back to the beginning.
The parameters for the three voices are in the subroutines in lines 60, 70 and 80.
The subroutine in line 50 adds a delay so each voice can be monitored as the program advances. If any/all of the voices are missing or sound "muddy", suspect a bad SID.

JOYSTICK:

Control port pins 1 through 4 and pin 6 normally measure +5 volts all the time unless "pulled low" by an external switch connected to ground (pin 8). That's what a simple joystick is doing when you move the stick in any direction or press the fire button. With no movement of the stick or fire button, all switches are open circuit. Note that those switched lines are also used as inputs for the computer keyboard. Note also that two switches at once can be activated by diagonal movement of the joystick. That provides a total of eight possible combinations not including the fire button. The two analog input pins 5 and 9 are not used by the joystick nor is the +5V supply line needed because unlike most all the other input devices a Commodore computer uses, the joystick is a "passive" device. Commodore and Atari used the same pinout for joysticks.

1350 MOUSE:

Not a true mouse, and sometimes called a "rolling joystick", the Commodore 1350 looks just like a 1351 but has no identification number on it as the 1351 "proportional" mouse does. This device uses pins 1 through 4 as inputs by "pulsing" them repeatedly as the mouse is moved. For example, if the mouse is moved forward, a negative-going 20

millisecond pulse (electrically called a "logic low") is generated by the mouse which "grounds" pin 1 for that length of time. That's the equivalent of tapping a joystick handle forward once. A continuous forward movement of the mouse is equivalent to holding the joystick handle forward because it keeps the line grounded as long as the mouse is moving. Similarly, movement in other directions creates pulses on the other joystick lines. Diagonal movement creates a logic low on two lines at once, just as a joystick does.

The left "fire" button grounds pin 6 and functions the same as on a joystick. The right mouse button grounds one analog input pin 9 (reason unknown, unless to keep some kind of compatibility with a 1351), same as the 1351 in joystick mode. The POT lines are otherwise unused by a 1350.

1351 MOUSE:

The 1351 has two modes of operation: true proportional mode and 1350 joystick emulation mode. If a 1351 is connected and the right mouse button is held down as the computer is powered up, the mouse switches to "joystick" mode and operates exactly as a 1350. This is useful for some games that do not work with a proportional mouse or mouse driver software is not available. In joystick mode, the left mouse button grounds pin 6 (FIRE) when pressed. The right button grounds the POT line pin 9. The 1351 operator's manual says this button "shall be ignored". (See 1350)

If the right mouse button is -not- pressed at computer power up, the 1351 defaults to proportional mode. Electrically, a moving mouse generates two signals called variable duty cycle square waves as inputs to the POT lines. The computer interprets those signals as variable DC voltages and uses them as direction control for such things as the pointer in GEOS. The voltage variation on pin 5 is used for X axis (forward/backward) movement and the variation on pin 9 is for Y axis (side to side) movement. Diagonal movement generates signals on both POT inputs. A DC voltmeter on those lines (mouse connected, of course) will show a small voltage variation when the mouse is moved. The computer requires mouse "driver" software to detect and process the analog information from the POT lines. A driver is usually embedded in programs that use the mouse for direction control. In proportional mode, the left mouse button grounds pin 6 (equivalent to the "fire" button on a joystick) and the right button grounds pin 1 (equivalent to the "UP" joystick function)... a bit different than 1350 joystick emulation mode.

GAME PADDLES:

These dual-paddle controllers share some features of both a mouse and a joystick. There are two paddles, each with a cable that cross connects and terminates in a single female 9 pin D plug. Some games utilize two sets of paddles allowing four players at once. Each paddle has a control knob which rotates an internal potentiometer or "pot", and a single "fire" button. Each pot is wired to access one of the POT inputs of the control port. Like a mouse, paddles require a software driver to process their variable voltage inputs on the POT lines, but in this case, the variation is derived from a simple voltage divider comprised of the computers internal circuits and the external 470K (K=1000) ohm pot wired as a variable resistor or "rheostat" inside the paddle. Electrically, one end of a pot is wired to the +5V source (pin 7) and the slider contact to one of the two POT inputs (pin 5 or 9). Turning the control changes the pot resistance from a maximum of 470K

ohms (at full counter-clockwise) to zero ohms (full clockwise). The voltage on that corresponding POT line goes from about 1 volt DC at maximum resistance to +5 volts at minimum resistance of the control. The fire button grounds pin 6, the same as a joystick. Commodore and Atari apparently used the same pinout for their paddles. I have taken both apart and they are identical inside.

GRAPHICS TABLET:

One common product is called the Koala Pad. This input device is similar to a mouse but uses a matrix of pressure sensitive contacts under its surface panel to generate X and Y inputs on the POT lines when the tablet surface is pressed with a finger or stylus. Similar to a mouse, a Koala pad generates variable duty cycle square waves which are interpreted by the computer to tell which part of the tablet has been touched.

Unlike a mouse or game paddle, the left and right buttons connect respectively to pins 3 and 4 of the control port. A Koala tablet therefore requires its own software to operate properly. There is both a Koala software cartridge and software on floppy disk. Some commercial software programs were written specifically to use a Koala and so have embedded drivers.

DIAGNOSTICS:

Now we get down to the "nuts and bolts", how to troubleshoot equipment that's not working properly. A VOM (volt-ohmmeter) will be necessary to check for continuity (a closed circuit or zero resistance).

If you don't already have one, now is the time to purchase a meter. Even an inexpensive one is a good investment. It allows you to make passive resistance checks of switches and cables, and lets you check AC and DC voltage levels. Mechanical faults like bad switches or broken wires (inside cables where it doesn't show) account for some failures. If "static" (non powered equipment) resistance tests don't reveal any problems, you can go on to voltage checks. Be careful when measuring at the pins of the computer control ports while it's running. Accidentally shorting pins together can destroy ICs in the computer, especially the CIA chip. Be especially careful of the +5V source at pin 7. Accidentally grounding that pin can destroy components in the computer. I suggest wrapping some electrical tape on your meter probes so only the very tip is exposed to contact the connector pins. That should help prevent accidental shorts. Also, some devices like the Commodore 1351 mouse have a metal shell on their 9 pin connector. If you attempt to plug that in while the computer is running, you could accidentally short port pins together. I've done it myself in a moment of carelessness.

IMPORTANT NOTE: It's easy to get confused about the pinout of that 9 pin connector. The diagram above shows what it looks like facing the computer or the -wire- end of the plug. However, when you're making your resistance checks of a device like a joystick, you'll be facing the pins of the plug, so you'll be looking at a mirror image of the connector. Be careful! I always mark pin 1 with a dab of ink or paint before I begin tests to eliminate that confusion.

CONTROL PORT TESTS:

If you have no mouse or joystick to test the ports, run the BASIC test program and use a 100 to 470 ohm resistor to ground each of the joystick pins and watch the results on the screen. A resistor is used

to limit the current just in case you accidentally touch the wrong pin, so it will not do any damage. Pin 8 is the ground, so one end of the resistor should be connected to that pin and the other end touched to each of the joystick input pins, one at a time. The numbers on the screen should change as indicated above. If more convenient, add a short length of wire to the resistor and use the metal frame of the computer at the rear panel as a ground connection. Don't stick it in any of the other ports back there... just to the metal.

Measured with a voltmeter, you should find about +5VDC with respect to ground on those five control port connector pins (1 through 4 and pin 6) when nothing is connected to the control ports. If any of the lines measure low or zero, there is a short somewhere inside the computer. Unplug the keyboard to eliminate that as a source of the low reading. If the short clears, troubleshoot the keyboard. If the short remains, use your ohmmeter (system unplugged from power) to trace the reason for the low resistance reading on that line... bad IC, leaky diode, shorted bypass capacitor, etc.

The unconnected POT input lines (pins 5 and 9) of the two control ports will normally measure 0.5VDC to 1VDC. They are "driven" higher by a mouse, tablet or paddle when one is connected. Use the test resistor to momentarily connect pin 5 or 9 to the supply pin 7. The number on the screen for that port input should change (to a lower number if the test resistor is 470 ohms or lower in value). If one or both ports don't respond, the switch IC and SID are suspect.

JOYSTICK:

A bad joystick is pretty easy to diagnose. It's just five switches that are normally open circuit. To test, first unplug it and see if all the keyboard keys work properly. If so, see the above pinout diagram of the control ports and prepare to use your ohmmeter to do some resistance checks of the joystick itself (unplugged from the computer, of course). If you push the joystick handle forward (the UP function), it should press on one of the internal switches and close the contacts which connects pin 1 (UP) to pin 8 (ground). For the rest of the switches, connect your meter to the appropriate pins of the plug, move the joystick and note if the meter shows continuity.

It's important you don't damage those plug contacts by forcing anything. The correct size wire should slide in easily. Two small metal paper clips are just the right size and work well to attach your meter after reshaping the clips to hold the meter probes. Note that you may have to wiggle the paper clips gently in the holes to make good contact, so don't mistake a poor connection here for a bad switch or cable.

If one switch doesn't work and the switch doesn't feel or sound the same as the others, that switch may be bad. The joystick will have to be opened up for a visual inspection and tests of the switches. Depending on the type of switch used, it may be repairable. If not, replace it. A broken wire inside the cable is a possibility, especially if the device is used a lot. Wires usually break near the body of the joystick because it's stressed the most there. Connect one probe of your meter to the internal wire of the switch that doesn't work (don't forget to check the ground wire if no switches work) and the other meter probe to the appropriate plug contact. If you find one line open (or intermittent when the cable is moved), the cable will have to be repaired. That's pretty easy if the wire break is near the joystick. Just cut the cable, strip the ends, route it into the joystick and

splice the wires back to the connections inside. Your cable will be a bit shorter, but it should work fine once again.

If you have a bad (intermittent) connection at the plug end of the cable, you can try squeezing the plug with a pair of pliers to tighten the contacts inside. If that doesn't work, you may have to replace the female 9 pin plug... if you can find one. Joystick connectors are usually molded plugs that don't come apart. Each wire inside will be a different color, so installing another plug requires matching all the pins correctly. Since there are many different manufacturers, it's impossible to list the wiring color code for all of them. However, with the pinout as a guide, plug wiring can be determined by which switch is activated in normal operation.

OK, lets say you have tested all the joystick switches and they seem fine but the computer doesn't respond to one or more joystick functions. Examine the joystick port connectors on the computer to see if any of the pins are bent, missing or pushed back and not making contact. If that's OK, the next step is to check all the keyboard keys for normal function. Some keys like the function keys will not produce a character on the screen but you can tell a key has been pressed by carefully observing the flashing cursor of the opening screen... it "flickers" slightly when those keys are pressed.

1350 MOUSE:

Since this is an "active" device, unlike a joystick, it requires +5 Volts DC from the computer to produce direction control pulses. Therefore, static tests with an ohmmeter are limited to the left button switch. You should measure continuity (zero ohms) between pins 6 and 8 of the connector when the button is pressed. Use the BASIC test program to check the other joystick emulated functions.

1351 MOUSE:

This mouse needs a +5 volt source from the computer to generate signals to the POT lines because it is an "active" device. Static tests are limited to checking the left (connects pins 6 and 8 when pressed) and right (connects pins 1 and 8 when pressed) mouse buttons. Test the mouse in joystick mode by holding down the right mouse button for computer powerup, then use the BASIC test program and observe the readings when the mouse is moved and buttons pressed. Try the mouse again in proportional mode...

Problems with the 1351 include loss of direction control in one axis, jittery or stuck GEOS pointer, or totally "dead" mouse. Mechanical problems that make a mouse intermittent can be caused by dirt on the rollers that the ball rotates when the mouse is moved, or by a broken wire inside the cable.

To clean the mouse, remove the cover over the ball and let the ball fall out onto your hand. Observe the rollers inside. They could be snarled with hair, dirt or debris which must be cleaned to allow them to rotate freely. Use tweezers to remove hair and a Q-tip (cotton tipped swab) moistened with alcohol to clean the rollers. The ball can be washed with soap and warm water, then dried and reinstalled.

A dead/intermittent mouse can also be caused by a broken wire inside the mouse cable. That usually happens near the body of the mouse where the stresses of repeated movement are greatest. If wiggling the cable causes the pointer on the screen to jump, the cable is likely broken inside and will need to be repaired. The cable can be cut off at the break and the wires spliced back into the mouse using the wire colors as a guide.

If the rollers are turning and one axis doesn't work, there may be a bad sensor inside the mouse. It's usually the IR emitter that fails. As with most electronic gadgets nowadays, exact replacement parts are hard to find. Your best bet for spare parts might be another duff mouse that has a different problem.

GAME PADDLES:

Although paddles require +5V from the computer to work, they are essentially a passive device as there are no ICs or transistors inside. Therefore, all the internals can be static-tested with an ohmmeter. The control pots inside are 470K (K=1000) variable resistors. One paddle control connects from pin 7 (the +5V source) to pin 5 (X POT input). The other paddle control connects from pin 7 (+5V source) to pin 9 (Y POT input). The fire button on one paddle connect pins 4 and 8 (ground), and on the other paddle connect pins 3 and 8 (ground)

The most common problems with paddles are noisy controls and broken cable wires. A shot of spray control cleaner should fix the jitter caused by the noisy control. For repair of broken cables, see the above info on repairing joysticks.

GRAPHICS TABLET (KOALA):

As with the proportional mouse, this is an active device that requires +5V from the computer in order to generate signals on the POT lines. Static tests of the left and right buttons can be done with an ohmmeter. The left button connects pins 3 and 8, and the right button connects pins 4 and 8.

Typical problems range from broken cables to unrepairable failure of the tablet if someone used too much force and damaged the surface.

C128 & C128DCR 80 column picture distortion (or no picture)

02-22-99

This problem and solution requires a rather lengthy explanation. Through a series of lucky "accidents", a bit of intuition (plus user input :-) and half a day of digging, I have found the cause of this fault. It would only show up with the combination of a C128DCR and a 1084S monitor. Since I don't have a 1084S, I tried all the other monitors I have with my three DCR's.

One of my DCR computers hooked up to my CBM 2002 (made for the Amiga, just like the 1084S is) produced exactly the symptoms described! At low background brightness levels, the picture was almost normal with just a bit of horizontal bending in some of the characters. As the background (or character) level was increased, the picture would start tearing horizontally. Higher levels would blank out the picture completely.

Since only one of my 128DCR computers would produce the fault, I decided to look at the signal waveforms going to the monitor on my oscilloscope. The horizontal sync signal was reduced from a normal 3.2 volts peak to peak down to less than 1.5 volts, and it was contaminated with "garbage" from the video. The vertical sync signal was normal. I tried another RGB cable (one I had made up) and the distortion in H sync went away. But if the other cable were faulty somehow, why did it work with the other computers? It also worked fine with other monitors and the "faulty" 128DCR. What was going on here?

I pulled out the schematics and compared the RGB output circuits of a C128 (that never showed a problem) with the 128DCR (only one of which showed a problem). The circuits use the same "buffer" chip between the RGB video controller chip and the monitor outputs. Could the chip be marginal? I swapped it out and, although the waveform looked only slightly better with the replacement chip, the monitor now works just fine!

Summary: This "problem" has many factors that worked together perfectly to drive a technician (me) and a few Commodore users stark raving mad. 1) Different monitors vary on how much of a "load" they put on the signal and sync outputs of a computer. 2) Some monitors are more sensitive than others about the "quality" of the synchronizing signals they get. 3) A computer is designed to drive a "normal" load such as a monitor within a certain set of specs. 4) Cables are not all created equal!!! In this case, the cable I was using was a 6 foot straight-through (pin for pin) extension with a 9 pin D connector on each end. It is fully shielded inside. The one I made was not shielded, was shorter (about 3 feet long) and worked without distorting the H sync signal at all. I must assume that the internal capacitance of the shielded cable was too much for the computer output to drive. In addition, that particular monitor is sensitive to H sync distortion... my other monitors (1084, 1902A) are not. My guess is that the 1084S and the 2002 share the same sensitivity when it comes to marginal H sync. As for the one 128DCR that showed the fault... after I changed the driver chip (U23, 74LS244), that computer would drive the "marginal" monitor with the "bad" cable. The chip was not bad, but in this particular application, it may not have been good enough. This is the kind of fault that gives technicians and users alike prematurely grey hair (too late in my case). I would expect to see this same problem in the plastic C128 as well. The chip is the same, but the board location

is U24. In both models, the chip is next to the big RGB interface chip inside the tin can in the middle of the motherboard. Fortunately, there is plenty of room around the chip to do the replacement "operation". My recommendation for users that suffer from this problem: the easiest thing to do is change the cable. Go for the shortest one you can find and try one that's unshielded if you can. Digital signals are hard to "contaminate" from external sources. The next best thing... go for a replacement chip. They are cheap... only a few bucks at places like Jameco Electronics (www.jameco.com) in the USA. It's a generic TTL chip and should be available worldwide. Cut the old one out by snipping each pin close to the IC body. Solder the new one in by tack-soldering each pin on top of the old one's pin stubs. That way, you never have to remove anything from the motherboard. Desoldering is a pain, and you can do damage if you lift a trace or get the board too hot. Don't feel too bad if you do accidentally lift a trace... I did when I was making this investigation. Just make sure you fix it before you install the new chip or socket.

REPLACING CHIPS IN COMMODORE EQUIPMENT

7-5-05

For the small "glue logic" chips such as the RAM in a C64, cutting the pins off is probably the best way to remove them. Replacements are cheap and you don't risk damage to the board. The new chip can be soldered onto the stubs left from the old one or, for a neater job, you can remove the old pins one at a time and solder in the new chip or better yet, install a socket. Just make sure you clean the pins of a removed chip before you install it in a socket. If a blob of solder remains on a pin, it can damage the socket by forcing the contact areas too far apart. Another thing: NEVER solder a socket in place with a chip installed in it... you'll never get it out again!

The bigger and harder-to-get proprietary CBM chips such as the PLA and SID in the C64 require a more cautious approach than casual snipping of pins. Unless you're certain the chip to be removed is bad, it makes sense to desolder it intact. After doing that much work on the board, I always install a socket. If you're careful how you remove it, the old IC should be OK. It's important to use the proper equipment for chip removal so you do not damage the board or chips. I used to use a vacuum type of desoldering iron, but they tend to clog easily (requiring frequent cleaning) unless you have one of the very expensive models that has an electric vacuum pump. Now I use a separate iron and solder sucker, one called a Edsyn SoldaPullt. MCM Electronics (www.mcminone.com) sells several equivalent types. I prefer the larger ones because of the higher vacuum they create. That type is easier to keep clean inside than the all-in-one desoldering iron.

The PC boards in Commodore computers and drives are double sided (circuit traces on both sides) with plated-through holes. The main problem with removal of an IC is that the pins just barely fit the tiny holes. Each hole must be cleared of solder and all pins -must- be free before you attempt to lift the chip out. Otherwise, the pin will break off and/or the board will be damaged. A careful visual examination of the board after IC removal is important. Unless you look closely, you may not even notice a PC board trace is broken. The device will not work when you put it back together, and you've just added a problem that's hidden -under- the new chip or socket! <shudder>

Removing a chip is a "black art". After all these years, I'm still learning. Each IC pin needs to be heated for about two seconds, or until all the solder is molten on both sides of the board. Some have suggested using an additional iron on the opposite side of the board, but that obviously requires another set of hands... nice if you've got 'em. Before drawing the molten solder out, I move the tip of the iron slightly, and then press the button on the vacuum plunger to draw the molten solder away. I move the pin and hit the button at the same time so the pin is moving in the hole when the solder is being drawn off. If all goes well, the pin will then move freely in the hole. If it's still stuck to the wall of the hole and all the solder is gone, I free it by grasping with tweezers and wiggling it back and forth a few times, or by pressing sideways on the pin from the top of the board (inwards, towards the chip). If done properly, I can hear and feel it pop loose. If any solder remains in the hole, I add more fresh solder and try to desolder it again. The worst places to desolder are the larger areas of the board (power and ground points, usually at the ends of the chips). Those large copper areas tend to quickly draw the heat away from the iron, so it's difficult to get them hot enough to get all the solder

molten. For the really stubborn ones, I use high quality Solder Wick and a larger soldering iron tip to desolder those pins. In any case, I try not to hold an iron on the board for more than a few seconds at a time. Too much heat will lift the pads (solder holes) and copper board traces. The tendency is to press the iron into the solder, but too much force will likewise do damage to the board. That's why it's wise to practice on an old surplus board first.

Freeing up all the pins before extracting the chip is essential. I wiggle each one with tweezers to make sure its free. It's sometimes helpful to push on the top of a chip to force all the pins one way, then the other in the holes. You can hear them clicking as they break free of the holes. When you're sure they are all loose, try prying up one end of the chip with a small screwdriver. If any pins appear to be stuck, STOP. Free that pin and continue prying up one end, then the other.

If you are successful in getting the chip out of the board intact, by all means install a good quality socket. That way, you will never have to touch that area again with a soldering iron. It degrades it each time, so it's best to avoid resoldering if you can. After extraction of the old chip, examine the board on both sides with a strong light and a magnifier. Look for broken traces near the holes and solder splashes that may cause shorts between pins. Repair any damage and clean any holes that have enough solder left to prevent installing a socket. The easiest way is to poke a large pin in the hole and wiggle it around. Solder is soft and will be pushed out of the way. Hold the board up with a light behind it to see if all the holes are clear. If it looks OK, install the socket and solder each pin carefully. If you intend to reinstall a used chip you have previously removed, clean all the pins by squeezing each one with a small pair of needle nose pliers, then heat each with the iron to remove the excess solder. Don't bend the pins any more than you have to. They will break if flexed too many times. Assuming the worst happens and you break a pin, if there is any stub left on the body of the IC, you can tack solder a small wire to the stub and cut it off in line with the rest of the pins... not pretty, but it will work.

COMMODORE KEYBOARDS

Troubleshooting and maintenance of C64 and C128 (including SX & C128DCR)

5-30-06

Sooner or later with use, computer keyboards show their age. The most common "first sign" of a problem: some frequently used keys require more force to make them work, or they don't work at all. The Shift keys, Spacebar, and commonly used letters such as E and A are the first to show symptoms. To anyone who is proficient at the keyboard, it quickly becomes intolerable to have to stop and restrike a key that didn't work the first time. The most common way to overcome the problem, at least temporarily, is to strike the keys with more force. Very soon after, even that becomes useless... the keys do not respond no matter how much force is used, and the keyboard needs to be repaired. Other keyboard problems take a bit of detective work to diagnose and solve.

The design of a Commodore keyboard is simple and elegant. It works well and lasts a long time. When keys do become unresponsive, it can be from several causes. If only one or two are not working (or require a lot of force to make them work), it's usually because those internal keypads are worn or dirty. Sometimes dirt can work it's way into the internals of a keyboard. A bit of dirt, hair or <ooops> a liquid spill can render the key(s) inoperative if such debris gets between the conductive rubber keypad and the underlying PC board. If many keys are not working (a whole row, for example), the cause is normally either a failing CIA (keyboard interface) chip in the computer, or a bad connection between the keyboard and the motherboard. No problem with the keyboard itself will -prevent- the computer from displaying the startup screen, by the way. The keyboard can even be unplugged from the motherboard for diagnostic purposes, and the computer will still display the opening screen.

Electronically, pressing a key connects a matrix "row" (one of eight) with a "column" (one of eight) and provides "keyscan" data input to a chip called a CIA (Complex Interface Array). The coded 8 bit data output of that chip tells the microprocessor which key was pressed. Some of those keyboard data lines are "shared" with the joystick inputs. One key that doesn't go to the CIA is the RESTORE key. It simply grounds an input line to a timer chip. Two more inputs in a C128: the 40/80 switch, and the Caps Lock switch are likewise not part of the rows/columns inputs.

IF YOU MUST PRESS HARD TO MAKE KEYS WORK

Fortunately, most keyboard problems are of the "I have to step on this key to make it work" variety. Commodore keyboards are easy to pull apart and clean. That is sometimes all that's needed to make them work again. At worst, the little rubber keypads deteriorate and must be replaced, either with new ones or swapped with ones from seldom used keys. The pads are attached to "plungers" under each keytop... normally the plunger (with keypad attached) is swapped out as a unit, but you could remove just the rubber pad... it comes off the plunger easily. Very worn pads will look "shiny". If failing because they have been used a lot, unresponsive key pads don't benefit much (if at all) from cleaning... they must be replaced.

CLEANING

Cleaning the keypads and PC board will correct non-functioning keys -if the problem is dirt or other debris-. After removing it from the keyboard top, wipe the dust off the PC board with a clean cloth. Don't rub or scratch the conductive spots on the board. They normally have a coating to prevent corrosion and oxidation of the copper underneath. If there is some corrosion that you must remove from a copper clad board, rub the spots -gently- with a pencil eraser, then clean the board with alcohol and wipe dry. If bare copper is exposed, it will eventually oxidize, and the repair will not last. It's best to avoid rubbing those conductive traces if they don't need it. Clean any fingerprints from the board contact areas. Oil and moisture from your skin can cause problems. Some boards have a black conductive paint over the contact areas. Unless you encounter a liquid spill that needs to be cleaned off, it's best to leave those areas alone. If the conductive coating is rubbed off, the board may become unserviceable.

The rubber keypads can be cleaned with alcohol on a Q-tip. It's best not to spray anything inside the keyboard. The spray goes everywhere and just attracts dirt. To wipe off any residue from cleaners, lightly rub a clean sheet of paper over each key pad while pressing the key. The rubber is thin and flexible, so be careful you don't tear or dislodge it. Clean only the pads that need it... leave the others alone. Blow any dust out with compressed air, and remove any hair or fibers left behind from Q-tip or cloth. Don't touch the keypads with your fingers, but if you do accidentally, make sure you clean off the oil with alcohol or other solvent before reassembly. Never use abrasives on the board or keypads in an effort to clean them. It only makes matters worse and may render the entire board unserviceable.

CLEANING VS REPLACEMENT

I did some experiments with good and bad keypads. I tried various kinds of cleaners including solvents, and rubbing with paper and emery cloth. After all this, I have come to the conclusion that for a key worn out by normal use, cleaning is useless. The conductive rubber itself deteriorates and cannot be "rejuvenated". A new key will measure less than 1000 ohms (1K ohm) across the two ends of the rubber keypad. If used a lot and starting to fail, it will measure more than 10K ohms. At that point, the user will notice that it takes a lot of force to make the key work. Nothing I tried would make a bad key better (unless the problem was dirt or contamination of the PC board), and interestingly enough, nothing I could do (including sandpaper and solvents) would increase the electrical resistance (and therefore the pressure needed for proper key response by the user) of a good key. The good ones stayed good and the bad ones stayed bad, no matter what I did. So, with that in mind, if cleaning doesn't help (or you don't want to have to open the box again), just replace failing keypads or the entire plunger with pad attached.

REPLACEMENT OF KEYPADS

The quickest way to repair a keyboard if you have no spare parts on hand is to swap heavily used keys for ones not often used. The Shift keys, Spacebar, and letter keys like E and A for example, represent ones most used by the average user. Such keys as the Up Arrow, Back Arrow and pound key could be used as a "source of parts" for a quick keyswap. If you have an old C64 or VIC20 laying around, it could be used as a parts source for another similar computer. Many parts are interchangeable between computers and all keys are the same inside. To

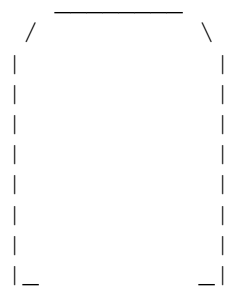
make sure you have a good one to install, either measure it with an ohmmeter across the two protrusions of the pad, or just examine it closely. Worn pads will look shiny... good ones will have a dull looking surface. New pads will measure between 100 and 1000 ohms (1K ohms). When they start to require more pressure to make them work, the resistance of the pad will be up around 10K ohms or more. If the resistance is too high, the computer does not sense a keypress.

STUCK KEY SYMPTOMS

A stuck key can produce some rather confusing symptoms, depending on which key is stuck down. If the keyboard has ever suffered a liquid spill, one or more keys can get "sticky" from days to months later. Of course a broken key can stick down. You can see it if you examine the keyboard as it will be lower than the other keys. If one letter appears on the command line of the startup screen with a flashing cursor after it, or it starts printing a letter repeatedly on the screen at startup, suspect that key of being stuck down. If the key feels OK, there might be some debris on the underlying PC board that simulates a key held down (shorted contact on the PC board. Unplug any mice or joystick(s) if used and try it again. If suddenly none (or only a few) of the keys work, check to see that none are stuck. Press each one and see if the "feel" of the key is right. A sticky one will not come back up like the others. A missing spring under a keytop can produce intermittent or "stuck key" symptoms. That's usually easy to spot just by looking. Beyond that, stuck keys or whole rows or columns that don't respond may be due to a failed CIA interface chip in the computer. If unplugging the keyboard doesn't resolve a "stuck key" symptom, that's another indication of a failing CIA. REMOVAL OF KEYTOPS

Removal of the keytops must be done with great care so as not to damage the top or break the plunger underneath. The tops are a press fit onto the plungers that stick up through the plastic housing. A spring under each top makes the key come back up when not pressed. You might be tempted to use a knife or screwdriver to remove a keytop, but that's not a good idea. The top must be pulled -straight- up and off. If you twist or bend it to one side, you may break the plunger, keytop shaft or both. Prying against another key will likely mar or scratch it.

You can make a simple tool that will pop those keytops off easily. Here's how to do it: With a pair of tin snips or metal shears cut a strip of metal from a tin can (I used the top cut out of a dog food can) about 2 1/2 to 3" long and about 1/2" wide. Bend the ends over at a right angle with pliers to form a tiny lip (1/32" or less) at each end of the strip. Bend the strip into a U shape that fits over the keytop. The tool should be big enough so your finger will fit inside.



The lip at each end must be small enough so the tool will fit between keys, but large enough to grab the underside of the keytop. Note: the cut ends of the tin strip are very sharp! Wrap tape around the strip if necessary for protection. Now, press the tool over the keytop and, squeezing the sides gently to hold it in place, pull up on the tool and the keytop will come off easily. When it pops off, don't lose the spring underneath. Don't remove more than a few tops at a time unless you know where they go back. It's easy to get confused with keys that are not often used. (Ask me how I know.) It's best to have the PC board in place (held by a few screws, if necessary) so the plungers don't fall out when the keytops are removed. Plungers are removed from the bottom of the assembly.

If you have a broken keytop and no spare parts handy, the shaft can be glued back on with Superglue, but first you have to extract the broken stub from the plunger. Don't be tempted to just glue it back without removing the broken stub from the plunger. If you do, you'll never get that keytop off again, ever. Also, that glue tends to wick its way into other areas. So, you'll probably end up with a key that's stuck forever. Make the extra effort and extract the broken stub of the keytop shaft out of the plunger, I use a paperclip with one end bent into an L shape small enough to fit into the small hole in the shaft. Insert the tool into the hole and pull it out quickly. It may take several tries, but that trick usually works and doesn't damage anything. Now, orient the broken shaft bit over the bottom of the keytop so it sits straight. Note the position and prepare to glue it back on. To reinforce the mend, trim a wooden toothpick or the wooden shaft of a Q-tip to tightly fit the tiny hole in the shaft and the broken stub. Force it into the bottom of the keytop and then the broken shaft down over it until it fits snug. When you are satisfied it sits straight and is a good tight fit, remove the stub from the stick and apply the glue, then press the stub back over the stick. Immediately wipe away any excess of glue that is pressed out with a Q-tip. Let the repair dry at least an hour before you try to use it. Trim off any wood sticking out of the hole if necessary. The repaired keytop should now work when pressed into place.

DISASSEMBLY / REASSEMBLY... C64 Computer

Remove three philips screws along the underside of the front edge of the computer. Lift up the top half-shell and unplug the keyboard and power indicator connectors. The keyboard connector may be hard to remove. Grasp the ends and gently rock it back and forth slightly while pulling straight up on it. Don't pull on the wires! Note that there is a blank pin on one end. That makes it difficult (but not impossible) to put the plug in backwards. The power LED connector will go either way... it doesn't matter, because it will work either way. The top half-shell can then be removed from the lower half. The rear fasteners are sometimes very tight and will "pop" when the top is folded back. That's normal.

Rest the top (keyboard) face down on a cloth or cushion to keep from scratching the keys. Unsolder the ShiftLock switch wires: heat the connection and just pull the wire out quickly when the solder melts. Remove 23 tiny philips screws holding the PC board to the keyboard assembly. The assembly need not be removed from the cabinet top, by the way. Lift the PC board up and out. Examine it for dirt or liquid spill residue, and inspect the rubber keypads for contamination or wear. Clean or replace pads as necessary. To remove a keypad, the keytop must be removed. (See REMOVAL OF KEYTOPS). With the keytop removed, the

spring and plunger (with rubber keypad attached) will fall out. Make sure you don't lose anything! The plunger should slide out from underneath easily. If it doesn't, look for residue or cracks in the plastic. If it's broken or worn out, the plunger/keypad must be replaced. A plunger will fit in any slot... they are all the same. When installing a new plunger, don't forget the spring under the keytop. Temporarily install the PC board when you're ready to press the keytop back on. It gives the plunger something to push against, since you must apply pressure to the keytop to get it to "snap" back on. Don't use your finger to hold the keypad... oil from your fingers will contaminate the pad.

When you're finished cleaning/repairing the assembly, reinstall the PC board and put the tiny screws back in. Don't forget to resolder the wires to the ShiftLock switch: heat the connection and poke the wire in when the solder melts. Plug the keyboard back into the motherboard, and plug the LED connector back in. Lay the back of the two half-shells together and fold the top back down. It helps to squeeze the cabinet together at the rear to seat the fasteners. Put the three screws back in the cabinet and you're done.

DISASSEMBLY / REASSEMBLY... C128 Computer

The procedure is very similar to the C64, but the C128 has three keyswitches to unsolder. These switches are plastic and can melt from too much heat on their terminals... desolder them quickly!

On the "flat" 128: remove six screws (standard philips or Torx) from the bottom of the 128 case. Note: the 128 may have special screws holding the cabinet together. The newer star-shaped type is call Torx. The screws require a special T-10 size driver to remove them, but a small flat blade screwdriver can be used if you're careful... just make sure it fits tightly in the screw head. Lift the top half-shell, starting at the front edges. Two small plastic "snaps" hold the case together on each side, and so may make it difficult until you press in slightly on both sides near the top row of keys on each side to pop it open. With the top shell loose, lift up on the left side of the top shell, reach under and remove the power LED plug from the motherboard. Now grasp the top half with both hands and shift it to the left to expose the wiring (still connected) between the top and bottom shells. You need to remove the keyboard connector and a small philips screw. The keyboard plug is usually very difficult to remove. Because it is recessed, you can't get enough of a grip on it to remove it with your fingers. Instead, grasp -all- of the wires tightly between thumb and forefinger as close to the plug as you can and pull up, gently rocking back and forth to loosen the plug from the socket. Next, disconnect the ground strap held to the motherboard on the right hand side with a small philips screw. You can now remove the top half-shell and set it face down on a cloth or padded surface.

Unsolder the wires to the three keyswitches. They are plastic and will melt if the soldering iron is held on them too long, so desolder quickly! The easiest way is to get under each connected wire and when the solder melts, lift the wire -gently- with the iron. If it's wrapped too tightly, you will need to unwrap it from the switch while the solder is molten. All I can say is: work quickly and carefully. I use tweezers to move the wires while the solder is molten. You can cut the wires, but try to leave enough to resolder them when it's time to reassemble the keyboard. There is no need to re-wrap them around the switch terminals when you solder them back on. "Tack" soldering is good enough.

Remove the 27 tiny philips screws and lift up the PC board. Notice the tiny spring off to one side... don't lose it! It will fall out if you turn the panel over. That spring provides a ground connection between the metal frame of the keyboard and the PC board. It's there to discharge static electricity safely and harmlessly to chassis ground.

Clean and replace parts as needed. The assembly is similar in design to the C64, but parts are not interchangeable between the two. Additional note: there are two versions of keyboards for the flat C128 but they look identical, and the PC board has the same CBM part number: 310401-01. The difference in the two versions is the length of the plungers under the keytops. In one version, green and white plungers are 3/8" long and in the other, blue and black plungers are 7/16". They are therefore not interchangeable. A longer plunger might fit and work as a replacement for a shorter one, but that keytop will stick up higher than all the others. Follow the previous instructions as far as parts replacement and cleaning. Reassemble in reverse order of disassembly. The keyboard connector will only go back one way. Be gentle. It's possible to bend pins over if you're not careful. The power LED plug will fit and will work either way. Don't forget the ground shield at the right side of the motherboard and don't over tighten any of the screws. The plastic can't take much torque before it strips out.

DISASSEMBLY / REASSEMBLY... C128DCR COMPUTER KEYBOARD

Unlike the keyboard in the C128, the 128DCR keyboard is inside of its own housing. It only requires the removal of six philips screws to get to the internals, but the screws are hidden beneath the rubber "feet" on the bottom of the keyboard. Those feet are held with double-sided tape and are easy to remove. I like to permanently remount them close to but not covering the access holes. That makes it easier the next time I need to open the case. Rather than "peel and stick" tape, I use glue to remount the rubber feet. Silicone rubber sealer works well as glue.

As with the 128 keyboard, there are 27 tiny screws that hold the PC board to the assembly. The interconnect cable is soldered to the board and a plastic wire tie secures that cable to the board. The board can be opened and cleaned without cutting that tie. Before you disassemble the keyboard, it's a good idea to blow the dust and debris from the top. Lint and hair will be trapped under the keys, so if there is a lot of it that doesn't respond to blowing it out with an air hose, you may need to remove some of the keytops to get at it. If you do that before you remove the board, the plungers will not fall out when keytops & springs are removed. Wide keys such as the ENTER key have a wire clip that is rather difficult to put back correctly. Note how it comes off, and work carefully so you don't break the plastic retainers that hold the clip in place.

The keys are all part of an integrated metal and plastic subchassis, and if that main deck is damaged, it may not be repairable. However, most of the time failures are due to bad contacts, a broken plunger or a broken keytop. The plastic subchassis is mounted over a "motherboard" where each plungers conductive pad touches the corresponding board contacts when a key is pressed. Don't use abrasives or rub on the conductive surfaces when cleaning the PC board. Those contacts are just a carbon powder coating and are easily damaged. Use a mild cleaner such as Windex or rubbing alcohol on a cloth to clean up

any spills on the board but -don't- rub hard. Wipe dust and debris off with a dry cloth or just use compressed air. .

The three keyswitches (Caps Lock, 40/80, & Shift Lock) are soldered to the board as in the C128. Use tweezers to unwrap (if necessary) the wires attached to the switch leads. As with a C128 keyboard, all keypads wear out with use and then require increased pressure on the keys to make them work. If cleaning doesn't restore normal operation, replace the pad. If you don't have spares, swap the pad or the entire plunger with one from another key that isn't used as often. The pads just snap onto the bottom of the plunger but that requires removing the plunger from the subchassis.

Note that the plungers and springs under the keytops are interchangeable with some C128 keyboards (there are two versions of flat 128 keyboard, each with a different length plunger). Although they look identical, C128DCR keytops have a longer shaft to fit their plungers, so not all C128 keytops will work. DCR keytops may therefore fit some C128 keyboards. My DCR keyboard is a Mitsumi and uses the longer keytops.

THE SX KEYBOARD: DISASSEMBLY AND CLEANING (from the SX64 article)

This keyboard is completely different than previous CBM designs. Therefore, some of the previous information in this article will not apply. You need to know how this one works to be able to safely take it apart for cleaning. The main component is a conductive rubber bladder separated from the PC board underneath by a white or grey plastic sheet with holes in it. The plastic sheet is an insulator. Until a key is pressed, the insulator holds the bladder away from the PC board contact points. If the insulator gets damaged or distorted, some keys will not work or may make contact all the time. Removing the bladder from the PC board requires great care. The insulator tends to stick to the board near each contact point. If pulled away quickly, it will most certainly be torn. I use a dental pick to slowly nudge the tiny areas that stick as I gently pull the bladder off the board. The last one took me about 10 minutes to remove. That work cannot be rushed. Some areas of the elastic insulator deform as they pull loose and must be pushed back into place before reassembly.

The keyboard comes apart for cleaning by pressing in on the four plastic snaps on the front edge while separating front and rear panels with fingers. The two center ones are easy... just press in and up on the brown plastic top panel and it will bend upward. The two side snaps need a bit of pressure... use a small flat tool like a screwdriver blade inserted into the slots to make them release. With the top off, the keyboard is visible as several rows of keys over a conductive rubber bladder, which in turn is mounted over a PC board. Each key plunger assembly can be removed for cleaning if one or more are sticky from a spill. They would -all- have to be removed to gain access to the PC board under the bladder. None of the keyboard parts are interchangeable with a C64. Note that the shift-lock key is not a latching switch as in a C64 or C128, but a momentary contact pushbutton like all the rest. A circuit in the SX forms the "latching" device and an LED on the keyboard key comes on when ShiftLock is on.

The following is a report from a fellow user who successfully cleaned his SX keyboard: "I am pleased to report complete success with my efforts to clean the key pads on my SX64 and the keyboard is working like new again. Although not a terribly difficult operation, care must be taken. After removing the upper keyboard case half I removed the five screws along the front of the circuit board that holds it in

place. I then removed the two screws holding the keyboard cable connector in place. At this point I removed the keyboard from the lower case half and removed the keys one at a time by pressing the two tabs together from the back side of the circuit board that hold the key assembly in place. I didn't bother to keep the keys in order as I would use a C64 keyboard as a guide when replacing the keys. I then removed the two tiny screws that hold a small strip of metal to the black rubber like bladder on the right side. At this point I was ready to lift the bladder from the circuit board. Under the bladder is a grayish colored membrane that is somewhat fragile and care must be taken not to tear it. On several occasions this membrane stuck to the circuit board as I attempted to lift the membrane from the circuit board. I used the tip of a very small thin flat screwdriver to ease the membrane off the circuit board when it would stick.

Once the membrane was removed I cleaned all contact pads on the circuit board using cotton swabs (Q-tips) and alcohol. I also cleaned the contact areas on the bladder in the same manner using VERY LIGHT pressure. I replaced the membrane onto the board and attached the metal strip with it's two tiny screws. I attached the cable connector and mounted the board in the lower case half with the five screws. Take care not to over tighten the screw that goes through the bladder to avoid damage. After the board was secure in the case half, I replaced the keys. They simply press into place. The space bar will require a little care to line up all three connectors. Replace the upper case half and that's it. Not that difficult but very time consuming and it does not pay to hurry. While the key assemblies are off the keyboard it is a good time to clean the keys themselves and to blow any dust or debris from the underside of the key. If you find this information useful please feel free to pass it along to others." Charles Houck

All I have to add to what Charles has said is some cautions when cleaning the contact points. Never use anything abrasive on the bladder. The black dots are the contacts. They are just a conductive coating on plastic, so rough treatment can easily destroy the bladder beyond repair. A -light- rub with a dry Q-tip is all that is needed on each black spot. For the copper keyboard contacts, I use a #2 pencil eraser to remove oxidation from each contact point, then rub each with a dry Q-tip to "polish" the surface. The resulting contacts should be shiny with no spots or blemishes. I don't use solvents unless the board and/or bladder is contaminated because of a liquid spill.

PINOUTS FOR AUDIO / VIDEO / POWER SUPPLIES / MISC.

01-15-05

A/V connector pinout for the VIC20
It is shown facing the rear of the computer:

```
          audio out -----3          1----- + 6 volts DC

 comp video out (high)-----5        4----- comp video out (low)
                                2----- ground
```

Notice that the video output is on two pins. They are the same (wired together inside the computer) on some versions, and output a slightly different signal level in others. Use pin 4 for interfacing a video monitor such as the 1702 and pin 2 for the shield (ground). Note: the prewired CBM cable should be the two wire type. A three wire cable used for Y/C video (C64 or C128) will not work.
Note: be careful of the +6 volt line! It's there to source power to the -external- RF modulator used with the VIC20.

Pinout for the C128 computer power connector
It is shown facing the rear of the computer. The C128 supply is a switcher and has two outputs: 5 volts DC at 4.3 Amps, and 9 Volts AC at 1 Amp. Note: the square metal shell of the plug is also a ground.

```
       GROUND -------4         3----- 9VAC

                           5---------- 9VAC

           +5VDC -----1       2----- NO CONNECTION
```

A/V connector of the C64 and C128
Shown facing the rear of the computer.
Note that early versions of the C64 have a 5 pin DIN connector while later versions have an 8 pin. The two are wired exactly the same, except that the 8 pin connector has a separated chroma (color) output on pin 6. Earlier C64's didn't have separated chroma. Note the "U" shape of the connector pins. It's different than the circular pattern of the RGB DIN connector on the 1902A monitor, for example.
Note: the early two wire cable (5 pin DIN) is used for composite video and audio only, and a three wire cable (8 pin DIN) is needed for Y/C video and audio.

```
  see note below -----8             7-----no connection
                               6---------chroma out
       audio out -----3             1----- luminance (B & W signal)

          audio in -----5         4----- composite video out
                               2----- ground
```

Important note: the later C64C and the C128 both have a power supply line going to one of the "unused" pins: pin 8. Be careful!!!

The power connector pinout for the C64
Shown facing the right side of the computer:

```
         9VAC -----7           6----- 9VAC

       ground -----3            1----- ground

         +5VDC -----5         4----- +5VDC or no connection
                          2----- ground
```

Note: although only four pins are actually used, the power connector is a 7 pin DIN, as shown.

Pinout for the joystick ports on the C64 and C128
It is shown facing the right side of the computer.

```
     1  2  3  4  5

       6  7  8  9
```

1 joy 0 (UP)
2 joy 1 (DOWN)
3 joy 2 (LEFT)
4 joy 3 (RIGHT)
5 POT Y (proportional mouse, paddle, or graphics tablet UP/DN input)
6 button (joystick fire button or left mouse button)
7 +5VDC
8 ground
9 POT X (proportional mouse, paddle, or graphics tablet LT/RT input)

Note that when a 1350 (rolling joystick) mouse is used, pins 1 through 4 will have pulses on them instead of logic low levels as a joystick would provide. Also, a pressed right mouse button grounds pin 9. The POT lines are otherwise unused by a 1350.

When a 1351 (proportional) mouse, a paddle, or graphics tablet is used, the two POT lines are used for direction control. A pressed right mouse button grounds pin 1.

Joysticks do not use the POT inputs.

C64/128 Datassette connector
This is a 6 pin Cinch inline type. Although there are 12 possible connections (six above and six below), only six are used. Note the bar between pins 2 and 3. This keeps the plug from being inserted upside down. This pinout is shown facing the computer:

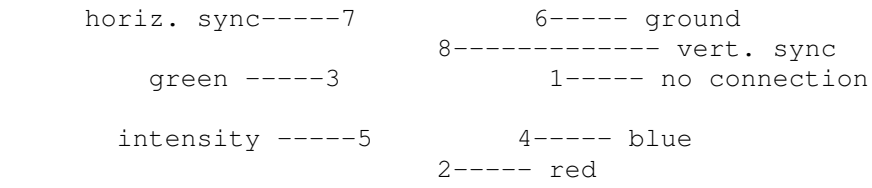
```
      1    2    3    4    5    6
     |-------||-----------------|
     |________||_________________|

      A    B    C    D    E    F
```

1 BLACK GROUND
2 GREEN +5VDC POWER
3 RED   CASS MOTOR DRIVE (+6VDC when motor runs)
4 WHITE CASS READ

5 BROWN CASS WRITE
6 BLUE   CASS SENSE
shield braid is grounded to metal chassis in USA

1902A monitor has several connectors:
an 8 pin DIN for RGBI (80 columns), a 6 pin DIN (like the C64 serial connector) for Y/C video, an RCA jack marked CVBS for composite video, and an RCA jack for audio. The pinouts of the DIN jacks are viewed facing the rear of the monitor.
Note: 80 column monochrome video is available at pin 7 of this connector.
Notice the circular arrangement of the pins. It's different than the "U" shape outline of pins on the C64/128 A/V connector.

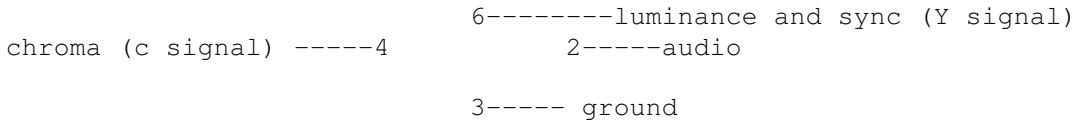


To interface the above connector to your C128, the pinout for the other end of the cable is a 9 pin D, as follows. It is shown facing the rear of the computer:

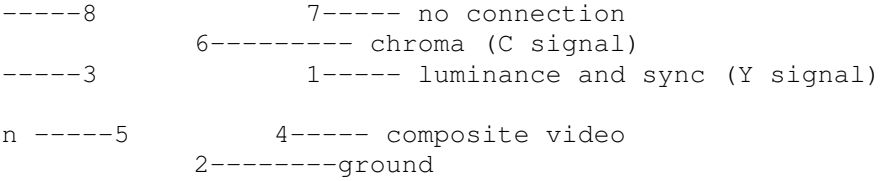


1 ground
2 ground
3 red
4 green
5 blue
6 intensity
7 monochrome (composite) video
8 horiz. sync
9 vertical sync

Pinout for the 1902A monitor Y/C DIN connector
Shown facing the rear of the monitor:

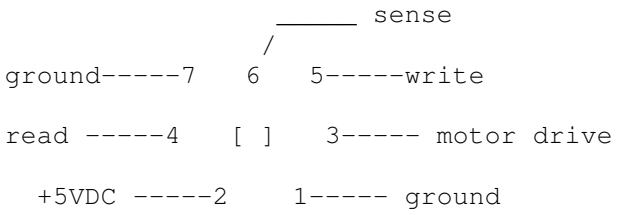


To interface this to a C128 or a C64, you need an 8 pin DIN connector, on the other end of the cable, wired as follows (shown facing rear of computer):

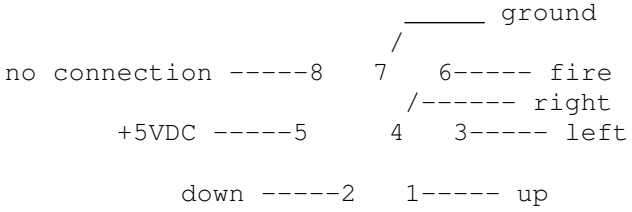


Note: this DIN connector has a "U" shaped arrangement of pins. Don't confuse it with the alternate "circular" 8 pin arrangement as used on the CBM 1902A and some 1084 monitors.

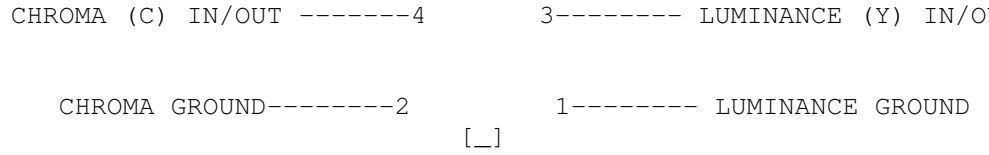
Pinout of the cassette connector of the C16, C116 and Plus/4
It is a mini-DIN, unlike the inline edge type connector of the C64. This pinout is shown facing the rear of the computer. It is important to get these pins correct if you are going to make an interface cable for your computer. A "mirror image" error in wiring will reverse power and ground connections, and will likely damage your Datassette and/or computer. Note the blank (unconnected) pin in the center of the connector.



Pinout of the joystick connectors of the C16, C116 and Plus/4
Shown facing the computer. Note: center pin 4 is offset to the right.



Pinout for an S-video connector
Shown facing the rear of the monitor/TV, SVHS VCR, or whatever. The connector is a four pin mini DIN. Note the "keyway" at the bottom. Note also that the active pins are labeled IN / OUT. If the device is a source of video like a VCR or DVD player, the pins are OUTputs. If you're wiring a cable for a monitor, they are INputs.



The luminance is the black and white information with sync. The chroma is the color information. Separated Y and C produces a better picture on a monitor screen than composite (single wire) video. To connect the Y/C output of a C64 or C128 to a Y/C monitor or TV, take the Y output of the computer (see 8 pin DIN AV output diagram) and connect it via a shielded cable to pin 3 of the miniDIN connector. Take the C output of the computer and connect it to pin 4 of the monitor. Don't depend on the metal shell as a ground connection between devices... some cables do not use the shell as a shield. Use the Y and C grounds, pins 1 and 2 respectively for the grounds on your shielded cable(s). Audio can be included in your hookup from the computer to the monitor or to your stereo system.

Pinout of the 1581 power connector
Shown facing the rear of the drive. Note that the same power supply is used for the 1541-II and the 1571-II. The supply puts out two voltages: +5 volts DC at 1 Amp and +12 volts DC at 1/2 Amp. Some versions of this supply are rated at .7 Amps on the 5 volt output.

```
          +12VDC -----O       O----- +5VDC

    no connection -----O     O----- GROUND
```

Pinout for the serial port of the C64/C128
Shown facing the rear of the computer. Pinout is the same for CBM drives, but then pins 3 and 6 are inputs. Serial cables are wired "straight through", that is, pin 1 to pin 1, pin 2 to pin 2, etc.

```
                     5         1

                          6

                     4         2
                          3
```

PIN	SIGNAL	DIRECTION	DESCRIPTION
1	/SRQ	IN	Enables fast serial, 128 mode only with 1571/81.
2	GND		Logic ground.
3	ATN	I/O	Logic low = interrupt, then query for device #.
4	CLK	I/O	Clock - timing for slow serial data.
5	DATA	I/O	Data to/from computer/drive.
6	/RST	OUT	Logic low pulse from computer = reset peripherals.

Pinout for the Oceanics / Excelerator Plus drive power supply connector
This diagram is shown facing the rear of the drive.

```
      +12VDC @ 1/2 Amp ------4         1------- +5VDC @ 1 Amp

                  Ground ------2       3------- Ground
                                     5------ no connection
```

Although the supply specs are the same as for a CBM 1541-II / 1581 supply, the connector is different. A Radio Shack # 274-003 DIN connector will fit the Excelerator drive.

RAM (RANDOM ACCESS MEMORY) PROBLEMS IN THE C64/128 COMPUTER

1-31-06

If you get an "out of memory" error or less than the normal number of bytes free (should be 38,911 for the C64) when you turn your computer on, that's a RAM problem and usually points to a partial failure in one of the RAM IC chips. Blank screen can be a RAM problem but can also be caused by many other failures such as a bad PLA or power supply which are actually more common. Bad RAM can produce a "garbage" screen which is a symptom where the screen fills up with random characters when the computer is turned on.

There are two memory control chips that should also be suspected when you have an apparent RAM problem: U13 and U25 in the C64, and U14 and U15 in a C128 and 128DCR. Those are generic 74LS257 logic chips. The C64C integrates all memory control inside its PLA and so doesn't use the 74LS257 chips. Early C64 computers have eight 4164 TTL RAM chips installed. Some interim brown case and all later OEM C64C (white case) computers have only two 4464 RAM ICs (41464 is the same IC) as those chips have four times the memory "density" of the 4164. They are not interchangeable with the earlier RAM. Early C128 computers have sixteen 4164 chips and a total memory count at startup of 122365 bytes free in 128 mode. The USA metal case C128DCR has four 4464 (41464) RAM chips and the same bytes free count on the 128 mode startup screen. The 64 mode in all C128 computers shows the same memory count at startup as a stock C64.

One common symptom of bad RAM is the error message "OUT OF MEMORY IN 0" at startup. That means the computer failed its RAM self test and therefore can't load programs or perform even simple tasks. Because it can produce the opening screen, this means one RAM IC has an open element or stuck bit... not as serious as a shorted chip. There are eight RAM ICs in there, so how do you find the bad one without just replacing them all one at a time? Fortunately, there are several methods. It's possible to calculate which RAM bank has failed the self test using the bytes free number, but I could never find exact information regarding that procedure, so I've never used it. Since the computer partially works (opening screen comes up), I use a method that usually works: to "piggyback" a known good 4164 RAM chip on top of each computer RAM IC and then power up the computer and observe the number of bytes free on the screen. If the value changes (even if it's still not correct), change that board RAM IC and try the computer again. Never just leave the piggyback chip in place as that may cause timing problems or may eventually stop working. The board chip can continue to deteriorate and could eventually short out. It's best to remove and replace it now. The piggyback method requires that you install the test chip over a board RAM chip so all pins make good contact and no pins short together. The test chip must be oriented correctly as well. There is a notch or dot (or both) on one end of those ICs. Those markings must line up because if the test chip is installed backwards, it will likely be damaged when power is applied. You can press the test chip pins against a tabletop to push all pins inward slightly, and that will provide some spring tension when the test chip is inserted over the board chip and can hold it in place. It's OK if you want to hold the chip with your fingers and then power up the computer. There is only five volts present and therefore absolutely no danger of electrical

shock. Again, if the bytes free number changes, that board IC is probably bad and should be changed.

If there is no change when all RAM is checked, suspect the two RAM control logic ICs mentioned above. They must be replaced to diagnose a problem there.

There are several ways to replace ICs on a computer board. One way that doesn't require a lot of work is to snip all the pins off close to the body of the IC with a pair of small cutters and just solder the new IC to the remaining pin stubs. It doesn't look very neat, but it works fine as long as no pins are shorted together. If you get the stubs too hot during soldering, they can loosen up in the PC board holes and start moving around... so you should solder quickly. Examine your work carefully when you're done. Look for shorts between pins and solder splashes or bad connections (sometimes called "cold solder" joints). The next method is a variation of the first, namely to snip all the pins of the bad chip, but in this case to desolder them one at a time so you can install a socket. Once the stubs are removed, you need to clean the residue of solder from the holes. That's easily done with your iron and a solder sucker, a vacuum device that slurps up molten solder when the trigger is pressed. If a hole is open but a tiny bit of solder remains, you can poke a straight pin through and wiggle it around a bit... gently! Solder is made of tin & lead and is relatively soft, but if you get too aggressive, you may damage a board trace (the copper wiring in and around the holes), and that MUST be repaired before you install a socket. If you install an IC or socket over an unrepaired trace, you've just created and covered up another problem that is -very- difficult to find, even for a tech.

With regards to sockets, I always use them when replacing chips. 4164 RAM chips usually cost under two US dollars each so just replacing suspected chips by snipping the pins is OK. I always desolder larger proprietary (expensive as well as hard to get) ICs such as the PLA or SID intact. That way, if the suspected IC happens to still be good, I have not ruined it by cutting the pins off. Removing any chip intact requires a lot more care and the proper tools to prevent chip and/or board damage. Once even a small IC is removed, it's still a good idea to install a socket. Then that area of the board will never be subjected to the heat of soldering again. Each board rework with a soldering iron results in weakening of board/trace bonds. The less of that the better.

Note that shorted RAM will always produce a blank screen and will often get very hot to the touch. RAM normally runs barely warm to the touch after several minutes of operation. Any that get hot quickly or even noticeably warmer than the other RAM chips are bad! One or more shorted RAM chips usually point to a failing power supply. That MUST be checked before you turn the computer on again after repairs are done. One easy way is to measure the voltage at the appropriate pins of the four pin DIN plug of the power supply while it's plugged in to AC power but disconnected from the computer. Don't short any pins together while testing! Two pins will measure 9 to 11 volts AC, which is normal. The other two pins should measure 5 volts DC. If that regulated source is high or low by more than a few tenths of a volt, the supply is failing and should be replaced.

All black or white original CBM 64 "brick" power supplies are potted with epoxy inside and therefore cannot be repaired. Note that some supply failures will not show up until the supply has been allowed to warm up for awhile. Therefore it's best to run the power supply with an artificial "load" (not a computer!) connected to it such as a small

12v light bulb. See the PS tester article for more information about that. Other chips may be damaged by overvoltage from a failing C64 power supply but RAM is particularly sensitive to that problem and will usually be the first to fail by shorting out. Obviously the piggyback method of chip testing will not work with shorted chips that produce a blank screen.

It's interesting to note that shorted RAM chips in the C128 are almost unheard of. The 128 switching supply is more reliable and rarely harms the computer even when it does fail. Voltage "sag" (lower than 5 volts output) when loaded usually points to failing filter capacitors in the supply. The C128 power supply is repairable unlike the 64 epoxy brick.

1581 DISK DRIVE DIAGNOSTICS

7-13-05

To properly diagnose a problem with your 1581, you need to know what should happen during normal operation of the drive. A visual inspection of the stepper and spindle activity is helpful in troubleshooting. To see the drive operate, you will need to remove the top cover from the mechanism, and that requires removal of the drive from the case. NOTE: It is especially important to note and write down the orientation of the four wire drive power cable at the PC board. This cable carries the +5 and +12 volt power sources from the PC board to the drive mechanism. Note that the red wire goes to pin 1. If that drive cable is accidentally reversed on the PC board, it will destroy the drive instantly when the drive is powered up! Make sure you get it back the way it came off. The 34 wire flat data cable also needs to be oriented properly. If put on backwards, the drive will not work but that mistake shouldn't cause any damage. I've done it a few times without a problem.

One difference between the 1581 and earlier drive types such as the 1541 and 1571 is the functioning of the drive activity light. In the 1581, the green activity light comes on during the power-up sequence (drive self-test) and during disk accesses, i.e. a read or write in progress, but disk errors are displayed by a flashing -power- (red LED) light. It will alternately flash dim and bright at about a 2 per second rate if a disk error is encountered. This is different than in a 1541 or 1571 where the drive activity light functions as an error indicator.

Normal operation:

When powered up without a disk in the drive, the 1581 power (red) and drive activity (green) lights will come on. The stepper motor will pull the heads back to track 1 if it is not already there. To see if the stepper is working, turn off the drive and push the head mechanism forward, then turn it back on. If it is already over track one, it will move forward -slightly-, then move back in one quick sequence. If you listen closely, you can hear it "burp" as the stepper operates. Then, as the drive completes the internal self test and initialization (about 2 seconds), the green activity light will go out and the stepper will "burp" again and remain in the "track zero" area. Note that the spindle motor does not turn unless there is a disk in the drive.

If there is an unformatted (blank) disk in the drive at power up, the spindle will turn and the stepper will pull the heads back to track 1 (if not already there). As the initial disk read fails, the heads will remain at track one and the stepper may burp again. The spindle motor will continue to run for about 15 seconds, then stop. Exception: if the computer is connected but turned off, the spindle will run continuously because one or more serial lines are held at a logic low level by the computer. If the computer accesses the drive by trying to read a blank disk, the drive error will flash the red (power) LED. If you access and read the error channel, it will indicate:

74,DRIVE NOT READY,00,00.

The same thing will happen if the drive heads are clogged.

If there is a formatted disk in the drive, but the drive cannot read the data for some reason (example: an IBM formatted disk), the

stepper will move the head back and forth seeking a good track to read. Depending on what the drive reads, the heads may remain in the track 1 area or move to the directory track (40) area, and the spindle will continue to turn for about 15 seconds after the green activity light has gone out. (See Note 1) If a computer is connected and a disk with unreadable (corrupted or incorrect) data is accessed, the 1581 red drive power light will flash. If the error channel is read, it will say:

20, READ ERROR,40,00

because the drive can't read the disk directory at track 40.

Lastly, if there is a correctly formatted and readable CBM disk in the drive at power up (or if connected, a computer reset), the stepper pulls the heads back to track 1 (if not already there), then the stepper will move the heads forward to track 40 (the directory) and "park" the heads over that track, and the green activity light will go out after about two seconds.

Note that during disk accesses, the green activity light will blink or stay on as the drive reads a good disk, and the spindle motor will stop about 10 seconds later. Long directories with many entries may take several seconds to load. If the same disk directory is accessed again by the user, note that the drive spindle doesn't move but the activity light turns on for a short time. That's because the BAM and directory information for that disk is stored in drive memory until the disk is changed. A disk change prompts the drive to reread the BAM from the disk the next time the drive is accessed by the computer. Therefore, after a disk change, the spindle will turn and the drive will read the disk again... even if the same disk is reinserted. There is a tiny switch just inside the drive door on the left side that closes when a disk is inserted. That's what the drive electronics uses to sense when a disk is changed. Another switch (or photo sensor in some mechanisms) is used for write protection. It checks to see if the hole in the disk is open (protected) or closed (OK to write). Note: that is exactly opposite to the way a 5.25" disk is write protected.

If the 1581 is connected to a C128 and the computer is turned on or reset in the 128 mode, the 1581 (like the 1571) will attempt to autoboot from the disk. If the disk contains a special USR file with the name COPYRIGHT CBM 86, the drive will read and execute that file and automatically run the program at the specified load address. Note 1: An IBM formatted disk has the same MFM encoding as a Commodore formatted disk, but other differences normally make IBM disks unreadable in a 1581. However, because of the similarities, with the proper software (such as Big Blue Reader), an IBM double density (720K) disk can be read or written to in a 1581. Likewise, a 1581 formatted disk can be read in an IBM type PC if the proper software is used. Of course programs from either system are not cross-compatible, but such things as text files can be accessed. Note that newer IBM 1.44M (high density) disks are not compatible and will not work in a 1581. Also, some PC systems will not automatically recognize 720K disks properly.

Drive problems:

The 1581 is a very reliable drive compared to other CBM types and actual breakdowns are rare. The most common drive failure is actually a fault in the external power supply. If the +5 volt regulated source "sags" (drops below 5 volts) during drive accesses, the drive will throw random errors or will not work at all. That supply problem is

usually intermittent and it may work when cold but fail after warmup. If you can borrow another supply, that's the easiest way to check for a bad one. An alternative diagnostic is to monitor the +5 volt line (the red wire on the four wire bundle to the drive mechanical deck) inside the drive with a voltmeter while the drive is being used. It should remain steady at 5 volts DC. If the voltage drops at any time, the power supply is probably failing.

One drive problem shows up as a continuous green activity light (the LED doesn't go out two seconds after power up) and there is no drive access. Most of the time, it's the DOS ROM chip U2 (CBM 318045-01) that's bad. That chip can be a ROM or an EPROM, and normally is the only socketed chip in the drive, unless someone has added other sockets during repairs or upgrades. Other chips that can produce that symptom are a bad VIA chip U5, a CBM 8520, (also used in the Amiga) or U9, a 74LS14 (a standard TTL IC). Note that if the drive doesn't complete its initialization sequence at powerup or reset (for whatever reason), two of the serial lines (pins 4 and 5 of the DIN connectors) will remain logic low instead of going high as they should.

Another thing that concerns some 1581 owners is the 1770 vs 1772 U4 drive controller IC dilemma. Some early drives failed because of a bad run of 1770 disk controller ICs from the factory. Because of that one time problem, some users are now routinely changing U4 to the later 1772. That "upgrade" requires a jumper change on the drive PC board. If the original chip was a WD1770, there may not be a jumper installed at J1 on the PC board. If a WD1772 is installed, a jumper wire or 47 ohm resistor should be installed at J1. It changes the step rate to 6mS. That jumper goes from U5 (8520) pin 25 (PHI-2) to pin 19 (TOD). Note that later drives may already have a WD1772 installed by the factory. If so, the board has no marking for J1 as it has already been hardwired elsewhere. The original fault with a failing 1770 was directory corruption. I had one 1772 that would not format a disk although everything else worked. I used a good 1770 to replace it and the drive now works fine. Note: the 1571 drive uses the same two controller ICs interchangeably, but has no jumper.

Another fault that Commodore found and fixed in some early 1581 drives was a bad connection between IC U10 pin 10 to ground. Some drives apparently had a bad connection at that point, and it should be checked and resoldered if necessary. That fault caused intermittent "device not present" errors.

Lastly, a fault that is not really a drive problem but that looks like one shows up when you connect a 1581 to a C64 (or VIC20) with a Datassette also connected. When accessed, the drive will lock up the serial bus and the green activity LED on the drive will stay on. The 1581 uses one serial line for burst mode (128 mode only) that the C64 doesn't support, and that line is also used by the Datassette for its read function. A 1581 pulls the \SRQ (pin 1) line low when the drive is accessed, and that locks the bus. Note that this problem doesn't happen with a 1571 or on a C128 (64 or 128 modes) with a 1581 and Datassette connected. If it is necessary to use a Datassette with a 1581 on a C64, one workaround would be to cut the computers \SRQ line to the serial port (it's never used anyway), or make up a special serial cable with that line disconnected.

REPLACING THE POWER SWITCH ON A COMMODORE MONITOR

2-28-06

The standard CBM 1084 series and 1902A monitors made by Philips have a separate power supply board mounted on a slide-in plastic tray. The power switch is fastened with two screws to the front end of that tray so it sits just behind the front panel push button assembly. Four wires connect the switch to the chassis. Note the position of the color coded wires and install them the same way on the new switch. View how it looks before and after switch replacement at:
http://staff.washington.edu/rrcc/uwweb/pics/1084.jpg

Position the monitor face down on a cloth or newspaper to prevent scratches on the front panel. Five screws must be removed to pull the rear cover off the monitor. Disconnect the speaker plug from the center upright sub-board as you remove the rear cover. To remove the PS tray from the cabinet, unplug two connectors on the PS board and unsolder the two braided ground straps from the bottom metal shield. One other braided strap connects the PS board to the CRT board, and that one may need to be removed to be able to pull the tray all the way rearward and out. The release for the tray is inside the square cutout underneath. Push the release in slightly with a small screwdriver as you pull the tray rearward.

The mounting holes of the replacement switch may be misaligned with the holes in the plastic tray by a fraction of an inch. If so, the holes in the tray may be trimmed (elongated) slightly with a thin sharp knife so the switch will fit. Although the new switch is designed for machine screws, the original self-tap screws will work fine. Once the wires are soldered, the tray may be pushed back into its slot. You may have to dress the wiring out of the way if it snags or binds. Resolder the three shield braids to their previous places and reconnect the two plugs to the PS board. Try the switch a few times to make sure it latches and unlatches properly before putting the rear cover back on. As you reattach the cover, don't forget to reconnect the speaker plug.

The CBM 1902 and 2002 monitors were made by Fujitsu and have a different layout for the power switch than a 1084. It mounts directly to the front panel and uses only two wires. Place the monitor face down on a cloth. Six screws must be removed to pull the rear cover off the monitor. Raise the cover slightly and disconnect the speaker plug by squeezing/pulling the connector, then remove the cover. Note how the original power switch is mounted and how the wires are connected with a small PC board. That board can be discarded along with the switch and the two wires soldered directly to two terminals of the new switch. The other two terminals of the switch are unused.

The original installation didn't use the switch mounting holes but just two large washers as clamps at the edges of the switch. The new switch can be mounted in a similar fashion. However, a slightly longer switch actuator may not allow it to release properly when turned off. If so, you can use extra washers underneath the edges as spacers or you can trim a small amount off the end of the switch shaft, no more than 1/8". Observe view before & after the switch replacement:
http://staff.washington.edu/rrcc/uwweb/pics/1902.jpg.

The CBM (Amiga) 1080 uses a completely different chassis made by Toshiba. The power switch mounts on the front panel, similar to the 1902 and 2002 versions. The small PC board must be left in place as it also connects to the front panel power indicator LEDs. However, the two

switch wires may be cut off and soldered directly to two terminals of the new switch. As before, you can use a few washers as shims if the switch actuator is too long and it doesn't release all the way when turned off. An alternative would be to trim no more than 1/8" off the end of the switch shaft. Note that only two switch terminals are used. View the 1902.jpg image <see above> as it is similar to this monitor.

Replacement switches are presently available from two sources. These two outlets have no minimum order requirements and you can order online, but shipping will exceed the cost of the part unless you order more from them. Shipping is by weight and UPS ground is the cheapest within the USA.

Jameco Electronics (www.jameco.com) switch part numbers are 174238PS ($0.85) and 127049PS ($1.95) as of this writing. The switches are identical except the former has small solder terminals and the latter has large spade lugs for press-on connectors. However, those lugs can be soldered to just as easily. Note that the length of the switch actuator shaft is almost 1/8" longer than the Commodore original. It can be trimmed or washers can be used as spacers to give the new switch adequate clearance. Otherwise the switch may not release far enough to turn off. That may or may not be a problem as it depends on the exact model and cabinet type.

MCM Electronics (www.mcminone.com) part number is SW00450 and it costs $3.11 as of this writing. That switch is a closer physical match to the Commodore original (no trimming or spacers needed) but it costs more than the Jameco switches.