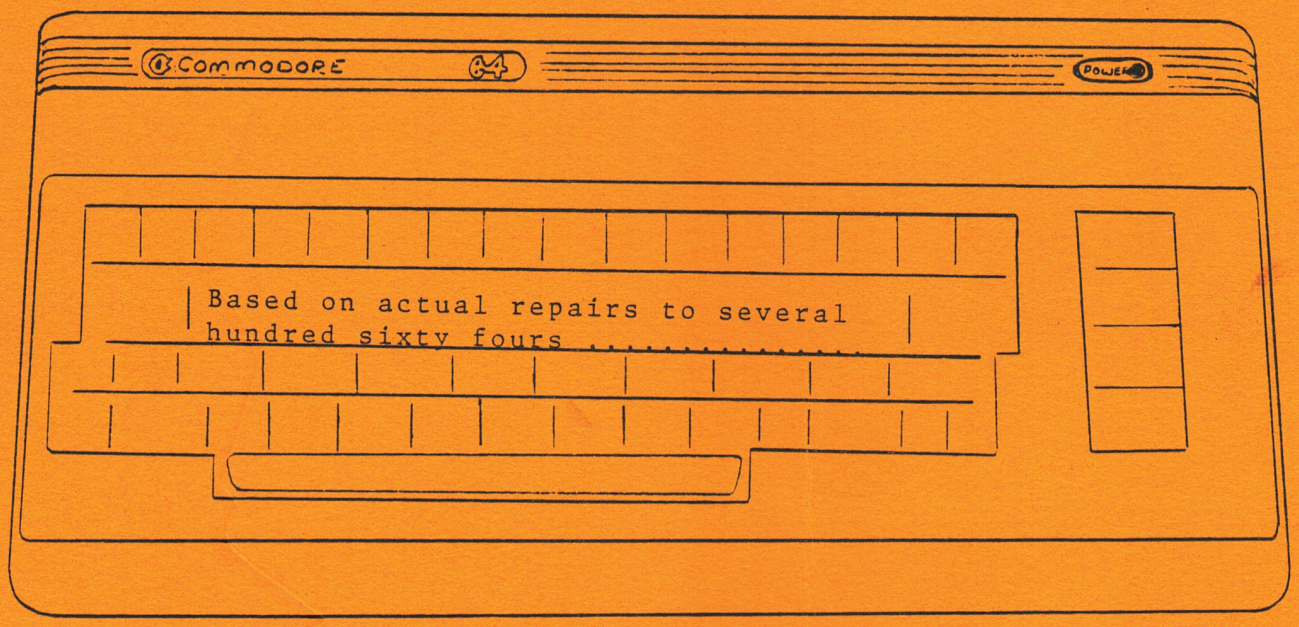
REPAIRING

THE

COMMODORE 64

COMPUTER



ALSO INCLUDED: Tips on peripheral problems and general troubleshooting techniques.

1985

REPAIRING THE COMMODORE 64

INDEX:

We are in no way connected with CBM and do not intend to imply that their equipment has a higher failure rate than any other.
Information contained within is believed to be correct. Not responsibile for any personal injury or property damage incurred from use of this information.
"BEWARE OF HIGH VOLTAGES" present in any AC line powered equipment. This is less of a concern with the 64 with the sealed power supply but always a risk with the disk drive, printers etc. Watch where you put your fingers ! AC CAN KILL !!

If a COMMODORE 64 dies after the warranty expires the owner has the option of finding a local repair shop or sending it off to Commodore.

Another option and the subject of this manual is fixing it yourself. How useful the tips found here will be depends on your electronics experience and resources. Even the most experienced technician can save a lot of time with repair history on a machine he has not worked on before. On the other extreme, some people may have great difficulty with the simplest repairs. Where you fit will determine how far you want to troubleshoot. This manual will be of use to electronic repair centers by bypassing some of the learning curve that goes with taking on any new line of equipment, in this case the Commodore 64.

After reading this manual a reader could justifiably say there are lots of other possibilities given little or no mention. In fact there are an infinite number of possible failures and a large number of possible symptoms. But as this manual is based on actual, not hypothetical problems, the odds are good that they will cover most you would likely see. Every machine has it's "weakest links" and after some time repairing them, the technician knows just where to look for the most likely cause of a problem.

To be fair to the service shops, don't expect them to give you a no charge estimate, telling you what the problem is, so you can then fix it yourself. With any electronics equipment, the time required to fix it is mostly finding the problem, not making the actual repair.

With the exception of the more obvious problems, you may not at first know for sure if the fault is in the computer or elsewhere. Depending on the situation the problem may be with the program ,(game etc.), disk drive, printer or modem etc. First try to eliminate software as the culprit. Is it only with one program or game ? This can be difficult at times because of memory requirements and other reasons why one program will run but not another. You could try to run the same program on another machine. A flacky diskette drive can cause programs to appear to load but not run properly. Inconsistent problems usually point to the drive as the culprit and alignment, (discussed later), is most likely the fault . The 64 is most likely at fault when no response is experienced when a load from the drive is attempted, (more on this later).

Hints on some of the more common diskette drive, tape deck and printer problems will also be discussed.

This manual will attempt to be brief and present only the "BEEF". Information presented elsewere many times over such as digital logic theory etc. is not included. Much information is available elsewere on the 64 and some of it can be useful at times for trouble shooting the "hardware". Basic electronic knowledge is assumed ! The repair details presented here represent the actual repair of several hundred 64s.

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* Rates: $30 an hour, $60 if you tried to fix it yourself ! Assume that if your efforts are unsuccessful you may have obscured the original fault and made matters worse. If you give up, tell the service people everything you did, it will be cheaper in the end !!
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THE BLANK SCREEN !

The most common symptom of a bad 64 is the "blank screen". When switched on the TV picture changes from noise to clear indicating that some life is present but the computer does not appear to be running, (and it usually is not !). This symtom can be caused by a number of different faults. The most common are the power supply, PLA chip and memory, (RAM or ROM) .

At first you might think that if the power supply was bad you would get nothing, no POWER ON LED ,(red light), or sign of life from the TV or monitor. The reason why this is not the case is that the power supply provides two voltages, five volts DC and 9 volts AC. One or the other, (or both), can fail. If the five volt side fails the LED will not be on and the 64 will not run. If the nine volt side fails the LED will be on but the 64 will not run. Fiqure 1 shows the two types of power supply connectors and the voltages you should be able to measure with a voltmeter. You could also try your supply on another 64 or vice versa. The earlier 64 had a repairable power supply with a replaceable voltage regulator. The regulator is usually at fault if you notice the 5 volt DC side fluxuate and intermittent problems with the computer. It is possible to use a commom 7805 5 volt regulator to replace the original, (the pin out is different). Use heat sink compound and make sure the mounting screw is tight for good heat transfer. If the

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* Never assume anything with AC line voltage, it may get you the first time you are careless !!
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9VAC side is dead, the transformer in the supply is bad and is not repairable. The regulator for the 5 volt side can completely fail and present up to 12 volts on the output causing damage to the computer. It is a good idea to check the supply as well even if the computer appears to have a problem. Intermittents can sometimes be traced to an overheated power supply. The sealed P.S. is not repairable in any case. You may prolong the life of the power supply by unplugging it when not in use.

If you find the supply to be good the next step is to remove the three screws from the bottom of the 64 and open it up. There is a fuse in the nine volt line near the power connector which may have blown for some reason, (something incorrectly plugged into USER port for example may have caused it to blow). You may find you can replace it and all is well again. (With 9VAC from P.S. bad or fuse blown you may see no change on TV screen on power up)

You may also find that when you replace a bad power supply the machine still does not work or has a different problem. A part can fail and burn out the power supply, (or vice versa). There is a slight risk that you might burn out the new one troubleshooting the computer.

The 64 schematic found in the Programmers Reference Guide is a useful addition to this manual for any serious troubleshooting.

Using your voltmeter you should be able to find 5 volts DC across pins 16 and 8 of U15 for example. Note that this

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* ALWAYS make sure device is off before removing or installing parts !!
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5VDC is supplied by the power supply directly. Another 5VDC is derived from the 9VAC, (VR2), for the video. You should find 12 volts DC, (VR1), on pin 13 of the 6567 at U19 and 5VDC on pin 40. If the power supply is good but the voltages are not present there may be a problem between the power supply and chips, (switch or regulators for example). Although this is not common it is easy to check voltages before digging deeper.

Some of the earlier 64s did not have a heat sink on the 5V regulator VR2. This can cause problems after it has been on for awhile, such as locking up or distorted screen displays.

Another more common problem with the 64 is bad memory, (RAM). There are 8-4164 chips ,U9-12 & U21-24. You can quite often find the bad ones by feel, they will get hot, (short), sometimes very hot. Unfortunately very often more than one can be bad and they are not cheap. You may find, for example, two hot and replace them only to find it still does not work because another one is also bad. If you have access to an oscilloscope look at pin 2 of each RAM and you should see a waveform between 0 and about 5 volts. A waveform approching only about 3 volts for example is a good indication of a bad ram. There are cases where the RAM output looks OK but still could be bad. Suspect any one the appears to be a little lower in amplitude or warmer than the others.

It is possible to have a partially bad 4164, the

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* Static electricity can ZAP chips, discharge your body on something metal before touching printed circuit board !!
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indication being less than normal bytes free displayed on power up. Sometimes the bad one can be pinpointed with a simple test program to poke and peek to find the bad "bit", (U21 is D0, the "1" bit for example, U9 the "2" bit, U22 the "4" bit and so on).

In some cases it may be wise to remove all 8, install sockets, replace all RAMs and then try the original RAMs one at a time to determine which ones are bad. This may seem drastic but will certainly make it easier the next time a RAM fails on that machine.

In order to attempt to replace any component on the board you have to remove a foil shield on all but the very early 64s. You can use a solder sucker or solder wick to remove as much solder as possible from the tabs and bend then back, (small side cutters work well to break any remaining hold).

If you do not have any experience removing chips, you may want to let someone else with experience do it, as you can do a lot of damage to the printed circuit foil.

If you find that none of the RAM chips seem to be hot and appear OK on a scope, the next place to look is at the ROMs and PLA chip. If you have a machine with some chips in sockets and have access to another 64 with some socketed chips you can easily one at a time check to see if one of these is the source of the problem. For a machine with a blank screen the PLA at U17 and the ROMs at U4 and U3 are suspect in that order. Of course any chip

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* If replacing a bad RAM does not cure the problem, suspect more bad RAMs or a bad P.S. !!!
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running very hot is suspect . For example the 6581 SID, (sound), chip at U18 is not required for the 64 to "come up" but in one case it was running very hot, (short), and prevented the 64 from coming up, (pulling down a common BUS line).

We have seen the 74LS139 at U15 fail, (very hot!) and cause a "blank" screen.

A 64 with a problem can cause some chips to run warmer than normal but not be the cause of the problem.

Don't forget the 6567 video chip in the the larger metal enclosure. It is not as often the cause of a "blank" screen but can be. The 6510 CPU at U7 can cause a "blank" screen.

Obviously there can be many other failure possibilities that will prevent the 64 from "coming up" but these are the more common.

OTHER FAILURES: (that allow the computer to "come up" but not run properly)

* If the cassette motor is running all the time the 6510 CPU at U7 is most likely at fault, (no "press play on tape").

* Problems with joysticks are likely caused by a bad 6526 at U1, (paddles are supported by the 6581 at U18).

* Keyboard and "no cursor" problems are often caused by a bad 6526 at U1.

* Disk and printer problems can often be traced to the 6526 at U2.

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* Sockets can be great for troubleshooting but they also can BE the trouble !!
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You may find that by swapping the two 6526s the problem changes. For example "no cursor" becomes a disk problem indicating the 6526 you removed from U1 is bad.

The "user port" also is supplied by U2.

* With a logic probe, oscilloscope or DC meter you should see the RESET signal on pin 40 of the 6510 change from 0 to 5V shortly after power on. If it stays at 0 volts the machine will not come up. Suspect the 556,(timer),at U20.

* If certain keys on the keyboard are dead or intermittent it is most often cured by removing the many small screws and cleaning the keyboard foil contacts with alcohol. Cracked circuit foil on the keyboard can cause a number of keys to be dead. Partial failure of the keyboard can also be caused by a bad 6526 at U1.

* The chip at U5 is the character generator and is suspect if you experience unusual character display problems, for example the power on display is "garbage", (random, "broken" or blank characters).

There are a number of adjustments in the 64 related to colour and sound but there is usually no reason to touch them if the 64 had been working OK. If you attempt to adjust the sound/picture tuning with the coils in the modulator do not use a metal tool as the slugs WILL crack. It is possible for someone to adjust the pots and coils so far out that you lose the picture or colour, (try adjusting the pots in the video section on a good 64 to see the affect on the display). The 6567 is not as often a

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* If the problem symptoms change in the troubleshooting process, STOP ! BACK UP ! and check what you did last. You can easily introduce another fault that can make for a very time consumming repair !!
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problem but is usually socketed and easy swap out if suspect. A 64 with all the larger chips in sockets will usually be a lot easier to troubleshoot.

Back to the problem to the blown fuse in the 64. I leave this tip to the more experienced troubleshooters as it is a bit more risky but often quicker. If the fuse blows again you can put in a larger fuse to smoke out the bad component. For example the bridge rectifier CR4 may start to get hot and burn up. Be quick to spot the problem and shut off the machine as you can damage the power supply or the printed circuit foil.

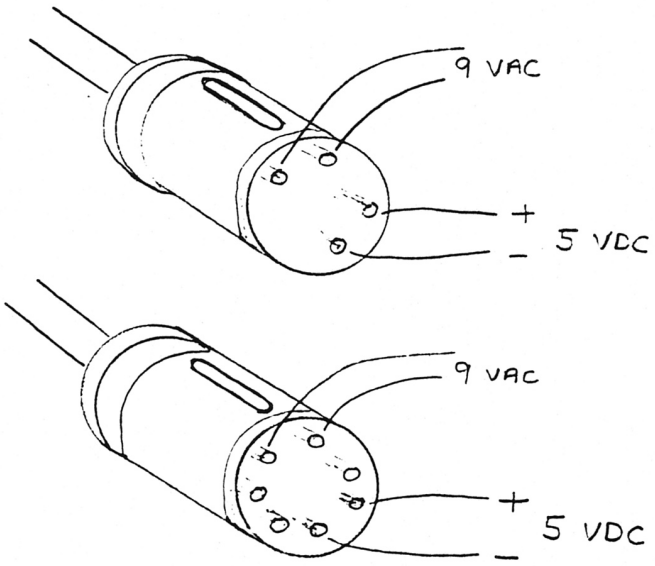

Figure 1: POWER SUPPLY CONNECTORS

* You may find power supply and expansion port intermittent problems can be cured by using a pin to slightly bend the power input contacts and expansion port pins for better contact. This can make up for the gradual weaking of the spring force of the pins over time. If a cartridge or expander kills the display or does not work properly weak expansion port contacts should be suspect. It is often a good idea to clean the contacts with alcohol.

* Intermittent power problems that appear to be related to moving the power supply connector at the computer can often be cured by removing the foil shield from the bottom of the computer and resoldering the power connector, (and power switch), pins on the underside of the printed circuit board.

Intermittents can on rare occasion be cured simply by pressing down on all socketed chips to reseat them. The lack of sockets is not always a disadvantage as the sockets themselves can be problem.

* The 2114 "color" RAM at U6 can cause a number of problems. If on power up all you get is the blue on blue border suspect the 2114. Intermittent syntax errors for valid commands such as list etc. can be caused by the 2114 RAM. (also if the only color you get is blue!)

* A "border only" display can also be caused by a bad BASIC ROM at U3.

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* Be very careful removing or installing chips as legs can very easily break off.
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One of the most difficult problems to trace on any electronic equipment is the intermittent caused by a hair line crack on the printed circuit foil. This is not a commom problem with the 64 but should be suspect if flexing the board causes or cures an intermittent problem such as locking up for example. First suspect socketed chips that are not making good contact. It is possible for the intermittent in such a case to be internal to a chip, replacing chips in the area that appears to have the fault may cure the problem. I have seen at least one such case where the computer "locked up" intermittently when it was moved because of a bad 74LS258 at U25. Flexing the board in that area found the problem.

A useful pin to check with the oscilloscope or logic probe is pin 20 of the ROMs. With bad memory you often will see pin 20, ("select"), toggling on U4 and no activity on U3 or U5. A screen full of garbage, (random characters), is often a symtom of bad memory, (4164 RAM).

One last hint that can save someone hours of probing. If the picture appears to be trying to lock in on the TV or monitor but is out of sync suspect the .47 uf capacitor at C85 is leaky causing the sync frequency to be off.

Finding the cause of the problem is not of much value if you cannot get the parts to repair. Most of the small parts are common off the shelf components available from most suppliers. The 6510, 6526, 6581, 82S100 PLA, and the ROMs are hard to obtain from anywhere but Commodore.

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* When reinstalling screws into plastic case, do not overtighten as the plastic will strip !
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Parts list and Commodore part numbers are included. If you have access to the right prom burner you can copy the ROMs for repair requirements.

A Commodore dealer that provides service may or may not be willing to sell parts.

The power supply, (the newer style is disposable), can be purchased for about $40.

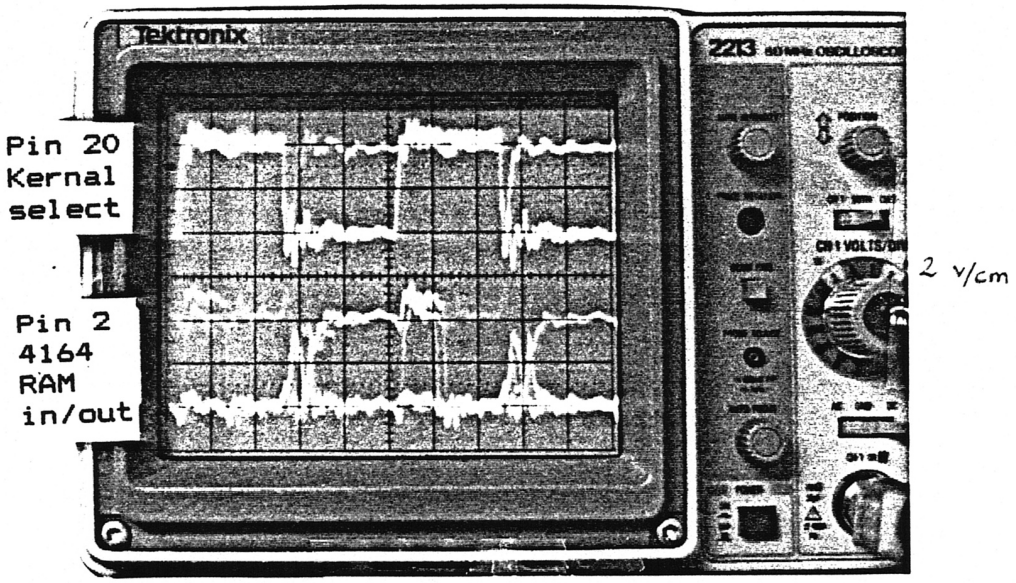

Figure 2: Scope display of normal 4164 RAM I/O pin 2 and KERNAL ROM "select" pin 20.

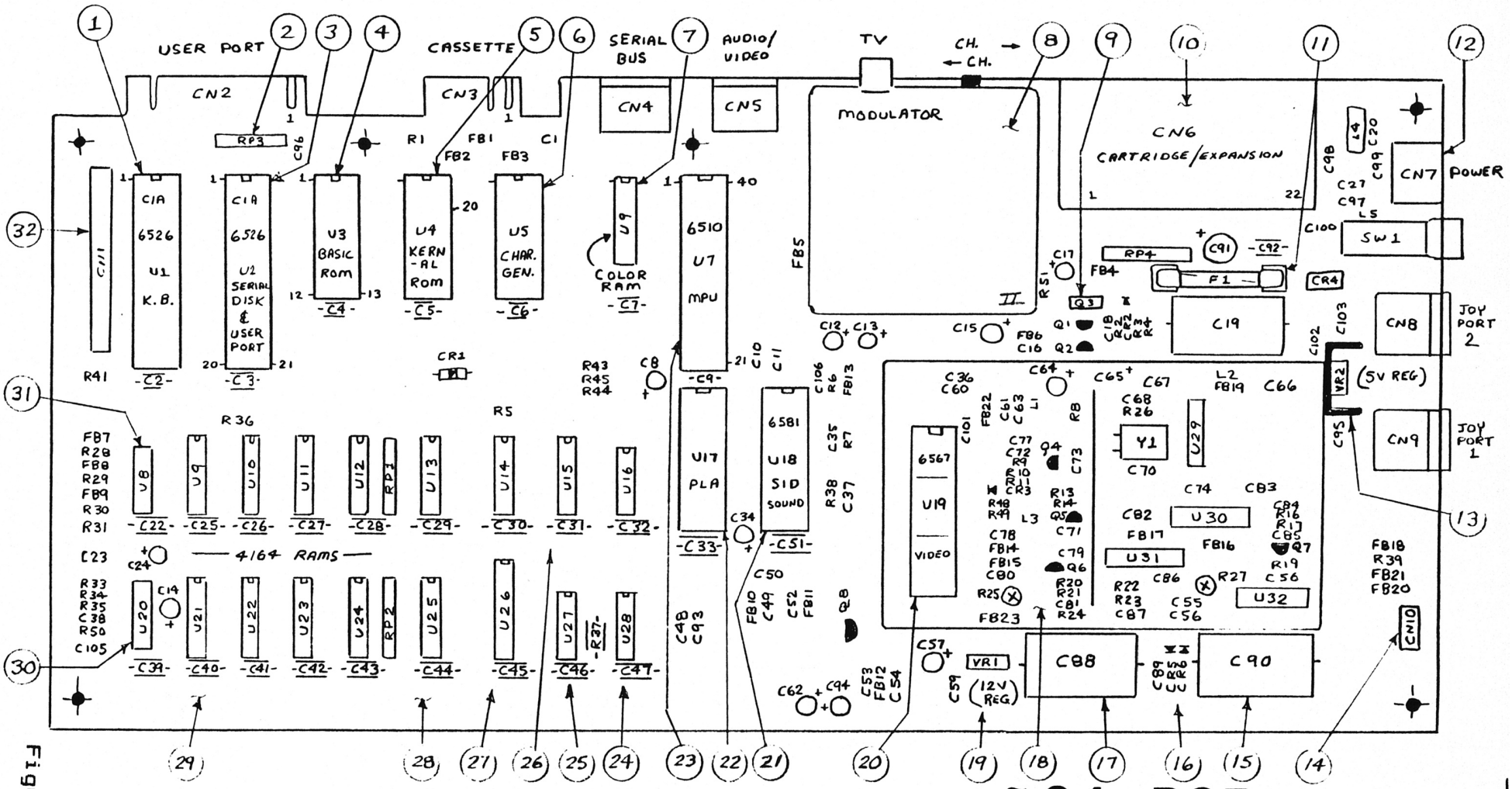

Figure 3:

≈64 PCB≈

PCB, (Printed Circuit Board), layout discription:

1> 6526 CIA, (Complex Interface Adapter), at U1 is an I/O device accessed in the 64 from locations $DC00 to DC0F. The I/O lines are used by the keyboard matrix and joysticks. Timers in this chip are used to generate the IRQ, (interrupt request).

2> RP3 is pull-up resistor pack for the serial port.

3> 6526 CIA at U2 is used for the serial port and RS232 as well as used with the video chip.

4> The BASIC ROM occupies $A000 to $BFFF, (8K 2364), and contains most of the BASIC interpreter.

5> The KERNAL ROM occupies $E000 to $FFFF, (8K 2364), and contains code for sound, video, I/O LOAD/SAVE as well as some BASIC functions, (COS, SIN etc.)

6> The CHARACTER GENERATOR is a 4K ROM, (2332) used to create all 512 displayed symbols.

7> The 2114, (1K * 4 bit), RAM, ($D800 to $DBFF) uses 4 bits for each of the 1000 screen locations to represent the 16 colors supported.

8> The RF modulator mixes the video from the 6567 with a high frequency required to drive a TV. It is shielded to prevent RF radiation noise.

9> Q3 is controlled by bit 5 of the 6510 to drive the cassette motor.

10> Address and data bus etc. are brought out on this port for use with external cartridges. On power up this port is checked for a cartridge ROM to be switched in place of

memory.

11> The fuse is in the 9VAC line from the power supply.

12> The external power supply supplies 5VDC, to power all the logic except the video, and 9VAC which is converted to 5VDC and 12VDC for the video chip. The 9VAC is also used for the 60HZ, (cycles per second), for the time of day clock, (U27 to the 6526s), and 9V unregulated for the cassette deck.

13> 5VDC is supplied by the power supply and also by this 5V 7805 regulator from the 9VAC from the supply. This 5VDC is used by the video and clock circuit in the shielded video area. (Add a heat sink to the 7805 if there is not one present. The 7805 can "shut down" locking up the 64 if it overheats without permanent damage.)

14> This connector powers the LED on the top from the 5VDC in the external supply, (the 9VAC side of the supply can be dead and the LED will still be on).

15> 470UF/50V 12VDC circuit

16> 1N4001 (last digit can be higher ex.1N4003) diodes for step up circuit for 12VDC (CR5) and 9VDC unregulated for cassette (CR6).

17> 470UF/50V 12VDC circuit

18> This video section is shielded to prevent RF radiation from interfering with TV and radio reception. The cover also acts as a heat sink for the 6567 chip, (VR2 can also be fixed to it as a heat sink). The clocks, 1.02 MHZ for the CPU and 8.18 MHZ for the video, are generated here,(Y1, U29, 30, 31, 32).

19> The 12VDC is supplied by this 7812 regulator from the 9VAC from the power supply and voltage step up circuitry.

20> The 6567 video chip handles all the text and "sprites" on the screen. Addressing for this chip is partially supplied by the 6526 at U2.

21> The 6581, "SID", Sound Interface Device, "Synthesizer Chip", supplies the sound output and also supports the game paddles, (A/D converters). It is not required for the 64 to "come up" but can prevent the 64 from running if it is bad by pulling down a BUS line.

22> The PLA, Programmed Logic Array, is a custom device similar to a ROM. It contains logic to manage the 64 addressing. This device is one of the major suspects in a "blank screen" 64 and other faults.

23> The 6510 is the CPU, Central Processing Unit, (Microprocessor), and also controls directly the cassette port.

24> 4066 (or 14066) is quad bilateral switch (paddles to 6581). U16 is also a 4066.

25> 74LS08 used for 60HZ clock to 6526s, color select (2114) and RDY line.

26> 74LS139 dual 2 to 4 line address decoder (selects for SID, VIC video etc.)

27> 74LS373 Octal 3-state (address) latch

28> Because the 4164 RAMs present their high and low addresses, (16), on the 8 lines alternately these 74LS257 multiplexers U13 & U25 are required to convert the 16 address lines into 8 address lines and 2 selects.

29> The 4164 Dynamic RAM chips are 64K by 1 bit and are available from a number of chip manufacturers and often by slighty different part numbers. They seem to the weakest part in the 64, in some cases all 8 can be bad. A bad power supply should often be suspect or possibly had been plugged in, (forced), wrong.

30> The 556 is a dual 555 and in the 64 supplies the RESET and NMI. The restore key which uses the NMI has circuitry to ignor accidental restores. Pressing STOP/RESTORE slowly will not be accepted and can often be reported as a non functioning or intermittent RESTORE.

31> This 7406 open collector driver is used for the serial port outputs.

32> This keyboard connector along with the LED connector allow the keyboard to be easily detached for servicing. (The keyboard is not required for troubleshooting as it will not prevent the 64 from "coming up".)

Other chips not included above:

U14- 74LS258 Quad 2-1 multiplexer 3-state

U29- 74LS74 Dual positive edge-triggered flip-flop (clock circuit)

U30- 74LS193 4-bit up/down counter (clock circuit)

U31- 74LS629 VCO, (Voltage Controlled Oscillator), in clock circuit.

U32- MC4044, (frequency phase detector), in clock circuit.

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* It is very easy to accidently bend a leg under a chip when inserting into a socket or into a PCB !!
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* Chips can be easier to insert in sockets by first gently pushing each row of pins against a flat surface.
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DISKS, CASSETTES, PRINTERS etc.:

If a problem related to an external device is determined to be not in the 64, (not the 6526 at U2 for disk/printer, not 6510 at U7 or transistors Q1,2,3, zener CR2 for cassette etc.), the peripheral is now suspect. In some cases the disk can prevent the 64 from coming up, a bad 74LS14 reset chip in the 1541 for example, (disconnecting the disk allows 64 to run).

The most common problem with the 1541 is alignment. There are a number of packages available that are intended as an alignment aid, some are useful some are not. It is possible to align the drive by trial and error if you are patient. If the red LED on the drive flashes often when loading and hangs up often, then alignment is suspect.

Begin by removing the cover and the PCB in the 1541. Remove the drive unit itself and reinstall the PCB. Reconnect the drive connections with the drive standing next to the chassis. Be careful not to get the connections off by one pin or get the head connector on backwards, ("file not found" on load with head connector reversed). With this setup you can get at the screws in the elongated holes on the stepper motor to adjust the alignment. One of the reasons for the alignment drift is the stepper motor shaft slipping in the collar, (repeated banging track 1 stop). You may wish to secure this shaft by drilling for a

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* If something works, don't fix it !! *
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pin to be installed or by using epoxy etc.

One method that appears to work well is adjusting the stepper motor while running VERIFY, (open1,8,15, "V0":close1), until the red LED stays on steady during VERIFY. Try "PERFORMANCE TEST" before reassembling as it is possible to be 1 whole track off and VERIFY to appear to run OK. Try running this before adjusting to confirm you actually have a alignment problem,(the new position should not be far from where you started.)

The track 1 stop should be adjusted using the "display track and sector" on the demo disk so that when track 1 sector 1 is selected there is a slight gap between the stop and the collor.

There is a strobe disk on the spindle that when properly adjusted, with the pot on the motor PCB, will appear to be stopped.

The disk can also have overheating problems that can often be cured by tighting the regulator screws to the heat sink and the heat sink to the frame, (use heat sink compound). Check that all socketed chips are pushed in all the way. The shield over the PCB in some 1541 can retain heat but can create problems if removed, such as read errors due to noise.

The logic on the PCB is not often a problem. There are 2 6522s that can be swapped around to "change" a problem if one is bad, (not a fool proof test.). A 6522 is on the interface port to the 64 and should be suspect early in

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* Quite often the problem is simply a blown fuse !
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troubleshooting for a "no responce" or "hanging up the 64" drive for example. The 6502 is a common CPU and usually socketed and easy to swap out. Check the reset line, (0 to 5V on power up), pin 40 of the 6502 for a drive that keeps running and never comes ready. A bad 6502 can also be the reason for a motor that never stops on power up. The 1541 appears to have some undocumented fault indicators. In one case the motor never stopped on reset and the LED flashed 3 times continuously, the 6502 was bad. Another case the LED flashed 2 times continuously with the motor running, a ROM was bad.

Dirty heads can cause read problems and should be cleaned with alcohol, (tape head cleaner). A common problem and one that is easy to cure is when the diskette does not eject. By removing the PCB you will often find that the latch eject mechanism has jumped over. Gently lift it up and back where it belongs.
This would cause the same symtom,(file not found),as a head out beyond it's normal range which can often be cured simply with a LOAD"*",8

The most common complaint with the cassette deck is save/load problems caused by dirty capstan and head. Clean with alcohol. Check for breaks at the head, the connector end at the 64 and on the PCB, resolder on the PCB if in doubt. A machine that loads but will not save could be a bad chip, (many different versions), or the switch on the PCB not being depressed all the way.

There are many different printers being used with the 64.

Some poor print problems can be cured by dropping alcohol into the head to clean out ink buildup. Some of the simpler fixes are often worn ribbons or incorrectly installed ribbons, interface chips at the input port,(6532s for example in some CBM printers), reset stuck at 0, labels and other garbage stuck in the paper path. Check for a fuse on the PCB that may have blown.

It is often wise to ask the user, in the case of a repair shop, if it ever worked with that computer. There are many nonstandard practices going on with the so-called standardized interfaces. In some cases with the "Centronics" interface it is necessary to wire 5V to pin 18 in the printer to power an interface adapter.

Unless you have some TV repair experience MONITORS may be best left to the TV repair shops due to the HIGH VOLTAGES present. CBM monitors are made by JVC and use a number of IC devices often available from their service dealers. The first thing to suspect with poor displays or no display are the various adjustments, external and internal. There are cables, (from computer), being used which do not color match the colored connectors and could account for some poor display complaints when plugged into the wrong spot. It is possible to zap the 6581 in the 64 by plugging the monitor cable in the wrong place.

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* Remove chips by prying up, alternating from one end to the other to avoid bending and possibily breaking legs.
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There are some diagnostic disks available that can be useful to confirm that the computer is probably OK but with a 64 that does not run, they are of little value. There are also some cartridge type diagnostics available. One we have tried is useful at times but usually does nothing with a dead 64. It will often point to a bad 6526 or PLA and can save some time. It is also a quick check that all is well, sound etc. without having to load a program. This one showed a fault where none existed due to a later version of the KERNAL ROM, (-03).

I hope this manual although brief and to the point is useful. If you would like to add any problems and cures of your own I will attempt to return to you any up to date additions as they become available.

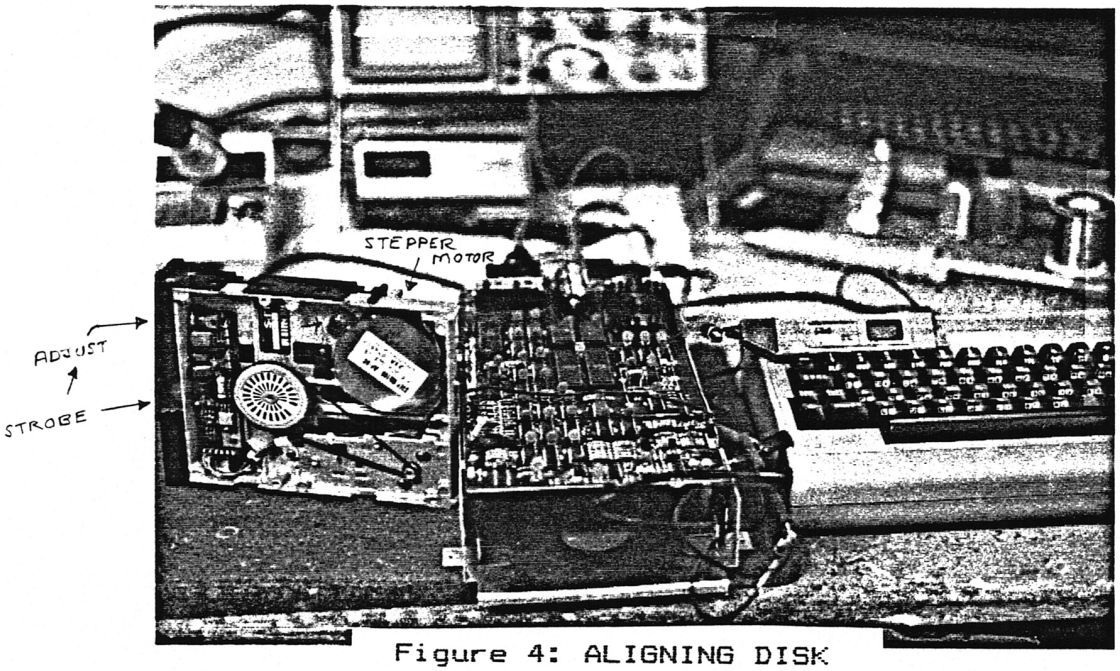


Figure 4: ALIGNING DISK

TROUBLESHOOTING TECHNIQUES:

For the average computer hobbiest who may not be familiar with digital logic repair some of the tools and techniques are described:

LOGIC PROBE: Used to detect logic levels at IC pins, 1 or a 0, (5V or 0V), or pulses, by means of a lamp. It is easy to build a simple logic probe but for short pulses a one-shot to stretch the pulse is required. Useful to detect activity but not as useful as an OSCILLOSCOPE which displays the electrical activity on a screen. For troubleshooting digital logic at least a 10MHZ scope is required. Logic probes cost from $20 up. A good scope will cost at least $500 but surplus scopes are worth considering.

LOGIC PULSER: Used to inject a digital pulse train into logic to test for an expected output.

LOGIC CLIPS: Clips over IC to allow easy scope connection or actually display with LEDs the logic activity. Simple clips cost from $5 to $20. Clips which include LEDs for each pin run up to $70.

LOGIC COMPARATOR: By installing the comparators clip on a suspect IC and installing a known good IC of the same type in the comparater, the outputs are compared and the IC in the circuit is confirmed bad or likely good, (there is always the possibility that another chip is pulling it's output down). Comparators can cost over $400.

CIRCUIT COOLER and HEAT GUNS: A computer that acts up only after it warms up is often a good candidate for Circuit Cooler. When the fault is present a suspect IC for example is sprayed with cooler and the computer reset to see if the problem is gone. Heat guns, (also used for heat shrink tubing), are useful to bring on a fault by heating up the suspect area.

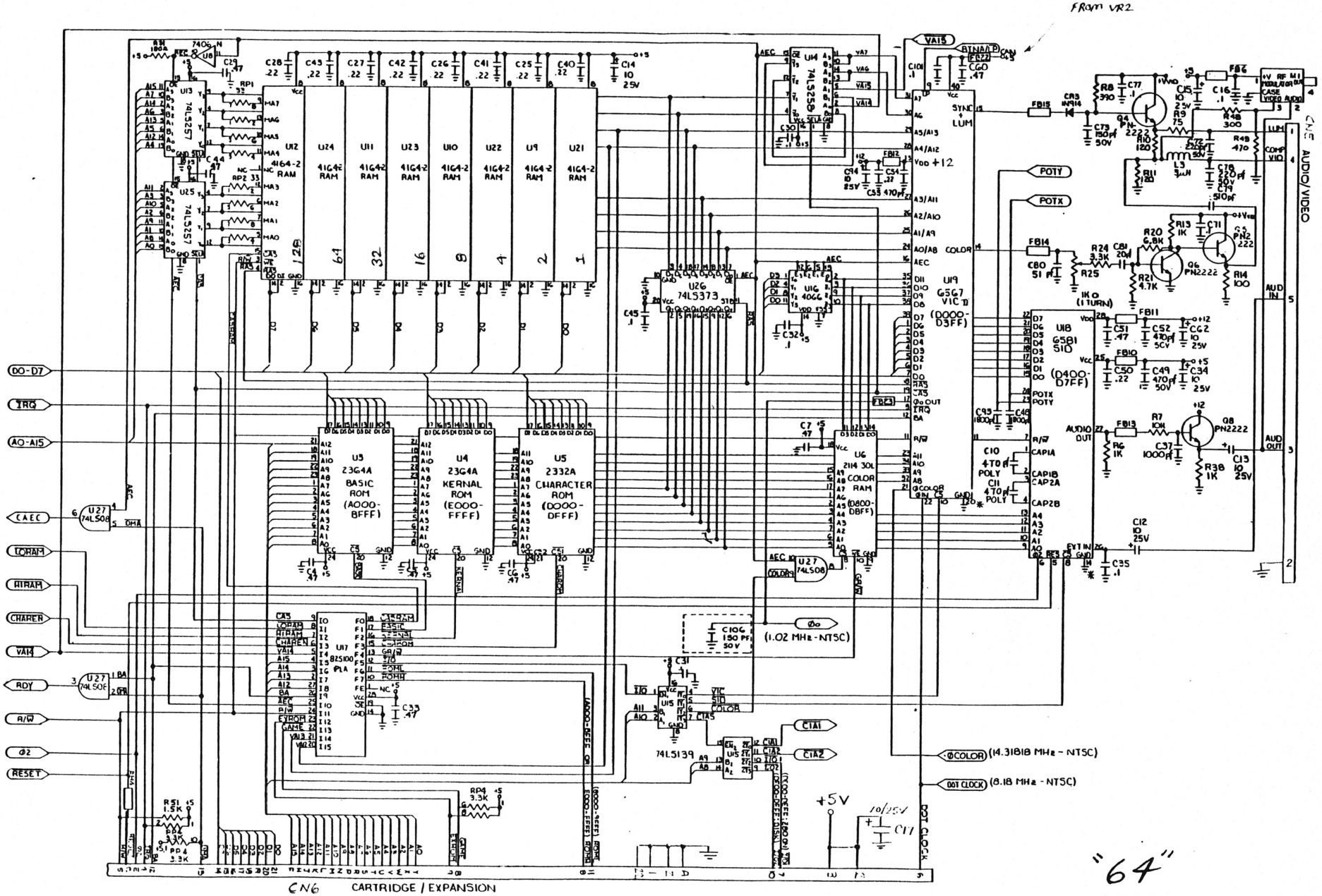
CURRENT TRACER: Used to trace the source of a fault drawing excess current, a shorted component pulling down a BUS line for example.

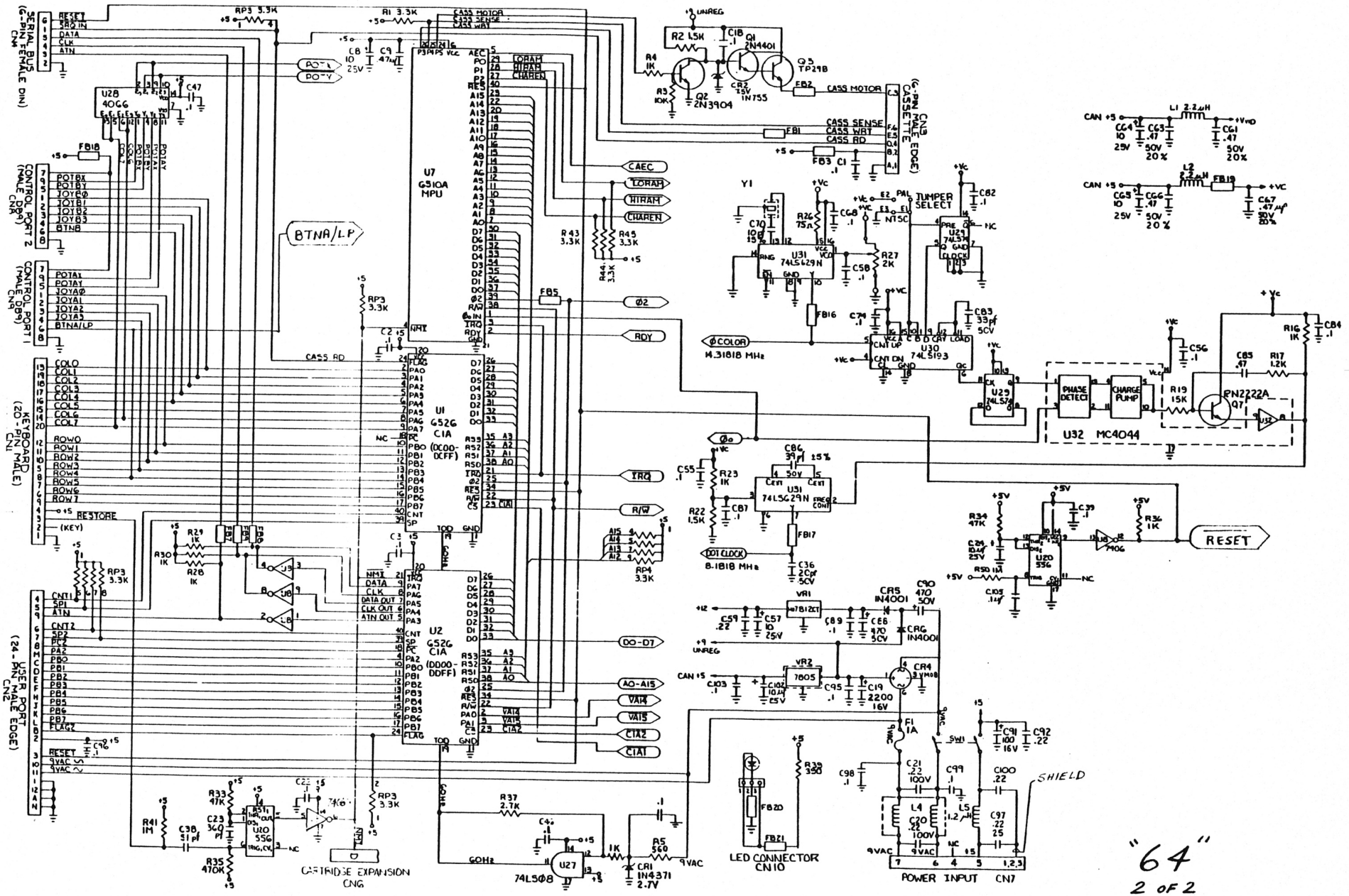
PIGGYBACK: A technique where a good IC of the same type is parallelled with a suspect IC , to find an intermittent a dead IC.

SMOKE IT OUT: A technique used to find the IC pulling a BUS line low by connecting the line to the 5V rail through a 10 ohm resistor to see which IC gets hot and likely the source of the problem.

VOLTMETERS and FREQUENCY COUNTERS: Unless you can afford several meters there is no real need to purchase a digital type. In fact for quicker resistance measurement the analog neddle type is prefered. A frequency counter is useful at times, to measure a clock frequency for example, but not a high priority item for an occasional troubleshooter.

There are a lot of very expensive digital service tools on the market that would make life a lot easier but unfortunately would take a lot of service work to pay for. The Fluke microprocesser tester, for example, stores information on the BUS circuitry of a working board, (write to all addresses, checks responce), and uses this information to study a bad board and reports discrepancies.


FROM VR2
DO-D7
IRQ
AO-A15
CAEC
LORAM
HIRAM
CHAREN
VA14
RDY
R/W
Ø2
RESET
U3 23G4A BASIC ROM (A000-BFFF)
U4 23G4A KERNAL ROM (E000-FFFF)
U5 2332A CHARACTER ROM (D000-DFFF)
U6 2114 30L COLOR RAM (D800-DBFF)
U8 6581 SID (D400-D7FF)
U9 6567 VIC II (D000-D3FF)
U26 74LS373
U27 74LS08
U17 82S100 PLA
74LS139
Ø0 (1.02 MHz-NTSC)
ØCOLOR (14.31818 MHz - NTSC)
DOT CLOCK (8.18 MHz - NTSC)
+5V
CN6 CARTRIDGE / EXPANSION
CN5 AUDIO/VIDEO
POTY
POTX
COLOR
AUDIO OUT
"64"
1 OF 2


SERIAL BUS (6-PIN FEMALE DIN) CN4
CONTROL PORT 2 (MALE DB9) CN3
CONTROL PORT 1 (MALE DB9) CN4
KEYBOARD (20-PIN MALE) CN1
USER PORT (24-PIN MALE EDGE) CN2
CASSETTE PORT (EDGE) CN6
U7 6510A MPU
U1 6526 CIA (DC00-DCFF)
U2 6526 CIA (DD00-DDFF)
U28 4066
U31 74LS629N
U30 74LS193
U29 74LS74
U31 74LS629N
U32 MC4044
U20 556
U27 74LS08
VR1 7812CT
VR2 7805
Q1 2N4401
Q2 2N3904
Q3 TP29B
Y1
BTNA/LP
RESTORE
RESET
CARTRIDGE EXPANSION CN6
LED CONNECTOR CN10
POWER INPUT CN7
PAL JUMPER SELECT
SHIELD
"64"
2 OF 2
- 125 -

COMMODORE part numbers (*=harder to find)

U31	74LS629N	901521-68
U32	MC4044CP	906128-01
U7	6510A	*906107-01
U1,U2	6526A	*906108-01
U19	6567	*906109-01
U18	6581	*906112-01
U3	2364 BASIC	*901226-01
U4	2364 KERNAL	*901227-02 (-03)
U5	2364 CHAR GEN	*901225-01
U17	82S100N PL	*906114-02
U9-U12		
U21-U24	4164-2	901505-01
U20	NE556	901523-03
U16,U28	4066	901502-01
U6	2114L-30	901453-01
U13,U25	74LS257N	901521-57
U15	74LS139N	901521-18
U26	74LS373N	901521-29
U8	7406	901522-06
U27	74LS08N	901521-03
U14	74LS258N	901521-58
L5	coil 1.2uh	*901152-01
L1,L2	coil 2.2uh	*901151-17
L3	coil 3.0uh	*901151-21
L4	line filter	*906127-01

Heat sink

[With the newer style PCBs you will find components in different locations but reference numbers to be the same except that now more of the video circuitry is contained in the MODULATOR enclosure. It is now possible to have MONITOR problems due to a bad MODULATOR. The RF modulator itself is not necessary for a MONITOR, only for a TV display.]

Y1	crystal ntsc	*900558-01
CR1	(2.7)zener 1N4371	906103-02
CR2	(7.5)zener 1N755	900941-01
CR4	bridge Varo VM08	906129-01
RP	3.3K resistor pack	902410-06
RP	3.3K resistor pack	902442-29
RP	33ohm resistor pack	902422-03
M1	Modulator	326130-01
CN8,CN9	9pin conn.	906126-01
CN7	7pin DIN conn.	906130-01
CN6	44pin edge	906100-02
CN5	5pin DIN conn.	903362-01
CN4	6pin DIN conn.	903361-01
SW1	DPDT switch	904500-01

CAPACITOR values...

C36,81	= 20pf/50v	C83	= 33pf mica 5%
C86	= 39pf mica 5%	C80,38	= 51pf/50v
C79	= 510pf/50v	C73	=150pf/50v
C72,78	= 220pf/50v	C23	=360pf/50v
C49,52,53	=470pf/50v	C37	=1000pf/50v
C25,28	=.22uf	C97,100	=.22uf/250v ceramic
C61,63,66	= .47uf/50v	C8,C12-15	=10uf/25v
C70	= 10pf/50v mica 5%		
C48,93	=1800pf/50v	C20,21	=.22uf/100v
C98,99,101	= .1uf/50v		
C91	=100uf/16v	C88,90	=470uf/50v

C19 =2200uf/16v C107 =220pf

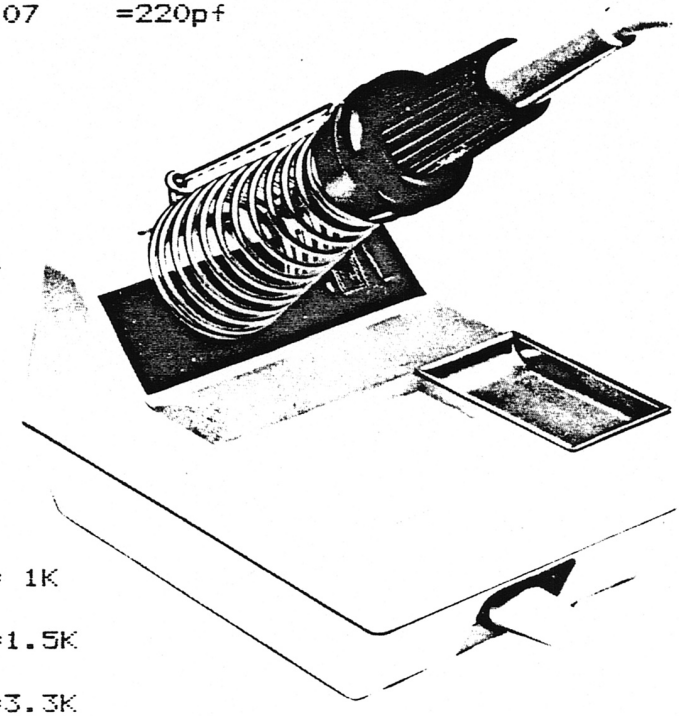
OTHER....

CR5,CR6 power diode 1N4001

CR3 signal diode 1n914

R25 1K potentiometer

R27 2K potentiometer



Soldering station

Resistors.... 1/4 Watt

R4,6,13,16,23,28,29,30,38 = 1K

R2,22,51 =1.5K

R1,43,44,45,24 =3.3K

R26,9 =75 ohm

R39,8 =390ohm

R33,34 =47K

R10,11 =120ohm

R9,24 =75 ohm

R3,7 =10K

R5 =560 ohm

R17 =1.2K

R19 =15K

R14 =100ohm

R21 =4.7K

R20 =6.8K

R35 =470K

R31 =180 ohm

R43 =2K

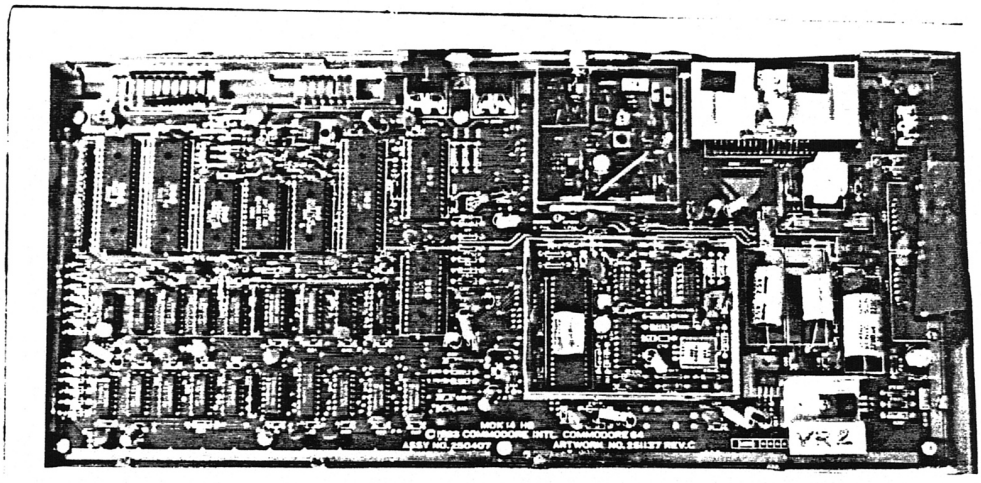


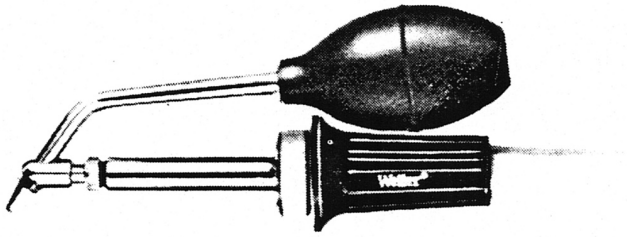
Figure 5: Later generation 64 PCB layout
(Position of parts may differ from discription)

R31 =180 ohm

R43 =2K

R37 =2.7K

Vacuum desoldering-resoldering tool



TRANSISTORS.....

Q4,5,6,7,6 =PN2222 (902686)

Q1 =2N4401 (902652-01)

Q2 =2N3904 (902658-01)

Q3 =TIP29B (902653-01)

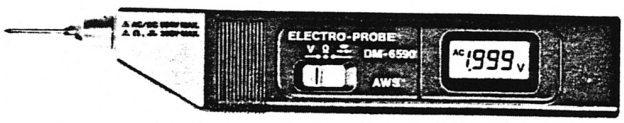
REGULATORS.....

VR1 =MC7812 (901527-01) 12 V

VR2 =MC7805 (901527-02) 5 V

NOTE: Many of these capacitors, resistors, transistors, chips and regulators are common off the shelf parts available if not locally, then from many of the mail order suppliers.

****
* The fact that the 1541 fails "performance test" is often a good indication when it is out of alignment. The fact that it passes "performance test" is NOT always a good indication that it's alignment is OK.
****



Digital multimeter

REMOVING CHIPS !

I include this, somewhat off the track, subject as I have not seen much on it elsewere .

It is very easy to damage PCB foil when removing chips and often difficult to repair. Also, as trouble shooting can often be trial and error, the chip you removed is often good and reuseable if not damaged.

For readers that have little or no experience in this art, I offer these hints on one method that works quite well. There is no substitute for experience so be patient.

Solder wick, (copper braid that absorbs the solder when melted), is often used but a solder sucker is better for IC chips. Try to find the larger type as the smaller ones don't work as well.

The solder at each pin is melted one at a time and the solder sucker vacuum plunger released to draw the solder up into it's barrel. Apply heat only long enough to melt the solder and draw it up.

If you are not successful on some pins simply resolder the pin, (use small diameter solder), and try again. You will need to apply heat a little longer on the power rail pins as the larger foil tends to draw the heat away.

Do not use excess force to move a pin as you will tend to pull the solder thru eyelet away from the board. After all pin holes appear to be free you may want to apply heat to each one again to break them away from the sides, (heat and gently push each toward the center of the PCB hole).

Now turn the PCB over and with a slot type screwdriver gently press inward on all pins to break any remaining solder hold. If any pin appears to be still soldered and not free, resolder it and try again. Do not force the chip out of it's position if any pins are not free as you will likely take the foil with it and then have to repair the foil. With all pins free gently pry up on the bottom of the chip to remove it. At this time check to make sure no damage was done. At least if you notice it, you will know what lines have to be repaired , (a piece of wire can repair a broken trace).

You may wish to install a socket to make future repairs easier. A socket will prevent soldering on the chip side of the foil and should only be used when you are sure you have done a good desoldering job, (no damage). The socket can also be useful to confirm later if the chip removed is still good and reusable when that exercise was not the final fix. Some people do not like to reuse desoldered chips but some are expensive enough to make exceptions. Keep in mind that unsoldered chips, (rough pins), inserted in sockets can damage the socket.

If you access to some old PCBs practice on these before attempting something more valuable.

Solder sucker (desoldering pump)

"NO OP" TESTER: When trouble shooting any piece of electronic equipment it is often faster to make an educated guess and replace the most likely suspect. This method is not always best, especially when getting to the final solution involves unsoldering many good chips.

With a dead 64 it is often of little value to look at address lines etc. with an oscilloscope because there is often no activity. The "NO OP" tester is a 6510 hardwired with an instruction code that will cause the address lines and data lines to "toggle". With a "scope" or logic probe it is now possible to probe the various address, data and control lines. looking for suspicious inactivity. Obviously this technique requires more insight into digital logic theory because, for example, the lack of activity on a gate output may be the correct for the conditions present. With a difficult to find problem and the lack of better test equipment, (multi-trace scope for example), you may have to take "a shot in the dark" and replace a suspect part.

There are a number of TRANSISTORS,(NPN),in the 64 which, although not a commom problem, can be checked with a simple Volt Ohm Meter. For example, when there appears to be no activity on the emitter with activity at the base, the transistor can be removed from the circuit and tested. You should be able to see diode action from the base to emitter and base to collector, (low ohms with meter leads one way and high ohms with meter leads the other way). The collector to emitter will present relatively high ohms in both directions. A bad transistor, for example may show a dead short from collector to emitter. With a simple battery volt ohm meter the base emitter should show low ohms with the red + lead on the emitter and the black - lead on the base. This is useful for testing diodes as well, low ohms meter leads one way, high ohms the other way. In order to be a 100% sure would require a transistor tester, some of which can test the transistor in-circuit.

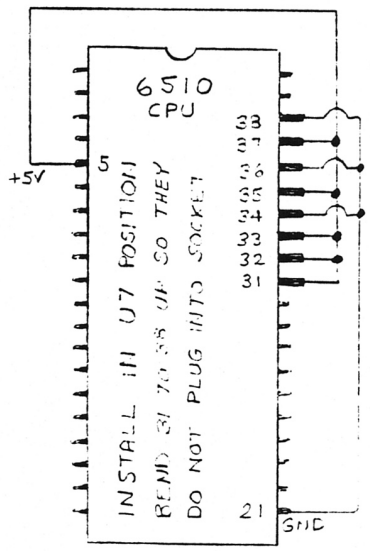


Figure 6: NO OP tester

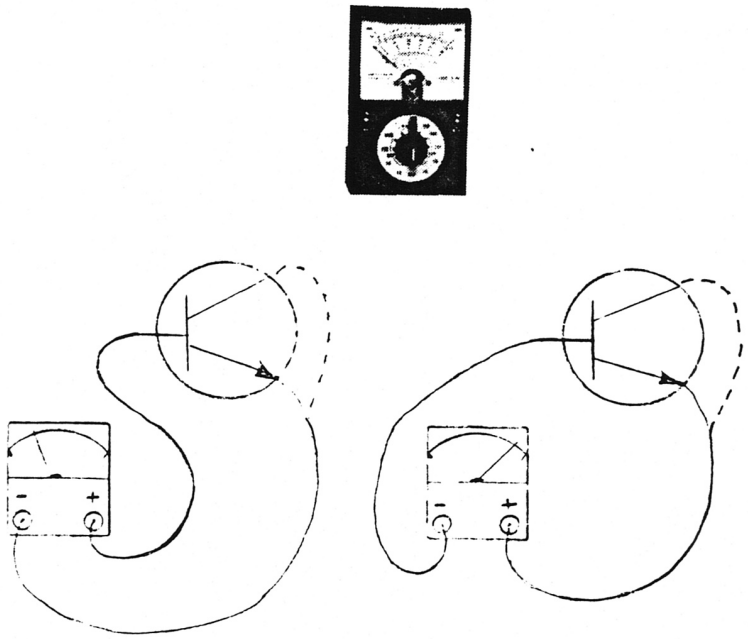


Figure 7: Testing transistors with a VOM

SOME LAST MINUTE NOTES:

As stated previously a bad 6526 at U1 can be responsible for no cursor or what appears to be partial keyboard failure. Similar complaints that can be traced to U1 are no responce from the keyboard, ("cursor does not move"), and runaway cursor, ("cursor advances on it's own, keyboard has no effect").

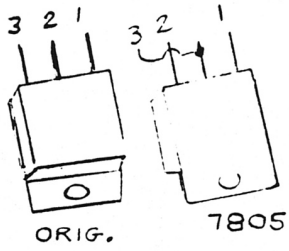
Note the figure on this page of the regulator in the earlier power supply. It can be replaced with a commom 7805, (5V, 1 amp), type but the pin out is different. It is important to maintain good heat transfer to the heat sink or the 7805 may "shut down" when it gets hot.

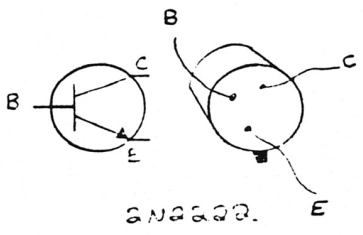
The newer sealed supply is not repairable with the exception of possible breaks in the AC power plug or output connector. The diodes in the repairable supply can be checked with an ohmmeter, low ohms meter leads one way, high ohms the other. If the 9VAC side is dead the transformer is most likely bad and not worth the expence to replace. There is a large capacitor in the old supply that could fail. This and other caps in the 64 can often be checked with an ohmmeter. A large cap. (47uf for example) will cause the neddle to move towards low ohms and then drop back as the cap charges up with the ohmmeter's battery. A bad cap. of this size may show little or no movement indicating an open, or may stay at low ohms indicating a short. Smaller caps would require a capacitance meter to test although a shorted or leaky cap can often be observered with an ohmmeter regardless of size.

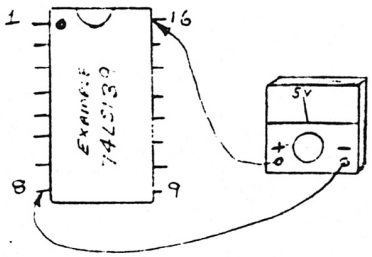
In order to keep within the objective of this manual we should state that although bad caps are a common source of electronic problems, our experiences with the 64 would indicate that they are not often the problem. The 64 like most digital circuitry uses many small bypass caps across the DC voltage rails that could short and present a bit of a problem to find. If one of these was open it would not likely cause a problem.

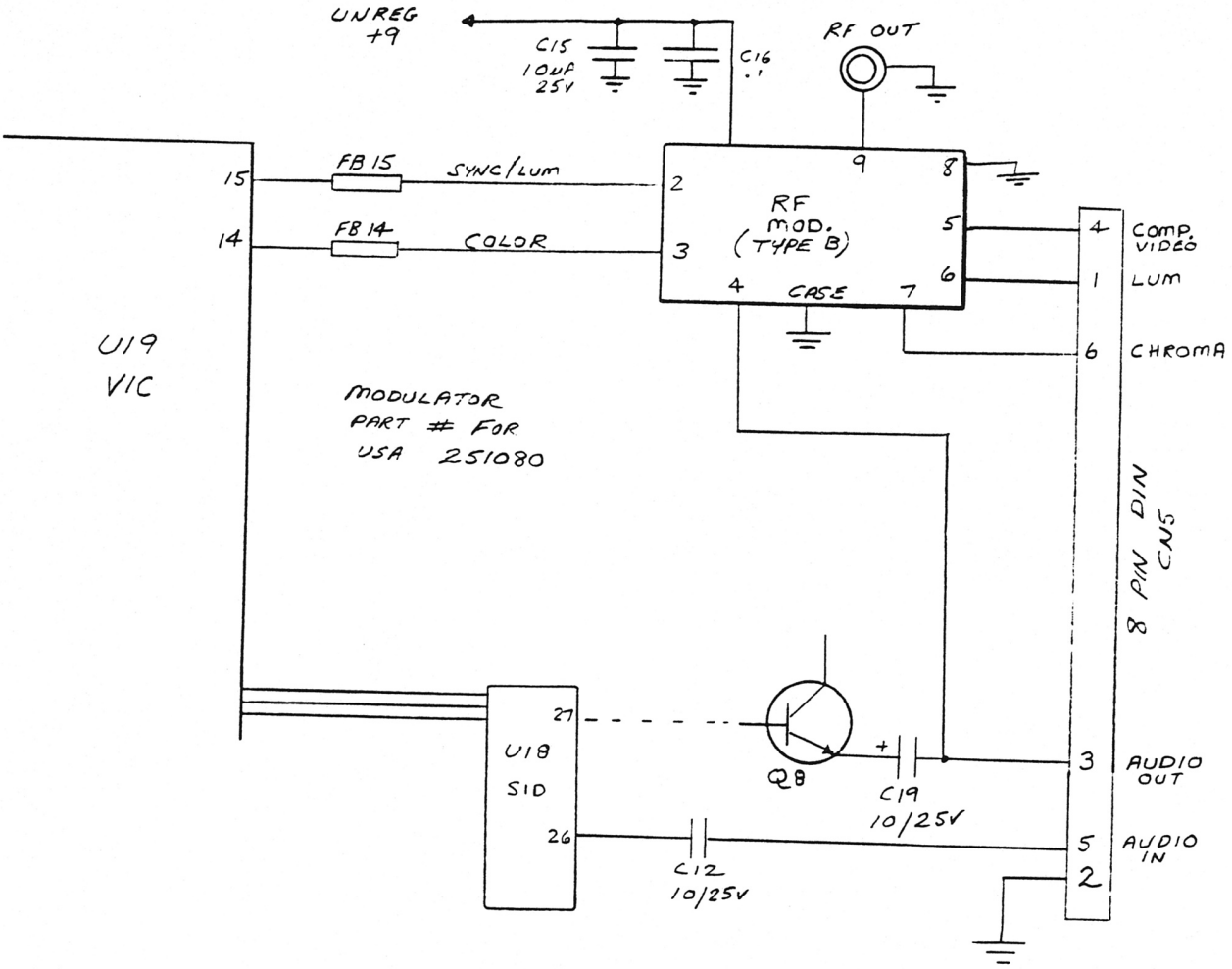
For those that have not worked with ICs before note the figure on this page of the location of pins. In most but not all cases you will find 5VDC on pin 16 and ground on pin 8 for a 16 pin chip. With a 14 pin chip this would be pin 14 and 7. Note the notch or dot to indicate pin 1.

Note also the transistor pin outs. When working with substitute transistors be aware that pin outs may differ!









NOTE: NEWER STYLE PCB USES DIFFERENT MODULATOR CIRCUIT AS SHOWN ABOVE. NOTE 8 PIN AUDIO/VIDEO CONNECTOR AND 9V UNREGULATED POWER SOURCE FOR MODULATOR. (5 PIN CABLE WILL WORK)

(IT IS POSSIBLE TO BLOW THE 6581 CHIP, [SOUND], BY INCORRECT MONITOR CABLE CONNECTIONS!)