# **KENBAK-1** Computer

# Binder Contents

- Packing Lists
- Color Construction Guide
- Parts Placement List
- PCB Layout
- MITS Kit Assembly Hints

*Vintage KENBAK-1 Manuals:*

- Installation and Maintenance Manual
- Theory of Operation Manual
- Programming Worksheets
- Laboratory Exercises

# KENBAK-1 PCB Parts Packing List

| Received: | Quantity: | Description: | Value: | Package: |
|---|---|---|---|---|
| | 4 | Red-Violet-Brown | 270 1/4W | Bag #1 |
| | 2 | Red-Red-Brown | 220 1/2W | Bag #1 |
| | 4 | Brown-Red-Brown | 120 1/4W | Bag #1 |
| | 2 | Blue-Grey-Black | 68 1/4W | Bag #1 |
| | 4 | Orange-Black-Red | 3k 1/4W | Bag #1 |
| | 27 | Brown-Black-Red | 1K 1/4W | Bag #1 |
| | 1 | Green-Blue-Black | 56 2W | Bag #1 |
| | 25 | Axial – 104K | .1u 50v | Bag #1 |
| | 2 | Axial – 152K | .0015u or .001u | Bag #1 |
| | 2 | Radial – 682G | .0068u | Bag #1 |
| | 4 | Elec. Radial | 100u 100v | Bag #1 |
| | 3 | Elec. Radial | 33u 50v | Bag #1 |
| | 1 | Elec. Radial | 100u 50v | Bag #1 |
| | 2 | Elec. Radial | 100u 25v | Bag #1 |
| | 1 | Elec. Radial | 220u 100v | Bag #1 |
| | 1 | 5.1v Zener | 5.1v | Bag #1 |
| | 8 | Small Signal Diode | 1N914 | Bag #1 |
| | 6 | NPN General Purpose Amplifier | 2N4401 | Bag #1 |
| | 2 | PNP General Purpose Amplifier | MPS3702 | Bag #1 |
| | 2 | CAN Heatsink | 8 pin CAN | Bag #1 |
| | 8 | DIP Heatsink | 14/16 pin DIP | Bag #1 |
| | 0.8 | Single Row Header | 40 position | Tubes |
| | 3 | Keying Plug | N/A | Bag #2 |
| | 2 | SW/LAMP Receptacle | 1 position | Bag #2 |
| | 2 | SW1/SW2 Receptacle | 8 position | Bag #2 |
| | 1 | LAMP Receptacle | 14 position | Bag #2 |
| | 35 | Female Crimp | | Bag #2 |
| | 4 | 8x.3 DIP | N/A | Tubes |
| | 126 | 14x.3 DIP | N/A | Tubes |
| | 4 | 16x.3 DIP | N/A | Tubes |
| | 3 | Hex Inverter | 7404 | Static Box |
| | 2 | Shift Register | 1404A | Static Box |
| | 1 | Dual 2 Wide-2 Input AND/OR/Invert Gate | 7451 | Static Box |
| | 3 | Quad 2 Input Exclusive/OR Gate | 7486 | Static Box |
| | 2 | Quad 2 Input NAND Gate (Open Collector) | 7403 | Static Box |
| | 10 | 4 Wide-2 Input AND/OR/Invert Gate | 7454 | Static Box |
| | 10 | 8 Input NAND Gate | 7430 | Static Box |
| | 3 | Hex Inverter Buffer/Driver (O. C. - High Voltage) | 7416 | Static Box |
| | 1 | Quad 2 Input AND Gate | 7408 | Static Box |
| | 15 | Triple 3 Input NAND Gate | 7410 | Static Box |
| | 13 | 4 Bit Right Shift/Left Shift Register | 7495 | Static Box |
| | 9 | Dual 4 Input NAND Gate | 7420 | Static Box |
| | 4 | BCD to Decimal Decoder | 7442 | Static Box |
| | 46 | Quad 2 Input NAND Gate | 7400 | Static Box |
| | 10 | Dual D Edge Triggered Flip Flop | 7474 | Static Box |

# KENBAK-1 Case/Front Panel Packing List

| Received: | Quantity: | Description: | Value: | Package: |
|---|---|---|---|---|
| | 15 | Keyswitch | Tactile | Bag #1 |
| | 8 | Black Key | N/A | Bag #2 |
| | 7 | White Key | N/A | Bag #2 |
| | 1 | Small Switch and hardware | Toggle | |
| | 1 | Switch Boot | White | Bag #1 |
| | 1 | Power Switch | Toggle | Bag #1 |
| | 47.81 | 26ga White Wire | Feet | Bag #2 |
| | 2 | 20ga Brown Wire | Feet | Bag #2 |
| | 1.33 | 20ga Red Wire | Feet | Bag #2 |
| | 1.33 | 20ga Black Wire | Feet | Bag #2 |
| | 2 | 22ga Blue Wire | Feet | Bag #2 |
| | 2 | Fuse | | Bag #1 |
| | 1 | Fuse Holder | 3AG | Bag #1 |
| | 1 | Collet Cord Clamp | N/A | Bag #1 |
| | 1 | Cheap Cord Clamp | N/A | Bag #1 |
| | 4 | Rubber Feet | Square | Bag #1 |
| | 3 | #4-40 threaded 1/2” Female Hex Standoff | 18-8 SS | Bag #1 |
| | 8 | #4-40 3/8” Phillips Screw | 18-8 SS | Bag #1 |
| | 7 | #4 Flat Washer | 18-8 SS | Bag #1 |
| | 4 | #4 Lock Washer | 18-8 SS | Bag #1 |
| | 15 | #6-32 3/8 Phillips Screw | 18-8 SS | Bag #1 |
| | 15 | #6-32 Flat Washer | 18-8 SS | Bag #1 |
| | 7 | M3-12 Metric Phillips Screw | 18-8 SS | Bag #2 |
| | 3 | M3 Nylock Nut | 18-8 SS | Bag #2 |
| | 1 | 1/16” Hex Wrench | HS Steel | Bag #1 |

| | Options: | | | |
|---|---|---|---|---|
| | | Green LED | N/A | Bag #2 |
| | | Amber LED | N/A | Bag #2 |
| | | Red LED | N/A | Bag #2 |
| | | Green Keycap | N/A | Bag #2 |
| | | Red Keycap | N/A | Bag #2 |
| | | Yellow Keycap | N/A | Bag #2 |
| | | Blue Keycap | N/A | Bag #2 |
| | 14 | Lamp | T-1 Flange Bulb | Bag #2 |
| | 4 | Yellow Lens | N/A | Bag #2 |
| | 8 | White Lens | N/A | Bag #2 |
| | 12 | Lamp Body | N/A | Bag #2 |

# KENBAK-1 Overall Packing List

| Received: | Quantity: | Description: | Value: | Package: |
|---|---|---|---|---|
| | 1 | Manual | | Bubble Wrap |
| | 1 | PCB | | Inside Case |
| | 1 | Kenbak Case | | Bubble Wrap |
| | 1 | Power Supply | +5/+12/-12 | FedEx Box |
| | 1 | Bag #1 | | FedEx Box |
| | 1 | Bag #2 | | FedEx Box |
| | 1 | Static Box | | |

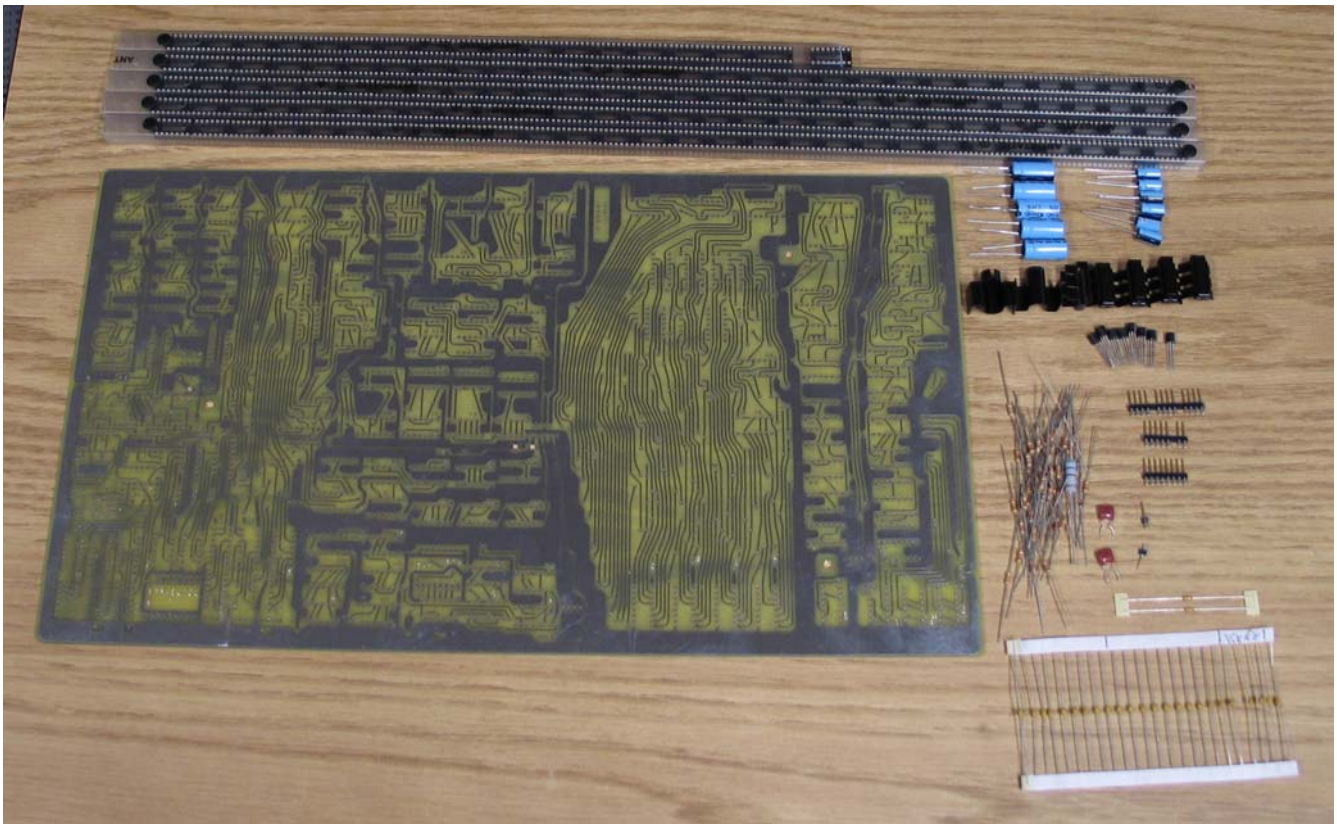
| | Options: | |
|---|---|---|
| | | John's Signature |
| | | My Signature |

# KENBAK-1 Motherboard PCB Assembly Guide

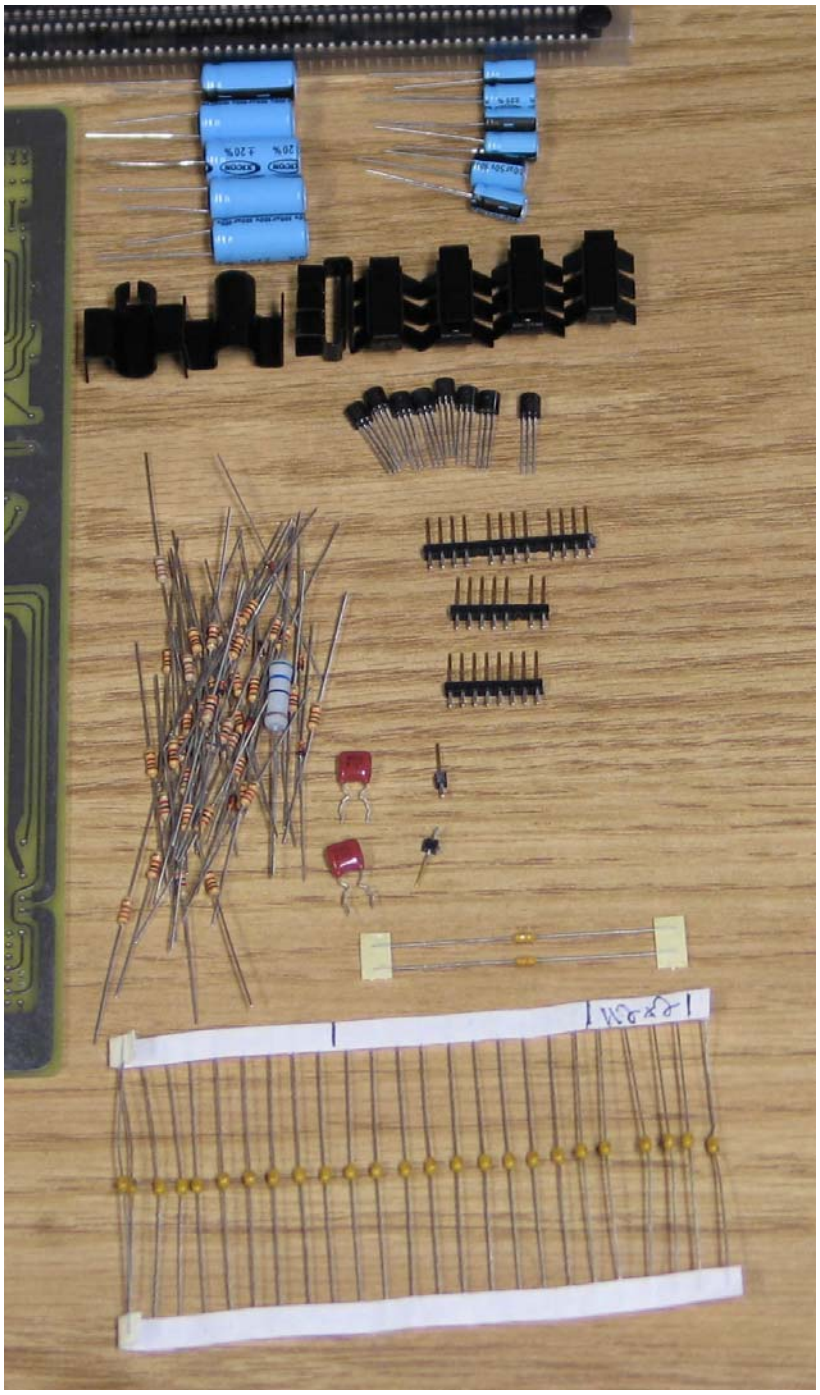
The KENBAK-1 computer is an easy but long project. There are 126-14 pin, 4-16 pin, and 2-8 pin devices as well as a few dozen capacitors and resistors. Because of the volume of parts I recommend that you take time in making sure all solder joints are good (free of bridges, cold joints, etc). When I built my second unit I had one cold joint that kept the computer from functioning. It took a few hours to find out where the problem was by observing the operational characteristics and swapping ICs.

I have included the “MITS Kit Assembly Hints” booklet (from ~1975) for additional tips and hints on constructing the kit.

The first step is to verify that you have all of the parts required to complete this kit. Read through the entire assembly guide before starting! You will need a non-blunt tipped soldering iron and some solder. I recommend .031 or smaller rosin core. DO NOT USE ACID CORE SOLDER! A wire stripper, crimper, snippers, needle noise pliers, and a screw driver will also be required. (a 1/16” hex wrench is also required – and included)



**Contents of the KENBAK-1 PCB Kit**

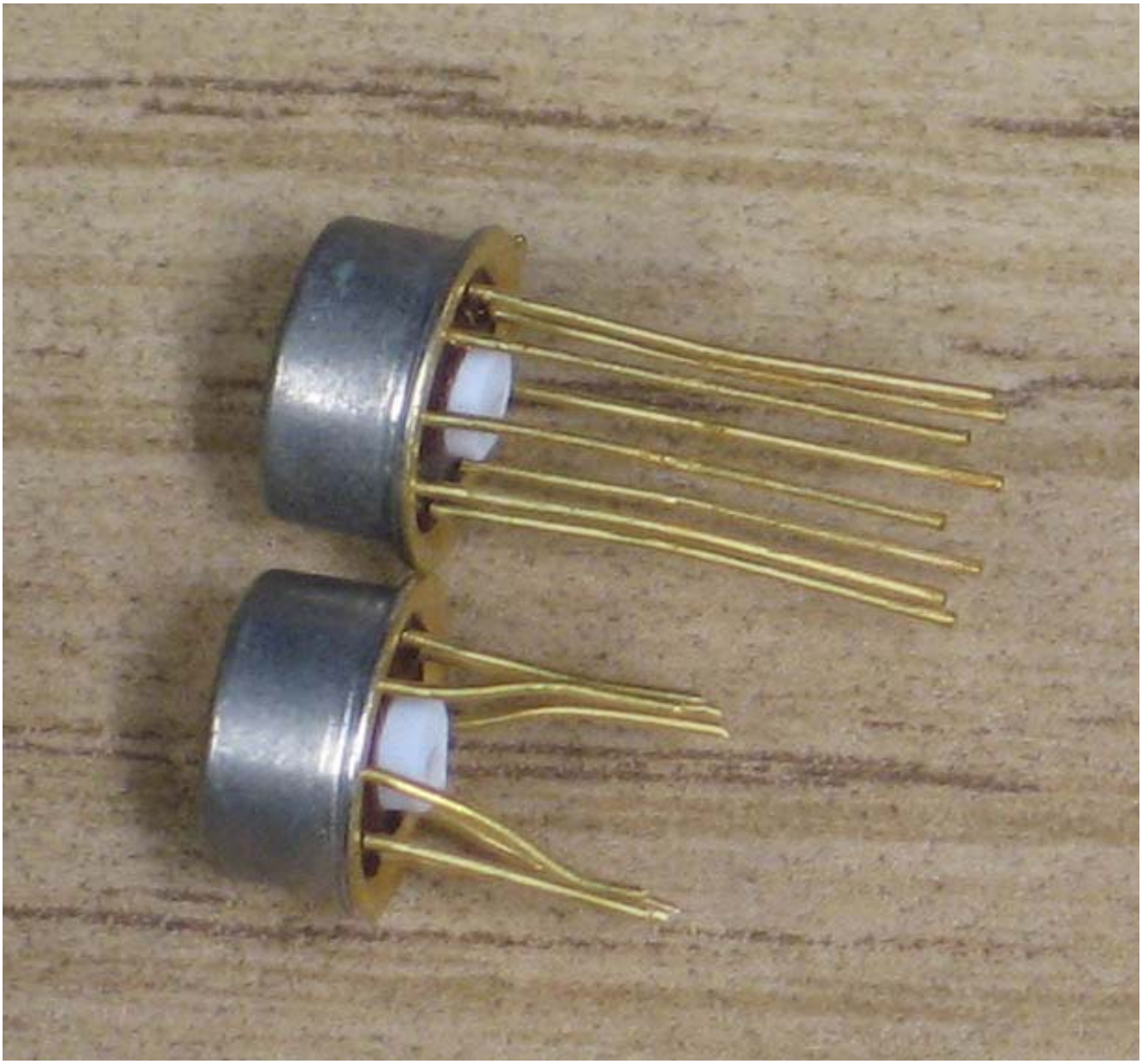


I recommend that you start by soldering in all of the DIP sockets. Normally I would suggest starting with capacitors and resistors since sometimes they are caught closely between packages. The vintage KENBAK-1 never had a silkscreen so there is quite a mess of holes to deal with! Having the sockets in place will reduce the number of holes to look at. Pay very close attention to the orientation of the sockets! For the most part they follow a predictable pattern, but in other cases they do not!

After the sockets I would install the remaining parts (capacitors, resistors, transistors, and headers). I recommend waiting until you are done assembling the kit to install the ICs.

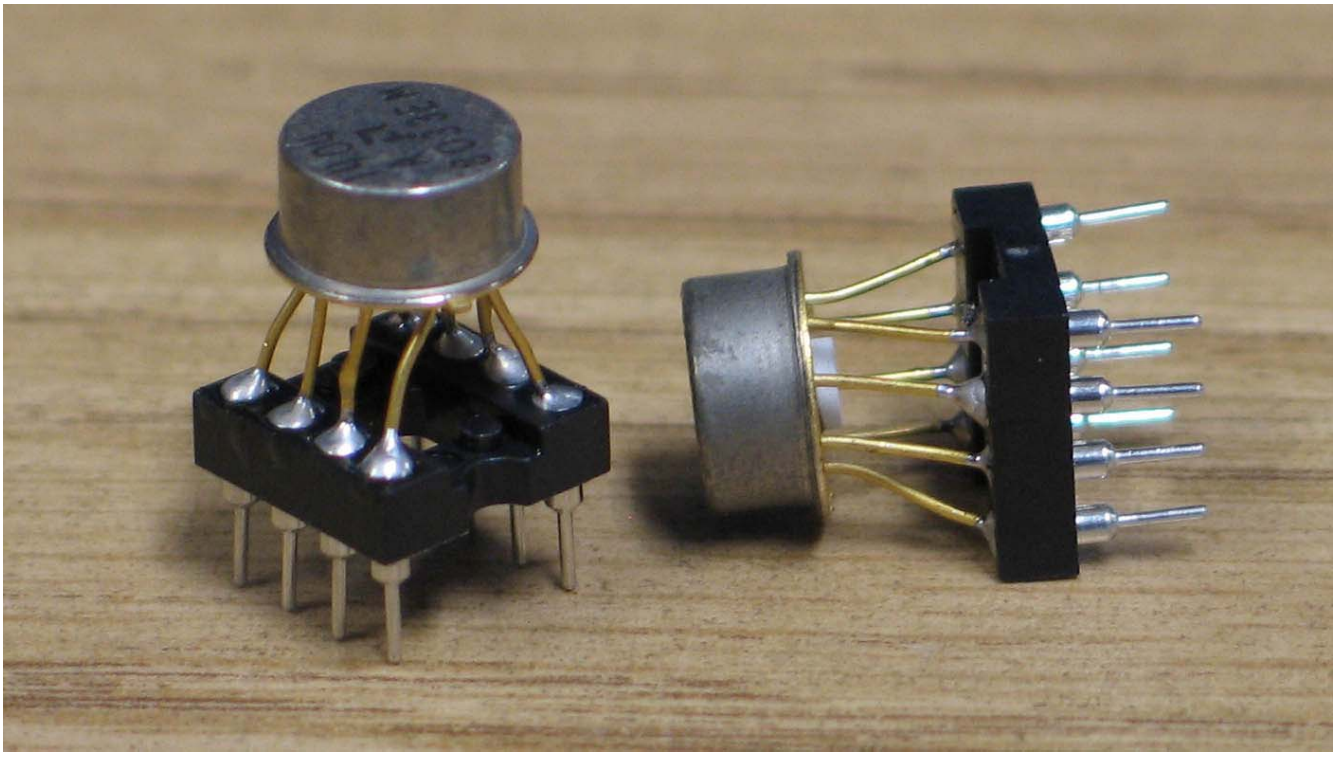
When I built my prototype and second unit I found that **only capacitors C10, C11, C14, C18, and C19 were required for operation**. Of those I can't say how many are absolutely required, however that is what worked for me. I can't imagine how more decoupling capacitors and electrolytic capacitors could hurt, so I have included them and plan to install them myself. For initial power up and operational tests I recommend that you only install those. I have run my KENBAK-1 with a clock frequency of 250kHz to 10MHz (because it is divided by two, 125kHz to 5MHz was the KENBAK-1's operating frequency). It appears to be stable, even at such a high frequency, but your mileage may vary. **; )** 1-2MHz is the historical clock speed of the vintage KENBAK-1.

I have provided some parts which were never used on a vintage KENBAK-1. The sockets are the first, then there are the heat sinks for both a few DIP parts and the memory CANs. (The memory in the KENBAK-1 is not RAM, since you can't randomly address it!) I will describe how to use these heat sinks later.



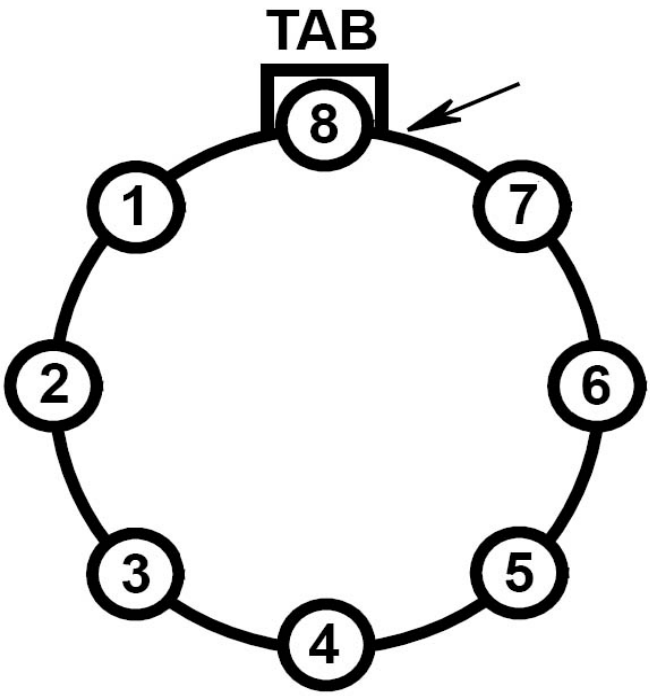
**KENBAK-1 Memory**

The memory CANs in the vintage KENBAK-1 were soldered directly to the PCB. I wanted to use sockets on all ICs, including the memory. To do this I soldered the memory can to an 8 pin machine pin socket, and then installed a second machine pin socket on the motherboard. To form the leads I used some needle nose pliers to bend them as shown above.

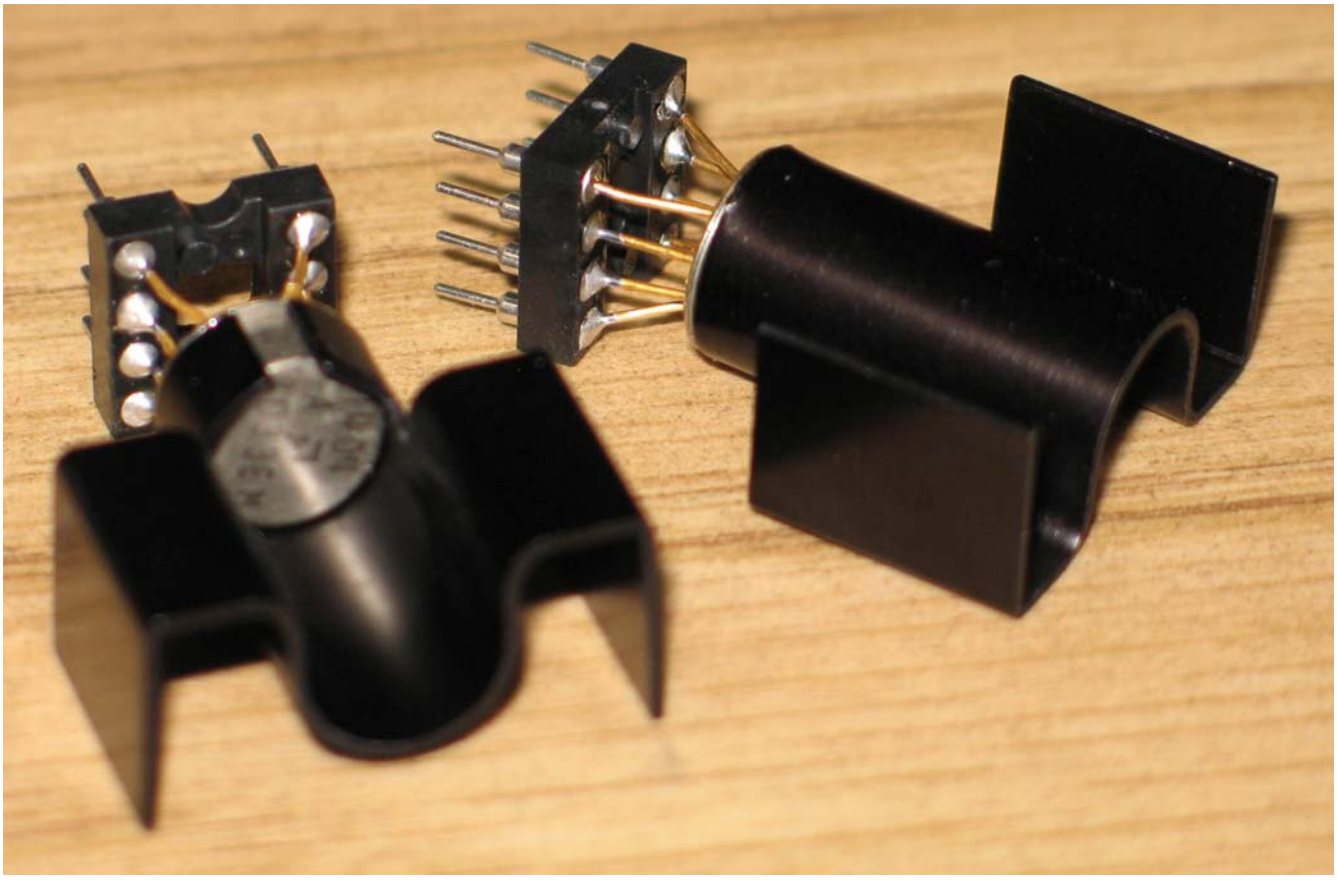


**Memory Soldered to Sockets**

Try to not heat the machine pin socket any more than necessary.  You could soften the socket and cause the pins to shift.

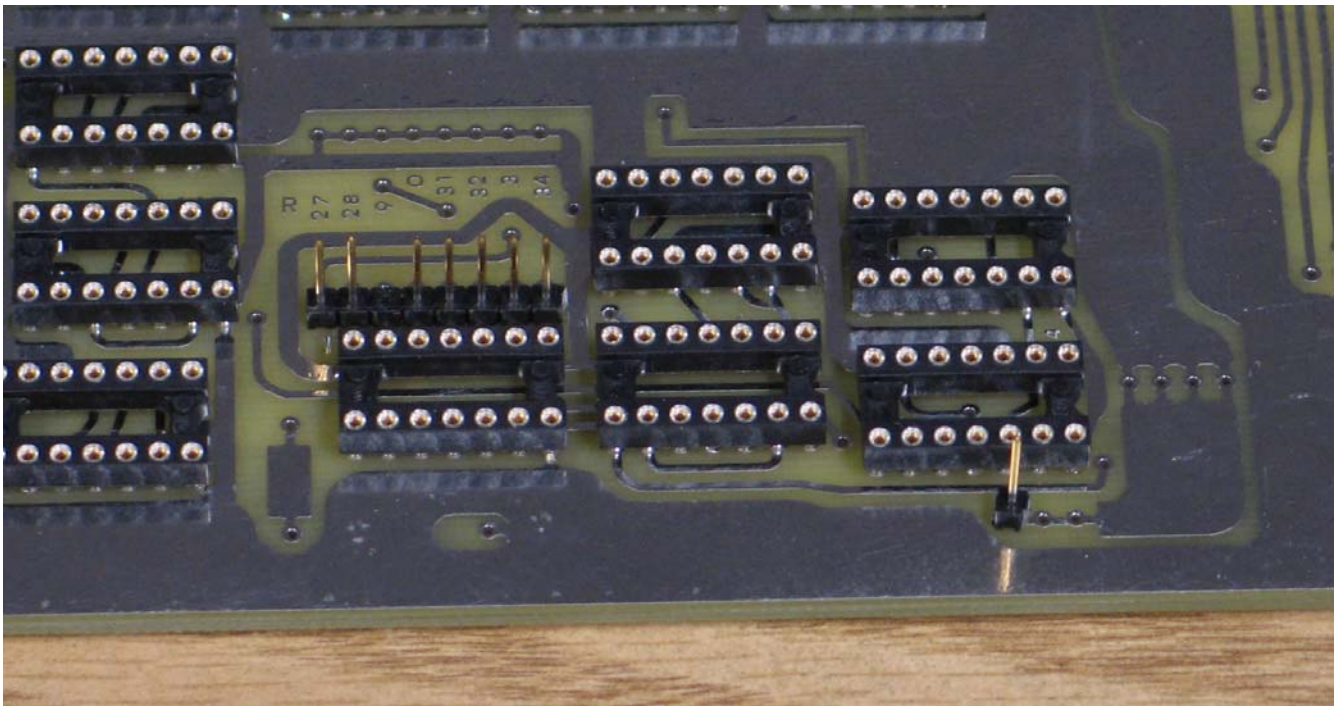



Pin 8 is marked by the notch.  If you need more detailed pictures or instructions on the memory, or anything, feel free to ask and I will provide them!

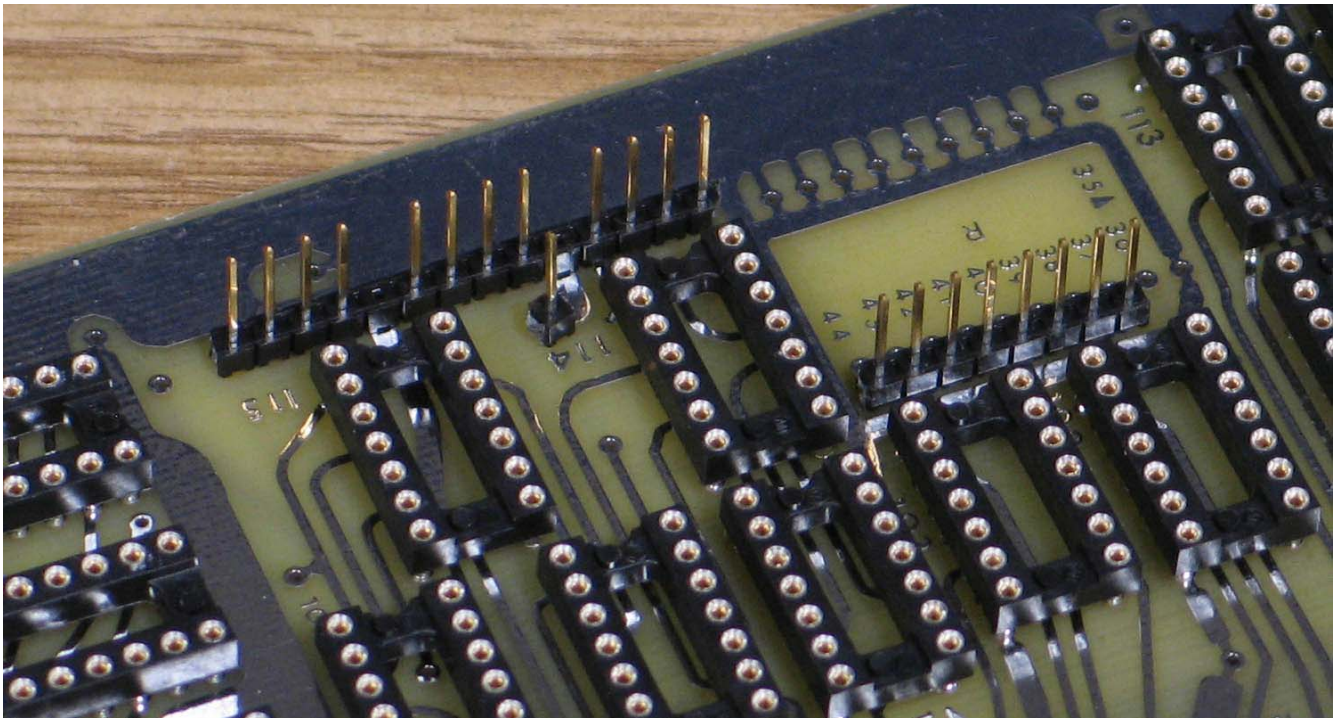


**Heat sink Installation**

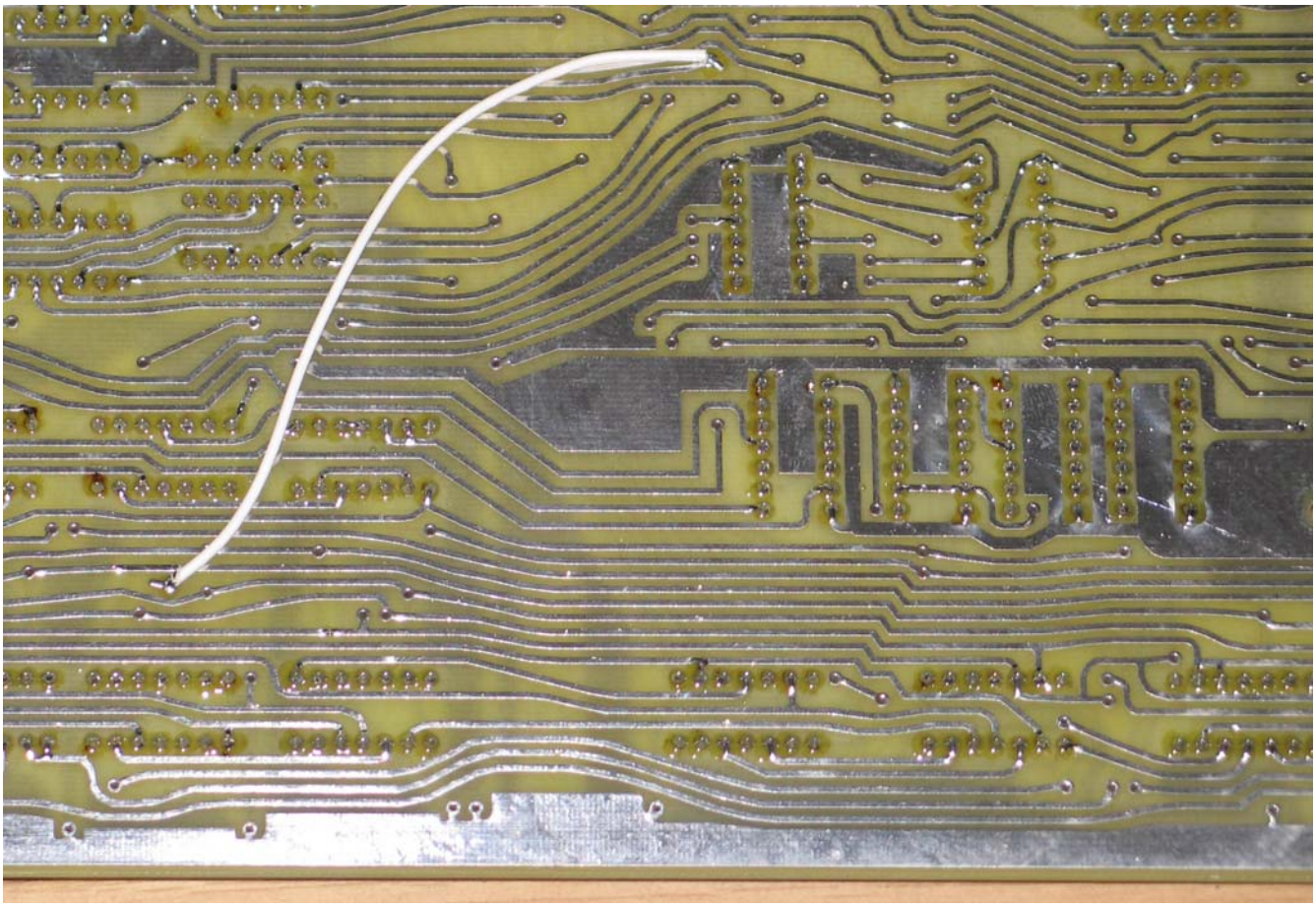
To use heat sinks with the cans just slide them on. These were not used with the vintage KENBAK-1, and John said he never had a memory failure. Heat is the enemy of ICs, and these memory ICs are at least 25 years old. Unlike the other 130 TTL ICs, these are harder to find. Spares are available at $15 each. I figure every bit helps. **: )**



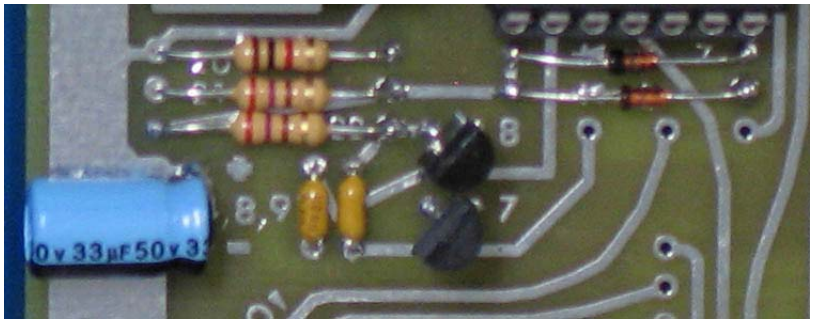
**Switch Header #2 (8x1) and Switch Ground Common (1x1 single pin)**



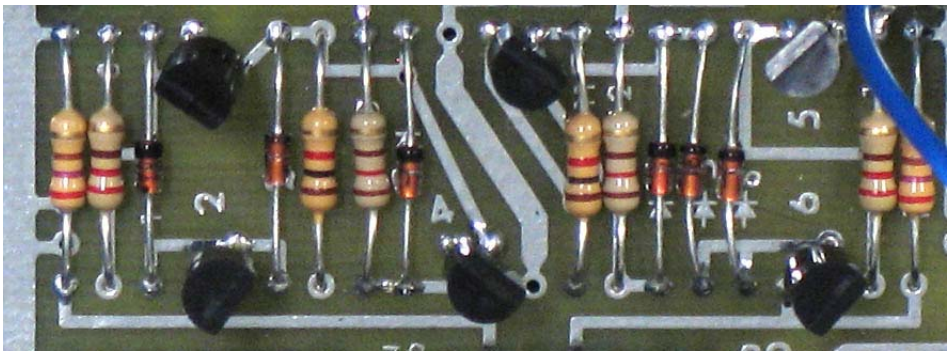
**Switch Header #1 (8x1), Lamp Header (14x1) and Lamp +5v Common (1x1 single pin)**



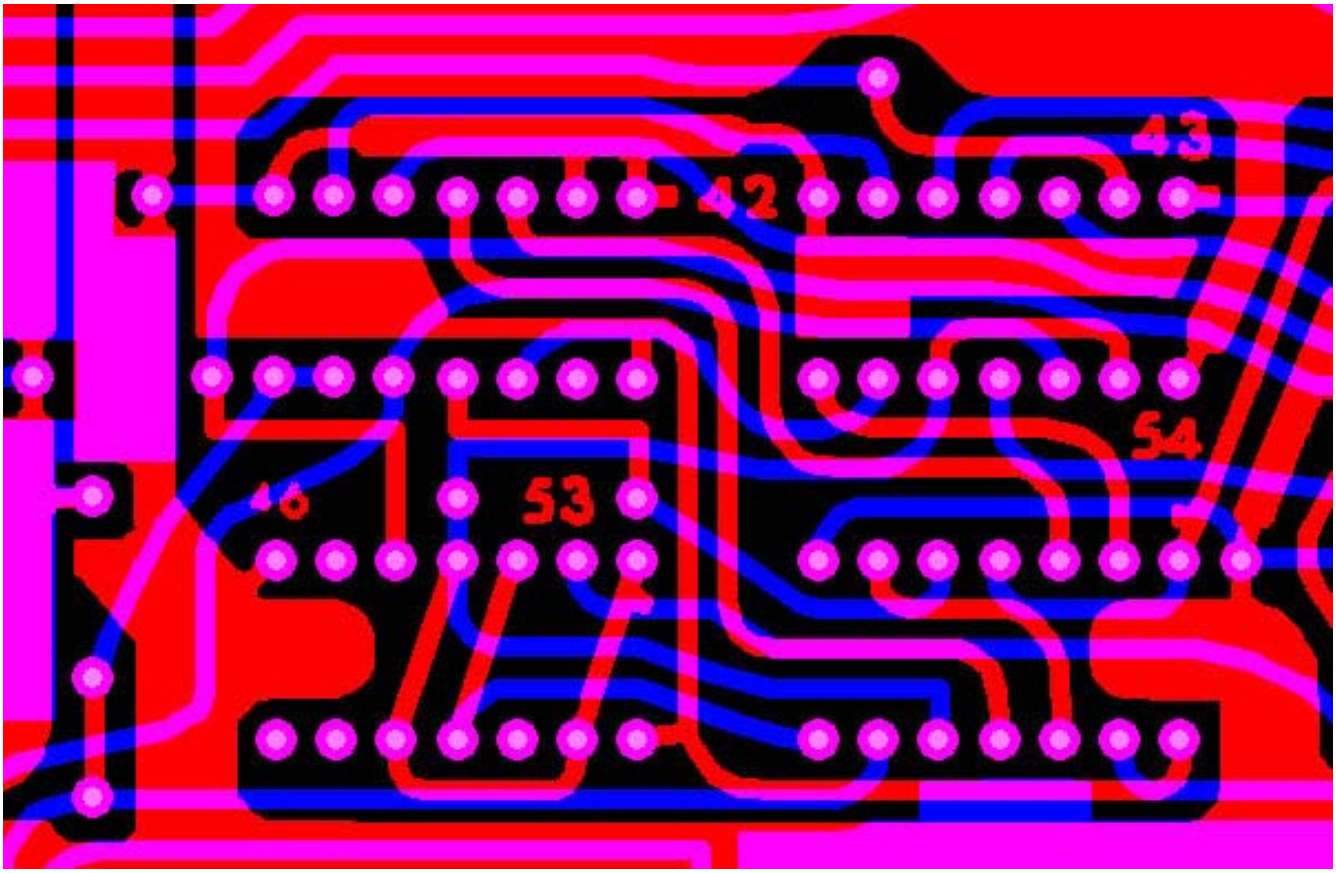
There is one jumper which can be installed on either the top or bottom of the PCB. The jumper was installed on the bottom of the vintage KENBAK-1.



**Clock Generation Section for Transistor Orientation**



**Two Phase Clock Generation Section for Transistor Orientation**



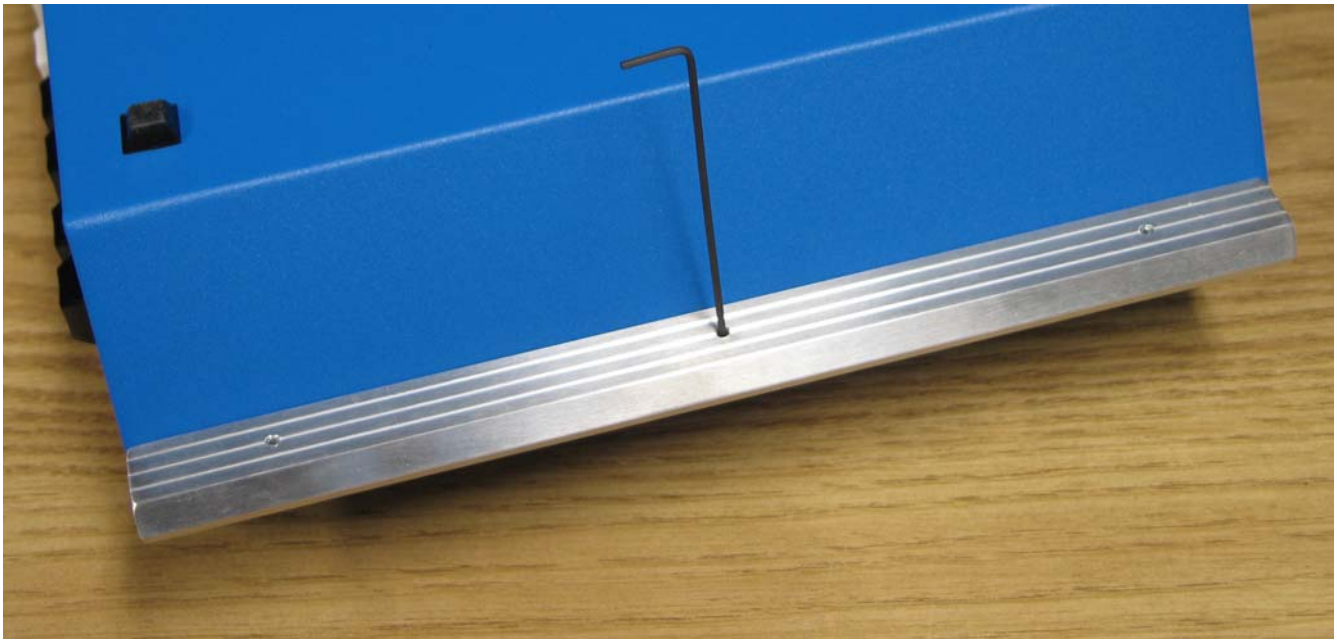

**Sample PCB Artwork**

**Red: Top**
**Blue: Bottom**

Because the vintage KENBAK-1 did not have a silkscreen, part designations and IC orientation were included in the copper layers. You can see in the above pictures how the IC locations have pin 1 marked by a little square trace coming off of either pin 1 or a trace connected to pin 1.

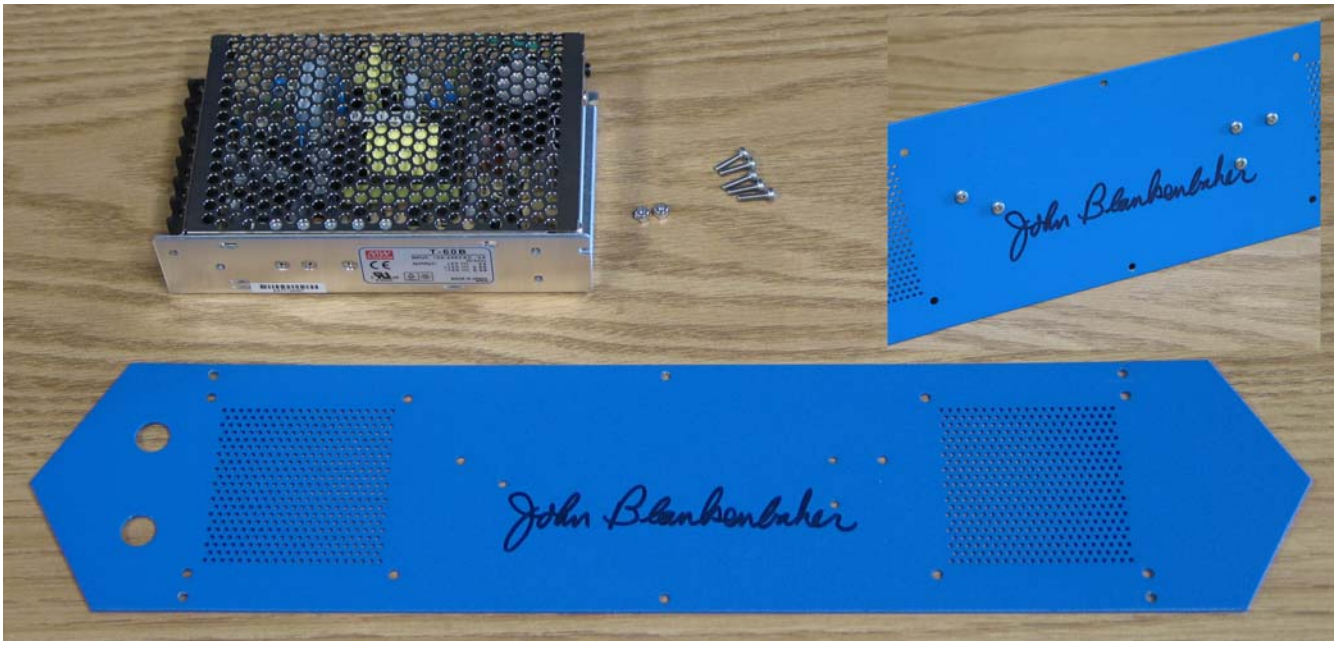
# KENBAK-1 Case
# Assembly/Disassembly Guide

Before starting the front panel assembly you'll need to take the case apart. The case is held together with both the front and back panels and the side handle extrusions. There are three set screws on each handle that take a 1/16” hex wrench. One has been provided in the kit since this isn't a standard tool. The set screws may be replaced with a #6 screw with 32 threads per inch (known as a 6-32). DO NOT OVERTIGHTEN ANY of the fasteners!



While the case is upside down it would be a good time to install the rubber feet!

The middle set screw goes through the hole and tightens against the handle its self. If the other two set screws are loose this will keep the handle from falling off. The other two set screws clamp the case halves together.



There are 6 screws to remove on the front panel and 6 to remove on the rear.

The 60W power supply included provides:

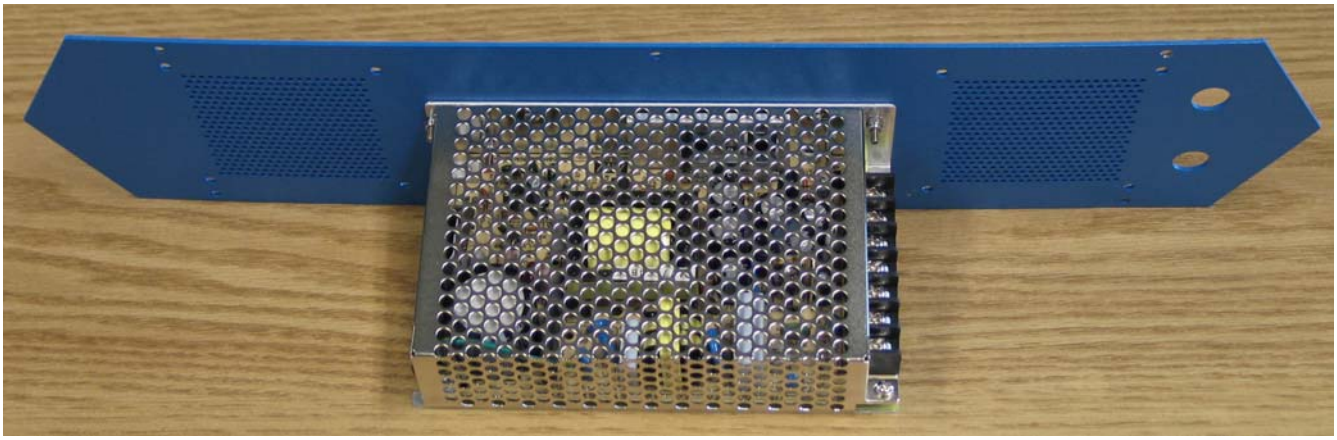
- +5vDC @ 5A
- +12vDC @ 2.5A (not used)
- -12vDC @ 0.5A

It is a little oversized for the KENBAK, but will run cool without ventilation.

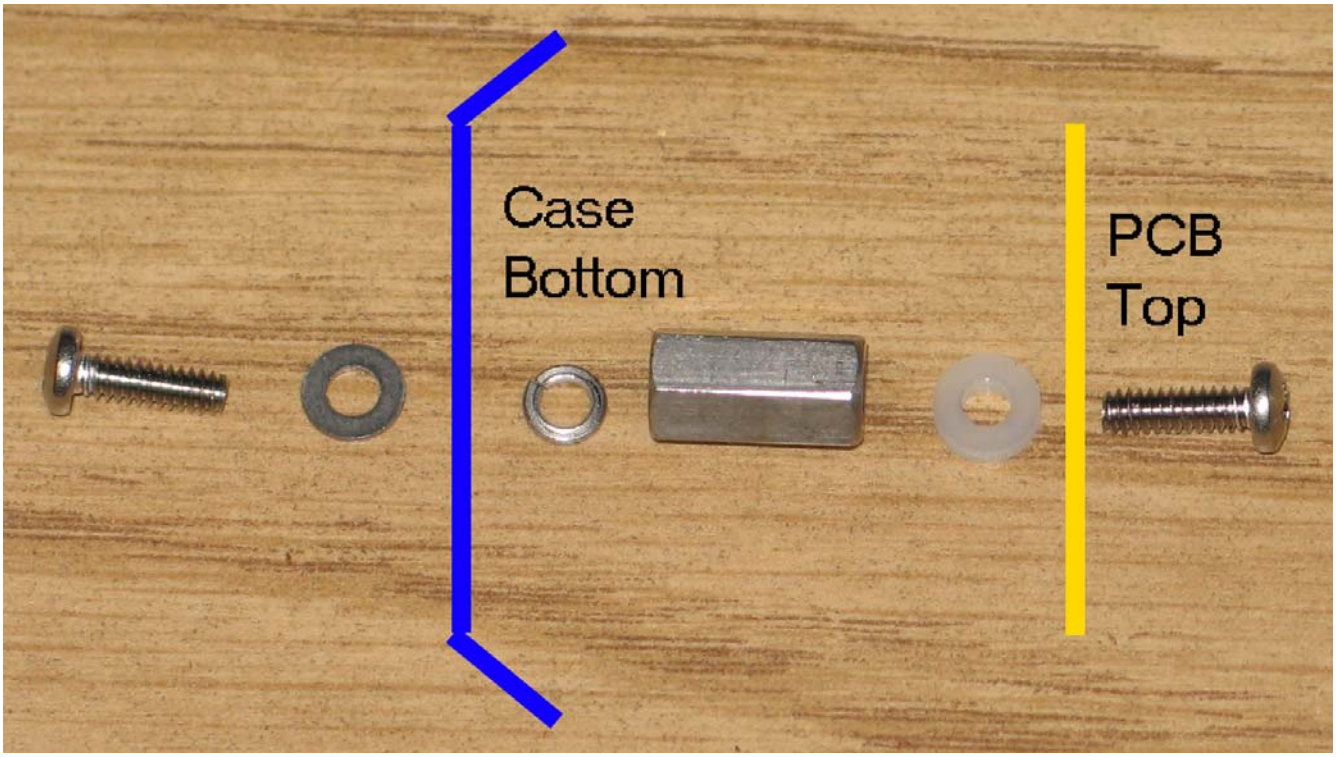
It accepts an input voltage of 100-240vAC without any input voltage switch. You should consult someone qualified in AC wiring to hookup the input of the power supply and switch. I don't want anyone to get hurt. Because of this the kit does not come with a power cord or instructions on wiring the high voltage section. Be safe! **: )**

The power supply uses metric fasteners where every other part of the kit uses inch measurement. They are M3x12. 3 of the screws thread into the power supply. Two of the others do not, but metric nylock nuts are provided for these. The metric fasteners are separated from the others because the M3 is visually VERY similar in appearance to the #4-40! If in doubt, and it doesn't go smoothly, don't force it! The M3 screws are 12mm long (~1/2) and the longest #4 screw in the kit is 3/8". So if they end up getting mixed up you could measure them.


Here is one of the M3 nylocks used with a M3 screw on the power supply.



**Power Supply Installed**



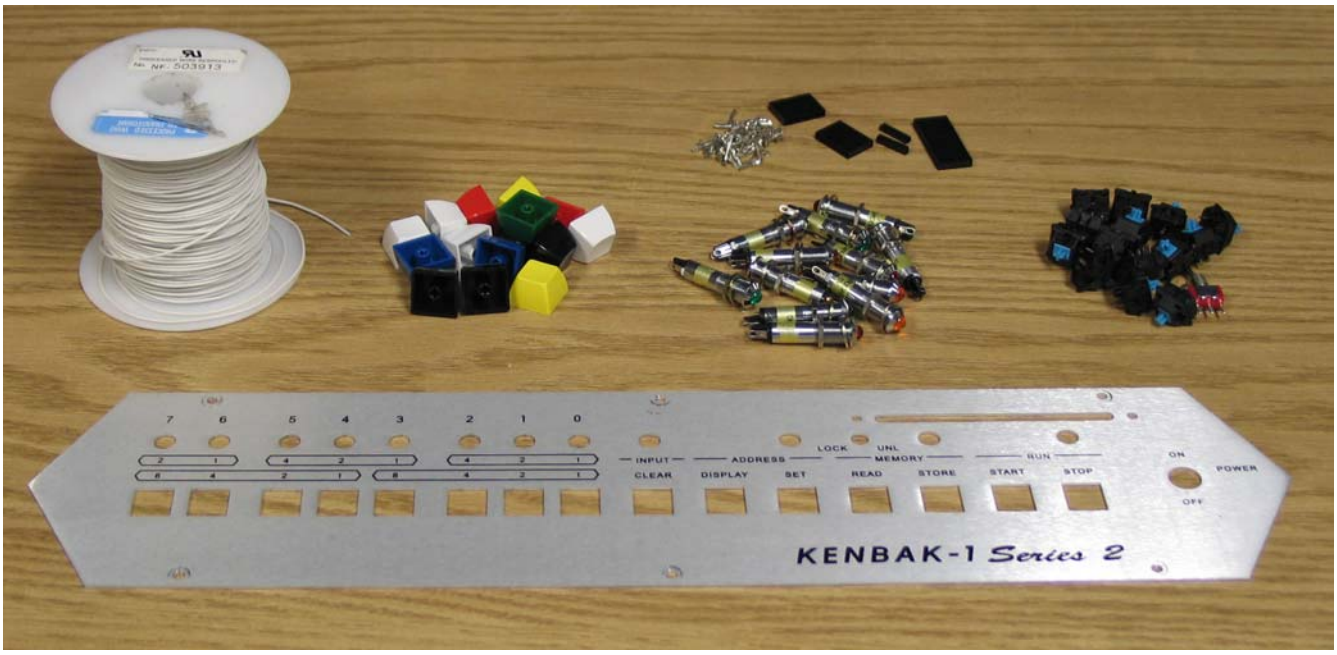

The parts required to mount the PCB to the case are shown above. A #4-40 screw with flat washer are on the outside/bottom of the case with a lock washer and standoff on the inside. You may want to use a mild thread locking compound such as “Locktite” on the bottom side (but not the screw holding the PCB down)

**Left:** Bottom of the case bottom showing the screw head and flat washer.
**Right:** Inside of the case bottom showing the lock washer, standoff, and nylon insulator.

In the vintage KENBAK-1 the nylon washer was glued to the standoff. I've just layed them on top and carefully placed the PCB over it. To keep them from sliding around you could insert a wire or resistor leg in the hole.

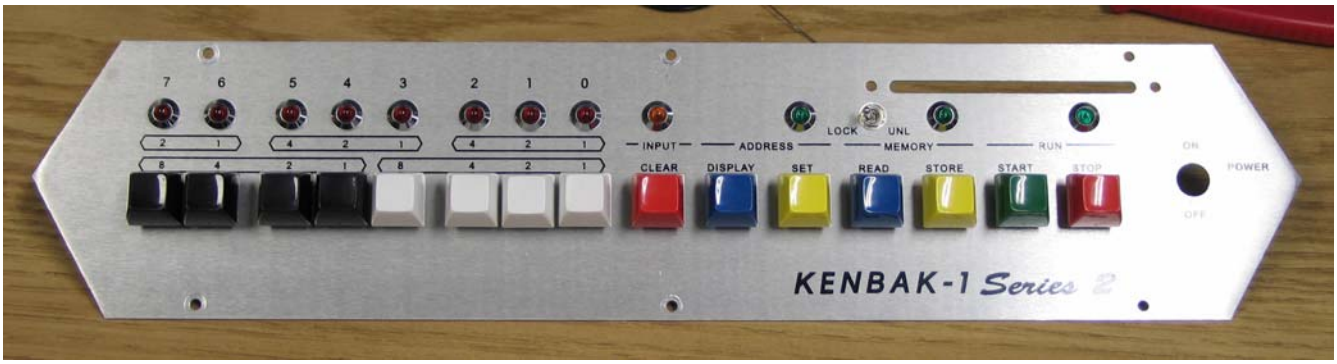
# KENBAK-1 Front Panel Assembly Guide

Completing the front panel will also take quite a lot of time, but not as much as the PCB! This is another area of the kit construction where attention to detail will result in a better quality unit.




The pictures in this section will show a front panel with LEDs. The process for incandescent lamps is virtually the same.

The first thing to do is install all of the switches and lights. There are two kinds of lights sold with the kit. Incandescent and LED. There are also two ways to mount the switches, from the front or back. When the switches are mounted from the back they hit the front panel when fully pressed. This is how the vintage KENBAK-1 worked. The switches when mounted from the back will require glue to hold them in but when mounted from the front will snap in.

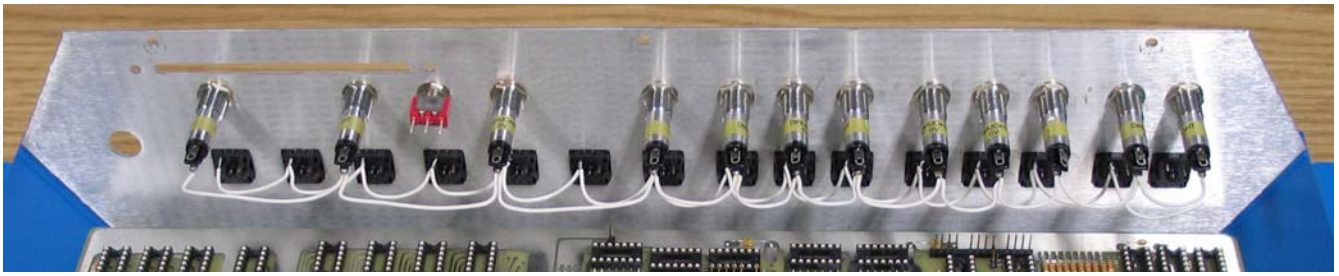



I used the vintage key cap colors for the 8 data switches, but chose to use colored switches for the other functions. For the Lock/Unlock switch you may choose to use the white switch boot (one was used on the vintage model).


Shown above are the switches mounted from the back, incandescent lamps, and the white boot installed.

Shown here is the back side of the incandescent lamps and the switches. Notice the hot glue I used. The glue seems to work well enough. The switch will hit the front panel AFTER contacting, but before bottoming out (so the glue will not get any force from pushing straight in)

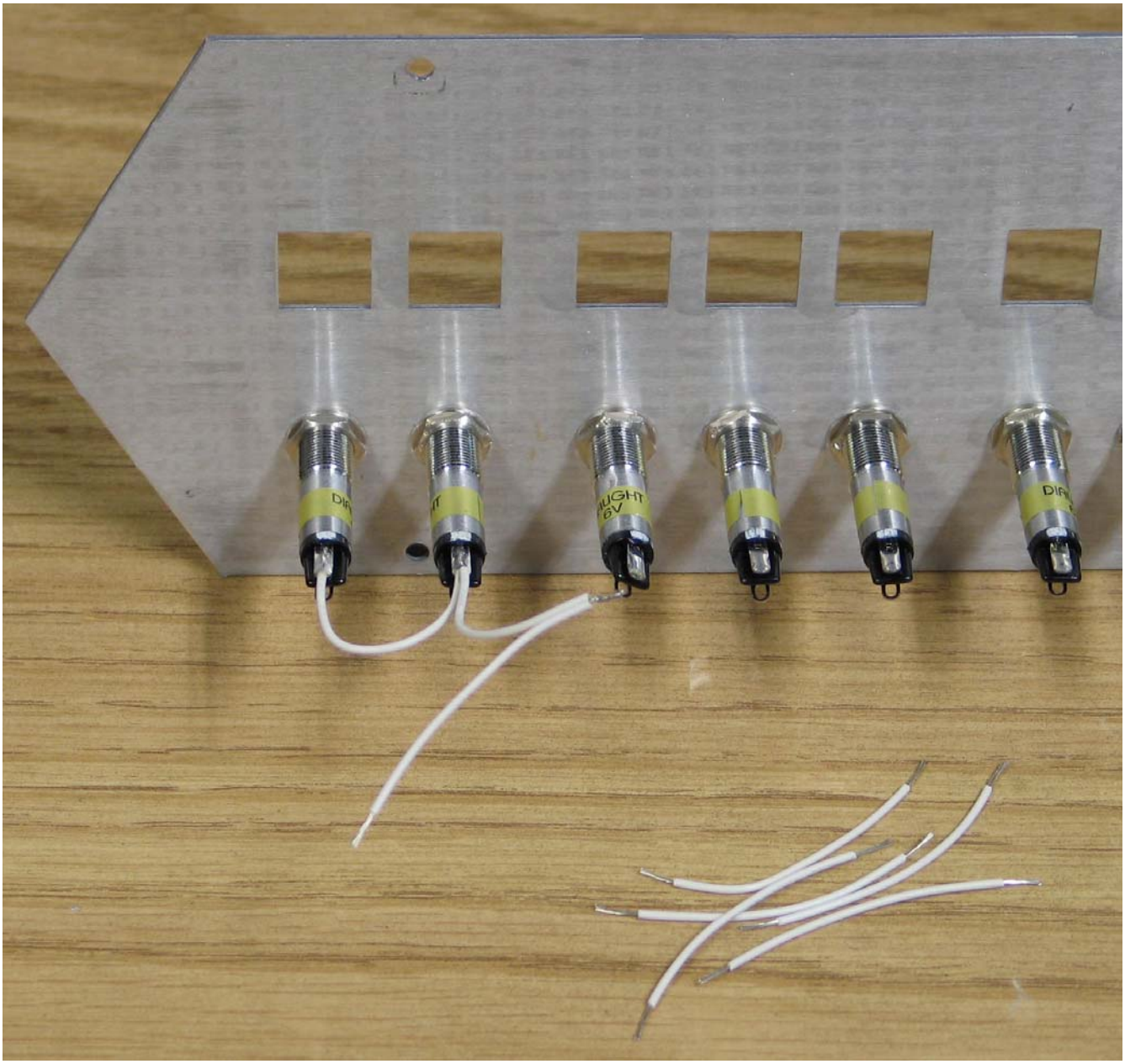
For wiring both the switches and LEDs I wired them as shown above. The other method of wiring would be to just run shorter/individual loose wires directly to the switches and lights as was done on the vintage KENBAK-1. I like this method better because it results in a clean interior. I left the two commons wire an inch or two longer than the rest. I trimmed the individual wires to about the back of the case. It does not matter which wire on the switches is common, but you might as well stay consistent from switch to switch. For the LEDs, the common terminal is marked by a white dot.



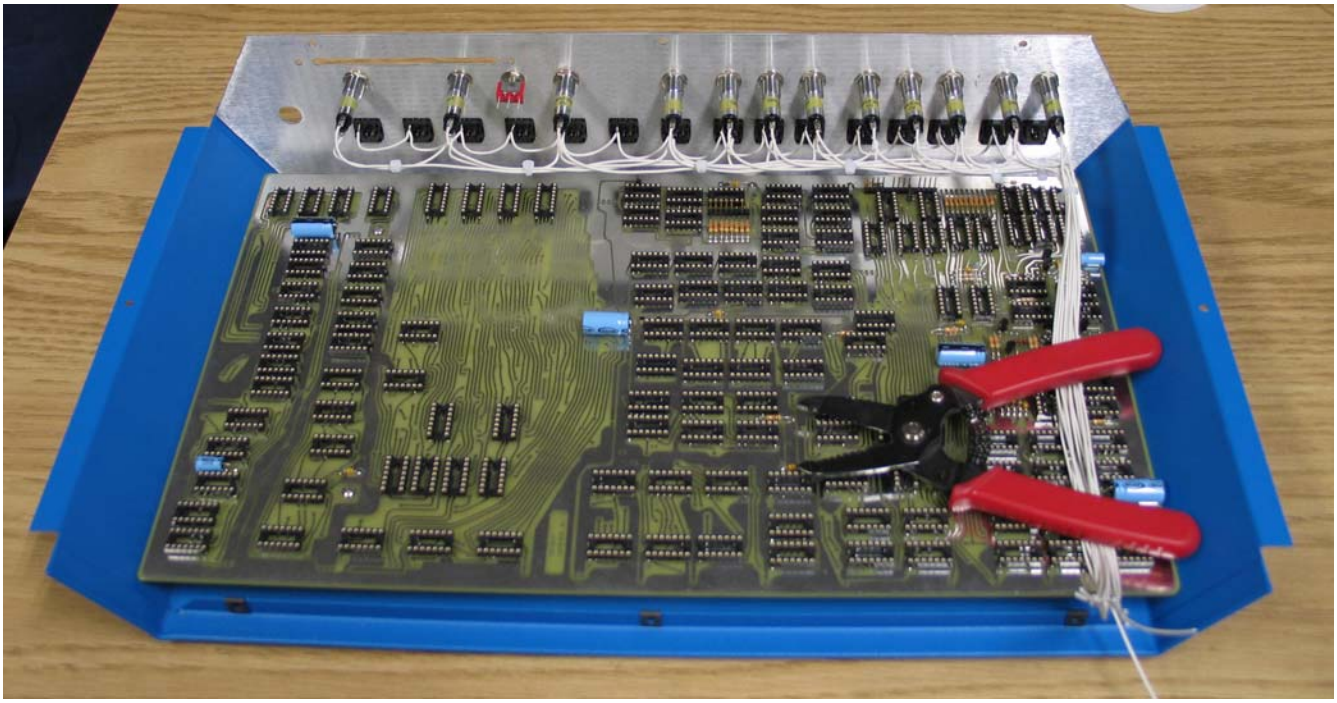
All the switches and LEDs with their commons tied together.

**Schematics of the switch and light wiring are on the pages below:**

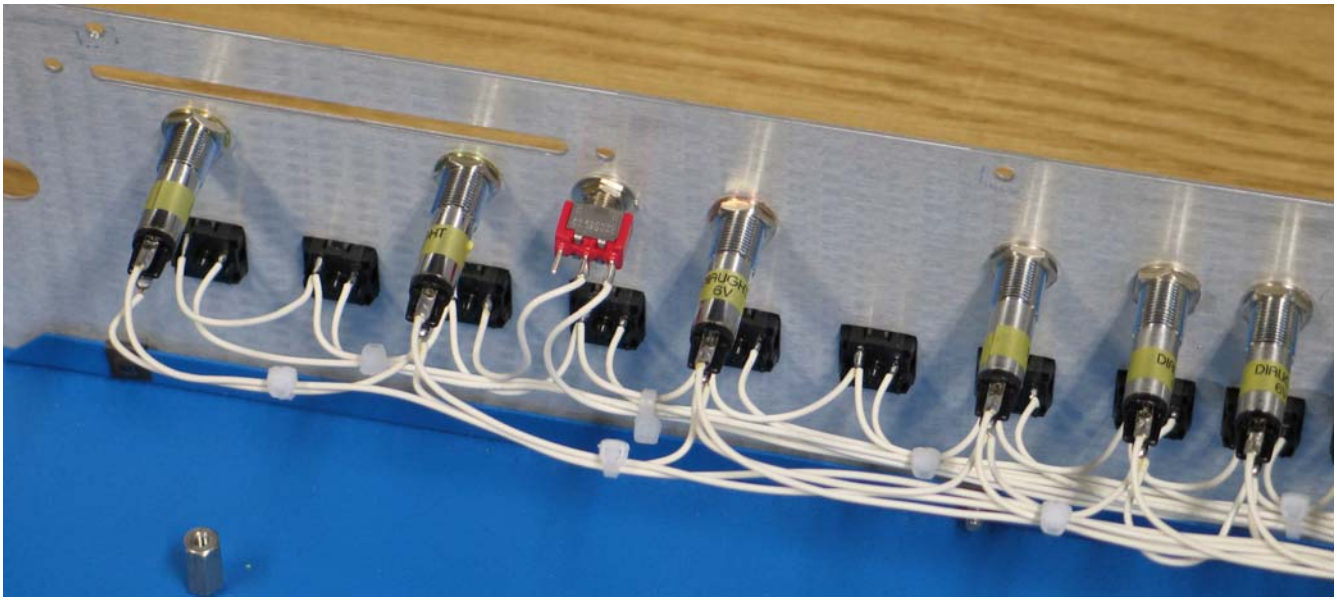
- Data Lights – 07
- Status Lights – 06
- Data Switches – 05
- Function Switches – 04



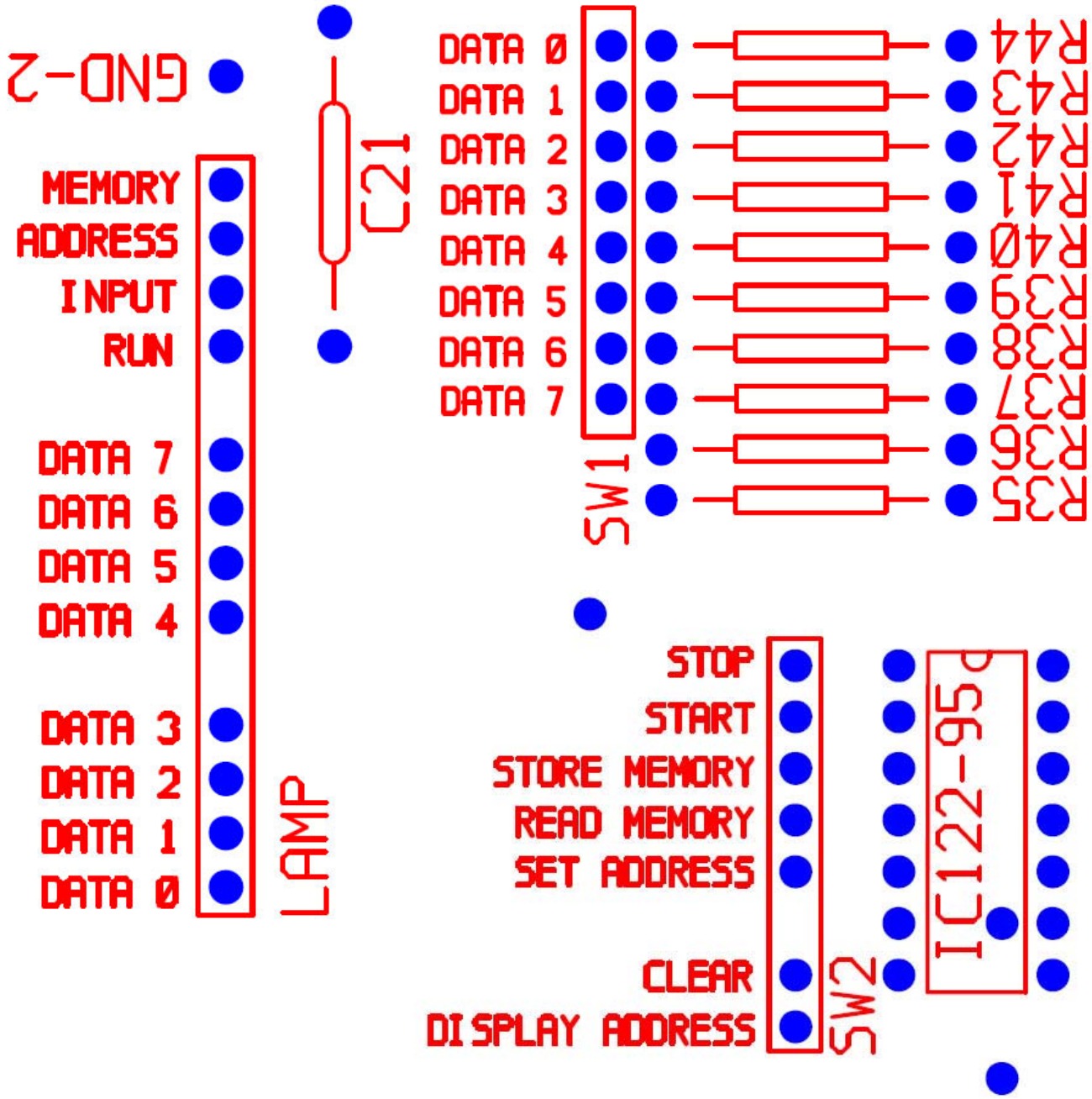
The common terminal of the LEDs being wired in parallel.



When wiring the switch and LED signal wires I trimmed the individual signal wires to about the back of the case. This is ~10 inches. I left the two common wire an inch or two longer than the rest. In the picture above I forgot to wire the “MEMORY STORE” switch in series with the “LOCK/UNL” toggle switch. The toggle switch is used as a write protect switch to prevent you from accidentally overwriting memory when the computer is stopped. The picture below shows this wired correctly.

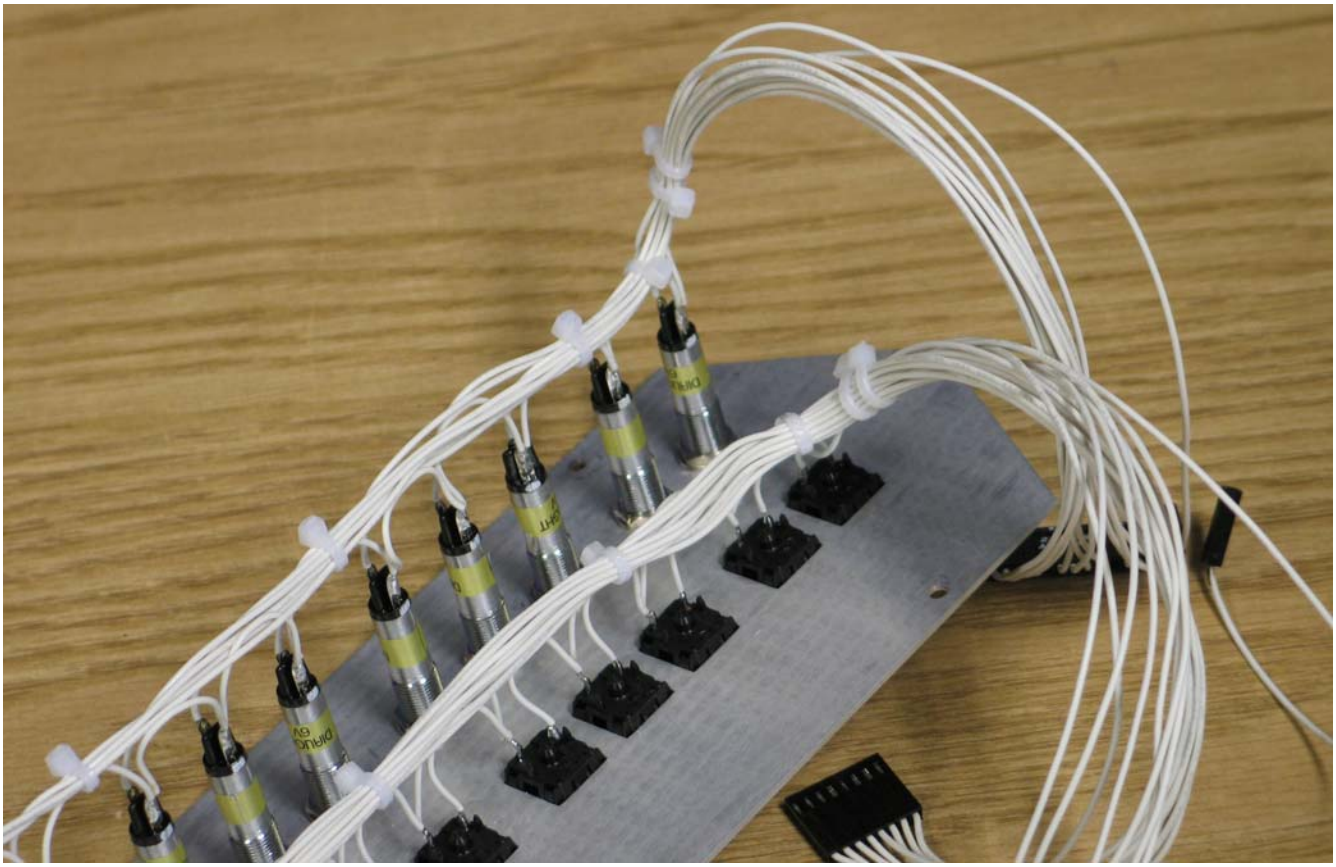


After I was done I trimmed all of the wires to equal lengths for crimping and connector installation. When backtracking and determining the function of each switch wire I used a continuity meter. For determining which wire belonged to each light I used 3vDC (2xAA battery). The LEDs have internal current limiting resistors, so don't worry about that.




**Switch and Lamp Header Pinout**

NOTE: These three segments are not found on the PCB as shown. I have taken objects around them to help you locate it on the full page part layout diagram.

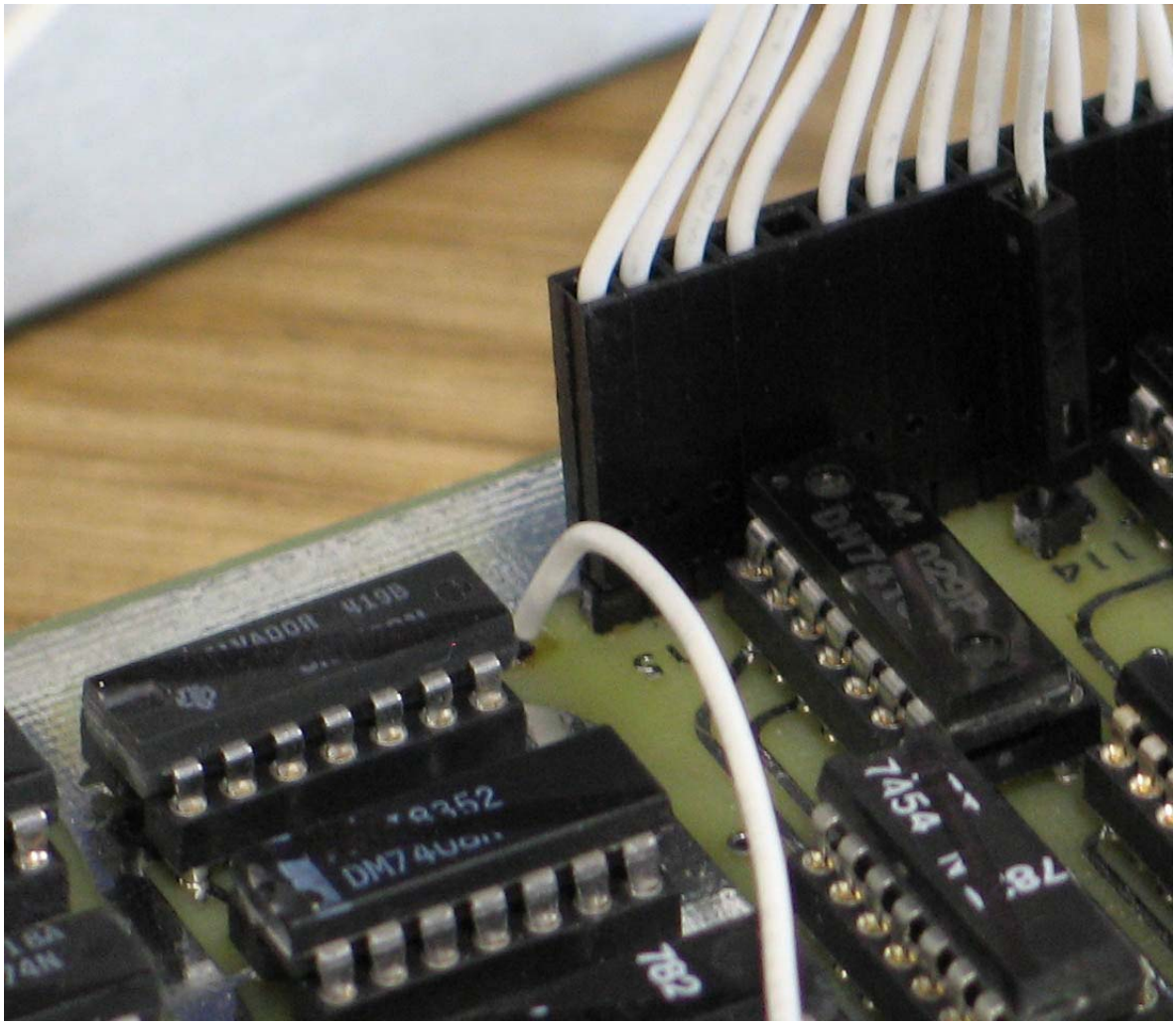


By holding the wires in a “bent” right angle shape while installing the tie wraps I was able to leave them in a formed shape.  Leave a little extra slack on the last switch/light wires to keep them from getting any strain.

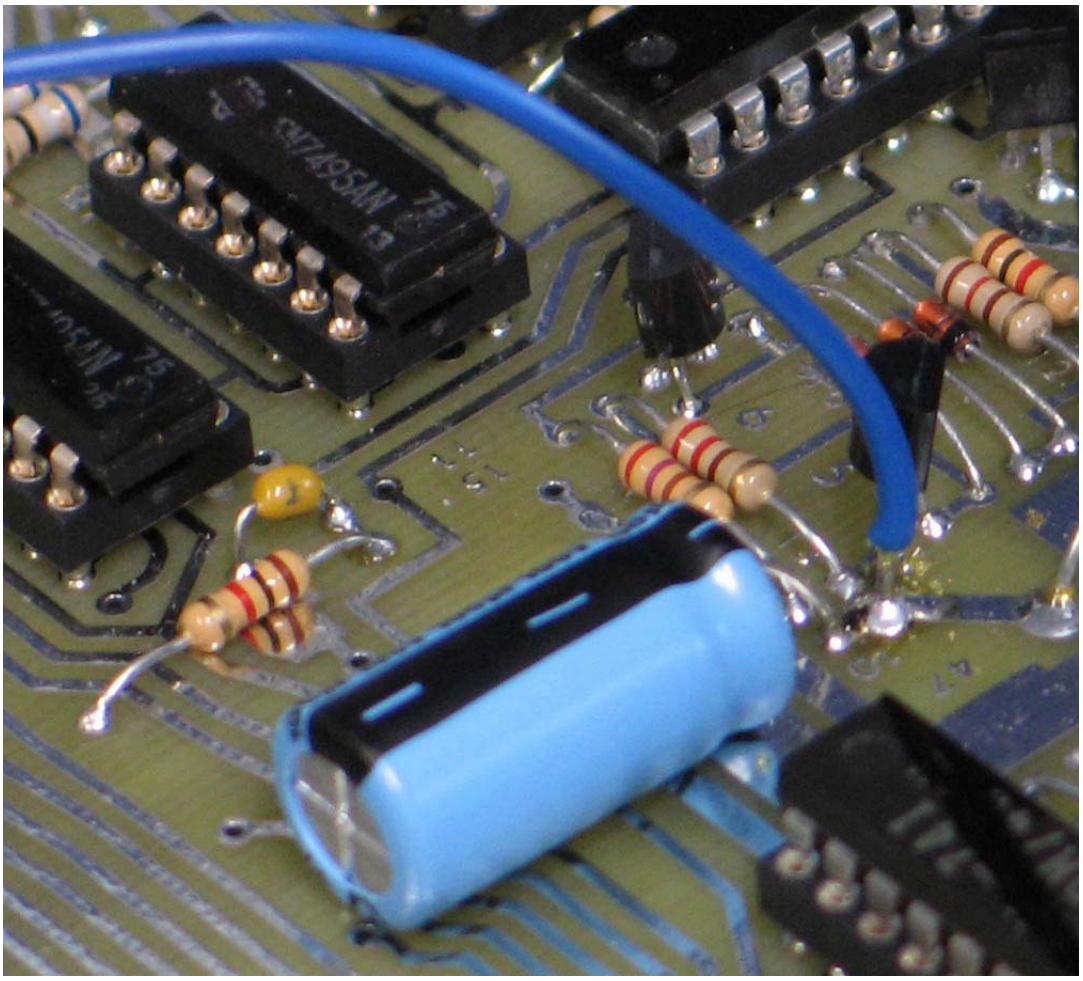
Now its time to wire the low voltage DC side of the power supply!

# KENBAK-1 Power Supply
# Low Voltage Wiring

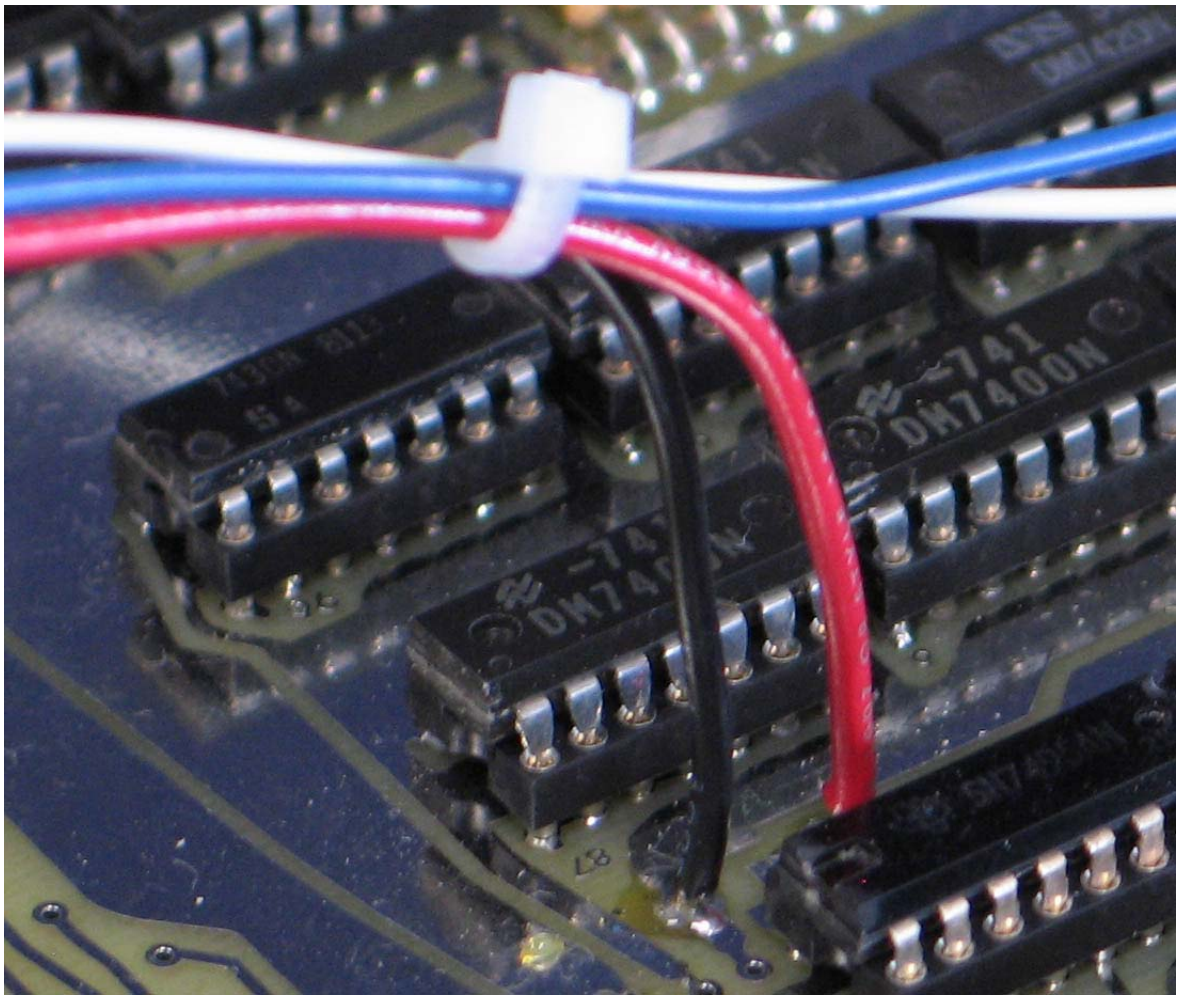
It's easy to see from the parts layout where the +5vDC and GND (Power Supply Common or COM) go. There is also a -12vDC AND an additional GND connection. I don't know why in the vintage KENBAK-1 that this point on the PCB was brought all the way back to the power supply instead of to an adjacent pad. I'm not one to second guess the vintage configuration, so I copied the vintage KENBAK-1 on this one. **: )**



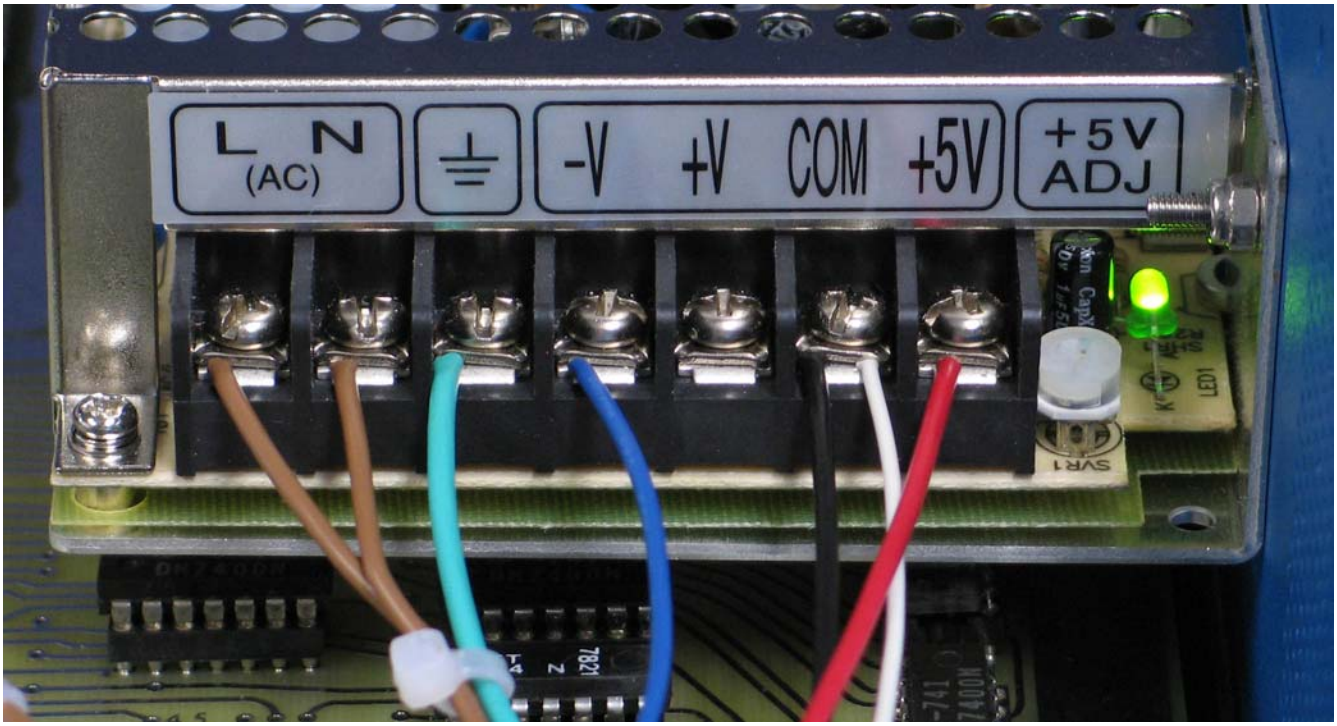

**“Extra” Ground, shown as “GND-2” on the parts layout sheet (near LAMP header)**



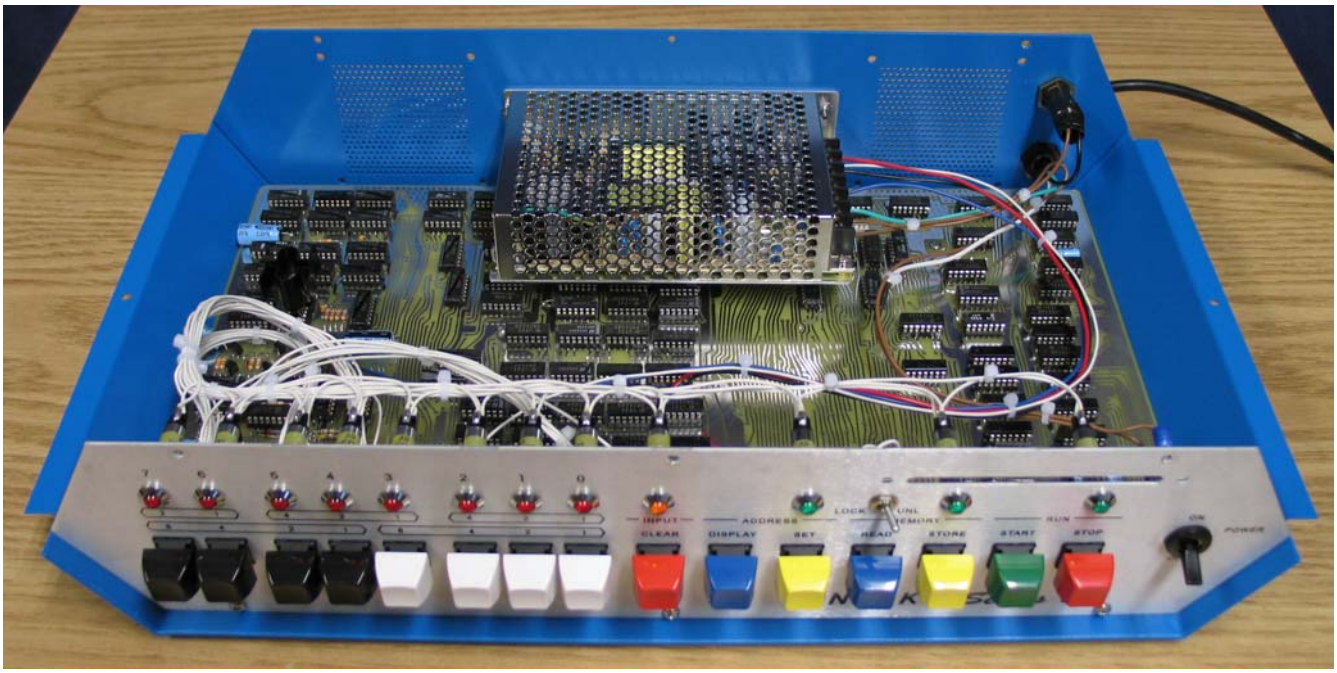

**-12vDC Supply**

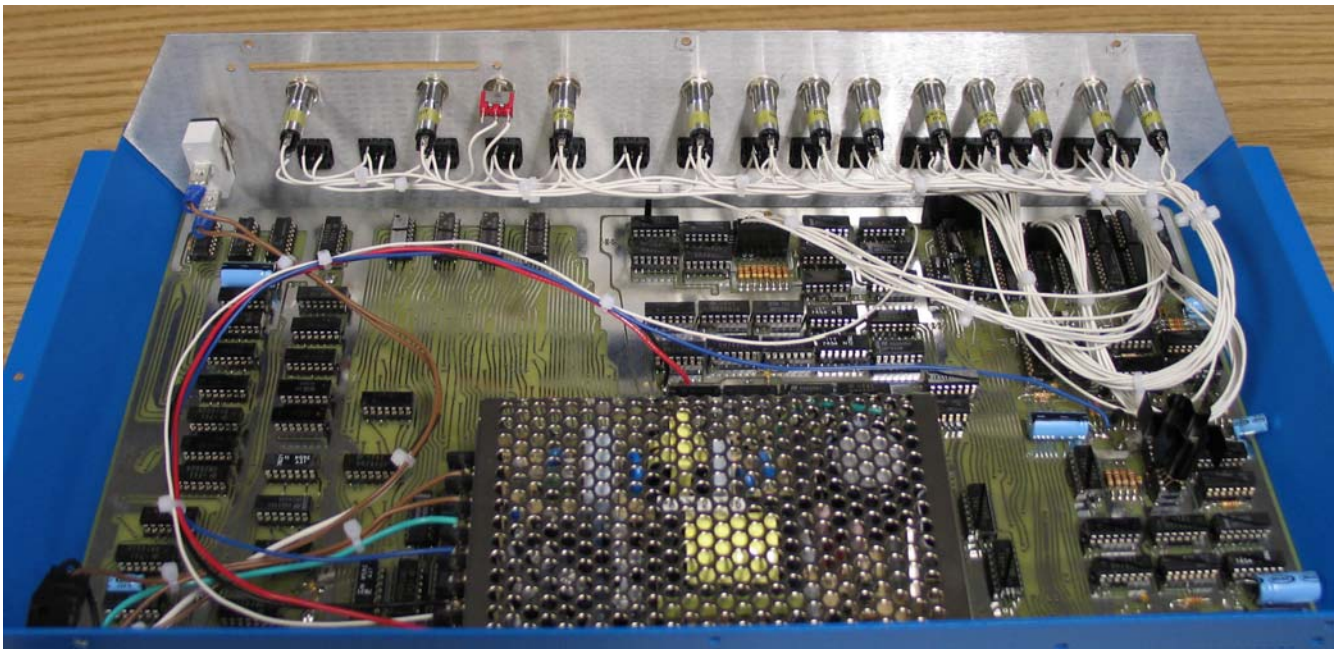



**Main GND and +5vDC Connections**




**Power Supply Connections**

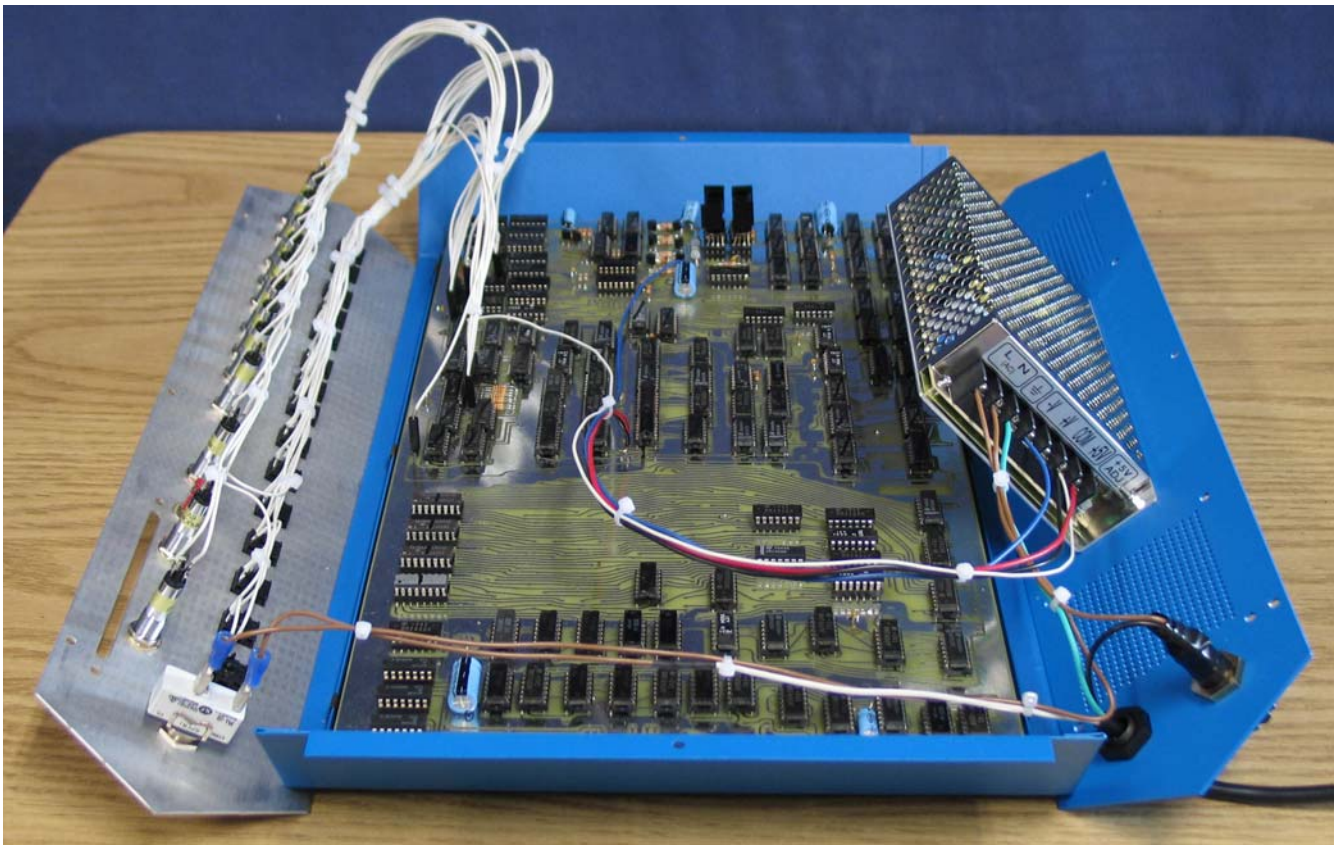

INPUT
CLEAR
ADDRESS
DISPLAY
SET
LOCK
READ
UNL
MEMORY
STORE
RUN
START
STOP
ON
POWER




John Blankenbaker

# KENBAK-1 Notes
# Tips and Hints

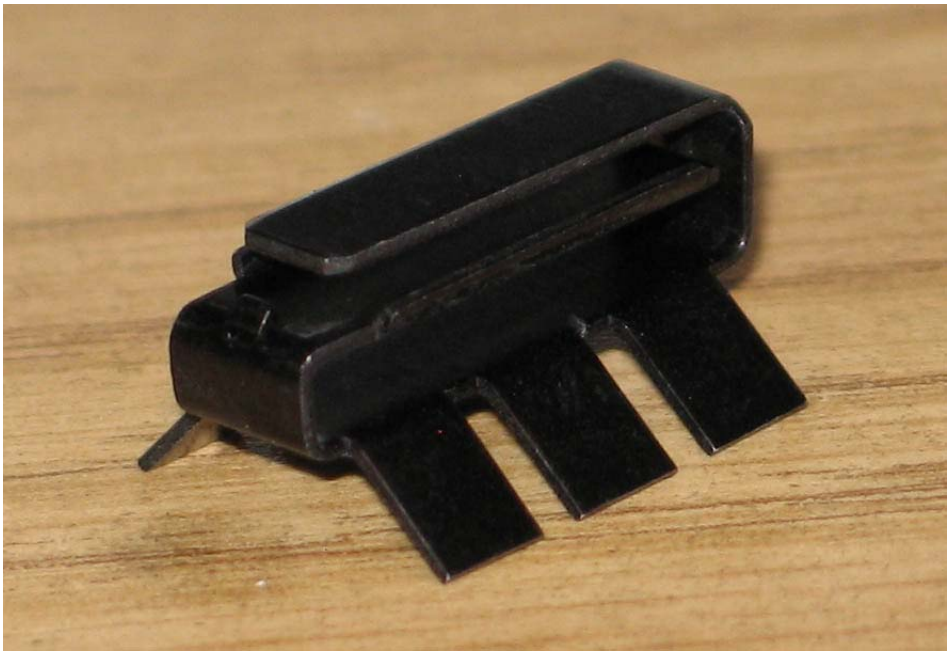
It may not seem obvious when wiring each section of the KENBAK-1 why long wire lengths are helpful. In fact, when I constructed my second unit for the creation of this manual I cut my power switch wires too short! It is very helpful to have the wiring long enough to disassemble the KENBAK-1 for trouble shooting and assembly.

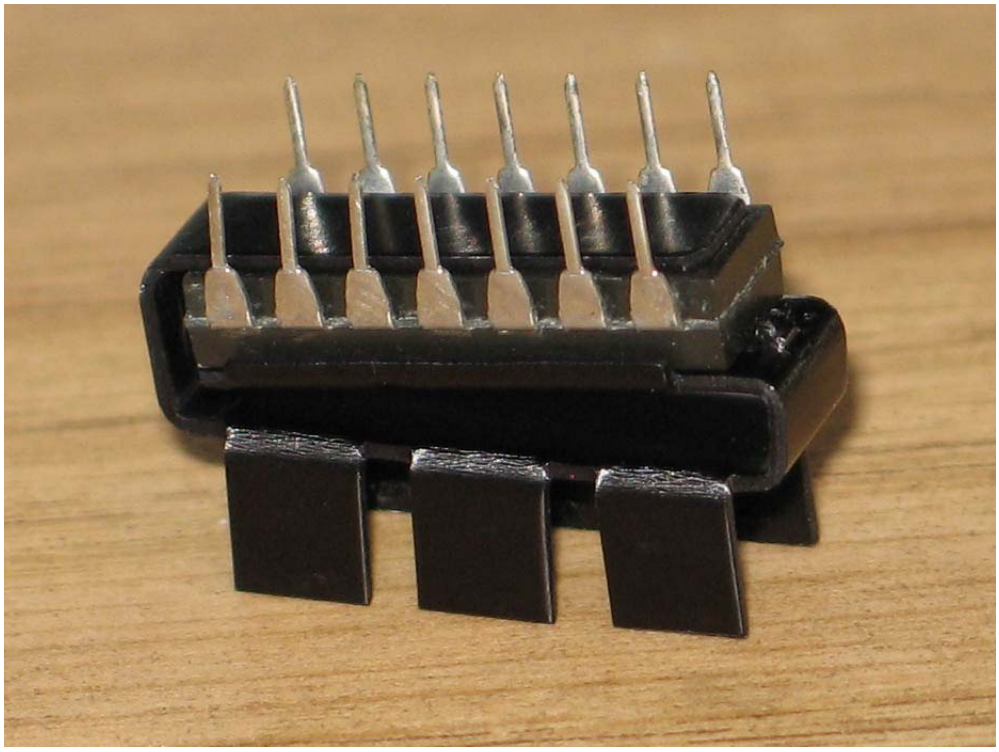


- I have included some #6-32 3/8" screws and flat washers for optional replacement of the screws that came with the case. I like the 18-8 stainless screws better.

- I bought a TOP2004 programmer off of ebay for testing TTL devices for $79. It has been able to test all devices except the 7451 and 7454. For some reason it reported those as bad even if they are good. However, the programmer was able to detect some previously known bad parts as bad. A 7400, 7404, 74376, etc. I bought the programmer from ebay seller MCUMall (www.mcumall.com). The shipping was fast. This programmer can be bought off other international sellers on ebay too. It will also program other (E)EPROMs, Flash devices, PLDs, microcontrollers, etc. If your unit doesn't work on the first power up I recommend testing the TTL devices.

- I am available for phone and e-mail support on most week nights and weekends. Past 8PM PST I can call US Domestic long distance for free. International callers will need Skype or will have to call me directly.





I have provided some IC heat sinks for the computer. There are about 5 ICs which get very hot in operation. For example, I measured IC99 at 190F, IC100, IC111, and IC112 at 136F. I'm not sure the infrared sensor was working correctly, but they feel that hot! **; )**

In order to use heat sinks on those devices you will have to bend the fins straight up and bend the little “notch” in the heat sink down. The heat sink on two adjacent parts will have to be installed backwards because of the close spacing.

# KENBAK-1 Power Up

Before powering up for the first time, do the obvious things like check the orientation of diodes, electrolytic capacitors, transistors, and ICs. If you have an oscilloscope it wouldn't hurt to verify the clock signals. Oscilloscope screen capture images are available on the support forum (see below).

For KENBAK operation see the Laboratory Exercises Manual. Exercise #1 will teach you the operation of the switches and how to read/store memory locations. Exercise #2 has a quick program that counts from 0x00 to 0xFF (or 000 to 377). This is the program I use to test the Kenbak, and the one I enter in about every time I walk past it. **: )** In the first week of October 2007 I will have videos of operation available on the Internet. I will notify you by e-mail when they are ready.

I have retargeted “AS” (http://john.ccac.rwth-aachen.de:8000/as/) to the KENBAK-1 and would be happy to provide the source patches to anyone interested. I am also completing an online interface to the assembler that anyone can use regardless of computer platform. I will also notify you by e-mail when this is ready.


I hope you had fun assembling the KENBAK-1 and working with such a unique and rare architecture! I would love to receive pictures of construction in progress and of the finished model! You can never take too many pictures...

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E-mail: grant@stockly.com
http://www.kenbakkit.com

Support Forum: http://www.stockly.com/forum.

**Kenbak-1 Part Placement –** http://www.kenbakkit.com – http://www.stockly.com

**ICs:**

| | | | | | |
|---|---|---|---|---|---|
| IC1 | 7410 | IC50 | 1404A | IC100 | 7486 |
| IC2 | 7495 | IC51 | 7400 | IC101 | 7474 |
| IC3 | 7400 | IC52 | 7420 | IC102 | 7403 |
| IC4 | 7420 | IC53 | 7474 | IC103 | 7403 |
| IC5 | 7400 | IC54 | 7400 | IC104 | 7495 |
| IC6 | 7495 | IC55 | 7410 | IC105 | 7495 |
| IC7 | 7400 | IC56 | 7410 | IC106 | 7454 |
| IC8 | 7404 | IC57 | 7400 | IC107 | 7454 |
| IC9 | 7430 | IC58 | 7400 | IC108 | 7400 |
| IC10 | 7404 | IC59 | 1404A | IC109 | 7420 |
| IC11 | 7400 | IC60 | 7400 | IC110 | 7430 |
| IC12 | 7400 | IC61 | 7410 | IC111 | 7495 |
| IC13 | 7410 | IC62 | 7400 | IC112 | 7495 |
| IC14 | 7400 | IC63 | 7430 | IC113 | 7400 |
| IC15 | 7400 | IC64 | 7400 | IC114 | 7416 |
| IC16 | 7400 | IC65 | 7454 | IC115 | 7416 |
| IC17 | 7410 | IC66 | 7400 | IC116 | 7408 |
| IC18 | 7410 | IC67 | 7430 | IC117 | 7474 |
| IC19 | 7400 | IC68 | 7474 | IC118 | 7400 |
| IC20 | 7495 | IC69 | 7451 | IC119 | 7400 |
| IC21 | 7420 | IC70 | 7400 | IC120 | 7420 |
| IC22 | 7454 | IC71 | 7410 | IC121 | 7410 |
| IC23 | 7474 | IC72 | 7495 | IC122 | 7495 |
| IC24 | 7400 | IC73 | 7495 | IC123 | 7420 |
| IC25 | 7400 | IC74 | 7430 | IC124 | 7400 |
| IC26 | 7454 | IC75 | 7420 | IC125 | 7442 |
| IC27 | 7454 | IC76 | 7400 | IC126 | 7442 |
| IC28 | 7400 | IC77 | 7420 | IC127 | 7442 |
| IC29 | 7410 | IC78 | 7430 | IC128 | 7442 |
| IC30 | 7400 | IC79 | 7410 | IC129 | 7400 |
| IC31 | 7400 | IC80 | 7416 | IC130 | 7474 |
| IC32 | 7454 | IC81 | 7495 | IC131 | 7474 |
| IC33 | 7400 | IC82 | 7495 | IC132 | 7474 |
| IC34 | 7454 | IC83 | 7410 | | |
| IC35 | 7400 | IC84 | 7454 | | |
| IC36 | 7410 | IC85 | 7400 | | |
| IC37 | 7410 | IC86 | 7400 | | |
| IC38 | 7400 | IC87 | 7400 | | |
| IC39 | 7486 | IC88 | 7430 | | |
| IC40 | 7400 | IC89 | 7430 | | |
| IC41 | 7400 | IC90 | 7474 | | |
| IC42 | 7495 | IC91 | 7400 | | |
| IC43 | 7486 | IC92 | 7400 | | |
| IC44 | 7410 | IC93 | 7454 | | |
| IC45 | 7400 | IC94 | 7420 | | |
| IC46 | 7404 | IC95 | 7400 | | |
| IC47 | 7400 | IC96 | 7430 | | |
| IC48 | 7400 | IC97 | 7430 | | |
| IC49 | 7474 | IC98 | 7400 | | |
| | | IC99 | 7400 | | |

**Resistors:**

| | |
|---|---|
| R1 | 1.0k |
| R2 | 1.0k |
| R3 | 3.0k |
| R4 | 3.0k |
| R5 | 3.0k |
| R6 | 3.0k |
| R7 | 270 |
| R8 | 220 |
| R9 | 1.0k |
| R10 | 120 |
| R11 | 1.0k |
| R12 | 120 |
| R13 | 220 |
| R14 | 270 |
| R15 | 1k |
| R16 | N/A |
| R17 | 1.0k |
| R18 | 120 |
| R19 | 120 |
| R20 | 1.0k |
| R21 | 270 |
| R22 | 270 |
| R23 | N/A |
| R24 | N/A |
| R25 | 68 |
| R26 | 68 |
| R27 | 1.0k |
| R28 | 1.0k |
| R29 | 1.0k |
| R30 | 1.0k |
| R31 | 1.0k |
| R32 | 1.0k |
| R33 | 1.0k |
| R34 | 1.0k |
| R35 | 1.0k |
| R36 | 1.0k |
| R37 | 1.0k |
| R38 | 1.0k |
| R39 | 1.0k |
| R40 | 1.0k |
| R41 | 1.0k |
| R42 | 1.0k |
| R43 | 1.0k |
| R44 | 1.0k |
| R45 | 1.0k |
| R46 | 1.0k |
| R47 | 56 2W |

***Color Codes:***

| | |
|---|---|
| 1k | Brown-Black-Red |
| 3k | Orange-Black-Red |
| 270 | Red-Violet-Brown |
| 220 | Red-Red-Brown |
| 120 | Brown-Red-Brown |
| 68 | Blue-Grey-Black |
| 56 | Green-Blue-Black |

**Capacitors:**

| | |
|---|---|
| C1 | 100u100v |
| | or 0.1u |
| C2 | 0.1u |
| C3 | 0.1u |
| C4 | 100u25v |
| | or 0.1u |
| C5 | 0.1u |
| C6 | 0.1u |
| C7 | 0.1u |
| C8 | 0.1u |
| C9 | 100u25v |
| | or 0.1u |
| C10 | 100u100v |
| C11 | 0.1u |
| C12 | 0.1u |
| C13 | 0.1u |
| C14 | 100u100v |
| | or 33u50v |
| C15 | 100u100v |
| | or 100u50v |
| | or 0.1u |
| C16 | ~6800p |
| C17 | ~6800p |
| C18 | 0.0015u |
| | or 0.001u |
| C19 | 0.0015u |
| | or 0.001u |
| C20 | 0.1u |
| C21 | 0.1u |
| C22 | 0.1u |

**Diodes:**

| | |
|---|---|
| D1 | 1N914 |
| D2 | 1N914 |
| D3 | 1N914 |
| D4 | 1N914 |
| D5 | 1N914 |
| D6 | 1N914 |
| D7 | 1N914 |
| D8 | 1N914 |
| D9 | 1N4733 |

**Transistors:**

| | |
|---|---|
| Q1 | 2N4401 |
| Q2 | MPS3702 |
| Q3 | 2N4401 |
| Q4 | 2N4401 |
| Q5 | 2N4401 |
| Q6 | MPS3702 |
| Q7 | 2N4401 |
| Q8 | 2N4401 |

**Miscellaneous:**

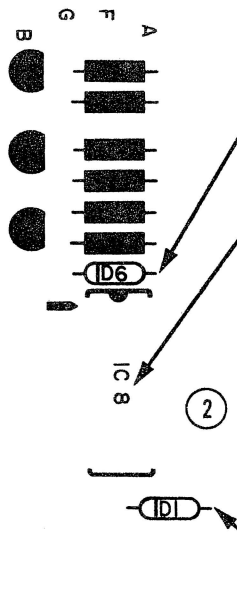
| | |
|---|---|
| 1x1 | LAMP +5v |
| 1x1 | SWITCH Gnd |
| 1x14 | LAMP |
| 1x8 | SW1 |
| 1x8 | SW2 |
| J1 | JUMPER WIRE |

# MITS KITS ASSEMBLY HINTS

These assembly hints have been designed to assist the novice kit builder with the assembly of a MITS kit and to give the "old pro" some helpful hints as well as some important warnings. MITS kits are of the highest quality and offer only the finest components, pre-drilled printed circuit boards and detailed instructions to the purchaser. These hints will give the beginner valuable instructions on soldering which is the most critical aspect of kit building. Information on necessary tools and component orientation will also be included with the assembly hints.

## ASSEMBLY MANUAL

Each MITS assembly manual consists of step-by-step assembly instructions (1) and illustrations (2) along with operating instructions and a theory of operation. It is quite important to follow the assembly instructions in the order presented in the manual. Taking what you think is a shortcut may prove to be a mistake later in the process. You should read each step, including any accompanying warnings or notes (3) , before beginning the work. If the instruction refers to any illustration look at it carefully before beginning the assembly procedure. After you have performed the work step, check it off in the space provided (4) .




(2)

( ) Install the 89-0438 zener diode (D6). Make sure the band on one end of the diode matches the printed marking on the circuit board. (1)

(4)

( ) Install the 16 pin integrated circuit socket at IC8. If necessary, straighten anypins which may be bent before inserting them into the board.

(3) NOTE: Make sure the number 1 pin on the socket is inserted in the proper position, as indicated by the arrow.

( ) Invert the board and solder each pin to the foil.

NOTE: To solder the pins, place the tip of the iron on one side of a pin for a second or two. Then touch a length of solder to the other side. The solder will flow neatly around the pin and surrounding foil.

Install the 14 pin sockets at IC9, 10, 11, and 12 in a similar manner.

## PRINTED CIRCUIT BOARD

At the core of each MITS kit is at least one pre-drilled, fiberglass circuit board. These circuit boards are printed on both sides and have plated-through connecting holes. This cuts down on the number of jumper wires necessary which, of course, allows the use of smaller boards. The plated-through holes also mean better solder connections. Each circuit board is silk-screened on one side, so component designation/locations are clearly marked. Special orientations are also marked on the board, i.e., a band indicating negative polarity of diodes.

## ELECTRONIC COMPONENTS

Various electronic components -- resistors, transistors, diodes, capacitors, and integrated circuit sockets -- are soldered to the circuit board. Most of these components have identifying numbers or values which simplify their installation. When necessary, these identifying marks are called out specifically in the assembly manual. You should always note them carefully.

Resistors are quite special ... each resistor has a specific value in ohms and this is denoted by colored bands around one end of the component. The chart below represents the color coding for resistors. The first two bands (nearest the end of the resistor) correspond to the first two digits of the resistor's value in ohms. The third band indicates the multiplier, and the fourth band represents the tolerance. For example, a resistor with red, violet, yellow, and silver bands has a value of 270,000 ohms and a tolerance of 10%. By looking at the chart below, you see that red is 2 and violet 7. By multiplying 27 by the yellow multiplier band (10,000), you find you have a 270,000 ohm (270K) resistor. The silver band denotes the 10% tolerance. When the manual calls for the installation of a 270KΩ resistor, this process is the way the correct resistor is chosen.

| COLOR | 1st BAND | 2nd BAND | 3rd BAND (Multiplier) |
|---|---|---|---|
| BLACK | 0 | 0 | 1 |
| BROWN | 1 | 1 | 10 |
| RED | 2 | 2 | 100 |
| ORANGE | 3 | 3 | 1,000 |
| YELLOW | 4 | 4 | 10,000 |
| GREEN | 5 | 5 | 100,000 |
| BLUE | 6 | 6 | 1,000,000 |
| VIOLET | 7 | 7 | 10,000,000 |
| GRAY | 8 | 8 | 100,000,000 |
| WHITE | 9 | 9 | 1,000,000,000 |

Tolerance (4th band): gold — 5%; silver — 10%
none — 20%

Capacitors also come in several sizes and shapes; each manual will call out the type of capacitor used, as well as its value, for easy identification.

## TOOLS

The tools necessary for kit building are few but extremely important. A pair of needle-nosed pliers is essential for bending component leads and other mechanical chores, as is a pair of diagonal cutters for cutting leads and trimming newly soldered components. Both instruments should have insulated handles, for comfort and to prevent shorting of the electrical components. An assortment of screw-drivers is also necessary. Both standard blade and phillips 1/8 inch and 3/16 inch tools are most useful. Other tools that are helpful include blunt-nosed pliers, a ruler, a set of nut drivers, and wire strippers (the inexpensive variety).

The right soldering iron is a key to successful kit building. You must use a 25-30 watt iron for all printed circuit assemblies. The soldering tip should be chisel-shaped. The delicacy and size of printed circuit boards precludes using a blunt-tipped iron. MITS recommends an Ungar 776 body with a 533 heating element. The 7155 chisel shaped tip is ideal for printed circuit work. These can be purchased at most electronic parts stores.

### WARNING

DO NOT USE A SOLDERING GUN OR HIGH WATTAGE IRON WHEN SOLDERING COMPONENTS TO A PRINTED CIRCUIT BOARD. EITHER MAY CAUSE DAMAGE TO BOTH THE BOARD AND THE COMPONENTS . . . AND WILL VOID YOUR WARRANTY.

## TINNING

New soldering irons must be properly tinned before they can be used. Tinning is the application of a thin layer of solder to the iron's tip to discourage oxidation and to facilitate good heat transfer from the iron to the solder connection.

Tin the new tip as follows: plug in the iron's cord and wait for the tip to become hot enough to melt solder (approximately 60 to 90 seconds). Then apply a generous amount of solder to the tip. Wait a few minutes and then repeat the procedure. Wipe off any excess solder on a damp sponge. The tip should have a shiny appearance which means it's ready for soldering.

To ensure continued good soldering and an extended life for the soldering iron, you must keep the iron well-tinned by applying a coat of solder when it is heated, but not in use. While using the iron you need to remove excess solder and any foreign material by wiping the tip of the iron on a damp sponge. Keep the heated tip away from wood, plastic, or other materials which can leave deposits and ruin the tinning.

It is important to use the right kind of solder. We recommend Weller, Ersin, or Kester rosin cored solder with a .025-.030 inch diameter. Any electronic parts store should carry these or comparable brands if you find that the solder length supplied with the kit is not enough.

ABSOLUTELY DO NOT USE ACID CORE SOLDER! SINCE ACID CORE SOLDER INVARIABLY CAUSES PERMANENT DAMAGE TO PRINTED CIRCUIT BOARDS AND ELECTRONIC COMPONENTS, ITS USE AUTOMATICALLY VOIDS THE MITS KIT WARRANTY.

## SOLDERING

The purpose of soldering is to join two or more electrically conducting wires or components with a hard metallic bond which provides both mechanical strength and a low-resistance electrical path. This is the most significant aspect of kit building since the majority of problems in the completed unit can be traced to improper soldering. If you are a beginner or have had little soldering experience, you should read these instructions carefully.

Most of the soldering required for the assembly of MITS kits involves attaching electronic components to printed circuit boards. The board has specially laid out plated-copper wiring patterns called lands which join various components and/or wires. There are holes at various locations on the lands where the components are inserted. If the circuit boards have lands on both sides (and most MITS boards do), the holes are plated through, so it is only necessary to solder on one side of the board.

If you will follow a few simple procedures, soldering should not be a problem. The basic steps are summarized in the following text.

First, insert the component leads into the appropriate holes on the board (determined by consulting the assembly manual) so that the component rests flat against the board. In most cases the component is on the silk-screened side of the board and soldering is done on the foil side. The assembly manual will call out any exceptions to this. The leads of resistors, diodes, and capacitors must be bent at right angles so the proper fit can be achieved. It is a good idea to look at the space where the component goes so you can bend the leads at the right place. If the lead flexes while it is being inserted, it is best to take the component out, straighten the lead completely and then bend it at right angles again. Except in cases where the fit is critical, each component is soldered as it is inserted in the board. The assembly manual will spell out specific instances where several components are installed before any are soldered.

After the component is inserted and has been double-checked for any special orientation or identification, the board should be turned over so that the component will remain in place while it is being soldered. Then check that the area to be soldered is clean; any foreign substances will keep the solder connection from being a good one. Next, touch the heated tip of the soldering iron to the component lead and the adjoining plated-copper land. After several seconds touch the length of solder to the heated lead and allow a small amount of solder to flow over and around the lead so that a smooth bond is formed. Only a second or two is needed for the correct amount of solder to flow. It is important not to get too much solder but at the same time you should check to see that the plated-through hole is filled and the solder has flowed through to the other side of the circuit board.

The solder connection should be shiny and smooth. If the circuit board or the component is moved while the solder is cooling, the connection may be dull or crystalline in appearance. This means it is a poor connection, a "cold solder joint." You should remelt the old solder and wipe it off; then use fresh solder to mount the component. When the connection is cool, use the wire cutters to clip the lead off, close to the connection.

## SOLDERING TIPS AND HINTS

When soldering you must be careful not to use so much solder that a "bridge" is formed across adjacent lands. If such a bridge should occur, remove it by applying heat on one of the lands it is across and wiping the molten solder away with a small stiff brush or a dry cloth. A good brush can be made by trimming the bristles on a small paint brush to about a quarter of an inch.

Don't heat any portion of the circuit board for more than a few seconds or you will risk having the lands separate from the board. Sometimes it may be necessary to remove a component that is soldered incorrectly to the board. This "un-soldering" procedure applies stress to the plated-copper lands and should be done quite carefully. You must heat the soldered connections one at a time and gently rock the component back and forth while pulling upward until the lead pulls free from the board.

After the component is pulled out, the molten solder will quickly fill up the hole. It will have to be removed so that the proper component can be inserted. To accomplish this, heat the solder and gently insert a wooden toothpick into the hole (while the solder is flowing). Do not twist

or pry with the toothpick; simply remove it when the solder is cooled and the obstruction will be removed too. If the plated-through hole comes out with the solder, you must make sure that the new components inserted into that hole are soldered on both sides of the board so that all the necessary electrical connections are made.

Since it obviously is somewhat difficult to "unsolder" components, it pays to double-check the components for proper orientation and identification before soldering them to the board.

## SERVICE

MITS offers a variety of services to its customers. For example, if you have difficulty in assembling your kit or if you have some technical question that is not answered in the assembly manual, we invite you to write to our technical services or engineering departments and they will be happy to give you any help they can. You should provide a detailed description of the problem and any other information which will assist them in preparing a reply. If the problem is with operating an assembled kit, be sure to describe switch positions and operating conditions along with a precise summary of the difficulty.

MITS maintains a complete parts department, so if you need a replacement part you should be able to get it within a few days. Your kit contains a complete parts/price list and order form. When ordering parts be sure to include the following information:

your name and address
the model and serial number of your kit
the part number
description of the part

The minimum parts order is $2.00.

Consult the Service section of your assembly manual for details on warranty and repair.

# ASSEMBLY HINTS

Before beginning the construction of your unit, it is important that you read the "Kit Assembly Hints" booklet. Pay particular attention to the section on soldering because most problems in the ALTAIR occur as the result of poor soldering. Failure to heed the warnings in the "Kit Assembly Hints" booklet may cause you to void your warranty.

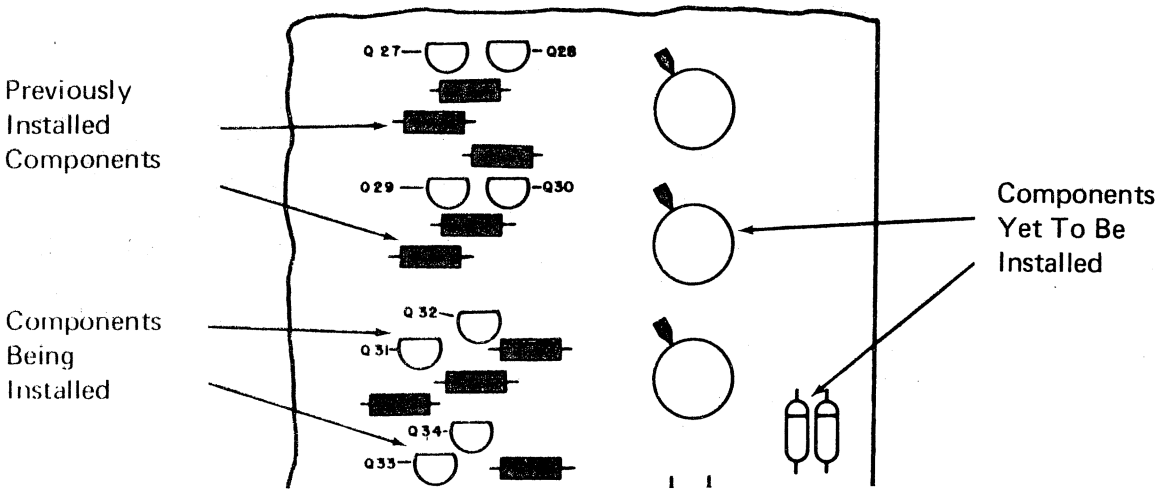
The type of soldering iron used is critical. Use a 30-40 watt iron with a chisel tip, such as an Ungar 776 with a 7155 tip. The delicate soldering necessary for this unit precludes using a blunt-tipped iron.

Each component should be installed in the order presented in the assembly instructions. Each component must be placed in its correct position on the board. There are drawings throughout the assembly instructions which will aid you in installing the components correctly. Some components (diodes, integrated circuits, some capacitors, and transistors) have special orientations on the board. These special orientations are called out in the assembly instructions; it is important that you note them carefully before installing the components.

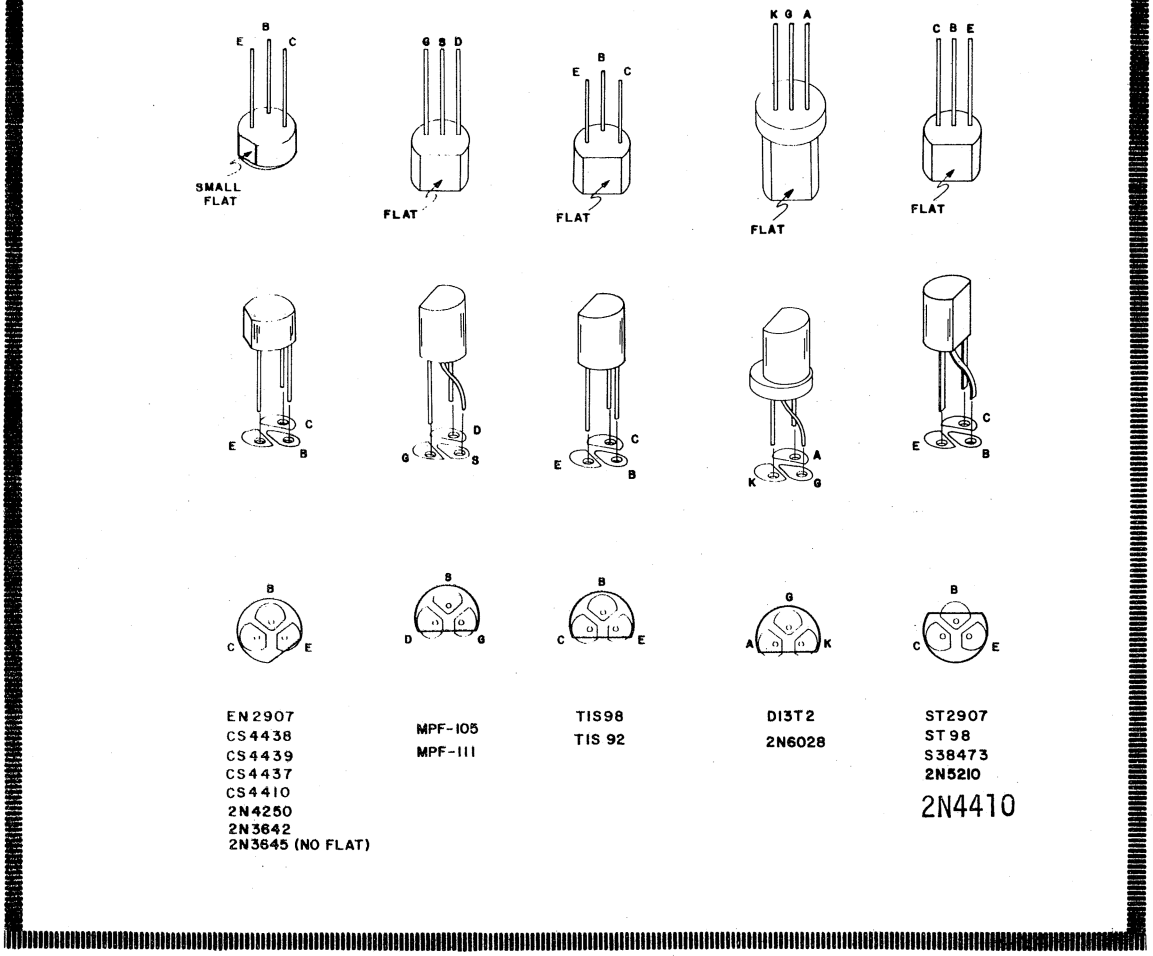
After a component has been soldered to the board, check it off in the space provided on the page. Before going on to a new page, check to make sure all the components on that page have been installed.

Check the contents of your kit against the enclosed parts list to make sure you have all the required components, hardware and parts. The components are in plastic envelopes; do not open them until you need the components for an assembly step. You will need the tools called for in the "Kit Assembly Hints" booklet.

To assist you in assembling your unit, a coding system is used to identify the components already installed, components being installed, and components to be installed later. Compare each page with your circuit board to ensure that all components are installed before going on to a new page.



# TRANSISTOR IDENTIFICATION CHART



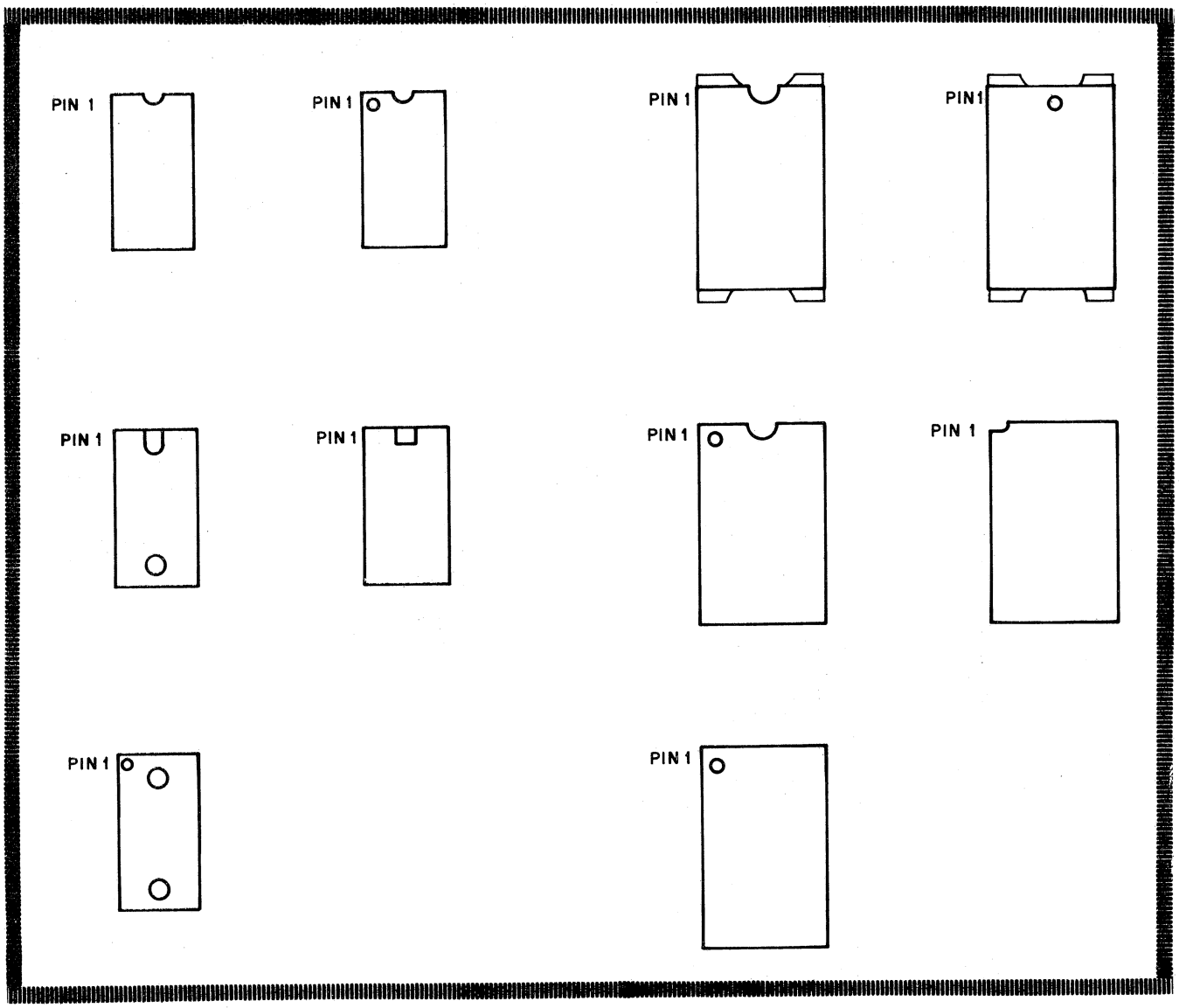

IN THE ILLUSTRATION ABOVE THE OUTLINE OF EACH TYPE OF TRANSISTOR IS SHOWN OVER THE PADS ON THE CIRCUIT BOARD WITH THE CORRECT DESIGNATION FOR EACH OF THE THREE LEADS. USE THIS INFORMATION TOGETHER WITH THE INFORMATION IN THE ASSEMBLY MANUAL FOR THE CORRECT ORIENTATION OF THE TRANSISTORS AS YOU INSTALL THEM.

THE FOLLOWING IS A LIST OF POSSIBLE SUBSTITUTIONS; IF ANY OTHERS ARE USED YOU WILL RISK DAMAGING YOUR UNIT:

2N4410 = CS4410 = CS4437, CS4438, TIS98, ST98, S38473 (NPN)
EN2907 = ST2907, CS4439 (PNP)

FOR SUBSTITUTIONS REFER TO THE INFORMATION ABOVE TO DETERMINE THE CORRECT ORIENTATION FOR THE THREE LEADS.

## IC ORIENTATION CHART




INTEGRATED CIRCUITS (IC's) CAN COME WITH ANY ONE OF, OR A COMBINATION OF, SEVERAL DIFFERENT MARKINGS. THESE MARKINGS ARE VERY IMPORTANT IN DETERMINING THE CORRECT ORIENTATION FOR INSTALLATION. REFER TO THE ABOVE DRAWING TO DETERMINE THE POSITION OF PIN 1 OF THE IC AND USE THIS INFORMATION TO ORIENT IT AS DESCRIBED IN THE ASSEMBLY MANUAL.

WARNING: IF THE IC's ARE NOT PROPERLY ORIENTED DURING INSTALLATION, IT MAY RESULT IN PERMANENT DAMAGE TO YOUR UNIT.

## MOS IC SPECIAL HANDLING PRECAUTIONS

There are several MOS integrated circuits contained in this kit. These IC's are very sensitive to static electricity and transient voltages. In order to prevent damaging these components, read over the following precautions and adhere to them as closely as possible. FAILURE TO DO SO MAY RESULT IN PERMANENT DAMAGE TO THE IC.

1) All equipment (soldering iron, tools, solder, etc.) should be at the same potential as the PC board, the assembler, the work surface and the IC itself along with its container. This can be accomplished by continuous physical contact with the work surface, the components, and everything else involved in the operation.

2) When handling the IC, develop the habit of first touching the conductive container in which it is stored before touching the IC itself.

3) If the IC has to be moved from one container to another, touch both containers before doing so.

4) Do not wear clothing which will build up static charges. Preferably wear clothing made of cotton rather than wool or synthetic fibers.

5) Always touch the PC board before touching the IC to the board. Try to maintain this contact as much as possible while installing the IC.

6) Handle the IC by the edges. Avoid touching the pins themselves as much as possible.

7) Dry air moving over plastic can build up considerable static charges. Avoid placing the IC near any such area or object.

8) In general, never touch anything to the IC that you have not touched first while touching both it and the IC itself.