PAIA ELECTRONICS, INC.

# (P) 8782A

# DIGITALLY ENCODED KEYBOARD

An n key roll-over, scanning matrix encoder tied to a 37 note AGO keyboard provides 6 bits of data and both STROBE and $\overline{\text{STROBE}}$ control outputs. Input control lines to the encoder include SCAN (starts and stops encoder clock), RESET, START and RANDOM making the keyboard universally applicable to all computer/processors from the very largest to the very smallest. Additional instructions guide in retro-fitting the PAIA 8700 computer for a fully developed intelligent musical keyboard system.

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# INTRODUCTION

The (P)8782A manual is a comprehensive instruction set to be used when assembling the PAIA Digitally Encoded Keyboard in any of its configurations. The three basic types of products this manual covers are:

1) The PAIA 8782A - a basic digitally encoded keyboard for use as a monotonic controller in conjunction with the PAIA 8780 D/A Converter, or for use in polyphonic systems using external computers.
2) The PAIA P/8782A - an intelligent digitally encoded keyboard which includes an integral PAIA 8700 computer for direct interface to a PAIA 8780 D/A Converter and up to four 8781 Quad output modules.
3) As a retrofitting guide for those who purchase the PAIA 8700 Computer for installation into an existing 8782, 8782A, or other keyboards which have been converted to digital encoding through the use of the PAIA EK-3.

Immediately following each section heading, instructions will be given to indicate whether you should use that particular section for the system you are assembling, or jump to the following section. If you are using this manual for a retrofitting guide, all retrofitting instructions are outlined at the rear of this manual. Refer first to this section. The retrofitting section will then refer to various sections of the manual for assembly steps.

Throughout this manual, any steps involving the 8700 computer, PS-87 Power supply, or CS-87 Cassette Interface assume that these kits have been assembled and tested as outlined in their respective manuals. If you have not assembled these kits yet, do so before proceeding with assembly of the keyboard. If you are building only the keyboard (8782A) you may proceed with the case assembly section.

# PARTS LISTS

Prior to beginning assembly, check the supplied parts against the following parts lists. If you should find any parts missing, damaged, or otherwise unusable, contact PAIA Tech Services for replacement. Along with your request for replacements, we must have the packer number from the parts bag, and the order number under which this kit was shipped.

8782 PC bag ( provided with all kits)

One each:

8782A printed circuit board
40" length of foam tape
CD4024 IC (do not remove from protective foam)
vinyl handle strap with metal insert
4 feet bare wire
2.7K ohm resistor (red-violet-red)
470 ohm resistor (yellow-violet-brown)
.01 mfd. capacitor
bag of 56 #4 X 3/8" self tap screws
bag of 38 1N914 or 1N4148 diodes
.005 mfd. capacitor
.05 mfd. capacitor
9 lug terminal strip
14 pin IC socket
#4-40 X 1/4" machine screw

#4 lockwasher
#4-40 nut
bundle of 4 X 17 feet insulated hookup wire

Two each:
male long pin slip hinges
male short pin slip hinges
handle end caps
10K resistors (brown-black-orange)
CD4001 IC (in protective foam)
#8 X 1 inch plated flathead machine screw
3/16 inch flat washers
CD4051 IC (in protective foam)
2.2 mfd., 10 volt (or greater) electrolytic capacitor

Three each:
150K resistor (brown-green-yellow)

Four each:
1/4 inch spacer
#8 nut
wire ties
#8 X 1 inch dark flathead machine screws
#8 lockwashers
latch sets ( two pieces each)
female slip hinge sections
#4 X 3/4 inch self tap screws

Eight each:
corners
rubber feet

8782FP Bag (provided only with 8782A kits)

One each:
8782 front panel
line cord
12 volt center tapped transformer
500K potentiometer
9 lug terminal strip
#6 flat washer
cable clamp
SPDT slide switch
DPDT 3 position slide switch
220 mfd., 10 volt (or greater) electrolytic capacitor
push-on knob
.22 mfd. mylar capacitor
mated DB-25 plug and socket
DB-25 plastic hood
14 pin DIP plug
vinyl covered plywood panel

Two each:
Mini SPST pushbutton switches
3/8 inch potentiometer nuts
1N4001 diodes

Four each:
#4 X 3/4 inch self tap screws

Six each:

#4 X 3/8 inch self tap screws
#4-40 X 1/4 inch machine screw
#4 lockwasher
#4-40 nut

8700 HDW bag (provided only with P8782A kits)

One each:

metal mounting bezel
mated DB-25 plug and socket
DB-25 plastic hood
14 pin IC socket
14 pin jumper cable
bundle of 4 X 24 ft. hookup wire
24" length of co-ax cable

Two each:

14 pin DIP plug
mini-phone jacks
#4-40 X 1/4 inch machine screws
#4 lockwashers

Four each:

#4 X 3/8 inch self tap screws
#4 flat washers

Six each:

#4-40 nuts

## MASTER PACKING

The 8782A kit should contain one each : 8782 PC bag, 8782 FP bag, this manual, 3 piece case, AGO-37A keyboard ( do not unwrap until called for in the instructions).

The P8782A kit will contain one each: 8782 PC bag, 8700 HDW bag, three piece case, AGO-37A keyboard (do not unwrap until called for), this manual, 8700 computer, PS-87 power supply, CS-87 cassette option, RAM bag.

## SOLDERING

Use care when mounting all components. Use only rosin core solder (acid core solder is never used in electronics work.) A proper solder joint has just enough solder to cover the round soldering pad and about 1/16-inch of the lead passing through it. There are two improper connections to beware of: Using too little solder will sometimes result in a connection which appears to be soldered but actually there is a layer of flux insulating the component lead from the solder bead. This situation can be cured by reheating the joint and applying more solder. If too much solder is used there is the danger that a conducting bridge of excess solder will flow between adjacent circuit board conductors forming a short circuit. Unintentional solder bridges can be cleaned off by holding the board upside down and flowing the excess solder off onto a clean hot soldering iron.

Select a soldering iron with a small tip and a power rating not more than 35 watts. Soldering guns are completely unacceptable for assembling transistorized equipment because the large magnetic field they generate can damage solid state components.

## CASE ASSEMBLY

(THIS SECTION APPLIES TO ALL KITS)

Parts for this section are contained in the 8782 PC bag.

In the following steps, refer to the case blow-up (figure 1) for determination of proper parts placement. A 1/16-inch drill will be helpful in producing pilot holes for any screws which go into the wooden case structure.

( ) Locate the 8782 case bottom, which is the largest wooden structure. Prepare the four corners by using a sharp knife to cut the point from the corner. (See figure 1.) This will allow the metal corners to mount flush with all case sides in the next step.

( ) Install four metal corners on the 8782 case bottom, using twelve #4 X 3/8" screws. NOTE that the four screws used to mount the corners to the BOTTOM SURFACE are also used to mount four rubber feet. ALSO NOTE that the two screws used to mount the corners to the REAR SURFACE will hold two rubber feet. The rear of the case is the longest edge which does not have additional wooden mounting structures next to it. (See figures 1 and 6).

( ) Select the top rear case section, which we will call the "electronics cover". The electronics cover is the wider of the two remaining case sections on which the front lip is built up to a thickness of one inch (2.54 cm) rather than 1/2-inch (1.26 cm).

( ) Prepare the electronics cover by trimming the points from the two REAR corners.

( ) Using six #4 X 3/8" metal screws, mount two metal corners on the electronics cover where the corners have been trimmed. NOTE that the two screws used to mount the corners to the REAR case surface are also used to mount two rubber feet.

( ) Locate the remaining case section, which will be called the "keyboard cover". Prepare the two front corners of the keyboard cover by trimming the points from the corners.

( ) Mount two metal corners over the trimmed corners of the keyboard cover. Use six #4 X 3/8" screws to mount this hardware.

( ) Place the two upper case sections on a sturdy work surface with the edges butted together. Using eight #4 X 3/8" screws, install two slip hinge assemblies 3" (7.62 cm) in from each side. Note that one assembly should use a hinge with a long pin, the other a hinge with a short pin. Both pin sections hould be mounted to the keyboard cover. Both sleeve sections should be mounted to the electronics cover. The sleeve sections should be mounted first, with the sleeve itself being centered over the joint of the two case sections. The pin sections are then slipped into the sleeves and mounted to the keyboard cover. Make sure the front and rear case sections are properly aligned with one another during assembly.

( ) Place the upper case assembly on the lower case section, checking to make sure the rear surfaces (the ones with installed rubber feet) are together.

( ) Install two slip hinge assemblies on the rear surface of the case. As before, one hinge assembly should use a long pin and one should use a short pin. First, mount the sleeve sections on the lower case assembly. The sleeves should be centered over the joint of the upper and lower case sections. The hinges should be located 3" (7.62 cm) in from each side. Slip the pin sections into the sleeves and mount the pin sections to the rear of the electronics cover. Use eight #4 X 3/8" metal screws to mount this hardware. Make sure the case sections remain properly aligned during assembly. This will insure that the case will close properly when finished.

( ) Remove the upper case sections. Locate the two predrilled handle mounting holes which are 5/8" (1.6 cm) down from the top edge of the case front, and 11.5" (29.4 cm) in from each side. Cut the vinyl away from these holes and mount the handle assembly. Note that the handle consists of a metal strap with a rubber sleeve plus two end caps, all of which are mounted with two plated #8 X 1" flathead bolts, two #8 lockwashers, and two #8 nuts. Do not overtighten these nuts or the end caps will deform and restrict handle movement.

( ) Locate the line cord exit hole which is 1.5" (4 cm) from the outside edge of the rear left corner. This hole is centered on the joint of the upper and lower case sections. Using a sharp knife, slit the vinyl directly over the semicircular notches. The line cord can now exit from this point when the keyboard is in use.

( ) Slide the electronics cover into place on the case bottom assembly. Mount a latch assembly on each side, 1" (2.54 cm) back from the front edge of the electronics cover. Each latch assembly consists of two parts: the lower square section and the upper section which is the movable latch. Mount the lower latch section on the bottom case assembly so the top edge is even with the joint of the two case sections. Then mount the upper latch section on the electronics cover. Make the latch somewhat tight to avoid accidental unlatching. Use eight #4 X 3/8" screws to mount these latches.

( ) Slip the keyboard cover back onto the case and close the cover. Mount two latch assemblies on the front edge of the 8782 assembly. The latches should be 3" (7.62 cm) in from either side, and each should be mounted using four #4 X 3/8" metal screws. Mount the lower latch sections on the lower case section before mounting the spring latch to the keyboard cover section. Make these latches have a tight fit when opening and closing. This will help keep the keyboard from accidentally opening while it is being carried.

# POWER SUPPLY ASSEMBLY

(THIS SECTION APPLIED ONLY TO 8782A kits.
for "P" systems, proceed to "Keyboard Preparation".)

Parts for this section are contained in the 8782 FP bag.

( ) Open all latches and remove the top half of the case. With the bottom half of the case in front of you so you are looking at the case front, mark two points in the left rear section on the case bottom panel. Mark one point 2 inches ( 5 cm ) from the left side and 1-3/8 inches (3.5 cm) from the case back. Mark another point 4 inches ( 10 cm ) from the left side and 1-3/8 inches (3.5 cm) from the case back. These points should be made with reference to the inside edges of the case side and back. Use a 1/6 inch drill or awl to start the pilot holes at these points.

( ) Prepare the power transformer (T1) by cutting all five transformer leads to a length of 2" (5.1 cm). Prepare the leads by stripping 1/4" (7 mm) of insulation from the end and twisting the loose stranded wire together. Tin the leads by melting a small amount of solder into the exposed ends of the leads.

( ) Prepare the AC line cord by separating the two wires to a point 1" (2.54 cm) from the end of the line cord. Strip 1/4" (7 mm) of insulation from the end of each lead. Twist the exposed strands together before tinning each of the two leads.

( ) Locate the nylon cable clamp and place it around the AC line cord at a point 4" (10.2 cm) from the prepared end of the line cord.

( ) Using one #4 X 3/8" metal screw and one #6 flat washer, mount the clamp/line cord assembly and one end of the power transformer (T1) to the case bottom. Note the orientation of cable clamp, transformer, and leads as shown in power supply detail figure 2.

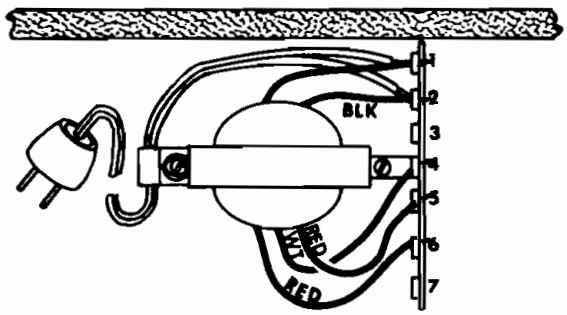



Figure 2

( ) Locate the 9-lug terminal strip. Using a pair of diagonal cutters, or other suitable tool, cut one terminal from each end of the strip. The terminal strip should now look like figure 3.

( ) Using one #4 X 3/8" metal screw, mount the previously prepared terminal strip and the remaining end of the power transformer (T1) as shown in figure 2.

( ) Connect one of the black transformer leads to lug #1 of the terminal strip. Do not solder at this time.

( ) Connect the remaining black transformer lead to lug #2 of the terminal strip. Do not solder.

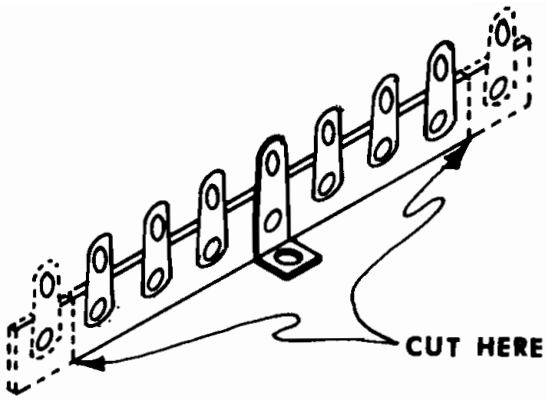



Figure 3

( ) Connect one lead of the AC line cord to lug #1 of the terminal strip. Solder two wires at this point.

( ) Connect the remaining lead of the AC line cord to lug #2 of the terminal strip. Solder two wires at this lug.

( ) Connect the center tap (middle lead) of the power transformer secondary to lug #4 of the terminal strip. This should be the lug which is part of the mounting bracket. Do not solder this connection at this time.

( ) Connect one of the outer secondary leads of T1 to lug #5 of the terminal strip. Do not solder at this time.

( ) Connect the remaining secondary lead to lug #6 of the terminal strip. Do not solder.

During the following component installation, refer to figure 4.

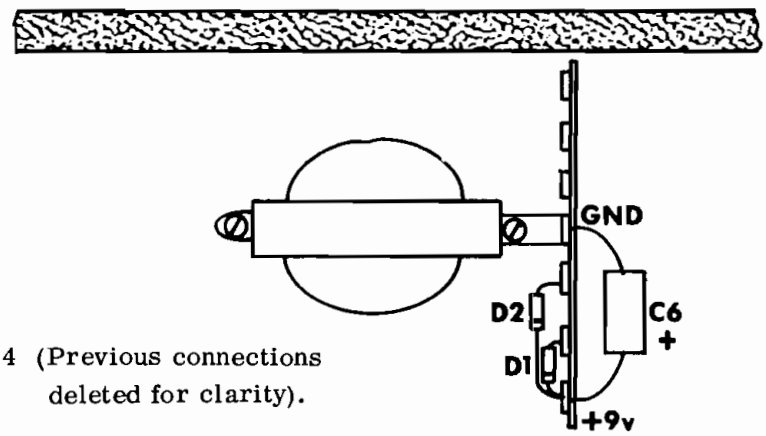



Figure 4 (Previous connections deleted for clarity).

( ) Clip each lead of C6 (220 mfd. or 250 mfd., 10 volts or higher) to a length of 3/4" (2 cm) from the body of the capacitor.

( ) Install C6 between lugs #4 and #7 of the terminal strip. Note that the positive lead of C6 must be connected to lug #7, while the negative lead goes to lug #4. Do not solder at this time.

( ) Prepare D1 (1N4003) by clipping each lead to a length of 1/2" (1.3 cm). Install D1 between lug #5 and lug #7, making sure the cathode (banded end) is connected to lug #7. Orient as shown and solder only the two connections at lug #5.

( ) Prepare D2 (1N4003) by clipping each lead to a length of 1/2" (1.3 cm). Install D2 between lugs #6 and #7, making sure the banded end is connected to lug #7. Orient as shown and solder only the two connections at lug #6.

( ) Using the wire supplied in the 8782 PC bag, cut a 6-1/2" (16.6 cm) length. Prepare this wire by first stripping 1/4" (7 mm) of insulation from each end, and then tightly twisting the exposed strands. "Tin" the stranded wire by flowing a small amount of solder into the strands. Connect this wire to lug 7 of the power supply terminal strip. Solder the four connections at this point.

( ) In a similar manner, cut and prepare another 6-1/2 inch (16.6 cm) length of wire. Connect this wire to lug 4 of the power supply terminal strip. Solder the three wires at this point.

This completes primary assembly of the 8782 case. Set this assembly aside while proceeding with following sections.

## KEYBOARD PREPARATION

(THIS SECTION APPLIES TO ALL KITS)

Parts for this section are contained in the 8782 PC bag.

( ) Locate the keyboard assembly and set it on your workspace upside down with the rear of the keyboard facing you.

( ) At the extreme left of the metal keyboard mainframe, note that there is a small hole which is approximately halfway between the front and rear edges of the mainframe. Using one #4-40 X 1/4 " machine screw, one #4 lockwasher and one #4-40 nut, mount the 9-lug terminal strip as shown in figure 5.

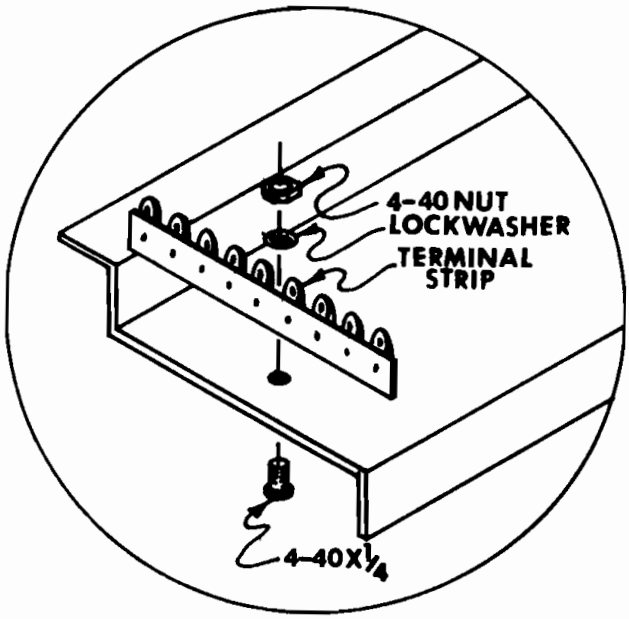



Figure 5

( ) Note that the rearmost gold buss rod on the keyboard has been divided into five sections, each separated by a small gap. In the following steps, these sections will be connected to the terminal strip. The lugs on the terminal strip are numbered 1 to 9 from the front of the keyboard (nearest the gold bus rods) to the rear of the keyboard ( nearest the row of 37 solder lugs on the keyboard).

( ) Cut a 2" (5.1 cm) length of the insulated wire provided. Prepare the wire by stripping 1/4" (7 mm) of insulation from each end. Twist and tin the exposed strands of wire. Using a pair of needlenose pliers, form a small U with the exposed wire at one end only. Hook this U over the extreme left end of the divided gold buss rod. See figure 7. Solder this connection. Use only enough solder to make a solid connection. Do not allow excess solder or rosin flux to flow around the area where the first keyspring contacts the buss rod. This condition will cause improper keyboard operation after completion. If rosin flux should flow down the buss rod, it can be removed with acetone or isopropyl alchohol and a cotton swab. Attention to detail and careful work while building the keyboard will reward you with trouble-free performance in the future.

( ) Connect the free end of the previously connected wire to lug #3 of the terminal strip. You may solder this connection, however solder the wire to the lower half of the solder lug hole. This will leave a space at the top of the lug where an additional wire can be added later.

( ) Cut and prepare (as before) a 7-1/2" (19.1 cm) length of insulated wire. Hook this wire over the second buss rod section just to the right of the third plastic support post from the left. Carefully solder this connection.

( ) Connect the free end of this wire to lug #4 of the terminal strip. As before, solder this connection leaving room for an additional wire to be added later.

( ) Cut and prepare a 13" (33 cm) length of wire. Hook this wire around the third buss rod section just to the right of the fifth plastic buss rod support. Carefully solder this connection.

( ) Connect the free end of this wire to lug #6 of the terminal strip. Solder.

( ) Cut and prepare a 19-1/2" (49.5 cm) length of insulated wire. Hook this wire around the fourth buss rod section just to the right of the seventh buss support post. Carefully solder.

( ) Connect the free end of this wire to lug #7 of the terminal strip. Solder.

( ) Cut and prepare a 24" (61 cm) length of wire. Hook this wire around the fifth buss rod section at the far right end of the keyboard. Solder.

( ) Connect the free end of this wire to lug #8 of the terminal strip. Solder.

( ) If you have not done so as you were working, carefully route the five previously installed wires through the space between the buss rod supports and the front flange of the keyboard mainframe. Check to make sure the wires do not inhibit the motion of any of the delicate keysprings.

( ) Using a nutdriver or pliers, remove the L-shaped mounting brackets on the rear edge of the keyboard mainframe. Turn the brackets around so the small foot is facing towards the front of the keyboard instead of the rear. Remount the brackets with the original metal screws.

( ) In the following steps, wires will be connected to the row of 37 solder lugs on the rear of the keyboard. Starting with the second solder terminal from the left, number the terminals 1 through 37, using a pencil or felt-tip pen.

( ) In each step, prepare the insulated wire as before, cutting it to length, stripping 1/4" of insulation from each end, and tinning the exposed strands. Using needle-nose pliers, bend a small "U" in the tinned portion of one end of the wire. This end will be looped around the terminal and soldered. It will be necessary to hold the wire carefully in place until the solder hardens. Be sure to rotate your wire colors.

( ) Solder a 17-1/2" (44.5 cm) length of wire to terminal 37.
( ) Solder a 17" (43.1 cm) length of wire to terminal 36.
( ) Solder a 16-1/2" (42 cm) length of wire to terminal 35.
( ) Solder a 16" (40.6 cm) length of wire to terminal 34.
( ) Solder a 15-1/2" ( 39.4 cm) length of wire to terminal 33.
( ) Solder a 15" (38.1 cm) length of wire to terminal 32.
( ) Solder a 14-1/2" (36.9 cm) length of wire to terminal 31.
( ) Solder a 14" (35.6 cm) length of wire to terminal 30.
( ) Solder a 13-1/2" (34.5 cm) length of wire to terminal 29.
( ) Solder a 13" (33 cm) length of wire to terminal 28.
( ) Solder a 12-1/2" (31.8 cm) length of wire to terminal 27.
( ) Solder a 12" (30.5 cm) length of wire to terminal 26.
( ) Solder an 11-1/2" (29.3 cm) length of wire to terminal 25.
( ) Solder an 11" (28 cm) length of wire to terminal 24.
( ) Solder a 10-1/2" (26.7 cm) length of wire to terminal 23.
( ) Solder a 10-1/2" (26.7 cm) length of wire to terminal 22.
( ) Solder a 10-1/2" (26.7 cm) length of wire to terminal 21.
( ) Solder a 10" (25.4 cm) length of wire to terminal 20.
( ) Solder a 9-1/2" (24.2 cm) length of wire to terminal 19.
( ) Solder a 9" (22.9 cm) length of wire to terminal 18.
( ) Solder an 8-1/2" (21.6 cm) length of wire to terminal 17.
( ) Solder an 8" (20.4 cm) length of wire to terminal 16.
( ) Solder a 7-1/2" (19.1 cm) length of wire to terminal 15.
( ) Solder a 7" (17.8 cm) length of wire to terminal 14.
( ) Solder a 7" (17.8 cm) length of wire to terminal 13.
( ) Solder a 6-1/2" (16.7 cm) length of wire to terminal 12.
( ) Solder a 6" (15.3 cm) length of wire to terminal 11.
( ) Solder a 5-1/2" (14 cm) length of wire to terminal 10.
( ) Solder a 5" (12.7 cm) length of wire to terminal 9.
( ) Solder a 5" (12.7 cm) length of wire to terminal 8.
( ) Solder a 4-1/2" (11.4 cm) length of wire to terminal 7.
( ) Solder a 4-1/2" (11.4 cm) length of wire to terminal 6.
( ) Solder a 4" (10.2 cm) length of wire to terminal 5.
( ) Solder a 4" (10.2 cm) length of wire to terminal 4.
( ) Solder a 4" (10.2 cm) length of wire to terminal 3.
( ) Solder a 4" (10.2 cm) length of wire to terminal 2.
( ) Solder a 4" (10.2 cm) length of wire to terminal 1.

Note that the terminal on the extreme left end of the keyboard is left unconnected. This completes the keyboard preparation

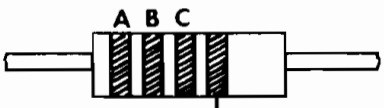
Double check your keyboard. It should have all buss rod sections connected to the left terminal strip. All but the leftmost terminal should have a wire connected to it. If your keyboard looks like this — proceed.

## CIRCUIT BOARD ASSEMBLY

(THIS SECTION APPLIES TO ALL KITS)

Parts contained in the 8782 PC bag.

( ) Prepare the circuit board for assembly by thoroughly cleaning the conductor side with a scouring cleanser or soapy steel wool pad. Rinse the board with clear water and dry completely. Solder each of the resistors in place following the parts placement designators printed on the circuit board and shown in parts placement figure 8. Note that the resistors are non-polarized and may be mounted with either of their two leads in either of the holes provided. Cinch the reistors in place prior to soldering by putting their leads through the holes and pushing the resistor firmly against the board. On the conductor side of the board, bend the leads outward to about a 45° angle. Clip off the excess lead flush with the solder joint after the part has been soldered in place.




Silver or gold - disregard this band.

| DESIGNATION | VALUE | COLOR CODE A-B-C |
|---|---|---|
| ( ) R1 | 10K | brown-black-orange |
| ( ) R2 | 150K | brown-green-yellow |
| ( ) R3 | 150K | brown-green-yellow |
| ( ) R4 | 2700 ohm | red-violet-red |
| ( ) R5 | 10K | brown-black-orange |
| ( ) R6 | 150K | brown-green-yellow |
| ( ) R7 | 470 ohm | yellow-violet-brown |

( ) Using the bare wire provided, form and install the 25 jumper wires as indicated by the solid lines in figure 8 and on the circuit board.

SPECIAL JUMPERS

On the 8782A circuit board, note that there are four dotted lines indicating special jumpers. Decide which jumpers need to be installed to allow the 8782A to work with your particular system.

The short jumper directly above pin "RST" of the I/O socket is used to allow external reset of the scan counter. This feature is not required for the PAIA system, with OR without the computer. You will need to install this jumper only if you wish to use the feature in conjunction with other types of microprocessor systems.

The dotted jumper directly above points "A", "B", and "$\overline{\text{RND}}$" is used to allow access to the $\overline{\text{SCAN}}$ signal at pin 1 of the I/O socket. The slightly shorter jumper above the $\overline{\text{SCAN}}$ jumper is used to allow access to the $\overline{\text{STROBE}}$ signal at pin 2 of the I/O socket. If you are using the 8782 keyboard with only the 8780 D/A Converter, you will need to install these two jumpers. For keyboards which will be interfaced with the PAIA computer, do not install these jumpers. For keyboards which will be interfaced with other types of micro-processors, you may or may not need the jumpers depending on the features you will need for interfacing with your computer.

The remaining short jumper near IC4 labeled "TEMPO" must be installed in one of two ways. The scanning clock for the keyboard encoder is used as a "master" clock for much of the software in the PAIA system, including timing for sequencing and various types of playback for music stored in memory. By installing a wire jumper at this position, all your computer timing changes will need to be done with software changes. Alternatively, you could install two wires at the "TEMPO" jumper holes with sufficient length to reach the front panel of the keyboard system. Connect each wire to a potentiometer with a value between 10K and 100K. This will allow an analog means of altering the timing reference for the computer operations.

( ) Install Special jumpers as selected.

Install the ceramic disk capacitors. The values will be marked on the body of the component.

| DESIGNATION | VALUE |
|---|---|
| ( ) C1 | .005 mfd. |
| ( ) C2 | .01 mfd. |
| ( ) C5 | .05 mfd. |

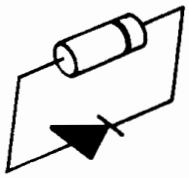
Up to this point all components have been non-polarized and either lead could be placed in either of the holes provided without affecting the operation of the unit. Electrolytic capacitors are polarized and must be mounted so that the "plus" lead of the capacitor goes through the "plus" hole on the circuit board. In the event that the "minus" lead of the capacitor is marked, it should go through the unmarked hole on the circuit board.

Note that the specified operating voltage (v.) is only a minimum rating. Capacitors supplied with the kit may have a higher voltage rating, but can be used without affecting operation of the unit. For instance, a 100 mfd. 25 v. capacitor may be used in place of a 100 mfd. 16 v. capacitor.

Mount the electrolytic capacitors and solder them in place. Their values, rating, and polarization are marked on the body of the part.

| DESIGNATION | VALUE |
|---|---|
| ( ) C3 | 2.2 mfd. 10 v. |
| ( ) C4 | 2.2 mfd. 10 v. |

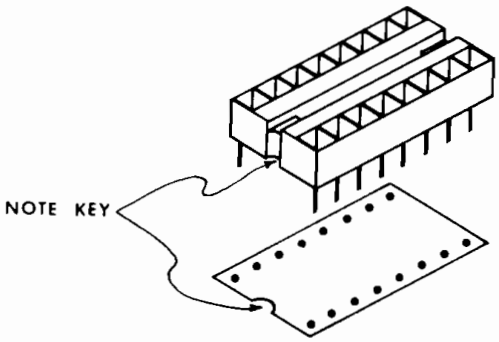
Install the 38 diodes. Note that diodes are polarized and should be installed according to the drawing. Diodes are also heat sensitive and the leads should be heat sinked with a pair of needlenose pliers while soldering.



( ) 37 of the diodes should be installed in the locations marked between the "3 octaves" logo on the circuit board. Although not all 37 are indicated on the circuit board graphics, the polarization for all are identical.

( ) The last diode is installed in the extreme left position. This position is labelled on the circuit board graphics, and should be marked position "0" on the copper side of the board.

( ) Install the supplied socket in the I/O location. Note that like ICs, the socket is polarized as designated by a notch at one end of the socket body. Align the notch with the semi-circular key on the circuit board graphics, insert and solder into place.




Install the integrated circuits. Note that the orientation of the IC's is keyed to the notch at one end of the IC body. This notch is lined up with the semicircular key on the designators printed on the circuit board. Use care when installing IC's as they are heat sensitive and can be destroyed by using excessive soldering time or temperatures. Make sure the IC's are oriented properly prior to soldering, as the devices are hard to remove without destroying them.

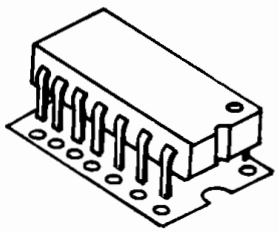
WARNING: CMOS CIRCUITS

In addition to the above warnings, the IC's used in this kit are additionally sensitive to static damage. You should not experience any problems if you follow these precautions:

1) The circuits are supplied to you in a block of conductive foam. Leave the IC's in these holders until you are ready to install the part.
2) Do not install the IC's in sequence other than that called for in the instructions.
3) Do not wear synthetic (nylon, rayon) clothing while handling these parts.
4) A three wire grounded soldering iron is ideal but if you don't have one your present one may be used by first allowing it to heat, then UNPLUGGING it during the actual soldering process. Before soldering and after unplugging, touch the tip momentarily to the ground screw of an electrical outlet to drain static charges.

The IC's can now be mounted.

| DESIGNATION | VALUE |
|---|---|
| ( ) IC1 | CD4024 |
| ( ) IC2 | CD4051 |
| ( ) IC3 | CD4051 |
| ( ) IC4 | CD4001 |
| ( ) IC5 | CD4001 |



In the following steps wires will be soldered to the circuit board that in later steps will connect to the keyboard. At each step, cut the wire to the length indicated and strip 1/4" (7 mm) of insulation from each end. Twist the exposed wire strands together and tin them by melting a small amount of solder into the strands. Be sure to rotate your wire colors.

( ) A 10" (25.4 cm) length at row 0.
( ) A 10" (25.4 cm) length at row 1.
( ) A 9-1/2" (24.1 cm) length at row 2.
( ) A 9-1/2" (24.1 cm) length at row 3.
( ) An 8-1/2" (21.7 cm) length at row 4.
( ) An 8-1/2" (21.7 cm) length at row 5.
( ) An 8-1/2" (21.7 cm) length at row 6.
( ) An 8-1/2" (21.7 cm) length at row 7.

During the following steps, the keyboard and circuit board will be wired together. Orient the keyboard in front of you on a towel or soft rag, such that the keyboard is upside down with the rear of the keyboard facing you (as when you were wiring the keyboard). Orient the circuit board between you and the keyboard, copper side up, with the row of diodes nearest the keyboard.

( ) Connect the wire coming from keyboard terminal #1 (second from the left) to the hole above the diode labeled '16'. Solder.

( ) Connect the free end of the wire originating at keyboard lug #2 to the connection pad above diode #17.

( ) In a similar manner, continue to connect the keyboard terminal wires consecutively to the diode connection points until the last keyboard wire from terminal #37 is connected to diode #52. NOTE that all keyboard wiring should be within the "3 octave" designator brackets which appear on both sides of the circuit board. Double check all wiring to make sure the keyboard is wired to the circuit board in a one-to-one correspondance with no wires out of order.

( ) Locate the free end of the wire connected to row 0 on the circuit board. Connect this wire to lug #1 (nearest the front of the keyboard, farthest from you) of the leftmost terminal strip on the keyboard. There should be no other wire connected to this lug at this time. Do not solder at this time, unless you will be deleting the next step.

( ) ( PERFORM THIS STEP ONLY FOR 8782A KITS)
Cut and prepare a 12 inch (30.5 cm) length of insulated wire. Connect one end of this wire to lug #1 of the leftmost terminal strip. Solder two wires. The free end of this extra wire will be connected to the front panel at a later time.

( ) Similarly, connect the row 1 wire to lug #2 of the same terminal strip. Solder this connection.

( ) Connect the row 2 wire to lug #3 of the left terminal strip. Solder.

( ) Connect the row 3 wire to lug #4. Solder.

( ) Connect the row 4 wire to lug #6. Solder.

( ) Connect the row 5 wire to lug #7. Solder.

( ) Connect the row 6 wire to lug #8. Solder.

( ) Connect the row 7 wire to lug #9. Solder.

The keyboard is now fully wired and ready to be mounted in the case.

( ) Locate the case subassembly. Prepare the case by carefully cutting away the vinyl covering the four #8 countersunk holes on the bottom of the case.

( ) Insert a #8 - 32 X 1 inch flat head bolt in the two holes nearest the front of the case. Place a #8 flat washer over each bolt from the inside of the case, followed by a #8 star lockwasher and a #8 nut. DO NOT fully tighten the nuts at this time. The nuts must remain loose enough to allow 1/8 inch of space between the large flatwasher and the case bottom. The front flange of the keyboard will slide into this space.

( ) Turn the keyboard/circuit board assembly over, and lay it in the case bottom. Slide the keyboard forward making sure the front flange of the keyboard slides under the large flatwashers on the front keyboard mounting bolts. See figure 6.

( ) Orient the 36 wires coming from the keyboard terminals so they all run between the two rear keyboard "L" mounting brackets. The wires between the terminal strip and the circuit board should pass outside the left bracket.

( ) Bundle the wires to the keyboard solder terminals using two wire ties. Wrap one around the wires behind the low A key, and the other around the wires behind the middle A key. Clip off the excess wire tie about two notches from the bundle.

( ) While holding the keyboard firmly against the case bottom, carefully tip the case forward so that it is sitting on its front edge. Pass the two remaining #8 X 1 inch bolts through the rear keyboard mounting holes. These bolts screw directly into the keyboard "L" brackets. Tighten the two rear and two front keyboard mounting bolts. All bolts should be quite tight to prevent any keyboard motion during transport.

## FRONT PANEL ASSEMBLY

(THIS SECTION IS TO BE USED ONLY FOR 8782A KITS.
FOR "P" PACKAGES, PROCEED TO 'COMPUTER INSTALLATION')

Parts for this section contained in the 8782 FP bag.

( ) Locate the metal front panel and lay it face down on a soft rag to prevent marring the finish.

( ) Select the DB-25S socket. Using two #4-40 X 1/4" machine screws, two #4 lockwashers, and two #4-40 nuts, mount the socket in location J1 as shown in figure 9. Make sure the socket is oriented as shown before mounting.

( ) Select the single pole slide switch (S4) and mount as shown using two each 4-40 X 1/4" machine screws, #4 lockwashers, and 4-40 nuts. Orient as shown in figure 9.

( ) Select the double pole double throw slide switch (S3) and mount in a similar manner to the previous step.

( ) Select one of the mini-pushbutton switches and mount in position S1 as shown. Use the lockwasher and nut provided with the switch, with the lockwasher located between the rear of the panel and the switch.

( ) In a similar manner, mount pushbutton switch S2.

( ) Select the 500K potentiometer (R8) and mount as shown in figure 9. Use two 3/8" nuts, one behind the panel as a spacer, and the second as the mounting nut in front of the panel. Orient as shown before mounting.

( ) From the front of the panel, orient the knob so it is pointing to 7:00 of an imaginary clock face. Push the knob onto the shaft of R8.

( ) Cut each lead of the .22uf mylar capacitor (C7) to a length of 1/2" (1.26 cm). Connect this capacitor between lug #1 of S3 and lug #3 of S3. Solder only the connection at lug #1.

( ) Cut a 2" (5.1 cm) length of insulated wire. Prepare the ends of this wire by stripping 1/4" (7 mm) of insulation from each end. Twist the exposed strands of wire together and tin them by flowing a small amount of solder into the exposed strands. Connect one end of this wire to lug #1 of S2. Solder.

( ) Connect the remaining end of the above wire to lug #1 of S4. Do not solder.

( ) Cut and prepare another 2" (5.1 cm) length of wire. Connect one end to lug #2 of S2. Solder.

( ) Connect the free end of the above wire to lug #2 of S4. Do not solder at this time.

( ) Cut and prepare a 1-1/4" (3.2 cm) length of wire. Connect one end of this wire to lug #15 of socket J1. Solder this connection, making sure there are no solder bridges or possible shorts.

( ) Connect the remaining end of the above wire to lug #1 of S4. Do not solder at this time.

( ) Cut and prepare a 2-1/2" (6.3 cm) length of wire. Connect one end of this wire to lug #7 of socket J1. Solder.

( ) Connect the other end of this wire to lug #3 of S3. Do not solder at this time.

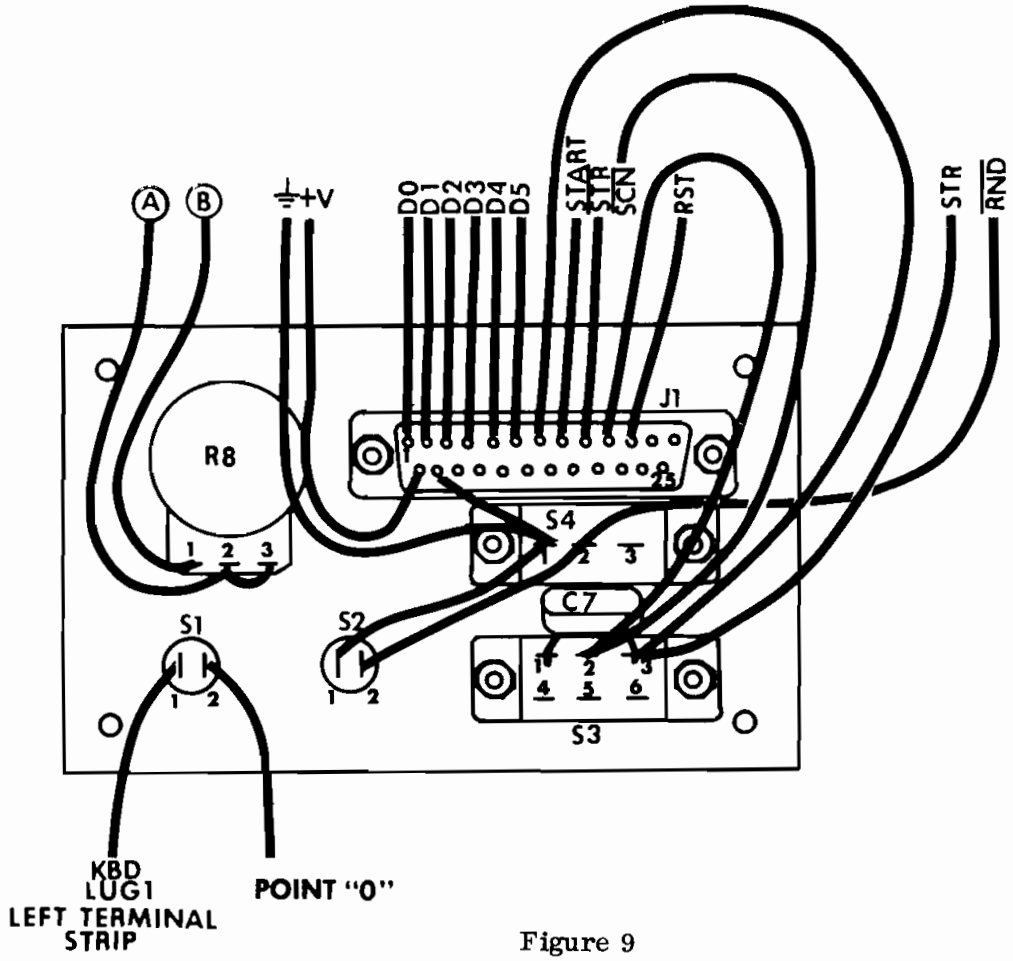



Figure 9

( ) Cut and prepare a 2-1/4" (5.7 cm) length of wire. Connect one end of this wire to lug #10 of socket J1. Solder.

( ) Connect the free end of this wire to lug #2 of S3. Do not solder at this time.

( ) Locate the plywood panel which has been covered with leatherette. Note that this panel has four predrilled mounting holes, a large rectangular cutout, and a 3/8" circular hole. The circular hole WILL NOT be used in this kit, so do not remove the vinyl from this hole. Use a sharp knife to cut the vinyl covering out of the large rectangular cutout. Using an awl or ice pick, punch through the vinyl at the four mounting holes.

( ) Using four #4 X 3/8" screws mount the metal front panel on the plywood panel. NOTE that the mounting flanges on J1 and S3 may keep the panel from setting flush against the plywood panel. In this case, use your knife to shave a thin layer from the corners of the rectangular hole to allow a flush mount.

In the following steps wires will be connected to the front panel which will in later steps be connected to the circuit board and other components. In each step, cut the wire to the specified length and prepare by stripping, twisting and tinning the ends of the wire.

( ) An 11 inch (28 cm) length to S1 lug 2. Solder

( ) A 13 inch (33 cm) length to R8 lug 1. Solder

( ) A 13 inch (33 cm) length to R8 lugs 2 and 3. Solder both lugs.

( ) A 14 inch (35.6 cm) length to J1 lug 1. Solder carefully.

Double check for solder bridges and shorts when making connections to J1.

( ) A 14 inch (35.6 cm) length to J1 lug 2. Solder.

( ) A 14 inch (35.6 cm) length to J1 lug 3. Solder.

( ) A 14 inch (35.6 cm) length to J1 lug 4. Solder

( ) A 14 inch (35.6 cm) length to J1 lug 5. Solder

( ) A 14 inch (35.6 cm) length to J1 lug 6. Solder.

( ) A 14 inch (35.6 cm) length to J1 lug 8. Solder

( ) A 14 inch (35.6 cm) length to J1 lug 9. Solder

( ) A 14 inch (35.6 cm) length to J1 lug 11. Solder.

( ) A 14 inch (35.6 cm) length to S4 lug 2. Solder two wires at this point.

( ) A 14 inch (35.6 cm) length to S3 lug 2. Solder two wires.

( ) A 14 inch (35.6 cm) length to S3 lug 3. Solder three wires.

( ) A 14 inch (35.6 cm) length to J1 lug 14. Solder.

( ) A 14 inch (35.6 cm) length to S4 lug 1. Solder three wires.

Thirteen of the wires just connected to the front panel must now be terminated in a 14 pin DIP plug which will mate with I/O socket on the 8782A encoder circuit board. NOTE that the plug is somewhat fragile and can also be damaged by excessive heat during soldering. While soldering to the plug, some type of vise must be used to act as a heat sink and to hold the pins rigid while soldering. A vise of this type can be rigged by using the jaws of needle nose pliers which have been held closed by wrapping a rubber band around the handles. PROVIDING SOME SORT OF MECHANICAL SUPPORT AND HEAT SINKING IS ESSENTIAL. Do not attempt the following steps without this.

Also, proper preparation of both wires and plug will simplify assembly. Pre-tin the "U" shaped forks on the DIP plug before soldering the wire in place.

DO NOT tin the long fingers which mate with the socket. Prepare the ends of the wires which will connect to the plug by stripping, twisting, and tinning as before. Finally, clip the prepared exposed wire so that only 1/8 inch extends beyond the end of the insulation. When making the connection to the DIP plug, hold the wire against the tinned fork of the plug. Touch the connection with the soldering iron and hold the connection in place until the solder cools. Double check for solder bridges or cold solder joints which could cause problems later. Reheat the connection if problems exist.

( ) Locate the free end of the wire connected to S3 lug 2. After preparing as discussed above, solder this wire to pin 1 of the DIP plug. NOTE that pin 1 is closest to the angled or marked corner of the plug.

( ) Connect the wire from J1 lug 9 to pin 2 of the plug.

( ) Connect the wire from J1 lug 8 to pin 3 of the plug.

( ) Connect the wire from J1 lug 6 to pin 4 of the plug.

( ) Connect the wire from J1 lug 4 to pin 5 of the plug.

( ) Connect the wire from J1 lug 2 to pin 6 of the plug.

( ) Connect the wire from J1 lug 14 to pin 7 of the plug.

( ) Connect the wire from J1 lug 11 to pin 8 of the plug.

( ) Connect the wire from J1 lug 1 to pin 9 of the plug.

( ) Connect the wire from J1 lug 3 to pin 10 of the plug.

( ) Connect the wire from J1 lug 5 to pin 11 of the plug.

( ) Connect the wire from S3 lug 3 to pin 12 of the plug.

( ) Connect the free end of the wire from lug 1 of S4 to pin 14 of the plug.

Pin 13 of the plug remains unused.

( ) Place the wood panel subassembly in the space to the left of the keyboard in the case subassembly.

( ) Locate the free end of the wire which was connected to lug 1 of the terminal strip at the left end of the keyboard. Route this wire to the front panel and solder to S1 lug 1.

( ) Connect the wire originating at S1 lug 2 to the encoder circuit board at the leftmost isolated diode. Connect to the hole labeled "O". Solder.

( ) Connect the wire from lug 1 of R8 to point "B" on the circuit board. Solder.

( ) Connect the wire from lugs 2 and 3 of R8 to point "A" of the circuit board. Solder.

( ) Connect the wire from lug 2 of S4 to point "$\overline{\text{RND}}$" of the circuit board. Solder.

( ) Connect the wire from lug 7 of the power supply terminal strip to the "+" hole near the left edge of the circuit board. Solder.

( ) Connect the wire from lug 4 of the power supply terminal strip to point "$\perp$" (ground) of the circuit board. Solder.

The circuit board is now ready to be mounted in the case.

( ) Using four #4 X 3/4 inch self tap screws and four 5/16 inch spacers, mount the circuit board such that the rear edge of the board is against the rear case side and the left edge of the board is 7-1/4 inches (18.4 cm) from the left case side. To ease mounting with the screws provided, it would be easiest to start pilot holes as outlined in case assembly sections.

( ) Orient the wooden mounting panel in its final position to the left of the keyboard as shown in figure 10. Using four #4 X 3/4 inch self tap screws, mount the panel assembly onto the mounting blocks.

( ) Carefully orient the wire bundle and 14 pin DIP plug to where it can be inserted into the encoder board I/O socket. Note that the angled marked corner of the plug represents pin 1. On the socket, the small semi-circular notch at one end of the socket also designates the number 1 position. After aligning both of the designated ends of the connectors, carefully press the DIP plug into the socket.

( ) Using the wire ties provided, bundle the wires at two points between the front panel and the encoder board. After pulling the wire ties tight, clip the excess length at a point about two notches beyond the fastener.

( ) Cut a 30" (76.2 cm) length of the foam tape provided. Mount this piece on the bottom of the front lip of the electronics cover case section. The tape should be flush with the front edge of this case section. See figure 10.

( ) Cut a 8-3/4" (22.2 cm) length of foam tape. Mount this piece on the plywood panel assembly just installed. Note that the front edge of the tape should be on a line 6" (15.2 cm) from the front edge of the case.

( ) Cut a 1" (2.5 cm) length of the foam tape. Mount this piece in the small case section just to the right of the keyboard. Note that the front edge of this foam should be 6" (15.2 cm) back from the front of the case.

This completes assembly of your 8782A digitally encoded keyboard. At this point you may install the case cover section and proceed to Testing and Familiarization sections.

## COMPUTER INSTALLATION

(THIS SECTION APPLIES ONLY TO "P" PACKAGES)

CS-87 SPECIAL NOTE

When assembling the CS-87 cassette interface connectors as shown in page 6 of the CS-87 manual, terminate the input and output lines using the miniature phone jacks supplied with the 8700 HDW bag. Use leads approximately 9 inches (23 cm) long as shown in figure 11. Save the phone plugs supplied with the CS-87 to use as connectors to your recorder.

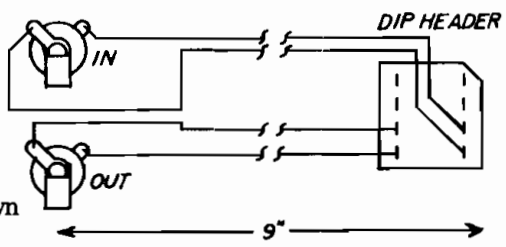


Figure 11

## COMPUTER/SYNTHESIZER CONNECTIONS

Parts for this section are in the 8700 HDW bag.

Connections are made between the computer and synthesizer head by means of a 25 pin DB-25 socket which in later steps will be fastened to the computer mounting bezel. The connector set required here terminates on one end in the DB-25 socket and on the other end in a pair of DIP headers.

Assemble this connector set as follows:

( ) Prepare eleven (11) 6" (15 cm) lengths of the insulated wire provided by stripping 1/4" of insulation from each end of the wire and twisting and tinning the exposed wire strands.

The wires prepared above will now be used to make connections from the DB-25 connector to the first DIP header.

Pre-tin the solder lugs of both connectors before connecting the wires (this helps keep soldering temperatures down) and observe carefully the cautions previously mentioned relative to soldering to the DIP headers. To avoid confusion, solder both the DB-25 and the DIP header end of each wire before proceeding to the next.

| COMPUTER DIP HEADERS Con # | Pin # | line name | 8780/8781 D Connector Pin # |
|---|---|---|---|
| J1 | ( ) 1 | D7 | 8 |
| | ( ) 2 | D5 | 6 |
| | ( ) 3 | D3 | 4 |
| | ( ) 4 | D1 | 2 |
| | ( ) 7 | +5 | 14 |
| | ( ) 8 | Gnd | 15 |
| | ( ) 9 | $\overline{CASS}/\overline{RDY}$ | 9 |
| | • | • | • |
| | ( ) 11 | D0 | 1 |
| | ( ) 12 | D2 | 3 |
| | ( ) 13 | D4 | 5 |
| | ( ) 14 | D6 | 7 |

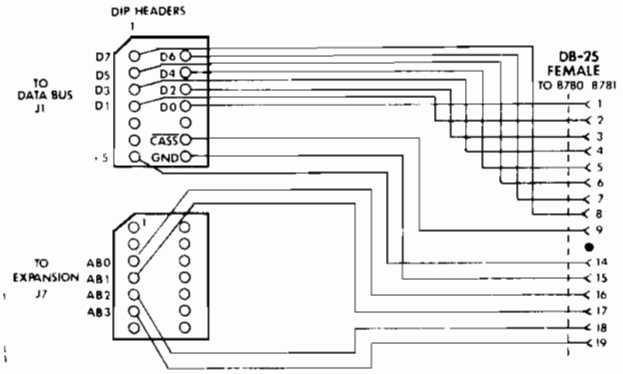



Figure 12

( ) Prepare four (4) additional 6" (15 cm) lengths of insulated wire as above, observing all of the precautions mentioned earlier. These wires will be used to make the connections from the DB-25 connector to the second DIP header as follows:

| COMPUTER DIP HEADERS Con # | Pin # | line name | 8780/8781 D Connector Pin # |
|---|---|---|---|
| J7 | ( ) 3 | A0 | 16 |
| | ( ) 4 | A1 | 17 |
| | ( ) 5 | A2 | 18 |
| | ( ) 6 | A3 | 19 |

You are now ready to fasten the 8700 Computer/Controller to its mounting bezel and attach jacks and connectors as shown below. DO NOT mate any connectors until told to do so.

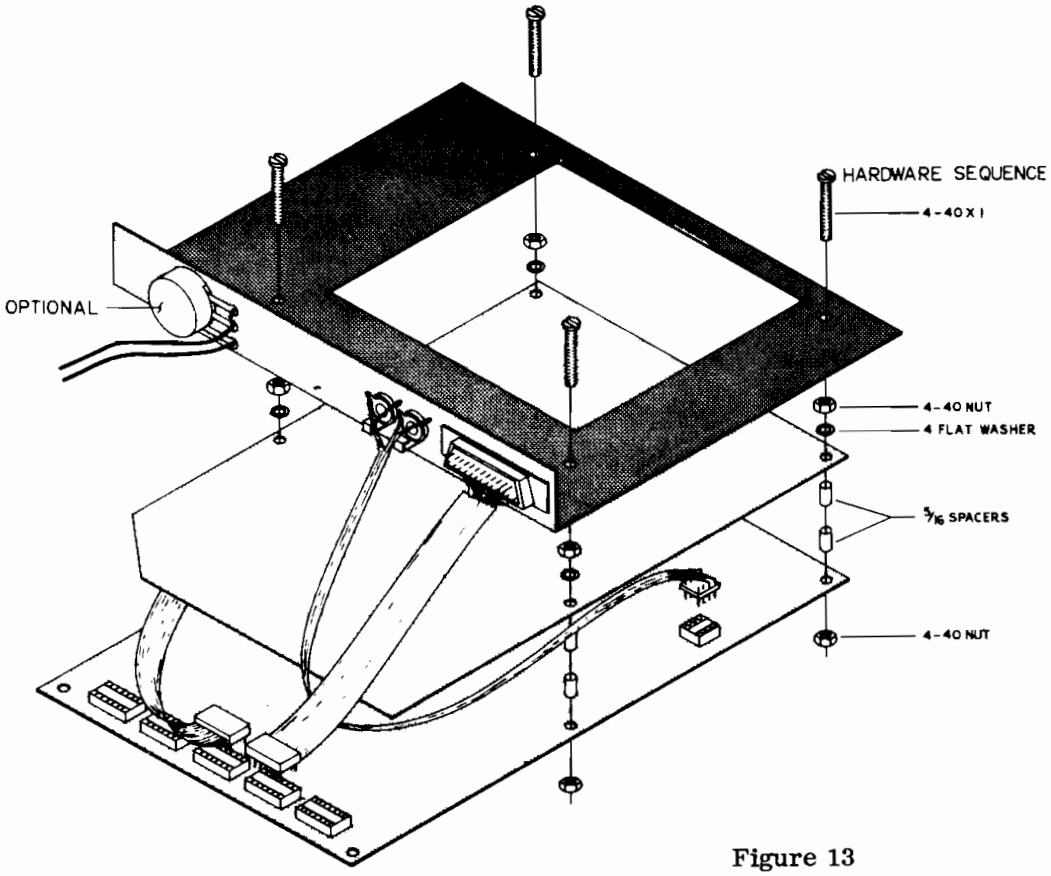



Figure 13

( ) If your system has the CS-87 tape interface, mount the miniature phone jacks in the bezel holes indicated.

( ) Mount the DB-25 connector in the bezel cut-out indicated. Fasten in place with 4-40 hardware; 1/4" machine screw, lock-washer and nut.

( ) Fasten the four 4-40 X 1" machine screws (which in later steps will mount the 8700) to the bezel as shown. Note the 4-40 nuts and #4 lockwashers which will serve as spacers for the 8700 board as well as holding these screws in place now. Note that the 1 inch screws, spacers and four of the nuts are actually the hardware supplied with the 8700 Computer kit.

( ) With the 8700 keyboard disconnected from the CPU board, press the keyboard onto the mounting bolts installed above. A modest amount of "forcing" may be required, however, if the panel bows or if the keyboard will not seat against the #4 nuts, it may be necessary to loosen and reposition the #4 X 1" bolts. Make sure the keyboard is mounted with the labeling visible through the cut-out in the bezel.

( ) You are now ready to mate connectors and mount the 8700 CPU board. If you have not yet done so, you should now install the 14 pin DIP socket supplied in the location marked as J7 on the 8700 CPU board. Be sure to observe the polarizing notch on this connector.

Mate the following connectors. Be careful of polarity.

( ) The connector from the cassette jacks with socket J9 on the 8700 board.

( ) The connector from the DB-25 socket pins 1-15 with the 8700 DATA BUS connector J1 (do not be confused by figure 13 which would seem to indicate that this header goes to another socket).

( ) The connector from the DB-25 socket pins 16-25 with the 8700 EXPANSION CONNECTOR J7.

( ) The connector from the 8700 keyboard with the keyboard socket J3.

( ) Mount the 8700 CPU board using two 5/16" spacers on each mounting bolt as shown. Fasten with a 4-40 nut on each of the bolts. Note that the rubber feet supplied with the 8700 are not used.

( ) The entire 8700 assembly may now be mounted in the case as shown in figure 14. Fasten in place with the four #4 wood screws provided.

( ) Using four #4 X 3/4 inch self tap screws and four 5/16 inch spacers, mount the encoder circuit board such that the rear edge of the board is against the rear of the case, and the left edge of the board is 7-1/4 inches (18.4 cm) from the left case side. To ease mounting, remember to use pilot holes.

( ) Using the #4 X 3/4 inch self tap screws supplied with the PS-87 Power Supply, mount the supply in the position indicated in figure 14. NOTE that the rubber feet supplied with the supply should still be used as spacers and shock absorbers for this assembly. Also note that the "output" end of this supply should be facing the left end of the case as shown, and that the supply should be against the rear edge of the case.

( ) Using the 14 pin jumper cable supplied, connect the encoder board I/O to the 8700 INPUT #1 socket J4. Be sure to observe the polarization of both plugs and sockets. Note that the cable will connect to the left central section of the encoder board rather than the right central section as shown in figure 14.

( ) Mate the PS-87 connector and cable with the power connector on the 8700 board.

( ) Use the 16 inch coax and two mini phone plugs provided plus two connectors of your own to make two patch cords for use between your external cassette recorder and the computer's cassette interface.

This completes assembly of the P8782A Keyboard/Computer. Proceed to the testing and familiarization section.

TESTING

The 8782 Encoded Keyboard is most conveniently tested using the displays on the face of the 8780 D/A control panel as a test instrument, but may also be tested using various processors.

Begin by mating the male "D" connector of the 8780 with the matching connector on the 8782 control panel. (note that power for the displays as well as switching logic in the 8780 D/A are provided by the 8782 Encoded Keyboard's internal power supply).

You may want to connect the Control Voltage output of the 8780 D/A to a Voltage Controlled Oscillator and the output of the VCO, in turn, to an audio amplifier - but this is not essential to the tests to be performed.

Set the NORM/RND and STOP/DELAY slide switches on the 8782 control panel to their NORM and STOP positions respectively. The setting of the TEMPO control is not important at this point.

Press the Special Function (SF) push-button on the 8782 control panel and observe that the LED for the first trigger flag (D6) on the panel of the 8780 lights while the key is held down and extinguished when the key is released. NOTE that it is also normal for the second trigger flag (D7) to randomly be either lit or not lit as the SF key is pressed but that NONE OF THE DATA LEDs (D0 - D5) should light. In fact, in all of the following test steps, it will be normal for the second trigger flag to be randomly lit or not lit.

Now, beginning with the lowest C key on the keyboard, press each key in turn and observe that the 8780 LEDs show the first trigger to be activated (while the key is down) and that the six data lights (D0 - D5) are all extinguished with the exception of D4 which should be lit.

Progress up the keyboard pressing each key ( including accidentals) in turn and observing that the LED "count" in the normal binary sequence:

010000 - C
010001 - C#
010010 - D
010011 - D#
010100 - E
010101 - F
010110 - F#
010111 - G
011000 - G#
etc. up to
110100 - C (the last key)

If you have a VCO connected to the output of the D/A, it should be producing a pitch corresponding to each key on the keyboard.

Slide the NORM/RND switch to the right (RND) and observe that the LEDs on the face place of the 8780 wink in random patterns at a rate proportional to the setting of the TEMPO control. NOTE that in the random (RND) mode, the first trigger flag (D6) should not light. If the control voltage output of the D/A is connected to a VCO, you should be hearing random notes during this test.

Return the NORM/RND switch to the NORM position and, with the TEMPO control set to approximately mid-range, press the RND push-button and observe that for each press of the button, a random note is indicated (and/or heard) by the LEDs on the 8780. If the RND button is held depressed for any appreciable length of time, its effect is identical to sliding the NORM/RND switch to the RND position.

Finally, slide the STOP/DELAY switch fully to the right and press the lowest C on the keyboard. Under these conditions, D6 should be lit (while the key is down - and it will actually be blinking very rapidly) D7 should be winking on and off many times a second (though at an observable rate) and D4 should be lit with no evidence of blinking.

Note that this delay mode of operation is intended as a quasi-polyphonic mode and is not intended for playing single notes. When a single note is played in this mode the keyboard may from time to time add an extraneous note. Press down the first C on the keyboard and the next higher C simultaneously and observe that D2, D3, and D4 wink but that the remaining three DATA indicators show no change. (With a VCO connected, you should also hear the oscillator changing between these two C's.)

Successful completion of these tests provide a high degree of assurance that the Encoded Keyboard and Digital to Analog Converter are properly communicating with one another.

## USING THE PAIA 8782 DIGITALLY ENCODED KEYBOARD

The 8782 Keyboard has been carefully configured to be used either as part of an essentially drift-free, digital sample and hold apparatus for conventional analog synthesizers or as an interface between a computer system and the AGO environment with which all musicians are familiar.

Switching from one application to another is simply a matter of un-plugging one system and plugging in another.

There are four special jumpers which must be installed for custom system configurations. See "SPECIAL JUMPERS" section on page 13 of this manual.

### DIGITAL SAMPLE AND HOLD APPLICATIONS

In a music system without the digital computer/processor, the combination of the 8782 Encoded Keyboard and the 8780 Equally Tempered Digital to Analog Converter replace the standard keyboard/ analog S/H circuitry.

The Wiring schedules provided for the female and male, respectively DB-25 type connectors allows the 8780 D/A to plug directly into the OUT connector on the 8782.

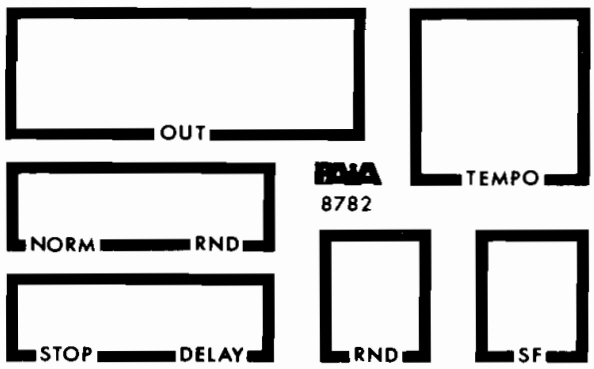



figure a. Panel Graphics.

Under these conditions, the 8782 controls perform the following functions:

OUT The 25 pin, "D" type connector in the upper left hand corner of the panel provides convenient connections to all of the control inputs and data outputs of the 8782. While a 25 pin connector here provides more connections than will ever be reasonably needed to the keyboard, this connector was selected to be consistent with that provided on the 8780 D/A, which will in its ultimate configuration make use of most of the connection points.

NORM/RND This two position slide switch directly below the "D" connector selects either the normal mode of keyboard operation (NORM), or a special mode of operation which causes the keyboard to generate random notes. Sliding the switch to the RND position enables the random note generator (see also later section on 8780/8782 uses)

TEMPO This knob in the upper right hand corner of the control panel provides a control over the rate at which random notes are generated when the NORM/RND switch is in the RND position - and will also serve as a tempo control for some (but not all ) of the special effects generated by the keyboard.

STOP/DELAY This three (3) position slide switch in the lower left hand corner of the control panel provides essentially three separate modes of operation for the keyboard:

STOP - The left-most position of this slide switch is the most "normal" mode of operation. With the switch in this position, the combination 8780 and 8782 will behave in essentially the same manner as a conventional analog S/H device. In this mode of operation, the keyboard will "hold" the last note played, ignoring any further key activations until the key currently being played is released.

DELAY - With the switch set to its rightmost position, you are operating in a mode that many people confuse with polyphonic. Unlike the STOP mode, which causes the keyboard scanner to stop completely when a note is found down, the DELAY mode causes the encoder to stop only momentarily, issue a command to the D/A to play the note currently down and then after a short delay go looking for any other keys that are down. The result is an arpeggiation (of sorts) of all of the keys that are currently activated on the keyboard. If the keys that are activated form an interval or triad, the individual notes will be heard in turn. If a large group (or all) of the keys are held down at once, the effect is a sequentially stepping up-scale arpeggiation of all of the notes activated.

There are no external controls to regulate the rate at which the arpeggiation takes place, except that in very special circumstances the keyboard's TEMPO control can serve this function.

RND This left-most of the two push-buttons on the 8782 control panel is a duplicate of the RND position of the NORM/RND slide switch. It can be either pressed and held for a series of random notes or may be activated only momentarily to produce a single random note.

S. F. The SF is a Special Function key which occupies the "zero key" position in matrix. This key has significance only in computer-based systems where its function is defined by whatever program is currently running on the computer.

A couple of points need to be prominently mentioned:

1) You now have a unit which combines keyboard, encoder and computer in a single package and this would be as good a time as any to begin thinking of these things as a single device. Perhaps the concept of an "intelligent" keyboard would be useful here. In any case, you need to fully realize that this new device has little personality of its own. At the risk of beginning to sound like a broken record, the keyboard's personality is a function of the program that the computer is running. Further, without some program to run, your new intelligent keyboard becomes dumb to the point that it will do nothing.

2) For a variety of reasons, the 8700's multiple channel output structure winds up being shared by the cassette port and the keyboard beeper. The cassette port presents no difficulties, but under some conditions the beeper will chatter while running synthesizer programs. We do not currently have a means of avoiding this short of disconnecting the beeper. We feel that, considering the volume of the beeper, its use in a typical performing environment is marginal anyway. Meanwhile, we are working on a means of overcoming this cosmetic defect.

## TESTING

After checking all connections and connectors to make sure that they are wired and mated properly, apply power to the keyboard and observe that the 8700's twin seven segment displays light with some random number. RESET the 8700.

A logical first testing procedure would be to make sure that the computer portion of this system is running properly. Load the counting demo from the 8700 assembly manual and verify that it still runs.

In this system configuration, the keyboard encoder is running constantly and the only indication that a key is down occurs when the STR (STROBE) line from the encoder goes high - indicating that the number currently on the encoders DATA output lines represents a closed switch.*

One easy and quick way to tell whether the encoder is running or not is to use the 8700's PIEBUG monitor to directly read the activity on the input port assigned to the keyboard. The address of this port is $810. Read this address using the following 8700 keyboard entry sequence:

| KEYSTROKES | COMMENT |
|---|---|
| 0-8-1-0-DISP | ; causes PIEBUG to read<br>; INPUT PORT #1 and display<br>; the results. |

*See Summary

The displays will show some random number. Read the port again like this:

| KEYSTROKES | COMMENT |
|---|---|
| BACK-ENT | ; decrements pointer to<br>; previous location (IN #1)<br>; and displays results again. |

The displays should again show some random number that will most certainly be diffcrent from the one displayed previously. Go through the BACK-ENT sequence several times and observe that there is no obvious pattern to the numbers displayed. If you do see an obvious pattern (let's say always FF or 00 or 80 or something) it is a strong indication that the encoder for the keyboard is malfunctioning.

If everything looks OK to this point, we're ready to enter a short diagnotic program that will test the keyboard under normal dynamic operating conditions. Here is that program:

```
0000     KTEST     E8          INX           ; increment counter
  01               8E 20 08    STX DISP      ; show counter
  04     LOOP 0    2C 10 08    BIT KBD       ; check keyboard
  07               30 FB       BMI LOOP 0    ; no scan, loop
  09     LOOP 1    AD 10 08    LDA KBD       ; get keyboard
  0C               30 F2       BMI KTEST     ; scan done, no keys
  0E               2A          ROL           ; prepare-check for trigger
  0F               10 F8       BPL LOOP 1    ; no trigger, continue
  11               6A          ROR           ; trigger-restore key #
  12               8D 20 08    STA DISP      ; and show it
  15     LOOP 2    2C 10 08    BIT KBD       ; check keyboard
  18               10 FB       BPL LOOP 2    ; wait for scan end
  1A               30 E8       BMI LOOP 0    ; branch always for more
```

After entering this diagnostic from the keyboard, go to location 0000 and begin running the program.

KEYSTROKES
0-0-0-0-RUN

You should immediately see the displays begin to count in hexadecimal beginning at some random number and proceeding sequentially.

This portion of the program is in effect counting the number of keyboard scans and it should take several seconds (five or so) for the displays to count from 00 to FF before beginning again at 00. NOTE that the time required for the complete cycling of the display represents 256 scans of the keyboard.

With the program still running, pressing AGO keyboard keys will cause the displays to stop, showing the hexadecimal number which represents key pressed.

Press the lowest C on the keyboard and observe that the displays show 50*. The next key (C#) will show as 51 and so on sequentially through the next C (5C - hex, remember) and the next C (68) and the highest key on the keyboard, the final C (74). If any keys which are pressed in sequence cause the display to show a number out of sequence it is an indication that one or more of the wires from the keyboard to the keyboard encoder are interchanged.

Successful completion of the tests to this point indicate that the keyboard is talking to the computer with no difficulties. We now need to make sure that the computer is also talking to the D/A and QuASH in those systems which use them.

Mate the DB-25P plug which terminates the control lines from the D/A and QuASH with the DB-25S socket on the computer mounting bezel (turn the power off first) and load the testing programs supplied with the D/A or QuASH and run them as outlined in the manuals supplied with those kits.

*For additional details see the SUMMARY section at the end of this manual.

# RETRO-FITTING GUIDE

RETRO-FIT HARDWARE KIT

Those of you with stock 8782 keyboards who wish to update to an intelligent keyboard system at a later date can order part #8700 HDW which contains all hardware and additions which will be required for this change. Cost of the kit is $24.95 ppd.

The following information is provided to assist in retro fitting PAIA 8700 Computer/Controllers to existing 8782 keyboards or to keyboards which have been up-dated by the addition of the PAIA EK-3 keyboard encoder kit.

It may at first appear that extensive modifications are required to implement this change, but these recommended procedures will minimize re-wiring.

## WHAT TO REMOVE

Some things will, of course, have to be removed.

POWER SUPPLY

The existing low wattage, unregulated supply will be completely removed and replaced with the PS-87 regulated supply or its equivalent.

Clip the two leads running from the power supply to the encoder board flush at the point where they connect to the board. Remove the power supply assembly - these parts will not be re-used. Neither will the two holes on the encoder board ("+" and "⏚") be re-used as power for this board will be supplied through its computer connections when the modification is complete.

FRONT PANEL

The front panel controls will be removed entirely to make room for the computer. To minimize dis-assembly, proceed as follows:

Remove the 4 wood screws that hold the control panel in place (save the screws to mount the computer) and lift the front panel.

Clip the connections from R8 (TEMPO control) to points "A" and "B" of the encoder board flush with the board and remove these wires from the harness.

Clip the wires from push-button S1 (SF key) at the points at which they connect to the encoder circuitry. In the original 8782 and EK-3 systems, these wires can be clipped at the right and left terminal strips under the keyboard. If you do not wish to remove the keyboard, these wires can be clipped behind the keyboard where they are exposed, but you must tape or insulate the ends to prevent any electrical contact. In the latest 8782A systems, one wire from

S1 can be clipped flush at the encoder board at point 0. The second wire can be clipped behind the keyboard and insulated as above.

## THE DB-25S CONNECTOR

Many of the connections made to the DB-25 connector can stay as they are. Clip the following wires at a point 4-1/2" (11.5 cm) from the DB-25 socket.

| line name | DB-25 pin # |
|---|---|
| D0 | 1 |
| D1 | 2 |
| D2 | 3 |
| D3 | 4 |
| D4 | 5 |
| D5 | 6 |
| • | • |
| START | 8 |
| • | • |
| +5 | 14 |

Some of the connections currently made to the DB-25S are no longer needed at all. These wires may be clipped at the pins of the connector and at the point at which they connect to the encoder board's I/0 cluster. After being so liberated, these wires may then be removed from the harness.

| line name | DB-25S pin # | Encoder I/0 cluster pin # |
|---|---|---|
| $\overline{\text{SCN}}$ | 10 | 9 |
| RST | 11 | 12 |

In most cases, the following connections to the DB-25S will not be long enough to reach from the connector's future location on the mounting bezel to the required 8700 connector. These wires must be de-soldered at the DB-25S and new 4-1/2" (11.5 cm) long wires soldered in their place.

| line name | DB-25S pin # |
|---|---|
| STR | 7 |
| $\overline{\text{STR}}$ | 9 |
| • | • |
| ⏚ | 15 |

Finally, clip the wires connected to the $\overline{\text{RND}}$ and $\overline{\text{STR}}$ pads of the encoder board flush with the board.

At this point, the DB-25S may be removed from the front panel completely (save the hardware) and there should be no remaining wires attaching it to the keyboard or encoder.

Two remaining wires connect the front panel to the Encoder I/0 cluster (STR and " ⏚ ") and these wires should be cut so that they are the same length as the other 8 wires still coming from these connections. (Approx. 4-1/2" from front panel)

There are two special jumpers adjacent to the "A", "B", and "RND" points on the 8782A circuit board which will need to be cut or removed when changing from a stock to computerized system. Also, if the "RST" jumper adjacent to the I/O socket was installed for your special application, you will need to clip or remove it also. See page 13 for additional clarification of special jumpers.

## PUTTING IT ALL BACK TOGETHER

You should now have a DB-25S with eleven 4-1/2" wires coming from it. Terminate these 11 leads in a 14 pin DIP header as shown on page **23** of this manual.

Continue with the 4 additional 6" leads (the QuASH address lines) terminated in a second DIP header as shown on page **23.**

If you are adding a computer to the older format 8782 or EK-3 systems, terminate the 10 remaining wires from the encoder board I/O cluster in a 14 pin DIP plug as outlined below:

| ENCODER I/O | line name | 8700 IN #1 J4 |
|---|---|---|
| ( ) 1 | D0 | 9 |
| ( ) 2 | D1 | 6 |
| ( ) 3 | D2 | 10 |
| ( ) 4 | D3 | 5 |
| ( ) 5 | D4 | 11 |
| ( ) 6 | D5 | 4 |
| ( ) 7 | START/D7 | 3 |
| • | • | • |
| ( ) 11 | STROBE/D6 | 12 |
| • | • | • |
| ( ) 13 | GROUND | 14 |
| ( ) 14 | +5 | 1 |

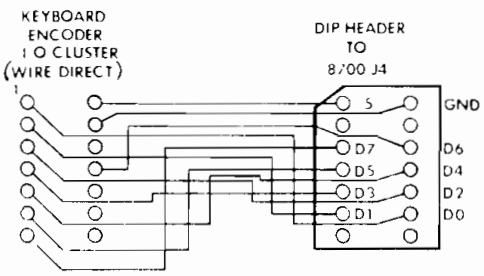



Figure 15

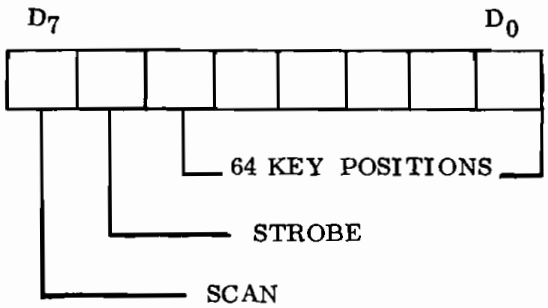
If you are adding a computer to the newer 8782A system, remove the existing DIP plug and wires from the I/O socket.

Finish the conversion by following the final mechanical assembly instructions from the Computer Installation section of this manual.

# SUMMARY

KEYBOARD PORT ADDRESS - X810

ENCODER OUTPUT WORD




KEYBOARD PROTOCOLS

The output of the encoder connected to the AGO keyboard consists of 8 bits.

The low order 6 bits of this 8 bit word indicate the number of the key position on the keyboard that is currently being interrogated. In binary, the key positions are numbered sequentially from 000000 to 111111. Note that not all key positions are occupied by keys, the lowest and highest key positions are in fact empty as shown in the chart below.

DATA (in HEX) AND CORRESPONDING NOTE NAMES

| | OCTAVE | | | | | |
|---|---|---|---|---|---|---|
| NOTE | 0 | 1 | 2 | 3 | 4 | 5 |
| G# | 00 | 0C | 18 | 24 | 30 | 3C |
| A | 01 | 0D | 19 | 25 | 31 | 3D |
| A# | 02 | 0E | 1A | 26 | 32 | 3E |
| B | 03 | 0F | 1B | 27 | 33 | 3F |
| C | 04 | 10 | 1C | 28 | 34 | |
| C# | 05 | 11 | 1D | 29 | 35 | |
| D | 06 | 12 | 1E | 2A | 36 | |
| D# | 07 | 13 | 1F | 2B | 37 | |
| E | 08 | 14 | 20 | 2C | 38 | |
| F | 09 | 15 | 21 | 2D | 39 | |
| F# | 0A | 16 | 22 | 2E | 3A | |
| G | 0B | 17 | 23 | 2F | 3B | |

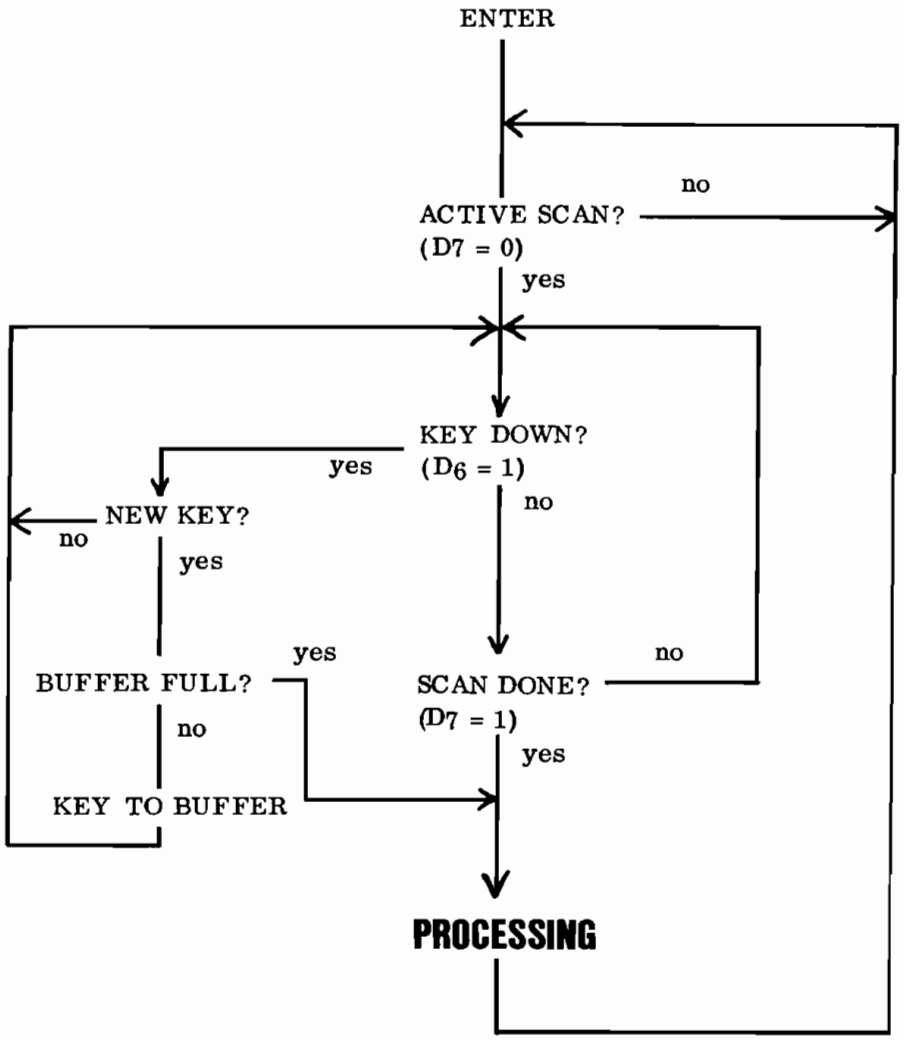
Shaded area represents PAIA 8782 Keyboard active area.

NOTE: Moving across horizontal rows transposes by octaves.

The 7th bit (D6) is the keyboard STROBE (STR) line. If the key that corresponds to the key position represented by the low order 6 bits of data is being held down, the strobe bit goes high (to a binary "1"). Otherwise, this bit is low.

It is instructive to observe the change that the strobe bit makes in the hexadecimal representation of the data. In hex, ($), the first key of the three octave keyboard is $10 (00010000 in binary) if the key is up. If the key is down, the strobe bit will be set producing 01010000 (in binary) or $50. Any key which is down will be read by the computer as $40 greater than the values shown in the preceding table.

The 8th bit (D7) can be thought of in most cases, as an encoder status bit with the useful (though somewhat arbitrary) convention that when this bit is low (0) an "active" scan of the keyboard is underway. This bit being high is then considered to be a "dummy" scan. Reading of the keyboard and the transfer of the list of down keys to the output buffer* happens only during "active" scans while "dummy" scans are reserved for processing.



As is shown in the flow chart for a typical keyboard reading program (on the preceding page), once processing is finished, the computer will go into a waiting loop until the next active scan of the keyboard begins.

The major advantage to this protocol is that it simplifies timing considerations when the processing function involves recording and playback procedures.

For a detailed analysis of the encoder design and circuitry see "Computer Music With or Without The Computer", included.

*The output buffer is simply an area in the memory of the computer which has been designated and set aside for this purpose. In most PAIA software it is called KTABLE (see "What The Computer Does", included).