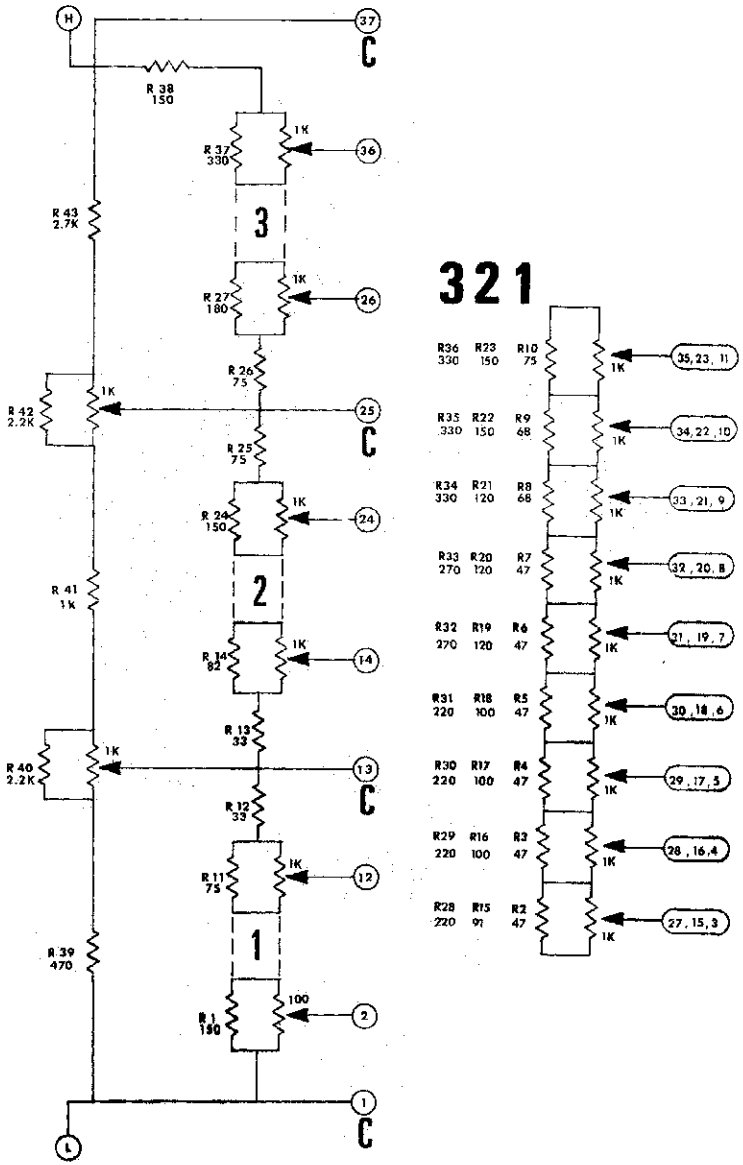
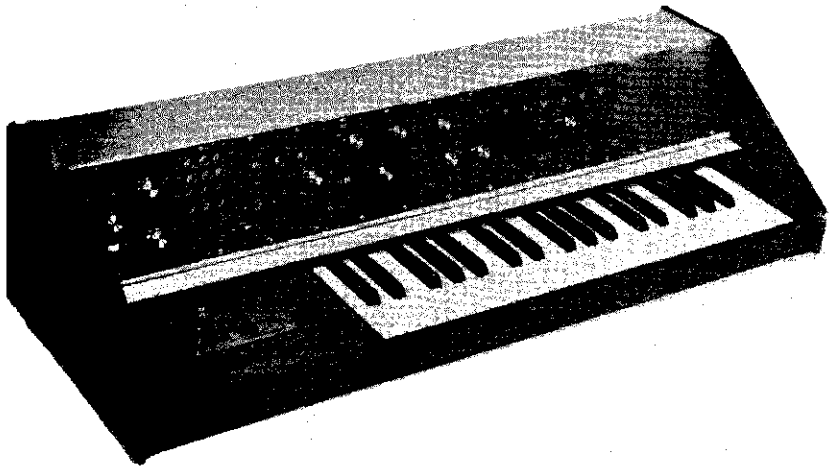


PAIA Electronics

P. O. BOX 14358 OKLAHOMA CITY, OKLA. 73114 (405) 842-5480

2720-8

Keyboard/Case



SPECIFICATIONS

Case Dimensions:	31" X 11½" X 7½"
Power Requirements:	-9v. @ 1.5 ma. 9v. @ 3 ma. 18v. @ 1 ma.
Configuration	Keyboard arranged for three octaves of key controllable voltage C through C. Pitch knob provides additional octave.
Control Out Range:	to 5v.
Control Buffering:	Sample and hold. 20 sec. min. hold time after key released.
Tuning:	Each key tunable
Trigger Outputs:	5v. pulse when any key pressed 5v. step while key held down.

SOLDERING

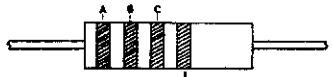
Use care when mounting all components. Use only rosin core solder (acid core solder is never used in electronics work.) A proper solder joint has just enough solder to cover the round soldering pad and about 1/16 inch of the lead passing through it. There are two improper connections to beware of: Using 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 re-heating 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 bridges can be cleaned off by holding the board up-side 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.

CIRCUIT BOARD ASSEMBLY

( ) Prepare for assembly by thoroughly cleaning the conductor side of the board with a scouring cleanser. Rinse the board with clear water and dry completely.

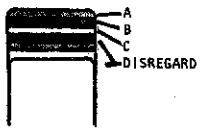
Solder each of the fixed value resistors in place following the parts placement designators printed on the circuit board and the assembly drawing figure 1. Note that the fixed value resistors are non-polarized and may be mounted with either of their two leads in either of the holes provided. Cinch the resistors in place prior to soldering by putting their leads through the holes and pushing them firmly against the board; on the conductor side of the board bend the leads outward to about a 45° angle. Clip off each lead flush with the solder joint as the joint is made. Note that not all of the fixed resistors are installed on the circuit board. In particular, R 1, and R 4 will be installed in later steps.



DESIGNATION		VALUE	COLOR CODE A-B-C
( )	R2	270 ohms	red-violet-brown
( )	R3	2700 ohms	red-violet-red
( )	R5	270 ohm	red-violet-brown
( )	R6	100K	brown-black-yellow
( )	R7	82K	grey-red-orange
( )	R8	68K	blue-grey-orange
( )	R9	82K	grey-red-orange
( )	R10	15K	brown-green-orange
( )	R11	2200	red-red-red
( )	R12	100K	brown-black-yellow
( )	R13	33K	orange-orange-orange
( )	R14	6800	blue-grey-red
( )	R15	10K	brown-black-orange
( )	R16	10K	brown-black-orange
( )	R17	680	blue-grey-brown
( )	R18	680	blue-grey-brown
( )	R19	680	blue-grey-brown

Install the ceramic disk and mylar capacitors. The ceramic disks without exception will have their value marked on the body of the part but the mylar capacitors may be color coded as shown below.

DESIGNATION		VALUE	COLOR CODE A-B-C
( )	C1	.1 mylar	brown-black-yellow
( )	C2	.1 mylar	brown-black-yellow
( )	C3	.001 ceramic disk	
( )	C5	.01 ceramic disk	
( )	C9	100 pf. ceramic disk	
( )	C10	.01 ceramic disk	



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 "+" lead of the capacitor goes through the "+" hole in the circuit board. In the event that the "-" lead of the capacitor is marked rather than the "+" lead it is to go through the unmarked hole in the circuit board.

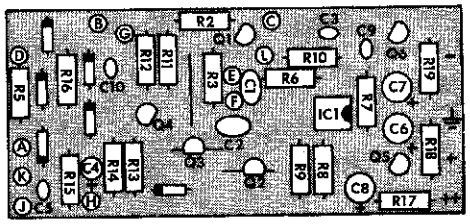


Figure 1

Note that the operating voltage (v.) specified for a capacitor is the minimum acceptable rating. Capacitors supplied with specific kits may have a higher voltage rating than that specified and may be used despite this difference. For instance, a 100 mfd. 25v. capacitor may be used in place of a 100 mfd. 16v. capacitor without affecting the operation of the circuit.

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

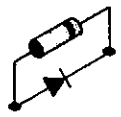
DESIGNATION		VALUE
( )	C4	2.2 mfd. 15v.
( )	C6	30 mfd. 10v.
( )	C7	30 mfd. 10v.
( )	C8	30 mfd. 15v.

Install the transistors. Orientation of the transistors is keyed by the flat on the side of the case and should be evident from inspection of the parts placement diagram shown in fig. 1 and the parts placement designators printed on the circuit board. All semi-conductors are heat sensitive and may be damaged if allowed to get too hot during soldering. To be on the safe side heat sink each transistor lead during the soldering operation by grasping it with a pair of needle-nosed pliers at a point between the circuit board and the body of the transistor. The part type no. is printed on the case.

DESIGNATION		TYPE NO.
( )	Q1	2N5139
( )	Q2	MPF-102
( )	Q3	MPF-102
( )	Q4	2N5139
( )	Q5	2N5129
( )	Q6	2N5139

Install all diodes. Note that these parts are polarized and must be properly oriented in order to operate properly. Polarization of the diodes is indicated by a colored band on one end of the case. Install as shown in figure 1. The physical appearance of the device is related to the schematic symbol used on the circuit board parts placement designators is the drawing below.

DESIGNATION		TYPE NO.
( )	D1	1N914
( )	D2	1N914
( )	D3	1N914
( )	D4	1N914
( )	D5	1N914
( )	D6	1N914



Install the integrated circuit IC-1. Note that the orientation of the integrated circuit is keyed by a notch at one end of the case which aligns with the semi-circular key on the designator printed on the circuit board. Use particular care when installing this part, like any other semi-conductor it is heat sensitive and should not be exposed to extraordinarily high soldering temperatures. Make sure that the orientation is correct before soldering, once the unit is in place it cannot be removed without destroying it.

( ) IC-1 ..... 748 or 301 type op-amp

( ) Using one of the pieces of excess wire clipped during resistor installation form and install the jumper shown in figure 1 and imprinted on the circuit board as a solid line.

In the following steps wires will be soldered to the circuit board which will in later steps connect to the keyboard, voltage divider circuit board and the front panel controls.

Part of this wiring is in the form of a 5 conductor cable. Begin by cutting an 8 inch length from the end of the cable supplied. At each end of this short length of cable strip away 1 inch of the outer insulation to expose the 5 conductors. The green wire in this bundle will not be used, at each end cut the green wire off flush with the end of the outer jacket. Strip 1/4 inch of insulation from the ends of the 4 remaining exposed wires (red, brown, black and white). "Tin" the exposed wires by melting a small amount of solder into the tightly twisted strands. Use the exposed wires at one end of the cable as follows:

( ) Solder the red wire to the circuit board point marked " +18"

( ) Solder the brown wire to the circuit board point marked " +9"

( ) Solder the black wire to the point marked with a ground symbol (⏚)

( ) Solder the white wire to the point marked " 9"

Prepare the remaining cable by stripping away 5 inches of the outer insulation from one end of the cable and separating out the 5 wire strands. In the following steps the individual wires exposed above will be cut to the proper length as measured from the end of the silver outer jacket. As each wire is cut to length strip away 1/4 inch of the insulation on that wire and tin the exposed strands.

( ) Cut the white wire to a length of 1 1/4 inch.
( ) Cut the black wire to a length of 2 3/4 inches.
( ) Cut the brown wire to a length of 4 1/4 inches.
( ) Cut the red wire to a length of 4 5/8 inches.
( ) Strip 1/4 inch of insulation from the end of the green wire. Twist and tin.

Solder the wires from the cable into the circuit board holes as follows:

( ) The white lead to "L".
( ) The black lead to "B".
( ) The brown lead to "A".
( ) The red lead to "K".
( ) The green lead to "J".

Prepare lengths of the single wire supplied by cutting to the indicated lengths and stripping 1/4 inch of insulation from each end of the wire. Tin both ends of the exposed wire and install in the circuit board holes indicated.

( ) A 24 inch length to "C".
( ) An 8 1/2 inch length to "D".

THIS COMPLETES THE 2720-8 SAMPLE AND HOLD CIRCUIT BOARD ASSEMBLY. TEMPORARILY PUT THIS BOARD ASIDE AND PROCEED TO THE ASSEMBLY OF THE VOLTAGE DIVIDER CIRCUIT BOARD.

( ) Prepare for assembly by thoroughly cleaning the conductor side of the board with a scouring cleanser. Rinse the board with clear water and dry completely.

Install the following 5% resistors on the long voltage divider circuit board. Note the gold tolerance band on all of these resistors. Avoid excessive soldering temperatures which could produce a permanent change in the resistor value. See figure 2.

	DESIGNATION	VALUE	COLOR CODE A-B-C
( )	R1	150 ohms	brown-green-brown
( )	R2	47 ohms	yellow-violet-black
( )	R3	47 ohms	yellow-violet-black
( )	R4	47 ohms	yellow-violet-black
( )	R5	47 ohms	yellow-violet-black
( )	R6	47 ohms	yellow-violet-black
( )	R7	47 ohms	yellow-violet-black
( )	R8	68 ohms	blue-grey-black
( )	R9	68 ohms	blue-grey-black
( )	R10	75 ohms	violet-green-black
( )	R11	75 ohms	violet-green-black
( )	R12	33 ohms	orange-orange-black
( )	R13	33 ohms	orange-orange-black
( )	R14	82 ohms	grey-red-black
( )	R15	91 ohms	white - brown-black
( )	R16	100 ohms	brown-black-brown

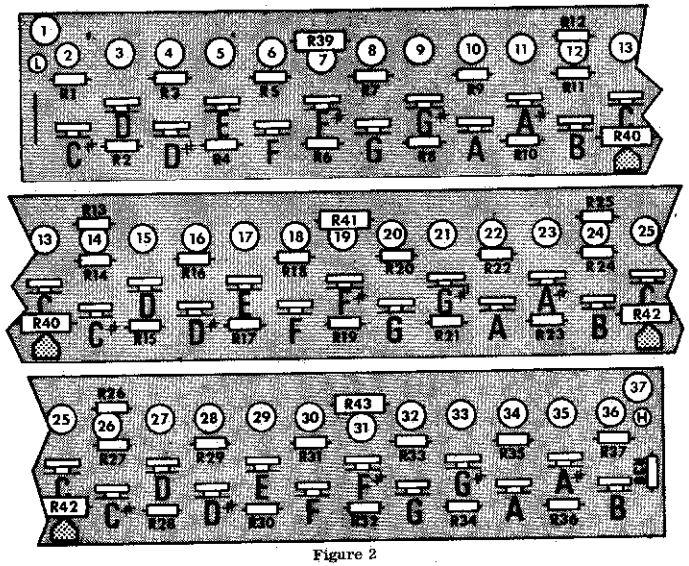


Figure 2

	DESIGNATION	VALUE	COLOR CODE A-B-C
( )	R17	100 ohms	brown-black-brown
( )	R18	100 ohms	brown-black-brown
( )	R19	120 ohms	brown-red-brown
( )	R20	120 ohms	brown-red-brown
( )	R21	120 ohms	brown-red-brown
( )	R22	150 ohms	brown-green-brown
( )	R23	150 ohms	brown-green-brown
( )	R24	150 ohms	brown-green-brown
( )	R25	75 ohms	violet-green-black
( )	R26	75 ohms	violet-green-black
( )	R27	180 ohms	brown-grey-brown
( )	R28	220 ohms	red-red-brown
( )	R29	220 ohms	red-red-brown
( )	R30	220 ohms	red-red-brown
( )	R31	220 ohms	red-red-brown
( )	R32	270 ohms	red-violet-brown
( )	R33	270 ohms	red-violet-brown
( )	R34	330 ohms	orange-orange-brown
( )	R35	330 ohms	orange-orange-brown
( )	R36	330 ohms	orange-orange-brown
( )	R37	330 ohms	orange-orange-brown
( )	R38	150 ohms	brown-green-brown

Install the 10% (silver or gold tolerance band) resistors as follows:

( )	R39	470 ohm	yellow-violet-brown
( )	R40	2200	red-red-red
( )	R41	1K	brown-black-red
( )	R42	2200	red-red-red
( )	R43	2700	red-violet-red

With one exception all of the trimmer resistors have a value of 1K ohms. The single exception is the trimmer that parallels R1. The value of this trimmer is 100 ohms and this part will be either separately bagged or otherwise marked. Install this trimmer at the left-most C* position.

( ) none ..... 100 ohm trimmer

Install the remaining 34 1K ohm trimmers.

( ) none ..... 34 each 1K trimmers.

( ) There is one solid wire jumper on the voltage divider board. Using a piece of excess resistor lead form and install this jumper.

THIS COMPLETES PRELIMINARY ASSEMBLY OF THE KEYBOARD VOLTAGE DIVIDER CIRCUIT BOARD. PROCEED TO THE MECHANICAL AND ELECTRICAL PREPARATION OF THE KEYBOARD.

NOTE: While assembling the keyboard be very careful not to bend the delicate gold-plated springs or rods that comprise the switch contacts.

( ) There are two steel "L" brackets attached to the rear of the frame of the keyboard assembly. Using a nut driver or pliers remove the self-tapping screws holding these brackets in place and reverse the brackets so that the short part of the "L" points toward the front of the keyboard.

( ) Using the insulated wire provided prepare thirty-seven (37) six inch (6") lengths of wire. Strip 1/4 inch of insulation from each end of each of the wires and twist and tin the exposed strands.

( ) On a broad, flat work surface place the keyboard upside down with the rear edge facing you. Attached to the rear edge of the circuit board that mounts the key switch springs are a total of thirty-eight (38) soldering lugs. Beginning at the right hand end of the keyboard, solder one of the wires prepared in the previous step to each of the solder lugs. Note that the final solder lug on the left hand end will not have a wire soldered to it at this point.

( ) Cut two 7 1/2 inch lengths of the wire provided and strip 1/4 inch of insulation from each end of each wire. Twist and tin the exposed ends. Solder one of these wires to the remaining left-most terminal lug on the switch board.

( ) Connect the second of these wires to switch buss "A" (left hand end of the keyboard, front rod) as shown in figure 3 by using a pair of needle nose pliers to form an eye in the wire and then closing this eye over the end of the buss rod. SOLDER CAREFULLY.

Prepare one end of the length of RG-174/U co-axial cable as follows:

( ) Strip away 1 inch of the outer insulation and un-braid the exposed shield wires. Before twisting the braid back together clip it off so that there is 3/8 inch extending beyond the outer jacket then clip off approximately half the strands flush with the outer jacket (this will "thin" the wire for ease of insertion into the circuit board hole in a later step). Twist the remaining strands of the shield together and tin. Remove 1/4 inch of insulation from the inner conductor and twist its strands together and tin.

Prepare the other end of this cable as follows:

( ) Strip away 1/2 inch of the outer insulating jacket and unbraid the exposed shield. Pull all of the unbraided strands to one side and twist them together. When tightly twisted, cut the strands so that they extend 1/4 inch from the body of the co-ax. Tin the strands carefully.(see figure 4)

( ) Strip 1/4 inch of insulation from the inner conductor of the co-ax and twist and tin the exposed strands.

Figure 4

( ) Locate the .01 mfd. ceramic disk capacitor C11. Starting as closely as possible to the body of this capacitor, wrap one of the leads tightly around the previously tinned shield wire as shown in figure 4 . Make sure that the wrapping starts close to the body of the co-ax and proceeds outward to the end of the tinned bundle. About 5 turns are all that are required. Carefully solder this joint and cut off any of the excess capacitor lead.

( ) Using a pair of needle-nose pliers form an "eye" in the end of the tinned inner co-ax conductor. Carefully solder this eye to the left end of switch buss "B" close to the buss support bracket.

( ) Solder the remaining free lead of capacitor C11 to the outer lead of switch buss "B". At this point the left end of the keyboard should appear as in figure 5 .

THIS COMPLETES MECHANICAL AND ELECTRICAL PREPARATION OF THE KEYBOARD. PROCEED TO PRELIMINARY CASE ASSEMBLY.

( ) Using 5 of the 1/4 inch spacers and #4 X 3/4 wood screws supplied fasten the voltage divider circuit board to the rear structural member of the case as shown in figure 6 . As viewed from the front of the case the right hand edge of the board should be 1 1/2 inches from the end of the case.

Install the keyboard in the case as follows: See figures 7 and 8.

( ) Orient the case so that the rear is facing you.

( ) Arrange the wiring from the keyboard switches so that the 37, 6 inch lengths of wire on the first 37 solder lugs come out between the keyboard frame "L" brackets while the wire from the last lug on the right end (as viewed from the top rear) as well as the co-ax and wire from the switch buss rods come out on the right side of the right hand "L".

( ) Carefully slip the left hand end of the keyboard into the case underneath the false key attached to the case end. The keyboard must be "cocked" slightly as shown in figure 7 so that the frame of the keyboard will clear the gusset that holds the case bottom in place.

( ) Now carefully lower the right end of the keyboard and slide the frame underneath the edge of the control panel support platform as shown in figure 8 .

( ) Slide the keyboard forward until the lip of the keyboard frame engages the slot formed between the case bottom and the keyboard front hold-down bar.

( ) Tilt the case forward until it is resting on its front edge and the bottom of the case is facing you. Using the two #8 X 1/2 machine screws provided fasten down the rear of the keyboard by passing the screws through the case bottom plate into the threaded holes in the "L"'s.

( ) With the case returned to its normal upright position mark two holes on the top surface of the rear structural member that are 4-3/16 inches apart. As viewed from the rear of the case the left mark should be about 1/2 inch from the right edge of the voltage divider strip and should be at least 3/16 inch from the rear edge of the member. Using two of the #4 X 1/4 inch wood screws provided fasten the two small "L" brackets to the rear structural member at the positions just marked. The unthreaded holes in the "L" brackets will be used in this step.

( ) Fasten the sample and hold circuit board to the "L" brackets using two #4 X 1/4 machine screws as shown in figure 9 .

BEGIN FINAL WIRING See figures 5 and 10.

( ) With the rear of the case still facing you, connect the 37, 6 inch lengths of wire coming from the keyboard to the corresponding points numbered 1 through 37 on the voltage divider circuit board. The wire coming from the first solder lug on the right end is not used here and if the previous steps have been closely followed this wire will be on the right side of the right keyboard "L" bracket.

( ) There should be an exact correspondance between the lug sequence on the keyboard and the connecting point on the voltage divider strip. Be very careful that no wires are crossed.

( ) Connect the wire originating at the right-most (as viewed from the top rear) lug of the keyboard switch assembly to point "H" on the S/H (sample/hold) circuit board. SOLDER. See figure 5.

( ) Connect the wire coming from switch buss "A" to point "G" on the S/H circuit board. SOLDER. See figure 5.

( ) Connect the shield of the co-ax coming from keyboard switch buss "B" to circuit board point "F". SOLDER. See figure 5.

( ) Connect the center conductor of the co-ax to circuit board point "E". SOLDER.

( ) Route the wire coming from circuit board point "C" on the S/H board behind the voltage divider board. So that the wire will not be loose, "sew" it in and out between the spacers holding the voltage divider board in place. Connect this wire to point "H" on the voltage divider board.

( ) Prepare an 8 1/2 inch length of wire by stripping 1/4 inch of insulation from each end and twisting and tinning the exposed strands. Solder one end of this wire to point "L" on the voltage divider circuit board.

Place the front panel face down on a soft rag to prevent marring the finish.

( ) Place a red pin jack (J1) in the hole provided as shown in figure 10 and fasten in place with a tinnerman nut as shown in detail figure 11. Press the tinnerman nut down firmly.

( ) In a similar manner mount red pin jack J2.

( ) In a similar manner mount red pin jack J3.

( ) Mount the 1K potentiometer R20 in the location shown in figure 10. Use two 3/8 inch nuts, one behind the front panel as a spacer and the second on the front side of the panel to secure the potentiometer. Adjust the rear nut so that none of the threaded shaft of the control is exposed when the front nut is tightened down. This will allow the control knob which will be mounted in a later step to seat as closely as possible to the front panel. Orient as shown.

( ) Cut one of the leads of the 1800 ohm (brown-grey-red) resistor R1 to a length of 1/2 inch. Cut the second lead to a length of 1 inch. Pass the 1 inch lead of this resistor through the upper lug on potentiometer R20 and solder it to the middle lug. Bend R1 around and connect the 1/2 inch lead to the bottom lug of R20. DO NOT SOLDER.

( ) Prepare the end of the longer of the two 5 conductor cables coming from the S/H circuit board by stripping away 1 3/4 inch of the outer insulation. Prepare the wires exposed by this operation by stripping 1/4 inch of insulation from each one and twisting and tinning the exposed strands.

( ) Route the 5 conductor cable under the control panel support platform and out through the large hole in the platform.

With the cable routed as above make the following connections to the control panel :

( ) White to pin jack J1. SOLDER

( ) Red to pin jack J2. SOLDER.

( ) Green to pin jack J3. SOLDER.

( ) Brown to the lower soldering lug of R20. SOLDER TWO WIRES.

( ) Black to the upper soldering lug of R20. SOLDER TWO WIRES.

( ) Use four #4 X 1/4 wood screws to mount the control panel. Be sure to center the panel so that it completely covers the hole in the control panel support platform.

( ) Using the cable clamp provided and one #4 X 1/4 wood screw take up the slack in the cable going to the control panel by clamping it to the left-hand case end plate.

In a later step the keyboard low-end adjustment potentiometer will be attached to the case cover. In the following steps you will be working with the control un-attached to any panel.

( ) Cut one lead of the 270 ohm (red-violet-brown) fixed resistor R4 to a length of 1/2 inch. Cut the other lead to a length of 1 inch.

( ) With the 1K potentiometer R21 oriented so that the shaft is pointing away and the solder terminals are up, pass the longer lead of R4 through the hole in the right hand solder lug and connect to the middle lug. SOLDER THE MIDDLE LUG.

( ) Bend R4 around and connect the free end to the left hand solder lug. DO NOT SOLDER.

( ) Connect the wire originating at point "L" on the voltage divider circuit board to the left hand lug of R21. SOLDER TWO WIRES.

( ) Connect the wire originating at point "D" on the S/H circuit board to the right hand lug of R21. SOLDER TWO WIRES.

Build up the power bus assembly as follows: See figure 12.

( ) Weight down the mounting tab of one of the 4 lug terminal strips so that the strip stands upright. Place two of the 17 inch nickel plate bus bars supplied through the outer lugs in the terminal strip. Note that these rods go through the hole that cinches the lug to the phenolic strip and not through the top part of the terminal. Arrange the rods so that approximately 1/4 inch pushes completely through the terminal strip and is exposed on the far side. Place a second terminal strip approximately half way along the rods to act as a temporary support. Solder together the rods and the end terminal strip. This step will require considerable heat but there is nothing that can be damaged during soldering.

( ) Slide the terminal strip that was acting as a support up to a position about 6 inches away from the terminal strip soldered in place in the above step. Slide a third terminal strip on to the rods to act as a temporary support. Solder the second terminal strip in place.

( ) Slide a fourth terminal strip onto the rods and arrange it so that about 1/4 inch of the rods passes completely through the strip and extends beyond the other side. Solder this terminal strip in place.

( ) Slide the unsoldered terminal strip from two steps above to a position about 6 inches from the terminal strip just soldered in place and solder it down.

( ) Slide a third rod through the holes in the bus assembly terminal strip lugs. (use the lugs that are not part of the mounting bracket) and solder in place.

AT THIS POINT THE POWER BUS ASSEMBLY IS A FAIRLY RIGID STRUCTURE AND MAY BE MOVED ABOUT.

( ) Place the entire power bus assembly on the power bus support rod in the case so that the end terminal strip is about 2 inches from the right hand end of the rod as viewed from the front side of the case. Fasten the bus assembly in place using 4 each #4 X 3/8 inch wood screws, one through each of the terminal strip mounting lugs. If possible, pre-drill the holes for the wood screws with a 1/16 inch drill.

( ) Slide the remaining rod through the holes in the terminal strip lugs and solder in place.

Make the following connections between the power bus assembly and the 5 conductor cable previously connected to the power input points of the S/H circuit board. Make the connections directly to the soldering lugs on the left hand end of the power bus but DO NOT SOLDER AT THIS TIME.

( ) The red wire to the upper-most lug.

( ) The brown wire to the second lug down.

( ) The black wire to the third lug down.

( ) The white wire to the bottom lug.

AT THIS POINT YOU ARE READY TO BEGIN MOUNTING THE UPPER CASE SHEET METAL AND LOWER MODULE SUPPORT BRACKET.

( ) Remove the paper backing of the 31" foam strip supplied and adhere this foam to the lower shorter side of the wooden bracket spacer as shown in figure 13B. Note that this foam strip must clear the holes in the end of the bracket spacer.

( ) Pass the two #4 X 1-1/2 wood screws through the lower module support bracket and the corresponding holes in the wooden bracket space as shown in figure 13A. AT THIS POINT THESE LONG SCREWS ARE BEING USED ONLY TO LOCATE THE PROPER RELATIVE POSITIONS OF THE BRACKET SPACER AND LOWER SUPPORT BRACKET. DO NOT FASTEN THIS ASSEMBLY TO THE CASE AT THIS TIME.

( ) Fasten the lower module support bracket to the wooden bracket spacer using two of the short wood screws provided (NOTE: some kits may contain only self tapping sheet metal screws. If this is the case in your kit substitute these for the wood screws in this step.)

( ) Temporarily mount the upper case sheet metal to the case by passing two short wood screws through the upper surface of the sheet metal into the wooden end pieces. NOTE that the mounting surfaces for the upper case sheet metal have been cut slightly undersized to allow for exact positioning of the front edges of the sheet metal and the case wood-ends. This may cause the rear edges of the corners of the sheet metal and wood-ends to be separated slightly but this will not matter. Do not install the screws in the rear of the case at this time.

( ) Temporarily set the lower module support bracket and attached wooden bracket spacer on top of the keyboard across the width of the case. When finally installed, the front edge of the short bottom side of the bracket spacer will be roughly even with the rear most edge of the accidental (black) keys of the keyboard.

( ) Attach the two 4" X 1/2" chrome steel bracket locating strips to the upper case sheet metal using two of the self tapping screws provided. Note that the second holes in from each end of the sheet metal are used in this step as shown in figure 14.

( ) Fasten the lower edges of the bracket locating strips to the lower module support bracket at the holes corresponding to those used on the upper case sheet metal.

AT THIS POINT THE BRACKET LOCATING STRIPS EXACTLY SIMULATE TWO MODULES BEING IN PLACE AT OPPOSITE ENDS OF THE CASE AND THE LOWER MODULE SUPPORT STRIP IS CONSTRAINED TO THE POSITION IT MUST OCCUPY IF FUTURE MODULES ARE TO FIT THE CASE.

( ) Use the two #4 X 1-1/2 wood screws, two 1/4" spacers and as many flat washers as are required to mount the lower module support assembly in place. Typicly, two washers will be required on each end and these are to go on either side of the spacers. At this point the bracket locating strips and upper case sheet metal may be removed. The lower module support assembly is not a very rigid structure at this point so be careful not to break it. It will become rigid again when modules are mounted.

WE MAY NOW FINISH THE CASE ASSEMBLY BY MOUNTING AND WIRING IN THE POWER SUPPLY MODULE AND RE-INSTALLING THE UPPER CASE SHEET METAL.

( ) Cut four pieces of wire to 10 inch length and strip 1/4 inch of insulation from each end of each of the wires. Twist the four wires into a bundle.

( ) Using a pair of needle-nose pliers mount the four "flea" clips in the "++", "+", "⏚" and "-" points at the rear edge of the Power Supply circuit board. Solder these clips in place. See figure page 12.

( ) Using the four wire bundle just prepared connect the power output points of the Power Supply Bus Rod assembly. Make the connections directly to the solder lugs that already have the supply connections for the S/H circuit board attached to them. Make sure that the "++" wire from the power supply connects to the upper rod of the Power Buss Assembly, the "+" to the second rod down, the "⏚" to the third and the "-" to the lowest rod. Solder the two wires connected to each of these lugs.

( ) Fasten the lower edge of the Power Supply front panel to the lower module support bracket using two of the short self-tapping sheet metal screws provided. Make sure that the power cord from the power supply module passes over the top of the rear case structural member that mounts the S/H and voltage divider circuit boards.

( ) Mount the low-end keyboard adjusting pot to the upper case sheet metal by passing its shaft through the circular 3/8 inch hole provided and using a single 3/8 inch nut to fasten it in place. No knob will be installed on this control.

( ) At a point 5 inches from the rear edge of the circuit board clamp the strain relief onto the line cord.

( ) Slip the strain relief into the notch provided on the rear edge of the upper case sheet metal and re-install this upper case part. Note that the notch that contains the strain relief is "closed" by the rear case structural member, thereby securing the strain relief.

( ) Use six short wood screws to secure the upper case sheet metal to the wood-ends.

( ) Use two of the self-tapping sheet metal screws provided to fasten the upper edge of the power supply front panel to the upper case sheet metal.

( ) Rotate the shaft of pitch control R20 fully counter-clockwise and install the knob so that the pointer is directed toward the "7 O'Clock" point of an imaginary clock face.

THIS COMPLETES THE ASSEMBLY OF THE 2720-8 KEYBOARD/CASE.

JUMPER LEADS

The flexible test lead provided is intended to be used for both control voltage and audio jumpers. Since the grounds of all the modules in use within a single system are common through the power supply, grounds from one module to another are not required as part of the jumpers. The cable or cables that connect the output of the synthesizer to the audio amplification system must be provided with a ground.

TESTING AND CALIBRATION

During the calibration procedure you will be working with a VCO that has been roughly calibrated following the tuning procedure outlined in the assembly manual for that module. The purpose of that procedure was to make the input voltage/output frequency response conform as closely as possible to the graph shown in figure 15. While the slope of this line is not super critical - small variations can be compensated for at the keyboard - the fact that it intersects the origin (zero frequency for zero control voltage) is of critical importance.

To clarify this some, assume for a moment that when the oscillator was calibrated errors in the VOM caused the actual response of the VCO to be as shown in figure 16. This graph is exaggerated but it is typical of the errors that occur in actual practice. Performing the first part of the calibration procedure that will follow would set up the three octave interval from C_5 to C_2. Everything is fine to this point, it doesn't really matter that the low end of the keyboard is about .45 volts rather than the design value of .625 because the trimmers on the voltage divider can make up the difference.

Now the problem. When we try to drop the keyboard an octave by pushing the C_5 key and cranking back the pitch knob until we hear C_4 we discover that the rest of the keyboard is no longer in tune. The reason is that turning the pitch knob has the effect of dividing the voltage at each tap on the divider by a constant factor (.493 in this case) but when the voltage at the low end of the keyboard is divided by this term the result is .22 volts - corresponding to a note considerably higher than the intended C_1.

A part of the keyboard calibration procedure will be concerned with calibrating the response curve of the VCO so that it does in fact intersect the origin. Two methods of calibrating the keyboard will be outlined. The first method uses an oscilloscope and signal generator while the second method relies on a tuned musical instrument as a pitch reference. The purposes of both of these procedures will be the same; first to exactly calibrate the voltage drop from one end of the keyboard to the other and secondly to set the proper voltage intervals using the trimmer potentiometers. Neither method has an appreciable edge as far as accuracy or simplicity of procedure is concerned.

Connect your VCO to the power bus assembly, the "++" power supply point goes to the second rod from the top, " + " to the third from the top and "-" to the bottom rod. Further adjustment of the oscillator's internal adjustments may be required so do not permanently mount the VCO at this time.

METHOD #1, USING TEST EQUIPMENT

As shown in figure 17 arrange the VCO, an audio generator and oscilloscope so that the 'scope will display a Lissajous figure such as those shown in figures 18 through 22. Set the frequency of the audio generator to 260 Hz and apply a control voltage to the VCO so that a pattern appears on the 'scope. Adjust the vertical gain of the 'scope and the output of the audio source so that the pattern fills the screen. Allow the VCO to run for about 10 minutes so that temperatures can can stabilize.

Before starting the calibration procedure set all trimmer potentiometers on the keyboard voltage divider circuit board to the mid point of their rotation.

(1) Remove the external control voltage source from the VCO and set the low end trimmer potentiometer (R21 located at the rear of the case) to about the mid-point of its rotation.

(2) Press and hold the highest key of the keyboard (C) and adjust the "pitch" knob (R20 located on the keyboard control panel) for the pattern shown in figure 22 indicating that the output of the VCO is exactly 4 times the reference frequency. (NOTE: you do not expect that the test oscillator will be any closer than about 5% to exactly 260 Hz. but because the frequency remains the same and Lissajous patterns are used to set the VCO to exact multiples of that reference it doesn't matter that the reference is not exact. Similarly, it is of little importance that 260 Hz. is not exactly C).

(3) Press the lowest C key on the keyboard (first key) and adjust low end trimmer R21 for the Lissajous pattern shown in figure 19 indicating that the VCO is exactly half of the reference frequency.

(4) Once again press the highest C and check to see if the frequency has changed slightly (it probably has). Readjust the pitch knob for the pattern shown in figure 22.

(5) Go back and forth between the highest and lowest C until the patterns corresponding to these keys are stable without further adjustment. (a slight rotation of the traces is acceptable, as long as you are able to recognize them)

(6) Press and hold the highest C key while rotating the pitch knob counter-clockwise until the point is reached at which the scope displays the pattern shown in figure 21 indicating that the frequency of the VCO is exactly twice that of the reference.

(7) Press and hold the Lowest C key and observe the scope trace. If it looks like figure 18 (indicating that the VCO is running at 1/4 the frequency of the reference) you're in business. Procede with setting the intervals starting with step 8. If the trace is not as shown in figure 18 (and chances are it won't be) adjust the ZERO CONTROL OF THE VCO (R4) until you get this trace. Repeat steps 1 through 7 until the patterns displayed in each step are stable (or experience only a slow rotation) without further adjustment of the keyboard low end trimmer or the VCO zero trimmer.

(8) Once again press and hold the highest key and rotate the pitch knob clockwise until the 'scope shown the pattern of figure 22.

(9) The trimmers for the intermediate C's of the keyboard are marked with arrowheads on the voltage divider circuit board. Press and hold the key corresponding to the higher of these two intermediate C's and adjust its trimmer potentiometer until the pattern shown in figure 21 is displayed on the 'scope.

(10) Similarly, press and hold the key corresponding to the lower of the two intermediate C's and adjust it's trimmer for a stable trace like the one shown in figure 20. NOTE: If a change of more than 45^0 of the rotation of the trimmers in steps 9 and 10 is needed to produce the required patterns it may indicate a solder bridge, cold solder joint or improper resistor placement on the voltage divider circuit board.

(11) Lower the keyboard an octave and check the traces of the intermediate C's against figures 19 and 20. NOTE: It is possible that there will be slight non-linearities in the response of the VCO that cause the intermediate C's to differ slightly as the pitch control is changed. For either of these C's it may be necessary to "split the difference" for optimum performance. Remember that you are seeing very small changes in frequency when using Lissajous patterns. In figure 19, for example, a complete rotation of the pattern every second corresponds to 1/2 cycle per second difference between the VCO and reference frequencies.

the major intervals of the keyboard are now set and you've gone as far as you can go using commonly available test equipment. At this point you can either set the semi-tone intervals by ear or with comparison with a tuned musical instrument. Don't scoff at the "by ear" method, most people can come amazingly close once they have the octave intervals set. (if you can't hear a difference does the difference really matter?) Adjust the pitch of each note by setting the corresponding trimmer potentiometer on the keyboard voltage divider circuit board. DO NOT ADJUST THE "C" TRIMMERS.

METHOD #2, USING A TUNED MUSICAL REFERENCE

Connect the Pulse output of the VCO to the line level input of a hi-fi or instrument amplifier and temporarily jumper a constant control voltage (from one of the power supply bias sources) to one of the control voltage inputs. Allow the VCO to run for about 10 minutes to allow temperatures to stabilize. Jumper the "out" pin jack from the keyboard control panel to the left hand control voltage input pin jack and center all trimmers on the voltage divider circuit board as well as the pitch and low end trimmer potentiometer.

(1) Press and hold the highest C on the keyboard and adjust the pitch knob for zero beat between this note and the second C above middle C on the reference instrument.

(2) Press and hold the lowest C on the keyboard and adjust for zero beat between this note and the C below middle C on the reference instrument.

(3) Go back and forth between steps 1 and 2 until there is zero beat for both notes without further adjustment.

(4) While holding down the highest C on the keyboard turn the "pitch" control counter-clockwise until the note produced is zero beat with the C above middle C of the reference instrument.

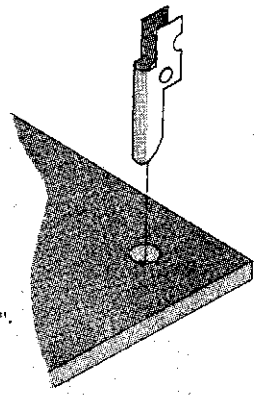
(5) Check the lowest C on the keyboard. If it is zero beat with the second C below middle C of the reference instrument you can proceed to step 6. If the two notes are not the same zero beat them by adjusting the ZERO CONTROL OF THE VCO. Repeat steps 1 through 5 until all notes are identical without any adjustment of either the VCO zero trimmer or the keyboard low end trimmer.

(6) Once the high and low end adjustments are made on the keyboard and VCO the two intermediate C's may be set by using the pitch control to return the highest C to zero beat with the second C above middle C then using the designated trimmers on the voltage divider circuit board to zero beat the second and third C down the keyboard with the C above middle C and middle C respectively.

(7) Press each key in turn and adjust the trimmer potentiometer corresponding to that key for zero beat with the corresponding note on the tuned reference instrument.

ADDING FUTURE MODULES

There is limited clearance between the rear of the keyboard and the positions occupied by the modules in the case. The module circuit boards must be perpendicular to the front panel if the circuit board is not to touch the back edge of the keyboard. Lock washers must be used on each of the four 4-40 screws that attach the circuit boards and front panels to the "L" brackets. If there is a slight "droop" to the circuit board it can be cured by using pliers to bend the "L" brackets slightly.



Miniature "flea" clips are supplied with each of the PAIA 2720 series module kits. These clips are to be installed in the power input points of the circuit boards when they are mounted in the 2720-8 Keyboard/Case.

Always be cautious that there is a direct correspondance between the power supply points on the modules that you are installing and the voltage supplied by the point of connection on the Power Buss Rod Assembly. Remember that the voltages present on the rods are decreasing magnitude from upper to lower with the topmost rod being "+" and the lowest rod "-". Power connections at the buss rods need not be mechanicly secure and in fact, a simple "L" bend in the pre-tinned lead from the module being installed may be looped over the rod at any point and soldered in place. The buss rods are pre-tinned and soldering to them should present no problems. If a module ever needs to be removed you will be glad that you didn't wrap several turns around the rod.

Mechanicly, all modules are installed as was the Power Supply. Place the module in the desired position and fasten it in place with as many self-tapping screws as there are mounting holes in the module's front panel. The appropriate number of screws required for mounting each module should be supplied with the module kit.

Blank panels in triple, double and single widths with mounting holes are available from the factory.

Prices are:			part #
	single width	$1.50	2720-BP1
	double width	2.00	2720-BP2
	triple width	2.50	2720-BP3

The appropriate panel needed to fill any gaps in package purchases are included with the package.

USING THE 2720-8 KEYBOARD

The purpose of any controller is to provide a manually variable source of voltage which can be used to change the parameters of any of the modules.

If the controller is to be a type of keyboard there are some additional design objectives that must be added to simply generating a voltage. For instance, for maximum versatility there should be some way to signal the rest of the modules when a key is pressed and when it is released. The 2720-8 provides these features by supplying two types of trigger output functions.

The first trigger output is a voltage step that goes high when any key is pressed and stays high until all keys are released. This trigger could be used directly as a control voltage but it will most often be used to start the 2720-4 Function Generator. Using this trigger will cause the output of the Function Generator to remain high as long as any key is held down (see 2720-4 instruction manual and "Using the 2720 Synthesizer" for further details).

The second trigger output is a short duration voltage pulse that rises whenever any key is pressed. All keys must be released before another pulse can be generated. This trigger output will always be used as an initiating pulse to the Function Generator as described in the 2720-4 Function Generator instruction manual.

Many of the effects produced using the 2720 will use the end of the voltage step trigger output as a signal to begin processing the decay portion of the sound. Since the step does not end until the keys are released there must be some way to hold the voltage that last appeared at the output of the controller; otherwise when the key is released the controller output will drop to zero causing the VCO (or other module connected to the Controller output) to go to its zero control voltage condition (no output in the case of the VCO). The sample and hold circuit that is part of the controller package solves this problem by serving as a short term analog memory. Every time a key is pressed the S/H will store the voltage corresponding to that key for a period of time greater than 20 seconds or until the next key is pressed. No apologies need to be made for the Sample and Hold, it is one of the best designs available and even through 20 seconds may not look like a long time it is more than long enough for practicly any application.

The design of the controller provides for three octaves of key selectable control voltage but since the range of the VCO is considerably greater than three octaves provision has been made for raising or lowering the keyboard a full octave, thereby giving it a four octave capability. The pitch knob can also be set to any position between the extremes of its rotation without altering the chromatic tuning of the keyboard. Manual glissando or very slow tremolo can be added to a note simply by holding down the key and rotating the pitch knob.

Pressing two keys simultaneously will not produce the notes corresponding to both keys (since only one control voltage can be generated at any one time) but it will produce a tone somewhere between the notes. Many interesting non-chrumatic melody lines can be produced by pressing two keys at the same time.

OPERATION OF THE CONTROLS IS AS FOLLOWS:

KEYS Pressing any key causes a pre-set voltage to appear at the control voltage output jack. In most cases these voltages will be set to generate a chromatic scale but other tunings are possible.

PITCH The pitch knob on the control panel allows the entire keyboard to be lowered an octave from the standard tuning. Counter-clockwise rotation of the knob decreases output voltage for any given key.

STEP The uppermost pin jack on the control panel provides access to a voltage that changes from 0 volts to 5 volts when any key is pressed. This voltage remains at the high level as long as the key is held down.

PULSE The middle pin jack provides access to a short duration trigger pulse that is generated when any key is pressed. All keys must be released for the pulse generator to re-set before it can produce another pulse. Re-set time is short, on the order of one ten-thousandth of a second. (.0001 sec.)

DESIGN ANALYSIS

Reduced to basics the controller is nothing more than a switch controllable voltage divider but it starts to get a little more complicated as "housekeeping" functions are added. In addition to the voltage divider the circuit includes both the current source, trigger circuit and sample/hold circuitry.

The constant current source is a standard design built around Q1 and using the voltage drop across the series combination of D1 and D2 as a reference. The output of the current source is regulated by changing the d.c. feed-back with emitter resistor R20. The current source feeds the voltage divider shown in figure 23 and represented by R_K in figure 24.

The voltage divider is implemented with a string of fixed and variable resistors as shown in figure 23. In order that the voltage output of the string be exponential, to duplicate the exponential nature of the equally tempered musical scale, the resistance values are calculated and selected so that the resistance of any parallel pair in the string is approximately 1.059 times greater than the resistance of the pair directly below it. This is further discussed in the 2720 User's Manual. In order to compensate for tolerance pile-ups over the length of the voltage divider, the trimmers for the octave points corresponding to the two middle C's of the keyboard are arranged so that they can raise and lower the voltage at those points over a 6 to 8 semi-tone spread rather than through a single semi-tone as are the other trimmers.

There are two sets of contacts associated with each key. The first set of contacts switches a voltage from the voltage divider corresponding to the key pressed and applies it to point "E" in figure 24. The second set of contacts are common to all keys and closes whenever any key is pressed. This set of contacts causes the S/H to store a new sample and also provides the step and pulse trigger outputs.

When any key is pressed it first causes the voltage pick-off switch to close, thereby applying a voltage corresponding to the position of the key to be applied to C1, which is simply an integrating capacitor to by-pass any noise that might be generated by dirt on the contacts. Next, the switch common to all keys closes, and this set of contacts does a number of things. A voltage begins to flow through the resistance string consisting of R11, R15 and R16. The current flow through R16 causes a voltage drop to appear across this resistor and this voltage is applied to the pin jack J3 where it serves as the step output. The step is differentiated by C5 and appears at pin jack J2 as the pulse output. Diode D6 serves to shunt to ground the negative pulse that would appear when the step returned to zero.

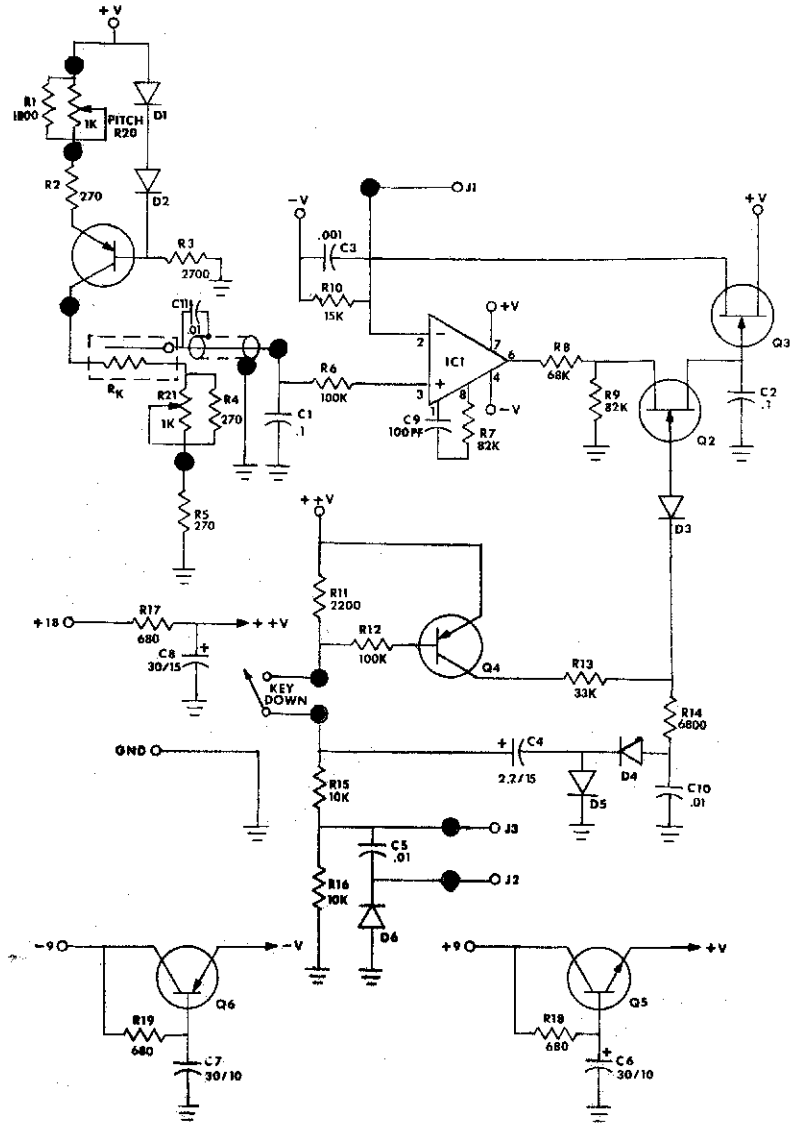
The current flow through R11 causes a voltage drop that allows current flow through R12, to turn on Q4. With Q4 on, current can flow through R13, R14, D4 and D5 to ground. This current flow raises the junction of R13 and R14 to a voltage that is high enough to insure that the Field Effect Transistor Q2 will be turned on (this FET will be covered shortly). The voltage that appears across the series string of R15 and R16 causes C4 to charge through the forward-biased D5, the significance of this will be shown presently.

The Sample and Hold circuit can further be broken down into a comparator (IC-1), a high impedance FET source follower (Q3) and a switch (Q2). The comparator is constantly comparing the input from the keyboard to the output appearing across the load resistor of the source follower (R10). The state of this comparator has no effect on the holding capacitor C2 (and consequently the output of the source follower for which this capacitor is an input) until the switch Q2 is turned on. With Q2 "on" the comparator works to make the voltages at its "+" and "-" inputs identical. When the voltages are identical the circuit is in a balanced condition.

When the key is released Q4 turns off which removes the current flow through D4 and D5. Simultaneously, the positive side of C4 is allowed to go to ground through R15 and R16. In this configuration the negative side of C4 is connected to C10 through D4 and D4 is forward biased for these conditions, the charge that was on C4 now "dumps" onto C10 and since the positive side of C4 is at ground, the ungrounded end of C10 is pushed about 15 volts negative with respect to ground. This high negative voltage is applied to the gate of Q2 thereby turning this FET off. All possible leakage paths for the voltage across C10 are at this point either reverse biased diodes, "off" transistors, or the reverse biased gate junction of Q2. Since there is no discharge path for C10 its voltage remains high and holds Q2 off for an extended period of time.

With Q2 off, the holding capacitor C2 is isolated from any discharge paths but the voltage across this capacitor still serves as the input for the source follower so the output voltage at point "L" does not change.

Q5 and Q6 serve as capacitance multipliers for the filter capacitors C6 and C7.



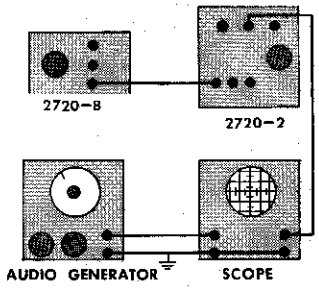


Figure 17

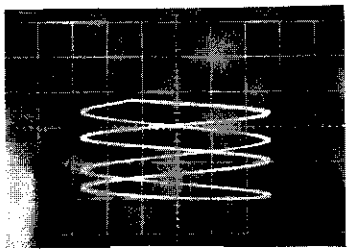


Figure 18

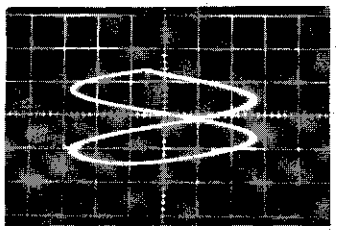


Figure 19

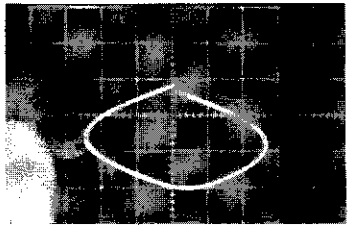


Figure 20

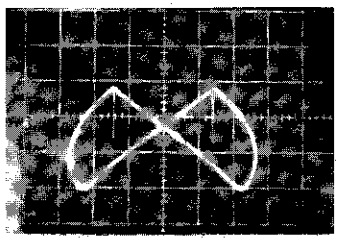


Figure 22

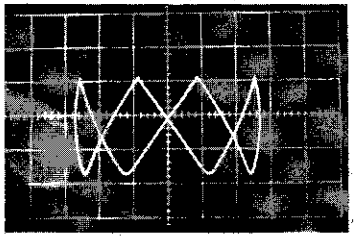


Figure 21

PAIA Electronics

P. O. BOX 14359 OKLAHOMA CITY, OKLA. 73114 (405) 842-5480

Keyboard/Case Assembly Diagrams

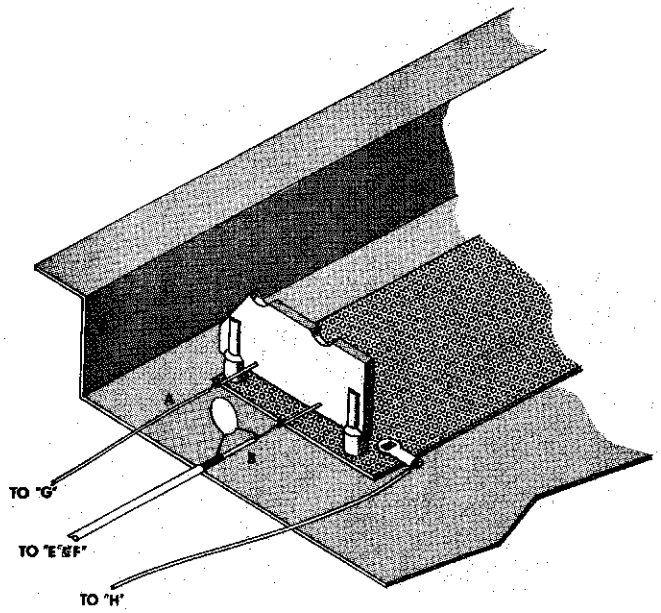
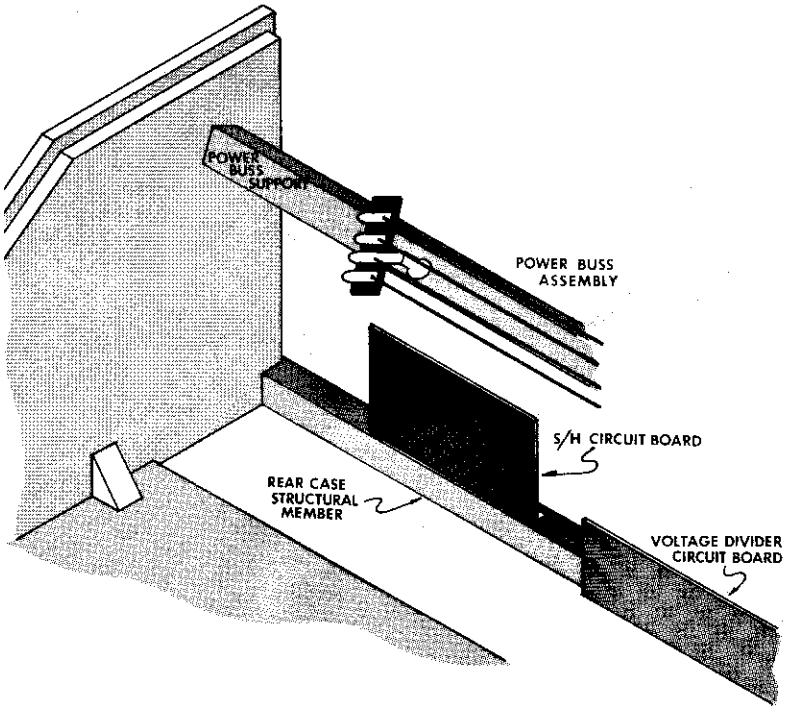


Figure 3



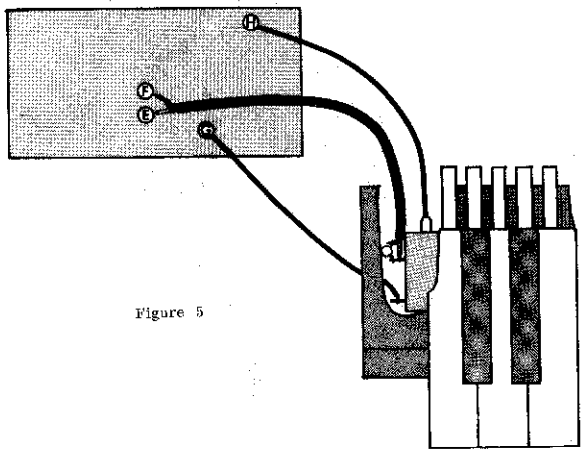


Figure 5

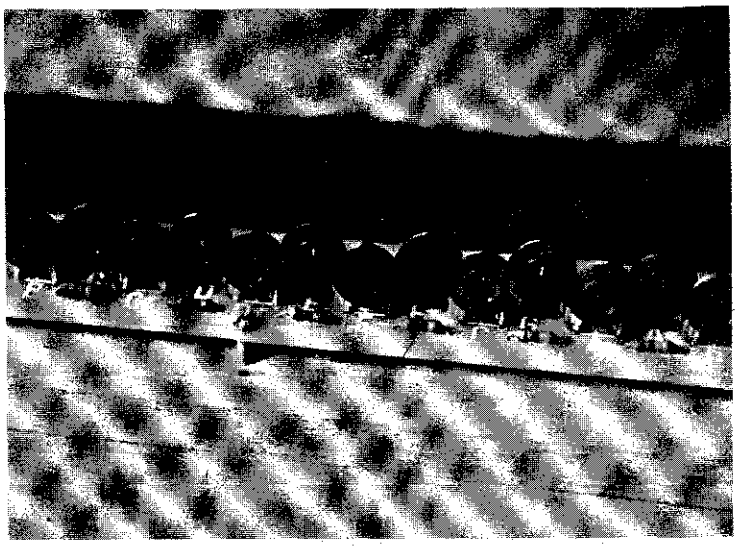


Figure 6

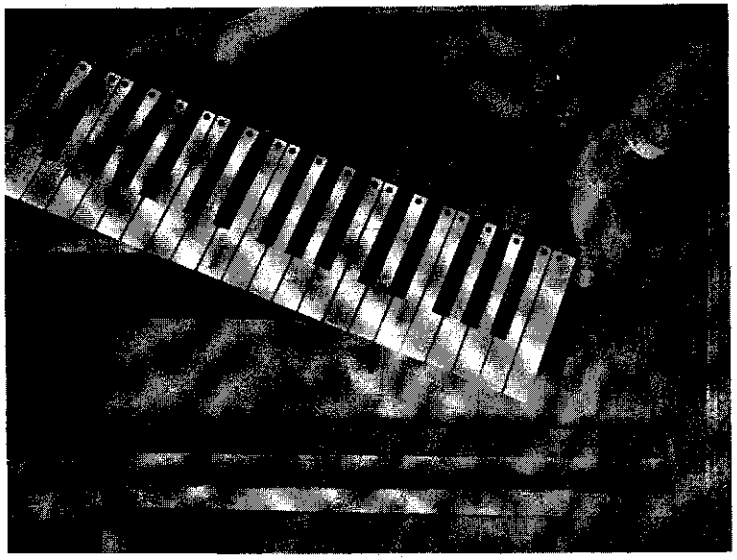


Figure 7

Figure 8

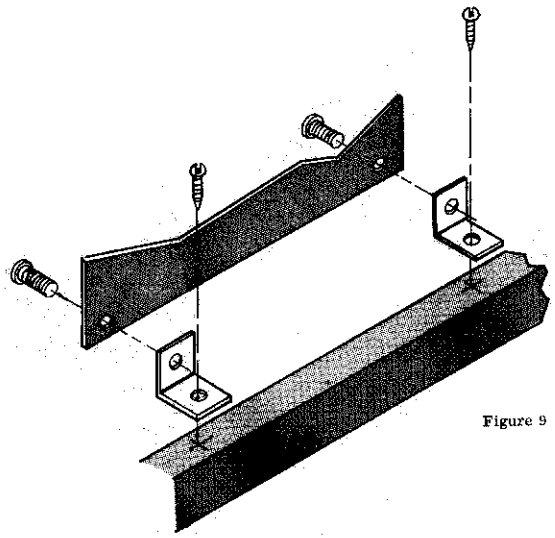


Figure 9

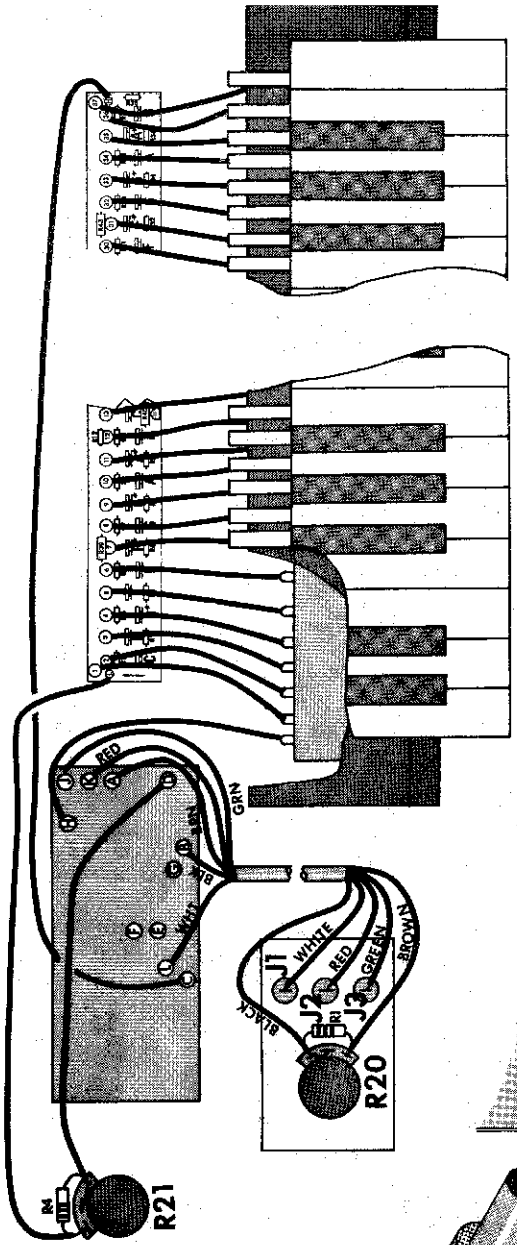


Figure 10

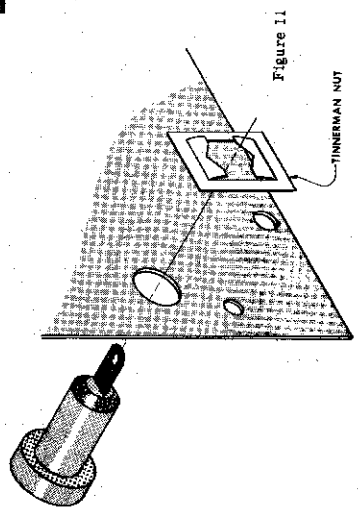


Figure 11

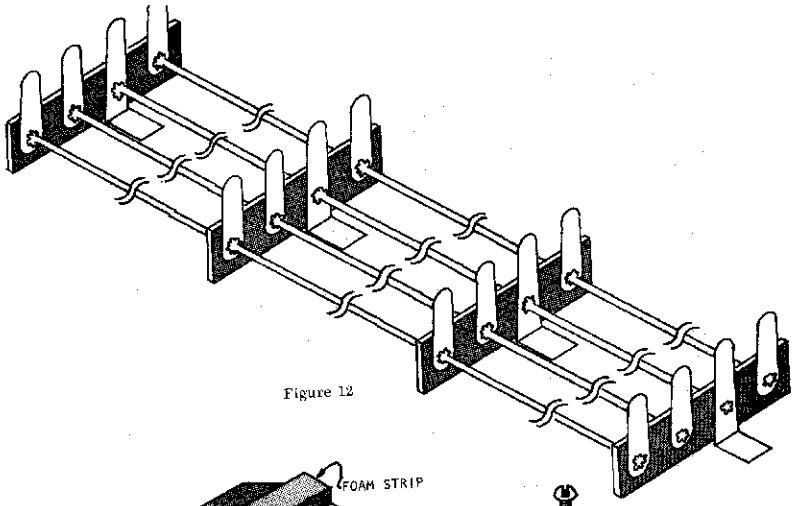


Figure 12

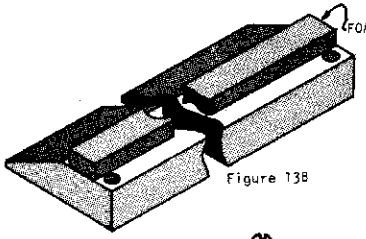


Figure 13B

Figure 13 A

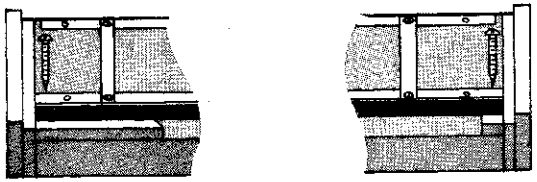


Figure 14

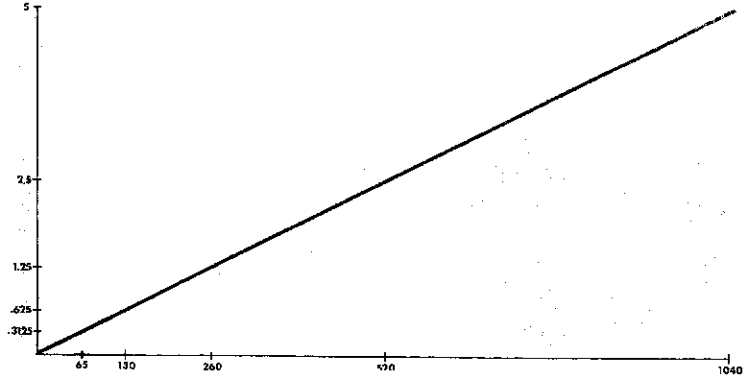


Figure 15

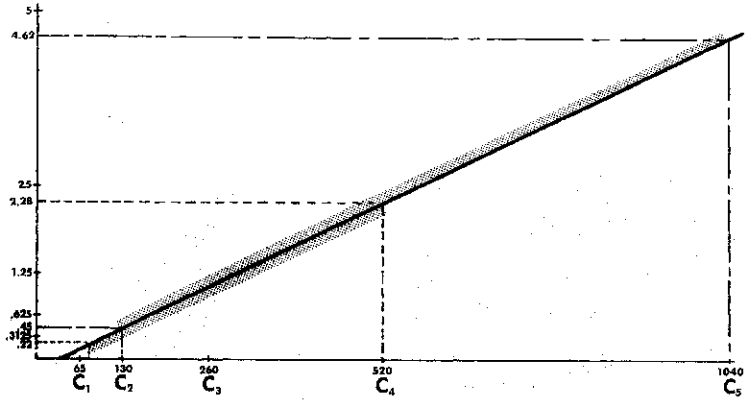


Figure 16