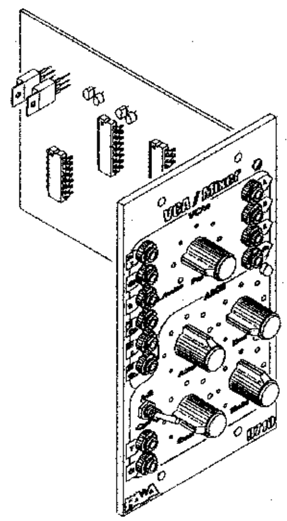
Triple VCA w/Modulator



Model 9710
Assembly and Using Manual

Ordinarily, Voltage Controlled Amplifiers are pretty routine. But by combining 2 VCAs, a Balanced Modulator, a White Noise Source and Envelope Generator in a single module and interconnecting them with a powerful normalization design, the 9710 redefines what a VCA module should be.

At the highest level, you can use the 9710 like a traditional VCA but with the added convenience of a built-in Voltage Controlled Input Submixer and ADSR Envelope Generator. This configuration of elements allows a couple of signals to be mixed together before being processed by the VCA which is controlled by the ADSR. It would ordinarily require three or four modules and a handful of patch cords but is embodied as a single element in the 9710.

And the versatility of individual modules is not sacrificed because patch cords can be used to override the normalization and access progressively lower level functional sub-groups or even the individual elements.

ASSEMBLING THE 9710 Triple VCA W/Modulator

Before beginning assembly, go through the manual. Look at the drawings. Feel the parts. You're naturally eager to plunge right in, but take a few deep breaths first. Check the parts supplied against the packing list on the last page of this manual.

In some cases, notes packed with the parts will be used to call your attention to special situations. These notes may be in the yellow "MISSING PARTS" postcard. ***If parts are missing*** *please notify PAiA at p405.340.6300, f340.6378, or damn@paia.com .*

Notice that each step in the manual is marked with a checkoff box like this:

DESIGNATION	VALUE	COLOR CODE
( ) R27	100 ohm	brown-black-brown

Checking off each step as you do it may seem silly and ritualistic, but it greatly decreases the chance of omitting a step and also provides some gratification and reward as each step is completed.

Numbered figures are printed in the Illustrations Supplement in the center of this manual. These pages may be removed for easy reference during assembly.

THE CIRCUIT BOARD

The 9710 VCA is built on a double-sided circuit board. No special preparation or cleaning is necessary before assembly. The "top" of the board is the side that is printed with component designations and parts are mounted from this side. The "bottom" of the board is also called the solder side and is masked with a conformal coating to lessen the chance of solder bridges. Solder pads are tin-lead plated for ease of soldering and assembly.

TOOLS

You'll need a minimum of tools to assemble the kit - a small pair of diagonal wire cutters and pliers, screwdriver, sharp knife, ruler, soldering iron and solder.

Modern electronic components are small (in case you hadn't noticed) and values marked on the part are often difficult to see. Another handy tool for your bench will be a good magnifying glass. Also use the magnifier to examine each solder joint as it is made to make sure that it doesn't have any of the problems described in the SOLDERING section which follows.

SOLDERING

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

Use only a high quality 60/40 alloy rosin core solder (acid core solder is for plumbing, and silver solder is for jewelry - neither is for electronics work). A proper solder joint has just enough solder to cover the soldering pad and about 1/16-inch of 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 when 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.

Too much solder may produce a conducting bridge of excess solder between adjacent pads causing a short circuit. If WAY too much solder is used it may flow through the hole and cause bridges between conductors on the component side of the board or even impede the action of mechanical components such as trimmer potentiometers. Accidental bridges can be cleaned off by holding the board upside down and flowing the excess solder off onto a clean, hot soldering iron.

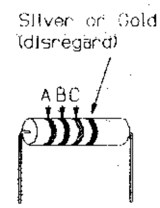
Use care when mounting all components. Never force a component into place.

Special thanks to the beta crew -

Scott Lee
Tim Furry
Johnny Klonaris
David Hillel Wilson
and me - John Simonton

Resistors

Solder each resistor in place following the parts placement designators printed on the circuit board and the assembly drawing fig 1. Note that resistors are nonpolarized and may be mounted with either lead in either of the holes in the board. Before mounting each resistor, bend its leads so that they are at a right angle to the body of the part. Put the leads through the holes and then push the resistor firmly into place. Cinch the resistor in place by bending the leads on the solder side of the board out to an angle of about 45 degrees. Solder both ends of each resistor in place as you install it. Clip each lead flush with the solder joint and save a few of the clippings for use in later steps.



A tip: If you can't find the location for a resistor, go on to the next one and come back. DO NOT CHECK OFF A PART UNTIL IT IS INSTALLED AND SOLDERED.

DESIGNATION	VALUE	COLOR CODE A-B-C	
listed below:	100	brown-black-brown	
( ) R28	( ) R33	( ) R40	( ) R44
listed below:	100k	brown-black-yellow	
( ) R4	( ) R5	( ) R8	( ) R9
( ) R11	( ) R14	( ) R65	( ) R67
( ) R73	( ) R89	( ) R92	( ) R94
( ) R96	( ) R105		
listed below:	10k	brown-black-orange	
( )R12	( ) R13	( ) R21	( ) R50
( ) R64	( ) R66	( ) R91	( ) R93
( ) R100	( ) R102	( ) R104	( ) R108
( ) R118			
( ) R38	10m	brown-black-blue	
( ) R48	10m	brown-black-blue	
listed below:	120k	brown-red-yellow	
( ) R3	( ) R6	( ) R7	( ) R10
( ) R19	( ) R76		
( ) R15	1500	brown-green-red	
( ) R18	1500	brown-green-red	

/DESIGNATION VALUE COLOR CODE A-B-C

lsted below: 15k brown-green-orange
( ) R41 ( ) R42 ( ) R85

listed below: 18k brown-grey-orange
( ) R71 ( ) R81 ( ) R87

listed below: 1k brown-black-red
( ) R25 ( ) R26 ( ) R80 ( ) R99
( ) R107

listed below: 220 red-red-brown
( ) R35 ( ) R36 ( ) R45 ( ) R46
( ) R98

( ) R20 2200 red-red-red
( ) R95 2200 red-red-red

listed below: 220k red-red-yellow
( ) R16 ( ) R17 ( ) R75 ( ) R78
( ) R88 ( ) R97

listed below: 22k red-red-orange
( ) R23 ( ) R37 ( ) R47 ( ) R60
( ) R69

listed below: 33 orange-orange-black
( ) R1 ( ) R2 ( ) R62 ( ) R68

( ) R82 3300 orange-orange-red

listed below: 330k orange-orange-yellow
( ) R53 ( ) R55 ( ) R58 ( ) R83
( ) R84

listed below: 33k orange-orange-orange
( ) R51 ( ) R52 ( ) R70 ( ) R103

( ) R29 390 orange-white-brown
( ) R30 3900 orange-white-red
( ) R32 3900 orange-white-red
( ) R79 3900 orange-white-red
( ) R74 4.7meg yellow-violet-green
( ) R27 470k yellow-violet-yellow
( ) R86 470k yellow-violet-yellow

DESIGNATION	VALUE	COLOR CODE A-B-C	
listed below:	47k	yellow-violet-orange	
( ) R31	( ) R49	( ) R54	( ) R56
( ) R57	( ) R59	( ) R90	( ) R101
( ) R106	( ) R119	( ) R120	
( ) R22	6800	blue-grey-red	
( ) R39	910k	white-brown-yellow	
( ) R43	910k	white-brown-yellow	
listed below:	91k	white-brown-orange	
( ) R61	( ) R63	( ) R72	( ) R77

Disk Capacitors

Many of the capacitors used in the 9710 are nonpolarized Ceramic Disk types. For each of these, either lead can go in either of the holes in the circuit board. The leads are already parallel to each other but still may need to be bent slightly to match the spacing of the circuit board holes. Like the resistors, insert the leads of these parts through the holes in the board and push the part against the circuit board as far as it wants to go. Don't force it, it's OK if it sits a little off the board.

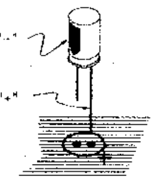
Capacitors are often marked with obscure codes that indicate their values. The 3 digit number that specifies value may be preceded or followed by letters indicating such things as tolerance. If you get confused about which capacitors are which, it may help to group them by same type and check them against quantities on the packing list at the end of this manual.

Ceramic Disk Capacitors

DESIGNATION	VALUE	MARKING	
( ) C18	0.0047	472	
( ) C22	0.0047	472	
( ) C23	0.0047	472	
listed below:	0.01	103	
( ) C3	( ) C5	( ) C7	( ) C9
( ) C10	( ) C13	( ) C17	
listed below:	100pF	101 or 100	
( ) C8	( ) C11	( ) C12	( ) C14
( ) C15			

Electrolytic Capacitors

The remaining capacitors are electrolytic types. Unlike the previous components, electrolytic capacitors are polarized and the leads are not interchangeable. Leads are marked "+" and/or "-" and the "+" lead must go through the "+" hole in the circuit board. Frequently the positive lead of the capacitor is significantly longer than the negative lead. Usually the Negative lead of the capacitor is marked rather than the positive. It naturally goes through the unmarked hole.



Capacitors supplied with specific kits may have a higher Voltage (V) rating than the minimum specified below.

DESIGNATION	VALUE
( ) C20	10uF / 15V
( ) C21	10uF / 15V
( ) C16	1uF / 15V
( ) C1	470uF / 25V
( ) C2	470uF / 25V
( ) C19	33uF / 15V
( ) C4	4.7uF / 15V
( ) C6	4.7uF / 15V

Diodes

Like the Electrolytic Capacitors, diodes are polarized and must be installed so that the lead on the banded end of the part corresponds to the banded end of the designator on the circuit board. Bend the leads so they are at right angles to the body of the part and insert them through the holes provided in the circuit board.

Diodes are also somewhat heat sensitive so the soldering operation should be done as quickly as possible.

DESIGNATION TYPE

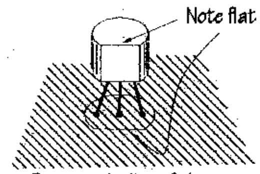
listed below: 1N4148 Silicon Diode (may be 1N914)

( ) D1 ( ) D2 ( ) D3 ( ) D4

( ) D5 ( ) D6 ( ) D7

The remaining diode will be installed in later steps

Transistors



The straight line of the pc graphic symbol corresponds to the flat face of the transistor case.

Install the transistors by inserting their three leads through the holes provided for them in the circuit board. Note that the transistors are polarized by the flat side of the case. When the transistors are properly installed this flat will align with the corresponding mark on the circuit board legending.

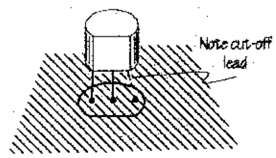
Notice that two different types of transistors (2N3904 and 2N3906) are used. The type will be written on the body of the part.

Two of the transistors have been specially selected to have matching characteristics and will be packed together. Keeping this pair together is important for optimum circuit performance. Since they are matched, it makes no difference which transistor is used for which designation.

DESIGNATION TYPE

( ) Q3/Q4 2N3904 NPN Si Transistor Matched Pair

One transistor has been selected for use as a noise source and has one of its leads cut short.



Q5 has one lead removed

( ) Q5 2N3906 Selected for noise.

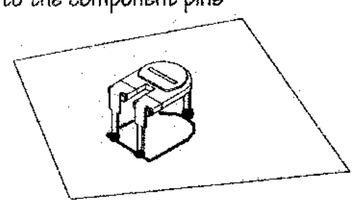
Install the remaining transistors as follows:

listed below: 2N3906 PNP Silicon Transistor
( ) Q1 ( ) Q2 ( ) Q6 ( ) Q7
( ) Q13

listed below: 2N3904 NPN Silicon Transistor
( ) Q8 ( ) Q9 ( ) Q10 ( ) Q11
( ) Q12 ( ) Q14 ( ) Q15

Trimmer Potentiometers

Trimmer potentiometers surface mount by tinning the mounting pads and remelting the solder to the component pins

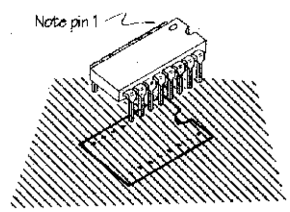


The two trimmer potentiometers surface mount to the board rather than having their leads pass through it. First "tin" the trimmer mounting pads on the circuit board by melting a little solder onto them. Solder the trimmer to the board by holding the pins against the tinned pads and remelting the solder.

DESIGNATION	VALUE	MARKING
( ) R24	100k	100K
( ) R34	100k	100K

Integrated Circuits

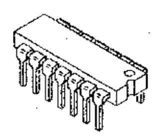
Of all the parts, the ICs are the most easily damaged and should be treated with some respect. In particular, they may be destroyed by discharges of static electricity. Modern ICs are not nearly as sensitive to this kind of damage as were earlier versions, but it is still good practice to handle these parts as little as possible. Also good practice: don't wear nylon during assembly. Don't shuffle around on the carpet immediately before assembly (or if you do, touch a lamp or something to make sure you're discharged). Don't be intimidated. It's rare for parts to be damaged this way.



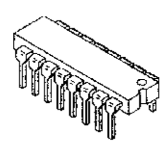
ICs are polarized in one or both of two ways; A dot formed into the case of the IC corresponding to pin 1 or a semicircular notch that indicates the end of the package with pin 1. Take care that this polarizing indicator corresponds to the similar indicator on the circuit board graphics.

The pins of the ICs may be splayed somewhat and not match the holes in the circuit board exactly. Carefully re-form the leads if necessary so that they are at right angles to the part.

Solder each IC in place as it is installed by initially soldering two pins in diagonal corners of the pattern. Make sure that the part is seated firmly against the circuit board by pressing it down while re-melting the solder joint at first one corner, then the other. Finally, solder the remaining connections.



LM324
LM1496
14 pins

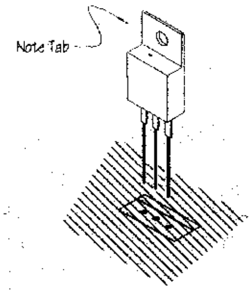


LM13600
16 pins

DESIGNATION	PART NO.	DESCRIPTION
( ) IC3	LM324	Quad OpAmp
( ) IC4	LM1496	Balanced Modulator
( ) IC5	LM13600	Dual OTA
( ) IC6	LM324	Quad OpAmp
( ) IC7	LM324	Quad OpAmp

Voltage Regulators

The voltage regulators are polarized and must be mounted so that their tabs correspond to the tab markings on the circuit board graphics. Solder all three leads and clip any excess off flush with the solder joint.

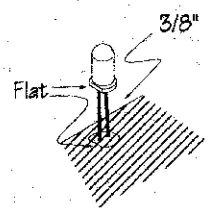


( ) IC1 7912 -12V Voltage Regulator
( ) IC2 7812 +12V Voltage Regulator

Light Emitting Diode

The LED is polarized by the flat in the collar at the base of part. When properly installed, this flat will align with the corresponding flat in the LED symbol printed on the circuit board.

When the 9710 is installed behind its front panel, the LED will engage the hole in the front panel and be supported by its leads. Install the LED by pushing it's two leads through the holes in the circuit board. With 3/8" of space between the bottom of the LED and the circuit board, solder one lead. Check spacing and polarization before soldering the second lead and trimming both leads off flush with the solder joint.



Leave about 3/8" space between the circuit board and LED base.

DESIGNATION TYPE

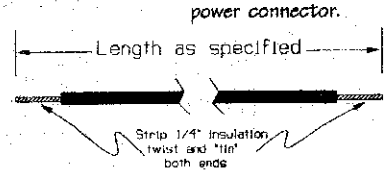
( ) LED1 Red LED

"Flying" Wires

(i.e. those which go from circuit board to panel mounted parts.)

In the following steps, wires will be soldered to the 9710 board which in later steps will be connected to the front panel controls and switches. At each step, cut a piece of wire to the specified length and strip 1/4" of insulation from each end. Twist the exposed wire strands together and "tin" them by melting a small amount of solder into the strands. This will make soldering easier when the wires are installed and prevents fraying of the wire strands when they are pushed through the holes. Solder each connection as it is made and clip any excess wire from the solder side of the board.

Note: If you also have the 9710frm FracRak Accessory kit do not use the wire from that kit in these steps. 9710frm wires are already cut to length for use with the power connector.



010410

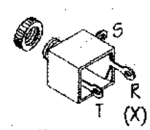
PC POINT	WIRE LENGTH	PC POINT	WIRE LENGTH
( ) "A"	6-1/2"	( ) "B"	6-3/4"
( ) "C"	6-1/2"	( ) "D"	7"
( ) "E"	5-3/4"	( ) "F"	6-1/2"
( ) "H"	5"	( ) "I"	5-1/4"
( ) "J"	4-3/4"	( ) "K"	4-1/2"
( ) "L"	4-1/2"	( ) "M"	4-1/2"
( ) "N"	5"	( ) "O"	7-1/4"
( ) "P"	7-1/4"	( ) "R"	7"
( ) "S"	5-3/4"	( ) "T"	5-3/4"
( ) "U"	5"	( ) "V"	4-1/2"
( ) "W"	6-1/4"	( ) "X"	6-1/2"
( ) "Y"	5-1/4"	( ) "Z"	5
( ) "AA"	5"	( ) "AB"	5"

This completes assembly of the 9710 circuit board. Admire your work for a few minutes then take a break. When you come back, admire your work again but this time be critical. It would be a good time to double check the orientation of polarized parts and that the right resistors and capacitors are in the right places. Examine the solder joints. On the component side make sure excess solder has not flowed though the hole. On the solder side, are they all nice and shiny? If they have the "lumpy" granular look that indicates a cold joint, reheat them. Solder bridges are less likely with a solder masked circuit board but they can still happen. If you're not sure about a bridge refer to the foil patterns in fig 1.

Front Panel Controls

Now we will put the circuit board aside temporarily and mount the controls, jacks and switch to the front panel. If you have the optional FracRak accessory kit you will be installing these parts at the locations shown in fig 2.

Two kinds of jacks are used in the 9710; Closed Circuit Mono (which have a built-in switch) and TRS (stereo). The differences between these types are not apparent on casual inspection so the two TRS jacks will be packed separately or otherwise indicated.



Stereo Jack lugs are labeled Tip (T), Ring (R) and (S) Sleeve. Closed Circuit Jacks have a Switch (X) in place of the R lug.

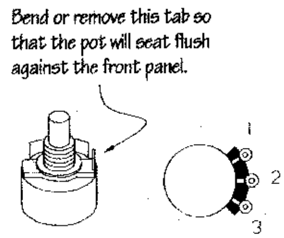
( ) Using the nuts supplied with them mount the two 1/8" TRS Jacks (J3, J6) at the locations shown in Fig 2. Orient as shown in Fig 3 and hand-tighten the nuts.

( ) Mount the 11 remaining jacks at the locations shown in fig 2. Orient as shown in fig 3 before fully tightening the nuts on all of the Jacks to secure them. Use only enough force to keep the jack from rotating. Do not overtighten.

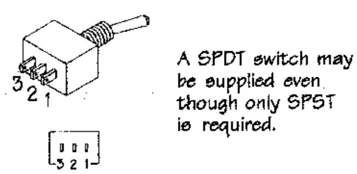
It will be easier to do the ground wiring of J10-J13 before the rest of the panel controls are mounted.

( ) Cut a 3" length of the bare wire supplied and pass it through the holes in the "S" lugs of J10 and J13 (lift these two lugs away from the panel and twist them so the wire can pass through). Solder the connection at J13 so the wire ends at that lug and at J10 so that a stub about 1-3/4" long extends beyond the lug. Connect the "S" lugs of J11 and J12 to the wire by bending them up until they touch the wire then soldering the two together.

( ) Using the flat washers and nuts supplied, mount the five potentiometers to the panel as shown in fig 2. Note that two different values are used so be careful that the correct value is placed in the correct location. Value is stamped or printed on the body of the part. Orient the pots with the solder lugs as shown in fig 3 and fully tighten the nuts to secure them. A tip: marking the part number (e.g. R109) on the back of the pots with an indelible pen will make later wiring easier and less prone to error.



( ) Using the nut and washer supplied, mount the miniature toggle switch as shown in fig 2. While the circuitry only requires a SPST switch (with two solder lugs) the part supplied will most likely be SPDT types (with three lugs) and only two of the lugs will be used. Orient the switch as shown in fig 3 and fully tighten the nut to secure it. The switch is symmetrical so whichever soldering lug is on the right is #1.



Now we'll continue wiring of the front panel parts as shown in fig 3. First, notice that Individual solder lugs are identified by part number and lug number. For example, R109-1 means the lug labeled "1" of the Potentiometer R109.

Also, this convention will be followed in these steps: Do not solder a connection to a lug until told to do so with an instruction such as (s2), which means that at that point there will be two wires on the lug in question. If there are not the number of wires specified at the lug when you get ready to solder, recheck to see what has gone wrong. Connections which should not be soldered yet will be marked (ns) for NO SOLDER. On these unsoldered connections simply push the end of the wire through the lug and crimp it back to mechanically secure it.

( ) Connect the free end of the solid bare wire extending beyond J10-S to R109-3 (ns).

( ) Cut a 6-1/4" length of bare wire and pass it through the holes in the "S" lugs of J1 and J9 so that a stub about 1-1/4" long extends beyond J9. Solder the connections to the "S" lugs of J1 and J9 first, then bend the "S" lugs of J2-J8 up and solder them to the wire as was done on the previous jacks.

( ) Connect the free end of the wire extending from J9-S to R111-1 (s1).

( ) Connect the free end of the wire extending from J1-S to R109-3 (ns)

The remaining 1N4148 diode mounts on R-110 between lugs 2 & 3. See fig 3.

( ) Locate the remaining diode (D8) and cut both leads off to a length of 1/2". Connect the banded end of the diode to R110-3 (ns) and the other end to R110-2 (s1). Hold the diode lead with a pair of needle nose pliers or other heat sink while soldering.

In the following steps cut a piece of insulated stranded wire to the length indicated, strip 1/4" of insulation from each end and twist and tin the exposed strands before using it to connect the component lugs specified. "Clipping" indicates that a component lead clipping saved from previous steps is to be used for the connection. See Fig 3.

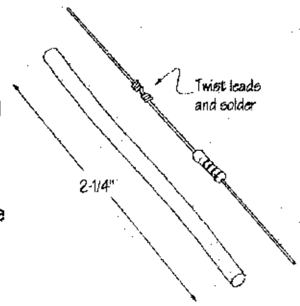
LENGTH	FROM	TO
( ) 4-3/4"	R109-1 (ns)	R111-3 (s1)
( ) 1-1/2"	R110-3 (s2)	R112-2 (ns)
( ) clipping	R112-2 (s2)	R112-3 (ns)
( ) 3-1/2"	R112-3 (s2)	R113-3 (ns)
( ) clipping	R113-3 (s2)	R113-2 (ns)

The resistors not used during circuit board assembly will now mount directly on the lugs of the controls (see fig 3).

( ) Locate a 10K ohm resistor (brown-black-orange) and bend the leads at right angles to the part as if installing on a circuit board but slip one lead through J11-T and the other through J12-T. Position the resistor close to the lugs and bend the leads back to mechanically secure them then cut off the excess. **Do not solder** these connections. This is R117 in fig 3.

( ) Locate a 10k (brown-black-orange) resistor and trim both leads off to 1/2". Connect one lead to J12-T (ns) and the other to J10-X (s1). This is R116.

( ) Locate the 91k resistor (white-brown-orange) and extend one lead with a 1-1/2" length of bare wire as shown. Cut a 2-1/4" length of the large sleeving and slide it over the resistor to make sure 1/4" or more of lead extends from each end of the sleeving. If length is OK, remove the sleeving and connect the extended lead to J12-T. Solder the three wires at this connection. This is R115 in fig 3.



( ) Slip the length of sleeving from above over R115 and connect the free lead to J3-R. Bend back to secure **Do not solder**.

( ) Locate the remainint 10k resistor (brown-black-orange) and trim both leads off to a length of 1/2". Slip one lead through J9-T and solder this connection. This is R114.

( ) Slip the free end of R114 through S1-2 and bend back to secure. **Do not solder** this connection.

This completes the wiring between parts on the front panel.

A few connections will be made between the circuit board and front panel before the two are fastened together. The figure that illustrates the connection is shown to the right of the step.

FROM	TO		FROM	TO	
( ) "U"	R110-1 (s1)	***Fig 5***	( ) "Z"	R112-1 (s1)	***Fig 5***
( ) "F"	J10-T (s1)	***Fig 6***	( ) "T"	J11-T (s2)	***Fig 5***
( ) "I"	J13-T (s1)	***Fig 4***			

Now it's time to use the #4 hardware and "L" brackets to attach the front panel to the circuit board. Before beginning, take a good look at the "L" Brackets and note that one of the holes is threaded and the other is not.

( ) Attach the "L" brackets to the circuit board using two 4-40 X 1/4" Machine Screws through the board from the solder side and then through the **unthreaded** holes in the "L" brackets. Secure each with a #4 nut. Some adjustment will be required when the board is attached, so do not fully tighten the screws. See fig 2.

( ) Bend the LED over so that it engages the hole provided for it in the front panel as shown in fig 2. Attach the circuit board to the front panel by passing 4-40 X 1/4" Machine Screws through the panel from the front and into the **threaded** hole in the "L" brackets. When satisfied with the alignment of panel, LED and circuit board, fully tighten the hardware.

Finish panel assembly by connecting the remaining wires from the circuit board to the jacks and controls on the front panel. Solder as indicated. Proceed with wiring by columns, doing all the wiring in fig 4 before continuing with wiring from fig 5. This order will prevent installed wiring from blocking access to future connections.

Fig 4

FROM	TO
( ) "W"	R113-1 (s1)
( ) "A"	R109-1 (s2)
( ) "C"	R109-2 (s1)
( ) "D"	R109-3 (s3)
( ) "X"	R111-2 (s1)
( ) "M"	R113-2 (s2)
( ) "O"	J1-T (s1)
( ) "S"	J2-T (s1)
( ) "V"	J3-T (s1)
( ) "E"	J4-T (s1)
( ) "H"	J5-T (s1)

Fig 5

FROM	TO
( ) "J"	J6-T (s1)
( ) "N"	J7-T (s1)
( ) "AA"	S1-2 (s2)
( ) "AB"	S1-1 (s1)
( ) "R"	J8-T (s1)
( ) "P"	J1-X (s1)
( ) "K"	J3-R (s2)
( ) "Y"	J4-X (s1)
( ) "B"	J5-X (s1)
( ) "L"	J6-R (s1)

Note: *Be careful when soldering the wires to the switch. Too much heat can soften the body of the part causing the solder lugs to shift position. If you are using a 30W or less soldering iron there is little danger, but higher power irons should not be left on the lugs too long.*

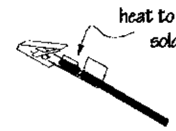
POWER CABLE AND CONNECTOR

If you have the 9710frm accessory kit, locate the power connector housing and pins. You will be connecting wires to the pins and will need to be able to hold the pin steady while soldering. Using an old-fashioned wooden clothes pin as a vise is a good choice, but try to find one these days. A pair of needle-nose pliers with a rubber band around the handle to hold the jaws closed works but too heavy a rubber band can apply too much pressure and crush the pin.

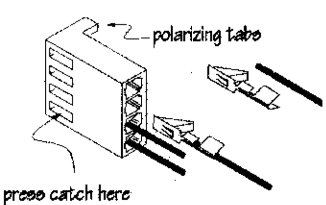
Proceed with assembly of the power connector as follows:

( ) Prepare the four 16" lengths of stranded insulated wire supplied with the 9710frm kit by stripping 1/4" of insulation from one end of each wire only. Twist and tin the exposed wire strands then clip off the tinned end so that a 1/8" stub remains.

( ) Solder one of the power connector pins to the end of each wire. Steady the pin as discussed above and lay the tinned end of the wire in the "trough" of the pin as shown in the illustration. Solder the connection by holding the soldering iron against the wire and pin until the solder remelts. You should not need to add more solder. Allow the joint to cool and test it by wiggling the wire to make sure the joint is firm. Do not wrap the "wings" of the pin around the wire.

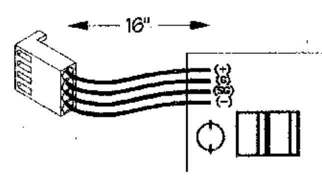


( ) Slide the power pins into the connector body. Note the orientation of the pin as shown in the illustration. Slide the pin in until the catch on the back of the pin engages the slot in the connector body and you feel the "snap" as it locks in place. Give the wire another good tug to test the solder joint and that the pin is latched in place.



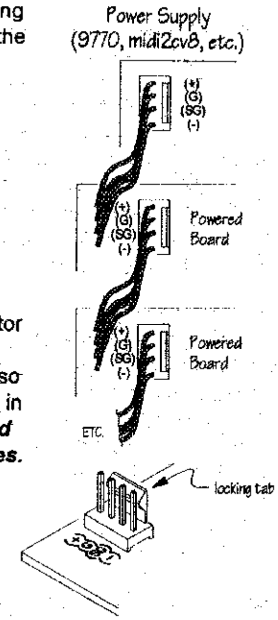
If the wire comes loose, don't panic. The pins can be released from the connector by using a knife blade or small tool to reach through the slots in the connector body to press down the catch.

( ) Prepare the free ends of the wires by stripping 1/4" of insulation from the end and twisting the exposed wire strands tightly. Do not tin these wires. Push each wire though the "+", "G", "SG" and "-" holes in the board as shown in the illustration (note the polarizing tabs on the connector body) and check to make sure there are no stray wire strands before soldering in place. Clip off any excess on the solder side of the board.



Use the 3 nylon wire ties to group the four wires together by placing one in the middle and the other two halfway to either end. Cinch the ties tight and clip off the excess.

( ) Turn the control shafts of all the potentiometers fully Counter ClockWise and mount each knob in turn by placing it on the shaft and aligning the pointer with CCW end of the panel graphic. Tighten the set screw slightly and rotate the control back and forth to see that its range of rotation is centered with respect to the panel graphic. Loosen the screw and realign the knob as needed and fully tighten when done.

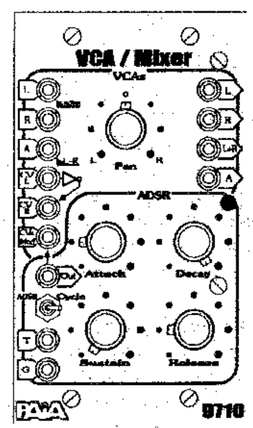


Locate the power connector header. If there is an unused connector location on the power supply, this is the best place to mount the header. Because of the 9700 series star grounding system it is also acceptable to chain power from one module to the next as shown in the illustration. ***Be very careful that the Signal Ground (SG) and power Ground (G) lines are not interchanged between modules.*** Note the orientation of the locking tab shown in the illustrations.

( ) Push the header's 4 pins through the board but solder only one. Make sure the base is flush with the board before soldering the remaining three pins.

The next step will be to power up the module and start testing, which makes this is a great time to take another break, stretch and think about something else for a while. When you come back take the time to do a final check. The flying wires to the panel aren't bundled with wire ties yet, and we'll leave them that way for now, so move them around a little to check the connections. Inspect the wiring on the panel and make sure none of the bare wire used as the panel ground is in danger of shorting against other connections. One more pass of inspecting the board for component polarity and quality of solder joints is a good idea too.

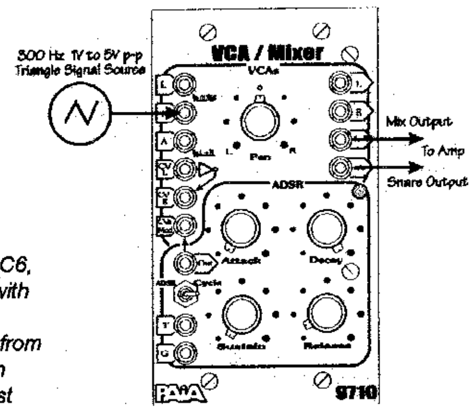
TESTING



Set the Modulation Null and Carrier Null trimmers (R24 and R34) to the midpoint of their rotation, make sure the power supply is turned off and mate the power connectors. No signal inputs or outputs are needed for these first tests.

1) Set the 9710 knobs and switch as shown and turn on power. First observe the POWER light on the power supply and if it doesn't come on stop and find out why. *It may be just a dead outlet or some more serious problem such as a solder bridge on the 9710 board. If the power supply light comes on when the 9710 is disconnected, it's a sure sign of a problem on the 9710 board. The most likely area for this problem is in the area around the power connector, R1, R2, C1, C2 and regulators IC1 and IC2.*

2) With the controls still set as on the preceding page check the front panel ADSR LED which should be cycling between fully on and fully off over a period of less than a second. *If the LED is "stuck" in a dark or lit condition, quickly feel around on the circuit board to see if any parts are hot or very warm. If you find any, disconnect the power and carefully examine the circuitry around the hot part looking for solder bridges, backward capacitors or other polarized parts. If nothing seemed warm but the LED is still not cycling between dark and light it may be a problem in the Modulator circuit. Carefully check the modulator parts (Q9-Q15, IC7, panel controls R110-R113 and associated components). Check the LED, it may be in backwards or may be bad. It's human to suspect the ICs but most problems relate to the mechanics of assembly - the wrong part in the wrong place or facing the wrong way or not soldered well.*



3) Connect a signal source such as a 1V to 5V p-p 300 Hz. triangle or sine to the "R" input and an amplifier to the "L+R" output. Rotate the Pan control back and forth and observe that at "L" the output is exclusively the white noise source and at "R" you just hear the pitched source. At intermediate settings you should hear a mix of the two.

Problems here probably involve IC3, IC5, IC6, Q1, Q2 or the other components associated with the L and R VCAs. Patterns of failure will help narrow the possibilities; e.g., if when panning from L to R you hear the pitched source increase in volume but hear no noise it means that at least the R VCA is working OK. But you can infer more than that - since sections of all the ICs mentioned are part of the working VCA and it's unusual to have only a single section of an IC go bad (though it does happen) probably all of the ICs mentioned above are functional. You can check the VCAs individually by listening to the L and R outputs.

If you hear no noise it may be the noise source itself is not working. You can check this by removing the amp input from the L+R output jack and inserting it ***VERY GENTLY*** *into the "L" input jack (just enough that the tip of the plug touches the Tip connection of the jack without going in far enough to activate the switch that is part of the Jack). If the noise source is working, you should be able the hear it here and if not focus your attention on the components around Q5-Q7. If noise is OK, check on the components associated with the R VCA (see schematic and Design Analysis sections starting on page 22 for more details) and particularly the parts that are unique to that block, Q2 and D2 for example.*

If one of the VCAs is on and the other off no matter the setting of the Pan control, focus your attention on the connections to the Pan control R109, the common element.

4) Disconnect the amp from the L+R output and listen to the A output. You should hear the noise/tone mix being modulated in volume following the changes in the ADSR output. Turn the Pan control to full R and Toggle the ADSR/Cycle switch to ADSR. While still listening to the A output, adjust the Modulation Null Trimmer (R24 on the circuit board) to minimize any tone that you hear from the Amp.

 010410

A problem here most likely involves IC4, Q3, Q4 or associated parts. IC6 might be a problem, but sections of it are working OK in the VCAs so the chip is most likely good. Check front panel wiring involving J3 and J6. If you don't find anything, continue to the next test which may help localize the difficulties.

5) Switch the modulator from Cycle to ADSR and connect a gate source to Modulation input G (Gate). Gate signals should be "true positive" (transition from ground to a positive voltage between 4 and 15V to trigger the ADSR). Set all the ADSR controls at about their mid-range and activate the Gate. Either by listening or watching the LED verify that the output rises to a peak level then falls back to a Sustain level where it holds until the Gate is removed then falls back to 0. Try different setting of all controls from minimum (fully CounterClockWise) to maximum (full CW). Change the gate signal from the Gate input to the Trigger input and verify that the Sustain phase is eliminated.

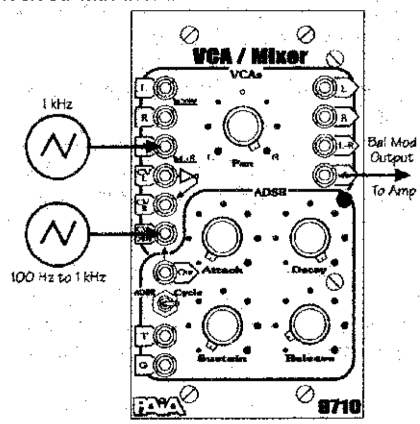
Most of the ADSR circuitry has been verified while using it as an LFO. If there is a problem now it most likely has to do with the wiring of the J8 and J9 or the ADSR controls R110 - R113 and the board components directly involved with them.

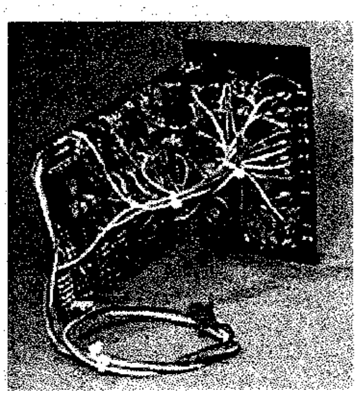
6) Connect a second signal source to the CVa (Mod) input and listen to the A output for a balanced modulator sound while the relative frequencies of the two sources are varied. If you're not sure what Balanced Modulator should sound like there are .wav file samples at `http://paia.com/9710.htm`.

If this step checks out OK but step 4 didn't, you should suspect the expo converter, which comprises Q3 and Q4 and the parts around them.

If this is not working and there was also a problem in step 4 the culprit may be IC4 or the parts associated with it. The Carrier input buffer IC6:C or the differential output buffer IC6:D may not be working.

If step 4 was OK but there's a problem here in step 6 there is probably something wrong with the way J6 is wired.





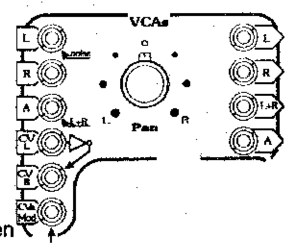
Successful completion of these tests is a good indication that the module is working properly.

( ) Gather the wires from the circuit board to the front panelcontrols together and cinch the bundle with the Nylon Wire Ties supplied as shown in the photo. Cinch the ties tight and clip off the excess.

THE PANEL CONTROLS

You got to know the panel controls pretty well during testing. Here's a different perspective on what they do.

VCAs



Left input. 5V p-p nominal max input. The arrow is a reminder that the Noise source normals to this input. The normal is overridden by an external input.

Right input. 5V p-p nominal max input. May be audio signal or Control Voltage.

A input. 5V p-p nominal max input. The mix of L and R input is normalled to this input and overridden when an external input is applied.

Left and Right Control Voltage inputs. The symbol from CVL to CVR is a reminder that these inputs are normalized with an inverter between them so that an increasing Control Voltage applied to CVL increases the gain of the Left VCA while decreasing the gain of the Right resulting in a panning or morphing between the Left and Right inputs. An external CV applied to CVR interrupts the inverter and increasing CVs increase gain.

A Control Voltage Input. The arrow reminds that this input normals to the ADSR output. You'll have to remember on your own that there's a 10dB/V exponential converter as part of this connection. External inputs interrupt the normal and the expo converter. External signals may be up to +/- 10V p-p for VCA or Balanced Modulator.

Left output. The output of the Left VCA. It's not shown on the graphics but a plug inserted in this jack interrupts its normal connection to the L+R output and also the A input which allows the noise source to isolated and used alone.

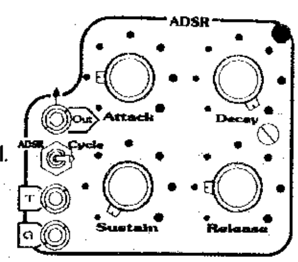
Right output. The output of the Right VCA.

Left + Right mix output. The mix of the L VCA and R VCA outputs as set by the Pan control and other CVs on the CVL and CVR inputs. Because of the passive mixing at this output it is -6dBV relative to either of the direct outputs or the nominal peak A VCA output.

A output. The output of the A VCA. Like most VCAs the 9710 sections are actually attenuators that have unity gain when CVs are their nominal max (10V).

PAN Control - Sets the relative gain of the L and R VCAs. The linear control voltage response of the L and R VCAs means that for equal L and R inputs, Peak signal level at either the L+R or A outputs remains constant during panning.

ADSR



ADSR output. A 0 - 10V peak output function with Attack, Decay, Sustain and Release phases.
The arrow shows that this output normals to CVa. Plugging into this output for external use **DOES NOT** interrupt the normal.

Trigger input. This AC coupled input cause the ADSR to generate the Attack and Release phases of its output function in response to the leading edges of 4V to 15V positive pulses.

Gate input. A 4 to 15V positive voltage applied to this input starts the ADSR function. After an initial Attack phase to a peak and Decay to a Sustaining level that is stable as long as the Gate is present, the Release phase is generated when the gate falls to zero.

Attack control. This panel control sets the rate at which the ADSR function increases during the Attack phase. Clockwise rotation of the control slows the rate which is variable from 500uS to as long as 10 seconds.

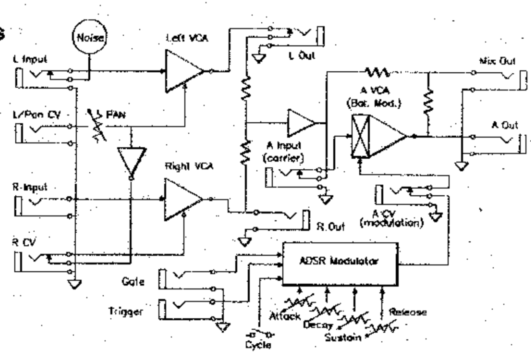
Decay control. Sets the rate at which the ADSR function falls from the peak reached at the end of the Attack phase to the level set by the Sustain control. There is some interaction with the Sustain control with a given setting of Decay producing longer times when Sustain is set to a low level. Time is variable from 2mS (fully CounterClockWise) to about 7 seconds (fully ClockWise)

Sustain control. Sets the level that the ADSR function falls to at the end of the Decay phase. Sustain voltage is variable from 0V (CCW) to 10V (CW).

Release control. Sets the rate at which the ADSR function falls from the Sustain level back to 0V output. Time is variable from 2mS (CCW) to about 7 seconds (CW).

ADSR Cycle **ADSR - Cycle.** When set to Cycle the ADSR self-triggers for an LFO function.

The block diagram shows general signal flow and other details of the normalization design.



CALIBRATION
Modulation and Carrier Nulling

Modulation Null - Set ADSR/Cycle to ADSR. Set Pan control to it's midrange position for an equal mix of noise and a second signal patched to the R VCA input. Gate the ADSR on with maximum sustain to get a listening level set then turn the Gate off. Any tone that you hear now is called "feed-through". Adjust Modulation Null trimmer R24 on the circuit board for minimum feed-through.

Carrier Null- Set Pan control to it's midrange position and insert a patch plug into the VC L input to disable noise. Remove any input to the VC R input so there is effectively no input to either L or R VCA. Set ADSR controls with Attack at Min, Decay at Max, Sustain at Min and Release at Min and set the ADSR/Cycle switch to cycle (these setting turn the ADSR into a 500 Hz oscillator). Listen to the A Output and adjust the Carrier Null trimmer R34 on the circuit board for minimum tone.

DESIGN ANALYSIS

ADSR Modulator (see schematic fig 6 in the Illustrations Supplement)

The output of the ADSR, at J7, is the output of a voltage follower (IC7:A) that reads the voltage on capacitor C16. The rest of the circuit controls the charging and discharging of this capacitor.

The cross-connected transistor pair Q8 and Q9 form a bistable circuit and when power is first applied, the circuitry settles into a stable state where Q8 is off and Q9 is on. The high collector voltage on Q8 holds Q11 on and consequently C16 is held in a discharged state by R99 and R113. The initial state of two other bistable elements, comparators w/hysterisis built around IC7:C and IC7:D, are useful to keep in mind also, IC7:C is high and IC7:D is low.

A Gate input toggles the Q8/Q9 bistable and the now low voltage at Q8's collector turns Q11 off. Q9's collector voltage is now high and the emitter follower Q10 buffers this voltage and provides the current necessary to charge C16. The ADSR output begins to rise at a rate set by the Attack control R110. Also, the Gate input is coupled by C23 and R120 to the base of Q15 turning this transistor on briefly which resets the IC7:C comparator to a low output state.

As the voltage on C16, and consequently the output, increases it will at some point exceed the Sustain level and IC7:D will switch from low to high but this simply prepares the circuit for the Decay phase which will happen later and produces no effect at this time. When the voltage on C16 reaches the peak value of 10V., IC7:C changes state from low to high marking the end of the Attack phase and the beginning of Decay.

D5 and D6 along with R100 form a simple "and" gate and since both comparator outputs are now high the gate's output is high. The resulting current flow through R106 turns on Q12 which begins to discharge C16 at a rate determined by the Decay control R112. But notice that the output does not decay on a path that takes it to ground but rather to the Sustain voltage at the emitter of Q13, which is an emitter follower that buffers the voltage from the wiper of the Sustain control and provides the current for discharging C16. When the capacitor voltage is the same as Q13's emitter voltage no more current will flow through Q12 and discharging stops. As long as the Gate remains high this is a stable state and the ADSR output holds at the Sustain level.

When the Gate goes low, Q8 can turn off so the Q8/Q9 bistable is reset. When Q8's collector voltage goes high it turns on Q11 and consequently C16 continues discharging from the Sustain voltage at a rate set by the Release control R113 until it is fully discharged or the Gate once again goes high.

When a Trigger is used instead of a Gate many of the same things happen but the Decay and Sustain portions happen so quickly that you can think of them as being skipped. C22 couples Trigger pulses to steering diode D3 so that the Q8/Q9 bistable is set and to R101 so that Q15 is turned on briefly to reset the IC7:C comparator for retriggering.

For an LFO function, Q14 inverts the state of the IC7:D comparator, which is high as long as the Output voltage is greater than the Sustain level. When S1 is closed the collector voltage of Q14 serves as a Gate that goes on when the Sustain voltage at the end of the Decay phase is reached.

VCAs and Balanced Modulator (see schematic fig 7)

The L and R VCAs are designed around an LM13600 type Dual Operational Transconductance Amplifier (IC5). Taking the L VCA as typical, signals applied to the OTA's inverting input (pin 4) by way of the voltage divider R37 and R35 are converted to a bidirectional current from pin 5 which is then converted to a voltage by IC6:A and R51. The darlington output structures that are part of LM13600s are not used because of the unavoidable output offset voltage they produce.

The "gain" of the OTA is controlled by a current into pin 1 and as this current increases, a constant level voltage input on pin 4 produces increasing output currents from pin 5 and consequently larger output voltage from IC6:A. The control current for the L VCA is produced by opamp IC3:D, Q1 and associated components. This current is proportional to the sum of the voltages from the Pan control R109 (coupled by R10), the CVL input (coupled by R11) and an offsetting voltage that assures the VCA can be turned fully off (R17).

The Panning function is produced by increasing the gain of the L VCA while decreasing the R gain and vice-versa. While the voltage on the wiper of the Pan control goes from 0 to 12V and increase the L gain, IC3:B and associated components outputs a voltage that is the inverse of the Pan control setting for decreasing R gain. Similarly, the circuitry around IC3:A provides an inverse of the CVL input.

The L and R VCA outputs are passively mixed by R116 and R117 and become the A VCA input.

The terms "Carrier" and "Modulation" can be confusing when applied to a physical device like the 1496 Balanced Modulator (IC4) because they're information theory terms. In terms of function, there is no difference between these inputs. Another name for a Balanced Modulator is "Four Quadrant Multiplier", which means that the output is proportional to the product of voltages on the two inputs and that the sign is preserved - if either of the inputs goes negative the output goes negative and if both inputs go negative the output goes positive. When a Balanced Modulator is used as a VCA it is equivalent to using only two of the four quadrants and one of the inputs (the Control Voltage) is constrained to only positive voltages. As this voltage increases the output voltage swing increases.

The Carrier input is buffered by the opamp summer built around IC6:C which also provides a +5V offset from ground required for proper operation of the BM.

Q3 and Q4 form an exponential converter circuit that sinks a 10dB/V exponential current into the collector of Q4 in response to the 0 to 10V output of the ADSR. Inserting an external input plug into J6 causes the Ring to ground the junction of R66 and R63 which disables the expo circuit. External Modulation inputs are always treated as a linear input allowing Balanced Modulator operation.

NOISE

The 9710 Noise source uses the common approach of reverse-biasing the emitter-base junction of a transistor to the point of break-over and amplifying the white noise that results from avalanching. The transistor that supplies the noise is Q5 with Q6 and Q7 configured as a two stage discrete amplifier.

9710 Parts List

Semiconductors

1	7912	IC1
1	7812	IC2
8	1N4148 Diodes (may be 1N914)	D1,D2,D3,D4,D5, D6,D7,*D8
1	Red LED	LED1
1	LM13600 Dual OTA	IC5
1	LM1496 Bal. Mod	IC4
3	LM324 Quad Opamp	IC3,IC6,IC7
7	2N3904 NPN Transistor	Q8,Q9,Q10,Q11,Q12, Q14,Q15
5	2N3906 PNP Transistor	Q1,Q2,Q6,Q7,Q13
1	2N3906 (noise)	Q5
1	3904 NPN Matched Pair	(Q3/Q4)

Ceramic Disk Capacitors

3	0.0047 uF	C18,C22,C23
7	0.01 uF	C3,C5,C7,C9,C10,C13,C17
5	100pF	C8,C11,C12,C14,C15

Electrolytic Capacitors

2	10uF	C20,C21
1	1uF	C16
2	470uF	C1,C2
1	33uF	C19
2	4.7uF	C4,C6

Potentiometers

2	100k	PC Mount Trimmer	R24,R34
2	10k	Panel Mount	*R109,*R111
3	5meg	Panel Mount	*R110,*R112,*R113

1/4 W. 5% Resistors - all values in ohms

4	100	brown-black-brown	R28,R33,R40,R44
14	100k	brown-black-yellow	R4,R5,R8,R9,R11, R14,R65,R67,R73, R89,R92,R94,R96,R105
16	10k	brown-black-orange	*R114,*R116,*R117,R12, R13,R21,R50,R64,R66,R91, R93,R100,R102,R104,R108, R118
2	10m	brown-black-blue	R38,R48
6	120k	brown-red-yellow	R3,R6,R7,R10,R19,R76
2	1500	brown-green-red	R15,R18
3	15k	brown-green-orange	R41,R42,R85
3	18k	brown-grey-orange	R71,R81,R87
5	1k	brown-black-red	R25,R26,R80,R99,R107
5	220	red-red-brown	R35,R36,R45,R46,R98
2	2200	red-red-red	R20,R95
6	220k	red-red-yellow	R16,R17,R75,R78,R88,R97
5	22k	red-red-orange	R23,R37,R47,R60,R69
4	33	orange-orange-black	R1,R2,R62,R68
1	3300	orange-orange-red	R82
5	330k	orange-orange-yellow	R53,R55,R58,R83,R84
4	33k	orange-orange-orange	R51,R52,R70,R103
1	390	orange-white-brown	R29
3	3900	orange-white-red	R30,R32,R79
1	4.7meg	yellow-violet-green	R74
2	470k	yellow-violet-yellow	R27,R86
11	47k	yellow-violet-orange	R31,R49,R54,R56,R57,R59, R90,R101,R106,R119,R120
1	6800	blue-grey-red	R22
2	910k	white-brown-yellow	R39,R43
5	91k	white-brown-orange	*R115,R61,R63,R72,R77

Misc

1	SPST Min Toggle Switch
1	9710 Circuit Board
1	Assembly Manual
5	Set Screw Knobs
3	5' lengths #22 stranded
1	18 inch length small bare wire
1	3 inch length large sleeving
3	Nylon Wire Ties

9710 FRM

11	Closed Circuit Phone Jacks
2	Stereo (TRS) Phone Jacks
2	# 4 "L" Brackets
4	4-40 X 3/16" Machine Screws
2	#4 Machine Nuts
1	2W FracRak Panel
4	self-tap screws

Power Connector Parts

1	4 pin .1 friction lock header
1	4 pin .1 terminal housings
4	.1 crimp terminals
4	16" lengths #22 stranded wire
3	Nylon Wire Ties

PAiA Electronics, Inc
3200 Teakwood Ln
Edmond, OK 73013
phn 405-340-6300
fax 405-340-6300
info@paia.com

010410

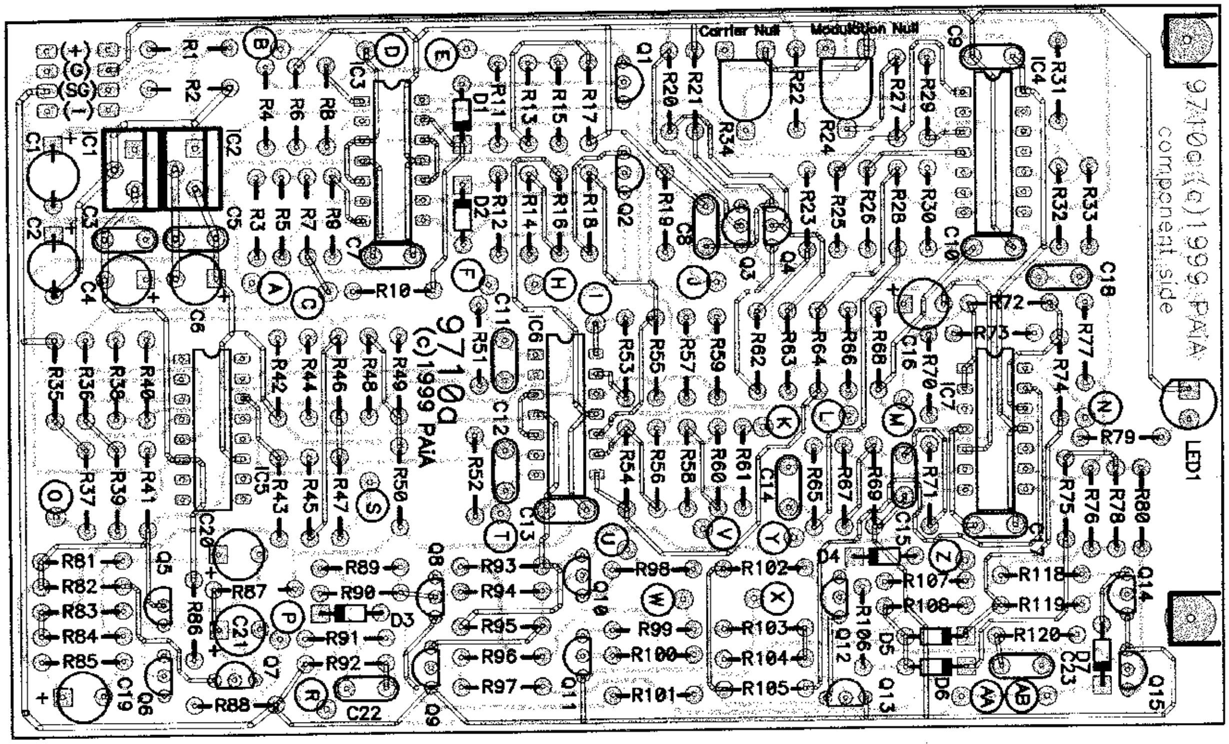


Fig 1. Circuit board parts placement and trace routings. Copper traces on the top of the board are shown in bold outline, useful if you need to trace the circuit though areas covered by ICs or other parts. Traces on the bottom of the board and their connections to components are shown in grey.

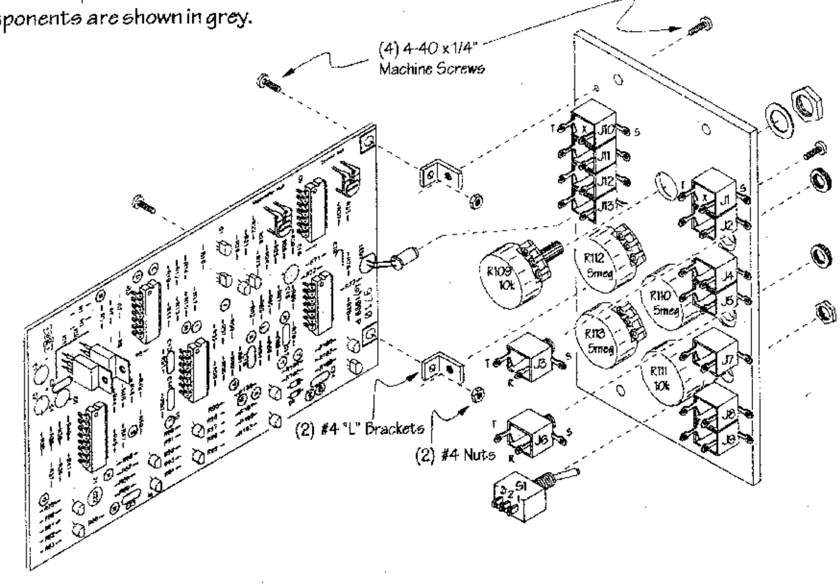


Fig 2. J3 and J6 are Stereo (TRS) Jacks and the rest are Closed Circuit types. The Front Panel attaches to the circuit board with "L" brackets and #4 hardware. Note that the threaded bracket holes are used to attach the brackets to the panel.

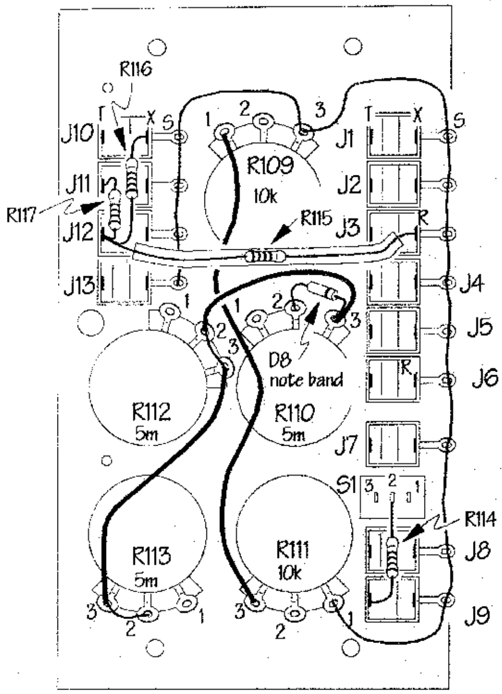
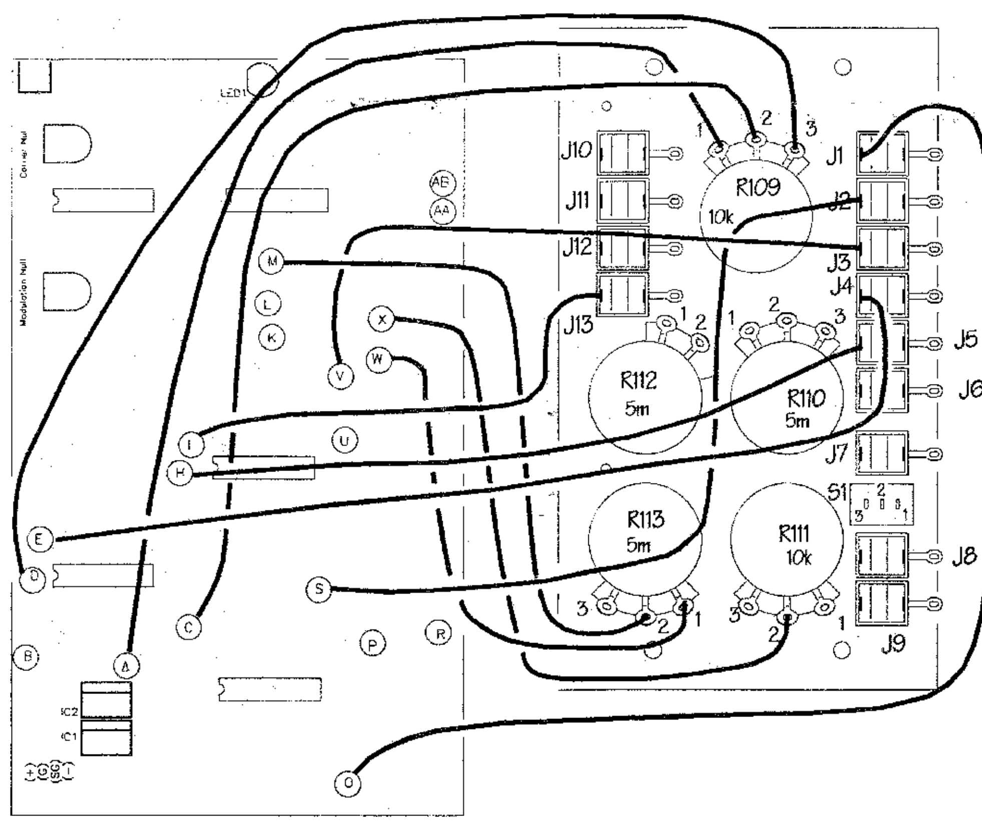


Fig 3 (left). Wiring on the panel uses bare wire and #22 stranded, insulated wire. Connecting to the "S" (Sleeve) lugs of J10-J13 will be easier if done before the potentiometers are mounted. Note the insulation over R115.

Fig 4 (below). #22 insulated, stranded wire is used for the connections between front panel and circuit board. Previous wiring has been eliminated for clarity.



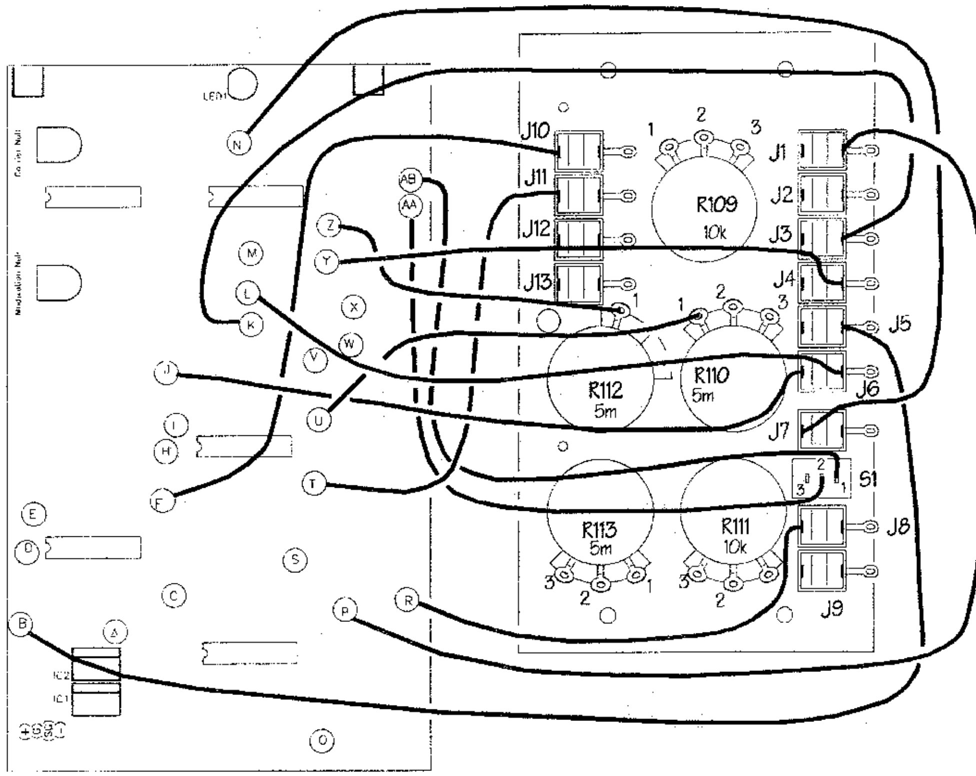
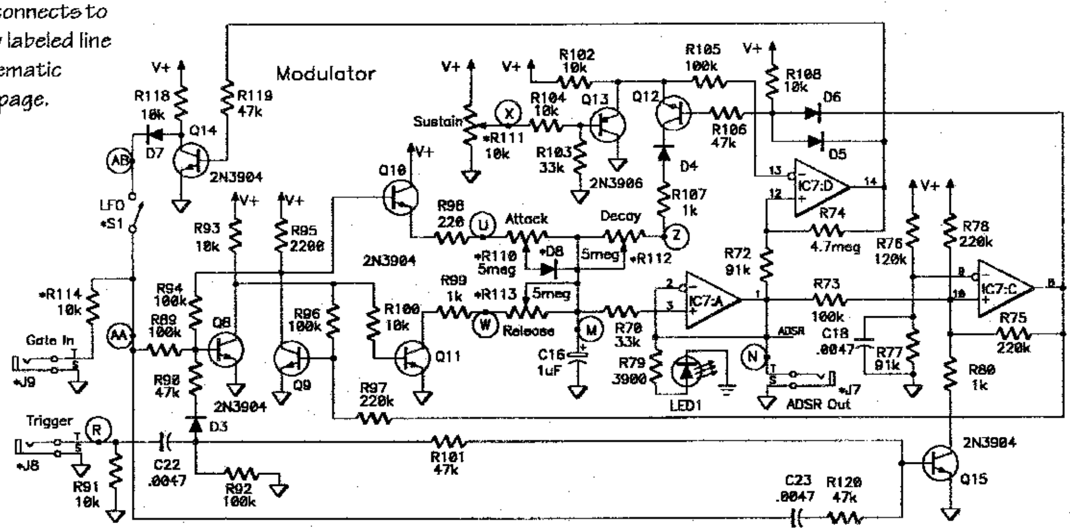


Fig 5. Wiring between panel and circuit board continues with #22 stranded, insulated wire as above. Previous connections omitted for clarity.

Fig 6 - The 9710 ADSR Modulator schematic. Notice line labeled "ADSR" above J7 which connects to correspondingly labeled line in the VCAs schematic on the following page.



010321

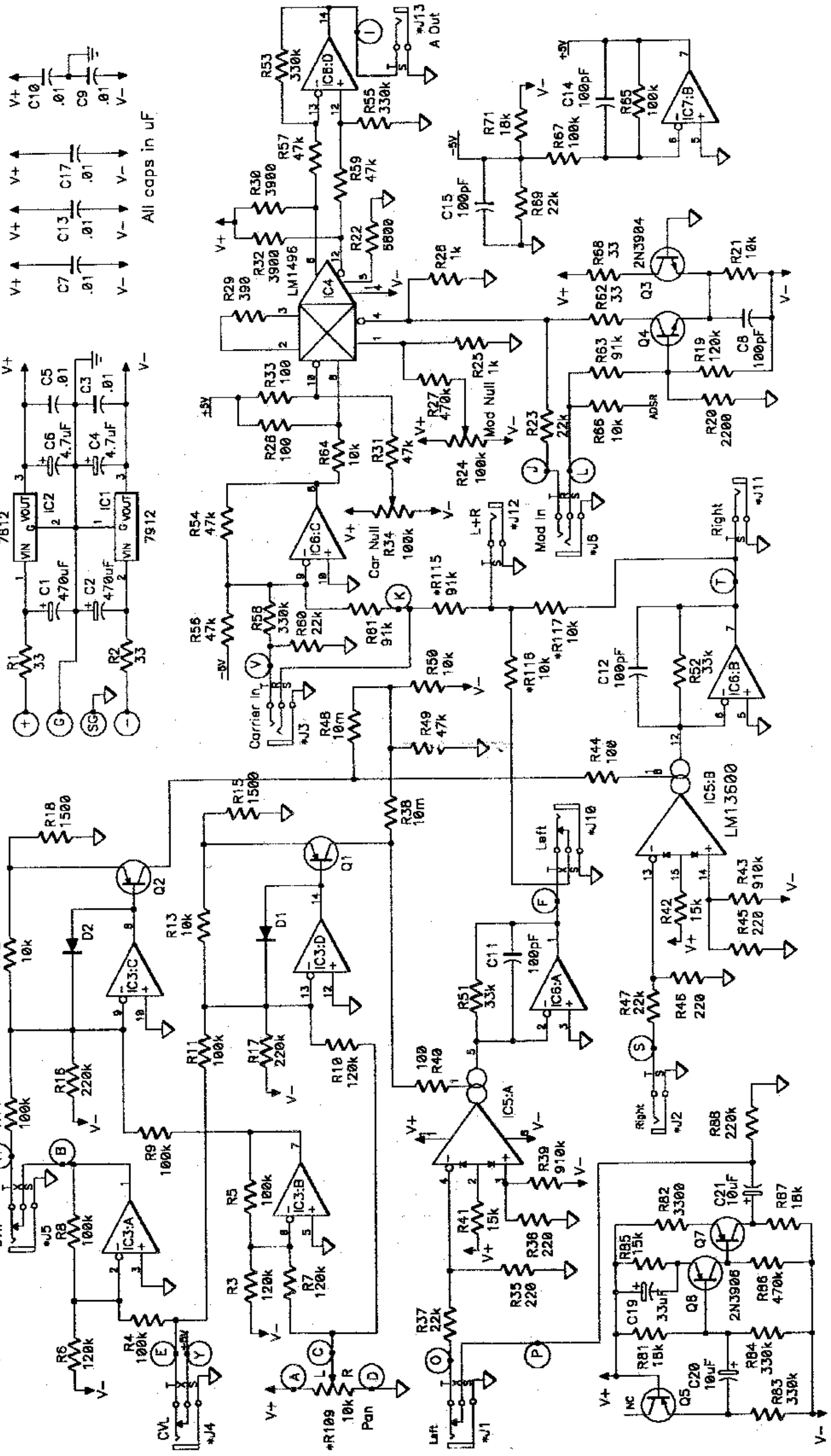


Fig 7. Triple VCA schematic. A 1496 type Balanced Modulator is used for one VCA while 13600 OTAs are used for the other two. Notice line labeled "ADSR" below R66 which connects to corresponding line in the Modulator schematic fig 6.

010321