

REALISTIC[®]

Service Manual

42-4000

CONCERTMATE MODEL MG-1

Catalog Number: 42-4000



CUSTOM MANUFACTURED FOR RADIO SHACK  A DIVISION OF TANDY CORPORATION

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1. SPECIFICATIONS

NOTE

All specifications are typical and may vary slightly from unit to unit.

POWER REQUIREMENTS

Operating Voltage Range 95–127 volts, 60 Hertz
190–254 volts, 50 Hertz

Power Consumption 19 watts, maximum

CONTROLLERS

Keyboard 31 note (F to C)

Glide Time Slide Control Linear, continuously variable from 5 milliseconds to 2.3 seconds

Tone Source Tune Control Range (\flat – \sharp) +/- 3 semitones

Polyphony Tune Control Range (\flat – \sharp) +/- 3 semitones

Modulation Rate Slide Control 0.3 Hertz to 31 Hertz

Modulation Waveshape Switch Triangle, square or random

Tone Source Modulation Slide Control Zero to 18 semitones

Filter Modulation Slide Control Zero to 5 octaves

Auto Contour Trigger Switch Triggers contour generator with modulation oscillator frequency (rate)

TONE SOURCE ONE

Reference frequency for Low F (octave = -2) 43.65 Hertz

Waveforms (\surd \square) Sawtooth and pulse wave of 50% duty cycle

Octave Settings 0, -1, -2 octaves

Sync (Synchronization) 2–1 Locks the fundamental frequency of Tone Source Two to Tone Source One

TONE SOURCE TWO

Reference Frequency for Low F (Octave = -1) 87.31 Hertz

Waveforms (\surd \square) Sawtooth and pulse wave of 10% duty cycle

Octave Settings +1, 0, -1 octaves

Detune (\flat – \sharp) Slide Control with Sync 2 – 1 Switch Out Varies Tone Source Two +/- 7 semitones relative to Tone Source One

Detune (\flat – \sharp) Slide Control with Sync 2 – 1 Switch In Varies Tone Source Two's harmonic spectrum over a 2 octave range

NOISE

Type Digital pseudorandom pink noise

BELL TONE

Type Digital exclusive "OR"

Inputs Tone Sources One and Two

Input Waveforms Pulse waves

POLYPHONY

Reference Frequency for Low F 87.31 Hertz

Waveform Square

Keying System On-Off keyboard keying over the 31 note range

Master Oscillator Frequency 125 kHz

CONTOUR GENERATOR

Rise Time 4 milliseconds minimum
4.7 seconds maximum

Fall Time 10 milliseconds minimum
15 seconds maximum

Sustain Level at U1013B with Key Depressed and Sustain Switch "IN" 6 volts

VOLTAGE CONTROLLED AMPLIFIER (VCA)

(ALL OUTPUTS MEASURED AT U1011 PIN 6)

Tone Source One Sawtooth	-30dBm minimum
Tone Source Two Sawtooth	-30dBm minimum
Tone Source One Pulse	-25dBm minimum
Tone Source Two Pulse	-33dBm minimum
Bell Tone	-20dBm minimum
Noise Source	-30dBm minimum
Polyphony (One Note Depressed)	-30dBm minimum

VOLTAGE CONTROLLED FILTER (VCF)

Type	Patented 24dB/octave low pass filter
Filter Keyboard Tracking	
Out	Filter does not track keyboard
1/2	50% of keyboard control voltage effects filter cutoff
1	100% of keyboard control voltage effects filter cutoff
Regeneration Frequency (Self Oscillation) with Filter Cutoff Centered and Filter Keyboard Tracking Out and Contoured Cutoff at Zero	610 Hertz reference frequency

VOLTAGE CONTROLLED FILTER (VCF) (Continued)

Range of Filter Cutoff Control	11 octaves
Maximum Sweep of Cutoff Frequency by Contour Generator (with Sustain In)	7 octaves

INTERFACE PORTS

Pitch Scale Factor	1 volt/octave
Trigger	Shorting to ground starts the contour generator

SIGNAL TO NOISE RATIO

Bleedthrough (From All Sources)	50dB
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WEIGHTS AND DIMENSIONS

Synthesizer Dimensions	18" long x 12-1/2" wide x 5-1/4" high (46cm x 32cm x 13cm)
Synthesizer Weight	12-1/2 pounds (5.6kg)
Single Carton Dimensions	23" long x 14" wide x 7" high (58cm x 36cm x 18cm)
Shipping Weight (of One Synthesizer)	15 pounds (6.8kg)

2. CIRCUIT DESCRIPTION

For the purposes of this circuit description, all circuit designations are coded with a numerical prefix.

Control Board 1 = 1000 Series

Keyboard and Jack Boards 2 and 3 = 2000 Series

Example: R29 on Board 1 becomes R1029; R54 on Boards 2 and 3 becomes R2054.

Since there are separate power supply feeds to different parts of the circuit, these separate feeds are coded with an A, B, C or D suffix.

Example: The +12 volt source for Tone Source 1 is listed on the schematic as +12V (A).

POLYPHONIC TONE GENERATOR

The polyphonic tone generator consists of a high frequency master oscillator U2001, top octave synthesizer U2002 and dividers U2003 through U2006. In a simplified operation summary, the high frequency oscillator produces a 125kHz square wave. The top octave synthesizer divides this square wave down by different ratios to generate the frequencies of the top octave on the keyboard. The rest of the dividers divide the top octave frequencies by factors of 2 or 4 to generate the rest of the pitches on the keyboard.

The master oscillator, U2001, utilizes a CMOS phase lock loop as a voltage controlled oscillator (VCO). The frequency is set by the current pulled from pin 11 on U2001 plus the voltage on pin 9. C2001, R2002 and Poly Freq Trim R2001 set the basic frequency of oscillation at 125kHz. The POLYPHONY TUNING control R1076 adjusts the frequency over +/-2.5 semitones. The square wave output appears on pin 4 of U2001.

U2002 divides down the 125kHz square wave to form the top octave notes on the keyboard. The output of U2002 feeds resistors R2009 through R2021 which feed directly to the keyboard. The output of the top octave synthesizer (TOS) also feeds the appropriate inputs on the rest of the dividers U2003 through U2006. The output of these dividers feed their appropriate 22K resistors connected to the keyboard.

KEYBOARD AND TRIGGER EXTRACTOR CIRCUITRY

The keyboard circuit consists of the keyboard, current source U2009, KEYBOARD GLIDE control R1063, track and hold amplifier U1007A, polyphonic summing amplifier U2007A, and trigger extractor U2007B and U2008. When at least one note is depressed on the keyboard, a DC voltage appears on the pitch buss and a square wave current from the polyphonic tone generator is coupled to the summing node on the polyphonic buss. The trigger extractor detects the output of the polyphonic summer and generates a voltage trigger, which stays on as long as any note is depressed. A DC voltage corresponding to the highest note depressed is coupled through the GLIDE slider R1063 to the keyboard track and hold amplifier. The output of this amplifier is routed to both Monophonic Tone Sources and through the KEYBOARD TRACKING switch to the Voltage Controlled Lowpass Filter. A rear panel PITCH jack J1007 is provided to control the pitch of the synthesizer from an external source and to output the keyboard voltage to an external accessory.

The Monophonic Keyboard Circuit consists of U2009, an inverter used as a constant current source, and associated circuitry. Hi End Trim R2057 sets the high end keyboard voltage at 2.58 volts. R2052 feeds approximately 870 microamps through the 31 resistors in the keyboard, generating one volt per octave across the keyboard. Since the high end of the keyboard is fixed at 2.58 volts, we have a high note priority keyboard. Low End Trim R2051 sets the low end of the keyboard to 0 volts for 1 volt/octave.

The voltage corresponding to the highest note depressed is routed to the PITCH jack J1007. J1007 allows the internal monophonic keyboard voltage to be replaced by an external voltage source. Without a plug in J1007, the keyboard buss voltage is routed to KEYBOARD GLIDE slider R1063. With a stereo plug inserted into J1007, the internal connection is interrupted. The keyboard buss voltage appears on the ring of the plug and an input external voltage source appears on the tip.

The selected input voltage from J1007 is routed to the KEYBOARD GLIDE slider R1063. R1063 and C1013 form a lowpass filter with an adjustable time constant. With the KEYBOARD GLIDE slider R1063 set at its lowest value, each successive note on the keyboard will give a discrete pitch jump. At high values of the KEYBOARD GLIDE slider, two successive notes will cause the voltage to slide between notes. C1013 is buffered by U1007A and the voltage is fed to the Tone Source summer U1007B, inverter U1008 and the lowpass FILTER through the KEYBOARD TRACKING switch SW1006.

Unlike the monophonic section, the polyphonic section produces actual pitches instead of a DC control voltage. Square waves from the top octave synthesizer and dividers feed 22K resistors connected to each keyswitch on the keyboard. When any note is depressed, the resistor connected to that note feeds a square wave current to the polyphonic pitch buss connected to U2007A. U2007A converts the current to a 1 volt peak-to-peak square wave which feeds directly to the POLYPHONY level slider R1054 and to the trigger extractor U2007B.

U2007B and U2008 form the trigger extractor. U2007B amplifies the output of the polyphonic summer and charges C2006 through CR2001. As the voltage across C2006 exceeds 1 volt, it causes the output of U2008 to change from +12 to -15V, generating a voltage trigger. C2006 and R2047 have a long time constant which yields a constant trigger as long as any single note is depressed. When all notes are released, R2047 discharges C2006 causing U2008 to turn off the trigger. The voltage trigger is fed to the contour generator.

TONE SOURCE SUMMER AND INVERTER

The Tone Source summer U1007B adds the pitch control voltage from the PITCH jack J1007, the TONE SOURCE TUNING control R1068, and the modulation signal from the MODULATION TONE SOURCE slider R1071. The pitch control voltage from J1007 can be the keyboard voltage or an externally applied voltage on the tip of J1007. The output of U1007B is inverted by U1008 and applied to both oscillators.

LINEAR VOLTAGE TO EXPONENTIAL CURRENT CONVERTER

The linear voltage to exponential current converter circuit takes the linear voltage from the Tone Source summer/inverter and converts it to an exponentially varying current directly related to musical intervals. After processing by the converter, each 1 volt increase of the keyboard is converted to an octave increase (doubling) in current which results in an octave increase (doubling) in frequency of the Tone Sources.

The linear voltage to exponential current converter (hereafter referred to as the exponential converter) consists of a reference current source Q1002 and U1002A and the exponentiating transistor Q1001. The reference current source is used to cancel the increase in reverse saturation current with temperature.

The reference current (I_{REF}) is maintained in Q1002 by U1002A. U1002A senses the voltage drop across R1004 and R1005 and pulls current out of the emitter of Q1002 to maintain the voltage drop at 12 volts. With TONE SOURCE OCTAVE switch SW1001 in the -2 position, it places R1004 and R1005 in series, and the 12 volt drop forces six microamps into the collector of Q1002. Since the base current of Q1002 can be neglected, the six microamps flows out of the emitter of Q1002 into U1002A. The TONE SOURCE OCTAVE switch SW1001 arranges the connection to R1004 and R1005 to produce octave increments in the reference current. At the -1 setting of SW1001, I_{REF} equals 12 microamps and at the 0 setting, I_{REF} equals 24 microamps. R1004 and R1005 are matched to 0.1% to ensure the accuracy of the octaves. C1001 prevents the reference current loop from self-oscillating.

The actual exponentiating element is Q1001. The collector current of Q1001, I_C , is characterized by the following formula:

$$I_C = I_{REF} e^{\frac{V_{IN}}{V_T}}$$

where:

I_{REF} = reference current through Q1002

V_{IN} = input voltage to base of Q1001

$$V_T = \frac{kT}{q} \approx 28.8\text{mV at room temperature of } 80.6^\circ\text{F (300}^\circ\text{ Kelvin)}$$

k = Boltzmann's constant = 1.380×10^{-23} Joules/degree Kelvin

T = absolute temperature in degrees Kelvin

q = charge of one electron = 1.6×10^{-19} Coulombs

At V_{IN} equal to zero volts, the collector current from Q1001 equals the reference current flowing through Q1002. For every 17.9mV increase in the voltage V_{IN} , the current through the collector of Q1001 doubles. This can be verified with a scientific calculator as follows:

$$I_C = I_{REF} e^{\frac{17.9\text{mV}}{25.8\text{mV}}} = I_{REF} \times 2.001 \approx 2 \times I_{REF}$$

Tone Source 1's frequency is directly proportional to the current flowing through Q1001, and therefore, a 17.9mV

increase in V_{IN} means the Tone Source frequency will double (increase one octave).

R1007, R1006, and R1008 attenuate the keyboard voltage so a one volt keyboard voltage will result in 17.9mV at the input (base) of Q1001. Scale 1 Trim R1008 adjusts the input voltage to 17.9mV/octave for exactly 1 volt/octave of keyboard voltage. FREQ 1 trim R1001 adjusts the "offset" of the current source to set the reference pitch of the Tone Source.

R1007 is a temperature compensating (T.C.) resistor. An examination of the formula for the collector current shows that V_T varies with absolute temperature at a rate of 3300 parts per million per degree Kelvin. This causes the octave relationship to go "flat" (decrease) as temperature increases. For example, it would take an input of 19mV to equal a change of one octave of collector current at 113°F or 318° Kelvin. Therefore, as the current source goes flat, so do the tone sources. To maintain good tuning accuracy, R1007 has a temperature coefficient of +3300 parts per million to compensate for the temperature effect. R1007 is mounted underneath U1001 with thermal grease to maintain good thermal contact.

TONE SOURCE 1

The exponential current source drives a current controlled oscillator (CCO) which operates very simply. The exponential converter pulls a constant current out of a capacitor causing a ramp voltage which decreases with time. When the ramp voltage hits zero, a comparator fires, turning on a transistor. The transistor discharges the capacitor to +12 volts and the process repeats forming a sawtooth waveform whose frequency is directly proportional to the current pulled through the exponentiator. The sawtooth voltage is routed to another comparator to produce a rectangular pulse.

Now for the more detailed operation, Q1001 draws current from C1002 through R1009. This generates a linear ramp starting at 12 volts and decreasing (charging) towards zero volts. U1002B buffers the capacitor voltage and applies it to comparator U1003B. As long as the ramp voltage is above zero volts, the output of U1003B is at +12 volts, Q1006 is off and C1002 continues to charge towards ground.

When the ramp hits zero, U1003B fires to -12 volts, Q1006 turns on, discharging C1002 to +12 volts. U1003B then resets to +12 volts, Q1006 turns off, and the process repeats producing a sawtooth wave. Since the output of U1002B cannot go to exactly +12 volts, the sawtooth wave has a flat spot on the top of it. C1005 and R1013 add a 1.5

microsecond hysteresis to the comparator to guarantee that C1006 is fully discharged.

As stated earlier, the CCO's frequency is directly proportional to the current through Q1001 which results in a 1 volt per octave keyboard response. This 1 volt per octave relationship goes "flat" (decreases) at higher frequencies due to the influence of two factors; first, at higher currents the exponential current source deviates from a true exponential response causing it to flatten out, and second, due to the oscillator reset time of 1.5 usec. R1009 is added to compensate for both these effects. As the current pulled from C1002 is increased, the voltage drop across Hi Freq Trim R1009 increases causing the voltage from buffer U1002B to go to ground early. This causes the oscillator to go "sharp" with increasing current. The "flatness" caused by the exponential current source and the reset time is compensated by the oscillator going "sharp" and true exponential response is maintained.

The sawtooth wave from U1002B is routed to the WAVE SHAPE selector switch SW1002, TONE SOURCE 1 level slider R1051, and the pulse generator U1003A which compares the sawtooth to a +6 volt reference voltage. The output of U1003A is high when the sawtooth voltage is above 6 volts and low when the sawtooth is below 6 volts, thereby generating a square wave. Square Trim R1016 adjusts the threshold voltage to set the duty cycle of the square wave at 50%. The square wave is also routed to WAVE SHAPE selector SW1001.

TONE SOURCE 2

Tone Source 2 is identical to Tone Source 1 except in four areas: it's tuned an octave higher, it has a DETUNE slider R1025, it can be synchronized to Tone Source 1 and its pulse generator produces a 10% duty cycle pulse. Tone Source 2 has a timing capacitor C1008 that is one half the size of C1002, causing Tone Source 2 to be one octave higher at the same control positions. The TONE SOURCE 2 DETUNE slider R1025 offsets the current source for Tone Source 2 allowing its frequency to be varied independently from Tone Source 1. The pulse width output is 10% because R1046 and R1047 set the threshold of U1006A at a 1.2 volt reference instead of 6 volt as in the case of Tone Source 1.

Synchronization locks the fundamental frequency of Tone Source 2 to Tone Source 1. SYNC 2-1 is accomplished by allowing the Tone Source 1 reset pulse to also reset Tone Source 2. Tone Source 2 can also reset itself when its own sawtooth hits zero.

When SYNC 2-1 switch SW1003 is OUT, Tone Source 1 and 2 free run, producing representative waveforms **A** and **B** as shown in the illustration (Figure 1) along with their respective reset pulses for both tone sources. As you can see, the tone sources are not harmonically related. When the SYNC 2-1 switch is in the IN position, the negative reset pulses from U1003B and U1006B are "OR'd" by Q1013 and Q1014 and used to reset C1008. This produces a waveform characterized by waveform **C**. Therefore, the fundamental period of **B** is the same as the original time period of sawtooth **A**.

The SYNC 2-1 switch SW1003 also increases the range of the DETUNE slider R1025. This increase in range is used to generate harmonic changes in Tone Source 2 in the synchronization mode. As the DETUNE slider R1025 is increased, the pitch of Tone Source 2 tries to increase. Since it is locked to Tone Source 1, its fundamental frequency cannot move. But as you can see, the increase in drive causes the waveform of Tone Source 2 to change, generating a new harmonic spectrum. As the DETUNE slider is decreased, a waveform similar to **D** will result. Since Tone Source 2 is trying to run slower, it will not reach zero to reset itself. Therefore, Tone Source 2 will be only reset by Tone Source 1 producing a sawtooth identical to Tone Source 1. As the DETUNE slider is decreased, the amplitude of the sawtooth will decrease. This decrease in the sawtooth will also cause the pulse output to disappear because the sawtooth will always be above the pulse generator trigger threshold of 1.2 volts.

The actual circuits used in synchronization are quite simple. Tone Source 1's negative reset pulse from U1003B is buffered by Q1007 and applied to SYNC 2-1 switch SW1003. A separate feed to the DETUNE slider R1025 is also routed to SW1003. With SYNC 2-1 OUT, neither of these are routed to the circuits and the tone sources free run. When the SYNC 2-1 switch is IN, the reset pulse is coupled to Q1013 and the DETUNE slider R1025 is coupled through R1029 to the base of Q1010. The reset pulse from Q1007 causes Q1013 to fire, resetting C1008. This locks Tone Source 2 to Tone Source 1. The increased control feed into Q1010 increases the range of the DETUNE slider for spectrum changes.

NOISE GENERATOR

Noise is generated by a pseudo random digital noise generator U1016. U1016 produces a varying digital pulse stream which has a frequency spectrum of white noise over the audio range. The white noise output is fed through a 3dB/octave filter to produce a pink noise. Pink noise is amplified by U1017B, routed through the MIXER NOISE level slider R1058 and then routed through the Voltage Controlled Filter.

The amplified pink noise from U1017B is also filtered by R1162 and C1033, buffered by U1017A and fed to the sample-and-hold switch Q1032 to produce a random modulation voltage. R1158, R1159 and CR1002 limit the negative excursions on C1033 to prevent accidental turn on of Q1032.

BELL TONE GENERATOR

The Bell Tone output is generated by a digital "exclusive OR" gate in U2001. The "exclusive OR" gate has a +12 volt output when either input is at +12 volts but not both inputs. U2001 has a 0 volt output when both inputs are 0 volts or both are +12 volts. When the square wave from Tone Source 1 and rectangular pulse from Tone Source 2 are applied to the two respective inputs of U2001, sum and difference frequencies are generated realizing the bell tone effect.

Each Tone Source output is level shifted by Q2001 and Q2002 to +12 volt to 0 volt rectangular waveforms. These are applied to phase comparator one (P.C. 1) in U2001 (the exclusive "OR"). The output of U2001 is routed to the MIXER BELL TONE level slider R1056 and through the Voltage Controlled Filter.

VOLTAGE CONTROLLED LOWPASS FILTER

A lowpass filter attenuates the high frequency components of the signal while allowing low frequency components to pass. The Voltage Controlled Lowpass Filter (VCF) used in this instrument uses a patented Moog design utilizing the incremental base to emitter resistance of silicon transistors as a control element to vary the cutoff frequency of the filter. The VCF consists of a linear voltage to exponential current converter, a four stage current controlled filter ladder, two buffers and a regeneration amplifier. The exponential current converter first sums the voltages from the FILTER CUTOFF FREQ slider R1108, the MODULATION FILTER slider R1105, the FILTER CONTOURED CUTOFF slider R1117, the Filter Cutoff Trim R1110, and the KEYBOARD TRACKING switch SW1006. The summed linear voltages are then converted to an exponential current which is used to vary the cutoff frequency of the filter ladder.

The current controlled filter ladder consists of Q1015 to Q1024. The audio input for the filter is the combined output from TONE SOURCE 1 slider R1051, MIXER POLYPHONY slider R1054, MIXER BELL TONE level slider R1056, MIXER NOISE slider R1058, and MIXER TONE SOURCE 2 slider R1060 which is applied to Q1024.

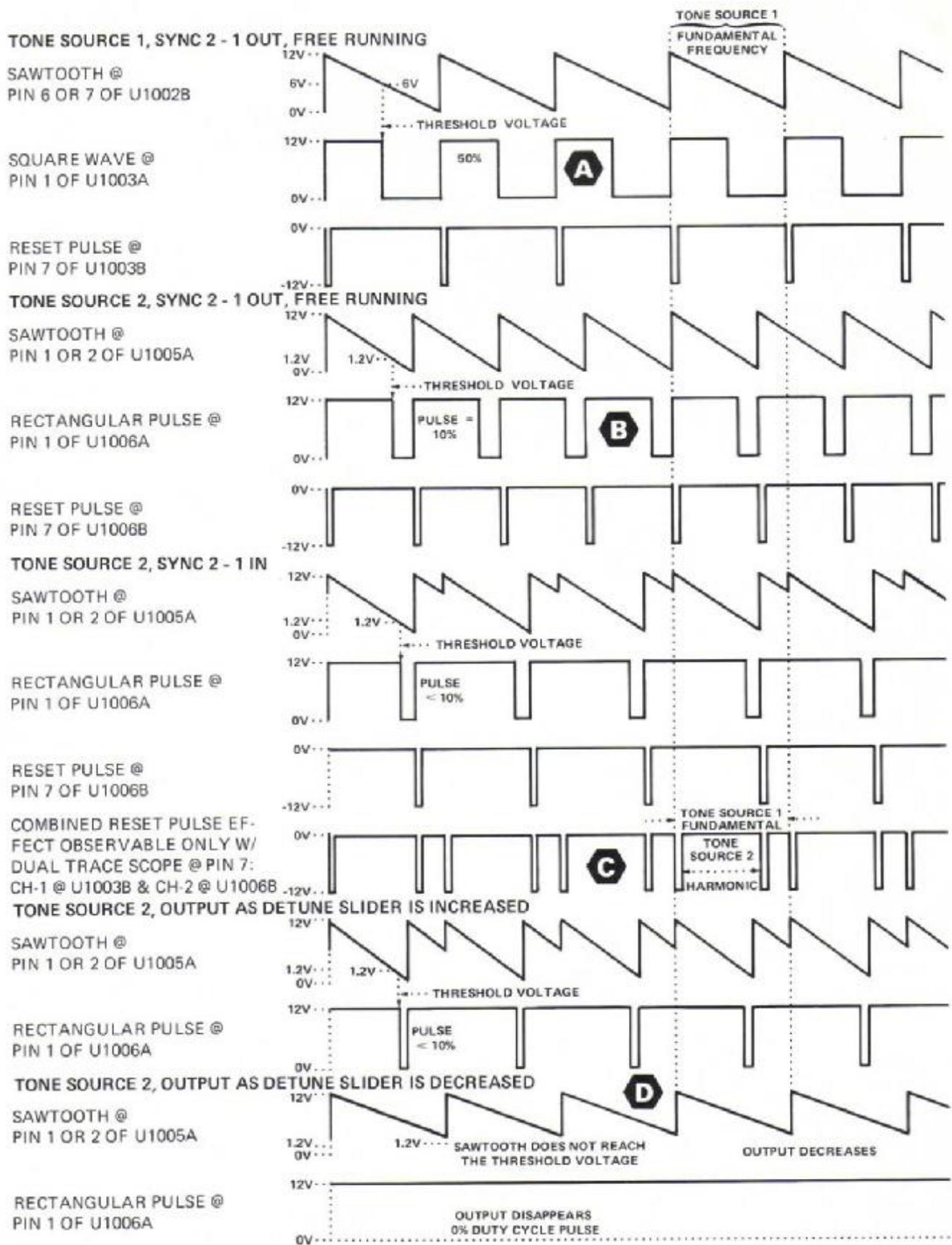


FIGURE 1 TYPICAL TONE SOURCE WAVEFORMS

Q1024 and Q1023 convert the audio signal voltage into a small differential signal current which is superimposed on the control current flowing down through the filter ladder. The four 6dB/octave filter sections in the ladder add to give a 24dB/octave overall filter response. The lowpass differential signal current is converted to a differential voltage by Q1015 and Q1016 and then buffered by U1010A and U1010B. The buffered differential signal voltage is applied to the voltage controlled amplifier (VCA) U1011 and the emphasis amplifier U1012. U1012 converts the differential signal to a single ended signal and then routes this signal through FILTER PEAK EMPH slider R1100 to the base of Q1023. This applies positive feedback around the filter producing a resonant peak at the cutoff frequency. The FILTER PEAK EMPH slider controls the height of the resonant peak.

The overall filter frequency response is characterized by the accompanying illustration (Figure 2).

The linear voltage to exponential current converter consists of Q1025 and Q1026. As stated earlier, the exponential current converter takes linear voltages from many sources, combines them and then generates a current proportional to exponent of them. Since the filter does not require as accurate an exponential current converter as the Tone Sources, a simple PNP-NPN transistor pair can be used. In this case, the temperature dependent base-to-emitter voltage of Q1025 and Q1026 cancel one another.

The current from the collector of Q1026 is approximately equal to:

$$I = I_{REF} e^{\frac{V_{IN}}{V_T}}$$

where:

V_{IN} = voltage on base of Q1025

I_{REF} = current through R1115 = 120 μ amps

V_T = 25.8mV @ room temperature

Therefore, for every 17.9mV increase in voltage on the base of Q1025, the current through Q1026 doubles. For a more detailed explanation, see earlier explanation of "Linear Voltage to Exponential Current Converter."

The current through Q1026 is used to vary the cutoff frequency of the filter ladder. This arrangement allows many voltage sources to vary the filter cutoff frequency. The circuits that control the filter cutoff frequency are the Keyboard Voltage, the FILTER CUTOFF FREQ slider R1108, the Modulation Oscillator, and the Contour Generator. The keyboard voltage from U1007A controls the filter through the KEYBOARD TRACKING switch SW1006. With SW1006 in the OUT position, no keyboard control is allowed.

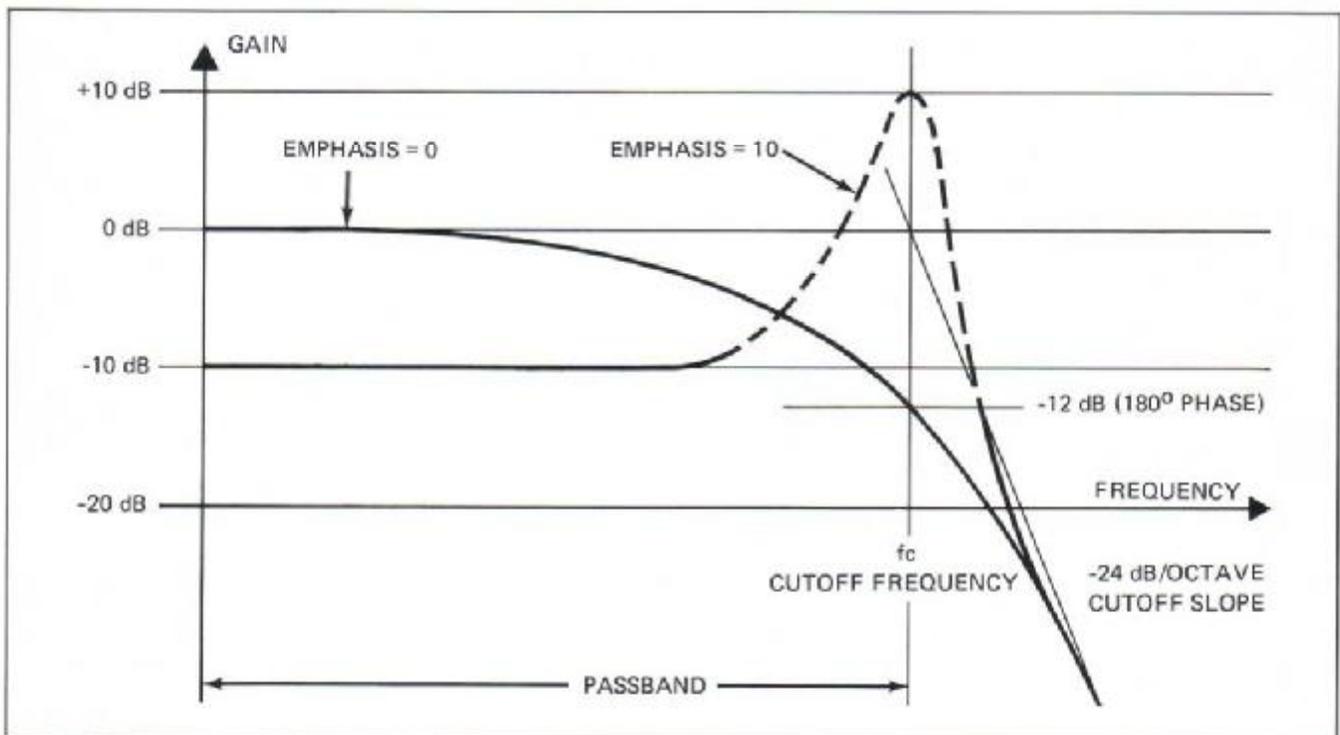
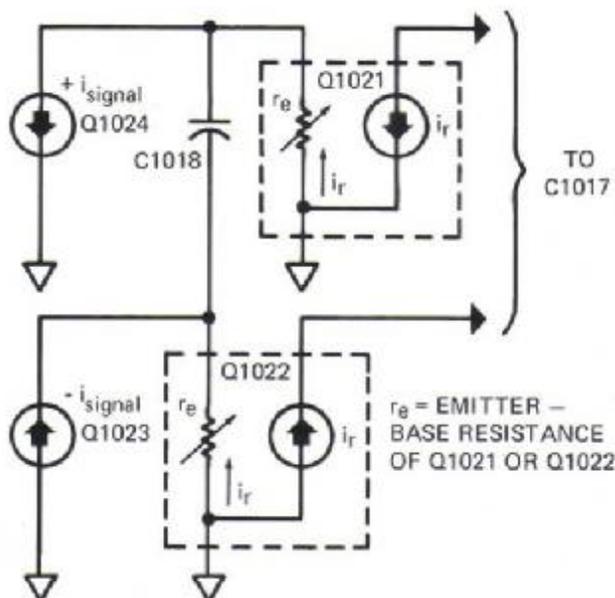


FIGURE 2 VCF FREQUENCY RESPONSE CURVES

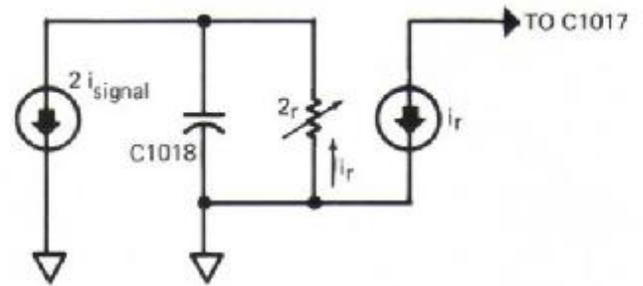
In the 1/2 position, one octave of keyboard travel changes the filter cutoff frequency by 1/2 octave. In the FULL position, one octave of keyboard travel changes the filter cutoff frequency 1 octave. Filter Scale Trim R1113 adjusts the input voltage so the filter tracks the keyboard when the KEYBOARD TRACKING switch SW1006 is in the FULL position. The filter cutoff frequency can also be controlled by the FILTER CUTOFF FREQ slider R1108 and has approximately an 11 octave range. The MODULATION FILTER slider R1105 routes the modulation oscillator output from U1015A to the filter. Thereby, the modulation oscillator's waveform will sweep the filter cutoff frequency. The FILTER CONTOURED CUTOFF slider R1117 routes the output of the contour generator to the filter. The Filter Cutoff Trim R1110 is used to set the reference frequency of the filter.

The actual audio signal for the VCF is supplied from the Tone Sources, the Bell Tone Generator, the Polyphonic Section and the Noise Source through their appropriate level potentiometers (for example, R1051). These signals are routed to individual summing resistors and AC coupled to the base of Q1024. R1082 attenuates these input voltages. Q1024 and Q1023 are differential drivers for the filter ladder and serve two functions. First, they split the current pulled through Q1026 into identical halves for each leg of the filter ladder. Second, they convert the audio input voltage into a small differential signal (push-pull) currents which are superimposed on the control current.

The bottom filter element consists of Q1024, Q1023, Q1021, Q1022 and C1018. The collectors of Q1024 and Q1023 act as current sources. The base to emitter junction of Q1021 and Q1022 acts as the control resistors. The first stage of the filter can be represented by the following, small signal, equivalent circuit:



This equivalent circuit can also be simplified to a single ended circuit as follows:



This represents a current source lowpass filter whose cutoff frequency (f_c) is:

$$f_c = \frac{1}{2\pi (2r_e) C}$$

r_e is the incremental base-emitter resistance of the transistors which is given by:

$$r_e = \frac{V_T}{I_f} = \frac{25.8\text{mV}}{I_f} \quad \text{where the control current } I_f = 1/2 \text{ current flowing through Q1026}$$

From the formula r_e is inversely proportional to the current through Q1026, it therefore follows that I_f can be used to change the cutoff frequency of the filter. As the control current I_f increases, so does the cutoff frequency of the filter. For example, at I_f equal to 11.5 microamps, $r_e = 4.465\text{K}$ and $f_c = 660\text{Hz}$.

Therefore, this section yields a filter element with a 6dB/octave rolloff with variable cutoff frequency controlled by a current.

The rest of the transistors and capacitors make up the other three filter sections. Since all the filter stages are in series, the same current flows through all. Also, since each filter stage is isolated by the transistors below it, the stages do not interact. The total of four stages yields a differential 24dB/octave filter with the cutoff current controlled by Q1026. The filter cutoff frequency is the same for all stages.

The output signal is taken from the emitters of Q1015 and Q1016. Since the current levels in the ladder are very low, the signals must be buffered by U1010A and U1010B. The buffered differential signals are sent to the Voltage Controlled Amplifier U1011 and the Emphasis Amplifier U1012. The Voltage Controlled Amplifier will be discussed in its own section later.

The **Emphasis Amplifier** is part of a positive feedback loop around the filter which produces a resonant peak at the cut-off frequency. Each lowpass filter element produces a phase shift of 45° at the cutoff frequency. The four stages add up to a total phase shift of 180° . If the output voltage from the filter is fed back to the inverting filter input, a 0° phase shift loop will occur at the cutoff frequency. This puts a resonant peak at the cutoff frequency of the filter (see VCF Filter Response Curves, Figure 2). With no feedback, normal filter response is maintained. As the feedback is increased, the height of the resonant peak increases until a point is reached when the filter breaks into oscillation. Therefore, the VCF can be used as a sine wave tone source.

U1012 is a differential amplifier that converts differential inputs into a single ended signal. The buffers U1010A and U1010B have an AC coupled differential audio signal on them and also have a common mode signal resulting from the control current change in the ladder. As the control current is changed, the top of both sides of the ladder see a voltage proportional to the control current. This voltage change is much larger than the actual "signal" level and would "swamp" the audio signal unless it is removed. Since the audio signals are differential signals and the control signal is common mode, the control signal can be removed from the audio by subtracting the output of one buffer from the other.

U1012 operating as a differential amplifier accomplishes this. The output of U1012 is the audio output of the filter with a gain of 15. This output is fed through the FILTER PEAK EMPH slider R1100 to Q1023 at the base of the ladder. Q1023 is the inverting input of the filter and, therefore, adds the 180° phase shift required for positive feedback. R1100 controls the amount of feedback and, thereby, the height of the resonant peak. Emphasis Trim R1093 sets the threshold of oscillation.

VOLTAGE CONTROLLED AMPLIFIER

All audio signals after passing through the VCF are processed by the Voltage Controlled Amplifier (VCA) to generate the overall loudness contour. The VCA consists of U1011 and Q1028.

The differential signal output from the VCF buffers U1010A and U1010B is applied to an operational transconductance amplifier (OTA) U1011. The gain of the OTA is directly proportional to the current flowing into pin 5 of the device. The control current is supplied through Q1028 by the voltage across R1104. The OTA has a differential input which rejects any common mode signal from the filter but retains the audio signal.

The VCA has three gain control modes set by the CONTOUR TONE SOURCES (Articulator) switch SW1009. In the CONTOURED mode, the gain is determined by the Contour Generator. A slow rise time will result in a slow build up in volume. In the KEYED mode, the Trigger Extractor controls the VCA in an off/on mode. Whenever any note is depressed, the VCA turns on and holds on for as long as any note is depressed. When all notes are released, the VCA turns off immediately. In the CONTINUOUS mode, the VCA is left on generating a continuous sound.

The VCA will respond to any voltage applied to its input including any DC offset from the buffers. Since the input audio signal level is on the order of 20mV, even a small DC offset will cause loud clicks in the output of the VCA. VCA Balance Trim R1094 cancels the input offset voltage of U1010A, U1010B and U1011.

The output of the VCA feeds the MASTER VOLUME control R1103. The output of R1103 is connected to the Headphone Amplifier U2010, Board 2.

HEADPHONE AMPLIFIER AND OUTPUT CIRCUIT

The Headphone Amplifier U2010 is the headphone driver and the main output amplifier. The output of the MASTER VOLUME control R1103 is routed to U2010 and amplified by about 20dB (10 times). The output is passed through C2011 and fed to R2060 and R2061 to drive the headphone jack to J2005. R2058 and C2012 prevent the headphone amplifier from oscillating.

The output of headphone amplifier is also tapped off by R2059 and applied to Board 3, the stereo OUTPUTS (TO AMPS) jacks J2001 (L) and J2002 (R) through a series of resistors. R2068 and R2067 allow an external stereo signal such as a tape out signal from a receiver to be mixed with synthesizer output.

CONTOUR GENERATOR

The contour generator produces a voltage waveform in response to a received trigger that is characterized by a rise time, sustain level and a fall time. When a trigger is received, the output of the contour rises toward +12 volts. When the output voltage reaches 6 volts, the contour will either hold at 6 volts when the CONTOUR SUSTAIN switch SW8 is in the IN position, or fall toward ground if there is no sustain. If the CONTOUR SUSTAIN switch SW8 is in the OUT position, the contour voltage will hold at 6 volts for as long

as any key is depressed. When all keys are released, the voltage will then fall to ground at the fall rate. If all keys are released before the rise phase is complete, the contour will complete the rise phase and then enter the fall phase. The trigger for the contour can be generated by the Trigger Extractor, AUTO CONTOUR TRIGGER switch SW1007, or an externally applied trigger through TRIG jack J1006.

A negative trigger from the Trigger Extractor or the Modulation Oscillator is selected by AUTO CONTOUR TRIGGER switch SW1007, inverted by Q1029 and turns U1014 off. The output of Q1029 is used to trigger the contour generator and used as the keyed signal for the VCA.

On the positive slope of the trigger of Q1029, C1024 feeds a positive pulse to U1013A which drives its output to -15 volts. Q1031 turns on, turning U1014A on which applies 6 volts to pin 2 of U1013A. U1013A latches in this state with its output held at -15 volts and +6 volts at pin 2. The output of U1013A turns U1014E on, which charges C1023 through R1123. This starts the rise phase of the contour.

C1023 charges toward +12 volts at a rate set by RISE TIME slider R1123. When the voltage on C1023 reaches 6 volts, the output of U1013A jumps to +12 volts. This shuts Q1031 off, which turns U1014A off. This kills the positive feedback around U1013A and puts a slight negative voltage on pin 2 of U1013A.

The +12 volts on U1013A also turns off U1014E, stopping the charging of C1023, turning U1014C on. If the CONTOUR SUSTAIN switch SW1008 is set to OUT, U1014C will discharge C1023 through FALL TIME slider R1124, setting the rate of discharge.

In the IN mode of CONTOUR SUSTAIN switch SW1008, U1014C is disconnected from the circuit and has no effect. As stated before, at the end of the rise phase, the voltage at pin 3 of U1014A rises to +12 volts turning U1014B on which connects the 6 volts on divider R1136 and R1137 through the FALL TIME slider R1124 to C1023. This holds C1023 at 6 volts for as long as a trigger is present and, thus sustain is achieved.

When the input trigger is removed, U1014D turns on discharging C1023 to ground through R1124, U1014B and U1014D. The fall time is again determined by FALL TIME slider R1124.

The voltage on C1023 is buffered by U1013B and applied to the FILTER CONTOURED CUTOFF slider R1117 and the CONTOUR SUSTAIN switch SW1008 for the VCA.

The interface TRIG jack J1006 at the rear of the synthesizer allows a switch-trigger to ground to activate the contour generator.

MODULATION OSCILLATOR AND SAMPLE/HOLD

The Modulation Oscillator is a standard op amp triangle and square wave generator followed by a MODULATION WAVE-SHAPE selector switch SW1010, sample/hold buffer, and two modulation amount sliders.

U1015B produces both a 3 volt triangle and a 27 peak-to-peak volt square wave with MODULATION RATE slider R1041 controlling the frequency. Both waveforms are routed to the MODULATION WAVESHAPE selector switch SW1010. SW1010 also feeds the square wave to a differentiator C1027 and R1152 to produce a 100usec sampling pulse for the sample-hold.

When SW1010 is set to the sample-hold mode (RANDOM), the 100usec sampling pulse fires Q1032 sampling the noise voltage on U1017A. This produces a random voltage across C1028 which changes at the modulation rate. U1015A buffers the switch and feeds the modulation signal to the TONE SOURCE and MODULATION FILTER slider R1071 and R1105, respectively. U1015B drives the RATE LED L1 and AUTO CONTOUR TRIGGER switch SW1007.

REGULATED POWER SUPPLY

All the circuitry in the MG-1 Synthesizer is powered by four regulated power supply voltages derived from two precision three terminal regulators.

The line voltage is dropped to +/-23 volts by transformer T1, the bridge rectifier CR2002 through CR2005 and filter capacitors C2015 and C2016. The raw DC is applied to the +12 volt regulator U2013 and -15 volt regulator U2012 to supply the main +12 volt and -15 volt power supply voltage. Since the synthesizer TUNE control and DETUNE slider need symmetrical supply voltages, R2062, R2063 and U2011 drop the -15 volts to -12 volts. The -12 volt reference is also used as a reference for Q2003 which supplies -22 volts to the Headphone Amplifier.

3. DISASSEMBLY AND ADJUSTMENTS

DISASSEMBLY (Refer to the Accompanying Photographs)

NOTE

Minor or "touch-up" tuning may be accomplished WITHOUT disassembly. The Tone Source Scale and Frequency Trim adjustments may be accessed through the rear panel holes using a 1/8-inch (3mm) screw driver. Follow shaded portions of adjustment procedures which are outlined later in this section.

Complete Tone Source Tuning requires further disassembly as described in the procedures that follow.

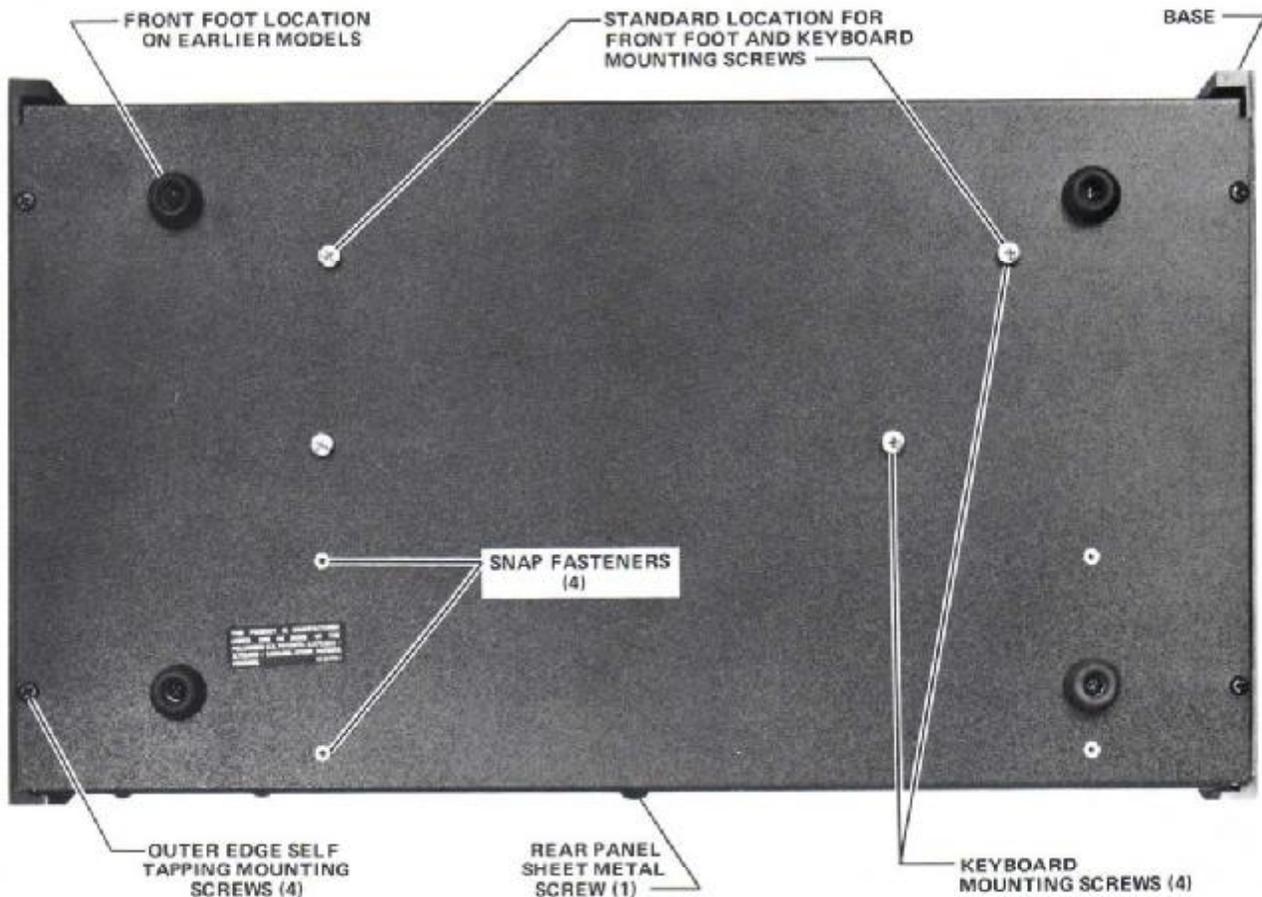
WARNING – SHOCK HAZARD

Removal of the base exposes line fuses and transformer connections. Only a qualified service technician should attempt any further disassembly.

Removing the Base

Turn unit upside down on a cushioned surface with keyboard facing away. Remove four (4) self tapping sheet metal screws on bottom of unit and one (1) sheet metal screw on rear panel. The keyboard remains attached to the base. Carefully turn the synthesizer upright and separate the cabinet from the base being sure to clear the front edge of the keyboard. Lean the cabinet back onto its rear panel.

All adjustments can be made from this position. Control Printed Circuit Board 1 access trim controls through the rear panel, and the remaining Control Printed Circuit Board 1 trim controls through small printed circuit board holes. Trims for Keyboard Printed Circuit Board 2 are easily adjusted using a 1/8-inch (3mm) diameter flat blade screw driver.



CAUTION

Before proceeding with disassembly of Control Printed Circuit Board 1 and Jack Board Printed Circuit Board 2, extreme care should be taken to protect the keyboard from:

- The excessive heat of a soldering iron;
- Scratches from the solder spikes of the printed circuit boards;
- Chemical reaction of special cleaners or sprays to the plastic key parts.

Cover the keyboard with a piece of cardboard or similar protective material, providing a place for the Control Printed Circuit Board 1 to rest on top for servicing.

Removing Control Printed Circuit Board 1

Remove all rotary and slide pot knobs.

NOTES

Do not attempt to remove switch cap knobs as they are an integral part of the switch.

During reassembly, these switches must be placed in their mechanically centered position to clear the front panel mounting holes. This center position may be unrelated to the actual switch operating positions.

Remove the five (5) screws securing the printed circuit board in place. Carefully remove the two (2) foam dust covers.

This stage of disassembly facilitates easy adjustment, troubleshooting and component replacement.

Removing Keyboard Printed Circuit Board 2 (Bottom Board)

To facilitate component replacement, remove all connectors with the exception of the keyboard connectors. Remove the four (4) screws securing the board in place. The board may now be positioned for servicing. On later models there are no screws securing this board in place. Screw-mount plastic board supports are supplied and the board can be lifted from these supports.

Removing Jack Board Printed Circuit Board 3

The jack board is removed by simply drilling out the three (3) retaining rivets, using a 1/8-inch drill bit.

Removing Keyboard

This is accomplished by removing all connectors from Keyboard Printed Circuit Board 2 and removing the four (4) screws securing the keyboard frame and mounting brackets in place through the base plate. Identify and disconnect wiring from keyboard. Place keyboard face down, using cushioning material to protect the keys. Separate the keyboard from the base.

Removing Keys

Keys may be removed with the keyboard in the cabinet if replacement becomes necessary.

Depress key at the hole in the aft key surface. This will permit the rear notches in the key to disengage from the rear bracket. Retain tension on key at this point.

Pull out and down on opposite end of key. This will disengage the key hook from its mounting, permitting removal. A tension spring is mounted on a detent on the key and can be lifted out.

To replace the key, engage the forward hook on the key in the bracket, press rear end of key to depress tension spring and move key to the rear until the notches on the key engage the rear bracket.

Removing Keyboard Switches

In order to remove the switch assembly, the keyboard must be removed from the base as described above.

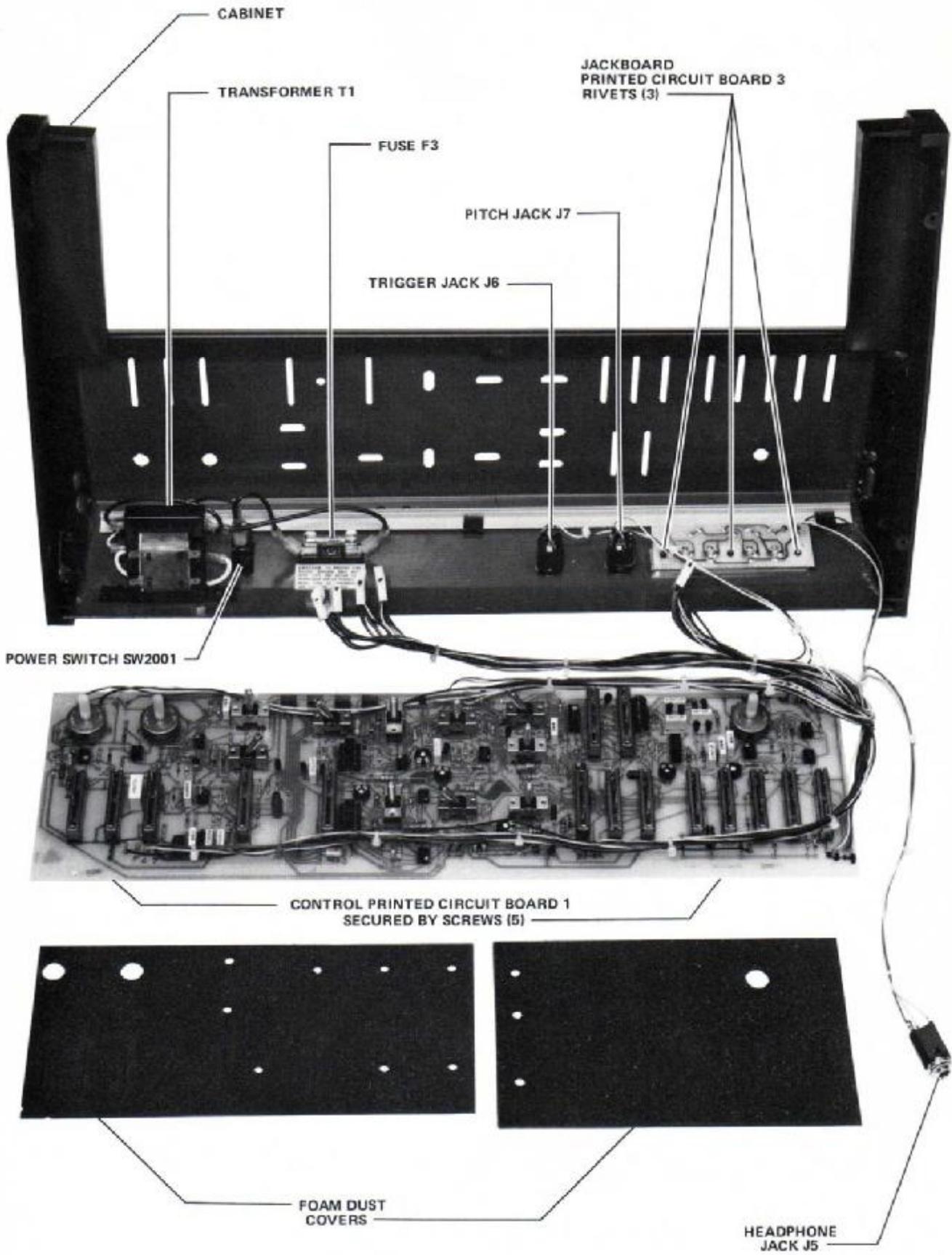
Remove mounting screws from the switch assembly on the bottom of the keyboard. Remove the rear mounting brackets and the switch assembly.

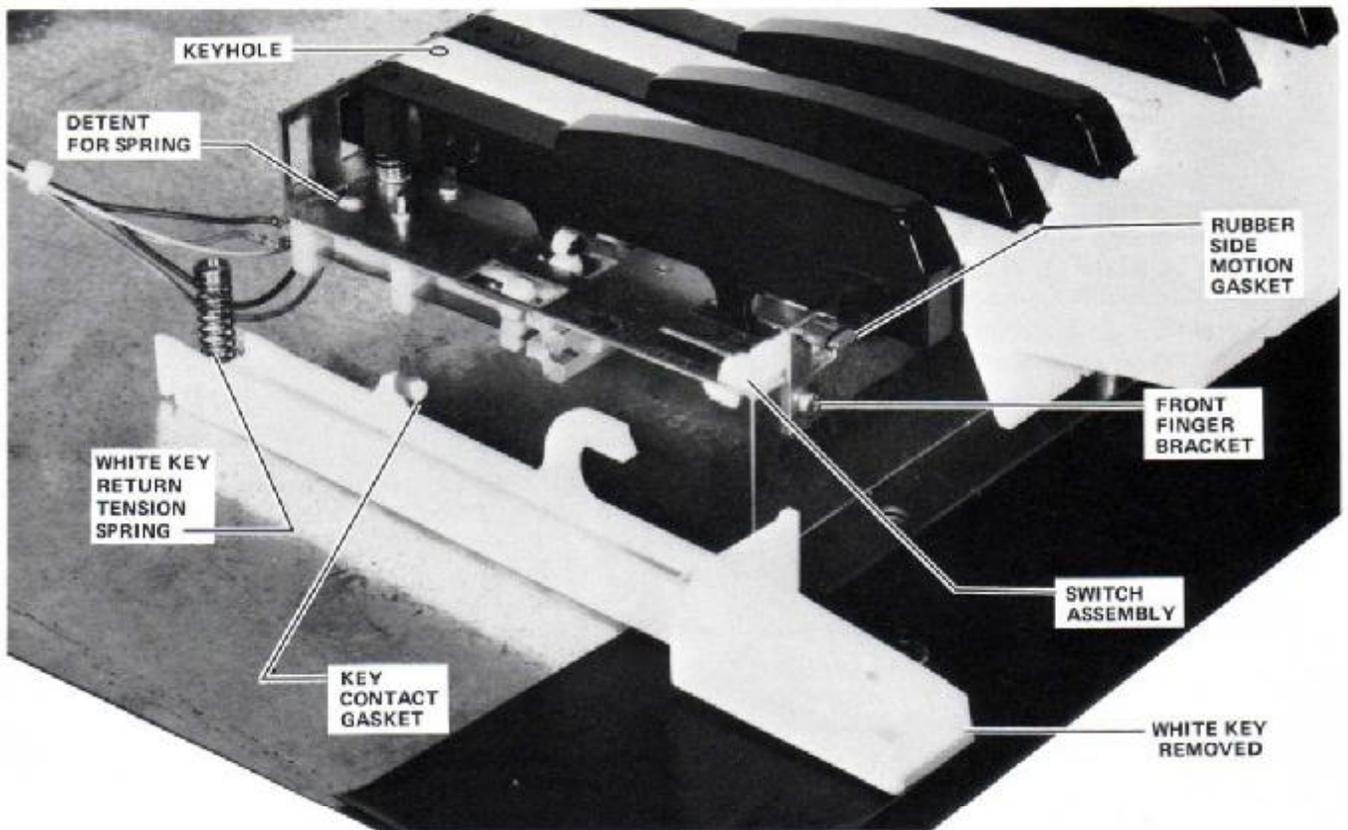
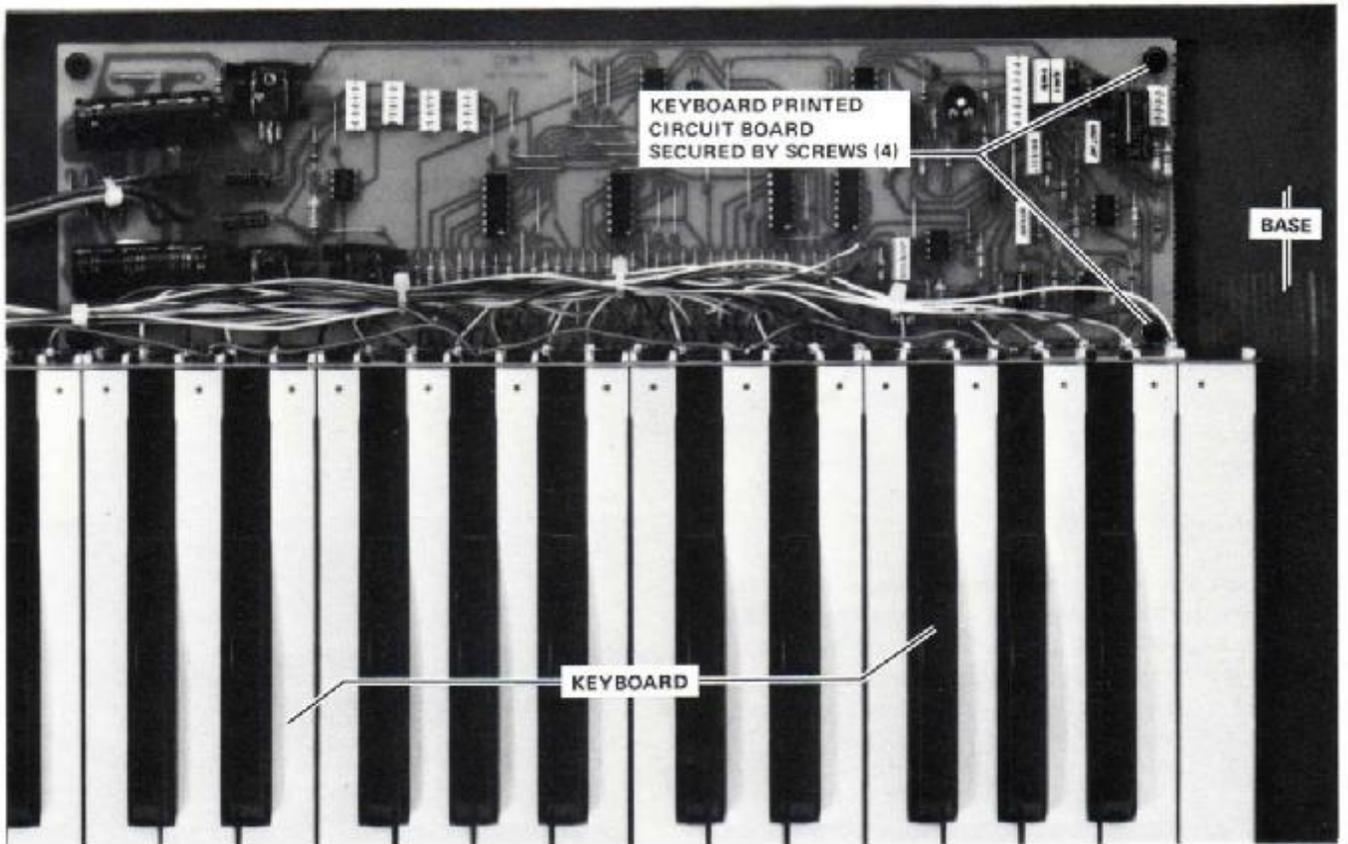
Removing Side Motion and Key Contact Gaskets

Remove screws from front finger bracket on the keyboard and separate bracket from its mount.

Side motion gaskets on the finger bracket are rubber. Remove by pulling out from finger bracket.

With key removed, the key contact gasket is removed by pulling it away from key.





ADJUSTMENTS (Refer to the Accompanying Photographs (3) and Location Diagram)

RECOMMENDED TEST EQUIPMENT

To perform the adjustments, repair or troubleshooting of the MG-1 Synthesizer, the following test equipment is recommended:

Function Generator or Oscillator
 Dual Trace 5MHz Oscilloscope
 AC Voltmeter (True R.M.S. with dB Scale)
 Digital Voltmeter of 4-1/2 Digits
 Strobe Tuner
 Monitor Amplifier

GENERAL INFORMATION

Adjustment or tuning is rarely required once set at the factory but is necessary if any power supply regulator is changed. A power supply regulator change will involve complete instrument recalibration, whereas replacement of any other active device or IC will require adjustment of only the specific circuit which has an associated trim potentiometer.

Tone Sources should be tuned only after the instrument is fully assembled and turned on for at least 15 minutes.

Any portion of this procedure which is shaded may be used as a "touch-up" tuning procedure which does not require disassembly.

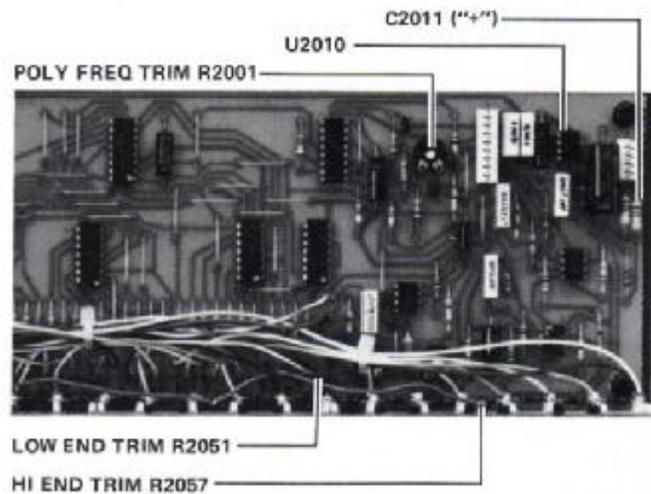
The term "zero beat" used throughout the alignment procedure refers to the acoustic properties of two closely related sound sources which slightly vary in frequency. The closer these sound sources are, the slower the beat frequency will be. When the two sources are identical, the beating will cease and the two sources will sound as one — yielding the "zero beat" frequency. As a practical matter, this "zero beat" frequency usually is reached when the two sound sources beat at a rate of approximately one Hertz.

Multiple electronic sound sources which are exactly set to "zero beat" would produce a "sterile" singular tone, whereas two or more sound sources beating slowly create a "fat" rolling sound. A similar principle applies to acoustic instruments such as the multiple strings in a piano.

The "zero beat" of the Tone Sources can be set by ear, observation of each Tone Source on a dual trace oscilloscope, or by observing the combined output on a single trace oscilloscope. The most common method is to listen, and at the same time, observe the combined audio output. Then both the oscilloscope trace and listening process discern one Tone Source as the reference frequency and the movement or beating from the second Tone Source.

KEYBOARD CURRENT SOURCE ADJUSTMENT

1. Set KEYBOARD GLIDE slider R1063 at minimum.
2. Monitor voltage at pin 1 of U1007A with DVM.
3. Depress and hold the high C key and adjust Hi End Trim R2057 for +2.580 VDC.
4. Depress and hold the low F key and adjust Low End Trim R2051 for 0.000 VDC.
5. Repeat steps 3 and 4 until no further adjustment is necessary.



KEYBOARD PRINTED CIRCUIT BOARD 2 TRIM ADJUSTMENTS AND LOCATION DIAGRAM

POLYPHONIC TUNE ADJUSTMENT

1. Set the following controls:

TONE SOURCE TUNING R1068	Electrical 0
POLYPHONY TUNING R1076	Electrical Center
MODULATION TONE SOURCE R1071	Minimum
MODULATION FILTER R1105	Minimum
KEYBOARD GLIDE R1063	Minimum
AUTO CONTOUR TRIGGER SW1007	OUT
CONTOUR TONE SOURCES SW1009	KEYED
FILTER CUTOFF FREQ R1108	Maximum
EMPH FILTER PEAK R1100	Minimum
FILTER CONTOURED CUTOFF R1117	Minimum
MIXER TONE ONE R1051	Minimum
MIXER TONE TWO R1060	Minimum
MIXER NOISE R1058	Minimum
MIXER BELL TONE R1058	Minimum
MIXER POLYPHONY R1054	Maximum
MASTER VOLUME R1103	Maximum
TONE SOURCE 1 OCTAVE SW1001	-2

2. Monitor audio output at "+" of C2011 with Strobe Tuner.
3. Adjust Poly Freq Trim R2001 for 440Hz with High A depressed.

TONE SOURCE 1 SCALE, FREQUENCY AND HI FREQUENCY ADJUSTMENT

NOTE

Allow unit to warm up for 15 minutes before making these adjustments.

One method of scaling the Tone Sources is to use the Polyphonic section as a tuning reference.

1. Set controls the same as for Polyphonic Tune Adjustment, step 1.

2. Center the following trimpots:

Tone Source 1 Freq Trim R1001
Tone Source 1 Scale Trim R1008
Tone Source 1 High Freq Trim R1009

3. Monitor audio output at "+" of C2011 with Strobe Tuner.

4. Depress and hold High A. Set POLYPHONY TUNING control R1076 for 440Hz output frequency.

5. Set MIXER TONE ONE control R1051 to maximum.
6. Depress and hold Low A. Zero beat Tone Source 1's waveform against the polyphony waveform such that the Tone Source 1 frequency is 55Hz (one octave lower than the polyphony) using Tone Source 1 Freq Trim R1001.

7. Depress and hold High A. Zero beat Tone Source 1's waveform against the polyphony waveform such that the Tone Source 1 frequency is 220Hz using Scale 1 Trim R1008.

8. Repeat steps 6 and 7 until a perfect two octave spread is obtained.

9. Change TONE SOURCE 1 OCTAVE switch SW1001 to 0. Depress and hold Low A and zero beat such that the Tone Source 1 frequency is 220Hz using Tone Source 1 Freq Trim R1001.

10. Depress and hold High A and zero beat such that Tone Source 1's frequency is 880Hz using Hi Freq Trim 1 R1009.

11. Repeat steps 9 and 10 until a perfect two octave spread is obtained.

12. Repeat steps 4 through 11 until tuning is satisfactory on all ranges.

TONE SOURCE 1 SQUARE WAVE ADJUSTMENT

1. Set controls the same as for Polyphonic Tune Adjustment, step 1, with the following exceptions:

MIXER POLYPHONY R1054	Minimum
MIXER TONE SOURCE 1 R1051	Maximum
TONE SOURCE 1 WAVESHAVE SW1002	

2. Monitor audio output at "+" of C2011 with Strobe Tuner.

3. Depress any note and adjust Tone Source 1 Square Trim R1016 until the waveform has a 50% duty cycle.

TONE SOURCE 2 SCALE FREQUENCY AND HI END ADJUSTMENTS

NOTE

Allow unit to warm up 15 minutes before making these adjustments.

1. Set controls the same as for Polyphonic Tune Adjustment, step 1, with the following exceptions:

TONE SOURCE ONE SYNC -1 SW1003	OUT
TONE SOURCE TWO OCTAVE SW1004	-1
TONE SOURCE TWO DETUNE R1025	Electrical 0

2. Center the following trimpots:

Tone Source 2 Freq Trim R1026
Tone Source 2 Scale Trim R1037
Tone Source 2 Hi Freq Trim R1038

3. Monitor audio output at "+" of C2011 with Strobe Tuner.

4. Depress and hold High A. Set POLYPHONY TUNING control R1076 for 440Hz output frequency.

5. Set MIXER TONE Two control R1060 to maximum.
6. Depress and hold Low A. Zero beat Tone Source 2's waveform against the polyphony waveform such that the Tone Source 2 frequency is 110Hz using Tone Source 2 Freq Trim R1026.

7. Depress and hold High A. Zero beat Tone Source 2's waveform against the polyphony waveform such that the Tone Source 2 frequency is 440Hz using Tone Source 2 Scale Trim R1037.

8. Repeat steps 6 and 7 until a perfect two octave spread is obtained.

9. Change TONE SOURCE 2 OCTAVE switch SW1004 to +1. Depress and hold Low A and zero beat such that the Tone Source 2 frequency is 440Hz using Tone Source 2 Freq Trim R1026.

10. Depress and hold High A and zero beat such that Tone Source 2's frequency is 1760Hz using Hi Freq Trim 2 R1038.

11. Repeat steps 9 and 10 until a perfect two octaves is obtained.

12. Repeat steps 4 through 11 until tuning is satisfactory on all ranges.

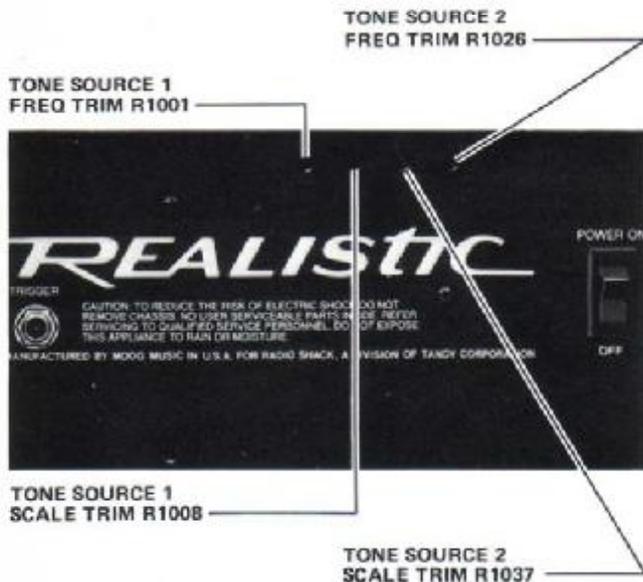
FILTER SCALE, EMPHASIS AND CUTOFF FREQUENCY ADJUSTMENTS

NOTE

Filter drift is normal since the VCF is uncompensated for temperature.

1. Set the following controls:

MODULATION FILTER R1105	Minimum
KEYBOARD GLIDE R1063	Minimum
All MIXER controls R1051, R1054, R1056, R1058, R1060	Minimum
FILTER CUTOFF FREQ R1108	Electrical 0
FILTER PEAK EMPH R1100	Maximum
FILTER CONTOURED CUTOFF R1117	Minimum
FILTER KEYBOARD TRACKING SW1006	OUT



REAR PANEL ACCESS TONE SOURCE SCALE AND FREQUENCY TRIM ADJUSTMENTS

CONTOUR TONE SOURCES SW1009	CONTINUOUS
MASTER VOLUME R1003	Maximum

2. Center the following trimpots:

Filter Cutoff Trim R1110
Filter Scale Trim R1113
Emphasis Trim R1093

3. Verify that the filter is oscillating at "+" of C2011. If not, adjust the Emphasis Trim R1093 until oscillation occurs.

4. Adjust Filter Cutoff Trim R1110 until frequency of oscillation is 660Hz +/-50Hz measured at pin 5 of U2010.

5. Adjust Emphasis Trim R1093 until oscillation at pin 6 of U1012 is -23dBm +/-3dBm. (55mv RMS, 155mv peak-to-peak).

6. Change FILTER KEYBOARD TRACKING switch SW1006 to FULL.

7. Depress and hold Low A. Adjust Filter Cutoff Trim R1110 until frequency of oscillation is 440Hz +/-100Hz measured at "+" of C2011.

8. Depress and hold Low A. Using Filter Scale Trim R1113 zero beat filter against external oscillator, set to 3520Hz, such that the filter frequency is 440Hz.

9. Depress and hold High A. Using Filter Cutoff Trim R1110 zero beat filter frequency for 1760Hz. (It may be easier to first depress Middle A and adjust frequency for 880Hz. Then try the High A, 1760Hz adjustment.)

10. Repeat steps 8 and 9 until a satisfactory two octave spread is obtained.

11. Check FILTER CUTOFF FREQ control R1108 for electrical zero and set FILTER KEYBOARD TRACKING switch SW1006 to OUT.

12. Depress any key and set frequency to 660Hz +/-10Hz by using the Filter Cutoff Trim R1110.

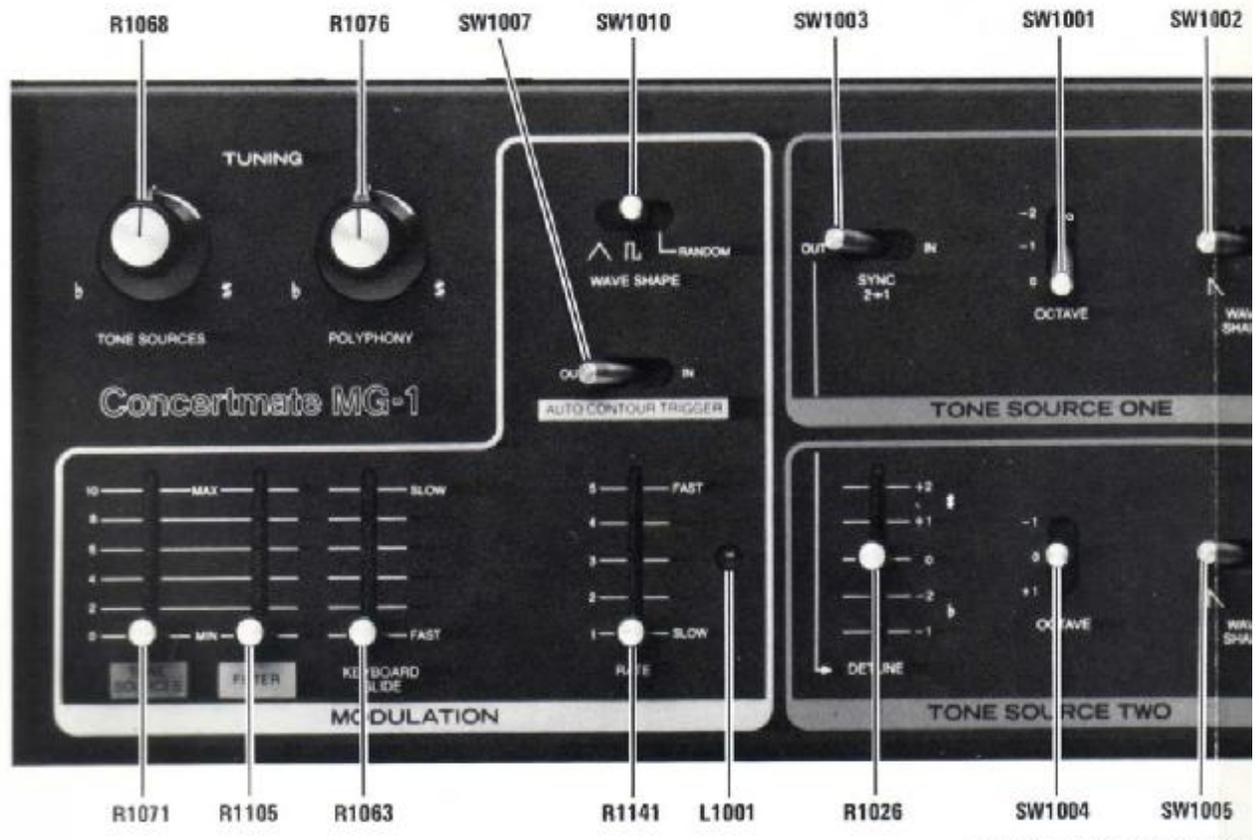
VCA BALANCE ADJUSTMENT

1. Set the following controls:

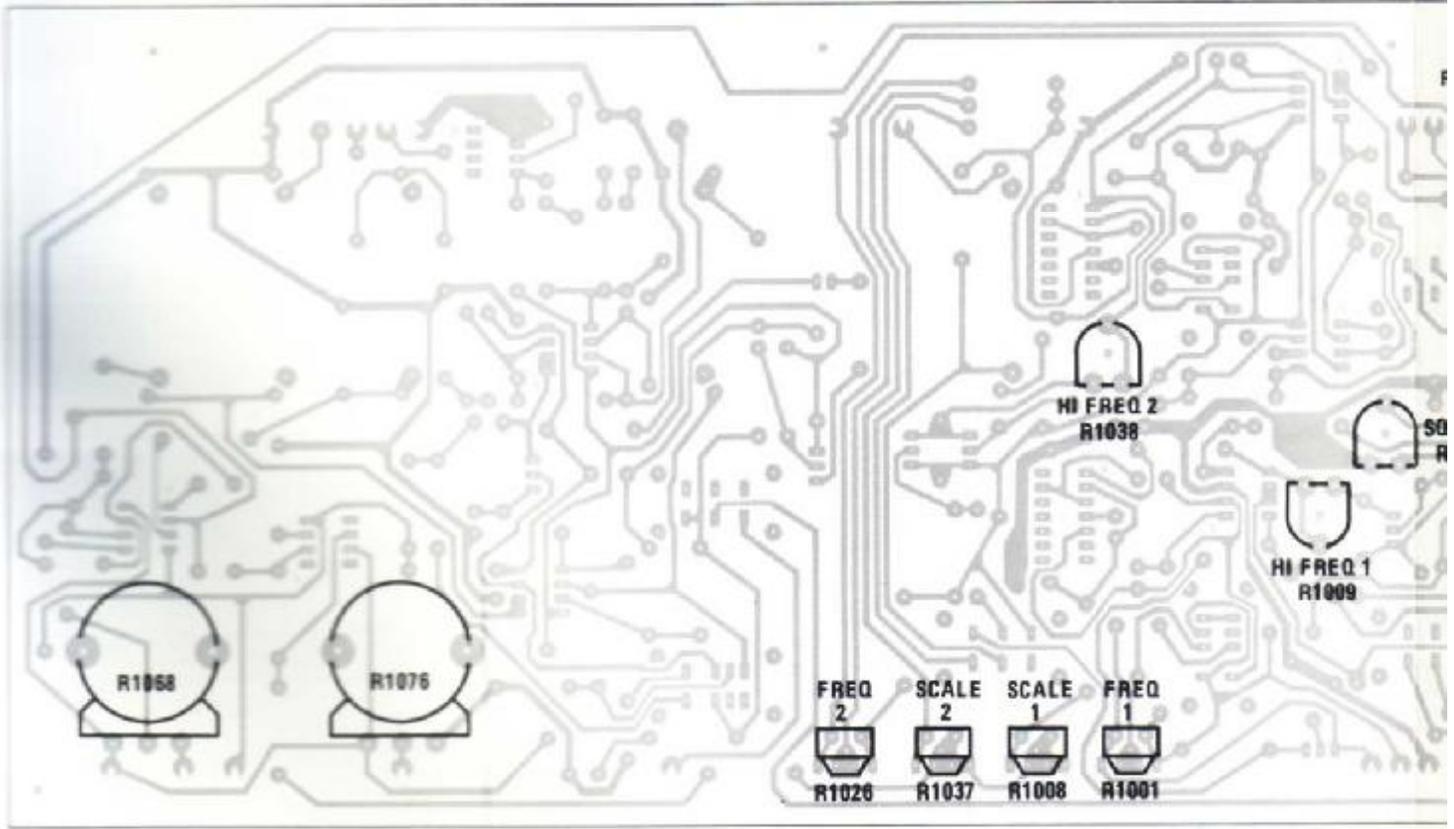
MODULATION FILTER R1105	Minimum
MODULATION RATE R1141	Maximum
MODULATION AUTO CONTOUR TRIGGER SW1007	IN
CONTOUR TONE SOURCES SW1009	KEYED
FILTER CUTOFF FREQ R1108	Maximum
FILTER PEAK EMPH R1100	Minimum
MASTER VOLUME R1103	Maximum
All MIXER Controls R1051, R1054, R1056, R1058, R1060	Minimum

2. Monitor pin 6 of U1011 with AC Voltmeter.

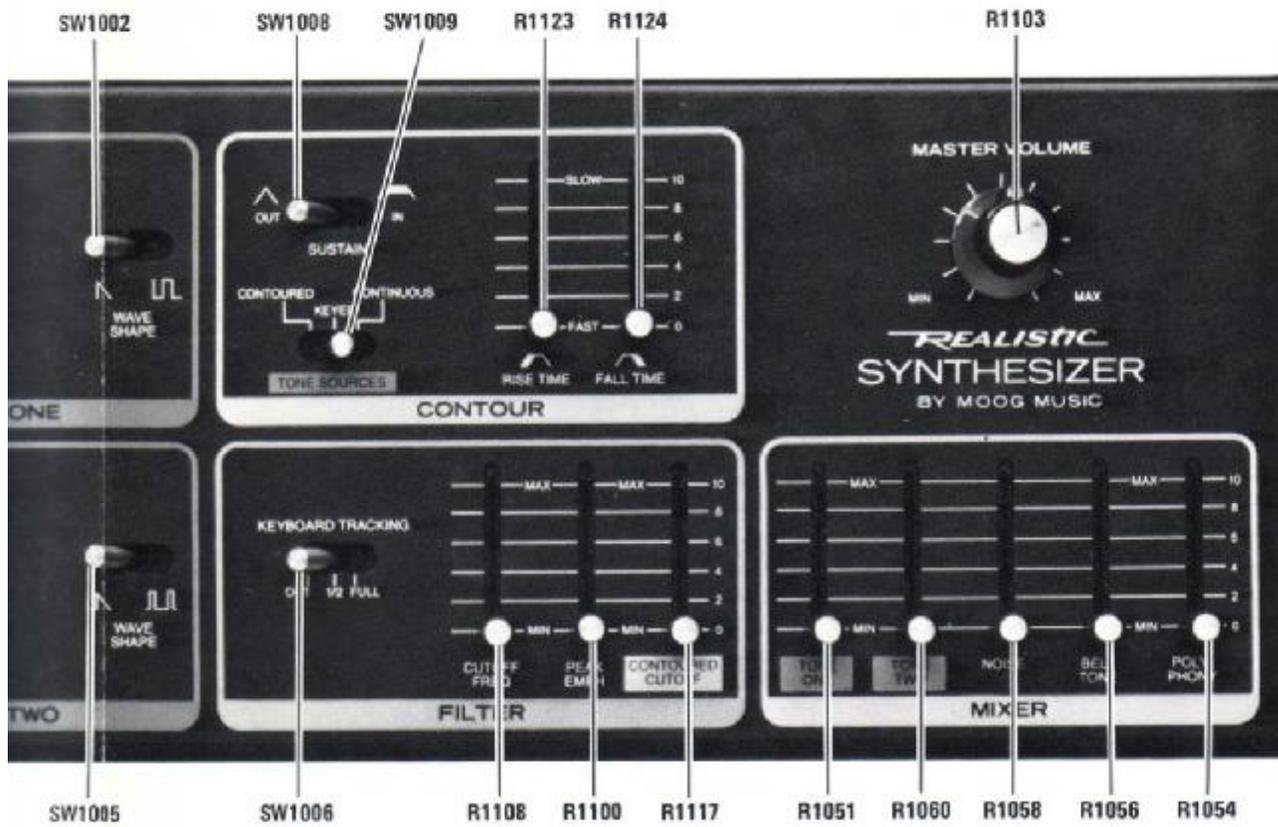
3. Adjust VCA Balance Trim R1094 for minimum output level.



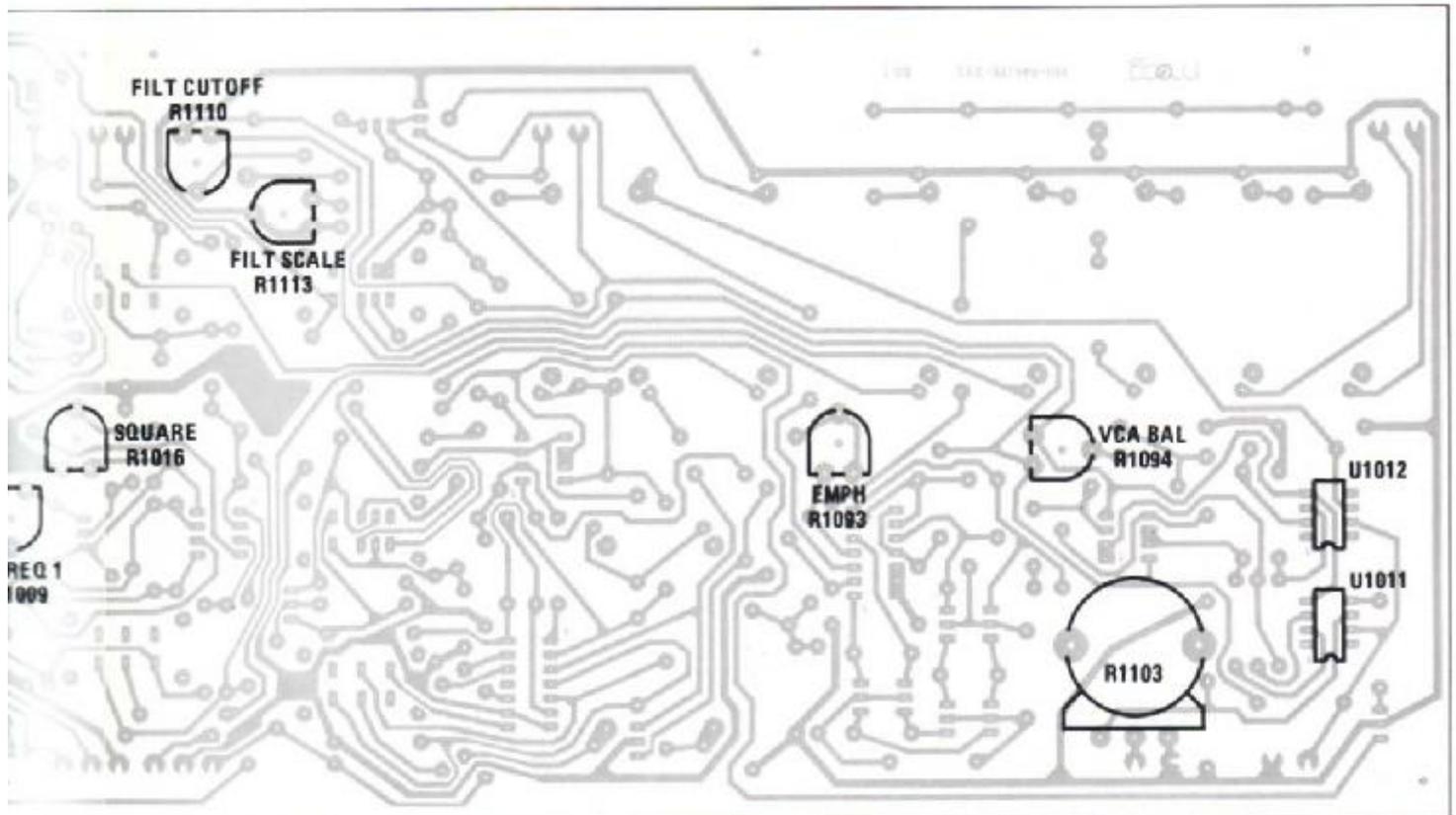
FRONT PANEL ADJUSTM



CONTROL PRINTED CIRCUIT BOARD

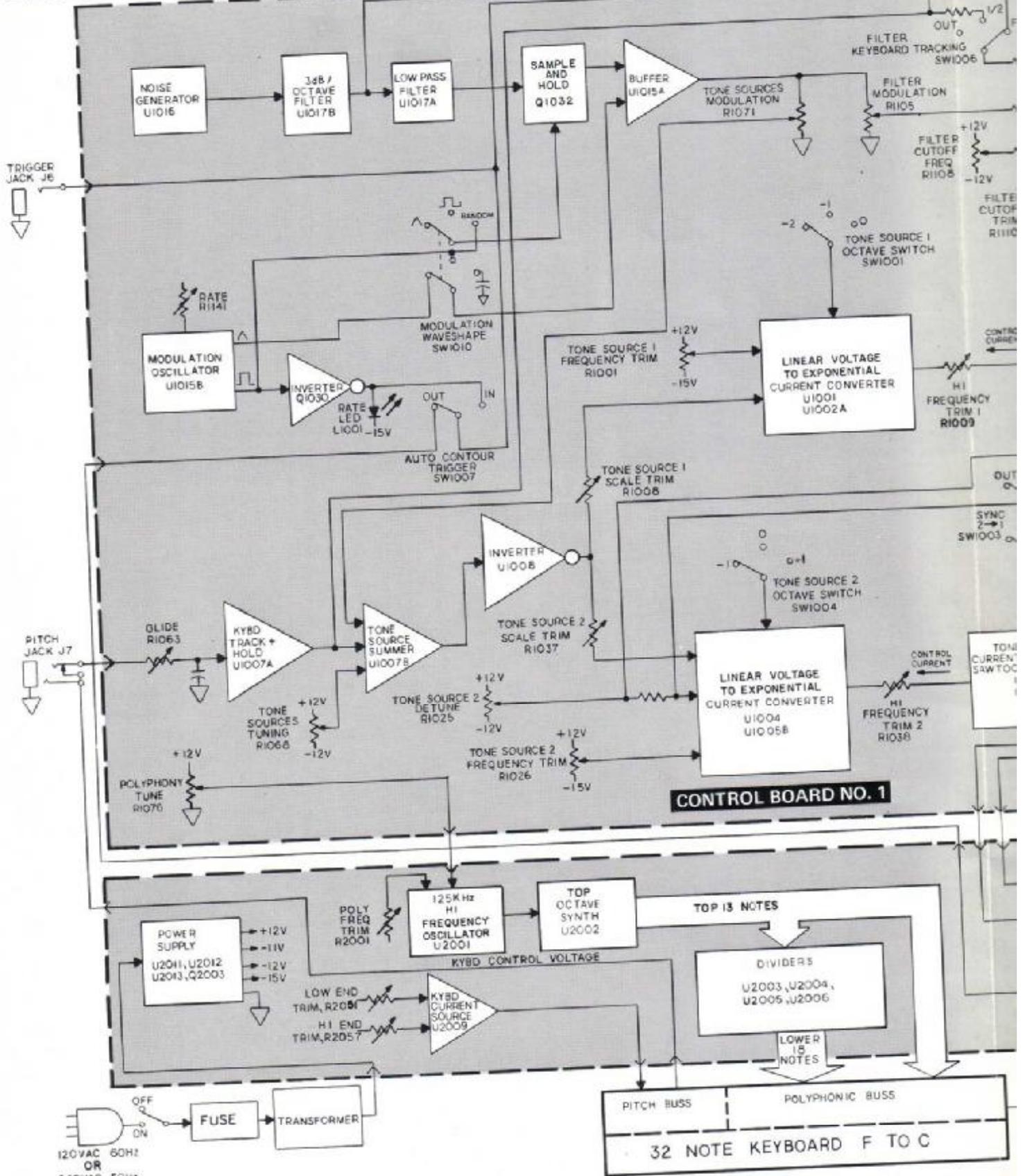


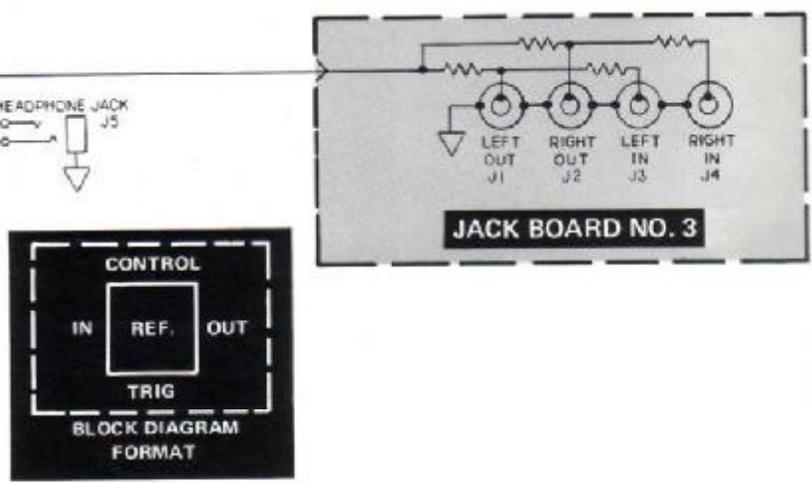
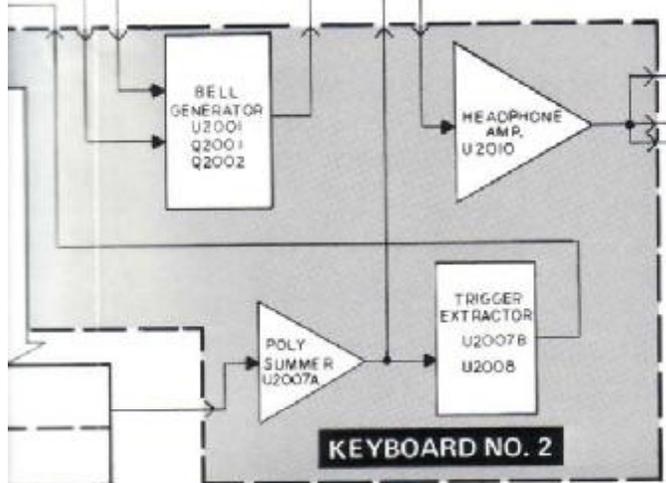
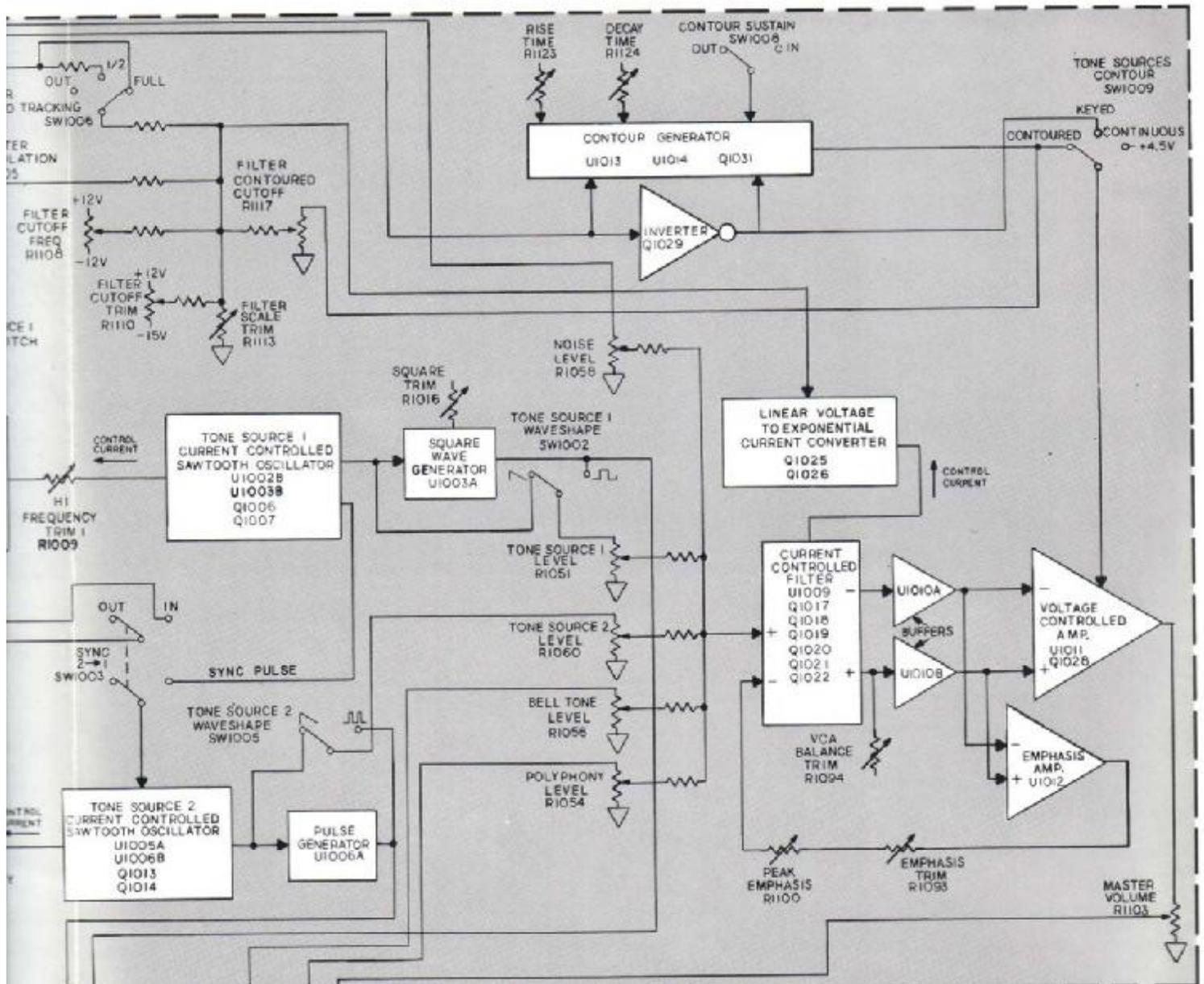
CONTROL ADJUSTMENT CONTROLS



PCB BOARD 1 TRIM SCALE ADJUSTMENTS

BLOCK DIAGRAM





4. REPAIR AND TROUBLESHOOTING

CONNECTOR REPAIR AND REPLACEMENT

There are two basic types of connectors in the MG-1 Synthesizer. The first type is the single pin, wire wrap, crimp socket which connects the keyboard notes to the keyboard circuit board. It can be replaced by cutting off the old terminal and soldering a new one in its place.

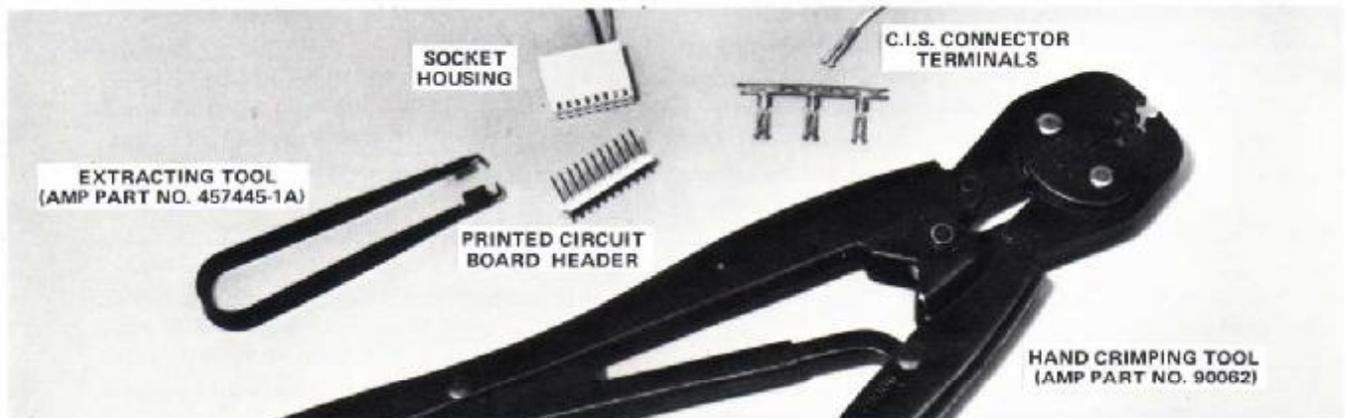
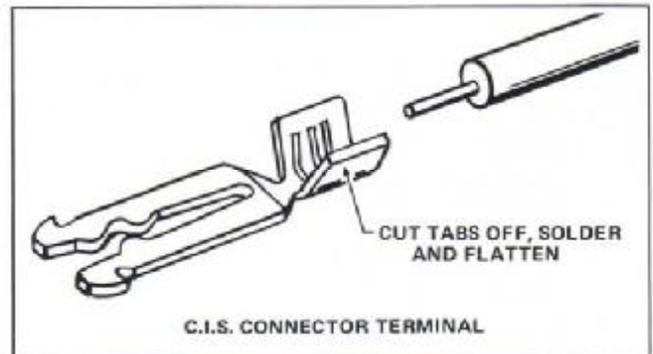
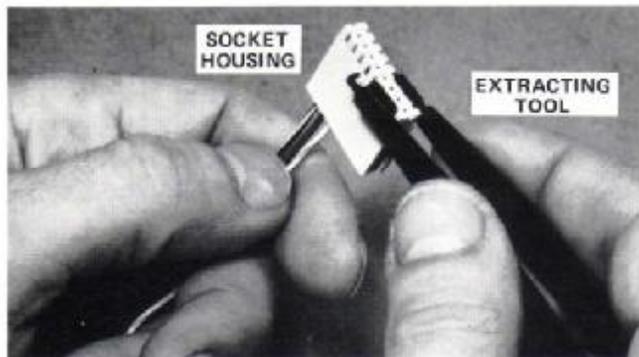
The second type of connector is the C.I.S. crimp socket made by AMP which has 0.1 inch (2.5mm) mounting centers. This is a reliable connection system which can easily be replaced if necessary. The portion of the connector attached to the printed circuit board (header) is replaced by simply soldering a new one in place. Headers of 5, 6 or more pins can easily be cut using wire cutters to replace 1, 2, 3 or 4 pin versions. Simply score the header where the desired cut is to be made and cut the header appropriately. Refer to the accompanying illustrations.

Headers which are causing poor or intermittent solder connections on a printed circuit board should be resoldered to ensure the best possible electrical and mechanical connection. If connector plating problems are suspected, use an extra activated multicore solder such as 0.064 diameter ERSIN No. 782/745 solder and a 40 watt soldering iron.

NOTE

Be sure to avoid long exposure of the iron to the printed circuit board traces and to clean the activated flux residue from the printed circuit board after soldering is complete. Recommended flux cleaner is Miller-Stephenson MS-190HD, "Heavy Duty Flux Remover" or a methyl ethyl ketone product.

Replacement of the female C.I.S. connector terminal is sometimes necessitated if a wire breaks at the crimp within the socket. The spring loaded terminal may be removed using an AMP Extracting Tool, AMP Part No. 457445-1A or by inserting two pointed instruments into each side of the socket allowing a particular terminal to be pulled out or pushed out using an existing header pin or 1/4 watt resistor lead. The new terminal may be attached to the wire by using an AMP Hand Crimping Tool, AMP Part No. 90062, or by cutting the tabs off the new terminal and tack soldering it to the appropriate wire which has been stripped back 5/32 inch (3.9mm). The soldering must be neat and flattened with needle-nose pliers to ensure an easy fit into the connector housing.



KEYBOARD AND CASE MAINTENANCE

To clean the molded plastic end caps, the vinyl coated aluminum chassis and front panel overlays, a damp cloth with a mild detergent is sufficient.

The keyboard may also be cleaned by using a damp cloth and mild detergent. However, if there is light dirt or scratch marks on keys, hand rubbing with a fine polishing compound works best. For deeper scratch marks or ground-in dirt, a variable high speed drill with cloth buffing wheel is recommended. The buffing wheel should

be used carefully with a small amount of fine polishing compound. Be sure to use light pressure as heavy pressure or long exposure to one area will cause the plastic keys to melt or warp due to friction.

The keyboard contacts may be cleaned by using a cotton swab moistened in a 99% solution of isopropyl alcohol. The gold plated contacts do not oxidize but may have a residue build-up from use in atmospheres containing cigarette smoke. See Section 3 for information on disassembly procedures.

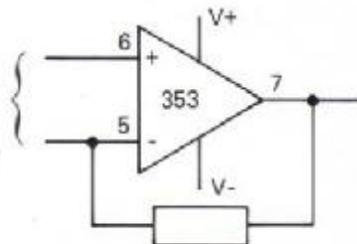
TROUBLESHOOTING

GENERAL

Many synthesizer repairs involve the replacement of integrated circuits. However, before replacing a suspect device, always double check the inputs and power supply terminals before proceeding.

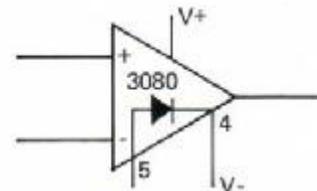
LINEAR IC

DC Inputs Offset measured between the + and - inputs should be no greater than 10mV apart or device is bad.



IC used in a linear mode with negative feedback. Example: U1007B

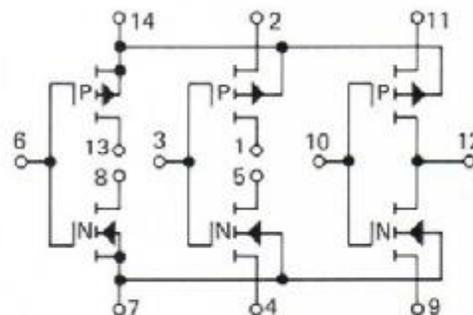
OTA



Pin 5 should be 0.7V more positive than pin 4 when turned on. Troubleshoot like a forward biased diode.

CMOS IC

Usually fails by latching up the output(s) and gets hot.



CD4007A
Functional Diagram
Terminal No. 14 - V_{DD}
Terminal No. 7 - V_{SS}

Once it is determined that an IC must be replaced, install the new one in a high quality IC socket. This will protect the printed circuit board in case further troubleshooting is necessary. Sometimes an IC known to be good can be used from another circuit to further confirm a suspected problem.

NOTE

If the old IC is found to be good, put the old one back in. The old IC has more time in use and is therefore more reliable than a new IC of unknown performance.

Many faulty or shorted ICs will operate "hot" and can be detected with the "wet finger test." Top Octave Synthesizer (T.O.S.) ICs normally operate warm to the touch.

Use the chart provided (pages 23 through 26) along with the circuit description and block diagram to participate a problem. Then using the schematics and parts location diagrams, the final diagnosis and repair can be effected.

SYMPTOM	CAUSE/REMEDY
<p>1) No audio output, LED not flashing or blows fuse(s).</p>	<p>1) Faulty rectifier diodes CR2002 through CR2005. 2) Faulty regulator U2011, U2012, U2013 or Q2003. 3) Faulty IC on Keyboard Printed Circuit Board 2 or Control Printed Circuit Board 1 has shorted the +12V and -15V supplies together. Disconnect Power Supply connectors S3 through S6 to isolate problem.</p>
<p>2) No audio output with: FILTER CUTOFF FREQ R1108 – maximum. FILTER CONTOURED CUTOFF R1117 – minimum. FILTER PEAK EMPH R1100 – minimum. CONTOUR TONE SOURCES SW1009 – CONTINUOUS MASTER VOLUME R1103 – maximum. Any MIXER slide – maximum <u>except</u> POLYPHONY or NOISE.</p>	<p>1) Defective VCF circuit. Check for VCF input ($\approx 40\text{mV}$ peak-to-peak) at pin 2 of U1009 and VCF output ($\approx 20\text{mV}$ peak-to-peak) at pins 7 and 10 of U1009. If no output is present, short Q1026 collector to emitter and re-check output at pins 7 and 10 of U1009. If output is present with Q1026 shorted, problem is defective transistor Q1025, Q1026 or associated resistors. If no output is present with Q1026 shorted, problem is defective U1009 or Q1017 through Q1022 or C1015 through C1018 or associated resistors. 2) Defective VCA circuit U1011, Q1028. Input of U1011 pins 2 and 3 $\approx 20\text{mV}$ peak-to-peak. Output of U1011 pin 6 $\approx 150\text{mV}$ peak-to-peak. 3) Defective CONTOUR TONE SOURCES switch SW1009. 4) Defective shielded wire that goes from Control Printed Circuit Board 1 pin 25 to P1 pin 1. 5) Defective MASTER VOLUME control R1103. 6) Defective component in Headphone Amplifier circuit U1010. 7) Defective component on Jack Board 3.</p>
<p>3) No audio output with: FILTER CUTOFF FREQ R1108 – maximum. FILTER CONTOURED CUTOFF R1117 – minimum. FILTER PEAK EMPH R1100 – minimum. CONTOUR TONE SOURCES SW1009 – KEYED. MASTER VOLUME R1103 – maximum Any MIXER slide – maximum <u>except</u> POLYPHONY or NOISE.</p>	<p>1) Same causes as for step 2) Symptom, "no audio output." 2) Defective inverter Q1029. 3) Defective AUTO CONTOUR TRIGGER switch SW1007. 4) Defective white wire that goes from Control Printed Circuit Board 1 pin 9 to P1 pin 7. 5) Defective Trigger Extractor circuit U1007B, U1008. 6) Defective Polyphony Summer U1007A. 7) Faulty wire in keyboard harness. 8) Defective Hi Frequency Oscillator U2001. 9) Defective Top Octave Synthesizer IC U2002.</p>
<p>4) No audio output with: FILTER CUTOFF FREQ R1108 – maximum. FILTER CONTOURED CUTOFF R1117 – minimum. FILTER PEAK EMPH R1100 – minimum. CONTOUR TONE SOURCES SW1009 – CONTOURED MASTER VOLUME R1103 – maximum. Any MIXER slide – maximum <u>except</u> POLYPHONY or NOISE.</p>	<p>1) Same causes as for steps 2) and 3) Symptom, "no audio output." 2) Defective Contour Generator components U1013, U1014 or Q1031. 3) Faulty Contour Generator slide pots R1123 (RISE TIME) or R1124 (FALL TIME).</p>

SYMPTOM	CAUSE/REMEDY
5) Loud, noisy hissing sound when key is depressed.	1) Defective IC in the VCF circuit U1009.
6) Output is very low or intermittent.	1) Defective VCA circuit U1011, Q1028.
7) Output jumps to full volume or crackles.	1) Faulty MASTER VOLUME control R1103. Clean or replace.
8) Excessive audio output in Left or Right output jacks.	1) Defective Headphone Amplifier U2010 or associated components.
9) Intermittent or continuous buzz.	1) Faulty connection of Power Supply electrolytic capacitors C2013, C2014, C2017 or C2018. 2) Open rectifier diodes CR2002 through CR2005. 3) Faulty Regulator U2011, U2012, U2013 or Q2003.
10) Synthesizer will not produce an audio output unless several keys are depressed simultaneously.	1) Defective Trigger Extractor circuit U1007B or U1008.
11) One of the polyphony notes will not play. (Example: G3.)	1) Defective Polyphonic Generator IC U2003, U2004, U2005 or U2006. (Example: U2004 pin 9.) 2) Faulty wire from Keyboard Printed Circuit Board 2 to keyboard of that note. 3) Faulty wiper of the keyboard switch of that note.
12) Pitch of both Tone Sources changes after key is released.	1) Defective Keyboard Track and Hold circuit U1007A, C1013. 2) Defective Keyboard Current Source U2009.
13) Tone Sources play only one note no matter what key is played.	1) Defective Keyboard Track and Hold circuit U1007A. 2) Defective Keyboard Current Source U2009. 3) Faulty PITCH jack J7. 4) Faulty KEYBOARD GLIDE control R1063.
14) One note plays continuously and returns to this note after other keys are released.	1) The Wiper of the keyboard switch of that note is continuously touching the buss bar.
15) Both Tone Sources do not stay in tune.	1) Defective Power Supply Regulators U2011, U2012 or U2013. 2) Faulty Keyboard Current Source U2009. 3) Defective Keyboard Track and Hold circuit U1007A. 4) Defective Tone Source summer U1007B.
16) One Tone Source out of tune with other Tone Source or Polyphony.	1) Faulty Scale Trim or out of adjustment. Tone Source One – R1008. Tone Source Two – R1037.
17) One of the Tone Sources drifts and will not stay in tune.	1) Faulty current source. Tone Source One – U1001. Tone Source Two – U1004.

SYMPTOM	CAUSE/REMEDY
17) One of the Tone Sources drifts and will not stay in tune (continued).	2) Faulty capacitor. Tone Source One – C1001, C1002, C1003 or C1004. Tone Source Two – C1007, C1008, C1009 or C1010. 3) Faulty Temperature Compensating resistor. Tone Source One – R1007. Tone Source Two – R1033.
18) One of the Tone Sources jitters or jumps in pitch.	1) Same causes as for step 17) Symptom, "one of the Tone Sources drifts and will not stay in tune." 2) Faulty transistor. Tone Source One – Q1006. Tone Source Two – Q1013 or Q1014. 3) Dirty OCTAVE switch. Tone Source One – SW1001. Tone Source Two – SW1004.
19) No Tone Source One.	1) Faulty WAVESHAPE switch SW1009. NOTE: The switch is open when the lever is placed between the waveform positions. 2) Faulty MIXER TONE ONE control R1051. 3) Faulty Tone Source One circuitry. Remove U1001 from its socket and connect a 1 Meg, 1/4 W, +/- 5% resistor between pins 1 and 13 of the socket. Tone Source One should oscillate at $\approx 155\text{Hz}$. If Tone Source One now works, problem is defective component in Voltage to Current Converter U1001, U1002A, R1007 or C1001. If Tone Source One is still dead, problem is defective component in the Current Controlled Oscillator circuit U1002B, U1003B, Q1006 or Q1007.
20) No Tone Source Two.	1) Faulty WAVESHAPE switch SW1005. NOTE: The switch is open when the lever is placed between the waveform positions. 2) Faulty MIXER TONE TWO control R1060. 3) Faulty Tone Source Two circuitry. Remove U1004 from its socket and connect a 1 Meg, 1/4 W, +/-5% resistor between pins 1 and 13 of the socket. Tone Source Two should oscillate at $\approx 330\text{Hz}$. If Tone Source Two now works, problem is defective component in Voltage to Current Converter U1004, U1005B, R1033 or C1007. If Tone Source Two is still dead, problem is defective component in the Current Controlled Oscillator circuit U1005A, U1006B, Q1013 or Q1014.
21) When the SYNC 2 – 1 SW1003 is in the IN position and the TONE SOURCE TWO DETUNE control R1025 is decreased, the pulse waveform disappears.	1) Operator trap. See Circuit Description of TONE SOURCE TWO.
22) No audio noise.	1) Defective Noise Generator IC U1016 or 3dB/octave filter circuit U1017B. 2) Faulty MIXER NOISE control R1058.

SYMPTOM	CAUSE/REMEDY
22) No audio noise (continued).	3) Faulty wire that connects the output of U1017B to the MIXER NOISE control R1058 on Control Printed Circuit Board 1.
23) No bell tone.	1) Defective Bell Tone Generator circuit U2001, Q2001 or Q2002.
24) No polyphony.	1) Faulty MIXER POLYPHONY control R1054. 2) Faulty wire from pin 24 of Control Printed Circuit Board 1 to P1 pin 8 on Keyboard Printed Circuit Board 2.
25) MODULATION RATE LED L1001 does not flash.	1) Defective LED L1001 or defective transistor Q1030.
26) TONE SOURCES and FILTER MODULATION controls have no effect.	1) Defective U1015 or Q1032. 2) Faulty MODULATION RATE control R1141. 3) Faulty TONE SOURCE 1 WAVESHAPE switch SW1010.
27) WAVESHAPE MODULATION – random inoperative.	1) Defective FET Q1032 or IC U1017A. 2) Faulty TONE SOURCE 1 WAVESHAPE switch SW1010. 3) Defective capacitor C1028. 4) Defective diode CR1003 or capacitor C1027.
28) FILTER PEAK EMPH control inoperative.	1) Faulty FILTER PEAK EMPH control R1100. 2) Emphasis Trim R1093 set too low; readjust. 3) Defective IC U1012.

5. PARTS LIST

CAPACITORS					
Ref. No.	Value (F)	Volt. (V)	Tol. (%)	Material	Manufacturer's Part No.
C1001	100p	50	+/-10	Ceramic Tubular	947-045008-101
C1002	0.01 μ	50	+/-10	Polyester	946-041978-103
C1003	0.01 μ	50	+80/-20	Ceramic Tubular	947-045011-103
C1004	0.01 μ	50	+80/-20	Ceramic Tubular	947-045011-103
C1005	100p	50	+/-10	Ceramic Tubular	947-045008-101
C1006	0.01 μ	50	+80/-20	Ceramic Tubular	947-045011-103
C1007	100p	50	+/-10	Ceramic Tubular	947-045008-101
C1008	.0047 μ	50	+/-10	Polyester	946-041978-472
C1009	0.01 μ	50	+80/-20	Ceramic Tubular	947-045011-103
C1010	100p	50	+/-10	Ceramic Tubular	947-045008-101
C1011	0.01 μ	50	+80/-20	Ceramic Tubular	947-045011-103
C1012	0.01 μ	50	+80/-20	Ceramic Tubular	947-045011-103
C1013	1.0 μ	50	+/-10	Polyester	946-041978-105
C1014	10.0 μ	25	+/-10	Electrolytic	945-044465-003
C1015	0.027 μ	50	+/-10	Polyester	946-041978-273
C1016	0.027 μ	50	+/-10	Polyester	946-041978-273
C1017	0.027 μ	50	+/-10	Polyester	946-041978-273
C1018	0.027 μ	50	+/-10	Polyester	946-041978-273
C1019	0.1 μ	50	+/-10	Polyester	946-041978-104
C1020	0.1 μ	50	+/-10	Polyester	946-041978-104
C1021	220 μ	16	+50/-10	Electrolytic	945-040209-019
C1022	10 μ	25	+50/-10	Electrolytic	945-044465-003
C1023	6.8 μ	16	+/-20	Electrolytic	945-045049-001
C1024	0.01 μ	50	+80/-20	Ceramic Tubular	945-045011-103
C1025	6.8 μ	16	+/-20	Electrolytic	945-045049-001
C1026	0.1 μ	50	+/-10	Polyester	946-041978-104
C1027	0.01 μ	50	+80/-20	Ceramic Tubular	947-045011-103
C1028	0.1 μ	50	+/-10	Polyester	946-041978-104
C1029	0.1 μ	50	+/-10	Polyester	946-041978-104
C1030	10.0 μ	25	+50/-10	Electrolytic	945-044465-003
C1031	0.12 μ	50	+/-10	Polyester	946-041978-124
C1032	0.033 μ	50	+/-10	Polyester	946-041978-333
C1033	0.022 μ	50	+/-10	Polyester	946-041978-223
C2001	100p	50	+/-10	Ceramic Tubular	947-045008-101
C2002	10 μ	25	+50/-10	Electrolytic	945-044465-003
C2003	10 μ	25	+50/-10	Electrolytic	945-044465-003
C2004	10 μ	25	+50/-10	Electrolytic	945-044465-003
C2005	.0047 μ	50	+/-10	Polyester	946-041978-472
C2006	0.12 μ	50	+/-10	Polyester	946-041978-124
C2007	0.001 μ	50	+/-10	Polyester	946-041978-102
C2008	10 μ	25	+50/-10	Electrolytic	945-044465-003
C2009	0.1 μ	50	+/-10	Polyester	946-041978-104
C2010	0.1 μ	50	+/-10	Polyester	946-041978-104
C2011	220 μ	16	+50/-10	Electrolytic	945-040209-019

CAPACITORS (Continued)					
Ref No.	Value (F)	Volt. (V)	Tol. (%)	Material	Manufacturer's Part No.
C2012	0.047 μ	50	+/-10	Polyester	946-041978-473
C2013	10 μ	25	+50/-10	Electrolytic	945-044465-003
C2014	10 μ	25	+50/-10	Electrolytic	945-044465-003
C2015	0.01 μ	50	+80/-20	Ceramic Tubular	947-045011-103
C2016	0.01 μ	50	+80/-20	Ceramic Tubular	947-045011-103
C2017	1000 μ	35	+50/-10	Electrolytic	945-040209-011
C2018	1000 μ	35	+50/-10	Electrolytic	945-040209-011
DIODES – Silicon					
Ref. No.	Description	Device Manufacturer	Supplier's Part No.		
CR1001	1N4148/Signal	FAIRCHILD	919-041075-001		
CR1002	1N4148/Signal	FAIRCHILD	919-041075-001		
CR1003	1N4148/Signal	FAIRCHILD	919-041075-001		
CR2001	1N4148/Signal	FAIRCHILD	919-041075-001		
CR2002	1N4004, 1A, 400V	GEN. INSTR.	919-042019-001		
CR2003	1N4004, 1A, 400V	GEN. INSTR.	919-042019-001		
CR2004	1N4004, 1A, 400V	GEN. INSTR.	919-042019-001		
CR2005	1N4004, 1A, 400V	GEN. INSTR.	919-042019-001		
FUSES					
Ref. No.	Description	Device Manufacturer	Supplier's Part No.		
F1	Not Used				
F2	Not Used				
F3	T.5 x 20MM .315MA TIME LAG TYPE (European/Australian)	H.SCHURTER	939-044094-011		
F3	.25A, 250V, Slo Blo, 3AG (UL, CSA, Japan)	BUSSMAN	939-041620-002		
INTEGRATED CIRCUIT					
Ref. No.	Description	Device Manufacturer	Supplier's Part No.		
U1001	CA3046N	NATIONAL	991-041104-001		
U1002	LF353N	NATIONAL	991-042908-001		
U1003	LM393N	NATIONAL	991-042388-001		
U1004	CA3046N	NATIONAL	991-041104-001		
U1005	LF353N	NATIONAL	991-042908-001		
U1006	LM393N	NATIONAL	991-042388-001		
U1007	LF353N	NATIONAL	991-042908-001		
U1008	UA741TC	FAIRCHILD	991-041101-001		
U1009	CA3046N	NATIONAL	991-041104-001		
U1010	LF353N	NATIONAL	991-042908-001		
U1011	CA3080AE	RCA	991-041089-003		
U1012	UA741TC	FAIRCHILD	991-041101-001		
U1013	RC45580N	NATIONAL	991-041146-001		
U1014	MC14007UBCP	MOTOROLA	991-041086-001		

INTEGRATED CIRCUIT (Continued)					
Ref. No.	Description	Device Manufacturer	Supplier's Part No.		
U1015	LF353N	NATIONAL	991-042908-001		
U1016	MM5837N	NATIONAL	991-042016-001		
U1017	RC4558DN	NATIONAL	991-041146-001		
U2001	CD4046BE	RCA	991-041091-001		
U2002	M083	SGS	991-041105-002		
U2003	MM5823N	NATIONAL	991-042015-001		
U2004	MM5823N	NATIONAL	991-042015-001		
U2005	MM5823N	NATIONAL	991-042015-001		
U2006	CD4013BCN	NATIONAL	991-041110-001		
U2007	RC4558DN	NATIONAL	991-041146-001		
U2008	UA741TC	FAIRCHILD	991-041101-001		
U2009	UA741TC	FAIRCHILD	991-041101-001		
U2010	LM386N-1	NATIONAL	991-045137-001		
U2011	UA741TC	FAIRCHILD	991-041101-001		
U2012	UA79M15AUC	FAIRCHILD	991-044316-002		
U2013	UA78M12UC	FAIRCHILD	991-041112-002		
LIGHT EMITTING DIODE					
Ref. No.	Description	Manufacturer	Supplier's Part No.		
L1001	LSM-6L	OPCOA	939-041850-001		
RESISTORS					
Ref. No.	Value (ohm)	Wattage	Tol. (%)	Material	Manufacturer's Part No.
R1002	120K	1/4	5	Carbon	852-312124-001
R1003	10K	1/4	5	Carbon	852-312103-001
R1004	1M	1/4	1	Metal Film	949-044333-001
R1005	1M	1/4	1	Metal Film	949-044333-001
R1006	4.75K	1/4	1	Metal Film	853-424751-031
R1007	100Ω	1	1 TC*	Metal Film	924-040183-002
R1010	10K	1/4	5	Carbon	852-312103-001
R1011	1K	1/4	5	Carbon	852-312102-001
R1012	5.1K	1/4	5	Carbon	852-312512-001
R1013	1M	1/4	5	Carbon	852-312105-001
R1014	10K	1/4	5	Carbon	852-312103-001
R1015	10K	1/4	5	Carbon	852-312103-001
R1017	33K	1/4	5	Carbon	852-312333-001
R1018	10K	1/4	5	Carbon	852-312103-001
R1019	10K	1/4	5	Carbon	852-312103-001
R1020	10K	1/4	5	Carbon	852-312103-001
R1021	5.1M	1/4	5	Carbon	852-312515-001
R1022	2K	1/4	5	Carbon	852-312202-001
R1023	24K	1/4	5	Carbon	852-312242-001
R1024	100K	1/4	5	Carbon	852-312104-001
R1027	82K	1/4	5	Carbon	852-312823-001
R1028	120K	1/4	5	Carbon	852-312124-001
R1029	51K	1/4	5	Carbon	852-312513-001
R1030	1M	1/4	1	Metal Film	949-044333-001
R1031	1M	1/4	1	Metal Film	949-044333-001
R1032	4.75K	1/4	1	Metal Film	853-424751-031
R1033	100Ω	1	1 TC*	Metal Film	924-040183-002
R1034	10K	1/4	5	Carbon	852-312103-001
R1035	5.1K	1/4	5	Carbon	852-312512-001
R1036	1K	1/4	5	Carbon	852-312102-001
R1039	1K	1/4	5	Carbon	852-312102-001
R1040	5.1K	1/4	5	Carbon	852-312512-001

* Temperature Compensated

RESISTORS (Continued)					
Ref. No.	Value (ohm)	Wattage	Tol. (%)	Material	Manufacturer's Part No.
R1041	1M	1/4	5	Carbon	852-312105-001
R1042	10K	1/4	5	Carbon	852-312103-001
R1043	10K	1/4	5	Carbon	852-312103-001
R1044	10K	1/4	5	Carbon	852-312103-001
R1045	5.1K	1/4	5	Carbon	852-312515-001
R1046	9.1K	1/4	5	Carbon	852-312912-001
R1047	1K	1/4	5	Carbon	852-312102-001
R1048	2K	1/4	5	Carbon	852-312202-001
R1049	2.4K	1/4	5	Carbon	852-312242-001
R1050	100K	1/4	5	Carbon	852-312104-001
R1052	240K	1/4	5	Carbon	852-312244-001
R1053	51K	1/4	5	Carbon	852-312513-001
R1055	33K	1/4	5	Carbon	852-312333-001
R1057	100K	1/4	5	Carbon	852-312104-001
R1059	240K	1/4	5	Carbon	852-312244-001
R1061	1K	1/4	5	Carbon	852-312102-001
R1062	1K	1/4	5	Carbon	852-312102-001
R1064	1K	1/4	5	Carbon	852-312102-001
R1065	100K	1/4	1	Metal Film	853-421003-031
R1067	90.9K	1/4	1	Metal Film	853-429092-031
R1069	5.1M	1/4	5	Carbon	852-312515-001
R1070	200K	1/4	1	Metal Film	853-422003-031
R1072	39K	1/4	5	Carbon	852-312393-001
R1073	5.1K	1/4	5	Carbon	852-312512-001
R1074	10K	1/4	1	Metal Film	853-421002-031
R1075	10K	1/4	1	Metal Film	853-421002-031
R1077	200Ω	1/4	5	Carbon	852-312201-001
R1078	200Ω	1/4	5	Carbon	852-312201-001
R1079	200Ω	1/4	5	Carbon	852-312201-001
R1080	200Ω	1/4	5	Carbon	852-312201-001
R1081	200Ω	1/4	5	Carbon	852-312201-001
R1082	1K	1/4	5	Carbon	852-312102-001
R1083	200Ω	1/4	5	Carbon	852-312201-001
R1084	60.4K	1/4	1	Metal Film	853-426042-001
R1085	120K	1/4	5	Carbon	852-312124-001
R1086	60.4K	1/4	1	Metal Film	853-426042-001
R1087	1K	1/4	5	Carbon	852-312102-001
R1088	1M	1/4	5	Carbon	852-312105-001
R1089	1M	1/4	5	Carbon	852-312105-001
R1090	100Ω	1/4	5	Carbon	852-312101-001
R1091	51K	1/4	5	Carbon	852-312513-001
R1092	75K	1/4	1	Metal Film	853-427502-031
R1095	10K	1/4	1	Metal Film	853-421002-031
R1096	100Ω	1/4	5	Carbon	852-312101-001
R1097	100Ω	1/4	5	Carbon	852-312101-001
R1098	10K	1/4	1	Metal Film	853-421002-031
R1099	75K	1/4	1	Metal Film	853-427502-031
R1101	10K	1/4	5	Carbon	852-312103-001
R1102	1K	1/4	5	Carbon	852-312102-001
R1104	15K	1/4	5	Carbon	852-312153-001
R1106	36K	1/4	5	Carbon	852-312363-001
R1107	120K	1/4	5	Carbon	852-312124-001
R1109	200K	1/4	5	Carbon	852-312204-001
R1111	200K	1/4	1	Metal Film	853-422003-031
R1112	953Ω	1/4	1	Metal Film	853-429530-031
R1114	39K	1/4	5	Carbon	852-312393-001
R1115	100K	1/4	1	Metal Film	853-421003-031
R1116	1K	1/4	5	Carbon	852-321102-001
R1118	1K	1/4	5	Carbon	852-321102-001
R1119	10K	1/4	5	Carbon	852-312103-001
R1120	100K	1/4	5	Carbon	852-312104-001
R1121	100K	1/4	5	Carbon	852-312104-001
R1122	100Ω	1/4	5	Carbon	852-312101-001

RESISTORS (Continued)					
Ref. No.	Value (ohm)	Wattage	Tol. (%)	Material	Manufacturer's Part No.
R1125	1K	1/4	5	Carbon	852-312102-001
R1126	10K	1/4	5	Carbon	852-312103-001
R1127	5.1M	1/4	5	Carbon	852-312515-001
R1128	100K	1/4	5	Carbon	852-312104-001
R1129	10K	1/4	5	Carbon	852-312103-001
R1130	1K	1/4	5	Carbon	852-312102-001
R1131	91K	1/4	5	Carbon	852-312913-001
R1132	10K	1/4	5	Carbon	852-312103-001
R1133	100K	1/4	5	Carbon	852-312104-001
R1134	100K	1/4	5	Carbon	852-312104-001
R1135	100K	1/4	5	Carbon	852-312104-001
R1136	10K	1/4	5	Carbon	852-312103-001
R1137	10K	1/4	5	Carbon	852-312103-001
R1138	5.1K	1/4	5	Carbon	852-312512-001
R1139	10K	1/4	5	Carbon	852-312103-001
R1140	10K	1/4	5	Carbon	852-312103-001
R1142	9.1K	1/4	5	Carbon	852-312912-001
R1143	100K	1/4	5	Carbon	852-312104-001
R1144	620K	1/4	5	Carbon	852-312624-001
R1145	1K	1/4	5	Carbon	852-312102-001
R1146	12K	1/4	5	Carbon	852-312123-001
R1147	47K	1/4	5	Carbon	852-312473-001
R1148	10K	1/4	5	Carbon	852-312103-001
R1149	2K	1/4	5	Carbon	852-312202-001
R1150	51K	1/4	5	Carbon	852-312513-001
R1151	20K	1/4	5	Carbon	852-312203-001
R1152	10K	1/4	5	Carbon	852-312103-001
R1153	10Ω	1/4	5	Carbon	852-312100-001
R1154	10K	1/4	5	Carbon	852-312103-001
R1155	3.3K	1/4	5	Carbon	852-312332-001
R1156	220	1/4	5	Carbon	852-312221-001
R1157	100K	1/4	5	Carbon	852-312104-001
R1158	10K	1/4	5	Carbon	852-312103-001
R1159	1K	1/4	5	Carbon	852-312102-001
R1160	100K	1/4	5	Carbon	852-312104-001
R1161	300K	1/4	5	Carbon	852-312304-001
R1162	Not used				
R1163	100K	1/4	5	Carbon	852-312104-001
R2002	33K	1/4	5	Carbon	852-312333-001
R2003	100K	1/4	5	Carbon	852-312104-001
R2004	100K	1/4	5	Carbon	852-312104-001
R2005	100K	1/4	5	Carbon	852-312104-001
R2006	100K	1/4	5	Carbon	852-312104-001
R2007	100K	1/4	5	Carbon	852-312104-001
R2008	300K	1/4	5	Carbon	852-312304-001
R2009	22K	1/4	5	Carbon	852-312223-001
R2010	22K	1/4	5	Carbon	852-312223-001
R2011	22K	1/4	5	Carbon	852-312223-001
R2012	22K	1/4	5	Carbon	852-312223-001
R2013	22K	1/4	5	Carbon	852-312223-001
R2014	22K	1/4	5	Carbon	852-312223-001
R2015	22K	1/4	5	Carbon	852-312223-001
R2016	22K	1/4	5	Carbon	852-312223-001
R2017	22K	1/4	5	Carbon	852-312223-001
R2018	22K	1/4	5	Carbon	852-312223-001
R2019	22K	1/4	5	Carbon	852-312223-001
R2020	22K	1/4	5	Carbon	852-312223-001
R2021	22K	1/4	5	Carbon	852-312223-001
R2022	22K	1/4	5	Carbon	852-312223-001
R2023	22K	1/4	5	Carbon	852-312223-001
R2024	22K	1/4	5	Carbon	852-312223-001
R2025	22K	1/4	5	Carbon	852-312223-001

RESISTORS (Continued)					
Ref. No.	Value (ohm)	Wattage	Tol. (%)	Material	Manufacturer's Part No.
R2026	22K	1/4	5	Carbon	852-312223-001
R2027	22K	1/4	5	Carbon	852-312223-001
R2028	22K	1/4	5	Carbon	852-312223-001
R2029	22K	1/4	5	Carbon	852-312223-001
R2030	22K	1/4	5	Carbon	852-312223-001
R2031	22K	1/4	5	Carbon	852-312223-001
R2032	22K	1/4	5	Carbon	852-312223-001
R2033	22K	1/4	5	Carbon	852-312223-001
R2034	22K	1/4	5	Carbon	852-312223-001
R2035	22K	1/4	5	Carbon	852-312223-001
R2036	22K	1/4	5	Carbon	852-312223-001
R2037	22K	1/4	5	Carbon	852-312223-001
R2038	22K	1/4	5	Carbon	852-312223-001
R2039	22K	1/4	5	Carbon	852-312223-001
R2040	22K	1/4	5	Carbon	852-312223-001
R2041	100K	1/4	5	Carbon	852-312104-001
R2042	2K	1/4	5	Carbon	852-312202-001
R2043	10K	1/4	5	Carbon	852-312103-001
R2044	10K	1/4	5	Carbon	852-312103-001
R2045	200K	1/4	5	Carbon	852-312204-001
R2046	1K	1/4	5	Carbon	852-312102-001
R2047	200K	1/4	5	Carbon	852-312204-001
R2048	110K	1/4	5	Carbon	852-312114-001
R2049	10K	1/4	5	Carbon	852-312103-001
R2050	5.1M	1/4	5	Carbon	852-312515-001
R2052	11.5K	1/4	1	Metal Film	853-421152-031
R2053	130K	1/4	5	Carbon	852-312134-001
R2054	19.1K	1/4	1	Metal Film	853-421912-031
R2055	300K	1/4	5	Carbon	852-312304-001
R2056	66.5K	1/4	1	Metal Film	853-426652-031
R2058	10Ω	1/4	5	Carbon	852-312100-001
R2059	3.3K	1/4	5	Carbon	852-312332-001
R2060	51Ω	1/2	5	Carbon	852-512510-001
R2061	51Ω	1/2	5	Carbon	852-512510-001
R2062	4.75K	1/4	1	Metal Film	853-424751-031
R2063	19.1K	1/4	1	Metal Film	853-421912-031
R2064	1K	1/4	5	Carbon	852-312102-001
R2065	47K	1/4	5	Carbon	852-312473-001
R2066	47K	1/4	5	Carbon	852-312473-001
R2067	47K	1/4	5	Carbon	852-312473-001
R2068	47K	1/4	5	Carbon	852-312473-001

SWITCHES		
Ref. No.	Description	Manufacturer's Part No.
SW1001	OCTAVE 1, 2P3T	960-045016-001
SW1002	WAVE SHAPE 1, 2P2T	960-045214-001
SW1003	SYNC, 2P2T	960-045214-001
SW1004	OCTAVE 2, 2P3T	960-045016-001
SW1005	WAVE SHAPE 2, 2P2T	960-045214-001
SW1006	KEYBOARD TRACKING, 2P3T	960-045016-001
SW1007	AUTO CONTOUR TRIGGER, 2P2T	960-045214-001
SW1008	CONTOUR SUSTAIN, 2P2T	960-045214-001
SW1009	CONTOUR TONE SOURCES, 2P3T	960-045016-001
SW1010	MODULATION WAVE SHAPE, 2P3T	960-045016-001
SW2011	POWER ON/OFF (UL, CSA) 1P1T 125V 15A, 250V 10A	960-042753-001
SW2011	POWER ON/OFF, 2P1T (European/Australian)	960-042800-001

TRANSISTORS			
Ref. No.	Type No.	Device Manufacturer	Supplier's Part No.
Q1006	2N3906	MOTOROLA	991-041052-002
Q1007	2N3906	MOTOROLA	991-041052-002
Q1013	2N3906	MOTOROLA	991-041052-002
Q1014	2N3906	MOTOROLA	991-041052-002
Q1017	2N3904	MOTOROLA	991-041051-002
Q1018	2N3904	MOTOROLA	991-041051-002
Q1019	2N3904	MOTOROLA	991-041051-002
Q1020	2N3904	MOTOROLA	991-041051-002
Q1021	2N3904	MOTOROLA	991-041051-002
Q1022	2N3904	MOTOROLA	991-041051-002
Q1025	2N3906	MOTOROLA	991-041052-002
Q1026	2N3904	MOTOROLA	991-041051-002
Q1028	2N3906	MOTOROLA	991-041052-002
Q1029	2N3906	MOTOROLA	991-041052-002
Q1030	2N3906	MOTOROLA	991-041052-002
Q1031	2N3904	MOTOROLA	991-041051-002
Q1032	J112	SILICONIX	991-041055-002
Q2001	2N3904	MOTOROLA	991-041051-002
Q2002	2N3904	MOTOROLA	991-041051-002
Q2003	TIP-30	TEXAS INST.	991-041050-001

VARIABLE RESISTORS			
Ref. No.	Description	Manufacturer's Part No.	
R1001	10K Ω , Cermet, Freq 1 Trim	925-042526-003	
R1008	500 Ω , Cermet, Scale 1 Trim	925-042526-006	
R1009	10K Ω , Carbon, Hi Freq Trim	925-040275-004	
R1016	10K Ω , Carbon, Square Trim	925-040275-004	
R1025	10K Ω , Slide, Linear, TONE SOURCE TWO DETUNE	925-045013-001	
R1026	10K Ω , Cermet, Freq 2 Trim	925-042526-003	
R1037	500 Ω , Scale 2 Trim	925-042526-006	
R1038	10K Ω , Carbon, Hi Freq 2 Trim	925-040275-004	
R1051	10K Ω , Slide, Linear, MIXER TONE ONE	925-045013-001	

MECHANICAL PARTS LIST			
Ref. No.	Description	Supplier's Part No.	
1	Housing Assembly	967-045192-941	
2	Overlay, Front Panel	913-045189-001	
3	Overlay, Rear, Domestic	913-045198-001	
	Overlay, Rear, Domestic, Canada	913-045198-002	
	Overlay, Rear, Export	913-045199-001	
4	Keyboard and Jack Board PC Board Assembly	996-045179-001	
5	Dust Seal, Front Panel, Left	914-045203-001	
6	Dust Seal, Front Panel, Right	914-045204-001	
7	Knob Assembly, Rotary, Clear	915-042764-943	
8	Knob Assembly, Slide, Clear	915-040272-952	
9	Transformer, Power, 115/230V Primary, 38VAC, 5A Secondary (UL, CSA, European, Japan)	954-045083-001	
	Transformer, Power, 240V Primary, 36VAC, 35A Secondary (Australian)	954-045348-001	

VARIABLE RESISTORS (Continued)			
Ref. No.	Description	Manufacturer's Part No.	
R1054	10K Ω , Slide, Linear, MIXER POLYPHONY	925-045013-001	
R1056	10K Ω , Slide, Linear, MIXER BELL TONE	925-045013-001	
R1058	10K Ω , Slide, Linear, MIXER NOISE	925-045013-001	
R1060	10K Ω , Slide, Linear, MIXER TONE TWO	925-045013-001	
R1063	10K Ω , Slide, Audio, MODULATION KEYBOARD GLIDE	925-045013-002	
R1068	10K Ω , Rotary, Linear, TUNING TONE SOURCES	925-045012-001	
R1071	10K Ω , Slide, Linear, MODULATION TONE SOURCES	925-045013-001	
R1076	10K Ω , Rotary, Linear, TUNING POLYPHONY	925-045012-001	
R1093	1K Ω , Carbon, Emphasis Trim	925-040275-002	
R1094	10K Ω , Carbon, VCA Balance Trim	925-040275-004	
R1100	50K Ω , Slide, Audio, PEAK EMPH.	925-045013-004	
R1103	10K Ω , Rotary, Audio, MASTER VOLUME	925-045012-003	
R1105	10K Ω , Slide, Linear, MODULATION FILTER	925-045013-001	
R1108	10K Ω , Slide, Linear, FILTER CUTOFF FREQ	925-045013-001	
R1110	10K Ω , Carbon, Filter Cutoff Trim	925-040275-004	
R1113	470 Ω , Carbon, Filter Scale Trim	925-040275-011	
R1117	10K Ω , Slide, Linear, FILTER CONTOURED CUTOFF	925-045013-001	
R1123	1 Meg Ω , Slide, Audio, CONTOUR RISE TIME	925-045013-002	
R1125	1 Meg Ω , Slide, Audio, CONTOUR FALL TIME	925-045013-002	
R1141	1 Meg Ω , Slide, Audio, MODULATION RATE	925-045013-002	
R2001	100K Ω , Carbon, Poly Freq Trim	925-040275-001	
R2051	10K Ω , Carbon, Low End Trim	925-040275-004	
R2057	10K Ω , Carbon, Hi End Trim	925-040275-004	

MECHANICAL PARTS LIST (Continued)			
Ref. No.	Description	Supplier's Part No.	
10	Control PC Board Assembly	996-045176-001	
11	Power Cord (UL, Japan)	957-041789-003	
	Power Cord (European, Belgium)	957-043400-001	
	Power Cord (Australian)	957-043400-004	
12	Strain Relief, Power Cord	977-041637-003	
13	Fuse Holder (UL, CSA, Japan)	906-041331-006	
	Fuse Holder (European, Australian)	906-042911-001	
14	Switch, Power (UL, CSA, Japan)	960-042753-001	
	Switch, Power (European, Australian)	960-042800-001	
15	Phone Jack, TRIGGER	910-041306-001	
16	Phone Jack, HEAD PHONES	910-041306-004	
17	Phone Jack, PITCH	910-041306-010	
18	Guide, PC Board	964-040897-003	
19	Label, Fuse, Caution (UL)	913-042088-001	
	Label, Fuse, Caution (European)	913-044344-010	
20	Foot, Rubber, 7/8 Diameter x 3/8	916-042584-001	

MECHANICAL PARTS LIST (Continued)

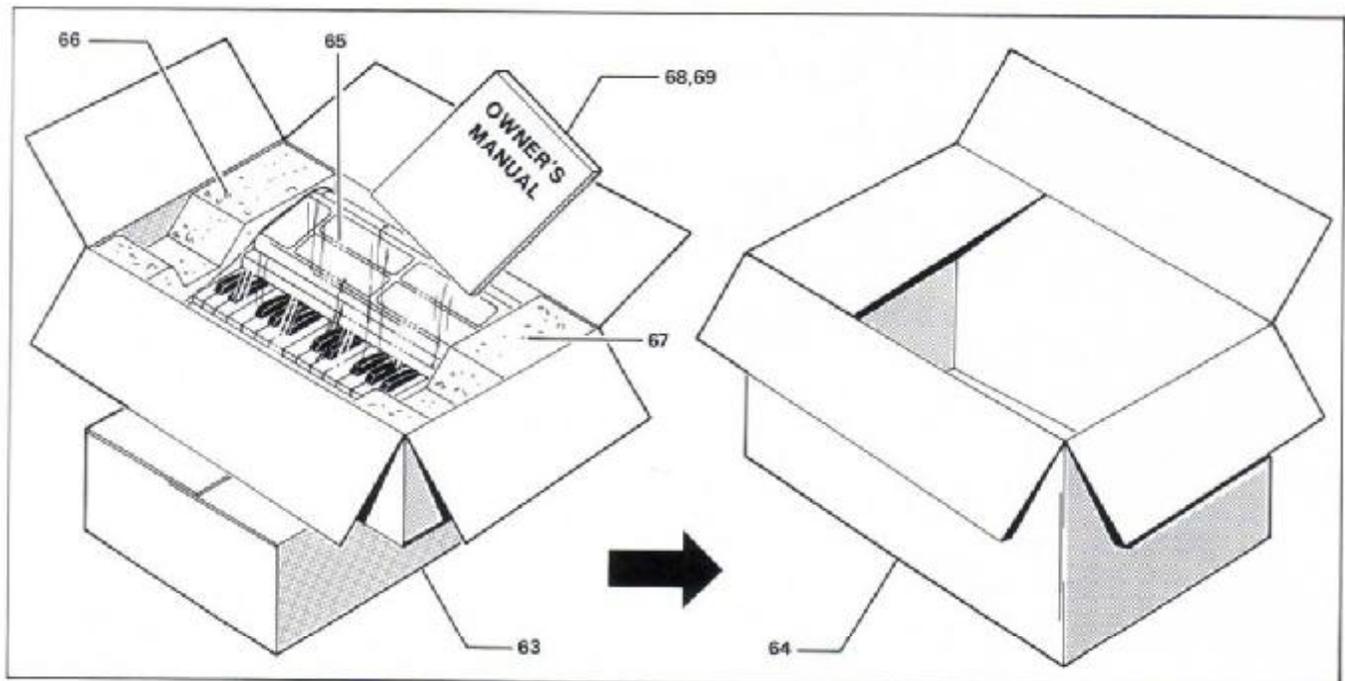
Ref. No.	Description	Supplier's Part No.
21	Label, Patent	913-040825-001
22	Keyboard, 32 Note	979-045190-001
23	Plate, Spacer	963-045226-001
24	Screw, Machine, Pan Head, M5 x 12mm, Phillips	903-044310-001
25	Nut, Round 3/8 x 32, Knurled, (Phone Jack)	902-045212-001
26 ▲	Standoff, 6-32 x 3/8	973-041308-020
27	Screw, Self Tapping, 6A x 5, Pan Head	811-040039-008 902-040500-005
28	Speed Nut, U, 8A	816-050039-006
29	Screw, Self Tapping, Pan Head, 8B x 3/8 Lg.	902-040500-001
30	Speed Nut, U, 6A	902-040504-007
31	Nut, Hex, 3/8-32	904-042026-001
32	Flat Washer, 3/8 Conical	904-040065-014
33	Lock Washer, 3/8	903-045216-001
34	Screw, No. 8 x 5/8 Lg. (Akko Plascrew)	806-055039-005
35	Screw, Machine, Pan Head, 8-32 x 5/16 Lg., Phillips	911-040189-002
36	Lug, No. 8 (Crimp)	801-055446-000
37	Nut, No. 8-32	802-023222-000
38	Nut, No. 4-40 (KEPS)	806-023039-006
39	Screw, Machine, Pan Head, 4-40 x .375" Lg.	806-045039-007
40 ▲	Screw, Machine, Pan Head	904-041390-017
41 ▲	Flat Washer, No. 6	904-040495-016
42 ▲	Lock Washer, No. 6	911-044062-002
43	Faston Receptacle with Tab, .187"	911-041317-002
44	Faston Receptacle, .250"	911-041317-004
45	Faston Receptacle, .187"	905-040498-034
46	Pop Rivet, 1/8"	

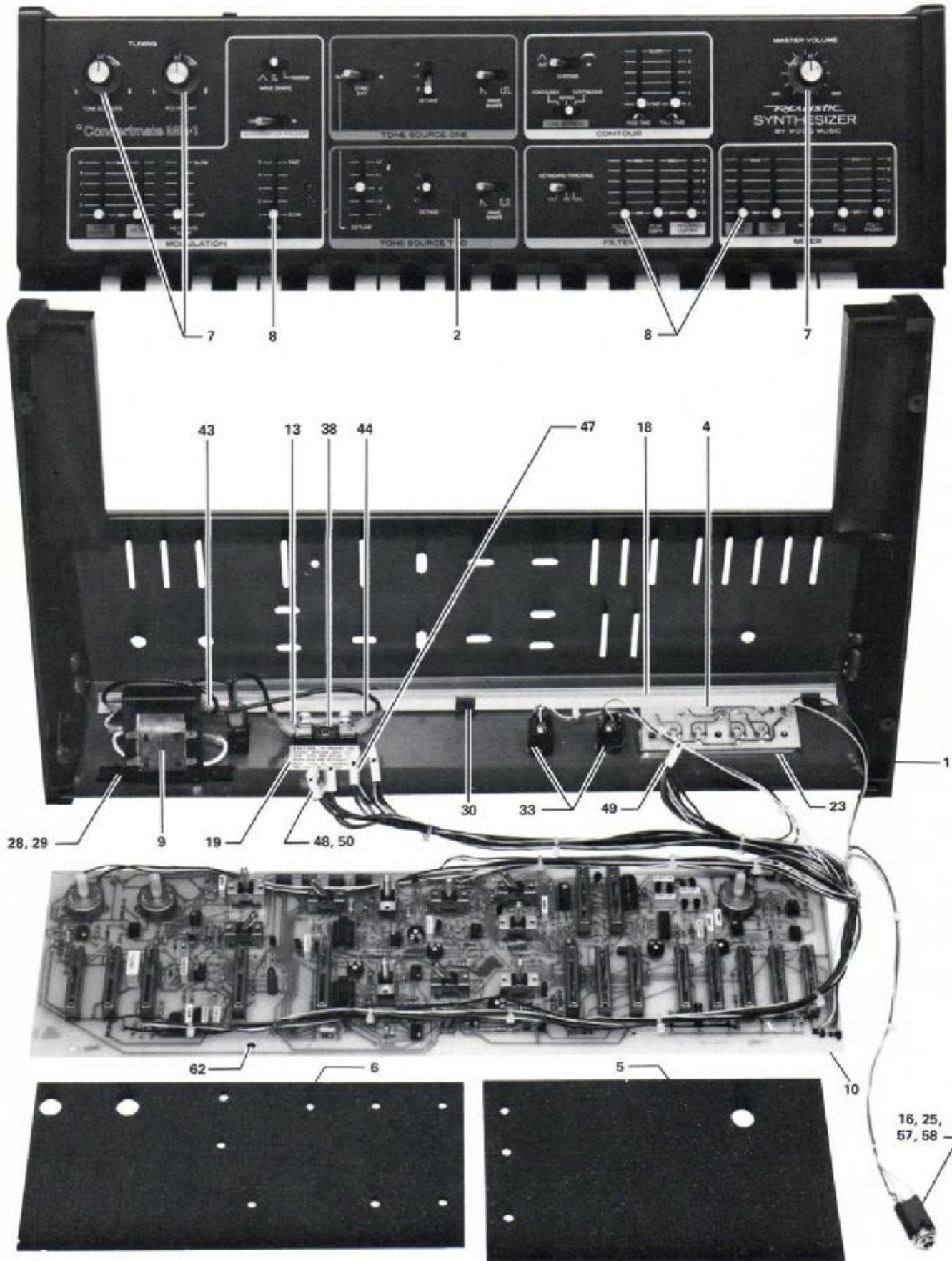
MECHANICAL PARTS LIST (Continued)

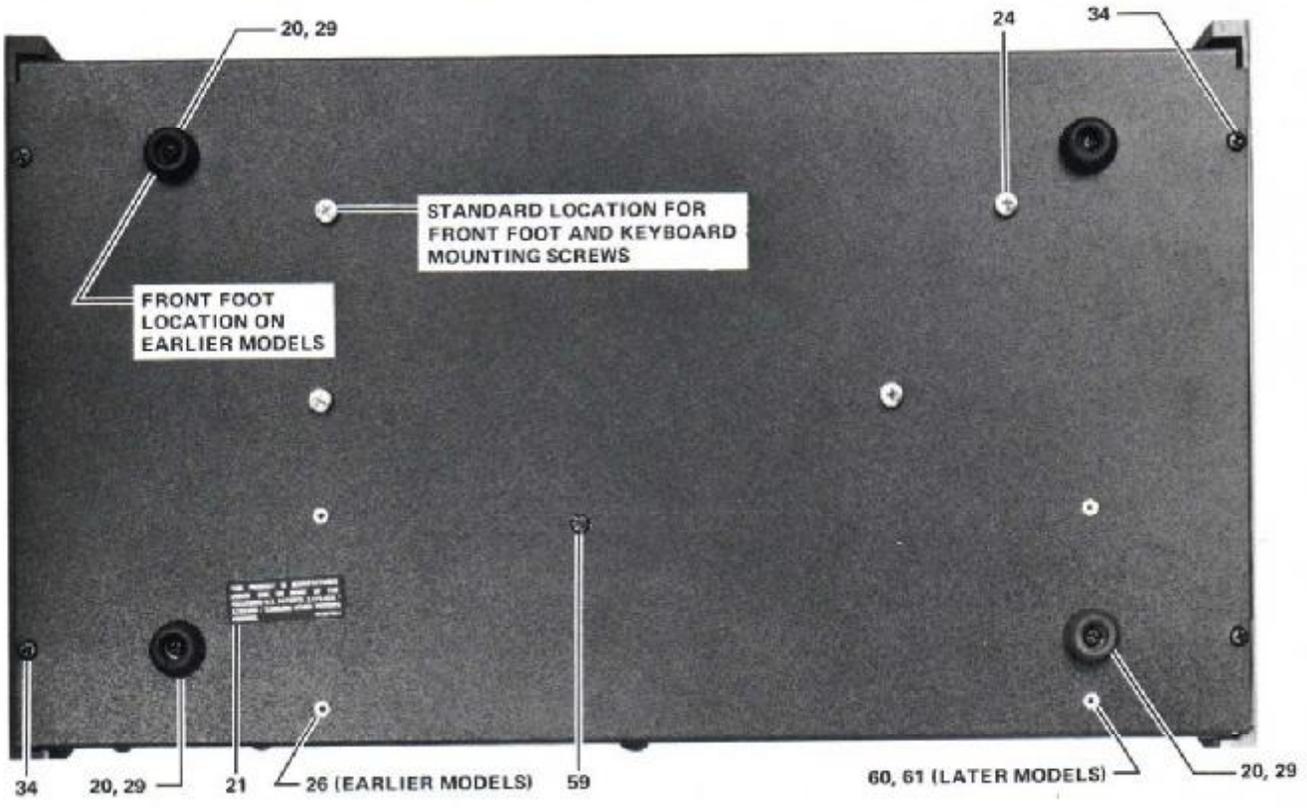
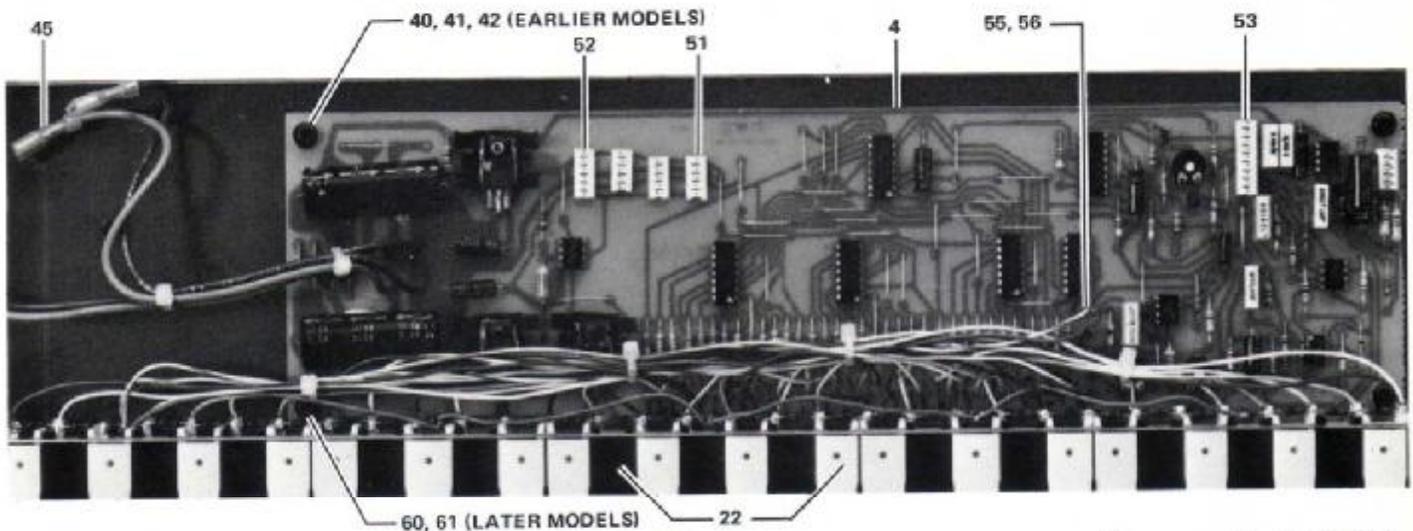
Ref. No.	Description	Supplier's Part No.
47	Socket Housing, 5 Pin, .1" Centers, (AMP 350091-5) C.I.S.	906-040298-005
48	Socket Housing, 6 Pin, .1" Centers, (AMP 350091-6) C.I.S.	906-040298-006
49	Socket Housing, 9 Pin, .1" Centers, (AMP 350091-9) C.I.S.	906-040298-009
50	Crimp Socket, (AMP 350090-1) C.I.S.	910-040308-001
51	Header, 5 Pin, (AMP 640098-5) C.I.S.	910-040299-005
52	Header, 6 Pin, (AMP 640098-6) C.I.S.	910-040299-006
53	Header, 9 Pin, (AMP 640098-9) C.I.S.	910-040299-009
54	Phono Jack, PC Mount, .328" Diameter	910-045194-001
55	Crimp Socket, Keyboard	910-040346-001
56	Crimp Pin, Keyboard	911-042029-001
57	Nameplate, Phone Jack	913-045211-001
58	Hole Plug, 1/4" Diameter	930-042872-001
59 ■	Bumper, Rubber Stem	916-045163-001
60 ■	Support, PCB Mount	973-045326-002
61 ■	Screw, Machine, 6 x 5/16 Lg.	811-040339-005
62	Washer, Fibre	904-040601-004
63	Single Carton, USA	932-045210-001
	Single Carton, Canada	932-045210-002
64	Double Carton, USA and Canada	932-045202-001
	Double Carton, Europe, Australia, Japan	932-045202-002
65	Plastic Bag	932-042562-002
66	LH Insert, Molded Foam	964-045200-001
67	RH Insert, Molded Foam	964-045200-002
68	Owner's Manual	993-045209-001
69	Customer Questionnaire	993-045380-001

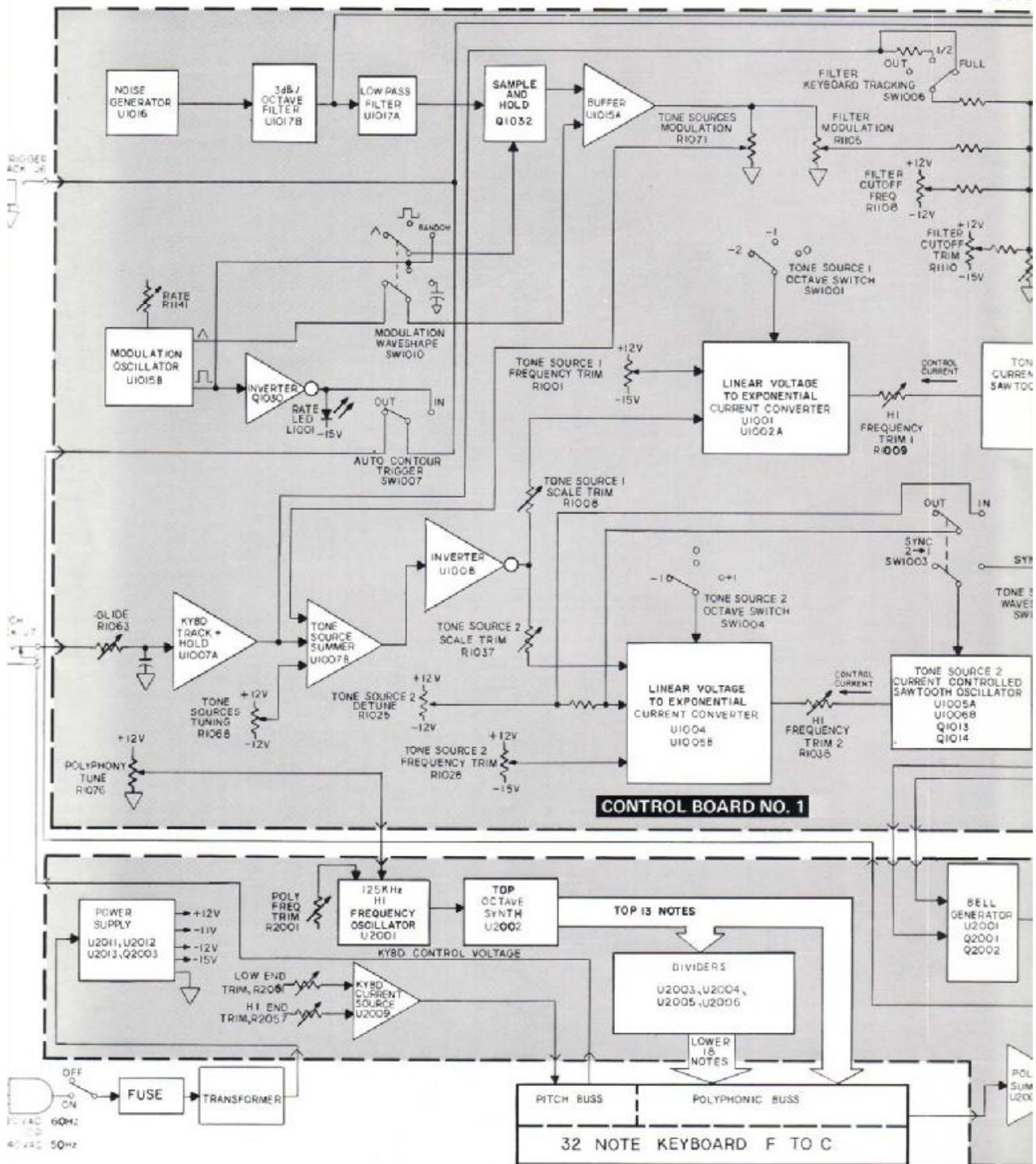
▲ Earlier Models - Keyboard No. 2 Mounting
■ Later Models - Keyboard No. 2 Mounting

PACKAGING:

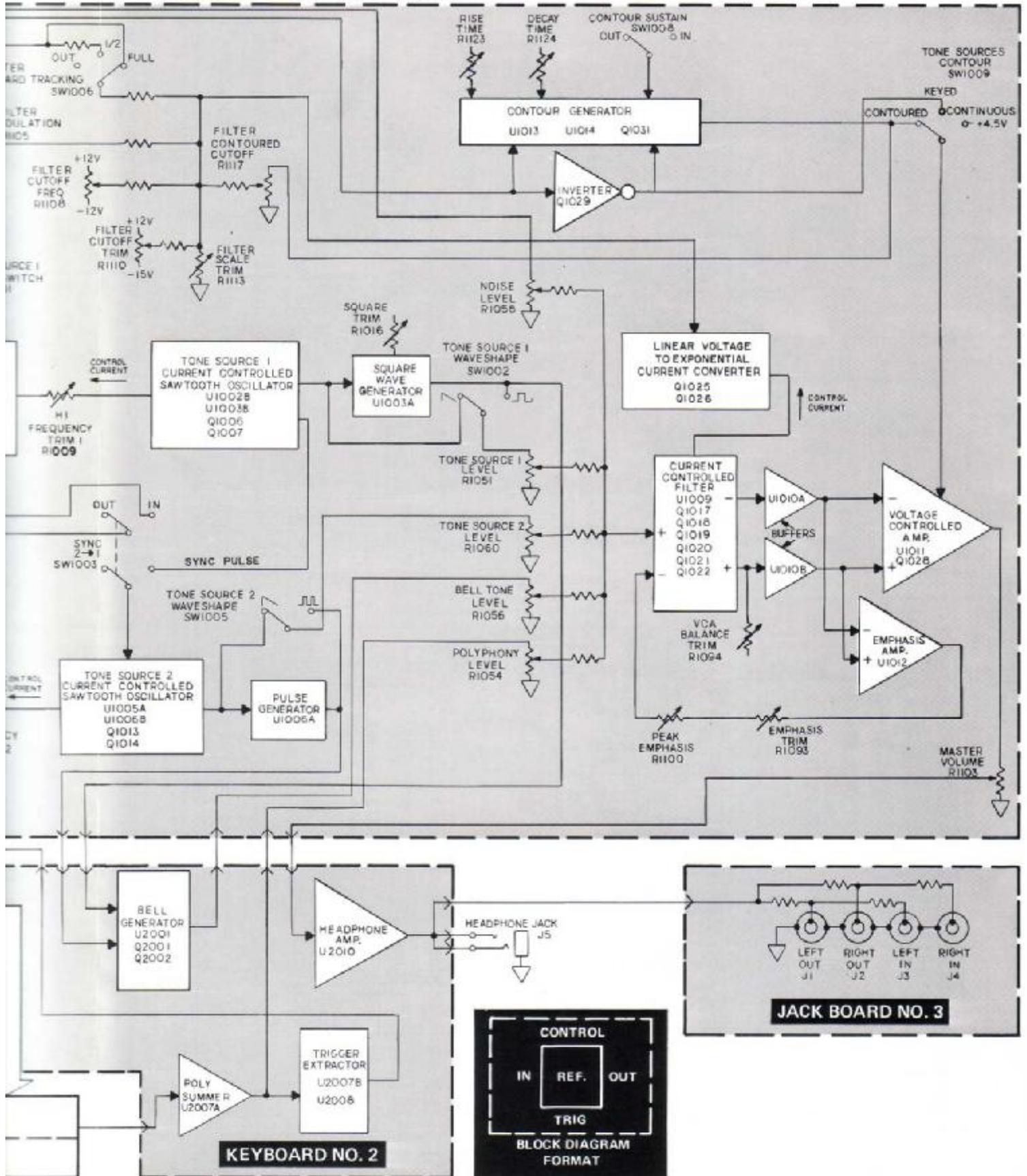


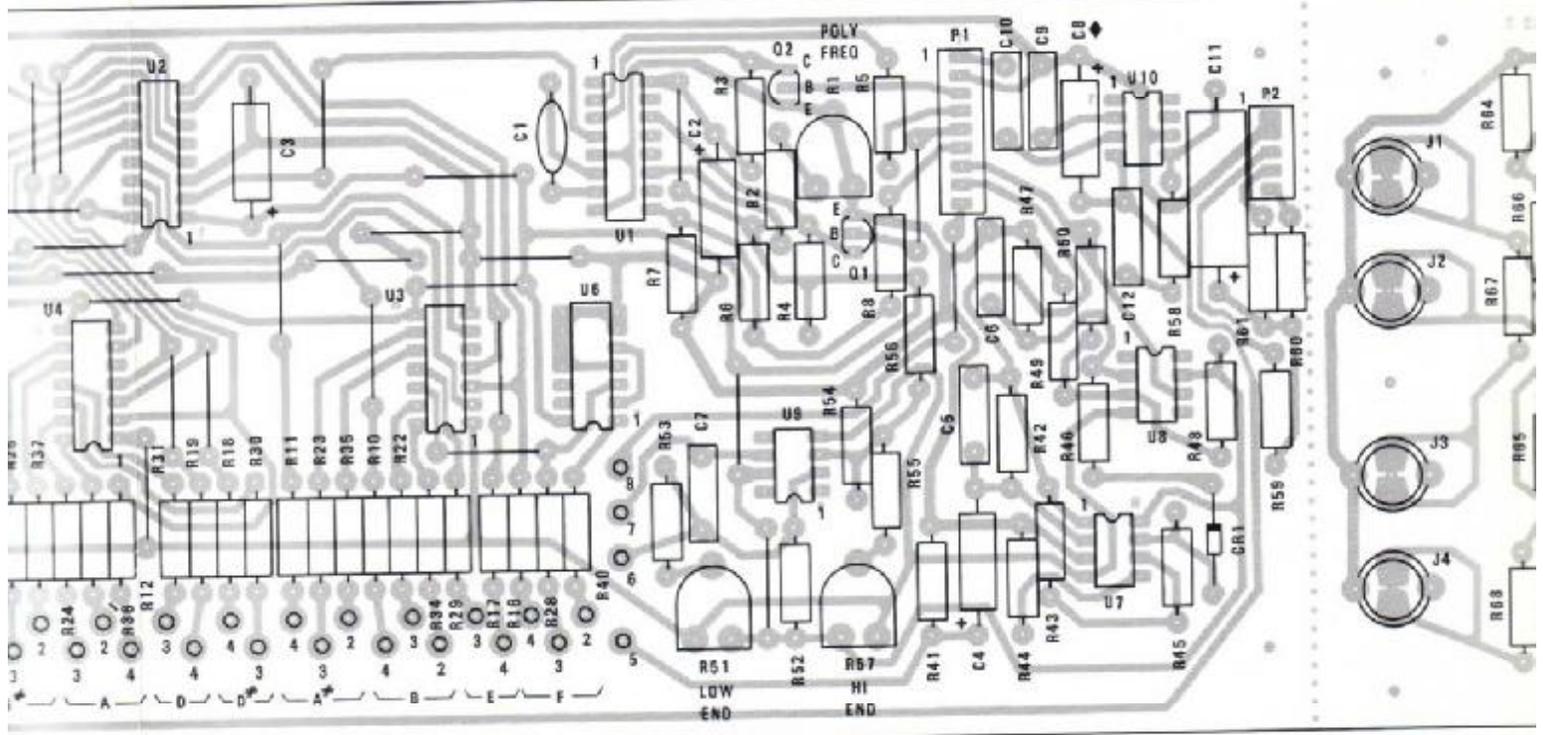
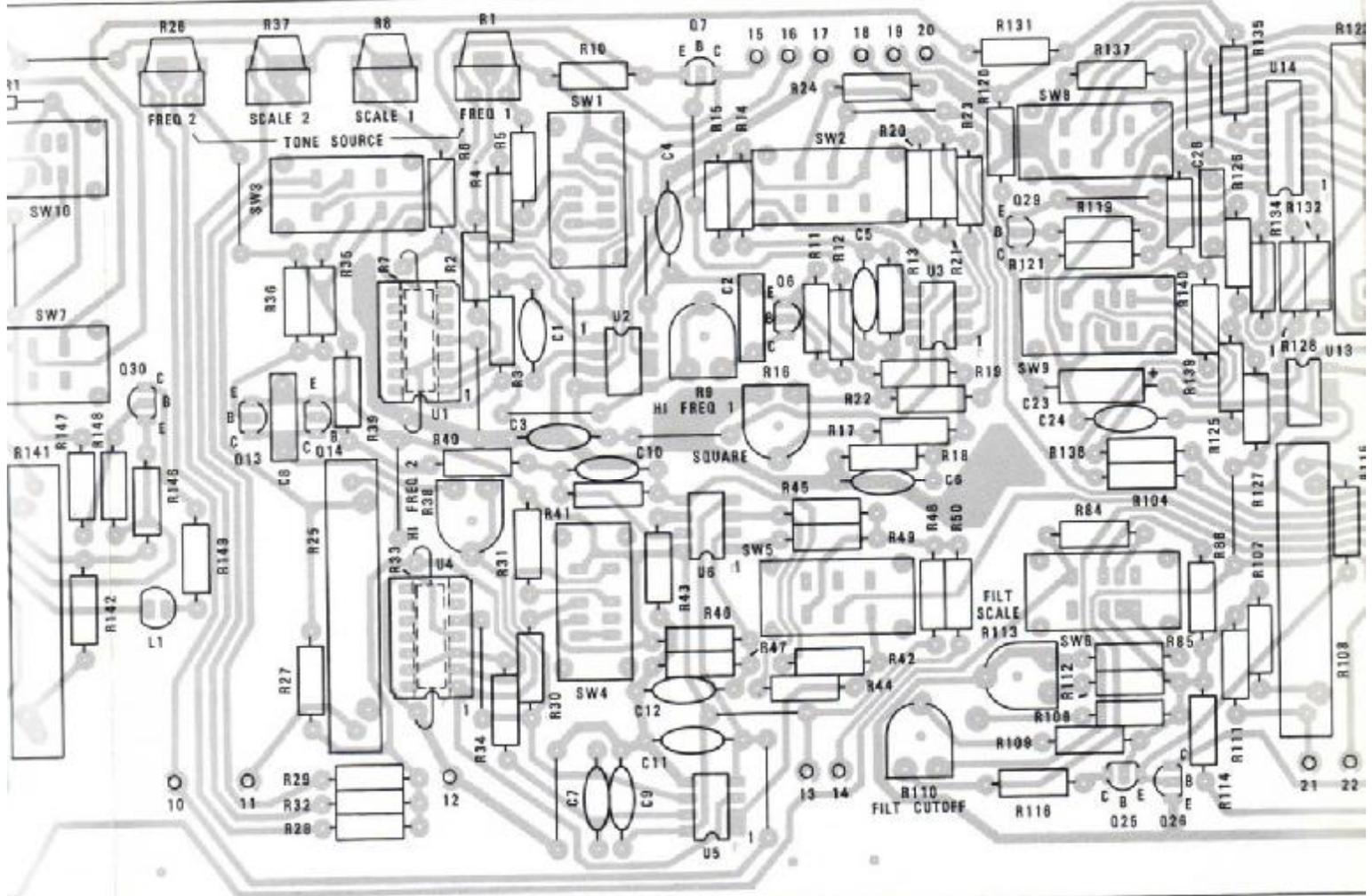


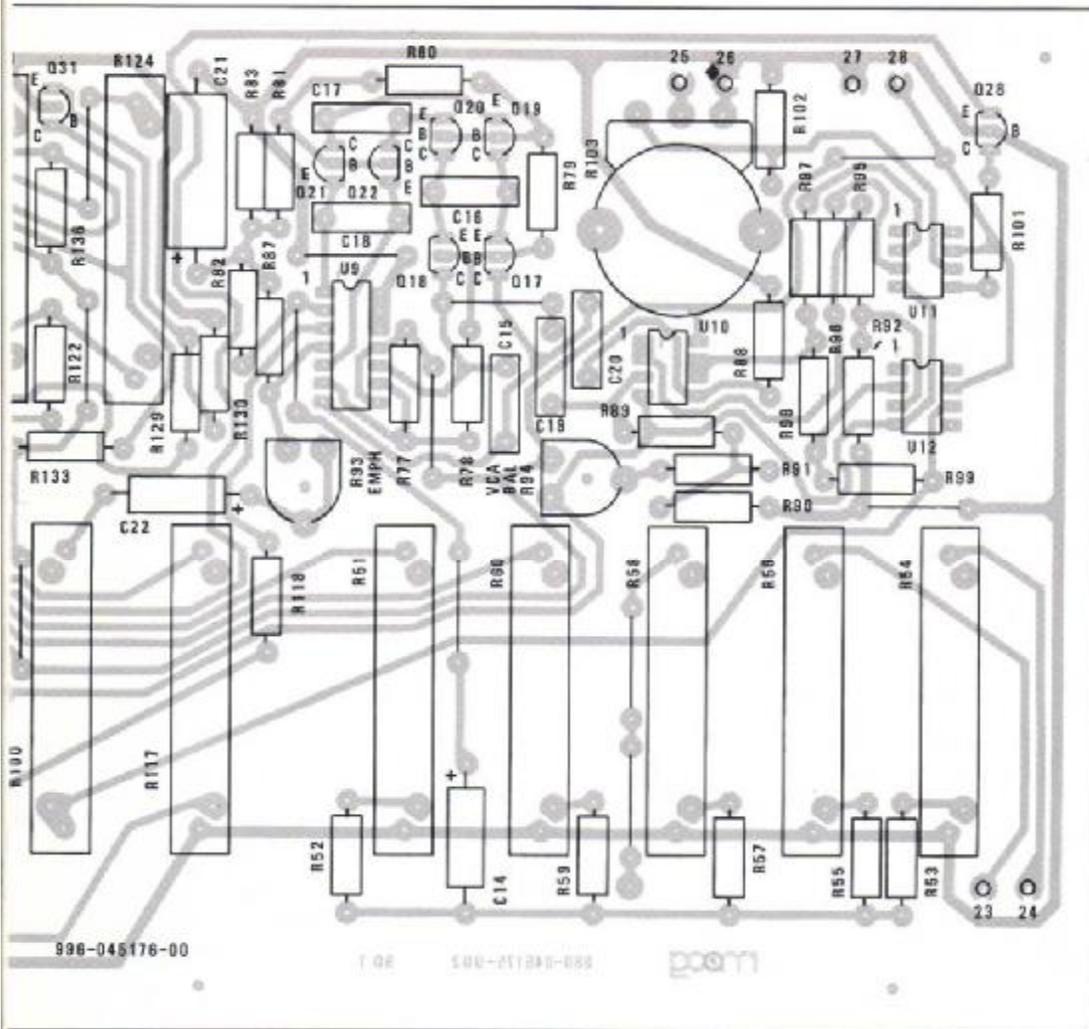




6. BLOCK DIAGRAM







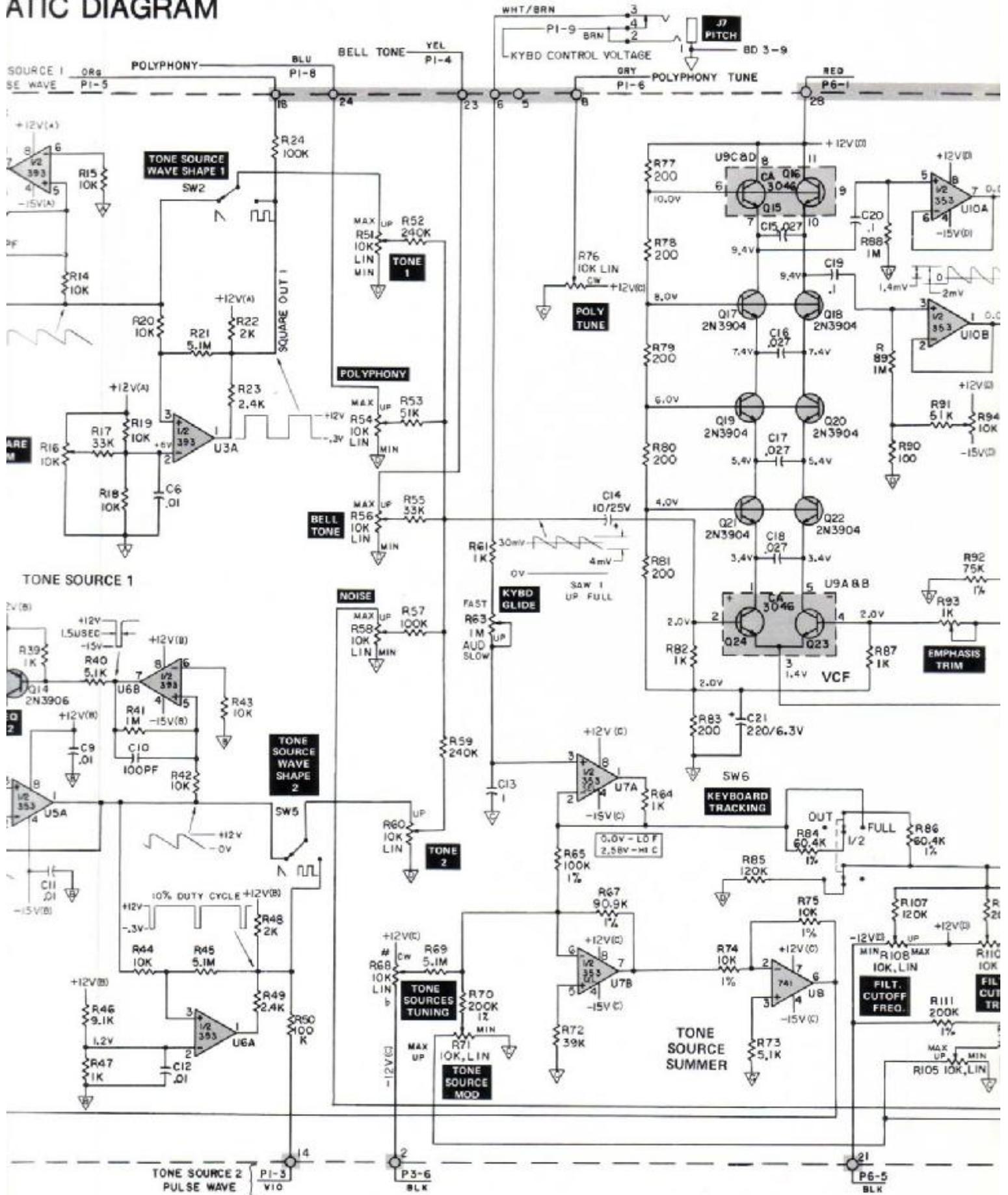
◆ BELOW S/N 6000
 WHITE/GREEN
 GROUND WIRE
 FROM C8 (+)
 BOARD 2

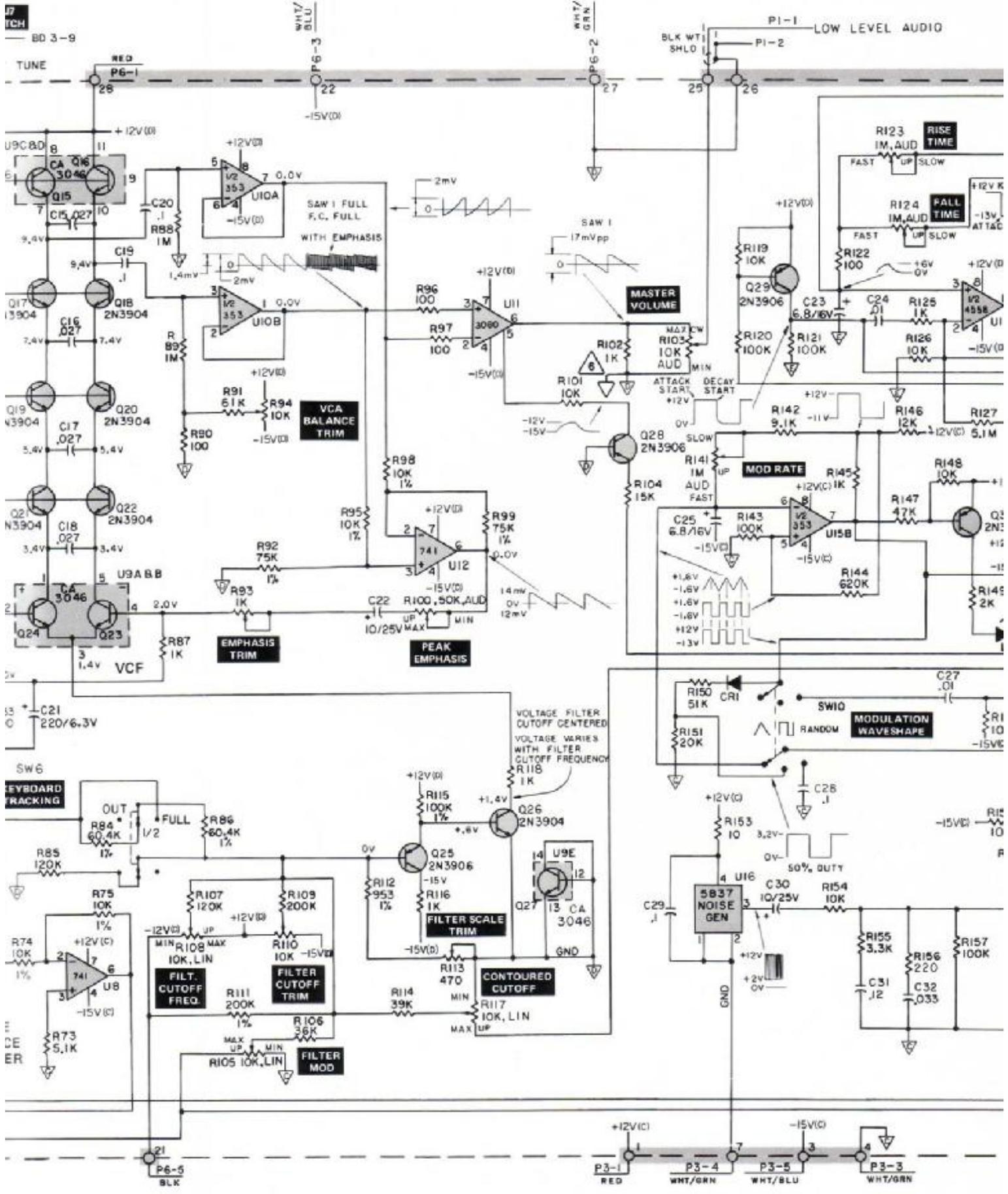
7. CONTROL PRINTED CIRCUIT BOARD 1

◆ BELOW S/N 6000
 ADD WHITE/GREEN
 WIRE TO MASTER VOLUME
 WIRE TO R103 (TERMINAL 26) BOARD 1

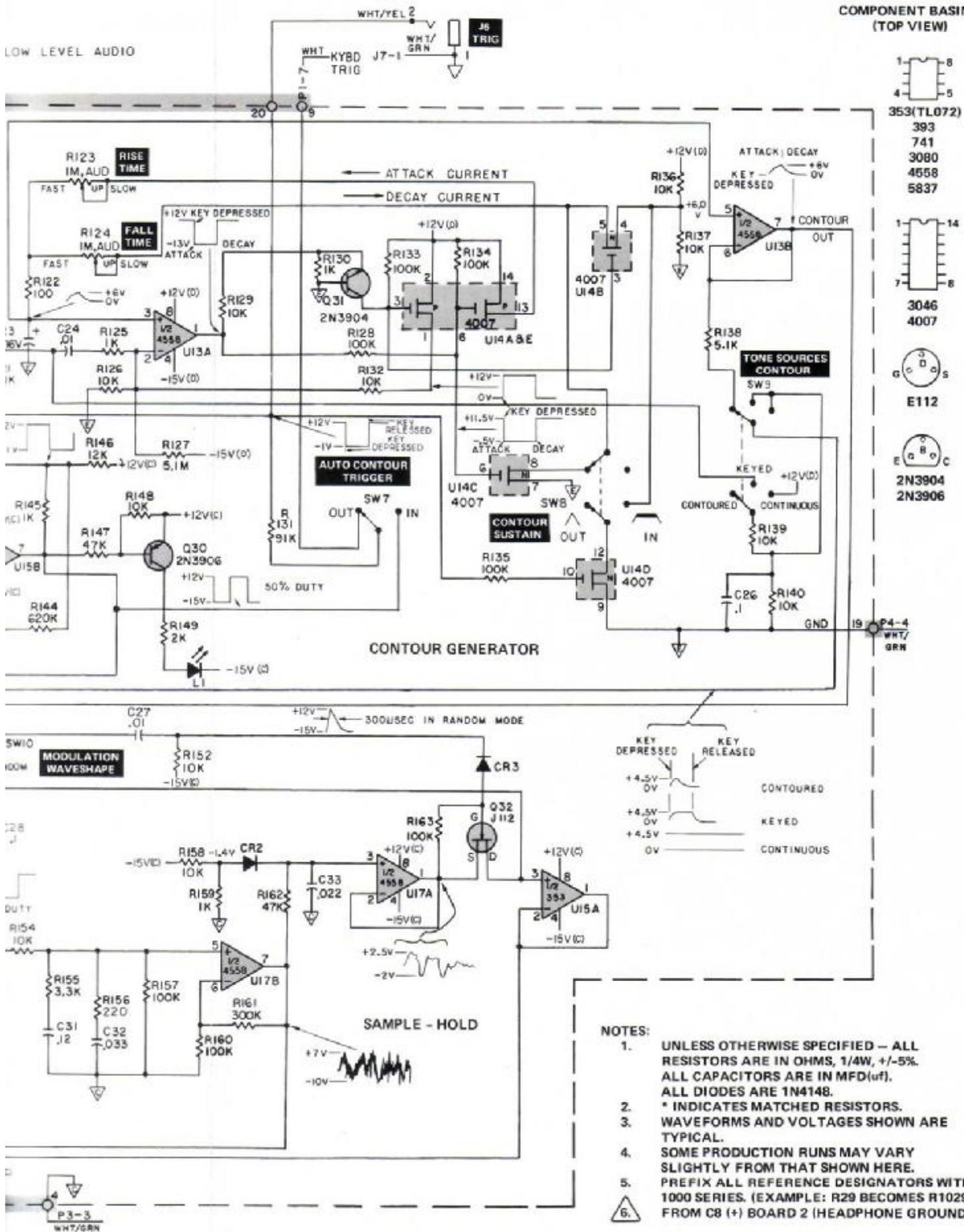
◀ 8. KEYBOARD AND JACK BOARD PRINTED CIRCUIT BOARDS 2 AND 3

ATIC DIAGRAM





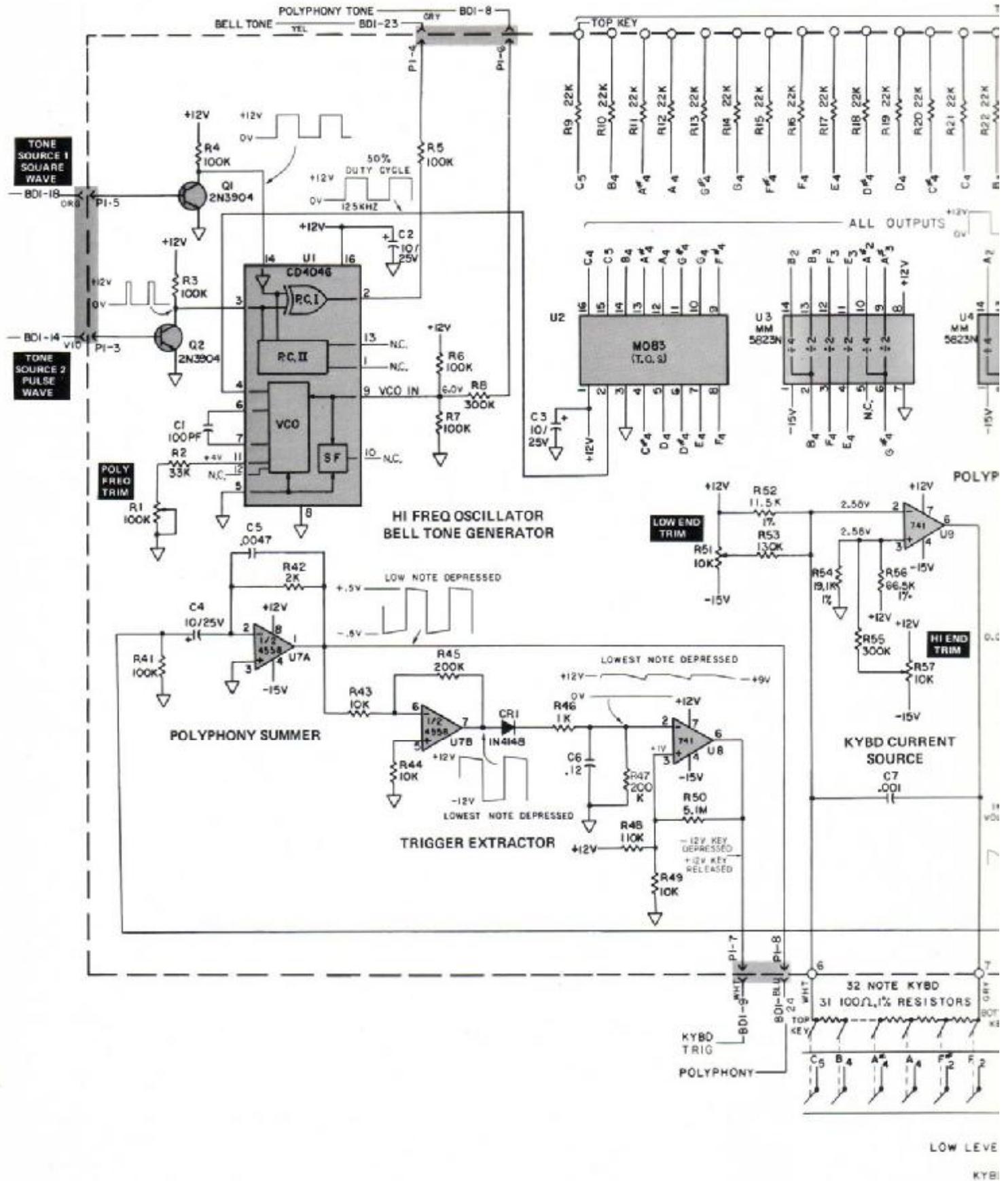
LOW LEVEL AUDIO



- 353(TL072)
- 393
- 741
- 3080
- 4558
- 5837
- 3046
- 4007
- E112
- 2N3904
- 2N3906

- NOTES:
1. UNLESS OTHERWISE SPECIFIED - ALL RESISTORS ARE IN OHMS, 1/4W, +/-5%. ALL CAPACITORS ARE IN MFD(uf). ALL DIODES ARE 1N4148.
 2. * INDICATES MATCHED RESISTORS.
 3. WAVEFORMS AND VOLTAGES SHOWN ARE TYPICAL.
 4. SOME PRODUCTION RUNS MAY VARY SLIGHTLY FROM THAT SHOWN HERE.
 5. PREFIX ALL REFERENCE DESIGNATORS WITH 1000 SERIES. (EXAMPLE: R29 BECOMES R1029).
 6. FROM C8 (+) BOARD 2 (HEADPHONE GROUND).

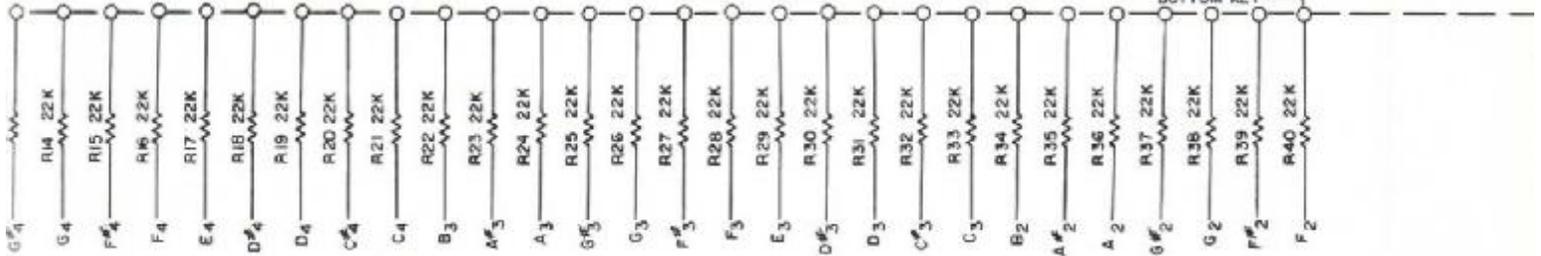
10. KEYBOARD AND JACK BOARDS 2 AND 3 SCHEMATIC DIAGR.



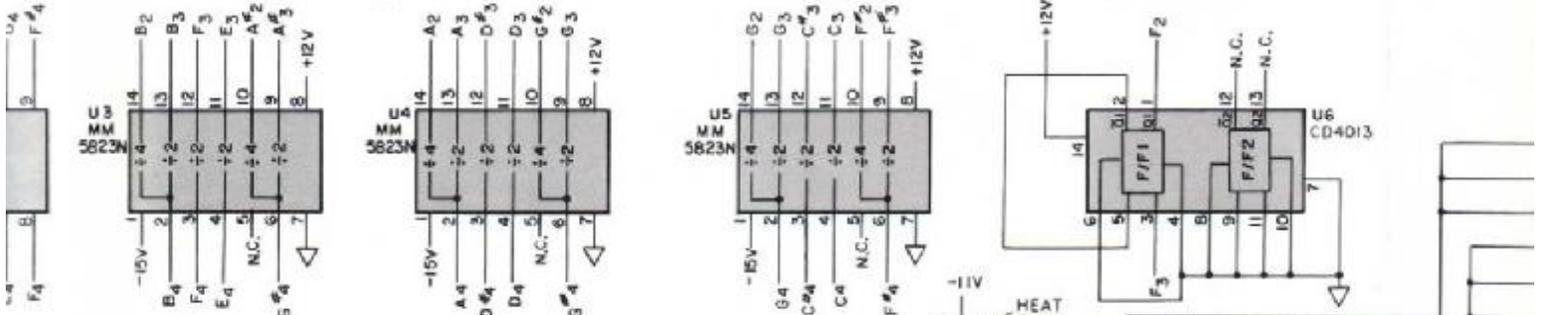
SCHEMATIC DIAGRAMS

TO 32 NOTE KEYBOARD

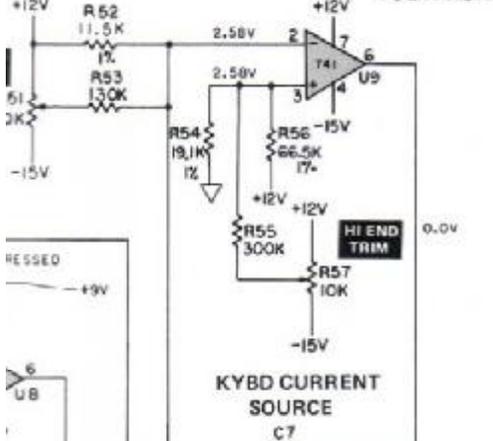
BOTTOM KEY



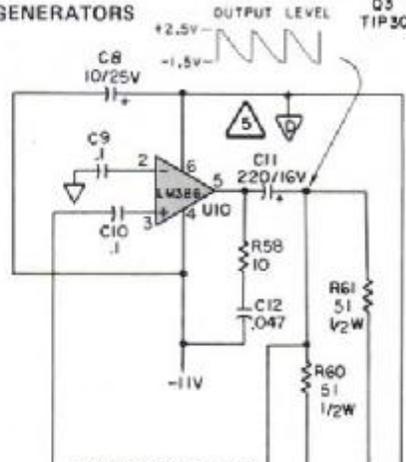
ALL OUTPUTS +12V 0V 50% DUTY CYCLE



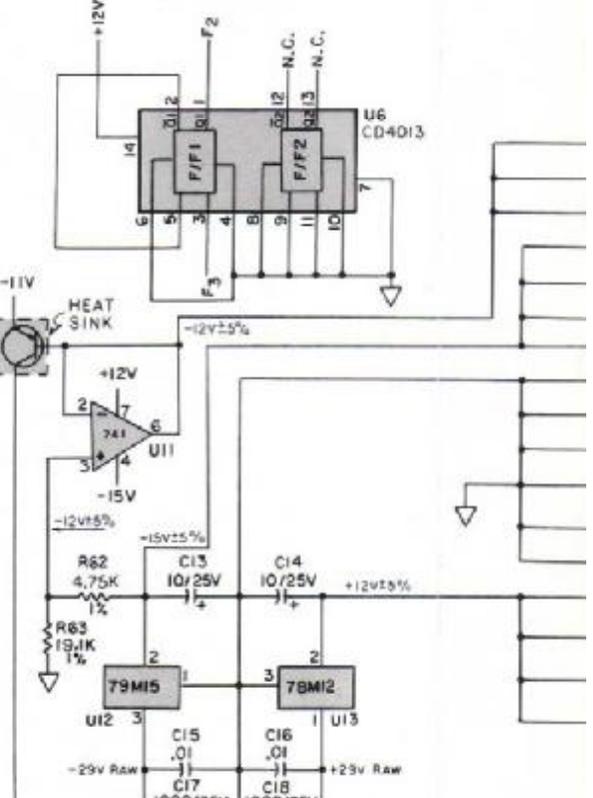
POLYPHONIC GENERATORS



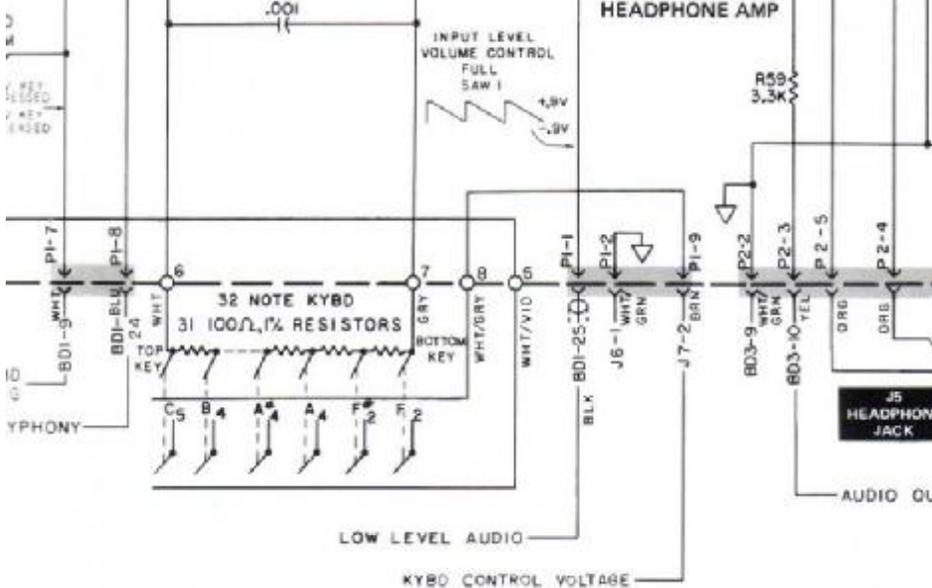
KYBD CURRENT SOURCE



HEADPHONE AMP

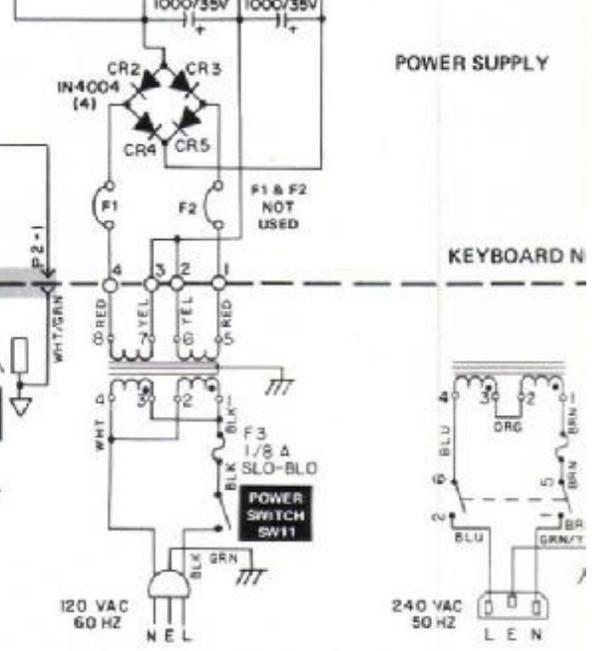


POWER SUPPLY



LOW LEVEL AUDIO

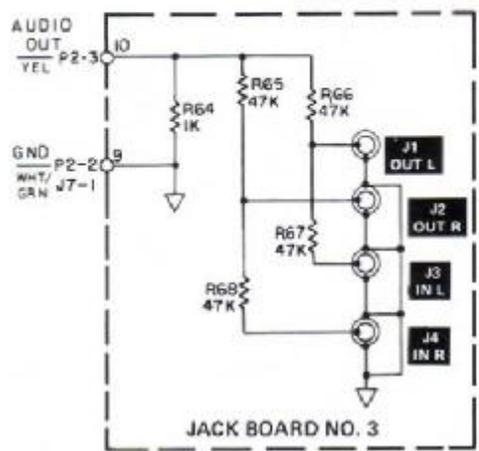
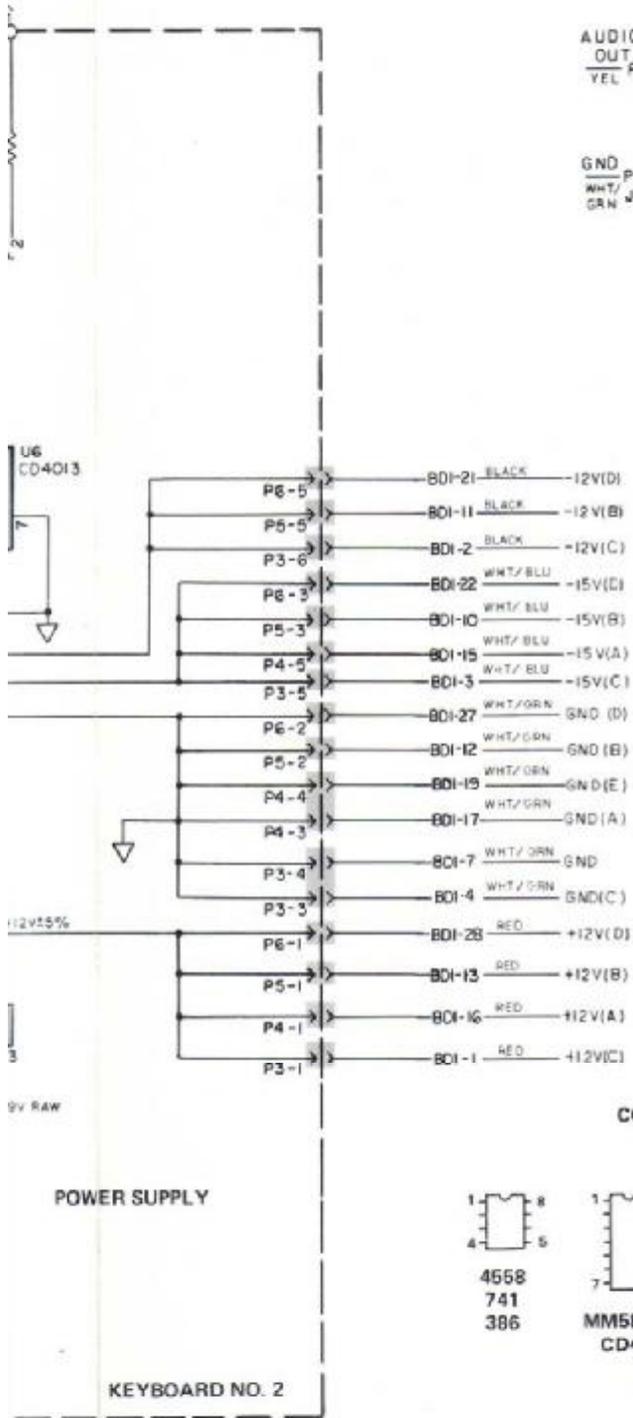
KYBD CONTROL VOLTAGE



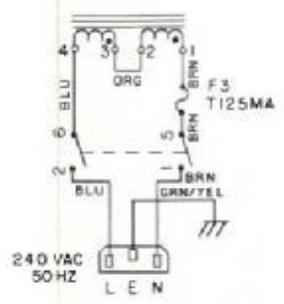
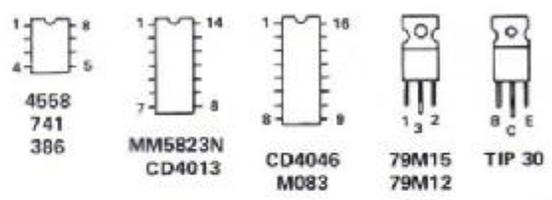
KEYBOARD N

120 VAC 60 HZ

240 VAC 50 HZ



COMPONENT BASING (TOP VIEW)



- NOTES:**
- UNLESS OTHERWISE SPECIFIED - ALL RESISTORS ARE IN OHMS, 1/4W, +/-5%. ALL CAPACITORS ARE IN MFD(uf).
 - WAVEFORMS AND VOLTAGES SHOWN ARE TYPICAL.
 - SOME PRODUCTION RUNS MAY VARY SLIGHTLY FROM THAT SHOWN HERE.
 - PREFIX ALL REFERENCE DESIGNATORS WITH 2000 SERIES. (EXAMPLE: R49 BECOMES R2049.)
 - TO MASTER VOLUME GROUND R103 BOARD 1.

RADIO SHACK  A DIVISION OF TANDY CORPORATION

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CANADA: BARRIE, ONTARIO L4M 4W5

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BILSTON ROAD WEDNESBURY
WEST MIDLANDS WS10 7JN