

I N S T R U C T I O N M A N U A L

Panoramic*

TWO-TONE AUDIO GENERATOR

MODEL TTG-3

Serial No. _____

Instruction Manual No. 110-5033

SINGER
INSTRUMENTATION

Precision electrical and electronic instruments for measurement



THE SINGER COMPANY • METRICS DIVISION

ADDENDUM

for

TWO-TONE AUDIO GENERATOR MODEL TTG-3

1. In figure 5-1:
 - a. Delete capacitors A4C16 and A4C18.
 - b. Change the values of capacitors A4C3 and A4C9 from 0.0024 to 0.0022.
2. In table 6-2:
 - a. Change the entry for "A4C15 THRU A4C18" to read "A4C15."
 - b. Add an entry for A4C17. The description is to read "SAME AS A4C15."
 - c. Change the description of A4C3 to read: "CAPACITOR, FIXED, DIPPED MICA, 2200 PF, PORM 5 PCT, 500 V, SINGER PART NO. 150-2003-222FJO.
 - d. Change the manufacturer's part number for A4C3 to read: DM19F222JO500 WV4CR
 - e. Change the manufacuter's code for A4C3 to read "72136."

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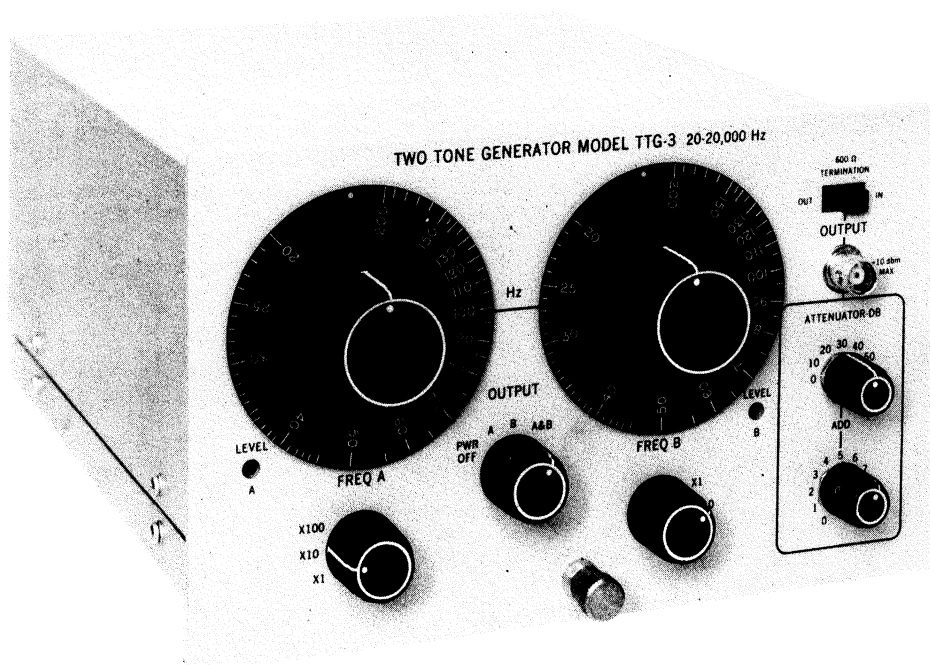


Figure 1-1. Model TTG-3 Two-Tone Audio Generator

SECTION I

INTRODUCTION

1-1. GENERAL.

1-2. This instruction manual provides operating and maintenance instructions for the PANORAMIC* Two-Tone Audio Generator, Model TTG-3 (hereafter referred to as the Generator), manufactured by The Singer Company, Metrics Division. Included in the manual are a general description of the Generator, installation and operating instructions, theory of operation, maintenance information and data, a schematic diagram and a repair parts list. The Generator is illustrated in figure 1-1.

1-3. The information contained in this manual refers to the standard version of the Generator and is current only to the date of publication. Differences in equipment components, specifications and performance resulting from The Singer Company's continuous product improvement program or individual customer design and application requirements are described in addendum sheets.

1-4. PURPOSE AND USE OF THE EQUIPMENT.

1-5. The Generator is a plug-in unit designed to develop a single- or two-tone audio signal of known frequency and amplitude when used in the PANORAMIC Model SSB-50 Single Sideband Analyzer System. Some typical applications of the Generator are listed below:

- a. Single- or two-tone modulation of single sideband transmitters.
- b. Intermodulation distortion measurements.
- c. Harmonic distortion measurements.
- d. Troubleshooting audio systems.

1-6. Inquiries are invited regarding special applications of the Generator to particular requirements. Such inquiries should be directed to the attention of the Applications Engineering Department.

1-7. GENERAL DESCRIPTION.

1-8. The Generator is a completely solid-state plug-in unit that is a source of continuously tunable single- or two-tone audio signals for testing of single sideband transmitters, exciters and audio systems. The frequency range of each test tone is adjustable from 20 Hz to 20 kHz in three decade ranges. The single- or two-tone output of the Generator is available at a front panel BNC jack for application to the system or device under test. Calibrated step attenuators permit adjustment of the output level from +10 to -60 dBm and a switchable internal 600-ohm termination enables the equipment to operate into 600-ohm or high impedance loads. The Generator occupies a half-rack width in the Model MF-50 Main Frame of the Model SSB-50 Single Sideband Analyzer System. Components are mounted on the rear of the front panel and on four printed circuit boards. Operating power for the Generator is provided by the main frame in which it is installed, thereby eliminating the need for an integral power supply.

1-9. SPECIFICATIONS.

1-10. Table 1-1 lists the electrical and physical characteristics of the Generator.

1-11. TRANSISTOR AND DIODE COMPLEMENT.

1-12. The transistor and diode complement of the Generator is given in table 1-2.

TABLE 1-1. SPECIFICATIONS

Frequency range (each tone):	Continuously tunable (in three decade ranges) from 20 Hz to 20 kHz
Frequency accuracy (each tone):	±3% of dial indication
Outputs:	Tone A, Tone B or Tones A and B algebraically summed

(Cont'd)

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TABLE 1-1. SPECIFICATIONS (Cont'd)

Output impedance:	600 ohms (unbalanced) to ground
Maximum power output (each tone):	+10 dBm
Attenuation range:	0 to 70 dB (+10 to -60 dBm), in 1-dB increments
Attenuator accuracy:	0.05 dB/dB, referenced to 0 dB
Flatness:	±0.5 dB from 20 Hz to 20 kHz
Intermodulation distortion:	At least 60 dB below output signal level from 100 Hz to 10 kHz; at least 55 dB below output signal level from 20 Hz to 20 kHz
Harmonic distortion:	At least 60 dB below output signal level from 100 Hz to 10 kHz; at least 55 dB below output signal level from 20 Hz to 20 kHz
Hum and noise:	At least 66 dB below single-tone output signal level
Power requirements:	+15 volts (regulated) at 70 ma. -15 volts (regulated) at 70 ma.
Operating temperature range:	0 to +55°C (32 to 131°F)
Physical characteristics:	
Weight:	4-1/2 pounds
Width:	8-1/4 inches
Height:	5 inches
Depth (behind panel):	10-3/32 inches

TABLE 1-2. TRANSISTOR AND DIODE COMPLEMENT

Reference Designation	Type	Function
Transistors		
A1Q1 and A1Q2	2N3565	Emitter-coupled difference amplifier
A1Q3	2N3638A	Amplifier
A1Q4	2N3642	Emitter follower
A1Q5 and A1Q6	2N3638	Compound emitter follower
A2Q1 and A2Q2	2N3565	Emitter-coupled difference amplifier
A2Q3	2N3638A	Amplifier
A2Q4	2N3642	Emitter follower
A2Q5 and A2Q6	2N3638	Compound emitter follower

(Cont'd)

TABLE 1-2. TRANSISTOR AND DIODE COMPLEMENT (Cont'd)

Reference Designation	Type	Function
Transistors (cont'd)		
A3Q1 and A3Q2	2N3565	Emitter-coupled difference amplifier
A3Q3	2N3638A	Amplifier
A3Q4	2N3642	Emitter follower
A3Q5 and A3Q6	2N3642	Darlington emitter follower
A3Q7	2N3638	Part of complementary emitter follower
A3Q8	2N3642	Part of complementary emitter follower
Diodes		
A3CR1 through A3CR3	1N251	Temperature compensation and crossover distortion elimination diodes

SECTION II

OPERATION

2-1. GENERAL.

2-2. This section contains installation and operating instructions for the Generator. The Generator has been factory tested and aligned and is shipped in a ready-to-operate condition. However, no attempt should be made to install or operate the unit until the operator is thoroughly familiar with the contents of this section. Figure 2-1 is an outline dimension drawing of the Generator.

2-3. INSTALLATION.

2-4. To install a Generator in the Model MF-50 Main Frame, insert the Generator in the cavity and firmly seat it in place. If any resistance is noted while inserting the Generator, withdraw it and

examine the connector on the rear of the Generator and the rear wall of the main frame cavity for proper alignment. Tighten the front panel fastener on the Generator to mechanically secure it to the main frame.

2-5. OPERATION.

2-6. OPERATING CONTROLS AND CONNECTORS. The operating controls and connectors for the Generator are described in table 2-1 and shown in figure 2-2.

2-7. Paragraphs 2-8 through 2-10 describe how to operate the Generator. These procedures assume that power is applied to the unit.

2-8. PRELIMINARY ADJUSTMENTS. Perform the following preliminary adjustments prior to using the Generator.

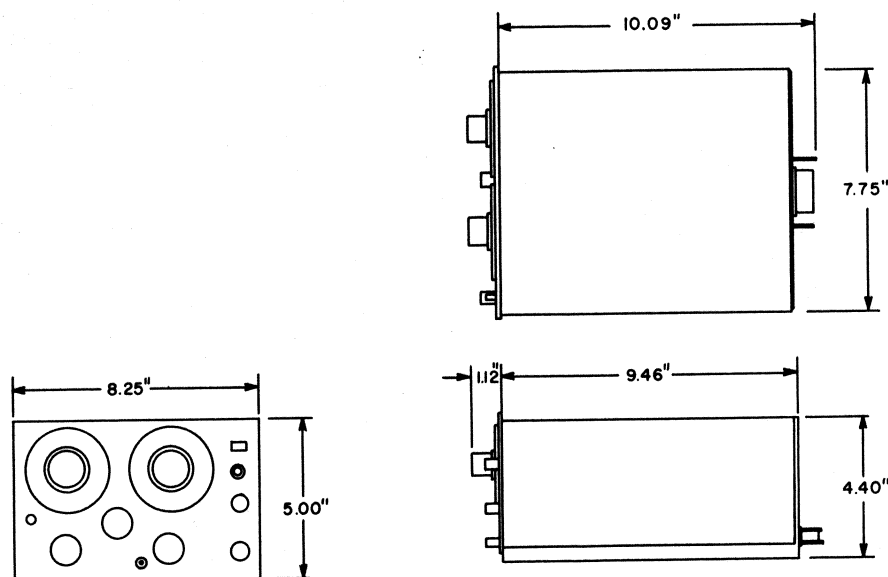


Figure 2-1. Outline Dimension Drawing, Generator

TABLE 2-1. OPERATING CONTROLS AND CONNECTORS

Index No. (Figure 2-2)	Reference Designation	Name	Function
1	S1	FREQ A range multiplier switch	Decade range multiplier for frequency tone A.
2	A4R28	FREQ A screwdriver control	Adjusts output level of tone A at +10 dBm into 600 ohms.
3	R1	FREQ A control and dial	Tunes tone A oscillator (in conjunction with FREQ A range multiplier switch) to any frequency between 20 Hz and 20 kHz.
4	S3	OUTPUT selector switch	Permits operation as either a single-tone or two-tone generator.
5	S2	FREQ B range multiplier switch	Decade range multiplier for frequency tone B.
6	R2	FREQ B control and dial	Tunes tone B oscillator (in conjunction with FREQ B range multiplier switch) to any frequency between 20 Hz and 20 kHz.
7	S5	600 Ω TERMINATION switch	Inserts internal 600-ohm termination (when set to IN) to maintain output level calibration accuracy when operating into high impedance loads.
8	J1	OUTPUT +10 DBM MAX jack	Connector at which the single- or two-tone output of the generator is available for application to external load.
9	A4R29	LEVEL B screwdriver control	Adjusts output level of tone B at +10 dBm into 600 ohms.
10	S4	ATTENUATOR DB decade switch	Attenuates output signal up to 60 dB in 10-dB steps.
11	A4S1	ATTENUATOR DB ADD units switch	Attenuates output signal up to 10 dB in 1-dB steps.
12	-	Fastener	Secures Generator to main frame.

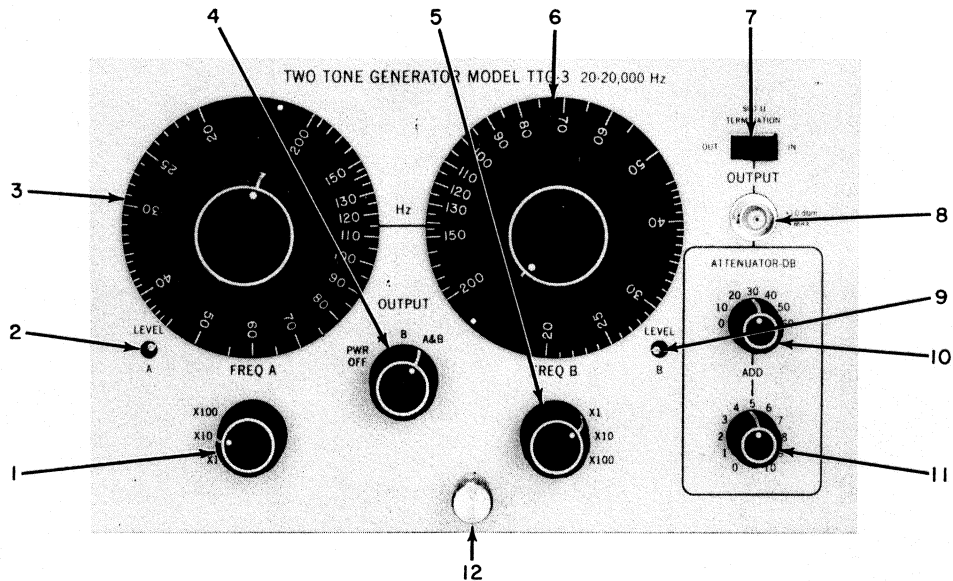


Figure 2-2. Generator Operating Controls and Connectors

- a. Set the ATTENUATOR DB decade and ATTENUATOR DB ADD units switches to 0 and set the 600 Ω TERMINATION switch to IN.
- b. Connect a vtm to the OUTPUT +10 DBM MAX jack and set the OUTPUT selector switch to A.
- c. Adjust the FREQ A control to obtain a dial indication of 100 and set the FREQ A range multiplier switch to X10.
- d. Carefully adjust the LEVEL A screwdriver control to obtain a vtm indication of +10 dBm (2.45 volts into 600 ohms).
- e. Set the OUTPUT selector switch to B.
- f. Adjust the FREQ B control to obtain a dial indication of 100 and set the FREQ B range multiplier switch to X10.
- g. Carefully adjust the LEVEL B screwdriver control to obtain a vtm indication of +10 dBm (2.45 volts into 600 ohms).
- h. Disconnect the vtm. The Generator is ready for operation.
- a. Perform the preliminary adjustments detailed in paragraph 2-8.
- b. Set the OUTPUT selector switch to A.
- c. Set FREQ A dial and the corresponding range multiplier switch to obtain the desired signal frequency.
- d. Set the 600 Ω TERMINATION switch to that position corresponding to the load. (If the output of the Generator is to be coupled to a 600-ohm load, set the 600 Ω TERMINATION switch to OUT. Conversely, if the output is to be coupled to a high-impedance load, set the 600 Ω TERMINATION switch to IN.)
- e. Set the ATTENUATOR DB decade and ATTENUATOR DB ADD units switches to obtain the desired output level (see table 2-2).
- f. Couple the OUTPUT +10 DB MAX jack to the device under test. Note that the Generator may be shut off, without de-energizing the remainder of the system, by setting the OUTPUT selector switch to OFF.

2-9. SINGLE-TONE OUTPUT. Proceed as directed below to obtain a single-tone output.

2-10. TWO-TONE OUTPUT. Proceed as directed below to obtain a two-tone output from the Generator.

TABLE 2-2. DBM (INTO 600 OHMS) TO RMS VOLTS CONVERSION CHART

dBm	Rms Volts	dBm	Rms Volts	dBm	Rms Volts
+10	2.45	-14	1.55×10^{-1}	-38	9.75×10^{-2}
+9	2.18	-15	1.36×10^{-1}	-39	8.68×10^{-3}
+8	1.95	-16	1.23×10^{-1}	-40	7.74×10^{-3}
+7	1.74	-17	1.09×10^{-1}	-41	6.90×10^{-3}
+6	1.55	-18	9.75×10^{-2}	-42	6.15×10^{-3}
+5	1.36	-19	8.68×10^{-2}	-43	5.49×10^{-3}
+4	1.23	-20	7.74×10^{-2}	-44	4.88×10^{-3}
+3	1.09	-21	6.90×10^{-2}	-45	4.35×10^{-3}
+2	9.75×10^{-1}	-22	6.15×10^{-2}	-46	3.86×10^{-3}
+1	8.68×10^{-1}	-23	5.49×10^{-2}	-47	3.46×10^{-3}
0	7.74×10^{-1}	-24	4.88×10^{-2}	-48	3.08×10^{-3}
-1	6.90×10^{-1}	-25	4.35×10^{-2}	-49	2.74×10^{-3}
-2	6.15×10^{-1}	-26	3.86×10^{-2}	-50	2.45×10^{-3}
-3	5.49×10^{-1}	-27	3.46×10^{-2}	-51	2.18×10^{-3}
-4	4.88×10^{-1}	-28	3.08×10^{-2}	-52	1.95×10^{-3}
-5	4.35×10^{-1}	-29	2.74×10^{-2}	-53	1.74×10^{-3}
-6	3.86×10^{-1}	-30	2.45×10^{-2}	-54	1.55×10^{-3}
-7	3.46×10^{-1}	-31	2.18×10^{-2}	-55	1.36×10^{-3}
-8	3.08×10^{-1}	-32	1.95×10^{-2}	-56	1.23×10^{-3}
-9	2.74×10^{-1}	-33	1.74×10^{-2}	-57	1.09×10^{-3}
-10	2.45×10^{-1}	-34	1.55×10^{-2}	-58	9.75×10^{-3}
-11	2.18×10^{-1}	-35	1.36×10^{-2}	-59	8.68×10^{-4}
-12	1.95×10^{-1}	-36	1.23×10^{-2}	-60	7.74×10^{-4}
-13	1.74×10^{-1}	-37	1.09×10^{-2}		

a. Perform the preliminary adjustments detailed in paragraph 2-8.

b. Set the OUTPUT selector switch to A & B.

c. Set the FREQ A control and FREQ A range multiplier switch to obtain one of the desired tones.

d. Set the FREQ B control and FREQ B range multiplier switch to obtain the second desired tone.

e. Set the 600 Ω TERMINATION switch to that position corresponding to the load. (If the output of the Generator is to be coupled to a 600-ohm load, set the 600 Ω TERMINATION switch to OUT. Conversely, if the output is to be coupled to a high impedance load, set the 600 Ω TERMINATION switch to IN.)

f. Set the ATTENUATOR DB decade and ATTENUATOR DB ADD units switches to obtain the desired output level (see table 2-2). Note that, to obtain an output level of -27 dBm, subtract -27 dBm from +10 dBm; this yields a difference of 37 dB.

Therefore, set the ATTENUATOR DB decade switch to 30 and the ATTENUATOR DB units switch to 7.

g. Couple the OUTPUT +10 DBM MAX jack to the device under test. Note that the Generator may be shut off, without de-energizing the remainder of the system, by setting the OUTPUT selector switch to PWR OFF.

2-11. PACKAGING INSTRUCTIONS.

2-12. The following packaging instructions provide information for short-term and long-term storage and shipping of the Generator.

2-13. SHORT-TERM PACKAGING. For short-term packaging, the Generator should be enclosed in a polyethylene bag and placed in a suitable carton for protection. The carton should be stored in a clean and moisture-free area. All accessories and literature should be securely fastened to the equipment.

2-14. LONG-TERM PACKAGING AND PACKAGING FOR SHIPMENT. Figure 2-3 illustrates the packaging procedure for the Generator.

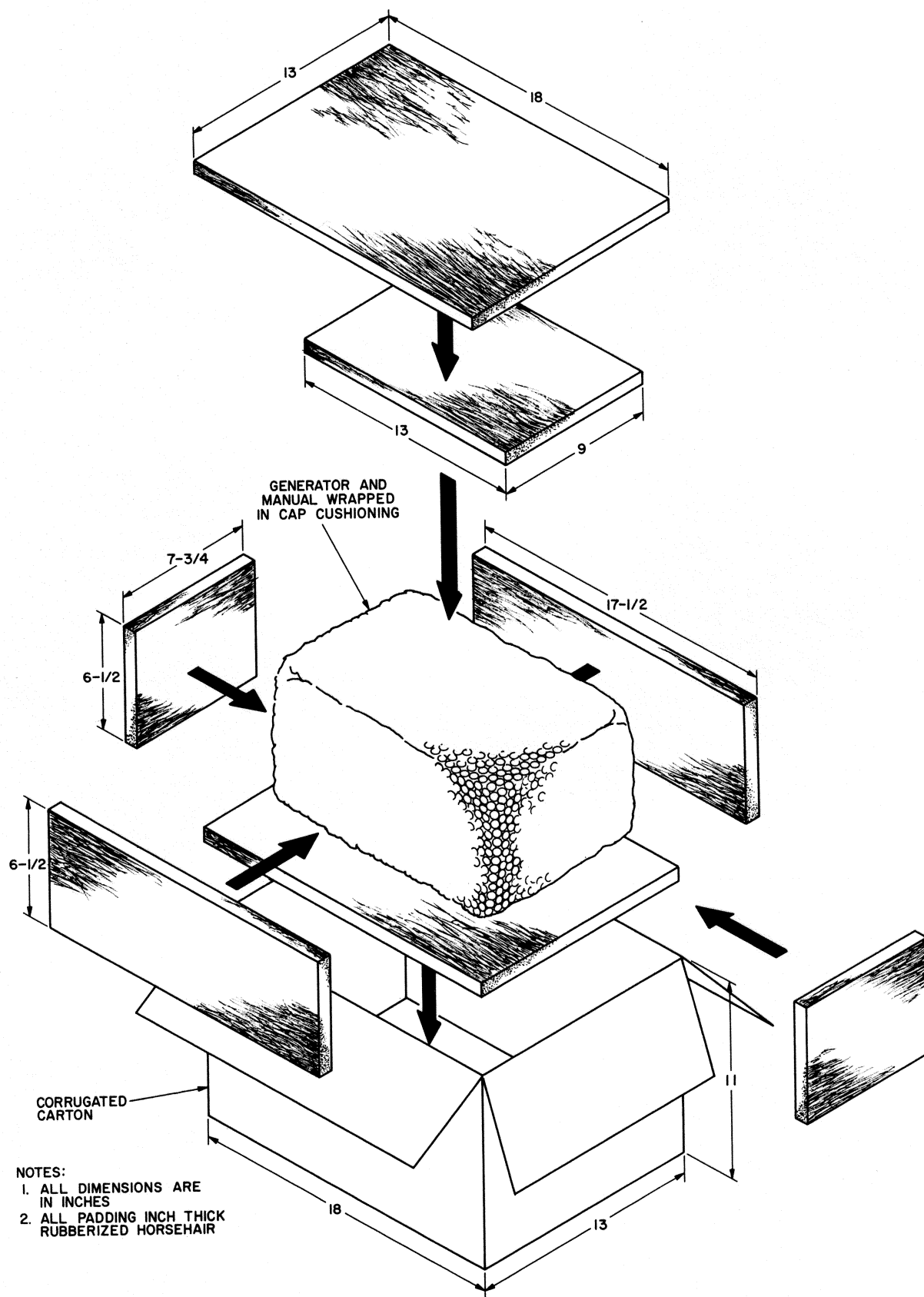


Figure 2-3. Packaging the Generator

SECTION III

THEORY OF OPERATION

3-1. GENERAL.

3-2. This section contains the theory of operation for the Generator. The Generator is a completely solid-state plug-in device that generates either a single-tone or two-tone audio signal, the frequency of each tone being continuously and independently tunable over the frequency range from 20 Hz to 20 kHz. Operating power for the Generator is provided by its associated main frame.

3-3. BLOCK DIAGRAM ANALYSIS.

3-4. The Generator (figure 3-1) consists of two bridged-T oscillators which each develop an audio tone continuously tunable over the frequency range from 20 Hz to 20 kHz. The output of either one or both of the oscillators, determined by the setting of the OUTPUT selector switch, is applied to a summing amplifier. The resulting single-tone or two-tone output of the summing amplifier is coupled to the OUTPUT +10 DBM MAX jack through an attenuator that provides up to 70 dB of signal attenuation. An internal 600-ohm termination is provided to permit the Generator to operate into high impedance loads.

3-5. DETAILED THEORY OF OPERATION.

(See Figures 3-1 and 5-1.)

3-6. The Generator consists of four major sections: two oscillators; summing amplifier; and output attenuator. Each of these is discussed below.

3-7. **OSCILLATORS.** Each oscillator consists of a four-stage amplifier chain containing two feedback loops. Since both the tone A and tone B oscillators are electronically identical, the ensuing discussion will only cover the operation of the tone A oscillator.

3-8. Transistors A1Q1 and A1Q2 form a highly-stable emitter-coupled difference amplifier. The output of a positive feedback loop (refer to paragraph 3-10) is fed back to the base of A1Q1, while that of a negative feedback loop (refer to paragraph 3-9) is applied to the base of A1Q2. The output of the difference amplifier, taken at the collector of A1Q2, is proportional to the difference between the two feedback voltages. This difference voltage is coupled through amplifier A1Q3 and emitter A1Q4 and applied to a compound emitter follower consisting of A1Q5 and A1Q6. This stage is effectively a very low output

impedance emitter follower in which A1Q6 functions as a variable emitter resistance.

3-9. The positive feedback network consists of resistors A1R6 through A1R8 and thermistor A4RT1. Any circuit disturbance (such as component aging or variations in supply voltage) which causes the oscillator output level to increase will simultaneously increase the voltage across the thermistor. This, in turn, will cause the thermistor to dissipate more power with a corresponding increase in temperature. Since thermistors have a negative temperature coefficient of resistance, this rise in power dissipation (temperature) will result in a reduction of the feedback voltage. This action tends to return the oscillator output level to the proper value (refer to paragraph 3-12). Conversely, should the oscillator output level tend to fall off, the feedback voltage will increase to return the level to its proper value.

3-10. The negative feedback path consists of a frequency-selective bridged-T rejection filter. For the purposes of this discussion, it is expedient to redraw the bridged-T network as illustrated in figure 3-2. The full input voltage to the bridged-T rejection filter network (E_{IN}) is applied across R1-C2. (Since the output of the network is applied to the high impedance input of A1Q1, the effects of loading will be neglected.) The output voltage (E_{OUT}) of the bridged-T rejection filter network is the sum of the voltages across R2 and C2. It is readily seen that the sum of the voltages across C1 and R2 is equal to the voltage across R1.

3-11. When the voltage vector E_{IN} is resolved to yield E_{R1} and E_{C2} and when E_{R1} is resolved to yield E_{R2} and E_{C1} (see figure 3-2b), it may be shown that, for proper component values, the vector sum of E_{R2} and E_{C2} ($= E_{OUT}$) will be a minimum for only one frequency (f_0). A composite plot of the transfer function and phase characteristics of the bridged-T network as a function of frequency is illustrated in figure 3-2c. For the given component values there will be the frequency f_0 where transmission through the network will be a minimum and the total phase shift will be 0° .

3-12. At frequency f_0 , the null in the negative feedback path results in an overall closed-loop gain of slightly greater than unity, thereby enabling the circuit to sustain oscillations at the selected frequency. Vernier control of the oscillator is achieved by varying the resistance in the arms of the bridged-T network, while decade ranging is accomplished by switching the capacitive elements.

Section III Theory of Operation

3-13. **SUMMING AMPLIFIER.** The output of the selected oscillator is coupled through OUTPUT selector switch S3 and applied to a resistive summing network consisting of A3R1, A3R2 and feedback resistor A3R19. LEVEL A screwdriver control A4R28 and LEVEL B screwdriver control A3R29 are in series with the selected signal and serve to adjust the output level of each oscillator to obtain a calibrated output level of +10 dBm when the oscillator is tuned to 1 kHz. The summed signal voltage is applied to the base of an emitter-coupled difference amplifier (A3Q1 and A3Q2) and the output of the amplifier, taken at the collector of A3Q2, is coupled through amplifier A3Q3 and emitter follower A3Q4 to the output stage.

3-14. The output stage consists of a Darlington-type emitter follower (A3Q5 and A3Q6) and a complementary-pair emitter follower (A3Q7 and A3Q8) which function essentially as a totem pole amplifier. Diodes A3CR1 through A3CR3 develop a small forward bias voltage for the bases of A3Q5 and A3Q7 to eliminate unwanted cross-over distortion. Low distortion, an extremely flat frequency response and a low output impedance is achieved through the use of negative

feedback. The overall gain of the summing amplifier is adjustable over a range of 10 dB (in 1-dB increments independent of the setting of the decade step attenuator) by means of ATTENUATOR DB ADD switch A4S1 and associated circuitry, which adjusts the shunting resistance across feedback resistor A3R19.

3-15. **OUTPUT ATTENUATOR.** The output of the summing amplifier is coupled to OUTPUT +10 DBM MAX jack J1 through a 60-dB step attenuator. When ATTENUATOR DB switch S4 is set to any position other than 0, the output impedance of the Generator, seen looking back into the attenuator, is 600 ohms. When the ATTENUATOR DB switch is set to 0, the Generator has a very low output impedance and approximates an ideal voltage source.

3-16. Operation of the Generator into a high impedance load requires that a 600-ohm terminating resistor be inserted to maintain the calibration accuracy of the equipment. This termination is provided by 600 Ω TERMINATION switch S5 which, when set to IN, ties R5 to the output of the decade step attenuator.

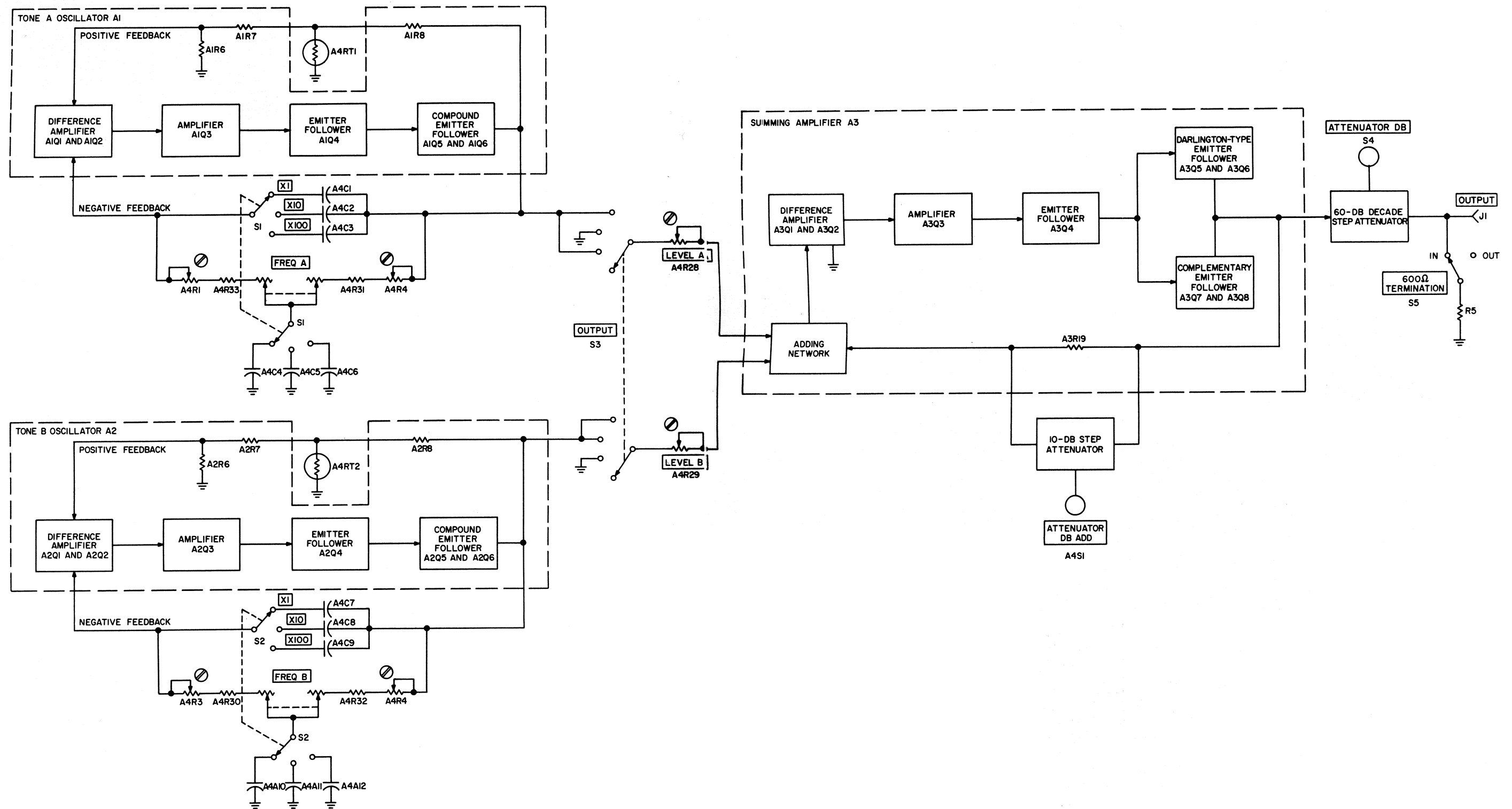
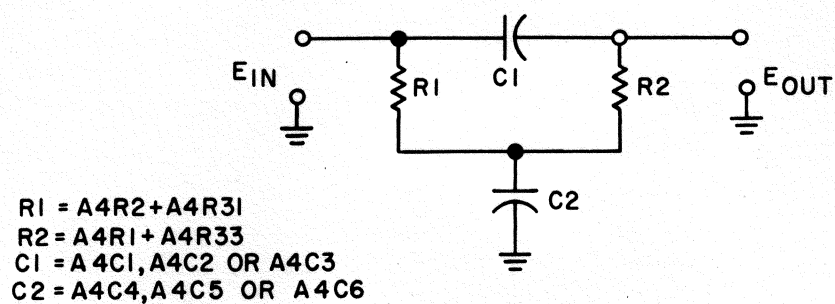
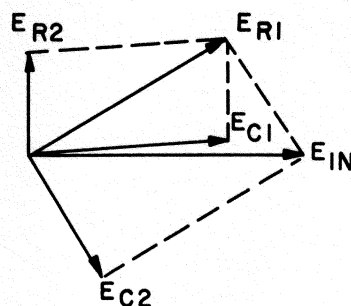


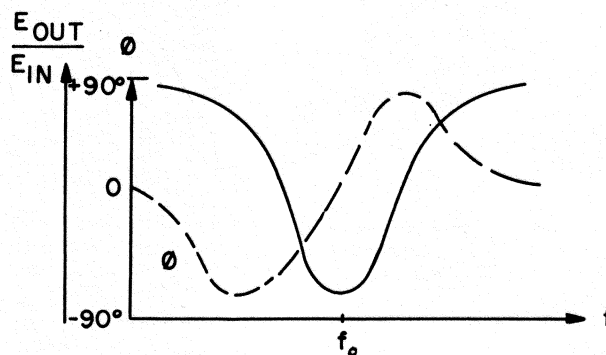
Figure 3-1. Generator, Block Diagram



a. Redrawn Bridged-T Network



b. Vector Diagram



c. Transfer and Phase Characteristics

Figure 3-2. Bridged-T Circuit Analysis.

SECTION IV MAINTENANCE

4-1. GENERAL.

4-2. This section contains maintenance instructions for the Generator. No attempt should be made to repair internal components or make adjustments until the operator is thoroughly familiar with the information contained in this section.

4-3. The performance of the Generator may be checked using the minimum performance standards checks provided to determine whether the equipment is operating within published specifications. A systematic troubleshooting procedure to isolate the trouble in the Generator and an alignment procedure to restore the equipment to proper operating condition after the required repairs have been effected are also included in this section.

4-4. TEST EQUIPMENT REQUIRED.

4-5. The test equipment required for the maintenance and alignment of the Generator is listed in table 4-1. Equipment having similar characteristics may be substituted for those listed in the table.

4-6. PRELIMINARY INSPECTION.

4-7. Preliminary inspection of the equipment is performed with the Generator removed from the main frame and without operating power applied. This type of check is designed to detect conditions that might otherwise lead to a breakdown. Frequent causes of equipment failure are overheating of components due to improper ventilation, accumulation of dust and dirt and/or loose connections and fittings. Inspection is carried out with emphasis on finding evidence of these conditions.

4-8. COMPONENT LOCATIONS. The location of components mentioned in the inspection routines, alignment and troubleshooting procedures are illustrated in figure 4-1.

4-9. PRELIMINARY INSPECTION ROUTINE. Table 4-2 lists the preliminary inspection routine for the Two-Tone Generator.

4-10. MINIMUM PERFORMANCE STANDARDS.

4-11. The minimum performance standards checks listed in table 4-3 provide a rapid, convenient means of ascertaining proper Generator operation. These

TABLE 4-1. TEST EQUIPMENT REQUIRED

Type of Equipment	Suggested Manufacturer Name and Model No.	Use
Frequency Counter	General Radio Model 1153-A	Frequency calibration
Oscilloscope	Tektronix Model 503	General waveform analysis
Vtvm	RCA Model WV-98C	Voltage measurements
Wave Analyzer	Hewlett-Packard Model 302A	Measuring harmonic and intermodulation components
Signal Generator	General Radio Model 1210-C	Troubleshooting
AC Vtvm	Ballantine Model 303	Measuring flatness and accuracy of output attenuator

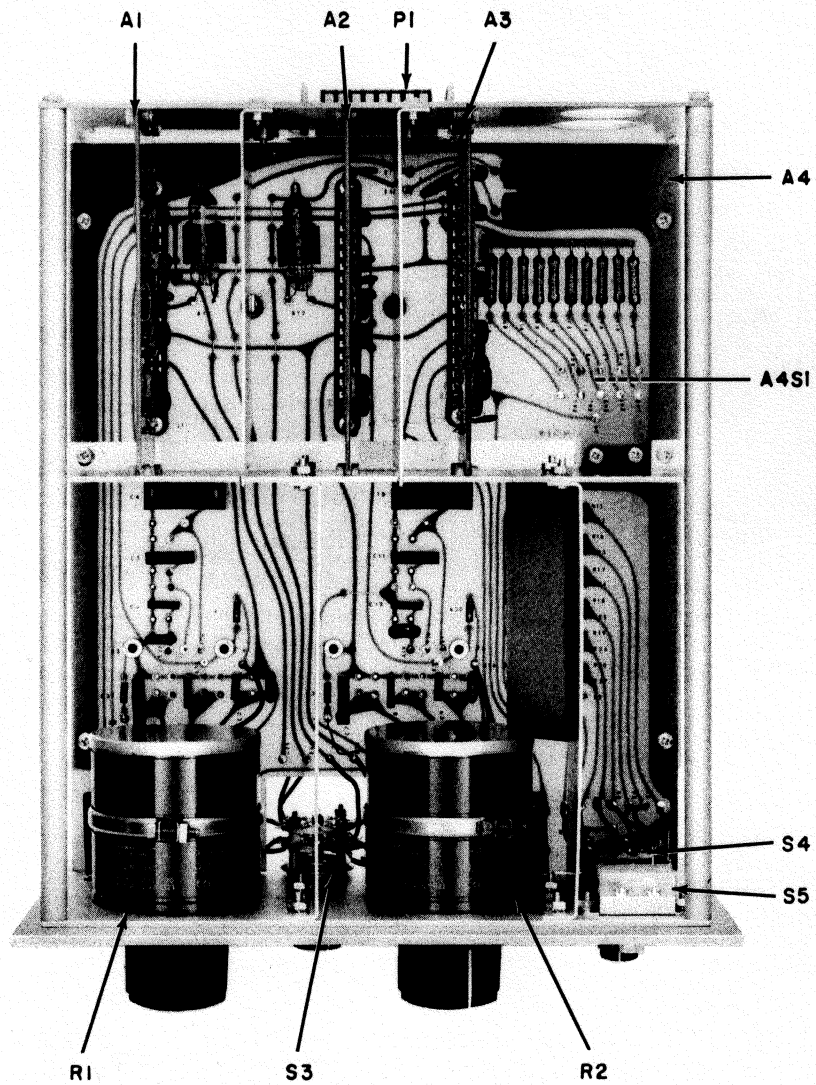


Figure 4-1. Generator, Top View

TABLE 4-2. PRELIMINARY INSPECTION ROUTINE

Item	Inspect For	Corrective Action
Plug P1 at rear of Generator	Looseness, bent or corroded contacts, signs of arcing	Clean contacts with cloth moistened with cleaning solvent (trichloroethylene or equivalent). Replace plug if damaged.
Generator case and panels	Dirt and Corrosion	Replace jack if damaged or corroded. Clean with cloth moistened with cleaning solvent (trichloroethylene or equivalent).
Knobs, screws, connectors, clamps	Looseness	Tighten using appropriate torque so as not to strip threads.
Switches	Looseness	Tighten mounting screws or nut.
Wiring	Looseness Frayed, worn, or missing insulation	Resolder, recable, or reclamp. Rewire as required.
Solder joints	Loose or cold solder connections; corrosion	Clean carefully and resolder.
Printed circuit boards	Mounting looseness Loose components	Replace mating plug if required. Resolder loose components.
Resistors	Cracks, chipping, blistering, discoloration, and other signs of overheating	Replace resistor and ensure that overheating is not due to other defective components.
Capacitors	Leaks, bulges, signs of aging Loose mounting bracket	Replace capacitor. Tighten nuts or screws holding bracket.
Switch contacts	Dirt, dust, and/or corrosion Bent or broken contacts	Clean with cloth, aerosol spray, syringe or camel-hair brush using trichloroethylene or equivalent. Replace switch wafer or assembly.
Transistors	Looseness	Tighten clips.

checks are performed with the Generator operating in the Model SSB-50 Single Sideband Analyzer System (or equivalent). The quality of these checks presupposes that the MF-50 is operating within acceptable limits, thus, procedures in the technical manual for the MF-50 should be performed prior to performing the checks. Before performing these

checks, position the controls of the SSB-50 system as indicated below:

- a. On the MF-5:
SCALE ILLUMINATION-OFF control OFF
- b. On the MF-50:
Power switch OFF

TABLE 4-3. MINIMUM PERFORMANCE STANDARDS CHECKS

Step	Purpose	Procedure	Acceptable Indication
1	To check frequency accuracy of tone A and B oscillators.	a. Connect the frequency counter to the OUTPUT +10-DBM MAX jack and set the OUTPUT selector switch to A. Observe indication on frequency counter. b. Repeat step 1a for all numerical markings on FREQ A control (25, 30, 35, etc.). c. Set the FREQ A range multiplier switch to X10 and repeat steps 1a and 1b. d. Set the FREQ A range multiplier switch to X100 and repeat steps 1a and 1b. e. Set the OUTPUT selector switch to B and repeat steps 1a through 1d, using corresponding controls of tone B oscillator.	Frequency counter reads within $\pm 3\%$ of selected frequency.
2	To check flatness of tone A and B oscillators.	a. Set the OUTPUT selector switch to A, the FREQ A control to 100 and the FREQ A range multiplier switch to X10. Disconnect the frequency counter and connect the AC vtvm to the OUTPUT +10DBM MAX jack. Adjust the LEVEL A screwdriver control to obtain a 2.45 volts rms indication (or +10 dBm) on the AC vtvm. b. While observing the indication on the AC vtvm, slowly adjust the FREQ A control through its entire range. c. Set the FREQ A range multiplier switch to X1 and repeat step 2b. d. Set the FREQ A range multiplier switch to X100 and repeat step 2b. e. Set the OUTPUT selector switch to B, the FREQ B control to 100, and the FREQ B range multiplier switch to X10. Repeat steps 2a through 2d, using corresponding controls of the B oscillator.	AC vtvm indicates 2.45 volts rms at 1000Hz and variation thereafter does not vary more than $\pm 0.5\text{dB}$ as FREQ A or FREQ B control is adjusted through its entire range. Note Disregard transient amplitude fluctuations as the FREQ A or FREQ B control is adjusted.

(Cont'd)

TABLE 4-3. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont'd)

Step	Purpose	Procedure	Acceptable Indication
3	To check accuracy of output attenuator.	a. Set the OUTPUT selector switch to B, and FREQ B control to 100, and the FREQ B range multiplier switch to X10. Observe that with the ATTENUATOR DB decade and ATTENUATOR DB ADD switches set to 0, the AC vtvm (connected as in step 2) indicates 2.45 volts rms. While observing the AC vtvm, vary the ATTENUATOR DB ADD switch in 1-dB steps from 0 to 10. b. Return the ATTENUATOR DB ADD switch to 0 dB. While observing the indication on the AC vtvm, vary the ATTENUATOR DB switch in 10-dB steps from 0 to 60.	a. Ac vtvm indication decreases in 1-dB steps (approximately) as the ATTENUATOR DB ADD switch is increased in 1-dB steps from 0dB. b. Ac vtvm indication decreases in 10-dB steps ($\pm 0.5\text{dB/dB}$) as the ATTENUATOR DB switch is increased in 10-dB steps from 0dB.
4	To check harmonic distortion.	a. Disconnect the AC vtvm and connect a wave analyzer to the $\pm 10\text{DBM}$ MAX jack. Set the FREQ A control to 100, the FREQ A range multiplier to X10, the OUTPUT selector switch to A, and the ATTENUATOR DB decade and ATTENUATOR DB ADD units switches to 0. Tune the wave analyzer to the selected frequency and record the wave analyzer indication. Then tune the wave analyzer to the second and third harmonics of the selected frequency and note the wave analyzer indication. b. Repeat step 4a for tone A frequencies of 2kHz, 5kHz, and 10kHz. c. Repeat step 4a for a tone A frequency of 20kHz. d. Repeat steps 4a through 4c for the tone B oscillator.	a. Harmonic distortion is at least 60dB below the selected frequency. b. Same as step 4a. c. Harmonic distortion is at least 55dB below the selected frequency. d. Same as steps 4a through 4c.
5	To check intermodulation distortion.	a. With the wave analyzer still connected to the $\pm 10\text{DBM}$ MAX jack, set the tone A oscillator frequency to 5kHz and the tone B oscillator frequency to 7kHz. Set the ATTENUATOR DB decade and ATTENUATOR DB ADD units switches to 0 and the OUTPUT selector switch to	a. All intermodulation distortion products are at least 60dB down.

(Cont'd)

TABLE 4-3. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont'd)

Step	Purpose	Procedure	Acceptable Indication
5 (Cont'd)		AB. Adjust the wave analyzer for a reference level and then measure the amplitudes of the following distortion products: 2kHz; 3kHz; 9kHz; and 12kHz. b. Repeat step 5a with tone A and B frequencies of 18kHz and 20kHz, respectively, and measure the amplitudes of the following distortion products: 2kHz; 16kHz; 22kHz, and 38kHz.	b. All intermodulation distortion products are at least 55dB down.

c. On the Generator:

OUTPUT selector switch	PWR OFF
600 Ω TERMINATION switch	IN
FREQ A control	20
FREQ A range multiplier switch	X1
FREQ B control	20
FREQ B range multiplier switch	X1
ATTENUATOR DB decade switch	0
ATTENUATOR DB ADD units switch	0

a. No tone A signal is obtainable but a tone B signal can be obtained.

b. No tone B signal is obtainable but a tone A signal can be obtained.

c. Neither tone A nor tone B signal is obtainable.

Before referring to table 4-4 for problems a or b above (only one of the tones is obtainable), interchange boards A1 and A2 to quickly determine whether the malfunction is on board A1 (or A2). If it is, troubleshoot the particular board using the corresponding procedure (symptom 1 of 2) in table 4-4. If it isn't, check the components and connections on mother board A4 which relate to the missing tone. Also check the front panel controls and switches affecting the defective circuit.

4-12. POWER SUPPLY CHECK.

4-13. Before proceeding with systematic troubleshooting of the Generator, the +15 vdc and -15 vdc input voltages from the main frame should be checked. This check will usually determine whether abnormal d-c voltages are causing the malfunction. To check these voltages, remove the Generator from the main frame and connect d-c power to it using the service cable provided with the SSB-50 system. Remove the top cover and use the RCA Model WV-98C VTVM to measure the +15 vdc supply voltage between pin P1-2 (positive) and P1-9 (negative); and the -15 vdc supply voltage between pin P1-11 (negative) and P1-9 (positive).

4-14. SYSTEMATIC TROUBLE LOCALIZATION.

4-15. Three possible troubles are presented in table 4-4 to illustrate a systematic approach to the isolation of trouble within the Generator. This procedure is performed with the Generator operating in an SSB-50 system and connected to the Model MF-50 Main Frame via the supplied service cable. Note that full use is made of the maintenance information in the manual (e.g., the block diagram, the voltage charts and the schematic diagram).

4-16. The three possible problems that will be considered are:

4-17. FREQUENCY CALIBRATION.

4-18. To calibrate the frequency of either oscillator, proceed as directed in the following steps.

Note

The information contained within parenthesis applies to the tone B oscillator, and immediately follows the corresponding data applicable to the tone A oscillator.

a. With the ATTENUATOR DB decade and ATTENUATOR DB ADD units switches set to 0 and the 600 Ω TERMINATION switch set to IN, connect a frequency counter to the OUTPUT +10DBM MAX jack. Set the OUTPUT selector switch to A (B).

b. Set the FREQ A (FREQ B) range multiplier switch to X10 and rotate the FREQ A (FREQ B) control fully clockwise. At the fully clockwise position of the FREQ A (FREQ B) control, the dot on the FREQ A (FREQ B) dial should line up with the fiducial marker on the front panel. If not, loosen the setscrew that secures the FREQ A (FREQ B) knob to its control shaft and remove the knob.

TABLE 4-4. SYSTEMATIC TROUBLE LOCALIZATION

No.	Symptom	Test Procedure	If Indication Is Normal	If Indication Is Abnormal
1	No tone A signal is obtainable but a tone B signal can be obtained.	a. Set the OUTPUT selector switch to PWR OFF and withdraw tone A oscillator board A1. Insert the extender board (supplied with the SSB-50 system) into the vacated connector and mount A1 atop the extender board. Ground the base of A1Q2 and connect an audio generator (tuned to 1 kHz) to the base of A1Q1 through a 1-uf capacitor. Connect an oscilloscope to the base of A1Q1. Adjust the FREQ A control and FREQ A range multiplier switch for a Generator frequency of 1 kHz. Set the OUTPUT selector switch to A and adjust the signal generator output level to obtain a 10-millivolt peak-to-peak signal, as displayed on the oscilloscope. b. Connect the oscilloscope to the collector of A1Q1 and note the display; it should be a sinusoidal waveform having a peak-to-peak amplitude of approximately 75 millivolts. c. Connect the oscilloscope to the collector of A1Q2 and note the oscilloscope display; it should be a sinusoidal waveform having a peak-to-peak amplitude of approximately 70 millivolts. d. Connect the oscilloscope to the collector of A1Q3 and note the display; it should be a sinusoidal waveform having a peak-to-peak amplitude of approximately 13 volts. e. Connect the oscilloscope to the emitter of A1Q6 and note the display; it should be a sinusoidal waveform having a peak-to-peak amplitude of approximately 13 volts.	b. Go to step c. c. Go to step d. d. Go to step e. e. Check S1 and associated circuitry.	b. Check A1Q1 and associated circuitry. c. Check A1Q2 and associated circuitry. d. Check A1Q3 and associated circuitry. e. Check A1Q4, A1Q5, A1Q6 and associated circuitry.

(Cont'd)

TABLE 4-4. SYSTEMATIC TROUBLE LOCALIZATION (Cont'd)

No.	Symptom	Test Procedure	If Indication Is Normal	If Indication Is Abnormal
2	No tone B signal is obtainable but a tone A signal can be obtained.	a. Set the OUTPUT selector switch to PWR OFF and withdraw tone B oscillator board A2. Insert the extender board into the vacated connector and mount A2 atop the extender board. Ground the base of A2Q2 and connect an audio oscillator (tuned to 1 kHz) to the base of A2Q1 through a 1-uf capacitor. Connect an oscilloscope to the base of A2Q1. Adjust the FREQ B control and FREQ B range multiplier switch for a Generator frequency of 1 kHz. Set the OUTPUT selector switch to B and adjust the signal generator output level to obtain a 10-millivolt peak-to-peak signal, as displayed on the oscilloscope. b. Connect the oscilloscope to the collector of A2Q1 and note the display; it should be a sinusoidal waveform having a peak-to-peak amplitude of approximately 75 millivolts. c. Connect the oscilloscope to the collector of A2Q2 and note the display; it should be a sinusoidal waveform having a peak-to-peak amplitude of approximately 70 millivolts. d. Connect the oscilloscope to the collector of A2Q3 and note the display; it should be a sinusoidal waveform having a peak-to-peak amplitude of approximately 13 volts. e. Connect the oscilloscope to the emitter of A2Q6 and note the display; it should be a sinusoidal waveform having a peak-to-peak amplitude of approximately 13 volts.	b. Go to step c. c. Go to step d. d. Go to step e. e. Check S2 and associated circuitry.	b. Check A2Q1 and associated circuitry. c. Check A2Q2 and associated circuitry. d. Check A2Q3 and associated circuitry. e. Check A2Q4, A2Q5, A2Q6 and associated circuitry.

(Cont'd)

TABLE 4-4. SYSTEMATIC TROUBLE LOCALIZATION (Cont'd)

No.	Symptom	Test Procedure	If Indication Is Normal	If Indication Is Abnormal
3	Neither tone A nor tone B signal is obtainable.	a. Check tone A oscillator board A1 (refer to 1 above). Check tone B oscillator board A2 (refer to 2 above). b. With oscillator boards A1 and A2 properly seated in their receptacles, adjust the Generator for a single-tone output at 1 kHz. Connect an oscilloscope to the collector of A3Q1 and note the oscilloscope display; it should be a sinusoidal waveform having a peak-to-peak amplitude of approximately 0.03 volts. c. Withdraw summing amplifier board A3. Insert the extender board into the vacated connector and mount A3 atop the extender board. Connect the oscilloscope to the collector of A3Q2 and note the display; it should be a sinusoidal waveform having a peak-to-peak amplitude of approximately 0.03 volts. d. Connect the oscilloscope to the A4J3-S and note the display; it should be a sinusoidal waveform having a peak-to-peak amplitude of approximately 7 volts.	a. Go to step b. b. Go to step c. c. Go to step d. d. Check attenuator circuitry.	a. Effect the necessary repairs and/or replacements. b. Check S3A, A4R28 and associated circuitry (if tone A oscillator is being employed); check S3A, A4R29 and associated circuitry (if tone B oscillator is being employed). Check A3Q1 and associated circuitry. c. Check A3Q2 and associated circuitry. d. Check A3Q5, A3Q6, A3Q7, A3Q8 and associated circuitry.

With the knob removed, loosen the two setscrews that secure the setting of the dial to the shaft. Exercise extreme care not to rotate the shaft while slipping the dial. Once the dial has been slipped, carefully tighten the two setscrews to secure the dial to the shaft.

- c. Adjust A4R2 (A4R4) fully counterclockwise.
- d. Set the FREQ A (FREQ B) control until 200 on the dial lines up with the fiducial marker on the front panel. Then adjust R1 (R3) until the frequency counter indicates 2000 Hz.
- e. Rotate the FREQ A (FREQ B) control shaft to obtain a dial indication of 20 and note the counter indication; it should read between 194 and 206 Hz.
- f. Rotate the FREQ A (FREQ B) control shaft to obtain a dial indication of 200 and set the FREQ A (FREQ B) range multiplier switch to X100. Note and record the counter indication; it should be between

19,400 and 20,600 Hz. If it does not read between these limits, continue to step h.

- g. Rotate the FREQ A (FREQ B) control shaft to obtain a dial indication of 20. Note the counter indication; it should read between 1,940 and 2,060 Hz.
- h. Rotate the FREQ A (FREQ B) control shaft to obtain a dial indication of 200 and set the FREQ A (FREQ B) range multiplier switch to X1. Note and record the counter reading; it should read between 194 and 206 Hz. If it does not, proceed to step j.
- i. Rotate the FREQ A (FREQ B) control shaft to obtain a dial indication of 20. Note the counter indication; it should read between 19.4 and 20.6 Hz.
- j. Divide the counter reading recorded in step f by 10. Multiply the counter reading recorded in step h by 10. Add these two frequencies to 2000 and divide the total by 3. Record this frequency.

k. Set the FREQ A (FREQ B) range multiplier switch to X10 and rotate the FREQ A (FREQ B) control shaft to obtain a counter indication equal to that recorded in step j.

l. Slip the dial, as directed in step b, to obtain an indication of 200.

m. Repeat steps b through l until the frequency calibration accuracy of $\pm 3\%$ is obtained over the entire 20 Hz to 20 kHz range.

n. Replace the knob on the control shaft and secure the knob by tightening its setscrew.

4-19. VOLTAGE MEASUREMENTS.

4-20. Voltage measurements for each of the transistor stages in the Generator are given in tables 4-5 and 4-6. These voltages were obtained using an RCA Model WV-98C vtvm and the Generator adjusted to produce a single-tone output of 10 kHz.

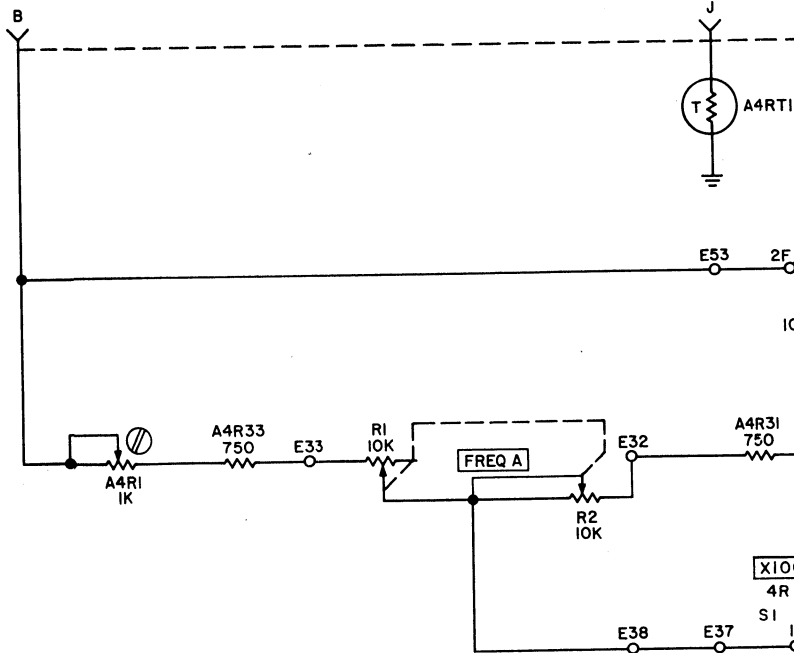
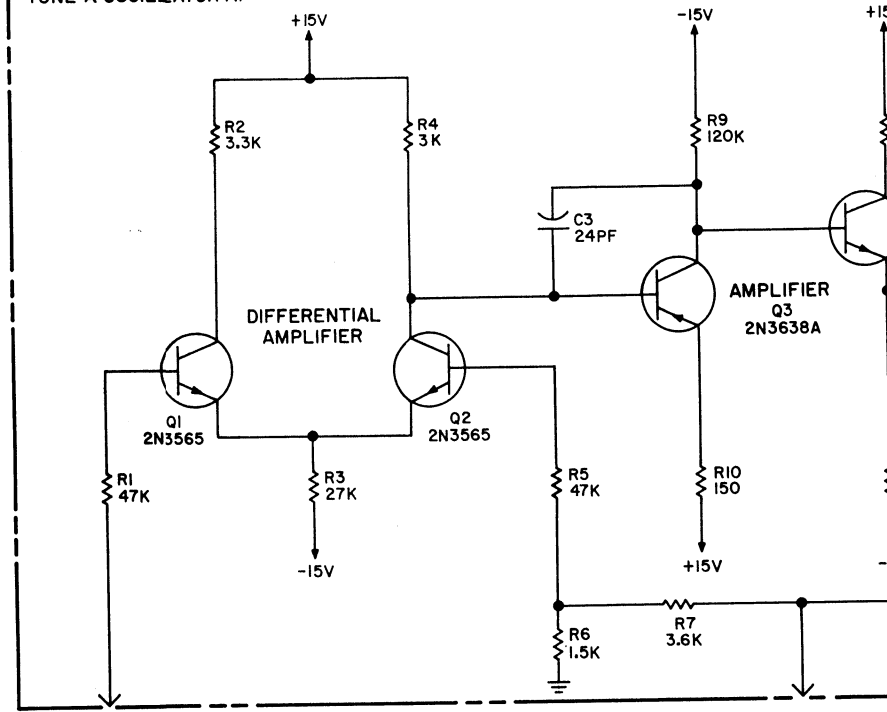
TABLE 4-5. VOLTAGE MEASUREMENTS, OSCILLATOR BOARDS A1 AND A2

Reference Designation	Transistor Type	Terminal Voltage		
		Emitter	Base	Collector
Q1	2N3565	-0.6	0	+13.8
Q2	2N3565	-0.6	0	+14.3
Q3	2N3638A	+14.8	+14.3	0
Q4	2N3642	-0.6	0	+14
Q5	2N3638	+12.6	+12	0
Q6	2N3638	0	-0.6	-11.4

TABLE 4-6. VOLTAGE MEASUREMENTS, SUMMING AMPLIFIER BOARD A3

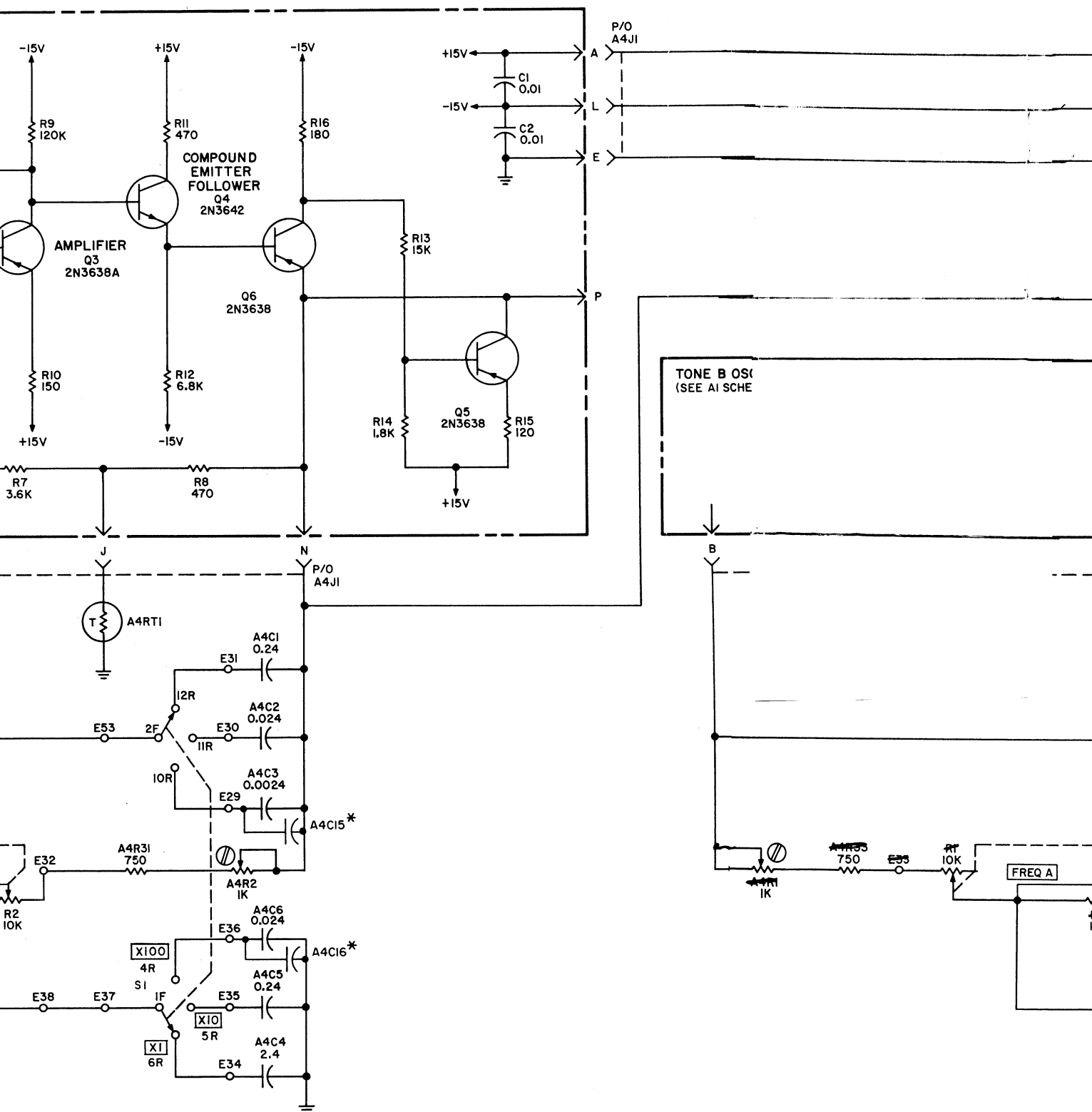
Reference Designation	Transistor Type	Terminal Voltage		
		Emitter	Base	Collector
Q1	2N3565	-0.5	0	+13.7
Q2	2N3565	-0.5	0	+14.3
Q3	2N3638A	+15	+14.3	+0.9
Q4	2N3642	+0.2	+0.9	+13.1
Q5	2N3642	+0.75	+1.3	+14.7
Q6	2N3642	+1.8	+0.75	+14.5
Q7	2N3638	+0.15	-0.4	-14.3
Q8	2N3642	-14.7	-14.3	+0.15

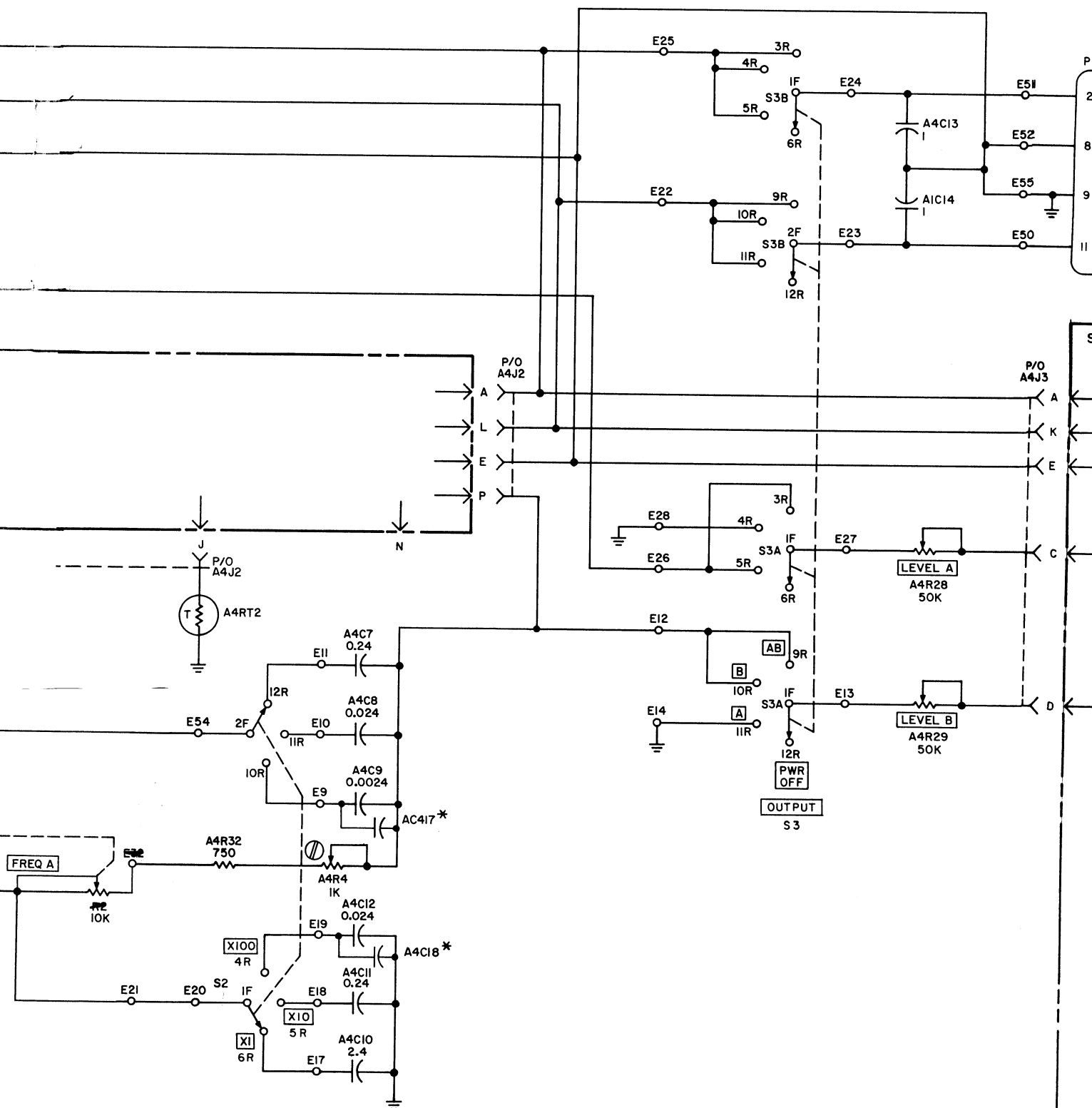
TONE A OSCILLATOR A1

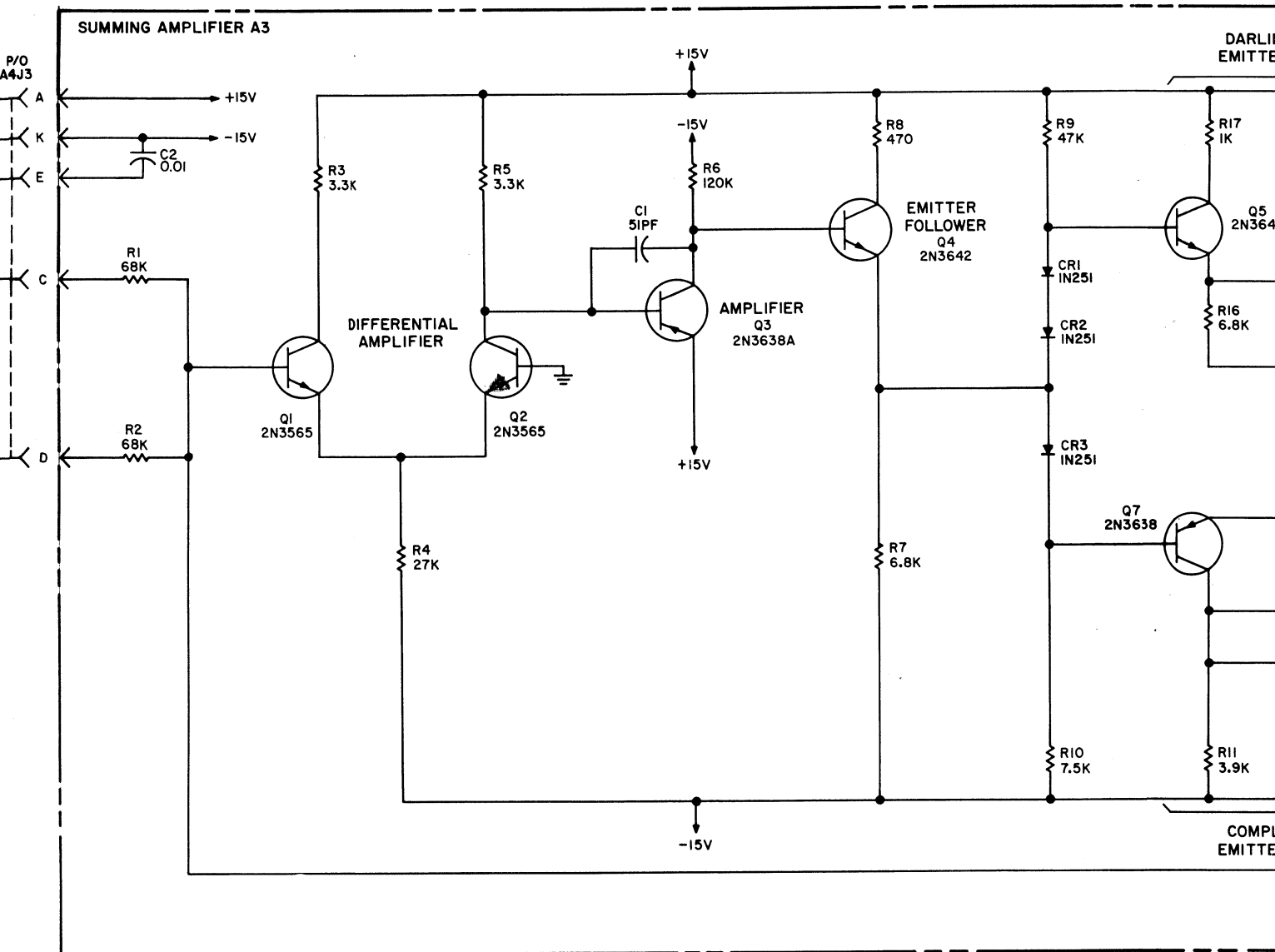
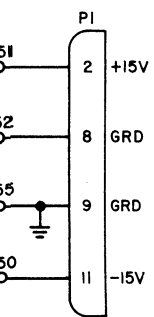


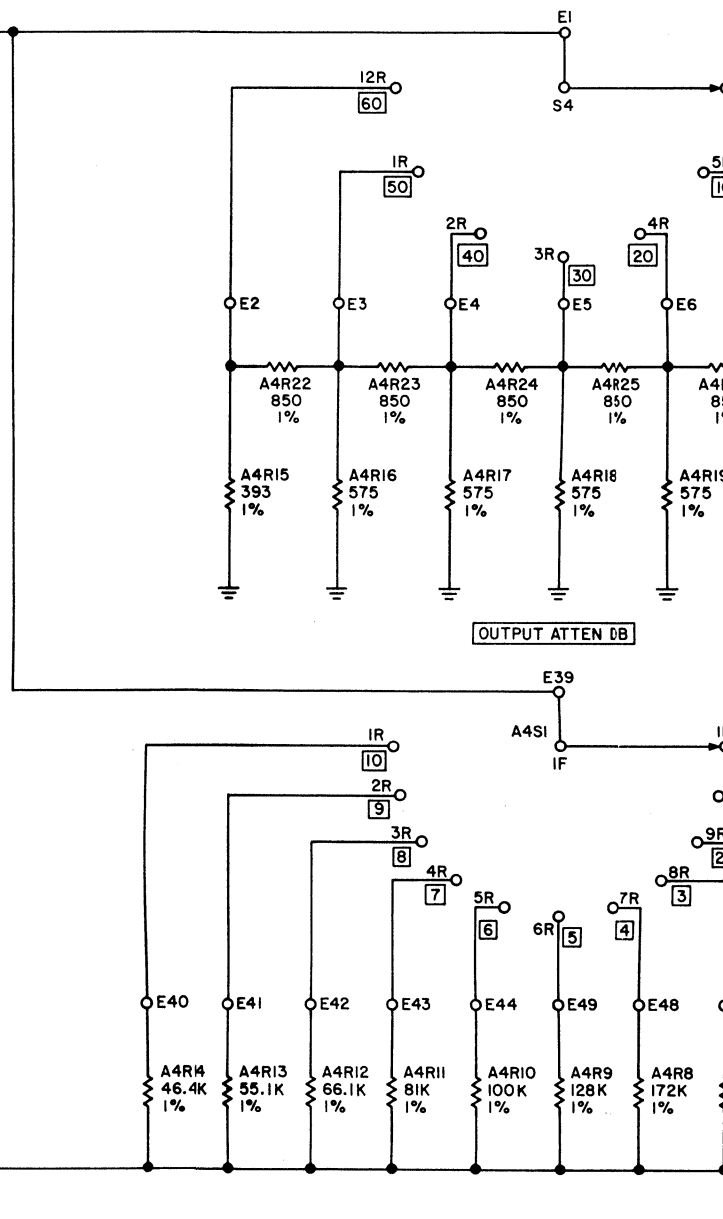
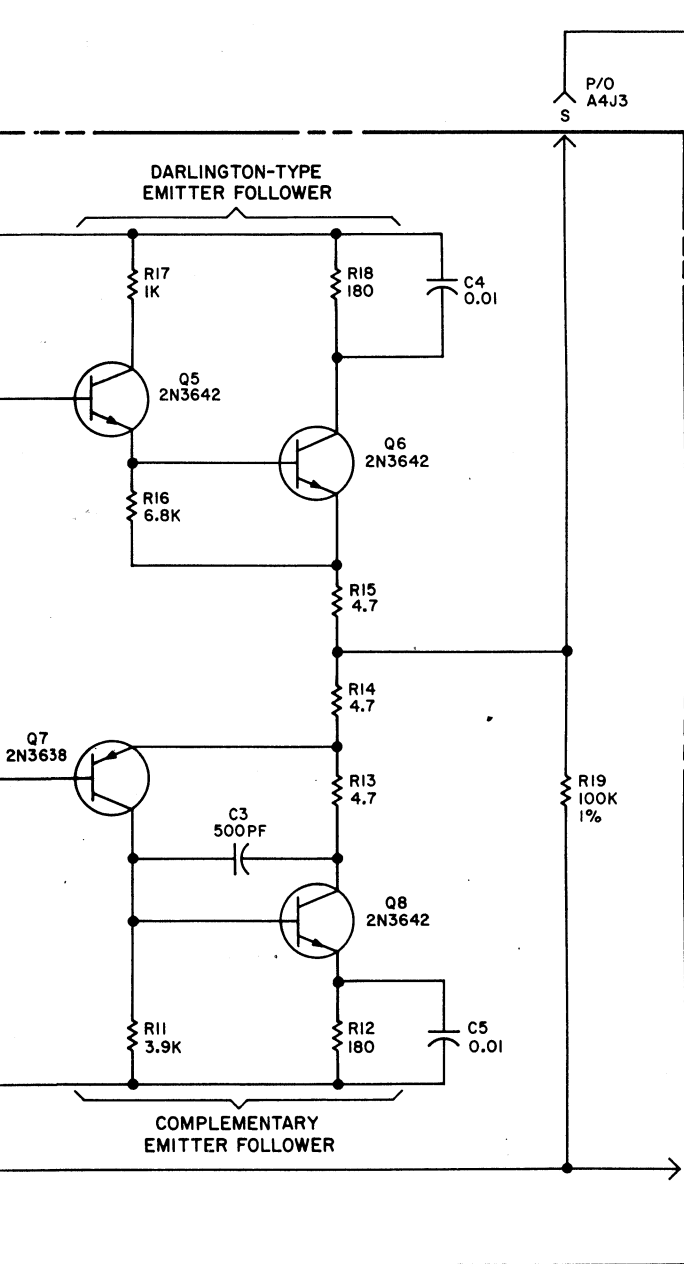
106-0502 100

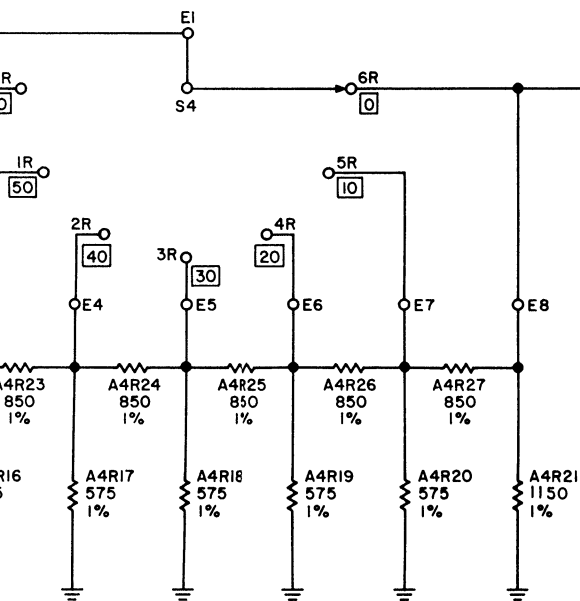
X10
4R
S1
X
61



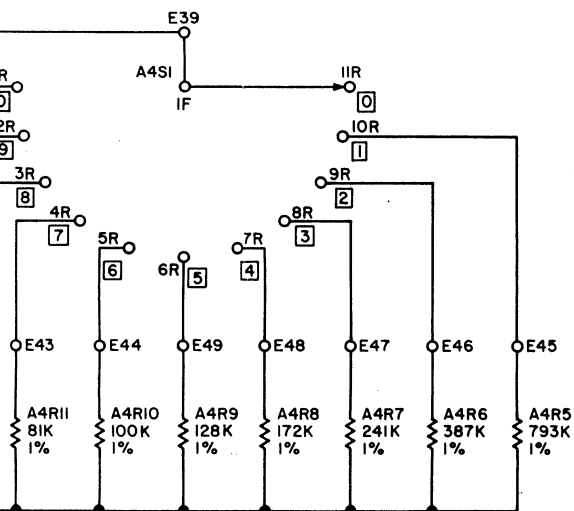








OUTPUT ATTEN DB



NOTES:

1. UNLESS OTHERWISE SPECIFIED:
ALL RESISTANCE VALUES ARE IN OHMS, $\pm 5\%$, 1/4 WATT
CAPACITANCE VALUES ARE IN MICROFARADS
2. INDICATES FRONT PANEL MARKING.
3. INDICATES SCREWDRIVER CONTROL
4. ALL SWITCH WAFERS ARE VIEWED FROM REAR OF SWITCH
WAFER A OF S3 IS CLOSEST TO FRONT PANEL

* 5. DENOTES FACTORY ADJUST COMPONENT

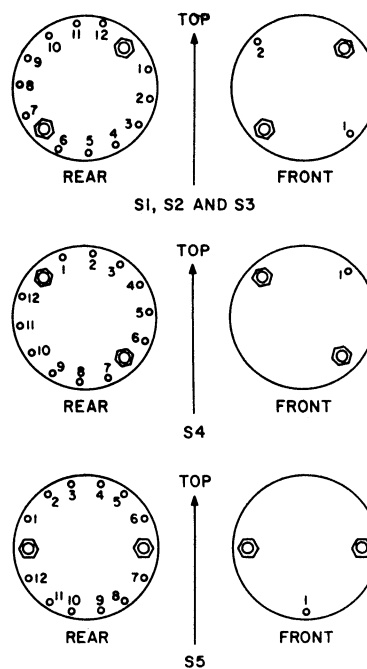


Figure 5-1. Schematic Diagram, Generator

SECTION VI

PARTS LIST

6-1. INTRODUCTION.

6-2. This parts list section includes all pertinent data necessary to locate, identify, and procure additional parts for the equipment. Parts are listed alpha-numerically by reference symbol and include all replaceable items such as electronic, electro-mechanical, and mechanical parts of the equipment. In some cases, values, ratings and manufacturer sources shown are nominal and variations may be found. Satisfactory replacement may be made with either the listed component or an exact replacement of the part(s) removed from the equipment.

6-3. ORDERING INFORMATION.

6-4. The following instructions will aid in ordering parts from the Parts Lists, table 6-2.

- a. Address all inquiries or orders to:

CUSTOMER SERVICE
Department 500-1
The Singer Company
Metrics Division
915 Pembroke Street
Bridgeport, Connecticut, 06608

- b. Include the following information:

- 1) Model and Serial Number of instrument.
- 2) Singer Part Number.
- 3) Reference Symbol Number.
- 4) Description (as shown on list).

6-5. HOW TO USE THE PARTS LIST.

6-6. Paragraphs 6-7 through 6-11 describe the use and meaning of the five columns included in the parts list (see figure 6-1).

6-7. REF SYMBOL COLUMN. The Ref Symbol Column (1, figure 6-1) contains an alpha-numerical listing of parts as they appear on equipment chassis, illustration, or schematic. The reference designation identifies the parts as to their component function in the instrument.

6-8. DESCRIPTION COLUMN. The Description Column (2, figure 6-1) contains the identification of component parts including all pertinent specifications and Singer part number. When the description column is used for a part which is identical to a part which has already been described; SAME AS (3) is used along with the reference symbol of the previously used part. In these instances, columns 3, 4, 5 are left blank. When the description column is used for a reference symbol for which no part exists; NOT USED (4) is placed in the column. In these instances, columns 3, 4, 5, are left blank.

6-9. MANUFACTURER'S PART NUMBER COLUMN. The Manufacturer's Part Number column (5, figure 6-1) contains the part number as designated by the manufacturer of the part.

6-10. MFR'S CODE COLUMN. The Mfr's Code column (6, figure 6-1) references the manufacturer by an assigned code number as listed in Federal Supply Code Handbook H4-2. For manufacturers not listed in H4-2, a letter code will be assigned. Table 6-1 includes the manufacturer and his code designation.

6-11. MAINT QTY COLUMN. The Maint Qty column (7, figure 6-1) contains the number of additional components recommended to keep the equipment at an optimum performance level. The recommended number of components in the Maint Qty column is based on 2000 hours of equipment operation.

SECTION VI
PARTS LIST

TABLE 6-2. PARTS LIST

REF SYMBOL	DESCRIPTION	MANUFACTURER'S PART NUMBER	MFR'S CODE	MAINT QTY
C109	CAPACITOR, ELECTROLYTIC, 20uf, MINUS 10PCT, PLUS 75PCT, 600V SINGER PART NO. 150-5004-001	D40690	56289	2
C110 THRU C124	SAME AS C109			
C125	NOT USED			
DS1	LAMP, INCANDESCENT SINGER PART NO. 160-6001-004	327	08806	2
R1 THRU R14	RESISTOR, FIXED COMP., 750 ohms, PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-751J	EB7515	01121	1

Figure 6-1. Parts List Sample

TABLE 6-1. MANUFACTURER'S CODE

Number	Name	Number	Name
01121	Allen-Bradley Co. Milwaukee, Wis.	71590	Centralab Division of Globe-Union Inc. Milwaukee, Wis.
02660	Amphenol-Borg Electronics Co. Maywood, Ill.	72136	Electro-Motive Mfg. Co. Inc. Willimantic, Conn.
02777	Hopkins Engineering Co. San Fernando, Calif.	73138	Beckman Instruments Inc. Helipot Division Fullerton, Calif.
07263	Fairchild Camera and Instrument Corp. Semiconductor Division Mountain View, Calif.	76854	Oak Mfg. Co. Crystal Lake, Ill.
12126	Kidco Inc. Medford, N.J.	78488	Stackpole Carbon Co. St. Marys, Pa.
14752	Electro-Cube Inc. Pasadena, Calif.	80294	Bourns Inc. Riverside, Calif.
16665	The Singer Co., Metrics Division Bridgeport, Conn.	81349	Military Specifications
18065	Samarius Inc. Derby, Conn.	95354	Methode Mfg. Co. Chicago, Ill.
		B	Standard Telephones and Cables LTD. London, W.C. 2., England

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
J1	CONNECTOR,JACK SINGER PART NO.168-4006-001	UG-1094/U	81349	1
P1	CONNECTOR,PLUG, 16 PIN SINGER PART NO. 556166-045	26-190-16	02660	1
R1 R4	THRU RESISTOR,VARIABLE 10K OHMS	149-0165-001	16665	1
R5	RESISTOR,FIXED,PREC.,600 OHMS,PORM 1 PCT, 1/2W SINGER PART NO. 151-1008-B6000F	C1/2E601OHMS PORM1PCT	12126	1
S1 S2	AND SWITCH,ROTARY,3 POSITIONS SINGER PART NO. 556146-711	399223A	76854	
S3	SWITCH,ROTARY,4 POSITIONS SINGER PART NO. 556146-712	339225A	76854	
S4	SWITCH,ROTARY,7 POSITIONS SINGER PART NO. 556146-708	399217A	76854	
S5	SWITCH,SLIDE,SPST SINGER PART NO. 556146-713	SS47	78488	
A1	OSCILLATOR ASSY	103-1280-001	16665	1
A1C1 A1C2	AND CAPACITOR,FIXED,CERAMIC DISC, 0.01 UF,250V SINGER PART NO. 556060-146	DA140-172B	71590	1
A1C3	CAPACITOR,FIXED,DIPPED MICA, 24 PF, PORM 5 PCT,500V SINGER PART NO. 150-2002-240EJO	DM15E240J0500WV4CR	72136	1
A1Q1 A1Q2	AND TRANSISTOR SINGER PART NO. 556146-254	2N3565	81349	1
A1Q3	TRANSISTOR SINGER PART NO. 556146-401	2N3638A	81349	1
A1Q4	TRANSISTOR SINGER PART NO. 556146-702	2N3642	07263	
A1Q5 A1Q6	AND TRANSISTOR SINGER PART NO. 556146-255	2N3638	81349	1
A1R1	RESISTOR,FIXED,COMP., 47K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-473J	CB4735	01121	1
A1R2	RESISTOR,FIXED,COMP., 3.3K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-332J	CB3325	01121	1
A1R3	RESISTOR,FIXED,COMP., 27K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-273J	CB2735	01121	1
A1R4	RESISTOR,FIXED,COMP., 3K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-302J	CB3025	01121	1
A1R5	SAME AS A1R1			
A1R6	RESISTOR,FIXED,COMP., 1.5K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-152J	CB1525	01121	1
A1R7	RESISTOR,FIXED,COMP., 3.6K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-362J	CB3625	01121	1
A1R8	RESISTOR,FIXED,COMP., 470 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-471J	CB4715	01121	1
A1R9	RESISTOR,FIXED,COMP., 120K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-124J	CB1245	01121	1

Section VI
Parts List

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A1R10	RESISTOR, FIXED, COMP., 150 OHMS, PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-151J	CB1515	01121	1
A1R11	SAME AS A1R8			
A1R12	RESISTOR, FIXED, COMP., 6.8K OHMS, PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-682J	CB6825	01121	1
A1R13	RESISTOR, FIXED, COMP., 15K OHMS, PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-153J	CB1535	01121	1
A1R14	RESISTOR, FIXED, COMP., 1.8K OHMS, PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-182J	CB1825	01121	1
A1R15	RESISTOR, FIXED, COMP., 120 OHMS, PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-121J	CB1215	01121	1
A1R16	RESISTOR, FIXED, COMP., 180 OHMS, PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-181J	CB1815	01121	1
A2	OSCILLATOR ASSY /SAME AS A1/ SEE A1 OSCILLATOR ASSY FOR LIST OF REPLACEABLE PARTS	103-1280-001	16665	1
A3	SUMMING AMPLIFIER ASSY	103-1277-001	16665	1
A3CR1 THRU A3CR3	SEMICONDUCTOR DEVICE, DIODE SINGER PART NO. 556118-046	IN251	81349	1
A3C1	CAPACITOR, FIXED, DIPPED MICA, 51 PF, PORM 5 PCT, 500V SINGER PART NO. 150-2002-510EJO	DM15E510J0500WV4CR	72136	1
A3C2	SAME AS A1C1			
A3C3	CAPACITOR, FIXED, DIPPED MICA, 500 PF, PORM 5 PCT, 500V SINGER PART NO. 150-2002-501EJO	DM15E501J0500WV4CR	72136	1
A3C4 AND A3C5	SAME AS A1C1			
A3Q1 AND A3Q2	SAME AS A1Q1			
A3Q3	SAME AS A1Q3			
A3Q4 THRU A3Q6	SAME AS A1Q4			
A3Q7	SAME AS A1Q5			
A3Q8	SAME AS A1Q4			
A3R1 AND A3R2	RESISTOR, FIXED, COMP., 68K OHMS, PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-683J	CB6835	01121	1
A3R3	SAME AS A1R2			
A3R4	SAME AS A1R3			
A3R5	SAME AS A1R2			
A3R6	SAME AS A1R9			
A3R7	SAME AS A1R12			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A3R8	SAME AS A1R8			
A3R9	SAME AS A1R1			
A3R10	RESISTOR, FIXED, COMP., 7.5K OHMS, PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-752J	CB7525	01121	1
A3R11	RESISTOR, FIXED, COMP., 3.9K OHMS, PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-392J	CB3925	01121	1
A3R12	SAME AS A1R16			
A3R13 THRU A3R15	RESISTOR, FIXED, COMP., 4.7 OHMS, PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-4R7J	CB4R75	01121	1
A3R16	SAME AS A1R12			
A3R17	RESISTOR, FIXED, COMP., 1K OHMS, PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-102J	CB1025	01121	1
A3R18	SAME AS A1R16			
A3R19	RESISTOR, FIXED, FILM, 100K OHMS, PORM 1 PCT, 1/4W SINGER PART NO. 556146-714	RN60D1003F	81349	1
A4	MAIN CHASSIS ASSY MOTHER BOARD	103-1324-001	16665	1
A4C1	CAPACITOR, FIXED, METALLIZED MYLAR, 0.24 UF, PORM 2 PCT, 100V SINGER PART NO. 556146-638	217A1B244G	14752	1
A4C2	CAPACITOR, FIXED, METALLIZED MYLAR, 0.024 UF, PORM 2 PCT, 100V SINGER PART NO. 556146-639	217A1B243G	14752	1
A4C3	CAPACITOR, FIXED, METALLIZED MYLAR, 0.0024 UF, PORM 2 PCT, 100V SINGER PART NO. 556146-640	217A1B242G	14752	1
A4C4	CAPACITOR, FIXED, METALLIZED MYLAR, 2.4UF, PORM 2 PCT, 100V SINGER PART NO. 556146-637	217A1B245G	14752	1
A4C5	SAME AS A4C1			
A4C6	SAME AS A4C2			
A4C7	SAME AS A4C1			
A4C8	SAME AS A4C2			
A4C9	SAME AS A4C3			
A4C10	SAME AS A4C4			
A4C11	SAME AS A4C1			
A4C12	SAME AS A4C2			
A4C13 AND A4C14	CAPACITOR, FIXED, METALLIZED PAPER, 1 UF, PORM 10 PCT, 50V SINGER PART NO. 556118-143	P12D	02777	1
A4C15 THRU A4C18	FACTORY ADJUSTED COMPONENT			

TABLE 6-2. PARTS LIST

Ref	Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A4J1 A4J3	THRU	CONNECTOR, JACK, 15 PIN SINGER PART NO. 556146-635	71-6015-1300	95354	
A4RT1 A4RT2	AND	THERMISTOR SINGER PART NO. 556146-709	STCR54	B	
A4R1 A4R4	THRU	RESISTOR, VARIABLE, 1K OHM SINGER PART NO. 556146-516	62PR1K	73138	
A4R5		RESISTOR, FIXED, PREC., 793K OHMS, PORM 1 PCT, 1/2W SINGER PART NO. 151-1008-B7933F	C1/2793KOHMPORM1PCT	12126	1
A4R6		RESISTOR, FIXED, PREC., 387K OHMS, PORM 1 PCT, 1/2W SINGER PART NO. 151-1008-B3873F	C1/2387KOHMPORM1PCT	12126	1
A4R7		RESISTOR, FIXED, PREC., 241K OHMS, PORM .5 PCT, 1/2W SINGER PART NO. 151-1008-B2413D	C1/2241KOHMPORM.5PCT	12126	1
A4R8		RESISTOR, FIXED, PREC., 172K OHMS, PORM 1 PCT, 1/2W SINGER PART NO. 151-1008-B1723F	C1/2172KOHMPORM1PCT	12126	1
A4R9		RESISTOR, FIXED, PREC., 128K OHMS, PORM 5 PCT, 1/2W SINGER PART NO. 151-1008-B1283J	C1/2128KOHMPORM5PCT	12126	1
A4R10		RESISTOR, FIXED, PREC., 100K OHMS, PORM .5 PCT, 1/2W SINGER PART NO. 151-1008-B1003D	C1/2100KOHMPORM.5PCT	12126	1
A4R11		RESISTOR, FIXED, PREC., 81K OHMS, PORM 1 PCT, 1/2W SINGER PART NO. 151-1008-B8102F	C1/2810KOHMPORM1PCT	12126	1
A4R12		RESISTOR, FIXED, PREC., 66.1K OHMS, PORM 1 PCT, 1/2W SINGER PART NO. 151-1008-B6612F	C1/266.1KOHMPORM1PCT	12126	1
A4R13		RESISTOR, FIXED, PREC., 55.1K OHMS, PORM 1 PCT, 1/2W SINGER PART NO. 151-1008-B5512F	C1/255.1KOHMPORM1PCT	12126	1
A4R14		RESISTOR, FIXED, PREC., 46.4K OHMS, PORM 1 PCT, 1/2W SINGER PART NO. 151-1008-B4642F	C1/246.4KOHMPORM1PCT	12126	1
A4R15		RESISTOR, FIXED, PREC., 393 OHMS, PORM 1 PCT, 1/2W SINGER PART NO. 151-1008-B3930F	C1/2393OHMSPOORM1PCT	12126	1
A4R16 A4R20	THRU	RESISTOR, FIXED, PREC., 575 OHMS, PORM 1 PCT, 1/2W SINGER PART NO. 151-1008-B5750F	C1/2575OHMSPOORM1PCT	12126	1
A4R21		RESISTOR, FIXED, PREC., 1150 OHMS, PORM 1 PCT, 1/2W SINGER PART NO. 151-1008-B1151F	C1/21151OHMPORM1PCT	12126	1
A4R22 A4R27	THRU	RESISTOR, FIXED, PREC., 850 OHMS, PORM 1 PCT, 1/2W SINGER PART NO. 151-1008-B8500F	C1/2850OHMSPOORM1PCT	12126	1
A4R28 A4R29	AND	RESISTOR, VARIABLE, 50K OHMS SINGER PART NO. 151-0014-503P	3068-P-503	80294	1
A4R30 A4R33	THRU	RESISTOR, FIXED, COMP., 750 OHMS, PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-751J	CB7515	01121	1
A4S1		SWITCH, ROTARY, 11 POSITIONS SINGER PART NO. 556146-708	399217A	76854	1