MODEL 2213
STEREO GENERATOR
INSTRUCTIONAL MANUAL

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GENERAL DESCRIPTION

The AEL Model 2213 Stereo Generator (See Figure 1) is an all solid state unit which develops a stereo composite signal for use in FM broadcasting installations. It was designed for use with the AEL Model 2202 FM Exciter but can be used with similar direct FM transmitting systems that provide sufficient bandwidth to maintain separation.

MECHANICAL DESCRIPTION

The Stereo Generator is self-contained in a 19" wide by 3-1/2" high by 6" deep chassis designed for rack type mounting. Removable top and bottom covers are provided for accessibility to the printed circuit board and chassis components. See Figures 2 and 3. Two printed circuit boards are used and are easily removed by the use of quick-disconnect terminals.

An audio input terminal strip is provided on the rear chassis along with a stereo composite BNC output connector and a 3 prong power line receptacle.

THEORY OF OPERATION

The AEL 2213 Stereo Generator uses complete matrixing to form the L plus R (L+R) and L minus R (L-R) audio signals so that the L-R signal can be processed to obtain the double sideband (DSB) suppressed-carrier signal. The 19KHz Pilot Subcarrier is added to the L+R and the L-R signal to permit the receiver to recover the left and right channels in the demodulation process.

Referring to the block diagram, the left and right signals are applied through individual pre-emphasis networks.

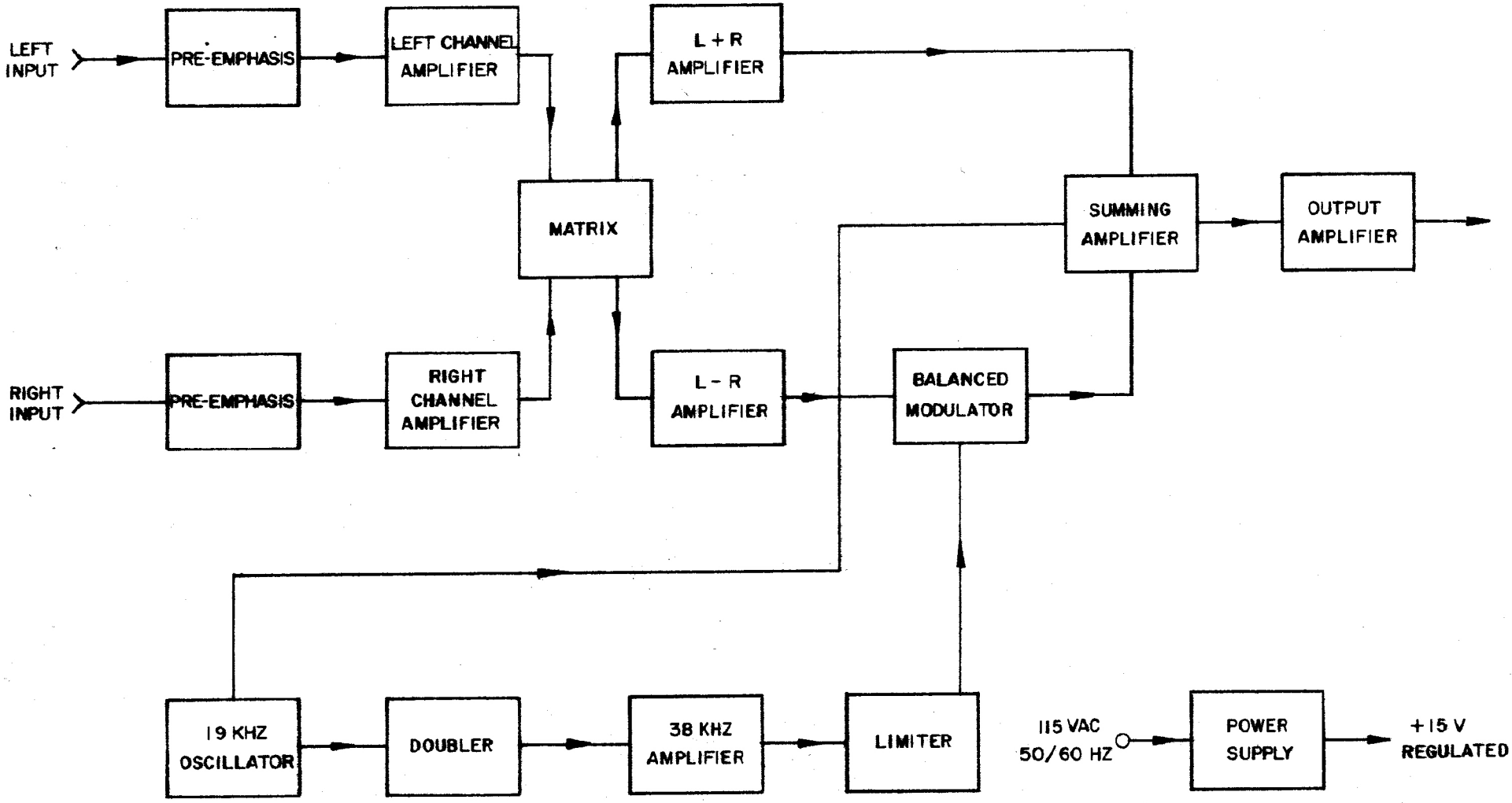
The right channel signal and the left channel signal are amplified with conventional low distortion amplifiers, Q1 and Q6 respectively. The output of each is applied to the resistive matrixing network where they algebraically add and subtract the left and right inputs to form the L+R and L-R signals. The L+R signal is fed to the L+R amplifiers Q2 and Q3. Q3 is emitter coupled to the Summing Amplifier Q9. The L-R signal is applied to the L-R amplifier Q7. The output of Q7 is emitter coupled to the balanced bridge modulator. The modulator is switched at a 38KHz rate, each side of the bridge conducting on alternate half cycles. Since each side of the bridge generates the L-R double sideband signal along with the modulating frequency and because they are out of phase with the modulating frequency the modulating frequency is cancelled leaving only the L-R DSB signal. The balanced output of the modulator drives the inputs of A2 (1C2). The output of A2 is singled-ended and drives the L-R double sideband amplifier Q8.

The 38KHz used to drive the modulator is developed first by the 19KHz Pilot Subcarrier. This is a crystal-controlled, low distortion oscillator Q10, Q11. The output of Q11 is coupled to a pair of matched diodes CR1 and CR2 in a full wave rectifier configuration to develop the 38KHz which is amplified by Q12. The output of Q12 is fed to an integrated circuit A1 which is connected

in a limiter configuration. This delivers a constant amplitude 38KHz signal to the modulator.

The outputs of both the L+R Amplifier and the L-R DSB Amplifier are emitter coupled to the Summing Amplifier Q9. The 19KHz Pilot Subcarrier is applied to the base of Q9. The output of the Summing Amplifier delivers the composite stereo wave form to the output amplifiers Q4, Q5 where the composite wave-form is further amplified and applied to the Stereo Input of the FM Exciter.

The power supply is a conventional bridge rectifier circuit with a regulated voltage feeding all circuits.



MODEL 2213 STEREO GENERATOR BLOCK DIAGRAM

OPERATORS' CONTROLS

ON/OFF	Actuates the primary AC line voltage to T5 as indicated.
PILOT GAIN	Sets the 19KHz pilot and is adjusted for 8-10% injection level.
Pilot Gain ON/OFF	Actuates the 19 KHz pilot signal as indicated.
Pilot Phase	Sets the 19 KHz pilot signal to cross the time axis with a positive slope simultaneously with the 38 KHz subcarrier.
L - R	Sets the amplitude of the L-R DSB signal.
L-R On/Off	Actuates the L - R channel as indicated.
Separation	Sets the composite signal for maximum separation.
L + R	Sets the amplitude of the L + R main channel.
L + R On/Off	Actuates the L + R main channel as indicated.

FACTORY ALIGNMENT CONTROLS

CAUTION	The following controls should only be adjusted when necessary.
C16	Sets the exact frequency of the 19KHz oscillator.
R70/R71	Sets the 38KHz subcarrier for minimum output.
R67	Sets the 38KHz level to the balanced modulator for maximum amplitude.
R80	Sets the power supply output voltage for 15 VDC.

INSTALLATION AND ADJUSTMENTS

The Model 2213 Stereo Generator is factory adjusted with the Model 2202 FM Exciter and normally will not require installation adjustments. Nevertheless the following steps should be reviewed to maintain optimum stereo performance.

STEP 1. Upon physical installation connect the AC line cord to a 117 VAC power source.

STEP 2. With a short coaxial cable connect the stereo generator composite output BNC to the direct FM Exciter stereo input connector.

STEP 3. Actuate the LINE ON/OFF switch of both the Stereo Generator and the Exciter and preheat for twenty minutes.

STEP 4. Make certain the direct FM Exciter is properly tuned and that it is prepared for stereo operation, that is a jumper between TB1-5 and TB1-6. An FCC type approved stereo monitor is necessary to perform the following tests.

STEP 5. Pilot Subcarrier check.

A. Turn PILOT GAIN ON, L-R and L+R switches to the OFF position.

B. Observe the pilot carrier on the stereo monitor and set the PILOT GAIN control for 8-10% injection level.

STEP 6. Left Channel check.

A. Actuate the PILOT GAIN, L-R and L+R switches to the ON position.

B. Apply a 400 cycle signal to the left audio input only TB1 and TB2 until 100% total modulation (90% modulation, 10% pilot), is observed on the monitor. This level will be +10 $\pm$2 DBM.

C. With an oscilloscope confirm that waveform No. 1 is present at the wideband output of the stereo monitor. See Figure 4.

D. Actuate the PILOT GAIN ON/OFF switch to OFF. Check that waveform No. 2 is present. See Figure 4. In this condition the separation can be more readily observed on the scope but will not read on the monitor until the pilot is injected.

STEP 7. Right Channel Check.

A. Actuate the PILOT GAIN, L-R and L+R switches to the ON position.

B. Apply a 400 cycle signal to the right audio channel only TB4 and TB5 until 100% total modulation is observed on the monitor. This level will be +10 $\pm$ 2 DBM.

C. With an oscilloscope confirm that waveform No. 1 is present at the wideband output of the stereo monitor. See Figure 4.

D. Actuate the PILOT GAIN ON/OFF. Check that waveform No. 2 is present.

STEP 8. Pilot Subcarrier Phase Adjustment.

A. Actuate the PILOT GAIN and L-R switches to ON. Actuate the L+R switch to OFF.

B. Apply a 400 cycle signal to either one of the audio input until 55% total modulation (45% modulation, 10% pilot) is observed on the monitor. This level will be +10 $\pm$2 DBM.

C. With an oscilloscope confirm that waveform No. 3 is present. Refer to waveform No. 4 and if necessary carefully adjust the PILOT PHASE control to the desired 'diamond' pattern as shown in waveform No. 3. Final adjustment of this control is made using the stereo monitor.

STEP 9. Stereo Subcarrier Level Check.

A. Actuate the L-R switch to ON and the PILOT GAIN and L+R to OFF.

B. Apply a 400 cycle signal to either one of the audio inputs until 45% total modulation is observed on the monitor. This level will be +10 ±2 DBM.

C. Waveform 5 shows the desired signal. This signal will measure approximately .7V P-P.

D. If necessary adjust R67 for maximum carrier level. See Figure 4. Waveform No. 5.

STEP 10. Stereo Subcarrier Suppression (38KHz)

A. Actuate the PILOT GAIN, L-R and L+R switches to ON.

B. Apply a 5KHz to 15KHz signal to either one of the audio inputs until 100% total modulation is obtained. This test can also be accomplished without modulation applied.

C. Measure the 38KHz carrier on the monitor. In the event suppression is not adequate, remove the bottom cover and alternately null the 38KHz with R70 and R71.

STEP 11. L-R, L+R Level Check.

A. Actuate the PILOT GAIN, L-R and L+R switches to the ON position.

B. Apply a 400 cycle signal to either audio input for 100% modulation.

C. Check that waveform No. 1 is available. In the event waveform 6 or waveform 7 is present adjust the L-R and L+R controls as indicated until waveform 1 is obtained.

STEP 12. Normal Operation

A. Connect left and right audio lines to the terminal strip on the rear chassis.

B. Actuate all switches to their ON position.

C. Apply normal programming.

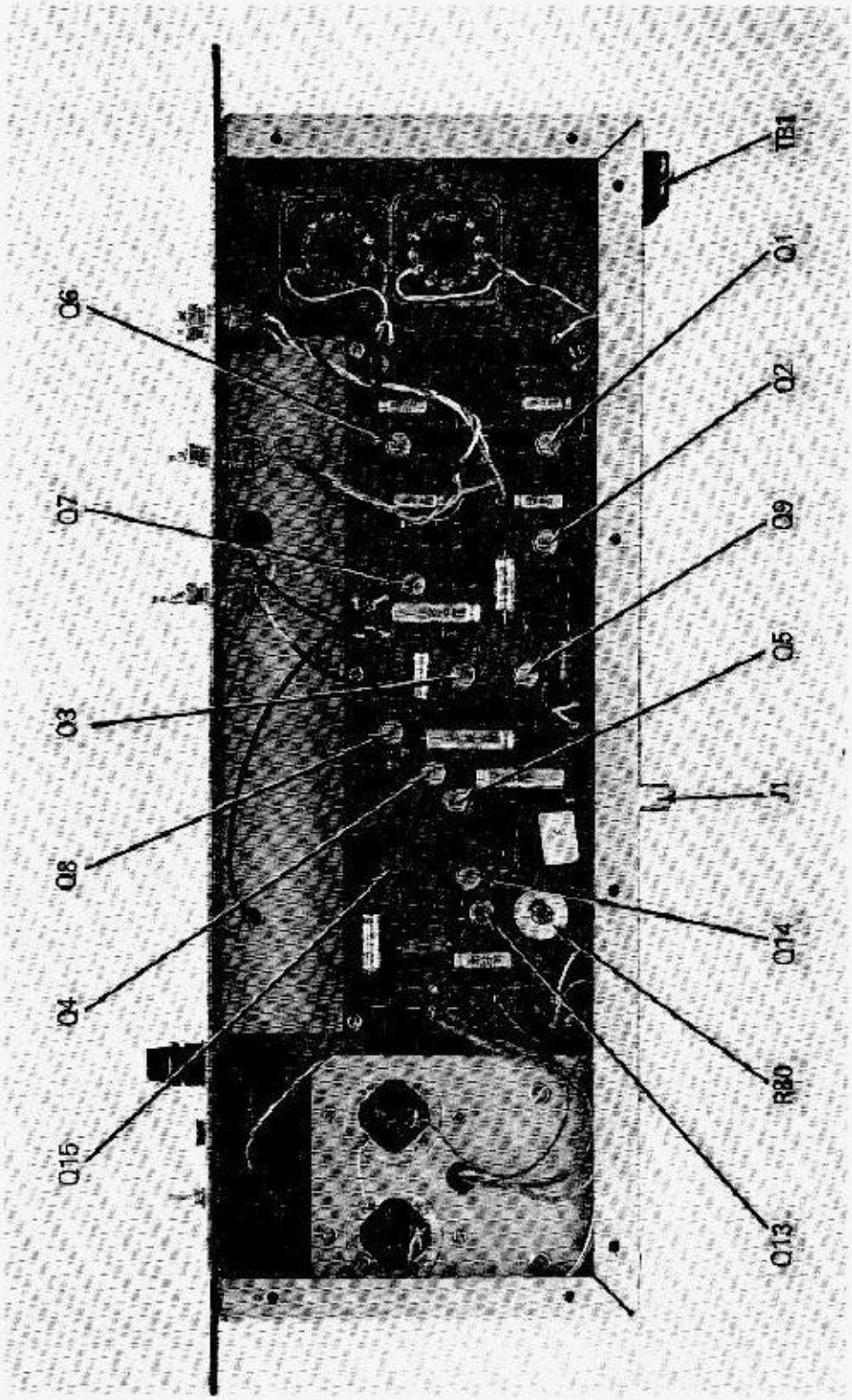


Figure 2. Model 2213 Stereo Generator, Top View

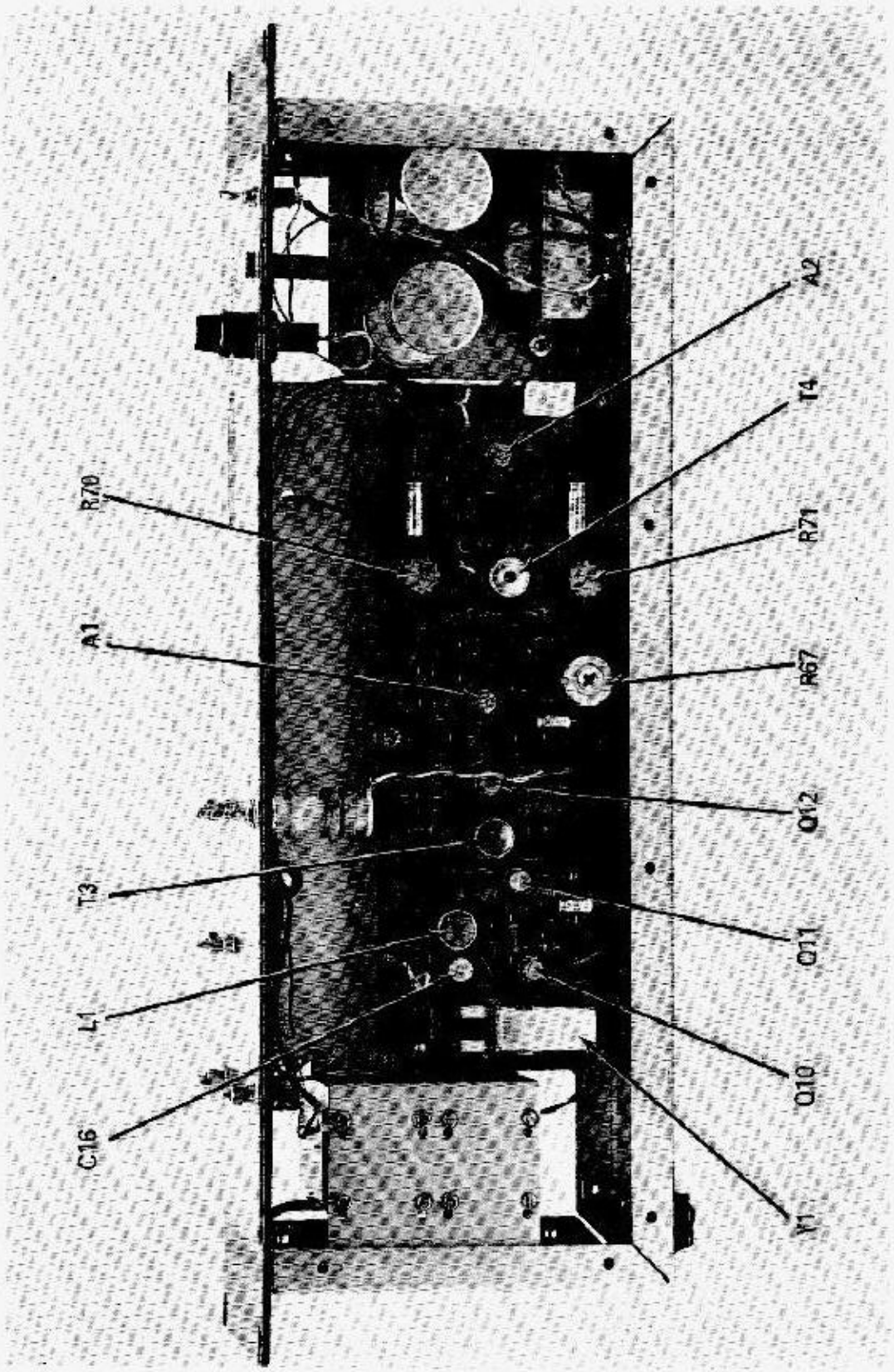
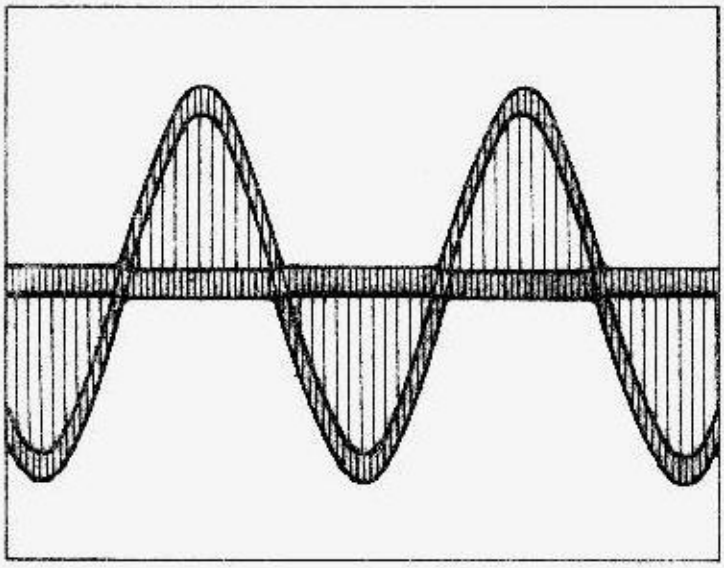
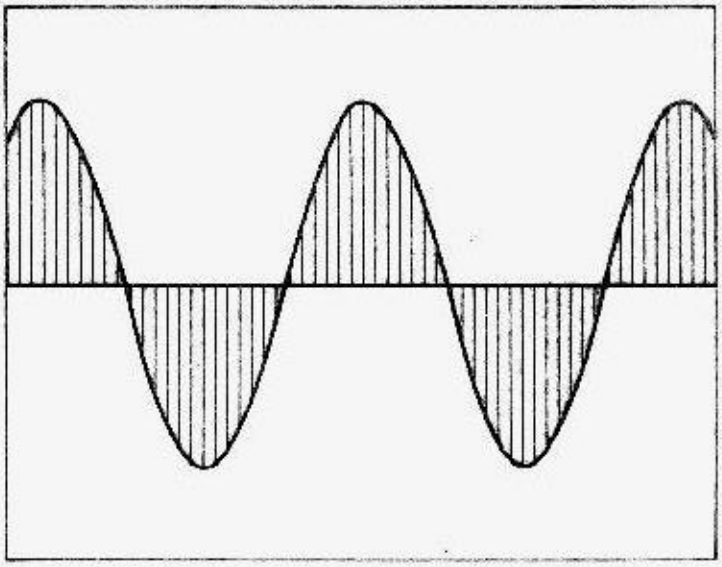


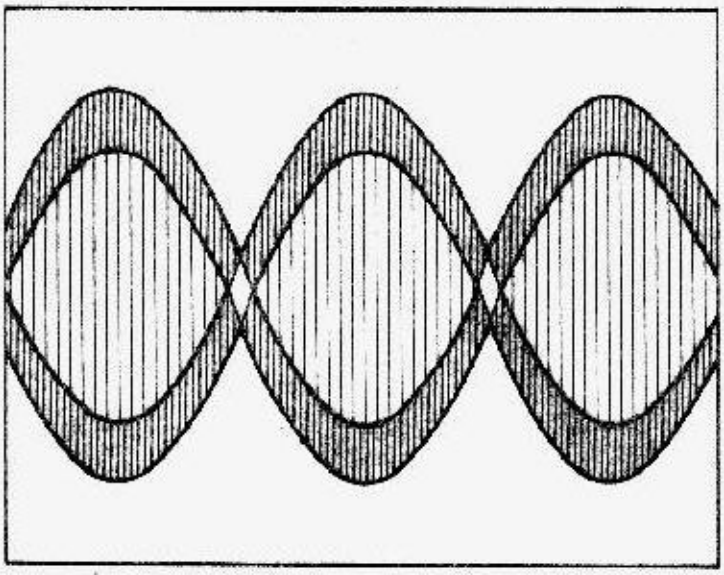
Figure 3. Model 2213 Stereo Generator, Bottom View



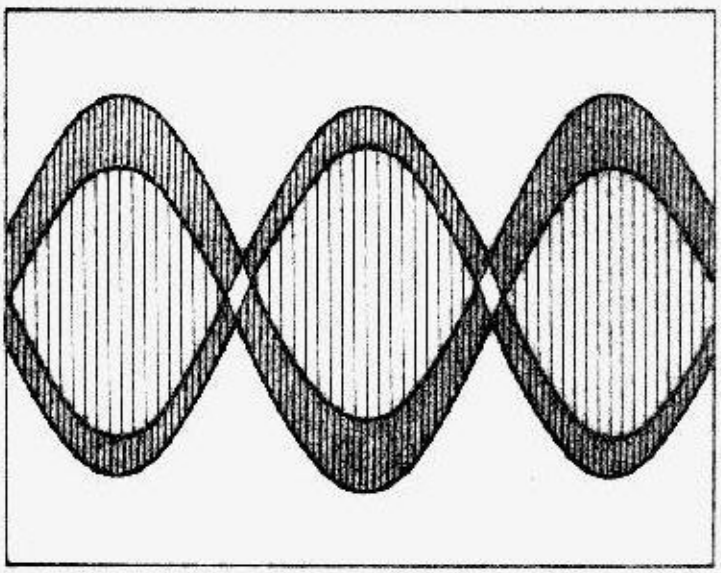
NO. 1 COMPOSITE STEREO WAVEFORM



NO. 2 COMPOSITE STEREO WAVEFORM LESS PILOT

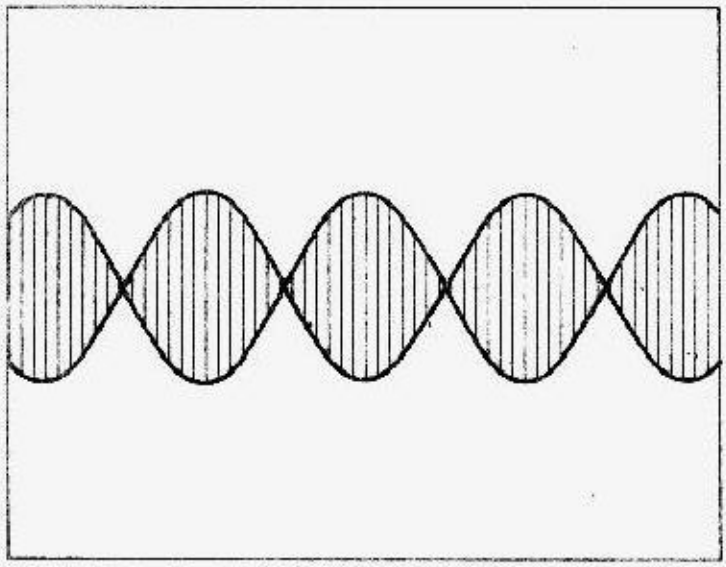


NO. 3 (L-R) SUBCARRIER WITH PILOT
PILOT IN PHASE

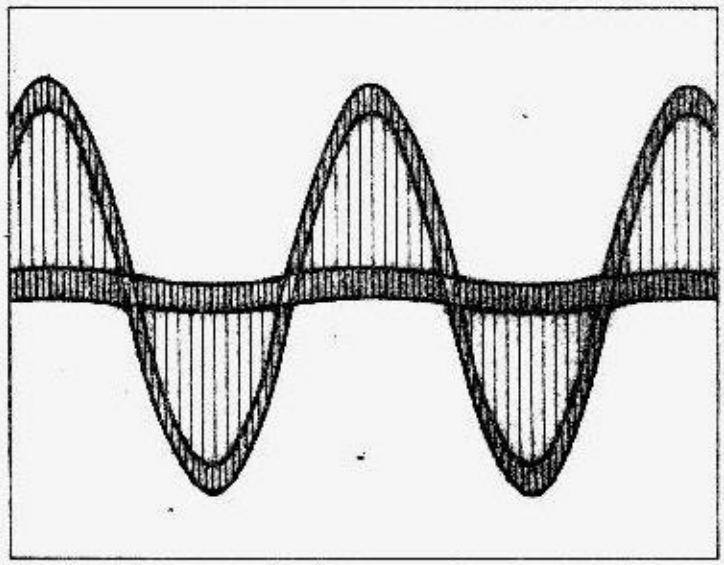


NO. 4 SUBCARRIER WITH PILOT
PILOT OUT OF PHASE

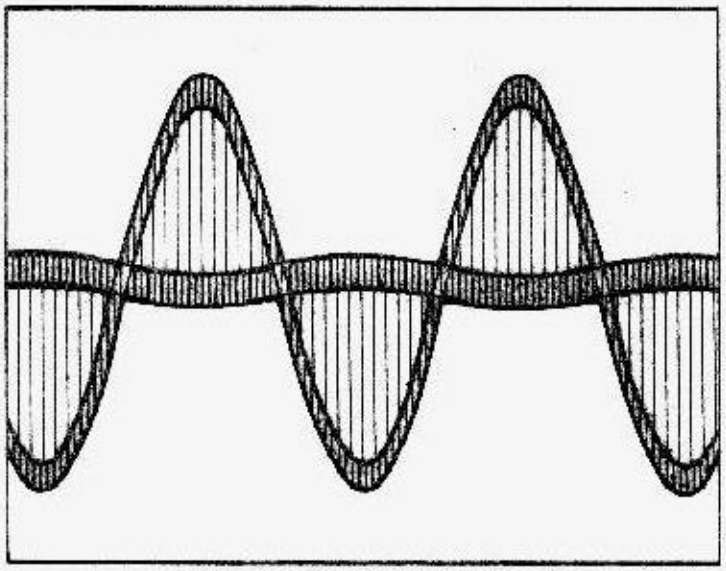
FIGURE 4.



NO. 5 (L-R) SUBCARRIER LESS PILOT



NO. 6 COMPOSITE STEREO WAVEFORM
EXCESS (L-R) SUBCARRIER OR INSUFFICIENT (L+R)



NO. 7 COMPOSITE STEREO WAVEFORM
INSUFFICIENT (L-R) SUBCARRIER OR
EXCESS (L+R)

TRANSISTOR VOLTAGE CHART

TRANSISTOR	EMITTER V	BASE V	COLLECTOR V
Q1	4.5	5.1	9.3
Q2	.66	1.2	6.8
Q3	6.5	6.8	14.0
Q4	.47	1.0	7.0
Q5	6.3	7.0	14.0
Q6	4.7	5.2	8.5
Q7	6.3	6.7	14.0
Q8	6.3	6.7	14.0
Q9	6.1	6.6	14.0
Q10	1.35	1.55	9.5
Q11	5.8	6.0	14.0
Q12	1.6	2.0	14.0
Q13	5.9	6.5	15.0
Q14	14.5	15.0	24.0
Q15	14.0	14.5	24.0

INTEGRATED CIRCUITS	PIN NUMBER											
	1	2	3	4	5	6	7	8	9	10	11	12
A1 (IC1)	6.6	6.5	3.8	2.5	2.1	3.1	6.6	0	14.0	13.0	13.	64
A2 (IC2)	6.6	6.5	0	2.1	2.4	*	0	8.9	14.0	13.0		

* Voltage Varies with Meter Range Setting

Model 2213 Stereo Generator Typical Transistor Voltages (to ground)

STEREO GENERATOR PARTS LIST

SEMICONDUCTOR

Symbol	Description
Q1	TRANSISTOR, 2N3053
Q2	TRANSISTOR, 2N3053
Q3	TRANSISTOR, 2N3053
Q4	TRANSISTOR, 2N3053
Q5	TRANSISTOR, 2N3053
Q6	TRANSISTOR, 2N3053
Q7	TRANSISTOR, 2N3053
Q8	TRANSISTOR, 2N3053
Q9	TRANSISTOR, 2N3053
Q10	TRANSISTOR, 2N3053
Q11	TRANSISTOR, 2N3053
Q12	TRANSISTOR, 2N3053
Q13	TRANSISTOR, 2N2102
Q14	TRANSISTOR, 2N3053
Q15	TRANSISTOR, 2N3053
A1	INTEGRATED CIRCUIT, CA3005
A2	INTEGRATED CIRCUIT, CA3000
CR1	DIODE, 1N4454 — Matched pair
CR2	DIODE, 1N4454 — Matched pair
CR3	DIODE, 5082-2870 — Matched Quad
CR4	DIODE, 5082-2870 — Matched Quad
CR5	DIODE, 5082-2870 — Matched Quad
CR6	DIODE, 5082-2870 — Matched Quad
CR7	DIODE, 1N2070
CR8	DIODE, 1N2070
CR9	DIODE, 1N2070
CR10	DIODE, 1N2070
VR1	DIODE, ZENER 1N753A

RESISTOR

Symbol	Description
R1	RESISTOR, 620 ohm 1/2W 5%
R2	RESISTOR, 10K 1/2W 5%
R3	RESISTOR, 2.7K 1/2W 5%
R4	RESISTOR, 1.6K 1/2W 5%
R5	RESISTOR, 499 ohm 1/2W 1% CGW
R6	RESISTOR, 499 ohm 1/2W 1% CGW
R7	RESISTOR, 5.1K 1/2W 5%
R8	RESISTOR, 5.1K 1/2W 5%
R9	RESISTOR, 47K 1/2W 5%
R10	RESISTOR, 5.1K 1/2W 5%
R11	RESISTOR, 4.7K 1/2W 5%
R12	RESISTOR, 47 ohm, 1/2W 5%
R13	RESISTOR, 22K 1/2W 5%
R14	RESISTOR, 22K 1/2W 5%
R15	RESISTOR, 1K 1/2W 5%
R16	RESISTOR, 47K 1/2W 5%
R17	RESISTOR, 47K 1/2W 5%
R18	RESISTOR, 1.5K 1/2W 5%
R19	RESISTOR, 110 ohm 1/2W 5%
R20	RESISTOR, 1K 1/2W 5%
R21	RESISTOR, 270K 1/2W 5%
R22	POTENTIOMETER, 500 ohm, ± 10%
R23	POTENTIOMETER, 500 ohm, ± 10%
R24	RESISTOR, 620 ohm 1/2W 5%
R25	RESISTOR, 10K 1/2W 5%
R26	RESISTOR, 2.7K 1/2W 5%
R27	RESISTOR, 1.6K 1/2W 5%
R28	RESISTOR, 499 ohm 1/2W 1% CGW
R29	RESISTOR, 499 ohm 1/2W 1% CGW
R30	RESISTOR, 5.1K 1/2W 5%
R31	RESISTOR, 1K 1/2W 5%
R32	RESISTOR, 5.1K 1/2W 5%
R33	RESISTOR, 10K 1/2W 5%
R34	RESISTOR, 9.1K 1/2W 5%
R35	RESISTOR, 1K 1/2W 5%
R36	RESISTOR, Determined by Manufacturer
R37	POTENTIOMETER, 10K ±10%
R38	RESISTOR, 20K 1/2W 5%
R39	RESISTOR, 22K 1/2W 5%
R40	RESISTOR, 1K 1/2W 5%
R41	RESISTOR, 1K 1/2W 5%
R42	RESISTOR, 1K 1/2W 5%
R43	RESISTOR, 10K 1/2W 5%
R44	RESISTOR, 10K 1/2W 5%
R45	RESISTOR, 150K 1/2W 5%
R46	RESISTOR, 22K 1/2W 5%
R47	RESISTOR, 1K 1/2W 5%
R48	RESISTOR, 8.2K 1/2W 5%
R49	RESISTOR, 120 ohm 1/2W 5%
R50	RESISTOR, 2.4K 1/2W 5%

RESISTOR

Symbol	Description
R50	RESISTOR, 2.4K 1/2W 5%
R51	POTENTIOMETER, 1K ±10%
R52	RESISTOR, 12K 1/2W 5%
R53	RESISTOR, 33K 1/2W 5%
R54	RESISTOR, 39K 1/2W 5%
R55	RESISTOR, 5.6K 1/2W 5%
R56	RESISTOR, 47K 1/wW 5%
R57	RESISTOR, 10K 1/2W 5%
R58	RESISTOR, 620 ohm 1/2W 5%
R59	RESISTOR, 6.2K 1/2W 5%
R60	RESISTOR, 6.2K 1/2W 5%
R61	RESISTOR, 1K 1/2W 5%
R62	RESISTOR, 1K 1/2W 5%
R63	RESISTOR, 1.5K 1/2W 5%
R64	RESISTOR, 1.5K 1/2W 5%
R65	RESISTOR, 6.2K 1/2W 5%
R66	RESISTOR, 5.6K 1/2W 5%
R67	POTENTIOMETER, 1K 2W 20%
R68	RESISTOR, 8.2K 1/2W 5%
R69	RESISTOR, 12K 1/2W 5%
R70	POTENTIOMETER, 300 ohm 2W 20%
R71	POTENTIOMETER, 300 ohm 2W 20%
R72	RESISTOR, 10K 1/2W 1% MDC-1
R73	RESISTOR, 10K 1/2W 1% MDC-1
R74	RESISTOR, 10K 1/2W 1% MDC-1
R75	RESISTOR, 10K 1/2W 1% MDC-1
R76	RESISTOR, 1K 1/2W 5%
R77	RESISTOR, 1K 1/2W 5%
R78	RESISTOR, 150K 1/2W 5%
R79	RESISTOR, 1K 1/2W 5%
R80	POTENTIOMETER 300 ohm 2W 20%
R81	RESISTOR, 1.2K 1/2W 5%
R82	RESISTOR, 3.6K 1/2W 5%
R83	RESISTOR, 3K 1/2W 5%
R84	RESISTOR, 68 ohm 1/2W 5%
R85	RESISTOR, 120 ohm 3W 5%
R86	RESISTOR, 2.7K 1/2W 5%
R87	RESISTOR, 120 ohm 3W 5%

CAPACITOR

Symbol	Description		
C1	CAPACITOR, Dipped Mylar	.0075uf	100V.
C2	CAPACITOR, Electrolytic	25uf	12V.
C3	CAPACITOR, Electrolytic	25uf	12V.
C4	CAPACITOR, Dura Mica	33pf	100V.
C5	CAPACITOR, Electrolytic	100uf	25V.
C6	CAPACITOR, Electrolytic	200uf	12V.
C7	CAPACITOR, Electrolytic	200uf	12V.
C8	CAPACITOR, Dipped Mylar	.0075uf	100V.
C9	CAPACITOR, Electrolytic	25uf	12V.
C10	CAPACITOR, Dura Mica	51pf	100V.
C11	CAPACITOR, Electrolytic	25uf	12V.
C12	CAPACITOR, Electrolytic	200uf	12V.
C13	CAPACITOR, Electrolytic	25uf	12V.
C14	CAPACITOR, Polyester	.0022uf	200V.
C15	CAPACITOR, Polyester	.1uf	80V.
C16	CAPACITOR, Variable Ceramic	5.5-18pf	
C17	CAPACITOR, Dura Mica	27pf	100V.
C18	CAPACITOR, Polyester	.047uf	200V.
C19	CAPACITOR, Polyester	.01uf	200V.
C20	CAPACITOR, Electrolytic	5uf	25V.
C21	CAPACITOR, Dura Mica	500pf	100V.
C22	CAPACITOR, Polyester	.22uf	80V.
C23	CAPACITOR, Determined by manufacturer		
C24	CAPACITOR, Dura Mica	3300pf	
C25	CAPACITOR, Polyester	.047uf	200V.
C26	CAPACITOR, Polyester	.01uf	200V.
C27	CAPACITOR, Polyester	.047uf	200V.
C28	CAPACITOR, Electrolytic	5uf	25V.
C29	CAPACITOR, Dipped Mylar	.01uf	100V.
C30	CAPACITOR, Determined by manufacturer		
C31	CAPACITOR, Electrolytic	50uf	25V.
C32	CAPACITOR, Electrolytic	50uf	25V.
C33	CAPACITOR, Electrolytic	50uf	25V.
C34	CAPACITOR, Polyester	.22uf	80V.
C35	CAPACITOR, Electrolytic	50uf	25V.
C36	CAPACITOR, Electrolytic	1000uf	50V.
C37	CAPACITOR, Electrolytic	500uf	50V.

Symbol	Description
L1	COIL, 19KHz Pilot
L2	COIL, Pilot Phase
T1	TRANSFORMER, Audio
T2	TRANSFORMER, Audio
T3	TRANSFORMER, 38 KHZ
T4	TRANSFORMER, Modulator
T5	TRANSFORMER, Power
TB1	TERMINAL BLOCK, Audio Input Strip
S1	TOGGLE SWITCH, L + R Off/On
S2	TOGGLE SWITCH, L - R Off/On
S3	TOGGLE SWITCH, Pilot Off/On
S4	TOGGLE SWITCH, Off/On
Y1	CRYSTAL, 19KHZ
J1	CONNECTOR, BNC, Female Chassis
	CONNECTOR, AC Input
DS1	PILOT LAMP ASSEMBLY
	AC CORD
	HEAT SINK