

FM STEREO TUNER

MODEL AJ-12

Assembly and

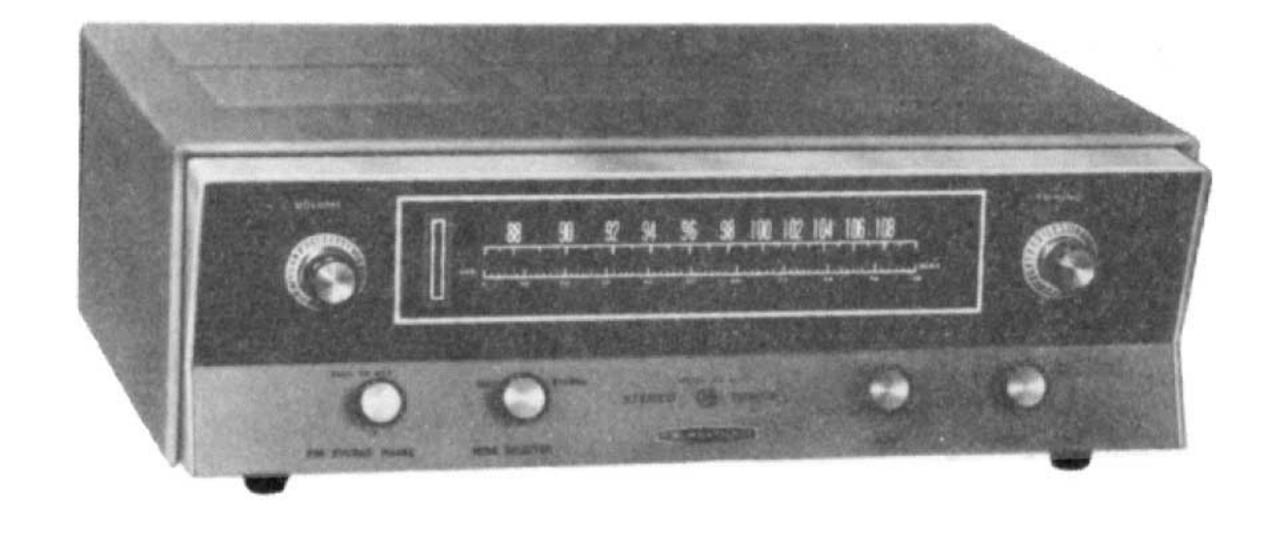
Operation

of the



FM STEREO TUNER

MODEL AJ-12



HEATH COMPANY BENTON HARBOR, MICHIGAN

TABLE OF CONTENTS Not Included Not Included *Fold-out from page.

----> Also Parts Pictorial

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SPECIFICATIONS

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Tuning Range	88 to 108 megacycles.
Intermediate Frequency	10.7 megacycles.
Antenna	Balanced input for external 300 Ω antenna. Internal line antenna.
Output Impedance	Variable to 15 K Ω (cathode follower).
Output Voltage	.5 volt (1000 μv at 30% modulation in).
Image Ratio	-45 db (30 μv , 30% modulation at 98 megacycles in).
Harmonic Distortion	Less than 1% (25 μv , 100% modulation at 98 megacycles in).
IF Rejection	-55 db (98 megacycles).
Audio Response	±1 db from 20 to 20,000 cps.
AFC Correction Factor	100 kilocycles per volt (full AFC).
AM Suppression	-27 db.
Hum And Noise	-48 db (25 μv at 30% modulation in).
Quieting Sensitivity	20 db - 2-1/2 μv . 30 db - 3-1/2 μv . 48 db - 30 μv (maximum quieting).
FM STEREO MULTIPLEX	
Audio Response	±2 db from 50 to 15,000 cps.

Audio Response	±2 db from 50 to 15,000 cps.
Subcarrier Bandpass	±3 db from 23,000 to 53,000 cps.
Channel Separation	30 db or more at 1000 cps. 25 db or more at 10,000 cps.
Hum And Noise	-55 db relative to 1 volt rms output.

GENERAL

Output Impedance	Variable to 15 K Ω , each channel (cathode follower).
Outputs	Left Channel and Right Channel.
Power Supply	Transformer-operated with silicon diode rectifiers.
Power Requirements	120 volts AC, 50/60 cps, 50 watts.
Tube Complement	 6C9: FM RF Amplifier, mixer, and oscillator. 6AU6: 1st and 2nd IF amplifiers and limiter. 12AT7: 19 kc amplifier. 12AU7: 19 kc amplifier and cathode followers. 12BH7: subchannel amplifier and oscillator doubler. 6BN8: ratio detector and squelch amplifier. 6FG6: tuning indicator.
Front Panel Controls	VOLUME control. TUNING. FM STEREO PHASE control. MODE SELECTOR, FM and STEREO. AFC, variable from OFF to FULL. POWER, OFF-ON.
Rear Panel Controls	SQUELCH. SEPARATION.
Dimensions	Overall: $5-1/4$ " high x $15-1/2$ " wide x $10-1/4$ " deep.
Net Weight	14 lbs.
Shipping Weight	16 lbs.

All prices are subject to change without notice. The Heath Company reserves the right to discontinue instruments and to change specifications at

any time without incurring any obligation to incorporate new features in instruments previously sold.



INTRODUCTION

Your new Heathkit Model AJ-12 FM Stereo Tuner is designed for high quality FM, and FM stereo reception. The Tuner has a prealigned, preassembled front end, a FM circuit board, and a FM multiplex circuit board for ease of assembly.

Its many features include a tuning indicator tube, a neon lamp to indicate when a FM stereo signal is being received, and a between-station squelch circuit. The squelch circuit eliminates between-station noise when tuning from one

station to another. A heavy die-cast flywheel is used on the tuning control for smooth tuning action.

The Tuner incorporates cathode follower outputs to minimize hum and high frequency losses due to long connecting cables. The Volume controls for the left and right channels are ganged for ease of operation. Its excellent performance and ease of assembly and operation, plus its many quality features make this FM Stereo Tuner a desirable addition to your hi-fi system.

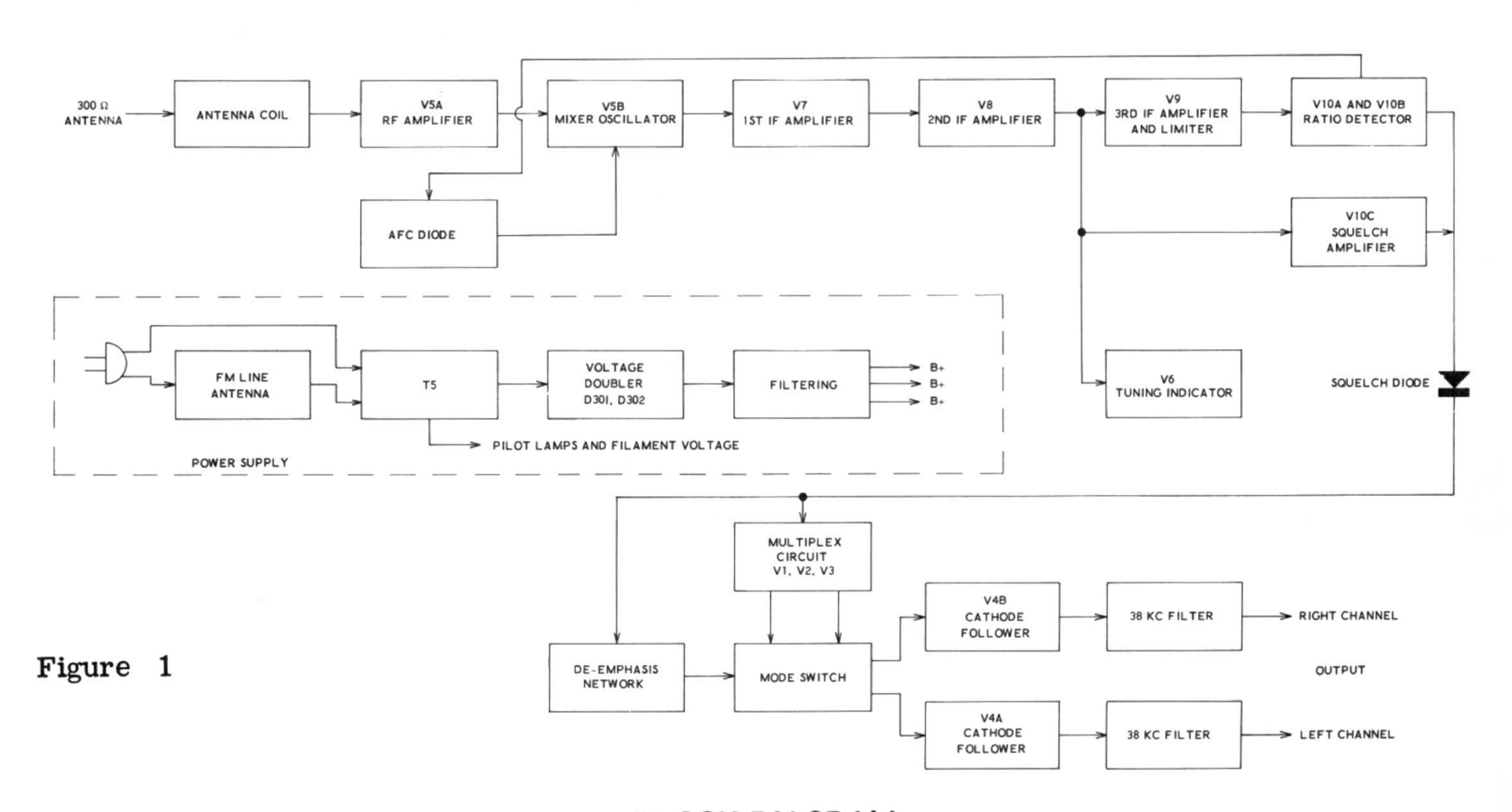
CIRCUIT DESCRIPTION

Each major section of the Tuner will be described while reading this description, refer to the Block and Schematic Diagrams.

FM TUNER

FM (frequency modulation) means that the carrier amplitude is held constant while the carrier frequency is varied above and below the station frequency at a rate determined by the audio being

transmitted. This is illustrated in Figure 2. The audio signal (B) is applied to the RF carrier (A) to produce the FM signal (C). This signal is received by the Tuner FM antenna and is applied through a bandpass filter, consisting of coils L100 and L101 and capacitor C103A, to the grid of RF amplifier tube V5A. The amplified signal from V5A is coupled through C106 and the secondary of L103 to the grid of the mixer oscillator tube, V5B. The local oscillator tank circuit



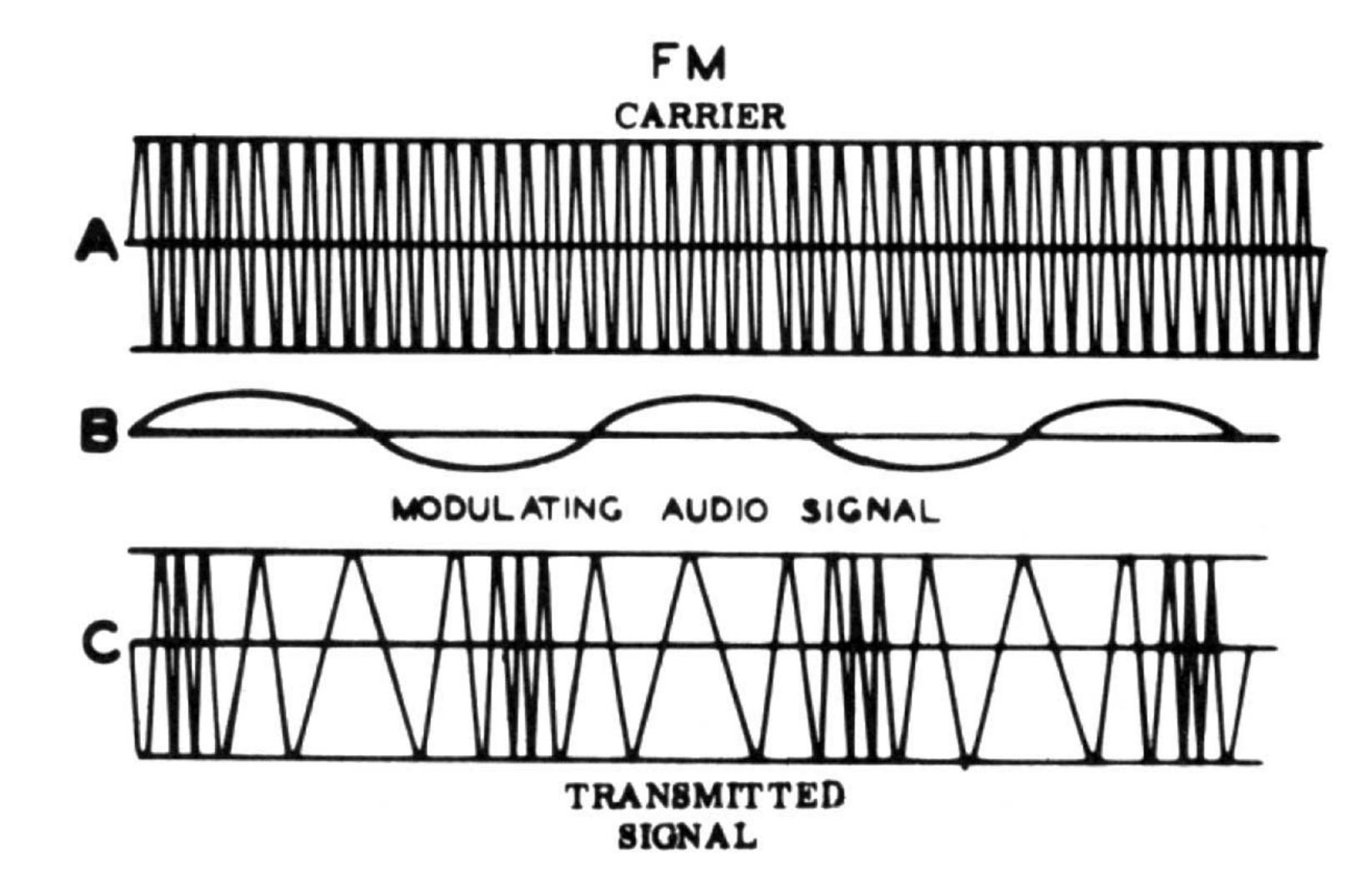


Figure 2

made up of C103C and the primary of coil L103, is tuned to operate at 10.7 mc (megacycles) above the received FM signal. The oscillator signal and the received signal are mixed in V5B. The output of the tube then contains three frequencies; the received FM signal frequency, the sum of the oscillator and the signal frequencies, and the difference of the oscillator and signal frequencies. These three signals are applied to the first IF transformer T1, which passes only the difference frequency of 10.7 mc.

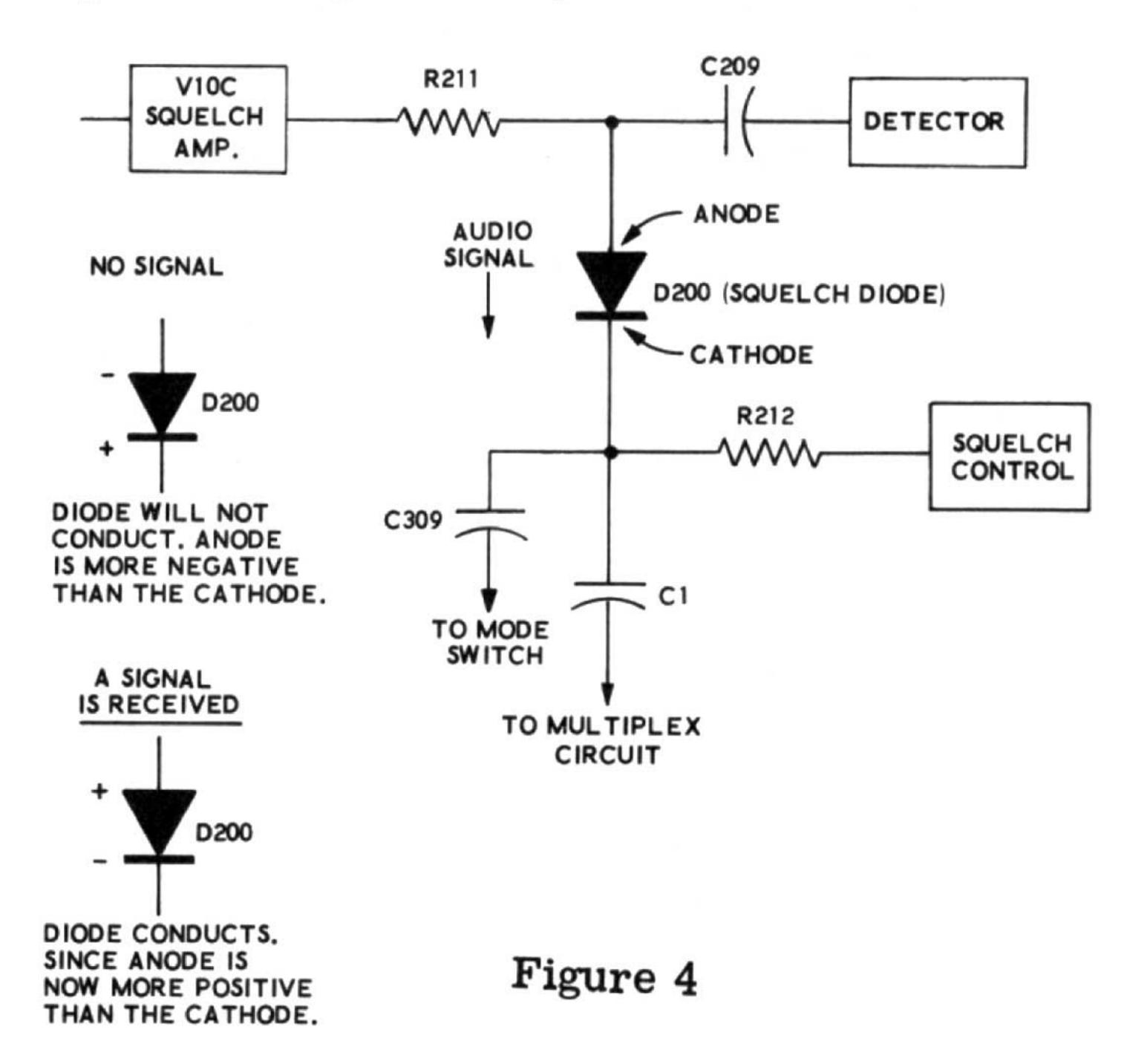
This 10.7 mc IF (intermediate frequency) signal from T1 is applied to IF amplifier tube V7 and then is coupled to second IF amplifier tube V8. From V8, the amplified IF signal is coupled through third IF transformer T3 to limiter stage V9.

The amount of signal at the grid of V9 determines the value of negative DC voltage developed at this point. This negative DC voltage is taken from the junction of T3 and R205 and is applied through R306 to the grid of tuning indicating tube V6 which indicates the signal strength and proper tuning.

V9 acts as an IF amplifier for weak signals and as a limiter for strong signals. The limiter stage in an FM tuner is used to remove any amplitude modulation of the FM signal. See Figure 3. The limited signal from V9, is applied through detector transformer T4 to ratio detector tube V10A and V10B. The ratio detector recovers the audio from the modulated IF signal.

If the oscillator frequency changes (drifts), a small negative DC voltage is developed in the ratio detector. This voltage is applied back through AFC diode D1 to the oscillator tank circuit to correct the frequency drift. This voltage is called AFC (automatic frequency control) voltage and is adjustable by AFC control R300.

The audio signal from the detector is coupled through capacitor C209 to the anode of squelch diode D200. See Figure 4. Squelch diode D200 acts as a switch. The opening and closing of the switch is determined by the polarity of the DC voltages across this diode. The DC voltages across the diode are determined by the plate voltage of tube V10C, the squelch amplifier, and by the setting of the Squelch control.



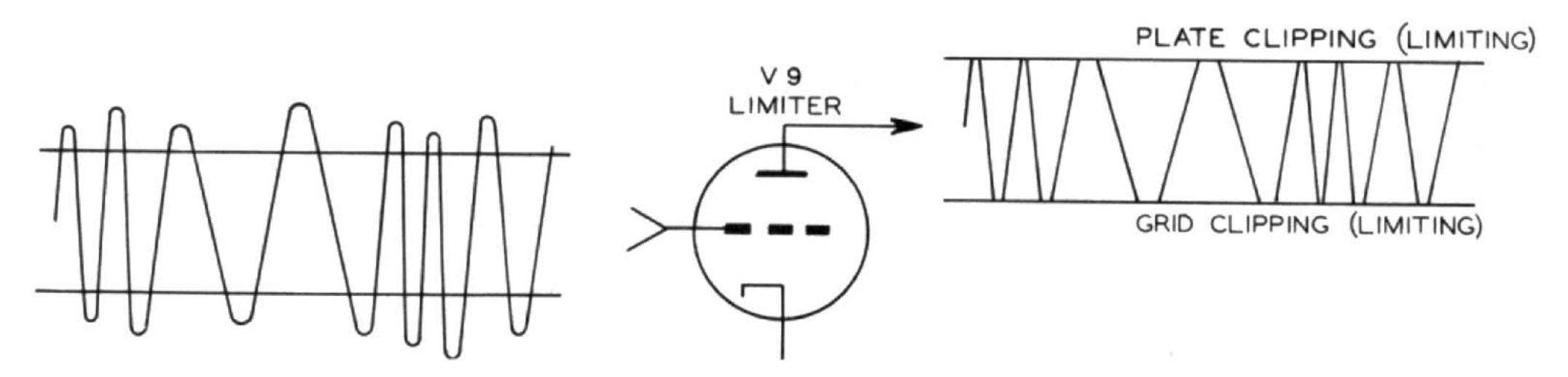


Figure 3

The cathode of diode D200 is connected to the Squelch control through resistor R212. Resistor R309 and Squelch control R310, form a voltage divider between B+ and ground. The anode of diode D200 is connected through resistor R211 to the plate of tube V10C. During no-signal operation, the anode of diode D200 is held more negative than the cathode. The amount of this voltage can be varied by the Squelch control. This prevents the diode from conducting and the noise signals cannot pass on to the following stages. When a signal is received, the limiter voltage applied to the grid of tube V10C causes the tube to draw less current; thus the plate voltage becomes more positive because this voltage is applied through resistor R211 to the anode of diode D200. The anode will now become more positive than the cathode, allowing the diode to conduct. The Squelch control setting may be varied from the fully counterclockwise position, in which case diode D200 is always conducting, to the fully clockwise position, in which case a very strong signal will be required to make diode D200 conduct.

On monophonic FM, the audio signal is taken from the de-emphasis network, made up of resistor R305 and capacitor C310, to the Mode switch. The Mode switch parallels the output signal, and it is then applied to each grid of cathode followers V4A and V4B. From V4A, the signal is coupled through a filter network made up of coil L301, resistor R315 and capacitors C315 and C316 to the Left Channel output. From tube V4B the signal is coupled through the right channel filter network to the output socket.

For stereo operation the audio signal is taken ahead of the de-emphasis network, since all the information needed for stereo multiplex operation is of high frequency nature, and is applied to the multiplex circuit.

FM STEREO MULTIPLEX

FM stations that broadcast stereo, transmit a complex signal which a monophonic FM tuner will receive as a standard monophonic program.

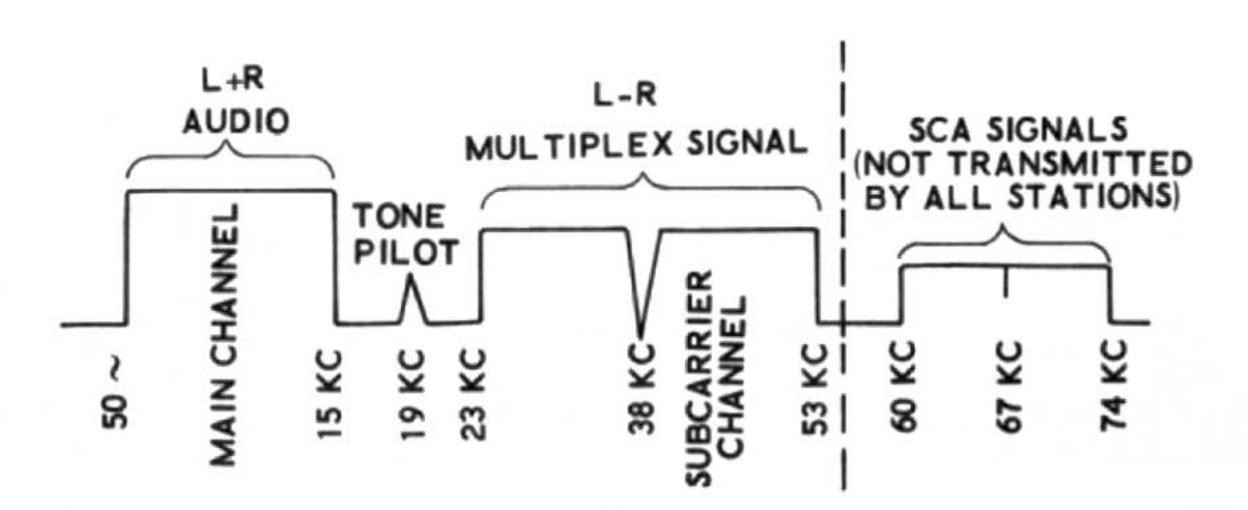


Figure 5

See Figure 5. However, a stereo FM tuner will receive this complex signal and separate it into its original counterparts of left and right channel stereo. Since FM transmitters are capable of broadcasting a complex signal, a subcarrier is used for the multiplex part of the signal. So that the two channels can be identified during this description, the left channel (L) will be represented as the sine wave and the right channel (R) as a spike. See Figure 6. These waveforms are for illustration purposes only and are not likely to be actually transmitted.

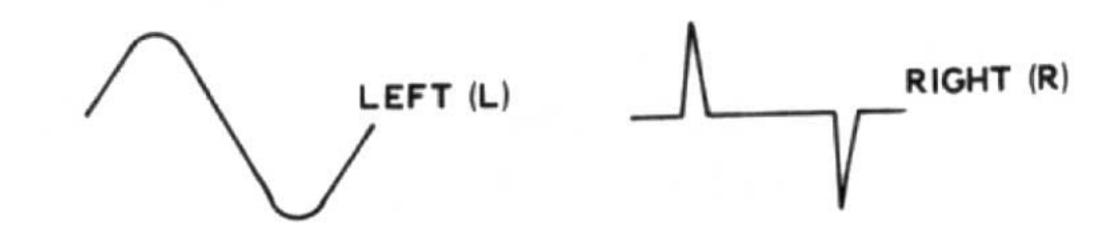


Figure 6

If these two signals were added together (L+R) and the instantaneous sum of their voltage plotted, they would appear as shown in Figure 7A. If the two signals were combined in such a way that the R signal were subtracted from the L signal (L-R), the instantaneous difference in the voltage would be represented as in Figure 7B. The difference part of the signal (L-R) is transmitted on a 38 kc subcarrier. The pilot signal of 19 kc is also broadcast by the transmitter and will be represented as shown in Figure 7C.

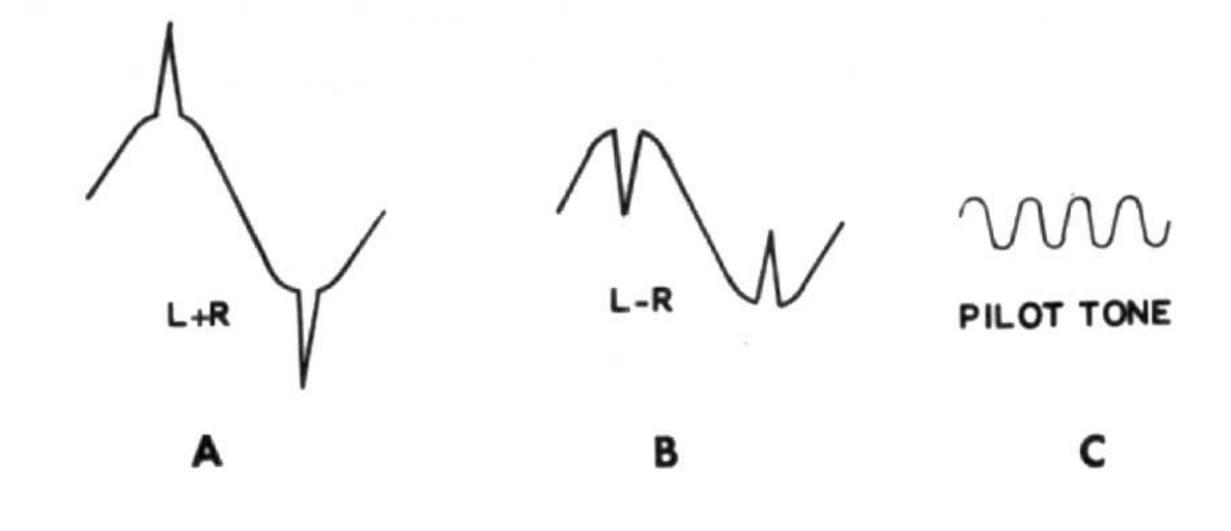
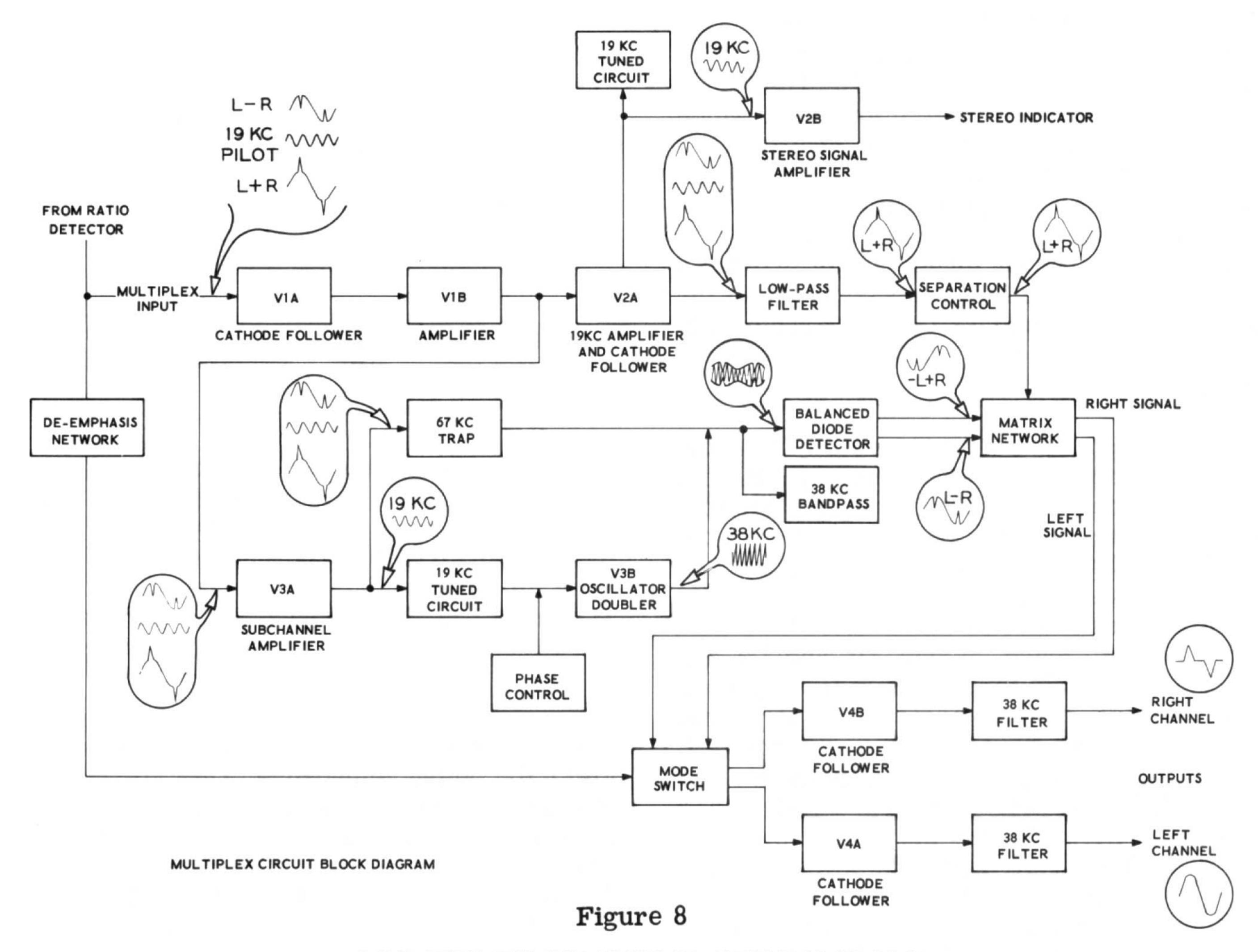


Figure 7



MULTIPLEX CIRCUIT BLOCK DIAGRAM

A Multiplex Block Diagram is furnished for clarification. The multiplex circuit description may be followed best by using this diagram in conjunction with the Schematic. The Multiplex circuit is used only when the Mode switch is in the Stereo position.

The signal for stereo multiplex operation is coupled through capacitor C1 to the grid of tube V1A. Basically, this signal consists of the (L+R) main signal, the (L-R) subchannel, and the 19 kc pilot signal. These signals are then amplified by V1A and V1B. Tube V2A acts as an impedance matching stage between V1 and the low-pass filter, consisting of coil L2 and capacitor C8 which pass only the (L+R) signal. This signal can then be adjusted to the proper level by the

Separation control for insertion into the matrix network. The switch across the Separation control is used to turn off the (L+R) signal (main channel) when adjusting the 19 kc oscillator frequency and phase.

The output of tube V1B is also applied to the grid of tube V3A through coupling capacitor C11. This tube is the subchannel amplifier. The (L-R) signal is coupled from the plate of tube V3A through the 67 kc (SCA) filter, consisting of coil L5 and its associated capacitors. SCA (Subsidiary Communications Authorization) is a commercial music channel transmitted on the same FM carrier as the stereo program. See Figure 5. The output from the 67 kc filter is applied to the balanced detector across the bandpass filter.

The output from tube V3A is also fed through capacitor C12 to the 19 kc tuned circuit, consisting of coil L3 and capacitor C13. This tuned circuit accepts only the 19 kc pilot signal, which locks the oscillator doubler stage, consisting of tube V3B, coil L4 and its capacitor. This stage doubles the 19 kc oscillator signal, providing a 38 kc carrier signal. Capacitor C14 and control R312 across the 19 kc tuned circuit provide a fine adjustment of the frequency, and enables the phase of the 38 kc carrier to be set accurately for reinsertion with the (L - R) subchannel information.

The 38 kc carrier is then coupled from the secondary of coil L4 through resistor R21 to a tuned circuit, consisting of L6 and its capacitor. Thus, the 38 kc carrier is reinserted with the (L - R) subchannel signal across this tuned circuit. The resulting composite signal is then fed to the balanced diode detector where the signal is demodulated. Since diodes D1 and D2 are connected in opposite directions in the balanced detector circuit, a demodulated (L - R) signal will appear across capacitor C19, and the (- L + R) signal across capacitor C17. Resistors R23 and R24, and capacitor C18 form a matrix and de-emphasis network for the Right Channel; resistors R25 and R26, and capacitor C20 form the matrix network for the Left Channel. The matrix network is used to recombine the (L - R)and (- L + R) signals with the (L + R) signals as follows:

If (L + R) is added to (L - R) as shown in Figure 9A, the instantaneous sum will be 2L. The spikes, or (R) portions of the wave, cancel out each other while the rest of the wave, or (L) portions, re-enforce each other to reproduce the original left channel sine wave. This left channel signal is connected from the output matrix network through the Mode switch to the grid of V4A, the Left Channel cathode follower output tube.

If (L + R) is added to (- L + R) as shown in Figure 9B, the result will be 2R. The sine waves, or L portions of the waves, will now cancel out each other and the instantaneous sum of the R spikes will produce 2R. The output of this side of the matrix network is applied through the Mode switch to the grid of V4B, the Right Channel cathode follower output tube.

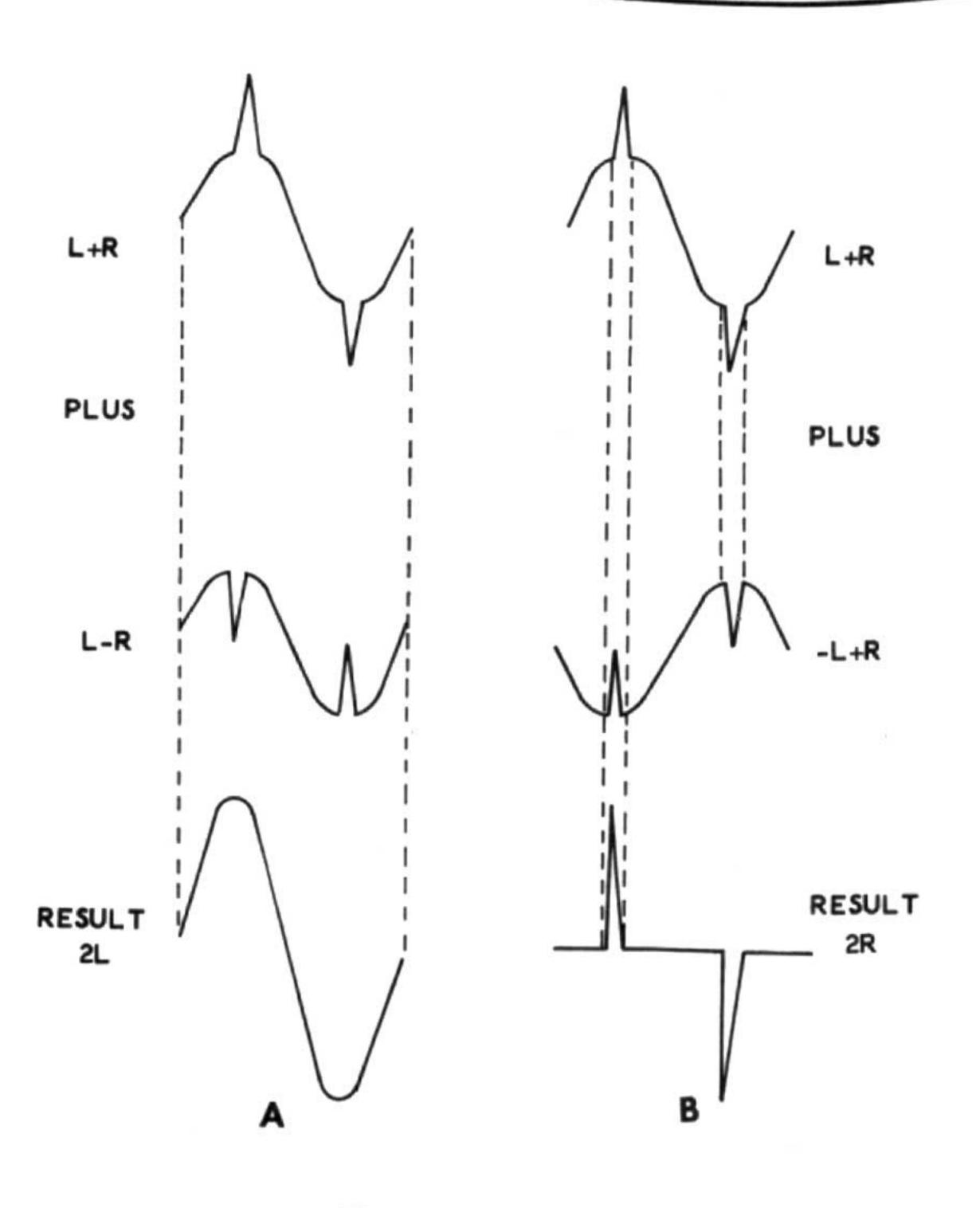


Figure 9

The cathode follower output stages serve to lower the output impedance. This allows the use of longer connecting cables to the amplifier without the loss of high audio frequencies. Coil L302 and capacitors C318 and C319 form a 38 kc filter and high frequency rolloff network in the Right Channel output. Coil L301 and capacitors C315 and C316 form a similar network in the Left Channel output. These networks enable stereo broadcasts to be tape recorded by eliminating the unwanted multiplex signals (38 kc, 57 kc, 76 kc, etc.) which could beat with the recorder bias and erase signals, causing undesirable noises in the tape recording.

STEREO INDICATOR

V2A has a tuned plate circuit which is tuned to the 19 kc pilot signal frequency. Capacitor C7 couples this signal to the grid of stereo indicator amplifier tube V2B. Thus, when a stereo FM station is tuned in, the pilot signal is amplified and the indicator will light with a steady glow. In some instances the indicator may flicker momentarily on noise when tuning. Also, some monophonic stations use a "commercial killer" which may cause the indicator to light during the commercial.



POWER SUPPLY

The fused, transformer-operated power supply uses silicon diodes D300 and D301 with capacitors C301 and C302 as a full-wave voltage-doubler circuit. The DC voltage output is fed to a 3-

section filter and voltage divider network made up of capacitors C303, C304, and C305, and resistors R301, R302, and R303. This filter network provides decoupling and smooths outpower supply ripple. A separate filament winding in the power transformer furnishes the pilot lamp and tube filament voltages.

CONSTRUCTION NOTES

This manual is supplied to assist you in every way to complete your kit with the least possible chance for error. The arrangement shown is the result of extensive experimentation and trial. If followed carefully, the result will be highly stable and dependable performance. We suggest that you retain the manual in your files for future reference, both in the use of the equipment and for its maintenance.

UNPACK THE KIT CAREFULLY AND CHECK EACH PART AGAINST THE PARTS LIST. In so doing, you will become acquainted with the parts. Refer to the information on the inside covers of the manual to help you identify the components. If some shortage or parts damage is found in checking the Parts List, please read the Replacements section and supply the information called for therein.

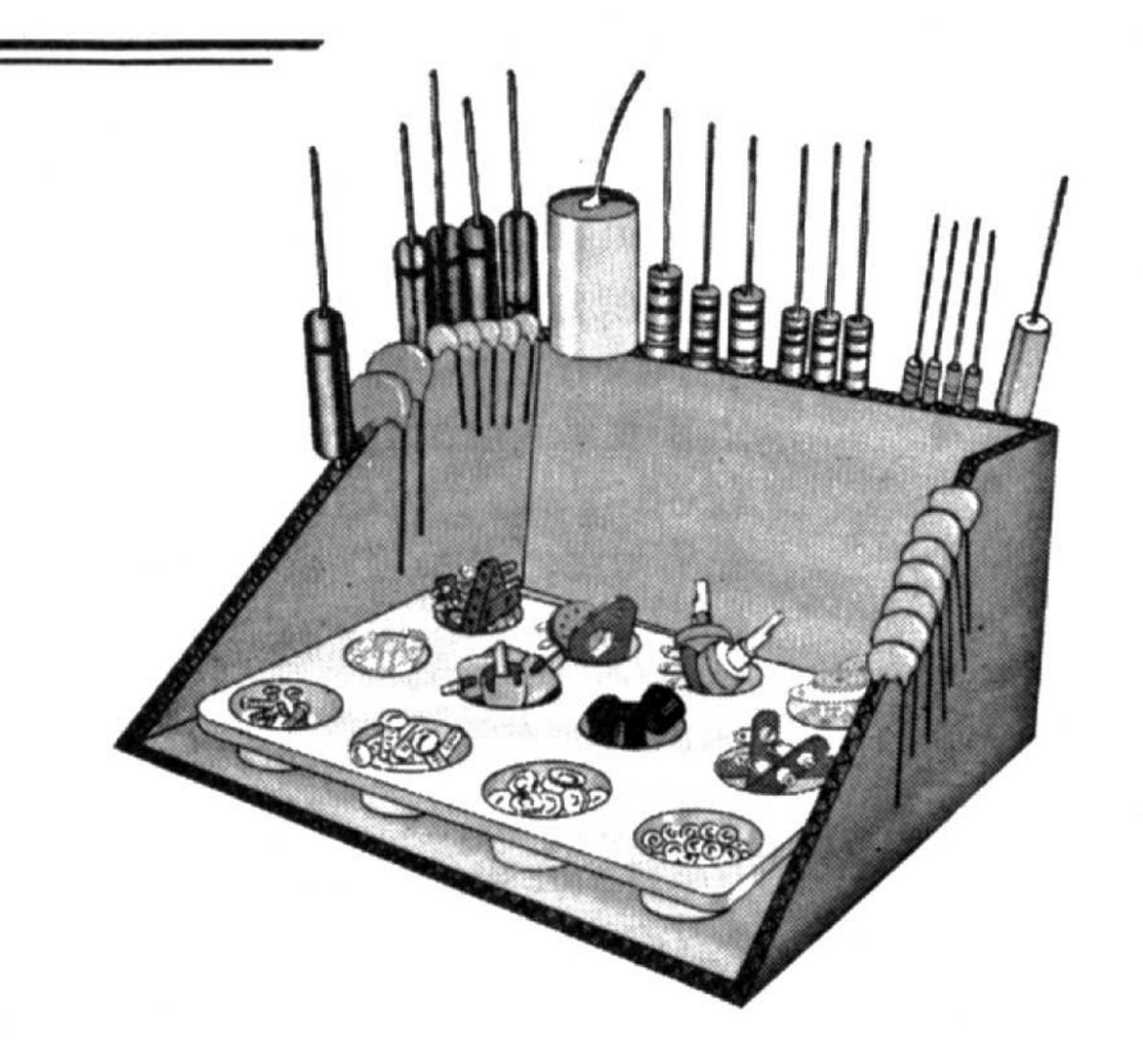
Resistors generally have a tolerance rating of

10% unless otherwise stated in the Parts List. Tolerances on capacitors are generally even greater. Limits of +100% and -20% are common for electrolytic capacitors.

We suggest that you do the following before work is started:

- 1. Lay out all parts so that they are readily available.
- 2. Provide yourself with good quality tools. Basic tool requirements consist of a screw-driver with a 1/4" blade; a small screw-driver with a 1/8" blade; long-nose pliers; wire cutters, preferably separate diagonal cutters; a penknife or a tool for stripping insulation from wires; a soldering iron (or gun) and rosin core solder. A set of nut drivers and a nut starter, while not necessary, will aid extensively in construction of the kit.

Most kit builders find it helpful to separate the various parts into convenient categories. Muffin tins or molded egg cartons make convenient trays for small parts. Resistors and capacitors may be placed with their lead ends inserted in the edge of a piece of corrugated cardboard until they are needed. Values can be written on the cardboard next to each component. The illustration shows one method that may be used.





PARTS LIST

The numbers in the parentheses in the Parts List are keyed to the numbers on the Parts Pictorial to aid in parts identification.

PART No.	PARTS Per Kit	DESCRIPTION	PART No.	PARTS Per Kit	DESCRIPTION		
Resistor	°S		Capacito	ors			
$(1) \overline{1-66}$	1	150 Ω 1/2 watt	$(4) \overline{20-118}$	1	15 $\mu\mu$ f silver mica		
		(brown-green-brown)	20-102	2	100 $\mu\mu$ f silver mica		
1-9	2	1000 Ω 1/2 watt	20-108	2	200 $\mu\mu$ f silver mica		
		(brown-black-red)	20-111	1	230 $\mu\mu$ f silver mica		
1-11	2	1500 Ω 1/2 watt	20-106	1	390 $\mu\mu$ f silver mica		
		(brown-green-red)	20-107	1	680 $\mu\mu$ f silver mica		
1-44	6	2200 Ω 1/2 watt	20-122	3	1000 $\mu\mu$ f silver mica		
		(red-red)	20-132	1	10,000 $\mu\mu$ f silver mica		
1-14	1	3300 Ω 1/2 watt	(5) 21-6	1	$27~\mu\mu f~disc$		
		(orange-orange-red)	21-9	1	100 $\mu\mu$ f disc		
1-20	2	10 K Ω 1/2 watt	21-11	1	150 $\mu\mu$ f disc		
		(brown-black-orange)	21-56	2	470 $\mu\mu$ f disc		
1-21	4	15 K Ω 1/2 watt	21-14	1	.001 μ fd disc		
		(brown-green-orange)	21-36	3	.002 μ fd disc		
1-22	2	22 KΩ 1/2 watt	21-26	1	.003 μ fd disc		
4 00		(red-red-orange)	21-27	7	.005 μ fd disc		
1-23	1	27 K Ω 1/2 watt	21-16	1	.01 μ fd disc		
4 0-		(red-violet-orange)	21-82	1	.02 μ fd disc		
1-25	2	47 K Ω 1/2 watt	21-48	5	.05 μ fd disc		
1 -0		(yellow-violet-orange)	21-81	2	.1 μ fd disc		
1-50	4	68 K Ω 1/2 watt 5%	(6) 23-59	1	.05 μ fd tubular		
1 00		(blue-gray-orange)	23-28	3	.1 μ fd tubular		
1-26	Z	100 K Ω 1/2 watt	(7) 27-28	3	.1 μfd Mylar*(polyester film)		
1 07		(brown-black-yellow)	$(8)\ 25-39$	1	$2 \mu fd$ at 150 V electrolytic		
1-27	3	150 K Ω 1/2 watt	25-4	1	10 μfd at 25 V electrolytic		
1 20	9	(brown-green-yellow)	25-58	1	50-50 μ fd at 200 V electro-		
1-29	2	220 KΩ 1/2 watt	05 70	-	lytic		
1-31	1	(red-red-yellow)	25-70	1	100-40-40 μ fd at 250-250-200		
1-31	1	330 K Ω 1/2 watt			V electrolytic		
1 25	•	(orange-orange-yellow)					
1-35	9	1 megohm 1/2 watt	C 1 -				
1 27	4	(brown-black-green)		s-Switches	10 ICO control (tob mounting)		
1-37	4	2.2 megohm 1/2 watt	(9) 10 - 57	1	10 KΩ control (tab mounting)		
1 71	1	(red-red-green)	10-59	1	250 KΩ control (tab mount-		
1-71	1	4.7 megohm 1/2 watt	(10) 10 140	4	ing)		
(2) 1A-18	1	(yellow-violet-green)	$(10)\ 10-140$	1	7.5 megohm control		
(2) $1A-10$	1	$150 \Omega 1 \text{ watt}$	(11) 12-31	1	Dual-tandem control, 50 KΩ		
(3) 1B-12	1	(brown-green-brown) 470 Ω 2 watt	10 74	1	each section		
(3) 113-12	1	(yellow-violet-brown)	19-74	1	20 KΩ control with push-pull SPST switch		
1B-19	1	1200Ω 2 watt	63-249	1	SPST Switch SPST switch		
110-10	1	(brown-red-red)	(12) 63-249	1	Rotary switch		
		(~1 0 1111 1 0 0 - 1 0 0)	(12) 00-010		Itotal y D WICCII		

^{*} Du Pont Registered Trademark

		PARTS Per Kit	DESCRIPTION			PARTS Per Kit	DESCRIPTION
	Coila Ch	oleog Trans	afonmona		Handwan	e (cont'd.)	
(1.2)		okes-Ira	nsformers				
,	40-149	1 T	FM line cord antenna coil	• •		26	#3 lockwasher
(14)	40-448	1	19 kc oscillator coil	,	254-1	44	#6 lockwasher
	40-449	1	38 kc doubler coil		254-5	1	Control lockwasher
	40-450	2	19 kc trap coil	•	255-1		1/8" spacer
	40-451	1	38 kc trap coil	•	255-2	4	3/16" spacer
	40-452	1	67 kc trap coil	1	258-1	1	Dial cord spring
	45-35	3	1.7 μh filament choke		259-1	_	#6 solder lug
	45-48	2		(47)	259-11	2	#6 spade lug
	52-59	1	Input IF transformer				
	52-60	1	Output IF transformer			s-Wire-Sl	
	53-7	1	Ratio detector transformer		73-1	2	3/8" rubber grommet
	54-137		Power transformer		89-1	1	Line cord
(1.0)		ubes-Lan	nps-Fuse		344-59	1	Length solid hookup wire
(18)	56-24	1	Crystal diode (yellow-green-		344-15	1	Length stranded hookup wire
	-0 11	_	gray)		347-2	1	Length twin lead
	56-11	1	Crystal diode (matched pair,		343-6	1	Length shielded cable
(10)		_	black-blue-black)		346-1	1	Length sleeving
(19)	57-27	2	Silicon diode			.	
	411-11	3	6AU6 tube			1 Strips-So	ockets-Plugs
	411-24	1	12AT7 tube	(48)	431-6	1	2-lug screw type terminal
	411-25	2	12AU7 tube	(40)	404 44	_	strip
	411-73	1	12BH7 tube	(49)	431-14	3	2-lug terminal strip, second
	411-128	1	6BN8 tube	(EO)	401 0		lug ground
	411-132	1		(50)	431-2	1	2-lug terminal strip, no
	412-1 412-13	2	47 pilot lamp	/E 1\	491 19	•	ground lug
	421-20	1	Red neon lamp	•	431-12	2	4-lug terminal strip, second
	421-20	1	1/2 ampere slow-blow fuse		434-68	1	lug ground
	Hardware	Α.		• '	434-08	3	9-pin molded tube socket
(20)	250-170	4	#6 x 1/4" sheet metal screw	•	404-129	3	7-pin tube socket, circuit
	250-8	8	#6 x 3/8" sheet metal screw		434-130	5	board type 9-pin tube socket, circuit
	250-49	12	$3-48 \times 1/4$ " screw		404-100	J	board type
18	250-172		$3-48 \times 3/8$ " screw	(54)	434-82	1	Double phono socket
	250-138	2	$6-32 \times 3/16$ " screw	. ,	434-88	2	Pilot lamp socket
	250-56	$2\overline{4}$	$6-32 \times 1/4$ " screw	(00)	438-4	4	Phono plug
	250-31	1	$6-32 \times 1/4$ " screw		100-1	-	r nono prug
		it	(round head)				
(27)	250-89	3	$6-32 \times 3/8$ " screw		Sheet Me	tal Parts	
	250-10	7	$6-32 \times 1/2$ " screw		90-255	1	Cabinet
	250-26	1	$6-32 \times 5/8$ " screw		100-M42	0F 1	Dial plate assembly
	250-127	2	$6-32 \times 1/2$ " self-tapping		200-M37		Proceed Controls
			screw			1	Chassis
(31)	250-100	2	6-32 x 5/16" setscrew		203-M33	8F857	
	250-43	1	$8-32 \times 1/4$ " setscrew			94.20	Trim panel, vinyl clad
	252-1	14	3-48 nut		203-M33	-1	Subpanel
	252-3	38				1F498, 856	
	252-4	4	8-32 nut			1	Front panel
(36)	252-7	5		(56)	204-M36	6 1	Left-hand bracket
(37)	252-32	1	Push-on speednut	5	204-M36		Right-hand bracket
(38)	253-9	4	•	(57)	204-M399	9 1	Shaft mounting bracket
(39)	253-11	2	E washer		205-M400		Bottom plate



PART	PARTS Per Kit	DESCRIPTION		PARTS Per Kit	DESCRIPTION
No.				rei Kit	
Misce	ellaneous		Miscellan	eous (con	t'd.)
$(58) \overline{75-24}$	1	Line cord strain relief	462-117	4	Small pointer knob
(59)84-25	1	Ratio detector network	462-120	1	Large plain knob
		P.E.C. (packaged electronic	462-124	1	Large pointer knob
		circuit) (62)	463-20	1	Dial pointer
110-1	6 1	Assembled FM tuning unit (63)		2	Capacitor mounting wafer
$(60)\ 206-6$	8 3	9-pin expandable tube shield	85-55F84	6 1	FM circuit board
		1-3/4'' long	85-56F86	0 1	Multiplex circuit board
206-2	06 2	9-pin expandable tube shield	100-M62	1	Dial drum
		2'' long	100-M152	2 1	Dial cord
206-7	7 3	7-pin expandable tube shield (64)	100-M302	2 2	Pulley bracket assembly
210-1	4 1	Bezel	446-13F9		
$(61)\ 261-1$	7 4	Plastic feet		1	Dial window
391-1	7 1	Nameplate	331-6		Solder
423-1	1	Fuse holder	490-1	1	Alignment tool
453-9	3 1	Dial shaft	595-605	1	Manual
454-2	1	Flywheel			

PROPER SOLDERING TECHNIQUES

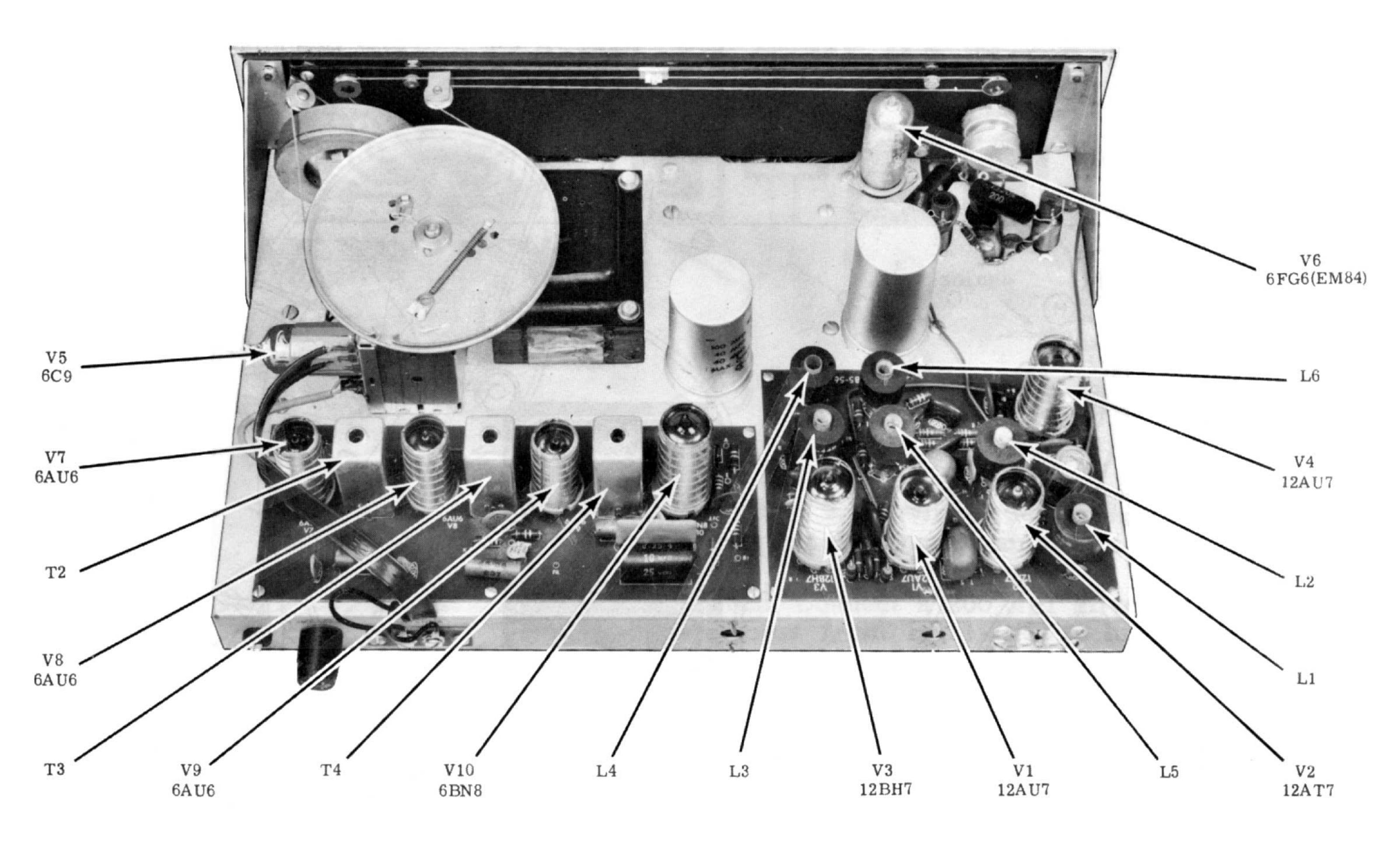
Only a small percentage of customers find it necessary to return equipment for factory service. By far the largest portion of malfunctions in this equipment are due to poor or improper soldering.

If terminals are bright and clean and free of wax, frayed insulation and other foreign substances, no difficulty will be experienced in soldering. Correctly soldered connections are essential if the performance engineered into a kit is to be fully realized. If you are a beginner with no experience in soldering, a half hour's practice with some odd lengths of wire may be a worth-while investment.

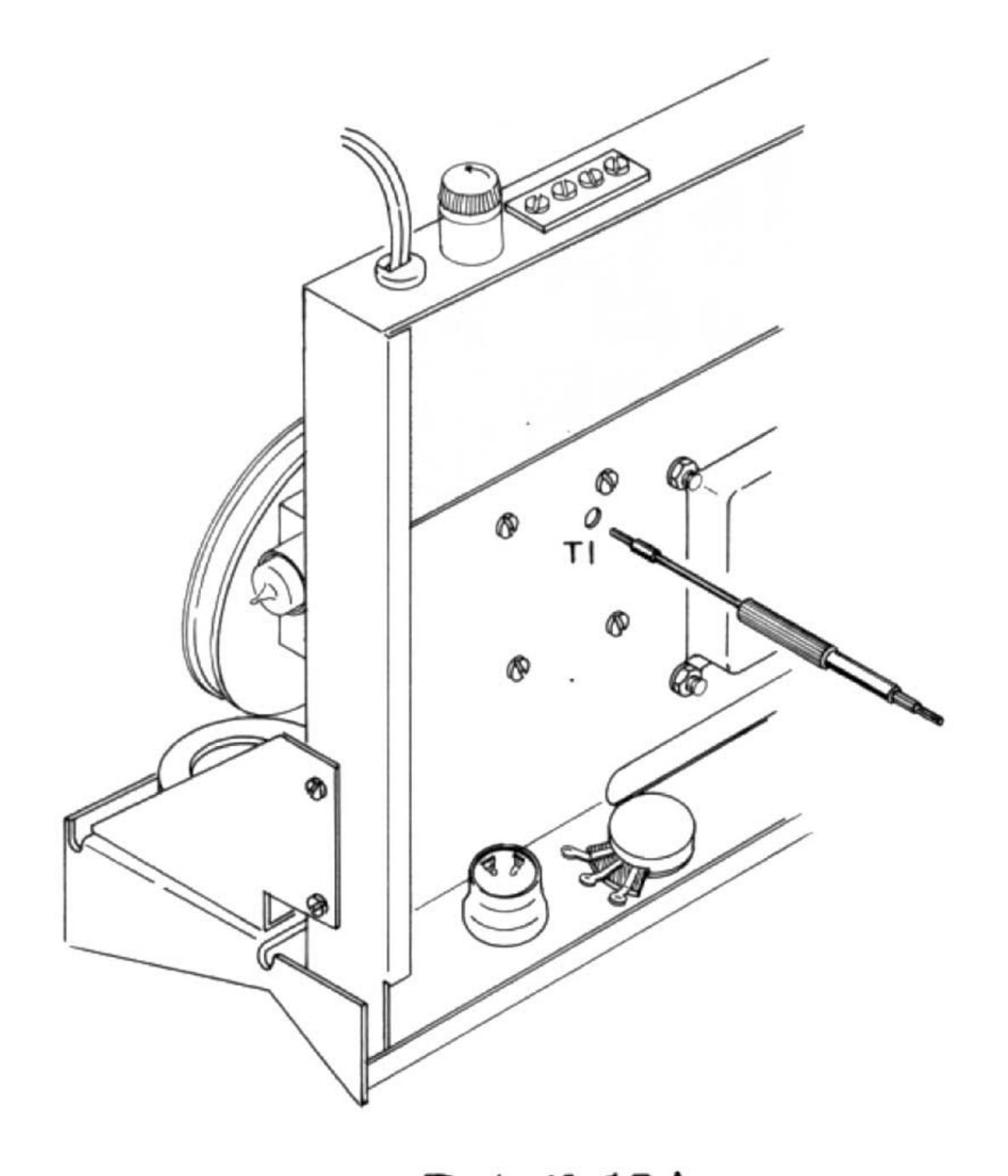
For most wiring, a 25 to 100 watt iron or its equivalent in a soldering gun is very satisfactory. A lower wattage iron than this may not heat the connection enough to flow the solder smoothly. Keep the iron tip clean by wiping it from time to time with a cloth.

CHASSIS WIRING AND SOLDERING

- 1. Unless otherwise indicated, all wire used is the type with colored insulation (hookup wire). In preparing a length of hookup wire, 1/4" of insulation should be removed from each end unless directed otherwise in the assembly step.
- 2. To avoid breaking internal connections when stripping insulation from the leads of transformers or similar components, care should be taken not to pull directly on the lead. Instead, hold the lead with pliers while it is being stripped.
- 3. Leads on resistors, capacitors, and similar components are generally much longer than need be to make the required connections. In these cases, the leads should be cut to proper length before the part is installed. In general, the leads should be just long enough to reach their terminating points.



Pictorial 15



Detail 15A



This completes the wiring of your Tuner. Carefully inspect the wiring for shorts caused by excess solder and unclipped lead ends. Shake

out any clipped off wire ends that may be lodged in the wiring.

INITIAL TEST AND ADJUSTMENT

Refer	to	Pictorial	15	(fold-out	from	Page	30)
for the	e f o	llowing st	e ps	•			

() Place the controls in the following positions:

VOLUME - maximum counterclockwise. MODE SELECTOR - FM.

POWER - OFF.

FM STEREO PHASE - "in" and at half rotation.

AFC - OFF.

SEPARATION - center of rotation. SQUELCH- maximum counterclockwise.

- () Install the 6FG6 (EM84) tube in tube socket V6.
-) Install the remaining tubes in their respective sockets.
- () Place a 1/2 ampere slow-blow fuse in the fuse holder.
- () Plug the line cord plug into a standard AC outlet and turn the POWER switch to ON. The dial lamp should light immediately. The tuning indicator tube should start to glow green after a few seconds.
- () Check the components on the circuit boards and any components mounted underneath the chassis to be sure none of them are overheating. Check all the tubes (including front end tubes) to see that the filaments are lit.

- () If any difficulty is encountered, turn the Tuner off and refer to the In Case of Difficulty section of the manual on Page 45.
- () If no difficulty has been experienced up to this point, connect the L STEREO output of the Tuner to the left channel input of your amplifier, and connect the R STEREO output of the Tuner to the right channel input of your amplifier, using the audio cables prepared previously.
- () Connect an antenna to the ANTENNA connector of the Tuner. This can be a FM or TV antenna, or if you have FM stations in your locality the internal FM line cord antenna may be used by connecting either spade lug to either ANTENNA terminal and the remaining spade lug to the other AN-TENNA terminal.
- () Tune in an FM station of known frequency and position the dial pointer on the cord to indicate the proper frequency. Bend the dial pointer tabs over the cord to hold the pointer in place. Be careful not to cut the dial cord.
- () Install the tube shields on all the tubes except V6.



RATIO DETECTOR ADJUSTMENT

() Set the controls as follows:

VOLUME - 1/2 clockwise.

MODE SELECTOR - FM.

POWER - ON.

FM STEREO PHASE - "in" and at half rotation.

AFC - OFF.

- () Tune to a strong local station and adjust for maximum closure of the tuning indicator tube.
- () Adjust the VOLUME control for the desired listening level and, while watching the tuning indicator tube and listening to the sound from the speakers, adjust the top slug of ratio detector transformer T4 for the loudest sound. T4 is prealigned and should not be turned more than 1/4 turn in either direction.

FM STEREO MULTIPLEX ADJUSTMENTS

Place the MODE SELECTOR switch in the STEREO position. Tune in a station that is known to be broadcasting a stereo multiplex signal. Refer to a local FM program guide or newspaper listing of FM programs in your area. Set the SEPARATION control 1/3 clockwise. Test this setting by pulling the FM STEREO PHASE knob "out" and setting the control to the center of its range. The station should now be producing a sound output in each speaker. This sound may be garbled or distorted, but this will be taken care of by adjusting oscillator coil L3 later.

A <u>stereo</u> signal <u>must</u> be used to make the following adjustments. If the station you have tuned in is broadcasting a monophonic (non-stereo) signal, there will be very little sound from the speaker systems. If this is the case, and no stereo program is being broadcast, tune the FM tuner to a station that usually broadcasts stereo. Leave the Tuner on with the FM STEREO PHASE knob pulled "out." Now nothing

will be heard from the speakers until a stereo signal is received.

When a stereo signal is received, insert the alignment tool into the slug of coil L3. Now carefully adjust the slug (not more than one turn in either direction) first in one direction and then in the other, until you hear the clearest reproduction from the speaker systems. If there are two or three maximum loudness points, adjust the slug to the one in the center. Remove the alignment tool carefully so as not to disturb the adjustment.

NOTE: After about 10 hours of operation to allow all components to stabilize, it may be necessary to repeat the above adjustments to assure continued good performance and maximum stereo separation.

Push the FM STEREO PHASE knob "in." Next, adjust the SEPARATION control 1/3 rotation clockwise or for maximum channel separation as heard from the speaker systems. Maximum channel separation can be recognized by one of the following conditions:

- 1. Maximum difference between the program material heard from the left and right speaker systems.
- 2. In instances when the FM station broadcasts material on only one channel, set the SEPARATION control for minimum sound from one of the speaker systems.

Once the SEPARATION control has been set properly, it should not have to be readjusted.

Next, adjust the slug of coil L1 counterclockwise for the brightest glow of the STEREO indicator lamp.

This completes Initial Test and Adjustments. Turn to Final Assembly, unless alignment is needed.



ALIGNMENT

EQUIPMENT NEEDED: Sweep generator, marker generator and oscilloscope.

Set the controls as follows:

TUNING - off station
VOLUME - full clockwise
AFC - OFF
SQUELCH - full counterclockwise
MODE SELECTOR - FM

	SWEEP GE	NERATOR	OSCILLOSCOPE	ADJUST	
PREPARATION	Connect sweep generator	Sweep generator and test point test point frequency		for maximum gain and bandwidth	for approximate response
	Through .01 µfd capacitor to Pin 1 of V9	10.7 mc		Bottom slug of T4	
Disconnect positive (+)	Through .01 µfd capacitor to Pin 1 of V8	10.7 mc	To 2 through 100 KΩ resistor	Top and bottom slugs of T3	
lead of C215 from the FM board.	Through .01 μ fd capacitor to Pin 1 of V7	10.7 mc	10.7 mc		
	Through .01 µfd capacitor to Pin 1 of V9	10.7 mc	To 3 through 100 KΩ resistor	Top slug of T4 for straightest center portion of curve and balanced plus (+) and minus (-) swing.	+
Reconnect (+) lead of C215 Tune the dial pointer to 98 mc.	To Antenna input with 120 Ω in series with each lead (for 50 Ω generator Z).	Sweep generator 98 mc Marker generator 10.7 mc	To pin 1 of V9 through 100 KΩ resistor. Ground lead to V9 center post	Top and bottom slugs of T1 located on prewired front end.*	

^{*}Refer to Detail 15A (fold-out from Page 30).

FM STEREO MULTIPLEX ALIGNMENT

EQUIPMENT NEEDED: An audio VTVM, an audio generator, and an oscilloscope.

Refer to Pictorial 15 (fold-out from Page 30) and the X-ray views (on Pages 43 and 44) of the multiplex circuit board for the points referred to in this alignment procedure.

- 1. Refer to the top side of the chassis. Disconnect the lead of capacitor C1 (.1 μfd) nearest the edge of the circuit board, from the Multiplex circuit board.
- () 2. Short pin 2 of tube V3B to ground (chassis) with a short clip lead.
- () 3. Connect a generator to the disconnected lead of C1 (.1 μ fd) and set it to 67 kc. Adjust the generator output level to 0.3 volt rms.
- () 4. Connect one lead of a 47 KΩ resistor to test point 1. Connect an AC VTVM to the other lead of this resistor with short unshielded leads. Connect an oscilloscope to the VTVM with a low capacity probe, or two short test leads.
- () 5. Plug the Tuner in and turn it on. Set the MODE switch in the STEREO position. Push the PHASE switch 'in' and set the control to the center of its range.
- () 6. After the unit has warmed up, adjust coil L5 for minimum output. The voltmeter should indicate about .02 volt rms, or less. NOTE: This adjustment will be quite sharp.
- () 7. Disconnect the shorting clip lead from pin 2 of tube V3B.
- () 8. Set the generator to 19 kc ±100 cps. Adjust the output level to 0.1 volt rms.
- () 9. Adjust coil L3 (#40-448) for maximum output. Observe the scope to make sure the 38 kc output is locking on the 19 kc input signal (evidenced by amplitude difference of adjacent peaks). NOTE: This adjustment will be very sharp and should be made carefully.
- () 10. Next, adjust coil L4 (#40-449) for maximum output. NOTE: This adjustment will also be quite sharp and should be peaked carefully.

- () 11. Finally, adjust coil L6 (#40-451) for maximum output. NOTE: This coil will be very broad and the slug will probably have to be rocked back and forth to find the peak.
- () 12. The voltmeter should indicate about 10 volts rms.
- () 13. Adjust the slug of coil L1 for the brightest glow of the stereo indicator lamp.
- () 14. Reset the generator to 1000 cps and adjust its output level to .5 volt.
- () 15. Remove the scope and voltmeter leads from test point 1 and connect them to the Left Channel output socket. Set the voltmeter on the 3 volt range.
- () 16. Set the VOLUME control fully clockwise.
- () 17. With the SEPARATION control in the maximum counterclockwise position, there should be no output (voltmeter on the 3 volt range).
- () 18. With the SEPARATION control in the maximum clockwise position, the voltmeter should indicate between 1 and 1.5 volts rms and the scope should show an undistorted sine wave.
- () 19. Remove the scope and voltmeter leads from the Left Channel output socket and connect them to the Right Channel output socket.
- () 20. Repeat steps 17 and 18 to check the Right Channel output.
- () 21. Remove the scope and voltmeter from the Right Channel output socket.
- () 22. This completes alignment of the multiplex section of the Tuner.

NOTE: No adjustment of coil L2 (#40-450) should be made unless a multiplex or stereo generator is available. This adjustment determines the amount of high frequency separation, and the factory preset adjustment of the coil should be very close. However, if you desire to check the setting of this coil, and you have a stereo generator, adjust coil L2 (#40-450) for maximum separation at 10 kc (should be about 25 db).

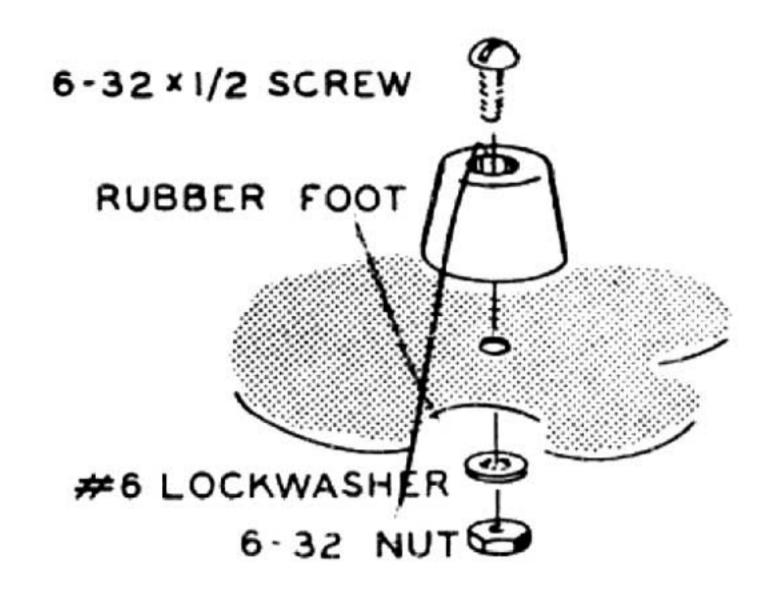
() 23. Reconnect the lead of capacitor C1 that was disconnected in step 1.



FINAL ASSEMBLY

Refer to Pictorial 16 for the following steps.

Locate the bottom plate and mount a plastic foot in each corner, using a $6-32 \times 1/2$ " screw, a #6 lockwasher, and a 6-32 nut for each foot as shown in Detail 16A.



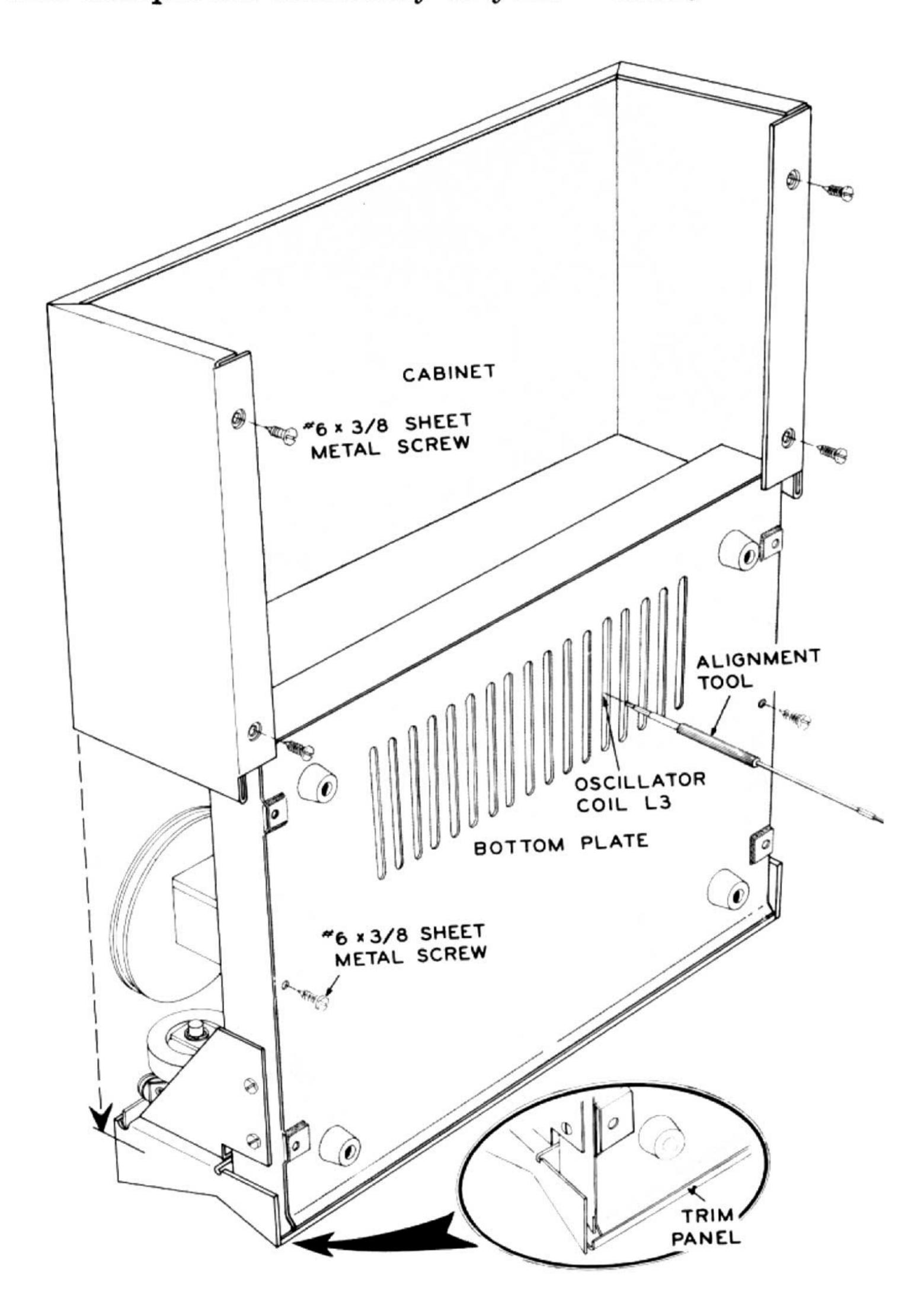
Detail 16A

- () Mount the bottom plate to the chassis, using one #6 x 3/8" sheet metal screw in the center hole on each side of the chassis as shown. The front edge of the bottom plate must fit under the bottom edge of the trim panel.
- () Slide the cabinet over the Tuner from the back and fasten it to the bottom, using four #6 x 3/8" sheet metal screws.
- () Install the nameplate to the trim panel by removing the paper backing from the name-plate. Then apply the nameplate with firm, even finger pressure, to the trim panel.

NOTE: The blue and white identification label shows the Model Number and Production Series Number of your kit. Refer to these numbers in any communications with the Heath Company; this assures you that you will receive the most complete and up-to-date information in return.

- () Install the identification label in the follow-ing manner:
 - 1. Select a location for the label where it can easily be seen when needed, but will not show when the unit is in operation. This location might be on the rear panel or the top of the chassis, or on the rear or bottom of the cabinet.
 - 2. Carefully peel away the backing paper. Then press the label into position.

This completes assembly of your Tuner.



Pictorial 16

INSTALLATION

MOUNTING THE TUNER

Refer to Figure 10 for installing the tuner in your system.

One of the main considerations in mounting the Tuner is to make sure there is adequate ventilation. Do not enclose the Tuner so that the heat from the tubes will not be able to flow away in a normal manner.

The Tuner can be panel mounted in a custom installation by removing the feet and the cabinet.

It is not recommended that the Tuner be vertically mounted, hanging from the front panel alone. Some other means of added support will be necessary to hold the Tuner up, keeping the weight off of the front panel. Also, provisions should be made to allow the trapped heat to flow out from under the front panel.

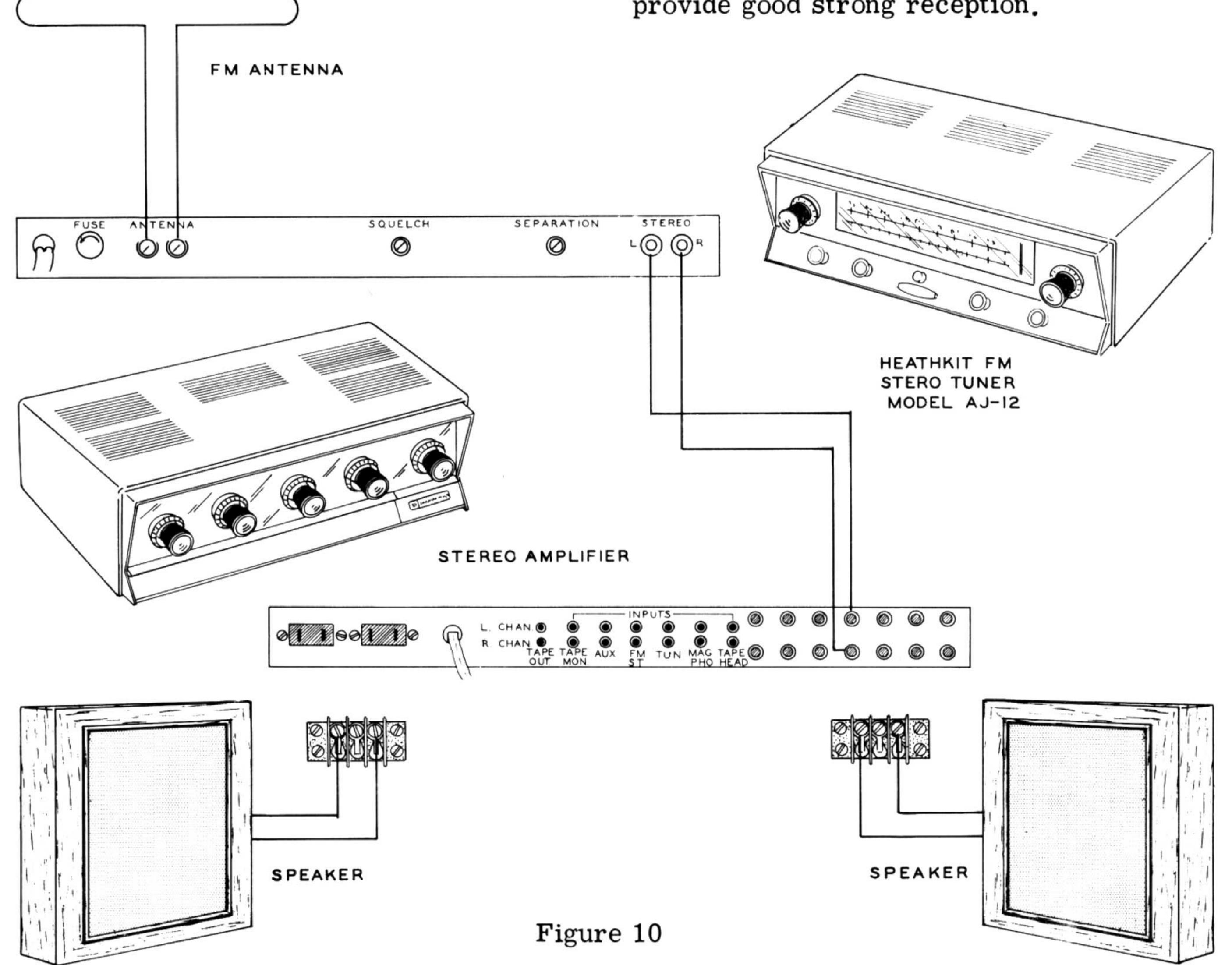
AUDIO CONNECTIONS

Connect one of the audio cables from the Left Channel output socket of the Tuner to the left channel tuner input of your amplifier. Connect the other audio cable from the Right Channel output socket of the Tuner to the right channel input of your amplifier.

INSIDE ANTENNAS

The internal antenna coil picks up the FM signals from strong local stations present on the power lines. The "line cord antenna" may be connected to the antenna terminals with the two stranded hookup wires near the antenna terminals.

FM stereo reception normally requires a higher signal strength than necessary for FM monophonic reception. If distortion or fading is encountered when receiving an FM stereo station, an outdoor TV or FM antenna should be used to provide good strong reception.





OUTSIDE ANTENNAS

To receive the weaker stations, or in weak signal areas, an external antenna will be necessary.

A TV antenna can always be used as an FM antenna since the FM stations are actually tuned in between TV channels 6 and 7. Do not hook a TV antenna to both the TV set and the FM Tuner at the same time unless a TV antenna coupler is used. If the two units are both connected to the antenna without a TV coupler to separate them, a weak and distorted signal may result on both units.

A simple folded dipole antenna can be made of standard 300 Ω twin lead as shown in Figure 11. This antenna can be placed on the rear of a large cabinet or nailed or stapled to a piece of wood to reinforce it. Keep the antenna broadside to the stations you wish to receive for best reception.

Best reception of all would be from a commercial FM outside antenna with a 300 Ω impedance to match the antenna input of the Tuner.

Be sure that the leads of the internal antenna of the Tuner are disconnected from the antenna terminals before connecting an external antenna. It is also advisable to use approved TV lead-in lightning arrestors with an outside antenna.

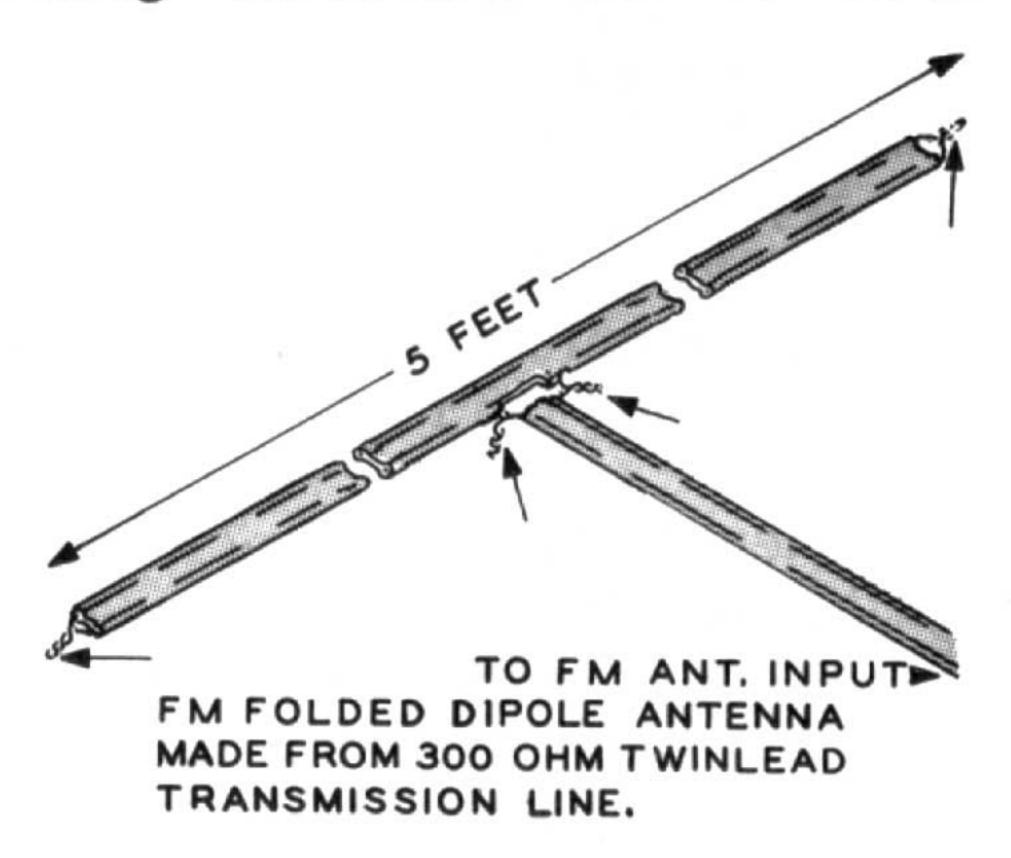


Figure 11

OPERATION

FRONT PANEL CONTROLS

POWER SWITCH

The POWER switch turns the Tuner ON or OFF.

AFC CONTROL

The AFC control is used to vary the amount of AFC (automatic frequency control) voltage required for minimum drift and ease of tuning. In the OFF position there is no AFC; in the MAX position, full AFC is applied to the tuning unit.

It is often difficult when using the same amount of AFC, to tune in a weak station that is near a strong station. This is because the AFC tries to "lock in" on the strong station. Turning the AFC OFF makes possible the sharper, more careful tuning that is needed for weak stations. Turning the AFC control up again should "lock in" the weak station.

FM STEREO PHASE CONTROL AND SWITCH

This control and switch are used only when tuned to a FM stereo station. To set this control the knob should be pulled "out," to activate the switch.

In this position, only the subchannel information will be heard (see Circuit Description).

The STEREO PHASE control is adjusted, first in one direction and then in the other, until you hear the clearest reproduction from the speaker systems. If there are two or three maximum points, adjust the control to the center maximum point.

Push the knob back in without disturbing the setting of the control. This control allows the user to obtain maximum separation. It should be adjusted each time a stereo station is tuned in.

NOTE: If this adjustment can not be made, return to the section entitled "FM Stereo Multiplex Adjustments" and repeat the adjustment of coil L3 as described there. If the cabinet and bottom plate are on the unit, this adjustment can be made through one of the slots in the bottom plate. See Pictorial 16 on Page 38.

STEREO INDICATOR LAMP

This indicator will light up with a steady glow when a FM station that is broadcasting stereo is tuned in. In some cases it may flicker on noise between stations. It may also light for



short periods of time on stations that use a "Commercial Killer" signal to eliminate the commercials from the music so that it may be sold to business establishments.

FM SQUELCH CONTROL

The SQUELCH control is used to adjust the squelch circuit to eliminate the noise that is heard when tuning between stations. This control should be adjusted in a clockwise direction only far enough to eliminate the noise between stations. If it is turned maximum clockwise, only the strong stations will be heard. To receive a very weak station, it may be necessary to turn the control completely counterclockwise.

MODE SELECTOR SWITCH

The MODE SELECTOR switch selects the operating mode; Normal or Stereo.

In the FM position, the same monophonic signal is present at the Left and Right OUTPUT sockets.

In the STEREO position one channel signal is at the Left and the other channel signal is at the Right OUTPUT socket. NOTE: The STEREO position should be used only when a station is broadcasting stereo so that the subchannel noise will not be heard on regular FM programs.

TUNING INDICATOR

The indicator tube indicates the signal strength of the tuned-in FM station. Each FM station should be tuned for maximum indication on the tube (maximum closure). Only extremely strong local stations will cause the indicator to close all the way.

In fringe areas the sensitivity of the indicator tube can be increased by replacing the 1 megohm resistor (R307) with a 3.3 megohm resistor from lug 1 of tube socket V11 and lug 3 of terminal strip U.

FM TUNING CONTROL

By turning the TUNING control you can change the dial setting to select the station you desire to listen to.

VOLUME CONTROL

Simultaneously adjusts the Left and Right output signals.

REAR PANEL CONTROLS

SEPARATION CONTROL

The SEPARATION control is adjusted for maximum stereo channel separation in your system. Normally the control will be set about 1/3 rotation clockwise. Usually once it is adjusted, it need not be changed. Maximum channel separation can be recognized by one of the following conditions:

- 1. Maximum difference between the program material heard from the left and right speaker systems.
- 2. In instances when the FM station broadcasts material on only one channel, set the SEPARATION control for minimum sound from one of the speaker systems.

HOW TO GET THE MOST OUT OF YOUR TUNER

The following procedure is presented to help the new user realize the most enjoyment that this high quality Stereo Tuner is capable of providing. The Tuner should be connected, as illustrated, to a good quality stereo amplifier or two separate amplifiers. The speakers should be placed far enough apart to provide good stereo separation; approximately 4 to 8 feet.

1. Set the Tuner controls as follows:

POWER switch to ON.
AFC control to OFF.
FM STEREO PHASE control "in" and set it to the center of its range.
FM SQUELCH to OFF.
MODE SELECTOR to FM.
SEPARATION control to 1/3 rotation clockwise.

2. Tune in a station broadcasting stereo as indicated by a steady glow of the STEREO indicator and maximum closure of the tuning indicator tube.



- Adjust the volume control of the amplifier to produce equal volume from each speaker at the desired listening level.
- 4. Make sure that the speakers are in phase. This can be accomplished by standing between the speakers and switching the polarity of the voice coil leads on one of the speakers. The connections that give the indication that the sound comes from between the speakers is correct. Most Heathkit stereo amplifiers have a phase switch to reverse the speaker leads.
- 5. Turn the MODE SELECTOR switch to the STEREO position.
- 6. Pull "out" the FM STEREO PHASE knob and carefully adjust it, first in one direction and then in the other, until you hear the clearest reproduction from the speaker systems. If there are two or three maximum points, adjust the control to the center maximum point. Now push the knob "in" without disturbing the setting of the control.

NOTE: This control adjusts the frequency and phase of the 38 kc reinserted carrier. Because the phase angle of this carrier is critical (±3 degrees) it may be necessary to periodically repeat step 6 to obtain maximum separation.

- 7. The SEPARATION control should be left at 1/3 rotation unless there is program material on one channel only, such as commercials and announcements that are switched from one channel to the other; thus the sound will come from only one speaker. If the station you are listening to broadcasts in this manner the SEPARATION control should be adjusted for minimum output in the channel not being used. Once this adjustment is made, the control should always be left in that position.
- 8. Turn the AFC control to MAX. This control should always be in this position unless you want to tune in a weak station adjacent to a strong station.
- 9. Turn the TUNING off station so that only a loud hiss is heard. Now adjust the SQUELCH control clockwise until the loud hiss is no longer heard. The SQUELCH control should be left in this position unless you want to receive a very weak station. This adjustment is best made with the AFC control in the OFF position.
- 10. To receive all FM programs not in stereo, turn the MODE SELECTOR switch to the FM position. This will produce the best signal-to-noise ratio.

X-RAY VIEW OF MULTIPLEX CIRCUIT BOARD

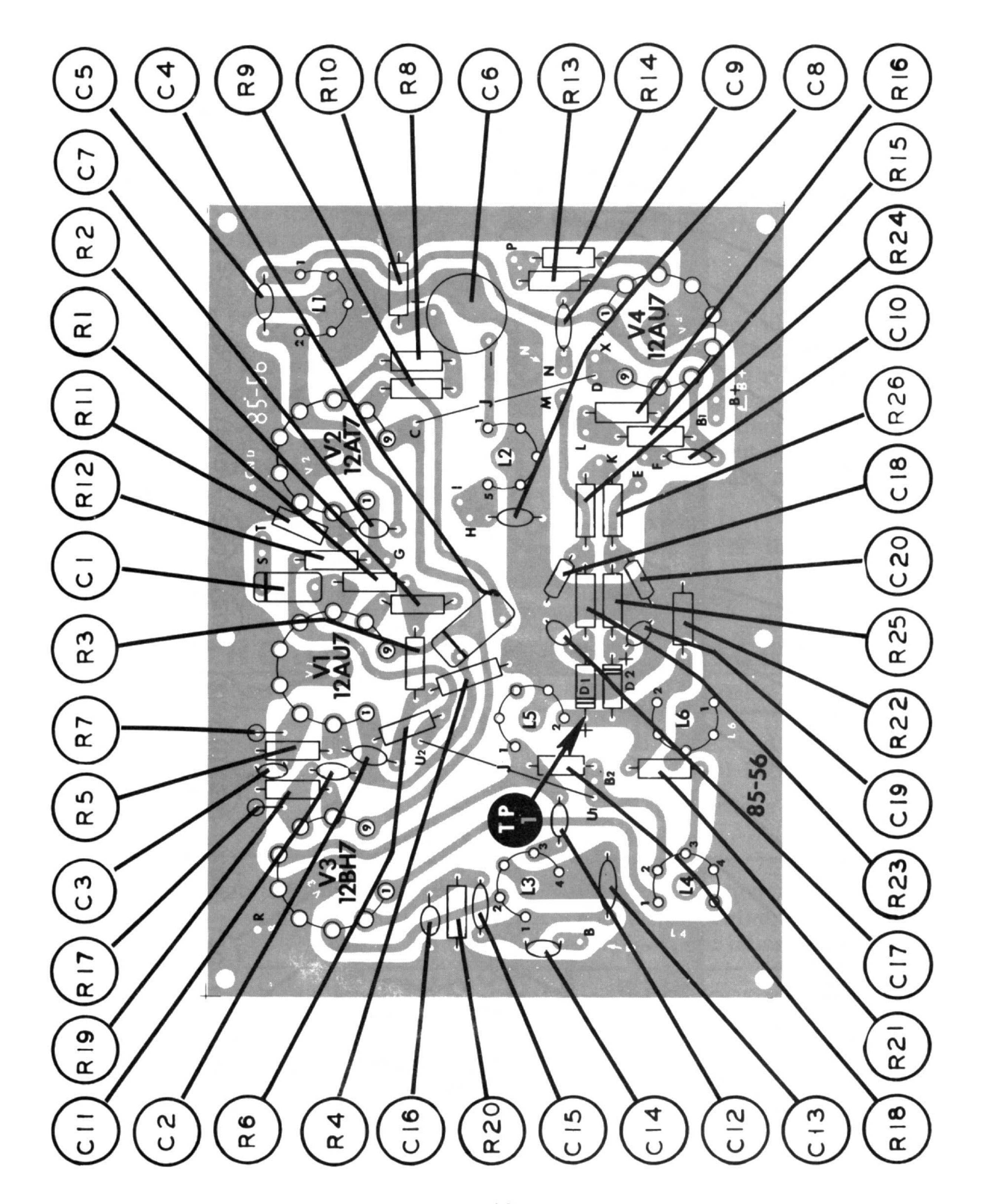


Figure 12

X-RAY VIEW OF FM CIRCUIT BOARD

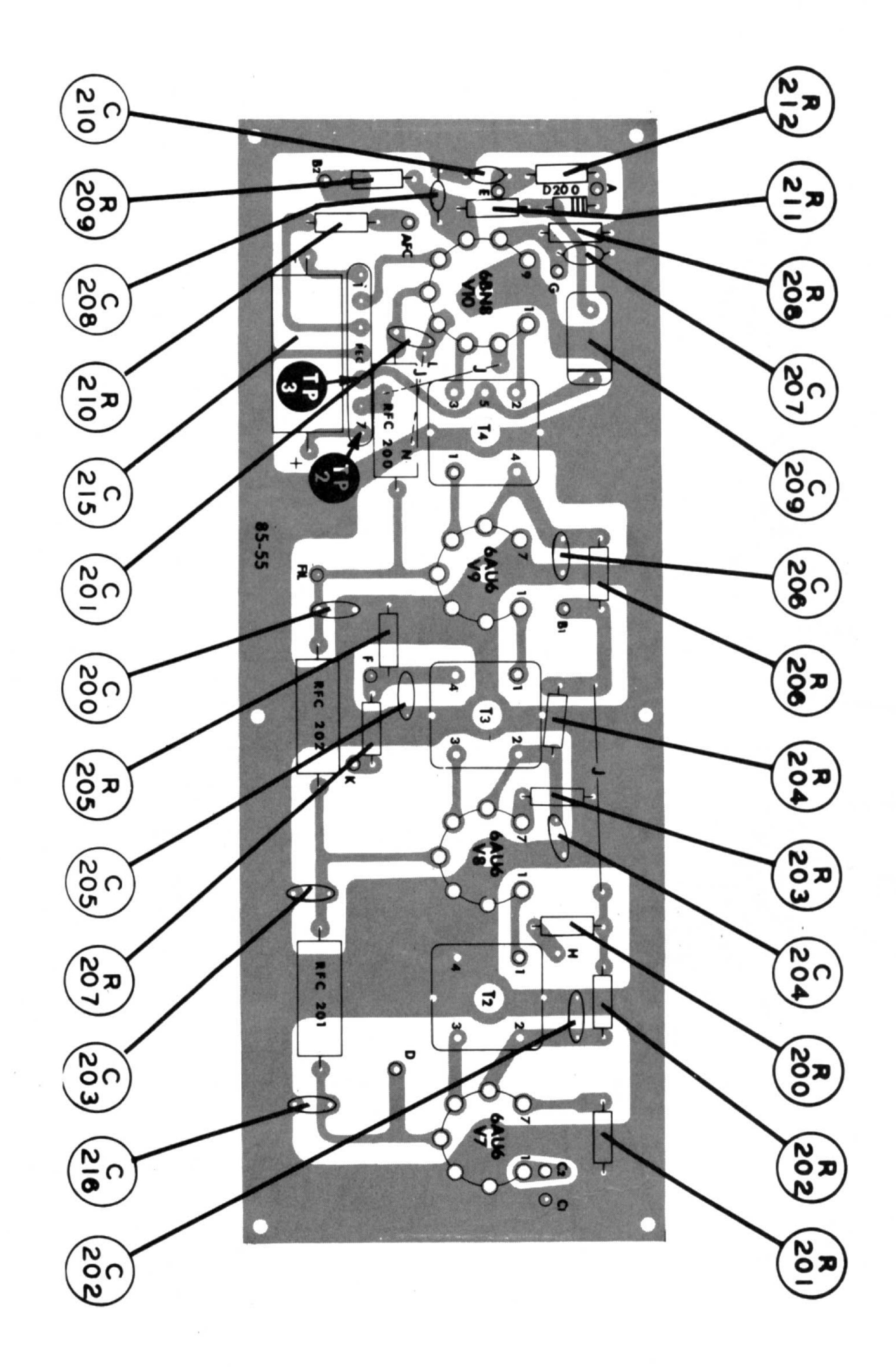


Figure 13



IN CASE OF DIFFICULTY

- 1. Recheck the wiring. Trace each lead in colored pencil on the Pictorial as it is checked. It is frequently helpful to have a friend check your work. Someone who is not familiar with the unit may notice something consistently overlooked by the constructor.
- 2. It is interesting to note that about 90% of the kits that are returned for repair, do not function properly due to poor connections and soldering. Therefore, many troubles can be eliminated by reheating all connections to make sure that they are soldered as described in the Proper Soldering Techniques section of this manual.
- 3. Check to be sure that all tubes are in their proper locations. Make sure that all tubes, including front end tubes, light up properly.
- 4. Check the tubes with a tube tester or by substitution of tubes of the same types and known to be good.

- 5. Check the values of the parts. Be sure that the proper part has been wired into the circuit, as shown in the pictorial diagrams and as called out in the wiring instructions.
- 6. Check for bits of solder, wire ends or other foreign matter which may be lodged in the wiring.
- 7. If, after careful checks, the trouble is still not located and a voltmeter is available, check voltage readings against those shown on the Schematic Diagram. NOTE: All voltage readings were taken with an 11 megohm input vacuum tube voltmeter. Voltages may vary as much as 10%.
- 8. A review of the Circuit Description will prove helpful in indicating where to look for trouble.

TROUBLESHOOTING CHART

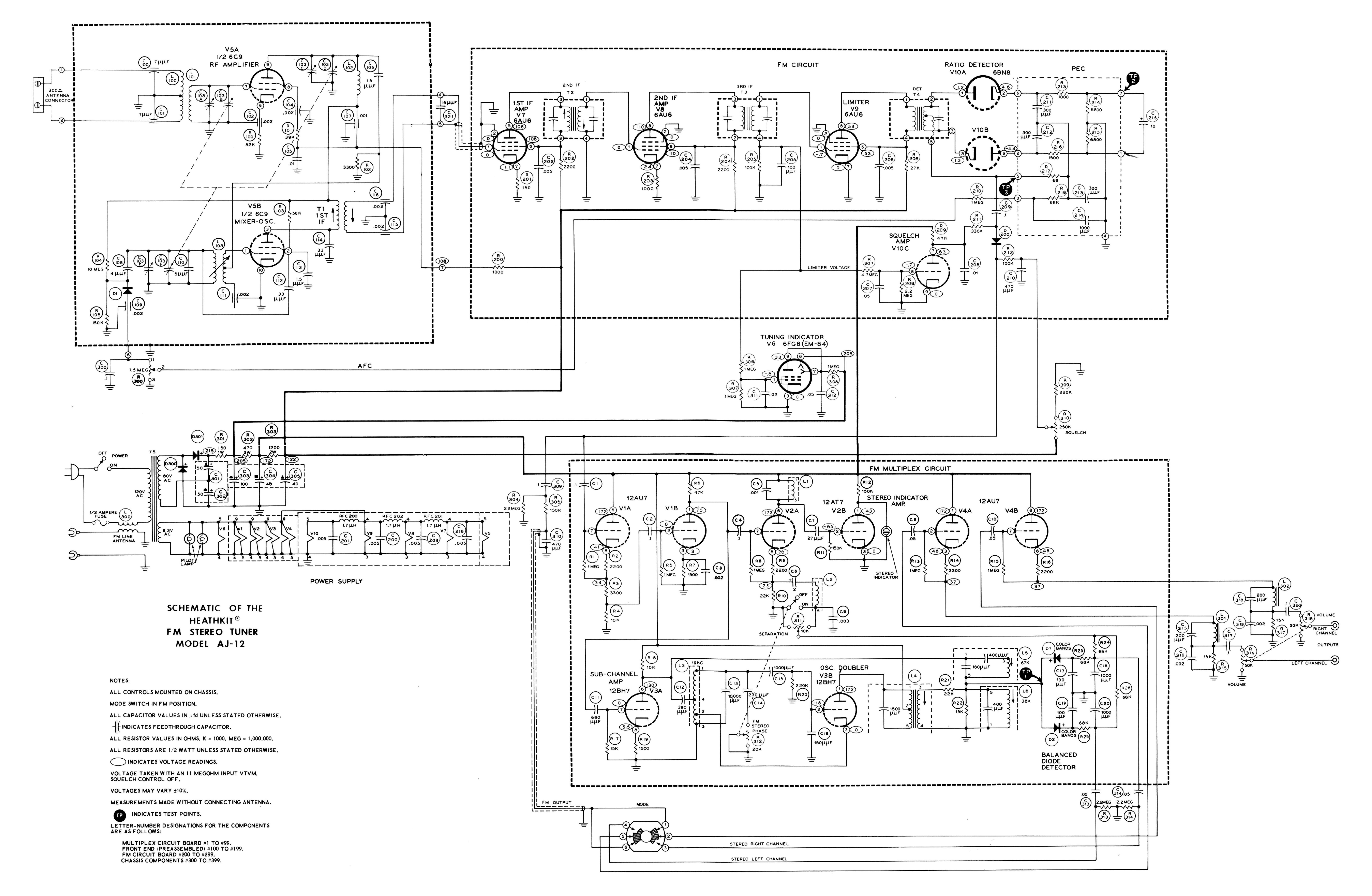
DIFFICULTY	POSSIBLE CAUSE
Dead Tuner, filaments not lit.	AC line cord, fuse, bad AC switch, open FM line cord antenna coil L300, power transformer. Cold solder connections on circuit board filament wiring.
Dead Tuner, filaments lit but no output.	Open or shorted output cable, volume control turned counterclockwise, no B+, silicon rectifiers open, open or shorted filter capacitors.
Noise but no sound.	Check antennas, MODE SELECTOR switch, RF and oscillator tube defective.
Hum.	Reverse AC line plug in outlet, filter capacitors leaky, heater to cathode leakage in tubes.
AFC inoperative.	Control R300, detector transformer T4 align- ment, shorted AFC lead.
Distorted output.	V4 and V9, alignment of T4, shorted FM IF tubes V4 through V8 filter capacitors, coupling capacitor C.
Filament not lit in front end tuner tubes.	Wire coming from hole D on FM board not properly connected to pin 3 of front end tuner.



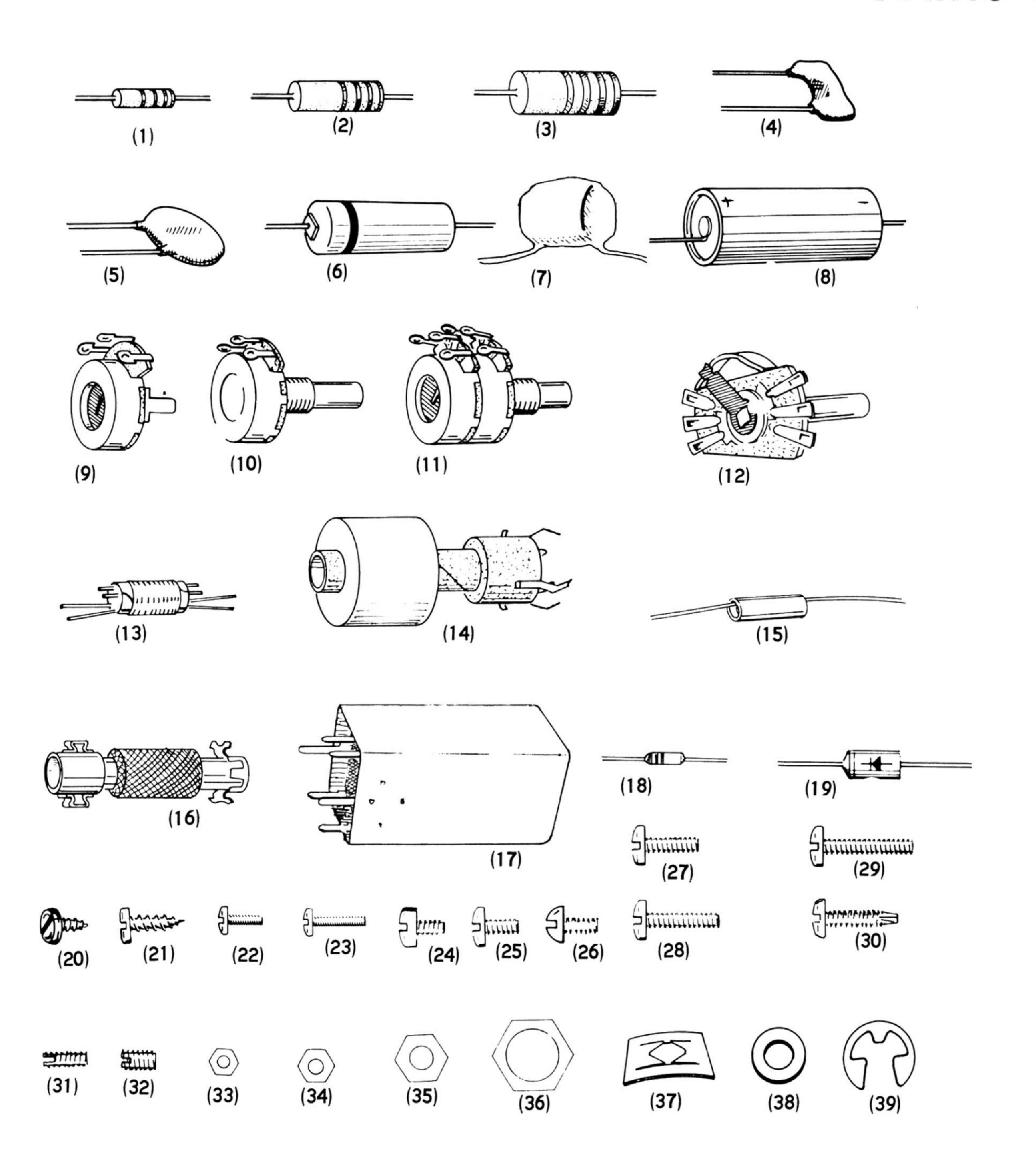
DIFFICULTY	POSSIBLE CAUSE
Nonlinear AFC action.	Alignment of the bottom slug of T4.
No squelch and no tuning tube indication.	Check tube V10C, resistors R208 and R211, capacitors C207 or C208 shorted.
Tuning tube all right, but no squelch action.	Diode D200 shorted. Check resistors R212, R309, and control R310, capacitors C1, C209, C210, and C310.
FM all right, FM STEREO dead.	Tube V1 defective. Capacitor C1 open.
FM STEREO output all right on monaural signal, but garbled on stereo signal.	Misadjustment of coil L3, and/or stereo phase control R312. Capacitor C12 open.
FM stereo subchannel dead (no output when phase switch is 'out'').	Signal is not stereo (see Circuit Description and operation sections on "Commercial Killers.") Check tube V3, capacitor C11, coils L5, L6, diodes D1 and D2.
Little or no FM stereo separation.	Signal is not stereo (see above). Misadjustment of coil L3 and/or stereo phase control R312. Stereo phase switch is in the "out" position. Main channel dead; check tube V2A, coil L2, capacitors C6, C8, control R311, resistors R24 and R26. Separation control R311 misadjusted.
FM STEREO indicator fails to operate on stereo signals.	Misadjustment of coil L1. Open or shorted capacitors C5, C7, or coil L1. Open tube V2B, Faulty STEREO indicator (NE-2).

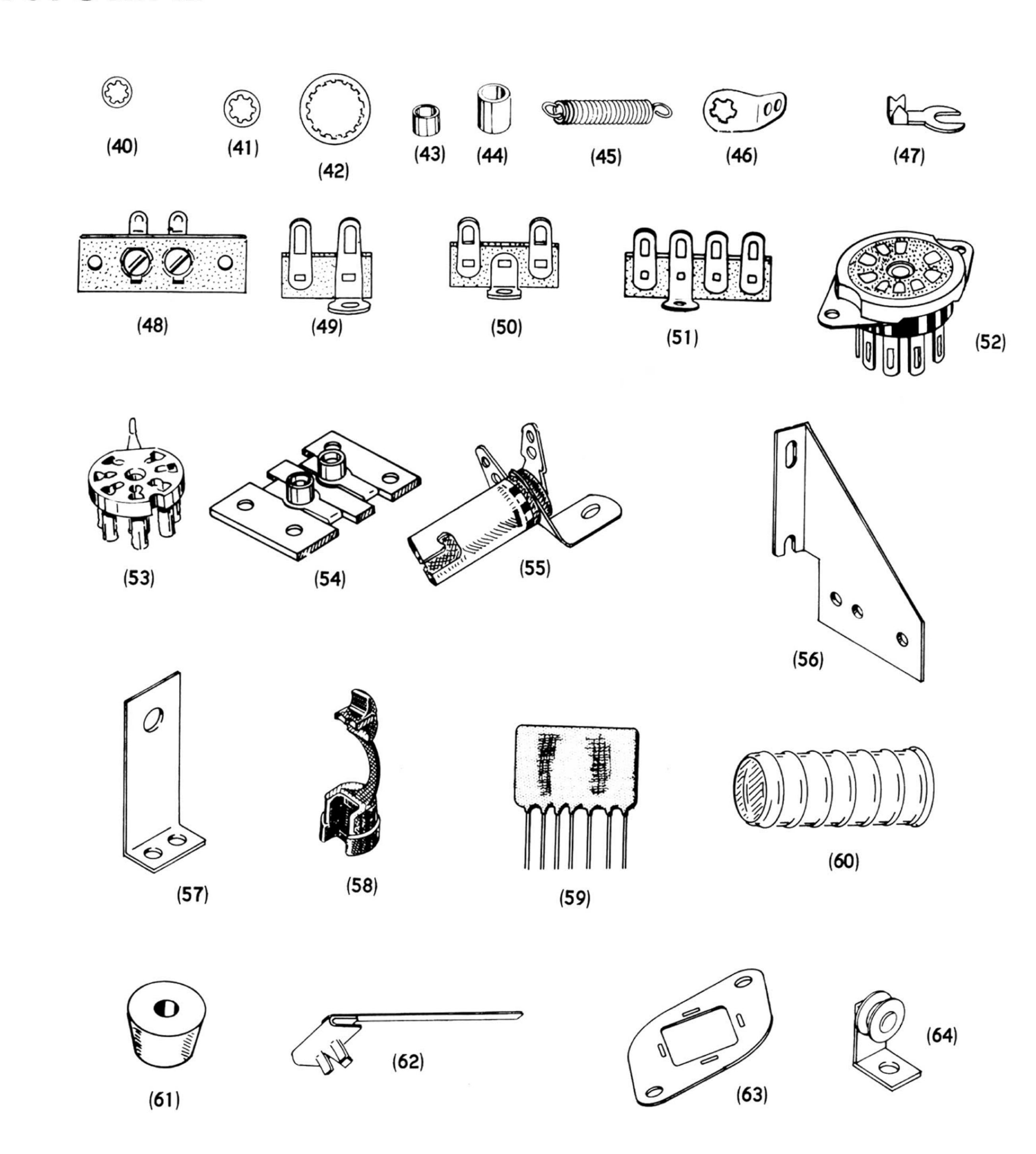
MECHANICAL TROUBLESHOOTING

DIFFICULTY	POSSIBLE CAUSE
No flywheel action of tuning knobs.	Setscrews not tight in flywheel, tuning shaft binding, improper dial cord stringing.
Tuning shaft binds.	Shaft not in line, mounting bracket bent.
Dial cord slips.	Check dial cord tension and stringing, oil on dial cord, dial pointer binding.



PARTS PICTORIAL

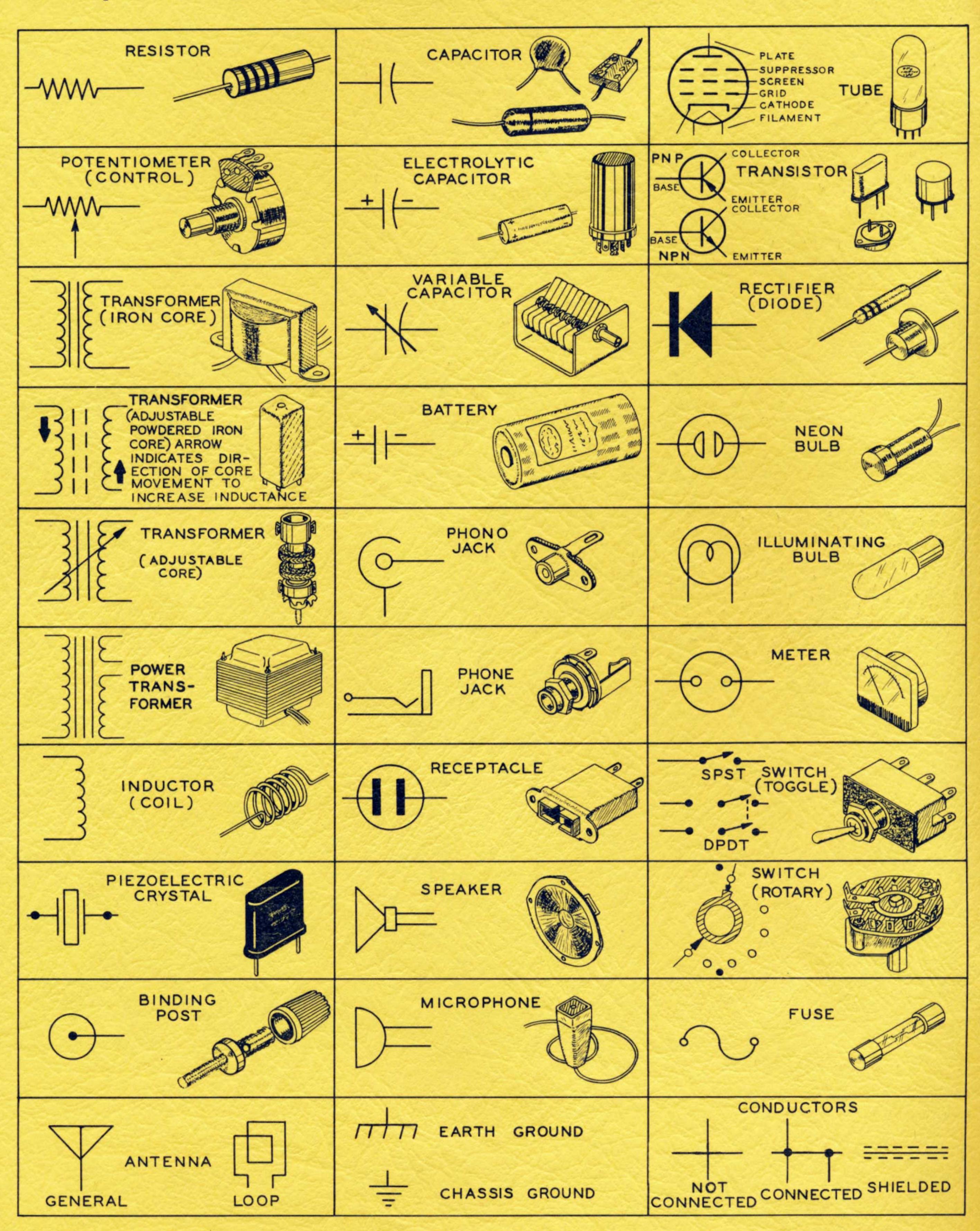




TYPICAL COMPONENT TYPES

This chart is a guide to commonly used types of electronic components. The symbols and related illustra-

tions should prove helpful in identifying most parts and reading the schematic diagrams.



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