Models, 4100, 4110
FM Volumax

Serial # 3774

OPERATING AND MAINTENANCE INSTRUCTIONS

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CBS LABORATORIES
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Stamford, Connecticut 06905

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SECTION I

INTRODUCTION

1-1. GENERAL

This manual provides instructions for the CBS Laboratories Model 4100 (Monaural) and Model 4110 (Stereo) FM Volumax* automatic audio peak controllers.

These instruments have been designed for use in FM and TV broadcasting applications in which the use of pre-emphasis is mandatory. Either instrument will enable the full modulation capability of the transmitter to be utilized with no risk of overmodulation. It replaces any limiter or clipper that may now be in use. When used with SCA** systems, it prevents crosstalk caused by overmodulation from entering into adjacent channels. It should be operated with well-controlled audio input levels such as provided by the CBS Laboratories Audimax* automatic level control.

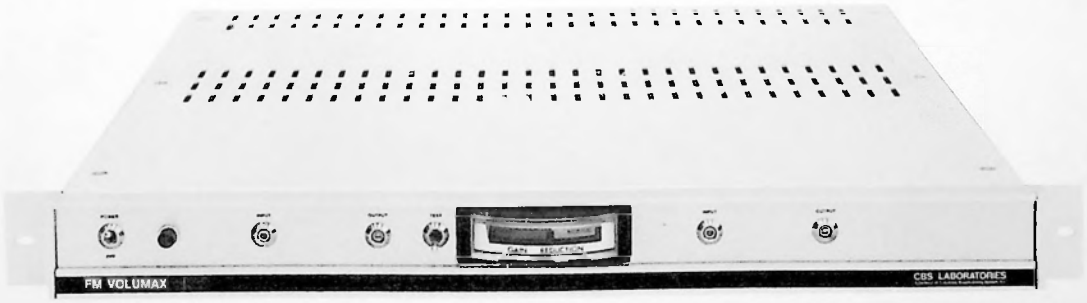


Figure 1-1. FM Volumax Automatic Peak Controller

* CBS Laboratories Trademark
** Subcarrier Authorization

1-2. FUNCTIONAL DESCRIPTION

The Models 4100 and 4110 are late designs based on the foundation established in the earlier Model 410 FM Volumax unit. They extend the original technology to yield a cleaner, brighter sound while still retaining absolute protection against overmodulation.

A very familiar problem in FM and TV broadcasting is caused by the mandatory 75-μs pre-emphasis curve (fig. 1-2). This is a long established requirement of the FCC for the improvement of the overall signal-to-noise ratio. At the time the FM and TV broadcasting standards were adopted, the long-term average spectral distribution of music signals showed a steady decline with frequency above 1,000 Hz. This meant that high-frequency pre-emphasis with subsequent de-emphasis at the receiver could be employed to improve the overall signal-to-noise ratio. However, in recent years, improvements and other changes in recording techniques in conjunction with social changes in musical style have led to increasing problems with the overmodulation caused by high-amplitude high-frequency program signals.

The FM Volumax unit solves this problem uniquely by quadruple-action control. Low-, middle-, and high-frequency portions of the program wave are independently processed and overall, instantaneous, final limiting is used to assure that no overmodulation will occur. See also figures 1-3 and 1-4.

1-3. PHYSICAL DESCRIPTION

The Models 4100 and 4110 FM Volumax units are housed in the same new slimline packages as the CBS Laboratories Audimax and AM Volumax units.

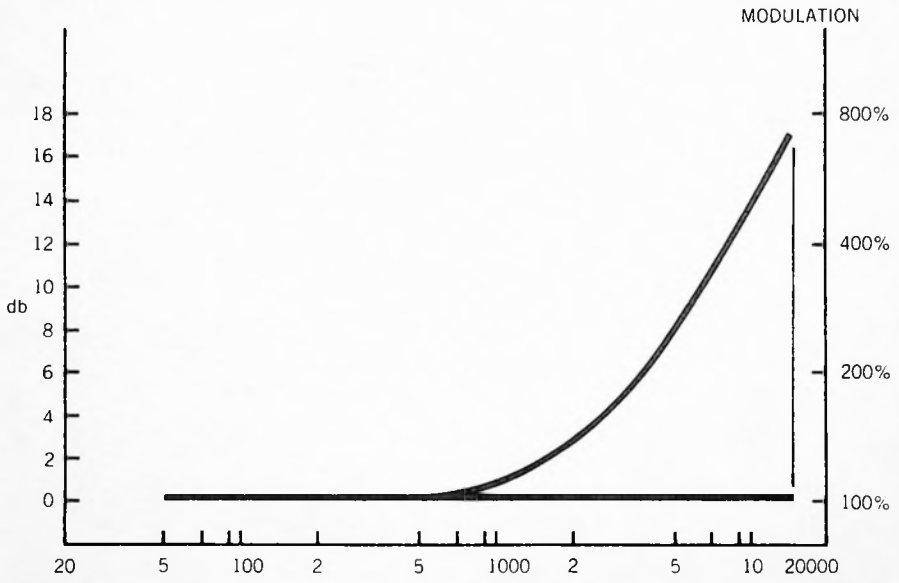


Figure 1-2. Area of Potential FM Over-modulation (75-μs Pre-Emphasis Curve)

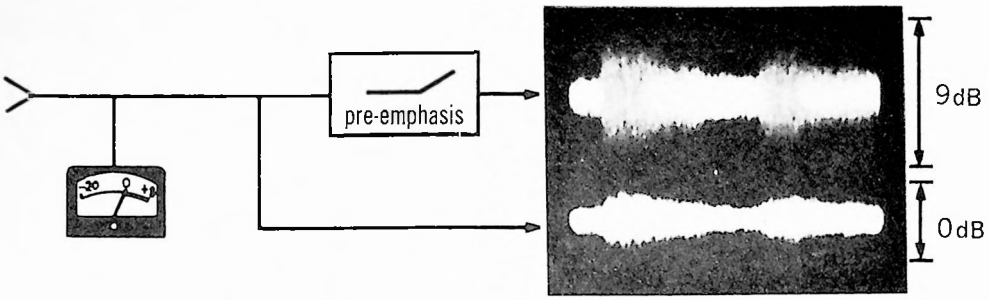


Figure 1-3. Diagram and Oscilloscope Photos Showing Audio Peak Levels of Cymbal Clash with and without Pre-Emphasis

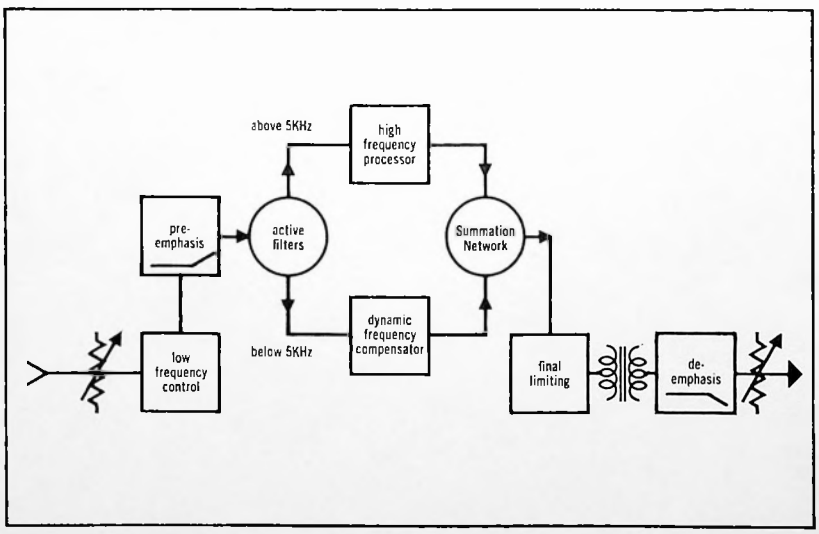


Figure 1-4. Simplified Block Diagram, FM Volumax Model 4100

This package requires only 1-3/4 inches of height in a standard 19-inch rack and 18-1/2 inches of depth behind the front panel. The reliable solid-state circuitry is functionally packaged on three circuit boards in the monaural FM Volumax model and on five circuit boards in the stereo model. Both models are equipped with appropriate test points to speed the process of maintenance tests or troubleshooting procedures.

The entire unit slides forward on rack slides for easy servicing without disconnections from the transmitting system. Front panel controls are conveniently arranged and, in the stereo unit, are grouped according to channel--left channel controls on the left of the unit and right channel controls on the right of the unit. A front panel meter indicates the relative degree of gain reduction.

The unit can be operated from either a 115-volt or 230-volt single-phase 50- or 60-Hz power source. On delivery, the unit is wired for 115-volt operation. Wiring changes for 230-volt operation are explained in paragraph 2-3.

1-4. WARRANTY

A standard warranty card has been included with your FM Volumax unit. To validate your warranty, complete and return the postcard section to CBS Laboratories as soon as possible.

1-5. SERVICE AND REPAIR

If there is difficulty in operating or maintaining your FM Volumax unit, call on your local authorized distributor from whom you originally purchased the unit. If you do not know the name and address of your local distributor, call

CBS Laboratories, Professional Products Department, Stamford, Conn., 06905, telephone (203) 327-2000.

1-6. SPECIFICATIONS

Input impedance	600 ohms, balanced or unbalanced; 10 kilohms or 150 ohms available on request
Output impedance	600 ohms, floating or single ended; 150 ohms available on request
Input level	-22 dBm to +8 dBm
Maximum output level	25 dBm
Frequency response	±1 dB, 50 - 15,000 Hz below limiting threshold. Variable as a function of level above limiting threshold, reaching the 75-μs de-emphasis characteristic ±1 dB at maximum level
Harmonic distortion	Less than 1%, below threshold of limiting, 50 - 15,000 Hz
Attack time	Between 1 μs and 2 ms, depending on program waveform
Recovery time	200 ms (low frequencies) 5 ms (middle frequencies) 1 μs or less (high frequencies)
Signal-to-noise ratio	Greater than 70 dB
Tracking accuracy (stereo model):	
Amplitude	Within 1/2 dB
Phase	Within 1.5 degrees
Maximum operating temperature	+55°C (+130°F)

Power requirements:	12 watts, 115/230 vac, 50/60 Hz (monaural)
	15 watts, 115/230 vac, 50/60 Hz (stereo)
Dimensions	1-3/4 inches high, 18-1/2 inches deep; fits standard 19-inch rack with universal hole spacing
Shipping weight:	
Monaural model	13 pounds
Stereo model	14 pounds

SECTION II

INSTALLATION

2-1. UNPACKING

Carefully unpack your FM Volumax unit and examine it for evidence of damage that may have occurred in shipment. In the event of damage, file a claim immediately with the transportation carrier. If future transportation of the unit can be expected, save the shipping carton for re-use.

2-2. MECHANICAL INSTALLATION AND OPERATIONAL CONSIDERATIONS

The FM Volumax unit is shipped with a pair of rack slides which help to ensure a stable mounting in the rack and permit easy access to the internal parts of the unit if servicing should be necessary. A means of mounting the slides to the rack is detailed in figure 2-1.

The unit and its slides are designed to be mounted in a standard 19-inch electronic equipment rack with universal hole spacing. The front panel requires 1-3/4 inches of space in the height dimension, and 18-1/2 inches of depth behind the front panel are needed for the chassis. As for all transistor equipment, the unit must be installed in a reasonably well ventilated position with no high-heat-producing equipment beneath it.

CAUTION

The ambient temperature should not exceed 130°F (55°C).

Figure 2-2 is a block diagram of a recommended installation. When a Telco line is used to link the studio and transmitter sites, the FM Volumax unit is normally installed at the transmitter site, immediately before the audio input

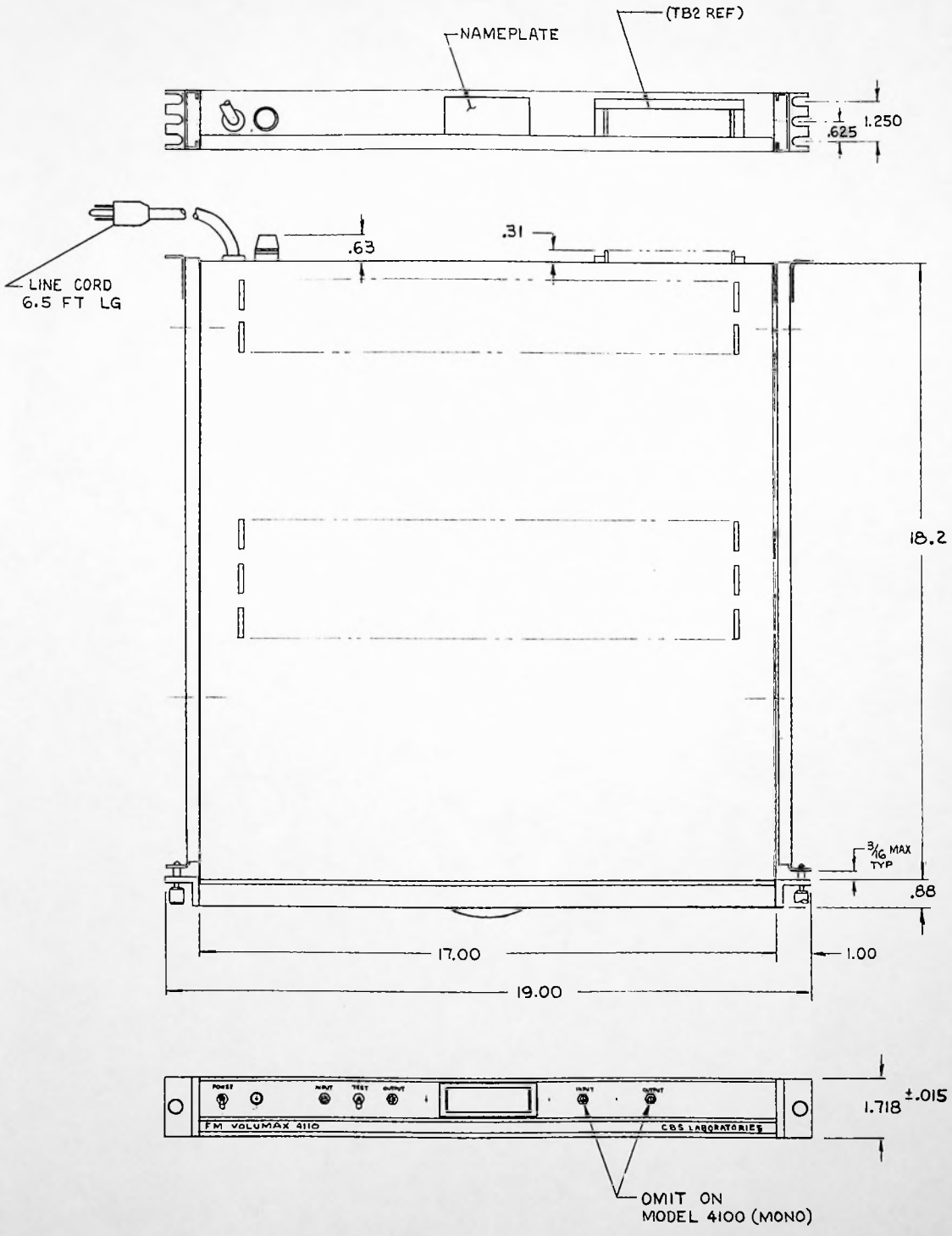


Figure 2-1. Outline Drawing (Sheet 1 of 2 Sheets)

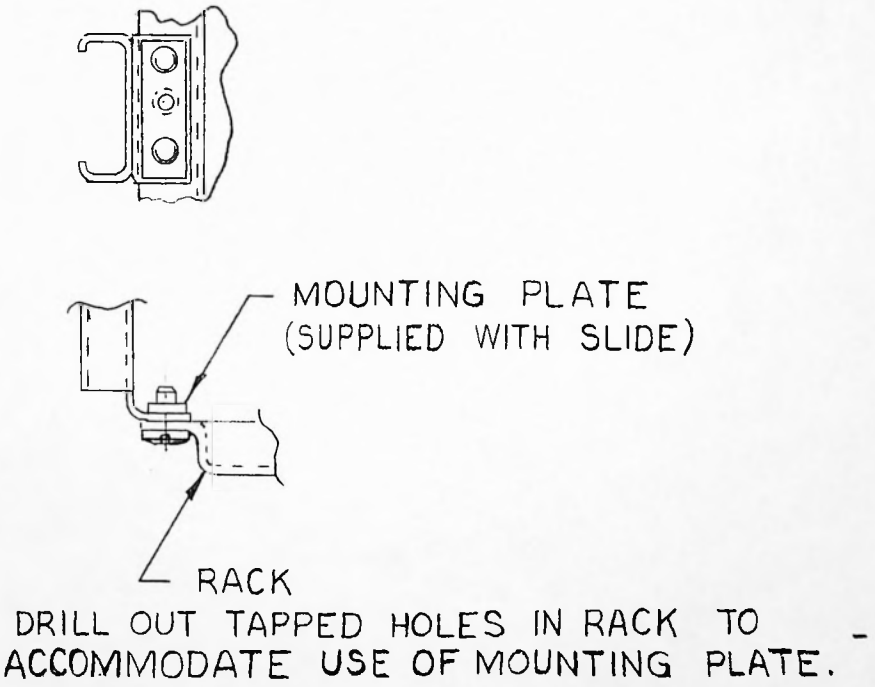


Figure 2-1. Outline Drawing (Sheet 2 of 2 Sheets)

terminals of the transmitter. The FM Volumax unit has sufficient gain to correct for long-line and equalizer losses. However, if a pre-emphasized microwave STL* is used, the FM Volumax unit should precede the STL transmitter.

It should be remembered that the function of the FM Volumax unit is that of peak protection; this unit should not be used as a "gain riding" device for a program line. Optimum operation will be obtained when the FM Volumax unit is supplied with uniform input levels such as those produced by the CBS Laboratories Audimax unit or other high-quality automatic gain control.

Input levels as low as -24 dBm can be accommodated. If high input levels are used -- as will be the case when an FM Volumax unit is connected immediately after an Audimax unit -- a fixed attenuator pad such as the "T" or "H" shown in figure 2-3 should be inserted immediately ahead of the FM Volumax unit.

2-3. POWER SOURCE

The FM Volumax unit is equipped with a power transformer which permits either 115 vac or 230 vac operation. As delivered, the unit is wired for 115 vac operation. If 230 vac operation is desired, make the following modifications at the internal terminal strip TB1 at the rear of the unit next to the rear panel.

A. Remove the black/white lead from terminal 4 of TB1.

B. Remove the brown and white leads from terminal 5 of TB1.

* Studio-Transmitter Link.

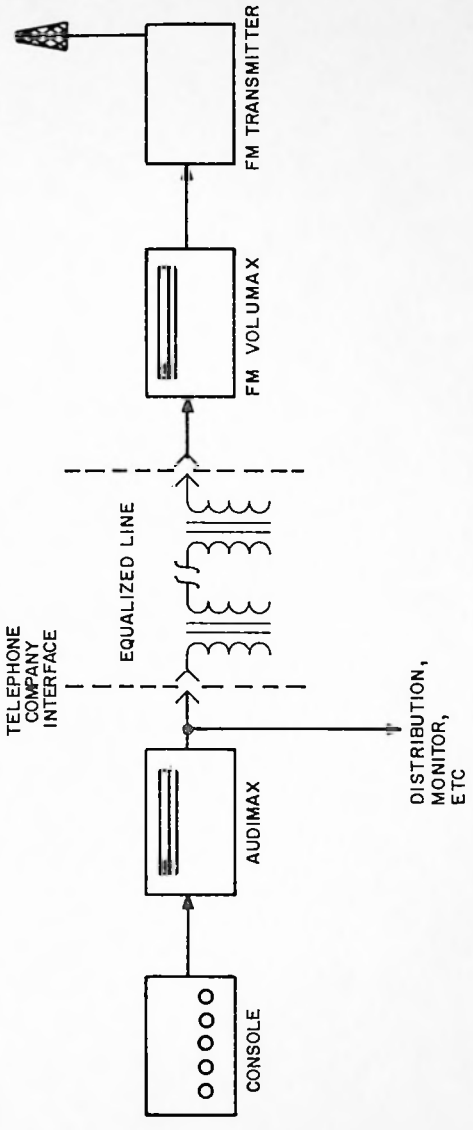
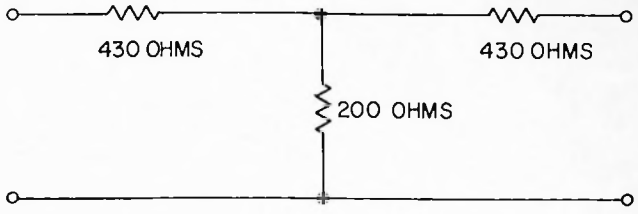
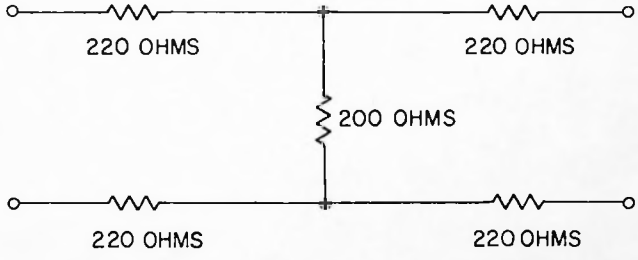


Figure 2-2. Typical FM Volumax Installation Block Diagram



A. SYMMETRICAL "T" 16dB PAD, 600 OHMS IN/OUT



B. SYMMETRICAL "H" 16dB PAD, 600 OHMS IN/OUT

Figure 2-3. Typical Attenuator for FM Volumax Input Line (Schematic Diagram)

C. Connect the brown, white, and black/white leads together and sleeve the connection.

D. Replace the original fuse with a type 3AG-0.15 amp (SLO-BLO).

2-4. ELECTRICAL CONNECTIONS

The 10-terminal strip TB2 at the rear of the chassis is used for all input and output connections to the FM Volumax unit. Use pins 1 and 2 for the monaural or left-channel-stereo input and pins 4 and 5 for the corresponding output. Similarly, for the stereo model, use pins 6 and 7 for the input to the right channel and pins 9 and 10 for the right-channel output. Pins 3 and 8 are chassis grounds.

To maintain correct stereophonic phasing (stereo model), the signals at terminals 1 and 6 should be in phase when a monaural signal is applied. Signals at terminals 4 and 9 will then also be in phase.

If the FM Volumax unit is terminated with an unbalanced load, terminals 4 and 9 should be used as the "high"-side terminals, and terminals 5 and 10 should be used for the common connections.

The standard FM Volumax unit is wired for 600-ohm operation. If 150-ohm operation is desired, consult the factory. In any case, terminate outputs in their characteristic impedances.

Input impedance may be converted to 150 ohms by changing A2R5 (and A5R5 in the stereo model) to 150 ohms.

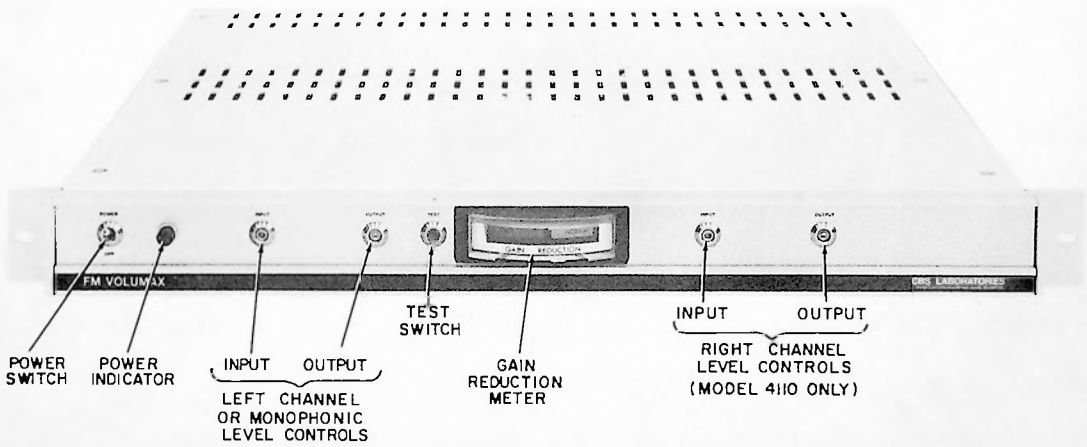


Figure 3-1. FM Volumax Controls

SECTION III

OPERATIONAL SET-UP

3-1. GENERAL

All of the necessary operational controls are located on the front of the FM Volumax unit as shown in Figure 3-1. In the stereo version, input and output controls for the left channel are located at the left of the meter and input and output controls for the right channel are located at the right of the meter. In the monaural version, all controls are located at the left of the meter, and, in either model, the power switch is located at the extreme left end of the front panel. A switch to control an internal broad-band limiter is located on the left side of the front panel in either model. The gain reduction meter in the center of the panel measures the amount of broad-band gain reduction and should be used as a general guide in adjusting the input level controls.

3-2. SET-UP OF STEREO FM VOLUMAX UNIT

A. After all electrical connections have been made as in Section II, turn the INPUT and OUTPUT level controls fully counterclockwise. Be sure both outputs are terminated in their characteristic impedances. Push the POWER switch up. Leave the TEST switch down.

B. Apply a 400-Hz left channel sine-wave at normal reference level to the FM Volumax unit. Adjust the left INPUT level control for a GAIN REDUCTION meter deflection to the red/green junction.

C. Move the TEST switch up to the TEST position and turn the left OUTPUT level control clockwise as far as necessary to produce the maximum desired left channel modulation. This step provides a precise setting of the

modulation level with a pure sine wave. In operational use, small errors in the pre-emphasis network plus phase shifts in the transmitter may combine to cause slight overmodulation with complex program waveforms. If this occurs, a slight re-adjustment of the OUTPUT level control may be necessary.

NOTE

The phase-shift problem can be reduced at installations where it is easy to disable or remove the pre-emphasis network from the transmitter. If this is done, the de-emphasis network at the FM Volumax output must also be removed. The de-emphasis network can be effectually removed by disconnecting C9 and placing a jumper across L1 on each high-frequency processor board (A1 and A4).

D. Remove the left channel signal and place the TEST switch in the "off" position (down).

E. Apply a 400-Hz right channel sine wave at normal reference level to the FM Volumax unit. Adjust the right INPUT level control for a GAIN REDUCTION meter deflection to the red/green junction.

F. Place the TEST switch in the TEST position and turn the right OUTPUT level control clockwise as necessary to produce the maximum desired right channel modulation.

G. Place the TEST switch in the "off" position, remove the 400 Hz signal, and apply stereo program signals to the instrument. Adjust the program master gain control as required to cause the GAIN REDUCTION meter to indicate in the green (NORMAL) area with occasional peaks producing deflections into the red (HEAVY) area.

NOTE

The design calibration of the meter is, of necessity, based on subjective considerations. Hence, not all users will desire operation with the same degree of limiting action. A setting for heavy limiting action will produce higher average modulation but with a reduction of dynamic range.

In the event that very heavy limiting action is desired, advantage may be taken of existing provisions for an optional meter compression circuit on the power supply/AGC board A3. Add a 470-ohm, 1/4-watt resistor in the board position marked R32 and add a 1N3121 germanium diode at the position marked CR4. Observe the diode polarity marked on the board. The meter will then indicate an additional "on scale" compression of 2 to 3 dB. When calibrating the unit, be sure to disable this meter-compression circuit by

opening R32 or CR4 for the duration of the calibration procedure.

3-3. SET-UP OF MONAURAL FM VOLUMAX UNIT

A. After all electrical connections have been made as in Section II, turn the INPUT and OUTPUT level controls fully counterclockwise and place the POWER switch in the "on" position. Leave the TEST switch down.

B. Apply a 400-Hz sine wave at normal reference level to the FM Volumax unit. Adjust the INPUT level control as required to cause the GAIN REDUCTION meter deflection to appear at the red-green junction.

C. Move the TEST switch up to the TEST position and turn the OUTPUT level control clockwise as far as necessary to produce a modulation level of 100 percent or any other desired maximum. Read the Note on phase shift errors immediately following subparagraph C of the stereophonic unit set-up procedure (paragraph 3-2). This Note also applies to the monaural unit.

D. Place the TEST switch in the "off" position and replace the sine-wave test signal with a normal program.

E. If necessary, readjust the INPUT level as needed to keep the meter deflection primarily in the green area with occasional peak deflections into the red area. Read the Note on meter calibration at the end of paragraph 3-2. This Note also applies to the monaural unit.

3-4. PROOF-OF-PERFORMANCE MEASUREMENTS

Generally accepted procedures for performing Proof-of-Performance tests usually call for these measurements to be made "without compression".

In the FM Volumax unit, the compression action can be disabled by placing the TEST switch in the TEST position; however, in so doing, care must be taken to insure that the instrument is not overloaded.

The following technique is recommended as the most satisfactory method of proof-of-performance measurements.

A. Frequency Response

NOTE

See also subparagraph B. The frequency response and distortion tests may be performed concurrently.

(1) With the TEST switch in TEST position, apply a 100-Hz tone through a calibrated attenuator at a level sufficient to cause the output of the FM Volumax unit to be clipped. Adjust the output level for transmitter modulation of slightly over 100 percent. In the stereo case, the measured channel output should be set to its relative maximum output level.

(2) Reduce the input as needed for 100 percent modulation. No clipping should now occur.

(3) Measure the system frequency response by incrementally increasing the input-signal frequency and adjusting the calibrated attenuator as needed to maintain a constant percentage of modulation. The readings of the calibrated attenuator plotted against frequency should be the inverse of the standard 75-microsecond pre-emphasis curve.

(cont)

NOTE

Be certain that the Volumax output is not clipped.

(4) Repeat the above measurements for other desired modulation levels.

NOTE

Do not attempt to apply maximum level at frequencies above 1 kHz. The combination of Volumax pre-emphasis, limited amplifier headroom, zener clipping, and the de-emphasis network will produce a falling characteristic and considerable distortion, even with the AGC action disabled.

B. Distortion

Harmonic distortion in the FM Volumax unit has been minimized for operation in the normal limiting mode. It may not be quite as low when the unit is operated at high level without compression. When checking distortion, apply signal(s) below limiting level as in the frequency response tests (subparagraph A). (See Section V for maintenance tests of distortion.)

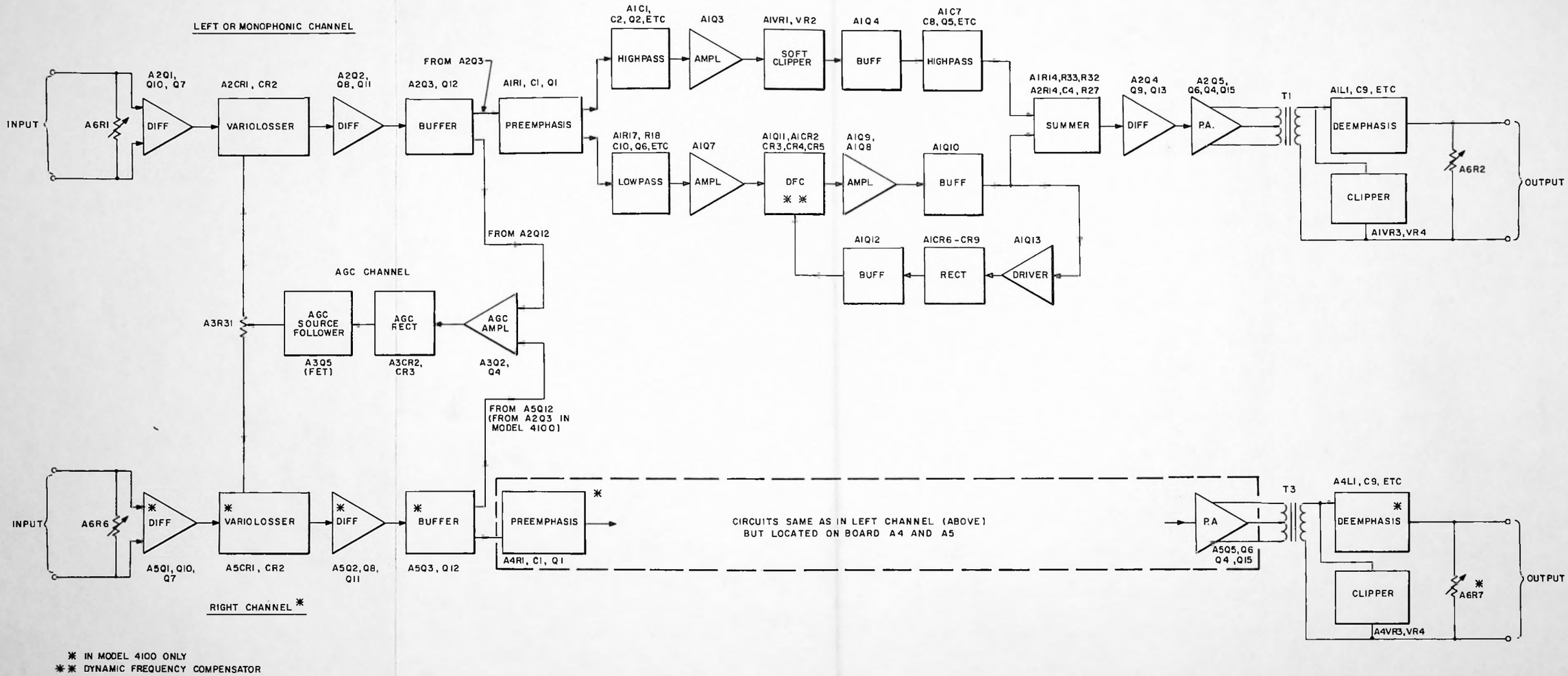


Figure 4-1. FM Volumax Block Diagram

SECTION IV

THEORY OF OPERATION

4-1. GENERAL

The FM Volumax Models 4100 and 4110 are functionally similar to conventional peak limiters in that either unit prevents the overmodulation of a radio-frequency carrier by acting on instantaneous program peaks. The FM Volumax circuit, however, has been designed to overcome the limitations of conventional peak limiters and, in addition, contains patented circuits which anticipate the effects of transmitter pre-emphasis. The result is a peak controller for FM broadcasting that permits a very high level of average modulation, positively prevents over-modulation, and yet maintains a clean bright sound without "pumping" or other audible distortion.

A. The Problems

A shortcoming of conventional limiters is that program material with a high peak factor drives the limiter further into a gain reduction than material with a low peak factor, even though both signals may have equal VU levels. Consequently, high-peak-factor signals are lower in average level at the output of a conventional limiter.

In another shortcoming, most conventional limiters must moderate audible pumping by the use of comparatively long recovery times. Consequently, immediately after each large peak in the signal, the program is transmitted at less than optimum gain. This reduces the average modulation level and wastes a valuable capability of the transmitter.

Finally, with conventional limiters, the effect of pre-emphasis in the FM transmitter -- a problem unique to FM and TV audio broadcasting -- can upset attempts to control overmodulation. If the limiter operates before pre-emphasis, the boosts in response by 5 dB of 3-kHz signals, 14 dB of 10-kHz signals, and 17 dB of 15-kHz signals preclude accurate control of high-frequency peak overmodulation. If the limiter operates after pre-emphasis, overmodulation will be prevented but at the expense of average level loss and potentially severe pumping effects. In either situation, the high levels of high-frequency energy found in cymbal clashes, muted trumpets, speech silibants, et cetera, are difficult to control without overmodulation.

B. The Solution

FM Volumax overcomes these problems in an esthetically acceptable manner by precisely controlling the audio signal in four distinct stages.

First, wide-band AGC controls average peaks in a conventional manner. The attack time constant is held within 1 to 2 milliseconds so that transients with any faster rise times are passed along to subsequent stages of control. The recovery time is also quite fast -- at the syllabic rate of about 150 milliseconds -- to permit the retention of high average levels.

Next, the signal is pre-emphasized to the standard pre-emphasis curve and active filters divide the signal into two bands above and below 5 kHz. Dynamic frequency compensation is used for the band below 5 kHz. Meanwhile, the band above 5 kHz passes through a very fast limiter (a variation of soft clipping) and is filtered. Thereupon the signals from the two bands are summed. The filtering and summation take place both concurrently and independently.

Finally, instantaneous diode limiting is used to prevent overmodulation from being caused by initial transient peaks with rise times faster than 1 ms. Following de-emphasis and the OUTPUT level attenuator, the controlled signal proceeds to the transmitter where pre-emphasis restores the accurately controlled 100-percent modulation point. Frequency response families illustrating this action appear in figure 4-2.

A front panel meter indicates the degree of AGC control and is a useful indication of how much limiting is being applied to a particular signal. A TEST switch, when actuated, clamps all of the internal variable-gain stages, and permits the modulation level to be set or proof-of-performance measurements to be made.

4-2. INPUT SECTION (BOARD A2 OR A5)

(See figures 4-1 and 7-3.)

The input signals to the FM Volumax unit at TB2 are terminated on board A2 or A5 in an appropriate load, R5, and pass to the front panel INPUT level control, A6R1 or A6R6. (See also figure 7-1.) From the front-panel control, they return to A2 or A5 where they are capacitively coupled into a differential amplifier Q1, Q10. In the stereo model, board A2 and A6R1 process the left-channel signal and A5 and A6R6 process the right-channel signal. In the monaural model, which has neither A5 nor A6R6, the single-channel signal is processed by A2 and A6R1.

On either A2 or A5, the differential amplifier Q1, Q10 has a high common mode rejection ratio to eliminate common mode hum, noise, etc., from the

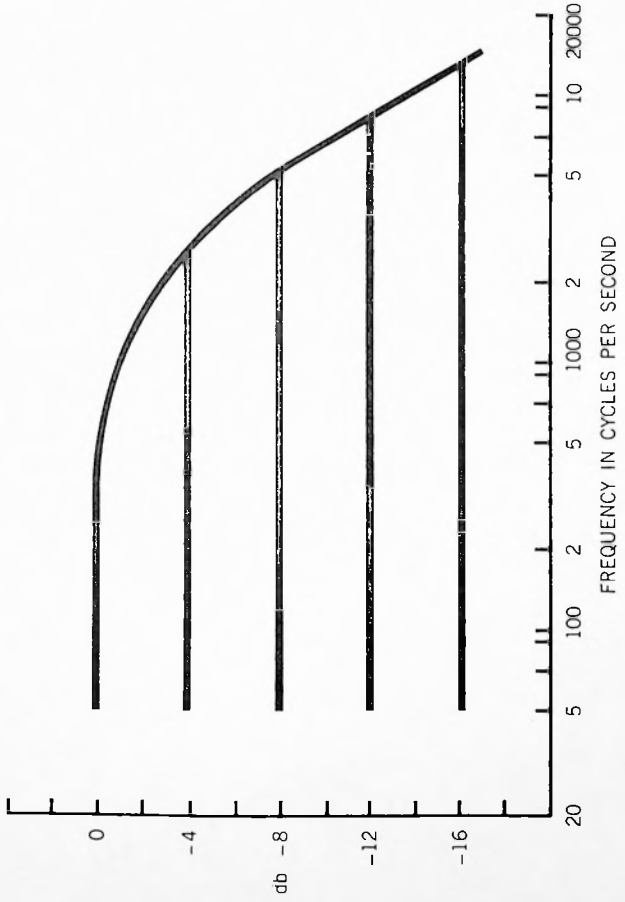


Figure 4-2. FM Volumax Amplitude Response

incoming line, and also obviates the need for an input transformer. Transistor Q7 is a constant current source which suitably biases the differential amplifier.

Subsequently, the signals are applied to a Variolosser, CR1, CR2 (a pair of matched silicon diodes), whose attenuation to small signals varies as a function of a control current derived on board A3. The Variolosser and its associated circuitry on A3 constitute the AGC subchannel, described in Section I, which limits the input signal on a broad-band basis before any further processing.

Another differential amplifier, Q2, Q8, Q11, and the emitter-follower buffers, Q3, Q12, complete the input section. The audio signal path then enters the high-frequency processor board A1 (left channel or monaural) or A4 (right channel, stereo only) and simultaneously drives the AGC amplifier section on board A3.

4-3. AGC AMPLIFIER (BOARD A3)

(See figures 4-1 and 7-4.)

Two high-gain AGC amplifiers, Q2, Q4 on board A3, use signals from the input section of A1 or A5 to drive biased rectifiers, CR2, CR3. In the monoaural model, 4100, the two amplifiers sample the two sides of the balanced audio from A1. In stereo units (4110), the interconnections are such that each AGC amplifier samples one of the two separate channels. Rectifier bias set by the potentiometer R17 determines the point at which AGC action begins along the input/output curve. The outputs of the two rectifiers are summed at the gate of the field effect transistor (FET) Q5, while the AGC time constant is

determined by R20 and C9. The FET is connected as a source follower to provide a low source-impedance drive for the front-panel GAIN REDUCTION meter, A6M1 and the Variolosser on board A1 (or A5) which was described in paragraph 4-2. The potentiometer R24 sets the amplitude of the quiescent (no-signal) current which passes through R28 to the Variolosser(s), while the potentiometer R31 (stereo model only) is used to balance the AGC control current for the left and right channel Variolossers.

4-4. HIGH FREQUENCY PROCESSOR (BOARD A1 OR A4)

(See figures 4-1 and 7-2.)

Following AGC control on A2 or A5, the audio signals pass to A1 or A4 where they are first pre-emphasized to the standard 75-microsecond curve by R1, C1 and are buffered by the emitter follower Q1. In the stereo model, A1 is used for the left channel and A5 is used for the right channel. In the monaural model, A1 is used for the single channel and A5 is omitted.

The insertion of pre-emphasis at this point ensures that the subsequent processing will anticipate and correct for the ultimate effect of the transmitter pre-emphasis.

Next, the signal is divided into two bands by active filters: Q2, C2, C3, R4, and R5, constituting a high-pass filter; Q6, R17, R18, C10, and C11, constituting a low-pass filter. The crossover frequency is 5 kHz, and each filter rolls off at 12 dB/octave, permitting essentially independent and parallel processing of signals above and below 5 kHz.

A. Signals above 5 kHz

The output of the high-pass filter is amplified by Q3 and is applied to a soft clipper, VR1, VR2, C21. The soft clipper acts as a very fast limiter for those signals whose pre-emphasized peak factor above 5 kHz exceeds a threshold determined by the amplifier emitter potentiometer R8. While it is true that some harmonic and intermodulation distortion products are created by this method, the fact that only signals above 5 kHz are so processed precludes the generation of any significant harmonic products below 15 kHz. Also, a second active high-pass filter formed by C7, C8, R11, R12, and Q5 removes any undesirable intermodulation products below 4 kHz. The emitter follower Q4 buffers the output of the soft clipper and the input to the second high-pass filter.

B. Signals below 5 kHz

Simultaneously, the output of the low-pass filter is acted upon by the dynamic frequency compensator (DFC) circuit. The heart of the DFC is a variable-reactance circuit: Q11, CR2, CR3, CR4, CR5, C13, and R24. At low input levels, this circuit has a flat frequency response and merely passes signal through to the output at TP4. For higher input levels, the circuit has a high-frequency roll-off characteristic of about 6 dB per octave with a variable break-point determined by a control voltage in such a way as always to limit the pre-emphasized signal to a pre-determined amplitude.

When Q11 is fully cut off, approximately 10 ma of current flows through the four DFC diodes, and capacitor C13 sees an effective ac ground. Resistor R24 and capacitor C13 form a low-pass RC filter with a corner frequency of about 1 kHz. When Q11 is fully "on" (saturated), the 10 ma of current flows

through this transistor rather than the diodes. Thus, C13 floats and the frequency response does not roll off. At intermediate points in the active region for Q11, the ac impedance of the diodes is a function of the control voltage at TP6. Therefore, the roll-off characteristic is also a function of the control voltage at TP6.

The DFC circuit operates as a closed loop in which the control voltage is generated by using the potentiometer R31 to sample the output of the emitter follower Q10 and driving the full-wave rectifier CR6, CR7, CR8, and CR9 by means of the sample voltage amplifier Q13. Potentiometer R35 sets the quiescent bias for Q11 and Q12. Potentiometer R39 sets the dc level of the control voltage. Capacitor C17 determines the DFC recovery time, 5 ms.

C. Recombination

The wide-band, processed signals are recombined at TP5 through R14 and R33. The potentiometer R32 is used to balance the outputs of the two independent processors so that the low-level frequency response is flat.

4-5. OUTPUT SECTION (BOARD A2 OR A5)

(See figures 4-1, 7-3, 7-1, and 7-2.)

The processed and recombined signal is amplified to line level by the output section and is coupled to a floating output by an output transformer. The output section comprises Q4, Q5, Q6, Q9, Q13, Q14, and Q15 on board A2 (left channel or monaural) or board A5 (stereo only, right channel). The output transformers are located on the chassis and are fully shown in figure 7-1. The left channel or monaural output transformer is T1 and the right channel output

transformer (stereo model only) is T3. Following safety limiting and de-emphasis on board A1 or A4 (VR4, VR3, L1, R15, R16, C9, R47), the signal is attenuated to the desired OUTPUT level by A6R2 (left channel or monaural) or A6R7 (right channel -- stereo only) on the front panel.

4-6. POWER SUPPLY (BOARD A3)

(See figures 7-4 and 7-4.)

Either 115 vac or 230 vac nominal may be applied to the primary of the power transformer T2 (figure 7-1) to yield 50 vac which is rectified by the full-wave bridge CR1 (figure 7-4) to derive an unregulated supply of 28 vdc. The series pass NPN transistor Q1, whose base is referenced to the zener diode VR1, provides a regulated B+ supply of 19.4 vdc while the series pass PNP transistor Q3, referenced to VR2, provides a regulated B- supply of 14.4 vdc.

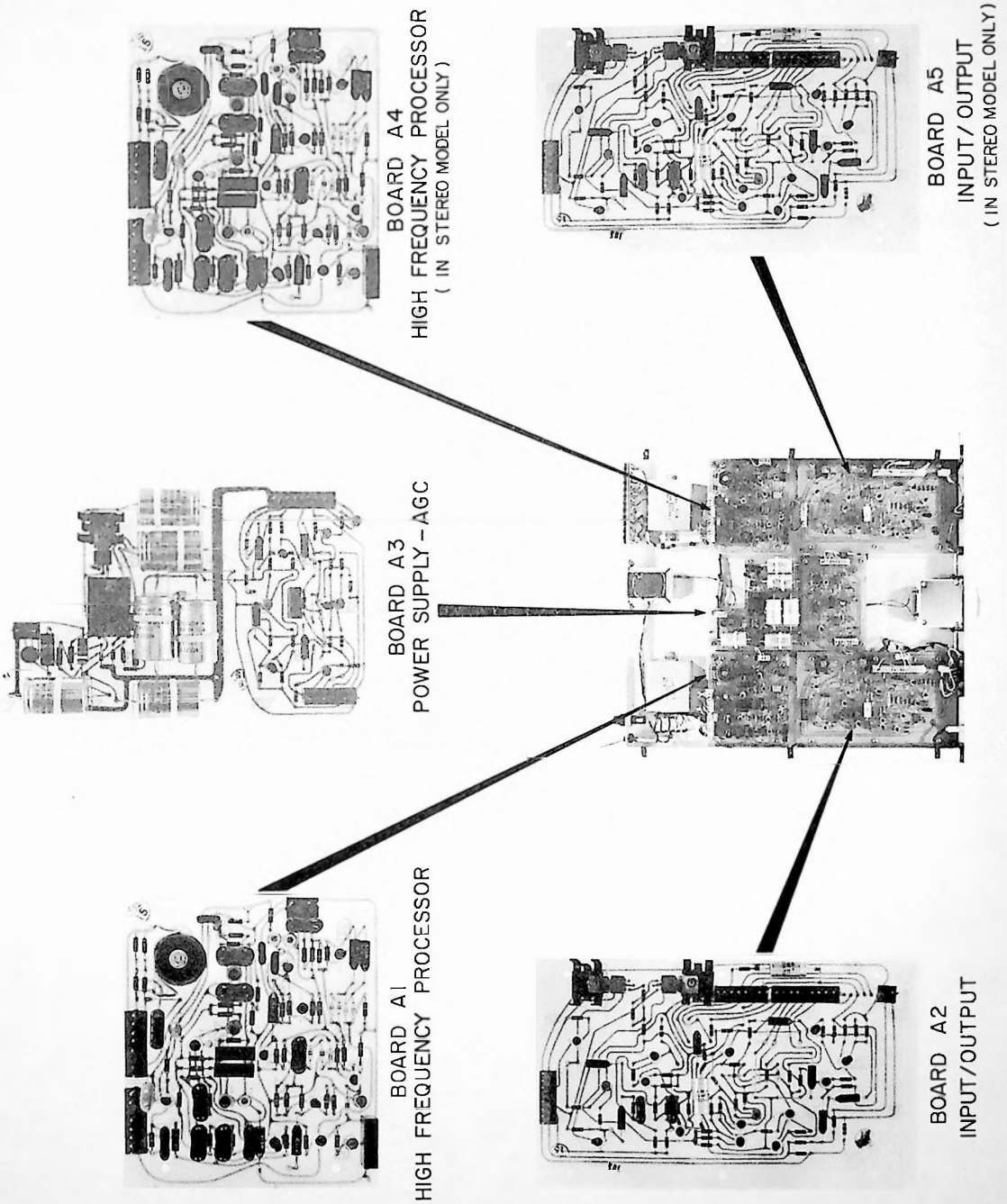


Figure 5-1. Locations of Circuit Boards and Chassis Parts in FM Volumax Unit

SECTION V

MAINTENANCE

5-1. GENERAL

A. Access to Internal Components

If necessary to reach the internal parts of the FM Volumax unit, unscrew the bolts which lock the rack slides at the sides of the unit. Slide-out the unit on the rack slides until the unit locks itself in position; then remove the top cover. See figures 5-1 and 7-1 for locations of panel parts, chassis parts, and circuit boards. See figures 7-2 through 7-4 for locations of parts on circuit boards.

B. Troubleshooting Method

The troubleshooting of any apparent malfunction of the FM Volumax unit should always begin with checks of the power supplies. Dc voltages as measured with a digital voltmeter (DVM) or a VTVM should fall within the limits shown in table 5-1 near the end of this section.

CAUTION

Accidental shorting of either the +20v or -15v supply might cause the respective regulating transistor A3Q1 or A3Q3 to develop a collector-emitter short. This would destroy the regulation, allowing unregulated dc to be applied to the signal circuits. The regulating transistor A3Q1 or A3Q3 may be suspected of being

shorted if the output voltage of the respective power supply is significantly high and excessive ripple is present. If ripple is excessive but the voltage is correct, check for open or leaky power supply filter capacitors. Look for defective filter capacitors on signal boards as well as on the power supply board A3.

If the power supplies are satisfactory, proceed with the following checks for the isolation of other trouble:

(1) In the extreme case of no output from an audio channel, check input and output connections. Inspect the connections to the various circuit boards for a possible open lead. If this visual inspection does not indicate any defects, stage-by-stage signal tracing will be necessary.

(2) To find the circuit point at which the signal is lost or degraded, turn the appropriate INPUT level and OUTPUT set controls fully clockwise and apply a 1 kHz signal at 10 mv rms to the appropriate channel input terminals of the FM Volumax unit. Then check ac and dc voltages in advancing signal-stage order, as listed in table 5-2 near the end of this section. Table 5-2 gives the proper ac and dc voltages at various points in the signal path with respect to chassis ground. Compare your measurements with those in the table.

(3) On reaching a circuit board or a point where the signal is lost or an improper ac or dc voltage is found, proceed to paragraphs 5-2 through 5-7.

The adjustment procedures (paragraph 5-7) may eliminate the trouble if the signal is not lost. However, avoid adjustments until they are definitely needed. (See paragraph 5-7.)

5-2. TROUBLESHOOTING GAIN METER CIRCUIT

The front panel GAIN REDUCTION meter reads full scale to the right for the zero indication. If this meter cannot be mechanically zeroed (table 5-3), the meter is defective and must be replaced. If the mechanical zero setting is satisfactory but electrical zero (table 5-3) is unsatisfactory, suspect power supply trouble (table 5-1) or an improper ground or defective resistor in the following circuit: R7, R12, and R30 on board A3. (See figure 7-4.) Replace the meter only as a last resort.

CAUTION

If your FM Volumax unit contains the optional meter compression circuit, R32 and CR4 on board A3, be sure the meter compression circuit is opened (disconnected) when electrically zeroing the meter, also when performing any other procedure in table 5-3.

A faulty resistor A3R32 or faulty diode A3CR4 in the meter compression circuit may be the cause of improper meter readings during in-service operation.

5-3. TROUBLESHOOTING INPUT SECTION (BOARD A2 OR A5)

On board A2 or A5: if signal is present at the collectors of Q1 and Q10 but is too low or too high at the bases of Q2 and Q11, measure the quiescent control voltage at TP2. This should be -0.5v ±0.1v. If the control voltage is incorrect, the potentiometer A3R24 on board A3 should be adjusted according to the procedure in paragraph 5-7 (table 5-3). If the attempt to set A3R24 fails to correct the problem, suspect the Variolosser diodes CR1 and CR2 on board(s) A2 (and A5). If these diodes must be replaced, select matched diodes for each replacement pair; the forward voltage drops should be within 10 mv of each other at 1 ma of forward current. The remainder of the circuitry in the input section(s) of the equipment is conventional. See paragraph 5-6 for possible Variolosser troubles.

5-4. TROUBLESHOOTING HIGH FREQUENCY CONTROL SECTION (BOARD A1 OR A4)

The action of the 75-microsecond pre-emphasis network R1, R2, and C1 on board A1 or A4 should be apparent when monitoring the emitter of Q1 on the same board and sweeping the frequency range of the input signal. Transistor stages Q2 and Q6 are complementary active filters which divide the frequency band at 5 kHz. This action should be apparent by examining the respective high and low frequency outputs at TP1 and TP3.

The high-frequency side (Q2) is followed by clipping and filtering. This action should be apparent by comparing the signal at TP2 with that at TP1 at frequencies above 5 kHz. The amplitude of the input should be sufficient to cause an indication on the GAIN REDUCTION meter.

Similarly, the mid-highs are acted upon by the dynamic frequency compensation (DFC) circuit in a proprietary CBS Laboratories technique. This action can be observed by comparing the signal at TP6 with the signal at TP3 while the mid-high region (1-5 kHz) is being swept at a high-enough level to cause an indication on the GAIN REDUCTION meter.

The foregoing checks should isolate any trouble to a narrow region.

5-5. TROUBLESHOOTING OUTPUT SECTION (BOARD A2 OR A5)

On board A2 or A5: if signal is present at J3-9 but not at TP4, TP6, check Q4 and Q13. If signal is present at TP4, TP6, but not at the primary of the output transformer T1 or T3 (on the chassis), check transistors Q5, Q6, Q14, and Q15. If signal is present but too low at T1 or T3, either Q6 or Q15 may be at fault, since each operates as a class A stage.

5-6. TROUBLESHOOTING AGC SECTION (BOARD A3)

To check for proper AGC action, first set the front-panel TEST switch in the "off" (lower) position and set the INPUT level control(s) fully clockwise. Then apply a 1-kHz signal to either or both FM Volumax channels. Increase the input until the GAIN REDUCTION meter reading just begins to move toward the left. Note the appropriate output level(s) across the 600-ohm* load(s). Finally, increase the input 10 dB; the output should increase less than 2 dB.

(1) If the GAIN REDUCTION meter reading moves downscale during this test but the output is not compressed as indicated above, check the Variolosser diodes CR1 and CR2 on board A2 (or A5).

* or other appropriate characteristic impedance.

(2) If the GAIN REDUCTION meter does not move downscale, monitor the voltage at TP7 on board A3, using a meter that has an input impedance of 10 megohms. Meanwhile, vary the input level as described above. Here, at TP7, the voltage should vary from about 0.0 vdc at an input level of 30 mv to about -0.3 vdc at input level of 100 mv (10 dB greater). The FET A3Q5 is to be suspected if the gate voltage at TP7 varies as previously described but no gain reduction occurs. If the voltage at TP7 does not vary as described, there are two other possibilities:

(a) The voltage may vary, but over a different range than described. In this case, potentiometer A3R17 is incorrectly set; see the adjustment procedures, paragraph 5-7.

(b) There may be no voltage variation. In this case, no control voltage is being generated. Adjust the 1-kHz input level to 30 mv. The signal level at A2J3-4, 8 or A5J3-4, 8 should then be 1.2v. The ac signal levels at the bases of A3Q2, A3Q4 should be approximately 75 mv. Next, measure the voltages at TP2, TP6 on board A3; each should be 2.5 vac. Correct voltages here in combination with no control voltage indicates defective diodes A3CR2 and/or A3CR3. If, after any changes in the AGC section, the meter reading with no signal applied is not at reference (full scale), see paragraph 5-2.

TABLE 5-1. POWER SUPPLY VOLTAGES

CAUTION

Do not short power supply voltages to ground.

Supply	Correct Output	Maximum Ripple
+20v	+19.4v ±1v	10 mv rms
-15v	-14.4v ±3/4v	5 mv rms

TABLE 5-2. TYPICAL VOLTAGES

NOTE

All measurements are made to chassis ground with an unbalanced 10 mv rms signal input at 1 kHz with front panel INPUT and OUTPUT controls fully clockwise (cw).

Test Point	Correct Voltage Ac (Rms)	Dc
INPUT SECTION -- BOARD A2 OR A5:		
TP1	Ground	Ground
Bases Q1, Q10	Unbalanced input, 6.4/1.8 mv	-0.1
Collectors Q1, Q10	11.0 mv	17.0
Bases Q2, Q11 (Variolosser)	3.0 mv	-0.05
Emitters Q3, Q12, (TP3, TP5)	420 mv	9.0

TABLE 5-2. TYPICAL VOLTAGES (cont)

Test Point	Correct Voltage Ac (Rms)	Dc
HIGH FREQUENCY SECTION -- BOARD A1 OR A4:		
Emitter Q1	27 mv	0.00
TP1	1.7 mv	-1.0
Emitter Q4	30 mv	-0.6
TP2	4.4 mv	-0.1
TP3	27 mv	-1.0
Collector Q8	55 mv	10.0
Collector Q9	420 mv	10.0
TP4	420 mv	9.4
TP5	280 mv	5.0
OUTPUT SECTION -- BOARD A2 OR A5:		
TP1	Ground	Ground
Base Q4	240 mv	-0.05
Base Q13	180 mv	-0.05
Collectors Q4, Q13	660 mv	11.00
TP4, TP6	175 mv	4.3
J1-4, J1-8	2.0v	18.5
Across 600-ohm output load	2.8v (approx +11 dBm)	--

5-7. TEST AND ADJUSTMENT PROCEDURES

The FM Volumax maintenance test and adjustment procedures are given in table 5-3 at the end of this section. Table 5-3 may be used for a complete alignment procedure, if desired, but usually it will be necessary only to perform those steps of concern to a particular problem. (See preceding instructions and the instructions in Preliminary Step B of the test and adjustment table.)

Always keep front panel INPUT and OUTPUT controls in fully clockwise (cw) positions when performing the ac and dc voltage measurements in table 5-2 or when performing any step in table 5-3.

It is normally bad practice to disturb internal potentiometer settings until a need for a new adjustment is definitely determined. All internal potentiometers have been carefully preset in a complete factory test and alignment procedure before the delivery of your FM Volumax unit. Therefore, try to avoid making unnecessary adjustments. If a malfunction occurs, re-read paragraphs 5-1 through 5-7. Perform pertinent tests (table 5-3) and make adjustment, if necessary, after making repairs. If an adjustment fails to correct a problem, return the potentiometer to its factory setting.

If the foregoing measures fail to correct malfunctions or many potentiometers have been moved from their factory settings, table 5-3 may be used as a complete re-alignment procedure "from scratch". In such case -- and only then -- place the internal potentiometers in the following positions before advancing beyond Step 1 of the table.

NOTE

Read the foregoing text before placing potentiometers in the following positions.

Potentiometer	Function	Circuit Board	Preliminary Setting
R8	Clipper gain	A1/A4	Fully ccw
R35	DFC bias		Midpoint
R39	DFC gain		Midpoint
R31	DFC ac gain		Fully cw
R32	Processor balance		Midpoint
R10	Input channel balance	A2/A5	Midpoint
R30	Output channel balance		Midpoint
R24	Variolosser bias	A3	Fully cw
R17	AGC bias		Midpoint
R25	AGC rectifier balance		Midpoint
R12	Meter electrical zero		Midpoint
R31	Stereo AGC balance		Midpoint

TABLE 5-3. FM VOLUMAX MAINTENANCE TESTS AND ADJUSTMENTS

Note: See figure 5-2 or 5-3 for Model 4100 or Model 4110 Test Setup.

All ac voltages in this table are rms values except where otherwise stated.

Preliminary:

A. Turn on power and test power supply outputs (table 5-1), using digital voltmeter and ac VTVM (figure 5-2 or 5-3). Proceed no farther until power supply outputs are correct.

B. Apply unbalanced 1 kHz signal at 10 mv to the monaural FM Volumax input (Model 4100) or to both stereo FM Volumax inputs (Model 4110). Turn front-panel INPUT and OUTPUT controls fully cw and measure all ac and dc voltages in table 5-2. Use oscilloscope or digital voltmeter and ac VTVM. Unless complete series of tests and adjustments is desired, proceed then only to steps 1 through 4 below and the later steps pertaining to the circuit board where improper voltages (table 5-2) are found.

Step	Action	Circuit	Remarks
1	Turn power off.	Power supply (board A3)	
	Set front panel INPUT and OUTPUT controls fully cw.	Input-output board (A2, A5) and signal output line(s)	
	Place front panel TEST switch at TEST (upper -- "on -- position).	"Compression" circuits: boards A1, A4, and A3.	
	Wait 1 or 2 minutes before beginning step 2.	Power supply (board A3 and elsewhere).	Allow capacitors to discharge.

TABLE 5-3. FM VOLUMAX MAINTENANCE TESTS AND ADJUSTMENTS (Cont)

Step	Action	Circuit	Remarks
	CAUTION If your FM Volumax unit has the optional meter compression circuit consisting of R32 and CR4 on board A3 (figure 7-4), open (disconnect) one end of R32 or CR4 on A3 before proceeding farther in this table.		
2	Mechanically adjust front panel GAIN REDUCTION meter for full scale indication to the right.	GAIN REDUCTION meter mechanical zero set	Power off. Adjust using lever at bottom of meter. Lever is available at front of meter.
3	Power on. No signal input.		
	Wait for warmup.	Power supply (board A3 and elsewhere)	Wait 5 minutes. if unit is cold Wait 1 or 2 minutes if unit is warm.
	Adjust R12 on board A3 for front panel GAIN REDUCTION meter reading at full scale to the right.	GAIN REDUCTION meter electrical zero set.	
4	Connect FM VOLUMAX unit to a 600-ohm* audio signal source and 600-ohm* load(s) in accordance with figure 5-2 or 5-3, as applicable. Leave or turn audio signal source OFF.		

*Or other characteristic impedance

TABLE 5-3. FM VOLUMAX MAINTENANCE TESTS AND ADJUSTMENTS (Cont)

Step	Action	Circuit	Remarks
	INPUT CIRCUIT ON BOARDS A2, A5		
5	If R26 on board A2 is not in approximately mid-position and voltage measurements at A2TP3 and A2TP5 per table 5-2 were significantly unbalanced, set this potentiometer in midposition. Otherwise, do not disturb setting.	Post-variolosser input-amplifier channel balance.	Usually A2R26 (and A5R26) should be left in midposition.
6	At board A5 in Model 4110: repeat step 5 for R26 on that board.		
7	Set audio signal source to 200 Hz and apply a 4 mv rms signal to the input(s).	All internal circuits plus input and output lines.	Check input level(s) on input AC VTVM(s) (figure 5-2 or 5-3).
8	Observe output AC VTVM indication. Reading should be in range of 0.53v to 1.11 v rms*. If reading is out of range, proceed with next four steps before making repairs.	Output lines.	Observe both channel outputs when testing Model 4110. Reading should be within range for each channel.
9	Remove input signal(s). Place front panel TEST switch in lower (off) position.	"Compression" circuits on A1/A4 and A3 in non-TEST state	

* For 600-ohm output termination.

TABLE 5-3. FM VOLUMAX MAINTENANCE TESTS AND ADJUSTMENTS (Cont)

Step	Action	Circuit	Remarks
	INPUT CIRCUIT ON BOARDS A2, A5 (Cont)		
10	At board A2: Measure quiescent voltage between TP1 (ground) and TP2. Reading should be -0.5v ± 0.1 vdc.	AGC control line from board A3.	No signal input. If reading is erroneous in Model 4100, place R31 on board A3 in midposition.
11	At board A5 in Model 4110: repeat step 10 at TP1 and TP2 on that board.		Balance-out any significant difference in readings at TP1,TP2 on boards A2 and A5 by means of R31 on board A3.
	NOTE If readings are correct at ends of steps 8, 10, and 11, step 12 below may probably be omitted.		
12	Remedial adjustment: If readings in steps 8, 10, and 11 are incorrect, turn potentiometer R24 on board A3 fully cw. Then re-raise TEST switch, and re-apply the 200 Hz signal at 4 mv rms. Output AC VTVM indication should now be in range of 0.80 to 1.5v rms.	AGC control current amplitude ("compression" circuits in TEST state).	
	Turn A3R24 ccw to point for which output AC VTVM indication is decreased by 3 ± 0.5 dB.	AGC control current amplitude ("compression" circuits in TEST state).	

TABLE 5-3. FM VOLUMAX MAINTENANCE TESTS AND ADJUSTMENTS (Cont)

Step	Action	Circuit	Remarks
	HIGH FREQUENCY PROCESSOR BOARDS A1, A4		
	NOTE Steps 13 through 17 below are necessary only when aligning the dynamic frequency compensator (DFC) circuit.		
13	Put A1R35 and A1R39 in midpositions. Connect DVM (fig. 5-2 or 5-3) between A1TP7 and A1TP6. Put TEST switch in upper position.	"Compression" circuits in TEST state	No signal input. TP7 is ground.
14.	Adjust A1R35 for reading of 10 ± 0.2 vdc on DVM.	DFC control transistor (Q11) bias.	No signal input. Do not vary setting of A1R35 if DVM reading is within limits.
15	Move DVM + lead to A1TP9.		
16	Adjust A1R39 for reading of 9.5 ± 0.2 vdc on DVM.	DFC control transistor (Q11) bias.	No signal input. Do not vary setting of A1R39 if DVM reading is within limits.
17	At board A4 in Model 4110: repeat steps 13 through 16 FOR TP6, TP7, TP9, R35, and R39 on that board.		
18	Place TEST switch in lower (off) position and apply a continuous 10 kHz signal at 4.0 mv level to the input(s).	"Compression" circuits on A1/A4 and A3 in non-TEST state.	Check input level(s) on input AC VTVM(s) (figure 5-2 or 5-3).

TABLE 5-3. FM VOLUMAX MAINTENANCE TESTS AND ADJUSTMENTS (Cont)

Step	Action	Circuit	Remarks
	HIGH FREQUENCY PROCESSOR BOARDS A1, A4 (Cont)		
19	On board A1: measure ac level at TP2. Should be 0.7v rms ± 0.5 dB.	High frequency processing channel output.	
	If reading is out of limits, adjust to 0.7v rms with R8 on that board.	High-level high-frequency signal limiter threshold of soft clipper.	
20	Increase the input signal level by 10 dB. Signal at TP2 on board A1 should be clipped at 1.59v rms ± 2 dB (4.5v ± 1v p-p).		Check input level(s) on input AC VTVM(s) (figure 5-2 or 5-3).
21	Connect oscilloscope to base of Q4 (junction of R9 and C6) on board A1. Observe 5v ± 1v p-p limited signal.	Soft clipper stage.	
22	At board A4 in Model 4110: repeat steps 18 through 21 for R8, TP2 and base of Q4 on that board.		
23	Apply a continuous 15 kHz signal at 4 mv to the input(s).		Check input level(s) on input AC VTVM(s) (figure 5-2 or 5-3).
24	Alternately switch the frequency of the input(s) between 15 kHz and 150 Hz while maintaining the same input level (4 mv) for both frequencies.		Check input level(s) on input AC VTVM(s).
	Observe output levels. For either frequency, these levels should be the same within ± 0.25 dB.		Observe both channel outputs when testing Model 4110. (Channel outputs may be a little unbalanced at this time.)

TABLE 5-3. FM VOLUMAX MAINTENANCE TESTS AND ADJUSTMENTS (Cont)

Step	Action	Circuit	Remarks
	HIGH FREQUENCY PROCESSOR BOARDS A1, A4 (Cont)		
24 (Cont)	If not the same within 0.25 dB, adjust for this condition with R32 on board A1. Vary R32 only in times when the 150 Hz signal is being applied.	Balancing of outputs from high- and low-frequency processing channels. (Adjusts output of low-frequency processing channel.)	
25	At board A4 in Model 4110: perform steps 24 for R32 on that board if necessary.		
26	Change input signal frequency to 1.5 kHz, maintaining same input level(s) in steps 24, 25.		Check input level(s) on AC VTVM(s).
	Observe that output level(s) differ no more than ±1 dB from levels in steps 24 and 25.		Observe both channel outputs when testing Model 4110. (Channel outputs may be a little unbalanced at this time.)
27	Vary input signal frequency over the range of 50 Hz to 15 kHz, maintaining same level as in steps 24, 25.		Check input level(s) on AC VTVM(s).
	Observe that output level(s) do(es) not vary more than ±1 dB with changes in frequency over this range.		Observe both channel outputs when testing Model 4110. (Channel outputs may be a little unbalanced at this time.)

TABLE 5-3. FM VOLUMAX MAINTENANCE TESTS AND ADJUSTMENTS (Cont)

Step	Action	Circuit	Remarks
	HIGH FREQUENCY PROCESSOR BOARDS A1, A4 (Cont)		
27 (Cont)	Remedial measure: Try padding capacitance of A1C23 (and/or A4C23 if appropriate in Model 4110) if output variation exceeds 1 dB. Do this by connecting a small-C capacitor between A1TP2 and A1TP5 or between A4TP2 and A4TP5.		
	NOTE The AGC rectifier bias on board A3 should be correct before proceeding farther on board A1 or A4. See steps 34 and 35 under AGC CIRCUIT ON BOARD A3 later in this table.		
28	Apply a 450 Hz signal at a level sufficient to drive the front-panel GAIN REDUCTION meter to the green region.	All	TEST switch down.
	Record the output level(s). (Record for each channel is Model 4110.)		Observe output oscilloscope and output AC VTVM(s) (figure 5-2 or 5-3).
29	While maintaining constant input level, increase the input-signal frequency to 4.5 kHz.	All	
	Tone-burst the input signal. Gate the signal on for 10 ms. Gate it off for at least 20 ms.		

TABLE 5-3. FM VOLUMAX MAINTENANCE TESTS AND ADJUSTMENTS (Cont)

Step	Action	Circuit	Remarks
	HIGH FREQUENCY PROCESSOR BOARDS A1, A4 (Cont)		
30	Connect oscilloscope to TP4 on board A1. Set oscilloscope sweep speed to 5 ms/cm. Synchronize the oscilloscope sweep with the tone bursts.		
31	Observe the waveform on the oscilloscope at TP4. It should be similar to the CORRECT waveforms in the upper part of figure 5-4.		See figure 5-4.
	If necessary, adjust for CORRECT waveform with R31 on board A1. Also, use R35 and/or R39 on the same board as needed to eliminate any tendency of the waveform to resemble the INCORRECT waveforms in the lower part of figure 5-4. When properly adjusted, the attack time should be less than 5 ms.	DFC feedback and DFC control transistor (Q11) bias.	
32	Apply a continuous 4.5 kHz input signal at level used in steps 28 and 29. Trim R31 on board A1 cw until the output is 5 ±0.25 db less than recorded in step 28.	DFC feedback.	Observe output oscilloscope and output AC VTVM(s) (figure 5-2 or 5-3).
33	At board A4 in Model 4110: repeat steps 29 through 32 for TP4, R31, R35, and R39 on this board.		

TABLE 5-3. FM VOLUMAX MAINTENANCE TESTS AND ADJUSTMENTS (Cont)

Step	Action	Circuit	Remarks
	AGC CIRCUIT ON BOARD A3		
Ref	(See Remarks -- opposite.)	Meter electrical zero set (A3R12)	Adjusted in step 3 of this procedure. To adjust separately, perform Preliminary step A and steps 1 through 3 of this procedure. (INPUT, OUTPUT, and TEST controls may be in any positions.)
Ref	(See Remarks -- opposite.)	AGC control current amplitude (A3R24)	Adjusted in step 12 of this procedure. To adjust separately, perform preliminary steps A and B and steps 1 through 4 and 7 through 12 of this procedure. Return TEST switch to lower position after step 12.
34	Place TEST switch in upper position.	"Compression" circuits in TEST state	
	Apply 200 Hz signal to input(s), increasing input level until it can be seen that any further increase will cause clipping in output. This should occur at an output level of 35v ±4v p-p (12.5v rms ±1 dB).		Observe oscilloscope and AC VTVM(s) at output (figure 5-2 or 5-3). Use L-R switch when testing Model 4110.

TABLE 5-3. FM VOLUMAX MAINTENANCE TESTS AND ADJUSTMENTS (Cont)

Step	Action	Circuit	Remarks
	AGC CIRCUIT ON BOARD A3 (Cont)		
34 (Cont)	Measure and record the present output level. Do this for both channels in Model 4110.		
	Return TEST switch to lower (off) position at end of this step.	"Compression" circuits in non-TEST state	
35	Alternately adjust the input level and R17 on board A3 until GAIN REDUCTION meter indicates at the red-green junction and the output is 2 dB below the value recorded in step 34.	AGC rectifier bias	
36	For Model 4100: Monitor the ripple at A3TP7. Adjust A3R25 if necessary for equal contributions from both sides of the driver and rectifier circuitry. (See figure 7-4.) This will be characterized by 2.5 ms pulse separation in the ripple as opposed to 5 ms separation.	AGC rectifier balance	
	For Model 4110: Omit this step at the present time. See step 47 under STEREO ADJUSTMENTS later in this table.		

TABLE 5-3. FM VOLUMAX MAINTENANCE TESTS AND ADJUSTMENTS (Cont)

Step	Action	Circuit	Remarks
	AGC CIRCUIT ON BOARD A3 (Cont)		
Ref	(See Remarks -- opposite)	AGC output balance (A3R31)	For Model 4100, this potentiometer is normally left in midposition. (See Remarks opposite step 10 of this procedure. For Model 4110, see step 46 under STEREO ADJUSTMENTS later in this procedure.
	OUTPUT CIRCUITS ON BOARDS A2, A5 AND OUTPUT MEASUREMENTS		
37	For Model 4110 only: Apply a 200 Hz signal to the two inputs at 4 mv level. Compare the two stereo output levels. They should be the same within 1 dB. Remedial measure: If difference exceeds 1 dB, add a bridging resistor between the base of Q4 and base of Q13 on board A2 or board A5 as appropriate. Select resistor value as needed to match outputs within 0.5 dB. Place resistor on board A2 if left channel output is the higher; place on board A5 if right channel output is the higher.		Check input levels on input AC VTVMs (figure 5-3). Observe output AC VTVM (using L-R switch) and oscilloscope in figure 5-3.

TABLE 5-3. FM VOLUMAX MAINTENANCE TESTS AND ADJUSTMENTS (Cont)

Step	Action	Circuit	Remarks
OUTPUT CIRCUITS ON BOARDS A2, A5 AND OUTPUT MEASUREMENTS (Cont)			
38	Apply a 50 Hz signal to the input(s) at about 30 mv level (below gain reduction threshold)		Perform this and later steps for either Model 4100 or 4110.
39	Measure the harmonic distortion at the output(s). If 1% or greater, adjust to less than 1% with A2R30 (and/or A5R30 in Model 4110).	Input balance for output drivers.	Observe distortion analyzer (figure 5-2 or 5-3). Use L-R switch when testing Model 4110.
40	Apply a 3 kHz signal at 15 mv to the input(s).		
41	Measure the distortion in the output signals. The distortion should be less than 1%.	All	Measure in both outputs of Model 4110.
42	Apply a 15 kHz signal at 3 mv to the input(s). Measure the distortion in the output(s). Distortion should be less than 1%.	All	Use 1 kHz high pass filter in distortion analyzer. Measure in both outputs of Model 4110.
43	Remove input signals and terminate the inputs in 600 ohms*. Measure the average output noise. It should be less than 4.4 mv average for 600 ohm input.	All	Perform all of this step for each channel of Model 4110. If noise is excessive, suspect A1Q8 (or A4Q8).

*Or other characteristic input impedance.

TABLE 5-3. FM VOLUMAX MAINTENANCE TESTS AND ADJUSTMENTS (Cont)

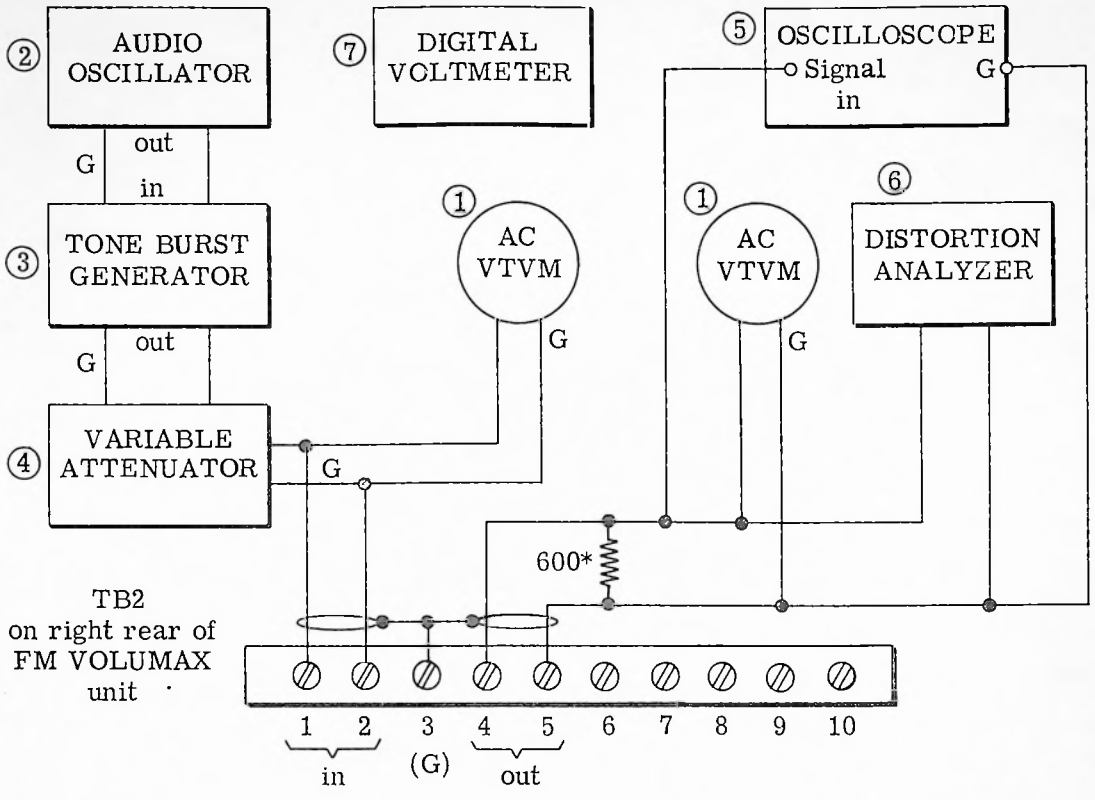
Step	Action	Circuit	Remarks
OUTPUT CIRCUITS ON BOARDS A2, A5 AND OUTPUT MEASUREMENTS (Cont)			
44	Apply a 200 Hz signal to the input(s) at level sufficient to drive the GAIN REDUCTION meter to the red-green junction.		
45	Increase input level until GAIN REDUCTION meter reading reaches left edge.		
	Verify that the output(s) is (are) not clipped.		Check both outputs of Model 4110.
	NOTE This completes all tests and adjustments for the monaural Model 4100. See NOTE at end of table.		
	STEREO ADJUSTMENTS (MODEL 4110)		
46	Apply equal 200 Hz signals to both inputs at level sufficient to drive the GAIN REDUCTION meter to the mid-green region.		Observe both outputs of the Model 4110 on oscilloscope and AC VTVM (figure 5-3). Use L-R switch.
	Adjust R31 on board A3 as required for the L and R output levels to be matched within 0.25 dB.	AGC output L-R division.	

TABLE 5-3. FM VOLUMAX MAINTENANCE TESTS AND ADJUSTMENTS (Cont)

Step	Action	Circuit	Remarks
	STEREO ADJUSTMENTS (MODEL 4110) (Cont)		
46 (Cont)	Reduce inputs 10 db. Check that output levels are matched within 1.0 dB.		
47	Apply 200 Hz signals to both inputs at level sufficient to drive the GAIN REDUCTION meter to the red-green junction. Then perform step 36 of this procedure.	AGC rectifier balance	Perform same as for Model 4100.
48	Using signal inputs as in step 47, raise TEST switch and check that symmetrical clipping occurs. Clipping points in the two channels should be the same within 5%.	"Compression" circuits in TEST state.	Observe oscilloscope at outputs (figure 5-3).
49	Place TEST switch in lower (off) position. Increase input level until GAIN REDUCTION reading reaches left edge. Verify that neither output exhibits any clipping.	"Compression" circuits in non-TEST state.	
50	Verify that left (L) and right (R) channel outputs are in phase.		If not in phase, look for and correct an error that may have been made in a repair.

TABLE 5-3. FM VOLUMAX MAINTENANCE TESTS AND ADJUSTMENTS (Cont)

Step	Action	Circuit	Remarks
	NOTE The optional meter compression circuit consisting of R32 and CR4 on board A3 may be re-connected at the end of step 45 in the Model 4100 or end of step 50 in the Model 4110.		

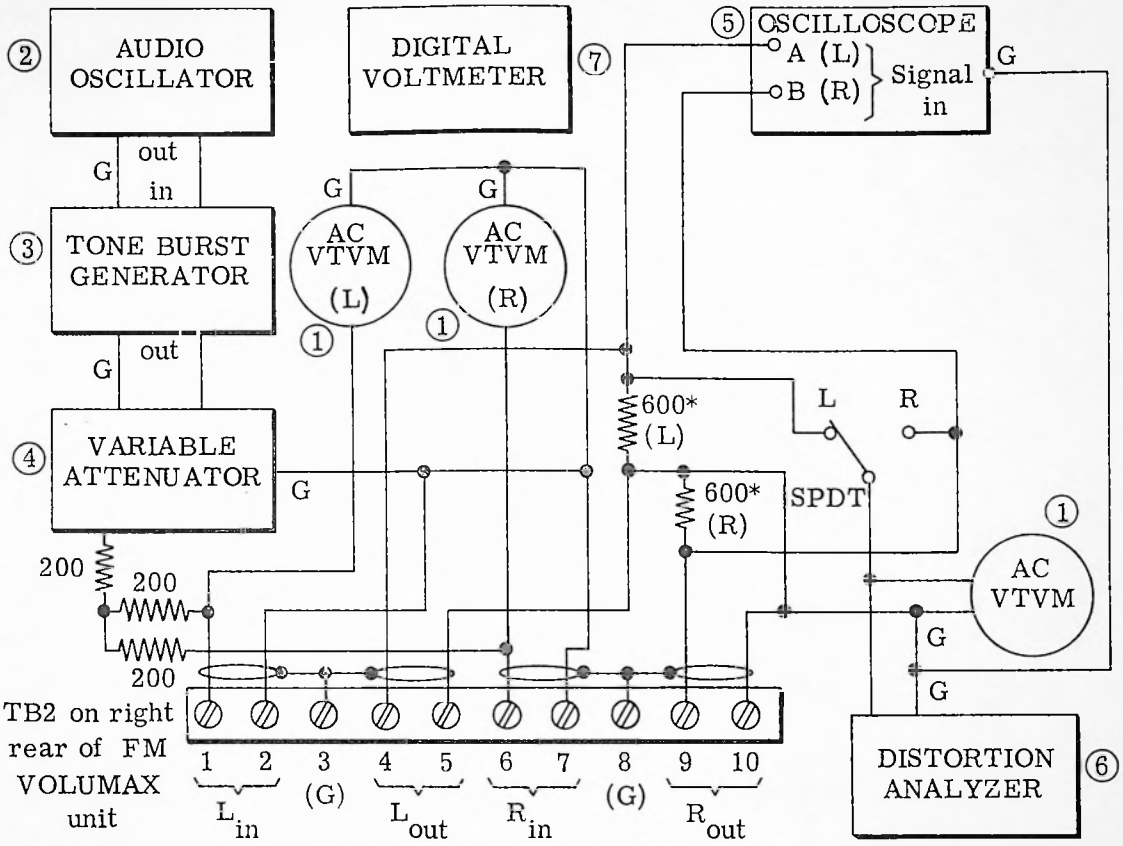


TEST EQUIPMENT:

1	Ballantine or equal (qty 2)
2	Signal generator with less than 0.1% distortion (Hewlett Packard Model 200 CD or 406A or equal)
3	General Radio 1396-B or equal
4	20-dB stepped attenuator
5	General purpose oscilloscope
6	Hewlett Packard 332A, 333A, or equal
7	Fairchild Model 7050 or equal

*or other characteristic output impedance

Figure 5-2. Complete Test Setup for Monaural Model 4100



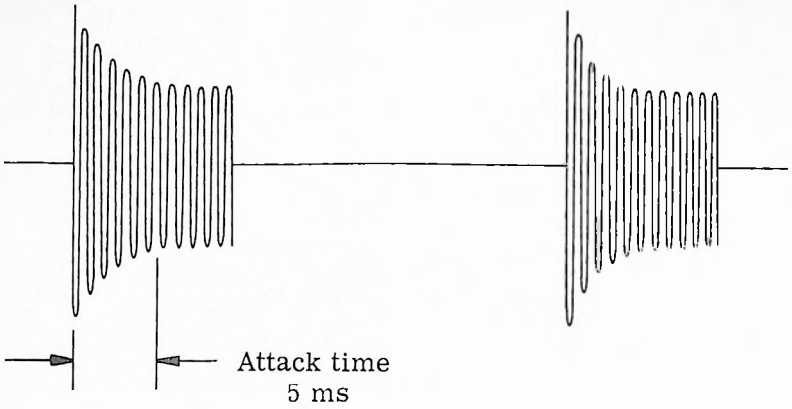
TEST EQUIPMENT:

1	Ballantine or equal (qty 3)
2	Signal generator with less than 0.1% distortion (Hewlett Packard Model 200 CD or 406A or equal)
3	General Radio 1396-B or equal
4	20-dB stepped attenuator
5	General purpose oscilloscope (pref dual trace)
6	Hewlett Packard 332A, 333A, or equal
7	Fairchild Model 7050 or equal

*or other characteristic output impedance

Figure 5-3. Complete Test Setup for Stereo Model 4110

CORRECT



INCORRECT

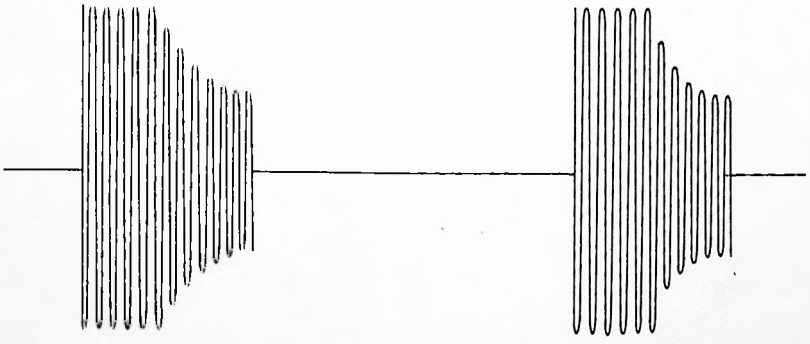


Figure 5-4. Attack Time Test Waveform

SECTION VI

PARTS LISTS

6-1. GENERAL

This section contains parts lists for the complete FM Volumax. Each list gives the circuit designation of the part, an electrical description, a reference to the manufacturer where significant, and that manufacturer's part number. In all cases, the use of original manufacturers' parts is recommended for any necessary replacements. If the part cannot be readily obtained, contact the Professional Products Department at CBS Laboratories to procure it.

6-2. RESISTORS

Except where otherwise indicated in the parts lists, all resistors used in the FM Volumax are carbon composition, 1/4 watt, plus or minus 5%.

6-3. DIODES AND TRANSISTORS

When replacing diodes and transistors called out in the parts lists with 1N and 2N standard numbers, replace them with the same manufacturing brand of diode or transistor as removed, when possible. Where the parts list indicates a specific manufacturer and part number, only that manufacturer's part and part number should be used for the replacement.

6-4. MANUFACTURERS' NAME ABBREVIATIONS

AB	Allen Bradley
ALCO	Alco Electronic Products, Inc.
AMRA	American Radionic
AO	Allen Organ
AUG	Augat
BEL	Belden
BECK	Beckman
CBS	CBS Laboratories
CDE	Cornell-Dubilier Electronics
CIN	Cinch Manufacturing
ELM	Elmenco
GEN	General Electric
IND	Industrial Devices
IRC	International Resistance
LF	Little Fuse, Inc.
MAL	Mallory
MOL	Molex
MOT	Motorola
NYT	Nytronics
SPR	Sprague
TI	Texas Instruments
VER	Vero

6-5. MAIN ASSEMBLY (MODEL 4110 OR 4100)

Ref	Description	Mfr	Part No.	Used on (X) Model 4110	Used on (X) Model 4100
	Chassis assembly	CBS	962200	X	X
	Nameplate	CBS	960315-69	X	
	Nameplate	CBS	960315-70		X
	Cord, 3 wire, 18 AWG	BEL	17237	X	X
A1, A4	High-frequency Processor board (Para 6-6.)	CBS	962193-1	X	
A1	High-frequency Processor board (Para 6-6.)	CBS	962193-2		X
A2, A5	Input-output board (See paragraph 6-7.)	CBS	962197-1	X	
A2	Input-output board (See paragraph 6-7.)	CBS	962197-2		X
A3	Power supply and AGC board (See paragraph 6-8.)	CBS	962188	X	X
(A3J1)	Connector, 4 pin	MOL	2139-4	X	X
	Pin, connector	MOL	2138-TL	X	X
	Key, polarizing	MOL	2139-K	X	X
A6	Front panel assembly (See paragraph 6-9.)	CBS	962203-1	X	
A6	Front panel assembly (See paragraph 6-9.)	CBS	962203-2		X
F1	Fuse, 3/10 amp	LF	3AG SLO-BLO	X	X

6-5. MAIN ASSEMBLY (MODEL 4110 OR 4100) (cont)

Ref	Description	Mfr	Part No.	Used on (X) Model 4110	Used on (X) Model 4100
C1, C2*	Capacitor, 0.05 mfd	SPR	TG-S50	X	X
L1, L2*	Inductor, 12 microhenries	NYT	DD-12	X	X
T1	Transformer, audio	CBS	962132	X	X
T2	Transformer, power	CBS	962229	X	X
T3	Transformer, audio	CBS	962132	X	
TB1	Strip, terminal, 5 term.	CIN	54-C	X	X
TB2	Block, terminal	CIN	353-18-10-001	X	X
XF1	Fuseholder	LF	342012	X	X

6-6. HIGH FREQUENCY PROCESSOR BOARD A1 AND A4**

Ref	Description	Mfr	Part No.
	RESISTORS		
R1, R46	75 kilohms		
R2	4.7 kilohms		
R3, R6, R10, R13, R19	7.5 kilohms		
R4	4.53 kilohms, 1/8w, 1%	IRC	CEA-TO
R5, R17, R18	9.09 kilohms, 1/8w, 1%	IRC	CEA-TO
R7	15 kilohms		
R8	Variable, 1 kilohm	BECK	62PR1K
R9	100 kilohms		

* C2 and L2 used only on Model 4110.
** A4 is used on Model 4110 only.

6-6. HIGH FREQUENCY PROCESSOR BOARD A1 AND A4* (cont)

Ref	Description	Mfr	Part No.
	RESISTORS (cont)		
R11	5.62 kilohms, 1/8w, 1%	IRC	CEA-TO
R12	11.3 kilohms, 1/8w, 1%	IRC	CEA-TO
R14	30 kilohms		
R15, R16	620 ohms		
R20, R41	8.2 kilohms		
R21	27 kilohms		
R22, R23, R26, R30, R43, R44	1 kilohm		
R24	24 kilohms		
R25	5.1 kilohms		
R27	12 kilohms		
R28	68 kilohms		
R29, R33	10 kilohms		
R31	Variable, 5 kilohms	BECK	62PR5K
R32, R35	Variable, 20 kilohms	BECK	62PR20K
R34	5.6 ohms, 1/2w		
R36, R42	51 kilohms		
R37, R38	1.00 kilohms, 1/8w, 1%	IRC	CEA-TO
R39	Variable, 10 kilohms	BECK	62PR10K
R40	9.1 kilohms		
R45	33 kilohms		

* A4 is used on Model 4110 only.

6-6. HIGH FREQUENCY PROCESSOR BOARD A1 AND A4* (cont)

Ref	Description	Mfr	Part No.
	CAPACITORS		
C1	1200 pf, 2%	ELM	DM-19-122G
C2, C3, C7, C8, C10	5000 pf, 2%	ELM	DM-19-502G
C4, C12, C14 C19, C20	4.7 μf, 35v	MAL	TAC475M035P04
C5, C6	0.47 μf, 100v	AMRA	2MBPC1474M
C9	0.12 μf, 100v	ELM	IMDF-3-124
C11	2500 pf, 2%	ELM	DM-19-252G
C13	7500 pf	ELM	DM-19-752J
C15, C21	51 pf	CDE	CD15ED510J03
C16	47 μf, 20v	SPR	196D476X0020LA3
C17	1 μf, 100v	AMRA	2MBPC1105K
C18	3000 pf	ELM	DM-19-302J
C22**	68 μf, 25v	SPR	196D686X0025MA3
C23	200 pf		CM05FD201J03
	SEMICONDUCTORS		
CR1, CR6, CR7, CR8, CR9	Diode		1N456A
CR2, CR3, CR4, CR5	Diode, matched set***		1N456A***
Q1, Q8*	Transistor		2N3391A****

* A4 is used on Model 4110 only.
** Used on Model 4110 only.
*** V_f matched to within 10 mv at I_f = 1.0 ma
**** Select Q8 for output noise of 4.5 mv or less.

6-6. HIGH FREQUENCY PROCESSOR BOARD A1 AND A4* (cont)

Ref	Description	Mfr	Part No.
	SEMICONDUCTORS (cont)		
Q2, Q5, Q6, Q13	Transistor		2N5308
Q3, Q9, Q12	Transistor		2N3906
Q4, Q7, Q10, Q11	Transistor		2N3904
VR1, VR2	Diode, zener	MOT	1N748A
VR3, VR4	Diode, zener		1N968B
	MISCELLANEOUS		
J1, J2	Wafer pin assy, 8 pin	MOL	A-2183-8A
J3	Wafer pin assy, 4 pin	MOL	A-2183-4A
L1	Inductor, 50 mhy	CBS	991601
XQ8	Socket, transistor	AUG	8060-1G7
	Etch, drill and mark assy	CBS	962191

6-7. INPUT-OUTPUT BOARD A2 AND A5*

Ref	Description	Mfr	Part No.
	RESISTORS		
R1, R45	1.5 kilohms		
R2, R46	5.1 kilohms		
R3, R34	2.4 kilohms		
R4, R6, R25, R26, R35	4.7 kilohms		

* A4 and A5 are used on Model 4110 only.

6-7. INPUT-OUTPUT BOARD A2 AND A5* (cont)

Ref	Description	Mfr	Part No.
	RESISTORS (cont)		
R5	620 ohms		
R7, R13, R14, R19, R21, R22, R24, R36, R41, R42	10 kilohms		
R8, R20	240 ohms		
R9	1.8 kilohms		
R10	Variable, 1 kilohm	BECK	62PR1K
R11, R23	24 ohms		
R12	1 kilohms		
R15, R47	3 kilohms		
R16, R40	5.6 kilohms		
R17, R48	30 kilohms		
R18	10 ohms		
R27, R38	100 kilohms		
R28, R39	75 ohms		
R29	1.2 kilohms		
R30	Variable, 2 kilohms	BECK	62PR2K
R31, R43	9.1 kilohms		
R32	15 ohms		
R33, R44	33 ohms		

* A5 is used on Model 4110 only.

6-7. INPUT-OUTPUT BOARD A2 AND A5* (cont)

Ref	Description	Mfr	Part No.
	RESISTORS (cont)		
R37	Not used		
R49*	51 ohms		
R50*	20 ohms		
	CAPACITORS		
C1, C4, C5, C6, C10	4.7 μf, 35v	MAL	TAC475M035P04
C2, C7	8.2 μf, 35v	MAL	TAC825K035P04
C3, C9	Not used		
C8	20 pf, 5%		CMO5
C11*, C12*	75 μf, 25v	MAL	TT25X75A
C13, C14	2500 pf	ELM	DM-19-252G
	SEMICONDUCTORS		
CR1, CR2**	Diode		1N456A
Q1, Q3, Q4, Q5, Q7 thru Q10, Q12 thru Q14	Transistor		2N3393
Q2, Q11	Transistor		2N3391
Q6, Q15	Transistor		D40D4
	MISCELLANEOUS		
J1, J2	Wafer pin assy, 8 pin	MOL	A-2183-8A
J3	Wafer pin assy, 10 pin	MOL	A-2183-10A

* Used on Model 4110 only.
** Matched pair for V_f within 10 mv at I_f = 1.0 ma

6-7. INPUT-OUTPUT BOARD A2 AND A5*(cont)

Ref	Description	Mfr	Part No.
	MISCELLANEOUS (cont)		
J4	Wafer pin assy, 3 pin	MOL	A-2183-3A
	Etch, drill, and mark assy	CBS	962196

6-8. POWER SUPPLY AND AGC BOARD A3

Ref	Description	Mfr	Part No.
	RESISTORS		
R1	Wirewound, 3.9 ohms, 1w		
R2	Wirewound, 3.9 ohms, 1w	SPR	239E3R95
R3	470 ohms, 1/2w		
R4	68 ohms, 1/2w		
R5, R22	360 kilohms		
R6, R23, R30**	5.1 kilohms		
R7	6.8 kilohms		
R8, R15	10 kilohms		
R9, R16	82 ohms		
R10	7.5 kilohms		
R11, R18	100 kilohms		
R12	Variable, 2 kilohms	BECK	62PR2K
R13	1 kilohm, 1/2w		
R14	82 ohms, 1/2w		

* Used on Model 4110 only.
**Select R30 at test.

6-8. POWER SUPPLY AND AGC BOARD A3 (cont)

Ref	Description	Mfr	Part No.
	RESISTORS (cont)		
R17, R31	Variable, 5 kilohms	BECK	62PR5K
R19	2.4 kilohms		
R20	470 kilohms		
R21	100 ohms, 2w		
R24	Variable, 1 kilohm	BECK	62PR1K
R25	Variable, 100 ohms	BECK	62PR100
R26	4.3 kilohms		
R27	Not used		
R28	1.8 kilohms		
R29	3 kilohms		
R32*	470 ohms		
R33, R34	91 kilohms		
	CAPACITORS		
C1 thru C4, C7, C8	500 μf, +100%, -10%, 50v	MAL	TCW501N050L1F3P
C5, C6, C10, C11	4.7 μf, ±20%, 35v	MAL	TAC475M035-P04
C9	0.47 μf, ±10%, 100v	AMRA	2MBPC1474K
C12, C13	8.2 μf, 35v	MAL	TAC825K035P04
	SEMICONDUCTORS		
CR1	Bridge rectifier	VER	VE18
CR2, CR3	Diode		1N456A

* Optional

6-8. POWER SUPPLY AND AGC BOARD A3 (cont)

Ref	Description	Mfr	Part No.
	SEMICONDUCTORS (cont)		
CR4*	Diode		1N3121
Q1	Transistor		2N3766
Q2, Q4	Transistor		2N3393
Q3	Transistor	GEN	D41D1
Q5	Transistor, field effect	TI	TI558 (Grn)
VR1	Diode, zener, 20v, 5%		1N4747A
VR2	Diode, zener, 15v, 5%		1N4744A
	MISCELLANEOUS		
J1	Wafer pin assy, 4 pin	MOL	A2183-4A
J2	Wafer pin assy, 8 pin	MOL	A2183-8A
J3	Wafer pin assy, 10 pin	MOL	A2183-10A
XQ5	Socket, transistor	AUG	8060-1G7
	Etch, drill, and mark assy	CBS	962187

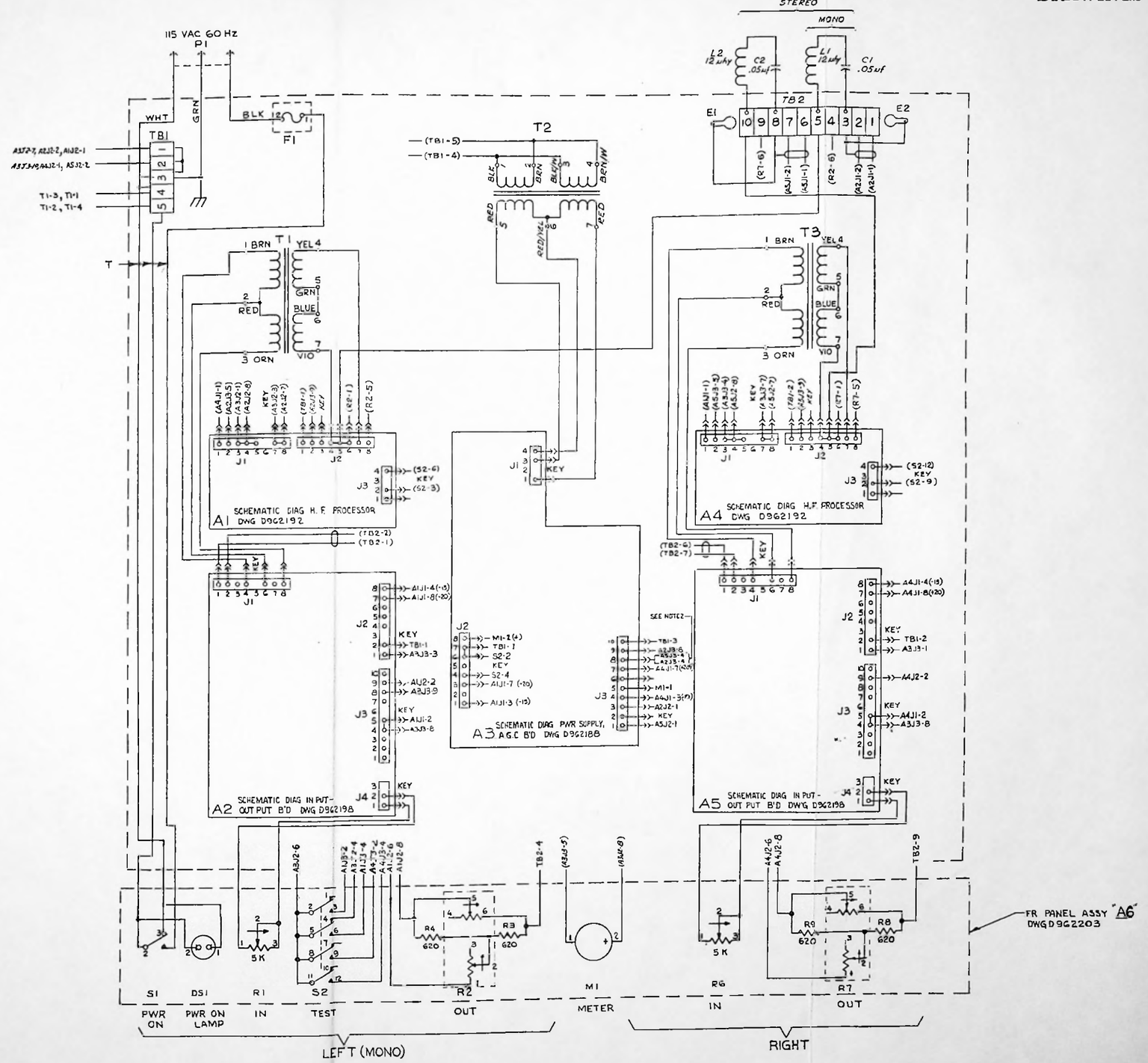
* Optional

6-9. FRONT PANEL ASSEMBLY A6 (MODEL 4110 OR 4100)

Ref	Description	Mfr	Part No.	Used on (X) Model 4110	Used on (X) Model 4100
	Nameplate	CBS	962199-4	X	
	Nameplate	CBS	962199-5		X
DS1	Lamp, pilot (red)	IND	2150-A1	X	X
M1	Meter	CBS	962212	X	X
R1	Variable, 5 kilohms	AB	WA4N020S-502AA	X	X
R2	Variable, 600 ohms, T pad	AB	GD4N020S-601NE	X	X
R3, R4	620 ohms			X	X
R5	Not used				
R6	Variable, 5 kilohms	AB	WA4N020S-502AA	X	
R7	Variable, 600 ohms, T pad	AB	GD4N020S-601NE	X	
R8, R9	620 ohms			X	
S1	SPDT	ALCO	MST-105D	X	X
S2	4PDT	ALCO	MST-405N	X	
S2	DPDT	ALCO	MST-205N		X

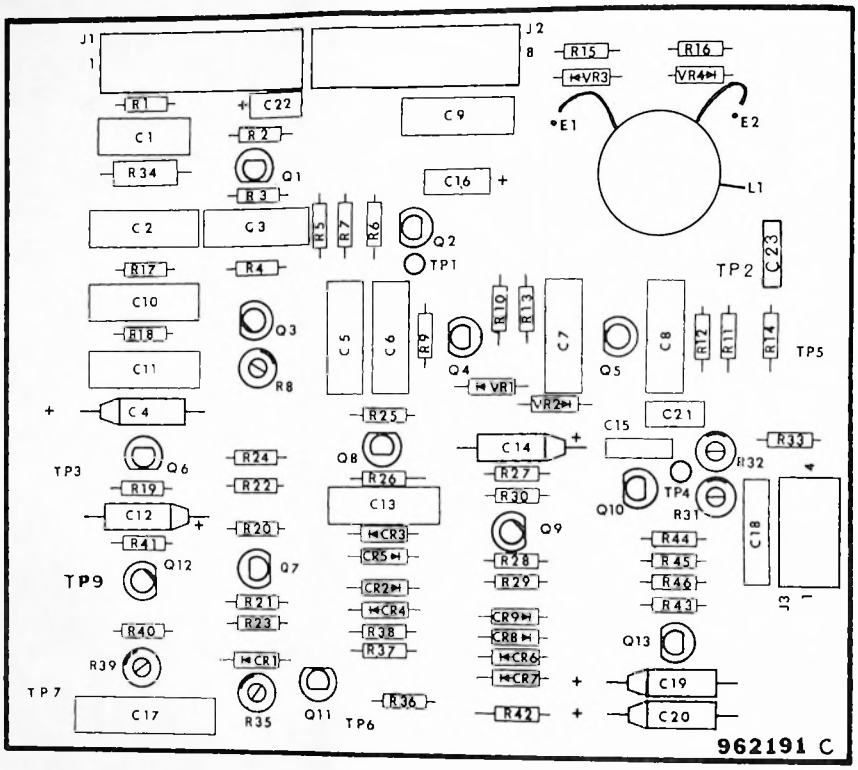
SECTION VII

DRAWINGS



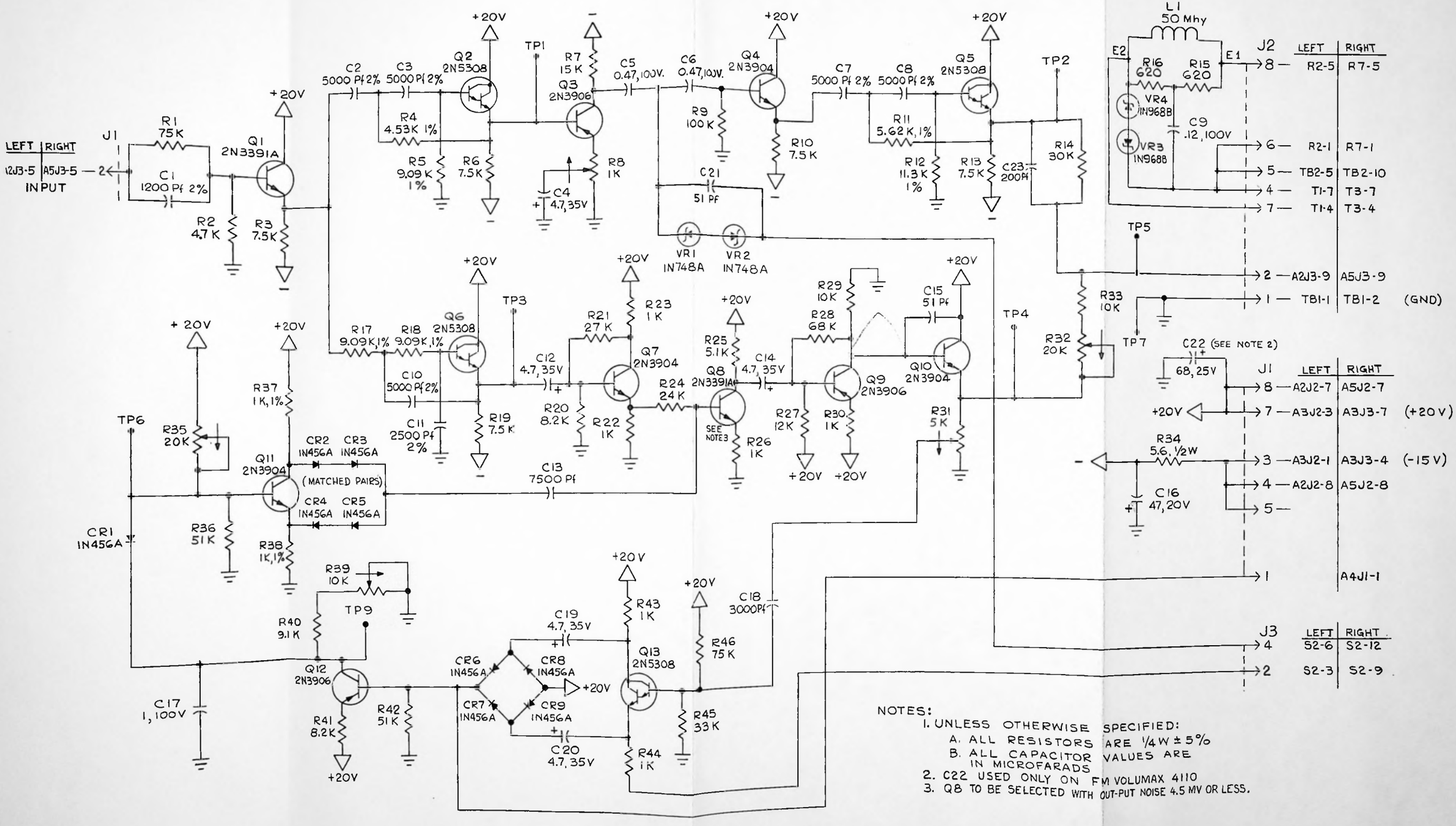
NOTES:
1. R6 THRU R9, A4, A5, T3, E1, TERMINALS TB2-6 THRU 10 ARE USED ON MODEL 4110 (STEREO) ONLY.
2. MONO UNITS (*4100) CONNECT PIN 8 OF A3J3 TO A2J3-4 ONLY.
   STEREO UNITS (4110) CONNECT PIN 8 OF A3J3 TO A5J3-4 ONLY.

Figure 7-1. FM Volumax, Internal Interconnections



NOTES:

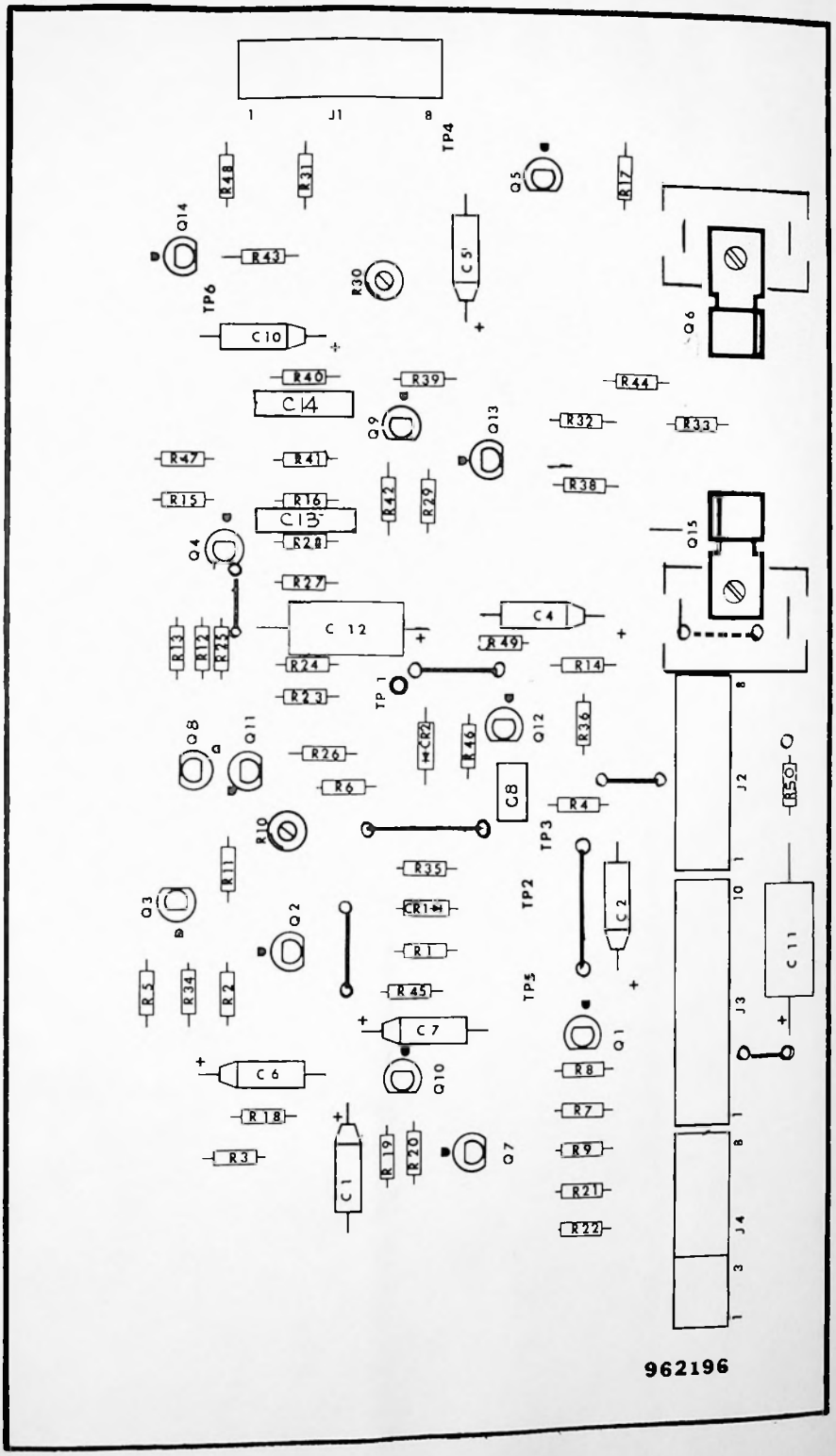
1. REMOVE (CUT) FROM CONNECTORS J1, J2 & J3 RESPECTIVELY PIN N°6, 3, & 3 FOR POLARIZATION.



NOTES:

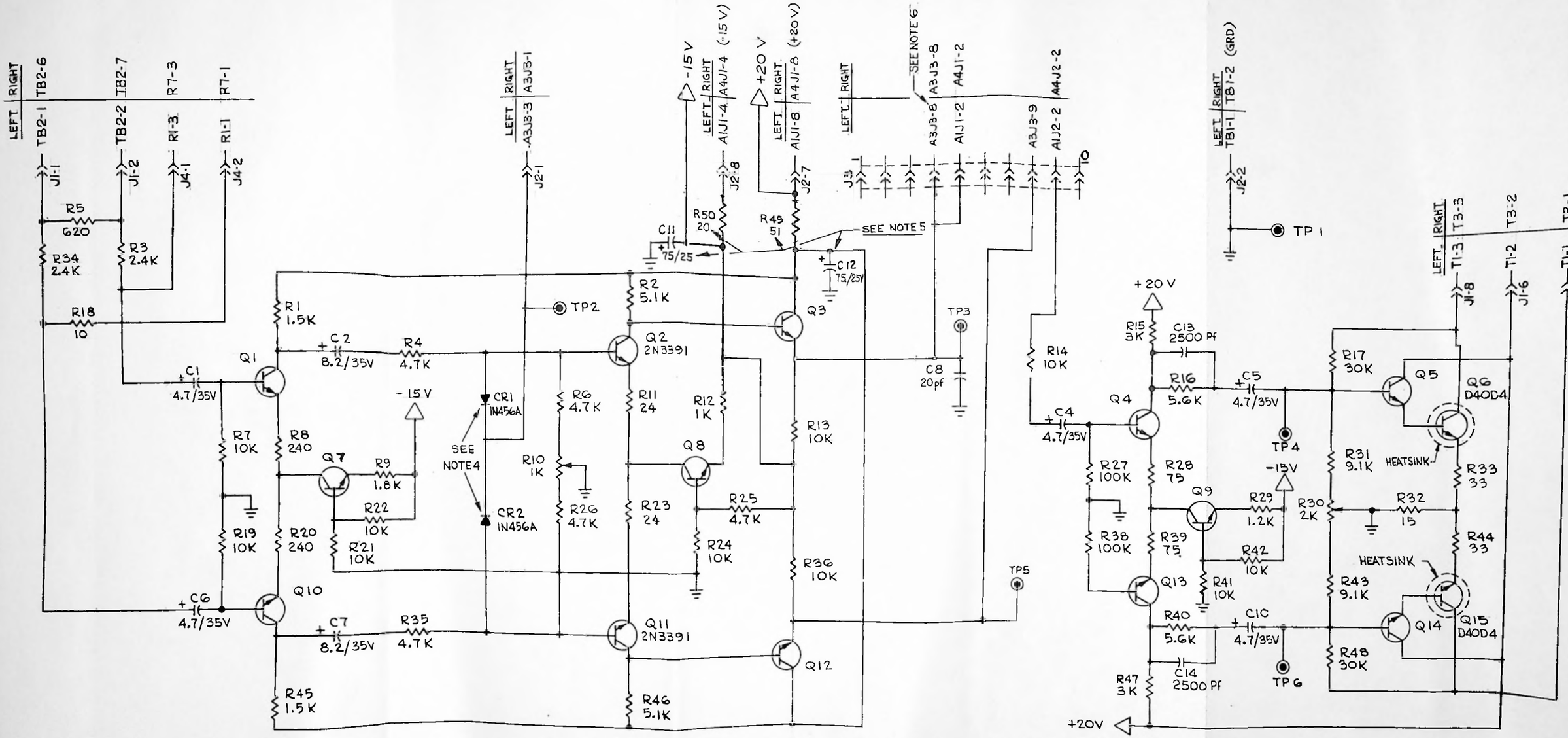
1. UNLESS OTHERWISE SPECIFIED:
   A. ALL RESISTORS ARE 1/4 W ± 5%
   B. ALL CAPACITOR VALUES ARE IN MICROFARADS
2. C22 USED ONLY ON FM VOLUMAX 4110
3. Q8 TO BE SELECTED WITH OUT-PUT NOISE 4.5 MV OR LESS.

Figure 7-2. High Frequency Processor Board A1 or A4, Schematic and Parts Location Diagrams



NOTES:

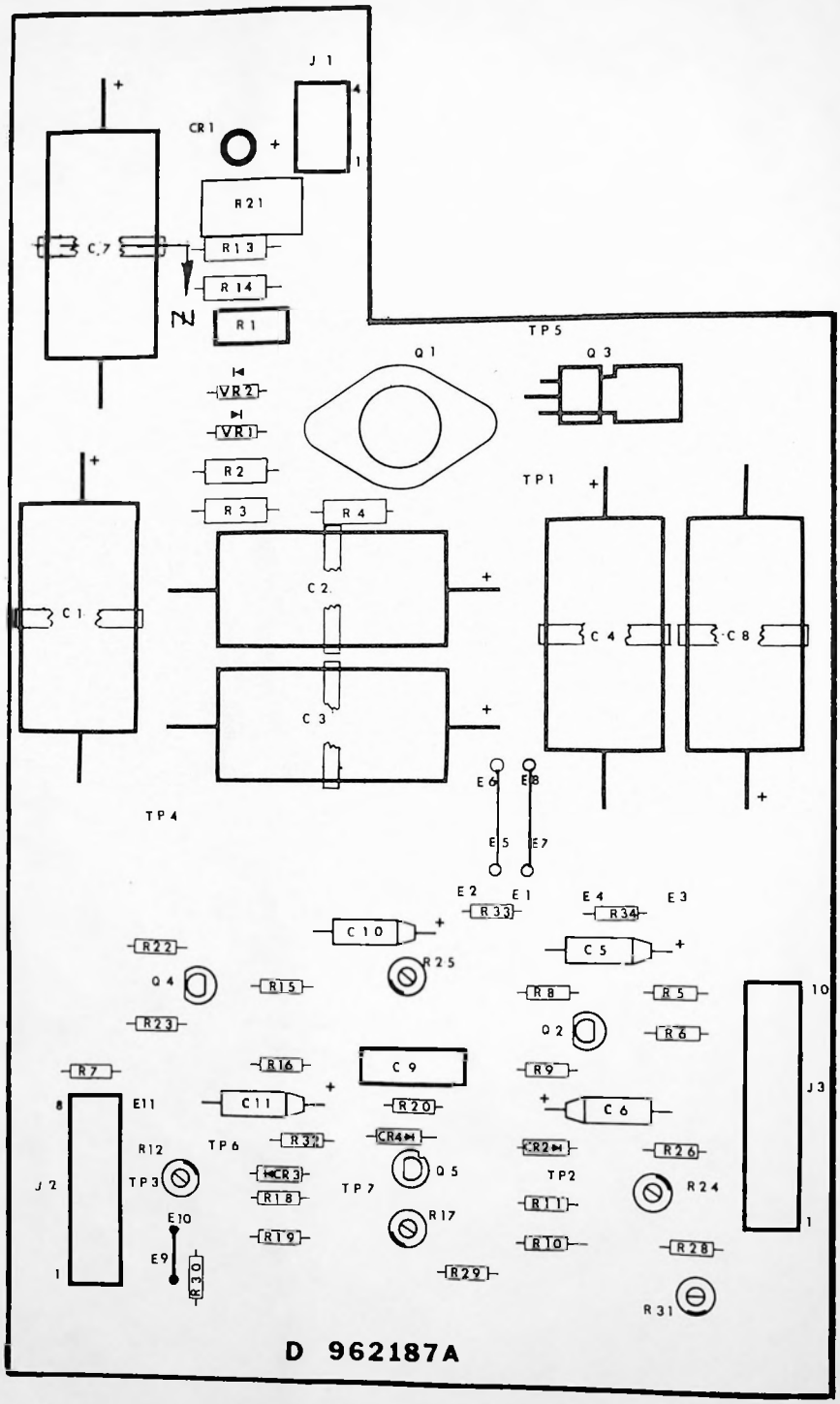
1. REMOVE (CUT) FROM CONNECTORS J1, J2, J3 & J4 RESPECTIVELY PIN N°S 5, 3, 6, & 3 FOR POLARIZATION.



NOTES:
(UNLESS OTHERWISE SPECIFIED)

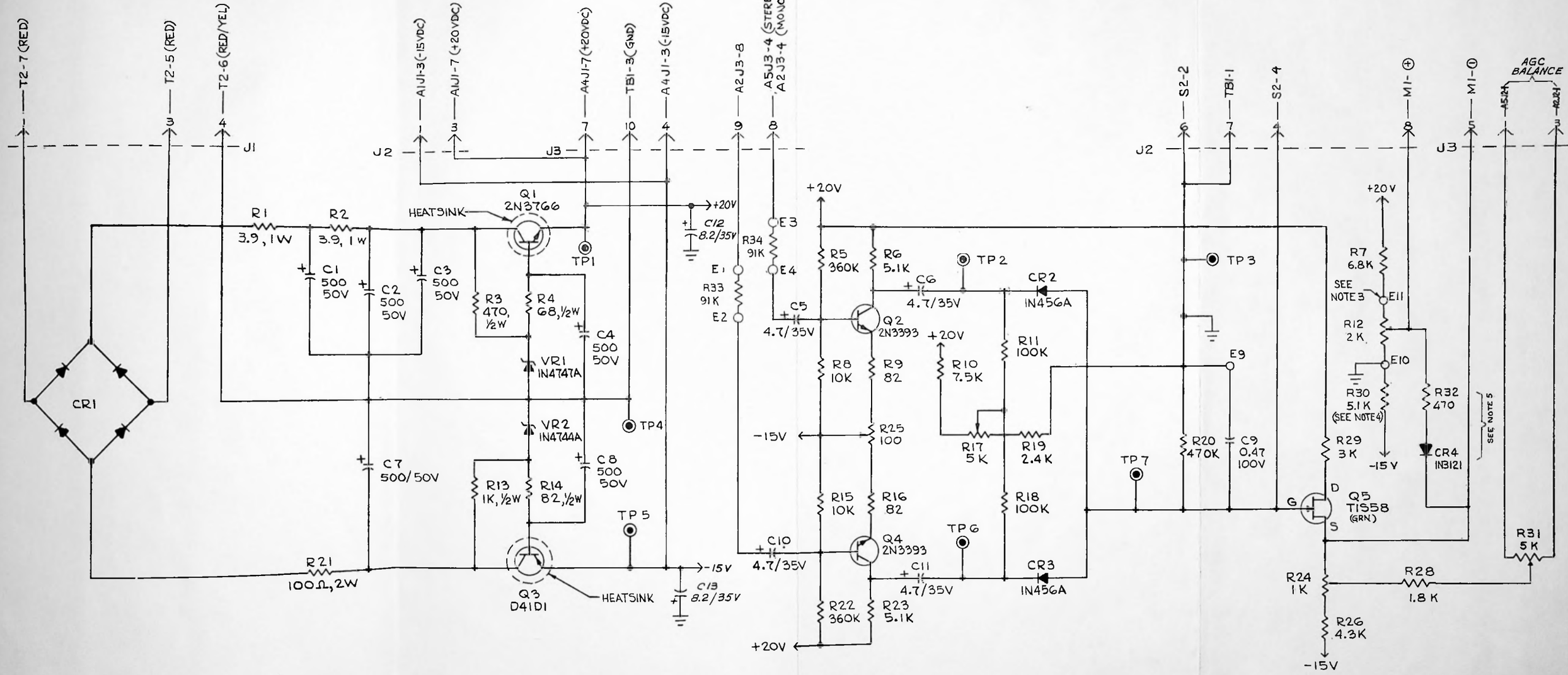
1. ALL RESISTOR VALUES ARE IN OHMS, POWER RATING 1/4 W, 5%
2. ALL CAPACITOR VALUES IN MICROFARADS
3. ALL TRANSISTORS ARE 2N3393
4. CR1 & CR2 ARE MATCHED DIODES
5. R50 AND R49 ARE REPLACED WITH BUS JUMPERS AND C11 AND C12 ARE NOT USED ON FM VOLUMAX 4100.
6. USE FOR MODEL 4100 ONLY.

Figure 7-3. Input-Output Board A2 or A5, Schematic and Parts Location Diagrams



NOTES:

1. REMOVE (CUT) FROM CONNECTORS J1, J2, & J3 RESPECTIVELY PIN Nº 2, 5 & 2 FOR POLARIZATION
2. TERMINATE BUS WIRE JUMPERS BETWEEN "E5","E6", & "E7","E8" AS SHOWN



NOTES:
(UNLESS OTHERWISE SPECIFIED)

1. ALL RESISTOR VALUES ARE IN OHMS, POWER RATING 1/4 W, 5%
2. ALL CAPACITOR VALUES IN MICROFARADS
3. E10 OR E11 MAY BE GROUNDED.
4. SELECT AT TEST.
5. R32 & CR4 ARE OPTIONAL, ONLY USED FOR METER COMPRESSION.

Figure 7-4. Power Supply-AGC Board A3, Schematic and Parts Location Diagrams