VOLUMAX
Model 4300
Automatic Peak Controller

OPERATING AND MAINTENANCE INSTRUCTIONS

OCTOBER 1974

PROFESSIONAL PRODUCTS
CBS LABORATORIES
A Division of CBS Inc.
Stamford, Connecticut 06905

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

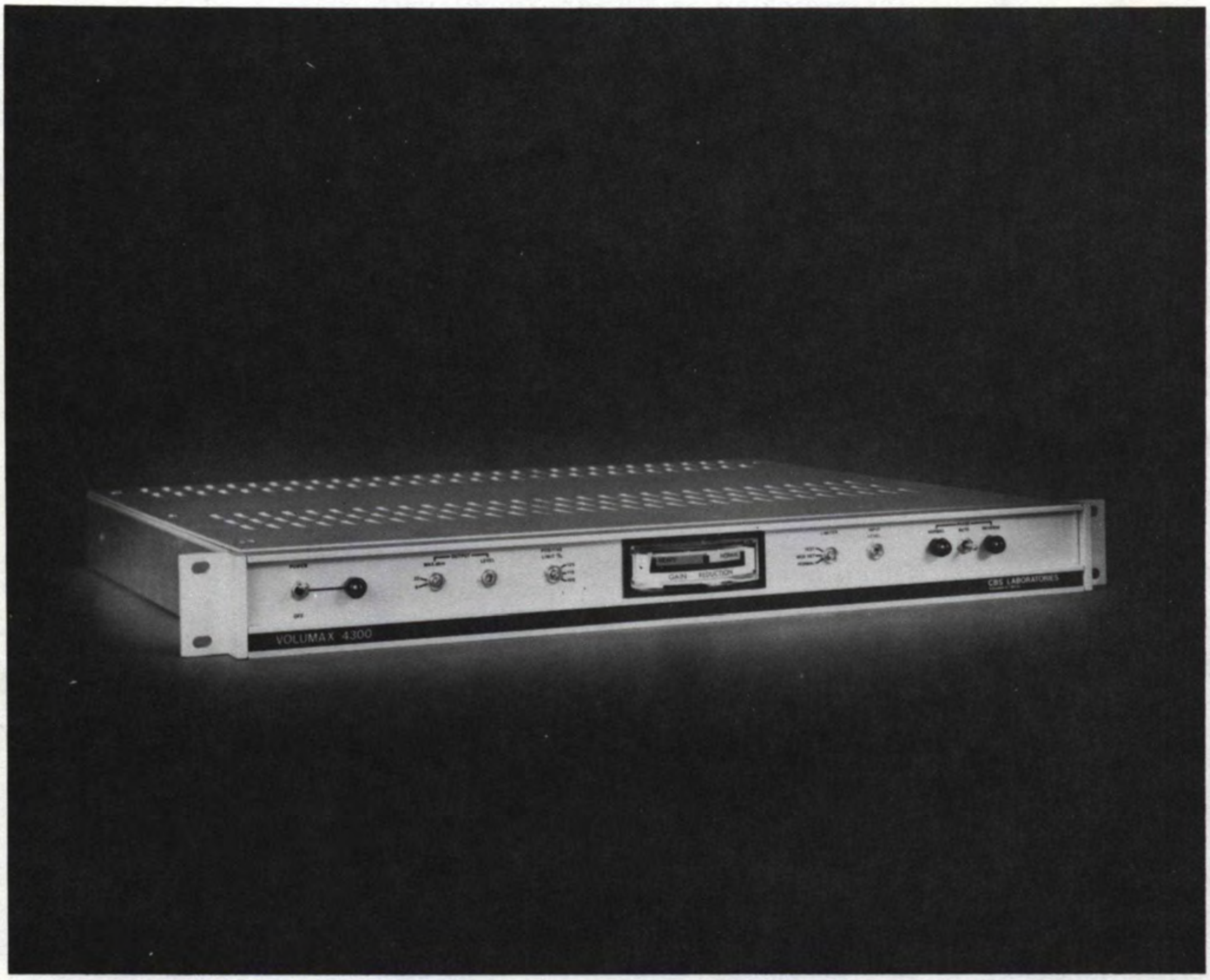


Figure 1-1. Volumax Model 4300

SECTION I

INTRODUCTION

1-1. GENERAL

This manual contains instructions for the CBS Laboratories Model 4300 Volumax[R] unit, a specialized professional audio peak limiter for AM broadcasters that prevents overmodulation while providing maximum program power in each watt of carrier power. When used in conjunction with an automatic level control such as the CBS Laboratories Audimax[R], it also guarantees program-power gains several times greater than those obtained by conventional methods. The present Volumax model combines the achievements of earlier Volumax models with higher standards of quality and fidelity. Among the improvements is an excellent signal-to-noise ratio of at least 70 db with respect to maximum output.

1-2. FUNCTIONAL DESCRIPTION

The Volumax unit combines a superior dual-action peak limiter with an automatic peak phaser to ensure that the higher amplitude peaks of a program wave always modulate the carrier in the positive direction and that negative peaks are precisely limited to 100 percent. The positive direction is used to obtain modulation levels up to 125 percent as allowed by the FCC. Audio is passed without modification when there are no instantaneous peaks that would cause overmodulation, but each such peak is silently limited as just described. No audible clicks occur when a Volumax function is performed.

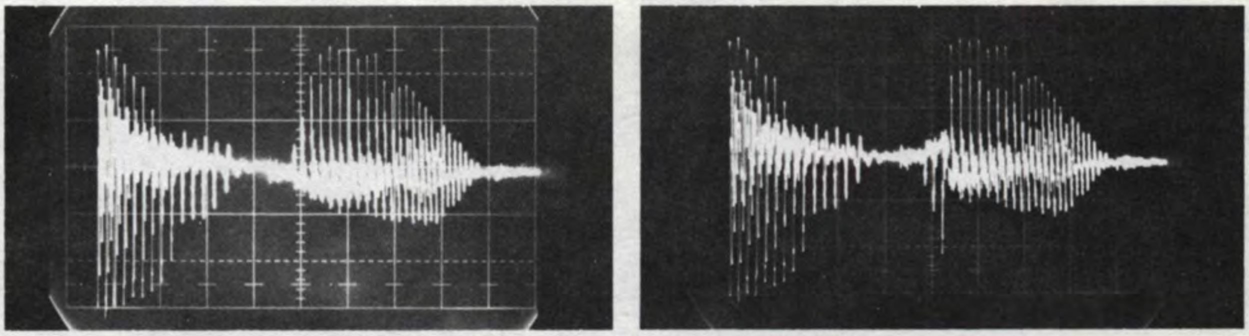
[R]Registered trade mark

Designed primarily for use with well controlled average input levels such as provided by Audimax, the Model 4300 Volumax unit supersedes all other peak limiters in the process of preventing carrier overmodulation.

A. Conventional Peak Limiters and Instantaneous Phase Switches

With conventional peak limiters, the broadcaster must either reduce the program level so much that the limiting of peaks is not severe enough to cause "pumping" -- thus lowering average modulating power -- or must tolerate the "pumping" and consequent distortion. Although conventional limiters moderate "pumping" by using long recovery times, the intervals immediately following high program peaks waste modulation capability; in these times, the limiter is insensitive while it recovers from reduced gain.

The Volumax unit may be regarded as an instantaneous phase-switch limiter. Limiters of this type may waste less power, but those other than Volumax introduce audible clicks whenever phase switching occurs. Volumax is silent, as shown in figure 1-2.



SILENT SWITCHING The two photographs above show the word "content" displayed on an oscilloscope. The photo on the left taken with the VOLUMAX in operation, shows clearly that phase switching took place during the momentary pause between syllables—completely and silently. The photo on the right using an instantaneous phase switch shows that the phase switching took place during the second syllable—and with an audible click.

Figure 1-2. Phase Switching, Comparison Waveforms absolute limits have a ratio of 1.15 positive to 1.00 negative. If the 125 percent position of the switch is chosen, the Volumax AGC amplifier increases this ratio to 1.25 to 1.00. Because of the FCC ruling which places the limit on positive modulation at 125 percent, the 125 percent position may be used without violation. (See Section III.)

CAUTION

The front-panel LIMITER switch should be kept in NORMAL position during regular broadcast operation.

1-3. PHYSICAL DESCRIPTION

Packaged in CBS Laboratories' slimline design, the Volumax unit requires only 1-3/4 inches of standard 19-inch rack height and only 15 inches of depth behind the front panel. The weight is 6.5 pounds. Its reliable solid-state circuitry is packaged on a printed circuit board with appropriate test points to speed maintenance tests and troubleshooting. Front panel controls are conveniently arranged, and those requiring infrequent use (e.g., INPUT LEVEL, OUTPUT LEVEL, AND OUTPUT MAX dbm) are screwdriver adjustments. 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 connected for 115-volt operation. Wiring changes for 230-volt operation are explained in paragraph 2-3.

The unit can be rack mounted simply by means of its panel mounting flanges (ears), but an optional chassis slide accessory kit is available (CBS Laboratories p/n 962163-4).

1-4. PRINCIPLES OF OPERATION

NOTE

For a complete circuit description, see Section IV of this manual.

The program input is fed to a differential amplifier allowing balanced or unbalanced inputs. An AGC amplifier with fast attack and moderately fast recovery times is then used to reduce the gain of the program signal on peaks as described in paragraph 1-2. This action in conjunction with microsecond-fast diode limiting ensures absolute control of the limit point.

Meanwhile, the input program signal also drives a polarity detector and a pause detector. These circuits sample the signal and determine from its asymmetry and level whether the phase of the signal needs to be reversed to allow the higher peaks to produce positive modulation of the carrier. They also determine <u>when</u> that change should occur. The actual phase reversal is accomplished by a clocked flip-flop -- an integrated circuit "borrowed" from the computer industry. This flip-flop determines whether the program signal will pass through an inverting or non-inverting path in the Volumax unit.

The operation of the automatic peak phasing circuit is predicated on the fact that most speech waves are asymmetric; in other words, that the amplitude of one side may be as much as 10 dB above the other. The Volumax unit can sense asymmetry factors as low as 3 dB and turn them into useful positive supermodulation.

The **OUTPUT LEVEL** control on the front panel of the unit provides a wide range of adjustment of modulation level. This control is a 600-ohm* variable H-pad attenuator. In conjunction with an adjacent, switchable, 16-db attenuator labelled **OUTPUT MAX** dbm, the **OUTPUT LEVEL** control can be set anywhere in a 0-to-20 dB range with maximum output at 6 or 22 dBm.

1-5. WARRANTY

A warranty with a return postcard is included with your Volumax unit. Fill out the postcard and return it to CBS Laboratories as soon as possible to validate your warranty.

1-6. FACTORY SERVICE AND REPAIR

If you should experience difficulty in installing, operating, or repairing your Volumax unit, please contact your distributor for assistance. If necessary, call CBS Laboratories, Professional Products Department, Stamford, Connecticut (Area Code 203, 327-2000).

1-7. SPECIFICATIONS

Input and output impedance	600 ohms, balanced or unbalanced; 150 ohms on special order
Input level	-24 to +18 dBm
Maximum output	22 dBm

* 150 ohms in units manufactured for the 150-ohm output impedance option. (See Volumax specifications in paragraph 1-7.)

Positive peak limiting	100%, 115% or 125%* of negative peaks
Maximum gain	50 dB
Signal to noise ratio	70 dB with respect to maximum output level at normal gain
Frequency response	±0.5 dB, 50-15,000 Hz
Harmonic distortion	Less than 1%, 50-15,000 Hz
Attack time	Less than 1 microsecond or 2 milliseconds, depending on program waveform
Recovery time	250 milliseconds
Maximum operating temperature	55^{o}C (130^{o}F)
Power requirements	105-130 vac, 50-60 Hz, 20 watts (210-250 vac, 50-60 Hz optional)
Physical dimensions	Standard 19 inches wide x 1-3/4 inches high x 14-1/2 inches deep
Weight	6.5 lb.
Optional equipment	Chassis slide accessory kit 962163-4

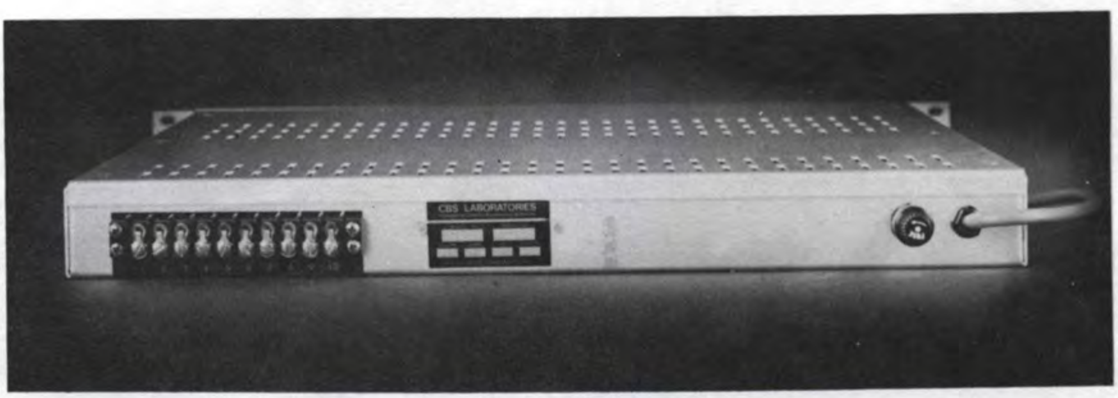


Figure 1-3. Volumax 4300 Rear View

* For 125 percent operation, it may be necessary to trim the 125 percent peak limiter. See Section III.

SECTION II

INSTALLATION

2-1. UNPACKING

Carefully unpack your Volumax unit and examine it for evidence of physical damage that may have occurred in transit. If the unit is damaged, file a claim immediately with the shipping carrier and notify CBS Laboratories. Should future transportation of the unit be anticipated, save the shipping carton for re-use.

2-2. PHYSICAL INSTALLATION

The Volumax unit is designed to be mounted in a standard 19-inch-wide electronic equipment rack. It requires 1-3/4 inches of space for the panel height and is 15 inches deep behind the front panel. See figure 2-1. Sheet 2 of this illustration provides instructions for mounting with the optional chassis slides. As for all transistorized equipment, the unit must be installed in a reasonably well-ventilated position with no high-heat producing equipment beneath it.

CAUTION

Ambient temperature should not exceed 130°F.

Figure 2-2 is the block diagram of a recommended installation. The Volumax unit is normally installed at the transmitter site immediately preceeding the transmitter audio input terminals. However, it may be installed at the studio, ahead of the program line to the transmitter, when the phase-amplitude characteristic between studio and transmitter are known to be uniform under all climatic conditions and service conditions such as telephone-

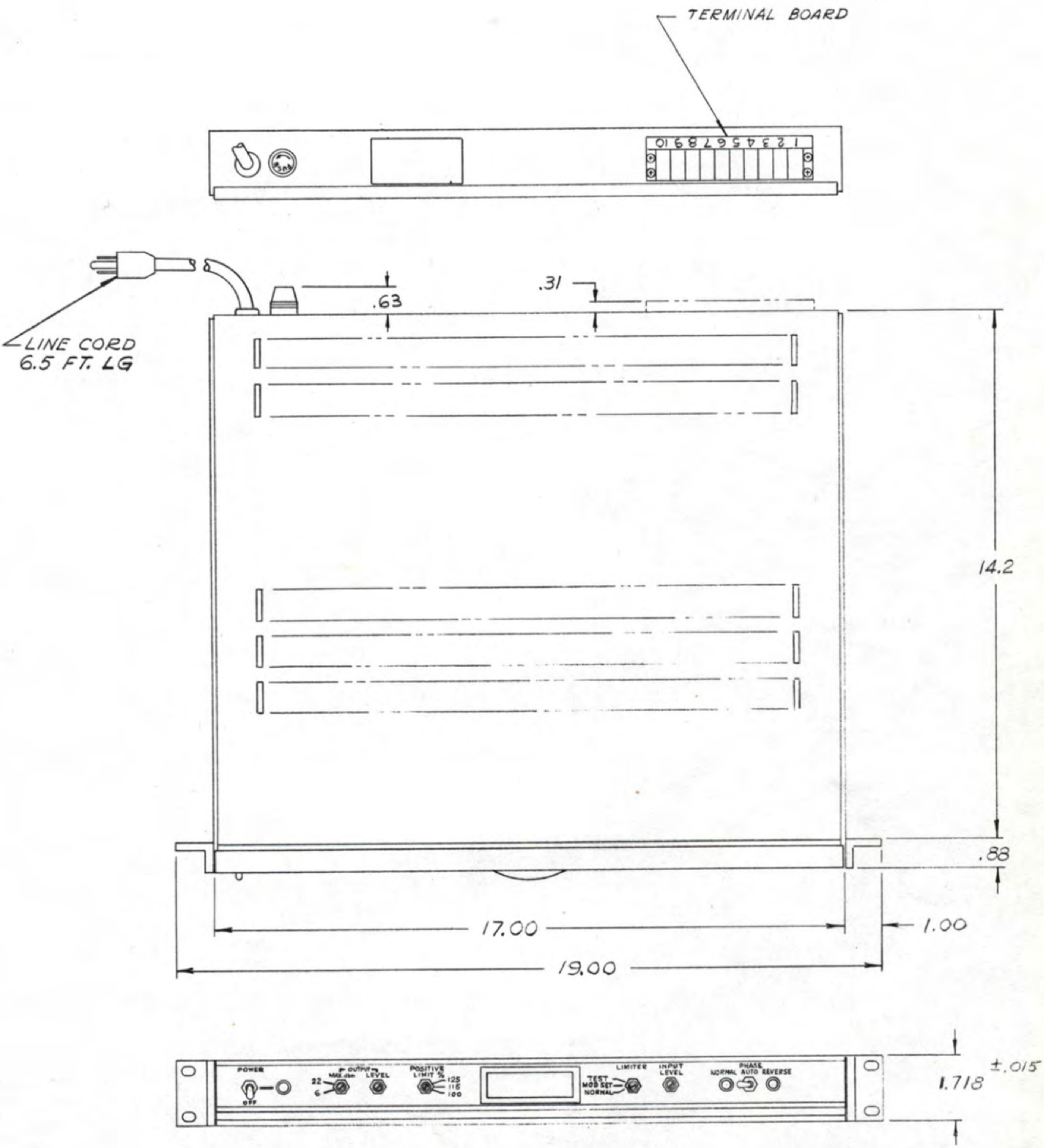


Figure 2-1. Volumax Model 4300, Installation Drawings (Sheet 1 of 2 Sheets)

SLIDE INSTALLATION

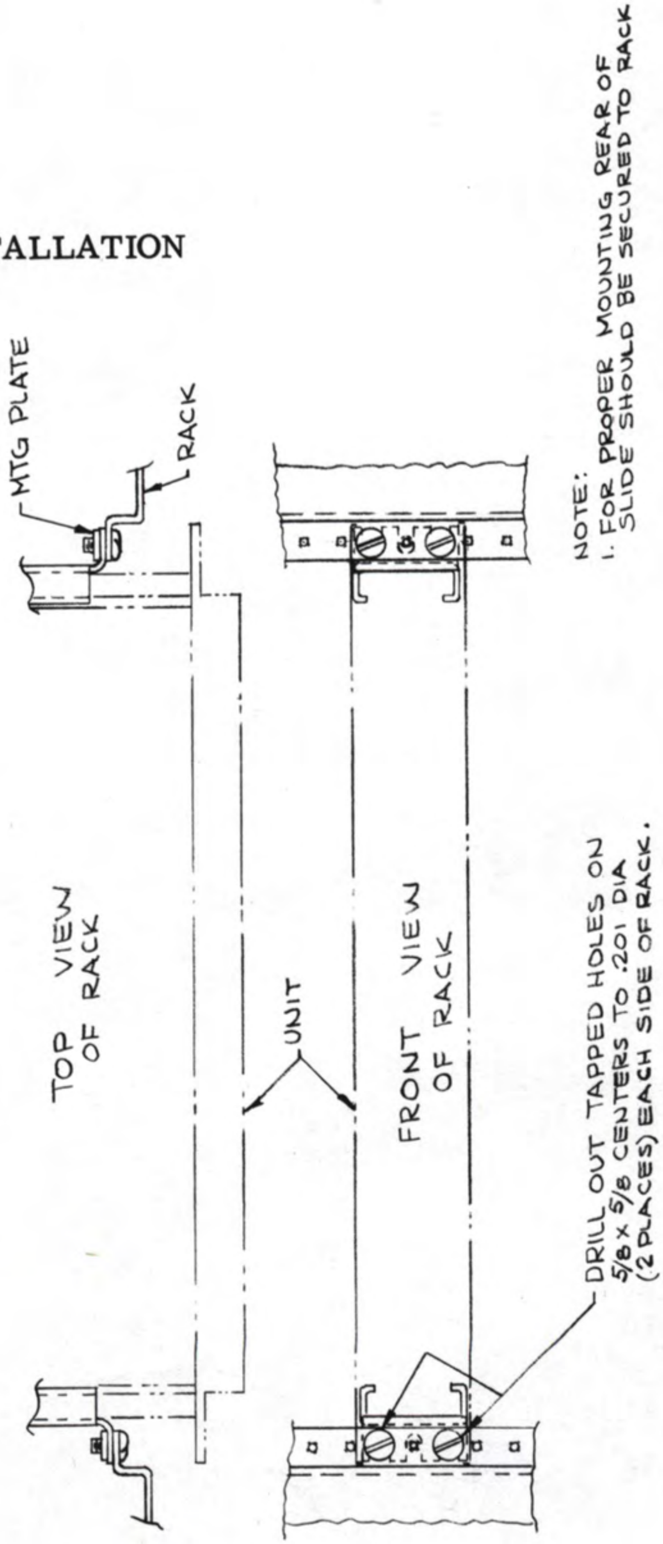


Figure 2-1. Volumax Model 4300, Installation Drawings (Sheet 2 of 2 Sheets)

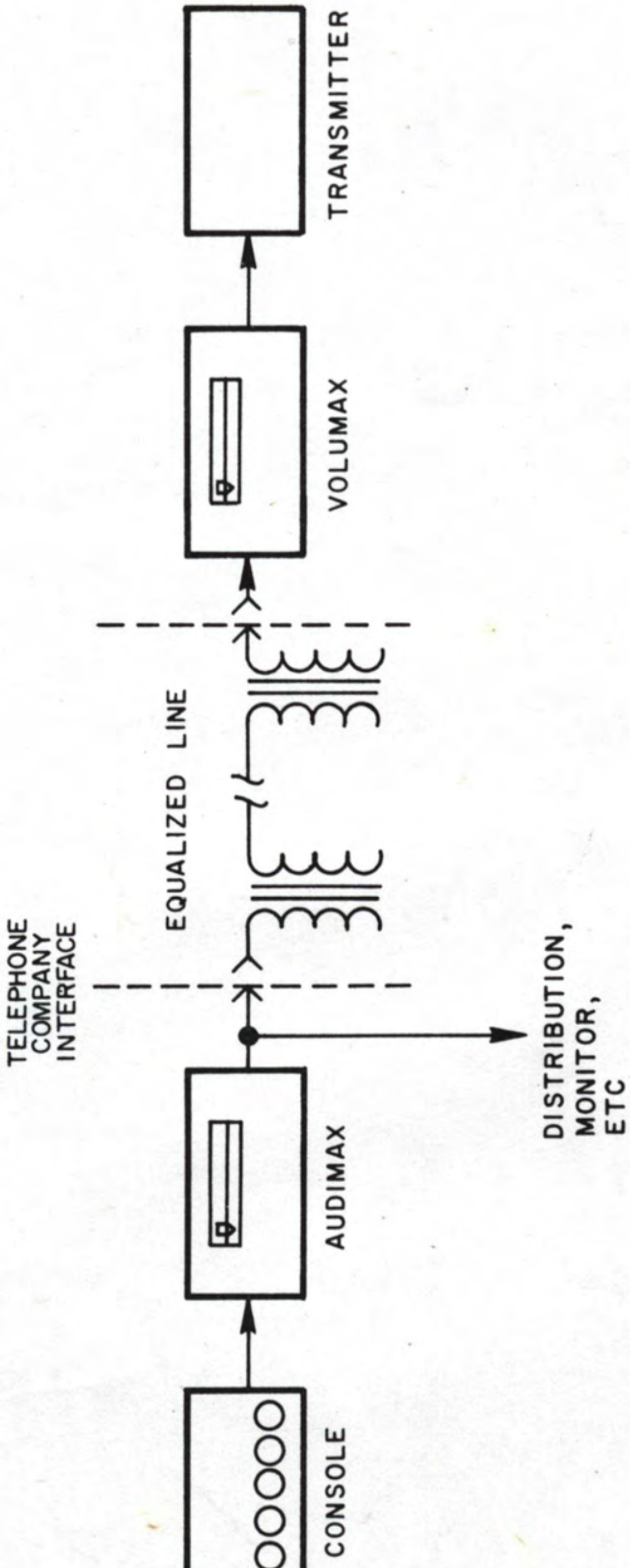


Figure 2-2. Typical Volumax Installation Block Diagram

company changes of equipment. This is particularly important for maximum utilization of the effects of the Volumax automatic peak phasing.

It should be remembered that the Volumax equipment is designed for peak protection and that it should not be used for "gain riding" on a program line. Its use is predicated on uniform average VU input levels. Therefore, the use of an automatic level control such as the CBS Laboratories Audimax unit is highly recommended. Since phase-scrambling devices tend to defeat the purpose of automatic peak phasing, such devices are not recommended.

The Volumax unit has sufficient gain to correct for long-line and equalizer losses incurred when the transmitter is remotely located.

Input levels as low as -24 dBm can be accommodated. If the input level exceeds +18 dBm, the range of the input level control will not be sufficient; in such case, a fixed pad should be used in the line to the Volumax unit.

2-3. POWER SOURCE

The Volumax unit is equipped with a three-wire power cord and a power transformer permitting either 115 vac or 230 vac operation. In either case, be sure the green wire in the power cord will connect to service box ground. As delivered, the unit is wired for 115 vac operation. If 230 vac operation is desired, make the following modifications at the terminal strip TB1 at the inside rear of the unit, next to the power transformer T2.

A. Remove the white/brown lead of the transformer T2 from terminal 3 of TB1 (figure 7-1). Leave the brown lead of T2 connected to terminal 3.

B. Remove the black lead of T2 from terminal 4 of TB1. Leave the white/black lead of T2 connected to terminal 4.

C. Connect the white/brown and black leads of T2 to TB1-1. This connects the two primary windings of T2 in series as required for a 230 vac input.

D. Replace the original fuse F1 with a type 3AG-0.15 amp (SLO-BLO) fuse.

2-4. ELECTRICAL CONNECTIONS

Connect the audio input and output leads to the barriered terminal strip on the rear panel of the Volumax unit. Use terminals 1 and 2 for the input and terminals 4 and 5 for the output. Terminal 3 is a chassis ground. Terminals 6 through 10 are not used. The phasing of the connections is such that if the side of the input line with the higher peaks is connected to terminal 1, the automatic peak phaser in the Volumax unit will seek its "normal" phase state. Therefore, be sure to connect output terminal 4 to the transmitter in the phase arrangement that will positively modulate the carrier. If unsure of the phase of either the audio feed or the transmitter input, see the setup procedures in Section III of this manual. Either balanced or unbalanced lines may be used.

Temporarily set the OUTPUT MAX dbm switch on the front panel in the 6 position. Then connect the power cord to the power source (paragraph 2-3). The unit is now ready for operation. (Place OUTPUT MAX dbm in the 22 position only when this is known to be the appropriate setting. See Section III.)

SECTION III

OPERATIONAL SET-UP PROCEDURES

3-1. GENERAL

The Volumax 4300 may be used with a wide variety of a-m transmitters differing in reactions to supermodulation control. Hence, the capabilities and limitations of the transmitter of concern must be considered when adjusting the Volumax unit for use, particularly in the selection of the 115 or 125 (positive modulation percent) position of the front-panel **POSITIVE LIMIT %** switch.

Within the transmitter, the power supply for the final amplifier (and modulator, as well, where plate modulation is used) should have a reserve capability if supermodulation is to be obtained without excessive carrier shift or other undesirable effects. Though some transmitters are marginally designed, with little or no reserve current capability, most modern a-m transmitters have enough power-supply reserve for an appreciable amount of supermodulation. All operating a-m broadcast transmitters, of course, have enough power-supply capability for 100 percent positive and negative modulation.

If 125 percent positive modulation would be both desirable and satisfactory, the modulation obtained for the 125 position of the **POSITIVE LIMIT %** switch should be measured in the initial tests of the Volumax unit (paragraphs 3-2 through 3-5). If the positive modulation measured in these tests is more or less than 125 percent, see paragraph 3-7 at the end of this section for a corrective measure.

In the operation of the Volumax unit, remember that musical programming has little or no asymmetry while speech can have an asymmetric peak factor as great as 10 dB -- depending on the particular voice and the nature and the amount of electrical processing which its analog signal undergoes. Therefore, the most dramatic increases in positive modulation should be expected to occur during live speech programming. As delivered, the Volumax 4300 can sense an asymmetry factor as low as 3.0 dB and make the decision to change phase when desirable. The correct moment for the reversal, as determined by an internal pause detector circuit, is the next 120-millisecond or longer program amplitude drop of more than 16 dB.

3-2. INPUT AND OUTPUT PHASING

Terminal 4 on the barriered terminal strip (figure 2-1) should be connected to a point in the system where the Volumax output will cause positive modulation of the transmitter carrier. This can be tested in the following manner:

A) Turn power on and select the 6 or 22 position of the OUTPUT MAX dbm switch as appropriate for a maximum Volumax output of 6 or 22 dBm, respectively. See figure 3-1. See also paragraph 3-3. Then turn the OUTPUT LEVEL control (figure 3-1) fully counterclockwise.

B) Set the POSITIVE LIMIT % switch at 125 (percent)

C) Use a 1 kHz sine-wave input signal to deflect the reading on the front-panel GAIN REDUCTION meter to the red-green (HEAVY - NORMAL) junction.

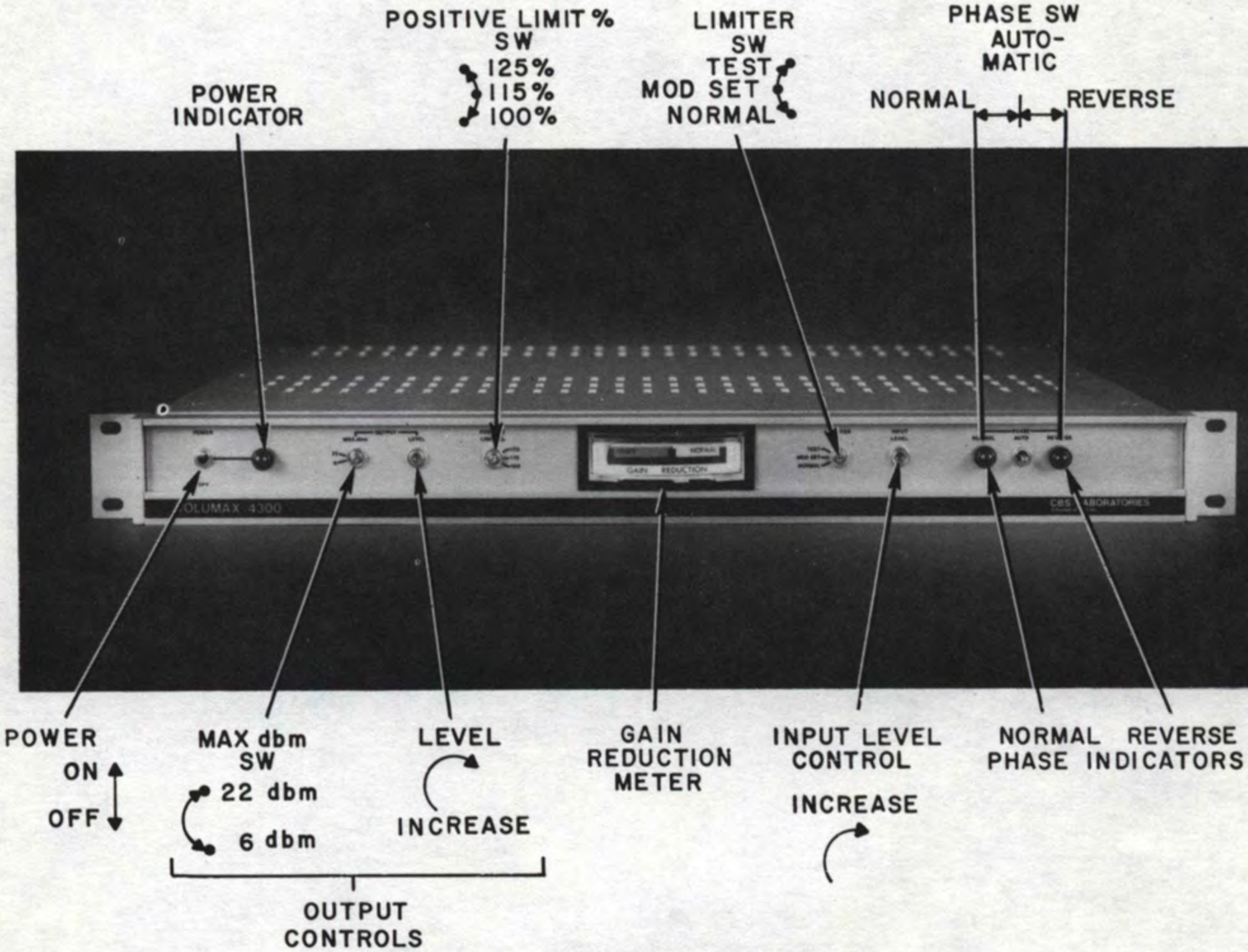


Figure 3-1. Volumax Model 4300 Front Panel Controls

D) Set the **PHASE** switch in **NORMAL** position. (Push toggle toward **NORMAL** indicator on front panel.)

E) Place the **LIMITER** switch in the **MOD SET** position and observe the Volumax output on an oscilloscope. An asymmetrically clipped sine wave should be present.

F) Increase the **OUTPUT LEVEL** of the Volumax unit as necessary to produce approximately 100 percent negative modulation.

G) Observe the modulated r-f envelope on an oscilloscope.

H) Figure 3-2 shows a correctly phased waveform. If a waveform as in figure 3-3 is obtained, reverse the output leads to obtain the waveform in figure 3-2.

I) Set the **POSITIVE LIMIT** switch in the appropriate position as previously discussed in paragraph 3-1.

Correct input phasing can be verified once the Volumax unit is in operation. While the unit will always select the proper phase for the output, it may be desirable for the phase to be in the **NORMAL** state when using the main announcing microphone or playback device. Thus, if the Volumax unit consistently selects the **REVERSE** phase when speech is originating at the main announcing position, reverse the <u>input</u> connections. Similarly, each auxiliary microphone or other in-house program source can be correctly phased at its input to the console.

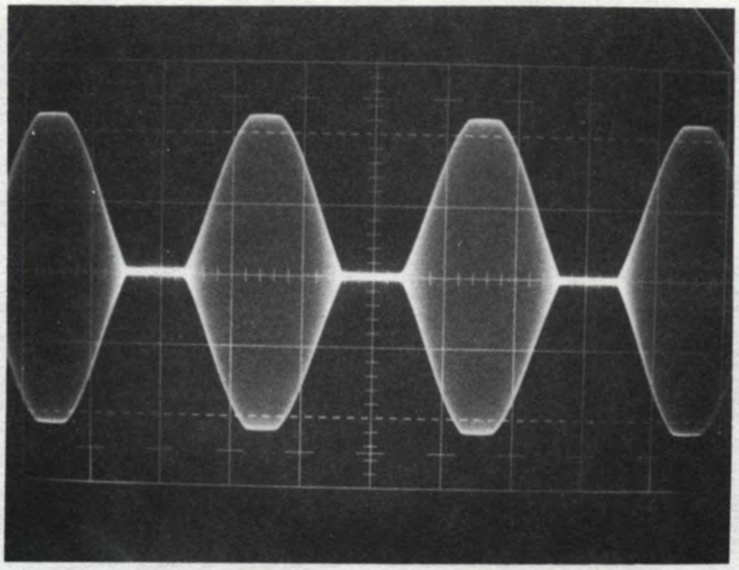


Figure 3-2. Correctly Phased Modulated R-F Envelope

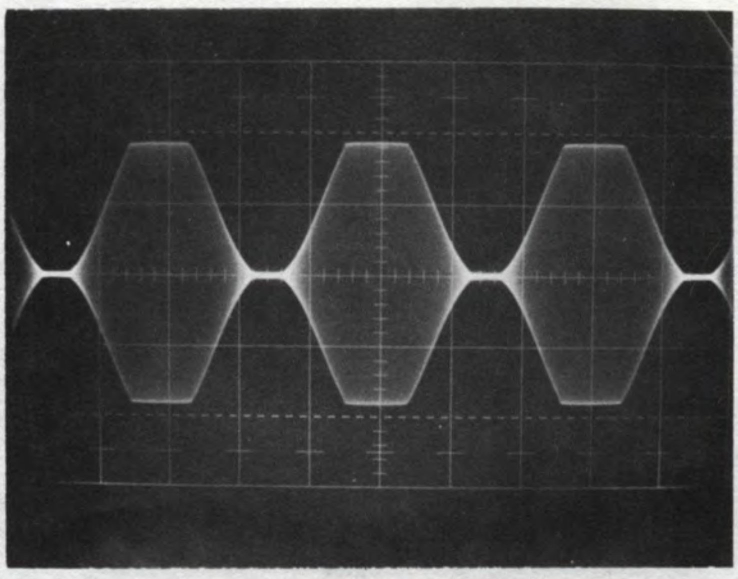


Figure 3-3. Incorrectly Phased Modulated R-F Envelope

3-3. ADJUSTMENT FOR MAXIMUM MODULATION

A) Turn the OUTPUT LEVEL control (figure 3-1) fully counterclockwise. Then turn the OUTPUT MAX dbm switch to the 6 position.

B) Use a 1 kHz input signal to deflect the meter reading to the red-green junction.

C) Place the LIMITER switch in the MOD SET position; then turn the OUTPUT LEVEL control clockwise as far as necessary to produce the maximum desired modulation. (If greater output level is needed, repeat this procedure with the OUTPUT MAX dbm switch in the 22 position.) If the r-f envelope is being observed on an oscilloscope, its appearance should be similar to the waveform in figure 3-4.

D) Return the LIMITER switch to the NORMAL position and apply a normal level-controlled program input to the Volumax unit.

E) Adjust the Volumax INPUT LEVEL control as required to cause the GAIN REDUCTION meter to indicate in the NORMAL area with occasional peaks deflecting into the HEAVY region.

The foregoing squared-tone method can be used to set the Volumax output level precisely; however, it should be recognized that phase shifts in

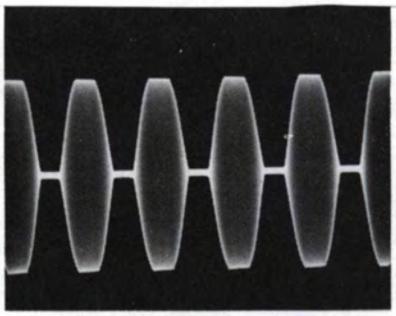


Figure 3-4. Squared Tone Modulation (95 Percent)

transmitting equipment may cause previously limited program peaks to exceed the 100 percent level. A slight readjustment of the output level may therefore be necessary if the modulation appears to be excessive.

3-4. ALTERNATE METHOD OF PHASING AND SETTING MODULATION LEVEL

If it is not practical to adjust the Volumax unit by means of the sine-wave method (paragraphs 3-2 and 3-3), the following procedure may be used:

A) Apply normal level-controlled program input to the Volumax unit.

B) Adjust the INPUT LEVEL control (figure 3-1) as necessary to cause the GAIN REDUCTION meter to operate in NORMAL area with occasional peaks deflecting into the HEAVY region.

C) Set the POSITIVE LIMIT % switch at 125 (percent).

D) Place the PHASE switch in the NORMAL position. (Push toggle toward NORMAL indicator lamp.)

E) Adjust the OUTPUT LEVEL and OUTPUT MAX dbm controls as required to produce 50 to 60 percent modulation as indicated on the modulation monitor. Do not set for maximum modulation at this time.

F) Connect an oscilloscope as required to produce a trapezoidal modulation pattern.

G) Observe the pattern closely, preferably while using speech modulation. The oscilloscope pattern should be slightly longer in the direction of positive modulation, as illustrated in figure 3-5, if the Volumax output phasing to the transmitter is correct. If the trapezoidal pattern is longer on the left side, as in figure 3-6, reverse the output connections.

H) Once the correct output phasing has been determined, input phasing can be corrected as described in paragraph 3-2.

I) Now set the POSITIVE LIMIT switch in the appropriate position. (See paragraph 3-1.) Then, while observing the trapezoidal modulation pattern, adjust the OUTPUT LEVEL and OUTPUT MAX dbm controls as required for approximately the desired negative modulation.

Though 99.9 percent negative modulation is theoretically possible using the foregoing method, in practice there usually are phase shifts in transmitting equipment causing previously limited peaks to exceed 100 percent.

3-5. HEADROOM CONSIDERATIONS

The proper operation of the automatic peak phasing (A. P. P.) circuit in the Volumax unit depends upon an input signal relatively free of distortion caused by clipping. If the signal being applied to the Volumax unit has a considerable amount of clipped waveform content, erratic and/or overly frequent phase reversals will occur in the A. P. P. circuit.

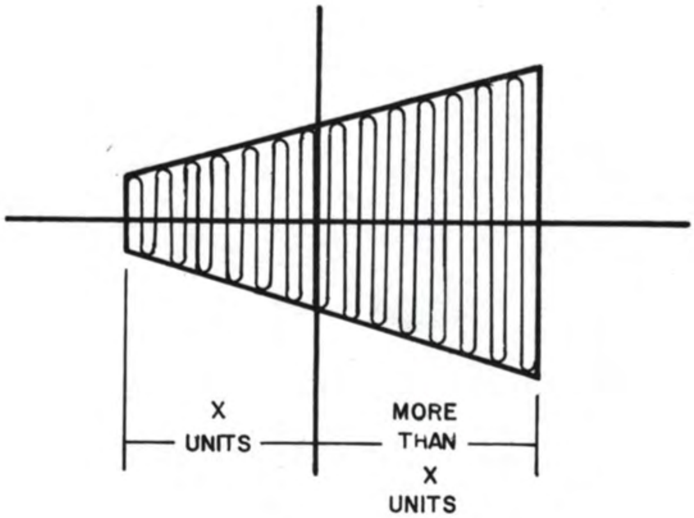


Figure 3-5. Correctly Phased Modulated R-F Envelope (as Indicated by a Trapezoidal Pattern)

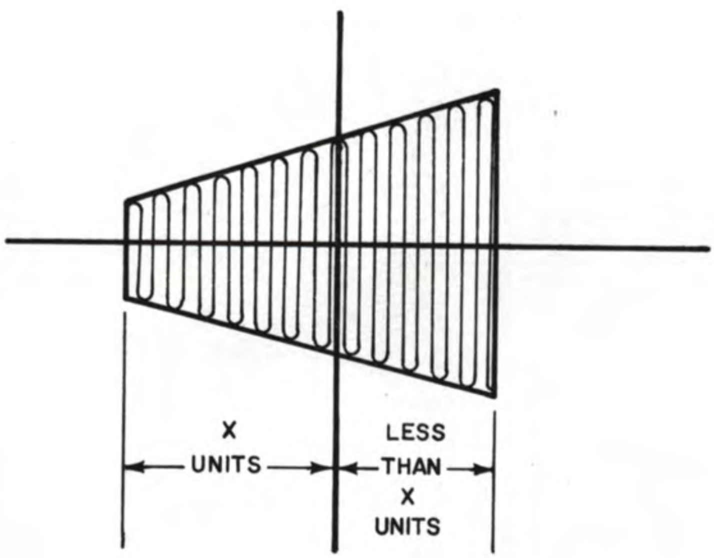


Figure 3-6. Incorrectly Phased Modulated R-F Envelope (as Indicated by a Trapezoidal Pattern)

Even though the audio equipment preceding the Volumax unit may be free of distortion when testing while using a sine wave, the natural asymmetry and high peak factor of some program material may drive one or more audio stages into saturation, thereby clipping the signal. This can be prevented by operating each stage in the audio chain at less than its maximum sine-wave capability, using margins as great as 10 dB. For example, if a program amplifier is capable of only +24 VU output with acceptable distortion, it is probably best to operate it at +14 VU during actual programming.

The most common sources of clipping caused by lack of headroom are program amplifiers in consoles, telephone line amplifiers, overdriven compressors, and overdriven microphone preamplifiers. To eliminate this trouble, repair the offending amplifier if it is defective or decrease the level of the input to the amplifier (using fixed pads where necessary) until the clipping is eliminated. Clipping caused by lack of headroom is most easily observed with an oscilloscope connected to the input terminals of the Volumax unit. Once clipping is identified, its source can be traced by reducing the input to each device in the audio chain, in reverse order from the Volumax end, until the clipping disappears.

3-6. PROOF-OF-PERFORMANCE MEASUREMENTS

FCC rules stipulate that proof-of-performance tests be made "without compression."

The compression action of Volumax can be disabled by placing the LIMITER switch (figure 3-1) in the TEST position. When this is done, however, the amplifier section of the Volumax unit must not be driven at levels significantly higher than in normal operation. Proceed as follows:

First, with the LIMITER switch in the NORMAL position, apply a 1 kHz input signal to the Volumax unit at reference level or full-scale VU from your console. Disable any other gain-control devices in the program line. Turn the INPUT LEVEL control counterclockwise until the GAIN REDUCTION meter reading just reaches full scale to the right. Then adjust the output level controls until normal modulation levels are reached again. Now place the LIMITER switch in the TEST position. The Volumax unit now acts as a flat amplifier, and this procedure assures that you will not overload it. After completing the FCC measurements, be sure to reset the INPUT LEVEL and OUTPUT controls and return the LIMITER switch to the NORMAL position.

3-7. INTERNAL TRIMMING OF OUTPUT LEVEL

Due to necessary tolerances in the electrical values of component parts, the ratio of positive to negative peaks may vary a few percent (± 4 percent maximum). Therefore, provisions have been made to enable the user to trim out the net component error, if desired, when the Volumax unit has been installed and tested.

A. If Positive Modulation Exceeds 125 Percent

If, after installation, the positive modulation measurement exceeds 125 percent, trim the output level as follows.

(1) Remove the jumper from terminals E3 and E4 on the printed circuit board.

(2) Connect a 1N914 or equivalent diode between E3 and E4. Connect the cathode of the diode (-) to E3 and the anode of the diode (+) to E4.

B. If Positive Modulation for 125 Position of POSITIVE LIMIT % Switch is Less Than 125 Percent

If, after installation, the positive modulation for the 125 position of the POSITIVE LIMIT % switch is less than 125 percent, the user may proceed as in A above but should remove the jumper between E1 and E2 and connect the cathode of the diode (-) to E2 and the anode (+) to E1.

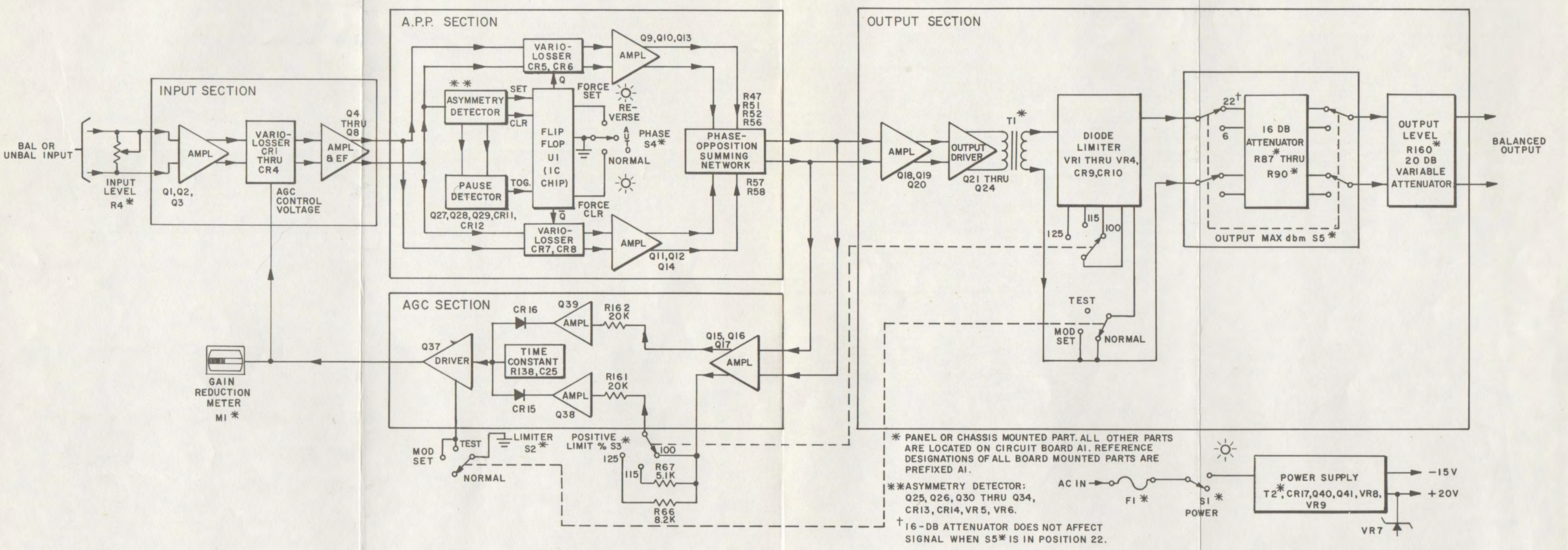


Figure 4-1. Volumax Model 4300 Block Diagram

SECTION IV

THEORY OF OPERATION

4-1. BLOCK DIAGRAM AND SCHEMATIC

As shown in the block diagram, figure 4-1, most of the Volumax circuitry is located on the printed circuit board A1. This includes the power supply components except for the power transformer which is mounted on the chassis. Important signal components include the front panel controls and meter and the audio output transformer which is mounted on the chassis.

For the complete schematic diagram see figure 7-1. For parts locations, see figures 5-1 and 7-2. Figure 7-2 is a parts layout diagram of the circuit board. Refer to both figures 4-1 and 7-1 in conjunction with the discussions in this theory section.

4-2. INPUT/OUTPUT CIRCUITRY AND AGC ACTION

Transistor stages A1Q1 through A1Q8 and A1Q18 through A1Q24 on the circuit board comprise a high quality balanced-input audio amplifier whose gain is a function of several major variables. First, the Variolosser formed by A1CR1 through A1CR4 is the AGC control element that varies the gain of the amplifier by acting as a variable shunt impedance across the audio path. Here the loss is a function of the adjustable voltage received from A1Q37 in the AGC feedback amplifier. Also, the OUTPUT MAX dbm switch S5 and the OUTPUT LEVEL control R160 on the front panel, and an internal diode limiter act as steady-state controls of the gain to determine the output level. The MAX dbm switch affords two steps of gain range with 16 dB separation. The OUTPUT LEVEL control provides 20 dB of continuous control range with respect to either position of the MAX dbm switch. The diode limiter limits high peaks.

As shown in the block diagram, the amplifier is divided into input and output sections with intervening limiter processing stages. Transistors A1Q1 through A1Q8 and the Variolosser comprise the input section. Transistors A1Q18 through A1Q24, the output transformer T1, a diode limiter, and the gain controls comprise the output section.

The input signal is applied through a shunt type INPUT LEVEL control, R4, on the front panel. The first stage of gain is provided by A1Q1 and A1Q2, which act with A1Q3 as a differential amplifier. The latter transistor is a constant-current source of bias for this stage. Common mode signals, such as line noise and induced transients, are effectively suppressed by the high common-mode rejection ratio (CMRR) of the differential circuit. This differential stage provides the drive for the balanced Variolosser previously discussed.

The Variolosser is followed by another differential amplifier A1Q4, A1Q5, and A1Q6 which has a similar CMRR and is used to provide gain while also rejecting common-mode d-c thump from the Variolosser action. Potentiometer A1R18 is used to balance the Variolosser/differential-amplifier system for minimum thump.

The input section is completed with a balanced emitter-follower, A1Q7 and A1Q8, which is used to achieve a low driving-point impedance for the succeeding A. P. P. circuitry.

The output section contains a high quality balanced push-pull output amplifier -- A1Q21, A1Q23 and A1Q22, A1Q24 -- which drive the output transformer T1. This amplifier is driven by the differential amplifier consisting of A1Q18, A1Q19, and A1Q20, which is used to provide gain. Potentiometer A1R81 is used to balance the output stage for minimum harmonic distortion.

The circuit functions of T1 and the OUTPUT MAX dbm and OUTPUT LEVEL controls are apparent in the schematic, figure 7-1. The diode limiter A1VR1 through A1VR4 and A1CR9 and A1CR10 provides appropriately different peak limiting levels for various combinations of front-panel POSITIVE LIMIT and LIMITER switch positions (S2 and S3). Here the limiting insures that transients as short as 1 microsecond cannot pass through the Volumax unit to overmodulate the carrier.

4-3. AGC AMPLIFIER

The AGC amplifier consists of transistor stages A1Q38, A1Q39 and the field effect transistor (FET) A1Q37. The first two of these transistors drive respective rectifiers A1CR15 and A1CR16 and thus develop dc voltages across the capacitor A1C25. These voltages are proportional to the signals presented at the bases of A1Q38 and A1Q39. Since the rectifier drivers are referenced to ground, each amplifies one side of the balanced input with respect to ground, allowing discrimination between opposite-phase ("positive" and "negative") peaks. When the front-panel POSITIVE LIMIT switch is in the 100 percent position, equal signals are applied to A1Q38 and A1Q39 through 20 kilohm resistors; thus, the composite control voltage developed at the gate of A1Q37 is equally proportional to waveform excursions in both directions. If S3 is placed in the 115 percent position, the "positive" peak rectifier is slightly de-sensitized by the insertion of a 5.1 kilohm series resistor A1R67 in addition to the 20 kilohm resistor used with A1Q38. Then the composite control voltage at the gate of A1Q37 becomes principally a function of negative peaks; positive peaks must be 15 percent higher to affect AGC action. Finally, in the 125 percent position, much more AGC control voltage is derived from negative peaks, as the resistance in the line to the "positive" rectifier driver is then increased to 20 + 8.2 kilohms by the insertion of A1R66.

The FET A1Q37 is connected as a source follower and provides a low-impedance drive for the AGC Variolosser A1CR1 through A1CR4, and the front-panel GAIN REDUCTION meter circuit. The capacitor A1C25 and resistor A1R138 between the gate of A1Q37 and ground determine the time constant of the AGC action. The FET gate is connected directly to ground, thus disabling all AGC, by the LIMITER switch S2 when placed in its MOD SET or TEST position. (For the TEST position, another section of S2 disables the diode limiter in the output circuits. See secondary side of T1 in figure 7-1.)

4-4. AUTOMATIC PEAK PHASING (A. P. P.) CIRCUIT

The A. P. P. circuit consists of all signal transistor stages not previously discussed. The purpose of this circuit is to examine program material for asymmetry, and, if the degree of asymmetry exceeds a preset threshold, to control the signal polarity such that the higher-amplitude peaks are always in the same direction.

A. Automatic Phase Reversal Decision (Asymmetry Detector)

The Volumax decision of whether or not to reverse the phase is made as follows.

The emitter-follower transistors A1Q25 and A1Q26 drive two diode rectifiers, A1CR13 and A1CR14. Since each diode is referenced to ground, the voltages developed across A1C22 and A1C23 are directly proportional to the amplitude of the program wave on each side of the balanced line with respect to ground. Thus, a sine wave would develop equal voltages at the bases of A1Q30 and A1Q31 (the main elements of another differential amplifier), but an asymmetric wave will develop unequal voltages. Because of the high common-mode rejection ratio of this stage, the balanced outputs from the collectors are essentially only functions of the asymmetry of the input: a "positively" asymmetric wave drives the collector of A1Q31 to a more positive voltage and a "negatively" asymmetric wave drives the collector of A1Q30 to a more positive voltage. Symmetric or nearly symmetric program material does not disturb the balance or alter the values of the quiescent voltages on the two collectors.

As an easy scheme of varying the sensitivity of this asymmetry detector, the collector outputs of A1Q30 and A1Q31 are passed through the 12v zener diodes A1VR5 and A1VR6. These diodes set a threshold which the differential output of A1Q30 and A1Q31 must exceed to provide any drive for the next stage. The collector voltages of A1Q30 and A1Q31 are determined by the respective collector currents, which are, in turn, determined by the constant current source A1Q32. The potentiometer A1R120 can be used to vary the combined collector current between about 0.37 and 0.26 ma, this current being equally split by the potentiometer A1R117 in the path to the two emitters. Hence, the collector voltages can be varied from about +12.7 volts down to +10 volts. Potentiometer A1R117 is used to compensate for small variations in the components of the circuit. Thus, for various settings of A1R120, the collector voltages of A1Q30 and A1Q31 are varied in a range near the zener breakdown potential. The closer the collector voltages approach the breakdown potential, the more sensitive the asymmetry detection action becomes, as the signal threshold level is much closer.

B. Clocked Flip Flop

The two outputs from A1VR5 and A1VR6 drive a pair of emitter followers A1Q33 and A1Q34. These stages are low-impedance logic drivers for the clocked flip flop A1U1. Capacitors A1C37 and A1C38 serve as short-term memories of recent asymmetric peaks. Actually, A1U1, an integrated circuit, is a pair of flip-flops connected as master and slave with a toggle-inhibit gate. The outputs Q and $\overline{Q}$ at pins 6 and 9 can be either manually or automatically controlled. If the front panel PHASE switch S4 is in NORMAL position, Q will be continuously "low"* and $\overline{Q}$ will be continuously "high"** regardless of the behavior of the asymmetry detector. Similarly, when S4 is in REVERSE position, Q will be continuously "high" and $\overline{Q}$ will be continuously "low". But when S4 is in its center, AUTO, position, the flip flop outputs are completely controlled by the asymmetry detector. Then, whenever the flip-flop toggle input (pin 2) is "low", the master flip flop is set and reset as determined by the inputs applied to the set and clear gates (pins 3, 4 and 11, 12) with a consequent change of state, if appropriate, in the Q and $\overline{Q}$ outputs at pins 6 and 9. But whenever the toggle input is "high", the information stored in the master flip flop has no effect on the slave flip flop, thus leaving Q and $\overline{Q}$ in the most-recent logical condition.

C. "Pause Detector"

The flip flop toggle drive is developed in a "pause detector" comprising A1Q27, 28, and 29 and the diodes A1CR11 and A1CR12. Program is sampled and rectified by the two diodes, the voltage thus developed being stored across the capacitor A1C18. This voltage operates a modified

* "Low" describes logical voltage level, negative with respect to the "high" voltage level.

** "High" describes logical voltage level, positive with respect to the "low" voltage level.

Schmitt trigger circuit, A1Q27 and A1Q28, whose sensitivity can be varied with the potentiometer A1R101. With the emitter of A1Q27 at ground (potentiometer fully ccw), slightly more than 0.6v is required to turn on the transistor. However, as the potentiometer is advanced cw, the emitter is biased more negatively (up to about -1.4 volts), thus lowering the threshold level for turn-on. The emitter follower A1Q29 driven by the Schmitt trigger circuit is a low-impedance logic driver for the toggle input of A1U1.

D. Phase Reversal Control

The flip-flop outputs separately drive the two A.P.P. Variolossers A1CR5, 6 and A1CR7, 8 which separately control respective succeeding differential amplifiers. These amplifiers are A1Q9, 10, 13 and A1Q11, 12, 14, which receive the audio output of the input section (paragraph 4-2). The Variolosser diodes are connected such that if $\overline{Q}$ is "high" (implying that Q is "low"), the program passes through the Volumax unit without phase reversal, and the NORMAL indicator DS2 is lighted; but if Q is "high", the phase is reversed, and the REVERSE indicator DS3 is lighted. Because the Q and $\overline{Q}$ outputs are applied directly to the Variolossers, either one Variolosser or the other is always "turned off", i.e., forward biased to present an essentially shorted path for audio signals. The outputs from the Variolossers are amplified separately for maximum common-mode transient suppression. Then the two outputs are combined in a balanced, resistance network, A1R47, 57, 58, 51, 52, and 56.

Now assume an input signal phasing A → B at pins 1 → 2 of the rear panel terminal strip TB2 (figure 7-1). With two phase reversals in the audio input section, the A → B phasing is also present at A1TP2 → A1TP3. Next, assume that $\overline{Q}$ is "high" and Q is "low". The phase of the input to A1Q11 → A1Q12 is B → A, but this input is "shorted" by A1CR7, 8. The phase of the input to A1Q9 → A1Q10 is A → B without a diode "short"; hence, A1Q9 and A1Q10 pass the audio signal while A1Q11 and A1Q12 do not. The differential-amplifier output phasing at A1TP4 → A1TP5 is therefore B → A, giving a phase reversal in the A.P.P. circuits. (See also subparagraph F below.) However, if $\overline{Q}$ were "low" and Q were "high", opposite conditions would prevail: the input to A1Q9 → A1Q10 would be "shorted" and the A.P.P. output phasing at A1TP4 → A1TP5 would be A → B as at pins 1 → 2 of TB2.

E. Input Drive to Output Section and AGC Signal Amplifier

The signal from A1TP4, 5 drives the output section of the amplifier discussed in paragraph 4-2 and, for buffering and POSITIVE LIMIT control of the AGC feedback, is separately amplified in the differential amplifier A1Q15, 16, and 17. In one side of the output from this differential amplifier (collector of A1Q15), half of the POSITIVE LIMIT % switch S3 selects the appropriate AGC feedback resistance for equally positive and negative peaks (symmetrical, or 100 percent) or for 15 percent higher positive peaks (115 percent), or for maximum allowable positive peaks (125 percent). The other side of the differential amplifier output (collector of A1Q16) supplies the AGC feedback received through the unvariable resistance path. (See paragraph 4-3.)

F. Front Panel PHASE Indicators

While the flip-flop outputs Q and $\overline{Q}$ are driving the A.P.P. Variolosser as discussed above, in subparagraph D, they are also controlling a pair of emitter follower drivers used to light the front panel NORMAL and REVERSE PHASE indicators. When Q is "high", A1Q35 is switched on, lighting the REVERSE indicator DS3, a light-emitting diode (LED). When $\overline{Q}$ is "high", A1Q35 is switched off but A1Q36 is switched on, lighting the NORMAL indicator DS2, another LED. The indicator lights show the phase relationship between the Volumax input and output rather than the condition of the A.P.P. circuit. The "normal" phase relationship is defined as an instantaneously positive signal at pin 1 of TB2 creating an instantaneously positive signal at pin 4 of TB2.

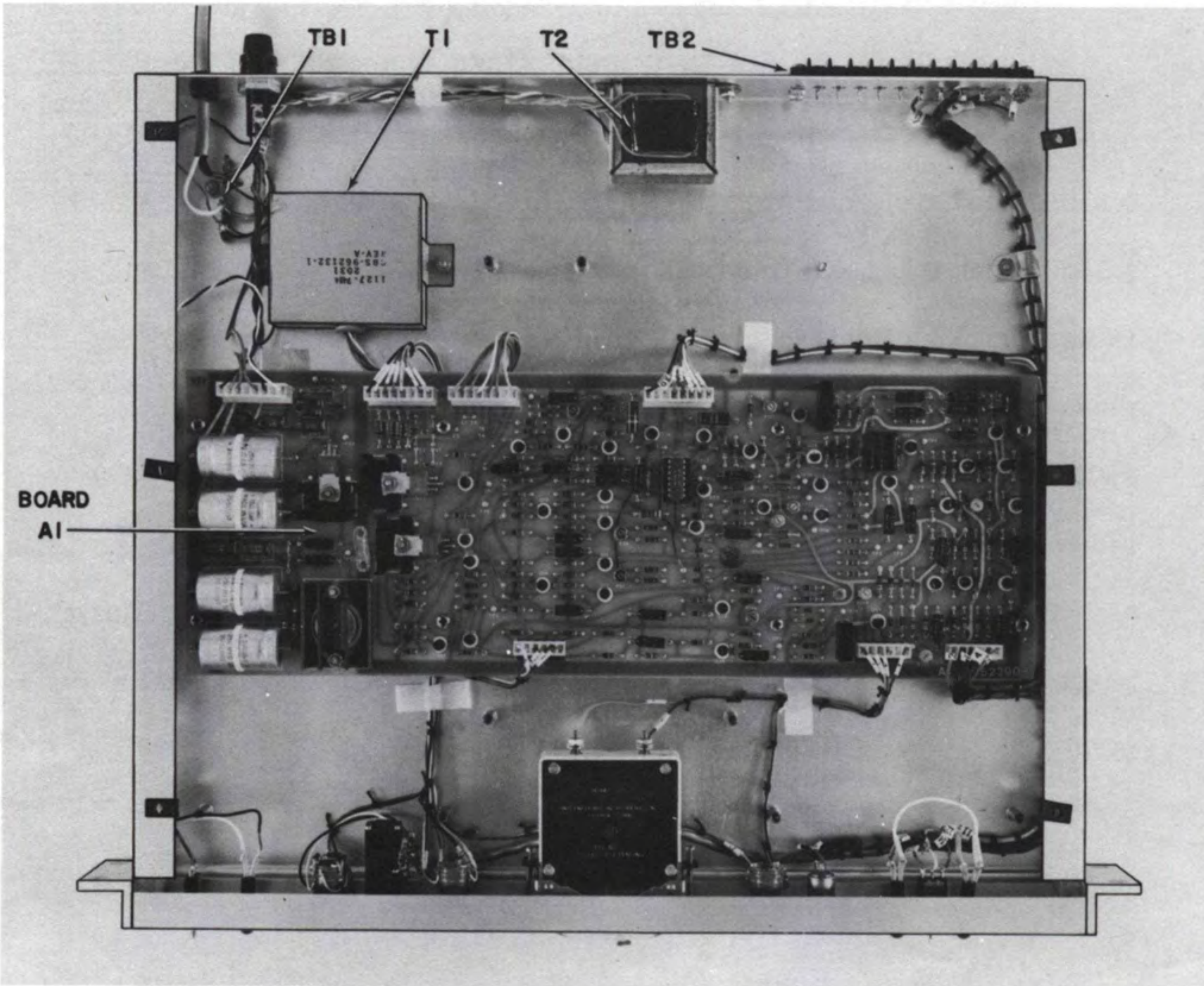


Figure 5-1. Volumax Unit with Top Cover Removed

SECTION V

MAINTENANCE

5-1. GENERAL

A. Access to Internal Components

If necessary to make internal adjustments or troubleshooting checks and replacement in the Volumax unit, remove the cover (which has been removed in figure 5-1).

See figure 7-2 for circuit-board parts locations.

B. Recommended Test Equipment

Item	Description
Ac voltmeter (pref two)	10 mv full-scale sensitivity, Ballantine or equal
VTVM	0 - 50 vdc
Audio signal generator	Hewlett-Packard Model 200 CD or 406A or equal with less than 0.1 percent distortion
Stepped attenuator*	20 dB in 1 dB steps
Oscilloscope	General purpose type with 10X probe
Multimeter	Simpson 260 or equal
Tone burst generator*	General Radio 1396-B or equal
Asymmetry test signal source	(See paragraph 5-2.)
Phase reversal switch*	Two-pole, three-position (center position for OFF)
Distortion analyzer*	

*Desirable but not mandatory

C. Troubleshooting Method

The troubleshooting of any apparent malfunction of the Volumax unit should always begin with a check of the power supply circuits. Dc voltages as measured with a VTVM should fall within the limits in table 5-1.

NOTE

Accidental shorting of either the +20v or -15v supply could cause the respective regulating transistor A1Q40 or A1Q41 to develop a collector-emitter short. This would allow unregulated dc to be impressed on circuits.

If either power-supply voltage is too high and there is excessive ripple, suspect A1Q40 or A1Q41. If the voltages are correct but the ripple content is too high, check for open or leaky power-supply filter capacitors. If the power supplies are satisfactory, proceed with the following recommended checks for trouble isolation.

1) In the extreme case of zero output, check input and output connections thoroughly. Inspect the connections to the printed circuit board for a possible open lead. If this visual inspection does not indicate any defects, stage-by-stage signal tracing will be necessary.

2) To determine at what circuit point the signal is lost or degraded, place the OUTPUT MAX dbm switch at 22, turn the INPUT LEVEL and OUTPUT LEVEL controls fully clockwise and apply a 1 kHz signal at 5 or 10 mv to the Volumax unit. Table 5-2 gives proper voltages at various points in the signal path with respect to chassis ground. This table is arranged in advancing signal-path order.

3) When the point of signal loss or other malfunction is reached, see paragraphs 5-2 through 5-9. The alignment procedure (paragraph 5-2) may eliminate the trouble if the signal is not lost. If the signal is lost or further troubleshooting is necessary for other reasons, see paragraphs 5-3 through 5-9.

TABLE 5-1. POWER SUPPLY VOLTAGES

Supply	Test Point	Correct Output	Maximum Ripple
+20v	A1TP22	+19.4v ±1v	10 mv p-p
-15v	A1TP23	-14.5v ±3/4v	10 mv p-p

TABLE 5-2. VOLTAGE MEASUREMENTS

NOTES

All measurements are made to chassis ground.

Except where otherwise noted, ac measurements are made with 10 mv applied to the input; both LEVEL controls fully cw, OUTPUT MAX dbm switch at 22, POSITIVE LIMIT % switch at 100, LIMITER switch at NORMAL, and PHASE switch at NORMAL.

Dc measurements are made with or without 10 vac input signal, controls set the same as for ac measurements.

Test Point	Correct Ac Voltage	Correct Dc Voltage
AUDIO INPUT SECTION:		
A1J7-5	Ground	0
A1J7-6	10mv	0
Bases A1Q1, A1Q2	Unbalanced input 6.4/1.8 mv	-0.05v
Collectors A1Q1, A1Q2	30mv	+16.5v
Bases A1Q4, A1Q5 (Vario-losser)	13.0mv	-0.10v
A1TP2, A1TP3	0.25v	+0.25v
PHASE REVERSAL SECTION:		
A. Phase switch S4 in NORMAL position:		
Bases A1Q9, A1Q10	20mv	+0.05v
Collectors A1Q9, A1Q10	0.40v	+10.0v
A1TP4, A1TP5	30mv	-0.01v
Bases of A1Q11, A1Q12	2mv	+0.50v
Collectors A1Q11, A1Q12	25mv	+10.0v

TABLE 5-2. VOLTAGE MEASUREMENTS (Cont)

Test Point	Correct Ac Voltage	Correct Dc Voltage
PHASE REVERSAL SECTION (Cont):		
B. Phase switch S4 in REVERSE position:		
Bases A1Q11, A1Q12	20mv	+0.05v
Collectors A1Q11, A1Q12	0.40v	+10.0v
A1TP4, A1TP5	30mv	-0.01v
Bases of A1Q9, A1Q10	2mv	+0.50v
Collectors of A1Q9, A1Q10	25mv	+10.0v
C. Phase switch S4 in any position:		
Collectors A1Q15, A1Q16	0.60v	+9.5v
A1VR7 cathode		+4.7v ±0.25v
AUDIO OUTPUT SECTION:		
Base A1Q18, A1Q19	30mv	-0.60v
Collectors A1Q18, A1Q19	1.0v	+11.50v
A1TP6, A1TP7	0.27v	+5.0v
A1J3-5, A1J3-8	2.7v	+18.0v
Across 600-ohm output load using 5mv input	2.3v rms ±1.5 dB	0

5-2. ALIGNMENT PROCEDURE AND TESTS

The following is a simplified version of the CBS Laboratories production alignment procedure, and can be used to bring the Volumax characteristics back within specifications after long-term aging or component changes. Under normal circumstances, it should seldom be necessary to realign unless component changes are made. Figure 5-2 shows the factory test setup. Similar versions of this setup will usually be satisfactory.

Inspect the GAIN REDUCTION meter on the front panel for accurate zeroing before undertaking any of the following steps. (See paragraph 5-9 for meter zeroing instructions.)

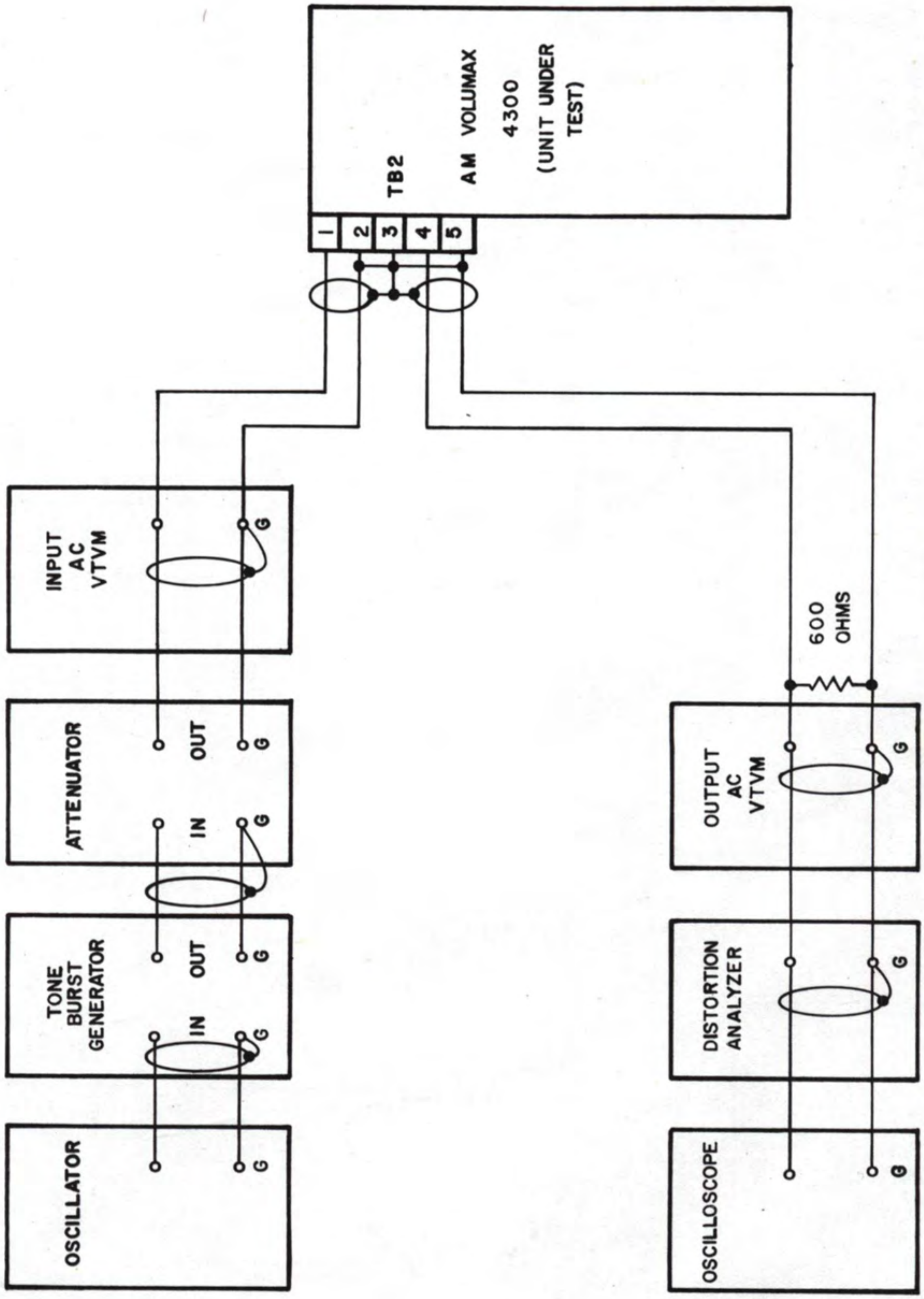


Figure 5-2. Factory Test Setup

A. AGC Alignment

(1) Set controls as listed for table 5-2 (INPUT LEVEL and OUTPUT LEVEL fully cw; OUTPUT MAX dbm at 22).

(2) Apply a 1 kHz signal at 5 mv to the Volumax input. Set potentiometer A1R135 fully ccw ~~clockwise~~. Measure the output and then adjust A1R135 for a 1 dB reduction in the output signal.

(3) If necessary, adjust A1R133 until the GAIN REDUCTION meter reads full scale (to the right).

(4) Increase the input signal as required to cause the meter to read at the NORMAL - HEAVY (red-green) junction. Keep the POSITIVE LIMIT % switch S3 in the 100 (percent) position.

(5) Turn A1R142 fully cw and place the LIMITER switch S2 in the MOD SET position. The output as seen on an oscilloscope set to the dc input should be clipped. Decrease the input level until the output just begins to exhibit clipping. Both the negative and positive sides of the waveform should clip at approximately the same time. Further reduce the input enough to bring the output just to the verge of clipping. Record the output level obtained at the verge of clipping. It should be 10v rms, ±1.0 dB. F.60

(6) Increase the input level 10 dB. Then measure the positive and negative excursions of the clipped output waveform. The voltages measured should be within the limits indicated in figure 5-3 for the 100 percent positive limit.

(7) Perform the measurement in step (6) for the 115 percent and 125 percent settings of the POSITIVE LIMIT % switch. The measured peak voltages should be within the appropriate limits indicated in figure 5-3.

(8) Place the LIMITER switch in the TEST position and look at the output for all positions of the POSITIVE LIMIT switch. There should be no signs of asymmetrical clipping.

NOTE

Symmetrical clipping will be observed at a higher output level than that observed for the positive excursion in step (6) (125 percent) when the headroom of the output stage is exceeded.

(9) Return the LIMITER switch to the NORMAL position and the POSITIVE LIMIT switch to 100 (percent). Turn A1R142 fully cw. Adjust the 1 kHz input as needed to drive the GAIN REDUCTION meter reading to the NORMAL - HEAVY (red-green) junction. Then alternately adjust A1R142 and the input signal level until a) the output level is exactly 1.2 dB below the voltage recorded in step (5), and, b) the meter reads at the red-green junction. Now adjust A1R146 for maximum output from the Volumax unit.

(10) Set the LIMITER switch at MOD SET. Observe the oscilloscope for symmetrical clipping.

(11) Return the LIMITER switch to NORMAL. Increase the input 5 dB. The meter should deflect well into the HEAVY (red) area. The output as observed on the oscilloscope should not now show clipping of either

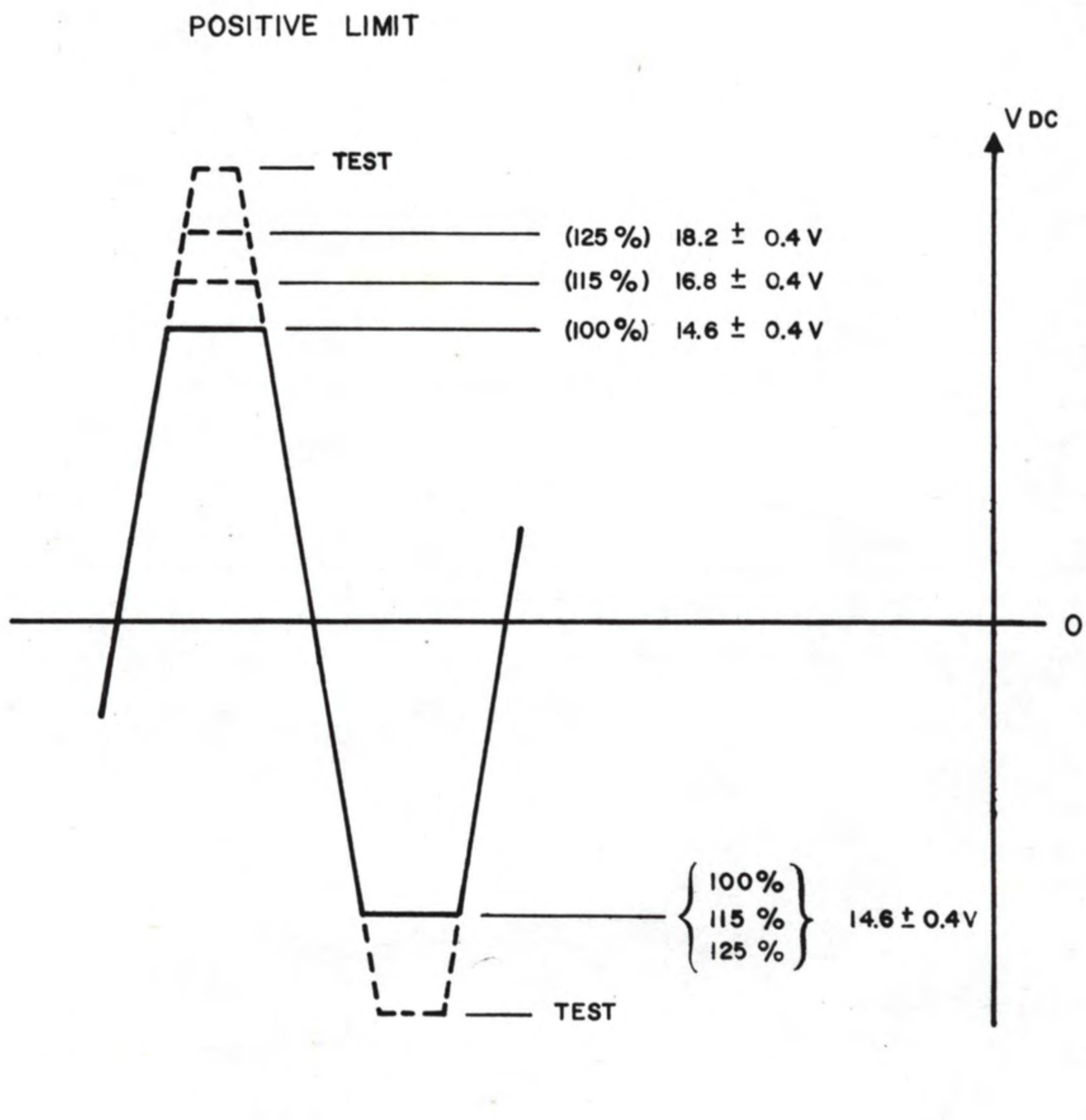


Figure 5-3. Positive Limit Output Levels for the Three Positions of S3

peak. But continue to increase the input signal level until the output waveform is clipped; the meter should be deflected off scale to the left. If the clipping occurs while the meter is on scale, repeat step (9), reducing the output level an additional 1/2 dB below the voltage recorded in step (5).

(12) Reduce the input signal level enough to deflect meter reading to the red-green junction. Then reduce the input signal level 8 dB. The meter should now deflect well into the green area and may reach the full-scale reading to the right.

B. Harmonic Distortion Alignment

(1) Apply a 5 kHz input signal at sufficient level to bring the GAIN REDUCTION meter reading to the NORMAL - HEAVY (red-green) junction. While alternately setting the PHASE switch at NORMAL and REVERSE, adjust A1R18 as necessary to obtain minimum harmonic distortion for the two PHASE switch positions, thus balancing the Variolosser. The distortion should be less than 1 percent for both the NORMAL and REVERSE positions of the PHASE switch S4. If the distortion figures are unequal, adjust A1R8 as needed to equalize the distortion for the NORMAL and REVERSE switch positions.

(2) Set the POSITIVE LIMIT % switch at 100 (percent) and apply a constant-level 50 Hz input signal. Adjust A1R81 for minimum distortion, which should be less than 1 percent. Adjust A1R46, if necessary. (Excessive adjustment of this potentiometer should not be needed.)

C. Checking Frequency Response and AGC Release Time

(1) Reduce input until the GAIN REDUCTION meter just reads full scale to the right. Set the LIMITER switch in the TEST position. Sweep through the audio frequency band from 50 Hz to 15 kHz. The output should remain flat within 1/2 dB.

(2) Connect an X10 'scope probe to A1TP19 and set the 'scope to D.C. Set the LIMITER switch at NORMAL and adjust the audio oscillator to 500 Hz. Place the tone burst generator in the continuous output mode, and trigger the oscilloscope from the tone-burst generator sync output.

(3) Adjust the input signal as required to drive the GAIN REDUCTION meter to the red-green junction.

(4) Remove the input signal from the Volumax unit. The dc voltage at A1TP19 will be near zero. Adjust the vertical sensitivity of the 'scope and position the baseline at the highest graticule marking.

(5) Re-connect the input signal. Set the tone burst generator for 128 (cycles) of on time and 1.0 second of off time.

(6) Observe the oscilloscope for a release time waveform as indicated in figure 5-4.

NOTE

The tests indicated in steps (2) through (6) above may be performed by manually disconnecting the input signal and observing the rising part of the waveform in figure 5-4.

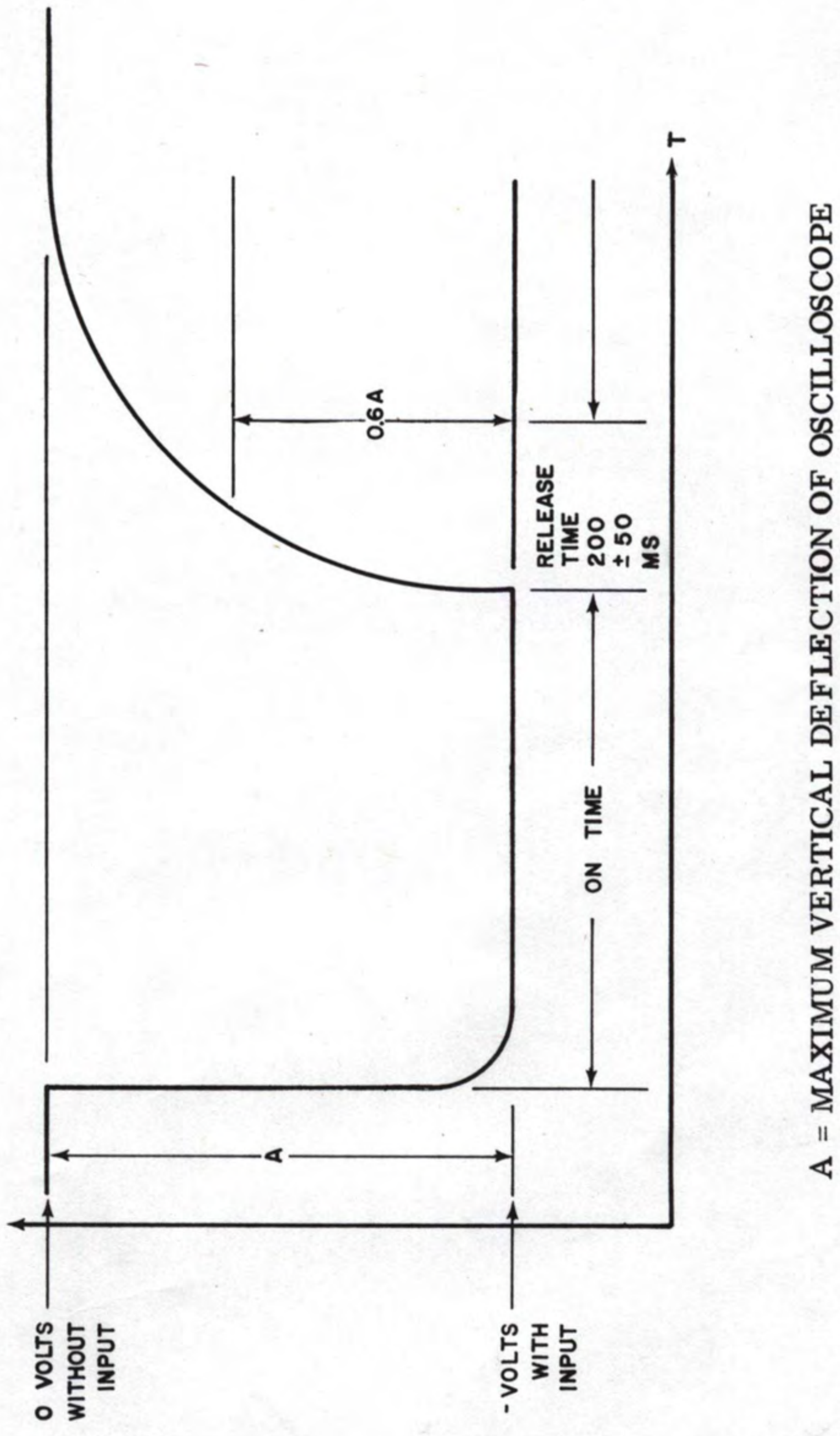


Figure 5-4. Release Time Waveform

D. Pause Detector Adjustment

Monitor the voltage at A1TP17 (pin 2 of A1U1) while making the following adjustments. Place the LIMITER switch at NORMAL and the POSITIVE LIMIT % switch at 100 (percent). With no signal input, measure the dc voltage at A1TP17. It should be within the limits of +0.6v ±0.1v. If not, adjust to this value with A1R101. Verify that the dc voltage at A1TP10 (Schmitt trigger) is +1.1v ±0.1v. See Note below and also subparagraph E.

NOTE

As this A1R101 is rotated clockwise, the pause detector sensitivity is increased; that is, the program level must become lower in amplitude to cause a momentary logical "high" at the pause detector output, A1U1 pin 2. The potentiometer should not be advanced too far, as a point can be reached where the pause detector output will not "go low" during any pause in programming; this would defeat the ability of the clocked flip flop in U1 to change state. The factory setting for 1.1v at A1TP10 should cause the quiescent voltage at A1TP17 to be about +0.6v as above.

E. Asymmetry Detector Alignment

To align the asymmetry detector, set the LIMITER switch at NORMAL and the POSITIVE LIMIT % switch at 100 (percent). Then proceed as follows:

(1) Turn A1R120 fully cw. With no signal input, monitor the dc voltage from A1TP14 to A1TP25 on the circuit board. Adjust A1R117 until the voltage is 0 ±0.1 vdc.

(2) Measure the voltage between A1TP14 and ground. Turn A1R120 ccw until a reading of +12v ±0.1v is obtained. Check that the voltage from A1TP25 to ground is also +12v ±0.1v. Alternate adjustments of A1R117 and A1R120 may be necessary.

NOTES

The unit is now adjusted to optimum sensitivity for use with normal speech waveforms. If more sensitivity is desired, use the same procedure as just described but adjust a higher voltage (e.g., 12.5v) rather than 12v. Similarly, a less sensitive setting can be found by reducing the voltage A1TP14 to a lower voltage (e.g., 10 volts).

The remainder of this procedure may be helpful if the tone burst generator (figure 5-2) is available and is connected in the test setup.

(3) Set the tone burst generator for a continuous 500 Hz output. Adjust the attenuator for a -30 dBm input level to the Volumax unit at TB2.

(4) Set the tone burst generator for the tone bursts of the 500 Hz signal 128 cycles long, spaced about one second apart. This spacing is not critical; set it to a convenient value for the next step.

(5) Monitor A1TP17 with an oscilloscope, dc coupled with 0.5v/cm vertical sensitivity (0.05v/cm if a 10 X probe is used). When the signal is "on", the trace should rise to +1.5v ±0.5v. When the signal is "off" the trace should drop below +0.6v before rising again. If it does not, readjust A1R101 until it does.

F. A.P.P. Test

To check the automatic peak phasing (A.P.P.) function of the Volumax circuitry, a clipped sine wave can be used as a test input signal. Connect the unit under test to the A.P.P. test circuit indicated in figure 5-5.

(1) Set the "diode" switch in the normal position (the unclipped side of the sine wave to TB2-1). Set the input at TB2-1, 2 of the Volumax unit at approximately 2.0 volts p-p and the frequency at 500 Hz. Leave the Volumax LIMITER switch at NORMAL. The POSITIVE LIMIT % switch should be at 100 (percent).

(2) Adjust the INPUT LEVEL control as necessary to bring the GAIN REDUCTION meter indication to the NORMAL - HEAVY (red-green)

junction. Place the PHASE switch in the AUTO position; the PHASE NORMAL indicator should be lighted.

(3) Remove the signal (set by the diode switch in the center, off, position). Upon removal, the PHASE NORMAL indicator should remain lighted, indicating an unreversed phase state. Unclipped side of the sine wave must be connected to TB2-1 and the clipped side to TB2-2.

(4) Re-apply the test signal by setting the diode switch in the reverse position (the unclipped side of the sine wave connected to pin 2 of TB2); then remove the signal. The phase state should reverse, indicated by the lighting of the PHASE REVERSE indicator and an output phase reversal as seen on the oscilloscope at TB2-4, 5.

(5) Test manual control of phasing by placing the PHASE switch alternately in the NORMAL and REVERSE positions; indicators should appropriately light and phase changes should be visible on the oscilloscope.

(6) With clipped side of the sine wave at TB2-1, (reverse position of the diode switch), return the PHASE switch from REVERSE to AUTO; the REVERSE phase should return after the diode switch is turned to the OFF position.

(7) If any one of the six preceding steps fails, adjust A1R120 and/or A1R117 slightly until proper operation is obtained. If proper operation cannot be obtained by adjusting A1R120 such that the dc voltage measurement from A1TP14 to ground is +12.5, troubleshoot the automatic peak phasing circuitry.

(8) If transients caused by phase-change switching seem excessive in the oscilloscope display, adjust the A. P. P. balance potentiometers A1R34 and A1R37 with no signal input to minimize transient amplitudes. Proceed carefully, as these two potentiometers interact somewhat. Note original settings and return to original settings if the adjustments cannot be made to reduce transients equally for NORMAL - REVERSE and REVERSE - NORMAL phase switching.

G. Output Measurements

(1) Re-connect the Volumax unit in the test configuration shown in figure 5-2. Set the PHASE switch in NORMAL position. The tone burst generator (if used) should be set for continuous output.

(2) Adjust the input signal level as required for a GAIN REDUCTION meter reading at the red-green junction.

(3) Check that when the OUTPUT MAX. dbm switch is turned from the 22 to the 6 position the output level drops 16 ± 1 dB. The OUTPUT MAX. dbm control S5 is probably defective if any other drop, or no drop, is obtained.

(4) Verify that the OUTPUT LEVEL control varies the output level over a 20 ± 3 dB range. The OUTPUT LEVEL attenuator R160 is probably defective if this result is not obtained.

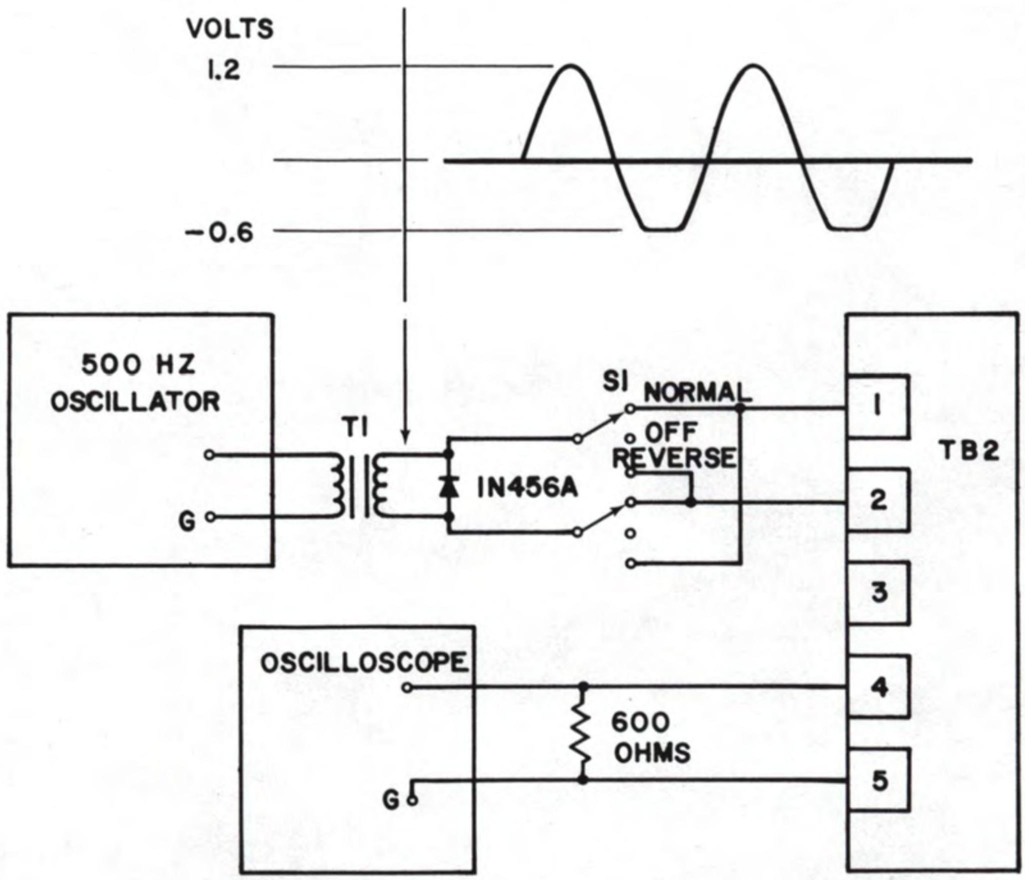


Figure 5-5. A.P.P. Test Circuit

5-3. TROUBLESHOOTING AUDIO INPUT SECTION

Check ac and dc voltages as listed in table 5-2. If signal is present at the collectors of A1Q1 and A1Q2 but is too low or too high at the bases of A1Q4 and A1Q5, measure the quiescent control voltage at A1TP1. This should be -1.0v ±0.1v. If it is not, potentiometer A1R135 should be adjusted according to the alignment procedure in paragraph 5-2. If the attempt to set A1R135 fails to correct the problem, suspect the Variolosser diodes A1CR1 through A1CR4. If these diodes must be replaced, select matched replacement pairs in which the forward voltage drops are within 10 mv of each other at 1 ma of forward current. (Realign unit.)

The remainder of the circuitry in this section is conventional.

5-4. TROUBLESHOOTING PHASE REVERSAL SECTION

Depending on whether the phase switch S4 is in the NORMAL or REVERSE position, transistor pair A1Q9, A1Q10, or A1Q11, A1Q12 will amplify the signal. If the integrated-circuit clocked flip flop A1U1 is defective or loose in its socket, it is possible that neither Variolosser A1CR5, A1CR6, or A1CR7, A1CR8 is biased on, in such case impressing signal at both differential-amplifier pairs. Since the two amplifier signals are summed out of phase at A1TP4, A1TP5, there will be little or no output.

With the PHASE switch in the NORMAL position, verify that pin 9 of A1U1 is at +1.0v and that pin 6 is at +0.1v. Place the PHASE switch in the REVERSE position and re-measure. Converse readings should be obtained.

Also verify that the supply potential for A1U1 is +4.7v ±0.25v. If it is not, check zener diode A1VR7.

The remainder of this section is conventional in design. If any of the three amplifiers (Q9 and Q10, Q11 and Q12, or Q15 and Q16 on the circuit board) seems abnormal, check for the voltages indicated in table 5-2.

5-5. TROUBLESHOOTING AUDIO OUTPUT SECTION

If signal is present at A1TP4, A1TP5 but not at A1TP6, A1TP7, check the voltages at A1Q18, A1Q19. If signal is present at A1TP6, A1TP7 but not at the collectors of A1Q23 and A1Q24, check transistors A1Q21, A1Q23, A1Q22, and A1Q24. If the signal from the collectors of A1Q23, A1Q24 is present but too low, either A1Q23 or A1Q24 may be at fault, since they both operate in the class A mode.

5-6. TROUBLESHOOTING AGC SECTION

To check for proper AGC action, set the LIMITER switch in the NORMAL position and set the INPUT LEVEL control fully clockwise; then apply a 1 kHz signal to the Volumax unit. Increase the input until the GAIN REDUCTION meter reading just begins to move toward the left. Note the output level across the 600 ohm load. Now increase the input 10 dB; the output should increase less than 2 dB.

(1) If the GAIN REDUCTION meter reads downscale doing this test but the output does not compress as indicated above, check the AGC Variolosser diodes A1CR1 through A1CR4.

(2) If the GAIN REDUCTION meter does not read downscale, monitor the voltage at A1TP19 while varying the input level as described above. Here the voltage should vary from about -0.33 vdc at an input level of 30 mv to about -1.5v at an input level of 100 mv (10 dB greater). The FET A1Q37 is to be suspected if the gate voltage at A1TP19 varies as previously described but no gain reduction occurs. If the A1TP19 voltage 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 A1R143 may be incorrectly set; see the alignment procedure, paragraph 5-2.

(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 and set the POSITIVE LIMIT % switch at 100 (percent). The signal level at TP4 or TP5 should then be 60mv rms and the signal level at A1J5-6 (pole of POSITIVE LIMIT % switch S3 or collector of A1Q15) should be 1.2v rms. The ac signal levels at the bases of A1Q38, A1Q39 should be approximately 300mv. Next, measure the voltages at A1TP20, A1TP21; each should be 8.0 vac. Correct voltages here in combination with no control voltage indicates defective diodes A1CR15 and/or A1CR16. If, after any changes in the AGC section, the meter reading with no signal applied is not at reference (full scale), see paragraph 5-9.

5-7. TROUBLESHOOTING AUTOMATIC PEAK PHASING SECTION

Before checking for any suspected malfunction in this section, be sure that the signal input has sufficient asymmetry to activate the circuit. A test for proper operation with asymmetric signals can be made using an artificial asymmetric signal, as described in paragraph 5-2. If the unit does not respond to the artificial asymmetric signal, align this portion of the circuit as described in paragraph 5-2. Then, if proper operation still cannot be obtained, make the following checks:

(1) Check the integrated circuit A1U1, a clocked flip-flop, in this manner:

(a) Alternately ground pins 5 and 10 on the flip flop (see figure 5-6) or operate the PHASE switch S4 back and forth between its NORMAL and REVERSE positions. Each switch or alternate grounding operation should change the flip-flop state as indicated by the two front-panel

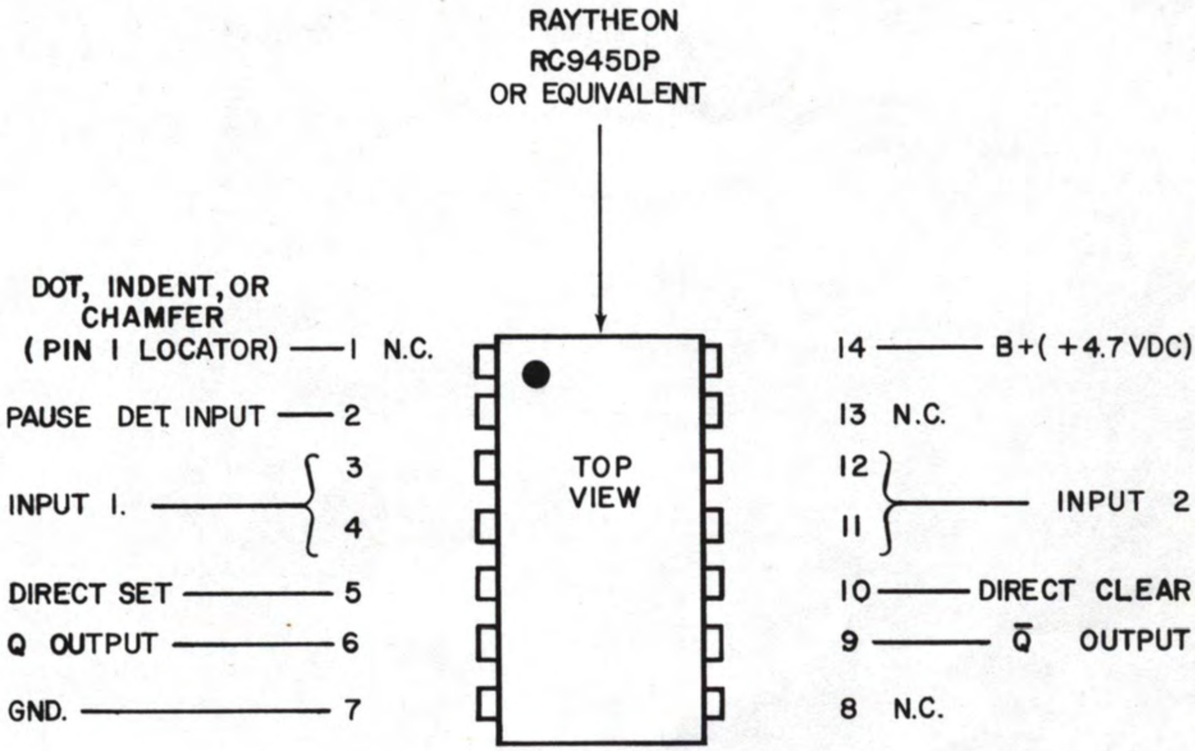


Figure 5-6. Integrated Circuit Pin Identifications

PHASE indicators. (Be sure that both LEDs and the lamp driver transistors A1Q35 and A1Q36 are operational. See paragraph 5-8.)

(b) Place S4 in the AUTO position. Using a grounded 1.5v battery or other low-impedance power supply, apply +1.5v at A1TP16. Then apply and remove +1.5v at A3TP17. Upon removal of the voltage from TP17, the flip-flop should be in the NORMAL state as indicated by the lighting of the NORMAL indicator (if not already lighted). Next, apply +1.5v at A3TP18; then apply and remove +1.5v at A1TP17 again. Now, upon removal of the voltage from TP17, the NORMAL light should go out and the REVERSE indicator should light. Remove all test leads at the end of this step.

(c) If proper results are obtained in (a) and (b) above, the flip-flop is eliminated as a source of trouble.

(2) Check the pause detector circuit.

(a) Monitor the voltage at A1TP17. With sufficient input to bring the GAIN REDUCTION reading to the red-green junction, the voltage at that point should be +1.2v or greater.

(b) Drop the audio input level until the voltage falls to +1.0v. This input level should be at least 16 dB below the level in step (a) above.

(c) Re-increase the input level to bring the GAIN REDUCTION reading to the red-green junction. Then remove the input entirely. The voltage at A1TP17 should drop to less than +0.6 momentarily. The sensitivity can be increased by turning potentiometer A1R101 clockwise; however, do not advance this potentiometer beyond the point where the voltage at A1TP17 fails to drop as just described when signal is applied and then removed.

(3) Check the asymmetry detector.

(a) Apply a 1 kHz input signal to the Volumax unit at sufficient level to bring the GAIN REDUCTION reading to the red-green junction. The ac measurements at the emitters of A1Q25, A1Q26 should be 0.50v rms.

(b) Check the dc voltages at A1Q30, A1Q31, and A1Q32. See table 5-2. If these voltages are correct, set A1R117 and A1R120 as described in the alignment procedure, paragraph 5-2.

5-8. TROUBLESHOOTING PHASE INDICATOR CIRCUITS

With power turned on, either one of the two phase indicator LEDs, NORMAL or REVERSE, should be lit. When the phase switch S4 is in the NORMAL position, the NORMAL (left) indicator should be lit; when S4 is in the REVERSE position, the REVERSE (right) indicator should be lit. For the AUTO position, either the NORMAL or REVERSE indicator should be lit. If either indicator fails to light, check the LED and associated driver transistor. (The LEDs should have extremely long lives.) Transistor A1Q36 drives the NORMAL LED; transistor A1Q35 drives the REVERSE LED. If both LEDs light simultaneously, or neither lights in any of the above tests, check the flip flop A1U1 as directed in paragraph 5-7.

5-9. TROUBLESHOOTING GAIN METER CIRCUIT

If, after thorough warmup with no input, the resting position of the GAIN REDUCTION meter is not precisely at full scale, it can be reset with the circuit-board potentiometer A1R133. If the meter does not read at full scale when power is off, however, turn power off and adjust the meter to full scale with the mechanical zero adjust arm on the meter unit. Restore power, wait for warmup, and adjust A1R133 if necessary

SECTION VI

PARTS LISTS

6-1. GENERAL

This section contains parts lists for the complete Volumax unit. 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 Volumax unit are carbon composition, 1/4 watt, plus or minus 5%.

6-3. TRANSISTORS AND DIODES

When replacing transistors and diodes called out in the parts lists with 1N and 2N standard numbers, replace them with the same manufacturing brands of transistors or diodes 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 Switch
AMRA	-	American Radionics
AUG	-	Augat
BECK	-	Beckman
BEL	-	Belden
CBS	-	CBS Laboratories
CDE	-	Cornell-Dubilier
CIN	-	Cinch Mfg.
FCH	-	Fairchild
GE	-	General Electric
HEY	-	Heyco
HHS	-	Herman H. Smith
IERC	-	International Electronic Research Corp.
IRC	-	IRC Division of TRW
LF	-	Littlefuse
MAL	-	Mallory
MOL	-	Molex Products
MOT	-	Motorola
OHM	-	Ohmmite
PAN	-	Panduit
RAY	-	Raytheon
ROS	-	M. Ross
SCHA	-	Schauer
SPR	-	Sprague
THER	-	Thermalloy
TI	-	Texas Instruments
TRW	-	TRW, Inc.
VERO	-	Vero Electronics, Inc.
WEC	-	Weckesser

6-5. MAIN ASSEMBLY, VOLUMAX 4300 (CBS LABORATORIES PART NO. 962400)

Ref	Description	Mfr	Mfr. Part No.	CBS Laboratories Part No.
A1	Printed circuit board assy (See paragraph 6-6.)	CBS		962397
DS1, DS2, DS3	Indicator, LED	FCH	FLV 102	991704
F1	Fuse, 0.3 amp	LF	3AG SLO-BLO	991256
M1	Meter			961798-2
P1 thru P4	Connector, 8-pin (individually keyable) (mate w/A1J1 thru A1J4)	MOL	2139-082	991464
P5 thru P7	Connector, 6-pin (individually keyable) (mate w/A1J5 thru A1J7)	MOL	2139-062	991447
	Key, polarizing	MOL	2139-K	991449
R1 thru R3	Not used			
R4	Resistor, variable, 5 kilohms, log taper (10% of R at 50% or rotation)		WA4N020S502AA	991303
R5 thru R86	Not used			
R87, R90	Resistor, 825 ohms, 2%	IRC	Type RG07	
R88, R89	Resistor, 931 ohms, 2%	IRC	Type RG07	
R91, R92, R94, R95	Resistor, 300 ohms (p/o R160)	AB	Type CB	
R93	Resistor, 62 ohms (p/o R160)	AB	Type CB	

6-5. MAIN ASSEMBLY, VOLUMAX 4300 (CBS LABORATORIES PART NO. 962400) (Cont)

Ref	Description	Mfr	Mfr Part No.	CBS Laboratories Part No.
R94 thru R159	Not used			
R160	Resistance, H-pad attenuator, 600 ohms, 20 db (includes R91 thru R95)	CBS		962403-1
S1	Switch, spdt	ALCO	MST-105D	991176
S2, S3	Switch, rotary, two-pole, three-position			962401-1
S4	Switch, spdt	ALCO	MST-105E	991225
S5	Switch, rotary, four-pole, two-position			962401-2
	Ear, mounting	FCH	FLS 001	991705
T1	Transformer, audio			962132
T2	Transformer, power			962133
TB1	Strip, terminal	HHS	850	991188
TB2	Block, terminal	CIN	353-18-10-001	991518
	Strip, marker (terminal block)	CIN	363-12-10-010	991519
XDS1, XDS2, XDS3	Socket, indicator (LED type)	AUG	8060-1G34	991708
XF1	Fuseholder	LF	342012	990595
W1	Cable assy (power cord w/plug)	BEL	17237	991443

6-5. MAIN ASSEMBLY, VOLUMAX 4300 (CBS LABORATORIES PART NO. 962400) (Cont)

Ref	Description	Mfr	Mfr Part No.	CBS Laboratories Part No.
	Strain relief	HEY	SR-5P-4	991444
	Terminal, wire (end)	MOL	2478-TL	991448
	Clip, press	WEC	PC-2-5	991126
	Clip, press	WEC	HPC-37	991274
	Clamp, cable	HHS	8910	991674
	Accessory kit and assy (chassis slides)*	CBS		962163-4

* Customer option

6-6. PRINTED CIRCUIT BOARD ASSEMBLY (A1)

Ref	Description	Mfr	Mfr Part No.	CBS Laboratories Part No.
	RESISTORS			
R1	750 ohms	AB	Type CB	
R2, R3	1.2 kilohms	AB	Type CB	
R4	Not used			
R5	10 ohms	AB	Type CB	
R6, R7, R12, R14, R24, R25, R28, R47, R49, R50, R51, R52, R54, R55, R56, R63, R76, R78, R121, R150, R152	10 kilohms	AB	Type CB	

6-6. PRINTED CIRCUIT BOARD ASSEMBLY (A1) (Cont)

Ref	Description	Mfr	Mfr Part No.	CBS Laboratories Part No.
	RESISTORS (Cont)			
R8, R11	1.5 kilohms	AB	Type CB	
R9	110 ohms	AB	Type CB	
R10, R145, R147	82 ohms	AB	Type CB	
R13, R48, R53	1.8 kilohms	AB	Type CB	
R15, R16, R17, R19, R27, R65	4.7 kilohms	AB	Type CB	
R20, R23, R39, R42, R43, R46, R59, R62, R67, R119, R132, R144, R148	5.1 kilohms	AB	Type CB	
R18, R101, R117, R133, R135	Variable, 1 kilohms	BECK	62PR1K	991161
R21, R22	240 ohms	AB	Type CB	
R26, R57, R58, R64, R125, R126, R128, R129	1 kilohm	AB	Type CB	
R29, R30, R31, R32	47 kilohms	AB	Type CB	
R33, R35, R36, R38, R105	27 kilohms	AB	Type CB	
R34, R37, R142	Variable, 5 kilohms (audio taper)	BECK	62PR5K	991311
R40, R41, R44, R45, R109	150 ohms	AB	Type CB	

6-6. PRINTED CIRCUIT BOARD ASSEMBLY (A1) (Cont)

Ref	Description	Mfr	Mfr Part No.	CBS Laboratories Part No.
	RESISTORS (Cont)			
R60, R61	200 ohms	AB	Type CB	
R66	8.2 kilohms	AB	Type CB	
R68, R69, R98, R99, R110, R111, R114, R115, R140, R141	100 kilohms	AB	Type CB	
R70, R73, R106, R134	3 kilohms	AB	Type CB	
R71, R72	56 ohms	AB	Type CB	
R74, R75, R100	56 kilohms	AB	Type CB	
R77	1.2 kilohms	AB	Type CB	
R79, R83	30 kilohms	AB	Type CB	
R80, R82	9.1 kilohms	AB	Type CB	
R81	Variable, 2 kilohms	BECK	62PR2K	991314
R84	15 ohms	AB	Type CB	
R85, R86	33 ohms	AB	Type CB	
R87 thru R95	Not used			
R96, R97	3.9 kilohms	AB	Type CB	
R102, R161, R162	20 kilohms	AB	Type CB	
R103	7.5 kilohms	AB	Type CB	

6-6. PRINTED CIRCUIT BOARD ASSEMBLY (A1) (Cont)

Ref	Description	Mfr	Mfr Part No.	CBS Laboratories Part No.
	RESISTORS (Cont)			
R104, R108	910 kilohms	AB	Type CB	
R107, R136	4.3 kilohms	AB	Type CB	
R112, R113	3.3 kilohms	AB	Type CB	
R116, R118	51.1 kilohms, 1/8w, 1%	IRC	Type CEA-TO	
R120	Variable, 10 kilohms	BECK	62PR10K	991315
R122	24 kilohms	AB	Type CB	
R123, R124	182 kilohms, 1/8w, 1%	IRC	Type CEA-TO	
R127	510 ohms	AB	Type CB	
R130, R131	750 ohms, 1w	AB	Type GB	
R137	Not used			
R138	470 kilohms	AB	Type CB	
R139	15 kilohms	AB	Type CB	
R143	2.4 kilohms	AB	Type CB	
R146	Variable, 100 ohms	BECK	62PR100	991164
R149, R151	360 kilohms	AB	Type CB	
R153	5.6 ohms, 5-1/4w	OHM	Class-PC 58 No. 5852A	991688
R154	4 ohms, 3w	OHM	Class-PC 58 No. 5805	991686
R155	470 ohms, 1/2w	AB	Type EB	
R156	68 ohms, 1/2w	AB	Type EB	

6-6. PRINTED CIRCUIT BOARD ASSEMBLY (A1) (Cont)

Ref	Description	Mfr	Mfr Part No.	CBS Laboratories Part No.
	RESISTORS (Cont)			
R157	100 ohms, 3w	OHM	Class PC 58 No. 5816	991687
R158	1 kilohm, 1/2w	AB	Type EB	
R159	82 ohms, 1/2w	AB	Type EB	
R160	Not used			
R163	1 kilohm, 3w	OHM	Class-PC 58 No. 5833	991706
	CAPACITORS			
C1, C2, C20, C21, C24	22 mfd, 15v, 20%	MAL	TAC226M015P04	991319
C3, C4, C33, C36	8.2 mfd, 35v, 10%	MAL	TAC825K035P04	991318
C5 thru C14, C17, C19, C26 thru C29, C37, C38	4.7 mfd, 35v, 20%	MAL	TAC475M035P04	991317
C15, C16	20 pf, 5%	CDE	CM05ED200J03	990764
C18	1.0 mfd, 100v, 10%	AMRA	2MBPC1105K	991326
C22, C23	0.47 mfd, 100v, 10%	AMRA	2MBPC1474K	991325
C25	0.56 mfd, 50v, 10%	AMRA	2MBPC1564K	991712
C30, C31 C32, C34	250 mfd, 50v	MAL	TCW250N050P1J	991320
C35	68 mfd, 25v, ±20%	SPR	2C023474D8500C4	991548

6-6. PRINTED CIRCUIT BOARD ASSEMBLY (A1) (Cont)

Ref	Description	Mfr	Mfr Part No.	CBS Laboratories Part No.
	SEMICONDUCTORS			
CR1-CR2, CR3-CR4	Diodes, silicon, matched pairs		1N456A	
CR5, CR6, CR7, CR8, CR11 thru CR16	Diode, silicon		1N456A	
CR9, CR10	Diode, silicon		1N914 or 1N914A	
CR17	Diode, bridge rectifier	VERO	VE18	991219
Q1, Q2, Q18, Q19	Transistor		2N3391A	
Q3 thru Q17, Q20, Q21, Q22, Q25, Q26, Q27, Q29 thru Q36, Q38, Q39	Transistor	GE	2N3393	
Q23, Q24	Transistor	GE	D40D4	
Q28	Transistor	MOT	2N3906	
Q37	Transistor	T1	2N5953	
Q40	Transistor		2N3055	
Q41	Transistor	GE	D41D1	
U1	Integrated circuit	RAY	RC945DP	991331
VR1, VR4	Diode, zener, low noise, 14v, 2%	SCHA	SZ14.0	991545
VR2	Diode, zener, low noise 16.2v, 2%	SCHA	SZ16.2	991683

6-6. PRINTED CIRCUIT BOARD ASSEMBLY (A1) (Cont)

Ref	Description	Mfr	Mfr Part No.	CBS Laboratories Part No.
	SEMICONDUCTORS (Cont)			
VR3	Diode, zener, low noise 17.6v, 2%	SCHA	SZ17.6	991684
VR5, VR6	Diode, zener, low noise, 12v, 1%	SCHA	SZ12.0	991707
VR7	Diode, zener, 4.7v, 5%	TRW	LVA 47A	
VR8	Diode, zener, 20v, 5%		1N4747A	
VR9	Diode, zener, 15v, 5%		1N4744A	
	MISCELLANEOUS			
J1 thru J4	Wafer pin assy (connector)	MOL	A-2183-8A	991459
J5, J6, J7	Wafer pin assy (connector)	MOL	A-2183-6A	991438
XQ23, XQ24, XQ41	Heat sink, transistor	IERC	PA1-1CB	991316
XQ40	Heat sink, transistor	THER	6103A	991685
XU1	Socket, integrated circuit	AUG	314-AG5D-3	991222
	Transipad	ROS	10171	990747
	Tie, cable	PAN	PLT1M	991710
	Etch, drill and mark assy	CBS		962390

SECTION VII

DRAWINGS

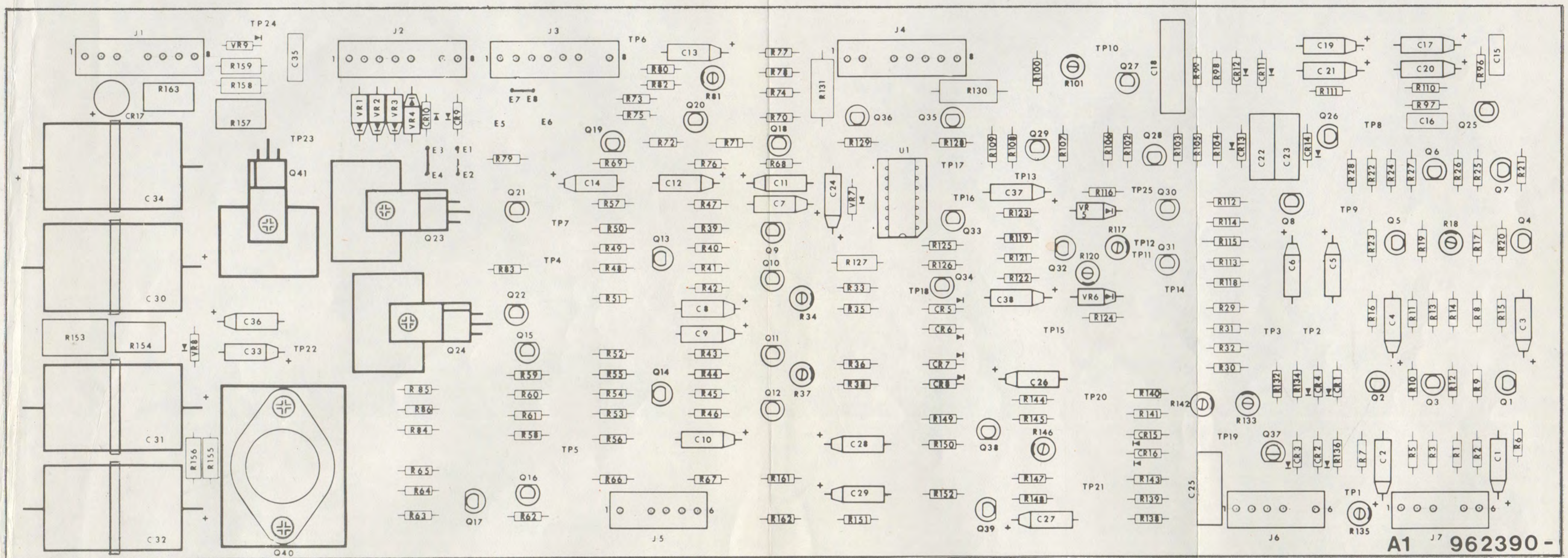
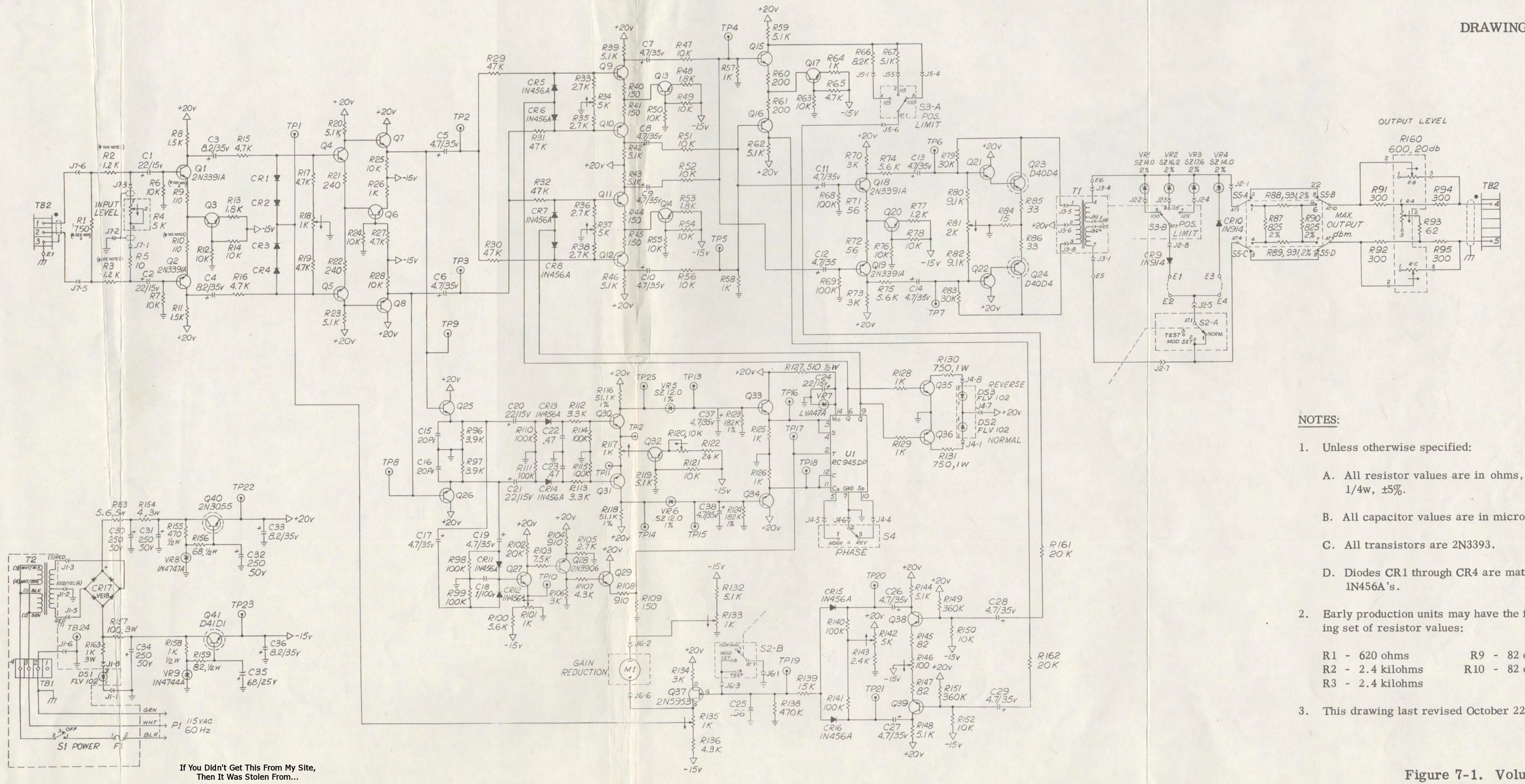


Figure 7-2. Circuit Board A1
Parts Locations



NOTES:

1. Unless otherwise specified:

   A. All resistor values are in ohms, 1/4w, ±5%.

   B. All capacitor values are in microfarads.

   C. All transistors are 2N3393.

   D. Diodes CR1 through CR4 are matched 1N456A's.

2. Early production units may have the following set of resistor values:

   R1 - 620 ohms R9 - 82 ohms
   R2 - 2.4 kilohms R10 - 82 ohms.
   R3 - 2.4 kilohms

3. This drawing last revised October 22, 1974

Figure 7-1. Volumax 4300 Schematic Diagram