VOLUMAX
Model 4000A
Automatic Peak Controller

OPERATING AND MAINTENANCE INSTRUCTIONS

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

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SECTION I

INTRODUCTION

1-1. GENERAL

This manual provides instructions for the CBS Laboratories Model 4000A Volumax^{TM} unit, a high quality peak limiter for AM broadcasters that positively prevents overmodulation. 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.

1-2. FUNCTIONAL DESCRIPTION

The Model 4000A Volumax 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. Designed primarily for use with well controlled average input levels such as provided by Audimax, the Volumax supersedes all previous peak limiters in the prevention of carrier overmodulation by instantaneous program peaks.

With conventional peak limiters, the broadcaster must choose between two "evils": either the program level must be reduced so that the limiting of peaks will not be drastic enough to cause "pumping" -- thus lowering average power -- or the pumping (which amounts to an audible distortion) has to be tolerated. Furthermore, since conventional limiters moderate pumping by use of long recovery times, the intervals immediately following high program peaks waste modulation capability while the limiter recovers from reduced gain.

The Volumax circuitry solves these problems in a unique manner. Control is effected in two ways: time-varying AGC action, and microsecond-fast diode limiting. The result is an even, pleasant sound plus the capability of transmitting program signals with high peak factor at twice the average program power level usually expected when conventional limiters are used.

When the Volumax POSITIVE LIMIT switch is set for 100%, the time-varying AGC action responds equally to both positive and negative wave excursions and the limiting action is completely symmetric. If the 120% position is chosen, the Volumax AGC amplifier requires positive peaks 1.2 times higher than the negative peaks to cause equal amounts of limiting; furthermore, the "peak ceiling" for positive program excursions is moved up so that the absolute limits have a ratio of 1.2 positive to 1.0 negative. Because of the FCC ruling which places an absolute limit on positive modulation of 125 percent, the 120% position is the recommended operating position for the Volumax 4000A. This will provide a 5 percent safety margin to allow for component tolerances within the unit.

CAUTION

The 300% position of the POSITIVE LIMIT switch should be used only during maintenance procedures.

1-3. PHYSICAL DESCRIPTION

Packaged in a new, 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. Its reliable solid-state circuitry is packaged in functional groups on three circuit boards, and has appropriate test points to speed maintenance tests and troubleshooting. Front panel controls are conveniently arranged, and those requiring infrequent use (e.g., the INPUT LEVEL and OUTPUT SET controls) are recessed 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.

1-4. PRINCIPLES OF OPERATION

NOTE

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

Briefly, the program input is fed to a differential amplifier allowing balanced or unbalanced inputs. An AGC amplifier with a 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, coupled with microsecond-fast diode limiting, ensures absolute control of 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 higher peaks to produce positive modulation of the carrier and determine when 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. For a precise adjustment of the modulation level, a calibrated output attenuator allows the operator to vary the output level upward or downward by 2.5 dB in 0.5 dB steps with respect to a nominal OUTPUT SET level.

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 1.6 dB and turn them into useful positive supermodulation.

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

Dimensions	Fits standard 19-inch rack, 1-3/4 inches high, 15 inches deep.
Input and output impedances	600 or 150 ohms, balanced or unbalanced
Input level	-24 to +8 dBm
Output level	Negative peaks: 24 dBm peak 24 dBm peak at 100% 25.5 dBm peak at 120%
Maximum gain	50 dB
Noise level	Less than -46 dBm, 20 to 20,000 Hz
Frequency response	±0.5 dB, 50-15,000 Hz over entire operating range
Harmonic distortion	Less than 1.0%, 50-15,000 Hz throughout control range
Attack time	Less than 1 microsecond or 2 milliseconds, depending on program signal waveform
Recovery time	100 milliseconds
Maximum operating temperature	55°C (130°F)
Power requirements	105-130 vac, 50/60 Hz, 20 watts (230V, 50/60 Hz optional)

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.) 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 pre-ceeding 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-

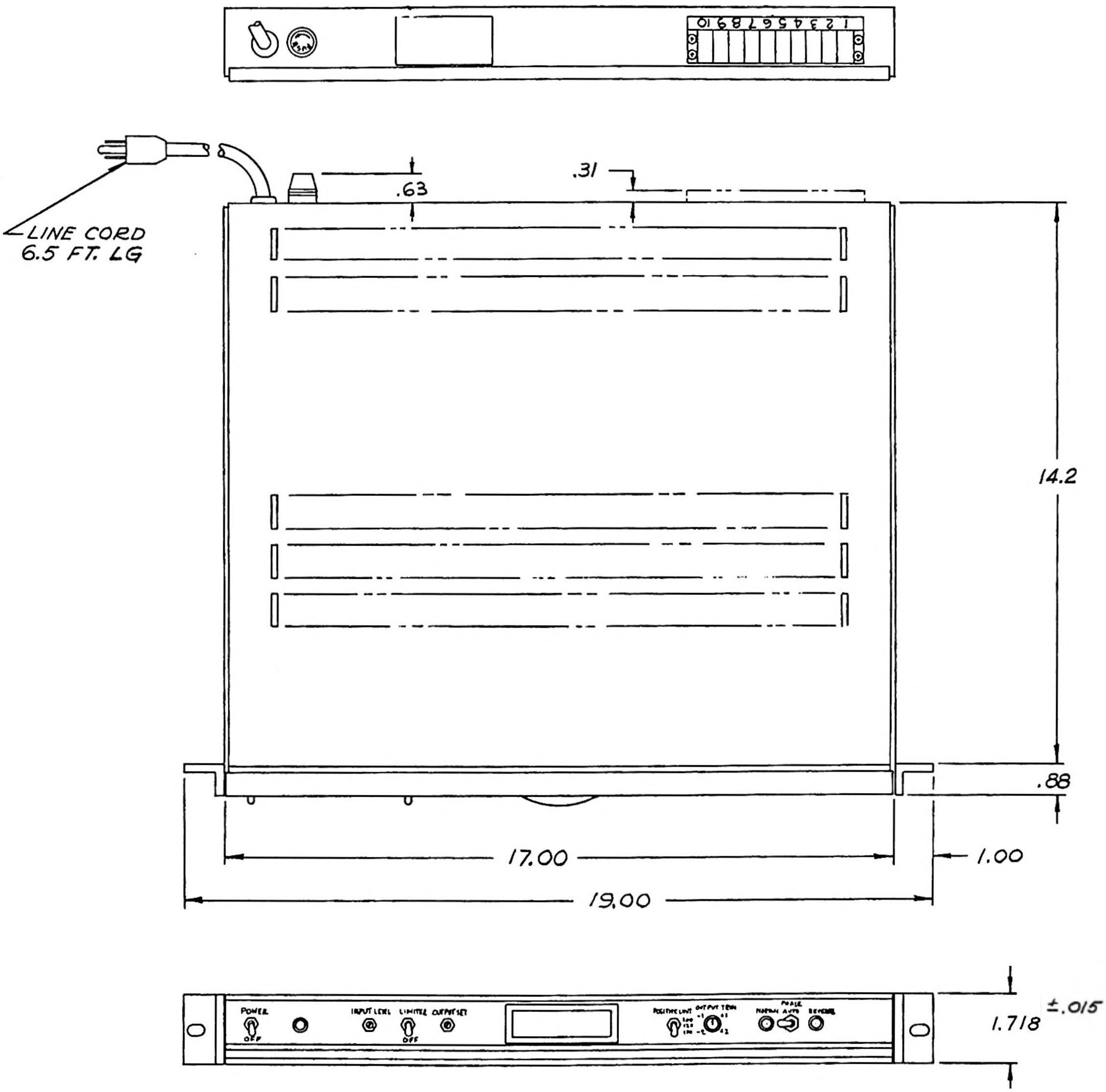


Figure 2-1. Volumax Model 4000A, Outline Drawing

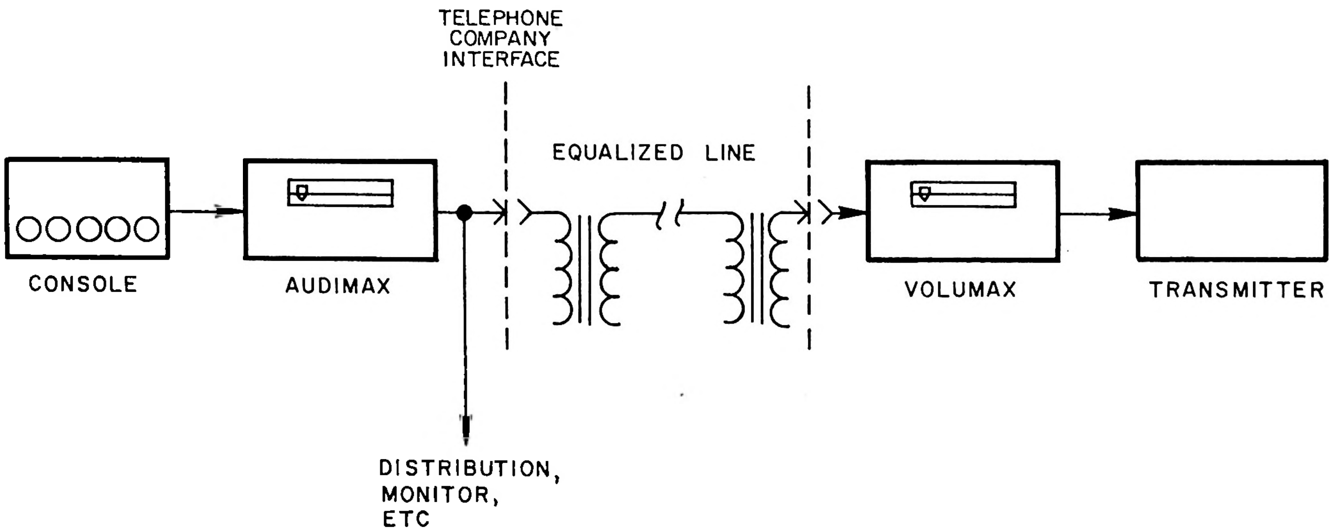


Figure 2-2. Typical Volumax Installation Block Diagram

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.

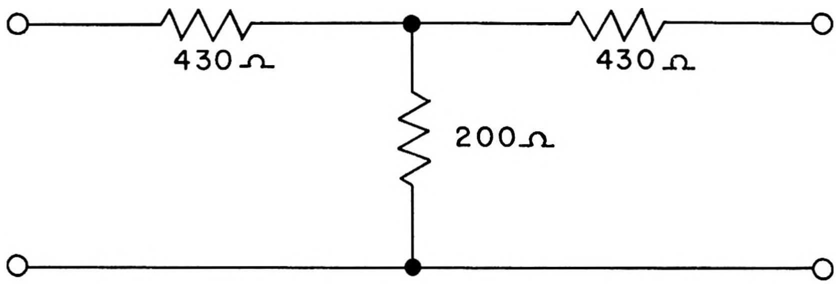
Input levels as low as -24 dBm can be accommodated. If the input level exceeds +18 dBm, the range of the input level control will not be sufficient. A convenient fixed attenuator which can be used in the line to the Volumax is shown in figure 2-3.

2-3. POWER SOURCE

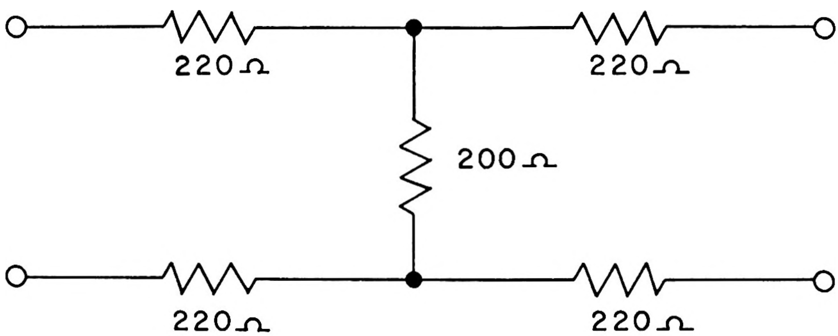
The Volumax unit is equipped with a power transformer which permits either 115 vac or 230 vac operation. As delivered, the unit is wired for 115 vac operation. If 230 vac operation is desired, make the following modifications at the terminal strip TB1 at the inside rear of the unit, next to the power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

A. Remove the black/white and the white leads from terminal 4 of TB1 (figure 7-1).

B. Remove the brown lead from terminal 3 of TB1.



A. SYMMETRICAL "T"



B. SYMMETRICAL "H"

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

C. Connect the black/white, brown, and white leads to TB1-1.

D. Unsolder and remove the white lead from TB1-4 and connect it to TB1-1.

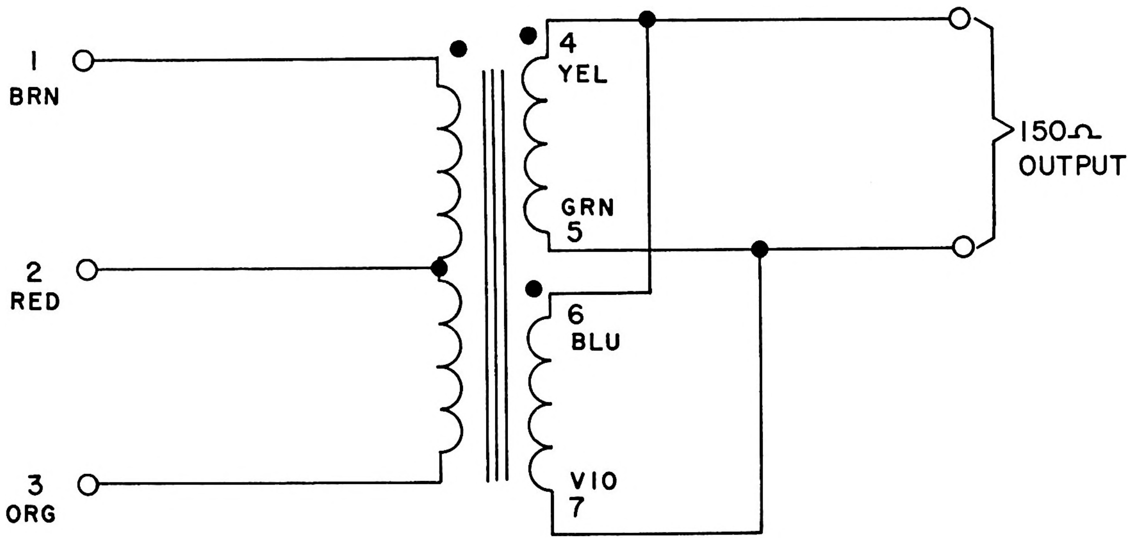
E. Replace the original fuse with a type 3AG-0.15 amp (SLO-BLO).

2-4. ELECTRICAL CONNECTIONS

Connect the input and output leads to the barrier strip at the rear of the chassis. 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 pin 1, the automatic peak phaser will seek its "nominal" phase state. In either case, connect output pin 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.

The standard Volumax unit is wired for 600-ohm operation. For 150-ohm operation, replace R5 on the input/output board A1 (figure 7-2) with a 150-ohm resistor, and re-strap the output transformer T2 (figure 7-1) as shown in the re-strapping diagram, figure 2-4.

OUTPUT TRANSFORMER



INSTRUCTIONS

1. REMOVE STRAP BETWEEN 5 & 6.
2. STRAP 5 TO 7.
3. STRAP 4 TO 6.

Figure 2-4. Transformer T2 Re-Strapping Connections for 150-Ohm Operation

SECTION III

OPERATIONAL SET-UP PROCEDURES

3-1. GENERAL

The Volumax 4000A may be used with a wide variety of a-m transmitters that differ in their reactions to supermodulation control. Hence, the capabilities and limitations of the particular transmitter must be considered when adjusting the Volumax unit for use in a system. 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. Some transmitters are marginally designed, with little or no reserve current capability; however, most modern a-m transmitters have enough power-supply reserve for an appreciable amount of supermodulation.

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 it undergoes. Therefore, the most dramatic increases in positive modulation should be expected during live speech programming.

As delivered, the Volumax 4000A can sense an asymmetry factor as low as 1.6 dB and make the decision to change phase if desirable. The correct moment for the reversal, as determined by the pause detector circuit, is the next 120-millisecond or longer program drop of more than 16 dB.

3-2. INPUT AND OUTPUT PHASING

Terminal 4 on the output barrier 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:

1) Turn the OUTPUT SET control (figure 3-1) fully counter-clockwise.

2) Set the POSITIVE LIMIT switch at 300%.

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

4) Set the phase switch at NORMAL. (Push toggle toward NORMAL indicator lamp.)

5) Increase the 1-kHz signal by 16-18 dB. (The meter will read off-scale toward the left, but the Volumax unit is now being intentionally overdriven.)

6) Increase the output level of the Volumax unit as necessary to produce approximately 30 to 40 percent modulation.

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

8) Figure 3-2 shows a correctly phased waveform. If a waveform as in figure 3-3 is obtained, reverse the output leads. The output is now correctly phased.

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

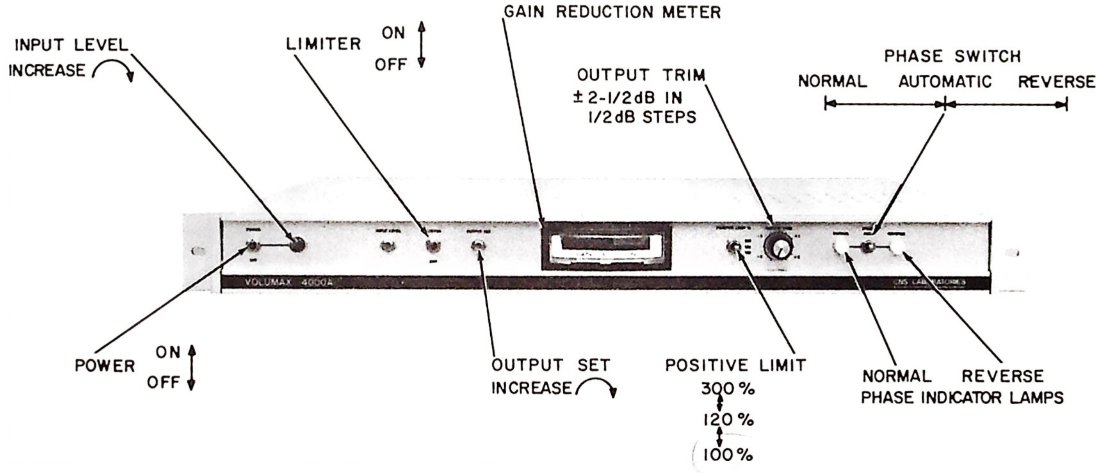


Figure 3-1. Volumax Model 4000A Front-Panel Controls

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 position. Thus, if the Volumax unit consistently selects the REVERSE phase when speech is originating at the main announcing position, reverse the input connections. In a similar manner, each auxiliary microphone or other in-house program source can be correctly phased at its input to the console.

3-3. ADJUSTMENT FOR MAXIMUM MODULATION

1) Turn the OUTPUT SET control (figure 3-1) fully counterclockwise.
2) Use a 1-kHz input signal to deflect the meter reading to the red-green junction.
3) Place the LIMITER switch in the OFF position; then turn the OUTPUT SET control clockwise as far as necessary to produce the maximum desired modulation. If the r-f envelope is observed on an oscilloscope, its appearance should be similar to figure 3-4.
4) Return the LIMITER switch to the upper position and apply a normal level-controlled program input to the Volumax unit.
5) Adjust the Volumax INPUT LEVEL control as required to cause the GAIN REDUCTION meter to indicate in the

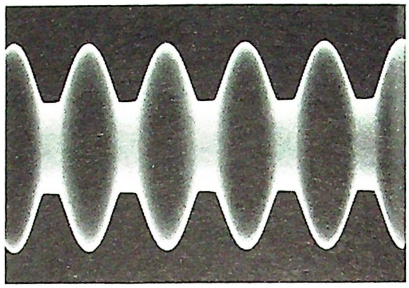


Figure 3-2. Correctly Phased Modulated R-F Envelope Obtained from Intentionally Overdriven Volumax Unit

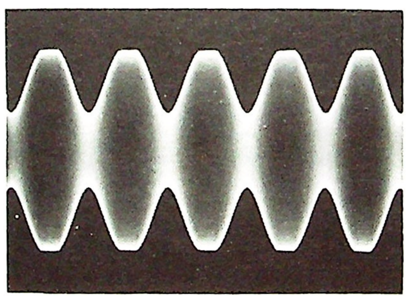


Figure 3-3. Incorrectly Phased Modulated R-F Envelope Obtained from Intentionally Overdriven Volumax Unit

green or NORMAL area with occasional peaks deflecting into the red region.

The above squared-tone method can be used to set the Volumax output level precisely; however, it should be recognized that phase shifts in transmitting equipment may cause previously limited program peaks to exceed the 100 percent level. A slight readjustment of the output level may be necessary if the modulation appears to be excessive. Operationally, this is most easily done by roughly adjusting the Volumax output with the OUTPUT SET control, then adjusting it more accurately with the OUTPUT TRIM control, which is calibrated in 1/2-dB steps through ranges of 2-1/2 dB above and below the nominal setting.

3-4. ALTERNATE METHOD FOR PHASING AND SETTING OF 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:

1) Apply normal, level-controlled program input to the Volumax unit.
2) Adjust the INPUT LEVEL control (figure 3-1) as necessary to cause the GAIN REDUCTION meter to operate in the green or NORMAL area with occasional peaks deflecting into the red region.
3) Set the POSITIVE LIMIT switch at 300%.
4) Place the phase switch in the NORMAL position. (Push toggle toward NORMAL indicator lamp.)

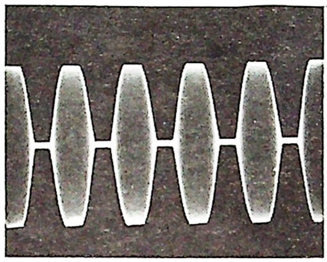


Figure 3-4. Squared Tone Modulation (95 Percent)

5) Adjust the OUTPUT SET and OUTPUT TRIM 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.

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

7) Observe the pattern closely, preferably while using speech modulation. If the oscilloscope pattern has a well defined limit in the direction of negative modulation, as shown in figure 3-5, the Volumax output is connected properly; that is, it is controlling the negative modulation peaks. If, however, no distinct limiting is evident on the negative modulation peaks but does appear in the positive direction, as in figure 3-6, the output connections must be reversed.

8) Once the correct output phasing has been determined, input phasing can be corrected as previously described. (See paragraph 3-2.)

9) Now set the POSITIVE LIMIT switch in the appropriate position, as previously discussed in paragraph 3-1. Then, while observing the trapezoidal modulation pattern, turn the OUTPUT LEVEL control clockwise as required for approximately the desired negative

modulation. Finally, use the OUTPUT TRIM control for a fine adjustment to the exact level desired.

Although 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 which is relatively free of the distortion caused by clipping. If the signal being fed into the Volumax unit contains a considerable amount of clipped waveform, erratic and/or overly frequent phase reversals will occur in the A.P.P. circuit.

Even though the audio equipment preceding the Volumax unit may be free of distortion when tested with 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 would be advisable to operate it at +14 VU during actual programming.

The most common sources of clipping, due to lack of headroom, are program amplifiers in consoles, telephone line amplifiers, overdriven compressors, and overdriven microphone preamplifiers. To cure the trouble, repair the offending amplifier if it is defective or decrease the level of the

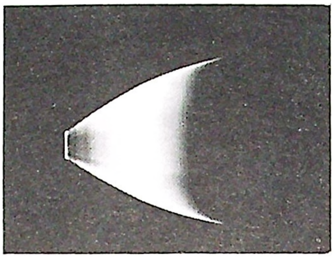


Figure 3-5. Correctly Phased Modulated R-F Envelope
(as Indicated by a Trapezoidal Pattern)

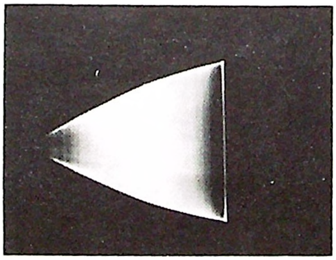


Figure 3-6. Incorrectly Phased Modulated R-F Envelope
(as Indicated by a Trapezoidal Pattern)

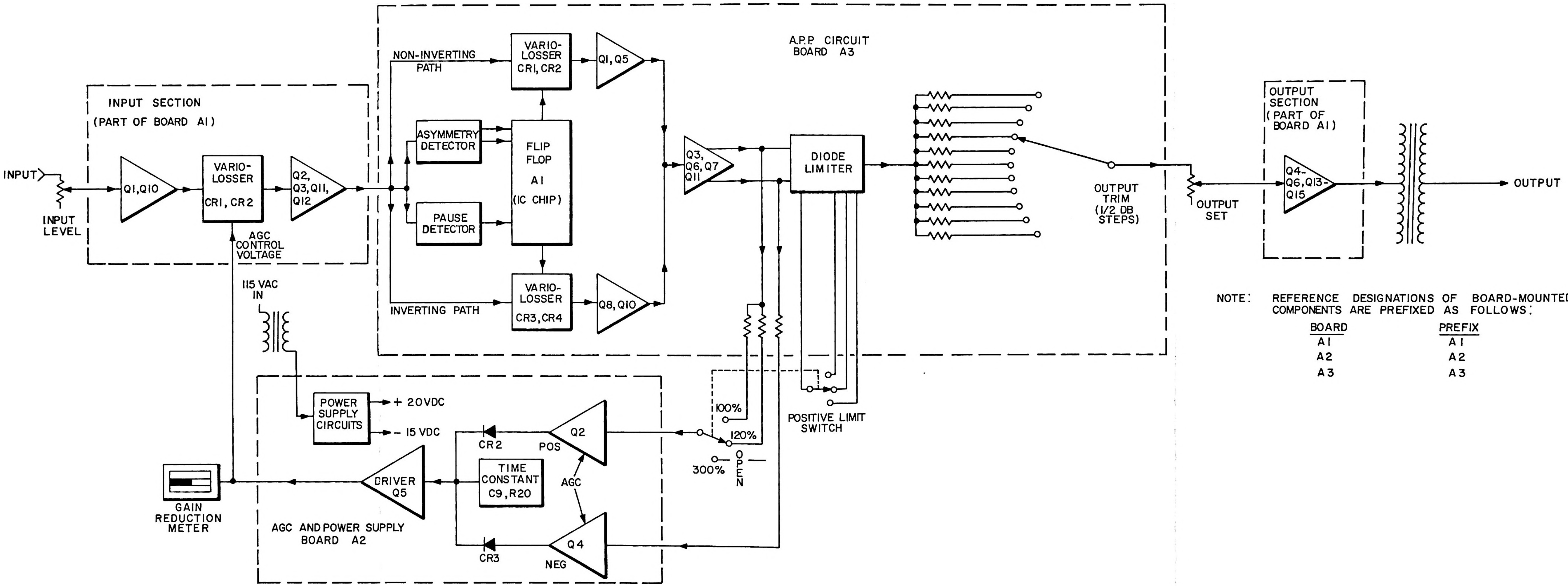
input to the amplifier (using fixed pads where necessary) until the clipping is eliminated. Clipping caused by lack of headroom is most easily observed with an oscilloscope which is connected to the INPUT of the Volumax unit. Once clipping is identified, its source can be traced by reducing the input 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 OFF 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:

With the LIMITER switch in the "on" (upper) 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 turn the OUTPUT SET control clockwise until normal modulation levels are reached again. Now return the LIMITER switch to the OFF 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 SET controls, and return the LIMITER switch to the "on" (upper) position.



NOTE: REFERENCE DESIGNATIONS OF BOARD-MOUNTED COMPONENTS ARE PREFIXED AS FOLLOWS:

BOARD	PREFIX
A1	A1
A2	A2
A3	A3

Figure 4-1. Volumax Model 4000A
Block Diagram

SECTION IV

THEORY OF OPERATION

4-1. BLOCK DIAGRAM

As shown in figure 4-1, the Volumax circuitry is divided functionally among the three circuit boards. Most of the input and output circuits are located on board A1. The AGC control voltage circuits, which act upon a Variolosser in the input amplifier, are located on board A2; this board also mounts the power-supply components, except for the power transformer which is mounted on the deck. The automatic peak phasing (A. P. P.) and fast-limiting control circuits are located on board A3. Other important signal components include the INPUT LEVEL, OUTPUT SET, and POSITIVE LIMIT controls which are mounted on the front panel, and the output transformer which is mounted on the deck.

For the overall internal interconnection schematic, see figure 7-1. For the schematic diagrams of the individual circuit boards A1, A2, and A3, see figures 7-2, 7-3, and 7-4, respectively.

4-2. INPUT/OUTPUT CIRCUITRY AND AGC ACTION (BOARD A1)

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

Transistor stages A1Q1 through A1Q15 on the input/output board comprise a high quality balanced-input audio amplifier whose gain is a function of several major variables. First, the Variolosser formed by

A1CR1 and A1CR2 is the AGC control element which 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 applied control voltage from board A2. Also, the OUTPUT TRIM control A3S1 and OUTPUT SET control R2 on the front panel act as fixed controls of the gain to determine the output level, the former being calibrated in 1/2-dB steps.

The input signal is applied through a shunt type INPUT LEVEL control, R1, on the front panel. The first stage of gain is provided by transistors A1Q1 and A1Q10, which act as a differential amplifier. Transistor A1Q7 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 (CMMR) of the differential circuit. This differential stage provides the drive for the balanced Variolosser previously discussed.

The first stage is followed by another differential amplifier which has a similar CMRR and is used to provide gain while also rejecting common-mode d-c thump from the Variolosser. Potentiometer A1R10 is used to balance the Variolosser/differential-amplifier system for minimum thump.

The input section is completed with a balanced emitter-follower, A1Q3, A1Q12, 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 -- A1Q5, A1Q6 and A1Q14, A1Q15 -- which drive the output transformer T2. This amplifier is driven by the differential amplifier consisting of A1Q4 and A1Q13, which is used to make up for losses in the output level attenuator. Potentiometer A1R30 is used to balance the output stage for minimum harmonic distortion.

4-3. AGC AMPLIFIER (BOARD A2)

(See figure 7-3.)

The AGC amplifier consists of transistor stages A2Q2, A2Q4 and the field effect transistor (FET) A2Q5. The first two of these transistors drive respective rectifiers and thus develop d-c voltages across the capacitor A2C9. These voltages are proportional to the signals presented at the bases of A2Q2 and A2Q4. 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 peaks ("positive peaks" and "negative peaks"). When the front-panel POSITIVE LIMIT switch S3 is in the 100% position, equal signals are applied to A2Q2 and A2Q4 through 91-kilohm resistors; thus, the composite control voltage developed at the gate of A2Q5 is equally proportional to waveform excursions in both directions. If S3 is placed in the 110% position, the "positive" peak rectifier is slightly de-sensitized by the substitution of a 110-kilohm series resistor in place of the 91-kilohm resistor; thus, the composite control voltage at the gate of A2Q5 is then principally a function of negative peaks; positive peaks must be 20 percent higher to affect AGC action. Finally, in the 300% position, all AGC control voltage is derived from negative peaks, as the line to the "positive" rectifier driver is then open. Although, for this position, the positive peaks are not limited by AGC action, they are limited in practice to about 300 percent by the "headroom" of the Volumax circuitry.

The FET A2Q5 is connected as a source follower and provides a low-impedance drive for the AGC Variolosser A1CR1 and A1CR2, and the front-panel GAIN REDUCTION meter circuit. The capacitor A2C9 and resistor A2R20 between the gate of A2Q5 and ground determine the time constant of the AGC action.

4-4. AUTOMATIC PEAK PHASING (A. P. P.) (BOARD A3)

(See figure 7-4.)

The function of the A. P. P. circuit board 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. The decision whether or not to reverse the phase is made in the following manner.

The emitter-follower transistors A3Q13, A3Q20 drive two diode rectifiers, A3CR6 and A3CR7. Since each diode is referenced to ground, the voltage developed across A3C9 and A3C14 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 A3Q14 and A3Q21 (another differential amplifier), while an asymmetric wave would develop unequal voltages. Because of the high common-mode rejection ratio of this stage, the balanced output of the collectors is essentially only a function of the asymmetry of the input: a "positively" asymmetric wave drives the collector of A2Q14 more positive, while a "negatively" asymmetric wave drives the collector of A3Q21 more positive. Program material with little or no asymmetry does not change the quiescent collector voltages.

As an easy scheme for varying the sensitivity of this asymmetry detector, the collector outputs of A3Q14 and A3Q21 are passed through the 12v Zener diodes A3VR4 and A3VR6. These diodes set a threshold which the differential output of A3Q14 and A3Q21 must exceed to provide any drive for the next stage. The collector voltages of A3Q14 and A3Q21 are determined by the collector currents through these transistors, which are, in turn, set by the constant current source A3Q18. The potentiometer A3R69 can be used to vary the combined collector current between about 2.9 ma and 6.7 ma, this current being equally split by potentiometer A3R68 in the path to the emitters of A3Q14 and A3Q21. Hence, the collector voltages can be varied from about +12.5 volts down to +4 vdc. Potentiometer A3R68 is used to balance out small variations in the 5-percent tolerance components. Thus, for various settings of A3R69, the collector voltages, A3Q14 and A3Q21 are varied below the Zener breakdown potential. The closer they approach the breakdown potential, the more sensitive the asymmetry detector action becomes, as the signal threshold level is much closer. The relationship of collector voltage to asymmetry-detection sensitivity is graphically shown in figure 4-2.

The two outputs from the Zener diodes A3VR4 and A3VR6 drive a pair of emitter followers which provide low-impedance logic drives for the integrated circuit A3A1, a clocked flip flop. Capacitors A3C10 and A3C15 provide for a short-term memory of recent asymmetric peaks. The clocked flip flop is actually a pair of flip-flops connected in a master-slave configuration with a toggle-inhibit gate. Whenever the toggle input (pin 2) is "low," the master flip flop may be set and reset as determined by the two inputs to the set and clear gates (pins 3, 4 and 11, 12) without affecting the output. Whenever the toggle input is "high," information stored in the master flip-flop is transferred to the slave flip-flop and the outputs Q and $\overline{Q}$ at pins 6 and 9 are determined. The toggle drive is developed in a "pause detector" circuit comprising A3Q24, 25, and 26 and diodes A3CR8 and A3CR9. Program is sampled and rectified by A3CR8 and A3CR9, the voltage developed being stored across the capacitor A3C17. This voltage operates a modified Schmitt trigger circuit, A3Q24 and A3Q26, whose sensitivity can be varied with

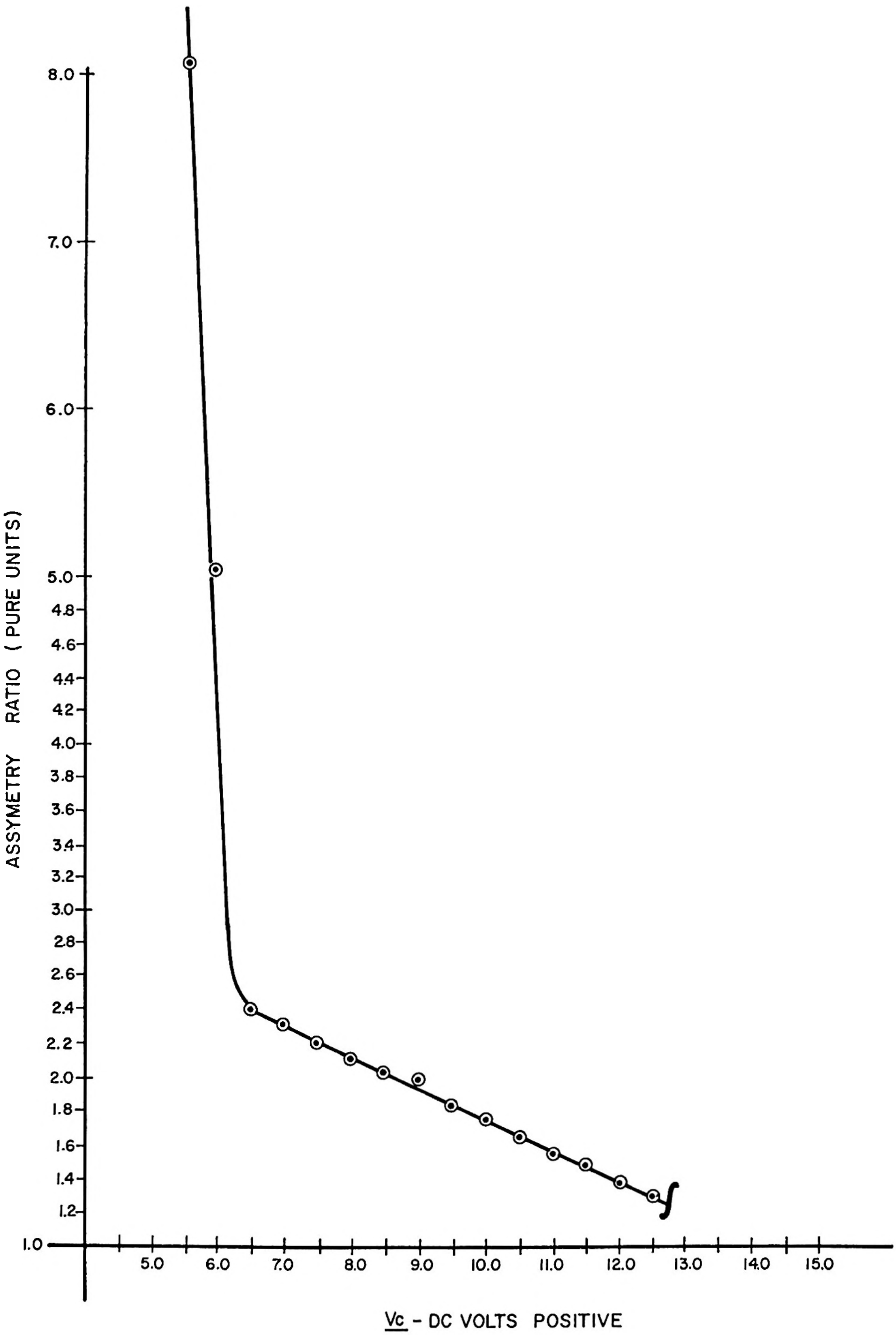


Figure 4-2. Asymmetry Sensitivity as a Function of the Voltage at TP8, Board A3

A3R99. With the emitter of A3Q26 at ground (A3R99 fully ccw), slightly more than 0. 6v is required to turn on A3Q26. However, as A3R99 is advanced cw, the emitter is biased more negatively (up to about -1.4 volts), thus lowering the threshold for turn-on. The Schmitt trigger circuit drives an emitter follower, A3Q25, which provides a low-impedance logic drive for the toggle input of A3A1.

The flip-flop outputs Q and $\overline{Q}$ each drive Variolossers connected in such a way that if $\overline{Q}$ is "high" (implying that Q is "low"), the program passes through without phase reversal, but if Q is "high", the phase is reversed. Because the Q and $\overline{Q}$ outputs are applied directly to the Variolossers, either one Variolosser or the other is always "off", i.e., forward biased to present an essentially shorted path for audio signals. The output from each Variolosser is amplified separately for maximum common-mode transient suppression, and then the two outputs are combined in a resistive network, A3R3, 9, 22, 26, 30, and 54. The signal is again amplified by a differential amplifier A3Q3 and A3Q6, and an emitter-follower pair A3Q7, A3Q11 drives the calibrated switchable attenuator A3S1 and limiting diodes A3CR5 and A3VR1, 2, and 3. The attenuator is calibrated in 1/2-dB steps, ±2-1/2 dB from the nominal setting. The limiting diodes insure that even microsecond-long transients cannot pass through the Volumax unit to overmodulate the transmitter. The second half of the POSITIVE LIMIT switch S3 selects the appropriate diode for equally positive and negative peaks (symmetrical, or 100%) or for 20-percent higher positive peaks (120%), or for unlimited positive peaks (300%).

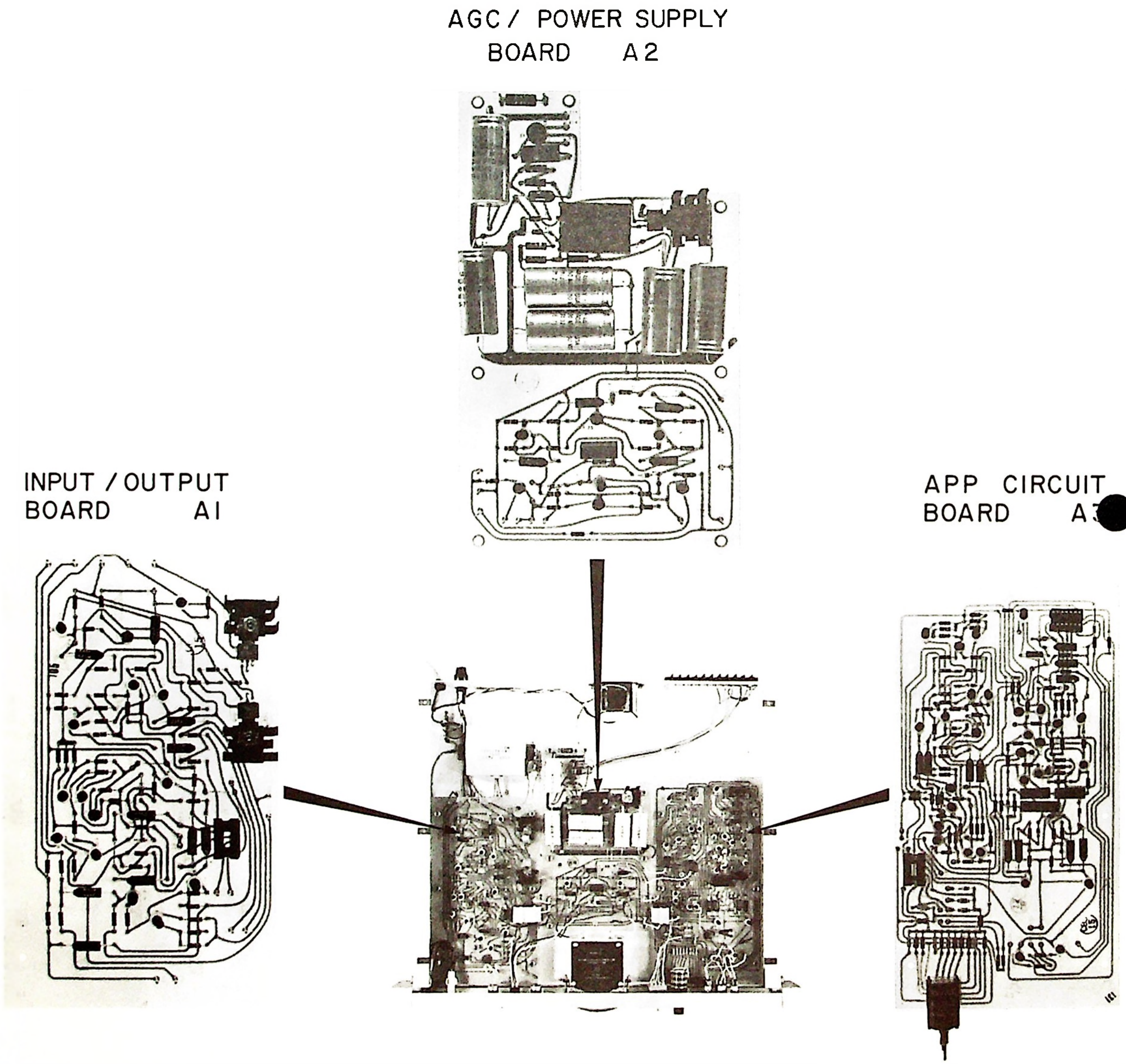


Figure 5-1. Locations of Volumax Circuit Boards

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 figures 7-2 through 7-4 for circuit-board parts locations.

B. Troubleshooting Method

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

NOTE

Accidental shorting of either the +20v or -15v supply could cause the respective regulating transistor A2Q1 or A2Q3 to develop a collector-emitter short. This would allow unregulated dc to be impressed on the circuit.

If either power-supply voltage is too high and there is excessive ripple, suspect A2Q1 or A2Q3. 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 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 determine at what circuit point the signal is lost or degraded, turn the INPUT LEVEL and OUTPUT SET controls fully clockwise and apply a 1-kHz signal at 10 mv to the Volumax unit. Table 5-2 gives the proper a-c 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 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	Correct Output	Maximum Ripple
+20v	+19.4v ±1v	10 mv rms
-15v	-14.5 ±3/4v	5 mv rms

TABLE 5-2. AC SIGNAL VOLTAGES

NOTE

All measurements are made to chassis ground.

Test Point	Correct Voltage
INPUT SECTION -- Board A1:	
TP1	Ground
E18, E19	10 mv
Bases Q1, Q10	Unbalanced input, 6.4/1.8 mv
Collectors Q1, Q10	35 mv
Bases Q2, Q11 (Variolosser)	9.0 mv
TP3, TP5	0.5 v
PHASE REVERSAL SECTION -- Board A3:	
A. Phase switch S4 in NORMAL position:	
TP2	Ground
Bases Q1, Q5	14 mv
Collections Q1, Q5	0.28 v
TP1, TP3	23 mv
B. Phase switch S4 in REVERSE position:	
Bases Q8, Q10	14 mv
Collectors Q8, Q10	0.28 v
TP1, TP3	23 mv

TABLE 5-2. AC SIGNAL VOLTAGES (cont)

	Test Point	Correct Voltage
C.	Phase switch S4 in any position:	
	Collectors Q3, Q6	0.53 v
	Emitters Q7, Q11	0.52 v
D.	OUTPUT TRIM switch A3S1 in 0 (zero) position:	
	E13, E14	0.1 v
OUTPUT SECTION -- Board A1:		
	TP1	Ground
	Base Q4	6.6 mv
	Base Q13	35 mv
	Collectors Q4, Q13	0.5v
	TP4, TP6	0.14 v
	E17, E15	1.3 v
	Across 600-ohm output load	2.2 v rms (approx +8 dBm)

5-2. ALIGNMENT PROCEDURE

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.

A. AGC Alignment

(1) Set the INPUT LEVEL and OUTPUT SET controls fully clockwise.

(2) Apply a 1-kHz signal at 5 mv to the Volumax input. Set potentiometer R24 on board A2 fully clockwise. Measure the output and adjust A2R24 for a 6 dB reduction in the output signal.

(3) Adjust R12 on Board A2 until the GAIN REDUCTION meter reads full scale.

(4) Increase the input signal as required to cause the meter to read at the red-green junction; then set the POSITIVE LIMIT switch S3 at 100%.

(5) Place the LIMITER switch S2 in the OFF position and decrease the input level until the output as seen on an oscilloscope just begins to exhibit clipping. 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.

(6) Return the LIMITER switch to the upper (on) position and adjust the INPUT LEVEL control until the GAIN REDUCTION meter reading is at the red-green junction. Alternately adjust the INPUT LEVEL control and A2R17 until a) the output level is exactly 1 dB below the voltage recorded in step (4), and, b) the meter reads at the red-green junction.

B. Harmonic Distortion Alignment

(1) Apply a 5-kHz input signal at sufficient level to bring the GAIN REDUCTION meter reading to the red-green junction. While alternately setting the phase switch at NORMAL and REVERSE, adjust R10 on board A1 as

necessary to obtain minimum harmonic distortion for both phase switch positions, thus balancing the Variolosser.

(2) Set the POSITIVE LIMIT switch at 100% and apply a 1-kHz input signal at sufficient level to bring the GAIN REDUCTION meter reading to the red-green junction. Adjust R25 on board A2 for maximum output.

(3) Apply a 50-Hz input signal at a level just below the amplitude needed to deflect the GAIN REDUCTION meter downscale. Adjust R30 on board A1 for minimum harmonic distortion.

C. Pause Detector Adjustment

Monitor the voltage at TP6 on board A3 while making the following adjustments:

(1) Apply a 1-kHz input signal at sufficient level to bring the GAIN REDUCTION meter reading to the red-green junction.

(2) Measure the voltage at TP6 on board A3. It must be greater than +1.2 vdc; typically it should be about +1.5 vdc.

(3) Remove the input signal; the (now quiscent) voltage at A3TP6 should momentarily drop to +0.6 vdc or less.

(4) Adjust R99 on board A3 if necessary. As A3R99 is rotated clockwise, the pause detector sensitivity is increased; that is, the program level must drop lower to cause a momentary logical "high" at the pause detector output, A3TP6. Potentiometer A3R99 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 integrated circuit to

change state. The factory setting of A3R99 is such that the voltage at A3TP10 is about -1.2, which should cause the quiescent voltage at A3TP6 to be about +0.6 vdc.

D. Asymmetry Detector Alignment

To align the asymmetry detector, set R68 and R69 on board A3 as follows:

(1) With no signal input, monitor the dc voltage from A3TP8 to ground on the A.P.P. board. Adjust R69 until the reading is 10.0v ± 0.2v.

(2) Measure the voltage between A3TP8 and the junction of VR4, R59 and the collector of Q14. This voltage may be either positive or negative. Adjust R68 for a measurement of 0 ±0.2v.

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 to 11.0 volts, rather than 10. Similarly, a less sensitive setting can be found by reducing the value of A3TP8 to 9.0 volts.

Figure 4-2 shows the relationship of the voltage at A3TP8 to asymmetry sensitivity. Here "asymmetry" is defined as the ratio of higher peak amplitude to lower peak amplitude. This factor can vary between 1.0 for a pure sine wave to as much as 4.0 for unprocessed speech.

E. 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 signal.

(1) Set the output of a signal generator to approximately 1.5 volts and the frequency to 500 Hz. Place a silicon diode across the generator output. (Any diode such as a 1N456, 1N458, etc., may be used.) Then verify that the signal is sine-wave clipped on one side only.

(2) Apply this test signal to the Volumax unit and adjust the INPUT LEVEL control as necessary until the GAIN REDUCTION meter indication reaches the red-green junction.

(3) Remove the signal. Upon removal, the phase state should be NORMAL if the unclipped side of the sine wave was connected to pin 1 of the input-output connector.

(4) Re-apply the test signal with the unclipped side of the sine wave going to pin 2 of the input-output connector; then remove it. The phase state should change to REVERSE.

5-3. TROUBLESHOOTING INPUT SECTION -- BOARD A1

Check quiescent voltages as shown on the schematic diagram, figure 7-2. If signal is present at the collectors of A1Q1 and Q10 but is too low or too high at the bases of A1Q2 and Q11, measure the quiescent control voltage at A1TP2. This should be -0.5v ±0.1v. If it is not, potentiometer R24 on board A2 should be adjusted according to the alignment procedure in paragraph 5-2. If the attempt to set R24 fails to correct the problem, suspect the Variolosser diodes A1CR1, CR2. If these diodes must be replaced, select a matched replacement pair in which the forward voltage drops are within 10 mv of each other at 1 ma of forward current.

The remainder of the circuitry in this section is conventional.

5-4. TROUBLESHOOTING PHASE REVERSAL SECTION -- BOARD A3

Depending on whether the phase switch S4 is in the NORMAL or REVERSE position, transistor pair A3Q1, Q5, or A3Q8, Q10 will amplify the signal. If the integrated-circuit clocked flip flop A3A1 is defective or loose in its socket, it is possible that neither Variolosser A3CR1, CR2 or A3CR3, CR4 is biased off, in such case impressing signal at both A3Q1, Q5, and A3Q8, Q10. Since the two amplifier signals are summed out of phase at TP1, TP3, there will be little or no output.

With the phase switch in the NORMAL position, verify that pin 6 of A3A1 is at +1.3 vdc and that pin 9 is at +0.05 vdc. Place the phase switch in the REVERSE position and re-measure. Converse readings should be obtained.

Also verify that the supply potential for A3A1 is +4.7v ±0.4v. If it is not, check Zener diode A3VR5.

The remainder of this section is conventional in design. If any of the three push-pull amplifiers (Q1 and Q5, Q8 and Q10, or Q3 and Q6) appears to be at fault, check for the quiescent d-c voltages indicated on the schematic diagram, figure 7-4.

5-5. TROUBLESHOOTING OUTPUT SECTION -- BOARD A1

If signal is present at E3, E5 but not at TP4, TP6, check the quiescent d-c voltages of A1Q4, Q13. If signal is present at TP4, TP6 but not at E15, E17, check transistors A1Q5, Q6, Q14, and Q15. If the signal at E15, E17 is present but too low, either A1Q6 or Q15 may be at fault, since they both operate in the class A mode.

5-6. TROUBLESHOOTING AGC SECTION -- BOARD A2, FRONT HALF

To check for proper AGC action, set the LIMITER switch in the "on" (upper) 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 Variolosser diodes CR1 and CR2 on board A1.

(2) If the GAIN REDUCTION meter does not read downscale, monitor the voltage at A2TP7 while varying the input level as described above. Here the voltage should vary from about 0.0 vdc at an input level of 30 mv to about -0.3 vdc at an input level of 100 mv (10 dB greater). The FET A2Q5 is to be suspected if the gate voltage at A2TP7 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 A2R17 is 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%. The signal level at A2E6 should then be 1.5v and at E7 should be 0.12v rms. The a-c signal levels at the bases of A2Q2, Q4 should be approximately 110mv. Next, measure the voltages at A2TP2, TP6; each should be 4.3 vac. Correct voltages here in combination with no control voltage indicates defective diodes A2CR2 and/or A2CR3. 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 -- BOARD A3

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 A3A1, a clocked flip-flop, in this manner:

(a) Alternately ground pins 5 and 10 on the flip flop (see figure 5-3) or operate the phase switch S4 back and forth between the NORMAL and REVERSE positions. Each switch or alternate grounding operation should change the flip-flop state as indicated by the two front-panel indicator lamps. (Be sure that both lamps and the lamp driver transistors are operational. See paragraph 5-8.)

(b) Using a 1.5v battery or other low-impedance power supply, apply +1.5 vdc at A3TP5. Then apply and remove +1.5 vdc from A3TP6. Upon removal of the voltage from TP6, the flip-flop should be in the NORMAL state as indicated by the lighting of the NORMAL lamp (if not already lighted). Next, apply +1.5 vdc at A3TP7, then apply and remove +1.5 vdc at TP6 again. Now, upon removal of the voltage from TP6, the NORMAL light should go out and the REVERSE lamp 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 phase detector circuit.

(a) Monitor the voltage at A3TP6. With sufficient input to bring the GAIN REDUCTION reading to the red-green junction, the voltage at that point should be +1.2 vdc or greater.

(b) Drop the input level until the voltage falls to +1.0 vdc. This input level should be at least 16 dB below the original.

(c) Re-increase the input level to bring the GAIN REDUCTION reading to the red-green junction. Then remove the input entirely. The voltage should drop to less than +0.6 momentarily. The sensitivity may be increased by turning potentiometer A3R99 clockwise; however, do not advance the control above the point where the voltage at TP6 fails to drop as just described on the application and removal of signal.

(3) Check the asymmetry detector.

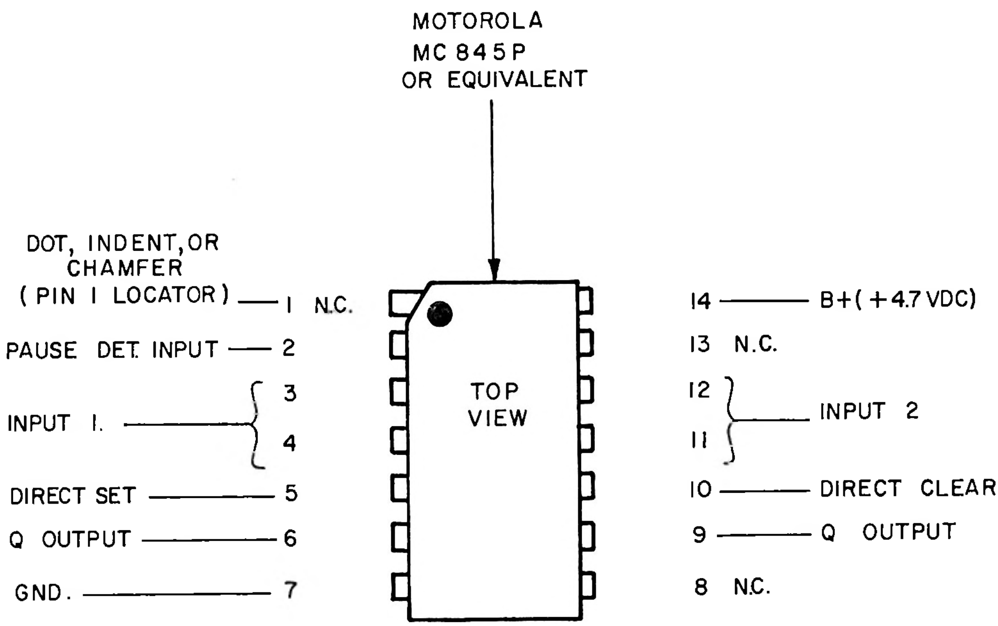


Figure 5-2. Integrated Circuit Pin Identifications

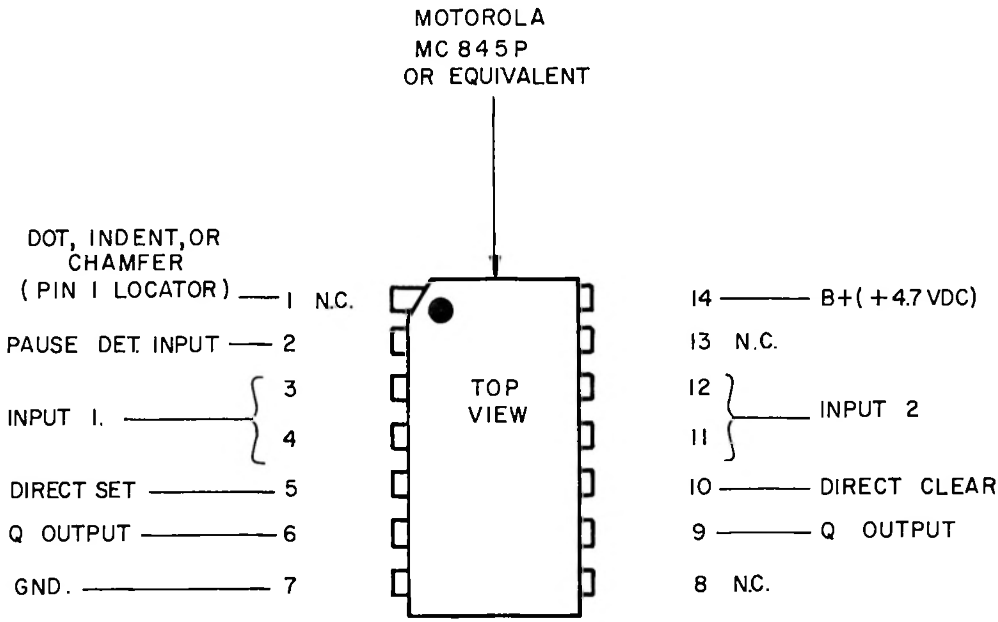


Figure 5-2. Integrated Circuit Pin Identifications

(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 a-c measurements at the emitters of A3Q13, Q20 should be 0.53 v rms.

(b) Check the quiescent d-c voltages at A3Q14, Q18, and Q21. See figure 7-4. If these voltages are correct, set A3R68 and A3R69 as described in the alignment procedure, paragraph 5-2.

5-8. TROUBLESHOOTING PHASE INDICATOR LAMP CIRCUITS

With power turned on, either one of the two phase indicator lamps, NORMAL or REVERSE, should be lit. When the phase switch S4 is in the NORMAL position, the NORMAL (left) lamp should be lit; when S4 is in the REVERSE position, the REVERSE (right) lamp should be lit. For the AUTO position, either the NORMAL or REVERSE lamps should be lit. If either lamp fails to light, check the bulb first. These are 18-volt bulbs operated at about 12 volts, and should have extremely long life. If the bulb is good, check its associated driver. Transistor Q23 on board A3 drives the NORMAL bulb while A3Q16 drives the REVERSE bulb. If both bulbs light simultaneously, or neither lights in any of the above tests, check the flip flop A3A1 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 using R12 on board A2.

SECTION VI

PARTS LIST

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 brand of transistor or diode 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.
AMPH	-	Amphenol
AMRA	-	American Radionics
AUG	-	Augat
BECK	-	Beckman
CBS	-	CBS Laboratories
CIN	-	Cinch Mfg.
CK	-	C and K Components
DIAL	-	Dialight
GE	-	General Electric
GRHL	-	Grayhill
HHS	-	Herman H. Smith
ID	-	Industrial Devices
IRC	-	International Resistance
LF	-	Littlefuse
MA	-	Mallory
MO	-	Motorola
SPR	-	Sprague
TI	-	Texas Instruments
TRW	-	TRW, Inc.
VE	-	Vero

6-5. MAIN ASSEMBLY (VOLUMAX 4000A)

Ref	Description	Mfr	Part No.
	Chassis assembly	CBS	962156
	Nameplate	CBS	960315-48
	Front panel assembly (See paragraph 6-6.)	CBS	962166
A1	Input/output printed circuit board assy (See paragraph 6-7.)	CBS	961611
A2	AGC/Power Supply circuit board assy (See paragraph 6-8.)	CBS	961607-2
A3	A.P.P. printed circuit board assy (See paragraph 6-9.)	CBS	961603
F1	Fuse, 0.3 amp	LF	3AG SLO-BLO
T1	Transformer, power	CBS	962133
T2	Transformer, audio	CBS	962132
TB1, TB3	Strip, terminal	HHS	850
TB2	Block, terminal	CIN	353-18-10-001
W1	Cable assy, jumper (includes plug connectors)		961684
XF1	Fuseholder	LF	342012
	Accessory kit and Assy*	CBS	962163-2
	Cable assy	CBS	961689-2
	Cable assy	CBS	961689-3
	Cable assy	CBS	961688-6

* Customer option

6-6. FRONT PANEL ASSEMBLY

Ref	Description	Mfr	Part No.
	Panel, front	CBS	962120-1
DS1	Lamp, pilot	ID	2150A1
DS2	Not used		
DS3, DS4	Lamp, cartridge	ID	515-0050
M1	Meter	CBS	961798-2
R1, R2	Resistor, variable, log taper, to 5 kilohms (10% of R at 50% of rotation)	AB	WA4N0125502AA
S1	Switch, SPDT	ALCO	MST-105D
S2	Switch, PPDT	ALCO	MST-205N
S3	Switch, 4PD5	CK	7411-HB
S4	Switch, SPDT	ALCO	MST-105E
XD53, XD54	Connector, lamp cartridge	DIAL	515-0050

6-7. INPUT/OUTPUT CIRCUIT BOARD ASSEMBLY A1

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		
R5	620 ohms		

6-7. INPUT/OUTPUT CIRCUIT BOARD ASSEMBLY A1 (cont)

Ref	Description	Mfr	Part No.
	RESISTORS (cont)		
R7, R13, R14 R19, R21, R22, R24, R36, R37, R41, R42	10 kilohms		
R8, R20	82 ohms		
R9	1. 8 kilohms		
R10	Variable, linear, Helitrim, to 1 kilohm	BECK	62PR1K
R11, R23, R28, R39	75 ohms		
R12	1 kilohm		
R15, R47	3 kilohms		
R16, R40	5. 6 kilohms		
R17, R48	30 kilohms		
R18	10 ohms		
R27, R38	100 kilohms		
R29	1.2 kilohms		
R30	Variable, linear Helitrim, to 2 kilohms	BECK	62PR2K
R31, R43	9.1 kilohms		
R32	15 ohms		
R33, R44	33 ohms		

6-7. INPUT/OUTPUT CIRCUIT BOARD ASSEMBLY A1 (cont)

Ref	Description	Mfr	Part No.
	CAPACITORS		
C1, C3 thru C6, C8 thru C10	Tantalum, Electrolytic, 4.7 µf ±20%, 35v	MA	TAC475M035P04
C2, C7	Tantalum, 8.2 µf, ±20%, 35v	MA	TAC825K035P04
	SEMICONDUCTORS		
CR1 and CR2	Diodes, matched pair, 1N456A		
Q1 thru Q5, Q7 thru Q14	Transistor, 2N3393		
Q6, Q15	Transistor, D40D4		
	MISCELLANEOUS		
	Etch, drill, and mark assy	CBS	961610

6-8. AGC/POWER SUPPLY CIRCUIT BOARD ASSEMBLY A2

Ref	Description	Mfr	Part No.
	RESISTORS		
R1	12 ohms, 3w, wirewound	SPR	242E1205
R2	3.9 ohms, 1/2w		
R3	470 ohms, 1/2w		
R4	68 ohms, 1/2w		
R5, R22	360 kilohms		
R6, R7, R23	5.1 kilohms		
R8, R15	10 kilohms		

6-8. AGC/POWER SUPPLY CIRCUIT BOARD ASSEMBLY A2 (cont)

Ref	Description	Mfr	Part No.
	RESISTORS (cont)		
R9, R16	82 ohms, 1/4w		
R10	7.5 kilohms		
R11, R18	100 kilohms		
R12, R24	Variable, linear, Helitrim, to 1 kilohm	BECK	62PR1K
R13	1 kilohm, 1/2w		
R14	82 ohms, 1/2w		
R17	Variable, linear, Helitrim, to 5K	BECK	62PR5K
R19	2.4 kilohms		
R20	470 kilohms		
R21	100 ohms, 2w		
R25	Variable, linear, Helitrim, to 100 ohms	BECK	62PR100
R26	4.3 kilohms		
R27	Not used		
R28	1.8 kilohms		
R29	3 kilohms		
*	91 kilohms		
*	36 kilohms		

* Option at terminals E17, E18, and E19, E20. See figure 7-3.

6-8. AGC/POWER SUPPLY CIRCUIT BOARD ASSEMBLY A2 (cont)

Ref	Description	Mfr	Part No.
	CAPACITORS		
C1 thru C4, C7, C8	Electrolytic, 250 μf, +100%, -10%, 50v	MA	TCW250N050P1J
C5, C6, C10, C11	Tantalum electrolytic, 4.7 μf, 20%, 35v	MA	TAC475M035P04
C9	0.47 μf, 10%, 100v	AMRA	2MBPC1474K
	SEMICONDUCTORS		
CR1	Bridge rectifier diode assy	VE	VE 18
CR2, CR3	Diode, 1N456A		
Q1	Transistor, 2N3766		
Q2, Q4	Transistor, 2N3393		
Q3	Transistor, D41D1	GE	
Q5	Transistor, field effect	TI	TIS58 (Yel stripe)
VR1	Diode, zener 20v, 5%, 1N4747A		
VR2	Diode, zener 15v, 5%, 1N4744A		
	MISCELLANEOUS		
	Etch, drill, and mark assy	CBS	961606

6-9. A.P.P. CIRCUIT BOARD A3

Ref	Description	Mfr	Part No.
	RESISTORS		
R1, R5, R19, R24	47 kilohms		
R2, R25, R29, R53, R59, R81, R91	5.1 kilohms		
R3, R15, R21, R23, R26, R30, R37, R52, R54, R82	10 kilohms		
R4, R31	5.11 kilohms, 1%, 1/8 w	IRC	CEA-T-O
R6, R20, R32, R50, R96	2.7 kilohms		
R7, R14, R33, R51, R100	150 ohms		
R8, R27, R34, R35	1.8 kilohms		
R9, R11, R22, R61, R71, R72, R83	1 kilohm		
R10, R16	180 ohms, 1%, 1/8 w	IRC	CEA-T-O
R12	91 kilohms		
R13, R36	Variable, linear to 5 kilohms	BECK	62PR5K
R17	4.7 kilohms		
R18	110 kilohms		
R28, R38	Metal film, 15.00 kilohms, 1%, 1/8w	IRC	CEA-T-0

6-9. A.P.P. CIRCUIT BOARD A3 (cont)

Ref	Description	Mfr	Part No.
	RESISTORS (cont)		
R39	Metal film, 7,500 ohms, 1%, 1/8w	IRC	CEA-T-0
R40	Metal film, 8,250 ohms, 1%, 1/8w	IRC	CEA-T-0
R41	Metal film, 9,090 ohms, 1%, 1/8w	IRC	CEA-T-0
R42	Metal film, 10,000 ohms, 1%, 1/8w	IRC	CEA-T-0
R43	Metal film, 11.3 kilohms, 1%, 1/8w	IRC	CEA-T-0
R44	Metal film, 12.40 kilohms, 1%, 1/8w	IRC	CEA-T-0
R45	Metal film, 14.00 kilohms, 1%, 1/8w	IRC	CEA-T-0
R46	Metal film, 15.80 kilohms, 1%, 1/8w	IRC	CEA-T-0
R47	Metal film, 18.2 kilohms, 1%, 1/8w	IRC	CEA-T-0
R48	Metal film, 21.0 kilohms, 1%, 1/8w	IRC	CEA-T-0
R49	Metal film, 6,810 ohms, 1%, 1/8w	IRC	CEA-T-0
R55 thru R57	Not used		
R58, R79	3.3 kilohms		
R60	510 ohms, 1/2w		
R62 thru R64	Not used		

6-9. A.P.P. CIRCUIT BOARD A3 (cont)

Ref	Description	Mfr	Part No.
	RESISTORS (cont)		
R65, R77	3.9 kilohms		
R66, R67, R78, R80, R92, R94	100 kilohms		
R68	Variable, linear Helitrim, to 200 ohms	BECK	62PR200
R69	Variable, linear Helitrim, to 2 kilohms	BECK	62PR2K
R70	1.5 kilohms		
R73, R84	300 ohms		
R74 thru R76	Not used		
R85 thru R87	Not used		
R88	20 kilohms		
R89	7.5 kilohms		
R90, R97	910 ohms		
R93	4.3 kilohms		
R95	3 kilohms		
R98	5.6 kilohms		
R99	Variable, linear, to 1 kilohm	BECK	62PR1K
R101, R102	18 kilohms		
R103	Variable, 50 kilohms	BECK	62PR50K
R104	300 kilohms	AB	CB

6-9. A.P.P. CIRCUIT BOARD A3 (cont)

Ref	Description	Mfr	Part No.
	CAPACITORS		
C1, C3, C4, C6, C10, C15, C16, C18	Tantalum electrolytic, 4.7 μf, 20%, 35v	MA	TAC475M035P04
C7	Not used		
C8, C11, C13	Tantalum electrolytic 22 μf, 20%, 15v	MA	TAC226M015P04
C9, C14	Metalized polyester, 0.47 μh, 10%, 100v	AMRA	2MBPC1474K
C12	Not used		
C17	Metalized polyester, 1 μf, 10%, 100v	AMRA	2MPC1105K
	SEMICONDUCTORS		
CR1-CR2, CR3-CR4, CR6-CR7, CR8-CR9	Diodes, silicon, matched pairs, 1N456A		
CR5	Diode, silicon, 1N456A		
Q1 thru Q11, Q13 thru Q16, Q18, Q20 thru Q23, Q25, Q26	Transistor, 2N3393		
Q12	Not used		
Q17	Not used		
Q19	Not used		
Q24	Transistor, 2N3906	MO	
VR1, VR3	Diode, avalanche, zener, 5.6v, 5%	TRW	LVA56A

6-9. A.P.P. CIRCUIT BOARD A3 (cont)

Ref	Description	Mfr	Part No.
	SEMICONDUCTORS (cont)		
VR5	Diode, avalanche, zener, 4.7v, 5%	TRW	LVA47A
VR2	Diode, zener, 5%	TRW	LVA68A
VR4, VR6	Diode, zener, 12v, 10%, 1N4742A		
	MISCELLANEOUS		
A1	Integrated circuit, clocked flip flop	MO	MC845P
S1	Switch, 11-position, shorting	GRHL	9YY-232-02-1-11S*
XA1	Socket, integrated circuit	AUG	314-AG5D-3
	Etch, drill, and mark assy	CBS	961602

* Pins on one side (CBS Laboratories p/n 991328)

SECTION VII

DRAWINGS

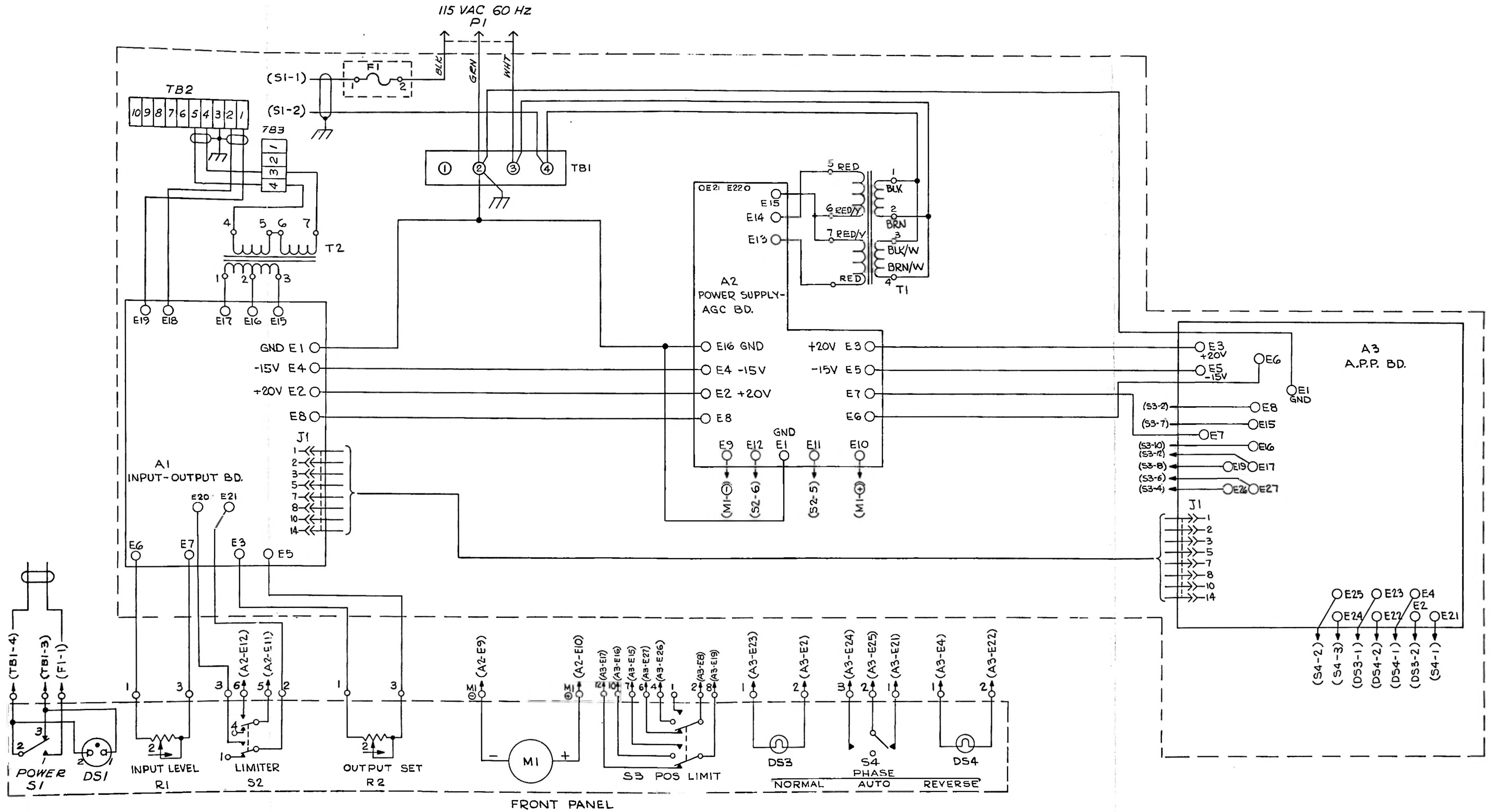
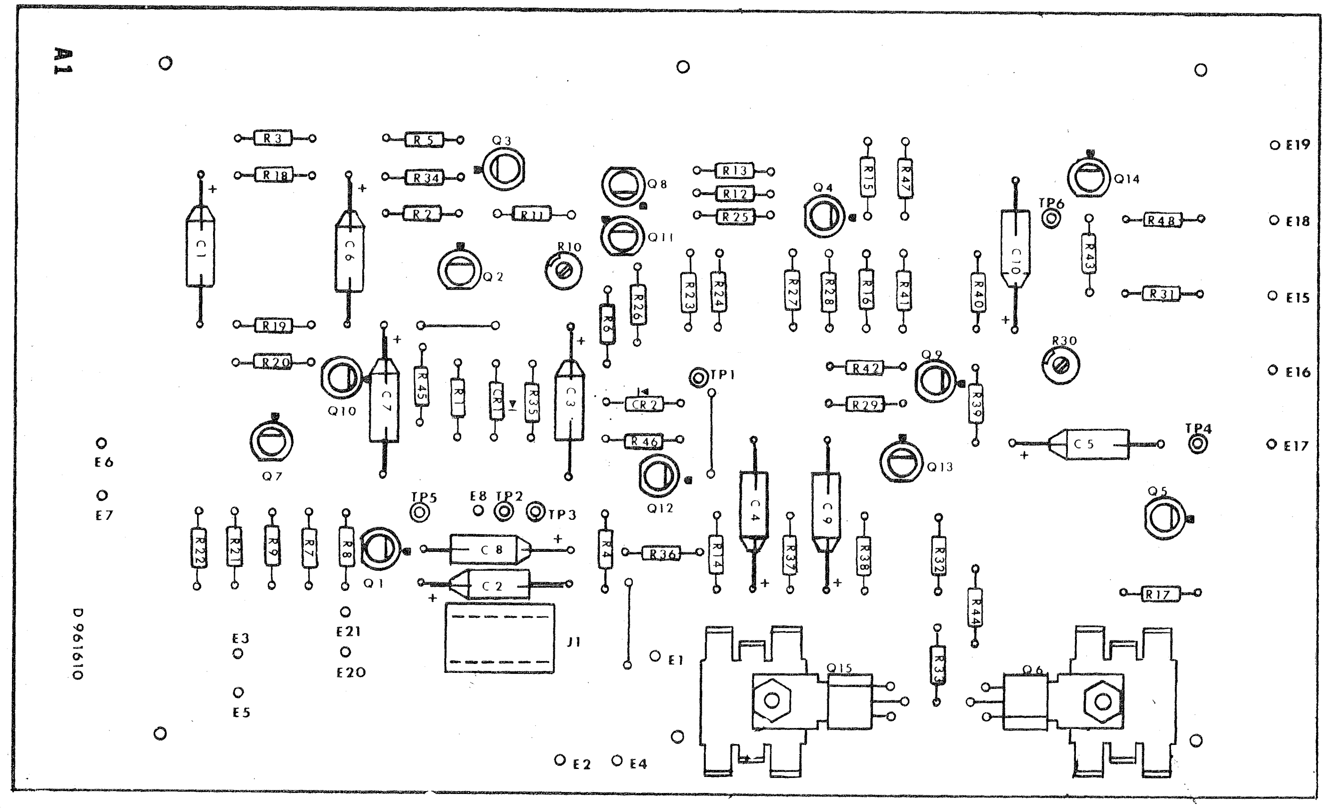
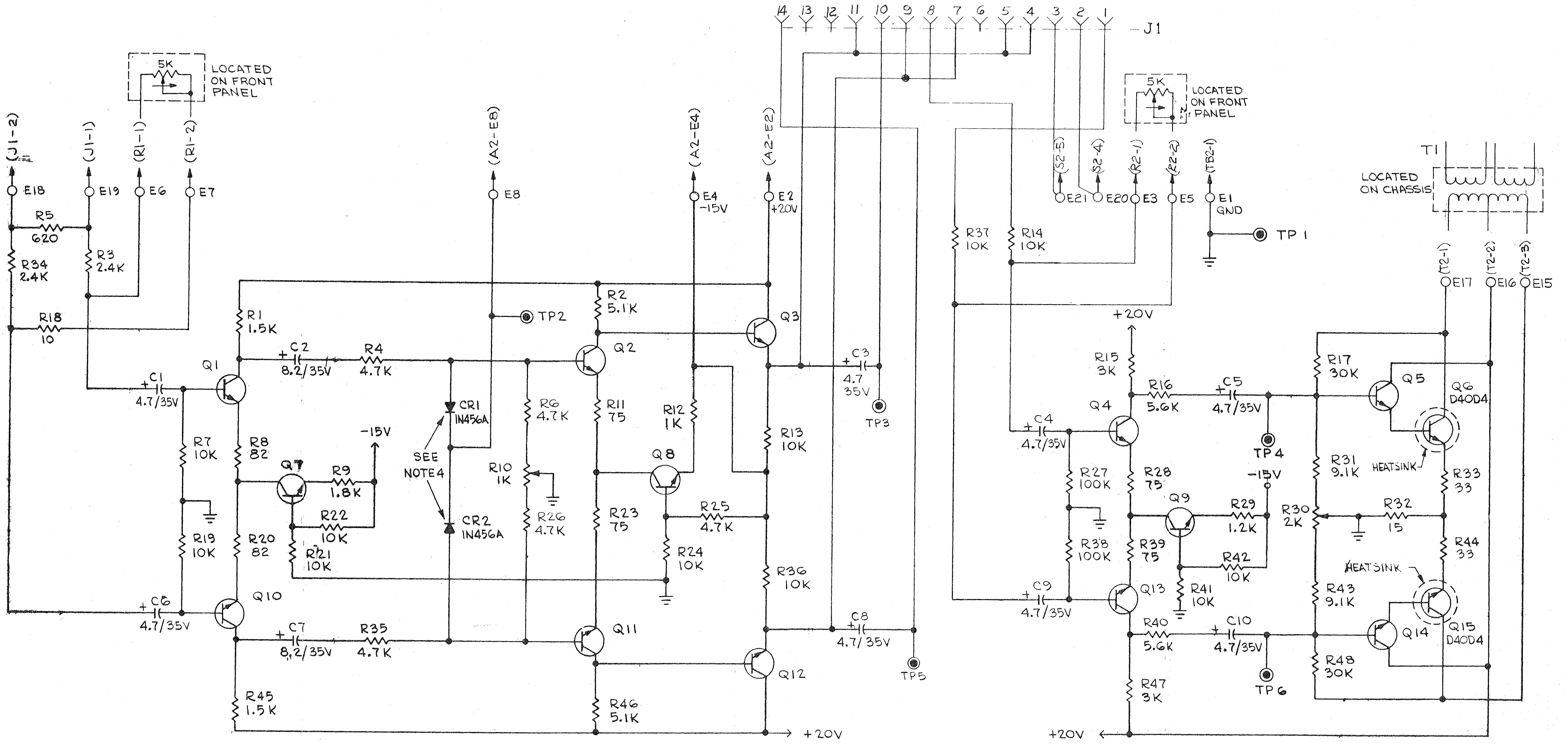


Figure 7-1. Volumax Model 4000A, Internal Interconnections

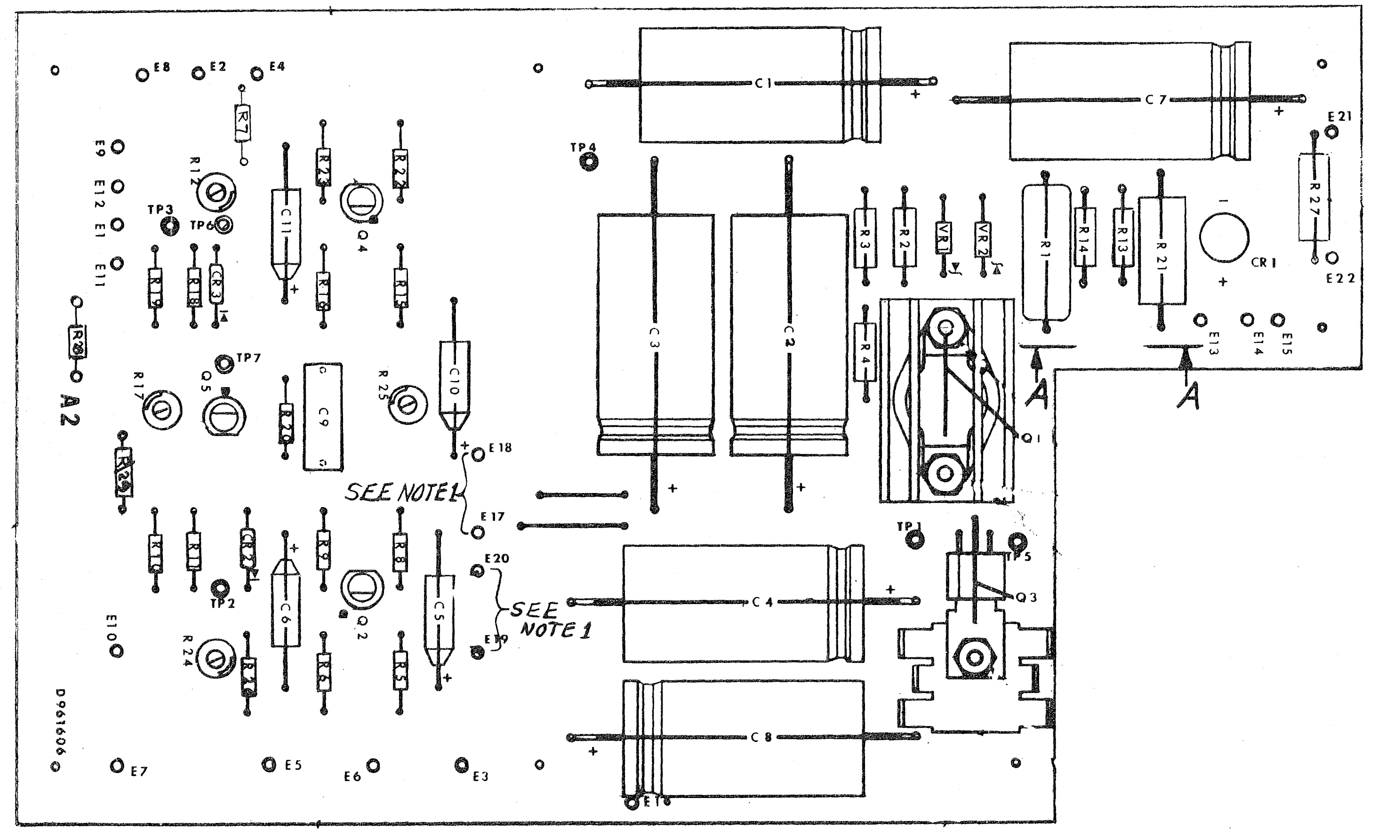


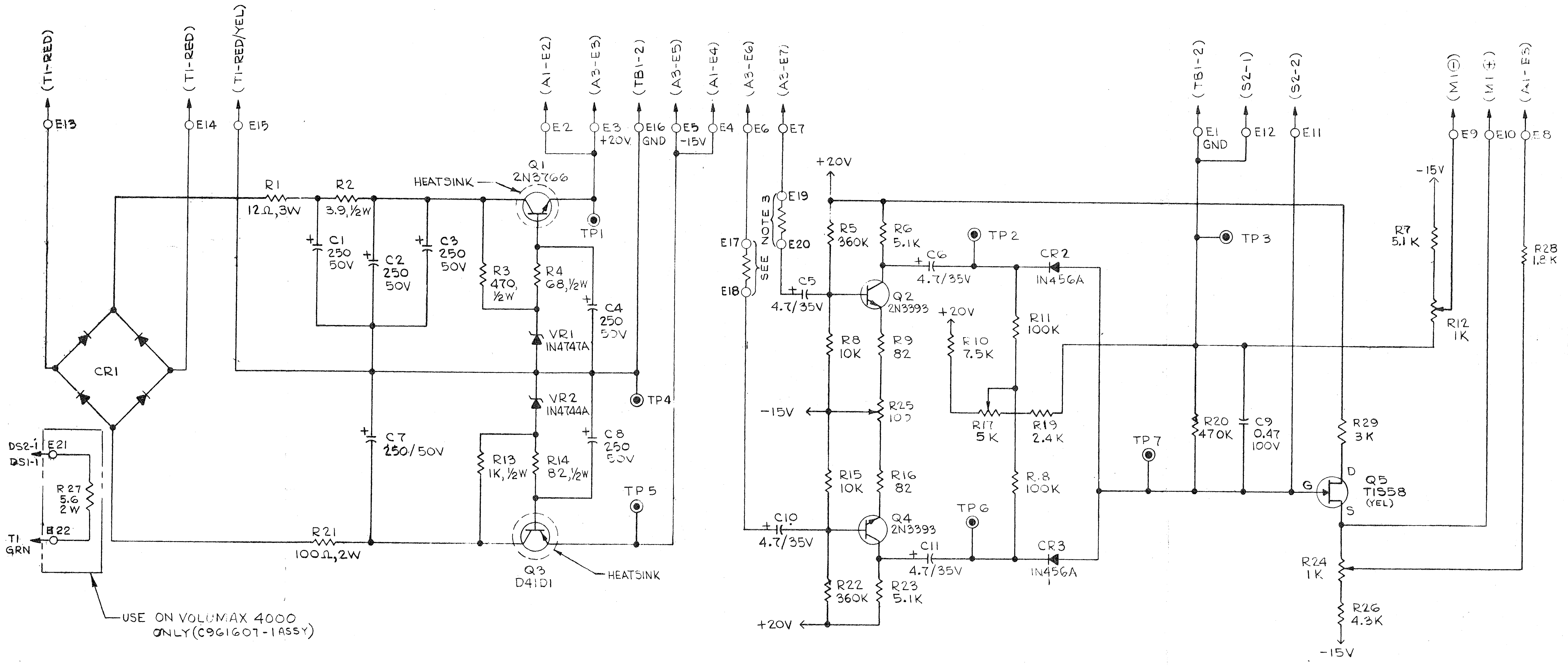


NOTES: (UNLESS OTHERWISE SPECIFIED)
1. ALL RESISTOR VALUES ARE IN OHMS, POWER RATING 1/4 W, 5%.
2. ALL CAPACITOR VALUES IN MICROFARADS
3. ALL TRANSISTORS ARE 2N3393
4. CR1 & CR2 ARE MATCHED DIODES

HIGHEST REFERENCE DESIGNATIONS
C10, CR2, Q15, R48, TP6, E21
REFERENCE DESIGNATIONS NOT USED
E9-14

Figure 7-2. Input/Output Board A1, Schematic Diagram and Parts Locations





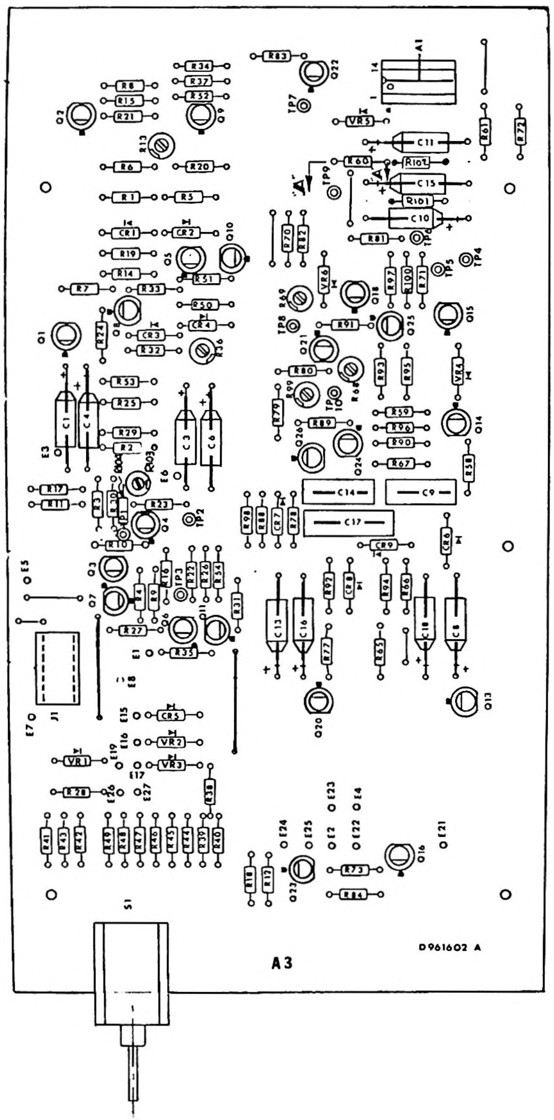
NOTES:

(UNLESS OTHERWISE SPECIFIED)

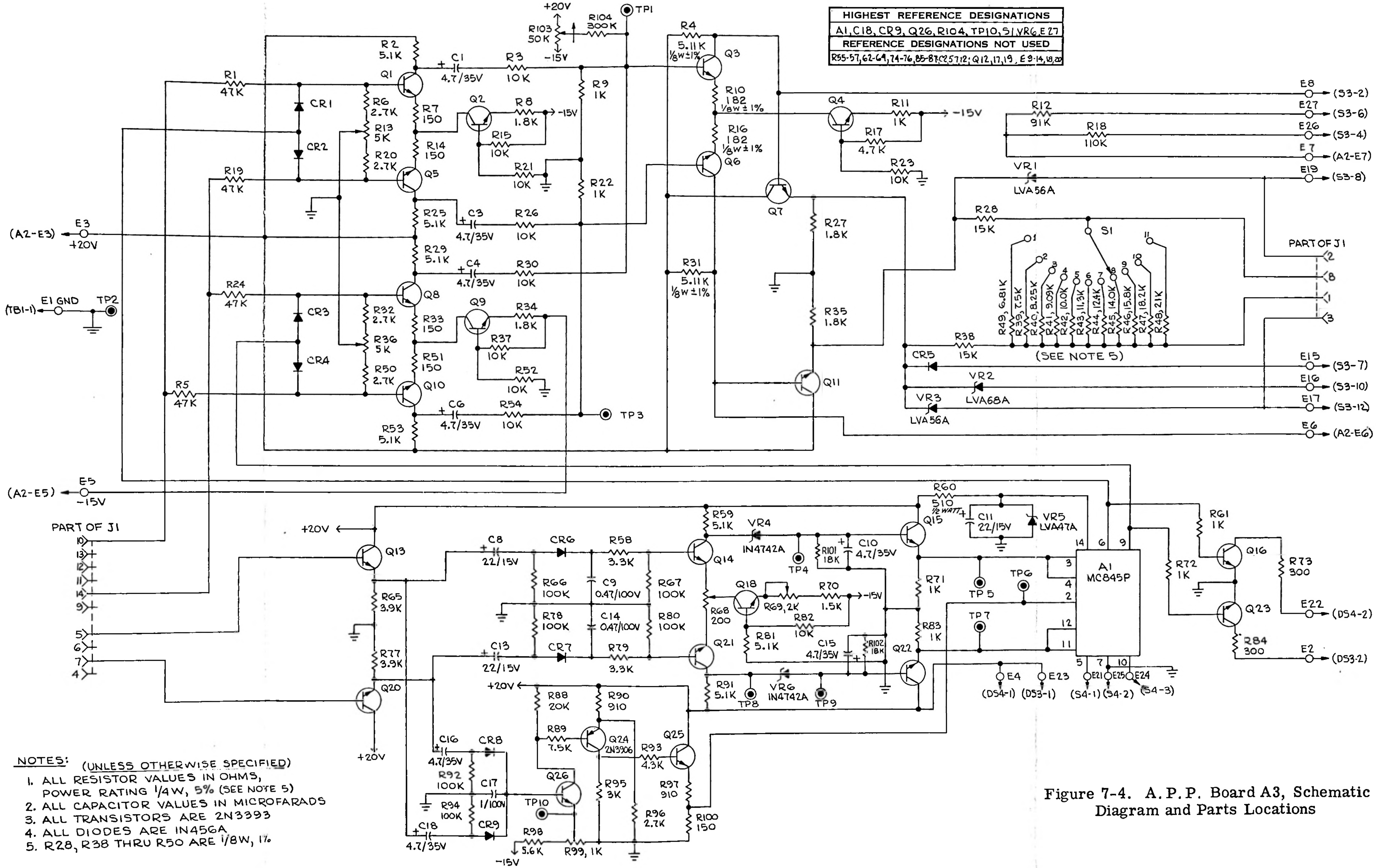
1. ALL RESISTOR VALUES ARE IN OHMS, POWER RATING 1/4 W, 5%
2. ALL CAPACITOR VALUES IN MICROFARADS
3. VOLUMAX 4000: E17-E18 CONNECT 91 K Ω 1/4 W. RESISTOR
   E19-E20 SHORT TERMINALS
   VOLUMAX (WITHOUT APP FUNCTION):
   E17-E18 CONNECT 36 K Ω 1/4 W. RESISTOR
   E19-E20 CONNECT 36 K Ω 1/4 W. RESISTOR
4. FOR METER CBS Nº 961675: R28 IS REPLACED BY A JUMPER AND R7 IS REPLACED BY A 82 K Ω RESISTOR.

HIGHEST REFERENCE DESIGNATIONS
C11, CR3, Q5, R29, TP7, VR2, E22
REFERENCE DESIGNATIONS NOT USED

Figure 7-3. Power Supply/AGC Board A2, Schematic Diagram and Parts Locations


A3
D961602 A
S1
J1
A1

HIGHEST REFERENCE DESIGNATIONS
A1, C18, CR9, Q26, R104, TP10, S1, VR6, E27
REFERENCE DESIGNATIONS NOT USED
R55-57, 62-64, 74-76, 85-87, C2, 5, 7, 12; Q12, 17, 19, E9-14, 18, 20



NOTES: (UNLESS OTHERWISE SPECIFIED)

1. ALL RESISTOR VALUES IN OHMS, POWER RATING 1/4W, 5% (SEE NOTE 5)
2. ALL CAPACITOR VALUES IN MICROFARADS
3. ALL TRANSISTORS ARE 2N3393
4. ALL DIODES ARE IN456A
5. R28, R38 THRU R50 ARE 1/8W, 1%

Figure 7-4. A.P.P. Board A3, Schematic Diagram and Parts Locations https://bh.hallikainen.org