OPERATING AND SERVICE MANUAL

MODEL 1801F
AND
PL-1186A/USM
DUAL CHANNEL VERTICAL AMPLIFIER

SERIALS PREFIXED: 901–

Refer to Section I For Instruments With Other Serial Prefixes

HEWLETT-PACKARD COMPANY/COLORADO SPRINGS DIVISION
1900 GARDEN OF THE GODS ROAD, COLORADO SPRINGS, COLORADO, U.S.A.

02659-1

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Table 1-1. Specifications

MODE OF OPERATION

Channel A alone.

Channel B alone.

Channels A and B displayed on alternate sweeps (ALT).

Channels A and B displayed by switching at approximately a 400 kHz rate, with blanking during switching (CHOP).

Channel A plus Channel B (algebraic addition, A + B).

Channel A and B displayed on alternate sweeps but triggered by B Channel only (ALT B TRIGGER).

EACH CHANNEL

Deflection Factor (Sensitivity): 0.005 V/div to 20 V/div (12 positions in a 1, 2, 5 sequence); vernier extends minimum sensitivity to 50 V/div, a sensitivity calibration adjustment for each channel is provided on the front panel.

Attenuator Accuracy: ± 3%.

Magnification: X1-X5 Magnifier extends the most sensitive range to 1 mV/div.

Bandwidth (Direct or with probes, 3 db down from 6 div, from 25 ohm source.): DC coupled, dc to 50 MHz; AC coupled, 2 HZ to 50 MHz. In X5 the bandwidth of the amplifiers is reduced to 20 MHz.

Risetime (Direct or with probes): Less than 7 nsec with 6 div input step; 10% to 90% from 25 ohms source.

Input RC: 1 megohm shunted by approximately 25 pF.

Maximum Input Signal: AC coupled, ± 600 volts (dc + peak ac); DC coupled, 150V (dc + peak ac) at 5 mV/div increasing to ± 350V (dc + peak ac) at 20 V/div.

Polarity Presentation: + or — UP selectable.

A + B INPUT

Amplifier: Bandwidth and sensitivity remain unchanged. Either Channel A or B may be inverted to give ±A ±B operation.

Differential Input (A—B): DC to 26 MHz, common mode rejection is at least 26 db on all ranges with maximum common signal equivalent to 12 divisions.

TRIGGERING

Mode:

Channel A or Channel B alone, or Channel A plus Channel B; on the signal displayed (A or B).

Channel A and Channel B displayed by switching at approximately a 400 kHz rate; on Channel B alone (CHOP).

Channel A & B displayed on alternate sweeps; on each channel or Channel B alone (ALT and ALT B TRIGGER).

Frequency:

Provides sufficient signal to the time base for triggering over the range of dc to 50 MHz in all modes except CHOP (100 kHz in CHOP) with 0.5 div pk-pk signal or more displayed on the CRT.

WEIGHT

Net, 4 lbs (1,8 kg); Shipping, 6-1/2 lbs (3,0 kg).

SECTION I

GENERAL INFORMATION

1-1. INSTRUMENT DESCRIPTION.

1-2. The Hewlett-Packard Model 1801F Dual Channel Vertical Amplifier (shown in Figure 1-1) is a ruggedized, militarized wideband plug-in unit for the HP Model 180-series Oscilloscopes. The Model 1801F meets all requirements of the military environmental specifications, Mil-0-24311 (DC) providing the plug-in is used in a Model 180F system. Dual channel capability allows display of one signal alone or two signals simultaneously. Two waveforms can be superimposed, each with the full 8-div amplitude. Each channel of the plug-in has a bandwidth of 50 MHz, a risetime of less than 7 nsec, and a maximum calibrated deflection factor (sensitivity) of 5 millivolts per division. The minimum calibrated deflection factor is 20 volts per division and a vernier can extend the minimum sensitivity to 50 volts per division. The vertical sensitivity can be increased by a factor of 5. In X5 the bandwidth of the amplifiers is reduced to 20 MHz.

1-3. In addition to a display of either signal alone, either a chopped or alternating display of two signals is possible. With the chopped display, switching occurs at a 400 kHz rate and the CRT trace is automatically blanked during switching (eliminating undesirable transients from the display). In the chopped mode, the sweep is triggered from the Channel B signal. With alternate operation, the time base may be triggered either on the signal displayed by each channel or on the Channel B signal alone. Channel A plus Channel B (algebraic addition) may also be selected and either channel can be inverted to obtain a differential (A—B or B—A) display. Common mode rejection for the differential input (A—B) operation is at least 26 db on all ranges. Complete specifications for the Model 1801F are provided in Table 1-1.

1-4. SCOPE OF MANUAL.

1-5. This manual provides operating and service information for the HP Model 1801F Dual Channel Vertical Amplifier. This manual supplements that information presented in the Operating and Service Manual for the HP Model 180-series Oscilloscopes. For specific information on other plug-ins for the Model 180-series Oscilloscope, refer to the manual for the specific plug-in unit.

1-6. INSTRUMENT IDENTIFICATION.

1-7. Hewlett-Packard uses a two-section eight-digit serial number to identify instruments. The first three digits (preceding the dash) are the serial prefix which identifies a series of instruments; the last five digits identify a particular instrument in the series. The serial number appears on a plate located on the rear panel. All correspondence with a Hewlett-Packard Sales/Service Office in regard to an instrument should reference the model number and the complete serial number.

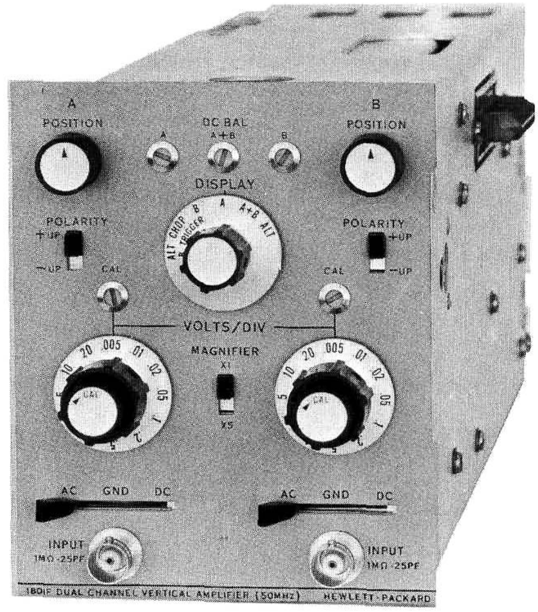


Figure 1-1. Model 1801F Dual Channel Vertical Amplifier

1-8. MANUAL CHANGES.

1-9. This manual provides complete information for any Model 1801F with a serial number prefixed (see Paragraph 1-6) by the three digits indicated on the title page. If the serial prefix of the instrument is different from that on the title page, a MANUAL CHANGES' sheet supplied, or Section VII of this manual, will describe changes which will adapt this manual to provide correct coverage. Technical corrections (if any) to this manual, due to known errors in print, are called ERRATA and are shown on the change sheet. For information on manual coverage of any HP instrument, contact the nearest HP Sales/Service Office (addresses are listed at the rear of this manual).

1-10. OPTIONS.

1-11. There are two options available for the Model 1801F. Option 20 has navy nomenclature (PL1186A) on the front panel and also has a Navy serial tag on the rear panel along with Hewlett-Packard's serial tag. Option 21 also has Navy nomenclature (PL1186A) on the front panel but does not have a Navy serial tag.

SECTION IV

PRINCIPLES OF OPERATION

4-1. INTRODUCTION.

4-2. The Model 1801F Dual Trace Vertical Amplifier allows two input signals to be displayed separately or simultaneously on Model 180-series Oscilloscopes. Descriptions of basic circuits used in Model 1801F are covered first in the section. A block diagram of the Model 1801F is shown in Figure 4-6 and a brief explanation of its function is given in next several paragraphs. The last several paragraphs give detailed circuit description of the overall Model 1801F.

4-3. The following paragraphs contain information on basic circuits used in the Model 1801F. The information which follows is intended to be used in conjunction with the information given in the detailed circuit portion of this section. No attempt has been made to cover all phases of each circuit operation, however, the information given should prove helpful to a better understanding of this instrument.

4-4. ATTENUATOR. An attenuator network is essentially a frequency compensated voltage divider that is used to control the input level to an amplifier. The attenuator shown in Figure 4-1 is a ten-to-one divider, because the resistance of R2 equals one-tenth the total resistance of R1 plus R2. However, to maintain a constant 10:1 division ratio over a board frequency range, capacitances must be compensated. C3 is inherent capacitance of the attenuator and includes input capacity of the amplifier when connected to an amplifier. Capacitor C2 is variable to provide compensation and equal reactance ratio between branches of the attenuator. C2 is adjusted for an optimum square wave response (since a square wave is multi-harmonic) to assure wide band operation. Input capacitance is set by adjusting C1.

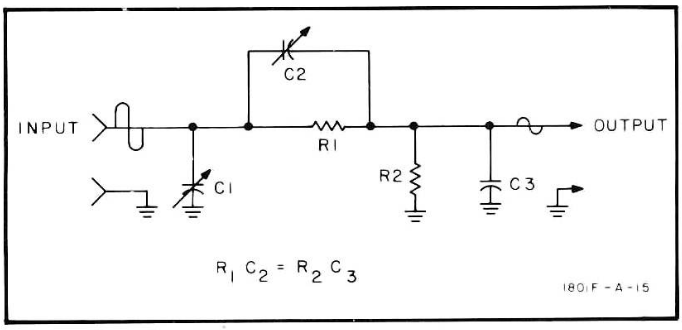


Figure 4-1. Basic Attenuator Circuit

4-5. IMPEDANCE CONVERTER. Although there are several methods of accomplishing impedance conversion, the circuit shown in Figure 4-2 is used frequently in HP equipment. An impedance converter is a circuit designed to make use of a high input impedance and then convert to a low output impedance. Q1, the field effect transistor (FET), provides this high input impedance (similar to a vacuum tube).

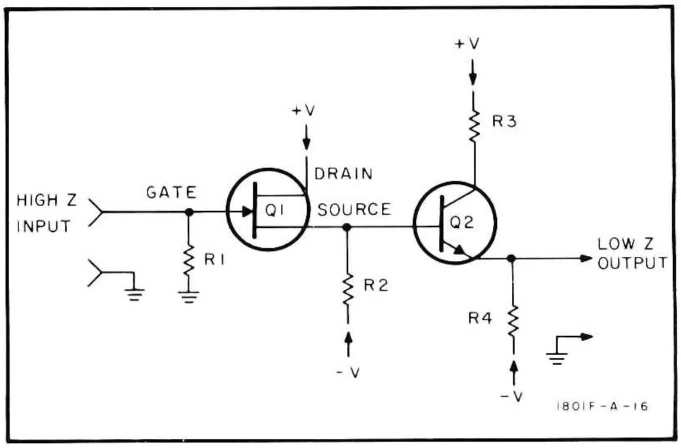


Figure 4-2. Basic Impedance Converter Circuit

4-6. Source follower (FET) Q1 coupled with emitter follower Q2 produces a high to low impedance conversion. Due to the high input impedance of Q1, the input resistance is established by R1. Output impedance, at the emitter of Q2, is low and voltage gain is approximately one.

4-7. CASCODE AMPLIFIER. A basic Cascode Amplifier, shown in Figure 4-3, consists of a common base stage Q2 driven by common emitter stage Q1. This combination makes it possible to achieve the frequency response and gain necessary for wide band operation.

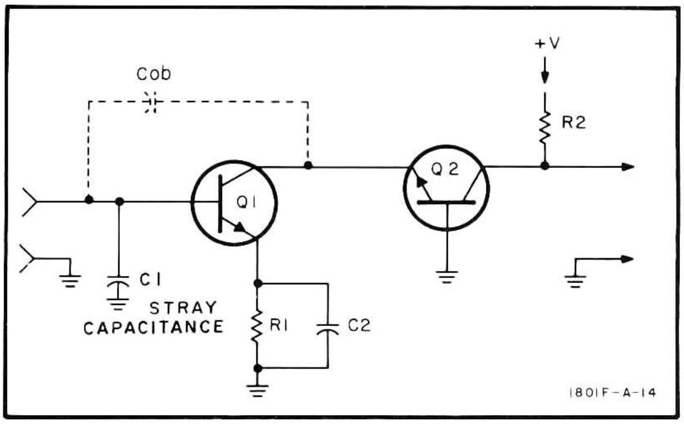


Figure 4-3. Basic Cascode Amplifier Circuit

for Q103/Q104. Protection against excessive signal input to Q101 is provided by R119, R120 and CR102. The back-resistance current flow through CR102, although small, is compensated for by CR101. High-frequency signals through R119 are provided a low reactance path by C129, which ensures that there will be no loss of high frequency signal components. DC balance adjustment of the input converter is accomplished with R124, which is used to equalize the source voltages of Q101 and Q102.

4-26. INPUT AMPLIFIER.

4-27. The signal from the emitter of Q103 and Q104 is applied to the differential cascode amplifier Q301/Q303 and Q302/Q304. Differential amplifier action is obtained by cross-coupling Q301 and Q302 emitter current flow through R304 and C301. The differential signal current generated flows into the emitter of Q303 and Q304. The over-all gain of the cascode amplifier is controlled by R308 (Calibrate) and R309 (VERNIER), which shunt current from the emitter of Q303 and Q304. Differences in the base-emitter drop of Q303 and Q304 are compensated for by adjustment of R317 to eliminate variation of the DC output level of the instrument when an amplification change is made by varying R309 and/or R308. The over-all DC level is adjusted by R303.

4-28. Compensation for the signal phase-delay occurring in the undriven section of the differential cascode amplifier is the function of the network consisting of T301, C305, and C306; and is accomplished prior to driving emitter-followers Q305/Q306.

4-29. Polarity diode gates are used for selection of +UP (non-inverting) or —UP (inverting) of the instrument input signal. This action is controlled by the POLARITY selection switch, S301. Selecting +UP turns on CR306-CR309, coupling the signal from Q305 to Q307 and from Q306 to Q308. When —UP is selected CR302-CR305 are turned on, coupling the output of Q305 to Q308 and the output of Q306 to Q307. The front-panel control POSITION (R338) establishes the relative base voltages of Q307 and Q308, thus determining the vertical position of the trace on the CRT. Frequency compensation for this stage is accomplished in the emitter circuits of Q307 and Q308. A portion of the Channel B signal at the bases of Q407 and Q408 is directed to the Sync Amplifier through R718 and R719.

4-30. Channel A or Channel B selection and switching is accomplished by the use of channel diode gates. Voltages for operation of the gates are obtained from a multivibrator, which is controlled by the front panel DISPLAY switch. A negative output voltage from the multivibrator will cause CR313 and CR314 to become non-conducting and CR315 and CR316 to conduct. Channel A signals are thus passed on for further amplification and display. Application of a positive voltage from the multivibrator causes CR313 and CR314 to conduct and short circuit the signal voltage, while CR315 and CR316 become non-conducting and disconnect the channel amplifier. In the A+B mode of DISPLAY, both channels are turned on by negative voltages from the multivibrator. R354 is used to balance the gate current flowing through delay line DL501. A portion of the differential signal from the output of the channel diode gates is fed to the Sync Amplifier through R701 and R702.

4-31. MAIN AMPLIFIER.

4-32. The differential signals from the channel selector diode gates pass through the 160 nsec Delay Line, DL501, to the current summing amplifiers Q501 and Q502. Capacitor C501 is used to match the delay line and amplifier impedances for optimum response. Signals from the collectors of Q501 and Q502 are applied to emitter-followers Q503/Q504 with drive signal amplifiers Q505 and Q506. The amplified output signal is coupled through emitter-followers Q507/Q508 to the cascode differential amplifiers Q509/Q512, and the oscilloscope vertical deflection plates are driven by the output voltage variation of the cascode amplifiers. Diodes CR501 and CR502 are used to provide high frequency compensation for Q509 and Q510 by utilizing their variation in reverse-bias capacitance occurring with changes in signal voltage.

4-33. Also in the emitter circuits of Q509 and Q510 is the X1-X5 magnifier. This switch will extend the sensitivity of the vertical amplifier by a factor of five. When the switch is in the X5 position, the relay closes and decreases the emitter resistance of Q509 and Q510. This decreases the amount of degeneration and increases the gain of this stage by a factor of five.

4-34. BEAM FINDER.

4-35. Current for operation of the cascode amplifier flows through the normally closed contacts of the FIND BEAM switch of the oscilloscope. When this switch is depressed, the contacts are opened and the current source for the amplifier is reduced by R528 to limit the vertical excursion of the CRT beam so that it is on screen.

4-36. MULTIVIBRATOR.

4-37. Operation of multivibrator Q601/Q602 is controlled by the DISPLAY switch, S302. Its outputs are applied through emitter followers Q603/Q604 to the Channel A and B diode gates.

4-38. When the DISPLAY switch is set in the ALT or ALT B TRIGGER position the multivibrator is bistable. This is accomplished by connecting the +15V supply to R607 and R610. A negative-going alternate trigger signal is generated by the oscilloscope at the end of each sweep. These pulses are coupled to the bases of Q601 and Q602 through the steering diodes CR603 and CR604. Each trigger pulse turns on the non-conducting transistor, switching the multivibrator to its other state. Thus each channel is alternately switched on for a complete sweep.

4-39. In the CHOP B TRIGGER mode of operation the multivibrator is made astable by applying −12V through R607 and R610, and +15V through R611. Diodes CR603 and CR604 are biased off, blocking the alternate trigger signal, and the multivibrator operates to switch the channels on and off at a 400 kHz rate.

4-40. Selecting Channel A, Channel B or A+B (both channels) sets the multivibrator to a fixed state. The accompanying Table 4-1 provides details of the multivibrator status and voltage output for each of these selected operating modes. Keep in mind that a + voltage puts the channel diode gate in a condition of shorting the amplifier signal and disconnecting the channel, resulting in no display signal from that channel.

Table 4-1. Multivibrator Status and Output

Display Selected	MV STATE		Output voltage to Channel Diode Gates	
	Q601	Q602	A	B
A	OFF	ON	–	+
B	ON	OFF	+	–
A+B	OFF	OFF	–	–

4-41. In the CHOP mode of operation, the junction of R626/R627 is grounded, turning off Q605. The square wave signal from Q603 and Q604 is differentiated by C607/R618 and C608/R620, and the positive going pulses are detected by CR608 and CR609. Applied to the base of Q605 the positive-going signal turns on Q605, resulting in a negative-going pulse at its collector. Current flow through the divider network R630/R631 holds Q606 biased off. The negative pulse from the collector of Q605 is differentiated and turns Q606 on, resulting in a positive collector voltage. This positive voltage is directed to the oscilloscope CRT blanking circuitry, and results in CRT trace blanking during channel switching.

4-42. When any other mode of operation is selected, +15V is applied to the base of Q605 through R626/R627, resulting in saturation. CR608 and CR609 are also biased off by the positive voltage. Therefore, no signal will be developed at the input to Q605.

4-43. SYNC AMPLIFIER.

4-44. The deflection signal from the channel gates is applied to the base of Q701 and Q702. After being inverted it is coupled through emitter followers Q703/Q704 to a diode gate, CR701 through CR704. R707 adjusts the operating point of the inverter. The Channel B signal is coupled through emitter followers Q705 and Q706 to a diode gate, CR705 through CR708. The DISPLAY switch determines which diode gate is on. In the ALT, A+B, A, and B modes, CR701 through CR704 are turned on, and the composite signal is applied to the cascode amplifier, Q707 through Q710.

4-45. Selecting either CHOP B TRIGGER or ALT B TRIGGER modes turns on CR705 through CR708, directing the Channel B signal to the cascode amplifier. When the composite signal is selected R715 provides for Balance adjustment of the dc output of the cascode amplifier. The output is balanced by R729 when the Channel B signal is selected. The output of the cascode amplifier is applied to the balun amplifier which converts the balanced push-pull signal from the cascode amplifier into a single ended output signal. R751 adjusts the operating point of the balun amplifier.

4-46. Amplified by Q714, the single-ended signal is coupled through complementary emitter follower Q715/Q716 to the Horizontal Plug-In. CR710 and CR711 prevent Q714 from saturating in an overload condition.

4-47. Selecting CHOP B TRIGGER forward biases CR712 and CR713, thus inserting C719 into collector circuit of Q714. The addition of C719 decreases the bandwidth of the Sync Amplifier, preventing the possibility of triggering on high frequency noise.

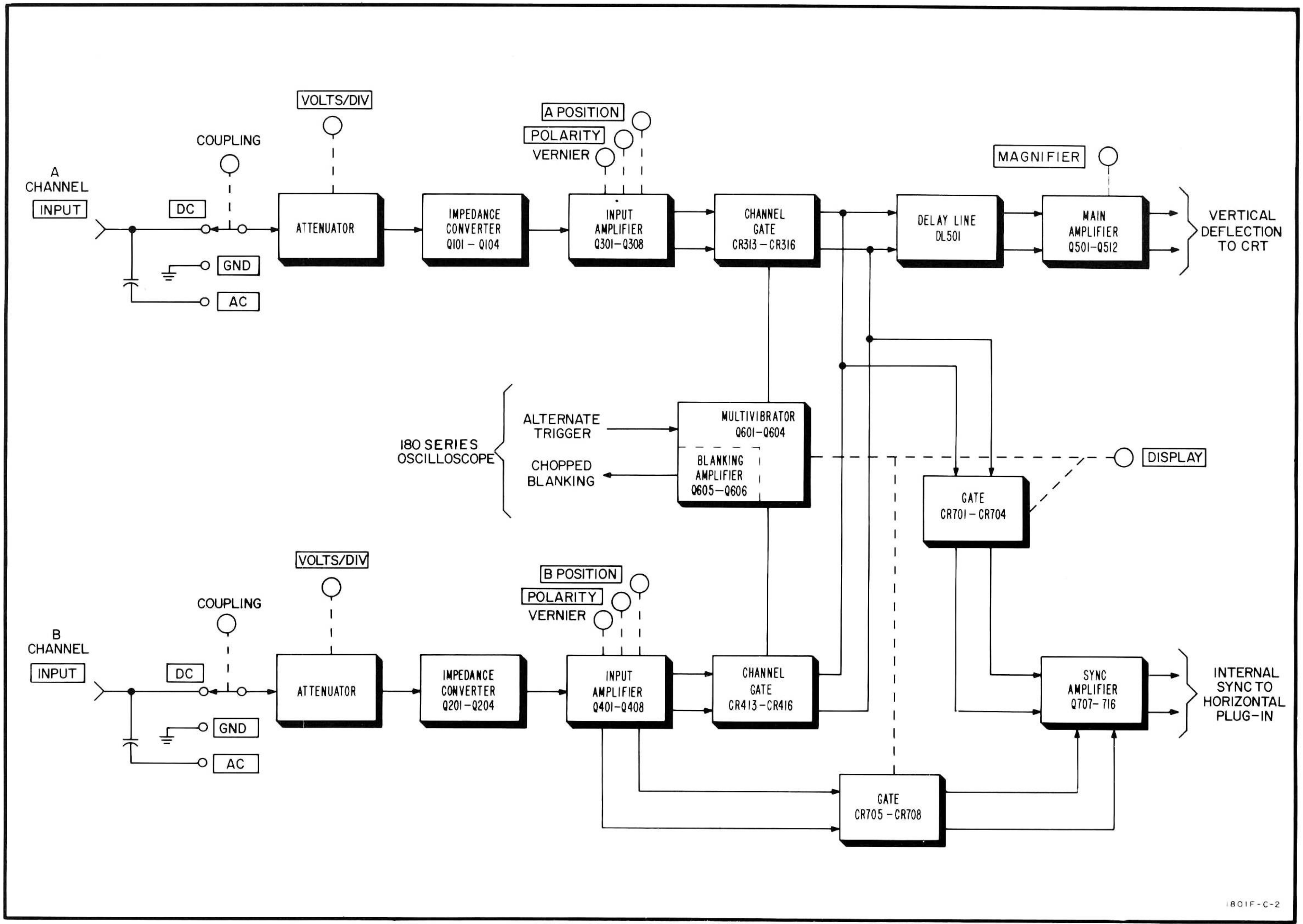


Figure 4-6. Model 1801F Block Diagram

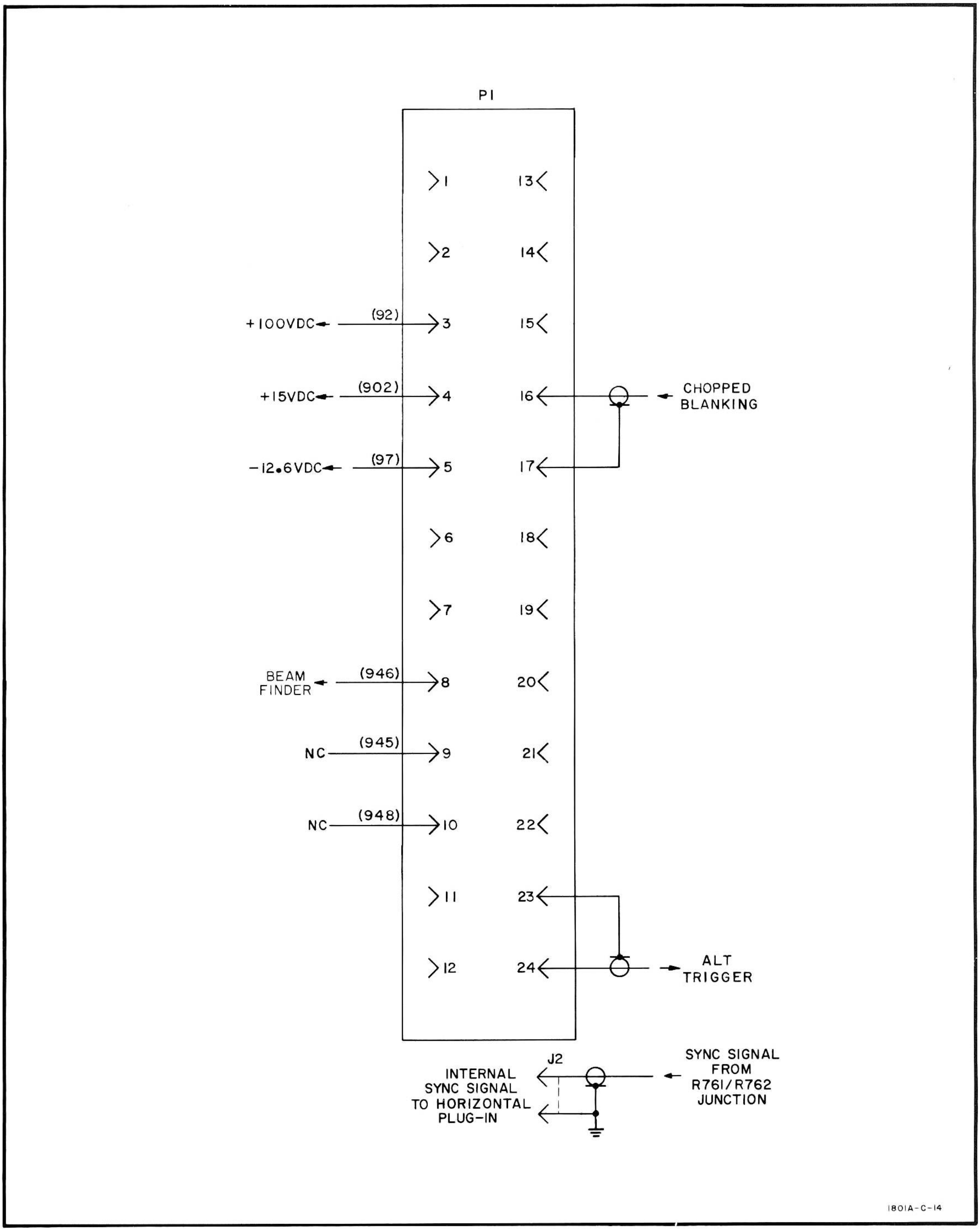


Figure 8-1. Plug and Jack Connection

Component Location
for A3 inside fold

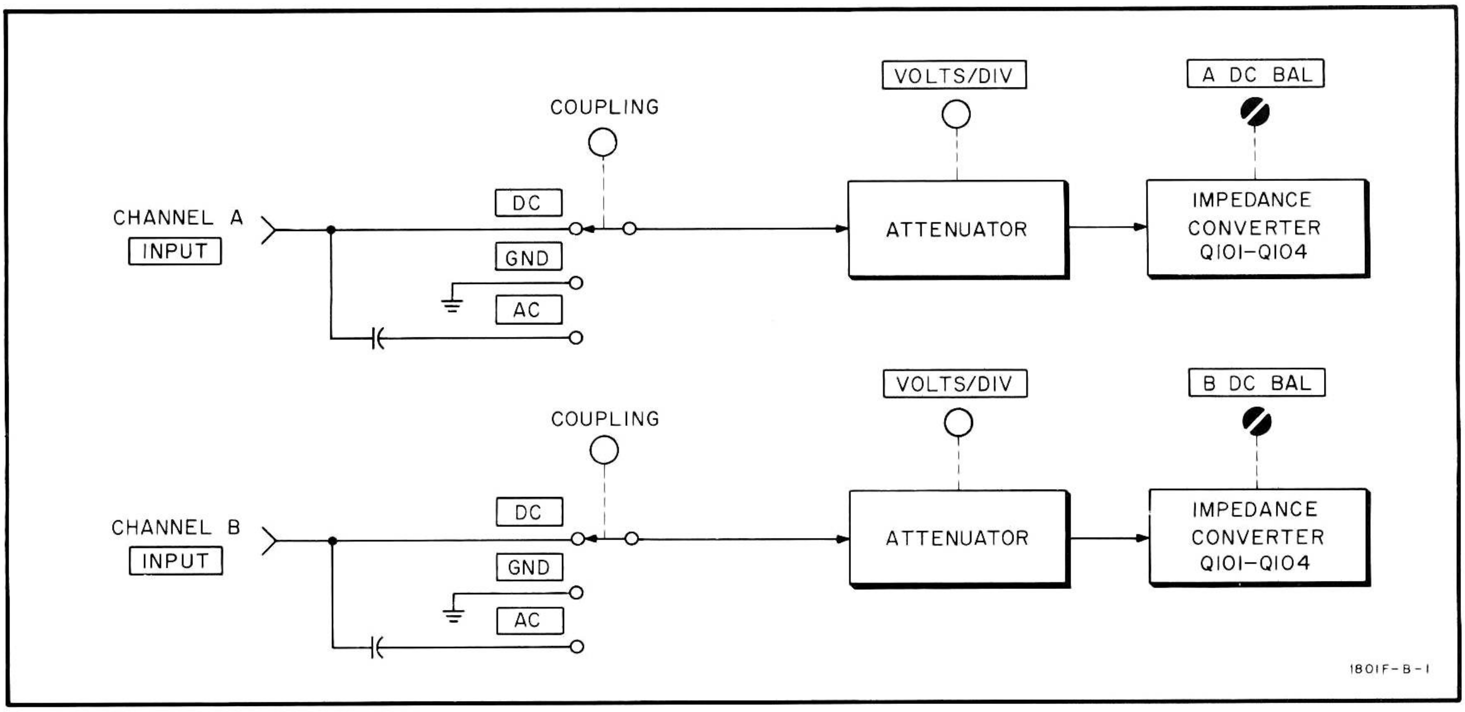
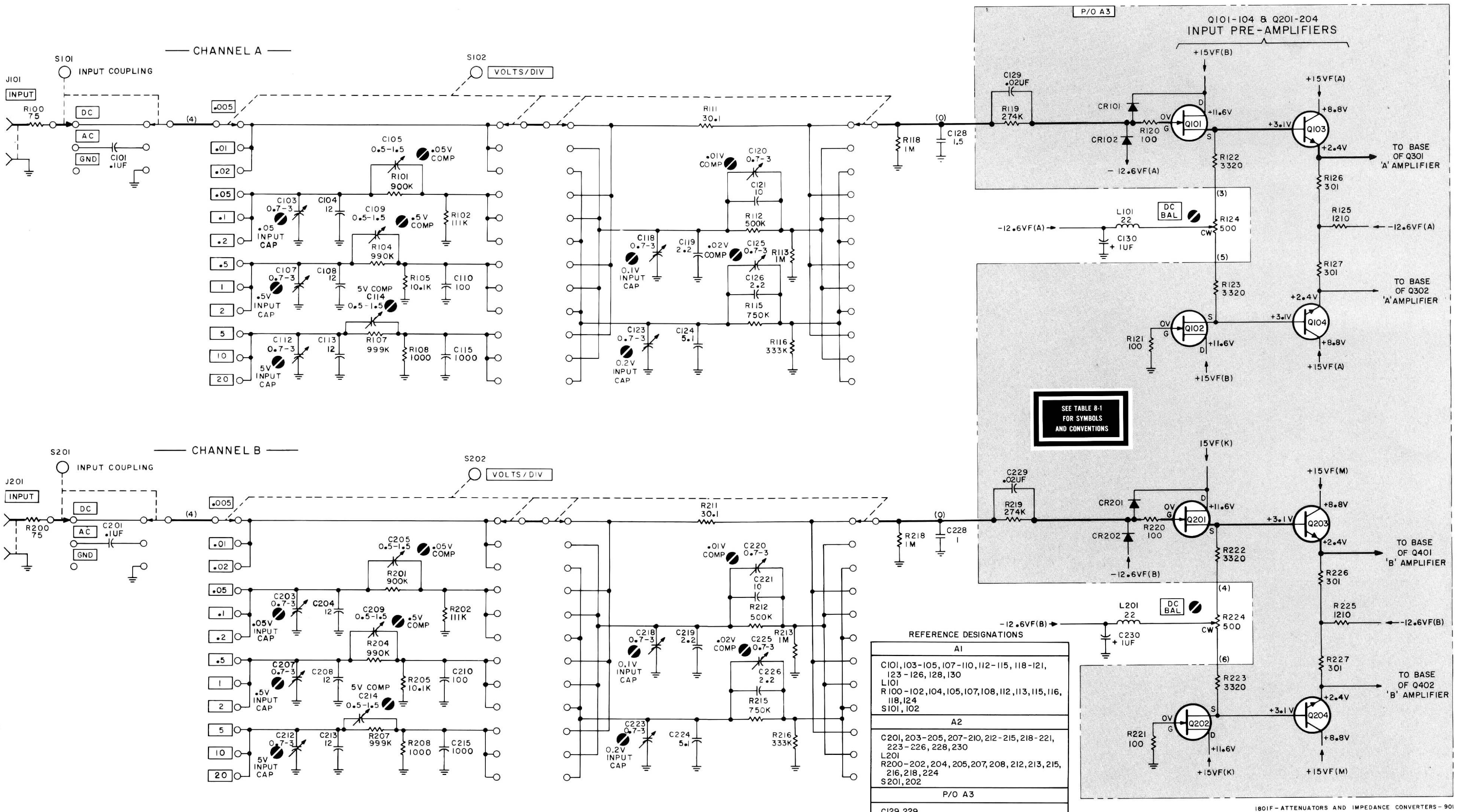


Figure 8-3. Attenuators and Impedance Converters Block Diagram



REFERENCE DESIGNATIONS

A1
C101, 103-105, 107-110, 112-115, 118-121, 123-126, 128, 130 L101 R100-102, 104, 105, 107, 108, 112, 113, 115, 116, 118, 124 S101, 102
A2
C201, 203-205, 207-210, 212-215, 218-221, 223-226, 228, 230 L201 R200-202, 204, 205, 207, 208, 212, 213, 215, 216, 218, 224 S201, 202
P/O A3
C129, 229 CR101, 102, 201, 202 Q101-104, 201-204 R119-123, 125-127, 219-223, 226, 227

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Figure 8-5. Attenuators and Impedance Converters
Schematic Diagram 8-5

Component Location
for A3 in Figure 8-2

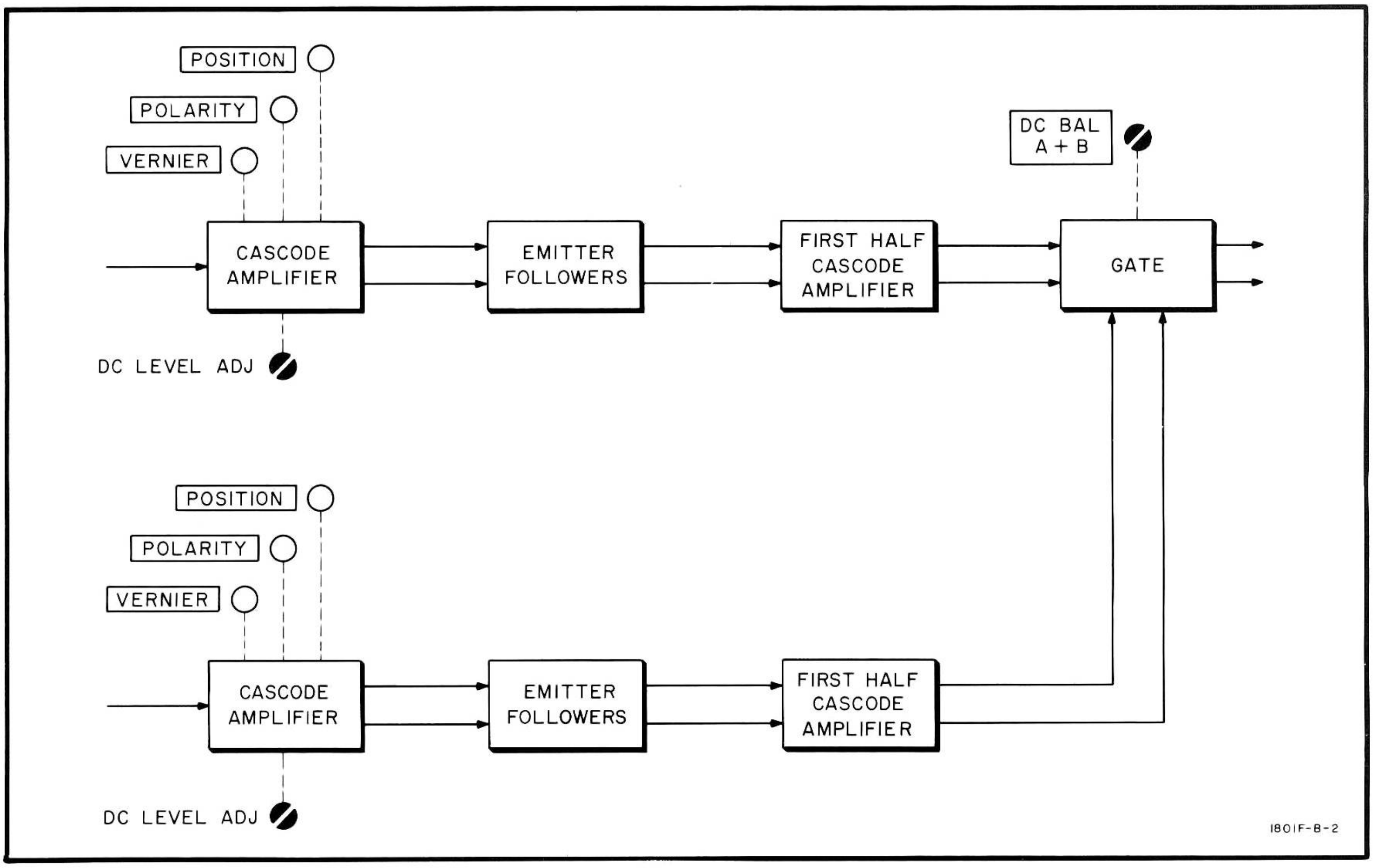


Figure 8-6. Input Amplifiers Block Diagram

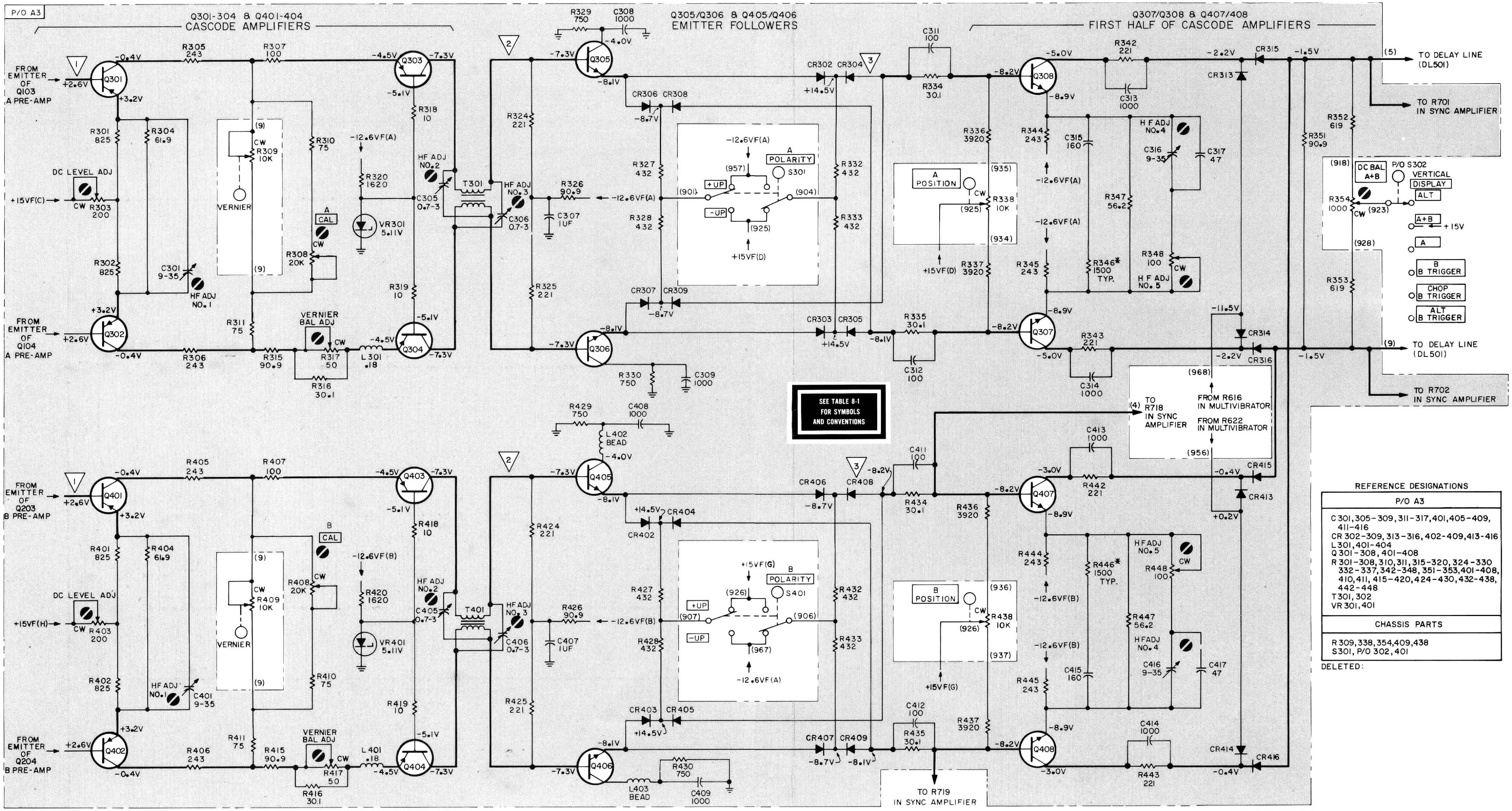


Figure 8-8. Input Amplifiers Schematic Diagram

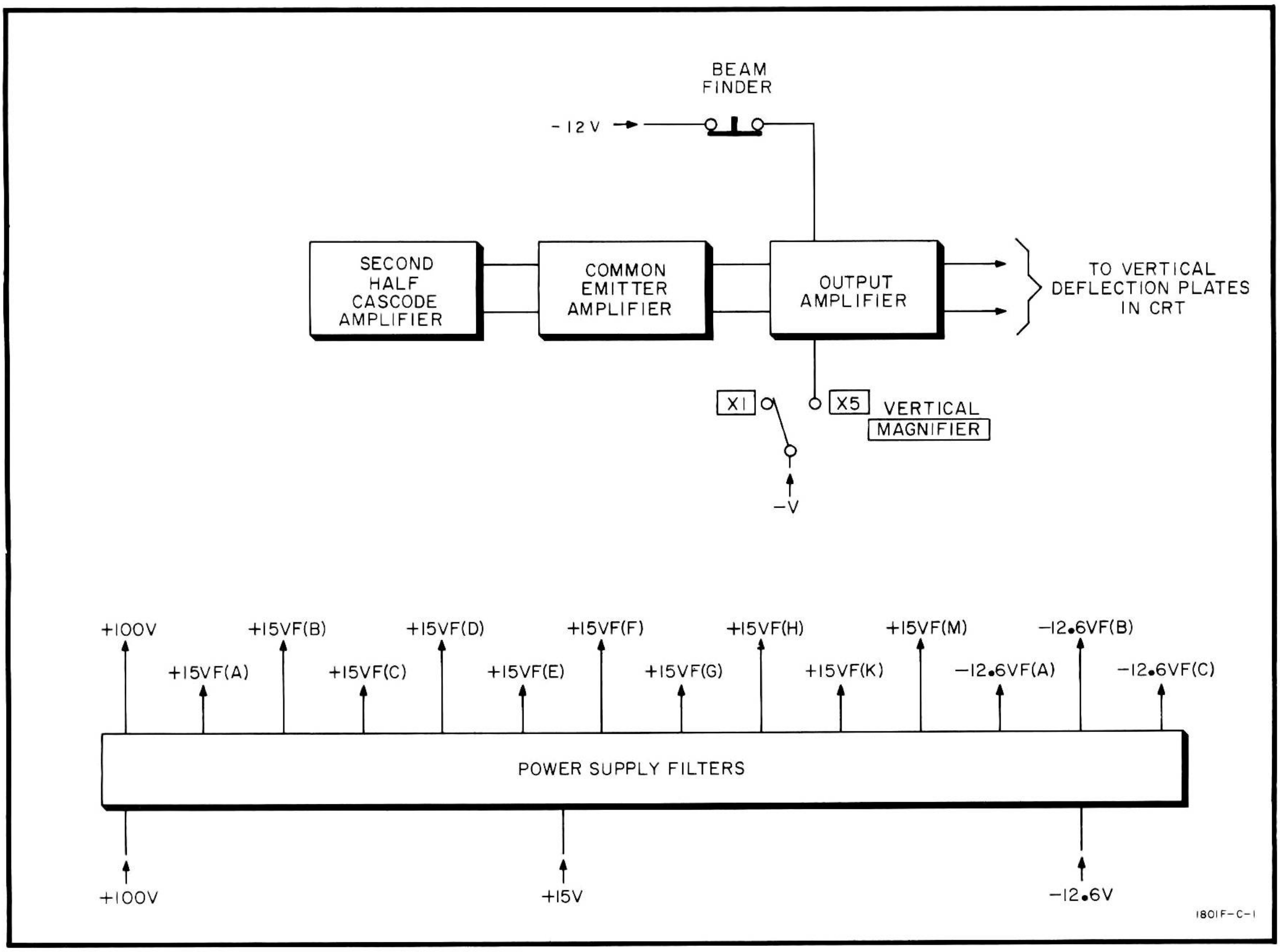
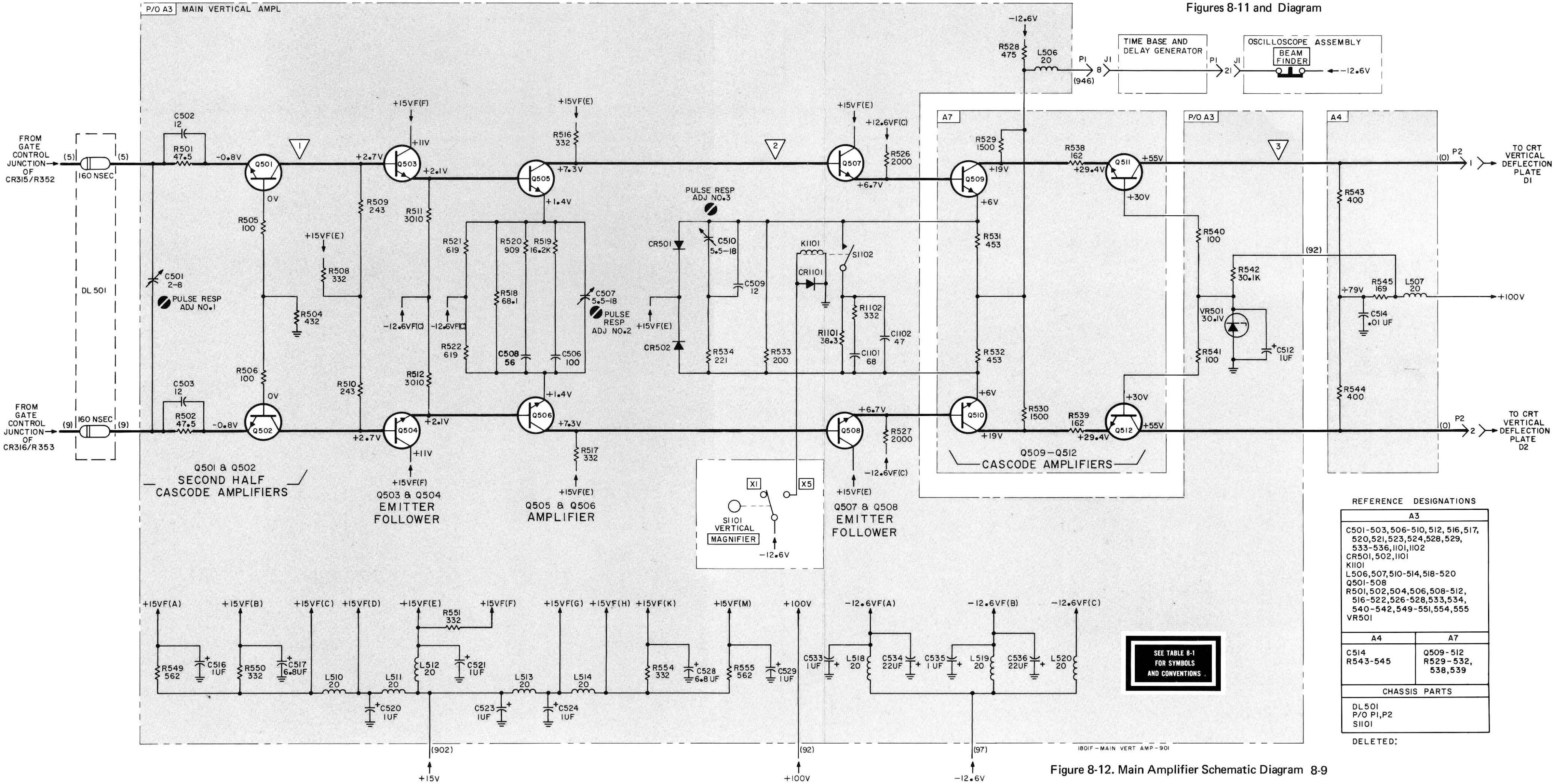


Figure 8-9. Main Amplifier Block Diagram



REFERENCE DESIGNATIONS

A3	
C501-503, 506-510, 512, 516, 517, 520, 521, 523, 524, 528, 529, 533-536, 1101, 1102 CR501, 502, 1101 K1101 L506, 507, 510-514, 518-520 Q501-508 R501, 502, 504, 506, 508-512, 516-522, 526-528, 533, 534, 540-542, 549-551, 554, 555 VR501	
A4	**A7**
C514 R543-545	Q509-512 R529-532, 538, 539
CHASSIS PARTS	
DL501 P/O P1, P2 S1101	

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SEE TABLE 8-1 FOR SYMBOLS AND CONVENTIONS

Figure 8-12. Main Amplifier Schematic Diagram

Component Location
for A5 inside fold

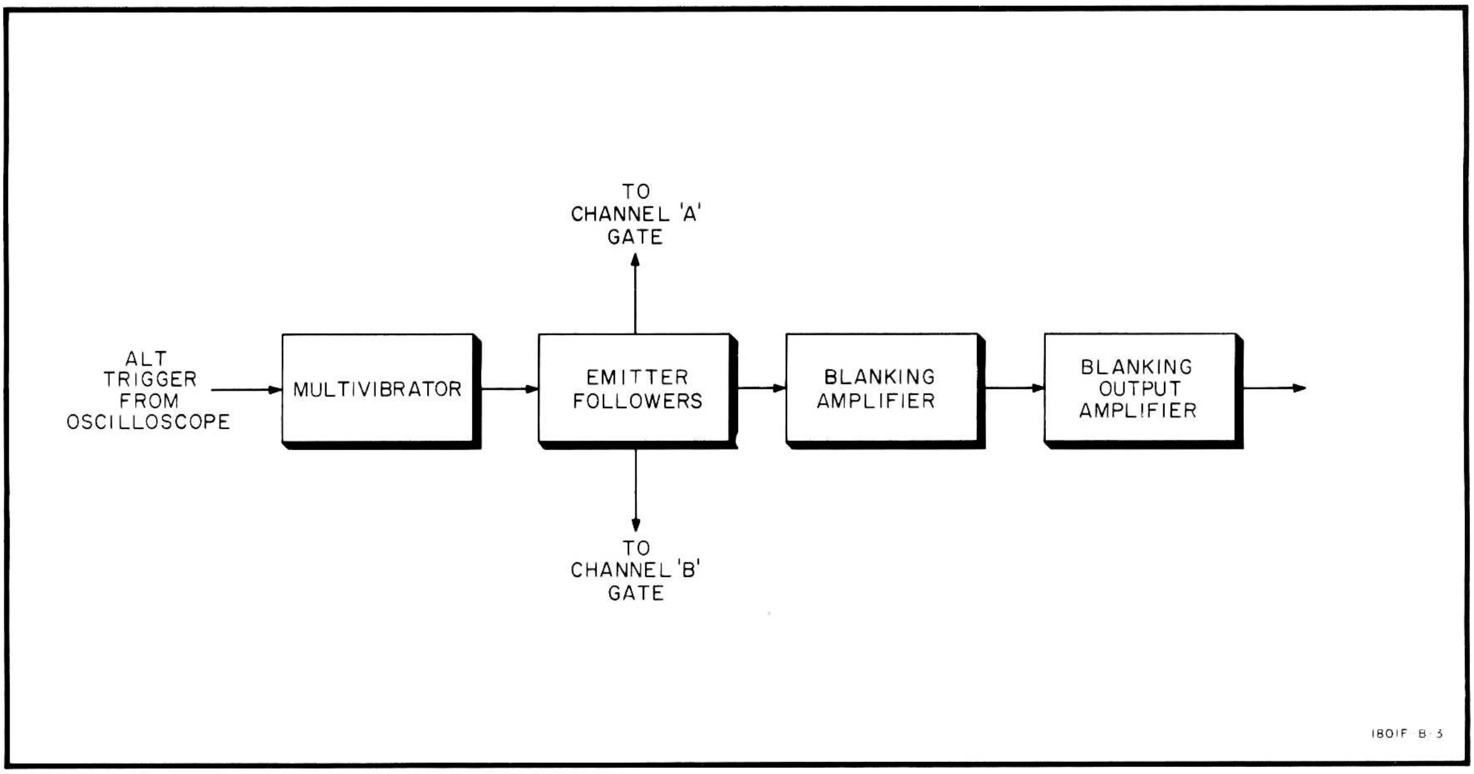
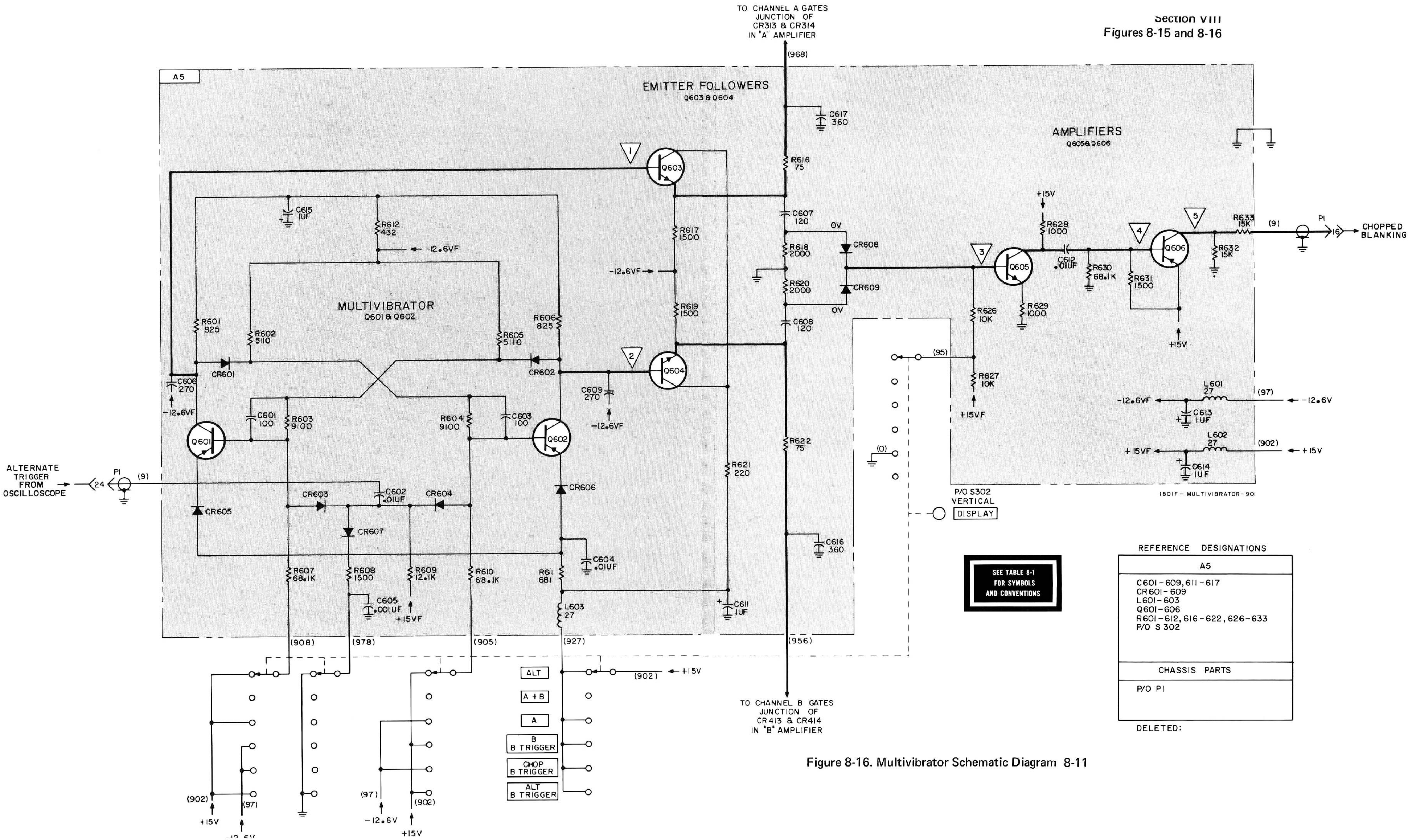


Figure 8-14. Multivibrator Block Diagram



SEE TABLE 8-1 FOR SYMBOLS AND CONVENTIONS

REFERENCE DESIGNATIONS

A5
C601-609, 611-617 CR601-609 L601-603 Q601-606 R601-612, 616-622, 626-633 P/O S302
CHASSIS PARTS
P/O P1

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Figure 8-16. Multivibrator Schematic Diagram

Component Location
for A6 inside fold,
for A2 in Figure 8-2

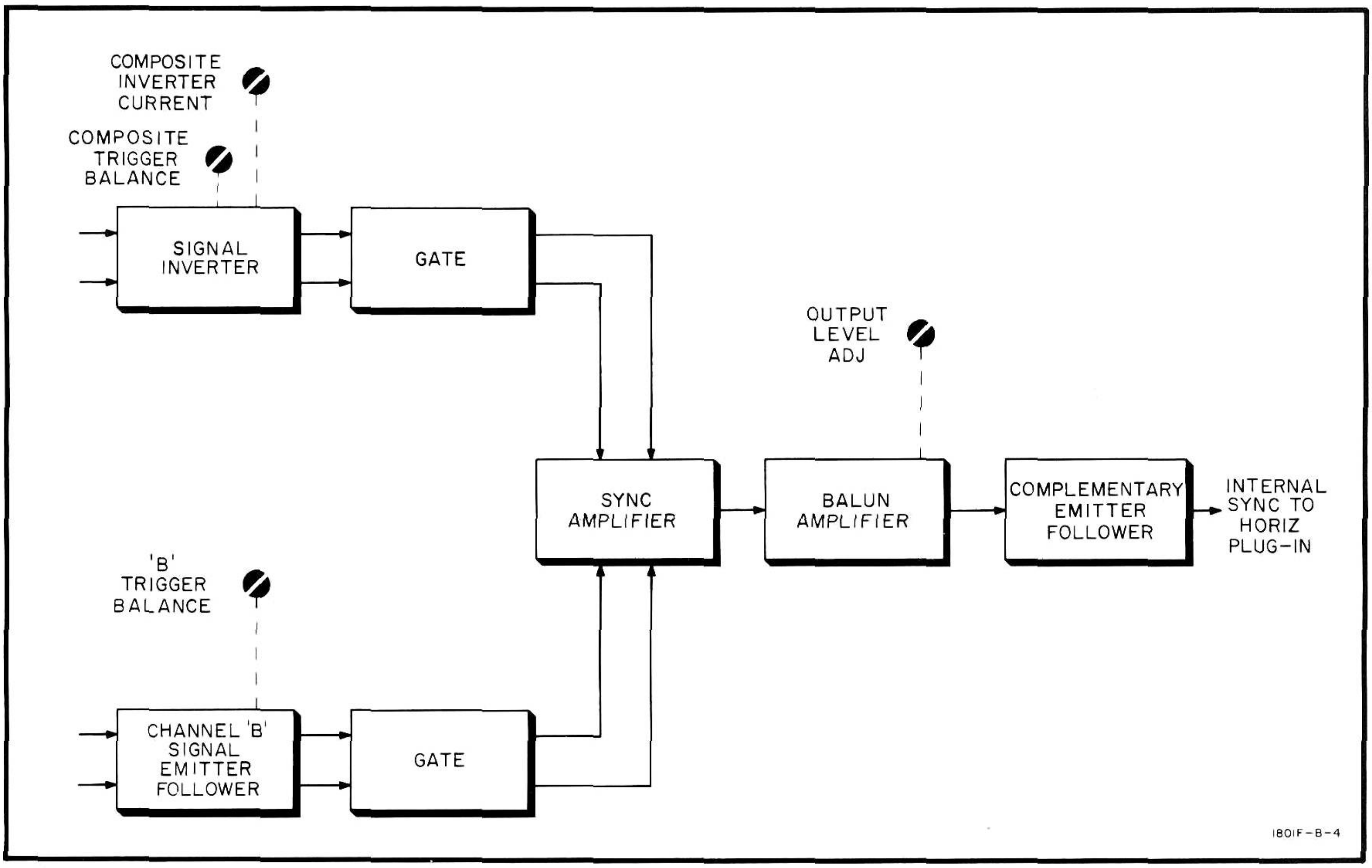

Figure 8-18. Sync Amplifier Block Diagram

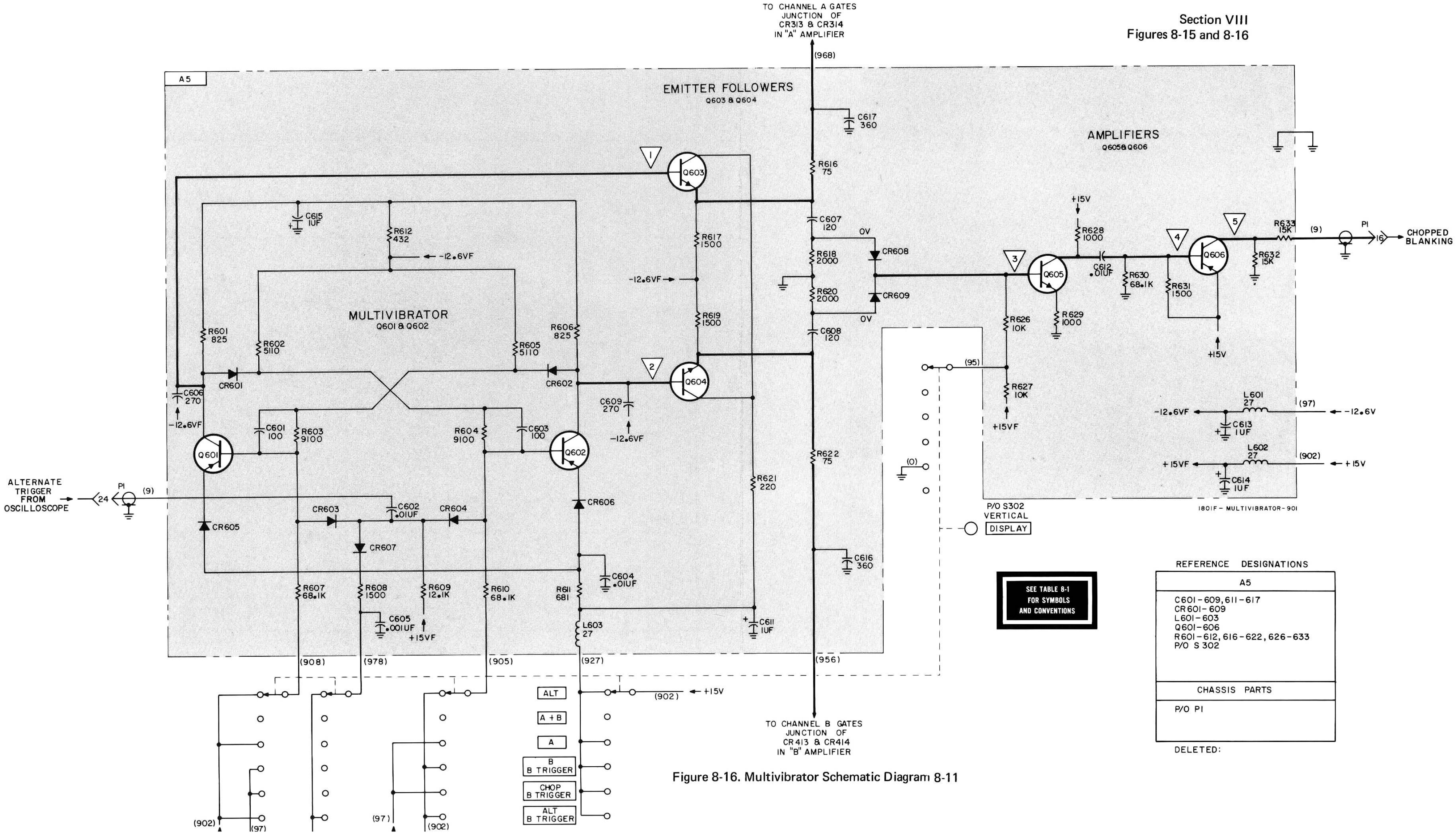

Figure 8-16. Multivibrator Schematic Diagram 8-11

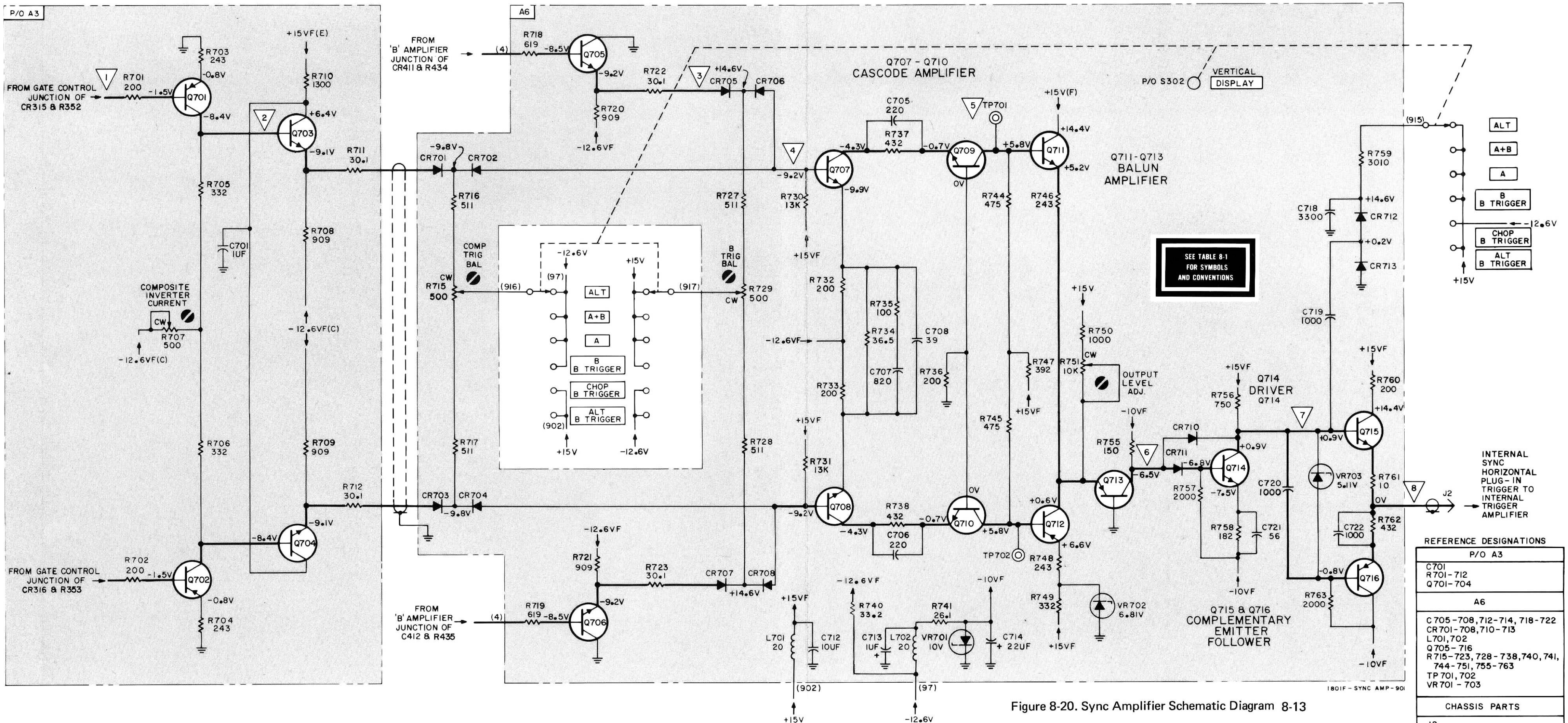

Figure 8-20. Sync Amplifier Schematic Diagram

REFERENCE DESIGNATIONS

P/O A3
C701 R701-712 Q701-704
A6
C705-708,712-714, 718-722 CR701-708,710-713 L701,702 Q705-716 R715-723, 728-738,740,741, 744-751, 755-763 TP701,702 VR701 - 703
CHASSIS PARTS
J2 P/O S302

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