INSTRUCTION MANUAL

Serial Number ____________

TYPE 10A2A DUAL-TRACE AMPLIFIER

Tektronix, Inc.

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070-0615-00

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TYPE 10A2A DUAL-TRACE AMPLIFIER
CH 1
VAR BAL
POSITION
VOLTS/CM
VARIABLE
CAL
AC
INPUT
UNCAL
GND
INVERT PULL
GAIN
1 MΩ 20 pF
DC
TRIGGER
NORM
CH 2 ONLY
MODE
CH 1
CH 2
ALT
CHOP
ADD
CH 2
GAIN
VOLTS/CM
INVERT PULL
INPUT
AC
GND
UNCAL
DC
1 MΩ 20 pF
POSITION
CH 2 OUTPUT
>.1 V/cm
VAR BAL
SERIAL
TEKTRONIX ®
PORTLAND, OREGON, U.S.A.

SECTION 1
CHARACTERISTICS

Introduction

The Tektronix Type 10A2A Dual-Trace Amplifier plug-in unit provides DC to 100 megahertz vertical capabilities for the Tektronix Type 647A Oscilloscope system. The Type 10A2A contains two similar input-amplifier channels which provide calibrated deflection factors from 0.01 to 20 volts/centimeter. Either channel can be used independently to produce a single-channel display, or they can be electronically switched to produce a dual-trace display. In addition, the signals on both channels can be algebraically added to display the sum of two signals, or the two channels can be cascaded to provide a minimum deflection factor of one millivolt/division (uncalibrated). Each channel has separate input coupling, input step attenuator, variable attenuator, variable balance, gain, position and polarity controls which allow each channel to be adjusted independently to produce the desired display.

The electrical characteristics which follow are divided into two categories. Characteristics listed in the Performance Requirement column are checked in the Performance Check and Calibration sections of this manual. Items listed in the Supplemental Information column are provided for reference use and do not directly reflect the measurement capabilities of this instrument. The Performance Check procedure given in Section 5 of this manual provides a convenient method of checking the Performance Requirements listed in this section. The following characteristics apply over a calibration interval of 1000 hours at an ambient temperature range of —30° C to +65° C, except as otherwise indicated. Warm-up time for given accuracy is 20 minutes.

Characteristics	Performance Requirement		Supplemental Information
Deflection Factors	0.01 to 20 volts/centimeter in 11 calibrated steps		Steps in 1-2-5 sequence
Variable Deflection Factor	Uncalibrated deflection factor to at least 2.5 times the VOLTS/CM switch indication. This provides a maximum uncalibrated deflection factor of at least 50 volts/centimeter in the 20 volts/centimeter position		
Attenuator Accuracy	0° C to +40° C	—30° C to +65° C	
	Within ±1.5%	Within ±2%	With VARIABLE control at CAL
Attenuator Accuracy of P6047 10× Probe	Within ±2%	Within ±2%	
Amplifier Gain Stability with Temperature			See Fig. 1-2
Bandwidth (at —3 dB point)			
In Type 647A	DC to 100 MHz or greater	DC to 90 MHz or greater	The associated time-base unit must have compatible triggering characteristics to obtain a stable display at high frequencies. See the 11-series instruction manual.
In Type 647	DC to 55 MHz or greater	DC to 50 MHz or greater	
Risetime (calculated)			Bandwidth and risetime performance are the same with a P6047 10× probe.
In Type 647A	3.5 nanoseconds or less	4.1 nanoseconds or less	
In Type 647	6.4 nanoseconds or less	7 nanoseconds or less	
Low-Frequency Limit with AC Coupling (—3 dB point)			Approximately 1.6 Hz (0.16 Hz with 10× probe).
Input RC Characteristics			1 megohm paralleled by 20 pF in AC and DC positions of Input Coupling switches. Input RC characteristics with P6047 10× Probe are 10 megohm paralleled by 10 pF.
Maximum Input Voltage			600 volts DC + peak AC (1 kHz or less). Peak-to-peak AC not to exceed 600 V
Input Coupling Modes	AC or DC, selected by front-panel switch. Input signal is internally disconnected and input circuit grounded in GND position		Input impedance remains one megohm in GND position

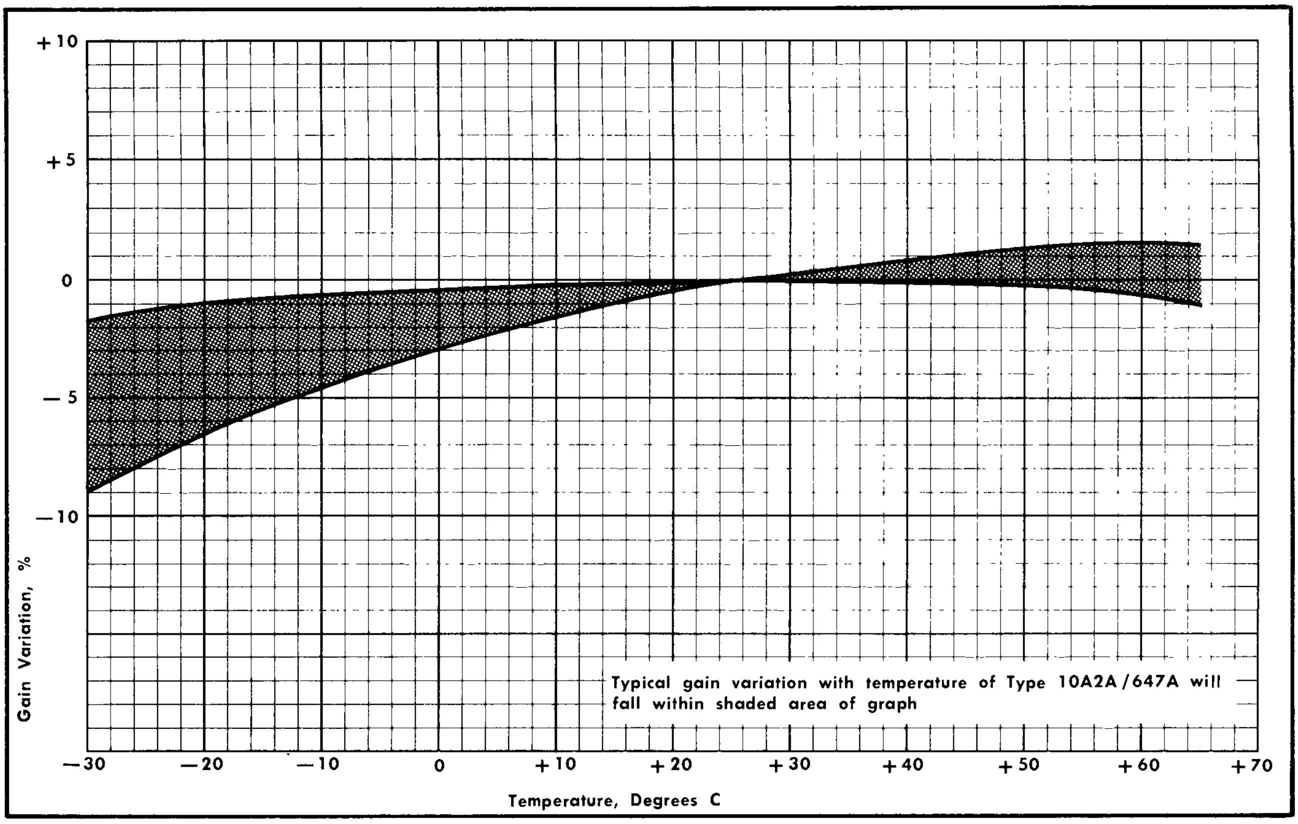

Fig. 1-2. Gain Stability with temperature of Type 10A2A and Type 647A.

Characteristics	Performance Requirement	Supplemental Information
Vertical Display Modes	Channel 1 only Channel 2 only Dual-trace, alternate between channels Dual-trace, chopped between channels Added algebraically	
DC Drift with Time		
Long term		0.5 centimeter or less/hour at 25° C
Short term		0.2 centimeter or less/minute at 25° C
DC Drift with Temperature		0.05 centimeter or less/degree C
Trace Shift Due to Input Grid Current	0.2 division or less at .01 VOLTS/CM	Equal to two nanoamps or less (adjustable to zero)
Inter-Channel Isolation		
Attenuator	10,000:1 or greater, DC to 25 MHz	
Amplifier	200:1 or greater, DC to 25 MHz	For CH 1 or CH 2 modes
Common-Mode Rejection Ratio	20:1 or greater, DC to 50 MHz, for common-mode signals less than 10 divisions in amplitude	With optimum GAIN adjustment at low frequencies. Measured at .01 volts/centimeter at 25° C
Linear Dynamic Range in Added Mode		±12 times, or greater the VOLTS/CM switch setting for 5% or less distortion
Chopped Repetition Rate	1 MHz, ±15%	
Polarity Inversion	Displayed signal from either channel can be inverted	
Channel 2 Output		
Amplitude	100 millivolts or greater/centimeter of CRT display, unterminated	
Bandwidth (at —3 dB point)	DC to 30 MHz or greater when cascaded with Channel 1	Using eight-inch BNC cable

Characteristics	Performance Requirement	Supplemental Information
DC level		Internally adjustable to zero volts
Output coupling		DC coupled
Output resistance		Approximately 100 ohms
Trigger Signal for Internal Triggering		
Trigger selection	From displayed channel(s) or from Channel 2 only	
Signal amplitude		Approximately 0.2 volt/centimeter of CRT display in NORM position of TRIGGER switch
Risetime		NORM: Typically 4 nanoseconds CH 2 ONLY: Typically 7 nanoseconds

ENVIRONMENTAL CHARACTERISTICS

The following environmental test limits apply when tested in accordance with the recommended test procedure. This instrument will meet the electrical performance requirements given in this section following environmental test. Complete details on environmental test procedures, including failure, criteria, etc., may be obtained from Tektronix, Inc. Contact your local Tektronix Field Office or representative.

Temperature		
Operating	—30° C to +65° C	
Non-operating	—55° C to +75° C	
Altitude		
Operating	15,000 feet maximum	Derate maximum operating temperature by 1° C/1000 feet change in altitude above 5000 feet
Non-operating	50,000 feet maximum	May be tested during non-operating temperature test
Humidity		
Non-operating	Five cycles (120 hours) of Mil-Std-202C, Method 106B	Exclude freezing and vibration
Vibration		
Operating and non-operating	15 minutes vibration along each of the three major axes at a total displacement of 0.025-inch peak to peak (4 g at 55 c/s) from 10-55-10 c/s in one-minute cycles. Hold at 55 c/s for three minutes on each axis	Instrument secured to vibration platform during test. Total vibration time, about 55 minutes
Shock		
Operating and non-operating	Two shocks of 20 g, one-half sine, 11 millisecond duration each direction along each major axis	Guillotine-type shocks. Total of 12 shocks
Transportation	Meets National Safe Transit type of test when packaged as shipped from Tektronix, Inc.	
Package vibration	One hour vibration slightly in excess of 1 g	Package should just leave vibration surface
Package drop	30-inch drop on any corner, edge or flat surface	

MECHANICAL CHARACTERISTICS

Characteristic	Information
Construction	
Chassis	Aluminum alloy
Panel	Aluminum alloy with anodized finish

Characteristic	Information
Dimensions	Fits 10-series plug-in compartments of Tektronix 647-series Oscilloscopes
Connectors	BNC
Weight (without accessories)	Approximately five pounds

SECTION 3
CIRCUIT DESCRIPTION

Introduction

This section of the manual contains an electrical description of the circuitry used in the Type 10A2A Dual-Trace Amplifier. The description begins with a discussion of the instrument using the basic block diagram shown in Fig. 3-1. Then each circuit is described in detail using a detailed block diagram to show the interconnections between the stages in each major circuit and the relationship of the front-panel controls to the individual stages.

A complete block diagram is located in the Diagrams section at the rear of this manual. This block diagram shows the overall relationship between the circuits in this instrument. Complete schematics of each circuit are also given in the Diagrams section. Refer to these diagrams throughout the following circuit description for electrical values and circuit relationship.

BLOCK DIAGRAM

General

The following block diagram is provided to aid in understanding the overall concept of the Type 10A2A before the individual circuits are discussed in detail. A basic block diagram of the Type 10A2A is shown in Fig. 3-1. Only the basic interconnections between the individual blocks are shown on this diagram. Each block in this block diagram represents a major circuit within the instrument. The number on each block refers to the circuit diagram at the rear of this manual which shows the complete circuit.

Input signals for vertical deflection on the indicator oscilloscope CRT are connected to either the Channel 1 INPUT connector or the Channel 2 INPUT connector (both for dual-trace operation). The input signals are then amplified by the Channel 1 Input Amplifier and/or the Channel 2 Input Amplifier. The VOLTS/CM switch in each Input Amplifier circuit provides the calibrated attenuation needed to display high-amplitude signals. Each Input Amplifier also includes separate position, input coupling, gain, invert, variable attenuation and balance controls. A trigger pickoff in the Channel 2 Input Amplifier circuit allows the time-base unit to be triggered from only the signal applied to Channel 2. The output of both Input Amplifier circuits is connected to the Channel Switching and Output Amplifier circuit.

The Channel Switching portion of the Channel Switching and Output Amplifier circuit selects the channel(s) to be displayed and determines the vertical mode of operation. An output signal from this circuit is connected to the indicator oscilloscope to blank out the between-channel switching transients when in the chopped mode of operation. The Output Amplifier portion of this circuit amplifies the vertical signal and provides the output to the indicator oscilloscope for vertical deflection on the CRT. A trigger-pickoff in the Output Amplifier portion provides a sample of the displayed vertical signal(s) for internal triggering. The TRIGGER switch selects the internal trigger signal from this signal or the signal from the Channel 2 Input Amplifier. The selected signal is amplified and connected to the time-base unit through the indicator oscilloscope.

CIRCUIT OPERATION

General

The following circuit analysis is written around the detailed block diagrams which are given for each major circuit. These detailed block diagrams give the names of the individual stages within the major circuits and show how they are connected together to form the major circuit. The block diagrams also show the inputs and outputs for each major circuit and the relationship of the front-panel controls to the individual stages. The circuit diagrams from which the detailed block diagrams are derived are shown in the Diagrams section of this manual. The names assigned to the individual stages on the detailed block diagrams are used throughout the following discussion.

This circuit analysis attempts to describe the electrical operation and circuit relationships in the Type 10A2A. The theory of operation for circuits which are commonly used in the electronics industry is not described in this discussion. Instead, references are given to textbooks or other source material where more complete information on these circuits can be found. Circuits which are unusual to this instrument are described in detail.

Channel 1 Input Amplifier

General

Input signals for vertical deflection of the indicator oscilloscope CRT can be connected to the Channel 1 INPUT connector. The Channel 1 Input Amplifier provides control of input coupling, vertical deflection factor, balance, vertical position, polarity inversion and gain for the signal applied to the Channel 1 INPUT connector. Fig. 3-2 shows a detailed block diagram of the Channel 1 Input Amplifier circuit. A schematic of this circuit is shown on diagram 1 at the rear of this manual.

Input Coupling

Input signals connected to the Channel 1 INPUT connector can be AC-coupled, DC-coupled or internally disconnected. When the Input Coupling switch, SW101, is in the DC position, the input signal is coupled directly to the Channel 1 Input Attenuator stage. In the AC position, the input signal passes through a blocking capacitor, C100. This prevents the DC component of the signal from passing to the amplifier. The GND position opens the signal path and connects the input circuit of the amplifier to ground. This provides a ground reference without the need to disconnect the applied

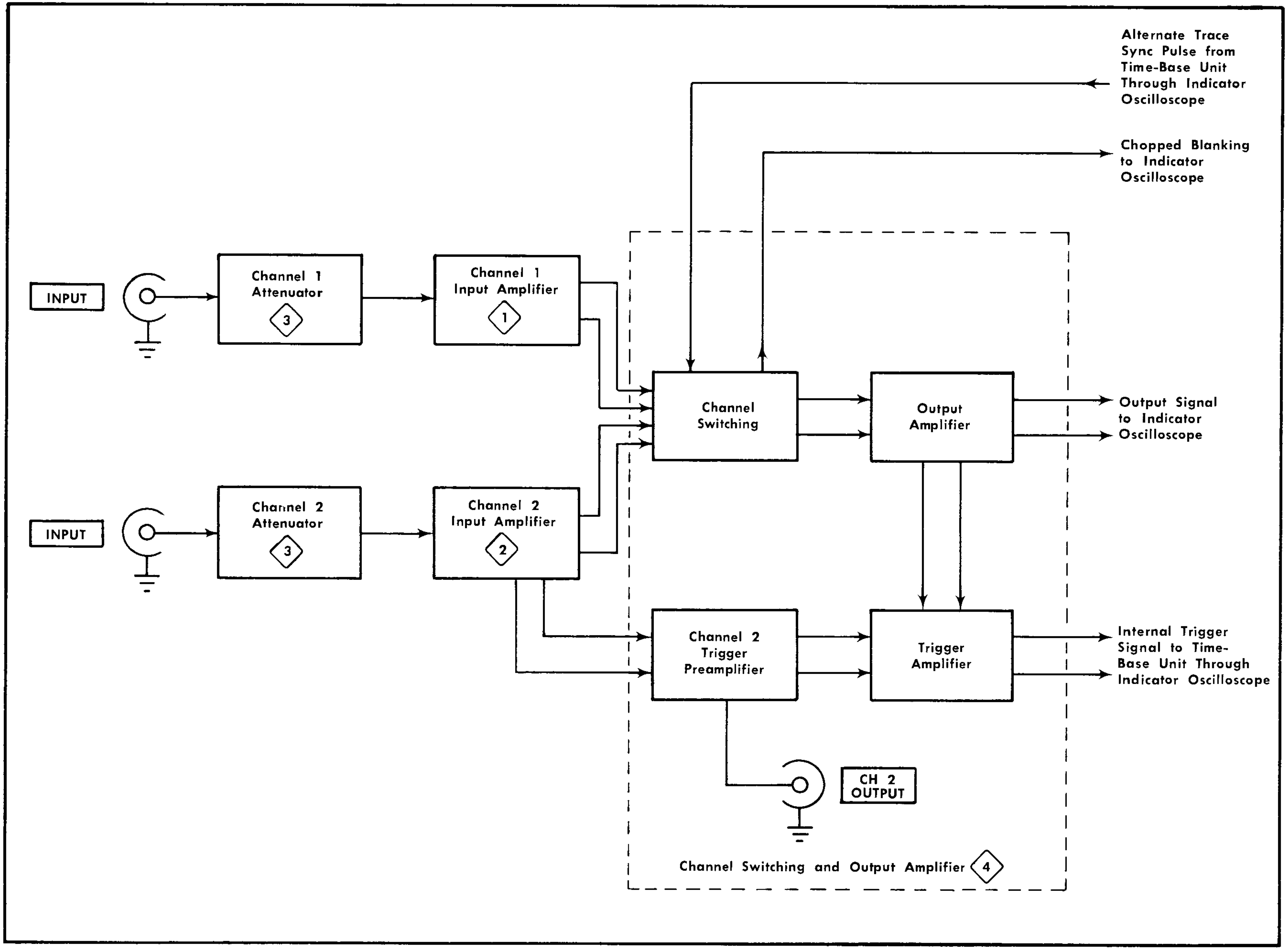

Fig. 3-1. Basic block diagram of the Type 10A2A.

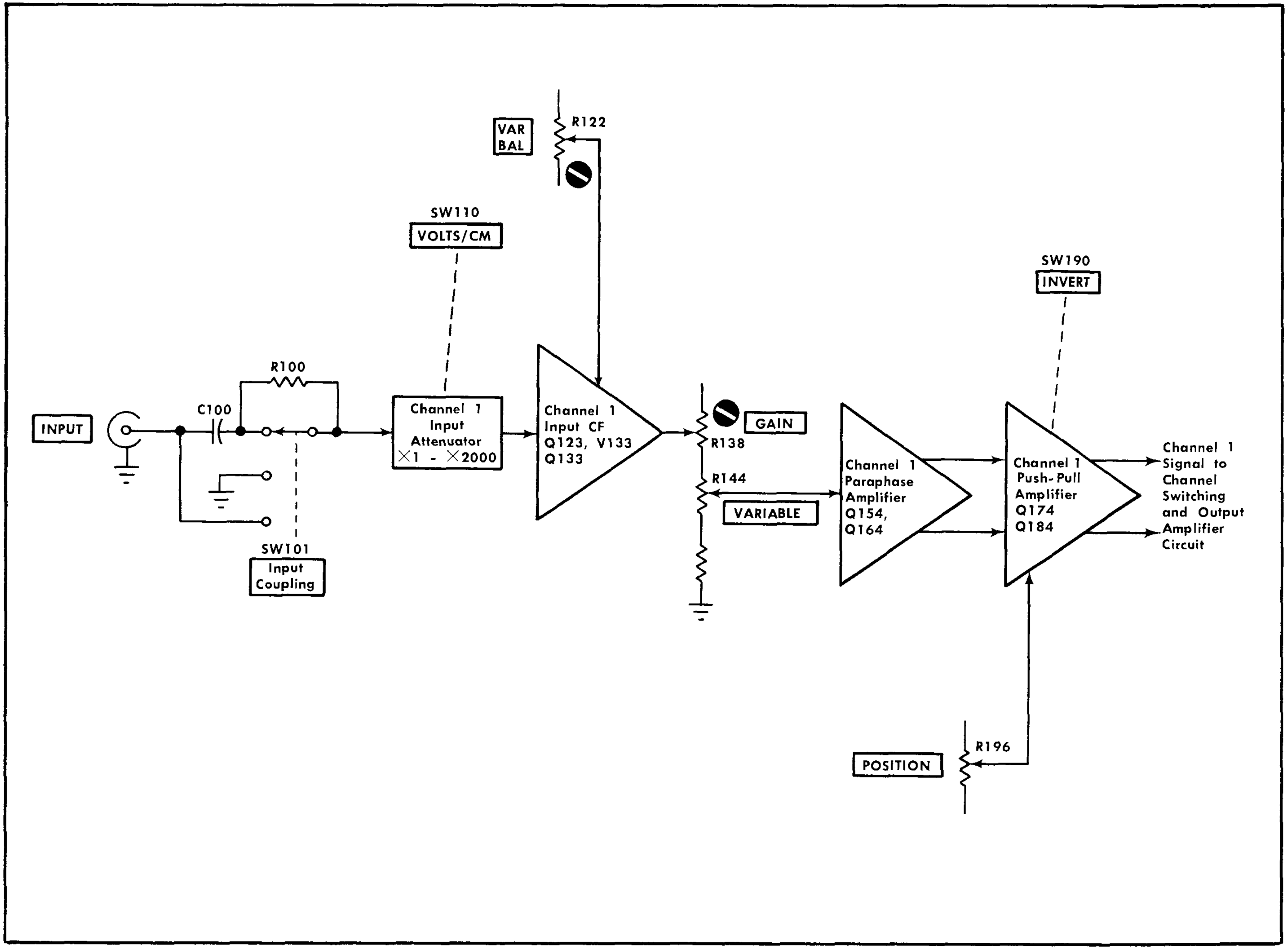

Fig. 3-2. Channel 1 Input Amplifier detailed block diagram.

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signal from the INPUT connector R101 maintains the one megohm input impedance in the GND position and also allows the input capacitor, C100, to be pre-charged.

Channel 1 Input Attenuator

The effective overall vertical deflection factor of the Type 10A2A is determined by the VOLTS/CM switch and the VARIABLE control. In all positions of the VOLTS/CM switch, the basic deflection factor of the unit is 0.01 volt/centimeter. To increase this basic deflection factor to provide the variety of deflection factors given on the front panel, precision attenuators are switched into the circuit. These attenuators are frequency compensated voltage dividers. For DC and low-frequency signals, they are resistive dividers and the voltage attenuation is determined by the resistance ratio in the attenuator. At higher frequencies, the reactance of the capacitors decreases and the attenuator becomes primarily a capacitive voltage divider. Each attenuator contains an adjustable series capacitor to match the high-frequency attenuation to the DC attenuation and an adjustable shunt capacitor to adjust the input RC product to the correct value. Diagram 3 shows the individual attenuators used in this circuit.

In addition to providing correct attenuation at all frequencies, the Input Attenuator is designed to maintain the same input resistance (one megohm) for each setting of the VOLTS/CM switch. The variable capacitors are adjusted to maintain the same input time constant (nominally one megohm $\times$ 20 pF) at each setting of the VOLTS/CM switch.

Channel 1 Input Cathode Follower

The Channel 1 Input Cathode Follower stage, V133, provides a high input impedance with a low impedance drive for the following stages. This stage also serves to isolate the input circuit and signal source from the remaining amplifier circuitry. R114 in the grid circuit of V133 is the input resistor. This resistor is part of the attenuation network at all VOLTS/CM switch positions. D133 provides protection for the Channel 1 Input Cathode Follower stage, and clamps the cathode at about —0.6 volts during warm-up time to protect Q154 until the filament of V133 reaches normal operating temperature.

Transistor Q133 sets the operating plate voltage for V133. This voltage, in turn, is controlled by the VAR BAL adjustment, R122, at the base of Q123. The VAR BAL adjustment is set to produce a quiescent voltage level at the cathode of V133 which equals the voltage at the junction of R148-R149. Diode D125 disconnects Q133 from Q123 if a high positive input voltage is connected to the grid of V133.

The CH 1 Grid Current Zero adjustment, R117, is adjusted to offset any grid current in V133. This prevents quiescent current from flowing through the input resistor or Input Attenuator and producing a deflection when no signal is applied. The Q154 Base Current adjustment, R140, cancels the base current of Q154, when properly adjusted, so the quiescent current to Q154 from the VARIABLE control is zero. With these three controls correctly adjusted as described, the only current through the Input Attenuator and VARIABLE control is due to the applied signal. This prevents the display trace (or DC level) from shifting when the VOLTS/CM switch is changed or VARIABLE control is rotated.

The GAIN adjustment, R138, provides variable signal-current attenuation for the output signal at the cathode of V133. The overall gain of the amplifier is set by controlling the amount of signal current which reaches the following stage. The VARIABLE control, R144, provides continuously variable uncalibrated deflection factors between the positions selected by the CH 1 VOLTS/CM switch. When the VARIABLE control is set to the CAL position (fully clockwise), maximum signal voltage reaches the base of Q154. Switch SW144, ganged with the VARIABLE control, is open and current does not flow through neon bulb B144. As the VARIABLE control is rotated counterclockwise from the CAL position, SW144 closes and the UNCAL light, B144, lights to indicate that the vertical deflection factor is uncalibrated. Also, as the VARIABLE control is rotated counterclockwise the signal voltage to Q154 is reduced.

Channel 1 Paraphase Amplifier

Transistors Q154 and Q164 are connected as a common-emitter phase inverter (paraphase) amplifier[1] to convert the single-ended input signal to a push-pull output signal. The push-pull output is obtained from the single-ended input signal in the following manner: Assume that the signal voltage at the base of Q154 is increasing. This produces a corresponding increase in current through Q154 and its collector voltage goes negative. At the same time, the emitter of Q154 goes positive (more current flows through emitter resistor) and this change is connected to the emitter of Q164 through R169. As far as signal change is concerned, Q164 is connected as a grounded base stage so that it operates as the emitter-driven section of the paraphase amplifier. Then, the collector current of Q164 decreases by about the same amount as the emitter current change through the emitter resistor. Thus the single-ended input signal has been amplified and is available as a push-pull signal at the collectors of Q154 and Q164.

The CH 1 Com Mode Current adjustment, R150, establishes the collector voltage of both Q154 and Q164. This control sets the common-mode output DC current for the Channel 1 Input Amplifier. Transformer T169 provides a high impedance for common-mode signals at the emitters of Q154 and Q164 to reduce the common-mode signal components to the following stages. Adjustable capacitor C169 controls the high-frequency emitter degeneration of Q154 and Q164 to provide optimum high-frequency response from this stage. The CH 1 Inv Bal adjustment, R160, balances the DC current of this stage to provide overall DC balance for the amplifier. Balance is checked by inverting the display with the INVERT switch, SW190, and adjusting for minimum trace shift.

Channel 1 Push-Pull Amplifier

The Channel 1 Push-Pull Amplifier stage amplifies the push-pull output from the Channel 1 Paraphase Amplifier which is connected to the bases of Q174 and Q184. Common-mode temperature compensation for this stage is provided by D157 in the base ground-return path. The voltage change across D157 with change in temperature is about

[1]Lloyd P. Hunter (ed.), "Handbook of Semiconductor Electronics", second edition, McGraw-Hill, New York, 1962, pp. 11-94.

equal but opposite to the voltage change across the base-emitter junction of Q174 and Q184. This minimizes any change in the common-mode output current with a change in temperature. Gain of this stage is determined by the emitter degeneration between Q174 and Q184. As the resistance between the emitters of Q174 and Q184 increases, emitter degeneration increases also, resulting in less gain. The CH 1 Gain Range adjustment, R176, varies the resistance between the emitters to set the gain of this stage so the GAIN adjustment, R138, on the front panel operates near the center of its range. Variable capacitor C172 and variable resistor R172 provide high-frequency compensation for this stage.

The INVERT switch, SW190, allows the displayed Channel 1 signal to be inverted. When the switch is pulled out, the output signal from the Channel 1 Push-Pull Amplifier is connected to the opposite input of the Common-Base Stage (in Channel Switching and Vertical Output circuit). The POSITION control, R196, provides a variable push-pull current to the next stage to control the vertical position of the display.

Channel 2 Input Amplifier

General

The Channel 2 Input Amplifier circuit is basically the same as the Channel 1 Input Amplifier circuit (corresponding) circuit numbers are assigned in the 200-299 range). Only the differences between the two circuits are described here. Fig. 3-3 shows a detailed block diagram of the Channel 2 Input Amplifier circuit. A schematic of this circuit is shown on diagram 2 at the rear of this manual.

Channel 2 Push-Pull Amplifier

The basic Channel 2 Push-Pull Amplifier configuration and operation is the same as for Channel 1. The only difference is that a sample of the Channel 2 signal is obtained from the emitter circuit of the Channel 2 Push-Pull Amplifier stage to provide internal triggering from the Channel 2 signal only. This sample is obtained from the junction of R272-R273 and R282-R283. The emitter resistance provided by R271-R272, R281-R282 and the input resistance of the Channel 2 Trigger Preamplifier stage is about the same as the resistance of R171 and R181 in the emitter circuit of the Channel 1 Push-Pull Amplifier stage. This arrangement provides similar signal response from each channel.

Channel 2 Trigger Preamp

The internal trigger signal obtained from the Channel 2 Input Amplifier circuit is connected to the Channel 2 Trigger Preamp stage (shown on diagram 4). This stage amplifies the Channel 2 trigger signal so it is about the same amplitude as the normal trigger signal which is obtained from the Output Amplifier stage. Q504-Q523 and Q514-Q533 are connected as a push-pull amplifier stage with emitter follower output. Feedback resistors R525 and R535 set the signal voltage amplitude at the emitters of Q523 and Q533. The push-pull output signal at the emitters of Q523 and Q533 is connected to the Trigger Amplifier stage through R526-R541, R536-R543 and SW540.

An amplified sample of the Channel 2 signal at the collector of Q533 is connected to the CH 2 OUT connector. This output signal allows Channel 2 to be monitored or it can be connected to the Channel 1 INPUT connector for increased deflection factor (with reduced frequency response). The CH 2 Out DC Level adjustment, R530, sets the collector level of Q533 for a zero-volt output level with zero volts at the input of the Channel 2 Input Amplifier circuit.

Channel Switching and Output Amplifier

General

The Channel Switching and Output Amplifier circuit determines which of the Input Amplifier signals is displayed on the indicator oscilloscope CRT. In the ALT and CHOP positions of the MODE switch, both channels are displayed on a shared-time basis. The Output Amplifier stage provides the final amplification for the signal before it is connected to the vertical amplifier in the indicator oscilloscope. The TRIGGER switch selects between the sample of the signal applied to Channel 2 or the sample of the composite vertical signal from the Output Amplifier stage. The Trigger Amplifier stage amplifies the internal signal to the level necessary to drive the trigger circuits in the associated time-base unit. Fig. 3-4 shows a detailed block diagram of the Channel Switching and Output Amplifier circuit. A schematic of this circuit is shown on diagram 4 at the rear of this manual.

Channel 1 and Channel 2 Common-Base Stages

The Channel 1 and Channel 2 Common-Base Stages, Q304-Q314 and Q324-Q334, provide a low impedance load for Q174 and Q184 in the Channel 1 Input Amplifier and Q274 and Q284 in the Channel 2 Input Amplifier. They also provide isolation between the Input Amplifier circuits and the Diode Gate. The output signals from the Channel 1 and 2 Common-Base Stages are connected to the Diode Gate.

Diode Gate

The Diode Gates, consisting of four diodes each, can be though of as switches which allow either of the Input Amplifier output signals to be displayed. D302-D305-D309-D312 control the Channel 1 output signal and D322-D325-D329-D332 control the Channel 2 output signal. These diodes are in turn controlled by the Switching Multivibrator for dual-trace displays or by the MODE switch for single-trace displays.

CH 1. In the CH 1 position of the MODE switch, SW350, diodes D325-D329 in the Channel 2 Diode Gate are forward biased through R351 and R353 to the +15-volt supply (see simplified diagram in Fig. 3-5). This reverse biases D322-D332 to block the Channel 2 signal so it cannot pass to the Output Amplifier stage. At the same time in the Channel 1 Diode Gate, the diodes D305-D309 are reverse biased with anode voltages of about +2.8 volts established by divider R342-R343-R344-R357 between the +15-volt and −15-volt supplies. The anodes of D302-D312 are at about +7.0 volts. Since D302-D312 are forward biased, the Channel 1 signal passes to the Output Amplifier stage.

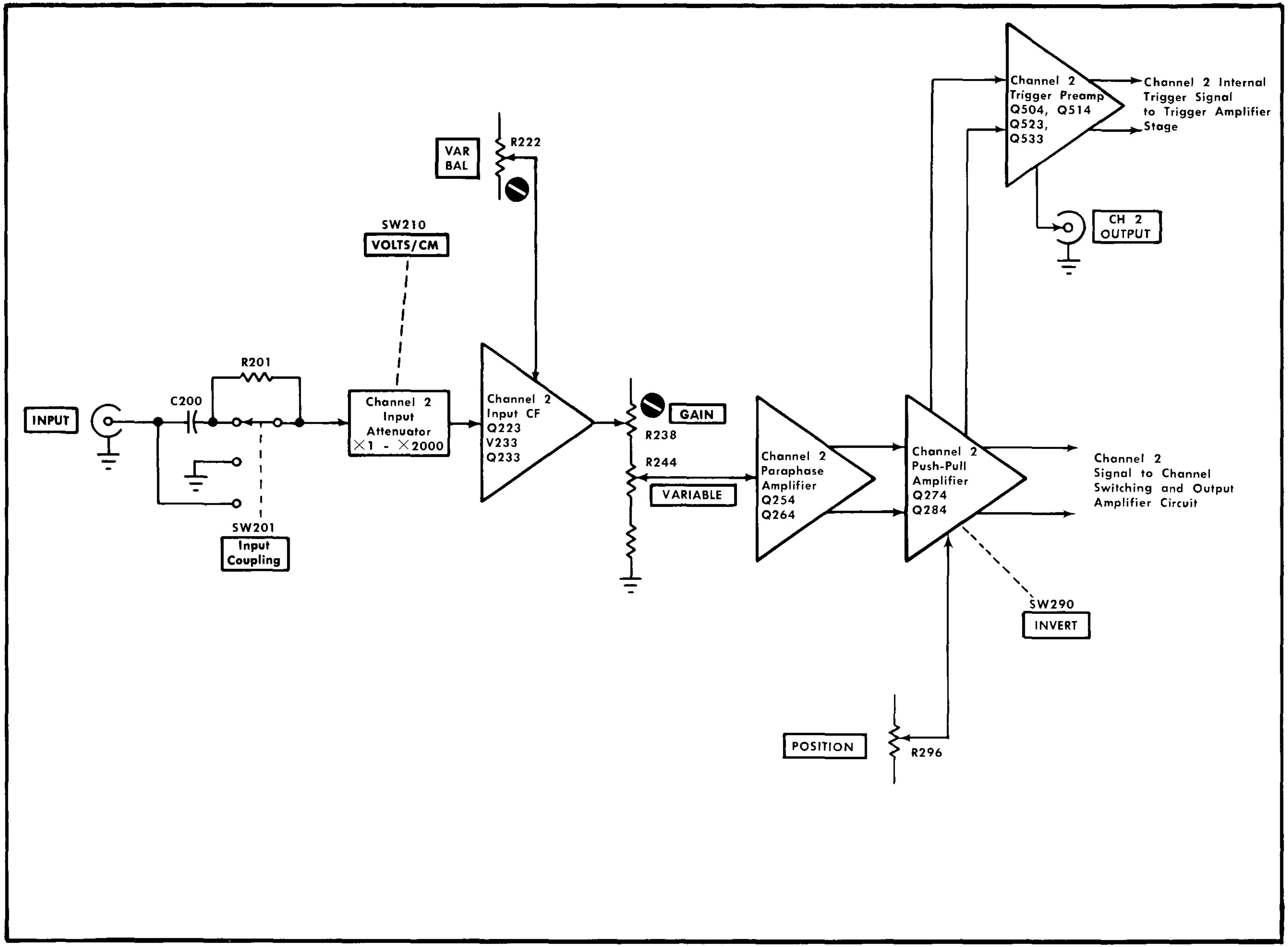

Fig. 3-3. Channel 2 Input Amplifier detailed block diagram.

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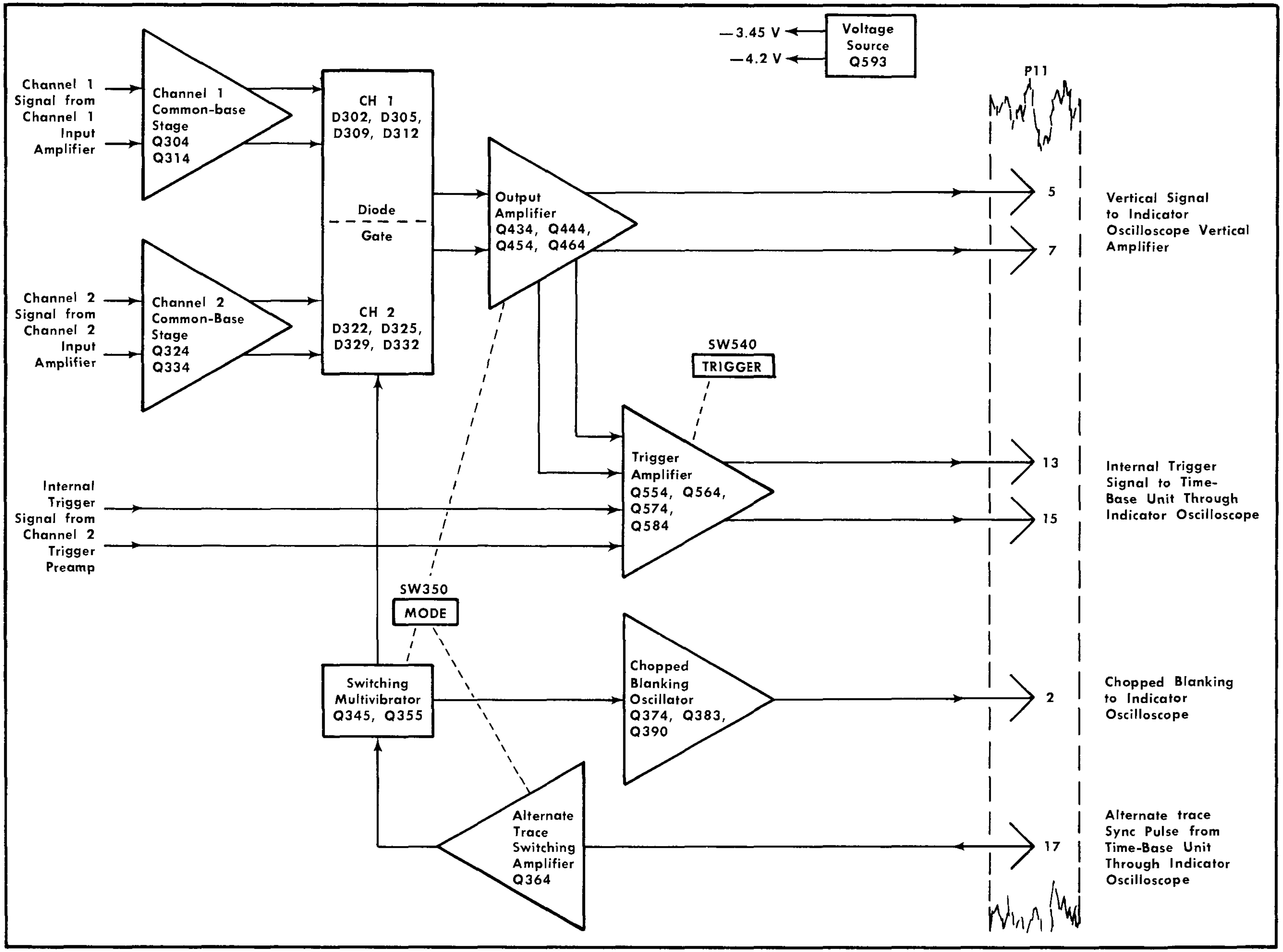


Fig. 3-4. Channel Switching and Output Amplifier detailed block diagram.

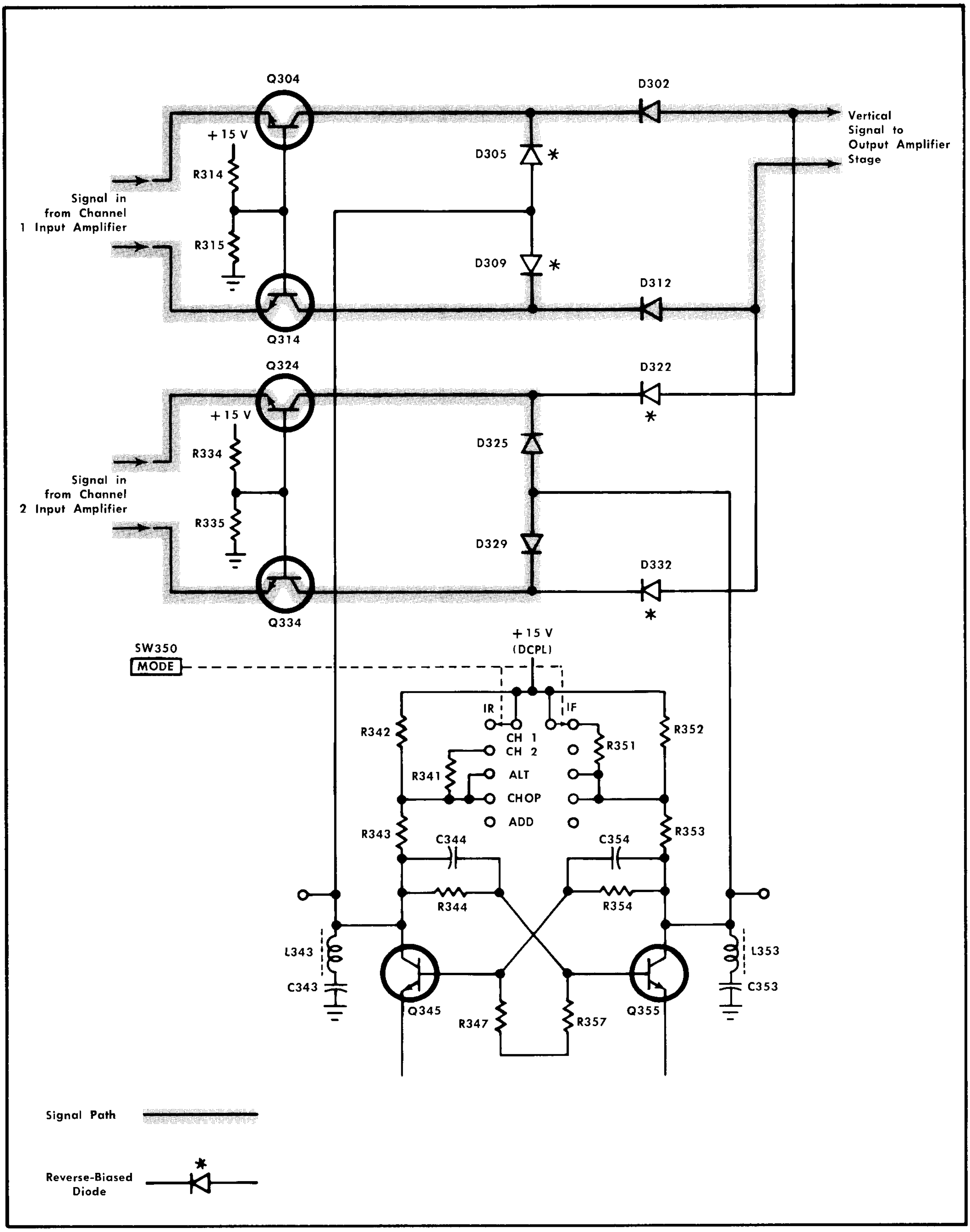


Fig. 3-5. Effect of Diode Gates on signal path (simplified diagram). Conditions shown for CH 1 position of the MODE switch.

of the transistors begins to conduct; for example Q345. Q345 reverse biases the Channel 1 shunt diodes and allows the Channel 1 signal to reach the Output Amplifier stage. The Channel 2 signal is shunted by the forward biased diodes, D325-D329.

The frequency-determining components in the CHOP mode are C348-R345-R355. Switching action occurs as follows: When Q345 is on, the base of Q355 is biased lower than the base of Q345 by the DC coupling from the collector of Q345 to the base of Q355 through divider R344-R357. When Q355 is turned off, its emitter is more positive than the emitter of Q345. Thus the emitter-base junction of Q355 is reverse biased. C348 begins to charge toward —15 volts through R355 and the emitter level of Q355 goes negative. After about 0.5 microseconds, the emitter of Q355 drops negative enough to forward bias it. The collector current of Q355 results in a more negative collector voltage change and is coupled through divider R354-R347 to cut Q345 off. This switches the Diode Gate to connect the Channel 2 signal to the Output Amplifier stage. Now Q345 is held off by the base level established by divider R354-R347 and the emitter level of Q345 which was raised positive by the emitter level of Q355 coupled through C348. Again C348 begins to charge toward —15 volts, but this time at the emitter of Q345 through R345. After about 0.5 microseconds, C348 charges negative enough to turn Q345 on again and the cycle is complete.

The Chopped Blanking Oscillator stage, Q374-Q383-Q390, provides an output pulse to the indicator oscilloscope CRT circuit to blank the transition between the Channel 1 trace and the Channel 2 trace. In the CHOP mode, —15 volts is connected to the emitter of Q374 by the MODE switch. When the Switching Multivibrator stage changes states, the voltage across T371 momentarily increases. A positive pulse is applied to the base of Q374 to turn it on and it goes into saturation. Its collector goes negative to about —12 volts and this negative voltage change is connected to the base of Q383 through R374. As the voltage across T371 collapses, Q374 turns off and is held off by the stored charge on C371 until the Switching Multivibrator changes states again.

Quiescently, Q383 is conducting and it holds blocking oscillator transistor Q390 reverse biased through R387 and R389. Diode D387 prevents the emitter level of Q390 from rising more positive than about +0.6 volts. The negative-going pulse at the base of Q383, when the Switching Multivibrator changes states, turns Q383 off and its emitter starts to go negative. However, the emitter level of Q390 drops at a rate determined by the discharge of C387 through R387-R384. As the voltage across C387 drops to about —0.7 volts, Q390 is forward biased and it conducts. The collector of Q390 goes negative and the feedback winding of T390 pulls the base positive to make Q390 conduct even harder. Current flows through D392 to produce a positive-going output pulse at terminal 2 of the Interconnecting Plug which is coincident with the trace switching of the Switching Multivibrator stage. Inductor L392 is the timing element which determines the width of the blocking oscillator output pulse. The positive voltage at the base of Q390 produced by the output pulse results in a current increase through L392 which is linear with time. This current increase is coupled to the collector through T390 to increase the collector current of Q390. When the collector current approaches the emitter current, the blocking oscillator regeneratively switches off. Since the emitter level of Q390 has returned to the quiescent level of +0.6 volts (Q374 and Q383 have already returned to quiescent conditions), it is reverse biased. D391 and R391 by-pass the collector winding of Q390 so the turn off current of Q390 does not produce a corresponding negative voltage at the base which would exceed the base-emitter voltage limit. The chopped blanking pulse connected to the indicator oscilloscope CRT circuit is about 1.5 milliamperes in amplitude with a duration of about 0.08 microseconds.

ADD. In the ADD position of the MODE switch, the Diode Gate stage allows both signals to pass to the Output Amplifier stage. The shunt diodes, D305-D309 and D325-D329, in both halves of the Diode Gate stage are reverse biased. A current equal to the DC current from one of the Input Amplifier circuits is connected into the circuit in this mode through R318 and R338 to offset the additional current delivered through both Diode Gates. The signal from both Diode Gates is connected to the Output Amplifier stage. The output signal is the algebraic sum of the signals connected to Channel 1 and Channel 2.

Output Amplifier

The output signal from the Diode Gate stage is connected to the Output Amplifier stage, Q434-Q444-Q454-Q464. Zener diodes D318A and D318B provide a DC voltage offset to drive the base of Q434-Q444 without the corresponding signal current loss which would occur with a voltage divider. The Main Amp Diff Bal adjustment, R335, balances the quiescent base levels of Q434 and Q444 to provide a centered trace when the POSITION controls are centered. The DC level at the output of this unit is adjusted by the Main Amp Current adjustment, R336, by varying the common-mode current in the Output Amplifier.

The amplified signal at the collector of Q434 and Q444 is connected to the bases of Q454 and Q464. These transistors provide the final amplification for the signal before it is connected to the indicator oscilloscope. R450 and R460 are feed-back resistors for the combined amplifier stages, Q434-Q454 and Q444-Q464. This negative feedback sets the signal voltage amplitude at the emitters of the output transistors, Q454-Q464. The emitter-to-emitter resistor, R465, sets the signal current amplitude at the collectors of the output transistors. Fixed coil L465 and adjustable capacitor C456 provide high-frequency compensation for this stage. The Main Amp HF Damping adjustment, R462, provides high-frequency damping for the Output Amplifier. The signal at the collectors of Q454 and Q464 is connected to the vertical amplifier in the indicator oscilloscope through terminals 5 and 7 of the interconnecting plug.

The trigger signal for NORM trigger operation is obtained from the emitter circuit of Q454-Q464. A sample of the vertical deflection signal at the emitters of these transistors is connected to the Trigger Amplifier stage through dividers R457-R458 and R467-R468. The Norm Trig DC Bal adjustment, R546, adjusts the DC level of the output signal so the time-base unit triggers at the zero-volt level of the displayed signal when the trigger level control of the time-base unit is set to 0.

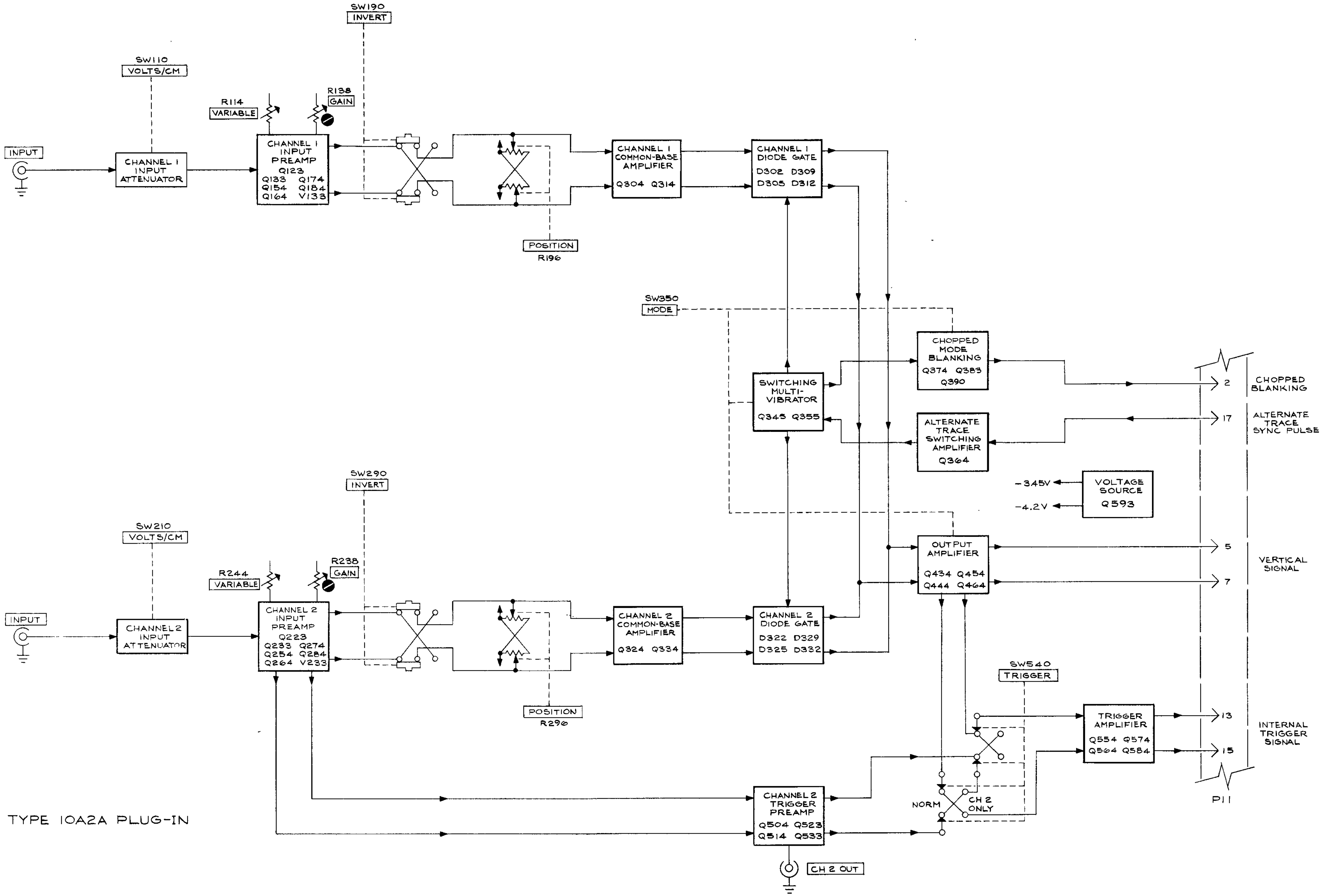
Trigger Amplifier

The Trigger Amplifier stage selects the internal trigger signal from the sample of the signal applied to Channel 2 or a sample of the composite vertical signal in the Output Amplifier stage. When the TRIGGER switch, SW540, is set to the NORM position, the internal trigger signal from the Output Amplifier stage is connected to the Trigger Amplifier. The Channel 2 Trigger Preamp output is terminated by R548. The load provided by R548 is about the same as provided by the input circuit of Q554-Q564. In the CH 2 ONLY position of the TRIGGER switch, the internal trigger signal from the Channel 2 Input Amplifier circuit is connected to the Trigger Amplifier stage. The trigger signal output from the Output Amplifier is terminated by R548 for constant loading on the Output Amplifier stage.

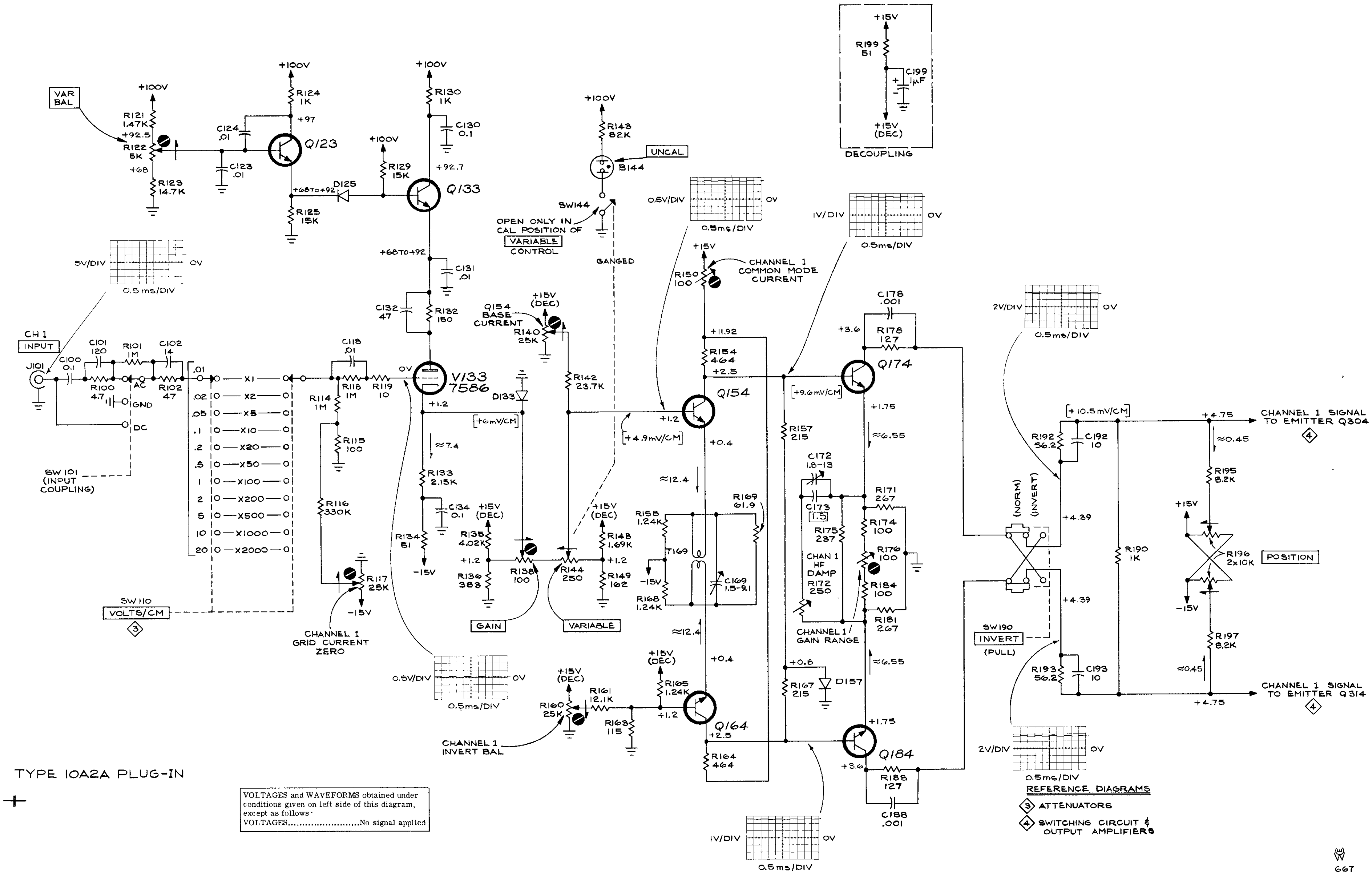
The Trigger Amplifier stage consists of two push-pull amplifier stages. Negative feedback from the emitters of Q574-Q584 is connected to the bases of Q554-Q564 through resistor R579 and R589. The amplified internal trigger signal at the collectors of Q574 and Q584 is connected to the associated time-base unit through terminals 13 and 15 of the interconnecting plug.

Voltage Source

Voltage Source transistor, Q593, provides —3.45 volts to the Channel 2 Trigger Preamp stage and —4.2 volts to the Trigger Amplifier stage. The base level of Q593 is set by precision voltage divider R591-R592 between the —15-volt supply and ground. This establishes the —3.45-volt level at the emitter of Q593. The —4.2-volt level is established by precision divider R595-R597 from the emitter of Q593 to the —15-volt supply.



TYPE 10A2A PLUG-IN

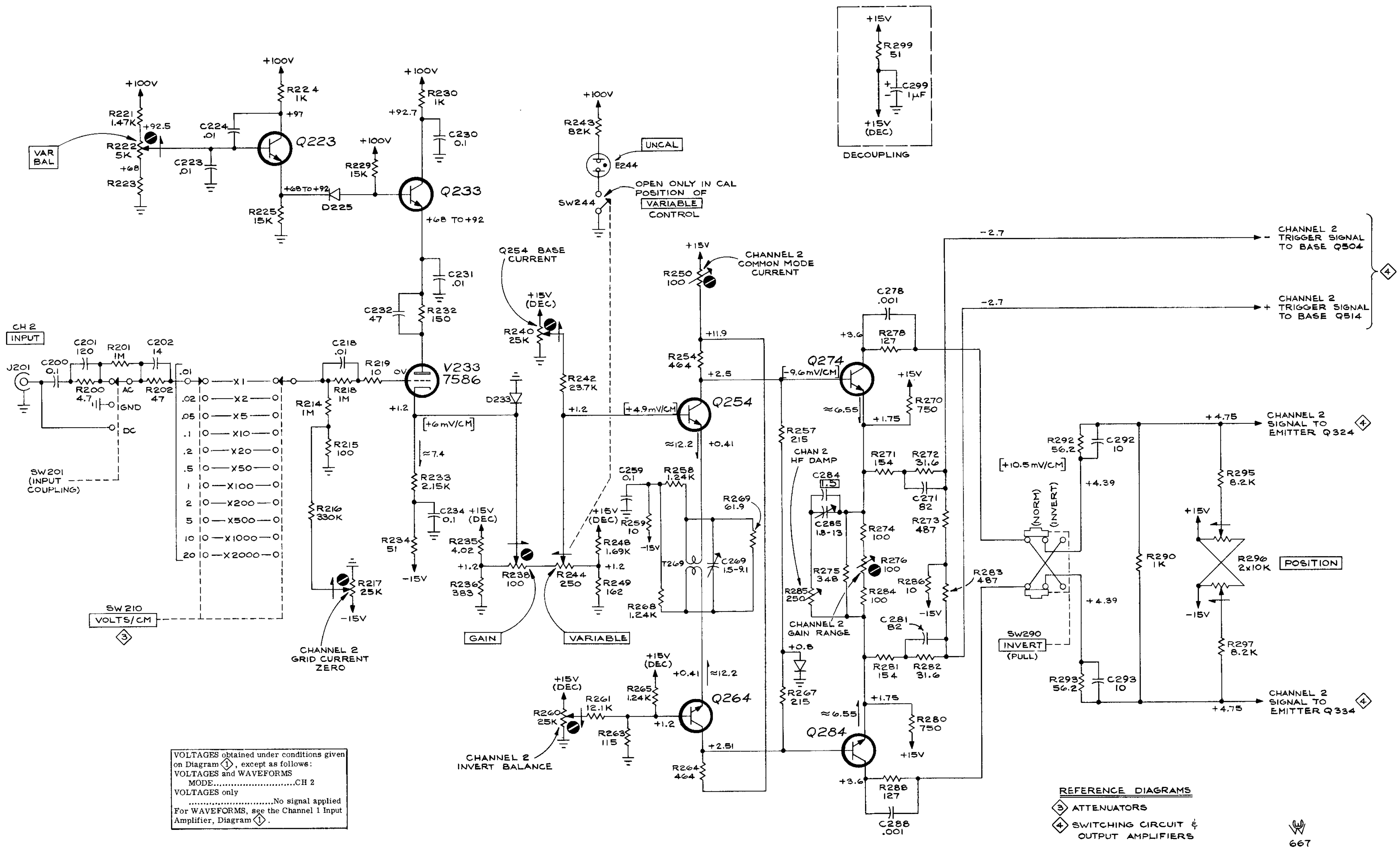


TYPE 10A2A PLUG-IN

VOLTAGES and WAVEFORMS obtained under conditions given on left side of this diagram, except as follows:
VOLTAGES..........................No signal applied

667

CHANNEL 1 INPUT AMPLIFIER ⟨1⟩



VOLTAGES obtained under conditions given on Diagram ⟨1⟩, except as follows:
VOLTAGES and WAVEFORMS
MODE..............................CH 2
VOLTAGES only
..............................No signal applied
For WAVEFORMS, see the Channel 1 Input Amplifier, Diagram ⟨1⟩.

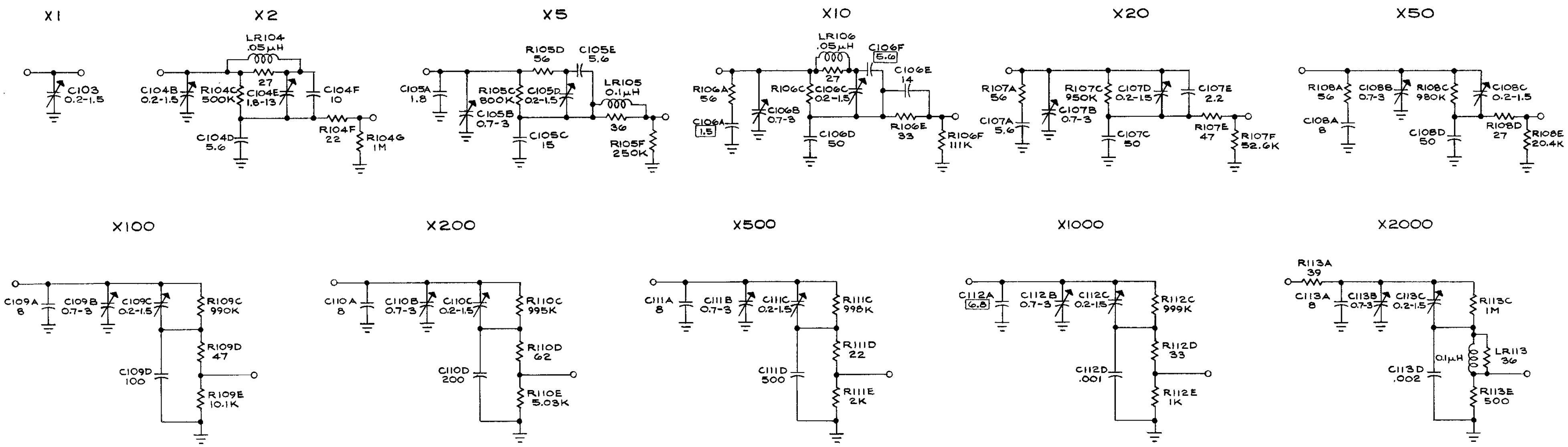
REFERENCE DIAGRAMS
⟨3⟩ ATTENUATORS
⟨4⟩ SWITCHING CIRCUIT & OUTPUT AMPLIFIERS

667

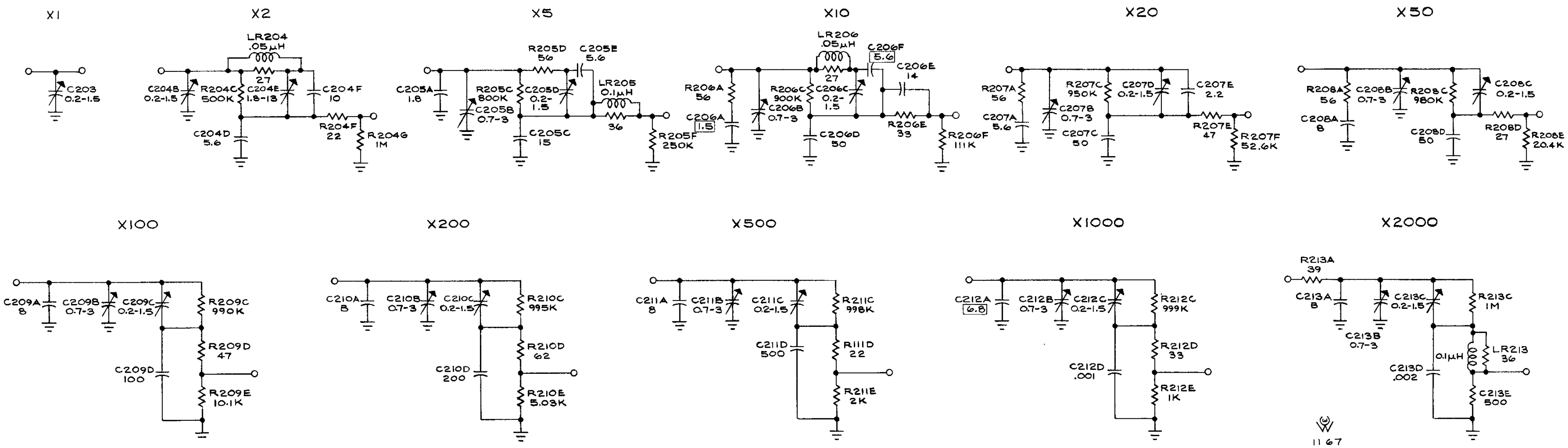
TYPE 10A2A PLUG-IN

CHANNEL 2 INPUT AMPLIFIER ⟨2⟩

CHANNEL 1



CHANNEL 2



TYPE 10A2A PLUG-IN

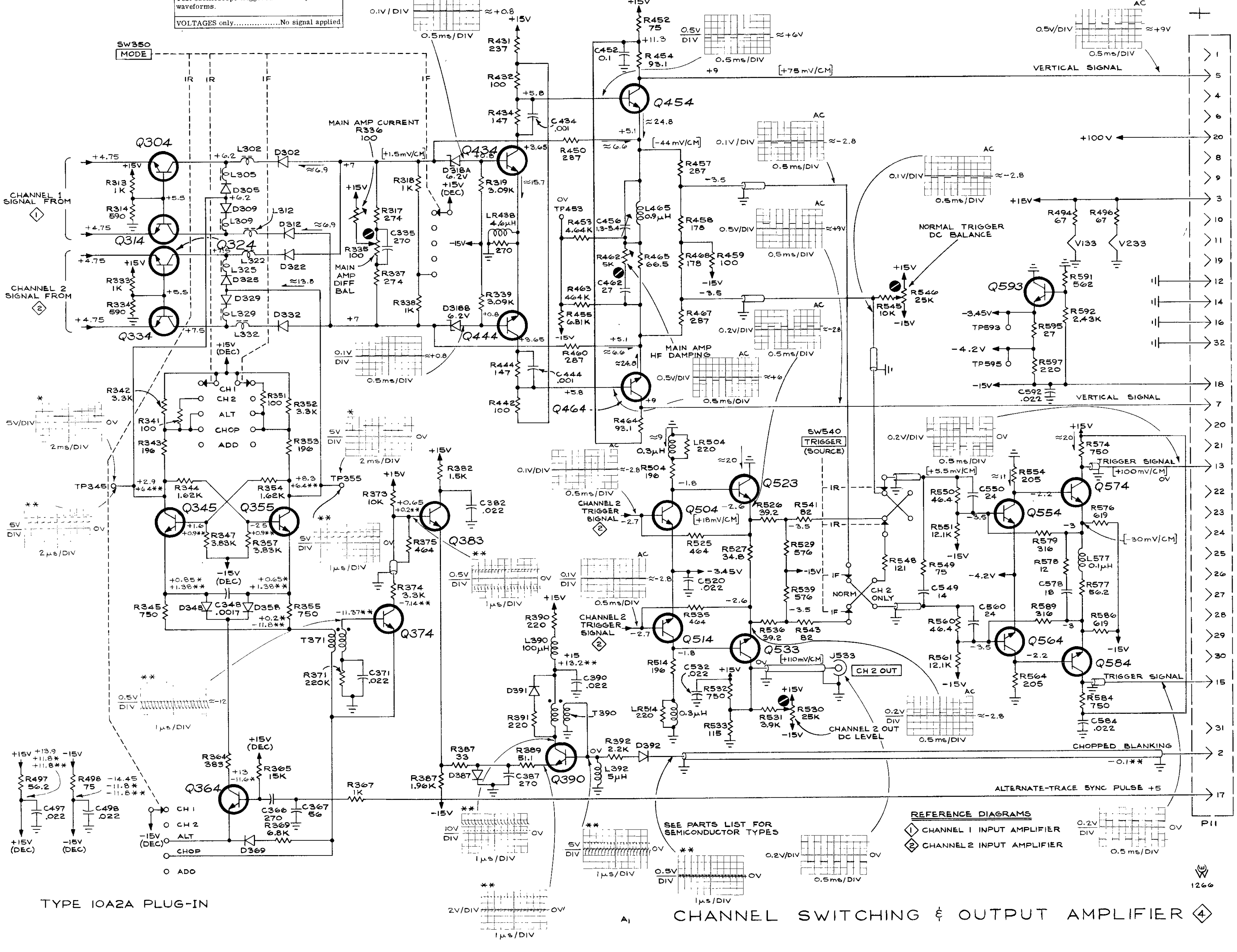
11 67

ATTENUATORS ③

VOLTAGES and WAVEFORMS obtained under conditions given on Diagram ⟨1⟩ except as follows:

VOLTAGES and WAVEFORMS:
*MODE....................ALT
**MODE....................CHOP
Test oscilloscope triggered internally for waveforms.

VOLTAGES only..................No signal applied



TYPE 10A2A PLUG-IN

CHANNEL SWITCHING & OUTPUT AMPLIFIER ⟨4⟩