

INSTRUCTION MANUAL

Serial Number 27285

TYPE 1A1
Dual-Trace
Plug-in Unit
SN 20,000--Up

Tektronix, Inc.

S.W. Millikan Way • P. O. Box 500 • Beaverton, Oregon 97005 • Phone 644-0161 • Cables: Tektronix
070-0885-00

TYPE 1A1 DUAL-TRACE PLUG-IN UNIT

TEKTRONIX, INC., PORTLAND, OREGON, U.S.A.



SECTION 1

CHARACTERISTICS

Change information, if any, affecting this section will be found at the rear of the manual.

Introduction

The Type 1A1 Dual-Trace Plug-In Unit contains two identical high-gain fast-rise calibrated preamplifier channels. Either channel can be used independently to produce a single display or electronically switched to produce dual-trace displays. In addition, both channels can be combined at the output, adding or subtracting according to the settings of the polarity switches.

For single- or dual-trace operation, each channel has its own input selector, attenuator, gain, polarity and position controls so the display can be adjusted for optimum viewing and information.

In dual-trace operation there are two operating modes, chopped or alternate. In the chopped mode, an internal mul-

tivibrator switches the channels at a free-running rate of about 1 MHz. In the alternate mode, the oscilloscope time-base generator internally switches the channel at the end of each sweep during the retrace interval.

Each channel has a basic deflection factor of 0.005 volt/cm. Channel 1 can be used as a 10X (uncalibrated) AC-coupled preamplifier for Channel 2, thus extending the deflection factor of Channel 1 to 500 μ V/cm.

The Type 1A1 can be used with any of the Tektronix 530-, 540-, or 550-Series oscilloscopes. It can also be used with the 580-Series oscilloscopes in conjunction with the Type 81 or 81A Plug-In Adapter. The Type 1A1 can also be used with other oscilloscopes and devices through the use of the Types 127, 132, or 133 Plug-In Power Supplies.

CALIBRATED PREAMPLIFIER

| Characteristic | Performance Requirement | | | Supplemental Information |
|--|---|----------------|--------------|---|
| Deflection Factor | 5 mV/cm to 20 volts/cm in 12 calibrated steps for each channel. | | | Steps in 1-2-5 sequence. |
| Deflection Accuracy | Within $\pm 3\%$ of indicated deflection with VARIABLE VOLTS/CM control set to the CALIB position. | | | With gain correct at 50 mV/cm. |
| Variable Deflection Factor | Uncalibrated deflection factor at least 2.5 times the VOLTS/CM indication. This provides a maximum uncalibrated deflection factor of 50 volts/cm in the 20 volts/cm position. | | | |
| Frequency Response (not more than -3 dB): Type 1A1 with Tektronix oscilloscopes; | $\approx 500 \mu$ V/cm Channels 1 and 2 cascaded. | 5 mV/cm | 50 mV/cm | With VARIABLE VOLTS/CM control set to CALIB. |
| 544, 546, 547, 556, 581, 581A, 585, or 585A | 2 Hz to 15 MHz | DC to 28 MHz | DC to 50 MHz | Using a Type 81A Plug-In Adapter with Type 580-Series Oscilloscope. |
| 581, 581A, 585 or 585A | 2 Hz to 14 MHz | DC to 23 MHz | DC to 33 MHz | Type 81 Plug-In Adapter must be used. |
| 541, 541A, 543, 543A, 543B, 545, 545A, or 545B | 2 Hz to 14 MHz | DC to 23 MHz | DC to 33 MHz | |
| 551 or 555 | 2 Hz to 13 MHz | DC to 21 MHz | DC to 27 MHz | |
| 531, 531A, 533, 533A, 535, or 535A | 2 Hz to 10 MHz | DC to 14 MHz | DC to 15 MHz | |
| 536 | 2 Hz to 8 MHz | DC to 10.5 MHz | DC to 11 MHz | |
| ¹ Risetime (calculated minimum): Type 1A1 with Tektronix oscilloscopes; | | | | Using a Type 81A Plug-In Adapter with Type 580-Series Oscilloscope. |
| 544, 546, 547, 556, 581, 581A, 585, or 585A | 24 ns | 13 ns | 7 ns | |

¹Calculated using this formula

$$\text{Risetime} = \frac{.35}{* \text{Frequency}}$$

*Use the upper bandwidth limit stated for the system.

CALIBRATED PREAMPLIFIER (Cont)

| Characteristic | Performance Requirement | | | Supplemental Information |
|---|--|-------|-------|--|
| 581, 581A, 585, or 585A | 25 ns | 16 ns | 11 ns | Using a Type 81 Plug-In Adapter. |
| 541, 541A, 543, 543A, 543B, 545, 545A, 545B, or 555 | 25 ns | 16 ns | 11 ns | |
| 551 | 27 ns | 17 ns | 13 ns | |
| 531 531A, 533, 533A, 535, or 535A | 35 ns | 25 ns | 24 ns | |
| 536 | 44 ns | 35 ns | 32 ns | |
| Input RC Characteristics | | | | Typically 1 M Ω ($\pm 1\%$) parallel with approximately 15 pF. |
| Maximum Input Voltage | | | | 600 volts combined DC and peak AC. |
| Input Coupling Modes | AC or DC, selected by front-panel switch. | | | GND, disconnects signal and grounds amplifier input. |
| AC Low-Frequency Response | | | | Down less than -3 dB at 2 Hz direct, 0.2 Hz with 10X probe. |
| Vertical Display Modes | Channel 1 only. Channel 2 only. Dual-trace, alternate between channels. Dual-trace, chopped between channels. Added algebraically. | | | |
| Chopped Mode Rate | Approximately 1-MHz rate to show successive 500-ns segments of each trace. | | | Approximately 300-ns of each segment is visible when the CRT cathode selected switch is set to Chopped Blanking. |
| Common-Mode Rejection Ratio | 20:1 for 1-kHz common-mode signals up to 10 cm in amplitude. | | | With optimum GAIN adjustment for both channels. |
| Polarity Inversion | Signal on either Channel 1 or 2 can be inverted. | | | |
| Trace Drift (after warm up) VOLTS/CM at .005 | | | | Typically less than 5 mV/hour. |
| Noise, any position of INPUT SELECTOR switch | | | | Approximately 200 μ volts internal noise, peak to peak. |
| Channel 1 SIGNAL OUT | | | | |
| Output Signal Voltage | Gain of 10, $\pm 10\%$ | | | Channel 1 VOLTS/CM at .005. |
| Output Impedance | | | | Approximately 50 ohms. |
| Output Coupling | DC | | | DC level approximately 0.45 volt, not affected by Channel 1 POSITION control. |
| Frequency Response (not more than -3 dB down) | DC to 35 MHz. | | | Channel 1 VOLTS/CM set to .05. |
| | DC to 24 MHz. | | | Channel 1 VOLTS/CM set to .005. |
| Channel 1 TRIGGER OUT | | | | |
| Output Trigger Voltage | Gain of 100, $\pm 20\%$. | | | Channel 1 VOLTS/CM set to .005. |
| Bandwidth | Sufficient to obtain stable triggering on a 50 MHz waveform which is two cm or more in displayed amplitude. | | | With Type 544, 546, 547, or 556 Oscilloscopes only. |
| Output Coupling | DC | | | DC level -0 volt, ± 1 volt. Not affected by Channel 1 POSITION control. |
| Output Impedance | | | | Approximately 5 k ohms at DC decreasing to essentially 50 Ω at 2 MHz. |

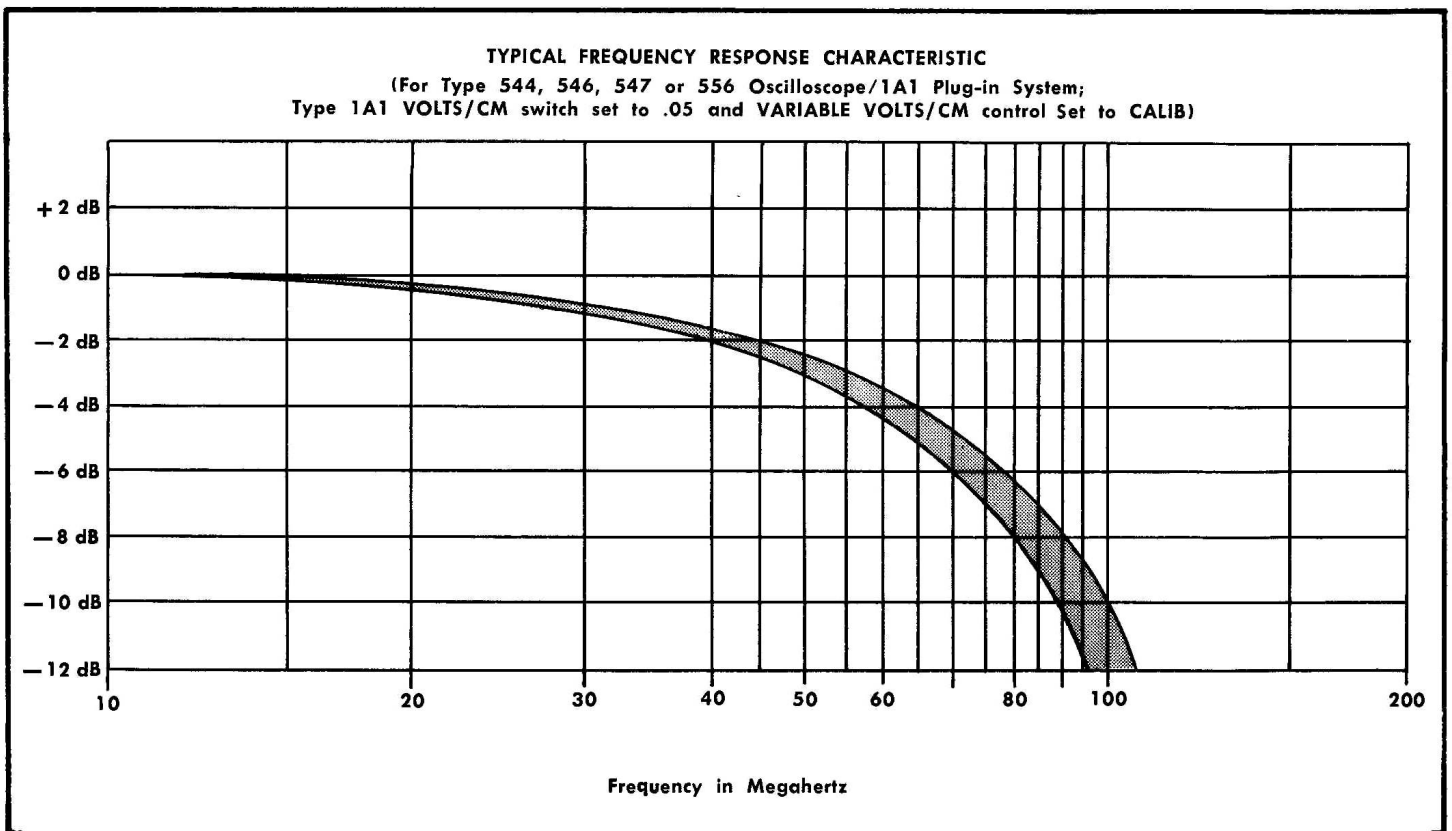


Fig. 1-2. Typical frequency response curve of the Type 1A1 when used in conjunction with the Type 544, 546, 547 or 556 Oscilloscope. A 25-ohm resistor source (generator 50-ohm output applied through a 50-ohm cable terminated in 50 ohms) was used to drive the Type 1A1.

MECHANICAL CHARACTERISTICS

Finish

Anodized front panel.

| Characteristic | Information |
|----------------|---|
| Construction | Aluminum-alloy chassis with three plug-in circuit cards and two circuit boards. |

ACCESSORIES

Standard accessories supplied with this instrument will be found on the last pull-out page of the Mechanical Parts List. For optional accessories, see the current Tektronix, Inc. catalog.

CIRCUIT DESCRIPTION

SECTION 4

Change information, if any, affecting this section can be found at the rear of the manual.

AMPLIFIERS

Introduction

The Type 1A1 Dual-Trace Plug-In Unit consists of two switched-amplifier channels and an output amplifier. Channel 1 is identical to Channel 2 except for additional stages which provide signal and trigger outputs for Channel 1. Therefore, only Channel 1 is described in the following description.

NOTE

Voltages and currents given in the circuit description are approximate. Throughout the circuit description discussion, refer to the block and circuit diagrams located in Section 10.

Input Coupling

The signal to be displayed is applied to Input Source Follower Q122 via INPUT SELECTOR switch SW101 and VOLTS/CM switch SW105. In the DC position of the INPUT SELECTOR switch, input coupling capacitor C102 is bypassed so the input is DC coupled. In the AC position, the signal must pass through C102, which blocks the DC component. Capacitor C102 limits the low-frequency response to less than 2 Hz at -3 dB. In the GND position, the signal path is open and the input circuit of the channel is grounded.

Input Attenuation

VOLTS/CM switch SW105 and SW129 is a 12-position two-section rotary switch. The first section (SW105), containing attenuator networks, is electrically connected in the gate circuit of Input Source Follower Q122; the second section (SW129), containing emitter resistors, controls the gain of Input Amplifier Q124/Q144. A special mechanical coupling between the two sections holds the first section (SW105) stationary while the second section (SW129) rotates through the first four positions (.005, .01, .02 and .05). Then, the mechanical coupling transfers the switch drive from the second section of the switch to the first section. As a result, the second section will remain stationary at the .05 position while the first section rotates through its positions.

In the first four positions of the VOLTS/CM switch, the signal is coupled straight through the first section of the switch without attenuation to the Input Source Follower Q122. When the signal arrives at Input Amplifier Q124/Q144, emitter resistors inserted by the second section of the

switch set the gain of the stage and hence the amount that the signal is amplified.

In the remaining positions of the VOLTS/CM switch (.1 through 20) individual attenuator networks are switched into the gate circuit of Input Source Follower Q122 so the signal applied to the gate is always 0.05 volt for each centimeter of CRT deflection, providing the VARIABLE VOLTS/CM control is set to the CALIB position and the gain of the Type 1A1 and associated oscilloscope is set properly.

The attenuator networks are frequency compensated RC voltage dividers. Their attenuation factor can generally be expressed as follows:

$$\text{Attenuation Factor} = \frac{\text{total divider resistance (including R116)}}{\text{Ground-leg resistances (including R116)}}$$

Using the $\times 2$ attenuator as a specific example (see Fig. 4-1), the formula is:

$$\text{Attenuation Factor} = \frac{(R105C)(R116) + (R105C)(R105E) + (R105E)(R116)}{(R105E)(R116)} = 2$$

At low frequencies the dividers are resistive because the impedance of the capacitors is high and their effect in the circuit is negligible. As the frequency of the input signal increases, however, the impedance of the capacitors decreases and their effect in the circuit becomes more pronounced.

For high-frequency signals, the impedance of the capacitors is low in comparison to the resistance of the circuit and the attenuators become capacitive voltage dividers. For these frequencies, the attenuation factor is similar to the resistance case, except that the capacitive reactances are the dominant factors involved. A variable capacitor in each attenuator, such as C105C in the $\times 2$ attenuator (see Fig. 4-1), provides a method for adjusting the capacitive reactance ratios equal to the resistance ratios.

The variable capacitor at the input to each attenuator (see Fig. 4-1), provides a means for adjusting the input RC of the attenuator to an arbitrary standard value of 15 pF \times 1 M Ω when using a 15 pF input time constant normalizer as a reference. Similarly, C104 provides a method for normalizing the input time constant when the VOLTS/CM switch is set to any of the input straight-thru positions. In addition to providing the same input capacitance, the resistance values of the attenuators are chosen to provide an input resistance of 1 M Ω for each setting of the VOLTS/CM switch. Thus, an attenuator probe, when connected to the input connector of the Type 1A1, will work into the same time constant to eliminate the need for readjusting the probe capacitance compensation for different VOLTS/CM switch settings.

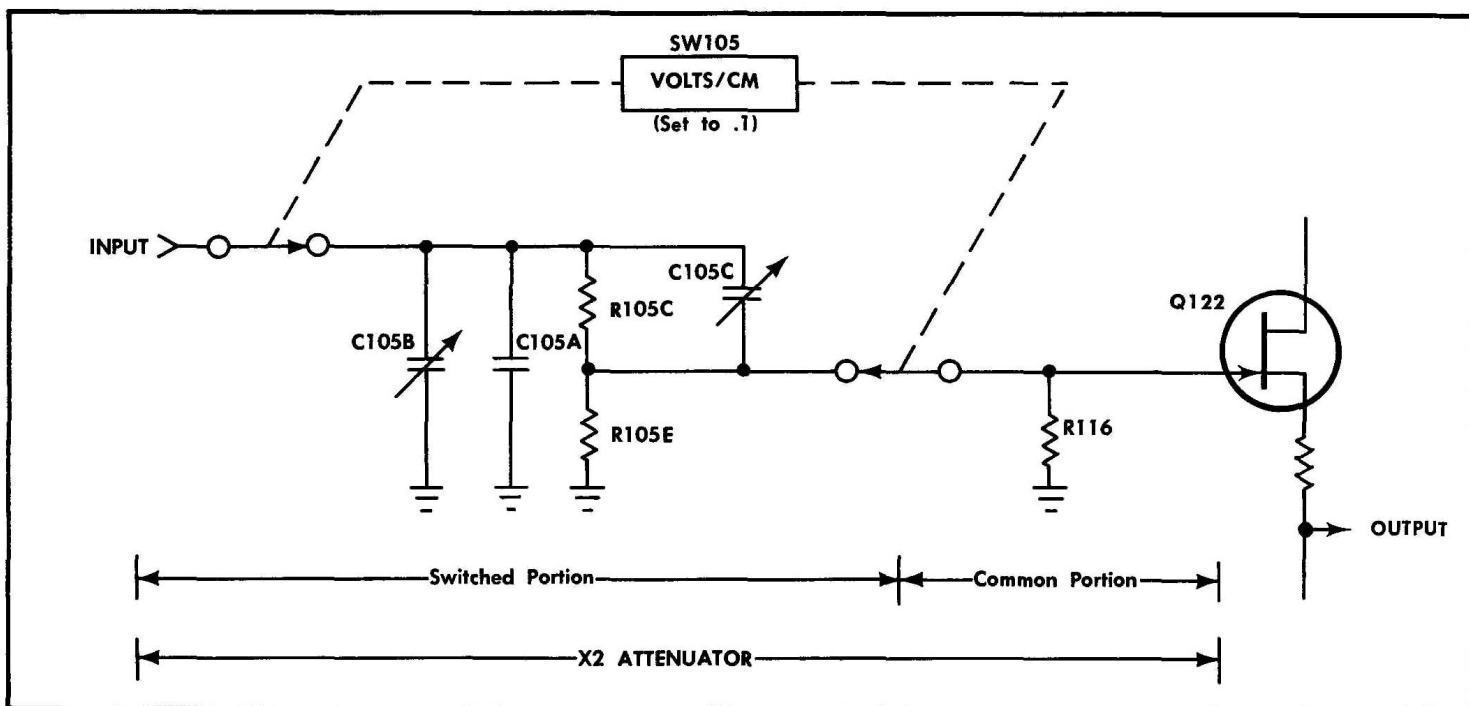


Fig. 4-1. Simplified circuit diagram showing the most important components involved when calculating the $\times 2$ attenuation factor.

Input Source Follower (Q122)

Q122 is a field-effect transistor (FET) that presents a high-impedance, low-capacitance load to the input circuit and isolates the input from the remaining stages. Resistor R116 is the input resistor for the VOLTS/CM positions from .005 to .05, and then is part of the input attenuation network in all positions of the VOLTS/CM switch above .05.

A network consisting of C119, R119, D118, D119 and R118 form a protection circuit in Q122 gate circuit. The resistive component R119 limits the steady-state current if a negative- or positive-going overload signal is inadvertently applied to the Channel 1 INPUT connector. At normal signal amplitudes R119 will deteriorate the high-frequency AC response. To offset this effect, C119 is added to pass the high frequency information around R119.

If a negative-going overload signal is applied to the Channel 1 INPUT connector, D119 will conduct and limit the voltage to -20.6 V at the gate element of Q122. Zener diode D118 sets the voltage of D119 at -20 V. If a positive-going overload signal is applied, D122 conducts and clamps the base of Q123 at $+5.6$ V.

Zener diode D121, connected between ground and the drain elements of Q122 and Q142, clamps the drain elements at $+10$ V for all operating conditions.

A capacitive-coupled bootstrap circuit is connected between the source and the capacitive elements connected to the gate of Q122 to reduce the effective capacitance of the input circuit. By reducing the input capacitance, sufficient adjustment range is provided for the variable input capacitors in the attenuators and the $\times 1$ input circuit, such as C104 for example. The input capacitance is effectively reduced two ways: (1) By encircling Q122 gate terminal with an etched wire and connecting this etched wire to the source element; (2) by connecting D119 diode case lead to Q122

source element instead of ground. (Capacitance exists between the diode case and the diode chip inside the case).

The capacitance that exists between the base of the mounting posts for C119 and R119 and the etched wire that encircles these posts improves the response of the circuit when a fast rising square wave is applied to the Channel 1 INPUT connector.

DC Balance Source Follower (Q142)

The DC Balance Source Follower (Q142), the Input Source Follower (Q122), and the Emitter Follower (Q123/Q143) stages constitutes a complete symmetrical circuit for the purpose of balancing out objectionable low-voltage power-supply fluctuations. Voltage variations common to the signal circuit and the DC balance drive circuit arrive in phase at the bases of the Input Amplifier stage (Q124/Q144) and therefore cancel.

In the gate circuit of Q142, the .005 V/CM VAR ATTEN BAL control (R130) is a dual concentric potentiometer with both sections driven by the same front-panel shaft. This control has built-in backlash coupling between its two sections. Thus, the control serves as a combined coarse-fine adjustment to permit setting the DC balance drive accurately and yet provide a wide range of coarse adjustment.

C138 bypasses any fast voltage fluctuations to ground. C140 bypasses the chopped mode switching transients that are induced in the ground-current loop when chopped mode of operation is used.

First Emitter Follower (Q123/Q143)

In addition to providing a means for balancing out power-supply fluctuations, as described previously, the First Emitter

Follower stage (Q123/Q143) provides a low-impedance drive to the Input Amplifier stage (Q124/Q144). The signal at the source element of Q122 is DC coupled to the base of Q124.

A plastic cover is placed over Q123 and Q143 to minimize the differential variations of ambient temperature between the transistors.

Input Amplifier (Q124/Q144)

This stage is an emitter-coupled paraphase amplifier. It converts the single-ended input signal applied to the base of Q124 to differential current signals at the collectors. Both emitters are long tailed (through R127, R147, R148 and R149) to the —150-volt supply for greater stability with respect to transistor parameters.

As mentioned previously, the second section of the VOLTS/CM switch controls the deflection factor for the first four steps by changing the emitter resistance of this stage, thus controlling the gain of the stage. At the .005 VOLTS/CM POSITION, gain ratio is 10 to 1; at the .05 position, gain ratio is 1 to 1. For the .005 position, the .005 V/CM GAIN adjustment (R128A) is adjusted so the 10-to-1 gain ratio is accurate. Precision resistors set the gain ratio accurately for the three remaining steps.

To balance the emitters of Q124 and Q144 under no-signal conditions, the VOLTS/CM switch is set to the .005 position and the .005 V/CM VAR ATTEN BAL control (R130) is adjusted for no trace shift while the VARIABLE VOLTS/CM control is rotated back and forth. After noting the position of the trace, the VOLTS/CM switch is set to .05 and .05 V/CM DC BAL control (R148) is adjusted to position the trace to the previously noted position. When the stage is correctly balanced, the emitters will be at the same voltage and there will be no current between emitter resistors regardless of the VOLTS/CM switch positions.

The value of the collector resistors R126 and R146 is chosen to provide proper base-emitter junction temperature compensation for their respective transistors. C125, C152 and C156 provide a means for adjusting the high-frequency response to compensate for losses introduced by temperature compensation resistor networks and to balance the output of the two channels.

Resistors R124, R125, R144 and R145 develop the signal for application to the following stage.

The second Emitter Follower stage (Q153A/Q153B) couples the push-pull signal from the Input Amplifier to the Output Amplifier first stage. In addition, the second Emitter Follower stage provides the necessary low-impedance drive for the circuit card connectors, the PULL FOR INVERT switch (SW405), and the interconnecting leads.

When the PULL FOR INVERT switch is set to the normal (in) position, the signal at the emitter of Q153A is coupled via the switch contacts to the base of Q414 (Output Amplifier) and the signal at the emitter of Q153B is coupled via the switch contacts to the base of Q404 (Output Amplifier). Thus, the display will have the same polarity as the input signal applied to the Channel 1 connector. If the input signal is positive-going at the Channel 1 connector, for example, the display waveform will also be positive going. However, when the switch is set to the

invert position, the display will be inverted because the switch reverses the signal leads to the bases of the following stage. Thus, a positive-going signal will be displayed as a negative-going waveform.

The INV BAL control (R152) in the base circuit of Q153A DC balances the outputs of the second Emitter Follower stage so there is no trace shift when the PULL FOR INVERT switch is changed from normal to invert under no-signal conditions.

Output Amplifier First Stage (Q404/Q414)

This stage is an emitter-coupled push-pull amplifier providing a total gain of about 2. Collector current for the stage is supplied through the diode switches (see Fig. 4-2).

There are two gain controls located in the common-emitter circuit of Q404 and Q414—VARIABLE VOLTS/CM control (R408) and GAIN control (R409). Both controls vary the emitter degeneration and, thus, affect the gain of the stage. With the VOLTS/CM switch in the .05 position and the VARIABLE VOLTS/CM control set to CALIB, the GAIN control is adjusted so the CRT deflection agrees with the setting of the VOLTS/CM switch. The VARIABLE VOLTS/CM control has a gain attenuation ratio of 2.5 to 1. However, this ratio is actually greater than 2.5 to 1 due to SW409. As the VARIABLE VOLTS/CM control is rotated a few degrees from the CALIB position, SW409 closes and shorts out R409. Gain increases, thus providing overlapping coverage between the calibrated VOLTS/CM switch positions.

The POSITION control (R422), connected between the differential inputs to the diode switches, provides differential currents that act as positioning signals superimposed on the output signal currents of Q404 and Q414. When the POSITION control is set to its electrical center, no current flows in either leg. When the POSITION control is moved to either end from center, a change of about 0.6 volt per side occurs at pins 1 and 3 of the interconnecting plug to the oscilloscope. This voltage range corresponds to about 12 cm positioning range at the CRT.

Diode Switches

The push-pull signal from the Output Amplifier first stage is applied to diode switches D421, D422, D423 and D424. These diodes act like a double-pole double-throw switch. Each pair, D421 and D422 or D423 and D424, is on while the other pair is off. Switching of the diodes to connect or disconnect a channel is controlled by the MODE switch via the Switching Multivibrator in the Channel Switching Circuit.

Assume Channel 1 is turned on (MODE switch is set to CH 1) and the POSITION control is centered. The state of the Switching Multivibrator (Q305 and Q315) is such that +7.7 volts from its conducting transistor Q305 is applied to cathode junctions of Channel 1 shunt diodes D422 and D423 (see Fig. 4-2). The lowest voltage seen by the cathodes of the diodes switches is +4.6 volts at the cathodes of Channel 1 series diodes D421 and D424. The series diodes conduct and the drop across these diodes sets their anodes at +5.6 volts. The +5.6 volts reverse biases the shunt diodes. With the series diodes conducting, the Channel

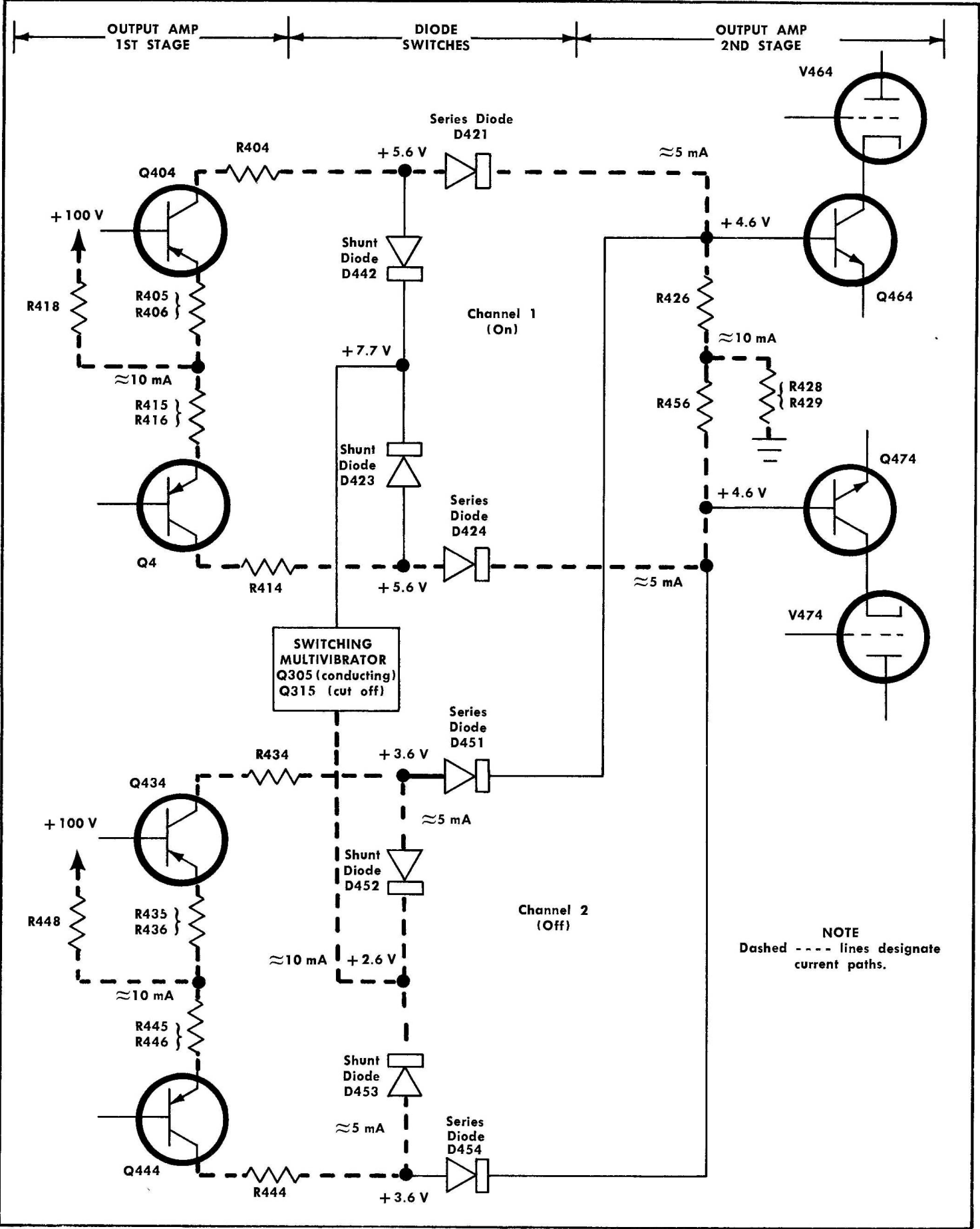


Fig. 4-2. Simplified circuit diagram showing the main DC current paths when Channel 1 is on and Channel 2 is off.

1 signal passes through these diodes to the Output Amplifier second stage.

Meanwhile, +2.6 volts is applied from the Switching Multivibrator's cutoff transistor Q315 to the cathode junctions of the Channel 2 shunt diodes D452 and D453 (see Fig. 4-2). This is the lowest voltage seen by cathodes of the Channel 2 diode switches. As a result, Channel 2 shunt diodes conduct and the voltage drop across the shunt diodes sets their anode level at +3.6 volts. The +3.6 volts reverse biases Channel 2 series diodes and blocks the signal from going to the Output Amplifier second stage. With the shunt diodes conducting, the Channel 2 signal is shunted into the common-mode point located at the cathode junction of the shunt diodes.

In the CH 2 position of the MODE switch, the opposite condition exists—Channel 1 is off and Channel 2 is on because the Switching Multivibrator changes state. The Switching Multivibrator's cutoff transistor Q305 applies +2.6 volts to the cathode junction of Channel 1 shunt diodes. Under these conditions, Channel 1 shunt diodes conduct and reverse bias the series diodes. The reverse-biased series diodes disconnect the Channel 1 signal from the Output Amplifier second stage. Simultaneously, Channel 2 diodes conduct and reverse bias the shunt diodes. With Channel 2 series diodes conducting, the Channel 2 signal passes through the series diodes to the Output Amplifier second stage.

During dual-trace operation when the MODE switch is set to either ALT or CHOP position, the diode switches connect and disconnect their respective channels to the Output Amplifier second stage alternately at the same rate as the Switching Multivibrator rate. The cycle of operation for the diode switches is as previously described.

When the MODE switch is set to ADD, the Switching Multivibrator goes into a state in which both of its transistors are conducting simultaneously. The conducting transistors apply +7.7 volts to the cathode junctions of the shunt diodes in both channels. As a result, the shunt diodes reverse bias and series diodes conduct. The signals in both channels pass through their respective series diodes and algebraically add in the input circuit of the Output Amplifier second stage.

In the ADD mode of operation, R429 is shorted by the MODE switch, thus decreasing the effective resistance to ground in the base and diode switch circuits. With two channels on, the decreased resistance sets the cathode voltages of the series diodes in both channels and the bases of Q464 and Q474 to their proper levels. The voltage levels will then be the same as those of the turned-on channel in the other modes of operation. Proper voltage levels in this portion of the circuitry allow the Switching Multivibrator to operate at its correct design levels.

Output Amplifier Second Stage (Q464/V464/Q474/V474)

This stage is a push-pull, hybrid, cascode configuration. The hybrid circuit is used to raise the +4.6-volt input level at the bases of Q464 and Q474 to the +67.5-volt output

level required for driving the oscilloscope vertical amplifier for linear operation.

Signals applied to the bases of transistors Q464 and Q474 cause current variations in the base-collector circuit of the transistors. Since the transistors are connected in series with the cathode circuit of V464 and V474 and the grids of the tubes are at AC ground, any current variations in the cathode circuit of the tubes produce corresponding in-phase current signals at the plate of the tubes. The signals at the plates are then applied through pins 1 and 3 of the interconnecting plug to the oscilloscope vertical amplifier.

Voltage signals applied to the bases of Q464 and Q474 are inverted 180° at the collectors. No phase inversion occurs as the signals go through V464 and V474. With the PULL FOR INVERT switch set to normal, a positive-going signal applied to the input connector of a channel will be positive going at pin 1 of the interconnecting plug to the oscilloscope and negative going at pin 3 of the same plug (see Block Diagram, Section 10 for signal polarity comparisons).

Variable peaking inductors L460 and L470 in the base circuit of Q464 and Q474 provide interstage high-frequency compensation adjustments for the high frequencies. Variable capacitors C466 and C476 are emitter compensation adjustments for the high frequencies.

Resistors R464 and R474 aid in matching the output impedance of the Type 1A1 to the input impedance of the oscilloscope vertical amplifier.

Channel 1 Signal Pickoff Emitter Follower (Q163/Q173)

The Channel 1 signal is taken off in a push-pull fashion from the emitters of the second Emitter Follower stage (Q153A/Q153B). This is the signal which is applied to the Channel 1 Signal Pickoff Emitter Follower stage (Q163/Q173) and then to the following stages for use as Channel 1 Signal and Trigger outputs from the Type 1A1.

The reasons for taking the signal off at the emitters of Q153A and Q153B are as follows:

1. The emitters are low-impedance points where the signal can be extracted with least effect on the bandwidth or transient response of the Type 1A1.
2. The takeoff points are isolated from the diode switches.
3. A gain of 10 is obtained through the Input Amplifier stage when the VOLTS/CM switch is set to the .005 position.
4. The push-pull takeoff signal is not affected by use of the PULL FOR INVERT switch, POSITION control, VARIABLE VOLTS/CM control, GAIN control or MODE switch.
5. By using push-pull takeoff, common-mode signals such as noise, hum and DC drift are cancelled in the common collector circuit of Q163 and Q173, and in the common emitter circuit of Q164 and Q174.

Channel 1 Signal Pickoff Amplifier (Q164/Q174)

Q164 and Q174 with its associated circuitry is a push-pull amplifier for the Channel 1 signal arriving from the emitter of Q163 and Q173. Voltage gain for the stage is about 2 for Q164 and about 6 for Q174. In the collector circuit of Q164 the signal at the junction of R164 and R165 is applied to the CH 1 SIGNAL OUT connector. The polarity of the signal at the connector is the same as that of the signal applied to the Channel 1 INPUT connector.

Output DC level of the signal at the CH 1 SIGNAL OUT connector is about +0.45 volt.

Channel 1 Trigger Output Amplifier (Q184/Q194)

The Channel 1 takeoff signal which is used as a trigger output source, is obtained from the junction of divider resistors R174 and R175 in the collector circuit of Q174. This trigger takeoff signal is applied to the bases of Q184 and Q194.

Transistors Q184 and Q194 with associated circuitry form a complementary amplifier having a signal-voltage gain of about 3.3. The outputs from these two transistors are combined to produce a single-ended signal. This signal, which is used as a trigger source, is applied to the CH 1 TRIGGER OUT connector and to pin 5 of the interconnecting plug to the oscilloscope.

The trigger at pin 5 is available for use as an internal trigger source. However, to make use of this trigger, the associated oscilloscope must be capable of selecting it with a Triggering Source switch. If the Channel 1 trigger cannot be selected internally, external triggering must be used instead. The Channel 1 trigger has the same polarity as the signal applied to the Channel 1 INPUT connector. Output DC level is approximately zero volts.

SWITCHING CIRCUIT

Selection of the input channel whose output is to be applied to the Output Amplifier is accomplished by the Switching Circuit. The Switching Circuit consists of the following stages in order: Switching Multivibrator Q305/Q315, Alternate Trigger (Blocking Oscillator) Q330, and the Blanking Multivibrator Q343/Q353.

Switching Multivibrator (Q305/Q315)

The Switching Multivibrator stage (Q305/Q315) is basically a bistable circuit that switches Channels 1 and 2 in the Type 1A1. When Q305 conducts, Channel 1 signal or trace is displayed. When Q315 conducts, Channel 2 signal or trace is displayed. The setting of the MODE switch determines whether the Switching Multivibrator rests in one of its stable states (CH 1 or CH 2), is astable (CHOP), is bistable (ALT—base triggered by the alternate trigger pulse), or is dual-conducting (ADD).

(1) CH 1, CH 2

Assume that the MODE switch is set to CH 1. In this position, base-biasing network R302, R303 and R304 in the

base circuit of Q305 is grounded at the switch end of R302. A similar network in the base circuit of Q315 is connected to +39 volts at the switch end of R312. The MODE switch disconnects emitter resistors R301 and R311 from the +39-volt supply. As a result, both emitters are now returned to +39 volts through D301, D311 and R300. Under these conditions, the Q315 base-biasing network cuts off Q315 and the base biasing network for Q305 turns on Q305. Diode D303 is conducting while D313 is reverse biased. These diodes control the base impedance of their respective transistors so that proper currents are provided for the operation of transistors in each of their states.

With Q305 conducting, its collector rests at +7.7 volts; the collector voltage of Q315 during cutoff is +2.6 volts. As described earlier, the +7.7 volts reverse biases the Channel 1 shunt switching diodes D422 and D423. Channel 1 series diodes D421 and D424 are forward biased and they connect Channel 1 Input Amplifier to the Output Amplifier. Simultaneously, the +2.6 volts at the collector of Q315 causes Channel 2 shunt diodes D452 and D453 to become forward biased and series diodes D451 and D454 to become reverse biased. Thus, Channel 2 Input Amplifier is disconnected from the Output Amplifier.

If the MODE switch is set to the CH 2 position, just the opposite occurs. The MODE switch connections cause Q305 to cut off and Q315 to conduct. Diode D303 becomes reverse biased and D313 forward biases. Then, the +2.6 volts at the collector of Q305 causes the Channel 1 diode switches to disconnect Channel 1 from the Output Amplifier. At the same time, the +7.7 volts at the collector of Q315 causes Channel 2 diode switches to connect Channel 2 to the Output Amplifier.

(2) Alternate Mode of Operation

When the MODE switch is set to the ALT position, the Switching Multivibrator becomes a bistable circuit. Initially, the circuit is resting in one of its stable states. When triggered by a positive-going pulse applied to the junction of diodes D308 and D318, the circuit switches to its other stable state, and remains there until triggered again.

With the MODE switch set to ALT, the switch ends of R302 and R312 in both base-biasing networks are connected to +39 volts. The emitters are tied to a common point through D301 and D311 at R300. Using this method of biasing, the Switching Multivibrator is converted into a bistable circuit. With initial application of DC power, one of the transistors begins to conduct first while the other is cut off. Regenerative action causes the conducting transistor to saturate, holding the other transistor in cutoff. Thus, the circuit initially rests in one of its stable states.

At the end of each sweep a positive-going trigger is generated by the time-base circuit in the oscilloscope. This alternate trace sync pulse is applied via the oscilloscope Sync Amplifier tube cathode circuit to pin 8 of the interconnecting plug. The sync pulse goes through pin 8 of the plug and then through a single-pin connector on the Output Amplifier board connector to the Alternate Trigger Blocking Oscillator stage (Q330). A positive-going trigger of suitable waveshape and amplitude is generated in the output winding of T330. The trigger is then applied to the junction of diodes D308 and D318. The trigger forward biases both diodes and goes through the diodes to the

bases of both transistors in the Switching Multivibrator stage. The trigger affects only the conducting transistor in the stage.

Assume for this discussion that Q305 is conducting and Q315 is cut off. Since Q305 is conducting, it is affected by the trigger. The trigger causes Q305 collector current to decrease, which decreases collector voltage. The decreasing voltage is applied via C306 to the base of Q315, causing it to conduct. Q315 collector current increases, causing more positive voltage to be applied via C316 to the base of Q305. This regenerative feedback continues until Q315 is driven into saturation and Q305 is cut off.

Since the Switching Multivibrator controls the diode switches, Channel 1 is turned off as Q305 cuts off and Channel 2 is turned on as Q315 is driven into saturation, thus completing one-half cycle of the Switching Multivibrator action. For the other half cycle, the next trigger applied through diodes D308 and D318 will cause Q315 to decrease its collector current and the regenerative feedback action finally causes Q305 to saturate and Q315 to cut off. As a result, Channel 2 is turned off and Channel 1 is turned on.

By rapidly coupling the changing voltages to the bases of the transistors in the Switching Multivibrator, capacitors C306 and C316 speed up the regenerative feedback action and ensure rapid switching of the transistors.

In the alternate mode of operation, diodes D301 and D311 are forward biased, effectively shorting out C301 and C311. Thus, no pulses from the Switching Multivibrator are coupled through these capacitors to drive the Blanking Multivibrator stage. Since the channels switch states during the retrace interval and the trace is already blanked out by the oscilloscope circuitry, no blanking pulses from the Type 1A1 are needed.

In an oscilloscope which has an alternate sweep feature, the two time bases in the oscilloscope can be displayed alternately on the CRT by setting the oscilloscope Horizontal Display switch to the Alternate (A and B) position. In this position of the switch the A and B sweep generators are alternately generating sweeps. During the time that the B Sweep Generator is generating its sweep, this same generator also produces a negative-going (+45 volts to ground) slave pulse. The pulse is applied to pin 7 of the interconnecting plug between the oscilloscope and the Type 1A1. From pin 7 of the interconnecting plug the pulse is applied through pin X of the Output Amplifier card to the junction of R313 and D313 via C313.

The negative-going slave pulse, applied to the junction of R313 and D313, ensures that Q315 is triggered into conduction so that Channel 2 turns on while the B Sweep Generator is generating its sweep. While Channel 2 is on, Channel 1 is off because Q305 is cut off. At the end of the B sweep, the slave signal terminates and the alternate trace sync pulse from the B Sweep Generator triggers the Alternate Trigger Blocking Oscillator. The trigger from the Alternate Trigger Blocking Oscillator drives Q315 toward cutoff, turning Channel 2 off and Channel 1 on. During the time that Channel 1 is on, A Sweep Generator is generating its sweep so the signal in Channel 1 can be displayed. Channel 2, meanwhile, is turned off as long as Q315 is cut off.

(3) Chopped Mode of Operation

When the MODE switch is set to the CHOP position, the Switching Multivibrator becomes an astable circuit. It free runs at approximately a 1 MHz rate, driving the diode switches at the same rate. The diode switches alternately turn the channels off and on. Thus, each channel is on for about 0.5 μ s while the other is off the same amount of time.

With the MODE switch set to the CHOP position, the base-biasing networks are connected to +39 volts, the same as for alternate mode of operation. The junction of emitter resistors R301 and R311 is now connected via the MODE switch to +39 volts. In addition, the switch end of R300 is grounded to reverse bias D301 and D311. The reverse-biased diodes remove the low-impedance path from across coupling capacitors C301 and C311. These capacitors AC couple the emitters together to make the Switching Multivibrator free run at a rate determined by the resistance and capacitance values used in the emitter circuits.

Each time the Switching Multivibrator switches states, a fast negative-going pulse followed by a slow-rise positive-going ramp is produced at the junction of C301 and C311. The ramp rises in amplitude until the Switching Multivibrator switches states, then the cycle is repeated. This ramp-type pulse at the junction of the capacitors is the algebraic addition of the timing voltage signals developed at the emitters of the transistors. The ramp pulse is applied to the base of Q343 in the Blanking Multivibrator stage.

(4) Added Mode Of Operation

Setting the MODE switch to the ADD position grounds the switch end of R302 and R312 of the base-biasing networks. The MODE switch disconnects the switch end of emitter resistors R301 and R311 from +39 volts. Instead, the emitter of the transistors are now tied through forward-biased diodes D301 and D311 to R300. The switch end of R300 is connected to +39 volts via the MODE switch to apply forward-bias voltage to the diodes. The bases of both transistors are lowered toward ground since the switch ends of R302 and R312 are tied to ground. As a result, both transistors go into conduction simultaneously. With both transistors conducting, both channels are turned on via their respective diode switches.

In order to make the diode switches operate properly in the ADD position, the collectors of Q305 and Q315 must be raised to about the same level as the collector level of the single conducting transistor in the other modes of operation. To raise the collector level, the switch end of R321 is disconnected from ground so it can be connected in series with R322. Resistor R322 raises the voltage level at the collectors to the normal +7.7-volt level.

Alternate Trigger Blocking Oscillator (Q330)

The main function of the Alternate Trigger Blocking Oscillator stage (Q330) is to provide a fast positive-going trigger of definite shape and energy content for triggering the Switching Multivibrator in alternate mode of operation. Reshaping the trigger assures that the Type 1A1 will function properly with any oscilloscope capable of accepting the unit.

Circuit Description—Type 1A1

When the MODE switch is set to the ALT position, the MODE switch connects +225 volts via R355 and pin 16 of the interconnecting plug to the plate of the Sync Amplifier tube in the oscilloscope circuitry. The Sync Amplifier stage operates as a cathode follower when the Type 1A1 is used with the oscilloscope, because the base winding of T330 is connected in the cathode circuit of the tube. The connection is made via a single-pin connector on the Output Amplifier card connector and pin 8 of the interconnecting plug.

In its quiescent state, Q330 is not conducting. At the end of each sweep cycle a positive-going pulse is generated in the base winding of T330, causing Q330 to conduct. The collector winding of T330 supplies regenerative feedback to the base winding to drive Q330 into saturation, and collector current ceases to increase.

Since the collector current becomes constant, no feedback voltage is induced, Q330 is reverse biased, and the collapsing field produces a slight backswing voltage. During the time that the Alternate Trigger Blocking Oscillator is going through its cycle, the approximate voltage induced in the output tertiary winding is about a 2-volt positive-going pulse which is applied to the Switching Multivibrator stage. This is the trigger which flips the Switching Multivibrator. The Switching Multivibrator in turn, switches the channels via the diode switches.

Diode D330 is in Output Amplifier cards Model 4-up to clip the slight backswing voltage caused by the collapsing field of T330. This prevents double triggering of the Switching Multivibrator.

The dots above the individual T330 windings, as shown on the schematic diagram, are phasing dots. They show that there is no phase reversal if pulse polarities are compared between the dot end of the windings. However, there is a phase reversal if the signal at the dot end of one winding is compared with the signal at the no-dot end of the other windings. The signals can be compared between the ends of the windings that are not at AC or DC ground.

When the MODE switch is set to any position other than ALT, the +225 volts is disconnected from the switch end of R355. The result is that the Sync Amplifier stage in the oscilloscope no longer functions as a cathode follower to drive the Alternate Trigger Blocking Oscillator stage. Since the Alternate Trigger Blocking Oscillator stage is not being driven, the stage is inoperative during these modes of operation.

Blanking Multivibrator (Q343/Q353)

The Blanking Multivibrator stage Q343/Q353 is a monostable, common-emitter, collector-to-base clamp multivibrator. When triggered during chopped mode of operation, this stage produces a blanking pulse of sufficient amplitude and duration to blank the beam during the switching interval. Timing of the switching and blanking multivibrators in the Switching Circuit of the Type 1A1 allows for the delay in the vertical amplifier of the oscilloscope. That is, the blanking pulse arrives at the CRT cathode at the same time that the switching-transient portion of the composite signal arrives at the vertical deflection plates. Correct timing and wave-shape assures that the beam is blanked out during the switching time between channels. However, due to the

nature of the circuitry, some intensification of the unblanked trace does occur during the sweep.

Setting the MODE switch to the CHOP position causes the Switching Multivibrator to free run, as stated earlier. The ramp pulses at the junction of C301 and C311 are applied through R341 to the base of Q343 in the Blanking Multivibrator stage.

In its quiescent state Q343 is cut off and Q353 is conducting. C343 is charged to about +12.5 volts at the base of Q353; clamp diode D345 is forward biased by about 0.2 volt. The instant that the Switching Multivibrator switches states, the ramp pulse terminates as it drops rapidly from its peak amplitude. The terminating ramp causes the voltage at the base of Q343 to drop from +12.7 volts to about +11 volts. This sudden drop in voltage drives Q343 into conduction. The rise in voltage at the collector of Q343 is coupled to the base of Q353. D345 unclamps and Q353 goes toward cutoff. With D345 unclamped, C343 discharges at a constant rate through R345 toward the -150-volt supply. Finally, a point is reached where Q353 is cut off. At about this time D345 conducts and clamps the base of Q353 at +12.5 volts, thus completing the first half of the cycle. For the last half of the cycle the ramp at the base of Q343 causes Q343 to go from saturation to cutoff as Q353 goes into conduction. Near the end of the cycle, the ramp pulse drives Q343 into cutoff. Then, the ramp pulse terminates and begins its slow rise to repeat the cycle.

Negative-going blanking pulses, about 6 volts or more in amplitude, are produced at the collector of Q353. The pulse reaches its peak about 0.25 μ s after the Switching Multivibrator has triggered the Blanking Multivibrator. The 0.25- μ s delay equals the delay of the applied signal as it goes through the vertical amplifier and delay line of the oscilloscope. Thus, the switching portion of the signal and the blanking pulse arrive at the same time at the CRT.

To get the pulse to the CRT, the pulse at the collector of Q353 is coupled through C353 and then through a single-pin connector on the Output Amplifier card to pin 16 of the interconnecting plug. From pin 16 the blanking pulse goes to the plate circuit of the Sync Amplifier tube in the oscilloscope. This tube is inoperative as a Sync Amplifier (or a cathode follower) during this mode of operation. The components in the plate circuit of the tube combined with R355 in the Type 1A1 Blanking Multivibrator stage form an RC coupling network to couple the pulse to the grid of the Blanking Amplifier, the pulse is applied through the CRT Cathode Selector switch to the cathode of the CRT to blank the beam during the time that the channels switch.

Diode D353 is in Output Amplifier cards Model 7-up to protect Q353 from being damaged by the large transients which occur at some positions of the MODE switch.

If the MODE switch is set to the ALT position, no pulses from the Switching Multivibrator stage are coupled through C302 and C311 to the Blanking Multivibrator. Conduction of diodes D301 and D311 effectively shorts out the coupling capacitors, thus, preventing the pulses from triggering the Blanking Multivibrator. Shorting out the coupling capacitors is an indirect result obtained when the Switching Multivibrator functions as a bistable circuit in the alternate mode. On the other hand, no blanking pulses need be generated in this mode because switching from channel to channel occurs

during the retrace interval when the trace is already blanked.

In alternate mode of operation as well as all other modes except chopped, the Blanking Multivibrator remains in its quiescent state since no blanking pulses are needed or applied.

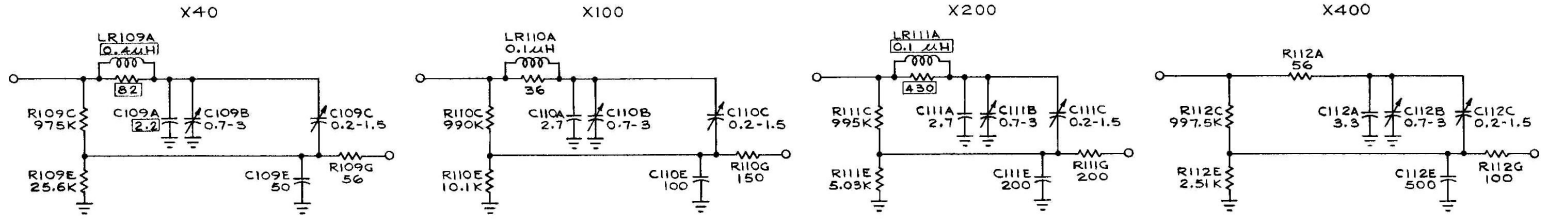
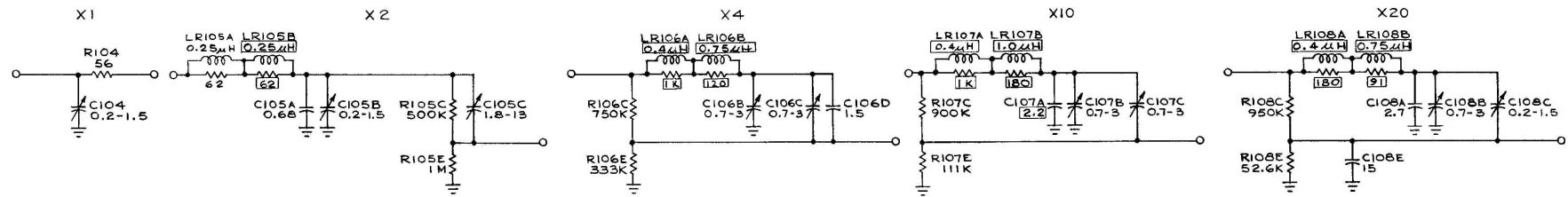
HEATER CIRCUIT

The heaters in the Type 1A1 are supplied with direct current from the +100-volt regulated supply in the oscilloscope. This DC source prevents the possibility of 60-hertz cathode modulation, which might result if the heaters were supplied with alternating current.

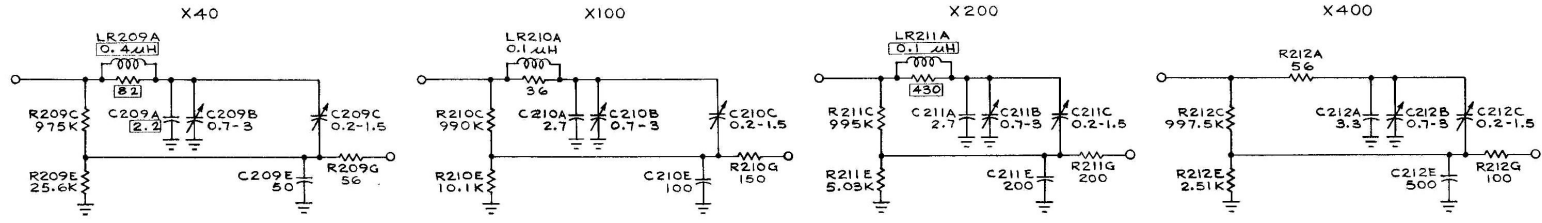
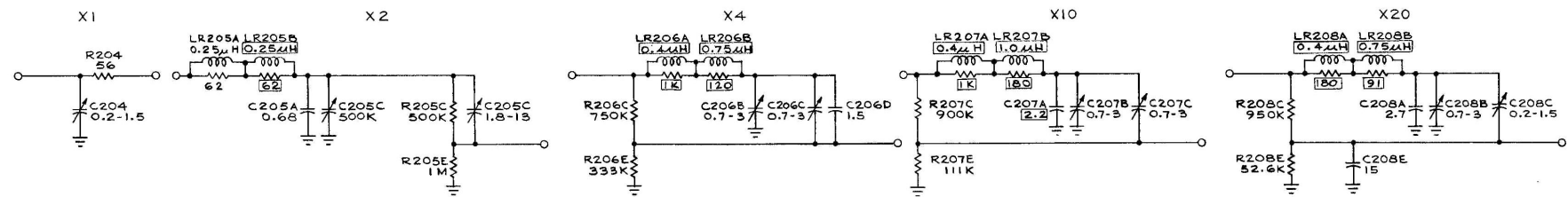
Power for the heater circuit (+75 V at about 150 mA) is obtained from pin 15 of the interconnecting plug to the oscilloscope. The +75 volts is obtained from the +100-volt

regulated supply by dropping 25 volts either across two tubes or a resistor in the oscilloscope, depending on whether the oscilloscope has two time bases or one.

The nuvistors in the Type 1A1 draw about 135 mA which leaves about 15 mA to be shunted through R494. In the heater-string branch circuit, the total drop of the heaters, including R491 and R492, connected in series is about 36 volts. This 36-volt drop leaves about 39 volts which is applied to the Channel 1 and 2 emitter Follower stages, and the switching circuit. Resistors R493 and R499 aid in keeping the current constant in the heater-string branch circuit for the various modes of operation. The +39 volts is also divided up to provide +11 volts at the junction of R495 and R496 to power Channel 1 and 2 Input Amplifiers. In addition, it is used for setting the grid potential of V464 and V474 in the Output Amplifiers second stage. At the junction of R496 and R497 the + 5 volts available at this point is applied to the cathodes of protection diodes D122 and D222 in the base circuits of Q123 and Q223.

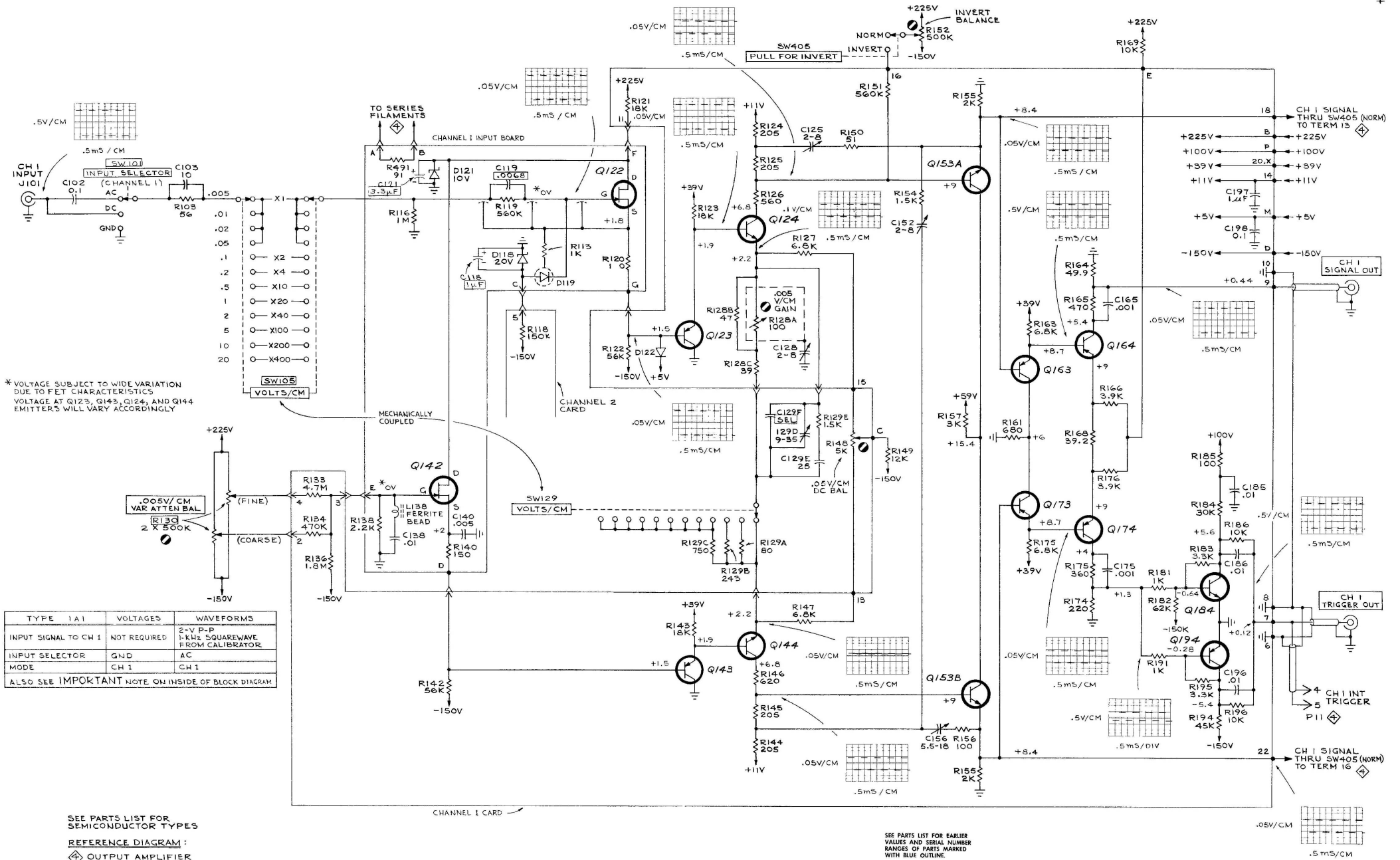


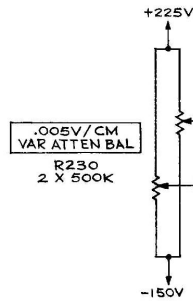
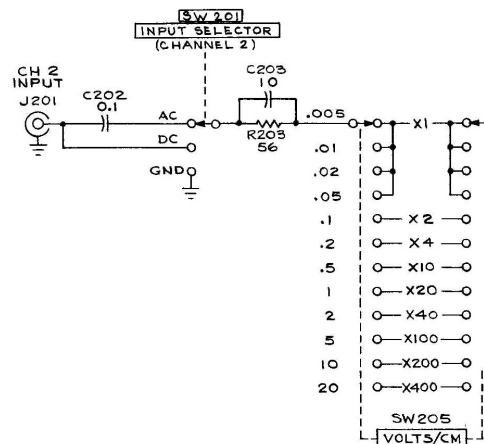
CHANNEL 1



CHANNEL 2

SEE PARTS LIST FOR EARLIER
VALUES AND SERIAL NUMBER
RANGES OF PARTS MARKED
WITH BLUE OUTLINE.



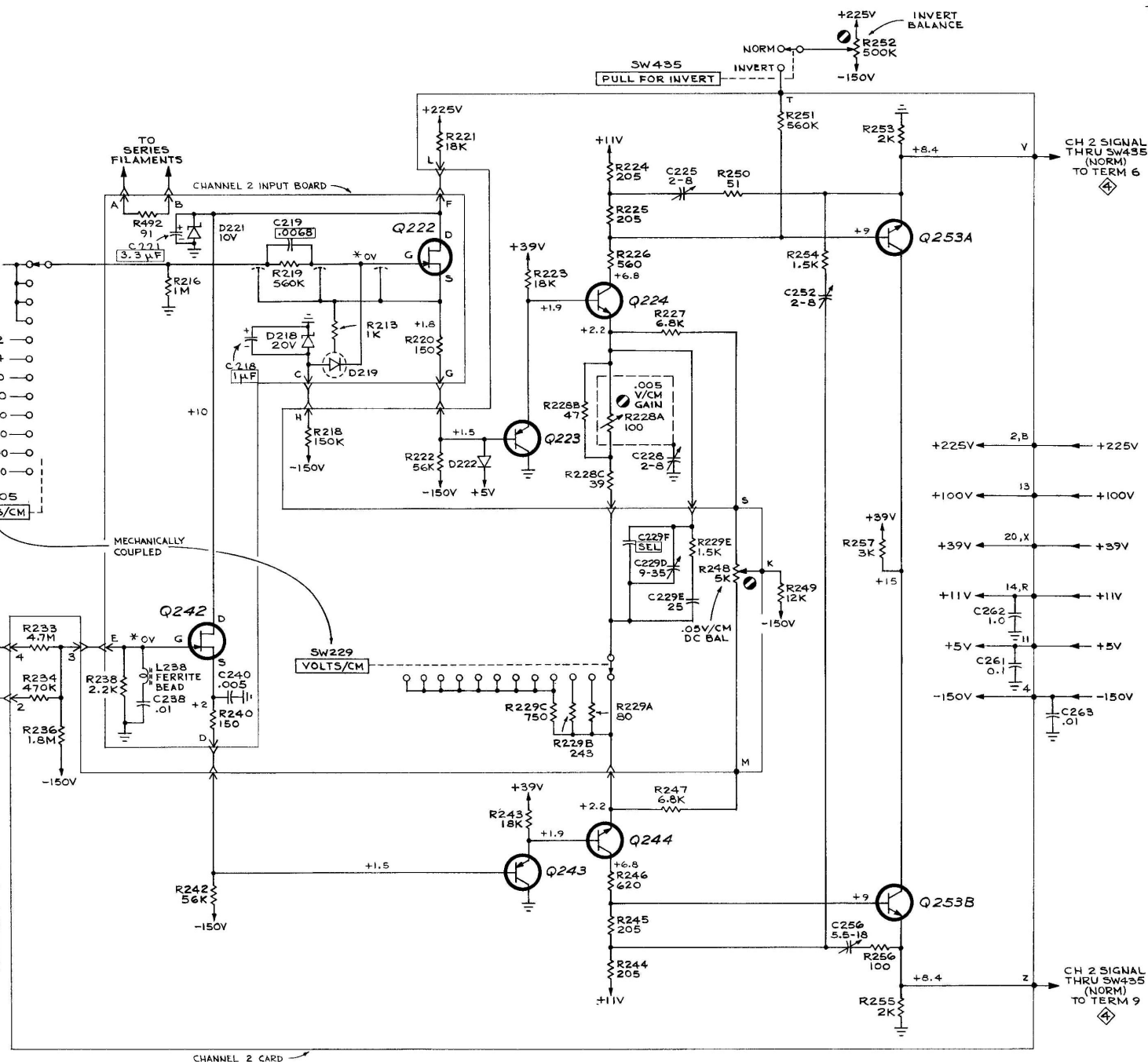


| TYPE 1A1 | VOLTAGES | WAVEFORMS |
|---------------------|--------------|---|
| INPUT SIGNAL TO CH2 | NOT REQUIRED | WAVEFORMS FOR CHANNEL 2 ARE THE SAME AS THE WAVEFORMS FOR CHANNEL 1 |
| INPUT SELECTOR | GND | |
| MODE | CH2 | |

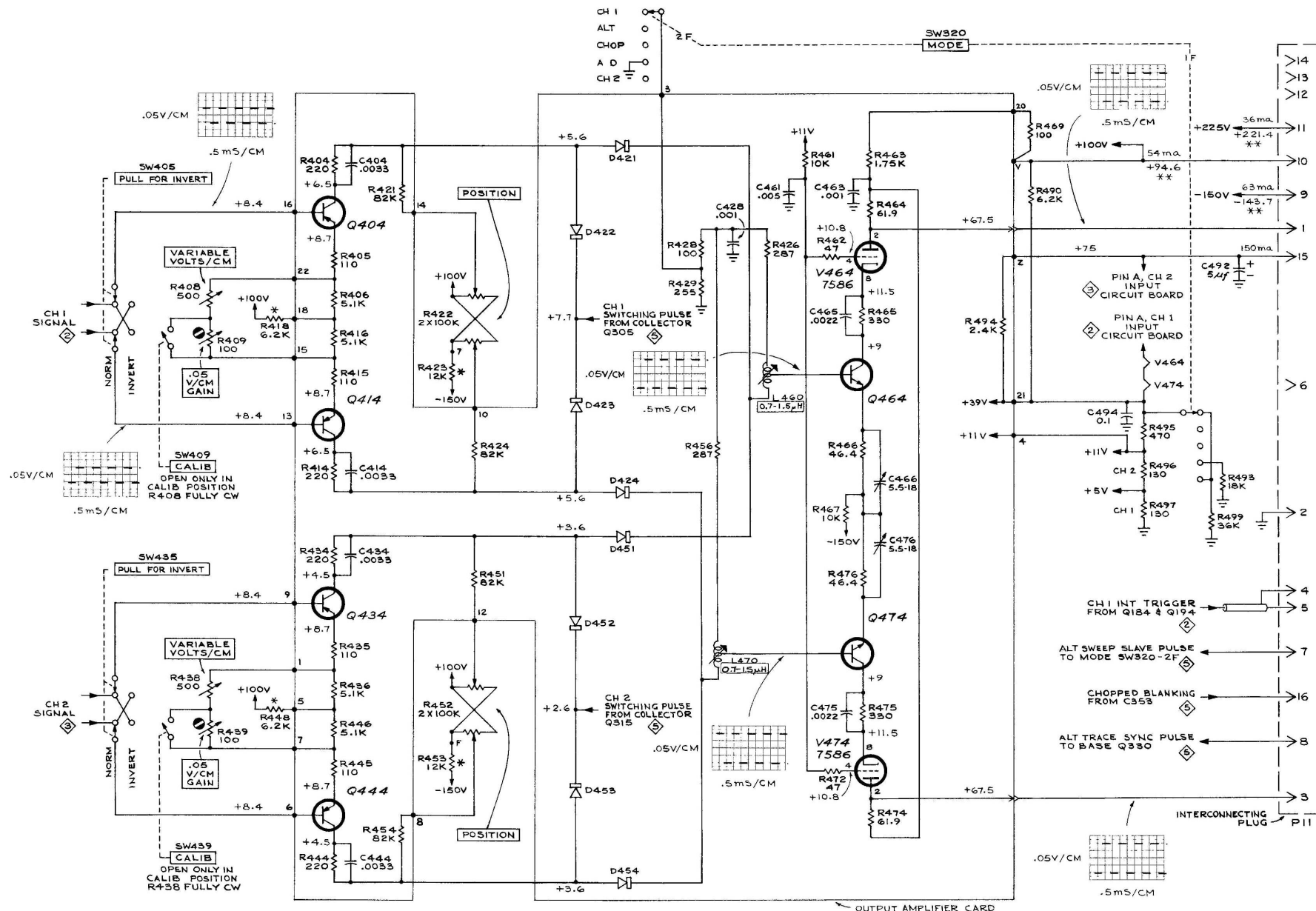
ALSO SEE IMPORTANT NOTE ON INSIDE SECTION OF BLOCK DIAGRAM

* VOLTAGE SUBJECT TO WIDE VARIATION DUE TO FET CHARACTERISTICS
VOLTAGES AT Q223, Q243, Q224, AND Q244 EMITTERS WILL VARY ACCORDINGLY

SEE PARTS LIST FOR SEMICONDUCTOR TYPES
REFERENCE DIAGRAM:
④ OUTPUT AMPLIFIER



SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.



REFERENCE DRAWINGS:

- ② CH 1 INPUT AMPLIFIER
- ③ CH 2 INPUT AMPLIFIER
- ⑤ SWITCHING CIRCUIT

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

* ON CH 2 CARD

| TYPE 1A1 | VOLTAGES | WAVEFORMS |
|----------------------|--------------|--|
| INPUT SIGNAL TO CH 1 | NOT REQUIRED | 2-V P-P 1-KHz SQUAREWAVE FROM CALIBRATOR |
| INPUT SELECTOR | GND | AC |
| MODE | CH 1 | CH 1 |

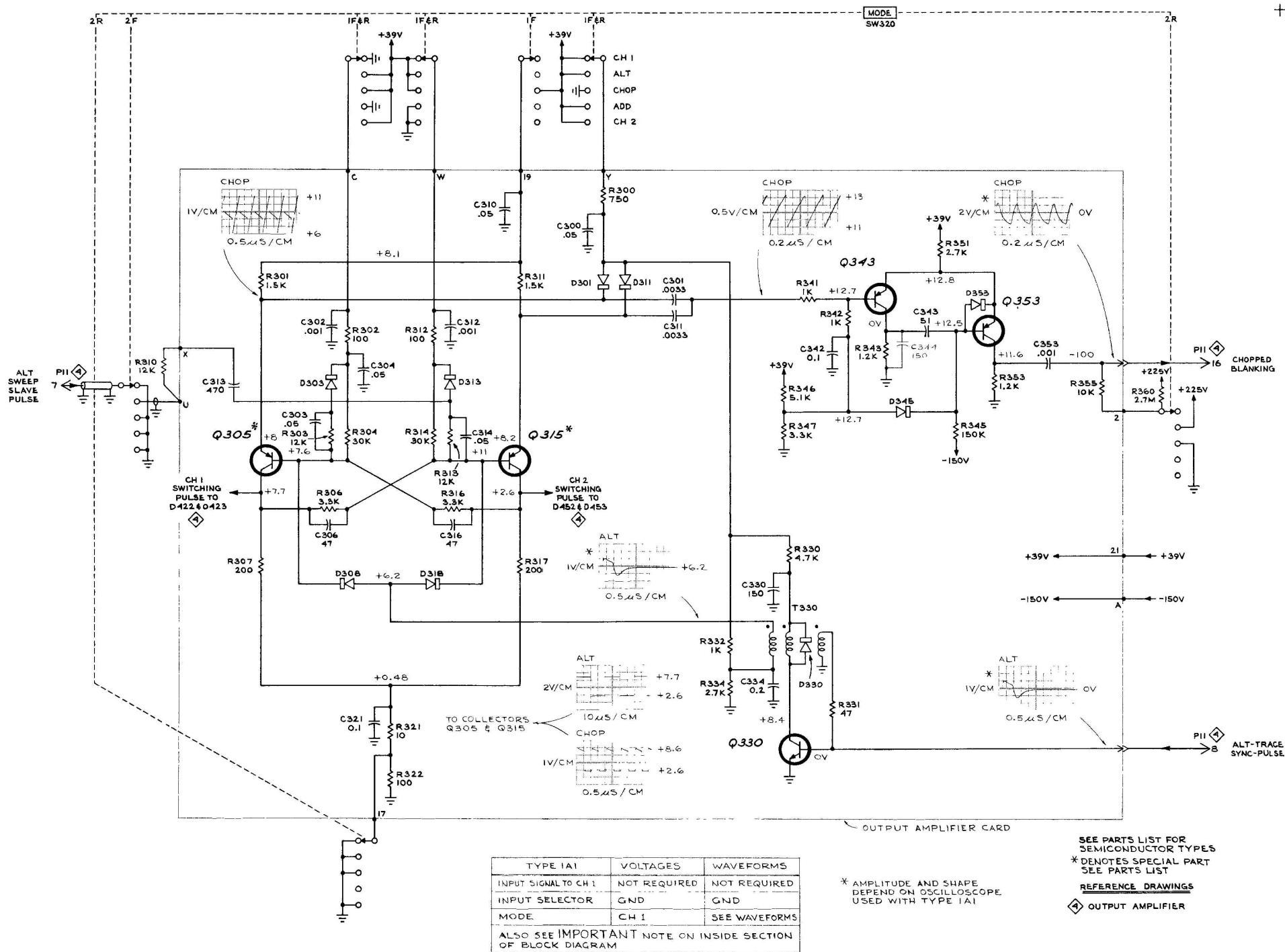
ALSO SEE IMPORTANT NOTE ON INSIDE SECTION OF BLOCK DIAGRAM

** DECOUPLED SUPPLY VOLTAGES

NOTE:

ON SOME PLUG-INS THERE MAY BE A DIFFERENCE IN WAVEFORM AMPLITUDES AT PINS 1 AND 3 OF P11. (ALSO AN AMPLITUDE DIFFERENCE MAY EXIST BETWEEN THE TWO SIDES OF PREVIOUS AMPLIFIERS). THIS IS NOT AN ABNORMAL CONDITION FOR THE AMPLIFIERS INVOLVED.

S/N 20,000-UP
OUTPUT AMPLIFIER ④ MRH
668



MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages.

A single change may affect several sections. Sections of the manual are often printed at different times, so some of the information on the change pages may already be in your manual. Since the change information sheets are carried in the manual until ALL changes are permanently entered, some duplication may occur. If no such change pages appear in this section, your manual is correct as printed.

ELECTRICAL PARTS LIST AND SCHEMATIC ADDITIONS

ADD:

| | | | | |
|------|-------------|-------------|-----|------|
| C118 | 290-0267-00 | 1 μ F | EMT | 35 V |
| C121 | 290-0246-00 | 3.3 μ F | EMT | 10 V |
| C218 | 290-0267-00 | 1 μ F | EMT | 35 V |
| C221 | 290-0246-00 | 3.3 μ F | EMT | 10 V |

