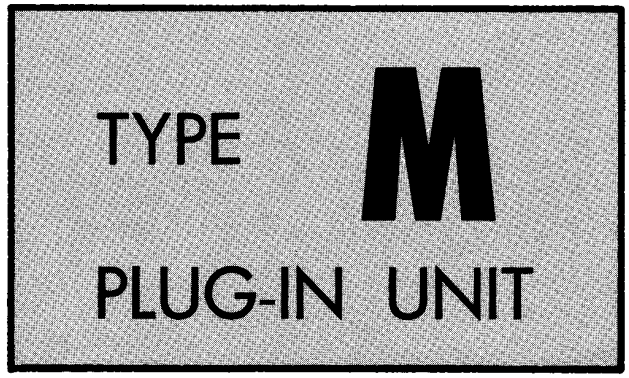
INSTRUCTION MANUAL

Serial Number _____



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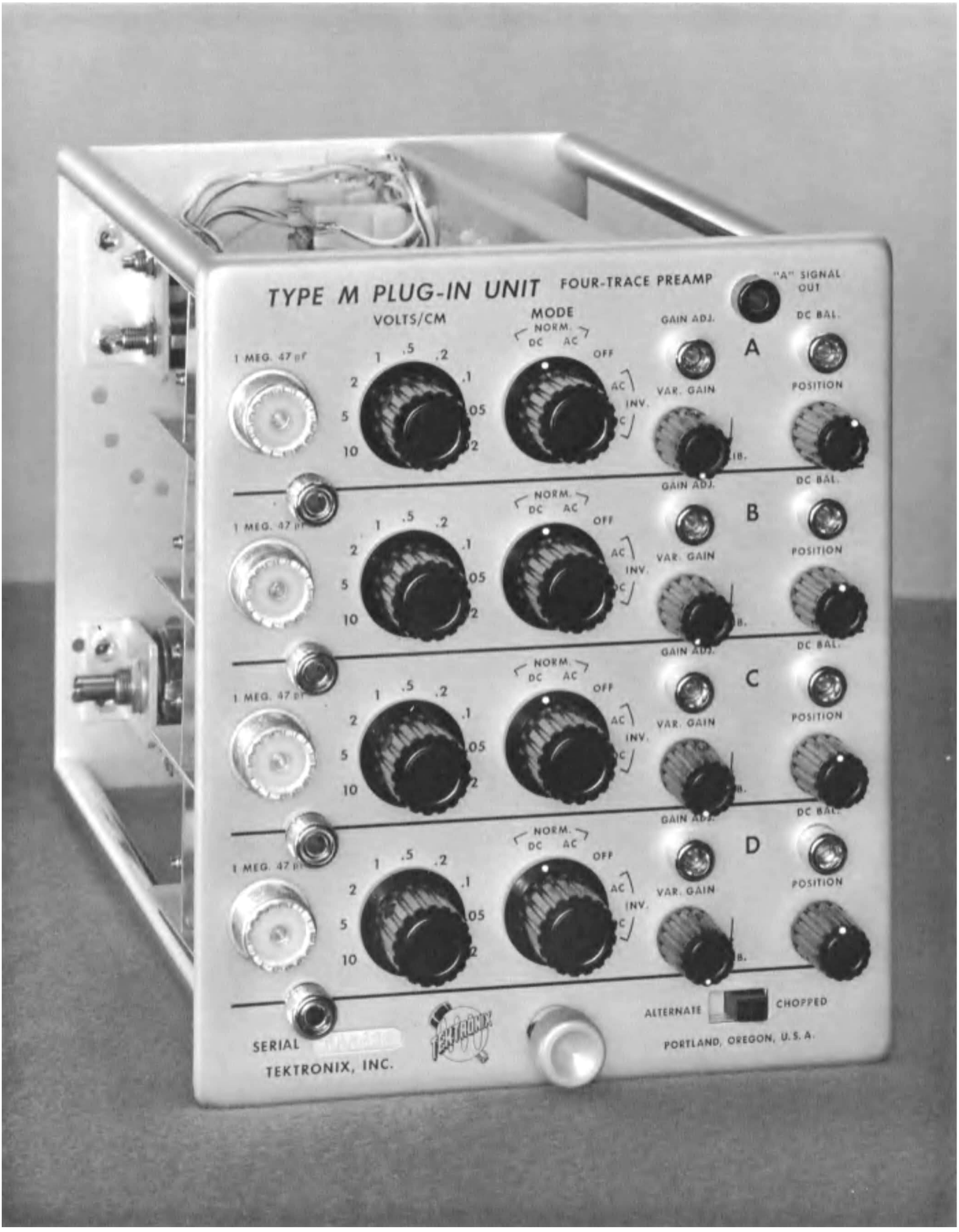

TYPE M PLUG-IN UNIT
FOUR-TRACE PREAMP
"A" SIGNAL OUT
VOLTS/CM
MODE
NORM.
DC AC
OFF
AC
INV.
GAIN ADJ.
DC BAL.
VAR. GAIN
POSITION
A
B
C
D
1 MEG. 47 pF
1
.5
.2
.1
.05
.02
2
5
10
ALTERNATE
CHOPPED
SERIAL
TEKTRONIX, INC.
PORTLAND, OREGON, U.S.A.

SECTION 1

CHARACTERISTICS

General Information

The Type M Plug-In Unit preamplifier contains four identical channels that can be used separately or electronically switched to produce single- or multi-trace displays. The unit thus provides a convenient means for viewing one to four signals, either separately or in combination, reducing cable switching to a minimum. Each amplifier in the unit has its own attenuator, mode, gain, and position control, which enables the display to be adjusted for optimum viewing and information.

When using the channels separately (without electronic switching), the M Unit is useful in all single-trace applications within its frequency and sensitivity capabilities.

During the alternate mode of operation, when the oscilloscope sweep is set for free-running operation, the sweep triggers the M Unit and one to four traces can be displayed alternately. The number of traces depends upon the setting of the MODE switches. In applications where signals, related in repetition rate to the sweep, are applied to the M Unit input connectors, a stable display can be obtained.

In the alternate mode of operation, when the oscilloscope is set for triggered operation, stationary displays of four signals unrelated in frequency can be obtained. The signals internally trigger the sweep which, in turn, triggers the M Unit to produce alternate displays. Because the sweeps are identical and time-delay characteristics of the four channels are equal, accurate time comparisons can be made between signals.

In the chopped mode of operation, channel switching occurs at a rate of approximately 1 mc divided by the number of channels in use, making it possible to view from one to four simultaneous transients. The number of displayed waveforms depends on the setting of the MODE switches and the number of inputs used. In four-trace operation transients of as little as 0.5 millisecond duration can be well delineated, with approximately 125 elements in each trace. For many purposes, shorter transients can be adequately observed.

Amplifier Sensitivity

Nine calibrated steps are provided for each channel: 0.02, 0.05, 0.1, 0.2, 0.5, 1, 2, 5 and 10 volts/cm. Accuracy is within 3% of panel reading. Variable controls for each channel permit continuous adjustment (uncalibrated) from 0.02 to 25 volts/cm.

Amplifier Transient Response and Bandwidth

Your instrument was adjusted at the factory for optimum transient response. Table 1-1 summarizes the risetime and approximate bandwidths available when the M Unit is used in combination with various oscilloscopes.

TABLE 1-1
TRANSIENT RESPONSE AND BANDWIDTH

Oscilloscope - M Unit Combination	Risetime	Bandwidth (at —3 db points)	
	MODE switch in any position except OFF	MODE switch in either DC position	Mode switch in either AC position
541, 541A, 543, 543A, 545, 545A, 555, 581*, 585*, 581A*, 585A* or RM585A*	17 nsec	dc to 20 mc	2 cps to 20 mc; 0.2 cps to 20 mc with P6006 Probe or equivalent
551	18 nsec	dc to 19 mc	2 cps to 19 mc; 0.2 cps to 19 mc with P6006 Probe or equivalent
531, 531A, 533, 533A, 535 or 535A	25 nsec	dc to 14 mc	2 cps to 14 mc; 0.2 cps to 14 mc with P6006 Probe or equivalent
536	35 nsec	dc to 10 mc	2 cps to 10 mc; 0.2 cps to 10 mc with P6006 Probe or equivalent
532	70 nsec	dc to 5 mc	2 cps to 5 mc; 0.2 cps to 5 mc with P6006 Probe or equivalent

Type 81 or Type 81A Plug-In Adapter required for use with the Type 580A Series Oscilloscopes.

Operating Modes

Channels A, B, C, or D, separately.

Chopped—Sequential electronic switching of channels at approximately 1-mc rate.

Alternate—Triggered electronic switching of channels at the end of each sweep, during retrace intervals.

Front-panel switches, in conjunction with the chopped or alternate modes of operation, permit viewing any combination up to four channels.

Polarity Inversion

Polarity of any channel selected can be inverted for comparison of signals 180° out of phase.

Input Coupling

Choice of ac or dc coupling. In the AC positions of the MODE switch a coupling capacitor is inserted, limiting the low-frequency response to approximately 2 cycles at 3 db down.

Input Characteristics (Approximate)

1 megohm ±1% paralleled by approximately 47 pf.

Maximum Allowable Combined DC and Peak AC Input

600 volts.

Construction

Aluminum-alloy chassis.

Finish

Anodized aluminum front panel.

Accessories

Information on accessories for use with this instrument is included at the rear of the mechanical parts list.

SECTION 3

CIRCUIT DESCRIPTION

AMPLIFIERS

Introduction

The M Unit consists of four identical input amplifiers, a common output amplifier, and a signal-out amplifier for channel A. Since the input amplifiers are identical, the following description applies to all. Throughout the circuit-description discussion, you should refer to the block and circuit diagrams located near the back of this manual.

Input Coupling

The signal to be displayed is applied to the input cathode follower V5323 through one section of the MODE switch (SW5300, 1F) and the VOLTS/CM switch (SW5310). In the DC positions of the MODE switch, input coupling capacitor C5301 is bypassed with a direct connection. In the AC positions the signal must pass through C5301 so the dc component of the signal is blocked. In the OFF position the signal is disconnected.

Input Attenuation

The M Unit requires an input signal of 0.02 volt, peak-to-peak, to produce one centimeter of calibrated deflection on the crt. In order to satisfy this condition, and to make the instrument applicable to a wide range of input voltages, precision attenuation networks can be switched into the input circuitry by means of the VOLTS/CM switch SW5310. The voltage-attenuation ratios of these networks are X2½, X5, X10 and X100.

When the VOLTS/CM switch is in the .02 position, the signal is coupled without attenuation to the Input Cathode Follower, V5323. For the other settings of the VOLTS/CM switch, the attenuation networks are switched into the circuit, either singly or in tandem pairs, so that the input voltage to V5323 is always 0.02 volt for each centimeter of crt deflection when the VAR. GAIN control R5326 is set to the CALIB. position.

The attenuators are frequency-compensated voltage dividers. For low-frequency signals they are resistive dividers, and the degree of attenuation is proportional to the ratio of the resistances. This is because the impedance of the capacitors, at low frequencies, 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, compared to the resistance of the circuit, and the attenuators become capacitive voltage dividers. For these frequencies, the degree of attenuation is inversely proportional to the ratio of the capacitances. A variable capacitor in each attenuator (for example, C5308C in the X2½ attenuator) provides a method for adjusting the capacitance ratios equal to the resistance ratios.

The variable capacitor at the input to each attenuator (for example, C5308B in the X2½ attenuator) provides a means for adjusting the input capacity of the attenuator to a standard value of 47 picofarads. Similarly, C5317 provides a method of standardizing the input capacity when the VOLTS/CM switch is in the .02 position. In this manner, the probe, connected to the input connector, works into the same input capacity regardless of the setting of the VOLTS/CM switch. In addition to providing the same input capacity, the resistance values in the attenuators are chosen to provide the same input resistance (1 megohm) for each setting of the VOLTS/CM switch.

Input Amplifier

The Input Amplifier consists of two stages: Input Cathode Follower V5323 and the Paraphase Amplifier Q5324/Q5334.

Input Cathode Follower V5323. This stage employs a Nuvistor which is essentially a subminiature triode. Nuvistor V5323 presents a high-impedance, low-capacitance load to the input circuit and isolates the input circuit from the succeeding stages. The cathode of V5323 is long-tailed through R5323 to the —150-volt supply. With this configuration, stable gain is obtained, and large input signals can be handled without distortion.

C5318 and R5318 form a protection circuit in the grid circuit of V5323. These components prevent excessive grid current from V5323 in case a positive-going overload signal is inadvertently applied to the input connector. Positive-going signals passing through V5323 are prevented from damaging Q5324 by protective diode D5324. Negative-going signals cannot damage Q5324 because current flow in the transistor is limited to about 3 ma. R5316 and R5319 in the grid circuit of V5323 are parasitic suppressors.

Paraphase Amplifier Q5324/Q5334. This stage is a transistorized, emitter-coupled amplifier. In addition to amplifying the signal, the stage converts the single-ended

input signal at the base of Q5324 to a push-pull output signal between the two collector circuits. Push-pull gain of the stage is approximately 2.2. Both emitters are long-tailed (through R5325 and R5335) to the +100-volt supply for greater stability with respect to transistor parameters and temperatures.

There are two gain controls located in the common-emitter circuit of the Paraphase Amplifier. One is the VAR. GAIN control R5236 and the other is GAIN ADJ. control R5336, a front-panel screwdriver-adjust potentiometer. Both controls vary the emitter degeneration and thus affect the gain of the stage. The GAIN ADJ. is adjusted so that the amount of crt deflection agrees with the setting of the VOLTS/CM switch when the VAR. GAIN control is set to the CALIB. position.

The DC BAL. control R5332, a front-panel adjustment, is used to adjust the dc level of Q5334 so that its emitter will be at the same voltage as the emitter of Q5324 when no input signal is applied to the unit. With the emitters at the same voltage there will be no current through the VAR. GAIN control. With this configuration an adjustment of the VAR. GAIN control will not affect the dc level in the collector circuit of the Paraphase Amplifier stage, and will therefore not affect the positioning of the beam.

Collector loads R5324 and R5334 develop the output signal of Q5324 and Q5334. The output signal is push-pull and is applied to a gate consisting of four diodes—D5345, D5347, D5346 and D5348. During multi-trace operation a positive-going gating pulse is applied to the junction of R5345 and R5347. The pulse at this junction causes the diodes to conduct and the push-pull signal passes from the Input Amplifier, through the diode gate and MODE switch contacts, to the Output Amplifier.

If the MODE switch is set to either the AC- or DC-NORM. position, the signal passes through the diode gate and MODE switch directly to the Output Amplifier to produce a normal display on the crt. However, when the MODE switch is set to either the AC- or DC-INV. position, the switch reverses the signal-grid connections of V5364 and V5374 and inverts the displayed waveform. When the MODE switch is set to the OFF position, the Input Amplifier is disconnected from the Output Amplifier and no signals pass through the diode gate.

When all MODE switches are set to OFF, diodes D5360 and D5370 clamp the grids of V5364 and V5374 near ground, preventing the grids from moving toward —150 volts. In addition, the diodes provide a very convenient method for checking the dc balance of the Output Amplifier. With all MODE switches in the OFF position the grids are essentially connected together.

Vertical Positioning

The POSITION control, connected between R5341 and R5343, changes the current through collector load resistors R5324 and R5334. With the control centered, the current through each load resistor, under no-signal conditions, is the same. When the control is moved to either end, a change of 2 ma per side occurs. This current change results in a positioning voltage range of approximately 300 millivolts at the transistor collectors. The voltage range corresponds to about ±10 centimeters positioning range at the crt since direct coupling is employed.

Output Amplifier

The Output Amplifier, which is a common amplifier for all channels, consists of two stages: Push-Pull Amplifier V5364/V5374 and Output Cathode Follower V5383.

Push-Pull Amplifier V5364/V5374. The Push-Pull Amplifier stage provides a total gain of about 5 for signals and dc-positioning voltages that arrive when the diode gate for the operating channel is gated "on" by the switching pulse from the Ring Counter. The gating pulse itself is not amplified because it is common mode and cancels out in the cathode circuit of the stage.

Static current drain in this stage is about 6 ma per side; 1.5 ma is screen current and 4.5 ma is plate current. Static plate voltage is about 65 volts.

Peaking inductors L5360 and L5370 provide necessary high-frequency compensation in the grid circuits of the stage. In the plate circuits variable inductors L5363 and L5373 compensate the stage for high-frequency attenuation caused by the tube and stray capacity. The m-derived sections of the variable inductors provide a means for adjusting the stage for optimum transient response.

A position range network consisting of R5377, R5378 and R5365 in the cathode circuits of this stage cancel any static imbalance for centering the traces. With the VERT. POS. RANGE control, R5378, all traces can be made to coincide as a group with the vertical system electrical center. Range of the VERT. POS. RANGE control is about 200 mv at each grid of V5383, equal to about a 4-centimeter change in trace position, 8 centimeters push-pull.

Output Cathode Follower V5383. The Output Cathode Follower stage operates much the same as the Input Cathode Follower stage. That is, it provides a high-impedance, low-capacitance load to the Push-Pull Amplifier stage, and a low-impedance driving source for the capacitance of the inter-connecting plug and the input of the main vertical amplifier in the oscilloscope.

Peaking coils L5384 and L5386 form a series-peaking circuit with the stray capacitance in their respective circuits. These peaking circuits are damped by the cathode impedance of each side of V5383. Due to the fairly large cathode resistors (9.1 k) employed, the cathode impedance is approximately equal to the reciprocal of the transconductance of the tube ($1/G_m$). By varying the current through the tube, the H.F. PEAKING control can vary the transconductance, thereby varying the effect of the peaking circuits.

Channel A Signal Output Amplifier

The Channel A Signal Output Amplifier Q5344 and Q5354 is a two-stage transistorized auxiliary amplifier for channel A only. It provides a dc-coupled signal obtained from channel A for external triggering purposes, particularly for use during multi-trace operation in the CHOPPED mode.

The signal is taken from the junction of R5326 and R5327 located in the common-emitter circuit of Q5324 and Q5334. The R5326-R5327 junction is a convenient low-impedance point for extracting the signal without affecting the M-Unit bandwidth and with least pick up of switching transients when using the M unit in the CHOPPED mode.

With the VAR. GAIN control set to the CALIB. position, the signal amplitude at the junction is about 80% of that at the grid of V5323. At the base of Q5344, the signal amplitude decreases to about 60% of that at the grid of V5323. The gain of the Channel A Signal Output Amplifier is about 160; Q5344 has a gain of approximately 10 and Q5354 has a gain of about 16. The overall gain of 160 results in an output signal of approximately 2 volts at the "A" SIGNAL OUT connector for each centimeter of vertical deflection on the crt. Bandwidth of the amplifier is dc to about 1.0 mc —3 db (750 kc —3 db, S/N 101-2759), and the rolloff is long and gradual.

The OUTPUT DC LEVEL control R5354 is the current source for adjusting and matching the dc level at the "A" SIGNAL OUT connector to the level at the channel A input connector. Normally, when making the adjustment, the A input connector is grounded and the OUTPUT DC LEVEL control is adjusted to obtain a voltmeter reading of zero at the "A" SIGNAL OUT connector. This control compensates for variations between Nuvistors and the effects of tube aging. The high gain of the Channel A Signal Output Amplifier and the relatively wide variation in transconductance between Nuvistors makes the control somewhat sensitive. Therefore, the control should be adjusted carefully when matching dc levels. Exact zero volts is difficult to obtain and a setting within a few hundred millivolts of zero is adequate for triggering purposes. However, if this amplifier is used as a dc preamplifier, the control has to be adjusted more carefully for a setting less than a few hundred millivolts from zero.

S/N 2760-up

Above serial number 2759, Q5344 is replaced with a double transistor. The A side of the transistor performs the same basic functions as did Q5344. The B half comprises a comparator circuit with A side.

When channel A was initially set up the DC BAL control was adjusted for no movement of the trace as the VAR GAIN control was turned away from its CALIB position. The GAIN ADJ control was then adjusted to provide the proper gain. When the above adjustments are made, there will exist a given potential on the base of Q5344A and the base of Q5344B. The OUTPUT DC LEVEL control is then adjusted for a zero volt dc level at the "A" SIGNAL OUT connector.

If the Type M is now moved to another oscilloscope and the DC BAL control is adjusted properly, the given potential on the bases of Q5344A and Q5344B will be close to those which existed the first time the OUTPUT DC LEVEL was adjusted. Since the OUTPUT DC LEVEL control is already adjusted for these potentials, the dc level at the "A" SIGNAL OUT connector is still close to ground.

SWITCHING CIRCUIT

Ring Counter

The Ring Counter consists of Q6315, Q6325, Q6335 and Q6345 and associated circuitry. Each transistor controls one Input Amplifier channel. The Ring Counter is tetrastable; that is, each of its four states is stable and a trigger from the Switching B.O. Q6350 during multi-trace operation is required to make it switch channels. When triggered, the Ring Counter performs the task of sequencing and gating the Input Amplifiers.

When only one channel is on (single-trace operation), Q6350 is inoperative and the Ring Counter remains switched on or "locked" on the one channel, keeping it on. When all channels are turned off (all MODE switches set to OFF), the Ring Counter is in a quiescent state.

In the following discussion the Ring Counter is described under four modes of operation. These are: (1) all channels off, (2) single-trace operation, (3) alternate multi-trace operation, and (4) chopped multi-trace operation.

(1) All channels off. With all MODE switches set to the OFF position, the Ring Counter is placed as close as possible to a quiescent or static condition. All transistors in the Ring Counter are reverse-biased except the one that is switched off last. Assume for this discussion that the channel A MODE switch was set to the OFF position last.

The base voltage for each transistor is determined by a matrix of three 10.1-k resistors located in each base circuit. Matrix currents through R6310, R6320, R6330, R6340 and R6360 hold all bases at about +6.5 volts. The common emitter bus is held at about +6.8 volts by the emitter current of Q6315 (channel A turned off last). The collector bus rests at about —7 volts by the current drawn by Q6315 and the matrix circuits.

The voltage at the collector of Q6315 is held at about +3.7 volts by the current through Q6315; the remaining collectors are held at about —1.4 volts. With three transistors cut off, the —1.4 volts at the collectors of these transistors reverse bias their D5345/D5347 diodes. Channel A diodes D5345 and D5347 are forward biased by the +3.7 volts at the collector of Q6315, but no signals are passed since the MODE switch is set to OFF.

(2) Single-trace operation. When the channel A MODE switch is turned on, the voltage at the base of Q6315 decreases from about +6.5 volts to about +5.9 volts since the base is no longer connected to R6310. Current through Q6315 increases slightly, causing the collector voltage to change from +3.7 volts to about +4 volts. The voltage at the other collectors remains at about —1.4 volts and the common collector bus drops slightly to about —6.9 volts. The diode gate for channel A, being forward biased, couples the channel A signal from the Input Amplifier through the MODE switch to the Output Amplifier. The diode gates for the other channels remain reverse biased.

Total collector current for Q6315 is about 9 ma . . . 5 ma through R6317 and 4 ma through the channel A diode gate. The total current through R6316 is the sum of the base and collector current of Q6315.

Matrix currents through R6320, R6330, R6340 and R6360 reverse bias D6360 and forward bias D6352. D6352 sets the base level of Q6364. Transistor Q6350 is clamped into cutoff by emitter current through Q6364, thus preventing the Switching B.O. from operating. This same action also occurs when all channels are off, assuming that Q6315 is the conducting transistor.

Resistors R6319, R6329 and R6339 are series-connected parasitic suppressors. During single-channel operation, they prevent the conducting transistor in the Ring Counter from oscillating. This is accomplished by providing ample resistance in the feedback path existing from the collector of the conducting transistor through the MODE switches and back to the base of the same transistor.

(3) Alternate multi-trace operation. When two or more MODE switches are turned on, Q6350 is biased so that it can be triggered. (Biasing of Q6350 is explained in the subsequent description of the Switching B.O.) In the ALTERNATE position of the ALTERNATE/CHOPPED switch, the trigger to drive Q6350 is obtained by applying the sync trigger from the oscilloscope time-base generator via pin 16 of the interconnecting plug. The trigger is regenerated by the blocking oscillator action of Q6350, differentiated by C6352, and applied to the common-emitter bus in the Ring Counter.

The negative-going regenerated trigger, when applied to the emitter bus, drives all emitters in the negative direction. Since only one transistor in the Ring Counter conducts at any given time, it is the only one affected by the trigger.

If Q6315 is the conducting transistor when the regenerated trigger is applied to the emitter bus, the collector current of Q6315 is sharply reduced and the collector voltage goes quickly negative, producing a fast, negative-going collector pulse. This pulse is then coupled through "speed-up" capacitor C6317 and the channel A MODE switch contacts to the base of Q6325. The pulse is also coupled through the matrix resistors to the bases of the other transistors in the Ring Counter. The pulse applied to the other bases is of much lower amplitude and is not significant. However, the larger and faster pulse applied to the base of Q6325 drives Q6325 into conduction and a 6-volt positive-going gating pulse is produced at its collector. The gating pulse is applied to channel B diode gate and turns it on for the duration of the gate pulse.

Due to the matrix action, the positive-going gate pulse at the collector of Q6325 is coupled to the bases of the other transistors, tending to hold them in cutoff and completing the cutoff of Q6315. As stated previously, in multi-trace operation the trigger from Q6350 is required to make the transistors switch states. When the transistors in the Ring Counter switch states, they always switch in sequence, regardless of the setting of the ALTERNATE/CHOPPED switch. The important components that make sequential switching possible are "speed-up" capacitors C6317, C6327, C6337 and C6347. It is these capacitors that provide the means for coupling the pulse from the "on" transistor to the base of the following transistor in a sequential order. If a MODE switch is set to OFF, during multi-trace operation, the transistor controlled by the MODE switch is bypassed and excluded from the switching cycle.

(4) Chopped multi-trace operation. When the ALTERNATE/CHOPPED switch is set to the CHOPPED position and two or more channels are on, the Switching B.O. Q6350 becomes a trigger generator by operating in a free-running mode at a rate of approximately 1 mc. The 1-mc triggers generated by Q6350 drive the Ring Counter. Operation of the Ring Counter in this mode is the same as its operation in the multi-trace alternate mode.

Switching Blocking Oscillator

The Switching Blocking Oscillator (Switching B.O.) Q6350, during single-trace operation, is inoperative to allow the desired channel to remain "locked on". During multi-trace operation, Q6350 operates in a triggered mode when the ALTERNATE/CHOPPED switch is set to ALTERNATE, and in a free-running mode when set to CHOPPED.

S/N 825-up

(1) Single-trace operation. Assume all channels are on and that channels B, C, and D are about to be turned off. When the MODE switch for channel B is set to OFF, approximately 0.5 ma matrix current flows through R6320. When channel C and D MODE switches are set to OFF, total current flowing from R6320, R6330 and R6340 is about 1.4 ma. The total current is enough to starve the current path through D6360. Diode D6360 reverse biases and unclamps the junction where it is tied to R6360. Resistor R6360 is "long-tailed" to the +225-volt supply so that the current through it remains the same regardless of the operating mode.

When D6360 reverse biases, the voltage at the junction of D6360 and R6360 drops from about 12.9 volts to about 12.2 volts. The voltage decrease causes diode D6355 to conduct. D6355 conducting causes the emitter of Q6350 to become more negative than its base. Under these conditions, Q6350 is cutoff and will not operate regardless of the setting of the ALTERNATE/CHOPPED switch.

(2) Multi-trace triggered operation. When the ALTERNATE/CHOPPED switch is set to ALTERNATE, one side of the switch connects pin 8 of the interconnecting plug to ground, which grounds R6368 and the cathode of the oscilloscope sync amplifier. The sync amplifier differentiates and amplifies the positive-going sync trigger generated by the oscilloscope sweep-gating multivibrator at the end of each sweep cycle. The negative-going sync trigger produced at the plate of the sync amplifer is applied through pin 16 of the interconnecting plug to the junction of R6365 and R6366, located in the collector circuit of Q6364.

The other side of the ALTERNATE/CHOPPED switch disconnects +100 volts from the emitter circuit of Q6350. Current through R6353 and R6356 determines the emitter level of Q6350.

The sync trigger which is applied to the R6365/R6366 junction, coupled through D6362 to the base of Q6350 turns on Q6350 which was biased just into cutoff. The sync trigger is also at the collector of Q6364, however since the base, emitter, and collector of Q6364 are all at 13.6 volts, the transistor remains cutoff.

The signal at the anode of D6352 is a single regenerated negative-going pulse that occurs each time the sync trigger from the oscilloscope is applied to the Q6350 base circuit. This regenerating of the sync triggers standardizes the varying size and shape of the sync triggers originating from the various types of oscilloscopes. The regenerated trigger becomes a sharp negative-going spike when coupled through C6352 and is easily handled without jitter by the Ring Counter.

(3) Free-running operation. The switching B.O. free runs when two or more channels are on and the ALTERNATE/CHOPPED switch is set to CHOPPED. When the switch is in this position, one side of the switch disconnects pin 8 of the interconnecting plug from ground disabling the oscilloscope sync amplifier and connects one side of R6364 to ground.

The other side of the ALTERNATE/CHOPPED switch connects +100 volts to a voltage divider consisting of R6362 and R6364. This voltage divider makes 35 volts available for the collector of Q6364.

The 35 volts at the collector of Q6364 causes D6362 to be reverse biased. With D6362 reverse biased, Q6364 is just into cutoff. Since both Q6350 and Q6364 are now in cutoff, the voltage divider of R6353 and R6356 starts charging C6355, C6356 and C6352. The charging of these three capacitors continues until the anode of D6352 is elevated positive enough to cause D6352 and Q6350 to conduct. When Q6350 starts to conduct, current through T6350 induces a negative-going voltage which is applied to the base of Q6350.

This negative-going voltage causes Q6350 to conduct more and more heavily until Q6350 is in saturation. When Q6350 is saturated the change in current through T6350 ceases. Since the base of Q6350 no longer has a negative-going voltage applied to it, it starts positive toward the 13.6 volt supply voltage.

The anode of D6352 has a large amount of capacitance tied to it which must change its charge if the anode is to change potential. The anode of D6352 is therefore very slow in changing its potential. The cathode goes positive more rapidly than the anode and reverse biases D6352. The anode of D6352 starts charging positive at a rate determined by R6353 and R6356, charging C6355, C6356 and C6352. When the three capacitors and the anode of D6352 are positive enough for D6352 and Q6350 to again conduct, the cycle repeats.

When the base of Q6350 starts positive toward the 13.6 supply voltage after saturation, it overshoots the 13.6 supply voltage because of the collapsing field of T6350. This positive overshoot is caught by the base-emitter junction of Q6364, turning it on. The collector of Q6364 now goes negative, producing a negative pulse which is capacitively coupled to the Blanking Amplifier in the oscilloscope. Since this pulse occurs delayed from the actual time of switching, it blanks the CRT at the same time as the switching transient reaches the deflection plates after being delayed in the vertical amplifier of the oscilloscope.

SN 101-824

(1) Single-trace operation. Assume all channels are on and that channels B, C, and D are about to be turned off. When the MODE switch for channel B is set to OFF, approximately 0.5 ma matrix current flows through R6320. When channel C and D MODE switches are set to OFF, total current flowing from R6320, R6330 and R6340 is about 1.4 ma. The total current is enough to starve the current path through D6360. Diode D6360 reverse biases and unclamps the junction where it is tied to R6360. Resistor R6360 is "long-tailed" to the +225-volt supply so that the current through it remains the same regardless of the operating mode.

When D6360 reverse biases, the voltage at the junction of D6360 and R6360 drops from about 12.9 volts to about 12.2 volts. The voltage decrease causes diode D6352 to conduct. The drop across D6352 and that across the base-emitter junction of Q6364 essentially cancel. Q6364 emitter current flowing through R6354 sets the emitter level for Q6350. Under these conditions, Q6350 is cutoff and will not operate, regardless of the setting of the ALTERNATE/CHOPPED switch. Thus, chopping-rate switching transients, which might interfere with the usefulness of single-trace displays, cannot occur, and triggers are not generated.

(2) Multi-trace triggered operation. When the ALTERNATE/CHOPPED switch is set to ALTERNATE, one side of the switch connects pin 8 of the interconnecting plug to ground, which grounds R6368 and the cathode of the oscilloscope sync amplifier. The sync amplifier differentiates and amplifies the positive-going sync trigger generated by the oscilloscope sweep-gating multivibrator at the end of each sweep cycle. The negative-going sync trigger produced at the plate of the sync amplifier is applied through pin 16 of the interconnecting plug to the junction of R6367 and C6364, located in the collector circuit of Q6364.

The other side of the ALTERNATE/CHOPPED switch disconnects divider resistors R6365 and R6366 from the emitter circuit of Q6350. The divider is now connected to the switch end of R6367 to supply an operating potential for the oscilloscope sync amplifier. Since the divider is disconnected from the emitter circuit of Q6350, current through R6355, R6353, R6354 and Q6364 determines the emitter level of Q6350.

When more than one channel is turned on, matrix currents to R6360 decrease. Diode D6360 becomes forward biased and supplies the current path to R6360. The voltage at the junction of D6360 and R6360 rises from about +12.2 volts to about +12.9 volts and reverse biases D6352. The clamping action of Q6364 holds Q6350 cutoff.

The sync trigger, applied to the R6367/C6364 junction, is coupled through C6364, R6364 and C6351 to the collector circuit of Q6350. The sync trigger is not applied to the collector of Q6364, however, because D6364 is reverse biased. To provide a load and a complete circuit for Q6364 during alternate operation, the collector of Q6364 ties to R6368 by forward biasing D6368. The switch end of R6368 connects to ground through the ALTERNATE/CHOPPED switch.

With the negative-going sync trigger applied to the collector circuit of Q6350, current flows through T6350 primary and into C6350. The varying magnetic flux in the primary induces a negative-going voltage at the base of Q6350 and starts the blocking oscillator action. This action continues until Q6350 is driven into saturation and collector current ceases to increase. Toroid T6350 field collapses

around the secondary, driving the base in a positive direction in excess of that needed to turn off the transistor. The base and emitter return to their original level and transistor Q6350 remains cut off until the next sync trigger arrives to repeat the cycle.

The signal at the emitter of Q6350 is a single regenerated negative-going pulse that occurs each time the sync trigger from the oscilloscope is applied to the Q6350 collector circuit. This regenerating of the sync triggers standardizes the varying size and shape of the sync triggers originating from various types of oscilloscopes. The regenerated trigger becomes a sharp negative-going spike when coupled through C6352 and is easily handled without jitter by the Ring Counter.

(3) Free-running operation. The Switching B.O. free runs when two or more channels are on and the ALTERNATE/CHOPPED switch is set to CHOPPED. When the switch is in this position, one side of the switch disconnects pin 8 of the interconnecting plug from ground, disabling the oscilloscope sync amplifier.

The other side of the ALTERNATE/CHOPPED switch disconnects the R6365/R6366 divider from R6367 and connects it to the emitter circuit of Q6350. Transistor Q6350 base-emitter junction becomes slightly forward biased. Diode D6360 is still forward biased and D6352 reverse biased. As soon as Q6350 conducts, the regenerative action of T6350 drives Q6350 rapidly into saturation. During this action, C6353 charges rapidly through the low emitter impedance.

At saturation, Q6350 collector current is constant and the T6350 field collapses. The collapsing field generates a positive-going backswing signal at the base, and the base returns quickly to its original level. Capacitor C6353 discharges through R6353 and the emitter returns to its original positive potential. When this happens, Q6350 conducts again, repeating the cycle. The repetition rate of the Switching B.O. is approximately 1 mc and is determined mostly by the R6353-C6353 time constant.

The negative-going signal at the emitter of Q6350 is coupled through C6352 to drive the Ring Counter. The signal at the base of Q6350 is a negative-going pulse with a duration of about 0.2 microsecond. The pulse ends with a positive-going backswing caused by the inductive kick in T6350. Normally, the backswing is undesirable. However, during chopped-mode multi-trace operation the backswing is useful as a blanking pulse to blank out the switching transients on the displayed waveform.

The positive-going backswing at the base of Q6350 drives D6352 into conduction. The diode serves two purposes during chopped-mode multi-trace operation—to limit the amplitude of the backswing, and to couple the backswing to the base of Q6364.

S/N 101-824

Chopped-Mode Blanking Amplifier

During multi-trace operation when the ALTERNATE/CHOPPED switch is set to CHOPPED, the Chopped-Mode Blanking Amplifier Q6364 amplifies and inverts the backswing signal. The Q6364 collector circuit, during this mode of operation, has the following configuration. The ALTERNATE/CHOPPED switch grounds the switch end of collector load resistor R6364. The other end of R6364 is connected to the collector through D6364, which is forward biased because Q6364 is conducting. Diode D6368 is reverse biased since its cathode return ties to +100 volts within the oscilloscope.

The signal developed across R6364 is coupled through C6364 and pin 16 of the interconnecting plug to the blanking amplifier in the oscilloscope time-base generator circuit. From there it is applied to the cathode of the crt via the CRT Cathode Selector switch. The signal blanks the beam during the switching-time interval occurring between channels. Blanking the beam during this time prevents the unwanted switching transient from appearing on the displayed waveform.

During either single-trace or multi-trace chopped-mode operation, diode D6368 is reverse biased when the M Unit is used with a single-beam or a Type 555 dual-beam oscilloscope. When the M Unit is used with a Type 551 dual-beam oscilloscope having a multi-trace plug-in unit in the other plug-in compartment, D6368 remains reverse biased when the other unit operates in a chopped mode, to isolate the two plug-in units. If the other unit in a Type 551 operates in an alternate mode, pin 8 is grounded and D6368 is forward biased. Although D6368 is forward biased, the diode has no important function during this mode of operation.

When the ALTERNATE/CHOPPED switch is set to ALTERNATE, diode D6364 is reverse biased. This prevents sync triggers from getting to the collector of Q6364, and prevents Q6364 from loading down the incoming sync.

HEATER CIRCUIT

The heaters in the Type M Plug-In Unit are supplied with direct current from the +100-volt regulated supply in the oscilloscope. This prevents the possibility of 60-cycle cathode modulation, which might result if the heaters were supplied with alternating current.

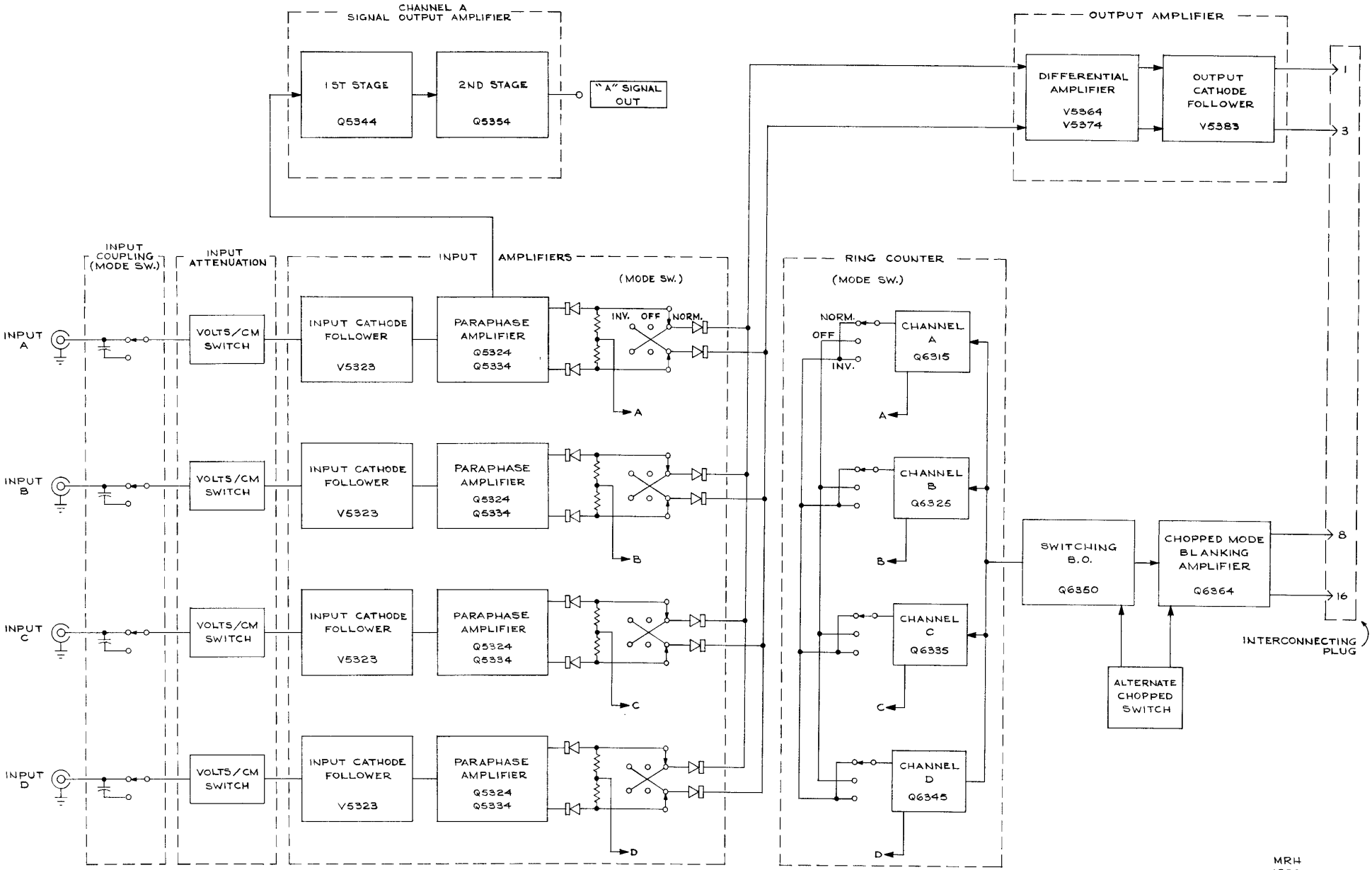
Power for the heater circuit (+75 v at 150 ma) is obtained from pin 15 of the interconnecting plug. For those oscilloscopes employing Delaying Sweep, the heaters of two of the tubes in the Delaying Sweep Generator are connected in series with the heater circuit of the M Unit to provide the necessary 25-volt drop. In those instruments employing only one Sweep Generator, a resistor connected between the heater string and the +100-volt bus provides the required drop.

The heater circuit also provides constant voltage sources for many circuits in the M Unit. The +13.6 volts developed across Zener diodes D5392 and D5393 (D5390 S/N101-3479) goes to the circuit of Q5344, Q5354, Q6350 and the base circuits of the transistors in the Ring Counter. The +6.3 volts developed across Zener D5391 goes to the base circuits of Q5334 (four channels). (S/N 101-824—the +38 volts goes

to the emitter circuits of Q6364 and Q6350.) The +50 volts goes to the plate circuit of V5323 (four channels) and the +69 volts goes to the plate circuit of V5364 and V5374.

The series-connected heaters of the tubes do not supply any current for the +50- and +69-volt sources; they simply act as a low-impedance divider to "fix" the voltages. Current (15 ma) is supplied to the +38-volt source (S/N 101-824), however. This current is conveniently obtained by the difference in heater current drawn by the Nuvistors (135 ma) and the current drawn by the remaining tubes (150 ma).

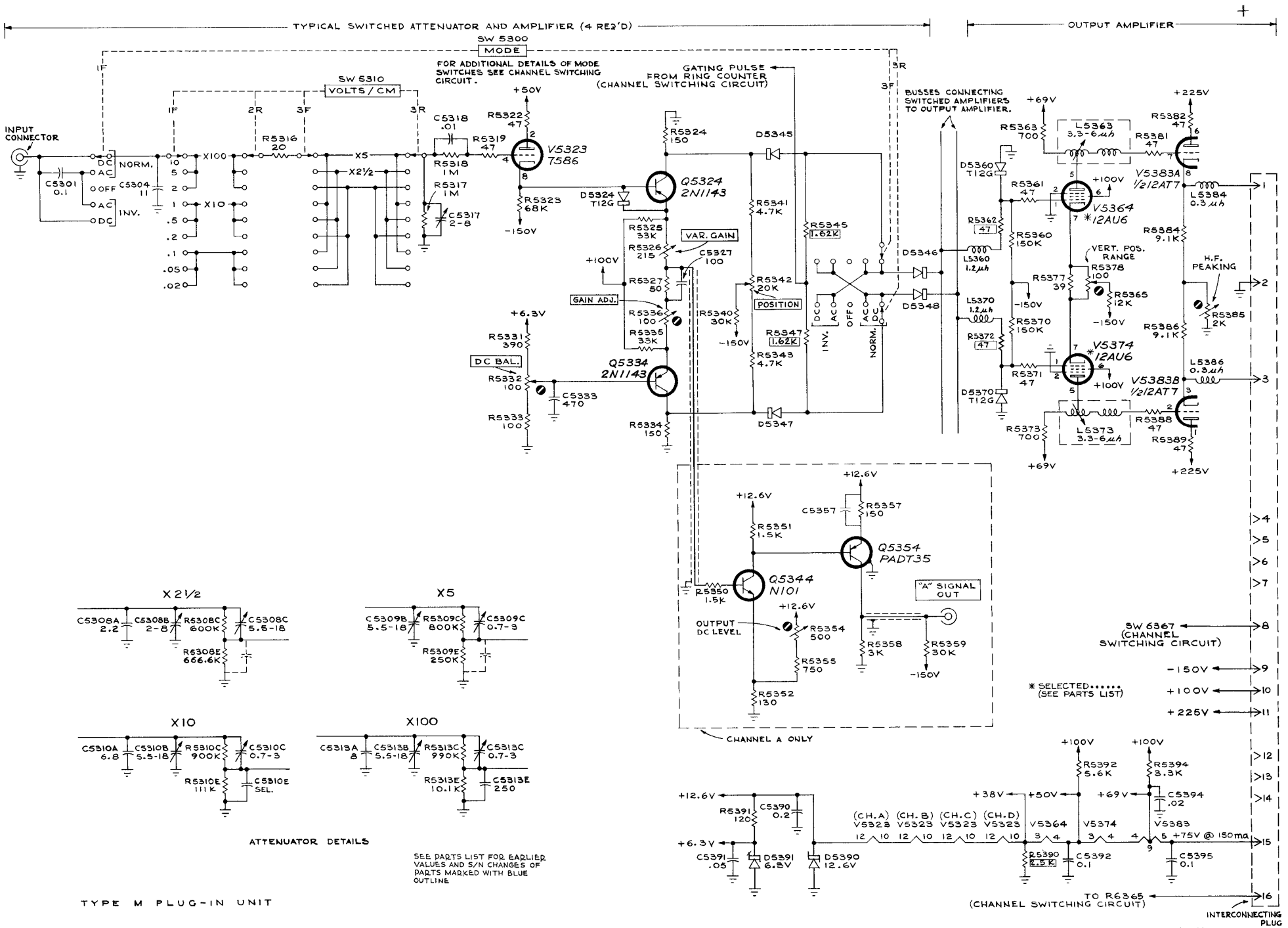
The series-connected heaters result in a total drop of about 61 volts. This drop, subtracted from the +75-volt source, leaves approximately 14 volts where it is applied across D5392 and D5390 (D5390 S/N 101-3479). The Zener diodes clamp the voltage to 13.6 volts, ±2% (12.6 volts, ±5%—S/N 101-3479).

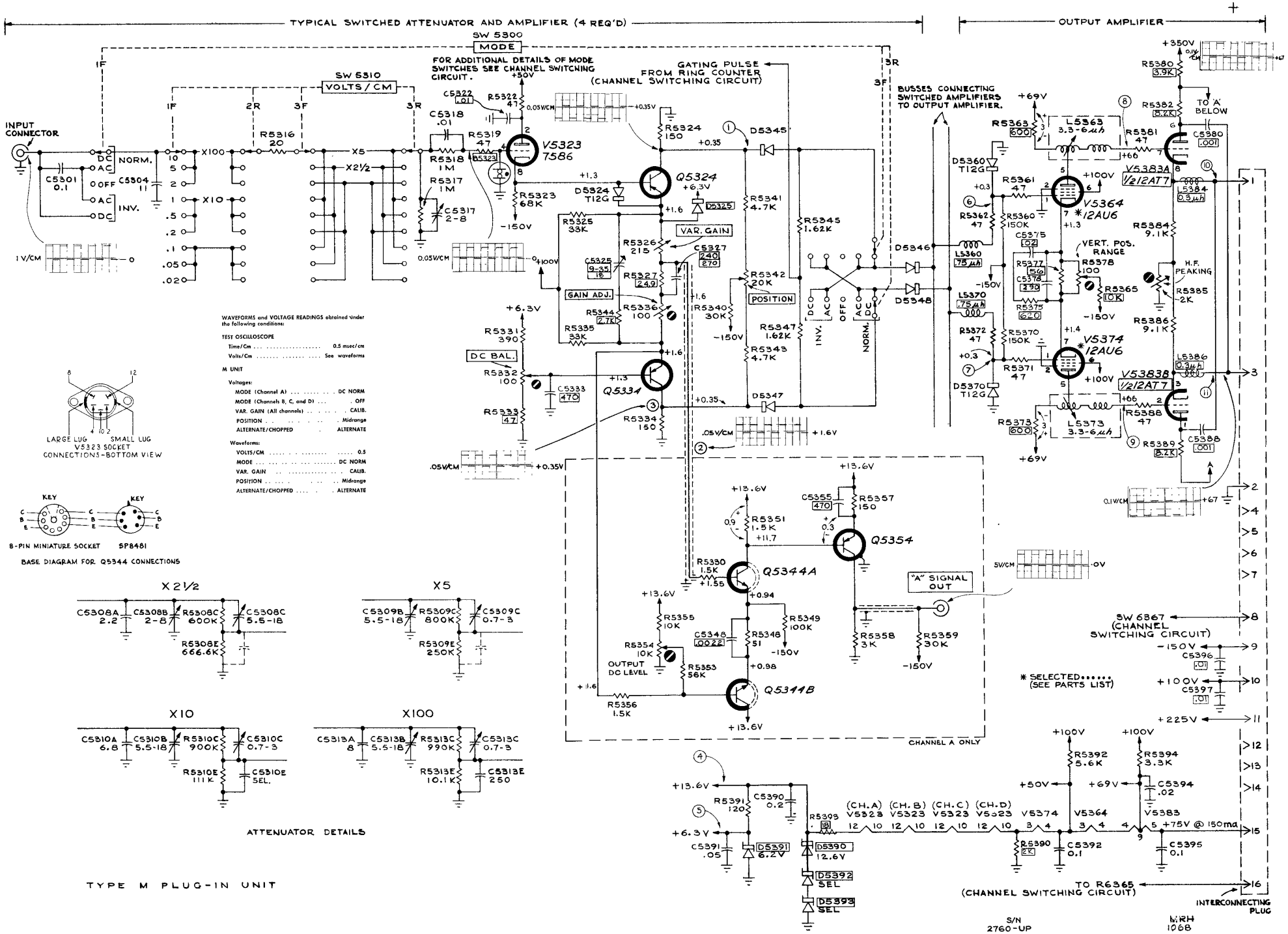


MRH
1263

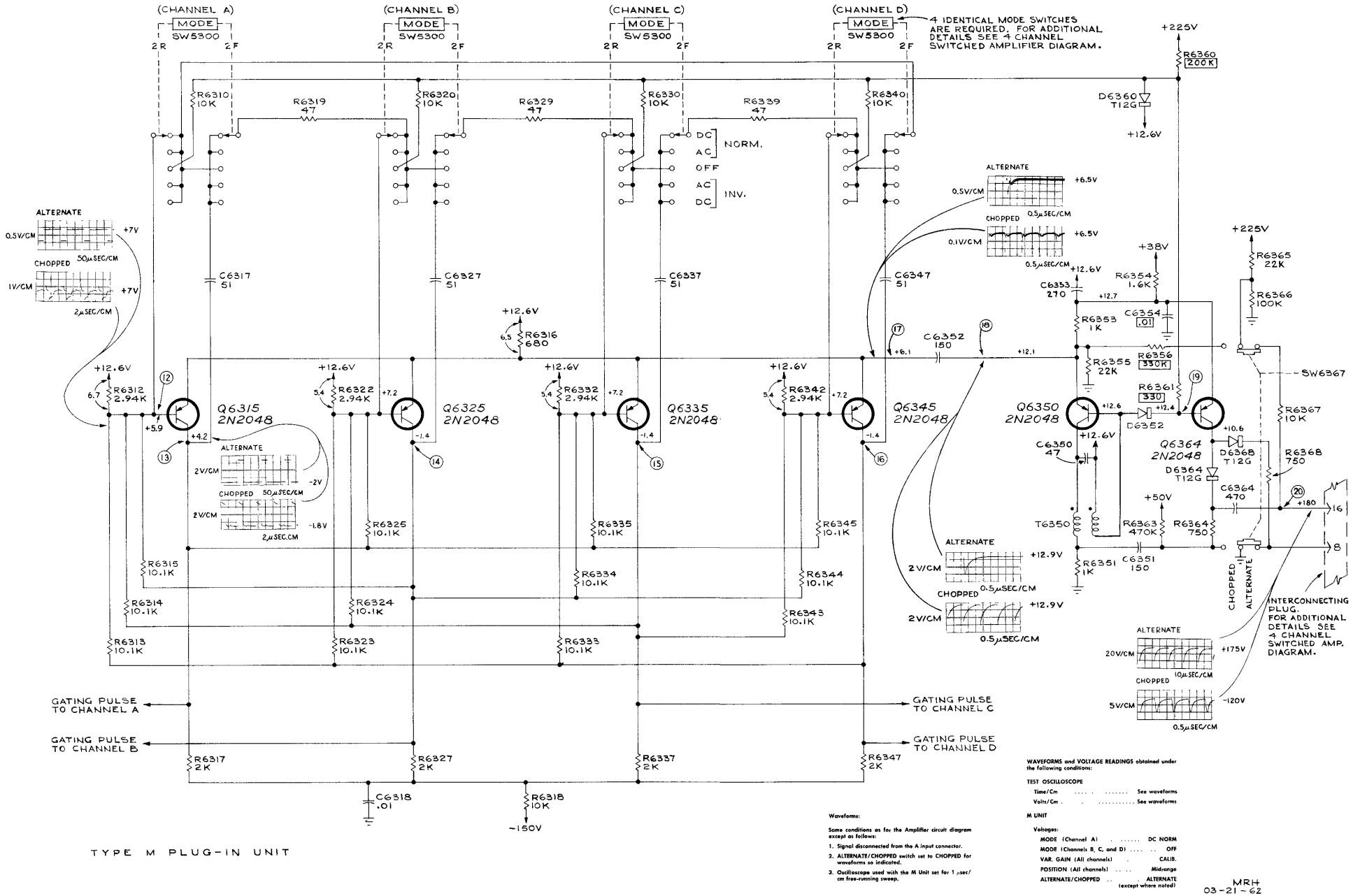
BLOCK DIAGRAM

TYPE M PLUG-IN UNIT


TYPICAL SWITCHED ATTENUATOR AND AMPLIFIER (4 REQ'D)
OUTPUT AMPLIFIER
SW 5300
MODE
FOR ADDITIONAL DETAILS OF MODE SWITCHES SEE CHANNEL SWITCHING CIRCUIT.
SW 5310
VOLTS / CM
GATING PULSE FROM RING COUNTER (CHANNEL SWITCHING CIRCUIT)
BUSSES CONNECTING SWITCHED AMPLIFIERS TO OUTPUT AMPLIFIER.
INPUT CONNECTOR
C5301 0.1
C5304 11
R5316 20
C5318 .01
R5319 47
R5318 1M
R5317 1M
C5317 2-8
R5322 47
V5323 7586
R5323 68K
+50V
-150V
R5324 150
Q5324 2N1143
D5324 T12G
R5325 33K
R5326 215
VAR. GAIN
C5327 100
R5327 50
GAIN ADJ.
R5336 100
R5335 33K
R5334 150
+100V
+6.3V
R5331 390
DC BAL.
R5332 100
C5333 470
R5333 100
Q5334 2N1143
D5345
R5341 4.7K
R5342 20K
R5343 4.7K
R5340 30K
R5347 1.62K
D5347
R5345 1.62K
POSITION
INV.
NORM.
D5346
D5348
+69V
R5363 700
L5363 3.3-6 μh
D5360 T12G
R5361 47
R5362 47
R5360 150K
L5360 1.2 μh
L5370 1.2 μh
R5370 150K
R5372 47
R5371 47
D5370 T12G
R5373 700
L5373 3.3-6 μh
R5377 39
R5378 100
R5365 12K
VERT. POS. RANGE
R5382 47
R5381 47
V5383A 1/2 12AT7
L5384 0.3 μh
R5384 9.1K
H.F. PEAKING
R5385 2K
R5386 9.1K
L5386 0.3 μh
V5383B 1/2 12AT7
R5388 47
R5389 47
+225V
V5364 * 12AU6
V5374 * 12AU6
+100V
-150V
+12.6V
R5351 1.5K
C5357
R5357 150
Q5354 PADT35
Q5344 N101
R5350 1.5K
"A" SIGNAL OUT
OUTPUT DC LEVEL
R5354 500
R5355 750
R5358 3K
R5359 30K
R5352 130
CHANNEL A ONLY
SW 6367 (CHANNEL SWITCHING CIRCUIT)
* SELECTED..... (SEE PARTS LIST)
-150V
+100V
+225V
>4
>5
>6
>7
>8
>9
>10
>11
>12
>13
>14
>15
>16
X2½
C5308A 2.2
C5308B 2-8
R5308C 600K
C5308C 5.5-18
R5308E 666.6K
X5
C5309B 5.5-18
R5309C 800K
C5309C 0.7-3
R5309E 250K
X10
C5310A 6.8
C5310B 5.5-18
R5310C 900K
C5310C 0.7-3
R5310E 111K
C5310E SEL.
X100
C5313A 8
C5313B 5.5-18
R5313C 990K
C5313C 0.7-3
R5313E 10.1K
C5313E 250
ATTENUATOR DETAILS
SEE PARTS LIST FOR EARLIER VALUES AND S/N CHANGES OF PARTS MARKED WITH BLUE OUTLINE
TYPE M PLUG-IN UNIT
+12.6V
R5391 120
C5390 0.2
+6.3V
C5391 .05
D5391 6.8V
D5390 12.6V
+38V
+50V
+69V
R5392 5.6K
R5394 3.3K
C5394 .02
(CH.A) V5328 (CH.B) V5323 (CH.C) V5323 (CH.D) V5323
V5364
V5374
V5383
+75V @ 150ma
R5390 2.5K
C5392 0.1
C5395 0.1
TO R6365 (CHANNEL SWITCHING CIRCUIT)
INTERCONNECTING PLUG
S/N 101-2759
MRH 03-21-62
4 CHANNEL SWITCHED AMPLIFIER
D2


TYPICAL SWITCHED ATTENUATOR AND AMPLIFIER (4 REQ'D)
OUTPUT AMPLIFIER
SW 5300
MODE
SW 5310
VOLTS / CM
FOR ADDITIONAL DETAILS OF MODE SWITCHES SEE CHANNEL SWITCHING CIRCUIT.
GATING PULSE FROM RING COUNTER (CHANNEL SWITCHING CIRCUIT)
BUSSES CONNECTING SWITCHED AMPLIFIERS TO OUTPUT AMPLIFIER.
INPUT CONNECTOR
V5323 7586
Q5324
Q5334
Q5344A
Q5344B
Q5354
V5364 *12AU6
V5374 *12AU6
V5383A 1/2 12AT7
V5383B 1/2 12AT7
VAR. GAIN
GAIN ADJ.
DC BAL.
POSITION
VERT. POS. RANGE
H.F. PEAKING
OUTPUT DC LEVEL
"A" SIGNAL OUT
TO 'A' BELOW
SW 6367 (CHANNEL SWITCHING CIRCUIT)
TO R6365 (CHANNEL SWITCHING CIRCUIT)
INTERCONNECTING PLUG
CHANNEL A ONLY
* SELECTED..... (SEE PARTS LIST)
(CH.A) V5323 (CH.B) V5323 (CH.C) V5323 (CH.D) V5323
+75V @ 150ma
WAVEFORMS and VOLTAGE READINGS obtained under the following conditions:
TEST OSCILLOSCOPE
Time/Cm ..... 0.5 msec/cm
Volts/Cm ..... See waveforms
M UNIT
Voltages:
MODE (Channel A) ..... DC NORM
MODE (Channels B, C, and D) ..... OFF
VAR. GAIN (All channels) ..... CALIB.
POSITION ..... Midrange
ALTERNATE/CHOPPED ..... ALTERNATE
Waveforms:
VOLTS/CM 0.5
MODE ..... DC NORM
VAR. GAIN ..... CALIB.
POSITION ..... Midrange
ALTERNATE/CHOPPED ..... ALTERNATE
LARGE LUG SMALL LUG
V5323 SOCKET CONNECTIONS-BOTTOM VIEW
8-PIN MINIATURE SOCKET SP8481
BASE DIAGRAM FOR Q5344 CONNECTIONS
X2½
X5
X10
X100
ATTENUATOR DETAILS
TYPE M PLUG-IN UNIT
S/N 2760-UP
W/RH 1068
4 CHANNEL SWITCHED AMPLIFIER

RING COUNTER — SWITCHING B.O. — CHOPPED MODE BLANKING AMPLIFIER



TYPE M PLUG-IN UNIT

Waveforms:

Some conditions as for the Amplifier circuit diagram except as follows:

1. Signal disconnected from the A input connector.
2. ALTERNATE/CHOPPED switch set to CHOPPED for waveforms so indicated.
3. Oscilloscope used with the M Unit set for 1 μsec/cm free-running sweep.

WAVEFORMS and VOLTAGE READINGS obtained under the following conditions:

TEST OSCILLOSCOPE

Time/Cm	See waveforms
Volts/Cm	See waveforms

M UNIT

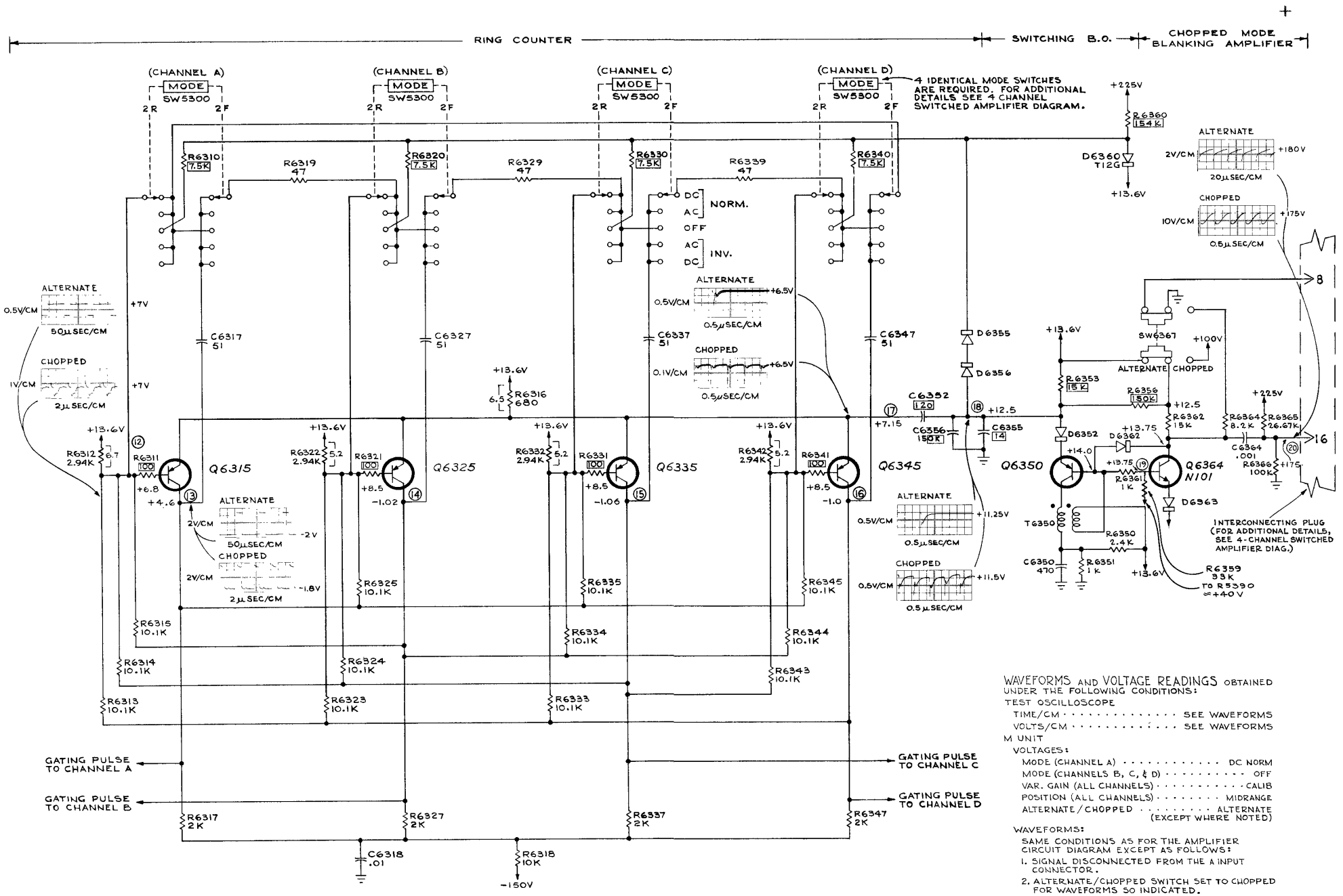
Voltages:

MODE (Channel A)	DC NORM
MODE (Channels B, C, and D)	OFF
VAR. GAIN (All channels)	CALIB.
POSITION (All channels)	Mid-range
ALTERNATE/CHOPPED	ALTERNATE (except where noted)

MRH
03-21-62

CHANNEL SWITCHING CIRCUIT

S/N 101-824



TYPE M PLUG-IN UNIT

WAVEFORMS AND VOLTAGE READINGS OBTAINED UNDER THE FOLLOWING CONDITIONS:

TEST OSCILLOSCOPE
- TIME/CM . . . . . SEE WAVEFORMS
- VOLTS/CM . . . . . SEE WAVEFORMS

M UNIT

VOLTAGES:
- MODE (CHANNEL A) . . . . . DC NORM
- MODE (CHANNELS B, C, & D) . . . . . OFF
- VAR. GAIN (ALL CHANNELS) . . . . . CALIB
- POSITION (ALL CHANNELS) . . . . . MIDRANGE
- ALTERNATE/CHOPPED . . . . . ALTERNATE (EXCEPT WHERE NOTED)

WAVEFORMS:

SAME CONDITIONS AS FOR THE AMPLIFIER CIRCUIT DIAGRAM EXCEPT AS FOLLOWS:
1. SIGNAL DISCONNECTED FROM THE A INPUT CONNECTOR.
2. ALTERNATE/CHOPPED SWITCH SET TO CHOPPED FOR WAVEFORMS SO INDICATED.
3. OSCILLOSCOPE USED WITH M UNIT SET FOR 1 μSEC/CM FREE-RUNNING SWEEP.

1068

CHANNEL SWITCHING CIRCUIT

EFF. S/N 825-UP