INSTRUCTION MANUAL

Serial Number _____

TYPE 3A1
DUAL-TRACE AMPLIFIER

Tektronix, Inc.
S.W. Millikan Way ● P. O. Box 500 ● Beaverton, Oregon 97005 ● Phone 644-0161 ● Cables: Tektronix

070-0343-01


TYPE 3A1
DUAL-TRACE
AMPLIFIER
1 MEG.
47 pf
VARIABLE
VOLTS/DIV.
.5
.2
1
.1
2
.05
5
.02
10
.01
CALIB.
POSITION
DC BAL.
UNCAL.
CH 1
AC
DC
GND
MODE
INV. (CH 1) NORM.
CH 1
CH 2
ALTER.
CHOP.
ADDED
CALIB.
SCAN
± 3CM
ONLY
VARIABLE
VOLTS/DIV.
AC
DC
GND
CH 2
DC BAL.
UNCAL.
POSITION
1 MEG.
47 pf
TRIGGER
CH1 ONLY
PULL
SERIAL
TEKTRONIX, INC.
PORTLAND, OREGON, U.S.A.

SECTION 1
CHARACTERISTICS

General

The Type 3A1 Dual-Trace Amplifier plug-in unit is designed to operate in Tektronix 560-Series Oscilloscopes. The unit has two identical amplifier channels with a switching circuit that can select independent operation of either channel, switch back and forth between channels either at an internally set chopping rate or on alternate sweeps, or select the algebraic sum of the two inputs.

OPERATING CHARACTERISTICS

Deflection Factor

Each channel has ten deflection factors from 0.01 volts/civ to 10 volts/div. in a 1, 2, 5 sequence. Accuracy is ±3% of indication. Each channel has a variable attenuator which may be used to introduce a continuously variable attenuation to a maximum of 2.5 X the indicated deflection factor. A warning indicator lights when the variable attenuator is not in the calibrated position.

Frequency Response

DC to at least 10 MHz at —3 dB

Risetime

Equal to or less than 35 nanoseconds

Input Characteristics

Approximately 1 megohm, paralleled by 47 pF (47 x 10^{-12} farads)

Input Coupling

AC or DC coupling of signals may be selected for either channel. A 0.1 μF capacitor limits low-frequency response to about 2 Hz on AC coupling.

Operating Modes

Channel 1 only: Channel 2 will not operate.

Channel 2 only: Channel 1 will not operate.

Alternate: Electronic switching between channels at the end of each sweep.

Chopped: Electronic switching between channels at a rate of about 100 kHz, with a 5 μsec sample of each channel. Blanking occurs while switching is taking place.

Added: The algebraic sum of both signals is displayed. When the channel 1 signal is inverted, the difference is displayed.

Triggering

An internal signal for triggering is fed from the Type 3A1 through the indicator unit to the time-base plug-in unit. Trigger signals may be supplied from channel 1 only, or from channel 1 and channel 2, depending on which channel is displayed.

Mechanical Features

Construction: Aluminum alloy chassis

Accessories

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

SECTION 4

CIRCUIT DESCRIPTION

General

The Type 3A1 Dual-Trace Amplifier contains two identical input channels, a common output amplifier, a switching circuit, and a trigger amplifier. The output of either or both input channel amplifiers may be fed to the output amplifier, depending on the condition of the switching circuit. Thus, the switching circuit makes it possible to display one signal as a single trace on the CRT, two signals simultaneously in a dual-trace display, or the algebraic sum or difference of two signals as a single trace. Fig. 4-1 is a block diagram of the Type 3A1.

Input Channel Amplifiers

Each input channel consists of an attenuation network, an input cathode-follower, and a three-stage amplifier with switched outputs. The input cathode-followers V113 and V123 (channel 1) and V213 and V223 (channel 2) isolate the attenuator input circuitry from emitter-followers Q133 and Q143 (channel 1) and Q233 and Q243 (channel 2). These transistors provide low-impedance drive to the next stage: Q134 and Q144 (channel 1), and Q234 and Q244 (channel 2). The output of these stages is fed to the diode gates in the switching circuits, which select the signals to be fed to the common output amplifier. The gain of the last stages in the input amplifiers is variable, with two calibration adjustments: R149 (channel 1), and R249 (channel 2) set the gain of the stage with the VOLTS/DIV. switches in the .01 position; R147 (channel 1), and R247 (channel 2) set the gain of the stage in the remaining positions of the VOLTS/DIV. switches. The VARIABLE VOLTS/DIV. control increases cathode degeneration when moved from the CALIB. position.

The input attenuators are resistance dividers with capacitive compensation. The attenuators maintain an input impedance of 1 megohm paralleled by 47 pF. With the VOLTS/DIV. switch in the .01 and .02 positions, the input is fed directly to the cathode-follower stages (V113 and V213). The 10MV GAIN controls adjust the amplifier sensitivity with the VOLTS/DIV. switches in the .01 position and the 20MV GAIN controls adjust the sensitivity in the remaining positions. In the VOLTS/DIV. switch positions which provide an input deflection factor greater than 20 mV per division (.02 to 10 on VOLTS/DIV. switch), the attenuator sections are stacked. In the .05 VOLTS/DIV. switch position, the 2.5X attenuator increases the basic 20 mV per division deflection factor to 50 mV per division. The 5X attenuator is used to increase the deflection factor to 100 mV per division in the .1 VOLTS/DIV. switch position. These three positions (1X, 2.5X, and 5X) are preceeded by the X10 or

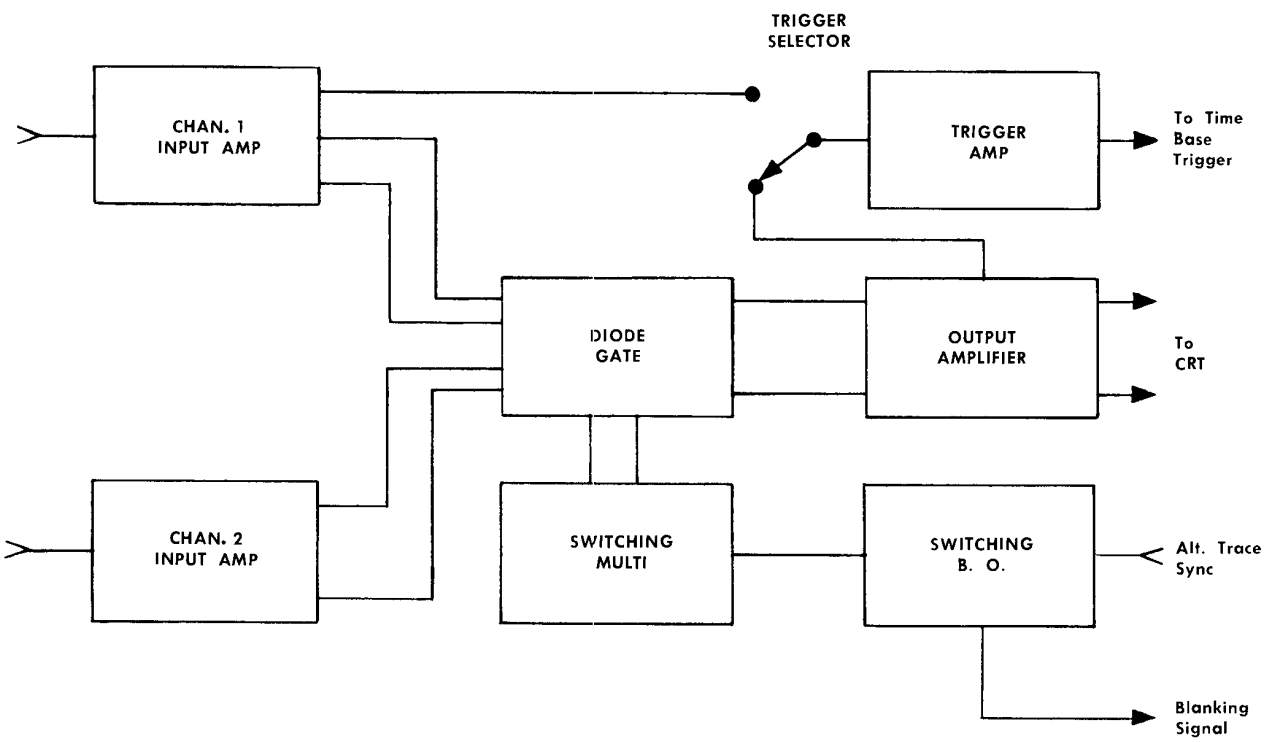


Fig. 4-1. Type 3A1 Block Diagram

X100 attenuators in the higher deflection factor positions of the VOLTS/DIV. switch.

The DC BAL. controls in the grid circuit of V123 and V223 adjust the potential at both emitters of each input amplifier so no current will flow through R139 and R149 (channel 1), and R239 and R249 (channel 2) under no-signal conditions. Otherwise, the position of a no-signal trace would shift on the CRT as the VARIABLE VOLTS/DIV. control or channel Gain adjustments were turned.

In the INV. position the INV. (CH 1) NORM. switch (SW155) inverts the channel 1 output to the diode gates.

The channel 1 input amplifier contains a three-stage trigger amplifier. The first stage is an emitter-coupled paraphase amplifier (Q164 and Q174) with double-ended input and single-ended output. The DC level of the output is set by CHAN. 1 TRIG. DC LEVEL control R171. The output of this stage is fed to emitter-follower Q173. Q173 drives the third stage, Q184, which is collector-coupled to the trigger-amplifier section of the output amplifier.

Switching Circuits

The switching circuit consists of two diode gates, a switching multivibrator, and a switching blocking oscillator which drives the multivibrator. In the following discussion, assume that the MODE switch is in the CH 1 position.

Each diode gate consists of two series diodes and two shunting diodes. When signals are to pass through the gate to the output amplifier, the series diodes are forward biased, and the shunt diodes are back biased, allowing the signal to drive the emitter of Q304 and Q314. Voltage to hold the series diodes (D155 and D158 in channel 1) in conduction is supplied through the emitter-base junctions of Q304 and Q314. Collector current for Q134 and Q144 flows through the series diodes. Shunt diodes D156 and D157 are back biased and thus cut off by MODE switch SW290, holding Q285 in the "off" state. Q275 is "off", and the junction of D156 and D157 is at —1.18 volts. The DC level in the signal output lines from the channel 1 input amplifier is —1.65 volts, and thus the shunt diodes are back biased.

In channel 2 diode gate, D256 and D257 are held at about —4.7 volts by Q285, which is "off". This holds the channel 2 output lines at about —4.3 volts. Since the outputs of the diode gates are about —2 volts, D255 ard D258 are back biased. With D255 and D258 cut off, the signal is not transmitted to the output amplifier. In addition, D256 and D257, when conducting, form a low-impedance path for any signals coming to the diode gate from channel 2 input amplifier.

When the MODE switch is in the CH 2 position, the conditions of the diode gates are reversed. In the channel 2 diode gate, D256 and D257 are back biased and the signal from the channel 2 input amplifier passes through D255 and D258 to the output amplifier.

When the MODE switch is in either the ALTER or CHOP positions, Q275 and Q285 operate as a common Eccles-Jordan bistable multivibrator. Positive pulses from the switching blocking oscillator pass through D278 or D288 to the collector of the "off" state transistor. This pulse is transmitted by either C277 or C287 to the base of the "on" transistor, turning it "off". The collector of the "off" transistor moves toward the —12.2-volt supply, turning the other transistor "on" because of the coupling through either C277 or C287. Resistive dividers R277-R286 and R287-R276 set the levels at the transistor bases. The levels are designed so switching action can occur when pulses are received from the blocking oscillator.

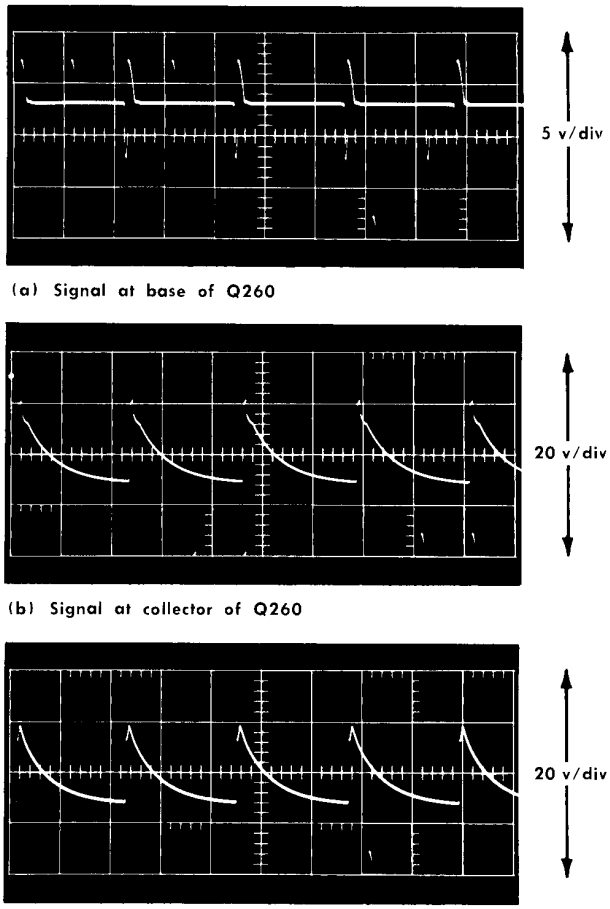
Operation of the diode gates in ALTER and CHOP is the same as described in the CH 1 and CH 2 positions of the MODE switch. However, the multivibrator is free to switch states when it receives a trigger signal, and thus operate the diode gates and transmit a signal to the output amplifier from channel 1 and channel 2 alternately. Also, in the ALTER and CHOP positions of the MODE switch, R292 is bypassed and the —12.2-volt supply is connected directly to the multivibrator circuit. In the other positions of the MODE switch, the multivibrator draws current through R292 and is not able to switch the diode gates. In the CH 1 position, additional current is supplied through R289; in the CH 2 position, current is supplied through R279.

When the MODE switch is in the ADDED position, current is supplied to the ouput amplifier through R293 and R294, holding the series diodes in both diode gates in conduction. Since the multivibrator transistors are both near cutoff, the diode-gate shunt diodes are back biased and thus inoperative.

In the CHOP and ALTER positions of the MODE switch, Q260 (the switching blocking oscillator) is energized, supplying pulses to the switching multivibrator. Fig. 4-2 shows the blocking oscillator waveforms with the MODE switch in the CHOP position. In the ALTER mode, the emitter of Q260 is connected to the —12.2-volt supply through R260. The base is also connected to the —12.2-volt supply through the base winding of blocking oscillator transformer T263. When a positive pulse is fed from the time-base plug-in unit through terminal 3 of the interconnecting plug, the emitter voltage rises. The transistor conducts, drawing current through the collector winding of blocking oscillator transformer T263, driving Q260 further into conduction. A normal blocking-oscillator cycle occurs with the backswing cutting the transistor off. The circuit is damped so the transistor is not turned on again until another sync pulse is received.

In the CHOP position of the MODE switch, the emitter of Q260 is connected to ground through R262. Normal blocking oscillator action occurs; however, when a cycle is completed, the base is forward biased since it is connected to the —12.2-volt supply. The blocking oscillator is thus automatically triggered and free-runs at a 150 kHz rate.

Pulses from the collector circuit of Q260 are fed to the switching multivibrator through C266. Only the positive pulses, which occur at the beginning of the blocking oscillator cycle, will switch the multivibrator. The collector pulse is also fed to pin 24 of the interconnecting plug for use as a blanking pulse in the CRT circuit of the oscilloscope.



(a) Signal at base of Q260

(b) Signal at collector of Q260

(c) Output to pin 24 of Interconnecting Plug

Fig. 4-2. Signals in blocking oscillator circuit. Oscilloscope AC coupled, sweep rate 2 μsec/div.

Output Amplifier

The output of the diode gates passes to Q304 and Q314. These transistors are arranged as a common-base push-pull amplifier. The signal passes from the collectors of these transistors to a second pair of current amplifier, Q323 and Q333. These transistors are connected as emitter-followers and couple the signal to the grids of V334. The push-pull signal drives the grids, and the output is taken from the plate circuit. V334 is stabilized against characteristic changes by 'long-tailing' through R329 and R339 to the —100 volt supply. (SN 101-6729 only) "D337 and D338 in the cathode circuit improve the linearity of the amplifier near the end of its dynamic range by shunting cathode coupling resistor R337 on large signals." In the plate circuit of V334, peaking coils L326, L341, L336, and L351 improve the high-frequency response of the amplifier.

The signal is direct-coupled through parasitic suppression resistors R341 and R351 to the grids of V353. This tube is connected as a cathode-follower and because of its high input impedance, presents almost no load to the previous stages.

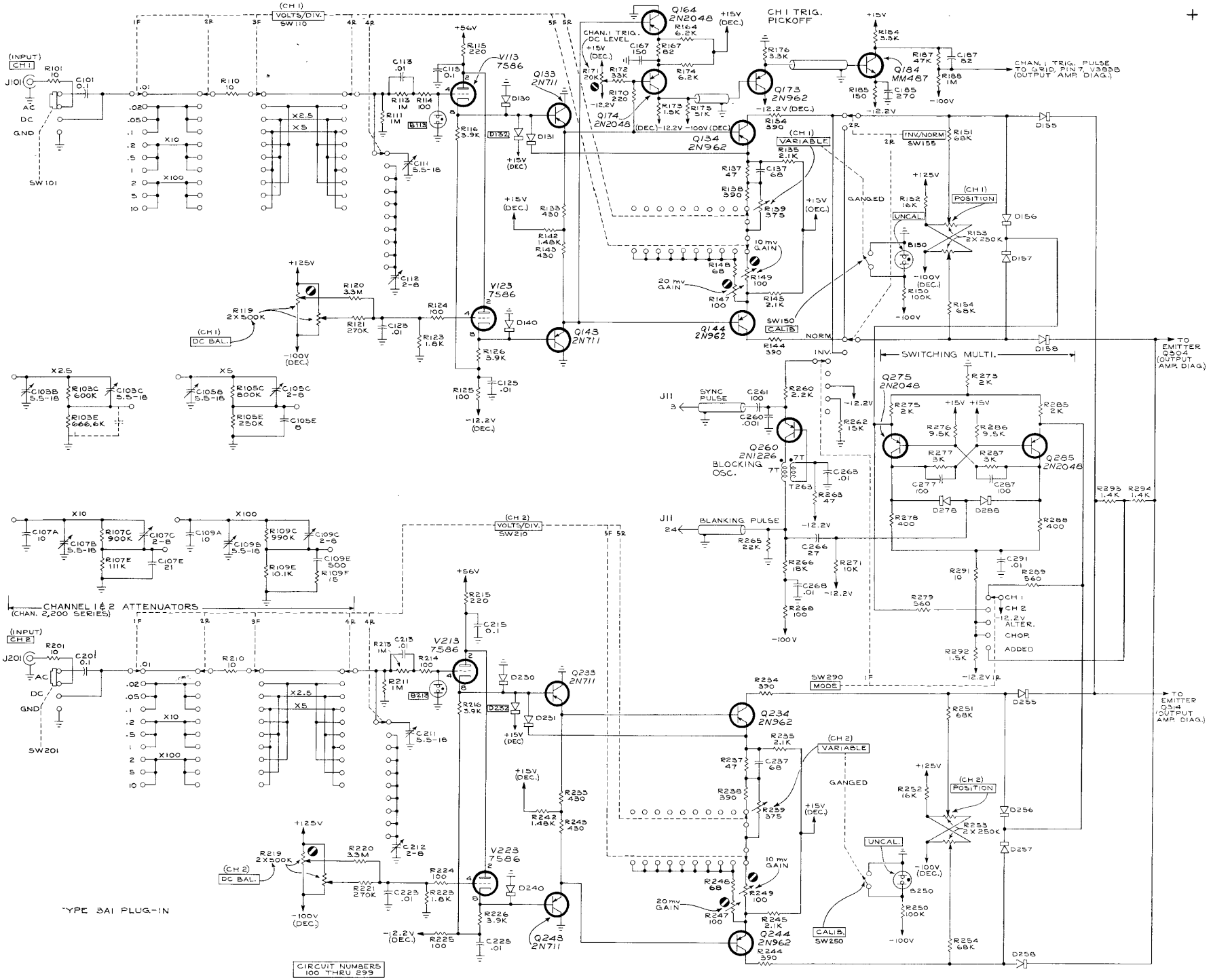
(SN 101-4327) The signal is coupled from the cathodes of V353 to the grids of output tubes V364 and V374. L344 and L354 in the coupling network provide additional high-frequency peaking while L345 (ferrite bead) and L355 (ferrite bead) are parasitic suppressors.

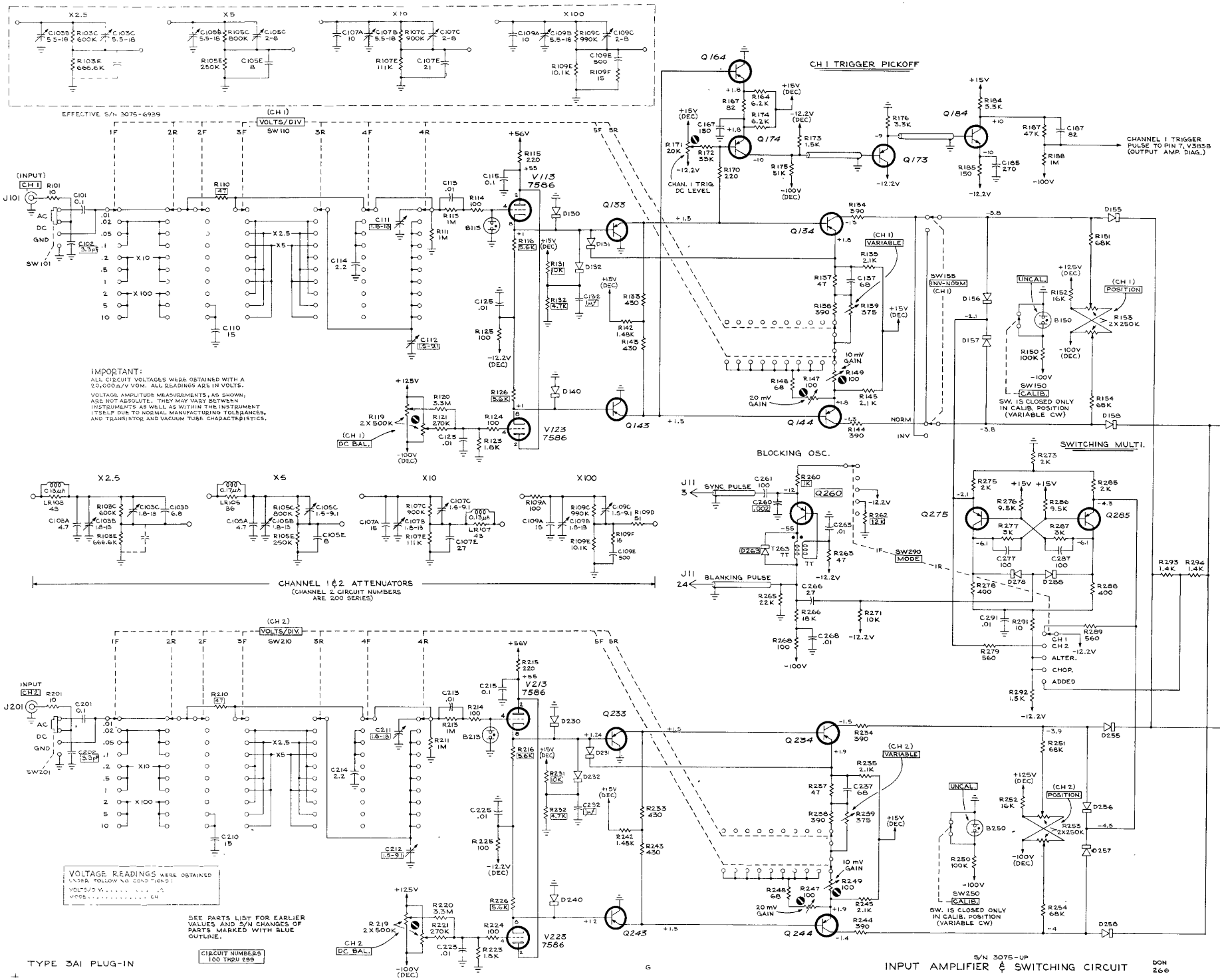
(S/N 4328-up) The signal is coupled from the cathode of V353 to the bases of feedback transistors Q364 and Q374 which in turn couple the signal to the grids of output tubes V364 and V374. The feedback from the output stage to the bases of Q364 and Q374 reduces the gain variation due to different tube transconductance (gm). This also increases the linear scan range of the output stage. Diodes D345 and D355 limit the voltage on the collectors of Q364-Q374 and therefore limit the dissipation of the transistors if one or the other of the output tubes (V364 or V374) cut off.

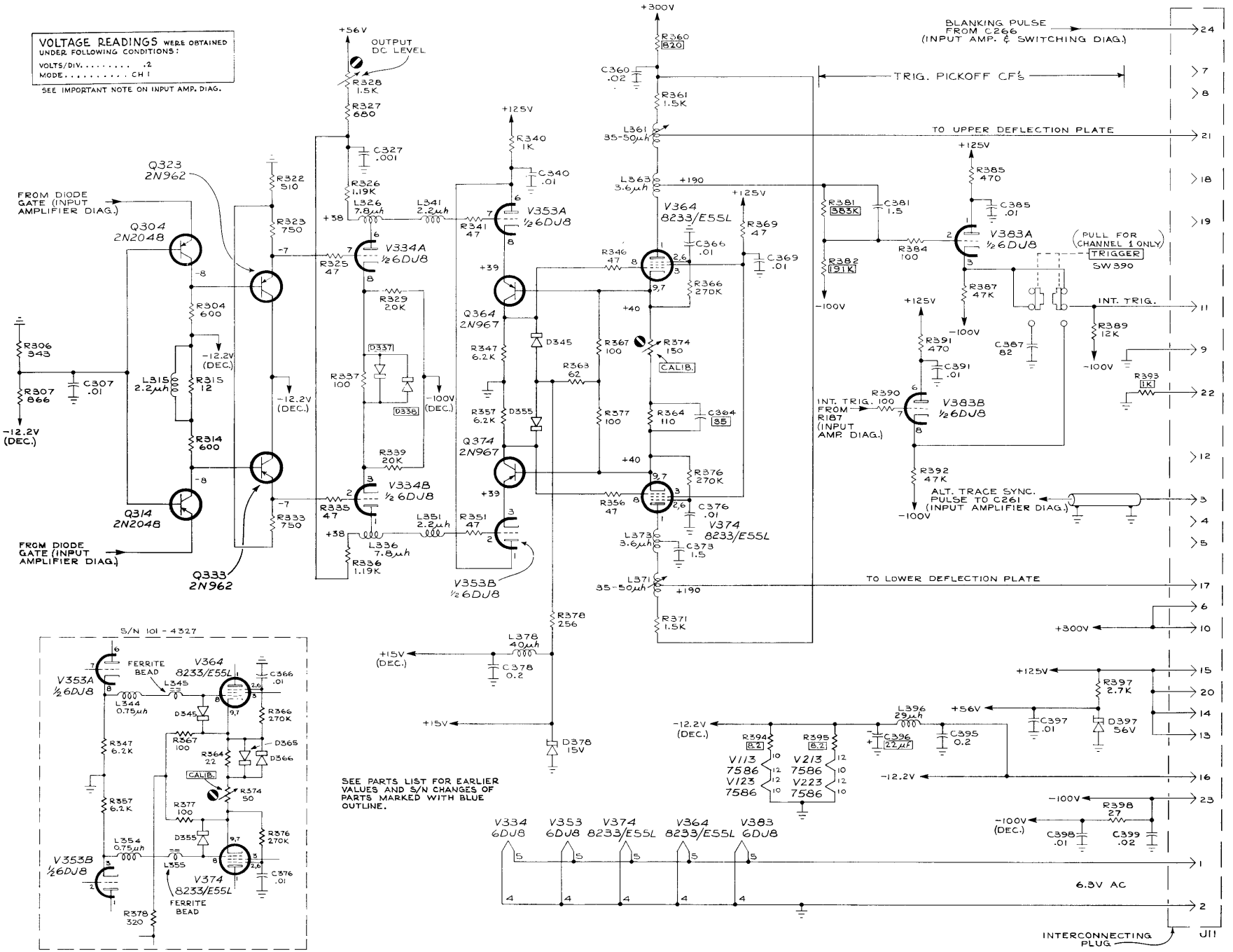
Output tubes V364 and V374 operate as a conventional push-pull amplifier. R374 (CALIB.) can be adjusted to match the deflection plate sensitivity of the CRT. This control varies cathode degeneration, and thus changes the output voltage swing of the amplifier. Maximum deflection occurs when this control is set for zero resistance. The two diodes D375 and D376 (D365 and D366 SN 101-4327) improve linearity on large signals by shunting R364. The two cathode resistors R367 and R377 return through R378 to Zener diode D378. This diode, together with L378 and C378, forms a +15-volt power supply that is used in the amplifier input circuit.

The plate circuits of V364 and V374 each contain two inductors: L361 and L363 in the plate of V364, and L373 and L371 in the plate of V374. These peaking coils tend to neutralize the effect of plate and distributed capacity, and thus improve the high-frequency response of the amplifier.

A portion of the output signal is picked off the center-tap of L363 and coupled to trigger amplifier V383A. This tube is connected as a cathode-follower and the signal is passed to the TRIGGER switch. In normal operation, this front-panel switch is pushed in and the trigger signal passed to the time-base plug-in comes from V383A. If the TRIGGER switch is pulled out, the trigger signal is coupled from the cathode of V383B (channel 1 signal).


(CH 1) VOLTS/DIV. SW110
CH 1 TRIG. PICKOFF
CHAN. 1 TRIG. DC LEVEL
CHAN. 1 TRIG. PULSE TO GRID, PIN 7, V385B (OUTPUT AMP. DIAG.)
(INPUT) CH 1
J101
AC
DC
GND
SW101
Q164 2N2048
Q174 2N2048
Q173 2N962
Q184 MM487
V113 7586
Q133 2N711
Q134 2N962
(CH 1) VARIABLE
GANGED
INV/NORM SW155
(CH 1) POSITION
UNCAL.
10 mv GAIN
20 mv GAIN
(CH 1) DC BAL.
V123 7586
Q143 2N711
Q144 2N962
SW150 CALIB
NORM
INV.
TO EMITTER Q304 (OUTPUT AMP. DIAG.)
SWITCHING MULTI.
Q275 2N2048
Q285 2N2048
Q260 2N1226 BLOCKING OSC.
SYNC PULSE
BLANKING PULSE
CHANNEL 1 & 2 ATTENUATORS (CHAN. 2,200 SERIES)
(CH 2) VOLTS/DIV. SW210
(INPUT) CH 2
J201
SW201
V213 7586
Q233 2N711
Q234 2N962
V223 7586
Q243 2N711
Q244 2N962
SW290 MODE
CH 1
CH 2
-12.2V ALTER.
CHOP.
ADDED
CALIB. SW250
TYPE 3A1 PLUG-IN
CIRCUIT NUMBERS 100 THRU 299
S/N 101 - 3074
INPUT AMPLIFIER & SWITCHING CIRCUIT
PLM 1163


X2.5
X5
X10
X100
EFFECTIVE S/N 3075-6939
(CH 1) VOLTS/DIV SW110
(INPUT) CH 1 J101
SW101
V113 7586
V123 7586
Q133
Q143
Q134
Q144
Q164
Q174
Q73
Q84
CH 1 TRIGGER PICKOFF
CHAN. 1 TRIG. DC LEVEL
CHANNEL 1 TRIGGER PULSE TO PIN 7, V385B (OUTPUT AMP. DIAG.)
IMPORTANT:
ALL CIRCUIT VOLTAGES WERE OBTAINED WITH A 20,000Ω/V VOM. ALL READINGS ARE IN VOLTS.
VOLTAGE AMPLITUDE MEASUREMENTS, AS SHOWN, ARE NOT ABSOLUTE. THEY MAY VARY BETWEEN INSTRUMENTS AS WELL AS WITHIN THE INSTRUMENT ITSELF DUE TO NORMAL MANUFACTURING TOLERANCES, AND TRANSISTOR AND VACUUM TUBE CHARACTERISTICS.
(CH 1) DC BAL.
(CH 1) VARIABLE
10 mV GAIN
20 mV GAIN
SW155 INV-NORM (CH 1)
NORM
INV
UNCAL.
(CH 1) POSITION
SW150 CALIB.
SW. IS CLOSED ONLY IN CALIB. POSITION (VARIABLE CW)
TO Q304 (OUTPUT AMP DIAG)
BLOCKING OSC.
SWITCHING MULTI.
J11 SYNC PULSE
J11 BLANKING PULSE
SW290 MODE
IF
IR
CH 1
CH 2
ALTER.
CHOP.
ADDED
CHANNEL 1&2 ATTENUATORS
(CHANNEL 2 CIRCUIT NUMBERS ARE 200 SERIES)
(CH 2) VOLTS/DIV. SW210
(INPUT) CH 2 J201
SW201
V213 7586
V223 7586
Q233
Q243
Q234
Q244
(CH 2) VARIABLE
CH 2 DC BAL.
(CH 2) POSITION
SW250 CALIB.
SW. IS CLOSED ONLY IN CALIB. POSITION (VARIABLE CW)
TO Q314 (OUTPUT AMP DIAG)
VOLTAGE READINGS WERE OBTAINED UNDER FOLLOWING CONDITIONS:
VOLTS/DIV. 1
MODE ..... CH
SEE PARTS LIST FOR EARLIER VALUES AND S/N CHANGES OF PARTS MARKED WITH BLUE OUTLINE.
CIRCUIT NUMBERS 100 THRU 299
TYPE 3A1 PLUG-IN
S/N 3075-UP
INPUT AMPLIFIER & SWITCHING CIRCUIT
DON 266



TYPE 3A1 PLUG-IN UNIT

F1

OUTPUT AMPLIFIER

CIRCUIT NUMBERS 300 THRU 399