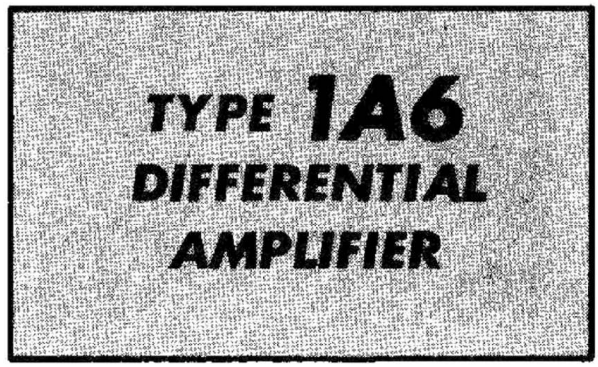
INSTRUCTION MANUAL

Serial Number



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

070-0537-00

766

Fig. 1-1. The Type 1A6 Differential Amplifier Plug-In Unit.

SECTION 1
CHARACTERISTICS

Introduction

The Type 1A6 Differential Amplifier is designed for use with 530, -540, -550, -580[1] Series oscilloscopes. The Type 1A6 features simplified common-mode signal range and deflection factor selection. The bandwidth is constant for all deflection factor ranges. Each input provides AC, ground and DC coupling with GND between the AC and DC positions to allow the coupling capacitor to be charged before switching to AC.

This instrument will perform to specifications in laboratory environment with ambient temperature range from 0° C to 50° C except as indicated. Warm-up time for rated accuracies at 25° C ±5° C is 30 minutes.

MECHANICAL FEATURES

Construction	Aluminum alloy chassis. Glass laminate circuit board assembly. Anodized front panel.

Standard accessories supplied with the instrument are listed at the end of the Mechanical Parts List section. For optional accessories see Tektronix, Inc. catalog.

ELECTRICAL CHARACTERISTICS

Characteristic	Performance Requirement	Supplemental Information
Bandwidth		
DC Coupled	DC to ≥2 MHz (at −3 dB point)	Equivalent to a risetime of 175 ns or less.
AC Coupled	≤2 Hz to ≥2 MHz (at −3 dB point)	
Transient Response	≤±2% aberration	
Input Cross Neutralization	≤3% aberration for normal amplitude	Adjustable to within 1%. Measured when driven grid is DC coupled and input coupling switch for the undriven grid is set from GND to DC. Aberration on the display is expressed as a percent of the original display amplitude.
DC Drift	≤200 μV per degree C	
VOLTS/CM		
Range		1 mV/CM to 50 V/Cm in 15 calibrated steps, in 1, 2, 5 sequence.
Accuracy		
1 mV to 50 mV	±1.5%	At ambient temperature of +25° C ±5°C.
0.1 V to 50 V	±2.5%	
VARIABLE	Provides continuous variable attenuation of the input signal by a factor of at least 2.5:1.	
Gain Variation (Thermal)		
1 mV/CM to 50 mV/Cm	≤0.5% at +25° C ±10° C ≤±1% at +25° C ±25° C	
.1 V/Cm to 50 V/Cm	≤±1% at +25° C ±10° C ≤±1.5% at +25° C ±25° C	
Common Mode Signal Range		
1 mV/Cm to 50 mV/Cm	≥±15 V (combined DC + peak AC)	
10 mV/Cm to 0.5 V/Cm	≥±150 V (combined DC + peak AC)	
0.1 V/Cm to 50 V/Cm	≥±500 V (combined DC + peak AC)	
Common Mode Rejection Ratio (CMRR)		
DC Coupled		
1 mV/Cm to 50 mV/Cm	≥10,000:1 (DC to 100 kHz)	
0.1 V/Cm to 50 V/Cm	Adjustable to ≥1000:1 (DC to 100 kHz)	
AC Coupled		
1 mV/Cm to 50 mV/Cm	≥2000:1 (at 60 Hz)	
0.1 V/Cm to 50 V/Cm	Adjustable to ≥1000:1 (at 60 Hz)	

[1]Type 81 or Type 81A Plug-In Adapter is required with the Type 580 Series oscilloscope.

ELECTRICAL CHARACTERISTICS (cont)

Characteristic	Performance Requirement	Supplemental Information
Maximum Input Voltage at 1 kHz DC Coupled 1 mV/CM to 50 mV/CM		200 volts DC + peak AC between inputs, or either input and ground
0.1 V/CM to 50 V/CM		±600 volts DC + peak AC at either input
AC Coupled 1 mV/CM to 50 mV		200 volts AC, peak to peak, differential or common mode
1 mV/CM (using precharge)		±600 volts DC ± peak AC at either input. AC not to exceed 200 volts peak to peak
1 mV/CM (not precharged)		200 volts DC + peak AC between inputs, or either input and ground
0.1 V/CM to 50 V/CM		±600 volts DC + peak AC at either input
Overload Indicator	Neon lights when $\geq +50$ V (referenced to ground) is applied to either or both inputs. Does not light with ≤ 20 V applied.	With no internal or external attenuation.
Input Characteristic	Input resistance of 1 MΩ ±0.75% paralleled by 33 pF ±3%.	Input C adjusted to combine with R for a time constant of 33 μs.

SECTION 3

CIRCUIT DESCRIPTION

Introduction

This section of the manual presents a description of the Type 1A6 circuitry, keyed to the block diagram and circuit schematics in Section 9. Detailed circuit analysis includes simplified drawings of the circuit to enable the reader to readily follow signal or current paths as the description is presented.

BASIC DESCRIPTION

Signals applied to either INPUT are coupled via the input selector switch (SW1 or SW10) to the input attenuators. The attenuators for both sides are the conventional RC type, however, the —Input attenuator contains an adjustable resistance so the —Input can be matched to the +Input side and provide optimum DC CMRR.

From the input attenuators, the signals are applied to the input amplifier stage. Special constant current bootstrap circuits in this input stage, with balanced input and output, provide all of the high DC CMRR for the Type 1A6.

Differential signals from the input amplifier are DC coupled to an emitter coupled, balanced, push-pull amplifier and applied through the grounded base transistor Q164A and B to the output stage.

Gain selection for the amplifier is obtained by selecting different collector load resistance values for the grounded base amplifier.

The output stage consists of a current amplifier driving an operational amplifier. Output DC level is determined by the ratio of feedback to load resistance in the operational amplifier and is designed for about 67.5 volts.

A single control provides differential current adjustment to the base of the operational amplifier to vertically position the trace on the CRT screen.

CIRCUIT DESCRIPTION

Input Coupling and Attenuator Switching

The input selector, switches SW1 and SW10, are connected to provide AC coupling through C1 or C10; ground (GND) or DC coupling to the + and — grids of the input amplifier through the attenuator (VOLTS/CM) selector switch SW40.

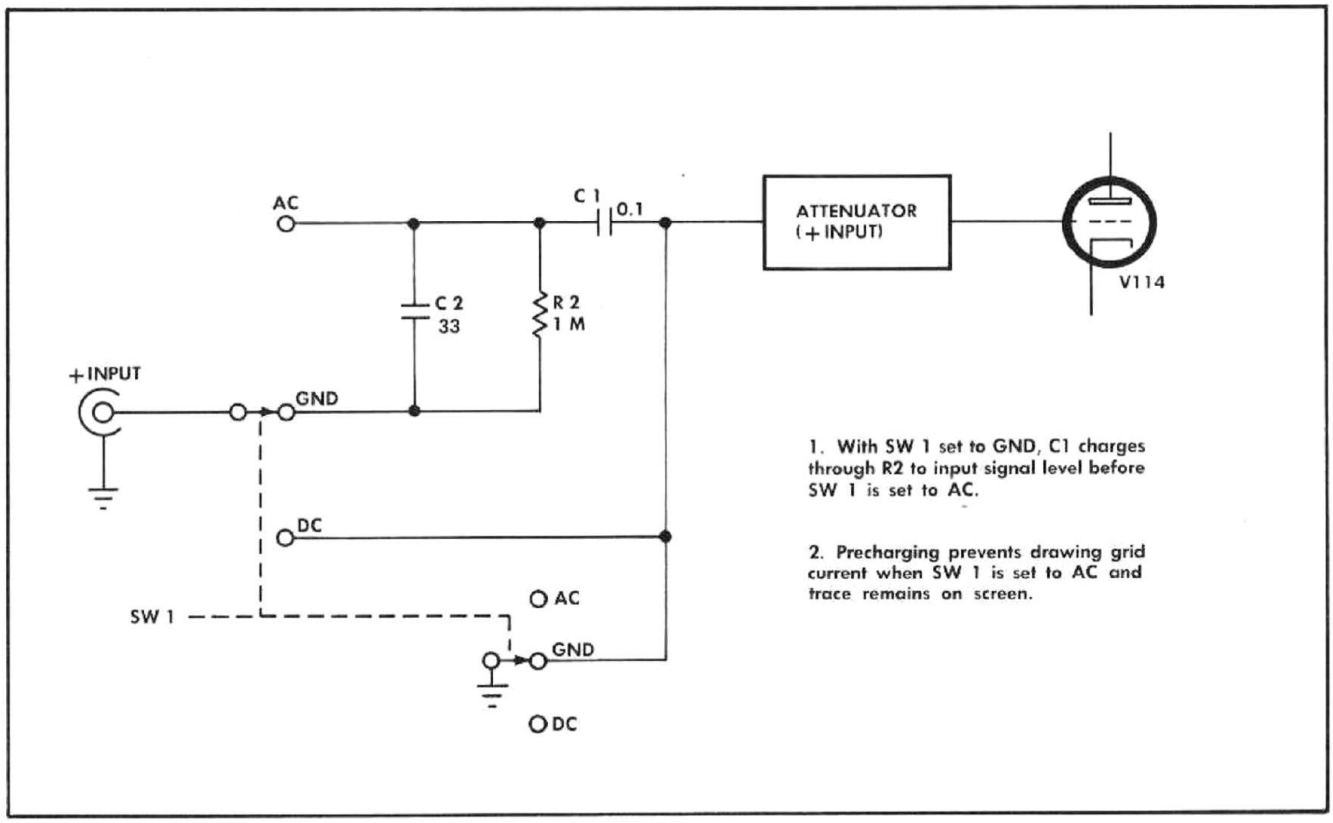


Fig. 3-1. + Input circuit showing C1 charge path.

When the +INPUT selector switch (SW1) is in the AC or DC position and the VOLTS/CM switch is in the 1× (1 to 50 mvolt) attenuator position, input R and C is established by the grid load resistor R103 and the stray circuit capacitance in parallel with C103.

Setting the +INPUT selector switch to GND position grounds the + grid and applies the input signal through R2 to charge coupling capacitor C1 to the DC or average level of the input signal. The selector switch may now be switched to the AC position and the display will remain on screen. See Fig. 3-1. Input R and C is maintained at 1 MΩ and 33 pF by R2 and C2.

NOTE

Operation of the two inputs of the Type 1A6 is symmetrical. To minimize duplication, the +input of the amplifier is described in more detail throughout the text.

Input Attenuators

Four decade attenuation factors that range from 1 to 1000 can be selected simultaneously for both the + and — inputs with the VOLTS/CM selector. These attenuators provide the following characteristics:

1. The input R and C is established at 1 MΩ and 33 pF and normalized at all settings of the VOLTS/CM switch for both input connectors. Adjustable capacitors C103 (1×), C20B (10×), C22B (100×) and C24B (1000×) provide this normalization for the +INPUT.

2. The resistive (DC or low frequency) attenuation ratios of the attenuators are equalized by adjusting R30E, R32E and R34E in each attenuator network for the —INPUT. With these adjustments accurately set, optimum common-mode rejection through the attenuators is achieved.

3. Attenuator (AC) compensation is provided by adjustable capacitors C20C, C22C and C24C for the + attenuators, and capacitors C30C, C32C and C34C for the — attenuators.

Grid emission current of the input amplifiers is balanced out by adjusting R101 and R201 for a net effective grid current of zero. This maintains a zero trace reference on the screen. See Fig. 3-2.

Three common-mode signal ranges, ±15 V, ±150 V and ±500 V, are provided when the VOLTS/CM attenuator selector is switched through its range. The ±500 or ±150 volt common-mode signal ranges may be retained through three higher sensitivity steps by pulling the VOLTS/CM selector knob at the ▲ position and then switching to any one of the next three higher sensitivity switch positions. For example; to retain ±150 V common-mode range for sensitivity ranges of 50 mV through 10 mV, pull the VOLTS/CM selector knob out when the switch is in the 0.1 Volt position, and turn the knob clockwise to any of the next three higher sensitivity positions.

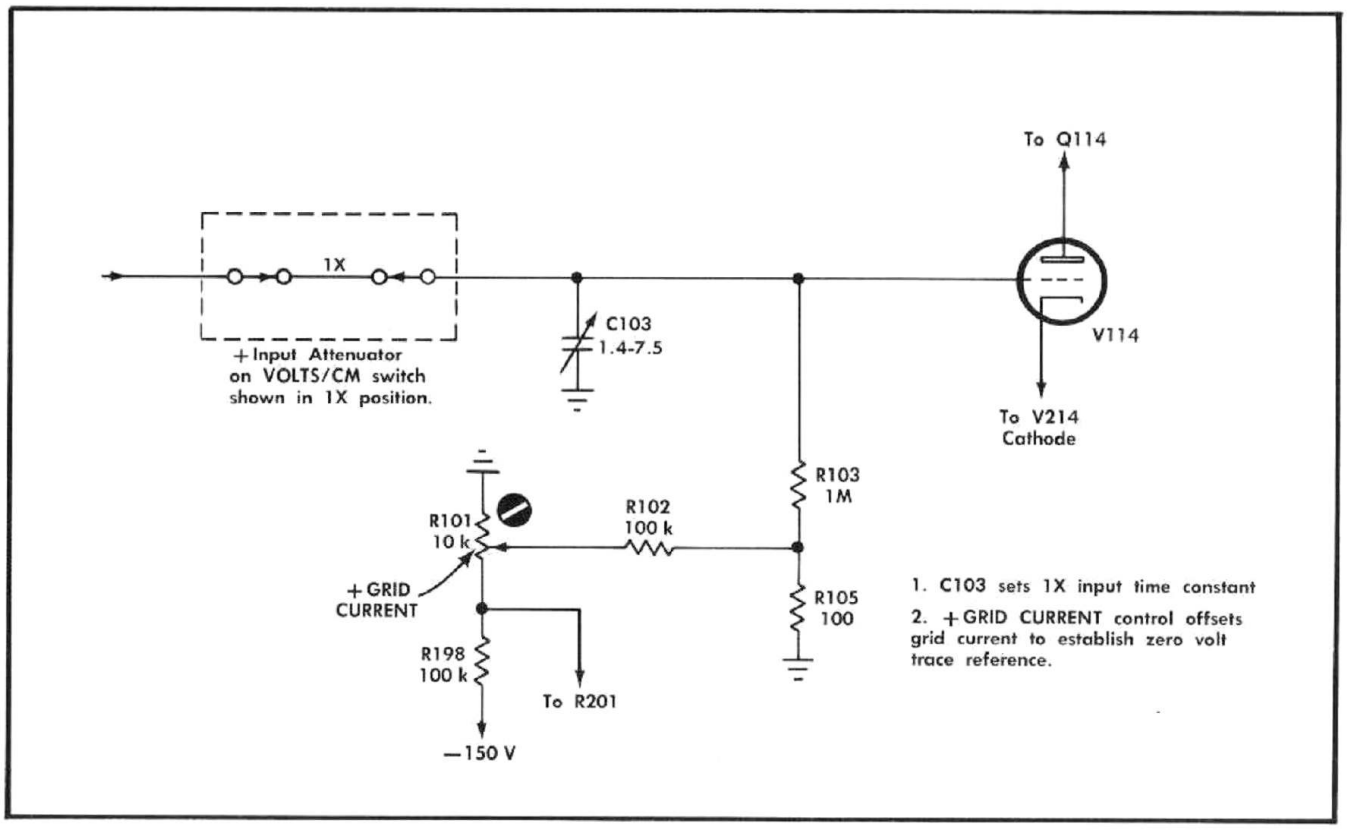


Fig. 3-2. Simplified grid circuit diagram of the + Input of the Input amplifier.

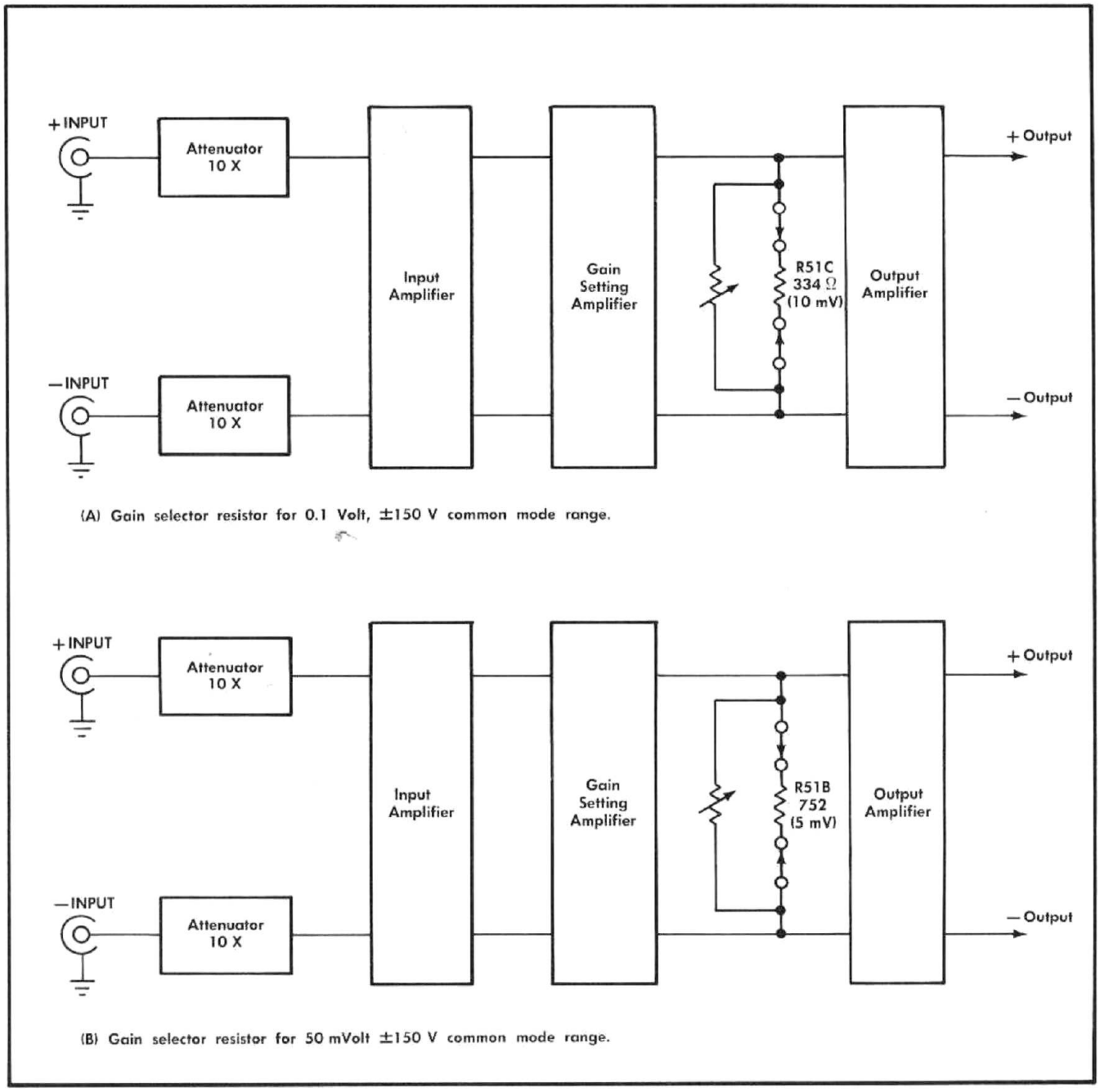


Fig. 3-3. In the ± 150 V common mode range the gain resistors may be selected to increase the gain by a factor of 2, 5 or 10 while the input attenuation remains constant.

When the VOLTS/CM selector knob is pulled out and turned to a more sensitive position, micro switch SW50 is switched from its normal position. The attenuator selector section of the VOLTS/CM switch remains in the respective 10× to 100× position and the CMRR is that of the normal attenuator position. See Fig. 3-3.

Input Amplifier

V114-Q114 and V214-Q214 are connected as a cascode paraphase or cascode differential amplifier, depending on the signal application to either one or both inputs. For true differential operation the dynamic, static and high frequency balance of the amplifier must be closely controlled. DC balance is obtained by adjusting R110 and Com Mode Bal R139.

R110 provides a differential adjustment of V114 and V214 filament voltage. This is set to equalize the tube plate currents (indirect function of cathode temperature) when the grid potentials are at zero volts. Zener diode D108 provides a regulated 12.6 volts DC for these filaments.

Com Mode Bal R139 and capacitor C136 provide differential adjustments to balance the dynamic plate impedance of the input tubes V114-V214. R139 provides DC and low frequency balance, and C136 provides the high frequency balance adjustment.

Transistor Q138 is a long-tailed (high impedance) constant current source which supplies the current for the input amplifier and a circuit that bootstraps the plate voltage of V114-V214. These features effectively minimize changes in the tube parameters as the common-mode input signal range shifts above and below an average reference.

An approximate 10 mA of source current from Q138 divides as follows: 6 mA divides to furnish a constant 3 mA per side to the input amplifier V114-V214. The fixed bias on Q128 sets a constant 2 mA through R129 to establish a fixed voltage drop across the resistor and the remaining 2 mA is absorbed by Q123. See Fig. 3-4.

Gain of the input amplifier is very stable because the constant current stabilizes the operating point on the characteristic curve of the input tube. Changes of common-mode signal at the input grids will have little effect on the CMRR of the amplifier. A positive-going shift in the average value of the common-mode signal reflects a positive shift at the common cathode point of V114-V214, and through R129 to the base of Q123. This positive voltage shift is applied to the base of Q114-Q214 by the emitter follower action of Q123 and bootstraps the plate voltage of V114-V214 to maintain a constant plate to cathode voltage (E_p). Therefore, there is no effective change in the tube parameters and current division between the tubes remains constant.

Common mode signal amplitudes (signals of equal amplitude and phase) up to ±15 volts peak at the grids produce essentially no change in the cathode current division. Input signal amplitudes in excess of ±15 volts will overdrive and unbalance the amplifier so it will no longer function as a differential amplifier. Common mode signals in excess of ±15 volts may drive the trace off screen and beyond the control of the front panel adjustments; however, at some further positive input voltage level the input amplifier saturates, the trace returns on screen and positions normally and operation appears normal. In this case, the gain will be zero. At an input signal level of approximately +50 volts the neon INPUT OVERLOAD indicator will light to indicate to the operator that an application error has been made and steps must be taken to correct the overload condition.

C140 provides a differential adjustment to equalize the load time constant of Q114-Q214 collectors and is set for optimum common mode rejection through the input amplifier as the input signal frequency is increased.

C112 and C212 provide cross neutralization of the tube inter-electrode capacitance of V114-V214. Diodes D115 and D215 limit V114-V214 grid current during the tube warmup time.

Approximately —30 volts is applied through R130 to the input amplifier chassis from the voltage divider R131-R132. Application of this negative voltage to the case of the Type 8393 tubes reduces spurious electron bombardment to the tube case.

Gain Setting Stage

Signal outputs at the collectors of Q114-Q214 are DC coupled to the base of an emitter coupled amplifier Q144A and B. Gain of the stage is determined by the emitter-to-emitter resistance of Q144 and the collector load for Q164. VARIABLE control R150, between the coupled emitters provides a gain adjustment for the amplifier.

The collector load impedance for the stage consists of the low impedance of the grounded base amplifier Q164 in parallel with R144-R244, so most of the emitter signal current of Q144A-Q144B is the collector current for Q164 and the gain becomes a function of the ratios of Q144 emitter resistance to Q164 collector resistance. The collector load impedance for Q164 is determined by R164-R264 in parallel with half of the selected gain resistors. R178 (1 mV gain adjustment) calibrates the 1 mVolt position of the VOLTS/CM selector SW40.

Step Atten Bal R155-R255 is a dual-type potentiometer with about 60° of backlash that provides both a coarse (10 kΩ) and fine (2 kΩ) adjustment. It provides a differential control of the current required to compensate and balance any DC voltage difference between the collectors of Q164A and B. When properly adjusted the voltage across the gain resistors is near zero, and DC shift on the base of Q184-Q284, as the VOLTS/CM selector is switched, is very slight.

VAR BAL is a dual potentiometer front panel control to allow the operator to seek coarse adjustment and then make a fine (backlash portion) adjustment to balance Q144 emitter-to-emitter voltages, plus compensation for unbalance due to tube aging in the input amplifier. This control supplements R110 (filament DC balance adjustment) which is an internal adjustment made when the instrument is calibrated.

Q168 sets the voltage at the collectors of Q164, the common base stage. Any fluctuations in DC current through R144-R244 which may be caused by changes in +225 volt supply, resistance values, or transistor parameters, is compensated by the addition or removal of collector current from Q168.

The emitter of Q168 is referenced to about 85 volts by a 15 V zener diode, D168. This sets the voltage on the collectors of Q164 near +82 volts.

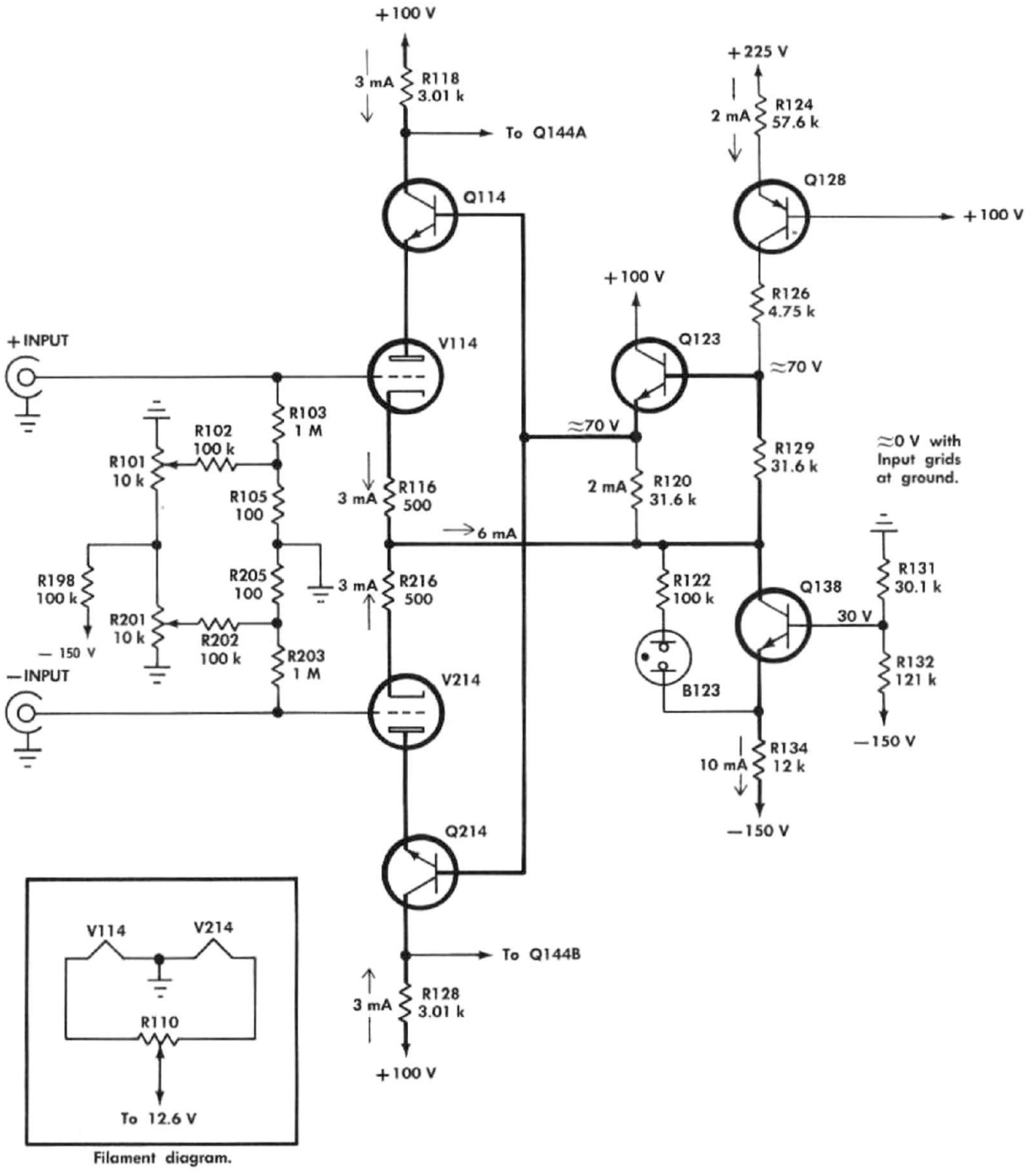
Since Q144 is a dual transistor, temperature variations of one side are transmitted to the other, so that both sides (Q144A and B) maintain thermal balance. This, with the RC thermal compensating network, R146-C146 and R246-C246, in the collector load, maintain the required thermal stability and balance for the stage.

The use of a dual transistor Q164 for the grounded base amplifier assures the required beta balance for the stage.

Output Amplifier

The amplifier output stage consists of two common emitter current amplifiers Q184-Q284 in cascode with push-pull operational amplifiers Q194-Q294.

DC output voltage level is established across R190-R290 and is a function of the ratio R180 to R190 (R280 to R290) rather than any other parameter. Positioning is determined by differential adjustment of the current to the bases of Q194-Q294 and is provided by POSITION control R184.



Filament diagram.

Fig. 3-4. Simplified (partial) diagram of the input amplifier stage with approximate current and voltage values. Heavy lines show path of bootstrap circuit.

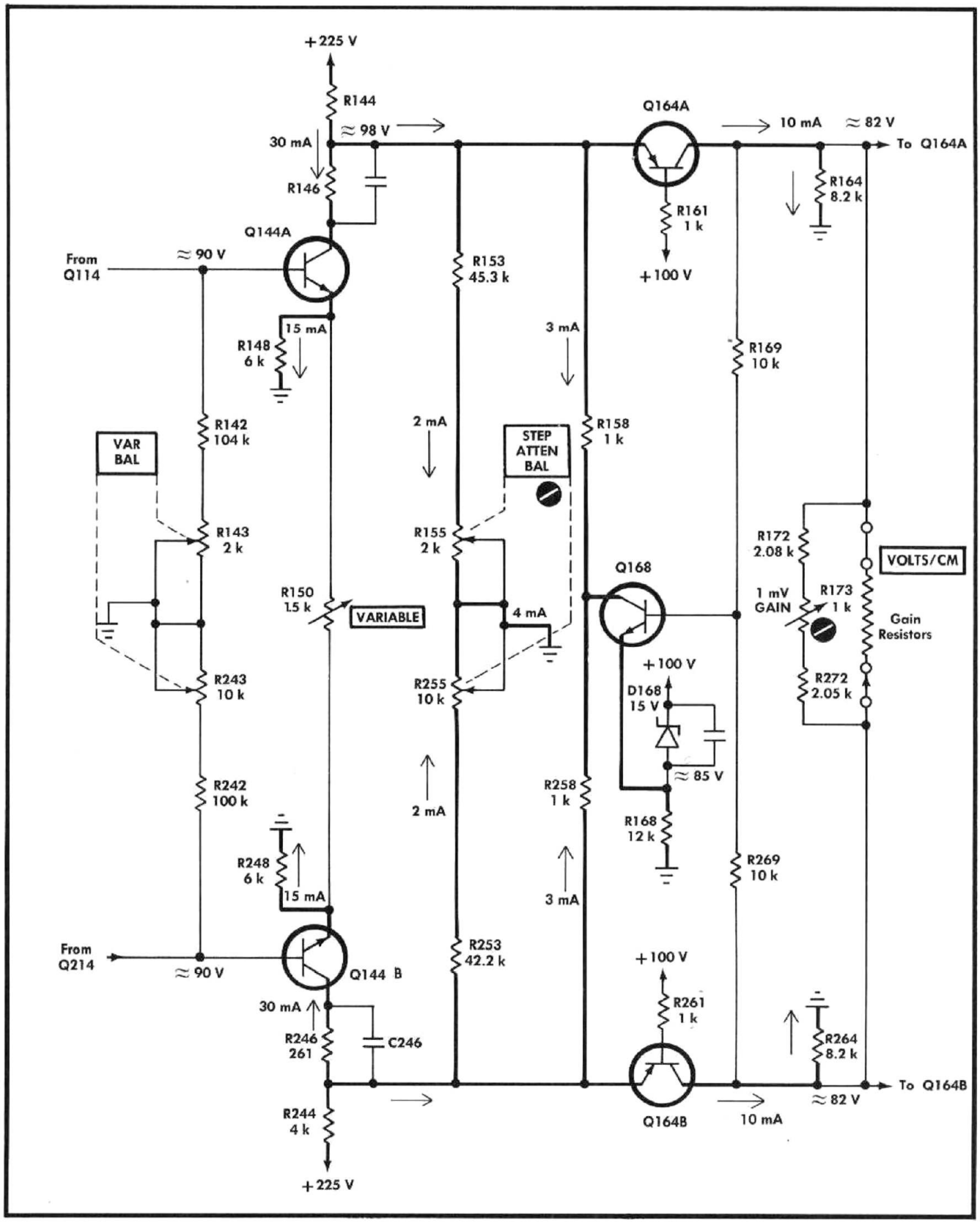


Fig. 3-5. Simplified drawing of the gain set amplifier, showing DC current and voltage levels. (All values are approximate.)

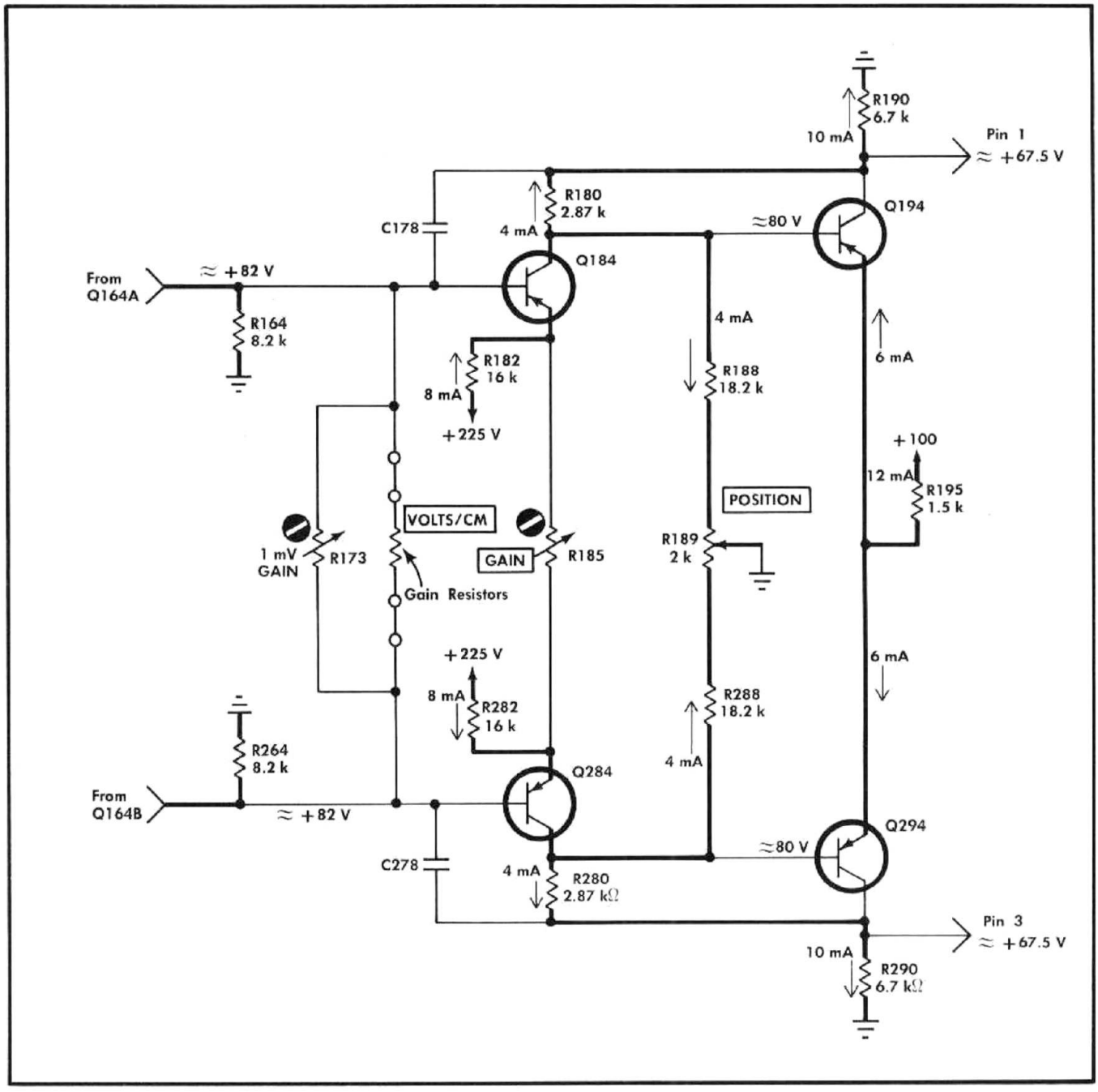


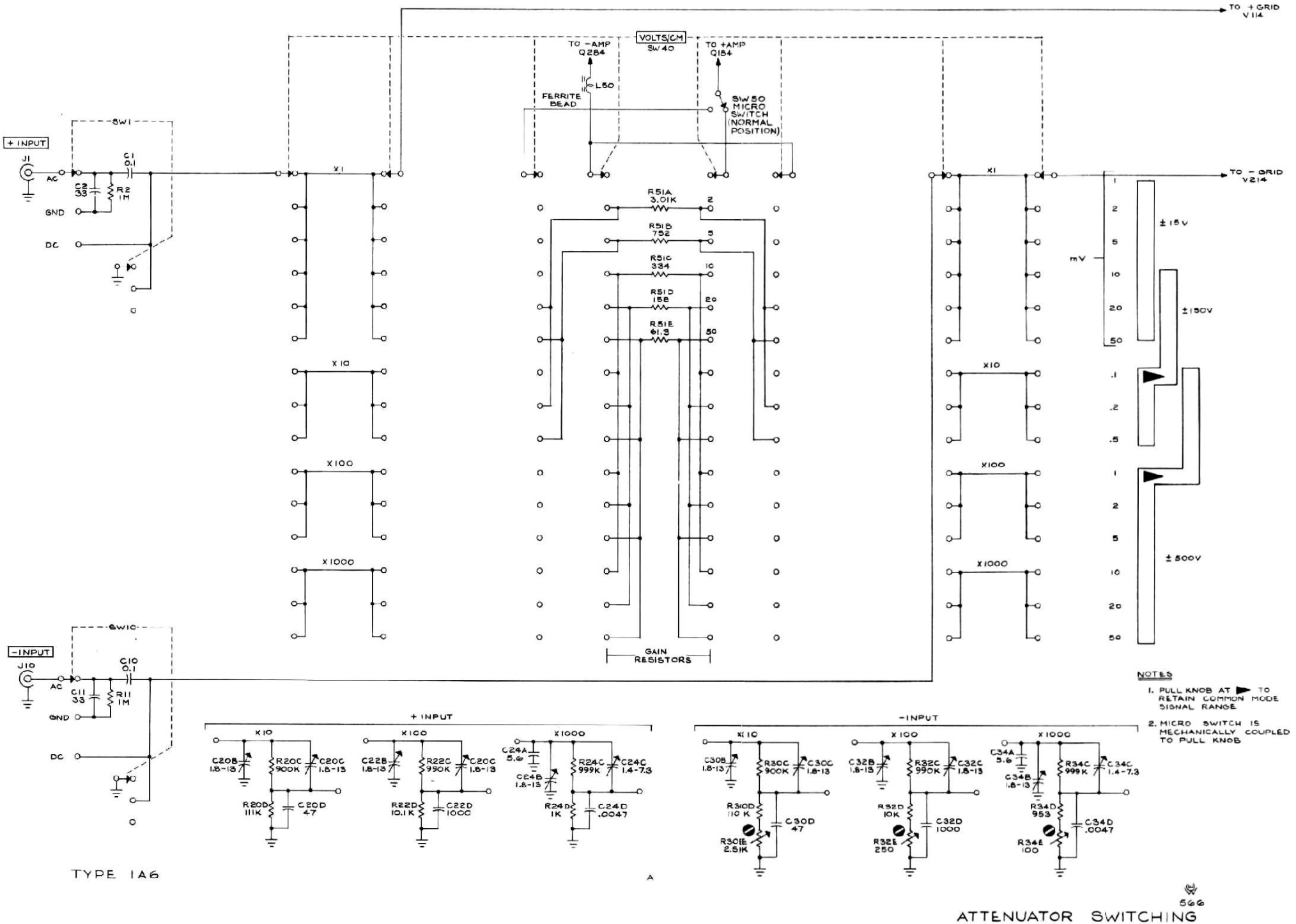
Fig. 3-6. Simplified drawing of the Output amplifier showing DC current and voltage levels. (All values are approximate.)

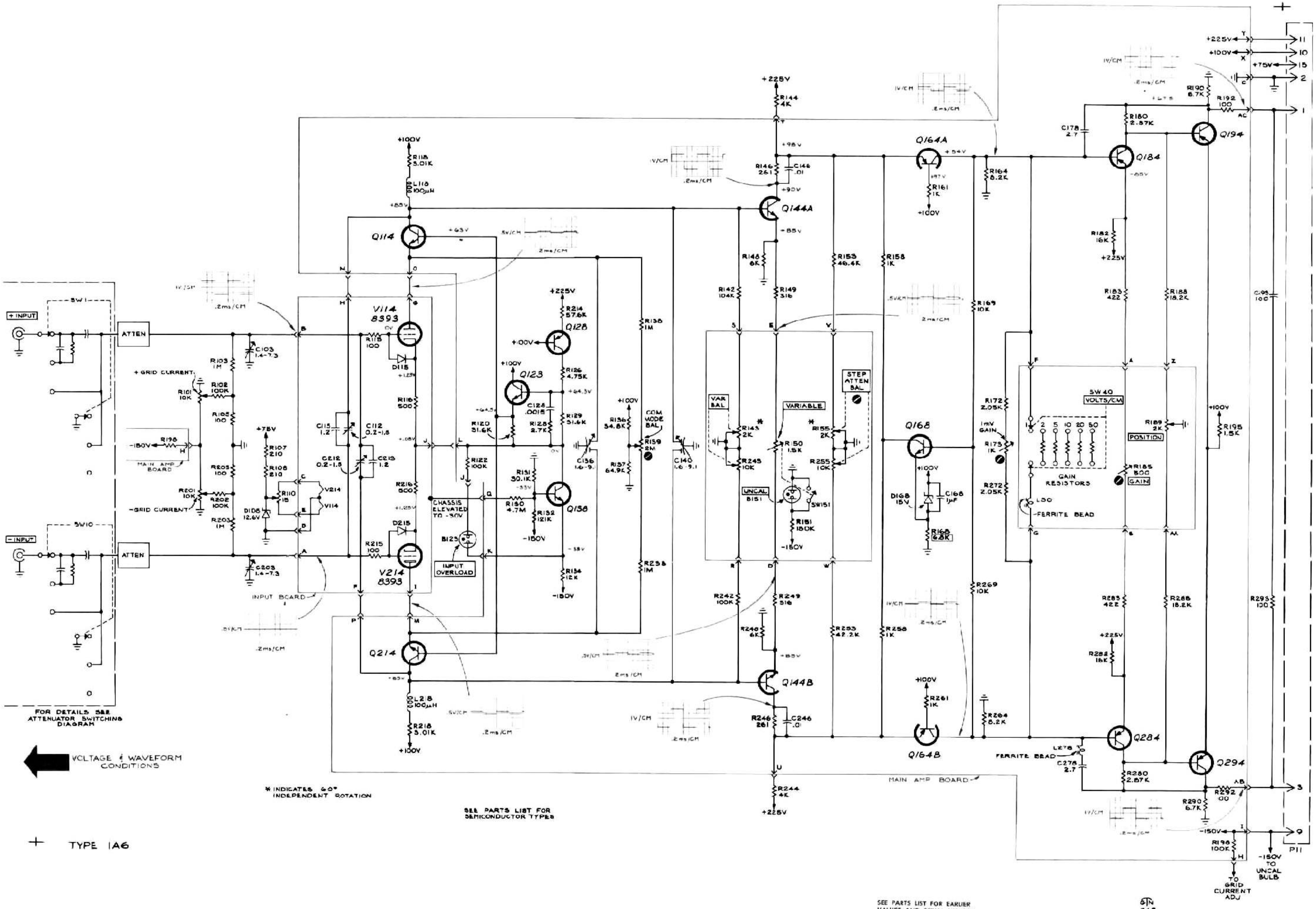
The fixed DC collector voltage of Q164 (about 82 V) is applied to the base of Q184 and establishes a constant DC emitter current of about 8 mA through Q184. Approximately 4 mA of this current is supplied through R188 as part of the collector current with the remaining 4 mA supplied through the feedback resistor R180. Collector current of Q194 is about 6 mA and adds to the 4 mA through R180 to provide approximately 10 mA DC current through R190 which sets the output DC voltage level of 67.5 volts. See Fig. 3-6.

AC signal currents on the base of Q184 are amplified and drive the common emitter operational amplifier Q194-Q294. This provides a balanced push-pull output to the main-frame oscilloscope amplifier.

Gain for the stage is determined by the emitter-to-emitter resistance between Q184 and Q284 and is set by adjusting the Gain control R185.

Bandwidth of the amplifier is primarily determined by the collector load of the grounded base stage and the RCL network in the collector of the input stage Q144-Q214. The amplifier bandwidth remains essentially constant throughout the sensitivity range. In the higher sensitivity positions of the VOLTS/CM selector, positive feedback through capacitors C178-C278 will boost the bandwidth of the stage so the output level is proportionate to the 50 mVOLT position.


TO +GRID V114
TO -GRID V214
VOLTS/CM SW40
TO -AMP Q284
TO +AMP Q184
FERRITE BEAD
L50
SW50 MICRO SWITCH (NORMAL POSITION)
+INPUT
-INPUT
J1
J10
SW1
SW10
C1 0.1
C10 0.1
C2 33
C11 33
R2 1M
R11 1M
AC
GND
DC
X1
X10
X100
X1000
R51A 3.01K
R51B 752
R51C 334
R51D 158
R51E 61.3
GAIN RESISTORS
mV
1
2
5
10
20
50
.1
.2
.5
1
2
5
10
20
50
±15V
±150V
±500V
NOTES
1. PULL KNOB AT ▶ TO RETAIN COMMON MODE SIGNAL RANGE
2. MICRO SWITCH IS MECHANICALLY COUPLED TO PULL KNOB
+INPUT
X10
C20B 1.8-13
R20C 900K
C20C 1.8-13
R20D 111K
C20D 47
X100
C22B 1.8-13
R22C 990K
C20C 1.8-13
R22D 10.1K
C22D 1000
X1000
C24A 5.6
C24B 1.8-13
R24C 999K
C24C 1.4-7.3
R24D 1K
C24D .0047
-INPUT
X10
C30B 1.8-13
R30C 900K
C30C 1.8-13
R30D 110K
R30E 2.51K
C30D 47
X100
C32B 1.8-13
R32C 990K
C32C 1.8-13
R32D 10K
R32E 250
C32D 1000
X1000
C34A 3.6
C34B 1.8-13
R34C 999K
C34C 1.4-7.3
R34D 953
R34E 100
C34D .0047
TYPE 1A6
A
566
ATTENUATOR SWITCHING



+INPUT
-INPUT
ATTEN
SW1
SW10
+GRID CURRENT
-GRID CURRENT
MAIN AMP BOARD
INPUT BOARD
FOR DETAILS SEE ATTENUATOR SWITCHING DIAGRAM
VOLTAGE & WAVEFORM CONDITIONS
* INDICATES 60° INDEPENDENT ROTATION
SEE PARTS LIST FOR SEMICONDUCTOR TYPES
V114 8393
V214 8393
Q114
Q214
Q123
Q128
Q138
Q144A
Q144B
Q164A
Q164B
Q168
Q184
Q194
Q284
Q294
CHASSIS ELEVATED TO -30V
INPUT OVERLOAD
COM MODE BAL
VAR BAL
VARIABLE
STEP ATTEN BAL
UNCAL
SW151
SW40 VOLTS/CM
GAIN RESISTORS
POSITION
GAIN
FERRITE BEAD
P11
TO GRID CURRENT ADJ
-150V TO UNCAL BULB

TYPE 1A6

B

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

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VERTICAL AMPLIFIER

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. If it does not, your manual is correct as printed.

TYPE 1A6 TENT SN 890

ELECTRICAL PARTS LIST CORRECTION

CHANGE TO:

V114 V214	157-0126-00	8393	Checked pair

TYPE 1A6

ELECTRICAL PARTS LIST CORRECTION

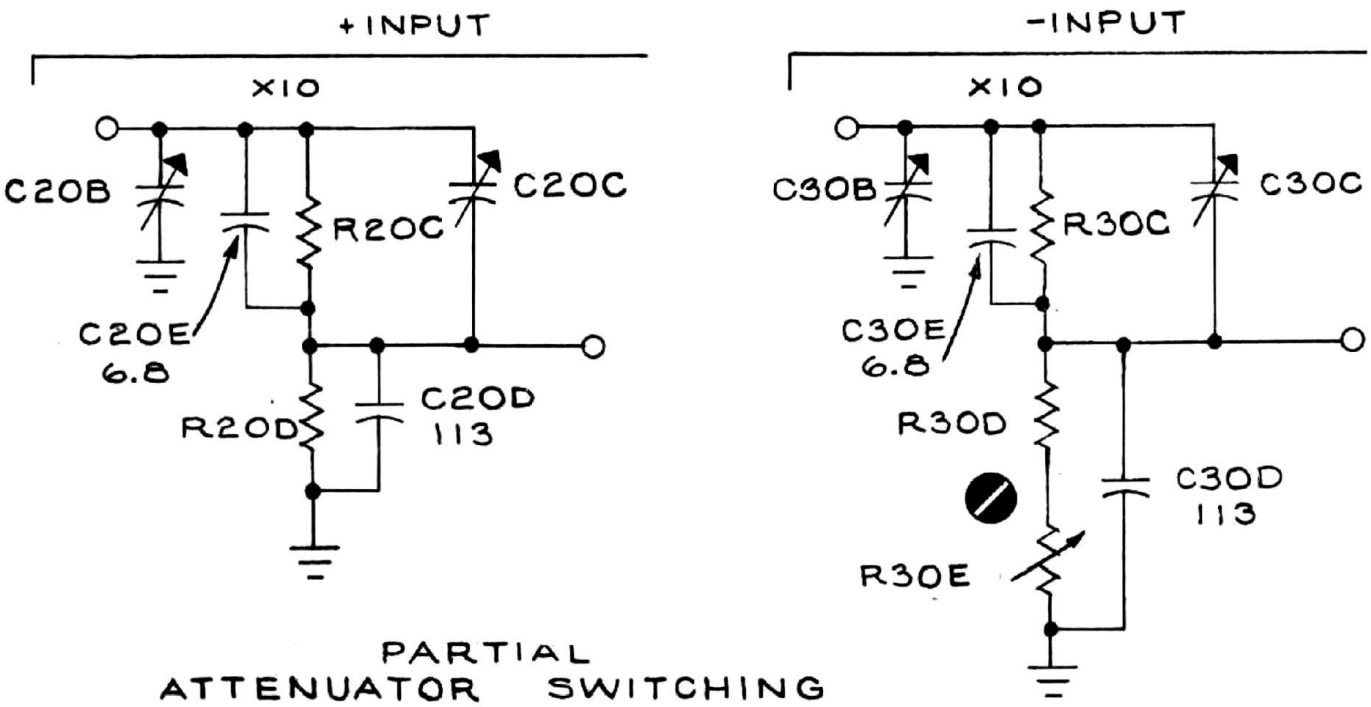
CHANGE TO:

C20D	283-0603-00	113 pF	Mica	300 V	2%
C30D	283-0603-00	113 pF	Mica	300 V	2%
C193	281-0540-00	51 pF	Cer		±5%
SW40	262-0777-01	Rotary	VOLTS/CM		

ADD:

C20E	281-0616-00	6.8 pF	Cer	200 V
C30E	281-0616-00	6.8 pF	Cer	200 V

SCHEMATIC CORRECTION



PARTIAL
ATTENUATOR SWITCHING

M14,025/568

TYPE 1A6 TENT SN 850

ELECTRICAL PARTS LIST CORRECTION

CHANGE TO:

R120	322-0336-00	30.9 kΩ	1/4 W	M. F.	1%
R124	323-0364-00	60.4 kΩ	1/2 W	M. F.	1%
R126	322-0270-00	6.34 kΩ	1/4 W	M. F.	1%
R129	322-0336-00	30.9 kΩ	1/4 W	M. F.	1%