INSTRUCTION MANUAL

Serial Number 333

Type 4S2

Plug-in Unit

Tektronix, Inc.
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Tektronix International A.G.
Terrassenweg 1A ● Zug, Switzerland ● PH. 042-49192 ● Cable: Tekintag, Zug Switzerland ● Telex 53.574

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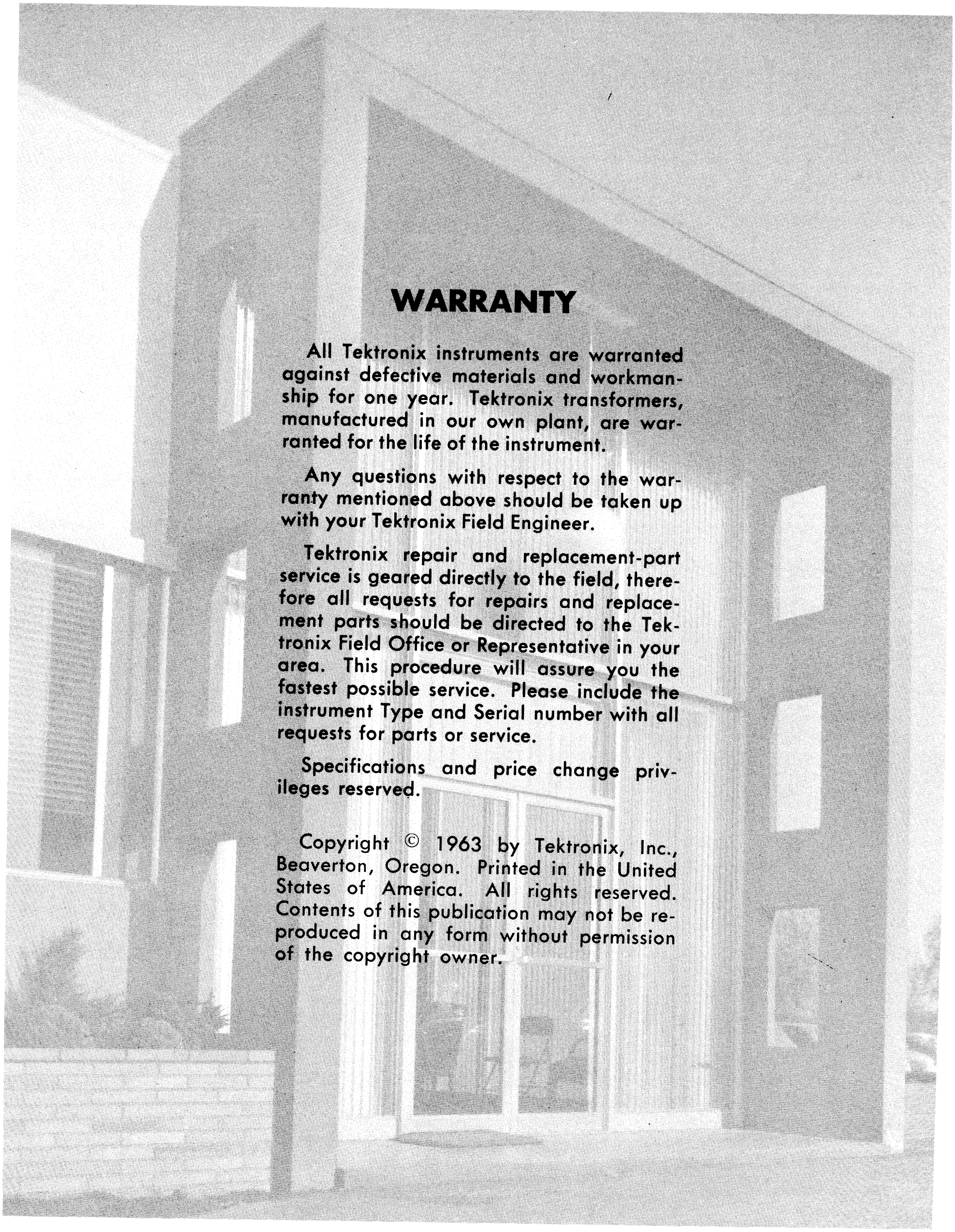


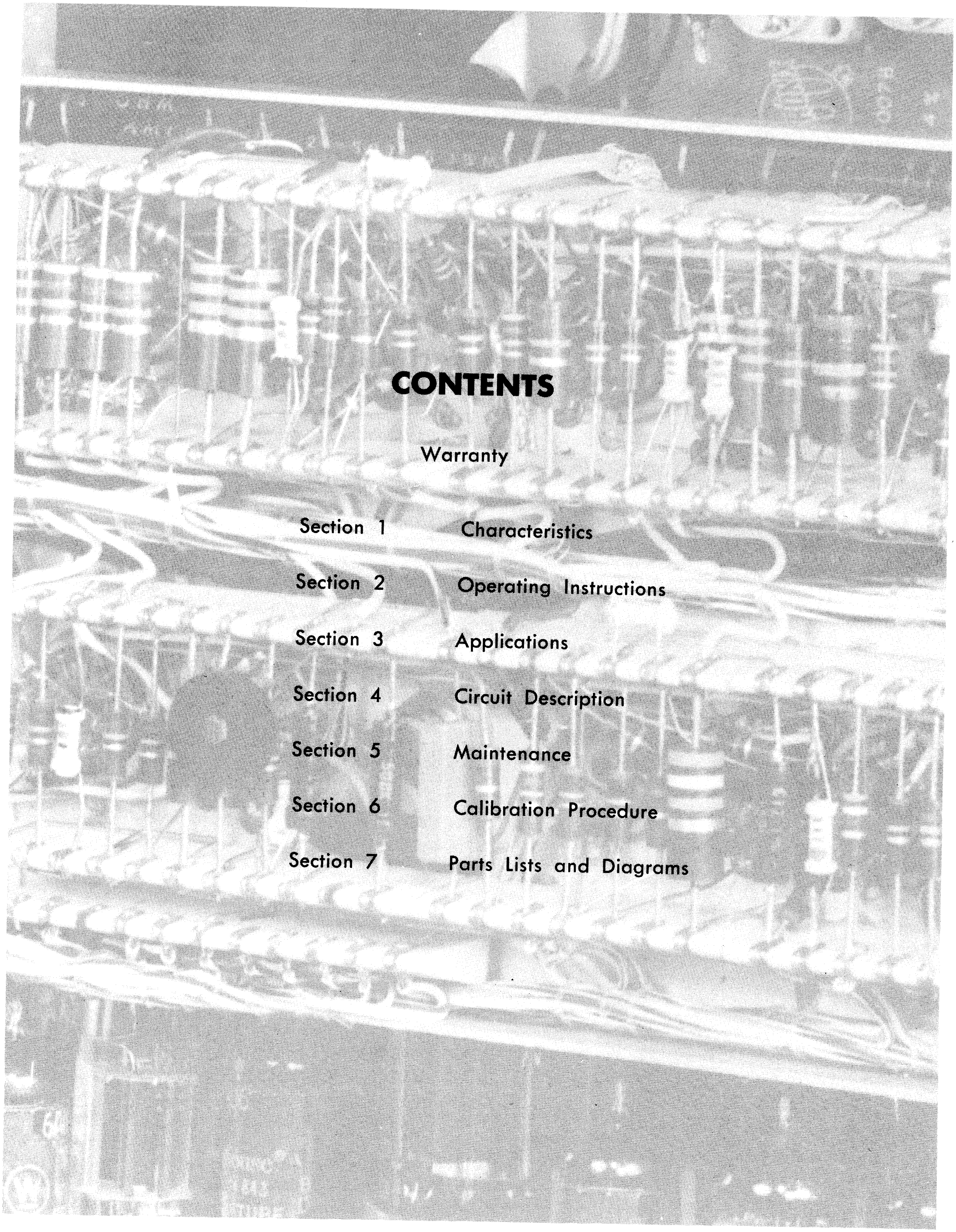
WARRANTY

All Tektronix instruments are warranted against defective materials and workmanship for one year. Tektronix transformers, manufactured in our own plant, are warranted for the life of the instrument.

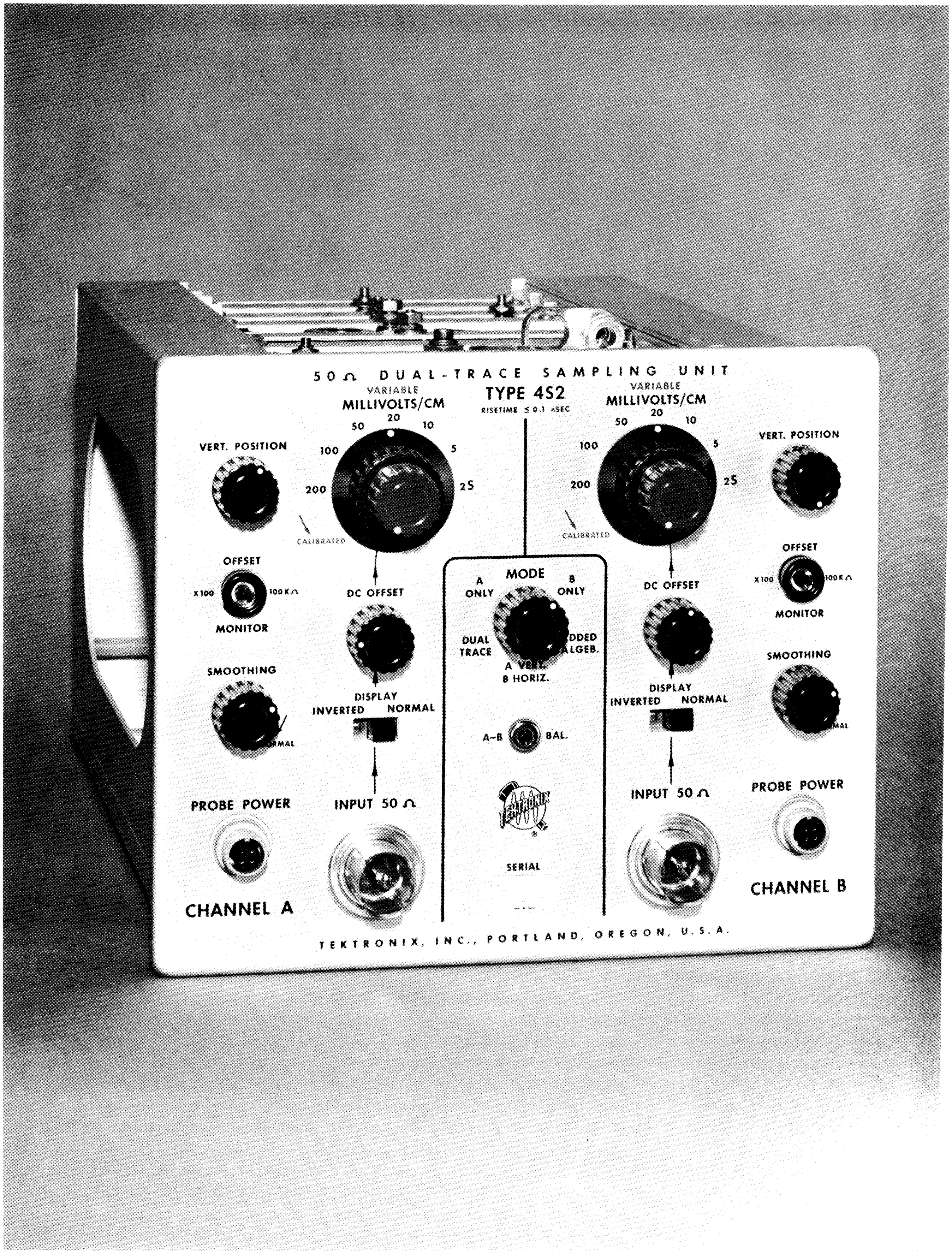
Any questions with respect to the warranty mentioned above should be taken up with your Tektronix Field Engineer.

Tektronix repair and replacement-part service is geared directly to the field, therefore all requests for repairs and replacement parts should be directed to the Tektronix Field Office or Representative in your area. This procedure will assure you the fastest possible service. Please include the instrument Type and Serial number with all requests for parts or service.

Specifications and price change privileges reserved.



CONTENTS


50 Ω DUAL-TRACE SAMPLING UNIT
TYPE 4S2
RISETIME ≤ 0.1 nSEC
VARIABLE
MILLIVOLTS/CM
CALIBRATED
VERT. POSITION
OFFSET
X100
100K Ω
MONITOR
DC OFFSET
SMOOTHING
DISPLAY
INVERTED
NORMAL
MODE
A ONLY
B ONLY
DUAL TRACE
A VERT. B HORIZ.
A–B
BAL.
SERIAL
PROBE POWER
INPUT 50 Ω
CHANNEL A
CHANNEL B
TEKTRONIX, INC., PORTLAND, OREGON, U.S.A.

SECTION 1
CHARACTERISTICS

General Information

The Tektronix Type 4S2 50Ω Dual-Trace Sampling Unit is a vertical channel plug-in unit for the Type 661 Oscilloscope. The Type 4S2 has a risetime of 0.1 nanosecond or less. It is capable of presenting accurate single- or dual-trace displays of repetitive high-speed signals with fractional nanosecond risetime. By taking successive samples of a repetitive signal, each sample at a slightly later time with respect to the previous sample, the system reconstructs the signal on a relatively long time base.

Characteristics

Input Impedance

50 ohms ±1%. Passive and cathode follower probes are available for higher input impedance at reduced sensitivity.

Risetime

0.1 nsec or less, measured between 10% and 90% amplitude points.

Deflection Factors

Calibrated steps of 2S, 2, 10, 20, 50, 100, and 200 mv/cm. Accuracies: DISPLAY switch at NORMAL, ±2.5%; at INVERTED, ±3%. 2 mv/cm is automatically smoothed 40% to 50%. SMOOTHING control still operates in addition to the fixed smoothing. An uncalibrated VARIABLE control with a 3:1 range permits decreasing the deflection factor of each setting of the MILLIVOLTS/CM switch setting. The 2S mv/cm factor can be decreased to about 2/3 mv/cm.

Dynamic Range

Input signals as high as +1 volt or —1 volt (not ±1-volt = 2 volts) may be viewed without overloading the system. Safe short-time overload, plus or minus 10 volts dc.

Noise

At deflection factor of 5 mv/cm, SMOOTHING control at NORMAL, MODE switch at A ONLY, B ONLY, or A VERT. B HORIZ: noise is not greater than 4 mv peak-to-peak. With MODE switch at DUAL TRACE or ADDED ALGEB: noise is not greater than 5 mv peak-to-peak. With SMOOTHING control fully counterclockwise; noise is typically less than 1.5 mv peak-to-peak.

Triggering

External to Timing Unit Only.

Operating Modes

A Only, B Only, Dual Trace, Added Algebraically, and A Vertical-B Horizontal (X-Y operation). The dual-trace switching frequency is approximately 50 kc.

Rejection ratio for Added Algebraic mode is 40:1 or better when each channel is driven with a 1-volt flat-top pulse and the deflection factor is 50 mv/cm, each channel. At 200 mv/cm, Added Algebraic Mode, a 4-cm identical signal in each channel will produce an 8-cm display, ±1.5 mm.

Display

Normal or Inverted, permitting the addition or subtraction of dual-trace displays. Valuable in X-Y displays for observation of hysterisis loops, or for inverting the phase of signals in or out of an amplifier for phase comparison. Inverted operation can add an additional 1% to 2% error to the deflection factors. With the Type 661 vertical signal outputs at zero, at 200 mv/cm, the trace will not shift more than 0.5 cm when switching the DISPLAY switch.

Smoothing

Each channel SMOOTHING control permits reduction of time jitter and random noise. Valuable when operating at lowest deflection factors. At 200 mv/cm, the trace will not move more than 1.5 cm while rotating the SMOOTHING control.

Dc Offset

The dc component of a signal may be offset up to ±1 volt (with a five-turn control) to either bring a display back onto the crt, or to make an incremental measurement.

Signal Outputs to Type 661

(The Type 661 signal output terminals are connected directly to the plug-in unit circuits through the interconnecting socket.) The signal output voltages are within 3% of a 1-volt signal applied to the input connectors when the deflection factor is 200 mv/cm. (Does not include crt display.) Output impedance is 10k, ±2%.

Dot Slash

The sampling dot vertical stability is such that no drift is visible when triggering at a rate above about 150 cps. At a triggering rate of 50 cps, the dot drift will not exceed 0.2 cm.

Co-Channel Time Coincidence

Dual-trace display of a fastrise pulse will produce no more than a 20-picosecond time difference between channels.

Probe Power

Two front panel connectors permit operation of Tektronix cathode-follower probes.

Mechanical

Aluminum-alloy chassis with six plug-in circuit boards. Photo-etched anodized panel.

Dimensions

Height 7 inches, width 8½ inches, depth 14 inches.

Weight

8 pounds.

NOTES

SECTION 2
OPERATING INSTRUCTIONS

CAUTION
ALWAYS TURN OFF THE OSCILLOSCOPE POWER BEFORE INSERTING OR REMOVING PLUG-IN UNITS.

General Information

The Type 4S2, when operated in a Type 661 Oscilloscope, is a dual-channel servo-type, slide-back sampling system. Each channel contains a sampling gate and rachet memory. The sampling principle is essentially that of an error signal device that corrects a memory output voltage each time a sample is taken. An external trigger pick-off or other source of triggering signal is required by the associated timing unit.

A minimum deflection factor of about 2/3 mv/cm may be employed to view low-level signals or portions of signals with a peak-to-peak value up to 1 volt. High resolution amplitude measurements may be made on any waveform, or any part of a waveform, through the use of the ±1-volt DC OFFSET control. A front-panel terminal permits voltmeter measurements of the offset voltage, at 100 times the internal ±1-volt maximum signal offset value.

At minimum deflection factors, random noise can be reduced by the use of the SMOOTHING control. Smoothing will not significantly affect the display risetime, but will reduce noise if each sample taken represents only a small increment of the total signal amplitude.

FUNCTIONS OF FRONT-PANEL CONTROLS AND CONNECTORS

MODE Switch—Selects one of five operational modes.

A ONLY: Only Channel A is displayed.

B ONLY: Only Channel B is displayed.

DUAL-TRACE: Both channels display separate signals simultaneously, switched between them at about 50 kc.

ADDED ALGEB: Both channels are combined to display the algebraic sum or difference of two signals as a single trace.

A VERT. B HORIZ.: With Type 661 SWEEP MAGNIFIER at X1, Channel A controls the vertical deflection and Channel B controls the horizontal deflection. Permits X-Y operation at full bandwidth.

VERT. POSITION Control (Both Channels) Permits moving the trace about 10 centimeters vertically.

MILLIVOLTS/CM Switch (Both Channels) Selects the desired vertical deflection factor. For example, with the MILLIVOLTS/CM switch at 100, each major division of vertical deflection corresponds to 100 millivolts of applied signal. Smoothing (about 50%) is automatically applied at 2S mv/cm.

VARIABLE Control (Both Channels)—Three-to-one range uncalibrated VARIABLE control makes possible a decreased deflection factor at each position of the MILLIVOLTS/CM switch. Minimum deflection factor is then about 2/3 millivolts/cm.

SMOOTHING Control (Both Channels)—A gain control in the servo amplifier that permits reduction of random noise.

Time and amplitude noise may be objectionable when operating at minimum deflection factors or maximum sweep rates. This is important when making documentation photographs. The SMOOTHING control reduces the loop gain of the automatic slideback feed-back system to allow random noise reduction. (See "Sampling Notes", Tektronix publication number 061-557, pages 5 and 6, for additional information about using the SMOOTHING control.)

To test for proper operation of the SMOOTHING control, change the timing unit SAMPLES/CM switch a factor of 2 or 2.5 and observe the amount of display change. If the change is insignificant, the SMOOTHING control is not substantially affecting the dot transient response.

DC OFFSET Control (Both Channels)—Applies an internal signal offset voltage of −1 to +1 volt. May be used to effectively cancel a dc component in the presence of a small ac signal. Permits a chosen portion of the waveform to remain relatively fixed on the crt when the vertical deflection factor is changed. By monitoring the voltage at the OFFSET MONITOR jack, highly accurate display voltage-difference measurements can be made. See the procedure for using the DC OFFSET control on page 3-2.

OFFSET MONITOR Jack (Both Channels)—The voltage at this jack is 100 times the offset voltage applied to the vertical signal. Useful for making voltage-difference measurements of all or part of the displayed signal. By positioning a display with the DC OFFSET control, the difference between two voltage levels can be accurately measured.

DISPLAY Switch (Both Channels)—In the NORMAL position, the crt display has the same polarity as the applied signal, + up and − down. Placing one DISPLAY switch at + and the other at −, the MODE switch at ADDED ALGEB. permits the difference of two signals to be presented as a single trace.

INPUT 50Ω (Both Channels)— 50Ω GR Type 847 connector for applying the input signal. Each channel has its own 50Ω termination, sampling bridge, and feedback system.

PROBE POWER Jack (Both Channels)—The PROBE POWER jacks provide heater and plate power for Tektronix cathode-follower probes.

A-B BAL.—Screwdriver adjustment of the Channel A gain. (Channel B gain adjustment is internal.) The A-B BAL. control permits the gain of Channel A to be adjusted ±10% to equal the Channel B gain. Useful when making common mode and/or differential measurements.

Signal Outputs To The Type 661 Oscilloscope

The Type 4S2 has two auxiliary output signals (in addition to the regular vertical signals to the crt). The two outputs are connected internally to the Type 661 front panel and are available at the connectors labeled SIGNAL OUTPUTS, VERT. A and VERT. B, both at 200 mv/cm through 10k. External loading of the signal output leads will not disturb normal sampling operations or the crt display. The two auxiliary outputs are for use by external analog paper recorders or oscilloscope monitors.

PRELIMINARY INSTRUCTIONS

The caution at the beginning of this section and on the front panel of the Type 661 (TURN POWER OFF BEFORE INSERTING OR REMOVING PLUG-IN UNITS) must be observed.

Since the Type 4S2 50Ω Dual-Trace Sampling Unit is part of a complete sampling system, we suggest that you read the operating instructions section of the Type 661 Oscilloscope and the Timing Unit Instruction Manuals before proceeding.

Installing the Type 4S2

With the Type 661 power off, begin plug-in insertion by placing the gray locking latch perpendicular to the oscilloscope front panel, then push the Type 4S2 as far into the cell as possible. Move the locking latch flush to the panel to complete the plug-in insertion, locking it in place.

To remove the plug-in, first turn off the power, then move the gray locking latch perpendicular to the front panel and withdraw the unit.

Connecting a Signal

The Type 4S2 is designed with 50-ohm transmission line input circuits. This permits extending the input terminals a reasonable distance while maintaining the same input characteristics. A 50-ohm signal source can drive a 50-ohm cable directly from a distance of several feet. Avoid using long cable lengths to minimize high frequency losses.

If it is necessary to use other than 50-ohm cables, suitable matching devices should be used to couple between the cables or inputs that have different characteristic impedances. The signal to be displayed may be connected to either INPUT 50Ω connector. Both are GR Type 874 50-ohm connectors and should be mated to a 50-ohm cable with the same type connector.

Another factor that may be important is the signal velocity of propagation within coax cables. This is especially important when making time-difference measurements between two signals in dual-trace or X-Y operation. In such cases, the signals should travel through cables of identical time delay in order to preserve their time relationships.

Special Tektronix signal probes are available that permit relatively high impedance measurements of nanosecond signals. Two forms are available for use with the Type 4S2: two moderate resistance passive probes, and a 10-megohm (at dc) cathode-follower probe. A brief description follows.

Passive Probes

Two Tektronix passive probes designed for use with the Type 4S2 are the P6034 10X Probe and the P6035 100X Probe. Both are small, permitting measurements in miniaturized circuitry.

The P6034 10X Probe places 500 ohms and less than 0.8 pf in parallel with the signal source. The 500 ohms drops to about 300 ohms and the capacitive reactance drops to about 450 ohms at 1000 mc. Probe risetime is less than 100 picoseconds, 10% to 90%.

The P6035 100X Probe places 5000 ohms and less than 0.7 pf in parallel with the signal source. The 5000 ohms drops to about 2000 ohms and the capacitive reactance drops to about 450 ohms at 1000 mc. Probe risetime is less than 200 picoseconds, 10% to 90%.

Both probes can withstand momentary voltage peaks to 500 volts. The 500-volt rating is not always available because of a high-frequency power restriction. The power rating for both probes is 0.5 watts up to 500 mc. Voltage derating is required at higher frequencies for both probes. Dynamic characteristics and curves are presented in the probe instruction manuals.

Cathode Follower Probe

The Tektronix P6032 Cathode-follower Probe is a high-impedance, high-frequency probe for Tektronix sampling systems. It is equipped with seven plug-on attenuators that provide attenuation ratios of 10X to 1000X. The probe must be operated with an attenuator, and the attenuation ratios are that of both the attenuator and probe combined. The P6032 Probe has a risetime of less than 0.4 nanosecond, and a basic 3-db upper frequency response of 850 mc for all attenuator heads. Input resistance is 10 megohms at dc, dropping to about 100 ohms for the 10X head and about 2000 ohms for the 1000X head at 1000 mc. The attenuator parallel capacitance ranges from 1.3 to 3.6 pf, depending on the particular attenuator, and the capacitive reactance drops to about 100 ohms at 1000 mc.

The advantage of the cathode-follower probe is the high input resistance and low capacitive loading at moderate frequencies. Dynamic characteristics and curves are included in the P6032 instruction manual.

Other Signal Coupling Methods

A good method for coupling fractional nanosecond signals from within a circuit is to design the circuit with a permanent 50-ohm output terminal. When not testing (with a 50-ohm cable to the Type 4S2), a 50-ohm terminating resistor can be substituted for the test cable. If this is not possible, be sure the circuit is not heavily loaded by the signal probe. The probe should be equally responsive to all frequencies within the limits of the system. In constructing

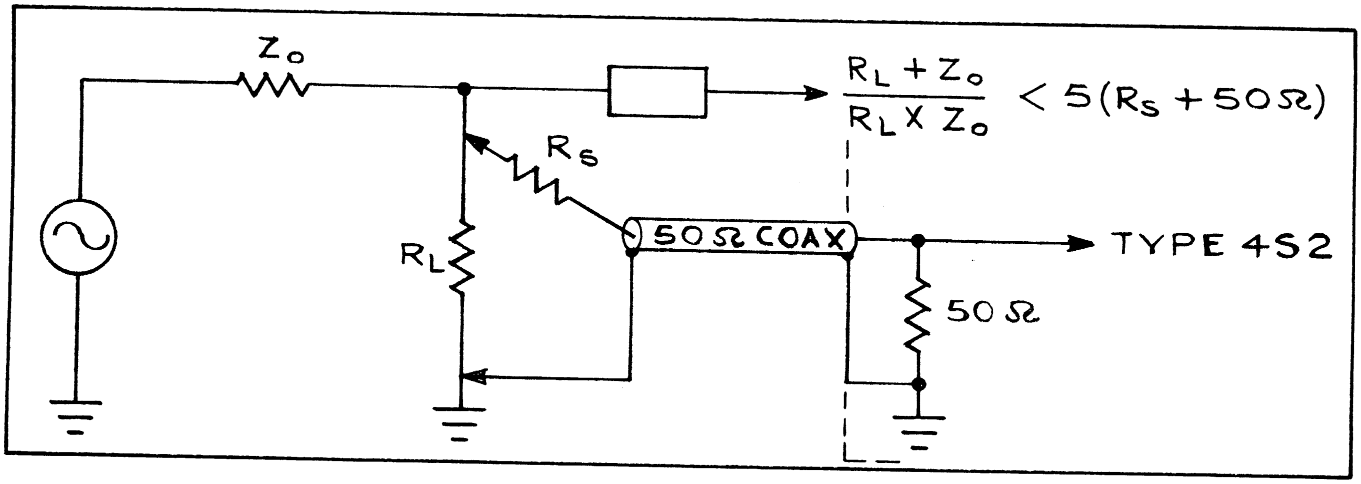


Fig. 2-1. Parallel probe method of signal coupling.

signal probes, it is advantageous to use ¼- or ⅛-watt resistors since their small size aids to obtain good high frequency response.

Figs. 2-1 and 2-2 show two coupling methods. In the parallel method (Fig. 2-1), a resistor (R_s) is connected in series with the 50Ω input cable to the Type 4S2. R_s + 50 ohms is then placed across the impedance in the circuit under test. A reasonable maximum circuit loading might be when the total resistance of R_s plus the 50-ohm input of the Type 4S2 is 5 times the impedance in the device (R_L in parallel with Z_O), requiring only 20% correction. The ground lead must be very short. The physical position of R_s will affect the fidelity of the coupling. This method usually requires use of an amplitude correction factor to the display.

In the series coupling method (Fig. 2-2), the 50-ohm input of the Type 4S2 replaces the impedance in the circuit under test. If the replaced impedance (shown as R_L) is more than 50 ohms, place a resistance in series with the cable input to the 4S2. The size of this resistance, plus 50 ohms, should equal the original impedance in the circuit. If R_L equals 50 ohms, you can simply substitute the cable to the Type 4S2 input with no additional series resistance. It is best to locate R_s in the original position of R_L and ground the coax where R_L was grounded. When not testing, a 50Ω resistor can replace the 50Ω cable.

A variation of the parallel method is the reverse terminated network shown in Fig. 2-3. This system is highly versatile and may be reasonably used across any impedance up to about 200 ohms. At higher source impedances, circuit loading will require more than 20% correction. The 0.01-μf capacitor in the probe network blocks any dc component and protects the resistors. Use of the 0.01 μf capacitor is optional.

The two 100Ω resistors (in Fig. 2-3), placed directly across the cable input, serve to reverse-terminate any small reflections due to imperfect connectors, cables, attenuators, etc. If signals of short duration are to be observed, the reflections may occur off the oscilloscope time-base (to the right) and will not be seen. Or if reflections of a few percent are unimportant, then the two resistors can be deleted with a two times increase in signal. In general, the two 100 Ω resistors are needed only when observing signals at high gain, and when a small reflection will distort the display.

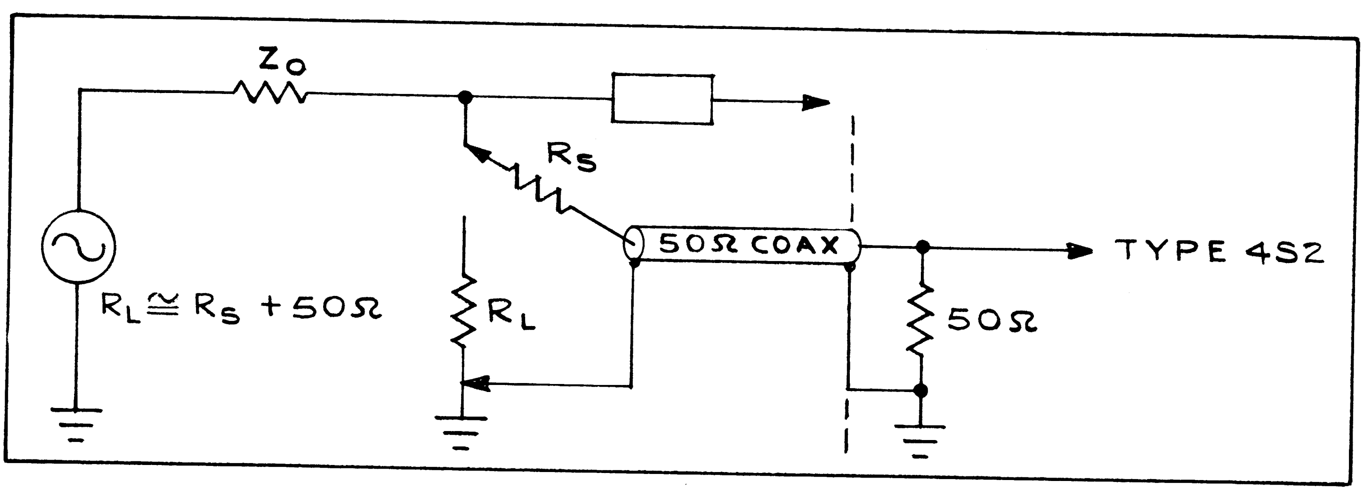


Fig. 2-2. Series probe method of signal coupling.

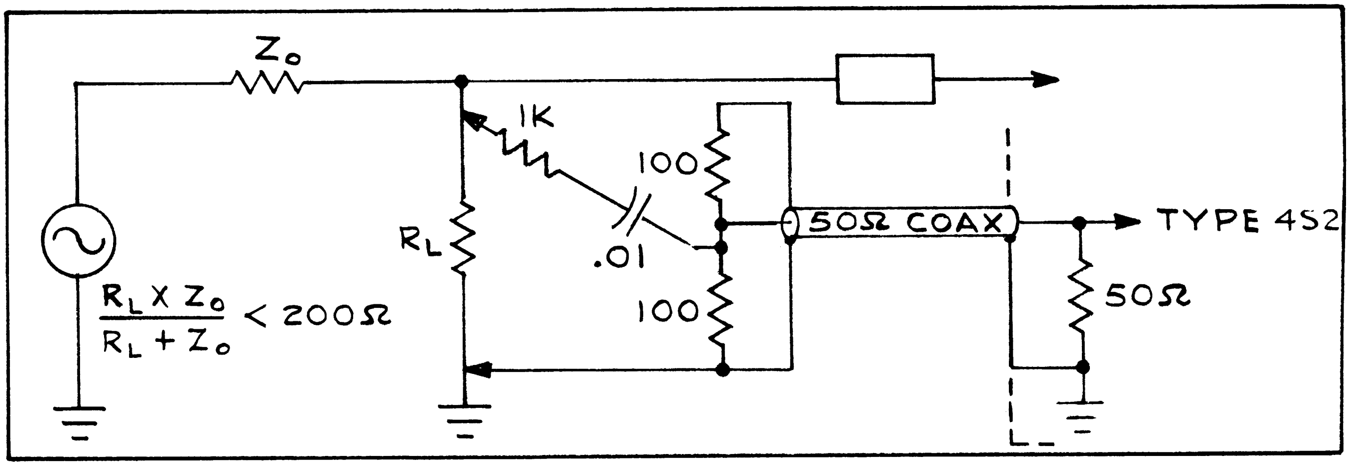


Fig. 2-3. Reverse terminated probe method of coupling a signal from within a circuit.

FIRST TIME OPERATION

The Type 4S2 is part of a complete sampling system. A first time operation procedure for the Type 661, Type 5T1, and Type 4S1 is included in the Type 661 instruction manual; it may be helpful if you read it before proceeding with this information.

The first time operation description to follow is written for dual-trace operation; it includes information that will also allow proper single channel operation.

Dual-Trace Operation

The dual-trace feature of the Type 4S2 permits viewing signals into and out of an amplifier or signals of differing amplitude and time delay; but not signals of differing repetition rate or frequency unless harmonically related or otherwise synchonously coupled. Connect the two signals, preferably with equal delay coax cables, so the display time difference will be that of the amplifier being tested (see Fig. 2-4). Use the following procedure for setting up the Type 4S2.

1. Set the MODE switch to DUAL TRACE.
2. Set the MILLIVOLTS/CM switches to the approximate values for 3 or 4 centimeters of display on each channel.
3. Adjust the SMOOTHING control as required to reduce random noise.
4. If the amplifier inverts the signal, you may wish to place one DISPLAY switch to NORMAL and the other DISPLAY switch to INVERTED.
5. If a signal has a dc component over 1 volt, be sure to ac couple it at the input. The rms input should not exceed 5 volts.

Triggering the Sampling System

The Type 4S2 has no internal trigger takeoff system. Therefore, an external trigger signal must be applied to the timing unit. Two basic forms of trigger signal source are: (a) an in-line trigger takeoff system, such as available in the Tektronix Type 110, or (b) an external trigger output signal from a pulse generator, such as found in the Tektronix Types 105, 107, or 111.

To complete the dual-trace operation, set the timing unit controls as follows (it is assumed you are using a Type 5T1):

1. Set the TRIGGERING SOURCE switch to EXT. and the POLARITY switch to the polarity of the triggering signal.
2. Select a sweep rate to display two or three cycles of the signals. If unknown, start at 10 nsec/cm.
3. Set the SAMPLES/CM switch to 50. This can be altered to suit your display as soon as step 6 is completed.
4. Set the TIME DELAY control to zero. It can be set later to bring the proper signals into view on the crt.
5. Set the RECOVERY TIME to MIN.
6. Set the THRESHOLD control to hold off the sweep (cw +, ccw —). Rotate the control toward zero to obtain proper triggering.
7. If triggering difficulties appear, establish whether the the trouble is due to: (a) insufficient or too much amplitude, (b) too high or too low a rate of change of trigger signal, or (c) interference due to recovery time. The cause can usually be found by operating the THRESHOLD, SWEEP TIME/CM, and RECOVERY TIME controls. Inability to hold off the sweep signifies too large a trigger signal; in this case use a coaxial input attenuator. If advancing the THRESHOLD control causes the sweep to free-run before obtaining a stable display, the triggering signal amplitude is too low.

   If confused triggering results, establish whether the problem is high repetition rate by means of the SWEEP TIME/CM control. If it is, then a trigger count-down circuit may be needed. For sine waves, the basic 5-mv, 2-nsec pulse rating requires at least 10 mv peak-to-peak below about 250 mc. External synchronizing operates to over 1000 mc; operating above 1500 mc may result in sweep distortion due to high-frequency feed-thru. If confused triggering results, and moving

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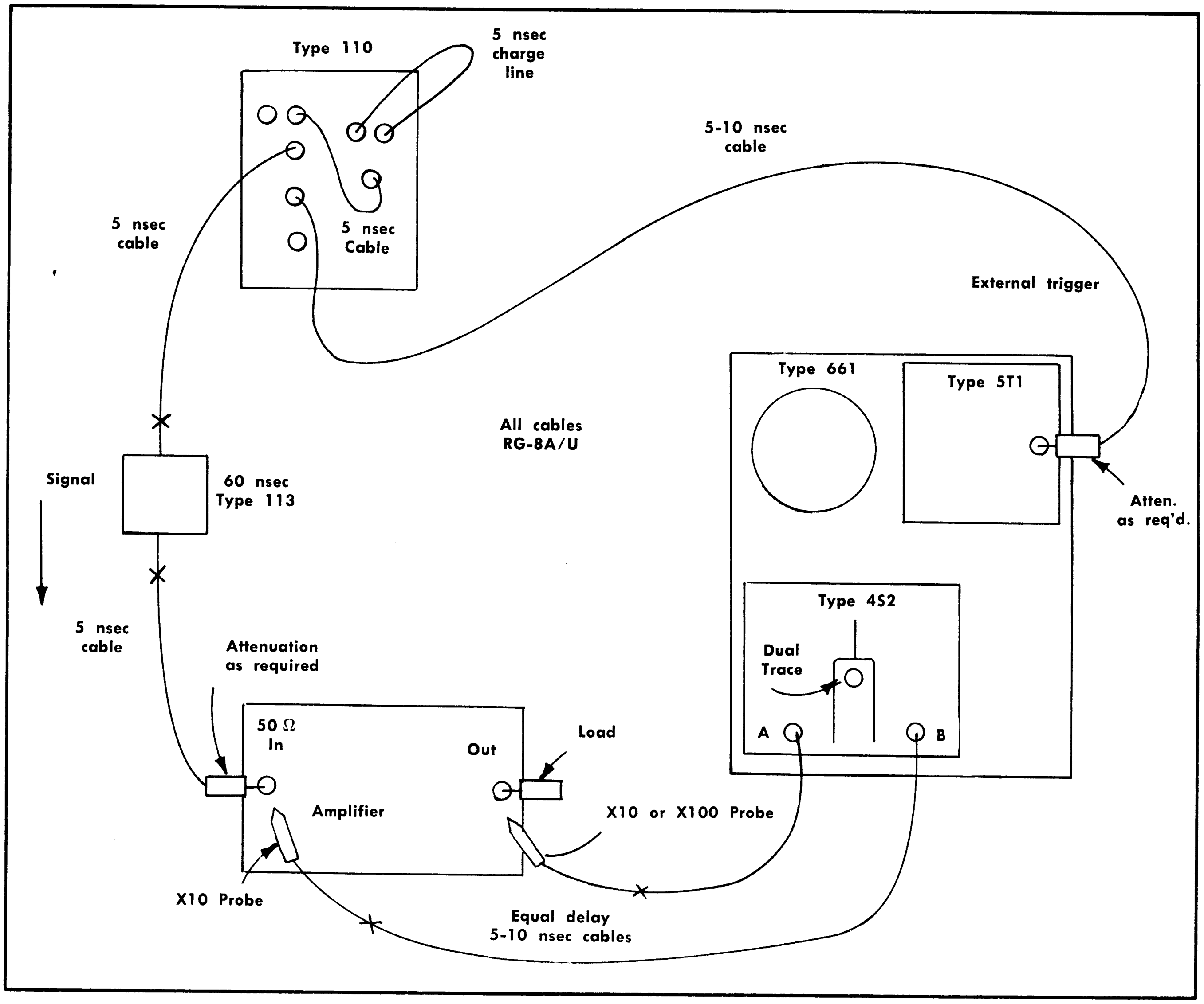

Fig. 2-4. Pulse testing an amplifier using Tektronix Types 4S2, 5T1, 661, 110, 113 and P6034 or P6035 Probes.

the SWEEP TIME/CM control establishes that the signal has a low rate of change (for example, sine waves below about 200 kc), then increase the triggering signal amplitude. If confused triggering results in the form of multiple traces, try operating the RECOVERY TIME control while varying the SWEEP TIME /CM switch. A combination of recovery time and sweep rate can be found which will produce a stable display except at low frequencies. The object is to time the signal with respect to the recovery of the trigger circuits to prevent premature retriggering. This is accomplished by having the signal interval of opposite polarity to that selected on the trigger POLARITY switch to provide supplementary hold-off.

If making time or voltage measurements directly from the crt it is usually advantageous to align the display with the appropriate vertical or horizontal graticule markings. The graticule can then serve as a scale from which to make either time or amplitude measurements.

With the aid of the DC OFFSET control, any point on a waveform within ±1 volt of ground can be made to stay relatively fixed on the crt independent of vertical sensitivity. The VERT. POSITION control will then place that portion of the waveform wherever desired within the vertical limits of the position control. Remember: The VERT. POSITION control is a ±5-cm control. The DC OFFSET is an input ±1-volt control.

NOTES

SECTION 3
APPLICATIONS

Voltage Measurements

Vertical displacement of the crt trace is directly proportional to the voltage at the Type 4S2 INPUT 50Ω connector. The amount of displacement, for a given voltage, can be selected with the MILLIVOLTS/CM switch. To provide sufficient deflection for best resolution, set the MILLIVOLTS/CM switch so the display spans a large portion of the graticule. Also, when measuring between points on a display, measure consistently from either the bottom or top of the trace so as not to include the width of the trace in your measurements.

To make a voltage-difference measurement between two points on a display, proceed as follows:

1. Using the graticule as a scale, note the vertical deflection, in divisions, between the two points on the display. Make sure the VARIABLE control is in the CALIBRATED position.

2. Multiply the divisions of vertical deflection by the numerical setting of the MILLIVOLTS/CM switch and the attenuation factor (if any) of an attenuator or probe. The product is the voltage difference between the two points measured.

As an example, Fig. 3-1 shows 2.4 divisions of deflection between two points on the display. With the MILLIVOLTS /CM switch set at 50, multiply 50 by 2.4 (the amount of deflection) for a product of 120 millivolts. This is the voltage at the INPUT connector of the 4S2. Now assume there is a 10X attenuator in the cable between the INPUT connector and the signal. To determine the signal voltage at its source, multiply 120 millivolts (the voltage at the INPUT connector) by 10 (the attenuation factor). The product of 1200 millivolts (1.20 volts) is the voltage at the source.

If desired, you can measure the instantaneous (or dc) voltage-to-ground of a signal. This is accomplished in the same general manner as described previously. However, with no signal applied, you must first establish a ground reference point on the crt. To do this, allow the timing unit to present a free-running trace. Then, vertically position the trace so that it is exactly aligned with one of the horizontal graticule lines. This assumes no vertical shift in the trace baseline due to unequal duty cycle of an ac coupled pulse train. The actual graticule line selected will be largely determined by the polarity and amplitude of the applied signal. After this point, make no further adjustments with the VERT. POSITION control. Once the ground reference is established, apply the signal and measure the voltage in the same manner as described previously. Use the established ground reference as the point from which to make all measurements.

If the applied signal has a relatively high dc level, the ground-reference point and the actual signal may be so far apart that one or both will not be in the viewing area of the graticule. In this case, refer to the following discussion regarding Dc Offset Voltage Measurements.

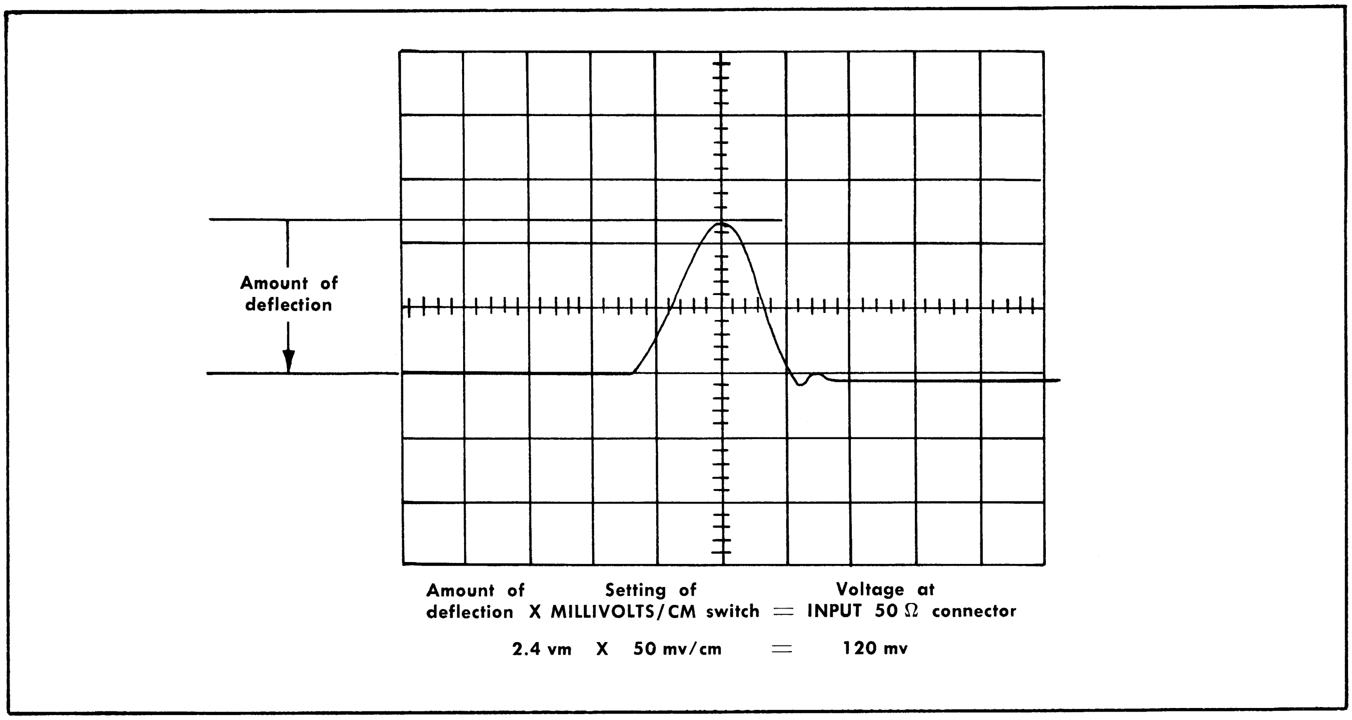

Fig. 3-1. Peak voltage measurement

Dc Offset Voltage Measurements

The Dc Offset voltage allows you to cancel the effects of a relatively high (up to ±1 volt) dc voltage in the presence of a low ac signal amplitude. Also, by measuring the offset voltage at the OFFSET MONITOR, you can determine the instantaneous voltage-to-ground at any point on a signal, or its peak-to-peak amplitude.

Voltage measurements made with the Type 4S2 and Type 661 system can be far more accurate than normal oscilloscope crt display resolution. The DC OFFSET control permits measuring any point on a waveform within ±1 volt of ground.

Procedure for using the DC OFFSET control:

1. Obtain the desired display through normal operating procedures.

2. Position the bottom of the waveform (or part thereof) to the graticule centerline. Use either or both the VERT. POSITION and DC OFFSET controls.

3. Measure and record the voltage at the OFFSET MONITOR jack with a high impedance voltmeter.

4. Using only the DC OFFSET control, position the display top (or other part thereof) to the graticule centerline.

5. Measure and record the voltage at the OFFSET MONITOR jack with the voltmeter. The difference between the two offset voltages, divided by 100, is the display amplitude in volts at the INPUT connector. If the input includes an attenuator, the signal source voltage is then the final offset voltage times the attenuation. The accuracy of the measurement is that of the two offset voltage measurements, and is not affected by the Type 4S2/661 system.

Phase Measurements

A complete cycle of a sinusoidal waveform is 360 degrees. Using this fact it is possible to calibrate the oscilloscope display directly in degrees per centimeter by means of the SWEEP TIME/CM controls on the Timing Unit. For example, if the SWEEP TIME/CM controls are adjusted so that one cycle of the input signal covers 9 centimeters, each centimeter then corresponds to 40 degrees. Under this condition the display is calibrated at 40 degrees per centimeter.

It is therefore possible to measure phase angles by: (1) calibrating the display in degrees per centimeter; (2) measuring the displacement between corresponding points on the two phases; and (3) multiplying the displacement by the number of degrees per centimeter. The relative amplitude of the two signals does not affect the phase measurement so long as the signals are both centered vertically about the centerline.

It is necessary to provide an external triggering signal from the reference signal since the Type 4S2 has no trigger takeoff system.

In making phase measurements it is very important that the width of the trace is not included. Measurements must consistently be made from either the top or bottom of the trace. The height of the display should be made as large as possible to improve accuracy. Accuracy of the measurement also depends to a large extent on how well the waveforms are centered vertically about the center-line of the graticule.

X-Y Phase Measurements

The following is a procedure for measuring phase difference between two sine waves of the same frequency.

1. Set the front-panel controls of the Type 4S2:

MODE Switch	A ONLY
DISPLAY Switches	NORMAL
DC OFFSET Controls	Midrange

2. Apply each sine wave to an INPUT 50Ω connector through identical electrical lengths of coaxial cable.

3. With the Type 661 SWEEP MAGNIFIER at X1, set the triggering controls of the Timing Unit for a stable display showing at least one complete cycle.

4. Adjust the following Channel A controls, as required, to obtain a vertically-centered 4-division display:

MILLIVOLTS/CM

VARIABLE

DC OFFSET

VERT. POSITION

5. Set the MODE switch to B ONLY and repeat steps 3 and 4 using the Channel B controls.

6. Set the MODE switch to A VERT. B HORIZ.

7. Using the Channel A VERT. POSITION control and either the Channel B DC OFFSET control or the Type 661 (HORIZONTAL) POSITION control, center the display on the graticule (both vertically and horizontally).

8. The display at this point may be an ellipse. (Note: If the display appears as a diagonal straight line the two sine waves are either in phase or 180° out of phase; if the display is a circle, the two sine waves are 90° out of phase. In any case, these instructions still apply.)

9. Measure the distance of A and B on the display as shown in Fig. 3-2. A divided by B equals the sine of the phase angle between the two sine waves.

Algebraic Addition or Subtraction of Signals

The algebraic sum or difference of two signals is displayed on the crt when the MODE switch is in the ADDED ALGEB. position. The sum of the signals is obtained with both DISPLAY switches set in the same position. The signal difference is obtained with the DISPLAY switches set in opposite positions.

In some applications, the desired signal is superimposed on an undesired signal such as line frequency hum or other coherent noise. The ADDED ALGEB. position of the MODE switch makes it possible in many cases to improve the ratio of desired to undesired signal. Connect one input

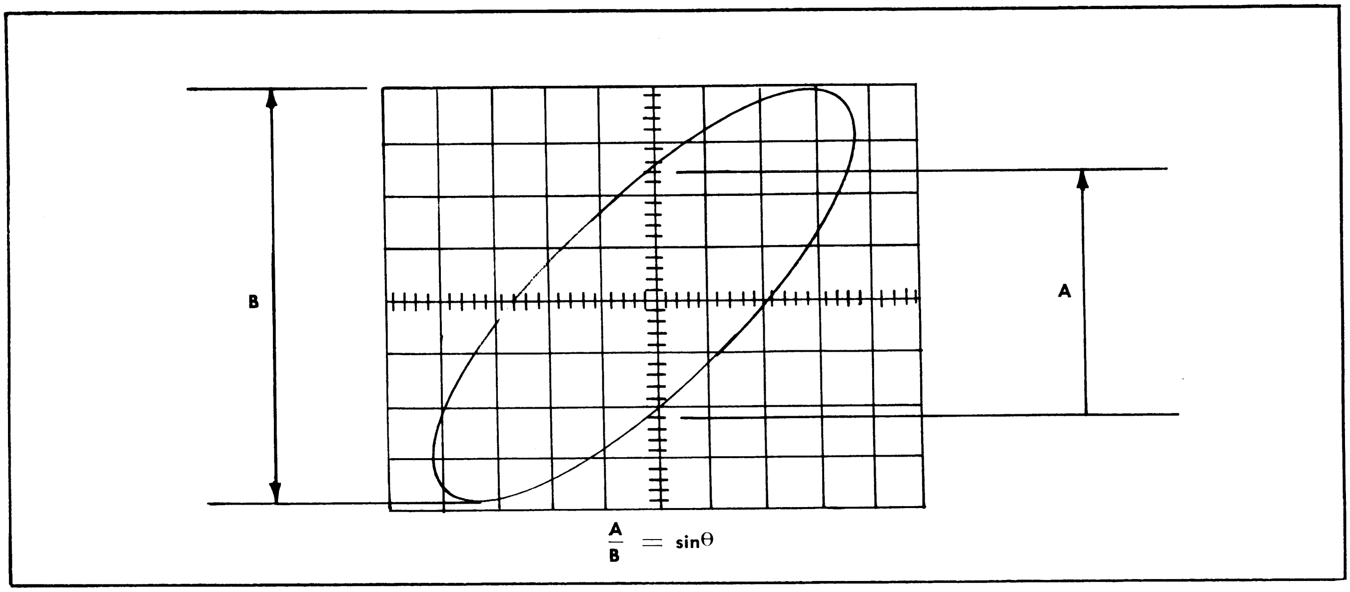

Fig. 3-2. X-Y method of calculating phase difference (Θ) between two sine-waves.

to the source of signal plus undesired information. Connect the other input to a source containing only the undesired signal. Place the MODE switch in the ADDED ALGEB. position. Set the DISPLAY switches so the undesired signal is viewed with opposite polarity. By careful adjustment of the MILLIVOLTS/CM and VARIABLE controls, the amplitude of the undesired signal display can be reduced to permit getting valid information from the display.

Another use of the added algebraic mode is for exact coax cable length matching. A short pulse fed to two input cables in parallel, one display inverted, permits quickly setting their two lengths equal. If the lengths are not equal, there will be a pulse displayed. Depending upon its polarity, you can determine which cable is either too long or too short. As the cables are made equal, the pulse disappears.

NOTES

SECTION 4
CIRCUIT DESCRIPTION

General Information

Most circuits in the Type 4S2 are on plug-in subchassis. The main frame contains only the sampler circuit, controls, interconnections, and cables. You may wish to refer to the Tektronix publication "Sampling Notes", publication number 061-557, during the following discussion.

Block Diagram

The Type 4S2 simplified block diagram of Fig. 4-1 shows each circuit in block form, with all front panel and internal controls identified. Since the two channels are identical, only the Channel A circuits are identified.

External trigger information to the Timing Unit starts the sampling cycle. The Timing Unit sends command pulses to the Type 4S2 Gate Generator. The Gate Generator sends very short duration push-pull pulses to both Sampler circuits, and slightly longer duration push-pull pulses to both Memory circuits. The two sets of pulses from the Gate Generator connect first the sampling gates to the sampler amplifiers, and then connect the AC Amplifier to the Memory circuits.

Input signals travel through about three inches of 50-ohm air line into the Sampler that includes the sampling gate and sampler amplifier. The sampling gate is biased to conduction by the Gate Generator as command pulses arrive from the timing unit via J7. The sampling gate output signal is a series of pulses, amplified by the sampler amplifier, and coupled through the MILLIVOLTS/CM switch into the Ac Amplifier. The Ac Amplifier (gain of about 200) amplifies the signal and presents it to the Memory. The Gate Generator biases a gate at the Memory input to conduction as the signal arrives.

The Memory amplifies and stores the signal. The Memory output is used by the Type 661 indicator to produce the crt display and to set the input circuit to the voltage of the signal at the time the sample was taken. (When the SMOOTHING control is at NORMAL, the next sample only corrects for any signal changes since the last sample.) The Memory output signal to the Type 661 can be inverted by a unity gain Inverter. The output of both channels then pass through the Dual Trace electronic switch where either or both are sent on to the Type 661.

Input and Sampler

The Type 4S2 input connectors are 50 ohm General Radio Type 874 connectors. They assure maximum uniformity of input impedance and a quick mate universal system. The input characteristic impedance is within 1% of 50 ohms.

The input system is shown in simplified form in Fig. 4-2. The input and sampler are the heart of the sampling system where the 0.1-nsec risetime performance is established. The input termination is a disc type 50-ohm resistor R1001. Located between the termination and the sampling gate is a low resistance ½ watt composition resistor, R1002. Fig. 4-2 shows Cc between R1002 and ground, indicating stray capacitance that helps compensate the input frequency response. (If your interests are sine waves, leave R1002 as factory installed. If interested in fastest pulse response, remove R1002, but remember the effect will be to produce about 10% overshoot to a 0.12-nsec risetime pulse.)

Fig. 4-2 shows the sampling gate is normally reverse biased a total of 4 to 5 volts. The relay contacts represent an equivalent method of applying forward bias to the sampling gate. If the relay is closed momentarily, the gate will be forward biased permitting the signal to be applied to the sampler amplifier. The actual forward biasing signal duration is slightly less than 0.1 nsec; so fast in fact, that the series inductance of L1021 and shunt capacitance of Cs, combined with the 25-ohm source impedance and the series 20 to 40 ohms of the gate, limit the signal to the sampler amplifier grid to about 10% of the input amplitude. Cs is stray input capacitance that stretches the 0.1-nsec signal at the sampler amplifier input. Because only about 10% of the signal gets to the amplifier, the sampling efficiency is about 10%.

The sampler amplifier has a very high input impedance and a gain of about 7. Refer to the Sampler diagram at the back of this manual (Channel A) during the following discussion. The input tube, V1024, amplifies the signal and couples it through a voltage divider to the base of Q1034. Q1034 amplifies the signal and sends it to both the Ac Amplifier subchassis and back to the cathode of V1024. This action bootstraps the input grid assuring a high-input-impedance stable amplifier. The Ac Amplifier, Memory, and feedback loop are discussed following the Gate Generator description.

Gate Generator

The pulses that gate the sampling diodes into conduction are formed by a special snap-off diode, D1065, driven by Avalanche transistor Q1064. The Avalanche transistor is normally biased to cutoff by −3 volts from Zener diode D1054. The collector voltage of Q1064 rests between +75 and +150 volts, as set by the AVALANCHE VOLTS control (R1057). As the positive trigger pulse arrives from the timing unit, Q1064 begins to conduct, soon reaching the avalanche state and conducting very heavily. C1064, at the collector of Q1064, initially prevents the collector voltage from falling. Since the avalanche condition is heavy conduction regardless of bias, the emitter of Q1064 rises abruptly. The heavy avalanche current lasts only as long as it takes to discharge C1064. The avalanche current charges the L1065-C1065 network so that it rings with a peak-to-peak amplitude of several volts.

As C1064 discharges, the collector of Q1064 falls, sending a negative-going signal through C1060 to the memory gate amplifier. Thus, Q1064 avalanche acts first upon its emitter circuit and D1065, then upon its collector circuit and the Memory Gate ampifier, Q2054.

Sampler Controls

The Gate Generator subchassis contains all sampler internal adjustments that control sampling efficiency and loop gain; they are: AVALANCHE VOLTS, MEMORY GATE WIDTH, A and B BRIDGE VOLTS, and A and B BRIDGE BAL.

The A and B BRIDGE VOLTS adjustments set the amount of sampling gate reverse bias (at least 4 volts). If the sampling gate reverse bias is less, there is a chance that an input signal greater than ±2 volts might break through to the sampler amplifier and distort the display.

The A and B BRIDGE BAL adjustments balance the sampling gate reverse bias to assure equal positive and negative signal linearity. Its effect upon the display is described in the calibration procedure.

AC Amplifier

The AC Amplifier receives its input signal (pulses) from the sampler amplifier through the front panel MILLIVOLTS/CM switch, amplifies it 200 times, inverts it, and feeds the memory circuit. The input dc level (to ground) is zero, and the input resistance ranges from 25 ohms at 200 mv/cm to 1000 ohms at 5 and 2 mv/cm. The Ac Amplifier is made up of two dc-coupled feedback amplifiers with a third dc feedback path around the whole circuit. The "outside" feedback path includes the front panel SMOOTHING control that allows a gain reduction of about 4 to 1 to reduce random noise. (When using SMOOTHING, the dot transient response must be considered and sufficient number of samples per centimeter obtained to make the display response correct.) The outside feedback path is for dc stabilization and does not act upon the main signal.

The signal pulses handled by the AC Amplifier are about 1 μsec in duration. The amplifier output voltage can change 1.6 volts in about 0.1 μsec. Normally the system causes the output pulses to be less than 1 volt, but if the display moves 8 centimeters in one sample, the output pulse will be about 1.6 volts peak. The output impedance of the circuit is low, so it can drive the memory input.

The gain of the first amplifier (Q1084 and Q1094) is about 40 times when the SMOOTHING control (R1081) is set to NORMAL (zero resistance). The gain is set by the ratio of R1089 to R1083. When using full smoothing, the gain is about 8 to 10, set by the ratio of R1089 to R1083 and R1081 (SMOOTHING) in series. The gain of the second amplifier (Q1104 and Q1113) remains fixed at about 5, set by the ratio of R1107 and R1096.

The frequency response of the first amplifier is fixed-compensated by C1089. The second amplifier frequency response is adjusted during calibration by C1107.

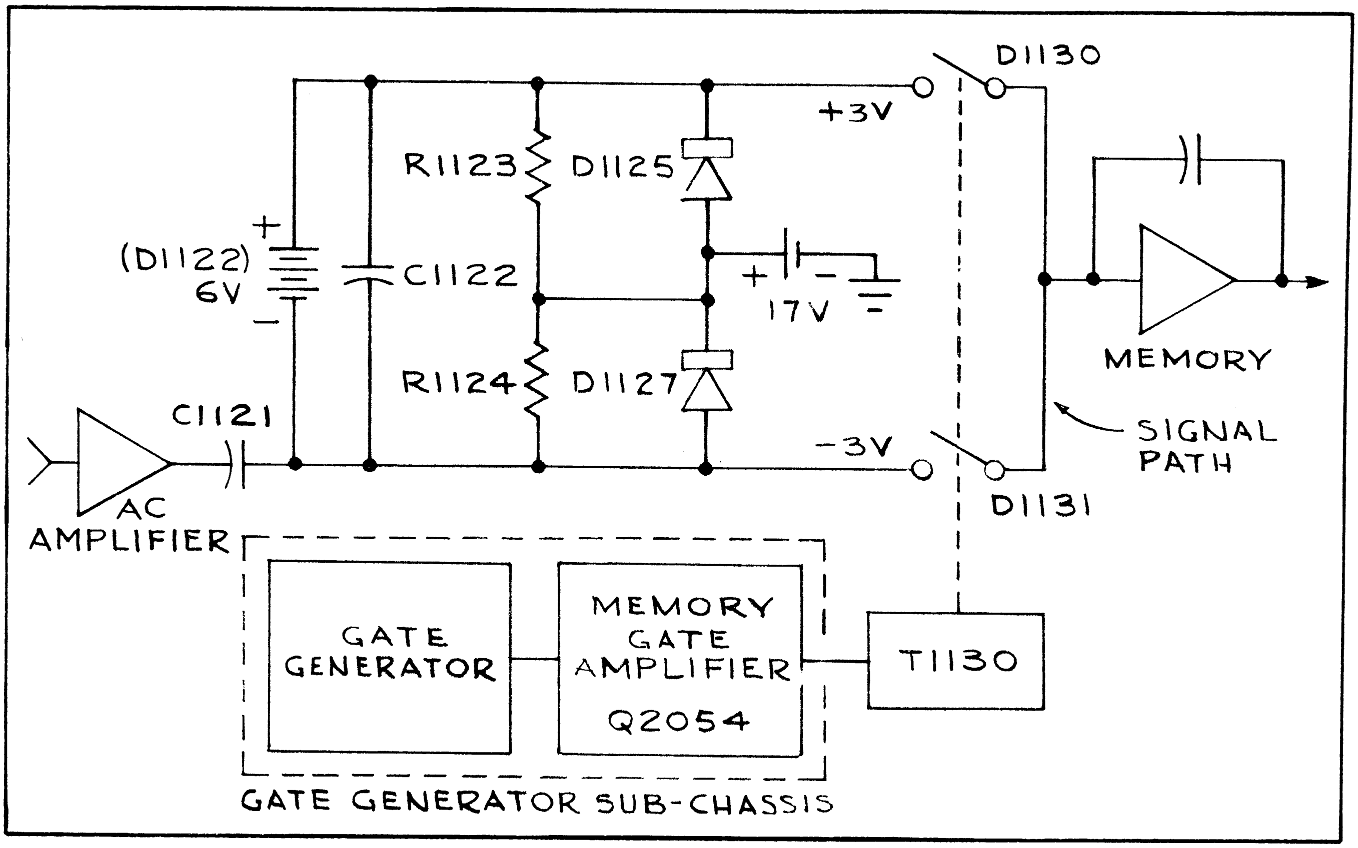

Fig. 4-3. Simplified memory gate.

Memory

A simplified schematic of the Memory circuit is shown in Fig. 4-3. The Gate Generator closes the Memory input gate (D1130 and D1131) at the correct time of each sampling cycle. The Memory circuit is a feedback amplifier with input and feedback elements both capacitors. The input capacitor is C1121, the feedback capacitor is C1132. V1133A is an input cathode follower, Q1134 is the amplifier, and Q1141 is an output emitter follower.

The input impedance at the grid of V1133A acts as a virtual ground because as the input signal changes the grid voltage, the signal is amplified and applied back to the input as negative feedback to cancel the original change.

The action of the memory is to transfer a charge from C1121 to C1132. The circuit between the AC Amplifier output and the grid of V1133A looks like 150 ohms and 510 pf in series (when the memory gate is conducting). Thus, as a signal appears at the AC Amplifier output, C1121 is charged. C1121 tries to couple the signal to the grid of V1133A, but feedback prevents the grid voltage from changing significantly; the result is for both C1121 and C1132 to receive a charge.

When the memory gate is not conducting, the grid of V1133A has a very high impedance to ground, and at this time the only possible discharge path for C1132 is by V1133A grid current or leakage current. The grid current is very low, and can be either positive or negative. Total leakage current is so low that there is essentially no change in the output voltage between samples even when sampling at the low rate of 150 dots/sec.

The circuit elements between C1121 and the grid of V1133A serve several purposes:

1. D1125 and D1127 are amplitude-limiting diodes. They normally do not conduct.

2. D1122 is a 6-volt Zener to provide back-bias for the gating diodes D1130 and D1131.

3. The resistors all aid in standardizing the input quiescent voltage level.

4. T1130 is a pulse transformer that allows instantaneous turn-on of the gating diodes to connect the input circuit to V1133A.

5. C1122 assures that both sides of D1122 follow the signal equally.

Within the memory amplifier:

1. C1138 corrects for transistor phase shift.

2. D1136 permits Q1134 to turn on hard, long enough for the stored charge (of D1136) to be removed, preventing damage to Q1134 in the event of turn-on overload.

3. D1142 assures that fast positive pulses at the base of Q1141 will be coupled to C1132 and the output, even if Q1141 has been momentarily cut off.

4. D1144 limits the positive swing of the output lead to about 10 volts and D1134 assures a high impedance when D1144 is reverse biased.

5. D1140 sets the maximum collector voltage of Q1141 at —9 volts.

6. R1145 prevents reverse reflections in the output cable from disturbing the display.

Between samples, the AC Amplifier output returns to its quiescent level, and C1121 charge (that was gained at the last sample) is cancelled. At the next sample, if there is any change at the sampler unit, C1121 will receive a new charging signal and can add to or subtract from the residual charge of C1132.

System Operation With No Signal

Items to remember when examining signals at various points between the sampler amplifier output and the memory output:

1. It is impossible to install perfectly balanced sampling gate diodes, so at each interrogation there will be some small error signal sent into the system.

2. The memory circuit does not retain a perfectly stable output voltage because C1132 cannot hold a charge permanently.

3. The memory output is coupled back to the sampler input (with proper attenuation).

4. Theoretically, if there is no input at the sampling gate, there will be no AC Amplifier signal, and the memory output will be zero. The memory output will be essentially zero, but there will always be a small pulse at the AC Amplifier output.

5. The SMOOTHING BALANCE control (R1125) sets the quiescent dc level at the memory input and if incorrectly adjusted will cause an offset voltage that looks like a continuous signal. For example, assume the SMOOTHING BALANCE control is off by +1 mv. If the memory amplifier internal gain is 500 (it isn't actually), the memory output will now be off by —500 mv. The —500-mv feedback to the input bridge creates an error signal which will drive the memory output nearly back to zero. After several dots the memory output will stabilize near zero, but slightly off from zero to provide enough error signal to correct for the original +1 mv error. Thus, a continuous minor error signal is amplified to place the output level near zero. If the AC Amplifier gain is reduced by the SMOOTHING control, the memory output must now be larger so the error signal fed into the AC Amplifier is larger, restoring again the —1 mv correction at the memory input. (A trace shift seen when the SMOOTHING control is rotated away from NORMAL is the increased memory output to make up for the reduced amplifier gain). Thus the memory input balance control is called the SMOOTHING BALANCE because its effect is seen by rotation of the SMOOTHING control.

DC Offset

The memory output of Q1141 is fed to the inverter or to the dual trace circuit. It is also fed to a voltage divider that controls the feedback signal sent to the sampler. The feedback attenuator resistors, R1147, (Plug-In Connectors

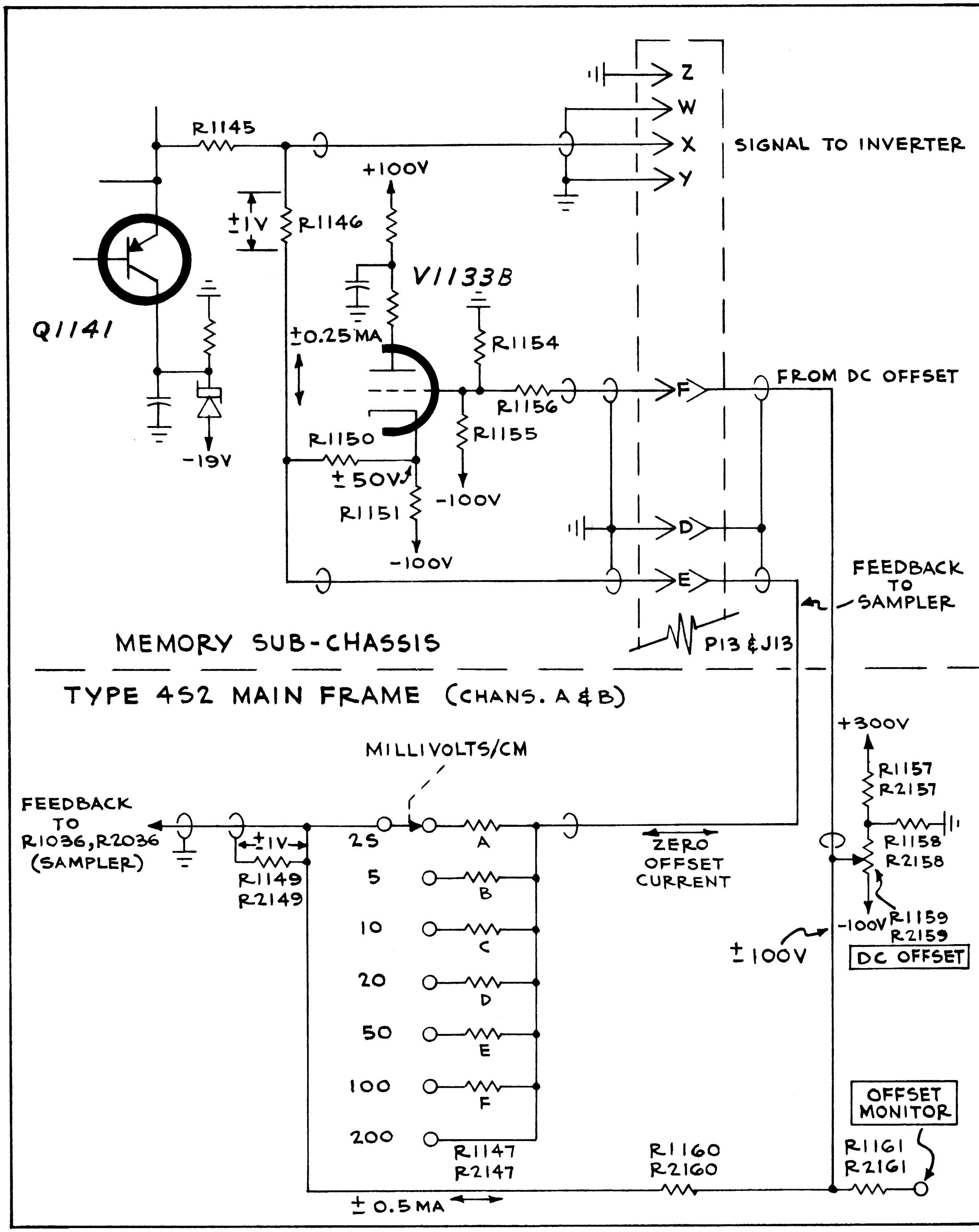

Fig. 4-4. DC Offset and Memory Feedback circuit.

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and Switching diagram, Channel A) set the feedback amplitude to keep the basic memory output of 600 mv/cm while the feedback voltage just matches the input signal.

The DC Offset circuit adds a dc shift to the feedback loop. It includes a current cancelling system that prevents offset current from flowing in R1147; see Fig. 4-4. The grid voltage of V1133B is set by the DC OFFSET control through a resistance divider. Rotating the DC OFFSET control from one end to the other causes a ±50 volt swing at the cathode of V1133B. The cathode of V1133B drives ±0.25 ma through R1146 via R1150. The DC OFFSET control ±100-volt swing drives ±0.5 ma through R1149 via R1160. The resulting voltage drop of ±1 volt across both R1146 and R1149 is the offset voltage sent to the sampler amplifier. The two points of offset injection assure there is no offset current in R1147 so that the offset system is not affected by the MILLIVOLTS/CM switch.

The DC OFFSET control may be used to null certain levels of the input signal in order to measure amplitude. The OFFSET MONITOR jack allows a voltmeter connection to read the effective dc offset voltage X100. The offset voltage is also useful when measuring small signals riding on larger signals.

Inverter

The Inverter is an X1 amplifier pair (10k input, 10k feedback) for each channel. Its function is to invert the display when the front panel DISPLAY switch is in the INVERTED position. When the DISPLAY switch is in the NORMAL position, the inverter is bypassed by interconnecting wiring in the Type 4S2 main frame.

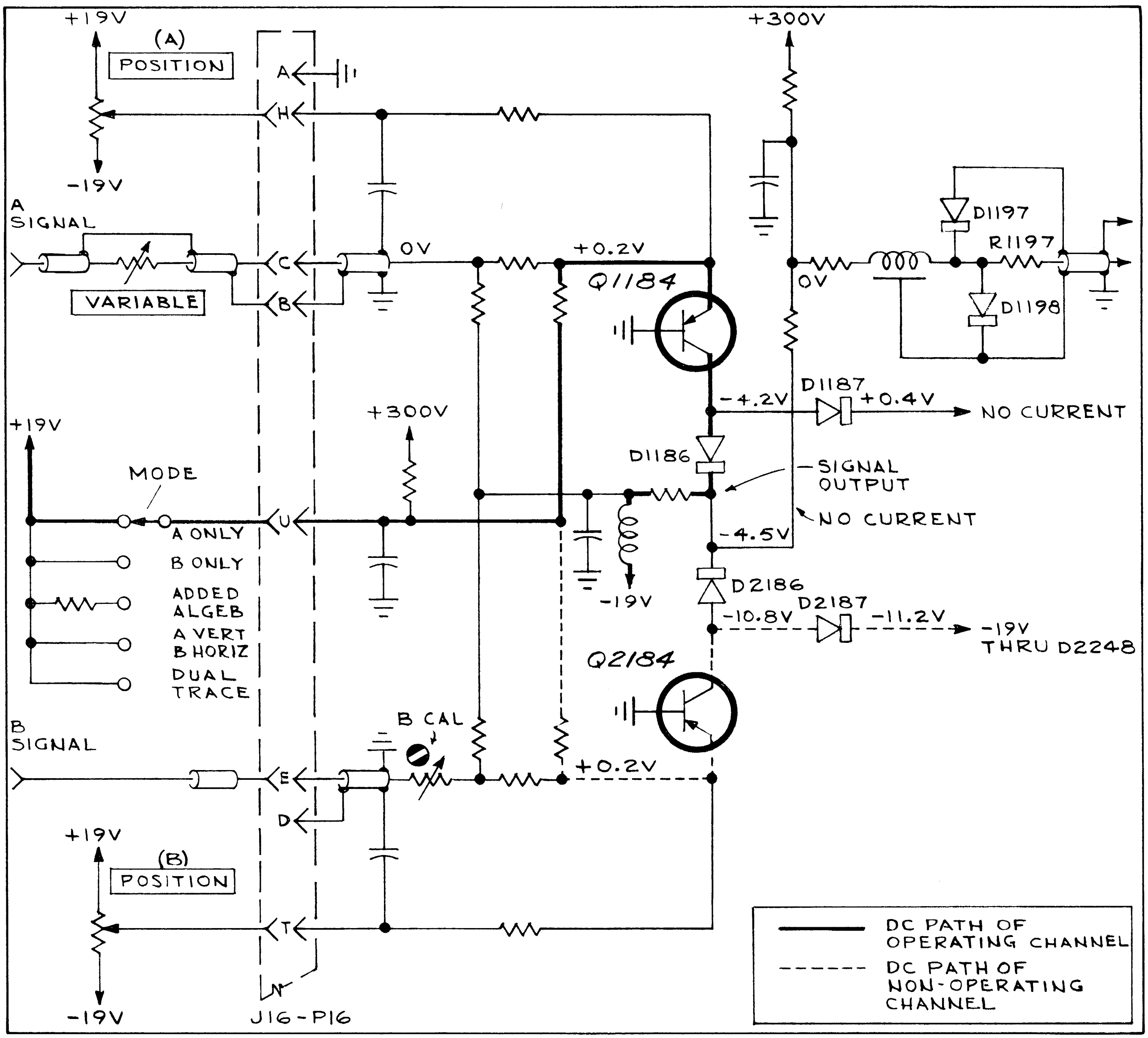

Fig. 4-5. Dual Trace circuit dc conditions. MODE A ONLY, DC OFFSET zero, trace centered, no signal, timing unit FREE RUN.

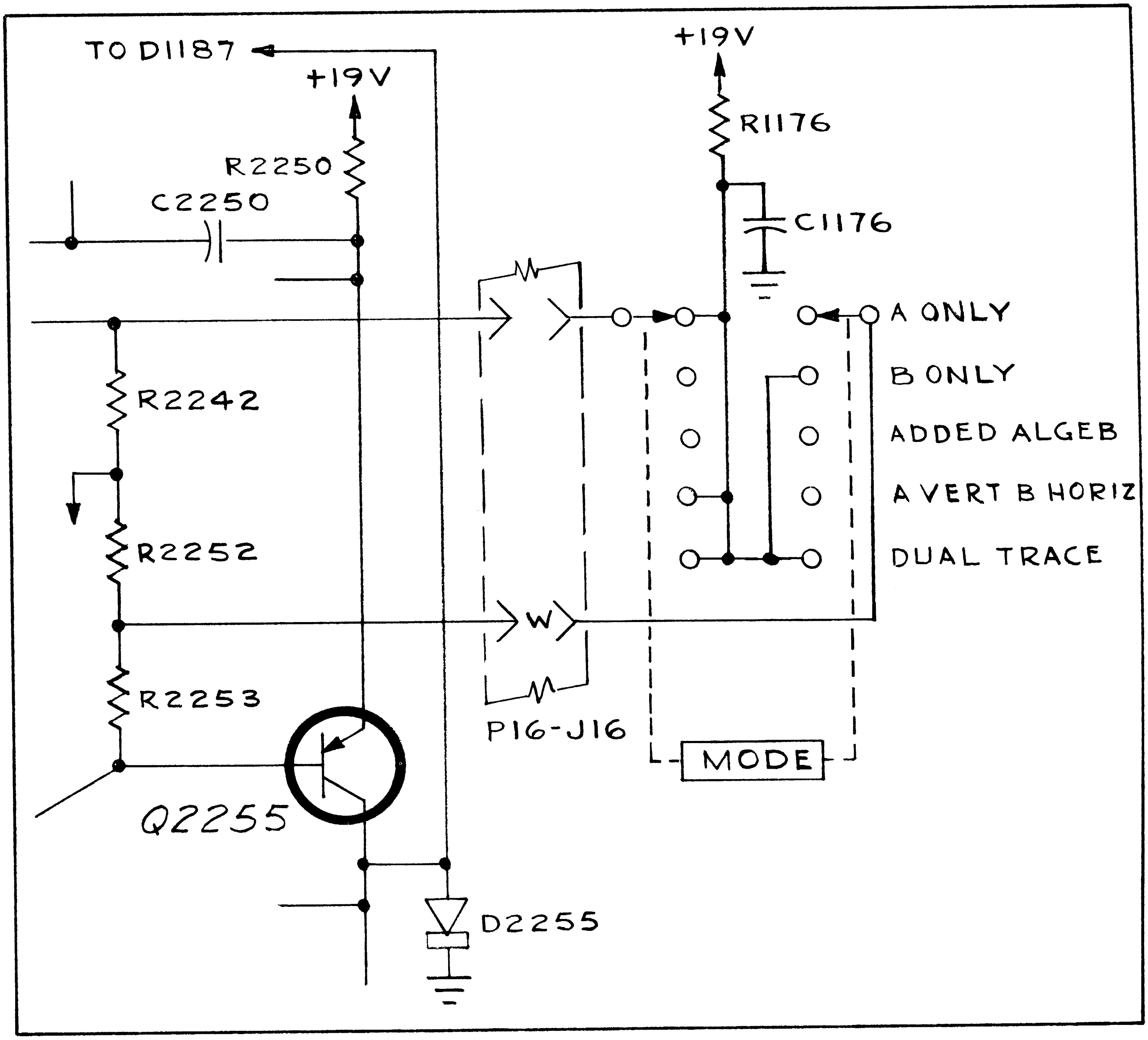

Fig. 4-6. MODE switch connections to the DUAL TRACE multivibrator.

Q1164 is collector coupled to Q1163. D1167 is a voltage offset Zener to raise the voltage at the base of Q1163 above that at the collector of Q1164 without signal attenuation. Q1163 is an output emitter follower. R1161, the A INVERTER ZERO control, and R1162 are a dc balance network to adjust the output dc level, eliminating trace shift when moving the DISPLAY switch from NORMAL to INVERTED. R1163 is the feedback resistor.

Dual Trace Model 3

The Dual Trace subchassis determines which channel is displayed by the Type 661; under some conditions, the signals from both channels are fed to the Type 661. Because of the various modes of operation possible in dual-trace, both the A and B channel will be discussed.

Two gated inverter amplifiers, Q1184 and Q2184, control passage of the signal. A multivibrator, Q2245 and Q2255, control the two amplifiers via switching diodes D116 and D216. Multivibrator operation is controlled by the front panel MODE switch. In the A ONLY, B ONLY, and A VERT B HORIZ modes, only one side of the multivibrator conducts. In the ADDED ALGEB mode, neither side conducts, and in the DUAL TRACE mode, the multivibrator free-runs at a switching rate of about 50 kc. Q2264 provides a dual-trace blanking signal to the Type 661 when the multivibrator switches.

A 0.25-μsec delay line couples the output signal from the dual trace unit to the Type 661 indicator. The delay allows the signal to phase properly with the Timing Unit unblanking of the Type 661 crt.

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Refer to Fig. 4-5, the Dual Trace, and the Plug-In Connectors and Switching diagrams during the following discussion. Each inverter is fed signals from the DISPLAY switch for its channel. The Channel A signal arrives through R1184, the Channel B signal arrives through R2182 and R2184. The inverter amplifier emitter circuits include positioning controls (R1180 and R2180) in parallel with the emitter return resistors (R1185 and R2185). Positioning is by current injection into the emitter circuits through R1181 and R2181. The major emitter current comes from the +19-volt supply, through MODE switch SW2190 and to the emitters through R1185 and R2185. In the ADDED ALGEB. position of the MODE switch, current limiting resistor R1179 is inserted in the emitter circuit to keep the common output lead average voltage the same as when only one transistor is conducting.

The amplifiers are connected in a common-base configuration. The current at their collectors is switched between two paths by the multivibrator to connect or disconnect them from the common collector load, R1189. There is essentially no change in the current of either transistor whether it is connected to the output or not. The input impedance is that of the series input resistors, R1184 in channel A, and R2182 and R2184 in channel B. Since the emitters of both transistors rest at about +0.2 volts, R1183 and R2183 are used to offset the input voltage to zero. The —4.5-volt collector voltage is offset to zero (for the output lead) by the series combination of R1191 and R1192.

Fig. 4-6 shows the MODE switch connections that set the operating conditons of the multivibrator. During single channel operation, with only one side of the multivibrator conducting, the conducting transistor saturates and Zener diode D2251 conducts. In A ONLY operation, multivibrator transistor Q2255 operates in saturation, and its collector is held at about +0.4 volt by D2255. This reverse biases both D2258 and D1187, so that Q1184 supplies the output signal. Since transistor Q2245 is cutoff, R2248 forward biases both D2248 and D2187, bypassing Q2184 from the output.

Operation in the A VERT B HORIZ mode sets the multivibrator and the inverter amplifiers the same as in the A ONLY mode. The Channel B signal bypasses the Dual Trace circuit and is fed separately to the Type 661 horizontal deflection system. In the B ONLY mode, operation of the multivibrator and inverter transistors is the reverse, with Q1184 disconnected and Q2184 supplying the output signal.

In the ADDED ALGEB mode, neither multivibrator transistor conducts. Both inverters are turned on, combining both signals in the common collector circuit at R1189. The output to the delay line is the algebraic sum of the A and B signals.

In the DUAL TRACE mode, Q2245 and Q2255 operate as a free-running multivibrator at about 50 kc. The inverter amplifiers pass signals alternately, providing a dual-trace display.

During multivibrator operation, neither transistor saturates, and Zener diode D2251 does not conduct. The multivibrator switching time constant, located between the emitters of Q2245 and Q2255, is composed of C2251 in series with the emitter return resistor (R2240 or R2250) of the nonconducting side. The collector-to-base coupling circuits (R2246-C2246 and R2256-C2256) do not set the time of operation; the capacitors are for high-frequency coupling to assure fast switching.

NOTE

Models 1 and 2 Dual-Trace Subchassis will operate in the Type 4S2, but are not recommended due to noise limits.

Blanking Circuit

Blanking transistor Q2264 normally rests in cutoff with its base at about +0.8 volt. As the multivibrator switches, C2240 or C2250 couples about a —2 volt signal to the base of Q2264 to turn it on. The turn-on pulse lasts only about 0.5 μsec, but it is heavy enough to saturate Q2264 and give it a storage time of about 1 to 1.5 μsec. There is some positive overshoot immediately before the —2 volt pulse. This is kept from the base of Q2264 by D2262 so that the storage time of Q2264 will be fairly consistent, and the crt will be properly blanked during the time the dual-trace multivibrator is switching channels.

NOTES

SECTION 5
MAINTENANCE

PREVENTIVE MAINTENANCE

Calibration

The Type 4S2 Plug-In Unit will not require frequent calibration. However, to insure that the unit is operating properly at all times we suggest that you check the calibration after each 500-hour period of operation (or every six months if the unit is used intermittently). A complete step-by-step procedure for calibrating the unit and checking its operation is included in Section 6.

The accuracy of measurements made with the Type 4S2 depends not only on the accuracy of calibration, but also on the calibration of the associated oscilloscope. It is important for the oscilloscope to be in proper calibration.

Visual Inspection

Troubles can sometimes be found by a visual inspection of the unit. For this reason, you should perform a complete visual check every time the instrument is calibrated or repaired. Look for such defects as loose or broken connections, damaged connectors, improperly seated tubes, scorched or burned parts, broken terminal strips, etc. The remedy for these troubles is apparent, except for heat-damaged parts. Heat damage is often the result of other, less apparent trouble. It is essential for you to determine the cause of overheating before replacing damaged parts.

Tube or Transistor Checks

Tester checks on the tubes and transistors used in the Type 4S2 are not recommended. Tube testers sometimes indicate a tube to be defective when that tube is operating satisfactorily in a circuit, or they may fail to indicate tube defects which affect the performance of the circuits. The same applies to similar tests made on transistors. The criterion for usability of a tube or transistor is whether or not it works properly in the circuit. If it does not, then it should be replaced. Unnecessary replacement is not only expensive but may also result in needless recalibration of the instrument.

COMPONENT REPLACEMENT

General

The procedures for replacing most parts in the Type 4S2 are easy. Detailed instructions for their removal are therefore not required. In some cases, however, additional information may help you. This information is contained in the following paragraphs. Because of the the circuit configuration, it will be necessary to recalibrate portions of the circuit when certain parts are replaced. Refer to the Calibration section of this manual.

Removal of Subchassis Circuit Boards

Most of the circuitry of the Type 4S2 is located on subchassis circuit boards. Each subchassis has a 22 contact connector that mates with the main-frame cables. Maintenance is made easier by the use of a special subchassis extender, and special extension cables that permit the Type 4S2 to be operated outside of the Type 661 (identified at the beginning of the calibration procedure). The Type 4S2 will operate correctly with any subchassis extended for testing.

Removal of a subchassis is accomplished by pressing down on the two tabs located at each side of the unit being removed. The removal tabs apply lifting pressure to the guides, aiding in disconnecting it from the interconnecting socket.

Installation of a subchassis requires careful observation of the mating connector at the base of the unit. A number located just to the right (front panel facing you) of the inter connecting socket identifies which subchassis will operate in that location. The number is identified on each schematic diagram as "Series—6" (the Gate Generator). The series number is a circuit guide, not a physical position guide, and mates with a number on the top lip of each subchassis.

To replace a unit, align all pins and the two plastic tips with their proper position at the interconnecting socket, and apply heavy hand pressure to push the unit fully into position. Take care not to rotate small screwdriver adjustments, as that will change the calibration. If the Gate Generator is being installed, you may wish to connect the six small cables to the subchassis after it is in place.

Switches

Procedures for the removal of defective switches are, for the most part, obvious and only a normal amount of care is required. If a switch is removed, careful notation of the leads to the switch should be made to facilitate connecting the new switch.

Single wafers are not normally replaced on the switches used in the Type 4S2. If one wafer is defective, the entire switch should be replaced. Switches may be ordered from Tektronix either unwired or with the parts wired in place.

Switch wafers shown with the circuit diagrams are coded to indicate the position of the wafer on the switches. The number portion of the code refers to the wafer number on the switch assembly. Wafers are numbered from the front of the switch to the rear. The letters F and R indicate whether the front or the rear of the wafer is used to perform the particular switching function.

Soldering Precautions

In the production of Tektronix instruments a special silver-bearing solder is used to establish a bond to the ceramic terminal strips. This bond may be broken by repeated use of ordinary tin-lead solder, or by excessive heating of the terminal strip with a soldering iron. Occasional use of ordinary 60-40 solder will not break the bond unless excessive heat is applied.

If you are responsible for the maintenance of Tektronix instruments, it is advisable to have a stock of solder containing about 3% silver. This type of solder is used in printed circuitry, and is generally available locally. It may also be purchased from Tektronix in one-pound rolls; order by part number 251-514.

Because of the shape of the terminals of the ceramic terminal strips, we recommend a wedge-shaped tip on your soldering iron. These tips allow you to apply heat directly to the solder in the terminals. It is important to use as little heat as possible while producing a full-flow joint.

The proper technique for soldering components in place requires: (1) the use of long-nose pliers to hold the lead securely between the component and the point where heat is applied, allowing the pliers to serve as a heat sink; (2) the use of a hot iron for a short time; and (3) careful manipulation of the leads to prevent lead breakage. Use a 50- to 70-watt iron when working on ceramic strips.

Ceramic Terminal Strips

Damaged ceramic terminal strips are most easily removed by unsoldering all connections, then knocking the plastic yokes out of the chassis. This can be done by using a plastic or hard-rubber mallet to hit the ends of the yoke protruding through the chassis. If space limitations prohibit use of the mallet directly, a plastic rod can be used between the mallet and the yoke of the strip. When the two yokes supporting the strip have been knocked out of the chassis, the strip and yokes can be removed as a unit. The spacers will probably come out with the yokes; if not, they can be removed separately.

Another way of removing the terminal strip is to cut off the side of the yoke holding the strip with diagonal cutters. This permits the strip to be removed from a difficult area where a mallet cannot be used. The remainder of the yokes and the spacers can be pulled out separately. Since a replacement strip is supplied with yokes already attached, the old yokes need not be salvaged. However, the old spacers can probably be used again.

When the damaged strip and yoke assembly has been removed, place the spacers into the holes in the chassis. Then set the ends of the yoke pins into the spacers. Press or tap lightly directly above the yokes to drive the yoke pins down through the spacers. Be certain that the yoke pins are driven completely through the spacers. Then cut off the portion of the yoke pin protruding past the spacers.

TROUBLESHOOTING

General Information

The Type 4S2 derives all of its operating voltages from the oscilloscope, and depends on the oscilloscope and the Timing Unit for its display, therefore be sure that the oscilloscope is not the cause of trouble.

If trouble occurs in the Type 4S2, try to isolate it by quick operational and visual checks. First check the settings of all controls. Then operate the controls to see what affect, if any, they have on the trouble. The normal or abnormal operation of each control may help you to establish the trouble symptoms. (The cause of trouble which occurs only in certain positions of a control can usually be determined immediately from the trouble symptoms.)

After the trouble symptoms are established, look first for simple causes of trouble. Check to see that the pilot light of the oscilloscope is on, feel for any irregularities in the operation of the controls, listen for any unusual sound, see that the tube filaments are lit, and visually check the entire instrument. The type of trouble will generally indicate the checks to make.

In general, a troubleshooting procedure consists of two parts: circuit isolation and circuit troubleshooting. Since the Type 4S2 is a complex unit, consisting of many circuits, you should study each schematic carefully while reading the circuit description to help determine which circuit is defective. After isolating the circuit, you can then troubleshoot in the circuit to find the cause of the trouble.

Most troubles will be caused by tube or semiconductor failures. Therefore, when trouble has been isolated to a circuit, the tubes and semiconductors in that circuit should be checked first. Be sure to return tubes and transistors found to be good to their original socket.

Trouble Symptoms

1. A display that may appear as trouble to someone not familiar with sampling techniques can occur when triggering information stops arriving from the Timing Unit. Each display dot is the result of a pulse from the Timing Unit arriving at the Type 4S2 Gate Generator via J7. If the information stops—even in the middle of a trace—sampling stops immediately. The spot does not extinguish, but it stops progressing across the crt horizontally and starts drifting up or down the crt and ultimately goes out of sight. This is normal, and is not to be confused with trouble in the Type 4S2. (It is the Memory drifting, without repeated correction.) Should the Timing Unit information begin again, the dot will return to the crt and the interrupted trace will be completed.

2. If the display appears to compress—or limit—at one end of the VERT. POSITION control range, set the DC OFFSET control so that a voltmeter at the OFFSET MONITOR jack reads zero. Then reduce the input signal to be 1 volt or less, peak-to-peak. If the symptom continues, recalibration of the Type 4S2 is necessary.

3. If trying to observe the Type 661 Delayed Pulse with less than 40 nsec of delay cable between the Delayed Pulse output connector and the Type 4S2 input, and the Timing Unit TIME DELAY control fails to bring the step into view, add more cable. (Use cable with good high frequency response, of 5 nsec or more, such as the Tektronix Type 113 Delay Cable. See Fig. 2-4.)

4. If the dots are spread all over the crt, the Gate Generator is free-running . . . recalibrate.

Testing Precaution

When observing waveforms in the Type 4S2 circuitry, always make certain that the test oscilloscope frame is connected to the Type 4S2 frame. Then if you wish to look at fast pulses inside the Type 4S2 circuits that are differential in nature, observe the following. The Tektronix P6034 and P6035 signal probes, used on one sampling system to observe another, can be used in a differential fashion singly. If the circuit being measured is not at ground potential, both the probe center conductor and ground return must be ac-coupled. The center conductor can be ac-coupled using a General Radio Type 874-K in-line capacitor. The ground return can be ac-coupled (for fast signals) by use of a 0.001-μf capacitor at the probe ground clip. Use short leads. If the test oscilloscope frame is not connected to the Type 4S2 frame, a 60-cycle stray pickup between the chassis can damage components in the Type 4S2.

NOTES

SECTION 6
CALIBRATION PROCEDURE

Introduction

The following paragraphs outline a procedure for calibrating the Type 4S2. The instrument should not require frequent recalibration, but occasional adjustments will be necessary when tubes and other components are changed. Also, a periodic recalibration is desirable from the standpoint of preventive maintenance.

Apparent troubles in the instrument are occasionally the result of improper calibration of one or more circuits. Consequently, calibration checks should be an integral part of any troubleshooting procedure. Abnormal indications occurring during calibration checks will often aid in isolating troubles to a definite circuit or stage.

In the instructions that follow, the steps are arranged in the proper sequence for a complete calibration of the instrument. Each numbered step contains the information required to make one check or adjustment or a series of related checks or adjustments. The steps are arranged to avoid unnecessary repetition of checks or adjustments.

Fig. 6-5 shows the Type 4S2 subchassis location keying system. Each subchassis is labeled with both a Series and a Model number. More than one Model may work in a given Series location, the higher Model number being the better. Do not insert a subchassis with conflicting Series number.

Equipment Required

The following equipment or its equivalent is required to perform a complete calibration of the Type 4S2.

1. A dc voltmeter with a sensitivity of 20,000 ohms per volt or more.

2. A nonloading dc voltmeter such as John Fluke Model 801B or 825B, or a Tektronix Type Z Plug-In Unit for use in item. 5.

3. An ohmmeter.

4. A resistance bridge, accuracy at least 0.2%.

5. A test oscilloscope with a bandpass to at least 30 mc and a maximum sensitivity of at least 50 millivolts per division. Oscilloscope such as Tektronix Type 540-Series and Type L or H Plug-In Unit is suitable.

6. An attenuator probe for use with the test oscilloscope. 10X attenuation, such as the Tektronix P6017 or P6000.

7. A probe without attenuation, such as the Tektronix P6027.

8. If using a Type Z Plug-In Unit, a 10X attenuator probe, P6032.

9. A calibrated Type 661 Oscilloscope with Type 5T1 or 5T1A Timing Unit.

10. A Tektronix Type 111 Pretrigger Pulse Generator.

11. A flexible interconnecting cable to go between the Type 4S2 and the Type 661, (Part No. 012-064).

12. A special 32" 50-ohm cable with Gremar connectors to go between the Type 4S2 and the Type 661, (Part No. 012-070).

13. A special subchassis extender board, (Part No. 012-069).

14. A 50-ohm 5X attenuator with GR connectors, (Part No. 017-045).

15. Two 50-ohm 10X attenuators with GR connectors, (Part No. 017-044).

16. Two 50-ohm (RG-8/AU) cables, 5-nsec signal delay, (Part No. 017-502).

17. A 50-ohm (RG-58/AU) cable, 2-nsec signal delay. (Part No. 017-505).

18. An insulated screwdriver, such as Jaco No. 125, (Part No. 003-000).

19. A 680 Ω, 10%, 1-watt resistor, and a 500 Ω potentiometer in series.

20. A clip lead about 2½ ft. long.

Preliminary Procedure

Make a complete visual check of the instrument. If calibration is being done as a result of trouble, check for correct transistors, tubes and sampler diodes and that they are in their correct locations. Sampler diodes have two green dots at their cathode end. Memory gate diodes have a red dot at their cathode end. All transistors with four leads that are plugged into sockets use all four leads.

Use an ohmmeter to check the resistance of each interconnecting plug lead to ground as shown in Tables 6-1 and 6-2.

Measure the input resistance of each channel. It must be 50 Ω, ±1%.

Set the Type 4S2 front-panel controls as follows when making resistance measurements:

MILLIVOLTS/CM	200
VARIABLE	CALIBRATED
VERT. POSITION	Midrange
SMOOTHING	NORMAL
DC OFFSET	Midrange
DISPLAY	NORMAL
MODE	A ONLY

TABLE 6-1

Resistance to ground at P1 (see Fig. 6-1). All subchassis in place.

Pin No.	Circuit	Ohmmeter Range	Res.
1	117 vac	X100	inf.
2	6.3 vac	X100	inf.
3	—19 v	X10	9-15 Ω
4	—25.2 v	X100	inf.
5	—100 v	X1	2-2.5 k
6	staircase in	X100	inf.
7	Gnd	X10	0
8	(B) out to Horiz	X10	0
9	braid for 21	X10	0
10	(B) Vert out	X1	8-11 k
11	(A) Vert out	X1	8-11 k
12	Gnd	X10	0
13	117 vac	X100	inf.
14	6.3 vac	X100	inf.
15	+300 v	X1	9 k
16	+400 v	X100	inf.
17	+100 v	X1	9 k
18	+19 v	X100	400 to 500 Ω
19	staircase out	X100	inf.
20	braid for 8	X10	0
21	blanking out	X100	10 to 50 meg
22	braid for 10	X100	inf.
23	braid for 11	X100	inf.
24	vert sig out	X1	4-5 k

TABLE 6-2

Resistance to ground at P2, all subchassis in place.

Pin No.	Circuit	Ohmmeter Range	Res.
1	open	X100	inf.
2	—12.6 v	X100	inf.
3	chop out	X1	10 k
4	(B) ÷ Gnd	X100	inf.
5	÷2	X100	inf.
6	(A) Dec. unit Gnd	X100	2 meg
7	open	X100	inf.
8	Dec. 3	X100	inf.
9	open	X100	inf.
10	open	X100	inf.
11	braid for 23	X100	inf.
12	(B) Vert out	X1	8-11 k
13	open	X100	inf.
14	braid for 3	X10	0
15	(A) ÷ Gnd	X100	inf.
16	÷1	X100	inf.
17	÷5	X100	inf.
18	(B) Dec. Unit Gnd	X100	2 meg
19	Dec. 2	X100	inf.
20	Dec. 4	X100	inf.
21	milli	X100	inf.
22	volt	X100	inf.
23	(A) Vert out	X1	8-11 k
24	braid for 12	X100	inf.

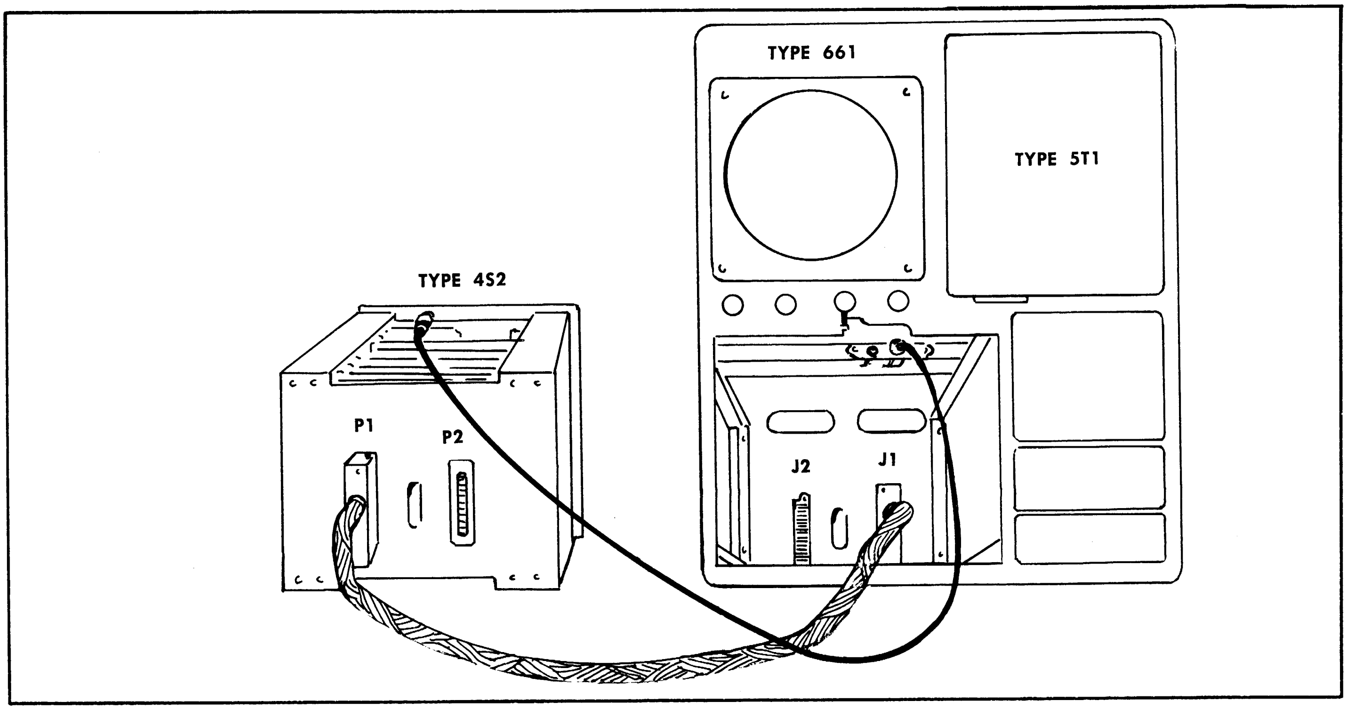


Fig. 6-1. Location of cables for operating Type 4S2 outside of Type 661.

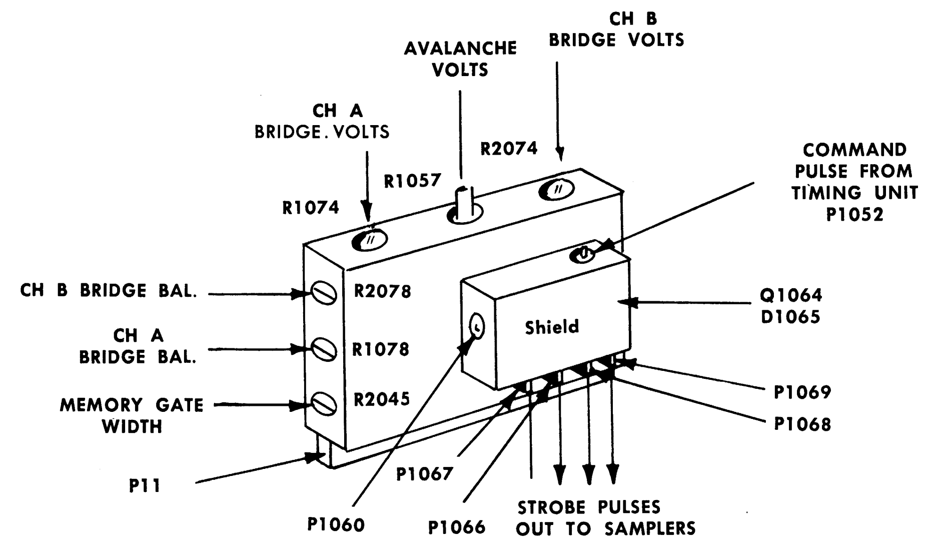


Fig. 6-2. Location of controls and connectors on Gate Generator sub-chassis.

After making any resistance measurements, install the Type 5T1 Timing Unit into the Type 661 Oscilloscope. Connect the Type 4S2 to the oscilloscope using equipment items 11 and 12 (connect as shown in Fig. 6-1). Pull out the AC Amplifier subchassis, and reinstall using the subchassis extender board. Set the INTENSITY control at about 2 or 3 o'clock. Set the POWER AND SCALE ILLUM. control to turn on the oscilloscope and allow the instrument to warm up for 10 or 15 minutes before proceding with the adjustments.

ADJUSTMENT PROCEDURE

1. AVALANCE VOLTS Check

Connect the test oscilloscope 10X attenuator probe to the center connection (wiper) of the AVALANCHE VOLTS control on the Gate Generator chassis (Fig. 6-2). Free run the Type 5T1 Timing Unit at 10 nSEC/CM. Internally trigger the test oscilloscope at 5μSEC/CM. You shoud see a display roughly like Fig. 6-3. Stop the sweep; the display should disappear. If it does not , rotate the AVALANCHE VOLTS control about 10° clockwise from the point where the waveform disappears.

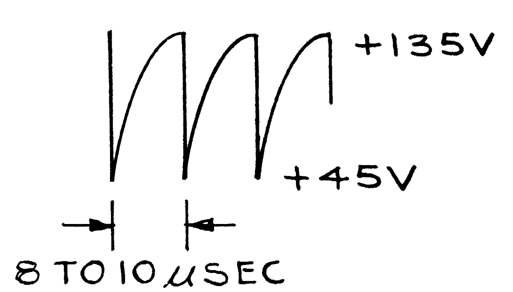


Fig. 6-3. Test oscilloscope typical waveform at arm of AVALANCHE VOLTS control.

2. DC OFFSET Adjustment

Using either the test oscilloscope dc-coupled, or the voltmeter, adjust the DC OFFSET controls for zero volts at the OFFSET MONITOR jacks. Set both BRIDGE VOLTS controls fully clockwise. Locate both traces using the MODE switch and the VERT. POSITION controls. (Be careful not to bump the DC OFFSET knobs as they must remain at a zero-volt output setting during the following.)

3. SMOOTHING BALANCE Adjustment

Set the MODE switch to A ONLY. Adjust the SMOOTHING BALANCE control (on the Channel A Memory subchassis located right behind the AC Amplifier) for no trace shift while rotating the SMOOTHING control throughout its range. (Set the MODE switch to B ONLY and repeat for Channel B on the second subchassis behind the AC Amplifier.)

4. BRIDGE VOLTS Preliminary Adjustment

Set up the Type 111 Pretrigger Pulse Generator as follows:

Connect a 2-nsec cable to CHARGE LINE connector. Set the following controls as indicated:

REPETITION RATE	near MAX.
RANGE	10 KC
OUTPUT POLARITY	+
VARIABLE	near MIN.
FIXED INCREMENT	0

Connect the PRETRIGGER OUTPUT to the Type 5T1 EXTERNAL TRIGGER INPUT with a 5-nsec cable and a 5X and 10X attenuator in series.

Connect the PULSE OUTPUT to the Channel A INPUT using a 5-nsec cable and a 10X attenuator in series.

Set the Type 5T1 controls as follows:

SWEEP TIME/CM	1 nSEC
SOURCE	EXT.
POLARITY	+
RECOVERY TIME	MIN.
THRESHOLD	just to right of 0
SAMPLES/CM	100
TIME DELAY	0
SWEEP MODE	REPETITIVE

Turn on the Type 111 and locate the pulse display by use of the Type 4S2 TIME DELAY and the Type 111 VARIABLE controls.

Adjust the Type 5T1 THRESHOLD and the Type 111 REPETITION RATE controls for three pulses of different amplitude (equal time of start of pulses). If pulses show more noise than shown on the trace, rotate the AVALANCHE VOLTS control clockwise until the noise disappears.

Adjust the A BRIDGE VOLTS control until the smallest amplitude pulse is at the same level as the baseline trace. Repeat for Channel B.

5. MEMORY GATE WIDTH Adjustment

With display as in step 4 in either channel, adjust the MEMORY GATE WIDTH control for maximum separation between pulses. Two maximums may be obtained; use the adjustment that is clockwise and permits you to "pass through" the peak. The counterclockwise peak does not "pass through" and is incorrect.

Now repeat step 4 and readjust Channel A and B BRIDGE VOLTS for zero amplitude of the small pulse.

NOTE

It is necessary to recheck the MEMORY GATE WIDTH adjustment each time the AVALANCHE VOLTS is changed.

6. AC AMPLIFIER C1107 and C2107 Adjustment

With the Type 111 multiple trace signal displayed on Channel A, adjust C1107 (on AC Amplifier) for minimum pulse height of the top pulse. Now readjust A BRIDGE VOLTS for zero amplitude of small pulse. Repeat for Channel B and C2107.

7. Sampler BRIDGE BALANCE Adjustment

Disconnect the Type 4S2 input cable at the Type 111 end (leave connected to Channel A). Recheck the OFFSET MONITOR and DC OFFSET for zero volts.

Adjust the A BRIDGE BAL. control for no trace shift while rotating the MILLIVOLTS/CM switch from 200 to 2S. (If multiple trace shows at 2S, free run the Type 5T1.)

Repeat for Channel B.

Leave both MILLIVOLTS/CM switches at 200.

Reconnect the Type 111 and obtain the three-pulse display described in step 4. Recheck the A and B BRIDGE VOLTS adjustments. If readjustment is necessary, repeat the BRIDGE BALANCE adjustments. Repeat these adjustments until both BRIDGE VOLTS and both BRIDGE BALANCE are correct.

NOTE

The 5-nsec cable, or an attenuator, must be connected to the INPUT when adjusting the BRIDGE BALANCE controls.

8. Noise Check

Trigger the Type 5T1 for a proper single-pulse Type 111 display. Remove the signal input connection to the Type 4S2. Set both MILLIVOLTS/CM switches to 5. Both channels should show less than 4 mv peak-to-peak noise. (This applies when SMOOTHING is NORMAL, MODE switch is at A ONLY, B ONLY, or A VERT. B HORIZ.). Set the MODE switch first to DUAL TRACE and then to ADDED ALGEB; the noise should not be over 5 mv peak-to-peak.

If the noise exceeds either of the above, the problem is probably misadjustment of the AVALANCHE VOLTS control. Repeat steps 4 through 7, paying close attention to the pulse noise in step 4.

9. MEMORY Drift Check

With the set-up as in step 8, set the MILLIVOLTS/CM switches to 200. Set the Type 111 repetition rate at 50 pps. The trace width (both channels) should be no greater than 2 mm. If it is, it may be necessary to recheck the SMOOTHING BALANCE adjustment (step 3) or replace V1133. If V1133 is replaced, repeat steps 3 through 5 after 10 minutes warm-up.

10. Sampler Bridge Volts Check

Turn the Type 4S2 on its side, free run the Type 5T1, and remove any input signal. Use the test oscilloscope with 10X probe, at 2 volts/cm dc coupled, to check the voltage to ground at R1010 and R1020, and at R2010 and R2020. (These resistors are all $\frac{1}{4}$ watt, 10k, located at the sampler bridge center.) Touch the probe to the junction between the resistors and thee leads going to J11. Each point must be at least + or — 2 volts. If it is less, repeat steps 4 through 7. (It is not likely that the bridge volts will be less than 2 volts each.)

11. INVERTER ZERO Adjustment

Set the test oscilloscope to 50 mv/cm (dc coupled) using the probe with no attenuation. Connect the probe to pin X of J13 (A Memory) and adjust the A DC OFFSET control for zero volts at pin X.

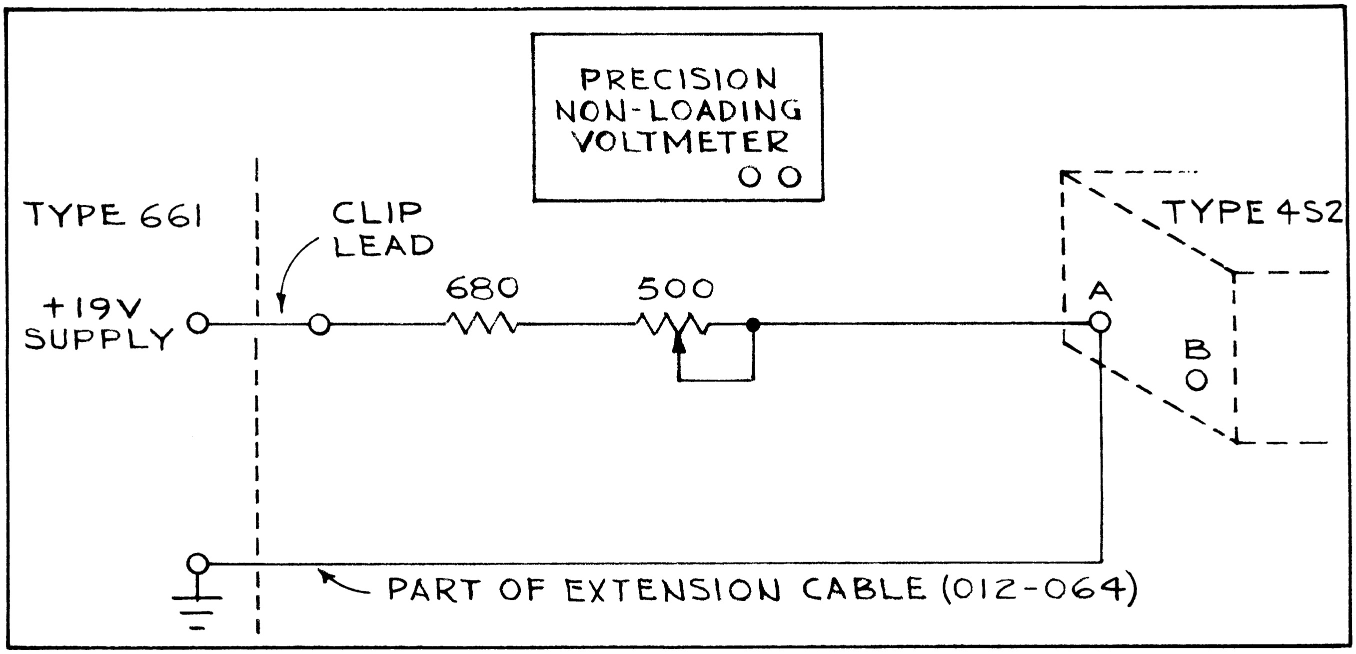


Fig. 6-4. Circuit used to set Type 4S2 Gain. Step 12.

Free run the Type 5T1 sweep and observe the crt display. Adjust the A INVERTER ZERO so there is no trace shift while switching the DISPLAY switch alternately between NORMAL and INVERTED.

Repeat for Channel B, with the test oscilloscope probe at pin X or J14 (B Memory). Turn off the Type 661 and install AC Amplifier in its normal position in the Type 4S2. Then turn the power back on and allow a 5-minute warm-up. Recheck that the Type 111 three-pulse display shows small pulse level with trace. Reset the BRIDGE VOLTS control if necessary.

NOTE

When steps 3 through 7 are completed correctly, and the three-pulse display shows the small pulse level with the trace, the sampling system loop gain is unity.

12. Gain Setting

Assemble the system shown in Fig. 6-4. Adjust the 500-ohm pot so exactly 1 volt is developed at the Type 4S2 input. Free run the Timing Unit and alternately connect and disconnect the system of Fig. 6-4. Set both VARIABLE controls at CALIBRATED.

With the MODE switch at A ONLY, adjust the front panel A-B BAL. control for exactly 5 cm between no signal and 1 volt.

With the MODE switch at B ONLY, adjust the B CAL control on top of the Dual Trace subchassis for exactly 5 cm between no signal and 1 volt.

13. Check MILLIVOLTS/CM Positions

To check the accuracy of each setting of the MILLIVOLTS/CM switches, use a system such as shown in Fig. 6-4, but use the series resistances listed in Table 6-3 in place of the 680-ohm resistor.

TABLE 6-3

MILLIVOLTS/CM Switches Check

Approx. Series Resistance	Voltmeter Reading	MV/CM Switch	Vert. Defl.	Tolerance
900 Ω	1.00 v	200	5 cm	0%
1850 Ω	0.50 v	100	5 cm	2%
3800 Ω	0.25 v	50	5 cm	2%
9.5 k	0.10 v	20	5 cm	2%
19 k	0.050 v	10	5 cm	2%
38 k	0.025 v	5	5 cm	4%
95 k	0.010 v	2S	5 cm	5%

14. QUICK CHECK ON RISETIME

Disconnect any external triggering to the Type 5T1. Connect a 5-nsec cable between the Type 661 DELAYED PULSE connector and the Channel A INPUT connector.

Operate the Type 5T1 at 1 nSEC/CM, and the Type 4S2 at 100 MILLIVOLTS/CM. With the Type 5T1 TIME DELAY control obtain a negative step display.

Use the VARIABLE control to set the display to 8 cm, peak-to-peak. Measure the system risetime (falltime by this display) between the 10% and 90% pulse points with the Type 661 SWEEP MAGNIFIER at 10 (100 psec/cm). Risetime should be 125 psec or less.

NOTES

SECTION 7
PARTS LIST and DIAGRAMS

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix Field Office.

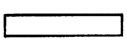
Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number including any suffix, instrument type, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix Field Office will contact you concerning any change in part number.

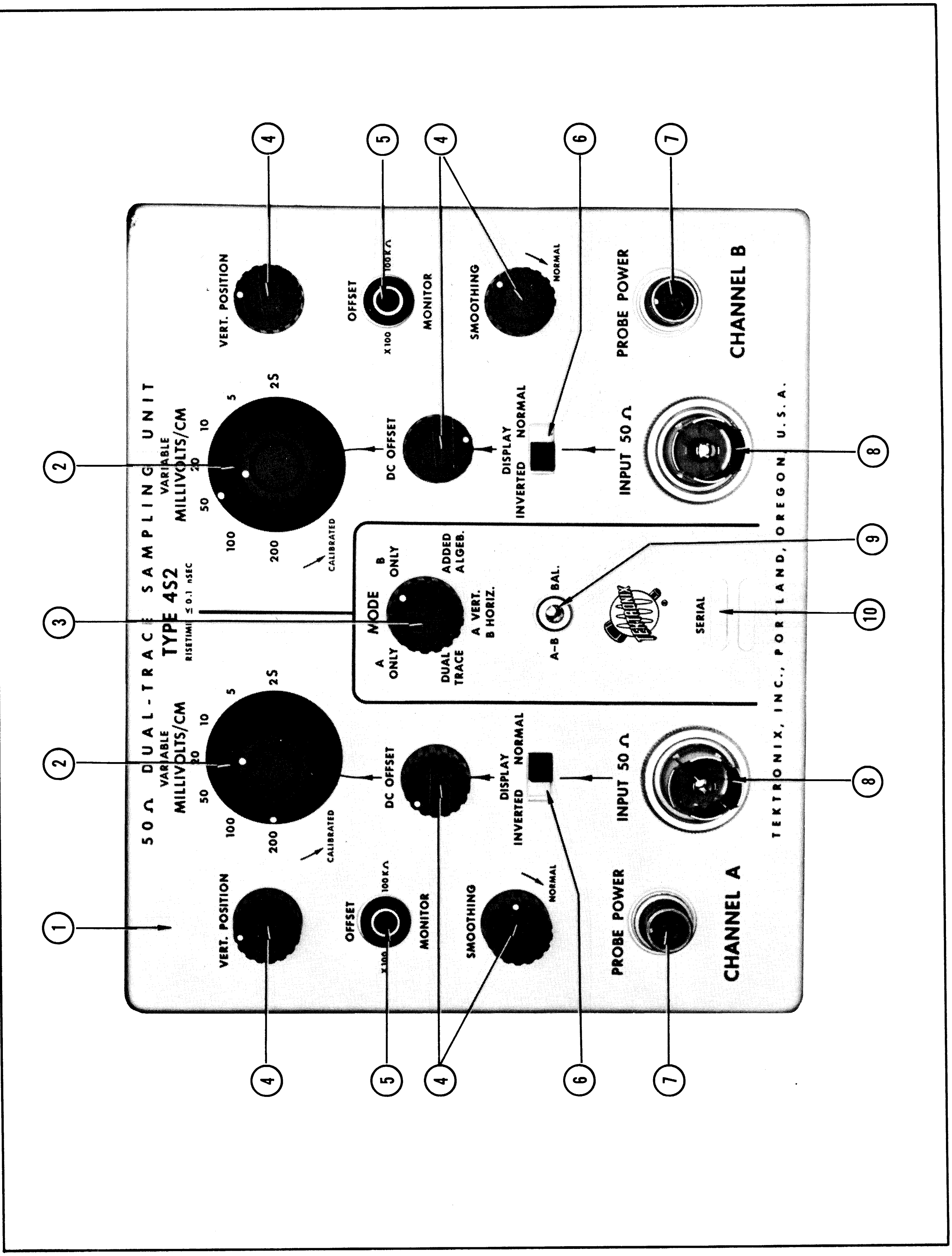
ABBREVIATIONS AND SYMBOLS

a or amp	amperes
BHS	binding head steel
C	carbon
cer	ceramic
cm	centimeter
comp	composition
cps	cycles per second
crt	cathode-ray tube
CSK	counter sunk
dia	diameter
div	division
EMC	electrolytic, metal cased
EMT	electroyltic, metal tubular
ext	external
f	farad
F & I	focus and intensity
FHS	flat head steel
Fil HS	fillister head steel
g or G	giga, or 10^9
Ge	germanium
GMV	guaranteed minimum value
h	henry
hex	hexagonal
HHS	hex head steel
HSS	hex socket steel
HV	high voltage
ID	inside diameter
incd	incandescent
int	internal
k or K	kilohms or kilo (10^3)
kc	kilocycle
m	milli, or 10^{-3}
mc	megacycle
mm	millimeter
meg or M	megohms or mega (10^6)
met.	metal
μ	micro, or 10^{-6}
n	nano, or 10^{-9}
Ω	ohm
OD	outside diameter
OHS	oval head steel
p	pico, or 10^{-12}
PHS	pan head steel
piv	peak inverse voltage
plstc	plastic
PMC	paper, metal cased
poly	polystyrene
Prec	precision
PT	paper tubular
PTM	paper or plastic, tubular, molded
RHS	round head steel
rms	root mean square
sec	second
Si	silicon
S/N	serial number
t or T	tera, or 10^{12}
TD	toroid
THS	truss head steel
tub.	tubular
v or V	volt
Var	variable
w	watt
w/	with
w/o	without
WW	wire-wound

SPECIAL NOTES AND SYMBOLS

X000	Part first added at this serial number.
000X	Part removed after this serial number.
*000-000	Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, or reworked or checked components.
Use 000-000	Part number indicated is direct replacement.
	Internal screwdriver adjustment.
	Front-panel adjustment or connector.

FRONT


50 Ω DUAL-TRACE SAMPLING UNIT
TYPE 4S2
RISETIME ≤ 0.1 nSEC
VERT. POSITION
VARIABLE
MILLIVOLTS/CM
CALIBRATED
OFFSET
X 100
100 KΩ
MONITOR
SMOOTHING
NORMAL
DC OFFSET
DISPLAY
INVERTED
NORMAL
INPUT 50 Ω
PROBE POWER
CHANNEL A
CHANNEL B
MODE
A ONLY
B ONLY
DUAL TRACE
A VERT. B HORIZ.
ADDED ALGEB.
A-B
BAL.
SERIAL
TEKTRONIX
TEKTRONIX, INC., PORTLAND, OREGON, U.S.A.
1
2
3
4
5
6
7
8
9
10

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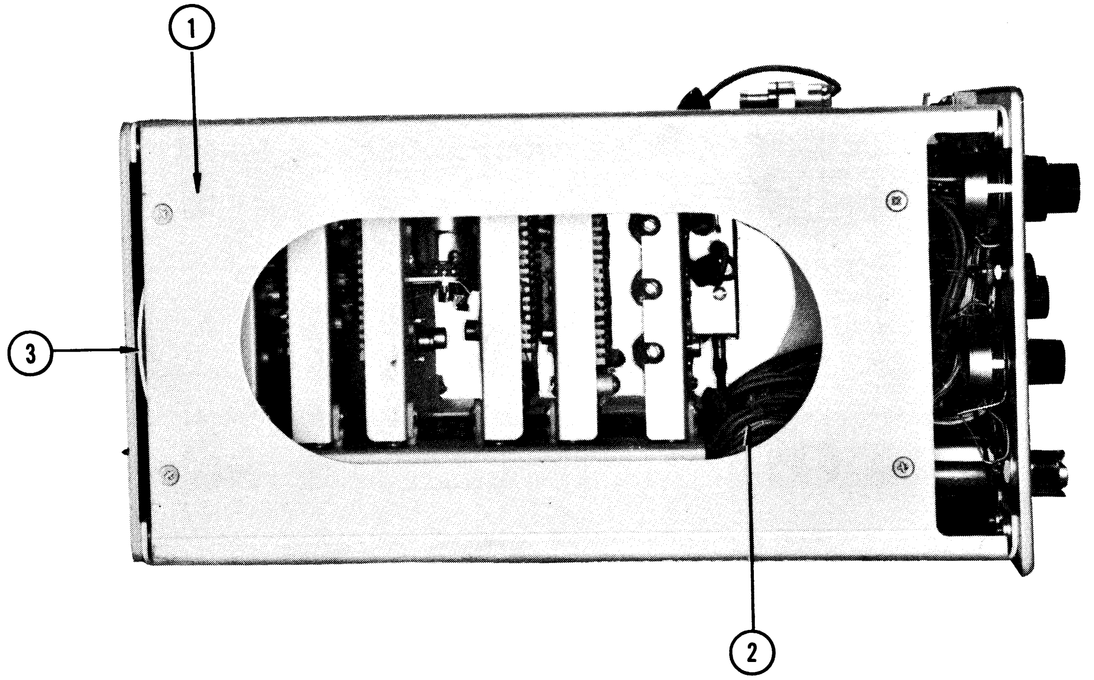
FRONT

REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
1	333-734			1	PANEL, front
	004-149			1	COVER, panel, plastic
	387-613			1	PLATE, front subpanel
2	336-160			2	KNOB, large charcoal, MILLIVOLTS/CM
	366-038			2	KNOB, small red, VARIABLE
3	366-113			1	KNOB, charcoal, MODE
	210-413			1	NUT, hex, 3/8-32 x 1/2
	210-840			1	WASHER, .390 ID x 9/16 OD
	210-012			1	LOCKWASHER, int, 3/8 x 1/2
4	366-148			6	KNOB, small charcoal
	210-413			6	NUT, hex, 3/8-32 x 1/2
	210-840			6	WASHER, .390 ID x 9/16 OD
	210-012			4	LOCKWASHER, int, 3/8 x 1/2
	210-013			2	LOCKWASHER, int, 3/8 x 11/16
	210-207			4	LUG, solder, pot, plain, 3/8
	200-263			2	COVER, dust, pot (not shown)
5	136-052			2	SOCKET, banana jack
	210-895			2	WASHER, insulating
	210-223			2	LUG, solder, 1/4
	210-465			4	NUT, hex, 1/4-32 x 3/8
6	210-406			4	NUT, hex, 4-40 x 3/16 (slide switch mounting)
7	131-206			2	CONNECTOR, probe power
	210-941			2	WASHER, 11/16 OD x .448 ID
	210-559			2	NUT, hex, 7/16-28
8	132-002			2	SLEEVE, conductor, outer
	132-028			2	INSULATOR
	132-029			2	CONDUCTOR, inner
	132-094			2	NUT, retaining
	210-588			2	NUT, panel mount
9	358-054			1	BUSHING, banana jack
	210-471			1	NUT, hex, 1/4-32 x 5/16
10	334-829			1	TAG, metal blank mod. insert
11	334-679			1	TAG, metal serial no. insert

LEFT SIDE



REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
1	426-147			1	FRAME, side rail, left
	387-627			1	PLATE, left, assembly (not shown)
					Mounting Hardware: (not included)
	213-107			4	SCREW, thread forming, 4-40 x 1/4 FHS phillips
	384-594			4	ROD, spacer
	211-559			4	SCREW, 6-32 x 3/8 FHS 100° phillips slot
	211-510			4	SCREW, 6-32 x 3/8 BHS
2	179-717			1	CABLE, harness, signal
3	105-039			2	DRUMLINER, delay line

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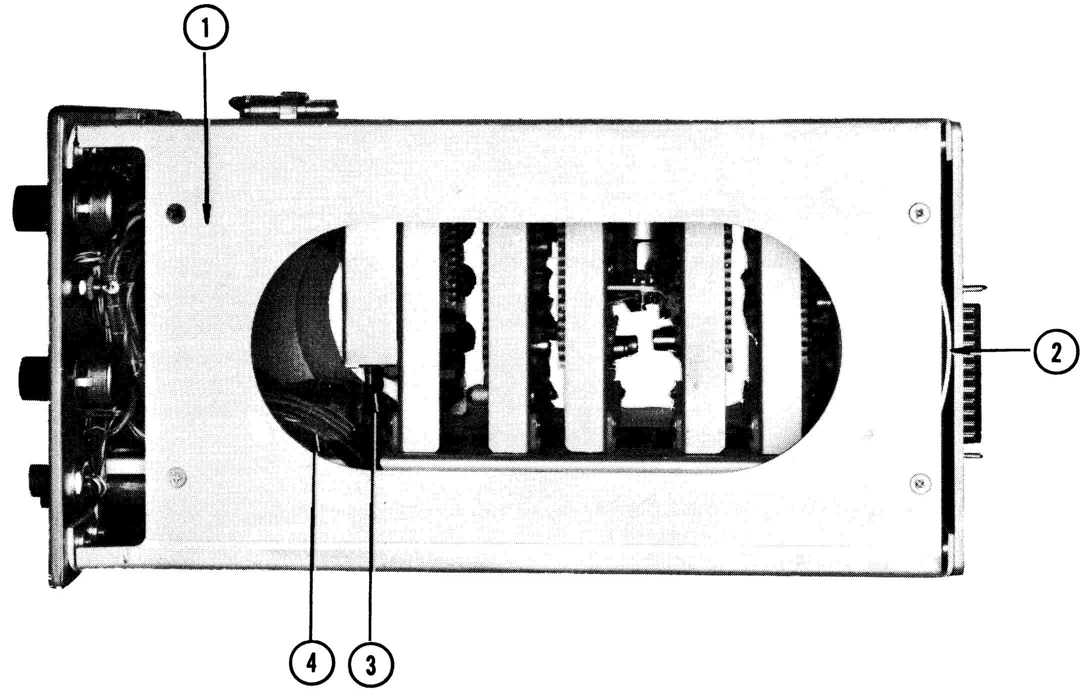
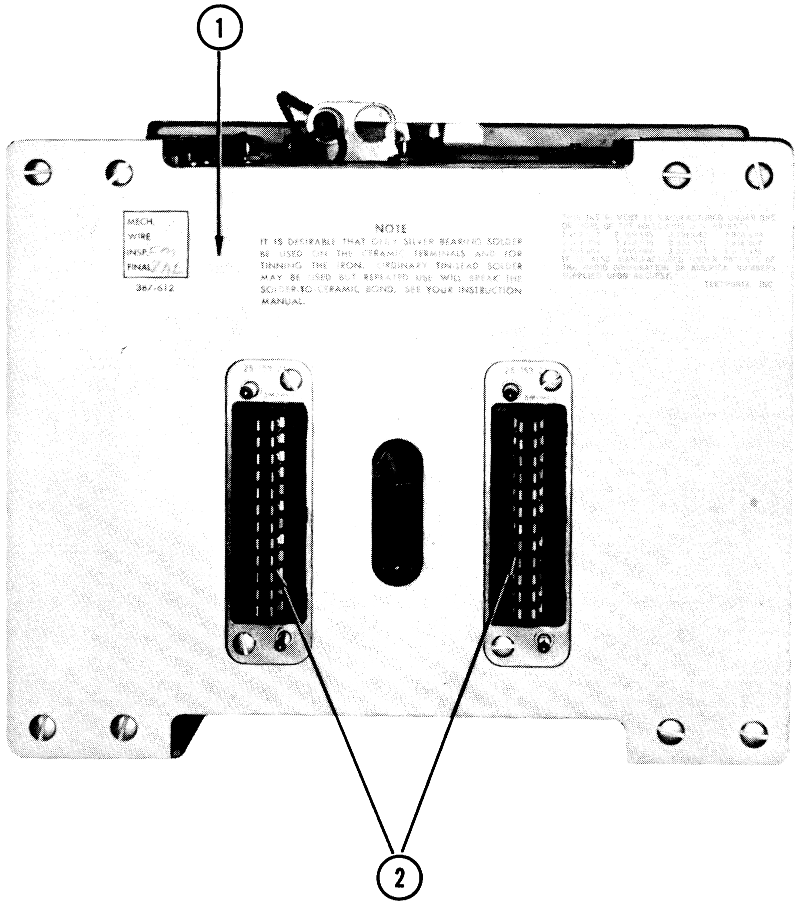
RIGHT SIDE



REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
1	426-146			1	FRAME, side rail, right
	387-743			1	PLATE, right, assembly (not shown)
					Mounting Hardware: (not included)
	213-107			4	SCREW, thread forming, 4-40 x 1/4 FHS phillips
	384-594			4	ROD, spacer
	211-559			4	SCREW, 6-32 x 3/8 FHS 100° phillips slot
	211-510			4	SCREW, 6-32 x 3/8 BHS
2	105-039			2	DRUMLINER, delay line
3	131-155			4	CONNECTOR, coaxial, miniature, 50 μ (not shown)
4	179-718			1	CABLE, harness, subpanel signal

REAR

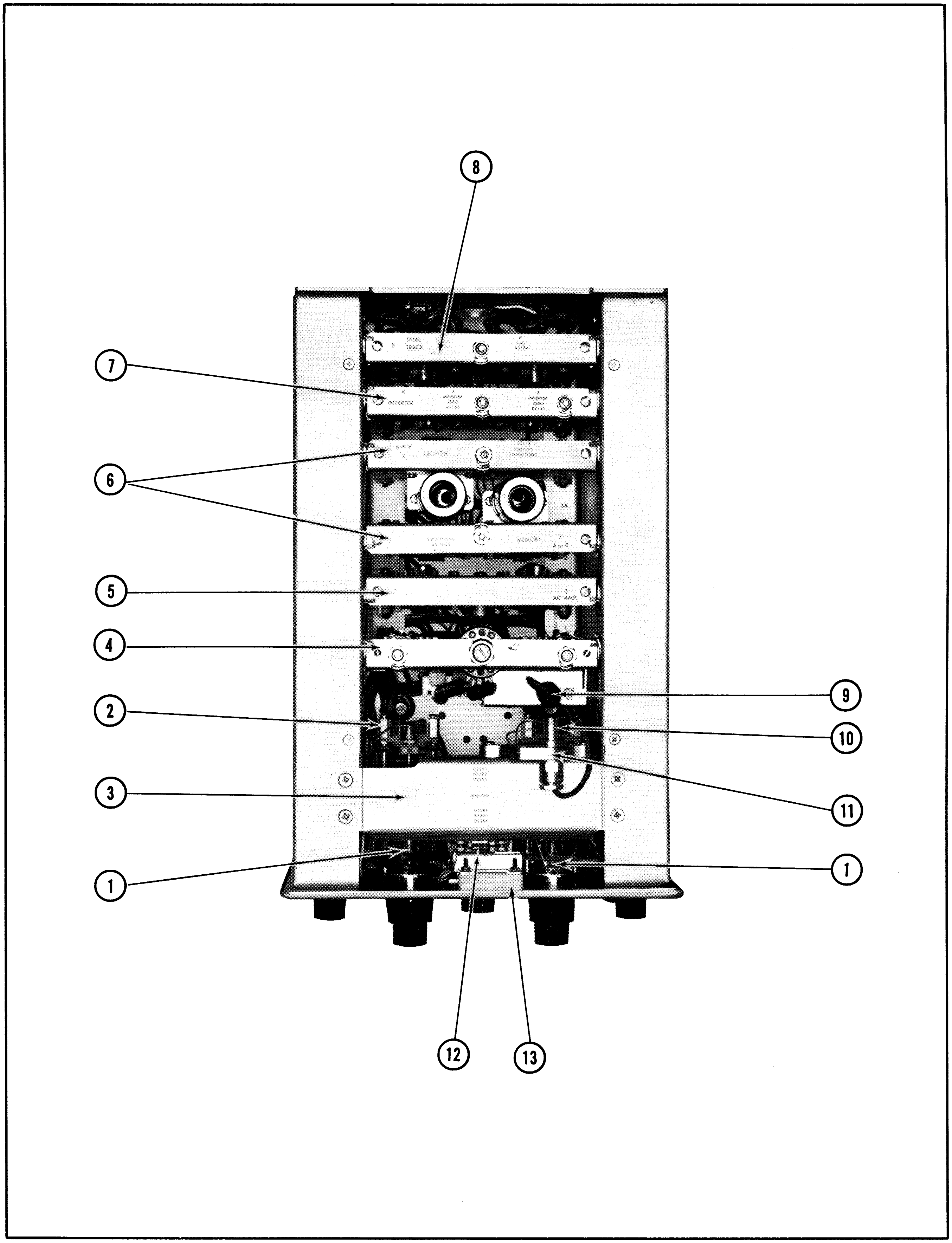


REF. NO.	PART NO	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
1	387-612			1	PLATE, rear
					Mounting Hardware: (not included)
	211-510			8	SCREW, 6-32 x 3/8 BHS
2	131-149			2	CONNECTOR, chassis mt., 24 contact, male
					Mounting Hardware For Each: (not included)
	211-008			2	SCREW, 4-40 x 1/4 BHS
	210-004			1	LOCKWASHER, int. #4
	210-201			1	LUG, solder, SE 4
	210-406			2	NUT, hex, 4-40 x 3/16

TOP

REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
1	262-538			2	SWITCH, MILLIVOLTS/CM, wired
					Each Includes:
	260-434			1	SWITCH, MILLIVOLTS/CM, unwired
2	210-406			2	NUT, hex, 4-40 x 3/16 (pot mounting)
					Mounting Hardware For Each Switch: (not included)
	210-413			1	NUT, hex, 3/8-32 x 1/2
	210-012			1	LOCKWASHER, int, 3/8 x 1/2
3	406-769			1	BRACKET, 50 Ω connector
					Mounting Hardware: (not included)
	211-559			4	SCREW, 6-32 x 3/8 FHS 100° phillips slot
4	605-014			1	ASSEMBLY, Gate Generator Plug-in Chassis
5	605-002			1	ASSEMBLY, A.C. Amp Plug-in Chassis
6	605-010			2	ASSEMBLY, Memory Plug-in Chassis
7	605-009			1	ASSEMBLY, Inverter Plug-in Chassis
8	605-004			1	ASSEMBLY, Dual Trace Plug-in Chassis
9	131-155			1	CONNECTOR, coaxial, miniature, 50 Ω
10	131-211			1	CONNECTOR, push on bulkhead jack
	358-172			1	BUSHING, rod
11	426-152			1	MOUNT, 50 Ω line connector
					Mounting Hardware: (not included)
	211-511			2	SCREW, 6-32 x 1/2 BHS
	210-006			2	LOCKWASHER, int. #6
	210-407			2	NUT, hex, 6-32 x 1/4
12	214-222			1	SPRING, striker
	361-029			1	SPACER, latch spring
					Mounting Hardware: (not included)
	211-082			2	SCREW, 4-40 x 3/8 FHS socket head
	210-004			2	LOCKWASHER, int. #4
	210-406			2	NUT, hex, 4-40 x 3/16
13	406-781			1	BRACKET, diode
					Mounting Hardware: (not included)
	211-538			2	SCREW, 6-32 x 5/16 FHS 100° phillips slot
	210-006			2	LOCKWASHER, int. #6
	210-407			2	NUT, hex, 6-32 x 1/4
	124-149			2	STRIP, ceramic, 7/16 x 7 notches
	361-007			4	SPACER, nylon, molded

TOP VIEW



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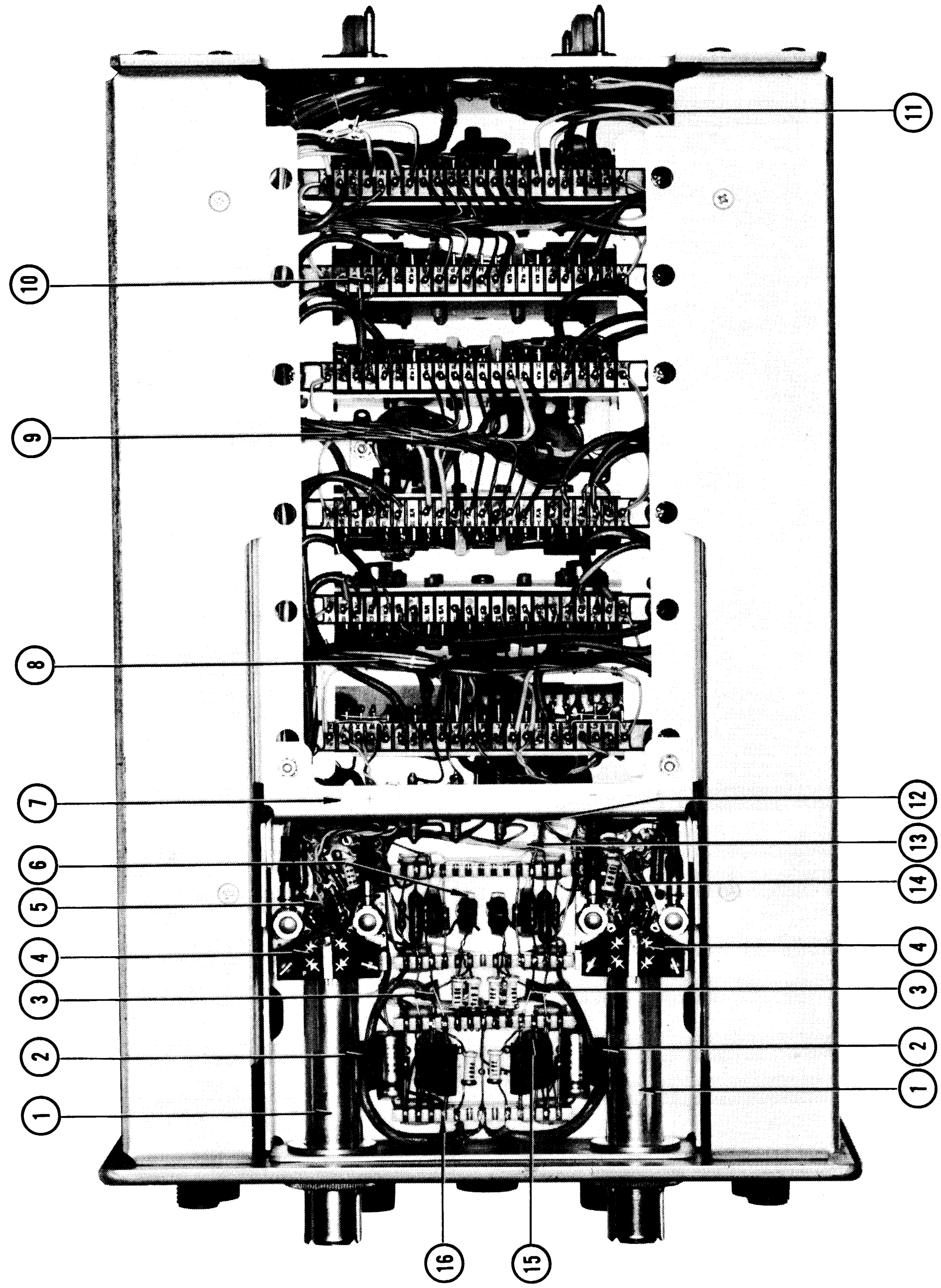
BOTTOM

REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
1	205-047			2	SHELL, outer air lines
	131-266			2	CONNECTOR, inner air line
2	348-004			2	GROMMET, rubber, $^3/_8$
3	210-201			2	LUG, solder, SE4
	213-044			2	SCREW, thread cutting, 5-32 x $^3/_{16}$ PHS phillips slot
4	391-056			4	BLOCK, mounting, gate chassis
	211-020			4	SCREW, 4-40 x 1$^1/_8$ RHS
5	670-032			1	ASSEMBLY, Diode Gate B Board
					Includes:
	131-265			2	CONNECTOR, coaxial, right angle
	344-064			8	CLIP, diode
	136-125			1	SOCKET, 5 pin tube
	387-603			1	PLATE, insulating, socket
	131-155			2	CONNECTOR, coaxial, miniature (not included)
	337-562			1	SHIELD, diode, sampler board (not included)
6	426-121			4	MOUNT, toroid
	361-007			4	SPACER, nylon, molded
7	441-470			1	CHASSIS, sampler
					Mounting Hardware: (not included)
	210-406			2	NUT, hex, 4-40 x $^3/_{16}$
	210-004			2	LOCKWASHER, int. #4
8	179-716			1	CABLE harness, subpanel power
9	179-631			1	CABLE harness, power supply
10	131-220			6	CONNECTOR, .22 contact, female
					Mounting Hardware for Each: (not included)
	211-578			2	SCREW, 6-32 x $^7/_{16}$ PHS phillips slot
	210-006			2	LOCKWASHER, int. #6
	210-407			2	NUT, hex, 6-32 x $^1/_4$
11	179-632			1	CABLE harness, digital readout
12	348-003			5	GROMMET, rubber, $^5/_{16}$
13	179-720			1	CABLE harness, sampler chassis
14	670-031			1	ASSEMBLY, Diode Gate A Board
					Includes:
	131-265			2	CONNECTOR, coaxial, right angle
	344-064			8	CLIP, diode
	136-125			1	SOCKET, 5 pin tube
	387-603			1	PLATE, insulating, socket
	131-155			2	CONNECTOR, coaxial, miniature (not included)
	337-562			1	SHIELD, diode, sampler board (not included)
15	136-095			2	SOCKET, 4 pin transistor
					Mounting Hardware for Each: (not included)
	213-113			2	SCREW, 2-32 x $^5/_{16}$ RHS phillips slot
16	124-147			4	STRIP, ceramic, $^7/_{16}$ x 13 notches
	361-007			8	SPACER, nylon, molded

BOTTOM



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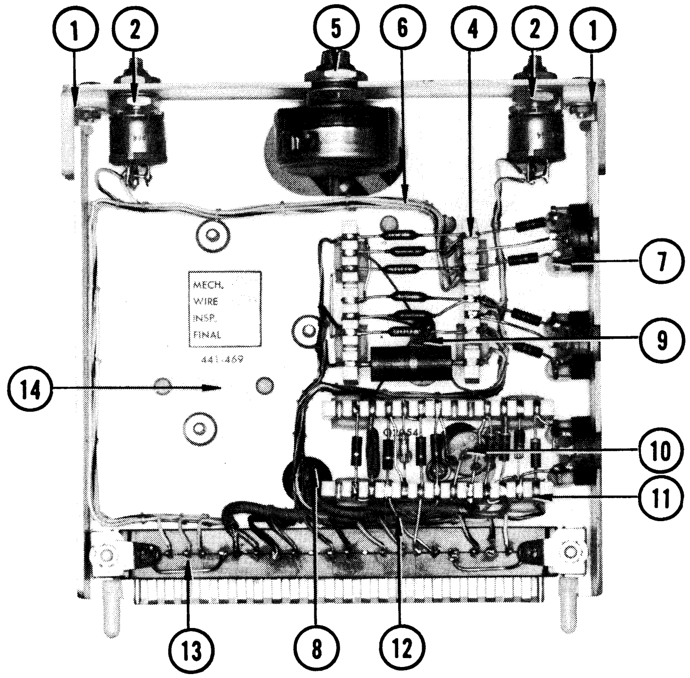
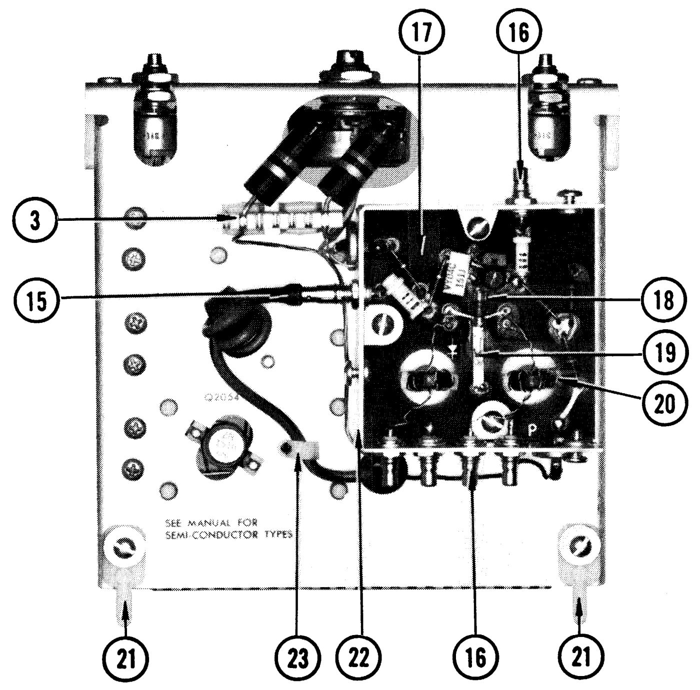
GATE GENERATOR CHASSIS

REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
	605-014			1	ASSEMBLY, Gate Generator Plug-in Chassis
					Includes:
1	352-039			2	HOLDER, plug-in chassis
					Mounting Hardware For Each: (not included)
	211-011			1	SCREW, 4-40 x $^5/_{16}$ BHS
	210-004			1	LOCKWASHER, int. #4
	210-406			1	NUT, hex, 4-40 x $^3/_{16}$
2	210-465			2	NUT, hex, $^1/_4$-32 x $^3/_8$
3	124-149			3	STRIP, ceramic, $^7/_{16}$ x 7 notches
	361-007			6	SPACER, nylon, molded
4	124-148			2	STRIP, ceramic, $^7/_{16}$ x 9 notches
	361-007			4	SPACER, nylon, molded
5	210-413			2	NUT, hex, $^3/_8$-32 x $^1/_2$
	210-012			1	LOCKWASHER, int., $^3/_8$ x $^1/_2$
6	179-740			1	CABLE, harness, gate channel B
7	406-635			3	BRACKET, low capacity pot mtg.
					Mounting Hardware For Each: (not included)
	213-035			2	SCREW, thread cutting, 4-40 x $^1/_4$ PHS phillips
	210-438			6	NUT, hex, 1-72 x $^5/_{32}$ (pot mounting)
8	348-003			2	GROMMET, rubber, $^5/_{16}$
9	210-201			1	LUG, solder, SE 4
	213-044			1	SCREW, thread cutting, 5-32 x $^3/_{16}$ PHS phillips
10	136-095			1	SOCKET, 4 pin transistor
					Mounting Hardware: (not included)
	211-081			2	SCREW, 2-56 x $^9/_{16}$ RHS phillips slot
	361-035			2	SPACER, transistor socket
11	124-147			2	STRIP, ceramic, $^7/_{16}$ x 13 notches
	361-007			4	SPACER, nylon, molded
12	179-719			1	CABLE, harness
13	131-218			1	CONNECTOR, 22 contact
					Mounting Hardware: (not included)
	211-016			2	SCREW, 4-40 x $^5/_8$ RHS
	210-003			2	LOCKWASHER, ext. #4
	210-201			2	LUG, solder, SE 4
	210-406			2	NUT, hex, 4-40 x $^3/_{16}$
14	441-469			1	CHASSIS
15	131-155			1	CONNECTOR, coaxial, miniature, 50 Ω
16	131-156			6	CONNECTOR, coaxial, miniature, 50 Ω
17	388-540			1	BOARD, etched circuit, charge line
	136-096			1	SOCKET, 4 pin transistor (not shown)
18	344-064			1	CLIP, diode
19	344-061			1	CLIP, diode
20	426-121			2	MOUNT, toroid
	361-007			2	SPACER, nylon, molded
21	384-593			2	ROD, pin index
22	406-891			1	BRACKET, avalanche generator
					Mounting Hardware: (not included)
	211-015			3	SCREW, 4-40 x $^1/_2$ RHS
	210-004			3	LOCKWASHER, int. #4
	210-406			3	NUT, hex, 4-40 x $^3/_{16}$
	200-456			1	COVER, avalanche generator (not shown)
					Mounting Hardware: (not included)
	211-007			3	SCREW, 4-40 x $^3/_{16}$ BHS
	210-004			3	LOCKWASHER, int. #4
	210-406			3	NUT, hex, 4-40 x $^3/_{16}$

GATE GENERATOR





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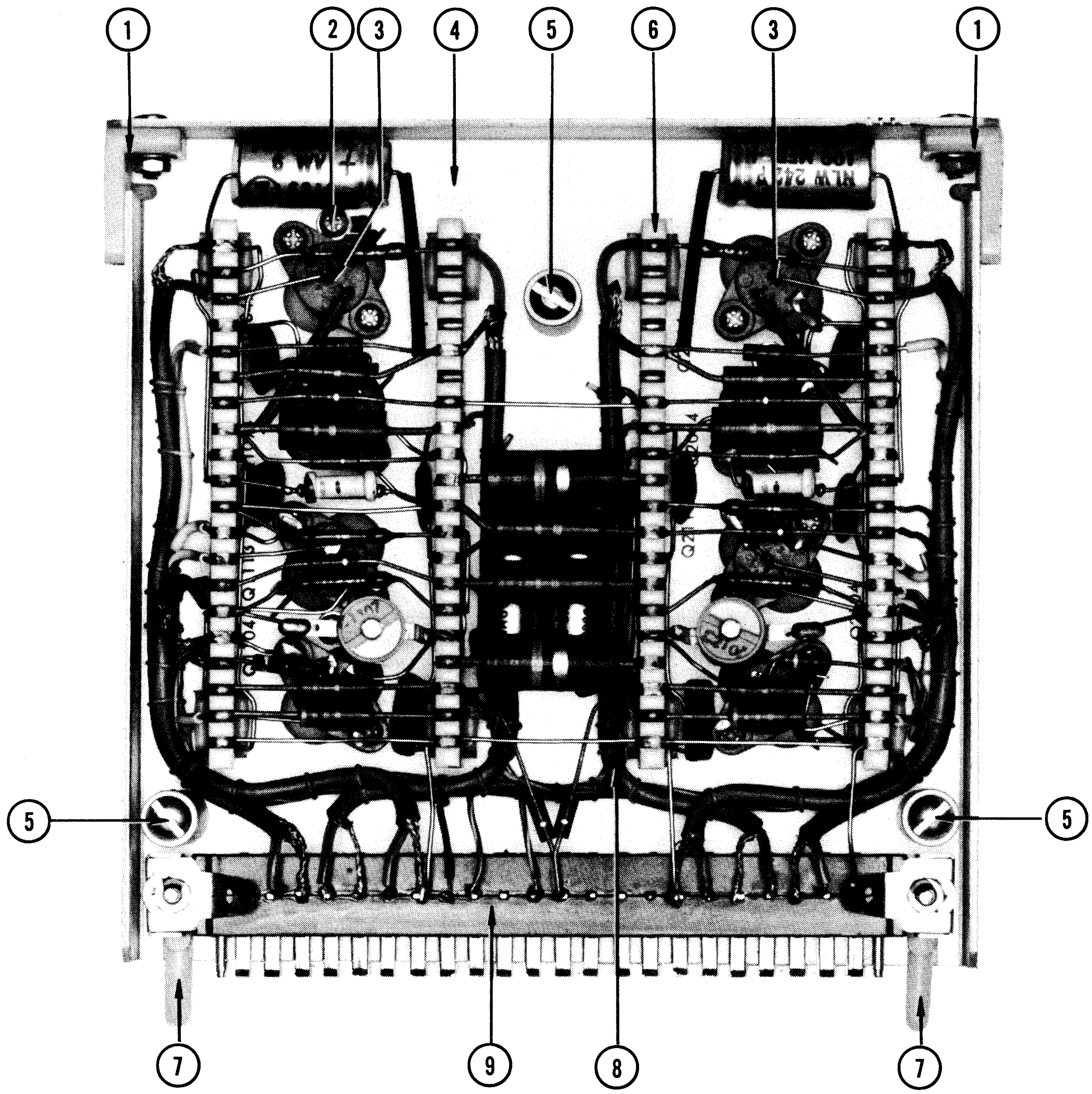
A.C. AMPLIFIER CHASSIS

REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
	605-002			1	ASSEMBLY, A.C. Amplifier Plug-in Chassis
					Includes:
1	352-039			2	HOLDER, plug-in chassis
					Mounting Hardware For Each: (not included)
	211-011			1	SCREW, 4-40 x $^5/_{16}$ BHS
	210-004			1	LOCKWASHER, int. #4
	210-406			1	NUT, hex, 4-40 x $^3/_{16}$
2	210-215			5	LUG, banana, peewee
	213-035			5	SCREW, thread cutting, 2-56 x $^3/_{16}$ PHS phillips
3	136-095			8	SOCKET, 4 pin transistor
					Mounting Hardware For Each: (not included)
	211-081			2	SCREW, 2-56 x $^9/_{16}$ RHS phillips slot
	361-035			2	SPACER, transistor socket
4	441-424			1	CHASSIS
5	385-160			3	ROD, spacer
					Mounting Hardware For Each: (not included)
	211-507			1	SCREW, 6-32 x $^5/_{16}$ BHS
	337-492			1	SHIELD, A.C. Amplifier (not included in assembly — not shown)
					Mounting Hardware: (not included)
	211-543			3	SCREW, 6-32 x $^5/_{16}$ RHS
6	124-145			4	STRIP, ceramic, $^7/_{16}$ x 20 notches
	361-008			8	SPACER, nylon, molded
7	384-593			2	ROD, pin index
8	179-626			1	CABLE, harness
9	131-218			1	CONNECTOR, 22 contact
					Mounting Hardware: (not included)
	211-016			2	SCREW, 4-40 x $^5/_8$ RHS
	210-003			2	LOCKWASHER, ext. #4
	210-201			2	LUG, solder, SE 4
	210-406			2	NUT, hex, 4-40 x $^3/_{16}$

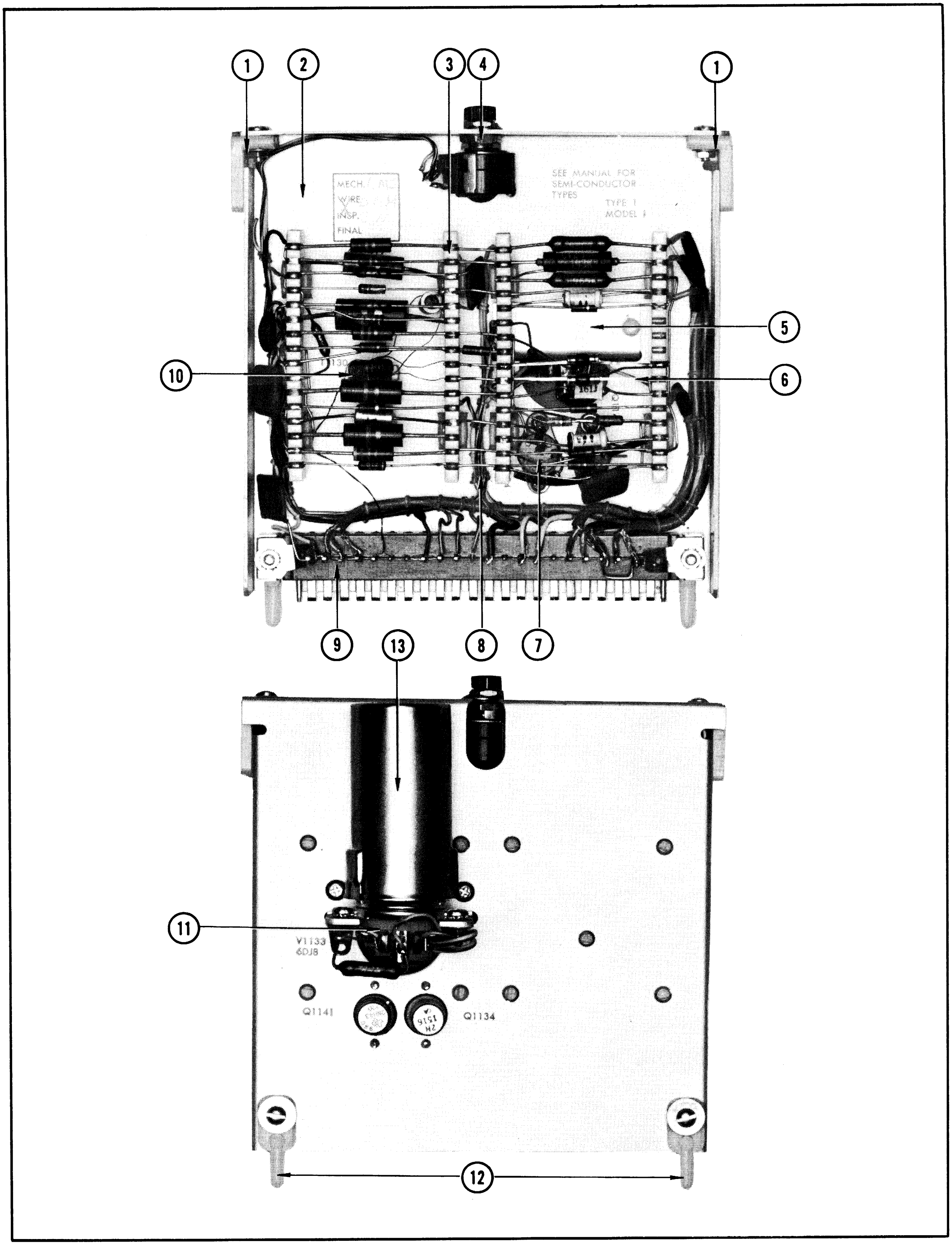
AC AMPLIFIER



MEMORY CHASSIS

REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
	605-010			2	ASSEMBLY, Memory Plug-in Chassis
					Each Includes:
1	352-039			2	HOLDER, plug-in chassis
					Mounting Hardware For Each: (not included)
	211-011			1	SCREW, 4-40 x $^5/_{16}$ BHS
	210-004			1	LOCKWASHER, int. #4
	210-406			1	NUT, hex, 4-40 x $^3/_{16}$
2	441-419			1	CHASSIS
3	124-146			4	STRIP, ceramic, $^7/_{16}$ x 16 notches
	361-008			8	SPACER, nylon, molded
4	210-465			1	NUT, hex, $^1/_4$-32 x $^3/_8$
5	406-765			1	BRACKET, socket mount
					Mounting Hardware: (not included)
	213-044			2	SCREW, thread cutting, 5-32 x $^3/_{16}$ PHS phillips
	200-174			1	CAP, screw, protective
6	344-061			4	CLIP, diode
7	136-095			2	SOCKET, 4 pin transistor
					Mounting Hardware For Each: (not included)
	213-113			2	SCREW, 2-32 x $^5/_{16}$ RHS phillips slot
	210-215			1	LUG, banana, peewee
8	179-627			1	CABLE, harness
9	131-218			1	CONNECTOR, 22 contact
					Mounting Hardware: (not included)
	211-016			2	SCREW, 4-40 x $^5/_8$ RHS
	210-003			2	LOCKWASHER, ext. #4
	210-201			2	LUG, solder, SE 4
	210-406			2	NUT, hex, 4-40 x $^3/_{16}$
10	426-121			1	MOUNT, toroid
	361-007			1	SPACER, nylon, molded
11	136-085			1	SOCKET, 9 pin shielded base
					Mounting Hardware: (not included)
	211-033			2	SCREW, 4-40 x $^5/_{16}$ PHS w/lockwasher
	210-004			1	LOCKWASHER, int. #4
	210-201			1	LUG, solder, SE 4
	201-406			2	NUT, hex, 4-40 x $^3/_{16}$
12	384-593			2	ROD, pin index
13	337-008			1	SHIELD, tube (not included in assembly)

MEMORY CHASSIS



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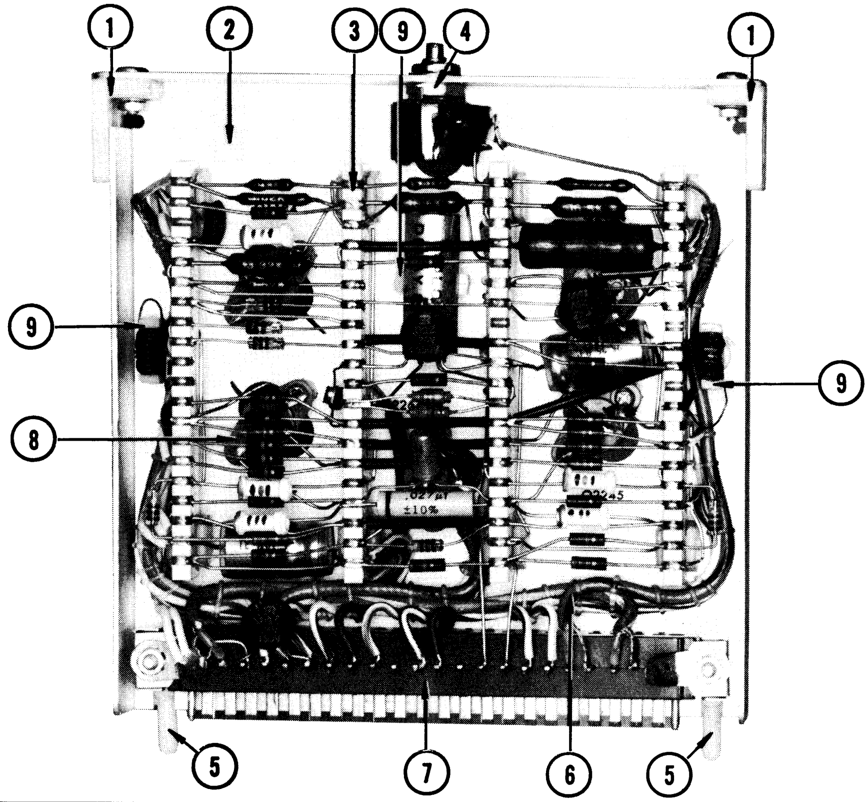
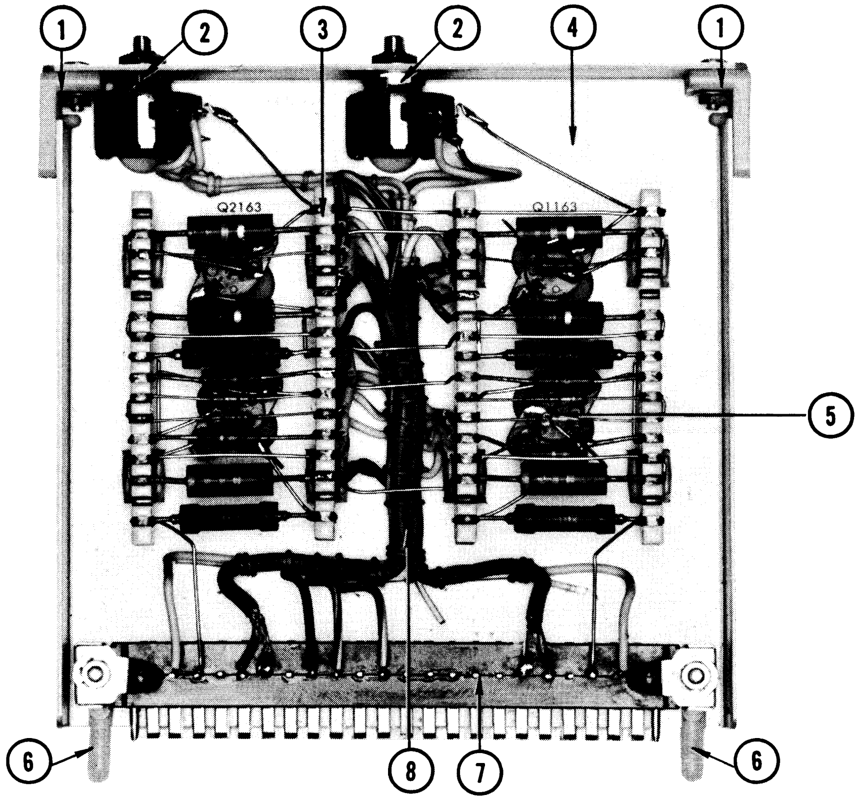
DUAL TRACE CHASSIS



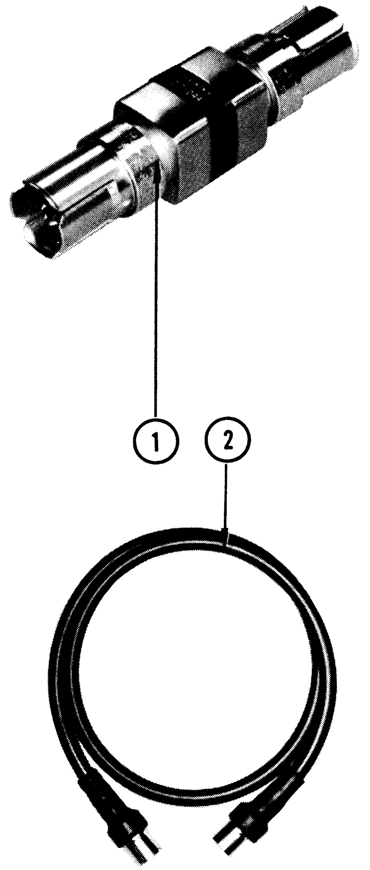
REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
	605-004			1	ASSEMBLY, Dual Trace Plug-in Chassis
					Includes:
1	352-039			2	HOLDER,plug-in chassis
					Mounting Hardware For Each: (not included)
	211-011			1	SCREW, 4-40 x 5/16 BHS
	210-004			1	LOCKWASHER, int. #4
	210-406			1	NUT, hex, 4-40 x 3/16
2	441-471			1	CHASSIS
3	124-145			4	STRIP, ceramic, 7/16 x 20 notches
	361-008			8	SPACER, nylon, molded
4	210-465			1	NUT, hex, 1/4-32 x 3/8
5	210-204			1	LUG, solder, DE 6
	213-044			1	SCREW, thread cutting, 5-32 x 3/16 PHS phillips
6	384-593			2	ROD, pin index
7	179-715			1	CABLE, harness
8	210-215			1	LUG, banana, peewee
	213-055			1	SCREW, thread cutting, 2-56 x 3/16 PHS phillips
9	131-218			1	CONNECTOR, 22 contact
					Mounting Hardware: (not included)
	211-016			2	SCREW, 4-40 x 5/8 RHS
	210-003			2	LOCKWASHER, ext. #4
	210-201			2	LUG, solder, SE 4
	210-406			2	NUT, hex, 4-40 x 3/16
10	136-095			5	SOCKET, 4 pin transistor
					Mounting Hardware For Each: (not included)
	211-081			2	SCREW, 2-56 x 9/16 RHS phillips slot
	361-035			2	SPACER, transistor socket
11	210-201			1	LUG, solder, SE 4
	213-044			1	SCREW, thread cutting, 5-32 x 3/16 PHS phillips

INVERTER CHASSIS



REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
	605-009			1	ASSEMBLY, Inverter Plug-in Chassis Includes:
1	352-039			2	HOLDER, plug-in chassis Mounting Hardware For Each: (not included)
	211-011			1	SCREW, 4-40 x 5/16 BHS
	210-004			1	LOCKWASHER, int. #4
	210-406			1	NUT, hex, 4-40 x 3/16
2	210-465			2	NUT, hex, 1/4-32 x 3/8
3	124-146			4	STRIP, ceramic, 7/16 x 16 notches
	361-008			8	SPACER, nylon, molded
4	441-418			1	CHASSIS
5	136-095			4	SOCKET, 4 pin transistor Mounting Hardware For Each: (not included)
	211-081			2	SCREW, 2-56 x 9/16 RHS phillips slot
	361-035			2	SPACER, transistor socket
6	384-593			2	ROD, pin index
7	131-218			1	CONNECTOR, 22 contact Mounting Hardware: (not included)
	211-016			2	SCREW, 4-40 x 5/8 RHS
	210-003			2	LOCKWASHER, ext. #4
	210-201			2	LUG, solder, SE 4
	210-406			2	NUT, hex, 4-40 x 3/16
8	179-628			1	CABLE, harness

ACCESSORIES

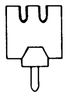


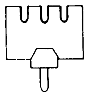
REF. NO.	PART NO	SERIAL NO. EFF.	SERIAL NO. DISC.	Q T Y.	DESCRIPTION
1	017-044			2	50 Ω 10X ATTENUATOR
2	017-502			2	50 Ω 5 NSEC CABLE

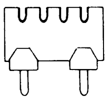
CERAMIC STRIPS AND MOUNTINGS

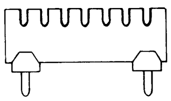
3/4 inch

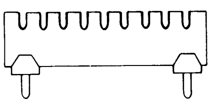

1 notch 124-100

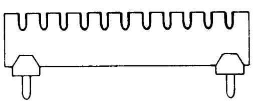

2 notch 124-086


3 notch 124-087


4 notch 124-088

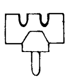

7 notch 124-089

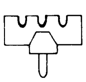

9 notch 124-090

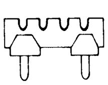

11 notch 124-091

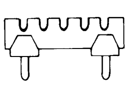
7/16 inch

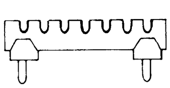

1 notch 124-118

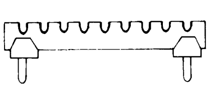

2 notch 124-119

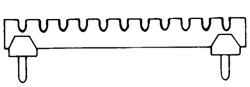

3 notch 124-092


4 notch 124-120

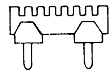

5 notch 124-093

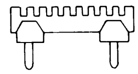

7 notch 124-094

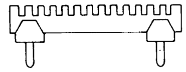

9 notch 124-095

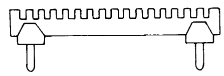

11 notch 124-106

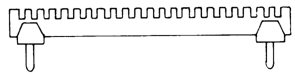
7/16 inch SMALL NOTCH —Short Stud


7 notch 124-149

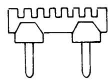

9 notch 124-148

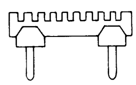

13 notch 124-147

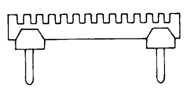

16 notch 124-146

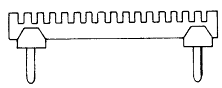

20 notch 124-145

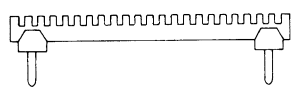
7/16 inch SMALL NOTCH —Tall Stud


7 notch 124-158


9 notch 124-157

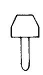

13 notch 124-156


16 notch 124-155


20 notch 124-154

MOUNTINGS


Stud, nylon, short..355-046


Stud, nylon, tall .. 355-082


Spacer, $^{11}/_{32}$ inch..361-039


Spacer, $^{3}/_{8}$ inch .. 361-009


Spacer, $^{1}/_{4}$ inch...361-008


Spacer, $^{5}/_{32}$ inch...361-007

Ceramic strips include studs, but spacers must be ordered separately by part no.

ELECTRICAL PARTS LIST

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Description				S/N Range

Capacitors

Tolerance ±20% unless otherwise indicated.

Tolerance of all electrolytic capacitors are as follows (with exceptions):

3 V — 50 V = —10%, +250%
51 V — 350 V = —10%, +100%
351 V — 450 V = —10%, +50%

C1007	283-074	20 pf	Disc Type	500 v	10%	
C1017	283-074	20 pf	Disc Type	500 v	10%	
C1031	283-024	.1 μf	Disc Type	30 v		
C1033	290-145	10 μf	EMT	50 v		
C1034	281-536	.001 μf	Cer.	500 v	10%	
C1037	281-513	27 pf	Cer.	500 v		
C1041	281-559	1500 pf	Cer.	500 v		
C1043	281-559	1500 pf	Cer.	500 v		
C1045	281-559	1500 pf	Cer.	500 v		
C1047	281-536	.001 μf	Cer.	500 v	10%	
C1049	281-536	.001 μf	Cer.	500 v	10%	
C1176	283-003	.01 μf	Disc Type	150 v		
C2007	283-074	20 pf	Disc Type	500 v	10%	
C2017	283-074	20 pf	Disc Type	500 v	10%	
C2031	283-024	.1 μf	Disc Type	30 v		
C2033	290-145	10 μf	EMT	50v		
C2034	281-536	.001 μf	Cer.	500 v	10%	
C2037	281-513	27 pf	Cer.	500 v		
C2047	281-536	.001 μf	Cer.	500 v	10%	
C2049	281-536	.001 μf	Cer.	500 v	10%	

Diodes

D1002, D1003	*152-114	Point contact, low capacitance (1 pair)		
D1004, D1005	*152-114	Point contact, low capacitance (1 pair)		
D1282	152-066	Silicon	1N3194	
D1283	152-066	Silicon	1N3194	
D1284	152-066	Silicon	1N3194	
D2002, D2003	*152-114	Point contact, low capacitance (1 pair)		
D2004, D2005	*152-114	Point contact, low capacitance (1 pair)		
D2282	152-066	Silicon	1N3194	
D2283	152-066	Silicon	1N3194	
D2284	152-066	Silicon	1N3194	

Inductors

Ckt. No.	Tektronix Part No.	Description	S/N Range
L1021	276-532	Core, Shield Bead	
L1026	*120-306	Toroid 40T TD91	
L2021	276-532	Core, Shield Bead	
L2026	*120-306	Toroid 40T TD91	

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

R1001	307-068	50 Ω				1%
R1002	301-151	150 Ω	½ w			5%
R1007	317-270	27 Ω	1/10 w			5%
R1008	317-201	200 Ω	1/10 w			5%
R1009	317-201	200 Ω	1/10 w			5%
R1010	315-103	10 k	¼ w			5%
R1017	317-270	27 Ω	1/10 w			5%
R1018	317-201	200 Ω	1/10 w			5%
R1019	317-201	200 Ω	1/10 w			5%
R1020	315-103	10 k	¼ w			5%
R1024	309-051	200 k	½ w		Prec.	1%
R1025	309-327	750 Ω	½ w		Prec.	1%
R1026	316-101	100 Ω	¼ w			
R1027	318-073	5.88 k	⅛ w		Prec.	1%
R1031	318-078	50.5 k	⅛ w		Prec.	1%
R1032	301-244	240 k	½ w			5%
R1033	316-101	100 Ω	¼ w			
R1034	303-273	27 w	1 w			5%
R1036	318-033	20.4 k	⅛ w		Prec.	1%
R1037	318-109	500 k	⅛ w		Prec.	1%
R1038	316-274	270 k	¼ w			
R1080B	318-037	500 Ω	⅛ w		Prec.	1%
R1080C	318-064	250 Ω	⅛ w		Prec.	1%
R1080D	318-050	150 Ω	⅛ w		Prec.	1%
R1080E	318-066	50 Ω	⅛ w		Prec.	1%
R1080F	318-038	24.9 Ω	⅛ w		Prec.	1%
R1080G	318-038	24.9 Ω	⅛ w		Prec.	1%
R1081	311-220	1 k		Var.		SMOOTHING A
R1147A	318-089	583 k	⅛ w		Prec.	1%
R1147B	318-088	229.7 k	⅛ w		Prec.	1%
R1147C	318-087	112 k	⅛ w		Prec.	1%
R1147D	318-086	53 k	⅛ w		Prec.	1%
R1147E	318-085	17.67 k	⅛ w		Prec.	1%
R1147F	318-073	5.88 k	⅛ w		Prec.	1%
R1149	321-601	2.141 k	⅛ w		Prec.	¼%

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Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
R1157	303-623	62 k	1 w			5%	
R1158	301-104	100 k	½ w			5%	
R1159	311-271	200 k		Var.		DC OFFSET A	
R1160	321-606	20 k	⅛ w		Prec.	¼%	
R1169	301-104	100 k	½ w			5%	
R1170	321-603	15 k	⅛ w		Prec.	¼%	
R1171	321-604	30 k	⅛ w		Prec.	¼%	
R1172	311-172	2.5 k		Var.		AC BAL.	
R1173†	*311-296	7 k		Var.	WW	VARIABLE A	
R1176	301-101	100 Ω	½ w			5%	
R1179	315-912	9.1 k	¼ w			5%	
R1180	311-016	10 k	2 w	Var.		POSITION A	
R1283	301-225	2.2 meg	½ w			5%	
R2001	307-068	50 Ω				1%	
R2002	301-151	150 Ω	½ w			5%	
R2007	317-270	27 Ω	1/10 w			5%	
R2008	317-201	200 μ	1/10 w			5%	
R2009	317-201	200 Ω	1/10 w			5%	
R2010	315-103	10 k	¼ w			5%	
R2017	317-270	27 Ω	1/10 w			5%	
R2018	317-201	200 Ω	1/10 w			5%	
R2019	317-201	200 Ω	1/10 w			5%	
R2020	315-103	10 k	¼ w			5%	
R2024	309-051	200 k	½ w		Prec.	1%	
R2025	309-327	750 Ω	½ w		Prec.	1%	
R2026	316-101	100 Ω	¼ w				
R2027	318-073	5.88 k	⅛ w		Prec.	1%	
R2031	318-078	50.5 k	⅛ w		Prec.	1%	
R2032	301-244	240 k	½ w			5%	
R2033	316-101	100 Ω	¼ w				
R2034	303-273	27 k	1 w			5%	
R2036	318-033	20.4 k	⅛ w		Prec.	1%	
R2037	318-109	500 k	⅛ w		Prec.	1%	
R2038	316-274	270 k	¼ w				
R2080B	318-037	500 Ω	⅛ w		Prec.	1%	
R2080C	318-064	250 Ω	⅛ w		Prec.	1%	
R2080D	318-050	150 Ω	⅛ w		Prec.	1%	
R2080E	318-066	50 Ω	⅛ w		Prec.	1%	
R2080F	318-038	24.9 Ω	⅛ w		Prec.	1%	
R2080G	318-038	24.9 Ω	⅛ w		Prec.	1%	
R2081	311-220	1 k		Var.		SMOOTHING B	
R2147A	318-089	583 k	⅛ w		Prec.	1%	
R2147B	318-088	229.7 k	⅛ w		Prec.	1%	
R2147C	318-087	112 k	⅛ w		Prec.	1%	
R2147D	318-086	53 k	⅛ w		Prec.	1%	

† Concentric with SW1282. Furnished as a unit.

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
R2147E	318-085	17.67 k	⅛ w		Prec.	1%	
R2147F	318-073	5.88 k	⅛ w		Prec.	1%	
R2149	321-601	2.141 k	⅛ w		Prec.	¼%	
R2157	303-623	62 k	1 w			5%	
R2158	301-104	100 k	½ w			5%	
R2159	311-271	200 k		Var.		DC OFFSET B	
R2160	321-606	203 k	⅛ w		Prec.	¼%	
R2169	301-104	100 k	½ w			5%	
R2170	321-603	15 k	⅛ w		Prec.	¼%	
R2171	321-604	30 k	⅛ w		Prec.	¼%	
R2173[1]	*311-296	7 k		Var.	WW	VARIABLE B	
R2175	315-753	75 k	¼ w			5%	
R2180	311-016	10 k	2 w	Var.		POSITION B	
R2283	301-225	2.2 meg	½ w			5%	

Switches

	Unwired	Wired		
SW1101	260-434	*262-538	Rotary	MV/CM A
SW1171	260-212		Slide	DISPLAY A
SW1282[2]	*311-296			CALIBRATED A
SW2101	260-434	*262-538	Rotary	MV/CM B
SW2171	260-212		Slide	DISPLAY B
SW2190	260-514	*262-550		MODE
SW2282[3]	*311-296		Rotary	CALIBRATED B

Transformers

T1049	*120-299	Toroid 8T TD84
T2049	*120-299	Toroid 8T TD84

Transistors

Q1034	151-063	PADT 35
Q2034	151-063	PADT 35

Electron Tubes

V1024	154-306	7586
V2024	154-306	7586

[1] Concentric with SW2282. Furnished as a unit.
[2] Concentric with R1173. Furnished as a unit.
[3] Concentric with R2173. Furnished as a unit.

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"GATE GENERATOR" Series 6

*605-014 Complete Board

Capacitors

Ckt. No.	Tektronix Part No.	Description					Model No.
C1052	281-543	270 pf	Cer.		500 v	10%	
C1054	283-549	25 pf	Mica			10%	
C1057	283-549	25 pf	Mica			10%	
C1060	281-512	27 pf	Cer.		500 v	10%	
C1064	283-589	150 pf	Mica		500 v	5%	
C1065	281-594	150 pf	Cer.		100 v	5%	
C2059	283-026	.2 μf	Disc Type		25 v		

Diodes

D1054	152-076	Zener		3 v ¼ w 10%			
D1065	*152-112	Snap off		32 v			
D2052	152-071	Germanium		ED2007			
D2057	152-025	Germanium		1N634			

Inductors

L1065	*388-540	Part of etched circuit board					

Resistors

R1053	316-472	4.7 k	¼ w				
R1054	315-104	100 k	¼ w			5%	
R1056	306-123	12 k	2 w				
R1057	311-357	10 k		Var.		AVALANCHE VOLTS	
R1058	306-472	4.7 k	2 w				
R1059	316-102	1 k	¼ w				
R1064	316-102	1 k	¼ w				
R1070	318-096	1.5 meg	⅛ w		Prec.	1%	
R1071	318-115	750 k	⅛ w		Prec.	1%	
R1074	311-350	500 k		Var.		BRIDGE VOLTS A	
R1075	318-109	500 k	⅛ w		Prec.	1%	
R1077	315-153	15 k	¼ w			5%	
R1078	311-017	10 k	.1 w	Var.		BRIDGE BAL. A	
R1079	315-153	15 k	¼ w			5%	
R2045	311-115	100 k		Var.		MEMORY GATE WIDTH	
R2051	315-470	47 Ω	¼ w			5%	
R2052	315-470	47 Ω	¼ w			5%	
R2053	316-472	4.7 k	¼ w				
R2056	315-621	620 Ω	¼ w			5%	
R2057	315-621	620 Ω	¼ w			5%	

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description					Model No.
R2058	316-221	220 Ω	¼ w				
R2059	316-100	10 Ω	¼ w				
R2065	305-101	100 Ω	2 w			5%	
R2070	318-096	1.5 meg	⅛ w		Prec.	1%	
R2071	318-115	750 k	⅛ w		Prec.	1%	
R2074	311-350	500 k		Var.		BRIDGE VOLTS B	
R2075	318-109	500 k	⅛ w		Prec.	1%	
R2077	315-153	15 k	¼ w			5%	
R2078	311-017	10 k	.1 w	Var.		BRIDGE BAL B	
R2079	315-153	15 k	¼ w			5%	

Transformers

T1051	276-535	Core, Toroid
T1067	*120-301	Toroid 8T TD85
T1069	*120-301	Toroid 8T TD85
T1071	276-535	Core, Toroid
T2051	276-535	Core, Toroid
T2071	276-535	Core, Toroid

Transistors

Q1064	*151-105	Tek. Spec.
Q2054	151-015	2N1516

"AC AMPLIFIER" Series 2

*605-002 Complete Board

Capacitors

C1081	290-105	100 μf	EMT		6 v	
C1089	281-501	4.7 pf	Cer.		500 v	±1 pf
C1107	281-060	2-8 pf	Cer.	Var.		
C1108	283-026	.2 μf	Disc Type		25 v	
C1109	290-145	10 μf	EMT		50 v	
C1113	283-023	.1 μf	Disc Type		10 v	
C1116	283-004	.02 μf	Disc Type		150 v	
C1119	283-004	.02 μf	Disc Type		150 v	
C2081	290-105	100 μf	EMT		6 v	
C2089	281-501	4.7 pf	Cer.		500 v	±1 pf
C2107	281-060	2-8 pf	Cer.	Var.		
C2108	283-026	.2 μf	Disc Type		25 v	
C2109	290-145	10 μf	EMT		50 v	
C2113	283-023	.1 μf	Disc Type		10 v	
C2116	283-004	.02 μf	Disc Type		150 v	
C2119	283-004	.02 μf	Disc Type		150 v	

Resistors

Ckt. No.	Tektronix Part No.	Description				Model No.
R1082	303-164	160 k	1 w		5%	X4-up
R1083	318-064	250 Ω	1/8 w	Prec.	1%	
R1086	303-223	22 k	1 w		5%	
R1087	315-222	2.2 k	1/4 w		5%	
R1088	306-154	150 k	2 w			
R1089	318-074	11.8 k	1/8 w	Prec.	1%	
R1095	303-153	15 k	1 w		5%	
R1096	319-042	1 k	1/4 w	Prec.	1%	
R1097	315-392	3.9 k	1/4 w		5%	
R1105	301-473	47 k	1/2 w		5%	
R1107	Use 309-388	6 k	1/2 w	Prec.	1%	
R1108	301-561	560 Ω	1/2 w		5%	
R1109	316-101	100 Ω	1/4 w			
R1113	315-101	100 Ω	1/4 w		5%	
R1115	301-102	1 k	1/2 w		5%	
R1116	316-101	100 Ω	1/4 w			
R1119	316-102	1 k	1/4 w			
R2082	303-164	160 k	1 w		5%	X4-up
R2083	318-064	250 Ω	1/8 w	Prec.	1%	
R2086	303-223	22 k	1 w		5%	
R2087	315-222	2.2 k	1/4 w		5%	
R2088	306-154	150 k	2 w			
R2089	318-074	11.8 k	1/8 w	Prec.	1%	
R2095	303-153	15 k	1 w		5%	
R2096	319-042	1 k	1/4 w	Prec.	1%	
R2097	315-392	3.9 k	1/4 w		5%	
R2105	301-473	47 k	1/2 w		5%	
R2107	Use 309-388	6 k	1/2 w	Prec.	1%	
R2108	301-561	560 Ω	1/2 w		5%	
R2109	316-101	100 Ω	1/4 w			
R2113	315-101	100 Ω	1/4 w		5%	
R2115	301-102	1 k	1/2 w		5%	
R2116	316-101	100 Ω	1/4 w			
R2119	316-102	1 k	1/4 w			

Transistors

Q1084	151-015	2N1516
Q1094	151-015	2N1516
Q1104	151-015	2N1516
Q1113	151-056	TI483
Q2084	151-015	2N1516
Q2094	151-015	2N1516
Q2104	151-015	2N1516
Q2113	151-056	TI483

"INVERTER" Series 9

*605-009 Complete Board

Diodes

Ckt. No.	Tektronix Part No.	Description			Model No.
D1165	152-025	Germanium	1N634		
D1166	152-025	Germanium	1N634		
D1167	Use 152-064	Zener	10 v ¼ w 10%		
D2165	152-025	Germanium	1N634		
D2166	152-025	Germanium	1N634		
D2167	Use 152-064	Zener	10 v ¼ w 10%		

Resistors

R1161	311-153	10 k		Var.		INVERTER ZERO A
R1162	301-224	220 k	½ w			5%
R1163	309-100	10 k	½ w		Prec.	1%
R1164	309-160	9.85 k	½ w		Prec.	1%
R1165	301-752	7.5 k	½ w			5%
R1166	303-433	43 k	1 w			5%
R1167	304-334	330 k	1 w			
R1168	304-223	22 k	1 w			
R2161	311-153	10 k		Var.		INVERTER ZERO B
R2162	301-224	220 k	½ w			5%
R2163	309-100	10 k	½ w		Prec.	1%
R2164	309-160	9.85 k	½ w		Prec.	1%
R2165	301-752	7.5 k	½ w			5%
R2166	303-433	43 k	1 w			5%
R2167	304-334	330 k	1 w			
R2168	304-223	22 k	1 w			

Transistors

Q1163	151-058	RT5204
Q1164	151-054	2N1754
Q2163	151-058	RT5204
Q2164	151-054	2N1754

"MEMORY" A, B (2 required) Series 8 (S/N 100-259)

*605-010 Complete Board

Capacitors

C1121	use 283-091	510 pf	Cer	500 v	1%
C1122	283-026	.2 μf	Disc Type	25 v	
C1127	283-003	.01 μf	Disc Type	150 v	
C1128	283-026	.2 μf	Disc Type	25 v	
C1129	283-024	.1 μf	Disc Type	30 v	
C1132	use 283-090	160 pf	Cer.	500 v	1%
C1138	281-504	10 pf	Cer.	500 v	10%
C1140	283-024	.1 μf	Disc Type	30 v	
C1153	283-003	.01 μf	Disc Type	150 v	

Diodes

Ckt. No.	Tektronix Part No.	Description		Model No.
D1122	152-016	Zener	RT6 6 v	
D1125	152-071	Germanium	ED2007	
D1127	152-071	Germanium	ED2007	
D1130 } D1131 }	*152-083	Capacitance 0.6 pf up (1 pair)		
D1136	152-066	Silicon	1N3194	
D1140	152-064	Zener	10 v ¼ w 10%	
D1142	152-026	Germanium	Q6-100	
D1143	152-008	Germanium	T12G	
D1144	152-064	Zener	10 v ¼ w 10%	

Resistors

Ckt. No.	Tektronix Part No.	Value	Wattage				Model No.
R1120	306-104	100 k	2 w				
R1121	315-101	100 Ω	¼ w			5%	
R1122	304-333	33 k	1 w				
R1123	318-034	2 k	⅛ w		Prec.	1%	
R1124	318-034	2 k	⅛ w		Prec.	1%	
R1125	311-343	1 k		Var.		SMOOTHING BALANCE	
R1127	318-045	3.92 k	⅛ w		Prec.	1%	
R1129	316-100	10 Ω	¼ w				
R1134	301-563	56 k	½ w			5%	
R1135	316-101	100 Ω	¼ w				
R1138	301-473	47 k	½ w			5%	
R1139	303-103	10 k	1 w			5%	
R1140	315-103	10 k	¼ w			5%	
R1143	316-683	68 k	¼ w				X2-up
R1144	303-153	15 k	1 w			5%	
R1145	315-820	82 Ω	¼ w			5%	
R1146	321-602	3.908 k	⅛ w		Prec.	¼%	
R1150	321-605	186 k	⅛ w		Prec.	¼%	
R1151	301-513	51 k	½ w			5%	
R1152	315-101	100 Ω	¼ w			5%	
R1153	315-101	100 Ω	¼ w			5%	
R1154	323-602	107 k	½ w		Prec.	¼%	
R1155	323-603	1.5 meg	½ w		Prec.	¼%	
R1156	323-601	92 k	½ w		Prec.	¼%	

Transformers

Ckt. No.	Tektronix Part No.	Description
T1130	*120-255	Toroid 3T TD51

Transistors

Ckt. No.	Tektronix Part No.	Description	
Q1134	*153-511	2N1516	Selected
Q1141	151-067	2N1143	

Electron Tubes

Ckt. No.	Tektronix Part No.	Description	Model No.
V1133	154-187	6DJ8	

"MEMORY" A, B (2 Required), Series 11 (S/N 260-up)

	*605-015	Complete Board

Capacitors

Ckt. No.	Tektronix Part No.	Value	Type	Voltage	Tolerance
C1121	283-091	510 pf	Cer	500 v	1%
C1122	283-026	.2 μf	Disc Type	25 v	
C1127	283-003	.01 μf	Disc Type	150 v	
C1128	283-026	.2 μf	Disc Type	25 v	
C1129	283-024	.1 μf	Disc Type	30 v	
C1132	283-090	160 pf	Cer	500 v	1%
C1138	281-504	10 pf	Cer	500 v	10%
C1140	283-024	.1 μf	Disc Type	30 v	
C1153	283-003	.01 μf	Disc Type	150 v	

Diodes

Ckt. No.	Tektronix Part No.	Description
D1122	152-016	Zener RT6 6 v
D1125	152-071	Germanium ED2007
D1127	152-071	Germanium ED2007
D1130, D1131	*152-083	Capacitance 0.6 pf up (1 pair)
D1136	152-066	Silicon 1N3194
D1140	152-064	Zener 10 v ¼ w 10%
D1142	152-026	Germanium Q6-100
D1143	152-008	Germanium T12G
D1144	152-064	Zener 10 v ¼ w 10%

Resistors

Ckt. No.	Tektronix Part No.	Value	Wattage	Type	Prec	Tolerance
R1120	306-104	100 k	2 w			
R1121	315-101	100 Ω	¼ w			5%
R1122	304-333	33 k	1 w			
R1123	318-034	2 k	⅛ w		Prec	1%
R1124	318-034	2 k	⅛ w		Prec	1%
R1125	311-343	1 k		Var		SMOOTHING BALANCE
R1127	318-045	3.92 k	⅛ w		Prec	1%
R1129	316-100	10 Ω	¼ w			
R1130	309-058	2 Ω	½ w		Prec	1%
R1134	301-563	56 k	½ w			5%
R1135	316-101	100 Ω	¼ w			
R1138	301-473	47 k	½ w			5%
R1139	303-103	10 k	1 w			5%

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description				Model No.
R1140	315-103	10 k	¼ w		5%	
R1143	316-683	68 k	¼ w			
R1144	303-153	15 k	1 w		5%	
R1145	315-820	82 Ω	¼ w		5%	
R1146	321-602	3.908 k	⅛ w	Prec	¼%	
R1150	321-605	186.2 k	⅛ w	Prec	¼%	
R1151	301-513	51 k	½ w		5%	
R1152	315-101	100 Ω	¼ w		5%	
R1153	315-101	100 Ω	¼ w		5%	
R1154	323-602	107 k	½ w	Prec	¼%	
R1155	323-603	1.5 meg	½ w	Prec	¼%	
R1156	323-601	92 k	½ w	Prec	¼%	

Transformers

T1130	*120-255	Toroid 3T TD51

Transistors

Q1134	*153-511	2N1516	Selected
Q1141	151-067	2N1143	

Electron Tubes

V1133	154-195	6922

"DUAL TRACE" Series 5

	*605-004	Complete Board

Capacitors

C1181	283-004	.02 μf	Disc Type	150 v	
C1189	283-004	.02 μf	Disc Type	150 v	
C1191	281-542	18 pf	Cer.	500 v	10%
C2181	283-004	.02 μf	Disc Type	150 v	
C2189	283-004	.02 μf	Disc Type	150 v	
C2240	281-543	270 pf	Cer.	500 v	10%
C2246	281-542	18 pf	Cer.	500 v	10%
C2250	281-543	270 pf	Cer.	500 v	10%
C2251	285-624	.027 μf	PMT	100 v	10%
C2256	281-542	18 pf	Cer.	500 v	10%
C2266	290-107	25 μf	EMT	25 v	
C2268	290-107	25 μf	EMT	25 v	

Diodes

D1186	152-071	Germanium	ED2007
D1187	152-071	Germanium	ED2007
D1197	152-095	Silicon	1N625
D1198	152-095	Silicon	1N625
D2186	152-071	Germanium	ED2007
D2187	152-071	Germanium	ED2007
D2245	152-008	Germanium	T12G
D2248	152-008	Germanium	T12G
D2249	152-055	Zener	11 v ¼ w 5%
D2251	152-016	Zener	RT6 6 v
D2255	152-008	Germanium	T12G
D2258	152-008	Germanium	T12G
D2262	152-008	Germanium	T12G

Inductors

L1189	*120-304	Toroid 3T TD89
L1195	119-021	Delay Line 1500 Ω .25 μsec.
L2266	*120-266	Toroid 10T TD63
L2268	*120-266	Toroid 10T TD63

Resistors

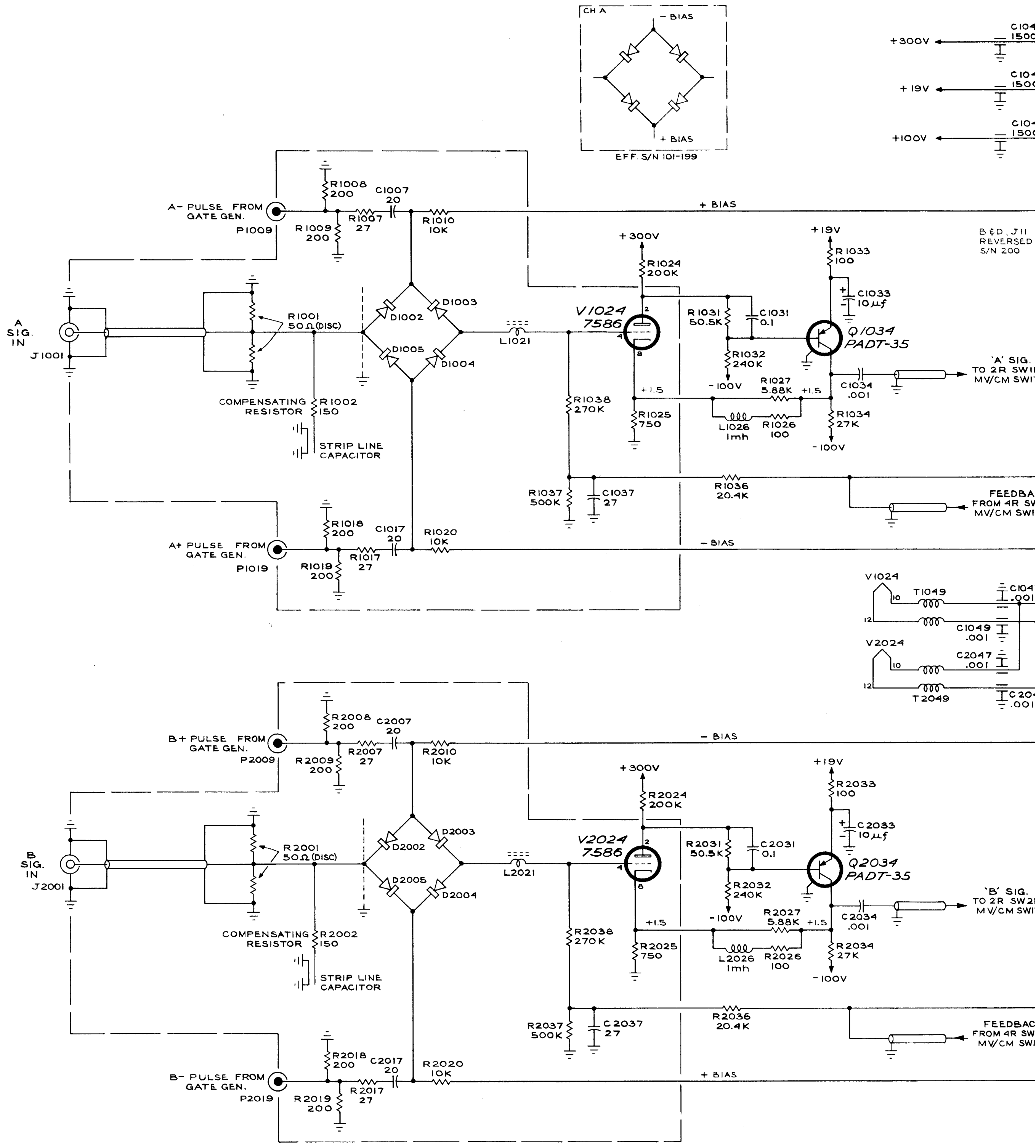
R1181	315-563	56 k	¼ w			5%
R1183	318-094	193 k	⅛ w		Prec.	1%
R1184	319-053	1.82 k	¼ w		Prec.	1%
R1185	309-429	16 5 k	½ w		Prec.	1%
R1189	318-105	5.62 k	⅛ w		Prec.	1%
R1191	324-415	205 k	1 w		Prec.	1%
R1192	309-387	3.32 k	½ w		Prec.	1%
R1195	315-272	2.7 k	¼ w			5%
R1197	315-152	1.5 k	¼w			5%
R2181	315-563	56 k	¼ w			5%
R2182	311-172	2.5 k		Var.		CAL. B
R2183	318-094	193 k	⅛ w		Prec.	1%
R2184	319-053	1.82 k	¼ w		Prec.	1%
R2185	309-429	16.5 k	½ w		Prec.	1%
R2189	319-031	1 meg	¼ w		Prec.	1%
R2195	315-623	62 k	¼ w			5%
R2196	315-183	18 k	¼ w			5%
R2199	315-363	36 k	¼ w			5%
R2240	315-102	1 k	¼ w			5%
R2242	315-223	22 k	¼ w			5%
R2243	315-103	10 k	¼ w			5%
R2246	315-273	27 k	¼ w			5%
R2247	315-224	220 k	¼ w			5%
R2248	315-202	2 k	¼ w			5%
R2249	315-822	8.2 k	¼ w			5%

Resistors *(Cont'd.)*

Ckt No.	Tektronix Part No.		Description		Model No.
R2250	315-102	1 k	1/4 w	5%	
R2252	315-223	22 k	1/4 w	5%	
R2253	315-103	10 k	1/4 w	5%	
R2256	315-273	27 k	1/4 w	5%	
R2257	315-224	220 k	1/4 w	5%	
R2258	315-202	2 k	1/4 w	5%	
R2261	315-332	3.3 k	1/4 w	5%	
R2264	315-823	82 k	1/4 w	5%	

Transistors

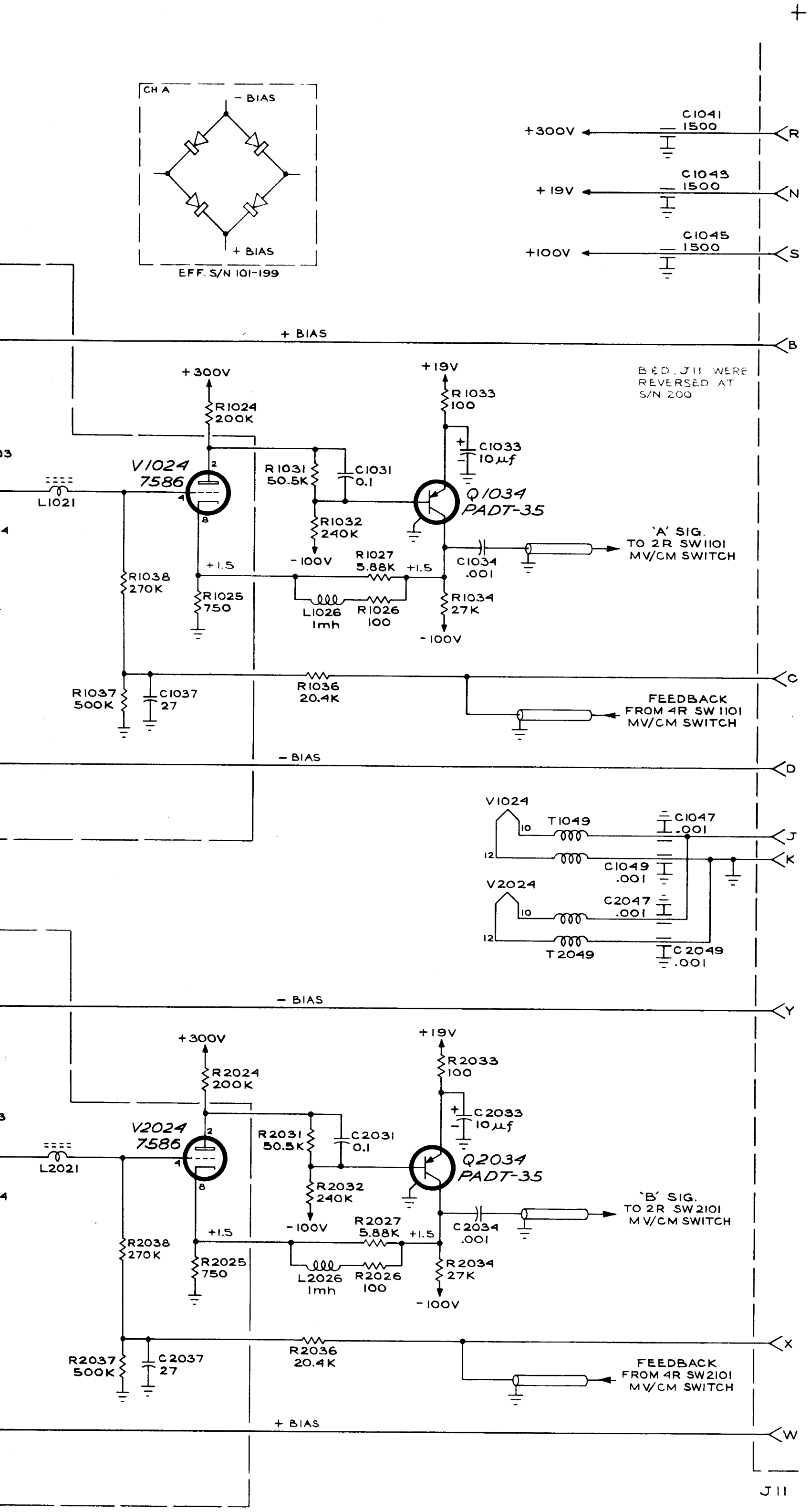
Q1184	151-076	2N2048
Q2184	151-076	2N2048
Q2245	151-076	2N2048
Q2255	151-076	2N2048
Q2264	151-015	2N1516



VOLTAGE READINGS WERE OBTAINED UNDER FOLLOWING CONDITIONS:

Signal .... None
Trace .... Centered

CMD
863

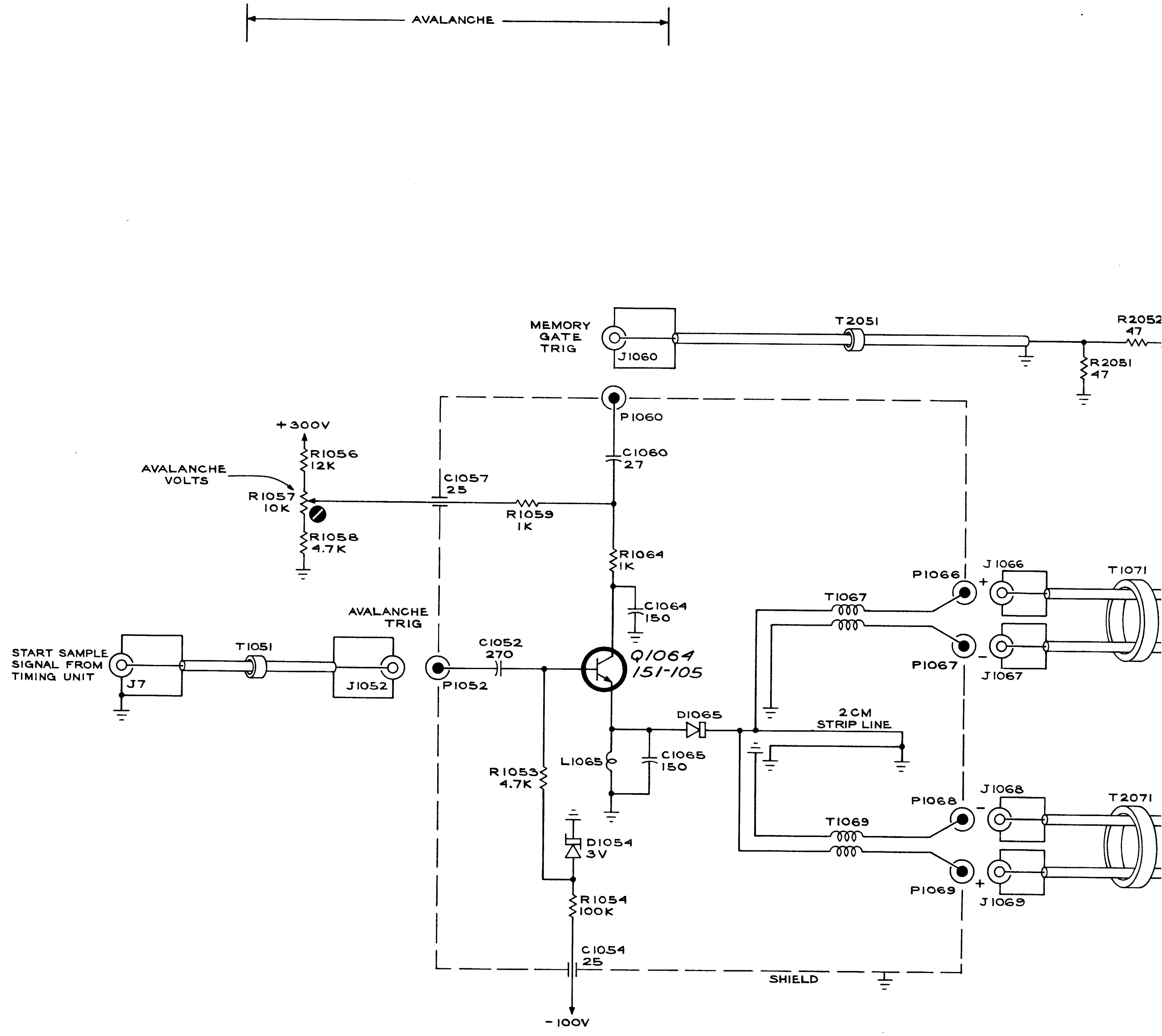


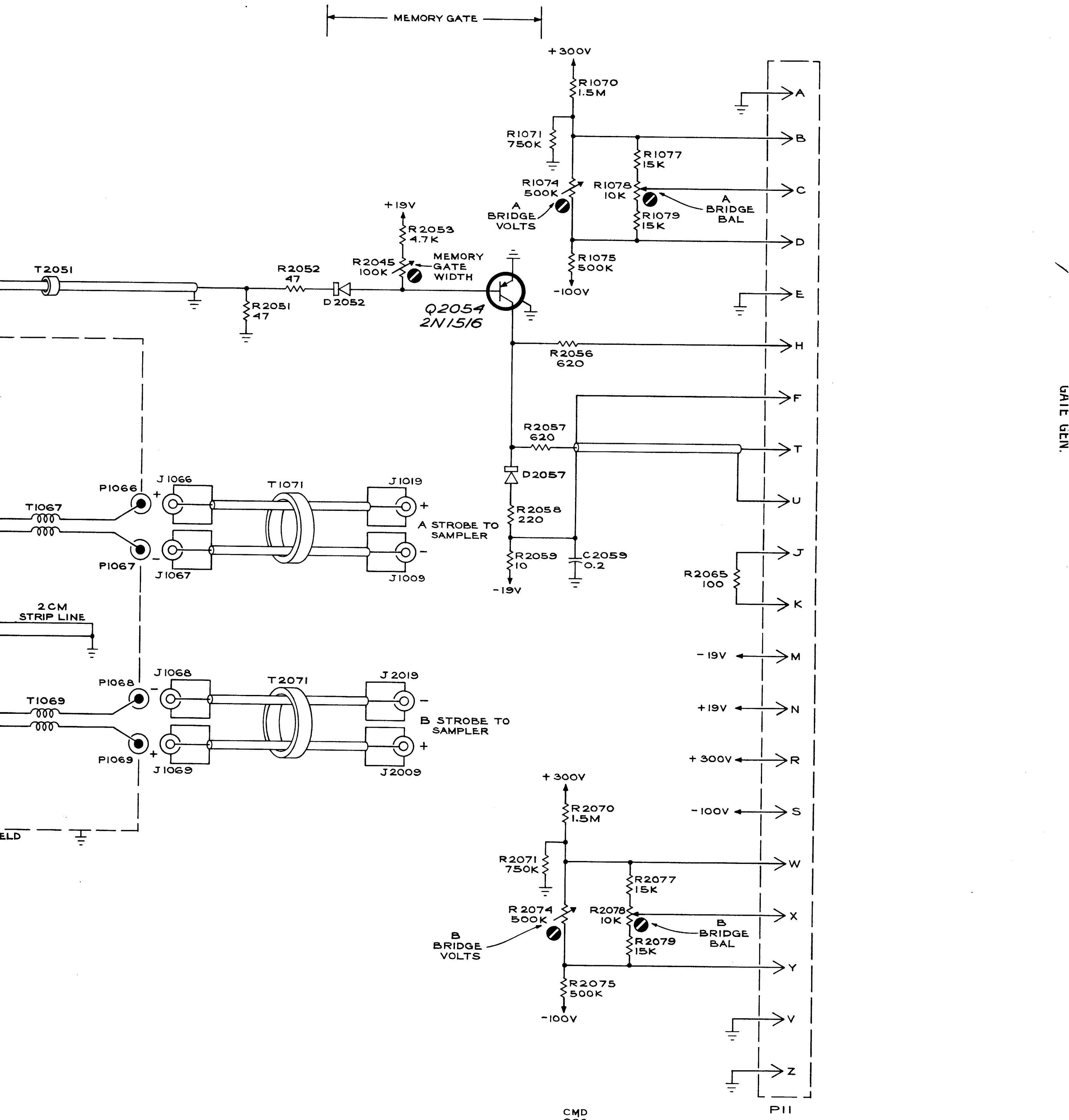
SAMPLER

VOLTAGE READINGS WERE OBTAINED UNDER FOLLOWING CONDITIONS:

Signal .... None
Trace .... Centered

A


AVALANCHE
MEMORY GATE TRIG
J1060
T2051
R2052 47
R2051 47
P1060
+300V
R1056 12K
AVALANCHE VOLTS
R1057 10K
R1058 4.7K
C1057 25
R1059 1K
C1060 27
R1064 1K
C1064 150
START SAMPLE SIGNAL FROM TIMING UNIT
J7
T1051
J1052
AVALANCHE TRIG
P1052
C1052 270
Q1064 151-105
D1065
L1065
C1065 150
R1053 4.7K
D1054 3V
R1054 100K
C1054 25
-100V
SHIELD
2 CM STRIP LINE
T1067
T1069
P1066
P1067
P1068
P1069
J1066
J1067
J1068
J1069
T1071
T2071

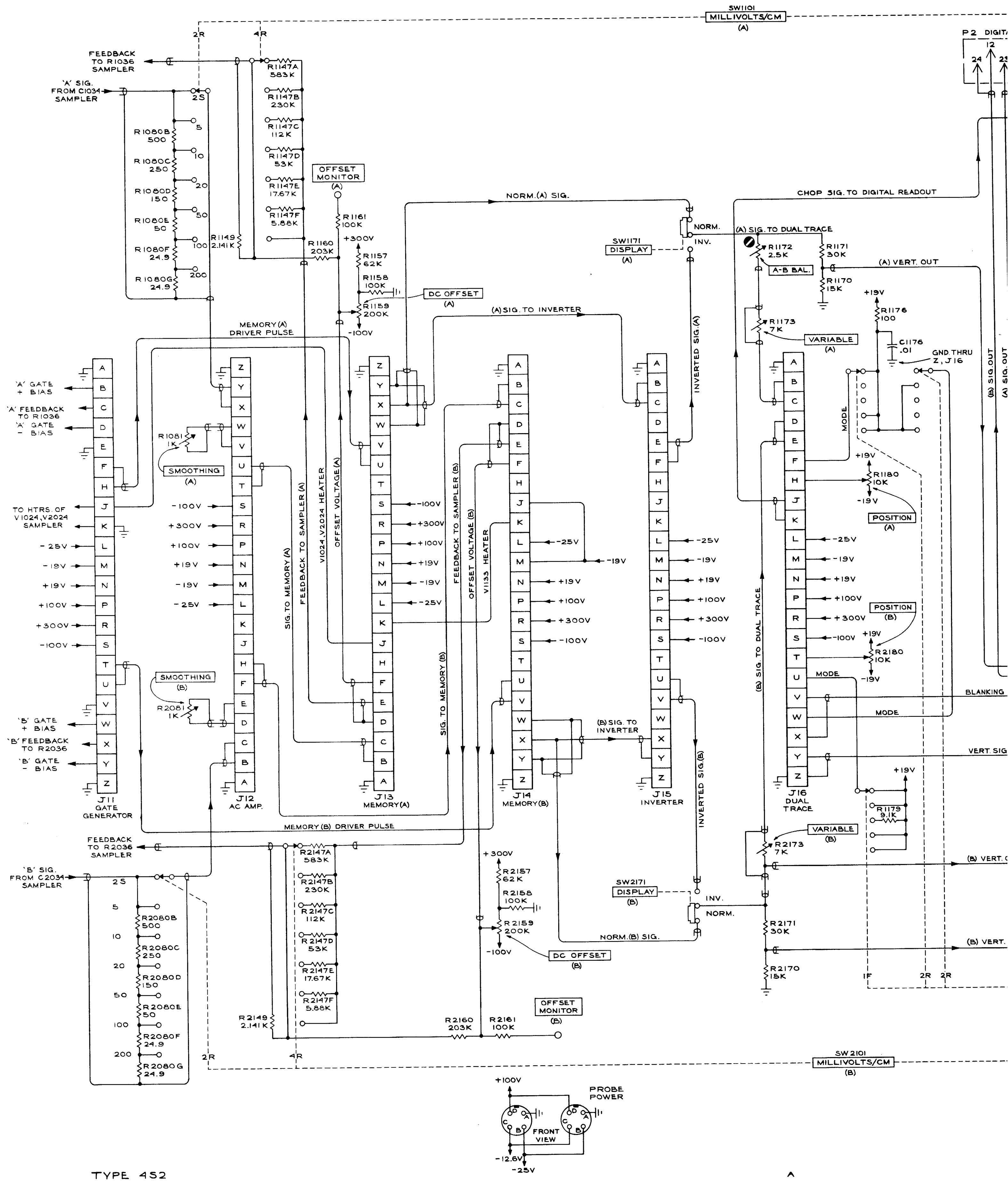


CMD
863

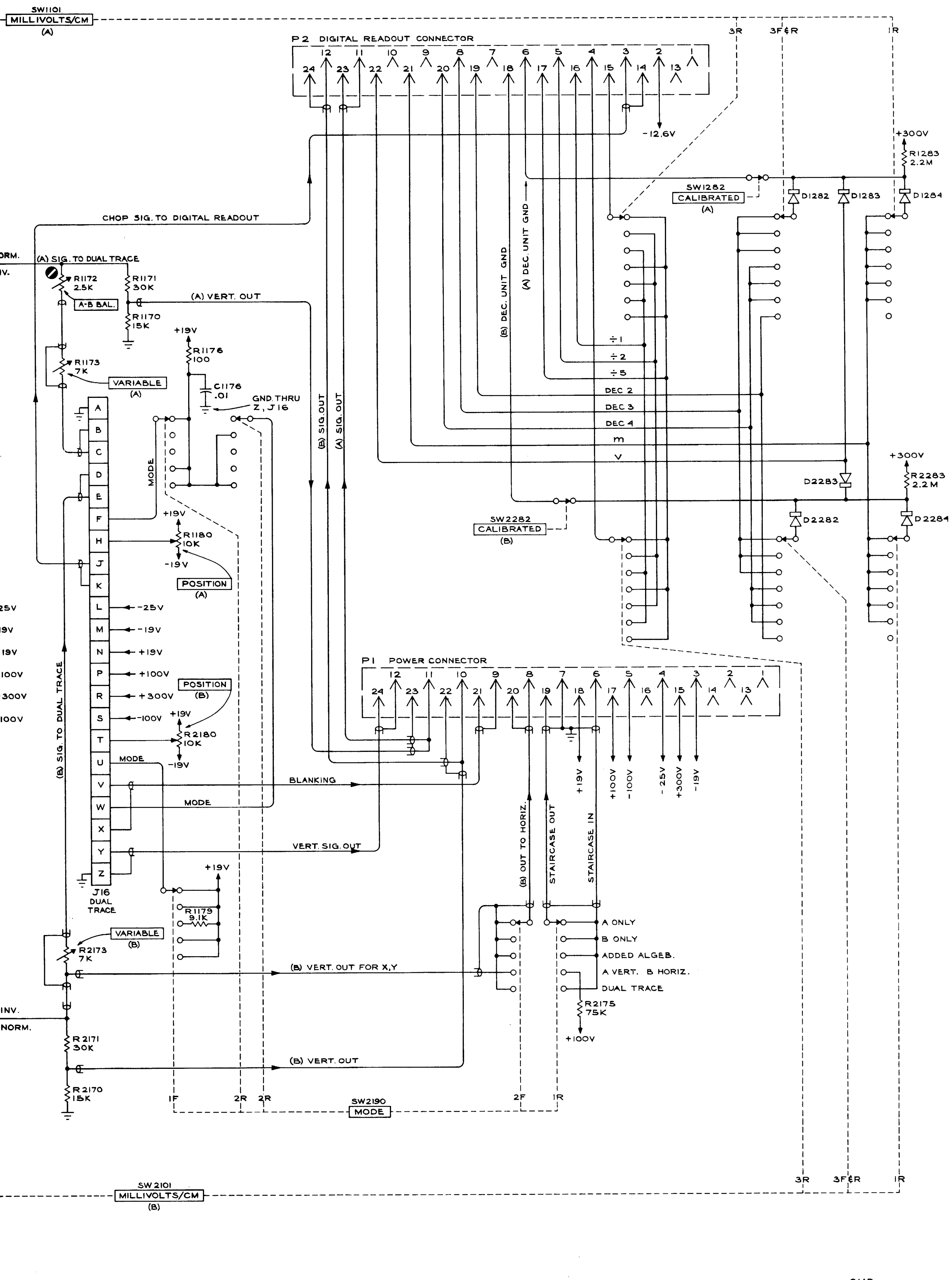
A

GATE GENERATOR

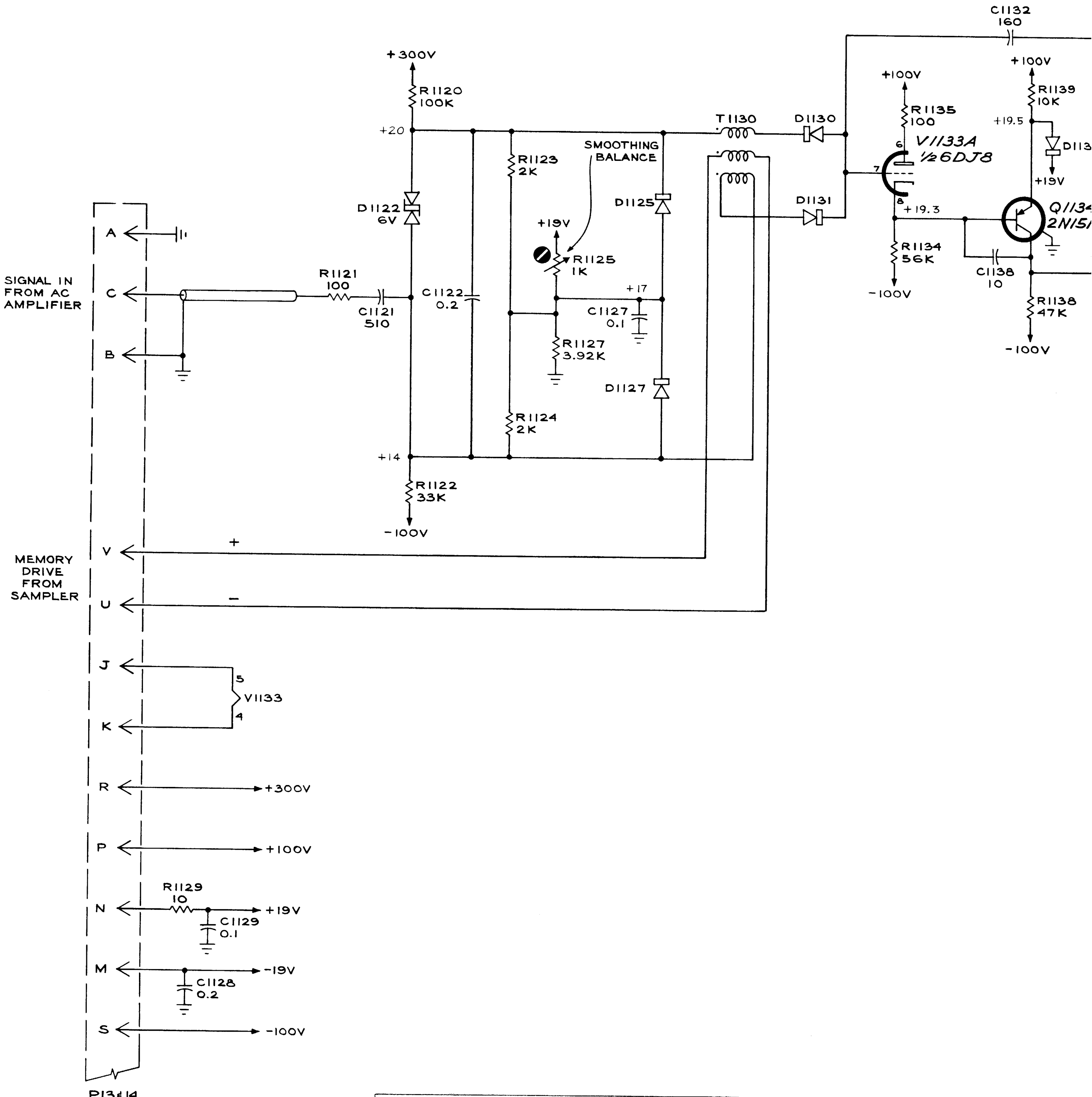
SERIES 6 MODEL I


SW1101 MILLIVOLTS/CM (A)
FEEDBACK TO R1036 SAMPLER
'A' SIG. FROM C1034 SAMPLER
OFFSET MONITOR (A)
NORM.(A) SIG.
CHOP SIG. TO DIGITAL READOUT
SW1171 DISPLAY (A)
(A) SIG. TO DUAL TRACE
A-B BAL.
(A) VERT. OUT
DC OFFSET (A)
(A) SIG. TO INVERTER
MEMORY (A) DRIVER PULSE
VARIABLE (A)
SMOOTHING (A)
POSITION (A)
POSITION (B)
SMOOTHING (B)
J11 GATE GENERATOR
J12 AC AMP.
J13 MEMORY(A)
J14 MEMORY(B)
J15 INVERTER
J16 DUAL TRACE
MEMORY (B) DRIVER PULSE
FEEDBACK TO R2036 SAMPLER
'B' SIG. FROM C2034 SAMPLER
SW2171 DISPLAY (B)
NORM.(B) SIG.
DC OFFSET (B)
VARIABLE (B)
OFFSET MONITOR (B)
SW2101 MILLIVOLTS/CM (B)
PROBE POWER
FRONT VIEW

TYPE 452



INTERCONNECTORS & SWITCHING



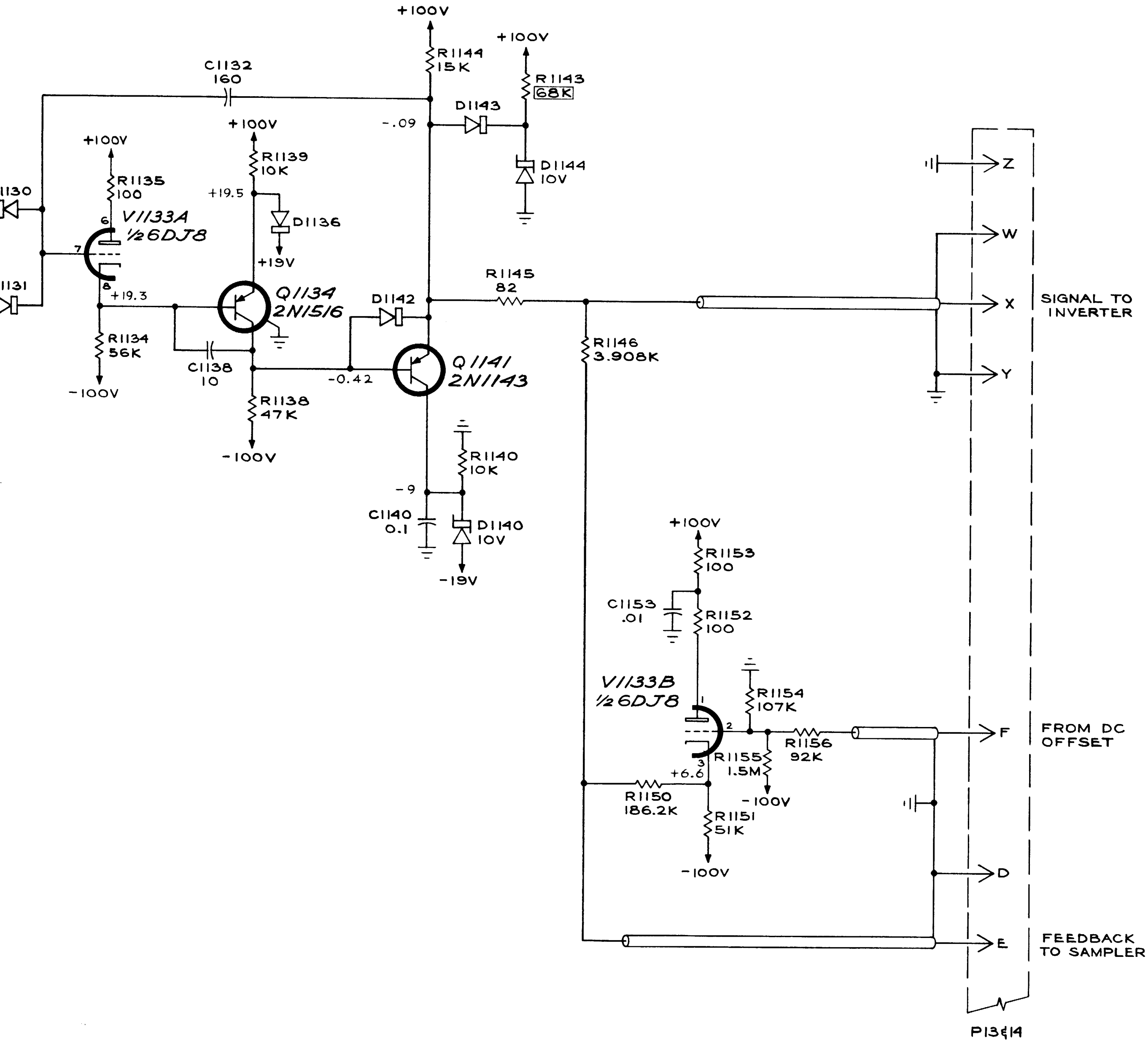
VOLTAGE READINGS WERE OBTAINED UNDER FOLLOWING CONDITIONS:

DC OFFSET . . . . Zero Volts

Trace . . . . Centered

TYPE 4S2

A



SEE PARTS LIST FOR EARLIER VALUES AND S/N CHANGES OF PARTS MARKED WITH BLUE OUTLINE

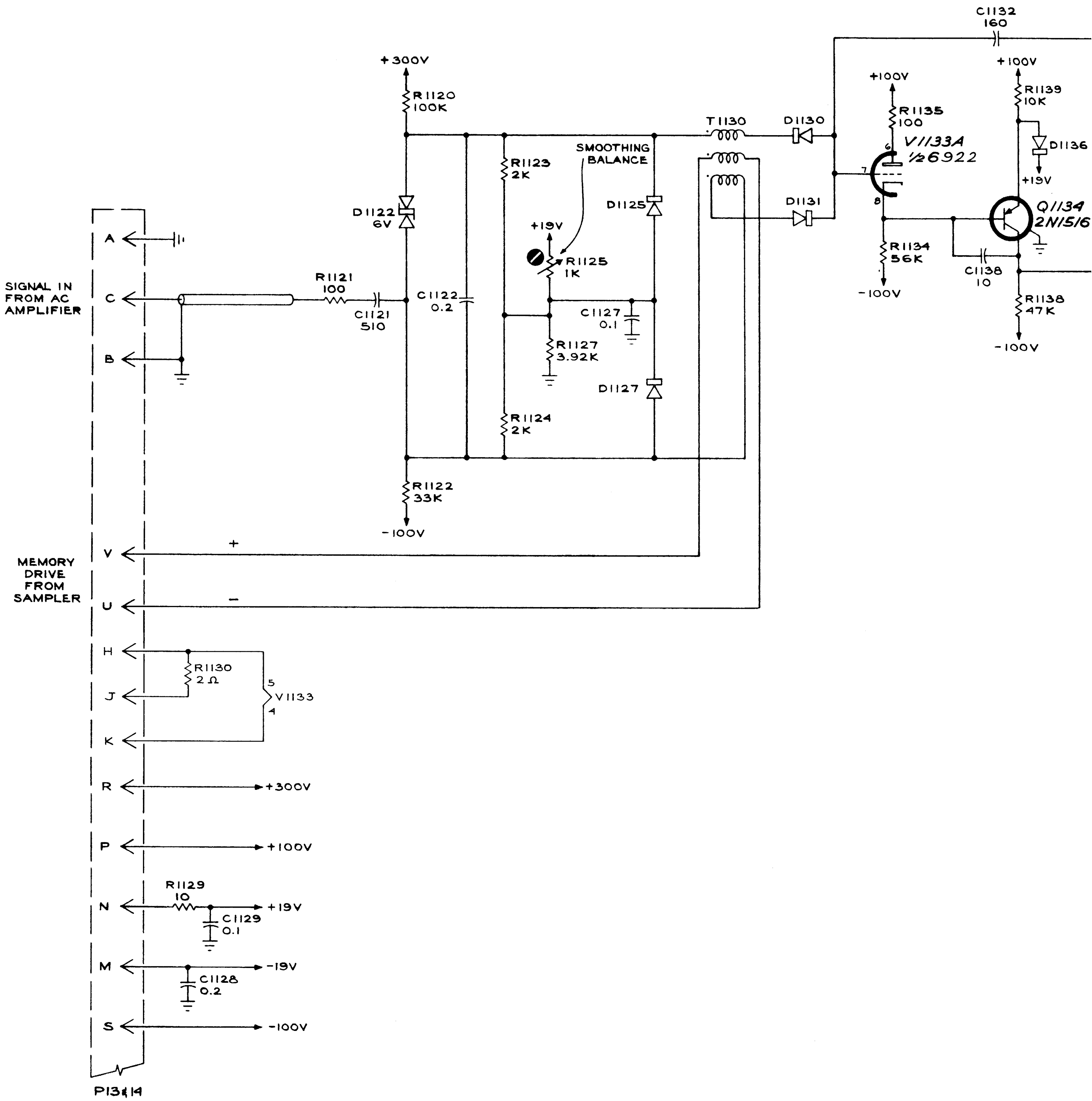
A

CMD
863

MEMORY

SERIES 8 MODELS 1&2

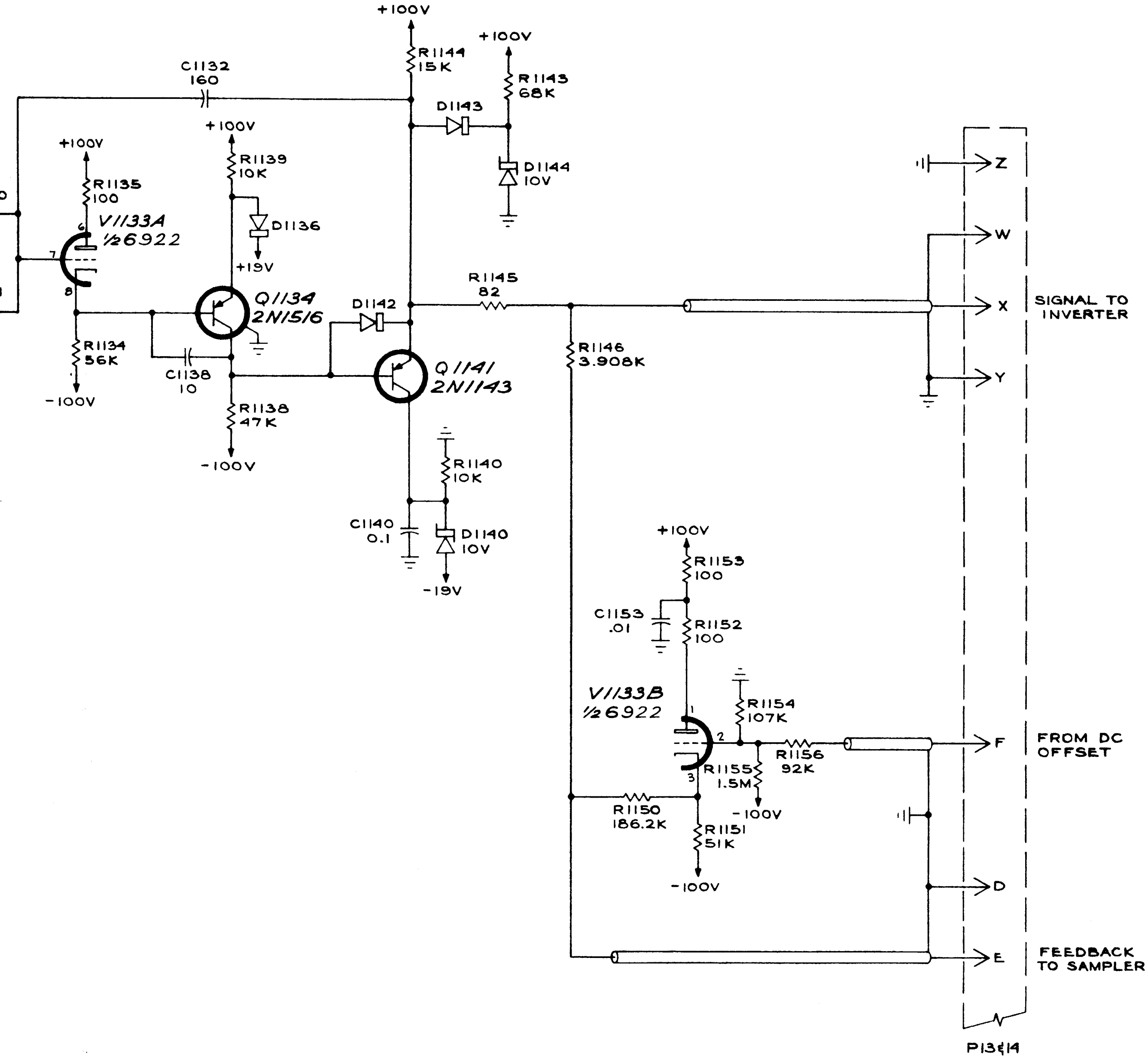
MEMORY



C1132
160
+300V
R1120
100K
+100V
R1135
100
+100V
R1139
10K
T1130
D1130
V1133A
½6922
D1136
+19V
SMOOTHING
BALANCE
R1123
2K
D1122
6V
D1125
D1131
Q1134
2N1516
+19V
R1125
1K
A
SIGNAL IN
FROM AC
AMPLIFIER
C
R1121
100
C1121
510
C1122
0.2
C1127
0.1
R1134
56K
-100V
C1138
10
R1138
47K
-100V
B
R1127
3.92K
D1127
R1124
2K
R1122
33K
-100V
MEMORY
DRIVE
FROM
SAMPLER
V
+
U
−
H
R1130
2 Ω
J
V1133
5
4
K
R
+300V
P
+100V
N
R1129
10
+19V
C1129
0.1
M
-19V
C1128
0.2
S
-100V
P13 & 14

TYPE 4S2

A

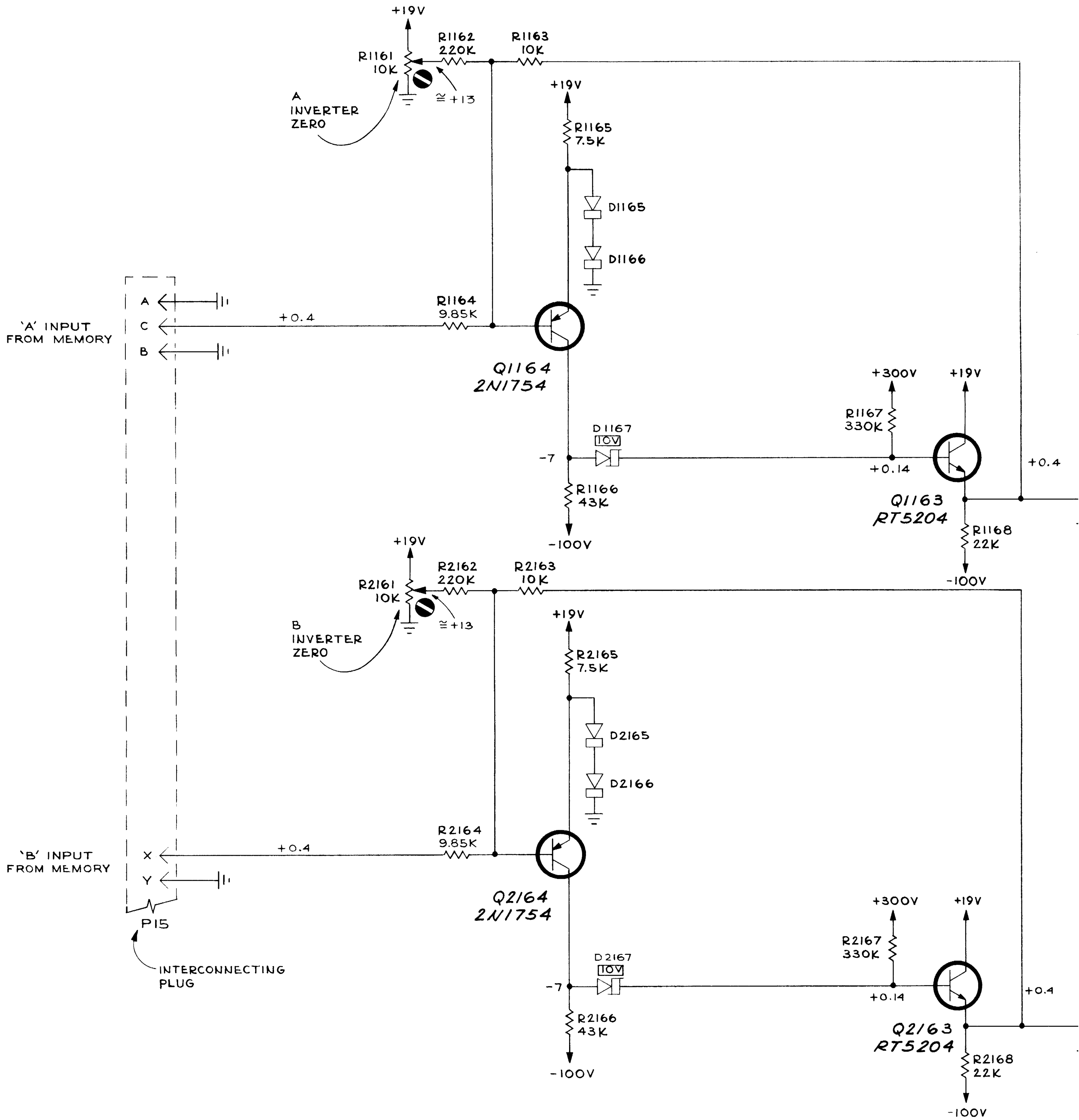


A

CMD
863

MEMORY

SERIES II MODEL I



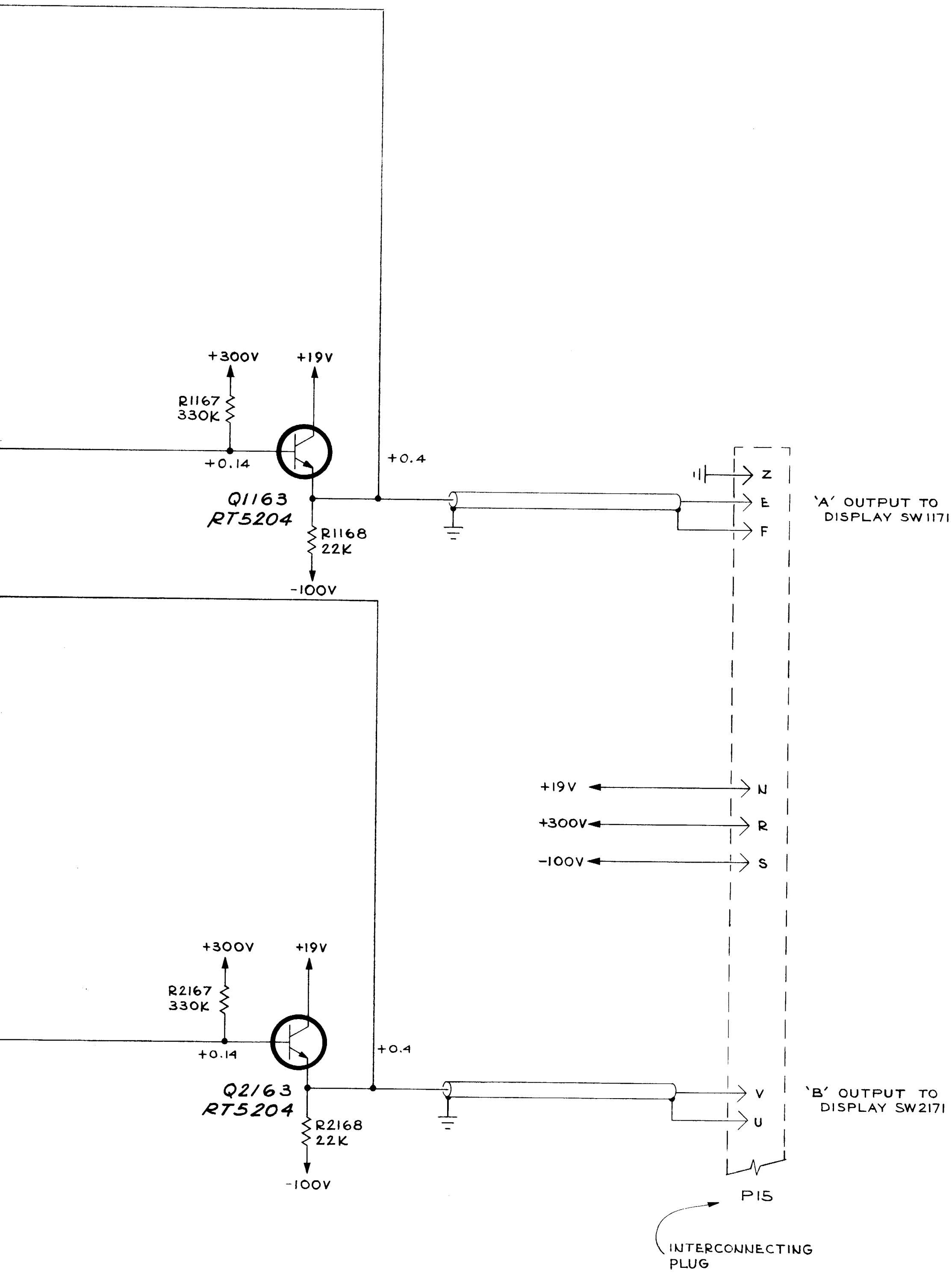
SEE PARTS LIST FOR EARLI
VALUES AND S/N CHANGES C
PARTS MARKED WITH BLUE
OUTLINE

VOLTAGE READINGS WERE OBTAINED UNDER FOLLOWING CONDITIONS:

DISPLAY . . . . INVERTED
Trace . . . . Centered

TYPE 4S2

A



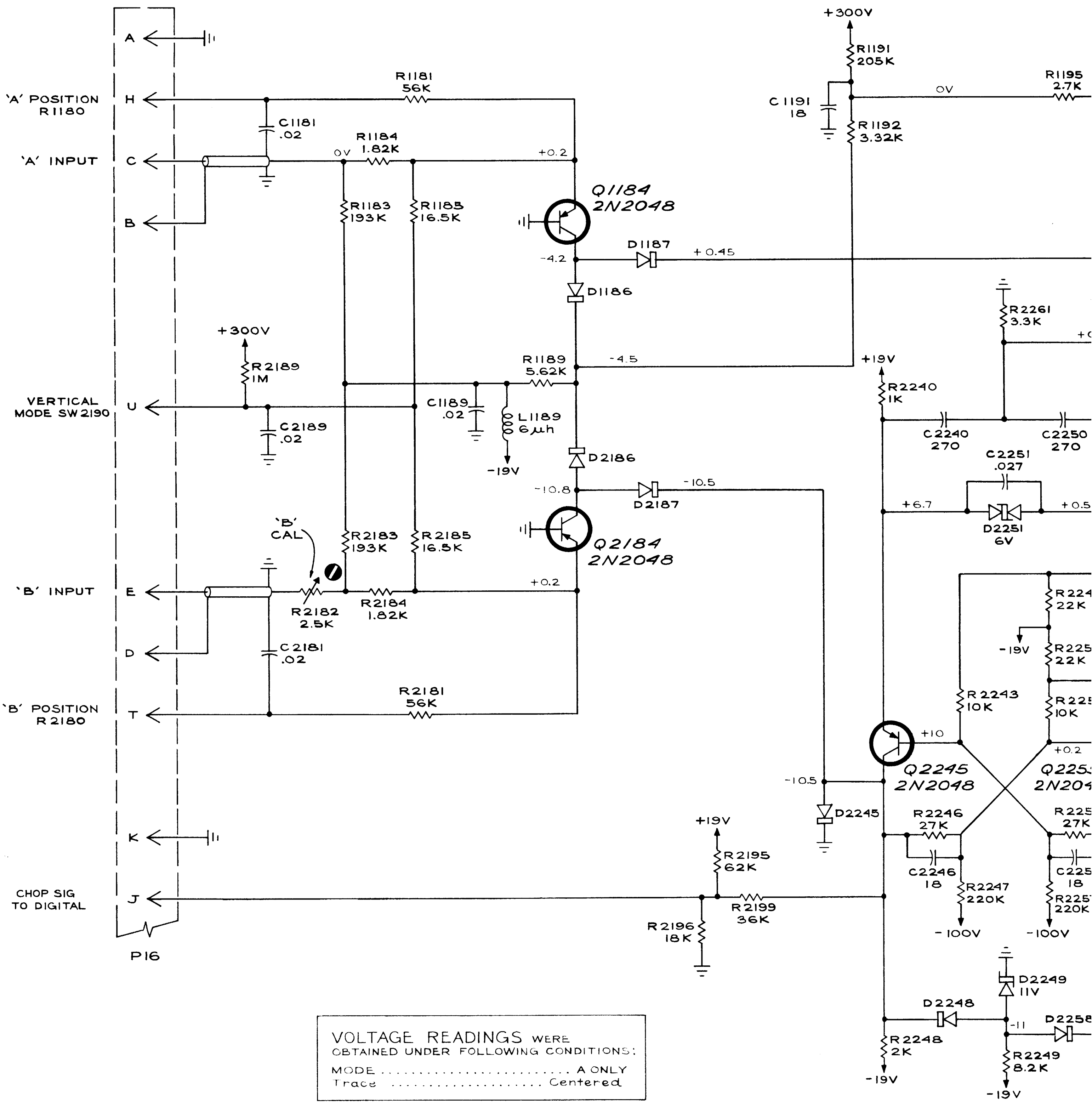
SEE PARTS LIST FOR EARLIER VALUES AND S/N CHANGES OF PARTS MARKED WITH BLUE OUTLINE

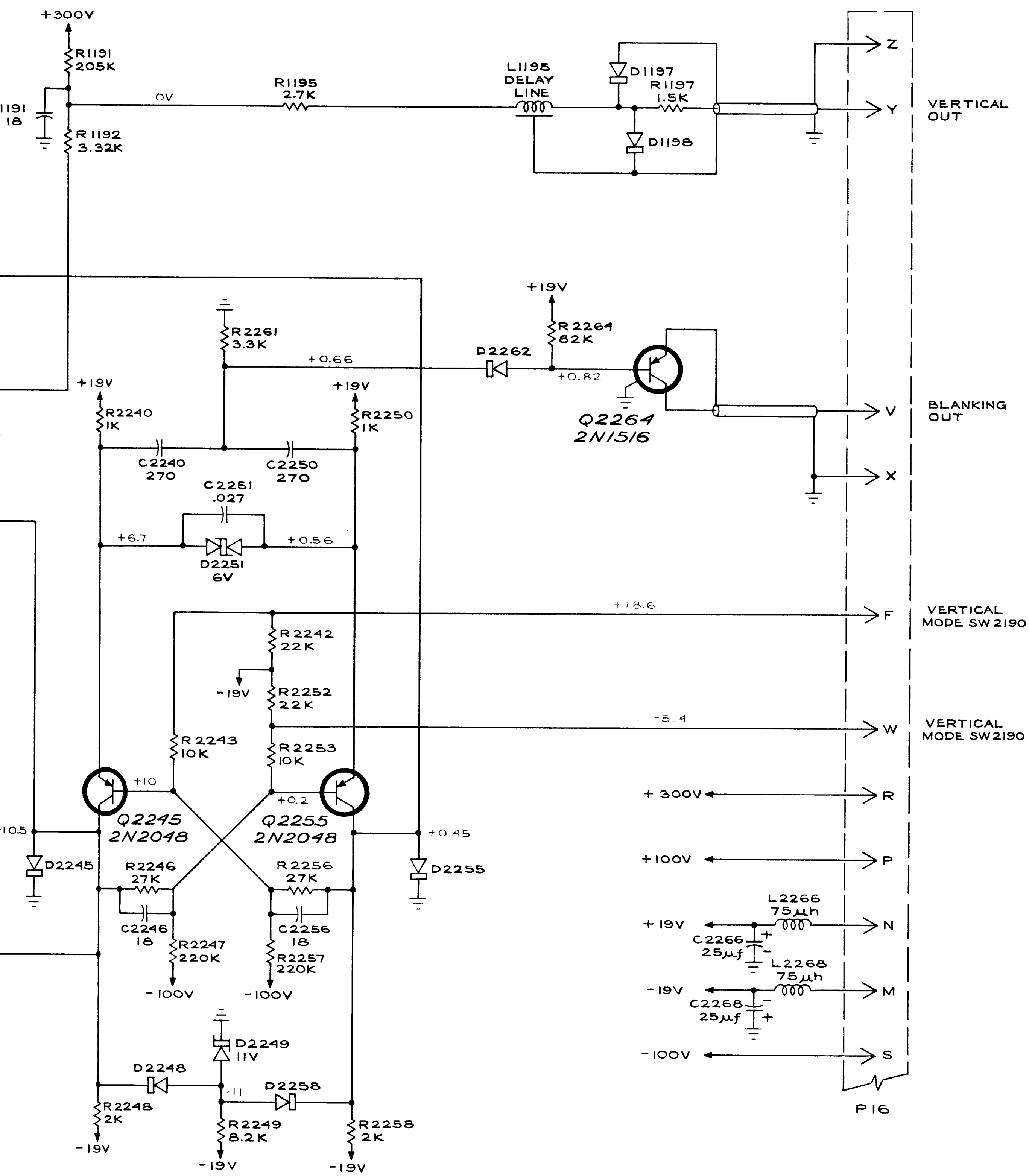
JN
863

A

INVERTER

SERIES 9 MODELS 1&2


'A' POSITION R1180
'A' INPUT
VERTICAL MODE SW2190
'B' INPUT
'B' POSITION R2180
CHOP SIG TO DIGITAL
A
H
C
B
U
E
D
T
K
J
P16
R1181 56K
C1181 .02
R1184 1.82K
0V
+0.2
R1183 193K
R1185 16.5K
Q1184 2N2048
D1187
+0.45
-4.2
D1186
+300V
R2189 1M
C2189 .02
R1189 5.62K
-4.5
C1189 .02
L1189 6μh
-19V
D2186
-10.8
D2187
-10.5
Q2184 2N2048
'B' CAL
R2183 193K
R2185 16.5K
R2182 2.5K
R2184 1.82K
C2181 .02
R2181 56K
+300V
R1191 205K
C1191 18
R1192 3.32K
0V
R1195 2.7K
R2261 3.3K
+19V
R2240 1K
C2240 270
C2250 270
C2251 .027
+6.7
D2251 6V
+0.5
R2243 10K
-19V
+10
+0.2
Q2245 2N2048
-10.5
D2245
R2246 27K
C2246 18
R2247 220K
-100V
-100V
+19V
R2195 62K
R2199 36K
R2196 18K
D2249 11V
D2248
-11
R2248 2K
-19V
R2249 8.2K
-19V
VOLTAGE READINGS WERE OBTAINED UNDER FOLLOWING CONDITIONS:
MODE .... A ONLY
Trace .... Centered

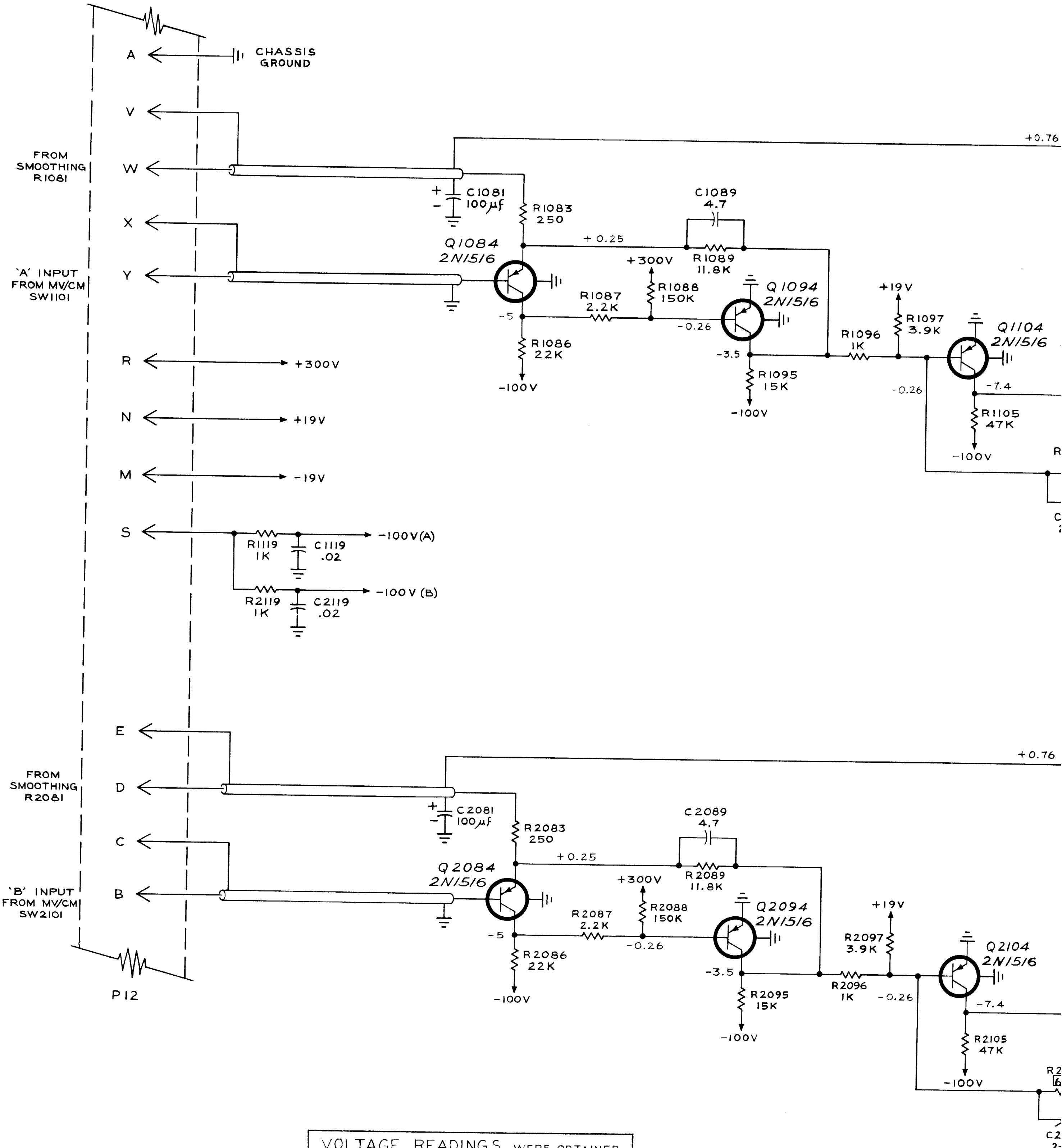


A

CMD
863

DUAL TRACE

SERIES 5 MODEL 3

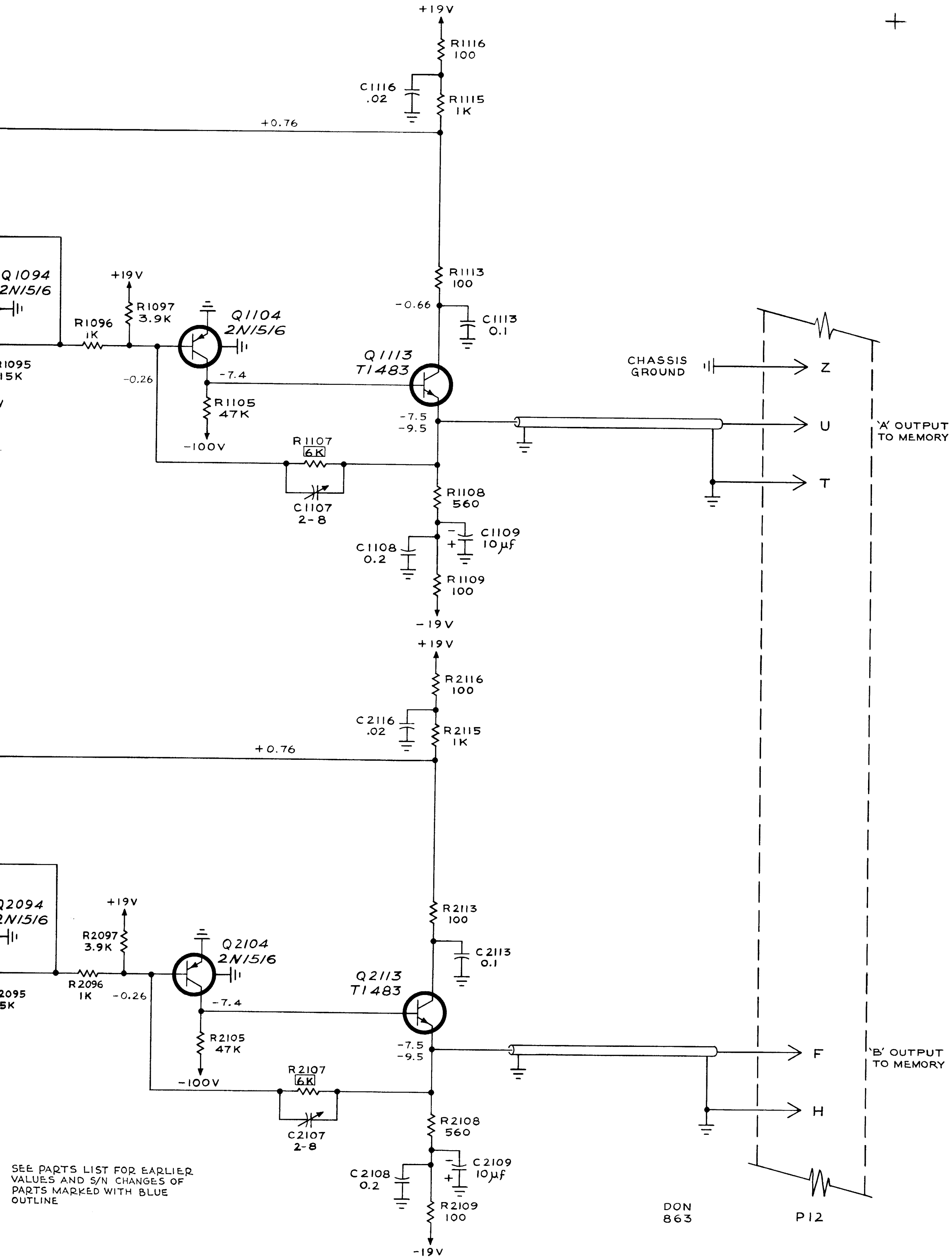


VOLTAGE READINGS WERE OBTAINED UNDER THE FOLLOWING CONDITIONS:

DC OFFSET . . . . .Zero Volts

SMOOTHING:
UPPER READINGS . . . . NORMAL
LOWER READINGS . . . . CCW

SEE PARTS LIST FOR EARLIER VALUES AND S/N CHANGES OF PARTS MARKED WITH BLUE OUTLINE



SEE PARTS LIST FOR EARLIER VALUES AND S/N CHANGES OF PARTS MARKED WITH BLUE OUTLINE

A

AC AMPLIFIER

SERIES 2 MODELS 2,3

AC AMP.

TYPE 4S2 - TENT. S/N 470

PARTS LIST CORRECTIONS

CHANGE TO:

C1007	283-099	33 pf	Cer	50 v	10%
C1017	283-099	33 pf	Cer	50 v	10%
C2007	283-099	33 pf	Cer	50 v	10%
C2017	283-099	33 pf	Cer	50 v	10%

TYPE 4S2

PARTS LIST CORRECTION

REMOVE

L1021	276-532	Core, Shield Bead
L2021	276-532	Core, Shield Bead

ADD

*C1031				
**R1021	317-201	220Ω	1/10w	5%
***R2021	317-201	220Ω	1/10w	5%

*This is a selected component. Its value can range from 0pf to 4.7pf depending on circuit requirements. When needed it is added between the grid of V1024 and ground.

**REPLACES L1021
***REPLACES L2021

TYPE 4S1 - TENT. Series 11, Model 3

TYPE 4S2 - TENT. Series 11, Model 3

TYPE 4S3 - TENT. Series 11, Model 3

PARTS LIST CORRECTION

(MEMORY BOARDS, TWO PER INSTRUMENT)

CHANGE TO:

D1130 } D1131 }	*152-145	with leads (1 pair)

TYPE 4S2

CHANGE TO: PARTS LIST CORRECTIONS

R1002	315-510	51Ω	1/4w	5%
R2002	315-510	51Ω	1/4w	5%

ADD:

C2030 This is a selected component. Its value can range from 0 pf to 4.7 pf depending on circuit requirements. When needed it is added at the grid of V2024 between L2021 and ground.

TYPE 4S2

PARTS LIST CORRECTIONS

REMOVE:

R1007	317-270	27Ω	1/10w	5%
R1017	317-270	27Ω	1/10w	5%
R2007	317-270	27Ω	1/10w	5%
R2017	317-270	27Ω	1/10w	5%

CHANGE TO:

D1002, D1003, D1004, D1005	*152-164	Point contact, low capacitance (2 pairs)
D2002, D2003, D2004, D2005	*152-164	Point contact, low capacitance (2 pairs)

ADD:

R1035	311-078	50k	.1w	Var
R1041	316-102	1k	1/4w	
R1045	316-221	220Ω	1/4w	
R2035	311-078	50k	.1w	Var

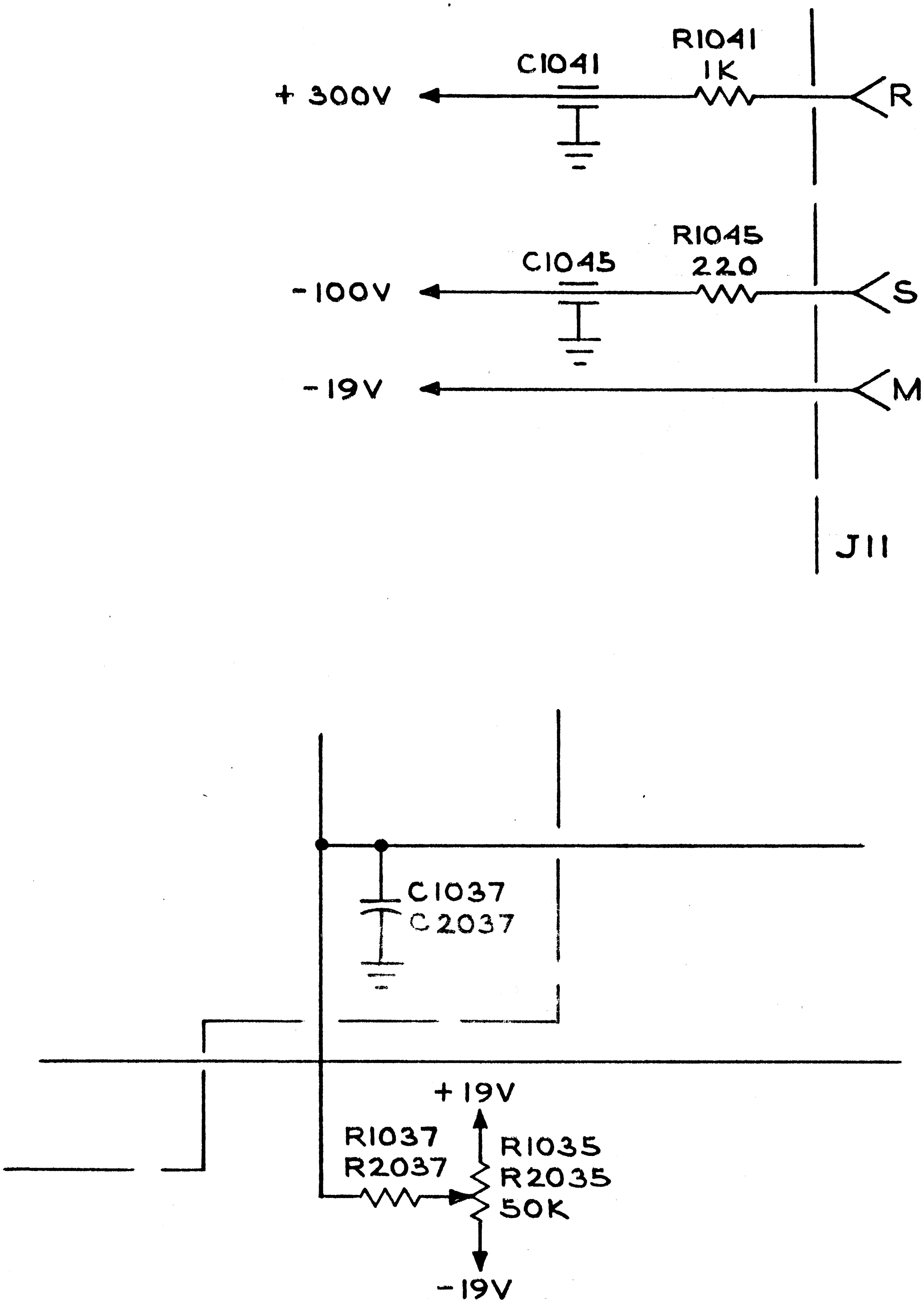
"GATE GENERATOR" Series 6 Model 2

CHANGE TO:

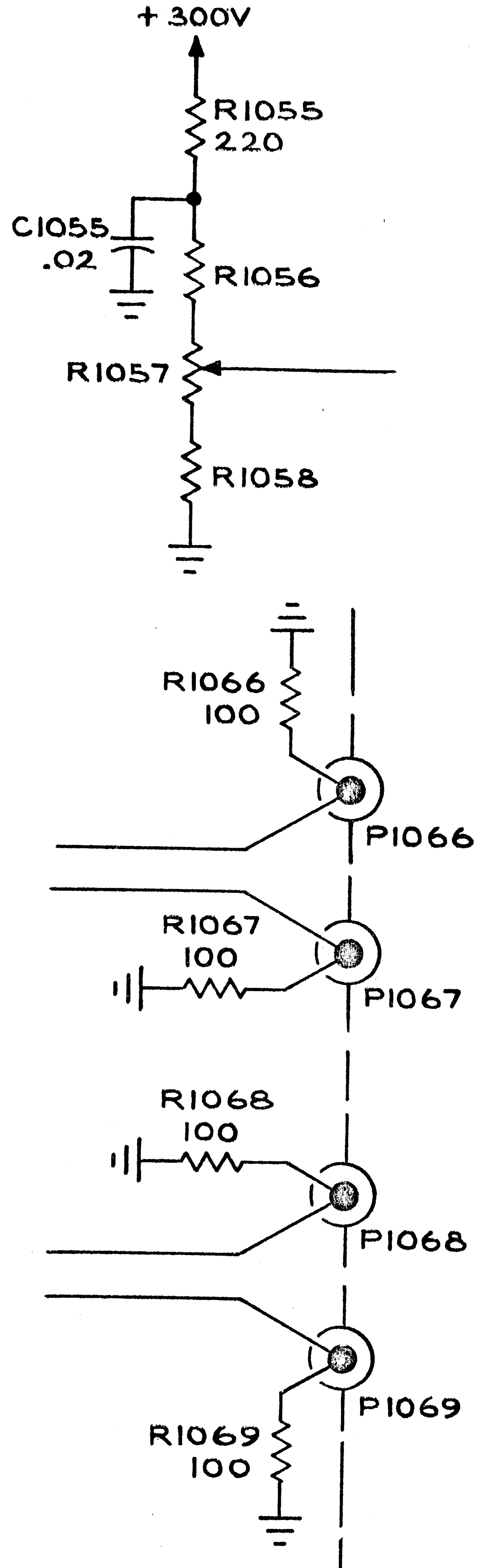
T1067	*120-340	Toroid 5T	TD115
T1069	*120-340	Toroid 5T	TD115

ADD:

C1055	283-006	.02μf	Disc Type	500v	
R1055	316-221	220Ω	1/4w		
R1066	321-097	100Ω	1/8w	Prec	1%
R1067	321-097	100Ω	1/8w	Prec	1%
R1068	321-097	100Ω	1/8w	Prec	1%
R1069	321-097	100Ω	1/8w	Prec	1%



PART. SAMPLER DIAG.



PART. GATE GEN. DIAG

TYPE 4S1, 4S2, 4S3

PARTS LIST CORRECTIONS

CHANGE TO:

R2240	301-102	1k	1/2w	5%	(DUAL TRACE BOARD) 4-up
R2248	301-102	1k	1/2w	5%	(DUAL TRACE BOARD) 4-up
R2250	301-102	1k	1/2w	5%	(DUAL TRACE BOARD) 4-up
R2258	301-102	1k	1/2w	5%	(DUAL TRACE BOARD) 4-up