INSTRUCTION MANUAL

Serial Number ______

TYPE 6R1 DIGITAL UNIT

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Tektronix International A.G.
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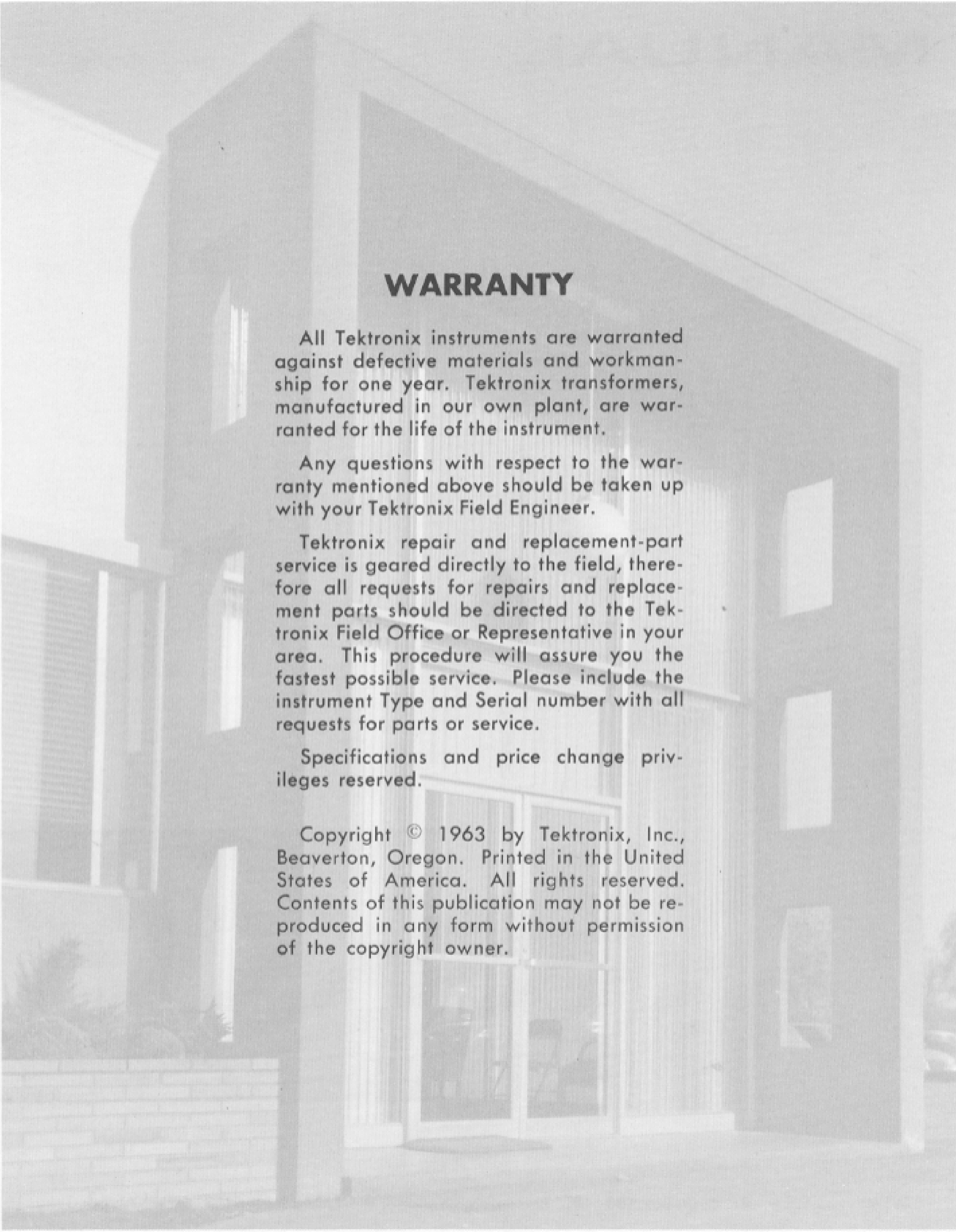


WARRANTY

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.

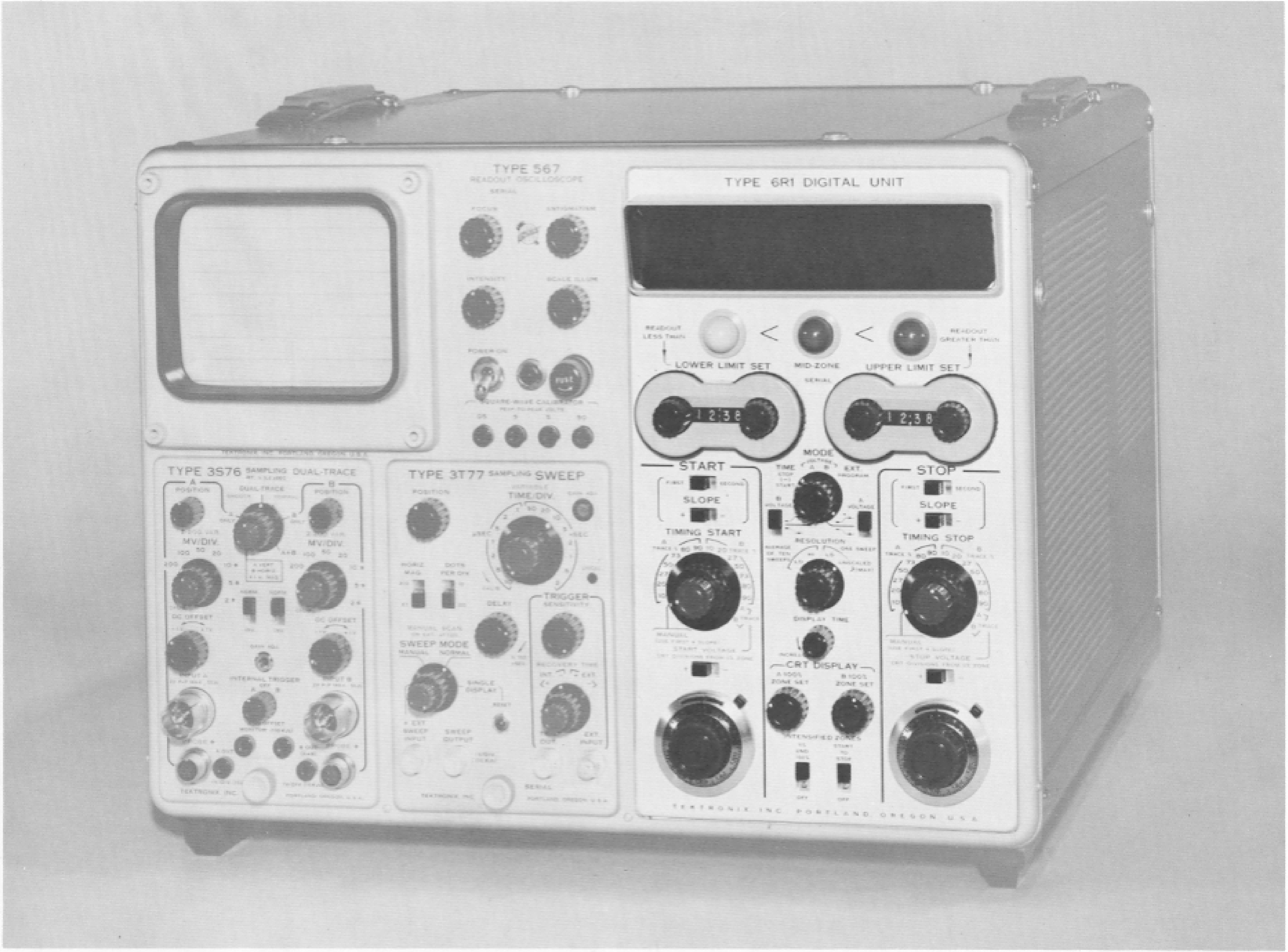
Any questions with respect to the warranty mentioned above should be taken up with your Tektronix Field Engineer.

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

A list of abbreviations and symbols used in this manual will be found on page 9-1.



The Type 6R1 Digital Unit installed in the Type 567 Readout Oscilloscope.

SECTION 1
CHARACTERISTICS

General Information

The Tektronix Type 6R1 Digital Unit presents, in digital form, measurement of time between percentages of pulse amplitudes, measurement of voltage, and the measurement of time difference between pulses when used with a dual-trace plug-in unit. The unit provides for automatic amplitude and time measurements with 4-digit readout plus unit of measure.

The Type 6R1 is designed for use in the Tektronix Type 567 Readout Oscilloscope. In conjunction with certain of the '3' series plug-in units, a wide variety of measurements can be made.

OPERATING CHARACTERISTICS

Input

Internally from horizontal and vertical plug-in units.

Units of Measure

Volts: Readout in millivolts (MV) and volts (V).

Time: Readout in nanoseconds (NS), microseconds (μS), milliseconds (MS), and seconds (S).

Numerical Range

Readout from .0000 to 9999.

Accuracy of Readout

The number shown on the readout is accurate to within 3% $\pm$1 count.

Display Time

Variable from 0.1 second to 6 seconds.

Preset No-Go Limits

Front-panel controls set lower and upper limits. Front-panel indicator lights show whether the number on the readout is less than, between, or greater than the preset limits.

Start and Stop Timing

A or B Trace %: Seven fixed percentages (10% through 90%), accurate to within 0.5%.

Manual Control: Uncalibrated.

Start and Stop Voltage: A precision dial to measure crt divisions from the 0% Zone, accurate to within 1%.

Maximum Sweep Rate

Non-Sampling Type Sweep: 10 μsec/div. maximum useful rate.

Sampling Type Sweep: Not limited.

External Programming

The Type 6R1 can be programmed externally from remote or automatic equipment. Readout information is available for external readout.

MECHANICAL CHARACTERISTICS

Construction

Aluminum-alloy chassis.

Front Panel

Photo-etched.

Net Weight

10.2 pounds.

CIRCUIT BOARD IDENTIFICATION

The end plate of each circuit board contains the name or function of the board, such as Counter, Voltmeter, etc., and a letter to show its location in the Type 6R1 chassis. The Counter boards, for example, have the letter A as a location guide; the Voltmeter board has the letter E as a location guide.

Circuit boards now under development for other instruments may also operate in the Type 6R1. These boards may be identified by two location guide letters. For example, a new Counter board may be identified as A/Z. This board will fit location A in the Type 6R1, and location Z in another instrument.

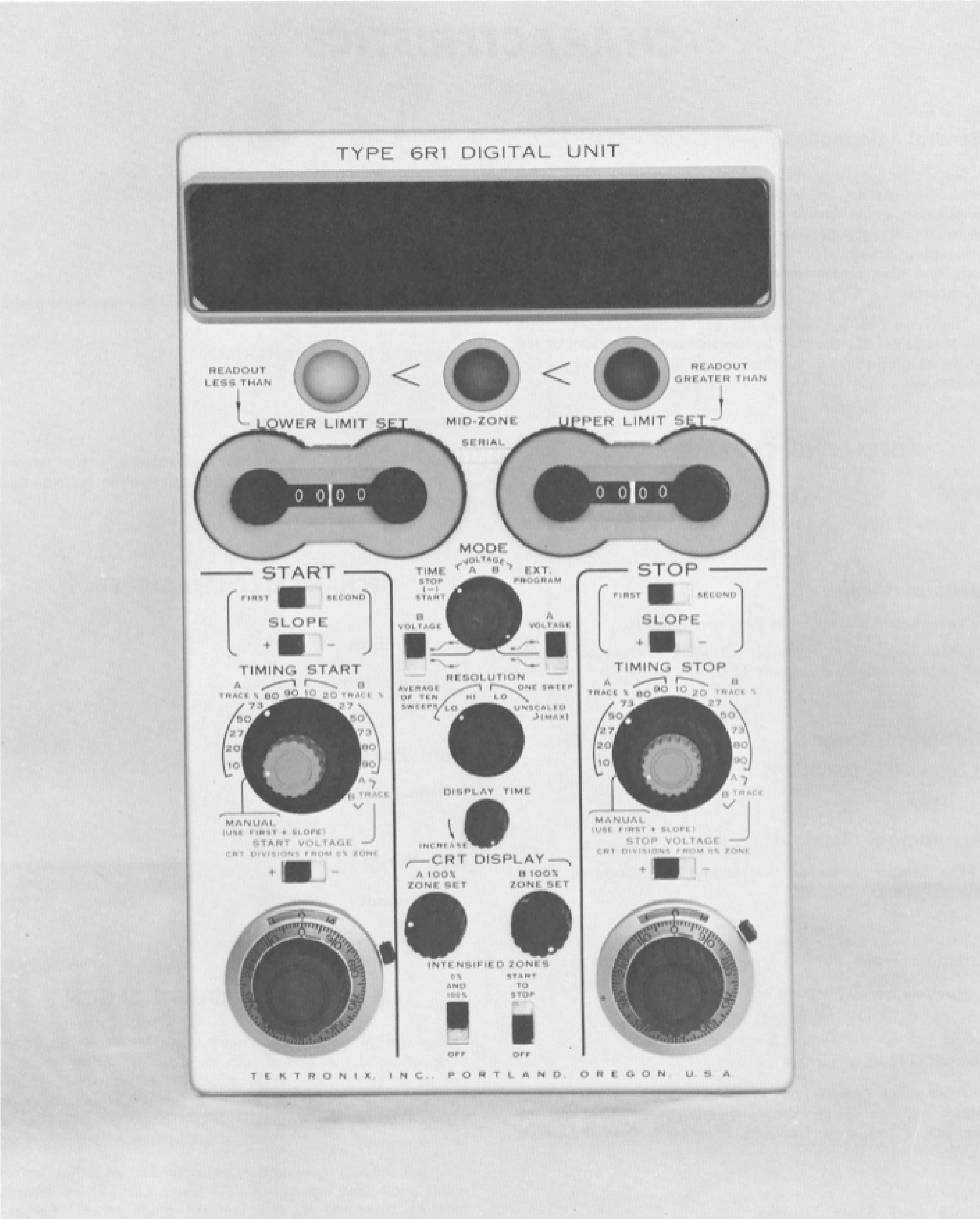


Fig. 2-1. Front panel of the Type 6R1 Digital Unit.

SECTION 2
OPERATING INSTRUCTIONS

Introduction

The Type 6R1 Digital Unit is an accurate readout device, for time and amplitude measurements, designed for use with the Tektronix Type 567 Readout Oscilloscope.

To get the most from your instrument, it is important to understand the function of each front-panel control. This section of the manual describes each control and its use in the operation of the instrument. As each control is described, note its location on the front panel of the Type 6R1 (see Fig. 2-1).

For the purpose of this procedure, the terms "intensified zone" and "slope" should be clearly understood. The following explanations define these terms as they apply to the Type 6R1.

The Type 6R1 produces three types of intensified zones on the crt as shown in Fig. 2-2. Each zone appears as a brightened portion of the trace.

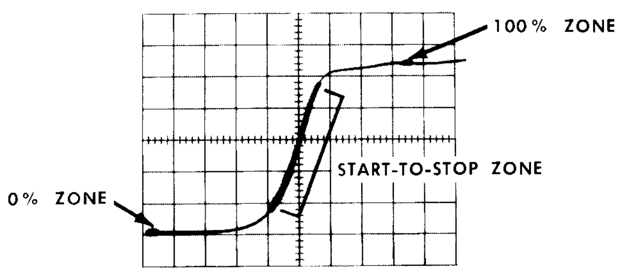


Fig. 2-2. Three types of Intensified Zones.

The first type of intensified zone is the 0% Zone. This zone appears at the start of the trace and has a fixed width and position. The 0% Memory circuit takes a voltage sample at this zone for use as a reference.

The second type of intensified zone is the Start-To-Stop Zone. The width of this zone is also fixed, but its position depends on the setting of the TIMING START and TIMING STOP switches. When the MODE switch is in the TIME position, this zone shows the portion of the waveform being measured. The Start-To-Stop Zone is extinguished when the MODE switch is set to the A or B VOLTAGE position.

The third type of intensified zone is the 100% Zone. Its position is variable with the A or B 100% ZONE SET control. The 100% Memory circuit takes a voltage sample at this zone.

All of the intensified zones can be turned off with the INTENSIFIED ZONES switches.

The term "slope" refers to the rising or falling portion of a pulse, as shown in Fig. 2-3. There are two kinds of slopes; a rising slope (positive going) and a falling slope (negative going). The SLOPE switches select the slope on which the measurement (time) starts and stops. The FIRST-SECOND SLOPE switch selects either the first or second positive-going slope, if the ± SLOPE switch is in the + position. If the ± SLOPE switch is in the — position, the FIRST-SECOND SLOPE switch will select either the first or second negative-going slope on the crt. To use the second position you need at least two pulses or cycles on the crt, since the second slope refers to the slope on the second pulse or cycle.

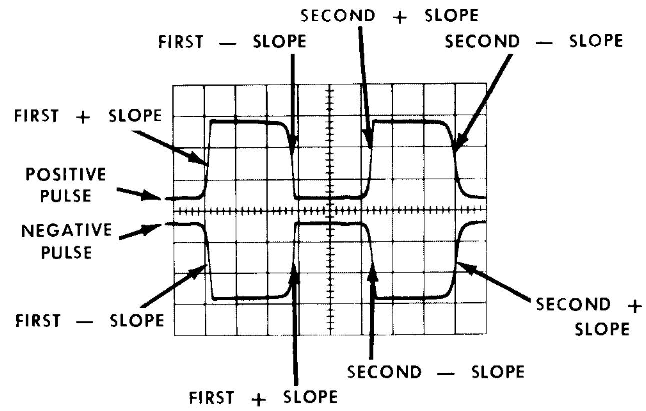


Fig. 2-3. Pulse slope definitions.

FUNCTION OF CONTROLS, SWITCHES, AND INDICATORS

START Block

The switches and controls in the START block are used only for time measurements.

SLOPE Switches

FIRST-SECOND	Selects the first or second slope on the display at which the measurement begins. To start on the second slope you need at least two cycles or pulses displayed on the crt. Always keep this switch in the FIRST position unless you are making a second-slope measurement.
±	Starts the measurement on the positive (+) or negative (—) slope of the pulse. To measure on a positive-going slope, use the + position. For measurement on a negative slope, use the — position. This switch, in conjunction with a similar switch in the STOP block, gives a variety of combinations. Keep in mind that you must set the START to precede the STOP, otherwise the display will be meaningless. Detailed use of this switch is covered later in this section.

TIMING START Switch

MANUAL: In this position of the TIMING START switch, you can turn the red knob on the front of the switch to manually set the start point of the measurement. (Be sure the SLOPE switches are in FIRST and + positions.) For example, if there were two pips on a waveform and you wanted to measure the time between them, first use this control to set the start of the intensified zone at the first pip, then use the MANUAL control on the TIMING STOP switch to set the end of the intensified zone at the second pip. The readout would give the time between pips.

A TRACE %: This precisely sets the percentage point at which the time measurement will start on the channel A trace. For example, in a risetime measurement, set this switch to A TRACE 10% to start, and set the TIMING STOP switch to A TRACE 90%. The readout would give the risetime of the waveform.

B TRACE %: This starts the measurement on the channel B trace when dual-trace plug-in units are used. Normally, when you start on B TRACE %, you also stop on B TRACE %. However, there are various combinations of A TRACE % and B TRACE % which will be described later in this section.

TRACE A-B—START VOLTAGE: In this position of the TIMING START switch you use the precision dial just below the switch. Each major division on the precision dial is calibrated to represent 1 vertical division on the crt, and will start the intensified zone at the selected point. For example, with the dial set at 1, the time measurement will start 1 vertical division up from the 0% Zone. The A-B refers to channel A or B and is set to the channel in use.

+ and — Switch

To start a measurement above the 0% Zone, use + (plus); to start below, use — (minus).

START VOLTAGE Control

A precision potentiometer and dial calibrated to move the start of the intensified zone 1 vertical graticule division for each major division (unit) on the dial. The dial consists of ten unit numbers (shown in the window) with one unit per complete turn. Each unit is divided into one hundred increments (numbers around the knob). For example, a 2 in the window and the number 43 opposite the index mark is a reading of 2.43.

The start of a measurement always has a 3 count or dot delay. Since the stop point has this same delay, the accuracy of a measurement is not affected. On fast-rising pulses the crt will show the Start-To-Stop Zone 3 dots above the start point and 3 dots below the stop point.

Center Controls

MODE Switch

TIME STOP (—) START: Position used for all time measurements.

VOLTAGE A-B: Position used for voltage measurements. The A and B refer to the channel of the vertical amplifier plug-in unit.

EXT. PROGRAM: Used when the instrument is set up to operate on external commands.

B VOLTAGE Switch

Set to the polarity (up, +; down, —) of the pulse being measured when the MODE switch is on channel B.

A VOLTAGE Switch

Set to the polarity (up, +; down, —) of the pulse being measured when the MODE switch is on channel A.

RESOLUTION Switch

AVERAGE OF TEN SWEEPS—LO-HI: Counts ten continuous sweeps, and moves the decimal point to indicate average. Right-hand digit (units) blanked in LO, visible in HI.

ONE SWEEP—LO: Measures one sweep of the displayed waveform.

UNSCALED (MAX): Turns off unit of measure (right-hand indicator tube) and decimals. Also, the count is direct (not divided down by the ÷ 1, 2, 5 circuit). The number on the readout must be divided by 2 when the TIME/DIV. switch is in a 5 position, and divided by 5 when the TIME/DIV. switch is in a 2 position.

DISPLAY TIME Control

Varies the time from one readout display to the next. During this period the readout holds the last number counted. No further count will be made until the display period ends (0.1 to 6 sec).

CRT DISPLAY Controls

A 100% ZONE SET — Sets the 100% zone (intensified) of the channel A waveform.

B 100% ZONE SET — Sets the 100% zone of the channel B waveform.

INTENSIFIED Zones Switches

0% and 100% — Turns off the intensified portion of the waveform in the 0% and 100% zones.

START TO STOP — Turns off the intensified part of the waveform between the Start-To-Stop zone.

STOP BLOCK

The switches and controls in the STOP block are used only for time measurements.

SLOPE Switches

FIRST-SECOND — Selects the slope on the waveform at which the measurement stops. For example, the time of one cycle is found by setting the TIMING START and STOP switches to 50%, the START block SLOPE switch to FIRST, and the STOP block SLOPE switch to SECOND.

± — Stops the measurement on the positive (+) or negative (—) slope of the waveform.

TIMING STOP Switch — MANUAL: The red knob on the front of the switch sets the stop point on the displayed waveform. (Be sure the SLOPE switches are in FIRST and +.)

A TRACE %: Sets the percentage point on channel A at which the measurement will stop.

B TRACE %: Sets the percentage point on channel B at which the measurement will stop.

TRACE A-B—STOP VOLTAGE: In this position of the TIMING STOP switch, use the precision dial just below the switch. Each major division on the precision dial is calibrated to represent one vertical division on the crt, and will stop the intensified zone at the selected point. For example, with the dial set at 3, the measurement will stop 3 divisions up or down from the 0% Zone.

+ and — Switch — To stop a measurement above the 0% Zone, use + (plus); to stop below, use — (minus).

STOP VOLTAGE Control — A precision potentiometer and dial calibrated to move the stop point of the intensified zone one vertical graticule division for each major division (unit) on the dial. The dial consists of ten unit numbers (shown in the window) with one unit per complete turn. Each unit is divided into one hundred increments (numbers around the knob). For example, a 2 in the window and the number 43 opposite the index mark is a reading of 2.43.

The start point of a measurement always has a 3 count or dot delay. Since the stop point has this same delay, the accuracy of a measurement is not affected. On fast-rising pulses the crt will show the Start-To-Stop Zone 3 dots above the start point and 3 dots below the stop point.

Upper Controls

LOWER LIMIT SET Dials and Lamp — In go-no-go (accept or reject) type measurements, these dials set the lower acceptable limit. If the number on the readout (indicator tubes) is less than the number shown on these dials, the LOWER LIMIT lamp will light. This information is also present at the external program plug for automatic reject mechanisms.

MID-ZONE Lamp — This lamp lights when the number on the readout is within the limits (inclusive) set on the LOWER LIMIT SET and the UPPER LIMIT SET dials.

UPPER LIMIT SET Dials and Lamp — Sets the upper acceptable limit. If the number on the readout is greater than the number shown on these dials, the UPPER LIMIT lamp will light. This information is also present at the external program plug.

The limit lamps also serve as a ready light to show that the instrument has completed a count. While the instrument is counting, these lamps are extinguished.

Digital Readout Indicators — The numbers (indicator tubes) are read direct.

Unit of Measure Indicator — The right-hand indicator tube gives the unit of measure in NS, μS, MS, MV, and V. This tube is dark when the RESOLUTION switch is in the UNSCALED (MAX) position or when either the VOLTS/DIV. or TIME/DIV. variable controls on the plug-in units are in the uncalibrated position.

Decimal Point Indicator — The decimal point is automatically placed in the proper position by the TIME/DIV. switch of the horizontal time-base plug-in unit when you measure time, and by the VOLTS/DIV. switch of the vertical amplifier plug-in unit when you measure voltage. No interpolation is necessary, since the reading is always direct.

MEASUREMENTS WITH THE TYPE 6R1 DIGITAL UNIT

The following paragraphs tell how to use the Type 6R1 Digital Unit. Four basic measurements are described. Once these basic techniques are mastered, you should be able to set up the instrument for other measurements.

In addition to the Type 567 Oscilloscope and two plug-in units (such as Types 3S76 and 3T77), a signal source is required. A Tektronix Type 109, 110, or 111 Pulse Generator, or a similar type generator, will serve this purpose.

Preliminary Set-Up

Set the front-panel controls and switches as follows:

START Block:

SLOPE Switches	FIRST and +
TIMING START	A TRACE 10%
START VOLTAGE	+
Dial	0.00

STOP Block:

SLOPE Switches	FIRST and +
TIMING STOP	A TRACE 90%
STOP VOLTAGE	+
Dial	0.00
MODE	TIME STOP (—) START
B VOLTAGE	Up
A VOLTAGE	Up
RESOLUTION	ONE SWEEP LO
DISPLAY TIME	Fully clockwise

CRT DISPLAY Controls:

A 100% ZONE SET	Fully counterclockwise
B 100% ZONE SET	Fully counterclockwise

INTENSIFIED ZONES Switches:

0% AND 100%	Up
START TO STOP	Up
LOWER LIMIT SET	0000
UPPER LIMIT SET	0000

Risetime Measurement

Risetime is the time required for a pulse to rise from 10% to 90% of its amplitude. For example, assume you have a 100-millivolt peak-to-peak pulse. The pulse begins at zero and starts to rise. When it reaches 10 millivolts (10% point) the count starts (microseconds, milliseconds, etc.). When the pulse amplitude reaches 90 millivolts (90% point), the count stops. The readout indicates the risetime of the pulse.

To make a risetime measurement proceed as follows (any control not mentioned should remain in the position called out in the preliminary set up):

1. Apply the signal to channel A of the vertical amplifier plug-in unit and display a single pulse on the crt. (Adjust the delay or trigger on the sweep plug-in unit so that the 0% intensified zone is on a flat portion of the trace before the rise of the vertical signal.)

2. Adjust the A 100% ZONE SET control to place the 100% zone at the peak of the waveform. Be sure the TIMING START switch is set to A TRACE 10% and the TIMING STOP switch to A TRACE 90%.

3. Turn the DISPLAY TIME control to midrange. Each change of the readout represents a new count.

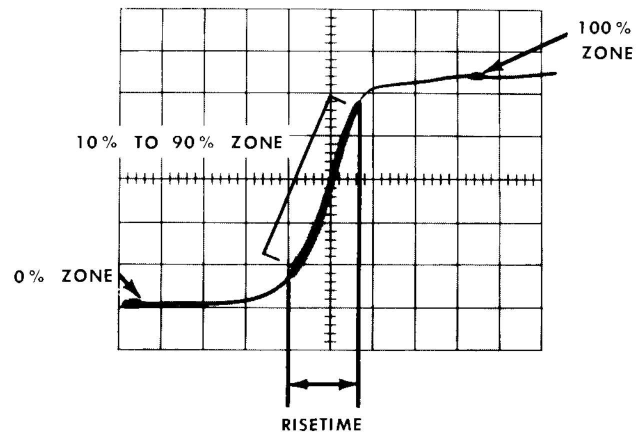


Fig. 2-4. Risetime measurement.

4. Read the risetime directly from the readout. This is the risetime of the pulse (see Fig. 2-4).

Notice the three intensified zones. First, on the left is the 0% zone. Next is the zone between 10% and 90% (Start-To-Stop zone) which was just measured. Last is the 100% zone. You can turn off the 0% and 100% zones by moving the INTENSIFIED ZONES 0% AND 100% switch to OFF.

Falltime Measurement

This is similar to the risetime measurement except that this is the time it takes the pulse to fall from 90% of its amplitude to 10% of its amplitude. In the case of a positive pulse, the measurement is on the first negative slope of the pulse. (For a negative pulse, use the first positive slope for this measurement.) Return all controls and switches to their preliminary position.

1. Adjust the time-base controls to trigger on the negative slope of the pulse. This places the 0% zone on the waveform peak. Set the 100% zone to the lowest point on the waveform (see Fig. 2-5).

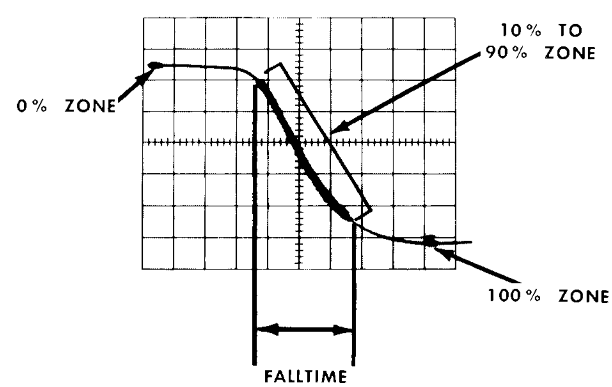


Fig. 2-5. Falltime measurement.

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2. Set the SLOPE switches in the START block to FIRST and —.

3. Set the TIMING START switch to A TRACE 10%.

4. Set the SLOPE switches in the STOP block to FIRST and —.

5. Set the TIMING STOP switch to A TRACE 90%.

6. Read the falltime on the readout.

Voltage Measurement

Using the same pulse as for the risetime measurement, the following steps show how to measure the peak amplitude (voltage) of this pulse.

1. Set the MODE switch to VOLTAGE A.

2. Set the A VOLTAGE switch up. (If the pulse were negative-going, this switch would be down.)

3. Turn the A 100% ZONE SET control until the 100% zone is on the peak of the pulse. (In cases where the pulse has overshoot, set the 100% zone on the flattened part of the pulse beyond the overshoot.)

4. Read the voltage shown on the readout. This is the peak amplitude of the pulse. (To include the overshoot, if any, move the 100% zone to the peak of the overshoot and note the reading. For amplitude of the overshoot only, subtract the first reading from the second.)

This measurement shows that voltage readings are taken between the 0% and 100% zones. Since you can move the 100% zone to any point, you can measure the amplitude at any point on a waveform.

Frequency Measurement

This measurement counts the repetition rate in cycles per second (cps) or pulses per second (pps). The counter starts at the 50% point on one pulse and stops at the 50% point on the following pulse. This gives the time of one pulse or cycle. The reciprocal of the time, in seconds, equals the frequency in cps or pps ($F = 1/T$). Return all controls to their preliminary position.

To measure frequency, proceed as follows:

1. Adjust the horizontal time-base plug-in unit to display 1½ cycles or pulses (see Fig. 2-6).

2. Adjust the 100% ZONE SET control to place the 100% zone on the peak of the second pulse or cycle.

3. Set the MODE switch to TIME STOP (—) START.

4. Set the TIMING START switch to A TRACE 50%.

5. Set the SLOPE switch in the STOP block to SECOND.

6. Set the TIMING STOP switch to A TRACE 50%.

7. Read the time for one pulse or cycle on the readout. The reciprocal of the time is the frequency in cps or pps.

Phase or Time-Difference Measurement

The following steps show how to measure the time difference between two similar pulses or cycles, one in channel A and the other in channel B (see Fig. 2-7). You measure the time from the 50% point on the channel A pulse to the 50% point on the channel B pulse. This is the time difference between channel B and A. Return the controls to their preliminary setting. To make a time-difference measurement, proceed as follows:

1. Set both START and STOP SLOPE switches to FIRST and +.

2. Set the TIMING START switch to A TRACE 50%.

3. Set the TIMING STOP switch to B TRACE 50%.

4. The number shown on the readout is the delay of channel B with respect to channel A.

In this example you could have had channel A delayed, in which case you would start on B TRACE 50% and stop on A TRACE 50%.

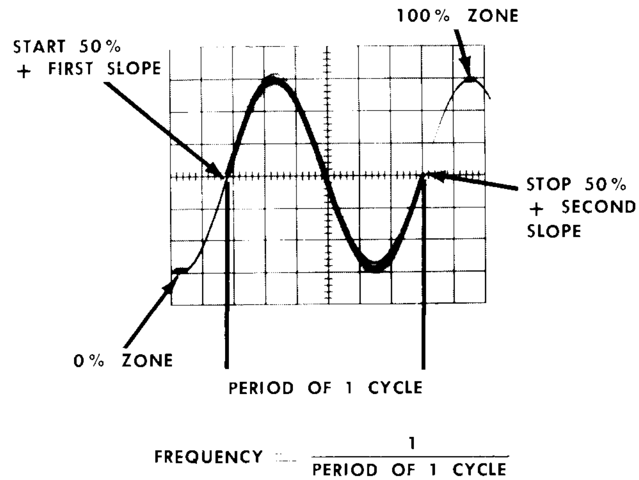

Fig. 2-6. Frequency measurement.

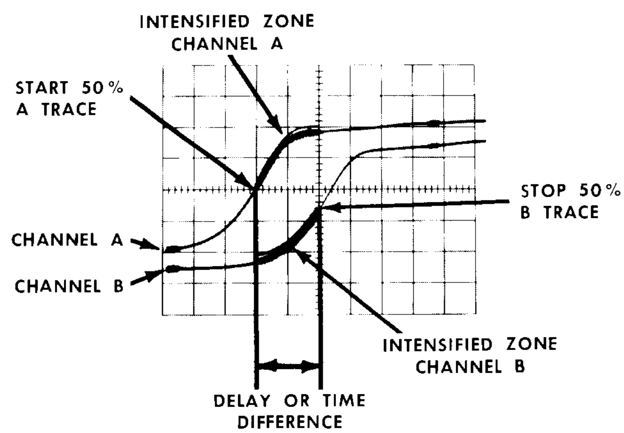

Fig. 2-7. Delay or time-difference measurement.

SECTION 3
APPLICATIONS

This section describes some typical applications of the Type 6R1 Digital Unit. Among these are transistor, diode, and delay-line measurements. In addition, other applications are illustrated to point out various features designed into the instrument. Since there are many applications for the Type 6R1, this manual covers only a few of the more general ones.

Transistor Characteristics

This application is illustrated in Fig. 3-1. A pulse is fed to one channel of a dual-trace vertical amplifier plug-in unit (such as the Type 3S76). The pulse is also fed to the transistor under test and the output from the transistor is fed to the other channel of the vertical plug-in unit. With the proper program set into the Type 6R1, a large variety of transistor characteristics can be measured. The equipment needed for this application is as follows:

1. Pulse generator, 0.5-nsec risetime (such as Tektronix Type 109, 110, or 111).

2. Transistor test fixture (such as Tektronix Type 290 Transistor Switching Time Tester).

3. Assorted 50 Ω cables.

Adjust the trigger stability of the time-base unit, and the pulse amplitude and polarity of the vertical amplifier unit, for a display similar to that shown in Fig. 3-2.

The following steps and Type 6R1 Program Chart outline a method for measuring eight different parameters of the transistor under test.

1. Set the MODE switch to TIME STOP (—) START.

2. Set the START and STOP SLOPE switch to FIRST.

3. The position of the ± SLOPE switches and the setting of the TIMING START and STOP switches for each measurement are listed in the chart.

4. Each measurement is read directly from the readout indicator.

	PROGRAM			
MEASUREMENT	START SLOPE	TIMING START	STOP SLOPE	TIMING STOP
Risetime B	—	10% B	—	90% B
Falltime B	+	90% B	+	10% B
Delay A to B	+	10% A	—	10% B
Storage A to B	—	90% A	+	90% B
Turn-on A to B	+	10% A	—	90% B
Turn-off A to B	—	90% A	+	10% B
Width A	+	50% A	—	50% A
Width B	—	50% B	+	50% B

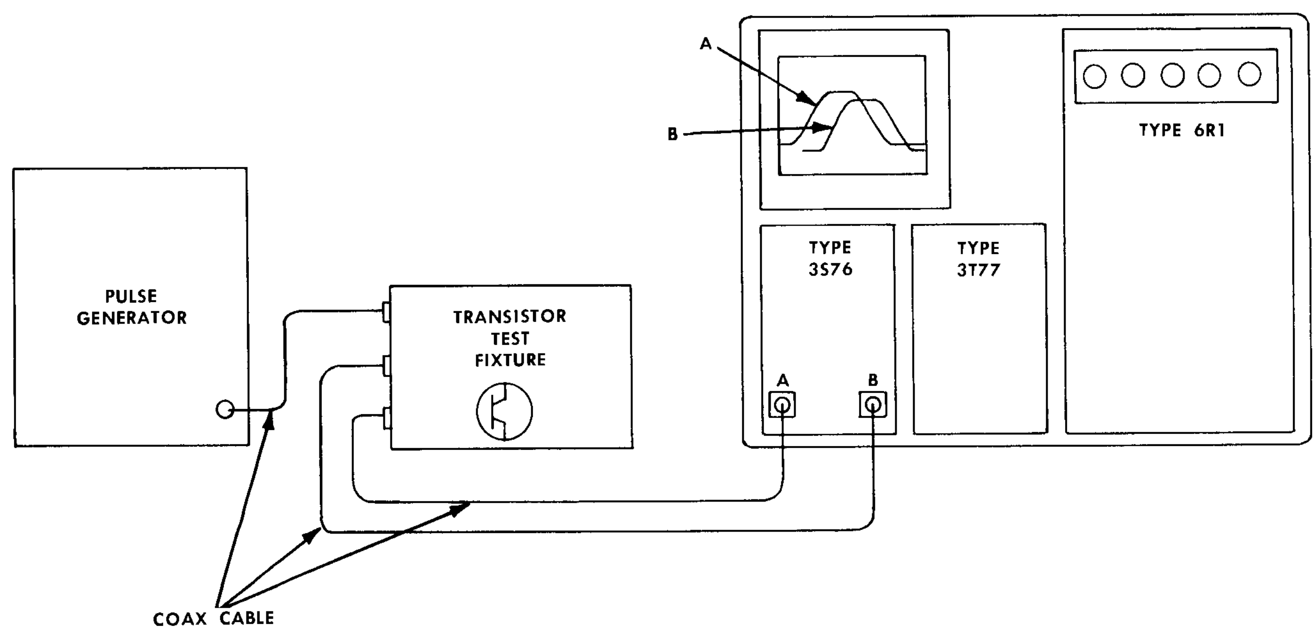

Fig. 3-1. Test setup for transistor measurements.

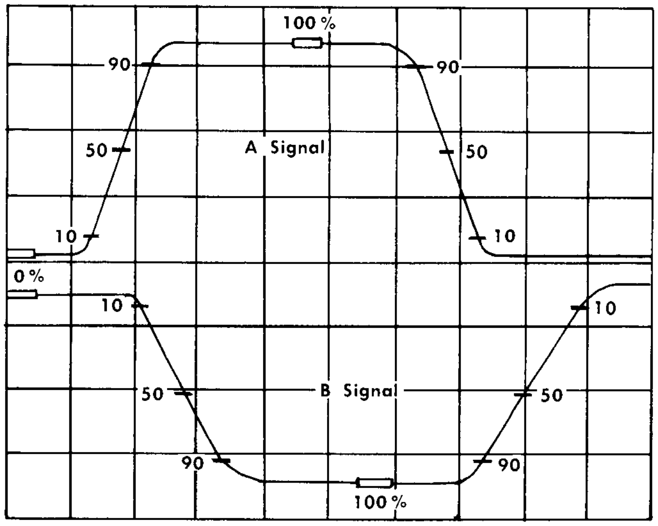

Fig. 3-2. Waveform display for transistor measurements. The channel A display is the pulse input to the transistor; the channel B is the output signal from the transistor.

Delay Line Measurements

The measurement of the delay time of a coaxial cable is easily done using the Type 6R1 with sampling plug-in units (Tektronix Type 3S76 and 3T77). A pulse is fed directly to channel A of a dual-trace vertical unit (Fig. 3-3). With a Tee connector (GR 874) at the input to channel A, the cable under test couples the pulse to the channel B input connector. The Type 6R1 measures the time between the 50% point on the rise of the channel A pulse and the 50% point on the rise of the channel B pulse. This time is the delay of the cable under test.

Set up the equipment as follows:

1. Adjust the pulse generator and sampling units to display a 50-nanosecond pulse (approximately) through a Tee connector (GR 874) to channel A of the Type 3S76.

2. Connect the cable under test from the Tee connector to the channel B input connector. Turn the MODE switch on the Type 3S76 to DUAL-TRACE.

3. Adjust the 100% zones on the Type 6R1 to the same point on the channel A and B pulse.

4. Set the Type 6R1 switches as follows:
   START Block: FIRST + SLOPE—A TRACE 50%
   STOP Block: FIRST + SLOPE—B TRACE 50%

5. The time shown on the readout is the delay time of the cable under test.

Another method to measure cable delay uses the charge line connector on the pulse generator. This method requires only a single-channel vertical amplifier.

1. Connect the pulse generator through a 50 Ω cable to channel A of the vertical amplifier.

2. Connect charge line (50 Ω) to the pulse generator and display a 50-nanosecond (approximately) pulse.

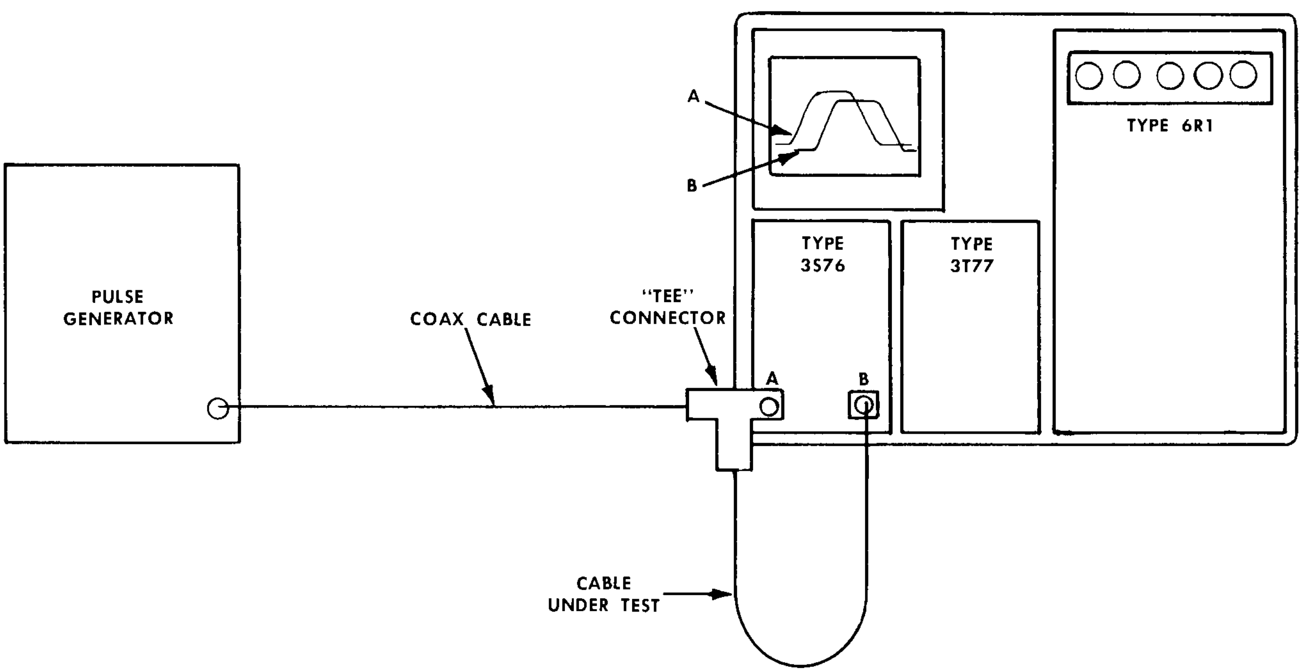

Fig. 3-3. Test setup for delay line measurement.

Set the Type 6R1 switches as follows:
START Block: FIRST + SLOPE—A TRACE 50%
STOP Block: FIRST — SLOPE—A TRACE 50%

4. Record the time shown on the readout.

5. Add the cable to be measured to the charge line on the pulse generator. Record the readout.

6. Subtract the reading in step 4 from the reading of step 5. Divide the remainder by 2. The result is the delay time of the cable under test.

For example, assume the charge line produced a 50-nanosecond pulse width. When the cable to be measured is added, the pulse width increases to 70 nanoseconds.

Subtract: 50 from 70 = 20

Divide by 2: 20 ÷ 2 = 10

Delay of Cable = 10 nanoseconds.

Diode Measurements

Switching and recovery time can be measured when the Type 6R1 is used with sampling plug-in units. Also, diodes can be compared and matched for particular response characteristics. Two basic diode test circuits are illustrated.

The first test circuit is shown in Fig. 3-4. This circuit measures reverse recovery time.

A pulse generator (such as the Tektronix Type 109, 110, or 111) with a +5-volt fast-rise pulse abruptly shuts off forward current through the diode. The leading edge of the pulse causes a reverse current peak followed by a drop to zero. The time between the current peak and zero is the diode reverse recovery time. (See Fig. 3-5.)

The second diode test measures turn-on time. A pulse generator is connected through a 50-ohm cable to the input connector of a dual-trace plug-in unit (sampling type). The diode under test is connected from the cable center conductor to ground with a Tee connector (see Fig. 3-6).

The dynamic impedance of the diode can be calculated from the oscilloscope display with the following formula.

$$Z = \frac{25V_2}{V_1 - V_2}$$

(V_1 and V_2 are identified in Fig. 3-6.)

With the Type 6R1 MODE switch set to the VOLTAGE position, V_2 can be measured at different time points on the display. From these voltages and time points, a turn-on curve for the diode can be plotted.

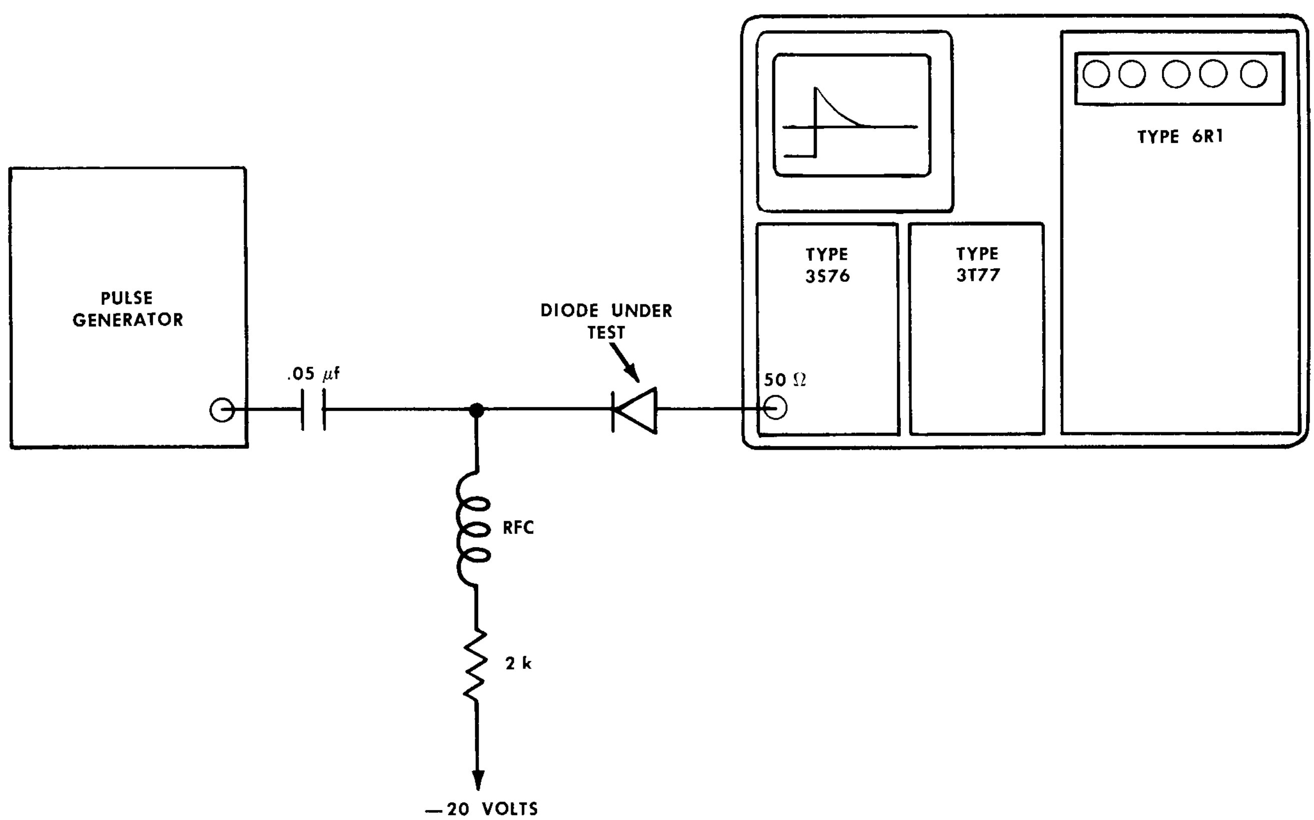

Fig. 3-4. Test setup for diode reverse recovery measurements.

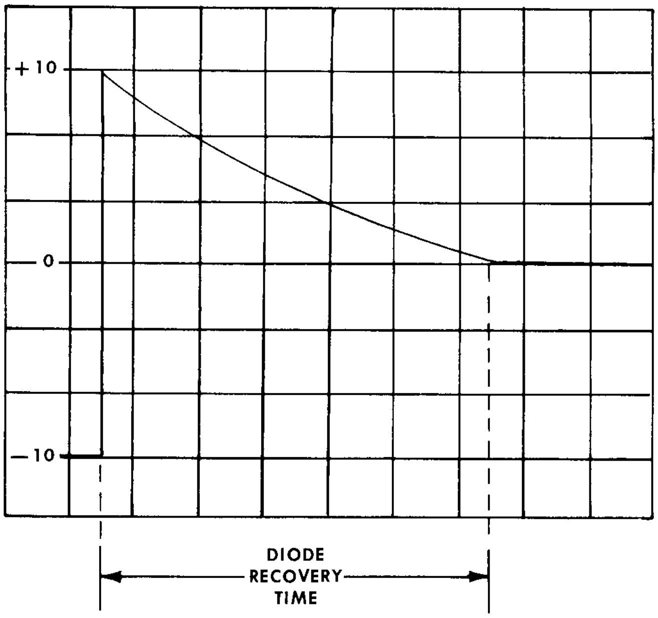

Fig. 3-5. Waveform measurement points for diode recovery time.

Tunnel Diode Risetime Measurement

The Type 6R1 with the Tektronix Tunnel Diode Risetime Tester can be used to compare and measure the risetime of tunnel diodes.

The instruction manual for the Tunnel Diode Risetime Tester gives the circuit and test setup needed to make this measurement.

Time Constants

The Type 6R1 with real-time plug-in units (Tektronix Type 3A2 and 3B2) can be used for production testing of capacitors and inductors.

The component under test is made part of an RC or RL circuit and the time constant is measured. The TIMING START and STOP switches have been specially designed to measure one RC time between the 27% and 73% points of a waveform (see Fig. 3-7).

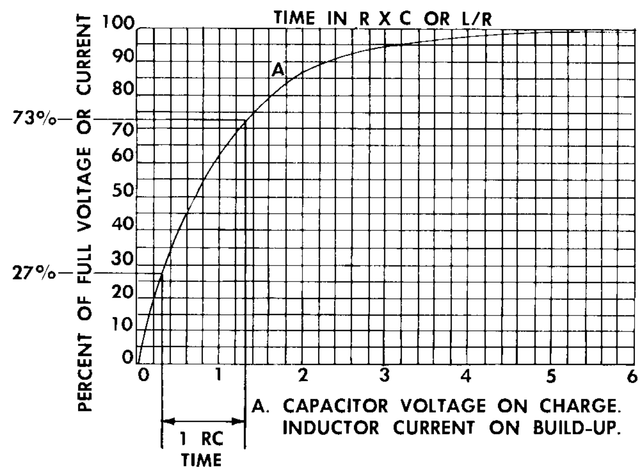

Fig. 3-7. Universal time constant chart.

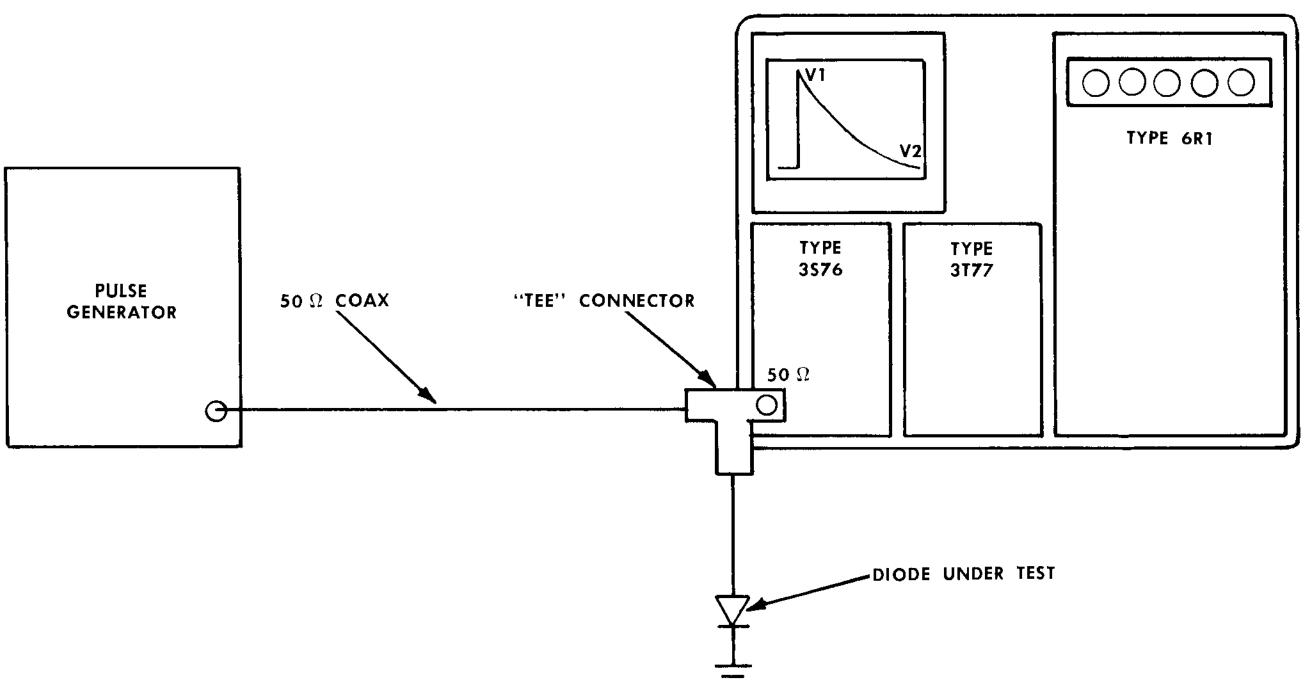

Fig. 3-6. Test setup to measure turn-on time.

The acceptable limits of tolerance of the component are calculated and these values are set on the UPPER and LOWER LIMIT SET dials. A component within the acceptable range will show a green light while component values outside the acceptable range will show either a yellow or red light.

Linearity Measurements

The rate-of-rise or linearity of a waveform such as a sawtooth can be checked with the calibrated START and STOP VOLTAGE dials.

1. Display the waveform on the crt. Adjust the amplitude for between 6 and 8 divisions of vertical deflection.

2. Adjust triggering and delay controls to set the start of the waveform to the right of the 0% zone.

3. Set the Type 6R1 controls and switches as follows:

START Block } FIRST + SLOPE—A TRACE START VOLTAGE +

STOP Block } FIRST + SLOPE—A TRACE STOP VOLTAGE +

MODE Switch: TIME STOP (—) START

4. Set the START VOLTAGE dial to 0.00. Turn the STOP VOLTAGE dial to 1.00. Note the readout.

5. Set the START VOLTAGE dial to 1.00 and the STOP VOLTAGE dial to 2.00. Note the readout.

6. Continue to move each dial 1 division higher and note the readout.

An exact linear rise will give the same reading for each part of the waveform measured.

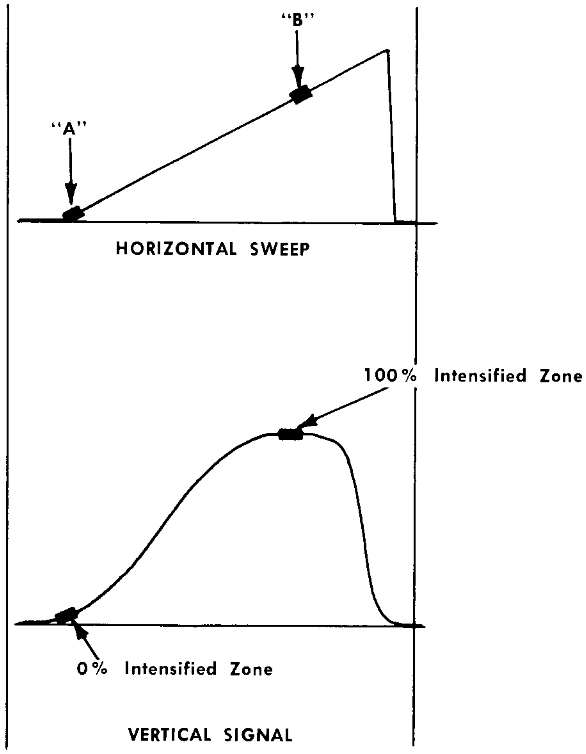

Fig. 4-1. Time relationship between the horizontal sweep and the vertical signal.

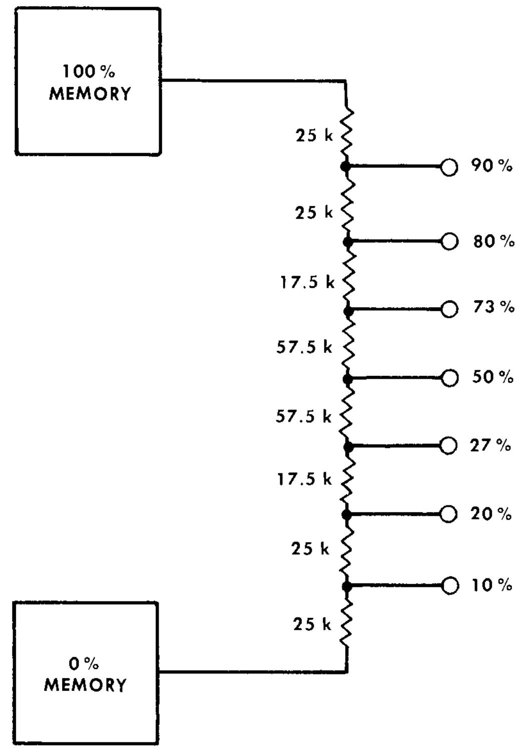

Fig. 4-3. Timing switch example.

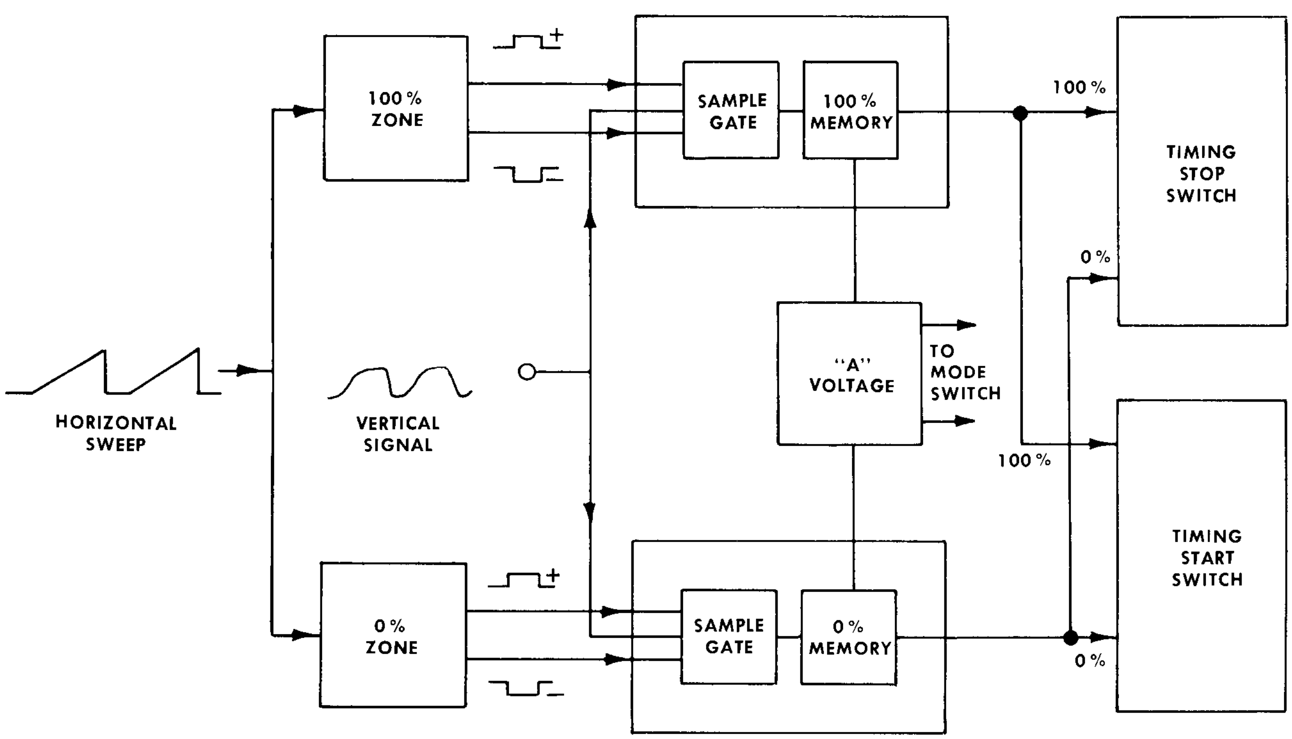

Fig. 4-2. Formation of 0% and 100% zones.

SECTION 4

CIRCUIT DESCRIPTION

Introduction

The Type 6R1 Digital Unit consists of a plug-in type chassis with controls, switches, and a readout on the front panel. The circuits of the unit are contained on 17 plug-in etched circuit boards.

This discussion will first describe the theory of operation of the instrument with progressive block diagrams, followed by an explanation of the makeup of the front-panel controls, and a detailed description of each etched circuit board.

THEORY OF OPERATION

The usual way to measure time periods with an oscilloscope is to count the horizontal divisions on the crt between the points to be measured. This distance multiplied by the setting of the TIME/DIV. switch equals the elapsed time.

With the Type 6R1, the elapsed time between two points on a waveform display is measured with a counter and presented as a digital readout. To do this, the instrument needs specific information from the vertical amplifier and time-base plug-in units.

The information required from the vertical plug-in unit includes:

1. The signal to be measured.
2. The unit of measure (millivolts, etc.).
3. The position of the decimal point for voltage measurements.

The information required from the time-base unit includes:

1. Horizontal sweep waveform.
2. Horizontal gate waveform.
3. Clock pulses (time measurements).
4. Unit of measure (nanoseconds, etc.).
5. The position of decimal point for time measurements.

Fig. 4-1 shows the time relationship between the vertical signal and the horizontal sweep waveform. In the description that follows, the 100% intensified zone on the crt is set to the peak amplitude of the input signal. In addition, the signal from the vertical amplifier plug-in has a quiescent dc level between +3 and +14 volts set by the amplifier POSITION control.

The horizontal sweep is applied to the 0% and 100% Zone circuits as shown in Fig. 4-2. The start of the sweep (point A in Fig. 4-1) causes the 0% Zone circuit to form a + and — pulse. These pulses are applied to the 0% Memory circuit Sample Gate. The gate opens and the circuit takes a sample of the vertical signal ('A' Voltage, Fig. 4-1) at point A. This sample is stored in the 0% Memory circuit. The output of the 0% Memory is applied to the bottom of a string of precision resistors (see Fig. 4-3).

When the horizontal sweep reaches point B (Fig. 4-1), the sweep voltage causes the 100% Zone circuit to form a + and — pulse that opens the 100% Memory circuit Sample Gate. Thus, a sample of the vertical signal is taken at point B and stored in the 100% Memory circuit. The output of this circuit is applied to the top of the resistor string (Fig. 4-3).

The position of the 0% Zone is fixed in relation to the sweep, but the 100% Zone can be moved to any point on the display and is set by a front-panel control (100% ZONE SET).

The precision resistors mentioned previously and shown in Fig. 4-3 make up the TIMING START and TIMING STOP switches. The voltage from the 0% Memory is applied to the bottom and voltage from the 100% Memory is applied to the top of both the TIMING START and TIMING STOP switches. Thus, the voltage across the switches represents 100% of the voltage between the 0% and 100% points on the signal. These switches allow the operator to make measurements between preselected points, for example, from 10% to 90%.

Since the Sample Gates and Memory circuits take a sample of the vertical signal on each sweep, any change in signal voltage will cause a like change in the Memory outputs. Thus, the Memory circuits automatically adjust to the signal voltage.

There are two Memory circuit boards, one for channel A and one for channel B. Both channels share the precision resistors that make up the TIMING START and TIMING STOP switches.

The next part of the system contains the circuits that feed the Start and Stop Signal Comparators (see Fig. 4-4). Since the Comparator inputs are different for each mode of operation, the modes will be described separately, starting with time measurements.

Each Comparator needs two input voltages:

1. A reference voltage that sets the point of comparison (start and stop of measurement).

2. The signal from the vertical amplifier (or the horizontal sweep voltage in the MANUAL position of the TIMING START and TIMING STOP switches).

The START SLOPE and STOP SLOPE switches (Fig. 4-4) are front-panel switches set to the polarity of the waveform slope being measured (+ positive-going; — negative-going). The two inputs to each switch pass to the MODE switch (time measurements) and on to the comparators.

The operator has a choice of reference voltages:

1. A voltage from the floating power supply that allows the operator to start and stop a time measurement an exact amount of crt divisions from the 0% zone. The front-panel precision dial is used for this purpose.

2. Precise percentage points, such as 10%, 20%, 27%, etc., between the 0% and 100% zones on the display.

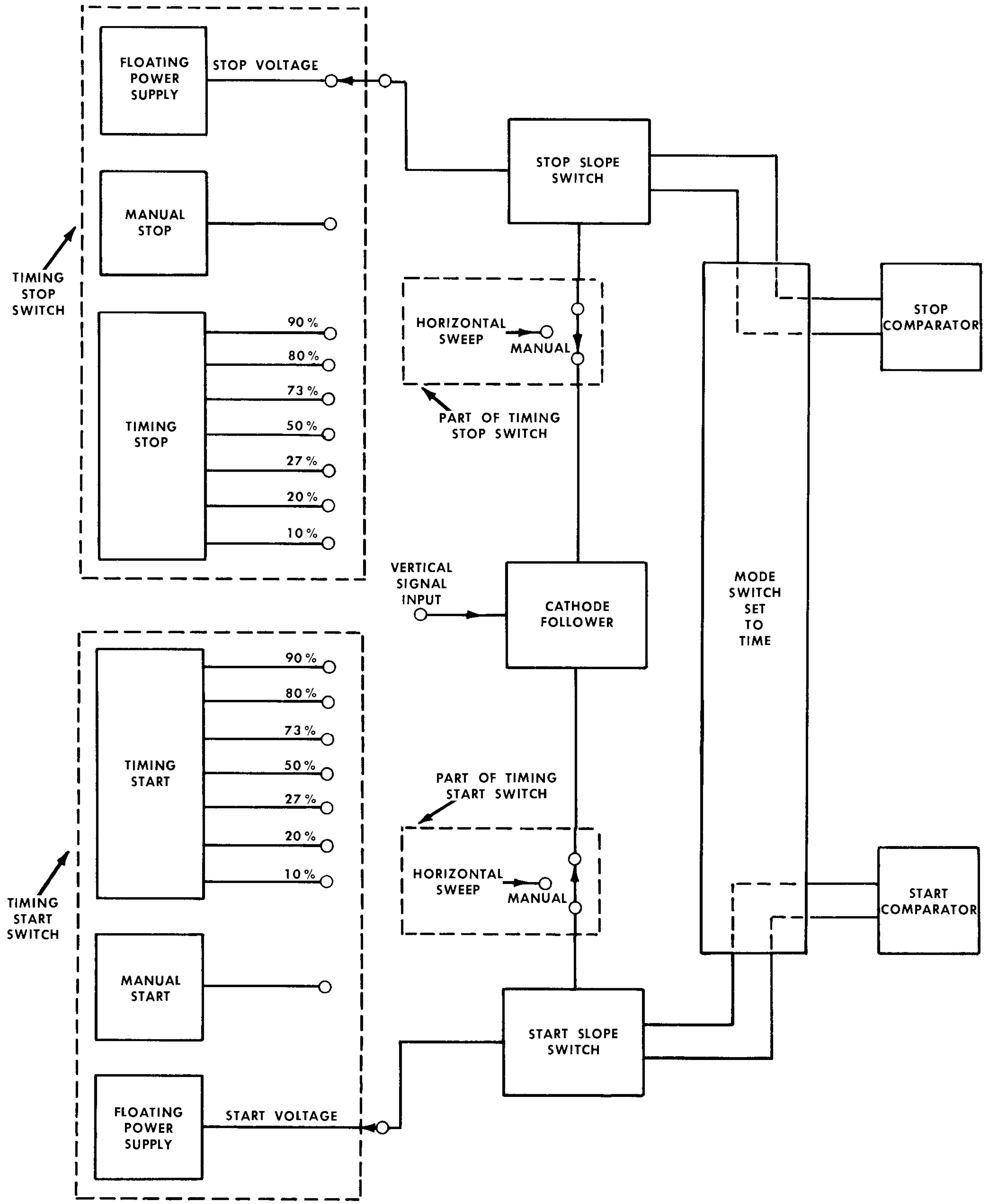

Fig. 4-4. Connection to Comparators in time measurements.

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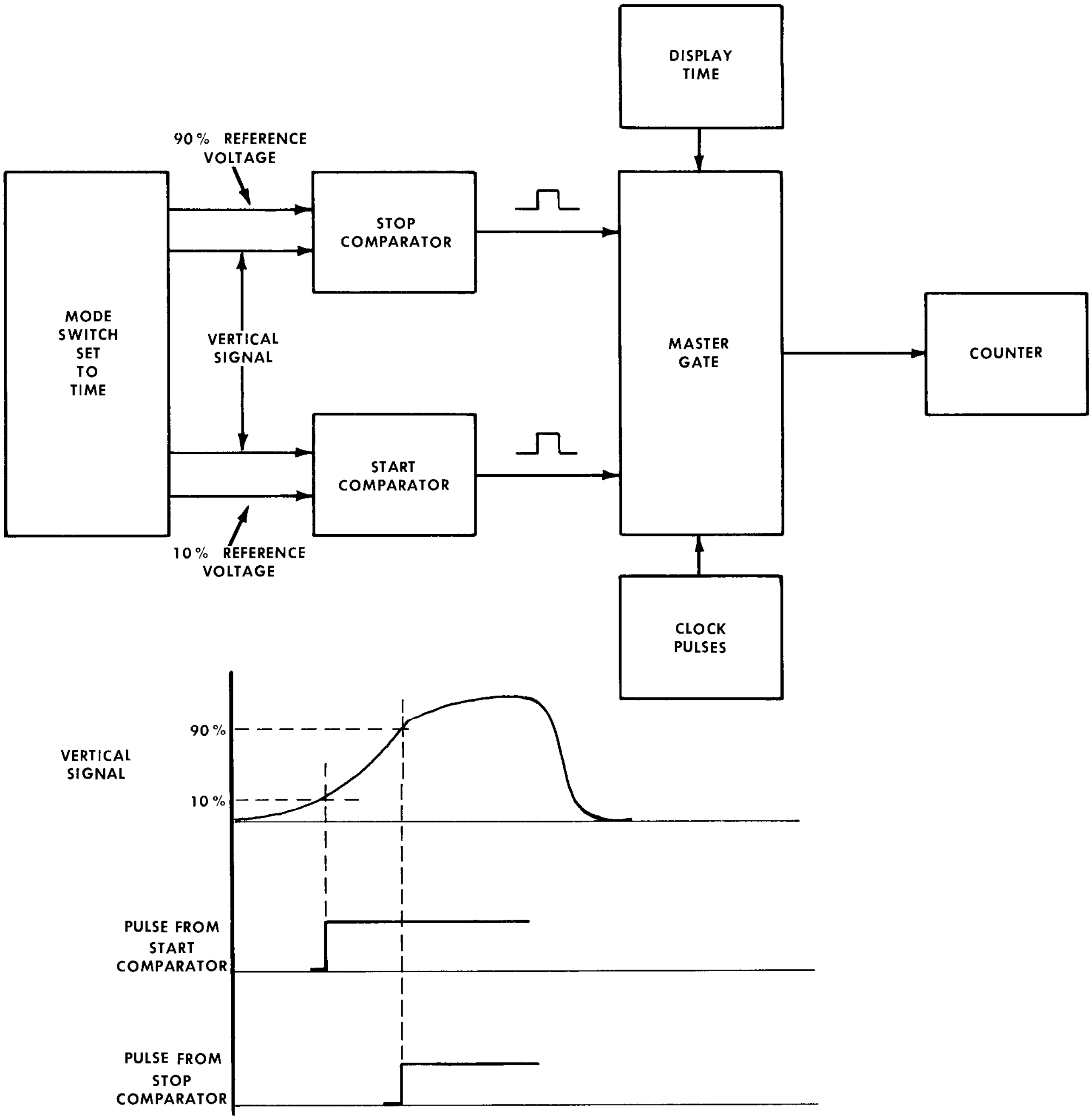

Fig. 4-5. Signal Comparator start and stop pulses to Master Gate.

3. A manually controlled voltage (uncalibrated) that allows the operator to set the start and stop points visually from the display. The second input to the Comparators, in the MANUAL position of the timing switches, is the horizontal sweep voltage.

Fig. 4-5 shows the Comparators and the time relationship between the reference and signal voltage. To illustrate the operation, a 10% to 90% time measurement is programmed into the instrument.

1. 10% of the signal voltage from the TIMING START switch is applied through the MODE switch to one input of the Start Comparator.

2. 90% of the signal voltage from the TIMING STOP switch is applied through the MODE switch to one input of the Stop Comparator.

The other input of each compartor receives the vertical signal from the MODE switch. When the vertical signal rises to 10% of its amplitude, the Start Comparator switches and sends a pulse to the Master Gate. The Master Gate opens and clock pulses pass to the Counter.

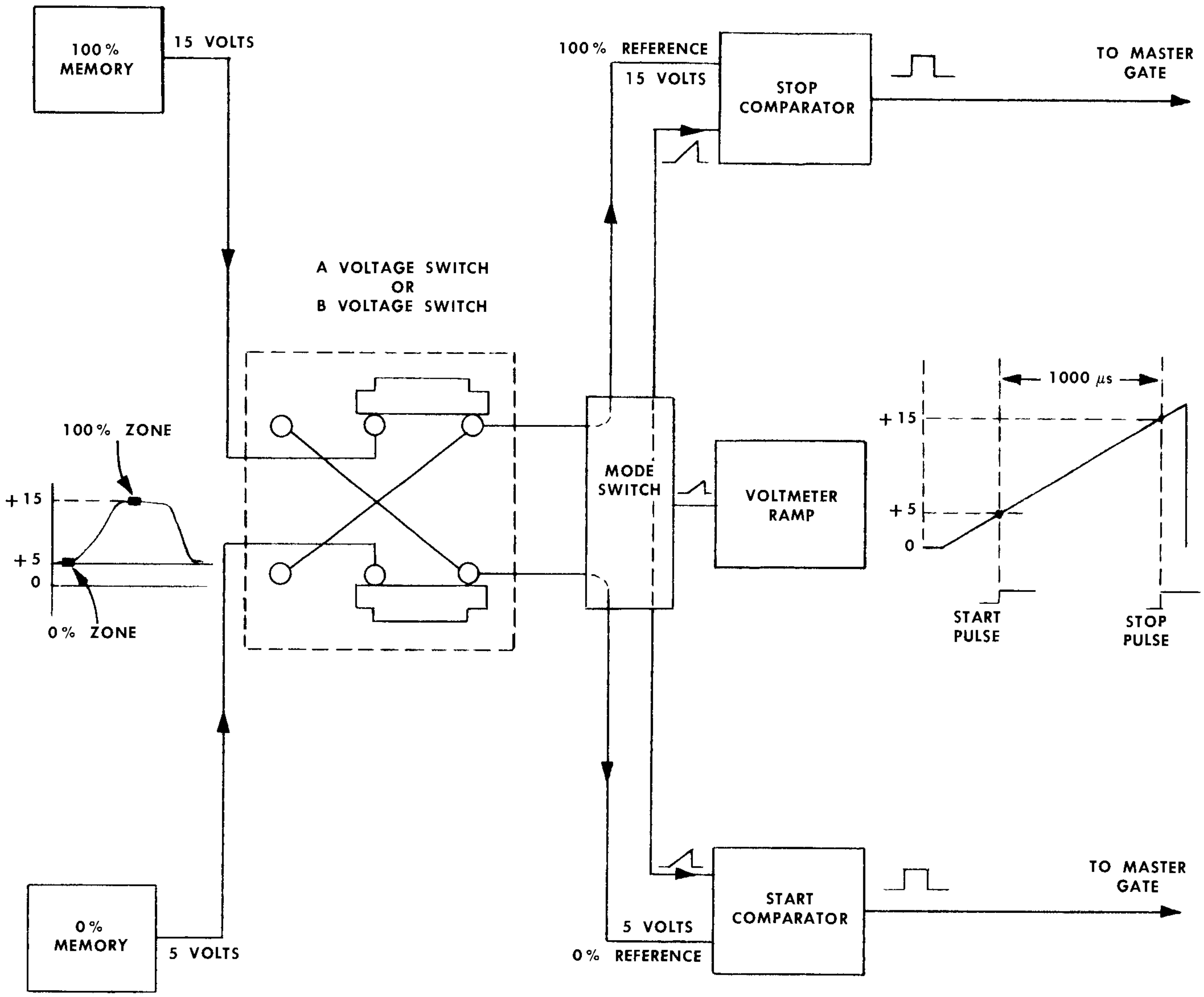

Fig. 4-6. Connections to Signal Comparators with MODE switch set to VOLTAGE. Voltages shown are for example in text.

When the vertical signal reaches 90% of its amplitude the Stop Comparator switches and sends a pulse to the Master Gate. This pulse closes the gate and blocks the clock pulses to the Counter.

As a result, the number shown on the readout is the time between the 10% and 90% voltage points of the vertical signal.

This illustration has been simplified to show the basic operation of the system to this point. The variety of programs such as negative-going signals, 2nd slope measurements, average of ten sweeps, start on channel A, stop on channel B, etc., can be understood by studying the individual circuits.

Fig. 4-6 shows the connections to the Comparators when making voltage measurements. Notice that the voltage of the signal is the difference between the output of the 0% and 100% Memory circuits. Also the reference voltage for the Comparators is the signal voltage while the variable voltage is the voltmeter ramp. The two output voltages from the Memory circuits pass through either the A VOLTAGE or B VOLTAGE switch and MODE switch to the Comparator inputs. The 0% and 100% Memory circuits output voltages are always positive to ground.

The second input to each Compartor is the Voltmeter ramp. The ramp is linear and the voltage rise is constant per unit of time. For example, with a ramp rise of 1 volt in 100 microseconds, 10 volts will take 1000 microseconds. In the example of Fig. 4-6, the Start Comparator has a 5-volt reference (signal level at 0% zone). When the ramp rises to 5 volts, the Start Comparator switches and sends a pulse to the Master Gate and the counter starts. The Stop Comparator has a 15-volt reference (signal level at 100% zone). When the ramp reaches 15 volts, the Stop Compara-

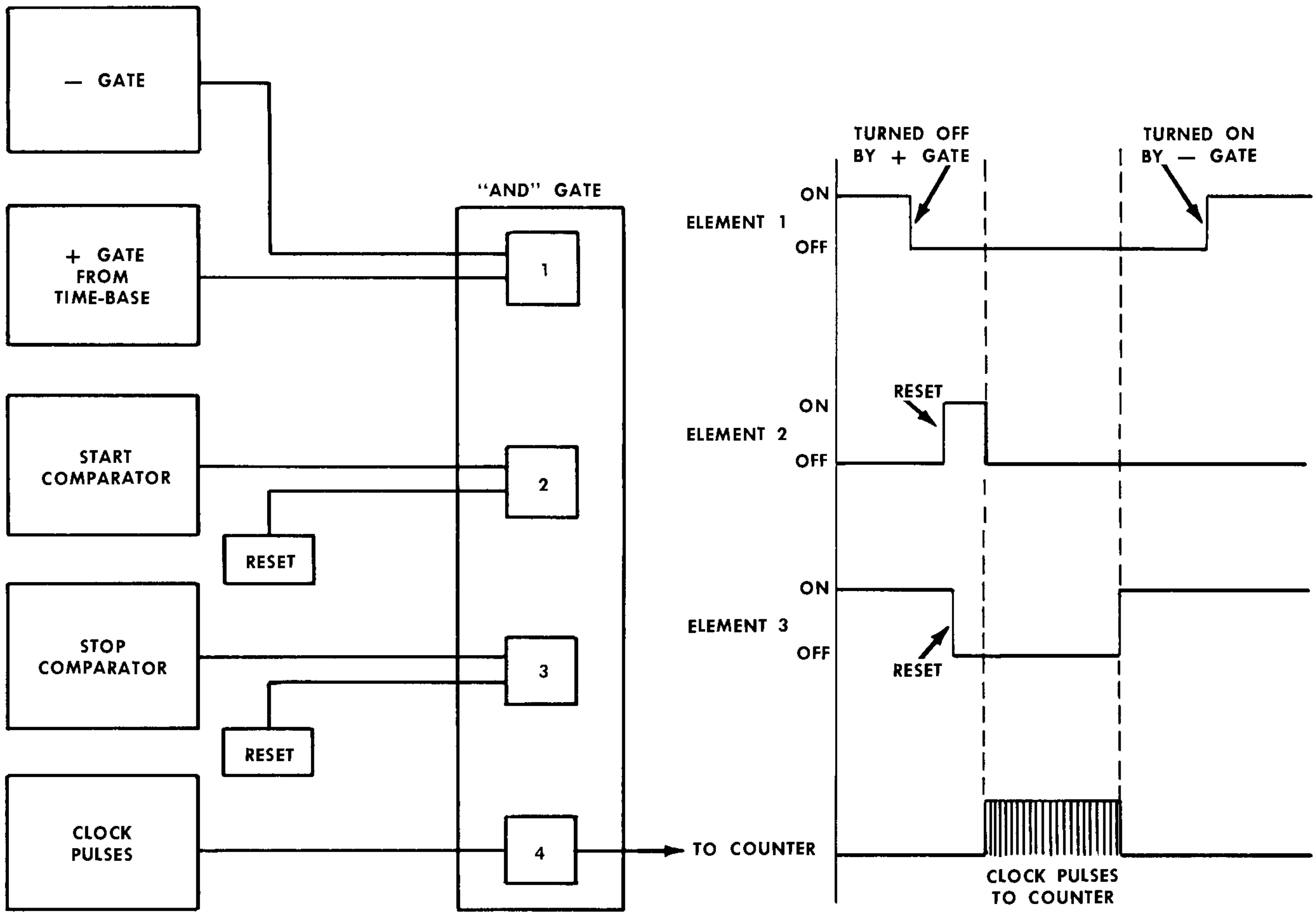

Fig. 4-7. Simplified illustration of the "And" gate portion of the Master Gate.

tor switches and sends a pulse to the Master Gate and the counter stops.

At a rate of rise of 1 volt per 100 microseconds, the readout shows 10.00 V. The position of the decimal point and unit of measure is explained later in the text.

If the 100% zone is moved down the slope of the signal waveform to 12 volts, the difference between the two Memory circuits would be 7 volts. The counter will count 700 microseconds and the readout will show 07.00 V. Since the 100% zone can be manually adjusted from the front panel, the voltage from the 0% zone to any point on the display can be measured.

For a negative-going signal, the voltage from the 100% Memory is less than that from the 0% Memory. (Both voltages still positive to ground.) The A VOLTAGE or B VOLTAGE switch reverses the inputs to the Comparators and the voltage from the 100% Memory is used as the reference for the Stop Comparator.

Note that the Start block and Stop block controls are not used during voltage measurements.

The Master Gate circuit is an "And" gate that controls the flow of clock pulses to the counter. Fig. 4-7 shows the four elements of the "And" gate and the conditions necessary to allow clock pulses to flow through the gate.

Elements 1, 2, and 3 must be turned off before clock pulses can pass through element 4. Element 1 is turned off by the + gate from the time-base plug-in unit. Element 2 is turned off by a pulse from the Start Comparator. Element 3 is turned off at the start of a cycle and then turned on by a pulse from the Stop Comparator to close the gate.

When the "And" gate closes, a digital display time circuit prevents the gate from being reopened until the display period is ended (see Fig. 4-8). This time period is set by the front-panel DISPLAY TIME control. When the display period ends, a reset pulse is sent to the counter circuit and the readout reverts to all zeros.

To improve the resolution, the — gate is switched through a ÷ 10 circuit. This allows the counter to accumulate the sum of 10 consecutive counts before the display time and counter reset. The RESOLUTION switch also causes the decimal point of the readout to move one place to the left and the resultant number is the average of ten counts.

To summarize the operation of the Master Gate: Element 1 is turned off by the + gate. While this element is off, the Start and Stop Comparators can allow clock pulses to pass through to the counter. At the end of a sweep, the — gate turns on element 1 which closes the "And" gate and also starts the display-time period (viewing period). At the end of this period, a reset pulse passes to the counter and it returns to zero. Since the — gate turns on element 1

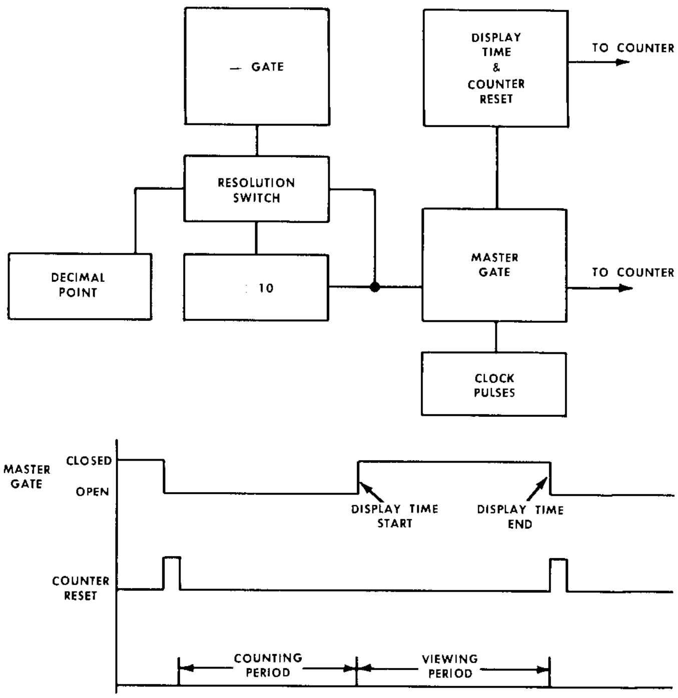

Fig. 4-8. Display time, reset, and ÷ 10 circuit relationship to the Master Gate.

(closes "And" gate), this waveform can be passed through a ÷ 10 circuit and the counter will accumulate the total count of 10 consecutive sweeps before display time and reset. Fig. 4-9 shows the time relationship in the AVERAGE OF TEN SWEEPS position of the RESOLUTION switch.

The clock pulses from the Master Gate circuit pass to the ÷ 1, 2, 5 circuit before they are applied to the counter (see Fig. 4-10). This circuit is necessary since the number of clock pulses that pass through the Master Gate is directly proportional to the number of crt divisions between the start and stop of a measurement. In time measurements, the correct division circuit is controlled by the TIME/DIV. switch in the time-base plug-in unit.

In voltage measurements, the selection of the proper division circuit is controlled by the VOLTS/DIV. switch in the vertical amplifier plug-in unit. Also, the clock pulses that pass through the Master Gate are directly proportional to the amount of vertical crt divisions between the 0% and 100% zones.

The output clock pulses from the ÷ 1, 2, 5 circuit pass directly to the counter that, in turn, drives the readout.

Fig. 4-10 also shows the location of the No-Go circuits.

The Upper and Lower Limit circuits operate in conjunction with the counter. During the display-time period, each counter board has a staircase output voltage that is proportional to the number stored within the counter board. Thus, there are four separate voltages from the four counter boards. These voltages are applied to both the Upper Limit and Lower Limit circuit boards. The front-panel UPPER LIMIT SET and LOWER LIMIT SET dials also apply a voltage to the limit circuits that is proportional to the dial numbers.

With the voltage information described, the logic circuits on the Upper Limit and Lower Limit boards cause the front-panel lamps to indicate a high, low, or mid-zone readout.

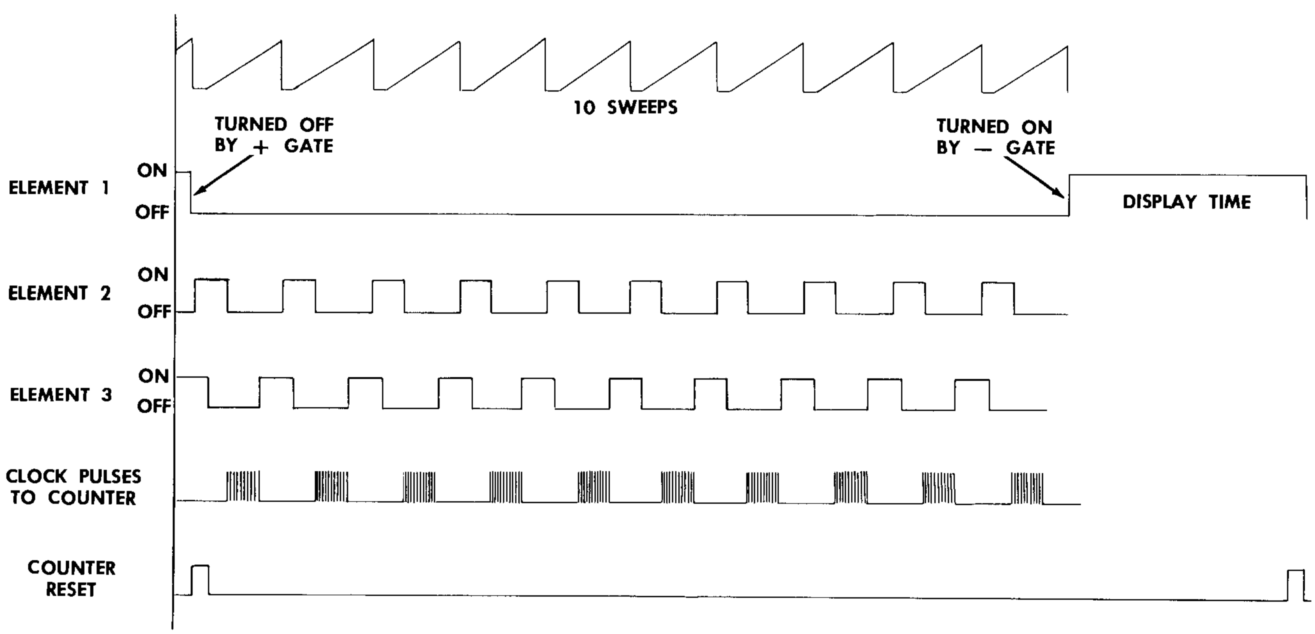

Fig. 4-9. Condition of the Master Gate with RESOLUTION switch in AVERAGE OF TEN SWEEPS.

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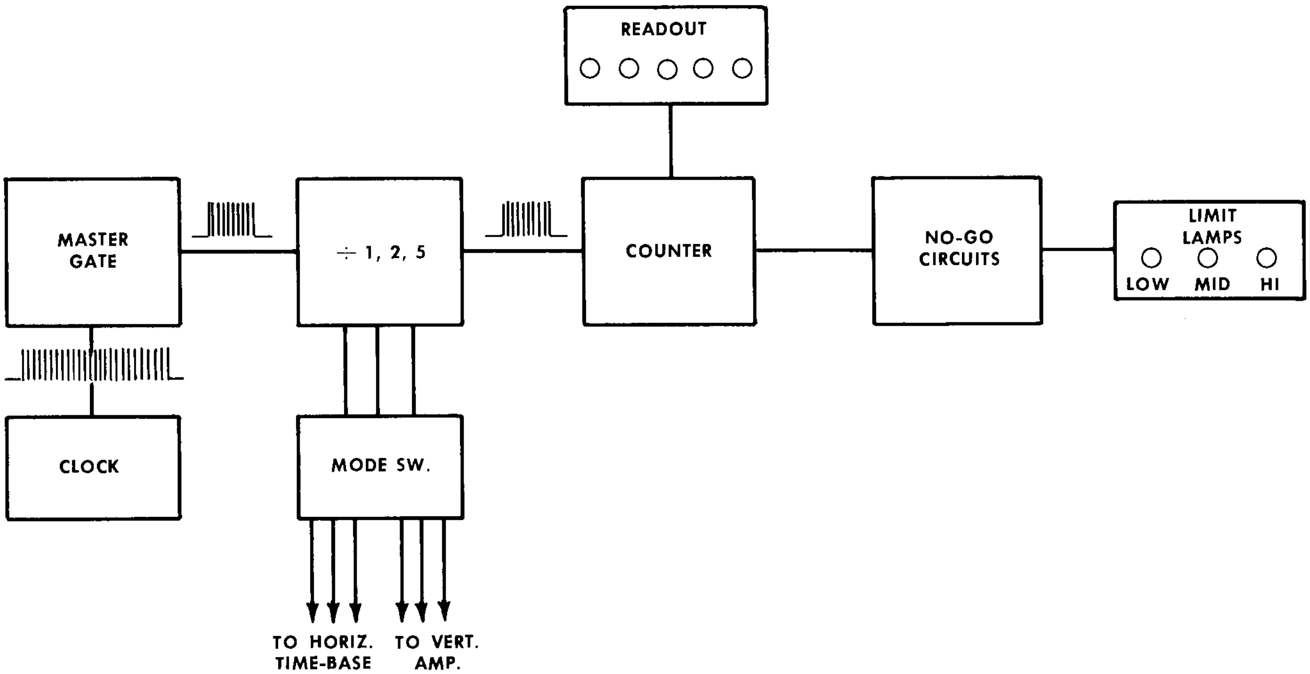

Fig. 4-10. Position of the ÷ 1, 2, 5 circuit in the overall system.

Trace Intensification

Fig. 4-11 illustrates the circuits that cause the intensified zones on the crt. The pulses that intensify the 0% and 100% zones are the pulses that open the Memory gates. Thus, the width of these zones on the display represents the time that the sample gates are open.

The start-to-stop pulse to the Analog Display circuit is formed by taking an output from the start and stop elements in the Master Gate. These outputs pass through another "And" gate that produces a pulse only when both elements are turned off.

The chopped signal from the vertical amplifier to the Analog Display circuit is used for correct intensification only during dual-trace operation.

External Programming

Refer to the External Programming section of this manual.

DECIMAL AND UNITS SWITCHING

Each neon decimal point in the readout is connected through the instrument wiring to the TIME/DIV. switch in the horizontal time base plug-in unit and the MV/DIV. switch in the vertical amplifier plug-in unit.

In the TIME position of the MODE switch, a ground is connected to the TIME/DIV. switch in the horizontal time base plug-in unit. As the TIME/DIV. switch is turned to different positions, the ground will be applied to the proper point to light the correct decimal. The TIME/DIV. switch schematic (Time Base plug-in unit) shows how this is done.

In the VOLTAGE position of the MODE switch, a ground is connected to the MV/DIV. switch in the vertical amplifier plug-in unit. The MV/DIV. switch will apply the ground to the proper neon to light the correct decimal.

The unit of measure shown in the right-hand indicator tube is controlled in a similar way. In time measurements, a ground connection is made to the TIME/DIV. switch in the horizontal plug-in unit. As the TIME/DIV. switch is turned, the correct unit of measure (NS, μS, MS, S) appears in the right-hand indicator tube. In voltage measurements a ground connection is made to the MV/DIV. switch in the vertical plug-in unit. The setting of this switch determines the unit of measure shown in the indicator tube (V, MV).

Certain plug-in units light only certain units of measure. For example, the Type 3S76 Dual-Trace Sampling Plug-In Unit lights only the volts (V) and millivolts (MV) letters in the indicator tube. An examination of the schematic which accompanies the plug-in unit will show which units of measure are used.

TIMING START and TIMING STOP SWITCHES

With the MODE switch set to TIME, the TIMING START and TIMING STOP switches set the point at which a measurement starts and stops.

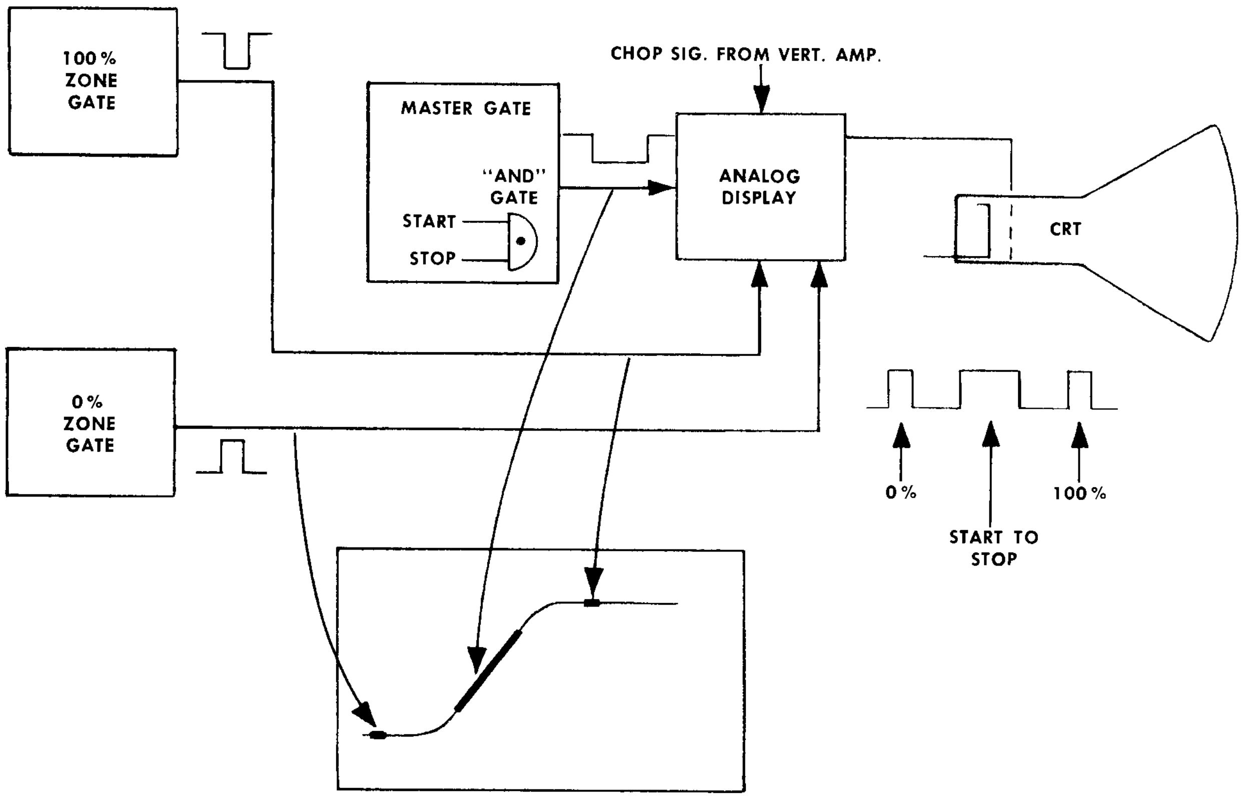

Fig. 4-11. Source of pulses for crt display intensified zones.

The switches are identical except for the signal cathode follower and the start voltage connect through the ± SLOPE switch to the Start Comparator circuit. On the TIMING STOP switch, these points connect through the ± SLOPE switch to the Stop Comparator circuit.

In the MANUAL position of the TIMING START and TIMING STOP switches, a dc voltage set by the MANUAL controls on the front panel is connected to each signal comparator. The second input of the comparators is the sweep voltage from the 0% zone connected through the signal cathode follower.

Note on the Timing Start Switching and the Timing Stop Switching schematics that the A 0% Memory is applied to the bottom of a string of precision resistors and the A 100% Memory is connected to the top of the string. While measurements are made on channel A, the channel B Memory circuits are terminated by R429. This resistor is switched across channel A when channel B is in use. Since both Timing switches have this resistor across the unused memory, the memories always have this resistance shunted across their output.

When the Timing switches are turned to a percentage position (10%, 20%, 27%, etc.), the Signal Comparators receive a percentage of the total memory signal. The other input of each signal comparator is fed by cathode followers that receive the signal from the vertical plug-in unit.

With the Timing switches in the A or B position, the signal comparator inputs are connected to the wiper arm of a ten-turn precision potentiometer that is connected across the floating power supplies located on the Voltmeter circuit board. The other input of each signal comparator is connected to cathode followers that receive the signal from the vertical plug-in unit.

The Analog Display wafers of the Timing switches ground either pin 5 or pin 10 of the Analog Display circuit to intensify the proper channel.

0% ZONE BOARD

This circuit board performs several functions. First, it uses the horizontal sweep voltage from the time base plug-in unit to form pulses that control the 0% Memory circuit.

It also converts the horizontal gate signal from the time base plug-in unit to plus (+) and minus (—) gates that are used in several other circuits in the instrument.

Finally, the channel A chopping pulses from the vertical plug-in unit are converted to plus (+) and minus (—) gates for use in the Analog Display circuit.

The sweep gate enters the circuit through pin 15 and is applied to the base of Q14. Q14 turns on and its collector goes negative. This change is coupled through R20 and C20 to the base of Q24 which turns off. The collector of Q24

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goes positive and this voltage is applied to the bases of Q23 and Q33 (a double-emitter follower). Q23 turns on and the + gate is taken from the emitter circuit to pin 13 of the circuit board. When Q23 turned on, it became a voltage source for Q54. It also applied a positive voltage to the bases of Q63 and Q64. Q63 turned off and its emitter voltage increased to +20 volts. This +20-volt signal is connected to pin 12 and is the start of the 0% positive pulse. The plus voltage on the base of Q64 turns this transistor off and its collecter drops toward ground. This negative signal is connected to pin 5 and is the start of the 0% minus pulse.

To end the pulses and establish the 0% intensified zone, the horizontal sweep voltage enters the circuit at pin 7 and is applied to the grid of V43. (D40 protects V43 from grid damage during warmup). The cathode follows the grid and the sweep voltage leaves the circuit through pin 10. The cathode of V43 is returned through a voltage divider consisting of R43 (0% ZONE WIDTH), R44 and R45. The junction of R44 and R45 is connected to the base of Q43. As the sweep voltage rises, the voltage at the base of Q43 rises, and tunnel diode D43 (in the emitter circuit of Q43) changes states. This positive change is applied to the base of Q54 and this transistor turns on. The collector of Q54 drops toward ground and this negative-going voltage is applied to the bases of Q63 and Q64. Q63 turns on, ending the + 0% pulse at pin 12. At the same time, Q64 turns on ending the — 0% pulse at pin 5.

From the foregoing, the 0% zone starts at the start of the horizontal sweep gate and ends when the horizontal sweep voltage reaches the point set by the 0% ZONE WIDTH adjustment. The quiescent level of voltage (no 0% zone being formed) at pin 12 is near zero, and near +20 volts at pin 5. This is necessary to maintain the diode gate transistors in the 0% and 100% Memory circuits in the proper state.

The channel A chopping pulse enters the circuit through pin 2 and is applied to the base of Q84. Q84 turns on and sends a negative pulse from its collector to pin 1 of the circuit board. When Q84 turned on, Q74 turned off. A positive pulse is taken from the collector of Q74 to pin 3 of the circuit board. Both of these pulses connect to the Analog Display board.

MEMORY BOARDS

The Memory boards contain the pulse forming network, diode gate, and Memory circuit of the 100% zone, and the diode gate and Memory circuit of the 0% zone. There are two of these boards; one for channel A and the other for channel B. Since they are identical, only one will be described.

Transistor Q3 acts as a voltage source switch for Q13 and Q23. It is turned on by the + gate from the 0% Zone board. When the + gate ends, Q3 turns off and the circuit will not operate. Tunnel diodes D13 and D23 may be considered as a pulse former. The front-panel 100% ZONE SET control, through pin 14, sets a negative voltage on the bases of Q13 and Q23. The sweep voltage from the 0% Zone enters through pin 15 and is applied through the 100% ZONE WIDTH control to the base of Q13, and through R11 to the base of Q23. As the sweep voltage overcomes its negative bias, Q23 conducts first. When Q23 conducts, tunnel diode D23 switches and raises the dc level at the base of Q24. Q24 turns on and its collector goes negative. This negative signal is coupled through a voltage divider to the base of Q34. Q34 turns off and its collector rises to +18 volts. (Q34 quiescently conducts and holds its collector at about +0.5 volt.)

The input sweep voltage continues to rise and Q13 turns on. Tunnel diode D13 switches and raises the dc level at the base of Q14. Q14 turns on and its collector drops to ground. Notice that the collectors of Q14 and Q34 are tied together. When Q14 turns on, the output pulse ends and the collector level drops back to +0.5 volt.

The time difference between the switching of D23 and D13 determines the pulse width. The point where this occurs on the display is set by the 100% ZONE SET control on the front panel.

The quiescent condition of the remainder of the circuit is as follows. Q33 is turned on and its emitter is near ground. The junction of D31 and D32 is connected to the emitter of Q33, hence this junction is near ground. Q44 is turned off and its positive collector voltage turns on Q43. With Q43 connected as an emitter follower, its emitter voltage rises, carrying with it the junction of D41 and D42. This condition back-biases D41 and D42, and vertical signals cannot pass through the bridge.

When a positive pulse is applied to the base of Q33, it turns off and its collector goes toward +125 volts. The positive pulse also turns Q44 on and its collector drops toward ground. This negative change turns Q43 off and its emitter goes toward —100 volts. This forward-biases D41 and D42 and the vertical signal passes through. The diode gate is open for the duration of the dc level set by the 100% ZONE WIDTH adjustment.

The vertical signal passes through the diode gate and enters the grid circuit of V53. The signal drives V53 and charges C50, the memory capacitor. C50 receives a sample during each sweep and holds this level until the next sample arrives. The grid of V53 follows the sample level. The sample is coupled from the cathode of V53 to the TIMING START and TIMING STOP switches. Q58 is a constant current source for V53. R53 (100% DC LEVEL control), from which the 100% Memory signal is obtained, allows for tube changes, permitting adjustment for the proper dc level across the Timing switches.

The 0% diode gate and Memory circuit operates the same as the 100% circuit. A positive and negative pulse from the 0% Zone circuit board enters through pins 1 and 2 and controls the diode gate. The vertical signal input at pin 5 is common to both circuits.

SIGNAL COMPARATOR BOARD

There are two identical Signal Comparator boards. One is the Start Comparator that forms a pulse to start a measurement, and the other is the Stop Comparator that forms a pulse to stop a measuremenr. The TIMING START switch (front-panel control) sets the point at which the Start Comparator delivers a pulse, and the TIMING STOP switch (front-panel control) sets the point at which the Stop Comparator delivers a pulse.

The pulse from the Signal Comparator circuits control the Master Gate circuit.

The input to the comparator is through pins 8 and 9. V4 and V14 are arranged as a comparator in which the triode with the most positive grid conducts and the other triode is cutoff. Thus, with a positive reference voltage on the grid of V14, the signal from the vertical amplifier is applied to the grid of V4. When the signal amplitude at V4 exceeds the reference voltage at the grid of V14, the comparator switches and V4 conducts and V14 cuts off.

D4 and D14 protect V4 and V14 during warmup. Q8 is a constant-current source to reduce nonlinearity caused by bias changes.

If the signal from the vertical amplifier is negative, the SLOPE switch on the front panel is placed in the minus (—) position. This reverses the inputs and puts the reference voltage on the grid of V4. (In both cases, V14 is in conduction at the start of a comparison.)

Transistor Q14 is a key component in this portion of the circuit. When V14 conducts, its plate voltage is about +100 volts. When V14 cuts off, its plate rises to +125 volts and Q14 cuts off. In this case, V4 and Q4 are both turned on, and Q4 and Q14 form a differential amplifier.

Q14 turns off when the signal applied at pin 8 exceeds the reference appplied to pin 9. The collector of Q14 is connected to the base of Q24 through R20. The collector of Q14 is also connected to the base of Q44 through R17. When Q14 turns off, its collector voltage drops to about +9 volts. Q24 turns on and Q44 turns off. R22 is the collector load for both Q24 and Q34. With Q24 turned on, Q34 cannot conduct since its collector is clamped at +20 volts. A similar situation exists between Q44 and Q43. With Q44 turned off, Q43 can conduct.

Pin 16 of the circuit board receives positive clock pulses from the Voltmeter board. The pulses are applied to the bases of Q43 and Q34. With Q43 turned on, the pulses are coupled from the emitter of Q43, through C42, to the charging circuit of C50. The rectified pulses charge C50. The cumulative charge of 3 pulses at C50 are needed to raise the grid of V53 to the point where tunnel diode D52 will switch. The circuit is designed to require three pulses to prevent a single transient from prematurely switching the tunnel diode. This three-pulse delay does not affect accuracy since the same delay exists in the Stop Comparator. Fig. 4-12 (a) shows the states of the various stages during the charge of C50.

When the clock pulses have charged C50 to 5 volts, D23 and D24 become forward-biased and limit the voltage across C50 to +5 volts.

When the signal at the input to the comparator (V4 and V14) drops below the reference, the comparator again switches and Q14 turns on. This reverses the state of the transistors that follow, and Q34 turns on and Q43 turns off (see Fig. 4-12 (b)). The clock pulses pass to the base of Q34 and appear across R22, the collector load resistor. The negative pulse couples through C22 to the circuit of C50. Each negative clock pulse removes some charge from C50 until the voltage drops to —1 volt. At —1 volt, D43 and D44 become forward-biased and prevent C50 from going further negative.

This circuit is called a "bucket and ladle". The positive clock pulses ladle charge into the "bucket" (C50), and negative clock pulses ladle charge out of the "bucket".

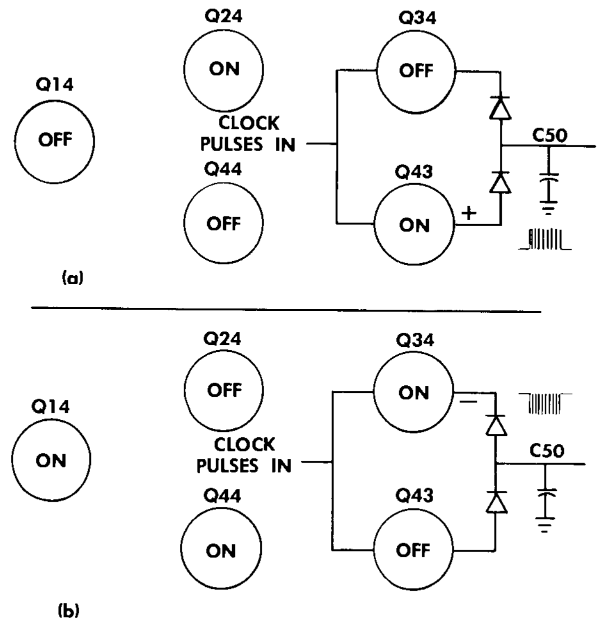

Fig. 4-12. (a) Condition of transistors when C50 is charging; (b) Condition during C50 discharge.

All of the foregoing circuitry is designed to switch tunnel diode D52 at the correct time.

The sharp rise in dc level caused by D52 is applied to the base of Q54. From Q54 the pulse can pass in two directions. If pin 4, which is connected to the front-panel SLOPE switch, is grounded (FIRST SLOPE position), the pulse will be amplified by Q94 and appear as a positive pulse at pin 2. If pin 5 (SECOND SLOPE position) is grounded, the pulse will be amplified by Q64 and will switch the bistable multivibrator Q65-Q75. The first multivibrator pulse does not appear at the output. A second pulse (from a second comparison at V4 and V14) will switch the multivibrator back to its initial state and send a negative pulse to the base of Q84. This pulse is amplified and passed from the collector of Q84 to the output at pin 2. The multivibrator is reset at the end of each display period. Thus, it is necessary to have 2 or more pulses or cycles on the crt to use the SECOND position of the SLOPE switches.

With the front-panel TIMING switches in their MANUAL position, the comparator reference is a dc voltage set by the MANUAL control. The signal side of the Comparators now receive the horizontal sweep voltage. As the sweep voltage rises it reaches the voltage set by the Start MANUAL control and the comparator delivers a pulse. As the sweep voltage continues to rise it reaches the point set by the Stop MANUAL control in the Stop Comparator and that circuit delivers a pulse. Both pulses pass to the Master Gate circuit and determine the time of measurement.

MASTER GATE BOARD

The Master Gate performs five functions:

1. Allows clock pulses to pass to the ÷ 1, 2, 5 circuit.
2. Forms a reset pulse.

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3. Forms a print command pulse.
4. Controls the display time of the readout.
5. Forms a start-to-stop pulse to the Analog Display (intensified zone).

Gating the Clock Pulses

The four transistors on the right side of the Master Gate schematic (Q13, Q43, Q63 and Q73) form an "And" gate. Thus, Q13, Q43, and Q63 must be turned off before a signal can pass through Q73. R13 is a common-emitter resistor for these four transistors. If Q13, Q43, or Q63 is turned on, the voltage at the emitter of Q73 prevents clock pulses from passing through.

The transistors and their control circuits are:

Q13: Horizontal Sweep Gate.

Q43: Start Comparator.

Q63: Stop Comparator.

In time measurements, Q13 is controlled by the + and — gates from the 0% Zone circuit board. In voltage measurements, the + gate turns Q13 off and the voltmeter reset pulse turns it on.

The voltage at the base of Q3 is very important to the circuit operation. With +20 volts on this base, Q13 in the "And" gate is turned on. With the base of Q3 at zero, Q13 is turned off. A voltage divider between the +125-volt and the —100-volt supplies (R16, R8, and R7) forms both a voltage source and a feedback path between the plate of V15 and the base of Q3. When V15 turns off, its plate voltage rises. This increases the base voltage of Q3 and this transistor turns off. The base voltage of Q3 continues to rise until both D5 and D3 become forward-biased. When this occurs, the base of Q3 is clamped at +20 volts.

The + gate, at pin 9 of the board, is differentiated by C3 and R3. The positive differentiated spike is attenuated by D3. The negative spike, however, momentarily back-biases D3. This permits the base voltage of Q3 to drop, and Q3 conducts. The emitter of Q3 (and the cathode of V15) drop toward ground, and V15 conducts. At the same time, Q13 in the "And" gate turns off. As V15 conducts, its plate voltage drops, driving the base of Q3 further negative. D4 and D2 serve to clamp the base of Q3 near ground.

To reverse the operation, the — gate (time measurements) or voltmeter reset pulse (voltage measurements) comes to the circuit through pin 7. The — gate leading edge (negative going) is differentiated by C2 and R2 and bypassed by D2. The positive going trailing edge of the — gate is differentiated and the positive spike back-biases D2, and increases the voltage at the base of Q3. Q3 turns off, V15 turns off, and Q13 in the "And" gate turns on. The base of Q3 returns to +20 volts.

Q43, the second "And" gate transistor, is operated by a bistable multivibrator that is alternately switched by a reset pulse* and a pulse from the Start Signal Comparator. Since the reset pulse always precedes the Start Signal Comparator pulse, it is used to reset the bistable multivibrator and turn Q43 on. With Q43 turned on, Q45 is also turned on. A positive pulse from the Start Signal Comparator enters the circuit at pin 2 and couples through C32 and D32 to the collector of Q35. It also passes through R36 and C36 to the base of Q45. This causes the multivibrator to switch and Q35 turns on. Q45 turns off, also turning off Q43, the "And" gate transistor.

Q63, the next transistor in the "And" gate, is also controlled by a bistable multivibrator. The circuit is switched by a reset pulse and a pulse from the Stop Signal Comparator. The reset pulse enters the circuit at pin 20 and couples through C52 and D52 to the collector of Q55 and then to the base of Q65. This causes Q55 to turn on and Q65 and Q63 to turn off. A pulse from the Stop Signal Comparator enters through pin 19 and couples through C62 and D62 to the collector of Q65. The multivibrator switches and Q63, the "And" gate transistor, turns on.

Fig. 4-13 shows when the "And" gate is open to allow clock pulses to pass. Positive clock pulses from the Voltmeter board enter the circuit at pin 4 and are applied to the base of Q73. This transistor is connected as an emitter-follower and the positive clock pulses couple from its emitter direct to the base of Q74. The pulses are amplified and pass from the collector of Q74 direct to the bases of Q83 and Q93. These transistors are arranged as a double-emitter follower to assure good fidelity of the clock pulses. The pulses pass from the junction of the common emitter resistors to the output of the circuit board at pin 5.

Forming the Reset Pulse

This large amplitude pulse (approximately 100 volts peak-to-peak) is used to reset the ÷ 1, 2, 5, the ÷ 10, and the four counter circuits. The pulse is formed when Q3 turns on. V15 turns on and a negative pulse is coupled through C16 to the base of Q24. The pulse is amplified by Q24 and applied to the base of Q23 (emitter follower). Q23 drives the pulse through C27 to pin 8 of the circuit board. The dc level of pin 8 is +125 volts through D28.

Forming the Print Command

The voltage at pin 13 of the circuit board follows the voltage at the emitter of Q3. When this transistor turns on, its emitter is at zero volts and the print command is at zero volts. When Q3 turns off, its emitter is at +20 volts from the +20-volt supply through R17. This dc level is also applied through R18 and the print command at pin 13 is at +20 volts (no load). The print command is used to gate the Voltmeter ramp, Limit Light Driver, and also for external programming.

Controlling the Display Time

When V15 conducts, its grid circuit is held near ground. When this tube is cutoff, C14 in its grid circuit starts to charge toward +16 volts through the DISPLAY TIME control (front panel). When the charge of C14 reaches 16 volts, V15 conducts and Q3 can again be turned on. When Q3 is turned on, C14 discharges through the grid to cathode path and returns to ground. The time constant of the DISPLAY TIME control (5 meg) and C14 determine the time interval between each count shown on the readout.

* The reset pulse in time measurements is the —0% zone pulse; in voltage measurements, the voltmeter reset pulse is used for this purpose. The change is made by the MODE switch.

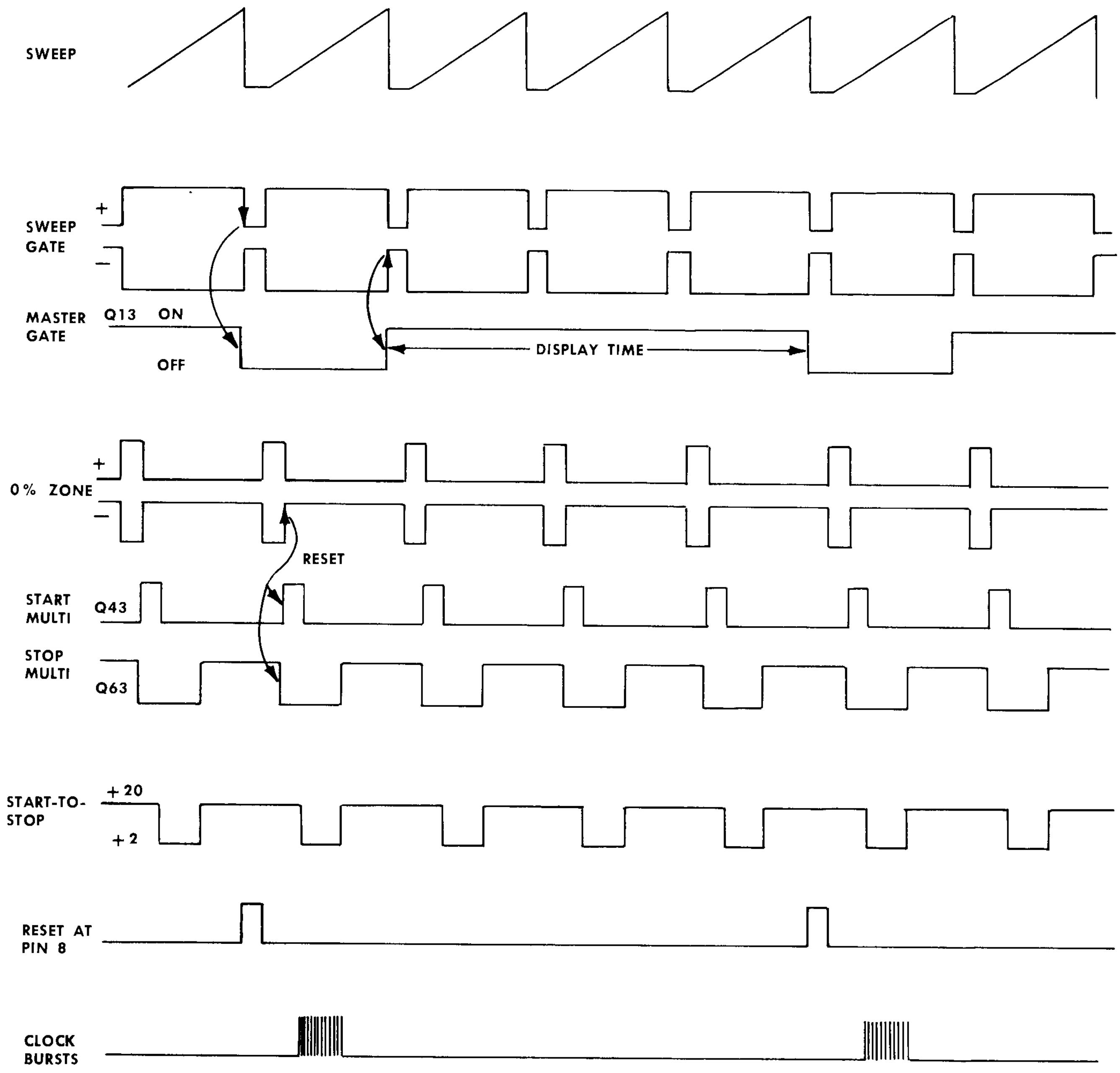

Fig. 4-13. Time relationship of waveforms in the Master Gate circuit.

Start-To-Stop Pulse to the Analog Display

Q53 and Q33 form a separate "And" gate that requires a low voltage (about +2 volts) on each base in order to get a similar low voltage from the output. With either transistor turned on, the common emitter output will be at +20 volts. The base of Q33 is connected to the collector of Q45 and the base of Q53 is connected to the collector of Q65. The "And" gate formed by Q53 and Q33 will have a low voltage output (about +2 volts) only when both Q45 and Q65 are turned off. This coincides with the time that Q43 and Q63 in the clock pulse "And" gate are turned off. The low voltage signal at pin 18 passes to the Analog Display circuit and is used to intensify the crt display between the points being measured.

÷1, 2, 5 BOARD

This circuit uses three binary sets (bistable multivibrators) to divide by 5, and 1 binary set to divide by 2. The divide-by-1 is a straight-through transistor amplifier. Refer to the

Counter circuit description for details on binary set operation. A positive clock pulse enters the circuit at pin 7 and moves in three directions:

1. Through C2, to the ÷ 5 circuit.
2. Through C62, to the ÷2 circuit.
3. Through C80 and R80 to the base of Q84.

Note transistors Q44, Q74, and Q84. The base of each transistor is connected through one side of a divider to a circuit board pin (Q44 to pin 2, Q74 to pin 10, Q84 to pin 1). These pins connect through the instrument wiring to the horizontal time base and vertical plug-in units. When the Type 6R1 MODE switch is in the TIME position, a ground connection is made at the TIME/DIV. switch in the horizontal plug-in unit. The ground is alternately connected to pin 1, 10, and 2 of the ÷ 1, 2, 5 board. The transistors connected to the ungrounded pins are biased to cutoff.

For example, if the TIME/DIV. switch on the horizontal plug-in unit is set at 10 microseconds/division, pin 1 of the ÷ 1, 2, 5 circuit board is grounded and the amount of clock pulses at pin 6 (output) is the same as the amount at pin 7 (input). If the TIME/DIV. switch is set at 5 microseconds/division, pin 10 of the board is grounded and the amount of clock pulses at pin 6 (from Q74) is one-half the amount at pin 7 (input). Finally, if the TIME/DIV. switch is set to 2 microseconds/division, pin 2 of the board is grounded and the amount of clock pulses at pin 6 (from Q44) is one-fifth the amount at pin 7.

Each position of the TIME/DIV. switch will ground either pin 1, 10, or 2, when the Type 6R1 MODE switch is in the TIME position.

When the Type 6R1 MODE switch is in a VOLTAGE position, a ground connection is made at the MV/DIV. switch in the vertical plug-in unit. When the MV/DIV. switch is set at 10, pin 1 of the ÷ 1, 2, 5 circuit board is grounded. The 5 millivolt/division position grounds pin 10, and the 2 millivolt/division position grounds pin 2.

Though the setting of the MV/DIV. switch on the vertical plug-in unit may be changed, the readout will remain the same due to the ÷ 1, 2, 5 circuit. This is also true of time measrements, and changes in the setting of the TIME/DIV. switch on the horizontal plug-in unit will not affect the readout.

All of the binary sets on the circuit board are reset at the beginning of a new count by a reset pulse at pin 8 from the Master Gate circuit.

COUNTER BOARD

Each counter board consists of four binary sets (bistable multivibrators), ten driver transistors, and a staircase emitter follower.

Since all binary sets are similar, only the first will be described in detail.

In a binary set, when one transistor is turned on, the other is off. Before a count is made, a positive reset pulse from the Master Gate is applied to the base of Q5 and this transistor turns off. Q15 turns on and its collector rises to +20 volts. D12, connected to the collector of Q15, is back-biased. With Q5 turned off, its collector is at ground and D2 is forward-biased. A positive pulse coupled through C2 finds a path through D2 but is blocked by D12. The positive pulse passes through D2, then through C6 to the base of Q15. Q15 turns off and its collector goes negative. This negative-going pulse couples through C16 to the base of Q5 and this transistor turns on. The binary set has changed states. D12 is now forward-biased and D2 back-biased. The next pulse coupled through C2 will pass through D12 to the collector of Q15. The binary set will change again and a positive voltage will appear at the collector of Q15. This is coupled as a pulse through C22 to the next binary set.

Pulse Number	Binary Set 1	2	3	4
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	0	1	0
5	1	0	1	0
6	0	1	1	0
7	1	1	1	0
8	0	0	0	1
9	1	0	0	1
10	0	1	0	1
11	1	1	0	1
12	0	0	1	1
13	1	0	1	1
14	0	1	1	1
15	1	1	1	1
0	0	0	0	0

(a)

Pulse Number	Binary Set 1	2	3	4	
0	0	0	0	0	
1	1	0	0	0	
2	0	1	0	0	
3	1	1	0	0	Feedback
4	0	1	1	0	
5	1	1	1	0	Feedback
6	0	0	1	1	
7	1	0	1	1	
8	0	1	1	1	
9	1	1	1	1	
0	0	0	0	0	

(b)

Fig. 4-14. Comparison between scale of 16 (a) and scale of 10 (b) counter.

It takes two positive pulses at the input to a binary set to get one positive pulse in the output. Thus, it divides by two.

By connecting a second binary set to the output of the first, the circuit divides by 4. A third divides by 8, and a fourth divides by 16.

To divide by 10, it is necessary to use feedback. C38 in the collector circuit of Q45, and C58 in the collector circuit of Q65, couple pulses back and change the states of the previous binary set to make the circuit divide by 10.

Fig. 4-14 (a) shows the state of each binary set in a scale-of-16 circuit without feedback. A one (1) in the column means that the input transistor of a binary set is turned on; a zero is an off condition.

A count-by-ten counter must have ten different arrangements of its binary sets caused by 10 consecutive pulse inputs, and must also return to its start point on the 10th input pulse.

Fig. 4-14 (b) shows the change caused by feedback. On the 4th input pulse, the circuit "skips" ahead to a condition that represents the number "6" (although the readout shows a 4). Note that the only difference between four and six is the state of the 2nd binary set. The feedback pulse holds the 2nd binary set on, and the counter has instantaneously skipped ahead two counts.

The 6th input pulse to the counter causes a feedback pulse from the last binary set to couple back to the 3rd binary set. This causes the counter to skip ahead four counts to the condition for number "12" (the readout shows a 7). The remaining pulses move the counter to the end of a cycle and it returns to zero on the 10th count. By skipping ahead a total of six counts, the circuit returns to zero on the 10th count (instead of the 16th count) and a count-of-ten is complete.

Fig. 4-15 shows the waveform condition of each binary set and includes the feedback points that convert the circuit to a scale-of-10 counter.

As each pulse passes through the counter circuit it should light a corresponding number on the readout tube. This is accomplished by the readout driver transistors, Q100 through Q109 inclusive.

Notice that the emitters of the odd transistors are connected to R109 in the collector of Q15. With Q15 turned on, the positive voltage developed across R109 will back-bias these odd transistors and prevent them from turning on. The even transistors are connected to R110 in the collector of Q5 and they become back-biased when this transistor is turned on. Thus the state of the first binary set determines whether the number on the readout is odd or even. Because of this, the bases of the pairs of transistors can be connected together since only one of the pair can turn on.

Q100 and Q101 drive the numbers 0 and 1. The voltage developed across R100 in the base circuit of this pair will determine whether they can be turned on. At the beginning of a count a pulse from the Master Gate circuit enters the board at pin 8 and resets each binary set. After reset, the right hand transistor in each binary set is turned on. Since Q5 in the first binary set is turned off, the number will be even. Notice that R100 in the base circuit of Q100 is connected through R75 to the collector of Q75, which is turned

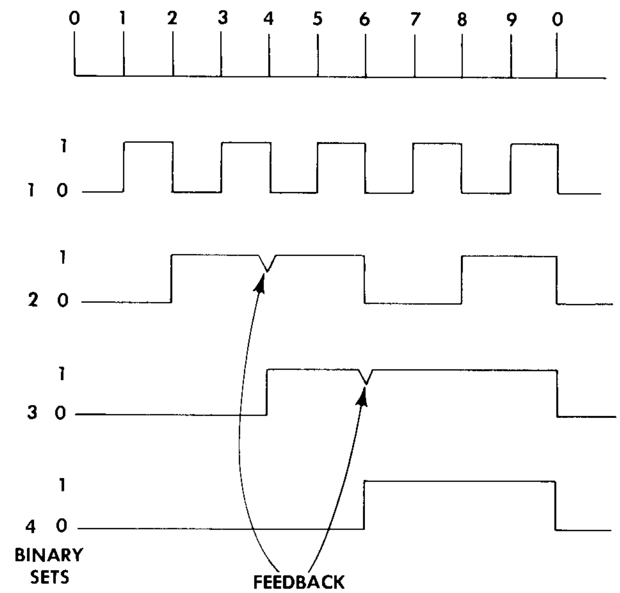

Fig. 4-15. Waveform relationship of Binary sets showing feedback.

on. Also, R100 is connected through R35 to the collector of Q35, which is turned on. The combined current from these two transistors add across R100 and Q100 turns on. The number zero (0) will show on the readout. Each pair works in the same way with the current being derived from the transistors in the binary sets.

The staircase voltage required by the No-Go circuits is formed by a voltage divider in the base circuit of Q83. The output level at the emitter of this transistor changes linearly with each count. For example, if the counter stops at the number 5, there will be a 12.4-volt dc level at pin 2 of the circuit board. R81 in the base circuit of Q83, together with R3, R23, R43, and R63, form a voltage divider that changes the value of voltage at the base of Q83 with each count. Each of these four resistors is connected in the collector circuit of the left hand transistors of each binary set. The on or off condition of these transistors determines the value of voltage applied to the base of Q83.

ANALOG DISPLAY BOARD

The Analog Display circuit intensifies the crt display during the 0% zone, 100% zone, and the area of the trace being measured (during time measurements).

The trace is intensified by increased dc level coupled from the collector of Q94 to the crt grid.

0% Intensified Zone

A negative pulse from the 0% Zone circuit board is received at pin 8. The pulse is applied to the base of Q43 which turns on. Its emitter follows the base and a negative pulse is applied to the base of Q53. This pulse appears in the emitter of Q53 and passes to the base of Q94 through R91 and C91. Q94 turns on and a positive pulse is coupled from its collector to the crt grid.

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100% Intensified Zone

The 100% zone pulses from the Memory circuit board enter the circuit through pin 14 (channel A) and pin 2 (channel B). The channel A pulse passes through Q3 and D12 to the base of Q53. The channel B pulse passes through Q23 and D32 to the base of Q53.

Start-To-Stop Intensified Zone

A negative pulse from the Master Gate circuit enters at pin 13 and is applied to the base of Q83 (emitter follower). The emitter of this transistor is coupled to the base of Q94. The positive pulse to the crt is taken from the collector of Q94.

Intensified Zones Switches

Pin 15 of the circuit board is connected to the 0% and 100% INTENSIFIED ZONES switch on the front panel. When this switch is turned to OFF, +20 volts is applied to the junction of R52 and D52. D52 becomes forward-biased and the +20 volts is applied to the base of Q53, which is held in cutoff. Pin 1 of the circuit board connects to the START TO STOP INTENSIFIED ZONES switch on the front panel. When this switch is turned to OFF +20 volts is applied to the junction of R82 and D82. D82 is forward-biased and holds Q83 in cutoff.

Dual-Trace

Due to the use of dual-trace, it is necessary to use a chopped signal in the Analog Display. Q13 and Q63 are controlled by the minus (—) chopped pulse from the 0% Zone circuit board. The plus (+) chopped signal controls Q33 and Q73. The action of the chopping pulses can be seen by examining Q3 and Q13. These two transistors are an "And" gate that require a negative signal on both bases to get an output. With either transistor turned on, its emitter is near +20 volts and D12 is back-biased. The junction of D12 and R42 is near +20 volts and Q53 (connected to this junction) is turned off. When both Q3 and Q13 receive a negative pulse, they both turn off, and D12 becomes forward biased through R13. Thus, the junction of D12 and R42 drops to about +3 volts and Q53 turns on.

Q63 and Q73 are used to gate the Start-to-Stop Zone to the proper channel during dual-trace operation (for example, a risetime measurement on channel A with both traces on the crt). Pin 5 is grounded by the Timing switches and Q73 is electrically removed from the circuit. Q63 receives the minus chop pulses from pin 12. During the time that the chopped trace on the crt is on channel A, Q63 does not affect the Start-to-Stop pulse to the base of Q83. When the crt trace switches to Channel B, the minus chop pulse is at +20 volts and this voltage turns Q63 off. The emitter of Q63 rises to about +15 volts. This forward-biases D63, which applies the positive voltage to the base of Q83. This transistor is cutoff for the duration of the chopped pulse and this period of time coincides with the time that the crt trace is on channel B.

If a measurement is made from one channel to the other, both pin 5 and pin 10 are grounded by the Timing switches and these two transistors (Q63 and Q73) are not used.

VOLTMETER BOARD

The Voltmeter board contains three separate circuits. They are the voltmeter, crystal oscillator, and floating power supplies. Each is described separately in this section.

Voltmeter

The Type 6R1 uses a counter to make voltage measurements. Consider a linear ramp (part of a sawtooth) such as shown in Fig. 4-16.

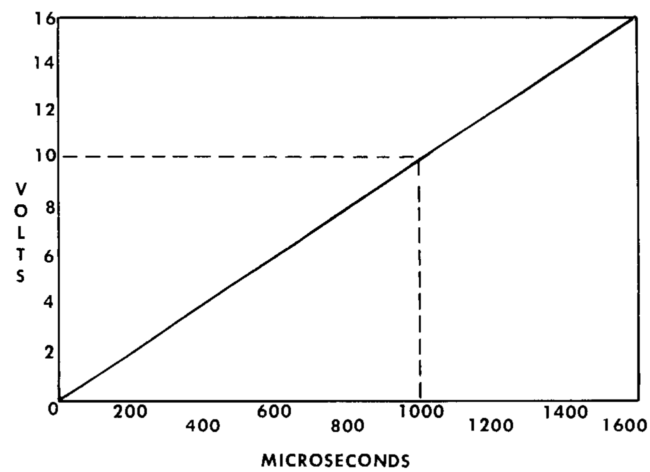

Fig. 4-16. Voltmeter ramp.

It takes 1000 microseconds for the ramp to rise 10 volts. Each volt takes exactly 100 microseconds. This waveform is used to measure voltage as shown in Fig. 4-17.

Voltage measurements are made between the 0% zone and the 100% zone. A sample of the voltage at the 0% zone is taken by the 0% Memory circuit and applied to one side of the Start Comparator. A sample is also taken from the 100% zone by the A Memory or B Memory circuit and applied to one side of the Stop Comparator. The Voltmeter Ramp is then applied to the opposite sides of both the Start and Stop Comparators. When the ramp reaches the 0% zone voltage level, the Start Comparator sends a pulse to the Master Gate circuit. The Master Gate opens and clock pulses pass to the counter.

In voltage measurements the clock pulses are produced by a 1-megacycle oscillator mounted on the Voltmeter board.

When the ramp reaches the voltage of the 100% zone applied to the Stop Comparator, this comparator sends a pulse to the Master Gate circuit which closes the gate. When the Master Gate closes, the counter stops and the time shown on the readout is read as volts, millivolts, or microvolts.

To maintain the correct reading when the MV/DIV. switch is changed, the clock pulses pass through a ÷ 1, 2, 5 circuit.

To measure a negative voltage, where the 100% zone is more negative than the 0% zone, the polarity switch

(A VOLTAGE or B VOLTAGE) is pushed down. This reverses the inputs to the comparators and the measurement starts at the 100% zone and stops at the 0% zone.

The Ramp Slope is formed across C111. With Q103 turned on, the cathode of V105 is near ground. The grid of V105 is also near ground. A positive pulse on the base of Q103 turns this transistor off. V105 turns off and its grid circuit is no longer clamped near ground. C111 starts to charge through R111, R112 (RAMP SLOPE adjustment), and D112 to the +300-volt supply. As C111 charges, this same voltage is on the grid of V111 and it increases conduction. The cathode of V111 follows the grid and couples the rising voltage through C118 and adds to the supply voltage. This "boot-strapping" keeps C111 charging on a linear rise.

When C111 rises to 17 volts, V105 conducts. With feedback from the plate of V105 to the base of Q103, this transistor turns on. Thus, C111 rapidly discharges through V105 by grid-to-cathode diode action and the ramp ends.

When the ramp ends and V105 conducts, a negative-going pulse appears on the base of Q104. A positive pulse passes from the collector of Q104 to the MODE switch.

A ramp is started by a —0% pulse from the 0% Zone board. Q93 and Q83 form an "And" gate. Q83 is controlled by the print command waveform from the Master Gate circuit. Q93 can only start a ramp when the print command waveform is absent. When Q93 can turn on, a positive pulse is coupled from its emitter through C83 and D86 to the base of Q103. Q103 turns off and V105 turns off, and the ramp starts.

Crystal Oscillator

The 1-megacycle crystal is connected between the base and collector of Q40. The oscillator signal is amplified by Q44 and appears across R44, the collector load resistor. From there it is coupled to the base of Q54. R52, from the base of Q54, is connected through pin 18 of the board to the front-panel MODE switch. When the MODE switch is in the VOLTAGE position, this point is grounded. Q54 is then biased as an "overdriven" amplifier and a 20-volt clock pulse appears across R54 and thus at pin 16 of the circuit board. With the MODE switch not in the VOLTAGE position, Q54 is biased beyond cutoff and the signal is blocked.

In the TIME START (—) STOP position of the MODE switch, clock pulses from the horizontal plug-in unit are applied through pin 5 to the base of Q64. Pin 12 is grounded in this position of the MODE switch and Q74 operates as an "overdriven" amplifier. The output of Q74 appears across R54 and at pin 16 of the circuit board.

Diodes D54 and D74, in the emitter circuits of Q54 and Q74, protect these transistors from excessive back-bias current.

Floating Power Supplies

There are two identical power supplies. The circuit consists of two transistors, with an 11-volt Zener diode connected between them. Q28 and Q38 supply the Timing Start voltage and Q8 and Q18 supply the Timing Stop voltage. The output is taken from the Zener diode and connected across the START VOLTAGE and STOP VOLTAGE controls located on the front panel. One output lead of each supply contains a variable resistor (START VOLTAGE CAL. and STOP VOLTAGE CAL.). This control adjusts the voltage to place approximately 10 volts across the START VOLTAGE and STOP VOLTAGE controls.

÷10 BOARD

This circuit is almost the same as the binary set portion of the Counter circuit and will not be described. For every

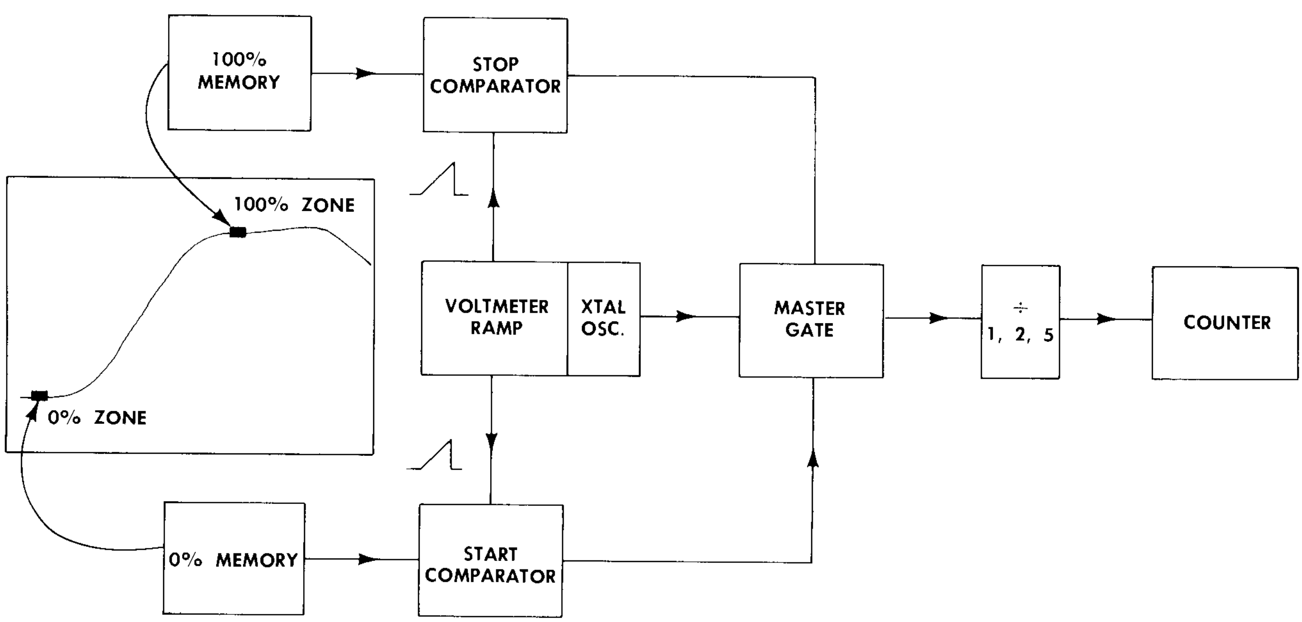

Fig. 4-17. Simplified diagram of circuits used for voltage measurements.

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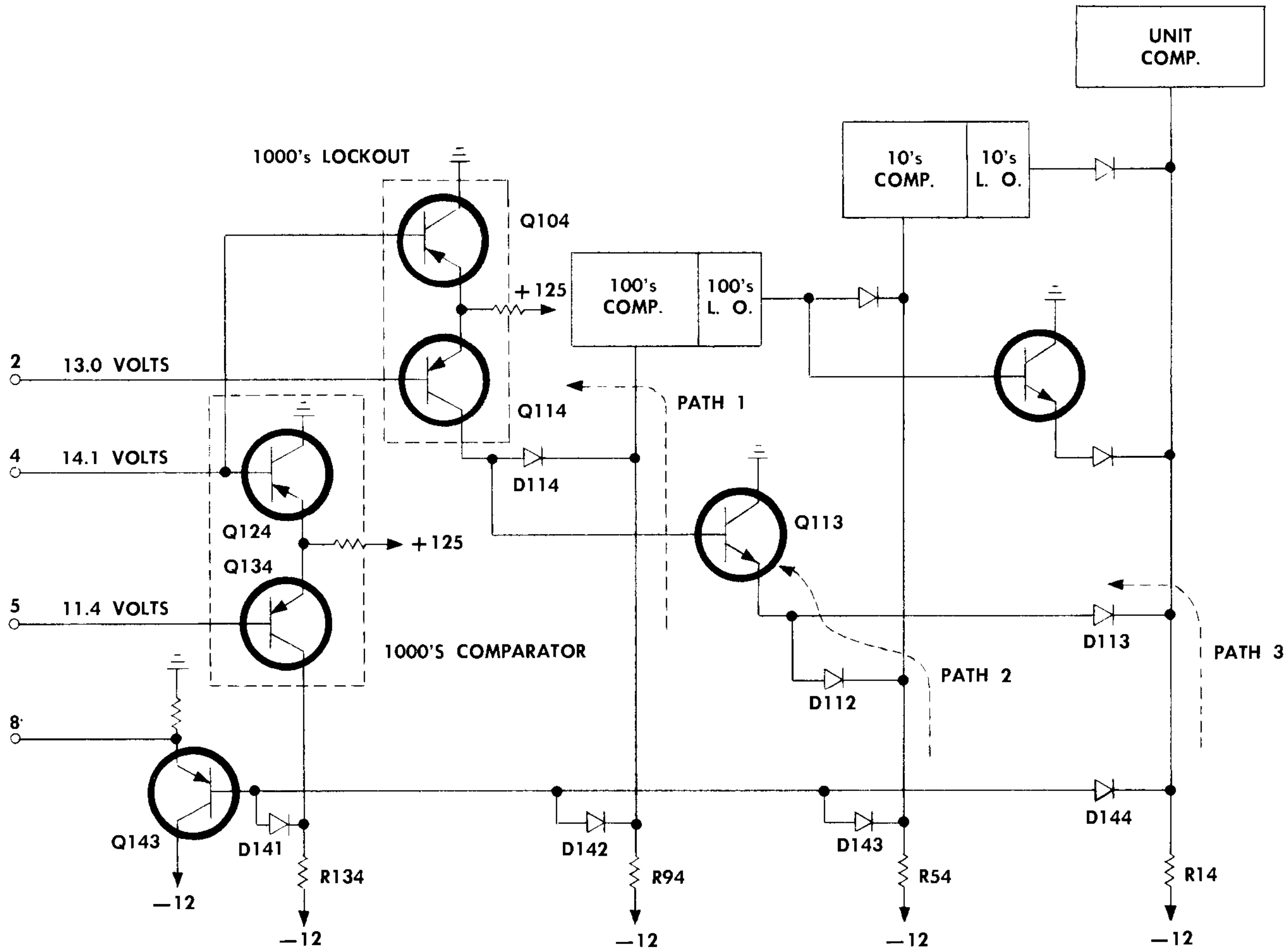

Fig. 4-18. Simplified diagram of Lower Limit No-Go circuit.

ten pulses applied to pin 15 (input) of the circuit board, one pulse is present at pin 4 (output).

LOWER LIMIT NO-GO BOARD

The Lower Limit No-Go circuit does two things.

1. It sends a signal to the Limit Lamp Driver circuit when the number on the readout is below the number set on the LOWER LIMIT SET dials.

2. If a number on the readout exceeds the numbers dialed on the LOWER LIMIT SET dials, the lockout portion of the circuit prevents the Lower Limit lamp from lighting.

The circuit consists of seven comparators; four of these compare the four digits of the readout and the other three are lockout comparators. Each digit comparator receives two voltages. The first is set by the LOWER LIMIT SET dials and corresponds to the number shown on the dials. The second is a staircase voltage that corresponds to the number on the readout and comes from the counter circuit. If the voltage from the counter circuit is below that supplied by the LOWER LIMIT SET dials, the Lower Limit lamp lights.

The voltages from the LOWER LIMIT SET dials are derived from a precision voltage divider. Two voltages are delivered to the Lower Limit No-Go board. The first represents the number shown on the dial and the second represents one digit higher in value than the number shown on the dial.

To help understand the circuit operation, consider only the thousands digit. Assume that the extreme left (thousands) digit shown on the LOWER LIMIT SET dials is 5. In the circuit, 11.4 volts is applied through pin 5 to the base of Q134. A count is made and the left-hand digit on the readout is 5. The counter circuit delivers 12.4 volts through pin 4 to the base of Q124. The base of Q134 has 11.4 volts and the base of Q124 has 12.4 volts; therefore Q134, being least positive, turns on. Due to current through Q134, its collector is positive and D141 is back-biased. With this diode back-biased, no signal is applied to the base of Q143 and this transistor cannot turn on.

If the number on the readout had been 4 instead of 5, then 10.7 volts would have been applied to the base of Q124, and this transistor, being least positive, would have turned on. In this case, Q134 would be turned off and D141 would be forward-biased with —12 volts on its cathode. This —12 volts would turn on Q143 and the signal to the Limit Lamp Driver circuit would light the Lower Limit lamp.

The other three comparators work the same way. Since each digit of the readout is compared with each digit on the LOWER LIMIT SET dials, it is possible for the total number to exceed the lower limit, yet one or more individual digits can be below the digits on the LOWER LIMIT SET dials. For example, assume the dials set at 5678, and the readout shows 6000. The total number on the readout is higher than the lower limit, but the units, tens, and hundreds digits are lower.

Since each comparator compares the individual digits, either the units, tens, or hundreds digit would light the Lower Limit lamp. To prevent this, each comparator has a second comparator that will lockout all other comparators when the total readout exceeds the total number on the LOWER LIMIT SET dials.

From the simplified diagram of Fig. 4-18 the LOWER LIMIT SET dials (set at 5678) put 11.4 volts on the base of Q134. The staircase voltage from the thousands counter puts 14.1 volts (6000) on the bases of Q124 and Q104. The LOWER LIMIT SET dials also put 13.0 volts on the base of Q114.

The comparator transistor with the least positive base turns on. The first comparator has 11.4 volts on Q134 and 14.1 volts on Q124, so Q134 turns on. Current flows through R134 and D141 is back-biased. No negative signal reaches the base of Q143.

Since the number on the readout (6000) is larger than the number on the LOWER LIMIT SET dials (5678), the second comparator must lock out the remainder of the circuit. Q104 has 14.1 volts on its base while Q114 has 13.0 volts. Q114 is least positive and turns on. Three current paths are formed. Path 1 through D114 draws current through R94 and D142 is back-biased. Path 2 turns Q113 on, and draws current through D112 and R54, and D143 is back-biased. Path 3 draws current through D113 and R14, and D144 is back-biased.

With current through each of the four resistors across the bottom of the diagram, the four diodes are back-biased, and no negative voltage is applied to the base of Q143. In this condition, neither the hundreds, tens, nor units comparators can affect the circuit since they are locked out.

Each of the comparators except the units comparator has an associated lockout comparator. When the digits on the readout are read from left, and each one is compared with the digit on the LOWER LIMIT SET dials, the first digit on the readout that exceeds its counterpart on the LOWER LIMIT SET dials will lockout all remaining digits to the right and their respective comparators will have no affect.

UPPER LIMIT NO-GO BOARD

This circuit is identical to the Lower Limit No-Go circuit with the following exceptions.

1. The voltage applied to the base of the first comparator (Q124) by the UPPER LIMIT SET dials is higher than the voltage supplied by the counter staircase.

2. The voltage applied to the base of Q104 in the lockout comparator is approximately 1.8 volts lower than the voltage applied to the first comparator.

LIMIT LAMP DRIVER BOARD

The Limit Lamp Driver circuit takes the outputs from the Upper and Lower Limit No-Go circuits and drives transistors that control the proper limit lamp on the front panel of the instrument.

The circuit is initially gated by a print command pulse (a positive pulse from the Master Gate circuit). Without this pulse, none of the lamps can light. The pulse length of the gate is set by the DISPLAY TIME control on the front panel of the instrument. The positive print command is applied to the base of Q14 which is quiescently conducting. Q14 turns off and its collector goes to —12 volts. The base of Q13 is connected to the collector of Q14 and the —12 volts turns Q13 on. The emitter of Q13 then becomes the source voltage for Q43, Q23, and Q64.

Q64 may be considered as a switch to ground. When the transistor is turned on, R64 is almost grounded and the —12 volts cannot be applied to the base of Q63 (MID-ZONE lamp). If a —12-volt signal is received from the Upper Limit No-Go circuit, Q23 turns on and applies —12 volts to the base of Q33 (the Upper Limit lamp). At the same time the voltage across R60 is sufficient to turn Q64 on which switches the voltage across R64 almost to ground.

The signal from the Lower Limit No-Go circuit works the same way. Without a signal from either the Upper or Lower Limit No-Go circuits, Q64 remains off and —12 volts turns on Q63 and lights the MID-ZONE lamp.

SECTION 5
MAINTENANCE

PREVENTIVE MAINTENANCE

Certain measures may be employed to insure continued, reliable performance of the Type 6R1. Such measures include thoroughly cleaning the instrument, and performing a periodic visual inspection and calibration.

Cleaning the Exterior

Loose dirt can be removed from the front panel and around the control knobs with a soft paint brush or cloth. Stubborn dirt can be removed with a soft cloth dampened with water and a small amount of detergent (avoid abrasive cleaners).

Cleaning the Interior

Remove the Type 6R1 from the oscilloscope and withdraw each of the circuit boards. Do not replace these boards until the cleaning and visual inspection is completed. Forced air may be used to remove free dust within the chassis shell. Clean the circuit boards by dipping in warm soapy water and brushing lightly.

CAUTION

Do not immerse any boards that contain controls since water will remove their lubricant.

Rinse the boards thoroughly in clean water and air dry. After cleaning, brush the contact pins with contact cleaner to assure good electrical connection.

Visual Inspection

Make a thorough visual inspection of the chassis and each circuit board. Look for loose or broken connections, cracks in the etched circuitry, improperly seated tubes and transistors, and scorched wires or components. For most of these defects, the repair is obvious. However, scorched wires or components are usually caused by other defects in the circuit; you must first find and correct the cause of overheating before installing new parts.

Calibration

The Type 6R1 is a stable instrument, and will provide many hours of trouble-free operation. To insure continued performance, however, we suggest that you check the calibration after each 500 hours of operation (or every six months if used intermittently). A calibration checks each circuit, and minor defects that do not show up in normal use may be found at this time. A step-by-step procedure for calibrating the instrument is included in Section 6 of this manual.

REMOVAL AND REPLACEMENT OF PARTS

General Information

Parts can be replaced in the Type 6R1 by following standard replacement procedures. However, the technique described under "Soldering Precautions" should be used when repairing etched circuit boards. If critical parts are replaced, you should check the calibration in that portion of the instrument to insure proper operation.

Tube and Transistor Replacement

Do not change tubes or transistors unless they are defective. If you remove a tube or transistor from a socket, be sure and return it to the same socket to avoid unnecessary recalibration. Use pretested high quality tubes and transistors if replacement is necessary.

Soldering Precautions

In Tektronix instruments, a special silver-bearing solder is used to establish a bond. While this bond may be broken by repeated use of ordinary tin-lead solder, occasional use will not break the bond if excessive heat is not applied. If you maintain several Tektronix instruments, you should have a stock of solder containing about 3% silver. This type of solder is generally available locally, or it can be purchased from Tektronix in one-pound rolls (part number 251-514).

The technique for soldering and unsoldering short-lead and etched circuit components requires: (1) the use of needle nose pliers between the soldering point and the component to act as a heat shunt; (2) use a hot iron for a short time; and (3) careful manipulation, since many small components have weak leads.

Ceramic Terminal Strip Replacement

To remove a terminal strip, unsolder all leads and components attached to the strip. Then pry the strip, with yokes attached, out of the chassis. If the spacers do not come out with the yokes, they can be removed separately or, if they are not damaged, they may be left in for use with the new strip assembly.

A second way to remove the strip is to cut off one side of each yoke with diagonal cutters to free the strip. The remainder of the yoke can be pulled out with pliers. Replacement ceramic strips are supplied with yokes attached (see Fig. 5-1).

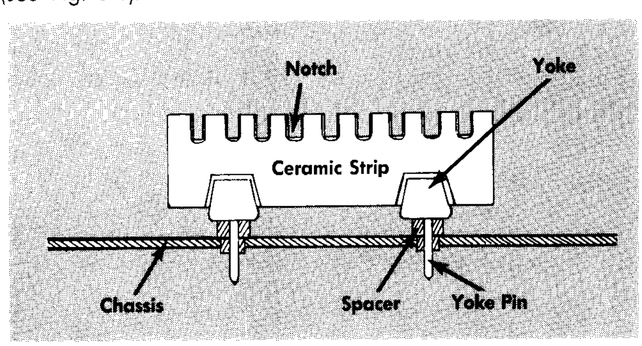

Fig. 5-1. Ceramic strip assembly.

TROUBLESHOOTING

General Information

This portion of the manual will help you if the Type 6R1 develops trouble. Information in other parts of the manual, particularly the circuit description section, may also prove helpful.

If trouble develops, first operate the front-panel controls to see what effect they may have. The operation of a control may help you establish a symptom. (The location of trouble which occurs only in certain control positions can usually be found immediately from the symptom.) Once the trouble symptoms are established, look for obvious causes; check to see that the power is on, feel for irregularities in control operation, listen for unusual sounds, and visually check the instrument.

The following troubleshooting procedure consists of two parts; circuit isolation and circuit troubleshooting. Table 5-1 outlines a general procedure to help you to isolate a defective circuit. Table 5-2 contains detailed checks within each circuit to help you locate the cause of the trouble.

Transistor Checks

If you have a Tektronix Type 575 Transistor Curve Tracer, the transistors in a suspected circuit can be quickly checked. If you do not have such an instrument, the transistors may be checked for opens or shorts with an ohmmeter. Check the resistance in both directions, between each of the transistor elements. Be sure to return transistors to their original sockets unless they are defective. If you doubt whether a transistor is good or not, substitute another in its place, but be sure the voltages and loads are normal before making the substitution.

CAUTION

When checking transistors with an ohmmeter, the RX1 scale meter voltage may cause damage. Use only the RX10 or RX100 scale.

Switch Wafer Code

Switch wafers shown on the schematics are coded to show their position on a switch. The number in the code refers to the wafer number on the switch assembly. Wafers are numbered from front to rear. The letters F and R show whether the front or rear of the wafer is used. The number that follows the code letter identifies the pin on the wafer.

Wire Code

All power supply wiring in the Type 6R1 is color coded. The widest stripe identifies the first color in the code.

White wire is used for plus (+) voltages (regulated).

Tan wire is used for minus (—) voltages (regulated).

Grey wire is used for unregulated voltages.

Voltage	Color Code
—12	Tan wire with brown and red stripes.
+20	White wire with red and black stripes.
—100	Tan wire with brown, black, and brown stripes.
+75 (unreg.)	Grey wire with brown and violet stripes.
+125	White wire with brown, red, and brown stripes.
+225 (unreg.)	Grey wire with brown and yellow stripes.
+300	White wire with orange, black, and brown stripes.
+400 (unreg.)	Grey wire with orange and red stripes.

Test Equipment

In the troubleshooting information that follows, reference is made to the use of an oscilloscope to check waveforms. Because of the short times involved in many of the waveforms, it is necessary to use a wide-band oscilloscope. The use of a transistor curve tracer is optional. The following equipment is required.

1. Wideband oscilloscope, such as Tektronix Types 541, 543, or 545, with Type K Plug-In Unit.

2. Ohmmeter, 20,000 ohms/volt, calibrated to 1% accuracy.

3. 20-pin etched circuit board extender, Tektronix part number 012-068.

4. 15-pin etched circuit board extender, Tektronix part number 012-067.

Power Supply Checks

The oscilloscope power supply should be checked before proceeding with the Type 6R1. Remove the top panel of the oscilloscope and check the pins of J31 for the following voltages. (J31 is the connector at the top rear of the Type 6R1 compartment.)

J31 Pin No.	Voltage
13	+225 unregulated
14	+300
15	+125
16	+20
17	—12
18	—100
19	6.3 vac
20	ground
21	+75 unregulated
24	+400 unregulated

NOTE

The voltage at pin 18 should be exactly —100 volts. All other voltages should be within 3%. See oscilloscope instruction manual.

Circuit Substitution

Because several of the circuit boards are identical, the trouble circuit can often be verified by substitution. For example, if measurements cannot be made on channel A and the Memory board is suspected, reverse the positions of the channel A and B Memory boards. If channel B is now inoperative, the Memory board is defective.

Similar substitutions can be made with the Signal Comparator and Counter circuit boards.

Circuit Board Input and Output Checks

The schematics show waveforms and voltages normally present at the pins of each circuit board. They also indicate the circuit from which each signal is obtained or the circuit to which a signal is applied. Where trouble in a circuit board is not obvious, check each of the connector pins for the proper voltage or waveform.

TABLE 5-1

CIRCUIT ISOLATION

Trouble	Probable Cause	Check
1. Readout not illuminated.	Instrument plugs J31 and J32 not properly mated to oscilloscope.	Reinstall Type 6R1 into compartment. Check for good electrical mating of rear plugs.
2. Readout numbers do not change in any position of front-panel switches.	Start SIGNAL COMPARATOR board.	Check for signal at INPUT PIN 8 or 9. Check for start pulse at OUTPUT jack.
	Master Gate board.	Check for clock pulses at pin 5.
	÷ 1, 2, 5 board.	Refer to ÷ 1, 2, 5 chart, Table 5-2.
	Units COUNTER board.	Check for clock pulses at pin 1. Reverse positions of Units and 100's boards.
3. Unit measures voltage, does not measure time.	No clock pulses from VOLTMETER board.	Check pin 5 for input clock pulses. Check pin 16 for output clock pulses.
4. TIMING START and STOP switches only work in MANUAL position.	No signal to MEMORY boards.	Check A signal and B signal cathode followers (located behind TIMING STOP and START switches respectively).
5. Unit measures time, does not measure voltage.	Oscillator on VOLTMETER board.	Check pin 16 for clock pulses.
	Voltmeter Ramp.	Check pin 17 for ramp waveform.
	Voltmeter reset.	Check pin 4 for reset pulse.
6. Does not make channel B time percentage measurements.	Channel B MEMORY board.	Refer to MEMORY board chart, Table 5-2.
7. Does not make channel A time percentage measurements.	Channel A MEMORY board.	Refer to MEMORY board chart, Table 5-2.
8. No 0% intensified zone on display.	0% ZONE board.	Check 0% ZONE WIDTH adjustment.
	ANALOG DISPLAY board.	Check Q43.
9. No 100% intensified zone on display.	MEMORY board.	Check 100% ZONE WIDTH adjustment.
	ANALOG DISPLAY board.	Check Q3 and Q23.
10. No Start-to-Stop intensified zone.	MASTER GATE board.	Check Q53 and Q33.
	ANALOG DISPLAY board.	Check Q83, D63, and D73.
11. No intensified zones.	ANALOG DISPLAY board.	Check Q94, Q83, and Q53.
12. Readout does not indicate in certain positions of MV/DIV. and TIME/DIV. switches.	÷ 1, 2, 5 board.	Refer to ÷ 1, 2, 5 circuit chart, Table 5-2.
13. Will not measure 2nd slope.	SIGNAL COMPARATOR board.	Check multivibrator in SIGNAL COMPARATOR boards.
14. START and STOP VOLTAGE dials will not set Start-to-Stop intensified zone.	VOLTMETER board.	Check floating power supplies.
15. Limit lamps will not light.	LIMIT LAMP DRIVER board.	Check Q14 and Q13. Check lamps.
16. Limit switches not operating properly.	UPPER or LOWER LIMIT NO-GO board.	Refer to appropriate circuit chart, Table 5-2.
17. Instrument will not operate with RESOLUTION switch in AVERAGE OF TEN SWEEPS position.	÷ 10 board.	Refer to ÷ 10 circuit chart, Table 5-2.

TABLE 5-2

CIRCUIT TROUBLESHOOTING

Trouble	Check or Possible Cause
0% ZONE Board	
1. No. + 0% waveform at pin 12.	Q63.
2. No − 0% waveform at pin 5 and no 0% intensified zone on display.	Q64.
3. No + or − 0% waveforms at output pins.	Q54, Q43, or D43.
4. No sweep at pin 10.	V43.
5. No − gate at pin 14.	Q13.
6. No + gate at pin 13.	Q24, Q23, or Q33.
7. Intensified zones are not correct in dual-trace operation.	Q74 and Q84.
MEMORY Board	
1. 100% intensified zone extends from start point through entire display.	Q13.
2. No 100% intensified zone.	Q23 or Q3.
3. 100% intensified zone raised several millimeters above display.	Q43.
4. No memory output voltage at pin 8.	Connect voltmeter to test point 1 (see Memory schematic). Display waveform on Type 567 Oscilloscope. Turn 100% ZONE SET control (front panel) from one end to the other. If voltage changes, check V53 and Q58. If no voltage change, check Q33, Q43, and the bridge diodes.
5. No memory output voltage at pin 7.	Connect voltmeter to test point 2 (see Memory schematic). Adjust DELAY control on time base to move display through the 0% intensified zone. If voltage changes, check V83 and Q88. If no change, check Q63, Q73, and bridge diodes.
SIGNAL COMPARATOR Board	
1. Instrument measures on 2nd slope only.	Q94.
2. Instrument measures on 1st slope only.	Q64, Q65, Q75, Q84, D62 and D72.
3. No output pulse at pin 2.	Connect test oscilloscope to test point 1. If waveform is not as shown on schematic, Q54, D42 or V53 may be defective. Connect probe to point 2. If waveform is absent, check Q34, Q43, and all diodes. Move test probe to point 3. If waveform is present, check Q24 and Q44, otherwise check V4, V14, Q4, and Q14.
MASTER GATE Board	
1. Instrument will not count.	One at a time, remove Q13, Q43, and Q63 until count starts. If count does not start, check Q73, Q74, Q83, and Q93.
2. Count starts when Q63 is removed.	Q63, Q55, Q65, D52, D62.
3. Count starts when Q43 is removed.	Q43, Q35, Q45, D32, D42.
4. Count starts when Q13 is removed.	Q13, Q3, diodes in base circuit of Q3, V15.
5. Counter does not reset to 0000 before each count.	Q24, Q23, D28.
6. No Start-to-Stop intensified zone on display.	Q53, Q33.
7. Start-to-Stop intensified zone begins at 0% zone and does not move when TIMING START switch is turned.	Q33.
8. Start-to-Stop intensified zone extends from start point to full length of display.	Q55.
VOLTMETER Board	
1. No Voltmeter Ramp output.	Connect test oscilloscope to test point 1. If ramp is present, check V111. If ramp is not present, check D112, Q103, or V105. Check for waveform at test point 2. If not present, check D86, D85, Q83, and Q93.
2. No reset pulse at pin 4.	Q104.
3. No clock pulses at pin 16 in VOLTAGE position of MODE switch.	Connect test oscilloscope to point 3. If 1-megacycle oscillator signal is present, check Q54, or D54. If no signal, check Q44, Q40, and the 1-megacycle crystal.
4. No clock pulses at pin 16 in TIME position of MODE switch.	Connect test oscilloscope to point 4. If clock pulses are present, check Q74 and D74. If no pulse, check Q64.

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TABLE 5-2 *(Cont'd)*

Trouble	Check or Possible Cause
5. Precision dials do not adjust start or stop points on display.	Voltage between pins 1 and 2, and pins 19 and 20, should be approx. 9.4 volts. Check transistors and Zener diodes in floating power supplies (Q28, Q38, D27, and Q8, Q18, and D7).
ANALOG DISPLAY Board	
1. No 0% intensified zone on display.	Q43.
2. No 100% intensified zone on display.	Q23, Q3, D12, or D32.
3. No intensified zones on display.	Q94.
4. No Start - to - Stop zone on display.	Q83, D82.
5. Channel B 100% zone also on channel A display.	Q33.
6. Channel A 100% zone also on channel B display.	Q13.
÷ 1, 2, 5 Board	
This board consists of three separate circuits that are individually selected by the TIME/DIV. and MV/DIV. switches on the horizontal and vertical plug-in units respectively. The circuit in use is determined by the setting of these switches as follows:	
TIME/DIV. OR MV/DIV.	Circuit Used
.1 1, 10	÷ 1
.5, 5, 50	÷ 2
.2, 2, 20, 200	÷ 5
1. Readout shows 0000 when TIME/DIV. switch is in .1, 1, or 10 position.	Q84, D84.
2. Readout shows 0000 when TIME/DIV. switch is in .5, 5, or 50 position.	Q74, D74. Check ÷ 2 multivibrator transistors and diodes.
3. Readout shows 0000 when TIME/DIV. switch is in .2, 2, or 20 position.	Q44, D44. Check transistors and diodes in ÷ 5 multivibrators.
4. Readout will not count in any position of the TIME/DIV. or MV/DIV. switches.	Check for input clock pulse at pin 7. If no output at pin 6, check Q84, Q74, and Q44.
COUNTER Boards	
The four Counter boards are identical, and may be interchanged.	
1. Single number within readout tube does not light.	Check readout tube driver transistor. (Q109 is 9's driver, Q103 is 3's driver, etc.). Check readout tube.
2. Readout does not return to 0000 at start of count.	Check for reset pulse at pin 8.
3. No staircase voltage supplied to no-go circuits.	Q83.
4. No count; readout remains at 0000.	Interchange Units and 1000's board.
÷ 10 Board	
If the instrument operation is normal when the RESOLUTION switch is in the ONE SWEEP position, but erratic when this switch is in the AVERAGE OF TEN SWEEPS position, the ÷ 10 circuit board is probably defective.	
1. Instrument will not operate properly with RESOLUTION switch in the AVERAGE OF TEN SWEEPS position.	Check for +20-volt gate pulse at pin 4. Check Q83.
2. Counter runs continuously with RESOLUTION switch in the AVERAGE OF TEN SWEEPS position.	Check for +20-volt gate pulses at test points 1, 2, 3, and 4.
LOWER LIMIT NO-GO Board	
1. Lower Limit lamp will not light when readout is below number on LOWER LIMIT SET dials.	Check lamp and Q143. Test point 5 should read —11 volts.
2. Lower Limit lamp on at all times.	Check Q143, Q134, Q94, Q54, and Q14.
3. Both Lower and Upper Limit lamps on at the same time when readout total exceeds LOWER LIMIT SET number.	Lower Limit circuit not locking out. Check test points 1 through 4 for zero volts.

The following chart shows the numbers and the resultant voltages delivered by settings of the LOWER LIMIT SET dials and the voltages delivered by the counter circuits that correspond to the numbers on the readout.

Number on LOWER LIMIT SET dials	Voltage at pins 1, 5, 12, 13	LOWER LIMIT Voltage at pins 2, 14, 15	Number shown on readout	LOWER LIMIT Voltage at pins 4, 11 7, 13
0000	3.0	4.7	0000	3.9
1111	4.7	6.5	1111	5.7
2222	6.5	8.0	2222	7.4
3333	8.0	9.7	3333	9.0
4444	9.7	11.4	4444	10.7
5555	11.4	13.0	5555	12.4
6666	13.0	14.8	6666	14.1
7777	14.8	16.5	7777	15.7
8888	16.5	18.2	8888	17.5
9999	18.2	20.0	9999	19.1

TABLE 5-2 *(Cont'd)*

Trouble	Check or Possible Cause
UPPER LIMIT NO-GO Board	
1. Upper Limit lamp will not light when readout is above number set on UPPER LIMIT SET dials.	Check lamp and Q143. Test point 5 should read —11 volts.
2. Upper Limit lamp on at all times.	Check Q143, Q134, Q94, Q54, and Q14.
3. Upper and Lower Limit lamps on at the same time when readout total is below number set by UPPER LIMIT SET dials.	Upper Limit circuit not locking out. Test points 1 through 4 should read zero volts.

The following chart shows the numbers and the resultant voltages delivered by settings of the UPPER LIMIT SET dials and the voltages delivered by the counter circuits that correspond to the numbers on the readout.

Number on UPPER LIMIT SET dials	Voltage at pins 1, 5, 12, 13	UPPER LIMIT Voltage at pins 4, 14, 15	Number shown on readout	UPPER LIMIT Voltage at pins 2, 11, 7, 13
0000	4.7	3.0	0000	3.9
1111	6.5	4.7	1111	5.7
2222	8.0	6.5	2222	7.4
3333	9.7	8.0	3333	9.0
4444	11.4	9.7	4444	10.7
5555	13.2	11.4	5555	12.4
6666	15.0	13.2	6666	14.1
7777	16.5	15.0	7777	15.7
8888	18.2	16.5	8888	17.5
9999	20.0	18.2	9999	19.1

Trouble	Check or Possible Cause
LIMIT LIGHT DRIVER Board	
First check for +18 volts at pin 12 of the circuit board.	
1. MID-ZONE lamp will not light.	Check lamp and Q64. Test point 4 should read —10 volts.
2. MID-ZONE lamp on at all times.	Check Q64 and Q63.
3. Upper Limit lamp will not light.	Check Q23 and Q33. Test point 1 should read —12 volts.
4. Upper Limit lamp on at all times.	4. Check Q33. Test point 1 should read zero volts.
5. Lower Limit lamp will not light.	Check Q43 and Q53. Test point 2 should read —12 volts.
6. Lower Limit lamp on at all times.	Check Q53. Test point 2 should read zero volts.
7. No lamp will light.	Check Q13. Test point 3 should read —11 volts.

SECTION 6
CALIBRATION PROCEDURE

Introduction

This section contains a complete calibration procedure for the Type 6R1 Digital Unit. The instrument should be calibrated after each 500 hours of operation (or every six months if used intermittently). When transistors, tubes and other components are changed, the calibration of the circuit under repair should be checked.

Trouble in the instrument is often caused by changes in component values. These troubles can usually be found by checking the calibration of the suspected circuit, together with the troubleshooting charts of Section 5.

The step by step instructions that follows are in proper sequence to calibrate the instrument and avoid unnecessary repetition of checks and adjustments.

Since the Type 6R1 can be calibrated with either sampling plug-in units (Types 3S76 and 3T77) or real-time plug-in units (Types 3A2 and 3B2) there are several steps in this procedure that apply to only one.

With real-time plug-in units, the SQUARE-WAVE CALIBRATOR of the Type 567 can be used as both a test waveform and a frequency standard (60-cycle line frequency). Because of the slower risetime of the Type 3A2, it is necessary to connect a 0.1-μf capacitor from the calibrator output jack (the jack being used) to ground as shown in Fig. 6-1.

The location of each circuit board is shown in the Circuit Board Location pull-out page, just ahead of the schematics.

EQUIPMENT REQUIRED

1. Vertical amplifier and horizontal time base plug-in units (Type 3S76 with Type 3T77, or Type 3A2 with Type 3B2).

2. A 30-megacycle test oscilloscope with 5-mv vertical sensitivity (Tektronix Type 540-Series oscilloscope with Type H Plug-In Unit recommended).

3. Differential voltmeter (to resolve ± 1 mv) such as John Fluke Model 801B or 825A, or Tektronix Type D High Gain Differential Plug-In Unit with 1$\times$ probes.

Either of these instruments can be used as a dc voltmeter in the calibration procedure. If another type of null detector is used, a separate dc voltmeter, 1%, will be needed.

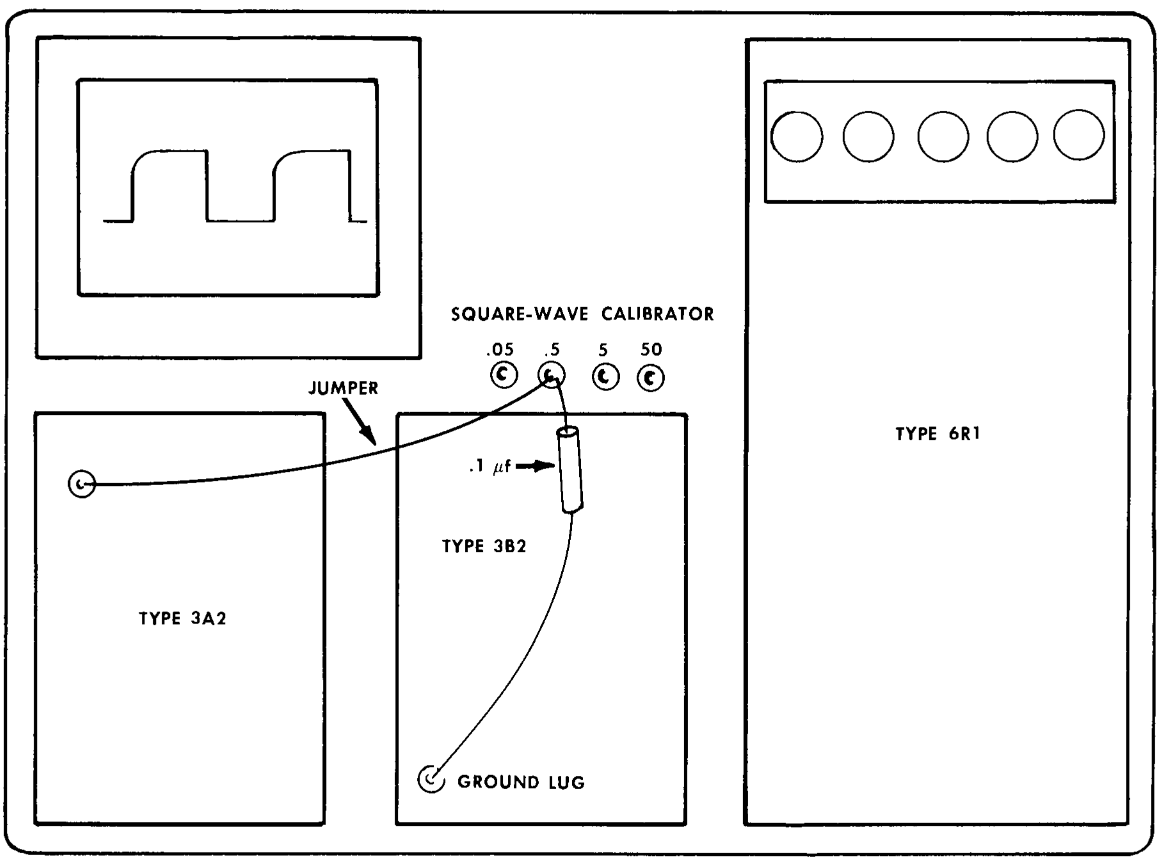

Fig. 6-1. Capacitor connection when Calibrator is used for test waveform.

4. 1-megacycle Counter (±1%).

5. Square-wave generator with variable frequency (100 cycles to 1 mc) and variable output (0 to 20 volts); Tektronix Type 105 recommended.

6. Sine-wave generator to produce a single frequency between 10 mc and 50 mc, accurate to at least 0.5%; Tektronix Type 180A Time-Mark Generator recommended.

7. 1-15 pin Extender Board (etched circuit) Tektronix part number 012-067.

8. 1-20 pin Extender Board (etched circuit) Tektronix part number 012-068.

ADJUSTMENT PROCEDURE

DC Levels

The purpose of this series of adjustments is to set the output of 6 cathode followers to within 1 millivolt of each other. These cathode followers are the A signal and B signal, and the two 0% and 100% cathode followers from the channel A and channel B Memory boards.

1A. Channel A and B Output DC Level (real-time plug-in units only).

a. Remove the channel B Memory board, put it into an extender board, and reconnect into the chassis (see Fig. 6-2). Adjust R443 (B SIG. DC LEVEL, behind TIMING START switch) to the center of its range.

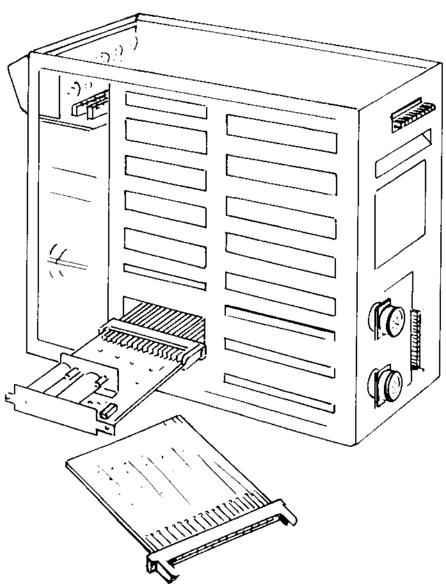

Fig. 6-2. Extender board used for circuit calibration.

b. Turn the TRIGGER SENSITIVITY control of the time base plug-in unit to FREE RUN.

c. Connect a voltmeter to pin 5 of the channel B Memory board and adjust the channel B POSITION control on the vertical plug-in unit for +10 volts on the voltmeter. Remove the voltmeter.

d. Connect a differential voltmeter between pin 5 of the channel B Memory board and the grid of V493 (behind TIMING STOP switch). Turn the TIMING START and STOP switches to B TRACE 50%.

e. Adjust the channel B POSITION control on the vertical plug-in unit for a null on the differential voltmeter. The output dc level of the two vertical channels is now the same.

1B. Channel A and B Output DC Level (sampling plug-in units only).

a. Connect the voltmeter to the A OUT jack on the Type 3S76 and adjust the channel A POSITION control for 10 volts.

b. Connect the differential voltmeter between the A OUT and the B OUT jacks on the Type 3S76 and adjust the channel B POSITION control for a null. The output dc level of the two channels is now the same.

2. B Signal DC Level.

a. Set the TIMING START switch to B TRACE 50%. Connect a voltmeter to INPUT PIN 8 on the Start Comparator board and measure approximately 10 volts. This checks the B Signal cathode follower.

3. Start Comparator DC Balance.

a. Connect a jumper between the two INPUT jacks (pins 8 and 9) of the Start Signal Comparator board. Connect a voltmeter to OUTPUT jack of this board.

b. Adjust R4 (DC BAL.) until the voltage jumps between zero and 20 volts. Adjust as close as possible to this crossover point and leave with +20 volts at the OUTPUT jack. Remove the jumper.

4. B Memory 0% DC Level.

a. Connect a differential voltmeter between INPUT PIN 8 of the Start Comparator board and the 0% OUTPUT jack of the channel B Memory (upper) board.

b. Adjust R83 (0% DC LEVEL) for a null on the voltmeter.

5. B Memory 100% DC Level.

a. Connect the differential voltmeter between INPUT PIN 8 of the Start Comparator board and the 100% OUTPUT jack of the channel B Memory board.

b. Adjust R53 (100% DC LEVEL) for a null on the voltmeter.

6. Channel B Memory Tracking.

a. Connect the differential voltmeter between the 0% OUTPUT and the 100% OUTPUT jacks on the channel B Memory board.

b. Slowly turn the channel B POSITION control on the vertical plug-in unit. The voltage difference may exceed 20 mv momentarily until the Memory circuits recover. The difference voltage should stay within ±20 mv as the POSITION control is varied between +4 and +16 volts (output voltage to Type 6R1).

Ⓐ

7. A Memory 0% DC Level.

a. Connect the differential voltmeter between INPUT PIN 8 of the Start Comparator board and the 0% OUTPUT jack of the channel A MEMORY board.

b. Adjust R83 (0% DC LEVEL) for a null on the voltmeter.

8. A Memory 100% DC Level.

a. Connect the differential voltmeter between INPUT PIN 8 of the Start Comparator board and the 100% OUTPUT jack of the channel A Memory board.

b. Adjust R53 (100% DC LEVEL) for a null on the voltmeter.

9. A Signal DC Level.

a. Connect the differential voltmeter between INPUT PIN 8 of the Start Comparator board and INPUT PIN 8 of the Stop Comparator board. Set the TIMING STOP switch to A TRACE 50%.

b. Adjust R493 (A SIG. DC LEVEL, behind the TIMING STOP switch) for a null on the voltmeter.

10. Channel A Memory Tracking.

a. Connect the differential voltmeter between the 0% OUTPUT and the 100% OUTPUT jack of the channel A Memory board.

b. Slowly turn the channel A POSITION control on the vertical plug-in unit. The voltage may exceed 20 mv momentarily until the Memory circuits recover. The difference voltage should stay within ±20 mv as the POSITION control is varied between +4 and +16 volts (output voltage to the Type 6R1).

11. Stop Comparator DC Balance.

a. Connect a jumper between the two INPUT jacks (pins 8 and 9) of the Stop Comparator board. Connect a voltmeter to the OUTPUT jack of this board.

b. Adjust R4 (DC BAL.) until the voltage jumps between zero and +20 volts. Adjust as close as possible to this crossover point and leave with +20 volts at the OUTPUT jack. Remove the jumper.

12. 0% Zone Width.

a. Turn the vertical plug-in unit to channel A and display a free-running trace on the crt.

b. Adjust R43 (0% ZONE WIDTH control on 0% Zone board) to make the 0% intensified zone on the trace 3 millimeters in width.

13. Channel A 100% Zone Width.

a. Use the same trace as in step 12.

b. Adjust R13 (100% ZONE WIDTH control on channel A Memory board) to make the 100% intensified zone on the trace 3 millimeters in width.

14. Channel B 100% Zone Width.

a. Turn the vertical plug-in unit to channel B and display a free-running trace on the crt.

b. Adjust R13, (100% ZONE WIDTH control on channel B Memory board), to make the 100% intensified zone on the trace 3 millimeters in width.

15. Start and Stop Voltage Calibration.

a. Connect a square-wave generator to channel A of the vertical amplifier plug-in unit. (Use Type 567 Square-Wave Calibrator when real-time plug-in units are used.) Set any convenient frequency and adjust the controls to display a single waveform with exactly 8 divisions of vertical deflection between the 0% and 100% zones.

b. Set the Type 6R1 MODE switch to TIME. Set TIMING START switch to A TRACE 10% and the TIMING STOP switch to A TRACE 90%. Note the readout.

c. Set TIMING START switch to START VOLTAGE A TRACE. Turn the START VOLTAGE precision dial to 0.80.

d. Adjust R23 (START VOLTAGE CAL. on Voltmeter board) until the readout shows the same number noted in step b.

e. Set TIMING START switch back to A TRACE 10% and TIMING STOP switch to STOP VOLTAGE A TRACE. Turn the STOP VOLTAGE precision dial to 7.20.

f. Adjust R3 (STOP VOLTAGE CAL. on Voltmeter board) until the readout shows the same number noted in step b.

16. Voltmeter Clock Frequency.

a. Turn the MODE switch of the Type 6R1 to VOLTAGE A. Remove the Voltmeter board and reinsert in an extender board. Connect the counter to pin 16 of the Voltmeter board and check for a frequency of 1 megacycle ±1%.

17A. Voltmeter Calibration (sampling plug-in units only).

a. Connect a square-wave generator to channel A of the vertical plug-in unit and display a single pulse of approximately 7 divisions of amplitude. Set the 100% intensified zone to the peak of the pulse.

b. Connect a dc voltmeter (1%) to the A OUT jack of the vertical amplifier plug-in unit.

c. Turn the SWEEP MODE switch on the time base plug-in unit to MANUAL and position the dot on the display at the 0% zone. Record voltmeter reading.

d. Turn the time base unit MANUAL SCAN control and position the dot at the 100% zone. Record voltmeter reading.

e. Return SWEEP MODE switch to NORMAL and Type 6R1 MODE switch to A VOLTAGE. Set RESOLUTION switch to UNSCALED (MAX).

f. Subtract voltmeter reading of step c from reading of step d. The result should be the same as the number shown on the readout. If it is not, adjust R112 (RAMP SLOPE on Voltmeter Board) to make the reading the same. For example, assume the voltmeter reading of step c is 7.25 volts and the reading of step d is 12.50 volts. 12.50 — 7.25 = 5.25 (number on readout).

NOTE

With the RESOLUTION switch in UNSCALED (MAX), the decimal point and unit of measure are both turned off. The actual readout from the example above would show 0525.

17B. Voltmeter Calibration (real-time plug-in units only).

a. Connect a 5-volt (0.5% amplitude accuracy) square-wave generator to the channel A input connector (see note below). Be sure the vertical amplifier plug-in unit is accurately calibrated.

NOTE

The Tektronix Type 105 Square-Wave Generator can be standardized at 5 volts by comparison in the Tektronix Type Z Differential Comparator Plug-In Unit. This plug-in fits all Tektronix Type 530- and 540-Series oscilloscopes.

b. Adjust triggering controls for a single-pulse stable display with the 0% intensified zone at the bottom of the waveform.

c. Adjust the 100% ZONE SET control to place the 100% intensified zone on the top of the square wave.

d. Set the Type 6R1 MODE switch to VOLTAGE A with the A VOLTAGE switch pushed up.

e. Turn the RESOLUTION switch to HI AVERAGE OF TEN SWEEPS.

f. Adjust R112 (RAMP SLOPE on Voltmeter board) until the readout shows exactly 05.00 V.

g. Set the TRIGGERING MODE switch on the time base plug-in unit to — (minus). Push the A VOLTAGE switch on the Type 6R1 down. The readout should show 05.00 V ±1 count.

h. Repeat step g with the signal in channel B and the Type 6R1 MODE switch on B VOLTAGE.

18. Check Ramp Slope Linearity.

a. Connect a square-wave generator to channel A of the vertical plug-in unit and adjust the controls for a stable display 1 division in amplitude.

b. Set the Type 6R1 to read the voltage of the waveform.

c. Use the vertical amplifier POSITION control and move the display to the bottom of the graticule and note the readout. Then move the display to the top of the graticule and note the readout. The count deviation on the readout should not exceed ±1 count.

19. 0% and 100% ZONE SET Range.

a. Turn the vertical amplifier MODE switch to DUAL-TRACE, free-run the sweep, and display two traces. Set the Type 6R1 MODE switch to TIME.

b. The 0% zone should be intensified at the start of both traces (left side of crt).

c. Turn both the A and B 100% ZONE SET controls on the Type 6R1 fully counterclockwise. The 100% intensified zones should both move within the first major division on the left of the crt.

d. Turn both the A and B 100% ZONE SET controls fully clockwise. The 100% intensified zones should both move within the last major division on the right side of the crt.

20. Intensified Zones.

a. Turn the vertical plug-in unit MODE switch to DUAL-TRACE, free-run the sweep, and display two traces.

b. Turn the TIMING START and STOP switches to MANUAL. Set the TIMING START MANUAL control one-quarter turn from the fully counterclockwise position. Adjust the TIMING STOP MANUAL control one-quarter turn from the fully clockwise position.

c. The 0%, Start-to-Stop, and 100% intensified zones should be seen on both traces.

d. Push the 0% and 100% INTENSIFIED ZONES switch to OFF. These zones should disappear.

e. Push the START TO STOP INTENSIFIED ZONES switch to OFF. This zone should disappear.

21. Display Time.

a. Turn the DISPLAY TIME control fully clockwise. The readout should change approximately 10 times each second.

b. Turn the DISPLAY TIME control fully counterclockwise. The readout should change every 6 seconds (approximately).

22. Resolution Switch.

a. Set the RESOLUTION switch to ONE SWEEP LO, and note the location of the decimal point. Then set the RESOLUTION switch to AVERAGE OF TEN SWEEPS HI; the decimal point should move one place to the left and the count should remain the same except one significant figure is added.

b. Set the RESOLUTION switch to AVERAGE OF TEN SWEEPS LO; the units indicator tube should turn off.

c. Set the RESOLUTION switch to ONE SWEEP UNSCALED (MAX); the decimal point and unit of measure indicator tube should turn off.

23. TIMING START and STOP Controls.

a. Connect the square-wave generator to both input connectors of the vertical amplifier plug-in unit. (The Type 567 Square-Wave Calibrator waveform may be used for real-time plug-in units.) Turn the MODE switch to channel A and adjust the time-base to display two cycles on the crt.

b. Set the TIMING START and TIMING STOP switches to MANUAL. Turn the TIMING START MANUAL control fully counterclockwise and the TIMING STOP MANUAL control fully clockwise. The intensified Start-To-Stop zone should start between graticule lines 0 and 1 on the left of the crt and stop between graticule lines 9 and 10 on the right of the crt. The intensified zone may disappear; if it does, turn each control back a few degrees from the extreme.

c. Set both SLOPE switches to FIRST and +. Set both Timing switches to A TRACE 10%. The readout should remain at 0000. Check each position from 10% to 90% with the same setting on both the TIMING START and STOP switches. Throughout these checks the readout should remain at 0000.

d. Set both SLOPE switches to FIRST and —, and repeat steps c and d.

e. Turn the MODE switch on the vertical amplifier to channel B and repeat the above checks on the B TRACE % side of the TIMING START and STOP switches. If any number other than 0000 is seen on the readout during the checks (c, d and e), recheck the calibration steps listed below.

B Signal Dc Level	2
Start Comparator Dc Balance	3
B Memory 0% Dc Level	4
B Memory 100% Dc Level	5
B Memory Tracking	6
A Memory 0% Dc Level	7
A Memory 100% Dc Level	8
A Signal Dc Level	9
A Memory Tracking	10
Stop Comparator Dc Balance	11

24. Start to Stop FIRST ± and SECOND ± SLOPE.

a. Connect the square-wave generator to channel A of the vertical amplifier plug-in unit (Calibrator waveform with real-time plug-in units) and adjust for two cycles of display.

b. Set the TIMING START switch to A TRACE 10%, TIMING STOP switch to A TRACE 90%, both START and STOP block SLOPE switches to FIRST +, and MODE switch to TIME. The Start-To-Stop zone should be on the rising portion of the first cycle between the 10% and 90% points on the waveform.

c. Change both START and STOP block SLOPE switches to SECOND +. The Start-to-Stop intensified zone should now be on the rising portion of the second cycle between the 10% and 90% points on the waveform.

d. Set both START and STOP block SLOPE switches to SECOND —. Set TIMING START to A TRACE 90% and TIMING STOP to A TRACE 10%. The Start-to-Stop intensified zone should be on the falling portion of the second cycle between the 10% and 90% points on the waveform.

e. Set both START and STOP block SLOPE switches to FIRST —. The Start-to-Stop intensified zone should now be on the falling portion of the first cycle between the 10% and 90% points on the waveform.

25. Readout Counting.

a. Turn the instrument off and remove the ÷ 1, 2, 5 board. Insert a 20-pin extender board in its place; do not reconnect the ÷ 1, 2, 5 board. Connect the square-wave generator (set to 20 volts peak-to-peak) through a clip lead to pin 6 of the extender board. Turn the instrument on.

b. Set the generator to its lowest frequency and see that the units indicator tube counts from 0 through 9. Increase the generator frequency and check each successive indicator tube for a correct count of 0 through 9. At the same time check that when an indicator tube count reaches 9, the next count transfers to the next tube on the left.

c. Do not remove the extender board and square-wave generator (they are used in the next step).

26. Counter Staircase Output.

a. Use same connections as step 25.

b. Remove the Upper Limit No-Go circuit board and reconnect it through an extender board.

c. Connect the probe from the test oscilloscope to pin 10 of the Upper Limit No-Go board.

d. Set the generator frequency to approximately 2 kc and adjust the test oscilloscope for a staircase waveform as shown in Fig. 6-3.

e. Measure the voltage between steps as follows: Turn the test oscilloscope to free-run and increase the sweep rate until 10 horizontal lines are displayed. Use the VOLTS/DIV. and graticule lines to check the voltage between each line.

f. Move the oscilloscope probe successively to pins 7, 11, and 12. Check the staircase output voltage at each of these pins. Increase the generator frequency where necessary to give the proper display on the test oscilloscope.

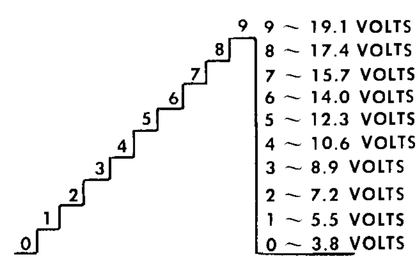

Fig. 6-3. Staircase voltages at pins 10, 7, 11 and 2 of the Upper Limit No-Go board.

g. Remove the extender board and replace the ÷ 1, 2, 5 board.

27A. Check of ÷ 1, 2, 5 Circuit (sampling plug-in units only).

a. Set the MODE switch to TIME. Set both TIMING START and STOP switches to MANUAL, and the RESOLUTION switch to ONE SWEEP LO.

b. Free-run a trace (no input signal needed) on the crt and adjust the TIMING START and STOP MANUAL controls for an 8-division Start-to-Stop intensified zone.

c. Set the TIME/DIV. switch on the time-base unit to 1 μsec; the readout should show 08.00 μS.

d. Set the TIME/DIV. switch to .5 μsec; the readout should show 04.00 μS.

e. Set the TIME/DIV. switch to .2 μsec; the readout should show 01.60 μS.

27B. Check of ÷ 1, 2, 5 Circuit (real-time plug-in units only).

a. Connect a jumper from the 5-volt jack of the Type 567 SQUARE-WAVE CALIBRATOR to the channel A input connector of the vertical amplifier.

b. Set the VOLTS/DIV. switch of the vertical amplifier to 5 volts.

c. Set the Type 6R1 MODE switch to A VOLTAGE. The readout should show 05.00 V.

d. Set the VOLTS/DIV. switch on the vertical amplifier to 2 volts. The readout should still show 05.00 V. Finally set the VOLTS/DIV. switch to 1 volt; the readout should still show 05.00 V.

28A. Time Readout Check (real-time plug-in units only).

a. Use the same connections as described in step 27B. Adjust the time base unit to display two pulses on the crt.

b. Set the Type 6R1 MODE switch to TIME.

c. Set the TIMING START and STOP switches to A TRACE 10%, START block SLOPE switches to FIRST +, and STOP block SLOPE switches to SECOND +.

d. The readout should show 16.66 MS.

e. Set the TIMING START and STOP switches to A TRACE 20%; the readout should remain the same. Make this same check for all numbered percentages on the A TRACE % side of the TIMING START and STOP switches.

f. Connect the signal to channel B and repeat steps c through e substituting B TRACE % for A TRACE %. The readout should remain at 16.66 MS.

28B. Time Readout Check (sampling plug-in units only).

a. Connect a sine-wave generator of known frequency (between 10 and 50 megacycles with an accuracy of 0.5%) to the channel A input connector of the vertical amplifier. Adjust the time base unit to display two cycles.

b. Calculate the period of one cycle by taking the reciprocal of the frequency. For example, the period of one cycle at 50 megacycles is 1/50 mc = 20 nsec.

c. Set the TIMING START and STOP switches to A TRACE 10%, START block SLOPE switches to FIRST +, STOP block SLOPE switches to SECOND +, and MODE switch to TIME.

d. The time shown on the readout should be the period of one cycle.

e. Check each percentage position of the TIMING START and STOP switches by setting both switches to the same percentage. The period should remain the same.

f. Connect the generator to channel B and repeat steps c through e substituting B TRACE % for A TRACE %. The period should remain the same.

29. UPPER and LOWER LIMIT SET Dials Check.

a. Set the MODE switch to TIME. Set both TIMING START and STOP switches to MANUAL, and the RESOLUTION switch to AVERAGE OF TEN SWEEPS HI.

b. Free-run a trace on crt (either channel) and adjust TIMING START and STOP MANUAL switches for a four-digit count (any count). Stop the sweep; the count will remain. Do this several times until the readout shows a count with no zeros or nines, such as 3258.

c. Set both UPPER and LOWER LIMIT SET dials to the count left in step b. The MID-ZONE lamp (green) should turn on.

d. Turn the UPPER LIMIT SET units dials one number counterclockwise (lower); the UPPER LIMIT lamp (red) should turn on. Return the dial to the original number. Turn the tens dial one number counterclockwise; the UPPER LIMIT lamp should turn on. Continue this procedure with the UPPER LIMIT SET hundreds and thousands dials. When this check is finished, return the dials to the original number.

e. Turn the LOWER LIMIT SET units dial one number clockwise (higher); the LOWER LIMIT SET lamp (yellow) should turn on. Continue this procedure with the LOWER LIMIT SET tens, hundreds, and thousands dials.

If the correct lamp does not turn on during this check, refer to the troubleshooting section of this manual.

SECTION 7
EXTERNAL PROGRAMMING

Introduction

This section of the manual describes the circuits and connections used for external programming and readout. A simplified illustration of a complete system is also included. Since each user may have different applications for the Type 6R1, this section should serve only as a system design guide.

External programming and readout is divided as follows:

1. Externally controlling the Type 6R1 circuits to make a measurement or series of measurements (measurement program).

2. Recording the test results with external equipment when the instrument has completed a measurement program (external readout).

Many combinations of measurement program and external readout can be used. For example, the controls on the instrument can be set by hand and the test results automatically recorded on a typewriter. Or, the measurement program can be set by an automatic programmer and the test results recorded by hand.

A completely automatic system can be built that will make a series of tests, record the results of each test, reject any component that fails to meet preset limits (go-no-go), and signal the end of the test.

Measurement Program

External programming can:

1. Set the mode of measurement for either time or voltage.
2. Start and stop a time measurement.
    a. On first or second slope.
    b. On a (+) or (—) slope.
    c. On A trace or B trace.
    d. On either trace at any percentage.
    e. Start or stop at some preselected voltage level.
3. Measure the voltage between 0% and 100% on either trace.
4. Override the A and B 100% zone settings.
5. Control the display time.
6. Provide voltages for go-no-go comparisons (counter staircase voltages).

When the Type 6R1 MODE switch is set to EXT. PROGRAM, several circuit connections within the instrument are broken, and the inputs and outputs of these circuits are connected to J34 on the rear of the instrument chassis. The circuits affected are the TIMING START and TIMING STOP switches, both (+) and (—) SLOPE switches, both FIRST and SECOND SLOPE switches, and both precision dials. These switches and controls must be supplied externally if they are needed for a planned program.

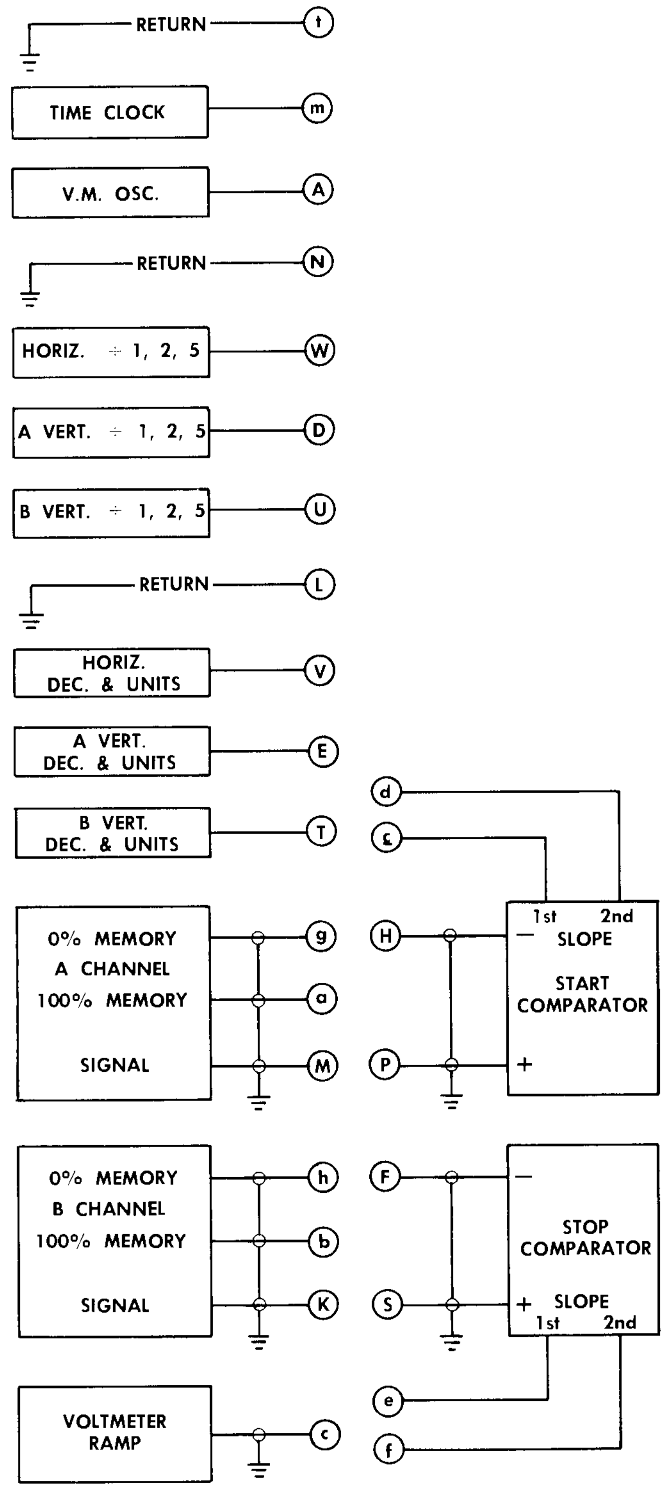

Fig. 7-1. Circuits used to interconnect an external program.

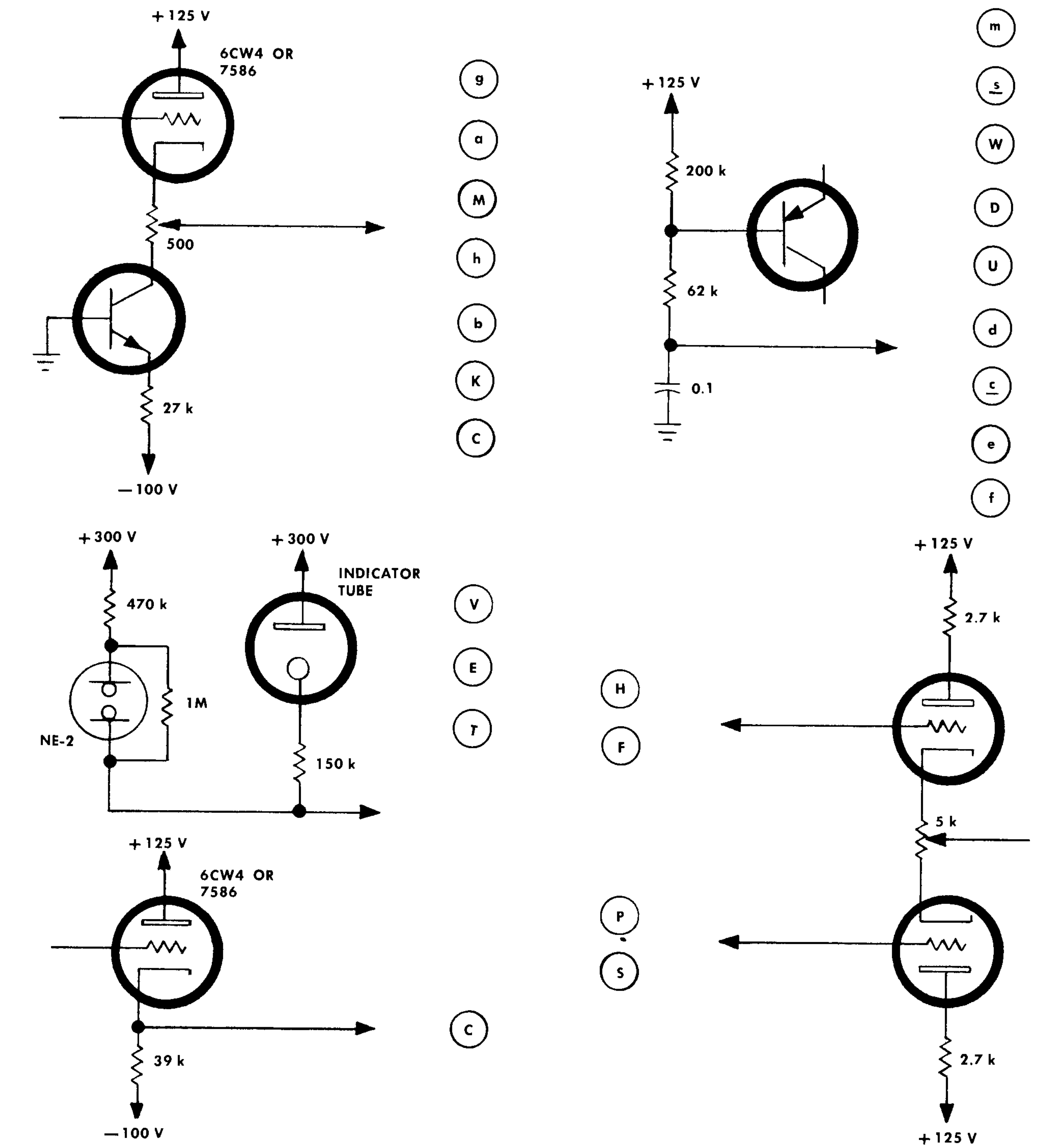

Fig. 7-2. The circled letters correspond to the pins of J34; the schematics show the circuits connected to these pins within the Type 6R1.

Fig. 7-1 shows the circuits that are used to interconnect an external program. This illustration may be reproduced and used as a work sheet to sketch in proprosed programs. Fig. 7-2 shows the general type of circuits that are connected to the pins of J34.

NOTE

Since pins t and N both connect to ground within the instrument, only one need be used. However, pin L must be used as a return for the decimal and units pin and should not be combined with the other returns. Otherwise the instrument will not work correctly when the Type 6R1 MODE switch is turned to TIME or VOLTAGE.

Typical Program Plan

For example, consider a transistor program in which you wish to measure:

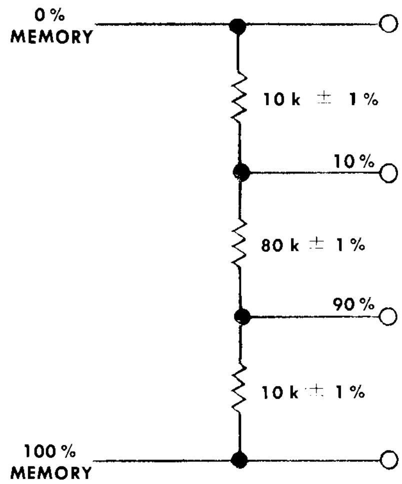

Fig. 7-3. Detail of TIMING START and STOP resistors.

1. Risetime.
2. Falltime.
3. Storage.
4. Delay.
5. Saturation.

The first requirement of an external programmer is the start and stop timing controls. Since these measurements require only the 0%, 10%, 90%, and 100% levels, and the signal output of each channel, the resistive divider shown in Fig. 7-3 is adequate for this purpose. The resistors should be at least 1% tolerance.

Next, coaxial leads should be connected from the proper pins of J34 to the timing resistors. Since the example program has a voltage measurement, the Voltmeter Ramp and clock control points must also be brought out.

The input leads (coaxial) to the Start and Stop Comparators and the slope-control leads of each comparator are also brought out from J34.

Since all of the measurements can be made on the FIRST SLOPE, pins c and e can be grounded and the SECOND SLOPE leads not used.

Because each measurement is a different set of connections between similar points, a mechanical switch can be used. A driven-type multiple-contact switch, such as a stepper, should suffice (relays can also be used).

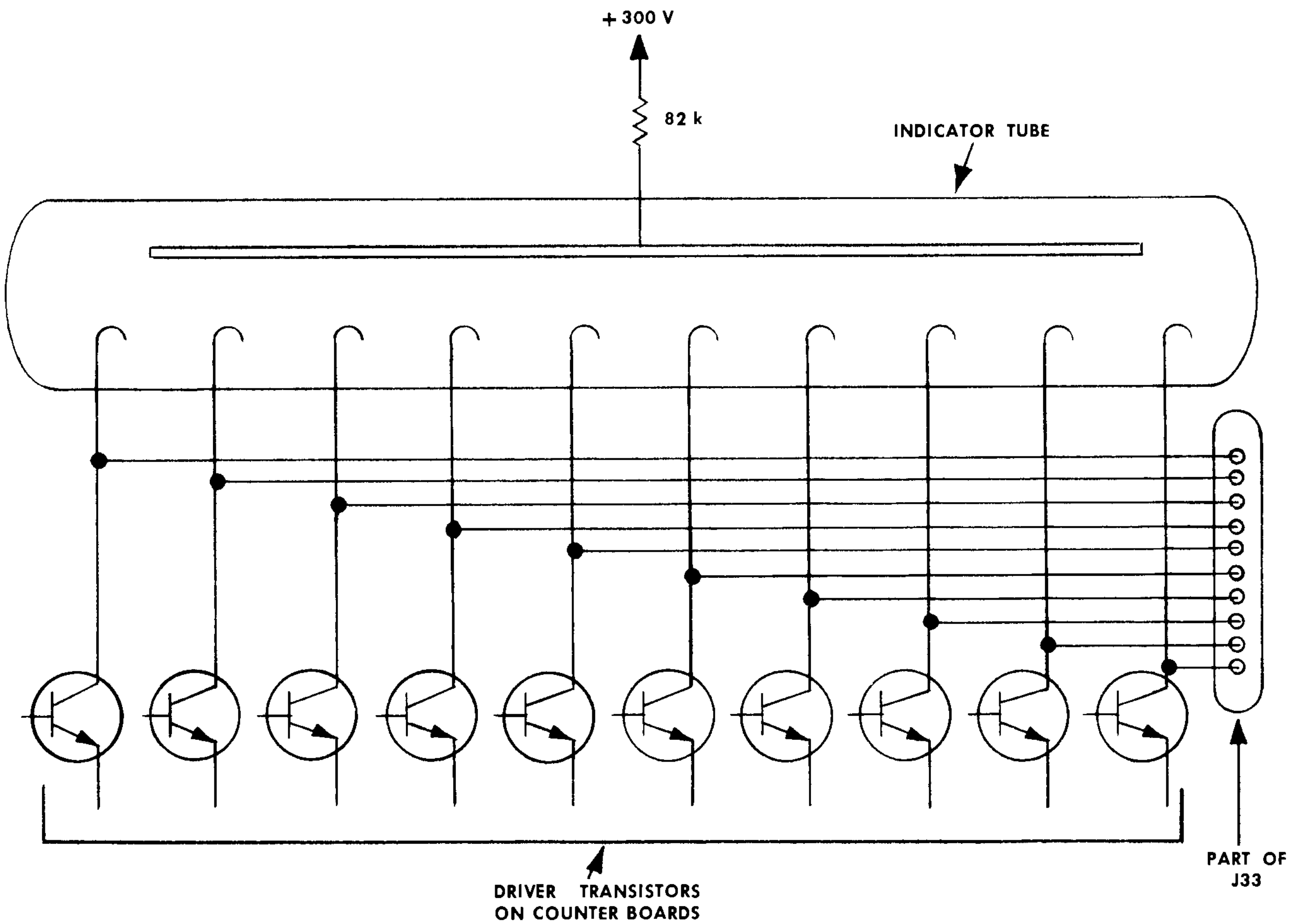

Fig. 7-4. Connection from indicator tube to external program jack.

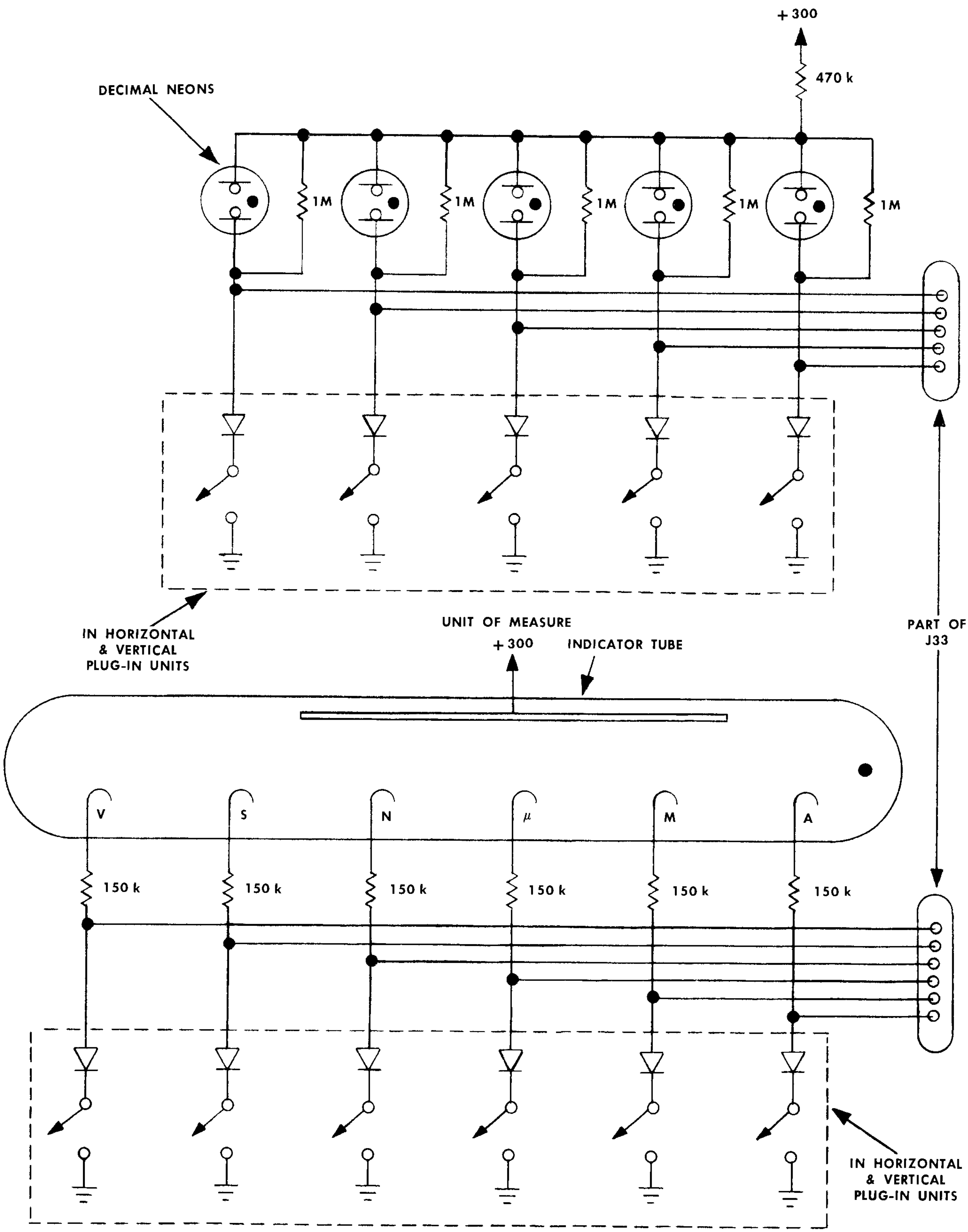

Fig. 7-5. Simplified decimals and unit of measure external outputs.

The switch can be advanced through each measurement by push-button control, or by using the Print Command voltage present at pin GG of J33 at the completion of a measurement.

With this type of external program, the operator plugs the test transistor into a fixture, starts the programmer, and records the values shown on the readout as the programmer passes through its cycle.

This is one method of external programming. Many variations of this system are possible. Plug-in program cards, punched tape, punched cards, and push-button switches are just a few of the possible methods.

Go-No-Go Programming

Because the acceptable limits of each measurement may be different, separate no-go comparisons are needed.

One method is to remove the Upper and Lower Limit circuit boards from the instrument and reinstall them in an external fixture. This fixture should supply the limit voltages in the same manner as the limit dials in the instrument. Thus, a second rotary switch can supply the correct limit voltages for each measurement in the program. The staircase voltages that represent the number shown on the readout are available at pins j, q, p, and Y of J34.

The operator can be alerted to an out-of-limit measurement by limit lamps, bells, buzzers, or rejection relays. If a typewriter readout is used, the ribbon can be made to change automatically from black to red when the limit is exceeded.

External Readout: Information From Connector J33

There are four 10-line outputs from the cathodes of each number indicator tube in the readout. Of the 10 cathodes

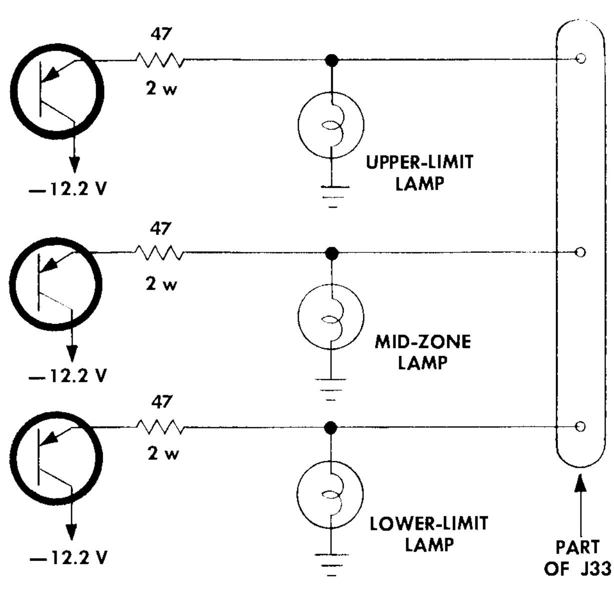

Fig. 7-6. External connections to Limit Lamps.

from an indicator tube, one will be at about +0.5 volt (turned-on cathode), while all others will range from about +40 to +140 volts. The turned-on indicator tube driver transistor (on Counter board) will supply about 1.5 ma for external circuits. See Fig. 7-4.

Decimal location data is contained on five lines. Output of the "On" decimal line will be about +0.5 volt, while others are +50 volts through 1.5 meg. See Fig. 7-5.

Outputs of the "On" units of measure (M, N, or μ, and V or S) are at about +0.5 volt, while others are +150 volts.

No-go outputs (limit lamps) are shown in Fig. 7-6. 50 ma is available for external circuit operation. This can be increased to 200 ma by removing the Type 6R1 front-panel limit lamps.

A and B 100% Zone Override

Pins R and J of J34 are used for 100% zone override. Two 100 k variable resistors should be connected between these points and ground. The A and B 100% ZONE SET controls on the Type 6R1 front panel should be turned fully clockwise. The two external variable resistors can be mounted on the external program fixture and used to control the A and B 100% ZONE positions.

A +20-volt print-command voltage is available at pin GG. The duration of this voltage is the same as the display time period. Whenever pin HH is grounded, the voltage at pin GG is +20 volts. Avoid loading this print-command voltage. An NPN emitter-follower, with its base resistor returned to some positive voltage, is suggested.

The display time waveform is present at pin HH. Grounding this point holds the Type 6R1 display and prevents it from making another measurement. When the ground is removed, the instrument waits through the display time set by the front-panel DISPLAY TIME control before making the next measurement.

Digital Recording

The number, decimal point, and unit of measure information shown on the Type 6R1 readout is present at J33 at the completion of a measurement. (The designer of a readout system can use either parallel or serial entry data recorders.)

Parallel Digital Recording

Several commercially available printers are suitable for this purpose. Usually they consist of number wheels that are positioned to the correct number by data from the device to be read.

One type of printer uses the four 10-line output from the indicator tubes. When the print command from the Type 6R1 is received, a clutch engages and turns number wheels. The number wheels turn until their individual armatures contact a negative voltage. The clutch disengages and the wheel stops at the correct number position. A print is made and the paper advances to display the count.

Some printers are designed to accept BCD code. With this type of instrument, a decimal-to-binary converter must be used between the output of the Type 6R1 and the printer.

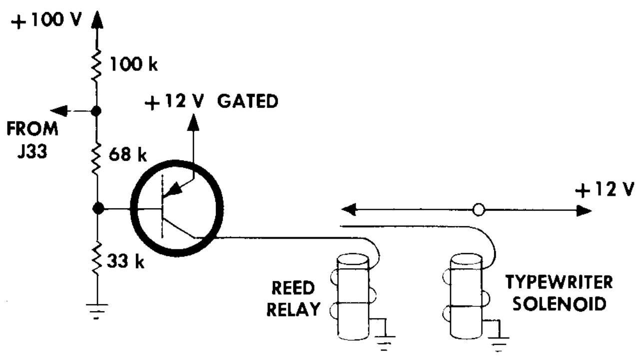

Fig. 7-7. Gated circuit used to convert data from Type 6R1 to an electric typewriter.

Serial-Entry Recording

Some examples of serial recording devices are: typewriter, tape punch, some adding machines, card punch, and magnetic tape.

The description that follows is for an electric typewriter; however, the general principles apply to all serial recording devices.

The readout data from the Type 6R1 is in parallel form. Because of this, a parallel-to-serial conversion is necessary. This can take several forms.

A multiple-contact stepper switch can connect the outputs of the indicator tubes to buffer transistors that drive the typewriter solenoids. Contacts on the switch can also be used to record decimal point and unit of measure data.

A variation of this method is a gating sequence. Fig. 7-7 shows a circuit that can be used to operate the solenoids of the electric typewriter. One of these circuits is needed for each bit of information from J33 of the Type 6R1. For example, there are five possible decimal point positions, thus one circuit is needed for each of these. The four 10-line outputs that represent the number on the readout require 40 circuits; however, only 10 relays are needed—one for each digit (zero through nine). The remaining circuits are needed for unit of measure information.

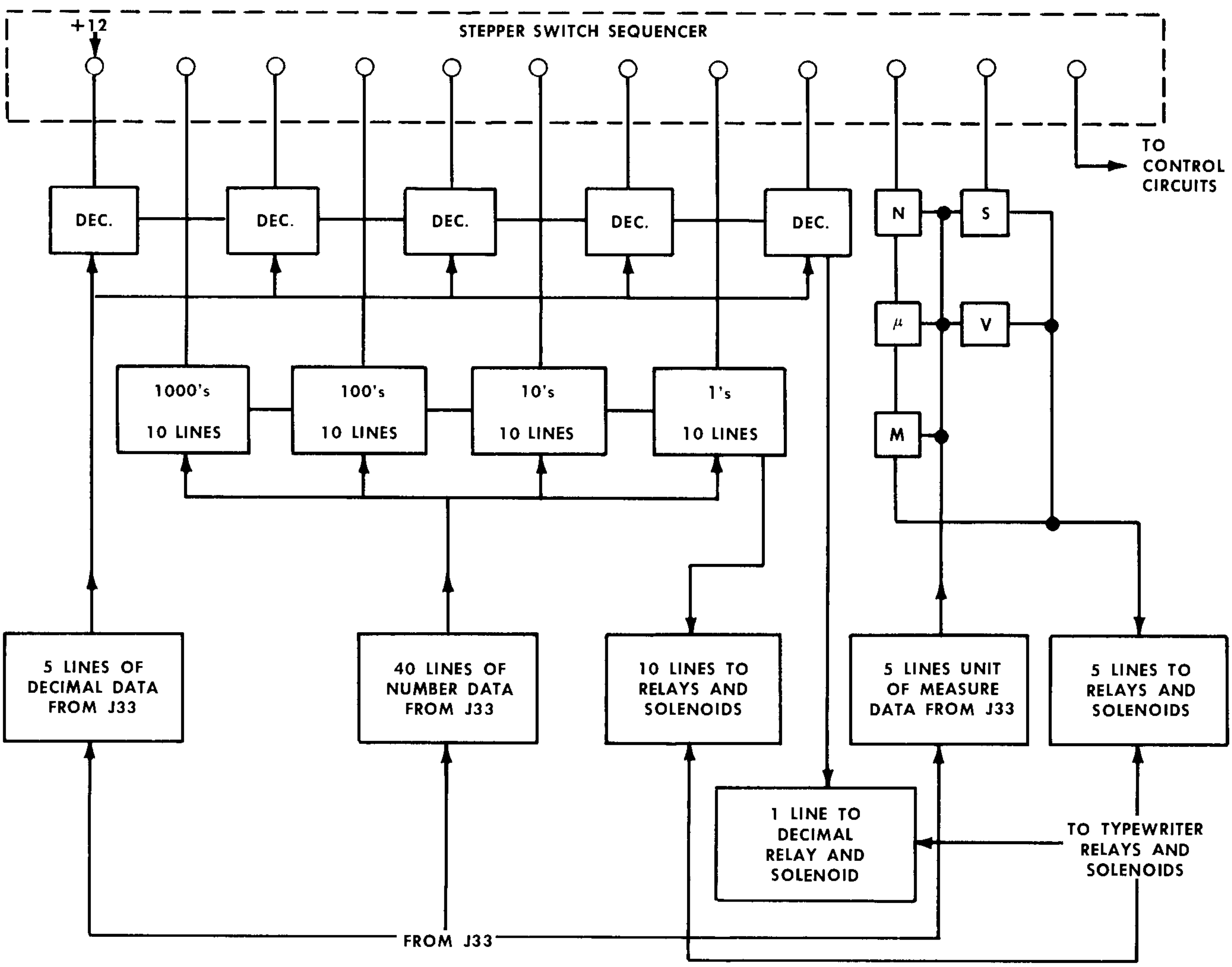

Fig. 7-8. A parallel to serial converter used to drive an electric typewriter.

The sequencer that gates the +12 volts to each line can be a commercial stepper switch. The step rate of the switch must be slow enough to allow the typewriter to strike and return. Fig. 7-8 is a simplified block diagram that shows the connections to such a switch.

The first position of the sequencer supplies +12 volts (enables) to a decimal point amplifier. If this is the correct position of the decimal point, the amplifier will turn on, and the typewriter will type a decimal. If this is not the correct point for the decimal, no action takes place. The sequencer moves to position 2. In this position, amplifiers are enabled by the +12 volts. These 10 amplifiers are connected to the 10-line output of the "thousands" counter in the Type 6R1. Of these 10 lines, one will be at +0.5 volt, while the others range from +40 to +140 volts. Only the amplifier connected to the +0.5-volt line will turn on. Assume this line is the number 5. The amplifier (no. 5) turns on, energizes the relay and solenoid, and the typewriter types a 5. Thus, the sequencer enables each group of amplifiers in serial order.

Notice that only one relay is needed for the decimal point. Also one relay is needed for each digit; zero through nine.

The 12th position of the sequencer can be used to step the programmer to the next program, work the typewriter tab, and release the ground on the DISPLAY TIME hold (pin HH).

The typewriter would show the results of the five tests like this:

52.02NS 84.15NS 95.82NS 88.65NS 325.6MV

Only the name of each test is absent. One possible way to include this vital information is to use the programmer to title each test. For example, when the programmer shifts to the first program, a switch contact on the programmer can energize the capital R solenoid of the typewriter. This shows a risetime measurement. In the same way, each program would cause a code letter to be typed that would identify the measurement, like this:

R52.02NS F84.15NS S95.82NS D88.65NS V325.6MV.

Since the letter S occurs twice in this program (storage, saturation), the letter V can be used for the saturation measurement.

Complete System

The combination of the programmer and readout as an automatic system is shown in block diagram form in Fig. 7-9.

The operator plugs in a transistor and pushes the start button; the system does the rest.

Fig. 7-10 shows the sequence of operation during the five measurements. The display time (set by the front-panel control) should be long enough to allow the programmer to shift and the typewriter to tab.

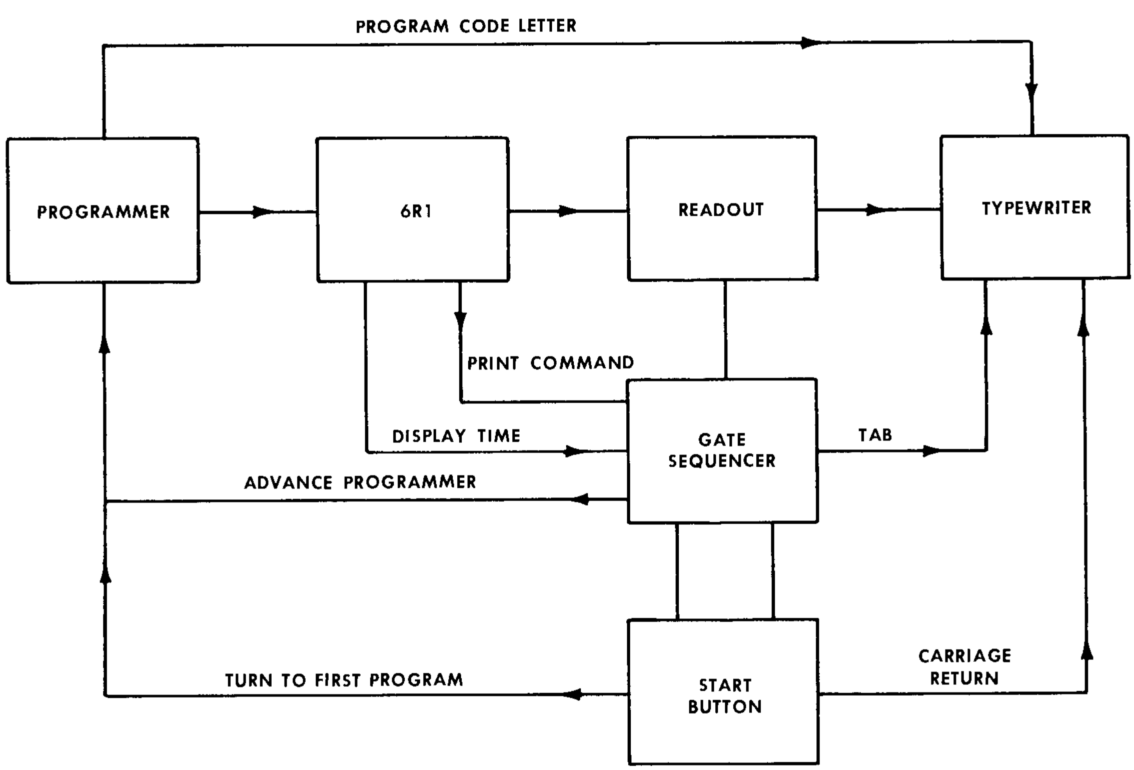

Fig. 7-9. Complete automatic programmer and readout.

Go-No-Go Limits

The complexity of an external no-go circuit depends on the degree of comparison needed. For example, in the test program outlined previously, the risetime was 52.02NS. If the acceptable limit was anything under 60NS, then only the "thousands" digit need be compared.

One comparator circuit like those in the Upper Limit No-Go board would do. The "thousands" staircase voltage from pin Y of J34 is connected to one input of the comparator while a voltage that represents the upper limit is connected to the other.

The voltage that is used to compare with the staircase will usually be different for each measurement. Because of this, contacts on the programmer should be used to supply this voltage. For example, the first program upper limit is 60NS, the second program 90NS, etc.

Since the test results are recorded by a typewriter, the red ribbon on the machine can be used to show an out of tolerance reading. The comparator is arranged to turn on a transistor whenever the staircase voltage exceeds the reference voltage. The turned-on transistor energizes a relay that, in turn, supplies voltage to the red ribbon solenoid of the typewriter. The print command voltage from the Type 6R1 can be used to enable the comparator.

If it is necessary to use greater resolution in the no-go comparison, the Upper and Lower Limit circuit boards can be removed from the instrument and installed in an external fixture.

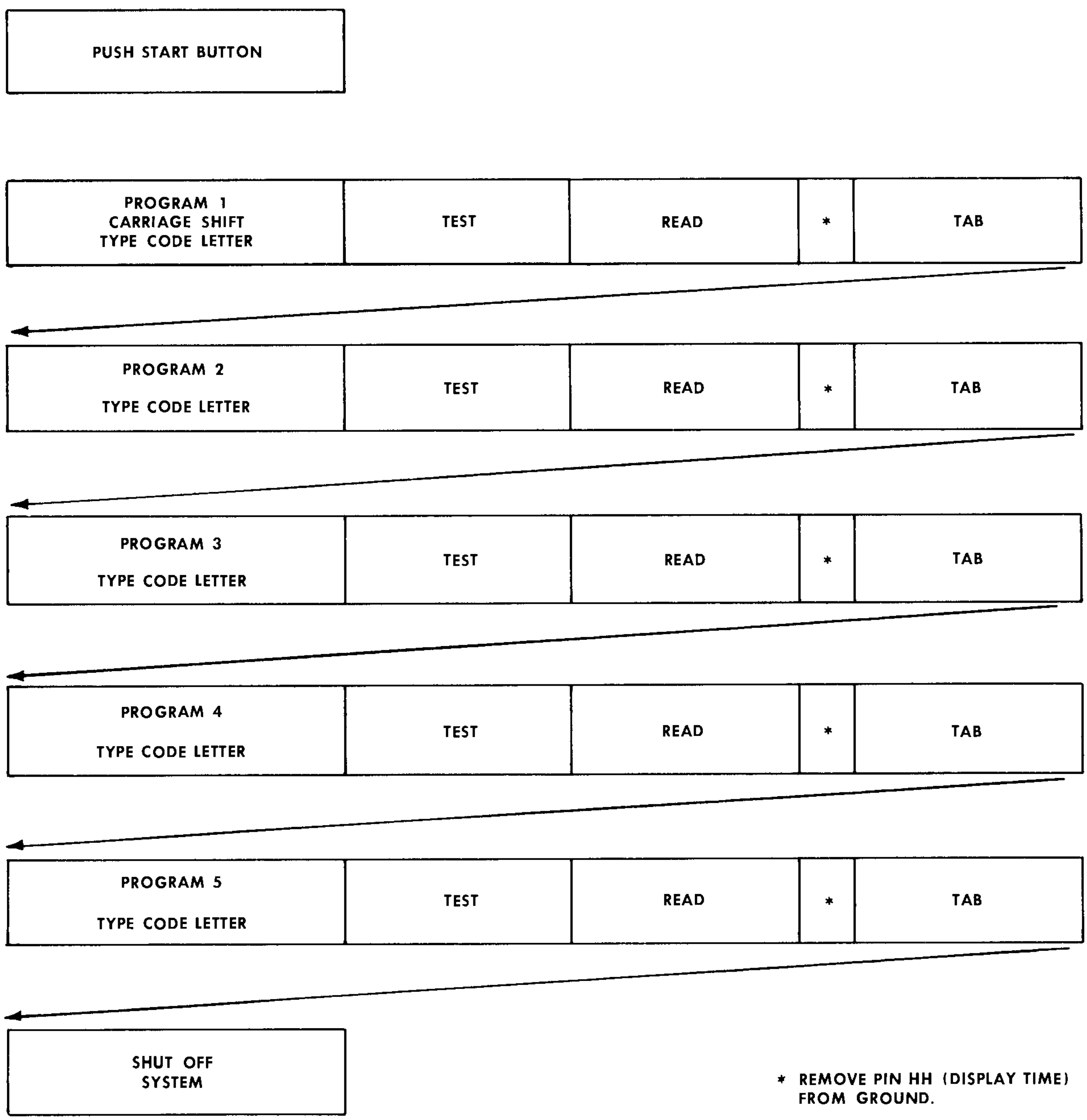

Fig. 7-10. Sequence of operation during automatic program and readout.

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SECTION 8
GLOSSARY

ALTERNATE TRACE	A method of dual-trace where a channel-A signal is displayed on the first sweep, a channel-B signal on the second sweep, channel A again on the third sweep, etc.
ANALOG DISPLAY	A crt display.
"AND" GATE	A circuit with two or more inputs and common output that produces an output signal only when all inputs are the same (positive or negative depending on the circuit arrangement).
BINARY SET	A bistable multivibrator used in counting and dividing. A single binary set divides by 2.
"BUCKET AND LADLE" CIRCUIT	A circuit where several pulses are required to charge a capacitor which switches a tunnel diode. Then, the same number of pulses of opposite polarity are needed to discharge the capacitor. The capacitor can be considered a "bucket" where the positive pulses are "ladled" in and the negative pulses "ladled" out.
CHOPPED TRACE	A method of dual-trace where the signals from two separate channels applied to the crt are switched at a high rate (100 kc, 250 kc, etc.).
CIRCUIT BOARDS	The etched boards with mounted components that plug into the Type 6R1 chassis.
CLOCK	The time pulses used to drive the counter circuits. In voltage measurements, clock pulses are obtained from a crystal oscillator on the voltmeter board. In time measurements, they are obtained from the horizontal plug-in unit.
CRT	The cathode-ray tube in the indicator unit.
DIFFERENTIAL AMPLIFIER	An amplifier that measures the difference between two voltages. The ability to resolve this difference is set by the common-mode rejection ratio of the amplifier.
DIGITAL	Quantities presented in regular rational numbers, such as 6.23 volts, 832.0 milliseconds, etc.
DIODE GATE	Four diodes arranged in a bridge network and quiescently back-biased. A positive and negative pulse across the bridge forward-biases the diodes and allows a sample to pass through.
DISPLAY TIME	The time that the readout remains steady between counts. The DISPLAY TIME control (front panel) varies this time from 0.1 second to 6 seconds.
÷ 10	A circuit consisting of 4 binary sets that extends the time between start and stop to allow 10 cumulative counts on the readout.
÷ 1, 2, 5	A circuit that uses several binary sets to divide the count and show a correct readout as either the VOLTS/DIV. or TIME/DIV. switch is changed.
DOUBLE-EMITTER FOLLOWER	A two-transistor circuit (PNP and NPN) with good switching characteristics when used with a capacitive load.
DUAL-TRACE	A method where two signals from two separate channels are displayed on the crt at the same time.
EXTERNAL PROGRAM	A feature of the Type 6R1 where the instrument can be controlled by external equipment or use external readouts. Or, both control and readout can be done externally. Two connectors on the rear of the chassis provide inputs and outputs for this purpose.
FIRST SLOPE	The first rise (+slope) or fall (—slope) of a waveform to the right of the 0% intensified zone.
FLOATING POWER SUPPLIES	A Zener diode and two transistors between the +125-volt and —100-volt supplies make up this supply. It is used across precision potentiometers to establish calibrated start and stop voltages.
GO-NO-GO	A clear-cut line of accept or reject. Refers to limits. Between limits, the item under test is "go". Outside the limits it is "no-go".
INTENSIFIED ZONES	Brightened portions of the crt display.
LOWER LIMIT	The number set on the LOWER LIMIT SET dials. When this number exceeds the number on the readout, the LOWER LIMIT lamp (yellow) lights.

MASTER GATE	An arrangement of 4 transistors where 3 must be turned off to allow the 4th to pass a signal. Also called an "And" gate.
MEMORY	A circuit that receives a voltage sample and holds the voltage level until the arrival of the next sample. A typical circuit is a sampling diode gate follower by a cathode follower with a large capacitor (1.0 μfd) in its grid circuit.
MID-ZONE	Any number between and including the numbers set on the UPPER and LOWER LIMIT SET dials.
MODE	The type of operation taking place. For example, voltage mode or time mode.
ONE SWEEP	The total count between the start and stop points during one sweep of the display.
OR GATE	A circuit with two or more inputs and a common output. Produces an output when any one of the inputs is activated.
PERCENTAGE OF A PULSE	If the start of a pulse is termed 0% and the peak amplitude represents 100%, the in-between points represent percentages of the pulse. For example, risetime is the time required for a pulse to rise from 10% to 90% of its maximum amplitude.
PLUG-IN	Any type unit designed to plug into or be withdrawn from an indicator unit or other housing. For example, the Type 6R1 is a plug-in designed to plug into the Tektronix Type 567 Readout Oscilloscope.
PROGRAM	Refers to the setting of the controls on the instrument. For example, one setting or program will measure risetime and another falltime.
READOUT	The five indicator tubes mounted across the top of the Type 6R1 front panel.
RESET PULSE	A pulse used to set the counters and divider circuits to the proper condition for the start of a measurement (for example, returning all numbers to zero).
RESOLUTION	The number of significant figures in the readout. HI resolution is the total of ten cumulative counts with the decimal point moved one place to the left.
SAMPLING SYSTEM	A method that takes amplitude samples from a repetitive input signal with each sample at a progressively later time, then reconstructs these samples into a replica of the original waveform at a much lower frequency.
START COMPARATOR	A circuit with two inputs. A reference level is applied to one and a varying signal to the other. Each time the signal equals the reference, the comparator delivers a pulse. Used to start the counter.
STAIRCASE VOLTAGE	A voltage from each counter circuit that represents the number stored in the counter.
STOP COMPARTOR	A circuit with two inputs. A reference level is applied to one and a varying signal to the other. Each time the signal equals the reference, the comparator delivers a pulse. Used to stop the counter.
SECOND SLOPE	The second rise (+slope) or fall (—slope) of a waveform to the right of the 0% intensified zone.
START BLOCK	A group of controls that set the point on the display where a measurement starts.
STOP BLOCK	A group of controls that set the point on the display where a measurement stops.
UNSCALED (MAX)	The total count between the start and stop zones. Not divided by the ÷ 1, 2, 5 board. Remains the same as the VOLTS/DIV. and TIME/DIV. switches are changed. Decimal-point and unit-of-measure indicator tubes are turned off.
UPPER LIMIT	The number set on the UPPER LIMIT SET dials. When this number is exceeded by the number on the readout, the UPPER LIMIT lamp (red) turns on.
VOLTMETER RAMP	A linear, precise sawtooth waveform used in voltage measurements.
0% ZONE	A point of measurement on a waveform; usually the lowest amplitude. Established by the sweep voltage and shown as an intensified zone at the extreme left side of the display.
100% ZONE	A point of measurement on a waveform; usually set to the highest amplitude of the waveform. Shows as an intensified zone that can be moved across the display by the 100% ZONE SET control.

SECTION 9

PARTS LIST AND SCHEMATICS

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.

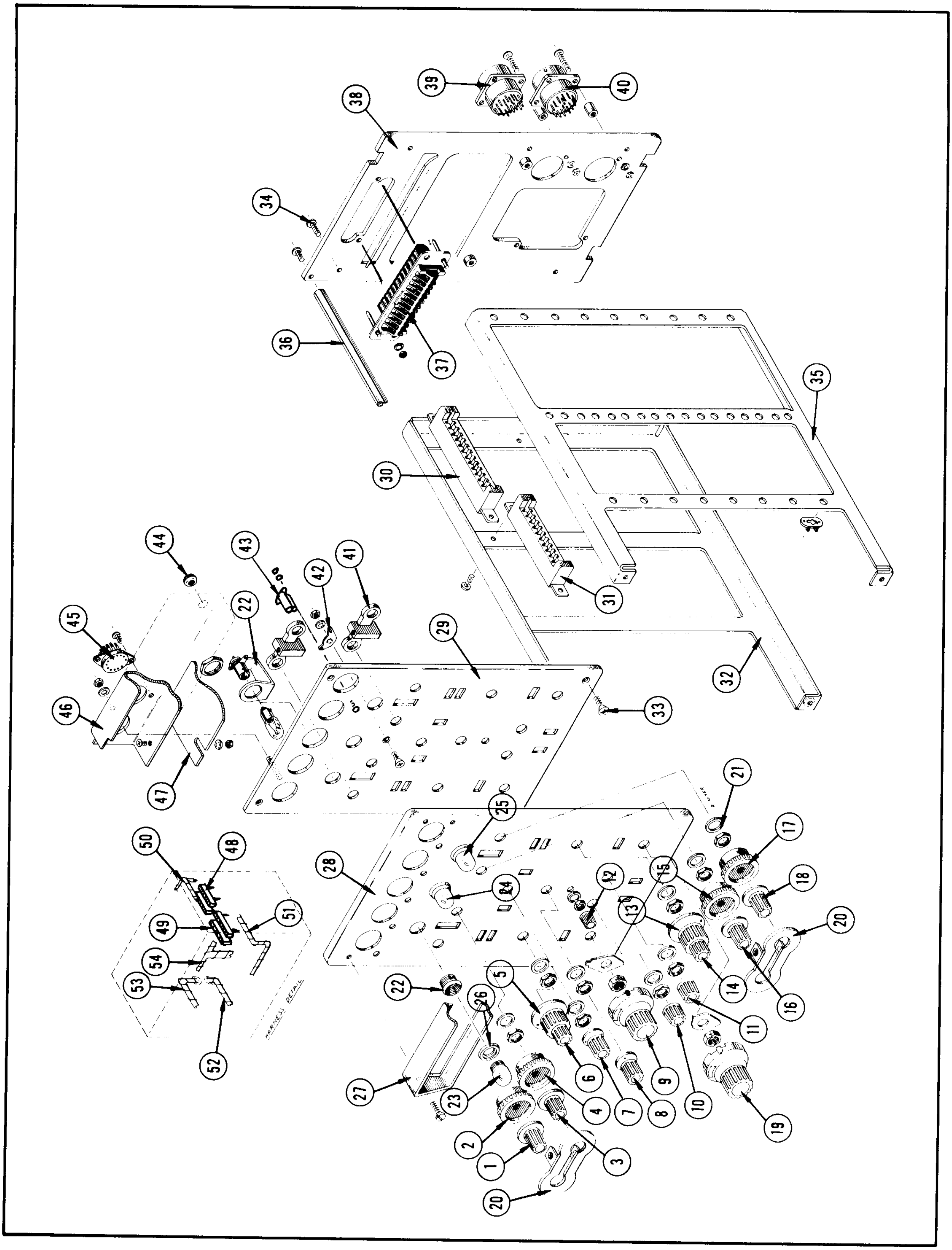
ABBREVIATIONS AND SYMBOLS

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.

MAIN GROUP



MAIN GROUP

REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
1	366-165			1	KNOB, LOWER LIMIT SET, charcoal small (left)
					Includes:
	213-004			1	SCREW, set, 6-32 x $^3/_{16}$ inch HSS
2	366-168			1	KNOB, LOWER LIMIT SET, charcoal large (left)
					Includes:
	213-004			1	SCREW, set, 6-32 x $^3/_{16}$ inch HSS
3	366-166			1	KNOB, LOWER LIMIT SET, charcoal small (right)
					Includes:
	213-004			1	SCREW, set, 6-32 x $^3/_{16}$ inch HSS
4	366-169			1	KNOB, LOWER LIMIT SET, charcoal large (right)
					Includes:
	213-004			1	SCREW, set, 6-32 x $^3/_{16}$ inch HSS
5	366-160			1	KNOB, TIMING START, charcoal
					Includes:
	213-004			1	SCREW, set, 6-32 x $^3/_{16}$ inch HSS
6	366-031			1	KNOB, MANUAL START, red
					Includes:
	213-004			1	SCREW, set, 6-32 x $^3/_{16}$ inch HSS
7	366-172			1	KNOB, MODE, charcoal
					Includes:
	213-004			1	SCREW, set, 6-32 x $^3/_{16}$ inch HSS
8	366-173			1	KNOB, RESOLUTION, charcoal
					Includes:
	213-004			1	SCREW, set, 6-32 x $^3/_{16}$ inch HSS
9	331-085			1	DIAL, with brake and charcoal knob, START VOLTAGE
10	366-148			1	KNOB, CRT DISPLAY "A", charcoal
					Includes:
	213-004			1	SCREW, set, 6-32 x $^3/_{16}$ inch HSS
11	366-148			1	KNOB, CRT DISPLAY "B", charcoal
					Includes:
	213-004			1	SCREW, set, 6-32 x $^3/_{16}$ inch HSS
12	366-153			1	KNOB, DISPLAY TIME, charcoal
					Includes:
	213-004			1	SCREW, set, 6-32 x $^3/_{16}$ inch HSS
13	366-160			1	KNOB, TIMING STOP, charcoal
					Includes:
	213-004			1	SCREW, set, 6-32 x $^3/_{16}$ inch HSS
14	366-031			1	KNOB, MANUAL STOP, red
					Includes:
	213-004			1	SCREW, set, 6-32 x $^3/_{16}$ inch HSS
15	366-168			1	KNOB, UPPER LIMIT SET, charcoal large (left)
					Includes:
	213-004			1	SCREW, set, 6-32 x $^3/_{16}$ inch HSS
16	366-165			1	KNOB, UPPER LIMIT SET, charcoal small (left)
					Includes:
	213-004			1	SCREW, set, 6-32 x $^3/_{16}$ inch HSS
17	366-169			1	KNOB, UPPER LIMIT SET, charcoal large (right)
					Includes:
	213-004			1	SCREW, set, 6-32 x $^3/_{16}$ inch HSS
18	366-166			1	KNOB, UPPER LIMIT SET, charcoal small (right)
					Includes:
	213-004			1	SCREW, set, 6-32 x $^3/_{16}$ inch HSS
19	331-085			1	DIAL, with brake and charcoal knob, STOP VOLTAGE
20	200-374			2	COVER, dial
					Mounting Hardware For Each: (not included)
	211-538			2	SCREW, 6-32 x $^5/_{16}$ inch FHS 100° CSK phillips
21	Pg 9-12				Switch Mounting Hardware
22	136-026			3	SOCKET, light
23	378-530			1	FILTER, light pilot yellow
24	378-531			1	FILTER, light pilot green

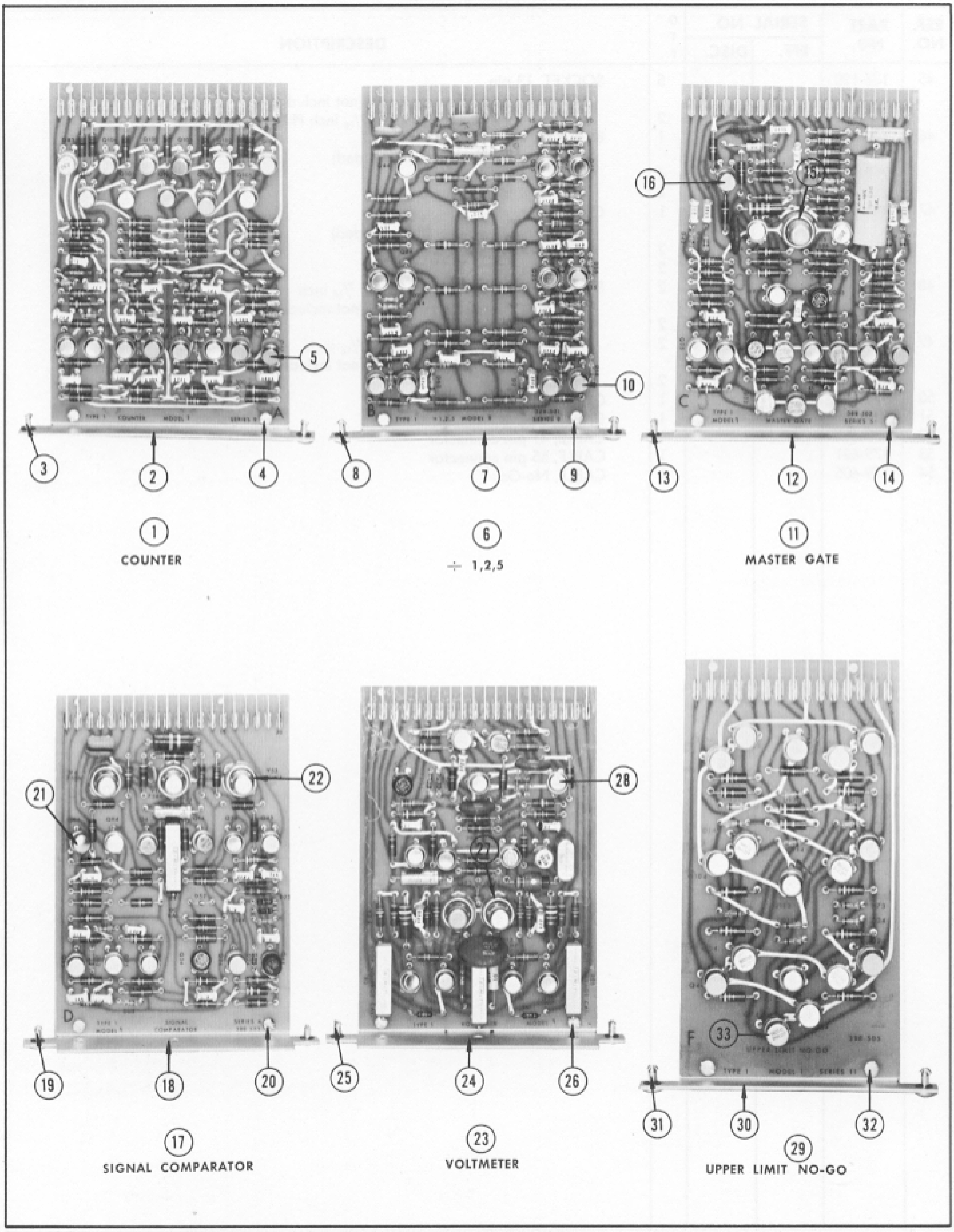
MAIN GROUP *(Cont'd)*

REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
25	378-529			1	FILTER, light pilot red
26	354-164			3	RING, pilot light
27	337-485			1	SHIELD, hood
	378-532			1	FILTER, polarized, light
					Mounting Hardware: (not included)
	211-014			3	SCREW, 4-40 x 1/2 inch BHS
28	333-697			1	PANEL, front
29	387-608			1	PLATE, subpanel
30	136-122			9	SOCKET, 20 pin
					Mounting Hardware For Each: (not included)
	213-044			2	SCREW, thread cutting, 5-32 x 3/16 inch Pan HS phillips
31	136-123			8	SOCKET, 15 pin
					Mounting Hardware For Each: (not included)
	213-044			2	SCREW, thread cutting, 5-32 x 3/16 inch Pan HS phillips
32	387-610			1	PLATE, left
					Mounting Hardware: (not included)
33	211-538			2	SCREW, 6-32 x 5/16 inch FHS 100° CSK phillips
34	211-507			3	SCREW, 6-32 x 5/16 inch BHS
35	387-609			1	PLATE, right
					Includes:
	214-205			34	RECEPTACLE, for turn fastener
					Mounting Hardware: (not included)
	211-538			2	SCREW, 6-32 x 5/16 inch FHS 100° CSK phillips
	211-507			3	SCREW, 6-32 x 5/16 inch BHS
36	384-566			2	ROD, frame spacing
					Mounting Hardware For Each: (not included)
	212-043			2	SCREW, 8-32 x 1/2 inch FHS 100° CSK phillips
	212-044			2	SCREW, 8-32 x 1/2 inch RHS phillips
37	131-149			2	CONNECTOR, chassis mount
					Mounting Hardware For Each: (not included)
	210-004			2	LOCKWASHER, int. #4
	210-201			2	LUG, solder
	210-406			2	NUT, hex, 4-40 x 3/16 inch
	211-011			2	SCREW, 4-40 x 5/16 inch BHS
38	387-607			1	PLATE, rear
39	131-212			1	CONNECTOR, 41 pin (included with 179-622)
					Mounting Hardware: (not included)
	166-107			4	TUBE, spacing
	210-004			2	LOCKWASHER, int. #4
	210-201			2	LUG, solder
	210-406			4	NUT, hex, 4-40 x 3/16 inch
	211-016			4	SCREW, 4-40 x 5/8 inch BHS
40	131-213			1	CONNECTOR, 55 pin (included with 179-621)
					Mounting Hardware: (not included)
	166-107			4	TUBE, spacing
	210-004			4	LOCKWASHER, int. #4
	210-406			4	NUT, hex, 4-40 x 3/16 inch
	211-016			4	SCREW, 4-40 x 5/8 inch BHS
41	406-757			2	BRACKET, spacer switch
42	210-207			1	LUG, solder
					Mounting Hardware: (not included)
	210-406			1	NUT, hex, 6-32 x 1/4 inch
	211-538			5	SCREW, 6-32 x 5/16 inch FHS 100° CSK phillips
43	352-038			5	HOLDER, single, neon
					Mounting Hardware For Each: (not included)
	210-004			1	LOCKWASHER, int. #4
	210-406			1	NUT, hex, 4-40 x 3/16 inch
	211-086			1	SCREW, 4-40 x 3/4 inch FHS 100° CSK phillips
44	348-003			1	GROMMET, rubber 5/16 inch

MAIN GROUP *(Cont'd)*

REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
45	136-120			5	SOCKET, 13 pin
					Mounting Hardware For Each: (not included)
	213-044			2	SCREW, thread cutting 5-32 x $^{3}/_{16}$ inch PHS phillips
46	406-761			1	BRACKET, alum.
					Mounting Hardware: (not included)
	210-006			4	LOCKWASHER, int. #6
	210-407			4	NUT, hex, 6-32 x $^{1}/_{4}$ inch
47	441-417			1	CHASSIS, No-Go
					Mounting Hardware: (not included)
	210-006			2	LOCKWASHER, int. #6
	210-407			2	NUT, hex, 6-32 x $^{1}/_{4}$ inch
48	124-146			2	STRIP, ceramic, 16 notches, $2^{7}/_{16}$ x $^{7}/_{16}$ inch
					Mounting Hardware For Each: (not included)
	361-007			2	SPACER, nylon
49	124-145			2	STRIP, ceramic, 20 notches, 3 x $^{7}/_{16}$ inch
					Mounting Hardware For Each: (not included)
	361-007			2	SPACER, nylon
50	179-606			1	CABLE, neon
51	179-610			1	CABLE, Stop-Start
52	179-622			1	CABLE, 41 pin connector
53	179-621			1	CABLE, 55 pin connector
54	179-605			1	CABLE, No-Go

CIRCUIT BOARDS



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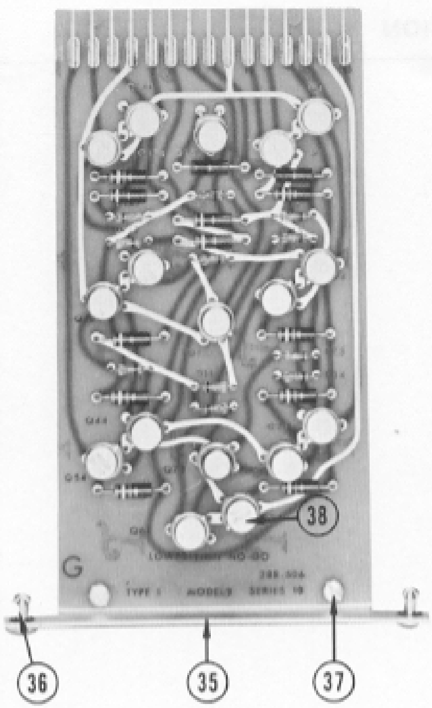
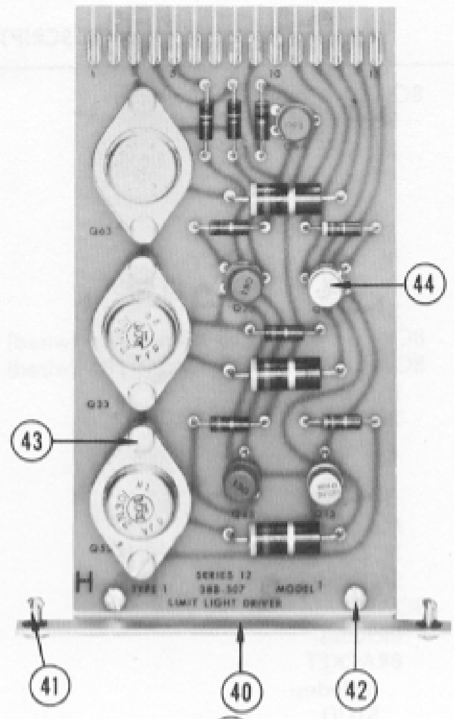
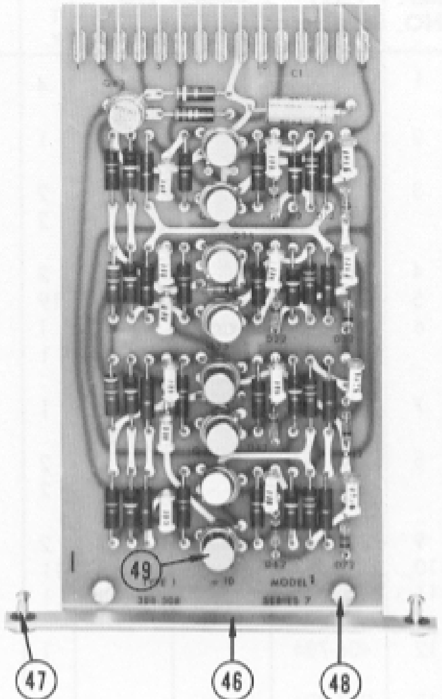
CIRCUIT BOARDS



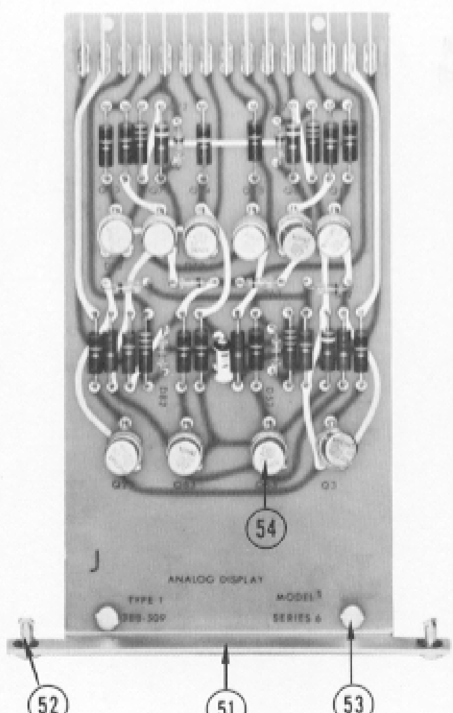
34
LOWER LIMIT NO-GO



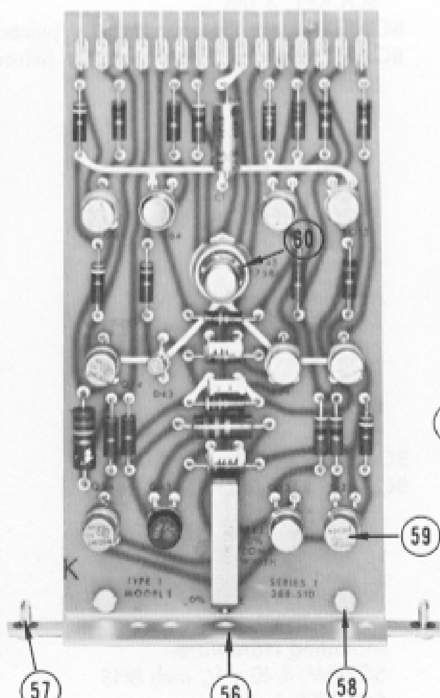
39
LIMIT LIGHT DRIVER



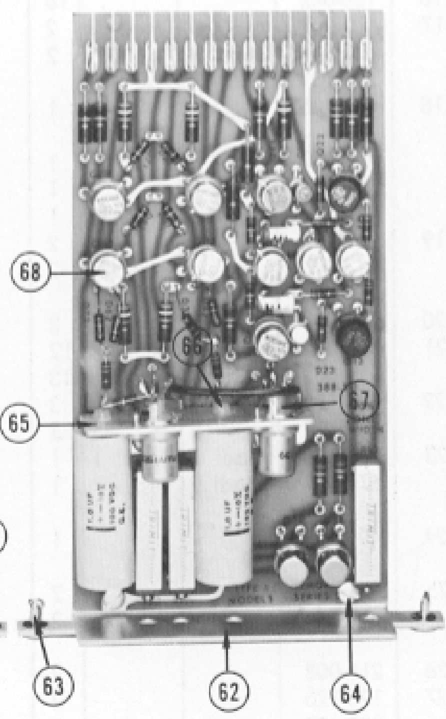
45
÷ 10



50
ANALOG DISPLAY



55
0% ZONE



61
MEMORY

CIRCUIT BOARDS

REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
1	670-004			4	BOARD, Counter /A/ (wired)
					Each Includes:
2	406-782			1	BRACKET
					Includes:
3	214-204			2	STUD
	214-206			2	RETAINER
					Mounting Hardware:
4	211-008			2	SCREW, 4-40 x 1/4 inch BHS
5	136-062			19	SOCKET, 4 pin
6	670-007	Modl 1	Modl 1	1	BOARD, ÷ 1, 2, 5 Circuit /B/ (wired)
	670-022	Modl 2		1	BOARD, ÷ 1, 2, 5 Circuit /B/ (wired)
					Includes:
7	406-783			1	BRACKET
					Includes:
8	214-204			2	STUD
	214-206			2	RETAINER
					Mounting Hardware:
9	211-008			2	SCREW, 4-40 x 1/4 inch BHS
10	136-062			11	SOCKET, 4 pin
11	670-009			1	BOARD, Master Gate /C/ (wired)
					Includes:
12	406-784			1	BRACKET
					Includes:
13	214-204			2	STUD
	214-206			2	RETAINER
					Mounting Hardware:
14	211-008			2	SCREW, 4-40 x 1/4 inch BHS
15	136-125			1	SOCKET, 5 pin
	387-603			1	PLATE, insulating
16	136-062			16	SOCKET, 4 pin
17	670-003	Modl 1	Modl 3	2	BOARD, Signal Comparator /D/ (wired)
	670-020	Modl 4		2	BOARD, Signal Comparator /D/ (wired)
					Each Includes:
18	406-785			1	BRACKET
					Includes:
	131-252	Modl 3		1	CONNECTOR, orange
	131-253	Modl 3		1	CONNECTOR, yellow
	131-255	Modl 3		1	CONNECTOR, blue
19	214-204			2	STUD
	214-206			2	RETAINER
					Mounting Hardware:
20	211-008			2	SCREW, 4-40 x 1/4 inch BHS
21	136-062	Modl 1-2		12	SOCKET, 4 pin
	136-062	Modl 3		13	SOCKET, 4 pin
22	136-125			3	SOCKET, 5 pin
	387-603			3	PLATE, insulating
23	670-002	Modl 1	Modl 1	1	BOARD, Voltmeter /E/ (wired)
	670-021	Modl 2		1	BOARD, Voltmeter /E/ (wired)
					Includes:
24	406-786			1	BRACKET
					Includes:
25	214-204			2	STUD
	214-206			2	RETAINER
					Mounting Hardware:
26	211-008			2	SCREW, 4-40 x 1/4 inch BHS
27	136-125			2	SOCKET, 5 pin
	387-603			2	PLATE, insulating
28	136-062			13	SOCKET, 4 pin

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CIRCUIT BOARDS *(Cont'd)*

REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
29	670-011			1	BOARD, Upper Limit No-Go /F/ (wired)
					Includes:
30	406-787			1	BRACKET
					Includes:
31	214-204			2	STUD
	214-206			2	RETAINER
					Mounting Hardware:
32	211-008			2	SCREW, 4-40 x $\frac{1}{4}$ inch BHS
33	136-062			17	SOCKET, 4 pin
34	670-010			1	BOARD, Lower Limit No-Go /G/ (wired)
					Includes:
35	406-788			1	BRACKET
					Includes:
36	214-204			2	STUD
	214-206			2	RETAINER
					Mounting Hardware:
37	211-008			2	SCREW, 4-40 x $\frac{1}{4}$ inch BHS
38	136-062			17	SOCKET, 4 pin
39	670-008			1	BOARD, Limit Light Driver /H/ (wired)
					Includes:
40	406-789			1	BRACKET
					Includes:
41	214-204			2	STUD
	214-206			2	RETAINER
					Mounting Hardware:
42	211-008			2	SCREW, 4-40 x $\frac{1}{4}$ inch BHS
43	......			..	Diode Mounting Hardware For Each:
	166-031			2	TUBE, spacer
	210-006			2	LOCKWASHER, int. #6
	210-407			2	NUT, hex, 6-32 x $\frac{1}{4}$ inch
	211-513			2	SCREW, 6-32 x $\frac{5}{8}$ inch BHS
44	136-062			5	SOCKET, 4 pin
45	670-001			1	BOARD, $\div$ 10 /I/ (wired)
					Includes:
46	406-790			1	BRACKET
					Includes:
47	214-204			2	STUD
	214-206			2	RETAINER
					Mounting Hardware:
48	211-008			2	SCREW, 4-40 x $\frac{1}{4}$ inch BHS
49	136-062			9	SOCKET, 4 pin
50	670-005			1	BOARD, Analog Display /J/ (wired)
					Includes:
51	406-791			1	BRACKET
					Includes:
52	214-204			2	STUD
	214-206			2	RETAINER
					Mounting Hardware:
53	211-008			2	SCREW, 4-40 x $\frac{1}{4}$ inch BHS
54	136-062			10	SOCKET, 4 pin
55	670-012			1	BOARD, 0% Zone /K/ (wired)
					Includes:
56	406-792			1	BRACKET
					Includes:
57	214-204			2	STUD
	214-206			2	RETAINER
					Mounting Hardware:
58	211-008			2	SCREW, 4-40 x $\frac{1}{4}$ inch BHS
59	136-062			11	SOCKET, 4 pin
60	136-125			1	SOCKET, 5 pin
	387-603			1	PLATE, insulating

CIRCUIT BOARDS *(Cont'd)*

REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
61	670-006			2	BOARD, Memory /L/ (wired)
					Each Includes:
62	406-793			1	BRACKET
					Includes:
	131-251	Modl 4		1	CONNECTOR, red
	131-254	Modl 4		1	CONNECTOR, green
63	214-204			2	STUD
	214-206			2	RETAINER
					Mounting Hardware:
64	211-008			2	SCREW, 4-40 x 1/4 inch BHS
65	406-760			1	BRACKET
					Mounting Hardware:
	210-004			2	LOCKWASHER, int. #4
	214-406			2	NUT, hex, 4-40 x 3/16 inch
	211-008			2	SCREW, 4-40 x 1/4 inch BHS
66	348-031			2	GROMMET, snap-in
67	136-101			2	SOCKET, 5 pin
					Mounting Hardware For Each:
	213-055			2	SCREW, thread cutting, 2-56 x 3/16 inch PHS phillips
68	136-062			13	SOCKET, 4 pin

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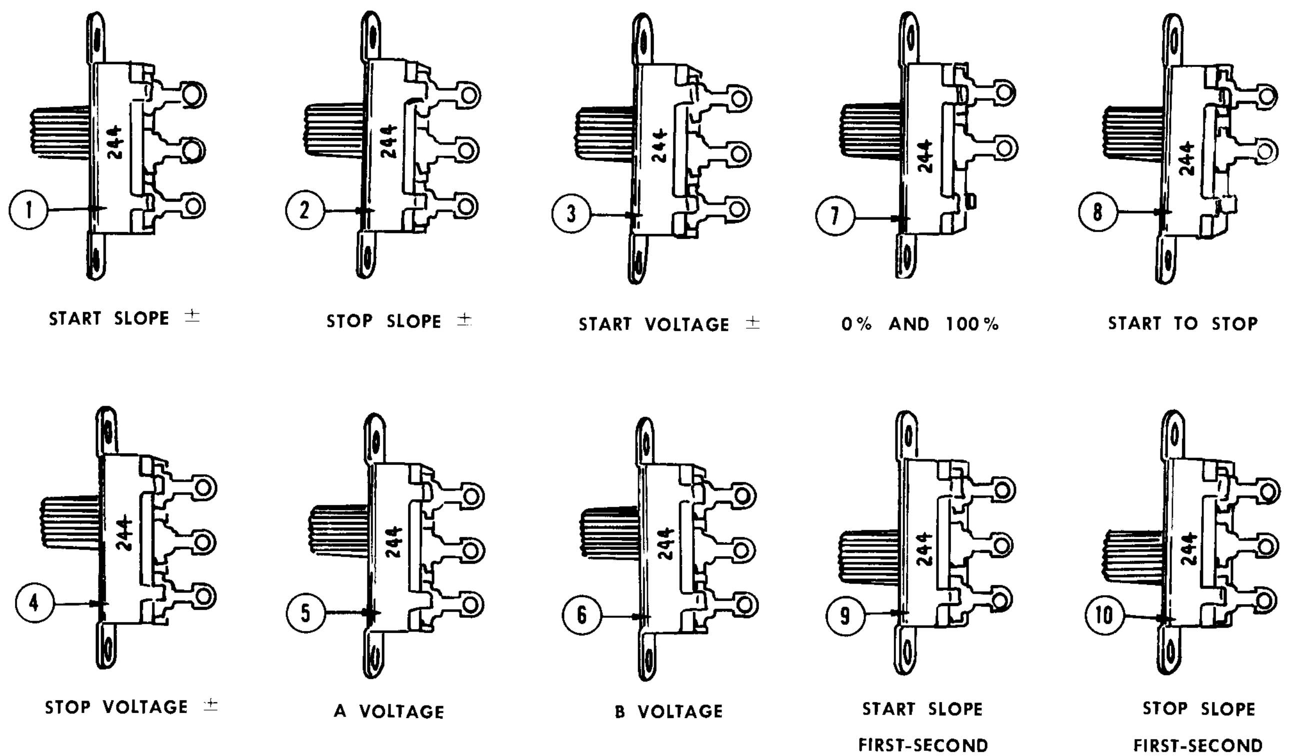
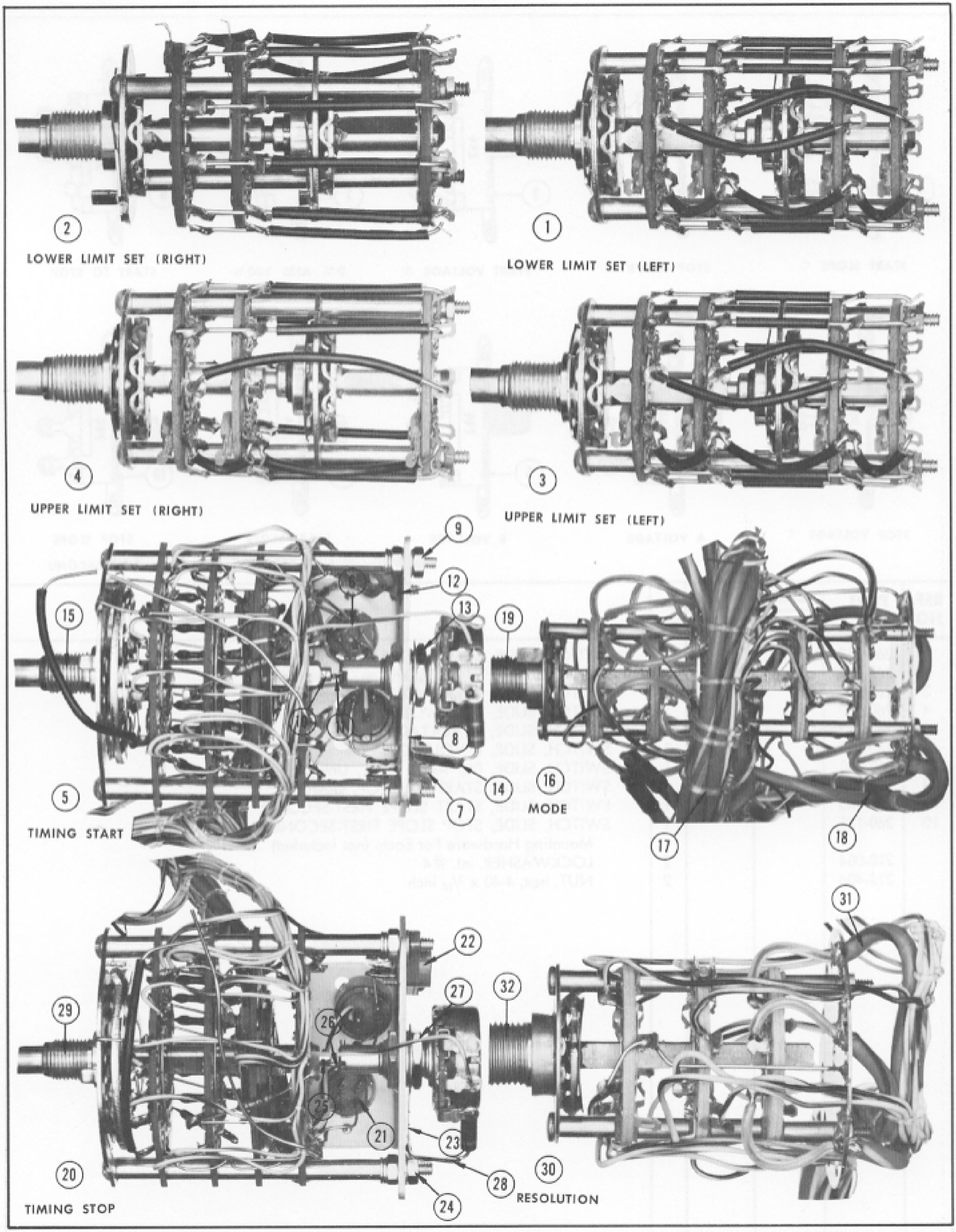
SWITCHES



REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
1	260-212			1	SWITCH, SLIDE, START SLOPE ±, Unwired
2	260-212			1	SWITCH, SLIDE, STOP SLOPE ±, Unwired
3	260-212			1	SWITCH, SLIDE, START VOLTAGE ±, Unwired
4	260-212			1	SWITCH, SLIDE, STOP VOLTAGE ±, Unwired
5	260-212			1	SWITCH, SLIDE, A VOLTAGE, Unwired
6	260-212			1	SWITCH, SLIDE, B VOLTAGE, Unwired
7	260-330			1	SWITCH, SLIDE, 0% AND 100%, Unwired
8	260-330			1	SWITCH, SLIDE, START TO STOP, Unwired
9	260-145			1	SWITCH, SLIDE, START SLOPE FIRST-SECOND, Unwired
10	260-145			1	SWITCH, SLIDE, STOP SLOPE FIRST-SECOND, Unwired
					Mounting Hardware For Each: (not included)
	210-004			2	LOCKWASHER, int. #4
	210-406			2	NUT, hex, 4-40 x $^{3}/_{16}$ inch

SWITCHES


2
LOWER LIMIT SET (RIGHT)
1
LOWER LIMIT SET (LEFT)
4
UPPER LIMIT SET (RIGHT)
3
UPPER LIMIT SET (LEFT)
9
12
13
15
19
8
14
5
TIMING START
16
MODE
7
17
18
31
22
27
32
29
26
25
21
23
20
TIMING STOP
28
24
30
RESOLUTION

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SWITCHES *(Cont'd)*

REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
1	262-458			1	SWITCH, LOWER LIMIT SET (left), wired
					Includes:
	260-417			1	SWITCH, LOWER LIMIT SET (left), unwired
					Mounting Hardware: (not included)
	210-012			1	LOCKWASHER, int. 3/8 x 1/2 inch
	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
	210-840			1	WASHER, .390 ID x 9/16 OD
2	262-461			1	SWITCH, LOWER LIMIT SET (right), wired
					Includes:
	260-418			1	SWITCH, LOWER LIMIT SET (right), unwired
					Mounting Hardware: (not included)
	210-012			1	LOCKWASHER, int. 3/8 x 1/2 inch
	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
	210-840			1	WASHER, .390 ID x 9/16 OD
3	262-458			1	SWITCH, UPPER LIMIT SET (left), wired
					Includes:
	260-417			1	SWITCH, UPPER LIMIT SET (left), unwired
					Mounting Hardware: (not included)
	210-012			1	LOCKWASHER, int. 3/8 x 1/2 inch
	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
	210-840			1	WASHER, .390 ID x 9/16 OD
4	262-459			1	SWITCH, UPPER LIMIT SET (right), wired
					Includes:
	260-418			1	SWITCH, UPPER LIMIT SET (right), unwired
					Mounting Hardware: (not included)
	210-012			1	LOCKWASHER, int. 3/8 x 1/2 inch
	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
	210-840			1	WASHER, .390 ID x 9/16 OD
5	262-455			1	SWITCH, TIMING START, wired
					Includes:
6	136-101			1	SOCKET, 5 pin
					Mounting Hardware:
	213-055			2	SCREW, thread cutting, 2-56 x 3/16 inch PHS phillips
7	136-095			1	SOCKET, 4 pin
					Mounting Hardware:
	211-057			2	SCREW, thread cutting, 2-56 x 5/16 inch RHS phillips
8	406-759			1	BRACKET, switch, left
					Mounting Hardware:
9	210-006			2	LOCKWASHER, int. #6
	210-406			2	NUT, hex, 6-32 x 1/4 inch
10	384-077			1	ROD, extension
					Mounting Hardware:
11	376-014			1	COUPLING, wire, steel
12	210-202			1	LUG, solder,
					Mounting Hardware:
	213-044			1	SCREW, thread cutting, 5-32 x 5/16 inch PHS phillips
13	210-012			1	LOCKWASHER, int. 3/8 x 1/2 inch
	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
14	210-207			1	LUG, solder, 3/8 inch
15	260-419			1	SWITCH, TIMING START, unwired
					Mounting Hardware: (not included)
	210-012			1	LOCKWASHER, int. 3/8-32 x 1/2 inch
	210-413			1	NUT, hex, 3/8 x 1/2 inch
	210-840			1	WASHER, .390 ID x 9/16 OD
16	262-457			1	SWITCH, MODE, wired
					Includes:
17	179-607			1	CABLE harness, MODE switch
18	179-608			1	CABLE harness, MODE A VOLTS switch

SWITCHES *(Cont'd)*

REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
19	260-420			1	SWITCH, MODE, unwired
					Mounting Hardware: (not included)
	210-012			1	LOCKWASHER, int. 3/8 x 1/2 inch
	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
	210-840			1	WASHER, .390 ID x 9/16 OD
20	262-454			1	SWITCH, TIMING STOP, wired
					Includes:
21	136-101			1	SOCKET, 5 pin
					Mounting Hardware:
	213-055			2	SCREW, thread cutting, 2-56 x 3/16 inch PHS phillips
22	136-095			1	SOCKET, 4 pin
					Mounting Hardware:
	211-057			2	SCREW, thread cutting, 2-56 x 5/16 inch RHS
23	406-759			1	BRACKET, switch, right
					Mounting Hardware:
24	210-006			2	LOCKWASHER, int. 3/8 x 1/2 inch
	210-406			2	NUT, hex, 6-32 x 1/4 inch
25	384-077			1	ROD, extension
					Mounting Hardware:
26	376-014			1	COUPLING, wire steel
27	210-012			1	LOCKWASHER, int. 3/8 x 1/2 inch
	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
28	210-207			1	LUG, solder, 3/8 inch
29	260-419			1	SWITCH, TIMING STOP, unwired
					Mounting Hardware: (not included)
	210-012			1	LOCKWASHER, int. 3/8 x 1/2 inch
	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
	210-840			1	WASHER, .390 ID x 9/16 OD
30	262-456			1	SWITCH, RESOLUTION, wired
					Includes:
31	179-609			1	CABLE harness, RESOLUTION switch
32	260-421			1	SWITCH, RESOLUTION, unwired
					Mounting Hardware: (not included)
	210-012			1	LOCKWASHER, int. 3/8 x 1/2 inch
	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
	210-840			1	WASHER, .390 ID x 9/16 OD

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ELECTRICAL PARTS

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Description			S/N Range
		Bulbs			
B361	150-025	Neon, NE-2E			
B362	150-025	Neon, NE-2E			
B363	150-025	Neon, NE-2E			
B364	150-025	Neon, NE-2E			
B365	150-025	Neon, NE-2E			
B560	150-001	Incandescent, #47		UPPER LIMIT	
B561	150-001	Incandescent, #47		MID-ZONE	
B562	150-001	Incandescent, #47		LOWER LIMIT	

Capacitors

Tolerance ±20% unless otherwise indicated.

Tolerance of electrolytic capacitors as follows (with exceptions):

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

C440	281-525	470 pf	Cer.	500 v	101-439X
C490	281-525	470 pf	Cer.	500 v	101-439X
C550	290-162	22 μf	EMT	35 v	
C552	290-162	22 μf	EMT	35 v	
C554	290-162	22 μf	EMT	35 v	
C556	290-162	22 μf	EMT	35 v	
C575	283-003	.01 μf	Disc Type	150 v	X450-up
C585	283-003	.01 μf	Disc Type	150 v	X450-up

Diodes

D443	152-008	Germanium T12G
D493	152-008	Germanium T12G

Resistors

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

R360	301-474	470 k	½ w	5%
R361	316-105	1 meg	¼ w	
R362	316-105	1 meg	¼ w	
R363	316-105	1 meg	¼ w	
R364	316-105	1 meg	¼ w	

Resistors *(Cont'd.)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
R365	316-105	1 meg	¼ w				
R370	301-823	82 k	½ w			5%	
R372	301-823	82 k	½ w			5%	
R374	301-823	82 k	½ w			5%	
R376	301-823	82 k	½ w			5%	
R381	301-154	150 k	½ w			5%	
R382	301-154	150 k	½ w			5%	
R383	301-154	150 k	½ w			5%	
R384	301-154	150 k	½ w			5%	
R385	301-154	150 k	½ w			5%	
R386	301-154	150 k	½ w			5%	
R410	301-623	62 k	½ w			5%	
R411	311-224	50 k		Var.		MANUAL START	
R412	301-562	5.6 k	½ w			5%	
R420	318-012	25 k	⅛ w		Prec.	1%	
R421	318-012	25 k	⅛ w		Prec.	1%	
R422	318-102	17.4 k	⅛ w		Prec.	1%	
R423	318-101	57.6 k	⅛ w		Prec.	1%	
R424	318-101	57.6 k	⅛ w		Prec.	1%	
R425	318-102	17.4 k	⅛ w		Prec.	1%	
R426	318-012	25 k	⅛ w		Prec.	1%	
R427	318-012	25 k	⅛ w		Prec.	1%	
R429	318-032	250 k	⅛ w		Prec.	1%	
R430	Use 311-318	30 k		Var.	WW	START VOLTAGE	
R443	311-095	500 Ω		Var.		B SIG. DC LEVEL	
R448	301-333	33 k	½ w			5%	
R460	301-623	62 k	½ w			5%	
R461	311-224	50 k		Var.		MANUAL STOP	
R462	301-562	5.6 k	½ w			5%	
R470	318-012	25 k	⅛ w		Prec.	1%	
R471	318-012	25 k	⅛ w		Prec.	1%	
R472	318-102	17.4 k	⅛ w		Prec.	1%	
R473	318-101	57.6 k	⅛ w		Prec.	1%	
R474	318-101	57.6 k	⅛ w		Prec.	1%	
R475	318-102	17.4 k	⅛ w		Prec.	1%	
R476	318-012	25 k	⅛ w		Prec.	1%	
R477	318-012	25 k	⅛ w		Prec.	1%	
R479	318-032	250 k	⅛ w		Prec.	1%	
R480	Use 311-318	30 k		Var.	WW	STOP VOLTAGE	
R493	311-095	500 Ω		Var.		A SIG. DC LEVEL	
R498	301-333	33 k	½ w			5%	
R500	318-040	100 Ω	⅛ w		Prec.	1%	
R501	318-040	100 Ω	⅛ w		Prec.	1%	
R502	318-040	100 Ω	⅛ w		Prec.	1%	
R503	318-040	100 Ω	⅛ w		Prec.	1%	

Resistors *(Cont'd.)*

Ckt. No.	Tektronix Part No.	Description				S/N Range
R504	318-040	100 Ω	1/8 w		Prec.	1%
R505	318-040	100 Ω	1/8 w		Prec.	1%
R506	318-040	100 Ω	1/8 w		Prec.	1%
R507	318-040	100 Ω	1/8 w		Prec.	1%
R508	318-040	100 Ω	1/8 w		Prec.	1%
R509	318-040	100 Ω	1/8 w		Prec.	1%
R510	309-366	173.4 Ω	1/2 w		Prec.	1%
R550	307-060	6.8 Ω	1/2 w			5%
R552	307-060	6.8 Ω	1/2 w			5%
R554	307-060	6.8 Ω	1/2 w			5%
R556	307-060	6.8 Ω	1/2 w			5%
R570	301-392	3.9 k	1/2 w			5%
R571	301-183	18 k	1/2 w			5%
R572	311-075	5 meg	.2 w	Var.		DISPLAY TIME
R575	301-203	20 k	1/2 w			5%
R576	311-026	100 k		Var.		B 100% ZONE SET
R585	301-203	20 k	1/2 w			5%
R586	311-026	100 k		Var.		A 100% ZONE SET

Switches

	Unwired	Wired		
SW310	260-330		Slide	0% and 100%
SW311	260-330		Slide	START TO STOP
SW320	*260-420	*262-457	Rotary	MODE
SW330	260-212		Slide	START SLOPE (±)
SW331	260-145		Slide	START SLOPE (FIRST-SECOND)
SW340	260-212		Slide	STOP SLOPE (±)
SW341	260-145		Slide	STOP SLOPE (FIRST-SECOND)
SW350	260-212		Slide	A VOLTAGE
SW351	260-212		Slide	B VOLTAGE
SW360	*260-421	*262-456	Rotary	RESOLUTION
SW430	260-212		Slide	START VOLTAGE
SW440	*260-419	*262-455	Rotary	TIMING START
SW480	260-212		Slide	STOP VOLTAGE
SW490	*260-419	*262-454	Rotary	TIMING STOP
SW500A & B	*260-417	*262-458	Rotary	LOWER LIMIT SET (Left)
SW502A & B	*260-418	*262-461	Rotary	LOWER LIMIT SET (Right)
SW504A & B	*260-417	*262-458	Rotary	UPPER LIMIT SET (Left)
SW506A & B	*260-418	*262-459	Rotary	UPPER LIMIT SET (Right)

Transistors

Ckt. No.	Tektronix Part No.	Description	S/N Range
Q448	*151-059	Tek Spec.	
Q498	*151-059	Tek Spec.	

Electron Tubes

V370	154-326	B5094	
V371	154-327	B5092	
V372	154-327	B5092	
V373	154-327	B5092	
V374	154-327	B5092	
V443	154-323	6CW4	
V493	154-323	6CW4	

Counter Board (4) Location A

Ckt. No.	Tektronix Part No.	Description				Model No.

Capacitors

	670-004	Complete Board				
C2	281-549	68 pf	Cer.	500 v	10%	
C6	281-523	100 pf	Cer.	350 v		
C16	281-523	100 pf	Cer.	350 v		
C22	281-518	47 pf	Cer.	500 v		
C26	281-523	100 pf	Cer.	350 v		
C36	281-523	100 pf	Cer.	350 v		
C38	281-524	150 pf	Cer.	500 v		
C42	281-518	47 pf	Cer.	500 v		
C46	281-523	100 pf	Cer.	350 v		
C56	281-523	100 pf	Cer.	350 v		
C58	281-524	150 pf	Cer.	500 v		
C62	281-518	47 pf	Cer.	500 v		
C66	281-523	100 pf	Cer.	350 v		
C76	281-523	100 pf	Cer.	350 v		

Diodes

D2	*152-075	Germanium 6075	
D12	*152-075	Germanium 6075	
D22	*152-075	Germanium 6075	
D32	*152-075	Germanium 6075	
D38	*152-075	Germanium 6075	
D42	*152-075	Germanium 6075	
D52	*152-075	Germanium 6075	
D58	*152-075	Germanium 6075	
D62	*152-075	Germanium 6075	
D72	*152-075	Germanium 6075	

Resistors

Ckt. No.	Tektronix Part No.		Description			Model No.
R2	301-563	56 k	½ w		5%	
R3	309-444	200 k	½ w	Prec.	1%	
R5	301-222	2.2 k	½ w		5%	
R6	301-153	15 k	½ w		5%	
R7	301-154	150 k	½ w		5%	
R15	301-222	2.2 k	½ w		5%	
R16	301-153	15 k	½ w		5%	
R17	301-154	150 k	½ w		5%	
R22	301-563	56 k	½ w		5%	
R23	Use 309-260	100 k	½ w	Prec.	1%	
R24	301-432	4.3 k	½ w		5%	
R25	301-432	4.3 k	½ w		5%	
R26	301-153	15 k	½ w		5%	
R27	301-154	150 k	½ w		5%	
R34	301-432	4.3 k	½ w		5%	
R35	301-432	4.3 k	½ w		5%	
R36	301-153	15 k	½ w		5%	
R37	301-154	150 k	½ w		5%	
R38	301-223	22 k	½ w		5%	
R39	301-473	47 k	½ w		5%	
R42	301-563	56 k	½ w		5%	
R43	Use 309-260	100 k	½ w	Prec.	1%	
R44	301-432	4.3 k	½ w		5%	
R45	301-432	4.3 k	½ w		5%	
R46	301-153	15 k	½ w		5%	
R47	301-154	150 k	½ w		5%	
R54	301-432	4.3 k	½ w		5%	
R55	301-432	4.3 k	½ w		5%	
R56	301-153	15 k	½ w		5%	
R57	301-154	150 k	½ w		5%	
R58	301-223	22 k	½ w		5%	
R59	301-473	47 k	½ w		5%	
R62	301-563	56 k	½ w		5%	
R63	Use 309-389	50 k	½ w	Prec.	1%	
R64	301-432	4.3 k	½ w		5%	
R65	301-432	4.3 k	½ w		5%	
R66	301-153	15 k	½ w		5%	
R67	301-154	150 k	½ w		5%	
R74	301-432	4.3 k	½ w		5%	
R75	301-432	4.3 k	½ w		5%	
R76	301-153	15 k	½ w		5%	
R77	301-154	150 k	½ w		5%	
R81	301-474	470 k	½ w		5%	
R83	301-104	100 k	½ w		5%	
R100	301-151	150 Ω	½ w		5%	

Resistors *(Cont'd.)*

Ckt. No.	Tektronix Part No.	Description			Model No.
R102	301-151	150 Ω	½ w	5%	
R104	301-151	150 Ω	½ w	5%	
R106	301-151	150 Ω	½ w	5%	
R108	301-151	150 Ω	½ w	5%	
R109	301-750	75 Ω	½ w	5%	
R110	301-750	75 Ω	½ w	5%	

Transistors

Q5	*151-054	2N1754
Q15	*151-054	2N1754
Q25	*151-054	2N1754
Q35	*151-054	2N1754
Q45	*151-054	2N1754
Q55	*151-054	2N1754
Q65	*151-054	2N1754
Q75	*151-054	2N1754
Q83	Use *153-520	2N404
Q100	*151-059	Tek Spec.
Q101	*151-059	Tek Spec.
Q102	*151-059	Tek Spec.
Q103	*151-059	Tek Spec.
Q104	*151-059	Tek Spec.
Q105	*151-059	Tek Spec.
Q106	*151-059	Tek Spec.
Q107	*151-059	Tek Spec.
Q108	*151-059	Tek Spec.
Q109	*151-059	Tek Spec.

÷ 1, 2, 5 BOARD (1) LOCATION B

	Use 670-022	Complete Board

Capacitors

C1	290-162	22 μf	EMT	35 v	
C2	281-549	68 pf	Cer.	500 v	10%
C6	281-523	100 pf	Cer.	350 v	
C16	281-523	100 pf	Cer.	350 v	
C22	281-518	47 pf	Cer.	500 v	
C26	281-523	100 pf	Cer.	350 v	
C36	281-523	100 pf	Cer.	350 v	
C38	281-524	150 pf	Cer.	500 v	
C42	281-518	47 pf	Cer.	500 v	
C46	281-523	100 pf	Cer.	350 v	
C50	281-511	22 pf	Cer.	500 v	10%
C52	283-024	.1 μf	Disc Type	30 v	
C56	281-523	100 pf	Cer.	350 v	
C62	281-549	68 pf	Cer.	500 v	10%
C66	281-523	100 pf	Cer.	350 v	

Capacitors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description				Model No.
C70	281-510	22 pf	Cer.	500 v		
C72	283-024	.1 μf	Disc Type	30 v		
C76	281-523	100 pf	Cer.	350 v		
C80	281-510	22 pf	Cer.	500 v		
C82	283-024	.1 μf	Disc Type	30 v		

Diodes

Ckt. No.	Tektronix Part No.	Description	Model No.
D2	*152-075	Germanium 6075	
D12	*152-075	Germanium 6075	
D18	*152-075	Germanium 6075	
D22	*152-075	Germanium 6075	
D32	*152-075	Germanium 6075	
D38	*152-075	Germanium 6075	
D42	*152-075	Germanium 6075	
D44	*152-075	Germanium 1N634	
D52	*152-075	Germanium 6075	
D62	*152-075	Germanium 6075	
D72	*152-075	Germanium 6075	
D74	*152-075	Germanium 6075	
D84	*152-075	Germanium 6075	

Resistors

Ckt. No.	Tektronix Part No.	Description			Model No.
R1	307-060	6.8 Ω	½ w	5%	
R2	301-563	56 k	½ w	5%	
R5	301-222	2.2 k	½ w	5%	
R6	301-153	15 k	½ w	5%	
R7	301-154	150 k	½ w	5%	
R15	301-222	2.2 k	½ w	5%	
R16	301-153	15 k	½ w	5%	
R17	301-154	150 k	½ w	5%	
R22	301-563	56 k	½ w	5%	
R25	301-222	2.2 k	½ w	5%	
R26	301-153	15 k	½ w	5%	
R27	301-154	150 k	½ w	5%	
R35	301-222	2.2 k	½ w	5%	
R36	301-153	15 k	½ w	5%	
R37	301-154	150 k	½ w	5%	
R38	301-223	22 k	½ w	5%	
R39	301-473	47 k	½ w	5%	
R42	301-563	56 k	½ w	5%	
R44	301-222	2.2 k	½ w	5%	1
	301-122	1.2 k	½ w	5%	2-up

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description			Model No.
R45	301-222	2.2 k	½ w	5%	
R46	301-153	15 k	½ w	5%	
R47	301-154	150 k	½ w	5%	
R50	301-473	47 k	½ w	5%	1
	301-273	27 k	½ w	5%	2-up
R51	301-204	200 k	½ w	5%	1
	301-104	100 k	½ w	5%	2-up
R52	301-623	62 k	½ w	5%	1
	301-243	24 k	½ w	5%	2-up
R55	301-222	2.2 k	½ w	5%	
R56	301-153	15 k	½ w	5%	
R57	301-154	150 k	½ w	5%	
R62	301-563	56 k	½ w	5%	
R65	301-222	2.2 k	½ w	5%	
R66	301-153	15 k	½ w	5%	
R67	301-154	150 k	½ w	5%	
R70	301-473	47 k	½ w	5%	1
	301-273	27 k	½ w	5%	2-up
R71	301-204	200 k	½ w	5%	1
	301-104	100 k	½ w	5%	2-up
R72	301-623	62 k	½ w	5%	1
	301-243	24 k	½ w	5%	2-up
R75	301-222	2.2 k	½ w	5%	
R76	301-153	15 k	½ w	5%	
R77	301-154	150 k	½ w	5%	
R80	301-473	47 k	½ w	5%	1
	301-273	27 k	½ w	5%	2-up
R81	301-204	200 k	½ w	5%	1
	301-104	100 k	½ w	5%	2-up
R82	301-623	62 k	½ w	5%	1
	301-243	24 k	½ w	5%	2-up

Transistors

Q5	*151-054	2N1754
Q15	*151-054	2N1754
Q25	*151-054	2N1754
Q35	*151-054	2N1754
Q44	*151-054	2N1754
Q45	*151-054	2N1754
Q55	*151-054	2N1754
Q65	*151-054	2N1754
Q74	*151-054	2N1754
Q75	*151-054	2N1754
Q84	*151-054	2N1754

MASTER GATE BOARD (1) LOCATION C

Ckt. No.	Tektronix Part No.	Description				Model No.
	670-009	Complete Board				
		Capacitors				
C1	290-162	22 μf	EMT	35 v		
C2	281-524	150 pf	Cer.	500 v		
C3	281-516	39 pf	Cer.	500 v	10%	
C8	283-032	470 pf	Disc Type	500 v	5%	
C14	285-576	1 μf	PTM	100 v	10%	
C16	283-000	.001 μf	Disc Type	500 v		
C25	283-010	.05 μf	Disc Type	50 v		X2A-up
C26	283-057	.1 μf	Disc Type	200 v		
C27	283-057	.1 μf	Disc Type	200 v		
C32	281-523	100 pf	Cer.	350 v		
C36	281-550	120 pf	Cer.	500 v	10%	
C42	281-543	270 pf	Cer.	500 v	10%	
C46	281-550	120 pf	Cer.	500 v	10%	
C52	281-543	270 pf	Cer.	500 v	10%	
C56	281-550	120 pf	Cer.	500 v	10%	
C62	281-523	100 pf	Cer.	350 v		
C66	281-550	120 pf	Cer.	500 v	10%	
C71	281-518	47 pf	Cer.	500 v		
		Diodes				
D2	*152-075	Germanium 6075				
D3	*152-075	Germanium 6075				
D4	*152-075	Germanium 6075				
D5	*152-075	Germanium 6075				
D23	*152-075	Silicon 6061				X2A-up
D28	*152-047	Silicon 1N2862 (or equal)				
D32	*152-075	Germanium 6075				
D42	*152-075	Germanium 6075				
D52	*152-075	Germanium 6075				
D62	*152-075	Germanium 6075				
		Resistors				
R1	307-060	6.8 Ω	½ w		5%	
R2	301-103	10 k	½ w		5%	
R3	301-103	10 k	½ w		5%	
R7	301-823	82 k	½ w		5%	
R8	301-223	22 k	½ w		5%	
R10	301-103	10 k	½ w		5%	
R13	301-222	2.2 k	½ w		5%	
R14	Use 301-363	36 k	½ w		5%	
R15	301-470	47 Ω	½ w		5%	
R16	303-433	43 k	1 w		5%	

Resistors *(Cont'd.)*

Ckt. No.	Tektronix Part No.		Description		Model No.
R17	301-332	3.3 k	½ w	5%	
R18	301-472	4.7 k	½ w	5%	
R20	301-104	100 k	½ w	5%	
R21	301-822	8.2 k	½ w	5%	
R24	301-104	100 k	½ w	5%	
R25	301-183	18 k	½ w	5%	
R26	301-124	120 k	½ w	5%	
R27	301-223	22 k	½ w	5%	
R30	301-101	100 Ω	½ w	5%	
R32	301-563	56 k	½ w	5%	
R35	301-222	2.2 k	½ w	5%	
R36	301-153	15 k	½ w	5%	
R37	Use 301-105	1 meg	½ w	5%	
R40	301-103	10 k	½ w	5%	
R42	301-563	56 k	½ w	5%	
R45	301-222	2.2 k	½ w	5%	
R46	301-153	15 k	½ w	5%	
R47	Use 301-105	1 meg	½ w	5%	
R50	301-101	100 Ω	½ w	5%	
R52	301-563	56 k	½ w	5%	
R55	301-222	2.2 k	½ w	5%	
R56	301-153	15 k	½ w	5%	
R57	Use 301-105	1 meg	½ w	5%	
R60	301-103	10 k	½ w	5%	
R62	301-563	56 k	½ w	5%	
R65	301-222	2.2 k	½ w	5%	
R66	301-153	15 k	½ w	5%	
R67	Use 301-105	1 meg	½ w	5%	
R70	301-474	470 k	½ w	5%	
R71	Use 301-393	39 k	½ w	5%	
R72	301-105	1 meg	½ w	5%	
R74	301-222	2.2 k	½ w	5%	
R83	301-101	100 Ω	½ w	5%	
R93	301-101	100 Ω	½ w	5%	

Transistors

Q3	151-010	2N404
Q13	151-069	2N1304
Q23	*151-059	Tek Spec.
Q24	151-055	2N398A
Q33	151-069	2N1304
Q35	*151-054	2N1754
Q43	151-069	2N1304
Q45	*151-054	2N1754
Q53	151-069	2N1304
Q55	*151-054	2N1754

Transistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description	Model No.
Q63	151-069	2N1304	
Q65	*151-054	2N1754	
Q73	Use 151-069	2N1304	
Q74	*151-054	2N1754	
Q83	Use 151-069	2N1304	
Q93	*151-054	2N1754	

Electron Tube

V15	154-306	7586	

SIGNAL COMPARATOR BOARD (2) LOCATION D

	670-020	Complete Board	

Capacitors

C1	290-162	22 μf	EMT	35 v		
C2	283-000	.001 μf	Disc Type	500 v		
C12	283-000	.001 μf	Disc Type	500 v		
C22	281-549	68 pf	Cer.	500 v	10%	
C31	281-510	22 pf	Cer.	500 v		
C42	281-549	68 pf	Cer.	500 v	10%	
C50	281-536	.001 μf	Cer.	500 v	10%	
C62	281-523	100 pf	Cer.	350 v		
C66	281-546	330 pf	Cer.	500 v	10%	
C68	281-518	47 pf	Cer.	500 v		
C76	281-546	330 pf	Cer.	500 v	10%	
C80	281-516	39 pf	Cer.	500 v	10%	
C82	283-024	.1 μf	Disc Type	30 v		
C90	281-516	39 pf	Cer.	500 v	10%	
C92	283-024	.1 μf	Disc Type	30 v		

Diodes

D4	*152-061	Silicon 6061	X3-up
D14	*152-061	Silicon 6061	X3-up
D23	*152-045	Silicon 6045	
D24	*152-075	Germanium 6075	
D43	*152-045	Silicon 6045	
D44	*152-075	Germanium 6075	
D52	152-081	Tunnel TD2 2.2 MA	
D62	*152-075	Germanium 6075	
D68	*152-075	Germanium 6075	
D72	*152-075	Germanium 6075	

Resistors

Ckt. No.	Tektronix Part No.	Description					Model No.
R1	307-060	6.8 Ω	½ w				
R2	301-470	47 Ω	½ w			5%	
R4	311-255	5 k		Var.	WW	5%	DC BAL 1, 2
	311-336	200 Ω		Var.	WW		3-up
R5	301-272	2.7 k	½ w			5%	1, 2
	301-472	4.7 k	½ w			5%	3-up
R6	305-223	22 k	2 w			5%	1, 2
	303-223	22 k	1w			5%	3-up
R7	301-273	27 k	½ w			5%	
R12	301-470	47 Ω	½ w			5%	
R15	301-272	2.7 k	½ w			5%	1, 2
	301-472	4.7 k	½ w			5%	3-up
R16	301-184	180 k	½ w			5%	
R17	301-273	27 k	½ w			5%	
R18	301-821	820 Ω	½ w			5%	
R20	301-273	27 k	½ w			5%	
R22	301-272	2.7 k	½ w			5%	
R24	301-392	3.9 k	½ w			5%	
R25	301-102	1 k	½ w			5%	
R30	301-155	1.5 meg	½ w			5%	
R31	301-433	43 k	½ w			5%	
R42	301-272	2.7 k	½ w			5%	
R50	301-101	100 Ω	½ w			5%	
R53	301-122	1.2 k	½ w			5%	
R54	301-753	75 k	½ w			5%	
R55	301-101	100 Ω	½ w			5%	
R57	301-101	100 Ω	½ w			5%	
R58	301-392	3.9 k	½ w			5%	
R61	301-392	3.9 k	½ w			5%	
R62	301-563	56 k	½ w			5%	
R65	301-222	2.2 k	½ w			5%	
R66	301-223	22 k	½ w			5%	
R67	301-204	200 k	½ w			5%	
R68	301-563	56 k	½ w			5%	
R75	301-222	2.2 k	½ w			5%	
R76	301-223	22 k	½ w			5%	
R77	301-204	200 k	½ w			5%	
R80	301-473	47 k	½ w			5%	
R81	301-224	220 k	½ w			5%	
R82	301-563	56 k	½ w			5%	
R84	301-222	2.2 k	½ w			5%	
R90	301-473	47 k	½ w			5%	
R91	301-224	220 k	½ w			5%	
R92	301-563	56 k	½ w			5%	

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Transistors

Ckt. No.	Tektronix Part No.	Description				Model No.
Q4	151-055	2N398A				
Q8	*151-059	Tek Spec.				X3-up
Q14	151-055	2N398A				
Q24	151-010	2N404				
Q34	*151-054	2N1754				
Q43	151-010	2N404				
Q44	151-082	TI495				
Q54	Use 151-069	2N1304				
Q64	*151-054	2N1754				
Q65	151-010	2N404				
Q75	151-010	2N404				
Q84	151-010	2N404				
Q94	151-010	2N404				

Electron Tubes

V4	Use 154-323	6CW4				
V14	Use 154-323	6CW4				
V53	154-323	6CW4				

VOLTMETER BOARD (1) LOCATION E

	Use 670-021	Complete Board				

Capacitors

C1	290-162	22 μf	EMT	35 v		
C40	281-518	47 pf	Cer.	500 v		
C50	281-572	6.8 pf	Cer.	500 v	10%	1
	281-509	15 pf	Cer.	500 v	10%	2-up
C52	283-012	.1 μf	Disc Type	100 v		
C70	281-572	6.8 pf	Cer.	500 v	10%	
C72	283-012	.1 μf	Disc Type	100 v		
C83	281-523	100 pf	Cer.	350 v		
C108	281-523	100 pf	Cer.	350 v		
C111	285-598	.01 μf	PTM	100 v	5%	
C118	283-008	.1 μf	Disc Type	500 v		

Diodes

D7	152-055	Zener 11 v 1/4 w 5%				
D27	152-055	Zener 11 v 1/4 w 5%				
D54	*152-075	Germanium 6075				
D74	*152-075	Germanium 6075				
D85	*152-075	Germanium 6075				
D86	*152-075	Germanium 6075				
D112	*152-075	Germanium 6075				

Inductor

Ckt. No.	Tektronix Part No.	Description	Model No.
L41	*108-068	600 μh	

Resistors

Ckt. No.	Tektronix Part No.	Description					Model No.
R1	307-060	6.8 Ω	½ w			5%	
R3	311-267	10 k	¼ w	Var.	WW	STOP VOLT CAL.	
R4	301-164	160 k	½ w			5%	
R8	301-303	30 k	½ w			5%	
R9	301-123	12 k	½ w			5%	
R14	301-164	160 k	½ w			5%	
R23	311-267	10 k	¼ w	Var.	WW	START VOLT CAL.	
R24	301-164	160 k	½ w			5%	
R28	301-303	30 k	½ w			5%	
R29	301-123	12 k	½ w			5%	
R34	301-164	160 k	½ w			5%	
R40	301-473	47 k	½ w			5%	1
	301-333	33 k	½ w			5%	2-up
R42	301-474	470 k	½ w			5%	
R44	301-272	2.7 k	½ w			5%	
R50	301-473	47 k	½ w			5%	1
	301-273	27 k	½ w			5%	2-up
R51	301-204	200 k	½ w			5%	1
	301-104	100 k	½ w			5%	2-up
R52	301-623	62 k	½ w			5%	1
	301-243	24 k	½ w			5%	2-up
R54	301-122	1.2 k	½ w			5%	
R64	301-392	3.9 k	½ w			5%	
R70	301-473	47 k	½ w			5%	
R71	301-204	200 k	½ w			5%	
R72	301-623	62 k	½ w			5%	
R80	301-103	10 k	½ w			5%	
R83	301-392	3.9 k	½ w			5%	
R85	301-103	10 k	½ w			5%	
R86	301-823	82 k	½ w			5%	
R90	301-103	10 k	½ w			5%	
R100	301-680	68 Ω	½ w			5%	
R101	301-332	3.3 k	½ w			5%	
R104	301-332	3.3 k	½ w			5%	
R108	301-223	22 k	½ w			5%	
R109	303-393	39 k	1 w			5%	
R111	Use 301-275	2.7 meg	½ w			5%	
R112	311-269	500 k	.2 w	Var.		RAMP SLOPE	
R118	303-393	39 k	1 w			5%	

Transistors

Ckt. No.	Tektronix Part No.	Description	Model No.
Q8	Use 151-081	2N1749	
Q18	*151-059	Tek Spec.	
Q28	Use 151-081	2N1749	
Q38	*151-059	Tek Spec.	
Q40	151-081	2N1749	
Q44	Use 151-015	2N1516	
Q54	*151-054	2N1754	
Q64	Use 151-069	2N1304	
Q74	*151-054	2N1754	
Q83	151-069	2N1304	
Q93	151-069	2N1304	
Q103	*151-054	2N1754	
Q104	*151-054	2N1754	

Electron Tubes

V105	154-306	7586	
V111	154-323	6CW4	

UPPER LIMIT NO-GO BOARD (1) LOCATION F

	670-011	Complete Board	

Diodes

D14	*152-075	Germanium 6075	
D34	*152-075	Germanium 6075	
D73	*152-075	Germanium 6075	
D74	*152-075	Germanium 6075	
D112	*152-075	Germanium 6075	
D113	*152-075	Germanium 6075	
D114	*152-075	Germanium 6075	
D141	*152-075	Germanium 6075	
D142	*152-075	Germanium 6075	
D153	*152-075	Germanium 6075	
D144	*152-075	Germanium 6075	

Resistors

R3	301-393	39 k	½ w	5%	
R14	301-392	3.9 k	½ w	5%	
R23	301-393	39 k	½ w	5%	
R43	301-393	39 k	½ w	5%	
R54	301-392	3.9 k	½ w	5%	
R63	301-393	39 k	½ w	5%	1
	301-363	36 k	½ w	5%	1A-up
R72	315-473	47 k	¼ w	5%	X1A-up
R83	301-393	39 k	½ w	5%	
R94	301-392	3.9 k	½ w	5%	

Resistors *(Cont'd.)*

Ckt. No.	Tektronix Part No.	Description			Model No.
R103	301-393	39 k	½ w	5%	1
	301-363	36 k	½ w	5%	1A-up
R112	315-473	47 k	¼ w	5%	X1A-up
R123	301-393	39 k	½ w	5%	
R134	301-392	3.9 k	½ w	5%	
R142	301-222	2.2 k	½ w	5%	
R143	301-100	10 Ω	½ w	5%	

Transistors

Q4	151-010	2N404
Q14	151-070	2N1377
Q24	151-010	2N404
Q34	151-070	2N1377
Q44	151-010	2N404
Q54	151-070	2N1377
Q64	151-010	2N404
Q73	*151-059	Tek Spec.
Q74	151-070	2N1377
Q84	151-010	2N404
Q94	151-070	2N1377
Q104	151-010	2N404
Q113	*151-059	Tek Spec.
Q114	151-070	2N1377
Q124	151-010	2N404
Q134	151-070	2N1377
Q143	151-010	2N404

LOWER LIMIT NO-GO BOARD (1) LOCATION G

	670-010	Complete Board

Diodes

D14	*152-075	Germanium 6075
D34	*152-075	Germanium 6075
D73	*152-075	Germanium 6075
D74	*152-075	Germanium 6075
D112	*152-075	Germanium 6075
D113	*152-075	Germanium 6075
D114	*152-075	Germanium 6075
D141	*152-075	Germanium 6075
D142	*152-075	Germanium 6075
D143	*152-075	Germanium 6075
D144	*152-075	Germanium 6075

Resistors

Ckt. No.	Tektronix Part No.	Description			Model No.
R3	301-393	39 k	½ w	5%	
R14	301-392	3.9 k	½ w	5%	
R23	301-393	39 k	½ w	5%	
R43	301-393	39 k	½ w	5%	
R54	301-392	3.9 k	½ w	5%	
R63	301-393	39 k	½ w	5%	1
	301-363	36 k	½ w	5%	1A-up
R72	315-473	47 k	¼ w	5%	X1A-up
R83	301-393	39 k	½ w	5%	
R94	301-392	3.9 k	½ w	5%	
R103	301-393	39 k	½ w	5%	1
	301-363	36 k	½ w	5%	1A-up
R112	315-473	47 k	¼ w	5%	X1A-up
R123	301-393	39 k	½ w	5%	
R134	301-392	3.9 k	½ w	5%	
R142	301-222	2.2 k	½ w	5%	
R143	301-100	10 Ω	½ w	5%	

Transistors

Q4	151-010	2N404
Q14	151-070	2N1377
Q24	151-010	2N404
Q34	151-070	2N1377
Q44	151-010	2N404
Q54	151-070	2N1377
Q64	151-010	2N404
Q73	*151-059	Tek Spec.
Q74	151-070	2N1377
Q84	151-010	2N404
Q94	151-070	2N1377
Q104	151-010	2N404
Q113	*151-059	Tek Spec.
Q114	151-070	2N1377
Q124	151-010	2N404
Q134	151-070	2N1377
Q143	151-010	2N404

LIMIT LIGHT DRIVER BOARD (1) LOCATION H

670-008 Complete Board

Resistors

R13	301-472	4.7 k	½ w	5%
R14	301-332	3.3 k	½ w	5%
R20	301-103	10 k	½ w	5%
R23	301-272	2.7 k	½ w	5%
R33	306-470	47 Ω	2 w	

Resistors *(Cont'd.)*

Ckt. No.	Tektronix Part No.	Description			Model No.
R40	301-103	10 k	½ w	5%	
R43	301-272	2.7 k	½ w	5%	
R53	306-470	47 Ω	2 w		
R60	301-680	68 Ω	½ w	5%	
R63	306-470	47 Ω	2 w		
R64	301-102	1 k	½ w	5%	

Transistors

Q13	151-070	2N1377
Q14	151-070	2N1377
Q23	151-010	2N404
Q33	151-001	2N301
Q43	151-010	2N404
Q53	151-001	2N301
Q63	151-001	2N301
Q64	151-010	2N404

÷ 10 BOARD (1) LOCATION I

	670-001	Complete Board

Capacitors

C1	290-162	22 μf	EMT	35 v	
C2	281-523	100 pf	Cer.	350 v	
C6	281-525	470 pf	Cer.	500 v	
C16	281-525	470 pf	Cer.	500 v	
C22	281-523	100 pf	Cer.	350 v	
C26	281-525	470 pf	Cer.	500 v	
C36	281-525	470 pf	Cer.	500 v	
C38	Use 281-551	390 pf	Cer.	500 v	10%
C42	281-523	100 pf	Cer.	350 v	
C46	281-525	470 pf	Cer.	500 v	
C56	281-525	470 pf	Cer.	500 v	
C58	Use 281-551	390 pf	Cer.	500 v	10%
C62	281-523	100 pf	Cer.	350 v	
C66	281-525	470 pf	Cer.	500 v	
C76	281-525	470 pf	Cer.	500 v	

Diodes

D2	*152-075	Germanium 6075
D12	*152-075	Germanium 6075
D22	*152-075	Germanium 6075
D32	*152-075	Germanium 6075
D38	*152-075	Germanium 6075

Diodes *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description	Model No.
D42	*152-075	Germanium 6075	
D52	*152-075	Germanium 6075	
D58	*152-075	Germanium 6075	
D62	*152-075	Germanium 6075	
D72	*152-075	Germanium 6075	

Resistors

R1	307-060	6.8 Ω	½ w	5%
R2	301-563	56 k	½ w	5%
R5	301-222	2.2 k	½ w	5%
R6	301-223	22 k	½ w	5%
R7	301-204	200 k	½ w	5%
R15	301-222	2.2 k	½ w	5%
R16	301-223	22 k	½ w	5%
R17	301-204	200 k	½ w	5%
R22	301-563	56 k	½ w	5%
R25	301-222	2.2 k	½ w	5%
R26	301-223	22 k	½ w	5%
R27	301-204	200 k	½ w	5%
R35	301-222	2.2 k	½ w	5%
R36	301-223	22 k	½ w	5%
R37	301-204	200 k	½ w	5%
R38	301-223	22 k	½ w	5%
R39	301-473	47 k	½ w	5%
R42	301-563	56 k	½ w	5%
R45	301-222	2.2 k	½ w	5%
R46	301-223	22 k	½ w	5%
R47	301-204	200 k	½ w	5%
R55	301-222	2.2 k	½ w	5%
R56	301-223	22 k	½ w	5%
R57	301-204	200 k	½ w	5%
R58	301-223	22 k	½ w	5%
R59	301-473	47 k	½ w	5%
R62	301-563	56 k	½ w	5%
R65	301-222	2.2 k	½ w	5%
R66	301-223	22 k	½ w	5%
R67	301-204	200 k	½ w	5%
R75	301-222	2.2 k	½ w	5%
R76	301-223	22 k	½ w	5%
R77	301-204	200 k	½ w	5%
R83	301-392	3.9 k	½ w	5%

Transistors

Q5	151-010	2N404
Q15	151-010	2N404
Q25	151-010	2N404
Q35	151-010	2N404
Q45	151-010	2N404

Transistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description				Model No.
Q55	151-010	2N404				
Q65	151-010	2N404				
Q75	151-010	2N404				
Q83	151-069	2N1304				

ANALOG DISPLAY BOARD (1) LOCATION J

	670-005	Complete Board				

Capacitor

C91	281-511	22 pf	Cer.	500 v	10%	

Diodes

D12	*152-075	Germanium 6075				
D32	*152-075	Germanium 6075				
D52	152-025	Germanium 1N634				
D62	*152-075	Germanium 6075				
D63	*152-075	Germanium 6075				
D72	*152-075	Germanium 6075				
D73	*152-075	Germanium 6075				
D82	152-025	Germanium 1N634				

Resistors

R2	301-103	10 k	½ w		5%	
R10	301-103	10 k	½ w		5%	
R13	301-222	2.2 k	½ w		5%	
R20	301-103	10 k	½ w		5%	
R30	301-103	10 k	½ w		5%	
R33	301-222	2.2 k	½ w		5%	
R40	301-103	10 k	½ w		5%	
R42	301-123	12 k	½ w		5%	
R43	301-222	2.2 k	½ w		5%	
R50	301-103	10 k	½ w		5%	
R52	301-333	33 k	½ w		5%	
R53	301-392	3.9 k	½ w		5%	
R60	301-103	10 k	½ w		5%	
R62	301-333	33 k	½ w		5%	
R63	301-392	3.9 k	½ w		5%	
R70	301-103	10 k	½ w		5%	
R72	301-333	33 k	½ w		5%	
R73	301-392	3.9 k	½ w		5%	
R74	301-123	12 k	½ w		5%	
R80	301-103	10 k	½ w		5%	
R82	301-333	33 k	½ w		5%	
R90	301-104	100 k	½ w		5%	
R91	301-103	10 k	½ w		5%	

Transistors

Ckt. No.	Tektronix Part No.	Description				Model No.
Q3	151-069	2N1304				
Q13	151-069	2N1304				
Q23	151-069	2N1304				
Q33	151-069	2N1304				
Q43	151-010	2N404				
Q53	151-010	2N404				
Q63	151-010	2N404				
Q73	151-010	2N404				
Q83	151-010	2N404				
Q94	151-010	2N404				

0% ZONE BOARD (1) LOCATION K

	670-012	Complete Board				

Capacitors

C1	290-162	22 μf	EMT	35 v		
C20	281-516	39 pf	Cer.	500 v	10%	
C47	281-523	100 pf	Cer.	350 v		
C61	281-509	15 pf	Cer.	500 v	10%	

Diodes

D40	152-008	Germanium T12G				X2-up
D43	*050-109	Replacement Kit				1, 2
	Use 152-081	Tunnel TD2 2.2 ma				3-up

Resistors

R1	307-060	6.8 Ω	½ w		5%	
R11	301-102	1 k	½ w		5%	
R13	301-272	2.7 k	½ w		5%	
R14	301-272	2.7 k	½ w		5%	
R20	301-473	47 k	½ w		5%	
R21	301-155	1.5 meg	½ w		5%	
R23	301-470	47 Ω	½ w		5%	
R24	301-392	3.9 k	½ w		5%	
R33	301-470	47 Ω	½ w		5%	
R40	301-470	47 Ω	½ w		5%	
R43	311-270	50 k	.2 w	Var.	0% ZONE WIDTH	
R44	303-273	27 k	1 w		5%	
R45	Use 301-105	1 meg	½ w		5%	
R47	301-332	3.3 k	½ w		5%	
R50	301-101	100 Ω	½ w		5%	

Resistors *(Cont'd.)*

Ckt. No.	Tektronix Part No.	Description				Model No.
R54	301-222	2.2 k	½ w		5%	
R60	301-155	1.5 meg	½ w		5%	
R61	301-104	100 k	½ w		5%	
R63	301-222	2.2 k	½ w		5%	
R64	301-332	3.3 k	½ w		5%	
R74	301-392	3.9 k	½ w		5%	
R75	303-183	18 k	1 w		5%	
R80	301-102	1 k	½ w		5%	
R84	301-392	3.9 k	½ w		5%	

Transistors

Q13	151-069	2N1304	
Q14	151-069	2N1304	
Q23	151-069	2N1304	
Q24	151-069	2N1304	
Q33	151-010	2N404	
Q43	151-082	TI495	
Q54	151-069	2N1304	
Q63	151-010	2N404	
Q64	*151-054	2N1754	
Q74	151-069	2N1304	
Q84	151-069	2N1304	

Electron Tube

V43	154-306	7586	

MEMORY BOARD (2) LOCATION L

	670-006	Complete Board

Capacitors

C30	281-509	15 pf	Cer.	500 v	10%	
C40	281-509	15 pf	Cer.	500 v	10%	
C50	285-576	1 μf	PTM	100 v	10%	
C80	285-576	1 μf	PTM	100 v	10%	

Diodes

D13	*050-109	Replacement Kit	1, 2
	152-093	Tunnel TD3 4.7 ma	3-up
D23	*050-109	Replacement Kit	1, 2
	152-093	Tunnel TD3 4.7 ma	3-up
D31	*152-045	Silicon 6045	

Diodes *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description				Model No.
D32	*152-045	Silicon 6045				
D41	*152-045	Silicon 6045				
D42	*152-045	Silicon 6045				
D61	*152-045	Silicon 6045				
D62	*152-045	Silicon 6045				
D71	*152-045	Silicon 6045				
D72	*152-045	Silicon 6045				

Resistors

R10	301-823	82 k	½ w			5%
R11	301-102	1 k	½ w			5%
R12	301-164	160 k	½ w			5%
R13	311-268	20 k	.2 w	Var.		100% ZONE WIDTH
R14	Use 315-242	2.4 k	¼ w			5%
R15	315-101	100 Ω	¼ w			5%
R24	Use 315-242	2.4 k	¼ w			5%
R25	315-101	100 Ω	¼ w			5%
R26	315-332	3.3 k	¼ w			5%
R30	315-104	100 k	¼ w			5%
R31	301-155	1.5 meg	½ w			5%
R34	315-222	2.2 k	¼ w			5%
R35	301-103	10 k	½ w			5%
R36	301-393	39 k	½ w			5%
R40	315-104	100 k	¼ w			5%
R41	301-155	1.5 meg	½ w			5%
R44	301-392	3.9 k	½ w			5%
R45	301-103	10 k	½ w			5%
R47	301-393	39 k	½ w			5%
R50	315-332	3.3 k	¼ w			5%
R51	315-102	1 k	¼ w			5%
R53	311-266	500 Ω	¼ w	Var.	WW	100% DC LEVEL
R58	301-273	27 k	½ w			5%
R60	301-103	10 k	½ w			5%
R63	301-393	39 k	½ w			5%
R70	301-103	10 k	½ w			5%
R73	301-393	39 k	½ w			5%
R80	315-332	3.3 k	¼ w			5%
R81	315-102	1 k	¼ w			5%
R83	311-266	500 Ω	¼ w	Var.	WW	0% DC LEVEL
R88	301-273	27 k	½ w			5%

Transistors

Q3	151-069	2N1304
Q13	151-082	TI495
Q14	151-069	2N1304
Q23	151-082	TI495
Q24	151-069	2N1304

Transistors *(Cont'd)*

Q33	151-071	2N1305
Q34	151-069	2N1304
Q43	151-069	2N1304
Q44	151-069	2N1304
Q58	*151-059	Tek Spec.
Q63	151-071	2N1305
Q73	151-069	2N1304
Q88	*151-059	Tek Spec.

Electron Tubes

V53	154-323	6CW4
V83	154-323	6CW4

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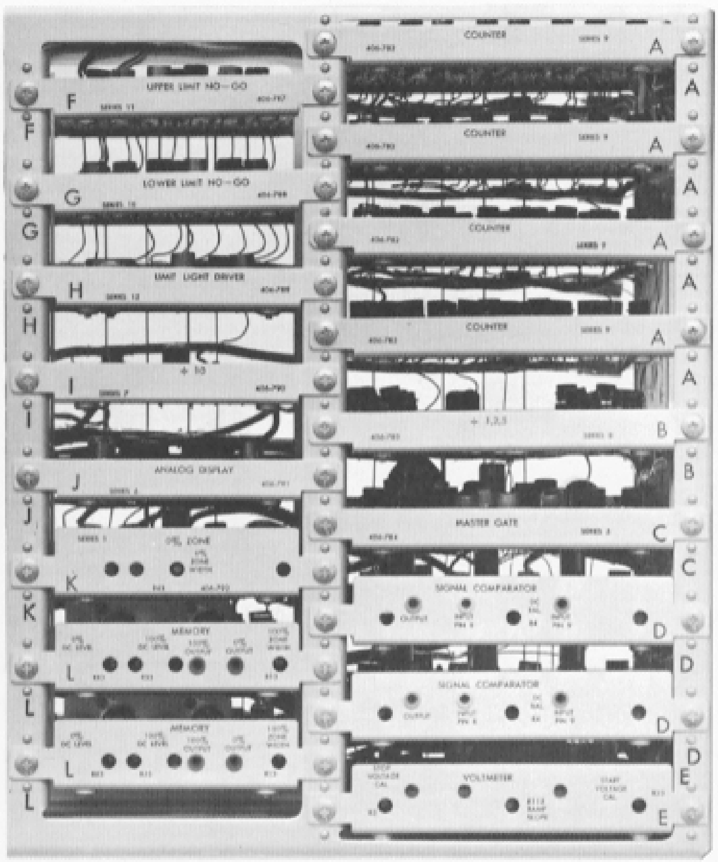
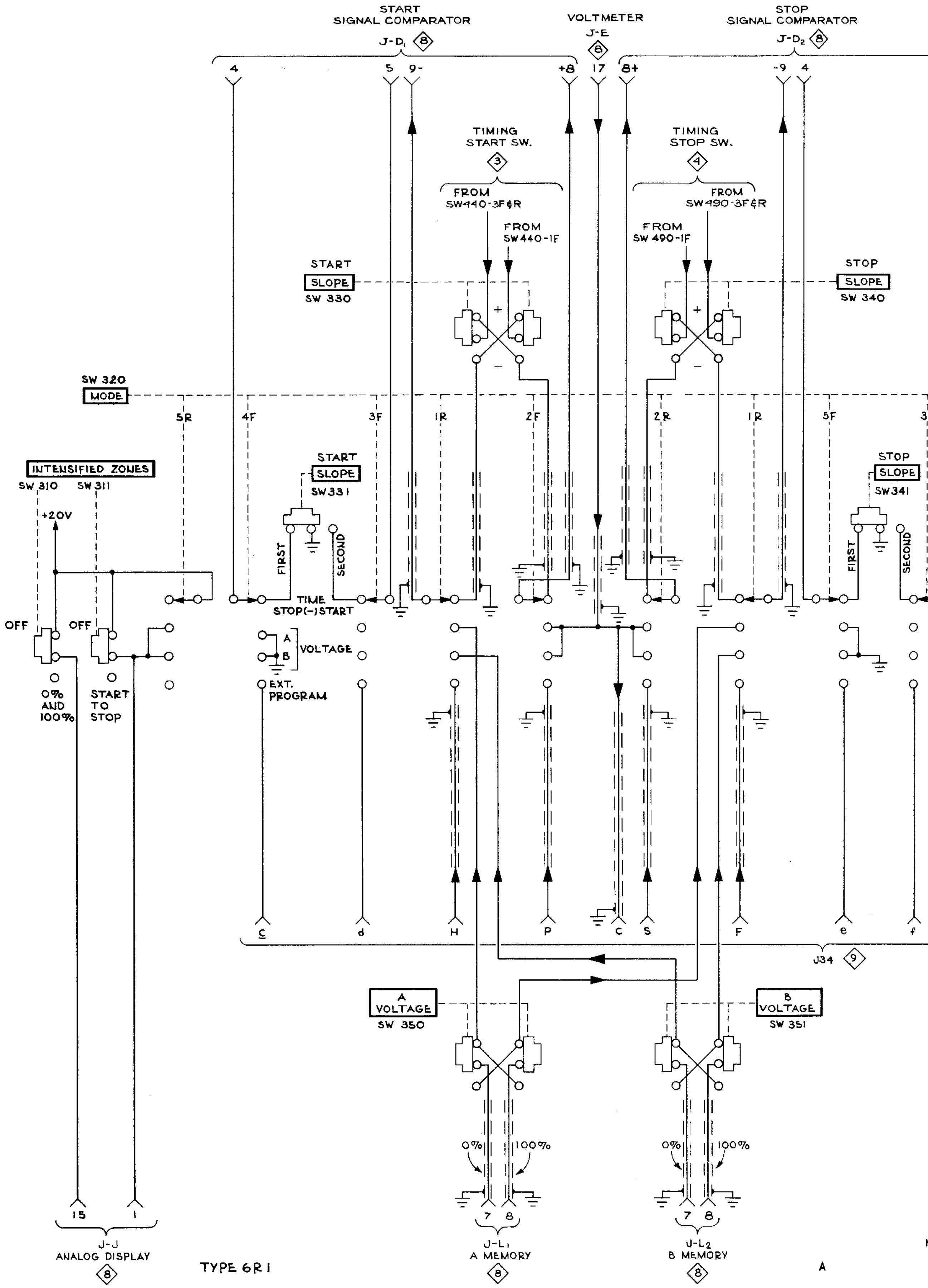


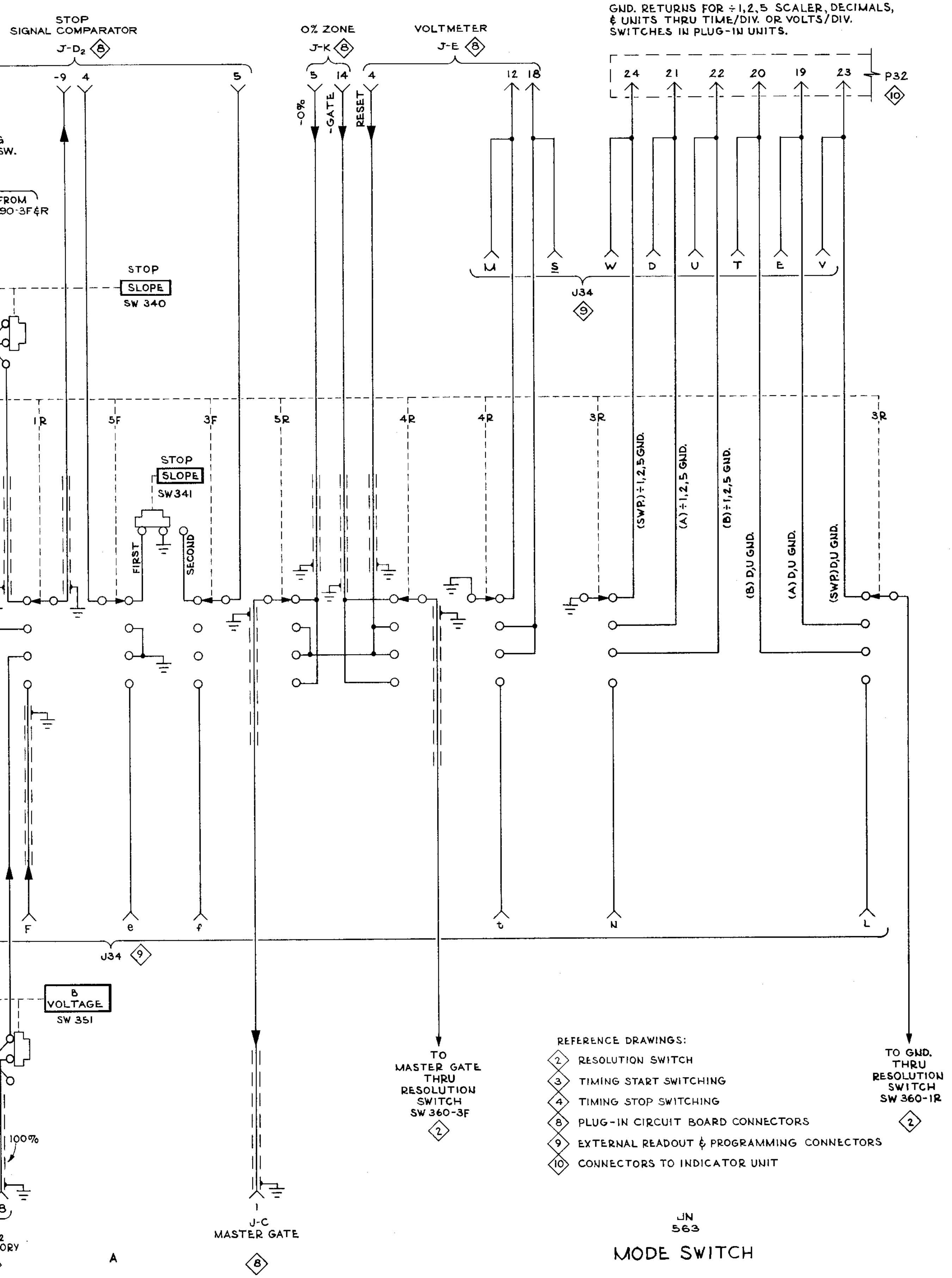
CIRCUIT BOARD IDENTIFICATION



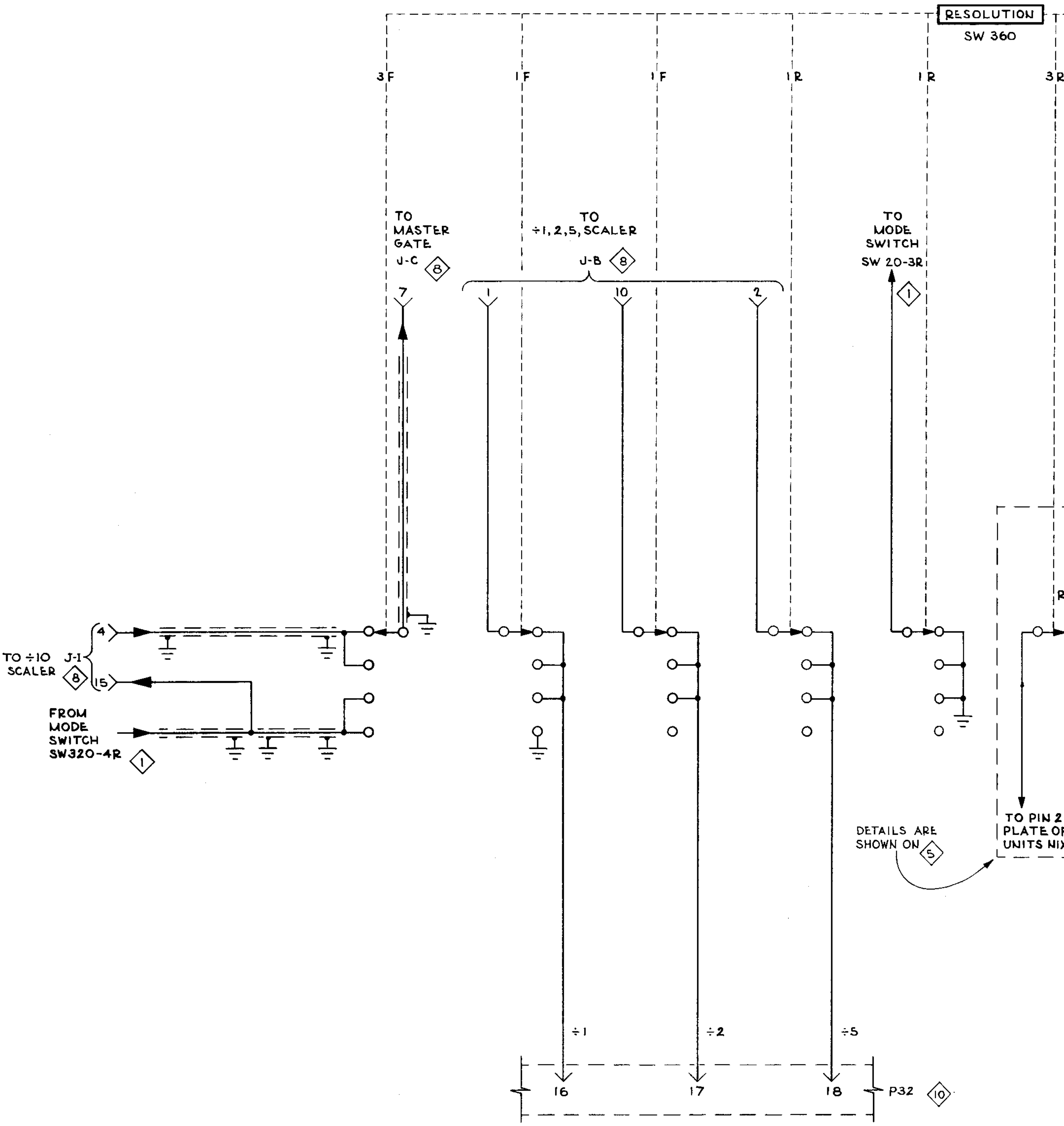
START
SIGNAL COMPARATOR
J-D1 8
VOLTMETER
J-E
8
STOP
SIGNAL COMPARATOR
J-D2 8
TIMING
START SW.
3
FROM
SW440-3F&R
FROM
SW440-1F
TIMING
STOP SW.
4
FROM
SW490-3F&R
FROM
SW 490-1F
START
SLOPE
SW 330
STOP
SLOPE
SW 340
SW 320
MODE
INTENSIFIED ZONES
SW 310
SW 311
+20V
START
SLOPE
SW331
STOP
SLOPE
SW341
FIRST
SECOND
TIME
STOP(-)START
OFF
OFF
VOLTAGE
EXT.
PROGRAM
0%
AND
100%
START
TO
STOP
J34 9
A
VOLTAGE
SW 350
B
VOLTAGE
SW 351
0%
100%
J-J
ANALOG DISPLAY
8
J-L1
A MEMORY
8
J-L2
B MEMORY
8

TYPE 6R1

A


STOP
SIGNAL COMPARATOR
J-D2 8
-9 4 5
0% ZONE
J-K 8
5 14
-0%
-GATE
RESET
VOLTMETER
J-E 8
4 12 18
GND. RETURNS FOR ÷1,2,5 SCALER, DECIMALS, & UNITS THRU TIME/DIV. OR VOLTS/DIV. SWITCHES IN PLUG-IN UNITS.
24 21 22 20 19 23
P32
10
M S W D U T E V
J34
9
STOP
SLOPE
SW 340
STOP
SLOPE
SW341
FIRST
SECOND
1R 5F 3F 5R 4R 4R 3R 3R
(SWP.) ÷1,2,5 GND.
(A) ÷1,2,5 GND.
(B) ÷1,2,5 GND.
(B) D,U GND.
(A) D,U GND.
(SWP.) D,U GND.
F e f t N L
J34 9
B
VOLTAGE
SW 351
100%
1
J-C
MASTER GATE
8
TO
MASTER GATE
THRU
RESOLUTION
SWITCH
SW 360-3F
2
TO GND.
THRU
RESOLUTION
SWITCH
SW 360-1R
2
REFERENCE DRAWINGS:
2 RESOLUTION SWITCH
3 TIMING START SWITCHING
4 TIMING STOP SWITCHING
8 PLUG-IN CIRCUIT BOARD CONNECTORS
9 EXTERNAL READOUT & PROGRAMMING CONNECTORS
10 CONNECTORS TO INDICATOR UNIT
A
JN
563

MODE SWITCH



REFERENCE DRAWINGS:

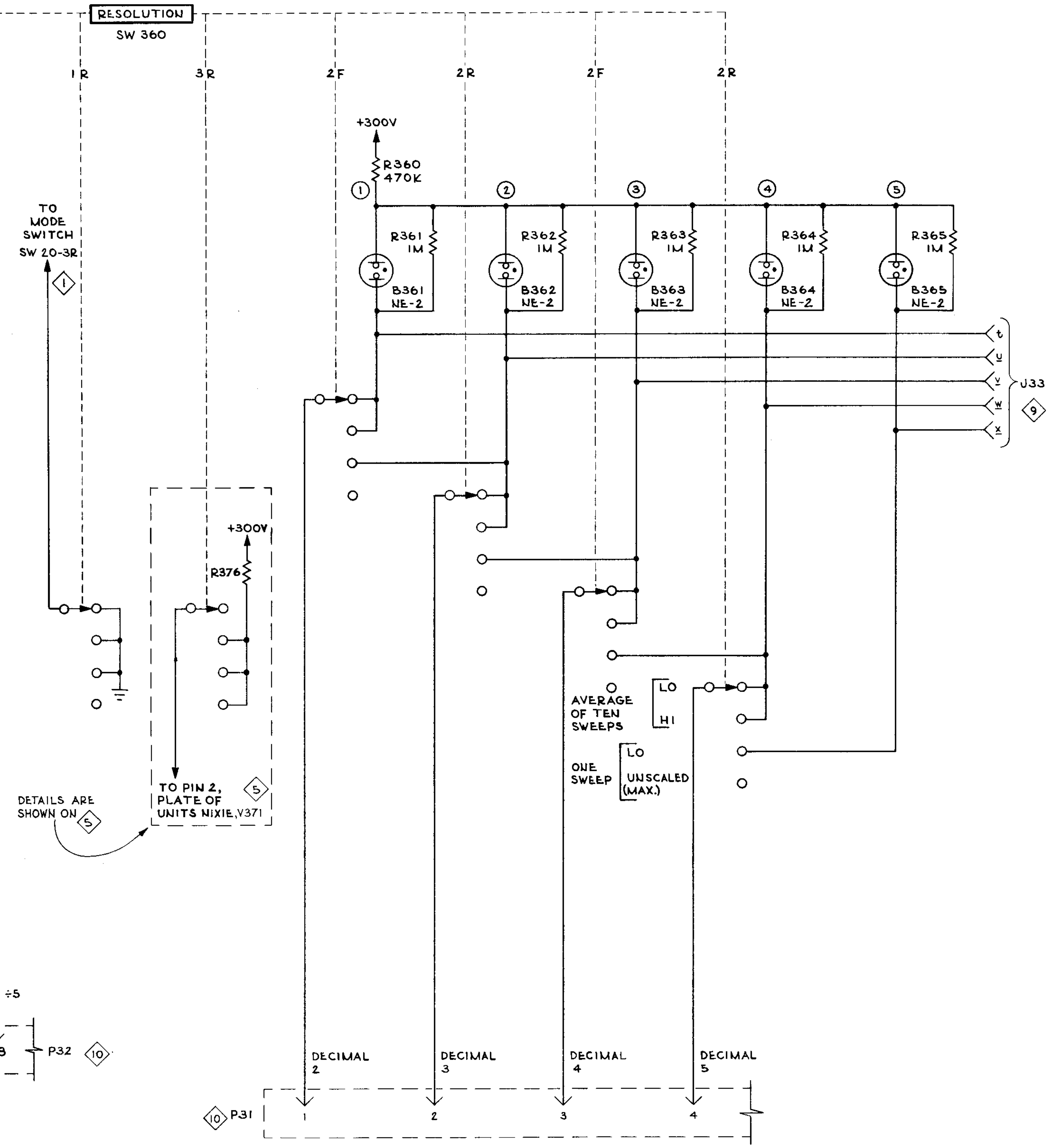
1 MODE SWITCH

5 READOUT TUBES

8 PLUG-IN CIRCUIT BOARD CONNECTORS

9 EXTERNAL READOUT & PROGRAMMING CONNECTORS

10 CONNECTORS TO INDICATOR UNIT



JN
563

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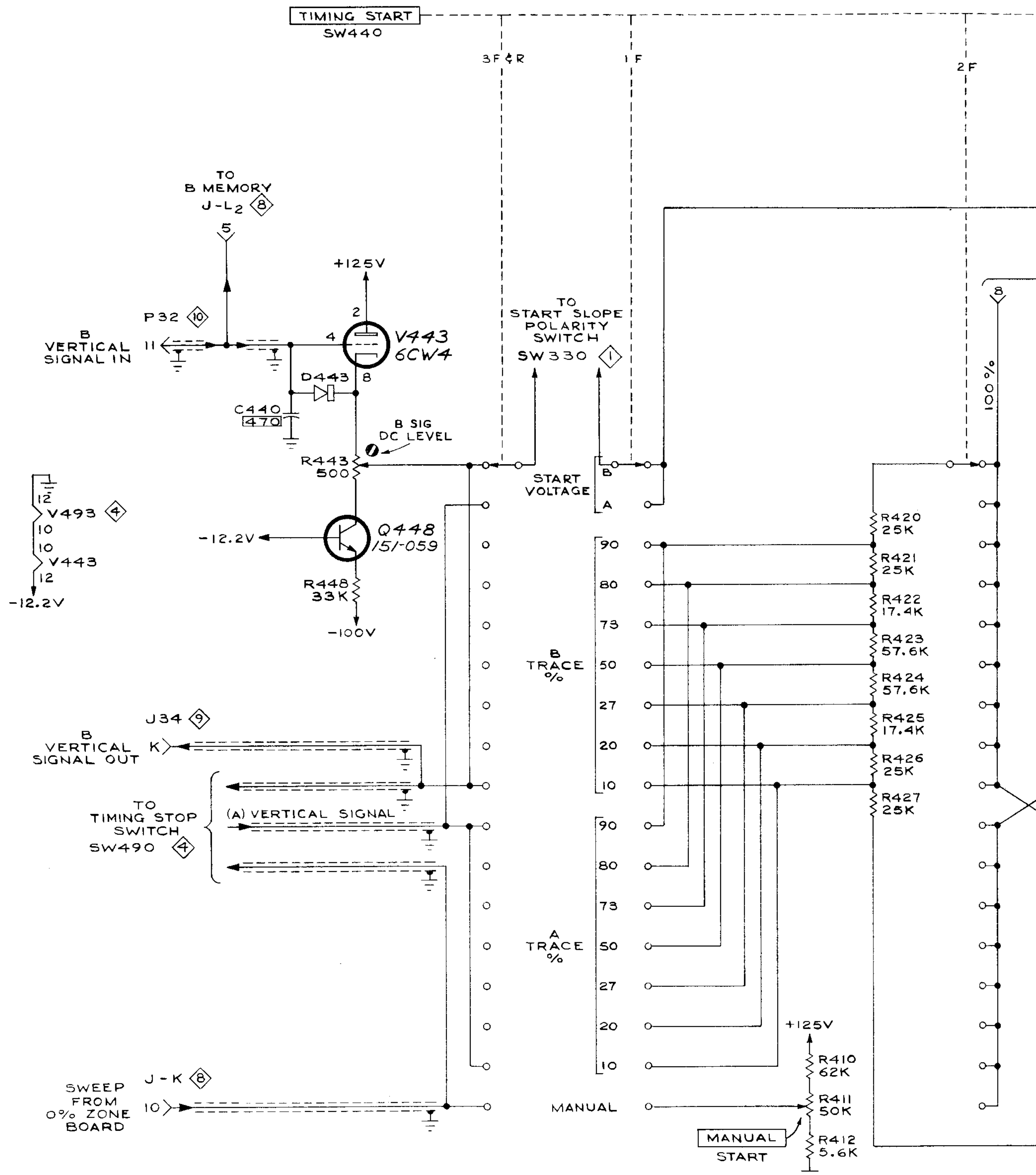
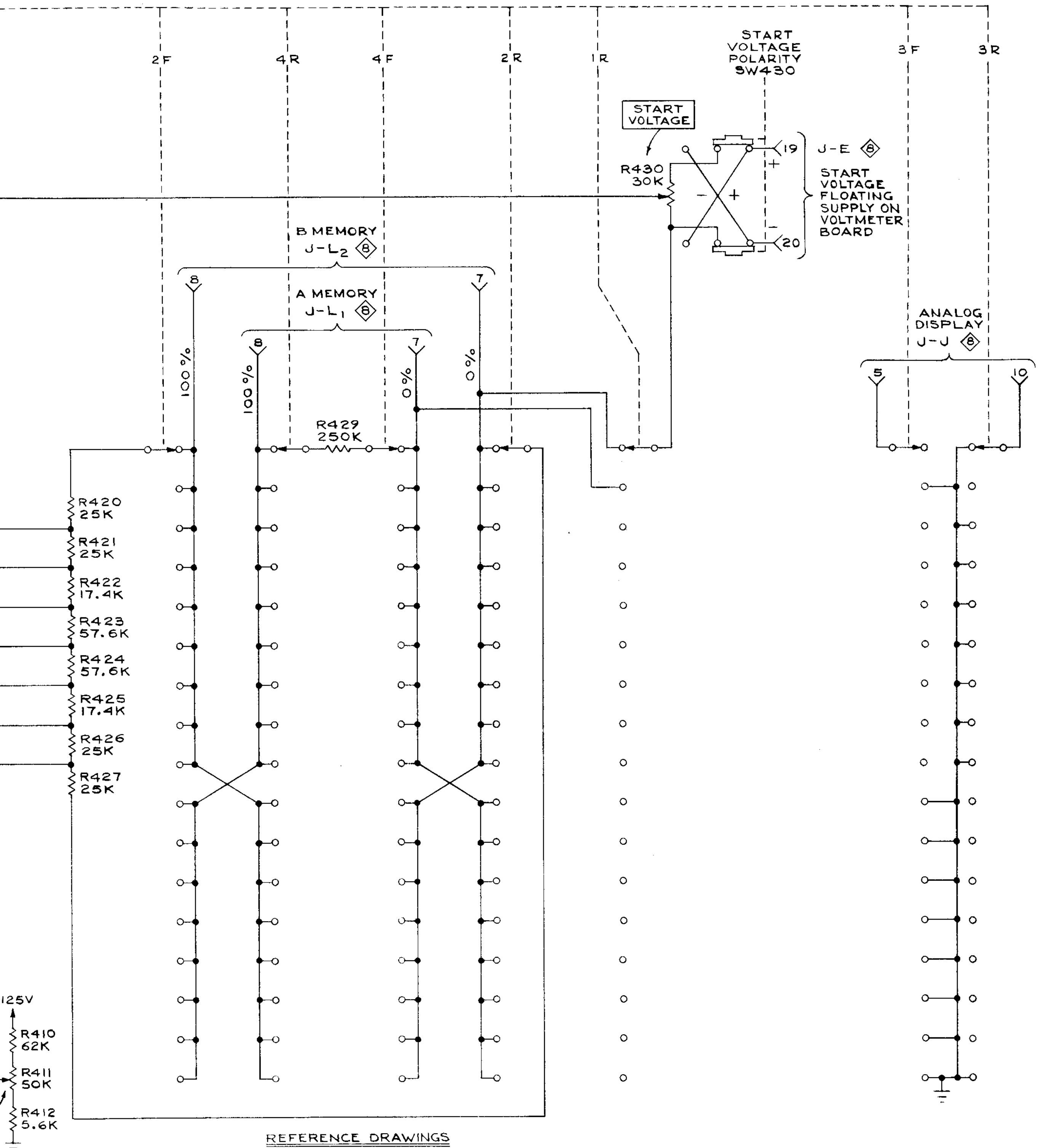
RESOLUTION SWITCH



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

TYPE 6R1

A



REFERENCE DRAWINGS

1 MODE SWITCH

4 TIMING STOP SWITCHING

8 PLUG-IN CIRCUIT BOARD CONNECTORS

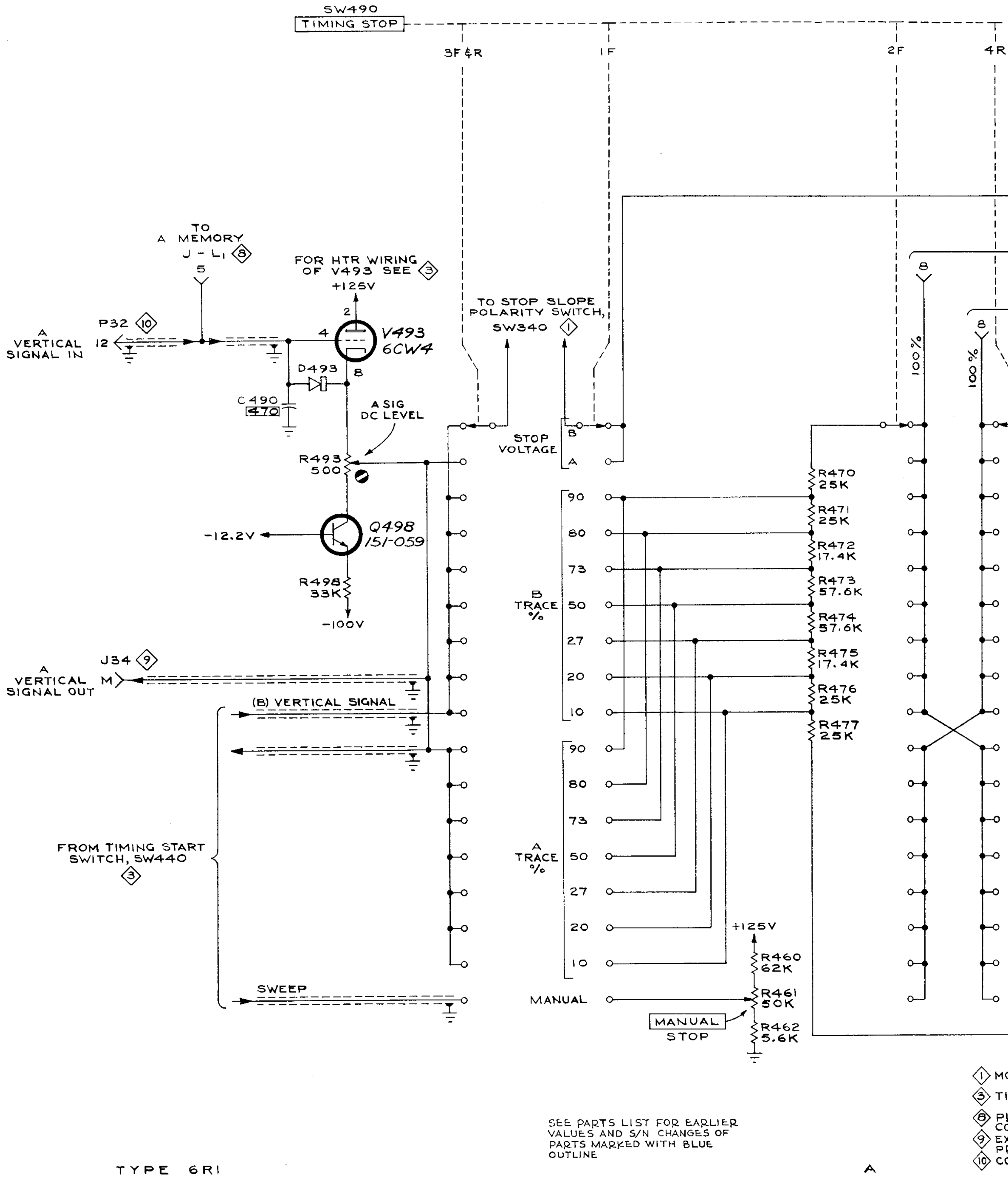
9 EXTERNAL READOUT & PROGRAMMING CONNECTORS

10 CONNECTORS TO INDICATOR UNIT

A

MRH
563

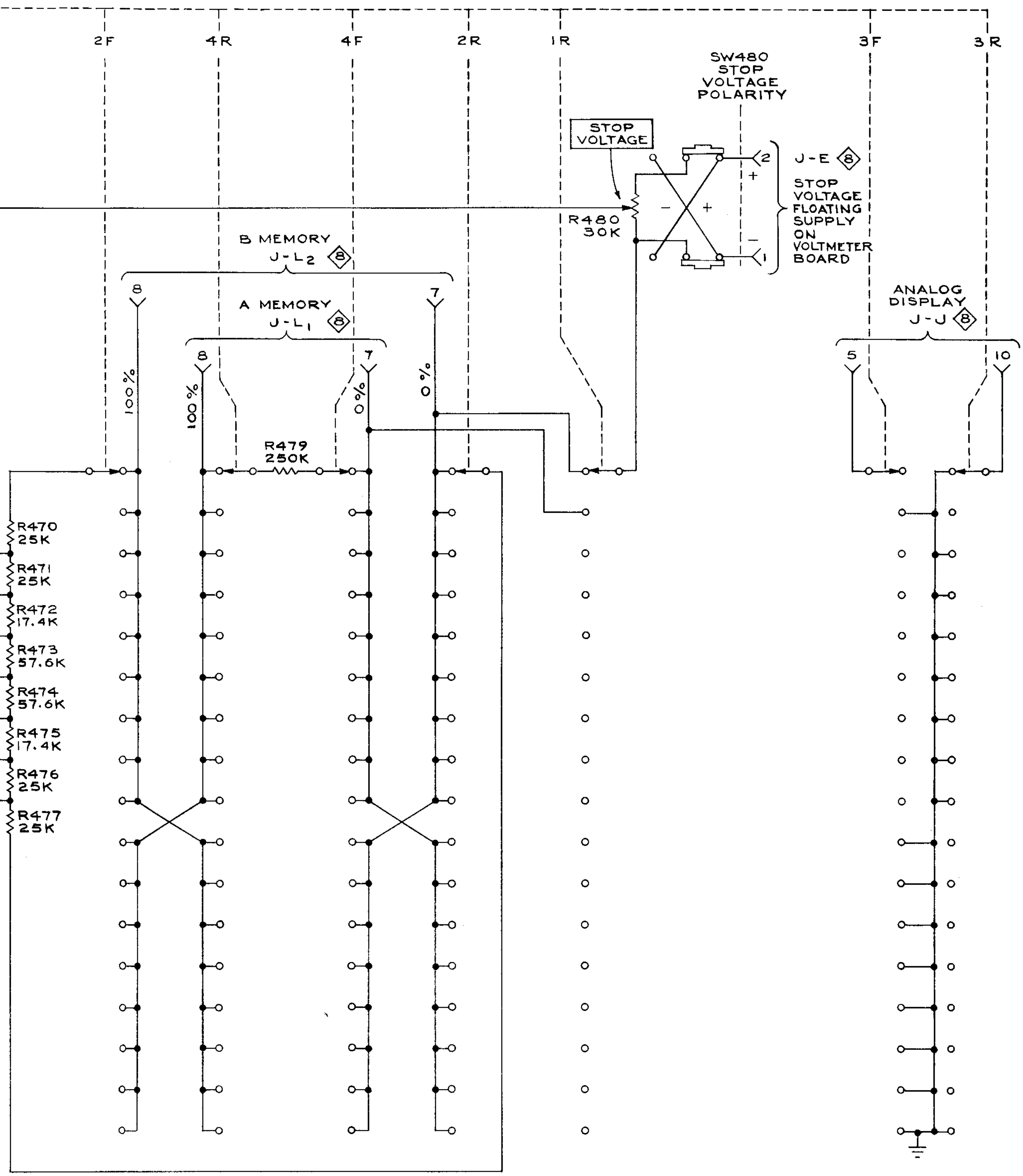
TIMING START SWITCHING



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

TYPE 6R1

A



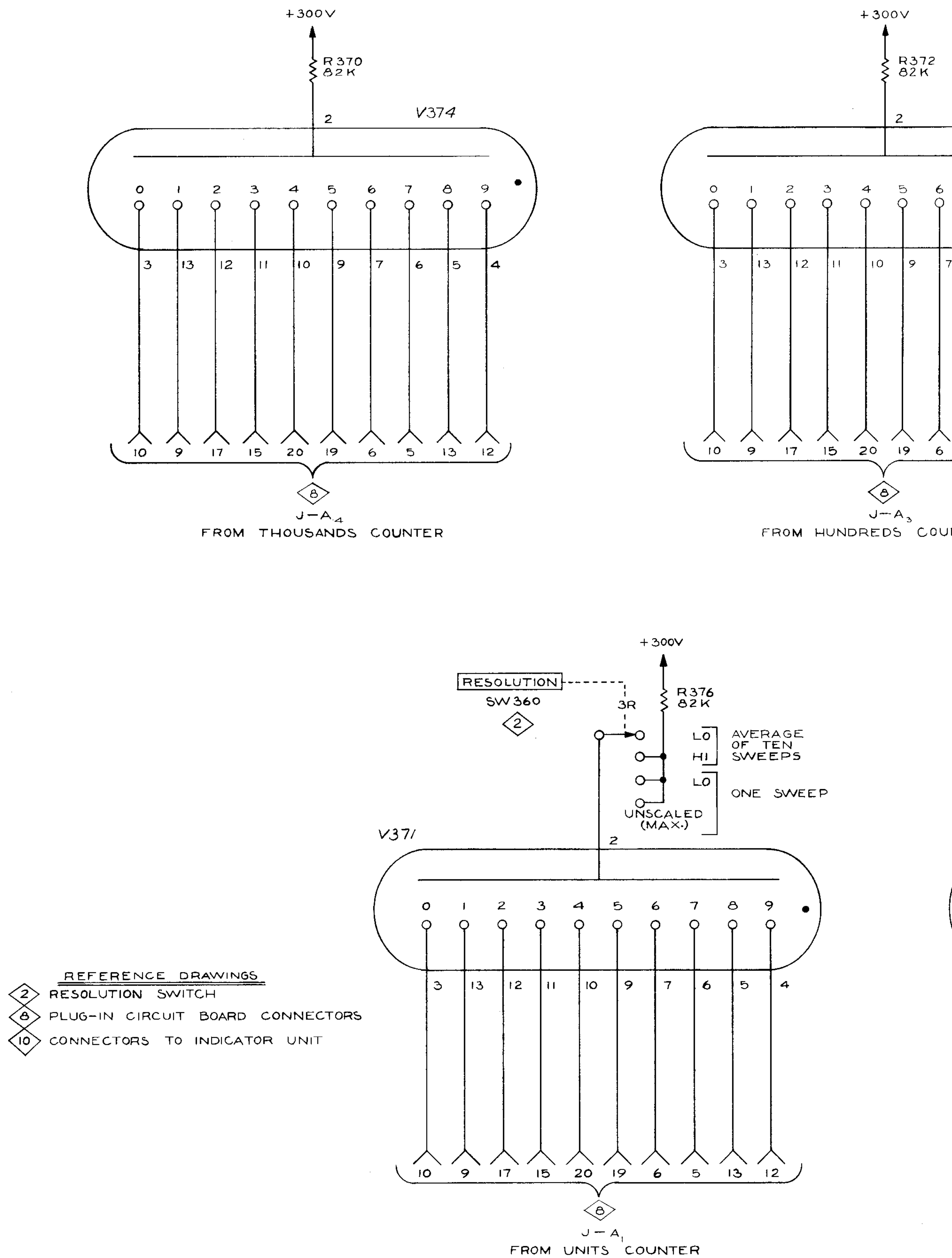
REFERENCE DRAWINGS

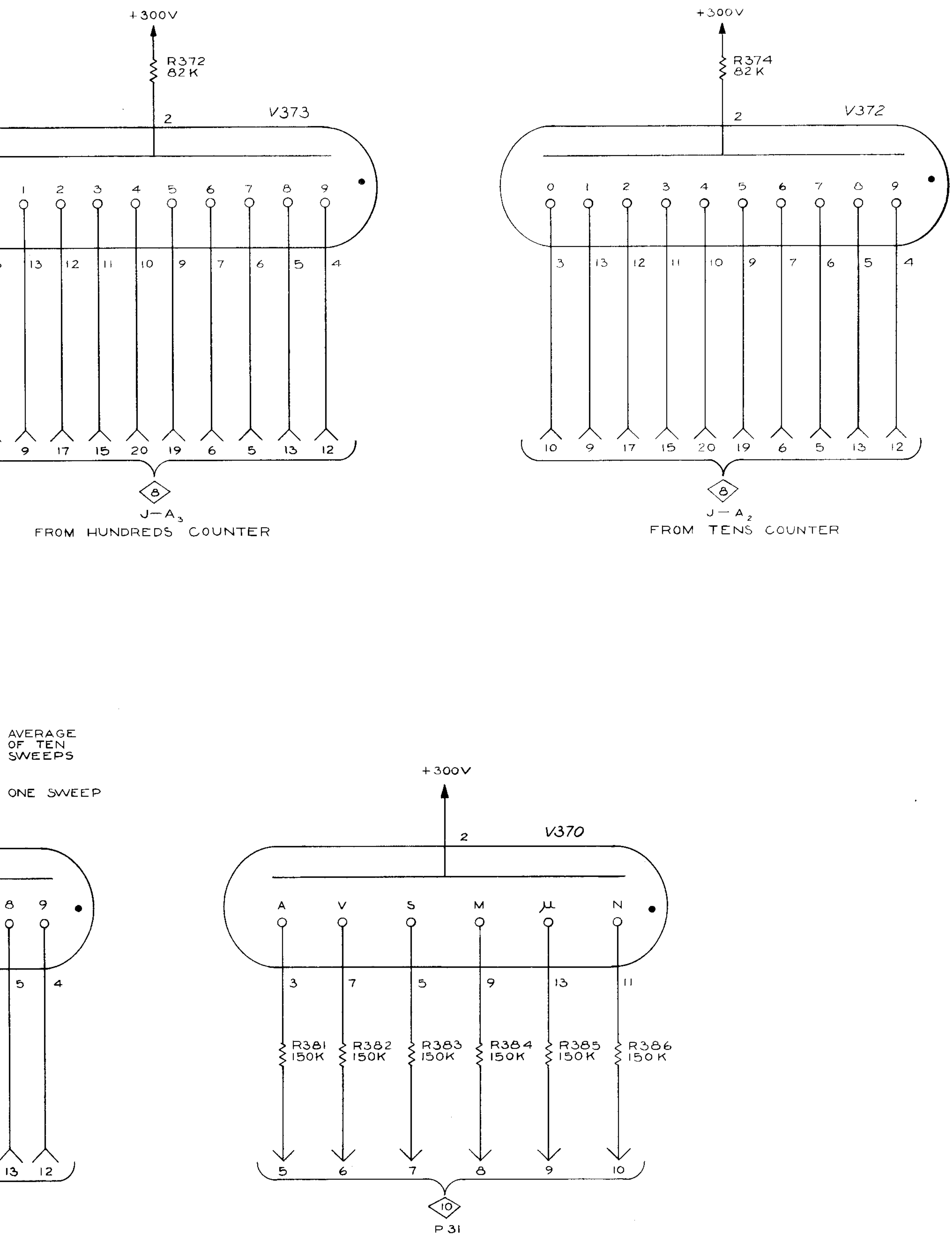
1. MODE SWITCH
3. TIMING START SWITCHING
8. PLUG-IN CIRCUIT BOARD CONNECTORS
9. EXTERNAL READOUT & PROGRAMMING CONNECTORS
10. CONNECTORS TO INDICATOR UNIT

A

MRH
563

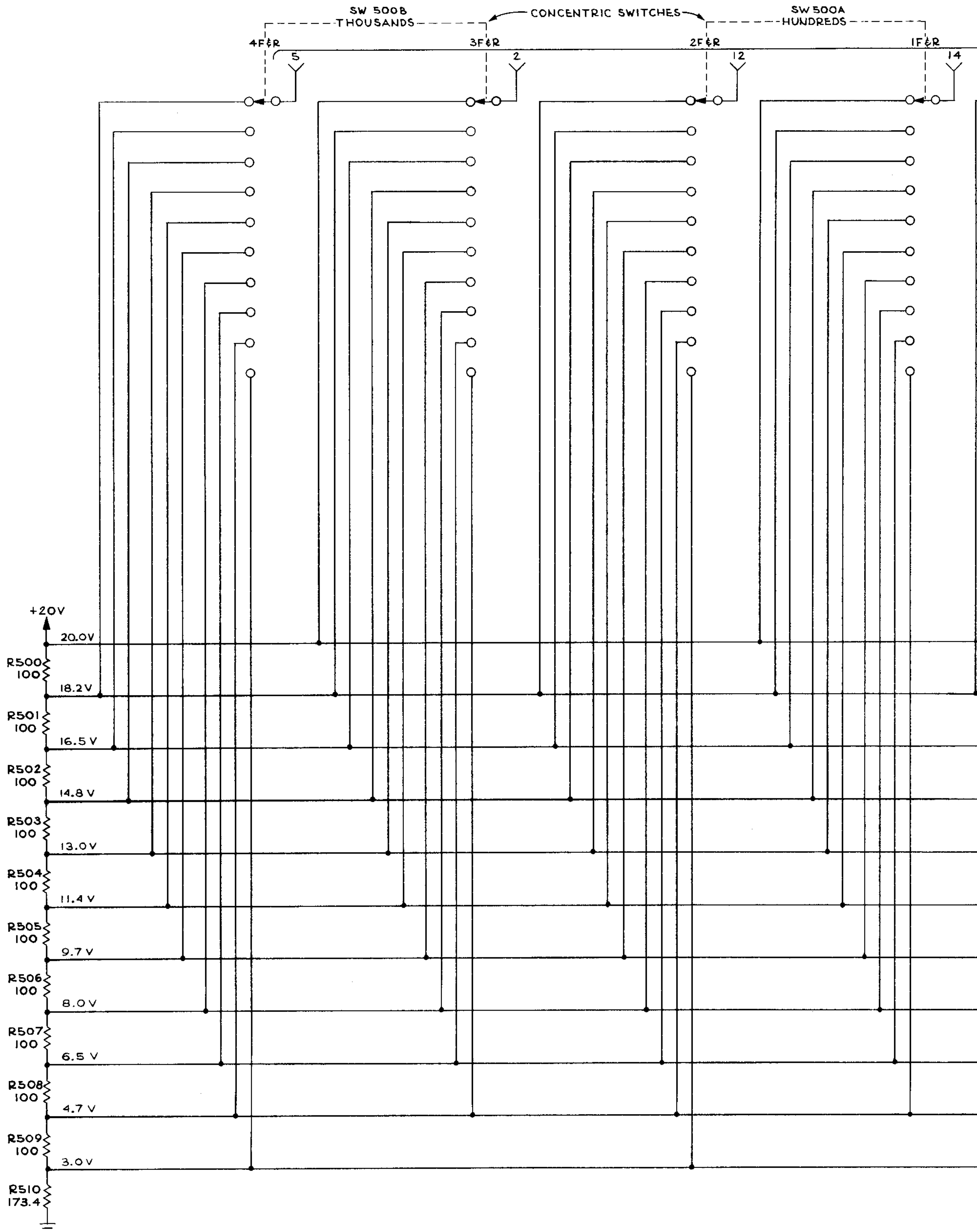
TIMING STOP SWITCHING

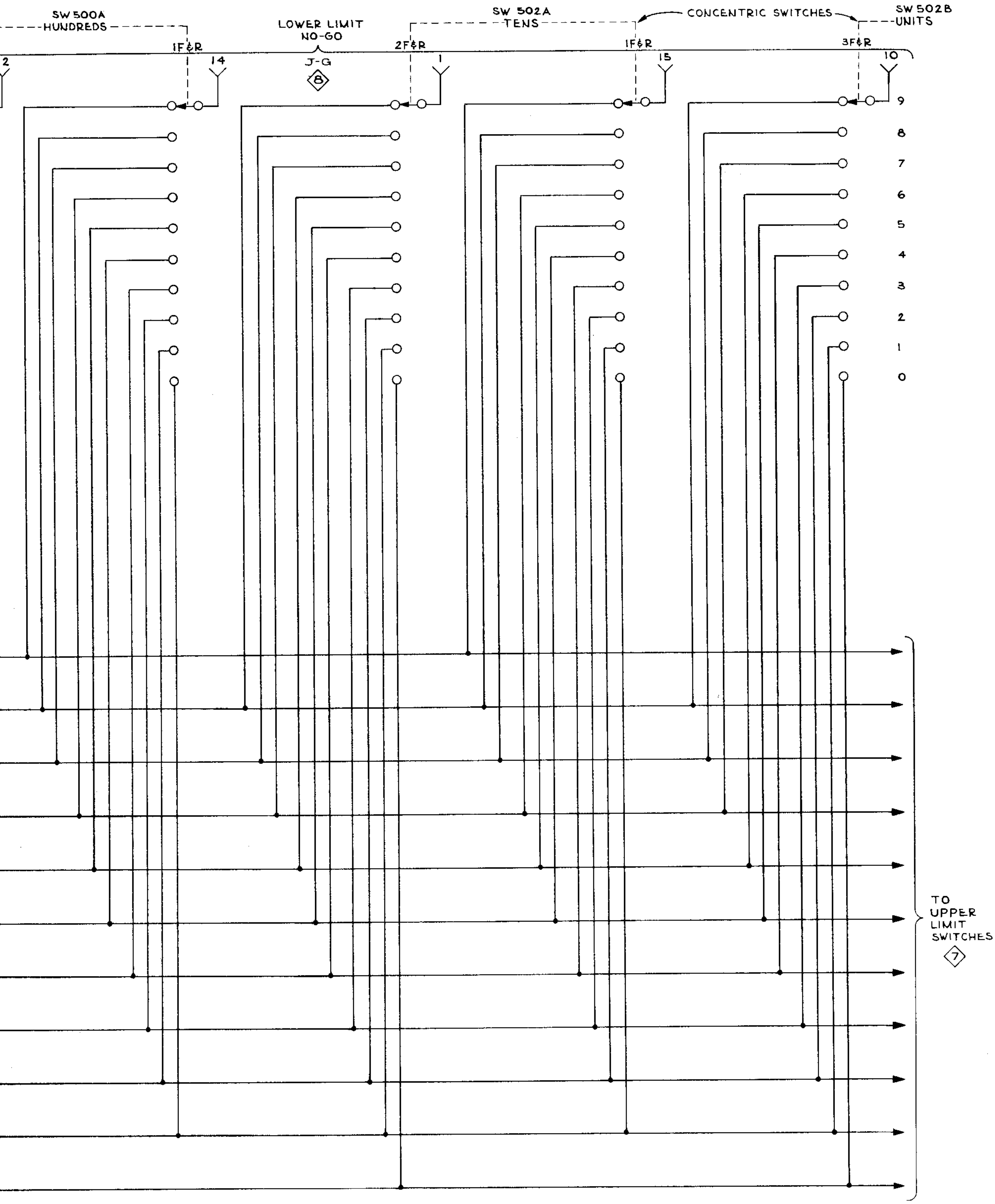

+300V
R370
82K
V374
2
0 1 2 3 4 5 6 7 8 9
3 13 12 11 10 9 7 6 5 4
10 9 17 15 20 19 6 5 13 12
8
J-A4
FROM THOUSANDS COUNTER
+300V
R372
82K
2
0 1 2 3 4 5 6
3 13 12 11 10 9 7
10 9 17 15 20 19 6
8
J-A3
FROM HUNDREDS COU
+300V
RESOLUTION
SW360
2
3R
R376
82K
LO
HI
AVERAGE OF TEN SWEEPS
LO
ONE SWEEP
UNSCALED (MAX.)
V371
2
0 1 2 3 4 5 6 7 8 9
3 13 12 11 10 9 7 6 5 4
10 9 17 15 20 19 6 5 13 12
8
J-A1
FROM UNITS COUNTER
REFERENCE DRAWINGS
2 RESOLUTION SWITCH
8 PLUG-IN CIRCUIT BOARD CONNECTORS
10 CONNECTORS TO INDICATOR UNIT



A

PLM
563
READOUT TUBES


SW 500B
THOUSANDS
CONCENTRIC SWITCHES
SW 500A
HUNDREDS
4F&R
3F&R
2F&R
1F&R
5
2
12
14
+20V
20.0V
18.2V
16.5V
14.8V
13.0V
11.4V
9.7V
8.0V
6.5V
4.7V
3.0V
R500 100
R501 100
R502 100
R503 100
R504 100
R505 100
R506 100
R507 100
R508 100
R509 100
R510 173.4



REFERENCE DRAWINGS

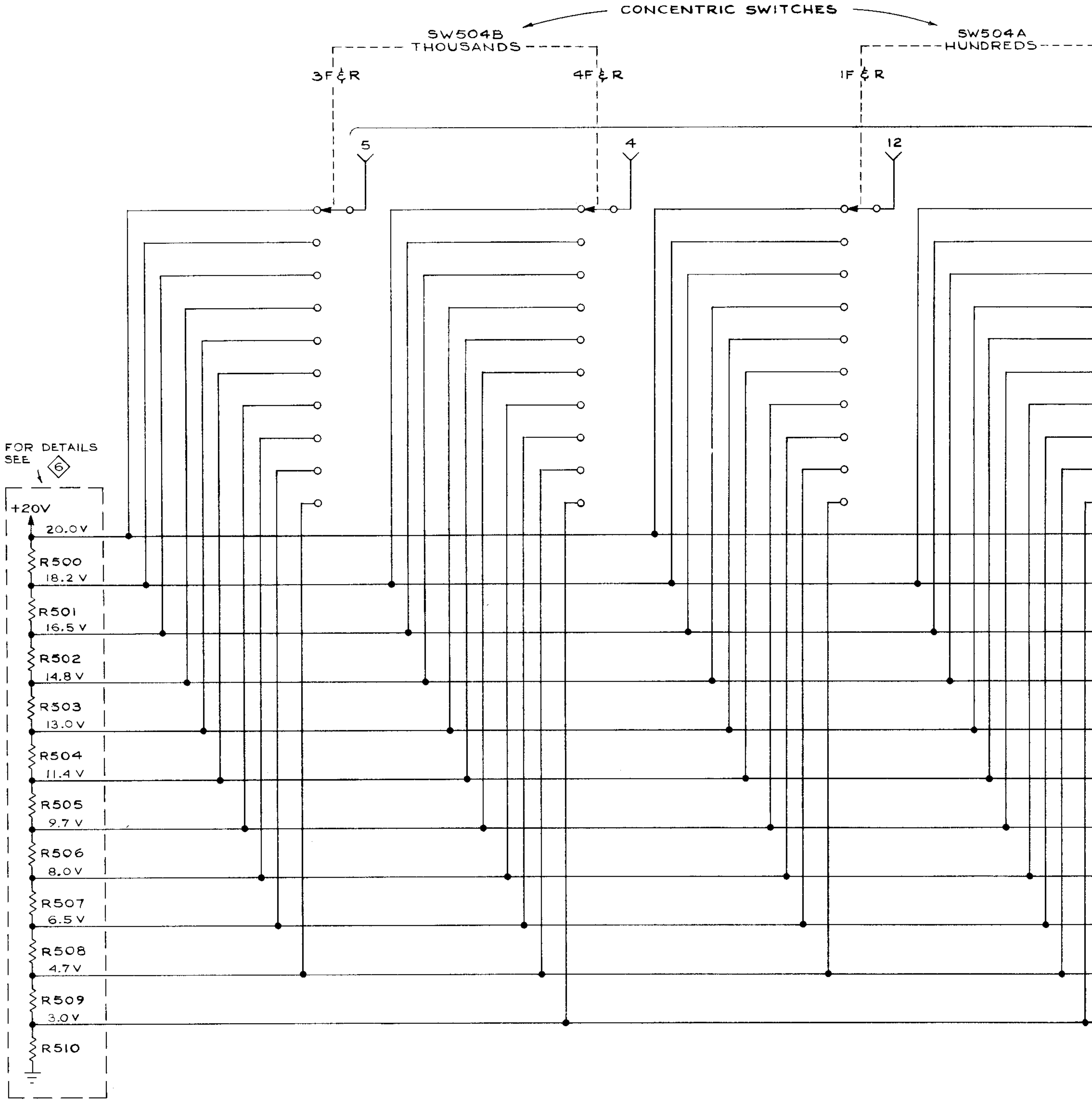
7 UPPER LIMIT SWITCHES

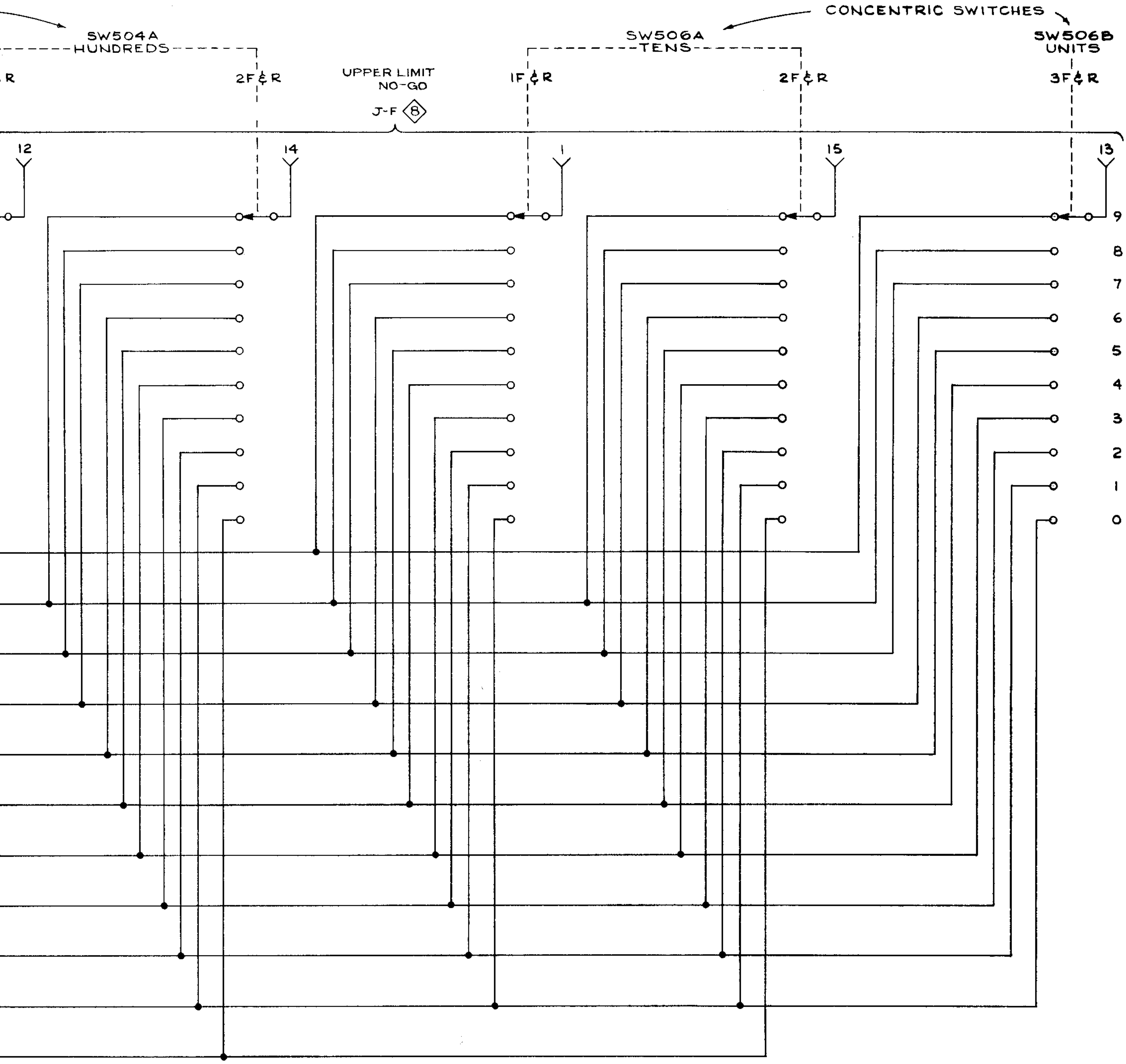
8 PLUG-IN CIRCUIT BOARD CONNECTOR

UN
563

LOWER LIMIT SWITCHES

A


CONCENTRIC SWITCHES
SW504B
THOUSANDS
SW504A
HUNDREDS
3F & R
4F & R
1F & R
5
4
12
FOR DETAILS SEE 6
+20V
20.0 V
R500
18.2 V
R501
16.5 V
R502
14.8 V
R503
13.0 V
R504
11.4 V
R505
9.7 V
R506
8.0 V
R507
6.5 V
R508
4.7 V
R509
3.0 V
R510



REFERENCE DRAWINGS

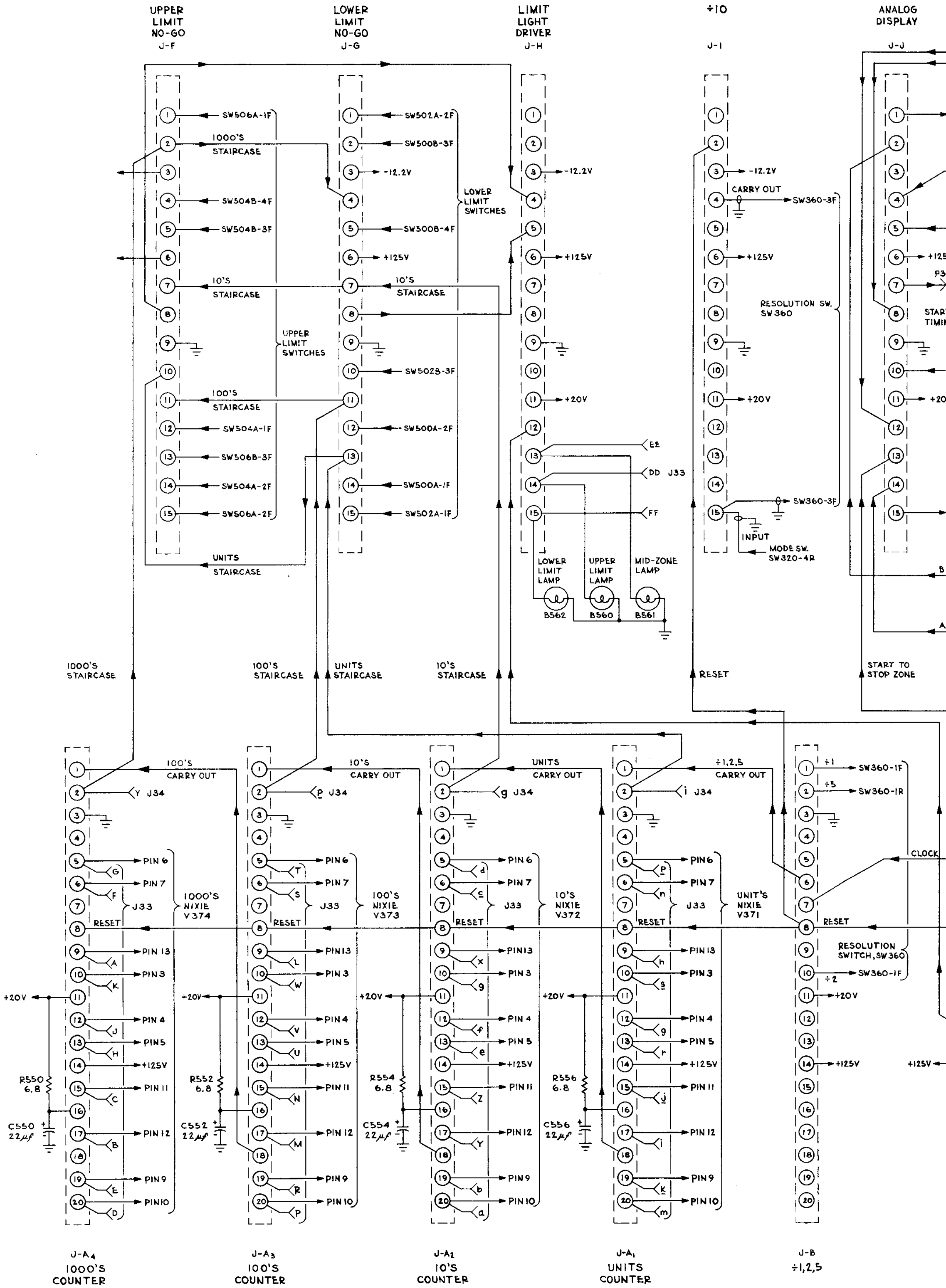
6 LOWER LIMIT SWITCHES

8 PLUG-IN CIRCUIT BOARD CONNECTORS

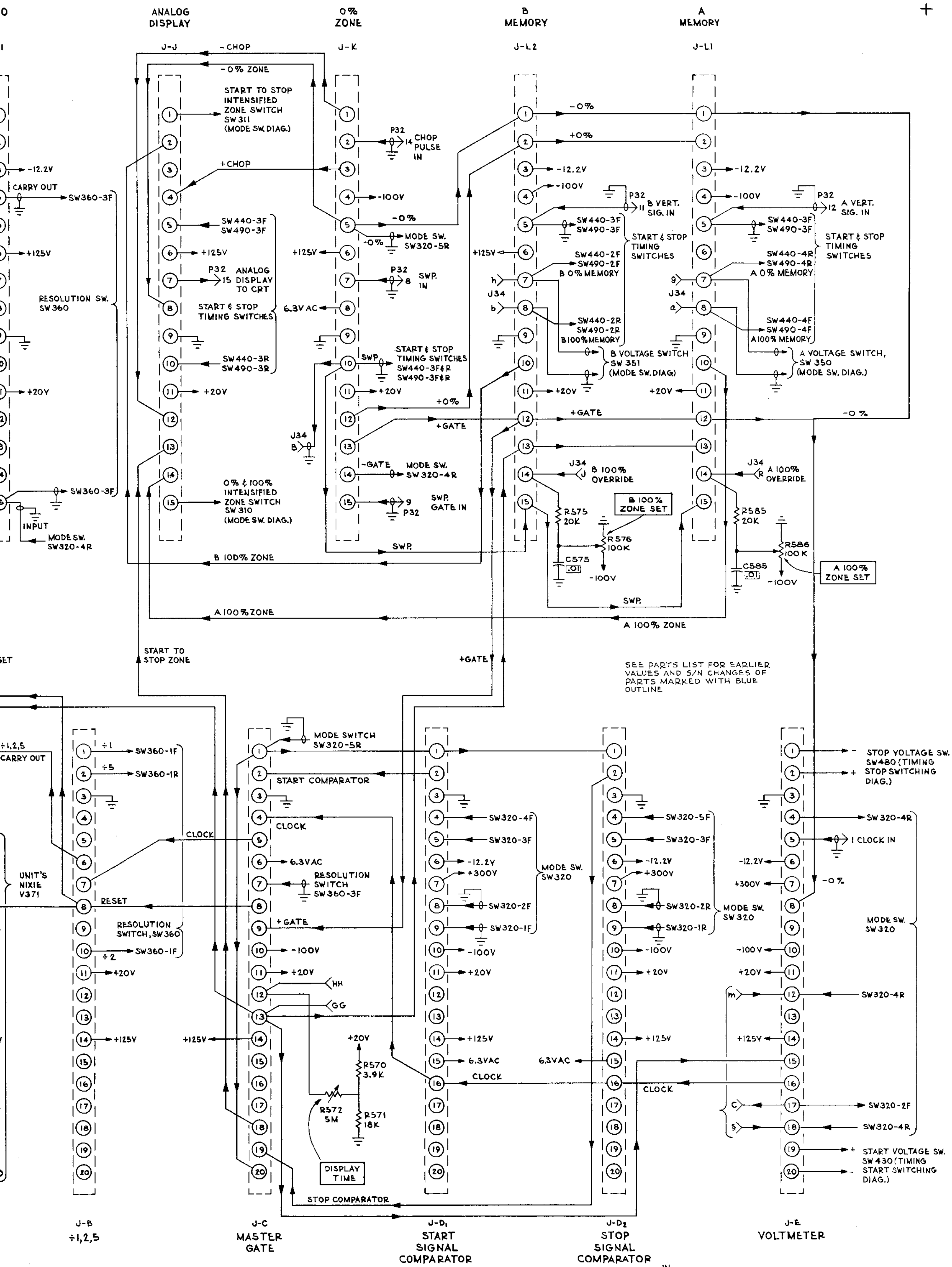
MRH
563

A

UPPER LIMIT SWITCHES

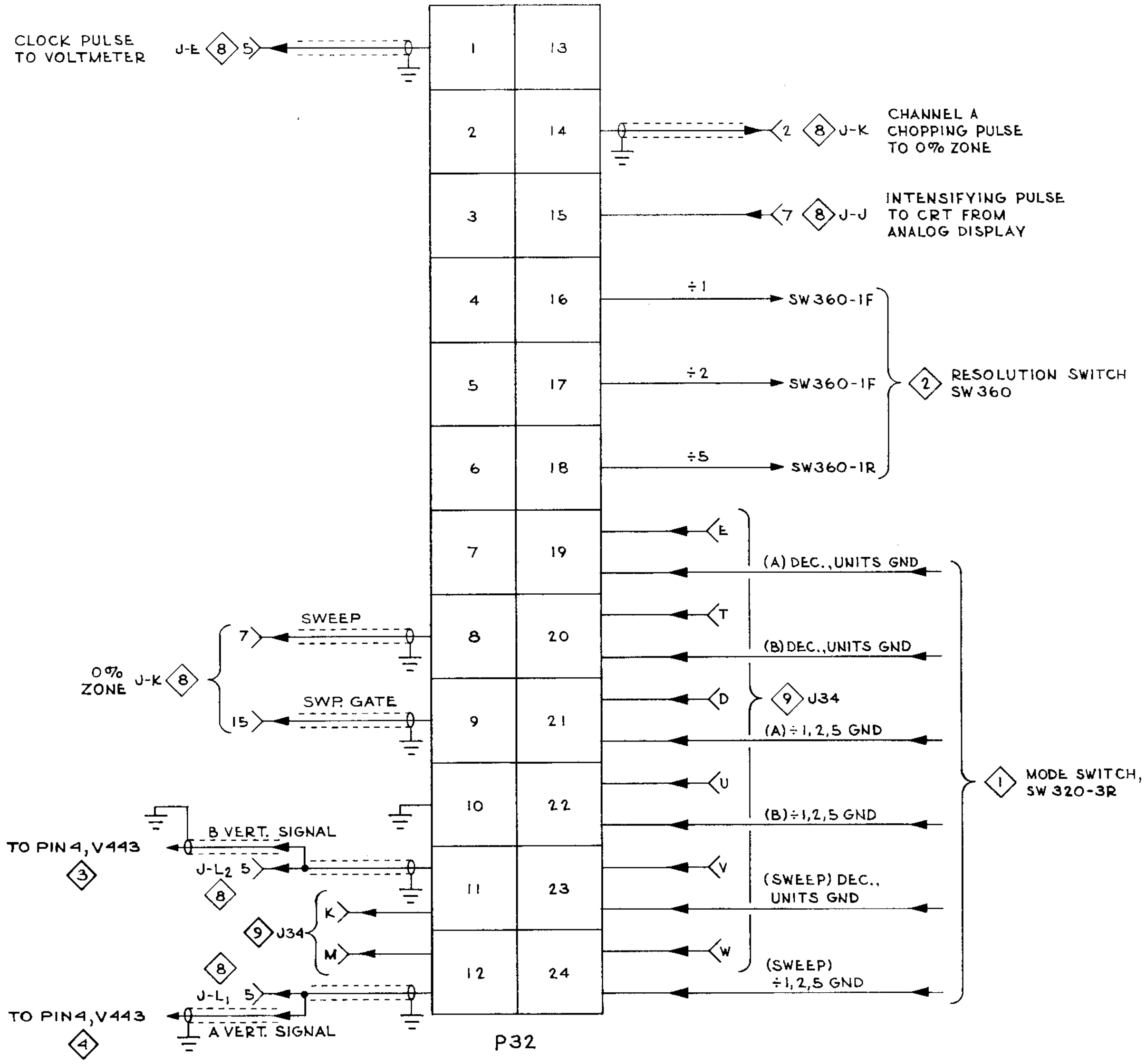


UPPER LIMIT NO-GO J-F
LOWER LIMIT NO-GO J-G
LIMIT LIGHT DRIVER J-H
÷10 J-I
ANALOG DISPLAY J-J
SW506A-1F
1000'S STAIRCASE
SW504B-4F
SW504B-3F
10'S STAIRCASE
UPPER LIMIT SWITCHES
100'S STAIRCASE
SW504A-1F
SW506B-3F
SW504A-2F
SW506A-2F
UNITS STAIRCASE
SW502A-2F
SW500B-3F
-12.2V
LOWER LIMIT SWITCHES
SW500B-4F
+125V
SW502B-3F
SW500A-2F
SW500A-1F
SW502A-1F
+20V
EE
DD J33
FF
LOWER LIMIT LAMP
UPPER LIMIT LAMP
MID-ZONE LAMP
B562
B560
B561
CARRY OUT
SW360-3F
RESOLUTION SW. SW360
INPUT
MODE SW. SW320-4R
START TO STOP ZONE
RESET
CLOCK
100'S CARRY OUT
10'S CARRY OUT
UNITS CARRY OUT
÷1,2,5 CARRY OUT
Y J34
P J34
g J34
i J34
PIN 6
PIN 7
J33
1000'S NIXIE V374
100'S NIXIE V373
10'S NIXIE V372
UNIT'S NIXIE V371
PIN 13
PIN 3
PIN 4
PIN 5
PIN 11
PIN 12
PIN 9
PIN 10
R550 6.8
R552 6.8
R554 6.8
R556 6.8
C550 22μf
C552 22μf
C554 22μf
C556 22μf
SW360-1F
SW360-1R
RESOLUTION SWITCH, SW360
J-A4 1000'S COUNTER
J-A3 100'S COUNTER
J-A2 10'S COUNTER
J-A1 UNITS COUNTER
J-B ÷1,2,5



JN 563
PLUG-IN CIRCUIT BOARD CONNECTORS

A



P3

REFERENCE DRA

1 MODE SWITCH

2 RESOLUTION

3 TIMING STAR

5 READOUT T

8 PLUG-IN CIR

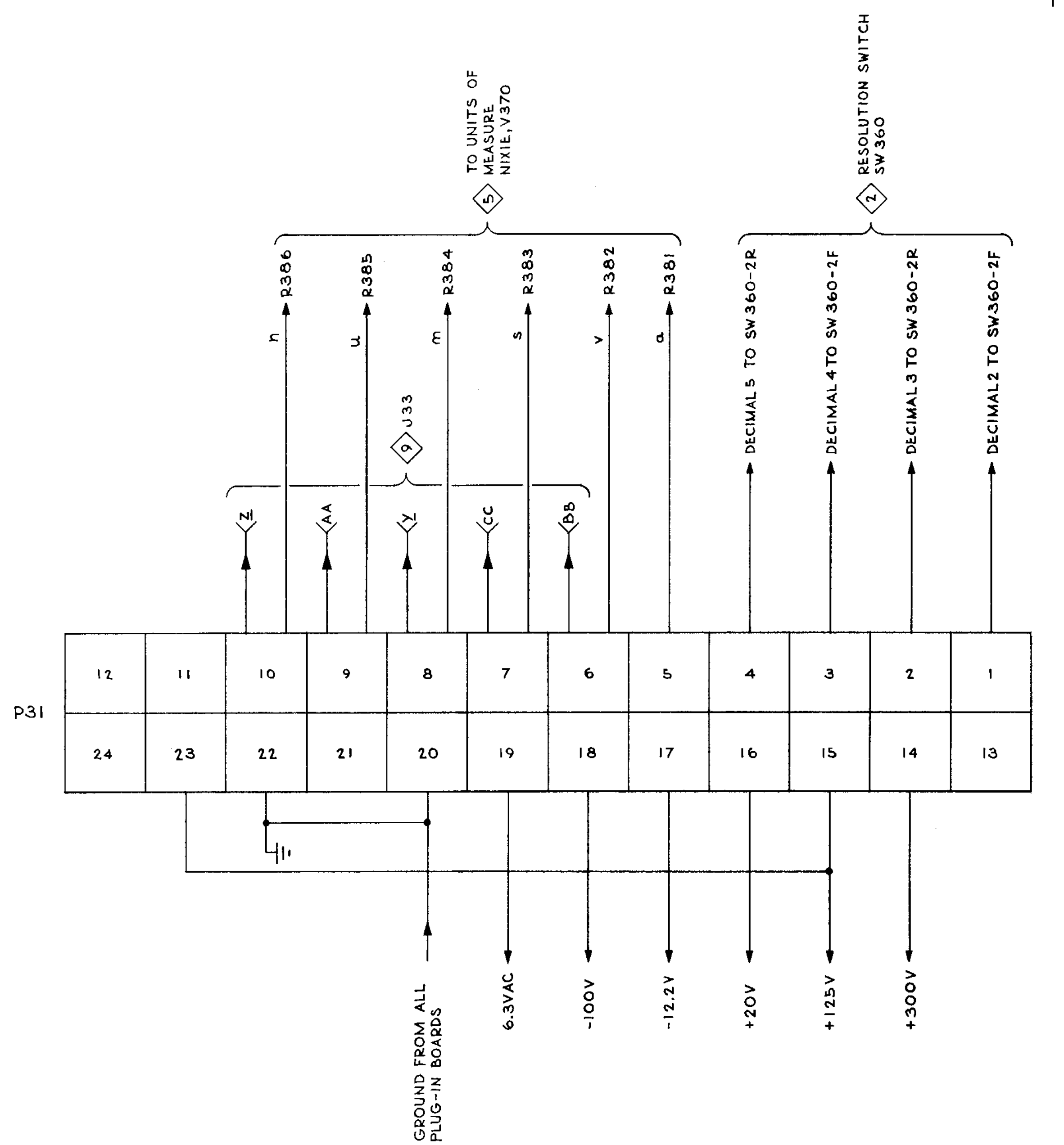
9 EXTERNAL R

4 TIMING STO

ULSE

TION SWITCH

MODE SWITCH,
SW 320-3R



REFERENCE DRAWINGS:

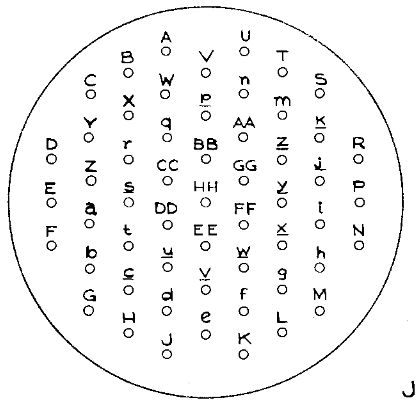
- 1 MODE SWITCH
- 2 RESOLUTION SWITCH
- 3 TIMING START SWITCHING
- 5 READOUT TUBES
- 8 PLUG-IN CIRCUIT BOARD CONNECTORS
- 9 EXTERNAL READOUT & PROGRAMMING CONNECTORS
- 4 TIMING STOP SWITCHING

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

JN
563

A

CONNECTORS TO INDICATOR UNIT

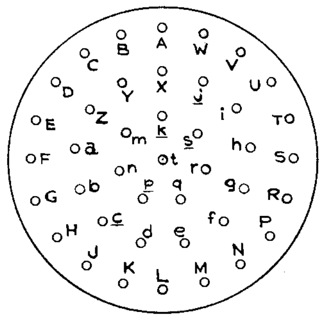


EXTERNAL
READOUT

J33

A	1000'S – 1,	PIN 9,	J – A4	⟨8⟩
B	" 2,	" 17,	"	
C	" 3,	" 15,	"	
D	" 4,	" 20,	"	
E	" 5,	" 19,	"	
F	" 6,	" 6,	"	
G	" 7,	" 5,	"	
H	" 8,	" 13,	"	
J	" 9,	" 12,	"	
K	" 0,	" 10,	"	
L	100'S – 1,	PIN 9,	J – A3	⟨8⟩
M	" 2,	" 17,	"	
N	" 3,	" 15,	"	
P	" 4,	" 20,	"	
R	" 5,	" 19,	"	
S	" 6,	" 6,	"	
T	" 7,	" 5,	"	
U	" 8,	" 13,	"	
V	" 9,	" 12,	"	
W	" 0,	" 10,	"	
X	10'S – 1,	PIN 9,	J – A2	⟨8⟩
Y	" 2,	" 17,	"	
Z	" 3,	" 15,	"	
a	" 4,	" 20,	"	
b	" 5,	" 19,	"	
c	" 6,	" 6,	"	
d	" 7,	" 5,	"	
e	" 8,	" 13,	"	

f	10'S – 9,	PIN 12,	J – A2	⟨8⟩
g	" 0	" 10,	"	
h	1'S – 1,	PIN 9,	J – A1	⟨8⟩
i	" 2,	" 17,	"	
j	" 3,	" 15,	"	
k	" 4,	" 20,	"	
m	" 5,	" 19,	"	
n	" 6,	" 6,	"	
p	" 7,	" 5,	"	
q	" 8,	" 13,	"	
r	" 9,	" 12,	"	
s	" 0,	" 10,	"	
t	DECIMAL 1	FROM	SW360 – 2F	⟨2⟩
u	" 2	"	" 2F & R	⟨2⟩
v	" 3	"	" 2R & F	⟨2⟩
w	" 4	"	" 2R & F	⟨2⟩
x	" 5	"	" 2R	⟨2⟩
y	m FROM	PIN 8,	P31	⟨10⟩
z	n "	" 10,	"	
AA	u "	" 9,	"	
BB	v "	" 6,	"	
CC	s "	" 7,	"	
DD	NO-GO UPPER LIMIT	FROM PIN 14,	J-H	⟨8⟩
EE	" MID-ZONE	" " 13,	"	
FF	" LOWER LIMIT	" " 15,	"	
GG	PRINT COMMAND	FROM PIN 13,	J-C	⟨8⟩
HH	DISPLAY TIME	FROM PIN 12,	J-C	⟨8⟩



EXTERNAL
PROGRAMMING

J34

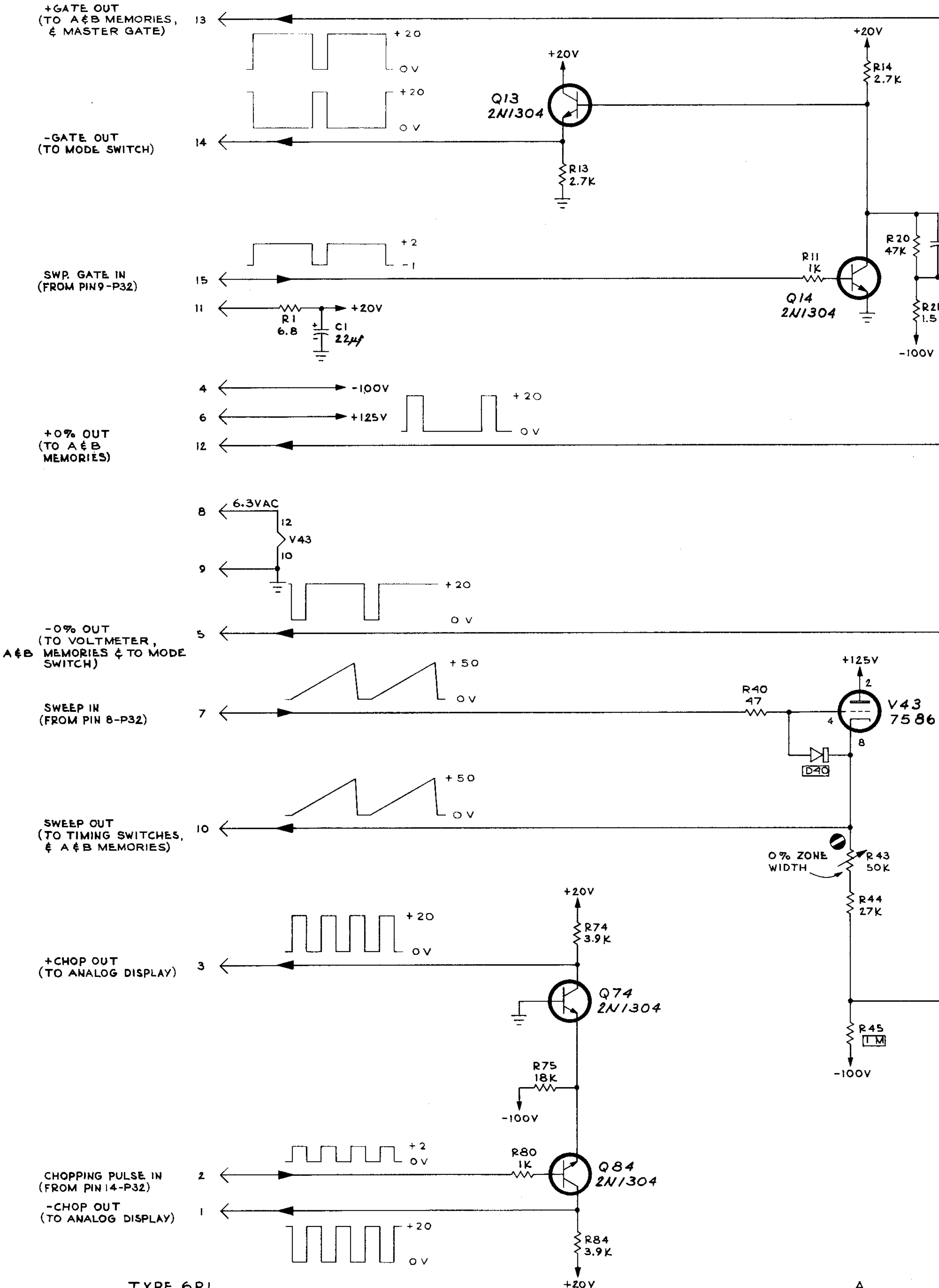
A	GROUND	
B	SWEEP OUT FROM PIN 10, J-K	⟨8⟩
C	VOLTMETER RAMP FROM PIN 17, J-E	⟨8⟩
D	A VERT. ÷1, 2, 5 GND TO PIN 21, P32	⟨10⟩
E	A VERT. DEC., UNITS GND TO PIN 19, P32	⟨10⟩
F	-STOP COMPARATOR TO SW320-1R	⟨1⟩
G	+20V	
H	-START COMPARATOR TO SW320-1R	⟨1⟩
J	B 100% OVERRIDE TO PIN 14, $J-L_2$	⟨8⟩
K	B SIGNAL FROM START, SW440-3F & R	⟨3⟩
L	DEC., UNITS RETURN FROM SW320-3R	⟨1⟩
M	A SIGNAL FROM STOP SW490-3F & R	⟨4⟩
N	÷1, 2, 5 RETURN FROM SW320-3R	⟨1⟩
P	+ START COMPARATOR TO SW320-2F	⟨1⟩
R	A 100% OVERRIDE TO PIN 14, $J-L_1$	⟨8⟩
S	+ STOP COMPARATOR TO SW320-2R	⟨1⟩
T	B VERT. DEC., UNITS GND TO PIN 20, P32	⟨10⟩
U	B VERT. ÷1, 2, 5 GND TO PIN 22, P32	⟨10⟩
V	HORIZ. DEC., UNITS GND TO PIN 23, P32	⟨10⟩
W	HORIZ. ÷1, 2, 5 GND TO PIN 24, P32	⟨10⟩
X	SPARE	
Y	1000'S STAIRCASE FROM PIN 2, $J-A_4$	⟨8⟩
Z	SPARE	

a	100% A MEMORY FROM PIN 8, $J-L_1$	⟨8⟩
b	100% B MEMORY FROM PIN 8, $J-L_2$	⟨8⟩
c	1ST START SLOPE TO SW320-4F	⟨1⟩
d	2ND START SLOPE TO SW320-3F	⟨1⟩
e	1ST STOP SLOPE TO SW320-5F	⟨1⟩
f	2ND STOP SLOPE TO SW320-3F	⟨1⟩
g	0% A MEMORY FROM PIN 7, $J-L_1$	⟨8⟩
h	0% B MEMORY FROM PIN 7, $J-L_2$	⟨8⟩
i	SPARE	
j	1'S STAIRCASE FROM PIN 2, $J-A_1$	⟨8⟩
k	SPARE	
m	TIME CLOCK TO PIN 12, J-E	⟨8⟩
n	SPARE	⟨8⟩
p	100'S STAIRCASE FROM PIN 2, $J-A_3$	⟨8⟩
q	10'S STAIRCASE FROM PIN 2, $J-A_2$	⟨8⟩
r	SPARE	
s	VOLTMETER OSC TO PIN 18, J-E	⟨8⟩
t	VOLTMETER OSC, TIME CLOCK RETURN FROM SW320-4R	⟨1⟩

REFERENCE DRAWINGS
- ⟨3⟩ TIMING START SWITCHING
- ⟨4⟩ TIMING STOP SWITCHING
- ⟨1⟩ MODE SWITCH
- ⟨2⟩ RESOLUTION SWITCH
- ⟨8⟩ PLUG-IN CIRCUIT BOARD CONNECTORS
- ⟨10⟩ CONNECTOR TO INDICATOR UNIT

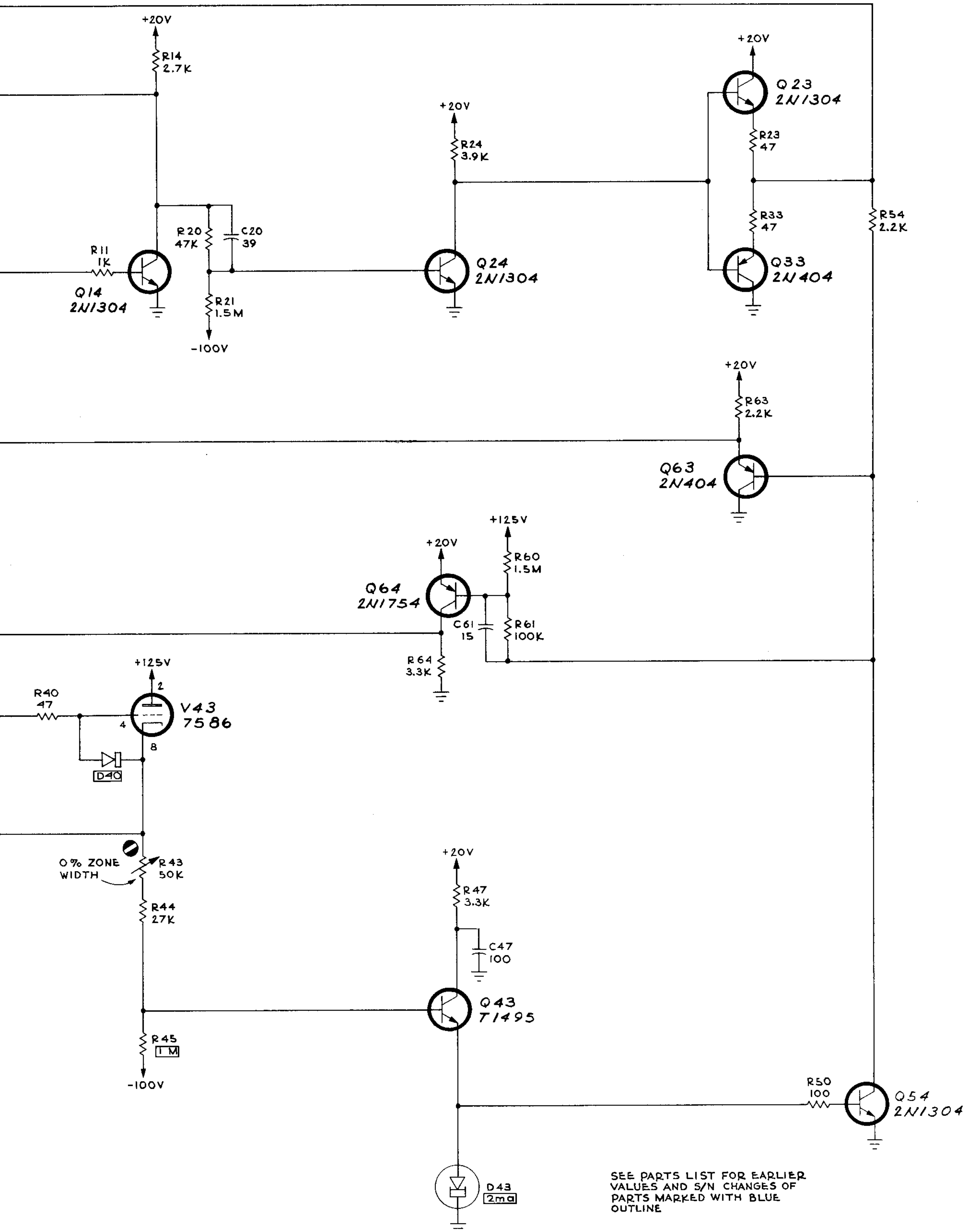
MRH
563

EXTERNAL READOUT & PROGRAMMING CONNECTORS


+GATE OUT
(TO A & B MEMORIES, & MASTER GATE)
13
+20
OV
+20
OV
+20V
Q13
2N1304
-GATE OUT
(TO MODE SWITCH)
14
R13
2.7K
+20V
R14
2.7K
R20
47K
+2
-1
SWP. GATE IN
(FROM PIN9-P32)
15
R11
1K
Q14
2N1304
11
R1
6.8
+20V
C1
22μf
R21
1.5
-100V
4
-100V
6
+125V
+20
OV
+0% OUT
(TO A & B MEMORIES)
12
8
6.3VAC
12
V43
10
9
+20
OV
-0% OUT
(TO VOLTMETER, A & B MEMORIES & TO MODE SWITCH)
5
+125V
+50
OV
SWEEP IN
(FROM PIN 8-P32)
7
R40
47
2
V43
7586
4
8
D40
+50
OV
SWEEP OUT
(TO TIMING SWITCHES, & A & B MEMORIES)
10
0% ZONE WIDTH
R43
50K
R44
27K
+20V
R74
3.9K
+20
OV
+CHOP OUT
(TO ANALOG DISPLAY)
3
Q74
2N1304
R45
1M
-100V
R75
18K
-100V
+2
OV
R80
1K
CHOPPING PULSE IN
(FROM PIN 14-P32)
2
Q84
2N1304
-CHOP OUT
(TO ANALOG DISPLAY)
1
+20
OV
R84
3.9K
+20V

TYPE 6R1

A



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

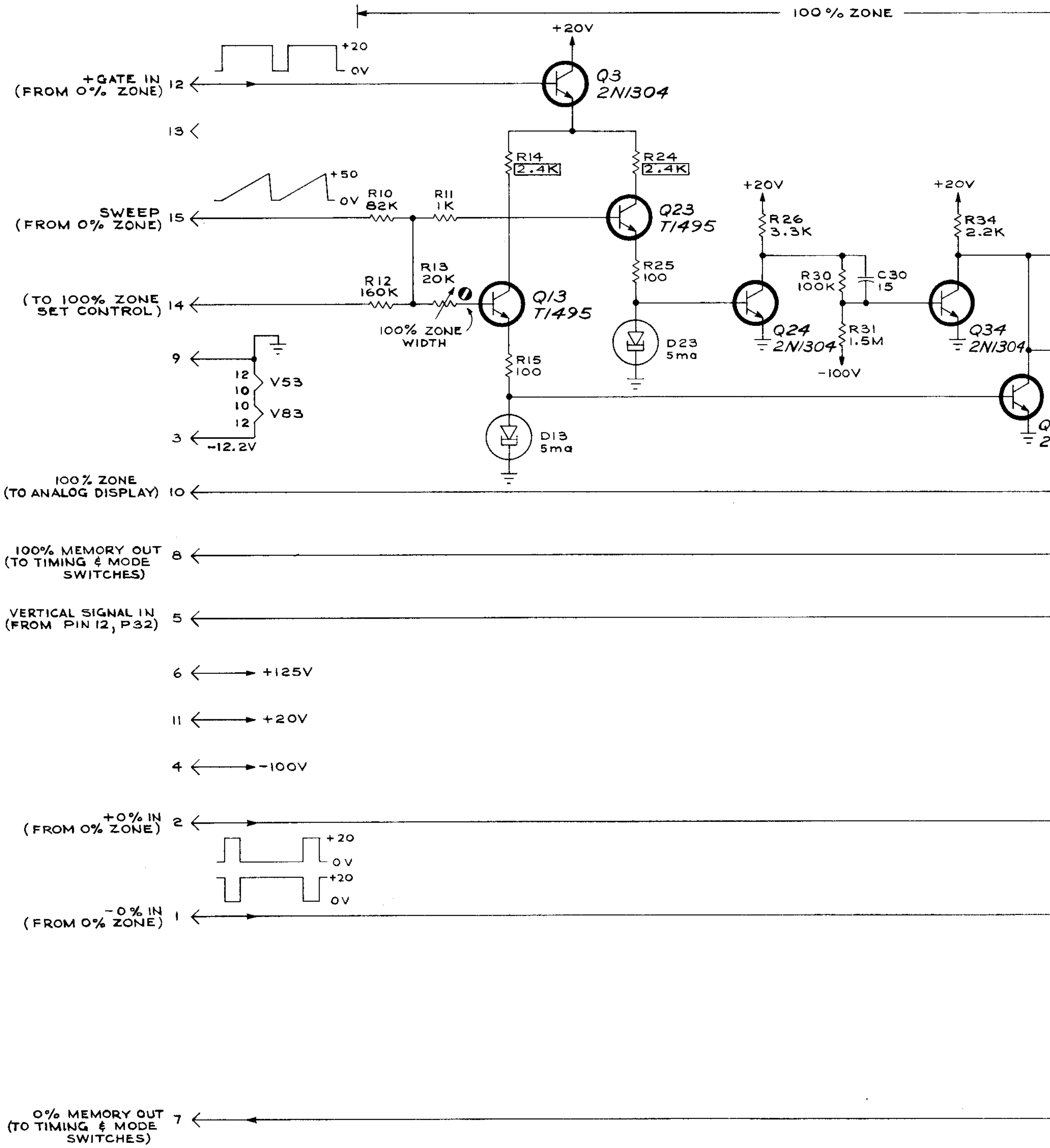
NOTE
ON SOME CIRCUIT BOARDS, A LETTER FOLLOWING THE MODEL NUMBER INDICATES A CHANGE AFFECTING ONLY THE BOARD DESIGNATED BY THIS LETTER.

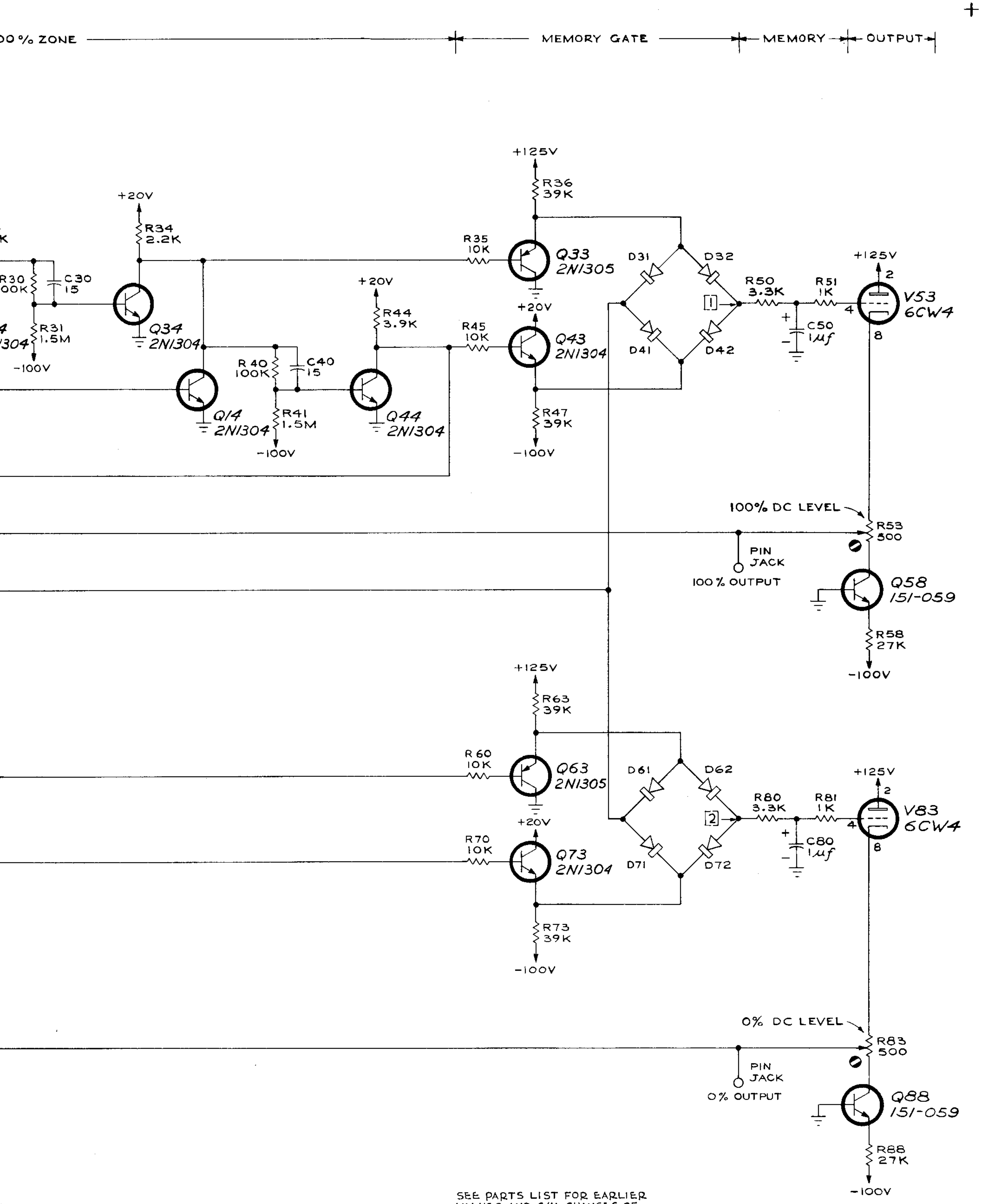
A

JN
563

0% ZONE

SERIES K MODELS 1,2,3,4


100 % ZONE
+20V
+20
0V
+GATE IN
(FROM 0% ZONE)
Q3
2N1304
R14
2.4K
R24
2.4K
+50
0V
R10
82K
R11
1K
SWEEP
(FROM 0% ZONE)
Q23
T1495
R26
3.3K
R34
2.2K
R13
20K
R25
100
R30
100K
C30
15
R12
160K
(TO 100% ZONE
SET CONTROL)
Q13
T1495
100% ZONE
WIDTH
D23
5ma
Q24
2N1304
R31
1.5M
-100V
Q34
2N1304
R15
100
V53
V83
-12.2V
D13
5ma
100% ZONE
(TO ANALOG DISPLAY)
100% MEMORY OUT
(TO TIMING & MODE
SWITCHES)
VERTICAL SIGNAL IN
(FROM PIN 12, P32)
+125V
+20V
-100V
+0% IN
(FROM 0% ZONE)
-0% IN
(FROM 0% ZONE)
0% MEMORY OUT
(TO TIMING & MODE
SWITCHES)



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

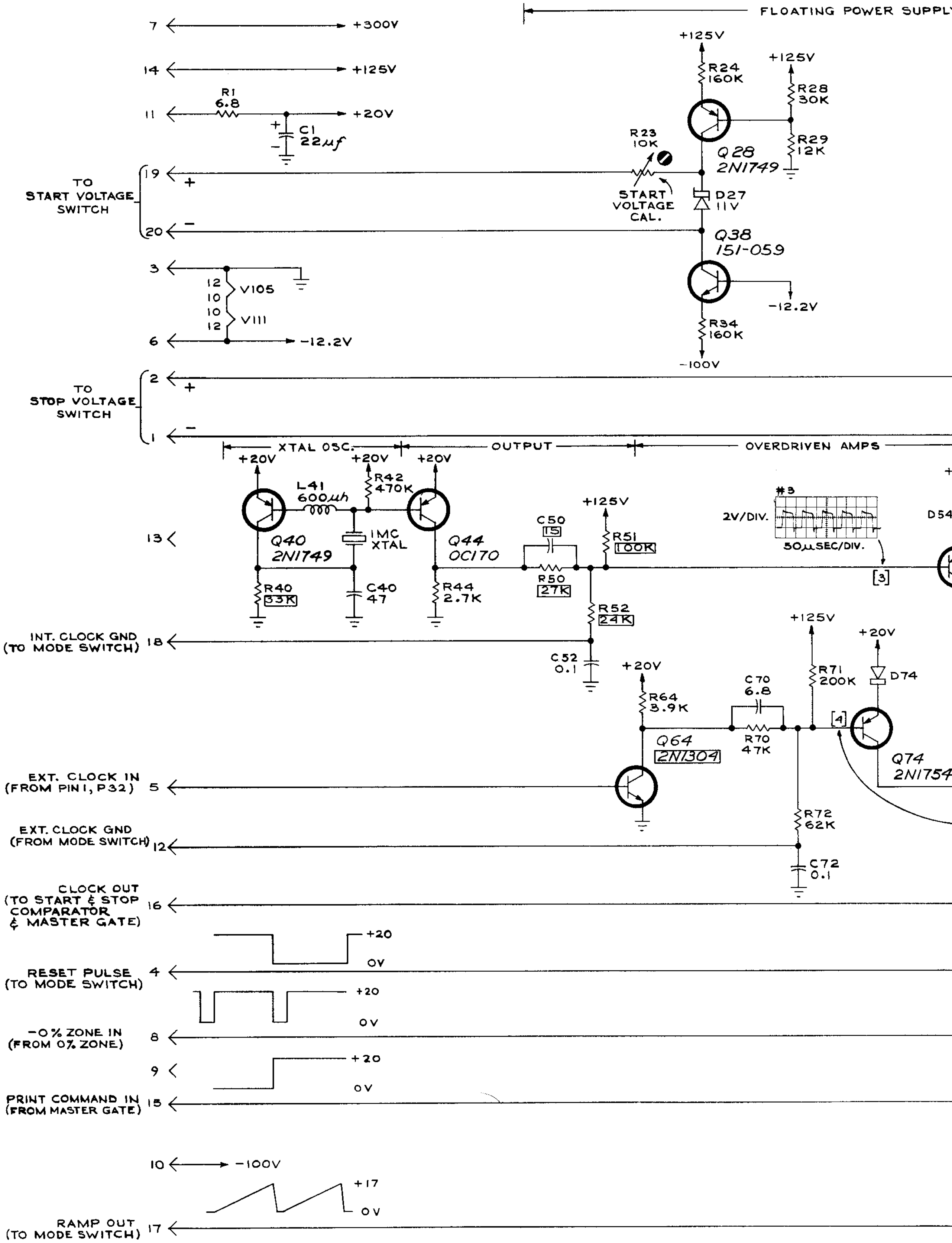
A

NOTE
ON SOME CIRCUIT BOARDS, A LETTER FOLLOWING THE MODEL NUMBER INDICATES A CHANGE AFFECTING ONLY THE BOARD DESIGNATED BY THIS LETTER.

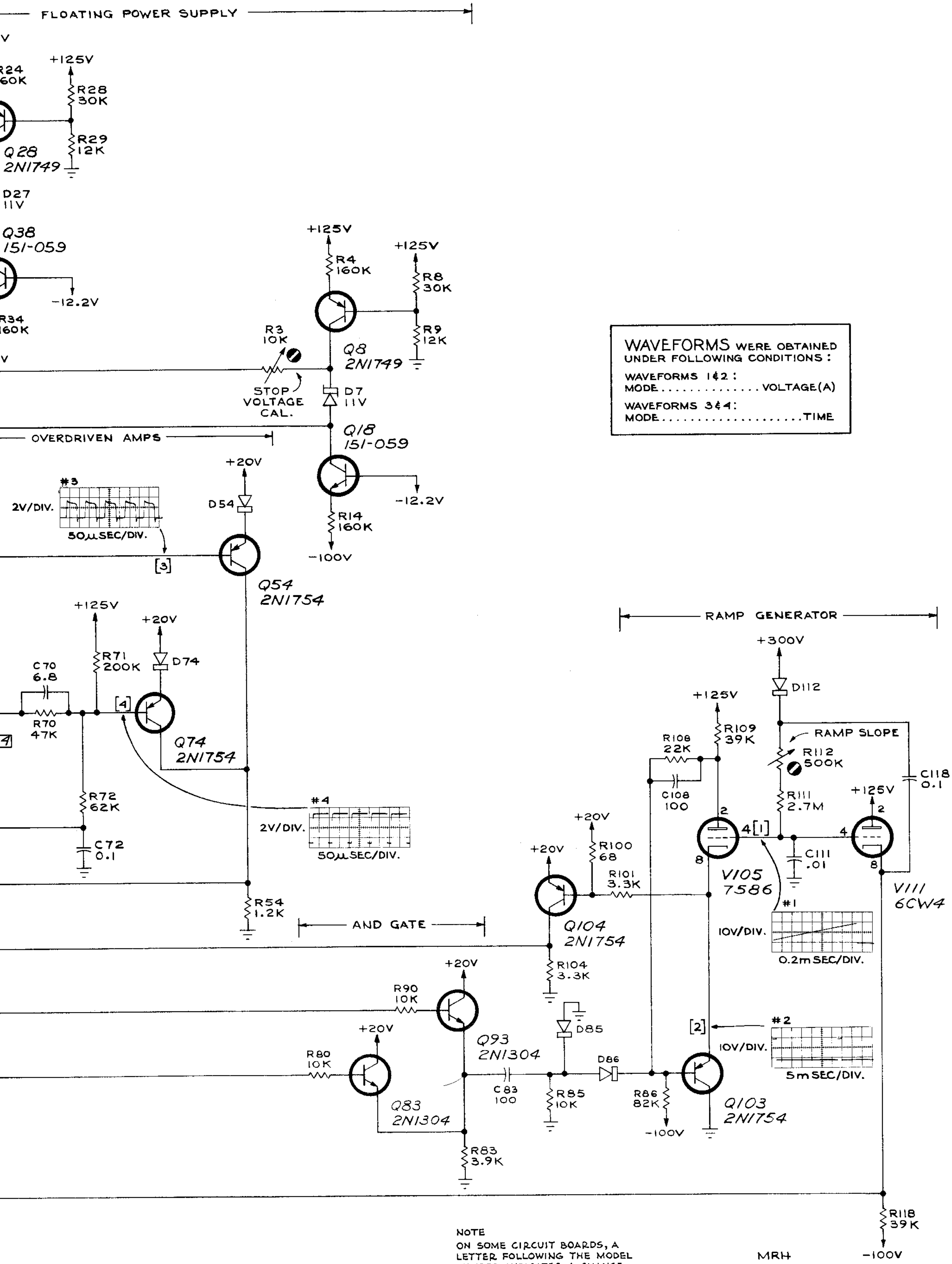
MRH
563

MEMORY

SERIES L MODELS 1,2,3,4



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

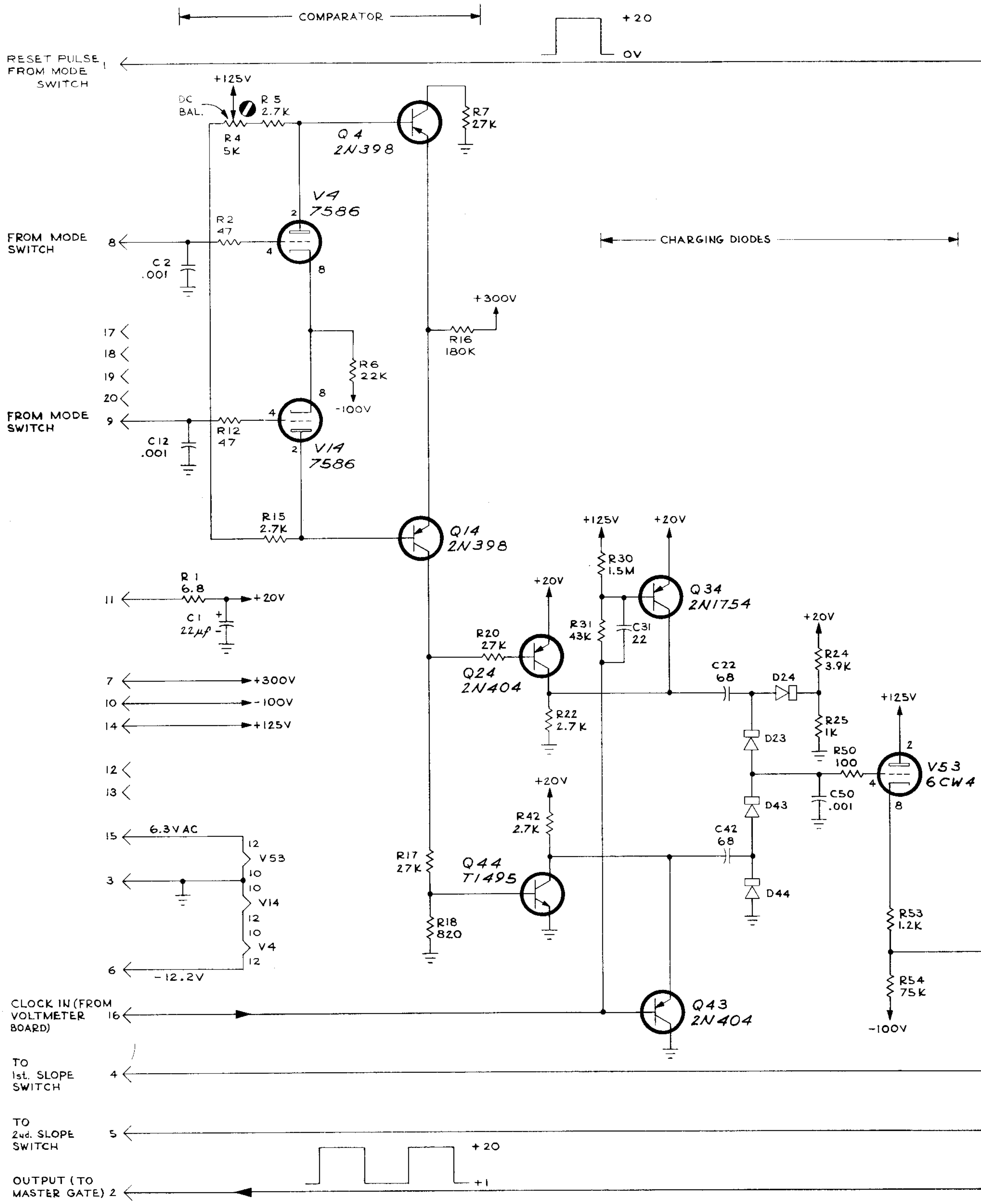


NOTE
ON SOME CIRCUIT BOARDS, A LETTER FOLLOWING THE MODEL NUMBER INDICATES A CHANGE AFFECTING ONLY THE BOARD DESIGNATED BY THIS LETTER.

A

MRH
563

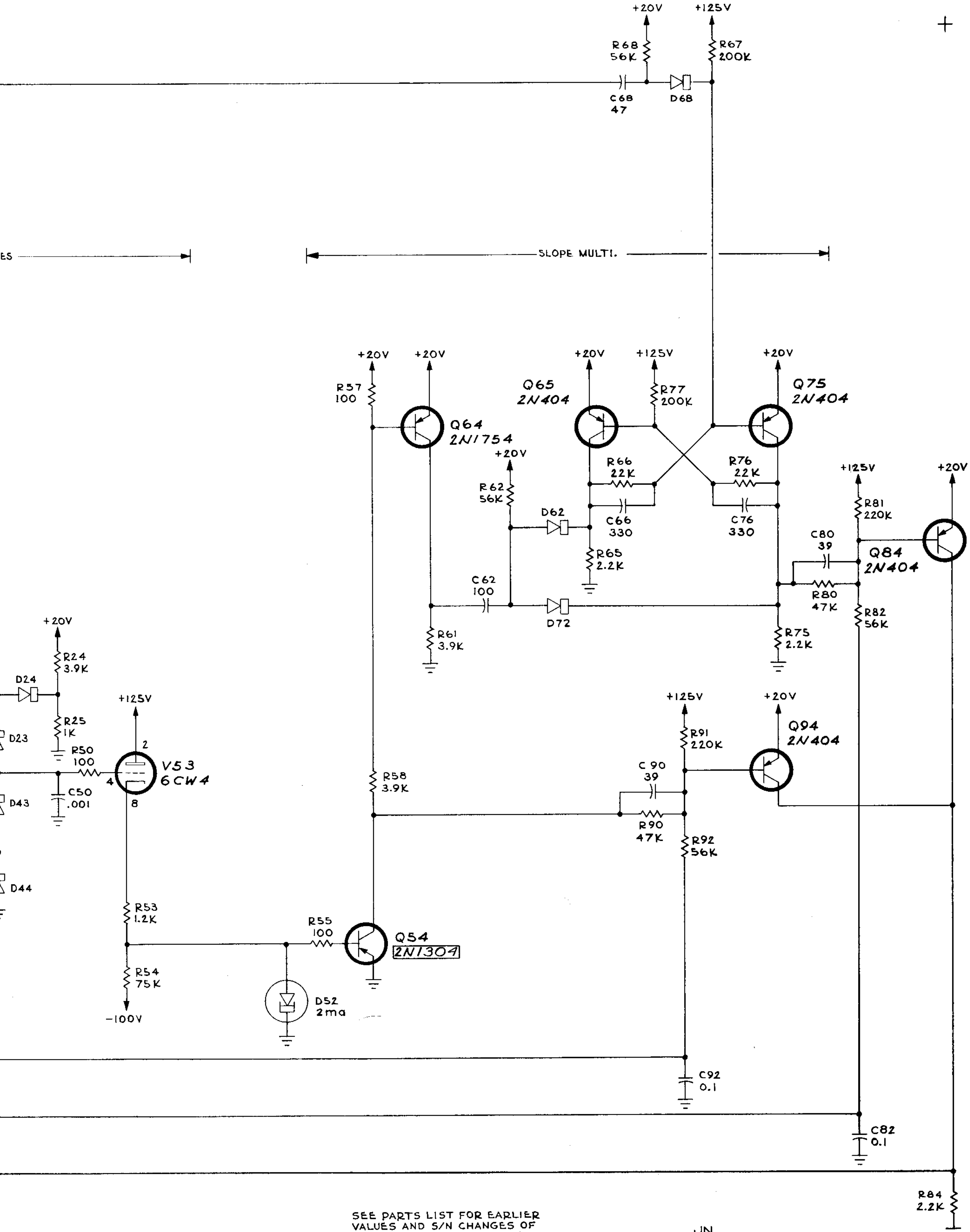
VOLTMETER
SERIES E MODEL 1¢2



COMPARATOR
CHARGING DIODES
RESET PULSE FROM MODE SWITCH 1
+20
0V
+125V
DC BAL.
R4 5K
R5 2.7K
R7 27K
Q4 2N398
V4 7586
FROM MODE SWITCH 8
R2 47
C2 .001
+300V
R16 180K
R6 22K
-100V
17
18
19
20
FROM MODE SWITCH 9
R12 47
C12 .001
V14 7586
R15 2.7K
Q14 2N398
R1 6.8
C1 22μf
11
+20V
7
+300V
10
-100V
14
+125V
12
13
15
6.3V AC
V53
3
V14
V4
6
-12.2V
R30 1.5M
Q34 2N1754
R31 43K
C31 22
R20 27K
Q24 2N404
R22 2.7K
C22 68
D24
R24 3.9K
R25 1K
D23
R50 100
V53 6CW4
C50 .001
D43
R42 2.7K
C42 68
D44
R17 27K
Q44 T1495
R18 820
R53 1.2K
R54 75K
CLOCK IN (FROM VOLTMETER BOARD) 16
Q43 2N404
TO 1st. SLOPE SWITCH 4
TO 2nd. SLOPE SWITCH 5
OUTPUT (TO MASTER GATE) 2
+20
+1

TYPE 6R1

A



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

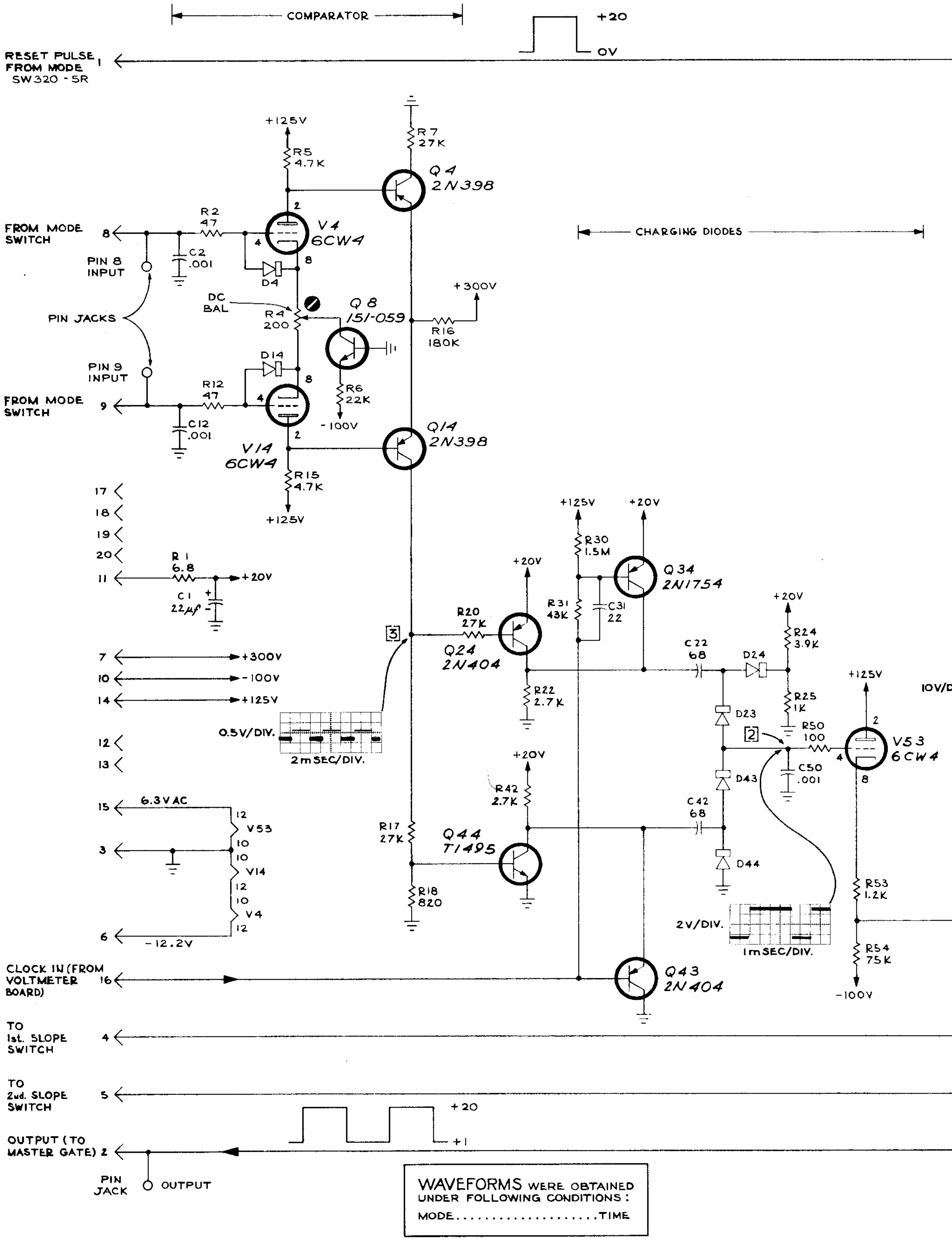
JN
563

A

NOTE
ON SOME CIRCUIT BOARDS, A LETTER FOLLOWING THE MODEL NUMBER INDICATES A CHANGE AFFECTING ONLY THE BOARD DESIGNATED BY THIS LETTER.

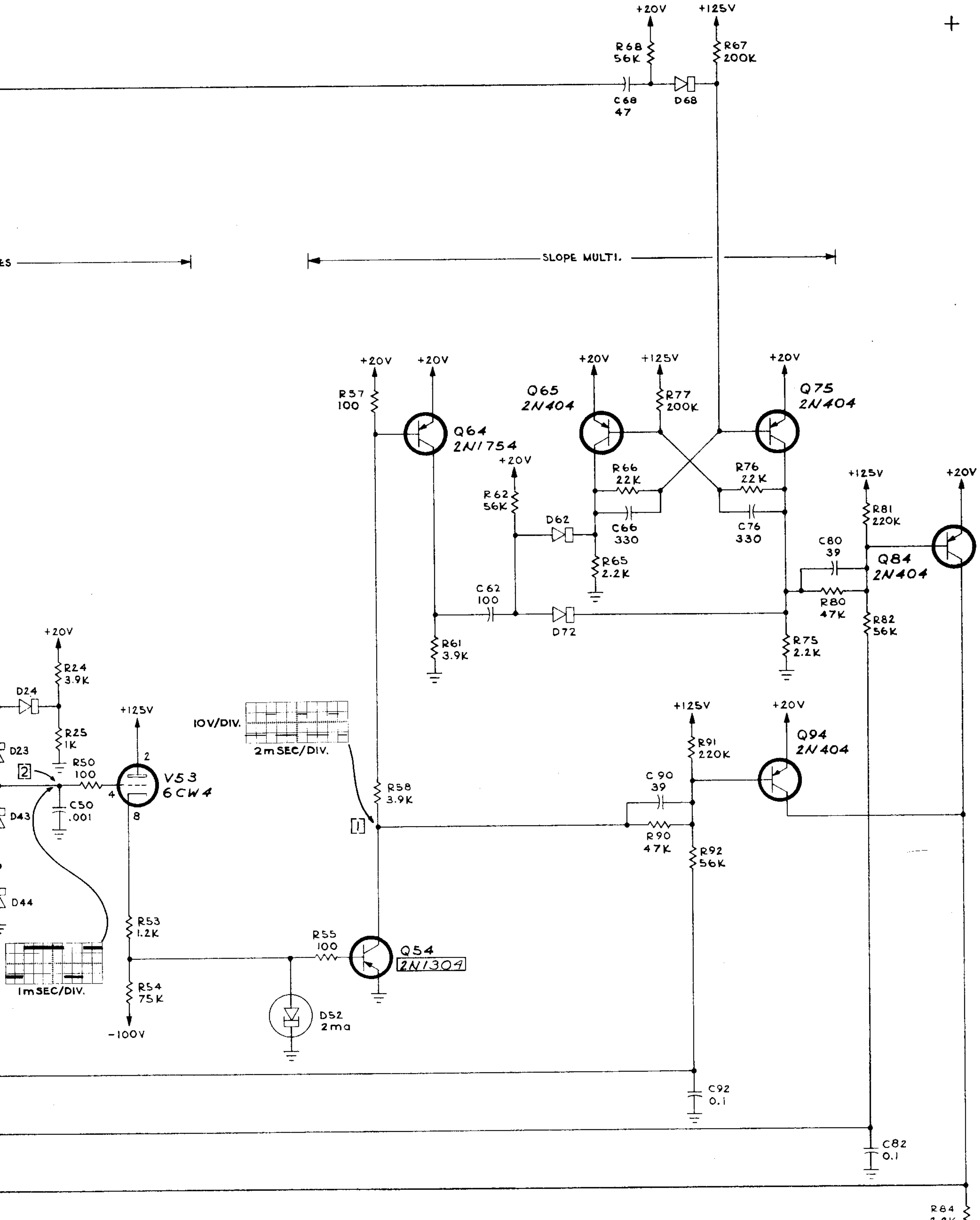
SIGNAL COMPARATOR

SERIES D MODELS 1&2



COMPARATOR
+20
0V
RESET PULSE FROM MODE SW320-5R 1
+125V
R5 4.7K
R7 27K
Q4 2N398
FROM MODE SWITCH 8
R2 47
V4 6CW4
C2 .001
PIN 8 INPUT
D4
DC BAL
R4 200
Q8 151-059
+300V
R16 180K
CHARGING DIODES
PIN JACKS
PIN 9 INPUT
D14
R6 22K
-100V
FROM MODE SWITCH 9
R12 47
C12 .001
Q14 2N398
V14 6CW4
R15 4.7K
+125V
17
18
19
20
R1 6.8
11
+20V
C1 22µf
+125V
+20V
R30 1.5M
Q34 2N1754
+20V
R31 43K
C31 22
R20 27K
Q24 2N404
3
7 +300V
10 -100V
14 +125V
R22 2.7K
C22 68
D24
R24 3.9K
R25 1K
+125V
10V/D
0.5V/DIV.
2mSEC/DIV.
12
13
D23
R50 100
2
V53 6CW4
C50 .001
D43
+20V
R42 2.7K
C42 68
15 6.3VAC
V53
3
V14
V4
6
-12.2V
R17 27K
Q44 T1495
R18 820
D44
R53 1.2K
2V/DIV.
1mSEC/DIV.
R54 75K
-100V
CLOCK IN (FROM VOLTMETER BOARD) 16
Q43 2N404
TO 1st. SLOPE SWITCH 4
TO 2nd. SLOPE SWITCH 5
+20
+1
OUTPUT (TO MASTER GATE) 2
PIN JACK
OUTPUT
WAVEFORMS WERE OBTAINED UNDER FOLLOWING CONDITIONS:
MODE....................TIME

A



R84 2.2K

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

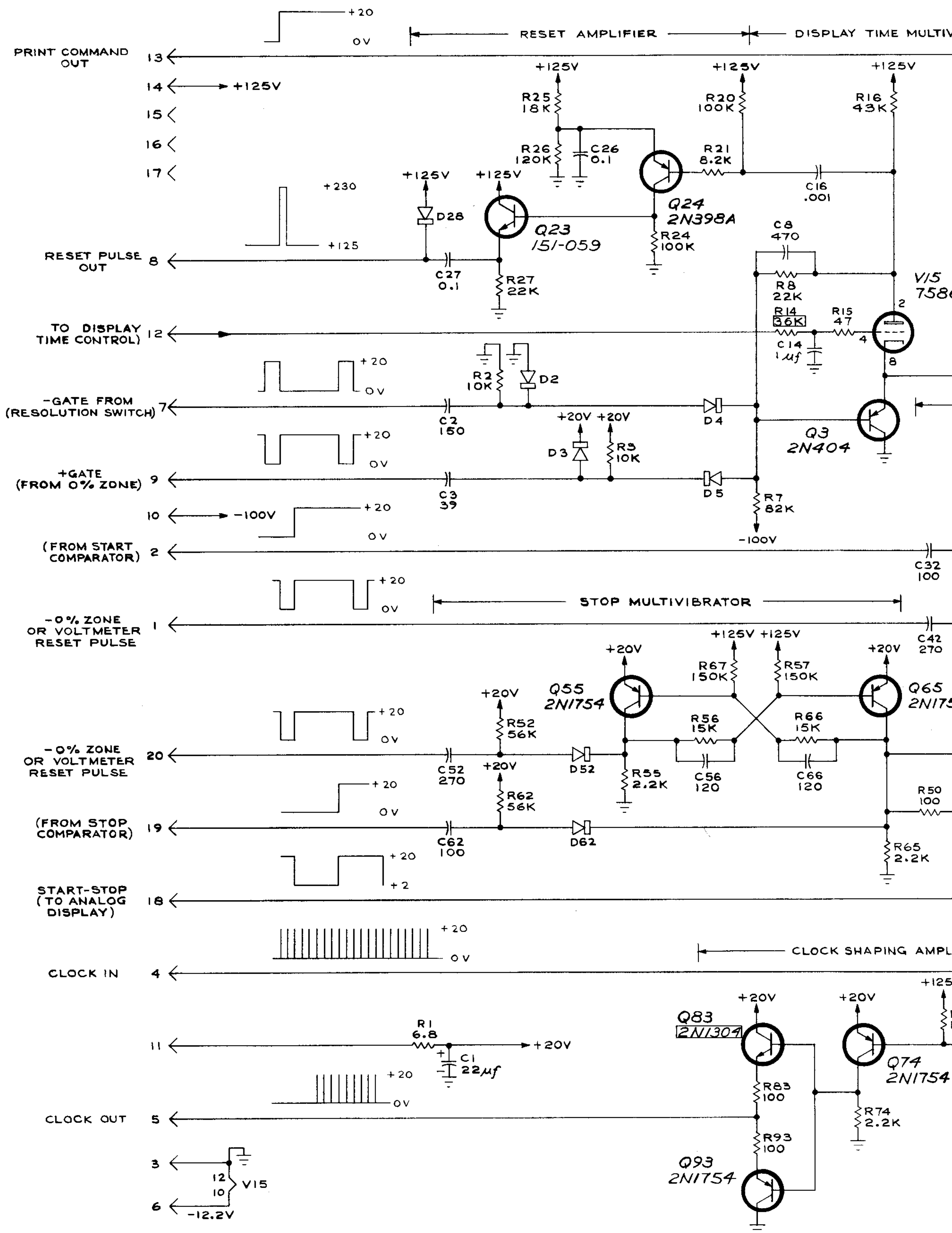
NOTE
ON SOME CIRCUIT BOARDS, A LETTER FOLLOWING THE MODEL NUMBER INDICATES A CHANGE AFFECTING ONLY THE BOARD DESIGNATED BY THIS LETTER.

A

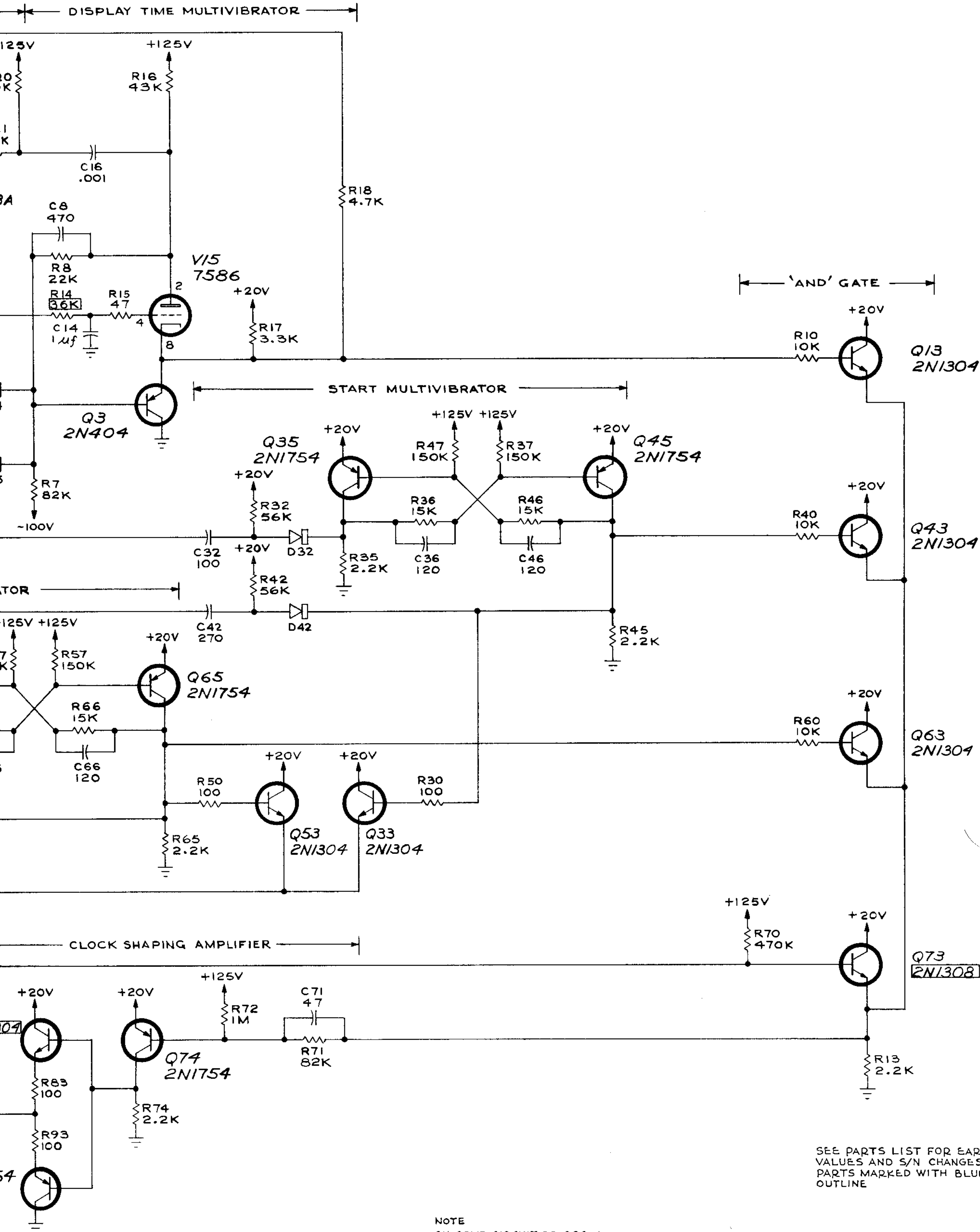
JN
563

SIGNAL COMPARATOR

SERIES D MODEL 3


RESET AMPLIFIER
DISPLAY TIME MULTIV
PRINT COMMAND OUT
RESET PULSE OUT
TO DISPLAY TIME CONTROL)
-GATE FROM (RESOLUTION SWITCH)
+GATE (FROM 0% ZONE)
(FROM START COMPARATOR)
-0% ZONE OR VOLTMETER RESET PULSE
STOP MULTIVIBRATOR
-0% ZONE OR VOLTMETER RESET PULSE
(FROM STOP COMPARATOR)
START-STOP (TO ANALOG DISPLAY)
CLOCK IN
CLOCK SHAPING AMPL
CLOCK OUT
Q23 151-059
Q24 2N398A
Q3 2N404
V15 758
Q55 2N1754
Q65 2N175
Q83 2N1304
Q74 2N1754
Q93 2N1754
R25 18K
R26 120K
C26 0.1
R20 100K
R21 8.2K
R16 43K
C16 .001
R24 100K
C8 470
R8 22K
R14 36K
R15 47
C14 1μf
D28
C27 0.1
R27 22K
R2 10K
D2
C2 150
D4
D3
R3 10K
C3 39
D5
R7 82K
C32 100
C42 270
R67 150K
R57 150K
R56 15K
R66 15K
R52 56K
C52 270
D52
R55 2.2K
C56 120
C66 120
R50 100
R62 56K
C62 100
D62
R65 2.2K
R1 6.8
C1 22μf
R83 100
R93 100
R74 2.2K
V15
+20
0V
+230
+125
+125V
+20V
-100V
-12.2V
+2
13
14
15
16
17
8
12
7
9
10
2
1
20
19
18
4
11
5
3
6

A



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

NOTE
ON SOME CIRCUIT BOARDS, A LETTER FOLLOWING THE MODEL NUMBER INDICATES A CHANGE AFFECTING ONLY THE BOARD DESIGNATED BY THIS LETTER.

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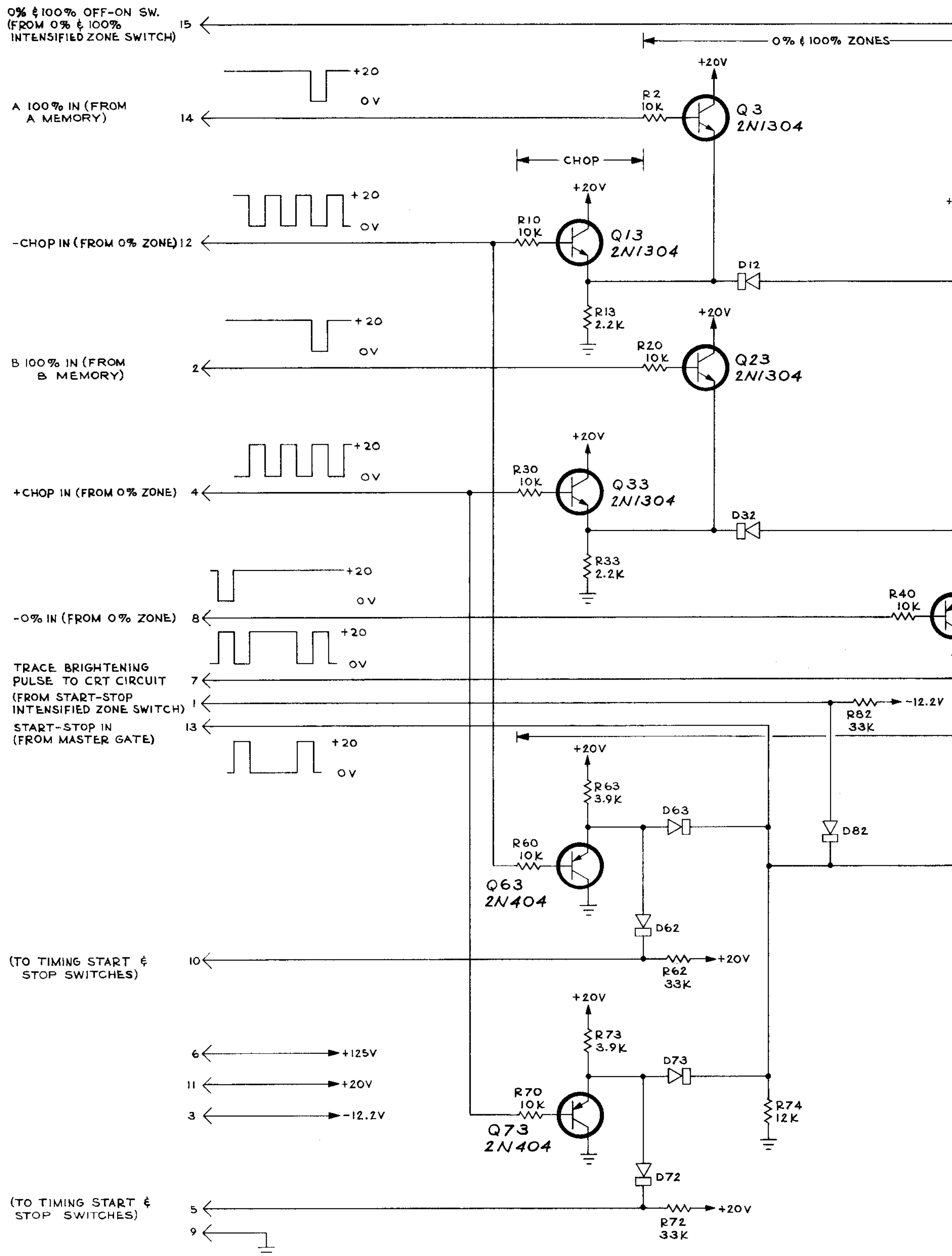
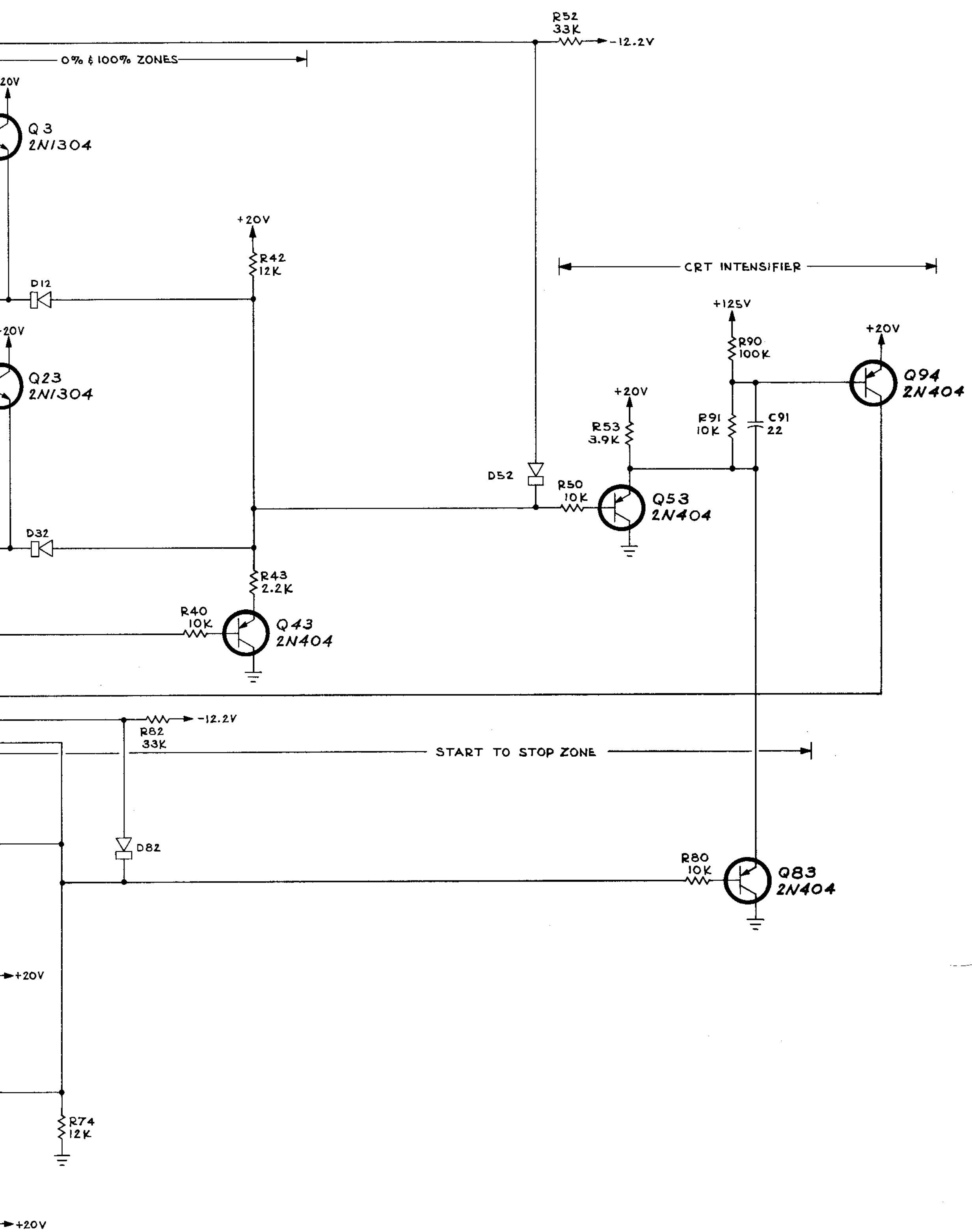
MASTER GATE

SERIES C MODELS 1 & 2


0% & 100% OFF-ON SW.
(FROM 0% & 100%
INTENSIFIED ZONE SWITCH)
0% & 100% ZONES
A 100% IN (FROM
A MEMORY)
CHOP
-CHOP IN (FROM 0% ZONE)
B 100% IN (FROM
B MEMORY)
+CHOP IN (FROM 0% ZONE)
-0% IN (FROM 0% ZONE)
TRACE BRIGHTENING
PULSE TO CRT CIRCUIT
(FROM START-STOP
INTENSIFIED ZONE SWITCH)
START-STOP IN
(FROM MASTER GATE)
(TO TIMING START &
STOP SWITCHES)
(TO TIMING START &
STOP SWITCHES)
+20
0V
+20V
+125V
-12.2V
Q3
2N1304
Q13
2N1304
Q23
2N1304
Q33
2N1304
Q63
2N404
Q73
2N404
R2
10K
R10
10K
R13
2.2K
R20
10K
R30
10K
R33
2.2K
R40
10K
R60
10K
R62
33K
R63
3.9K
R70
10K
R72
33K
R73
3.9K
R74
12K
R82
33K
D12
D32
D62
D63
D72
D73
D82



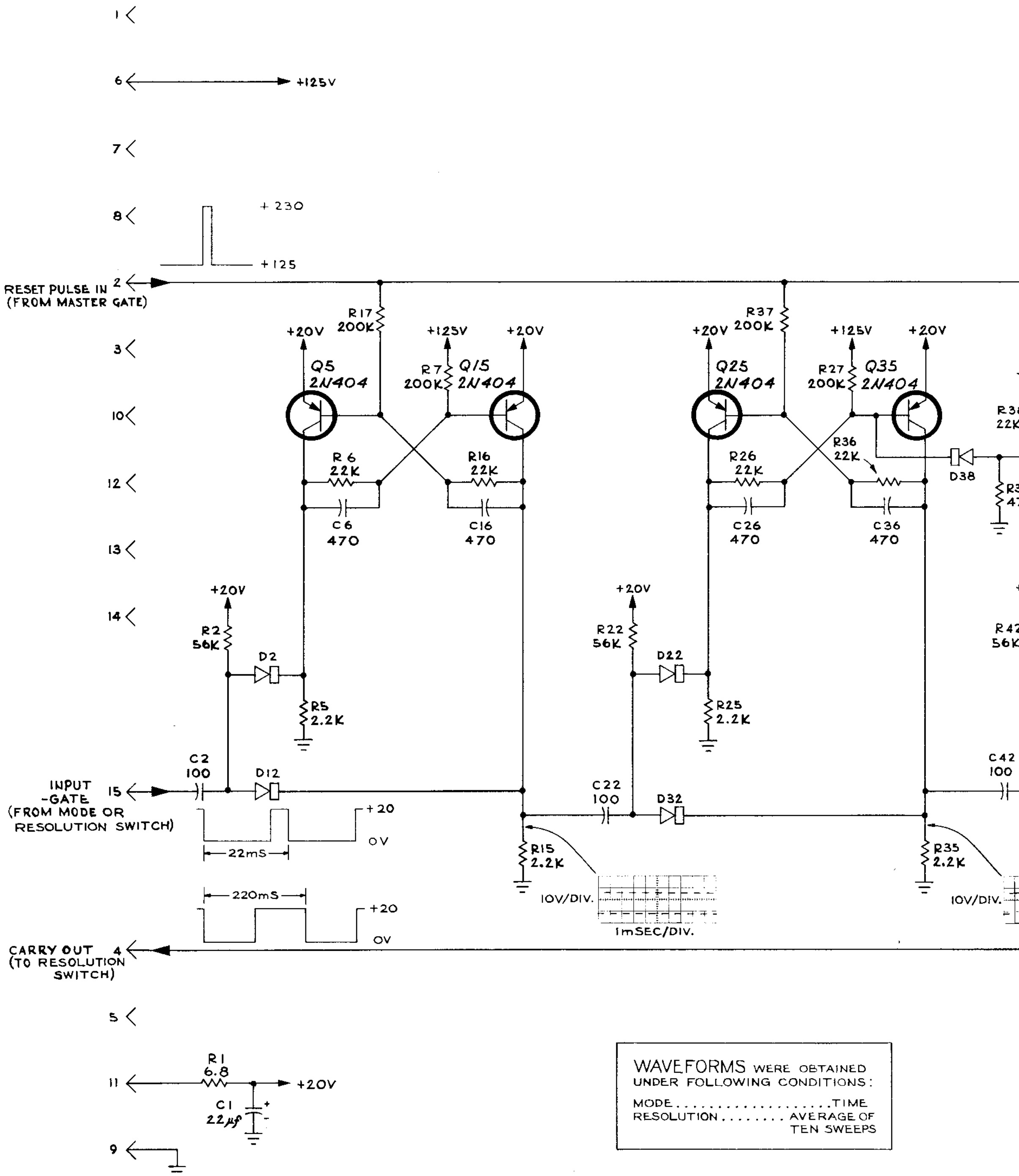
NOTE
ON SOME CIRCUIT BOARDS, A LETTER FOLLOWING THE MODEL NUMBER INDICATES A CHANGE AFFECTING ONLY THE BOARD DESIGNATED BY THIS LETTER.

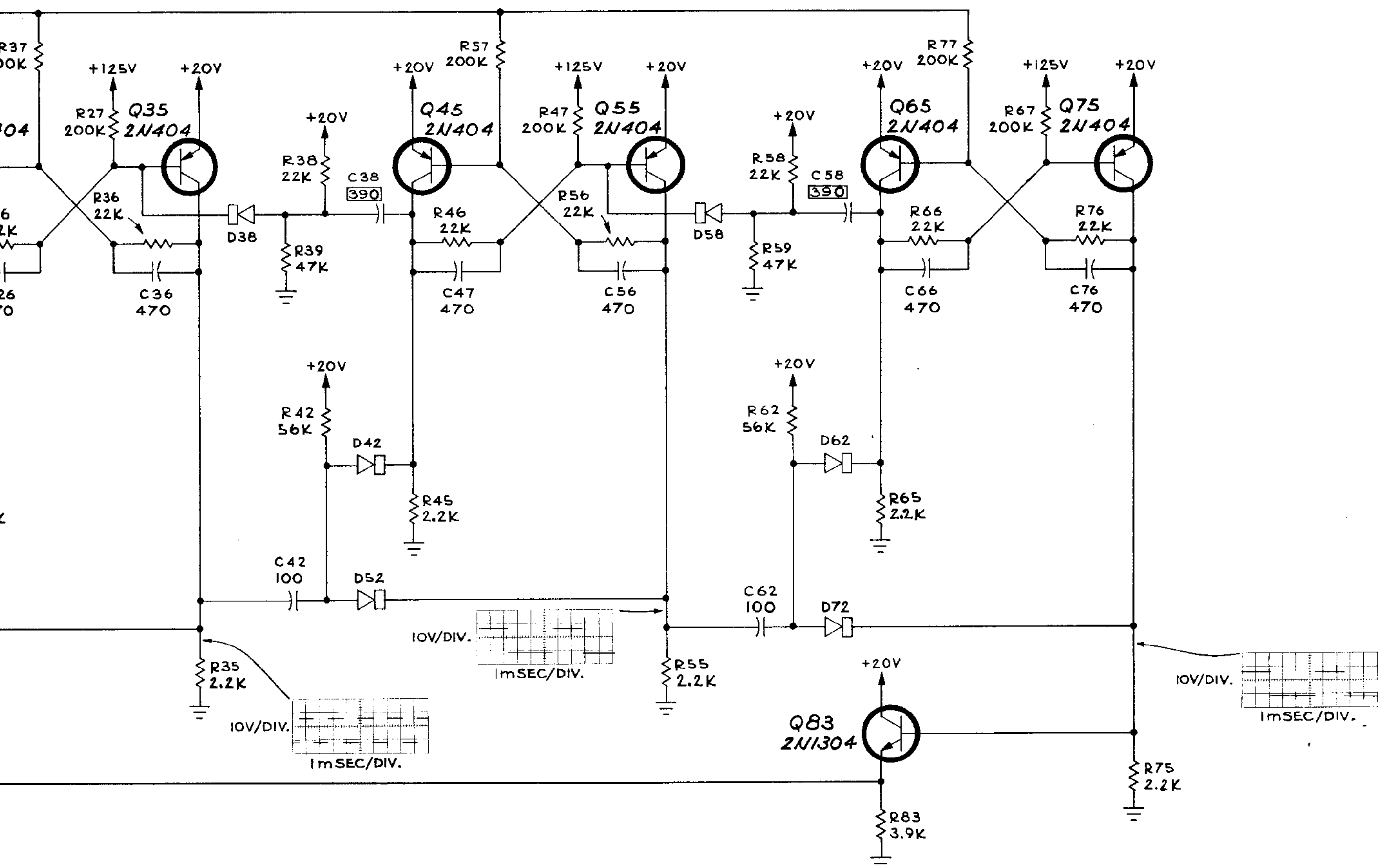
A

JN
563

ANALOG DISPLAY

SERIES J MODEL 1


+125V
+230
+125
RESET PULSE IN
(FROM MASTER GATE)
R17 200K
R37 200K
+20V
+125V
Q5 2N404
Q15 2N404
Q25 2N404
Q35 2N404
R7 200K
R27 200K
R6 22K
R16 22K
R26 22K
R36 22K
C6 470
C16 470
C26 470
C36 470
D38
R2 56K
R22 56K
D2
D22
R5 2.2K
R25 2.2K
C2 100
C22 100
C42 100
D12
D32
INPUT -GATE
(FROM MODE OR RESOLUTION SWITCH)
+20
0V
22mS
220mS
R15 2.2K
R35 2.2K
10V/DIV.
1mSEC/DIV.
CARRY OUT
(TO RESOLUTION SWITCH)
R1 6.8
C1 22µf
+20V
WAVEFORMS WERE OBTAINED UNDER FOLLOWING CONDITIONS:
MODE..................TIME
RESOLUTION........AVERAGE OF TEN SWEEPS



WERE OBTAINED
ING CONDITIONS:
............TIME
...... AVERAGE OF
TEN SWEEPS

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

NOTE
ON SOME CIRCUIT BOARDS, A LETTER FOLLOWING THE MODEL NUMBER INDICATES A CHANGE AFFECTING ONLY THE BOARD DESIGNATED BY THIS LETTER.

A

JN
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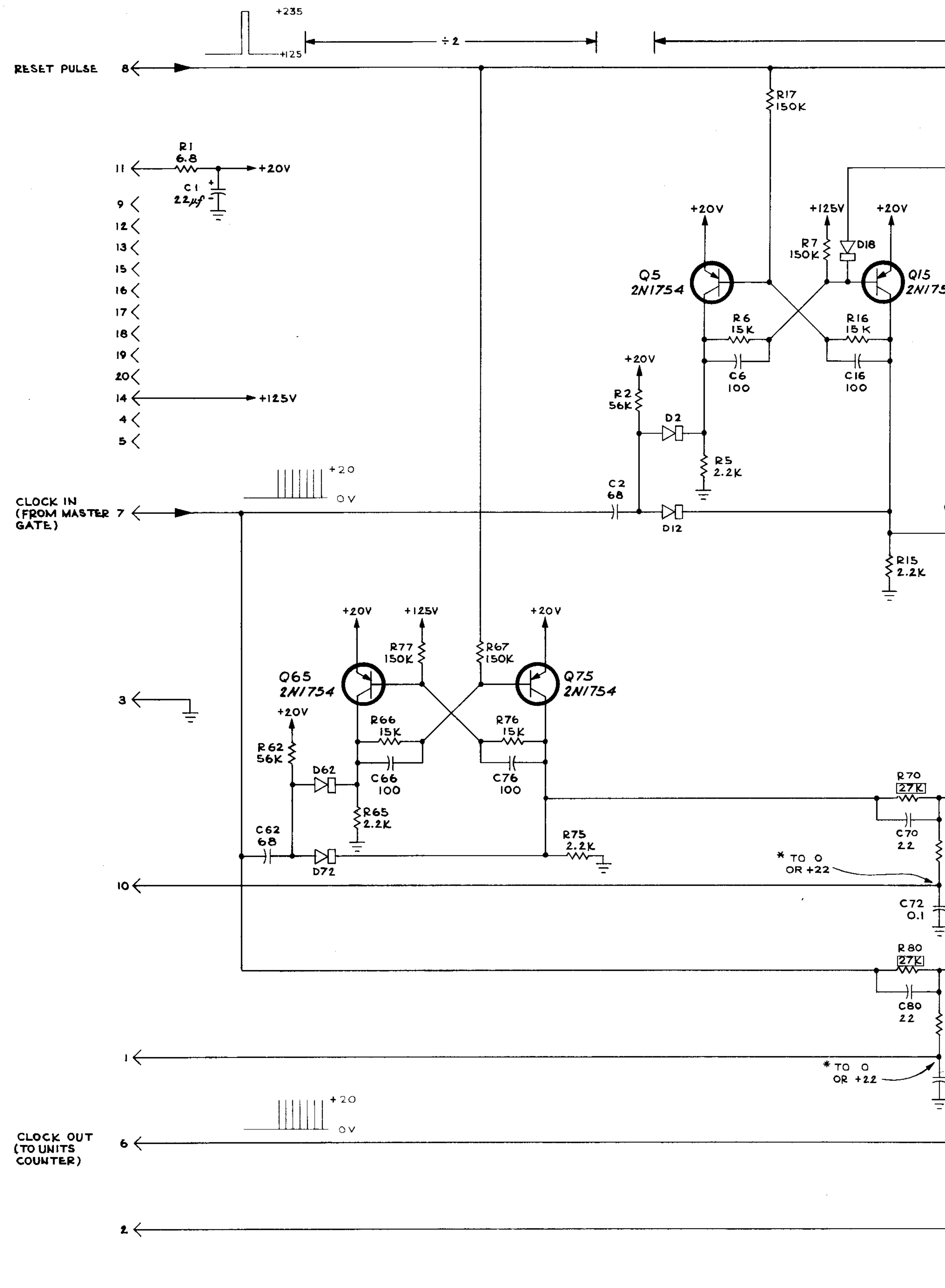
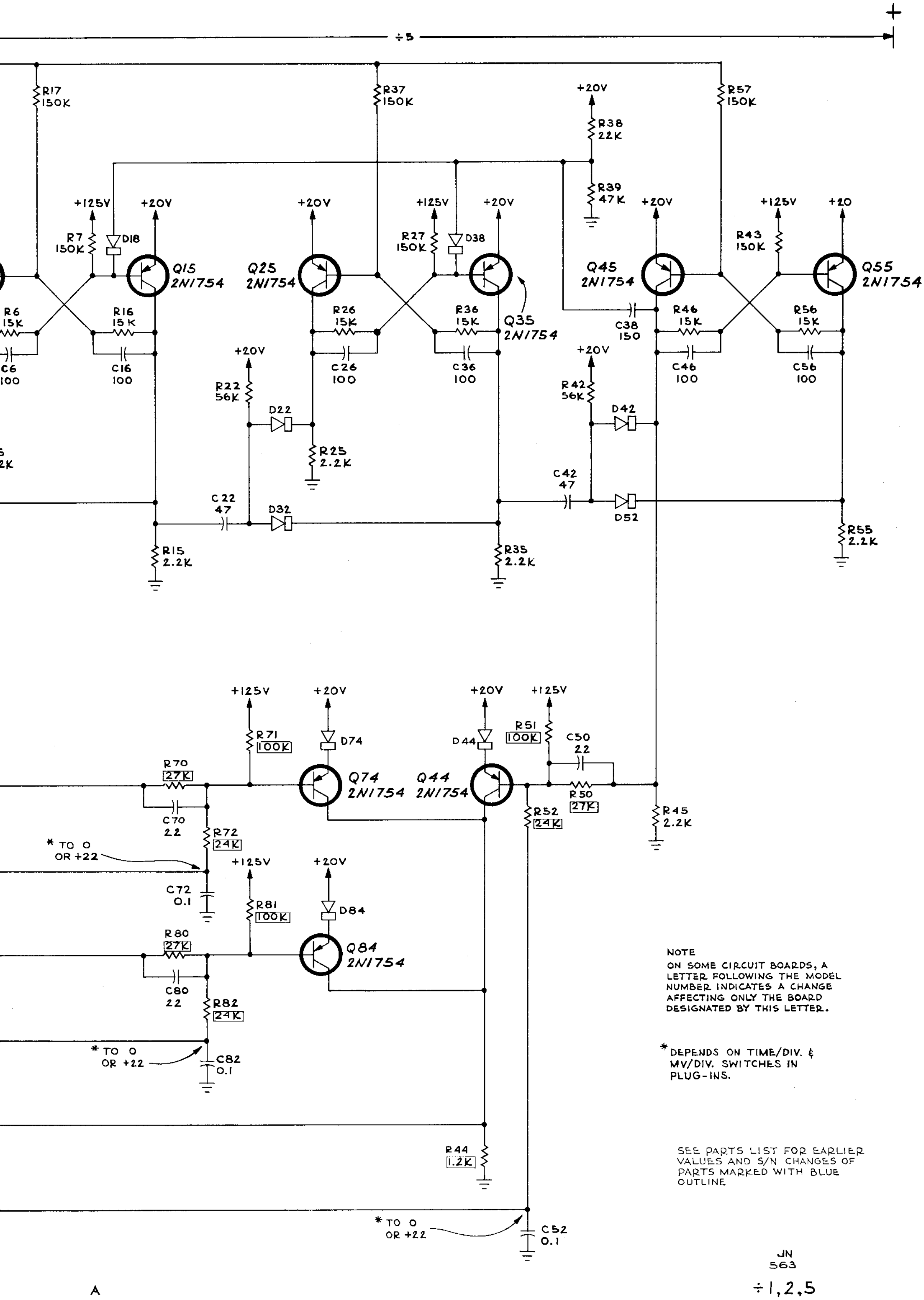
÷10

SERIES I MODELS 1&2


+235
+125
÷ 2
RESET PULSE 8
R17 150K
R1 6.8
11
+20V
C1 22μf
9
12
13
15
16
17
18
19
20
14
+125V
4
5
+20V
+125V
+20V
R7 150K
D18
Q5 2N1754
Q15 2N175
R6 15K
R16 15K
C6 100
C16 100
+20V
R2 56K
D2
R5 2.2K
+20
0V
CLOCK IN (FROM MASTER GATE) 7
C2 68
D12
R15 2.2K
+20V
+125V
+20V
R77 150K
R67 150K
Q65 2N1754
Q75 2N1754
3
+20V
R66 15K
R76 15K
R62 56K
D62
C66 100
C76 100
R65 2.2K
R70 27K
C70 22
C62 68
D72
R75 2.2K
* TO 0 OR +22
10
C72 0.1
R80 27K
C80 22
1
* TO 0 OR +22
+20
0V
CLOCK OUT (TO UNITS COUNTER) 6
2

TYPE 6R1 A



NOTE
ON SOME CIRCUIT BOARDS, A LETTER FOLLOWING THE MODEL NUMBER INDICATES A CHANGE AFFECTING ONLY THE BOARD DESIGNATED BY THIS LETTER.

* DEPENDS ON TIME/DIV. & MV/DIV. SWITCHES IN PLUG-INS.

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

JN
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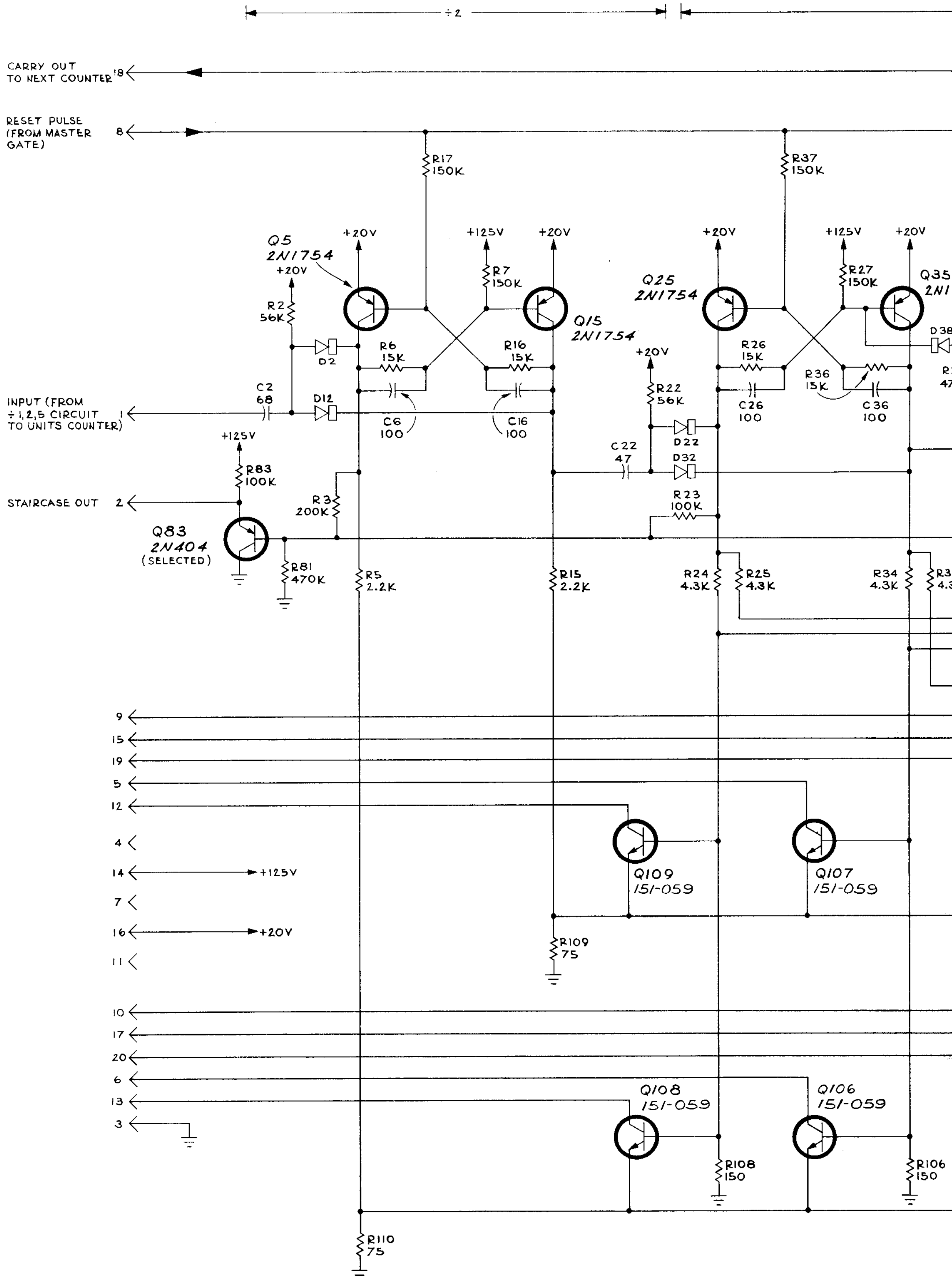
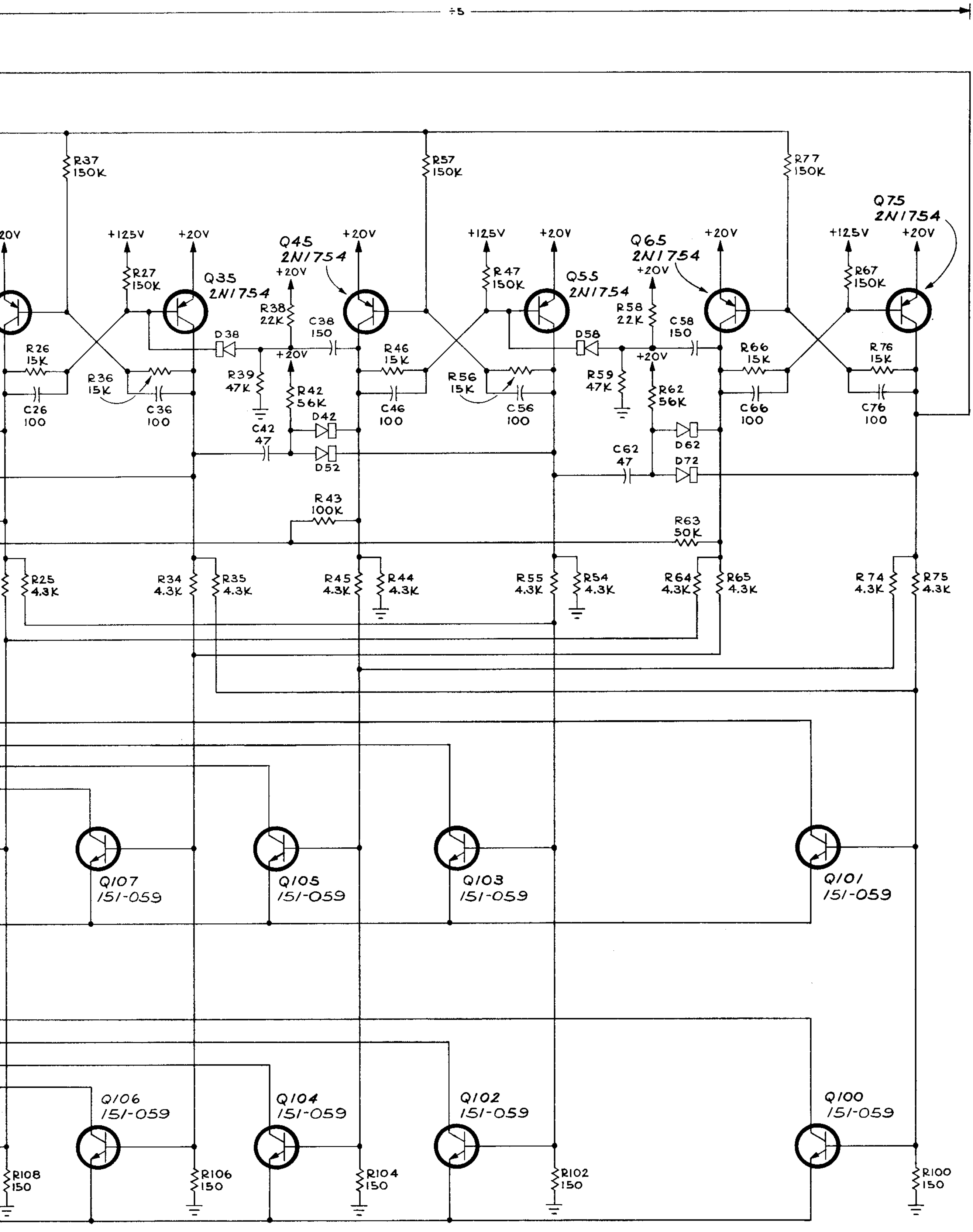
÷1,2,5

SERIES B MODELS 1&2


÷2
CARRY OUT TO NEXT COUNTER 18
RESET PULSE (FROM MASTER GATE) 8
INPUT (FROM ÷1,2,5 CIRCUIT TO UNITS COUNTER) 1
STAIRCASE OUT 2
Q5 2N1754
Q15 2N1754
Q25 2N1754
Q35 2N1
Q83 2N404 (SELECTED)
Q109 151-059
Q107 151-059
Q108 151-059
Q106 151-059
R17 150K
R37 150K
R7 150K
R27 150K
R2 56K
R22 56K
R6 15K
R16 15K
R26 15K
R36 15K
C2 68
C6 100
C16 100
C22 47
C26 100
C36 100
D2
D12
D22
D32
D38
R83 100K
R3 200K
R23 100K
R81 470K
R5 2.2K
R15 2.2K
R24 4.3K
R25 4.3K
R34 4.3K
R109 75
R108 150
R106 150
R110 75
+20V
+125V
9
15
19
5
12
4
14
7
16
11
10
17
20
6
13
3

TYPE 6R1

A



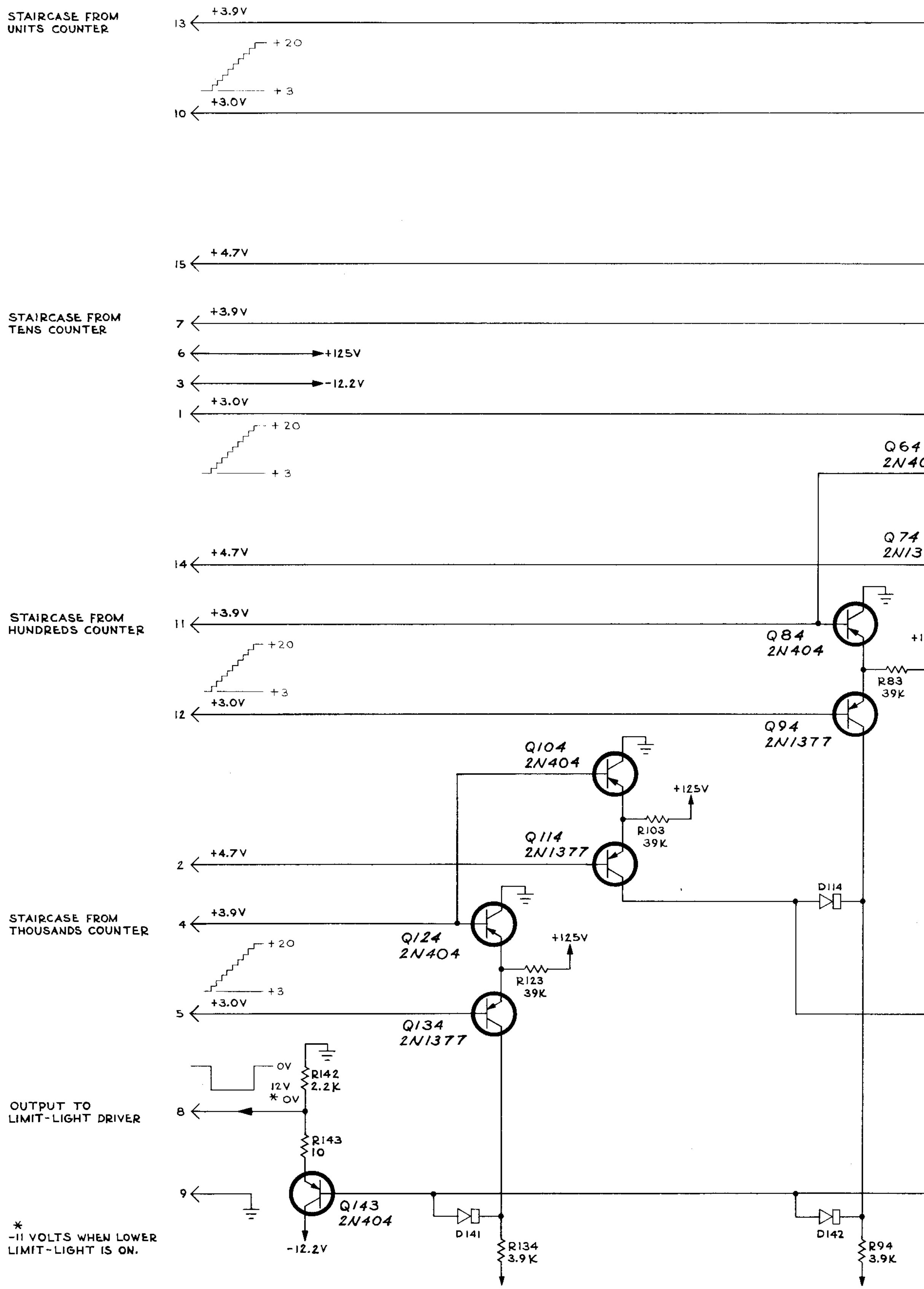
A

NOTE:
ON SOME CIRCUIT BOARDS, A LETTER FOLLOWING THE MODEL NUMBER INDICATES A CHANGE AFFECTING ONLY THE BOARD DESIGNATED BY THIS LETTER.

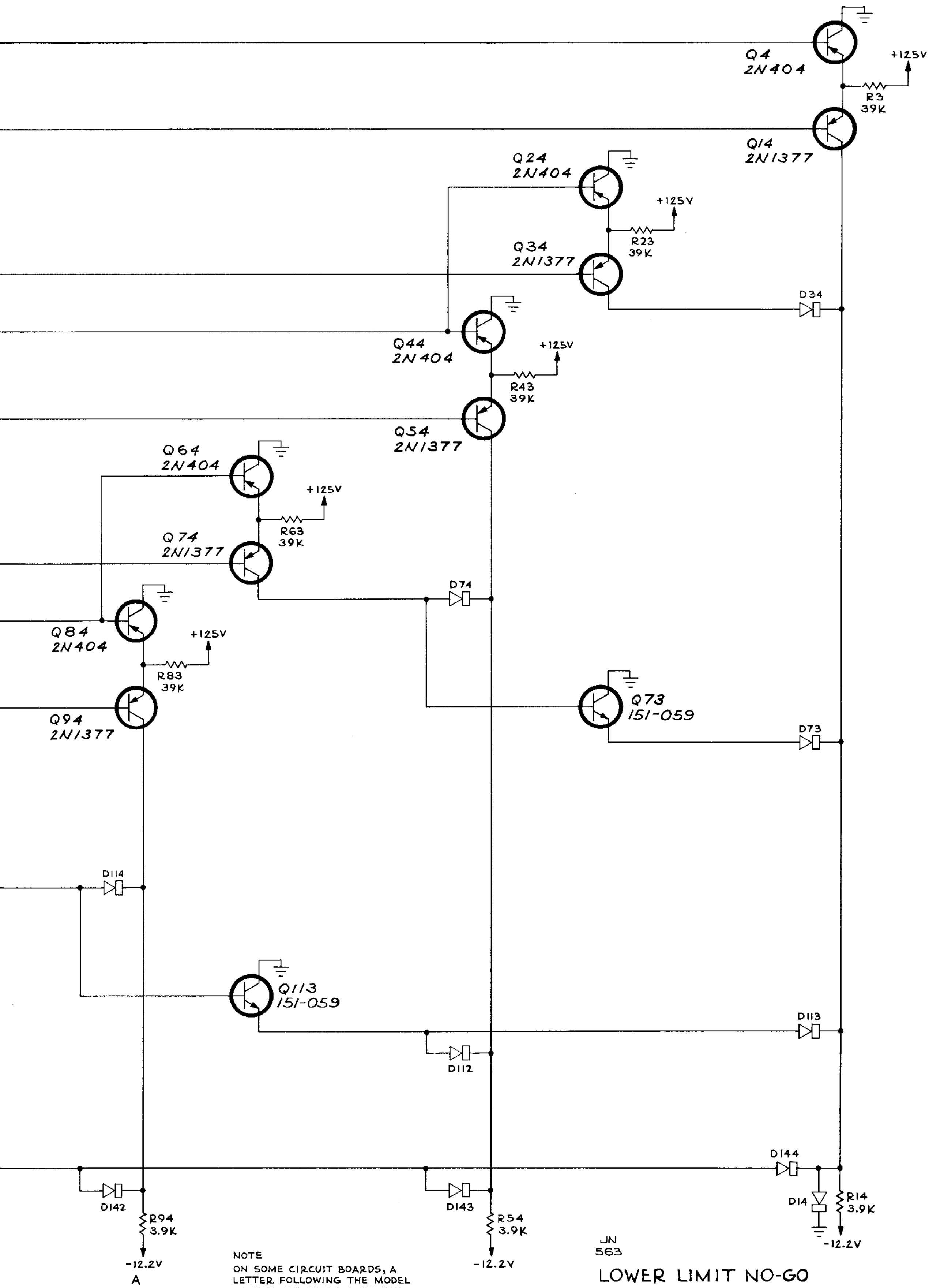
JN
563

COUNTER

SERIES A MODELS 1 ¢ 2


STAIRCASE FROM UNITS COUNTER
13
+3.9V
+20
+3
+3.0V
10
15
+4.7V
STAIRCASE FROM TENS COUNTER
7
+3.9V
6
+125V
3
-12.2V
1
+3.0V
+20
+3
Q64
Q74
14
+4.7V
STAIRCASE FROM HUNDREDS COUNTER
11
+3.9V
Q84
2N404
R83
39K
+20
+3
+3.0V
12
Q94
2N1377
Q104
2N404
+125V
R103
39K
Q114
2N1377
2
+4.7V
D114
STAIRCASE FROM THOUSANDS COUNTER
4
+3.9V
Q124
2N404
+125V
R123
39K
+20
+3
+3.0V
5
Q134
2N1377
0V
12V
* 0V
R142
2.2K
OUTPUT TO LIMIT-LIGHT DRIVER
8
R143
10
9
Q143
2N404
-12.2V
D141
R134
3.9K
-12.2V
D142
R94
3.9K
-12.2V
A
*
-11 VOLTS WHEN LOWER LIMIT-LIGHT IS ON.

TYPE 6R1

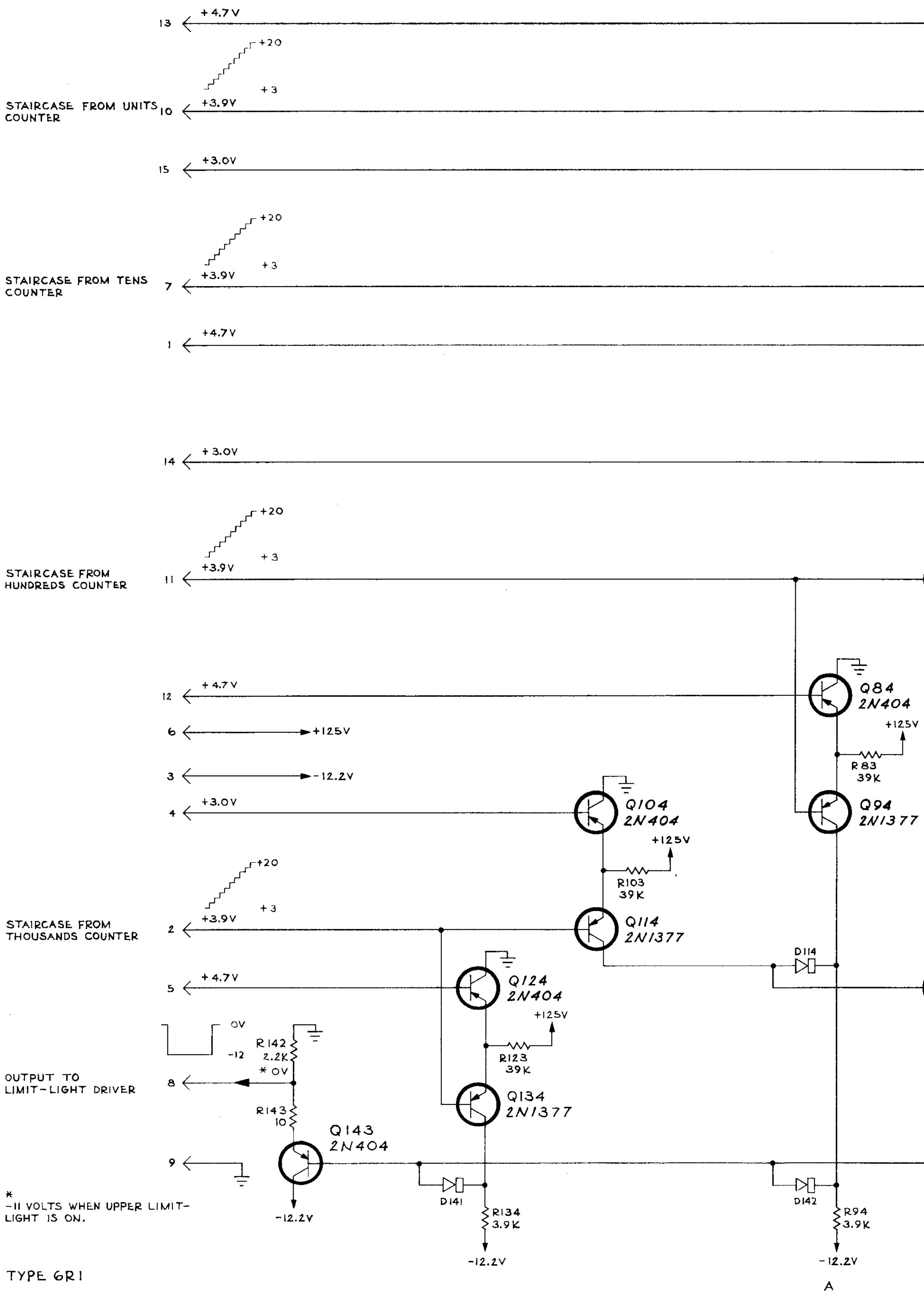


NOTE
ON SOME CIRCUIT BOARDS, A LETTER FOLLOWING THE MODEL NUMBER INDICATES A CHANGE AFFECTING ONLY THE BOARD DESIGNATED BY THIS LETTER.

JN
563

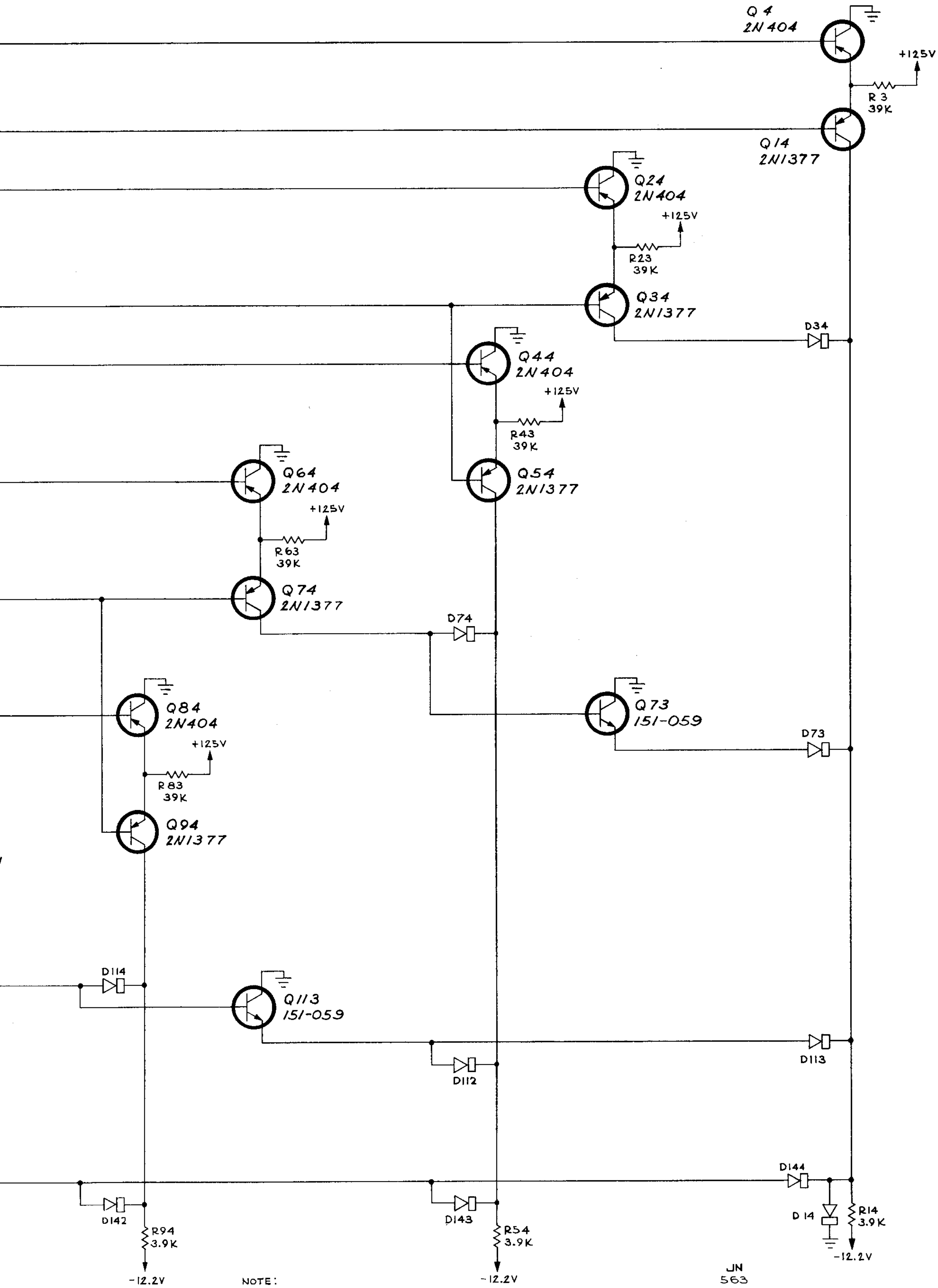
LOWER LIMIT NO-GO

SERIES G MODEL 1



*
-11 VOLTS WHEN UPPER LIMIT-LIGHT IS ON.

TYPE 6R1

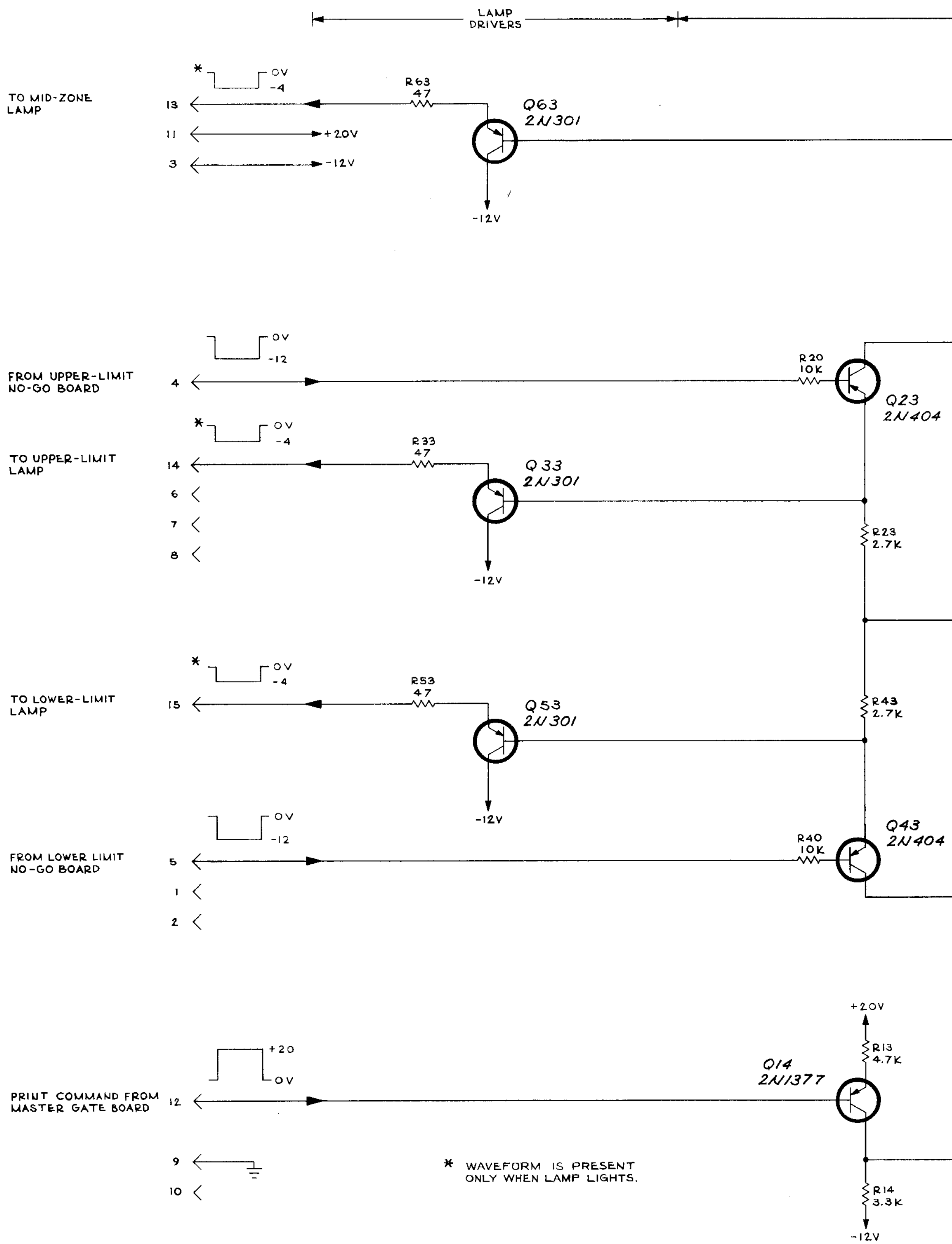


NOTE:
ON SOME CIRCUIT BOARDS, A LETTER FOLLOWING THE MODEL NUMBER INDICATES A CHANGE AFFECTING ONLY THE BOARD DESIGNATED BY THIS LETTER.

JN
563

UPPER LIMIT NO-GO

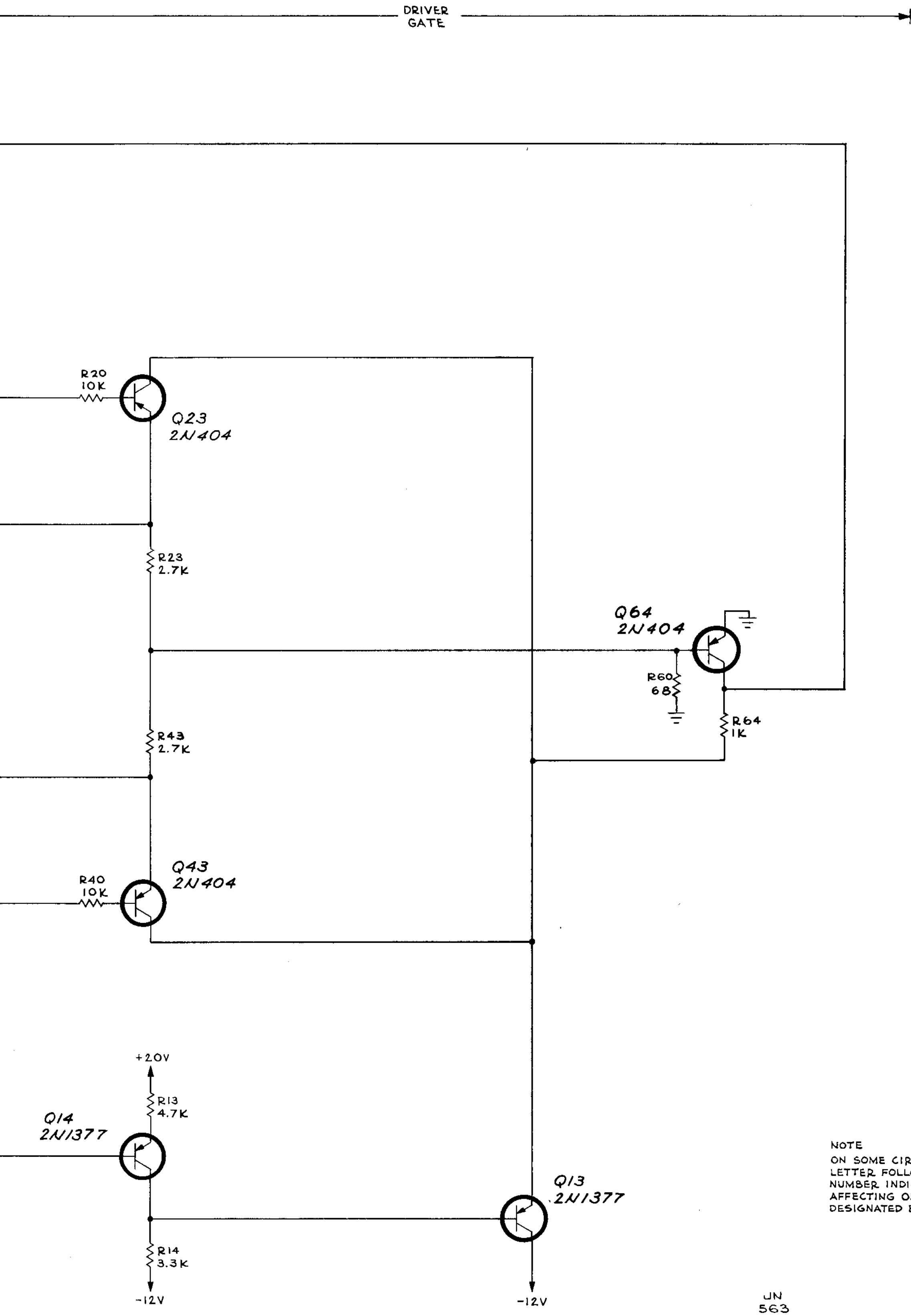
SERIES F MODEL I



LAMP DRIVERS
TO MID-ZONE LAMP
0V
-4
13
11
3
+20V
-12V
R63 47
Q63 2N301
-12V
FROM UPPER-LIMIT NO-GO BOARD
0V
-12
4
R20 10K
Q23 2N404
TO UPPER-LIMIT LAMP
0V
-4
14
6
7
8
R33 47
Q33 2N301
-12V
R23 2.7K
TO LOWER-LIMIT LAMP
0V
-4
15
R53 47
Q53 2N301
-12V
R43 2.7K
FROM LOWER LIMIT NO-GO BOARD
0V
-12
5
1
2
R40 10K
Q43 2N404
+20V
R13 4.7K
Q14 2N1377
PRINT COMMAND FROM MASTER GATE BOARD
+20
0V
12
9
10
* WAVEFORM IS PRESENT ONLY WHEN LAMP LIGHTS.
R14 3.3K
-12V

TYPE 6R1

A



NOTE
ON SOME CIRCUIT BOARDS, A LETTER FOLLOWING THE MODEL NUMBER INDICATES A CHANGE AFFECTING ONLY THE BOARD DESIGNATED BY THIS LETTER.

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563

A

LIMIT LIGHT DRIVER

SERIES H MODEL I

MANUAL CHANGE INFORMATION

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

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

TYPE 6R1, MASTER GATE BOARD, - TENT. MODEL 3A and 4

PARTS LIST CORRECTION

CHANGE TO:

R72	301-474	470k	1/2w	5%

M7366/763