Simpson

INSTRUMENTS THAT STAY ACCURATE

# INSTRUCTION MANUAL

## LABORATORY TYPE WIDE BAND OSCILLOSCOPE

## MODEL 2610

SIMPSON ELECTRIC COMPANY

5200 W. Kinzie St., Chicago, Illinois 60644
Area Code 312, Telephone 379-1121
In Canada, Bach-Simpson, Ltd., London, Ontario

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# TABLE OF CONTENTS

## TABLE OF CONTENTS

## 1.1 FOREWORD

The Simpson Laboratory Type, Wide Band Oscilloscope, Model 2610, has been designed for general purpose laboratory applications where wide bandwidth, with high gain, stable operation, and excellent flexibility are major requirements. It is intended to fill the gap between the "service" type instruments, which are limited because of performance versus cost considerations, and, on the other extreme, the very high performance type of oscilloscope where expense is more or less a secondary consideration. In satisfying this general purpose requirement, maximum performance and flexibility have been provided consistent with simplicity of adjustment, ease of operation, and reasonable price.

Its ruggedness, stability, and ease of operation, as well as initial cost, make it an ideal instrument for the factory and production line as well as the laboratory.

Quality and continuity of performance is assured by careful engineering, the use of top quality components throughout, plus modern Production and Quality Control Methods.

In addition, the Model 2610 provides a vertical calibration system whose accuracy, sensitivity, and bandwidth surpasses many of the commonly used Vacuum Tube Voltmeters.

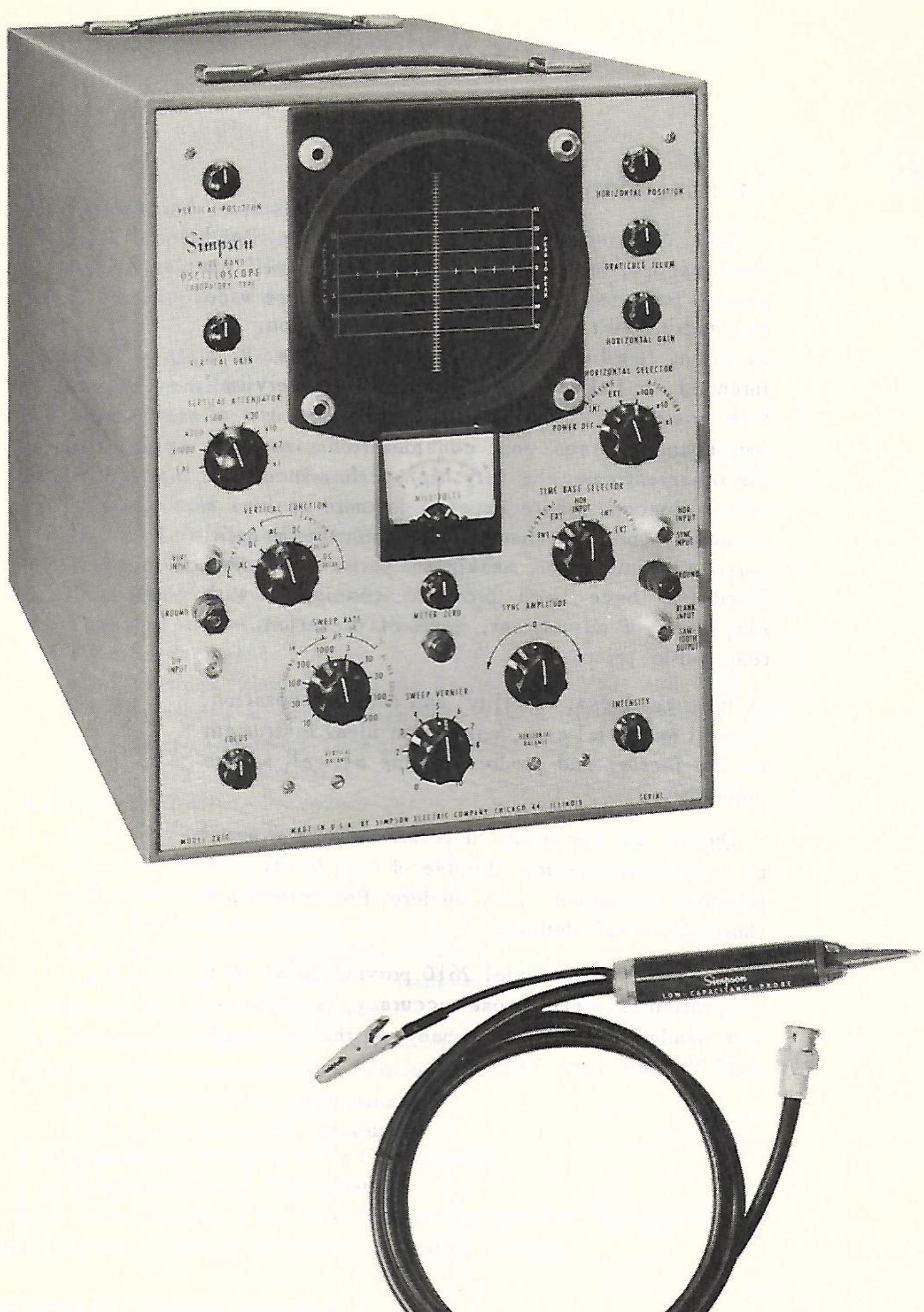



FIGURE 1 – MODEL 2610 WIDE BAND OSCILLOSCOPE WITH 10:1 LOW-CAPACITANCE PROBE

# SECTION I

# INTRODUCTION

## 1.3 ELECTRICAL & MECHANICAL SPECIFICATIONS

### 1.3.1 VERTICAL AMPLIFIER (VERT. INPUT)

(a) RESPONSE (Linear Positions): DC to 5.0 mc/sec. ± 0.5 db; DC to 8.0 mc/sec. ± 1.5 db. (Transient Positions): Rise time 0.08 microseconds; Overshoot 3% or less.

(b) SENSITIVITY (without Delay Line): Exceeds 2.5 millivolts RMS/cm;
(with Delay Line): Exceeds 5.0 millivolts RMS/cm.

(c) DELAY: 0.35 microsecond (Delay Line).

(d) ATTENUATION: 7 steps, providing divisors of X1, X3, X10, X30, X100, X300, and X1000; plus a variable attenuator which has a range of approximately 12 db.

(e) INPUT IMPEDANCE (without Probe): 1.0 megohm shunted by 30 $\mu\mu$f (maximum). The input may be either AC or DC coupled.

(f) MAXIMUM INPUT VOLTAGE: 600 volts peak.

(g) PROBE: A 10:1 probe is provided which has an input resistance of 10 megohms shunted by 12.0 $\mu\mu$f (maximum). Its maximum voltage rating is 600 volts peak.

(h) CALIBRATION: The amplitude of any part of the waveform displayed on the face of the CRT may be read with an accuracy of ± 3% under most operating conditions by a DC shift method.

### 1.3.2 VERTICAL AMPLIFIER (DIF. INPUT)

(a) RESPONSE: 2 cycles/sec. to 3.5 mc/sec; down 3 db at 3.5 mc/sec.

(b) SENSITIVITY: Exceeds 2.5 millivolts RMS/cm.

(c) MAXIMUM INPUT VOLTAGE: AC, 200 millivolts peak-to-peak; DC, 600 volts peak.

(d) ATTENUATION: Variable 0 to 12 db by means of the main vertical gain control.

(e) INPUT IMPEDANCE: 1.0 megohm shunted by 25.0 $\mu\mu$f (maximum). AC coupled only.

### 1.3.3 HORIZONTAL AMPLIFIER

(a) RESPONSE: 2 cycles/sec. to 1.0 mc/sec; down 3 db at 1.0 mc/sec.

(b) SENSITIVITY: Exceeds 12 millivolts/cm.

(c) ATTENUATION: 3 steps of 20 db/step, plus a variable attenuator having a total range of 22 db (approximately).

(d) INPUT IMPEDANCE: 1.0 megohm shunted by 55 $\mu\mu$f (maximum). AC only.

(e) MAXIMUM INPUT VOLTAGE: 600 volts peak.

(f) SWITCHING: May be connected to an external source through a BNC connector, or may be connected to the internal Time Base Generator.

### 1.3.4 TIME BASE (RECURRENT)

(a) FREQUENCY: 3 cycles/sec. to 500 kc/sec. in 10 ranges; 3–10, 10–30, 30–100, 100–300, 300–1000 cycles/sec; 1–3, 3–10, 10–30, 30–100, 100–500 kc/sec., plus a "FINE FREQUENCY" control.

(b) SYNCHRONIZATION: Internal or External; Plus or Minus.

### 1.3.5 TIME BASE (TRIGGERED)

(a) SWEEP DURATIONS: 1, 5, 50, 500 and 5000 microseconds. All are precalibrated except the 1.0 microsecond sweep.

(b) ACCURACY OF CALIBRATION: ±5%, except the 1.0 microsecond which is only approximate.

### 1.3.6 OTHER ELECTRICAL CHARACTERISTICS.

(a) OPERATING LINE VOLTAGE AND FREQUENCY RANGE: 100 to 125 volts RMS, 50 to 60 cycles/sec.

(b) POWER REQUIREMENTS: Approximately 225 watts at 117.5 volts 50/60 cycles/sec.

1.3.7 MECHANICAL SPECIFICATIONS

(a) GRATICULE: The vertical axis of the Graticule is calibrated in centimeters and millivolts (peak-to-peak, and RMS). The horizontal axis is calibrated in centimeters. Controlled edge illumination is provided.

(b) BEZEL: The bezel is removable. The mounting studs will accept a standard camera mount.

(c) CONNECTORS: All external connections are made with type BNC, 50 ohm connectors, except the ground connections, which are binding posts. The connection to the power line is a detachable type line cord.

(d) SIZE: 15½" high, 11½" wide, and 22¼" deep.

(e) WEIGHT: Approximately 65 pounds (unit only).

1.3.8 ACCESSORIES SUPPLIED WITH THE OSCILLOSCOPE

(a) 10:1 Low Capacitance Probe

(b) Green Filter

(c) Graticule

(d) Detachable Power Cord

(e) Instruction Manual

## 1.4 FUNCTION OF FRONT PANEL CONTROLS AND CONNECTORS

### FRONT PANEL CONTROLS

| Control | Function |
|---|---|
| VERTICAL POSITION | Controls vertical position of trace on CRT. |
| VERTICAL GAIN | Adjusts gain of Vertical Amplifier through a 12 db range. |
| VERTICAL ATTENUATOR | Seven position switch which coarsely selects the vertical gain for signals through VERT INPUT; eighth position furnishes a calibrating signal for the vertical amplifier. |
| VERTICAL FUNCTION | Selects mode of operation for Vertical Amplifier. |
| HORIZONTAL POSITION | Controls horizontal position of trace on CRT. |
| GRATICULE ILLUM. | Adjusts illumination level for the graticule. |
| HORIZONTAL GAIN | Adjusts gain of Horizontal Amplifier. |
| HORIZONTAL SELECTOR | 1. Selects blanking source for CRT.<br>2. Decade Attenuator for Horizontal Amplifier.<br>3. OFF–ON Power Switch. |
| TIME BASE SELECTOR | Selects time base mode of operation and input to Horizontal Amplifier. |
| SWEEP RATE | Coarse adjustment for recurrent sweep rate, and selects duration of triggered sweeps. |
| SWEEP VERNIER | Fine control for recurrent sweep rate. |
| SYNC. AMPLITUDE | Controls amplitude and polarity of synchronizing signal or trigger. |
| METER ZERO | Electrical zero adjuster for Millivoltmeter. |
| FOCUS | Adjusts focus of trace on CRT. |
| INTENSITY | Adjusts brilliance of trace on CRT. |
| VERTICAL BALANCE | Balance adjustment for Vertical Amplifier. |
| HORIZONTAL BALANCE | Balance adjustment for Horizontal Amplifier. |
| ASTIGMATISM (on right side of case) | Adjusts even-ness of focus across CRT trace. |

## FRONT PANEL CONNECTORS

| Connector | Use |
|---|---|
| VERT. INPUT | Main input to Vertical Amplifier. |
| DIF. INPUT | Differential input to Vertical Amplifier. |
| HOR. INPUT/SYNC. INPUT | Input to Horizontal Amplifier when TIME BASE SELECTOR is set at HOR. INPUT: external sync input when TIME BASE SELECTOR is in either EXT. positions. |
| BLANK. INPUT/SAW-TOOTH OUTPUT | External blanking input when HORIZONTAL SELECTOR is set at BLANKING EXT., and time base signal output when TIME BASE SELECTOR is set at any position except HOR. INPUT. |
| GROUND (2 Binding Posts) | Optional grounding connections. |

# SECTION II
# OPERATING INSTRUCTIONS

## 2.1 PRELIMINARY PRECAUTIONS AND ADJUSTMENTS

### 2.1.1 PRECAUTIONS

(a) Inspection. This instrument was tested thoroughly and inspected before shipment and is ready for use. However, before any operation is attempted, inspect carefully for any visible damage which may have occured during shipment. After carefully unpacking the unit, position it at various angles to ascertain that there are no loose pieces of hardware, tubes, or broken parts within the case. The perforated case will permit a partial inspection for any loose or improperly seated tubes.

Any damage or faults caused during shipment should be called to the shipper's attention immediately. If factory service is required, write the Simpson Electric Company, Attn: Repair Dept., indicating the nature of the required service and request shipping instructions.

(b) Ventilation. In order to obtain good ventilation, a perforated metal case is used on the Model 2610. For stable operation and long service life, do not restrict the ventilation by placing other equipment or objects either on top of, or in close proximity to, the case. This is especially important if the other equipment dissipates large amounts of heat.

(c) Stray Magnetic Fields. The Model 2610 is provided with a high quality magnetic shield around the CRT. Therefore, it is insensitive to the stray fields of a level normally encountered in a laboratory. Units containing components such as saturable core reactors, which develop high ambient magnetic fields, should be kept at some distance from the Model 2610. Other components with high ambient magnetic fields are saturable core type regulating transformers and shaded pole induction motor.

(d) Undeflected Electron Beam. Do not allow a bright, sharply-focused, undeflected beam to remain on the face of the CRT for any extended period of time. This will result in damage to the CRT screen.

### 2.1.2 ADJUSTMENTS

(a) "Zeroing" the Meter. The Millivoltmeter on the front panel should be checked for correct mechanical position of its pointer. With the power OFF, the pointer should indicate mid-scale (45 millivolts on the DC OR PEAK TO PEAK scale). If it does not indicate correctly, proceed as follows:

(1) Turn the "zero" adjuster screw (located in the plastic case below the center of the meter scale) counterclockwise to position the pointer at exactly mid-scale on the downward swing of the pointer.

(2) While turning the zero adjust screw, gently tap the cover of the meter case with the forefinger, This will minimize any small residual error due to friction.

(3) With the pointer resting at mid-scale, turn the adjuster screw clockwise very slightly, but do not cause the pointer to move. This relieves the mechanical pressure between the zero adjusting screw and fork.

If the instrument is not subjected to abuse, the mechanical zero pointer position will stay zeroed almost indefinitely.

## 2.2 OPERATING PROCEDURE

### 2.2.1 ENERGIZING THE UNIT

(a) Plug the detachable line cord into the socket on the rear of the case, and connect it to a 100-125 VAC, 50/60 cycle/sec. power source.

(b) Set the following controls at mid-range:

(1) VERTICAL POSITION

(2) HORIZONTAL POSITION

(3) VERTICAL GAIN

(4) SYNC. AMPLITUDE

(5) FOCUS

(6) INTENSITY

(c) Set VERTICAL ATTENUATOR at X1000, VERTICAL FUNCTION to DC LINEAR, SWEEP RATE at 1000 CYCLES PER SECOND, and TIME BASE at RECURRENT INT.

(d) Connect the Probe cable to the VERT. INPUT.

(e) Turn the HORIZONTAL SELECTOR TO INT. BLANKING. This will energize the instrument. If the pilot lamp does not glow, check the fuse on the rear panel.

The instrument will be ready for use after a warmup period of approximately 5 minutes. However, for complete stabilization of the DC Amplifiers, a warmup period of 10 to 15 minutes is recommended. It is suggested that the balance of the manual be read to become familar with the purpose, use and limits of each front panel control, connector and indicator.

2.2.2 VERTICAL AMPLIFIER SECTION

(a) General Information. The Vertical Amplifier Section consists of four direct coupled stages. These are a pre-amplifier, a cathode follower, a driver, and an output amplifier. This Amplifier is always connected to the vertical deflection plates of the CRT. Its input may be AC coupled by means of a series capacitor which is introduced between the VERT. INPUT jack and the VERTICAL ATTENUATOR.

A 0.35 microsecond delay line is included within the Vertical Preamplifier Section. It may be switched into or out of the signal path by means of the VERTICAL FUNCTION switch. It is used when transient type waveforms are being observed in conjunction with an internally triggered time base. The delay line should not be used when accurate amplitude measurements are to be made, or where maximum transient fidelity is required. It should only be used to observe the leading edge of transient waveforms.

A Calibration System is included within the Vertical Amplifier Section.

A 10:1 low capacity probe is provided for use with the Vertical Amplifier. It is used, (a) whenever very low capacity loading of the circuit under test is desired or, (b) whenever the amplitude of the signal to be displayed exceeds the maximum signal which can be applied directly to the VERT. INPUT jack.

In order to realize the maximum fidelity in the Vertical Channel of the Model 2610, the signal should be kept within the vertical limits of the graticule, namely, 6 centimeters.

(b) Inputs. There are two separate inputs to the Vertical Amplifier of the Model 2610. One is through the VERT. INPUT jack and the VERTICAL ATTENUATOR; the other is by way of the DIF. INPUT jack.

The VERTICAL ATTENUATOR is effective only when the VERT. INPUT jack is used as the signal input.

When the VERT. INPUT jack is used, the Vertical Amplifier may be either AC coupled or DC coupled to this jack.

The DIF. INPUT jack is always AC coupled to the Vertical Amplifier.

The maximum signal voltage that can be applied to the VERT. INPUT jack without overloading the Vertical Channel or exceeding the vertical limits of the graticule (6 cm), is 150 volts RMS. The maximum signal voltage that can be applied to the DIF. INPUT, without exceeding the vertical limits of the graticule, is 60 millivolts RMS.

When the 10:1 Low Capacitance Probe is used, the maximum voltage that can be applied to the probe is 600 volts peak. Since the probe is both DC coupled and compensated, true DC coupling is obtained from the probe input to the CRT deflection plates, whenever it is used with the Vertical Amplifier in any of its DC positions.

The normal input to the Vertical Amplifier is through the VERT. INPUT. However, the DIF. INPUT can be used whenever time markers are to be displayed on the horizontal trace or whenever a true differential input is desired.

(c) Vertical Step Attenuator. The VERTICAL ATTENUATOR is a seven position, compensated attenuator in steps of X1, X3, X10, X30, X100, X300, X1000. It is made up of accurate and stable values of resistance and capacitance. It is so designed that it cannot be overloaded either voltage or power wise as long as the Oscilloscope is operated within the specified ratings. Its overall accuracy is ± 1%. The eighth position on this switch is marked CAL. and is used whenever the Vertical Amplifier is to be calibrated for amplitude measurements.

(d) Vertical Gain Control. This control adjusts the gain of the Vertical Amplifier over a range of approximately 12 db. It is operative whether the signal is applied through the VERT. INPUT jack, the DIF. INPUT jack, or both. For best performance, adjust the VERTICAL ATTENUATOR and the VERTICAL GAIN control such that the VERTICAL GAIN control is at or near its CAL. position and the trace on the CRT screen does not exceed 6 cm in amplitude.

(e) Vertical Function Switch. This is a six position switch. For optimum fidelity and accuracy, the Vertical Amplifier has been designed for two modes of operation. These are designated LINEAR and TRANSIENT, respectively, on the VERTICAL FUNCTION switch. Use the LINEAR positions of the switch, either AC or DC coupled, whenever the Model 2610 is used to display or measure the amplitude of essentially sinusoidal waveforms.

Whether the DC or AC position is used depends on whether or not the DC component of the signal is to be considered or disregarded.

The AC TRANSIENT and DC TRANSIENT positions on this switch are used when transient waveforms are to be displayed and measured. Again, AC or DC coupling is available.

The AC DELAY or DC DELAY positions are used whenever the input signal is also used to trigger the Time Base. Since there is a finite delay in the Time Base circuits, one of the two DELAY positions must be used if the leading edge of the waveform is to be observed. When the VERTICAL FUNCTION switch is in either of these two positions, a 0.35 microsecond delay line is inserted in the Vertical Amplifier channel. This delays the signal applied to the CRT with respect to the signal supplied to the Time Base, and allows for the observation of the leading edge of the applied signal. The time delay provided by the delay line is more than adequate in compensating for the time delay of the Time Base Circuits.

When observing a waveform on the CRT, it will be noted that if the VERTICAL FUNCTION switch is switched from one of the undelayed positions to one of the delayed positions, the amplitude of the signal will be reduced to 50 percent of its original value. This results from the fact that for optimum fidelity, the delay line must be matched to the generator which drives it. When a generator is matched to its load, one half of the generated voltage appears across the internal impedance of the generator, the other half across the load. Therefore a 50 percent reduction in signal amplitude occurs when any of the DELAY positions are used on the VERTICAL FUNCTION switch.

(f) Vertical Balance Control. This is a screwdriver adjustment which is used to set the DC balance of the Vertical Amplifier. It requires only occasional adjustment if certain precautions are observed. It is characteristic of any high-gain DC amplifier to drift during the warm up period. The amount of drift, and the length of time it will drift after the power is turned on, depends on a number of factors.

These are the total gain, the stability of the applied electrode potentials, the quality of the vacuum tubes used and the electrical and temperature characteristics of the associated components. Several precautions have been taken to minimize drift in the Model 2610. Nevertheless, do not check or try to adjust DC balance during the warm-up period. After the unit has warmed-up for at least one-half hour and the normal vertical rest position of the beam on the CRT shifts as the VERTICAL GAIN control is rotated the DC balance of the Vertical Amplifier should be adjusted. See Page 21 for the correct adjustment procedure.

### 2.2.3 HORIZONTAL AMPLIFIER SECTION

(a) General Information. The Horizontal Amplifier of the Model 2610 consists of two direct coupled push-pull stages. The output of the amplifier is always connected to the Horizontal Deflection Plates of the CRT. The input to the Horizontal Amplifier may be connected either to the Time Base Section or to the HOR. INPUT/SYNC. INPUT jack through a three-step decade attenuator.

(b) Inputs. As mentioned above, the input to the Horizontal Amplifier may be a signal from the internal Time Base Generator or from an external source. Whenever the HORIZONTAL SELECTOR switch is in either the INT. or EXT. BLANKING position and the TIME BASE SELECTOR switch is in any position except the HOR. INPUT position, the Horizontal Amplifier will be connected to the Time Base Generator. This will be the most commonly used mode of operation for the Horizontal Amplifier.

When the TIME BASE SELECTOR switch is placed in the HOR. INPUT position, the input to the Horizontal Amplifier is connected to a three-step Decade Attenuator and the input of this attenuator is connected to the HOR. INPUT/SYNC. INPUT jack. When this connection is used, the Time Base signal can be supplied from an external source. The maximum voltage that can be applied to this jack is 600 peak volts.

Internally, the Horizontal Amplifier is DC coupled and directly coupled to the CRT. However, it is AC coupled to the HOR. INPUT/SYNC INPUT jack.

(c) Horizontal Gain Control. This control adjusts the gain of the Horizontal Amplifier through a control range of approximately 22 db. Although the overall gain of the Horizontal Amplifier can never be reduced to zero, a total control range of approximately 82 db is available, when this control is used in conjunction with the decade attenuator.

(d) Horizontal Selector Switch. This control is a six position switch and provides three control functions. It is the power OFF–ON switch, it selects the source of blanking signal for the CRT and it is a three-step decade attenuator for the Horizontal Amplifier. The oscilloscope is energized when the switch is in any of the five positions marked: INT., EXT., X100, X10 and X1.

When this switch is in the INT. BLANKING position, the blanking signal is derived from the internal Time Base Generator. In the EXT. blanking position the Blanking Amplifier is connected to the BLANK. INPUT / SAWTOOTH OUTPUT jack. In this position, the CRT may be blanked by an external signal.

With this switch in any one of the three attenuator positions, the input grid of the Horizontal Amplifier is connected to the Decade Attenuator. It, in turn, is connected to the HOR. INPUT/SYNC INPUT jack when the TIME BASE SELECTOR switch is in the HOR. INPUT position.

(e) Horizontal Balance Control. This control is similar to the Vertical Balance Control described in Section 2.2.2–(f). Refer to this section for the control description and to Section 4.1–(c) for the adjustment procedure.

2.2.4 TIME BASE GENERATOR SECTION

(a) General Information. The Time Base Generator is designed to provide two basic modes of operation.

One mode of operation provides recurrent sweeps over the range of 3 to 500,000 cycles/sec. For this type of operation, the Time Base Generator can be synchronized by the signal applied to the Vertical Amplifier channel or from an external signal applied to the HOR. INPUT/SYNC. INPUT jack.

The second mode of operation provides 5 triggered sweeps. The time duration of these sweep periods is fixed at 5000, 500, 50, 5 and 1 microseconds, regardless of the expansion provided by the HOR. GAIN control. When the triggered sweeps are used, the Time Base Generator may be triggered from the signal applied to the Vertical Amplifier channel or by an external signal applied to the HOR. INPUT/SYNC. INPUT jack.

(b) Time Base Selector. This control is a five position switch performing two basic functions. It controls the mode of operation for the Time Base Generator and switches the input to the Horizontal Amplifier.

When this switch is in the INT. RECURRENT position, the Time Base Generator is providing a continuous recurring sweep and the synchronizing signal is obtained from the main signal applied to the Model 2610. In the EXT. RECURRENT position, the operation is the same except an external synchronizing signal must be applied to the HOR. INPUT/SYNC. INPUT jack.

When this switch is in the INT. or EXT. TRIGGERED positions, the Time Base Generator must be triggered. In the INT. TRIGGERED position, the trigger is derived from the main signal input to the oscilloscope. When the switch is in the EXT. TRIGGERED position, an external trigger signal must be applied to the HOR. INPUT/SYNC. INPUT jack.

When this switch is in the HOR. INPUT position the Horizontal Amplifier with its Decade Attenuator is connected to the HOR. INPUT/SYNC. INPUT jack.

Generally, the recurrent sweeps with internal synchronization are used for the observation of sinusoidal waveforms. Also, the triggered sweeps are generally used for the transient type waveforms. Although the triggered sweeps can be triggered by a sine wave within the time duration limitation of each individual sweep, the availability of the recurrent sweeps makes this type of operation unnecessary.

The triggered sweeps are most useful when transients, with a short time duration as compared to the repetitive interval, are to be observed. Use of an internally derived trigger or external trigger depends primarily on two factors. If the leading edge of the waveform is to be observed, and an external trigger is available preceeding in time that part of the waveform to be observed, then EXT. TRIGGERED operation should be used.

(c) Sweep Rate Switch. This switch is used to select any one of the ten ranges of recurrent sweeps and any one of the five ranges of triggered sweeps. The total range of the recurrent sweeps is from approximately 3 cycle/sec. to 500 kc/sec. The markings on the front panel indicate the maximum repetition rate for each switch position. For example, with the SWEEP RATE switch in the 300 CYCLES PER SECOND position and in conjunction with the SWEEP VERNIER control, the total range will be at least 100 to 300 cycles/sec.

Correspondingly the total range with this switch in the 10 CYCLES PER SECOND position will be 3 to 10 cycles/sec. Actually, the Model 2610 has been designed to provide a generous overlap between adjacent ranges.

Five triggered sweep ranges are provided. These are designated as 5K, 500, 50 and 5 $\mu s$ on the SWEEP RATE switch. The fifth sweep has a duration of approximately one microsecond. It is not identified on this switch, but is available on either the 30, 100, or 500 KC PER SECOND positions.

(d) Sweep Rate Vernier Control. The SWEEP VERNIER control is a potentiometer. It is used to obtain incremental values of recurrent sweep rates over a range determined by the setting of the SWEEP RATE switch. It has arbitrary markings from 0 through 10 to assist in repeating any desired setting. This control is not used for Triggered Time Base operation.

(e) Sync. Amplitude Control. This control is a center-tapped potentiometer. It is used to set the amplitude and polarity of the synchronizing signal for the Recurrent Sweep and the triggering level and polarity for the Triggered Sweeps.

The table shown below indicates the polarity of sync. or triggering signal injected into the time base generator for all settings of the TIME BASE SELECTOR switch and the SYNC. AMPLITUDE control.

SYNC. AMPLITUDE

0

| | | | |
|---|---|---|---|
| INTERNAL SYNC. | RECURRENT | + | − |
| | TRIGGERED | − | + |
| EXTERNAL SYNC. | RECURRENT | − | + |
| | TRIGGERED | + | − |

To obtain stable Recurrent Sweep operation do not use more synchronizing signal than necessary to obtain a steady trace.

Also, for Triggered Sweep operation, do not use a higher trigger amplitude than required to obtain a stable sweep. Using a greater trigger amplitude than necessary will cause inaccuracy of the triggered sweeps and erratic operation.

Therefore, DO NOT OVER–SYNC. and DO NOT OVER–TRIGGER for best performance.

(f) Blanking Input/Sawtooth Output Jack. This jack serves two main functions. With the HORIZONTAL SELECTOR switch in the INT. BLANKING position, and the internal Time Base Generator operating, its sawtooth output is available at this jack. With the HORIZONTAL SELECTOR switch set at any other position, an external blanking signal can be applied to the jack.

Two particular precautions should be observed when the sawtooth signal is used. First, the external load must be AC coupled to this jack. Second the load must not exceed 50,000 ohms shunted by 50 $\mu\mu f$.

### 2.2.5 DISPLAY & CALIBRATION SECTION

(a) **General Information.** This section consists of the CRT, and its auxiliary controls and, the indicating meter and controls required to calibrate the Vertical Amplifier section.

The CRT controls are conventional and are identified as FOCUS, INTENSITY, VERTICAL POSITION, HORIZONTAL POSITION and Astigmatism. All of these are front panel controls except the Astigmatism which is a screw-driver control located on the right side of the case near the panel edge. Another control is the GRATICULE ILLUM. which is used to adjust the edge lighting for the Graticule.

(b) **Calibration System.** The Calibration System is used to standardize the gain of the Vertical Amplifier.

To use this system, proceed as follows:

(1) Establish the waveform to be measured on the CRT screen. Keep the maximum amplitude of the waveform within the vertical limits of the Graticule.

(2) Turn the VERTICAL ATTENUATOR switch to the CAL. position. The main signal will disappear and a waveform at the power line frequency will appear on the CRT.

(3) Adjust the VERTICAL GAIN control until the signal displayed has been nulled. Leave the VERTICAL GAIN control at this setting.

(4) Turn the VERTICAL ATTENUATOR to the original position that was used to establish the waveform to be measured. If the displayed signal exceeds the vertical graticule limits, select a higher value of attenuation using the VERTICAL ATTENUATOR. If the amplitude of the signal is less than two centimeters, use a lower value of attenuation. Do not re-adjust the VERTICAL GAIN control.

(5) Using the VERTICAL POSITION control, obtain coincidence between the top of the waveform to be measured and the horizontal center line on the graticule.

(6) Adjust the meter to the scale 0 using the METER ZERO control.

(7) Displace the waveform to be measured through its own amplitude using the VERTICAL POSITION control, i.e., position the bottom of the waveform to the same horizontal line on the graticule that was used in step 5 above.

(8) The meter will display two values: a DC or Peak-to-Peak value, and an RMS value. The meter reading multiplied by the VERTICAL ATTENUATOR multiplier factor will yield the total signal amplitude in millivolts.

The calibration procedure outlined above will yield an accuracy of ± 3% if the amplitude of the displayed signal is maintained between 3 to 6 centimeters and the adjustments and measurements are carefully made. When this order of accuracy is unnecessary and the VERTICAL GAIN control is left at its calibrated position, the signal amplitude can be read directly on the graticule using the appropriate multiplier factor. Under these conditions, the accuracy will be limited to the accuracy with which the value is read from the graticule.

### 2.2.6 OSCILLOGRAPH APPLICATIONS

The Model 2610 is designed to permit photographing of the waveform on the CRT. It will accept the conventional 5'' x 5'' camera mounts.

To mount the camera, remove the four round knurled nuts that hold the bezel, filter and graticule. If a calibrated reference is desired, leave the graticule in place. Replace the four knurled nuts to secure the camera.

The CRT screen has a P-1 phosphor operating at an acceleration potential of 2275 DCV. Relate this information to the instructions for the oscillograph camera used to obtain the best results.

# SECTION III
# THEORY OF OPERATION

## 3.1 THE COMPLETE SYSTEM

For the purpose of this discussion, the Model 2610 Oscilloscope can be divided into five basic sections, as follows:

3.2 VERTICAL AMPLIFIER SECTION

3.3 HORIZONTAL AMPLIFIER SECTION

3.4 TIME BASE GENERATOR SECTION

3.5 DISPLAY AND VERTICAL CALIBRATION SECTION

3.6 POWER SUPPLY SECTION

First, the system as a whole will be discussed using the Block Diagram shown in Figure 2 followed by a description of each section separately.

With a signal applied to the probe and the probe connected to the VERT. INPUT jack, the signal passes through the probe to the Vertical Step Attenuator. The position of switch S1 determines whether the signal path is DC or AC coupled. The probe is DC coupled; the Vertical Amplifier is DC coupled from the Vertical Attenuator to the Vertical Plates of the CRT. Thus, if the capacitor C1 is shorted out by the switch S1, the signal path is completely DC coupled from the input to the probe directly to the vertical plates of the CRT. If S1 is open, the signal path is AC coupled because of C1 only; the rest of the signal path is DC coupled.

From the Vertical Attenuator, the signal is coupled to the Pre-Amplifier. Then, the setting of the VERTICAL FUNCTION switch determines whether the signal is coupled to the phase inverter directly or through the delay line.

The Internal Synchronizing Signal for the Time Base Generator is derived after one stage of amplification and before the Vertical Gain control. This provides a very desirable feature in that once the incoming signal is stabilized on the face of the CRT, variations of the Vertical Gain control do not affect the stability of the display. Also, the signal that would be used to trigger the Time Base for Triggered Operation is also derived ahead of the Delay Line. As pointed out in Paragraph 2.2.2-(e), this provides for observing the leading edge of transient waveforms when the trigger for the Time Base is internally derived.

From the Phase Inverter, the signal is coupled to the Vertical Output Amplifier and, then, to the Vertical Deflection plates of the CRT.

The input to the second vertical channel is by way of the DIF. or Differential Input jack. This channel is arranged so that it can be only AC coupled as indicated in Figure 2. A signal applied to this jack is AC coupled to the Pre-Amplifier where it is amplified and again coupled to the phase inverter.

The Vertical Attenuator does not affect the amplitude of a signal applied through the Differential Input Channel. The signal amplitude is controlled only by the Vertical Gain control when the Differential Input Channel is used. Also, the Delay Line does not effect any signal applied to this channel. A study of Figure 2 reveals that the synchronizing signal must be obtained from an external source when the signal is applied only to the Differential Input Channel.

The Time Base provides either Recurrent or Triggered Sweeps. When the recurrent sweeps are used with internal synchronization, the synchronizing signal is amplified by the Sync. Amplifier and, then, depending on the position of the Sync. Amplitude Control, either a positive or negative signal is selected to synchronize the Time Base Generator. For this type of operation the Time Base Generator provides 2 output signals. One signal is a sawtooth type of waveform which is applied to the Horizontal Amplifier, amplified and then DC coupled to the Horizontal Plates of the CRT and providing the Time Base. The second signal is a positive pulse which is amplified by the Blanking Amplifier and then applied to the control grid of the CRT. This signal coincides in time with the trailing edge of the sawtooth waveform and is used to blank the CRT during the retrace period.

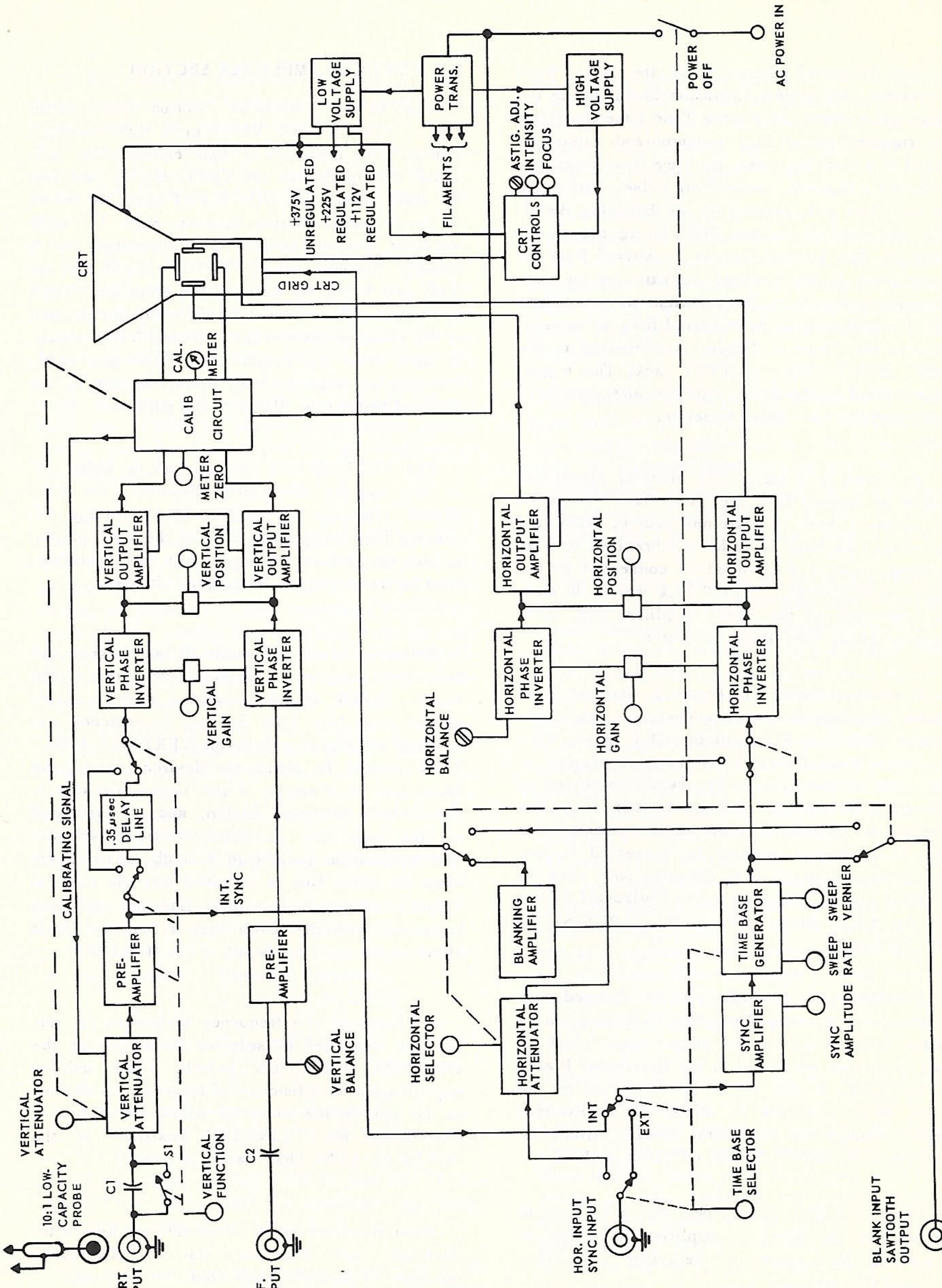



FIGURE 2 – BLOCK DIAGRAM OF MODEL 2610

For Triggered Operation of the Time Base Generator, the System Operation is similar to the description above, except the Time Base Generator is triggered rather than synchronized. Also, instead of a blanking pulse, the Time Base Generator provides a negative intensifying pulse. This pulse is amplified and inverted by the Blanking Amplifier and applied to the CRT during the sweep interval. The Internal Trigger is derived from the same point in the Vertical Amplifier as the synchronizing signal for the recurrent sweeps. When the Time Base is to be triggered from an external source, the External Trigger is connected to the HOR. INPUT/SYNC. OUTPUT jack. The trigger is amplified by the Sync. Amplifier and, then used to trigger the Time Base Generator.

As shown in Figure 2, the blanking signal can either be derived from the Time Base Generator, or obtained from an external source. When the recurrent time base is to be synchronized from an external source, the signal is connected to the HOR. INPUT/SYNC. INPUT jack which, in turn, is connected to the Sync. Amplifier and, then, coupled to the Time Base Generator.

It will be observed in Figure 2, that the Horizontal Amplifier is always connected to the Horizontal Deflection Plates of the CRT. Also, when the Time Base Generator is used, regardless of its mode of operation, it is always connected to the CRT through the Horizontal Amplifier. The Horizontal Attenuator is out of the circuit when the Time Base Generator is connected to the Horizontal Amplifier. It is effective only when an external signal is applied to the Horizontal Plates of the CRT through the HOR. INPUT/SYNC. OUTPUT jack.

The Horizontal Amplifier is a DC coupled, two stage, push-pull amplifier. The first stage is a phase inverter driving the output stage which in turn is always connected to the Horizontal Plates of the CRT. It may either be connected to the Time Base Generator or driven by an external signal through the Horizontal Decade Attenuator and the HOR. INPUT/SYNC. OUTPUT jack.

The Model 2610 is provided with a calibration system for the Vertical Amplifier as shown in Figure 2. This system is described in Section 3.5.2 of this manual.

## 3.2 VERTICAL AMPLIFIER SECTION

The Vertical Amplifier Section uses seven tubes, V101 through V107, in a direct-coupled circuit. Two independent input channels are provided. One is through the VERT. INPUT jack and the other through the DIF. INPUT jack. As shown on the Schematic Wiring Diagram, page 35 , each amplifier channel utilizes a pre-amplifier and a cathode follower stage. The pre-amplifiers are V101 and V102; the cathode followers are V103A and V103B. These two channels are then combined in the phase-inverter stage V104 and V105, which, in turn, drive the output stage V106 and V107. The output stage is then direct-coupled to the Vertical Deflection Plates of the CRT.

The VERT. INPUT channel can be either AC or DC coupled throughout. However, the DIF. INPUT channel, although it is completely DC coupled from the pre-amplifier to the CRT plates, is AC coupled at the input grid and, therefore, must be treated as an AC coupled channel.

Reference to the Schematic Wiring Diagram and the Block Diagram of Figure 2 will reveal the VERT. INPUT channel contains a 0.35 microsecond delay line. This line may be switched into or out of the signal path by the VERTICAL FUNCTION switch. To obtain the desired results, the delay line is driven by a low impedance source, the cathode follower, V103A, and is terminated at both ends into its characteristic impedance. The termination results in a 6 db loss in gain when the delay line is switched into the Vertical Amplifier Channel. The delay line has sufficient bandwidth with the result that it has very little effect on the total bandwidth of the Model 2610.

A choice of two frequency responses for the Vertical Amplifier is selected by means of the VERTICAL FUNCTION switch. Where uniform amplification as a function of frequency is desired as is usually the case for sinusoidal types of waveforms, the "LINEAR" positions of the VERTICAL FUNCTION switch are used.

When transient types of waveforms are to be observed and measured, the "TRANSIENT" positions of the switch are used.

In the transient positions, the circuits have been designed and compensated to achieve adequate rise time and overshoot characteristics. The frequency response is approximately 3 db down at 3.5 mc./sec. The rise time will be less than 0.08 microsecond with an overshoot less than 3%.

The linear response of the Vertical Amplifier is extended to 8.0 mc./sec. within ± 1.5 db by the use of compensating networks. These networks extend the linear response of the amplifier which is very desirable for certain applications; however, these networks will produce ringing and overshoot when transient type signals are applied. Therefore, the "LINEAR" modes of operation should not be used for observation and measurement of transient type waveforms.

For "LINEAR" modes of operation, the frequency response is within the limit specified when the VERTICAL GAIN control is used at, or near, its "Calibrated Setting". The Calibrated Setting is defined as "that particular VERTICAL GAIN control setting which results from the calibration of the Vertical Amplifier". The VERTICAL GAIN control setting has no affect on the frequency response below 6.0 mc./sec.

The Vertical Amplifier in the Model 2610 provides six modes of operation, as follows:

1. A.C. Coupled – Linear Response – No Delay
2. D.C. Coupled – Linear Response – No Delay
3. A.C. Coupled – Transient Response – No Delay
4. D.C. Coupled – Transient Response – No Delay
5. A.C. Coupled – Transient Response – With Delay
6. D.C. Coupled – Transient Response – With Delay

These modes are selected by the VERTICAL FUNCTION switch and are available only when the VERT. INPUT jack is used.

In addition, a second signal channel is available through the Differential Input jack. Since this signal channel operates entirely independent of the main input, it does not provide the modes of operation listed above. However, it is very useful for time base marking and for applications that require a differential type of input.

The Vertical Amplifier Section is equipped with a seven position attenuator having a total range of 60 db. It is a very precise device and is completely compensated for frequency resulting in a linear bandwidth of at least one order of magnitude greater than the overall bandwidth of the Vertical Amplifier.

In addition, the signal path from the Vertical Input jack to the VERTICAL ATTENUATOR is capacitively compensated so that the input capacitance is constant regardless of the VERTICAL ATTENUATOR setting. This yields a completely linear frequency response over a very wide range when the 10:1 Low Capacitance Probe is used.

The Vertical Amplifier in the Model 2610 is a high gain direct coupled amplifier. Therefore, several design precautions have been taken to reduce drift and instability to a minimum. First, all of the important potentials are well regulated. Second, high quality, stable components have been used throughout the unit. For example, the majority of the resistance elements are of the deposited carbon film type for stable and noise free operation and many of the capacitors are of the Mylar-Film Type. Hum and drift are virtually eliminated by using the combined cathode currents of V106, 107, 203 and 204 to energize the heater of V101 and 102. Since this current is obtained from pentodes operating from a well regulated source for the screen potential, this current is constant, ripple free and completely independent of wide line voltage variations. Hum and noise pick-up from other extraneous sources is also eliminated by the compartment shielding of the low level stages.

One of the requirements for the Vertical Amplifier in a wide band oscilloscope is that it have sufficient output capability to drive the Vertical Plates of the CRT to full screen deflection in a linear manner. Since wide band-width implies low values of plate loads for the output stage, the maximum bandwidth versus output voltage (and therefore, power dissipation) must be a compromise. In the Model 2610, the output stage V106 and V107 has sufficient power capability so that when the Vertical Amplifier is driven to produce full scale deflection on the CRT, there is no visible waveform distortion.

Under these conditions the linearity is better than 5 percent. When vertical amplitude of the waveform is confined within the vertical limits of the graticule, namely, 6 centimeters, the linearity of the Vertical Amplifier will be better than 2 percent.

## 3.3 HORIZONTAL AMPLIFIER SECTION

The Horizontal Amplifier Section uses four tubes, V201 through V204, in a direct-coupled push-pull circuit. The output of this amplifier is always connected to the Horizontal Deflection Plates of the CRT. As shown in Figure 2, the input may either be connected to the internal Time Base Generator or to an external signal source through the Horizontal Decade Attenuator and the Horizontal Input/Sync. Input jack. This amplifier has been compensated for optimum frequency response and has sufficient bandwidth to pass the high frequency components implied in the fast sweeps generated by the Time Base Generator. For complete information on the sensitivity and frequency response of the Horizontal Amplifier refer to page 1 Section 1.3.3.

The Horizontal Amplifier is equipped with a continuously variable gain control which has a range of approximately 10 to 1. This provides for a high degree of sweep expansion, and enhances the apparent sweep speeds. This control is a rheostat between the cathodes of the phase-inverter amplifier. The gain is varied by controlling the amount of cathode degeneration and signal coupling. This control is in a frequency sensitive circuit and therefore, its total value must be a compromise between the gain ratio and amplifier bandwidth. The value was selected to give the necessary bandwidth as well as the 10 to 1 gain ratio. For the reasons indicated above, the gain of this amplifier (and therefore the length of the horizontal trace) cannot be reduced to zero when the internal sweeps are being used.

When the Horizontal Section of the Model 2610 is connected to an external signal source, the input grid is switched to a three position decade attenuator, which in turn is connected to the Horizontal Input/Sync. Input jack. This attenuator is compensated for a flat frequency response and provides a total attenuation factor of 40 db.

## 3.4 TIME BASE GENERATOR SECTION

The Time Base Generator utilizes five tube envelopes (eight tube functions) V301 through V305 as follows:

- V301 – Phase splitter and first sync. amplifier
- V302 – Second sync. amplifier and triggering diode
- V303 – Sawtooth generator
- V304 – Blanking amplifier
- V305A – Clamping diode
- V305B – Cathode follower and linearizer.

This section provides two modes of operation. In one mode of operation, the Time Base Generator provides continuously variable, free running sweeps from 3 cycles/sec. to 500 Kc./sec. in ten overlapping ranges. It can either be synchronized by a signal derived from the signal passing through the Vertical Amplifier, or synchronized from an external signal source.

The other mode of operation provides four precalibrated, triggered sweeps, having durations of 5, 50, 500 and 5000 microseconds. Again, the trigger may either be derived internally from the main signal input or from an external trigger source. A fifth uncalibrated sweep, having a time duration of approximately one microsecond is also available. This sweep is obtained when the SWEEP RATE switch is in any position other than the 5, 50, 500 or 5K μs position.

The Time Base Generator also generates a positive pulse which is coincident in time with the trailing edge of the sawtooth. This pulse is coupled to the grid of the blanking amplifier, V304. It is amplified and coupled to the grid of the CRT for sweep retrace blanking.

When the triggered mode of operation is used, the Time Base Generator also provides a negative gate which is coincident in time and duration with the Time Base Sawtooth. It is amplified and inverted by the Blanking Amplifier and coupled to the grid of the CRT. This positive gate essentially turns the CRT beam ON during the sweep period and OFF for the remaining time. This minimizes the bright spot that would appear on the CRT if an intensifying gate were not used.

The Sync. Amplifier associated with the Time Base Generator consists of 1½ tube envelopes (three tube functions) which are V301A & B and V302A. V301A is a phase-splitter permitting the the desired polarity of trigger or synchronizing signal for the Time Base Generator regardless of the incoming trigger or sync. signal polarity. From the phase-splitter, the trigger or synchronizing signal is amplified by two wide band stages V301B and V302A. These stages have sufficient gain and bandwith to insure adequate sync. or trigger amplitude as well as the faithful reproduction of the respective waveform. Synchronization and triggering are possible at input signal levels as low as 5.0 millivolts peak-to-peak into the Vertical Amplifier.

The Blanking Amplifier, V304, consists of one stage of amplification using a high gain pentode. It is compensated for a wide pass band which provides the required fidelity to pass the blanking pulses for recurrent mode of operation, and the intensifying gate pulse for the triggered mode of operation. It is AC coupled to the control grid of the CRT when internal blanking or intensifying is used.

To simplify description, the two modes of operation of the Time Base Generator are described separately as follows:

### 3.4.1 RECURRENT MODE OF OPERATION

Refer to Figure 3, Page 16, for the simplified diagrams.

Only the components and potentials necessary for an explanation of the basic operation have been included in these diagrams. For more detailed circuit information, refer to the Schematic Wiring Diagram shown on Page 35.

When the Time Base Generator is operating in the recurrent mode, it is functioning as a free-running sawtooth generator and is capable of being synchronized by an appropriate signal.

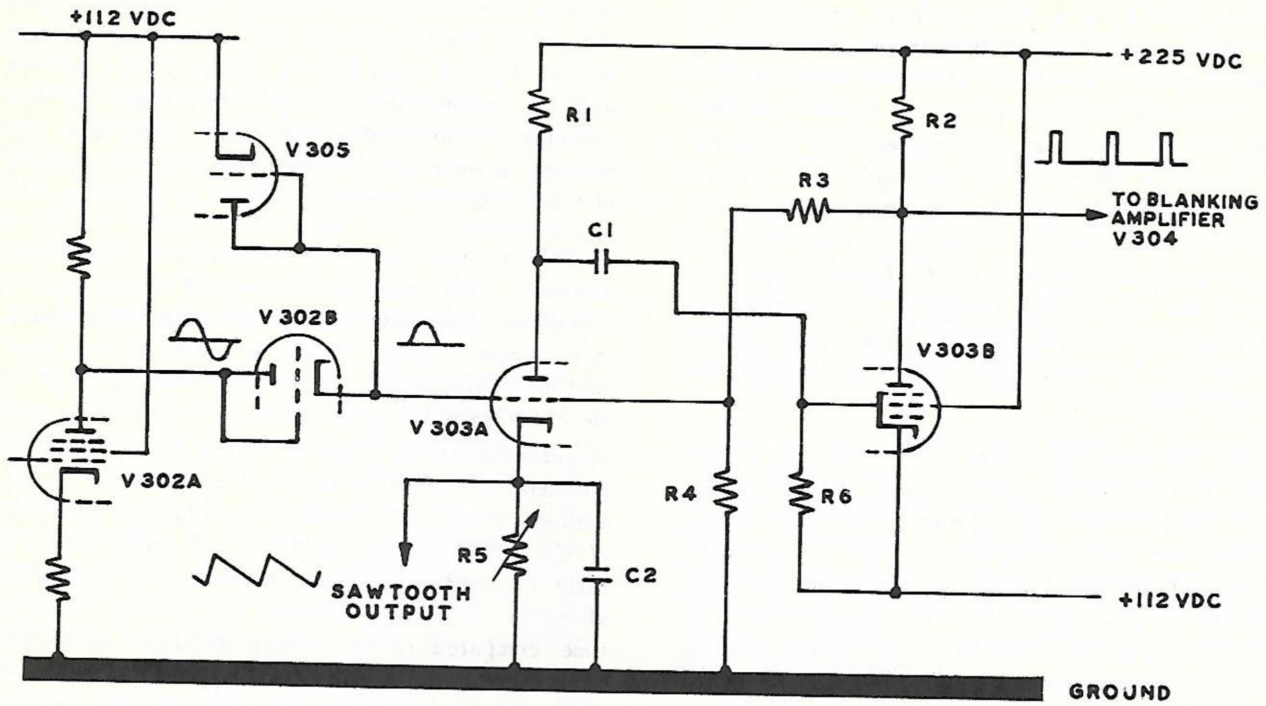
Figure 3A, will reveal that there are two levels of stable potentials relative to Ground; namely +112V DC and +225V DC. When power is applied to this circuit, V303A starts to conduct through R1, and will charge C2. The initial charging current of C2 causes the plate potential of 303A to drop to its lowest value at the instant potential is applied to the circuit. This drop in potential is coupled through C1 to the grid of V303B driving it into plate current cut-off. This causes the potential at the plate of V303B to very rapidly rise toward B+ creating the leading edge of the blanking pulse. Simultaneously, by the voltage divider action of R2, R3 and R4, the grid of V303A follows and C2 continues to charge toward the DC bus potential. This action continues until the difference in potential between the grid and cathode of V303A causes the plate current to decrease.

This causes the plate potential of V303A to increase. This increase is coupled to the grid of V303B as a positive going signal and by regenerative action, causes V303B to return to full conduction. This action creates the trailing edge of the blanking pulse at the plate of V303B. The drop in potential at the plate of V303B causes the grid potential of V303A to decrease with respect to the cathode which has assumed the charged potential of C2. This causes V303A to be cutoff with C2 fully charged. The part of the cycle described above is the retrace interval and is very short in time compared to the sweep duration. When the retrace interval becomes an appreciable portion of the total sweep time, the limits of this method have been reached and a very poor sweep results.

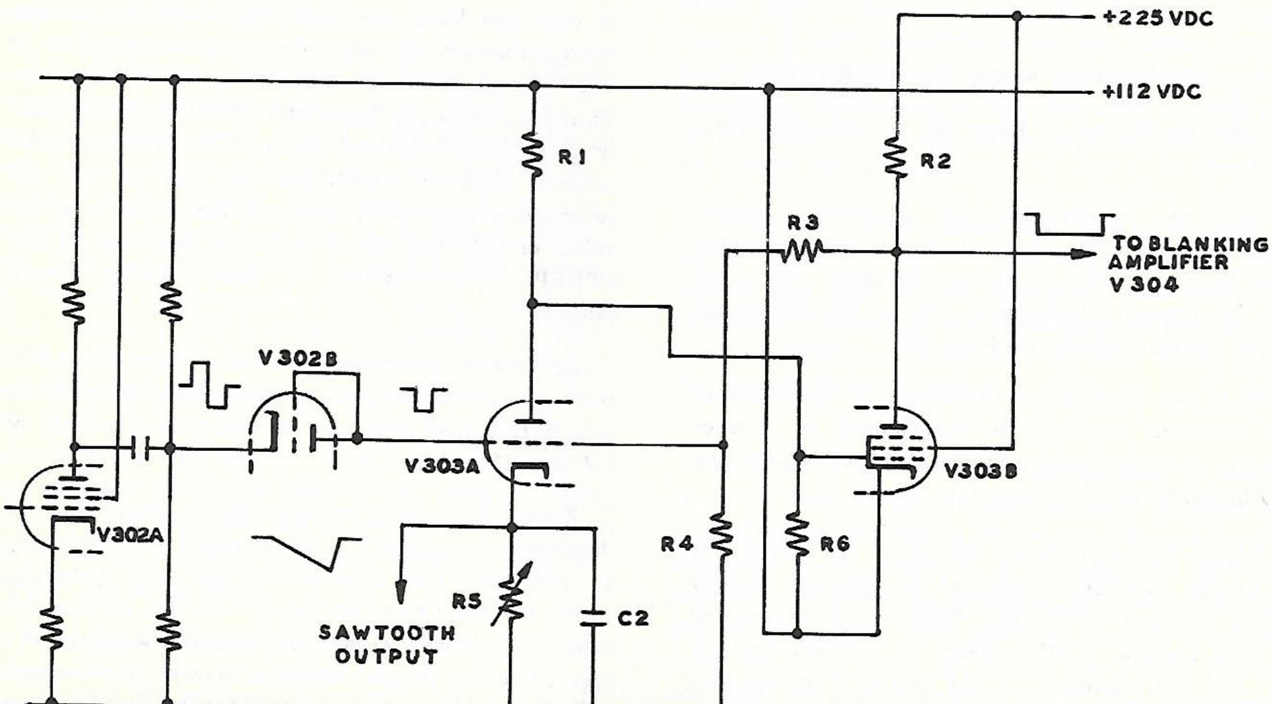
With C2 charged and V303A cut-off, C2 starts to discharge across R5 forming the sweep portion of the time base sawtooth. C2 continues to discharge through R5 until the cathode potential of V303A approaches a value to cause conduction. This completes the cycle and V303A instantaneously goes into full conduction. The fine frequency control (SWEEP VERNIER) is part of R5 and determines the sweep interval range for a given value of C2. The value of C2 is selected by the SWEEP RATE switch for the different sweep ranges.

Up to this point, the Recurrent Time Base has been described as a free running device with its rate determined primarily by the time constant of C2 and R5.

With V303A in a non-conducting state and C2 discharging through R5, the cathode is decreasing in potential and approaching the grid potential which is firmly fixed by the divider R2, R3 and R4. Now, if a positive signal of sufficient amplitude is applied to the diode V302B, a current flows which will then make the approach of potential between grid and cathode more rapid. A point is reached where the tube will again start to conduct and the sweep cycle will be repeated. This then corresponds to synchronization. The D.C. potential




(A) RECURRENT TIME BASE




(B) TRIGGERED TIME BASE

FIGURE 3 – MODEL 2610 TIME BASE GENERATOR SIMPLIFIED CIRCUIT DIAGRAMS

across the Triggering Diode V302B, is arranged so that it does not load the Time Base Generator except during the very short transition period between non-conduction and conduction of V303A. When V303A starts to conduct, the potential at the grid as well as the cathode of V302B starts rising rapidly toward B+ which very rapidly disconnects the triggering diode from the Time Base Generator. A clamping diode V305A is connected from the common junction of cathode V302B and grid V303A to B+ in order to limit the average V303A grid potential. This provides a stable sweep of constant length regardless of sweep frequency.

The sharp positive pulse which is generated at the plate of V303B, is coincident in time with the retrace interval of the sweep. It is coupled to the grid of the Blanking Amplifier which amplifies and inverts the pulse. This signal now has the correct polarity and sufficient amplitude to be coupled to the grid of the CRT for blanking during the retrace interval.

### 3.4.2 TRIGGERED MODE OF OPERATION

A simplified circuit diagram for the triggered mode of operation is shown in Figure 3B. Essentially, the same tubes are used and perform similar functions. However, the change of states must be initiated by a triggering signal which results in a one to one correlation between the trigger rate and the sweep rate.

The circuits are D.C. coupled and the potentials are so arranged that when the circuit is triggered, it goes through one cycle of operation and then "stands by" awaiting the next trigger.

The operation is as follows: The D.C. potentials associated with V303A cause it to conduct continuously during the OFF period of the sweep and Capacitor C2 is charged to a potential equal to its cathode potential. Simultaneously, V303B is cut off. Under these conditions, the grid of V303A is at a fixed positive potential relative to ground and its cathode. It is apparent then, that to be switched OFF, it must be triggered by a negative going signal. Applying a negative signal to the cathode of V302B causes the plate of V302B and the grid of V303A to decrease in potential. This in turn, causes the plate potential of V303A to rise toward B+. Since the grid of V303B is connected to the plate of V304A, its potential also increases toward B+.

The increase is very rapid toward a potential level which causes V303B to conduct. This causes its plate to fall from the potential of the B+ bus. This drop in potential at the plate of V303B causes the grid of V303A to drop even further negative from its initial fixed potential. Since the cathode potential of V303A is essentially fixed, by regenerative action the tube is quickly cutoff and essentially disconnects itself from C2 and R5.

Now, V303B is in full conduction and clamps the grid of V303A at a new potential. This new potential is below the cathode potential of V303A and determined only by the conducting condition imposed by V303B. With the grid of V303A solidly clamped, C2 starts to discharge through R5. It causes the cathode potential to decrease and approach the grid potential of V303A. At some time, determined by the time constant of R5 and C2, a cathode potential will be reached where V303A will rapidly rise to full conduction. Simultaneously, this will cause the potential at the plate of V303A and the grid of V303B to drop until V303B is cutoff. Thus, V303A will continue to conduct in a stable manner and V303B will remain cutoff until the circuit is again triggered.

Except for polarity, the action of the diode V302B in Figure 3 is similar to the action described under the Recurrent Mode of Operation. It is biased so that it has little effect on the grid of V303A until a negative going waveform is applied to its cathode. When this occurs, current flows, and the Sawtooth Generator is triggered and repeats the sequence of operation described above. Simultaneously, the grid of V303A and the plate of the trigger diode V302B start going negative with respect to their initial fixed potential. This drives the diode into plate current cutoff and therefore, it is essentially disconnected from the Sawtooth Generator.

From the Sawtooth Generator, the sweep waveform is coupled to a cathode follower. This provides several desirable results. First, since a cathode follower is a low impedance source, its output can be preserved even in the presence of fairly sizeable stray capacitance. Secondly, the waveform can be shaped and sweep linearity preserved. From the cathode follower V305B, the time base signal is coupled to the Horizontal Plates of the CRT through the Horizontal Amplifier.

## 3.5 DISPLAY AND VERTICAL CALIBRATION SECTION

### 3.5.1 DISPLAY SECTION

The Model 2610 uses a 5ABP1 Cathode Ray Tube in the display section. It is a 5" flat-faced tube equipped with a post-ultor accelerator element for maximum trace definition coupled with excellent sensitivity. The total acceleration potential is approximately 2275 DC volts. Of this total, −1900 DCV is applied to the cathode and +375 DCV to the Post-Ultor. The focus and intensity control potentials are obtained from the voltage divider string in the cathode circuit of the CRT. The horizontal and vertical shift potentials are obtained by varying the balance of DC potentials on the grids of the output tubes. This is possible because of the direct coupling between the plates of the output tubes and the CRT deflection plates.

The CRT is equipped with a green filter and ruled graticule held in position by a removable bezel. The ruled face of the clear graticule is nearest the screen of the CRT. This, in combination with the flat screen surface of the CRT, aids in eliminating parallax errors between a display on the CRT and the rulings on the graticule.

### 3.5.2 VERTICAL CALIBRATION SECTION

This oscilloscope is equipped with a unique, accurate and simple calibration system for the Vertical Section. Its basis is a fundamental principle, namely, that the turns ratio and the voltage ratio of a transformer once set by design, is invariant. The calibration systems in common use in other oscilloscopes generally utilize methods in which the accuracy can be affected by line voltage variations and/or component ageing. The method used in this oscilloscope is not affected by the factors indicated above.

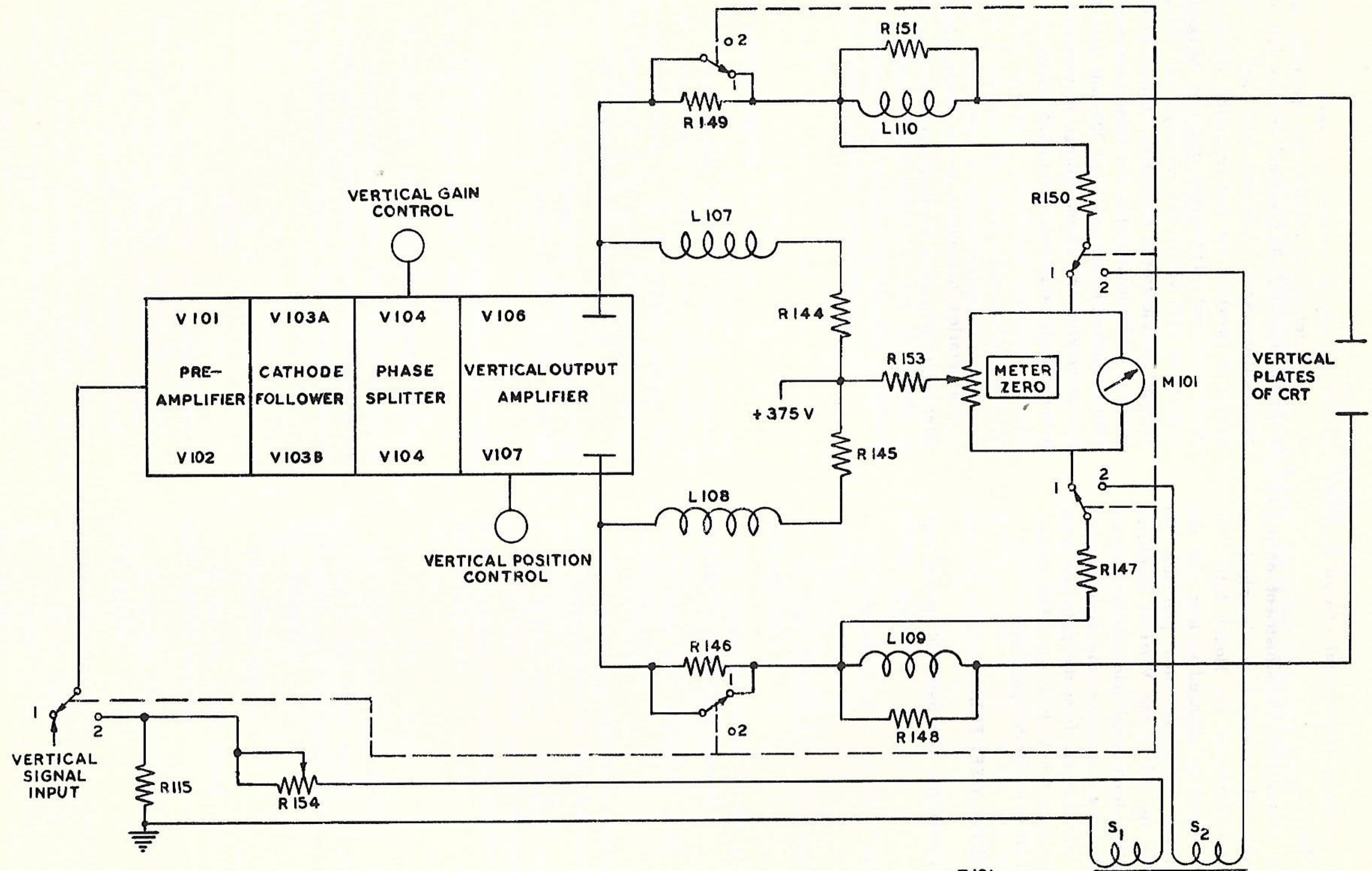
A simplified block-circuit diagram of the Vertical Calibration System is shown in Figure 4. With the VERTICAL ATTENUATOR switch in the CAL position (corresponding to position #2 for all switches shown in Figure 4), two AC potentials at line frequency are applied to the Vertical System. One is connected to the input of the Vertical Amplifier; the other is applied to a network which is common to the output stage and the Vertical Deflection Plates of the CRT. The phase of these voltages is arranged so that for one value of Vertical Amplifier gain, a trace null will be obtained on the CRT.

This system is adjusted at the factory in the following manner:

With the VERTICAL ATTENUATOR switch in the X1 position (this corresponds to position #1 for all switches shown in Figure 4), an AC signal with an accurately known amplitude is applied to the Vertical Input jack. The signal used is 20 millivolts RMS, ±0.25 percent, 500 cycles/sec. The millivoltmeter on the Model 2610 is set to its electrical zero by the METER ZERO control, R152. The VERTICAL GAIN control is adjusted so that when the signal displayed on the CRT is displaced through its own amplitude (using the VERTICAL POSITION control), the Millivoltmeter (M-101) indicates a value equal to the input signal, namely 20 millivolts RMS. Without disturbing this VERTICAL GAIN control setting, place the VERTICAL ATTENUATOR switch in the calibration (CAL) position (this corresponds to switch position #2 for all of the switches shown in Figure 4). A signal at power line frequency will appear on the CRT screen; its magnitude depends on the setting of R154. R154, which is a factory adjusted control, is adjusted until the signal on the CRT screen is nulled. This adjustment of R154 standardizes the Vertical Calibration System. It can always be returned to this state by simply turning the VERTICAL ATTENUATOR switch to the Calibrate position and adjusting the VERTICAL GAIN control until a trace null is obtained on the CRT.

The factory adjustment described above eliminates the component tolerance errors within this system and therefore have no bearing on the final overall accuracy of Vertical Calibration. Tolerance errors of the calibration transformer turns ratio, the value of R115, R147, R150, R154, including the full scale current of the meter are all removed during the calibration procedure. The only requirement for all of these components is stability; and not exactness of value. This is assured by careful selection of these components.

In addition, the CRT deflection sensitivity is not involved in the overall accuracy of the Calibration System. During the calibration procedure, it is merely a null-indicator, and during the measurement procedure, it is only a visual displacement indicator. The actual value of displacement is read on the meter and not on the CRT. Furthermore, operating line voltage variations have no effect on calibration accuracy. During calibration, any change in the voltage applied to the primary




SWITCH POSITION IDENTIFICATION

NO1 - VERTICAL ATTENUATOR SWITCH IN x 1 POSITION
NO2 - VERTICAL ATTENUATOR SWITCH IN CAL. POSITION

FIGURE 4 - MODEL 2610 SIMPLIFIED BLOCK-CIRCUIT DIAGRAM FOR THE VERTICAL CALIBRATION SYSTEM

of T101 will cause a proportional change in its secondary voltages.

During the overall factory adjustment of this section, another adjustment is made which increases the usefulness of the Model 2610. The millivoltmeter circuit is arranged so that with the Vertical Amplifier calibrated and precisely 30 millivolts RMS applied to the Vertical Amplifier input, the vertical trace amplitude will be 6 centimeters. Under these conditions, the signal amplitude can be read directly from the graticule with good accuracy when the VERTICAL GAIN control is maintained at its calibrated position.

### 3.6 POWER SUPPLY SECTION

The Model 2610 has two basic DC power supplies. One supply utilizes half-wave rectification with RC filtering and provides the operating potentials for the CRT. The second utilizes full wave rectification with capacitor input and a filter choke. It provides for two regulated voltages of +225 volts and +112 volts, and one unregulated voltage of +375 volts. The two regulated voltages incorporate electronic regulation. The +112 volts is obtained by means of a low impedance passing tube connected to the regulated 225 volt bus. This design provides excellent voltage regulation over a line voltage range from 100 to 125 V RMS.

For detailed information on the power supplies, refer to the Schematic Wiring Diagram on page 35.

# SECTION IV
# ADJUSTMENTS AND MAINTENANCE

## GENERAL INFORMATION

This section contains information regarding adjustments which are not considered a part of the operating control adjustments performed during normal use. These will be divided into two categories; namely, those that can be made without removing the case, and those requiring case removal. Logically, the latter adjustments fall under those made after a major repair job has been completed.

The maintenance procedure will be limited to tube replacement, voltage checks, and a general overall trouble shooting procedure.

## 4.1 ADJUSTMENTS

(a) Astigmatism Control - This is a slotted screwdriver control located on the right side of the main chassis. It is accessible through the right side panel of the case. It requires only occasional adjustment as follows:

1) Apply a low frequency signal within a 60 to 400 cycles/sec. range to the VERT. INPUT jack.

2) Adjust the signal amplitude for a trace about 6 cm. high on the CRT screen.

3) Adjust the time base for a stable display.

4) Alternately adjust the FOCUS, INTENSITY and ASTIGMATISM controls until a uniformly sharp trace is obtained throughout the display area on the CRT.

**NOTE**

*These three controls will interact and different settings will be obtained for different positions of the INTENSITY control. Therefore, this adjustment should be made at a level or beam intensity normally used. Under unusual operating conditions, the Astigmatism Control may have to be used as an operating control.*

(b) Vertical Balance Control:

**NOTE**

*Adjustment of this control should not be attempted until the unit has been operating for at least 15 to 30 minutes.*

Obtain a horizontal trace by setting the SWEEP RATE switch to one of the mid-range positions and use a recurrent sweep. Proceed as follows:

1) Set VERTICAL ATTENUATOR to the X1000 position.

2) Do not apply a signal to the VERTICAL INPUT.

3) Turn VERTICAL GAIN control fully counterclockwise.

4) Center the trace on the CRT using the VERTICAL POSITION control.

5) Turn the VERTICAL GAIN control fully clockwise.

6) Adjust the VERTICAL BALANCE control to recenter the trace on the CRT screen.

7) Repeat steps 3 through 6 until rotation of the VERTICAL GAIN control throughout its range does not alter the centered position of the trace on the CRT.

(c) Horizontal Balance Control. This control is adjusted in the same manner as the VERTICAL BALANCE control, except that the initial settings are different.

Proceed as follows:

1) Set the TIME BASE SELECTOR to the HOR. INPUT position.

2) Set the HORIZONTAL SELECTOR to the X100 position.

3) Set the VERTICAL ATTENUATOR to the CAL. position. Adjust the VERTICAL GAIN control to obtain a 3 to 4 cm trace on the vertical axis of the CRT.

4) Proceed as outline in steps 3 through 6 under Vertical Balance Control, using the HORIZONTAL GAIN control, HORIZONTAL POSITION control and the HORIZONTAL BALANCE control.

(d) 10:1 Low Capacitance Probe Adjustment. The probe that is furnished with the Model 2610 was adjusted at the factory to the oscilloscope with which it was shipped. No further adjustments are required unless the probe has been repaired, tampered with, or was purchased separately in which case, the factory adjustment will only be approximate.

In any case, proceed as follows:

1) Remove probe tip, slip off the outer cover and replace the tip.

2) Connect the probe cable to the VERT. INPUT jack on the scope.

3) Connect the probe tip to the output jack of a properly terminated Square Wave Generator which is adjusted for a 2.5 kc./sec. signal output.

On the Model 2610:

4) Set the VERTICAL ATTENUATOR to X1 position, and the VERTICAL GAIN control to its calibrated position.

5) Using an internally synchronized recurrent sweep, obtain a stable five cycle pattern about 4 cm. in amplitude on the CRT screen. DO NOT OVERLOAD THE VERTICAL AMPLIFIER FOR THIS ADJUSTMENT.

6) Adjust the compensating capacitor on the probe (accessible through the hole in the inner metallic housing) for maximum squareness using a non-metallic screwdriver with a 1/8'' bit.

7) Remove the probe tip, replace the outer cover and replace the tip. Reconnect the probe to the Square Wave Generator and recheck the squareness of the pattern. It should be the same as obtained under step 6.

### 4.2 DISASSEMBLING THE 10:1 LOW CAPACITANCE PROBE

When the 10:1 Low Capacitance Probe requires repairs and it must be disassembled, the following procedure should be used. As each part or assembly is removed its orientation with relation to the other parts should be noted so that it can be reassembled correctly.

1) Unscrew the probe tip and slip off the outer sleeve.

2) Remove the probe housing by first removing the 4 Fillister Head screws which hold the assembly together. (Remove the 2 front screws first.)

3) Unsolder from the inner conductor of the probe cable the assembly consisting of: the front insulating washer assembly, the resistor and the trimmer capacitor.

4) Using the spanner wrench supplied with the probe, unscrew the threaded collar which secures the cable and ground lead to the rear supporting assembly.

5) The cable, ground lead and collar can now be removed as an assembly. Note the lead dress of the outer cable braid and ground lead with respect to the threaded collar. This dress must be maintained for proper mechanical fit, when the probe is reassembled.

### 4.3 CASE REMOVAL AND REPLACEMENT

Before removing the case from the Model 2610, be sure power is turned off and the power cord is disconnected from the rear of the chassis. Disconnect all leads and interconnecting cables from the jacks and binding posts on the front panel. For ease of removal, select a convenient working surface at a level about two feet above the floor level.

Fold a blanket or furniture pad to a rectangular area somewhat larger than the front panel area of the Model 2610. Place the pad on the working surface selected, and the Model 2610 front-panel-down on this pad. Using a Phillips type screw driver remove the four screws from the rear of the case. Lift the case straight up from the working surface. The oscilloscope can now be handled by means of the two longitudinal rods from the front panel to the rear vertical chassis.

**WARNING**

*Always grasp these members near their supported ends to avoid bending them.*

## CAUTION – HIGH VOLTAGE

**WITH THE UNIT ENERGIZED, THERE ARE HIGH VOLTAGES PRESENT IN THE MODEL 2610 WHICH CAN BE LETHAL UPON CONTACT. WITH THE CASE REMOVED AND THE UNIT ENERGIZED, USE DUE CAUTION AND DO NOT HANDLE THE CHASSIS, REPLACE TUBES OR COMPONENTS, OR PROBE ABOUT WITH METALLIC DEVICES. WHEN MAKING VOLTAGE AND CURRENT MEASUREMENTS ON THIS UNIT, IT IS ALWAYS GOOD PRACTICE TO KEEP ONE HAND IN YOUR POCKET, PREFERABLY THE LEFT ONE. ALSO STAND CLEAR OF THE CHASSIS WHEN MAKING SUCH MEASUREMENTS.**

To replace the case, follow the same procedure outlined above in reverse order where required.

### 4.4 TUBE AND MAJOR COMPONENT LOCATION

The location of many of the tubes and major components in the Model 2610 is self evident. However, the locations of those tubes and components that are not, will be described below.

With the case removed and facing the left side of the unit, the Vertical Preamplifier tubes V101 and V102, the Cathode Followers V103, the Vertical Attenuator and the Delay Line are located within the shielded compartment directly behind the front panel.

The compensating trimmer capacitors for the Vertical Attenuator are accessible for adjustment without removing the cover of this shielded compartment. R124, the bias adjustment rheostat for V103, is also located in this compartment and is mounted on the terminal board above the socket for V103.

Viewed from this same position, V104, V105, V106 and V107 are located on the left hand side of the Vertical chassis.

Some of the power supply tubes, namely V404 through V408 are located on the main chassis and directly in front of the Vertical chassis. Viewed from left to right, these tubes are V407 and V406 in the front row and V404, V405 and V408 in the rear row.

Facing the right side of the unit, V301 through V305 are located in the other shielded compartment behind the front panel. With the cover of this compartment removed and viewed from left to right, V301 is at the left nearest the front panel followed in order by V302, V303, V305 and V304. The Horizontal Attenuator is also located in this compartment. Access for the adjustment of the trimmer capacitors for this attenuator is through two holes in the cover of this compartment.

Viewed from this same position, V201 through V204 are located on the right side of the Vertical Chassis.

Facing the rear of the oscilloscope, V403 is submounted through a hole in the main chassis and in front of the Vertical Chassis. V401 and V402 are mounted on the right hand corner of the main chassis. The calibration transformer is mounted on the main chassis to the right of V403. The calibration rheostat R154 is mounted on a terminal board directly behind V401 and V402.

With the Model 2610 resting on its left side with the front panel to the left of the observer, and viewing the underside of the main chassis, R310, the level setting rheostat, will be found directly behind R302, the SYNC. AMPLITUDE potentiometer. R329, the 5 $\mu s$ Time Base Adjustment is located on a terminal board directly behind the SWEEP RATE switch.

### 4.5 TUBE REPLACEMENT

The Model 2610 has been designed to use standard tubes, which are operated well below their maximum ratings. This should result in a reasonably long life for the tubes supplied in the unit. However, as is common with any piece of high performance electronic gear, tube replacement will eventually be required if optimum performance is to be maintained.

A certain amount of care when replacing some of the tubes used in the Model 2610 will insure the restoration of its performance to the original factory specifications.

Specifically, these tubes are V101, V102, V105 and V106 in the Vertical Amplifier Section, as well as V303 in the Time Base Generator Section. The following care should be used when replacing these tubes:

### 4.5.1 VERTICAL PREAMPLIFIER TUBE REPLACEMENT V101 AND V102

These tubes are used in a high gain, direct coupled amplifier stage and are operating at a very low signal level. The grid of V101 is direct coupled to the Vertical Attenuator, with the result that the resistance in its grid circuit is varied over a resistance range of 1000:1, with an upper limit of about 1.0 megohm. Even a small amount of grid current will cause an intolerable amount of DC unbalance in this stage.

Replacement of these tubes will be indicated when vertical balance becomes difficult to achieve and maintain, or is required at frequent intervals. If vertical balancing cannot be accomplished at all, replacement of either V101 or V102 or both is definitely necessary. When the Vertical Amplifier loses sensitivity to the extent that it cannot be calibrated using the Vertical Calibration Procedure, replacement of V101 and V102 may also be necessary.

These two tubes should only be replaced with selected aged tubes. They should be aged in the following manner.

The control grid, screen grid, and plate are connected together and the tube is operated at its rated heater voltage and a cathode current of 7 to 8 ma for 50 consecutive hours. A suitable resistor should be connected in series with the operating elements and the power supply to limit and stabilize the current during the ageing process. It is recommended that at least six tubes be aged at one time to insure the required yield.

After the tubes have been aged, use a defective 12AW6 tube or any other miniature tube which has the same heater characteristics and heater basing arrangement, and clip off all of the pins on the base except pins 2, 3 and 4. Then,

1) Insert this dummy tube in the V102 socket, and one of the aged tubes in the V101 socket.

2) Turn R124 to its zero resistance position.

3) Connect a voltmeter from pin 5 of V101 to ground.

4) Energize the unit and allow it to stabilize for about ten minutes.

5) Read the DC voltage from pin 5 to ground and record.

Select a second aged tube and continue to use the V101 socket while repeating the same measurements. When the plate voltage of two tubes are within 5 percent of each other as indicated on the DC voltmeter, remove the dummy tube and install these two selected tubes for V101 and V102. Next, connect a voltmeter from pin 8 of V103B to ground, and adjust R124 until the voltmeter indicates a voltage of 41-43V DC.

**NOTE**

*It may be necessary to adjust the value of R123 until it is possible to obtain such a reading.*

When these units leave the factory, R123 will either be a single 8K deposited carbon film resistor, or two such resistors in parallel. The adjusted value resulting from the above procedure should yield a value which falls in the range of 4K to 8K. Furthermore, the resistor or resistors used should be of the deposited carbon, or metal oxide film type, for stability. The tolerance accuracy is not important.

After tube replacement and the adjustments completed as outlined above, it should be possible to obtain excellent vertical balance, which will remain for long periods of time without further adjustment. A check should also be made to insure that the new tubes provide adequate sensitivity. It is suggested to the user, that when selecting tubes as outlined above, another pair of tubes be selected and identified at the same time for future use.

In lieu of the procedure outlined above for ageing and selecting tubes, matched tubes are available from the Simpson Electric Company. When requesting replacement tubes, indicate the value of R123 used in the oscilloscope in which the tubes are to be replaced.

### 4.5.2 VERTICAL OUTPUT AMPLIFIER TUBE REPLACEMENT V107 AND V108

Replacement of these tubes is indicated whenever the total range of the VERTICAL POSITION control is limited or, whenever a known good sinusoidal input with an amplitude of 10 to 12 centimeters indicates distortion, and no other source of malfunction exists. Again, aged tubes with a certain amount of selection are recommended but are not an absolute necessity. If tubes are aged and then selected, the down time will quite likely be reduced, and most certainly the electrical performance will be improved.

The tubes to be used in these sockets should be aged for 50 hours at rated heater voltage and 90 percent of maximum plate dissipation. These tubes can be connected as diodes when they are aged. A suitable limiting resistor connected in series with the tube is recommended during the ageing process.

After ageing, matched tubes should be selected to yield the following criteria:

(a) A sinusoidal signal amplitude equal to twice the CRT screen diameter will show no visible sign of amplitude distortion.

(b) A sinusoidal waveform amplitude equal to the CRT screen diameter can be shifted vertically throughout the display area with no visible signs of amplitude distortion.

(c) With the Vertical Attenuator in the CAL. position, it will be possible to obtain a very sharp null. The residual amplitude of the null voltage will be less than 0.1 cm. Furthermore, it will be possible to move the trace vertically ± 1.0 cm and the residual amplitude will not exceed 0.2 cm.

Of the three criteria indicated above, Item (c) is by far the most significant indication of a well balanced output stage.

### 4.5.3 SWEEP GENERATOR TUBE REPLACEMENT V303

This tube should be replaced whenever erratic time base operation is experienced. This of course, assumes that the balance of the associated circuitry is operating correctly.

Again, only aged tubes should be used in this socket. These tubes should be aged for 50 hours at rated heater potential and 90 percent of maximum plate dissipation for each of the tube sections. The two tube sections may be connected as diodes and a suitable series limiting resistor used to avoid damaging the tube or power supply during the ageing process.

Experience has shown that with some tubes in this socket, the Time Base Generator will operate satisfactorily over the complete range of recurrent sweeps, but it will also free-run on the triggered sweeps with no trigger applied. Conversely, other tubes will not free-run under either triggered sweep conditions or over part of the recurrent sweep ranges. Aged tubes tend to minimize these undesirable conditions. However, a certain amount of selection may still be necessary even with aged tubes. Therefore, after a new tube is installed, check for correct operation over the complete range of recurrent sweeps as well as for good triggered sweep operation.

### 4.5.4 C.R.T. REPLACEMENT

To replace the CRT, remove the bezel, graticule and filter. Disconnect the lead from the Post-Ultor terminal on the side of the CRT. Loosen the tube clamp around the base of the tube. Then, using a blunt object such as a short length of ½" fibre rod, force the tube out of its socket by pushing on the large bakelite stud which keys the tube to the socket. This stud is accessible from the rear of the CRT socket. While pushing on this stud with one hand, place a gloved hand over the face of the CRT so that the tube is not forced out in a violent manner. As soon as the tube is clear of its socket, it may be removed through the front panel opening.

After the new tube is installed, make sure the horizontal trace coincides and is parallel to the horizontal center line of the graticule. If not, loosen the two screws on the socket clamp and carefully rotate the tube until coincidence is obtained.

## CAUTION

**UNDER NO CIRCUMSTANCES ROTATE OR HANDLE THIS TUBE WITH THE UNIT ENERGIZED.**

In order to reduce the CRT alignment time to a minimum with the bezel, graticule, and filter removed, energize the unit and obtain a horizontal trace on the face of the CRT. Then, using a piece of insulating material such as plexiglass as a straight edge, use a grease pencil and draw a very fine line on the glass face of the CRT directly over the horizontal trace. This line can then be used to orient the CRT with respect to the graticule with the Model 2610 de-energized. Before the socket and base clamps are secured, be sure the front surface of the CRT is exactly flush with the front surface of the front panel.

## 4.6 TROUBLE SHOOTING PROCEDURE

A rigorous step-by-step Trouble Shooting Procedure for the Model 2610 would be quite difficult to organize, and probably would serve very little purpose for the majority of the failures that may occur. It would have to be so detailed and lengthy that it would quite likely never be used. Instead, a procedure is outlined which will help to localize the failure to a particular section or sections.

The following procedure is based on the assumption that obvious things have been recognized or attended to, namely, power into the unit, the line fuse operative, and that all the controls are set at their correct operating positions.

### 4.6.1 NO TRACE OR BEAM SPOT ON CRT

If there is no trace or beam spot on the face of the CRT, at least one of the following is wrong:

(a) High Voltage Power Supply has failed.

(b) High Voltage Divider String has opened up.

(c) CRT heater has opened.

(d) Low Voltage Power Supply has failed.

(e) Either Horizontal or Vertical Beam Position circuits have failed and moved the electron beam completely off the CRT screen.

### 4.6.2 NO VERTICAL TRACE ON THE CRT

With a horizontal trace on the CRT but no vertical trace, proceed as follows:

Turn the VERTICAL ATTENUATOR to the CAL. position and try to calibrate the Vertical Amplifier. If successful, the failure has occurred between the Vertical Input jack and the control grid of V101. If unsuccessful, try shifting the trace using the VERTICAL POSITION control.

If this works satisfactorily and has a normal shift range, it can be assumed that the output stage (V106 and V107) is probably operating satisfactorily and that the + 112 DCV, + 225 DCV, and + 375 DCV power supplies are also operating correctly. The trouble may then be ahead of the output stage. If this test failed, at least part of the trouble is in the output stage or part of the DC power supply. The heater in V101 or V102 may also have failed.

### 4.6.3 VERTICAL AMPLITUDE DISTORTION

When a signal of known fidelity is applied to the Vertical Amplifier and appears distorted on the CRT screen, it is likely that one of the output tubes (V106 or V107) has either failed completely or has deteriorated to the point where it should be replaced. This can be further assured if the range of the Vertical Position control has become limited, and if it is difficult to obtain a sharp null when the Vertical Amplifier is calibrated.

### 4.6.4 NO HORIZONTAL TRACE ON CRT

If there is a vertical trace on the CRT but no horizontal trace, it can be assumed that the DC power supplies are probably operating satisfactorily. The failure is most likely in the Horizontal Amplifier or the Time Base Generator.

Isolate the failure as follows:

Connect an AC signal to the HOR. INPUT/SYNC. INPUT jack. Switch the Time Base Selector switch to the HOR. INPUT position. Select a Horizontal Attenuator position and adjust the HORIZONTAL GAIN control that should produce a horizontal trace on the CRT screen. If successful, the Horizontal Amplifier is probably operating satisfactorily and the difficulty will likely be in the Time Base Generator. If unsuccessful, the Horizontal Amplifier can be suspected.

In the above test, if the Horizontal Amplifier was operating satisfactorily but no trace appeared with the Time Base Selector in the Recurrent or Triggered positions, it is likely the Time Base Generator tube V303, or its associated circuitry has failed.

### 4.6.5 TRACE CANNOT BE SYNCHRONIZED

When the trace cannot be synchronized for the recurrent mode of operation using an internal synchronizing signal, proceed as follows:

Apply a 1000 cycles/sec. signal having an amplitude of 0.1V RMS to the HOR. INPUT/SYNC. INPUT jack. Simultaneously, apply the same signal to the VERT. INPUT jack. Switch the VERTICAL ATTENUATOR to the X10 position and adjust the VERTICAL GAIN control for a vertical trace amplitude of 3 or 4 centimeters.

Set the TIME BASE SELECTOR to the EXT-RECURRENT position. Adjust the SYNC. AMPLITUDE control for a stable pattern. If successful, the circuit failure is in the circuitry and/or switching between C119, the sync. connection to the Vertical Amplifier, and the grid of the Sync. Phase Splitter, V301A. If unsuccessful, the failure is likely in the Sync. Chain.

When the Time Base Generator operates properly throughout the complete range of the recurrent sweeps but cannot be triggered for the triggered mode of operation, the trouble may be in the switching or circuitry associated with V302B.

### 4.6.6 MARGINAL OR INEFFECTIVE BLANKING

If the sweep retrace blanking is poor or completely ineffective, but the Time Base appears normal in other respects, it can be assumed that the Blanking Amplifier, V304, has either failed completely or has aged to the point of marginal blanking action. Replace V304. If unsuccessful, check the associated components and switching circuitry.

## 4.7 POWER SUPPLY VOLTAGE LIMITS

As soon as the case is removed for tube replacement or repairs, the main DC bus voltages should be checked first. When the Model 2610 is operating correctly and the input power supply voltage is 117.5V RMS 50/60 cycle/sec., the nominal bus voltage and their limits are as follows:

| Nominal Bus Voltage | Limits |
|---|---|
| + 112 DCV | + 110.0 to 114.0 DCV |
| + 225 DCV | + 221.0 to 229.0 DCV |
| + 375 DCV | + 370.0 to 390.0 DCV |
| - 2100 DCV | - 2000.0 to 2200.0 DCV |

All of these voltages are measured with respect to the Chassis.

Contact to the + 112 DCV bus can best be made at pin 6 of V104 or V105. The + 225 DCV can be contacted at pins 3 and 8 of V106 and V107. The + 375 DCV bus can be checked at the B+ end of R144 or R145 which are mounted on terminal boards behind the vertical chassis.

The - 2100 DCV measurement can be made at the junction of R146 and R404. R146 is mounted on the terminal board behind the vertical chassis and directly in front of V403 (2X2A) and the Calibration transformer.

### CAUTION

**USE EXTREME CARE WHEN MEASURING THIS VOLTAGE.**

Turn off the power before connecting the voltmeter.

It is wise to solder a small length of well insulated wire at the test point for ease of connection. To avoid false readings and obtain the required accuracy, this measurement must be made with at least a 20 K ohm/volt instrument such as the Simpson Model 270.

If the bus voltages are within limits, the next test that should be made is the regulation capability of the electronic regulating system. Proceed as follows:

Connect a variable voltage transformer between the power source and the Model 2610. Using a Simpson Model 270 or equivalent, vary the input voltage to the Model 2610.

Over the line voltage range of 100-125V RMS, the voltage of the + 112 DCV and + 225 DCV buses must not deviate more than ± 0.15% from the exact reading obtained for an input of 117.5 ACV. During these tests, vary the line voltage slowly and allow the circuits to stabilize for a few minutes before observing the readings.

If the regulating circuits fail to meet the specifications outlined above, check the tubes in the following order:

V407, V406, V405, V408, V401 and V402.

V407 should only be replaced with a tube that has been aged at 90% rated current for 50 hours.

If poor regulation still exists, check the components associated with the regulating circuits.

## 4.8 VERTICAL AMPLIFIER GAIN CALIBRATION

Whenever any of the components in the Vertical Calibration System are replaced, recalibration is necessary. Recalibration is unnecessary when the tubes or components in the Vertical Amplifier are replaced.

To recalibrate, proceed as follows:

(a) Apply a 500 cycles/sec. sinusoidal signal having an amplitude of 20 Millivolts RMS ± 0.25 percent to the VERT. INPUT jack.

(b) Set the VERTICAL FUNCTION switch to the AC LINEAR position.

(c) Set the VERTICAL ATTENUATOR to the X1 position and adjust the VERTICAL GAIN control for a trace amplitude of approximately 4 cm.

(d) Using an internally synchronized recurrent sweep, lock-in about seven or eight cycles on the horizontal trace.

(e) With VERTICAL POSITION control, set the top of the trace coincident with the horizontal center line of the graticule.

(f) Adjust the METER ZERO control for a zero scale indication.

(g) Adjust the VERTICAL POSITION control to displace the trace through its own amplitude. The meter should read exactly 20 MV RMS. If the meter reads high, reduce the vertical gain with the VERTICAL GAIN control; if too low, increase the gain.

(h) Repeat steps (e), (f) and (g) until the meter reads exactly 20 MV RMS.

(i) When the above is achieved, and without disturbing the "Calibrated Position" of the VERTICAL GAIN control, set the VERTICAL ATTENUATOR to the CAL. position. A signal at line frequency will appear on the CRT screen. Adjust R154 until a very fine trace null is obtained when the horizontal trace is coincident with the horizontal centerline of the Graticule. Calibration is complete.

(j) Without disturbing the VERTICAL GAIN control setting, set the VERTICAL ATTENUATOR to the X1 position. Center the trace vertically with the VERTICAL POSITION control. The vertical amplitude of the trace should be 4 cm ± 5%. If the trace amplitude is too low, the meter should be *shunted and steps (e) through (j) repeated until the above specifications are satisfied. If the trace amplitude is too high, *R145 and R150 should be reduced by equal amounts until all of the conditions in steps (e) through (j) have been satisfied.

*** NOTE**

*The resistor that is used to shunt the meter or to replace R147 and R150 as described in step (j) above, should be of the deposited carbon film or metal oxide film type. For reasons of stability, R147 and R150 should not be shunted with a high megohm value resistor of the deposited carbon film type in lieu of a lower value for these components. Resistors of this type in the high megohm values are less stable than the same type resistor having a value of approximately 450,000 ohms.*

## 4.9 ATTENUATOR COMPENSATION ADJUSTMENT

The Vertical and Horizontal Attenuator were both factory adjusted and require no further adjustment unless components are replaced in these networks. When adjustment is required, use the following procedure:

### 4.9.1 VERTICAL STEP ATTENUATOR

A square wave generator will be required which provides a good square wave with fast rise and decay time, no ringing, overshoot, or droop. It should be capable of delivering a signal of at least 50 volts at an impedance level of not more than 600 ohms. It must have an attenuator which is frequency insensitive and its total control range should be at least 80 db.

(a) Set the Square Wave Generator to deliver a 10 Kc./sec. signal, and connect its output to the VERT. INPUT jack of the Model 2610.

(b) On the Model 2610, set the VERTICAL FUNCTION switch to AC TRANSIENT position. Also, calibrate the Vertical Amplifier and leave the VERTICAL GAIN control in its Calibrated Position for the balance of the adjustments.

(c) Set the VERTICAL ATTENUATOR to the X3 position and adjust the amplitude control on the Square Wave Generator for a 4 or 5 cm vertical trace.

(d) Using an internally triggered recurrent sweep, synchronize a 5 or 6 cycle pattern on the CRT.

(e) Using an insulated screwdriver, adjust the top trimmer in the left hand vertical row (as viewed from the left side of the unit and facing the shielded compartment.) Adjust this trimmer until the trace on the CRT is perfectly square and with no ringing or overshoot.

(f) Set the VERTICAL ATTENUATOR to the X10 position and increase the amplitude of the signal (using the attenuator on the signal source) to approximately the same value established in step (c) above. Adjust the second trimmer from the top in the same row until maximum squareness is obtained for this attenuator position.

(g) Continue this procedure until all of the ranges on the VERTICAL ATTENUATOR have been adjusted in the same manner.

4.9.2 HORIZONTAL STEP ATTENUATOR

The Horizontal Attenuator adjustment is similar to the VERTICAL ATTENUATOR adjustment. However, a sweep must be provided for the Vertical trace. Apply a sine wave signal having a frequency of about 1000 cycles/sec. to the Vertical Amplifier through the VERT. INPUT jack.

Proceed as follows:

(a) Set the TIME BASE SELECTOR switch to the HOR. INPUT position. Connect the Square Wave Generator to the HOR. INPUT/SYNC. INPUT jack and, set the HORIZONTAL SELECTOR switch to the X10 position.

(b) Using the HORIZONTAL GAIN control on the Model 2610 and the Amplitude Control on the Square Wave Generator, obtain a horizontal trace approximately 5 or 6 cm. in amplitude.

(c) Using the VERTICAL GAIN control and the VERTICAL ATTENUATOR on the Model 2610, obtain a vertical trace approximately 5 or 6 cm. in amplitude.

(d) Carefully vary the frequency of the Sine Wave Generator until approximate synchronization is obtained between the vertical and horizontal signals.

(e) Using an insulated screwdriver, adjust the trimmer capacitor associated with the X10 position of the Horizontal Attenuator. This is the bottom trimmer and is accessible through a hole in the side of the shielded compartment that contains the Sync. Amplifiers and Time Base Generator. Adjust the trimmer for a symmetrical square wave with no overshoot.

(f) Adjust the trimmer for the X100 range of the Horizontal Attenuator in the same manner as outlined above.

## 4.10 EQUALIZING VERTICAL INPUT CAPACITANCE

A group of six trimmer capacitors are located in the shielded compartment which contains the Vertical Preamplifier. They are used to equalize the input capacitance of the Vertical Amplifier. There is one trimmer for each position of the VERTICAL ATTENUATOR except for the X1 position. The trimmers are located in a vertical stack to the right of the compensating capacitors for the VERTICAL ATTENUATOR, as viewed from the side of the shielded compartment. The top trimmer in this row is associated with the X3 position of the VERTICAL ATTENUATOR; the second is associated with the X10 position, etc. These capacitors were adjusted at the factory. They do not require further adjustment unless other components in the VERTICAL ATTENUATOR have been replaced. A good Square Wave Generator as described in section 4.9.1 will be required.

To make these adjustments, proceed as follows:

(a) Connect the 10:1 Low Capacitance Probe to the VERT. INPUT jack and to the Square Wave Generator. Adjust the probe as described in Section 4.1–(d) Page 22.

(b) Set the VERTICAL ATTENUATOR to the X3 position. With the probe still connected to the Square Wave Generator, re-adjust the Amplitude Control on the generator to restore the amplitude of the vertical pattern.

(c) Using an insulated screwdriver, adjust the top trimmer capacitor for maximum squareness of the trace with no overshoot.

(d) Set the VERTICAL ATTENUATOR to the X10 position. Re-adjust the amplitude of the Vertical trace using the Amplitude Control on the Square Wave Generator. Adjust the second trimmer capacitor until a square trace is obtained.

(e) Repeat the above procedure until all six trimmers have been adjusted for a good square-wave response for each position of the VERTICAL ATTENUATOR.

## 4.11 TRIGGERED SWEEP ADJUSTMENT

The rheostat, R329 is used to calibrate the time duration of the 5, 50, 500 and 5000 microsecond sweeps. It will only require re-adjustment if any one of the components, C324 through C328 or R328 are replaced. Since this adjustment affects all four of the triggered sweeps, the final setting will be a compromise.

The correct procedure is to measure the time duration of all four sweeps, determine the percent error (plus and minus) for each sweep and finally, adjust R329 for maximum accuracy for all four ranges.

To measure the time duration of each sweep and make the correct adjustment, the following procedure is recommended:

(a) Apply a good 5 microsecond pulse at a pulse repetition rate of 10,000 pulses/sec. to the VERT. INPUT. The Simpson Pulse Generator Model 2620 is recommended for this procedure.

(b) Set the VERTICAL FUNCTION switch to the AC TRANSIENT position and the SWEEP RATE switch to the 5 $\mu s$ position.

(c) Calibrate the Vertical Amplifier and leave the VERTICAL GAIN control at its Calibrated position for the duration of these adjustments.

(d) Using the Output Amplitude control on the Pulse Generator and, the VERTICAL ATTENUATOR on the Model 2610, obtain a vertical trace 3 or 4 cms. in amplitude.

(e) Set the TIME BASE selector to the INT.-TRIGGERED position and adjust the trigger amplitrude to obtain a stable trace. DO NOT OVER-TRIGGER.

(f) Adjust R329 until the beginning and the end of the sweeps are exactly coincident with the leading edge and trailing edge of the pulse.

(g) Set the SWEEP RATE switch to the 50 $\mu s$ position. Measure the duration of this sweep, record its value.

(h) Continue this procedure until the duration of all four sweeps has been determined and recorded. Since many Pulse Generators do not generate a 5000 microsecond pulse, the duration of the 5000 $\mu$sec. sweep can be measured using the time interval between pulses rather than the pulse width. Knowing the time duration of each sweep, compute the maximum deviation and re-adjust R329 for maximum overall sweep accuracy.

## 4.12 SYNC. THRESHOLD AND LOW FREQUENCY FREE RUN ADJUSTMENT

The internal control, R310, is used to set the DC level of the Triggering Diode, V302B.

To adjust this control, proceed as follows:

(a) Set the TIME BASE SELECTOR to the EXT.-RECURRENT position and the SYNC. AMPLITUDE control to zero.

(b) Set the SWEEP RATE to the 100 cycles per second position.

(c) Set the SWEEP VERNIER control to zero.

(d) Adjust R310 counterclockwise until the sweep stops.

(e) Now adjust R310 clockwise to a point just beyond that required to start the sweep.

(f) Insure that the Time Base "free-runs" throughout its complete range of Recurrent Sweeps, but does not free-run on the Triggered Sweeps.

The setting of this control is a compromise between two conflicting circuit conditions. At the higher frequencies (above 5.0 mc./sec.) the gain of the Sync. Chain falls off. Under these conditions, it would be desireable to keep the DC voltage across the diode as low as possible to promote diode conduction at low sync. signal levels. On the other hand, with these lower potentials across the diode, the Time Base Generator will not operate. Therefore, both of these factors must be considered in making the adjustment outlined above. The 1.0 volt potential drop across the diode will yield a good compromise. If not, replace V303.

# SECTION V

## TABLE OF REPLACEABLE PARTS

| Reference Symbol | Description | Simpson Part No. |
|---|---|---|
| **CAPACITORS, FIXED** | | |
| C101 | 0.1$\mu$f, +20% −10%, 600v, My | 1–116917 |
| C105 | 300, ±5%, 500v, Mi | 1–116919 |
| C106 | 100, ±5%, 500v, Mi | 1–116425 |
| C107 | 30, ±5%, 500v, Mi | 1–116424 |
| C111 | 0.01$\mu$f, ±5%, 300v, Mi | 1–116430 |
| C112 | 3000, ±5%, 500v, Mi | 1–117417 |
| C113 | 1000, ±5%, 500v, Mi | 1–116429 |
| C114 | 0.1$\mu$f, +20% −10%, 200v, My | 1–116915 |
| C115 | 0.1$\mu$f, +20% −10%, 600v, My | 1–116917 |
| C116 | 8$\mu$f, +50% −20%, 150v, El | 1–116402 |
| C117 | 1000, GMV, 500v, Ce | 1–115652 |
| C118 | 16$\mu$f, +50% −30%, 250v, El | 1–116406 |
| C119 | 0.1$\mu$f, +20% −10%, 200v, My | 1–116915 |
| C120 | 10$\mu$f, +50% −20%, 50v, El | 1–116403 |
| C121 | 300, ±5%, 500v, Mi | 1–116919 |
| C122 | 1$\mu$f, ±20%, 200v, Pa | 1–116419 |
| C123 | 300, ±5%, 500v, Mi | 1–116919 |
| C124 | 1000, ±20%, 500v, Mi | 1–113585 |
| C131 | 7.5, ±2%, 350v, Mi | 1–114687 |
| C203 | 100, ±5%, 500v, Mi | 1–116425 |
| C204 | 1000, ±5%, 500v, Mi | 1–116429 |
| C205 | 100, ±20%, 500v, Mi | 1–113718 |
| C206 | 0.1$\mu$f, ±20%, 2500v, Pa | 1–116414 |
| C207 | 0.25$\mu$f, +20% −10%, 400v, My | 1–116918 |
| C208 | 100-100$\mu$f, +50% −20%, 50v-50v, El | 1–116535 |
| C209 | 0.1$\mu$f, +20% −10%, 200v, My | 1–116915 |
| C210 | 400, ±5%, 500v, Mi | 1–116427 |
| C211 | 400, ±5%, 500v, Mi | 1–116427 |
| C212 | 20$\mu$f, +100% −10%, 25v, El | 1–116404 |
| C301 | 0.1$\mu$f, +20% −10%, 600v, My | 1–116917 |
| C302 | 20$\mu$f, +100% −10%, 150v, El | 1–114105 |
| C303 | 0.5$\mu$f, ±20%, 200v, Pa | 1–117670 |
| C304 | 0.5$\mu$f, ±20%, 200v, Pa | 1–117670 |
| C305 | 0.1$\mu$f, +30% −20%, 200v, Pa | 1–115500 |
| C306 | 150$\mu$f, +100% −10%, 6v, El | 1–117669 |
| C307 | 150$\mu$f, +100% −10%, 6v, El | 1–117669 |
| C308 | 0.05$\mu$f, +20% −10%, 400v, My | 1–116114 |
| C309 | 10, ±10%, 500v, Ce | 1–115465 |
| C310 | 10, ±10%, 500v, Ce | 1–115465 |
| C311 | 0.25$\mu$f, +20% −10%,400v, My | 1–116918 |
| C312 | 10, ±10%, 500v, Ce | 1–115465 |
| C313 | 16$\mu$f, +50% −20%, 150v, El | 1–112694 |
| C315 | 185, ±5%, 500v, Mi | 1–116426 |
| C316 | 600, ±5%, 500v, Mi | 1–116428 |
| C317 | 2000, ±5%, 600v, My | 1–116911 |
| C318 | 8000, ±5%, 200v, My | 1–116410 |
| C319 | 0.02$\mu$f, ±5%, 400v, My | 1–116411 |
| C320 | 0.08$\mu$f, ±5%, 200v, My | 1–116413 |
| C321 | 0.2$\mu$f, ±5%, 400v, My | 1–116416 |
| C322 | 0.4$\mu$f, ±5%, 200v, My | 1–116417 |
| C323 | 2$\mu$f, ±5%, 200v, Pa | 1–116421 |
| C324 | 270, ±2%, 350v, Mi | 1–116904 |
| C325 | 4000, ±5%, 200v, My | 1–116409 |
| C326 | 0.04$\mu$f, ±5%, 200v, My | 1–116412 |
| C327 | 0.4$\mu$f, ±5%, 200v, My | 1–116417 |
| C328 | 22, ±20%, 500v, Ce | 1–115503 |
| C329 | 25, ±10%, 350v, Mi | 1–117655 |
| C330 | 1$\mu$f, ±20%, 200v, Pa | 1–116419 |
| C331 | 100$\mu$f, +50% −20%, 25v, El | 1–116407 |
| C332 | 0.1$\mu$f, +20% −10%, 400v, My | 1–116916 |
| C333 | 0.1$\mu$f, +20% −10%, 400v, My | 1–116916 |
| C334 | 30$\mu$f, +50% −20%, 150v, El | 1–116405 |
| C335 | 220, ±10%, 500v, Ce | 1–113854 |
| C336 | 10 $\mu$f, ±10%, 500v, Ce | 1–115464 |
| C401 | 1$\mu$f, ±20%, 200v, Pa | 1–116419 |
| C402 | 0.1$\mu$f, ±20%, 3000v, Pa | 1–116415 |
| C403 | 0.1$\mu$f, ±20%, 3000v, Pa | 1–116415 |
| C404 | 0.1$\mu$f, ±20%, 3000v, Pa | 1–116415 |
| C405 | 30-30$\mu$f, +50% −20%, 450v-450v, El | 1–116408 |
| C406 | 150-40$\mu$f, +50% −20%, 150v-450v, El | 1–116536 |
| C407 | 0.02$\mu$f, +20% −10%, 400v, My | 1–116913 |
| C408 | 0.25$\mu$f, +20% −10%, 400v, My | 1–116918 |
| **CAPACITORS, VARIABLE** | | |
| C100 | 3.5 to 12, 600 v, Ce | 3–810601 |
| C102 | 4 to 30, Mi | 1–116901 |
| C103 | 4 to 30, Mi | 1–116901 |
| C104 | 4 to 30, Mi | 1–116901 |
| C108 | 4 to 30, Mi | 1–116901 |
| C109 | 4 to 30, Mi | 1–116901 |
| C110 | 4 to 30, Mi | 1–116901 |
| C125 | 4 to 30, Mi | 1–116901 |
| C126 | 4 to 30, Mi | 1–116901 |
| C127 | 4 to 30, Mi | 1–116901 |
| C128 | 4 to 30, Mi | 1–116901 |
| C129 | 4 to 30, Mi | 1–116901 |
| C130 | 4 to 30, Mi | 1–116901 |
| C201 | 2.2 to 20, Mi | 1–115573 |
| C202 | 2.2 to 20, Mi | 1–115573 |
| C314 | 4 to 30, Mi | 1–116901 |

Capacitance is shown in $\mu\mu$f unless otherwise indicated; $\mu$f = microfarads.

Ce = Ceramic El = Electrolytic Mi = Mica
My = Mylar Pa = Paper

## TABLE OF REPLACEABLE PARTS

| Reference Symbol | Description | Simpson Part No. |
|---|---|---|
| R100 | 9 meg, ±1%, ½ w, DC | 1–117719 |
| R101 | 667K, ±1%, ¼ w, DC | 1–117407 |
| R102 | 900K, ±1%, ¼ w, DC | 1–116312 |
| R103 | 967K, ±1%, ¼ w, DC | 1–117408 |
| R104 | 1 meg, ±1%, ½ w, DC | 1–113392 |
| R105 | 33.3K, ±1%, ½ w, DC | 1–117405 |
| R106 | 100K, ±1%, ½ w, DC | 1–113427 |
| R107 | 333K, ±1%, ½ w, DC | 1–117406 |
| R108 | 990K, ±1%, ¼ w, DC | 1–116311 |
| R109 | 997K, ±1%, ¼ w, DC | 1–117409 |
| R110 | 1 meg, ±1%, ¼ w, DC | 1–116310 |
| R111 | 1K, ±1%, ½ w, DC | 1–114742 |
| R112 | 3.33K, ±1%, ½ w, DC | 1–117404 |
| R113 | 10K, ±1%, ½ w, DC | 1–113306 |
| R115 | 5 ohms, ±5%, ½ w, DC | 1–117175 |
| R116 | 8.35 ohms, ±5%, ½ w, DC | 1–116313 |
| R117 | 1K, ±5%, ½ w, DC | 1–116330 |
| R119 | 1 meg, ±1%, ¼ w, DC | 1–116310 |
| R120 | 1.74 ohm, 3.4" #34 Manganin Wire | 2–111295 |
| R121 | 2.4K, ±1%, ½ w, DC | 1–116331 |
| R122 | 2.4K, ±1%, ½ w, DC | 1–116331 |
| R123 | Factory Selected | – |
| R125 | 700 ohms, ±5%, ½ w, DC | 1–116314 |
| R126 | 8K, ±5%, 1 w, DC | 1–116334 |
| R127 | 8K, ±5%, 1 w, DC | 1–116334 |
| R128 | 15K, ±5%, 1/2 w, C | 1–117530 |
| R129 | 2K, ±1%, 1/2 w, DC | 1–113422 |
| R130 | 2.2K, ±1%, ½ w, DC | 1–116321 |
| R131 | 6.8K, ±5%, 1 w, DC | 1–116345 |
| R132 | 6.8K, ±5%, 1 w, DC | 1–116345 |
| R134 | 10K, ±1%, ½ w, DC | 1–113306 |
| R135 | 1.8K, ±1%, ½ w, DC | 1–116323 |
| R136 | 1.8K, ±1%, ½ w, DC | 1–116323 |
| R137 | 10K, ±1%, ½ w, DC | 1–113306 |
| R138 | 3.5K, ±1%, ½ w, DC | 1–116324 |
| R139 | 45K, ±5%, ½ w, DC | 1–116325 |
| R141 | 45K, ±5%, ½ w, DC | 1–116325 |
| R142 | 3.5K, ±1%, ½ w, DC | 1–116324 |
| R143 | 1K, ±5%, 10 w, WW | 1–116340 |
| R144 | 2.5K, ±2%, 10 w, WW | 1–116374 |
| R145 | 2.5K, ±2%, 10 w, WW | 1–116374 |
| R146 | 130K, ±1%, ¼ w, DC | 1–116375 |
| R147 | 450K, ±1%, ½ w, DC | 1–116317 |
| R148 | 6.3K, ±5%, 1 w, DC | 1–116328 |
| R149 | 130K, ±1%, ¼ w, DC | 1–116375 |
| R150 | 450K, ±1%, ½ w, DC | 1–116317 |
| R151 | 6.3K, ±5%, 1 w, DC | 1–116328 |
| R153 | 250K, ±1%, ½ w, DC | 1–113428 |
| R201 | 990K, ±1%, ¼ w, DC | 1–116311 |
| R202 | 900K, ±1%, ¼ w, DC | 1–116312 |
| R203 | 111K, ±1%, ½ w, DC | 1–117908 |
| R204 | 10.1K, ±1%, ½ w, DC | 1–116348 |
| R205 | 1 meg, ±5%, ½ w, DC | 1–116349 |
| R206 | 470 ohms, ±5%, ½ w, DC | 1–116360 |
| R207 | 5 meg, ±10%, ½ w, C | 1–116346 |
| R209 | 19K, ±5%, ½ w, DC | 1–116352 |
| R210 | 2K, ±5%, ½ w, DC | 1–116350 |
| R211 | 22K, ±5%, ½ w, DC | 1–116351 |
| R212 | 2K, ±5%, ½ w, DC | 1–116350 |
| R213 | 1 meg, ±1%, ¼ w, DC | 1–116310 |
| R214 | 4K, ±5%, ½ w, DC | 1–116353 |
| R215 | 4K, ±5%, ½ w, DC | 1–116353 |
| R217 | 3.5K, ±1%, ½ w, DC | 1–116324 |
| R218 | 3.5K, ±1%, ½ w, DC | 1–116324 |
| R219 | 3.5K, ±1%, ½ w, DC | 1–116324 |
| R220 | 45K, ±5%, ½ w, DC | 1–116325 |
| R222 | 45K, ±5%, ½ w, DC | 1–116325 |
| R223 | 3.5K, ±1%, ½ w, DC | 1–116324 |
| R224 | 470 ohms, ±5%, ½ w, DC | 1–116360 |
| R225 | 870 ohms, ±5%, 10 w, WW | 1–116371 |
| R226 | 470 ohms, ±5%, ½ w, DC | 1–116360 |
| R227 | 4.5K, ±2%, 10 w, WW | 1–116356 |
| R228 | 4.5K, ±2%, 10 w, WW | 1–116356 |
| R301 | 1 meg, ±10%, ½ w, DC | 1–116358 |
| R303 | 1K, ±5%, ½ w, DC | 1–116330 |
| R304 | 3.3K, ±5%, ½ w, DC | 1–116322 |
| R305 | 470 ohms, ±5%, ½ w, DC | 1–116360 |
| R306 | 470 ohms, ±5%, ½ w, DC | 1–116360 |
| R307 | 470 ohms, ±5%, ½ w, DC | 1–116360 |
| R308 | 350 ohms, ±5%, ½ w, DC | 1–116354 |
| R309 | 3K, ±5%, ½ w, DC | 1–116344 |
| R311 | 135K, ±1%, ½ w, DC | 1–116333 |
| R312 | 89K, ±1%, ½ w, DC | 1–116335 |
| R313 | 65K, ±1%, ½ w, DC | 1–116336 |
| R314 | 200K, ±5%, ¼ w, DC | 1–116326 |
| R315 | 200K, ±1%, ½ w, DC | 1–113365 |
| R316 | 700 ohms, ±5%, ½ w, DC | 1–116314 |
| R317 | 3.3K, ±5%, ½ w, DC | 1–116322 |
| R318 | 2.5K, ±5%, ½ w, DC | 1–116319 |
| R319 | 5K, ±5%, ½ w, DC | 1–116337 |
| R320 | 1 meg, ±10%, ½ w, DC | 1–116358 |
| R321 | 3K, ±5%, ½ w, DC | 1–116344 |
| R322 | 1K, ±5%, ½ w, DC | 1–116330 |
| R323 | 12K, ±5%, ½ w, DC | 1–117251 |
| R324 | 3K, ±5%, ½ w, DC | 1–116344 |

C = Composition
DC = Deposited Carbon
WW = Wire Wound

## TABLE OF REPLACEABLE PARTS

| Reference Symbol | Description | Simpson Part No. |
|---|---|---|
| RESISTORS, FIXED (Continued) | | |
| R325 | 6K, ±5%, ½ w, DC | 1–117209 |
| R326 | 470 ohms, ±10%, ¼ w, DC | 1–116372 |
| R327 | 10 meg, ±10%, ½ w, DC | 1–116376 |
| R328 | 45K, ±5%, ½ w, DC | 1–116325 |
| R330 | 200 ohms, ±5%, ½ w, DC | 1–116342 |
| R331 | 1 meg, ±10%, ½ w, DC | 1–116358 |
| R332 | 8K, ±5%, ½ w, DC | 1–116343 |
| R333 | 3K, ±5%, ½ w, DC | 1–116344 |
| R334 | 1K, ±5%, ½ w, DC | 1–116330 |
| R335 | 160K, ±5%, ½ w, DC | 1–117850 |
| R337 | 9K, ±5%, ½ w, C | 1–113292 |
| R401 | 1 meg, ±10%, ½ w, DC | 1–116358 |
| R402 | 1 meg, ±10%, ½ w, DC | 1–116358 |
| R404 | 200K, ±10%, ½ w, DC | 1–116368 |
| R405 | 200K, ±10%, ½ w, DC | 1–116368 |
| R407 | 100K, ±10%, ½ w, DC | 1–116367 |
| R408 | 2.5 meg, ±10%, ½ w, DC | 1–116369 |
| R410 | 3.3 meg, ±10%, ½ w, DC | 1–116370 |
| R411 | 3.3 meg, ±10%, ½ w, DC | 1–116370 |
| R412 | 470 ohms, ±10%, ¼ w, DC | 1–116372 |
| R413 | 22 ohms, ±20%, ½ w, DC | 1–116359 |
| R414 | 470 ohms, ±10%, ¼ w, DC | 1–116372 |
| R415 | 22 ohms, ±20%, ½ w, DC | 1–116359 |
| R416 | 100K, ±10%, ½ w, DC | 1–116367 |
| R417 | 250K, ±1%, ½ w, DC | 1–113428 |
| R418 | 1K, ±20%, ¼ w, DC | 1–116361 |
| R419 | 144K, ±1%, 1 w, DC | 1–116362 |
| R420 | 23K, ±1%, ½ w, DC | 1–116363 |
| R421 | 1K, ±20%, ½ w, DC | 1–116361 |
| R422 | 15K, ±10%, 1 w, DC | 1–116364 |
| R423 | 470 ohms, ±10%, ¼ w, DC | 1–116372 |
| R424 | 22 ohms, ±20%, ½ w, DC | 1–116359 |
| R425 | 81K, ±1%, ½ w, DC | 1–116365 |
| R426 | 42K, ±1%, ½ w, DC | 1–113508 |
| R427 | 1K, ±20%, ¼ w, DC | 1–116361 |
| R428 | 104K, ±1%, ½ w, DC | 1–116366 |

C = Composition
DC = Deposited Carbon
WW = Wire Wound

| Reference Symbol | Description | Simpson Part No. |
|---|---|---|
| RESISTORS, VARIABLE | | |
| R114 | 1.5K, ±20%, 1/8 w, Ca | 1–117910 |
| R118 | 1K, ±20%, ¼ w, Ca | 1–116377 |
| R124 | 4K, ½ w, WW | 1–116318 |
| R133 | 1K, ±10%, 1 w, Ca | 1–117374 |
| R140 | 50K, ±20%, ¼ w, Ca | 1–116378 |
| R152 | 100K, ±20%, ¼ w, Ca | 1–113876 |
| R154 | 500 ohms, ½ w, WW | 1–116316 |
| R208 | 5K, ±20%, ½ w, Ca | 1–116384 |
| R216 | 5K, ±10%, ¼ w, Ca | 1–117435 |
| R221 | 50K, ±20%, ¼ w, Ca | 1–116378 |
| R302 | 50K, ±20%, ¼ w, Ca | 1–116379 |
| R310 | 500 ohms, ±20%, ½ w, Ca | 1–116383 |
| R329 | 50K, ±10%, ½ w, Ca | 1–115997 |
| R336 | 1 meg, ±20%, ¼ w, Ca | 1–116382 |
| R403 | 500K, ±20%, ¼ w, Ca | 1–116380 |
| R406 | 500K, ±20%, ¼ w, Ca | 1–116385 |
| R409 | 2 meg, ±20%, ¼ w, Ca | 1–116381 |
| R429 | 50 ohms, ±10%, 2 w, WW | 1–113882 |

Ca = Carbon
WW = Wire Wound

| Reference Symbol | Description | Simpson Part No. |
|---|---|---|
| INDUCTORS, FIXED (All are peaking coils) | | |
| L101 | 19μh, ±5%, P.I.C. | 10–860205 |
| L105 | 75μh, ±5%, P.I.C. | 10–860206 |
| L106 | 75μh, ±5%, P.I.C. | 10–860206 |
| L107 | 35μh, ±5%, P.I.C. | 10–860204 |
| L108 | 35μh, ±5%, P.I.C. | 10–860204 |
| L109 | 40μh, ±5%, P.I.C. | 10–860214 |
| L110 | 40μh, ±5%, P.I.C. | 10–860214 |
| L201 | 100μh, ±5%, P.I.C. | 10–860208 |
| L202 | 100μh, ±5%, P.I.C. | 10–860208 |
| L203 | 200μh, ±5%, P.I.C. | 10–860209 |
| L204 | 200μh, ±5%, P.I.C. | 10–860209 |
| L301 | 200μh, ±5%, P.I.C. | 10–860209 |
| L302 | 200μh, ±5%, P.I.C. | 10–860209 |
| L303 | 50μh, ±5%, P.I.C. | 10–860211 |
| INDUCTORS, VARIABLE | | |
| L102 | 15 to 30μh, P.I.C. | 1–117909 |
| L103 | 45 to 85μh, P.I.C. | 1–117976 |
| L104 | 15 to 30μh, P.I.C. | 1–117909 |

P.I.C. = Powdered Iron Core

## TABLE OF REPLACEABLE PARTS

| Reference Symbol | Description | Simpson Part No. |
|---|---|---|
| TUBES | | |
| V101 | 12AW6 Preamplifier | *3–810724 |
| V102 | 12AW6 Preamplifier | *3–810724 |
| V103 | 12AT7 Cathode Follower | 1–115466 |
| V104 | 6CB6 Phase Splitter and Amplifier | 1–116388 |
| V105 | 6CB6 Phase Splitter and Amplifier | 1–116388 |
| V106 | 6CL6 Vertical Output Amplifier | 1–116389 |
| V107 | 6CL6 Vertical Output Amplifier | 1–116389 |
| V201 | 6CB6 Phase Splitter and Amplifier | 1–116388 |
| V202 | 6CB6 Phase Splitter and Amplifier | 1–116388 |
| V203 | 6CL6 Horizontal Output Amplifier | 1–116389 |
| V204 | 6CL6 Horizontal Output Amplifier | 1–116389 |
| V301 | 6AN8 Sync. Input Phase Splitter & 1st Sync. Amplifier | 1–115373 |
| V302 | 6AN8 2nd Sync. Amplifier and Triggering Diode | 1–115373 |
| V303 | 6AN8 Sweep Generator | 1–115373 |
| V304 | 6CB6 Blanking Amplifier | 1–116388 |
| V305 | 12AT7 Clamping Diode, Output Cathode Follower and Linearizer | 1–115466 |
| V401 | 6W4 Main Supply Rectifier | 1–116390 |
| V402 | 6W4 Main Supply Rectifier | 1–116390 |
| V403 | 2X2A High Voltage Rectifier | 1–116392 |
| V404 | 6W6 +225 V Output Series Regulator | 1–116391 |
| V405 | 6W6 +225 V Output Series Regulator | 1–116391 |
| V406 | 6CB6 DC Amplifier | 1–116388 |
| V407 | OA2 Voltage Reference | 1–114316 |
| V408 | 6W6 +112 V Output Series Regulator | 1–116391 |
| V501 | 5ABP1 Cathode Ray Tube | 1–116393 |

* 2 – 12AW6 tubes, matched and aged

| Reference Symbol | Description | Simpson Part No. |
|---|---|---|
| TRANSFORMERS | | |
| T101 | Calibration, Special | 10–890317 |
| T401 | Plate and Filament Supply, Special | 1–117299 |
| SWITCHES, ROTARY | | |
| S101 | Vertical Function | |
| | Index Mechanism | 1–116759 |
| | S101A | 1–116526 |
| | S101B | 1–116761 |
| | S101C | 1–116760 |
| S102 | Vertical Attenuator | |
| | Index Mechanism | 1–117414 |
| | S102A | 1–117411 |
| | S102B | 1–118066 |
| | S102C | 1–116525 |
| S201 | Horizontal Selector | |
| | Index Mechanism | 1–116765 |
| | S201A | 1–116530 |
| | S201B | 1–116767 |
| | S201C | 1–116527 |
| | S201D | 1–116762 |
| | S201E | 1–116532 |
| S301 | Time Base Selector | 1–116531 |
| S302 | Sweep Rate | 1–118022 |
| MISCELLANEOUS | | |
| CH401 | Filter Choke, 5 Hy, 250 ma | 1–116927 |
| F401 | Fuse, Type 3AG, 3 amp, 250 v. | 1–116537 |
| J101 | Connector, Receptacle, type BNC, UG-657/U | 1–116539 |
| J102 | Connector, Binding Post | 1–116544 |
| J103 | Connector, Receptacle, type BNC, UG-657/U | 1–116539 |
| J201 | Connector, Receptacle, type BNC, UG-657/U | 1–116539 |
| J202 | Connector, Binding Post | 1–116544 |
| J301 | Connector, Receptacle, type BNC, UG-657/U | 1–116539 |
| M101 | Meter, 2" Wide-Vue, 50-0-50 50-0-50 $\mu$ amps | Meter Spec. 15–AA2610 |
| | Probe, 10:1 Low Capacity | 10–860299 |

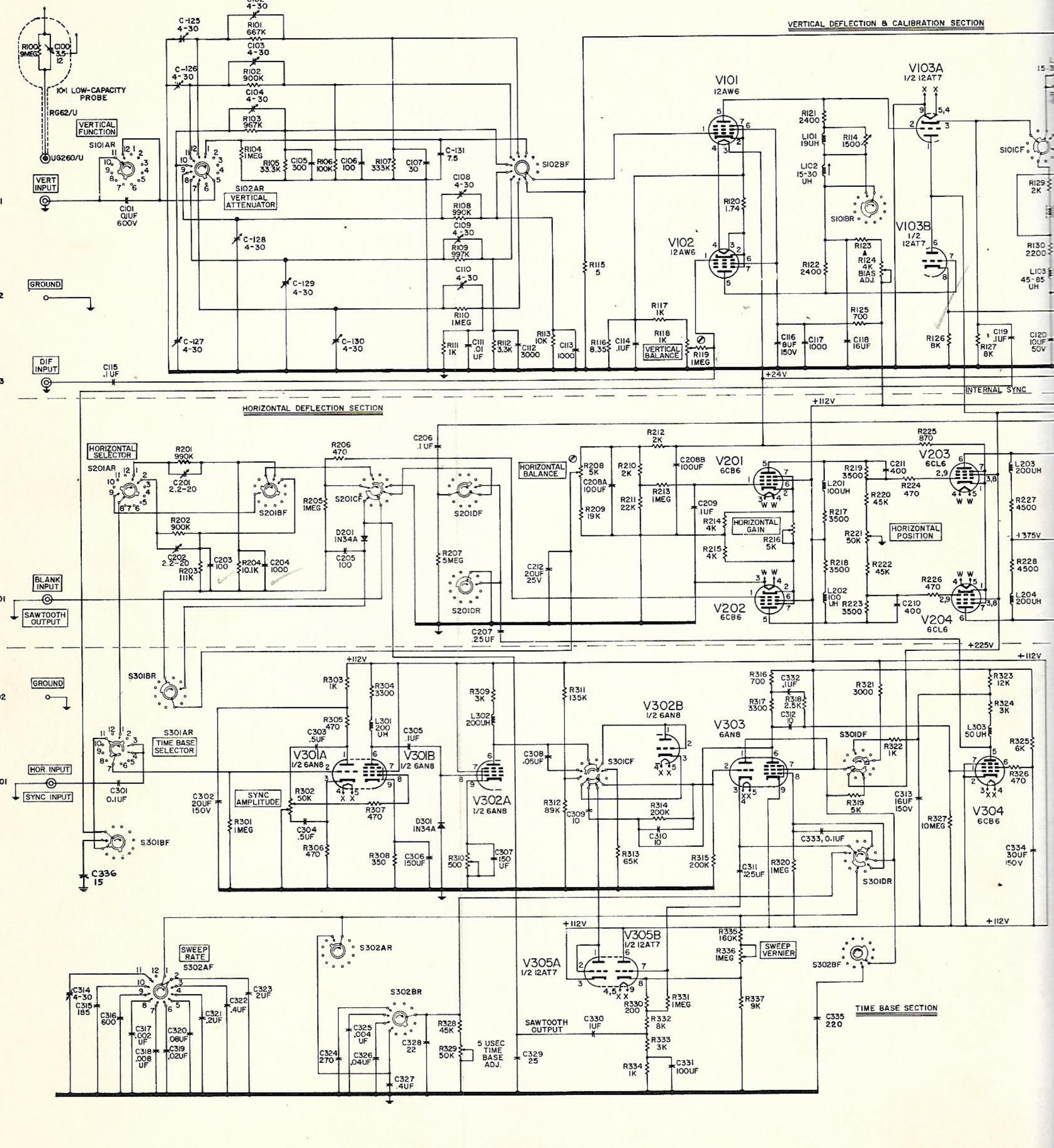
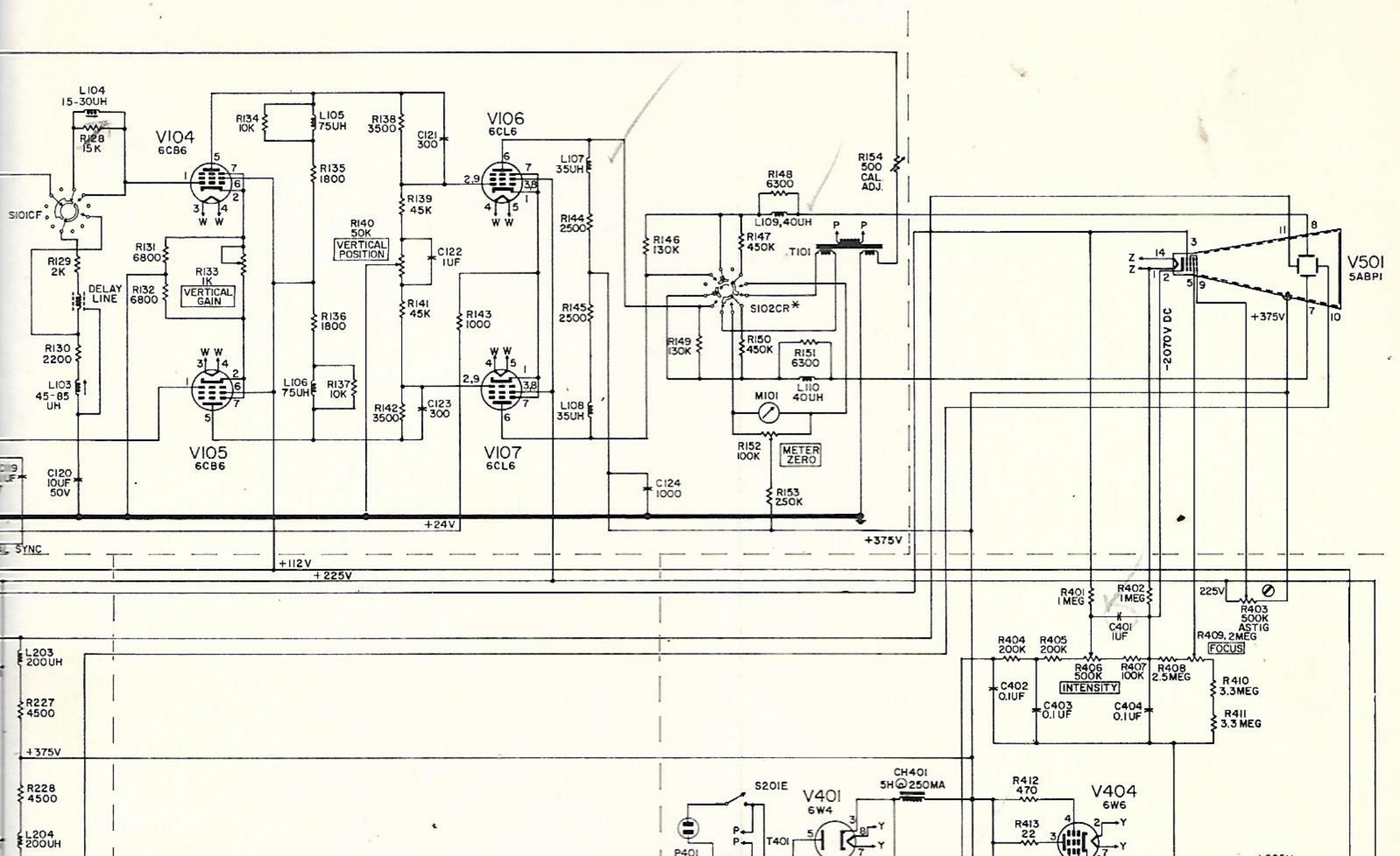
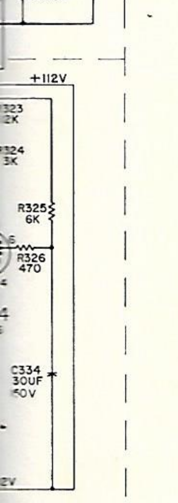
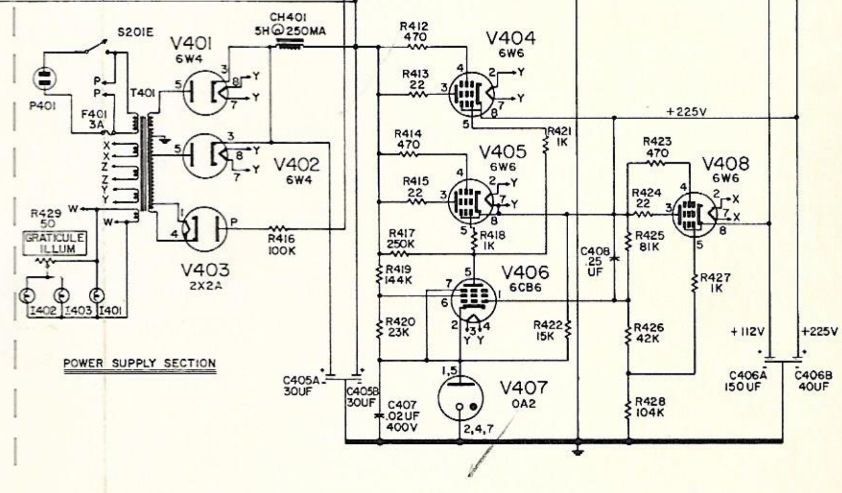



FIGURE 5. SIMPSON WIDE BAND OSCILLOSCOPE MO






NOTES:

1. UNLESS OTHERWISE SPECIFIED, RESISTORS ARE IN OHMS, CAPACITORS ARE IN UUF.
2. K = 1000
3. MEG = 1,000,000
4. TUBE FUNCTIONS,
   - V101-PREAMPLIFIER
   - V102-PREAMPLIFIER
   - V103A-CATHODE FOLLOWER
   - V103B-CATHODE FOLLOWER
   - V104-PHASE SPLITTER & AMPLIFIER
   - V105-PHASE SPLITTER & AMPLIFIER
   - V106-VERTICAL OUTPUT AMPLIFIER
   - V107-VERTICAL OUTPUT AMPLIFIER
   - V201-PHASE SPLITTER & AMPLIFIER
   - V202-PHASE SPLITTER & AMPLIFIER
   - V203-HORIZONTAL OUTPUT AMPLIFIER
   - V204-HORIZONTAL OUTPUT AMPLIFIER
   - V301A-SYNC INPUT PHASE SPLITTER
   - V301B-1ST SYNC AMPLIFIER
   - V302A-2ND SYNC AMPLIFIER
   - V302B-TRIGGERING DIODE
   - V303-SWEEP GENERATOR
   - V304-BLANKING AMPLIFIER
   - V305A-CLAMPING DIODE
   - V305B-OUTPUT CATHODE FOLLOWER & LINEARIZER
   - V401-MAIN SUPPLY RECTIFIER
   - V402-MAIN SUPPLY RECTIFIER
   - V403-HIGH VOLTAGE RECTIFIER
   - V404 +225V OUTPUT SERIES REGULATOR
   - V405-+225V OUTPUT SERIES REGULATOR
   - V406-DC AMPLIFIER
   - V407-VOLTAGE REFERENCE
   - V408-+112V OUTPUT SERIES REGULATOR
   - V501-CATHODE RAY TUBE
5. *SWITCHES SHOWN IN COUNTERCLOCKWISE POSITION AND AS VIEWED FROM THE SHAFT (KNOB) END.
   *S102CR IS A 2 POSITION SWITCH WHICH IS LINKAGE-ACTUATED BY S102 AND IS SHOWN IN THE MAXIMUM CLOCKWISE POSITION.
   SWITCH S201E IS A 2 POSITION SWITCH AND IS SHAFT ACTUATED (SHOWN IN POWER SUPPLY SECTION)

⊘ DENOTES SCREWDRIVER CONTROL (EXTERNAL)

▲ THIS IS A FACTORY SELECTED VALUE. IT WILL FALL IN THE RANGE OF 4K–8K

PE MODE 2610 (RUN #3), OVERALL SCHEMATIC DIAGRAM

# *Warranty*

SIMPSON ELECTRIC COMPANY warrants each instrument and other articles of equipment manufactured by it to be free from defects in material and workmanship under normal use and service, its obligation under this warranty being limited to making good at its factory any instrument or other article of equipment which shall within 90 days after delivery of such instrument or other article of equipment to the original purchaser be returned intact to it, or to one of its authorized service stations, with transportation charges prepaid, and which its examination shall disclose to its satisfaction to have been thus defective; this warranty being expressly in lieu of all other warranties expressed or implied and of all other obligations or liabilities on its part, and SIMPSON ELECTRIC COMPANY neither assumes nor authorizes any other person to assume for it any other liability in connection with the sale of its products.

This warranty shall not apply to any instrument or other article of equipment which shall have been repaired or altered outside the SIMPSON ELECTRIC COMPANY factory or authorized service stations, nor which has been subject to misuse, negligence or accident, incorrect wiring by others, or installation or use not in accord with instructions furnished by the manufacturer.