# OPERATOR'S MANUAL

## MODEL 452
## DUAL TRACE OSCILLOSCOPE



SIMPSON ELECTRIC COMPANY
853 Dundee Ave., Elgin, Illinois 60120
Area Code 312, Telephone 697-2260
In Canada, Bach-Simpson, Ltd., London, Ontario

Printed in U.S.A.
4-77

Part No. 5-119880

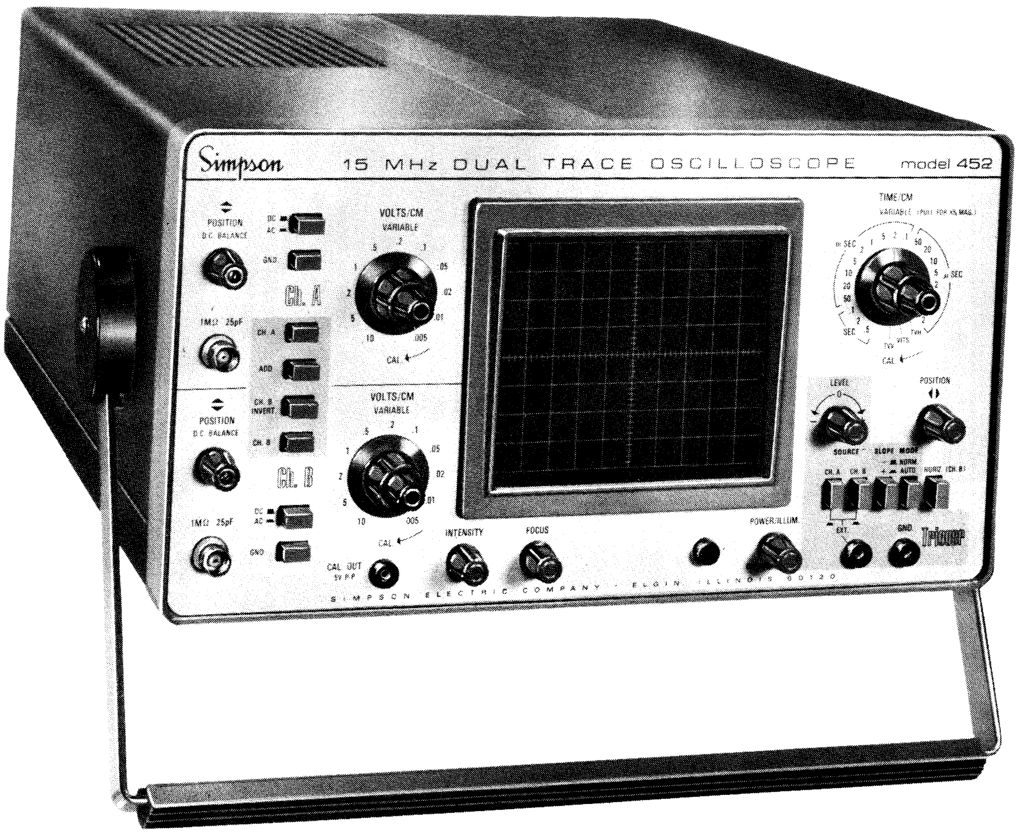



**Figure 1-1. Model 452 Dual Trace Oscilloscope**

# TABLE OF CONTENTS

**WARNING**

**This Instrument is designed to prevent accidental shock to the operator when properly used. However, no engineering design can render safe an instrument which is used carelessly. Therefore, this manual must be read carefully and completely before making any measurements. Failure to follow directions can result in a serious or fatal accident.**

**SHOCK HAZARD:** As defined in American National Standard, C39.5, Safety Requirements for Electrical & Electronic Measuring & Controlling Instrumentation, a shock hazard shall be considered to exist at any part involving a potential in excess of 30 volts rms (sine wave) or 42.4 volts DC or peak and where a leakage current from that part to ground exceeds 0.5 milliampere, when measured with an appropriate measuring instrument defined in Section 11.6.1 of ANSI C39.5.

NOTE: The proper measuring instrument for the measurement of leakage current consists essentially of a network of a 1500 ohm non-inductive resistor shunted by a 0.15 microfarad capacitor connected between the terminals of the measuring instrument. The leakage current is that portion of the current that flows through the resistor. The Simpson Model 229-Series 2 AC Leakage Current Tester meets the ANSI C39.5 requirements for the measurement of AC leakage current and can be used for this purpose. To measure DC Leakage current, connect a 1500 ohm non-inductive resistor in series with a Simpson 0-500 DC microammeter and use this as the measuring instrument.

# SECTION I

# INTRODUCTION

## 1.1 GENERAL

**1.1.1** The Simpson Model 452 Dual Trace Oscilloscope, hereafter referred to as Model 452, or simply as the Instrument, is a professional solid state instrument, highly reliable in laboratory and many other applications for observing and measuring waveforms in electronic circuits. It is designed with a dual vertical input that provides for simultaneous viewing of two waveforms. The chopping rate is 200 kHz for low repetition rate waveforms. The alternate mode is automatically selected when viewing high speed waveforms. The sum or difference of the two waveforms can be displayed as a single trace. Its design fulfills all major requirements of accurate performance and excellent dependability. Among its many applications are laboratory measurement, industrial maintenance, production line circuit alignment, checkout, troubleshooting of electronic circuit and servicing of color and black-and-white television receivers. Modern engineering methods and quality control assures its high quality and reliable performance.

**1.1.2** Other distinctive characteristics of the Model 452 include a DC to 15 MHz vertical amplifier, 5mV/cm vertical and horizontal sensitivity and 40 nanosec/cm to .5 sec/cm speed range for automatic and triggered sweeps. This makes the Model 452 useful for many laboratory, manufacturing and service applications. All the operating functions are controlled through circuits designed with highly reliable integrated circuits and the latest state-of-the art solid state components. In addition, differential amplifier from the input stage, through the deflection power stages, provide common mode noise rejection for reproduction of a stable low distortion waveform.

**1.1.3** The vertical and horizontal input attenuators are calibrated directly in volts to allow the Instrument to be used as a visual instantaneous waveform voltmeter. An internal .5 volt/cm square wave signal calibrated to 1% accuracy provides source for the voltage range calibration and low capacitance probe alignment.

**1.1.4** To expand the application of the Instrument, a low capacitance (11pF) high impedance (10MΩ) accessory probe is available.

## 1.2 ITEMS SUPPLIED WITH INSTRUMENT, AND ACCESSORIES

All items furnished with the Instrument are listed in Table 8-1.

## 1.3 TECHNICAL DATA

Listed below are the technical specifications for Model 452.

**Table 1-1. Model 452 Technical Data**

| | |
|---|---|
| **1. POWER REQUIREMENTS** | |
| AC Voltage: | 120 AC ±10%, 220V AC ±10% or 240V AC ±10% |
| Frequency: | 50 to 60 Hz |
| Average Power Consumption: | 45 VA |
| Fuse Ratings: | 2 Ampere 125V 3AG Slow-Blow fuse for 120 volt operation. 1 Ampere 250V 3AG Slow-Blow fuse for 220 and 240 volt operation. |
| **2. VERTICAL AMPLIFIER: (CH.A and CH.B) Bandwidth, at −3 dB:** | |
| DC: | DC to 15 MHz |
| AC: | 2 Hz to 15 MHz |
| Input Impedance: | 1M Ohm shunted by 25 pF |
| Maximum Input Voltage: | 500V (DC + AC peak) |
| Deflection Sensitivity: | 5mV/cm to 10V/cm calibrated in 1-2-5 sequence in eleven steps; accuracy within ±5% of full screen deflection; uncalibrated continuous variable control between steps. |
| Risetime: | 24 nanoseconds |
| Overshoot: | 5% or less |
| Display Modes: | Channel A only<br>Channel B only<br>Channel A and B, automatically chopped at 1msec/cm and slower sweep speeds, and automatically alternated for all faster sweep times.<br>Add: Algebraic sum of Channel A and B signals.<br>Channel B Invert: Inverting of Channel B (allows algebraic difference of Channel A and B signals). |
| Chopping Frequency: | 200 kHz |

**3. HORIZONTAL AMPLIFIER:**
**(Input through CH.B)**
**Bandwidth, at −3 dB:**

| | |
|---|---|
| DC: | DC to 1.5 MHz |
| AC: | 2 Hz to 1.5 MHz |
| Input Impedance: | 1M Ohm shunted by 25 pF |
| Maximum Input Voltage: | 500V (DC + AC peak) |
| Deflection Sensitivity: | 5mV/cm to 10V/cm calibrated in 1-2-5 sequence in eleven steps; accuracy within ±5% of full screen deflection; uncalibrated continuous variable control between steps. |

**4. CALIBRATION VOLTAGE:** .5V p-p ±1%, square-wave — 1kHz ±10%

**5. HORIZONTAL SWEEP RANGES:**

| | |
|---|---|
| Time/cm (20 Ranges): | .2μsec/cm to .5sec/cm (±5%) calibrated to 1-2-5 sequence in 20 steps; uncalibrated continuous variable control between steps. |
| TV-H: | 12.7 μsec/cm |
| TV-V: | 3.33msec/cm |
| VITS: | .1msec/cm |
| Magnifier: | X5 Expands the fastest sweep speed from .2μs/cm to 40nsec/cm |

**6. TRIGGERING:**

| | |
|---|---|
| Source: | External, CH.A or CH.B |
| Mode: | Normal and Automatic |
| Coupling: | AC |
| Slope: | Positive and Negative |
| Trigger Sources and Sensitivity: | |
| Normal: | |
| Internal: | 1 cm p-p of deflection for signal frequencies 3 Hz to 15 MHz.<br>.5cm p-p of deflection for signal frequencies 10 Hz to 10 MHz. |
| External: | .5V p-p for signal frequencies from 3 Hz to 15 MHz |
| Auto: | .5 cm p-p of deflection for signal frequencies from 50 Hz to 15 MHz |
| TV Sync: | .5 cm p-p of deflection. |

**7. SIZE AND WEIGHT:**

| | |
|---|---|
| Size: | 6½″ H x 12″ W x 16″ D |
| Weight: | 20 lbs. approx. |

**8. CRT:**

| | |
|---|---|
| Type: | 130 BHB31 |
| Screen Size: | 5″ round flat face |
| Display Area: | 8 x 10 cm |
| Screen Phosphor: | P31 |

**9. ENVIRONMENT:**

| | |
|---|---|
| Operating Temperature: | 0° to 45°C |
| Vibration Spec.: | EIA spec RS 152B |

# SECTION II

# INSTALLATION

## 2.1 UNPACKING AND INSPECTION

**2.1.1** Examine the shipping carton for obvious signs of damage and inspect the Instrument for possible damage incurred during shipment. If damage is noted, notify the carrier and supplier and do not attempt to use the Instrument. If the Instrument appears to be in good condition, read Operator's Manual in its entirety. Become familiar with the Instrument as instructed in the manual and proceed to check the electrical performance.

## 2.2 FACILITIES REQUIRED

If possible, use the Simpson 452 in a clean dry area, preferably one maintained at constant normal indoor temperature and humidity levels. Avoid dust and corrosive fumes. Isolate the oscilloscope from mechanical shock, vibration, and electrical interference.

## 2.3 POWER REQUIREMENTS

CAUTION

**Do not connect the Instrument to a power source until instructed to do so. Check that the power source agrees with the voltage requirements of your Instrument.**

The input power requirement of the Simpson 452 is prewired for 120 VAC, 50/60 Hz operation. To operate the Instrument from 220 or 240 VAC 50/60 Hz source, the input power line connections to the primary windings of the power transformer and pilot light resistor must be changed. To change input power requirements, refer to paragraph 7.4. The required power source must be a 3-wire, grounded outlet, wired according to the latest electrical code. The line voltage should be ±10% of the rated value for the Instrument.

CAUTION

**If the unit is operated on a 2-wire system (although it is not recommended), connect a ground lead from earth GROUND to chassis GND. terminal.**

## 2.4 OPERATION

The Model 452 is equipped to operate in a horizontal, vertical or inclined position. Assure at least three inches clearance on both sides of the Instrument for ventilation. Avoid operation with rubber feet missing because they provide air clearance from the bottom. Although CRT shielding is provided, the Instrument and test leads should be kept away from strong electrical fields (such as controllers, motors, blowers). This will assure accurate waveforms and stable triggering.

# SECTION III

# CONTROLS, CONNECTORS AND INDICATORS

## 3.1 GENERAL

All controls, connectors, indicators and other operational items are described in Table 3-1, and shown in Figures 3-1 and 3-2. Become thoroughly familiar with the name and purpose of each item before operating the Instrument.

**Table 3-1. Controls, Connectors and Indicators**

| Item | Description |
|---|---|
| **1. Cathode Ray Tube and Graticule** | 5″ flat-faced cathode ray tube with 8 x 10 cm edge-lighted graticule. |
| **2. VOLTS/CM, VARIABLE (CH.A)** | |
| Gray Knob | An 11 position step attenuator for 5 mV/cm to 10 V/cm. |
| Red Knob | Variable attenuator with CAL (calibrated) at max. CW. position. |
| **3. DC/AC Switch** | Selects input mode for CH.A vertical amplifier. |
| AC | Blocks DC component of input signal. |
| DC | Processes both DC and AC signal components. |
| **4. GND Switch** | Grounds input of vertical amplifier. Used to obtain DC reference (zero signal base line) on CRT screen without disconnecting signal leads. |
| **5. POSITION** | Adjusts vertical position of trace on CRT. |

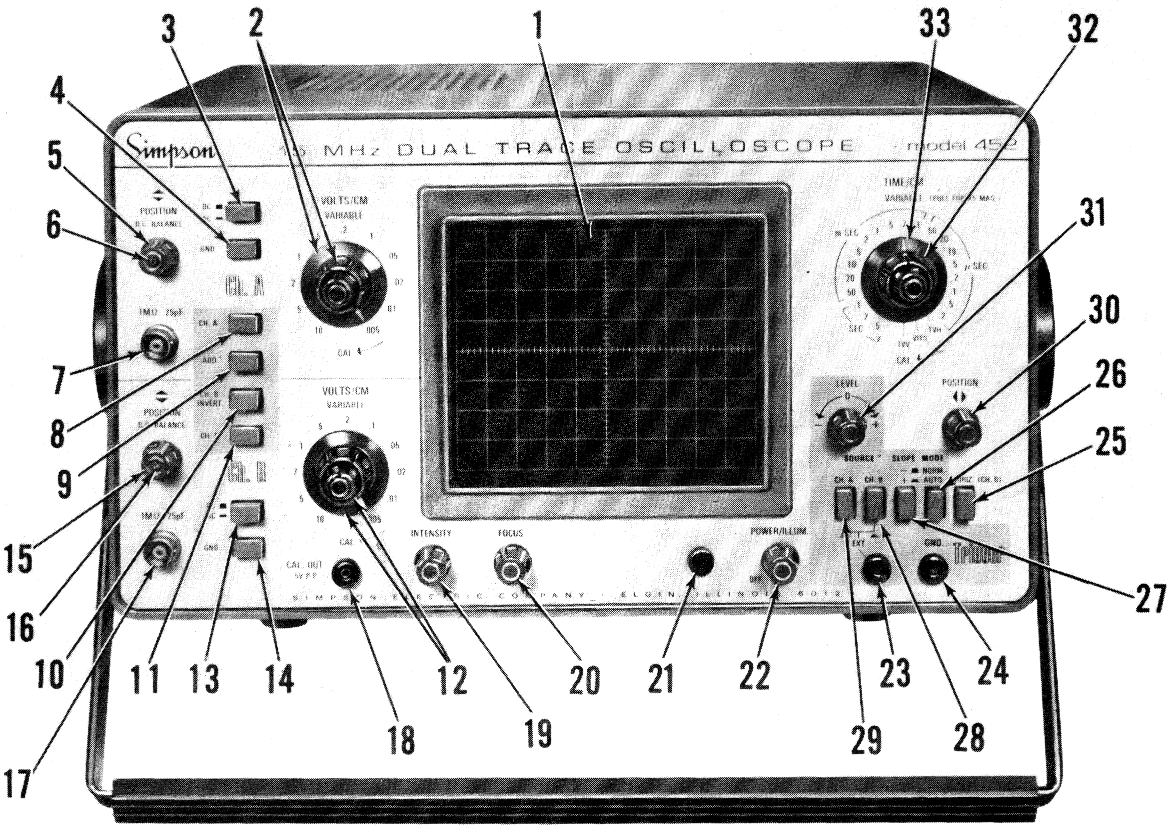



**Figure 3-1. Front Panel Controls, Connectors and Indicators**

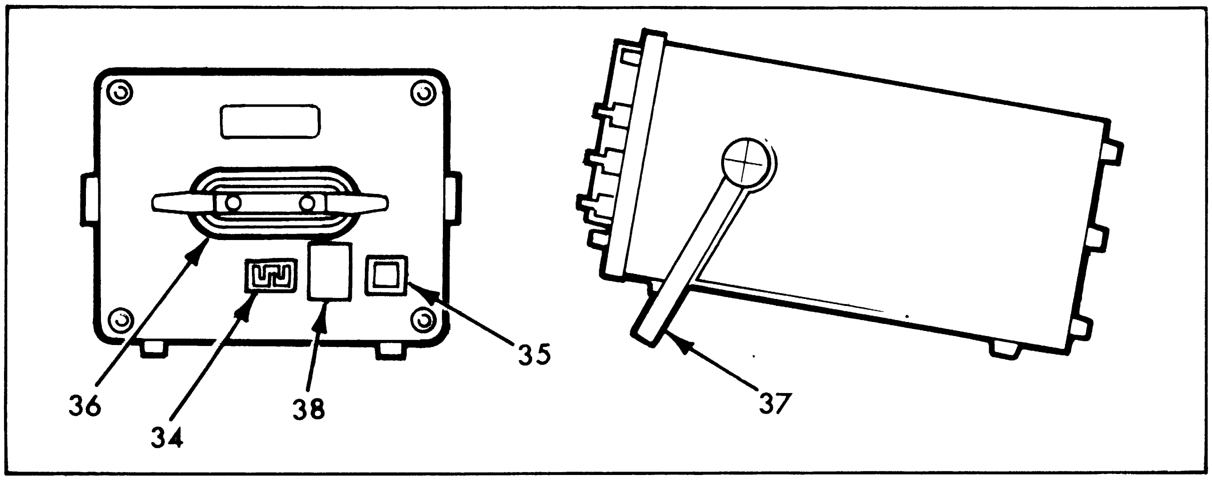



**Figure 3-2. Rear and Side Panel Facilities**

| | |
|---|---|
| **6. DC BALANCE** | Adjusts DC balance at input of vertical differential amplifier. |
| **7. VERTICAL INPUT** | BNC connector for vertical CH.A. signal input. |
| **8. CH.A** | Displays the input signal to channel A as a single trace or as a dual trace when CH.B switch is also depressed. |
| **9. ADD** | To display the algebraic sum of channel A and channel B signals. If CH.B INVERT switch is also depressed, the algebraic difference (channel A signal-channel B signal) is displayed. The switch overrides CH.A and CH.B switches. |
| **10. CH.B INVERT** | Invert the polarity of channel B signal displayed or applied in conjunction with ADD switch as described in item 9. |
| **11. CH.B** | Displays the input signal to channel B as a single trace or as a dual trace when the CH.A switch is also depressed. |
| **12. VOLTS/CM, VARIABLE (CH.B)** | |
| Gray Knob | An 11 position step attenuator for 5 mV/cm to 10 V/cm. |
| Red Knob | Variable attenuator with CAL. (calibrated) at max. CW. position. |
| **13. DC/AC Switch** | Selects input mode for CH.B vertical amplifier. |
| AC | Blocks DC component of input signal. |
| DC | Processes input of both DC and AC signal components. |
| **14. GND Switch** | Grounds the input of vertical amplifier. Used to obtain DC reference (zero signal base line) on CRT screen without disconnecting signal leads. |
| **15. POSITION** | Adjusts CH.B vertical position of trace on CRT. |
| **16. DC BALANCE** | Adjusts DC balance at input of vertical differential amplifier. |
| **17. VERTICAL INPUT OR HORIZONTAL INPUT** | BNC connector for vertical CH.B signal input as well as external horizontal signal input. |
| **18. CAL. OUTPUT** | Provides 1 kHz, .5 volt peak-to-peak square-wave signal which is used for calibration of the vertical (or horizontal) amplifier attenuators and to check the frequency compensation adjustment of the low capacitance probes. |
| **19. INTENSITY** | Adjusts brightness of trace. |
| **20. FOCUS** | Adjusts line width or sharpness of trace. |
| **21. Red Pilot Light** | Lamp lights when the power is turned on. |
| **22. POWER/ILLUM.** | Power on/off switch. Adjusts intensity of graticule illumination. |
| **23. EXT. Trigger Jack** | Input terminal for external trigger signal. |
| **24. GND. Jack** | Common ground connection for external trigger signal input and grounding of the instrument. |

| | |
|---|---|
| **25. HORIZ. (CH.B)** | Turns off sweep circuit and provides access to horizontal amplifier through channel B input. |
| **26. NORM./AUTO Mode** | Selects mode for triggering synchronization. |
| NORM | − or + LEVEL adjustment control determines points and waveform slope where sweep starts. |
| AUTO | When switch is set to automatic triggering, a sweep is generated even without an input signal. |
| **27. −/+ Slope** | Selects the slope of the point on the trace at which trigger starts. |
| **28. CH.B Source** | Sweep is triggered by channel B signal. |
| **29. CH.A Source EXT.** | Sweep is triggered by channel A signal. With both CH.A and CH.B switches depressed, the sweep is triggered by external signal applied to jack 23. |
| **30. POSITION** | Adjusts horizontal position of trace on CRT screen. |
| **31. −/0/+ LEVEL** | Adjusts the triggering level point for the display of a stable waveform. |
| **32. VARIABLE (PULL FOR X5 MAG.)** | Adjusts sweep time. In the extreme clockwise (CAL.) position the sweep time is calibrated. The control in the out position provides X5 magnification of the sweep. |
| **33. TIME/CM** | Twenty three positions switch selects sweep speed from .2 usec/cm to .5 sec/cm (calibrated with VARIABLE control set to maximum clockwise position at CAL.). Included, are three sweep speeds for displaying two horizontal lines, two vertical frames and the VITS information. |
| **34. Power Receptacle** | Provides power cord connection. |
| **35. Fuse Holder** | Accepts type 3 AG fuse. See label 38 for fuse ratings. |
| **36. Bracket** | Stores wrapped on power cord. |
| **37. Handle-Stand** | Handle for carrying the instrument and providing view angle stand. |
| **38. Nameplate** | Lists serial number of the instrument and rating for the fuse. |

# SECTION IV

# OPERATION

## 4.1 GENERAL

This section of the manual contains information required to use and operate the Simpson 452 in a safe and proper manner. Special notes and instructions also have been provided for added user safety and convenience.

## 4.2 SAFETY PRECAUTIONS

**WARNING**

**In equipment known to be (or thought to be) "solid-state", it can be very tempting to suppose that only low voltages are present. On the contrary, lethal shock situations are often present in transistor circuitry, and definitely in equipment which employs vacuum tubes. When servicing TV sets, do not suppose that the "high voltage compartment" is the only place where you must be careful. Other circuit sections can carry high voltages as well.**

**4.2.1** The Simpson 452 is intended to be used only by personnel qualified to recognize shock hazards and trained in the safety precautions required to avoid possible injury. Refer to SHOCK HAZARD definition on page iv.

**4.2.2** Do not work alone when making measurements or adjustments where a shock hazard can exist. Notify another nearby person that you are making, or intend to make, such measurements.

**4.2.3** Remember, voltages may appear unexpectedly in defective equipment. An open bleeder resistor can result in a capacitor's retaining a dangerous charge. Remove all power and discharge all capacitors in the circuit being measured before making connections or disconnecting the Instrument.

**4.2.4** Locate all voltage sources and current accessibility paths prior to making any connections.

**4.2.5** For your own safety, before each use, inspect the test leads, probes, connectors and power cable for cracks, breaks or crazes in the insulation. If any defects exist, destroy and replace the defective item(s) immediately.

**4.2.6** Do not make measurements in a circuit where corona is present. Corona can be identified by a pale-blue color emanating from sharp metal points in the circuit or a buzzing sound, or the odor of ozone. In rare instances, such as around germicidal lamps, ozone might be generated as a normal function. Ordinarily, the presence of ozone indicates presence of high voltage, and probably a malfunction of some kind.

**4.2.7** Hands, shoes, floor and workbench must be dry. Avoid making measurements under humid, damp, or other environmental conditions that could affect the dielectric withstanding voltage of the test lead or the Instrument.

**4.2.8** For maximum safety, do not touch test leads, circuits, or instrument while power is applied to the circuit being measured.

**4.2.9** Use extreme caution when making measurements in a circuit where dangerous composite voltages could be present, such as in an rf amplifier.

**4.2.10** When using the Simpson 452 Oscilloscope insure that it is connected to a three-wire power line outlet that is correctly wired in accordance with the latest National Electrical Code. If not sure of the integrity of the power line outlet, or you are forced to use a 3-wire to a 2-wire cheater plug, then be sure to ground by means of the GND. pin jack located along the lower right edge of the front panel.

**4.2.11** Do not exceed the maximum input voltage ratings of the Model 452, which are tabulated in Table 1-1. To do so endangers personal safety and may also damage the Oscilloscope.

**4.2.12** Do not attempt to float the grounded terminal (the GND pin jack and the body of the BNC input connector which are all electrically connected to the case), or the case of the Model 452 above earth power line ground. To do so risks personal safety and may damage the Model 452 as well as the equipment under test.

## 4.3 INITIAL CONTROL SETTINGS

a. Prior to performing any test or adjustments review paragraphs 4.1 and 4.2 then proceed as follows:

**CAUTION**

**Use the Model 452 in an area which is free from magnetic disturbances, to prevent possible waveform distortion. Magnetic fields from motors or transformers in nearby equipment may cause such distortion. During stand-by periods, when the beam of the cathode ray tube is concentrated in a particular spot on the screen, adjust the INTENSITY control to extinguish the spot, or keep the spot in motion. This precaution prevents burning a spot on the face of the CRT.**

b. Turn power off by setting POWER/ILLUM. control to OFF position.

c. Turn INTENSITY control to mid-position.

d. Rotate FOCUS control to mid-position.

e. Rotate all vertical and horizontal POSITION controls to mid-positions.

f. Set VOLTS/CM switches of both channels to .1.

g. Rotate both vertical VARIABLE controls to CAL. positions.

h. Push the vertical channel selector switches CH.A and CH.B in for dual trace operation.

i. Set sweep TIME/CM switch to 1 mSEC.

j. Rotate horizontal VARIABLE control to CAL. position.

k. Push the magnifier switch X5 MAG in for X1 position.

l. Set TRIGGER MODE switch to AUTO.

## 4.4 INITIAL OPERATIONAL TEST

a. Connect AC line cord receptacle to socket on rear panel of cabinet and the three prong plug to AC power source.

b. Rotate POWER/ILLUM. control clockwise until pilot light illuminates. The power is turned on and after approximately 20 seconds the two traces should appear on CRT screen.

c. If no trace appears rotate INTENSITY control clockwise until the traces are easily observed.

d. Adjust FOCUS and INTENSITY controls for sharpest trace of medium brightness.

e. Readjust vertical and horizontal POSITION controls if neccessary to center the traces, or adjust the traces for any other position within the screen periphery, as may be required.

f. Rotate VOLTS/CM VARIABLE control of channel A and that of channel B from extreme clockwise to extreme counterclockwise positions. Observe respective trace.

g. If the trace shifts up or down on the screen, DC BALANCE adjustment is required. This adjustment minimizes shift of the trace between two extreme positions of the VARIABLE control setting. (See MAINTENANCE SECTION 7-6 for more details).

h. Connect shielded probe to channel A BNC input connector.

i. Connect the tip of the probe to CAL. OUT .5V p-p pin jack.

j. Push the TRIGGER SOURCE CH.A switch in.

k. Adjust TRIGGER LEVEL control for a stable square-wave on the screen.

l. Readjust INTENSITY and FOCUS controls to obtain a clear well defined 5 cm p-p square-wave display.

m. To remove channel B trace (straight horizontal line) out of the way for better square-wave observation, push (to release) vertical CH.B switch.

n. Remove probe cable from channel A connector and connect it to channel B BNC connector input.

o. Push the vertical CH.B switch in and push (to release) the CH.A switch for single CH.B trace observation.

p. Depress CH.B switch for TRIGGER SOURCE.

q. Observe square-wave signal displayed. It should be 5 cm p-p. Adjust TRIGGER LEVEL as required for stable display.

r. Remove probe tip from CAL. OUT .5V p-p jack.

s. The oscilloscope is now ready for applications of waveform observation.

## 4.5 SINGLE-TRACE WAVEFORM OBSERVATION

a. Either channel A or channel B can be used for single-trace operation. The only difference between the two channels is that polarity of waveform on channel B can be reversed by actuating the CH.B INVERT switch.

b. Connect the probe to either channel A or channel B input and set vertical mode switches (CH.A and CH. B) correspondingly.

**WARNING**

**The ground lead is earth grounded in the oscilloscope. Make certain that the circuit point to which it is to be connected is also earth grounded or can tolerate being grounded by the lead.**

c. Connect the probe tip and ground lead to the signal source desired for observation or measurement.

d. Proceed with control adjustment procedure in paragraph 4.5.1.

### 4.5.1 DC AC Input and Signal Attenuation

a. Set input DC/AC switch to AC for measuring only the AC component and blocking DC component contained in test signal.

b. Use DC switch position for measuring both the AC and the DC component and any time a very low frequency waveform is to be observed.

c. The GND switch disconnects test signal from the amplifier input and provides zero-signal ground reference on the CRT.

d. Set VOLTS/CM selector and VARIABLE control to a position that gives 2 to 6 cm vertical deflection with the test signal to be observed.

### 4.5.2 Internal Sweep

a. TRIGGER MODE switch selects either AUTO for automatic recurrent sweep or NORM for triggered sweep operation. AUTO provides automatic recurrent sweep in the absence of trigger signal.

b. In the presence of trigger signal there is no difference between the AUTO and NORM modes of triggering. The point on the trace at which sweep triggering occurs is selected by adjusting TRIGGER LEVEL control. The main purpose of TRIGGER LEVEL control is to obtain a stable display.

c. Set TRIGGER SLOPE switch to (+) position if the sweep is to be triggered at a point on the positive going portion of the displayed waveform or to the (−) position if the sweep is to be triggered at a point on the negative going portion of the waveform.

d. Most waveforms can be observed by using internal trigger with either CH.A of CH.B trigger source switch button depressed. When an external trigger source is required, both, CH.A and CH.B TRIGGER SOURCE switches must be depressed and trigger signal applied to the EXT pin jack.

e. For normal operation the magnifying switch, X5 MAG, is pushed in to operate without magnification. If magnification of a waveform is desired, pull X5 MAG switch out. That will expand the sweep and waveform to be observed horizontally by a factor of 5. Use the horizontal POSITION control to bring the desired magnified position into view on the screen.

f. Set sweep TIME/CM switch and VARIABLE control for the desired number of wave cycles to be displayed.

Using the X5 magnification position, the trace becomes progressively dimmer with increased sweep speed. This is because the trace writing speed increases and less energy per unit time is absorbed by the light emitting phospor layer at the CRT screen.

### 4.5.3 External Horizontal Signal

For some specialized applications, the sweep can be controlled externally. This is accomplished as follows:

a. The HORIZ. (CH.B) switch is depressed which enables channel B to be the horizontal amplifier. The signal input to channel B is used to obtain and control the horizontal sweep.

b. The signal input to channel A deflects the beam vertically, which with the channel B input causes a variety of patterns to be displayed.

## 4.6 CALIBRATED VOLTAGE MEASUREMENTS

Peak voltages, peak-to-peak voltages, DC voltages and voltages of a specific portion of a complex waveform can be measured using the Model 452 as a voltmeter. Voltages can be measured whenever waveforms are observed using either CH.A or CH.B inputs. Proceed as follows:

a. Set controls of Model 452 as instructed in preliminary procedure, to display the desired waveform.

NOTE: For the vertical calibration (or horizontal calibration applying external horizontal signal to CH.B input) to be correct the VARIABLE knob of the VOLTS/CM variable control must be fully clockwise in the CAL. position.

b. Set VOLTS/CM control to obtain maximum vertical deflection within upper and lower limits of vertical scale.

c. For AC voltage, set DC/AC switch to AC, and note the amount of vertical deflection in centimeters. Adjust the horizontal POSITION control to shift the reference point for easier scale reading, if desired.

d. For DC or complex signals, set the input grounding switch to GND, and adjust the vertical POSITION control to a convenient reference level. Set the DC/AC switch to DC and observe the amount of deflection. A positive voltage input will deflect the trace upwards; a negative voltage input will deflect the trace downward.

NOTE: Use the accessory LOW CAPACITANCE X10 ATTENUATOR PROBE for display of short rise-time waveforms.

e. To calculate the voltage reading, multiply the vertical deflection (in centimeters) by the setting of the VOLTS/CM switch.

NOTE: When the accessory LOW CAPACITANCE PROBE is used, the deflection displayed on the Model 452 is only 1/10 of the actual voltage measured. See compensation procedure for probe.

## 4.7 ACCESSORY LOW CAPACITANCE PROBE (see Figure 4-1)

For all test procedures other than low-amplitude waveform (below .2 volt peak-to-peak) observations, the recommended accessory low capacitance probe is required. The shunt resistance and capacitance of the probe connected to the oscilloscope is 10 megohms and 11pF. This probe offers minimum loading to the signal and circuit under test. A 10 to 1 reduction in voltage to the CH.A and CH.B input will result and must be taken into account in quantitive measurements.

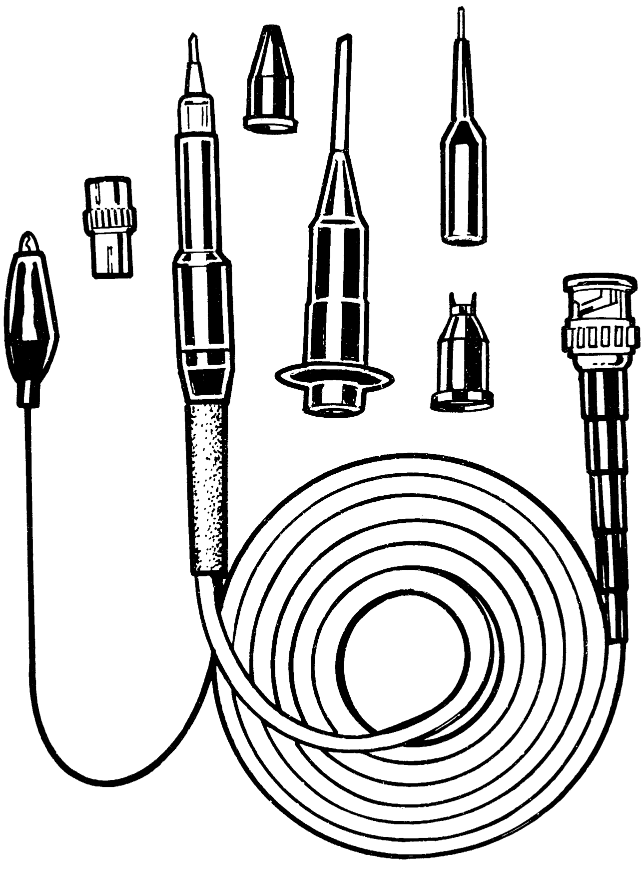


**Figure 4-1. Low Capacitance Probe, Model 00791**

## 4.8 PROBE COMPENSATION TEST

a. Set VOLTS/CM switch to .01 and VARIABLE control to CAL. Apply the CAL. OUT square wave to the probe tip. The deflection on the screen should be 5 cm p-p.

b. Adjust sweep rate for at least one complete rectangular waveform. The waveform should have square corners and flat top and bottom.

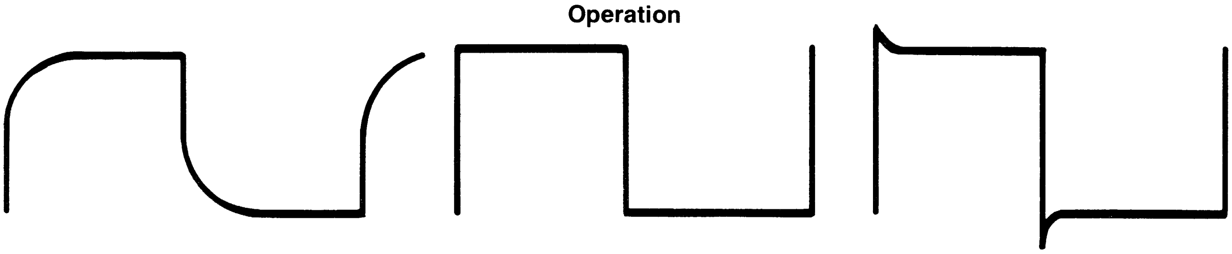



Figure 4-2. Compensation Waveforms

## 4.9 COMPENSATION PROCEDURE

Insert probe tip into CAL. OUT jack and adjust capacitor set screw with a tuning wand or a nonferrous screwdriver until a good sharp leading edge without any overshoot is obtained (B, figure 4-2).

## 4.10 DUAL-TRACE WAVEFORM OBSERVATION

In observing simultaneous waveforms on channels A and B, the necessary condition for having a stable display on both channels is that the frequency or repetition rate of one waveform is identical or a multiple to that of the other waveform. If this condition is met, the trigger signal could be from either channel in order to have a stable dual trace display. An example of this is in measuring the waveforms at the input and output of a multiplier or a divider using dual trace display.

To display two waveforms simultaneously, perform the steps as follows, starting with Initial Control Settings in 4.3 and 4.4.

1. Push vertical mode switches CH.A and CH.B in. Two traces should appear on the screen.
2. Connect test probe cables to both channel A and channel B input connectors.
3. Set both, channel A and B, DC/AC input switches to the AC position, which is used for most measurements. It must be used if the signals being measured include a large DC component and only AC component is desired to be measured.
4. Adjust channel A and B POSITION controls to obtain proper separation and reference.
5. Connect the ground clips of the probes to the chassis ground of the equipment under test. Connect the tips of the probes to points in the circuit where the waveforms are to be measured.
6. Set the VOLTS/CM switches of both channels A and B to positions that give vertical deflection of both waveforms within screen graticule area.
7. Push in either one of the TRIGGER SOURCE switches. If a trigger signal other than the waveforms displayed above is required, depress both TRIGGER SOURCE switches (CH.A and CH.B) for external triggering and connect a cable from EXT. and GND pin jacks to the trigger source.
8. Set the TRIGGER switch to the (+) position if the sweep is to be triggered on positive-going portion of the displayed waveform, or to the (−) position if the sweep is to be triggered on negative-going portion of the displayed waveform.
9. Adjust TRIGGER LEVEL control to obtain waveform display.
10. The observed waveforms of channels A and B can be expanded by a factor of 5 horizontally by pulling the VARIABLE (PULL for X5 MAG.) knob outward.
11. Calibrated voltage measurements and calibrated time measurements are identical to those previously described for single-trace operation. This can be done either by using the dual display operation with vertical mode selector switches CH.A and CH.B depressed or by reverting to a single-trace operation with only CH.A or CH.B switch depressed.
12. The channel A and channel B waveforms displays can be added algebraically by pushing vertical mode switches CH.A, CH.B and ADD. in, or subtracted algebraically by vertical mode switches CH.A, CH.B INVERT and ADD pushed in.

## 4.11 DIFFERENTIAL VOLTAGE MEASUREMENT

The Dual trace feature of Model 452 may be used to observe waveforms and measure voltages between points in a circuit, neither of which is circuit ground. Measuring of differential amplifier input, phase splitter outputs, push-pull amplifier outputs and many other measurements differential voltages require dual trace technique.

a. To perform these measurements connect ground clips of both the channel input probes to the chassis ground of equipment under test, and connect probe tips to the points in the circuit where measurements are to be made.

b. Proceed with the control setting as described in previous sections to display two waveforms simultaneously. Set DC/AC switches of both vertical channels for AC input.

c. Set channel A and channel B VARIABLE controls to CAL. position and VOLTS/CM selector switches of both channels to the same position.

d. Adjust TRIGGER LEVEL control to display a synchronized pattern.

e. If the channel A and channel B inputs observed in d are in phase subtract both waveforms algebraically by pushing vertical mode CH.A, CH.B INVERT and ADD switches in. The displayed waveform is the peak-to-peak difference between two points of measurement. If the difference is small the vertical sensitivity may be increased by resetting both channel A and channel B VOLTS/CM switches to a more sensitive position.

f. If the channel A and channel B inputs observed in step d are 180° out of phase, such as the output of a differential amplifier, push the vertical mode CH.A, CH.B INVERT and ADD switches in to measure the full peak-to-peak waveform. Push the vertical mode CH.A, CH.B and ADD switches in to measure any imbalance between the two points of measurement. Readjust the VOLTS/CM switches as above in step e to obtain as large a waveform as possible without exceeding the limits of the vertical graticule scale.

g. To measure DC voltage or the DC component of the waveform of differential signal proceed as described in preceding steps above with the following exceptions:

1. Set the DC/AC input switches of both vertical channels to DC positions (push in to release).

2. Push in GND. switches of both vertical inputs in and adjust channel A and channel B POSITION controls to bring both traces displayed in coincidence with graticule line selected as a zero base line for reference.

3. Release GND. switches of CH.A and CH.B one at a time observing direction of deflection so that polarity of differential voltage can be determined.

## SECTION V

## THEORY OF OPERATION

### 5.1 POWER SUPPLIES AND BLANKING SYSTEM (See Schematic Diagram Fig. 8-1 for Power Supply)

#### 5.1.1 Low Voltage Power Supply

Individual outputs of ±6V, ±24V, +200V and +260V are independently regulated.

#### 5.1.2 High Voltage Power Supply

A full wave doubler and a regulator consisting of Q401, Q402,Q403IC401 produces a regulated −1700V power supply source. The error amplifier IC401 controls the collector voltage of Q401 so that the high voltage (−1700V) is always constant regardless of the normal variation of line voltage.

#### 5.1.3 Blanking Circuit

The grid and the cathode of the CRT are, in essence, biased at the same potential. However, a DC restorer circuit during the re-trace interval produces an additional amount of negative voltage which is applied to the grid of the CRT and reduces the beam current (brightness) to zero. The amount of grid to cathode bias voltage is produced by 20 kHz oscillator, (Q413 and Q414) which is keyed on during the blanking interval.

### 5.2 HORIZONTAL SYSTEM (See Schematic Diagram Fig. 8-2 Horizontal Circuit)

#### 5.2.1 Triggering Circuit

The trigger signal, from the vertical amplifier is processed through comparator IC103 and is compared with a reference level set by VR101. The output of the comparator is inhibited by the sweep gate during the sweeping period. In the absence of triggering signal, the output of the comparator is inhibited by the sweep gate and the output of IC101 is held high so that in the Automatic Mode the sweep generator becomes recurrent.

Unless IC101 receives a trigger signal within approximately one second, its output will be held at a low level, thus disabling the sweep generator from producing a trace. Therefore, in the NORMAL mode, a trigger signal is required for the initiation of a trace.

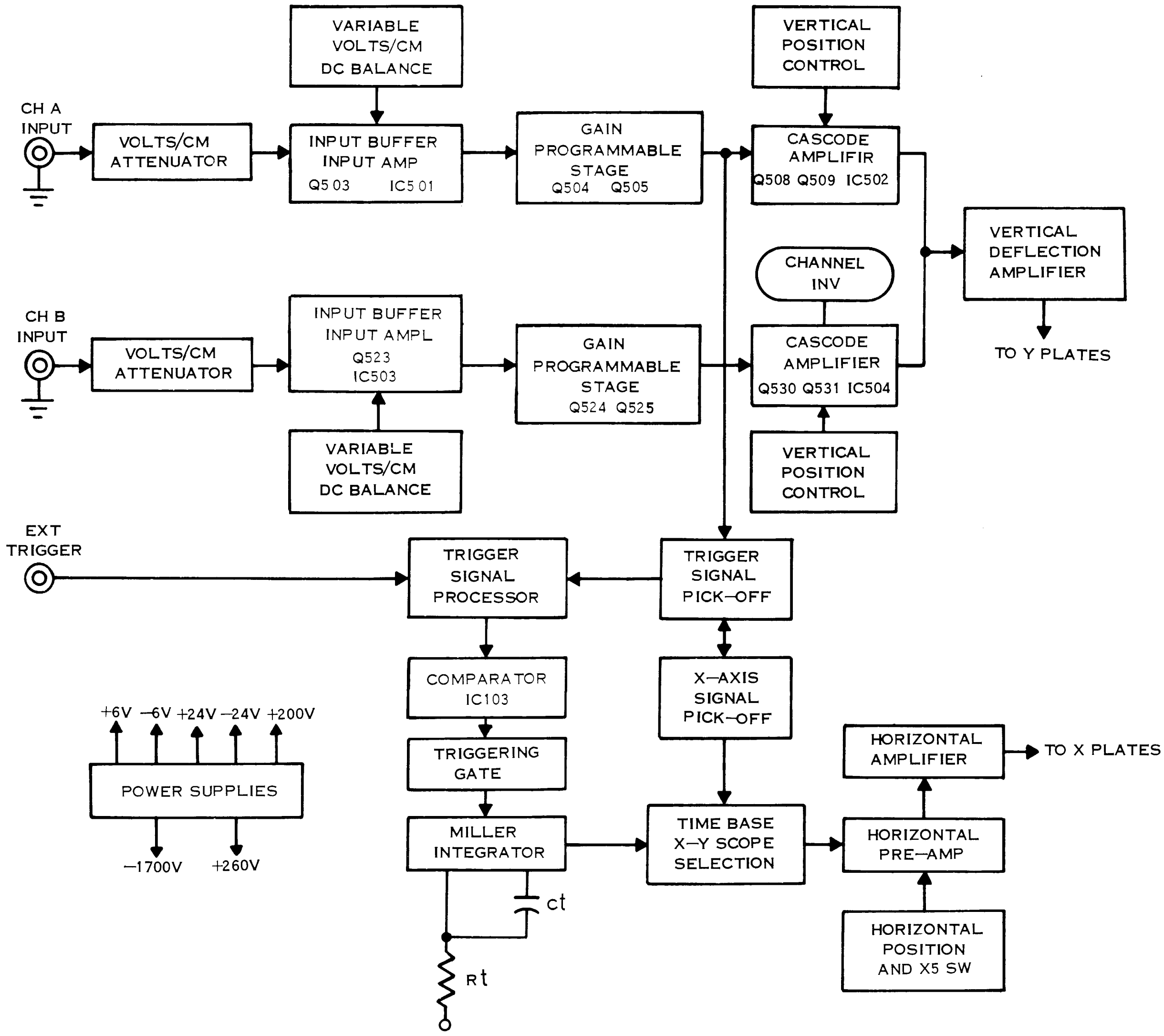



**Figure 5-1. Block Diagram**

### 5.2.2 Sweep Generator

Transistor Q106 through Q110 constitute the sweep generator which is a Miller Integrator. The slope of the sawtooth depends on the position of Time CM switch which switches various time constants, depending on the sweep speed. VR107 controls the height of the sawtooth which is the sweep length. At the termination of the sweep, the output of IC109 triggers IC108, which in turn, cuts-off Q107, thereby producing a rapid charge of the timing capacitor through Q106.

### 5.2.3 Horizontal Amplifier

The horizontal amplifier Q115 through Q125 provides sufficient amplification to deflect the beam horizontally. VR103 is the horizontal position control.

## 5.3 VERTICAL AMPLIFIER (See Schematic Diagram Fig. 8-3 For the Vertical Circuit)

### 5.3.1 Input Attenuation

The VOLTS/CM switches select the proper attenuator and fixed gain position of the vertical amplifier for an input signal from 5mV/cm to 10 V/cm. The input impedance always remains constant at 1 MΩ shunted by 25 pF.

### 5.3.2 Input Source Followers

The dual FETS Q503Q523Q524 maintain a high input impedance and low DC drift. VR501 and VR510 provide DC balance adjustment.

### 5.3.3 Input Amplifiers

IC501 and IC503 are served as input amplifiers with variable gain which is controlled by the Variable Volts/CM switch.

### 5.3.4 Gain Programmable Amplifiers

Transistors Q504,Q505,Q524-5 comprise two variable gain amplifiers that are part of the attenuator. Depending on the setting of the VOLTS/CM switches, three preset positions of 1/2/5 ratio can be selected. VR503 and VR512 provide DC balance adjustment due to the gain change of these stages.

### 5.3.5 Cascode Amplifiers

The emitter followers transistors Q506, Q507 and Q526, Q527 serve as buffers and provide sufficient drive to the inputs of the cascode amplifiers. Q508, Q509, IC502 and Q503, Q531, IC504 constitute the cascode amplifier for CH.A and CH.B respectively. VR507 and VR519 provide the vertical position control. Diodes D509 to D516 are used for amplitude limiting.

## 5.4 CHANNEL SELECTION MODE AND TRANSISTOR SWITCH

**5.4.1** Portions of the integrated circuits IC502 and IC504 are used as transistor switches to provide the following modes:

a. CH.A mode: In this mode, the CH.A switch on the front panel sets the output of IC505A to a high level and IC505B to a low level. This allows the CH.A amplifier to be enabled and CH.B amplifier to be inhibited.

b. CH.B mode: In conjunction with the CH.B switch and IC505A and B, CH.B is enabled and CH.A is inhibited.

c. CH.A ± CH.B Mode: In this mode, both cascode amplifiers of CH.A and CH.B are enabled by the add switch. The subtraction mode is accomplished by reversing the phase of CH.B.

d. Dual channel mode: When both CH.A and CH.B switches are pressed, the outputs of IC505A and IC505B are out of phase and are driven by a 200 kHz oscillator. This allows the two channels to be chopped at the rate of the oscillator for sweep speeds slower than 1 msec/cm. At sweep speeds faster than 1 msec/cm the sweep is automatically changed to the Alternate mode.

### 5.4.2 Output Amplifier

The two-stage differential amplifier consisting of Q511 through Q521 constitutes the vertical amplifier for CH.A and CH.B. VR509 provides the adjustment of operating point, while VR508 provides output centering adjustment. Capacitors C528 through C530, provide high frequency compensation.

### 5.4.3 Trigger Circuit

Depending on the trigger switch selection, transistors Q510 and Q532 constitute the trigger pick-off signal for CH.A and CH.B, respectively. The trigger signal is amplified by transistors Q533 and Q534

### 5.4.4 Horizontal Input

For X-Y vector scope operation, the channel B functions as the horizontal preamplifier. The input signal to the horizontal output amplifier is taken from the differential amplifier consisting of Q528 and Q529.

## SECTION VI

## APPLICATIONS

### 6.1 GENERAL

The complexity of much of today's electronics has made the modern wideband triggered sweep oscilloscope the backbone for the laboratory, manufacturing line and the service shop. There is more need today for the utilization of oscilloscopes with dual trace capabilities than ever before. Model 452 features speed and the capability of observing simultaneous signals that are related in terms of frequency and phase. Several applications utilizing dual trace as well as single trace applications of Model 452 are briefly reviewed here.

### 6.2 MEASUREMENTS OF WAVEFORM TIME RELATIONSHIP IN DIGITAL CIRCUITS

Capabilities for viewing simultaneously two waveforms and availability of calibrated horizontal display time axis makes the dual trace oscilloscope Model 452 an invaluable aid for measurement of digital circuit — frequency time relationships and pulse train propagation times.

Figure 6-1 illustrates the waveform relationships for Simpson Model 7016 frequency counter circuit with block diagram shown in Figure 6-2.

a. To view and compare any two of waveforms shown in Figure 6-1, press vertical mode switch buttons CH.A and CH.B in and adjust all other controls as indicated for viewing dual-trace display in Section IV.

b. Select a desired reference waveform and apply its signal to channel A input. Set TRIGGER SOURCE to CH.A (unless CH.B or EXTERNAL sync. is desired Apply the other signal to be compared to channel B input.

c. Set VOLTS/CM selectors of both channels A and B, the TIME/CM and the TRIGGER SLOPE switches and TRIGGER LEVEL control as required to produce suitable display of vertical amplitude and horizontal spread of the sychronized waveforms.

d. If the exact measurement of the pulse duration, pulse repetition rate (frequency), propagation delay time or any other specific time relationship between waveforms is desired set horizontal VARIABLE control to maximum clockwise CAL position.

   Set the VARIABLE controls of channel A and channel B to CAL. positions also whenever vertical amplitudes of these waveshapes have to be measured.

e. Increase horizontal time axis resolution and accuracy of time interval measurement either by spreading the display pattern with faster TIME/CM sweep setting or magnifier switch setting to X5 MAG. position.

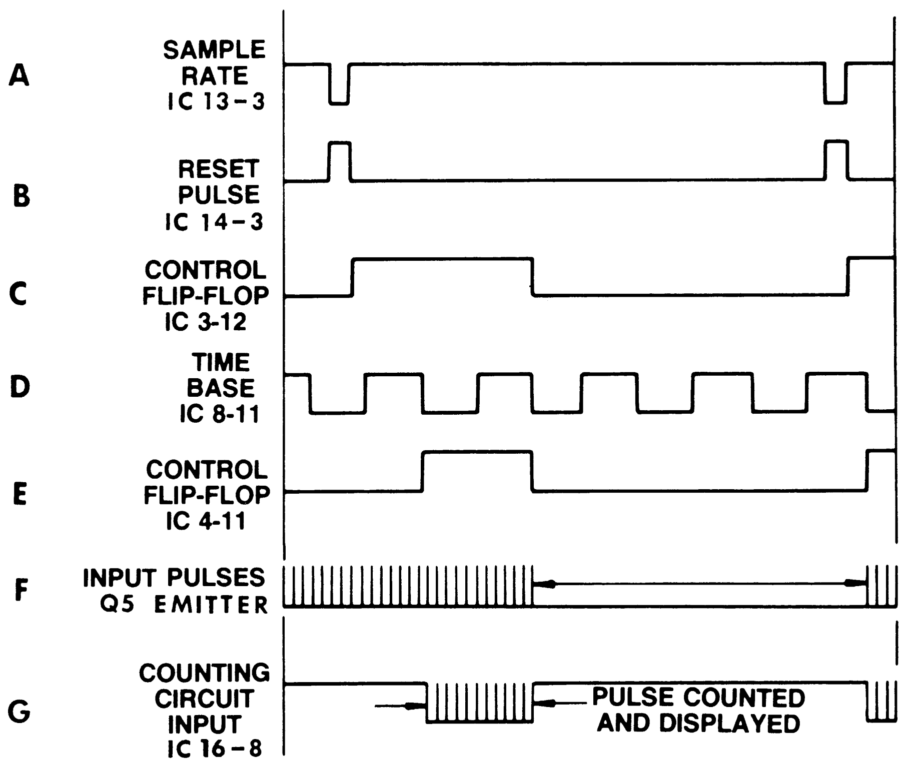



Figure 6-1. Family of Time Related Waveforms Found in Simpson Model 7016

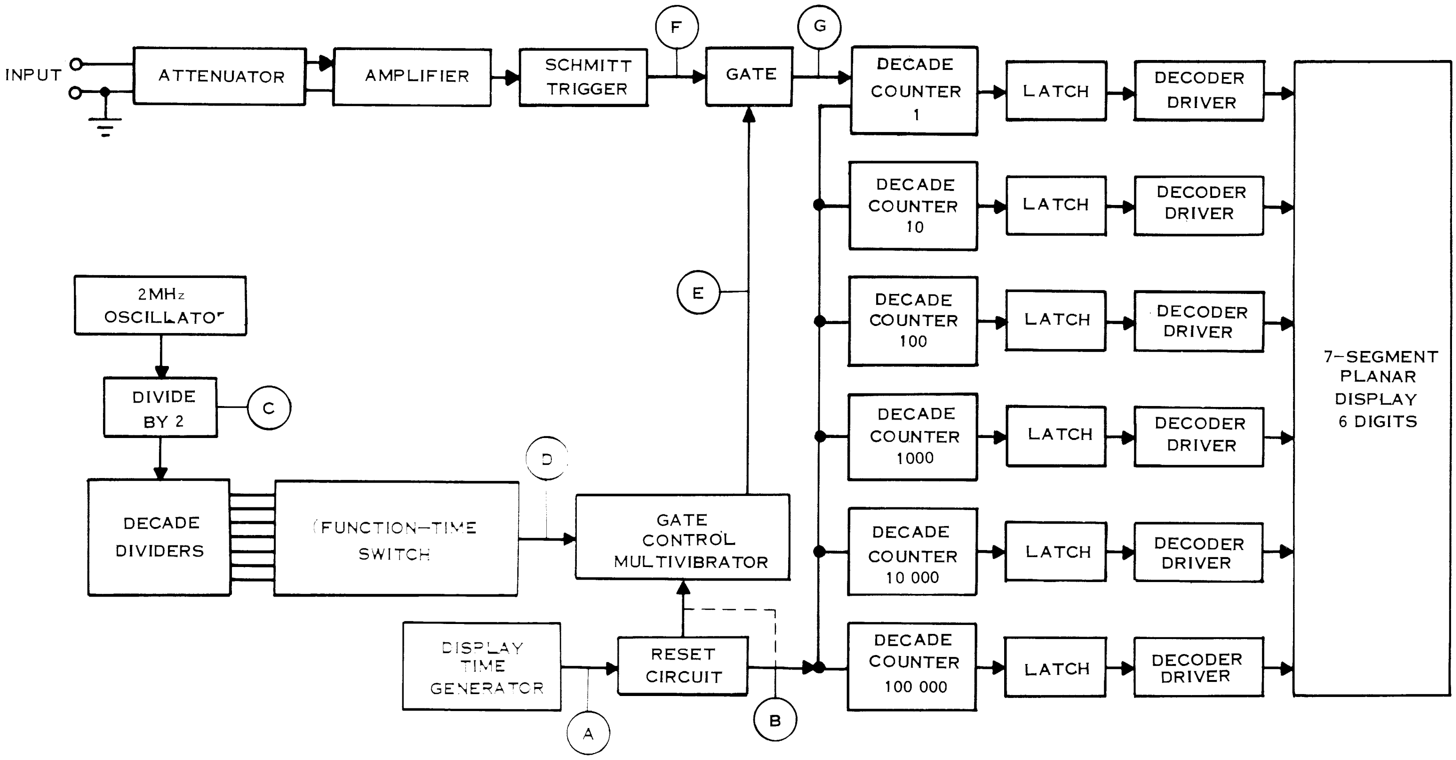



**Figure 6-2. Block Diagram, Frequency Counter-Timer Simpson Model 7016**

## 6.3 PHASE MEASUREMENTS

**6.3.1** Phase measurements by using dual-trace oscilloscope have distinct advantages. The dual-trace method contrary to the X-Y methods can measure phase difference accurately between signals of different amplitudes, frequency multiples and wave shapes. Checking amplifiers for phase shift is described below.

**6.3.2** Figure 6-3 shows the procedure for measuring phase shift between input and output signal of an amplifier consisting of several stages. The waveform at the input and output checked is sine wave of different amplitudes.

a. Preadjust the controls for a horizontal AUTO (automatic) trace display as described under initial control settings, adjustments and waveform observation in Section IV.

b. Set the vertical mode switches for both channel A and channel B operation and set DC AC input switches to AC on both channels.

c. Push TRIGGER SOURCE CH.A button in.

d. Apply the signal from amplifier input to the CH.A input and the signal from amplifier output to the CH.B input.

e. Set the VOLTS/CM switches and adjust VARIABLE and vertical POSITION controls to display the signals of both channels centered vertically within the screen area.

f. Select TIME/CM switch position and adjust TIME/CM VARIABLE and TRIGGER LEVEL controls until still standing waveforms are displayed. Spread the pattern displayed over the screen as much as possible or as desired by adjusting above switch and controls.

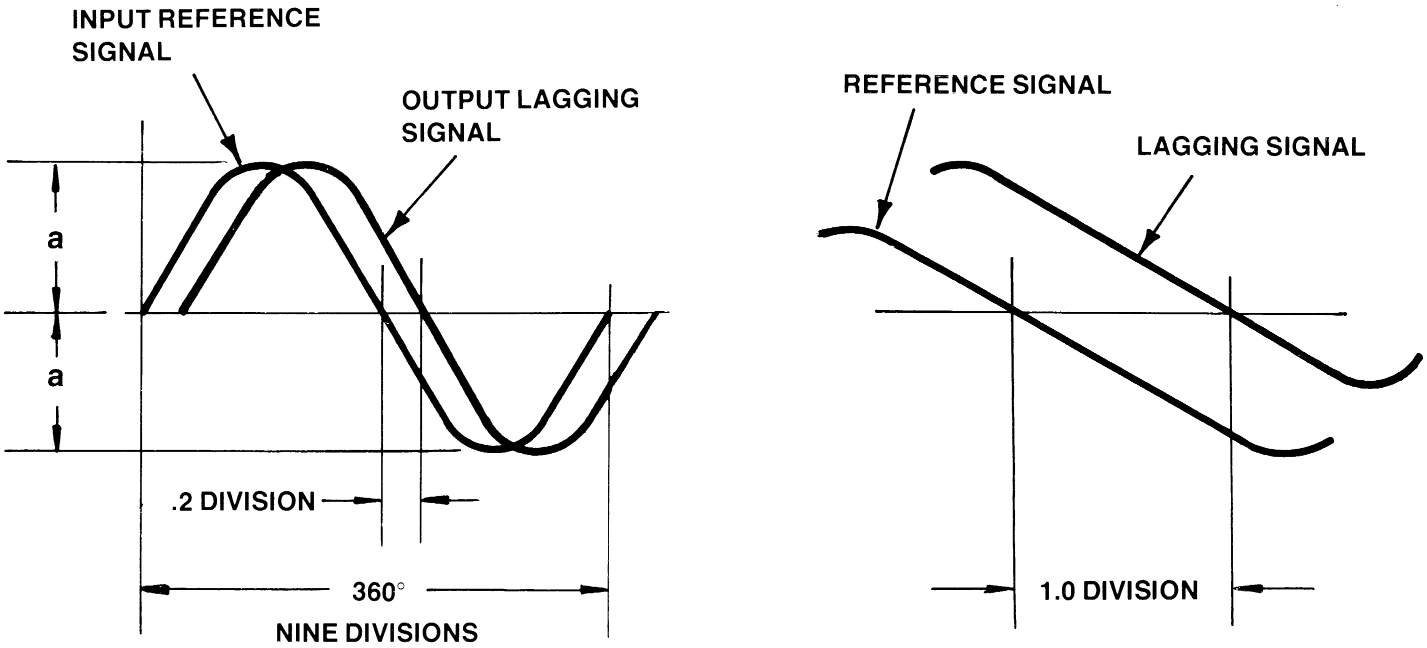
g. Select either of the two signals (input or output), unless otherwise required by specifications, as reference signal. Set CH.A input signal as reference waveform in this example.

h. Adjust sweep VARIABLE control until 1 cycle of the reference signal (CH.A input signal in this case) extends exactly 9 divisions (9cm) horizontally on the screen. This corresponds to the angle of a full cycle (360°). Divide this number by 9 divisions and the result is 40° per division, the factor for our phase shift scale.

i. Measure the horizontal distance in divisions or cm on graticule between the amplifier (Figure A) input and output waveform's corresponding points and multiply the distance by scale factor 40°/Div.

The product obtained will be the amount of phase difference in degrees between the input and output signals.

j. To increase the accuracy of measurement, especially in measuring minor phase differences, pull the sweep speed magnifier outward in X5 MAG. position. Now only a portion (one fifth) of one cycle of the waveform obtained in step h is displayed over nine divisions of the screen horizontally, and the scale factor is one fifth of 40°/Div., i.e. 8°/Div. (see Figure 6-3B).




Phase Difference $= .2 \text{ div.} \dfrac{360^\circ}{9 \text{ div.}} = 8^\circ$

Without sweep magnification (MAG switch in x1 position)

Phase Difference $= 1 \text{ div.} \times \dfrac{360^\circ}{9 \text{ div.} \times 5} = 8^\circ$

Sweep speed magnified by factor 5 (MAG switch in x5 position)

**Figure 6-3. Phase Shift Measurement**

## 6.4 DUAL TRACE APPLICATIONS IN TV SERVICING

The dual trace feature makes the Model 452 Scope ideal for analyzing TV chroma and video circuits. The phase relationships of burst and keying pulser, the matrixed waveforms of a colorcast and the incoming chroma signal, the video and sawteeth signal could be easily analyzed using dual trace display. Among other applications are the comparison of input and output waveforms of a phase shifter, simultaneous display of any two color bar signals and locating circuit intermittents, etc.

## 6.5 SQUARE WAVE TESTING

**6.5.1** One easily stated description of circuit performance is the faithfulness with which a square wave at specified frequency is transferred. The square wave testing method provides an easily applied and duplicated basis of comparing two circuits to determine whether a particular circuit still performs as it was designed to perform.

**6.5.2** A square wave is equivalent to the summation of numerous sine waves; a fundamental component of largest amplitude and odd-order harmonics of ever decreasing amplitude (higher order harmonics). For an idealized square wave, all these component waveforms are exactly in phase; that is, at the instant the fundamental component is passing through zero, all of the harmonics are passing through zero in the same direction.

**6.5.3** Assume the square wave is applied as an input signal to circuit under test and the output is monitored on the Model 452. If the harmonic components do not get through the circuit with their original relative amplitudes, or if the phase relationships among the input frequencies are upset, the appearance of the circuit output signal on the CRT will be distorted from its original squareness.

**6.5.4** A drop-off of response at low frequencies has the effect of imparting a downward slope or droop to the originally horizontal portions of the waveform. Vertical waveform transitions from high to low (and back again) customarily follow an exponential curve. The "risetime" of the circuit under test is the time required for the circuit output signal to go from 10% to 90% of its amplitude change. When resonance prevails in the signal path, the output squarewave might "ring"; that is, the display might show a suggestion of damped oscillation along portion of the wave that were originally horizontal. For example, the square wave response of a circuit might be specified as: 1kHz square wave, with a droop of no greater than 5%, rise time not to exceed 15 micro seconds and 10% maximum overshoot. A very brief test with the Model 452 will disclose whether performance of the circuit is within those specified limits.

**6.5.5** The rise time of the Model 452 is only 24 nanoseconds (0.24 $\mu$ second). This rise time must be taken into consideration only in quite high-speed circuits. At very low frequencies (below 10 Hz), the optional coupling capacitor, at the vertical channel inputs can introduce appreciable droop. In those cases be sure the vertical input switch is in the DC position.

## 6.6 PHASE SHIFT MEASUREMENTS BY X-Y METHOD

**6.6.1** The familiar Lissajous figures are stationary patterns displayed when the vertical and horizontal signal inputs are of fundamental frequencies related to each other by a whole number ratio.

**6.6.2** If the same frequency is applied at the vertical and horizontal inputs, simultaneously the CRT beam traces an ellipse. This ellipse becomes a line which will slant upward to the left for a perfect in-phase condition, and upward to the right for 180 degrees out-of-phase. For intermediate phase relationships, ellipses are displayed. The special case of a circular display results from sine waves of equal deflection amplitudes in a 90° phase relationship.

**6.6.3** To measure the phase shift of sine waves at the same frequency and deflection note the ratio of minor axis to major axis length. The angle of phase shift is twice that angle, the tangent of which is the ratio of width to length of the ellipse, that is $\emptyset = 2 \arctan (a/b)$, where $\emptyset$ is the phase difference in degrees, and a and b are the shorter and longer dimensions of the ellipse, respectively. For example, if the major axis of the ellipse slopes upward to the left and the ellipse is one-fourth as wide as it is long, then the angle which has a tangent of 1:4 is about 14 degrees. The phase shift therefore, is twice 14°, or 28°.

**6.6.4** The Model 452 has been designed and built with a far greater bandwidth in its vertical channels than in its horizontal channel. It is expected that somewhere in the supersonic range the scope will begin to introduce a phase difference between the two (vertical and horizontal) channels. For more accurate measurement use dual trace method described in paragraph 6.3.

**6.6.5** The frequency range for accurate phase shift measurements can be extended by calibrating the particular Instrument. Plot a curve of the scope's phase difference as a function of frequency. Correct your circuit readings accordingly.

## 6.7 STABILITY OF FEEDBACK AMPLIFIERS

**6.7.1** To obtain the superlative performance common in today's high-quality servo-mechanisms and hi-fi audio amplifiers, heavy usage of negative (inverse, or degenerative) feedback is required. Using this technique, a portion of the output voltage of an amplifier is fed back to the input, in proper polarity, to reduce net gain. The advantage of applying feed-back is that the extent of distortion, of whatever nature, that originally occurred throughout most of the passband, will be reduced by approximately that factor by which the voltage amplification is reduced when the feedback is connected.

**6.7.2** The presence of reactive elements (transformers, inductances, and various capacitances, both intended and stray) limit the amount of negative feedback that can be applied without regenerative trouble outside the intended passband. Often, there is some frequency (or frequencies) at which the phase shift around the overall loop will support oscillation. Oscillation will occur if the "gain" around the broken loop is at least unity at that frequency. Damped (transient) oscillations can occur, under signal conditions, if the loop gain is slightly less than one and if the phase requirement for sustained oscillation is almost satisfied.

**6.7.3** The avoidance of oscillation, either sustained or damped, plus the general desirability of knowing what safety factors prevail necessitate measurement with the proper instruments. The Model 452 can be very useful in this kind of measurement, especially when using dual trace method described in paragraph 6.3.

**6.7.4** Adequate safety margins for gain and phase stabilities are about 6 dB and 30°, respectively. To avoid spurious oscillations under signal conditions, limit the open-circuit loop again to no more than one half (6 dB down) the value that would result in sustained oscillations. For any frequency at which the open circuit loop gain exceeds unity, make sure the overall phase shift (around the open loop) differs by at least 30° from the in-phase condition that would produce oscillation, were the feedback loop actually closed. Since these measurements are made with the feedback disconnected, the feedback source and load impedances of the intended complete feedback loops must be simulated.

## 6.8 TUNING FOR MAXIMUM OR NULL

**6.8.1** The Model 452 may be used for tuning frequency selective circuitry. When tuning a filter or selective amplifier, the oscilloscope serves as a highly sensitive detector and also informs the user of whether the correct frequency component is being maximized or minimized. In the absence of this waveform indication, one can easily be misled by the presence of electrical noise (or a strong harmonic signal) and tune the circuit improperly.

**6.8.2** Equipment for measuring harmonic distortion usually involves measuring what remains when the fundamental frequency component has been nulled. By monitoring the null network with the Model 452, the nulling process can be simplified by observing the nature of the distortion products.

**6.8.3** The oscilloscope is excellent as a null indicator when balancing an impedance bridge (used for inductance of capacitance measurements). The CRT is a more flexible indicator than a simple meter. It permits the user to achieve a sharper null more quickly. The bridge nulls only the fundamental frequency of the test voltage, leaving the harmonics to cloud the issue. Usually, the harmonics originate in the bridge generator and the difficulty can be lessened by using a harmonic-free signal source. When measuring iron or ferrite core indicators, the nonlinearity of the sample can contribute harmonics in the bridge output. Use external sync. derived directly from the bridge signal source. You can easily follow your progress in nulling the fundamental component thereby bringing the bridge into proper balance.

## 6.9 TIME OR FREQUENCY MEASUREMENT

The measurement of frequency and time are closely related since frequency is the reciprocal of time (F = 1/T). With the highly stable and accurate horizontal sweep generator the Model 452, it is easy to measure the time duration of a given waveform. After the time for one cycle is known, the frequency can be readily obtained as follows:

a. Adjust the TRIGGER LEVEL and TIME/CM switches to display one or two complete cycles. Be sure the TIME/CM VARIABLE control is in the CAL. position.

b. Count the number of cm (left to right) from the start of the first waveform to the start of the second.

c. Multiply the number of cm by the sweep TIME/CM switch setting. This gives you the period of this waveform (or portion of interest) and reciprocal of it is the frequency.

NOTE: If the TIME/CM VARIABLE switch is in the X5 MAG. position, remember to divide the time by 5.

## 6.10 TV SERVICING

**6.10.1** The modern oscilloscope is invaluable for proper servicing and alignment of television receivers. The Model 452 is excellent for measuring signal levels, analyzing various signal waveforms, signal tracing and alignment of the many tuned circuits. This section is intended as a guide for some of the more common servicing procedures. Waveforms, test points, and procedures will vary with sets from different manufacturers and at times for sets by the same manufacturer. The first and most important step in television servicing is to obtain the manufacturers test procedure for the set. Otherwise, it is only a guess as to whether a given waveform or procedure is correct.

**6.10.2** The amplitude and shapes of signal waveforms throughout the TV circuits are the best indications of normal operation or where trouble is occurring. The sensitivities of the Model 452's vertical channels permits making virtually all needed TV measurements. A recommended accessory is the Low-Capacitance Probe, with its low 11 pF total capacitance when connected to Model 452. When the Low-Capacitance Probe is used, take into account that the actual signal voltage is 10 times that displayed on the CRT and control settings on the Instrument. The regular shielded input cables to be found in shops has about 90 pF capacitance and may interfere with normal operation of some TV circuits. Often an isolation resistor can be used to minimize the effect of this capacitance.

**6.10.3** While the description presented here is typical of standard television sets, it must be realized that minor departures prevail among various manufacturer's equipment. Signal shapes are primarily determined by the output of related test equipment or of a transmitted composite signal. Refer to the manufacturer's service data for representative signal amplitudes. The signal amplitude usually is quoted on a peak-to-peak basis, and usually without regard to a DC component that often is present. Ordinarily, keep the input DC/AC pushbutton switch in the AC position.

**WARNING**

**Be especially cautious when servicing strange equipment; a small AC signal might be riding on DC voltage of lethal proportions. Also do not exceed the input voltage ratings of the Model 452 (see maximum input voltage ratings in Table 1-1) and those of shielded cable or the10 : 1 Low Capacitance accessory probe used.**

## 6.11 ANALYZING TV COMPOSITE VIDEO WAVEFORM

**6.11.1** The composite video waveform is a combination of the video signal, blanking pedestals and synchronization pulses. Representative oscillograms of composite signals are shown in Figure 6-4. Naturally the display details differ depending on whether the scope's horizontal sweep is synchronized at the TV vertical or horizontal blanking rate.

a. For vertical: Set the sweep TIME/CM selector to TVV. Set the trigger mode to NORM. and adjust TRIGGER LEVEL for a stable display. When noise prevents this, use external line frequency sync. The display will move slowly due to the slight frequency difference between the local power line frequency and the vertical sync. rate established at the TV station.

b. For horizontal: Set the sweep TIME/CM selector to THH, internal CH.A. or CH.B trigger SOURCE and either AUTO or NORM. trigger MODES.

**6.11.2** When servicing any complex piece of electronic equipment, take the time to observe what waveforms prevail throughout a set known to be in good operating condition. It would be still better to compare the waveforms with data from the manufacturer for the particular set being worked.

**6.11.3** To set-up a composite waveform display, proceed as follows:

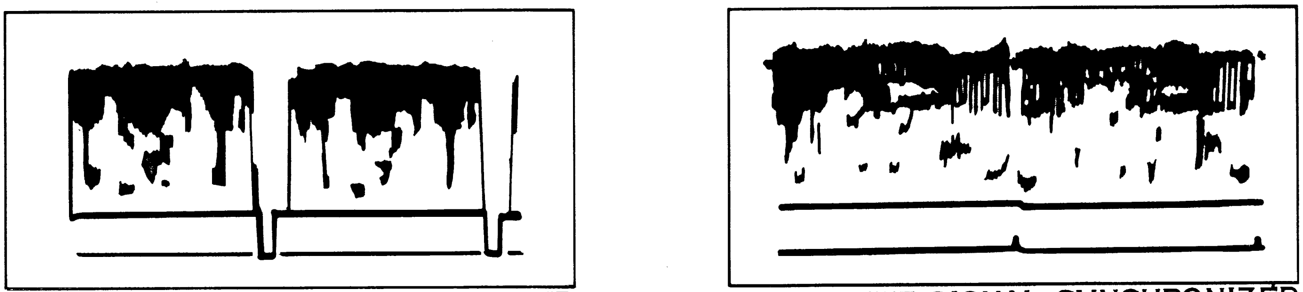
a. Tune in a strong TV signal. Finding a station broadcasting a stationary test pattern is helpful, but a satisfactory display can be set-up when using regular TV program material.

b. Turn the INTENSITY control clockwise to give a suitable bright trace. Adjust FOCUS control for minimum trace width. Set trigger MODE, SLOPE. and SOURCE switches to AUTO, +, and CH.A or CH.B channel sync. depending on which vertical channel is used.

c. Connect accessory Low-Capacitance Probe to vertical CH.A or CH.B input connector.

d. Connect ground clip of probe to chassis of TV set.

e. Connect the signal tip of probe to grid terminal on socket of TV picture tube.



COMPOSITE SIGNAL SYNCHRONIZED AT HORIZONTAL BLANKING RATE

COMPOSITE SIGNAL SYNCHRONIZED AT VERTICAL BLANKING RATE

Figure 6-4. **Representative Oscillograms of Composite Signals**

f. Set the Model 452 VOLTS/CM switch to .5 position.

g. To read vertical amplitude correctly, vertical gain VARIABLE control must be in CAL. position; however, to merely observe nature of waveform, adjust VARIABLE control for desired display height.

h. To synchronize at horizontal sweep rate, set sweep TIME/CM switch to TVH position; if desired, adjust sweep TIME/CM VARIABLE control for expansion to less than two horizontal line periods. There are times when a better sweep synchronization can be obtained by selecting "–" instead of "–" on trigger SLOPE switch or trigger LEVEL control.

i. To synchronize at vertical sweep rate on composite signal, set sweep TIME/CM switch to TVV position. When it becomes desireable to obtain complete signal independent sync., feed vertical sync. signal from TV set into EXT. trigger jack and switch to EXT. trigger SOURCE.

j. Typical composite signals for black-and-white TV are shown in Figure 6-4. Only synchronization pulses will show any resemblance of standing still on the display. The portion of the display which resembles electrical noise is the video signal. It continually varies and virtually never maintains at fixed appearance.

k. Figure 6-5 shows typical color TV signals. The color-burst is situated immediately to the right of the sync. pulse. When a color bar generator is used, the composite display resembles that of Figure 6-6.

l. Figure 6-7 shows variations possible in the shape of the sync. pulse when signal overload (or a biasing problem) prevails. Normally, the sync. pulse exceeds pedestal height by about 50%, as indicated in Figure 6-7A. If limiting occurs in the positive direction, clipping (sometimes referred to as "compression") occurs, as in Figure 6-7B. If limiting (or overload) occurs, in the opposite polarity, the sync. pulse proportions are changed as shown in Figure 6-7C.

m. Inspection of the shape of the horizontal sync. pulse is a quick way to appraise the overall alignment of RF and IF circuits. Figure 6-8 indicates the correlation between a sync. pulse shape and frequency response of the tuned circuits. Figure 6-8 also provides a brief description of the likely effect upon picture quality.

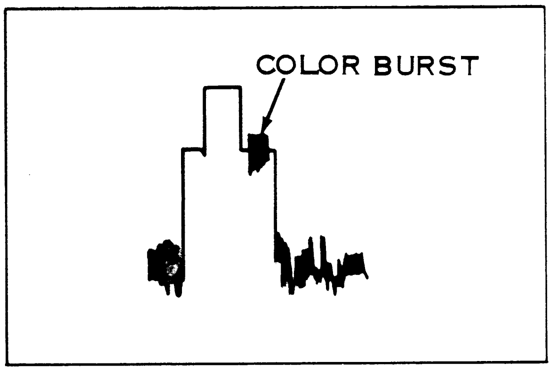



**Figure 6-5. Color-Burst Shows to Right of Sync. Pulse**

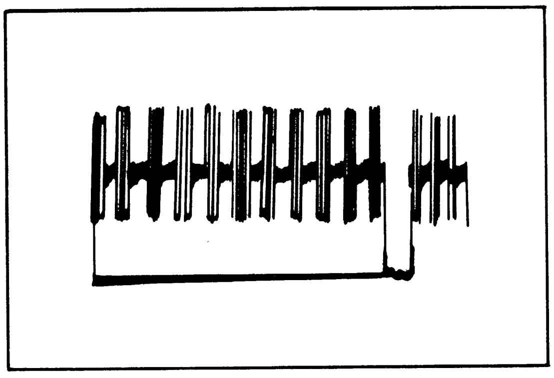


**Figure 6-6. Typical Output From Color-Bar Generator**

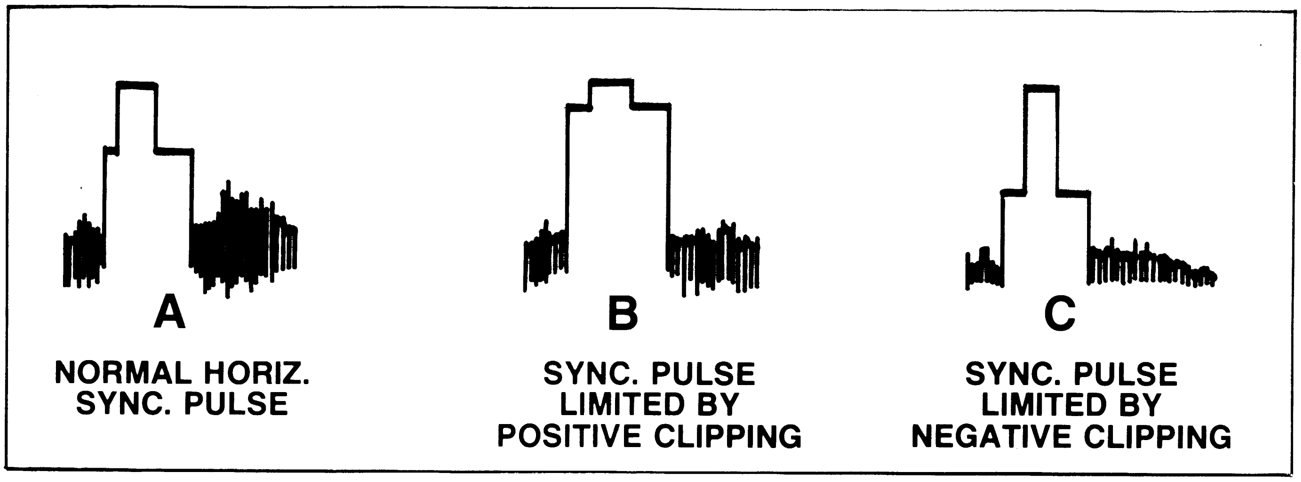



Figure 6-7. Sync. Pulse Supression

| CIRCUIT ALIGNMENT SITUATION | SHAPE OF HORIZONTAL SYNC PULSE | OVERALL FREQ. RESPONSE OF RECEIVER | EFFECT ON PICTURE |
|---|---|---|---|
| NORMAL | | | NORMAL PICTURE |
| HIGH—FREQUENCY LOSS | | | PICTURE BLURRED LOSS OF DETAIL |
| HIGH—FREQUENCY BUMP OR BOOST | | | VERTICAL SHADOWS OR GHOSTS APPEAR TO RIGHT OF SHARP DETAILS IN PICTURE |
| LOW—FREQUENCY LOSS OR ROLL—OFF | | PICTURE CARRIER SOUND CARRIER | NON—UNIFORM SHADING OF LARGE PICTURE AREAS |

Figure 6-8. Sync. Pulse and Frequency Response Waveforms

## 6.12 ALIGNING TV TUNED CIRCUITS

NOTE: If the Low-Capacitance Probe is used, compensation must be checked. See paragraph 4.8 and 4.9 for test and calibration procedures.

**6.12.1** The need for aligning a TV set can come from several common causes. Among these are drift due to aging of components, replacement of components and replacement of tubes. Sometimes the problem is merely maladjustment of accessible controls by someone who is not qualified or who does not have proper equipment.

**6.12.2** The following information applies to aligning the tuner ("front end"), I-F and subsequent detector circuits. While the basic principles are common among TV sets; it is always necessary to have the manufacturer's service procedures available for the particular set. You will save much time in evaluating the signals at the test points.

## 6.13 ALIGNING A TUNER

Proceed as follows:

a. Connect output of sweep generator to antenna terminals on the TV set.

b. Connect ground clip of scope's accessory Low-Capacitance Probe to metal frame or shield of TV tuner.

c. Most of the time, hum interference can be reduced by making the probe ground as close as possible to the test signal pickup point. Usually service instructions include the signal in the mixer grid circuit, where a demodulated signal is present. The signal level at this point is only a small fraction of a volt peak-to-peak, so the scope must be operated at a high gain and without Low-Capacitance probe, to avoid X10 attenuation of the signal. Therefore, the input capacitance of the overall scope and probe substituted cable might be much higher. To avoid upsetting the tuner by the scope cable connection, use a series 1/2-watt carbon resistor of about 10k ohms as isolation of the cable capacitance. If the resistor connections are not kept short, there might be so much hum pick-up that it becomes impossible to obtain a clear trace.

**WARNING**

**Even though tuner RF signal levels are low, there could be dangerous DC voltages present.**

d. One advantage of high vertical sensitivity of the Model 452 is that the sweep generator can be operated at a low enough level so as not to overload the tuner circuits. Such overload could prevent obtaining a true picture of the circuit alignment. On the other hand, with too little signal input, hum and noise can become very troublesome.

e. When using a sweep generator, apply an RF test signal to the tuner input. The signal frequencies sweeps periodically across the channel being aligned. The marker generator places a marker ("pip") on the trace at the instant the sweep generator frequency passes through a calibrated value. The oscilloscope monitors the instantaneous amplitude of the signal that comes through the input tuned circuits.

f. Figure 6-9 shows a typical "front end" frequency response obtained during sweep frequency measurement. The somewhat saddle-backed shape is typical of slightly over-coupled tuned circuits, and of properly adjusted stagger-tuned channels. Become familiar with setting up such a display on a TV set known to be good. Only with the technique perfected can one be fairly sure that an improper display is the fault of the set. A minor departure usually can be remedied by tuning adjustments. A major departure might also indicate a loose connection in the tuner, or possibly the need to find and replace a faulty component.

NOTE: Sweep generators and marker generators are set-up in various ways, according to their particular characteristics. Sometimes the functions are combined into one package. Follow the manufacturer's recommendations.

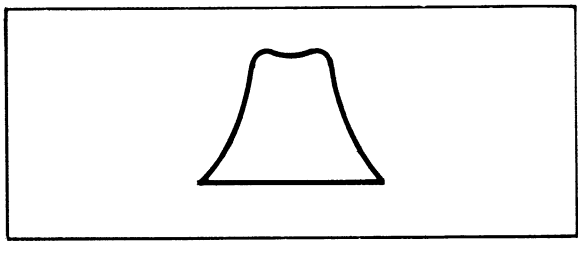


**Figure 6-9. Typical Appearance of Detected Output with Sweep Generation Input**

## 6.14 ALIGNING PICTURE I-F CIRCUITS

Proceed as follows:

a. When a good signal is present at the mixer, examine the frequency response of the I-F (Intermediate Frequency) portion of the set. Pick up the signal with the Low-Capacitance Probe (or use the shielded cable with isolating resistor).

b. Use the load resistor of the video detector as a test point. Sometimes the test point is located at the input of the first video stage.

c. To minimize the influence of hum pick-up, connect the ground clip of the scope probe to a ground point near the signal test point on the set. Since the signal will be larger here than at the tuner, a 10:1 Low-Capacitance probe can be used to reduce circuit loading and still achieve sufficient heights of the displayed wave amplitude.

NOTE: With all R-F of I-F measurements, proper impedance matching (per manufacturer's recommendation) is preferable. If possible, use a connector similar to that used for interconnection in the set.

d. Follow manufacturer's instructions for adjusting the bias level of the I-F amplifier. The signal from the sweep generator is quite unlike the signal that the set's AGC (Automatic Gain Control) was designed to accommodate. AGC must be disabled during sweep frequency alignment. The service instructions might include applying a fixed bias from an external battery. Sometimes the set manufacturer will recommend temporary wiring changes with the TV set.

e. Except for less vertical gain and bandwidth being required, display of I-F frequency response is similar to that obtained at the mixer. The indicating bandwidth will usually be substantially less.

NOTE: Be sure the output of the sweep generator is kept low to avoid overloading the video detector.

## 6.15 ALIGNING THE SOUND I-F CIRCUITS

TV Sound is transmitted via frequency modulation, for which the detector is either (usually) a discriminator or a ratio detector. Proceed as follows:

a. Connect a probe using a 10k ohm isolation resistor to output of sound detector.

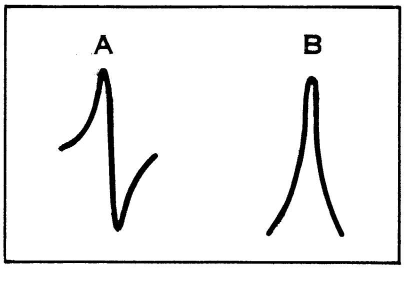



**Figure 6-10. Ratio Detector and Sound I-F Response Curves**

b. Connect sweep and marker generators to receiver as directed in set manufacturers instruction. Figure 6-10A shows the nature of the response curve which will be displayed. Faithful sound reproduction requires that the central slope of the curve be essentially a straight line.

c. A curve, similar to that shown in Figure 6-10B, will be obtained if the probe is connected to the grid return of the limiter stage.

## 6.16 ALIGNING COLOR TV AFPC CIRCUITS

With proper adjustment of the AFPC (Automatic Frequency and Phase Control) circuits, the hue (tint) control of a color TV can accommodate all the hue variations present in the transmitted picture. When all controls are adjusted properly, the hue control will not affect intensity. Color sync. will hold even on weak signals, and color balance will not be upset as luminance is varied.

## 6.17 VECTOR DISPLAY OPERATION

The vector display operation of the Model 452 is a good way to check and adjust the chroma section in color television receivers. A color bar/pattern generator is required to simulate the composite video signal. Because of the sensitivity of the Model 452, the vector pattern can be traced from the demodulators, through the amplifiers, and to the guns of the color tube. Normally the vector pattern is obtained at the guns of the color tube as follows (refer to Vector Pattern Display, Figure 6-11):

a. Connect color bar/pattern generator to antenna terminals and adjust pattern on television set, following instruction manual of particular color bar generator.

b. Set HORIZ. (CH.B) switch for horizontal input position.

c. Connect Low-Capacitance accessory probe from vertical input CH.A of scope to red gun of color tube.

d. Connect a shielded test lead from the CH.B (horizontal input) of scope, through a 2.2 megohm resistor to blue gun of color tube. Also connect test lead shield to chassis.

NOTE: Limit the signal input to the Horizontal amplifier to 5 volts peak-to-peak. A 2.2 megohm resistor in series with the input lead to the scope will attenuate the signal and provide isolation. Connect a capacitor of about 10 pF across the resistor to frequency compensate this external attenuator.

e. Turn on television set and adjust Model 452 horizontal and vertical (CH.B and CH.A) VARIABLE gain controls for a round pattern perimeter. Refer to Figure 6-12.

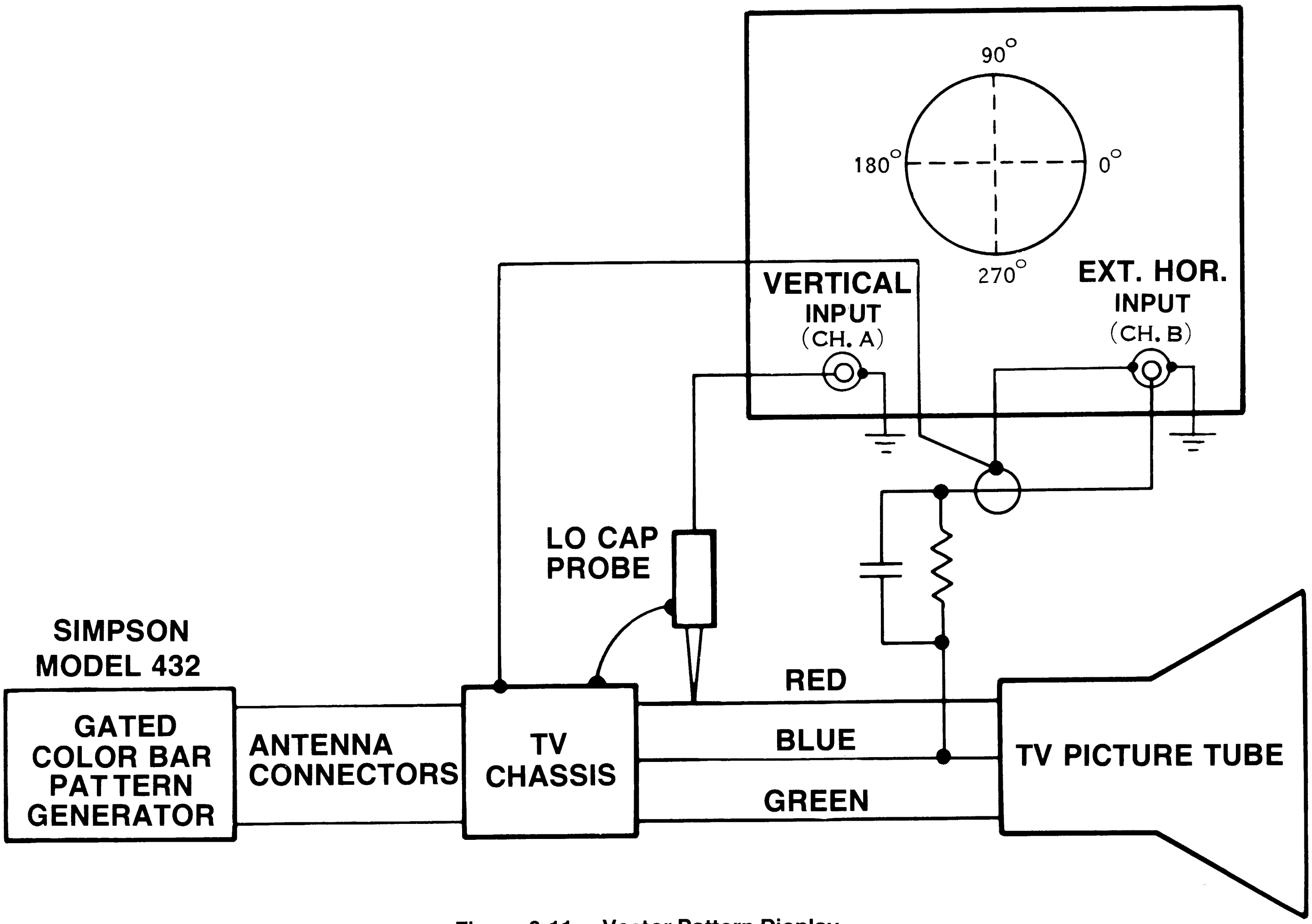



Figure 6-11. Vector Pattern Display

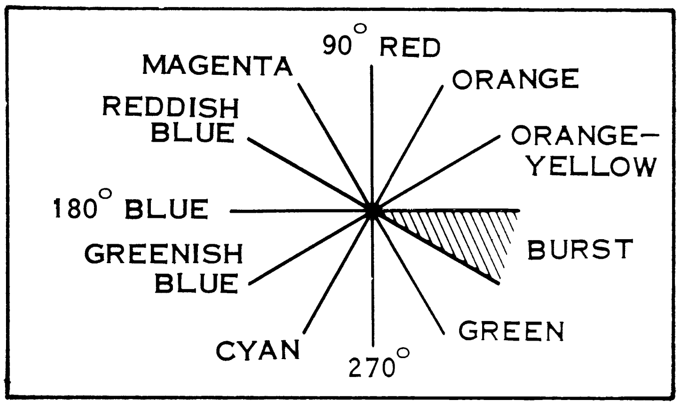



**Figure 6-12. Vector Pattern Analysis**

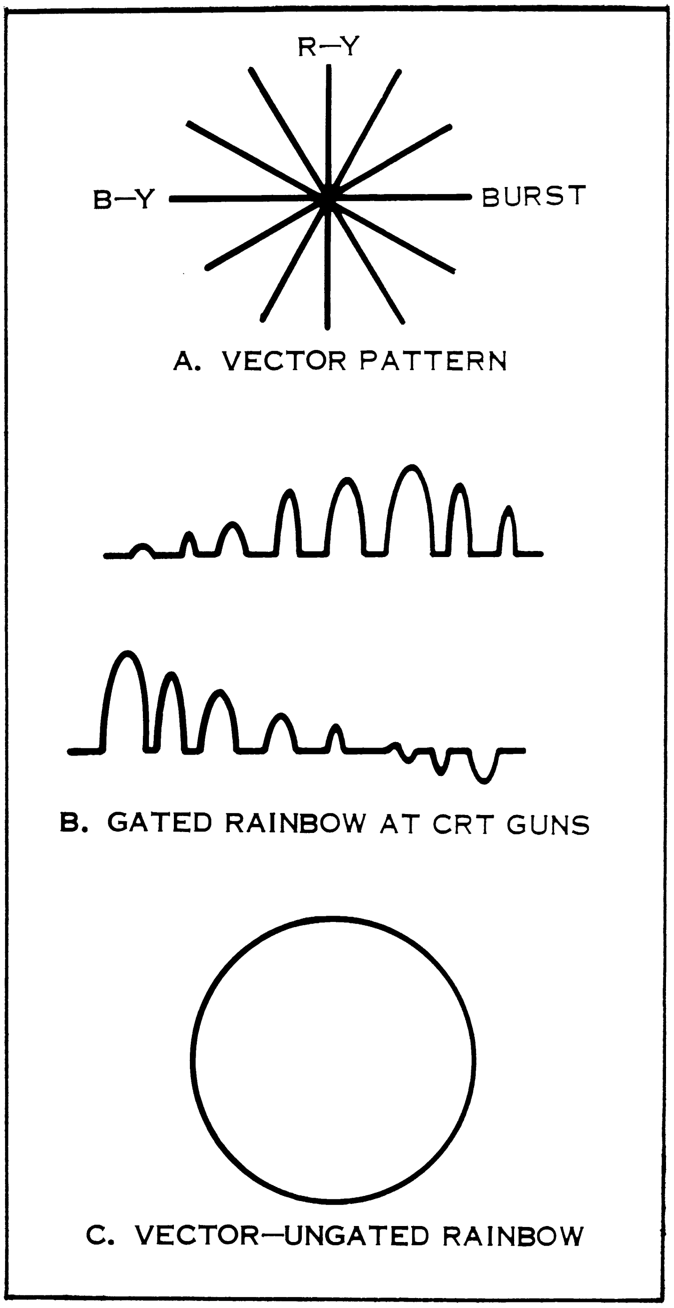



**Figure 6-13. Vector and Gun Displays**

f. Adjust hue control of television set to mid-position. The third red color bar (from burst), normally appears at 90° straight up. The sixth bar (blue) usually will appear somewhere between 180° and 210°.

## 6.18 VECTOR PATTERN ANALYSIS

**6.18.1** At the present time, very few manufacturers provide vector pattern information. They show the waveshape and voltage at each gun of the color tube. A typical representation of this information is shown in Figure 6-13B (vector pattern 6-13A). The R-Y and B-Y waveforms differ in phase by about 90° and if the envelope (assume a continuous pair of waveforms rather than gated waveforms) alone was supplied to the Model 452, a circular vector pattern would be formed as in Figure 6-13C. This is the pattern you would see with a pure rainbow color generator. With a gated rainbow pattern generator each pulse will bring the trace to the edge of the circle and then drop back to the center during the blanked portion, giving a flower petal effect.

**6.18.2** The idealized pattern most often shown rarely occurs on an actual television set. The reason is that intentional phase angle distortion is introduced in the demodulator to improve the flesh tones and to simplify tuning. This distortion moves the sixth color bar from its idealized 180° position to somewhere near 210°. The effect is to make the vector pattern slightly elliptical. When using the oscilloscope for most of your TV servicing, the best "teacher" is looking at the critical patterns in a set which is known to be properly adjusted.

## 6.19 VERTICAL INTERVAL TEST SIGNAL (VITS)

**6.19.1** The VITS is incorporated in the composite video of most network color broadcasts to help insure invariant high quality of the transmitted color picture. A part of this signal can be used for rapid analysis of color set performance. This is the multi-burst portion of VITS (see Figure 6-14). The multi-burst, as broadcast, consists of a white level signal followed by short bursts of frequencies from .5 MHz to 4.2 MHz, all of which are equal in amplitude. By looking at these bursts of frequencies at the video output of a TV set, it can be readily seen if the amplifiers and other circuits from the RF input are responding properly (see Figure 6-15).

**6.19.2** If the bursts, monitored at a video output test point, are not of equal amplitude, the signal should be checked at the video detector. If they are still unequal, the TV channel should be changed and the bursts rechecked. By doing this, the distortion can be traced to the RF or IF stages. If the bursts are still unequal on a different channel, the I-F amplifier probably needs alignment. If they are equal, the R-F tuner needs alignment.

**6.19.3** The VITS is difficult to display on an oscilloscope because it occurs twice per frame (1/30 seconds) and only lasts for 2 line intervals (125 $\mu$ seconds, see

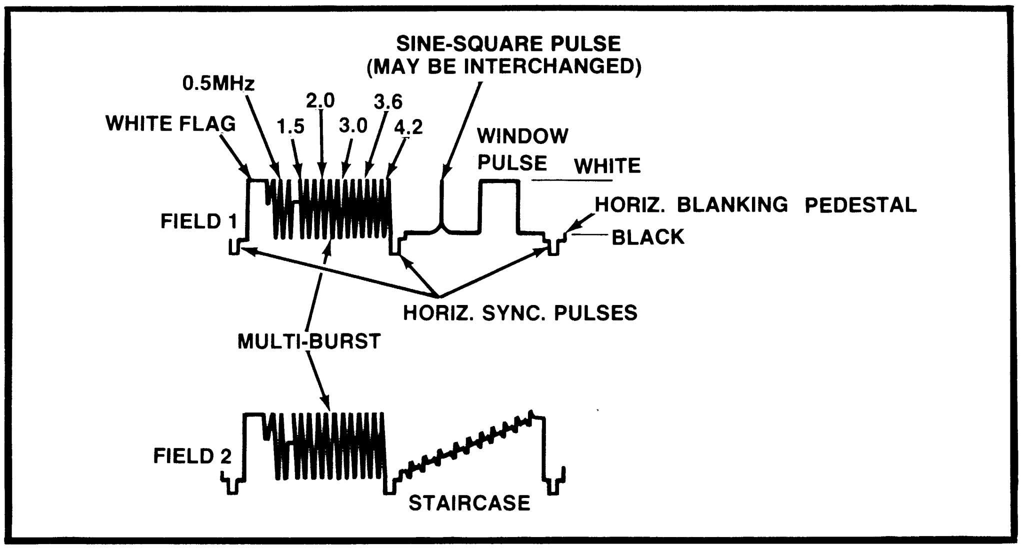



Figure 6-14. Standard Vertical Test Signal Waveform

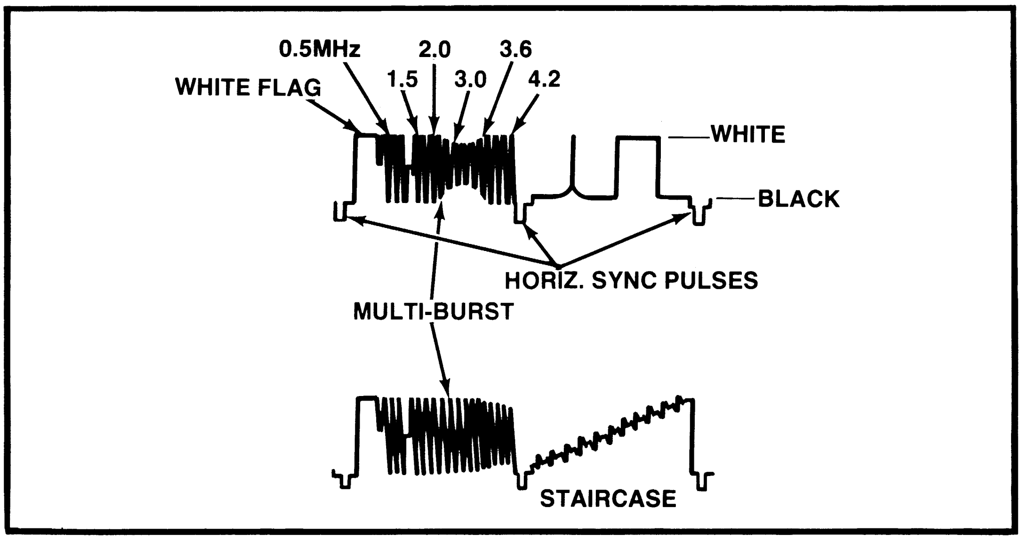



Figure 6-15. Distortion in Multi-Burst Waveform

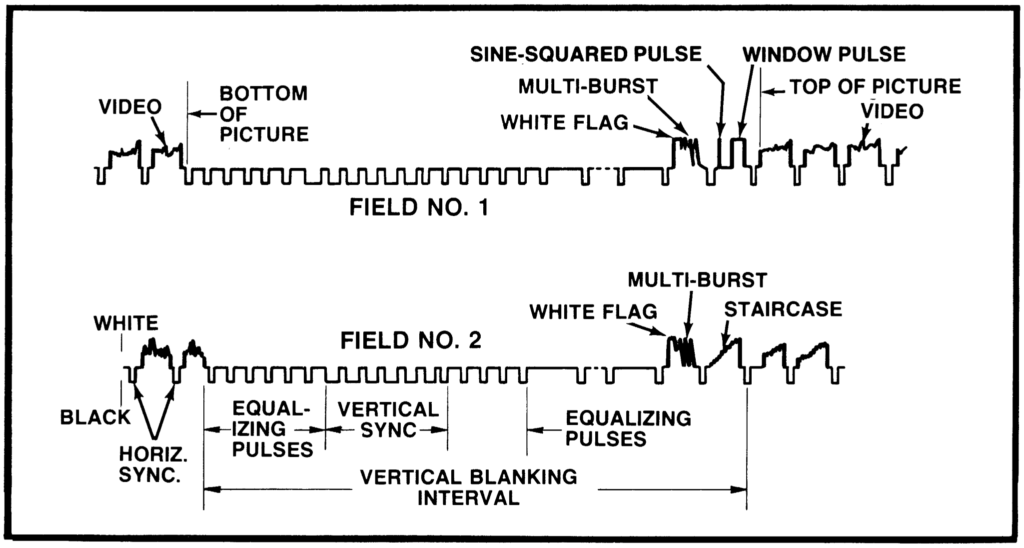



Figure 6-16. Vertical Blanking Interval Showing VITS Signal

Figure 6-16). It does not begin simultaneously with the vertical sync. pulse but occurs on lines 17 and 279. The trace brightness will be quite low because of the low display rate and because the X5 magnifier must be used to display the VITS 17 lines after occurrence of the vertical sync. pulse. Therefore, a scope hood or paper tube wrapped around the CRT bezel to achieve higher trace control is recommended for viewing the screen.

**6.19.4** The following procedure is to be followed for test set up for VITS:

a. Set sweep TIME/CM control to VITS and VARIABLE to CAL.

b. Depress X5 MAG. switch to X1 position.

c. Connect Low-Capacitance Probe, (be sure it has been adjusted for a square wave), from the Model 452 to TV video output. When the probe is connected, the TV set picture should not be affected. If the picture is affected, try to isolate the probe further by inserting a 10kΩ resistor, parallel with a 1.5 pF capacitor in series with the probe tip.

d. Connect a 0.005 μF capacitor from TV vertical sync. or composite sync. to EXT. trigger jack of Model 452. The composite sync. is located at the sync. separator. The vertical sync. can be picked up from the vertical output transformer at the input of the convergence circuit. A signal of .5V p-p to 100 V p-p is usable when applied to the EXT. trigger jack.

e. Set trigger MODE, SLOPE and SOURCE switches to NORM., +, EXT.

f. Adjust trigger LEVEL control to sync. on equalizing pulses as shown in Figure 6-16 and observe VITS on right side of screen.

g. Set magnifier switch to X5 MAG. position and adjust position controls to center VITS waveform on screen.

NOTE: In some TV sets, it will be necessary to disable the TV vertical blanking to properly sync. on the VITS.

## 6.20 ALIGNING AM RECEIVERS

**6.20.1** As with all superheterodyne receivers, whether TV, FM or AM, the overall shape and width of the passband is determined by the tuning of the I-F (Intermediate Frequency) portion of the system. The principles applied in aligning AM sets are similar to those for TV and FM. The differences are mainly the much lower frequencies and narrower bandwidths involved in a broadcast AM receiver.

**6.20.2** The sweep-generator/marker-generator method, in conjunction with a good oscilloscope like the Model 452, is the fastest and most effective method to use. The only simple alternative is alignment using a tunable signal generator and output indicator, combined with either mental calculations or a point-by plotting of frequency response. With sweep-generator/marker-generator method, not only is the present situation immediately apparent, but you can instantly see the effects of whatever adjustment you make.

**6.20.3** As with TV alignment, the set manufacturer's data is highly valuable in supplying critical frequencies and where the most useful test points are located on the chassis. Do not merely "peak up" the I-F amplifier response. Undue emphasis on gain alone, or on bandwidth alone cannot give optimum performance for either speech or music reception. Also, the center frequency of the I-F passband must be properly adjusted; otherwise it might be impossible to get the RF (front end) circuits to function over the full dial-calibrated frequency range of the set.

## 6.21 ALIGNING FM RECEIVERS

The sweep-generator/marker-generator method, vital to rapid TV servicing, has been a longtime favorite in FM servicing, too. The major practical distinction from TV alignment is that both tuner and I-F selectivity are notably less for FM. Otherwise, follow the guidelines of paragraphs 6.10 through 6.11. To the critical ear, the potential of FM for high-fidelity transmission is severly undermined by improper set alignment.

NOTE: Refer to the set manufacturers data for recommended frequency setting and test points. With common acceptance of FM mulitplex stereo and the new 4-channel systems, the importance of proper FM alignment has become even greater than before.

## SECTION VII

## MAINTENANCE

### 7.1 GENERAL

**WARNING**

**The Model 452 uses high internal voltages which constitute a SHOCK HAZARD (refer to page iv). For service or repair beyond the instructions contained in this manual, send the Instrument to a Simpson Authorized Service Center. These Centers are listed on the last pages of this manual.**

The Simpson Model 452 is carefully designed and constructed with high quality components. By using reasonable care and following the instructions in this manual, the Instrument can be expected to provide a long and useful service life.

### 7.2 WARRANTY

The Simpson Electric Company warranty policy is printed on the inside back cover of this manual. Read it carefully prior to requesting a warranty repair.

NOTE: For assistance of any kind, including help with the Instrument under warranty, contact the nearest Authorized Service Center listed on the last pages of this manual or contact the Factory Service Manager. Give full details of the difficulty and include the model and serial number of the unit and date of purchase. Shipping instructions will be promptly sent to you. If an estimate of charges for non-warranty work or other service work is required, a firm quote estimate will be furnished upon receipt of the unit. Service work will not be performed without customer approval.

### 7.3 SHIPPING

Pack the Instrument carefully, and ship prepaid to the proper destination. Insure the shipment.

### 7.4 CHANGING AC LINE VOLTAGE REQUIREMENTS

**WARNING**

**Remove all input power and connections to the Model 452 prior to removing the case cover, before changing the line voltage connections to the power transformer or replacing the fuse.**

The procedure for changing the AC line voltage provision of the Model 452 is as follows:

a. Remove case cover.

b. Interchange connections to the power transformer as shown in Figure 7-1.

c. Mark Instrument legibly (on the front and back case to indicate that the line voltage rating of the Instrument has been changed from its original marked value.

d. Replace pilot light resistor R1 — Use 68kΩ ±5%, 1/2 watt resistor for 220 or 240 VAC operation. Use 33kΩ ±5%, 1/2 watt resistor for 120 VAC operation.

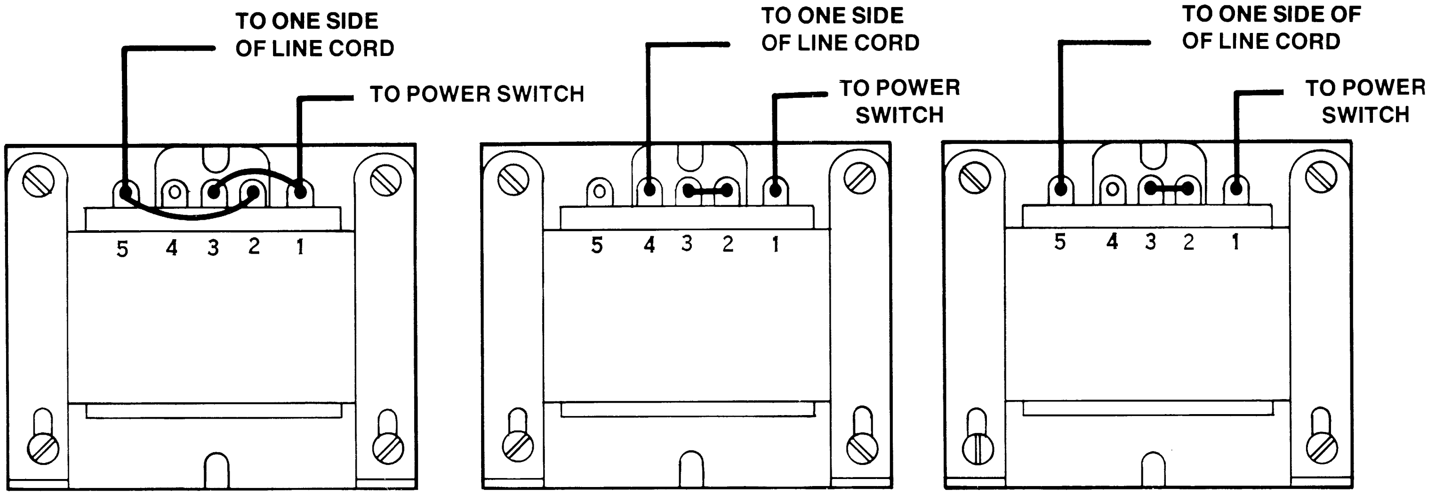
e. Be sure to change fuse appropriately (see paragraph 7.5 below).

### 7.5 FUSE REPLACEMENT

To replace the power line fuse proceed as follows:

a. Locate the fuse holder (see Figure 3-2). Fuse ratings are shown in Section 8, Table 8-1 and in Section 1, Table 1-1.

b. Replace defective fuse with one of equal rating.




TRANSFORMER WIRING FOR 120 VAC 50/60 Hz OPERATION

NOTE: USE 2 AMP 125 V 3AG SLO-BLO FUSE.

TRANSFORMER WIRING FOR 220 VAC 50/60 Hz OPERATION

NOTE: USE 1 AMP 250 V 3AG SLO-BLO FUSE.

TRANSFORMER WIRING FOR 240 VAC 50/60 Hz OPERATION

NOTE: USE 1 AMP 250 V 3AG SLO-BLO FUSE.

**Figure 7-1. Connections for Different Primary Voltages**

## 7.6 VERTICAL DC BALANCE ADJUSTMENT

With no DC input signal applied, rotate the variable gain control of a vertical channel to be checked through its rotation range. If the horizontal sweep trace display observed shifts up or down on the screen, the vertical DC BALANCE adjustment is required.

The following balance adjustment procedure is suggested:

a. Push vertical mode switch CH.A in (push switch CH.B in when balance of channel B is to be checked or adjusted).

b. Push in the vertical input GND switch of the channel to be balanced.

c. Set VOLTS/CM switch to .005 position.

d. Set trigger MODE switch to AUTO and push sweep magnifier switch X5 MAG. in to normal X1 position.

e. Set sweep TIME/CM switch to .1 mSEC.

f. Rotate vertical VARIABLE control to extreme counter clockwise position and set vertical and horizontal POSITION controls to center the trace displayed. Align the trace with a horizontal graticule for reference.

g. Adjust INTENSITY and FOCUS controls for sharp, medium brightness trace.

h. Rotate vertical VARIABLE control from counterclockwise to extreme clockwise "CAL." position.

i. If the trace moves more than ¼ of subdivision (.5mm) on the screen graticule, adjust DC BALANCE control to bring the trace back to the initial reference vertical center position.

j. Rotate vertical VARIABLE control to extreme counterclockwise position and readjust vertical POSITION control to bring the trace back to initial reference center position.

k. Repeat steps h, i, and j until the maximum trace shift is less than .5mm.

NOTE: DC BALANCE controls of either CH.A or CH.B are accessible from front panel side (see item 6 and item 16 in Figure 3-1). Use insulated 3/32″ wide blade tool for this adjustment.

## 7.7 PREVENTIVE MAINTENANCE

### 7.7.1 Daily Care

The Model 452 Oscilloscope is a reliable instrument, and requires very little maintenance. Daily care of the Instrument basically consists of the following:

a. Turn off power and disconnect any power and signal leads, etc. Immediately clean all spilled materials from the Instrument and wipe it dry. If the spillage is corrosive, remove the spillage and use a suitable chemical to neutralize the corrosive action. Then clean the Instrument and wipe it dry.

b. Whenever, possible, avoid prolonged exposure or usage of the Instrument in areas which are subject to temperature and humidity extremes, vibration or mechanical shock, dust or corrosive fumes, or strong electrical or electromagnetic interferences.

### 7.7.2 Monthly Care

Verify Instrument calibration by performing operational checks using known, accurate, stable sources. If the need for re-calibration is indicated, contact your nearest Simpson Authorized Service Center (refer to list on last pages of this manual).

### 7.7.3 Annual Care

It is recommended that the Instrument be returned annually to your nearest Simpson Authorized Service Center or the factory for complete overall check, adjustment, and calibration.

### 7.7.4 STORAGE

When the Instrument is not in use, store it in an area free from temperature extremes, dust or corrosive fumes, and mechanical vibration or shock.