CATHODE-RAY OSCILLOSCOPE
TYPE RM16

INSTRUCTION MANUAL

TEKTRONIX, INC.
MANUFACTURERS OF CATHODE-RAY AND VIDEO TEST INSTRUMENTS

Sunset Highway and Barnes Road • P. O. Box 831 • Portland 7, Oregon, U. S. A.
Phone: CYpress 2-2611 • Cables: Tektronix

Type RM16 **SERIAL NUMBER** ________

PREFACE

We have tried to provide you with the best instrument we can. In doing this we sometimes make changes in our products after the instruction manuals have been printed. Many changes are made to give you the benefit of the latest circuit improvements developed in our engineering department, and to accommodate improved components as they become available. Our Test and Calibration Engineers sometimes hand tailor the circuits to provide optimum individual performance.

When a particular instrument is changed in any manner, its manual is corrected accordingly. This is why the instrument serial number is written on the title page of the manual. If you need repair parts for an instrument, refer to the manual that belongs to the particular instrument.

This manual begins with a list of Spectifications, so that you will know the characteristics of your instrument. The second section of the manual contains installation instructions and information on connecting the primary of the power transformer for various input voltages. The third section relates to Getting Acquainted with your instrument. This section gives you some of the principal ways in which you can operate your instrument, and shows you in detail the effects of operating the various controls. Then the section on Operation Instructions provides the information in the previous Getting Acquainted section condensed for ready reference. This section also describes additional operations. Next is the Circuit Description section, where the instrument is described both in a simplified block-diagram manner and in a detailed form. The Maintenance and Recalibration sections are last. Here you will find valuable information on trouble-shooting and repairing your instrument and on carrying out a recalibration of the instrument, if necessary, in the field.

We hope you will find your instruction manual useful. Refer to it often. We welcome comments on this manual.

Tektronix, Inc.

Field Information Dept.

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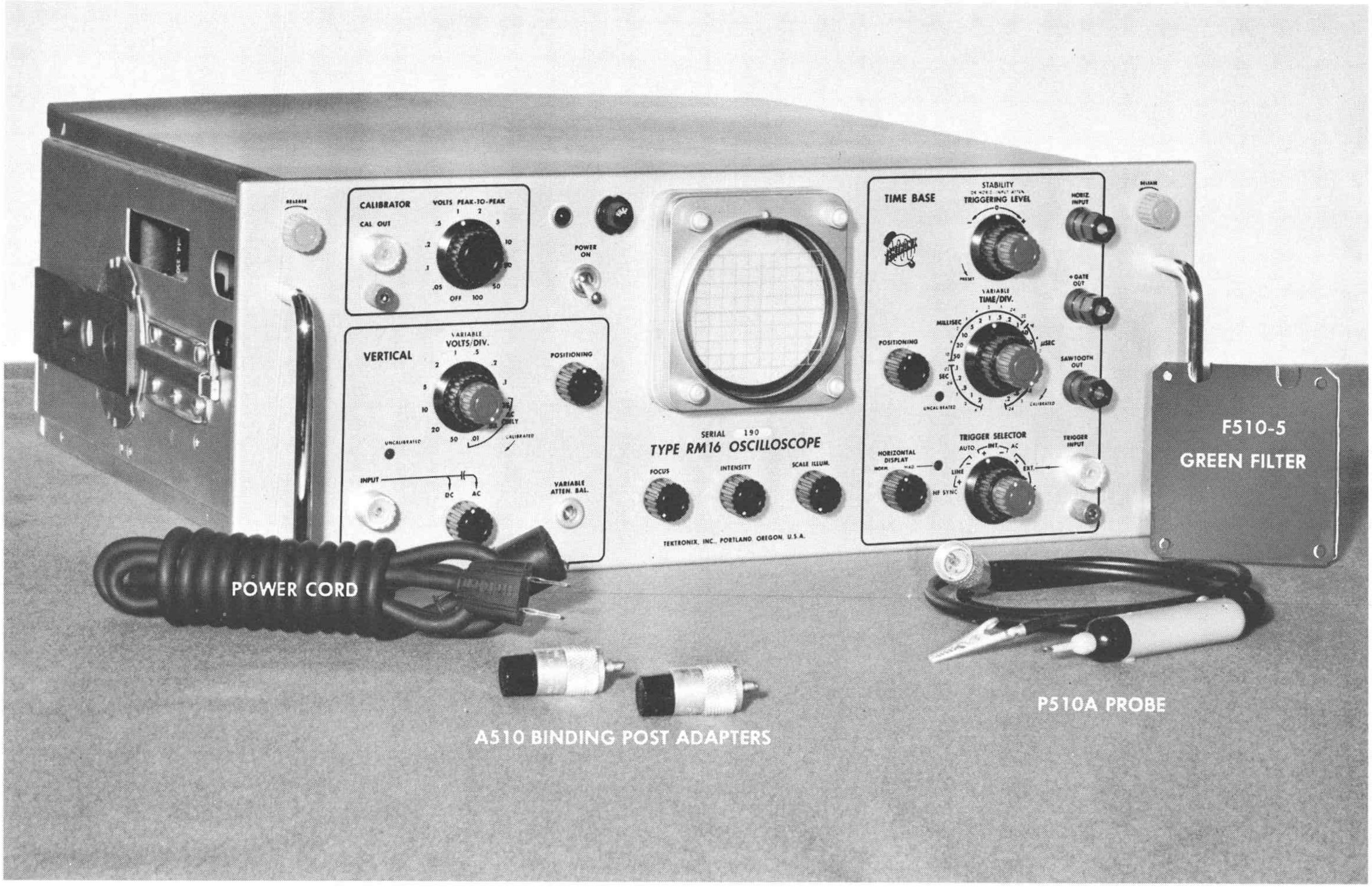


Fig. 1. TYPE RM16 OSCILLOSCOPE WITH ACCESSORIES.

SPECIFICATIONS

The Type RM16 Oscilloscope is a compact, rack-mounting, general purpose oscilloscope. The electrical specifications of the Type RM16 are identical with those of the Type 316 Oscilloscope. The dc-coupled amplifier and wide range of sweep rates, combined with small physical size, make the RM16 a versatile laboratory instrument.

VERTICAL-DEFLECTION SYSTEM

Input characteristics

Direct connection—1 megohm, 38 μμfd.
With P510A Probe—10 megohm, 13 μμfd.

Deflection factor

Twelve-position switch provides calibrated deflection factors from .1 v/div to 50 v/div, dc coupled, and from .01 v/div to 50 v/div, ac coupled, accurate within 3%.

Continuously variable deflection factors are available from .01 v/div to 125 v/div.

Frequency response

.1 v/div to 50 v/div:

DC coupled—dc to 10 mc.
AC coupled—2 cps to 10 mc (.2 cps to 10 mc when a Type P510A Attenuator Probe is used.)

.01 v/div to .05 v/div:

2 cps to 10 mc (1.3 cps to 10 mc when a Type P510A Attenuator Probe is used.)

Risetime

.035 microseconds.

HORIZONTAL-DEFLECTION SYSTEM

Sweep rates

Twenty-two-position switch provides calibrated sweep rates from 2 sec/div to .2 μsec/div.
Accuracy typically within 1% of full scale; in all cases, within 3% of full scale.
Continuously variable sweep rates are avail- from 6 sec/div to .2 μsec/div.

Magnifier

Expands sweep 5 times to the right and left of the crt-screen center. Extends the fastest sweep rate to .04 μsec/div. Accurate within 5%.

Unblanking

DC coupled

Triggering signal requirements

Internal—.2 major graticule division.

External—.2 v to 10 v, peak-to-peak.

Frequency range—dc to 15 mc.

Synchronizing frequency range

5 mc to 15 mc.

Horizontal input

Deflection factor—approx. 1.3 v/div.

Frequency response—dc to 500 kc.

OTHER CHARACTERISTICS

Cathode-ray tube

Type T31P2—P1, P7 and P11 phosphors optional.

Accelerating potential—1,850 volts.

Deflection factor at plates:

Vertical—9 v/div (36 v/in).

Horizontal—approx. 16.5 v/div (66 v/in).

Voltage calibrator

Square-wave output at approximately 1 kc.

Eleven fixed voltages from .05 volts to 100 volts, peak-to-peak.

Accuracy: ±3%.

Output waveforms available

Positive gate of same duration as sweep, 30 volts. Positive-going sweep sawtooth, 150 volts.

Power requirements

Line voltage—105 to 125, or 210 to 250 v, 50-60 cycles.

Power—260 w at 117 v line voltage.

Mechanical specifications

Mounting—steel slide arms mounted on central pivot. Fingertip release of pivot allows chassis to be locked in any of seven positions after it has been slid clear of rack.

Ventilation—filtered, forced-air.

Finish—photoetched, anodized panel.

Dimensions—19" wide, 7" high, 20" deep.

Weight—38 pounds.

Accessories included

1—P510A Probe.

2—A510 binding-post adapter.

1—F510-5 green filter.

1—Power Cord

1—Instruction Manual

INSTALLATION INSTRUCTIONS

REQUIREMENTS

Power

Unless tagged otherwise, this oscilloscope is connected at the factory for 117-volt operation. If you want to operate your oscilloscope using an input voltage other than 117 volts use the information given in Figure 2-1

The regulated power supplies of the Type RM16 will operate with line voltages from 105 to 125 volts, or from 210 to 250 volts. For maximum dependability and long tube life the voltage should be near the center of this range.

The power cord for the Type RM16 must be of sufficient length to allow the instrument to rotate freely when it is extended from the relay rack. Figure 2-2 shows the dimensions you must consider when providing the power cord.

Cooling

A fan maintains safe operating temperature in the Type RM16 Oscilloscope by circulating air through a filter and over the rectifiers and other components. The instrument must therefore be placed so that the air intake is not blocked. The air filter must be kept clean to permit adequate air circulation. If the interior temperature does rise too high for some reason, a thermal cutout switch will disconnect the power and keep it disconnected until the temperature drops to a safe value.

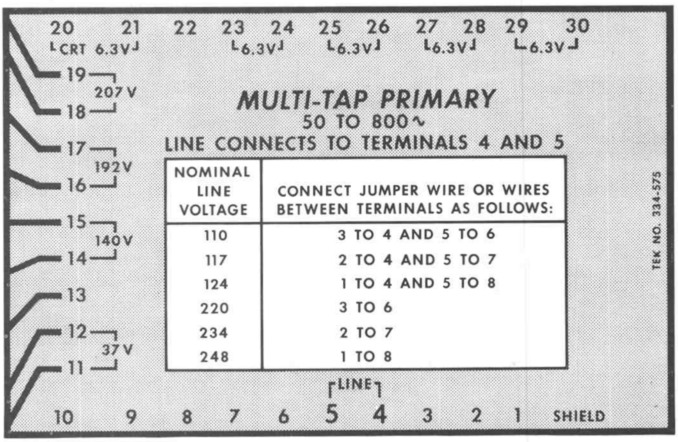


Fig. 2-1. Power transformer primary connection table. The table on the power transformer bottom plate lists the possible input voltages and their corresponding connections.

INSTALLATION

Enclosed Relay-Rack Mounting

To mount the RM16 in an enclosed relay rack:

1. Mark the point on the relay rack where you want to position the top of the front panel. Mark a second position 3¼ inches below this point. The center of the top mounting screw should fall on the second mark.

2. Using two 8-32 screws for each bar nut, fasten an 8-32 bar nut to the mounting holes. The top screw will go in the hole found in Step 1, and the bottom screw will go through a mounting hole approximately 1¾ inches below the first.

NOTE

In some cases it may be necessary to enlarge the mounting holes in the relay rack rails slightly to permit the mounting screws to turn freely.

3. Slip the front lip of the Chassis-Trak between the cabinet and the bar nut as shown in Figure 2-3A

4. Tighten the 8-32 screws so that the Chassis-Trak is held securely to the rail of the relay rack.

5. In some types of cabinets, you may need the extension brackets furnished with the Chassis-Traks. Figure **2-3A** shows you how to assemble the extension brackets furnished with each set of tracks.

6. Slide the Type RM16 into the Chassis-Trak slides. Pull the instrument out and push it back into the slides several times. If the slide mechanism seems to work stiffly, loosen all screws slightly and allow the Chassis-Traks to adjust to the weight of the instrument. When the slide mechanism is working smoothly retighten all screws.

Open Relay-Rack Mounting

To mount the Type RM16 in an open relay rack:

1. Bolt the rear of the Chassis-Trak to the rear of the corresponding cradle section using the 8-32 nuts and bolts provided as shown in Figure **2-3B**

2. Mark a point on the relay rack where you want to position the top of the front panel. Mark a second position 2 inches below this point. The center of the top mounting screw should fall at this point.

3. Using Figure 2-4 as a guide, assemble the cradle and Chassis-Trak on the corresponding rails of the relay rack, allowing 2 inches between the center of the top mounting screw and the position you selected for the top of the RM16 front panel.

4. Fasten the brace across the rear of the cradle assembly, making sure that it is mounted on the bottom of the cradle sides.

5. Place the Type RM16 in the Chassis-Trak slides as shown in Figure 2-4. Operate the slide mechanism several times with the instrument installed. If the operation of the slides is not smooth, loosen all the bolts and allow the slide mechanism to adjust to the weight of the instrument. Be sure to retighten all bolts after the mounting has been adjusted.

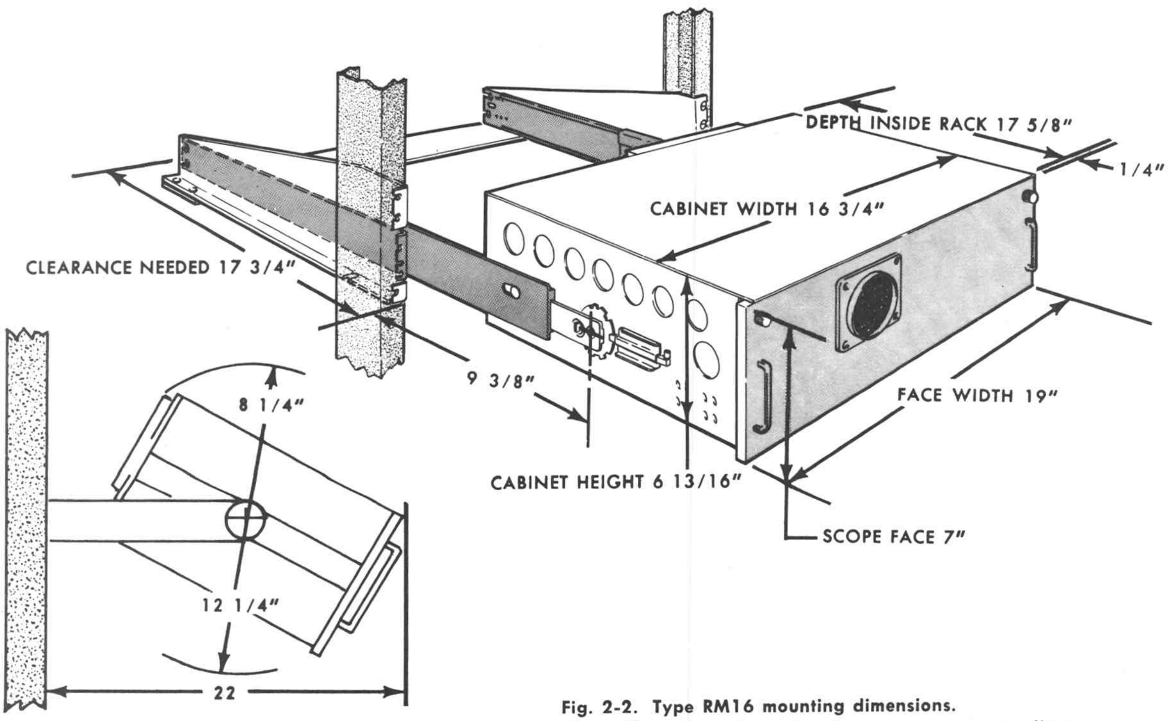


Fig. 2-2. Type RM16 mounting dimensions.
These dimensions determine the space you must allow for the installation of your RM16.

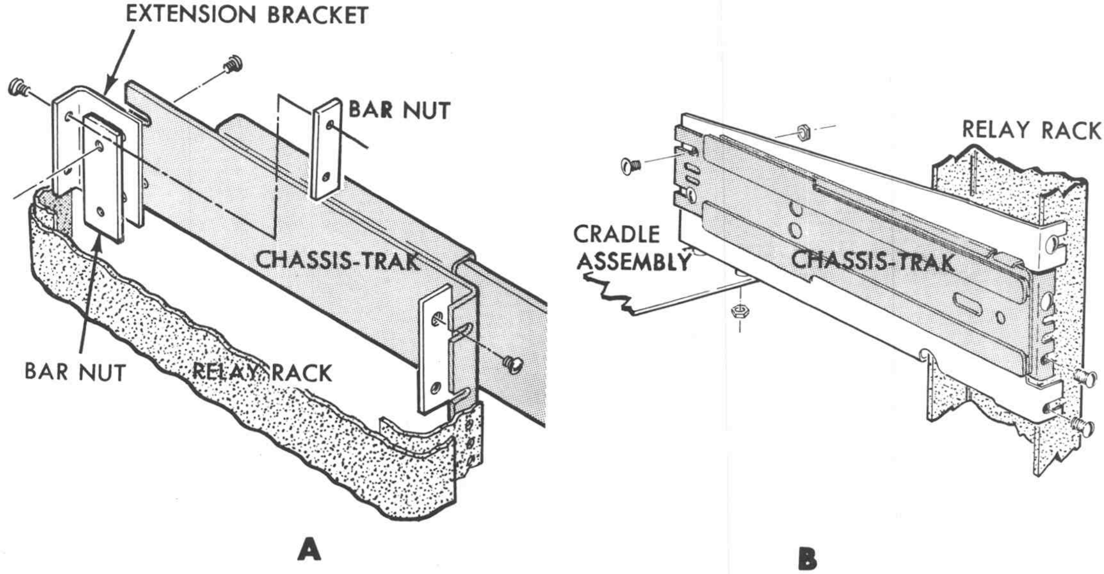


Fig. 2-3. Mounting the Chassis-Trak slides.
(A) The Chassis-Trak installed in an enclosed relay rack. (B) The Chassis-Trak installed in an open relay rack.

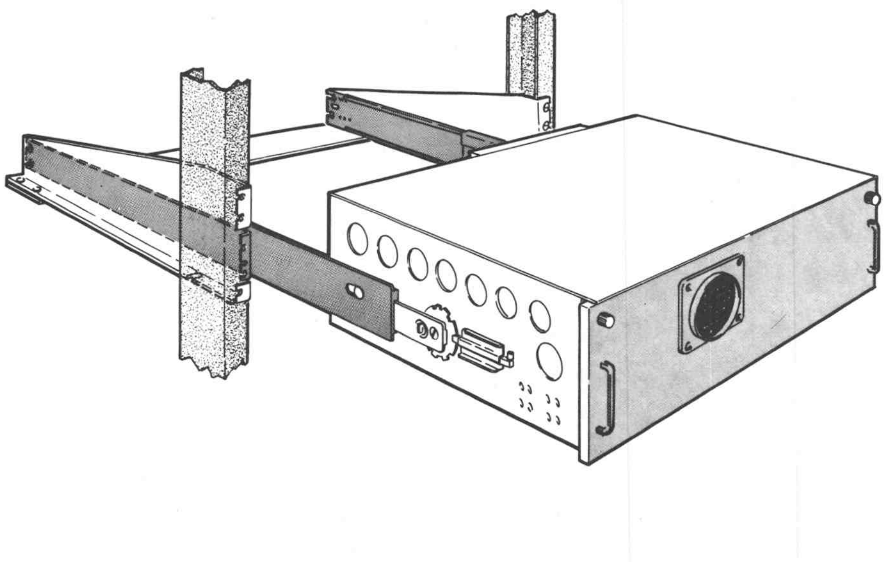


Fig. 2-4. The completed installation.
It may be necessary to loosen the bolts and allow the slide mechanism to adjust to the weight of the instrument.

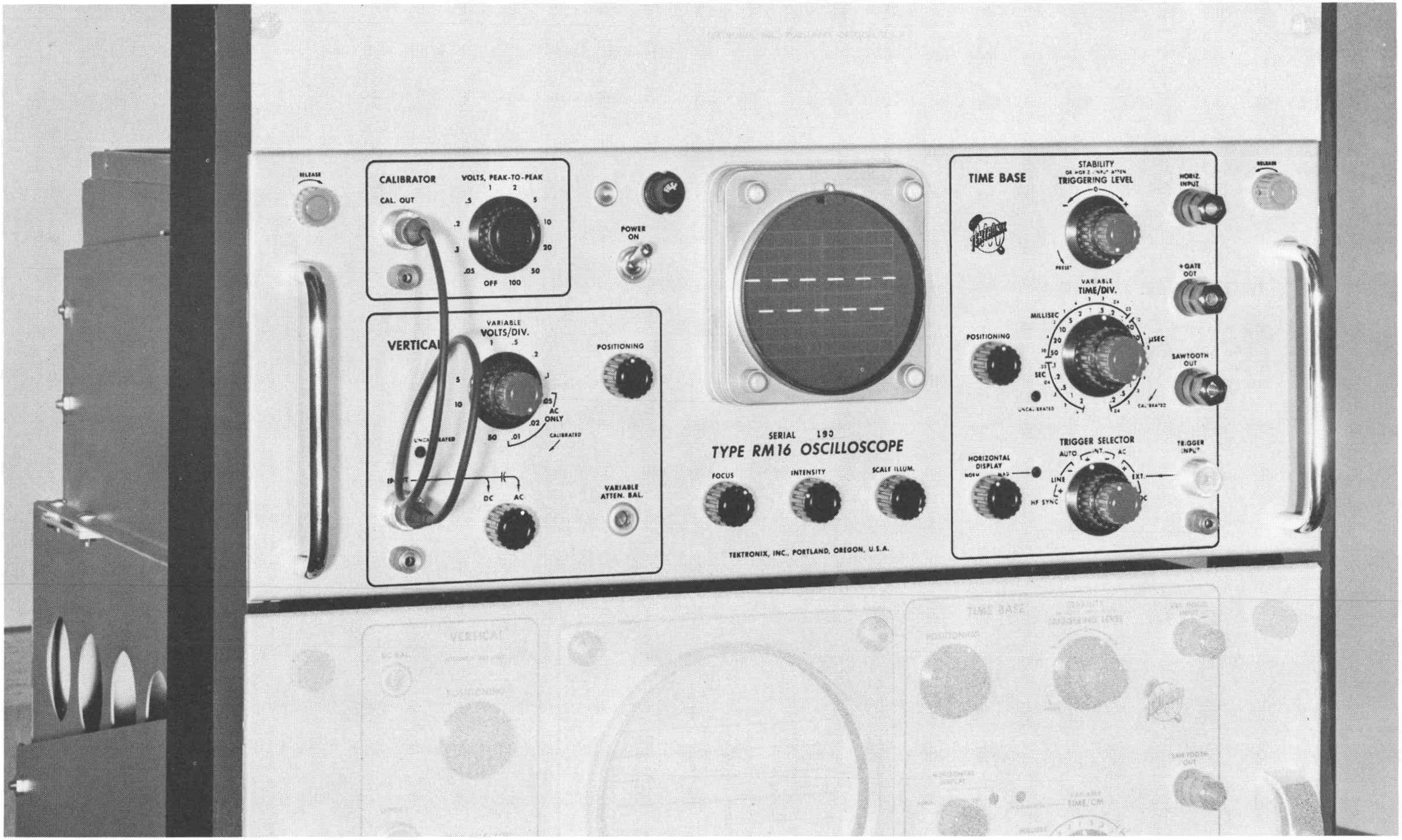


Fig. 3-1. TYPE RM16 OSCILLOSCOPE IN OPERATION.

GETTING ACQUAINTED

In order to help you begin using your new oscilloscope as soon as possible, we have outlined in this section some of the more frequently encountered oscilloscope operations.

The oscilloscope provides us with a means of actually looking at some voltage waveform we are interested in. To accomplish this, we feed this waveform into the INPUT connector on the oscilloscope front-panel. In most cases, we use the oscilloscope so that the display on the screen shows how the voltage of this waveform changes with time. For get-acquainted purposes, or to check the operation of the Type RM16, we shall first look at the square-wave signal generated by the CALIBRATOR which is built into the oscilloscope.

Initial Control Settings

Set the oscilloscope controls as follows:

FOCUS	centered
INTENSITY	full left (counter-clockwise)
POWER	ON
VOLTS/DIV. (black knob)	5
VARIABLE VOLTS/DIV. (red knob)	CALIBRATED (full right)
AC-DC	AC
TRIGGER SELECTOR (black knob)	+INT.
TRIGGER SELECTOR (red knob)	AUTO.
STABILITY	*PRESET
TRIGGERING LEVEL	full right or full left
HORIZONTAL DISPLAY	NORM.
TIME/DIV. (black knob)	.5 MILLISEC (black numbers)
VARIABLE TIME/DIV. (red knob)	†CALIBRATED (red letters)
Vertical POSITIONING	centered
Horizontal POSITIONING	centered
CALIBRATOR	10

*Turn the STABILITY control full left until the internal switch is actuated.

†Turn the VARIABLE control full right until the UNCALIBRATED light is extinguished.

Turn the INTENSITY control to the right until a horizontal trace of useful brightness appears on the screen. Adjust the FOCUS control for the sharpest trace. Connect a lead from the CAL. OUT connector to the INPUT connector. The display on the screen should now be a square wave. Slightly readjust the FOCUS and INTENSITY controls so that the display has the best sharpness and suitable brightness as shown in Fig. 3-1. Center the display on the graticule by means of the two POSITIONING controls.

Triggering in the Auto. Mode

The CALIBRATOR waveform you have been looking at is a periodic signal—that is, it recurs at regular intervals. We got a stable (stationary) display of this waveform by setting the oscilloscope controls so that each horizontal sweep of the spot across the screen started at a given point on the waveform we are looking at. These settings were given in the table at the left. For present purposes, the starting of each horizontal sweep across the screen can be called "triggering" the sweep. As in the procedure above, this can be accomplished with a minimum of adjustment by setting the red TRIGGER SELECTOR knob to the AUTO. (automatic) position. That is, we used the AUTO. mode of triggering.

Because of its simplicity of operation, the AUTO. mode is one of the most useful triggering modes. In particular, you don't have to adjust the TRIGGERING LEVEL or STABILITY controls when you use the AUTO. mode. Uses of these controls are described later in this manual.

Effect of the AC-DC Switch

Turn the AC-DC switch, located to the right of the INPUT connector, to DC. Notice the vertical shift in the position of the trace. This is due to the fact that the output waveform from the CALIBRATOR has both an ac (square wave) component and a dc component. When the AC-DC switch is in the AC position, the effect of the dc component of the waveform is excluded from the display. When this switch is in the DC position, the display indicates both the ac and the dc component of the waveform being viewed. The dc component of the waveform causes the entire display to rise or fall on the screen.

Effect of the Volts/Div. Controls

Turn the black VOLTS/DIV. knob successively to positions both to the right and to the left of the 5 position. Notice that when you set the VOLTS/DIV. switch to higher-numbered positions, the amount of vertical-deflection produced on the screen by the CALIBRATOR waveform is reduced, and vice versa.

Reset the black VOLTS/DIV. knob to the 5 position.

Turn the red VARIABLE knob to the left. Notice that this reduces the amount of vertical deflection produced on the screen by the CALIBRATOR waveform. Also notice that the UNCALIBRATED indicator lamp is lighted as soon as the red VARIABLE control is turned away from the full-right or CALIBRATED position.

Now reset the VARIABLE control to the CALIBRATED position.

The above operations point up the fact that the VOLTS/DIV. switch (black knob) and the VARIABLE control (red knob) provide control of the amount of vertical deflection which results from feeding a waveform having a given peak-to-peak voltage into the INPUT connector.

Effect of the Time/Div. Controls

Turn the black TIME/DIV. knob successively to positions both to the right and to left of the .5 MILLISEC position. Notice that the display expands or contracts horizontally as this switch is turned.

Reset the TIME/DIV. switch to the .5 MILLISEC position.

Turn the red VARIABLE control to the left. Notice that this contracts the display horizontally, so that a greater number of cycles of the square wave appears on the screen. Also notice that the UNCALIBRATED indicator lamp is lighted as soon as the red VARIABLE control is turned away from the full-right or CALIBRATED position.

Now reset the VARIABLE control to the CALIBRATED position.

The above operations point up the fact that the TIME/DIV. switch (black knob) and the VARIABLE control (red knob) provide control of the number of cycles of the display which appear on the screen when a waveform having a fixed repetition rate is displayed.

Effect of the Magnifier

Turn the TIME/DIV. switch to .1 MILLISEC and set the HORIZONTAL DISPLAY switch to the MAG. position. Notice the resulting horizontal expansion of the trace. Turn this switch from MAG. to NORM. and back several times. Observe that the portion of the waveform which occupies the middle two divisions of the graticule length when the switch is at NORM., is expanded to occupy the entire graticule length when the switch is at MAG.

With the HORIZONTAL DISPLAY switch at MAG., turn the Horizontal POSITIONING control through its range and notice that the display has been expanded beyond the limits of the graticule.

Also, notice that the MAG. indicator lamp has been lighted through the turning of the HORIZONTAL DISPLAY switch to the MAG. position.

Now reset the HORIZONTAL DISPLAY switch to the NORM. position and center the display on the screen.

Effect of the Black Trigger Selector Knob

Carefully observe that part of the display which appears at the left-hand end of the graticule. Notice that the trace begins during the

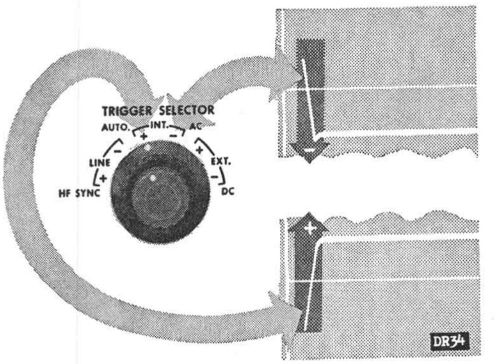


Fig. 3-2. Effect of the black Trigger Selector knob. When the black Trigger Selector knob is at +INT., the display will start during the positive-going part of the waveform. When the control is at —INT., the display will start during the negative-going part of the waveform.

rising portion of the square wave . That is, the sweep is **triggered** at a time when the **slope** of the wave is positive (see Fig. 3). This is because the black TRIGGER SELECTOR knob is set to +INT., rather than to —INT.

Now turn the black TRIGGER SELECTOR knob to —INT. Observe that the display appears to turn upside-down, so that it now begins during a falling portion of the square wave, at the left-hand end of the graticule. That is, the sweep is **triggered** at a time when the **slope** of the wave is negative.

Note that one of the purposes of the black TRIGGER SELECTOR knob is to provide control over whether the sweep is triggered when the slope of the waveform is positive, or whether it is triggered when the slope of the waveform is negative, as just described. Turn the black TRIGGER SELECTOR knob back and forth between +INT. and —INT. several times, observing the left-hand end of the display carefully to see how the sweep starts on either a rising or falling part of the waveform.

Further use of the black TRIGGER SELECTOR knob will be described in the Operating Instructions under the heading "Horizontal-Deflection System".

Now return the black TRIGGER SELECTOR knob to the +INT. position.

The AC Triggering Mode; Effect of the Triggering Level Control

Check that the black TRIGGER SELECTOR knob is set at +INT., that the TRIGGERING LEVEL control is turned full right or full left and that the STABILITY control is at PRESET. Turn the red TRIGGER SELECTOR switch to AC. The trace should now disappear from the screen.

Slowly turn the TRIGGERING LEVEL control toward the center of its range until the trace reappears; adjust this control for a stable display of the CALIBRATOR waveform. We say that triggering is now being effected in the AC mode.

Remove the CALIBRATOR lead from the INPUT connector. Note that this causes the trace to disappear. Now reconnect the CALIBRATOR lead to the INPUT connector so that the trace reappears.

Next, slowly turn the TRIGGERING LEVEL control several times back and forth throughout its range from —, through 0, to +. Carefully observe the left-hand end of the display while you do this. Note that there is a certain part of the range of this control that provides a display; settings too far towards the — or the + marks on the panel result in no display.

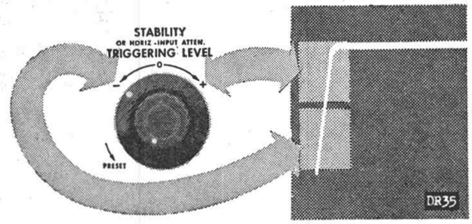


Fig. 3-3. Effect of the Triggering Level control when the red Trigger Selector knob is in the AC position. In the AC triggering mode, the display will start during the upper half of the leading edge for settings of the Triggering Level control in the + part of its range. When the control is turned to a setting in the — part of its range, the display will start during the lower half of the leading edge. This is true regardless of the position of the display on the graticule. In the drawings above, the start of the display occurs during the rising part of the waveform because the black Trigger Selector knob is set at + Int.

Also notice that, in that part of the range of the TRIGGERING LEVEL control where you get a display, this control determines the height or "level" of the point on the waveform where the trace starts. If you set this control more towards the — part of its range, the display starts on the lower part of the waveform. If you set the control more towards the + part of its range, the display starts higher on the waveform (see Fig. 3-3). Since the TRIGGER SELECTOR knob is set at +INT., the display in each case starts on the rising part of the waveform (where the slope is positive).

Next, set the black VOLTS/DIV. control to 10. The display will now be smaller and may disappear from the screen. If the display does disappear, turn the TRIGGERING LEVEL control toward its mid-range position (indicated by a 0 on the front panel). By carefully adjusting this control, a point will be found very near the 0 mark which will return the display to the crt screen. Notice that the range of settings for the TRIGGERING LEVEL control is now smaller than when the display was larger. This points up the fact that as the displayed signal amplitude is reduced. Conversely, as the signal amplitude is increased, reliable triggering is possible over a wider range of settings of the TRIGGERING LEVEL control and selecting the desired starting point for the display will be correspondingly easier. Return the VOLTS/DIV. switch to 5.

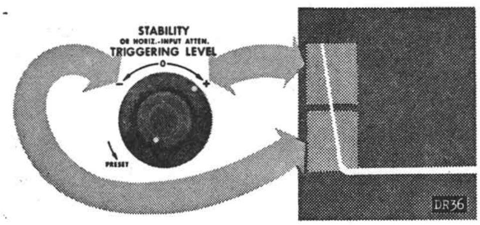


Fig. 3-4. Effect of the Triggering Level control when the red Trigger Selector knob is in the AC position.

These drawings differ from those of Fig. 3-3 in that the black Trigger Selector knob is set at —Int. This causes the display to start during the falling or negative-slope part of the waveform.

Now turn the TRIGGER SELECTOR knob to —INT., so that the waveform appears upside-down—that is, it starts on the falling part of the waveform (where the slope is negative). Repeat the observations of the previous paragraphs, and note that you can still control the height of the point where the trace starts by means of the TRIGGERING LEVEL control (see Fig. 3-4).

Reset the black TRIGGER SELECTOR knob to +INT. Now turn the Vertical POSITIONING control back and forth, so that the display is moved up and down on the graticule. Observe the left-hand end of the display while you do this. Notice that, for a fixed setting of the TRIGGERING LEVEL control, the trace always starts at a given point on the waveform, regardless of the setting of the Vertical POSITIONING control.

These brief statements can be made to compare the AC and AUTO. modes of triggering:

1. It is necessary to adjust the TRIGGERING LEVEL control when you use the AC mode of triggering, but not when you use the AUTO. mode.

2. When you use the AUTO. mode, you get a desirable horizontal reference trace on the screen, even when no input signal is used. This will be especially handy when you are testing equipment by moving the input connection from one point to another in the equipment. When you use the AC mode, no trace appears when there is no input signal.

3. In the AC mode the TRIGGERING LEVEL control provides control of the height or "level" at which the trace starts on the waveform being observed. This is not true in the case of the AUTO. mode.

4. The AUTO. mode is useful when you are looking at periodic waveforms. The AC mode is useful for both periodic waveforms and for waveforms which occur only once or at random intervals.

The DC Triggering Mode

After completing the previous operation, use the Vertical POSITIONING control to center the display vertically on the screen. Set the TRIGGERING LEVEL control for a stable display with the control located as close as possible to 0.

Turn the red TRIGGER SELECTOR switch to DC. If necessary, readjust the TRIGGERING LEVEL control for a stable display. You are now triggering the sweep in the DC mode.

Slowly turn the TRIGGERING LEVEL control several times back and forth throughout its range from — through 0, to +. Carefully observe the left-hand end of the display while you do this. Note that the results are very much like those you got when you used the AC mode.

Turn the black TRIGGER SELECTOR knob to —INT., and repeat the above operation. Again note the results are similar to those you obtained when you used the AC mode. Return the black TRIGGER SELECTOR knob to +INT.

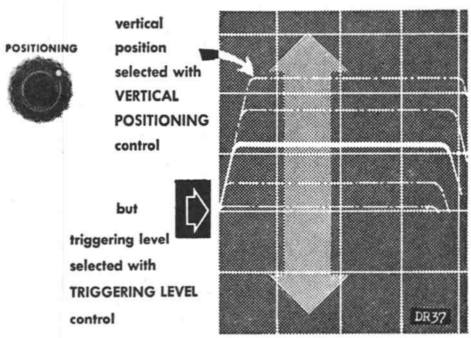


Fig. 3-5. Effect of the VERTICAL POSITIONING control when the red TRIGGER SELECTOR knob is in the DC position.

In the DC triggering mode, the display will always start at the same point on the graticule for a given setting of the black Triggering Level control. If the display is positioned so as to not include this starting point, the waveform will disappear. This is in contrast to the AC triggering mode, where the display starts at the same point on the waveform regardless of the position of the display on the graticule.

Now turn the Vertical POSITIONING control back and forth, so that the display is moved up and down on the graticule. Observe the left-hand end of the display while you do this. Notice that, for a given setting of the TRIGGERING LEVEL control, the trace starts at a given point on the graticule, regardless of the setting of the Vertical POSITIONING control (see Fig. 3-5). (If you position the trace too high or too low, so that the waveform doesn't include this starting point, the trace disappears.)

Notice, also that as you move the display up and down with the Vertical POSITIONING control, the waveform shifts from left to right on the screen (as shown in Fig. 3-5), so that the starting point always has the same position on the graticule. When the TRIGGERING LEVEL is set near 0, the starting point will be near the middle of the graticule height. If you move the TRIGGERING LEVEL control towards +, the starting point will be raised, while if you move the TRIGGERING LEVEL control towards —, the starting point will be lowered (Fig. 3-6).

The four comments at the close of the section on the AC triggering mode apply also to triggering in the DC mode. The following statements can be made to compare the DC and AC modes of triggering:

1. When you use the DC mode, the trace always starts at a given point on the **graticule**, for a given TRIGGERING LEVEL setting and the display must be positioned to pass through this point. But when you use the AC mode, the trace always starts at a given point on the **waveform**, for a given TRIGGERING LEVEL setting (regardless of the Vertical POSITIONING setting).

2. The DC mode is especially useful for viewing waveforms which change slowly.

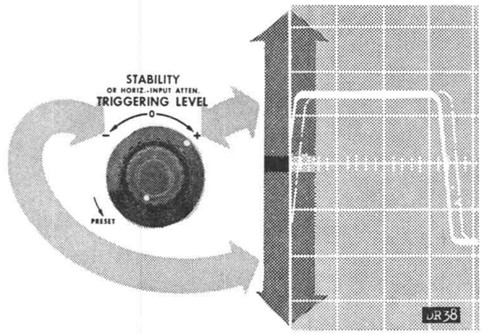


Fig. 3-6. Effect of the Triggering Level control when the red Trigger Selector knob is in the DC position.

In the DC triggering mode, the setting of the Triggering Level control determines the elevation of the point on the graticule at which the display starts.

OPERATING INSTRUCTIONS

This section includes the information in the previous section on "Getting Acquainted," in condensed form for easy reference. It also includes instructions on other applications of your oscilloscope.

HORIZONTAL-DEFLECTION SYSTEM

TRIGGERED OPERATION

For many uses of your oscilloscope, you will need to get a stable display of some recurrent waveform. To accomplish this, you can operate the oscilloscope so that each horizontal sweep of the spot across the screen starts at a given point on the waveform you are observing. This is called "triggered" operation. For present purposes, then, we can refer to the starting of the horizontal sweep at the left-hand end of the graticule as "triggering" the sweep.

Triggered operation is also useful in looking at a waveform which occurs only once, or which occurs at random intervals.

For any of the above uses, the oscilloscope can alternatively be used in such a way that each horizontal sweep of the spot is triggered by some waveform other than the one you are observing, but which has a time relationship to the observed waveform.

The waveform used to start the horizontal sweep is called a "triggering signal" (whether it is the waveform being observed, or some other waveform). The following instructions tell you how to select the triggering signal. They also contain information on triggering according to various modes, depending upon the nature of the triggering signal.

How to select the triggering signal source

1. To trigger the sweep from the waveform being observed, set the black TRIGGER SELECTOR knob to +INT. or to—INT.

2. To trigger the sweep from the power-line wave, as in the case where you are observing a waveform which has a time relationship to the power-line wave, set the black TRIGGER SELECTOR knob to +LINE or to —LINE.

3. To trigger the sweep from some externally derived waveform which has a time relationship to the observed waveform, connect the source of the triggering waveform to the TRIGGER INPUT connector. Set black TRIGGER SELECTOR knob to +EXT. or to —EXT.

If you want the start of the display, at the left-hand end of the graticule, to occur at a time when the triggering signal is rising (has a positive slope), use the +INT., the +LINE or the +EXT. position of the black TRIGGER SELECTOR knob, as described above. If you want the start of the display to occur when the triggering signal is falling (has a negative slope), use the —INT., the —LINE or the —EXT. position of the black TRIGGER SELECTOR knob.

AUTO. mode

This is an especially useful triggering mode, providing automatic triggering from periodic signals in the range from 60 cycles to 2 megacycles.

1. Select the desired triggering signal.

2. Set the HORIZONTAL DISPLAY switch to NORM., and set the red TRIGGER SELECTOR knob to AUTO. (The TRIGGERING LEVEL and STABILITY controls are not used in this mode.)

3. Set the TIME/DIV. switch for a sweep rate suited to the waveform being observed.

AC mode

This mode is useful for triggering either from transients or from periodic signals in the range from 16 cycles to 5 megacycles. Reliable triggering is possible at frequencies lower than 16 cycles if the product of the triggering-signal amplitude, in volts (external triggering) or in divisions of vertical deflection (internal triggering), and the frequency, in cycles, is greater than five. For example, a triggering signal having a frequency of 10 cycles should have an amplitude of at least 0.5 volt when triggering

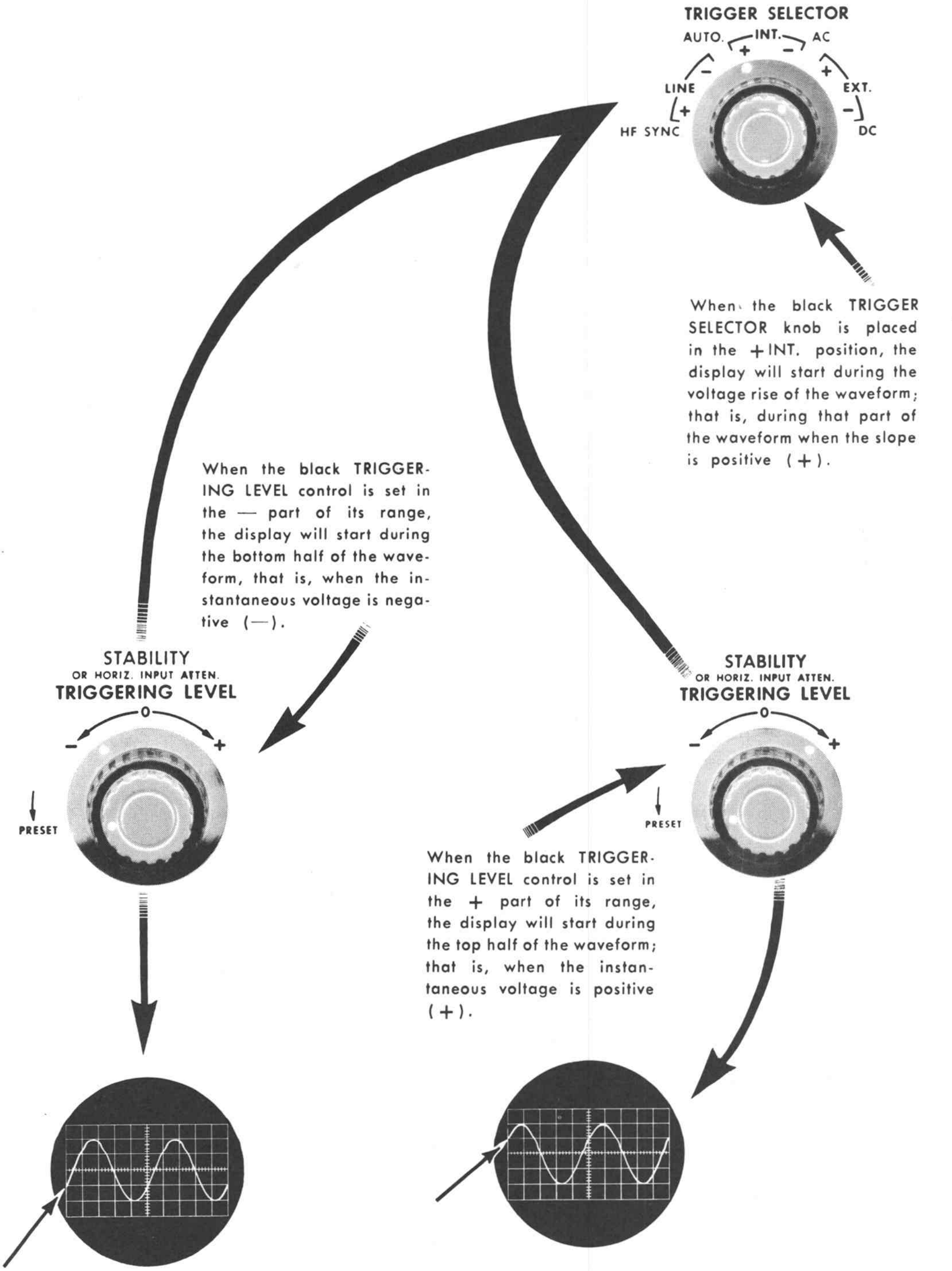


Fig. 4-1. Triggering on the positive-going portion of the input waveform

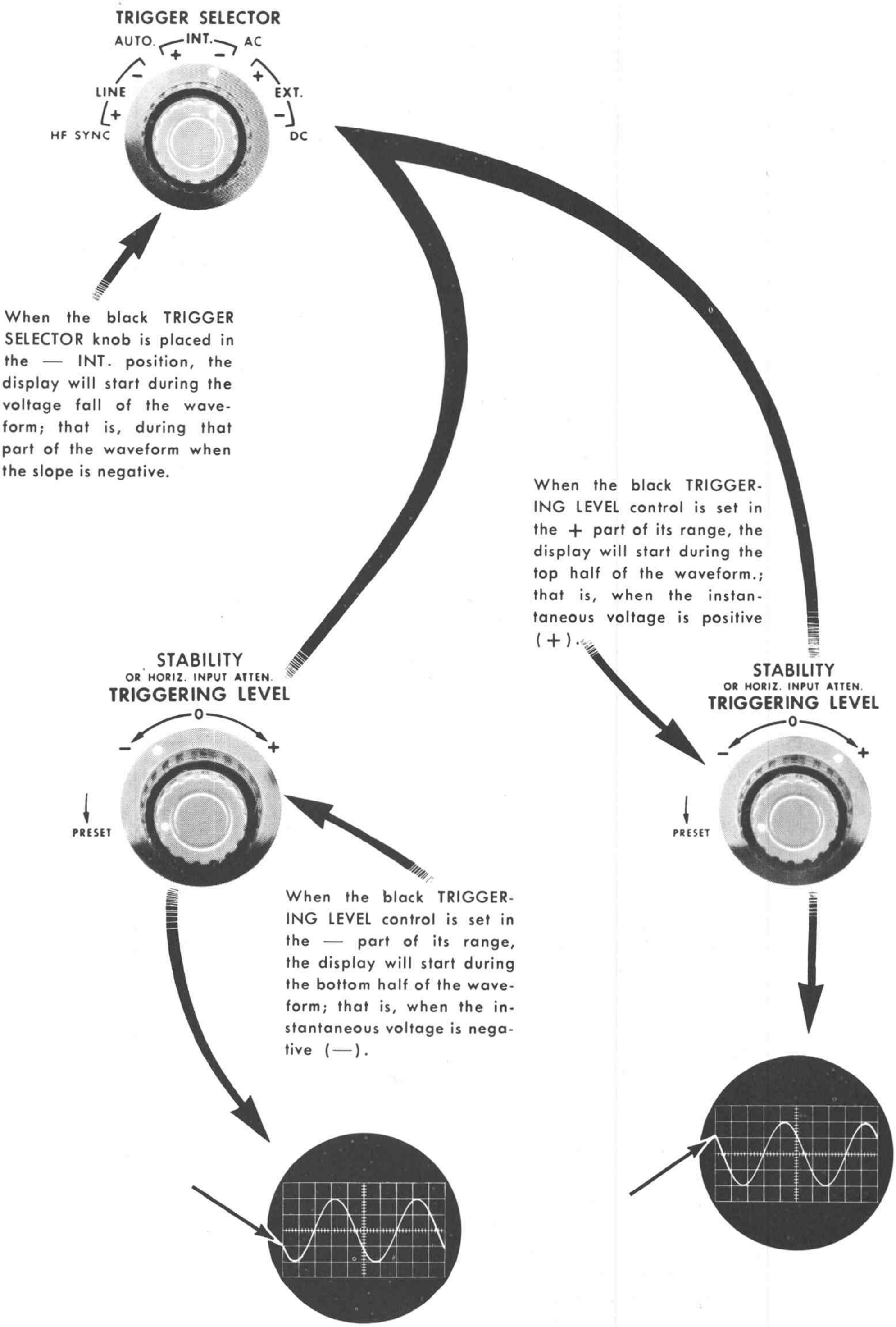


Fig. 4-2. Triggering on the negative-going portion of the input waveform

from an external source (+ or —EXT.) or 0.5 major division of vertical deflection when triggering from the displayed signal (+ or —INT.).

1. Select the desired triggering signal.

2. Set the controls as follows:

HORIZONTAL DISPLAY	NORM.
TRIGGER SELECTOR (red)	AC
TRIGGERING LEVEL	full right or full left
STABILITY	PRESET

3. Turn the TRIGGERING LEVEL control slowly toward the center of its range until the trace begins at the desired point on the waveform being observed.

4. Set the TIME/DIV. switch for a sweep rate suited to the waveform being observed.

DC mode

In the DC mode, triggering can be effected from periodic signals in the range from dc to 5 megacycles, or from transients. This mode is especially useful with trigger signals that change slowly; that is, signals below the lower-frequency limit of the AC mode.

For example, consider the case of a slowly-rising voltage. It is desired to start the display at a time when the voltage has risen to a particular value. In the AC mode, the signal connected to the triggering circuits would be distorted as shown in *b* of Figure 4-3. Obviously, in region *A*, where the voltage is almost constant, the voltage discriminating TRIGGER LEVEL control could not be set for reliable triggering at the desired point. On the other hand, in the DC mode, the triggering signal would appear as *a* in Figure 4-3. Here, the waveform has not been distorted and the TRIGGERING LEVEL control can be set to start the sweep when the voltage has risen to the desired value.

Another application of the DC triggering mode is to attain a stable display of a random-pulse train. The average voltage of this type of signal is dependent upon the time duration and amplitude of each pulse and the time lapse between successive pulses. Since these quantities are variable in a random-pulse train, the average voltage will also vary and this can cause unstable triggering in the AC mode. In the DC mode, however, the circuits are only sensitive to the instantaneous voltage and changes in the average voltage do not alter the operation of the circuits. As a result, the TRIGGERING LEVEL control can be set to initate a sweep whenever a pulse reaches the desired voltage.

Operating instructions are similiar to those given previously for the AC mode, except that you set the red TRIGGER SELECTOR knob to DC. It is important to remember, however, that the trace always starts at a given point on the graticule for a given TRIGGERING LEVEL setting. This is true regardless of the setting of the Vertical POSITIONING control.

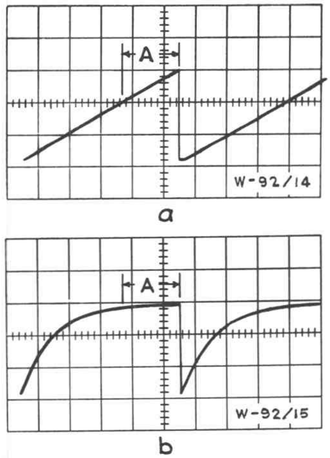


Fig. 4-3. Effect of ac coupling on a slowly-changing voltage.

The waveform a is changing at the rate of 0.3 volt per millisecond. In the DC triggering mode, it would not be altered by the dc-coupled triggering circuits and the voltage discriminating TRIGGERING LEVEL control could be set to initiate a sweep at some point in Region A.

In the AC triggering mode, the circuits are ac coupled and the triggering waveform would be altered as shown in b. Notice that the voltage is almost constant in Region A. It is this nearly constant voltage that prevents the selection of a specific starting point with the TRIGGERING LEVEL control.

How to use the variable STABILITY control

For a few particular difficult triggering applications, you may wish to use a setting of the STABILITY control other than the one available in the PRESET position. You can do this if you are using triggered operation in either the AC or the DC mode.

1. Start with the STABILITY control turned full right. Use other control settings as given in the instructions for the desired triggering mode.

2. Turn the STABILITY control left until the trace disappears, then two or three degrees further left.

3. Turn the TRIGGERING LEVEL control slowly toward the center of its range until the trace begins at the the desired point on the waveform being observed.

4. Set the TIME/DIV. switch for a sweep rate suited to the waveform being observed.

SYNCHRONIZED OPERATION

HF SYNC mode

When you use the HF SYNC mode, you get a recurrent horizontal sweep which can be synchronized, by means of the STABILITY control, with waveforms in the range from 5 megacycles to 15 megacycles.

When using the HF SYNC mode, you will usually want to synchronize the horizontal sweep with the waveform being displayed. To do this, set the controls as outlined in Step 1, at right. If, however, you want to synchronize the sweep with some external waveform, connect the source of this waveform to the TRIGGER INPUT connector and set the TRIGGER SELECTOR knob to the +EXT. or —EXT.

1. Set controls as follows:

HORIZONTAL DISPLAY	NORM.
TRIGGER SELECTOR (black)	+INT. or —INT.
TRIGGER SELECTOR (red)	HF SYNC
TRIGGERING LEVEL	not used in HF SYNC mode
STABILITY	full right

2. Set the TIME/DIV. switch for a sweep rate suited to the waveform being observed.

3. Turn the STABILITY control slowly to the left until you get a stable display of the waveform being observed.

FREE-RUNNING OPERATION

With the Type RM16, you can get a periodic, free-running sweep, independent of any external triggering or synchronizing signal. This operation is useful where the waveform being observed is initiated by the output from either the +GATE OUT or the SAWTOOTH OUT connector.

As an application of free-running operation, you can actuate the system under investigation by means of a signal from either the +GATE OUT or the SAWTOOTH OUT connector. (See "Output Waveforms" on next page.) The signals from these connectors have a starting time and a duration corresponding to the starting time and duration of the horizontal sweep of the crt spot. Note that this reverses the usual situation where the oscilloscope sweep is timed to the waveform under investigation. Here, the system being investigated is timed to the oscilloscope sweep. Thus a stable display is presented of the waveforms resulting from actuating the system under investigation.

1. Use no input to the TRIGGER INPUT connector.

2. Set the controls as follows:

HORIZONTAL DISPLAY	NORM.
TRIGGER SELECTOR (black)	INT. or EXT. (+ or —)
TRIGGER SELECTOR (red)	AC or DC
STABILITY	full right
TRIGGERING LEVEL	full right or full left

3. Set the TIME/DIV. switch for a sweep rate suited to the waveform being observed.

Alternatively, you can get a free-running sweep at a fixed repetition rate of approximately 50 cycles, using the AUTO. mode:

1. Use no input to the TRIGGER INPUT connector.

2. Set controls as follows:

HORIZONTAL DISPLAY	NORM.
TRIGGER SELECTOR (black)	INT. or EXT. (+ or —)
TRIGGER SELECTOR (red)	AUTO.
TRIGGERING LEVEL STABILITY	not used in AUTO. mode

3. Set the TIME/DIV. switch for a sweep rate suited to the waveform being observed.

MAGNIFIER

To expand a particular part of the display horizontally, first use the HORIZONTAL POSITIONING control to position that part of the display so that it falls near the center of the graticule. Then turn the DISPLAY switch to MAG. That part of the display which occupied two divisions of the graticule will now be expanded to fill the graticule horizontally. At the same time, the MAG. indicator lamp will be lighted, indicating that the display has been expanded. Each major graticule division will now have a time value one-fifth of the value indicated by the TIME/DIV. switch. When the HORIZONTAL DISPLAY switch is in the MAG. position, read the blue scale associated with the TIME/DIV. switch. When the switch is in the NORM. position, read the black scale associated with the TIME/DIV. switch.

EXTERNAL HORIZONTAL INPUT

You might need to effect horizontal deflection of the spot across the screen by means of some externally derived waveform, rather than by means of the time base in the Type RM16. To accomplish this, connect the source of this waveform to the HORIZ. INPUT connector, and turn the HORIZONTAL DISPLAY switch to EXT. Set the STABILITY OR HORIZ. INPUT ATTEN. knob for the desired amount of horizontal deflection.

The horizontal amplifier is primarily designed to amplifiy the linear positive-going portion of the sweep sawtooth waveform. The maximum rate at which the horizontal amplifier is capable of deflecting the spot from right to left is approximately .1 μsec/div. This is the rate attained in the center of the screen when a 300-kilocycle sine wave is used to deflect the beam 10 graticule divisions. If you wish to deflect the beam at a faster rate, the horizontal deflection must be limited to avoid overloading the amplifiers.

The effect of the HORIZ. INPUT ATTEN. control also must be taken into consideration when connecting external signals to the HORIZ. INPUT connector. As this control is rotated away from the minimum attenuation position, the high-frequency roll-off characteristic of the amplifier is altered. At mid-range, the response of the amplifier is down 3 decibels at 180 kilocycles. The response is improved with settings on either side of the mid-range position.

OUTPUT WAVEFORMS

A sawtooth waveform is available at the SAWTOOTH OUT connector on the front panel. This positive-going waveform starts at about ground and rises linearly to a peak amplitude of about 150 volts.

The start of the rising part of the sawtooth is determined in the same way as the start of the horizontal sweep on the oscilloscope. That is, the rising part of the sawtooth can be initiated by a triggering or synchronizing signal (see "Triggered Operation" or "Synchronized Operation"). Or the sawtooth can be generated in a periodic, free-running manner, without regard to any triggering or synchronizing signal (see "Free-Running Operation"). The rate at which the sawtooth rises is controlled by the TIME/DIV. switch, and by the VARIABLE knob.

A rectangular waveform is available at the +GATE OUT connector on the front panel. This waveform starts at ground and rises to a peak amplitude of about 30 volts. Its starting time and duration correspond to the starting time and duration of the positive-going part of the sawtooth available at the SAWTOOTH OUT connector.

VERTICAL-DEFLECTION SYSTEM

INPUT COUPLING

It is sometimes neither necessary nor desirable to display the dc component of the input waveform. A capacitor placed in series with the input connector will block this dc component, but at the same time, will allow the ac component to be displayed. This is done when the AC-DC switch is placed in the AC position.

DEFLECTION FACTOR

The VOLTS/DIV. switch controls the vertical deflection factor (vertical sensitivity) in accurately calibrated steps. The VARIABLE control provides variable deflection factors between the fixed steps of the VOLTS/DIV. control.

The front-panel UNCALIBRATED lamp will be lighted when the VARIABLE control is turned away from the CALIBRATED position.

NOTE: To make the deflection factor equal to that indicated by the VOLTS/DIV. switch, set the VARIABLE control to the CALIBRATED position.

CONNECTING THE OSCILLOSCOPE TO THE SIGNAL SOURCE

Here are some precautions you should observe in connecting your oscilloscope to the source of signals to be displayed.

1. Avoid errors in readings due to stray electric or magnetic coupling between circuits, particularly in the leads connected to the INPUT connector. In general, unshielded leads of appreciable length are unsuited to this use. This is true even in the audio-frequency range, except possibly when making measurements in low-impedance circuits. When shielded leads are used, the shields should be grounded to the oscilloscope chassis and to the chassis of the equipment being tested. Coaxial cables are recommended for many purposes.

2. In broadband applications, it might be necessary to terminate a coaxial cable with a resistor or an attenuating pad presenting a resistance equal to the characteristic impedance of the cable. This is to prevent resonance effects and ringing—that is, high-frequency damped oscillation. It becomes more necessary to terminate the cable properly as the length of the cable is increased. The termination is generally placed at the oscilloscope end of the cable, although many sources require an additional termination at the source end of the cable as well. Refer to the Accessories Section in the back of this manual for a listing of cables, terminating resistors and pads.

3. As nearly as possible, simulate actual operating conditions in the equipment being tested. For example, the equipment should work into a load impedance equal to that which it will see in actual use.

4. Consider the effect of loading upon the signal source due to the input circuit of the oscilloscope. The input circuit at the INPUT connector can be represented by a resistance of 1 megohm shunted by a capacitance of 38 micromicrofarads. With a few feet of shielded cable, the capacitance may well be 100 micromicrofarads. In many cases, the effects of these resistive and capacitive loads are not negligible, and to minimize them, you might want to use a probe in the manner described in the next section.

USE OF PROBES

An attenuator probe lessens both capacitive and resistive loading, at the same time reducing sensitivity. When making amplitude measurements with an attenuator probe, be sure to multiply the observed amplitude by the attenuation of the probe (marked on probe).

A Type P510A Probe is furnished as an accessory to the Type RM16 Oscilloscope. The probe is easily identified by its black, molded-plastic nose. Connected to the INPUT connector of the Type RM16, the probe presents an input characteristic of 10 megohms shunted by 13 micromicrofarads and has an attenuation ratio of 10:1. The maximum voltage which may be applied to the probe is 600 volts. Exceeding this rating, either in peak ac volts or dc volts, may result in damage to the components inside the probe body.

If the waveform being displayed contains fast changing portions, it is generally necessary to clip the probe lead to the chassis of the equipment being tested. Select a ground point near the probe-input connection.

Before using the probe, always check its adjustment.

An adjustable capacitor in the probe body compensates for variations in input capacitance from one instrument to another. To insure the accuracy of pulse and transient measurements, this adjustment should be checked frequently.

To make this adjustment, set the calibrator control for a calibrator output signal of suitable amplitude. Touch the probe tip to the CAL. OUT connector and adjust the oscilloscope controls to display several cycles of the waveform. Adjust the probe capacitor for a flat top on the calibrator square wave, as shown in the right-hand picture of Fig. 4-4.

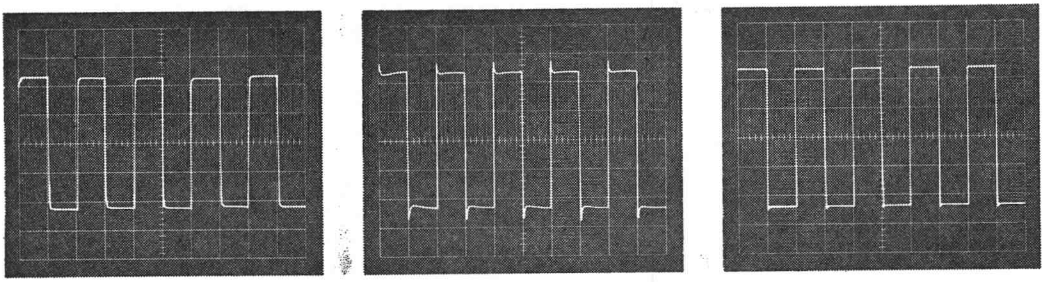


Fig. 4-4. Adjusting the probe.

The variable capacitor in the probe body should be adjusted so that the display of the CALIBRATOR waveform has a flat top as shown in the right-hand picture.

VOLTAGE MEASUREMENT

We describe here two categories of voltage measurements with the Type RM16 Oscilloscope: (1) measurement of the peak-to-peak voltage of a displayed waveform, and (2) measurement of the peak voltage of a waveform with respect to a reference voltage. The specific examples that follow are intended to show the general procedure. These examples can be modified to suit any particular application.

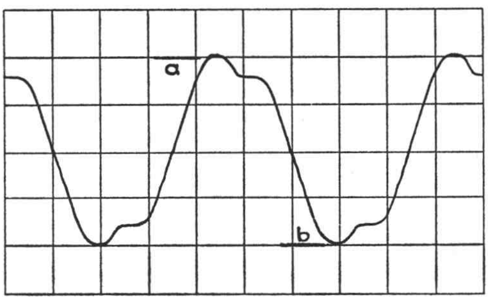


Fig. 4-5 Measuring peak-to-peak voltage.

The text explains to you how the calibrated VOLTS/CM switch may be used to measure the peak-to-peak voltage of a waveform.

In measuring signal amplitudes, it is important to remember that width of the trace may be an appreciable part of the overall measurement. This is particularly true when measuring signals of small amplitude. Notice in Fig. 4-5 that points a and b correspond to the bottom side of the trace. The measurement would be just as accurate if points a and b corresponded to the top or center of the trace.

How to measure peak-to-peak voltages

Suppose a given waveform produces the trace shown in Fig. 4-5 when a 10X probe is used and when the VERTICAL controls are set as follows:

AC-DC	AC
VOLTS/DIV.	.1
VARIABLE	CALIBRATED

The first step in measuring the peak-to-peak voltage of this waveform is to measure the amount of vertical deflection. The vertical distance from point a, the positive peak, to point b, the negative peak, is 4 divisions. Multiply this figure by the VOLTS/DIV. setting, .1, and the result is .4 volt. This figure represents the voltage present at the INPUT connector of the oscilloscope. Multiply this result by 10—the attenuation ratio of the probe. This gives 4 volts as the peak-to-peak voltage of the displayed waveform.

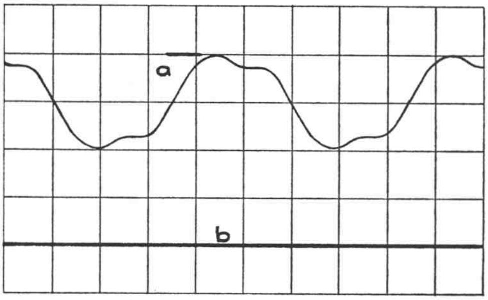


Fig. 4-6 Measuring a voltage with respect to ground. The text explains how the voltage difference between point "b" (ground) and point "a" may be measured with the aid of the calibrated VOLTS/CM switch.

How to measure a peak waveform voltage with respect to ground

Set the AC-DC switch to DC, and set the VARIABLE control to CALIBRATED. Adjust the oscilloscope for a free-running trace. Touch the probe tip to the oscilloscope ground terminal. Use the Vertical POSITIONING control to set the trace to a convenient position, such as b in Fig. 4-6. Next, disconnect the probe tip from the ground terminal and connect it to the waveform source without disturbing the VERTICAL POSITIONING control.

Adjust the oscilloscope controls for a stable display. Observe the vertical distance between the peak waveform voltage and the original trace position b. If this distance is inconveniently large or small, reset the VOLTS/DIV. switch to a more suitable position and repeat the above procedure.

As an example, suppose the vertical distance between a and b is 4 divisions when a 10X probe is used and when the VOLTS/DIV. switch is set at .1. Multiply the distance between a and b (4 div.) by the VOLTS/DIV. setting (.1 v/div.) and by the probe attenuation ratio (10). This shows the peak voltage of the waveform with respect to ground to be 4 volts.

VARIABLE ATTENUATOR BALANCE

The need for adjustment of the VARIABLE ATTEN. BAL. control is indicated by a vertical shift in the position of the trace as the red VARIABLE VOLTS/DIV. control is rotated. This adjustment should be made as follows:

1. With no signal connected to the INPUT connector, set the oscilloscope controls for a free-running trace.

2. Rotate the VARIABLE VOLTS/DIV. control back and forth, and adjust the VARIABLE ATTEN. BAL. control simultaneously until the trace position is no longer affected by rotation of the VARIABLE VOLTS/DIV. control.

AUXILIARY FUNCTIONS

Calibrator

The Calibrator provides a source of square waves of known amplitude at approximately one kilocycle (±30%). The output amplitude is accurate within 3% of the VOLTS-switch setting. The primary function of the Calibrator is to provide a convenient method for verifying the calibration of the vertical-deflection system and for adjusting the probes. It can be used for other purposes, however, if certain limitations are kept in mind.

The output impedance of the Calibrator varies with the output-voltage setting. It is as low as 10 ohms in the .05-volt position of the VOLTS switch and as high as 5 kilohms in the 50-volts position. In the 100-volts position, the output impedance is 250 ohms when the circuit is loaded by a resistance of not less than four kilohms. When the switch is at a setting other than 100 volts, the output may be loaded with any impedance without damaging the components. See Table I for the approximate output impedance for each position of the VOLTS switch.

TABLE I

Approx. Output Impedance of Calibrator

VOLTS switch	Output impedance
100	*250 ohms
50	5 kilohms
20	3.2 kilohms
10	1.8 kilohms
5	900 ohms
2	400 ohms
1	200 ohms
.5	100 ohms
.2	40 ohms
.1	20 ohms
.05	10 ohms

***Do not load with less than 4 kilohms.**

Graticule illumination

The graticule lighting control, labeled SCALE ILLUM., can be adjusted to suit the lighting conditions of the room. A green filter is supplied which can be used for increased contrast. This filter should be mounted next to the crt screen so it does not block the light from the graticule lines.

As a general rule, white graticule lines are superior to red for photographic purposes. Where it is desired to photograph a display, it it may be desirable to remove the red plastic inserts from the graticule so the lines will appear white. Where the volume of photographic work warrants it, you may want to obtain a clear graticule from your Tektronix Field Engineer.

Connection to crt deflection plates

In some applications, it may be desirable to connect a signal directly to either one or both sets of crt deflection plates—bypassing the internal oscilloscope amplifiers. This can be done in the Type RM16 if certain precautions are observed. One of these precautions is to maintain the average dc voltage on the deflection plates between +150 and +200 volts. To allow the voltage to fall outside of these limits may result in defocusing of the crt display.

For many applications, ac coupling of the signal to the deflection plates is permissible. It has the advantage of allowing the use of front-panel controls to position the display and permits the display of signals not having an average dc voltage between +150 and +200 volts. A diagram of this method of coupling is shown in Figure 4-7. Here, the leads from the oscilloscope amplifier are removed and a resistor is connected between each lead and its respective crt pin. The vertical-deflection-plate pins are located on the side of the crt neck and the horizontal-deflection-plate pins are located on the top.

In order to realize the desired amount of deflection sensitivity in the Type T31P2 Cathode-Ray Tube, the deflection plates have been placed as close as possible to the path of the electron beam. As a result, a small amount of current will flow in the deflection-plate circuits. This current flow varies non-linearly with the beam position, increasing rapidly in that plate toward which the beam is being positioned. In the Type RM16, the effects of these currents are negligible because of the low resistance of the horizontal- and vertical-deflection-plate circuits. However, if the resistance is increased, these currents can cause objectionable voltage drops. For values of resistance greater than 100 kilohms the voltage drops may become relatively large and

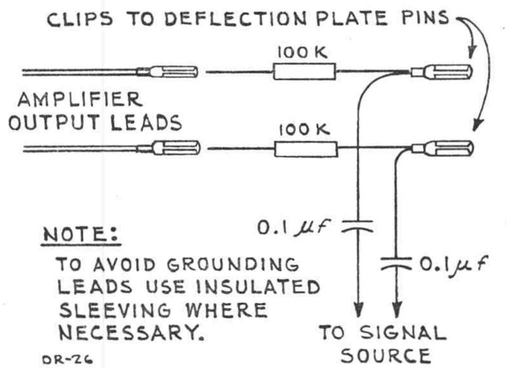


Fig. 4-7. Typical circuit for a ac coupling to crt deflecting plates.

The diagram shows how an external signal may be coupled to the deflection plates, bypassing the oscilloscope amplifiers. The connections may be made either to the horizontal or vertical deflection plates. Positioning of the display is controlled by the front-panel controls when this method is used.

cause serious defocusing or distortion. These effects are most noticable when the display is positioned close to the limits of the crt graticule. For this reason, series resistors having a value greater than 100 kilohms are not recommended.

A convenient method for connecting the resistors to the crt pins is to use clips removed from standard miniature tube sockets. Before connecting the resistors to the leads from the amplifier, slip a piece of insulated sleeving (spaghetti) over the wire. Then, after making the connections, draw the sleeving back over the uninsulated resistor pigtail. This will protect the leads from accidentally shorting to the chassis. The crt pins are easily bent, and you must exercise care when making these connections to avoid breaking the pins.

CAUTION

Do not allow the leads from the oscilloscope amplifiers to touch the chassis when the power is on. A short circuit of this type can damage the amplifier circuits.

If it is desired to couple the signal directly to the crt plates (dc coupling), it will be necessary to supply positioning voltages from the signal source. These voltages, of course, should fall within the +150- to +200-volt range mentioned previously. To dc couple the signal to the deflection plates, remove the leads from the crt pins and fold them back, out of the way. Taping the ends of the wires will prevent accidental shorting to the chassis. Connect the external signal source to the pins of the crt.

OPERATING DESCRIPTIONS OF CONTROLS AND CONNECTORS

TRIGGER SELECTOR (black knob)	Black TRIGGER SELECTOR switch selects triggering signal—either power-line wave (+LINE or —LINE), or the signal being displayed (+INT. or —INT.), or some signal fed into TRIGGER INPUT connector. In the +LINE, +INT. and +EXT. positions, triggering occurs during the voltage rise of the triggering waveform. In the —LINE, —INT. and —EXT. positions, triggering occurs during the voltage fall of the triggering waveform.
TRIGGER SELECTOR (red knob)	Four-position switch (red knob) selects one of three types of triggering (AC, DC or AUTO.), or synchonized operation (HF SYNC). See discussions of these operating modes under "Horizontal-Deflection System."
TRIGGERING LEVEL	Black TRIGGERING LEVEL control determines at what voltage on the triggering waveform the horizontal trace will start. This control is disabled when the red TRIGGER SELECTOR switch is in the AUTO. or HF SYNC positions.
STABILITY or HORIZ. INPUT ATTEN.	Red STABILITY control adjusts the time base for triggered or for free-running operation. Normally, it can be left in the PRESET position. It is disabled when the red TRIGGER SELECTOR control is in the AUTO. position. It also serves as the synchronizing control when the red TRIGGER SELECTOR switch is in the HF SYNC position. This knob also serves as an attenuation control for horizontal-deflection voltages when the HORIZONTAL DISPLAY switch is in the EXT. position.
HORIZONTAL DISPLAY	Three-position switch. In NORM. position, the sweep rates indicated in black numbers on the TIME/DIV. scale apply. When the HORIZONTAL DISPLAY switch is in the MAG. position, blue numbers on the TIME/DIV. scale apply, and that part of the display which originally occupied the middle two centimeters of graticule length are expanded to occupy the entire graticule length (magnification, 5X). In the EXT. position of the HORIZONTAL DISPLAY switch, horizontal-deflection voltage is to be supplied externally by way of the HORIZ. INPUT connector.
TIME/DIV.	Twenty-two-position switch to control horizontal sweep rate. Read black numbers when the HORIZONTAL DISPLAY switch is at NORM. Read blue numbers when the HORIZONTAL DISPLAY switch is at MAG.

HORIZONTAL POSITIONING	Positions trace horizontally.
VOLTS/DIV. (black knob)	Switch provides fixed calibrated vertical-deflection factors when the VARIABLE VOLTS/DIV. control is set to CALIBRATED.
VARIABLE VOLTS/DIV. (red knob)	Provides variable (uncalibrated) vertical-deflection factors between those provided on the VOLTS/DIV. switch.
VERTICAL POSITIONING	Positions trace vertically.
CALIBRATOR	Selects any one of eleven calibrated square-wave output amplitudes.
POWER	On-off switch for applying power to oscilloscope.
FOCUS	Controls sharpness of spot or trace.
SCALE ILLUM.	Controls graticule-scale illumination.
AC-DC	In the DC position, both the varying and dc components of the input waveforms are displayed. In the AC position, only the varying components of the input waveforms are displayed.
INPUT	Coaxial connector for accepting waveforms to be displayed vertically on the oscilloscope screen.
TRIGGER INPUT	Coaxial connector for accepting an external triggering signal for the time base when the black TRIGGER SELECTOR switch is in the +EXT. or the —EXT. position.
HORIZ. INPUT	Connector for accepting an externally derived horizontal-deflection signal.
SAWTOOTH OUT	Connector supplying a positive-going sawtooth having a peak value of about +150 volts. The rising part of the sawtooth coincides with the oscilloscope horizontal sweep, when the HORIZONTAL DISPLAY switch is in the NORM. or the MAG. position. The rate at which the sawtooth rises is controlled by the TIME/DIV. controls.
+GATE	Connector supplying a positive-going rectangular wave having a maximum value of about +30 volts. Its starting time and duration correspond to the starting time and duration of the positive-going part of the sawtooth available at the SAWTOOTH OUT connector.
CAL. OUT	Coaxial connector for supplying square-wave output voltage from calibrator at 100 cps ± about 30%.

CIRCUIT DESCRIPTION

VERTICAL-DEFLECTION SYSTEM

Preamplifier

The Vertical Amplifier in the Type RM16 Oscilloscope requires an input signal voltage of 0.1 v, peak-to-peak, to produce one division of **calibrated** deflection on the crt. In order to satisfy this condition, and to make the instrument applicable to a wide range of input voltages, a calibrated attenuation network and a Preamplifier are incorporated into the vertical-deflection system.

When the VOLTS/DIV. switch (shown on the Preamplifier circuit diagram) is in the .1 position, the signal is coupled through the X1 network—in which the attenuation is negligible—to the main Vertical Amplifier. The X1 network compensates for lead inductance in the input circuit. For settings of the VOLTS/DIV. switch between .2 and 50, the Attenuators are switched into the circuit, either singly or in tandem pairs, so that the input voltage to the main Vertical Amplifier is always .1 v for each division of crt deflection when the VARIABLE knob is in the CALIBRATED position.

The Attenuators are frequency-compensated voltage dividers. For low-frequency signals they are resistive dividers, and the degree of attenuation is proportional to the ratio of the resistances. The reason for this is that the impedance of the capacitors, at low frequencies, is so high that their effect in the circuit is negligible. As the frequency of the input signals increases, however, the impedance of the capacitances decreases and their effect in the circuit becomes pronounced. For high-frequency signals the impedance of the capacitances is so low, compared to the resistance of the circuit, that the Attenuators become capacitive voltage dividers. For these frequencies, the degree of attenuation is inversely proportional to the ratio of the capacitances.

The variable capacitor at the input to each Attenuator (except for the X1 network) provides a means for adjusting the input capacity of the Attenuator to equal that of the main Vertical Amplifier. Similarily, C441 provides a method of adjusting the input capacity of the Preamplifier. In this manner the probe, connected to the INPUT connector, works into the same input capacity regardless of the setting of the VOLTS/DIV. switch. In the "straight through" (X1) position, the probe works directly into the main Vertical Amplifier, so no adjustment is required for this network.

By means of the AC-DC switch (SW401) the signal may be either ac-coupled or dc-coupled to the Vertical Amplifier. In the AC position, the signal is coupled through C401; in the DC position, C401 is bypassed with a direct connection. When the VOLTS/DIV. switch is in any of the three positions marked AC ONLY, the AC-DC switch is electrically removed from the circuit and the signal is coupled through C401.

When working with very small voltages, greater sensitivity than that furnished by the main Vertical Amplifier may be required or desired. To provide this, the Preamplifier can be switched into the circuit by turning the VOLTS/DIV. switch to any of the positions marked AC ONLY. The Preamplifier is used in conjunction with either the X1, the X2 or the X5 Attenuator, depending on the setting of the switch, and provides three additional ranges of vertical sensitivity.

The Preamplifier, which has a **calibrated** signal gain of 10, consists of a single amplifier stage V454, a cathode follower output stage V463B, and a voltage-setting cathode follower V463A. The Voltage-Setting C.F provides a +175-volt source for the plate and screen circuits of V454, and for the plate of V463B.

The gain of the Preamplifier is regulated by the setting of the PREAMP GAIN ADJ. R454. This control regulates the gain of V454 over an approximate range of 7 to 17 by varying the degeneration in its cathode circuit. For **calibrated** operation, however, this control must be set so that the gain is exactly 10. (See Recalibration Procedure.)

High-frequency compensation for the Preamplifier is provided by a series-shunt peaking coil L450, and by series peaking coils L457 and L477. L450 and L477 provide a means for adjusting the circuit for optimum high-frequency response. R457 is included in the grid circuit of V463B to prevent parasitic oscillations that might occur.

Low-frequency accentuation for the Preamplifier is provided mainly by C446A in the plate circuit of V454. Together with R446 and R450, this circuit forms a low-frequency "boost" network to compensate for the attenuation in the cathode circuit, the screen circuit, and the rc coupling network between the Output C.F. and the Vertical Amplifier. The amount of compensation added to the circuit is, of course, fixed. The amount of attenuation, however, can be varied over a range with the L.F. ADJ. control R475. By adjusting the amount of attenuation to equal that of the compensation, low-frequency distortion in the amplifier is eliminated.

There are two protective devices incorporated in the design of the Preamplifier. One is the selenium rectifier SR454, which protects the electrolytic capacitor C454 from inverse voltage in the event the cathode circuit of V454 should go negative. This would occur, for example, if V454 were removed from its socket when the power was turned on. The other protective device is the neon lamp B463. This prevents the potential between the grid and cathode of V463B from exceeding the break-down rating of the tube in the interval from the time the instrument is first turned on and the time that V463 is warmed up to its operating condition.

Vertical Amplifier

The Vertical Amplifier consists of two stages of direct-coupled, push-pull amplification, each preceeded by a cathode follower. V483 is the signal-input cathode follower when the VOLTS/DIV. switch is in any position other than those marked AC ONLY (in other words, when the Preamplifier is not connected into the circuit). R484, bypassed by C484, prevents the grid from drawing excessive current in the event the stage should be overdriven when DC input coupling is used. R487 is a suppressor for parasitic oscillations.

The Input Amplifier stage, composed of V514 and V524, is a cathode-coupled phase inverter. That is, it converts a single-ended input signal to a push-pull output signal. The VARIABLE control, located between the two cathodes, regulates the gain of the stage over a 2½ to 1 range by varying the amount of degeneration in the cathode circuit.

When the Preamplifier is not connected into the circuit, as mentioned previously, the Input Amplifier stage receives its signal voltage from V483. The opposite cathode follower, V503, couples a fixed dc voltage from the VARIABLE ATTEN. BAL. control to the grid of V524. When this control is properly set, the cathode voltages at the two Input Amplifier tubes will be equal and no change in vertical trace positioning will occur as a result of any change in the setting of the VARIABLE gain control.

When the Preamplifier is connected into the circuit, by turning the VOLTS/DIV. switch to any of the positions marked AC ONLY, V503 becomes the signal-input cathode follower. This action removes V483 from the signal path by returning its grid circuit to ac ground through C482. The switching of Input C.F. tubes compensates for the 180-degree shift of signal polarity introduced by the Preamplifier. With this arrangement, positive-going portions of the input signal always produce an upward deflection of the crt beam. Thus, the Input Amplifier may receive its signal from either of the input cathode followers.

Vertical positioning of the crt beam is accomplished through the action of the VERTICAL POSITIONING control R531. This is a dual control, connected between +300 volts and ground. It is connected electrically so that as the voltage between ground and the movable arm in one increases, the voltage between ground and the movable arm in the other decreases. The voltage at the arm of each control can vary a maximum of 300 volts. The 300-volt variation is attenuated by a factor of 82 to 1.8 (the ratio of R530 to R513 on one side, and the ratio of R532 to R527 on the other) so that the maximum variation in voltage at the grids of V533 is about 6.5 volts. This change in grid voltage at the Driver C.F. stage will be reflected as a change in vertical deflection-plate voltage at the crt, since direct coupling is used between these two points.

The Input Amplifier stage, as well as all succeeding stages, contains high-frequency peaking coils to improve the high-frequency response of the amplifier. However, since direct-coupling is employed throughout, there is no low-frequency loss in the circuit and no low-frequency compensation is required.

The Input Amplifier is coupled to the Output Amplifier by the Driver C.F. V533. The GAIN ADJ. control, R544, sets the gain of the Output Amplifier to correspond with the front panel calibration when the VARIABLE control is turned full right to the CALIBRATED position.

Delay Line

The output signal from the Vertical Amplifier is coupled through the balanced Delay Line to the vertical-deflection plates of the crt. The function of the Delay Line is to retard the arrival of the waveform at the deflection plates until the crt has been unblanked and the horizontal sweep has been started. This delay insures that the very "front" of fast vertical signals can be observed. Because of the delay time and certain other characteristic, irregularities are introduced in the crt display when the delay line is misadjusted. And it is through analyzing the shape and position of these irregularities that we are able to effect the necessary adjustments.

So that you will better understand the adjustment procedure (described in the Recalibration Procedure, Section 7), we have outlined in the paragraphs that follow a brief description of the delay line operation and how it affects the crt display.

reflected energy travels down the delay line toward the input terminals, while at the same time the original step function is being traced on the crt screen.

The reflected energy reaches the delay-line input terminals in 0.25 microseconds (the delay time of the delay line) and is once again reflected since there are no terminating resistors to absorb the energy (waveform C in Fig. 5-1). As a result, the reflected energy is present at the crt deflection plates 0.5 microseconds (twice the delay-line delay time) after it was initially reflected. This energy is manifest in the crt display as an irregularity occuring 0.5 microseconds after the leading edge of the step function (waveform B in Fig. 5-1). Because the reflected energy is the result of a misadjustment in the delay-line terminating network, we call the ir-

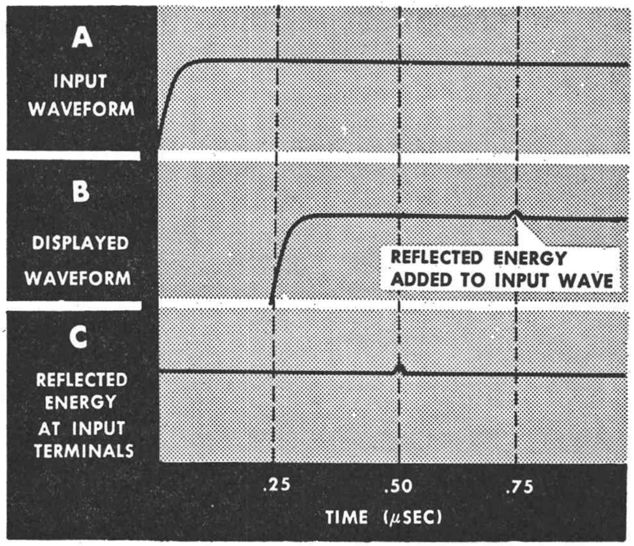


Fig. 5-1. Time relationship of delay-line signals.

The reflected energy is caused initially by a slight misadjustment in the delay-line termination network. As a result, the irregularity in the displayed waveform is called the Termination Bump.

Consider the sequence of events when a step function is applied to the delay-line input terminals (waveform A in Fig. 5-1). We'll assume for the moment that the delay line is in good adjustment except for two variable capacitors adjacent to the crt deflection plates.

0.25 microseconds after the application of the step function, the leading edge of the waveform will arrive at the crt deflection plates. The crt end of the delay line is terminated, and in normal operation the signal energy would be dissipated in the terminating resistors. However, the misadjustment of the two capacitors creates a slight impedance mismatch, resulting in the reflection of a small amount of signal energy. This

regularity on the displayed waveform the Termination Bump. For ease of discussion in the following paragraphs, we shall refer to the lapsed time from leading edge to Termination Bump as time T.

Consider next the effect of a misadjustment located $1/4$ of the delay-line length from the input terminals. Because the velocity of progagation is uniform over the length of the delay line, the step function will reach the point of misadjustment $1/4$ of the delay-line delay time after application. This is equivalent to $1/8$T. At this point, a small amount of energy is reflected back to the input terminals due to the impedance mismatch caused by the misadjustment. The re-

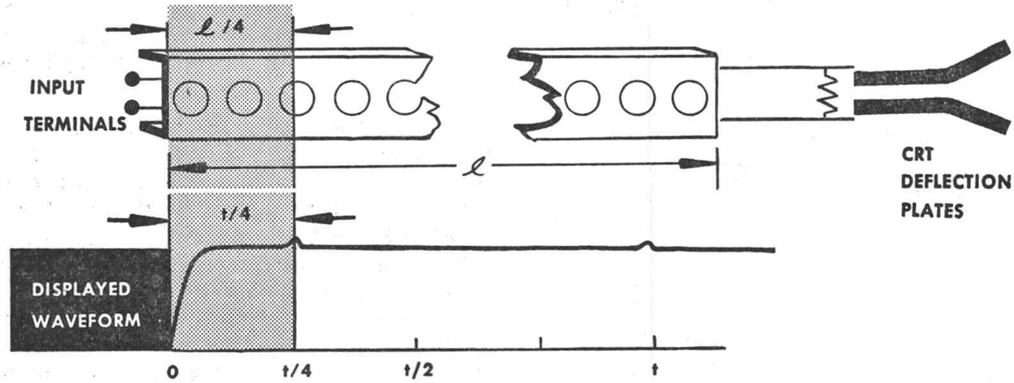


Fig. 5-2. Relationship of displayed waveform irregularities to delay-line misadjustment. The relative position of an irregularity between the start of the display and the Termination Bump corresponds to the relative position of the delay-line misadjustment between the input terminals and the terminating resistors.

flected energy will reach the input terminals $1/8$T after being reflected or $1/4$T after application of the step-function. This means, then, that the reflected energy will reach the crt deflection plates $1/4$T after the leading edge of the step function and will result in a bump located $1/4$ of the distance from the leading edge to the Termination Bump on the displayed waveform (see Fig. 5-2).

If the misadjustment of the previous paragraph were located elsewhere on the delay-line, it could be shown that its relative position between input terminals and termination network would correspond to the position of the resulting bump on the displayed waveform. It is this characteristic of the delay-line that allows us to locate and remedy a misadjustment.

Since the Delay Line is the load for the Vertical Output stage, it is elevated above ground by an amount equal to the plate voltage of the Output Amplifier stage. R593 and R594, in addition to terminating the line, are the plate load resistors for the output stage.

When **internal** triggering of the Time Base Generator is desired (black TRIGGER SELECTOR knob in either the + or —INT. position), a "sample" of the vertical output signal is used to develop the triggering pulse. The "sample" is obtained from a tap on a coil at the input to the Delay Line. This point provides a signal suitable for good triggering action, yet presents minimum loading to the Output Stage and the Delay Line. The "triggering" signal is coupled to the Time-Base Trigger circuit by the Trigger C.F. V563, shown on the Vertical Amplifier circuit diagram.

HORIZONTAL-DEFLECTION SYSTEM

Time-Base Trigger

The function of the Time-Base Trigger circuitry is to develop a negative-going triggering pulse to trigger the Time-Base Generator in the proper time sequence. The signal from which the negative-going triggering pulse is produced may emanate from one of three sources, as determined by the setting of the TRIGGER SELECTOR switch (black knob) SW20. When the switch is in the + or —EXT. position, an external signal is employed in the development of the triggering pulse. When the switch is in the + or —INT. position, the vertical signal itself is used to develop the triggering pulse. This was explained at the conclusion of the previous section. In the + or —LINE position of the switch, a voltage at the power line frequency is used to develop the triggering pulse.

In addition to selecting the source of the triggering voltage, switch SW20 (TRIGGER SELECTOR, black knob) also arranges the input circut of the Trigger-Input Amplifier so that a negative-going pulse is always produced at the plate of V35B regardless of whether the switch is in a + or in a — position.

The Trigger-Input Amplifier V14 is a polarity-inverting, cathode-coupled amplifier. The output is always taken from the pentode plate, but the grid of either stage may be connected to the input-signal source. When the black TRIGGER SELECTOR knob is in the — position (EXT., INT. or LINE range), the triode grid is connected to the input-signal source. The pentode grid is connected to a dc bias source, adjustable by means of the TRIGGERING LEVEL control. This bias voltage establishes the quiescent voltage at the pentode plate. When the TRIGGER SELECTOR knob is in the + position (for any of the three ranges), the pentode grid is connected to the input-signal source and the triode is connected to the bias source.

The voltage at the triode grid and the voltage at the pentode plate are in phase with each other; that is, they both go through ac zero in the same direction at the same time. Therefore, when the switch is in any of the — positions (the signal applied to the triode grid), the voltage at the plate of the pentode is in phase with the input-signal voltage. By this arrangement, the triode acts as a cathode follower, having a gain of approximately unity, and the signal voltage developed across the cathode resistor becomes the input signal to the pentode section.

When the switch is moved to any of the + positions, the pentode grid is connected to the input-signal source. With this configuration, the voltage at the plate of the pentode will be 180 degrees out of phase with the input-signal voltage. Thus, depending on the setting of the switch (+ or —), the pentode plate signal swing may be in phase, or 180 degrees out of phase, with the input-signal voltage.

The Schmitt Trigger consists of V35, A and B, connected as a dc-coupled multivibrator. In the quiescent state, i. e., ready to receive a signal, the pentode is conducting and its plate voltage is down. This holds the triode grid below cutoff, since the two circuits are dc-coupled by the voltage divider R35, R36 and R37. With the triode in a state of cutoff, its plate voltage is up; hence no output is being developed.

A negative-going signal is required at the pentode grid to drive the Schmitt Trigger into its other state in which a triggering pulse can be produced. However, the signal coupled to the pentode grid is a component of the vertical input signal, and therefore contains both negative- and positive-going voltages.

The negative-going portion will drive the pentode grid in the negative direction, and the cathodes of both tubes will follow the grid down. At the same time the pentode plate voltage starts rising, which causes the triode grid voltage to rise. With the triode grid going up and its cathode going down, the triode starts conducting. The cathodes will now follow the triode grid; hence the cathode voltages start going up. With the pentode grid down and its cathode up, the pentode cuts off. As the triode conducts its plate voltage drops, creating a negative step at the output. This transition occurs very rapidly, regardless of how slowly the pentode grid signal falls.

When the signal at the grid of the pentode starts in the positive direction, just the opposite will occur. That is, the pentode will start conducting again, the triode will be cutoff, and the circuit will revert to its original state with the triode plate voltage up. This completes the negative step voltage output from the Schmitt Trigger circuit.

The operation of the Schmitt Trigger circuit is exactly the same for both + and — positions of the black TRIGGER SELECTOR knob. However, since there is a reversal in signal polarity—between these two settings—at the output of the Trigger Input Amplifier, triggering will occur at different points with respect to the signal being observed. For example, when the switch is in the + position, triggering will occur during the positive slope of the waveform being observed. That is, the start of the trace will occur when the waveform is going in the positive direction. Conversely, when the switch is in the — position, the trace will start when the waveform is going in the negative direction.

The TRIGGER SELECTOR switch with the red knob, SW10, selects the type, or mode, of triggering. In the DC position, the vertical-input signal is dc-coupled from the Trigger C.F. to the Trigger-Input Amplifier, which in turn is dc-coupled to the pentode grid of the Schmitt Trigger. R22 isolates the pentode plate circuit of V14 from the capacitance of the switch; R24 isolates the pentode grid circuit of V35 from the switch.

In the AC position the switch capacitor C7 is connected into the input circuit; this, of course, removes any dc component of the input waveform. The Trigger-Input Amplifier, however, is still dc-coupled to the Schmitt Trigger stage.

In the AUTO. position of the switch, the Schmitt Trigger is converted from a bistable configuration to a recurrent configuration. This is accomplished by coupling the grid circuit of the triode section to the grid circuit of the pentode section via R31. In addition, the dc-coupling between the Trigger-Input Amplifier and the Schmitt Trigger is removed when the switch is in this position.

The addition of R31 to the circuit causes the Schmitt Trigger to free-run in the absence of a vertical-input signal. For example, assume the grid of the pentode section is just being driven into cutoff. The voltage at the pentode plate starts to rise, carrying with it the grid voltage of the triode section. The grid of the triode is coupled to the grid of the pentode through R31 and R24. This causes the grid voltage of the pentode to start rising. The time constant of the rc network R31, R24 and C23 is such that it takes about .01 second for the pentode grid voltage to rise exponentially from its starting point, below cutoff, to a value where plate current can flow.

As the pentode starts to conduct, its plate voltage drops, which in turn lowers the voltage at the triode grid. The voltage at the pentode grid then starts dropping exponentially toward cutoff. When the pentode grid reaches cutoff again, the circuit has completed one cycle of its approximately 50-cycle triangular waveform.

The range of voltage at the grid of the pentode, between pentode cutoff and triode cutoff, is about 3 volts when the circuit is used in the AUTO. mode (this is increased from about 0.5 volt, for the AC or DC mode, by the addition of R31 to the circuit). Since the pentode grid is never more than 3 volts from cutoff a triggering signal with a peak-to-peak amplitude of 3 volts or more can drive the grid to cutoff at any time and produce a trigger output. Smaller signals can also produce a trigger output, but only if they occur at a time when the sum of the signal voltage and the triangular grid voltage is sufficient to drive the pentode grid to cutoff. However, the duty cycle of operation is somewhat reduced when smaller triggering signals are being received.

With the circuit configuration just described, the horizontal sweep can be triggered with repetitive signals, over a wide range of frequencies, without readjustment. When not receiving triggers, the sweep continues at approximately a 50-cycle rate. Thus, in the absence of any vertical signal, the sweep generates a base line which indicates that the oscilloscope is adjusted to display any signal that might be connected to the vertical-deflection system.

When switch SW10 is in the HF SYNC position, the Time-Base Trigger circuits are bypassed and the input "triggering" signal is applied directly to the Time-Base Generator. This signal now acts as a synchronizing voltage, superimposed on the holdoff waveform (to be discussed in the section that follows). This synchronizes the Time-Base Generator at a sub-multiple of the triggering-signal frequency. This mode is useful for input signals in the range from 5 megacycles to 15 megacycles.

Time-Base Generator

The Time-Base Trigger produces a negative-going waveform which is coupled to the Time-Base Generator. This waveform is differentiated in the grid circuit of V135A to produce a sharp negative-going triggering pulse to trigger the Time-Base Generator in the proper time sequence. Positive-going pulses are also produced in the differentiation process, but they are not used in the operation of the Time-Base Generator.

The Time-Base Generator consists of three main circuits: a Bistable Multivibrator, a Miller Runup Circuit, and a Hold-Off Circuit. The Bistable Multivibrator consists of V135A, V145B and the cathode follower V135B. The essential components in the Miller Runup circuit are the Miller Tube V161B, the Runup C.F. V161A, the On-Off Diodes V152, the Timing Capacitor C160 and the Timing Resistor R160. The Hold-Off Circuit consists of the Hold-Off Driver V183A, the Hold-Off C.F. V183B, the Hold-Off capacitor C180 and the Hold-Off Resistor R181.

In the quiescent state, V135A is conducting and its plate voltage is down. This cuts off V145B through the cathode follower V135B, the voltage divider R141-R142, and the cathode resistor R143.

The quiescent state of the Miller Tube is determined by a dc network between plate and grid. This network consists of the neon lamp B167, the Runup C.F. V161A, and the On-Off Diode V152. The purpose of the dc network is to establish a voltage at the plate of the Miller Tube of such a value that the tube will operate above the knee, and thus over the linear region, of its characteristic curve.

In the quiescent state, the grid of the Miller Tube rests at about —2 volts. There is about a 1½-volt drop in the Runup On-Off Diodes, about 18.5 volts bias on the Runup C.F., and about a 55-volt drop across the neon lamp. This establishes a quiescent voltage of about +33 volts at the plate of the Miller Tube.

If the STABILITY control is now advanced, making the grid of V135A more negative, a point will be reached where a negative-going triggering pulse from the Schmitt Trigger stage will cause the Bistable Multivibrator to switch rapidly to its other state. That is, V135A will be cutoff and V145B will start to conduct. As V145B conducts, its plate voltage, and the voltage at the diode plates, drops. As a result the diodes are cutoff, which permits the grid of the Miller Tube and the cathode of the Runup C.F. to seek their own voltages. Any spiking that may occur, during this transition period, is attenuated by the R150-C150 network.

As there is no diode conduction at this time, the grid of the Miller Tube starts negative, since it is connected to —150 volts through the Timing Resistor R160. The plate of the Miller Tube then starts positive, carrying with it the grid and cathode of the cathode follower V161A. This raises the voltage at the top of the Timing Capacitor C160, which in turn raises the voltage at the grid of the Miller Tube and prevents it from going negative. The gain of the Miller Tube, as a Class A amplifier, is approximately 200. This means that a 150-volt change in plate voltage will maintain the grid voltage constant within three-quarters of a volt.

The Timing Capacitor C160 starts charging with current from the —150-volt bus. Since the voltage at the grid of the Miller Tube remains essentially constant, the voltage drop across the Timing Resistor, and hence the charging current through it, remains essentially constant. Thus, C160 charges linearly, and the voltage at the cathode of the Runup C.F. V161A rises linearly. Any departure from a linear rise in the voltage at this point will produce a change in the voltage at the grid of the Miller Tube in such a direction as to correct for the error.

The linear rise of voltage at the cathode of V161A is used as the sweep time base. Timing Capacitor C160 and Timing Resistor R160 are selected by means of the TIME/DIV. switch (SW 160). The Timing Resistor determines the current that charges the Timing Capacitor. By means of the TIME/DIV. switch, both the size of the capacitor being charged and the current charging the capacitor can be selected to cover a wide range of sawtooth slopes (sweep speeds). For high-speed sweeps the bootstrap capacitor C165 helps supply current to charge the stray capacitance at the plate of the Miller Tube, which permits the plate voltage to rise at the required rate.

If uncalibrated sweep speeds are desired, the VARIABLE TIME/DIV. (red knob) control may be turned away from the CALIBRATED position. This control, R162, varies the sweep speed over a 2½ to 1 range. Switch SW162 is ganged with the VARIABLE control in such a way that the UNCALIBRATED light comes on when the control is turned away from the CALIBRATED position.

As explained previously, the sweep speed (the speed at which the spot moves across the face of the crt) is determined by the timing circuit C160 and R160. The length of the sweep (the distance the spot moves across the face of the crt), however, is determined by the setting of the SWEEP LENGTH control R176. As the sweep voltage rises linearly at the cathode of V161A, there will be a linear rise in voltage at the arm of the SWEEP LENGTH control R176. This will increase the voltage at the grid and cathode of V183A, and at the grid and cathode of V183B. As the voltage at the cathode of V183B rises, the voltage at the grid of V135A will rise. When the voltage at this point is sufficient to bring V135A out of cutoff, the multivibrator circuit will rapidly revert to its original state with V135A conducting and V145B cutoff. The voltage at the plate of V145B rises, carrying with it the voltage at the diode plate V152B. The diode then conducts and provides a discharge path for C160 through R147 and R148, and through the resistance in the cathode circuit of V161A. The plate voltage of the Miller Tube now falls linearly, under feedback conditions essentially the same as when it generated the sweep portion of the waveform, except for a reversal of direction. The resistance through which C160 discharges is much less than that of the Timing Resistor (through which it charges). The capacitor current for this period will therefore be much larger than during the sweep portion, and the plate of the Miller Tube will return rapidly to its quiescent voltage. This produces the retrace portion of the sweep sawtooth, during which time the crt beam returns rapidly to its starting point.

The Hold-Off Circuit prevents the Time-Base Generator from being triggered during the retrace interval. That is, the hold-off allows a finite time for the Time-Base circuits to regain a state of equilibrium after the completion of a sweep.

During the trace portion of the sweep sawtooth the Hold-Off Capacitor C180 charges through V183A, as a result of the rise in voltage at the cathode of V183A. At the same time, the grid of V135A is being pulled up, through the Hold-Off C.F. V183B, until V135A comes out of cutoff and starts conducting. As mentioned previously, this is the action that initiates the retrace. At the start of the retrace interval C180 starts discharging through the Hold-Off Resistor. The time constant of this circuit is long enough, however, so that during the retrace interval (and for a short period of time after the completion of the retrace) C180 holds the grid of V135A high enough so that it cannot be triggered. However, when C180 discharges to the point that V183B is cut off, it looses control over the grid of V135A and the grid returns to the level established by the STABILITY control. The hold-off time required is determined by the size of the Timing Capacitor. For this reason the TIME/DIV. switch changes the time constant of the Hold-Off Circuit simultaneously with the change of Timing Capacitors.

The STABILITY control R110 regulates the dc level at the grid of V135A. In use, this control is adjusted so that the grid voltage is just high enough to prevent the circuit from free-running. Adjusted in this manner, a sweep will only be produced when a negative-going triggering pulse from the Schmitt Trigger can drive the stage into cutoff. For convenience, a PRESET Stability control can be connected into the circuit via switch SW110. When in this position a fixed negative dc voltage is obtained from R111 and applied to the grid of V135A. This control, adjusted at the factory, can be used in most triggering applications of the instrument. Where triggering may be critical, however, the variable STABILITY control should be used.

The positive rectangular pulse appearing at the cathode of V135B is coupled through the Unblanking C.F. to the grid circuit of the crt. This pulse, whose start and duration are coincident with that of the sweep portion of the sawtooth, unblanks the crt and permits the trace to be observed.

The unblanking pulse is also coupled through another cathode follower, V193B, to a jack on the front panel labeled +GATE OUT. This positive pulse, which starts at ground and rises to +30 volts, has a start and duration which are likewise coincident with that at the sweep portion of the sawtooth.

The sweep sawtooth voltage at the cathode of V161A, in addition to being coupled to the Horizontal Amplifier, is also coupled through the cathode follower V193A to a jack on the front panel labeled SAWTOOTH OUT. This provides a 150-volt linear rise in voltage, starting at zero volts with respect to ground.

Horizontal Amplifier

The Horizontal Amplifier consists of an input cathode follower, a driver cathode follower, a push-pull amplifier and an output cathode follower stage.

The sweep waveform is coupled to the grid of the Input C.F. V313B via the frequency-compensated voltage divider R310-R311. The Horizontal POSITIONING control R314A supplies a manually adjustable dc voltage to the grid of V313B for horizontal positioning of the crt beam. The R315-C315 network produces a small step at the start of the waveform at the faster sweep speeds. This step is necessary to compensate for the bandpass-limiting effect of the stray capacitance in the amplifier. By its application the waveform will start linearly at the faster sweep speeds. The Input C.F. V313B provides the necessary low impedance to drive the switch capacitances and the Driver C.F. V313A; the Driver C.F. isolates the Output Amplifier from the HORIZONTAL DISPLAY switch.

In the MAG. position of the HORIZONTAL DISPLAY switch, the waveform is coupled by cathode follower V313A to the Output Amplifier stage. This stage, V354A and V374A, a cathode-coupled phase inverter, converts the single-ended input to a push-pull output. The waveform is then coupled by the Output C.F. stage, V354B and V374B, to the horizontal-deflection plates. The MAG. GAIN ADJ. R358 varies the degeneration in the cathode circuit of the Output Amplifier and thus sets the gain of the stage. C358 reduces the degeneration at higher frequencies and thus compensates the amplifier for faster sweep speeds. Bootstrap capacitors C350 and C372 also improve the response at the faster sweep speeds by supplying current from the output cathode followers to charge the stray capacitance at the plates of the Output Amplifier. Neon lamp B300 is connected in the circuit when the HORIZONTAL DISPLAY switch is in the MAG. position to indicate that the magnifier circuits are in operation.

In the NORM. position of the HORIZONTAL DISPLAY switch the gain of the amplifier is reduced by a factor of five by a feedback loop between the cathode circuit of V354B and the grid circuit of V313A. This loop consists of R333 shunted by C333, and R324 and R325 shunted by C324. The amount of feedback, and hence the gain of the amplifier, is adjusted by means of R325, the HORIZ. GAIN ADJ. In the normal position of the HORIZONTAL DISPLAY switch (NORM.) both the MAG. GAIN ADJ. and the

HORIZ. GAIN ADJ. will vary the gain; for this reason the MAG. GAIN ADJ. must only be set when the HORIZONTAL DISPLAY switch is in the MAG. position.

The NORM./MAG. REGIS. control R335 adjusts the voltage at the grid of V313A to equal the voltage at the cathode of V313B when the spot is in the center of the screen and the HORIZONTAL DISPLAY switch is in the NORM. position. This insures that the portion of the waveform within the center two graticule divisions, when the HORIZONTAL DISPLAY switch is in the NORM. position, will be expanded the full length of the graticule when the HORIZONTAL DISPLAY switch is set to the MAG. position.

In the EXT. position of the HORIZONTAL DISPLAY switch the Driver C.F. is connected to an external binding post on the front panel marked HORIZ. INPUT. With this arrangement the horizontal waveform is obtained from an external source rather than from the Time-Base Generator.

The HORIZ.-INPUT ATTEN. control R330 varies the voltage at the grid of V313A to equal the voltage at the cathode of V313B when the spot is in the center of the screen and the HORIZONTAL DISPLAY switch is in the NORM. position. This insures that the portion of the waveform within the center two graticule divisions, when the HORIZONTAL DISPLAY switch is in the NORM. position, will be expanded the full length of the graticule when the HORIZONTAL DISPLAY switch is set to the MAG. position.

In the EXT. position of the HORIZONTAL DISPLAY switch the Driver C.F. is connected to an external binding post on the front panel marked HORIZ. INPUT. With this arrangement the horizontal waveform is obtained from an external source rather than from the Time-Base Generator. The HORIZ. INPUT ATTEN. control R330 varies the input voltage so that the waveform may be adjusted for the desired amplitude. In the EXT. position, horizontal beam positioning is provided by R314B rather than by R314A.

POWER SUPPLY

Plate and filament power for the tubes in the Type RM16 Oscilloscope is furnished by a single power transformer T600. The primary has two equal tapped windings; these may be connected in parallel for 105- to 125-volt operation, or in series for 210- to 250-volt operation. Selenium rectifiers are employed for the three separate full-wave, bridge-type, power supplies. The three supplies furnish regulated dc voltages of —150 volts, +100 volts and +300 volts. The +300-volt supply also has an unregulated output of about +400 volts for the oscillator tube in the high-voltage supply for the crt. It is unnecessary to regulate this supply as the high-voltage power supplies have their own regulation circuits.

Reference voltage for the —150-volt supply is established by a gas diode Voltage-Reference Tube V609. This tube, which has a constant voltage drop, establishes a fixed potential of about —84 volts at the grid of V606B, one-half of a Difference Amplifier. The grid potential for the other half of the Difference Amplifier, V606A, is obtained from a voltage divider consisting of R616, R617 and R618. R617, the —150 ADJ., determines the percentage of total voltage that appears at the grid of V606A and thus determines the total voltage across the divider. When this control is properly adjusted the output voltage is exactly —150 volts.

Should the loading on the supply tend to change the output voltage, the potential at the grid of V606A will change in proportion, and an error voltage will exist between the two grids of the Difference Amplifier. The error signal is amplified by V606B, whose plate is dc-coupled to the grid of the Series Tube V617B. The error voltage appearing at the grid of the Series Tube will change the voltage drop across the tube, and hence change the voltage at the plate of the tube. This change in voltage at the plate of the Series Tube, which will be in a direction to compensate for the change in the output voltage, is coupled through C601A to the output and thus pulls the output voltage back to its established value of —150 volts. C614 improves the ac gain of the feedback loop, and thus increases the response of the circuit to sudden changes in output voltage.

The —150-volt supply serves as a reference for the +100-volt supply. The voltage divider R641-R642 establishes a voltage of essentially zero at the grid of the Amplifier V636. (The actual voltage at this grid will be equal to the bias voltage required by the tube.) If the loading should tend to change the output voltage, an error voltage will appear at the grid of the Amplifier. The error voltage will be amplified and will appear at the grid of the Series Tube V637. The cathode of V637 will follow the grid, and thus the output voltage will be returned to its established value of +100 volts. C638 improves the response of the regulator circuit to sudden changes in output voltage.

A small sample of the unregulated-bus ripple will appear at the screen of V636 through R635. This ripple signal appearing at the screen (which acts as an injector grid) will produce a ripple component at the grid of V637 which will be opposite in polarity to the ripple appearing at the plate of V637. This tends to cancel the ripple at the cathode of V637, and hence reduces the ripple on the +100-volt bus. This same circuit also improves the regulation of the circuit in the presence of line voltage variation.

The +300-volt supply functions in the same manner as the +100-volt supply. Rectified voltage from terminals 18 and 19 of the power transformer is added to the voltage supplying the +100-volt regulator to supply power for the +300-volt regulator. As mentioned previously, the +300-volt supply also provides an unregulated +400-volt output for the crt high-voltage supply.

CRT CIRCUIT

High-Voltage Supply

A single 60-kilocycle Oscillator circuit furnishes energy for the two power supplies that provide accelerating voltages for the crt. The Oscillator is in the Hartley type, whose main components are V810 and the primary of T800 tuned by C811.

The rectifier circuits are of the half-wave type, with capacitor-input filter networks. Separate supplies are required for the grid and cathode circuits in order to provide dc-coupled unblanking to the grid supply. V822 supplies about —1850 volts for the grid of the crt (the actual voltage depends on the setting of the INTENSITY control). V832 supplies —1675 volts for the cathode. With the mean potential in the deflection area +175 volts and the cathode at —1675 volts, the accelerating potential for the crt beam is 1850 volts.

In order to provide a constant deflection sensitivity in the oscilloscope, and thereby maintain its calibration, it is necessary that the accelerating potentials in the crt remain constant. This is accomplished by regulating the grid and cathode supplies by comparing a sample of the high voltage to the regulated —150-volt supply. The "sample" voltage, obtained from the arm of R841 (H.V. ADJ.), is applied to the grid of V806B; the cathode of this tube is connected to the regulated —150-volt supply. The error signal is amplified by V806B and V806A. The output of V806A varies the screen voltage of the Oscillator tube, thus controlling its output.

Unblanking

As mentioned previously, dc-coupled unblanking is accomplished by employing separate high-voltage supplies for the grid and cathode. The cathode supply is tied to the +100-volt supply via the decoupling network R832 and C832. The grid supply, on the other hand, is not tied to any other supply and is therefore "floating". The unblanking pulses from the Time-Base Generator are transmitted to the grid of the crt via the floating grid supply.

At the faster sweep speeds the stray capacitance in the circuit would make it difficult to move the floating supply fast enough to unblank the crt in the required time. To overcome this, an isolation network composed of C822, R822 and R826 is employed. The fast leading edge of the unblanking pulse, at the faster sweep speeds, is coupled directly to the grid of the crt via C822; the power supply itself is not appreciably moved during this time due to the isolating resistors R822 and R826.

For longer unblanking pulses (at slower sweep speeds) the stray capacitance of the circuit is charged through R822; this holds the grid at the unblanked potential for the duration of the pulse.

CALIBRATOR

The Calibrator is a square-wave generator whose approximately 1-kilocycle output is available at a front-panel jack labeled CAL. OUT. It consists of a Multivibrator, V875, connected so as to switch the Cathode Follower V883 between two operating states—cutoff and conduction.

During the negative portion of the Multivibrator waveform the grid of V883 is driven well below cutoff and the cathode rests at ground potential. During the postive portion of the waveform the grid of V883 rises to slightly less than 100 volts. By means of the CAL. ADJ. R879, the grid voltage can be adjusted so that the voltage at the CAL. TEST PT (cathode) can be set to exactly 100 volts.

The Calibrator C.F. has a calibrated tapped voltage divider for its cathode resistor. By means of the VOLTS, PEAK TO PEAK switch, eleven calibrated voltages from .05 v to 100 v are available.

MAINTENANCE

PREVENTIVE MAINTENANCE

Air Filter

Your Type RM16 Oscilloscope is cooled by filtered, forced air. The instrument is equipped with a washable air filter, constructed of aluminum wool coated with an adhesive. If the filter becomes dirty it may restrict the flow of air and cause the instrument to overheat. The filter should be inspected, and cleaned or replaced if necessary, every three to four months.

To remove the loose dirt, the filter may be rapped gently on a hard surface. It should then be rinsed briskly, from the dirty side, with hot water. Or, if preferred, it may be washed with hot, soapy water. After rinsing and drying thoroughly, the filter should then be coated with "Handi-Koter" or "Filtercoat", products of the Research Products Corporation. These products are generally available from air-conditioner suppliers.

Fan Motor

The bearings in the fan motor should be oiled every three to four months. Use a good grade of light machine oil, and apply only a drop or two.

Soldering Precautions

In the production of Tektronix instruments, a special silver-bearing solder is used to establish a bond to the ceramic terminal strips. This bond may be broken by repeated use of ordinary tin-lead solder, or by the application of too much heat. However, occasional use of ordinary solder will not break the bond if too much heat is not applied.

For shops responsible for the maintenance of several Tektronix instruments, it is advisable to have a stock of solder containing about 3% silver. This type of solder is used frequently in printed circuitry and should be readily available. Or, it can be purchased directly from Tektronix in one-pound rolls (order by part number 002-664).

REPLACEMENT PARTS

Standard Parts

Replacement components can be obtained from Tektronix at current net prices. However, since most of the components are standard electronic and radio parts, they can generally be obtained locally in less time than required to obtain them from the factory. Before ordering or purchasing parts, be sure to consult the Parts List to determine the tolerances required.

Note: R441 in the Preamplifier, and R483 in the Vertical Amplifier, are specially Selected parts (as noted in the parts list). Because these resistors have been specially selected for value and tolerance, they will not, in general, be replaceable from dealer's stocks. These resistors (part number 312-583) may be obtained from the local Tektronix Field Engineering office, or directly from the factory.

Tektronix-Manufactured Parts

Tektronix manufactures almost all of the mechanical parts, and some of the electronic components, used in your instrument. When ordering mechanical parts, be sure to describe the part completely to prevent delays in filling your order.

The Tektronix-manufactured electronic components are so noted in the parts list. These components, as well as the mechanical parts, must be obtained from the factory or from the local Tektronix Field Engineering office.

Since the production of your instrument, some of the Tektronix-manufactured components may have been superceded with improved components. The part numbers for these new components will not be listed in your manual. If you order a Tektronix-manufactured component, and if the component has been superceded by a new, improved component, the new component will be shipped in place of the original component. Your local Tektronix Field Engineering office has knowledge of these changes and may call you if a change in your purchase order is necessary.

Replacement-information notes sometimes accompany the improved component to aid in its installation.

Parts Ordering Information

You will find a serial number on the frontispiece of this manual. This is the serial number of the instrument for which this manual was prepared. Be sure that the number on the manual matches the serial number of the instrument when ordering parts from the manual.

Each part in your instrument has a 6-digit Tektronix part number. This number, together with a description of the part, will be found in the parts list. When ordering parts, be sure to include both the description of the part and the part number. For example, a certain resistor should be ordered as follows: R160A, 100 k, 1/2 w, Fixed, Precision, 1%, part number 309-045, for a Type RM16 Oscilloscope, Serial Number ________. When parts are ordered in this manner we are able to fill your orders promptly, and delays that might result from transposed numbers (in the part number) are avoided.

NOTE

Always include the instrument TYPE and SERIAL NUMBER in any correspondence concerning this instrument.

TROUBLESHOOTING

PRELIMINARY INSPECTION

If your Type RM16 Oscilloscope fails to operate, make sure that it is properly connected to a source of power. If the pilot lamp on the front panel, and the fan at the rear of the instrument, do not come on when the instrument is turned on, check the source of power, the power cord connections and the fuse.

If the instrument is turned on, but no spot or trace is visible on the crt, check the position and intensity controls. Be sure that an input signal is not driving the beam off the screen.

Although your Type RM16 Oscilloscope is a complex instrument, it can be conveniently divided into basic circuits, as shown on the Block Diagram. The first circuit to check, for practically any type of trouble, is the low-voltage power supply. Proper operation of every circuit in the Type RM16 Oscilloscope depends on proper operation of the regulated power supplies.

The low-voltage supply can be checked at the points shown in the Bottom View pull-out sheet. If an improper voltage reading is obtained at any of the indicated points, the first thing to suspect is the tubes. Make sure that any tubes found to be good, however, are returned to their original socket. Color-coded wires, following the standard RETMA code, are used to identify the regulated supply voltages. The —150-volt bus wire is coded brown, green, brown; the +100-volt bus is coded brown, black, brown; and the +300-volt bus is coded orange, black, brown. The widest stripe always identifies the first color in the code.

For any troubles involving the loss of vertical and/or time-base calibration, the high-voltage supply must also be checked. This voltage can be measured at the —1675 TEST PT., also shown on the Bottom View pull-out sheet.

WARNING

Be careful of the power-supply voltages. The lower-voltage buses are considerably more dangerous than the high voltages in the crt circuit, due to the higher current capabilities and the larger filter capacitors used.

If the power supplies prove to be operating normally, the next step in troubleshooting an oscilloscope is to isolate the source of the trouble down to a particular circuit. The procedure for doing this is explained in the section that follows, entitled "Trouble Analysis and Circuit Isolation." Once the circuit at fault is known, you can then troubleshoot within this circuit to locate the component (or components) at fault. The Circuit Description for the circuit involved may prove useful when troubleshooting within a given circuit.

Circuit failure is often caused by tube failure. If replacement of a defective tube does not correct the trouble, then check that components through which the tube draws current have not been damaged. Shorted tubes will sometimes overload plate-load and cathode resistors.

NOTE

After servicing the Type RM16 Oscilloscope, it is important to check its calibration. For this, refer to the Recalibration Procedure section of this manual.

TROUBLE ANALYSIS AND CIRCUIT ISOLATION

Troubles that may be produced by a circuit failure in the Type RM16 Oscilloscope are as follows:

1. No spot or trace.
2. Insufficient or no vertical deflection.
3. Insufficient or no horizontal deflection.
4. Nonlinear horizontal sweep.
5. Improper sweep timing (horizontal sweep linear).
6. Improper triggering.
7. Waveform distortion.

As mentioned previously, the purpose of this section is to help you isolate the source of trouble to a particular section or circuit. Once the faulty circuit is known, the component(s) causing the trouble can be located by normal trouble-shooting procedures; i.e., voltage and resistance measurements, tube and component substitution.

1. No spot or trace.

When no spot or trace is visible on the crt, the circuit at fault can be:

a. The low-voltage power supply (which will also affect the high-voltage supply.)

b. The high-voltage power supply and the crt circuit.

c. The crt itself.

d. The vertical amplifier and/or the delay line.

e. The horizontal amplifier.

f. The time-base generator.

If the power supplies are operating normally, the following checks can be made to isolate the circuit causing the trouble. Short the vertical deflection plates together (at the neck pins on the crt) with a screwdriver. (Be careful not to short the vertical neck pins to any other pins, or to the metal tube shield.) Adjust the Horizontal POSITIONING control and see if the spot or trace appears on the crt. If so, a state of unbalance in the vertical-deflection system is indicated.

Next, short together the plates of the Output Amplifier (V544-V554). If the trace reappears, the Delay Line can be eliminated as the source of the trouble. The shorting strap can now be moved back, across correspondingly-opposite sides of the Vertical Amplifier, until a point is reached where the trace no longer appears. The stage immediately following this point will be the one in which the unbalance is being produced.

If the spot or trace does not appear, during the previous check, turn the instrument off and remove the leads that connect to the horizontal-deflection plates (make sure that the metal clips on the end of each lead do not touch the chassis). Turn the instrument back on and (after warmup) adjust the Vertical POSITIONING control. If the spot now appears on the crt, either the Horizontal Amplifier or the Time-Base Generator is causing the trouble.

To determine which circuit is at fault, reconnect the leads to the horizontal-deflection plates and turn the HORIZONTAL DISPLAY switch to the EXT. position. If the spot now reappears, the Horizontal Amplifier is in balance, and the trouble is being caused by an inoperative condition in the Time-Base Generator. To troubleshoot this circuit, turn the HORIZONTAL DISPLAY switch to the NORM. position, and turn the STABILITY control to the free-running (full right) position. Next, turn the TIME/DIV. switch through its range. If a sweep or trace appears for some positions of the switch, the trouble will be occurring in the components associated with the Timing Switch.

If no trace appears in any position of the TIME/DIV. switch, replace the tubes in the Time-Base Generator one at a time. Make sure that all tubes found to be good are returned to their original socket. If this does not reveal the source of the trouble, the voltages throughout the circuit can be checked. In particular, check to see that the STABILITY control varies the voltage at the grid of V135A. Neon lamp B167 is an important part of the Time-Base circuit; check to see that it is not burned out.

It is important that you understand the operation of the Time-Base Generator before proceeding with an extensive investigation of the circuit. For this reason we suggest that you thoroughly study that portion of the Circuit Description that pertains to this circuit.

If no spot appeared on the crt when the HORIZONTAL DISPLAY switch was turned to the EXT. position, the Horizontal Amplifier is causing the trouble. The faulty stage in this circuit can be isolated by shorting together correspondingly-opposite sides of the amplifier and checking for a spot or trace on the crt. This is the same procedure that was explained in troubleshooting the Vertical Amplifier.

If none of the previous checks indicates the source of the trouble, a defective crt is indicated.

2. Insufficient or no vertical deflection.

If there is no vertical deflection on the crt, an inoperative condition in the vertical-deflection system is indicated. The source of this trouble can be:

a. The delay line.

b. The vertical amplifier.

If the trace can be moved with the Vertical POSITIONING control, the trouble is originating ahead of the control in one of the input stages to the Vertical Amplifier (Input C.F., Input Amplifier).

If the trace cannot be moved with the Vertical POSITIONING control, one of the stages following the control, or the Delay Line, is inoperative. In either of the above cases the tubes should first be replaced. If the trouble still exists, connect a voltmeter between the two plates of the Output Amplifier (V544-V554). If the voltage at this point varies as the Vertical POSITIONING control is rotated, the Delay Line is causing the trouble. If the voltage at this point does not vary, the voltmeter can be moved back, point by point, across opposite sides of the amplifier. The stage producing the trouble will be indicated when a point is reached where the voltage does vary as the Vertical POSITIONING control is adjusted.

If there is some vertical deflection on the crt, but not enough to correspond to the calibrated value, the Vertical Amplifier can be investigated for insufficient gain. If there is only a slight deficiency in the deflection, as will usually be the case, the amplifier can generally be recalibrated for gain. Refer to the Recalibration Procedure for this. However, if the amplifier cannot be recalibrated, or if the decrease in gain is more pronounced, it will be necessary to check the tubes and circuit components.

If the trouble described in this section only appears when the VOLTS/DIV. switch is in one of the positions marked AC ONLY, the trouble is originating in the Preamplifier. Or, if the trouble only appears in one position of the VOLTS/DIV. switch, the Attenuator(s) associated with this setting of the switch will be at fault.

3. Insufficient or no horizontal deflection.

If there is no horizontal deflection on the crt, the circuit at fault can be:

a. The time-base generator.

b. The horizontal amplifier.

The operation of the Time-Base Generator can be checked from the front panel. Set the HORIZONTAL DISPLAY switch to NORM., the TIME/DIV. switch to .5 SEC., and adjust the STABILITY control for a free-running sweep (full right). Connect a voltmeter between the SAWTOOTH OUT connector and ground. If the voltage varies between zero and +150 volts, as the Miller circuit runs up and back, the Time-Base Generator is operating properly. No voltage variation at this jack indicates an inoperative Time-Base circuit.

When the trouble has been isolated to either the Time-Base Generator or the Horizontal Amplifier, the circuit at fault can be located by following the procedure outlined in Section 1.

If there is some horizontal deflection on the crt, but not enough to cover the ten-division length of the graticule, the trouble will either be due to insufficient output from the Time-Base Generator, or to insufficient gain in the Horizontal Amplifier.

The Time-Base Generator can be checked in the same manner as described previously. That is, by measuring for a 150-volt variation at the SAWTOOTH OUT connector, at a slow sweep rate. If this reading is not obtained, the Time-Base Generator is at fault, and its circuitry can be investigated. The SWEEP LENGTH control (R176) is very important in this respect, and its setting should be checked first. For the proper adjustment of this control, refer to the Recalibration Procedure.

If a voltmeter indicates the proper reading at the SAWTOOTH OUT connector, the Horizontal Amplifier will be the circuit at fault. There are two gain adjustments in this circuit: the HORIZ. GAIN ADJ. (325) and the MAG. GAIN ADJ. (R358). Any adjustment of these controls, however, will also affect the sweep timing. Be sure to refer to the Recalibration Procedure before making any adjustments in the Horizontal Amplifier.

4. Nonlinear horizontal sweep.

The linearity of the horizontal-deflection circuit can be checked by connecting a marker-generator to the Vertical INPUT connector and adjusting the Time-Base controls for a stationary display. If the displayed markers are not equally spaced across the graticule, a nonlinear horizontal sawtooth, at the horizontal deflection plates, is indicated. This can be caused by nonlinear amplification in the Horizontal Amplifier, or by nonlinear operation of the Time-Base Generator.

If another oscilloscope is available, the linearity of the Time-Base Generator can be checked by observing the sawtooth available at the SAWTOOTH OUT connector. If the **slope** of the trace portion of the sawtooth is constant, the Time-Base Generator is producing a linear sawtooth and the nonlinearity is being produced in the Horizontal Amplifier. If the **slope** of the trace is not constant, however, the nonlinearity is being produced by the Time-Base circuitry.

5. Improper sweep timing (horizontal sweep linear).

If the timing of the horizontal sweep appears to be improper, check to see if this is occuring in all positions, or just in certain positions, of the TIME/DIV. switch. If the timing appears to be off in all positions of the switch, the Horizontal Amplifier will probably be out of adjustment. Two adjustments, the HORIZ. GAIN ADJ. (R325) and the MAG. GAIN ADJ. (R358), affect the timing at all sweep rates. Refer to the Recalibration Procedure for the adjustment of these controls.

If the timing is off in just one setting, or in just one group of settings, of the TIME/DIV. switch, one (or more) of the components associated with the Timing Switch have probably changed in value. There are three variable capacitors associated with this switch: C160A, C160C and C160E. These capacitors should be adjusted only if the timing in the μSEC range appears to be off.

6. Improper triggering.

If the waveform you are observing cannot be triggered (locked into position) properly, the trouble can be:

a. The trigger-pickoff circuit (Trigger C.F. V563) in the vertical amplifier.

b. The time-base trigger circuit.

c. The time-base generator circuit.

The operation of the Trigger C.F. can be checked as follows: connect an external triggering signal (preferably the signal-input waveform) to the TRIGGER INPUT connector. Set the black TRIGGER SELECTOR knob to EXT. (+ or —). Check to see if the waveform can now be triggered. If so, the Trigger C.F. stage V563 is at fault; it is not passing the internal signal that develops the triggering pulse.

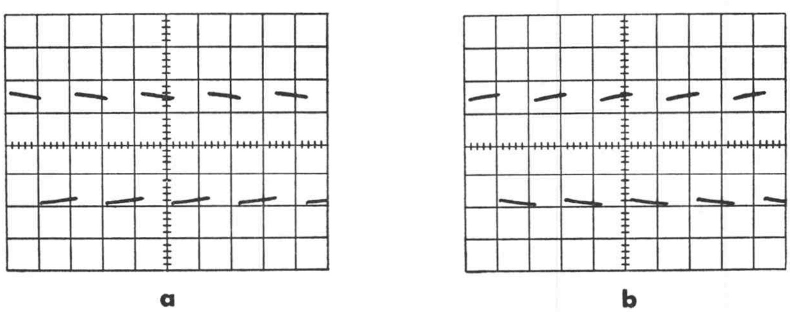


Fig. 6-1. Two types of low-frequency distortion.

If the waveform cannot be triggered in either the INT. or EXT. positions of the TRIGGER SELECTOR switch, some circuit in either the Time-Base Trigger or the Time-Base Generator is not operating properly. The Time-Base Generator can be eliminated if the trace can be turned off and on with the STABILITY control.

7. Waveform distortion.

Waveform distortion can be divided into two categories: (a) low-frequency distortion, illustrated in Fig. 6-1, and (b) high-frequency distortion, illustrated in Fig. 6-2. Any low-frequency distortion apparent in the waveform will be produced by the Preamplifier. The main Vertical Amplifier is dc-coupled; therefore its response is flat down to dc.

Low-frequency attenuation will produce the type of distortion shown in Fig. 6-1(a). This is caused by cathode- and screen-bypass capacitors, and by coupling capacitors. Before attempting any component replacement, however, be sure to check the adjustment of the L.F. ADJ. control R475, as explained in the Recalibration Procedure.

Overcompensation of low frequencies is illustrated in Fig. 6-1(b). This condition is produced by excessive low-frequency "boost". Refer to the Circuit Description for an explanation of how the "boost" circuit operates.

NOTE: Low-frequency distortion can also be produced by an improperly adjusted probe. Refer to the article on "Use of Probes", page 4-7.

High-frequency distortion can be produced in the Attenuators (shown on the Preamplifier diagram), the Preamplifier, the main Vertical Amplifier, and the Delay Line. When the VOLTS/DIV. switch is in the .1 (straight through) position the Attenuators and the Preamplifier are bypassed. Any distortion observed in the waveform, when the switch is in this position, will be produced by either the Vertical Amplifier or the Delay Line.

Insufficient high-frequency peaking, which limits the risetime and consequently the bandwidth, will produce the rounded-corner type of distortion illustrated in Fig. 6-2(a). Tubes are often a cause of this type of distortion. Shorted, or partially shorted, peaking coils are another common source.

The overshoot condition, illustrated in Fig. 6-2(b), is the result of excessive high-frequency peaking, and is produced by improperly adjusted peaking coils. The "wrinkle" condition, shown in Fig. 6-2(c), is produced by an improperly adjusted Delay Line. Refer to the Recalibration Procedure for the Delay Line adjustment procedure.

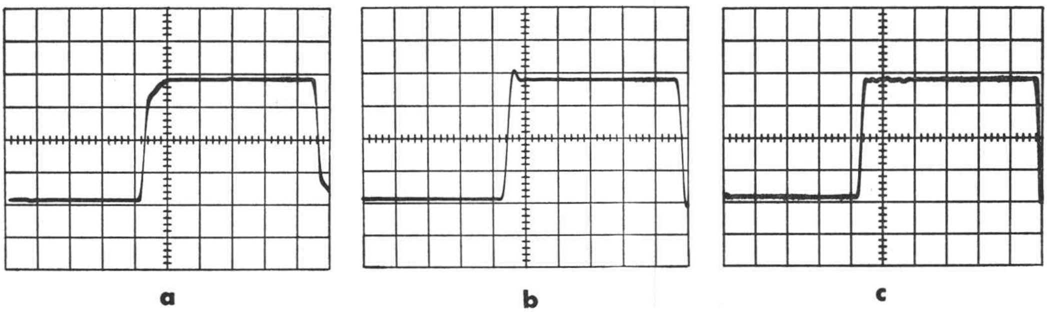


Fig. 6-2. Three types of high-frequency distortion.

RECALIBRATION PROCEDURE

The Type RM16 Oscilloscope is a stable instrument and should not require frequent recalibration. However, it will be necessary to recalibrate certain parts of the instrument when tubes or components are changed, and a periodic recalibration is desirable from the standpoint of preventive maintenance. In the instructions that follow, the steps are arranged in the proper sequence for a full recalibration of the instrument. Each numbered step contains the information necessary to make one adjustment. The location of each adjustment can be found by referring to either the Top View pull-out sheet or the Bottom View pull-out sheet.

Outline of Procedure

For purposes of recalibration, the Type RM16 Oscilloscope can be divided into five distinct parts: (1) the power-supply, calibrator and crt circuits, (2) the triggering circuits, (3) the horizontal-amplifier and time-base generator, (4) the vertical amplifier and (5) the delay line. Calibration adjustments made in any one of these categories will frequently affect another adjustment in the same category. For example, the HORIZ. GAIN ADJ. control affects the calibration of the time-base generator at all sweep speeds when the HORIZONTAL DISPLAY switch is in the NORM. position, and therefore affects the adjustment of C160E, the 10-microsecond per division timing adjustment. On the other hand, calibration adjustments made in one category will usually have little or no effect on adjustments in another category. There are a few exceptions, the most notable being the power-supply voltage adjustments.

Interaction of Adjustments

If you find it necessary to effect a single adjustment without recalibrating the rest of the instrument, it is most important that you be fully aware of the interaction of adjustments. Generally speaking, the interaction of controls will be apparent in the schematic diagram. If you are aware of the interaction of certain adjustments, you can refer to a particular adjustment procedure and make the adjustment without performing unnecessary steps. If you are in doubt, however, check the calibration of the entire section on which you are working. For example, if you make an adjustment in the horizontal-deflection system, check all of the adjustments listed under that heading in these instructions.

EQUIPMENT REQUIRED

The following equipment or its equivalent is necessary for a full recalibration of the Type RM16 Oscilloscope.

1. DC voltmeter (at least 5000 ohms per volt) calibrated for an accuracy within 1% at 100 volts, 150 volts and 300 volts, and calibrated for an accuracy within 3% at 1675 volts. Few portable test meters have comparable accuracy, particularly after a period of use. Be sure your meter is accurate.

2. Accurate rms-reading ac voltmeter, 0-150 volts. (0-250 or 0-300 for 210- to 250-volt operation).

3. Variable autotransformer (Powerstat, Variac, etc.) having a rating of at least 3 amperes.

4. Time-Mark Generator, Tektronix Type 180 or Type 181.

If neither of these instruments is available, it will be necessary to substitute a time-mark generator having output markers of 1-, 10- and 100-microsecond intervals, and a sine-wave output of 10 megacycles, with an accuracy of at least 1%.

5. Square-Wave Generator, Tektronix Type 105, with a type B52-R Terminating Resistor, a Type B52-L10 "L" Pad and a Type P52 Coaxial Cable.

A Tektronix Type 105 Square-Wave Generator is used, in these instructions, to describe the technique of adjusting the high-frequency compensation of the attenuators and the vertical amplifier. If you do not have a Tektronix Type 105 Generator, it will be necessary to substitute a square-wave generator with the following specifications: (1) output frequencies of approximately 50 cycles, 1 kilocycle and 400 kilocycles, (2) risetime no more than 20 millimicroseconds (when properly terminated), and (3) output amplitude variable from about 40 millivolts to 100 volts.

6. Constant-Amplitude Signal Generator, Tektronix Type 190 or Type 190A.

A Tektronix Type 190A Signal Generator is used in these instructions, to describe the technique of measuring the bandwidth of the vertical amplifier in the RM16. To make this measurement, it is necessary to have available at the INPUT connector of the RM16 a signal variable in frequency from 1 megacycle to over 12 megacycles and having at least two amplitudes: 30 millivolts and 300 millivolts. It is also necessary that the output be adjustable (manually or automatically) for equal amplitude at all frequency settings.

7. Tektronix Type P510A Probe.

8. Insulated alignment screwdrivers. See Fig. 7-1.

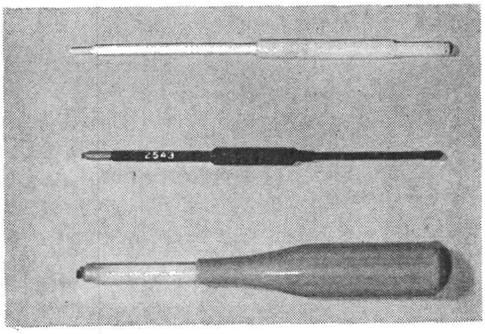


Fig. 7-1. Handtools necessary for calibrating the Type RM16 Oscilloscope.

The tools can be purchased through your Tektronix Field Engineer or direct from the factory.

POWER SUPPLY, CALIBRATOR AND CRT CIRCUITS

In this section, you will find six calibration steps outlining the method of adjusting the power-supply, calibrator and crt voltages. Two of these adjustments will affect the calibration of the entire instrument. They are Step 1, "Low-Voltage Supply" and Step 3, "High-Voltage Supply." If you find it necessary to make these adjustments, you will also have to check the calibration of the rest of the instrument. Therefore, before you adjust the controls, double check your meter readings to be sure the adjustment is needed.

Preliminary

Preset the front-panel controls of the Type RM16 as follows:

POWER	off
INTENSITY	full left
TRIGGER SELECTOR (black)	+INT.
TRIGGER SELECTOR (red)	AC
HORIZONTAL DISPLAY	NORM.
TRIGGERING LEVEL	centered
STABILITY	full right
TIME/DIV. (black)	.5 MILLISEC
TIME/DIV. (red)	CALIBRATED (full right)
Vertical POSITIONING	centered
Horizontal POSITIONING	centered
VOLTS/DIV. (black)	1
VOLTS/DIV. (red)	CALIBRATED (full right)
AC-DC	AC
CALIBRATOR	OFF

Remove the top and bottom panels from the Type RM16 and connect the power cord and the ac meter to the output of the variable autotransformer. Switch the Type RM16 power on and adjust the autotrasformer for a meter reading of 117 volts. Check the meter reading at regular intervals and maintain the autotransformer output voltage at 117 volts during the recalibration procedure. If the power transformer in your instrument is connected for 210-250-volt operation, adjust the autotransformer for a meter reading of 234 volts.

1. Low-Voltage Power Supply

Proper operation of your instrument is dependent upon correct power-supply voltages. Because the —150-volt supply is used as a reference for all of the other supplies, it is important that it be properly adjusted.

Measure the output voltage of the —150 volt, +100-volt and +300-volt supplies at the points indicated in the Bottom View pull-out sheet. Be sure your meter is accurate (see Section 1 of

"Equipment Required"). The output voltage of the —150-volt supply must be between —147 and —153 volts, and the output voltages of the +100-volt and +300-volt supplies must be within 3% of their rated values. You should be able to set the —150 ADJ. control so that all of these voltages are within their specified tolerances. Bear in mind that the calibration of the entire instrument is affected by changes in the power-supply voltages.

To check the operation of the voltage regulating circuits, vary the autotransformer output voltage from 105 to 125 volts (or from 210 to 250 volts if the power transformer is connected for 210-250-volt operation) while observing the effect on the regulated power-supply voltages. All of the voltages should remain essentially constant.

2. Internal-Calibrator Adjustment

When the CAL. ADJ. control is properly set, the calibrator output will be within 3% of the voltages indicated on the front panel. To make this adjustment, connect a voltmeter between the CAL. TEST PT and ground, turn the CALIBRATOR switch to OFF and adjust the CAL. ADJ. control for a meter reading of exactly 100 volts. To assure suitable symmetry of the calibrator waveform, the voltage at this point should not be less than 45 volts nor greater than 55 volts when the calibrator is turned on (to any of the output-voltage settings). Readings outside of this range are generally caused by an unbalanced multivibrator tube (V875).

3. High-Voltage Power Supply

This adjustment determines the total accelerating voltage on the crt and thus affects the deflection sensitivity.

Connect the voltmeter between ground and the —1675 TEST PT. Adjust the H.V. ADJ. control for a meter reading of —1675 volts. This voltage should not vary more than 10 volts between the following limits:

Upper Limit: Line voltage—125 v; INTENSITY control turned full left.

Lower Limit: Line voltage—105 v; INTENSITY control turned full right.

NOTE

To avoid possible burning of the crt screen while performing this check, position the crt spot off the screen.

4. CRT Alignment

The crt in the Type RM16 is held in position by a single clamp around the tube base. If the instrument is subject to considerable handling, the clamp may loosen—permitting the crt to turn. This would cause the crt display to appear canted in relation to the graticule lines. If you are going to perform a complete recalibration of the instrument, your job will be made easier if you align the crt at this point in the calibration procedure.

With no signal connected to the INPUT connector, free-run the Time-Base Generator by turning the STABILITY control full right. Position the free-running trace directly behind the center horizontal graticule line. If the trace and the graticule line do not coincide over the width of the graticule, it will be necessary to loosen the crt base clamp and rotate the tube until they do.

After you have aligned the crt trace with the graticule line, push the crt forward so that it rests snugly against the graticule. Then, tighten the crt base clamp. Recheck the alignment of the crt after tightening the clamp to be sure it didn't move while the clamp was being tightened.

5. CRT Astigmatism

Need for adjustment of the ASTIG. control is indicated if the display appears to be defocussed and it is impossible to improve the focus with the front-panel controls.

Connect a jumper from the CAL. OUT connector to the Vertical INPUT connector and adjust the controls for a reasonably bright display of four or five square-waves having a vertical deflection of 2 or 3 major divisions. Now adjust the ASTIG. and FOCUS controls for the sharpest possible display. The ASTIG. control does not require readjustment with changes in intensity of the trace.

6. CRT Geometry

The geometry of the crt display is adjustable over a limited range by means of the GEOM. ADJ. control. To achieve optimum linearity, vertical lines are displayed on the crt and the GEOM. ADJ. control is adjusted for minimum curvature in the lines. Nonlinearity is most noticeable at the edges of the graticule.

To make this adjustment, preset the oscilloscope controls as described at the beginning of this section with the exception of the TIME/DIV. and the VOLTS/DIV. controls. Set those controls to .2 MILLISEC and .2 volts respectively. Next, connect the Time-Mark Generator to the INPUT connector and display 100-microsecond markers. Position the base line of the timing comb below the bottom edge of the crt face so that it is not visible. The display should appear similar to one of the drawings in Fig. 7-2. Adjust the GEOM. ADJ. control for straight vertical lines running parallel to the left and right edges of the graticule.

The calibrator output waveform can be used in place of the Time-Mark Generator to make this adjustment, but due to the dimness of the trace, the adjustment is more difficult.

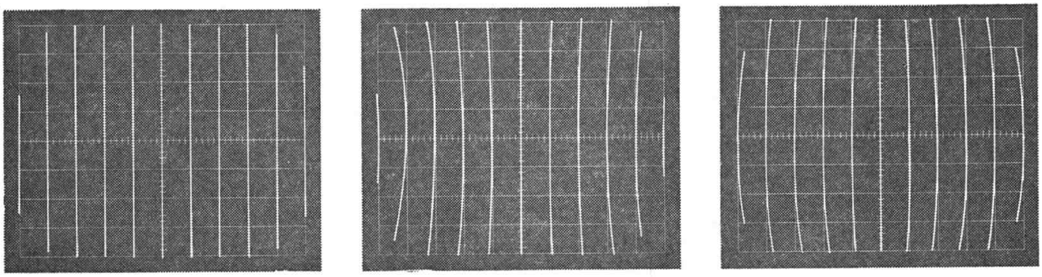


Fig. 7-2. Checking the crt geometry by displaying vertical lines. When the GEOM. ADJ. control is properly adjusted, the displayed lines will coincide with the vertical graticule lines as shown in the picture at the left.

TRIGGERING CIRCUITS

In this section you will find a three-step procedure for adjusting the triggering circuits. These adjustments should not affect the calibration of any other part of the oscilloscope and therefore can be made separately. Steps 7 and 8 interact, however, and these adjustments should be made in the order given.

7. Trigger Level Centering

When displaying a symmetrical waveform of small amplitude, with the red TRIGGER SELECTOR knob at AC, there should be a setting of the TRIGGERING LEVEL control where the display appears to invert as you switch the black TRIGGER SELECTOR knob from +INT. to —INT., without requiring readjustment of the TRIGGERING LEVEL control. Failure of the oscilloscope to perform in this manner indicates improper adjustment of the TRIG. LEVEL CENT. control.

To prepare the oscilloscope for this adjustment, connect a jumper from the CAL. OUT connector to the INPUT connector, and set the front-panel controls as follows:

TRIGGER SELECTOR (red)	AC
TRIGGER SELECTOR (black)	+INT.
TRIGGERING LEVEL	0
STABILITY	*PRESET
HORIZONTAL DISPLAY	NORM.
TIME/DIV. (black)	.5 MILLISEC
TIME/DIV. (red)	CALIBRATED
Vertical POSITIONING	centered
Horizontal POSITIONING	centered

If, in the preliminary inspection, you noticed a bump following the Termination Bump (that is, on the portion of the delay line not normally affected by delay-line adjustments), be sure to check the termination inductors for balance. The slugs in both inductors should be equidistant from the coil windings, as shown in Fig. 7-13. When you adjust the slugs, be sure to adjust each slug the same amount.

As a final step in the Physical Presetting procedure, dress the leads to the crt vertical-deflection plates. They are to be uniformly spaced—both with respect to each other and with respect to the crt shield.

Establishing a "Level" Display

The "level" of the flat top of the displayed square wave is determined by the collective effect of all of the delay-line capacitors. The characteristics to look for are described in the Preliminary Inspection section of these instructions, and are shown graphically in Fig. 7-10.

To make the display "level", adjust each delay-line capacitor a small amount in a direction that will result in a "level" display. Start at the termination network by adjusting the two inductors and the capacitor for a termination bump of minimum amplitude. Then, advance from capacitor to capacitor on the delay line, working toward the amplifier end. During your first attempt, you will probably find it most convenient to use a sweep rate of 5 microseconds/division. After you have adjusted all of the capacitors to gain an average "level" over the length of the flat top on the displayed square-wave, you can advance the sweep rate to 2 microseconds/division and repeat the procedure. This time, however, try to adjust the capacitors for a smooth transition from bump to bump, while at the same time maintaining a satisfactory "level". The important thing to remember is to reduce the amplitude of all of the bumps by the same amount and not try to acheive a perfectly straight line at this time.

Removing the Bumps and Wrinkles

After you have established a "level" display with the amplitude of the bumps and wrinkles reduced to within a trace width of the "level" line, you can start to remove the wrinkles and bumps over smaller sections of the display. It is usually best to start at the terminated end of the delay line and work toward the amplifier end.

Set the TIME/DIV. switch at .5 μSEC. and proceed to remove the bumps caused by the termination network. Do not try to arrive at a perfectly straight line during your first attempt. Just reduce the bumps by one-half. Then, advance to the first group of 4 or 5 capacitors in the delay line and adjust them for a smooth line over the portion of the display that they affect. Keep in mind that each capacitor will only require a slight adjustment—a mere "touch"—and that it is the combined effect of the group of capacitors that you should be concerned with.

While you are adjusting a group of capacitors to remove a bump or wrinkle, be sure to frequently turn to a sweep rate of 2 or 5 microseconds/division and check the level of the display.

Advance along the delay line from each group of capacitors to the next until you have traversed the entire length. Then, turn the TIME/DIV. switch to .2 μSEC and repeat the process. This time, however, you must be extra careful. The capacitors that require adjustment will only need a slight touch—to do otherwise might nullify all of your efforts up to this point. Be sure to check the "level" of the display frequently. It is very easy to concentrate on removing a particularly stubborn bump and, in so doing, introduce an upward or downward slope in the display.

At this point in the adjustment procedure, it will not be necessary to adjust every capacitor. "Touching up" here and there will probably produce the desired results.

Adjusting the High-Frequency Compensation

If you have successfully completed the adjustment procedure up to this point, the display on your oscilloscope should appear similar to the right-hand drawing of Fig. 7-12. That is, the display should be level and free of bumps and wrinkles with a pronounced rolloff on the leading edge. During this final part of the adjustment procedure, you will strive for a square corner on the leading edge, while at the same time maintaining the proper "level" without introducing wrinkles or bumps.

Set the TIME/DIV. switch at .2 μSEC and position the display to afford a good view of the leading edge and corner. Each pair of inductors in the amplifier affect the same part of the display. It is very important that you adjust each inductor the same amount as its corresponding-opposite inductor. That is, the slug in L544 should be in the same position as the slug in L554 when you complete the adjustment. This is also true for the slugs in L513 and L527.

Adjust the inductors, in pairs, for a square corner on the display. It may be necessary to readjust the first two or three capacitors in the delay line to achieve a wrinkle-free corner.

L477 and L450 determine the high-frequency response of the preamplifier and must be adjusted separately. To do this, set the VOLTS/DIV. switch at .01 and reduce the output signal from the signal generator. If using a Type 107, substitute a Type B52L10 10:1 "L" Pad for the B52R Terminating Resistor.

The coils are adjusted in the same manner as the coils in the main amplifier; do not, however, adjust the delay-line capacitors. They are only to be adjusted when the VOLTS/DIV. switch is at .1.

Main Amplifier Bandwidth

A good check on the completeness of your adjustments to the delay line and vertical amplifier is to measure the bandwidth of the vertical-deflection system. To make this check, it is necessary to establish a reference deflection on the crt. Then, without altering the oscilloscope control settings or the amplitude of the input signal, increase the frequency of the input signal until the crt deflection is reduced to .71 of the reference deflection. The input signal frequency at this point will be the high-frequency 3-db-down point and represents the upper frequency limit of the bandwidth.

To measure the bandwidth of the main amplifier, connect the output of a Type 190A Constant-Amplitude Signal Generator to the Type RM16 INPUT connector through a Type B52R Terminating Resistor. Set the front-panel controls of the instruments as follows:

Type RM16.

TRIGGER SELECTOR (red)	AUTO.
TRIGGER SELECTOR (black)	+ INT.
STABILITY	(not used in AUTO. mode)
TRIGGERING LEVEL	(not used in AUTO. mode)
HORIZONTAL DISPLAY	NORM.
TIME/DIV. (black)	1 MILLISEC
TIME/DIV. (red)	CALIBRATED
VOLTS/DIV. (black)	.1
VOLTS/DIV. (red)	CALIBRATED
AC-DC	AC

Type 190A

ATTENUATOR	10
RANGE SELECTOR	.75-1.7
RANGE IN MEGACYCLES	See text
OUTPUT AMPLITUDE	See text

Adjust the Type 190A RANGE IN MEGACYCLES control for a dial reading of 1.0 on the .75-1.7 scale, and adjust the OUTPUT AMPLITUDE control for a vertical deflection of exactly six major divisions on the graticule. Then turn the Type 190A RANGE SELECTOR control to 9-21.

Next, without adjusting any other controls, advance the Type 190A RANGE IN MEGACYCLES control until you reach the point where the crt display is reduced to 4.25 major divisions. You may have to position the display with the Vertical POSITIONING control to make this measurement, but do not adjust any other controls.

With the vertical deflection reduced to 4.25 major divisions, read the high-frequency 3-db-down frequency directly from the dial of the Type 190A. Typically, this frequency should fall within the range from 10.5 megacycles to 11 megacycles.

Preamplifier Bandwidth

To measure the bandwidth of the preamplifier, set the front-panel controls as described in the previous step with the exception of the VOLTS/DIV. switch and the Type 190A ATTENUATOR switch. Set these controls to .01 and 1, respectively. Adjust the Type 190A OUTPUT AMPLITUDE control for six major divisions of vertical deflection.

Increase the frequency of the Type 190A output signal, just as you did in the previous step, until the vertical deflection falls to 4.25 major divisions of deflection. Read the 3-db-down frequency directly from the dial of the Type 190A. Typically, the upper frequency limit should be between 10 and 10.5 megacycles.

CALIBRATOR	1
VOLTS/DIV. (black)	1
AC-DC	AC

*If your oscilloscope has not been calibrated for some time, it may be necessary to manually adjust the STABILITY control.

The control settings given above should result in a display of the calibrator waveform having a height of about 1 major graticule division.

With a short clip lead, ground the junction of R26, R27, R28 and C25 (see Figure. 7-3). Then, reduce the amplitude of the displayed signal with the VARIABLE VOLTS/DIV. control. If the display disappears you will be able to return it to the screen by slightly adjusting the TRIG. LEVEL CENT. control.

Continue to reduce the amplitude of the display until the vertical deflection is 3 minor divisions. Then, while switching the black TRIGGER SELECTOR knob back and forth between +INT. and —INT., slightly readjust the TRIG. LEVEL CENT. control to get stable triggering for both positions of the switch.

Remove the clip lead from the TRIGGER SELECTOR switch and check for reliable triggering in both positions of the black TRIGGER SELECTOR switch with the TRIGGERING LEVEL control set at 0. If the triggering point occurs at other than the 0 position, it will be necessary to loosen the set screw of the TRIGGERING LEVEL knob and rotate the knob to the 0 position (without rotating the shaft).

8. Internal Trigger DC Level Centering

In the DC triggering mode, if the TRIGGERING LEVEL control is set at 0, the crt display should start at the center horizontal graticule marker when the black TRIGGER SELECTOR knob is set at +INT. or —INT. If this does not occur, need for adjustment of the INT. TRIG. DC LEVEL ADJ. control is indicated.

To make this adjustment, set the oscilloscope controls as described in Step 7 with the exception of the red TRIGGER SELECTOR knob. Set this control to DC. Do not disturb the setting of the TRIGGERING LEVEL control estabished during the last part of Step 7.

As in Step 7, reduce the amplitude of the display with the VARIABLE VOLTS/DIV. control. This time, however, you must keep the display centered about the center horizontal graticule line as you decrease the amplitude. If the display disappears, you will be able to return it to the screen by slightly adjusting the INT. TRIG. DC LEVEL ADJ. control.

Continue to reduce the amplitude of the display until the vertical deflection is 3 minor di-

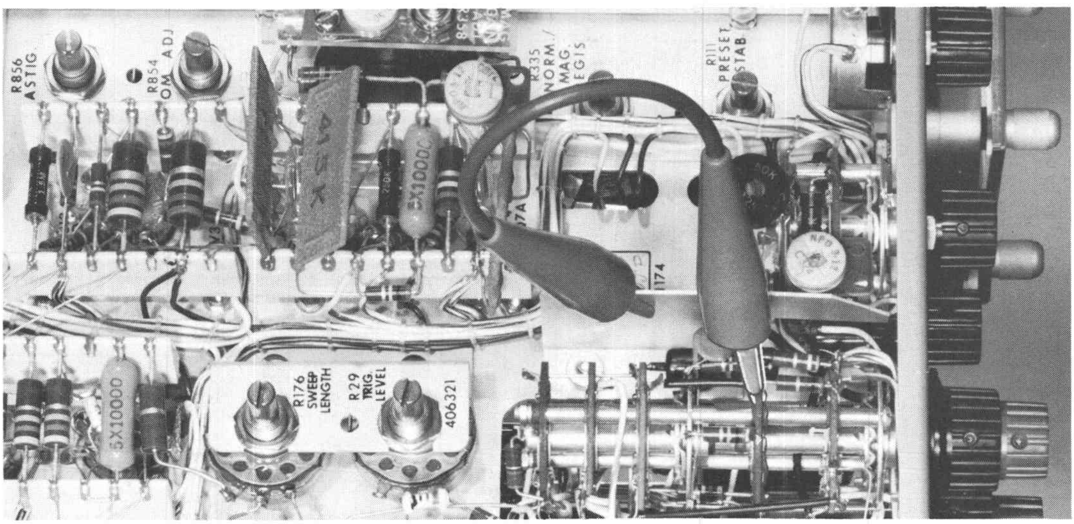


Fig. 7-3. Grounding the junction of R26, R27, R28 and C25.
Connecting the shorting jumper as shown simplifies the adjustment of the TRIG. LEVEL CENTERING control.

visions and the waveform is centered about the center horizontal graticule line. Then, while switching the black TRIGGER SELECTOR knob back and forth between +INT. and —INT., slightly readjust the INT. TRIG. DC LEVEL ADJ. control to get stable triggering for both positions of the switch.

9. Stability Preset

In the AUTO. mode of triggering, or when the STABILITY control is set at PRESET, the PRESET STAB. control provides a stability setting suitable for most triggering applications. If you cannot get reliable triggering when the STABILITY control is set at PRESET, but experience no difficulty in manually setting the control, the trouble is probably due to faulty adjustment of the PRESET STAB. control.

To make this adjustment, set the oscilloscope controls as described in Step 7 with the exception of the red TRIGGER SELECTOR knob, but do not connect a jumper from the CAL. OUT connector to the INPUT connector. Set the red TRIGGER SELECTOR knob to AUTO. Turn the PRESET STAB. control to its full-left (counter-clockwise) position.

Now, with no signal connected to the INPUT connector, slowly advance the PRESET STAB. control to the right until a trace appears on the crt screen. Note the position of the screwdriver slot. Then, turn the PRESET STAB. control further to the right until the trace brightens. Finally, set the control to a position midway between the points where the trace appeared and where it brightened.

HORIZONTAL AMPLIFIER AND TIME-BASE GENERATOR

The timing circuits of the Type RM16 should not require frequent readjustment. As a general rule, if the need for adjustment is indicated, you should first check all of the time-base ranges before making any adjustments. Often, only one control is misadjusted, yet it may not be the control for the range in which you first noticed the trouble.

If nonlinearity is present in the time-base, it will generally be confined to the first major division of horizontal deflection. Therefore, in these instructions, we recommend calibrating the timing circuits on the basis of time markers appearing between the second and tenth vertical graticule lines.

In the 11-step instructions that follow, all but two of the adjustments interact to some degree. The two exceptions are Steps 12 and 13. For this reason, it is important that you make the adjustments in the proper sequence.

Some of the horizontal amplifier adjustments described in the following sections affect the horizontal position of the crt display. As a result, it will be necessary to reposition the display with the Horizontal POSITIONING control to keep the time markers properly positioned with respect to the graticule lines.

10. Magnifier Gain

The MAG. GAIN ADJ. control determines the gain of the horizontal amplifier when the HORIZONTAL DISPLAY switch is in the MAG. position. To make this adjustment, set the front-panel controls as follows:

TRIGGER SELECTOR (red)	**DC**
TRIGGER SELECTOR (black)	**+INT.**
TRIGGERING LEVEL	**0**
STABILITY	**PRESET**
HORIZONTAL DISPLAY	**NORM.**
TIME/DIV. (black)	**1 MILLISEC**
TIME/DIV. (red)	**CALIBRATED**
Vertical **POSITIONING**	centered
Horizontal **POSITIONING**	centered

Next, connect the Time-Mark Generator to the INPUT connector, set the controls for 100-microsecond marker output and adjust the oscilloscope VOLTS/DIV. controls for a vertical deflection of approximately 2 major divisions. Center the display on the graticule with the POSITIONING controls.

To calibrate the magnifier circuits, turn the HORIZONTAL DISPLAY switch to MAG. and adjust the MAG. GAIN ADJ. control so that there are two time markers for every major graticule line. The MAG. GAIN ADJ. control is located on the plastic plate adjacent to the high voltage shield.

11. Horizontal Amplifier Gain

The HORIZ. GAIN ADJ. control, R325, is part of a feedback circuit that reduces the gain of the horizontal amplifier by a factor of five when the HORIZONTAL DISPLAY switch is in the NORM. position.

To make this adjustment, set the front-panel controls as described in Step 10 with the exception of the TIME/DIV. switch. Set this control to .1 MILLISEC.

Display 100-microsecond markers from the Time-Mark Generator and adjust the HORIZ. GAIN ADJ. control (R325, located on the HORIZONTAL DISPLAY switch) so that each time-marker coincides with a vertical graticule line.

12. Sweep Length

The SWEEP LENGTH control limits the left-right travel of the crt beam and, when properly adjusted, prevents the beam from hitting the side of the crt when the display is centered on the screen.

To make this adjustment, free-run the time-base generator at any convenient sweep speed in the millisecond range and adjust the SWEEP LENGTH control for a sweep length of 10.5 major divisions.

13. Magnifier Registration

When the NORM/MAG. REGIS. control is properly set, that part of the display immediately under the center vertical graticule line will remain there as the HORIZONTAL DISPLAY switch is turned from NORM. to MAG.

Prepare the oscilloscope for making this adjustment by turning the STABILITY control as far left as possible without actuating the internal preset switch, and turn the red TRIGGER SELECTOR knob to any position other than AUTOMATIC. This action will disable the time-base generator. Next, turn the INTENSITY control to the right until a spot is just visible on the crt. With the POSITIONING controls, position the spot to the center of the crt.

Now, set the HORIZONTAL DISPLAY switch to MAG. and position the spot directly under the center graticule lines.

With the spot accurately centered on the crt screen, turn the HORIZONTAL DISPLAY switch to NORM. and adjust the NORM/MAG. REGIS control to return the spot to the center of the screen.

14. 1 μsec/div Sweep Rate

Capacitor C160C determines the sweep rate for the 1-, 2-, and 5-μsec/div positions of the TIME/DIV. control.

Set the oscilloscope front-panel controls as outlined in Step 10 with the exceptions of the black TIME/DIV. control and the HORIZONTAL DISPLAY switch. Set these controls to 5μSEC and MAG. respectively. Connect the Time-Mark Generator to the INPUT connector and display 1-microsecond markers. With the Horizontal POSITIONING control, position the display to the left so that the last ten timing markers are visible. Adjust C160C so that each time mark is directly behind a vertical graticule line.

15. 1μsec/div Linearity.

Capacitor C310 compensates a voltage-divider network in the horizontal-amplifier input circuit and affects the sweep rate of the early part of the trace in the higher sweep-rate ranges.

With the controls unchanged from Step 14, position the trace to the right so that the start of the trace is visible. Adjust C310 to align each time mark with a vertical graticule line.

There is some interaction between C160C and C310 and it may be necessary to go back and forth several times between Steps 14 and 15 to obtain a satisfactory calibration.

16. 10 μsec/div Sweep Rate.

Adjustable capacitor C160E determines the sweep rate for the 10-, 20-, and 50-μsec/div positions of the TIME/DIV. switch.

Set the oscilloscope front-panel controls as outlined in Step 10 with the exception of the black TIME/DIV. control. Set this knob to the 10μSEC position. Be sure the red TIME/DIV. control is set at CALIBRATED. Connect the Time-Mark Generator to the INPUT connector and display 10-microsecond markers.

Adjust C160E to obtain one time marker for each major vertical graticule line.

17. 2 μsec/div Linearity.

Variable capacitor C324 is one of three adjustments that determines the high-frequency response of the horizontal amplifier, and thereby the linearity of the crt display at high sweep rates. The other two adjustments are C358 and C372. The time constants of these circuits are such as to permit adjusting at different sweep rates. C324 affects the high-frequency response when the HORIZONTAL DISPLAY switch is in the NORM. position only, and is initially adjusted to provide the best linearity in the 2 μsec/div. range.

Set the oscilloscope controls as outlined in Step 10 with exception of the black TIME/DIV. control. Set this control to 2 μSEC. Display 1 microsecond markers from the Time-Mark Generator and adjust C324 so that the sweep rate over the first two divisions of the display is the same as the sweep rate over the rest of the display.

18. .5 μsec/div Sweep Rate.

Variable capacitor C160A determines the sweep rate for the .2 and .5 μsec/div. positions of the TIME/DIV. switch.

Set the oscilloscope controls as outlined in Step 10 with the exception of the black TIME/DIV. knob. Set this control to .5 μSEC. Display 1-microsecond markers from the Time-Mark Generator and adjust C160A so that a time mark is aligned with every other graticule line.

19. .2 μsec/div Linearity.

At the .2 μsec/div sweep rate, the linearity of the crt display can be altered slightly by adjusting C358. What is more, at the high sweep rates, the linearity adjustments of lower sweep rates become timing adjustments. In particular, variable capacitor C324 (Step 17) has a pronounced affect on the sweep rate when the TIME/DIV. switch is at .2 μSEC. To adjust C358 and, perhaps, readjust C324, proceed in the following manner.

Set the oscilloscope front-panel controls as follows:

TRIGGER SELECTOR (red)	HF SYNC
TRIGGER SELECTOR (black)	+INT.
HORIZONTAL DISPLAY	NORM.
TIME/DIV. (black)	.2 μSEC
TIME/DIV. (red)	CALIBRATED
Vertical POSITIONING	centered
Horizontal POSITIONING	centered

Set the Time-Mark Generator to 10 megacycles and adjust the STABILITY control and the VOLTS/DIV. controls for a stable pattern having a vertical deflection of about five major divisions. Now, adjust C358 for the most linear display. This adjustment affects only the first few divisions. If the initial adjustment of C324 (Step 18) was performed properly, the .2 μsec/div sweep rate should be correct. If this is not the case, adjust C324 to obtain two cycles per major division. These circuits are sensitive to changes in capacitance and therefore the adjustment should be made with a nonmetallic alignment tool.

If it is necessary to readjust C324, repeat Steps 18 and 19.

20. .04 μsec/div Sweep Rate and Linearity.

Variable capacitor C372 affects the linearity and sweep rate of the crt display when the TIME/DIV. switch is set at .2 μSEC and the HORIZONTAL DISPLAY switch is set at MAG.

Set the oscilloscope controls as outlined in Step 19 with the exception of the HORIZONTAL DISPLAY switch. Set this control to MAG. Display a 10-megacycle sine wave from the Time-Mark Generator and adjust C372 to obtain four cycles of the sine wave within 10 major divisions of horizontal deflection.

In this section you will find instructions on how to perform six adjustments to the vertical amplifier. One of the adjustments (VARIABLE ATTEN. BAL.) is explained in the Operating Instructions and is repeated here for completeness. Of the remaining five, Steps 22 and 23 are interacting, as are Steps 24 and 25. None of the adjustments listed in this section affects the operation of any other part of the oscilloscope.

21. Variable Attenuator Balance.

This adjustment is performed by the operator of the oscilloscope during the course of normal operation. However, the maintenance technician must also make the adjustment before he can proceed to calibrate the vertical amplifier.

Misadjustment of the control is indicated if the entire crt display is positioned vertically as the VARIABLE VOLTS/DIV. control is rotated. To perform this adjustment, it is first necessary to get a horizontal reference trace on the crt. This can be done most easily by turning the red TRIGGER SELECTOR control to AUTO., and the TIME/DIV. to 1 MILLISEC.

With the trace vertically centered on the crt screen, adjust the VARIABLE ATTEN. BAL. control so that the trace remains stationary as the red VOLTS/DIV. control is turned back and forth through its range.

22. Amplifier Gain.

This adjustment determines the gain of the vertical amplifier and therefore the calibration of the VOLTS/DIV. control. Before you make this adjustment, however, you might save yourself considerable time and effort by first checking the power supply voltages. An unregulated voltage can affect the sensitivity of the crt and this could appear as though the vertical amplifier were at fault.

To adjust the GAIN. ADJ. control, first set the oscilloscope front-panel controls as follows:

TRIGGER SELECTOR (red)	AUTO.
TRIGGER SELECTOR (black)	+INT.
TRIGGERING LEVEL	(not used in AUTO. mode)
STABILITY	(not used in AUTO. mode)
HORIZONTAL DISPLAY	NORM.
TIME/DIV. (black)	.5 MILLISEC
TIME/DIV. (red)	CALIBRATED
Vertical POSITIONING	centered
Horizontal POSITIONING	centered
CALIBRATOR	.5
VOLTS/DIV. (black)	.1
VOLTS/DIV. (red)	CALIBRATED

Connect a jumper from the CAL. OUT connector to the INPUT connector.

Set the GAIN ADJ. control (R544) for five major divisions of vertical deflection.

23. Preamplifier Gain.

The PREAMP. GAIN ADJ. control determines the gain of the preamplifier and therefore the calibration of the VOLTS/DIV. switch in the .01, .02 and .05 positions.

Set the oscilloscope controls as outlined in Step 22 with the exception of the VOLTS/DIV. and CALIBRATOR controls. Set these controls to .01 and .05 respectively. Connect a jumper from the CAL. OUT connector to the INPUT connector.

Adjust the PREAMP. GAIN ADJ. control (located adjacent to the VOLTS/DIV switch) for exactly 5 major divisions of vertical deflection.

24. Attenuator High-Frequency Compensation.

Waveforms resulting from misadjusted attenuator compensation adjustments are shown in Figure 7-4. Notice that the area in which these adjustments have the most effect is limited to a

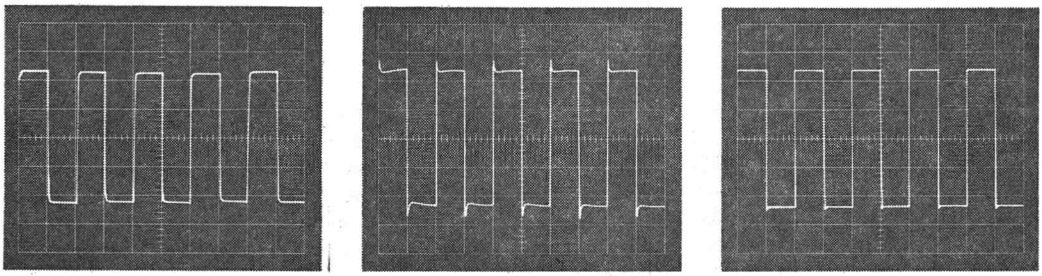


Fig. 7-4. Compensating the attenuator high-frequency response.
When the attenuators are properly adjusted, the display of the Type 105 output waveform will be similar to the drawing at the right.

small portion of the leading edge and corner. Conditions similar to these can exist for any setting of the VOLTS/DIV. switch.

To adjust the high-frequency compensation, set the oscilloscope front-panel controls as outlined in Step 22 and connect the Type 105 Square-Wave Generator to the Type RM16 INPUT connector. Set the controls of the Type 105 for an output frequency of one kilocycle.

An approximate adjustment of the attenuator high-frequency-compensation capacitors can be made using the output waveform from the internal calibrator. However, the calibrator waveform has a comparatively long risetime and the adjustment may result in over-compensation of the attenuators.

Set the VOLTS/DIV. switch to the positions indicated in the following table and adjust the corresponding capacitor for a square corner on the leading edge of the display (see Fig. 7-4). Maintain approximately 5 major divisions of vertical deflection by adjusting the Type 105 output control as you turn the VOLTS/DIV. switch from one setting to the next.

VOLTS/DIV. (red)	CAPACITOR*
.2	C432
.5	C426
1	C418
10	C412

*Located on VOLTS/DIV. switch.

25. Attenuator Input Capacitance.

Proper operation of a Type P510A Attenuator Probe is dependent upon the input characteristics of the oscilloscope to which it is connected. If, in a particular instrument, the input characteristics change as the VOLTS/DIV. switch is rotated, the performance of the probe will change accordingly. To avoid this situation, a variable capacitor has been connected in parallel with

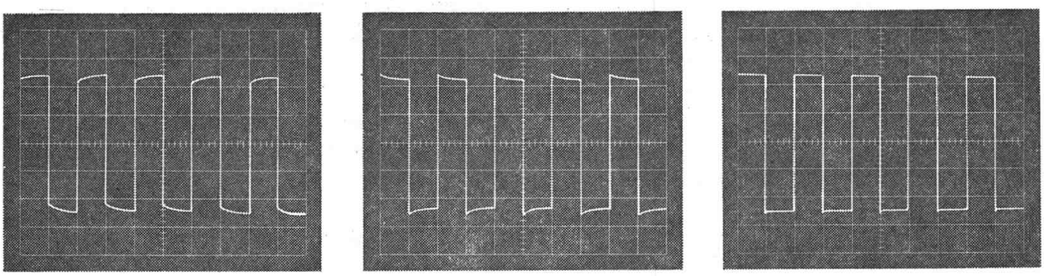


Fig. 7-5. Standardizing the input capacitance.
When the attenuator input capacity is standardized, the display of the Type 105 output waveform will be similar to the drawing at the right for all settings of the VOLTS/DIV. switch.

each attenuator in the Type RM16. By adjusting the capacitances to be equal for all positions of the VOLTS/DIV. switch, proper operation of the probe is assured.

To equalize the input capacitance for all positions of the VOLTS/DIV. switch, set the oscilloscope controls as outlined in Step 22. Connect the Type P510A Probe to the INPUT connector and connect the probe tip and ground clip to the Type 105 OUTPUT connector. Adjust the Type 105 for a one-kilocycle output signal. Set the VOLTS/DIV. switch to the positions indicated in the following table and adjust the associated capacitor for a flat-top on the square-wave display (see Fig. 7-5). As in Step 24, maintain approximately five major divisions of vertical deflection by adjusting the Type 105 output. (Maximum output of the Type 105 will give a deflection of slightly more than 1 division in the 10-volt position of the attenuator.) The CALIBRATOR waveform may be used for this step in place of the Type 105.

VOLTS/DIV.	CAPACITOR*
.1	Variable capacitor in probe body
.2	C430
.5	C424
1	C416
10	C410
.01**	C141†

*Located on VOLTS/DIV. switch.

**Reduce the Type 105 output by connecting a Type B52-R Terminating Resistor to the output connector.

†Located on bottom deck, next to V454.

26. Preamplifier Low-Frequency Compensation.

Need for the adjustment of the L.F. ADJ. control is indicated by a loss of low frequency response. Waveforms indicative of this trouble are shown in Figure 7-6.

To make this adjustment, set the front-panel controls as outlined in Step 22 with the exception of the TIME/DIV. control (set this control to 10 MILLISEC.), and the VOLTS/DIV. control (set this control to .01 volt). Connect a Type P510A Probe to the INPUT connector. Set the Type 105 controls for a fifty-cycle output signal and connect a Type B52-R Terminating Resistor to the output connector. To connect the oscilloscope to the Type 105, touch the probe tip to the center conductor of the coax connector on the Terminating Resistor and fasten the ground clip to the case of the Terminating Resistor. The ground lead must be as short as possible. If excessive hum is encountered, reinstall the bottom plate on the oscilloscope.

Adjust the LOW FREQ. COMP. control for a level top on the square-wave display.

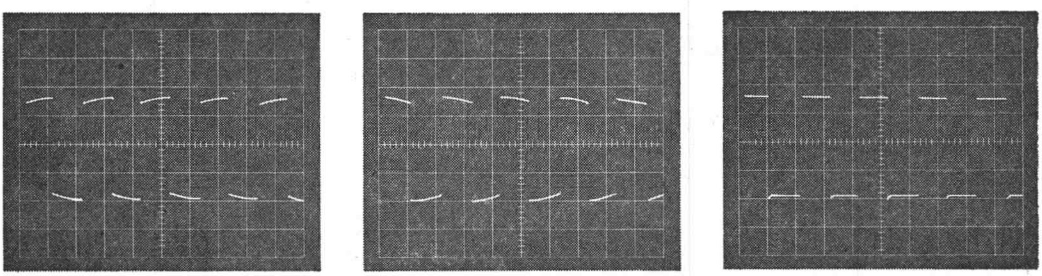


Fig. 7-6. Compensating the preamplifier low-frequency response.
The right-hand drawing shows the resulting display of a 50 kc waveform when the LOW FREQ. COMP. control is correctly adjusted.

Including Amplifier High-Frequency Compensation

Of all the adjustments you may be called upon to perform on the Type RM16, the adjustment of the delay line and the vertical-amplifier high-frequency compensation will be the most difficult. This is due largely to interaction between adjustments. There are 26 variable capacitors and 2 variable inductors associated with the delay line, and 6 variable inductors in the vertical amplifier. All of these adjustments interact to some degree.

Before attempting to perform any of the adjustments described in his section, read the instructions carefully until you are sure of what is to be done. Study the pictures and drawings to gain a clear mental picture of the result of each adjustment. Refer to the Circuit Description of this manual for an explanation of the operation of the Delay Line (Page 5-3). Attempts to adjust the delay line without adequate preparation frequently lead to a misadjustment more severe than the initial condition.

Displaying the Test Signal

To determine the extent of misadjustment of the delay line in your instrument, you will need to closely examine a displayed 400-kilocycle square wave. The square wave used to make this examination must have a risetime of no more than 20 millimicroseconds and must also be free of waveform irregularities during the positive half of the cycle. A Tektronix Type 105 or Type

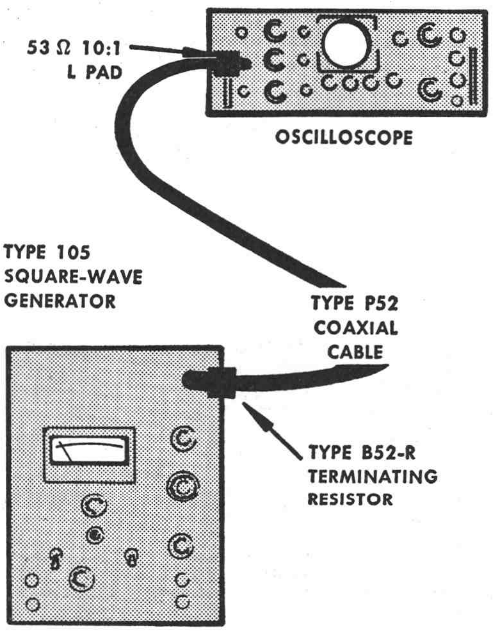


Fig. 7-7. Connecting the Type 105 Square-Wave Generator to the oscilloscope.
The Type 105 requires the use of both a Terminating Resistor and "L" Pad.

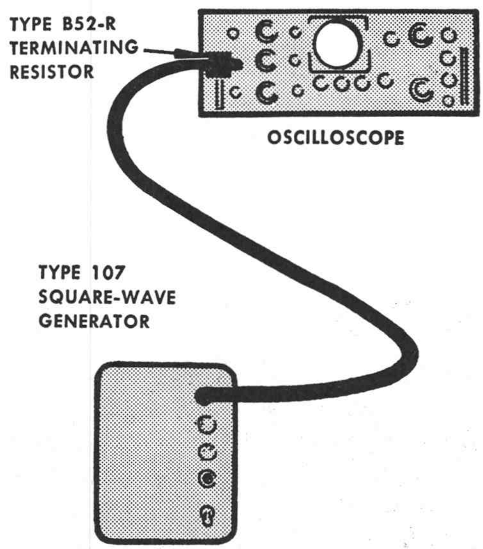


Fig. 7-8. Connecting the Type 107 Square-Wave Generator to the oscilloscope.
Only the Terminating Resistor is necessary when connecting the Type 107 to the oscilloscope.

107 Square-Wave Generator is recommended.

By following the recommendations in these instructions for terminating resistors and cables, you should not experience any difficulty in arriving at the desired results. If, however, it is necessary to use a signal generator other than a Type 105 or Type 107, you must exercise caution in connecting the instrument to the Type RM16. A good check on the suitability of your test equipment is to display the output waveform on another Tektronix oscilloscope (of a type having a delay line) known to be in good adjustment.

The drawings, Fig. 7-7 and 7-8, show the desired methods for connecting either the Type 105 or the Type 107 Square-Wave Signal Generator to the RM16 INPUT connector. Notice that a Type B52R Terminating Resistor is connected to the input end and a Type B52L10 10:1 "L" Pad is connected to the output end of the coaxial cable when using the Type 105, and that a Type B52R Terminating Resistor is connected to the output end of the coaxial cable when using a Type 107.

To display a 400-kilocycle waveform, set the square-wave generator controls for a 400-kilocycle output (a few degrees away from full-left on the Type 107 APPROXIMATE FREQUENCY control) and set the oscilloscope front-panel controls as follows:

TRIGGER SELECTOR (red)	AC
TRIGGER SELECTOR (black)	—INT.
STABILITY	PRESET
HORIZONTAL DISPLAY	NORM.
TIME/DIV. (black)	.5 μSEC.
TIME/DIV. (red)	CALIBRATED
VOLTS/DIV. (black)	.1
VOLTS/DIV. (red)	CALIBRATED
AC-DC	DC

Adjust the black TRIGGERING LEVEL control for a stable display and adjust the square-wave generator output-amplitude control for approximately 4 major divisions of vertical deflection. Position the display so that it is similar to the photograph of Fig. 7-9. You may have to adjust the square-wave-generator output-frequency control slightly to get the desired number of cycles displayed on the crt screen.

Now that you have the desired display, you can begin your examination for waveform distortion caused by faulty adjustment of the delay line. There are three general characteristics which you will have to appraise, and to do this, you will need to use three different sweep rates. The first characteristic to look for is the "level"

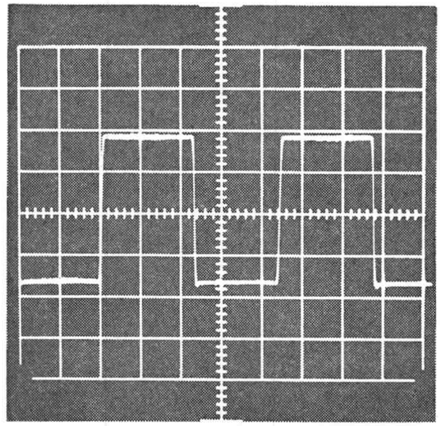


Fig. 7-9. The Type 107 output waveform displayed on a correctly adjusted Type RM16.
The frequency of the displayed waveform is approximately 400 kc.

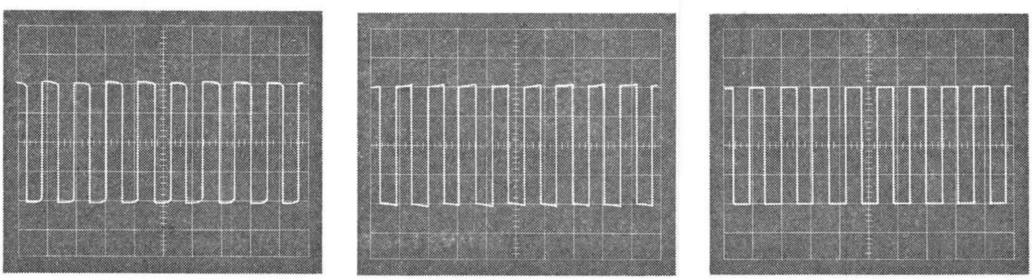


Fig. 7-10. Determining the "level" of a display
Departures from a "level" display occur as a result of the collective misadjustment of the delay-line capacitors. The "level" is most easily observed at a sweep rate of 2 or 5 μsec/div.

of the display; the second is the amount of "bumpiness" contained in the flat top of the displayed waveform; and the third is the "squareness" of the leading edge and corner of the displayed waveform.

Determining the "Level" of the Display

If the display of Fig. 7-9 were positioned on the screen so that the flat positive portion coincided with a graticule line, we would refer to the horizontal plane of the graticule line as the "level" of the display. If the crt trace coincided with the graticule line over the entire length of the positive half-cycle, we would say, "The display is level." If the leading corner of the waveform extended above the graticule line, we would say, "The display has an upward slope." Conversely, if the leading corner were to fall below the graticule line, we would say, "The display has a downward slope."

The drawings of Fig. 7-10 graphically show the three conditions described in the previous paragraph. Although it is possible to observe an upward or downward slope at a sweep rate of .5 microsecond/division, the "level" is most easily observed at 2 or 5 microseconds/division.

Determining the "Bumpiness" of the Display

The next characteristic to look for in the displayed waveform is the "bumpiness" of the first-half of the positive portion; that is, the portion that is affected by the delay-line adjustments. To make this observation, you will use two sweep rates: .5 microsecond/division and .2 microsecond/division.

There are two general types of bumps to be found in a poorly adjusted delay line. They are shown graphically in Fig. 7-11. The first type is the irregularity caused by the misadjustment of a group of capacitors. This type is most easily observed at a sweep rate of .5 microsecond/division. If the bumps occur at random intervals along the delay line, they are probably due to misadjustment of the delay line and can usually be corrected by a few slight adjustments. However, if there is a certain rhythmic waviness or symmetry to their appearance, the trouble may be due to a faulty adjustment in the terminating network or in the high-frequency compensation of the amplifier and a detailed adjustment may be necessary.

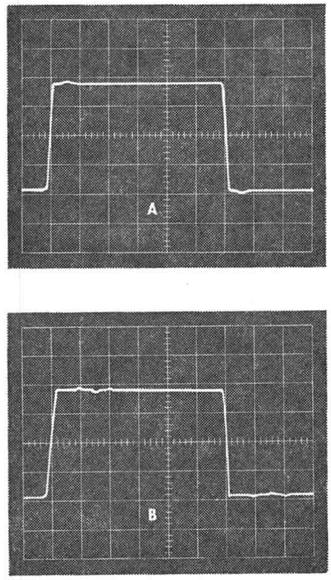


Fig. 7-11. Two types of "bumps" caused by delay-line misadjustment.
The "bump" in waveform A is caused by the misadjustment of a group of capacitors. The bumps in waveform B are the result of the misadjustment of single capacitors.

The second kind of bump is caused by misadjustment of a single delay-line capacitor. Use a sweep rate of .2 microsecond/division to see bumps of this kind. Here, the degree of misadjustment is minor in comparison to those we have discussed up to this point.

Determining the HF Response

The third characteristic to be investigated in the displayed waveform is the extreme leading edge and corner. This part of the waveform is affected by the vertical-amplifier HF peaking coils and the delay-line adjustments adjacent to the amplifier. These adjustments collectively determine the high-frequency response of the vertical-deflection system and for that reason are of the utmost importance.

The "squareness" of the leading corner is best observed by turning the TIME/DIV. switch to .2 μSEC. The corner should be as sharp as possible with no overshoot. The drawings of Fig. 7-12 show the three possibilities. While it is necessary that the corner be as sharp as possible for optimum frequency response, it is also necessary that there be no wrinkling or "bumpiness" in this portion of the display.

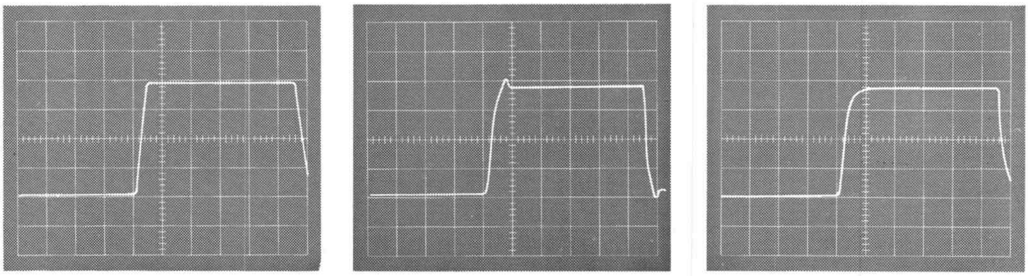


Fig. 7-12. Compensating the amplifier high-frequency response.
The left-hand drawing is typical of an instrument in good adjustment. The right-hand waveform will usually be the result of physically presetting the adjustments as described in the text. The middle waveform is the result of overcompensation.

There is a good deal of similarity in the effect of the amplifier peaking coils and the delay-line adjustments. For this reason, it is sometimes difficult to ascertain which adjustments are faulty. Perhaps the simplest way to determine the source of misadjustment is to check the physical position of each adjustment and compare it to the diagrams of Fig. 7-13.

ADJUSTMENT PROCEDURE

There are four major steps in adjusting the delay line and vertical amplifier of the Type RM16. They are: (1) physically presetting the adjustments, (2) establishing a level display, (3) removing the bumps and wrinkles from the display and (4) adjusting the high-frequency compensation.

In the instructions that follow, we outline a method for performing these steps. In some instances, it may be necessary for you to perform all of the steps given here. In other cases, it may only be necessary to perform certain parts of these instructions. In any event, the results of your preliminary inspection will indicate which parts to follow.

Physical Presetting

Perhaps the most important single bit of information for the novice is knowledge of the approximate positions of the various adjustments in a properly adjusted instrument. This knowledge will give him a good "starting off" point. And later, during the adjustment procedure, he can use the information as a check on his progress.

The variable inductors in the vertical amplifier can be preset according to the drawings of Fig. 7-13. In the drawings, the slugs are shown positioned deeper in the coil form than the positions they will have when your instrument is correctly adjusted. However, by positioning them as shown, you will reduce the effects of the inductors during the delay-line adjustment procedure. Then, during the last step of the adjustment procedure, you will move the slugs closer to the coil windings (usually about two or three turns).

If, in your preliminary investigation, you detected a cyclic waviness in the display, or if there was extreme overshoot at the leading edge, you will probably save yourself considerable time by presetting the variable inductors. Usually, turning the slugs too far out of the coil winding will only result in a rounding off of the leading edge. On the other hand, turning the slugs too far into the coil winding will result in severe wrinkles in the displayed square-wave—

wrinkles which can frequently be reduced by misadjusting the delay line. This might give you the impression that the delay line was at fault instead of the high-frequency peaking coils.

The variable capacitors in the delay line will not, as a rule, require presetting. If the performance of the instrument has deteriorated as a result of normal use and handling, the delay line should require only "touching up", and the original physical positions of the capacitors should be very nearly correct. On the other hand if the instrument has been tampered with, or if it has been subject to severe vibration or rough handling, it may be desirable to preset the delay-line capacitors as described in the following paragraph.

In a properly adjusted delay line, the adjusting screw extends above the capacitor body about $3/8$ inch. (The delay-line shields can be removed while making the preset adjustments. As soon as you have completed the presetting procedure, however, be sure to replace the shields before proceeding with the delay-line adjustment.) The important characteristic is that the tops of all the delay-line adjusting screws be about the same height. It is very important to keep this characteristic in mind as you adjust the delay line.

If you can observe a waviness in the height of the adjusting screws (while, at the same time, the display is "level"), the trouble is probably due to misadjustment of the inductors in the vertical amplifier. In this event, you should recheck the physical positions of the slugs as described in the previous paragraphs.

The inductors and capacitor at the terminated (crt) end of the delay line are the first to be adjusted and therefore are not usually preset. Should you have difficulty in adjusting the delay line, you can use the approximate positions shown in Fig. 7-13 as a guide to help you locate the source of trouble. The positions shown are typical of those in a properly adjusted instrument.

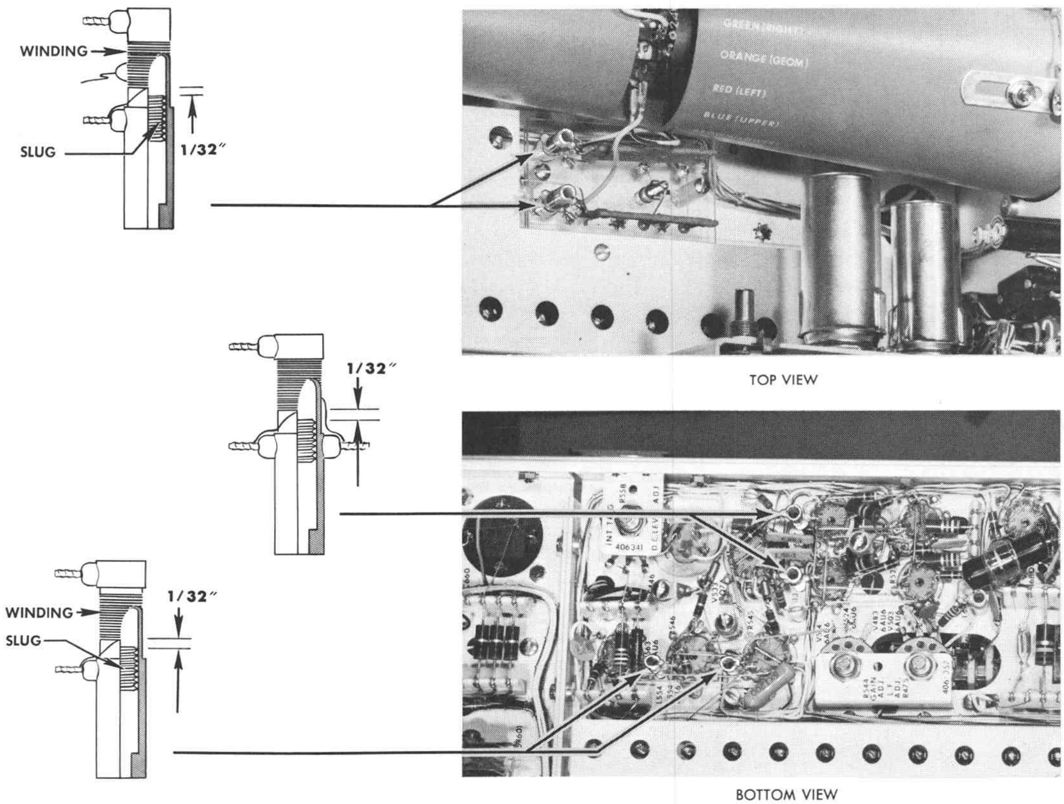
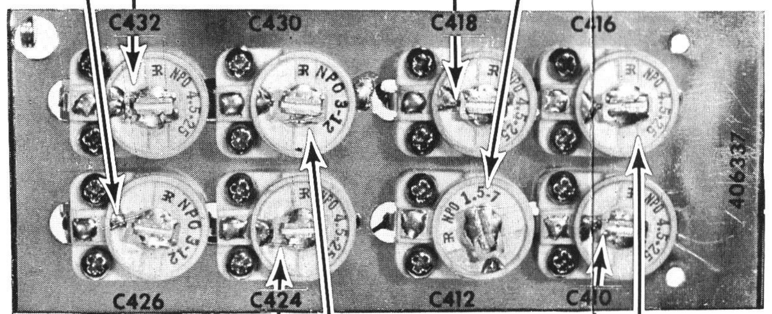


Fig. 7-13. Approximate physical positions of adjustments in a correctly adjusted instrument.

Initially, the adjustments can be preset as shown above. During the recalibration procedure, they will be moved slightly.

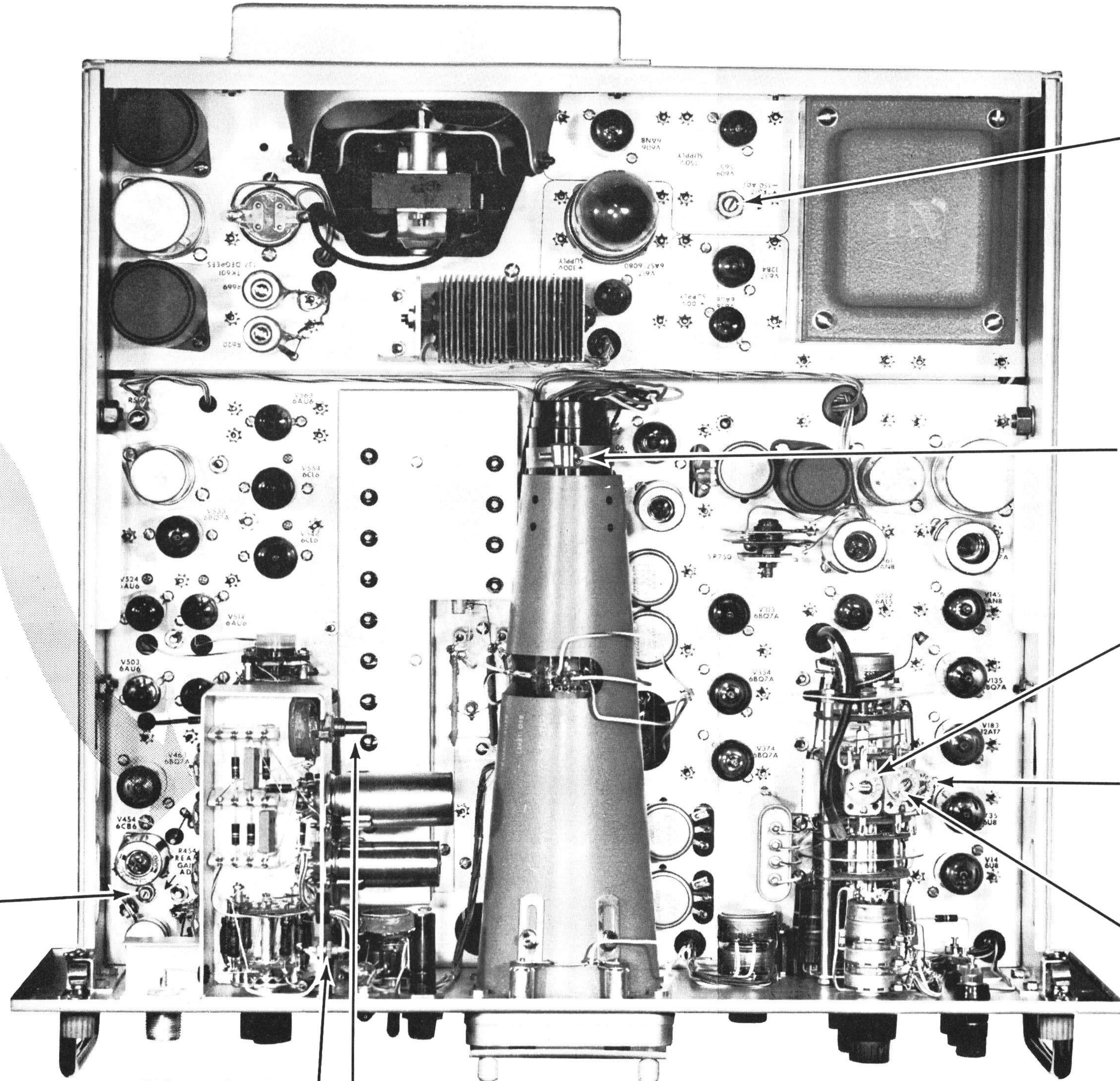
STEP 24 ATTENUATOR HIGH-FREQUENCY COMPENSATION

Connect signal generator directly to INPUT connector and adjust capacitors for square-cornered display of 1 kc square wave. Numbers indicate the corresponding positions of the VOLTS/DIV. switch.



STEP 25 ATTENUATOR INPUT CAPACITY

Connect the Type P510A Probe to the INPUT connector and display a 1-kc square wave. Compensate probe with VOLTS/DIV. switch at .1 and then standardize input capacity by adjusting capacitors. Numbers indicate the appropriate settings of the VOLTS/DIV. switch.



STEP 1 —150 V ADJ.

Adjust for —150 volts, ±3 volts at indicated point.

STEP 4 CRT ALIGNMENT

Loosen clamp and position free-running trace directly behind and parallel with center horizontal graticule line.

STEP 16 10 μSEC/DIV. SWEEP RATE (C160E)

Adjust for calibrated sweep rate with TIME/DIV. switch at 10 μSEC and DISPLAY switch at NORM.

STEP 18 .5 μSEC/DIV. SWEEP RATE (C160A)

Adjust for calibrated sweep rate with TIME/DIV. switch at .5 μSEC and DISPLAY switch at NORM.

STEP 14 1 μSEC/DIV SWEEP RATE (C160C)

Adjust for calibrated sweep rate with TIME/DIV. switch at 5 μSEC and DISPLAY switch at MAG.

STEP 23 PREAMPLIFIER GAIN

Adjust for calibrated vertical deflection with VOLTS/DIV. switch at .01, CALIBRATED.

CAL. CHECK POINT

STEP 2 CAL. ADJ.

Adjust for 100 volts with Calibrator turned off.

TOP VIEW

STEP 9 STABILITY PRESET

As you advance the control to the right, set it midway between the position where the trace appears and where it brightens.

STEP 13 MAGNIFIER REGISTRATION

Adjust so that the part of the display under the center vertical graticule line will remain there as the DISPLAY switch is turned to MAG.

STEP 17 2 μSEC/DIV. LINEARITY (C324)

Adjust for linear sweep rate over the width of the graticule with the TIME/DIV. switch at 2 μSEC and the DISPLAY switch at NORM.

STEP 20 .04 μSEC/DIV. SWEEP RATE (C372)

Use 10-mc sine wave to adjust for calibrated sweep rate with TIME/DIV. switch at .2 μSEC and the DISPLAY switch at MAG.

STEP 10 MAGNIFIER GAIN ADJUSTMENT

Adjust for calibrated deflection at 1 millisecond/division with DISPLAY switch at MAG.

STEP 26 PREAMPLIFIER LOW-FREQUENCY COMPENSATION

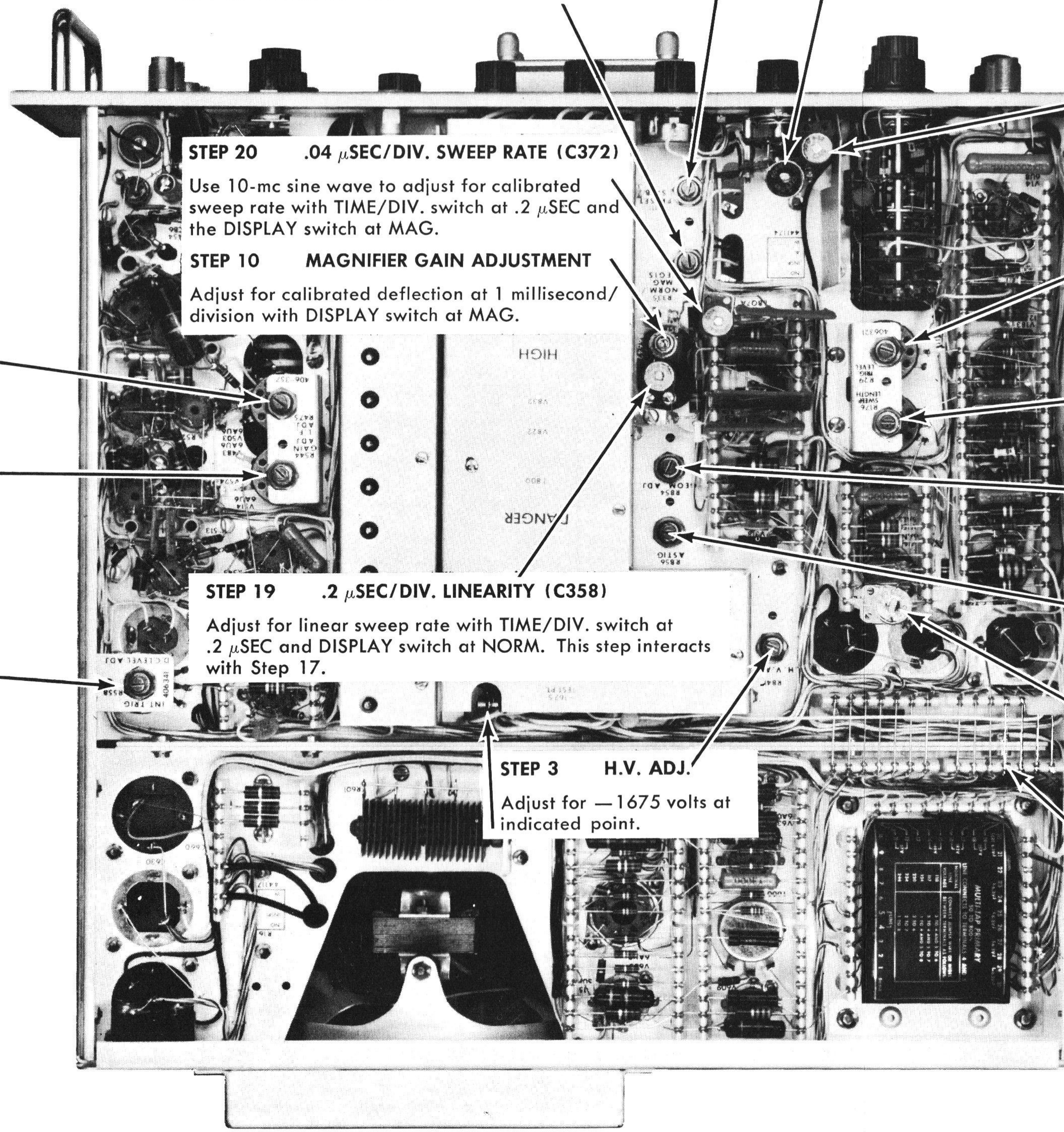
Adjust for a level display of 50-cycle square wave with VOLTS/DIV. switch at .01.

STEP 22 VERTICAL AMPLIFIER GAIN

Adjust for calibrated vertical deflection with VOLTS/DIV. switch at .1 CALIBRATED.

STEP 8 INTERNAL TRIGGERING DC LEVEL CENTERING

With TRIGGERING LEVEL control set at 0 and with 3 minor divisions of vertical deflection centered about the center horizontal graticule line, adjust this control for stable triggering in both the +INT. and —INT. positions of the black TRIGGER SELECTOR knob (DC triggering mode).



STEP 19 .2 μSEC/DIV. LINEARITY (C358)

Adjust for linear sweep rate with TIME/DIV. switch at .2 μSEC and DISPLAY switch at NORM. This step interacts with Step 17.

STEP 3 H.V. ADJ.

Adjust for —1675 volts at indicated point.

STEP 11 HORIZONTAL AMPLIFIER GAIN

Adjust for calibrated deflection at 100 μsecond/div. sweep rate with DISPLAY switch at NORM.

STEP 7 TRIGGER LEVEL CENTERING

With TRIGGERING LEVEL control set at 0 and with 3 minor divisions of vertical deflection, adjust this control for stable triggering in both the +INT. and —INT. positions of the black TRIGGER SELECTOR knob. (AC triggering mode).

STEP 12 SWEEP LENGTH

Adjust for 10.5 major divisions of free-running trace.

STEP 6 CRT GEOMETRY

Adjust so that displayed vertical lines are parallel with vertical graticule lines.

STEP 5 CRT ASTIGMATISM

Adjust for sharpest possible trace.

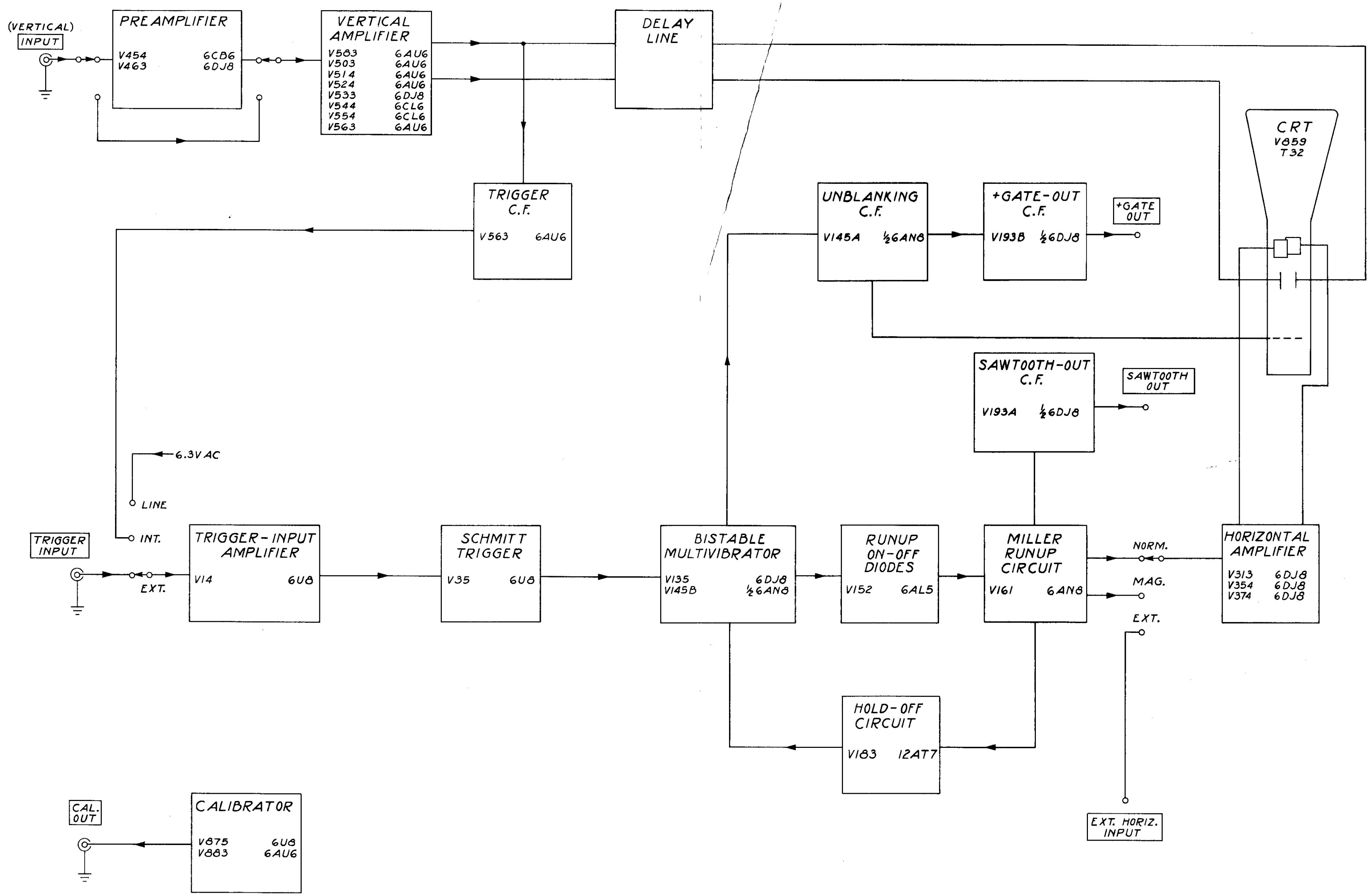
STEP 15 1 μSEC/DIV. LINEARITY (C310)

Adjust for linear sweep rate over the full width of the graticule with TIME/DIV. switch at 5 μSEC and DISPLAY switch at MAG. This step interacts with Step 14.

STEP 1 —150 V ADJ.

Adjust for —150 volts, ±3 volts at indicated point.

BOTTOM VIEW



TYPE RM-16 OSCILLOSCOPE B

1-14-59
R.O.W.

BLOCK DIAGRAM

Type RM16 Parts List Modification

Certain changes have been made in the design of your instrument to improve its performance and reliability. If parts in the instrument do not agree with those in your manual, refer to this list for the correct parts.

Capacitors

Values are fixed unless marked Variable.
Tolerance ±20% unless otherwise indicated.

							Tektronix Part No.
C195	101-268	12 µµf	Cer		500v	±1.2µµf	281-506
	269-up	10 µµf					281-504
C350	101-549	6.8 µµf	Cer		500v		281-541
	550-up	5-25 µµf	Cer		500v		281-011
C372	101-549	3-12 µµf	Cer	Var			281-009
	550-up	5-25 µµf					281-011
C401	101-497	.1 µf	MT		600v		285-547
	498-up	.1 µf	MT		600v		use 285-556
C414		250 µµf	Mica		500v	5%	283-543
C446	101-144	6.25 µf			300v		290-000
	145-up	3x10 µf	EMC				290-032
C447	101-144X	6.25 µf			300v		290-000
C467	101-144X	6.25 µf			300v		290-000
C568		.68 µµf	Cer			±.25µµf	281-537
C790	101-447	.01 µf	Cer		150v		283-003
	448-up	.02 µf			150v		283-004
C791	X448-up	.02 µf			150v		283-004
C822	101-519	.015 µf	PTM		3000v		285-513
	520-up	.01 µf	Cer		2000v		283-011
C824	101-579	.0068 µf	PTM		3000v		285-508
	580-up	.01 µf	Cer		2000v		283-011
C833	101-519	.015 µf	PTM		3000v		285-513
	520-up	.01 µf	Cer		2000v		283-011
C834	101-579	.0068 µf	PTM		3000v		285-508
	580-up	.01 µf	Cer		2000v		283-011
C848	101-519	.015 µf	PTM		3000v		285-513
	520-up	.01 µf	Cer		2000v		283-011

Inductors

L540	101-363	3.2 µh	Fixed	108-088
	364-up	2.5 µh		108-103
L550	101-363	3.2 µh	Fixed	108-088
	364-up	2.5 µh		108-103
L589	101-469	2.5 µh	Fixed	108-103
	470-up	3.2 µh		108-088
L590	101-469	2.5 µh	Fixed	108-103
	470-up	3.2 µh		108-088

Rectifiers

SR454	101-447X	Selenium 1 100-ma plate	106-037
SR601	101-363	Selenium 20 100-ma plates	106-015
	364-up	Silicon Diodes	(2) 152-011
SR630	101-363	Selenium 20 250-ma plates	106-031
	364-up	Silicon Diodes	(4) 152-011
SR660	101-363	Selenium 24 250-ma plates	106-030
	364-up	Silicon Diodes	(4) 152-011
SR750	101-447	Selenium 2 250-ma plates	106-038
	448-up	Silicon Diodes	(2) 152-011

Resistors

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

R147	101-430	680 Ω	1/2w				302-681
	431-up	1 k	1/2w				302-102
R159	X550-up	1 meg	1/2w				302-105
R162	101-363	20 k	2w	Var			311-083
	364-up	20 k	2w		WW		311-108
R195	101-268	15 k	1w				304-153
	269-up	18 k	1/2w				304-183
R324	101-363	150 k	1/2w		Prec	1%	309-049
	364-up	143 k	1/2w			1%	309-092
R350	101-363	6-30 k	5w				310-507
	364-up	7-35 k	5w			1%	310-524
R467		150 k	1/2w			5%	301-154
R516	101-171	660 Ω					use 311-135
	172-up	660 Ω					311-135
R544	101-447	100 Ω	2w	Var			use 311-004
	448-up	200 Ω					311-004
R557	101-317	300 k	1/2w		Prec	1%	309-125
	318-up	333 k	1/2w		Prec	1%	309-053
R751	101-447	2.2 Ω	1/2w		WW	5%	308-116
	448-up	3.3 Ω	1w				307-015
R822	101-539	100 k	1/2w				302-104
	540-up	33 k	1/2w				302-332

Switches

				wired unwired
SW160	101-363	Rotary,	TIME/DIV	262-122/260-174
	364-up			262-182/260-226

Transformers

T600	101-363	Power	120-064
	364-up		120-112

Electron Tubes and Semiconductors

V135	101-363	6BQ7A	154-028
	364-up	6DJ8	154-187
V193	101-363	6BQ7A	154-028
	364-up	6DJ8	154-187
V313	101-363	6BQ7A	154-028
	364-up	6DJ8	154-187
V354	101-363	6BQ7A	154-028
	364-up	6DJ8	154-187
V374	101-363	6BQ7A	154-028
	364-up	6DJ8	154-187
V442	X448-up	T12G Germanium Diode	152-008
V463	101-363	6BQ7A	154-028
	364-up	6DJ8	154-187
V533	101-363	6BQ7A	154-028
	364-up	6DJ8	154-187

PREAMPLIFIER

For an explanation of the abbreviations used in this parts list, see the indexed sheet marked ABBREVIATIONS & WARRANTY.

Lamps

		Order parts by number
B463	Neon, Type NE-2	150-002

Capacitors

C401	.1 μf	MT	Fixed	600 v	20%	285-547
C403	.001 μf	Cer.	Fixed	500 v		283-000
C410	4.5-25 μμf	Cer.	Var.			281-010
C412	1.5-7 μμf	Cer.	Var.			281-005
C414	250 μf	Mica	Fixed	500 v	5%	283-543
C416	4.5-25 μμf	Cer.	Var.			281-010
C418	4.5-25 μμf	Cer.	Var.			281-010
C420	150 μf	Mica	Fixed	500 v	10%	283-544
C424	4.5-25 μμf	Cer.	Var.			281-010
C426	3-12 μμf	Cer.	Var.			281-007
C430	3-12 μμf	Cer.	Var.			281-007
C432	4.5-25 μμf	Cer.	Var.			281-010
C436	270 μμf	Cer.	Fixed	500 v	10%	281-543
C441	.7-3 μμf	Tub.	Var.			281-027
C445	.005 μf	Cer.	Fixed	500 v		283-001
C446A,B,C	3x10 μf	EMC	Fixed	350 v		290-032
C454	500 μf	EMT	Fixed	6 v		290-030
C465	.005 μf	Cer.	Fixed	500 v		283-001
C471	.1 μf	PTM	Fixed	400 v		285-526

Inductors

L450	23-55 μh	Var.	114-086
L457	6.4 μh	Fixed	108-054
L477	.9-1.6 μh	Var.	114-051

Selenium Rectifiers

SR454	1	100-ma plate per leg	106-037

Resistors

R103	10 Ω	½ w	Fixed	Comp.	10%	302-100
R412	990 k	½ w	Fixed	Prec.	1%	309-013
R414	10.1 k	½ w	Fixed	Prec.	1%	309-034
R418	900 k	½ w	Fixed	Prec.	1%	309-111
R420	111 k	½ w	Fixed	Prec.	1%	309-046

Resistors *(Continued)*

R422	27 Ω	½ w	Fixed	Comp.	10%	302-270
R426	800 k	½ w	Fixed	Prec.	1%	309-110
R428	250 k	½ w	Fixed	Prec.	1%	309-109
R432	500 k	½ w	Fixed	Prec.	1%	309-003
R434	1 meg	½ w	Fixed	Prec.	1%	309-014
R436	22 Ω	½ w	Fixed	Comp.	10%	302-220
R441*	1 meg	½ w	Fixed	Prec.	1%	312-583
R443	47 Ω	½ w	Fixed	Comp.	10%	302-470
R444	22 k	½ w	Fixed	Comp.	10%	302-223
R445	100 Ω	½ w	Fixed	Comp.	10%	302-101
R446	12 k	2 w	Fixed	Comp.	10%	306-123
R450	3 k	½ w	Manufactured by Tektronix			310-539
R452	15 k	10 w	Fixed	WW	5%	308-024
R454	200 Ω	.5 w	Var.	Comp.		311-097
R457	47 Ω	½ w	Fixed	Comp.	10%	302-470
R463	22 k	2 w	Fixed	Comp.	10%	306-223
R465	47 Ω	½ w	Fixed	Comp.	10%	302-470
R466	1 k	½ w	Fixed	Comp.	10%	302-102
R467	150 k	½ w	Fixed	Comp.	5%	302-154
R468	200 k	½ w	Fixed	Comp.	5%	301-204
R471	8.2 k	1 w	Fixed	Comp.	10%	304-822
R474	390 k	½ w	Fixed	Comp.	10%	302-394
R475	2 meg	2 w	Var.	Comp.		311-042

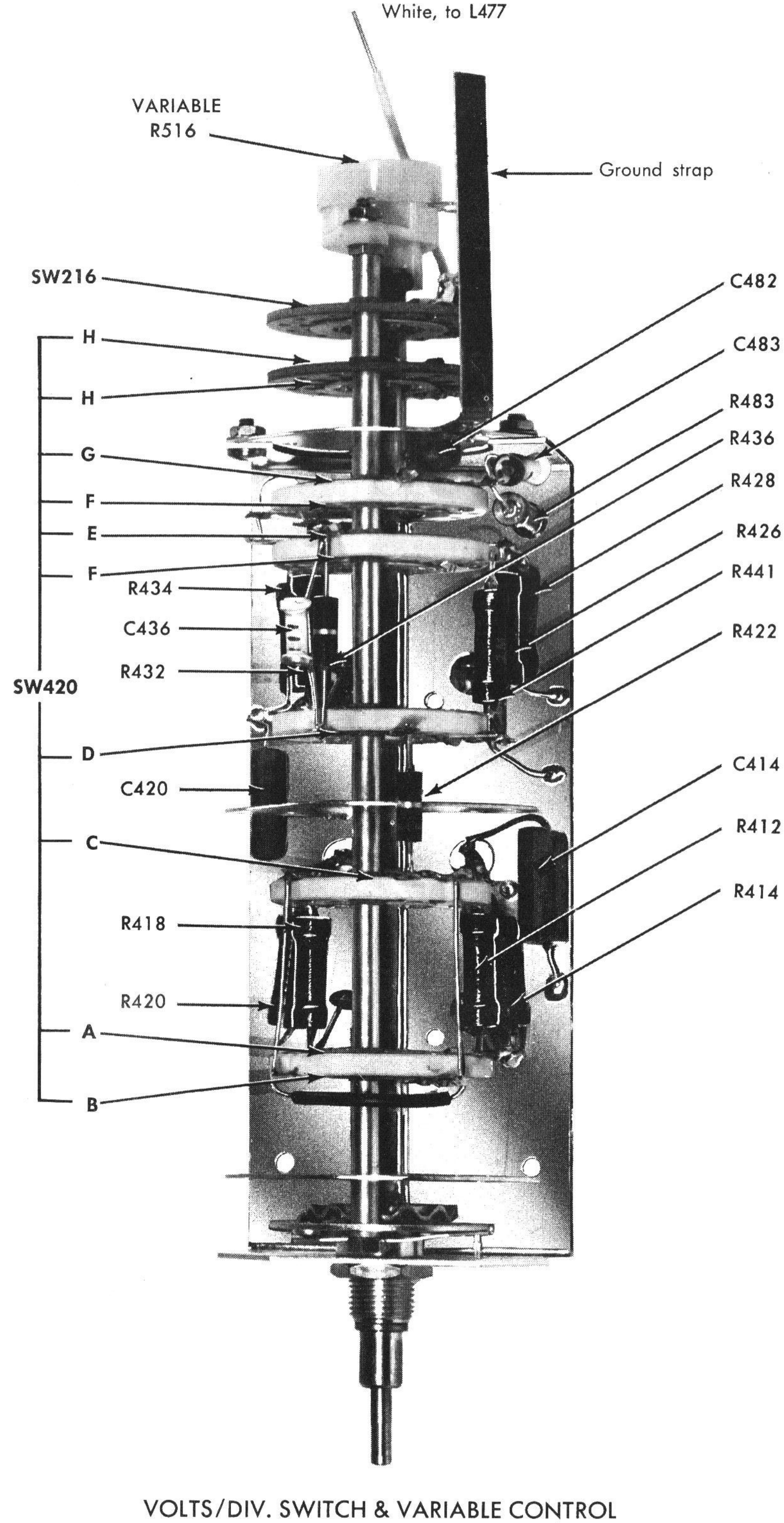
*Selected with R183. Furnished as a unit.

Switches

		not wired	wired
SW401	1-wafer, 2-position, rotary: AC-DC		260-122
SW420	7-wafer, 9-position, rotary: VOLTS/DIV.	260-187	262-144

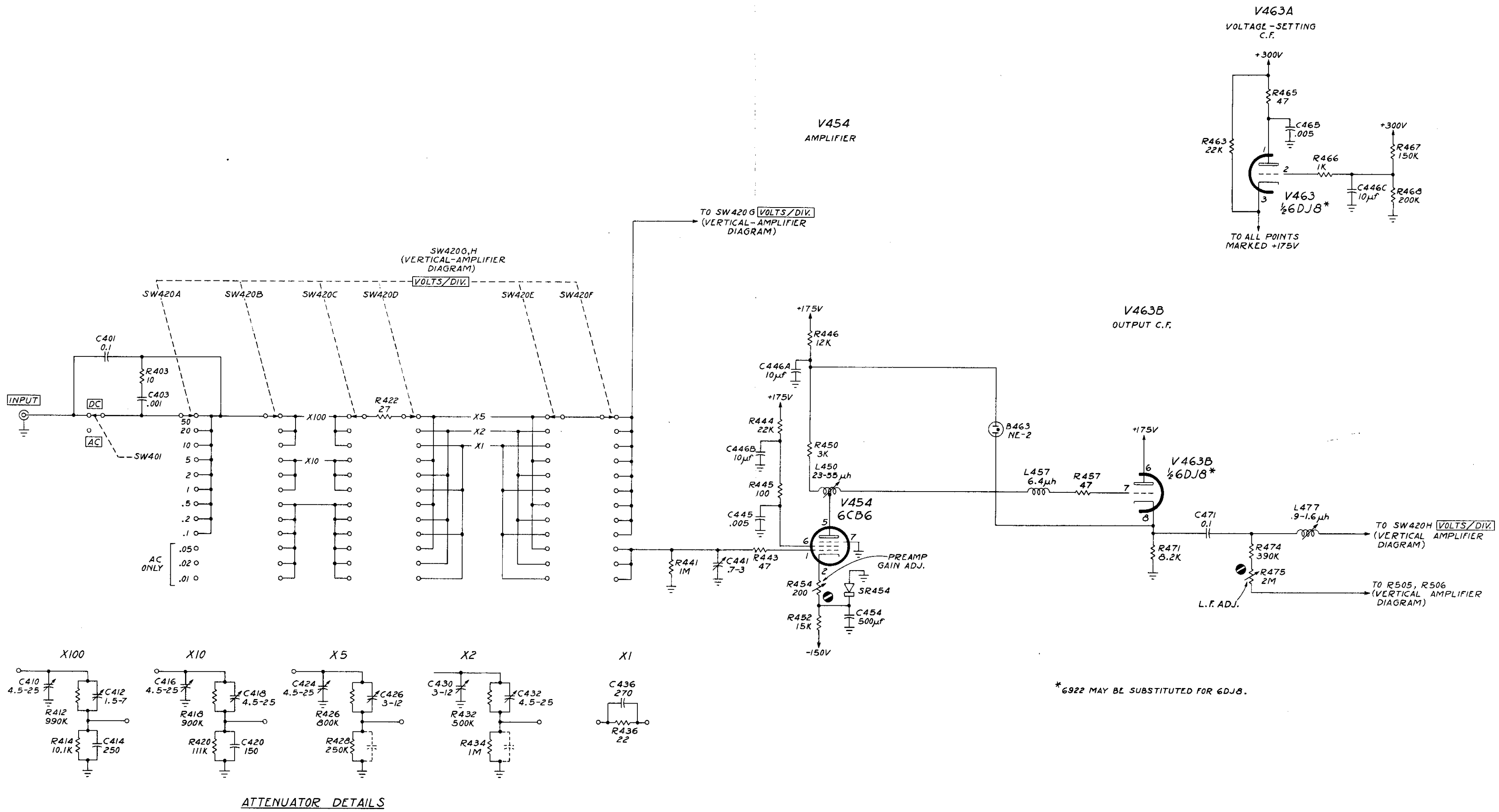
Vacuum Tubes

V454	6CB6	Amplifier	154-030
V463A	½6BQ7A	Voltage-setting Cathode Follower	154-028
V463B	½6BQ7A	Output Cathode Follower	



VOLTS/DIV. SWITCH & VARIABLE CONTROL

SWITCH DETAIL



PREAMPLIFIER

VERTICAL AMPLIFIER

For an explanation of the abbreviations used in this parts list, see the indexed sheet marked ABBREVIATIONS & WARRANTY.

Lamps

		Order parts by number
B517	Neon, Type NE-2	150-002

Capacitors

						Order parts by number
C482	.001 μf	Cer.	Fixed	500 v		283-000
C483	2.2 μμf	Cer.	Fixed	500 v	±0.5 μμf	281-500
C484	.005 μf	Cer.	Fixed	500 v		283-001
C490	.005 μf	Cer.	Fixed	500 v		283-001
C494	.01 μf	Cer.	Fixed	500 v		283-002
C507	.01 μf	Cer.	Fixed	150 v		283-003
C556	2.7 μμf	Cer.	Fixed	500 v		281-547
C562	.005 μf	Cer.	Fixed	500 v		283-001

Inductors

			Order parts by number
L513	15-30 μh	Var.	114-076
L527	15-30 μh	Var.	114-076
L540	2.5 μh	Fixed	108-103
L544	12-25 μh	Var.	114-077
L550	2.5 μh	Fixed	108-103
L554	12-25 μh	Var.	114-077

Resistors

						Order parts by number
R483*	1 meg	½ w	Fixed	Prec.	0.1%	312-583
R484	100 k	½ w	Fixed	Comp.	10%	302-104
R487	47 Ω	½ w	Fixed	Comp.	10%	302-470
R490	47 Ω	½ w	Fixed	Comp.	10%	302-470
R493	39 k	1 w	Fixed	Comp.	10%	304-393
R494	47 Ω	½ w	Fixed	Comp.	10%	302-470
R495	39 k	1 w	Fixed	Comp.	10%	304-393
R501	500 k	2 w	Var.	Comp.		311-034
R503	390 k	½ w	Fixed	Comp.	10%	302-394
R505	4.7 meg	½ w	Fixed	Comp.	10%	302-475
R506	3.9 k	½ w	Fixed	Comp.	10%	302-392
R507	47 Ω	½ w	Fixed	Comp.	10%	302-470
R510	10 Ω	½ w	Fixed	Comp.	10%	302-100
R512	1.2 k	½ w	Fixed	Comp.	10%	302-122
R513	1.8 k	½ w	Manufactured by Tektronix			310-533

*Selected with R441. Furnished as a unit.

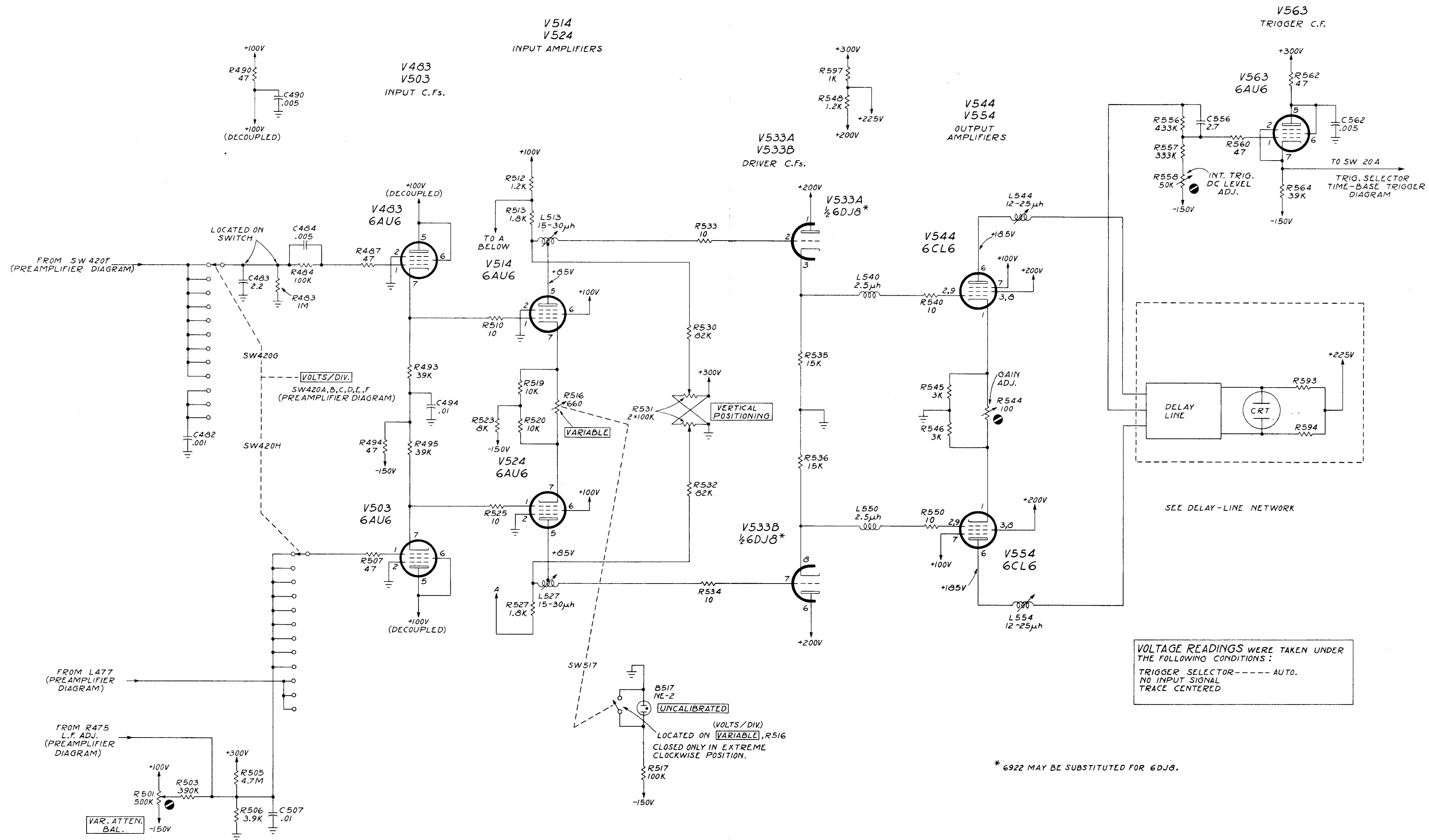
Resistors *(Continued)*

R516	660 Ω		Manufactured by Tektronix			311-135
R517	100 k	½ w	Fixed	Comp.	10%	302-104
R519	10 k	1 w	Fixed	Comp.	10%	304-103
R520	10 k	1 w	Fixed	Comp.	10%	304-103
R523	8 k	5 w	Fixed	WW	5%	308-007
R525	10 Ω	½ w	Fixed	Comp.	10%	302-100
R527	1.8 k	½ w	Manufactured by Tektronix			310-533
R530	82 k	½ w	Fixed	Comp.	10%	302-823
R531	2x100 k	2 w	Var.	Comp.		311-028
R532	82 k	½ w	Fixed	Comp.	10%	302-823
R533	10 Ω	½ w	Fixed	Comp.	10%	302-100
R534	10 Ω	½ w	Fixed	Comp.	10%	302-100
R535	15 k	1 w	Fixed	Comp.	5%	303-153
R536	15 k	1 w	Fixed	Comp.	5%	303-153
R540	10 Ω	½ w	Fixed	Comp.	10%	302-100
R544	100 Ω	2 w	Var.	Comp.		311-003
R545	3 k	5 w	Fixed	WW	5%	308-082
R546	3 k	5 w	Fixed	WW	5%	308-082
R548	1.2 k	5 w	Fixed	WW	5%	308-063
R550	10 Ω	½ w	Fixed	Comp.	10%	302-100
R556	433 k	½ w	Fixed	Prec.	1%	309-001
R557	333 k	½ w	Fixed	Prec.	1%	309-053
R558	50 k	2 w	Var.	Comp.		311-023
R560	47 Ω	½ w	Fixed	Comp.	10%	302-470
R562	47 Ω	½ w	Fixed	Comp.	10%	302-470
R564	39 k	1 w	Fixed	Comp.	10%	304-393
R597	1 K	10 w	Fixed	WW	5%	308-089

Vacuum Tubes

V483	6AU6	Input Cathode Follower	154-022
V503	6AU6	Input Cathode Follower	154-022
V514	6AU6	Input Amplifier	154-022
V524	6AU6	Input Amplifier	154-022
V533	6DJ8*	Driver Cathode Follower	154-187
V544	6CL6	Output Amplifier	154-031
V554	6CL6	Output Amplifier	154-031
V563	6AU6	Trigger Cathode Follower	154-022

*6922 may be substituted for 6DJ8.



TYPE RM-16 OSCILLOSCOPE B

VERTICAL AMPLIFIER

1-14-59
R.O.W.

VERTICAL AMPLIFIER

DELAY LINE

For an explanation of the abbreviations used in this parts list, see the indexed sheet marked ABBREVIATIONS & WARRANTY.

Capacitors

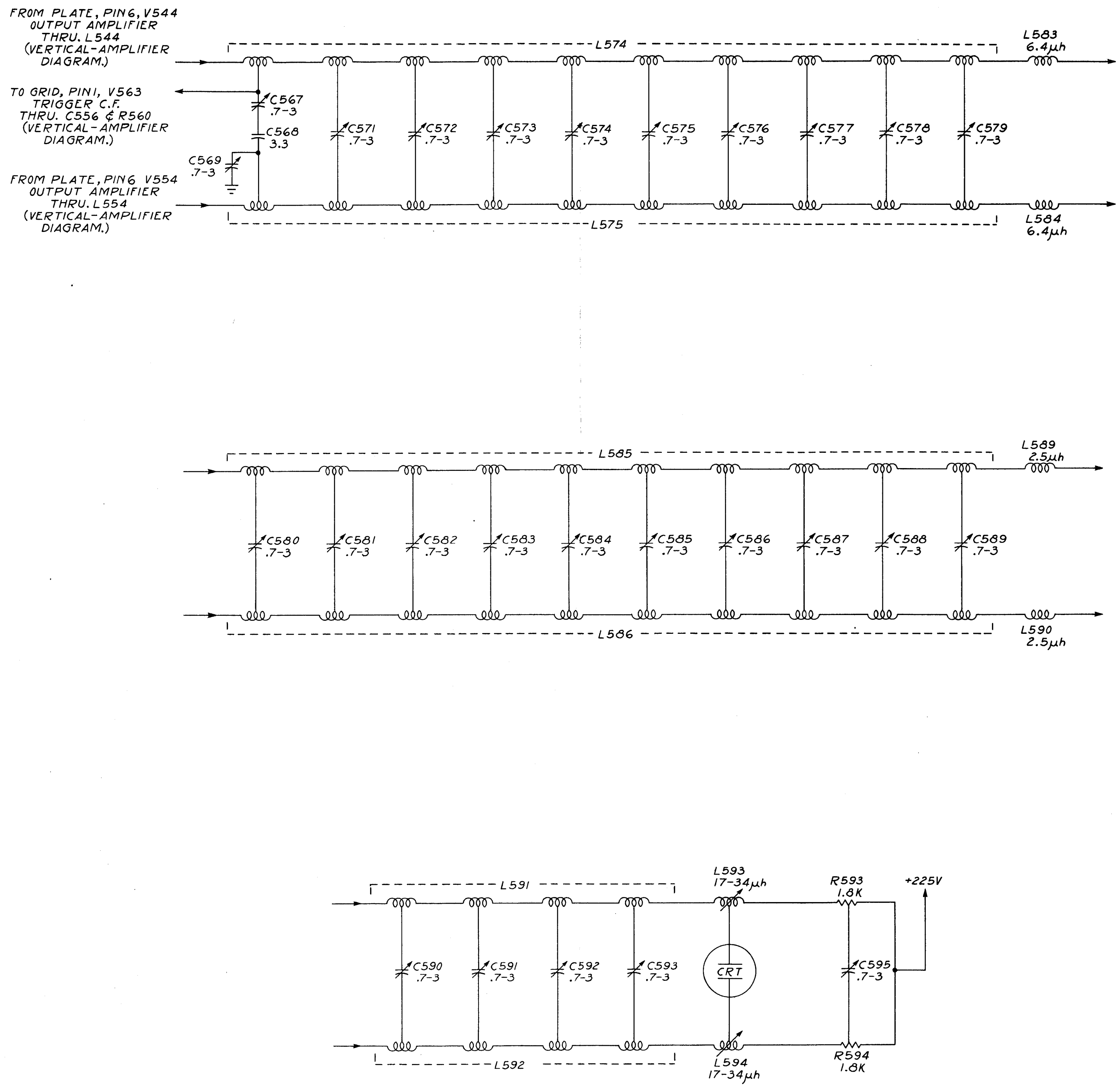
					Order parts by number
C567	.7-3 μμf	Tub.	Var.		281-027
C568	3.3 μμf	Cer.	Fixed	±.25 μμf	281-534
C569	.7-3 μμf	Tub.	Var.		281-027
C571-93	.7-3 μμf	Tub.	Var.		281-027
C595	.7-3 μμf	Tub.	Var.		281-027

Inductors

L574	Delay Line, 10 section		108-124
L575	Delay Line, 10 section		108-124
L583	5 μh on 15 meg, ½ w resistor		108-146
L584	5 μh on 15 meg, ½ w resistor		108-146
L585	Delay Line, 10 section		108-124
L586	Delay Line, 10 section		108-124
L589	2.5 μh	Fixed	108-103
L590	2.5 μh	Fixed	108-103
L591	Delay Line, 4 section		108-140
L592	Delay Line, 4 section		108-140
L593	17-34 μh	Var.	114-075
L594	17-34 μh	Var.	114-075

Resistors

R593	1.8 k	3 w	Manufactured by Tektronix	310-534
R594	1.8 k	3 w	Manufactured by Tektronix	310-534


FROM PLATE, PIN 6, V544
OUTPUT AMPLIFIER
THRU. L544
(VERTICAL-AMPLIFIER
DIAGRAM.)
TO GRID, PIN 1, V563
TRIGGER C.F.
THRU. C556 & R560
(VERTICAL-AMPLIFIER
DIAGRAM.)
FROM PLATE, PIN 6 V554
OUTPUT AMPLIFIER
THRU. L554
(VERTICAL-AMPLIFIER
DIAGRAM.)
L574
L575
L583 6.4μh
L584 6.4μh
C567 .7-3
C568 3.3
C569 .7-3
C571 .7-3
C572 .7-3
C573 .7-3
C574 .7-3
C575 .7-3
C576 .7-3
C577 .7-3
C578 .7-3
C579 .7-3
L585
L586
L589 2.5μh
L590 2.5μh
C580 .7-3
C581 .7-3
C582 .7-3
C583 .7-3
C584 .7-3
C585 .7-3
C586 .7-3
C587 .7-3
C588 .7-3
C589 .7-3
L591
L592
L593 17-34μh
L594 17-34μh
R593 1.8K
R594 1.8K
+225V
C590 .7-3
C591 .7-3
C592 .7-3
C593 .7-3
CRT
C595 .7-3

6-19-58
R.O.W

TIME-BASE TRIGGER

For an explanation of the abbreviations used in this parts list, see the indexed sheet marked ABBREVIATIONS & WARRANTY.

Capacitors

						Order parts by number
C7	.01 μf	PTM	Fixed	400 v		285-510
C10	.001 μf	Cer.	Fixed	500 v		283-000
C14	.001 μf	Cer.	Fixed	500 v		283-000
C23	.01 μf	Cer.	Fixed	150 v		283-003
C25	.01 μf	Cer.	Fixed	150 v		283-003
C35	18 μμf	Cer.	Fixed	500 v	10%	281-542

Resistors

R9	1 meg	½ w	Fixed	Comp.	10%	302-105
R10	470 k	½ w	Fixed	Comp.	10%	302-474
R12	100 Ω	½ w	Fixed	Comp.	10%	302-101
R14	27 Ω	½ w	Fixed	Comp.	10%	302-270
R15	5.6 k	½ w	Fixed	Comp.	10%	302-562
R17	20 k	8 w	Fixed	WW	5%	308-081
R19	100 Ω	½ w	Fixed	Comp.	10%	302-101
R22	100 k	½ w	Fixed	Comp.	10%	302-104
R23	100 Ω	½ w	Fixed	Comp.	10%	302-101
R24	220 k	½ w	Fixed	Comp.	10%	302-224
R25	100 k	½ w	Fixed	Comp.	10%	302-104
R26	3.9 meg	½ w	Fixed	Comp.	10%	302-395
R27	820 k	½ w	Fixed	Comp.	10%	302-824
R28	1 meg	½ w	Fixed	Comp.	10%	302-105
R29*	100 k	2 w	Var.	Comp.	20%	311-099
R31	2.2 meg	½ w	Fixed	Comp.	10%	302-225
R32	1 k	½ w	Fixed	Comp.	10%	302-102
R33	3.3 k	½ w	Fixed	Comp.	5%	301-332
R35	150 k	½ w	Fixed	Comp.	10%	302-154
R36	120 k	½ w	Fixed	Comp.	10%	302-124
R37	100 k	2 w	Var.	Comp.		311-026
R39	100 Ω	½ w	Fixed	Comp.	10%	302-101
R40	820 Ω	½ w	Fixed	Comp.	10%	302-821
R41	1 meg	½ w	Fixed	Comp.	10%	302-105
R42	11 k	2 w	Fixed	Comp.	5%	305-113

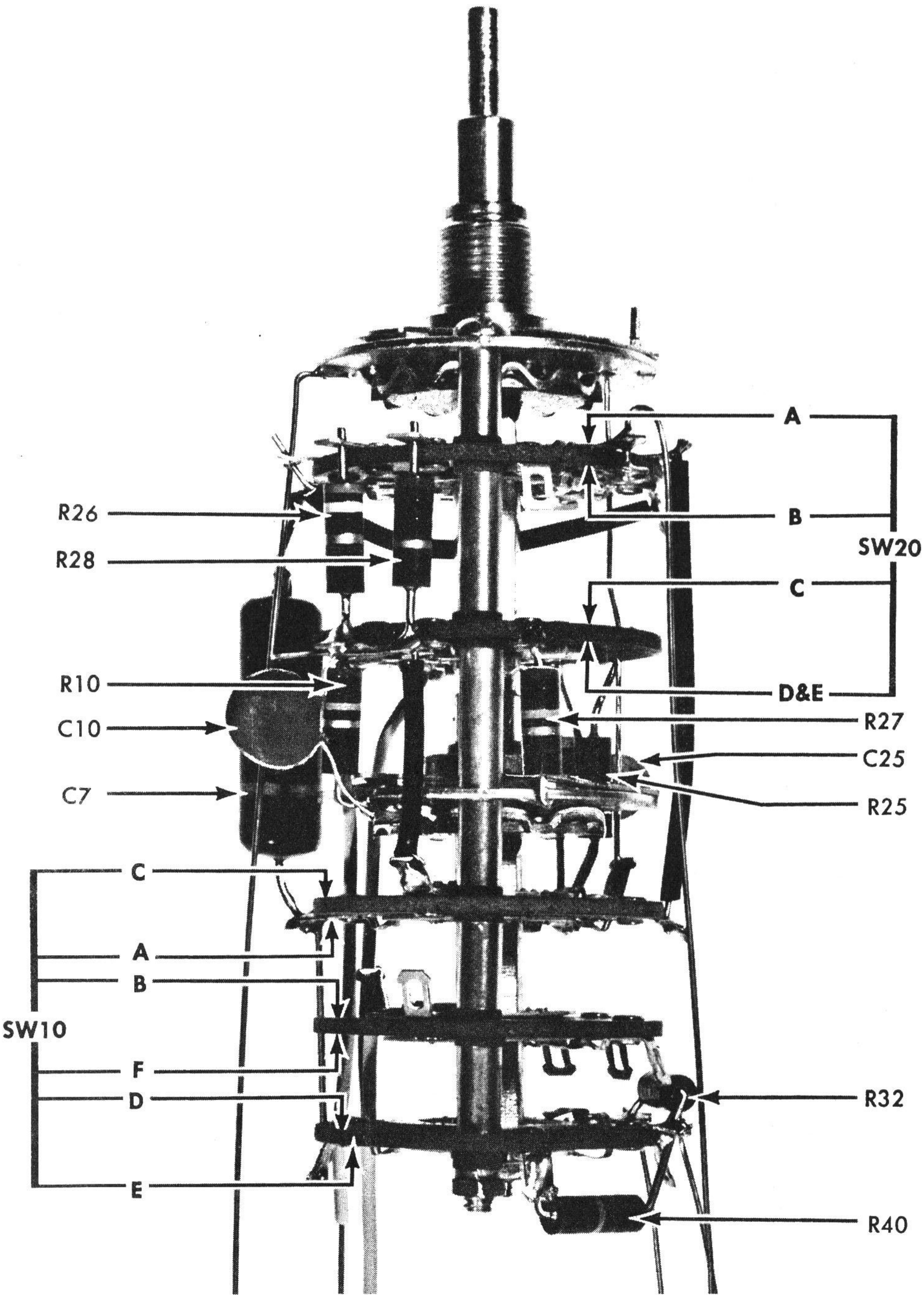
*Furnished as a unit with R110, R330 and SW110.

Switches

			not wired	wired
SW10	3-wafer, 4-position, rotary	TRIGGER SELECTOR	260-151	262-143
SW20	2-wafer, 6-position, rotary			

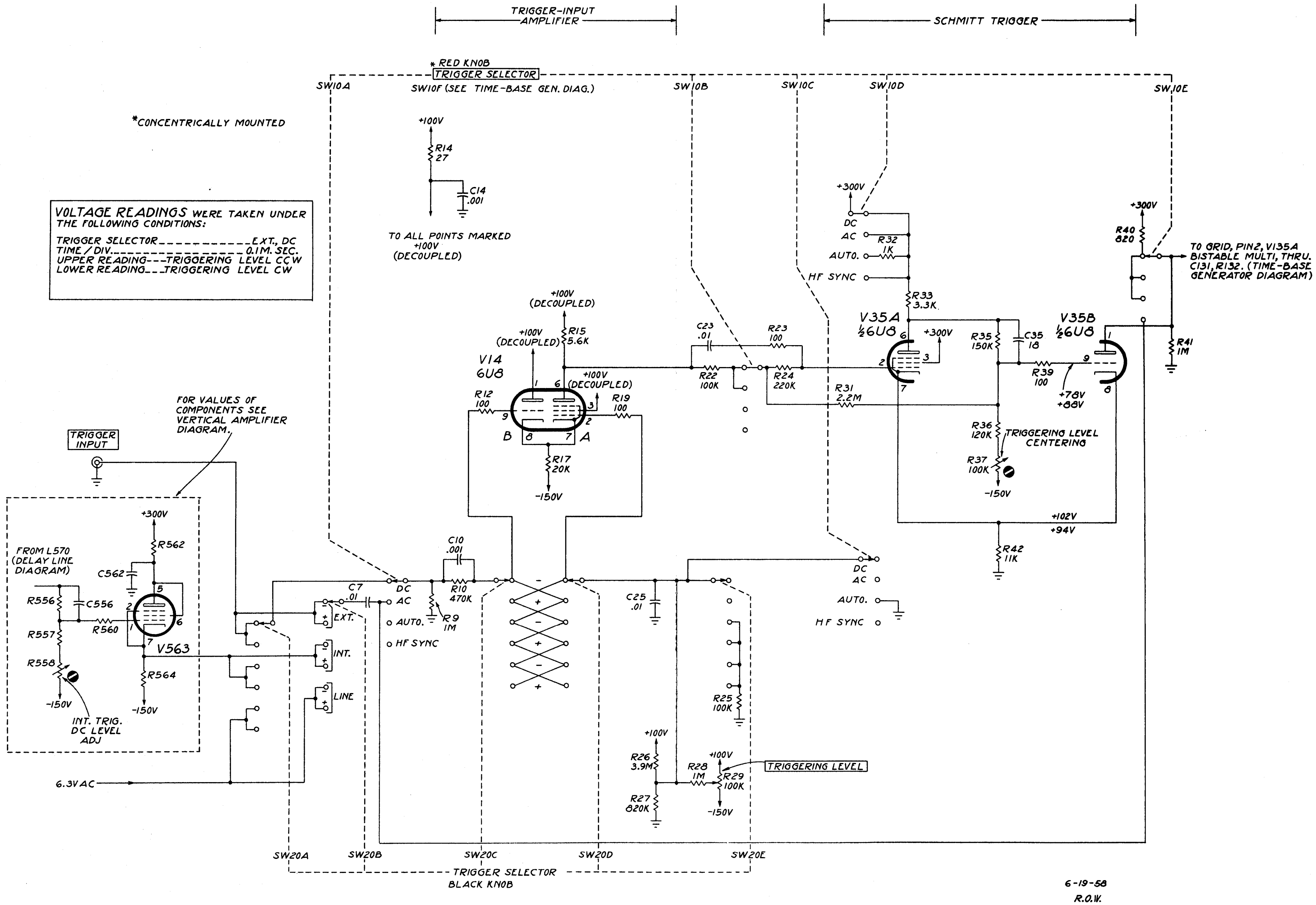
Vacuum Tubes

V14	6U8	Trigger-Input Amplifier	154-033
V35	6U8	Schmitt Trigger	154-033



TRIGGER SELECTOR SWITCH

SWITCH DETAIL



TYPE RM-16 OSCILLOSCOPE

A

TIME-BASE TRIGGER

TIME-BASE GENERATOR

For an explanation of the abbreviations used in this parts list, see the indexed sheet marked ABBREVIATIONS & WARRANTY.

Lamp

		Order parts by number
B163	Neon, Type NE-2	150-002
B167	Neon, Type NE-2	150-002
B170	Neon, Type NE-2	150-002

Capacitors

C131	27 μμf	Cer.	Fixed	500 v	±5.4 μμf	281-513
C133	8 μμf	Cer.	Fixed	500 v	±0.5 μμf	281-503
C138	.005 μμf	Cer.	Fixed	500 v		283-001
C141	5.6 μμf	Cer.	Fixed	500 v	10%	281-544
C144	.005 μf	Cer.	Fixed	500 v		283-001
C150	56 μμf	Cer.	Fixed	500 v	±5.6 μμf	281-521
C165	470 μμf	Cer.	Fixed	500 v	±94 μμf	281-525
C167	.001 μf	Cer.	Fixed	500 v		283-000
C191	.001 μf	Cer.	Fixed	500 v		283-000
C195	12 μμf	Cer.	Fixed	500 v	±1.2 μμf	281-506

Resistors

R110*	500 k	2 w	Var.	Comp.	20%	311-099
R111	100 k	2 w	Var.	Comp.	20%	311-026
R114	100 k	½ w	Fixed	Comp.	10%	302-104
R115	27 k	½ w	Fixed	Comp.	5%	301-273
R116	39 k	½ w	Fixed	Comp.	5%	301-393
R131	4.7 k	½ w	Fixed	Comp.	10%	302-472
R132	100 Ω	½ w	Fixed	Comp.	10%	302-101
R133	3.6 k	1 w	Fixed	Comp.	5%	303-362
R134	3.6 k	1 w	Fixed	Comp.	5%	303-362
R135	100 Ω	½ w	Fixed	Comp.	10%	302-101
R138	100 Ω	½ w	Fixed	Comp.	10%	302-101
R140	47 Ω	½ w	Fixed	Comp.	10%	302-470
R141	43 k	1 w	Fixed	Comp.	5%	303-433
R142	33 k	1 w	Fixed	Comp.	5%	303-333
R143	10 k	5 w	Fixed	WW	5%	308-054
R144	100 Ω	½ w	Fixed	Comp.	10%	302-101
R145	1 meg	½ w	Fixed	Comp.	10%	302-105
R146	47 Ω	½ w	Fixed	Comp.	10%	302-470
R147	680 Ω	½ w	Fixed	Comp.	10%	302-681
R148	150 k	1 w	Fixed	Comp.	10%	304-154

*Furnished as a unit with R29, R330 & SW110.

Resistors *(continued)*

R150	680 Ω	½ w	Fixed	Comp.	10%	302-681
R161	8.2 k	½ w	Fixed	Comp.	10%	302-822
R162	20 k	2 w	Var.	Comp.	20%	311-083
R163	100 k	½ w	Fixed	Comp.	10%	302-104
R164	100 Ω	½ w	Fixed	Comp.	10%	302-101
R165	47 k	1 w	Fixed	Comp.	10%	304-473
R166	47 k	1 w	Fixed	Comp.	10%	304-473
R167	1.5 meg	½ w	Fixed	Comp.	10%	302-155
R168	220 k	½ w	Fixed	Comp.	10%	302-224
R170	100 Ω	½ w	Fixed	Comp.	10%	302-101
R173	10 k	5 w	Fixed	WW	5%	308-054
R174	2.2 k	1 w	Fixed	Comp.	10%	304-222
R176	2 k	2 w	Var.	Comp.	20%	311-008
R178	6 k	5 w	Fixed	WW	5%	308-052
R181	4.7 meg	½ w	Fixed	Comp.	10%	302-475
R183	100 Ω	½ w	Fixed	Comp.	10%	302-101
R191	100 k	½ w	Fixed	Comp.	10%	302-104
R192	47 Ω	½ w	Fixed	Comp.	10%	302-470
R193	47 Ω	½ w	Fixed	Comp.	10%	302-470
R194	100 k	1 w	Fixed	Comp.	10%	304-104
R195	18 k	1 w	Fixed	Comp.	10%	304-183
R196	33 k	2 w	Fixed	Comp.	10%	306-333
R197	47 Ω	½ w	Fixed	Comp.	10%	302-470
R199	10 k	½ w	Fixed	Comp.	10%	302-103

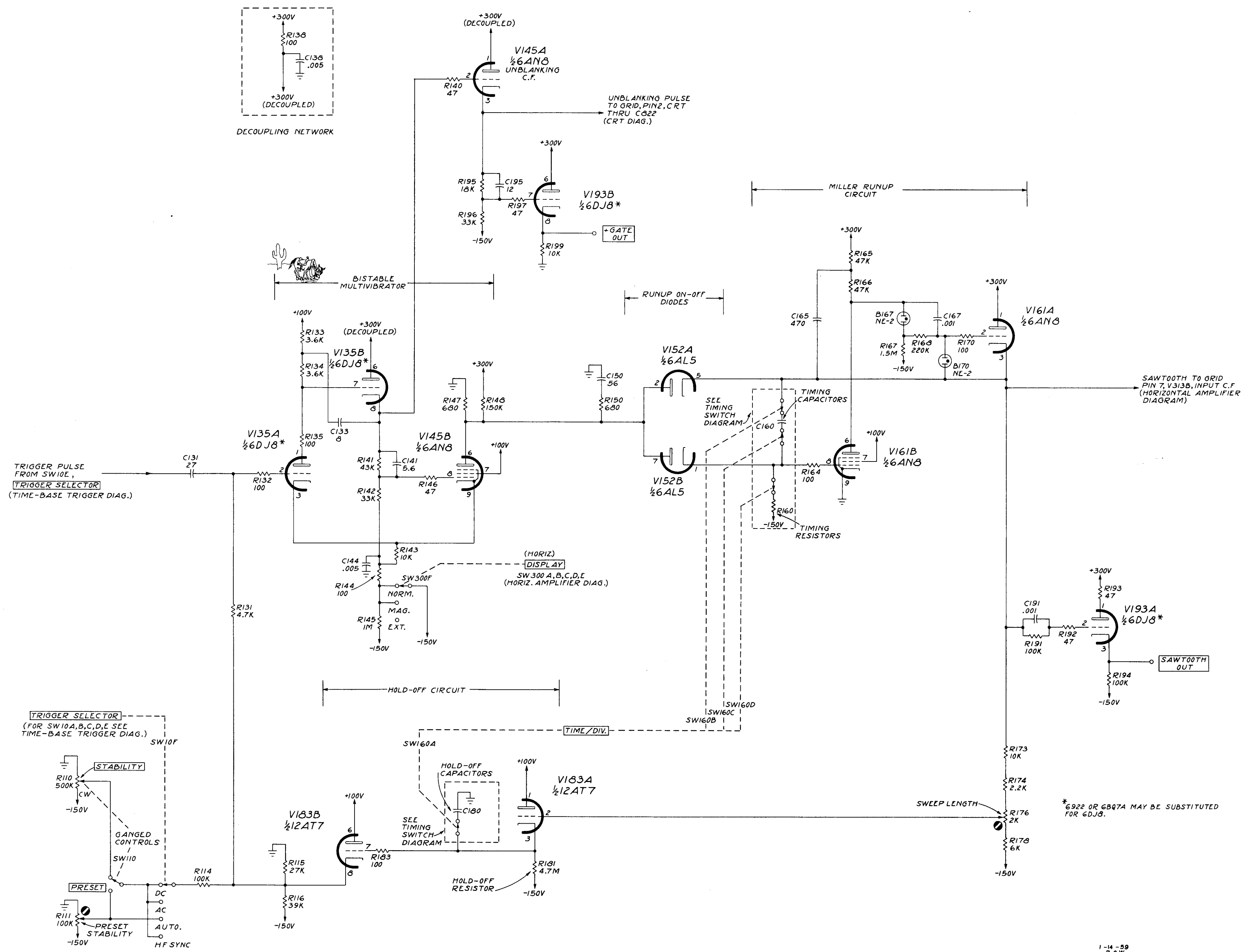
Switches

SW110*	Single-pole, double-throw, rotary: **PRESET**	311-099

*Furnished as a unit with R29, R110 & R330.

Vacuum Tubes

V135	6BQ7A	Bistable Multivibrator	154-028
V145A	½ 6AN8	Unblanking C.F.	154-078
V145B	½ 6AN8	Bistable Multivibrator	
V152	6AL5	Runup On-Off Diodes	154-016
V161A	½ 6AN8	Runup C.F.	154-078
V161B	½ 6AN8	Miller Runup	
V183	12AT7	Holdoff	154-039
V193A	½6BQ7A	Sawtooth-Out C.F.	154-028
V193B	½ 6BQ7A	+Gate-Out C.F.	



TYPE RM-16 OSCILLOSCOPE B

TIME-BASE GENERATOR

TIME BASE GENERATOR

TIMING SWITCH

For an explanation of the abbreviations used in this parts list, see the indexed sheet marked ABBREVIATIONS & WARRANTY.

Capacitors

						Order parts by number
C160A	3-12 μμf	Cer.	Var.			281-007
C160B	82 μμf	Mica	Fixed	500 v	5%	283-534
C160C	4.5-25 μμf	Cer.	Var.			281-010
C160D	82 μμf	Mica	Fixed	500 v	5%	283-534
C160E	4.5-25 μμf	Cer.	Var.			281-010
C160F*	.001 μf	Manufactured by Tektronix				291-007
C160G	.01 μf					
C160H	0.1 μf					
C160J	1 μf					
C180A	180 μμf	Mica	Fixed	500 v	10%	283-509
C180B	.0022 μf	PTM	Fixed	400 v	20%	285-543
C180C	.022 μf	PTM	Fixed	400 v		285-515
C180D	.1 μf	PTM	Fixed	400 v	20%	285-526
C180E	.1 μf	PTM	Fixed	400 v	20%	285-526
C181	39 μμf	Cer.	Fixed	500 v	10%	281-516

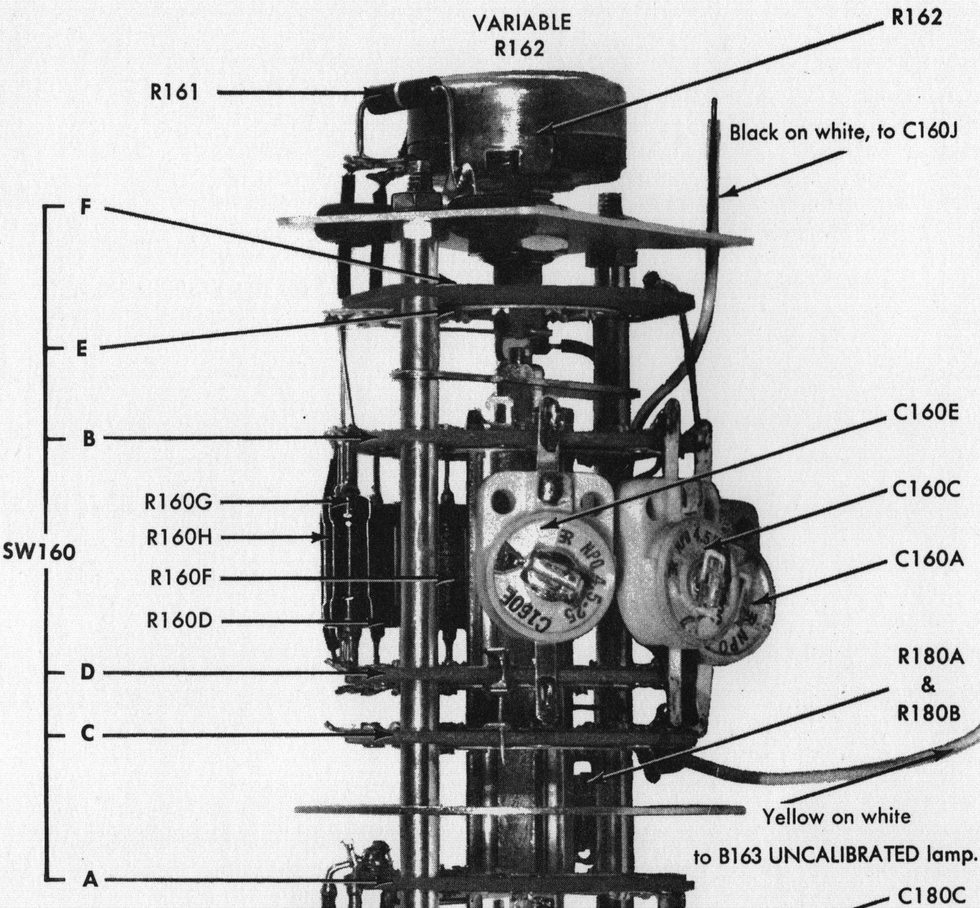
*This .001 μf timing capacitor may be ordered separately. When ordering, note the color band painted on the end of the capacitor. If the capacitor has a white color band, order #291-008A. If the capacitor has a black color band, order #291-008B.

Resistors

R160A	100 k	½ w	Fixed	Prec.	1%	309-045
R160B	200 k	½ w	Fixed	Prec.	1%	309-051
R160C	500 k	½ w	Fixed	Prec.	1%	309-003
R160D	1 meg	½ w	Fixed	Prec.	1%	309-014
R160E	2 meg	½ w	Fixed	Prec.	1%	309-023
R160F	5 meg	½ w	Fixed	Prec.	1%	309-087
R160G	10 meg	½ w	Fixed	Prec.	1%	309-095
R160H	10 meg	½ w	Fixed	Prec.	1%	309-095
R160J	10 meg	½ w	Fixed	Prec.	1%	309-095
R180A	470 k	½ w	Fixed	Comp.	10%	302-474
R180B	4.7 meg	½ w	Fixed	Comp.	10%	302-475

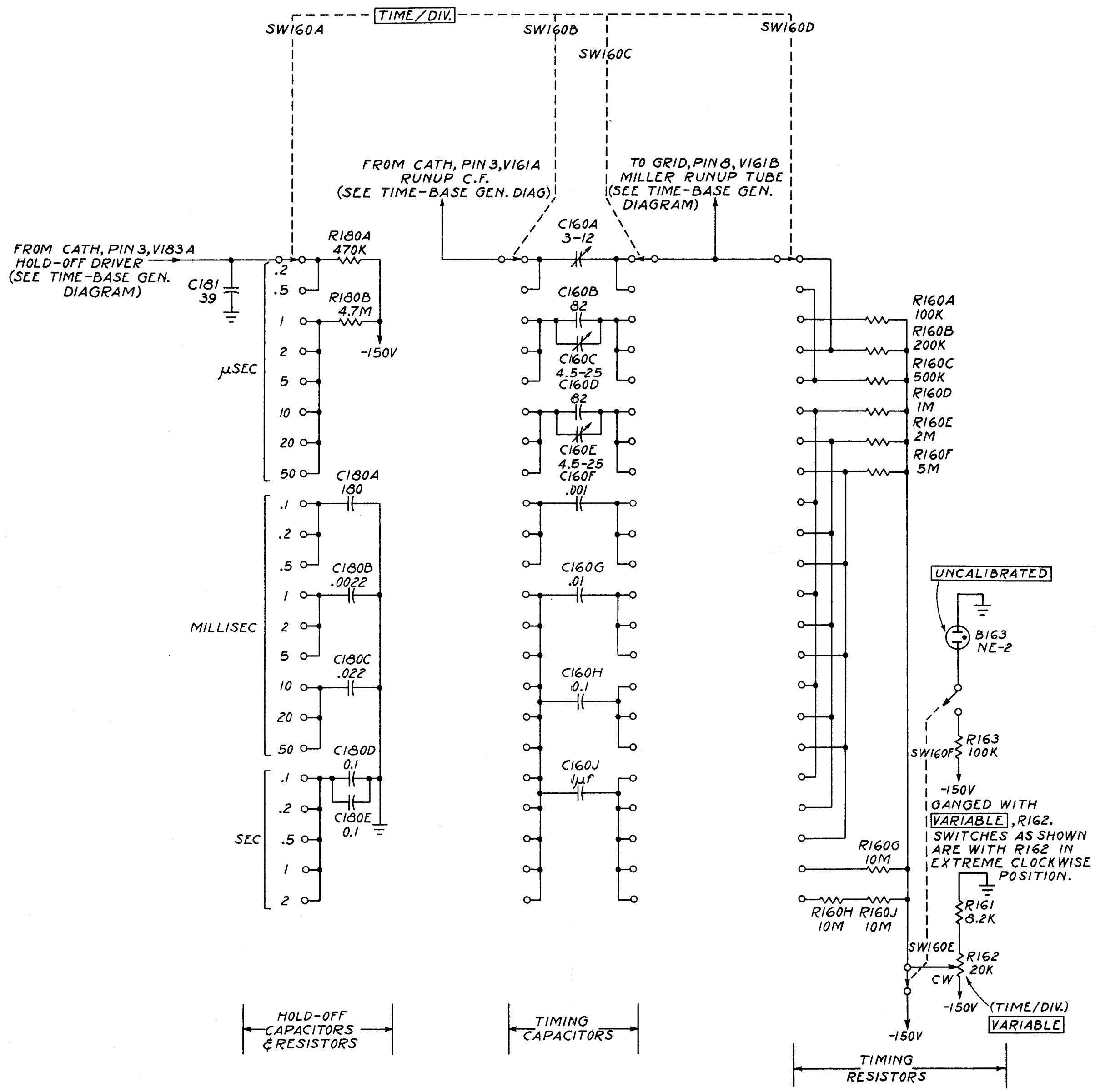
Switches

		not wired	wired
SW160	5-wafer, 22-position, rotary: TIME/DIVISION	260-174	262-122



TIME/DIV. SWITCH & VARIABLE CONTROL

SWITCH DETAIL



TYPE RM-16 OSCILLOSCOPE A TIMING SWITCH (TIME/DIV.) 6-16-58 R.O.W.

HORIZONTAL AMPLIFIER

For an explanation of the abbreviations used in this parts list, see the indexed sheet marked ABBREVIATIONS & WARRANTY.

Lamps

		Order parts by number
B300	Neon, Type NE-2	150-002
B359	Neon, Type NE-2	150-002
B379	Neon, Type NE-2	150-002

Capacitors

C310	4.5-25 μμf	Cer.	Var.			**281-010**
C315	15 μμf	Cer.	Fixed	500 v	10%	281-509
C324	3-12 μμf	Cer.	Var.			281-009
C333	1.5 μμf	Cer.	Fixed	500 v		281-526
C350	6.8 μμf	Cer.	Fixed	500 v		281-541
C358	8-50 μμf	Cer.	Var.			281-013
C367	.01 μf	Cer.	Fixed	500 v		283-002
C372	3-12 μμf	Cer.	Var.			**281-009**

Resistors

R300	100 k	½ w	Fixed	Comp.	10%	302-104
R310	1.84 meg	½ w	Fixed	Prec.	1%	309-021
R311	1.5 meg	½ w	Fixed	Prec.	1%	309-017
R314 A,B	2x20 k	2 w	Var.	WW	20%	311-090
R315	560 Ω	½ w	Fixed	Comp.	10%	302-561
R316	47 Ω	½ w	Fixed	Comp.	10%	302-470
R318	47 k	2 w	Fixed	Comp.	10%	306-473
R324	150 k	½ w	Fixed	Prec.	1%	309-049
R325	50 k	0.2 w	Var.	Comp.	20%	311-078
R330*	100 k		Var.	Comp.		311-099
R333	400 k	½ w	Fixed	Prec.	1%	309-126
R334	250 k	½ w	Fixed	Prec.	1%	309-109
R335	50 k	2 w	Var.	Comp.		311-023
R337	47 Ω	½ w	Fixed	Comp.	10%	302-470
R340	68 k	2 w	Fixed	Comp.	10%	306-683
R344	47 Ω	½ w	Fixed	Comp.	10%	302-470
R350	6-30 k	5 w	Manufactured by Tektronix			310-507
R351	47 Ω	½ w	Fixed	Comp.	10%	302-470
R353	15 k	1 w	Fixed	Comp.	5%	303-153
R354	10 k	5 w	Fixed	WW	5%	308-054
R356	15 k	1 w	Fixed	Comp.	5%	303-153
R358	2.5 k	½ w	Var.	Comp.	10%	311-086
R359	41.5 k	5 w	Manufactured by Tektronix			310-512
R365	22 k	1 w	Fixed	Comp.	10%	304-223
R366	100 k	½ w	Fixed	Comp.	10%	302-104

*Furnished as a unit with R110, R29, & SW110.

Resistors *(Continued)*

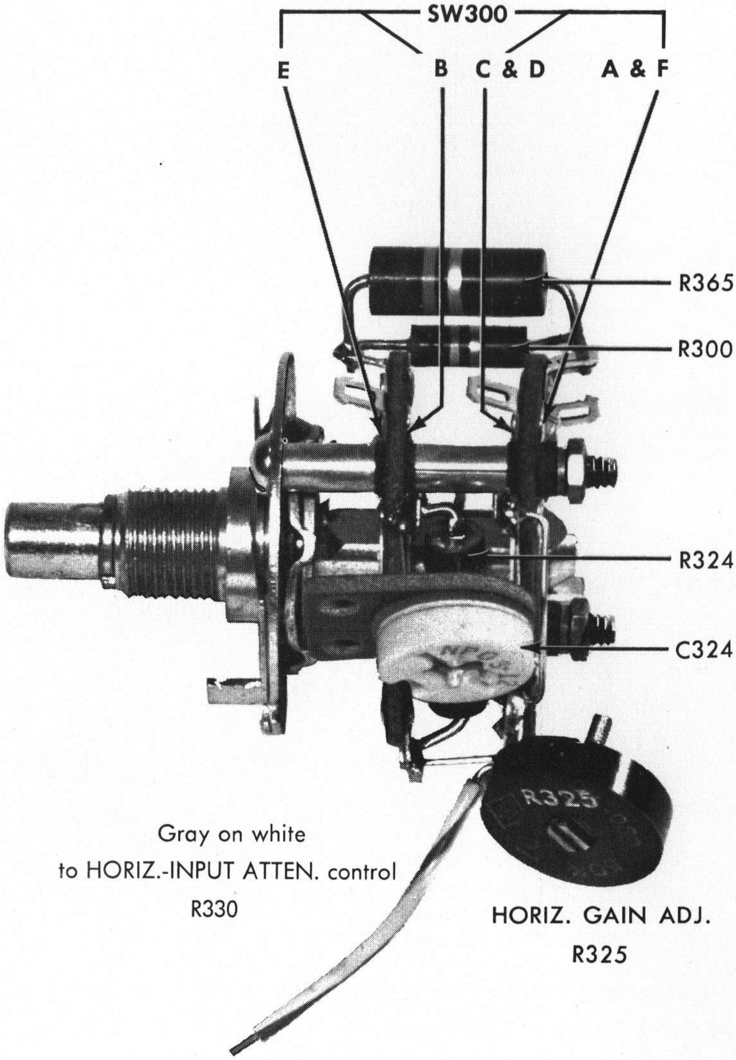
R367	5.6 k	½ w	Fixed	Comp.	10%	302-562
R370	47 Ω	½ w	Fixed	Comp.	10%	302-470
R372	7-35 k	5 w	Manufactured by Tektronix			310-524
R374	47 Ω	½ w	Fixed	Comp.	10%	302-470
R379	270 k	1 w	Fixed	Comp.	10%	304-274

Switches

		not wired	wired
SW300	2-wafer, 3-position, rotary: DISPLAY	260-186	262-146

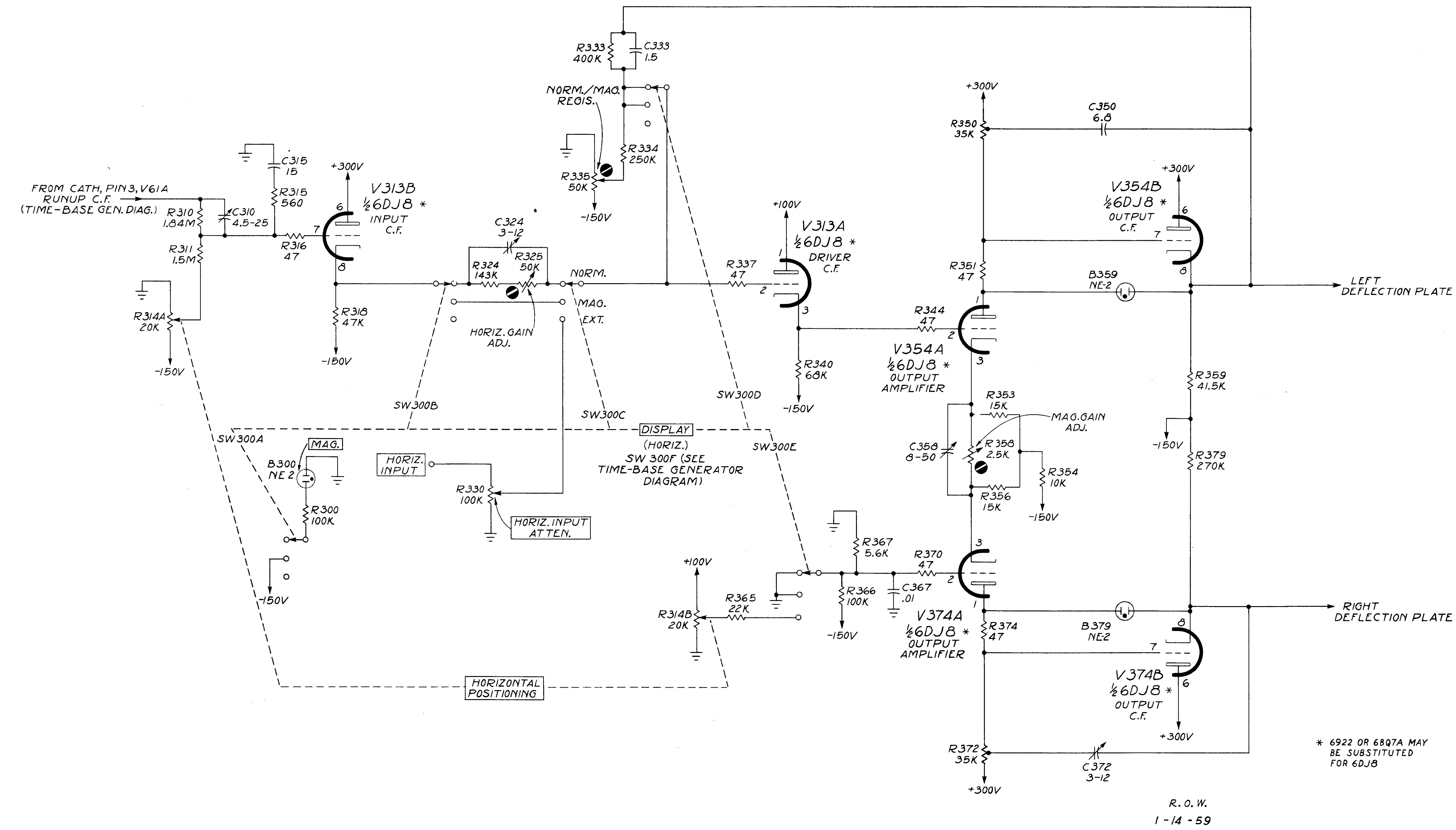
Vacuum Tubes

V313A	½ 6BQ7A	Driver Cathode Follower	154-028
V313B	½ 6BQ7A	Output Cathode Follower	
V354A	½ 6BQ7A	Output Amplifier	154-028
V354B	½ 6BQ7A	Output Cathode Follower	
V374A	½ 6BQ7A	Output Amplifier	154-028
V374B	½ 6BQ7A	Output Cathode Follower	



DISPLAY SWITCH

SWITCH DETAIL



HORIZONTAL AMPLIFIER

POWER SUPPLY

For an explanation of the abbreviations used in this parts list, see the indexed sheet marked ABBREVIATIONS & WARRANTY.

Lamps

		Order parts by number
B600	Incandescent, GE Type 328	150-004
B601	Incandescent, Type 47	150-001
B602	Incandescent, Type 47	150-001

Capacitors

C601	125 µf	EMC	Fixed	350 v	290-044
C603	.01 µf	PTM	Fixed	400 v	285-510
C614	.01 µf	PTM	Fixed	400 v	285-510
C630	125 µf	EMC	Fixed	350 v	290-052
C638	.01 µf	PTM	Fixed	400 v	285-510
C660	125 µf	EMC	Fixed	350 v	290-044
C668	.01 µf	PTM	Fixed	600 v	285-511
C701	2x20 µf	EMC	Fixed	450 v	290-037
C703	2x20 µf	EMC	Fixed	450 v	290-036
C750	2x1000 µf	EMC	Fixed	15 v	290-050
C751	.02 µf	Cer.	Fixed	150 v	283-004
C790	.01 µf	Cer.	Fixed	150 v	283-003

Fuses

F601	3 amp, Type 3AG, Slo-Blo	(117-v operation)	159-005
F601	1.6 amp, Type 3AG, Slo-Blo	(234-v operation)	159-003

Selenium Rectifiers

SR601	5	100-ma plates per leg	106-015
SR630	5	250-ma plates per leg	106-031
SR660	6	250-ma plates per leg	106-030
SR750	1	250-ma plate per leg	106-038

Resistors

R600	50 Ω	2 w	Var.	WW	20%	311-055
R601	10 Ω	1 w	Fixed	Comp.	10%	304-100
R603	33 k	1 w	Fixed	Comp.	10%	304-333
R605	5.6 k	½ w	Fixed	Comp.	10%	302-562
R606	220 k	½ w	Fixed	Comp.	10%	302-224
R607	68 k	½ w	Fixed	Comp.	10%	302-683
R609	1 meg	½ w	Fixed	Comp.	10%	302-105
R610	1 k	½ w	Fixed	Comp.	10%	302-102
R612	18 k	1 w	Fixed	Comp.	10%	304-183
R614	1 meg	½ w	Fixed	Comp.	10%	302-105

Resistors *(Continued)*

R616	68 k	1 w	Fixed	Prec.	1%	310-054
R617	10 k	2 w	Var.	WW	20%	311-015
R618	50 k	1 w	Fixed	Prec.	1%	310-086
R620	1.25 k	25 w	Fixed	WW	5%	308-102
R630	10 Ω	1 w	Fixed	Comp.	10%	304-100
R632	47 k	½ w	Fixed	Comp.	10%	302-473
R633	33 k	½ w	Fixed	Comp.	10%	302-333
R635	1 meg	½ w	Fixed	Comp.	10%	302-105
R636	1 meg	½ w	Fixed	Comp.	10%	302-105
R638	1 k	½ w	Fixed	Comp.	10%	302-102
R639	3 k	5 w	Fixed	WW	5%	308-062
R641	333 k	1 w	Fixed	Prec.	1%	310-056
R642	490 k	1 w	Fixed	Prec.	1%	310-057
R660	10 Ω	1 w	Fixed	Comp.	10%	304-100
R662	270 k	1 w	Fixed	Comp.	10%	304-274
R663	56 k	½ w	Fixed	Comp.	10%	302-563
R666	1 meg	½ w	Fixed	Comp.	10%	302-105
R668	1 k	½ w	Fixed	Comp.	10%	302-102
R669	1.25 k	25 w	Fixed	Comp.	5%	308-102
R671	1 meg	1 w	Fixed	Prec.	1%	310-100
R672	490 k	1 w	Fixed	Prec.	1%	310-057
R751	2.2 Ω	½ w	Fixed	WW	5%	308-116
R790	100 k	½ w	Fixed	Comp.	10%	302-104
R794	270 k	½ w	Fixed	Comp.	10%	302-274
R795	100 k	½ w	Fixed	Comp.	10%	302-104

Switches

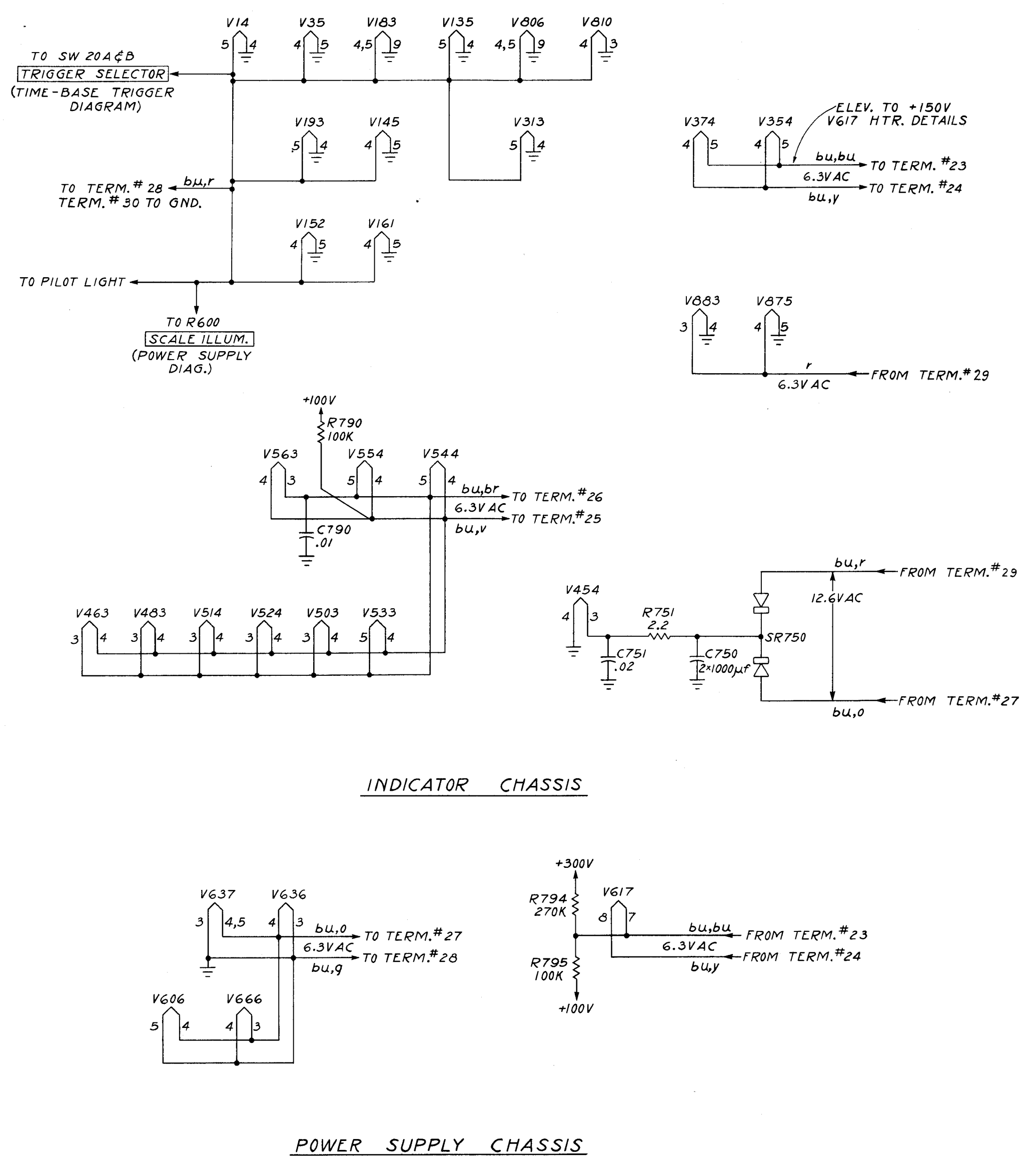
SW600	Single-pole, single-throw, toggle: POWER	260-134
TK601	Thermal Cutout, 137°, ±5°	260-120

Transformer

T600	Power	120-064

Vacuum Tubes

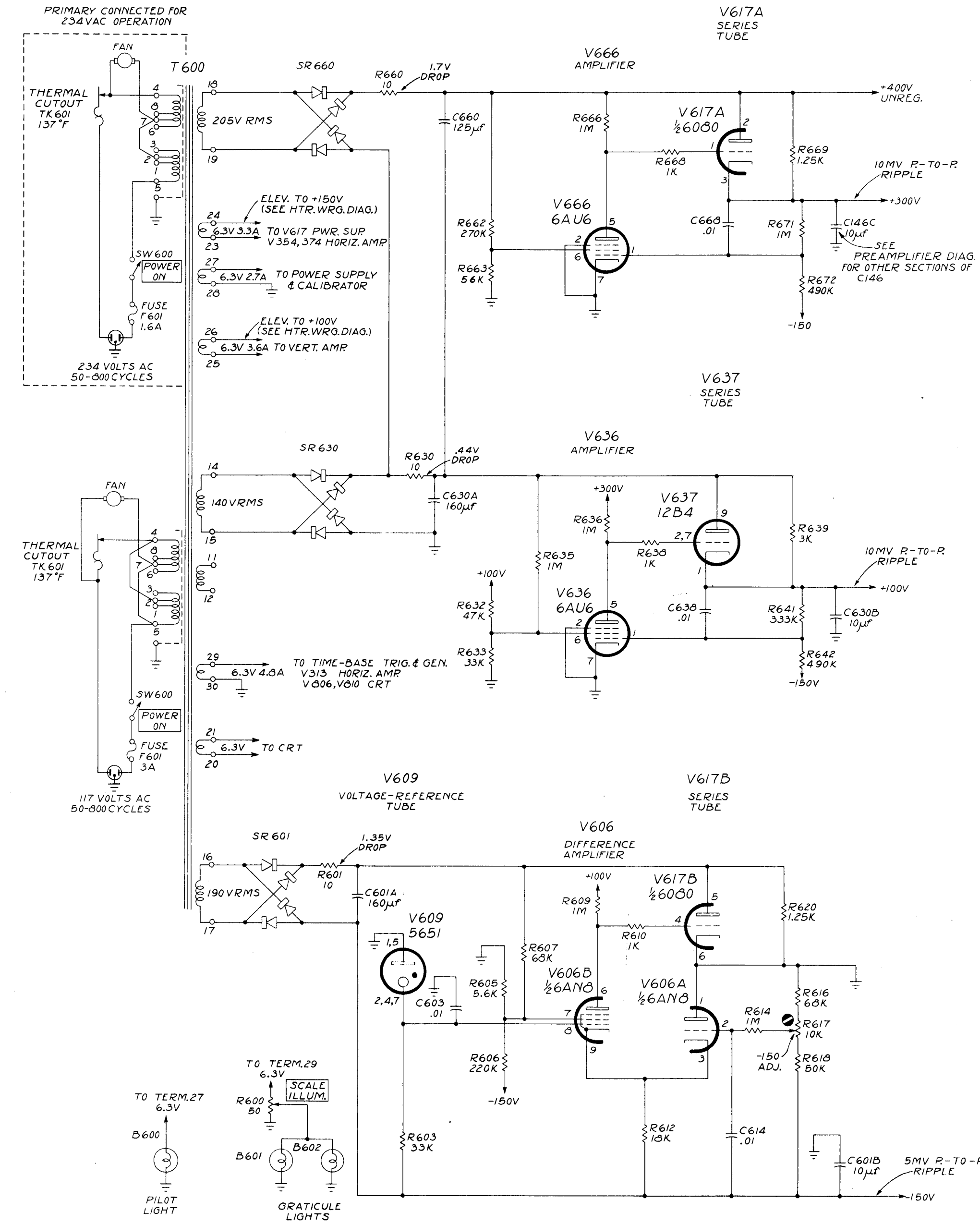
V606	6AN8	Difference Amplifier	154-078
V609	5651	Voltage-Reference	154-052
V617	6080	Series Tube	154-056
V636	6AU6	Amplifier	154-022
V637	12B4	Series Tube	154-044
V666	6AU6	Amplifier	154-022



TYPE RM-16 OSCILLOSCOPE B

1-14-59
R.O.W

HEATER WIRING DIAGRAM



R.O.W.
1-14-59

LV POWER SUPPLY

CRT CIRCUIT

For an explanation of the abbreviations used in this parts list, see the indexed sheet marked ABBREVIATIONS & WARRANTY.

Capacitors

					Order parts by number
C801	.001 μf	Cer.	Fixed	500 v	283-000
C805	.022 μf	PTM	Fixed	400 v	285-515
C810	.01 μf	Cer.	Fixed	500 v	283-002
C811	.001 μf	PTM	Fixed	1000 v	285-502
C822	.015 μf	PTM	Fixed	3000 v	285-513
C824	.0068 μf	PTM	Fixed	3000 v	285-508
C832	.01 μf	Cer.	Fixed	500 v	283-002
C833	.015 μf	PTM	Fixed	3000 v	285-513
C834	.0068 μf	PTM	Fixed	3000 v	285-508
C848	.015 μf	PTM	Fixed	3000 v	285-513
C852	.005 μf	Cer.	Fixed	500 v	283-001
C856	.005 μf	Cer.	Fixed	500 v	283-001

Resistors

R801	150 k	1 w	Fixed	Comp.	10%	304-154
R804	1.5 meg	½ w	Fixed	Comp.	10%	302-155
R808	47 k	½ w	Fixed	Comp.	10%	302-473
R810	4.7 k	½ w	Fixed	Comp.	10%	302-472
R822	100 k	½ w	Fixed	Comp.	10%	302-104
R823	5.6 meg	2 w	Fixed	Comp.	10%	306-565
R824	5.6 meg	2 w	Fixed	Comp.	10%	306-565
R825	1 meg		Var.	Comp.		311-041
R826	1.5 meg	½ w	Fixed	Comp.	10%	302-155
R832	3.3 k	½ w	Fixed	Comp.	10%	302-332
R840	1.5 meg	½ w	Fixed	Prec.	1%	309-017
R841	2 meg	2 w	Var.	Comp.	20%	311-042
R842	4.7 meg	2 w	Fixed	Comp.	10%	306-475
R843	2 meg	2 w	Var.	Comp.	20%	311-043
R844	470 k	2 w	Fixed	Comp.	10%	306-474
R846	27 k	½ w	Fixed	Comp.	10%	302-273
R850	150 k	½ w	Fixed	Comp.	10%	302-154
R852	120 k	½ w	Fixed	Comp.	10%	302-124
R854	100 k	2 w	Var.	Comp.	20%	311-026
R856	50 k	2 w	Var.	Comp.	20%	311-023

Transformer

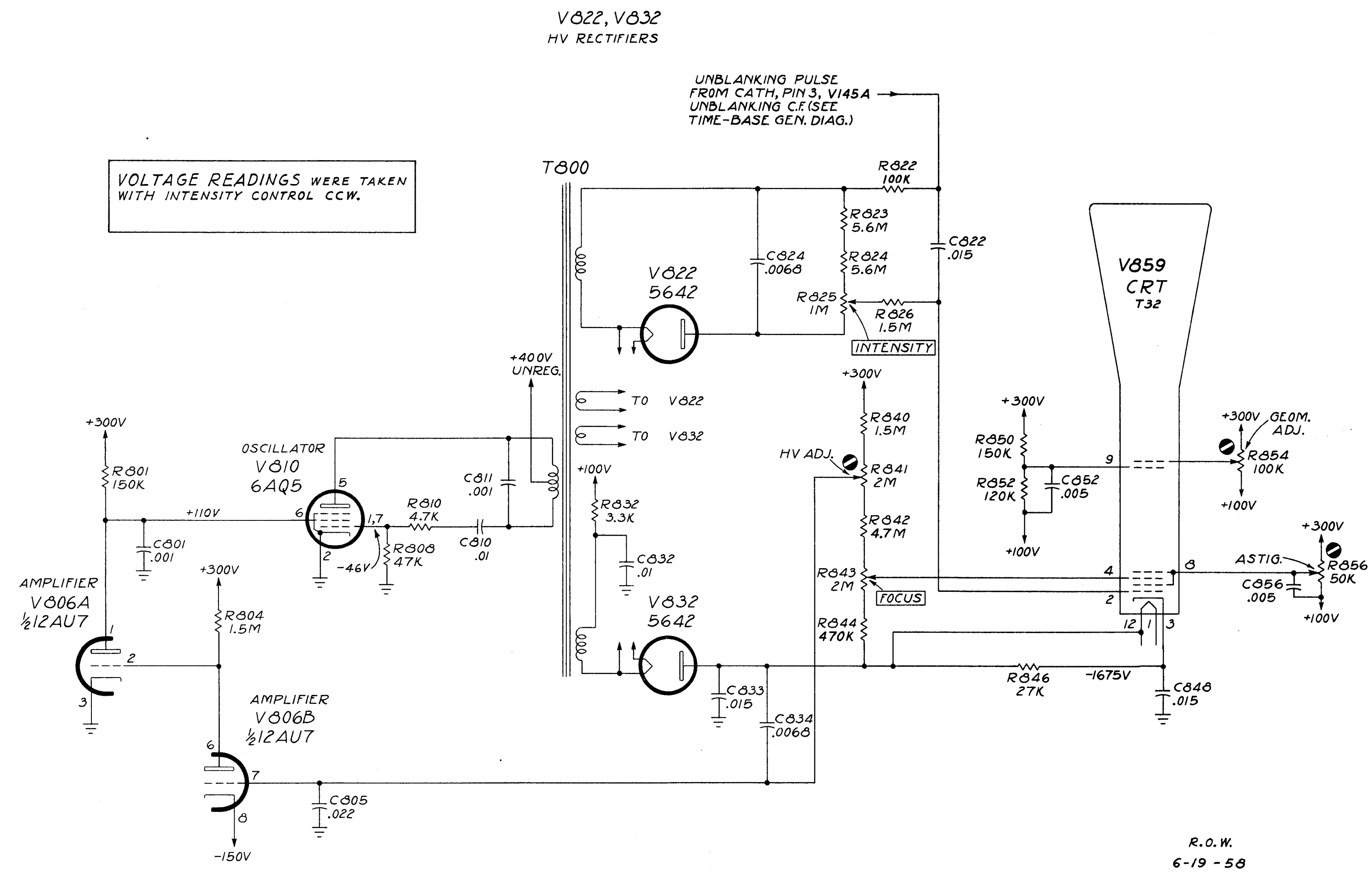
T800	CRT Supply	120-061

Vacuum Tubes

V806	12AU7	Amplifier	154-041
V810	6AQ5	Oscillator	154-017
V822	5642	H.V. Rectifier	154-051
V832	5642	H.V. Rectifier	154-051

Cathode-Ray Tube

V859	T32P2	(Standard Phosphor)	154-155


V822, V832
HV RECTIFIERS
UNBLANKING PULSE FROM CATH, PIN 3, V145A UNBLANKING C.F. (SEE TIME-BASE GEN. DIAG.)
VOLTAGE READINGS WERE TAKEN WITH INTENSITY CONTROL CCW.
T800
R822 100K
R823 5.6M
R824 5.6M
R825 1M
R826 1.5M
INTENSITY
C822 .015
C824 .0068
V822 5642
V859 CRT T32
+400V UNREG.
TO V822
TO V832
+300V
R840 1.5M
HV ADJ.
R841 2M
R842 4.7M
R843 2M
FOCUS
R844 470K
R846 27K
-1675V
C848 .015
OSCILLATOR V810 6AQ5
R801 150K
+110V
C801 .001
R810 4.7K
R808 47K
-46V
C810 .01
C811 .001
+100V
R832 3.3K
C832 .01
V832 5642
C833 .015
C834 .0068
AMPLIFIER V806A ½12AU7
AMPLIFIER V806B ½12AU7
R804 1.5M
C805 .022
-150V
R850 150K
R852 120K
C852 .005
+300V GEOM. ADJ.
R854 100K
ASTIG.
R856 50K
C856 .005
R.O.W.
6-19-58

CALIBRATOR

For an explanation of the abbreviations used in this parts list, see the indexed sheet marked ABBREVIATIONS & WARRANTY.

Capacitors

						Order parts by number
C872	330 $\mu\mu f$	Mica	Fixed	500 v	10%	283-518
C876	330 $\mu\mu f$	Mica	Fixed	500 v	10%	283-518
C885	27 $\mu\mu f$	Cer.	Fixed	500 v	$\pm$5.4 $\mu\mu f$	281-548

Resistors

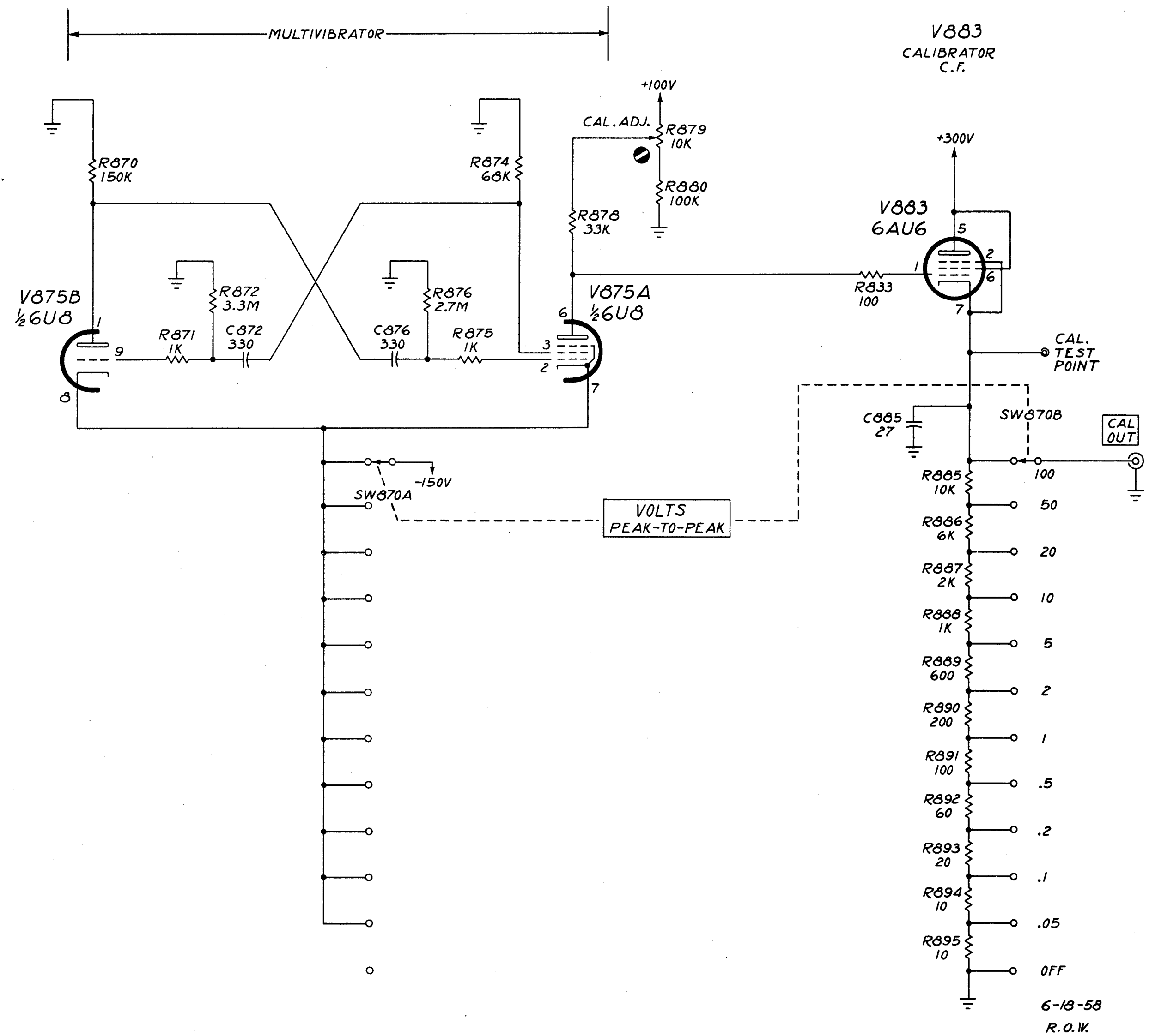
R870	150 k	½ w	Fixed	Comp.	10%	302-154
R871	1 k	½ w	Fixed	Comp.	10%	302-102
R872	3.3 meg	½ w	Fixed	Comp.	10%	302-335
R874	68 k	½ w	Fixed	Comp.	10%	302-683
R875	1 k	½ w	Fixed	Comp.	10%	302-102
R876	2.7 meg	½ w	Fixed	Comp.	10%	302-275
R878	33 k	1 w	Fixed	Comp.	10%	304-333
R879	10 k	2 w	Fixed	Comp.		311-016
R880	100 k	½ w	Fixed	Comp.	10%	302-104
R883	100 Ω	½ w	Fixed	Comp.	10%	302-101
R885	10 k	½ w	Fixed	Prec.	1%	309-100
R886	6 k	½ w	Fixed	Prec.	1%	309-099
R887	2 k	½ w	Fixed	Prec.	1%	309-098
R888	1 k	½ w	Fixed	Prec.	1%	309-115
R889	600 Ω	½ w	Fixed	Prec.	1%	309-097
R890	200 Ω	½ w	Fixed	Prec.	1%	309-073
R891	100 Ω	½ w	Fixed	Prec.	1%	309-112
R892	60 Ω	½ w	Fixed	Prec.	1%	309-067
R893	20 Ω	½ w	Fixed	Prec.	1%	309-064
R894	10 Ω	½ w	Fixed	Prec.	1%	309-096
R895	10 Ω	½ w	Fixed	Prec.	1%	309-096

Switches

		not wired	wired
SW870	2-wafer, 12-position: VOLTS, PEAK-TO-PEAK	260-098	262-145

Vacuum Tubes

V875	6U8	Multivibrator	154-033
V883	6AU6	Calibrator Cathode Follower	154-022



TYPE RM-16 OSCILLOSCOPE A CALIBRATOR

CALIBRATOR

MISCELLANEOUS PARTS LIST

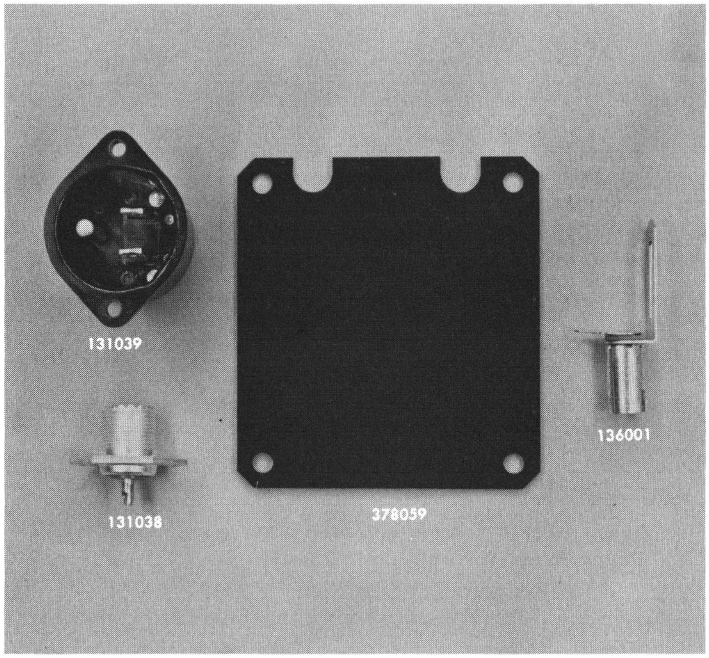
Front-Panel Parts

Binding post, 5-way: HORIZ. INPUT, +GATE OUT, SAWTOOTH	129001
Binding post, metal plated (ground)	129038
Graticule	331042
Graticule cover	200073
Knob, large black: CALIBRATOR	366028
Knob, large black: VOLTS/DIV., TRIGGER SELECTOR	366029
Knob, small red: TRIGGER SELECTOR, STABILITY, VARIABLE VOLTS/DIV.	366031
Knob, large black: TRIGGERING LEVEL	366030
Knob, small black: POSITIONING, HORIZONTAL DISPLAY	366033
Knob, small red: VARIABLE TIME/DIV.	366038
Light filter, green	378509
Light assembly; socket and jewel	136031
Nut for graticule mount	210434
Receptacle, coax, Type UHF: INPUT, CAL. OUT, TRIGGER INPUT	131038
Washer, neoprene, graticule spacer	210844
Knob, latch nut	366061

Chassis Parts

Air Filter	378017
Handle	367008
Cord, power, 8 foot	161008
Blade, fan	369011
Motor, fan	147009
Holder, fuse	352014
Probe tip, hook shank	206008
Probe tip, straight shank	206009
Receptacle, power	131093
Socket, neon lamp: UNCALIBRATED, MAG.	352008
Socket, graticule light	136001
Ceramic strip, 3/4" by 4 notches, 3/8" spacing	124012
Ceramic strip, 3/4" by 7 notches, 3/8" spacing	124014
Ceramic strip, 3/4" by 11 notches	124016
Ceramic strip, 3/4" by 9 notches, 3/8" spacing	124066
Ceramic post, slotted, 1/2 inch	129009
Nylon standoff rod, 1 5/8" with #44 hole	385076
Nylon standoff rod, 3/4" tapped through	385107
Rod, spacing, 1 15/16" tapped through	384541

MISC. PARTS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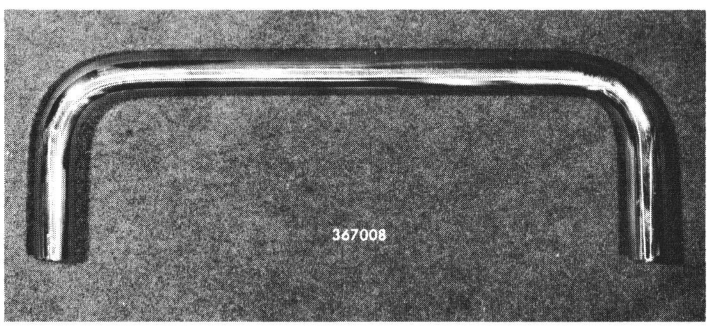
136001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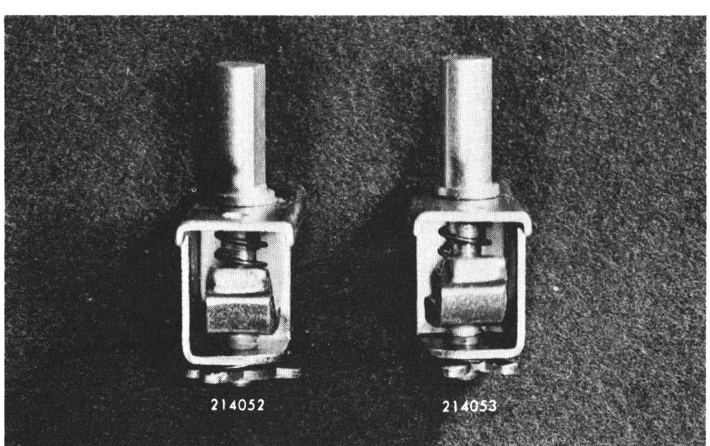
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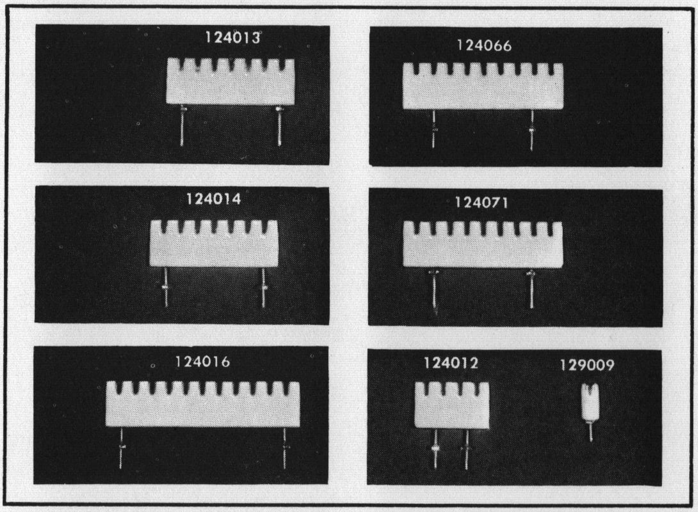
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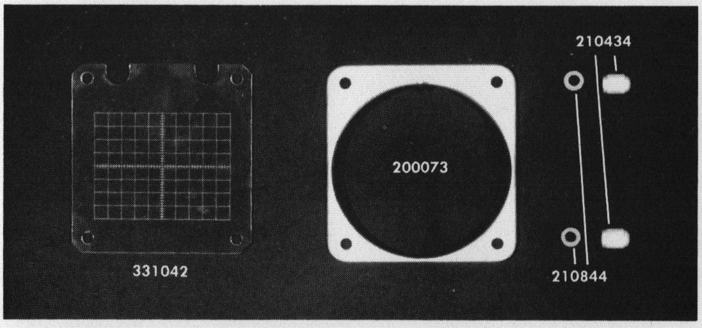
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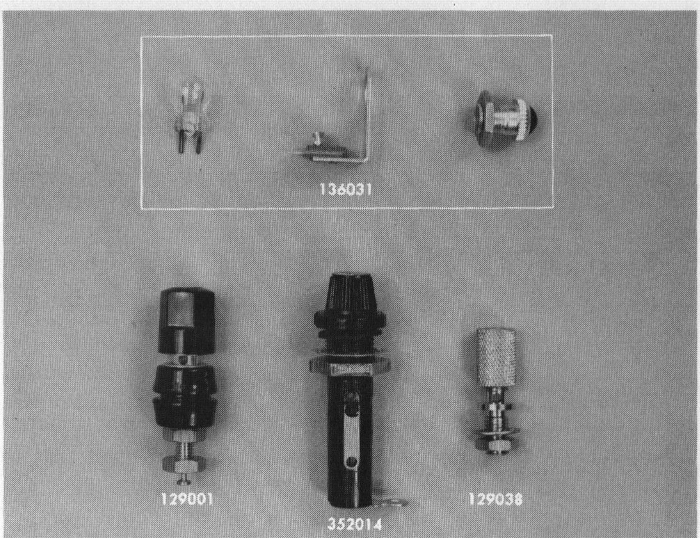
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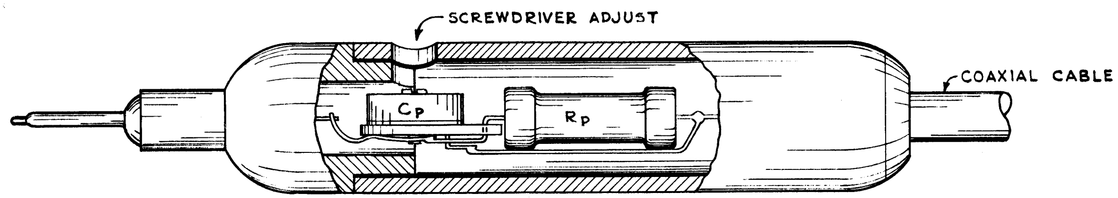
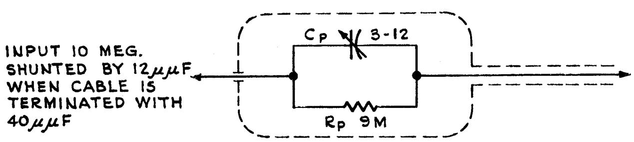
129038





Cp 3-12µµF CER. VAR. 500V
Rp 9 MEG. 1W FIXED PREC. 1%

RBH
1-13-55

TEKTRONIX TYPE P510A PROBE

ABBREVIATIONS USED IN OUR PARTS LISTS

Cer.	ceramic	m	milli
Comp.	composition	Ω	ohm
EMC	electrolytic, metal cased	Poly.	polystyrene
EMT	electrolytic, metal tubular	Prec.	precision
f	farad	PT	paper tubular
h	henry	Tub.	tubular
k	thousands of ohms	v	working volts dc
meg	megohms	Var.	variable
μ	micro	w	watt
$\mu\mu$	micromicro	WW	wire wound

GMV guaranteed minimum value

ABBREVIATIONS USED IN OUR CIRCUIT DIAGRAMS

Resistance values are in ohms. The symbol k stands for thousands. A resistor marked 2.7 k has a resistance of 2,700 ohms. The symbol M stands for million. For example, a resistor marked 5.6 M has a resistance of 5.6 megohms.

Unless otherwise specified on the circuit diagram, capacitance values marked with the number 1 and numbers greater than 1 are in $\mu\mu$f. For example, a capacitor marked 3.3 would have a capacitance of 3.3 micromicrofarads. Capacitance values marked with a number less than 1 are in μf. For example, a capacitor marked .47 would have a capacitance of .47 microfarads.

Inductance values marked in mh are in millihenrys. Inductance values marked in μh are in microhenrys.

Your instrument **WARRANTY** appears on the reverse side of this sheet.

SERIAL NO. ________

IMPORTANT

Include the INSTRUMENT TYPE and the above SERIAL NUMBER in any correspondence regarding this instrument. The above serial number must match the instrument serial number if parts are to be ordered from the manual. Your help in this will enable us to answer your questions or fill your order with the least delay possible.

TEKTRONIX

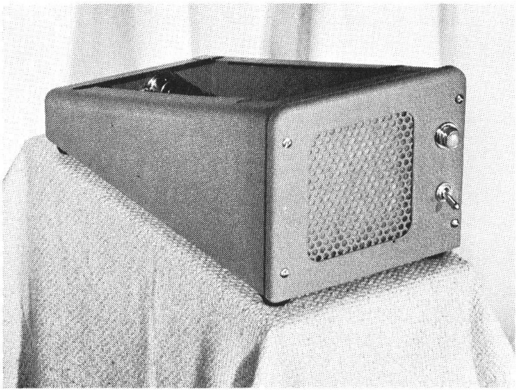
WARRANTY

All Tektronix instruments are fully guaranteed against defective materials and workmanship for one year. Should replacement parts be required, whether at no charge under warranty or at established net prices, notify us promptly, including sufficient details to identify the required parts. We will ship them prepaid (via air if requested) as soon as possible, usually within 24 hours.

Tektronix transformers, manufactured in our own plant, carry an indefinite warranty.

Accessories

FAN BASE . . .

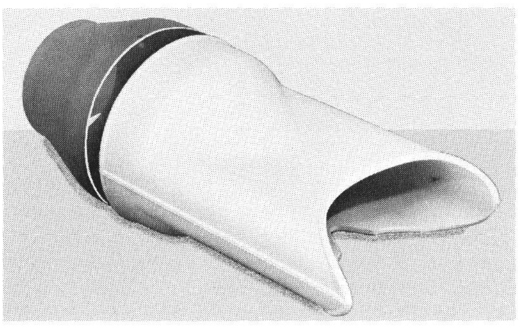


Type FB 310 Fan Base. For Type 310 Oscilloscope. Provides filtered, forced-air ventilation to assure safe operating temperature when the Type 310 Oscilloscope is being used continuously over long periods, or in hot or limited-ventilation areas. The fan base tilts the oscilloscope to a convenient viewing angle. For use on 105-125 v, 60 cycles only.
Part No. 016-008 .... $25.00

Type FB310-S1 Fan Base. Similar to Type FB-310, but for use on 210-250 v, 50 to 60 cycles only. Part No. 016-009 .... $25.00

VIEWING HOOD . . .

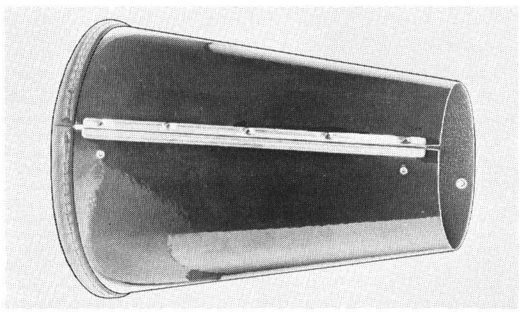
TYPE H310 Viewing Hood, for Tektronix 3" Oscilloscopes. Includes molded rubber eye-piece and spun-aluminum light shield.
Part No. 016-002 .... $4.50



CANVAS CARRYING CASE . . .

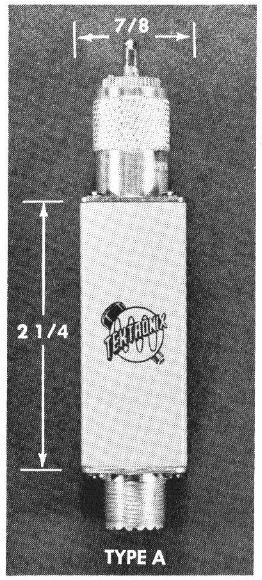
Type CC310 Canvas Carrying Case, for Tektronix Type 310 Oscilloscope. The case has a zipper fastener along the top and one end. The other end is padded for extra protection for knobs and cathode-ray-tube. A side pocket holds probes, power cords, etc. Color is forest green with olive-drab carrying straps.
Part No. 253-541 .... $12.00

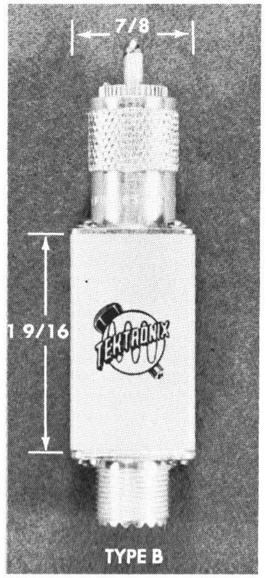
COLLAPSIBLE VIEWING HOOD . . .

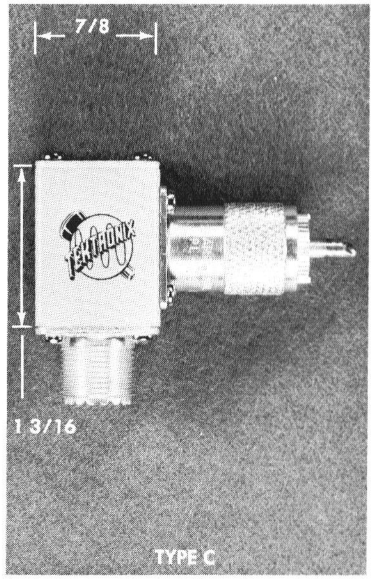


Type HC310 Collapsible Viewing Hood, for Tektronix 3" Oscilloscopes. It is made of black acrylic plastic with handy fastening arrangement.
Part No. 016-010 .... $3.50

CABLE TERMINATORS...







Type B52-R 52-ohm terminating resistor, 1.5 w, Type A case. Part No. 011-001 . . . . $8.50

Type B52-L5 52-ohm 'L' pad, 5 to 1 voltage ratio, 1.5 w, Type A case.
Part No. 011-002 . . . . $8.50

Type B52-L10 52-ohm 'L' pad, 10 to 1 voltage ratio, 1.5 w, Type A case.
Part No. 011-003 . . . . $8.50

Type B52-170 Minimum-loss pad, 52 ohms to 75 ohms, Type A case.
Part No. 011-004 . . . . $11.50

Type B52-75L Minimum-loss pad, 52 ohms to 170 ohms, Type B case.
Part No. 011-005 . . . . $11.50

Type B52-T10 52-ohm 'T' pad, 10 to 1 voltage ratio, 1.5 w, Type B case.
Part No. 011-006 . . . . $11.50

Type B75-R 75-ohm terminating resistor, 1.5 w, Type A case. Part No. 011-007 . . . . $8.50

Type B75-L5 75-ohm 'L' pad, 50 to 1 voltage ratio, 1.5 w, Type A case.
Part No. 011-008 . . . . $8.50

Type B75-L10 75-ohm 'L' pad, 10 to 1 voltage ratio, 1.5 w, Type A case.
Part No. 011-009 . . . . $8.50

Type B75-T10 75-ohm 'T' pad 10 to 1 voltage ratio, 1.5 w, Type B case.
Part No. 011-010 . . . . $11.50

Type B93-R 93-ohm terminating resistor, 1.5 w, Type A case Part No. 011-011 . . . . $8.50

Type B93-L5 93-ohm 'L' pad, 5 to 1 voltage ratio, 1.5 w Type A case.
Part No. 011-012 . . . . $8.50

Type B93-L10 93-ohm 'L' pad, 10 to 1 voltage ratio, 1.5 w, Type A case.
Part No. 011-013 . . . . $8.50

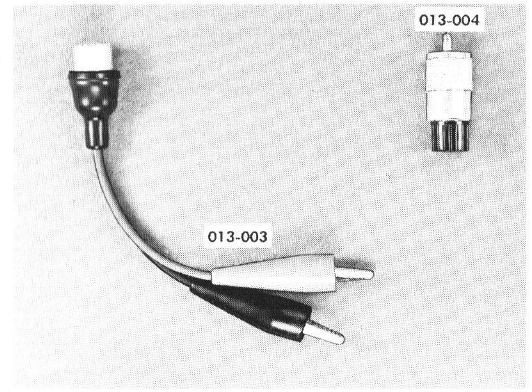
Type B93-52L Minimum-loss pad, 93 ohms to 52 ohms, 1.5 w, Type A case.
Part No. 011-014 . . . . $11.50

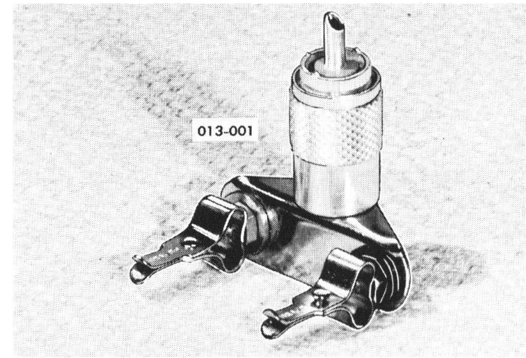
Type B93-T10 93-ohms 'T' pad, 10 to 1 voltage ratio, 1.5 w, Type B case.
Part No. 011-015 . . . . $11.50

Type B170-R 170-ohm terminating resistor, 1.5 w, Type C case. Part No. 011-016 . . . . . . $8.50

Type B170-A 170-ohm pi-attenuator, using 2% precision resistors, 1 to 64 db in 1-db steps, 0.25 w, not shown in photograph.
Part No. 011-017 . . . . $45.00

COAXIAL ADAPTERS...



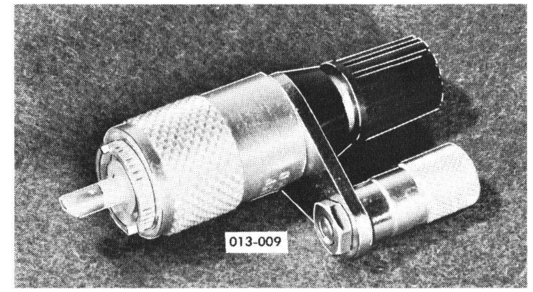


Type A100 Clip-Lead Adapter. Provides clip-lead connections for a coaxial cable.
Part No. 013-003 . . . . $2.00

Type A510 Binding-Post Adapter. Provides binding-post connection to the center conductor of a coaxial connector.
Part No. 013-004 . . . . $2.00

Binding Post Adapter. Similar to Type A510 binding post adapter, but includes ground terminal. 3/4" spacing between connector centers.
Part No. 013-009 . . . . $3.00

Type F30 Production Test Fixture. This fixture was designed for use with the Type 130 L,C Meter in production line sorting and testing. It may be used to terminate the output of any standard coaxial connector.
Part No. 013-001 . . . . $3.00



INTERCONNECTING CABLES...

Type W130B Black, 30" flexible output lead with banana-type connector at one end and alligator clip at other. Part No. 012-014 . . . $1.00

Type W130R Same as Type W130B except colored red. Part No. 012-015 . . . . $1.00

Type PC-6B Black, 6" flexible cord terminated in combination male and female banana-type connectors. The combination type connectors permit "stacking." Part No. 012-023 . . . . . $1.25

Type PC-6R Similar to Type PC-6B except colored red. Part No. 012-024 . . . . $1.25

Type PC-18R Similar to Type PC-6B except 18" long and colored red.
Part No. 012-031 . . . . $1.50

Type W-531B Black, 6" flexible cord terminated in male banana-type connectors.
Part No. 012-028 . . . . $1.00

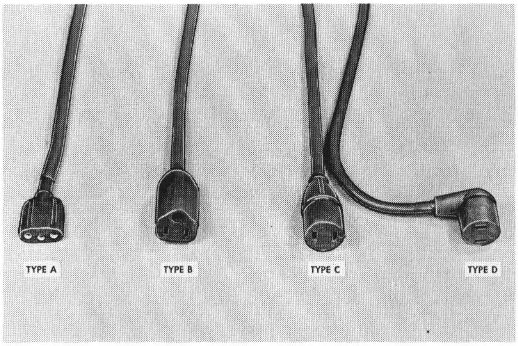
Type W-531R Similar to Type W-531B except colored red. Part No. 012-029 . . . . $1.00

Suppressor cord for Type 570. Similar to Type W-531 cords but includes 100 Ω resistor.
Part No. 012-025 . . . . $1.50

Suppressor cord for Type 570. Similar to Type W-531 cords except includes 300 Ω resistor.
Part No.012-026 . . . . $1.50

Suppressor cord for Type 570. Similar to Type W-531 cords except includes 1k resistor.
Part No.012-027 . . . . $1.50

POWER CORDS...



2-conductor, 8′ rubber-covered power cord with Type C connector. No. 18 wire.
Part No. 161-001 .... $1.25

2-conductor, 8′ rubber-covered power cord with no female connector. (For permanent connection to instrument). Part No. 161-002 .... $1.10

2-conductor, 1′ rubber-covered power cord with Type C connector. No. 18 wire.
Part No. 161-003 .... $ .85

2-conductor, 8′ rubber-covered power cord with Type C connector. No. 16 wire.
Part No. 161-004 .... $1.75

3-conductor, 8′ rubber-covered power cord with Type A connector. No. 16 wire.
Part No. 161-005 .... $2.00

3-conductor, 10′ rubber-covered power cord with no female connector. (For permanent connection to instrument). No. 16 wire.
Part No. 161-006 .... $3.00

2-conductor, 8′ rubber covered power cord with Type D connector. No. 18 wire.
Part No. 161-007 .... $1.25

3-conductor, 8′ rubber-covered power cord with Type B connector. No. 18 wire.
Part No. 161-008 .... $1.50

3-conductor, 8′ rubber-covered power cord with Type B connector. No. 18 wire.
Part No. 161-010 .... $1.75

3-conductor, 1′ rubber-covered power cord with Type B connector. No 18 wire.
Part No. 161-011 .... $1.25

3-conductor, 8′ rubber-covered power cord with no female connection. (For permanent connection to instrument). No. 18 wire.
Part No. 161-012 .... $1.25

Power cord adapter for connecting a 3-wire power cord to a 2-wire receptacle.
Part No. 102-013 .... $ .65

COAXIAL CABLES...

Type P52 Coaxial cable, 52 ohms nominal impedance, 42″ long. Part No. 012-001 .... $4.00

Type P75 Coaxial cable, 75 ohms nominal impedance, 42″ long. Part No. 012-002 .... $4.00

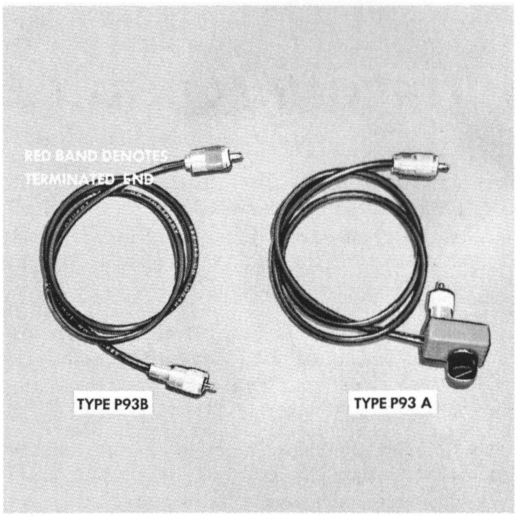
Type P93 Coaxial cable, 93 ohms nominal impedance, 42″ long. Part No. 012-003 .... $4.00

Type P93A Coaxial output cable, 93 ohms, terminated with variable attenuator, 42″ long (See photo). Part No. 012-004 .... $13.50

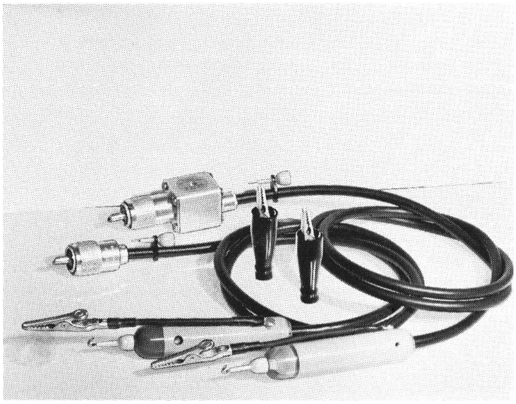
Type P93B Coaxial output cable, 93 ohms, terminated with ½-watt 93-ohm resistor, 42″ long. (See photo). Part No. 012-005 .... $5.00

Type P170 Coaxial cable, 170 ohms nominal impedance, 42″ long.
Part No. 012-006 .... $9.50

Coaxial cable, 170 ohms nominal impedance, 5′ long.
Part No. 012-034 .... $4.00



P400-SERIES PROBES...



This series of low-capacitance probes preserves the transient response of Tektronix fast-rise instruments. The P400-Series probes are free of overshoot and ringing and have relatively uniform high-frequency response. Input capacitance and insertion loss are affected by cable length. With cables up to 12′ in length, insertion loss is less than 3 db at 20 mc, and overshoot is less than 1%. With exception of the P450-L, these probes can be used on those instruments having input capacitances from 20 to 50 $\mu\mu$f.

General physical characteristics of the P400-Series probes are identical to the P510A probe. Color-coding of the plastic nose indicates attenuation ratio. Two interchangeable Tektips—a straight tip and a hooked tip—each adding less than 0.5 $\mu\mu$f to the input capacitance, and an alligator clip assembly are supplied with each probe.

PROBE TYPE	CABLE LENGTH	PART NO.	PRICE
P405 (green nose)	42″ 8′	010-006 010-013	$10.50 12.50
P410 (brown nose)	42″ 8′	010-007 010-014	10.50 12.50
P420 (red nose)	42″ 8′	010-008 010-015	10.50 12.50
P450 (clear nose, green inside)	42″ 8′	010-009 010-016	12.50 14.50
P450-L (clear nose, green inside)	42″ 8′	010-010 010-017	12.50 14.50
P4100 (clear nose)	42″ 8′	010-002 010-018	12.50 14.50

P400-SERIES PROBE SPECIFICATIONS

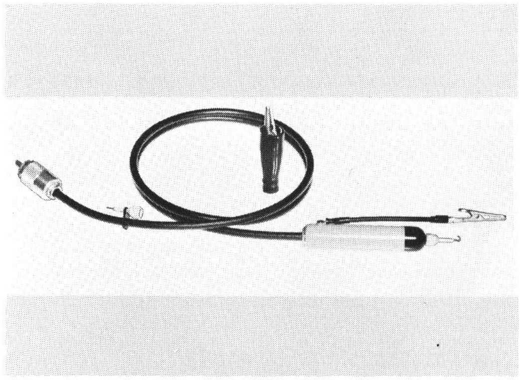
PROBE TYPE	ATTEN. RATIO	INPUT CHARACTERISTICS Resist. Meg Ω	Capacitance Minimum*	Capacitance Maximum†	DB Loss at 30 MC	Maximum Voltage Rating
P405	5:1	5	12 $\mu\mu$f 21 $\mu\mu$f**	19 $\mu\mu$f 30 $\mu\mu$f**	1-2	600
P410	10:1	10	8 $\mu\mu$f 12 $\mu\mu$f**	11 $\mu\mu$f 15 $\mu\mu$f**	1	600
P420	20:1	10	5.5 $\mu\mu$f 8 $\mu\mu$f**	7 $\mu\mu$f 9 $\mu\mu$f**	1	600
P450	50:1	10	3.5 $\mu\mu$f 4 $\mu\mu$f**	3.5 $\mu\mu$f 4 $\mu\mu$f**	1	1000
P450-L	50:1	10	2.5 $\mu\mu$f 3 $\mu\mu$f**		1	1000
P4100	100:1	10	2.5 $\mu\mu$f 3 $\mu\mu$f**	2.5 $\mu\mu$f 3 $\mu\mu$f**	1	1000

***When connected to instruments with 20-$\mu\mu$f input capacitance.**

†When connected to instruments with input capacitances up to 50 $\mu\mu$f.

****With 8-foot cable.**

P510A PROBES...



P510A Attenuator Probe provides an attenuation of ten times when used with Tektronix oscilloscopes and amplifiers. The P510A is small and streamlined, and presents an input impedance of 10 megohms parralleled by 14 $\mu\mu$f. The probe is completely insulated—made of high-impact-strength fiberglass-reinforced alkyd—and has an internal brass shield. Two interchangeable Tektips—a stright tip and a hooked tip, and an alligator clip assembly are furnished. Probe has a 42" cable with coaxial connector, and is rated at 600 v maximum.
Part No. 010-001 .... $8.50

P510A PROBES WITH LONG CABLES

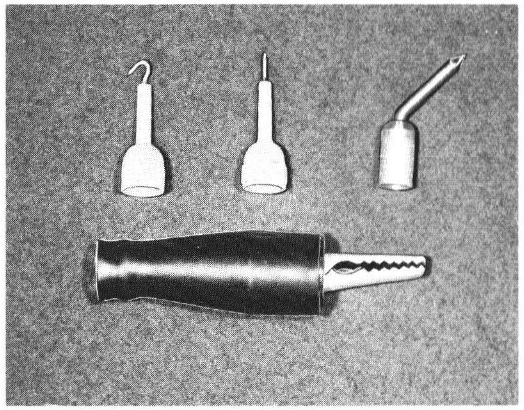
P510A probe cables ring at a period that depends on the cable length and, to a lesser degree, on the input capacitance of the oscilloscope used. Each particular cable length will be satisfactory only when zero transmission of the oscilloscope does not extend to a frequency that includes the resonant frequency of the probe. This difficulty has been eliminated in the P400-Series Probes.

P510A with 6' cable, Part No. 010-004 $9.00

P510A with 8' cable, Part No. 010-005 9.50

Prices for P510A Probes with other cable lengths available on request.

PROBE TIPS



Tek tip, Hook Shank, Part No. 206-008 ... $ .25

Tek tip, Straight Shank, Part No. 206-009 . $ .25

Pin Jack Probe Tip, Bent Shank (fits 0.082" pin jacks) Part No. 206-011 .... $ .25

Alligator Clip Assembly. Part No. 344-005 $ .40

MISCELLANEOUS...

INSTRUCTION MANUALS

310 .... $3.50

316, RM16 or RH16 .... 4.50

317 .... 4.50

AIR FILTERS

Spun glass, disposable $5\frac{1}{4}$ x $5\frac{1}{4}$ x 1 for FB310 Fan Base. Part No. 378-008 .... $ .25

Aluminum 7 x 7 x 1 for Type 316.
Part No .378-015 .... $2.25

Aluminum $6\frac{1}{2}$ x $6\frac{1}{2}$ x 1 for Types RM16 and 317.
Part No. 378-017 .... $2.25

MODIFICATION KITS

Supporting Cradles for rear slide support when the instrument is to be mounted in a backless rack. Two cradles with necessary mounting hardware are furnished, for Type RM16.
Part No. 426-064A $6.50

Fan Motor Kit for converting Type 316 for use on 50 to 800 cycle line frequency (Type 316-S1). Contains brackets, rectifier, and fan motor.
Part No. 040-141 .... $4.50

CATHODE-RAY TUBES...

PHOSPHORS

The catalog description of each oscilloscope gives the kind of phosphor that is normally provided in the crt. In general, your oscilloscope can be provided, on order, with any commercially available phosphor.

Phosphors, other than those of short persistence, may display an initial fluorescence of one color, followed by a phosphorescence of the same or another color. The following table describes some of the phosphors we can provide in your crt. Other phosphors are available. We welcome your inquiries.

PHOSPHOR CHARACTERISTICS

PHOSPHOR	FLUORESCENCE	PHOSPHORESCENCE	PERSISTENCE
P1	Green	Green	Medium
P2	Blue-green	Green	Long
P7*	Blue-white	Yellow	Long
P11	Blue		Short
P16	Violet and near ultra-violet		Extremely short
P24	Blue		Extremely short

***Double-layer type.**

PRICE LIST

316 and RM16:

T316P1/T32P1	154-154	$40.00
T316P2/T32P2	154-155	40.00
T316P7/T32P7	154-156	40.00
T316P11/T32P11	154-157	40.00
T316P16/T32P16	154-158	40.00
T316P24/T32P24	154-159	40.00

Type 310

3WP1	154-058	$25.20
3WP2	154-059	25.20
3WP7	154-060	29.35
3WP11	154-061	29.35
3WP16	154-077	29.35

GRATICULES

Ruled graticules. These graticules fit standard 3" Tektronix Oscilloscopes and can be ruled to fit your special application.
Part No. 386-395 .... $1.00

Type 310 graticule. Quarter-inch divisions; 8 divisions vertically, 10 horizontally.
Part No. 331-027 .... $1.50

Types 316, RM16, and 317 graticules. Quarter-inch divisions; 8 divisions vertically, 10 horizontally. Part No. 331-042 .... $1.50

LIGHT FILTERS

These filters are useful for applications where it is desirable to select certain light frequencies from different color fluorescent and phosphorescent characteristics. Use the same color filter as the color or light frequency component yon wish to view. For example, a color filter can be used to accentuate one of the two light outputs from a double-layer phosphor.

Under high ambient light conditions a filter of the same color as the trace is useful to increase the contrast between the trace and the face of the crt.

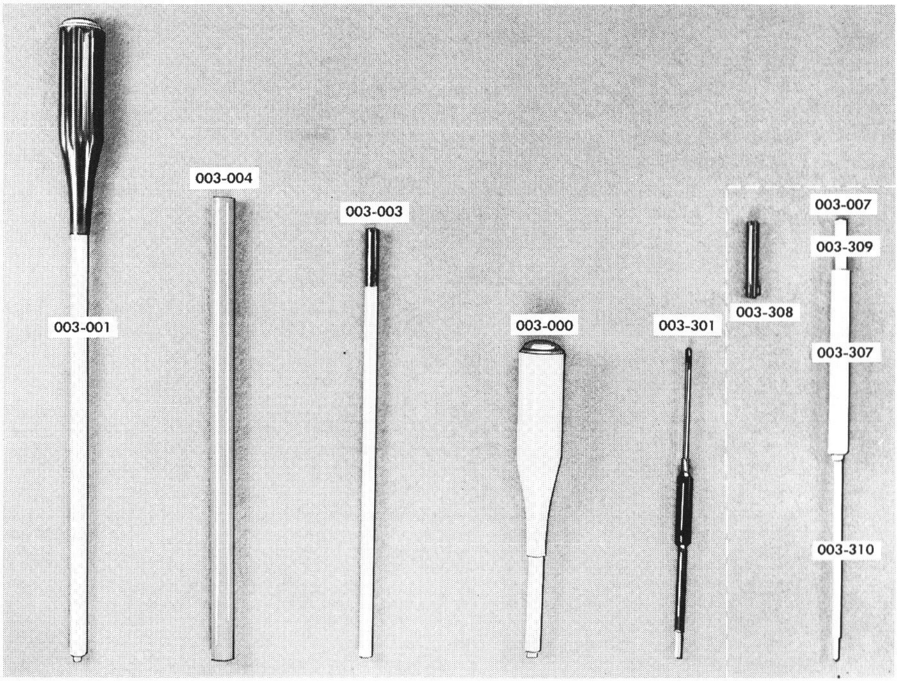
Amber, for all 3" oscilloscopes.
Part No. 378-511 .... $ .50

Green, for all 3" oscilloscopes.
Part No. 378-509 .... .50

Blue, for all 3" oscilloscopes.
Part No. 378-510 .... .50

Yellow, for all 3" oscilloscopes.
Part No. 378-512 .... .50

RECALIBRATION TOOLS...



The tools shown are handy—and in some cases, necessary—tools for the recalibration of Tektronix Instruments. All of the tools except the assembly at the right (003-007) are available through most radio-parts suppliers.

003-000 Jaco No. 125 insulated screwdriver. This tool is similar to 003-001 but has a 1½" shank . . . . $ .75

003-001 Jaco No. 125 insulated screwdriver with 7" shank and metal bit. This tool is useful for adjusting hard-to-reach adjustments on oscil-lloscopes $1.25

003-003 Walsco No. 2519 insulated alignment tool. This double-ended tool is useful for adjusting variable inductors in Tektronix Instruments $1.25

003-004 Walsco No. 2503¼" insulated hexagonal wrench. This tool is useful for tightening variable inductor lock nuts on older Tektronix Instruments. Current production instruments do not have lock nuts on coil assemblies . . . . $ .60

003-007 Tektronix recalibration tool assembly. This 4-unit tool assembly provides most of the necessary tools for adjusting variable inductors in Tektronix Instruments. The price for the entire assembly is $2.50

Individual unit prices are as follows:

003-307	Handle	$ .75
003-308	Red nylon insert with wire pin	.50
003-309	White cymac insert with wire pin.	.50
003-310	Hexagononal core insert	.75

003-301 Walso No. 2543 double-ended 0.1" hexagonal wrench. This tool is useful for adjusting variable inductors with hexagonal cores $1.00