

INSTRUCTION MANUAL

Serial Number 3888

3A74
TYPE
PLUG-IN

Tektronix, Inc.

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070-347

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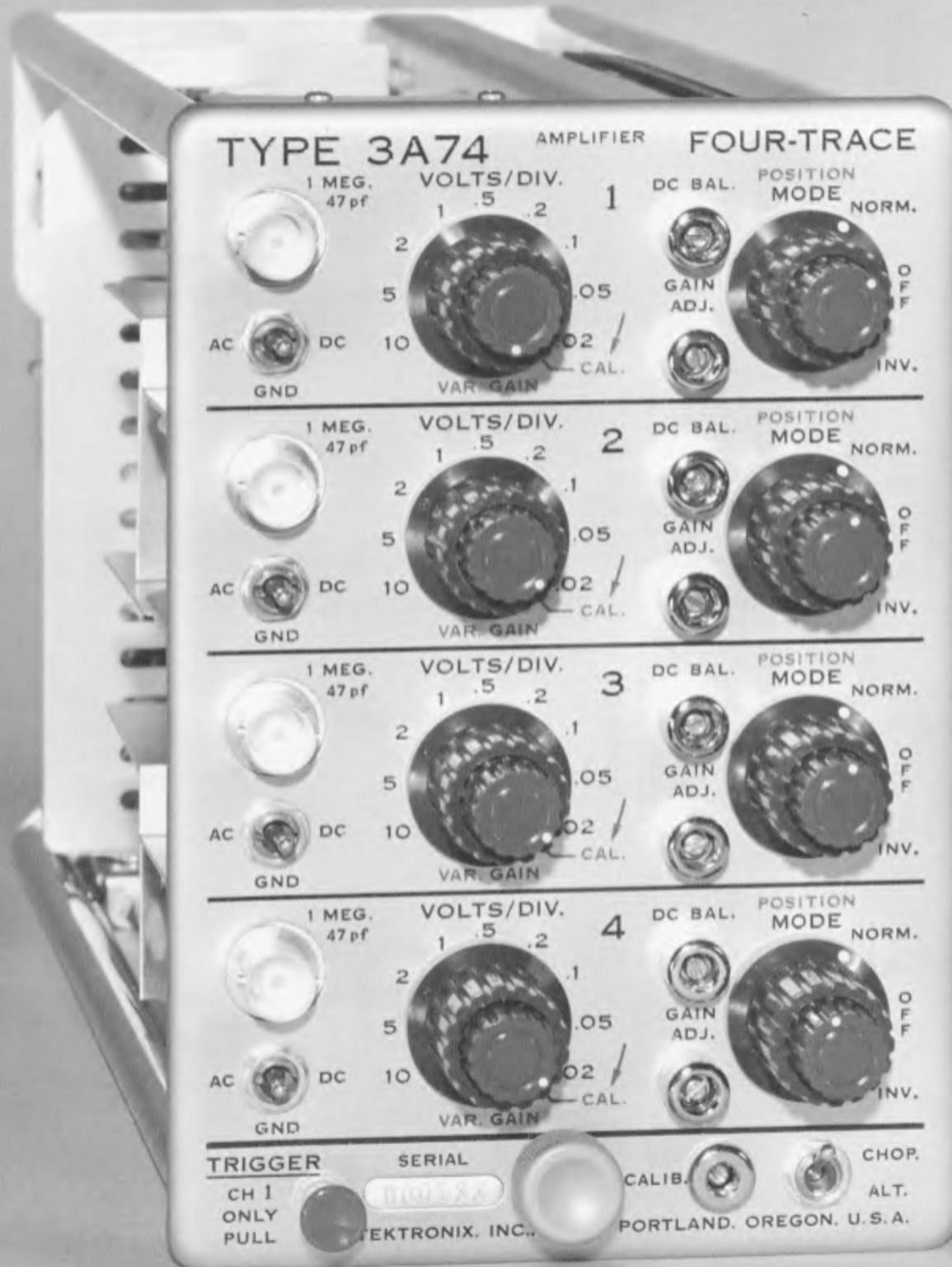
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Type 3A74

SECTION 1

CHARACTERISTICS

General Information

The Type 3A74 Four-Trace Amplifier Plug-In Unit is designed for use with all Type 560-Series Oscilloscopes* except the Type 560 itself. The Type 3A74 contains four independent amplifier channels. Each channel can be used separately to produce a single display or electronically switched to produce multi-trace displays. These features reduce cable switching to a minimum.

Each amplifier channel has its own input coupling, attenuator, variable gain, position and mode controls which permit individual adjustment of each channel for best measurement conditions.

In multi-trace operation there is a choice of two modes of operation—chopped or alternate. In the chopped mode (free-running electronic switching), an internal oscillator switches the channels sequentially at a free-running rate of about 500 kc. In the alternate mode (triggered electronic switching) the oscilloscope time-base generator internally switches the channels at the end of each sweep. Switching occurs during retrace intervals.

Bandpass

Dc to 2 mc.

Risetime

0.17 microsecond.

Calibrated Deflection Factors

Nine calibrated steps provided for each channel: 0.02, 0.05, 0.1, 0.2, 0.5, 1, 2, 5, and 10 volts/div. When the gain is set accurately for the 0.02 volt/div. step, the other steps will be accurate within 3% of their respective panel readings.

Uncalibrated Deflection Factors

Variable controls for each channel permit continuous uncalibrated adjustments from 0.02 volt/div. up to approximately 25 volts/div.

Input Impedance

1 megohm $\pm 1\%$ paralleled by 47 pf $\pm 3\%$.

*Type 561 Oscilloscopes below serial number 580 must be modified first to obtain proper multi-trace operation from the Type 3A74. If your oscilloscope needs to be modified, ask your Tektronix Field Engineer for Modification Kit No. 040-267. This modification is not needed in any of the Type RM561 Oscilloscopes because they are all compatible.

Maximum Allowable Signal Voltage at Input Connectors

± 600 volts dc or peak.

Input Coupling

Selectable AC or DC coupling. In the AC position a coupling capacitor is inserted, limiting the low-frequency response to about 2 cps at 3 db down. With a 10X attenuator probe low-frequency response is extended to 0.2 cps; with a 100X probe, response is 2 cps.

Operating Modes

Channel 1, 2, 3, or 4 only.

Chopped—Sequential electronic switching of two or more channels at approximately a 500-kc rate. The input for each channel is chopped into "on" and "off" segments. Thus the display of each channel is a series of 2- μ sec "on" segments.

Alternate—Triggered electronic switching sequentially from channel to channel during retrace intervals.

Polarity Inversion

Polarity switch for each channel permits inverting the displayed waveform.

Construction

Aluminum-alloy chassis.

Finish

Photo-etched anodized aluminum front panel.

Net Weight

6 lbs. 4 oz.

Included Accessories

Qty.	Tektronix Part Number	Description
4	103-033	Adapter, single binding post fitted with a BNC plug.
2	070-347	Type 3A74 Instruction Manuals.

NOTES

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SECTION 2

OPERATING INSTRUCTIONS

NOTE

The Type 3A74 can be used in either the X-axis or Y-axis plug-in opening of Tektronix Type 561-Series, 567, or RM567 oscilloscopes. In the following discussion assume that the Type 3A74 is inserted in the left-hand (Y-axis) opening which will provide vertical deflection with crt beam blanking of the channel switching transient. If the the Type 3A74 is used with a Type 565 or RM565 Dual-Beam Oscilloscope, assume the unit is inserted in the left-hand vertical opening.

FUNCTIONS OF FRONT-PANEL CONTROLS AND CONNECTORS

Table 2-1 describes the functions of the front-panel controls. Since the four channels are identical, the functions of channel 1 control and the inputs connector are described in the table. Functions of the controls for the other channels are identical. Fig. 2-1 shows the front-panel layout.

TABLE 2-1

INPUT CONNECTOR

BNC Type jack for coupling input voltages to the channel 1 amplifier.

AC-GND-DC

Three-position miniature toggle switch provides a choice of ac or dc coupling, or grounding the channel 1 input circuit without grounding the input connector.

VOLTS/DIV.

Nine-position switch to select the calibrated vertical deflection factors.

VAR. GAIN

Provides continuously variable attenuation between the calibrated deflection factors, and extends the attenuation range to approximately 25 volts/div. This control has 360° rotation and it has a detent position for the CAL. (calibrated) position.

DC BAL.

Screwdriver-adjustable potentiometer to balance the amplifier dc levels so the trace does not shift position as the VAR. GAIN control is varied.

GAIN ADJ.

Screwdriver-adjustable potentiometer to precisely adjust the deflection factor of the channel. (.02 VOLTS/DIV. is the deflection factor normally calibrated.)

POSITION

Potentiometer to provide vertical positioning of the trace.

MODE

Three-position switch provides the following choices: a normal display, an inverted display, or no display at all. In the NORM. position the display has the same polarity as the input signal. In the INV. position the polarity of the signal is inverted. In the OFF position the channel is turned off; during multi-trace operation the channel is excluded from the switching cycle.

TRIGGER

A push-pull switch which, when pulled, permits internal triggering on channel 1 signal only, regardless of the channel 1 MODE switch settings. When the switch is pushed in with two or more channels "on", the time-base triggers from the composite time-shared vertical signal. With only one channel on, the channel displayed provides the triggering signal.

Plug-In Securing Knob

Permits locking the Type 3A74 in the plug-in compartment. (This knob is located at bottom center of the plug-in unit.)

CALIB.

Master gain control for adjusting the common gain of all channels. Compensates for differences in crt deflection sensitivities.

NOTE

For plug-in units S/N 156 and up, including S/N 133 unit (modified out of sequence) CALIB. control shaft has a shorter length. The shorter shaft permits the front-panel mounting bushing to be used as a ground-connection banana jack.

CHOP.-ALT.

Two-position toggle switch to select either alternate or chopped mode of operation.

FIRST TIME OPERATION

To place the Type 3A74 into operation for the first time, rotate the plug-in securing knob counterclockwise to move the latch to its fully counterclockwise unlatched position. Insert the unit in the left-hand plug-in opening of a Tektronix Type 560-Series oscilloscope (except the Type 560). Rotate the plug-in securing knob clockwise until hand tight.

1. Turn on the oscilloscope power. Allow about 2 to 3 minutes warm-up time and free run the time base at 1 millisec/div. Set the front-panel controls of the Type 3A74 to these settings.

AC-GND-DC (all channels)	DC
VOLTS/DIV. (all channels)	.02
VAR. GAIN (all channels)	CAL.

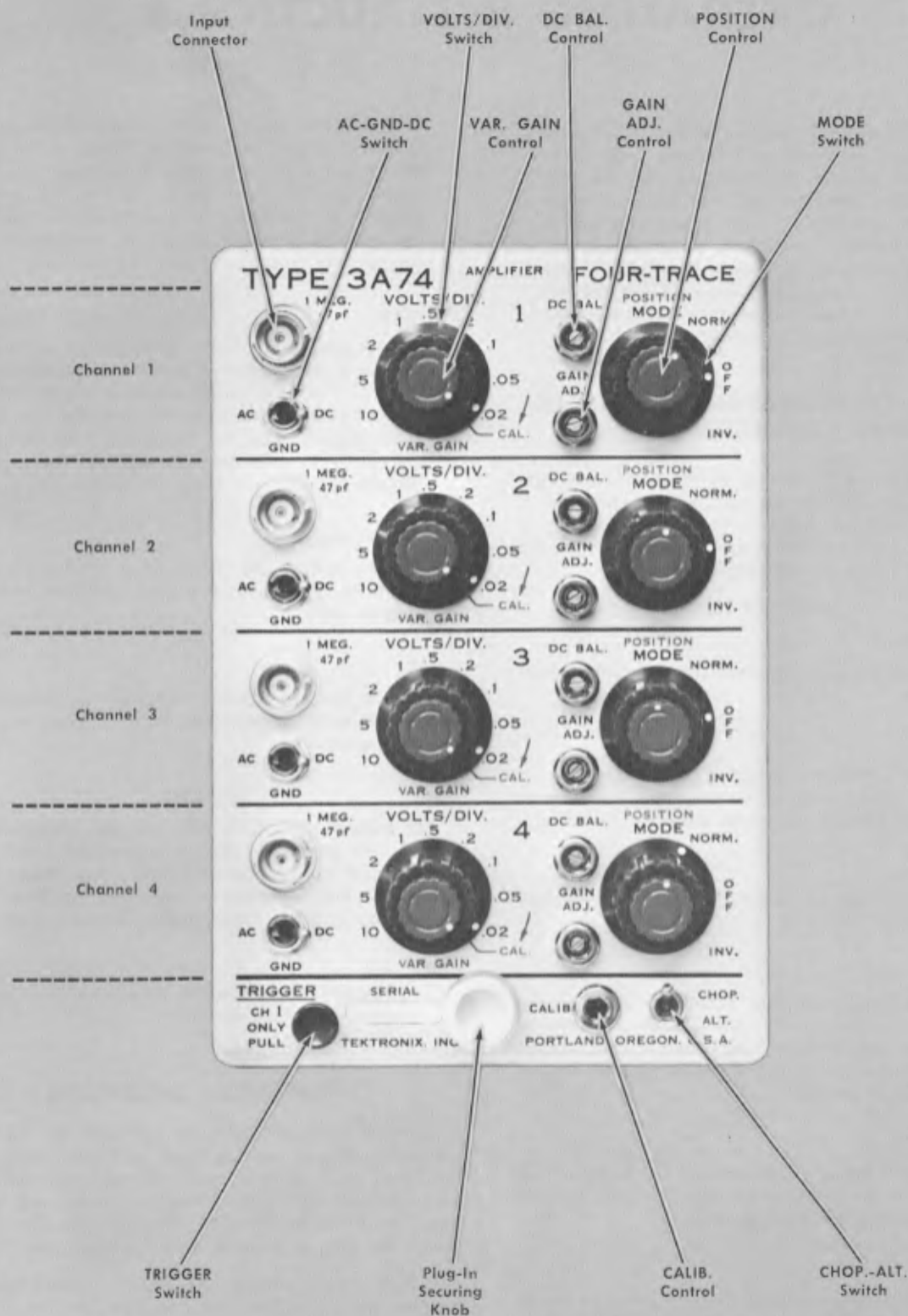
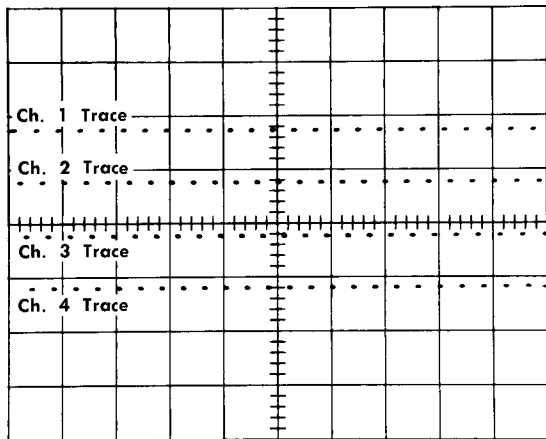
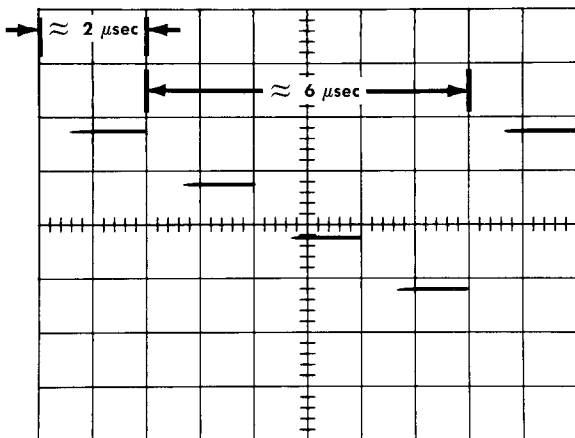


Fig. 2-1. Front-panel view of the Type 3A74 showing grouping of controls and connectors for each channel. Nomenclature, as used in the text, is also shown.

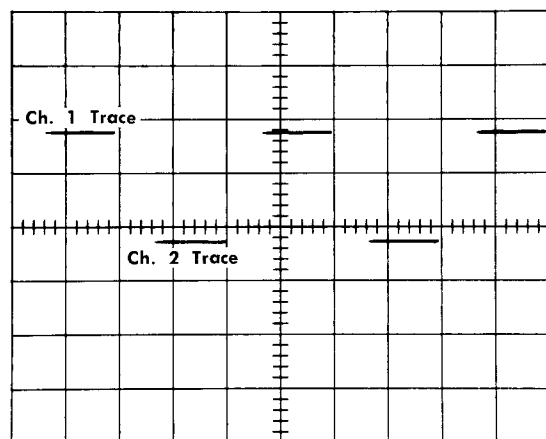
POSITION (all channels)	Centered
MODE (channel 1)	NORM.
MODE (channel 2, 3 and 4)	OFF
TRIGGER	Pushed in
CHOP.-ALT.	ALT.



(a) Chopping rate per channel is ≈ 125 kc; sweep rate is $20 \mu\text{sec}/\text{div.}$



(b) Chopping rate per channel is ≈ 125 kc; sweep rate is $1 \mu\text{sec}/\text{div.}$



(c) Chopping rate per channel is ≈ 250 kc; sweep rate is $1 \mu\text{sec}/\text{div.}$

2. Using the graticule centerline as a reference, vertically position the trace about two divisions above the centerline with the channel 1 POSITION control. (If you are using a Type 565 Dual-Beam Oscilloscope, use the upper beam graticule centerline as the reference.)

3. Place channel 2 MODE switch to NORM. and position the channel 2 trace about one division above the graticule center with the channel 2 POSITION control.

4. Set channel 3 MODE switch to NORM. and position its trace near the graticule centerline with the channel 3 POSITION control.

5. Place channel 4 MODE switch to NORM. and position its trace one division below the graticule center with the channel 4 POSITION control. This makes a total of four traces on the crt. For each sweep cycle one channel is displayed and the others are shut off. At the end of each sweep the time base switches to the next channel in succession during the retrace interval.

6. To view the alternate-trace switching cycle in slow motion, decrease the sweep rate to $0.1 \text{ sec}/\text{div.}$

7. To observe chopped mode of operation, set the CHOP.-ALT. switch to the CHOP. position. If your oscilloscope has a CRT Cathode Selector (Z-axis) switch mounted on the rear panel, set this switch to the Chopped Blanking position to blank (shut off) the crt beam while the Type 3A74 switches between channels.

8. Set the oscilloscope triggering controls for + internal triggered-sweep operation. Notice that all four traces seem to start simultaneously and continue on across the crt screen.

9. Increase the sweep rate to $20 \mu\text{sec}/\text{div.}$ Adjust the oscilloscope Trigger Level control to obtain a stable display. Notice that each trace is composed of many short-duration bits or segments (see Fig. 2-2a).

10. To see the chopped-mode switching action, increase the sweep rate to $1 \mu\text{sec}/\text{div.}$ and increase the crt intensity.

In chopped-mode operation all four channels are electronically switched sequentially at a rate of approximately 500 kc. Observe that each channel is "on" for about $2 \mu\text{sec}$ and then is turned off for $6 \mu\text{sec}$ while the other three channels are each "on" for $2 \mu\text{sec}$ (see Fig. 2-2b). The sampling rate of each channel is about 125 kc. (500 kc divided by the number of channels in use.) Switching time between channels is approximately $0.3 \mu\text{sec}$.

11. Now set channels 2 and 4 MODE switches to the OFF position. Readjust the Triggering Level control to obtain a stable display. Notice that the Type 3A74 switches between channels 1 and 3 only (see Fig. 2-2c). Each channel conducts for about $2 \mu\text{sec}$ and then is cut off while the other channel conducts for an equal time. The sampling rate for each channel is now about 250 kc.

Fig. 2-2. Chopped-mode operation.

GENERAL OPERATION

Any of the four amplifier channels can be used independently by setting the appropriate MODE switch to the NORM. or to the INV. position and connecting the signal to be observed to the appropriate input. The following discussion applies equally to each channel.

Signal Connections

The signal to be displayed is applied to the appropriate input connector on the front panel of the Type 3A74. For best results here are some precautions you should observe when making the connections.

1. It is often possible to make signal connections to the Type 3A74 with short-length, unshielded test leads*. This is particularly true for high-level, low-frequency signals. When such leads are used, you must also use a ground connection between the Type 3A74 or oscilloscope chassis ground and the chassis of the equipment under test. Position the leads away from any stray electric or magnetic field source to avoid obtaining erroneous displays.

2. In many low-level applications, however, unshielded leads are unsatisfactory for making signal connections because of unavoidable pickup resulting from radiating fields. To prevent unwanted signal pickup, use shielded (coaxial) cables. Be sure that the ground conductors of the

*To connect test leads to the Type 3A74, use the single binding post adapters (Tektronix Part No. 103-033) supplied with the unit.

cables are connected to the chassis of both the oscilloscope and the signal source.

3. As nearly as possible, simulate actual operating conditions in the equipment under test. 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 equipment under test due to the input circuit of the Type 3A74. The input circuit can be represented by a resistance of 1 megohm ($\pm 1\%$) paralleled by a capacitance of 47 picofarads ($\pm 2\%$). With a few feet of shielded cable, the capacitance is increased considerably. Where the effects of these resistive and capacitive loads will affect the operation of the device under test or distort the signal, use a probe in the manner described next.

Use of Probes

An attenuator probe lessens both capacitive and resistive circuit loading and at the same time reduces plug-in sensitivity. The attenuation introduced by the probe extends the vertical deflection factor of the Type 3A74 so that high-amplitude signal voltages can be conveniently displayed on the crt. When applying signals to the probe, consider the input voltage rating of the probe. When making the amplitude measurement, be sure to multiply the observed amplitude by the probe attenuation.

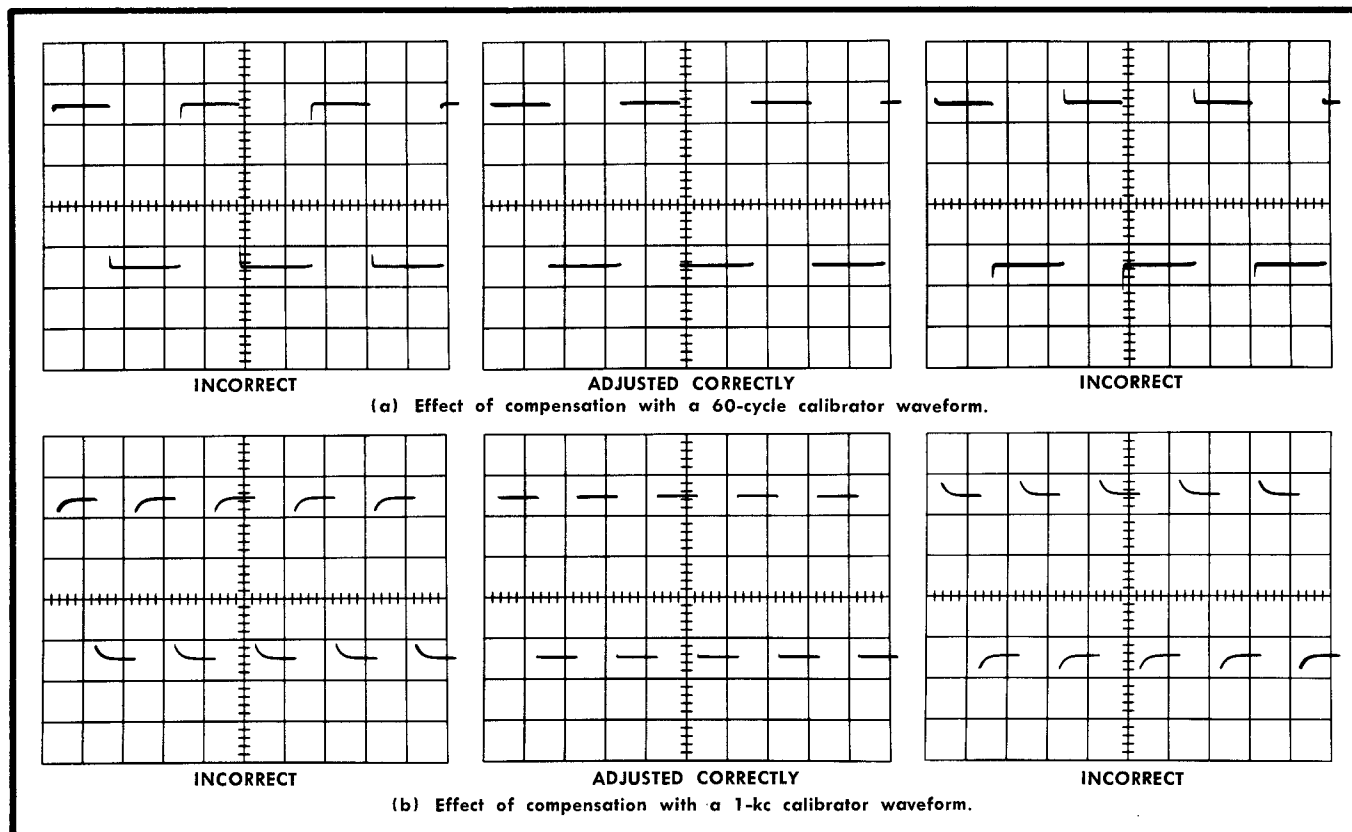


Fig. 2-3. Probe compensation waveforms.

To assure the accuracy of pulse or high frequency measurements, check the probe compensation. Once the probe is compensated for one channel, you can use the same probe on the other channels without recompensating it. The input circuits of the Type 3A74 have been adjusted at the factory so their time constants match each other very closely.

To adjust the probe input-compensation capacitor, set the oscilloscope Calibrator control for an output signal of suitable amplitude. For the Type 567 Oscilloscope use the calibrator jack that provides the proper output amplitude. Touch the probe tip to the appropriate calibrator output connector and adjust the oscilloscope controls to display several cycles of the waveform. Adjust the probe variable capacitor for best square-wave response as shown in Fig. 2-3 "Adjusted Correctly" waveforms.

NOTE

If you use a square-wave source other than the oscilloscope calibrator for compensating the probe, do not use a repetition rate higher than 5 kc. At higher repetition rates, the waveform amplitude appears to change as the probe is compensated, and you will not be able to compensate the probe properly. If the probe remains improperly compensated, transient and frequency response of the system will be poor and your measurements will be inaccurate.

AC-GND-DC Switch

To display both the ac and dc components of an applied signal, set the AC-GND-DC switch to DC; to display only the ac component of a signal, set the AC-GND-DC switch to AC.

In the AC position of the AC-GND-DC switch, the dc component of the signal is blocked by a coupling capacitor in the input circuit of the channel. The time constant of the input circuit is 0.1 second and the low-frequency response of the system is -3db at about 2 cps. Thus, when displaying a 60-cycle calibrator square wave, you can expect to see some drop in duration response (droop) of the square waveshape. If a 10X attenuator probe is used with the Type 3A74, the system low-frequency response will be extended to about 0.2 cps.

Placing the AC-GND-DC switch in the GND position grounds the input circuit of the Type 3A74 to provide a dc zero trace reference. At the same time the switch internally disconnects, but does not ground, the input connector or the applied signal.

VOLTS/DIV. Switch and VAR. GAIN Control

The amount of vertical deflection produced by a signal is determined by the signal amplitude, the attenuation factor (if any) of the probe, the setting of the VOLTS/DIV. switch, and the setting of the VAR. GAIN control. Calibrated deflection factors indicated by the settings of the VOLTS/DIV. switch apply only when the VAR. GAIN control is set to the detented CAL. position. Errors in display measurements may result if the setting of this control is unintentionally moved away from its CAL. position.

The range of the VAR. GAIN control is approximately 2.5:1 to provide continuously variable (uncalibrated) vertical-

deflection factors between calibrated settings of the VOLTS/DIV. switch. The VAR. GAIN control can be rotated in either direction from its detented CAL. position since there is no mechanical stop.

Voltage measurements can be made directly from the crt by noting the calibrated VOLTS/DIV. switch setting for the applicable channel and the amount of vertical deflection in major divisions. Then multiply the number of major divisions by the setting of the VOLTS/DIV. switch and the attenuation factor, if any, of the probe. An example is given in the Applications section of this manual.

MODE Switch

To display a single signal with the Type 3A74, apply the signal to one of the input connectors and set the appropriate MODE switch to the NORM. or INV. position. Set the MODE switches for the other three channels to OFF. Use the NORM position to display the signal with the same polarity as the applied signal. Use the INV. position to invert the signal display on the crt. The normal-inverted feature can be particularly useful when comparing two or more signals during multi-trace operation.

To display two or more signals in multi-trace operation, connect the signals to the input connectors and set the appropriate MODE switches to NORM. or INV., depending on whether you want to display the signals in a normal or inverted position. At any time one or more signals can be removed from the display without disconnecting the signal from the input connector(s). To do this, simply set the appropriate MODE switch to OFF. To remove the signal from a channel and still get a trace on the crt for that channel, set the AC-GND-DC switch to GND instead of setting the MODE switch to OFF.

CHOP.-ALT. Switch

1. General Information

When you are using the Type 3A74 for single-trace operation (i.e., the MODE switches of three channels are set to OFF), the unit acts as a single-channel amplifier. No switching to other channels occurs, regardless of the setting of the CHOP.-ALT. switch. However, when more than one channel is used, then the setting of the CHOP.-ALT. switch is important because it controls the mode of operation which produces the multi-trace displays.

In general, use the CHOP. position (chopped-mode operation) with lower sweep rates for displaying non-repetitive and low-repetition-rate signals. Non-repetitive signals are single-shot or randomly occurring signals. Use the ALT. position (alternate-mode operation) with the higher sweep rates for displaying high repetition-rate signals.

NOTE

If your oscilloscope has a CRT Cathode Selector (Z-axis) switch mounted on the rear panel, set this switch to the Chopped Blanking position during chopped-mode multi-trace operation. Leave the switch in the Chopped Blanking position at all times except for Z-axis modulation applications.

2. Specific Information

This information is provided as an operational guide concerning the use of chopped and alternate modes of operation.

(a) Displaying non-repetitive signals. To compare time and phase relationships of non-repetitive signals, use chopped-mode operation. The suggested fastest sweep rate that you can use and still obtain good resolution is summarized in Table 2-2.

TABLE 2-2

Chopped-Mode Resolution

Number of Channels in Use	Recommended Maximum Sweep Rate	Approx. Number of Segments in Each Trace
2	10 μ sec/div.	25
3	20 μ sec/div.	35
4	20 μ sec/div.	25

If sweep rates faster than those shown in Table 2-2 are used, resolution decreases and you may prefer to use single-trace operation.

(b) Displaying repetitive signals. The most likely dividing point between the use of chopped-mode operation at low sweep rates and alternate-mode operation at high sweep rates is 0.2 millisecc/div. At this sweep rate, or when using higher sweep rates, alternate-mode operation produces an uninterrupted display when viewing repetitive signals 500 cps or higher. That is, the alternate-mode switching cycle is sufficiently fast to produce an apparently steady display.

If the lower sweep rates are used for viewing signals 500 cps or lower, the alternate-mode switching cycle becomes more noticeable and you may prefer to use the chopped-mode of operation to produce steadier displays.

Multi-Trace Triggering

1. Comparing time-related signals. To obtain a stable display and to see true time or phase relationship between signals which bear a fixed time relationship to each other, apply the reference signal to channel 1. Use the channel 1 controls in a conventional manner. Pull the TRIGGER switch outward and the time base will internally trigger on channel 1 only. Apply the signals to be compared to the other channels. Set the CHOP.-ALT. switch to a position best suited for your application.

With the TRIGGER switch in its outward position, triggering on channel 1 only is independent of the channel 1 MODE switch setting. That is, you can set channel 1 MODE switch to OFF anytime you want to remove channel 1 waveform from the screen and exclude it from the switching cycle. Triggering will not be affected. Signals in the remaining channels will continue to be displayed unaffected and referenced to channel 1, regardless of the MODE switch setting.

2. Displaying signals unrelated in time. It is often possible to obtain a stable display of signals unrelated in time. This is accomplished by setting the CHOP.-ALT.

switch to ALT., pushing the TRIGGER switch to its inward position, and using ac-coupled internal triggering of the time base. Then, with a proper setting of the time-base Triggering Level control, the time base can trigger on the signal in each channel to assure proper electronic switching of the channels.

If you should experience some difficulty in finding a proper setting for the Triggering Level control, consider these factors which affect triggering: the setting of the Type 3A74 POSITION controls; the ac-coupled setting (AC, AC Slow, AC Fast, AUTO.—depending on which positions are available) of the time-base Triggering Coupling switch.

The Type 3A74 POSITION controls affect the dc component of the composite trigger from channel to channel, and the different ac-coupled settings of the time-base Triggering Coupling switch affect the waveshape of the trigger as it is ac-coupled into the time-base triggering circuits. Consequently, in addition to adjusting the Triggering Level control, you should also try vertically positioning the displayed waveforms to different points on the crt and try the different ac-coupled settings of the Triggering Coupling switch to find the best triggering conditions.

Calibrated Gain Adjustment

Any time you move the Type 3A74 from one oscilloscope plug-in opening to another you must adjust the common gain of the unit to compensate for differences in crt deflection sensitivities.

1. Set the front-panel controls of the Type 3A74 to these settings:

AC-GND-DC (channel 1)	DC
VOLTS/DIV. (channel 1)	.02
VAR. GAIN (channel 1)	CAL.
POSITION (channel 1)	Centered
MODE (channel 1)	NORM.
MODE (channel 2, 3 and 4)	OFF
TRIGGER	Either position
CHOP.-ALT.	Either position

2. Set the time-base sweep rate and triggering controls for a 0.1-millisecc/div. free-running sweep.

3. Apply a 0.1-volt signal from the oscilloscope Calibrator to the channel 1 connector. (Use a short test lead through a suitable connector adapter to make the direct connection. Use a 0.05-volt Calibrator signal if you are using a Type 567 Oscilloscope.)

4. Adjust the CALIB. control to obtain a deflection of exactly five major divisions. (2.5 major divisions if you are using a Type 567 Oscilloscope.)

NOTE

If the CALIB. control does not have sufficient range, set channel 1 GAIN ADJ. near midrange. (A setting a few degrees on either side of mid-range will give the CALIB. control enough range.) Then set the CALIB. control as described in step 4 of this procedure. Next, proceed to the Channel Gain Adjustments procedure and set the GAIN ADJ. for channels 2, 3, and 4.

Channel Gain Adjustments

From time to time you should check the gain of each channel to assure that the vertical deflection factor corresponds to the .02 VOLTS/DIV. switch panel marking. To check the gain of each channel, proceed as follows:

1. Check the gain of channel 1 by performing the previous Calibrated Gain Adjustment procedure. If you have done this, leave the controls as they were in that procedure and go to the next step.
2. Remove the signal from channel 1 and apply it to channel 2.
3. Set channel 1 MODE switch to OFF and channel 2 MODE switch to NORM.
4. Set the remaining channel 2 front-panel controls so they correspond to the settings used for channel 1.
5. Rotate channel 2 GAIN ADJ. to obtain a deflection of exactly five major divisions (2.5 major divisions if you are using a Type 567 Oscilloscope.)
6. Set the GAIN ADJ. for channels 3 and 4 in the same manner as for channel 2.
7. To double-check the exactness of your calibration, apply the calibrator signal to all four channels. Set all MODE switches to NORM. and superimpose the displays of all four channels. Check the displays of all four channels to see that they match in deflection and that the deflection is the same as described in step 5 of this procedure.

NOTE

Once all gain adjustments have been set properly and the CALIB. control has adequate range, you need only to adjust the CALIB. control when you

move the Type 3A74 from one plug-in opening to another.

DC Balance Adjustments

If the dc balance of a channel is not properly adjusted, the crt dc-reference-level position of the trace will shift as the VAR. GAIN control of that channel is rotated. Though the adjustment procedure for channel 1 is described here, the same basic procedure is used for the other channels. To properly set the dc balance, proceed as follows:

1. Set channel 1 AC-GND-DC switch to GND and the VAR. GAIN control to CAL.
2. Set channel 1 MODE switch to NORM. and position a 0.1-millisec/div. free-running trace to the center of the graticule. The centerline serves as a convenient reference point.
3. Rotate channel 1 VAR. GAIN control to the maximum attenuation position (a few degrees clockwise past the CAL. position). Note the direction and distance the trace moved.
4. Rotate channel 1 VAR. GAIN control back to its CAL. position.
5. As a preliminary adjustment, slowly adjust the DC BAL. control to move the trace in the same direction as the trace moved in step 3. Continue rotating the DC BAL. control to a point which positions the trace 1.5 times the distance noted in step 3.
6. As a final adjustment, rotate the VAR. GAIN control back and forth several times between the CAL. and maximum attenuation settings. At the same time, adjust the DC BAL. control until there is no trace shift.

NOTES

[illegible]

SECTION 3

APPLICATIONS

The following applications describe how to make basic voltage, phase, and time-delay measurements. These same techniques can be applied and extended to a wide variety of applications.

AC Voltage Measurement

To measure the ac peak-to-peak voltage or amplitude of a waveform, the AC-GND-DC switch should be set to the AC position. In this position only the ac components of the signal are displayed on the crt. (However, when the ac component of the signal is very low in frequency, use the DC position of the switch.)

Peak-to-peak voltage measurements of a signal applied to one channel are made as follows:

1. Set the appropriate VOLTS/DIV. switch such that the expected voltage to be applied to the input connector is not more than about six times the setting. If these conditions are fulfilled, the expected voltage will produce a vertical deflection of not more than 6 major divisions. Make sure the VAR. GAIN control is set to the CAL. position.
2. Apply a repetitive signal to the appropriate channel, preferably through a coaxial cable or an attenuator probe.
3. Set the appropriate MODE switch to NORM. and the other MODE switches to OFF.
4. Set the triggering controls and the sweep rate of the time base for a stable display of several cycles of the waveform.
5. Use the positioning controls to position the waveform to a convenient point on the crt so that the voltage measurement can be determined easily. For example, position the waveform so that the negative peaks of the waveform coincide with one of the lower graticule lines and one

of the positive peaks lies behind the vertical centerline of the graticule.

6. With the aid of the graticule, measure the vertical deflection in divisions from the negative peak to the positive peak.

In measuring signal amplitudes, it is important to remember that the width of the trace may be an appreciable part of the overall measurement. For this reason, you should consistently make all measurements from one side of the trace. This is particularly true when measuring signals of small amplitude. Notice in Fig. 3-1 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 side or center of the trace.

7. Multiply this distance by the setting of the VOLTS/DIV. switch and the attenuation factor, if any, of the probe. (Remember that the VAR. GAIN control must be set to the CAL. position.)

As an example, assume you measure a vertical distance of 4.6 divisions, the VOLTS/DIV. switch setting is .2, and you are using a 10X attenuator probe.

$$\begin{array}{ccccccc} \text{Vertical} & & \text{VOLTS/DIV.} & & \text{Probe} & & \\ \text{Deflection} & \times & \text{Switch} & \times & \text{Attenuation} & = & \text{volts (p-p)} \\ & & \text{setting} & & \text{Factor} & & \end{array}$$

$$4.6 \times .2 \times 10 = 9.2 \text{ volts (p-p)}$$

Instantaneous Voltage Measurements

To measure the dc level at a given point on a waveform, the following procedure using channel 1 as an example is given.

1. Set the channel 1 VOLTS/DIV. switch such that the expected voltage to be applied to the input connector is not more than about six times the setting, to obtain not more than about 6 major divisions of vertical deflection. Be sure the VAR. GAIN control is set to the CAL. position.
2. Set the triggering and time-base controls so that the sweep free runs at the desired rate.
3. Set the channel 1 AC-GND-DC switch to GND (or ground the probe tip), and vertically position the trace so that it lies along one of the horizontal graticule lines. This line will be used as a ground (zero) reference line. The reference line you choose will depend upon the polarity and dc level of the signal to be measured. Do not move the POSITION control of the Type 3A74 after the reference line has been established.

As an alternate method, you can set the oscilloscope for automatic triggering and use the trace of an unused channel as a visible reference. To establish a ground reference using channel 2 (for example), set channel 2 AC-GND-DC switch to GND. Check that channel 1 AC-GND-DC switch is set to GND also. Superimpose the traces. After establishing the reference, do not move the channel 1 and 2 POSITION controls.

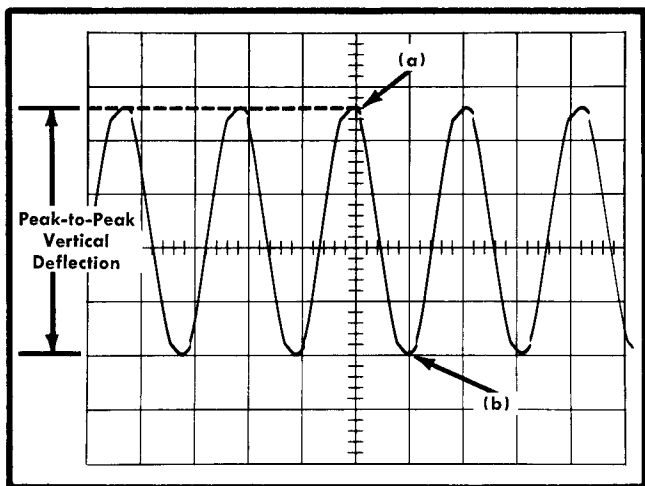


Fig. 3-1. Measuring peak-to-peak voltage.

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4. Set the channel 1 AC-GND-DC switch to DC.
5. Apply the signal, preferably through a coaxial cable or an attenuator probe, to the channel 1 input connector.
6. Set the triggering controls of the time base for a stable display.
7. Measure the vertical distance in divisions from the ground (zero) reference line established in step 3 to the point on the waveform that you wish to measure.

If the channel 1 MODE switch is set to NORM. and the point on the waveform is above the reference line, the polarity is indicated to be positive (+). If the point is below the line, the polarity is negative (—). If the MODE switch is set to INV., the indicated polarities will be reversed.

8. Multiply this distance measured by the setting of the VOLTS/DIV. switch and the attenuation factor, if any, of the probe. This is the instantaneous dc level of the point measured.

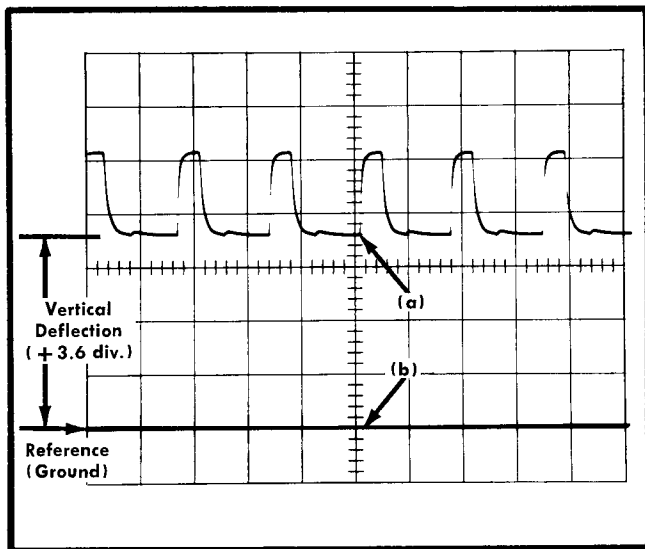


Fig. 3-2. Measuring a voltage with respect to some reference.

As an example, assume the MODE switch is set to NORM. You measure a vertical deflection of 3.6 divisions above ground reference line (see Fig. 3-2), the VOLTS/DIV. switch setting is 5, and you are using a 10X attenuator probe.

$$\begin{aligned} \text{Instantaneous Voltage with Respect to Reference} &= \text{Vertical Deflection} \times \text{VOLTS/DIV. Switch Setting} \times \text{Probe Attenuation Factor} \\ \text{Instantaneous Voltage With Respect to Reference} &= +3.6 \text{ div.} \times 5 \times 10 = +180 \text{ volts} \end{aligned}$$

9. If you want to recheck the (zero) reference or establish a new reference without disconnecting the applied signal, set the channel 1 AC-GND-DC switch to GND. If you want to establish a reference other than zero, set

the channel 1 AC-GND-DC switch to DC, touch the probe to the desired reference voltage, and position a free-running trace along one of the horizontal graticule lines.

Voltage Comparison Measurements

In some applications you could establish a set of deflection factors other than those indicated by the VOLTS/DIV. switch. This is useful for comparing signals which are exact multiples of a given voltage amplitude. The following procedure describes how to get deflection factors for channel 1. The same procedure can be used for the other channels.

1. Apply a reference signal of known amplitude to channel 1 and, with the channel 1 VOLTS/DIV. switch and VAR. GAIN control, adjust the amplitude of the display for an exact number of graticule divisions. Do not move the VAR. GAIN control after you have obtained the desired deflection.

2. Divide the amplitude of the reference signal (in volts) by the product of the deflection in divisions (established in step 1) and the VOLTS/DIV. switch setting. The result is the Deflection Conversion Factor.

$$\text{Deflec. Conv. Factor} = \frac{\text{Reference signal amplitude in volts}}{(\text{Deflec. in Div.}) (\text{VOLTS/DIV. Setting})}$$

3. To calculate the True Deflection Factor at any setting of the VOLTS/DIV. switch, multiply the VOLTS/DIV. switch setting by the Deflection Conversion Factor obtained in step 2.

$$\text{True Deflec. Factor} = (\text{VOLTS/DIV. Setting}) (\text{Deflec. Conv. Factor})$$

The true deflection factor obtained for any setting of the channel 1 VOLTS/DIV. switch applies only to this channel, and only as long as the VAR. GAIN control is not moved from the position to which it was set in step 1.

As an example, suppose the amplitude of the reference signal applied to channel 1 is 30 volts, and the VOLTS/DIV. switch setting is 5. The VAR. GAIN control is adjusted to decrease the amplitude of the display to exactly 4 divisions.

$$\text{Deflec. Conv. Factor} = \frac{30}{(4) (5)} = 1.5$$

$$\text{True Deflec. Factor} = (5) (1.5) = 7.5 \text{ volts/div.}$$

4. To determine the peak-to-peak amplitude of a signal to be compared, disconnect the reference signal and apply the signal to be compared to channel 1. Set the VOLTS/DIV. switch to a setting that will display the signal with adequate deflection so that a measurement can be made.

5. Measure the vertical distance in divisions and determine the amplitude by using this formula:

$$\text{Signal Amplitude} = \frac{\text{Deflec. Conv. Factor}}{\text{in div.}} \times \text{Deflec.} \times \frac{\text{VOLTS/DIV. Setting}}{\text{Setting}}$$

As an example, suppose the signal to be compared caused a deflection of 6 divisions at a VOLTS/DIV. setting of 10. The VAR. GAIN control was not moved from the setting used in the previous example. Substituting these values for

the Deflection Conversion Factor in the Signal Amplitude formula,

$$\text{Signal Amplitude (in volts)} = (1.5) (6) (10) = 90 \text{ volts}$$

Phase-Shift Measurements

Phase-shift comparisons of two to four sine-wave signals of the same frequency can be made using the multi-trace feature of the Type 3A74. To make the comparisons, proceed as follows:

1. Set the AC-GND-DC switches to identical settings—either all AC or all DC, depending on the type of coupling desired.
2. Set the MODE switches to NORM. and pull the TRIGGER switch outward.
3. Place the CHOP.-ALT. switch to the position desired. In general, the ALT. position is more suitable for high-frequency signals and the CHOP. position is more suitable for low-frequency signals.
4. Apply the reference signal to channel 1; apply the signals to be compared to the other channels. Use equal delay coax cables or probes.

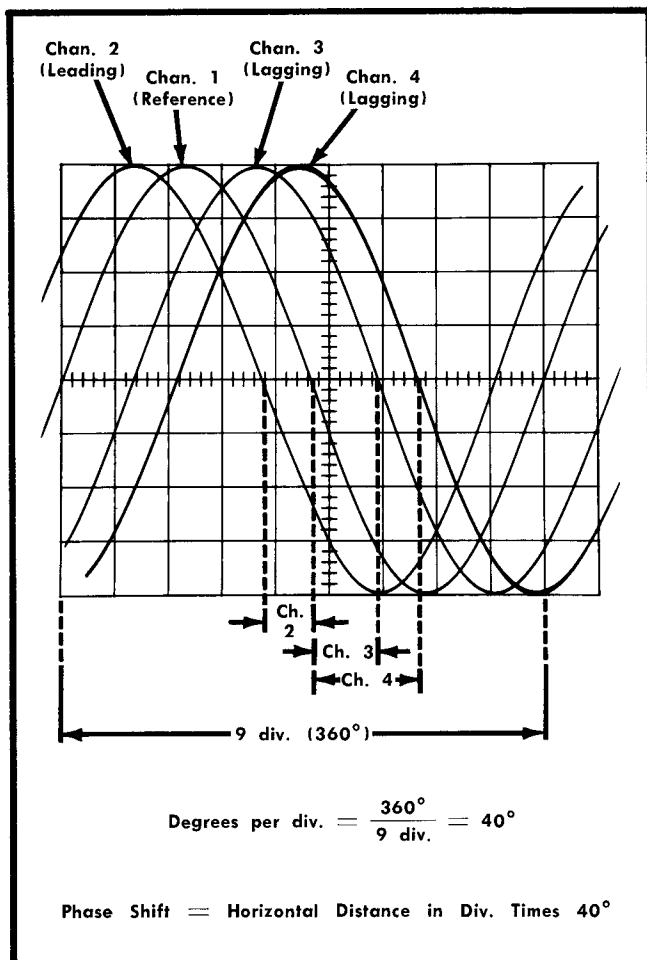


Fig. 3-3. Measuring the phase shift between electrical waveforms.

5. Set the VOLTS/DIV. switches for a suitable amplitude display.

6. Set the time-base sweep rate and triggering controls to obtain a stable display of less than one cycle of the waveforms.

7. Adjust the VAR. GAIN control for each channel so that the signal amplitudes are equal and fill the screen vertically. Reset the VOLTS/DIV. switches if there are settings available that will aid in obtaining the equal amplitude signal displays. Equal amplitudes are not essential but they help to make comparisons easier. Carefully center the signals vertically on the screen; that is, for equal distances above and below the center graticule line.

8. Rotate the Variable Time/Div. control of the time base counterclockwise until one cycle of the reference signal occupies exactly 9 divisions horizontally. Use the Slope switches and the Triggering Level control of the time base to trigger on the reference waveform at any point you desire. Each division on the screen now represents 40° of one cycle at this time-base setting (see Fig. 3-3).

9. Measure the horizontal distance between the reference waveform and each of the other waveforms. Note the distance for each channel and whether they are leading or lagging. To make each phase comparison measurement easier, switch the nonapplicable waveforms "off" by setting the appropriate MODE switches to the OFF position until you need to display them.

10. For each distance measured, multiply the distance by 40° per division to obtain the amount of phase shift compared to the reference waveform.

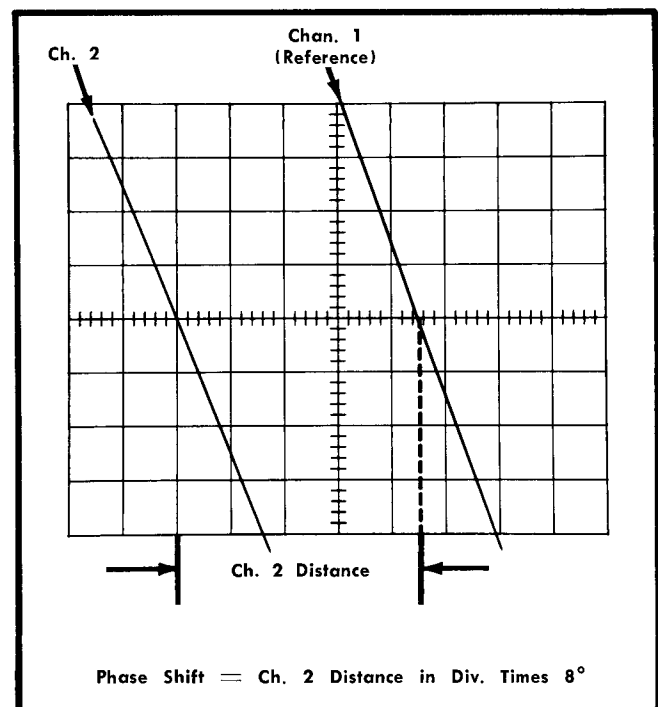


Fig. 3-4. Computing the phase shift when the oscilloscope sweep rate is increased 5X. Accurate phase-shift measurements within a range of 80° can be made using this method.

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For more precise measurements, you could increase equally the vertical sensitivity of all channels used and the sweep rate established in steps 6, 7, and 8, but do not change the setting of the time-base Variable Time/Div. control. However, when you increase the sweep rate, you must take this into consideration in your calculations.

For example, if you increase the sweep rate by a factor of 5, and then measure the distances between waveforms, each division will represent 8° ($40^\circ \div 5$) of a cycle. By doing this, you can measure phase shift up to 80° more accurately. When preparing to make the measurement, horizontally position the waveforms to points where the graticule markings aid in determining the exact distance. (To be certain that the waveform is centered vertically, check the DC. BAL. adjustment before vertical sensitivity is increased.) Fig. 3-4, for example, shows how the phase shift of channel 2 waveform can be computed using this method. Other phase-shift measurements can be determined using this same basic procedure.

Time-Delay Measurements

The calibrated sweeps of Tektronix oscilloscopes cause any horizontal distance on the screen to represent a definite known interval of time. Using this feature in combination with the multi-trace feature of the Type 3A74, you can measure the time lapse or delay between events displayed on the crt. This is done by using the following method:

1. Set the AC-GND-DC switch to AC or DC depending on the type of coupling desired.
2. Apply the reference signal to channel 1; apply the signals which have more delay than the reference signal to the other channels. Use coaxial cables or probes having equal delay.
3. Pull the TRIGGER switch to its outward position and set the CHOP.-ALT. switch to the position desired.
4. Set the MODE switches to NORM.
5. Set the VOLTS/DIV. switches and the VAR. GAIN controls to obtain suitable vertical deflections. Set the time-base sweep rate and triggering controls to obtain a stable display at a sweep rate that will allow you to measure the distance between waveforms accurately. Be sure the Variable Time/Div. control is set to the Calibrated position.
6. If some of the waveforms are negative-going and others are positive-going, you may prefer to set the appropriate MODE switches to the INV. position to make all waveforms go in the same direction on the display.
7. With the aid of the graticule markings, measure the horizontal distance between the reference waveform and each of the other waveforms. For most measurements the distance is usually measured between 50% amplitude points on the rising portion of the waveform. To make the measurements easier, switch the waveforms not being measured "off" by setting the appropriate MODE switches to the OFF position.
8. Multiply the distance measured for each channel by the setting of the time-base Time/Div. switch to obtain the apparent time interval.

9. To obtain the actual time interval, divide the apparent time interval by 5 if 5X sweep magnification is used, by 10 if 10X sweep magnification (Type 565 Oscilloscope) is used, and 1 if sweep magnification is not used.

$$\text{Time Delay} = \frac{(\text{Time/Div. Switch Setting}) (\text{Distance in Div.})}{\text{Sweep Magnification}}$$

For example, assume the Time/Div. switch setting is 2 μSec , the 5X magnification is in use, and you measure a horizontal distance of 3 divisions between the leading edge of the reference waveform and the leading edge of the waveform displayed on another channel. In this example, 3 divisions multiplied by 2 microseconds per division gives you an apparent time delay of 6 microseconds. The apparent time delay divided by 5 gives you an actual time delay of 1.2 microseconds.

Four-Trace X-Y Displays

It is possible to display up to four different sets of sampled X-Y parameters on the oscilloscope screen through the use of two Type 3A74 Plug-In Units.

To display four sets of X-Y parameters at the same time, proceed as follows:

1. Insert the Type 3A74's into the vertical (Y-axis) and horizontal (X-axis) openings of the oscilloscope.
2. Set the CHOP.-ALT. switch of the Y-axis unit to CHOP. and the X-axis unit to ALT. Best transient blanking response is obtained by setting these switches to the positions as stated.
3. Connect a pair of (X-Y) signals to each channel. For example, connect one signal of a pair to channel 1 of the Y-axis plug-in. Connect the other signal of the pair to channel 1 of the X-axis plug-in. Proceed in this manner to connect each pair of signals to the other channels of both units.

NOTE

Channel 4 in both units synchronize together through pin 18 of the interconnecting plugs. Therefore, it is important that you always leave channel 4 "on" in both units by setting their MODE switches to either NORM. or INV., as desired. In addition, always use the same number of channels between units to assure proper synchronization between pairs of signals.

4. Set the VOLTS/DIV. switches and the POSITION controls for the desired displays. If the displays do not properly synchronize, set the channel 4 MODE switch of the left-hand or Y-axis plug-in to OFF momentarily and then back to the "on" position.

If you are applying sine-wave signals of the same frequency to each channel, the resulting displays will appear as a straight line, ellipse, a circle, or other variations of the Lissajous pattern for phase differences between 0° and 360° . Fig. 3-5 shows an example of possible displays that can be obtained. To calculate the sine of the phase difference between a pair of signals, use this method:

- (a) Center one of the X-Y displays horizontally and vertically on the crt. Position the others off the crt.

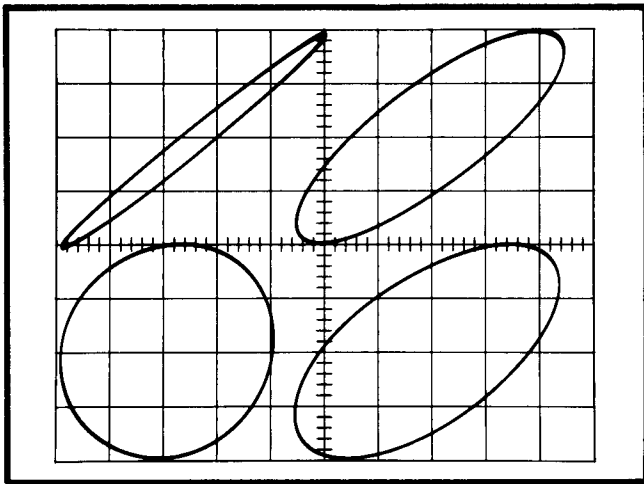


Fig. 3-5. X-Y displays obtained by using four pairs of channels simultaneously.

- (b) Increase the size of the display by increasing the input signal amplitudes or by increasing the vertical and horizontal sensitivities of the plug-in units. Center the display as described in the previous step.
- (c) Measure the distances A and B on the display as shown in Fig. 3-6. A/B is equal to the sine of the phase difference between the two signals (see Table 3-1).

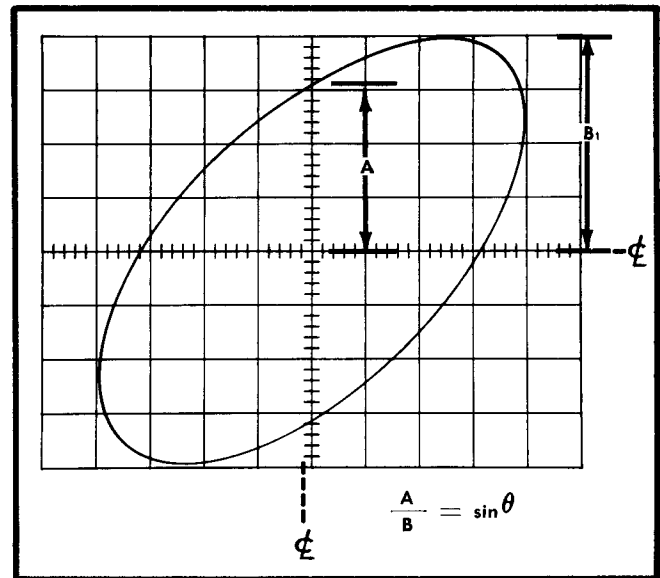


Fig. 3-6. X-Y method of calculating phase difference (θ) of two sine waves.

- (d) After making the calculation for one display, position it off the crt and position one of the other displays on the crt and calculate the phase difference. Continue in this manner for the remaining displays.

Natural Sine Functions

TABLE 3-1

ANGLE (in degrees)	SIN	ANGLE (in degrees)	SIN	ANGLE (in degrees)	SIN
0	.0000	30	.5000	60	.8660
1	.0175	31	.5150	61	.8746
2	.0349	32	.5299	62	.8829
3	.0523	33	.5446	63	.8910
4	.0698	34	.5592	64	.8988
5	.0872	35	.5736	65	.9063
6	.1045	36	.5878	66	.9135
7	.1219	37	.6018	67	.9205
8	.1392	38	.6157	68	.9272
9	.1564	39	.6293	69	.9336
10	.1736	40	.6428	70	.9397
11	.1908	41	.6561	71	.9455
12	.2079	42	.6691	72	.9511
13	.2250	43	.6820	73	.9563
14	.2419	44	.6947	74	.9613
15	.2588	45	.7071	75	.9659
16	.2756	46	.7193	76	.9703
17	.2924	47	.7314	77	.9744
18	.3090	48	.7431	78	.9781
19	.3256	49	.7547	79	.9816
20	.3420	50	.7660	80	.9848
21	.3584	51	.7771	81	.9877
22	.3746	52	.7880	82	.9903
23	.3907	53	.7986	83	.9925
24	.4067	54	.8090	84	.9945
25	.4226	55	.8192	85	.9962
26	.4384	56	.8290	86	.9976
27	.4540	57	.8387	87	.9986
28	.4695	58	.8480	88	.9994
29	.4848	59	.8572	89	.9998
				90	1.0000

SECTION 4

CIRCUIT DESCRIPTION

4-CHANNEL SWITCHED AMPLIFIER

Introduction

The Type 3A74 Four-Trace Amplifier Plug-In Unit consists of four identical switched amplifiers, a common output amplifier, and a Channel 1 Only internal trigger amplifier. Since the switched amplifiers are identical, the following description of channel 1 applies to all. Throughout the circuit-description discussion, you should refer to the block and circuit diagrams located near the back of this manual. Also, assume that a calibrated Type 3A74 is inserted in the left-hand or Y-axis opening to provide vertical deflection, and a time-base plug-in is inserted in the right-hand or X-axis plug-in opening of those oscilloscopes requiring plug-in units for both X- and Y-axis deflection.

NOTE

Voltages and currents given in the circuit description are not absolute but are approximate.

Input Coupling

The signal to be displayed is applied to the Input Cathode Follower V423 through the AC-GND-DC switch SW401 and the VOLTS/DIV. switch SW410. In the DC position of SW401, input coupling capacitor C401 is bypassed with a direct connection. In the AC position the signal must pass through C401 so the dc component of the signal is blocked. In the GND position the signal path is opened and the input circuit is grounded.

Input Attenuation

The Input CF (Cathode Follower) stage V423 requires an input signal of 0.02 volt, peak-to-peak, applied to its grid to produce one division of calibrated peak-to-peak deflection on the crt. In order to satisfy this condition, and to make the unit applicable to a wide range of input voltages, precision attenuation networks can be switched into the input circuitry by means of the VOLTS/DIV. switch SW410. The voltage-attenuation ratios of these networks are X2.5, X5, X10, and X100.

When the VOLTS/DIV. switch is in the .02 position, the signal is coupled without attenuation to the Input Cathode Follower, V423. For the other settings of the VOLTS/DIV. switch, the attenuation networks are switched into the circuit, either singly or in tandem pairs, so that the signal applied to the grid of V423 is always 0.02 volt for each division of crt deflection when the VAR. GAIN control R426 is set to the CAL. position.

The attenuators are frequency compensated rc voltage dividers, and the attenuation factor can be expressed in a general manner as follows:

$$\text{Attenuation Factor} = \frac{\text{total divider resistance (including R416)}}{\text{grounded-leg resistances (includes R416)}}$$

Using the X2.5 attenuator as a specific example (see Fig. 4-1), the formula is:

$$\text{Attenuation Factor} = \frac{(R407C) (R416) + (R407C) (R407E) + (R407E) (R416)}{(R407E) (R416)} = 2.5$$

At low frequencies the dividers are resistive because the impedance of the capacitors is high and their effect in the circuit is negligible. As the frequency of the input signal increases, however, the impedance of the capacitors decreases and their effect in the circuit becomes more pronounced.

For high-frequency signals the impedance of the capacitors is low, in comparison to the resistance of the circuit, and the attenuators become capacitive voltage dividers. For these frequencies, the attenuation factor is similar to the resistance case, except that the capacitive reactances are the dominant factors involved. A variable capacitor in each attenuator, such as C407C in the X2.5 attenuator (see Fig. 4-1) provides a method for adjusting the capacitive-reactance ratios equal to the resistance ratios.

The variable capacitor at the input to each attenuator, such as C407B in the X2.5 attenuator (see Fig. 4-1), provides a means for adjusting the input RC time constant of the attenuator to a "standard" value of 47-pf X1 meg. when using a 47-pf Input Time Constant Standardizer as a reference. Similarly, C416 provides a method for "standardizing" the input capacitance when the VOLTS/DIV. switch is set to the .02 position. In addition to providing the same input capacitance, the resistance values of the attenuators are chosen to provide an input resistance of 1 megohm for each setting of the VOLTS/DIV. switch. Thus, an attenuator probe, when connected to the Input connector of the Type 3A74, will work into the same time constant regardless of the setting of the VOLTS/DIV. switch. This means that once an attenuator probe is properly compensated to match one VOLTS/DIV. switch setting, the probe need not be readjusted each time another VOLTS/DIV. switch position is used.

Switched Amplifier

The Switched Amplifier for each channel consists of three stages: Input CF (Cathode Follower) V423, Input Amplifier Q424/Q434, and DC Balance CF (Cathode Follower) V433. Following the Input Amplifier stage is a four-diode switch to connect or disconnect the channel to the common Output Amplifier.

Input Cathode Follower V423. Tube V423 is a nuvistor which presents a high-impedance, low-capacitance load to the input circuit, and isolates the input circuit from the succeeding stages. The cathode is connected through R423 to the -12.2-volt supply. The large value of R423 permits the stage to operate near unity gain and to handle normal signals up to ± 2 volts in amplitude without distortion.

Resistor R417 protects the grid circuit of V423. This component limits the dc grid current through V423 if a positive-

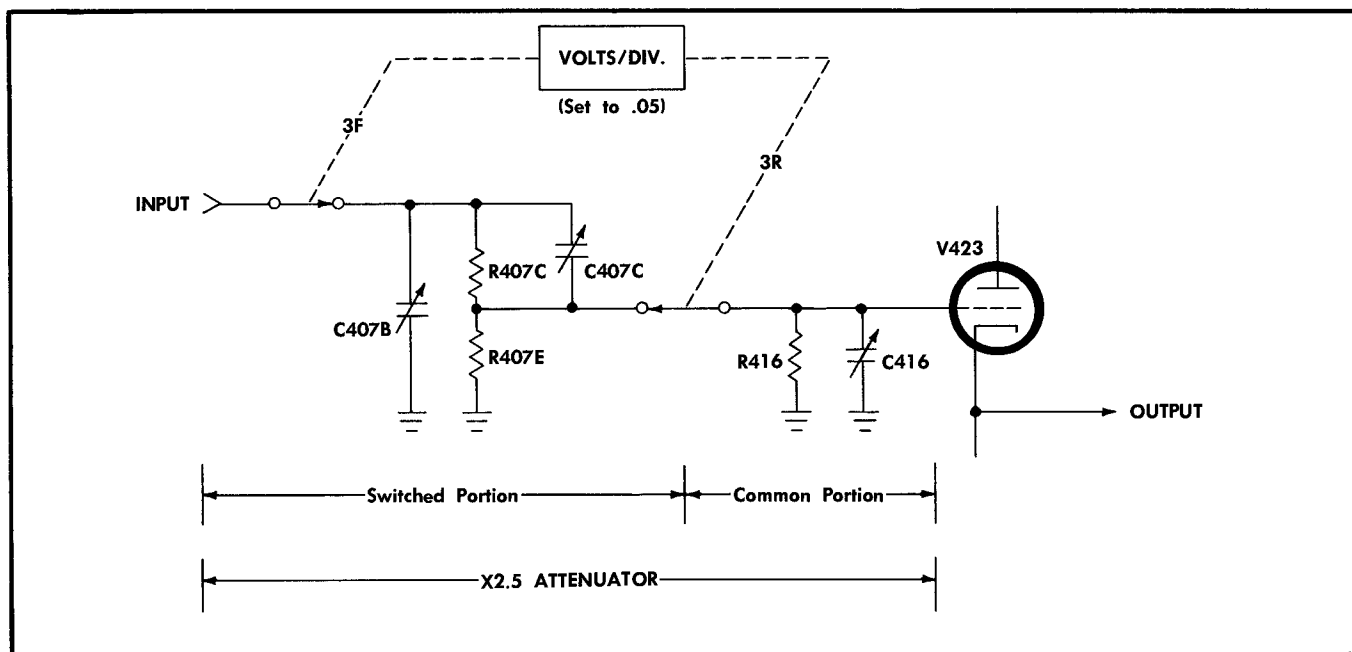


Fig. 4-1. Simplified circuit diagram showing the most important components involved when calculating the X2.5 attenuation factor.

going overload signal is inadvertently applied to the input connector. Since R417 alone would deteriorate the high-frequency ac response of the stage, C417 is added to pass the high-frequency ac components around R417. To protect transistor Q424 from the same overload signal, diode D424 is provided. This diode conducts during the overload interval, thus limiting the reverse bias of Q424.

Negative-going overload signals do not damage V423 because V423 is protected by B419. If V423 goes too far below cutoff, neon B419 ignites and clamps the grid of V423 at about -60 volts. The clamping action prevents the grid from going further negative and prevents grid-to-cathode arcing. Current through transistor Q424 for the duration of the overload signal is limited to 8 ma by its long-tailed circuitry.

Input Amplifier Q424/Q434. This stage is a transistorized emitter-coupled paraphase amplifier. It converts the single-ended input signal at the base of Q424 to differential current signals in the collector circuits. Both emitters are long-tailed (through R425 and R435) to the $+125$ -volt supply for greater stability with respect to transistor parameters and temperatures. The no-signal current through each of the transistors is nominally 2.5 ma.

There are two gain controls located in the common-emitter circuit of Q424 and Q434. One is the VAR. GAIN control R426 and the other is the GAIN ADJ. control R436, a front-panel screwdriver-adjust potentiometer. Both controls vary the emitter degeneration and thus affect the gain of the stage. With R426 set to the CAL. position, R436 is adjusted so that the total amplifier gain provided by this adjustment and the CALIB. adjustment R477 (in the Output Amp. 2nd Stage) causes the crt deflection to agree with the setting of the VOLTS/DIV. switch.

The value of collector resistors R424 and R434 is chosen to provide proper base-emitter junction temperature comp-

ensation for their respective transistors. C424 and C434 provide increased high-frequency response to compensate for the response losses introduced by R424 and R434.

DC Balance CF V433. This cathode follower stage provides a low-impedance drive for ac balancing the Q424/Q434 emitters of the Input Amplifier stage. To balance the emitters the DC BAL. control R427, located in the grid circuit of V433, is used to set the dc level of Q434. When correctly adjusted, the emitter level of Q434 will be the same as the emitter level of Q424 under no-signal conditions. (The usual method for quickly establishing a no-signal condition is to set the AC-GND-DC switch to GND.) With the emitters at the same voltage there will be no current through the VAR. GAIN control. Thus, the VAR. GAIN control can be rotated without affecting the dc level of the succeeding stages and thus not affect the vertical position of the beam.

Mode Switch. If the MODE switch is set to the NORM. position, the signal passes through diode switches D440 and D443 to the Output Amplifier. A normal display will appear on the crt; that is, the display will have the same polarity as the input signal. If the input signal is positive going, for example, the displayed waveform will also be positive going. However, when the MODE switch is set to the INV. position, the display is inverted because the switch reverses the signal leads to the diode switches. For example, a positive going input signal will be displayed as a negative-going waveform.

When the MODE switch is set to the OFF position, the output leads from the Input Amplifier stage are shorted together (refer to the block or schematic diagrams to see how this is accomplished). Therefore no differential current signals from the Input Amplifier stage or the positioning circuit is applied to the Output Amplifier. If all the MODE switches are set to OFF, a trace will appear centered on the crt. This is a quick, convenient method for checking the dc balance

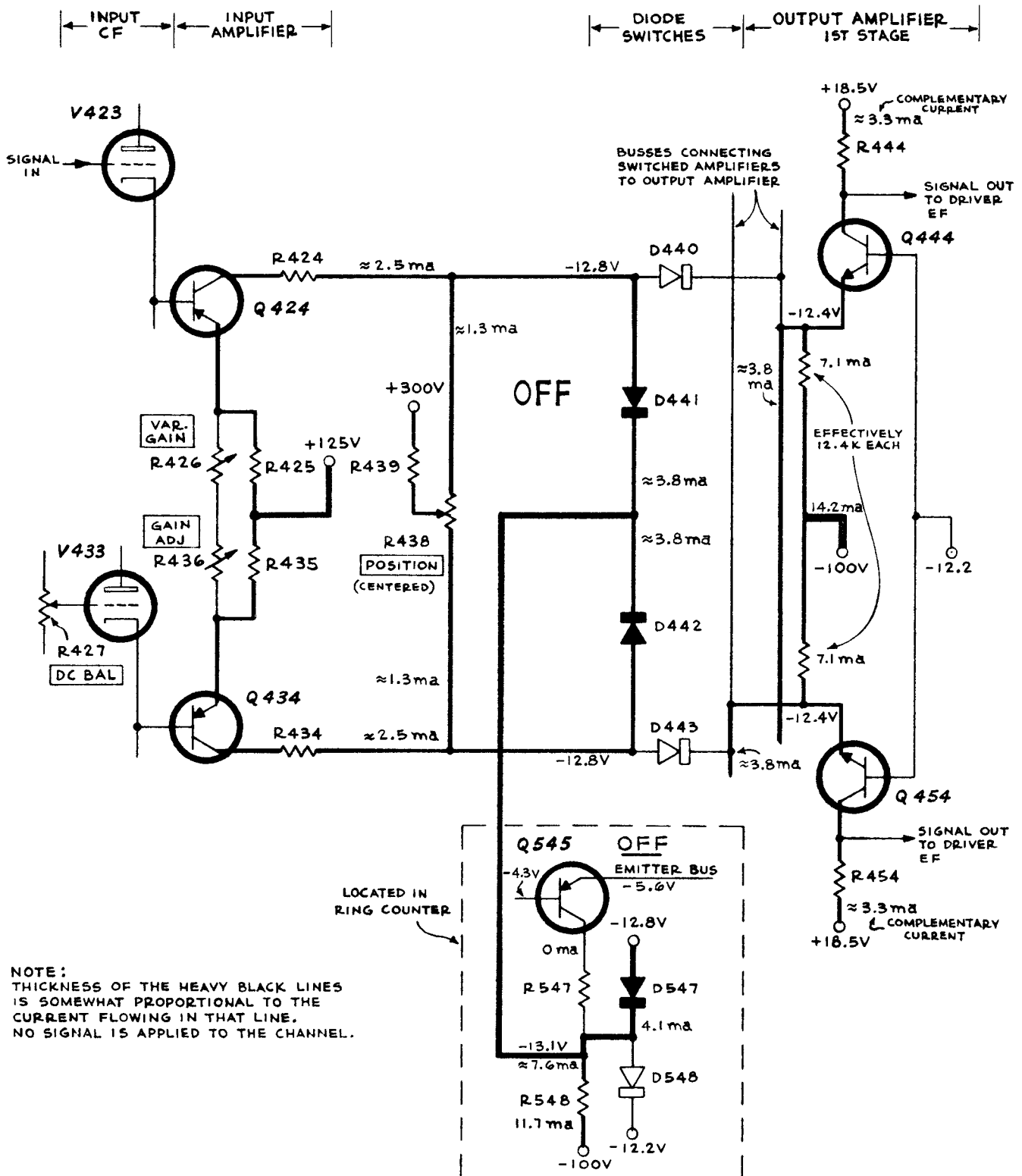


Fig. 4-2. Simplified circuit diagram showing the dc current paths when channel 1 is turned OFF.

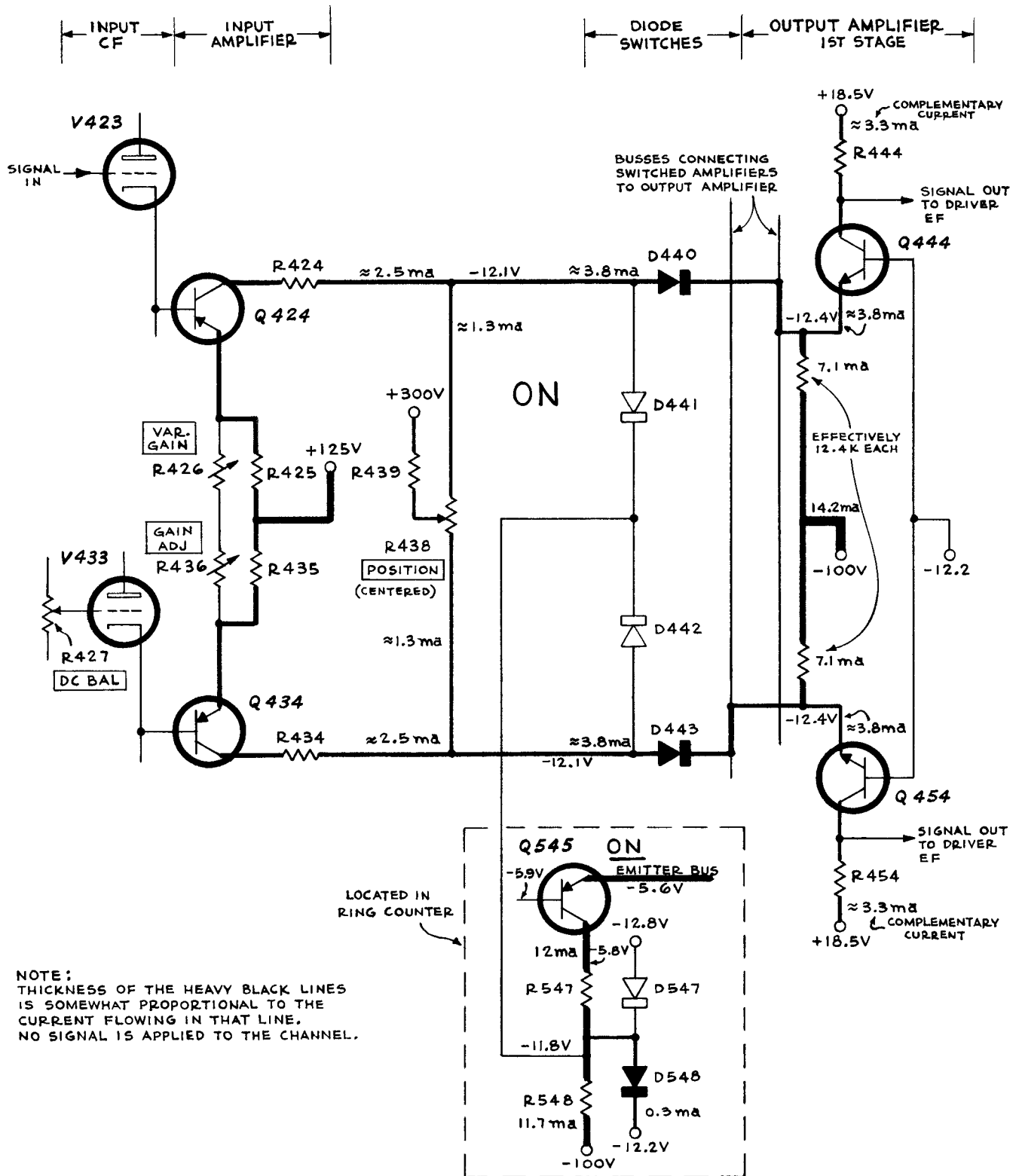


Fig. 4-3. Same as Fig. 4-2 except channel 1 is turned ON and the resulting current paths are shown.

of the Output Amplifier 2nd stage because the grids of V464 and V474 will be virtually grounded.

Vertical Positioning. The POSITION control R438, connected between the differential inputs to the diode switches, provides differential currents that act as positioning signals superimposed on the output signal currents of Q424 and Q434. When the POSITION control is set to its electrical center, approximately 1.3 ma flows in each leg.

When the POSITION control is moved to either end from center a change of about 3 volts per side occurs at the collectors of Q444 and Q454 (First Output Amplifier stage). This voltage range corresponds to at least ± 6 divisions positioning range at the crt.

Diode Switches. The combined differential current signals from the Input Amplifier stage and positioning circuit are applied to diode switches D440, D441, D442 and D443. These diodes act like a double-pole double-throw switch. Each pair, D440 and D443, or D441 and D442, is "on" while the other pair is "off". Switching of the diodes to connect or disconnect a channel is controlled by the MODE switch via the Ring Counter in the Channel Switching Circuit.

Assume that channel 1 is turned off (MODE switch is set to OFF) and the POSITION control is centered. With channel 1 turned off, Q545 in the Ring Counter stage is not conducting (see Fig. 4-2). The -13.1 -volt level at the cathodes of shunt diodes D441 and D442 is more negative than their anodes (-12.8 volts). As a result, D441 and D442 are forward biased and return channel 1 Input Amplifier and positioning currents through R548 to -100 volts. With the shunt diodes forward biased, series diodes D440 and D443 are reverse biased. The reverse-biased series diodes turn the channel off; that is they effectively disconnect channel 1 from the Output Amplifier.

If channel 1 only is turned on (MODE switch is set to NORM. or INV.), Q545 in the Ring Counter conducts. The voltage level at the junction of the shunt diodes reverse biases the shunt diodes permitting the series diodes to be forward biased. As a result the Input Amplifier and positioning currents are applied through the series diodes and connecting busses to join with the current from the first stage of the Output Amplifier. The dc-current paths are shown in Fig. 4-3.

In multi-trace operation (more than one channel is turned on with the MODE switch), positive-going gating pulses from the Ring Counter turn the channels on in sequence. Assume that all four channels are operating and channel 1 is "gated" on first (see Fig. 4-4). With channel 1 gating pulse at its -11.8 -volt "on" level, D441 and D442 are reverse biased. Diodes D440 and D443 are forward biased. With D440 and D443 conducting, the signals are applied through D440 and D443, and then through the connecting busses to the Output Amplifier.

At the termination of the channel 1 gating pulse, the -13.3 -volt "off" level disconnects channel 1, reverse biasing series diodes D440 and D443, and forward biasing shunt diodes D441 and D442. With channel 1 turned off by the -13.1 -volt level, the channel 1 signals cannot be applied to the Output Amplifier. While the -13.1 -volt level holds channel 1 off, each of the other channels is switched on (gated on) in sequence by its own gating pulse.

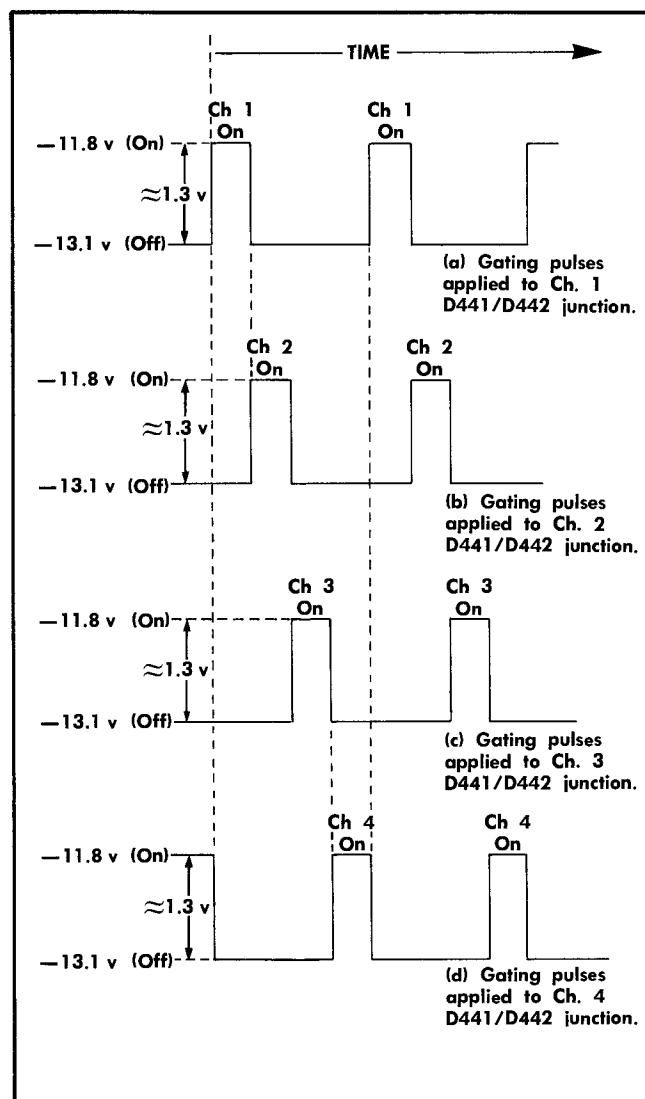


Fig. 4-4. Waveforms showing the time relationship of the gating pulses as they switch on their respective channels during four-trace operation. Note the 1-2-3-4 sequence.

As soon as channel 4 turns off, the channel 1 gating pulse turns channel 1 on again to repeat the cycle (see Fig 4-4). Note that only one channel is on at any one time.

Output Amplifier

The Output Amplifier, which is the common amplifier for all channels, consists of three stages: Output Amplifier 1st Stage Q444/Q454, Driver EF (Emitter Follower) Q463/Q473, and Output Amplifier 2nd Stage V464/V474.

Output Amplifier 1st Stage Q444/Q454. The bases of Q444 and Q454 are connected directly to -12.2 volts. These transistors operate in a common-base configuration. The voltage at their emitters is approximately -12.4 volts. Emitter resistors R447, R448, R457, R458 and the POSITION RANGE adjustment R449 combined together give each transistor an effective emitter resistor of 12.4 k referred to -100 volts (see Fig. 4-2 and 4-3). With the emitters at -12.4 volts about 7.1 ma flows in each of the 12.4 -k effective emitter

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resistors. This current comes from two sources which add together at the Q444/Q454 emitters. Under no-signal conditions 3.8 ma comes through each connecting bus from the series diodes of the channel then connected; 3.3 ma complementary current comes through each transistor (Q444 and Q454) to make up 7.1-ma total demanded by the 12.4-k effective emitter resistors (see Fig. 4-3).

Under signal conditions, the 3.3 ma complementary currents in the Output Amplifier 1st Stage Q444/Q454 follow the applied signal and/or positioning current variations in the turned-on channel. These variations in current develop voltage signals across collector-load resistors R444 and R454. Voltage gain up to this point, as measured between the single-ended input of V423 and the push-pull output of the Output Amplifier 1st Stage, is nominally 50. Gain is mostly determined by the emitter degeneration resistors in the Input Amplifier stage and collector resistors R444 and R454 in the Output Amplifier 1st Stage.

Peaking coils L444 and L454 improve the high-frequency response of the stage by providing an almost critically damped response rather than a simple rc response. Networks L445/R445 and L455/R455 compensate the stage for high-frequency attenuation due to the characteristics of the transistors and associated circuitry. Networks C460/R460 and C470/R470 are time constants that improve the transient response of the Type 3A74.

The POSITION RANGE adjustment R449, in conjunction with R448 and R458, differentially adjusts over a small range the quiescent currents through Q444 and Q454. Thus the dc levels throughout the Output Amplifier may be shifted so that the electrical center of the Output Amplifier coincides with the center of the crt screen. When R449 is properly adjusted, the positioning range of the individual channels is centered; that is, the positioning range up is equal to the positioning range down. As measured at the collector of each transistor in the Output Amplifier 1st stage, the range of R449 is about 2.8 volts. This is equivalent to a total of about 5.6 divisions on the crt.

Driver EF Q463/Q473. These transistors are connected as emitter followers to provide a low-impedance driving source for the Output Amplifier 2nd Stage. Thus, the input capacitance of the Output Amplifier 2nd Stage V464/V474 is isolated from the collector loads of Q444 and Q454, thereby increasing the frequency response of the Type 3A74.

The Driver EF stage dc couples the signal and the dc-positioning voltages from the collectors of Q444 and Q454 to the grids of V464 and V474. Voltage dividers R461/R462 and R471/R472 provide the emitters of Q463 and Q473 with a positive voltage source and sufficient source impedance for the stage to function as an efficient emitter follower. Resistors R462 and R472 are in the dividers to keep the grids of V464 and V474 from going to +125 volts in the event that Q463 and/or Q473 are removed from their sockets.

Output Amplifier 2nd Stage V464/V474. Output tubes V464 and V474 and the associated circuitry are a push-pull amplifier stage which drives the vertical deflection plates of the oscilloscope. The gain of the stage is nominally 20. Thus, the total gain of the Type 3A74, as measured from the single-ended input at the grid of V423 to the push-pull output at the plates of V464 and V474, is about 1000 (50 times 20).

In the cathode circuit, CALIB. control R477 is adjusted to compensate for variations in crt deflection plate sensitivity by altering the gain of the Type 3A74. This control is a master gain control for all the channels. When adjusted, R477 varies the cathode degeneration and thus the gain of the stage. Maximum gain, and therefore maximum deflection of an input signal, occurs when R477 is set for zero resistance.

Diodes D468 and D469 in conjunction with R468 improves the linearity of the Output Amplifier 2nd Stage for large signals by reducing cathode degeneration when the display is more than several major divisions from electrical center.

In the plate circuits variable inductors L464 and L474 provide a means of adjusting the stage for optimum transient response. R465 sets the output potential at an optimum value for the crt deflection plates.

Internal Trigger Circuits

The internal trigger circuits provide a choice of two internal trigger sources: composite and CH 1 ONLY. Either of these sources can be selected by means of the TRIGGER switch SW530.

Composite Internal Triggering. This means of triggering refers to the trigger signal derived from the plate of V474 in the Output Amplifier 2nd Stage. If more than one channel is on (multi-trace operation), the trigger is a composite of successive signals, sampled in time, arriving from the "on" channels.

During single-trace operation, the trigger is not time-shared since only one channel is operating. Though not time-shared as in multi-trace operation, the single-channel trigger is still called a composite trigger to distinguish it from the CH 1 ONLY trigger. Naturally, during single-trace operation, the composite trigger will resemble the displayed signal of the operating channel.

In multi-trace operation, the composite trigger contains both the ac and dc components of the time-sampled signals from the "on" channels. The dc component is made up from the dc level of the channel's POSITION control and, if the applied signal is dc coupled, also includes the dc level of the applied signal.

The composite signal, derived from the plate of V474, is applied across a divider consisting of V535, R535 and R536 in units S/N 101 to 589; in S/N 590 and up units the divider consists of C535, R535, R536 and R530. A portion of the signal is picked off from the divider for use as a composite internal trigger source. When the TRIGGER switch SW530 is pushed in (COMPOSITE on the schematic diagram), the composite trigger is applied to the grid of V533A in the Internal Trigger Output CF (Cathode Follower) stage V533A. Ferrite bead L532 in the grid circuit of V533A reduces the V533B blanking pulse radiation that couples into V533A grid circuit due to the close proximity of the circuitry.

At the cathode of V533A, the trigger is applied through pin 11 of the interconnecting plug to the time-base circuitry. The COMPOSITE INT. TRIG. DC LEVEL adjustment, R530, is used to set the cathode dc level of V533A to zero volts under no-signal conditions with only channel 1 turned on and with the trace vertically positioned to coincide with the

graticule center. When the TRIGGER switch is set to CH 1 ONLY, the lead from the divider is grounded and the channel 1 only trigger is applied to V533A.

Channel 1 Only Internal Trigger. The channel 1 trigger is derived from the cathode of V423, channel 1 Input CF stage. The cathode is a convenient low-impedance point for extracting the signal without affecting the frequency response of the channel 1 input amplifier. In addition, this point is isolated from the gating pulses that control the diode switches during multi-trace operation.

The trigger is applied to the Internal Trigger Input EF (Emitter Follower) stage Q503 whose output drives the Internal Trigger Amplifier 1st Stage Q504/Q514. A relatively high gain-bandwidth product is obtained from Q504 and its associated circuitry. This high performance can only be gotten by returning the emitter of Q504 to a low impedance source with a voltage level quite close to the base of Q504. Transistor Q514 provides this low impedance voltage source. When channel 1 is properly dc-balanced, the cathode voltages of V423 and V433 are at the same level. Thus, by using the cathode of V443 as a reference and inserting diode D512 to give the same amount of voltage offset as Q503, the bases of Q504 and Q514 are at the same voltage. Hence by emitter follower action the emitter of Q514 provides the proper voltage at a low impedance for the emitter of Q504 to look into. R510 degenerates the stage slightly to stabilize the gain.

Diode D502 protects Q503 in the event that a positive overload voltage is applied to the channel 1 Input connector. When the overload occurs, D502 conducts and limits the reverse bias of Q503.

The amplified trigger signal is then applied to the base of Q524, the Internal Trigger Amplifier 2nd Stage. Here the trigger is further amplified so that its amplitude approximates the amplitude of the composite trigger. Inductor L525 in the collector circuit of Q524 aids the high frequency response of the stage. With the TRIGGER switch SW530 set to CH 1 ONLY, divider resistors R529 and R528 offset the output of Q524 to provide proper dc voltage level at the grid of V533A. C529 compensates the small amount of attenuation in this divider.

The channel 1 trigger signal, applied via the TRIGGER switch to the grid of V533A, appears at the cathode. From the cathode of V533A the trigger is applied through pin 11 of the interconnecting plug to the time base circuitry. The CHAN. 1 INT. TRIG. DC LEVEL adjustment R521 is used to set the dc level at the cathode of V533A to zero volts. The adjustment is made when no signal is applied to channel 1 and the channel 1 trace is vertically positioned to coincide with the graticule center.

CHANNEL SWITCHING CIRCUIT

The Channel Switching Circuit is composed of these stages: Ring Counter (Q545/Q555/Q565/Q575), Blocking Oscillator Q590, Blanking Pulse Regenerator V533B, and the Sync Pulse IN EF (Emitter Follower) Q583. In the following discussion the operation of the Channel Switching Circuit is described in each of these modes of operation: (1) single-trace operation, (2) chopped-mode multi-trace operation, (3) alternate-mode multi-trace operation, and (4) X-Y multi-trace operation.

The individual stages in the Channel Switching Circuit are variously used in specific modes of operation, and they are subsequently described whenever convenient.

Ring Counter

The Ring Counter consists of Q545, Q555, Q565, Q575, and associated circuitry. Each transistor controls the application of one Switched Amplifier to the Output Amplifier. The Ring Counter is tetra-stable; that is, each of its four states is stable (meaning that one transistor is turned on and the other three transistors are turned off). Each stable state of the Ring Counter produces a positive-going current gate which closes the series diode switches between one channel and the Output Amplifier. During multi-trace operation, a trigger pulse is required to make the Ring Counter "count" and thereby sequentially apply each Input Amplifier channel to the Output Amplifier.

Single-trace operation. Assume for this discussion that channel 1 is turned on (MODE switch set to NORM. or INV.) and the other channels are turned off by means of their MODE switches. Under these conditions, the Ring Counter is locked into one of its stable states. In this case, then channel 1 transistor Q545 is conducting and the other transistors in the Ring Counter are reverse biased; that is, locked out.

The dc level at the base of each transistor in the Ring Counter is determined by a matrix consisting of three 10-k resistors and a 3.37-k resistor to ground. For each channel which is off there is an additional 10-k matrix resistor which connects from the junction of D580 and R580 through the MODE switch contacts to the base of the reverse biased transistor.

At the base of Q545 the resistor matrix is R542, R543, R544, and R545. Currents in the collector circuits of the reverse biased transistor flow through the Q545 resistor matrix and hold the base of Q545 at about -5.9 volts.

Base matrix currents flowing through R550, R560, and R570 serve two functions. First, they shift the base voltages in a less negative direction and thus add to the reverse biasing of Q555, Q565 and Q575. Secondly, these currents have a controlling influence over the operation of the Blocking Oscillator.

"Constant current" resistor R580 can supply about 0.85 ma of current to the base matrices without its D580/R580 junction going negative. Since the MODE switches for channels 2, 3, and 4 are set to OFF, as previously assumed, resistors R550, R560 and R570 draw about 0.4 ma each or a total current of about 1.2 ma. Since this is more current than R580 can supply, its D580/R580 junction voltage level decreases to the point where D580 reverse biases and D581 forward biases. D581 now supplies the current to the base matrices that R580 was unable to supply.

With D581 conducting, the voltage level at the anode of D590 is not sufficiently positive to forward bias D590 and turn on Q590 in the Blocking Oscillator stage. Under these conditions, there will be no blocking oscillator action during single-trace operation. With no trigger pulses from Q590, the Ring Counter cannot switch from the turned-on channel to a turned-off channel. In addition, with the Blocking Oscillator inoperative, no Blocking Oscillator initiated transients will occur to "feed-thru" and interfere with the single-channel display.

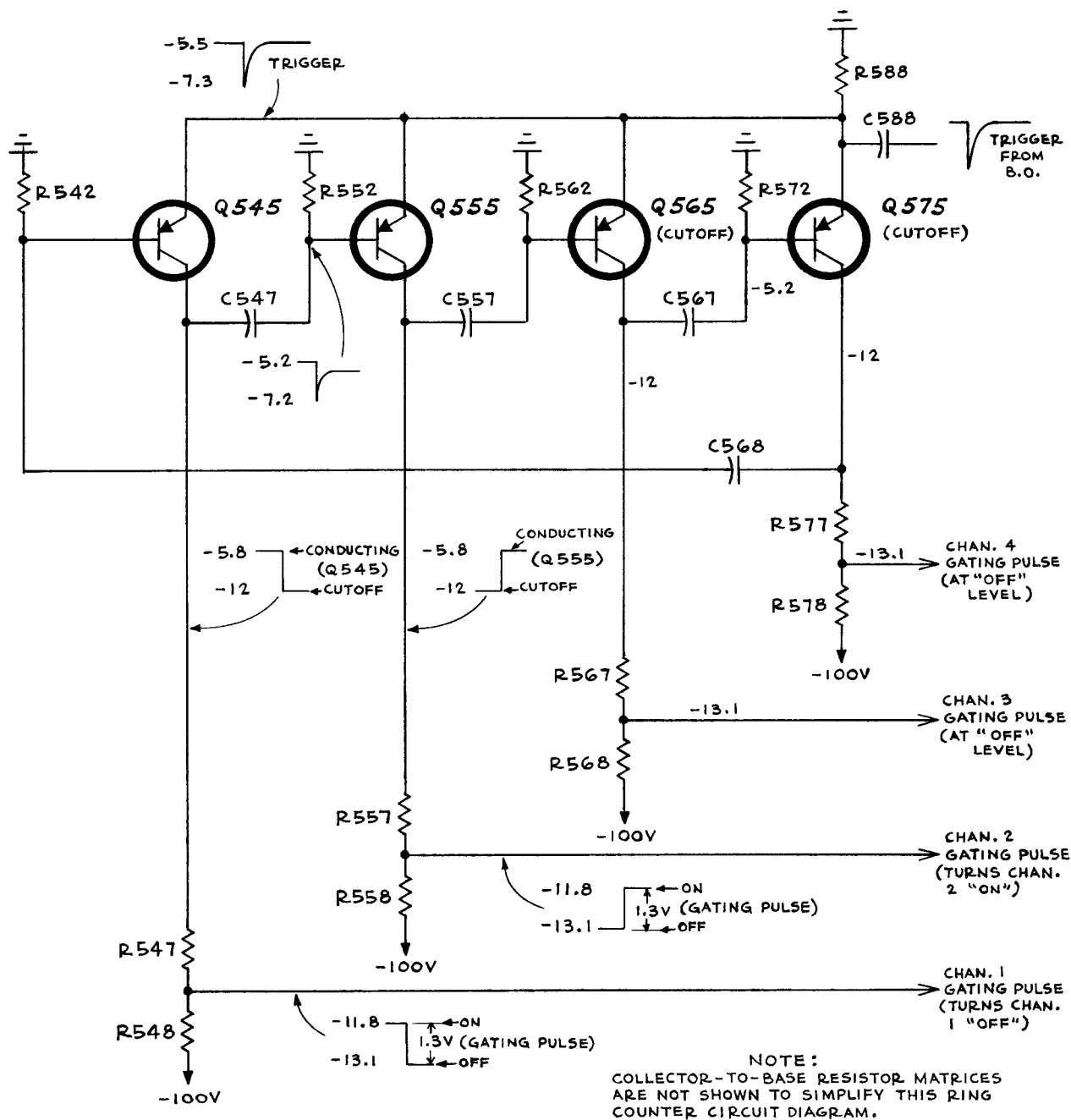


Fig. 4-5. Simplified circuit diagram of the Ring Counter showing the trigger turning off Q545. As Q545 cuts off, its collector pulse "turns off" channel 1 and drives Q555 into conduction.

With the base of Q545 at -5.9 volts, transistor Q545 is forward biased to saturation. Voltage at Q545 emitter and at the emitter bus is about -5.6 volts. Emitter current flowing through R586 and R588 is about 12 ma. The saturated collector of Q545 rests at about -5.8 volts.

Matrix currents for the other transistors in the Ring Counter hold the bases of their respective transistors at about -4.3 volts. With the emitter bus at -5.6 volts transistors Q555, Q565, and Q575 are reverse biased and therefore cutoff.

Their collectors rest at about -12 volts as set by the matrix currents.

Of primary importance to the switching operation of channel 1 is R548 which connects between the -12.2 -volt (via D548) and -100 -volt supplies. With channel 1 turned on, as assumed in this description, the majority (about 11.7 ma) of the 12-ma Q545 collector current flows through this resistor (R548) and R547. The small balance of collector current goes through D548. The current through D548 keeps the

junction of R547 and R548 from going less negative than -11.8 volts. This is the voltage which is applied to the cathodes of the channel 1 shunt diodes D441 and D442 that causes them to be reverse biased. D441 and D442 are reverse biased by about 0.3 volt since their anodes are effectively at -12.1 volts.

As previously discussed, the emitters of Q444 and Q454 (Output Amplifier 1st Stage) rest at -12.4 volts due to the base-emitter voltage drop of the stage. This is the voltage which is applied to the cathodes of channel 1 series diodes D440 and D443. The -12.4 volts is the lowest cathode voltage seen by either the shunt or series diodes, thus the series diodes conduct and the 0.3 -volt drop across these diodes set their anodes at -12.1 volts.

Meanwhile, channels, 2, 3 and 4 are in a turned-off state because transistors Q555, Q565 and Q575 in the Ring Counter are cut off. These transistors, being cut off, do not provide current to their respective R558, R568 and R578 resistors. Instead, about 7.6 ma of the 11.7 -ma required current through each one of these resistors is supplied from their respective Input Amplifier stages through their respective D441/D442 shunt diodes. (Fig. 4-2 shows the "OFF" condition that can be applied to channels 2, 3 and 4 described herein.) The additional 4.1 -ma currents (11.7 ma minus 7.6 ma) come through D566 and diodes D557, D567 and D577 respectively. These diodes keep R557/R558, R567/R568 and R577/R578 junctions from going any further negative than about -13.1 volts.

The -13.1 volts, applied to the cathodes of shunt diodes D441 and D442 in the turned-off channels, is the voltage which forward biases these shunt diodes. As a result, the currents from the Input Amplifiers of the turned-off channels flow through their respective D441/D442 shunt diodes rather than through their D440/D443 series diodes. With -12.8 volts at the series-diode anodes and -12.4 volts at their cathodes (using Fig. 4-2 as a study guide), the series diodes are reverse biased. Thus, channels 2, 3 and 4 are effectively disconnected from the Output Amplifier 1st Stage. Channel 1 remains turned on for single-trace operation as assumed at the start of this discussion.

Chopped-mode multi-trace operation. Assume that the MODE switches for channels 1 and 2 are turned on and the CHOP-ALT. switch is set to the CHOP. position. The matrix current paths through R540 and R550 are broken, necessitating no current drain through D581. In fact the voltage at the D580/R580 junction is slightly positive. Diode D581 reverse biases and the emitter of Q590 seeks the voltage level of divider R587/R585. This divider forward biases transistor Q590 and thus the Blocking Oscillator free runs.

When all MODE switches are turned on, D581 continues to be reverse biased and the Blocking Oscillator continues to free run. The trigger pulse from the Q590 emitter is negative going and is coupled through C588 to the emitter bus of the Ring Counter. The trigger drives all emitters negatively, in the direction of cutoff. Since only one transistor in the Ring Counter conducts at any given time, it is the only one directly affected by the trigger pulse.

Assume that Q545 is the conducting transistor when the trigger pulse is applied to the emitter bus (see Fig. 4-5). The collector current of Q545 is sharply reduced and the collector drops from about -5.8 volts toward -12 volts. This fast negative-going collector voltage couples through capacitor C547 through the channel 1 and channel 2 MODE

switch contacts to the base of Q555. When the trigger pulse at the emitter bus relaxes, the emitter bus voltage rises towards its quiescent level. Since the base of Q555 is the most negative of the Ring Counter transistor bases, Q555 is the first and only transistor to be forward biased. Regenerative action via the collector-to-base resistor matrices assures that all of the other Ring Counter transistors remain off. The result of switching Ring Counter conduction from Q545 to Q555 is to disconnect channel 1 from the Output Amplifier and to connect channel 2 in its place. (At this point let Fig. 4-2 represent channels 1, 3 and 4 in the OFF condition and let Fig. 4-3 represent channel 2 in the ON condition.)

To summarize the action during multi-trace operation with all four channels operating, the trigger pulse from the Blocking Oscillator is required to make the Ring Counter switch states. When the Ring Counter switches states, it always switches in a 1-2-3-4 sequence, regardless of the setting of the CHOP-ALT. switch. The important components that make the sequential switching possible are coupling capacitors C547, C557, C567 and C577. These capacitors provide the means of coupling the collector pulse from the conducting transistor, as it cuts off, to the base of the next transistor in the sequence.

If a MODE switch for one channel is set to OFF, during multi-trace operation, the transistor controlled by the MODE switch is reverse biased and bypassed (excluded) during the switching cycle. For example, if channel 2 MODE switch is set to OFF, the MODE switch connects C547 from the collector of Q545 to the base of Q565, thereby bypassing Q555. The channel 2 MODE switch also connects R550 into the base circuit to reverse bias Q555. The switching sequence is then 1-3-4-1-3-4, etc.

The purpose of ferrite bead, L588, in the emitter circuit of the Ring Counter is to provide smoother recovery of the trigger. The bead suppresses tendencies for the trigger to ring and thus provides improved triggering of the Ring Counter with least jitter. Resistor R586, added in units S/N 156 and up, also aids in reducing jitter.

Alternate-mode multi-trace operation. The operation of the Ring Counter is the same as for chopped-mode operation except for the triggering source. In alternate-mode operation, the Blocking Oscillator, operating in a triggered mode, generates a trigger pulse each time it is triggered by the alternate sync pulse arriving at pin 3 of the interconnecting plug. The usual source for the alternate sync pulse is from the time-base circuitry during the sweep-retrace interval.

Blocking Oscillator

If the B. O. (Blocking Oscillator) transistor Q590 is cut off, the primary winding of T592 serving as the collector load will have no changing current in it. The winding of T592 connected to T595 is a tertiary winding, and it also has no changing current in it. Also, there can be no voltage impressed upon the secondary winding of T592 that connects to the base of Q590. Since this winding is referenced to ground, the base voltage of Q590 will be zero.

B. O. action is initiated by the emitter of Q590 becoming slightly positive, thereby forward biasing the transistor, which then turns on. The action of the B. O. is essentially the same in either chopped or alternate. In chopped the emitter goes

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slightly positive due to the positive bias applied by +125 volts through R585. In alternate the positive emitter bias is applied in the form of a positive pulse from the Sync Pulse In Emitter Follower Q583.

In either mode of operation when Q590 is forward biased, the initial current flowing through the transistor and the primary of T592 causes a build-up of magnetic flux. Due to this varying magnetic flux the secondary of T592 impresses on the base of Q590 a negative turn-on voltage. This forward biases the transistor further, causing more current, which causes more flux and a further increase in the negative-going base voltage. This regenerative action results in the B. O. being suddenly turned from full off to full on. At full on Q590 is saturated, that is to say that there is very little voltage between emitter and collector, both being at approximately -6 volts.

The current increasing through the collector load (T592) raises the collector voltage positive while transformer coupling and inversion through the secondary applies a negative-going voltage to the base. This base voltage, in turn by emitter follower action pulls the emitter voltage negative until the transistor saturates. During this regenerative turn-on of the B. O., the rapidly falling emitter voltage causes a negative-going trigger pulse to be coupled through C588 to the common emitter bus of the Ring Counter. This trigger pulse causes the Ring Counter to switch to the next channel. The rapidly rising primary current also causes the tertiary winding of T592 to apply a positive pulse to the Blanking Pulse Regenerator V533B.

Once the transistor is saturated, there is no increase of collector current. Therefore, there is no changing magnetic flux to sustain the voltage on the base of Q590. The base then seeks its reference level (ground), and this tends to turn the transistor off. The reverse regenerative action occurs which causes the base voltage to rise very fast to about +5 volts. Thus, Q590 is suddenly turned off after having been momentarily on. Diode D590 is in the emitter circuit of Q590 to prevent breakdown of the emitter base junction during the regenerative back biasing of the base by T592.

Once the emitter-to-base junction of Q590 ceases to be forward biased, no more emitter current flows. The emitter therefore returns to its quiescent level as determined by the time constants and voltages of the emitter circuitry. In chopped mode R585 causes the emitter to seek a quiescent level that will again forward bias Q590, and thus initiate another cycle of B. O. action. The quiescent voltage level and the time constant determined by R585, R587, C585, and C587 is such that approximately 2 μ seconds elapse between B. O. actions. Thus, in chopped mode the Blocking Oscillator free runs at approximately a 500-kc rate.

In alternate mode C585 and R585 are disconnected by SW580 so that the quiescent level sought by the emitter is not sufficiently positive to automatically turn Q590 on. However, the emitter level is close enough to the base voltage to allow the B.O. to be triggered into operation by a positive pulse received through the ALT. position of SW580 from C583 in the Sync Pulse In Emitter Follower circuitry. Thus, during alternate-mode operation, the B. O. operates in a triggered mode.

Sync Pulse In Emitter Follower

When the CHOP.-ALT. switch is set to ALT., the Sync Pulse In EF stage provides a low-impedance drive for the Blocking Oscillator stage. Incoming sync pulses from the Time-Base unit are applied to the Sync Pulse In EF stage and the pulses at the output of the stage are used to trigger the Blocking Oscillator stage, which in turn, triggers the Ring Counter to switch the channels.

During quiescence, Q583 is zero biased and is effectively cut off. (Quiescence is the period of time when no sync pulses are applied to Q583.) If there is a time base in the X-axis opening, a positive-going square-wave sync pulse is generated by this time base during the sweep retrace interval. The sync pulse is applied to pin 3 of the Type 3A74 interconnecting plug. The time constant of C582 and R582 in the base circuit of Q583 differentiates this square-wave sync pulse and the positive-going leading edge drives Q583 into conduction.

NOTE

A time-base source is not mandatory for the proper functioning of the Sync Pulse In EF stage. Any 5-volt positive-going gate or pulse applied to pin 3 of the interconnecting plug will affect Q583 in a similar manner. For example, during X-Y operation, the sync pulse arriving through pin 3 of the interconnecting plug, comes from another multi-trace unit.

When Q583 goes into conduction, a positive-going pulse is produced at its emitter. With the CHOP.-ALT. switch set to the ALT. position, the pulse couples through C583 to the emitter circuit of the Blocking Oscillator. Then, as described earlier, the Blocking Oscillator is triggered into action. The Blocking Oscillator produces a negative-going trigger pulse which is coupled through C588 to drive the Ring Counter. The Ring Counter, in turn, switches the channels during the retrace interval.

Blanking Pulse Regenerator

V533B and its associated circuitry fulfills two purposes: (1) to provide a blanking pulse which will shut off the crt beam during the switching time between channels, and (2) to supply a sync pulse output which will trigger the switching circuits in another multi-trace unit. This second purpose is used in X-Y display applications.

Each time there is a blocking oscillator action, V533B functions. However, since chopped-mode multi-trace operation is the predominant mode during which the pulses are used, it is this mode which will be discussed herein. Assume for this discussion that the Type 3A74 is in the Y-axis opening of the oscilloscope and a time-base unit drives the X-axis.

V533B operates in a modified bootstrap circuit where a regenerated blanking pulse is taken from its cathode and a regenerated sync pulse is produced at its plate. In its quiescent state (when not driven by the Blocking Oscillator), V533B is essentially cut off. During chopped-mode multi-trace operation, each time the free-running B. O. turns on, the collector current in the primary of T592 induces a positive-going pulse into its 6-turn tertiary winding.

The induced impulse is coupled through a short coaxial cable to the grid winding of T595. Since the other end of the grid winding connects to the grid of V533B, the positive-going pulse drives V533B into conduction.

The rising cathode current produces a changing magnetic flux in T595. This induces a voltage in the 10-turn grid winding that causes the grid to bias the tube more into conduction. This regenerative bootstrapping continues until the positive pulse from the B. O. tertiary reaches its maximum, and begins to fall off. This falling-off action causes a slight decrease in grid voltage which decreases the cathode current and thus initiates a regenerative turn off of V533B. V533B remains essentially cut off until the next Blocking Oscillator pulse repeats the cycle.

The surge of current through V533B causes the cathode voltage to rise sharply. When V533B regeneratively turns off, the cathode voltage undergoes an rc decay determined by R595 and the total capacitance on pin 24 of the interconnecting plug. The resulting amplitude of the blanking pulse is about 50 volts peak. From pin 24 the pulse is coupled to the cathode of the crt. In oscilloscopes which have a CRT Cathode Selector (Z-axis) switch, the blanking pulse is applied to the crt cathode when the switch is set to the Chopped Blanking position. The duration of the rc decaying blanking pulse which is in excess of the crt beam current cutoff voltage is such that the pulse blanks the crt during the switch-over time between channels.

In order to stabilize the voltage at pin 24 between blanking pulses, diode D595 in the circuit of V533B clamps the downward swing of the blanking pulse at a voltage a little below ground. By holding the cathode near ground it also insures that V533B is essentially turned off in its quiescent state. T593 in the plate circuit of V533B provides a Sync Pulse Out, which indicates when the Type 3A74 is changing channels. This sync is a positive-going pulse that is applied to pin 4 of the interconnecting plug.

Multi-Trace Operation. Two Type 3A74 units can be used together (in those oscilloscopes which accept both X— and Y-axis plug-ins) to provide up to four synchronously chopped X-Y displays. This is accomplished by having the Y-axis Type 3A74 in **CHOPPED** and the X-axis Type 3A74 in **ALTERNATE**. The Y-axis plug-in free runs and provides a Sync Pulse Out to the left-hand interconnecting

plug pin 4. Due to the crossed inter-connections between pins 4 and 3 of the left and right-handed plug-in connectors, the Sync Pulse Out on the left-hand pin 4 becomes the Sync Pulse In on the right-hand pin 3. The X axis Type 3A74 is in **ALTERNATE** and thus its channels are switched at the same time as the Y-axis channels.

To insure that the Y-axis channel 1 is displayed with the X-axis channel 1, and the Y-axis channel 2 with X-axis channel 2, etc., the Ring Counters are locked in step by a ring counter sync pulse on pin 18 of both interconnecting plugs. Since the two pin 18's are tied together, the channel 4 Ring Counter transistors (Q575) of both Type 3A74's are ac-coupled to each other. The two Ring Counters are stable only when channel 4 in both units are operating in phase with each other; that is, Y-Channel 4 displayed with X-Channel 4. One or two like-numbered pairs of channels can be turned off (for example, channels 1 and 1) by means of their MODE switches and the remaining pairs of channels will synchronize as long as both channel 4's remain on.

For proper blanking of the X-Y display the Y axis Type 3A74 must be in **CHOPPED** and the X-axis Type 3A74 must be in **ALTERNATE**. In the reverse situation there is an X-Y display but the blanking is not optimum because of the time delay in the blanking pulse applied to the crt cathode. Since the crt cathode can be connected to only pin 24 of the Y-axis plug-in, it is imperative that a blanking pulse appear here as soon as possible after switching action is initiated. This is accomplished in a normal manner only when the Y-axis Type 3A74 is **CHOPPED**.

If the Y-axis Type 3A74 should be in alternate there is approximately a 0.3 microsecond delay before a blanking pulse is presented to the crt cathode. In this non-optimal (reverse situation) case the initial switching action begins in the free running B. O. of the X-axis Type 3A74. Subsequently a Sync Pulse Out from the Blanking Pulse Regenerator passes out of pin 4 of this right-hand unit. Traveling over to pin 3 of the left-hand interconnecting plug, it passes into the Sync Pulse In EF of the Y-axis Type 3A74. Since the Y-axis Type 3A74 is in **ALTERNATE** the Blocking Oscillator in this unit is triggered, which subsequently causes the Blanking Pulse Regenerator to present a blanking pulse to pin 24 of the Y-axis interconnecting plug. This entire sequence of operation accounts for the 0.3 microsecond delay and, hence, improperly-timed blanking.

[illegible]

SECTION 5

MAINTENANCE

PREVENTIVE MAINTENANCE

Visual Inspection

Many potential or existing troubles can be detected by a visual inspection of the unit. For this reason, a complete visual check should be performed periodically or every time the unit is inoperative, needs repair, or needs recalibration. Visual defects may include loose or broken connections, frayed coax-shield that could cause a short, damaged connectors, improperly seated tubes or transistors, scorched or burned parts, and broken terminal strips.

The remedy for these troubles is readily apparent except in the case of heat-damaged parts. Damage to parts due to heat is often the result of other less apparent troubles in the unit. It is essential that the cause of overheating be determined and corrected before replacing the damaged parts.

Recalibration

The Type 3A74 is a stable plug-in unit that will provide many hours of trouble-free operation. However, to insure the reliability of measurements, check the calibration of the unit after each 500-hour period of operation (or every six months if the unit is used intermittently). A complete step-by-step procedure for calibrating the unit and checking its operation is given in the Calibration section of this manual.

COMPONENT REPLACEMENT

General Information

Useful information concerning the replacement of important parts in the Type 3A74 is given in this portion of the manual. Because of the nature of the unit, replacement of certain parts such as the VOLTS/DIV. switches, variable capacitors or inductors, tubes or transistors, will require that you calibrate the unit to insure proper operation. Refer to the Calibration section of this manual for the complete procedure.

Switches

If any of the toggle or slide switches are defective, replace the switch. Use normal care in unsoldering and disconnecting the leads.

If any of the rotary switches are defective, single wafers on these switches are not normally replaced. If a wafer is defective, the entire switch should be replaced. The switches may be ordered from the factory, either unwired or wired, as desired. Refer to the Parts List to find the unwired and wired switch part numbers. Since the VOLTS/DIV. switches require great care to wire them properly, you may prefer to replace a defective switch with a wired one.

Because of the compact parts layout used in the Type 3A74, the instructions that follow describe removal methods for switches which appear difficult to replace. Each procedure describes how to remove a particular switch for repair or replacement. Connecting the leads correctly to or from a wired switch should be quite easy since there are three other channels to use as a guide and the wires are similarly color coded.

NOTE

When soldering leads to a terminal on a rotary-type switch, do not let solder flow around and beyond the rivet on the terminal. Otherwise the spring tension of the switch contact can be destroyed.

The terms "VOLTS/DIV. switch" and "MODE switch" as used in their respective procedures refer to the concentric controls (switch and potentiometer) as a unit.

Replacing the Channel 1 VOLTS/DIV Switch

1. Unsolder and disconnect the wires to the channel 1 VOLTS/DIV. switch so the switch can be removed.
2. Using a $\frac{1}{16}$ " hex wrench, remove the knobs from channel 1 and 2 VOLTS/DIV. switches.
3. Remove the 6-32 x $\frac{5}{16}$ " BHS screw, nut and washers which hold the channel 2 plastic clamp and 0.1 μ f capacitor (C401) to the lower shield on the channel 1 VOLTS/DIV. switch.
4. Remove the front-panel $\frac{3}{8}$ " nut and flat washer from the channel 1 VOLTS/DIV. switch.
5. Remove channel 2 V433.
6. Remove the two 6-32 x $\frac{1}{4}$ " BHS screws which hold the channel 2 VOLTS/DIV. switch mounting bracket to the chassis.
7. Slide the channel 2 VOLTS/DIV. switch back as far as it will go; that is, up against the 3.3-pf capacitor (C418) at the channel 2 V433 socket.
8. Remove the rear 8-32 x $\frac{1}{2}$ " RHS crossed-slot head screw from the upper left frame rod.
9. Raise the rear end of the rod slightly (about $\frac{1}{2}$ ") while removing the channel 1 VOLTS/DIV. switch.
10. Install the switch by reversing the order of the previous steps.

Replacing the Channel 2 VOLTS/DIV. Switch

1. Unsolder and disconnect the wires from the channel 2 VOLTS/DIV. switch so it can be removed.
2. Using a $\frac{1}{16}$ " hex wrench, remove the channel 2 VOLTS/DIV. switch knobs.

3. Remove the two 6-32 x $\frac{1}{4}$ " BHS screws which hold the channel 2 VOLTS/DIV. switch mounting bracket.
4. Remove channel 2 V433.
5. Unsolder and disconnect the grounded lead of channel 2 3.3 pf capacitor (C418), located at the channel 2 V433 socket.
6. Slide out and remove the channel 2 VOLTS/DIV. switch.
7. Remove the VOLTS/DIV. mounting bracket and install it on the replacement switch. Align the bracket properly before tightening the switch nut.
8. Reverse the order of the previous steps to install the switch.

Replacing the Channel 3 VOLTS/DIV. Switch

1. Unsolder and disconnect the leads to the channel 3 VOLTS/DIV. switch so the switch can be removed.
2. Using a $\frac{1}{16}$ " hex wrench, remove the knobs from channel 2, 3, 4 VOLTS/DIV. switches.
3. Remove the 6-32 x $\frac{5}{16}$ " BHS screw, nut and washers which hold the channel 4 plastic clamp and 0.1 μ f capacitor (C401) to the lower shield on the channel 3 VOLTS/DIV. switch.
4. Remove the front-panel $\frac{3}{8}$ " nut and flat washer from channel 3 VOLTS/DIV. switch.
5. Remove the two 6-32 x $\frac{1}{4}$ " BHS screws which fasten the channel 2 VOLTS/DIV. switch mounting bracket to the chassis.
6. Remove the two 6-32 x $\frac{1}{4}$ " BHS screws which hold the channel 4 VOLTS/DIV. switch mounting bracket to the chassis.
7. Remove channels 2 and 4 V433.
8. Unsolder the grounded leads of channel 2 and 4 capacitors C418, located next to their respective V433 sockets.
9. Disconnect the channel 2 and 4 VOLTS/DIV. switch leads that go to their respective AC-GND-DC switches.
10. Slide channel 2 and 4 VOLTS/DIV. switches back as far as possible; that is up to their respective V423 tubes.
11. Slide back and remove the channel 3 VOLTS/DIV. switch.
12. Reverse the order of the preceding steps to install the channel 3 VOLTS/DIV. switch.

Replacing Channel 4 VOLTS/DIV. Switch

Adapt the procedure, "Replacing the Channel 2 VOLTS/DIV. Switch", as a guide for removing and replacing the channel 4 VOLTS/DIV. switch.

Replacing the Channel 1 AC-GND-DC switch or input coupling capacitor C401

A method for replacing these components is as follows:

1. Use a $\frac{1}{16}$ " hex wrench to remove the knobs from the channel 1 VOLTS/DIV. switch.
2. Remove the 6-32 x $\frac{5}{16}$ " BHS screw, nut and washer which hold the channel 2 plastic clamp and 0.1 μ f capacitor (C401) to the lower channel 1 VOLTS/DIV. switch shield.
3. Remove the upper shield from the channel 2 VOLTS/DIV. switch.
4. Remove the front-panel $\frac{3}{8}$ " nut and flat washer from the channel 1 VOLTS/DIV. switch.
5. Slide the channel 1 VOLTS/DIV. switch back to the channel 2 VOLTS/DIV. switch front shield.
6. Unsolder the channel 1 VOLTS/DIV. switch lead at the AC-GND-DC switch terminal.
7. Unsolder the AC-GND-DC switch jumper wires and C401 lead from the channel 1 input connector.
8. Remove the front-panel $\frac{1}{4}$ " nut and flat washer from the channel 1 AC-GND-DC switch.
9. Remove the channel 1 AC-GND-DC switch together with C401 from the Type 3A74.
10. Install the replacement components and reassemble the loosened or removed parts.

Replacing the Channel 3 AC-GND-DC switch or input coupling capacitor C401

1. To clear the way for removing these components, it is necessary to first perform steps 2, 3, 4, 5, and 6 of the procedure, "Replacing the Channel 3 VOLTS/DIV. Switch".
2. Slide channel 2, 3, 4 VOLTS/DIV. switches back about $\frac{1}{4}$ ".
3. Unsolder the leads which allow the channel 3 AC-GND-DC switch and C401 to be removed together.
4. Remove the front-panel $\frac{1}{4}$ " nut and flat washer from channel 3 AC-GND-DC switch.
5. Remove the channel 3 AC-GND-DC switch with C401 attached.
6. Install the replacement components and reassemble the parts which were either loosened or removed.

Replacing the MODE switch (any channel)

1. Unsolder and disconnect the accessible cable-wiring leads from the MODE switch. (Make a drawing of the lead connections to make replacement of the switch easier.)
2. Unsolder the short jumper wire connecting the front wafer of the MODE switch to the adjacent channel MODE switch.

3. If there are transistors directly behind the POSITION control, remove them.
4. Use a $\frac{1}{16}$ " hex wrench to remove the knobs from the MODE switch.
5. Remove the front-panel $\frac{3}{8}$ " nut and flat washer.
6. Slide the MODE switch back and remove it sufficiently to disconnect the remaining cable-wiring leads.
7. Remove the MODE switch.
8. Install the replacement wired MODE switch by reversing the order of the previous steps.

Replacing a DC BAL. or GAIN ADJ. Control (Any Channel)

Since all these controls except the channel 1 DC BAL. control are located between the MODE switches and the chassis, it is necessary to slide back one or more MODE switch to remove a defective control. A removal method is as follows:

1. Perform steps 2, 3, 4 and 5 in the procedure, "Replacing the MODE switch", for the MODE switches that are near the control.
2. Slide back the loosened MODE switches.
3. Unsolder and disconnect as many wires as possible from the defective control.
4. Using a $\frac{5}{32}$ " hex wrench remove the bushing which mounts the control to the front panel.
5. Remove the control sufficiently to disconnect any remaining leads.
6. Install the replacement control by reversing the order of the preceding steps.

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 can be broken by repeated use of ordinary tin-lead solder, or by excessive heating of the terminal strip with a soldering iron. One or two uses of ordinary 60-40 tin-lead solder will not break the bond if excessive heat is not applied.

If you frequently perform work on Tektronix instruments, it is advisable that you have a stock of solder containing about 3% silver. This type of solder is used quite often in printed circuitry and is generally available locally. It may also be purchased directly from Tektronix in one-pound rolls. To order the solder specify Part Number 251-514.

Because of the shape of the terminals of the ceramic terminal strips, you may prefer to use a wedge-shaped tip on your soldering iron. Such a tip allows you to apply heat directly to the solder in the terminals and reduces the amount of heat required. It is important to use as little heat as possible while producing a full-flow joint. Fig. 5-1 shows the correct shape for the tip of the soldering iron. Be sure to file smooth the surfaces of the tip before tinning. This prevents solder from building up on rough spots where it will quickly oxidize.

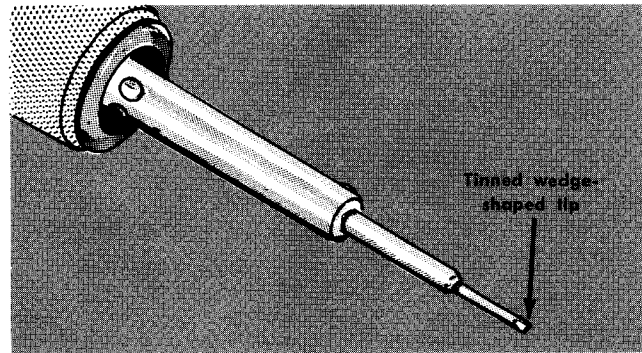


Fig. 5-1. Soldering iron tip properly shaped and tinned.

When removing or replacing components mounted on the ceramic strips, the procedure can be summed up as follows:

1. Use a soldering iron having a rating of about 40 to 60 watts.
2. Prepare the tip of the iron as shown in Fig. 5-1. Tin only the wedge portion of the tip with solder containing 3% silver.
3. Apply one corner of the soldering iron tip to the notch where you intend to unsolder the lead (see Fig. 5-2).

NOTE

If the tip of the iron is placed partly in the notch, do not twist the iron as this might chip or break the ceramic strip.

4. Apply only enough heat to melt the solder and remove the lead. If long-nose pliers are used to grip the lead to be removed, use the very tip of the pliers to keep from drawing away too much heat.
5. When resoldering the lead, apply enough heat to make the solder flow freely.
6. Do not attempt to fill the notch on the strip with solder; instead, apply sufficient solder to cover the wire adequately and to form a slight fillet on the wire as shown in Fig. 5-3.

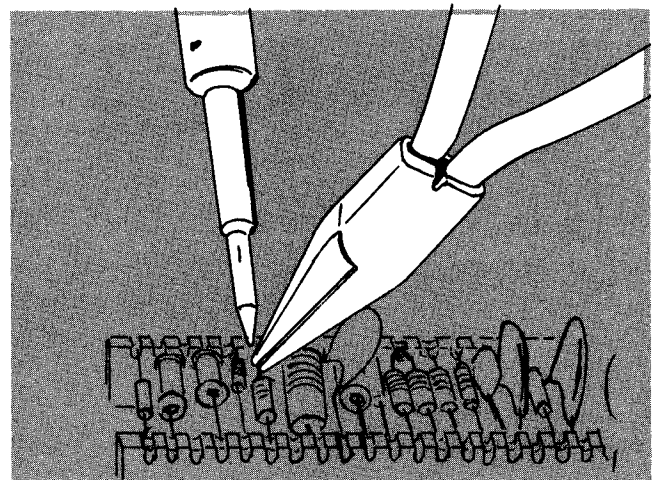


Fig. 5-2. Correct method of applying heat when unsoldering or soldering a lead in a ceramic strip.

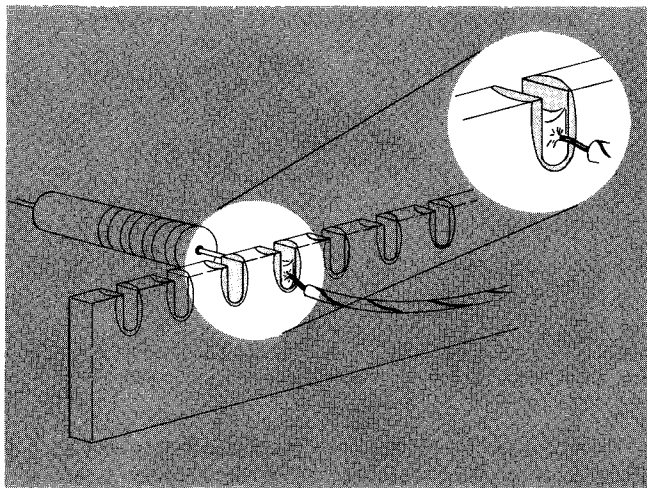


Fig. 5-3. A slight fillet of solder is formed around the wire when heat is applied correctly.

In soldering leads to metal terminals (examples: inter-connecting plug, pins on a tube or transistor socket) a similar technique should be employed. Use a soldering iron tip having a shank diameter of $\frac{1}{8}$ " so that it will go through small spaces between wiring. Prepare the soldering iron as outlined previously and apply the iron to the part to be soldered as shown in Fig. 5-2. Allow the joint to heat sufficiently to permit the solder to flow freely and to form a smooth, slight fillet around the wire as shown in Fig. 5-4.

If the lead extends beyond the solder joint, clip the excess as close to the solder joint as possible. In clipping ends of wires remove all clippings that fall into the chassis.

To hold down leads from components which are not adversely affected by heat during the soldering process, use a short length of wooden dowel with ends shaped as shown in Fig. 5-5. In soldering leads from thermal-sensitive components, such as semiconductors, and ceramic capacitors, it is necessary to use some form of "heat sink". A pair of long-nose pliers (see Fig. 5-6) makes a convenient tool for this purpose.

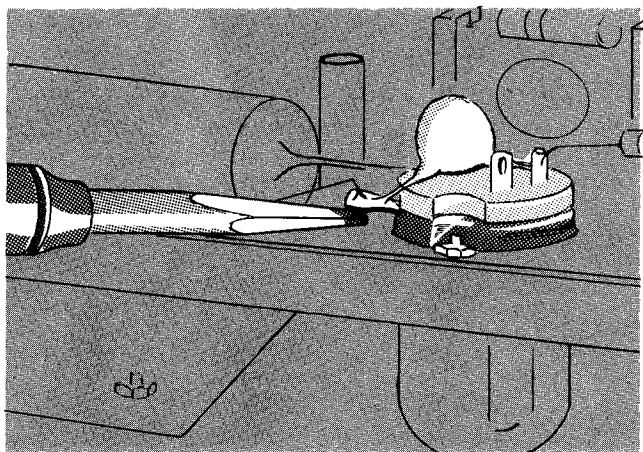


Fig. 5-4. Soldering to a metal terminal. Note the slight fillet of solder formed around the wire.

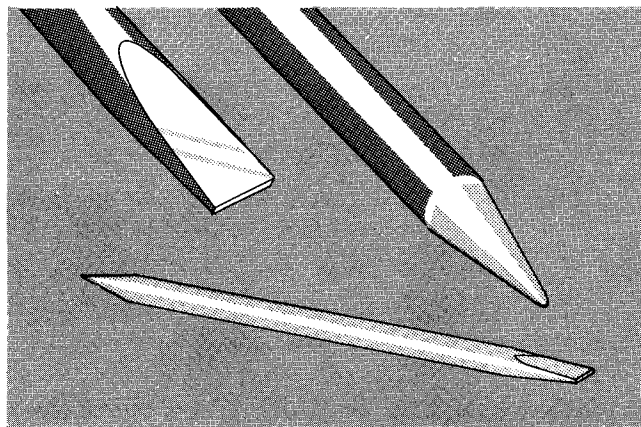


Fig. 5-5. A soldering aid constructed from a $\frac{1}{4}$ -inch wooden dowel.

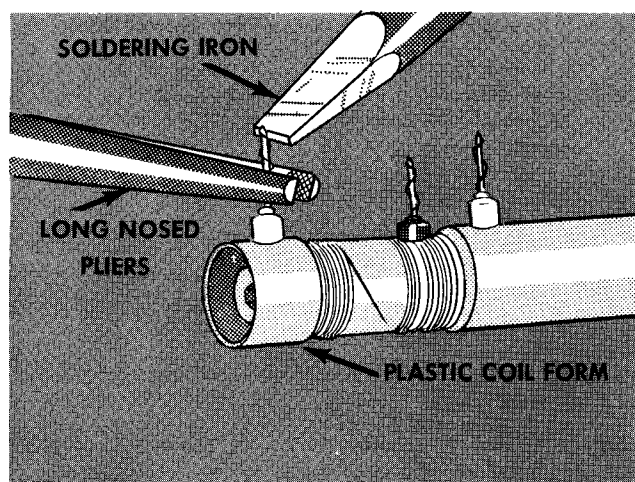


Fig. 5-6. Soldering to a terminal mounted in plastic. Note the use of the long-nose pliers between the iron and coil form to absorb the heat.

In soldering leads or coax braids to ground use a 50-to-60-watt iron with tip having a shank diameter of about $\frac{1}{4}$ ". The higher-wattage iron and heavier tip will assure that the joint receives adequate heat to form a good solder joint.

Replacing Ceramic Terminal Strips

To remove a ceramic terminal strip, unsolder all components and connections, then pry the strip with yokes attached, out of the chassis. An alternate method is to use diagonal cutters to cut off one side of each yoke to free the strip but try not to damage the spacer. After removing the strip, the remainder of each yoke can be easily extracted from the chassis with a pair of pliers. The yokes need not be salvaged since new ones are furnished with the new strips. If spacers are not damaged, they may be reused as long as they hold the strip assembly securely.

To install a new strip, place the spacers in the chassis holes, insert the yoke through the spacers, and press down on top of the strip above the yokes. Use a plastic or hard rubber mallet, if necessary, to seat the yokes firmly. Be sure

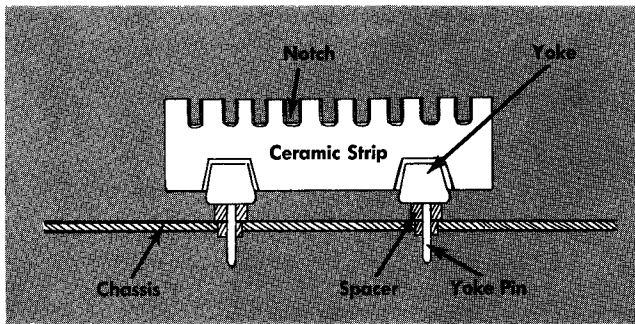


Fig. 5-7. Installation of a ceramic strip.

to tap lightly directly above the yokes and drive them down in equal increments to keep from placing too great a strain on the strip. Fig. 5-7 illustrates the way the parts fit together.

Observing all soldering precautions described earlier when soldering leads to the strip.

OBTAINING REPLACEMENT PARTS

Standard Parts

Replacement for all parts used in constructing the Type 3A74 can be purchased through your local Tektronix Field Engineering Office. Many of the components, however, are standard electronic parts that can usually be purchased locally in less time than required to obtain them from Tektronix, Inc. Before purchasing a part, be sure to consult the Parts List of this manual to determine the tolerance and rating required. The Parts List gives the values, tolerances, rating and Tektronix part numbers for all components used in the unit.

Special Parts

In addition to the standard electronic components mentioned in the previous paragraph, special parts are also used. These parts are manufactured or selected by Tektronix to satisfy particular requirements, or are manufactured especially for Tektronix by other companies. These parts and most mechanical parts should be ordered from Tektronix, since they are normally difficult or impossible to obtain from other sources. Order all parts through your local Tektronix Field Engineering Office.

TROUBLESHOOTING

Introduction

In the event that trouble develops use the information in this portion of the Instruction Manual to more efficiently troubleshoot the Type 3A74. The information begins with preliminary checks to make and then advances to detailed circuit troubleshooting.

Front-Panel Controls

Before troubleshooting, double-check the front-panel controls for proper settings. In addition, check the front-panel screwdriver-adjustable controls to determine if their

settings are proper. This is important since symptoms caused by incorrect control settings are not described in this section of the manual.

If you are in doubt as to the proper settings of the controls and their function, refer to the Operating Instructions section. If the front-panel controls are set properly and you know that a trouble definitely exists, proceed to check if the trouble is in the oscilloscope or the Type 3A74.

Type 3A74 or Oscilloscope

When following a troubleshooting procedure, it is assumed that the oscilloscope used with the Type 3A74 is operating normally. Since this is not always the case, check the operation of the oscilloscope before attempting to troubleshoot the Type 3A74.

Troubles occurring in the oscilloscope can usually be detected by substituting another plug-in unit for the Type 3A74. Preferably, another Type 3A74 or another multi-trace unit such as the Type 3A72, which is working normally, should be used if one is available. Then you can readily isolate such multi-trace troubles as loss of alternate-mode sync pulses or improper chopped-mode blanking to either the oscilloscope or the Type 3A74. If one of the foregoing units is not available, then the multi-trace troubles must be isolated by signal tracing the Type 3A74 and possibly the oscilloscope time-base circuitry.

NOTE

It is assumed, unless stated otherwise that the Type 3A74 is used in the Y-axis opening to provide vertical deflection and that a time-base unit is used in the X-axis opening for horizontal deflection. This applies to oscilloscopes having both Y-axis and X-axis openings.

If the Type 3A74 is definitely at fault and not the associated oscilloscope with its time-base circuitry, then make a careful operational check of the Type 3A74. Carefully note the effect that each front-panel control has on the symptom. By analyzing such effects, you can sometimes isolate a trouble to either a defective control or probable circuits containing the trouble. In addition, the normal or abnormal operation of each control should indicate to you the possible checks to make.

As an aid to more detailed troubleshooting, much of the information in the remaining portion of this Maintenance section can be used. As an example, Table 5-5 lists many symptoms and possible checks to make. In addition to this section of the manual, the step-by-step method of checking and adjusting the Type 3A74 as given in the Calibration procedure (Section 6) is a good way to check the operational standards of your own unit. Any deficiency that shows up while performing the steps can lead you to the area at fault and the possible causes.

CIRCUIT TROUBLESHOOTING

This portion of the manual contains circuit-troubleshooting information. The information is subdivided into clearly titled topics so that you can quickly choose the most useful information.

Diagrams

Block and circuit diagrams are contained in the pull-out pages near the back cover of this manual. The circuit diagrams contain component circuit numbers, voltages, and waveforms. Conditions under which the voltages and waveforms were taken are also indicated on the diagrams.

Coding of Switch Wafers

Switch wafers shown on the circuit diagrams are coded to indicate the physical location of the wafer on the actual switches. The number portion of the code refers to the wafer number on the switch assembly. Wafers are numbered from the first wafer located behind the detent section of the switch to the last wafer. The letters F and R indicate whether the front or the rear of the wafer is used to perform the particular switching function. For example, 2R of the VOLTS/DIV. switch is the second wafer when counting back from the detent section, and R is the rear side of the wafer.

Cable Color Coding

All wiring in the Type 3A74 is color coded to facilitate circuit tracing. The power-supply wires originating from the interconnecting plug are identified by the following color code; the widest stripe identifies the first color in the code.

Supply Voltage	Cable Color Code
+300 v	Orange-black-dark brown on white
+125 v	Brown-red-dark brown on white
+50 v	No code (bare jumper wires are used)
+12 v	Red on white
−12.2 v	Dark brown-red on tan
−100 v	Dark brown-black-dark brown on tan

Test Equipment

When preparing to circuit troubleshoot the Type 3A74, here is a list of suggested equipment that you may find useful. The list summarizes the various servicing equipment and other aids that are specifically mentioned in the remaining portion of the Maintenance section.

(1) Transistor Tester

Description: Tektronix Type 575 Transistor-Curve Tracer.
Purpose: To test transistors and diodes used in the Type 3A74.

(2) VOM

Description: 20,000 Ω /v dc, calibrated for an accuracy of 1% or better to measure these power-supply voltages: +300 v, +125 v, −100 v, and −12.2 v. Accuracy for other voltage readings, within $\pm 3\%$.

CAUTION

Be sure the test prods are well insulated to prevent accidental shorts when reaching a test point. If you use the VOM as an ohmmeter to measure resistances when semiconductors are in the circuit, know and use ranges (usually RX1K and higher) that deliver a current of less than 2 ma at full deflection.

Purpose: Precision and general-purpose use. Can also be used to check transistors and diodes if used with care. Not recommended as a substitute for a good transistor and diode tester.

(3) Milliammeter

Description: Range 0 to 2 ma.

Purpose: To determine full-scale current delivered by the VOM on ohmmeter ranges you intend to use.

(4) Test Oscilloscope

(a) Low-bandwidth Test Oscilloscope (with a 10X probe).
Description: Bandwidth, dc to about 300 kc or better. Calibrated vertical deflection factors down to 5 mv/div. without a 10X probe (50 mv/div. with a 10X probe). Input resistance, 1 megohm without a 10X probe and 10 megohms with a 10X probe. Has an EXT. Trig. input connector.

Purpose: To low-frequency signal trace and check dc levels in the amplifier and channel 1 only trigger stages. Can be used to signal trace the switching circuits if bandwidth limitation is considered.

(b) Wide-bandwidth Test Oscilloscope (with a 10X probe).
Description: Bandwidth, dc to 10 mc or better. Calibrated vertical deflection factors down to 0.1 volt/div. without a 10X probe (1 volt/div. with a 10X probe).

Purpose: To signal trace the switching circuits. If the deflection factor of this wide-band test oscilloscope is as low as 5 mv/div., use it in place of item 4a.

(5) An auto transformer with output voltage variable between 105 and 125 volts (or 210 and 250 volts if oscilloscope used with the Type 3A74 is wired to operate within this range). Minimum rating depends on current drawn by associated oscilloscope with plug-in units.

Purpose: To apply design-center line voltage to the oscilloscope/Type 3A74 combination.

(6) An accurate ac voltmeter capable of indicating voltages from 105 to 125 volts (or from 210 to 250 volts if the oscilloscope used with the Type 3A74 is wired for this operating range).

Purpose: To monitor the line voltage.

(7) Flexible Plug-In Extension Cable

Description: 30" long, Tektronix Part No. 012-066.

Purpose: Permits operating the Type 3A74 out of the oscilloscope plug-in compartment so that all sides of the Type 3A74 are accessible for servicing.

(8) Adapter (Use either a or b)

(a) Adapter with BNC plug and UHF jack connector fittings. Description: Tektronix Part No. 103-032.

Purpose: Accepts patch cord with a banana plug.

(b) Single Binding Post Adapter

Description: Fitted with a BNC plug connector. Tektronix Part No. 103-033.

Purpose: Accepts patch cord with banana plug.

(9) 18" Patch Cords (two required)

Description: Combination banana-plug and jack connectors on each end. Type PC-18R, Tektronix Part No. 012-031.

Purpose: Use in low-frequency signal-tracing setup to apply the calibrator signal to the Type 3A74 and test oscilloscope EXT. Trig. input connector.

(10) 30" Patch Cord

Description: Banana plug on one end, alligator clip on other end. Type W130B, Tektronix Part No. 012-014.

Purpose: Use in low-frequency signal-tracing setup to ground the Type 3A74 and test oscilloscope together.

(11) Miscellaneous: Replacement tubes, transistors, and diodes.

Tube Checks

Periodic tube checks on the tubes used in the Type 3A74 are not recommended. Tube testers in many cases indicate a tube to be defective when that tube is operating quite satisfactorily in the circuit, and fail to indicate tube defects which affect the performance of the circuits. The ultimate criterion of the useability of a tube is whether or not the tube works properly in the circuit. If it does not, then it should be replaced. If it is working correctly, it should not be replaced. Unnecessary replacement of tubes is not only expensive but may also result in needless recalibration of the unit.

CAUTION

Turn the oscilloscope power off when replacing tubes or transistors as this will safeguard their life expectancy.

Transistor Checks

Transistor defects usually take the form of the transistor either opening or shorting or developing excessive leak-

age. To check a transistor for these and other defects, use a transistor-curve display instrument such as the Tektronix Type 575. However, if a good transistor checker is not readily available, a defective transistor can be found by signal tracing, by making in-circuit voltage checks, by measuring the transistor forward-and-back resistances using proper ohmmeter ranges, or by substitution. Voltage and resistance checks can be made using the following information.

(1) In-Circuit Voltage Checks

To check transistors using a voltmeter, measure the base-emitter junction bias and the emitter-to-collectors voltage as shown in Fig. 5-8. Use Tables 5-1 and 5-2 to determine the condition of the transistor.

When substituting transistors as suggested in the table, first be sure that the voltages and loads on the transistor are normal before making the substitution. If a transistor is substituted without first checking out the circuit, the new transistor may immediately be damaged by some defect in the circuit.

TABLE 5-1

IN-CIRCUIT TRANSISTOR VOLTAGE CHECK

Step	Voltage Reading*	Action
1.	Normal base-emitter reading.	Go to step 3.
2.	Abnormal base-emitter reading and/or incorrect polarity.	Check associated circuit first to find probable cause. Then, if necessary substitute the transistor.
3.	Normal emitter-to-collector drop.	None**.
4.	Low emitter-to-collector voltage.	Possibly shorted***. Check associated circuit for proper voltages and resistances before substituting the transistor.
5.	High emitter-to-collector voltage.	Possibly open**. Check associated circuit for proper voltage before substituting the transistor.

*See schematic diagram to determine proper voltages.

**Q583 and Q590 are exceptions. They could be open. Check by substitution.

***Q545, Q555, Q565, and Q575 when conducting normally have very low voltage between emitter and collector. Try substituting the transistor.

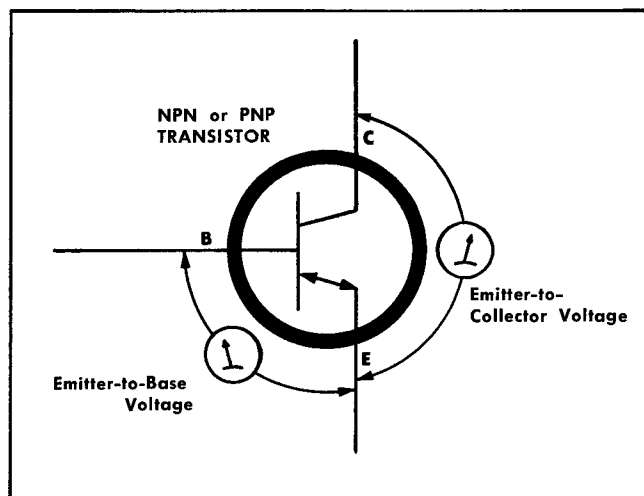


Fig. 5-8. In-circuit voltage checks of NPN or PNP transistors.

(2) Resistance Measurements

To check a transistor using an ohmmeter, know your ohmmeter ranges, the currents they deliver, and the internal voltage used. If your ohmmeter does not have sufficient resistance in series with its internal voltage source, excessive current may flow through the transistor under test and may permanently damage the transistor.

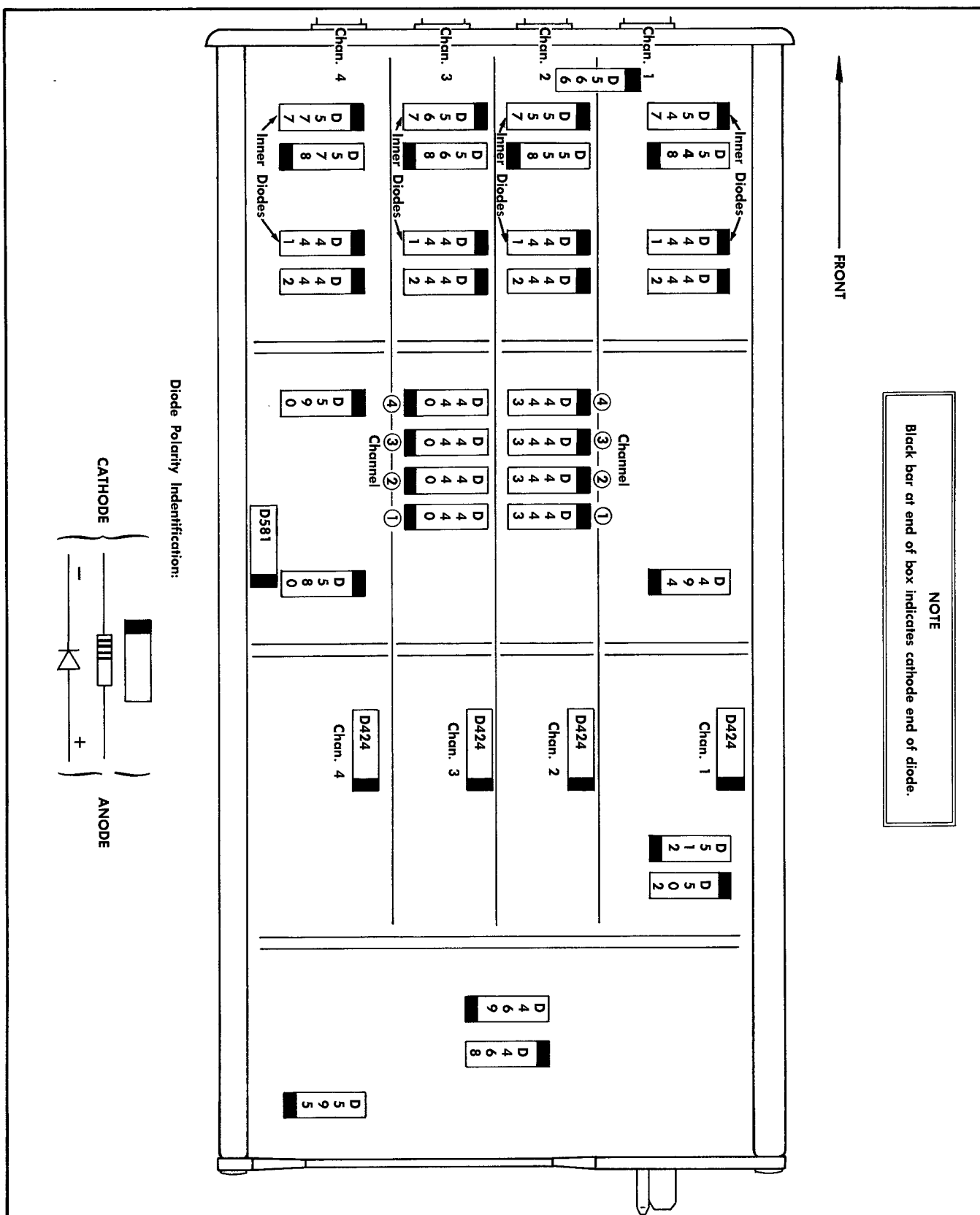


Fig. 5-9. Illustration showing physical location of the diodes.

NOTE

As a general rule, do not use the RX1 and RX10 ranges. Use the higher ranges where the current is limited to about 2 ma. You can quickly check the current by inserting a milliammeter between the ohmmeter leads and then noting the current for each range you intend to use.

When you know which ohmmeter ranges will not harm the transistor, then measure the resistance with the ohmmeter leads connected first one way and then the opposite way while using the information provided in Table 5-2.

TABLE 5-2**Transistor Resistance Checks**

Ohmmeter Connections*	Resistance Readings that can be expected using the RX1K Range
Emitter-Collector	High readings (but unequal) both ways (about 60 k to around 500 k.)
Emitter-Base	High reading one way (about 200k or more). Low reading the other way (about 400 Ω to 2.5k).
Base-Collector	

*Ohmmeter test prods are first connected one way to the transistor leads and then the test prods are reversed (connected the other way). Thus, the effects of the polarity reversal of the voltage applied from the ohmmeter to the transistor can be observed.

If there is doubt about whether the transistor is good or not, substitute the transistor in the Type 3A74; but first

be certain the supply voltages and the circuit are correct before making the substitution.

Diode Checks

Diode defects are similar to transistor defects when the diode opens or shorts. Therefore, checks similar to that described for transistors can be applied to diodes.

NOTE

If you use an ohmmeter, observe the same precautions as described for checking transistors.

In-circuit checks of diodes (except if D424, D502, D468, D469 or D595 open) can be made quite easily by using a voltmeter to find out if the diode is functioning properly in the circuit. Use Table 5-3 to determine whether a particular diode (excluding Zener D494) should be forward biased or not, then measure the voltage across it. By noting the difference between voltages on each side of the diode as given on the schematic diagrams, you can determine whether the diode is normal or not. Refer to Fig. 5-9 if you need to locate any of the diodes quickly.

If you are in doubt whether a diode is defective or not, unsolder one end and check the forward-and-back resistances. Use this method particularly for checking D424, D468, D469, and D595 because voltage checks may not be very conclusive if the diode is open. If the ohmmeter check proves inconclusive, check the diode on a good tester or use the substitution method.

TABLE 5-3**DIODE BIAS CONDITIONS**

Diode	Chan. 1 MODE switch set to NORM.; Chan. 2-3-4 MODE switches set to OFF.		All MODE switches set to NORM. or INV., CHOP.-ALT. switch set as follows:	
	Ch. 1 Diodes ¹	Ch. 2-3-4 Diodes ²	CHOP. ²	ALT. ^{1 3}
D424	Reverse	Reverse	Refer to page 5-10 for continuation of these 2 columns	
D440	Forward	Reverse		
D441	Reverse	Forward		
D442	Reverse	Forward		
D443	Forward	Reverse		
D468 ¹	Unbiased	Unbiased		
D469 ¹	Unbiased	Unbiased		
D502	Reverse	None used.		
D512	Forward	None used.		

¹ Exception—D468 and D469 are Output Amplifier diodes. The unbiased or zero volts reading is obtained by setting POSITION (control(s) at or near midrange) so that a zero volts reading is obtained on the VOM.

² With no signal applied to the Type 3A74 or the AC-GND-DC switches set to GND. Last two columns show apparent bias conditions since VOM follows average pulse level.

³ Time-base set for a 1 mSec/Div. free-running state.

TABLE 5-3 (Cont'd)
DIODE BIAS CONDITIONS

Channel Switching Circuit Diodes (MODE switches set as above)			
D547	Reverse	Unbiased ⁴	Unbiased ⁴
D548	Forward	Reverse	Reverse
D557	Forward	Unbiased ⁴	Unbiased ⁴
D558	Reverse	Reverse	Reverse
D566	Forward	Forward	Forward
D567	Forward	Unbiased ⁴	Unbiased ⁴
D568	Reverse	Reverse	Reverse
D577	Forward	Unbiased ⁴	Unbiased ⁴
D578	Reverse	Reverse	Reverse
D580	CHOP. — Forward; ALT. — Reverse	Forward	Forward
D581	Forward	Reverse	Reverse
D590	CHOP. — Forward; ALT. — Unbiased ⁴	Unbiased ⁴	Unbiased ⁴
D595	Forward	Reverse	Reverse

4. Unbiased but voltage across diode may not be exactly zero volts since voltage drop varies between Type 3A74 units from approximately -0.08 volt to $+0.08$ volt.

Interconnecting-Plug Resistance Checks

Table 5-4 lists the typical resistances measured between the interconnecting-plug pins and ground. These readings are particularly useful for locating a possible short circuit or low-resistance path in the Type 3A74, if such a trouble occurs.

The resistance measurements are not absolute and vary considerably since semiconductors are used in the circuitry. In addition, the readings can vary as much as 50% due to the type of ohmmeter you may be using, even if you use the same ranges. Therefore, space is provided in the table for logging your own measurements and the type of meter you are using for future reference.

Significant differences between ohmmeter types are: (1) the amount of internal voltage they use, (2) the currents they require to make the meter needle deflect full scale for each range, and (3) the scale readings on the meter itself. If ohmmeters did not differ so much in these respects, then the resistance measurements as given in the table would be more typical.

Symptoms

The symptoms that are listed in Table 5-5 are those that could happen if certain troubles occur. Since a diode could cause deceiving troubles if one breaks down, many of the symptoms are based on what could happen if a diode should become shorted or opened. Since it is impossible to list every kind of symptom that could happen, those that are included here provide a good basis or guide for finding the cause of a trouble.

Table 5-5 does not include those troubles that are caused by improperly adjusted front-panel controls. Refer to the

Operating Instructions (Section 2) if you are in doubt about the proper control settings. To use Table 5-5, proceed as follows:

- (1) Find the symptom in the first column.
- (2) Check the possible causes of trouble as listed in the second column.

NOTE

When troubleshooting the Type 3A74, it is suggested that the oscilloscope be operated at the design center line voltage to insure that proper supply voltages be applied to the plug-in unit. Use the autotransformer (item 5) and the ac voltmeter (item 6) for setting the line voltage to design center (117 volts or 234 volts, depending on the design center operating voltage for which your oscilloscope is wired).

- (3) If one of the listed causes is the trouble, make the repair.
- (4) If none of the causes are the trouble, go to the third column. This column indicates the possible circuit area at fault. The names of these areas are the same as those called out in the block and circuit diagrams.

As an aid to circuit troubleshooting an area, the third column sometimes directs you to Part I or Part II. Part I supplies information for troubleshooting the 4-Channel Switched Amplifier stages; Part II contains information for troubleshooting the Channel Switching Circuit.

In general, by using the troubleshooting information in conjunction with the information provided on the schematics as well as other portions of the manual, maintenance time can be reduced to a minimum.

TABLE 5-4

Typical Resistances at Interconnecting Plug

Control Settings: MODE (Channel 1) NORM. MODE (Channel 2, 3, 4) OFF CHOP.-ALT. CHOP. TRIGGER CH 1 ONLY				
Pin No.	Type of Meter: VOM*		Type of Meter: Manufactured By: Model No.: Type 3A74 Serial No.:	
	Resistance Readings**	Ohms Range Used	Resistance Readings**	Ohms Range Used
1	0.7 Ω	RX1		
2	0 Ω (Gnd.)			
3	Infinite	RX100K		
4	0 Ω	RX1		
5	600 Ω , 140 Ω	RX100		
6	94 k, 30 k	RX10K		
7	Infinite			
8	(No Connection)			
9	0 Ω (Gnd.)			
10	92 k, 29 k	RX10K		
11	49 k	RX10K		
12	Infinite (No Connection)			
13				
14	3 k, 3.3 k	RX1K		
15				
16	600 Ω , 140 Ω	RX100		
17	98 k, 34 k	RX10K		
18	Infinite	RX100K		
19	0 Ω (Gnd.)			
20	3 k, 3.3 k	RX1K		
21	98 k, 34 k	RX10K		
22	0 Ω (Gnd.)			
23	2.3 k, 2.3 k	RX1K		
24	2.1 k, 3.7 k	RX1K		

*VOM used to obtain these measurements is a 20,000 Ω /v dc meter with a center-scale reading of 4.5 k on the RX1K range. For the RX1K range, mid-scale deflection current is 160 μ a; at full scale it is 320 μ a. On the higher ranges, current never exceeds 520 μ a for full-scale deflection.

**Reverse the ohmmeter leads to get both readings.

TABLE 5-5
Trouble Isolation Procedure

Symptoms	Checks to Make	
	Some Possible Causes	Probable Area at Fault
1. Overheated or burned components in the Type 3A74.	Adjacent leads carrying different voltages shorted to each other. A lead (elevated in voltage above ground) is shorted to ground.	Isolate trouble to a branch circuit by first checking the interconnecting plug resistances to ground. Use Table 5-4 as a guide. Continue with resistance check until trouble is found.
2. Loss of all the channel traces. No trace appears when all MODE switches are set to OFF.	Q444, Q454, Q463, or Q473 defective. L444, L454, L464 or L474 open. Interconnecting plug defective. V464 or V474 heater open.	Check for dc imbalance in the Output Amplifier stages and locate cause of trouble. Refer to PART 1A.
3. Loss of all the channel traces or signals but a trace does appear on the crt that cannot be positioned with the front-panel controls. MODE switches set to any position.	C596 shorted. Q590 shorted. NOTE: If Q590 is defective, check D595 also. If D595 is shorted, the diode can damage the replaced Q590 transistor. —12.2 (DEC) buss may be at —6 v.	Check for trouble in the Blocking Oscillator Q590 and Blanking Pulse Regenerator V533B stages.
4. Loss of trace from one channel.	Possible causes in channel at fault: V423 or V433 defective. V424 or V434 defective. D424 shorted; trace can be positioned into view. D440 or D443 open. If chan. 1 is at fault, also check Q503, Q504 and D502.	Check for dc imbalance in channel at fault somewhere between its input circuit and emitters of Q444 and Q454. Refer to PART 1A, that follows this table.
5. Unable to position the trace of one channel. No waveform display.	Check for an open POSITION control in channel at fault. Check for shorted diode in collector circuit of Ring counter controlling channel at fault by using this pattern as an example: Chan. 1 at fault—check for shorted D547 diode; chan. 2—check D557.	Check collector circuitry of Q424 and Q434 in channel at fault. Also check Ring Counter circuitry.
6. Trace for one channel cannot be positioned to upper half of graticule and waveform decreases in amplitude as the channel's POSITION control is rotated clockwise.	Check for open D443 diode in channel at fault.	Check switching diodes in channel at fault.
7. Same as Symptom No. 6 but counterclockwise rotation of POSITION control decreases amplitude of display.	Check for open D440 diode in channel at fault.	Check switching diodes in channel at fault.
8. POSITION controls for three channels must be set at about 60° clockwise from center to position the traces at or near graticule center. Remaining channel seems to operate normally.	Check for shorted D443 diode in the apparently normal operating channel.	Check switching diodes in apparently normal-operating channel.
9. Same as Symptom No. 8 but POSITION controls of the three channels must be set at about 60° counterclockwise.	Check for shorted D440 diode in the apparently normal operating channel.	Check switching diodes in apparently normal-operating channel.
10. Traces for three channels cannot be positioned below bottom of graticule and waveform amplitudes change as their respective POSITION controls are varied. Remaining channel seems to operate normally.	Check for an open D442 diode in channel that seems to operate normally.	Check switching diodes in apparently normal-operating channel.

TABLE 5-5 (Cont'd)

Symptoms	Checks to Make	
	Some Possible Causes	Probable Area at Fault
11. Same as Symptom No. 10 but traces of three channels cannot be positioned to top of graticule.	Check for an open D441 diode in channel that seems to operate normally.	Check switching diodes in apparently normal-operating channel.
12. Limited positioning range (about 4 div.) for three channels. POSITION control of remaining channel affects trace position of other three channels. If signals are applied to all channels, 14% of remaining channel signal feeds into other three channels; amplitude of display in other three channels decreases by 92%.	Check for shorted diode in collector circuit of Ring Counter transistor that controls the remaining channel using this example as a pattern: channel 1—check for shorted D548 diode; channel 2—check D558 diode.	Check Ring Counter circuitry.
13. Microphonics in one channel exceeds one major division in amplitude when front panel of Type 3A74 is tapped lightly with one hand. AC-GND-DC switch is set to GND.	Check for microphonic V423 or V433 in channel at fault. NOTE: If AC-GND-DC switch for channel 1 or 3 is set to AC or DC and if VOLTS/DIV. switch is set to .02, C401 input coupling capacitor can cause a microphonic symptom if it is not rigidly mounted.	Check Input CF V423 and DC BAL CF V433 stages.
14. Trace of one channel is noisy.	Check C428 in channel at fault.	Check Input CF V423 and DC BAL CF V433 stages.
15. Trace of one channel shifts vertically more than one minor division when AC-GND-DC switch of that channel is set from AC or DC setting to GND or vice versa.	Excessive V423 grid current in channel at fault.	Check Input CF V423 stage.
16. No waveform display when using one of the channels. Positioning is normal.	Check VAR. GAIN, GAIN ADJ., or R437 for open circuit. Check for short or open circuit between Input connector of channel at fault and grid of V423.	Check the channel at fault. Refer to PART 1B.
17. Low gain in one channel. VOLTS/DIV. switch set to any position.	Check Q424 or Q434.	Check for trouble in the channel at fault. Refer to PART 1B.
18. Incorrect deflection factor when using some of the VOLTS/DIV. switch settings of one channel.	Check for faulty attenuator components used in those switch positions. For example: if the .05, .5 and 5 VOLTS/DIV. deflection factor settings are incorrect, the X2.5 attenuator is at fault.	VOLTS/DIV. switch SW410 in channel at fault.
19. Low gain in all channels and gain varies with rotation of POSITION control (s).	Check for an open arm of POSITION RANGE control.	Check Output Amplifier stages. Refer to PART 1B.
20. Gain is normal in all channels at graticule center. POSITION controls off center. Gain decreases up to 50% if display is positioned to top or bottom of graticule.	Check for open R448 or R458.	Check Output Amplifier stages. Refer to PART 1B.
21. Low gain in all channels. Gain decreased about 14%.	Check for shorted C478. Check for open R478.	Check Output Amplifier stages. Refer to PART 1B.
22. Gain increased by 14% in all channels.	Check for shorted D468 or D469 diode.	Check Output Amplifier stages. Refer to PART 1B.
23. Display of any channel compresses slightly (about 1/2 minor division) as the display is positioned to the bottom of screen.	Check for open D468.	Check for trouble in the Output Amplifier stages. Refer to PART 1B.

TABLE 5-5 (Cont'd)

Symptoms	Checks to Make	
	Some Possible Causes	Probable Area at Fault
24. Same as Symptom No. 23 except compression occurs as waveform is positioned to the top of the graticule.	Check for open D469.	Check for trouble in the Output Amplifier stages. Refer to PART 1B.
25. Vertical deflection factor of all channels decreases by 5% and about 5% of the applied signals feed-thru between channels and superimpose on the displayed waveforms.	Check for shorted D566 diode.	Check Ring Counter circuitry.
26. Square-wave distortion or poor transient response in one channel but not in the others; VOLTS/DIV. switch set to certain attenuator positions.	Check attenuator compensation adjustments. Refer to step 13 in the Calibration section.	Check VOLTS/DIV. attenuator in channel at fault. Refer to PART 1C.
27. No channel 1 only triggering when the TRIGGER switch is pulled outward.	Check D512 for short or open. Check for defective TRIGGER switch. NOTE: Q503, Q504, Q514 or D502 could also be defective but they would probably cause chan. 1 trace to deflect off the screen.	Check for trouble in the Channel 1 Only Internal Trigger Stages. Refer to PART 1B.
28. Poor channel 1 only triggering with TRIGGER switch in its outward position.	Check Q524 or for open L525. NOTE: Q503, Q504, Q514 or D502 could also be defective but they would probably cause chan. 1 trace to go off the screen.	Check for trouble in the Channel 1 Only Internal Trigger stages. Refer to PART 1B.
29. Incorrect channel 1 only triggering on a small-amplitude (less than $\frac{1}{2}$ major div.) signal with TRIGGER switch in its outward position. Time-base Triggering Level control set at or near zero and Coupling switch set to DC. (Triggering Level control has to be set too far in the — or + region to get proper triggering).	Check CHAN. 1 INT. TRIG. DC LEVEL R521 adjustment.	If adjustment does not have sufficient range to correct the trouble, check for dc imbalance in the Channel 1 Only Internal Trigger stages. Refer to PART 1B.
30. Same as Symptom No. 29 except TRIGGER switch is pushed in (Composite) and POSITION control is set to position the trace to crt vertical electrical center.	Check COMPOSITE INT. TRIG. DC LEVEL R530 adjustment.	If R530 does not have sufficient range to correct the trouble check for dc imbalance between plate of V474 and grid circuit of V533A. Refer to PART 1B.
31. No composite or channel 1 only triggering.	V533A half of tube V533 defective. R532 open. C533 or C535 shorted.	Check for trouble in the Internal Trig. Output CF V533A stage. Refer to PART 1B.
32. No multi-trace operation. One channel stays "on" all the time. All MODE switches set to NORM. or INV.	Check for shorted Ring Counter Transistor that controls the "on" channel. (Q545 controls channel 2, Q565 controls channel 3 and Q575 controls chan. 4).	Check Ring Counter circuitry. Refer to PART II.
33. No multi-trace operation. Turned-on channel can be turned off and another channel turned on by setting the MODE switch of the turned-on channel (or the channel preceding the "on" channel) from NORM. to OFF and then back to NORM. again.	No triggers to Ring Counter—check for shorted D580 or C587 components. Check for defective Q590 transistor. Check for open D590.	Check the Blocking Oscillator Q590 stage. Refer to PART II.
34. No multi-trace operation. Same as Symptom No. 33 except when CHOP. —ALT. switch is set to CHOP., trace on screen consists of chopped segments.	Triggers are applied to Ring Counter but triggers do not switch the Ring Counter Transistors—check for an open D566 diode.	Check the Ring Counter and Blocking Oscillator Q590 stages. Refer to PART II.

TABLE 5-5 (Cont'd)

Symptoms	Checks to Make	
	Some Possible Causes	Probable Area at Fault
35. Improper multi-trace operation. Only two channels operate in alternate mode and they can be switched to another two by operating the MODE switch. In chopped mode there are twice as many segments in chan. 1 and 4 traces as there are in chan. 2 and 3. Time duration of each segment is about 1.1 μ sec indicating that the Blocking Oscillator rate is about 900 kc.	Check for shorted D581 diode.	Check the Blocking Oscillator stage. Refer to PART II.
36. Improper chopped-mode multi-trace operation. Channel 2, 3, or 4 has twice as many segments as the others. Time duration of each segment is normal (about one μ sec).	Check for an open diode using this pattern as an example: if chan. 2 has twice as many segments, check for an open D547 diode; if chan. 3 has twice as many segments, check for an open D557 diode.	Check the Ring Counter circuitry. Refer to PART II.
37. Incorrect chopped-mode rate. Rate is higher than normal. Segments are 1.5 μ sec in duration indicating that the Blocking Oscillator free-running rate is about 670 kc.	Check for an open D580 diode.	Check the Blocking Oscillator stage and Ring Counter circuitry. Refer to PART II.
38. Switching transient pulses are present on trace when only one channel is on. Pulses are about 2 μ sec apart. As trace is positioned to top of graticule, pulses increase in amplitude and are negative going; when trace is positioned to bottom of graticule, pulses reach a maximum amplitude of about one major div. at top or bottom of graticule.	Pulses indicate that the Blocking Oscillator is free running when only one channel is on—check for an open D581 diode.	Check Blocking Oscillator stage. Refer to PART II.
39. No chopped-mode blanking during chopped-mode multi-trace operation.	Check for defective D595 diode. If shorted, check Q590.	Check Blanking Pulse Regenerator V533B stage.
40. No alternate-mode multi-trace operation.	Check Q583.	Check the Sync Pulse In EF Q583 stage.

Part I—Troubleshooting the Amplifier Stages

A. Isolating DC Imbalance

For free-running traces to appear within the useable viewing area of the crt screen, the dc voltage as measured between pins 17 and 21 of the interconnecting plug must be less than ± 72 volts (based on a crt vertical deflection factor of 18 volts/div). A voltage difference which exceeds ± 72 volts between these two points may position the trace above or below the range of visibility.

The dc voltages at pins 17 and 21 of the interconnecting plug depend on the dc balance of each stage in the Output Amplifier as well as all the stages between input and output of any channel that is turned on (MODE switch set to NORM. or INV). Since all the amplifier stages are dc coupled, any excessive imbalance condition anywhere between input

and output can unbalance the output and cause the trace to deflect out of the viewing area.

Fig. 5-10 shows the voltage difference limits between each stage. If the voltage limits are exceeded in one stage, the limits will be exceeded in the following stages (looking toward the output) and the trace will deflect off the screen. For example, if the voltage between the collectors of Q444 and Q454 reads ± 6 volts, the voltage between emitters of Q463 and Q474 will also be about ± 6 volts, and the voltage between the plates (pin 6 of V464 and V473 will be about ± 110 volts, causing the trace to be deflected off the screen.

One quick method for isolating dc imbalance either to one of the Switched Amplifier or to the common Output Amplifier is to turn one channel on at a time to see if its trace can be normally positioned onto the screen. If the trace for one channel cannot be positioned onto the screen, then the

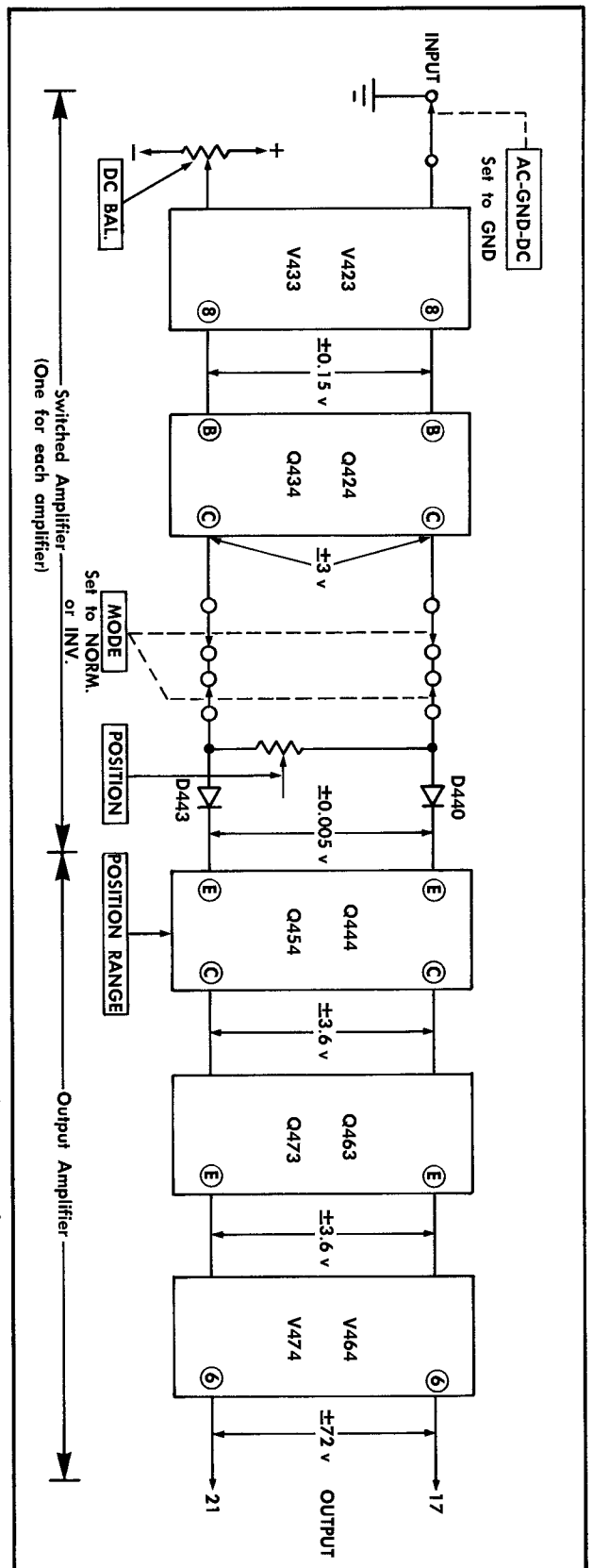


Fig. 5-10. Dc balance voltage limits at each stage which, if not exceeded, should position the trace on the screen.

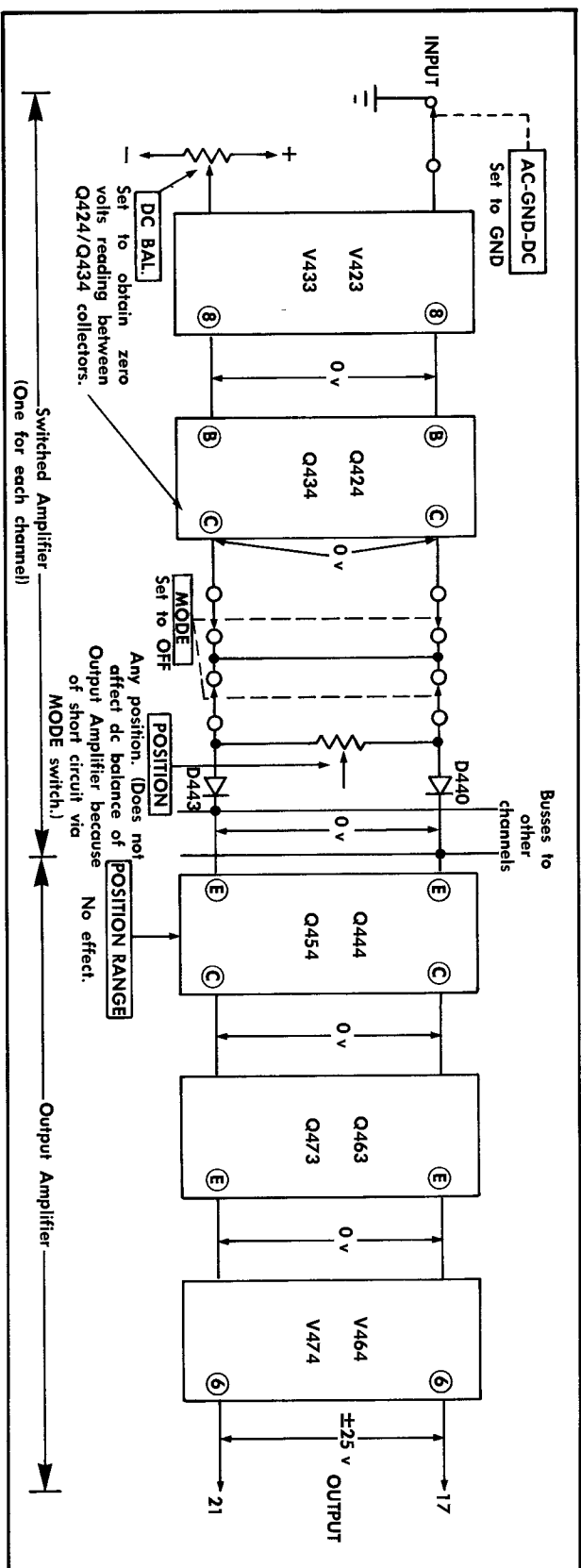


Fig. 5-11. Isolating dc imbalance by setting all MODE switches to OFF. Simplified block diagram shows normal dc-balance conditions that can be expected.

dc originates in that Switched Amplifier. If none of the traces appear on the screen, then the trouble is probably in the Output Amplifier.

Another quick method for isolating dc imbalance is to set all MODE switches to OFF, then the dc-balance voltages for a normal operating unit should be as shown in Fig. 5-11 and a trace should appear near (within ± 1 div.) of the crt electrical center. With the MODE switches set to OFF, all the Switched Amplifiers are disconnected from their associated series diodes (D440 and D443).

With all the Switched Amplifiers disconnected, the Output Amplifier will seek its own dc balance and the presence of the trace indicates that there is proper dc balance in the area between the busses (connecting the Switched Amplifiers to the Output Amplifier) with their associated circuitry and the output of the unit. If no trace appears, then the dc imbalance will have to be traced back through the Output Amplifier to the busses until the cause of the trouble is found.

B. Low Frequency Signal Tracing the Switched Amplifiers, Output Amplifier and Internal Trigger Stages.

Use this signal-tracing information for checking amplitude, polarity and dc level of the calibrator signal at various test points in the Type 3A74 4-channel Switched Amplifier circuitry. The technique used here is limited to the low frequencies because a 30" flexible cable extension is used to operate the Type 3A74 out of the oscilloscope vertical plug-in opening. Using the cable extension permits all sides of the Type 3A74 to be easily accessible for detailed signal tracing and troubleshooting.

After you have succeeded in isolating the trouble, making the repair, and getting the Type 3A74 to work properly when using the calibrator signal, then it is easy to go directly to the Calibration procedure to check square-wave response or to recalibrate the portion of the unit that was repaired, or to completely recalibrate the unit.

IMPORTANT

The amplitude and dc levels of the waveforms are intended to be used as a guide and are not absolute. They may vary due to control settings, normal manufacturing tolerances and characteristics of Zeners, transistors and tubes. In addition the power-supply voltages applied to the Type 3A74 vary between oscilloscopes within their tolerances.

To signal trace the 4-channel Switched Amplifier stages using channel 1 as an example, proceed as follows:

1. Set the Type 3A74 front-panel controls as follows:

AC-GND-DC (Channel 1)	DC
AC-GND-DC (Chan. 2, 3, and 4)	GND
VOLTS/DIV. (Channel 1)	5
VAR. GAIN (Channel 1)	CAL.
MODE (Channel 1)	NORM.
MODE (Chan. 2, 3 and 4)	OFF
POSITION (Channel 1)	Centered
CHOP.-ALT.	Either position
TRIGGER	See applicable waveforms

2. Connect a 30" flexible cable extension (item 7, Tektronix Part No. 012-066) between the Type 3A74 and the oscilloscope interconnecting socket in the vertical plug-in opening.

3. Apply 10 volts calibrator signal to the Type 3A74 channel 1 Input connector and to the Ext. Trig. Input connector on the test oscilloscope (item 4). Use patch cords, items 8 and 9 in the Test Equipment list to make the connections.

4. Connect a third lead (item 10) between the test oscilloscope ground terminal and the oscilloscope used with the Type 3A74 ground terminal. (Eliminates need for probe ground lead.)

5. Set the test oscilloscope input coupling switch to AC.

6. Touch the test oscilloscope probe tip to the CAL. Out connector and set the test oscilloscope front-panel controls to display two cycles of the calibrator waveform. Be sure to set the test oscilloscope triggering controls for external triggering and to display the first $\frac{1}{2}$ -cycle of the waveform as positive-going. Compensate the probe (if necessary). The displayed waveform should correspond to the Chan. 1 Input Connector waveform as shown in (a) at the end of this section. Disconnect the probe.

7. Touch the probe tip to the desired test point in the Type 3A74 circuitry. Set the test oscilloscope Volts/Div. switch to obtain a suitable amplitude display.

8. Check amplitude and phase of waveform. Compare the waveform with the appropriate illustration at the end of this Section. Disconnect the probe.

9. Set the test oscilloscope input coupling switch to DC. Preset the test oscilloscope Volts/Div. switch such that the expected dc voltage to be measured in step 10 will keep the trace within the graticule-marking area. Ground the probe tip to the Type 3A74 chassis and position the trace to establish a zero reference point.

10. Touch the probe tip to the same test point you used in step 7 of this procedure. Measure the dc level from the reference point established in step 9 to the same dc-level point indicated on the appropriate waveform at the end of the Section. Disconnect the probe.

11. Continue on to the next test point and repeat steps 7 through 10 until you reach a test point where an abnormal indication is obtained. Then proceed with detailed troubleshooting checks to find the cause of the trouble. Such checks usually consist of transistor or tube substitution, and voltage and resistance checks.

If you have replaced a defective soldered-in type of component and substituted tubes or transistors, return the good tubes or transistors to their original sockets. Such a procedure, if followed, results in less recalibration of the Type 3A74 upon completion of the servicing.

If you want to signal trace some other channel than channel 1, simply apply the calibrator signal to that channel and set the Type 3A74 front-panel controls for that channel similar to those used for channel 1. Set channel 1 MODE switch to OFF.

C. Checking Square-Wave Response.

In general, the best way to isolate square-wave distortion troubles is to go to the Calibration Section of this manual. The Calibration section describes the proper setup required for checking square-wave response and how to make the compensation adjustments properly. If you perform steps 13, 18, 19, 20, and 21 in the calibration procedure, they will furnish you an orderly approach for isolating a poor square-wave response type of trouble.

Causes of square-wave distortion are best found only by careful, detailed, voltage and resistance checks. If a component is suspected as a possible cause, substitution may prove the best method for finding it.

Part II—Troubleshooting the Channel Switching Circuits**A. Signal Tracing**

The technique of signal tracing the Switching Circuits is similar to the technique described for low-frequency signal-tracing. That is, the technique of checking the amplitude and dc level of the signal at the various test points. A wide-band test oscilloscope should be used for signal tracing as described in the Test Equipment list (item 4b). A short probe ground lead should also be used to minimize wave-form distortion.

Waveforms at the various important test points are shown on the Channel Switching Circuit diagram. The Type 3A74 CHOP.-ALT. switch setting, the test oscilloscope vertical-and-horizontal deflection factors, the waveshape, amplitude, and dc levels are all shown for quick troubleshooting.

B. Voltage Table

As an aid to making detailed voltage checks in the Blocking Oscillator and Blanking Pulse Regenerator circuitry, Table 5-6 is provided. This table gives typical voltage readings obtained when the CHOP.-ALT. switch is set to CHOP. and then to ALT.; all MODE switches were set to NORM. and the time base was set for a 0.1 mSec/Div. free-running sweep rate. A 30" flexible cable extension was used between the Type 3A74 and the associated oscilloscope.

Voltages obtained when channel 1 is turned on are indicated on the 4-Channel Switched Amplifier and channel Switching Circuit diagrams. If some other channel is turned on and the others are turned off, the voltages for the turned-on channel will be the same as those given for channel 1.

TABLE 5-6**Q590 and V533B VOLTAGE MEASUREMENTS**

Location	CHOP.-ALT. Switch Setting	
	CHOP.	ALT.
Q590 Emitter	-1.2	0
Q590 Collector*	-11.8	-12
V533B, pin 1	+294	+298
V533B, pin 2*	-12	-12
C595/D595 Junction	+14	-0.6

*Meter loading at these points may prevent the Blocking Oscillator from operating.

ADJUSTMENTS FOLLOWING REPAIR**Calibration Checks to Make**

When servicing the Type 3A74, a repair or an adjustment may affect the operation of another circuit. Table 5-7 shows the minimum calibration checks that should follow any repair or adjustment made in the area listed in the first column.

TABLE 5-7

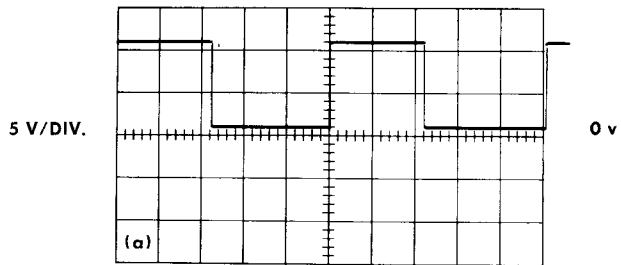
Repair Made In This Area	Calibration Steps to be checked																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
+50-Volt Supply	X																					
Attenuators*												X	X									
Channel Amplifier*		X		X	S	S		X	S												X	
Output Amplifier							X											X	X	X	X	
Internal Trigger Stages														X	X	X	X					
Ring Counter										X	X											X
Blocking Oscillator										X	X											
Sync Pulse In E.F.										X												
Blanking Pulse Regenerator											X											

"X" in any boxed area denotes the calibration step to be checked. Refer to the Calibration section to find the calibration step.

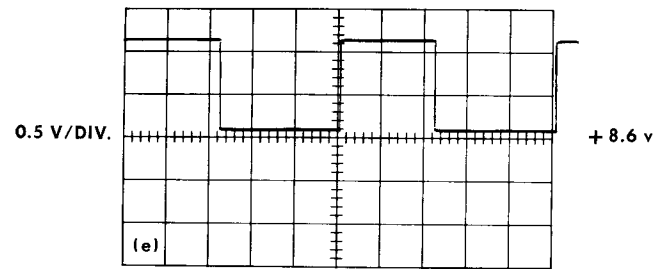
*Perform the calibration check for the channel that was repaired. The other channels do not require recalibration.

"S" in a boxed area denotes an operational check of a specific component; for example, step 5 is "Check Input Coupling Capacitor C401 for Leakage". Perform this step to check out the replaced component.

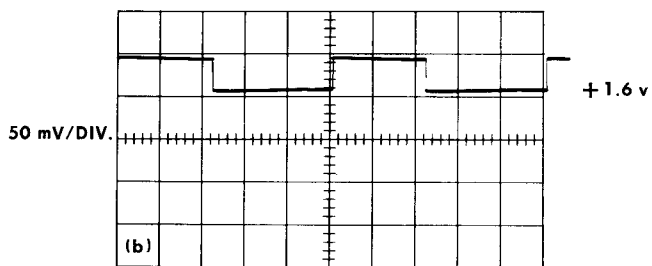
Chan. Input Connector (Input Signal)



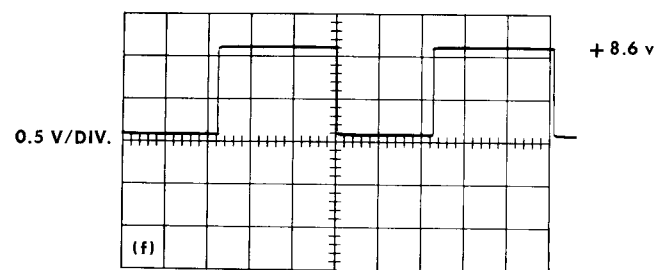
Q444 Collector



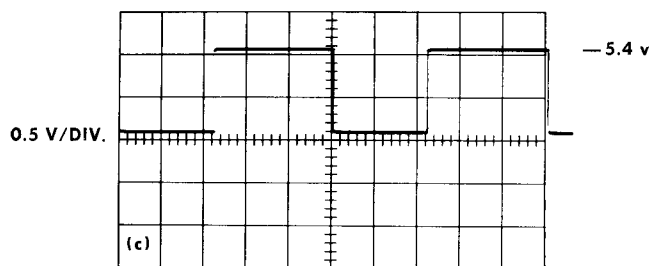
Pin 8 of V423



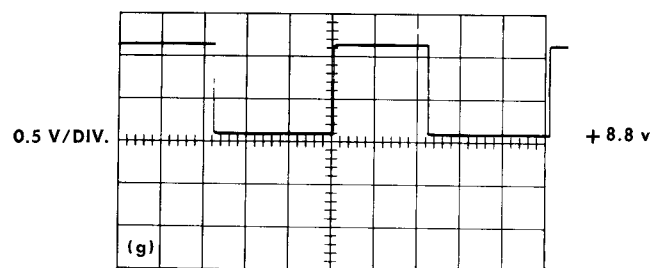
Q454 Collector



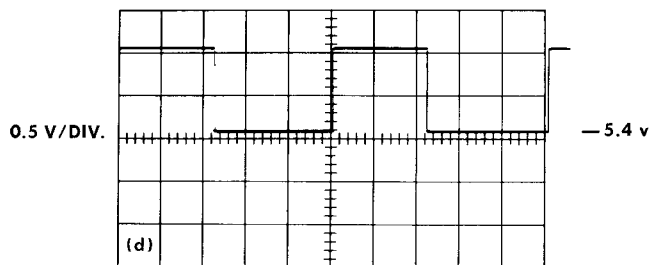
Q424 Collector



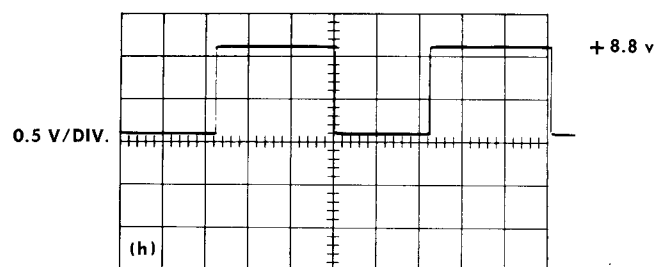
Q463 Emitter



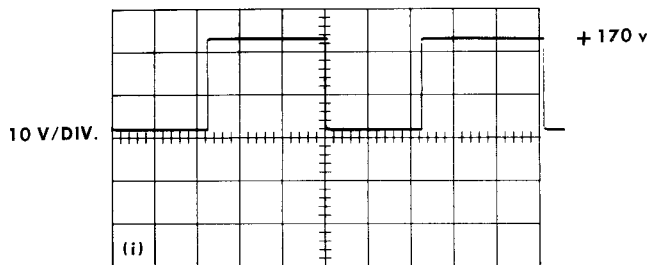
Q434 Collector



Q473 Emitter

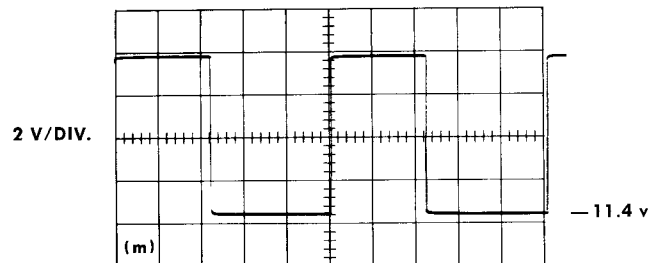


Pin 6 of V464

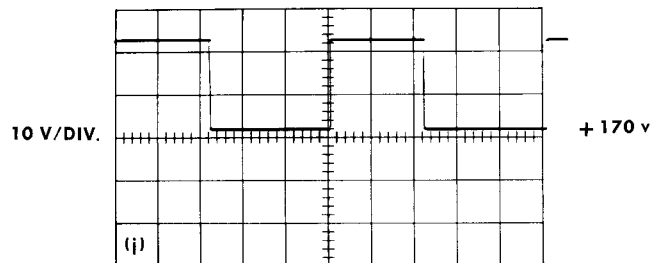


Pin 7 of V533A

CH 1 ONLY

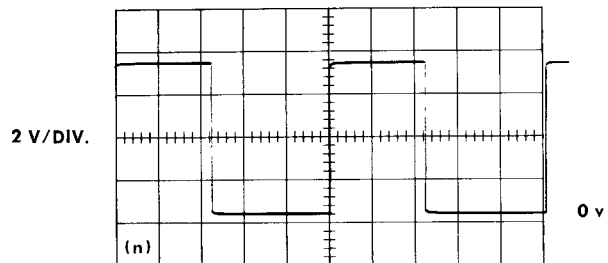


Pin 6 of V474

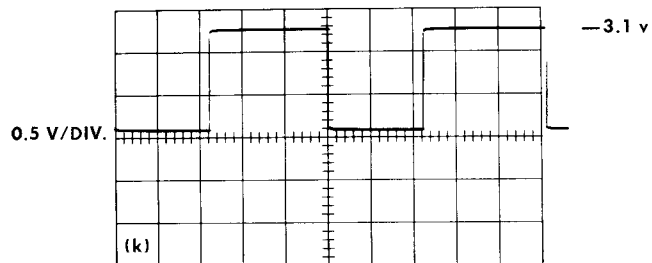


Pin 8 of V533A

CH 1 ONLY

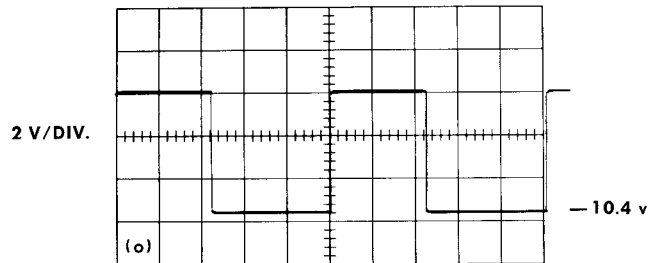


Q504 Collector



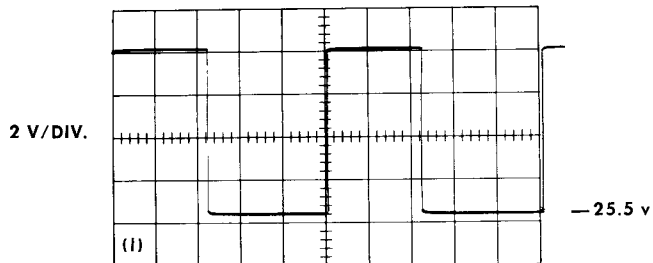
Pin 7 of V533A

Composite



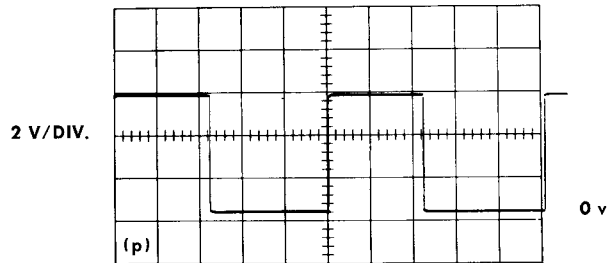
Q524 Collector

CH 1 ONLY



Pin 8 of V533A

Composite



SECTION 6

CALIBRATION PROCEDURE

Introduction

The following procedure should be used to check the operational standards and to calibrate the Type 3A74. The unit should not require frequent calibration, but occasional adjustments will be necessary when tubes and other components are changed. Also, a periodic recalibration is desirable from the standpoint of preventive maintenance.

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

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

NOTE

Calibration steps may be performed out of sequence, or a single step may be performed individually. However, it may be necessary to refer to the preceding step(s) and/or preliminary procedure for additional setup information, such as the proper front-panel control settings, test equipment required, and interconnecting cables or patch cords required and the manner in which they are connected. In addition, allow a 15-minute warm-up period when the oscilloscope used with the Type 3A74 is first turned on.

EQUIPMENT REQUIRED

The following equipment is required to perform a complete calibration of the Type 3A74 Four-Trace Amplifier Plug-In Unit.

- (1) Oscilloscope, Tektronix Type 560-Series Oscilloscope which accepts the Type 3A74 or equivalent. The oscilloscope must operate properly.
- (2) Type 2B67 (or 67) Time-Base Plug-In Unit, or equivalent. Required for use with item 1 to produce horizontal (X-axis) deflection. Not required if item 1 has its own internal time-base circuitry such as the Type 565 Dual-Beam Oscilloscope. Specifications of time-base: sweep rates—0.5 millise/c/div., 1 millise/c/div., 2 μ se/c/div. (calibrated), 0.2 μ se/c/div. (calibrated); internal triggering.
- (3) Type 3A74 Four-Trace Amplifier Plug-In Unit (optional). If available, this unit can be used to perform step 22 in the calibration procedure.
- (4) Test Oscilloscope with 10X Probe. Required specifications: ac coupled; bandwidth, 10 mc or higher, flat response 2 cps to 2 mc; calibrated vertical deflection factors—1 volts/div. Sweep rates—50 μ se/c/div., 1 μ se/c/div. (calibrated), 2 μ se/c/div. (calibrated), 5 μ se/c/div. 0.4 μ se/c/div. (5X magnification of 2 μ se/c/div., calibrated).
- (5) Amplitude Calibrator. For use in performing step 12 in the calibration procedure. Required if item 1 or 4 does not have its own calibrator with the following peak-to-peak output amplitudes in volts: 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, and 50; peak-to-peak amplitude accuracy of $\pm 3\%$ or better.
- (6) Square-wave generator, Tektronix Type 105 or equivalent. Required specifications: 13-nsec or less risetime into a 50-ohm cable terminated at both ends; output frequencies of approximately 1 kc, 10 kc, and 100 kc; output amplitude variable from approximately 10 to 100 volts across its 600-ohm internal load.
- (7) Sine-wave generator, Tektronix Type 190B Constant-Amplitude Signal Generator or equivalent. Required specifications: output frequencies of 50 kc (reference) and 2 mc; output amplitude must be adjustable (manually or automatically) for a constant amplitude of 0.08 volts at the stated frequencies.
- (8) Dc Voltmeter, Sensitivity of at least 20,000 Ω /volt.
- (9) 47 pf Input Time Constant Standardizer, (nominal) 2X voltage attenuation equipped with one BNC plug and one BNC jack connector fittings, Tektronix Part No. 011-068.
- (10) 5XT 50-ohm attenuator with one BNC plug and one BNC jack connector fittings, Tektronix Part No. 011-060.
- (11) 50-ohm termination with one BNC plug and one BNC jack connector fittings, Tektronix Part No. 011-049.
- (12) Adapter, single binding post fitted with a BNC plug. Binding post accepts a banana plug. Tektronix Part No. 103-033.
- (13) Coaxial connector adapter with BNC jack and UHF plug connector fittings. Tektronix Part No. 103-015. Required if test equipment is equipped with UHF jack connector fitting.
- (14) 50-ohm (nominal impedance) coaxial cable, 42 inches long with BNC plug connectors on each end, Tektronix Part No. 012-057.
- (15) 30" flexible cable plug-in extension for operating the Type 3A74 away from the oscilloscope, Tektronix Part No. 012-066.
- (16) Miscellaneous
 - 1—Jumper lead, 2' long, with insulated test prods on each end.
 - 1—Small screwdriver, shank about 2" long, 3/32" to 1/8" wide bit.
 - 1—Low capacitance alignment tool, consisting of a handle (Part No. 003-307), a gray nylon insert with a wire pin (Part No. 003-308), and a nylon insert with a metal screwdriver tip (Part No. 003-334).

PRELIMINARY PROCEDURE

- a. Remove the left-side panel from the oscilloscope.

NOTE

As you go through the procedure, various interconnecting plug and/or socket pins are called out as test points. Since different types of 560-Series oscilloscopes can be used with the Type 3A74 being calibrated, test-point accessibility differs from oscilloscope to oscilloscope due to their physical layout. Therefore, remove any additional panels, as required, during the procedure.

- b. Connect a 30" flexible cable plug-in extension (item 5) to the Type 3A74 interconnecting plug and to the oscilloscope interconnecting socket located in the vertical opening (Y-axis) of the oscilloscope.
- c. Install a (real-time) time-base unit (item 2) in the oscilloscope for horizontal deflection of the beam, if the associated oscilloscope requires a time-base unit.
- d. Connect the power cord of the oscilloscope to the proper operating voltage for which the oscilloscope is wired.
- e. Turn on the oscilloscope and allow about 15 minutes for warm-up and complete stabilization.
- f. Preset the Type 3A74 front-panel controls (all channels) as follows:

AC-GND-DC	DC
VOLTS/DIV.	.02
VAR. GAIN	CAL.
POSITION	Midrange
MODE	OFF
CHOP.-ALT.	ALT.
TRIGGER	Pushed in

- g. Preset the Type 2B67 Time-Base Unit or equivalent as follows:

Time/Div.	.1 mSEC
Variable Time/Div.	Calibrated
Mode	Norm.
Triggering Level	Free Run*
Triggering Slope	+
Triggering Coupling	AC Slow**
Triggering Source	Int.
Position	Centered
5X Mag.	Off

*Use Auto. or Line Triggering if your time-base does not have a Free Run switch position to obtain a trace on the crt.

**Use AC if your time base does not have an AC Slow switch position.

CALIBRATION PROCEDURE

1. Check Zener Regulated Voltage

- a. Connect a dc voltmeter between the D494/R494 junction (see Fig. 6-1) and ground.

- b. Meter reading should be +50 volts, within a tolerance of 5 volts.
- c. Disconnect the voltmeter.

CAUTION

When connecting to test points in the Type 3A74 or to the interconnecting plug and socket pins, be sure to use test prods or probe tips that are completely insulated, except for the very tip, to avoid accidental shorts to adjacent leads or connections.

2. Adjust DC BAL. (All Channels)

- a. Set channel 1 MODE switch to NORM.
- b. Adjust the oscilloscope Intensity control for desirable trace brightness.
- c. Adjust channel 1 DC BAL. control for minimum vertical trace shift as the channel 1 VAR. GAIN control is rotated several times from the CAL. detent position clockwise to minimum gain and back again.
- d. After adjusting the DC BAL. control, set the VAR. GAIN control to the CAL. position.
- e. Set channel 2 MODE switch to NORM. and repeat steps 2a, 2c and 2d using the appropriate channel 2 controls.
- f. After adjusting channel 2 DC BAL. control, proceed in the same manner (using steps 2a, 2c, and 2d as a guide) to adjust the DC BAL. controls for channels 3 and 4.

NOTE

If the DC BAL. control for a channel does not have sufficient range, there may be excessive dc imbalance between tubes V423 and V433 in that channel. Replace the tube causing the greatest imbalance, allow about 15 minutes warm-up time, and repeat step 2.

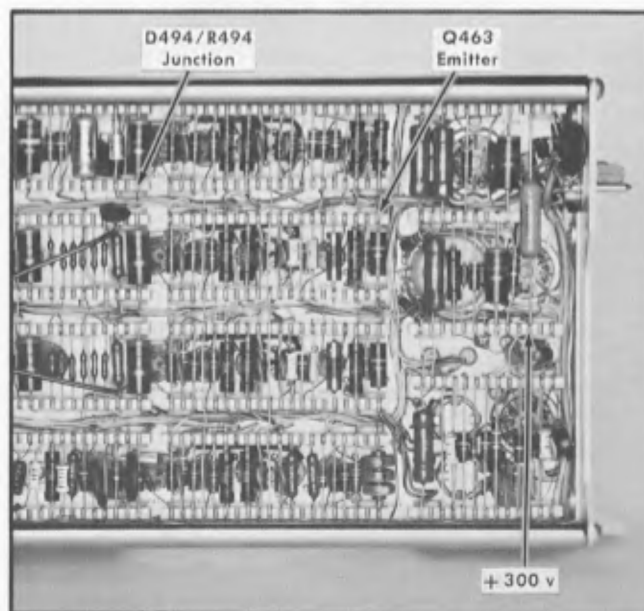


Fig. 6-1. Right side view, rear portion of the Type 3A74, showing the location of the test points.

3. Adjust POSITION RANGE R449

- Using a small screwdriver, short the plates (pin 6) of V464 and V474 together. Fig. 6-2 shows the location of the pin 6 leads.
- Note the exact position of the trace; this is the electrical center of the crt vertical deflection plates.
- Remove the short circuit.
- With all the Type 3A74 POSITION controls set to midrange and the MODE switches set to NORM., adjust the POSITION RANGE R449 control (see Fig. 6-2) to center all the traces as a group at the crt electrical center.

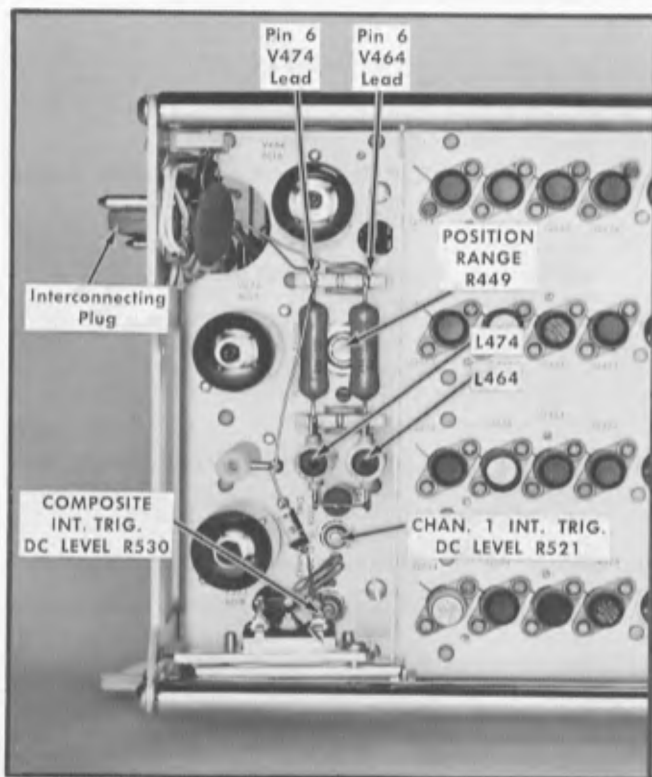


Fig. 6-2. Left side view, rear portion of the Type 3A74, showing location of test points, adjustments, and interconnecting plug.

NOTE

In a normal operating unit, when completing step 3d, the group of traces should fit within an area one major division above and below electrical center. If one trace is separated from the rest outside this ± 1 major division area, Q424 or Q434 or the DC BAL. control in that channel could cause the dc imbalance. Also, check for possibility of a bad switching diode—D440, D441, D442, or D443.

4. Check Input Amplifier Output Voltage Balance (All Channels)

IMPORTANT

Make certain step 2 has been performed properly. Any dc imbalance introduced by an improperly set DC BAL. adjustment can cause the trace to shift more than 1.5 major divisions.

- Set all MODE switches, except channel 1 MODE switch, to OFF.
- With channel 1 MODE switch at the NORM. position, note the position of the trace.
- Set channel 1 MODE switch to INV.
- Note the amount of trace shift compared to step 4b. Trace shift should be less than 1.5 major divisions.
- After completing the check, set channel 1 MODE switch to OFF.
- Using steps 4a through 4e as a guide, set the MODE switch for channel 2 to NORM. and then to INV., check the amount of trace shift, then repeat the procedure for channels 3 and 4.

NOTE

Step 4 mainly checks the push-pull balance of Q424 and Q434 in each channel. If the dc beta of these transistors closely match each other, trace shift will not exceed the amount stated in step 4d.

5. Check Input Coupling Capacitor C401 for Leakage (All Channels)

- Connect a binding post adapter (item 12) to the channel 1 input connector.
- Set channel 1 AC-GND-DC switch to GND and the MODE switch to NORM.
- Vertically position the Channel 1 trace to the graticule center using the channel 1 POSITION control.
- Connect a 2' (approx.) jumper lead with insulated test prods between the +300 volt test point (see Fig. 6-1) and the channel 1 Input connector center conductor.

CAUTION

Use care in making the connections to prevent grounding the +300 volts.

- Set channel 1 AC-GND-DC switch to AC. Note the trace position when it returns to the crt viewing area. Final trace displacement should be less than two major division from the original position.
- After completing the check for channel 1, disconnect the jumper lead and set channel 1 MODE switch to OFF.
- Using steps 5a through 5f as a guide, check input coupling capacitor C401 for leakage in each of the remaining channels.

6. Check for Grid Current and Microphonics (All Channels)

This step checks the Input CF tube V423 of each channel for grid current and checks both V423 and V433 in each channel for microphonics under no-signal conditions.

- Set channel 1 MODE switch to NORM. (Check that the other MODE switches are set to OFF.)
- Set channel 1 AC-GND-DC switch to GND and note the amount of vertical trace shift, if any. Trace shift due to grid current should not exceed one minor division.
- Tap lightly on the front panel of the Type 3A74; at the same time, check for excessive microphonics. Amplitude of the microphonics should not exceed one major division.
- Set channel 1 MODE switch to OFF.
- Using steps 6a through 6d as a guide, check channels 2, 3 and 4 individually for grid current and microphonics.

7. Adjust Output Amplifier Gain

- Set the oscilloscope Calibrator, or equivalent, for an output of 0.1 volt peak-to-peak.
- Connect a coaxial cable with BNC cable with BNC plug connectors on each end (item 4) between the Calibrator output connector and the channel 1 connectors. (Use a coaxial connector adapter, item 13, to complete the connections if required.)
- Set channel 1 AC-GND-DC switch to DC.
- Place channel 1 MODE switch to NORM.
- Set the time-base Time/Div. switch to .1 mSec.
- Rotate channel GAIN ADJ. control fully clockwise.
- Connect the probe from a test oscilloscope (item 4) to the emitter of Q463 (see Fig.6-1).

NOTE

To differentiate between the two oscilloscopes used in this calibration procedure, the term "test oscilloscope" is item 4 while the term "oscilloscope" is item 1.

- Rotate the Type 3A74 VAR. GAIN control so the calibrator waveform displayed on the test oscilloscope crt is 2 volts peak-to-peak in amplitude.
- Connect the probe from the test oscilloscope to pin 6 lead of V464 (see Fig. 6-2).
- Adjust the Type 3A74 CALIB. control so the calibrator waveform displayed on the test oscilloscope is 40 volts peak-to-peak in amplitude.

NOTE

This step sets the voltage gain of the Output Amplifier 2nd Stage for a nominal gain of 20.

- Connect the probe from the test oscilloscope to pin 6 lead of V474 (see Fig. 6-2) and check that the calibrator waveform displayed on the test oscilloscope is 40 volts peak-to-peak, within a tolerance of 2 volts.

- Disconnect the probe from the pin 6 lead of V474.

8. Adjust Input Amplifier Gain (All Channels)

- Remove the flexible-cable plug-in extension.
- Insert the Type 3A74 directly into the vertical plug-in opening of the oscilloscope.
- Rotate channel 1 VAR. GAIN control to the CAL. detent position.
- With 0.1-volt calibrator signal applied to channel 1, rotate channel 1 GAIN ADJ. control to obtain a deflection of exactly five major divisions.

NOTE

Use the channel 1 POSITION control for aligning the display with the graticule markings to aid in setting the gain accurately.

- Set channel 1 MODE switch to OFF.
- Disconnect the signal from the channel 1 Input connector and apply the signal to channel 2.
- Set channel 2 AC-GND-DC switch to DC and the MODE switch to NORM.
- Adjust channel 2 GAIN ADJ. control for proper vertical deflection as explained in step 8d. Then, set channel 2 MODE switch to OFF.
- Apply the signal to channel 3. Using steps d through h as a guide, adjust channel 3 GAIN ADJ. control for proper deflection. Then set channel 3 MODE switch to OFF and repeat the procedure for channel 4.
- After adjusting channel 4 GAIN ADJ. control, leave channel 4 MODE switch set to the NORM position.

9. Check VAR. GAIN Control (All Channels)

- With the display five major divisions peak-to-peak, rotate channel 4 VAR. GAIN control clockwise out of the detent or CAL. position so the control is set for minimum gain. The display should be no more than 2 major divisions. This indicates that the attenuation ratio of the VAR. GAIN control is at least 2.5 to 1.
- Continue to rotate the channel 4 VAR. GAIN control in a clockwise direction and check for smooth electrical operation throughout its entire range. (If rotation of the VAR. GAIN control causes erratic jumping of the trace, clean or replace the control.)
- After checking the control, set the control to the CAL. detent position and set channel 4 MODE switch to OFF.
- Apply the calibrator signal to channel 3 Input and set channel 3 MODE switch to NORM.
- Adapt steps 9a through 9c for checking the channel 3 VAR. GAIN control. Then, check the VAR. GAIN controls for channels 2 and 1.
- Disconnect the coaxial cable.

10. Check Alternate Mode Operation

- Set channel 2 MODE switch to NORM.

11. Check Chopped-Mode Operation

- Set the oscilloscope Time/Div. switch to $1 \mu\text{Sec}/\text{Div.}$
- Set the Type 3A74 CHOP.-ALT. switch to CHOP.
- Check the chopped segments of the trace for an "on time" duration of $2 \mu\text{sec}$, within a tolerance of $0.4 \mu\text{sec}$ (see Fig. 6-3). If the segments are within the specified time duration, the Blocking Oscillator stage is operating at a repetition rate of 500 kc, within a tolerance of 25%.

NOTE

Use the time-base triggering level control in this and succeeding steps, when necessary, to obtain a stable display. Also, use the POSITION controls to vertically position the display to a desired position on the crt.

- Connect the probe from the test oscilloscope to pin 24 of the oscilloscope vertical-amplifier interconnecting socket. Check that the amplitude of the blanking pulse is 50 volts or more in amplitude (see Fig. 6-4). (If the amplitude is lower than 50 volts, V533 may need replacing.) Leave the probe connected while performing step 11e to check for at least 50 volts amplitude.
- Check display on oscilloscope used with the Type 3A74 for proper "on" time duration ($2 \mu\text{sec}$, $\pm 0.4 \mu\text{sec}$) of each segment as channel 4, and then channel 3 MODE switches are set to OFF.
- Disconnect the probe from the test point.
- Set channel 2 MODE switch to OFF and check for a continuous (no-chopped) channel 1 trace.
- Set the oscilloscope Time/Div. switch to 1 mSec.
- Set channel 2, 3 and 4 MODE switch to NORM.
- If your oscilloscope has a CRT Cathode Selector Switch, set this switch to the Chopped Blanking position.
- At normal trace intensity check the width (thickness) of the traces. Trace width should be less than one-half minor division. (If a trace is too wide due to excessive tilting or distortion of the trace segments, a defective series or shunt switching diode—D440, D441, D442, or D443—could cause the trouble.)
- Set channel 2, 3, and 4 MODE switches to OFF.

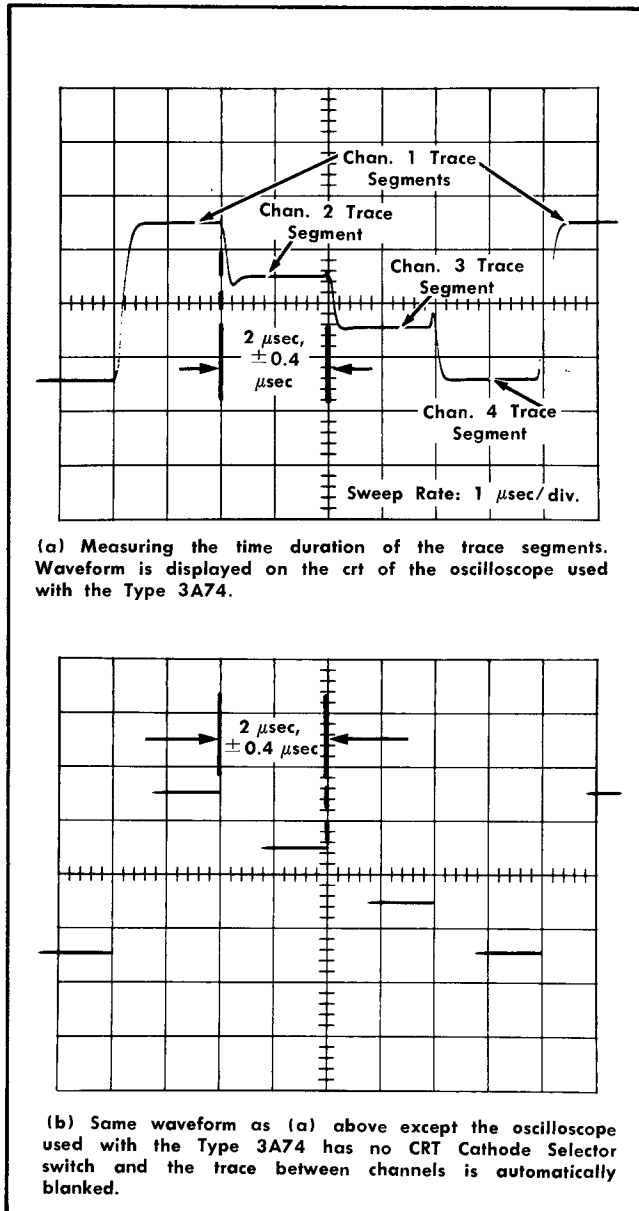


Fig. 6-3 Checking the free-running repetition rate of the Blocking Oscillator stage.

- Vertically position channel 1 and 2 traces so that channel 1 trace is located about one major division above channel 2, and they are both located slightly above the center graticule line.
- Set the oscilloscope Time/Div. switch to various sweep rates and check that the traces run sequentially across the face of the crt.
- Set channel 3 MODE switch to NORM. and vertically position channel 3 trace about one major division below channel 2 trace. Repeat step 10c.
- Set channel 4 MODE switch to NORM. and vertically position channel 4 trace about one major division below channel 3 trace. Check alternate-mode operation of all four channels using various sweep rates. The traces should always run in a 1-2-3-4 sequence down the crt.

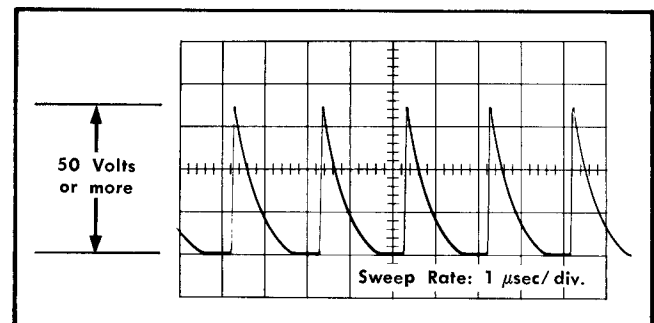


Fig. 6-4. Typical chopped-mode blanking pulse waveform as displayed on the test oscilloscope crt. Vertical deflection factor: 20 volts/div.

- m. Set the oscilloscope CRT Cathode Selector switch to Ext. CRT Cathode.

12. Check Volts/Div. Attenuation Ratios (All Channels)

- a. Apply a 0.1-volt signal from an amplitude calibrator through a coaxial cable to the channel 1 Input connector.
- b. Align the display with the horizontal graticule lines using the channel 1 POSITION control.
- c. Check for proper vertical deflection at each Volts/Div. switch position by using Table 6-1 as a convenient guide. If an oscilloscope calibrator is used as the signal source, the display-amplitude worst-case tolerance at each attenuator position can be $\pm 6\%$. (VOLTS/DIV. attenuators and oscilloscope calibrator tolerances are each $\pm 3\%$. At the factory, a $\pm 1/4\%$ calibrator was used to check the attenuation accuracy of the Type 3A74).

If the calibrator you are using has an accuracy better than $\pm 3\%$, then check the attenuation ratios based on the better accuracy.

TABLE 6-1

Volts/Div. Switch Attenuation Check

Volts/Div. Switch Setting	Amplitude Calibrator Output (peak-to-peak)	Vertical Deflection in Major Div.
.02	.1 volt	5
.05	.2 volt	4
.1	.5 volt	5
.2	1 volt	5
.5	2 volts	4
1	5 volts	5
2	10 volts	5
5	20 volts	4
10	50 volts	5

- d. After completing the check for channel 1 VOLTS/DIV. attenuation ratios, set the amplitude calibrator to 1 volt.
- e. Set channel 1 VOLTS/DIV. switch to .02 and the MODE switch to OFF.
- f. Set channel 2 MODE switch to NORM. and apply the calibrator signal to channel 2 Input connector.
- g. Check the attenuation ratios of channel 2, then channel 3, and finally channel 4, using steps 12b through 12e as a guide.
- h. After checking the attenuation ratios for all the channels, disconnect the calibrator signal from the channel 4 Input connector.

13. Set Input-Capacitance and Adjust Attenuator Compensation (All Channels)

This step describes how to properly adjust the input shunt capacitance of each channel so the input time con-

stant is the same for each position of the VOLTS/DIV. switch. Thus, an attenuator probe, when compensated to match one setting of the VOLTS/DIV. switch, will work into the same time constant using the other VOLTS/DIV. switch settings. As a result, the probe need not be recompen- sated each time any of the other switch positions are used.

NOTE

An emergency alternate method for standardizing the input capacitance of one channel, using a 10X attenuation probe instead of a 47-pf Input Time-Constant Standardizer, is also included. If a repair is made in the Input Amplifier of a channel (for example, V423 is replaced) and you do not have a time-constant standardizer (item 9), use alternate method as described in the last part of this step.

In addition to standardizing the input time constant, this procedure describes a method for compensating the attenuators so the ac attenuation is equal to the dc attenuation. Since there is some interaction between both sets of adjustments, faster, more accurate results can be obtained by combining both sets of adjustments in one procedure.

To perform the adjustments, proceed as follows:

- a. Turn on the Type 105 Square-Wave generator, or equivalent. Set the generator for an output frequency of 1kc and its output amplitude to minimum.
- b. Connect a 5XT attenuator (item 10) to the output connector of the generator. Use the connector adapter (item 13) if the generator has a UHF jack output connector.
- c. Connect one end of a 50-ohm coaxial cable to the 5XT attenuator and connect the other end of the cable to a 47-pf Input Time-Constant Standardizer (item 9).

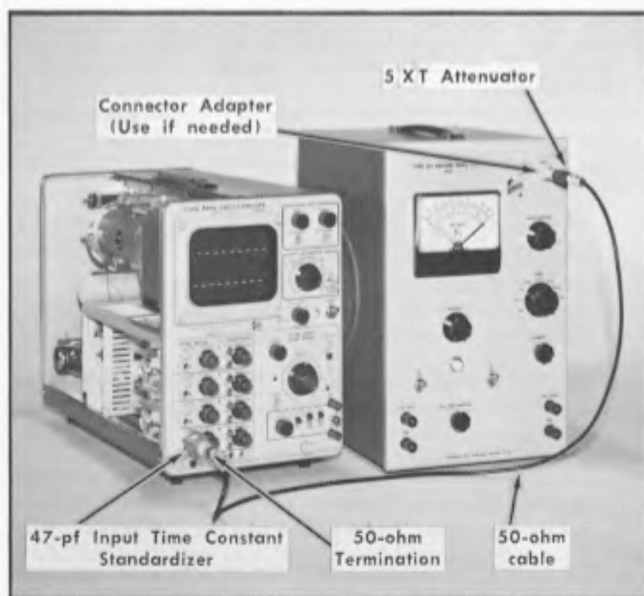


Fig. 6-5. The manner in which the Type 105 Square-Wave Generator should be connected to the Type 3A74 when preparing to adjust C416 (step 13f) in channel 4.

- d. Connect the other end of the standardizer to the channel 4 Input connector. Fig. 6-5 shows the entire setup.

IMPORTANT

Do not use 47-pf Input Time-Constant Standardizer that requires the use of a UHF-to-BNC connector adapter (item 12) between the standardizer and the Input connector of the Type 3A74. If such a combination is used, the input capacitance of the Type 3A74 will be adjusted to some other value than the design center value of 47 pf.

- e. Increase the output amplitude of the square-wave generator to produce a deflection of about 4 major divisions on the crt.

IMPORTANT

Before performing the adjustment procedure described in the following steps, be sure the signal-carrying lead connected between the AC-GND-DC switch and the VOLTS/DIV. switch in each channel

of the Type 3A74 is properly dressed or stays as is. Any change in lead dress in the Input CF grid circuit during the adjustment procedure or afterward means that the following procedure must be repeated to determine if the adjustments are still set properly.

- f. With channel 4 VOLTS/DIV. switch set to .02, adjust channel 4 C416 (see Fig. 6-6) for optimum flat-topped (best square-wave response) waveform. Fig. 6-7a shows the correct waveform to obtain. Waveforms (b) and (c) show result obtained when an input-capacitance adjustment is set incorrectly.
- g. Use Table 6-2 and the following information for adjusting the attenuator adjustments.

Column 1 in Table 6-2 lists the settings of the VOLTS/DIV. switch which connect each of the attenuators into the input circuit of a channel. The variable shunt capacitors and their effect on the waveform are listed in column 2; the frequency compensating capacitors and their effect on the waveform are listed in column 3. Figs. 6-7b through 6-7g waveforms show six types of distortion that can result if the capacitors are incorrectly adjusted. Fig. 6-7a shows the waveform obtained when the capacitors are correctly adjusted for optimum square corner and flat top. Fig. 6-6 shows the physical location of the adjustments.

TABLE 6-2

Input Time-Constant Standardization and Attenuator Compensation

VOLTS/DIV. Switch Setting	Affects Top of Square Wave (Adjust for optimum flat top)	Affects Corner of Square Wave (Adjust for optimum square corner)
.05	C407B	C407C
.1	C409B	C409C
.2*	C403B	C403C
2**	C405B	C405C

* Remove 5XT attenuator for rest of step.

** Remove the 50-ohm termination.

Maintain approximately 4 major divisions of vertical deflection by adjusting the Output Amplitude control on the square-wave generator each time the VOLTS/DIV. switch is moved from one position to the next.

In the .1 VOLTS/DIV. switch position it will be necessary to remove the 5XT attenuator to obtain more signal to drive the Type 3A74. In the 2 VOLTS/DIV. switch position remove the 50-ohm termination and connect the cable from the generator directly to the 47-pf Input Time-Constant Standardizer.

WARNING

To prevent a signal shock hazard, turn the DC-ON-OFF switch to OFF position on the Type 105 before removing the attenuator and termination. After making the proper connections, turn the Type 105 DC-ON-OFF switch to ON and continue with the adjustments.

After completing the channel 4 adjustments, decrease the Type 105 output signal level to minimum and apply the signal to channel 3. (Use the same setup as shown in Fig. 6-5

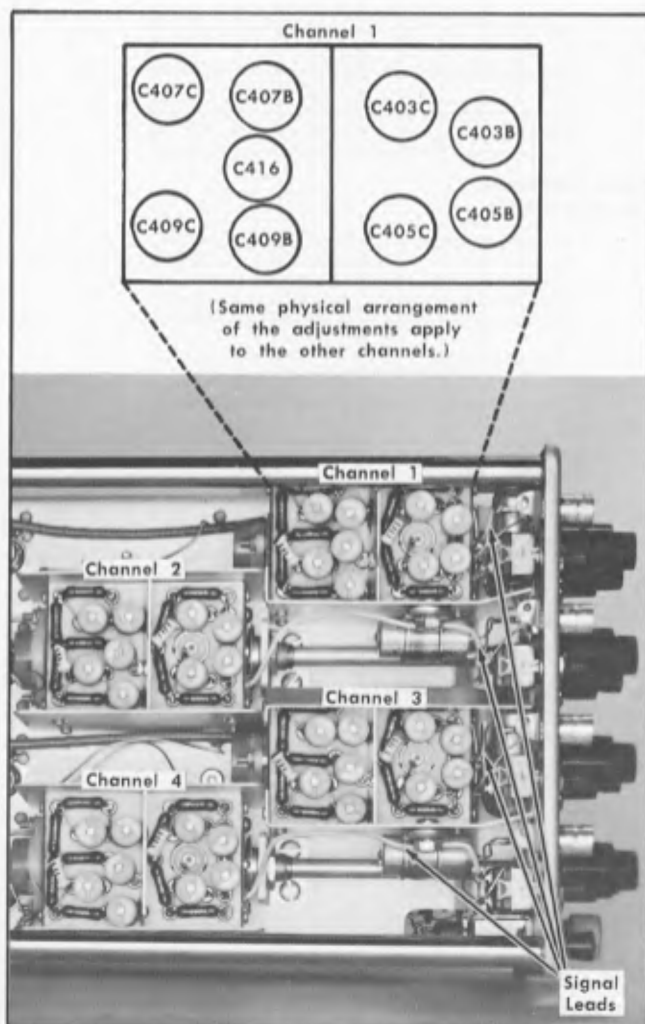
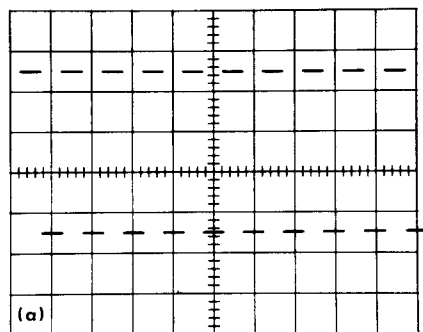
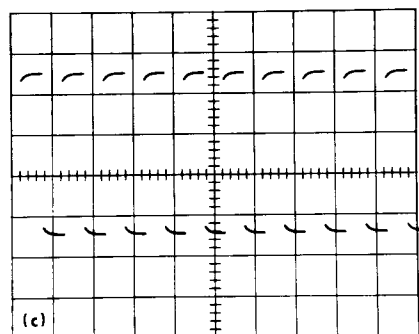
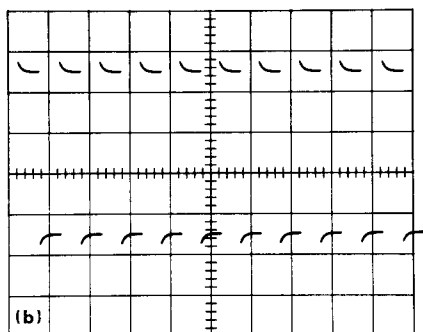


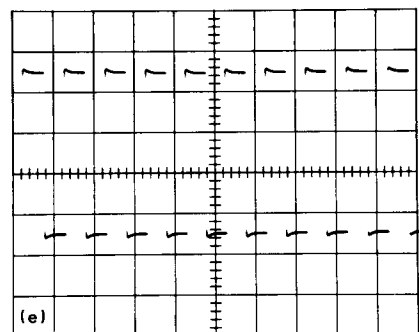
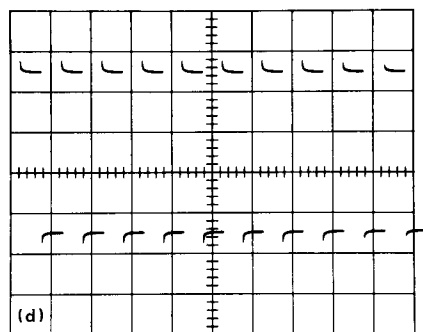
Fig. 6-6. Left side view, front portion of the Type 3A74, showing the location of the shunt capacitance and attenuator compensation adjustments. Location of the signal leads that should not be moved after the adjustments are made are shown.



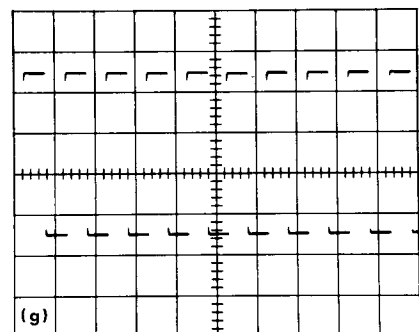
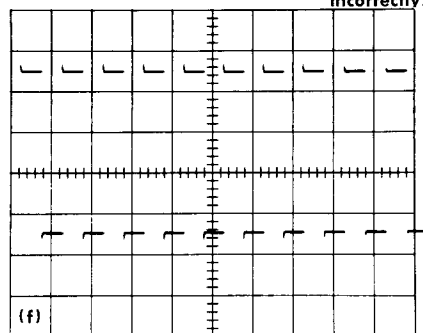
(a) Adjustments set correctly.



(b) and (c) Shunt capacitance adjustment, for example C416 or C407B, set incorrectly.



(d) and (e) Attenuator shunt capacitor (for example C407B) and a compensation adjustment (for example C407C) both set incorrectly.



(f) and (g) An attenuator compensation adjustment, for example C407C, set incorrectly.

Fig. 6-7. Effect caused by adjusting the input shunt capacitors and an attenuator compensation adjustment. Generator frequency is 1 kc and the oscilloscope sweep rate is 1 msec/div.

except that the signal is applied to channel 3.) Set channel 4 MODE switch to OFF and channel 3 MODE switch to NORM. Perform the channel 3 adjustments in the same manner as described for the channel 4 adjustments. Then, repeat the procedure for channels 2 and 1.

After completing the channel 1 adjustments, decrease the Type 105 output level to minimum and disconnect the 47-pf Input Time-Constant Standardizer from the channel 1 Input connector.

Alternate Method

To use a 10X attenuator probe as an emergency standardizer, proceed as follows:

- Connect the cable end of the 10X attenuator probe to a channel that has not been repaired. (We are assuming here that the non-repaired channel is properly adjusted as set at the factory and this channel will be used as the reference.)
- Set the VOLTS/DIV. switch of the reference channel to .02, the AC-GND-DC switch to DC, and the MODE switch to NORM.
- Connect a 5XT attenuator (item 10) to the output connector of the square-wave generator. Set the generator for an output frequency of 1 kc.
- Connect the probe tip to the other end of the 5XT attenuator and connect the probe ground lead to the generator ground. Adjust the generator amplitude control to produce a deflection of four major divisions on the oscilloscope crt.
- Adjust the variable capacitor in the probe for best square-wave response.

The probe is now standardized to match the input time constant of the reference channel. Do not adjust the probe further during the procedure. Disconnect the cable end of the probe from the reference channel and connect it to the channel that needs to be standardized.

With the signal applied to the probe tip, the adjustments listed in step 3 and Table 5-2 can be performed in the same manner as if you are using a 47-pf Input Time-Constant Standardizer.

14. Adjust Composite Int. Trig. DC Level

- Set the time-base triggering Level control to free run the time base.
- Position the channel 1 trace to the graticule horizontal centerline.
- Connect a voltmeter between pin 11 of the left-hand oscilloscope vertical-amplifier interconnecting socket and ground. (If pin 11 is difficult to reach, connect the voltmeter to pin 12 of the right-hand interconnecting socket in the oscilloscope which has an X-axis plug-in compartment.)
- Adjust the COMPOSITE INT. TRIG. DC LEVEL R530 control (see Fig. 6-2) for a zero voltage reading on the voltmeter. Overlook the normal (few tenths of a volt) drift in voltage reading.

15. Adjust Chan. 1 Int. Trig. DC Level

- Pull the TRIGGER switch outward to the CH 1 ONLY position.
- With the voltmeter connected as directed in step 14 and with the trace positioned to coincide with the graticule horizontal centerline, adjust CHAN. 1 INT. TRIG. DC LEVEL R521 control (see Fig. 6-2) for a zero reading on the voltmeter. Overlook the normal (few tenths of a volt) drift in the voltage reading.
- Disconnect the voltmeter.

16. Check Chan. 1 Trigger Output

- Set channel 1 VOLTS/DIV. switch to .02.
- Connect the 5XT attenuator to the output connector of the square-wave generator.
- Connect a 50-ohm coaxial cable to the 5XT attenuator and connect the other end of the cable to a 50-ohm termination.
- Connect the plug-end of the termination to the channel 1 Input connector. (This setup is similar to Fig. 6-5 except the 47-pf Input Time Constant Standardizer is not used.)
- Set the generator frequency for an output of approximately 100 kc.
- Increase the output amplitude from the generator to obtain a vertical deflection of exactly 4 major divisions.

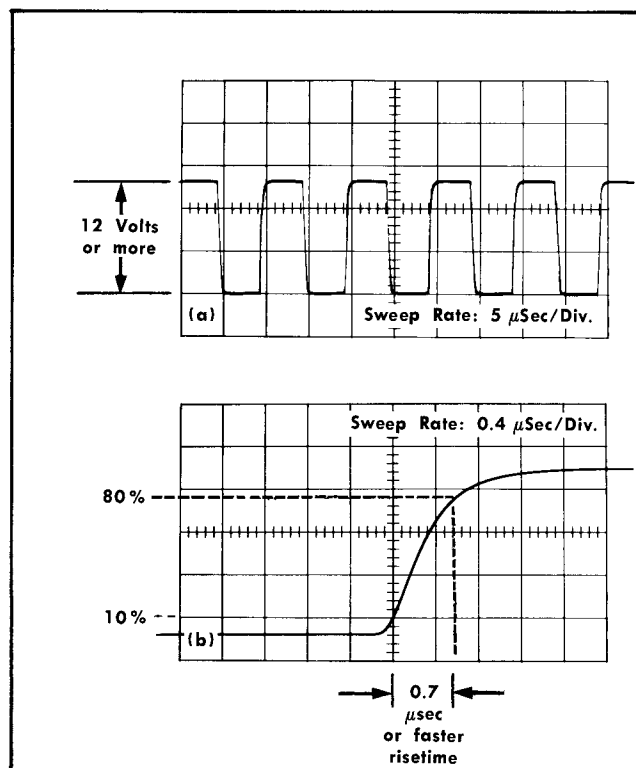


Fig. 6-8. (a) Typical channel 1 only trigger waveform as displayed on the test oscilloscope crt. Vertical deflection factor: 5 volts/div. (b) Measuring the risetime of the waveform. Vertical deflection factor: uncalibrated (see step 16i).

Calibration — Type 3A74

- g. Connect the probe from the test oscilloscope to pin 11 of the oscilloscope Y-axis interconnecting socket. (As mentioned in step 14, pin 12 of the X-axis socket can also be used as the test point.)
- h. Check the waveform display on the test oscilloscope for an amplitude of 12 volts or more (see Fig. 6-8a).
- i. Decrease the vertical deflection factor of the test oscilloscope for increased sensitivity to make the display exactly four major divisions in amplitude on the test oscilloscope crt. (Do not move the Output Amplitude control on the generator.)
- j. Using an appropriate sweep rate on the test oscilloscope ($2 \mu\text{sec}/\text{div.}$ and set 5X Magnifier to "on") measure the risetime between the 10% and 80% amplitude levels on the rising portion of the waveform (see Fig. 6-8b). The risetime should be 0.7 microseconds or faster.

NOTE

The 80% instead of the 90% amplitude level is used in this risetime measurement to exclude the rounded-top portion of the rise. Fig. 6-8b waveform is actually four major divisions in amplitude if viewed at a slower sweep rate so that several cycles of the waveform are displayed as in steps 16i and 16j.

17. Check Composite Int. Trigger Output

- a. Push the Type 3A74 TRIGGER switch in.
- b. Set the square-wave generator for an output frequency of about 10 kc.
- c. Adjust the generator Output Amplitude control to obtain a vertical deflection of 4 major divisions on the oscilloscope used with the Type 3A74.
- d. With the test oscilloscope probe connected to the same test point as described in step 16g and using the calibrated vertical deflection factor on the test oscilloscope, check the amplitude of the waveform. The amplitude should be 9.5 volts or more (see Fig. 6-9).
- e. Disconnect the probe.

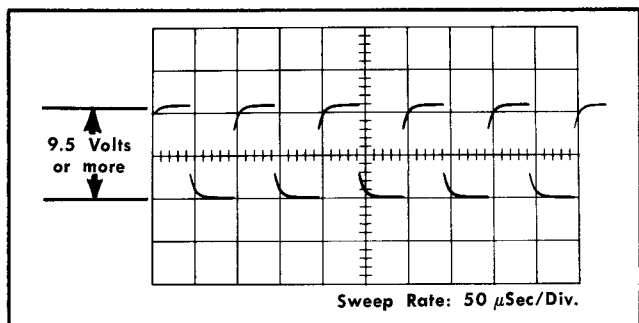


Fig. 6-9. Measuring the amplitude of the composite internal trigger as displayed on the test oscilloscope crt. Vertical deflection factor: 5 volts/div.

18. Adjust High-Frequency Compensation

- a. Set the square-wave generator for an output frequency of about 100 kc.
- b. Set the oscilloscope Time/Div. switch to $1 \mu\text{sec}$ and the Trigger Slope switch to —.
- c. Adjust the oscilloscope Triggering Level control to obtain a stable display.
- d. Adjust the generator Output Amplitude control so the waveform display is four major divisions in amplitude. Readjust the Triggering Level control, if necessary.
- e. Adjust L464 and L474 in equal increments to obtain an optimum square corner (see Fig. 6-10a) on the waveform, without appreciable overshoot and ringing. (Overshoot and ringing should not exceed $\frac{1}{2}$ minor division.) Fig. 6-10b shows one form of waveform distortion when L464 and L474 are improperly adjusted.

19. Check High-Frequency Response of Channels 2, 3 and 4

- a. Disconnect the signal from channel 1 and apply it to channel 2.

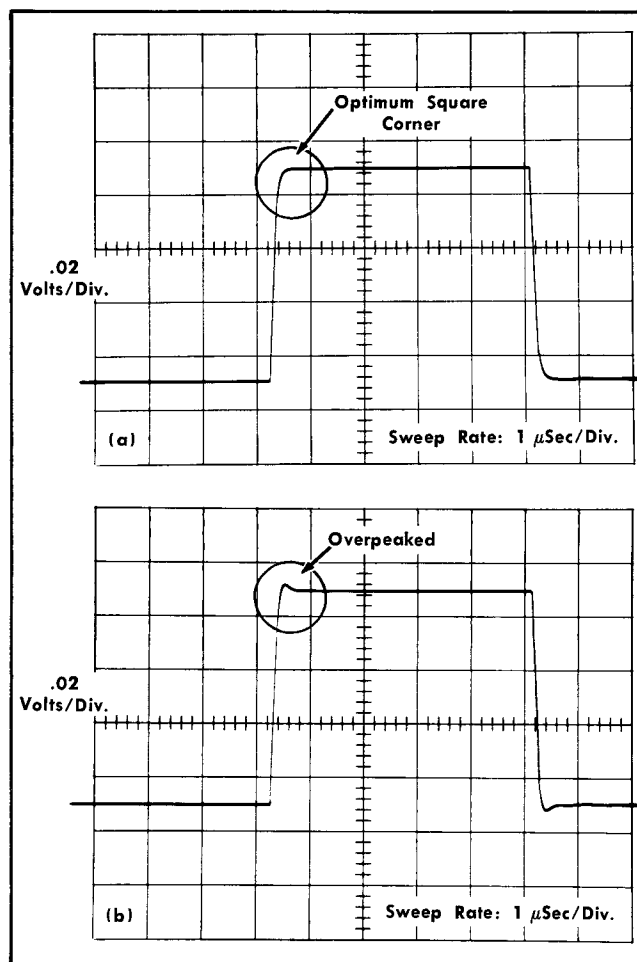


Fig. 6-10. Adjusting the high-frequency compensation of the Type 3A74. (a) L464 and L474 properly adjusted. (b) Overpeaking caused by an incorrect adjustment of L464 and L474.

- b. Set channel 1 MODE switch to OFF.
- c. Set channel 2 VOLTS/DIV. switch to .02 and the MODE switch to NORM.
- d. Check for a similar waveform display to that obtained through channel 1 and as shown in Fig. 6-10a.
- e. Using steps 19a through 19d as a guide, apply the signal to channel 3 and check the waveform. Then, apply the signal to channel 4 and check the waveform.

20. Check Vertical Compression and Expansion

- a. Decrease the output amplitude from the square-wave generator to produce a vertical deflection of 2 major divisions on the oscilloscope crt.
- b. Using the channel 4 POSITION control, position the waveform at the bottom of the graticule. Check that the vertical deflection is 2 major divisions within a tolerance of $\frac{1}{2}$ minor division.
- c. Position the waveform to the top of the graticule and check for a vertical deflection of 2 major divisions within a tolerance of $\frac{1}{2}$ minor division.
- d. Disconnect the signal.

21. Check Bandwidth (all Channels)

- a. Apply 50-kc sine-waves from the Type 190B Constant-Amplitude Signal Generator, or equivalent, (through a connector adapter, item 13, if needed) to the channel 4 input connector.
- b. Set the oscilloscope Time/Div. switch to .1 mSec and free run the sweep.
- c. Adjust the generator amplitude control to obtain four major divisions of vertical deflection on the crt.
- d. Center the display vertically on the crt.
- e. Set the sine-wave generator output frequency to 2 mc while keeping the generator output level constant.

NOTE

The Type 190B generator maintains a constant-amplitude output signal automatically. If the generator you are using does not maintain a constant-amplitude output signal, the generator output should be monitored and adjusted to the correct output level with the aid of a wide-band test oscilloscope (item 4) having a flat frequency response from about 2 cps to better than 2 mc.

- f. At 2 mc, check for at least 2.8 major divisions of vertical deflection on the oscilloscope used with the Type 3A74. This is the 3 db down point for the Type 3A74 channel 4.
- g. After checking channel 4, set channel 4 MODE switch to OFF, channel 3 MODE switch to NORM., and apply the signal to channel 3. Check channel 3 bandwidth using steps 21a through 21g as a guide. Then check channels 2 and 1 in the same manner.

- h. After completing the bandwidth check for each channel, disconnect the signal from the Type 3A74.

22. Check Four-Trace X-Y Operation

This operational check should be performed if the Type 3A74 being calibrated is going to be used with another Type 3A74 to produce X-Y displays. If another normal-operating Type 3A74 is available and if your oscilloscope has an X-axis opening, perform Check I. If another unit is not available or there is no X-axis opening in your oscilloscope, do Check II.

Check I:

- a. Remove the Time-Base unit from the X-axis opening of the oscilloscope and install a normal operating Type 3A74 in its place.
- b. Set all MODE switches of both units to NORM.
- c. Set the Y-axis unit CHOP.-ALT. switch to CHOP. and the X-axis CHOP.-ALT. switch to ALT.
- d. If your oscilloscope has a CRT Cathode Selector switch, set this switch to the Chopped Blanking position.
- e. Four dots should be displayed on the crt.
- f. Rotate the corresponding POSITION controls for each pair of channels (for example, a pair of channels is channel 1 of one unit and channel 1 of the other unit). Check that the POSITION controls of each pair of channels independently control the position of their respective dots.

Check II (Alternate Method):

- a. Set the MODE switches for all channels to NORM.
- b. Check that CHOP.-ALT. switch is set to CHOP.
- c. Connect the probe from the test oscilloscope to pin 18 of the oscilloscope interconnecting socket (either the X-axis or the Y-axis).
- d. Check Ring Counter sync pulse. The waveform should consist of positive-going pulses which have a duration of about $2 \mu\text{sec}$ and an amplitude of about 6 volts or more (see Fig. 6-11).

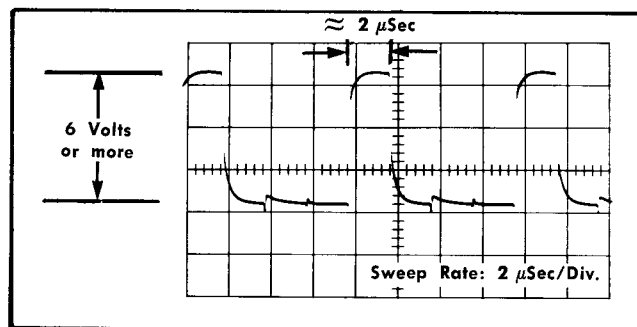


Fig. 6-11. Type 3A74 Ring Counter sync pulse as displayed on the test oscilloscope crt. Vertical deflection factor: 2 volts/div.

This image shows a single page of white paper with horizontal blue or grey ruling lines. The lines are evenly spaced and run across the width of the page, typical of notebook paper. There is no handwriting or other markings on the page.

SECTION 7

PARTS LIST AND SCHEMATICS

PARTS ORDERING INFORMATION

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


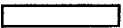
Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information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

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

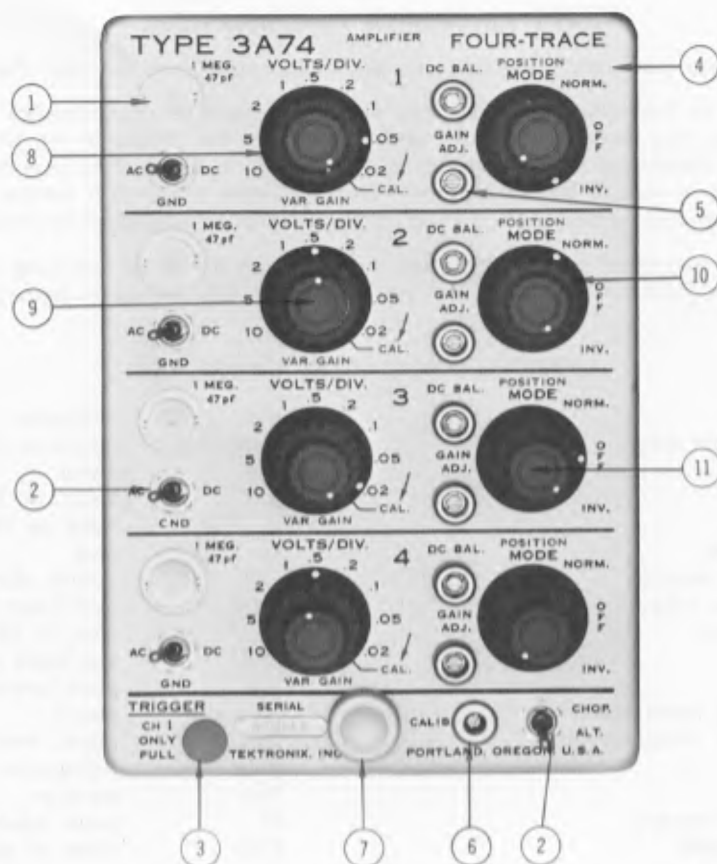
ABBREVIATIONS AND SYMBOLS

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

SPECIAL NOTES AND SYMBOLS

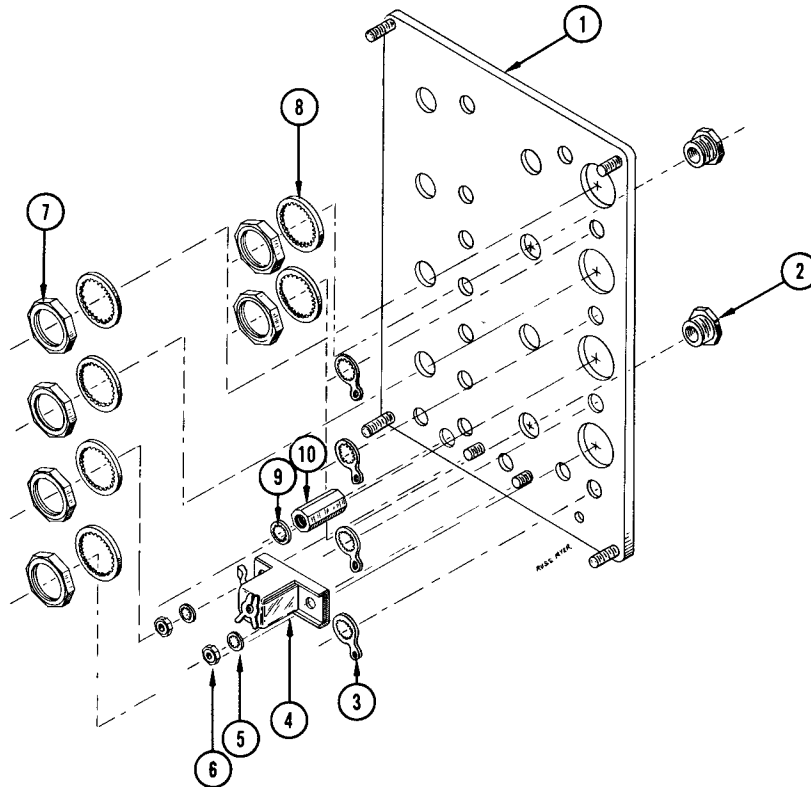
X000	Part first added at this serial number.
000X	Part removed after this serial number.
*000-000	Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, or reworked or checked components.
Use 000-000	Part number indicated is direct replacement.
	Internal screwdriver adjustment.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

FRONT GROUP



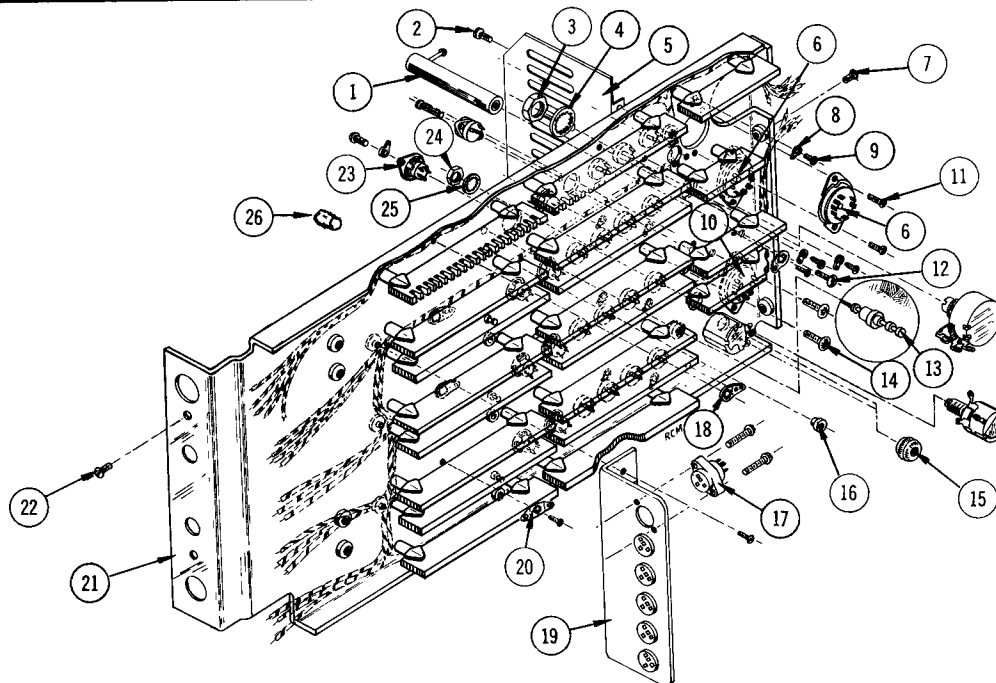
REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
1	131-0106-00			4	CONNECTOR, chassis mounted coaxial, female, Teflon center
2	210-0562-00			5	NUT, hex, brass, $\frac{1}{4} \times 40 \times \frac{5}{16}$ inch thick
	210-0940-00			5	WASHER, steel, $\frac{1}{4}$ ID x $\frac{3}{8}$ inch OD
3	384-0245-00	101	1389	1	ROD, ext. switch shaft, w/molded charcoal knob, gray
	384-0304-00	1390		1	ROD, ext. switch shaft, w/molded charcoal knob, gray
4	333-0670-00			1	PANEL, front
5	358-0054-00			8	BUSHING, banana jack, brass, $\frac{1}{4}$ -32 x $\frac{13}{32}$ inch
6	358-0075-00			1	BUSHING, brass, $\frac{1}{4}$ -32 x .295 inch long
7	366-0109-00			1	KNOB, plug-in securing
8	366-0175-00	101	1029	4	KNOB, charcoal—VOLTS/DIV.
	366-0250-00	1030		4	KNOB, charcoal—VOLTS/DIV.
9	366-0140-00			4	KNOB, small red—VAR. GAIN
10	366-0175-00	101	1029	4	KNOB, charcoal—MODE
	366-0250-00	1030		4	KNOB, charcoal—MODE
11	366-0140-00			4	KNOB, small rad—POSITION

SUBPANEL GROUP



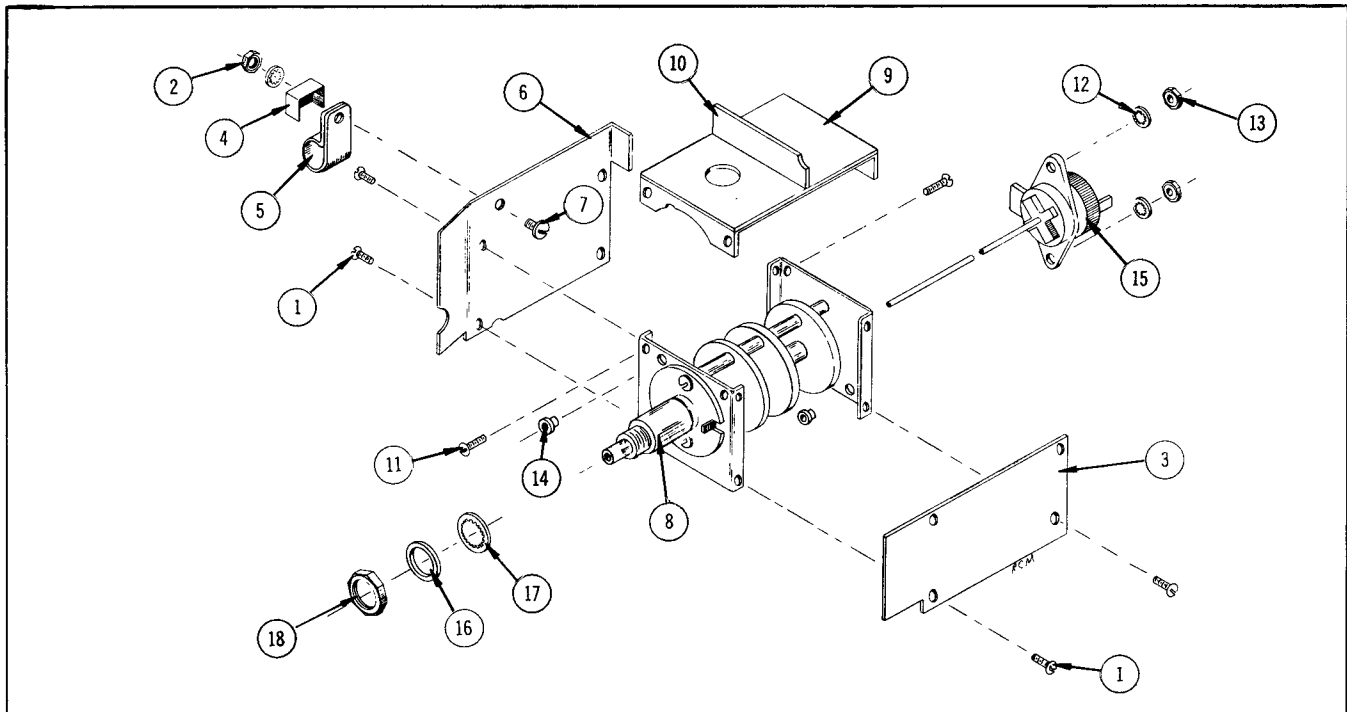
REF. NO.	PART NO.	SERIAL/MODEL NO.		Q T Y.	DESCRIPTION
		EFF.	DISC.		
1	387-0646-00			1	PLATE, sub-panel, aluminum, $4\frac{3}{64} \times 6\frac{3}{32}$ inches
2	358-0029-00			2	BUSHING, brass, hex, $\frac{3}{8}$ -32 x $1\frac{13}{32}$ inch
3	210-0223-00			4	LUG, solder, $\frac{1}{4}$ inch hole
4	214-0052-00			1	FASTENER, pawl right, w/stop
5	210-0004-00			2	LOCKWASHER, steel, internal, #4
6	210-0406-00			2	NUT, hex, brass, 4-40 x $\frac{3}{16}$ inch
7	210-0413-00			6	NUT, hex, brass, $\frac{3}{8}$ -32 x $\frac{1}{2}$ inch
8	210-0012-00			6	LOCKWASHER, steel, pot, internal, $\frac{3}{8}$ x $\frac{1}{2}$ inch
9	210-0006-00			1	LOCKWASHER, steel, internal, #6
10	210-0471-00			1	NUT, pot, miniature, hex, aluminum, $\frac{1}{4}$ -32 x $\frac{5}{16}$ dia. x $1\frac{9}{32}$ lg.

CHASSIS GROUP



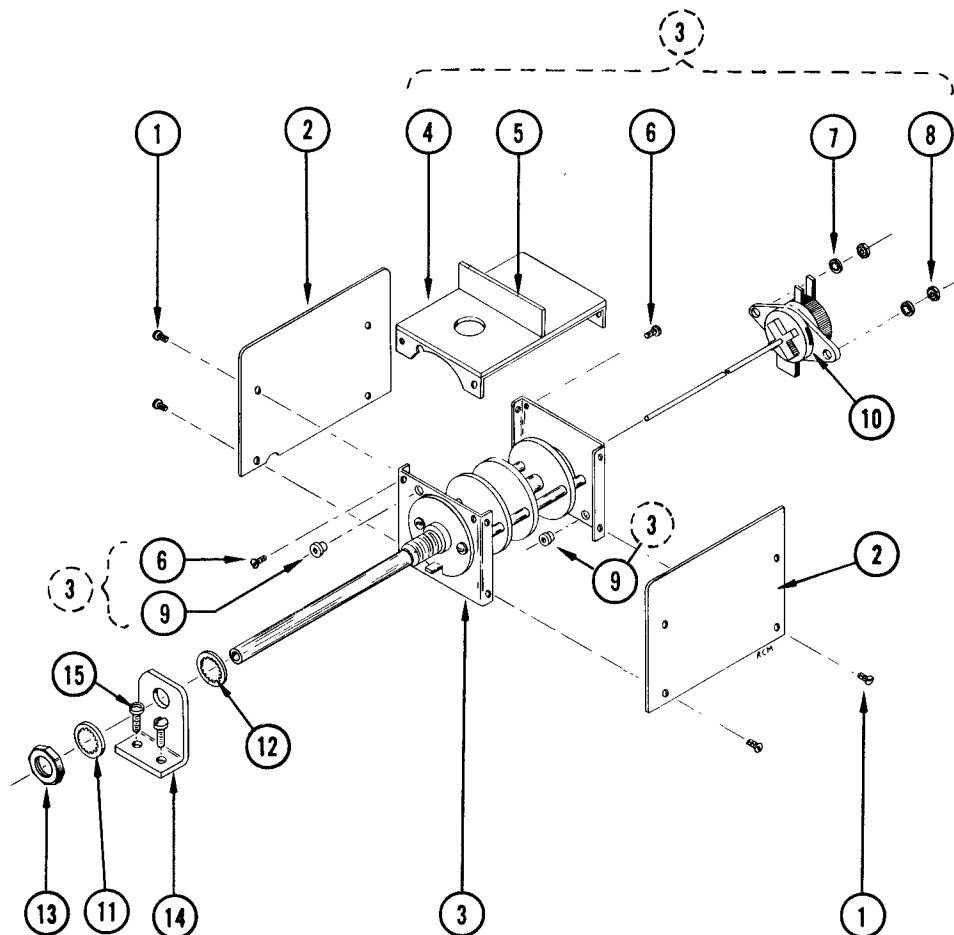
REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
1	385-0061-00			1	ROD, nylon, $\frac{5}{16}$ diameter x $1\frac{3}{4}$ inch w/pin
2	211-0007-00			5	SCREW, 4-40 x $\frac{3}{16}$ inch BHS
3	210-0413-00			1	NUT, hex, brass, $\frac{3}{8}$ -32 x $\frac{1}{2}$ inch
4	210-0012-00			1	LOCKWASHER, steel, pot, internal, $\frac{3}{8}$ x $\frac{1}{2}$ inch
5	337-0502-00			1	SHIELD, aluminum, $\frac{7}{16}$ x $2\frac{3}{8}$ x $5\frac{3}{8}$ inch (output)
6	136-0072-00			2	SOCKET, 9 pin, UHF miniature
7	211-0504-00			5	SCREW, 6-32 x $\frac{1}{4}$ inch BHS
8	210-0215-00			16	LUG, banana
9	213-0055-00			28	SCREW, thread cutting, 2-56 x $\frac{3}{16}$ inch PHS phillips
10	136-0015-00			1	SOCKET, STM9G
11	213-0044-00			11	SCREW, thread cutting, 5-32 x $\frac{3}{16}$ inch PHS phillips
12	211-0507-00			1	SCREW, 6-32 x $\frac{5}{16}$ inch BHS
13	131-0183-00			4	CONNECTOR, terminal
14	213-0054-00			2	SCREW, thread cutting, 6-32 x $\frac{5}{16}$ inch PHS phillips
15	348-0003-00			1	GROMMET, $\frac{5}{16}$ inch
16	348-0031-00			5	GROMMET, snap-in
17	136-0095-00	101	1649	22	SOCKET, 4 pin transistor
	136-0181-00	1650		22	SOCKET, 3 pin transistor
	- - - - -			-	mounting hardware for each: (not included w/socket)
	213-0113-00	101	1649	2	SCREW, thread forming, 2-32 x $\frac{5}{16}$ inch RHS phillips
	354-0234-00	1650		1	RING, transistor socket
18	210-0201-00			7	LUG, solder, SE 4
19	406-0801-00			1	BRACKET, transistor mounting
20	210-0204-00			1	LUG, solder, DE 6
21	441-0433-00			1	CHASSIS
22	211-0538-00			2	SCREW, 6-32 x $\frac{5}{16}$ inch FHS phillips
23	136-0101-00			8	SOCKET, 5 pin
24	210-0562-00			2	NUT, hex, $\frac{1}{4}$ -40 x $\frac{5}{16}$ inch
25	210-0046-00			2	LOCKWASHER, internal, .400 OD x .261 inch ID
26	214-0269-00			2	SINK, heat

SWITCHES



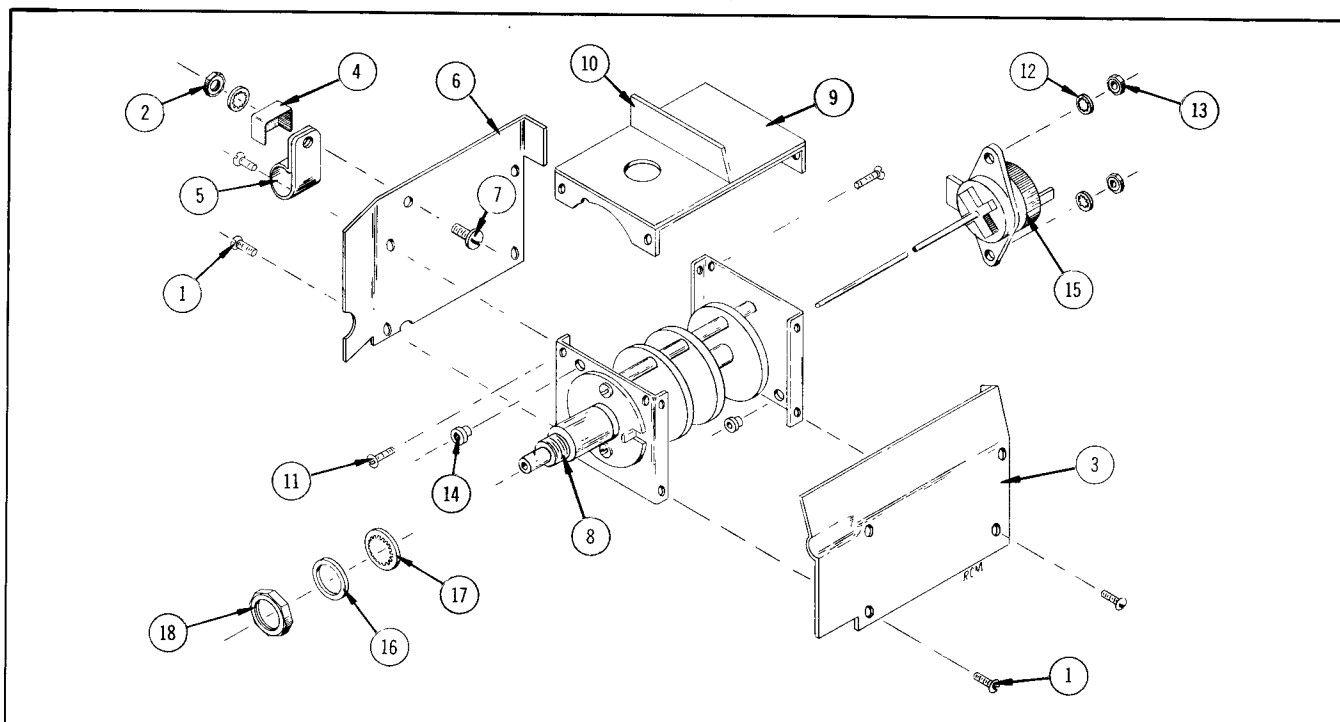
REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
1	213-0055-00			8	SCREW, thread cutting, 2-56 x $\frac{3}{16}$ inch PHS, phillips
2	210-0457-00	101	659	1	NUT, keps, 6-32 x $\frac{5}{16}$ inch
	210-0586-00	660		1	NUT, keps, 4-40 x $\frac{1}{4}$ inch
3	337-0503-00			1	SHIELD, top
4	210-0863-00	101	659	1	WASHER, "D" type
	210-0801-00	660		1	WASHER, 5S x $\frac{9}{32}$ inch
5	343-0006-00	101	659	1	CLAMP, cable, $\frac{1}{2}$ inch
	343-0072-00	660		1	CLAMP, cable, nylon, $\frac{1}{2}$ inch
6	337-0501-00			1	SHIELD, aluminum, $\frac{3}{8}$ x $5\frac{17}{64}$ x $2\frac{3}{8}$ inches (channel separator)
7	211-0507-00	101	659	1	SCREW, 6-32 x $\frac{5}{16}$ inch BHS
	211-0011-00	660		1	SCREW, 4-40 x $\frac{5}{16}$ inch BHS
8	262-0490-00	101	589	1	SWITCH, wired—VOLTS/DIV. #1
	262-0544-00	590		1	SWITCH, wired—VOLTS/DIV. #1
	- - - - -			-	switch Includes:
	260-0443-00	101	589	1	SWITCH, unwired—VOLTS/DIV. #1
	260-0512-00	590		1	SWITCH, unwired—VOLTS/DIV. #1
9	406-0806-00			1	BRACKET, attenuator
10	337-0497-00			1	SHIELD, attenuator bracket
11	213-0055-00			4	SCREW, thread cutting, 2-56 x $\frac{3}{16}$ inch PHS phillips
12	210-0004-00			2	LOCKWASHER, internal, #4
13	210-0406-00			2	NUT, hex, 4-40 x $\frac{3}{16}$ inch
14	348-0031-00			2	GROMMET, poly. snap-in
15	- - - - -			1	POT
	- - - - -			-	Pot includes:
	384-0247-00			1	ROD, extension
	- - - - -			-	mounting hardware: (not included w/switch)
16	210-0840-00			1	WASHER, steel, .390 ID x $\frac{9}{16}$ inch OD
17	210-0012-00			1	LOCKWASHER, steel, pot, internal, $\frac{3}{8}$ x $\frac{1}{2}$ inch
18	210-0413-00			1	NUT, hex, $\frac{3}{8}$ -32 x $\frac{1}{2}$ inch

SWITCHES



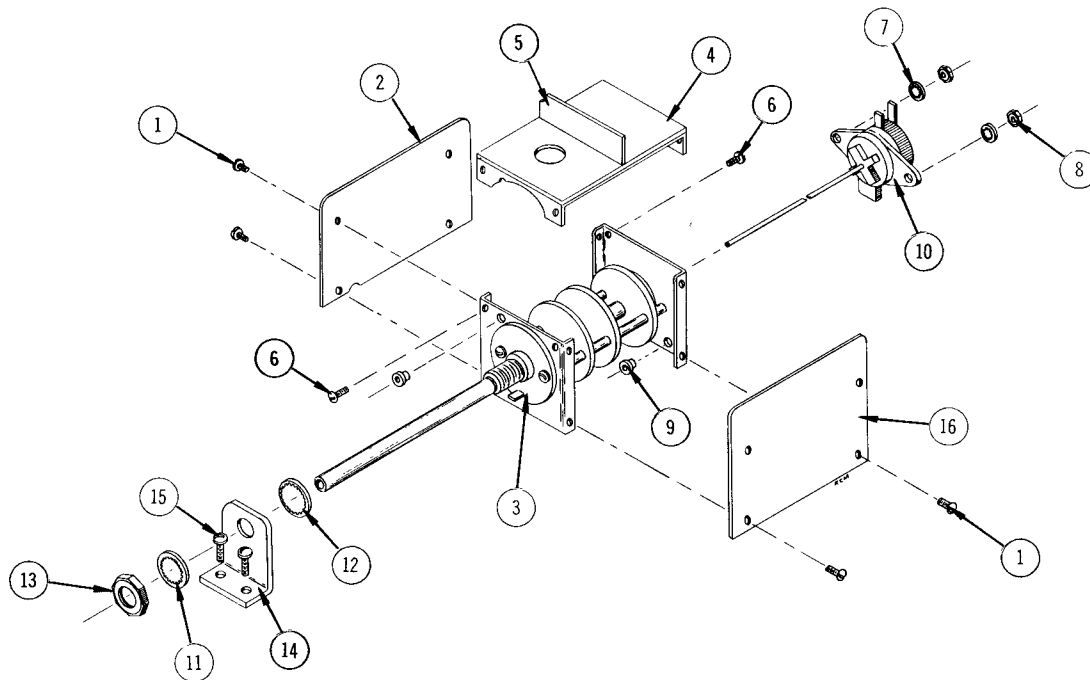
REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
1	213-0055-00			8	SCREW, thread cutting, 2-56 x 3/16 inch PHS, phillips
2	337-0512-00			2	SHIELD, aluminum, 2 1/4 x 3 inches
3	262-0491-00	101	589	1	SWITCH, wired—VOLTS/DIV. #2
	262-0545-00	590		1	SWITCH, wired—VOLTS/DIV. #2
	- - - - -			-	switch includes:
	260-0444-00	101	589	1	SWITCH, unwired—VOLTS/DIV. #2
	260-0513-00	590		1	SWITCH, unwired—VOLTS/DIV. #2
4	406-0806-00			1	BRACKET, attenuator
5	337-0498-00			1	SHIELD, attenuator bracket
6	213-0055-00			4	SCREW, thread cutting, 2-56 x 3/16 inch PHS, phillips
7	210-0004-00			2	LOCKWASHER, steel, internal #4
8	210-0406-00			2	NUT, hex, brass, 4-40 x 3/16 inch
9	348-0031-00			2	GROMMET, polypropylene, snap-in, 1/4 inch diameter
10	- - - - -			1	POT
	- - - - -			-	pot includes:
	384-0248-00			1	ROD, extension
	- - - - -			-	mounting hardware: (not included w/switch)
11	210-0012-00			2	LOCKWASHER, steel, pot, internal 3/8 x 1/2 inch
12	210-0840-00			1	WASHER, .390 ID x 9/16 inch OD
13	210-0413-00			1	NUT, hex, 3/8-32 x 1/2 inch
14	406-0804-00			1	BRACKET, switch mounting
15	211-0504-00			2	SCREW, 6-32 x 1/4 inch BHS

SWITCHES



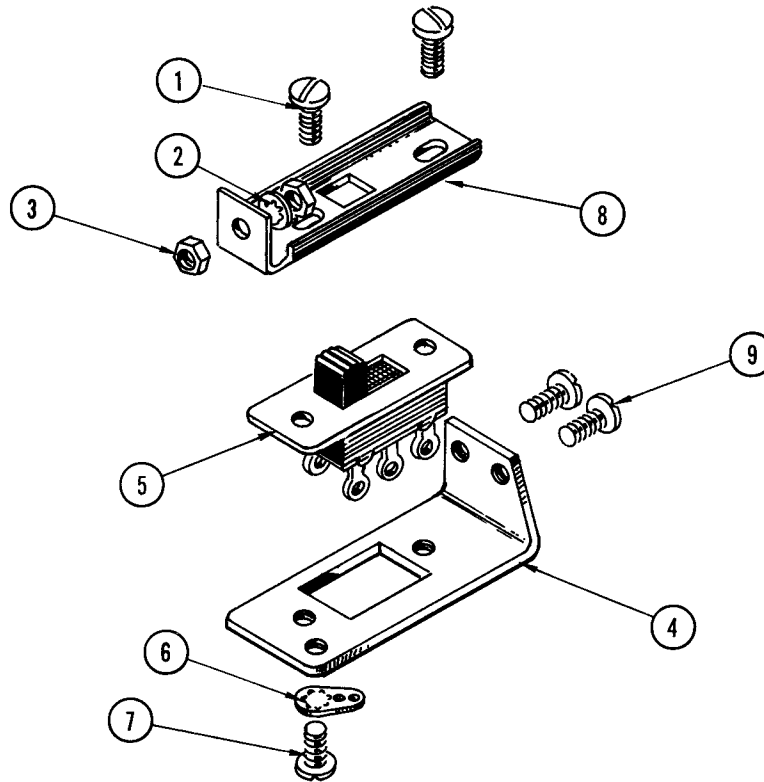
REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
1	213-0055-00			8	SCREW, thread cutting, 2-56 x $\frac{3}{16}$ inch PHS, phillips
2	210-0457-00	101	659	1	NUT, keps, 6-32 x $\frac{5}{16}$ inch
	210-0586-00	660		1	NUT, keps, 4-40 x $\frac{1}{4}$ inch
3	337-0500-00			1	SHIELD, channel separator
4	210-0863-00	101	659	1	WASHER, "D" type
	210-0801-00	660		1	WASHER, 5S x $\frac{5}{32}$ inch
5	343-0006-00	101	659	1	CLAMP, cable, plastic
	343-0072-00	660		1	CLAMP, cable, nylon, $\frac{1}{2}$ inch
6	337-0501-00			1	SHIELD, aluminum, $\frac{3}{8}$ x $5\frac{7}{64}$ x $2\frac{3}{8}$ inches (channel separator)
7	211-0507-00	101	659	1	SCREW, 6-32 x $\frac{5}{16}$ inch BHS
	211-0011-00	660		1	SCREW, 4-40 x $\frac{5}{16}$ inch BHS
8	262-0492-00	101	589	1	SWITCH, wired—VOLTS/DIV. #3
	262-0546-00	590		1	SWITCH, wired—VOLTS/DIV. #3
				-	switch includes:
	260-0443-00	101	589	1	SWITCH, unwired—VOLTS/DIV. #3
	260-0512-00	590		1	SWITCH, unwired—VOLTS/DIV. #3
9	406-0806-00			1	BRACKET, attenuator
10	337-0511-00			1	SHIELD, attenuator bracket
11	213-0055-00			4	SCREW, thread cutting, 2-56 x $\frac{3}{16}$ inch PHS, phillips
12	210-0004-00			2	LOCKWASHER, steel, internal #4
13	210-0406-00			2	NUT, hex, brass, 4-40 x $\frac{3}{16}$ inch
14	348-0031-00			2	GROMMET, polypropylene, snap-in, $\frac{1}{4}$ inch diameter
15	- - - - -			1	POT
				-	pot includes:
	384-0247-00			1	ROD, extension
	- - - - -			-	mounting hardware: (not included w/switch)
16	210-0840-00			1	WASHER, steel, .390 ID x $\frac{9}{16}$ inch OD
17	210-0012-00			1	LOCKWASHER, steel, pot, internal, $\frac{3}{8}$ x $\frac{1}{2}$ inch
18	210-0413-00			1	NUT, hex, $\frac{3}{8}$ -32 x $\frac{1}{2}$ inch

SWITCHES



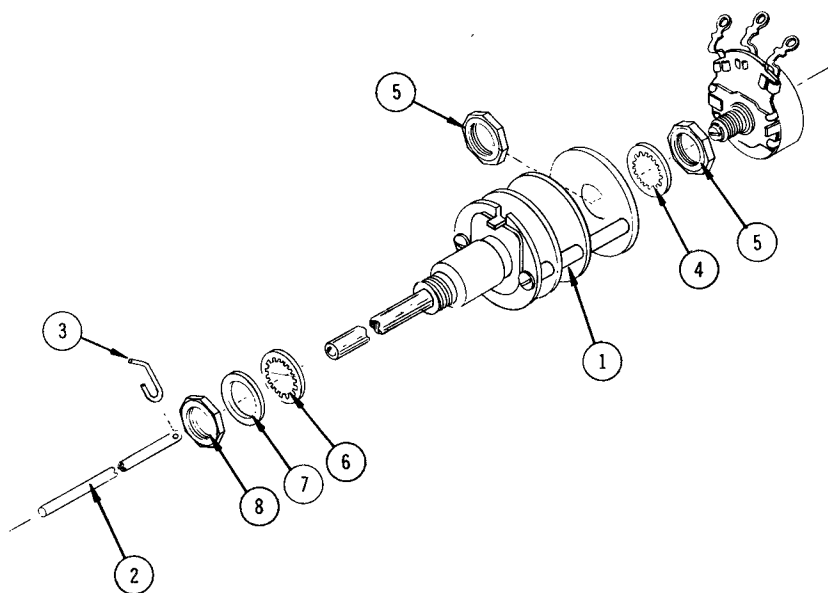
REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
1	213-0055-00			8	SCREW, thread cutting, 2-56 x $\frac{3}{16}$ inch PHS, phillips
2	337-0504-00			1	SHIELD, aluminum, $1\frac{7}{8}$ x 3 inches
3	262-0493-00	101	589	1	SWITCH, wired—VOLTS/DIV. #4
	262-0547-00	590		1	SWITCH, wired—VOLTS/DIV. #4
	- - - - -			-	switch includes:
	260-0444-00	101	589	1	SWITCH, unwired—VOLTS/DIV. #4
	260-0513-00	590		1	SWITCH, unwired—VOLTS/DIV. #4
4	406-0806-00			1	BRACKET, attenuator
5	337-0499-00			1	SHIELD, attenuator bracket
6	213-0055-00			4	SCREW, thread cutting, 2-56 x $\frac{3}{16}$ inch PHS, phillips
7	210-0004-00			2	LOCKWASHER, steel, internal, #4
8	210-0406-00			2	NUT, hex, brass, 4-40 x $\frac{3}{16}$ inch
9	348-0031-00			2	GROMMET, polypropylene, snap-in, $\frac{1}{4}$ inch diameter
10	- - - - -			1	POT
	- - - - -			-	pot includes:
	384-0248-00			1	ROD, extension
	- - - - -			-	mounting hardware: (not included w/switch)
11	210-0012-00			2	LOCKWASHER, steel, pot, internal, $\frac{3}{8}$ x $\frac{1}{2}$ inch
12	210-0840-00			1	WASHER, .390 ID x $\frac{9}{16}$ inch OD
13	210-0413-00			1	NUT, hex, $\frac{3}{8}$ -32 x $\frac{1}{2}$ inch
14	406-0804-00			1	BRACKET, switch mounting
15	211-0504-00			2	SCREW, 6-32 x $\frac{1}{4}$ inch BHS
16	337-0512-00			1	SHIELD, aluminum

SWITCHES



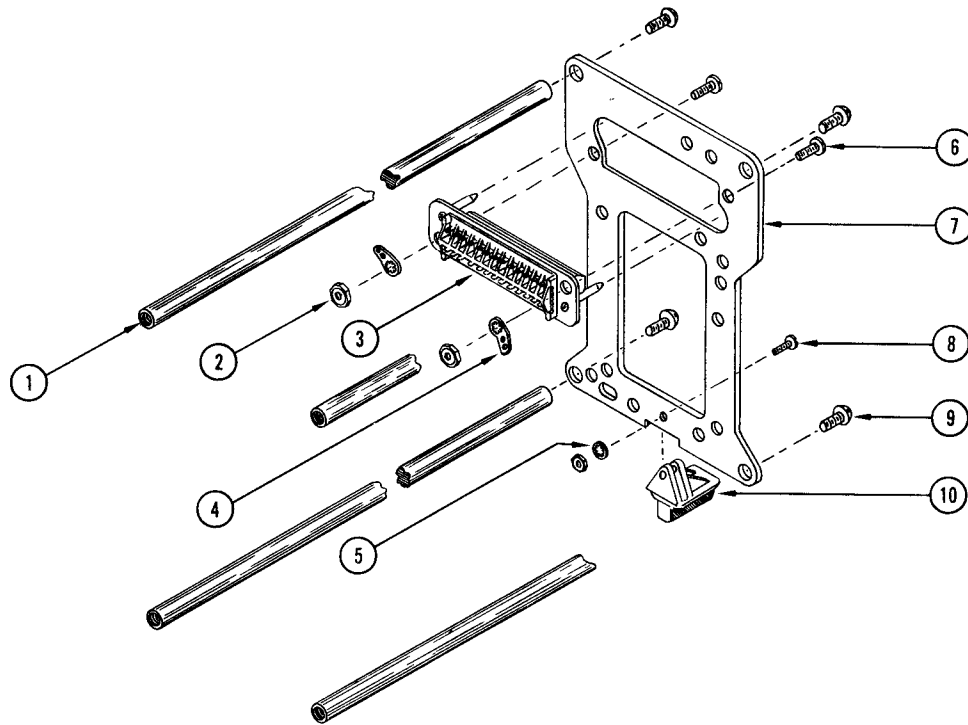
REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
1	213-0105-00	101	1389X	2	SCREW, shouldered, 6-32 x 2 1/64 inch
2	210-0006-00	101	1389X	1	LOCKWASHER, steel, internal, #6
3	210-0449-00	101	1389X	2	NUT, hex, 5-40 x 1/4 inch
4	406-0800-00			1	BRACKET, switch, slide
5	260-0212-00	101	1389	1	SWITCH, slide—TRIGGER
	260-0447-00	1390		1	SWITCH, slide—TRIGGER
6	210-0201-00			1	LUG, solder, SE 4
7	211-0007-00			1	SCREW, 4-40 x 3/16 inch BHS
8	406-0802-00	101	1389	1	BRACKET, switch actuating
	406-0918-00	1390		1	BRACKET, switch actuator
	406-0949-00	X1390		1	BRACKET, slide switch
9	211-0008-00			2	SCREW, 6-32 x 1/4 inch BHS

SWITCHES



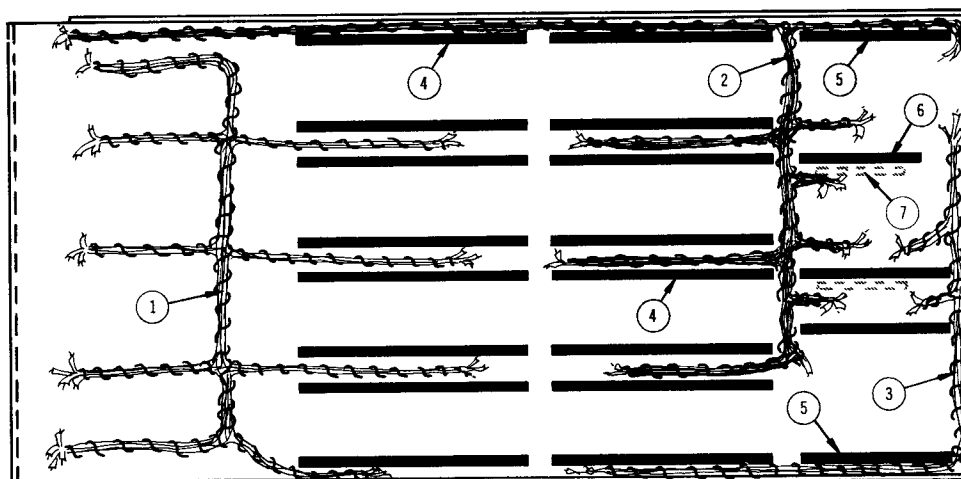
REF. NO.	PART NO.	SERIAL/MODEL NO.		Q T Y.	DESCRIPTION
		EFF.	DISC.		
1	262-0489-00	101	1309	4	SWITCH, wired—MODE
	262-0649-00	1310		4	SWITCH, wired—MODE
	- - - - -			-	each switch includes:
	260-0445-00			1	SWITCH, unwired—MODE
2	384-0250-00			1	ROD, extension
3	376-0014-00			1	COUPLING, pot
4	210-0012-00			1	LOCKWASHER, internal, $\frac{3}{8} \times \frac{1}{2}$ inch
5	210-0413-00			2	NUT, hex, $3\frac{1}{8}$ -32 x $\frac{1}{2}$ inch
	- - - - -			-	mounting hardware for each: (not included w/switch)
6	210-0012-00			1	LOCKWASHER, internal, $\frac{3}{8} \times \frac{1}{2}$ inch
7	210-0840-00			1	WASHER, .390 ID x $\frac{9}{16}$ inch OD
8	210-0413-00			1	NUT, hex, $\frac{3}{8}$ -32 x $\frac{1}{2}$ inch

REAR AND FRAME GROUP



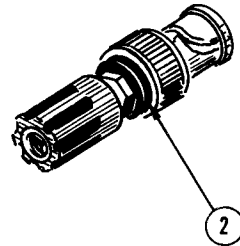
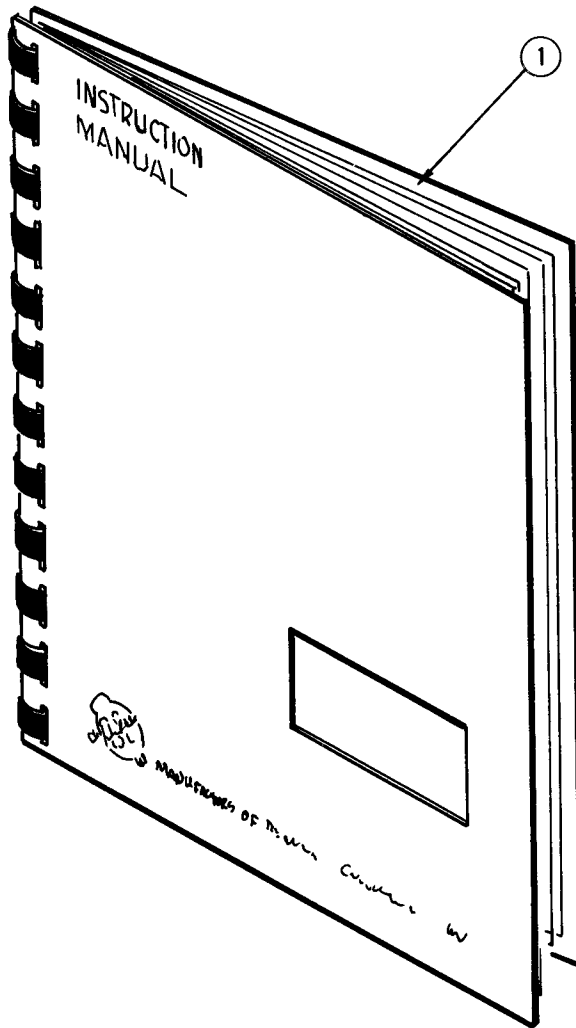
REF. NO.	PART NO.	SERIAL/MODEL NO.		Q T Y.	DESCRIPTION
		EFF.	DISC.		
1	384-0566-00	101	1074	4	ROD, frame, spacing
	384-0615-00	1075		4	ROD, frame, spacing
2	210-0406-00			3	NUT, hex, brass, 4-40 x $\frac{3}{16}$ inch
3	131-0149-00			1	CONNECTOR, chassis mounted, 24 contact, male
4	210-0201-00			2	LUG, solder, SE 4
5	210-0004-00			1	LOCKWASHER, steel, internal, #4
6	211-0008-00			2	SCREW, 4-40 x $\frac{1}{4}$ inch BHS
7	387-0647-00			1	PLATE, aluminum, $3\frac{1}{32}$ x $5\frac{31}{32}$ inches
8	211-0013-00			1	SCREW, 4-40 x $\frac{3}{8}$ inch BHS
9	212-0044-00			4	SCREW, 8-32 x $\frac{1}{2}$ inch RHS, phillips
10	351-0037-00			1	GUIDE, delrin, $\frac{5}{8}$ x $\frac{13}{16}$ inch

CABLE HARNESS & CERAMIC STRIP DETAIL



REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
1	179-0646-00	101	189	1	CABLE HARNESS, switch
	179-0708-00	190	1309	1	CABLE HARNESS, switch
	179-0861-00	1310	2589	1	CABLE HARNESS, switch
	179-0861-01	2590		1	CABLE HARNESS, switch
2	179-0644-00	101	189	1	CABLE HARNESS, chassis #1
	179-0707-00	190	589	1	CABLE HARNESS, chassis #1
	179-0741-00	590	1309	1	CABLE HARNESS, chassis #1
	179-0859-00	1310		1	CABLE HARNESS, chassis #1
3	179-0645-00	101	589	1	CABLE HARNESS, chassis #2
	179-0742-00	590	1309	1	CABLE HARNESS, chassis #2
	179-0860-00	1310		1	CABLE HARNESS, chassis #2
4	124-0145-00			16	STRIP, ceramic, $\frac{7}{16}$ inch x 20 notches
	- - - - -			-	each strip includes:
	355-0046-00			2	STUD, nylon
	- - - - -			-	mounting hardware for each: (not included w/strip)
5	124-0147-00			4	STRIP, ceramic, $\frac{7}{16}$ inch x 13 notches
	- - - - -			-	each strip includes:
	355-0046-00			2	STUD, nylon
	- - - - -			-	mounting hardware for each: (not included w/strip)
6	124-0148-00			1	STRIP, ceramic, $\frac{7}{16}$ x 9 notches
	- - - - -			-	strip includes:
	355-0046-00			2	STUD, nylon
	- - - - -			-	mounting hardware: (not included w/strip)
7	124-0092-00			3	STRIP, ceramic, $\frac{7}{16}$ inch x 3 notches
	- - - - -			-	each strip includes
	355-0046-00			1	STUD, nylon
	- - - - -			-	mounting hardware for each: (not included w/strip)
	361-0009-00			1	SPACER, nylon, $\frac{5}{32}$ inch
	- - - - -				

ACCESSORIES



REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
1	070-0347-00			2	MANUAL, instruction
2	103-0033-00			4	ADAPTER, BNC to binding post

NOTES

ELECTRICAL PARTS LIST

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Description	S/N Range
Bulbs			
B419	Ch. 1,2,3,4 150-025	Neon, NE-2E	
Capacitors			
Tolerance $\pm 20\%$ unless otherwise indicated.			
Tolerance of all electrolytic capacitors as follows with exceptions):			
3 V — 50 V = -10% , $+250\%$			
51 V — 350 V = -10% , $+100\%$			
351 V — 450 V = -10% , $+50\%$			
C401	Ch. 1,3 *285-609	.1 μ f MT	600 v 10%
C401	Ch. 2,4 *285-610	.1 μ f MT	600 v 10%
C403A	Ch. 1,2,3,4 281-504	10 pf Cer.	500 v 10%
C403B	Ch. 1,2,3,4 281-061	5.5-18 pf Cer.	Var.
C403C	Ch. 1,2,3,4 281-060	2-8 pf Cer.	Var.
C403E	Ch. 1,2,3,4 use 281-512	27 pf Cer.	500 v 10%
C405A	Ch. 1,2,3,4 281-504	10 pf Cer.	500 v 10%
C405B	Ch. 1,2,3,4 281-061	5.5-18 pf Cer.	Var.
C405C	Ch. 1,2,3,4 281-060	2-8 pf Cer.	Var.
C405E	Ch. 1,2,3,4 283-541	500 pf Mica	500 v 10%
C407B	Ch. 1,2,3,4 281-061	5.5-18 pf Cer.	Var.
C407C	Ch. 1,2,3,4 281-061	5.5-18 pf Cer.	Var.
C409B	Ch. 1,2,3,4 281-061	5.5-18 pf Cer.	Var.
C409C	Ch. 1,2,3,4 281-060	2-8 pf Cer.	Var.
C409E	Ch. 1,2,3,4 281-504	10 pf Cer.	500 v 10%
C416	Ch. 1,2,3,4 281-060	2-8 pf Cer.	Var.
	Ch. 1,2,3,4 281-061	5.5-18 pf Cer.	Var.
C417	Ch. 1,2,3,4 283-068	.01 μ f Disc Type	500 v
C418	Ch. 2,4 281-534	3.3 pf Cer.	$\pm .25$ pf 101-589X
C424	Ch. 1,2,3,4 Use 281-536	.001 μ f Cer.	500 v 10%
C428	Ch. 1,2,3,4 283-023	.1 μ f Disc Type	10 v
C433	Ch. 1,2,3,4 281-557	1.8 pf Cer.	500 v
C434	Ch. 1,2,3,4 Use 281-536	.001 μ f Cer.	500 v 10%
C435	281-027	.7-3 pf Tub.	Var.
C460	281-572	6.8 pf Cer.	500 v 10%
C470	281-572	6.8 pf Cer.	500 v 10%
C478	Use 283-057	.1 μ f Disc Type	200 v
C490	Use 283-081	.1 μ f Disc Type	25 v -20% $+80\%$
C491	283-006	.02 μ f Disc Type	600 v
C493	283-057	.1 μ f Disc Type	200 v
C494	290-145	10 μ f EMT	50 v
C497	283-0081-00	.1 μ f Disc Type	25 v X2590-up

Parts List—Type 3A74

Capacitors (Cont'd)

Ckt. No.	Tektronix Part No.	Description	S/N Range
C499	283-057	.1 μ f Disc Type	200 v
C529	281-551	390 pf Cer.	500 v
C533	283-002	.01 μ f Disc Type	500 v
C534	283-002	.01 μ f Disc Type	500 v
C535	281-544	5.6 pf Cer.	500 v
C547	Ch. 1 Use 281-524	150 pf Cer.	500 v
C557	Ch. 2 Use 281-524	150 pf Cer.	500 v
C567	Ch. 3 Use 281-524	150 pf Cer.	500 v
C576	283-004	.02 μ f Disc Type	150 v
C577	Ch. 4 Use 281-524	150 pf Cer.	500 v
C578	283-006	.02 μ f Disc Type	600 v
C580	283-006	.02 μ f Disc Type	600 v
C582	281-523	100 pf Cer.	350 v
C583	281-525	470 pf Cer.	500 v
C585	281-589	167 pf Cer.	500 v
C585	281-605	200 pf Cer.	500 v
C587	281-543	270 pf Cer.	500 v
C588	281-523	100 pf Cer.	350 v
C589	Use 283-081	.1 μ f Disc Type	25 v
C593	283-002	.01 μ f Disc Type	500 v
C594	283-059	1 μ f Disc Type	25 v
C595	281-549	68 pf Cer.	500 v
C595	281-0542-00	18 pf Cer.	500 v
C596	Use 283-081	.1 μ f Disc Type	25 v
C597	281-0022-00	8-50 pf Cer.	Var.
			10% X1310-up
			10% 101-859
			10% 860-up
			—20% +80%
			10% X1310-up
			10% 101-2589
			10% 2590-up
			—20% +80% X2590-up

Diodes

D423	Ch. 1,2,3,4	*152-0075-00	Germanium Tek Spec	X2590-3019
D423	Ch. 1,2,3,4	*152-0185-00	Silicon Replaceable by 1N3605	3020-up
D424	Ch. 1,2,3,4	152-008	Germanium	
D440	Ch. 1,2,3,4	152-079	Germanium HD1841	
D441	Ch. 1,2,3,4	152-079	Germanium HD1841	
D442	Ch. 1,2,3,4	152-079	Germanium HD1841	
D443	Ch. 1,2,3,4	152-079	Germanium HD1841	
D468		*152-061	Germanium Tek Spec	
D469		*152-061	Germanium Tek Spec	
D494		152-094	Zener 50 v $\frac{3}{4}$ w 10%	
D502		152-008	Germanium	
D512		*152-075	Germanium Tek Spec	
D547	Ch. 1	*152-075	Germanium Tek Spec	
D548	Ch. 1	*152-075	Germanium Tek Spec	
D557	Ch. 2	*152-075	Germanium Tek Spec	
D558	Ch. 2	*152-075	Germanium Tek Spec	
D566		*152-061	Silicon Tek Spec	
D567	Ch. 3	*152-075	Germanium Tek Spec	
D568	Ch. 3	*152-075	Germanium Tek Spec	
D577	Ch. 4	*152-075	Germanium Tek Spec	
D578	Ch. 4	*152-075	Germanium Tek Spec	
D580		*152-061	Silicon Tek Spec	
D581		*152-075	Germanium Tek Spec	101-1309
D581		152-079	Germanium HD1841	1310-up
D590		*152-075	Germanium Tek Spec	101-859
D590		152-079	Germanium HD1841	860-up
D595		*152-061	Silicon Tek Spec	

Inductors

Ckt. No.	Tektronix Part No.	Description	S/N Range
L444	*108-016	29 μ h	
L445	*108-251	12 μ h	wound on a 30 Ω resistor (R445)
L454	*108-016	29 μ h	
L455	*108-251	12 μ h	wound on a 30 Ω resistor (R455)
L464	*114-150	55-100 μ h	Var. Core 276-540
L474	*114-150	55-100 μ h	Var. Core 276-540
L525	108-254	600 μ h	
L532	276-507	Core, Ferramic Suppressor	101-1309X
L584	276-532	Ferrite Bead	X1310-up
L588	276-507	Core, Ferramic Suppressor	
L590	276-507	Core, Ferramic Suppressor	X2150-up

Resistors

Resistors are fixed, composition, $\pm 10\%$ unless otherwise indicated.

R401	Ch. 1,2,3,4	316-100	10 Ω	$\frac{1}{4}$ w			
R403C	Ch. 1,2,3,4	309-396	900 k	$\frac{1}{2}$ w	Prec.	1%	
R403E	Ch. 1,2,3,4	309-379	111 k	$\frac{1}{2}$ w	Prec.	1%	
R405C	Ch. 1,2,3,4	309-385	990 k	$\frac{1}{2}$ w	Prec.	1%	
R405E	Ch. 1,2,3,4	309-378	10.1 k	$\frac{1}{2}$ w	Prec.	1%	
R407C	Ch. 1,2,3,4	309-381	600 k	$\frac{1}{2}$ w	Prec.	1%	
R407E	Ch. 1,2,3,4	309-382	666.6 k	$\frac{1}{2}$ w	Prec.	1%	
R409C	Ch. 1,2,3,4	309-383	800 k	$\frac{1}{2}$ w	Prec.	1%	
R409E	Ch. 1,2,3,4	309-380	250 k	$\frac{1}{2}$ w	Prec.	1%	
R410	Ch. 1,2,3,4	316-100	10 Ω	$\frac{1}{4}$ w			
R416	Ch. 1,2,3,4	309-386	1 meg	$\frac{1}{2}$ w	Prec.	1%	
R417	Ch. 1,2,3,4	302-105	1 meg	$\frac{1}{2}$ w			
R419	Ch. 1,2,3,4	316-101	100 Ω	$\frac{1}{4}$ w			
R423	Ch. 1,2,3,4	301-103	10 k	$\frac{1}{2}$ w		5%	
R424	Ch. 1,2,3,4	301-272	2.7 k	$\frac{1}{2}$ w		5%	
R425	Ch. 1,2,3,4	309-090	50 k	$\frac{1}{2}$ w	Prec.	1%	
R426†	Ch. 1,3	*311-304	185 Ω		Var.	WW	VAR. GAIN
R426†	Ch. 2,4	*311-309	185 Ω		Var.	WW	VAR. GAIN
R427	Ch. 1,2,3,4	311-306	2.5 meg		Var.		DC BAL
R428	Ch. 1,2,3,4 Use	301-685	6.8 meg	$\frac{1}{2}$ w		5%	
R429	Ch. 1,2,3,4	301-274	270 k	$\frac{1}{2}$ w		5%	101-189
	Ch. 1,2,3,4	301-474	470 k	$\frac{1}{2}$ w		5%	190-up
R430	Ch. 1,2,3,4	316-101	100 Ω	$\frac{1}{4}$ w			
R431	Ch. 1,2,3,4	301-100	10 Ω	$\frac{1}{2}$ w		5%	X2460-up
R433	Ch. 1,2,3,4	301-103	10 k	$\frac{1}{2}$ w		5%	
R434	Ch. 1,2,3,4	301-272	2.7 k	$\frac{1}{2}$ w		5%	
R435	Ch. 1,2,3,4	309-090	50 k	$\frac{1}{2}$ w		1%	
R436	Ch. 1,2,3,4	311-258	100 Ω		Var.	Prec.	GAIN ADJ.
R437	Ch. 1,2,3,4	316-270	27 Ω	$\frac{1}{4}$ w			
R438††	Ch. 1,2,3,4	311-305	50 k		Var.		POSITION
R439	Ch. 1,2,3,4	305-114	110 k	2 w		5%	
R444		309-182	3 k	$\frac{1}{2}$ w		Prec.	1%
R445†††		301-300	30 Ω	$\frac{1}{2}$ w			5%

†R426 & SW410 A, B, C, D are concentric. Furnished as a unit.

††R438 & SW430 are concentric. Furnished as a unit.

†††Furnished as a unit with L445.

Parts List—Type 3A74

Resistors (Cont'd)

Ckt. No.	Tektronix Part No.		Description			S/N Range
R446	310-132	19.6 k	1 w		Prec.	1%
R447	310-115	15 k	1 w		Prec.	1%
R448	301-473	47 k	1/2 w			5%
R449	311-305	50 k		Var.		—100 POSITION RANGE
R454	309-182	3 k	1/2 w		Prec.	1%
R455†	301-300	30 Ω	1/2 w			5%
R456	310-132	19.6 k	1 w		Prec.	1%
R457	310-115	15 k	1 w		Prec.	1%
R458	301-473	47 k	1/2 w			5%
R459	309-105	4.21 k	1/2 w		Prec.	1%
R460	301-914	910 k	1/2 w			5%
R461	303-223	22 k	1 w			5%
R462	315-302	3 k	1/4 w			5%
R464	308-228	4 k	7 w		WW	5%
R465	308-067	750 Ω	5 w		WW	5%
R466	305-751	750 Ω	2 w			5%
R467	301-620	62 Ω	1/2 w			5%
R467	302-330	33 Ω	1/2 w			101-2168 2169-up
R468	301-470	47 Ω	1/2 w			5%
R470	301-914	910 k	1/2 w			5%
R471	303-223	22 k	1 w			5%
R472	315-302	3 k	1/4 w			5%
R474	308-228	4 k	7 w		WW	5%
R476	305-751	750 Ω	2 w			5%
R477	use 311-258	100 Ω	1/2 w	Var.		CALIB.
R477	311-097	200 Ω	1/2 w	Var.		CALIB.
R478	302-270	27 Ω	1/2 w			101-2168 2169-up
R491	308-106	1 k	5 w		WW	5%
R493	302-270	27 Ω	1/2 w			
R494	305-622	6.2 k	2 w			5%
R496	301-274	270 k	1/2 w			5%
R497	301-303	30 k	1/2 w			5%
R499	302-270	27 Ω	1/2 w			
R501	302-102	1 k	1/2 w			X1310-up
R502	301-164	160 k	1/2 w			5%
R503	302-183	18 k	1/2 w			
R504	309-333	3.65 k	1/2 w		Prec.	1%
R504	309-191	4.535 k	1/2 w		Prec.	1%
R506	309-332	6.8 k	1/2 w		Prec.	1%
R506	309-159	5 k	1/2 w		Prec.	1%
R508	309-042	68 k	1/2 w		Prec.	1%
R510	use 315-0820-00	82 Ω	1/4 w			5%
R512	301-334	330 k	1/2 w			5%
R512	301-0154-00	150 k	1/2 w			5%
R513	301-363	36 k	1/2 w			5%
R513	301-0183-00	18 k	1/2 w			5%
R518	309-042	68 k	1/2 w		Prec.	1%
R521	311-068	500 k	.2 w	Var.		CHAN. 1 INT. TRIG. DC LEVEL
R522	316-124	120 k	1/4 w			
R524	301-102	1 k	1/2 w			5%
R524	301-0561-00	560 Ω	1/2 w			5%
R525	301-123	12 k	1/2 w			5%
R526	301-163	16 k	1/2 w			5%

†Furnished as a unit with L455.

Resistors (Cont'd)

Ckt. No.	Tektronix Part No.		Description			S/N Range
R528	301-624	620 k	$\frac{1}{2}$ w		5%	101-1309
R528	301-684	680 k	$\frac{1}{2}$ w		5%	1310-up
R529	301-273	27 k	$\frac{1}{2}$ w		5%	101-1309
R529	301-223	22 k	$\frac{1}{2}$ w		5%	1310-up
R530	311-068	500 k	$\frac{1}{2}$ w	Var.	COMPOSITE INT.	
					TRIG. DC LEVEL	101-589
R530	311-157	100 k		Var.	COMPOSITE INT. TRIG.	
					DC LEVEL	590-up
						101-589X
R531	316-105	1 meg	$\frac{1}{4}$ w			
R532	Use 315-470	47 Ω	$\frac{1}{4}$ w		5%	
R533	Use 316-103	10 k	$\frac{1}{4}$ w			
R534	302-473	47 k	$\frac{1}{2}$ w			
R535	301-514	510 k	$\frac{1}{2}$ w		5%	
R536	301-224	220 k	$\frac{1}{2}$ w		5%	101-589
	301-204	200 k	$\frac{1}{2}$ w		5%	590-up
R540	Ch. 1 301-103	10 k	$\frac{1}{2}$ w		5%	101-1309
R540	Ch. 1 315-752	7.5 k	$\frac{1}{4}$ w		5%	1310-up
R542	309-320	3.37 k	$\frac{1}{2}$ w	Prec.	1%	
R543	318-084	10 k	$\frac{1}{8}$ w	Prec.	1%	
R544	318-084	10 k	$\frac{1}{8}$ w	Prec.	1%	
R545	318-084	10 k	$\frac{1}{8}$ w	Prec.	1%	
R547	309-250	500 Ω	$\frac{1}{2}$ w	Prec.	1%	
R548	305-752	7.5 k	2 w		5%	
R549	316-221	220 Ω	$\frac{1}{4}$ w			X1650-up
R550	Ch. 2 301-103	10 k	$\frac{1}{2}$ w		5%	101-1309
R550	Ch. 2 315-752	7.5 k	$\frac{1}{4}$ w		5%	1310-up
R552	309-320	3.37 k	$\frac{1}{2}$ w	Prec.	1%	
R553	318-084	10 k	$\frac{1}{8}$ w	Prec.	1%	
R554	318-084	10 k	$\frac{1}{8}$ w	Prec.	1%	
R555	318-084	10 k	$\frac{1}{8}$ w	Prec.	1%	
R557	309-250	500 Ω	$\frac{1}{2}$ w	Prec.	1%	
R558	305-752	7.5 k	2 w		5%	
R560	Ch. 3 301-103	10 k	$\frac{1}{2}$ w		5%	101-1309
R560	Ch. 3 315-752	7.5 k	$\frac{1}{4}$ w		5%	1310-up
R562	309-320	3.37 k	$\frac{1}{2}$ w	Prec.	1%	
R563	318-084	10 k	$\frac{1}{8}$ w	Prec.	1%	
R564	318-084	10 k	$\frac{1}{8}$ w	Prec.	1%	
R565	318-084	10 k	$\frac{1}{8}$ w	Prec.	1%	
R567	309-250	500 Ω	$\frac{1}{2}$ w	Prec.	1%	
R568	305-752	7.5 k	2 w		5%	
R570	Ch. 4 301-103	10 k	$\frac{1}{2}$ w		5%	101-1309
R570	CH. 4 315-752	7.5 k	$\frac{1}{4}$ w		5%	1310-up
R572	309-320	3.37 k	$\frac{1}{2}$ w	Prec.	1%	
R573	318-084	10 k	$\frac{1}{8}$ w	Prec.	1%	
R574	318-084	10 k	$\frac{1}{8}$ w	Prec.	1%	
R575	318-084	10 k	$\frac{1}{8}$ w	Prec.	1%	
R577	309-250	500 Ω	$\frac{1}{2}$ w	Prec.	1%	
R578	305-752	7.5 k	2 w		5%	
R580	301-154	150 k	$\frac{1}{2}$ w		5%	101-1309
R580	309-376	125 k	$\frac{1}{2}$ w	Prec.	1%	1310-up
R582	302-823	82 k	$\frac{1}{2}$ w			101-1309
R582	302-473	47 k	$\frac{1}{2}$ w			1310-up
R583	316-103	10 k	$\frac{1}{4}$ w			101-1309
R583	316-392	3.9 k	$\frac{1}{4}$ w			1310-up
R584	316-331	330 Ω	$\frac{1}{4}$ w			X1310-up
R585	309-376	125 k	$\frac{1}{2}$ w	Prec.	1%	101-859
R585	309-046	111 k	$\frac{1}{2}$ w	Prec.	1%	860-up

Parts List—Type 3A74

Resistors (Cont'd)

Ckt. No.	Tektronix Part No.	Description	S/N Range
R586	316-270	27 Ω $\frac{1}{4}$ w	X156-up
R587	309-098	2 k $\frac{1}{2}$ w	
R588	309-210	450 Ω $\frac{1}{2}$ w	
R589	302-270	27 Ω $\frac{1}{2}$ w	
R593	Use 302-103	10 k $\frac{1}{2}$ w	
R595	301-302	3 k $\frac{1}{2}$ w	X1310-up
R596	302-270	27 Ω $\frac{1}{2}$ w	
R597	316-821	820 Ω $\frac{1}{4}$ w	

Switches

		Unwired	Wired			
SW401	Channel 1,2,3,4	260-446		Toggle	AC/DC	
SW410A†	Channel 1	*050-093	*050-111	Rotary	VOLTS/DIV.	101-589
		260-512	*262-544			590-up
SW410B†	Channel 2	*050-094	*050-112	Rotary	VOLTS/DIV.	101-589
		260-513	*262-545			590-up
SW410C†	Channel 3	*050-093	*050-113	Rotary	VOLTS/DIV.	101-589
		260-512	*262-546			590-up
SW410D†	Channel 4	*050-094	*050-114	Rotary	VOLTS/DIV.	101-589
		260-513	*262-547			590-up
SW430††	Channel 1,2,3,4	260-445	*262-489	Rotary	MODE	101-1309
SW430††	Channel 1,2,3,4	260-445	*262-649	Rotary	MODE	1310-up
SW530		260-212		Slide	TRIGGER	101-1389
SW530		260-0447-00		Slide	TRIGGER	1390-up
SW580		260-0407-00		Toggle	CHOP/ALT.	

Transformers

T592	*120-274	Toroid 3T	TD69
T593	*120-284	Toroid 2T	TD76
T595	*120-273	Toroid 2T	TD68

Transistors

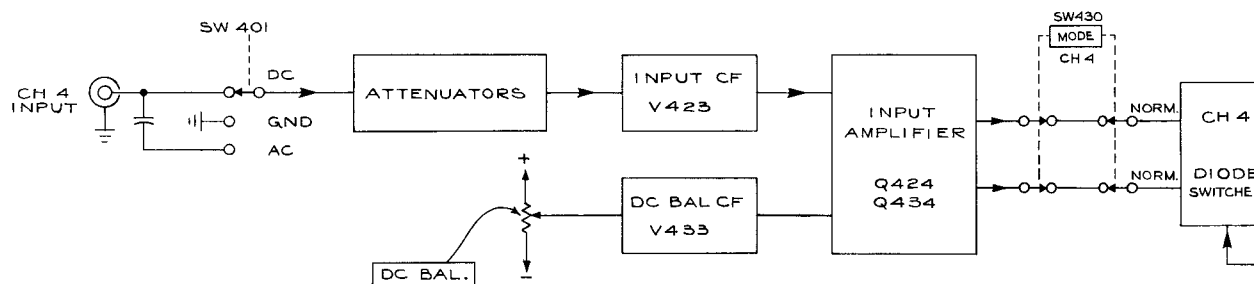
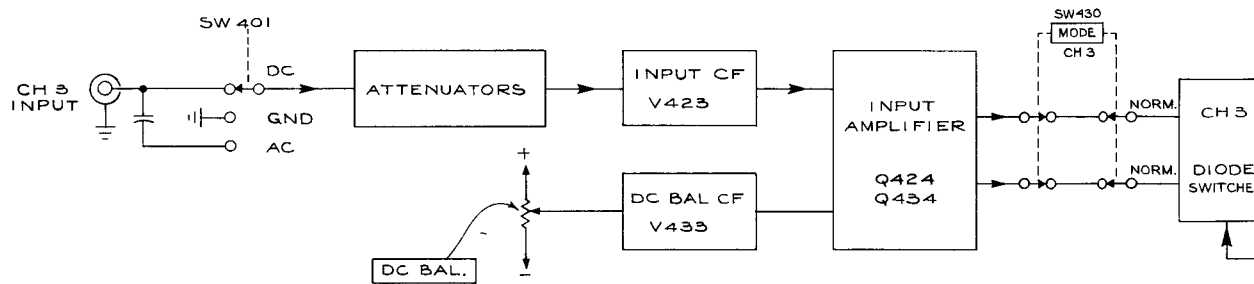
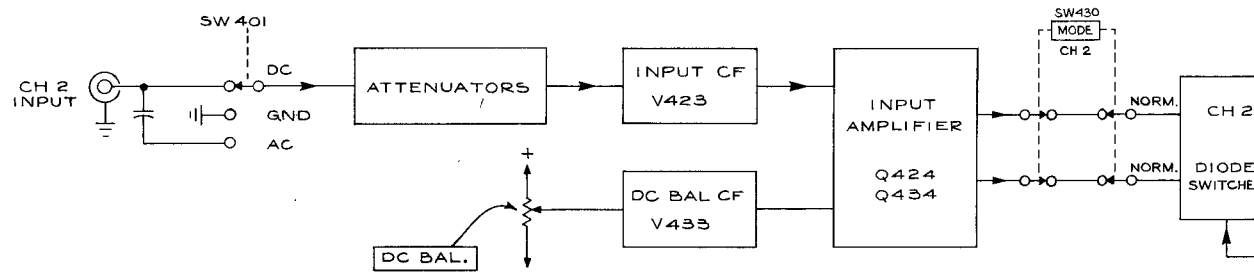
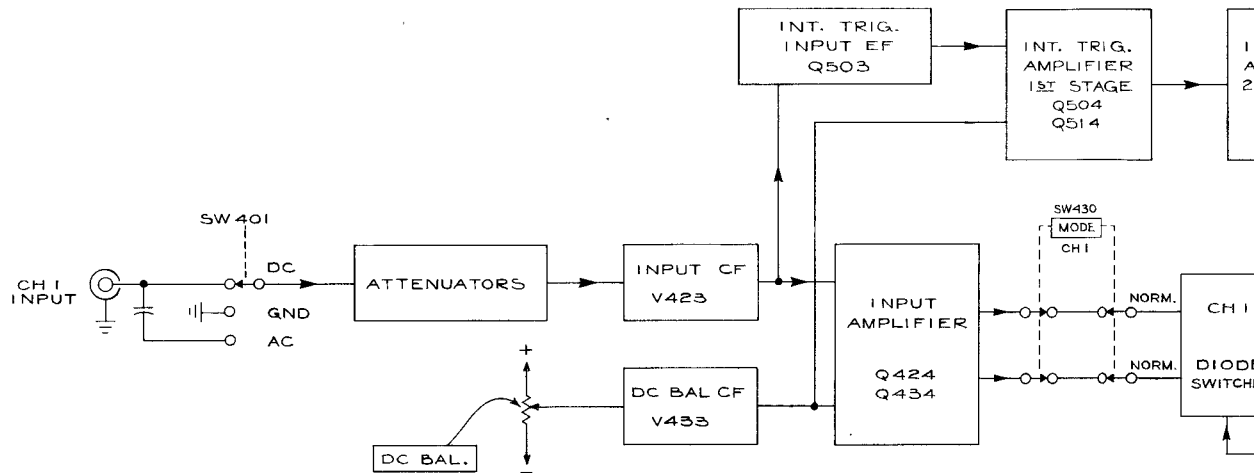
Q424 Ch. 1,2,3,4	Use 151-135	2N2635
Q434 Ch. 1,2,3,4	Use 151-135	2N2635
Q444	151-062	N101
Q454	151-062	N101
Q463	Use 151-135	2N2635
Q473	Use 151-135	2N2635
Q503	Use 151-135	2N2635
Q504	Use 151-135	2N2635
Q514	Use 151-135	2N2635
Q524	151-084	2N1225
Q545	Use 151-135	2N2635
Q555	Use 151-135	2N2635
Q565	Use 151-135	2N2635
Q575	Use 151-135	2N2635
Q583	151-062	N101
Q690	Use 151-135	2N2635

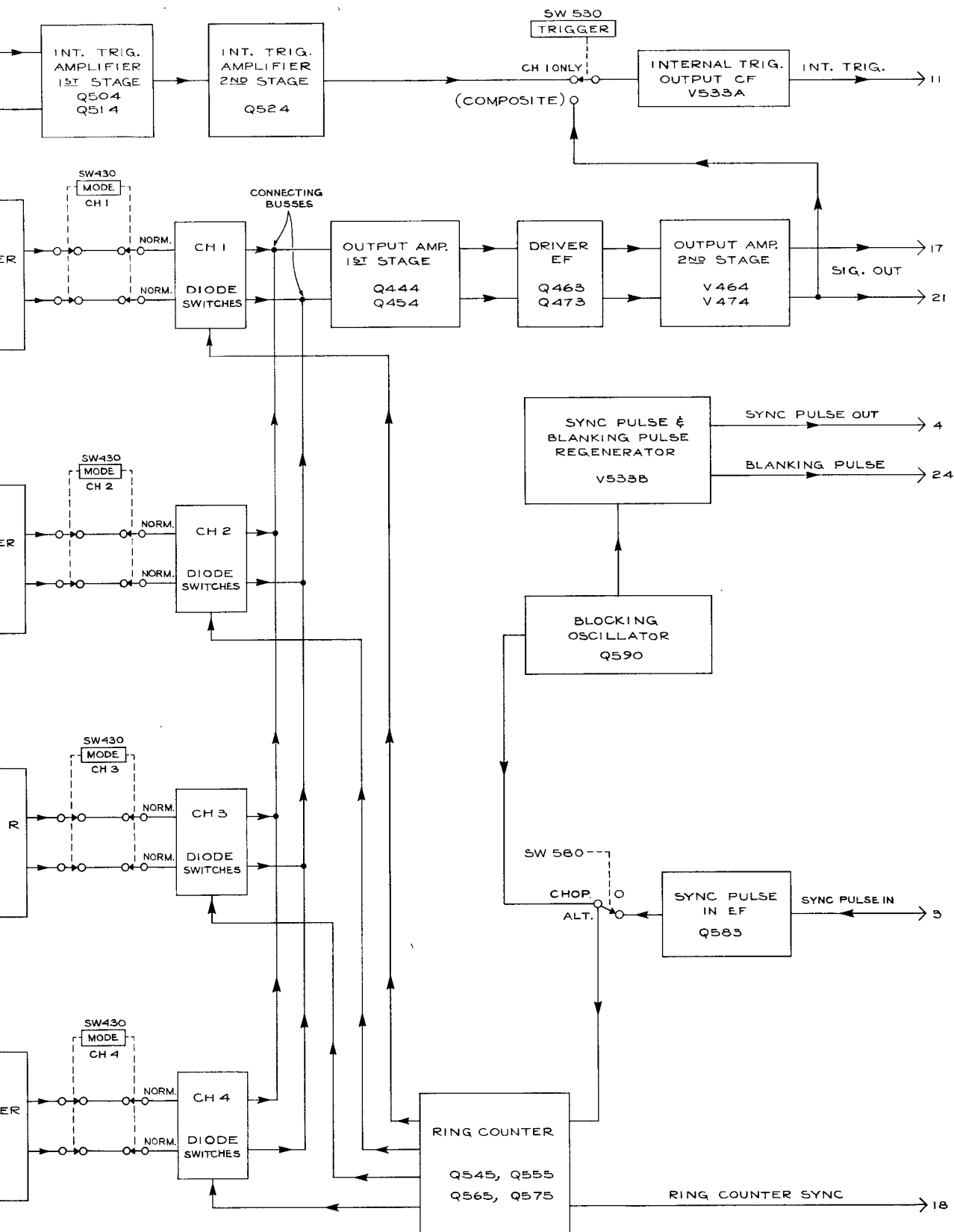
†SW410A, B, C, D & R426 are concentric. Furnished as a unit.

††SW430 and R438 are concentric. Furnished as a unit.

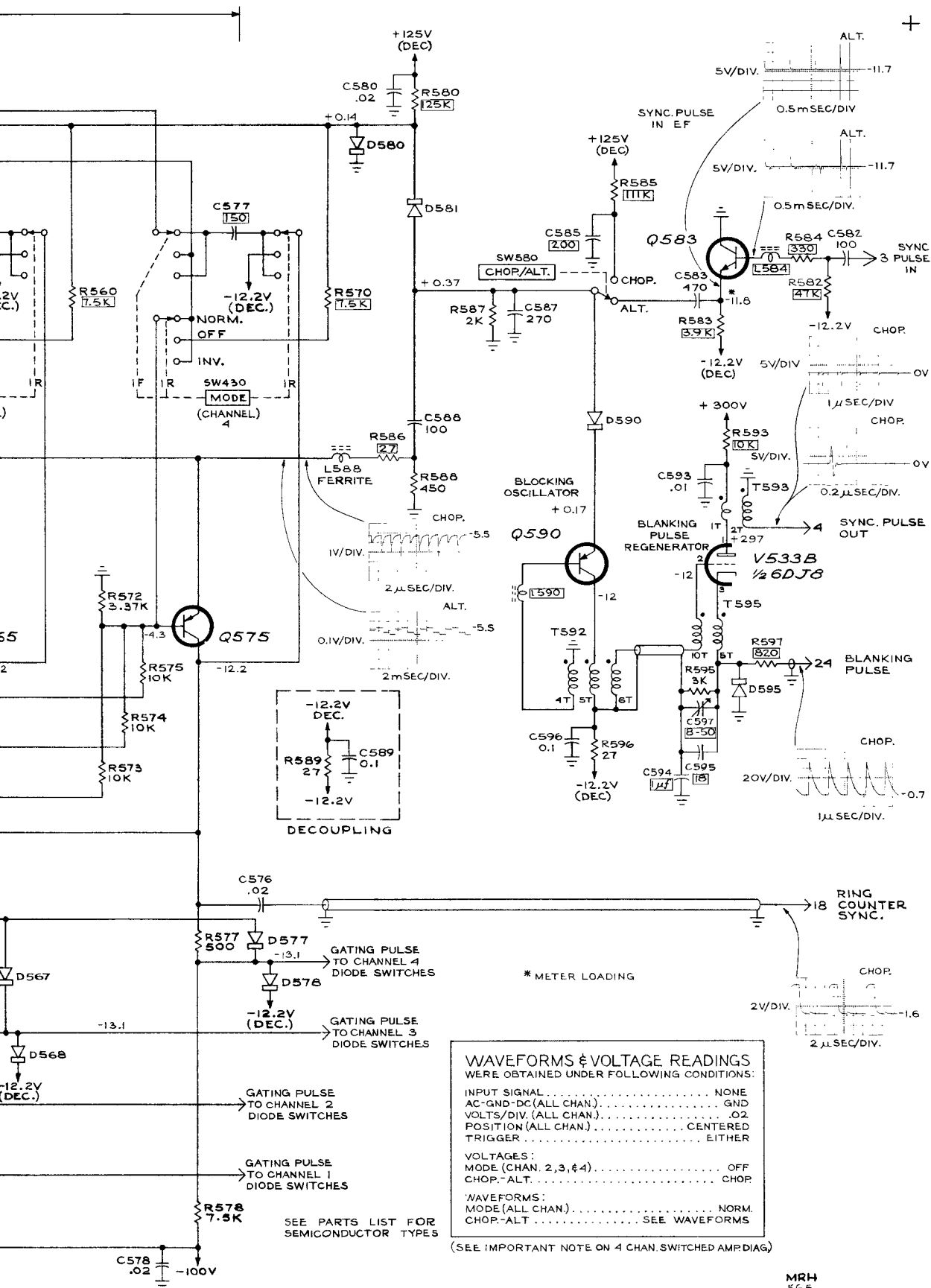
Electron Tubes

Ckt. No.	Tektronix Part No.	Description	S/N Range
V423 Ch. 1,2,3,4 Use	*154-0306-02	7586, aged	
V433 Ch. 1,2,3,4 Use	*154-0306-02	7586, aged	
V464	154-031	6CL6	
V474	154-031	6CL6	
V533	154-187	6DJ8	





PLM
863
BLOCK DIAGRAM



CHANNEL SWITCHING CIRCUIT

MRH
565

TYPICAL SWITCHED ATTENUATOR & AMPLIFIER (4 REQUIRED)

IMPORTANT

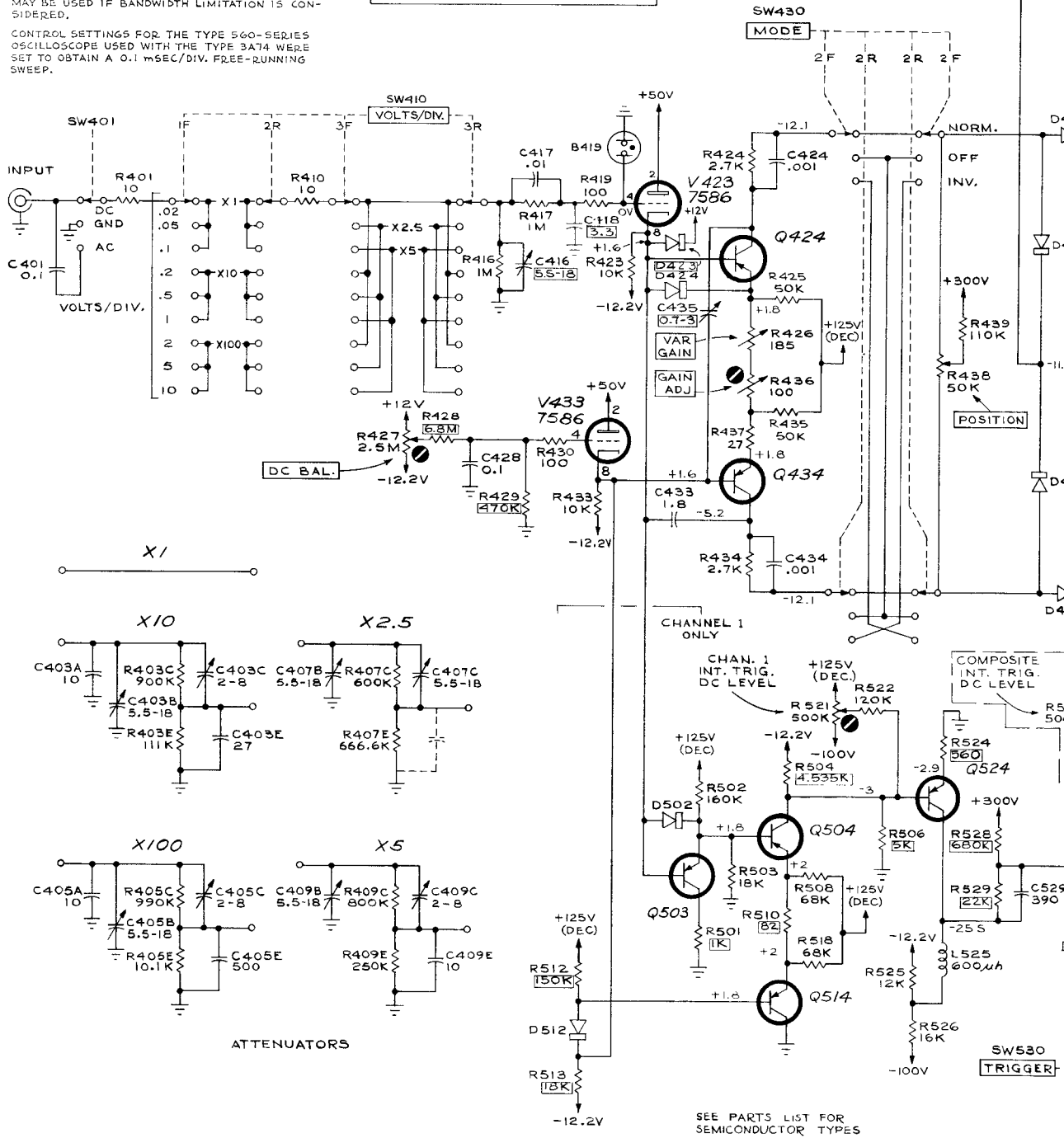
ALL CIRCUIT VOLTAGES WERE OBTAINED WITH A 20,000 Ω /V VOM. ALL READINGS ARE IN VOLTS. VOLTAGE AND WAVEFORM AMPLITUDE MEASUREMENTS ARE NOT ABSOLUTE. THEY MAY VARY BETWEEN UNITS DUE TO NORMAL MANUFACTURING TOLERANCES AND TRANSISTOR AND VACUUM TUBE CHARACTERISTICS.

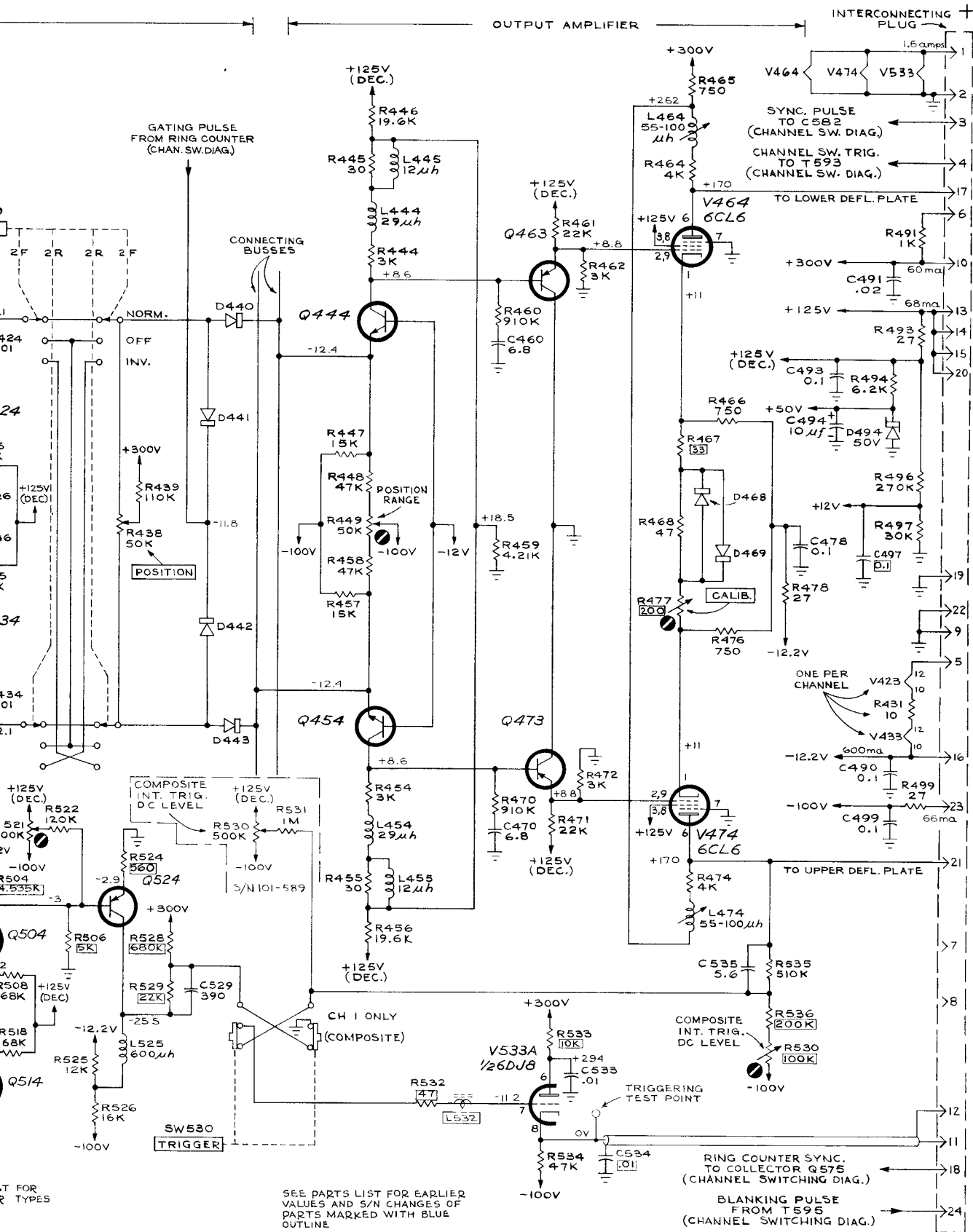
ACTUAL PHOTOGRAPHS OF WAVEFORMS ARE SHOWN, WITH THE TEST OSCILLOSCOPE SET ON +INT TRIGGERING. THE TEST OSCILLOSCOPE USED HAS A BANDWIDTH OF DC TO 10 MC, ALTHOUGH A DC TO 300 KC, OR BETTER, BANDWIDTH TEST OSCILLOSCOPE MAY BE USED IF BANDWIDTH LIMITATION IS CONSIDERED.

CONTROL SETTINGS FOR THE TYPE 560-SERIES OSCILLOSCOPE USED WITH THE TYPE 3A74 WERE SET TO OBTAIN A 0.1 msec/DIV. FREE-RUNNING SWEEP.

VOLTAGE READINGS WERE OBTAINED UNDER FOLLOWING CONDITIONS

INPUT SIGNAL.....NONE
AC-GND-DC(ALL CHAN.).....GND
VOLTS/DIV.(ALL CHAN.)......02
POSITION(ALL CHAN.).....CENTERED
MODE (CHAN 1).....NORM
MODE (CHAN. 2,3, & 4).....OFF
TRIGGER.....CH1 ONLY
CHOP-ALT.....CHOP





MANUAL CHANGE INFORMATION

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

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

TYPE 3A74

PARTS LIST CORRECTION

CHANGE TO:

R588

323-0158-00

432 Ω

1/2 W

1%

TYPE 3A74 TENT SN 3660

PARTS LIST CORRECTION

CHANGE TO:

R588

323-0676-00

386 Ω

1/2 W

1%