

FIELD

TRAINING

PACKAGE

**TYPE 1S1
SAMPLING
PLUG-IN**

**TYPE 1S1
SAMPLING
PLUG-IN**

Written and Produced in Field Training

By

LES HURLOCK and GENE SAMS

Material in this Training Package is

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FOR INTERNAL USE ONLY

PROJECT MANAGER ----- AL ZIMMERMAN

Project Engineer (E) ----- Gene Cowan (Vertical)

Project Engineer (E) ----- Chuck Edgar (Horizontal)

Project Engineer (M) ----- Bud Diebele

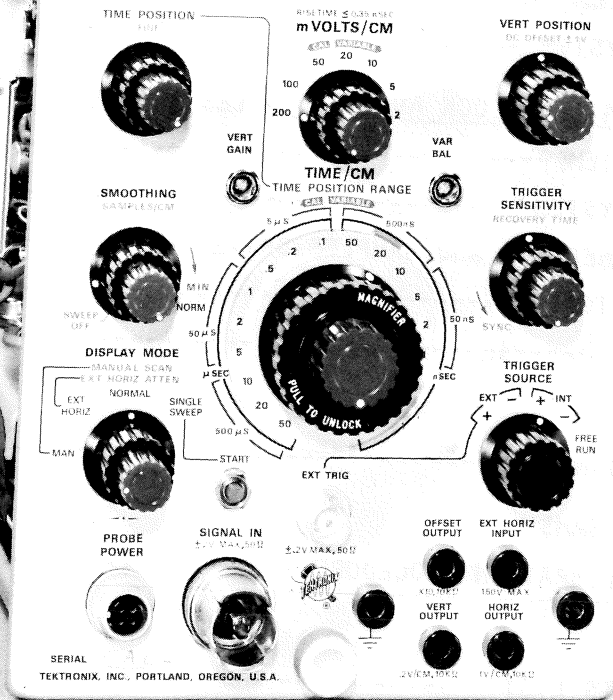
Evaluation Engineer (E) ----- Cecil Conrad

Evaluation Engineer (M) ----- Jesse Chappell

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TYPE 1S1 SAMPLING UNIT



INTRODUCTIONTHE 1S1 SAMPLING PLUG-IN

The Type 1S1 Sampling unit is a complete 50 Ω single-channel sampler. It may be used in any Tektronix oscilloscope which accepts Letter-Series and 1-Series plug-ins. Internal triggering is featured together with a displayed risetime of 0.35 nsec. A unique "Time Magnifier" arrangement allows any part of the display to be magnified up to 100X horizontally without reducing displayed dot density. Actual sweep rate, even when magnified, is read out directly on a single knob. A DC offset control permits observation of millivolt signals in the presence of up to ± 1 volt input levels.

Output signals are provided to drive both X-Y and Y-T recorders.

The 1S1 basically requires a power supply to function as a complete sampling unit, if the 1S1 is operated in a 132, 133 or 127 power supply the necessary display and driving signals will be available at the 1S1 front panel.

An external monitoring scope could be used in conjunction with the power supplies, however in order to retain Retrace Blanking the 1S1 Vertical signal must be taken from the Vertical Output of the 132 - 133 or 127.

Inter-dot blanking will not be available when using the Power Supplies.

The oscilloscope power supplies/plug-in power supplies are not critical to the operation of the 1S1, all critical supplies are either regenerated or re-regulated by the 1S1.

Customers familiar with the 30/40 series instruments should have no difficulty in operating the ISI. Most signals below 100 mc can be triggered by using the TRIGGER SENSITIVITY in a similar manner to a conventional TRIGGERING LEVEL control, signals up to 1 Gc may be viewed by using the ISI in the SYNC mode, here again this is roughly equivalent to using a conventional scope in the HF SYNC mode.

The TIME/CM readout and the mVolts/cm readout are quite straight-forward, however care should be taken not to exceed the maximum rating into the Vertical Input ($\pm 2v$ into 50 Ω).

The controls peculiar to Sampling, such as, Time Position, Smoothing, Samples/cm, Recovery Time and DC Offset will need to be reviewed by customers unfamiliar with Sampling techniques.

PERFORMANCE REQUIREMENTS SUMMARYVERTICAL SYSTEM

Number of Channels	One
*Dynamic Impedance	$\approx 50\Omega$
Risetime	≤ 350 psec
Frequency Range	DC to 1 Gc
Sensitivity	2 mVOLTS/CM to 200 mVOLTS/CM 1 - 2 - 5 Sequence
Variable mVOLTS/CM Range	$\geq 1:4$ increasing the sensitivity to ≈ 500 μ VOLTS/CM.
mVOLTS/CM Accuracy	$\pm 3\%$ all ranges
Maximum Input Voltage	2v combined DC and Peak AC
Delay Line	43 nSEC
Smoothing Range	$\geq 3:1$
Signal Change With Smoothing	$\leq \pm 3\%$
Tangential Noise	≤ 1 mVlt (unsmoothed)
Vertical Position Range	$\geq \pm 5$ cm
Front panel Vertical Output	200 mVlt per displayed cm $\pm 3\%$
Vertical Output Impedance	$\approx 10k$

*See Vertical Block Analysis - Page 3-1 for discussion on input impedance.

DC Offset Output Range (front panel)	$\geq \pm 10v$
DC Offset Accuracy	$\pm 2\%$ of 1/10 the measured offset at the front panel banana jack.
Inter-dot Blanking	$\geq 1.5 \mu\text{SEC}$
Retrace Blanking	No visible retrace with Vertical Position and DC Offset C.W. at 2 mVolts/cm.
Output D.C. Level	$67.5v \pm 2.5v$

HORIZONTAL SYSTEMTriggering -- EXT

Dynamic impedance	nominally 50Ω
Maximum overload	$\pm 2v$
Normal operating range	100kc to 1Gc
Sensitivity	4 to 8 mv over the frequency range of 100kc to 1Gc (Sinewave)
Ext. Trigger Kickout	$\leq 25 \text{ mVolts P.P.}$

Triggering -- INT

Normal operating range	100kc to 1Gc
Sensitivity	50 mVolts over the frequency range of 100kc to 1Gc (Sinewave)

Trigger Jitter -- InternalSinewave

100 kc	50 mv	$\leq .7 \mu\text{SEC}$
10 mc	50 mv	$\leq 5 \text{ nSEC}$
1 Gc	50 mv	$\leq 200 \text{ psec}$ (using Sync if needed)

Pulse $\leq 200 \text{ psec}$ Trigger Jitter -- ExternalSinewave

100 kc	4 mv	$\leq .5 \mu\text{SEC}$
10 mc	8 mv	$\leq 5 \text{ nSEC}$
1 Gc	8 mv	$\leq 200 \text{ psec}$

Pulse 7 mv $\leq 200 \text{ psec}$

DISPLAY JITTER

Time Position Range

50 nSEC
500 nSEC
5 μ SEC
50 μ SEC
500 μ SEC

$\begin{matrix} \vee \\ \vee \\ \vee \\ \vee \\ \vee \\ \vee \\ \vee \\ \vee \end{matrix} \begin{matrix} 40 \text{ pSEC} \\ 120 \text{ pSEC} \\ 1 \text{ nSEC} \\ 10 \text{ nSEC} \\ 100 \text{ nSEC} \end{matrix} \left. \begin{matrix} \\ \\ \\ \\ \end{matrix} \right\} \begin{matrix} \text{Triggered internally} \\ \text{on .4v to 1v} \end{matrix}$

SWEEP TIMING ACCURACY

Basic Accuracy

 $\pm 3\%$ normal or magnified

Time Position Range

50 nSEC
500 nSEC
5 μ SEC
50 μ SEC
500 μ SEC

Exclude first 4 nSEC of ramp
 " " 20 nSEC " "
 " " 200 nSEC " "
 " " 2 μ SEC " "
 " " 20 μ SEC " "

HORIZONTAL OUTPUT (Banana jack)

Normal Scan

10v to 10.3v

Output Resistance

 $\approx 10k$

Linearity

 $\pm 1\%$ with 5 to 50 Samples/cm

Manual Scan Range

10.5v \pm .5v

Single Sweep

Sweeps once per start.

Samples/cm

Continuously Variable -- Uncalibrated
4 to 6 Samples/cm to high sample density.

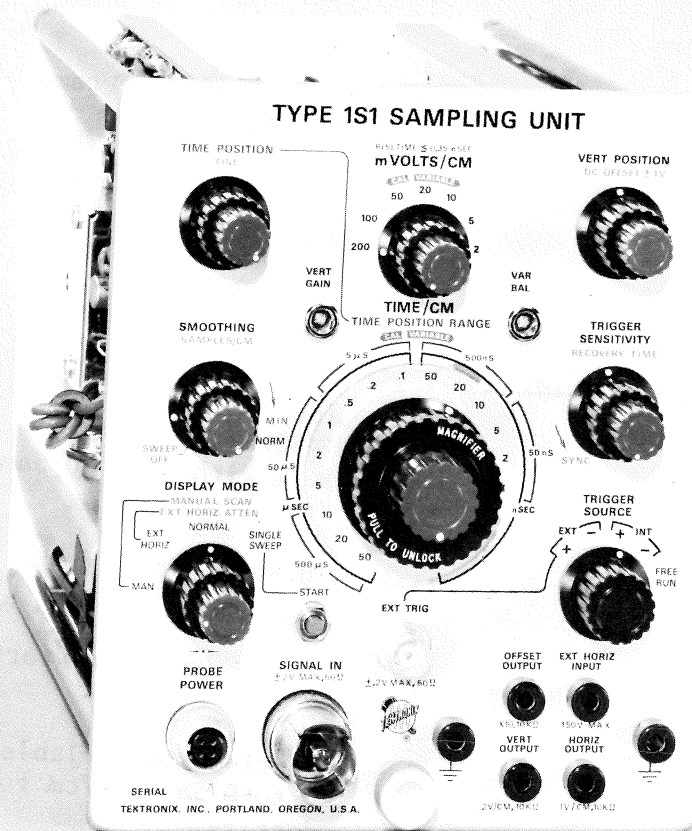
EXT. HORIZ. INPUT

Deflection Factor

1v $\pm 3\%$ per cm to ≥ 16 v per cm

Input Resistance

 $\approx 100k$ to $\approx 20k$



ISI CONTROLS and CONNECTORSGENERAL

The front panel of the ISI contains all the controls necessary to make Voltage and Time measurements. The only user controls not on the ISI front panel are:

1. The EXT HORIZ ATTEN control (main frame, for initial setup).
2. The HORIZ POSITION control (mainframe, for initial setup).
3. The CRT controls.

Generally, all controls operate smoothly, the mv/cm VARIABLE is a stopless type with strong detent action. The time/cm VARIABLE has a stop and detent action.

There are two other detent located controls that might be missed by a person unfamiliar with the unit--these are, the SYNC position on the Recovery Time pot, and the SWEEP OFF position on the Samples/cm control.

FIRST TIME OPERATION

The ISI is one of the most straight-forward sampling systems produced. The non-sampling man will find many similarities between this instrument and conventional oscilloscopes, however there are a few basic operations which must be performed to insure First Time success. These are--

1. Adjust the scope mainframe HORIZ sensitivity to 1 v/cm by injecting 5v from the mainframe AMPLITUDE CALIBRATOR and adjusting the mainframe VARIABLE, use the center of the CRT to avoid possible compression errors.

Early 530/40 series, use MAG X5 and HORIZ ATTEN X1.

530A/40A, 540B use HORIZ ATTEN X1.

544/46/47, use HORIZ ATTEN X10.

2. Some earlier scopes (for example - 531A) allow the time base to unblank the CRT--even when switched to EXT HORIZ. This will cause undesirable interference with ISI unblanking and blanking display. If, for example a 531A is used, the sweep should not be (a) free-running, (b) in a triggerable condition, or (c) in Auto.

Most later scopes lock out unblanking signals when in EXT HORIZ.

3. The CRT CATHODE SELECTOR on the back of the scope mainframe should be in the CHOPPED BLANKING position.

EARLY 30/40 Series Scopes

Many of these instruments have not had chopped blanking mods installed, the ISI will operate in these units but about .5 cm of Vertical stepping transients will show, these may not be bothersome, however if they are, the scope can be updated by installing chopped blanking mod 040-0403-00.

NOTE 1

Early 30/40 series scopes incorporating chopped blanking modes 040-0198-00 and 040-0200-00 will not perform the blanking function when used with the ISI. Install updating mod 040-0404-00.

NOTE 2

The 580/82 does not have any provision for chopped blanking (inter-dot blanking).

VERTICAL CONTROLS AND CONNECTORSmVOLTS/CM SWITCHRANGE - 200 mVolts/cm to 2 mVolts/cmACCURACY - $\pm 3\%$ all rangesSEQUENCE - 1 - 2 - 5VARIABLE - $\geq 1:4$

Stopless pot with detent - control increases gain
in the "Uncl" position.

VERTICAL POSITION - $\geq \pm 5$ cmD.C. OFFSETControl with $\approx 10:1$ reduction drive.Voltage referred to the input - $\geq \pm 1v$.D.C. OFFSET OUTPUT

Front panel Banana jack.

USE - For monitoring and initial setup.VOLTAGE - $\geq \pm 10v$ ACCURACY - $\pm 2\%$ of 10 times indicated offset.OUTPUT RESISTANCE $\approx 10k$ Possibility of damage due to shorting = NONESMOOTHING Control $\geq 3:1$ range.

Normal position - CW

SIGNAL INPUTTYPE - General RadioDYNAMIC IMPEDANCE $\approx 50\Omega$ (see Detailed Block Analysis Page 3-1).RISETIME - ≤ 350 pSEC*VSWR - $\approx 1.07:1$ at 500 Mc to $\approx 1.8:1$ at 1 GcMAX SIGNAL INPUT - $\pm 2v$ PROBE POWER Connector

Supplies +100v and -12.6v to P6032 cathode follower probe, if used.

VERTICAL OUTPUT - front panel Banana jackUSE - Vertical input to X - Y recorder.VOLTAGE < 200 mv per displayed cm $\pm 3\%$.OUTPUT RESISTANCE - $\approx 10k$ Possibility of damage due to shorting = NONE

* VSWR measurements were taken on an early "B" phase instrument, however current production instruments should not show any radical departure from these measurements. See Page 1-24 for VSWR chart and typical response curve.

HORIZONTAL CONTROLS AND CONNECTORSTIME/CM

RANGE - 50 μ SEC/CM to .1 nSEC/CM.

SEQUENCE - 1 - 2 - 5 (18 positions).

ACCURACY - \pm 3% normal or magnified.

TIME POSITION RANGE

Five ranges -

500 μ s

50 μ s

5 μ s

500 ns

50 ns

This control is mechanically and electrically interconnected with the TIME/CM control. It is designed so that any combination of TIME POSITION RANGE and TIME/CM setting always gives the correct TIME/CM readout.

This device deserves a separate chapter--please refer to the end of this section for more detail.

TIME POSITION

"Coarse" and "Fine" concentric controls.

COMBINED RANGE - \approx Time Position Range setting.

(Refer to special section on the Time/cm switch at the end of this section.)

DISPLAY MODE

Four position rotary switch.

1. NORMAL

2. SINGLE SWEEP - enables a single sweep to be displayed after the START button is depressed.

NOTE: The vertical system still needs repetitive information.

3. EXT HORIZ - Front panel Banana jackINPUT RESISTANCE - 100k (CCW) to 20k (CW).MAX INPUT VOLTAGE - .150 volts.USE - Can be driven from X - Y recorder, etc.DEFLECTION FACTOR - 1 v/cm \pm 3% to \geq 16 v/cm
(in conjunction with the
ISI EXT Horiz Atten control).4. MANUAL SCANRANGE - 10.5 v \pm .5 v (\approx 10.5 cm)In this position, the Ext Horiz Atten
control on the ISI becomes the Manual
Scan control.TRIGGER SOURCE

Five position rotary switch.

INT + or -FREQUENCY RANGE - 100 kc to 1 GcSENSITIVITY = 50 mv (at the vertical input) over
the frequency range of 100 kc to 1
Gc (Sine Wave).EXT + or -FREQUENCY RANGE - 100 kc to 1 GcSENSITIVITY = 4 to 8 mv over the frequency range
of 100 kc to 1 Gc (Sine wave).Dynamic Impedance \approx 50 Ω AC coupled.Trig Input - BNC jack - Max. overload \pm 2v.FREE RUNThis position on the Trigger Source switch puts
the unit into a free running condition. This feature
enables the operator to produce a trace without
readjusting the Trigger Sensitivity control. It also
provides a convenient way of initially setting up the
unit in regard to Vertical Position and Balance
adjustments.

TRIGGER SENSITIVITY

Trigger circuit starts to free run when the control is rotated CW to ≈ 2 o'clock. Sensitivity is increased in the CW direction on either + or - polarity.

Triggering is reliable and non-critical.

RECOVERY TIME

This control is concentric with the Trigger Sensitivity knob.

Adjustment of this control affects the hold-off time of the trigger circuit and therefore the Max. rep. rate.

For the majority of applications this control is not critical--it can be left in any position.

SYNC

The SYNC position is obtained by rotating the RECOVERY TIME control CCW to the detent position.

This position may provide better triggering beyond 100 mc. (See Trigger circuit--Block Analysis section).

SAMPLES/CM

Continuously variable. ≈ 5 samples/cm to high sample density.

SWEEP-OFF

If the SAMPLES/CM control is rotated CCW to the detent position the sweep will not run--this prevents the retrace blanking waveform from interfering with the display when using the ISI in a Real Time Sampling application.

The same condition can be obtained by switching the DISPLAY MODE to EXT HORIZ or MANUAL SCAN.

HORIZ OUTPUT

Front panel Banana jack.

Staircase output to mainframe.

1 v/cm

OUTPUT RESISTANCE - 10k

Possibility of damage due to shorting = NONE

SPECIAL SECTION on the

TIME/CM SWITCH AND TIME POSITION RANGE

TIME/CM SWITCH

The TIME/CM switch provides calibrated equivalent sweep speeds of 50 $\mu\text{SEC}/\text{CM}$ to .1 nanosec/ CM .

From the users point of view the TIME/CM switch is quite easy to operate.

1. The white dot on the grey knob ALWAYS indicates the actual equivalent sweep time.
2. In addition to the equivalent sweep time markings (50 $\mu\text{s}/\text{CM}$ to .1 ns/ CM) there are five blue sectors indicating the Time Position Range.

A blue rectangle on the clear plastic skirt of the TIME/CM knob can be placed in any one of these five sectors. Each sector indicates the Time Position Range available.

The five ranges are:

- 500 μsec
- 50 μsec
- 5 μsec
- 500 nsec
- 50 nsec

Time Position is similar to Time Delay in that the time of the first sample can be delayed in respect to the start of the fast ramp.

The five Time Position Range positions operate in conjunction with the front panel TIME POSITION Variable controls (concentric - coarse and fine). These two controls cover the range indicated by the TIME POSITION RANGE sector.

Figure 1-1 shows the TIME/CM switch in detail.

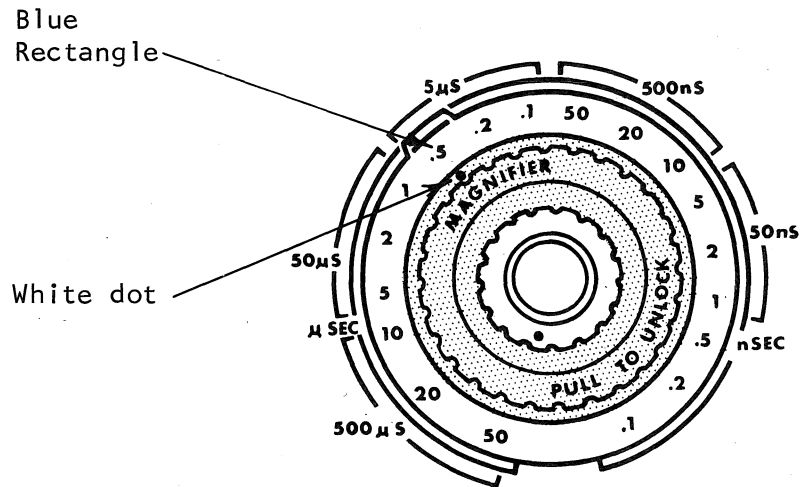


Figure 1-1

For example, if the white dot is lined up with the .5 $\mu\text{SEC}/\text{CM}$ mark the blue rectangle will normally be within the 5 μSEC TIME POSITION RANGE sector.

This means that:

- A. The equivalent time is .5 $\mu\text{SEC}/\text{CM}$ (or 5 μSEC = 10 CM).
- B. The start of the display (the first sample) can be delayed an additional 5 μSEC (blue Time Position Range sector = 5 μSEC).

The word "additional" is used here to indicate that there are other unavoidable delays between the receipt of a trigger signal and the occurrence of the first sample -- even with the TIME POSITION controls at minimum (CW).

To continue with the example, $.5 \mu\text{SEC}/\text{CM}$ and $5 \mu\text{SEC}$ Time Position Range.

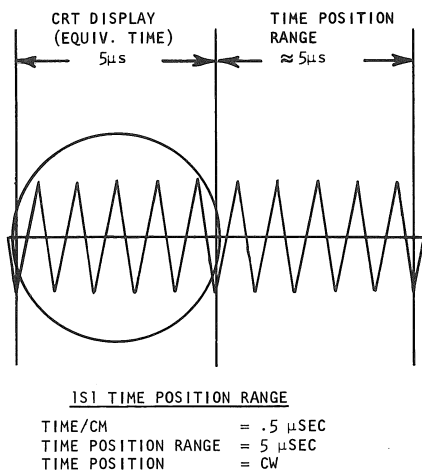


Figure 1-2

Any point on the display can be moved a maximum of $5 \mu\text{SEC}$ to the left, so in effect, we have a $5 \mu\text{SEC}$ "window" -- in addition to the displayed window already on the CRT; which in this case is $5 \mu\text{SEC}$ or a total window of $10 \mu\text{SEC}$ (see figure 1-2).

If the Time/CM switch is placed in the $.1 \mu\text{SEC}$ position the Time Position Range indicator will normally still be within the $5 \mu\text{SEC}$ sector. The CRT display now represents $.1 \mu\text{SEC}/\text{CM}$ or $1 \mu\text{SEC}$ for 10 CM. However, we still have $5 \mu\text{SEC}$ of Time Position Range available (see figure 1-3). The total available window now becomes approximately $6 \mu\text{SEC}$.

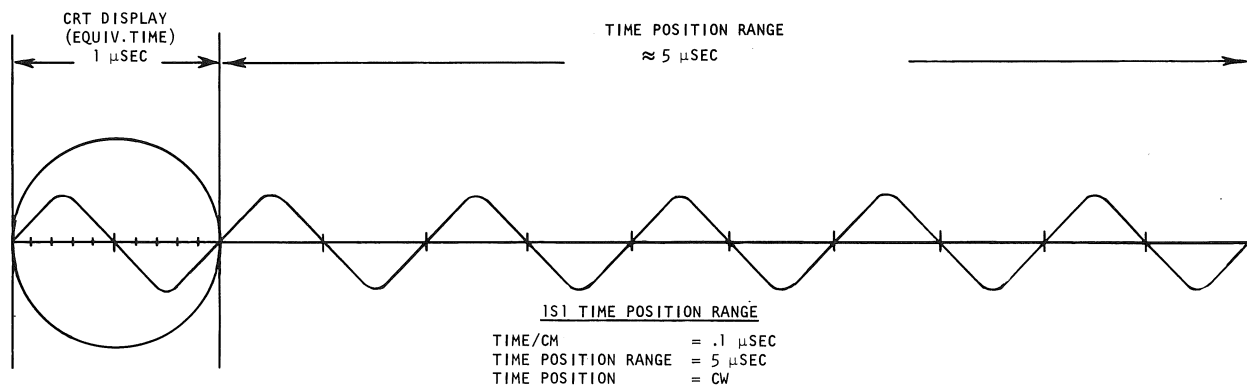


Figure 1-3

TIME/CM SWITCH - MAGNIFIED POSITIONS

Before getting into this mode of operation it may be desirable to discuss a few definitions.

MAGNIFIED

Since the white dot on the TIME/CM knob ALWAYS indicates correct Time/CM there is no magnification in the accepted sense. However, for a given Time Position Range, different Time/CM settings will give different ratios of displayed time to total time window (refer to figures 1-2 and 1-3).

In conventional oscilloscopes, two elements control the sweep time -- the timing caps and the timing resistors. Typically, one cap covers three Time/CM positions by switch selecting three different values of timing resistance in a 1-2-5 sequence.

The major differences between the two systems are -- in the conventional scope, the time base slope is changed during the 1-2-5 sequence; in the sampling scope, the time base slope (fast ramp) is not changed during the 1-2-5 sequence.

As each time base slope (fast ramp) is normally used for three timing positions, it can be represented on the front panel by a sector called TIME POSITION RANGE. There are five Time Position Range positions on the 1S1.

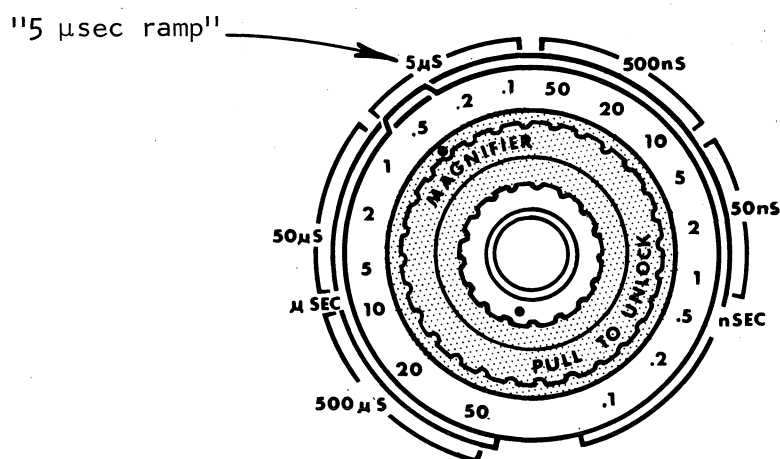
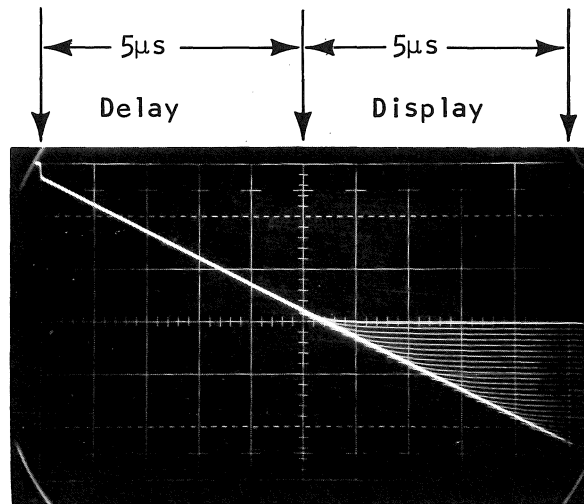


Figure 1-4

Referring to Figure 1-4, the 5 μ SEC TIME POSITION RANGE sector indicates a particular Fast Ramp slope, which can be referred to as "the 5 μ SEC ramp". The "5 μ SEC ramp" has to be capable of running down for a sufficient length of time to complete a 10 CM display (the last sample) -- plus approximately 5 μ SEC of Time Position.

Figure 1-5 shows a "5 μ SEC ramp" (5 μ SEC Time Position Range). The equivalent sweep speed of the ISI is .5 μ SEC/CM and the TIME POSITION controls are fully CCW (maximum delay).

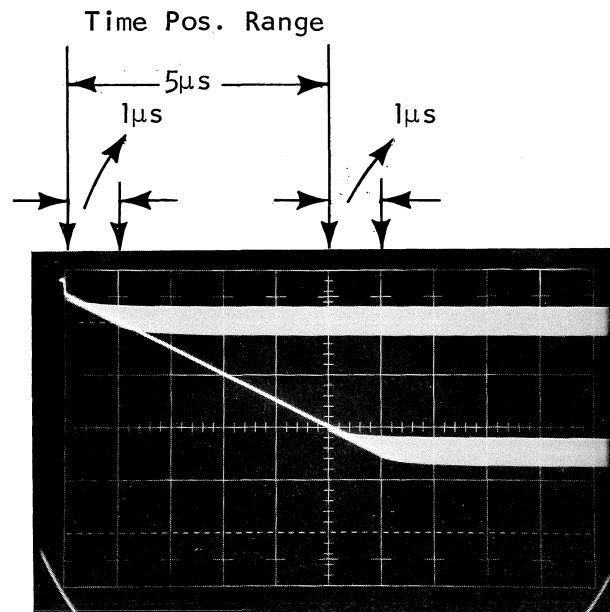


Test Scope
1 μ S/CM

Figure 1-5

Note that the Fast Ramp runs for approximately 5 μ SEC before the first sample is taken, showing maximum Time Position Range. Subsequent ramps run down for a further 5 μ SEC to complete the 10 CM display.

Figure 1-6 shows a double exposure of the same ramp (5 μ SEC) but at an equivalent sweep speed of .1 μ SEC/CM.



Test Scope
1 μ SEC/CM

Figure 1-6

The bar at the top of the photo indicates the length of time the fast ramp has to run to complete the last sample (at 10 CM). The equivalent sweep speed is .1 μ SEC/CM so the fast ramp runs for a maximum of 1 μ SEC, as indicated in the photo.

Note that the start of the first sample coincides approximately with the start of the fast ramp. This indicates zero Time Position, or zero delay.

If the TIME POSITION controls are turned fully CCW, maximum Time Position Range will be obtained -- in this case approximately 5 μ SEC. The first sample then starts approximately 5 μ SEC after the start of the ramp, as indicated in the lower half of Figure 1-6.

TIME POSITION RANGE SPECS

The word "approximately" has been used purposely in respect to Time Position Range.

Remember, the TIME POSITION controls are variables. The TIME POSITION RANGE sector only indicates the approximate range available. There are no specs at present on this characteristic; however, engineering feels that the indicated Range should be approximately $\pm 3\%$.

Engineering has done some work on a special -- the Coarse and Fine TIME POSITION controls are replaced by a Helipot and Dial. This mod enables accurate readout of TIME POSITION. Accuracy is increased by resistor selection to $\approx 1\%$. Check Product Information for further details.

TIME/CM SWITCH - MAGNIFIED

Normal rotation of the grey knob also rotates the plastic skirt. However, if the grey knob is pulled out it can be rotated in the CW direction -- leaving the plastic skirt behind. It is now possible to select a faster TIME/CM setting with the same TIME POSITION RANGE, or select a greater TIME POSITION RANGE with the original TIME/CM setting.

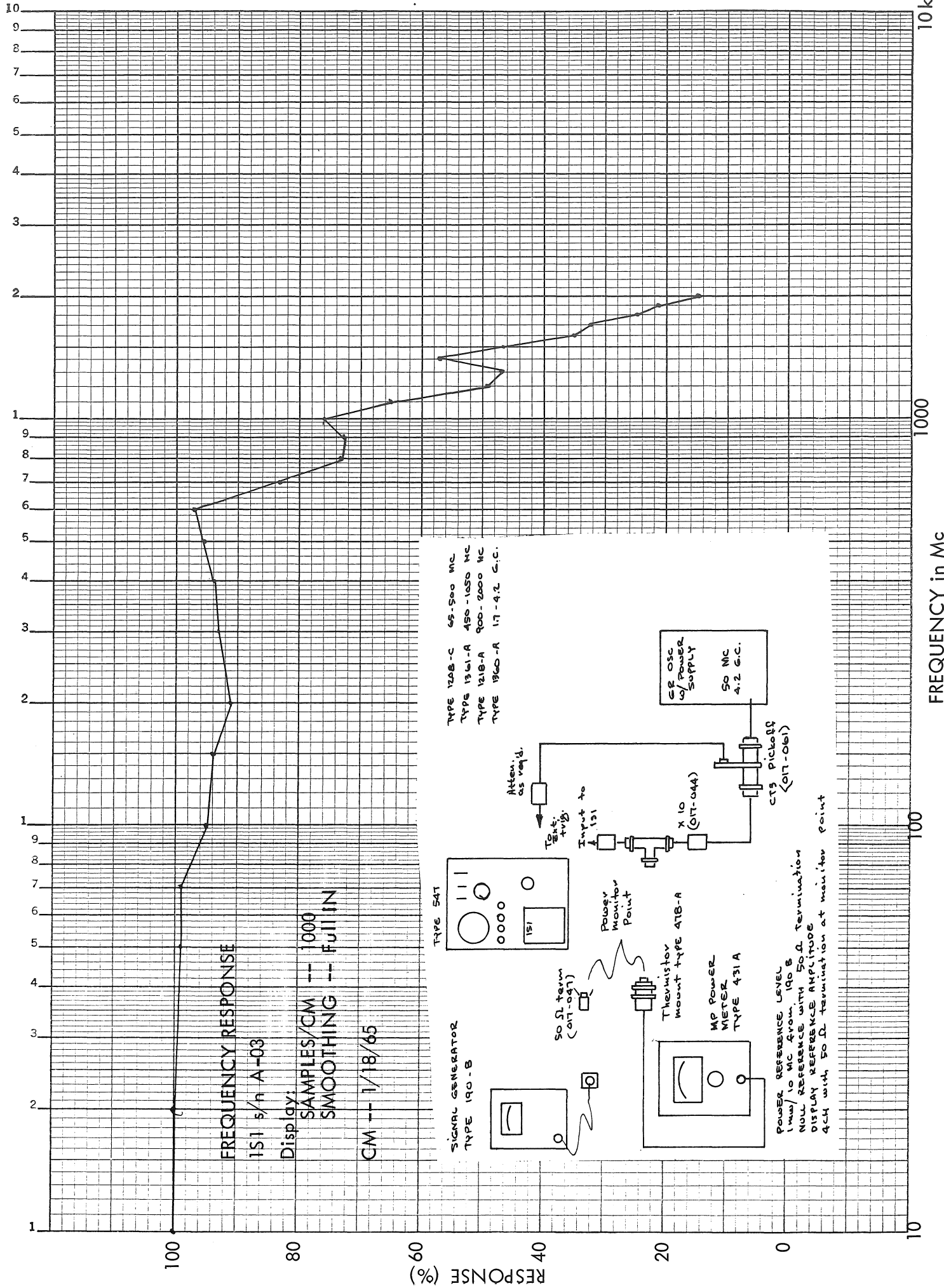
From our previous discussion it is apparent that if the TIME POSITION RANGE is changed the fast ramp is also changed. Yet, we can still obtain the same TIME/CM readout!

The answer is in the switching network on the TIME/CM switch. For example, if a ten times slower ramp is selected (ten times greater Time Position Range) the equivalent TIME/CM would normally be expected to be ten times slower. However, an ingenious mechanical and electrical switching network inserts either a ten times or a hundred times divider between the STAIRCASE GENERATOR and the input to the COMPARATOR. These dividers are only in circuit when a ten times or a hundred times longer Time Position Range is selected or, looked at another way, whenever the Time/CM white dot is in a different sector to the blue Times Position Range marker.

The three fastest positions on the TIME/CM switch are obtained by leaving the TIME POSITION RANGE at 50 nSEC (the fastest ramp) and advancing the grey knob to either .5, .2, or .1 nSEC/CM. (See INVERTER, Block Analysis section).

IS1 #B-04 V.S.W.R. POWER ON

<u>DIAL</u> <u>FREQUENCY</u>		<u>FREE</u> <u>RUN</u>	<u>CM</u>	<u>- INT</u>	<u>CM</u>	<u>+ INT</u>	<u>CM</u>	<u>EXT</u>	<u>CM</u>
500	mc	1.045	32.5	1.08	35.9	1.07	32.2	1.045	32.8
600		1.06	33.4	1.06	35.3	1.065	36.0	1.06	33.2
700		1.15	33.4	1.17	33.5	1.15	32.7	1.15	33.3
750		1.26	31.9	1.28	31.5	1.25	31.5	1.26	31.4
800		1.5	30.2	1.48	29.8	1.5	30.6	1.5	30.6
850		1.68	29.7	1.6	29.7	1.65	29.6	1.68	29.7
875		1.55	29.6	1.5	29.8	1.5	29.9	1.55	29.7
900		1.48	29.7	1.5	29.6	1.46	29.7	1.48	29.6
925		1.28	29.9	1.29	29.8	1.32	30.0	1.28	29.4
950		1.06	32.2	1.058	32.0	1.1	30.7	1.065	32.0
960		1.5	22.7	1.44	22.8	1.47	23.5	1.51	22.7
970		1.72	25.0	1.7	25.3	1.8	25.2	1.72	25.2
980		1.37	27.4	1.42	27.7	1.42	27.5	1.37	27.4
990		1.24	20.9	1.18	20.7	1.24	21.2	1.25	20.6
1.000	Gc	1.75	23.1	1.70	23.1	1.83	23.2	1.75	23.0
1.010		1.65	25.2	1.7	25.3	1.7	25.0	1.65	24.8
1.025		1.8	23.6	1.75	24.0	1.9	23.8	1.8	23.6
1.050		1.36	25.3	1.43	25.2	1.38	24.9	1.36	25.2



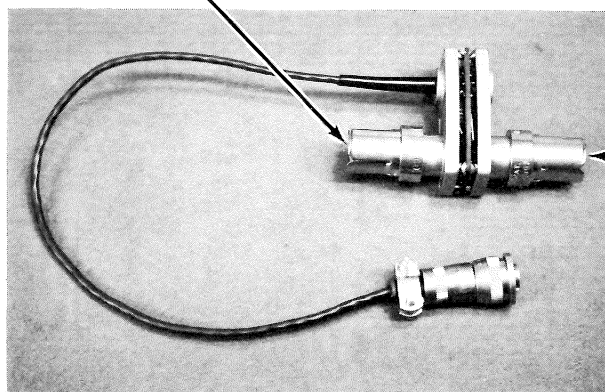
TYPE 281 TIME DOMAIN REFLECTOMETER
(Scheduled to be shown at WESCON)

The Type 281 can extend the applications area of the 1S1 by making it easier to perform Time Domain Reflectometry measurements.

The 281 consists of a free running pulse generator with a negative-going risetime of less than one nanosecond and a rep. rate of ≈ 70 kc.

The circuitry is built into a CT3 type housing and the operating voltages are obtained from the PROBE POWER socket on the sampler. (figure 1-7 shows an engineering prototype).

Unknown Test Cable



To 1S1 INPUT.

Figure 1-7

The 281 will also operate with a 3S76 or a 4S1, both these units have the required Internal Trigger Pick-off and the Probe Power connector.

The 281 switches a current of ≈ 18 ma into two paralleled G.R. connectors, the connectors are normally loaded with the 50Ω input of the ISI on one end and the test cable ($\approx 50\Omega$) on the other--making a generator load of $\approx 25\Omega$. The incident pulse will therefore $\approx 18 \text{ ma} \times 25\Omega = 450 \text{ mv}$.

The switching current is injected into the junction of the two G.R. connectors via the collector of a transistor, as the fast-rise current step is obtained by turning the transistor OFF it will be seen that the input circuit to the sampler will be essentially unloaded after pulse turn-off, except by the test cable, any reflections after the incident pulse will have free access to the ISI sampler.

The 281 will also operate with lines up to 300Ω impedance, however the techniques involved will not be covered at this time.

The off-period following the incident pulse is $> 5 \mu\text{sec}$. This means that coaxial lines up to ≈ 1600 feet could be checked.

The ISI can be obtained with a calibrated ten times helidial in place of the present TIME POSITION controls, see Product Information for details.

APPLICATIONS

The following examples are given in detail in order to illustrate some basic T.D.R. techniques.

EXAMPLE

Using the 1S1/281 to check --

- a. Cable delay
- b. Cable impedance
- c. Cable/termination matching

SETUP FOR THIS EXAMPLE

Connect 281 to 1S1 --

Time/cm = 2 nSEC

Triggering - Minus Int.

Mv/cm \approx 200

PROCEDURE

Connect the unknown cable to the 281. Leave the other end open. Figure 1-8 shows a typical display produced by an unterminated cable, the incident pulse is at the left and the reflected pulse at the right. Note that the reflection occurs ≈ 10 nSEC later.

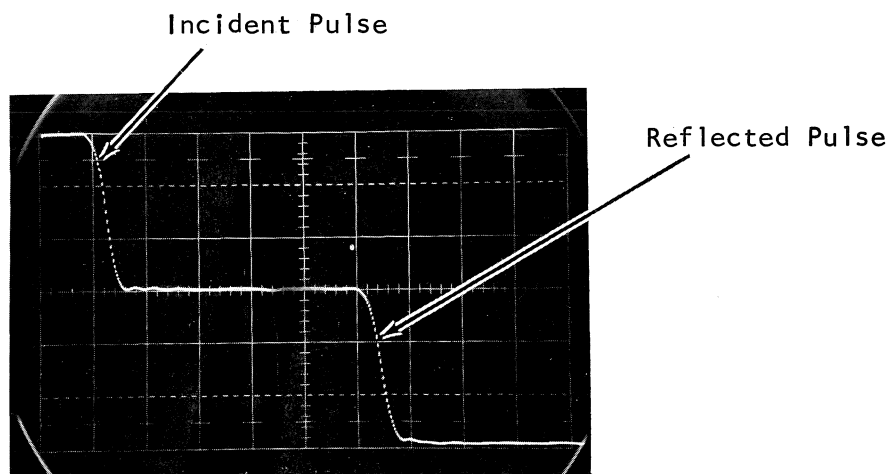


Figure 1-8

This is the time taken for a two-way trip up and down the cable, therefore the cable delay ≈ 5 nSEC.

For impedance measurements it is necessary to "Standardize" the incident pulse amplitude on the CRT.

Use the ISI VARIABLE to obtain 5 cm (see figure 1-9).

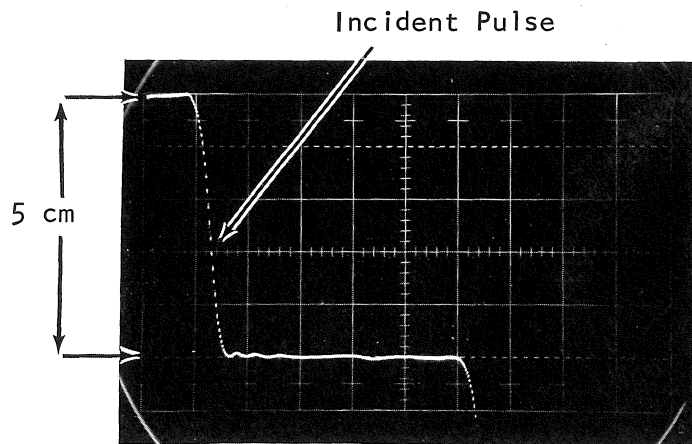


Figure 1-9

This formula can be used to find the unknown impedance.

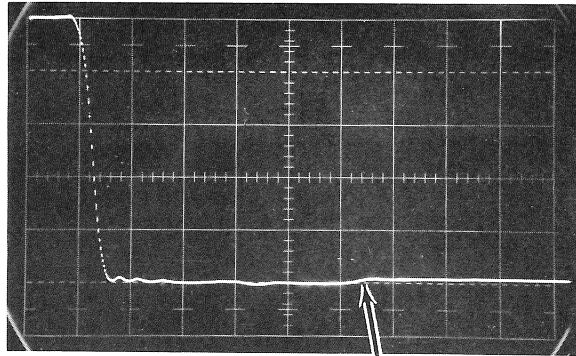
$$Z = \left(\frac{1 + \rho}{1 - \rho} \right) Z_0$$

ρ = ratio of the amplitude of the reflected to the incident pulse.

If 5 cm = 1, then 1 cm will = .2 (20%)

Connect a known termination to the end of the unknown cable. In this case, a 50 Ω terminator.

Figure 1-10 shows the effect of a 50Ω terminator on the unknown cable, however the mismatch is barely discernible.



Mismatch between cable and termination.

Figure 1-10

If the 1S vertical sensitivity is increased $\times 10$ (leaving the VARIABLE in the same position) 1 cm will now equal $.02$ (2%).

Figure 1-11 shows a positive-going transition into the 50Ω termination, (going in the direction of a short), therefore the cable must be of a slightly greater impedance than the termination.

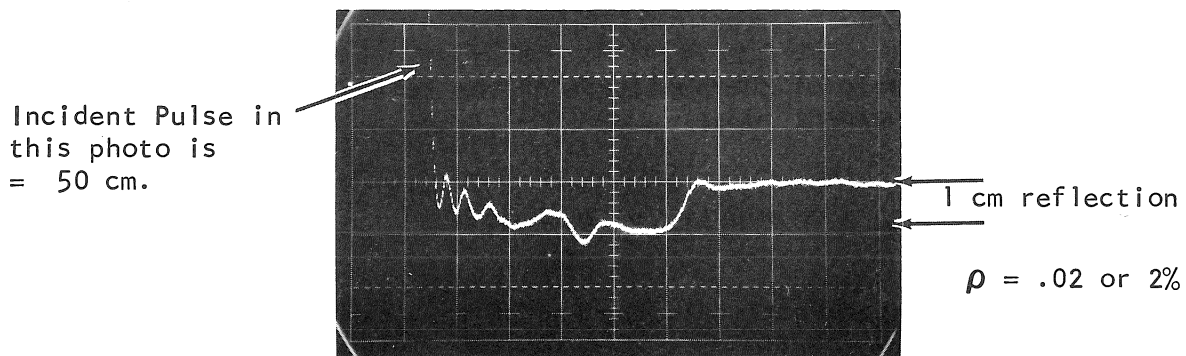


Figure 1-11

The 1cm transition indicates a ρ of $.02$. Inserting ρ in the formula:

$$Z(\text{cable}) = \left(\frac{1 + \rho}{1 - \rho} \right) Z \quad \text{therefore} \quad Z(\text{cable}) = \frac{1.02}{.98} \times 50 = 52\Omega$$

**COMPETITIVE
INFORMATION**

COMPANY CONFIDENTIAL

TYPE 1S1 Versus HEWLETT PACKARD

The Type 1S1 plug-in cannot be compared directly with any of Hewlett-Packards' equipment.

The Model 185B series is a full size sampling system with three vertical sampling plug-ins.

The 140 series offers a Type 1415A plug-in which is a Time Domain Reflectometer. The 1415A itself consists of a fast rise pulse generator, a single-channel sampler, and a time base generator. The controls of the 1415A TDR are labeled directly with TDR nomenclature. Instrument price is \$1050.

The 1S1, with a 281 pulser, is also a single-channel sampler, and a time-base generator. The only problem with using the 1S1 as a TDR, the reading on the CRT and the control setting will require interpretation depending on the type of cable under test. A brief description of the 281 is included on page 1-26 . Instrument Price is: 1S1 - \$1100

281 - not determined

TYPE 1S1 Versus ELECTRO DESIGN S-30

Information supplied by PAUL WHITLOCK, Product Information

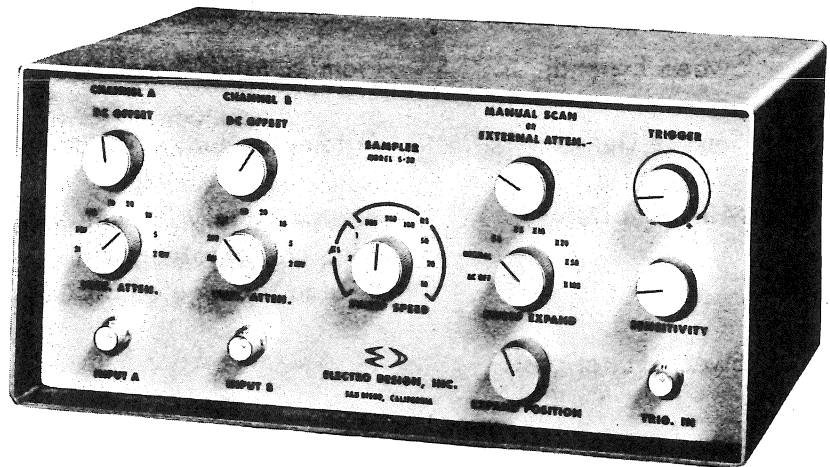
The closest competition that we are presently aware of is a unit produced by Electro Design of San Diego, California. This is called the "Sampler Model S-30". It is a self-contained separated unit to be used with any general purpose oscilloscope. Following is a side-by-side comparison of the 1S1 and the S-30. A preliminary data sheet is also included.

<u>CHARACTERISTIC</u>	<u>1S1</u>	<u>S-30</u>
Channels	Single	Dual
Risetime	$\leq .35$ nSEC	$< .35$ nSEC
Sensitivity	200 mv to 2 mv in seven ranges 1 - 2 - 5 sequence	500 mv to 2 mv in eight ranges 1 - 2 - 5 sequence
DC OFFSET	± 1 volt	± 1 volt
Input Impedance	$49\Omega \pm 0.65\Omega$	100k, ≈ 2 pf
Internal Delay Line	Yes	No
Dynamic Input Range	± 2 volts	± 2 volts
Sweep Speed	.1 nSEC/cm to 50 μ SEC	10 nSEC to 5 μ SEC with X100 gain .1 nSEC to 5 μ SEC
Sweep Functions	NORM-Manual-EXT SINGLE SWEEP	Normal-Manual-External
Triggering	\pm INT \pm EXT FREE RUN	\pm EXT
EXT Triggering Spec	4 mv 100 kc 8 mv <u>at</u> 1 Gc	< 5 mv
PRICE	\$1100	\$850

PRELIMINARY DATA SHEET

ELECTRO DESIGN, INC.
8141 ENGINEER ROAD
SAN DIEGO II, CALIFORNIA

Telephone 714-277-2471



SAMPLER - MODEL S-30

The Model S-30 Sampler is a completely self-contained unit that allows inputs to be sampled by an electronic switch with an equivalent closed time of less than .35 nanoseconds. The sample time is progressively delayed from a trigger source to give an effective modulated output having the same general shape as the input, but at a much lower frequency (typically 0 to 50 cycles). This unit, when used with any general purpose oscilloscope, becomes a complete sampling system with full performance: variable gain, DC offset, sweep expand, triggering controls, etc. Since all outputs are available on the rear panel, the unit may also be used to drive an X-Y plotter to give a permanent record of extremely fast waveforms. Because the unit does not modify the general purpose oscilloscope, the customer may go from sampling time to real time measurements in a matter of seconds by simply by-passing the sampler unit. This is particularly useful where a wide variety of waveforms at various impedances are to be viewed.

TENTATIVE SPECIFICATIONS

VERTICAL (Both Channels):

Rise Time:	Less than .35 nanoseconds. Typically .1 nanosecond.
Sensitivity: (referred to .1 volt output)	2 mv to 500 mv in eight ranges, with 1-2-5 sequence.
DC Offset:	± 1 volt to allow viewing low level signals on a relatively large DC voltage.
Dynamic Range:	± 2 volts.
Input Impedance:	100K, approximately 2 pf.

HORIZONTAL:

Sweep Speed:	10 nanoseconds per full sweep to 5 microseconds per full sweep in 1-2-5 sequence.
Sweep Expand:	From x1 to x100 in 1-2-5 sequence.
Sample Density:	Automatic control of dot density.
Minimum Delay:	Approximately 35 nanoseconds to allow viewing of leading edge and constant at all sweep speeds. This allows viewing of leading edge of wide pulses.
Sweep Functions:	
Normal:	Sweep is generated internally.
Manual:	This allows the operator to manually control the sample delay.
External:	This allows an external DC voltage to vary the sample delay.

TRIGGERING FUNCTIONS:

Input Impedance:	Nominal 50 ohms is AC coupled with approximately 10 micro-second time constant.
Sensitivity:	Less than 5 mv required for stable triggering.
Trigger Polarity:	Unit may be triggered on either positive or negative input by a zero center continuous control. This control allows both polarity and amplitude to be adjusted with one control.

CONSTRUCTION:

All solid-state circuitry on printed circuit boards.

SIZE:

5" H x 11" W x 7 1/2" D.

WEIGHT:

Approximately 10 pounds.

PRICE:

\$850.

OTHER MODELS AVAILABLE:

S-31	Same specifications as S-30, but with sampling switch in a small regular size scope probe.
S-32	Same specifications as S-30, but with 50 ohm vertical input impedance and internal delay line to allow internal triggering.

TYPE 1S1 Versus ANALAB TYPE 701

Analab-(Division of Benrus Watch Co. Inc.) has a sampling plug-in available.

The 701 sampling and sweep plug-in mates with any one of three presently available main frames:

1. The 1100 series single-trace oscilloscope (basic single-trace cathode-ray indicator). Price - \$435 (RM-\$445).
2. The 1120 series Dual-trace oscilloscope (permits simultaneous display of two vertical signals. Electronic switching circuitry included in the main frame.) Price - \$595 (RM-\$605).
3. The 1200 series storage oscilloscope. Price - \$1990 (RM-\$1950).

Published specifications for the Type 701 sampling and sweep plug-ins is lacking in detail. Advertising literature list the risetime as 0.35 nSECONDS. Vertical sensitivity to 2 millivolts (max. 200 mvolt) sweep ranges from MICROSECONDS ($2 \mu\text{s/cm}$) to picoseconds. Internal delay lines are matched. DC OFFSET range ± 1 volt. Input resistance 50Ω . Trigger source INT. A or B, EXT.

The literature describes the 701 as a 5 Gc sampling unit. The 5 Gc figure refers to the trigger capabilities. The passband being only 1000 mc.

Price of the Type 701 is \$2300 as compared to \$1100 for the 1S1.

TYPE 1S1 Versus LUMATRON 120A

The Lumatron 120A can be compared more favorably to the Type 661/4S1/4S2/5T1A than it can to the 1S1 plug-in. The Type 120A is a complete sampling instrument with T_r capabilities up to .1 nSEC. Lumatron displayed a 100 psecond dual-trace vertical plug-in, Model 2161, for the 120A at the 1965 IEEE. The specifications for this new plug-in is included at the end of this section for your information.

Even though the 1S1 cannot compete with a full size sampling system, following is a comparison of the Type 1S1 plug-in specification and the Lumatron 120A specifications with Model 2160A vertical plug-in.

<u>CHARACTERISTIC</u>	<u>1S1</u>	<u>120A WITH 2160A</u>
Vertical Channel	Single	Dual-Trace
Risetime	≤ 350 pSEC	350 pSEC
Input Resistance	$49\Omega \pm 0.65\Omega$	50Ω
mVOLTS/CM Accuracy	$\pm 3\%$	$\pm 3\%$
mVOLTS Range	2 mv/cm to 200	2 mv/cm to 200
DC OFFSET	$\geq \pm 1$ volt	± 1 volt
VARIABLE mVOLTS/CM Range	$\geq 1:4$	$\approx 1:3$
Vertical Noise	≤ 1 mv unsmoothed	1 mv unsmoothed 1/4 mv smoothed
Sweep Ranges	.1 nSEC to 50 μ SEC in 1,2, 5 sequence	1 ns/cm to 0.1 ms in 6 decade steps. Additional 1 ms/cm and 10 ms/cm ranges for unique chopper operation (real time sampling).
Samples/cm Range	≈ 5 samples/cm MIN.	5 - 10- 20 - 50 - 100 dots/cm
Triggering Modes	\pm Internal \pm External MAX ± 2 volts	Internal A or B External 5-400 mv
Triggering Range	≈ 1 Gc Internal	≈ 3 Gc + External ??? Internal

... the first manufacturer of Sampling Oscilloscopes ... a leader in nanosecond instruments.

convenient • flexible • reliable • completely modular

Lumatron 120A*
MODEL 120A*

Basic **1 KMC** (.35nsRT)
SAMPLING
OSCILLOSCOPE

with the unique
3rd plug-in

making it a complete
nanosecond laboratory

- exceptional triggering to over 3 Kmc built-in
- extended sweeps from 3 ps/cm to 1/10 sec.
- stable at low repetition rates
- dual channel . . . internal trigger with built-in delay lines
- wide choice of miniature probes to 10 megohms
- easy to use and service
- low crosstalk

INDEX:

this folder includes —

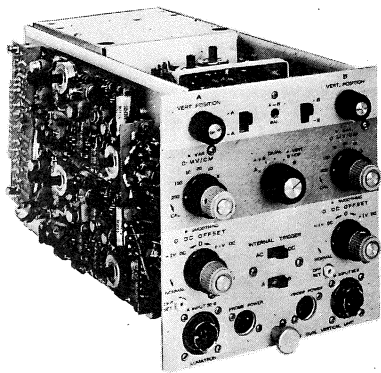
Basic oscilloscope with plug-ins • 3rd plug-in options •
complete accessories • associated nanosecond instruments

*Model 120A is an improved version of the Model 120 with lower crosstalk and greater pulse fidelity.

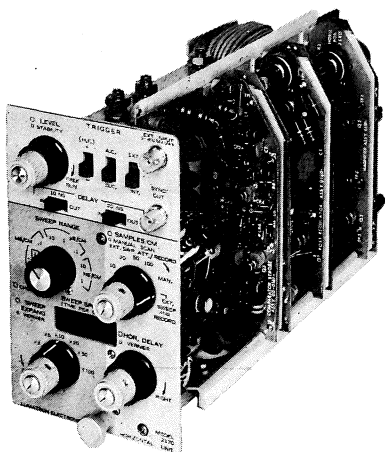
MARCH 1964

GENERAL APPLIED SCIENCE LABORATORIES INC.

MODEL 2160A DUAL VERTICAL UNIT (PLUG-IN)



TYPE 2170 HORIZONTAL UNIT



RISETIME ... 0.35 ns from 10% to 90% for an input step function (displayed RT will include input step RT and oscilloscope RT); equivalent to DC-1000 mc bandpass.

INPUT IMPEDANCE ... basic 50 ohm; can be increased to 10 megs by use of external probes (see 2160A).

DISPLAY MODES ... A or B only (normal or inverted), A+B, A-B, B-A, A and B (dual channel), A Vertical - B Horizontal (lissajous).

VERTICAL SENSITIVITY ... 2-200 mv/cm calibrated to 3% in seven 1-2-5 steps; vernier increases sensitivity to 0.6 mv/cm (uncalibrated) and turns on NOT CAL light.

DYNAMIC RANGE ... 2 V even at 0.6 mv/cm sensitivity without overload (up to 10 V will not cause damage).

DC-OFFSET CONTROL ... +1 V to -1 V permits viewing of large signals at any sensitivity, or small signals on top of ± 1 V DC; front panel jack allows monitoring of offset voltage.

INTERNAL TRIGGER ... selected from either channel by front panel switch; matched delay cables are built-in to permit viewing of leading edge of fast input signals.

NOISE ... 1 mv unsmoothed and less than 500 μ v smoothed; no increase in noise on dual channel operation. Noise is defined as tangential equivalent input noise, i.e. the input signal that appears equal to the noise level.

SMOOTHING controls for each channel minimize noise and jitter; warning lights indicate possible waveshape distortion, common to smoothing where dot density is insufficient, when smoothing is used.

INPUT CONNECTORS ... universal GR type with low VSWR, and with added locking feature to prevent loosening and inadvertent removal of attenuators or matching pads; semi-permanent adapters available to other connector series.

CROSSTALK ... less than 40db for 0.1 ns RT step.

PROBE POWER connector for active LUMATRON probes, such as Model 611 High Impedance Probe.

CONSTRUCTION of all circuits is on plug-in glass epoxy printed circuit boards, all of which can be tested in place in the unit; most transistors are plugged into sockets for easy replacement.

WEIGHT ... 17½ lbs.

TRIGGER SECTION

FREQUENCY RANGE extends to over 3 Kmc for external trigger without additional equipment; external triggering extends down to DC because of unique DC-AC trigger coupling switch; trigger actually "locks" the internal 100 Kc max. sampling rate to higher input frequencies.

SENSITIVITY ... 5 to 10 mv for ext. triggers 2 ns wide of fast RT; trigger dynamic range to 400 mv; sensitivity varies normally with pulse width and repetition rate.

JITTER ... to less than 30 ps on the 1 ns/cm and 10 ns/cm Sweep Ranges, and .01% of the full fast ramp (which is approx. 20x the Sweep Range setting) for slower sweep speeds; applies to pulses with fast RT at less than 100 Kc repetition rate; jitter increases slightly at some higher repetition rates.

INTERNAL trigger is selected by INT-EXT slide switch; requires approx. 8x input signal amplitude (A or B channel) as Ext. trigger requires; built-in delay cables in the Type 2160A Dual Vertical Unit allow viewing of the leading edge of fast RT signal on internal trigger on the 0.1 μ s/cm and faster ranges.

FREE RUNNING of trigger allows use of SYNC. OUT to start other equipment, such as the LUMATRON Model 2305 Pre-Trigger Pulser (3rd Plug-in); output is -400mv, 10 ns RT, from 1 K source, thru BNC connector.

INPUT IMPEDANCE at the external trigger input BNC is 100 ohms.

POLARITY switch selects positive or negative trigger slope.

FAMILIAR CONTROLS (LEVEL, STABILITY) adjust sensitivity and period; high frequency signals generally "pull-in" without adjustment - slight correction of the controls only to achieve least possible jitter.

SWEEP SECTION

SWEEP SPEED CALCULATOR provides exclusive digital display of actual calibrated sweep speed - product of SWEEP RANGE and SWEEP EXPAND settings - with correct units and decimal point location; NOT CAL. lights up in window when sweep VERNIER is used.

SWEEP RANGES from 1 ns/cm to 0.1 ms/cm in 6 decade steps for normal Sampling operation, accuracy within 3%; additional 1 ms/cm and 10ms/cm ranges for unique chopper operation (real time sampling).

SWEEP EXPAND switch provides expansion of 1-2-5-10-20-50-100 times sweep range, calibrated to 3% VERNIER provides uncalibrated expansion by an additional 3X or a max. sweep speed of 3 ps/cm; VERNIER lights the words NOT CAL. in SWEEP SPEED CALCULATOR window when used.

HORIZONTAL DELAY controls (coarse and vernier) proportional to Sweep Range; provide wide horizontal signal positioning thru approximately 2 unexpected screen widths (20x Sweep Range) to 2 ms on the 0.1 ms/cm range; slide switches provide additional delays of 10 ns and 20 ns for flexibility at fast sweep speeds.

SAMPLES/CM switch selects 5-10-20-50-100 dots per cm of display regardless of sweep expansion.

MANUAL SCAN provides up to infinite resolution for recording.

EXT. SWEEP allows use of Model 671 Recorder or other devices to which the sweep must be synchronized (rear connectors).

SINGLE SWEEP is provided by Recorder Control (see Main Frame).

CONSTRUCTION ... 6 plug-in boards all serviceable and all adjustments accessible with Unit in frame.

WEIGHT ... 5 lbs.

MAIN FRAME - SPECIFICATIONS

The Model 120A Main Frame provides a CRT tube display and power supplies for the Vertical and Horizontal plug-in units and for the "3rd plug-in"; it also provides recorder control with connections and a calibrator.

GRATICULE ... 8 cm vertical x 10 cm horizontal with 10% and 90% lines; markings are 1 cm with 0.2 cm marks along the center lines; additional lines on the front of the graticule over the center lines eliminate parallax.

CATHODE RAY TUBE ... 5" diameter, high resolution, flat-faced tube, normally supplied with a dual P7 phosphor, for adequate brightness at high and low repetition rates.

DISPLAY CONTROLS ... SCALE ILLUMINATION, INTENSITY, and FOCUS.

BEAMFINDER pushbutton compresses vertical deflection to bring trace on screen. If trace is then positioned near center of screen, it will remain on screen, when button is released.

CALIBRATOR provides sine waves (into 50 ohms). Amplitude: 1 volt and 100 mv at 100 Kc. Time: 1 mc, 10 mc, and 100 mc. Amplitude is within 2% and 4% for the 1 volt and 100 mv signals respectively; time periods are within 0.2% except 10 ns (100 mc) which is within 2%. (BNC-GR cable supplied to connect BNC Calibrator output to vertical inputs). Calibrator is switched OFF, when not in use.

RECORDER CONTROL pushbuttons simplify photography or operate Model 671 Recorder. **H. REV.** starts sweep from right (instead of left) to produce normal picture with reversing cameras (auxiliary reversed markings on the graticule are readable on reversed picture). **ARM** blanks screen, turns off graticule illumination, and lights warning light. **TRACE** provides a single sweep or starts

the recorder. **SCALE** lights graticule. **RESET** returns oscilloscope to normal operation.

RECORDER JACK (rear) provides receptacle for Model 671 Recorder plug; supplies power, deflection, and start command (TRACE pushbutton); Recorder feeds sweep to oscilloscope to synchronize oscilloscope time base to recorder.

X-Y RECORDER TERMINALS (rear) vertical output is at ground potential and varies plus and minus for a signal above and below the screen center; front panel positioning controls also affect the pen position; amplitude is 150 mv per cm of oscilloscope screen; up to 10 ma are provided for full scale deflection. Terminals are: Y Axis (A) and Y Axis (B); X Axis provides 0-10 Volts sweep signal output.

EXT. SWEEP INPUT (rear) requires 1 V per cm of screen deflection; 10 K input Z.

CLOCK PULSE OUTPUT (rear) provides -10V pulse, 3 μ s wide, 1 K source synchronized with sampling.

CONSTRUCTION is welded aluminum with durable epoxy finish outside; each power supply and the deflection amplifiers are on glass epoxy printed circuit boards that plug in from rear of the frame (removable panel); low voltage power supplies are transistorized. Cooling is by convection and conduction - there are no fans.

SIZE ... 16" high, 10½" wide, 20" deep.

WEIGHT ... 36 lbs. approx. (without Vertical and Horizontal plug-ins).

POWER ... 117 \pm 10% VAC, 50/60 cycles, 125 W; additional screw connections on power transformer for nominal 100, 110, 200, 220, 234 VAC (specify with order; can be changed in the field).

0.1 NS RISETIME - 3500 MC DUAL VERTICAL UNIT

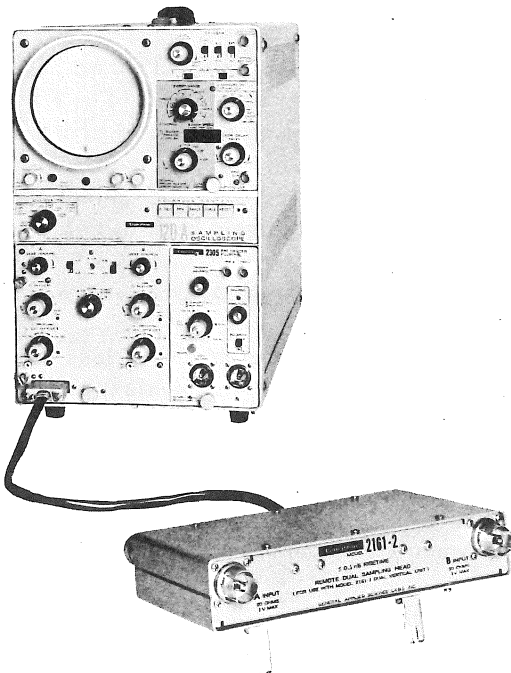
(for the Lumatron Model 120A Sampling Oscilloscope;
consisting of Model 2161 - 1 Dual Vertical Plug-in and
Model 2161 - 2 Remote Dual Sampling Head)

... unique remote feedthrough
sampling head eliminates hookup cable distortion.

Lumatron

Model 2161

Manufactured by
General Applied Science
Laboratories Incorporated



Lumatron Model 120A shown with Model 2161 installed. The remote Head is connected to the Dual Vertical Plug-in by a detachable power cable.

Applications Include Display and Measurement Of:

- fast semi-conductors
- fast tunnel diodes
- fast diode stored charge (in conjunction with Area Integrator "3rd Plug-in" Model 2430 which automatically reads area to picocoulombs)
- fast signal phase shift in lissajous mode (in conjunction with standard Model 2170 Horizontal Unit, which triggers to over 4 Kmc)

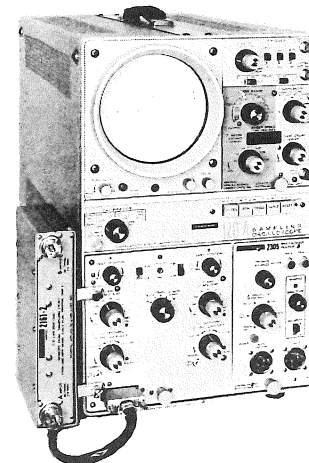
AUXILIARY PULSER

The Model 120A has been designed to accept a series of "3rd Plug-in" instruments in addition to the usual Horizontal and Vertical Plug-ins. A 3rd Plug-in particularly useful with the Model 2161 is the Model 2305 Pre-Trigger Pulser, which provides a low jitter, variable, pre-trigger pulse for the oscilloscope, while the main output pulse of ± 20 V, 1 ns RT is used to drive the circuits under test.

The Model 2161 0.1 ns Risetime Dual Vertical Unit provides a new flexibility in obtaining the ultimate from a very fast sampling oscilloscope. Since any hookup coax cable will cause some distortion of a 0.1 ns risetime pulse, the sampling circuits of the Model 2161 are located in a Remote Dual Sampling Head, which is brought to the circuit under test. This eliminates lengths of the cable usually required to connect the circuit under test to the oscilloscope.

A screw-on connector attaches the remote Head power cable to the Plug-in, which in turn fits into any Lumatron Model 120/120A Sampling Oscilloscope frame. The Model 2160 Horizontal Unit, which is standard with the Model 120/120A Sampling Oscilloscope was originally intended to work with fast sampling units such as the Model 2161. The Horizontal Unit, therefore, was designed to trigger over 4 Kmc, and has calibrated sweep speeds down to 10 ps/cm. No additional Horizontal Unit is necessary to take full advantage of the Model 2161.

The Samplers in the remote Head are of the feed-through type, which provide the added convenience of displaying a signal on the oscilloscope without having it terminate at the oscilloscope. As an alternative, the sampler may be terminated by providing a 50 ohm termination at the output connector. The combination of the remote and feedthru features of the Model 2161 make it possible to break into a coaxial connection in the circuit under test and insert the head without disturbing the circuit, except to add a delay of approximately $1/3$ ns.



Remote Head shown mounted, directly on the Dual Vertical Plug-in. The Plug-in may be removed and stored with the Head attached. A Model 2305 Pre-trigger Pulse Generator is shown in the 3rd Plug-in compartment in the frame. (lower right section)

GENERAL APPLIED SCIENCE LABORATORIES INC.

Manufacturers of Lumatron Nanosecond Instruments

Merrick and Stewart Avenues, Westbury, L. I., New York • (516) EDgewood 3-6960

MODEL 2161 DUAL VERTICAL UNIT -- 0.1 NS RISETIME

(consisting of Model 2161-1 Dual Vertical Unit which plugs into the Lumatron Model 210A Sampling Oscilloscope, and Model 2161-2 Remote Dual Sampling Head, which plugs into Model 2161-1).

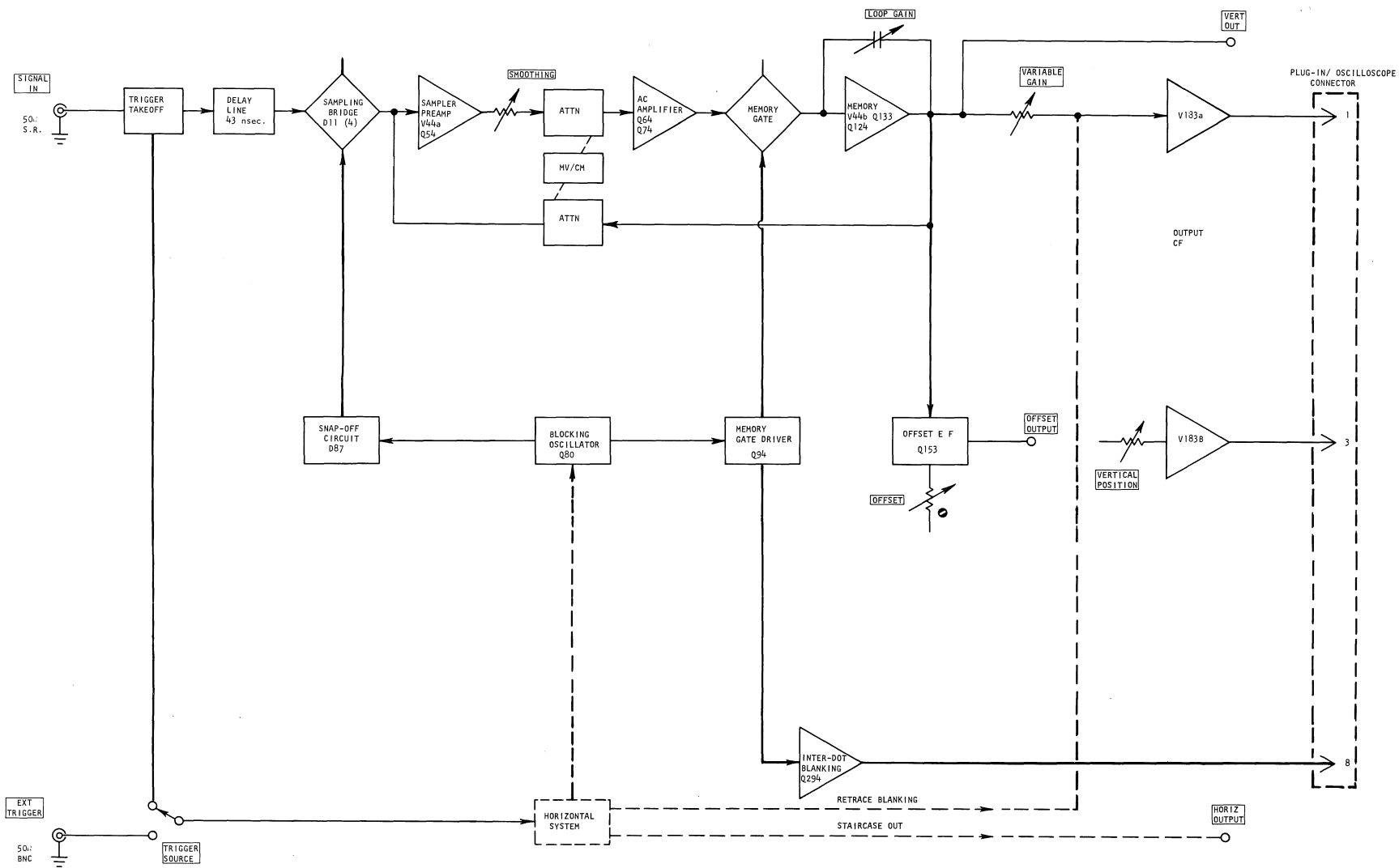
SPECIFICATIONS:

Risetime and Frequency Response	less than 0.1 ns, 10-90% equivalent to DC-3500 mc bandpass. (0.1 ns RT pulser will appear as less than 0.14 ns RT on the oscilloscope with no appreciable increase in overshoot.)
Flexibility	unique remote dual sampling head to provide direct sampling at the test circuit and therefore avoid hook-up cable losses.
Type of Sampler	remote-feedthrough; 50 ohm input and output.
Noise and Smoothing	less than 4 mv with smoothing control at minimum; less than 1 mv with smoothing control at maximum (noise is tangential equivalent input noise); front panel light goes on when smoothing control in use to warn of the possibility of false display when there is insufficient dot density.
Sensitivity	2 mv/cm to 200 mv/cm calibrated in 1-2-5 steps; approx. 2/3 mv/cm with vernier; front panel light goes on when vernier in use to indicate "NOT CAL"
Dynamic Range	± 1 V.
DC Offset	± 1 V variable with front panel control to allow display of small signals at full sensitivity superimposed on larger DC or other signals.
Triggering	external pre-trigger required approximately 70 ns before signal.
Input Impedance	50 ohm.
Connectors	Universal General Radio type 874.
Display Modes	A only, B only, A and B, $\pm A \pm B$, A Hor. - B Vert. for display of phase shift, hysteresis loops, etc.

PRICE

Model 2161	\$1590.00
(Complete 120A frame with Model 2161 Vertical Unit and 2170 Horizontal Unit)	\$3500.00

GENERAL BLOCK ANALYSIS



ISI VERTICAL SYSTEM

Figure 2-1

OUTLINE OF OPERATION

THE ISI VERTICAL SYSTEM

The purpose of this section is to familiarize the reader with the general system concepts involved, component values, auxiliary functions and performance requirements have been omitted, unless they are relevant to the discussion.

The ISI vertical uses a single channel, error-sampled feedback system, with a maximum calibrated sensitivity of 2 mv/cm and an equivalent bandwidth of DC to 1000 Mc.

The vertical system features internal trigger take-off, and a 3S76 type, 43 nsec, delay line--this combination enables the viewing of the leading edge of the signal source without the use of auxiliary equipment. (See figure 2-1).

INPUT CONNECTOR

The signal is applied to the front panel G.R. connector, either directly, (50 Ω input impedance) or via one of the available probes, such as the P6034, P6035 and P6032.

TRIGGER SOURCE

Trigger information can be selected from either the front panel BNC jack (EXT TRIG) or internally, from the trigger take-off transformer, step down ratio, 7:1. Triggering capability--100kc to 1 Gc.

DELAY LINE

After trigger take-off, the vertical signal is taken through the 43 nSEC delay line to the sampling bridge.

SAMPLING BRIDGE

The sampling bridge uses a matched set of 4S1 type bridge diodes. The bridge can be D.C. offset $\pm 1\text{v}$ from the front panel, enabling the examination of the top or bottom of a 1v pulse at 2 mv/cm sensitivity.

It will also be possible to examine the top or bottom of a 2v pulse-- providing it is centered around zero volts, however, this is not likely to be the case with odd duty cycle pulses.

Sampling efficiency is approximately 30%.

STROBE PULSE GENERATOR

The push-pull strobe pulse is produced by differentiating the step from the snap-off diode, D87, and applying it to a phase-splitting transformer right at the bridge. The pulses are 500 psec wide at the 50% point, which easily provides a 350 psec risetime capability.

BLOCKING OSCILLATOR

The blocking oscillator transistor, Q80, is gated on by a pulse from the horizontal system, when Q80 conducts it initially obtains its current supply from the stored charge in the snap-off diode, Q87. When the charge is swept out, the diode, D87, snaps off and produces the strobe pulse, simultaneously with snap-off, blocking oscillator action takes place, producing a regenerative negative going pulse out to the memory gate driver.

MEMORY GATE DRIVER

The memory gate driver, Q94, is switched into saturation by the negative going pulse from the blocking oscillator. The degree of saturation is controlled by the Memory Gate Width control, and therefore affects the storage time of Q94.

The Memory Gate Width is $\approx 350\text{ nSEC}$.

INTER-DOT BLANKING

The same circuit drives Q294, the inter-dot blanking amplifier. This amplifier drives the cathode of V154A in the main frame of the 30A/40A series (or its equivalent).

Time constants in the main frame stretch the original 350 nSEC pulse to $\approx 1.5 \mu\text{SEC}$ to effectively blank the dot progression.

NOTE: 30/40 series instruments would need a Chopped Blanking Mod installed in order to make use of this feature. See Page 1-8.

SAMPLER PREAMPLIFIER

During the time the sampling bridge is opened by the strobe pulse, the input signal charges the input C of V44A (1/2 9416).

Approximately 30% of the instantaneous signal voltage is stored in the input C, before the strobe pulse ends.

V44A and Q54 make up a DC coupled amplifier, the gain is controlled by several RC time constants, and one L/R time constant to produce in effect, high frequency boost over the leading edge of the error signal.

The gain under these conditions is ≈ 13 , while the DC gain is ≈ 1 . The upper bandwidth is limited by tube and transistor parameters, so in effect this amplifier approaches narrow bandwidth operation, with the consequent improvement in signal/noise ratio.

MV/CM ATTENUATORS

1 - 2 - 5 sequence.

200 mv/cm to
2 mv/cm

4:1 gain increase by means of a Variable control, giving a maximum sensitivity of $\approx 500 \mu\text{v/cm}$.

The first attenuator is between the sampler Preamp and the A.C. amplifier.

The second attenuator is in the feedback loop from the memory to the sampling bridge.

The two controls are ganged together.

The second attenuator in the feedback loop sets the ratio of memory output to sampler preamp input--and therefore sets the gain of the system.

The first attenuator changes the open loop gain of the system in inverse proportion to the feedback, and maintains correct dot-transient response.

SMOOTHING

This front panel control has a smoothing range of $\geq 3:1$. The control reduces the open loop gain of the system, and therefore its sensitivity to random noise.

The control must be clockwise (normal) to insure correct dot-transient response under conditions of low dot density.

AC AMPLIFIER

This amplifier is so called because the input and output are AC coupled, and also because the input time constant limits the low frequency response to 3 db down at ≈ 300 kc, insuring that this amplifier responds only to the transient error signal. The useful operational gain is ≈ 30 .

MEMORY GATE

The AC coupled output from the AC amplifier is applied to the memory gate.

The driving transformer for the memory gate is a four-winding balanced design to minimize unbalanced capacitive drive from primary to secondary.

The memory gate is opened long enough (≈ 350 nsec) to enable the memory to reach peak output.

MEMORY

The memory amplifier gain is set by the ratio of the Loop Gain feedback cap, to the output cap from the AC amplifier (C_{in} for the memory amplifier).

The open loop gain must be greater than 1500 to insure smoothing effects less than 1%.

Positive feedback is used between Q124 and Q133 to obtain a sufficient amount of open loop gain.

The output of the memory is:

- a. Fed back in the proper ratio to the input of the sampler, via the mv/cm attenuator.
- b. Applied to one side of the output CF (V183A) via the VARIABLE GAIN control.
- c. Available at the front panel (banana jack) at .2 v/cm, output resistance $\approx 10k$. This output can be used to drive an X-Y recorder, etc.

OUTPUT CATHODE FOLLOWER

V183A and V183B make the interface to the scope main frame. The DC level at pins 1 and 3 of the Blue Ribbon connector is the required +67.5v.

The signal level at pin 1 is 100 mv/cm single ended. The second half of V183 is used for vertical positioning ($\geq \pm 4$ cm).

RETRACE BLANKING

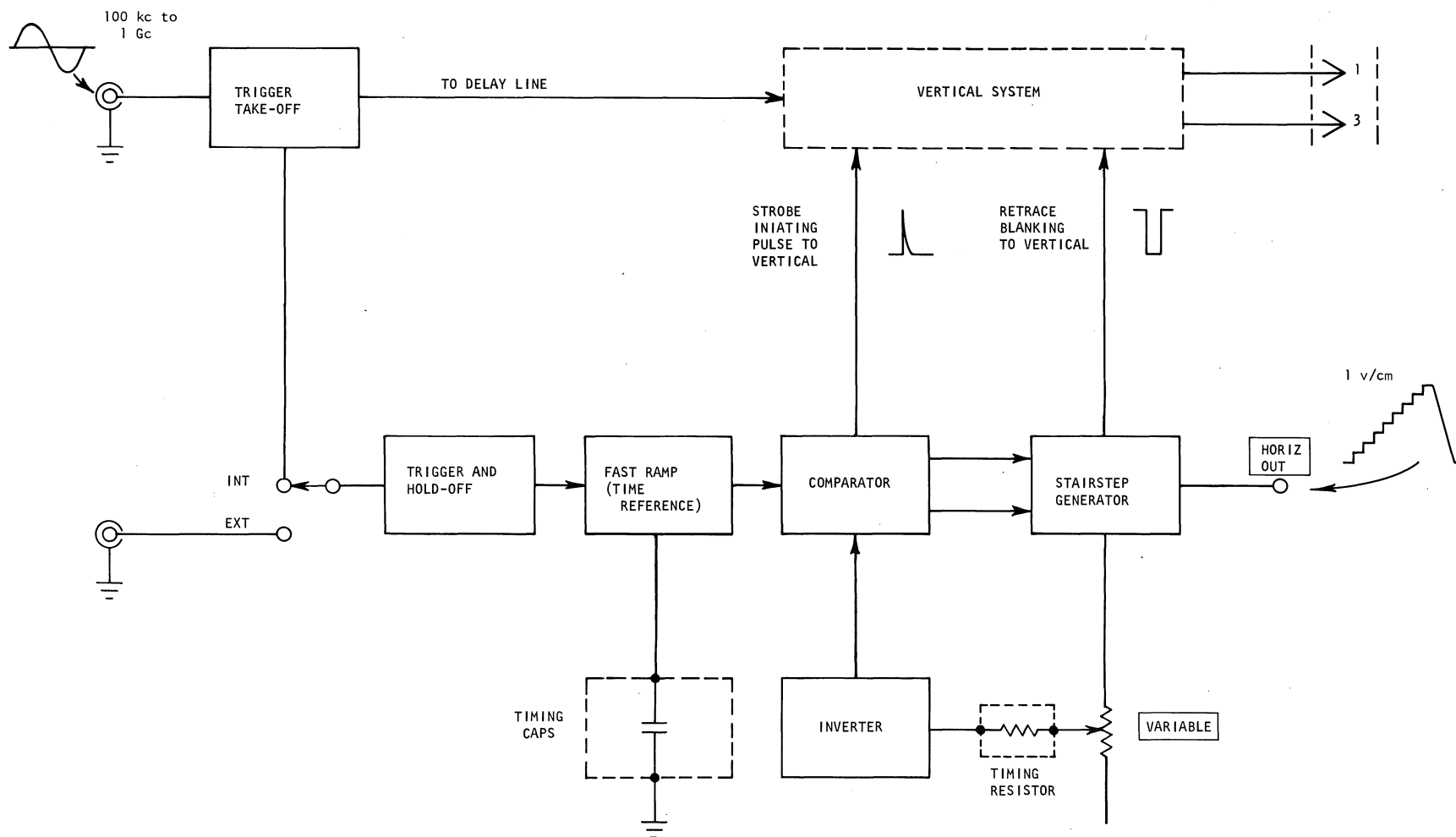
At the end of the sweep, the horizontal system applies a negative going gate to the grid of V183A, driving the beam downwards, offscreen. The offscreen deflection is limited to about 12 cm from center by protective diodes across pins 1 and 3.

DC OFFSET

The DC offset EF (Q153) gives an offset range at the input of ± 1 v.

X10, the offset voltage, is available at the front panel (banana jack) for monitoring purposes.

NOTES



SIMPLIFIED HORIZONTAL BLOCKS

Figure 2-2

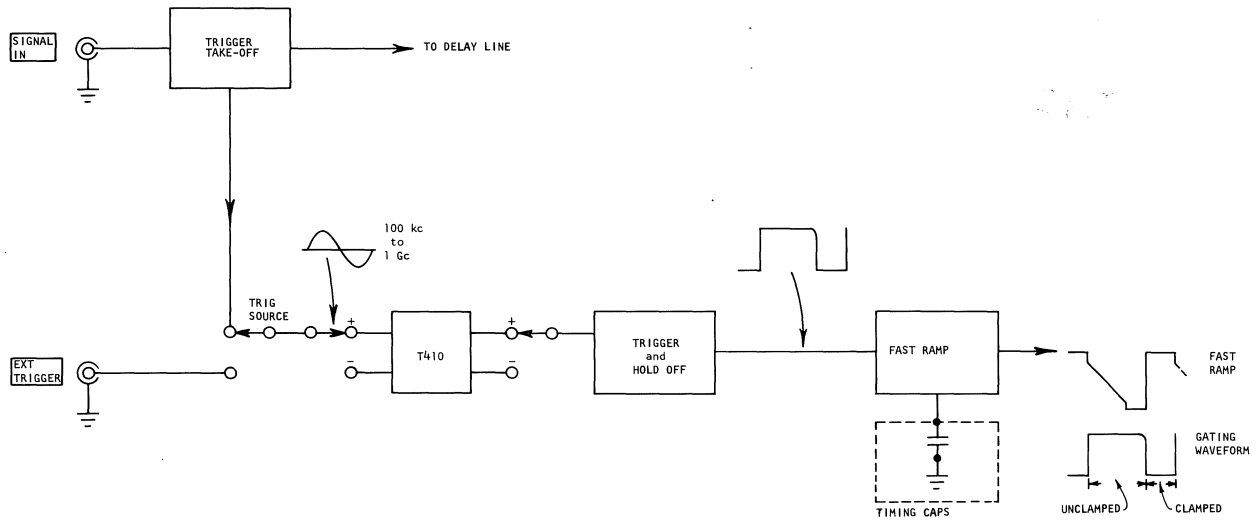
OUTLINE OF OPERATION

THE ISI HORIZONTAL SYSTEM

The purpose of this section is to familiarize the reader with the general system concepts involved, component values, auxiliary functions and performance requirements have been omitted, unless they are relevant to the discussion.

The horizontal system performs the following functions.
(See figure 2-2).

1. Produces the time reference for the unit.
2. Produces the horizontal deflection in the form of a stairstep.
3. Generates the slewed strobe information for the vertical system.
4. Generates retrace blanking.
5. Extracts triggering information from either internal or external sources.



IS1 TRIGGER CIRCUIT and FAST RAMP

Figure 2-3TRIGGER CIRCUIT

The prime function of the trigger circuit is to gate the Fast Ramp on and off. See figure 2-3.

The Trigger circuit incorporates hold-off circuitry that limits the maximum rep. rate to ≈ 100 kc, however this rate applies only to the two faster ramps, the maximum rep. rate is correspondingly reduced for the slower ramps. For example--when using the slowest ramp (500 μ SEC Time Position Range) the maximum rep. rate is limited to ≈ 500 cps.

The Trigger circuit accepts signals Internally, via a 7:1 step down trigger take-off transformer, or Externally - via the front panel BNC jack.

Polarity choice is made by selecting the output of T410--an inverting transformer.

FAST RAMP

The Fast Ramp circuit generates the basic timing reference. There are 5 different ramp slopes, selected by the TIME POSITION RANGE section on the TIME/CM switch.

Up to this point, the system consists of --

- a. Trigger selection and recognition.
- b. Fast Ramp run down and reclamping, controlled by trigger rep. rate and/or hold-off. (Refer to the ladder diagram in figure 2-3).

NOTE: The system will count down for frequencies above the rep. rate of the particular ramp/hold-off combination.

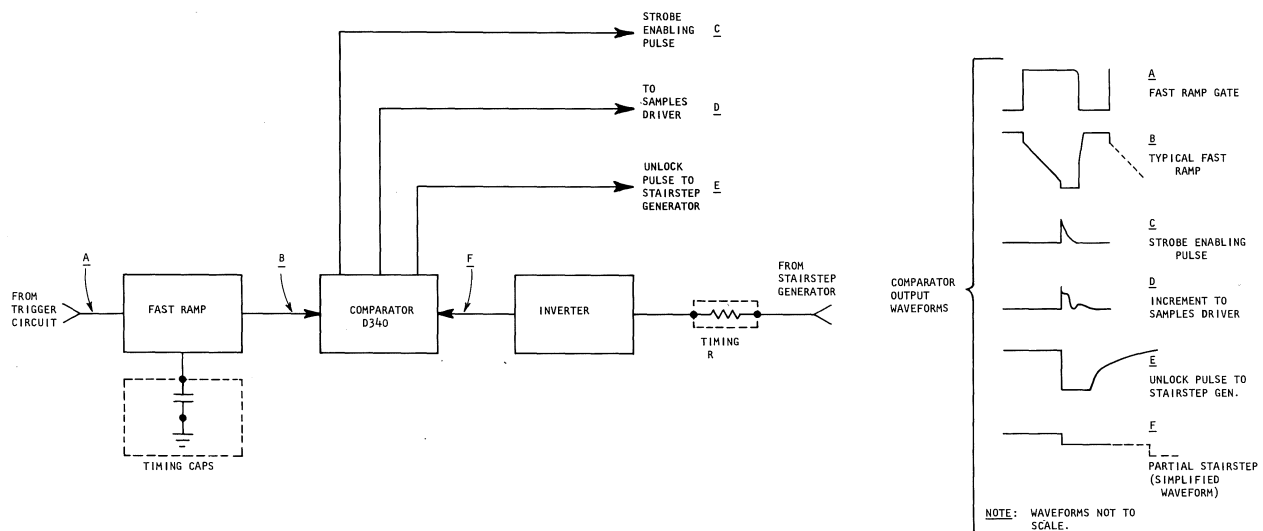
COMPARATOR

The function of the comparator is to produce an output when comparison is made between a certain voltage point on the fast ramp and a certain voltage point on the stairstep.

The stairstep voltage point is related to the horizontal position of the spot on the CRT and the fast ramp voltage point is related to the vertical signal in real time. Therefore, at the point of comparison, the horizontal position of the spot on the CRT is directly related to a point in real time on the input waveform.

If the ratio of comparator stairstep to CRT deflection is changed-- the readout in time/cm will be changed.

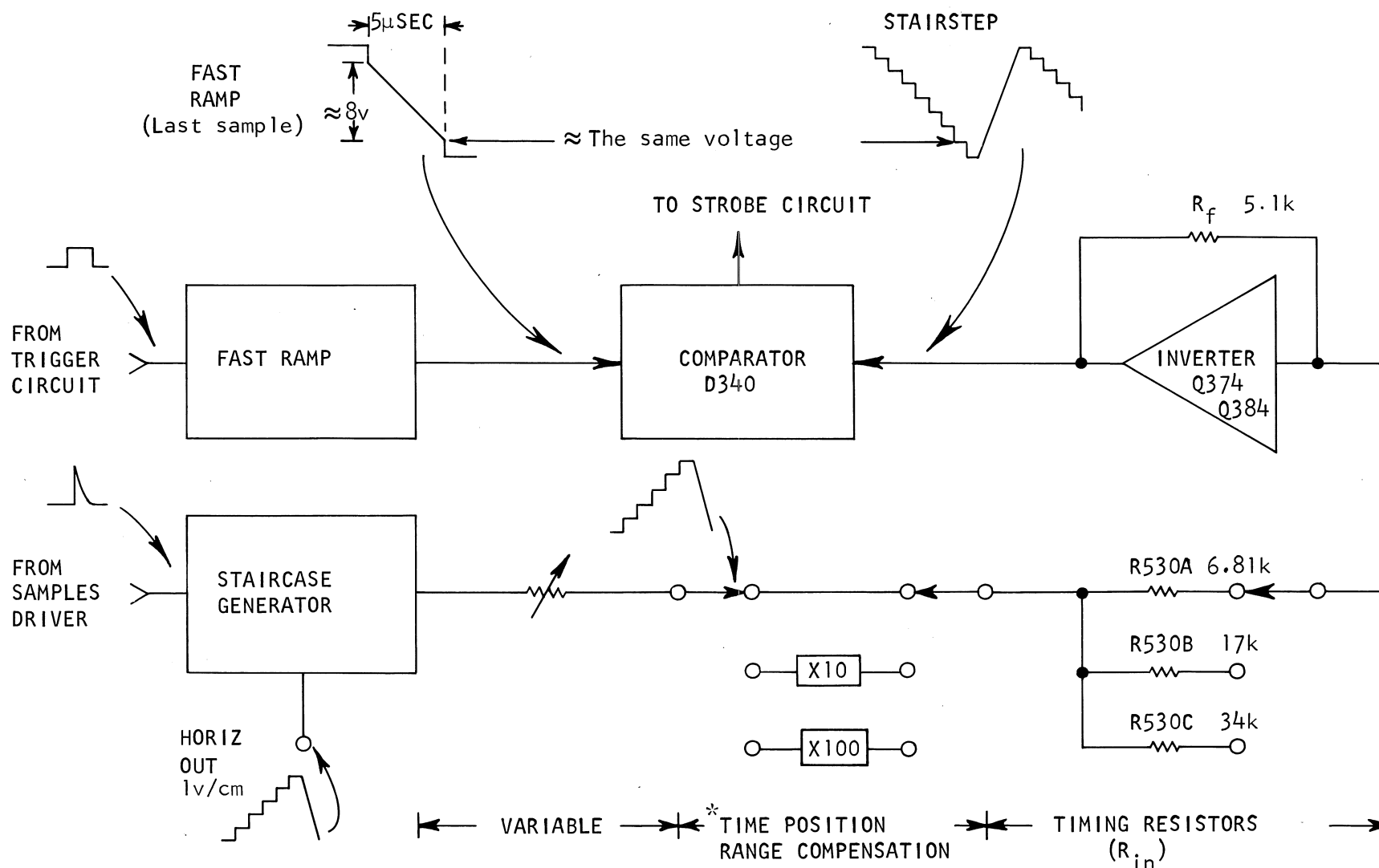
Figure 2-4 shows the comparator with its two basic inputs, one from the Fast Ramp and one from the Inverter.



1S1 COMPARATOR AND ASSOCIATED WAVEFORMS

Figure 2-4

NOTES



* Only used when the Blue Time Position Range marker is in a different sector to the Time/cm dot.

INVERTER GAIN

Figure 2-5

Comparison produces a standardized output pulse which is distributed to three separate areas.

1. Strobe initiating pulse to Vertical system.
2. Stairstep generator arming pulse (inverted and amplified).
3. Stairstep advancing increment to the samples driver.

The ladder diagram in Figure 2-4 shows the time relationships involved so far. Remember that each fast ramp will run for a slightly longer period before comparison, as the negative going stairstep advances.

INVERTER

The inverter is an operational amplifier, the closed loop gain is determined by a fixed R_f and one of three timing resistors. The overall gain between the Staircase and the Comparator is further modified by a X10 and X100 attenuator and the VARIABLE time/cm control.

The purpose of the inverter--apart from inverting the stairstep--is to provide the correct ratio of comparison voltage to horizontal spot position on the CRT, as previously mentioned.

Figure 2-5 illustrates the operational amplifier concept, in this example the equivalent sweep speed is $.5 \mu\text{SEC}/\text{CM}$ in conjunction with the $5 \mu\text{SEC}$ TIME POSITION RANGE ramp.

In this illustration, the fast ramp has just completed the last sample by running down $5 \mu\text{SEC}$ before comparison.

$5 \mu\text{SEC}$ on the fast ramp is $\approx 8v$. For comparison to have been made the stairstep input to the comparator must also have been at $\approx 8v$.

IF $5 \mu\text{SEC}$ at $.5 \mu\text{SEC}/\text{CM} = 10 \text{ cm}$
THEN $\approx 8\text{v}$ at the comparator must also equal 10 cm on the CRT.

IF the sweep speed is changed to $.1 \mu\text{SEC}/\text{CM}$ the gain of the inverter will be divided by 5, therefore 10 cm on the CRT will now equal $\frac{8}{5} = 1.6\text{v}$ at the comparator.

Therefore, at comparison, (sample at 10 cm) the fast ramp will run down $1.6\text{v} = 1 \mu\text{SEC}$

AND $1 \mu\text{SEC}$ in 10 cm = $.1 \mu\text{SEC}/\text{CM}$.

Note that the number of samples required to complete a 10 cm display has no bearing on the time/cm readout.

The SAMPLES/CM on the ISI are continuously variable from ≈ 5 samples/cm, to an extremely high dot-density condition--where the trace appears as an unbroken line that takes a considerable time to cross the screen.

STAIRCASE GENERATOR

The prime purpose of the staircase generator is to produce horizontal deflection on the CRT that is related to the fast ramp voltage at the time of comparison. As previously mentioned, the fast ramp voltage is directly related to real time--therefore the CRT deflection, in volts, can be read out in equivalent time/cm.

The staircase generator has all the characteristics of the well known Miller sweep generator, the basic difference being the manner in which the stairstep advances. (See figure 2-6).

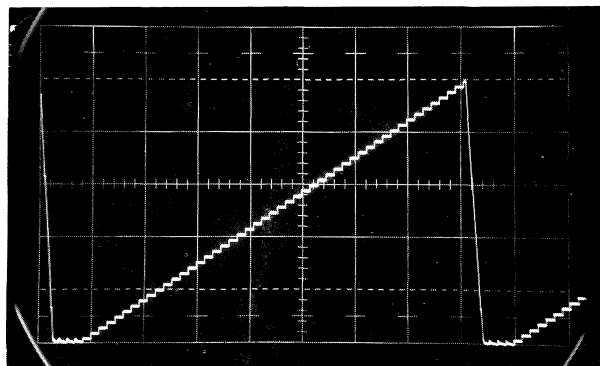


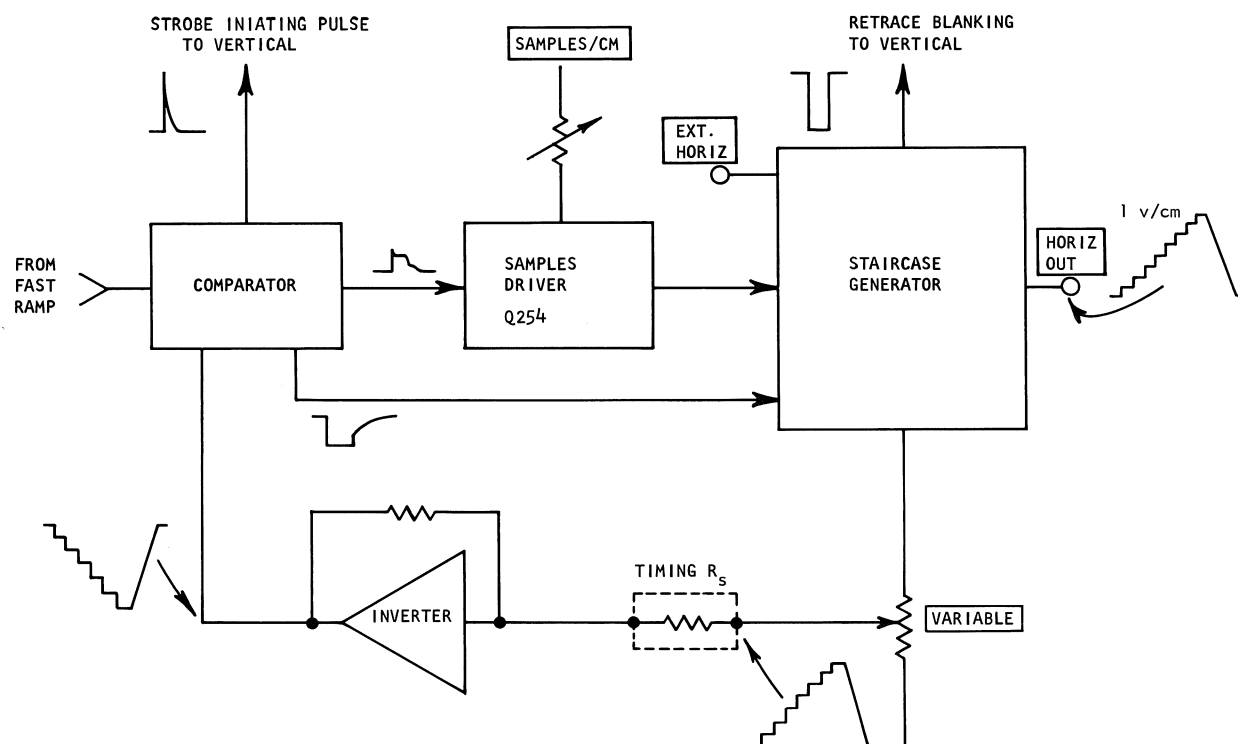
Figure 2-6

OPERATION

- a. In the waiting condition the stairstep is clamped by the sweep multi via the disconnect diodes. The spot is held downwards off-screen by the blanking circuit.
- b. On receipt of the first sample--(1) The sweep multi is armed--leaving the Miller free to run-up.
(2) Simultaneously, a current increment is dumped into the Miller C.

Coincident with sweep unlocking, the Retrace Blanking voltage is removed from the vertical system.

After the sweep multi is unlocked it does not see further arming pulses until the next sweep start.



STAIRCASE GENERATOR

Figure 2-7

The conventional timing resistor and current source of the Miller is replaced by a diode "Bucket and Ladle" arrangement that dumps small increments of current into the Miller C.

Figure 2-7 shows the staircase generator block and its associated control and driving units.

Remember, the comparator puts out 3 coincident signals at comparison (sampling) one initiates the strobe pulse in the Vertical System. The other two are fed to the staircase generator.

SAMPLES DRIVER (Refer to figure 2-7)

The Samples Driver, Q25⁴, is a current source for the "Bucket and Ladle" circuit (not shown).

The total current dispensed by the "Bucket and Ladle" circuit per increment is controlled by the SAMPLES/CM control.

If the increments seen by the Miller C are smaller, more of them will be required to complete a 10 cm sweep which will equal more samples/cm.

As the voltage ratio between the Horizontal output and the input to the comparator remains unchanged, the time/cm readout remains unchanged.

When the ISI is normally triggered on a repetitive signal an uninterrupted stream of sweep-multi arming pulses, and incremental step pulses are applied to the staircase generator.

However, when the horizontal display reaches 10 cm the staircase is reset in the conventional manner.

Hold-off circuitry in the generator locks out the arming pulse for approximately 200 μ SEC.

Incidentally, incremental step information is still being applied to the Miller C. However, the sweep is either running down or is clamped so the increments are ineffective during this period. (Refer to figure 2-6).

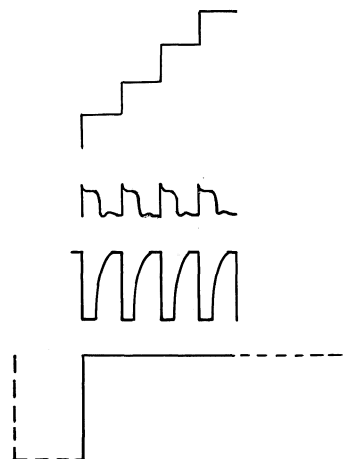
STAIRCASE GENERATOR WAVEFORMS

1. STAIRSTEP OUTPUT

INCREMENTAL INPUT

2. ARMING PULSES

RETRACE BLANKING

NOTES

1. The stepping rate depends upon the incoming trigger/countdown rate. Erratic rep. rate signals will produce erratic stairstep advance. However, this will not affect readout accuracy.
2. The first arming pulse after Staircase generator hold-off arms the sweep--succeeding pulses are not seen by the generator.

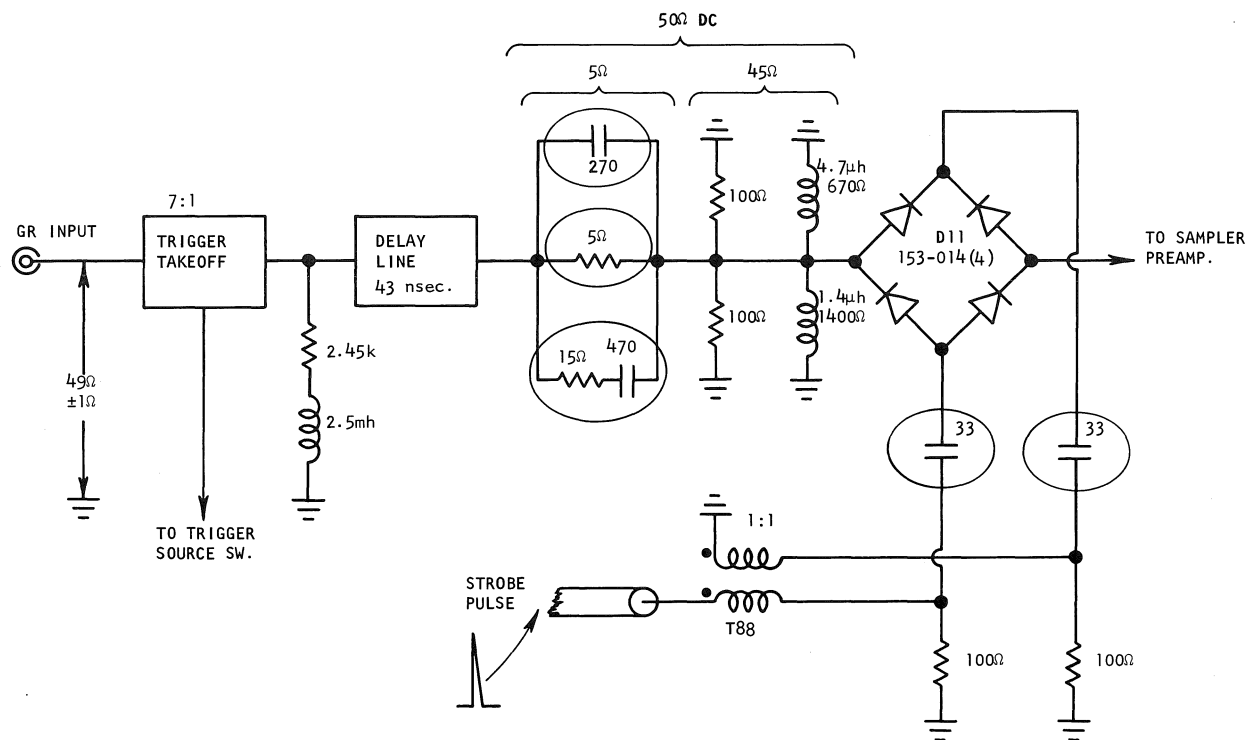
Figure 2-8

Figure 2-8 shows the time related input and output waveforms.

DETAILED BLOCK ANALYSIS

THE ISI VERTICAL SYSTEM

Figure 3-1 shows the input components of the ISI Vertical system. The purpose of these components is to correctly terminate the input signal over the operating range of the Vertical system (DC to 1 Gc), the effectiveness of this termination network is indicated by the VSWR and frequency response charts shown on page 1-24.



ISI INPUT COMPONENTS

Figure 3-1

Notice that the DC resistance of the input network is $49\Omega \pm 2\%$, however the indicated voltage will be correct when the sampler is looking into a 50Ω source.

Figure 3-2 shows the DC condition, $.99_e$ will appear at the sampler input, however this voltage is normalized to 1 by a system gain of X1.01.

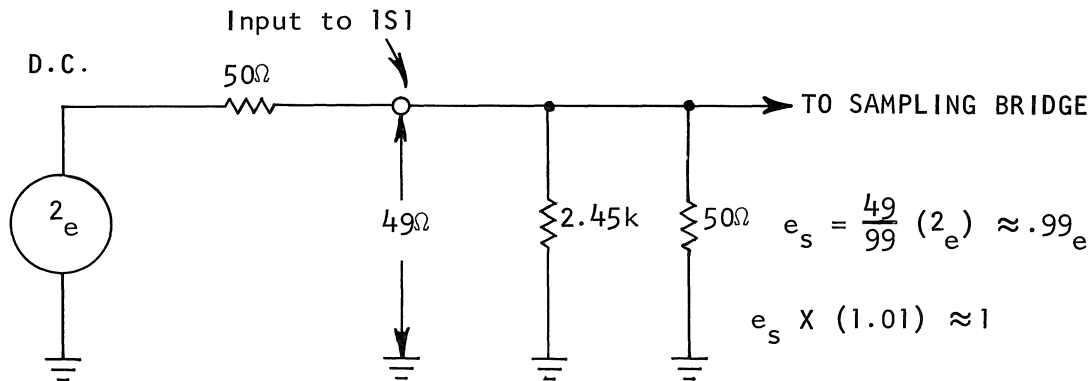


Figure 3-2

The CRT will display a voltage that would be present if the source were terminated in exactly 50Ω .

Figure 3-3 shows the HF case--the input to the sampler looks like 51Ω , $\approx 1\Omega$ of series resistance is reflected by the trigger take-off transformer, the impedance after the delay line is still $\approx 50\Omega$. The voltage appearing at the SAMPLING BRIDGE will be $.99_e$, therefore the normalized system gain of X 1.01 will be correct for all frequencies.

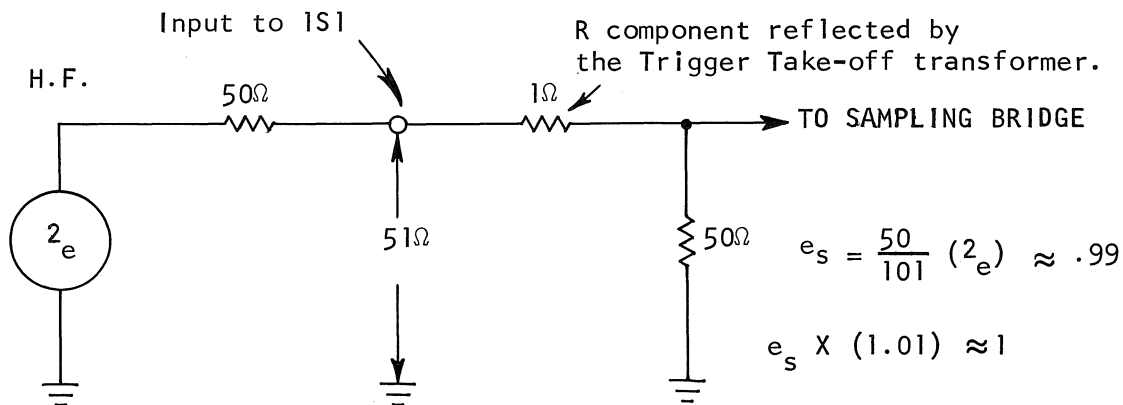


Figure 3-3

One interesting feature of the ISI input circuitry is the use of pellet parts.

The circled areas on figure 3-1 indicate the pellet components, the 15 Ω - 470 pf components are combined in one pellet.

The circular pellet parts are inserted in the board before plating. They are bonded into the board and then plated over. The board is then etched in the usual manner, leaving the location of the parts practically invisible to the eye.

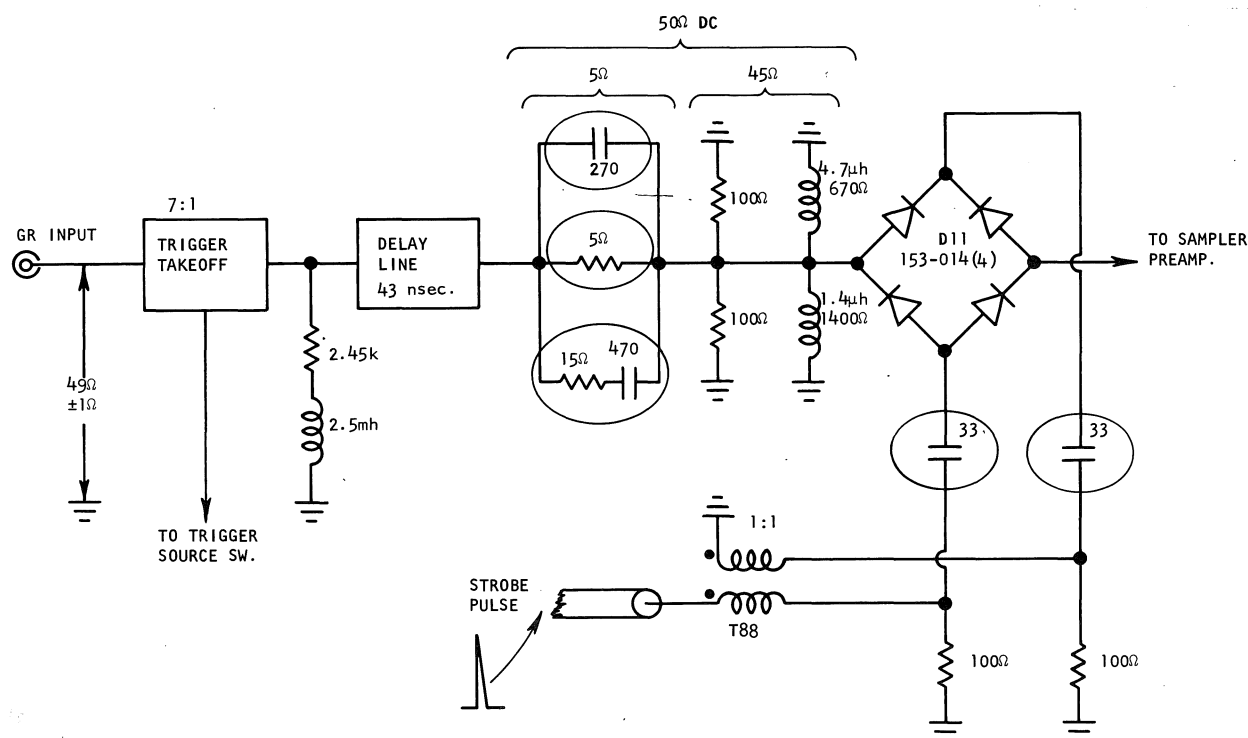
The important thing is, have faith in these parts, if there is a rise time problem or a termination problem, every other avenue should be explored first, before suspecting the pellets. If the pellets do become suspect the current advice is to ship the unit back to Portland, Attn. Bob Wruble.

SAMPLING BRIDGE AND STROBE GENERATOR

The sampling bridge uses a matched set of 4S1 type diodes.

The strobe pulse from the snap-off circuit is applied to inverting transformer T88, the secondary is loaded by 100Ω . This impedance is reflected back to the primary which is in series with another 100Ω , therefore one half the input voltage will appear across the primary and the other half will appear across the 100Ω series resistor.

Half of the uninverted pulse is taken from the primary/ 100Ω junction and the other half is taken from the secondary, which will be inverted.



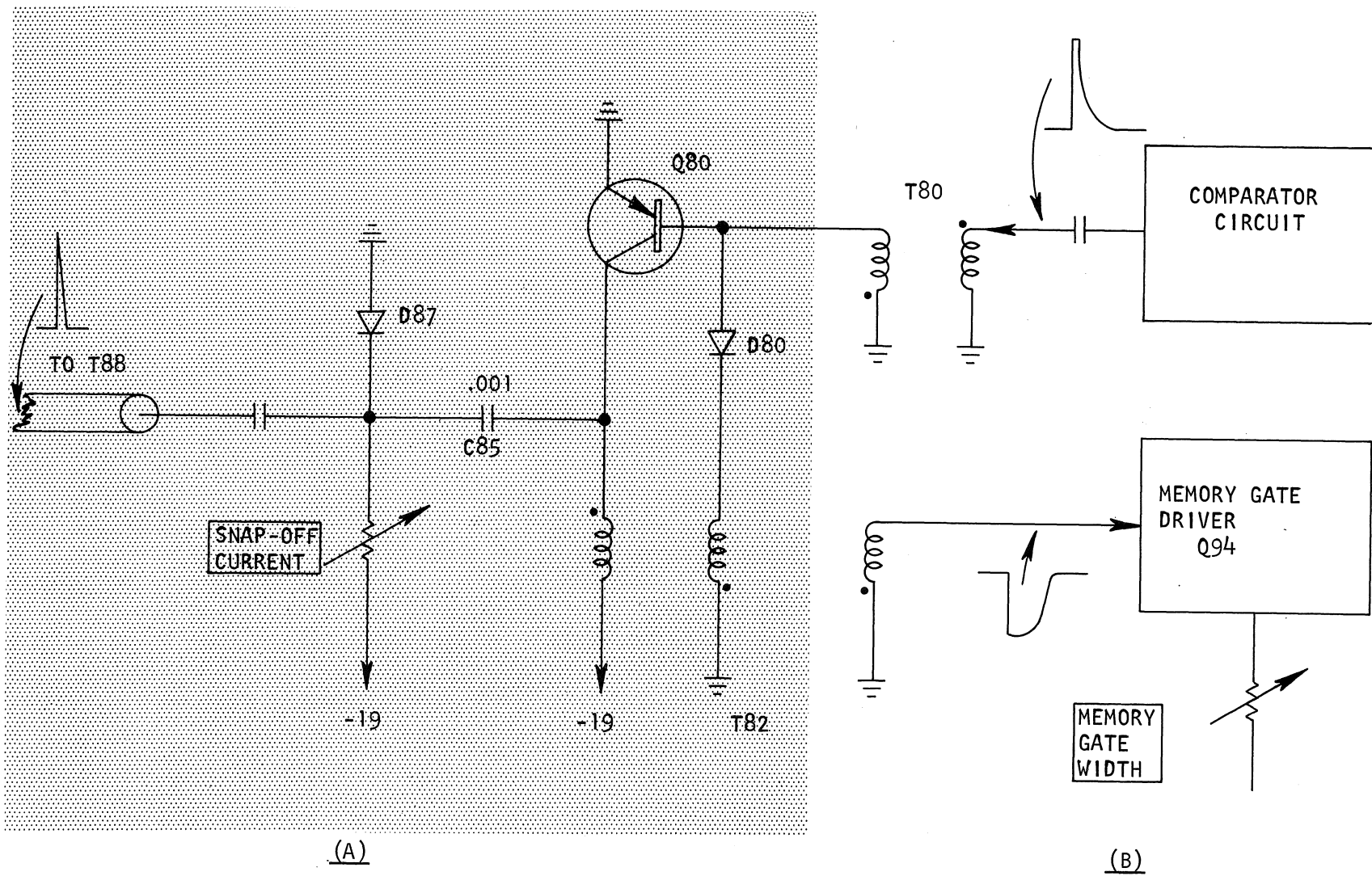
1S1 INPUT COMPONENTS

Figure 3-3 A

T88 and the 33 pf pellet parts are mounted right of the bridge. Provision is made for Bridge Balance and DC Offset (not shown here).

The strobe generating circuit is different from previous arrangements, however a snap-off diode is still used to produce the fast pulse. The circuit is unique in that blocking oscillator action takes place after snap-off.

NOTES



SNAP-OFF CIRCUIT (Showing driving circuit and output take-off to Memory Gate Driver.)

Figure 3-4

Figure 3-4 A shows the basic elements.

D87 is held in conduction by current through the snap-off current adjustment.

Q80--part of the B.O. circuit--is off, the collector is at -19v.

If Q80 is made to conduct by some means the collector tries to go to ground, however, the stored charge in D87 and C85 supply current to Q80 maintaining the collector voltage within a few tenths of a volt.

As both ends of the B.O. transformer primary are at practically the same voltage there is no change in current in the primary, and no B.O. action takes place.

When the stored charge in D87 is swept out, the collector of D80 can move and B.O. action will take place.

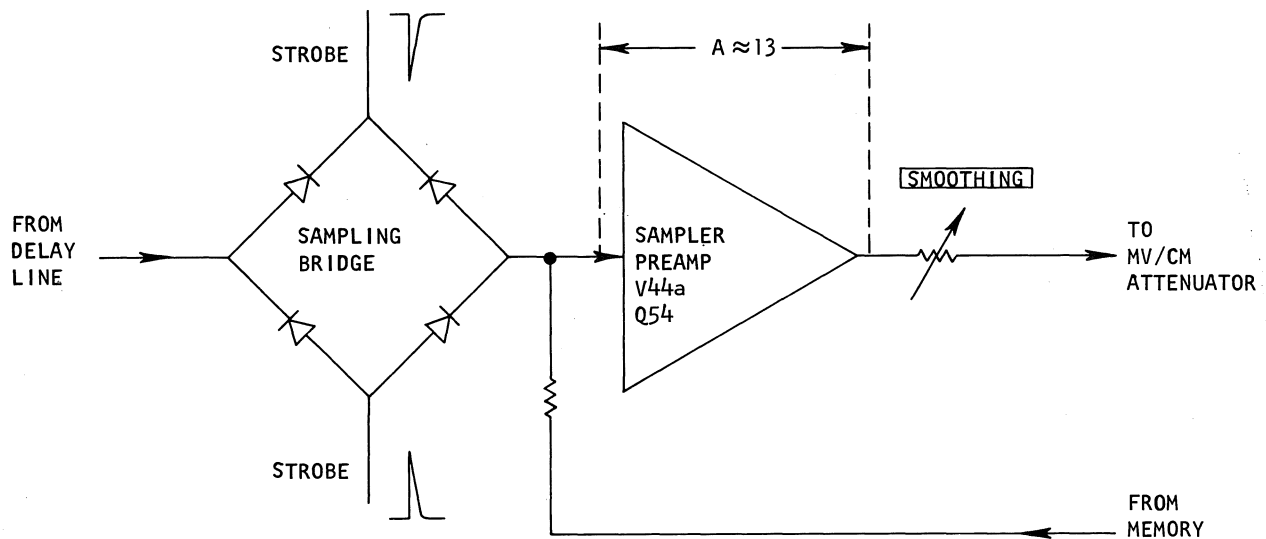
The negative going step from D87 is differentiated and piped to the sampling bridge transformer (refer to figure 3-3 A).

C85 is relatively large so it retains a good percentage of its original charge throughout the cycle, it is this voltage which back-biases the snap-off diode.

Figure 3-4 B shows the additional components necessary to (a) inject the enabling or turn-on pulse from the Comparator circuit, (b) extract the B.O. pulse for operating the Memory Gate Driver.

The positive going pulse from the comparator is inverted by T80 and applied to the base of Q80.

The diode D80 presents a high impedance to this pulse, so that all of the current can drive the base of Q80.



SAMPLER PREAMP

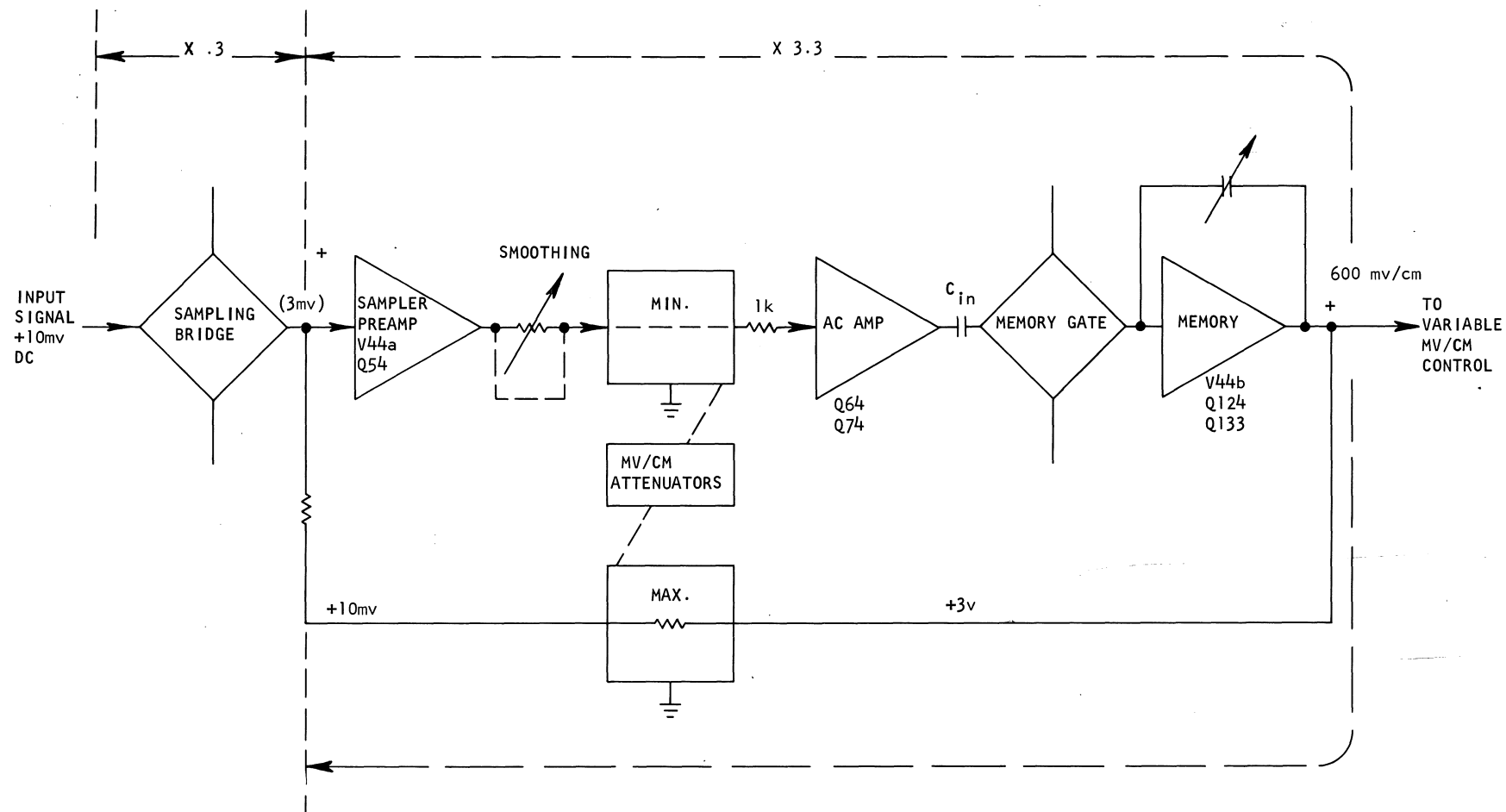
Figure 3-5SAMPLER PREAMPLIFIER

The preamp consists of V44 (1/2 8416) and Q54. (See figure 3-5).

The input C of V44 is exposed to the signal during the strobe time and it will charge to $\approx 30\%$ of the impressed voltage during this period, therefore the sampler is said to have 30% Sampling Efficiency.

The amplifier incorporates several R.C. time constants and one L/R time constant to produce an effective gain of ≈ 13 when handling the fast rise error signal. The DC gain is held at ≈ 1 while the upper frequency response is limited by transistor parameters, so in effect this amplifier approaches narrow bandwidth operation, with the consequent improvement in signal/noise ratio.

NOTES



MV/CM ATTENUATORS
(Showing response to +10 mv
DC at 2 mv/cm.)

Figure 3-6

MV/CM ATTENUATORSRequirement

At the first sample, approximately 30% of the instantaneous input voltage is stored in the input C of the Sampler Preamp. This voltage, after being amplified and applied to the Memory, must eventually appear back at the Sampler Preamp grid in the same phase (positive feedback) furthermore, the feedback voltage must equal 100% of the instantaneous input voltage to the sampling bridge.

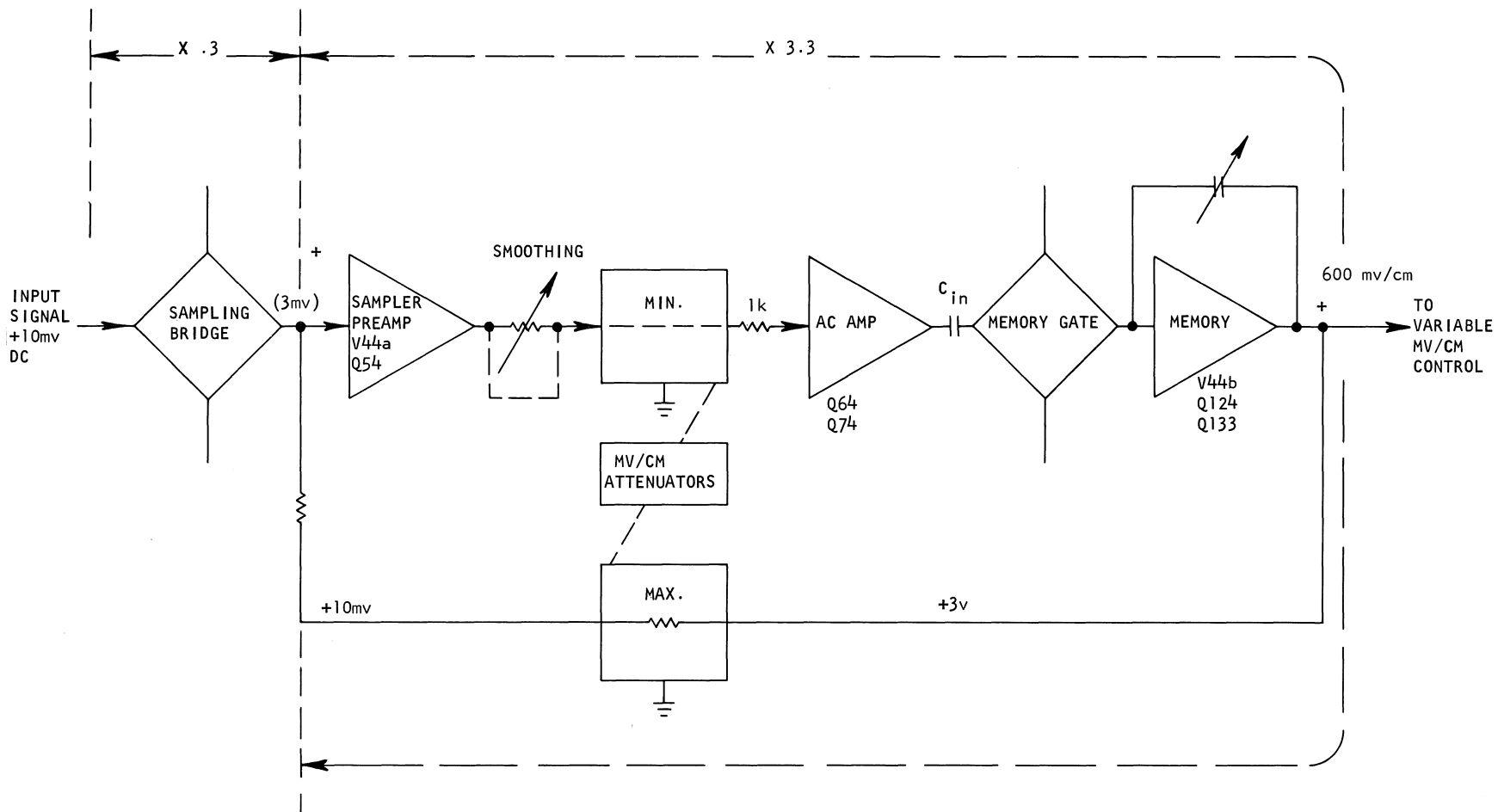
This will require an effective gain of ≈ 3.3 from sampler grid, back to the sampler grid, or an overall gain of one from sampling bridge input to the Sampler Preamp grid. (See figure 3-6).

Example

Input Signal = 10 mv DC.

The first sample will store ≈ 3 mv in the input C of the sampler preamp. This "error signal" ($\Delta 3$ mv) is amplified and applied in the memory. A voltage ≈ 3.3 times the stored sampler preamp grid voltage will eventually appear back at the sampler, to equal 10 mv. Subsequent sampling will produce no change at the sampling preamp grid and therefore no error signal. This system would produce correct Dot Transient Response.

It will be seen that many factors can influence the loop gain, for example, the feedback signal is a function of time, time duration of the strobe pulse (sampling efficiency change) and time duration of the memory gate (memory gate width).



MV/CM ATTENUATORS
(Showing response to +10 mv
DC at 2 mv/cm.)

Figure 3-7

Vertical Sensitivity

The Vertical Sensitivity setting is determined by the ratio of Vertical Input Voltage to Memory output voltage.

This ratio is set by a second attenuator in the positive feedback loop.

When the second attenuator is at maximum a large signal will have to appear at the memory output to produce eventual cancellation of the preamp error signal (maximum sensitivity), or a smaller input will be required to produce the same output.

With this amount of attenuation in the feedback loop the maximum amount of forward gain is required to produce a loop gain of one.

Therefore, under conditions of maximum calibrated sensitivity (2 mv/cm) the forward attenuation is minimum and the feedback attenuation is maximum. (See figure 3-7).

At 200 mv/cm the feedback attenuation is minimum (small memory output voltage needed to balance the input). Because the feedback attenuation is minimum the forward gain will have to be reduced to give an overall loop gain of one (correct dot transient response).

SMOOTHING

The memory output must eventually reach a voltage that is related to a D.C. input voltage--controlled by the feedback attenuator ratio--regardless of the system internal gain.

It follows therefore, that if the loop gain is made less than one, the Vertical Sensitivity will remain calibrated but the dot transient response will be undercompensated.

This condition can reduce random noise by feeding less than 100% of the original signal back to the sampler. It would take several identical samples to cancel the error signal and display the full voltage, however the noise is random so this can't happen--the result is less displayed noise.

The SMOOTHING control is inserted in front of the forward attenuator, it has a smoothing range of $\geq 3:1$.

The forward attenuator is a constant impedance type, the impedance looking in = 1K.

The attenuator must be terminated in 1K to divide correctly, the 1K load is provided by R_{in} to the A.C. Amplifier.

The 1K R_{in} sees the attenuator as a low impedance voltage source so it is not affected by attenuator output impedance changes.

The forward attenuator has no D.C. current flowing, therefore it does not contribute noise to the display, or baseline shift to a free running trace.

If the trace does shift it will probably be due to the D.C. OFFSET not being at zero. A quick way to adjust the DC OFFSET to zero is to remove the jumper from the HORIZ OUTPUT and touch it intermittently to the OFFSET OUTPUT jack while adjusting the DC OFFSET control. The main-frame horizontal amplifier is now being used as a voltmeter.

AC AMPLIFIER

This amplifier drives the memory gate.

The input time constant limits the low frequency gain to 3 db down at ≈ 300 kc, in addition, an RC negative feedback network produces a rising response, the net result is a useful gain of ≈ 30 when handling the error signal. The amplifier has an effective R_{in} of 1k and an output impedance of $\approx 10\Omega$.

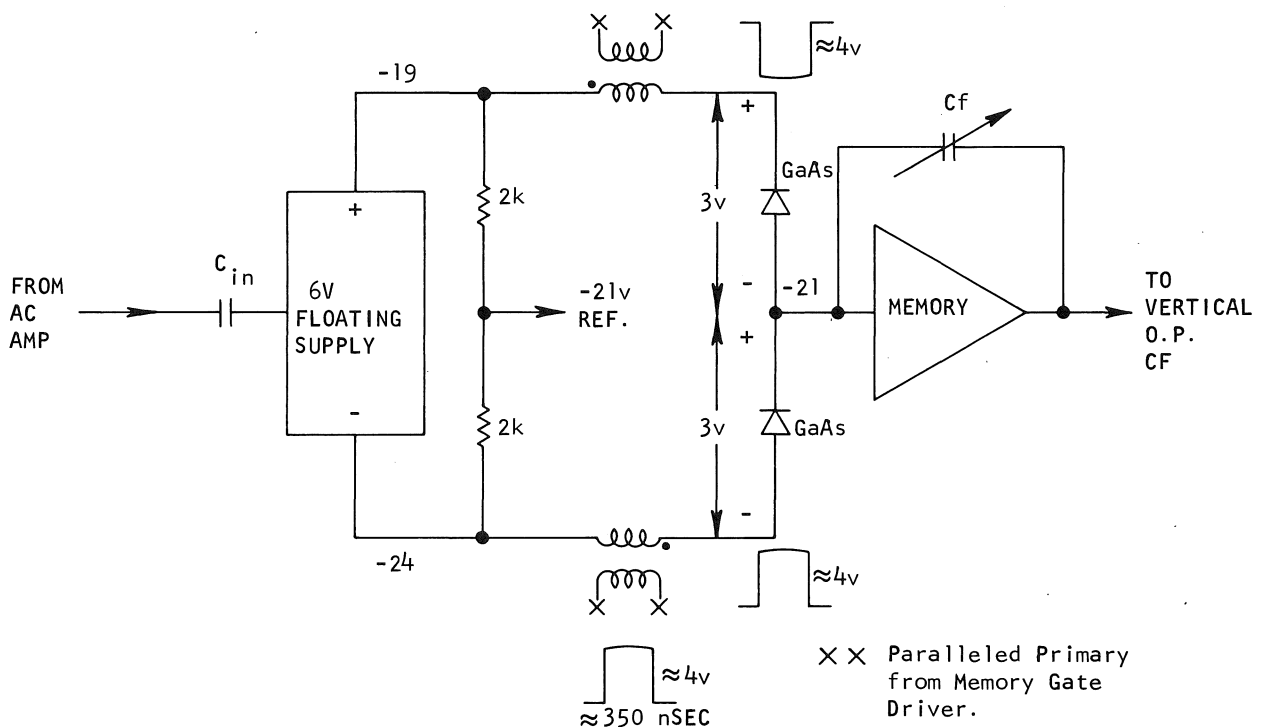
MEMORY GATE

The low impedance output from the A.C. amplifier drives the Memory through the Memory C_{in} and the Memory Gate.

The purpose of the gate is to connect the error signal to the Memory for the optimum time necessary to charge the memory to peak output, this time is typically about 350 nSEC.

The Memory Gate has some unusual features so it will be covered in detail.

Figure 3-8 shows a simplified version of the Memory Gate, it consists of (1) a 6v floating supply which is centered around -21 volts by a reference source (Memory Balance). (2) a four winding torroid transformer, and (3) two gallium arsenide gate diodes.



MEMORY GATE - SIMPLIFIED VERSION

Figure 3-8

OPERATION

In the waiting condition the 6v supply back-biases the two diodes by 3v each.

A GaAs diode has $\approx 1\text{v}$ of forward drop so $\approx 4\text{v}$ will be required to turn it on.

This voltage is obtained from the Memory Gate Driver. This voltage is injected into the two paralleled primary windings on the torroid.

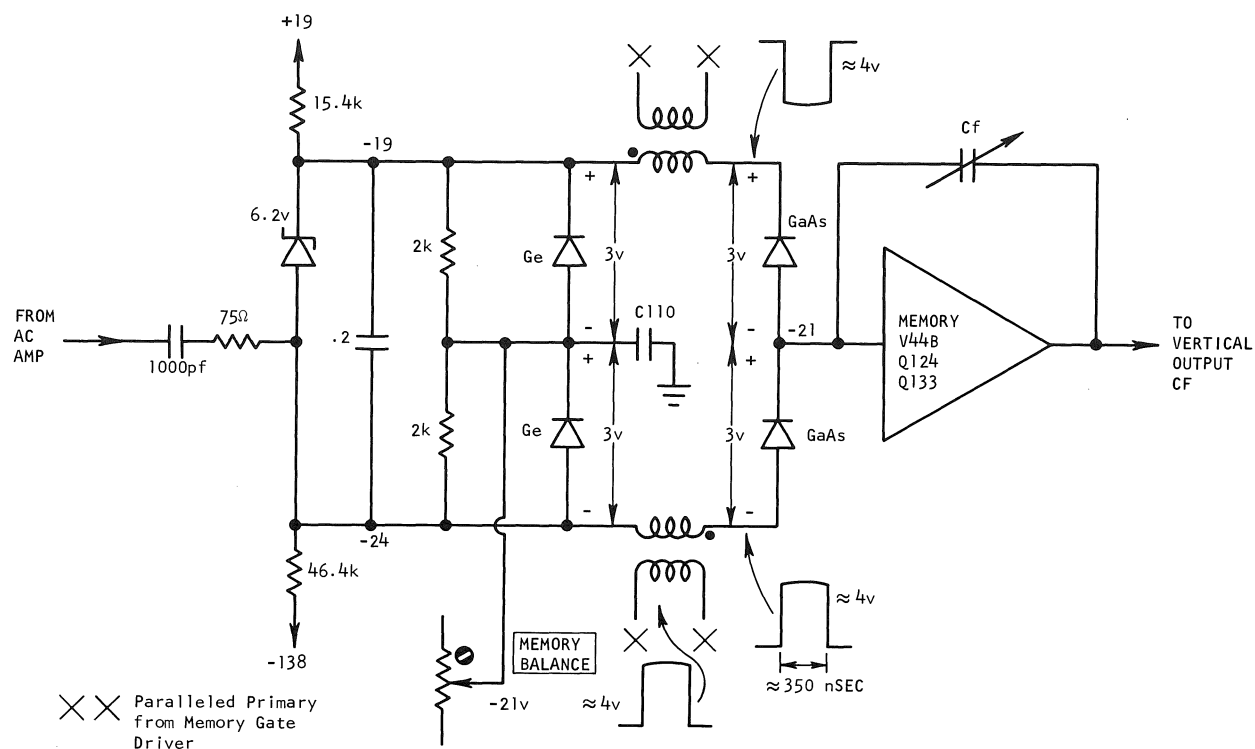
The dots on the secondary windings indicate polarity.

Each secondary winding tries to develop equal and opposite + and - 2v pulses, however the ends connected to the 6v supply oppose each other so the net result is the production of a 4v pulse at the diode ends of the secondaries.

The diodes conduct and connect the Memory to the floating supply, if an error signal is present the memory will charge to the peak error signal during the Memory Gate Time ($\approx 350\text{ nSEC}$).

The impedance looking Into the Memory Gate is $< 1\text{k}$ (two 2k is parallel) however, when the gate is open the AC amplifier (previous stage) sees the low impedance operational memory via C_{in} (1000 pf 1%).

Figure 3-9 shows the gate in more detail, note the Zener diode floating supply and the $\approx 21\text{v}$ reference called MEMORY BALANCE. This control is adjusted for no baseline shift when rotating the SMOOTHING control, balance is achieved when the Memory output is zero with no DC offset and no signal input, or if there is DC offset the memory must still feedback zero volts to the sampler, with zero signal in.



MEMORY GATE

Figure 3-9

Misadjustment of the MEMORY BALANCE will generate asymmetrical error signals which will produce a net + or - current through the SMOOTHING control, resulting in trace shift with rotation.

Figure 3-9 also shows two extra diodes, these are clamp diodes.

Operation

When the gate is closed, all four diodes are back biased by $\approx 3v$.

If the AC Amplifier swings more than $\pm 3v$ the germanium clamp diodes will conduct and clamp the memory via C110, the Memory Diodes being GaAs type would still be back-biased so the AC amplifier excursions will not get into the memory.

For normal on-screen deflection the clamp diodes are always back-biased, the diodes will come into action if a large DC Offset voltage is used.

MEMORY

The Memory is an operational amplifier, it consists of V44B (1/2 8416) Q124 and Q133.

The amplifier must have an open-loop gain in excess of 1500 in order to reduce the effects of gain change with smoothing to less than 1%, in other words, the system must achieve balance with a minimum error signal into the memory.

An open-loop gain > 1500 is obtained with the help of positive feedback between the emitters of Q124 and Q133.

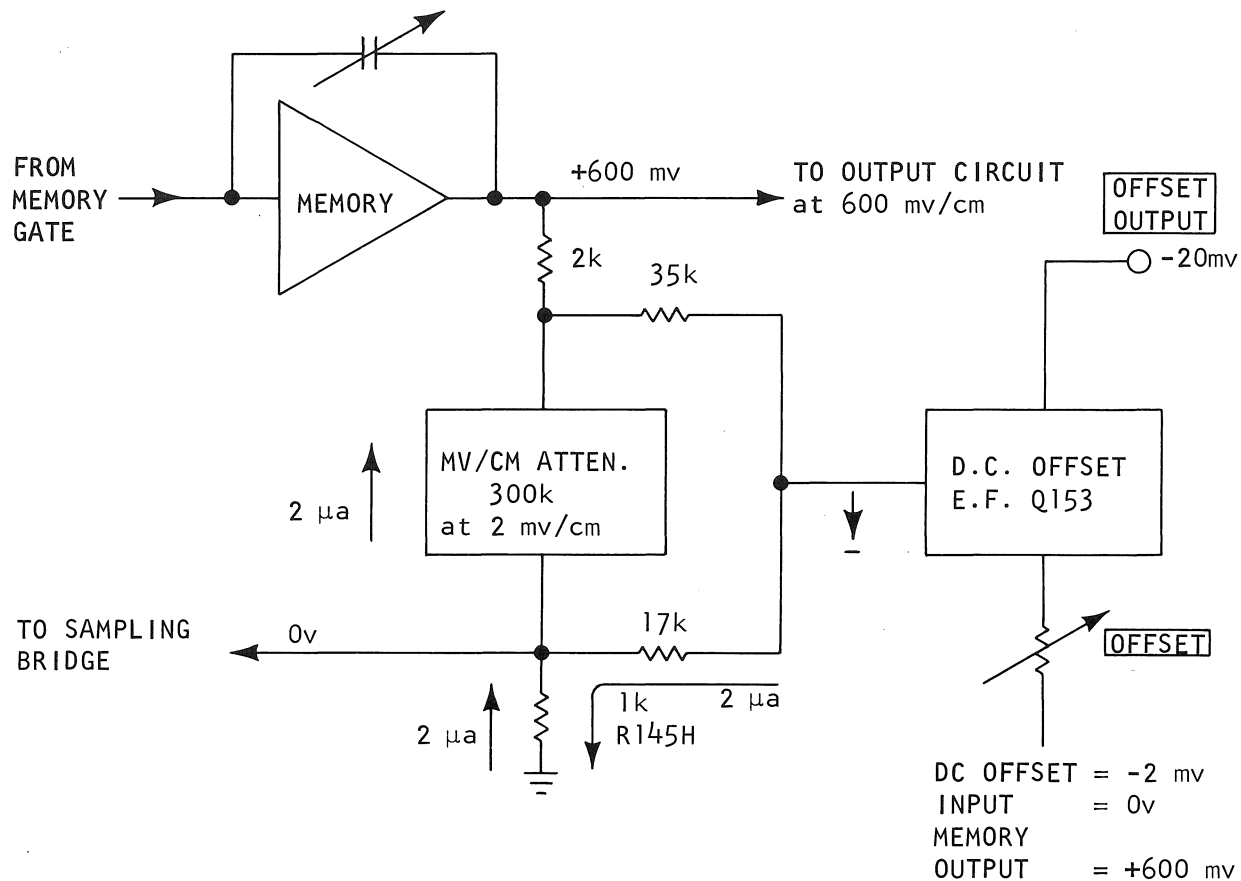
The forward gain of the Memory can be varied over a small range by adjusting C135 (part of C_f).

C_{in} , a 1000 pf 1% capacitor is located in front of the Memory Gate. Refer to figure 3-9.

DC OFFSET

This control can offset an input signal $\geq \pm 1\text{v}$ from center, or an equivalent of $\pm 500\text{ cm}$ at 2 mv/cm sensitivity.

Figure 3-10 shows a simplified diagram of the D.C. Offset system.



DC OFFSET
Figure 3-10

1st EXAMPLE

INPUT SIGNAL = 0v
SENSITIVITY = 2 mv/cm
DC OFFSET = 0v

Under these conditions the memory output will be zero, with zero volts being fed back to the sampling bridge.

If the DC Offset emitter follower output is made negative, a current will flow through the 17k resistor and through R145H, a 1k resistor.

If the DC Offset control is adjusted so that 2 μ amp flows through the 1k resistor, 2 mVolts would normally be dropped across it, however, this latter condition cannot exist because the sampler will see this voltage as an error signal, or to be correct, the sampler will see the zero input as an error signal in reference to the -2 mv offset.

The error signal will correct the Memory output to +600 mv,
= +1 cm. (At 2 mv/cm = (2 mv).

This is how it works-----For the sampler to be balanced with zero signal in, the top of R145H (1k) must be at zero volts. This point can be maintained at zero if an equal and opposite current to the offset current (-2 μ amp) is passed through the 1k resistor.

This opposing current is obtained from the memory output via the feedback mv/cm attenuator.

It will be seen that if 2 μ amp is drawn through the attenuator (which = 300k at 2 mv/cm) 600 mVolt will be dropped across it. This represents a state of balance for this mv/cm setting.

The Memory output has risen +600 mv (= +1 cm) to cancel the offset current of -2 μ amp (= -2 mv).

2nd EXAMPLE

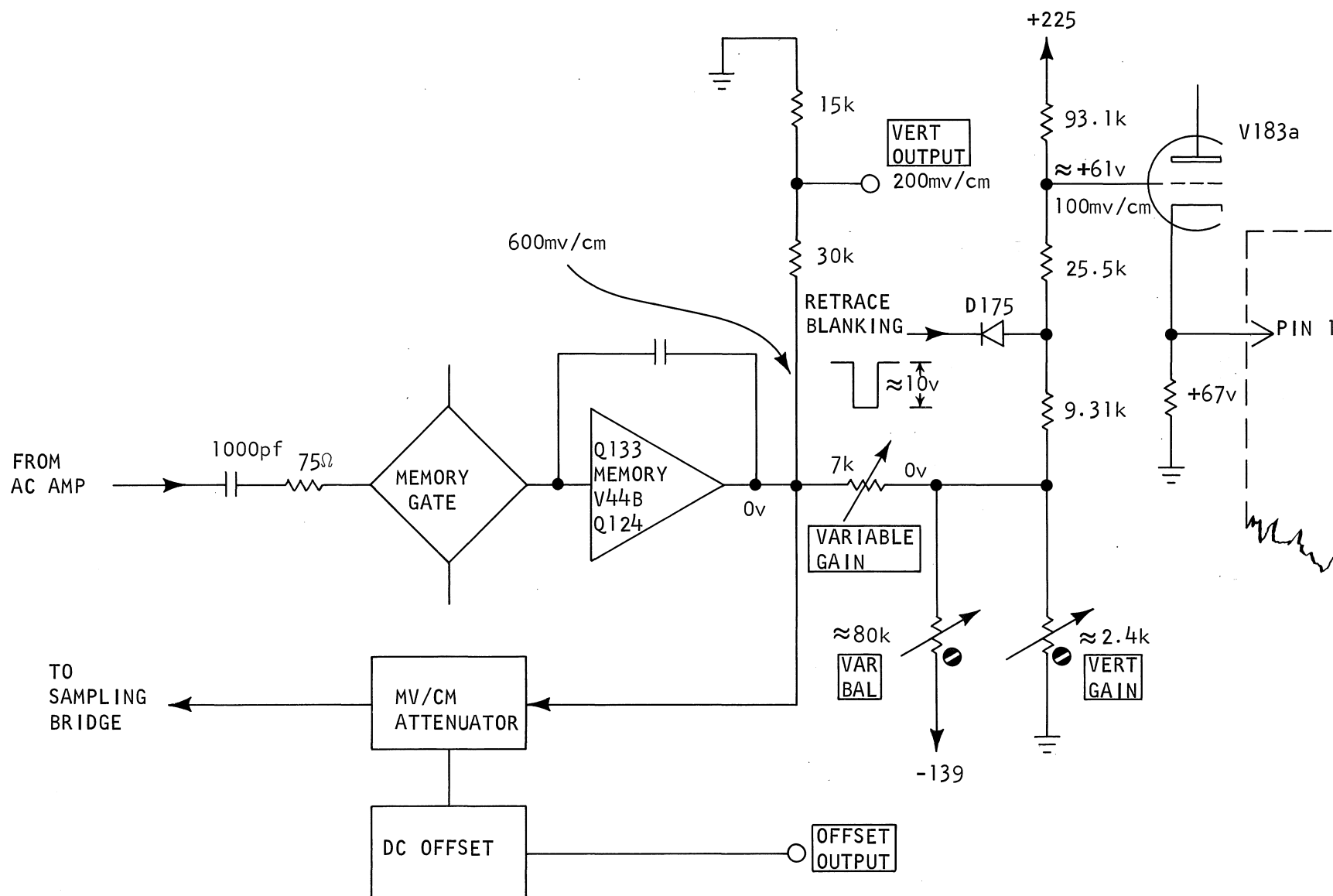
DC OFFSET = -1v

INPUT SIGNAL = -1v DC

SENSITIVITY = 2 mv to 200 mv/cm

Under these conditions, sampler balance will be obtained with -1v across R145H (1k), however the memory output is required to be zero volts (graticule center).

NOTES



MEMORY AND OUTPUT NETWORK

Figure 3-11

Note that the 1k and 17k resistors and the 2k and 35k resistors form 18:1 dividers. Therefore, with the assumption that the Memory output is zero, the junctions of the two dividers will be at the same voltage, in this case, -1v, so no current will flow through the attenuator. The only significant current flowing is that through R145H--1 ma, produced by DC Offset.

DC OFFSET OUTPUT

A suitable divider from the emitter of the offset E.F. presents X10 the actual offset at the front panel banana jack for monitoring purposes.

VERTICAL OUTPUT CIRCUIT

The Memory output voltage will be zero with no signal in, and no DC offset.

The level must be raised to $\approx +67v$ to make the interface with the mainframe.

Figure 3-11 shows the resistive network employed.

Some other requirements are:

- a. No D.C. through the VARIABLE GAIN pot, this is achieved by adjusting the VARIABLE BALANCE pot to obtain zero volts at the output end of the VARIABLE GAIN pot.
- b. The Memory output of 600 mv/cm has to be divided down to drive the main-frame at 100 mv/cm, this is achieved by changing the voltage division between the 7k VARIABLE GAIN pot and the VERTICAL GAIN preset.

Remember, the VARIABLE GAIN pot $\approx 7k$ in the "calibrated" position. This control has $\geq 4:1$ range, increasing the sensitivity to $\approx 500 \mu v/cm$.

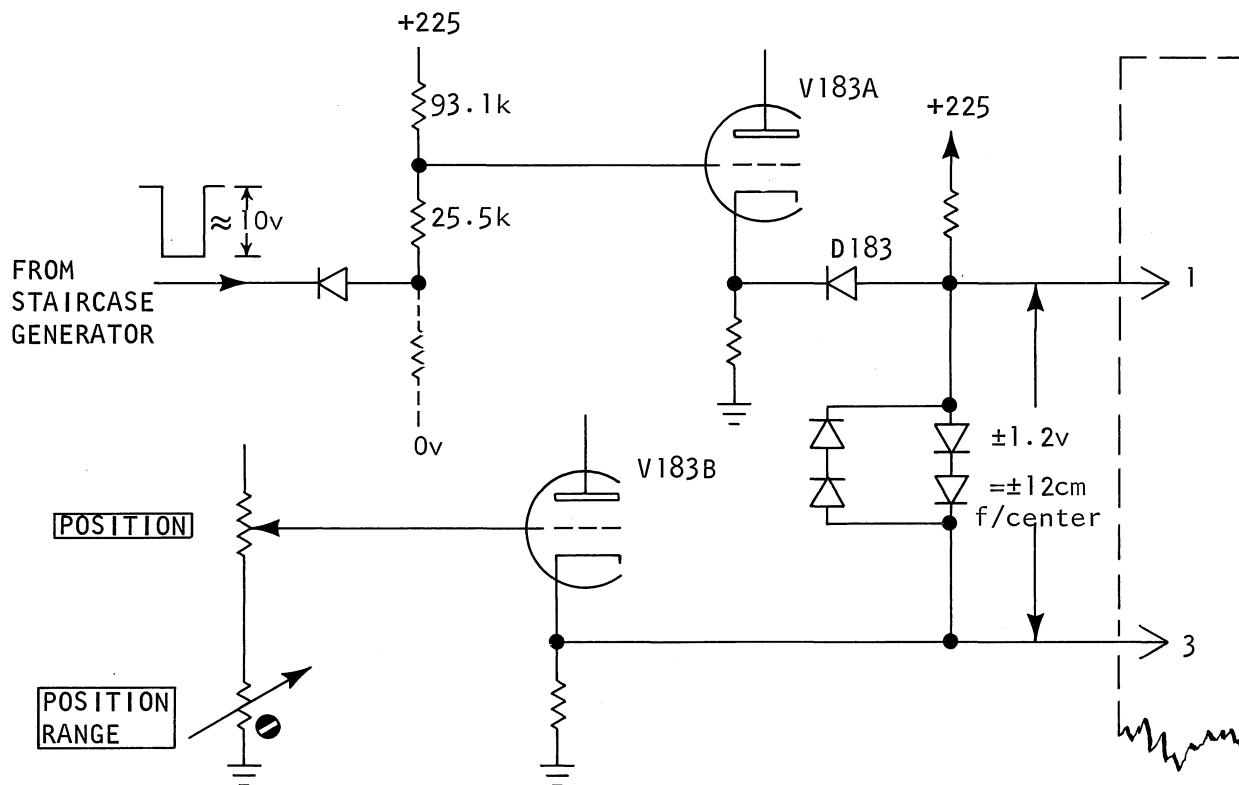
- c. Provision for Vertical Output

A 3:1 divider presents the Vertical Signal at the front panel banana jack at 200 mv/cm.

- d. Provision for Retrace Blanking

A retrace blanking gate of $\approx 10v$ is applied to the normally reverse-biased diode D175, this gate comes from the staircase generator.

The downward deflection of the trace is limited to ≈ 12 cm from center by a set of back to back silicon diodes. See figure 3-12. These diodes were added to prevent overdriving the main-frame vertical in the later series scopes, those using a transistorized vertical.



VERTICAL OUTPUT CATHODE FOLLOWER

Figure 3-12

D183 is normally conducting, however if the trace is driven upwards off-screen for more than 12 cm from center one section of the protective diodes will conduct and clamp pin one to the pin three voltage, plus ≈ 1.2 v. V183A will disconnect at this time, leaving the main-frame out of balance by no more than 1.2v.

POSITION and POSITION RANGE

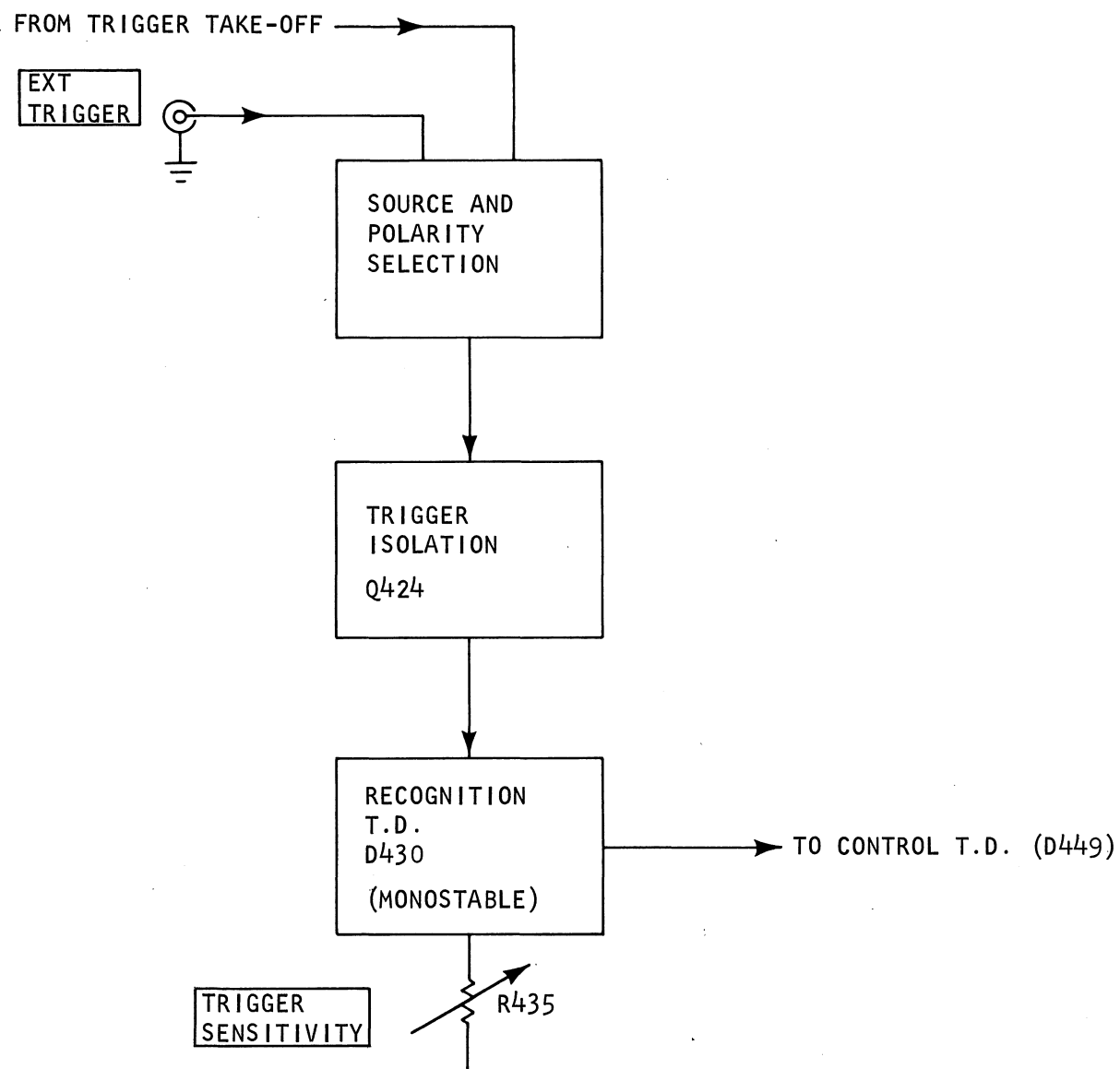
V183B operates as a positioning device only, a preset POSITION RANGE adjustment performs the usual function.

DETAILED BLOCK ANALYSIS

1S1 HORIZONTAL SYSTEMTHE TRIGGER CIRCUITGENERAL TRIGGER CIRCUIT REQUIREMENTS FOR SAMPLING SYSTEMS

The nature of a sampling system requires that a trigger circuit have the following characteristics.

1. The output signal must have a standard waveshape.
2. Must trigger on very small signals.
3. The amount of signal from the trigger circuit that appears at the input connector must be held to a minimum.
4. Must be triggerable on either + or - signals.
5. Must be capable of operation in three different modes-- free-run, synchronous, or triggerable.
6. Must be able to count down high frequencies.
7. Must not operate during the time of the fast ramp.
8. Maximum repetition rate of the output signal must be limited to ≈ 100 kc.



SIMPLIFIED TRIGGER BLOCKS

Figure 3-13

One of the primary things required of a trigger circuit is that all input signals must eventually have a standard waveshape. This is accomplished by causing the input signals to operate a monostable multivibrator; in this case a monostable TD circuit.

A second advantage of a TD trigger circuit is high sensitivity. Stable triggering can be obtained on signals as small as 5 mv.

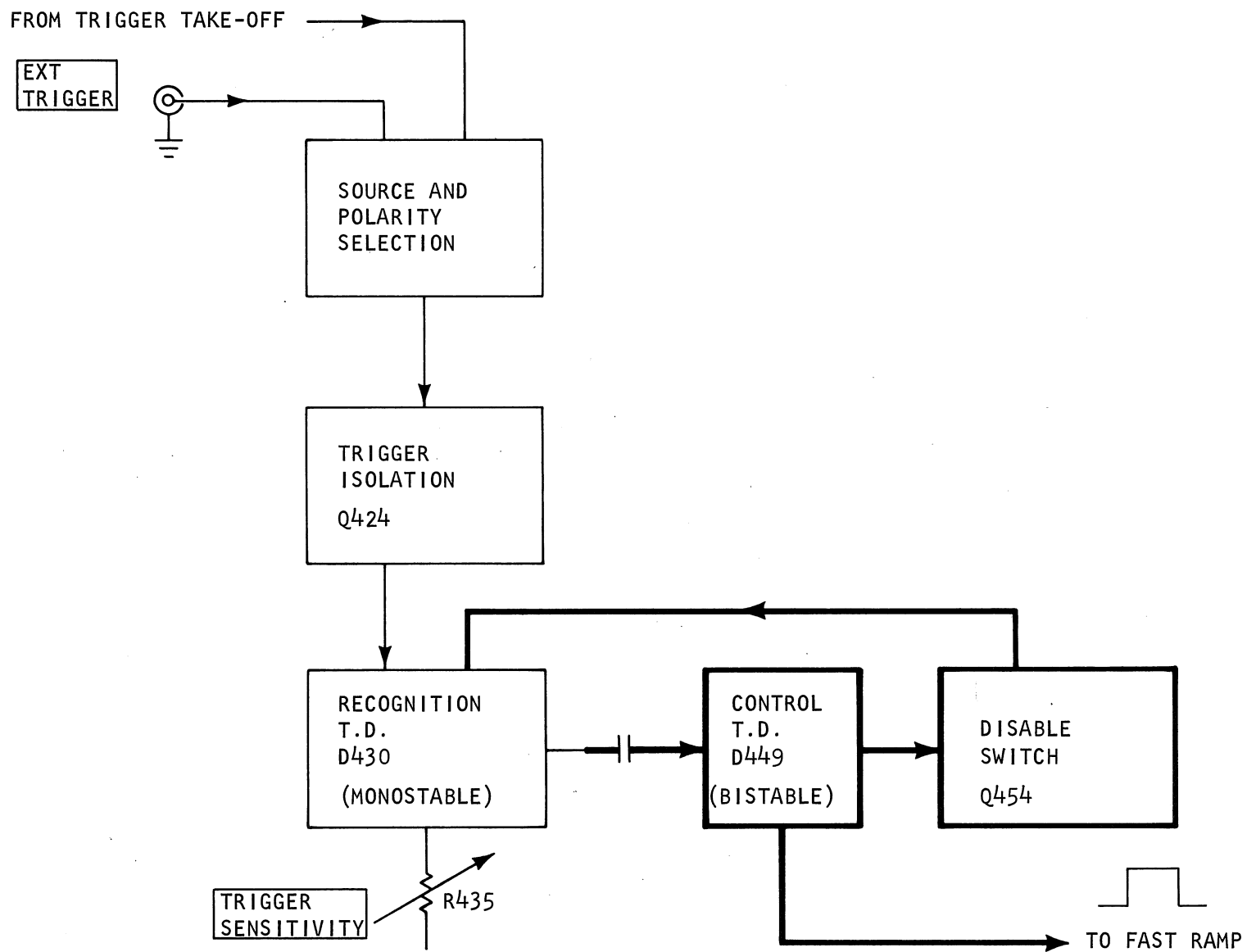
The output voltage of the monostable TD is $\approx .5$ volts. The TD output voltage can be considerably more than the input signal, so in order to avoid sending the TD waveform back to the input, a suitable circuit must be used to isolate the TD voltage from the input signal.

Figure 3-13 shows input switching, trigger isolation circuit, and monostable TD circuit. R435 is an operator control, located on the front panel. It is used to adjust the bias on the monostable TD, changing the switching current requirements as necessary to allow the TD to operate with a large variety of input signals.

The input switching performs source and polarity selection.

Signals may be selected from EXT (front panel BNC connector) or INT, from the trigger pick-off transformer in the vertical system.

The recognition TD D430 switches when a positive signal is fed into the trigger isolator, Q424. When triggering on negative signals is desired, an inverting transformer is used to change the signal polarity.



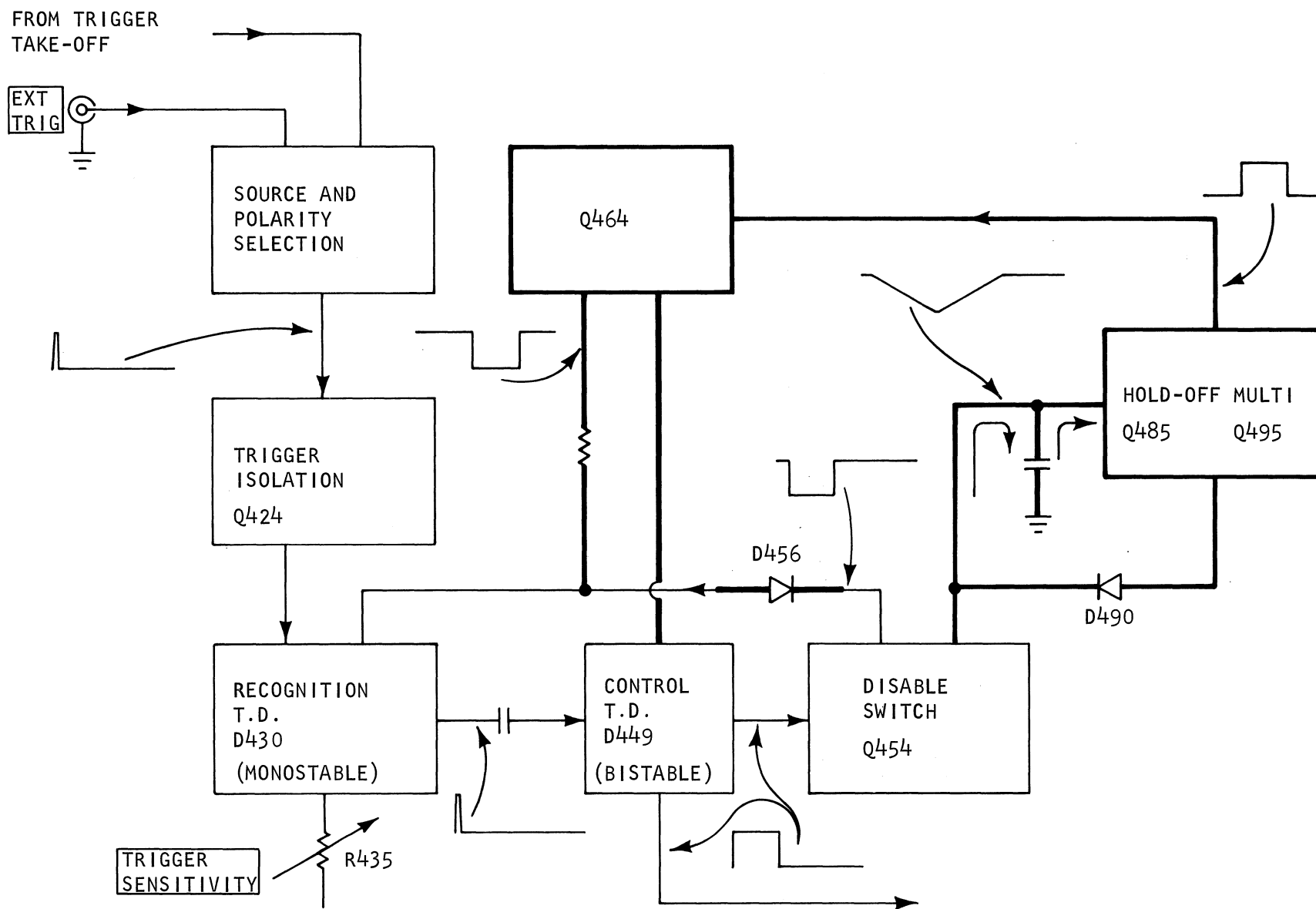
SIMPLIFIED TRIGGER BLOCKS

Figure 3-14

R435 has sufficient range to make the monostable circuit free-run. Free-running frequency can be varied over a range of 20% to 30% by varying the amount of bias to the monostable circuit by using R435. If the multi is made to barely free-run and a signal is applied at the input, the frequency of the multi will be influenced by the input signal; therefore the frequency of the monostable TD can be made a sub-multiple of a high-frequency input signal.

The input monostable TD (D430) serves as both a trigger shaper and a synchronous count-down circuit. The TD, when operated in the synchronous mode, will count down frequencies from ≈ 30 Mc to > 1 Gc.

If the input monostable runs while the fast ramp is being generated, the fast current excursions cause "wrinkles" in the fast ramp, producing non-linearity and jitter. A transistor switch, Q454, is used to disable the monostable TD circuit during the time of the fast ramp. (See figure 3-14).



SIMPLIFIED TRIGGER BLOCKS

Figure 3-15

The output of the bistable TD multi D449 in figure 3-14 is used to drive the fast ramp circuitry. Maximum signal rep rate to the fast ramp must be held to ≈ 100 kc to avoid problems in the vertical unit (snap-off blocking oscillator dissipation and memory circuit recovery). A hold-off circuit performs this function. (See figure 3-15).

When the control TD causes the switching transistor, Q454, to disable the recognition TD, the hold-off capacitor begins to charge. The voltage on the hold-off capacitor decreases from $\approx +12$ volts to ≈ 0 volts and D490 conducts. The current through D490 causes the hold-off multi to switch which cuts off Q464 and removes the bias on both TD circuits. The hold-off capacitor now charges back toward $\approx +12$ volts. When the voltage on the hold-off capacitor is $\approx +12$ volts, the hold-off multi reverts, arming both tunnel diodes.

The recognition TD is held off during the first half of hold off (negative slope of the waveform) by Q454. During the second half of hold-off (positive slope of the hold-off waveform) both TD circuits are held off by Q464.

When HF sync operation is desired, the arming bias to the control TD is applied (exponentially) after the recognition TD is armed. The following sequence of events takes place.

1. The recognition TD is armed at the completion of hold-off.
2. The recognition TD oscillates at some sub-multiple of the input frequency (synchronous operation).
3. Delayed arming bias is applied to the control TD via an integrating network.
4. When the arming bias plus the signal from the recognition TD is large enough, the control TD switches and initiates a sample.

The advantages of this method of HF sync are:

1. The recognition TD circuit acts as a count-down circuit and keeps the signal to the control TD at some frequency less than 50 Mc.
2. Jitter in the hold-off circuit cannot influence the output trigger because the recognition TD has enough time to "lock" on the input frequency before the control TD is allowed to fire.

Summary of the trigger circuit and hold-off block diagrams.

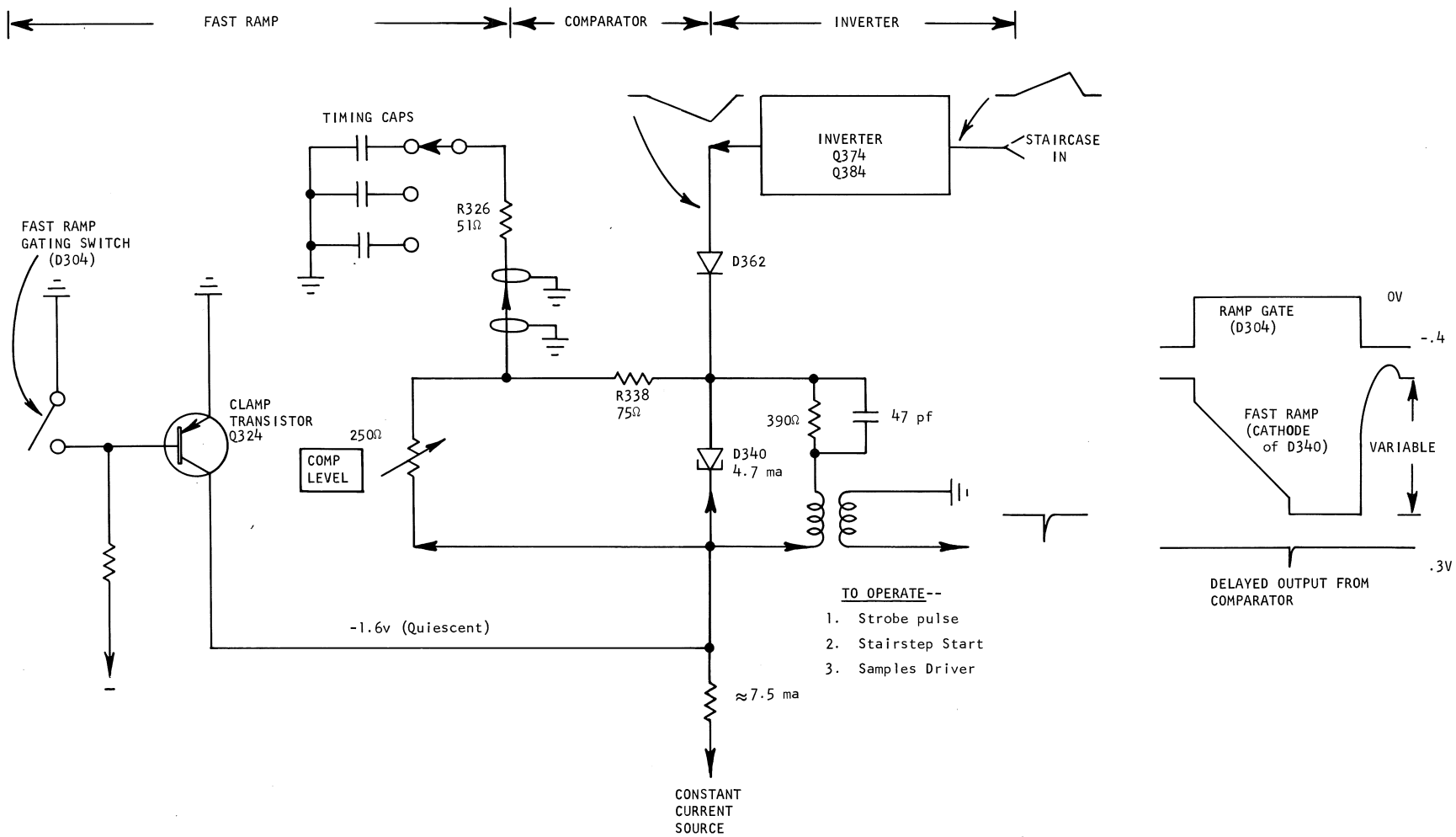
Trigger source (int or ext) is selected as desired. The trigger polarity switch selects the polarity of the trigger signal. The input to the trigger isolator will be positive. The trigger isolator pulls the recognition tunnel diode into its high state and this positive excursion is coupled to the control TD. The control TD goes to the high state, turning on the Fast Ramp and the recognition (mono) goes back to the low state.

The control TD, now in the high state, causes the recognition TD disable switch output to fall, removing the enabling bias to the recognition TD. Also the hold-off capacitor begins to charge. When the hold-off voltage decreases to ≈ 0 volts, the hold-off multi changes state and turns off the TD bias source. Bias current is removed from the control TD and the recognition TD disconnect switch output voltage increases. This concludes the first half of hold-off.

During the second half of hold-off, both TD circuits are held off by the TD bias source. When the hold-off cap is charged back to its original value, the hold-off multi changes state, turning on the TD bias source which provides arming current to the recognition and control tunnel diodes. The trigger circuit is now ready for another input trigger signal.

Adjustment of the recovery time control changes the time of hold-off by changing the negative slope of the hold-off waveform.

NOTES



FAST RAMP and COMPARATOR

Figure 3-16

FAST RAMP

The standardized positive-going pulse from the trigger circuit is capacitively coupled to the fast ramp circuit.

The fast ramp provides the basic time reference for the unit; it can be compared to the Miller sweep in a conventional oscilloscope.

The fast ramp is basically a clamp transistor R.C. sweep fed from a constant current source. (See figure 3-16).

The timing cap is quiescently held clamped at about -1.6v by the non-saturated transistor, Q324.

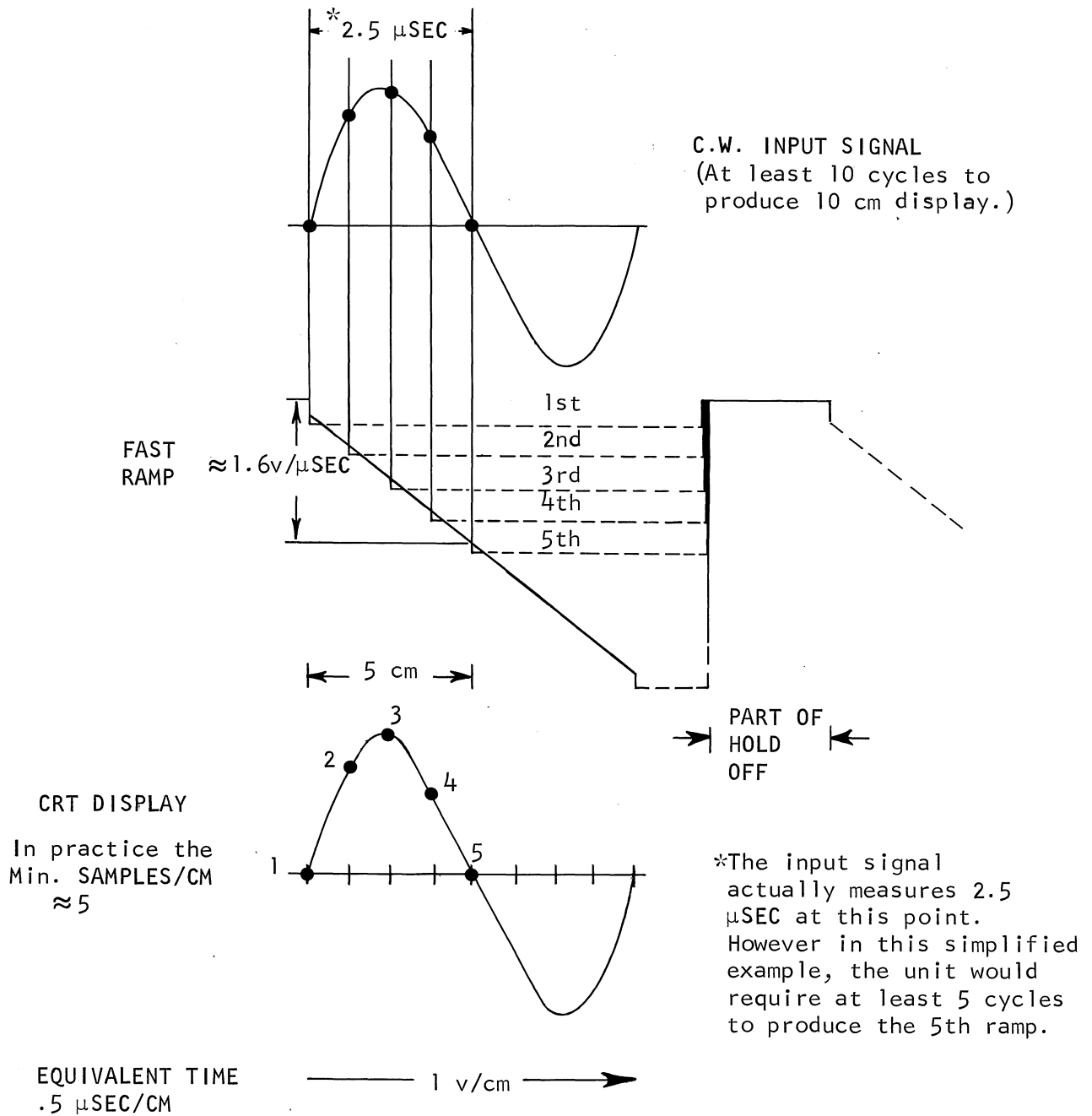
Q324 is gated on and off by T.D., D304, represented on the simplified schematic by a switch.

The switch (D304) is turned on and off from the trigger circuit. The hold-off multivibrator in the trigger circuit always allows enough time for the fast ramp to run completely down, with plenty of time to spare before re-clamping the fast ramp.

The ladder diagram in figure 3-16 shows the time relationship between the ramp gating waveform and a typical fast ramp. Note the fast step at the beginning of the ramp, caused by R326 and the Comparator Level pot.

R326 terminates the 50 Ω coax leading to the timing caps. If this resistor were left out, the unterminated coax would produce ringing at the start of the ramp.

The fast step at the bottom of the ramp is caused by the firing of the comparator T.D., D340.



SIMPLIFIED RELATIONSHIP BETWEEN
THE INPUT SIGNAL - THE FAST RAMP
AND THE CRT DISPLAY.

Figure 3-17

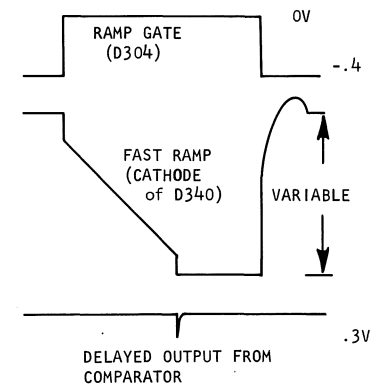
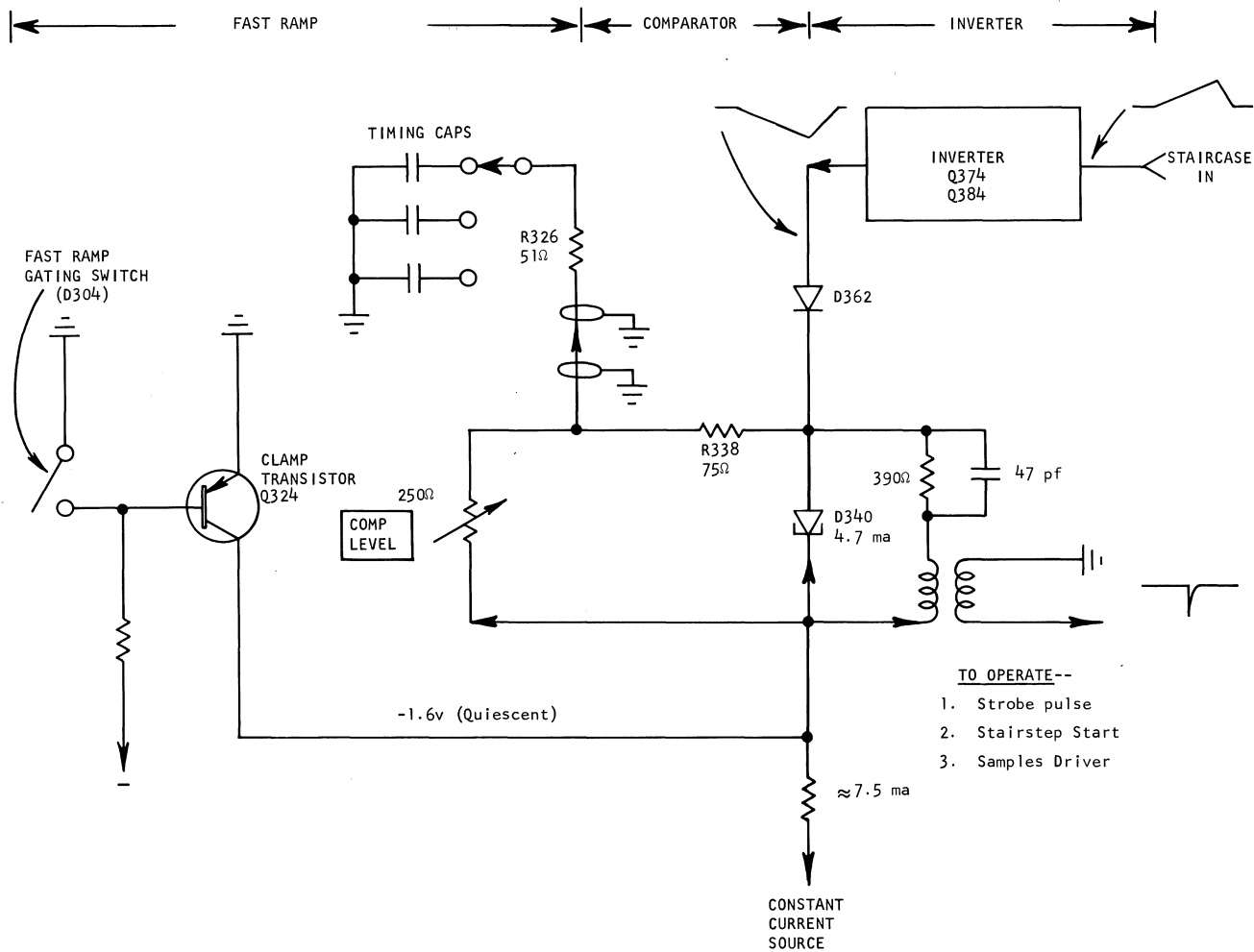
COMPARATOR

The purpose of the comparator is to produce an output pulse that is related in time to the initial triggering signal. The prime function of the output pulse is to initiate the strobe circuit in the vertical system. Each output pulse from the comparator is progressively delayed in time from the receipt of triggering information so that the vertical signal is strobed, or sampled at a slightly later point in time, each sample.

The time between samples have no bearing on the Time/cm readout on the ISI. The SAMPLES/CM are continuously variable from ≈ 5 samples/cm to an extremely high dot density condition--where the trace appears as an unbroken line that takes considerable time to cross the screen.

The output pulse from the comparator is also related to the horizontal position of the spot on the CRT--for example--if the equivalent time is $.5 \mu\text{SEC}/\text{CM}$, then 5 cm on the CRT will equal $2.5 \mu\text{SEC}$. Also, the fast ramp that produced (indirectly) the dot at 5 cm must have run down $2.5 \mu\text{SEC}$ in real time from the first sample position. (See figure 3-17).

The comparator T.D. (D340) is fully floating - the whole assembly moves up and down with the fast ramp (see figure 3-18). The comparator output pulse is coupled through a small torroid transformer. This output pulse will eventually (a) drive the strobe circuit, (b) unlock the Stairstep Generator, (c) advance the stairstep, via the Samples Driver.



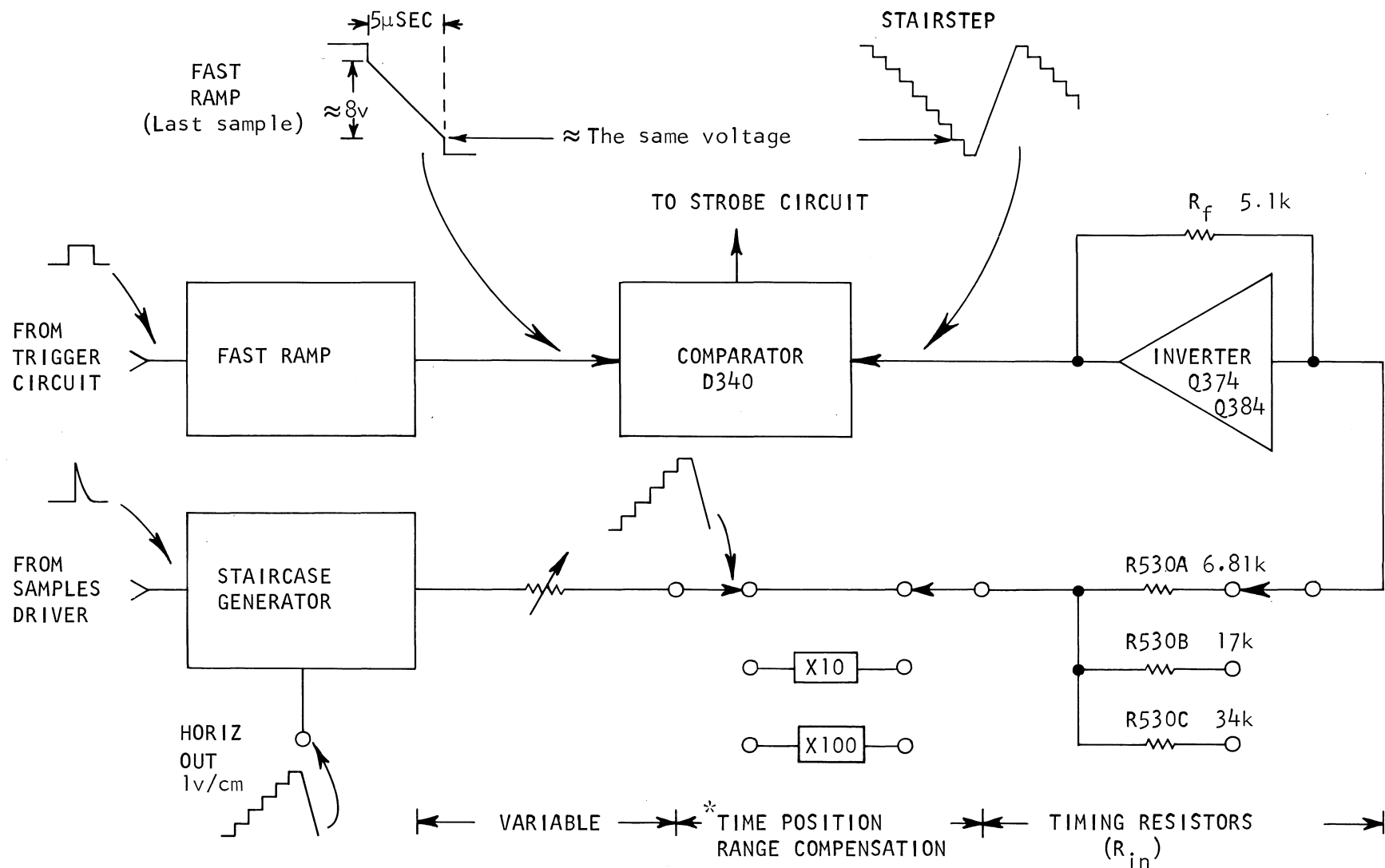
FAST RAMP and COMPARATOR

Figure 3-18

FAST RAMP and COMPARATOR OPERATION (Figure 3-18)

Quiescently, the bottom of the comparator is clamped at $\approx -1.5\text{v}$. D362 from the Inverter is disconnected, so there is no current flowing in the comparator circuit.

1. Gating information from the Trigger circuit turns off clamp transistor, Q324.
2. Approximately 7.5 ma flows into the timing cap and the ramp starts to run down.
3. Part of this current flows through the Comparator T.D. D340, the exact proportion is determined by the setting of the COMPARATOR LEVEL control.
4. While the ramp is running down the Comparator T.D. D340 is biased near its current peak.
5. When the ramp voltage reaches the voltage level at the output of the Inverter (plus the small drop across D362) D362 will conduct.
6. The current distribution within the comparator circuit is now changed so that the majority of the constant current flows through D340, switching it to the high state.
7. The negative going step is coupled through the torroid transformer. The R.C. time constant in series with the primary,--plus the low frequency roll-off of the torroid produce a fast differentiated spike out. This spike, through additional circuitry, is used to (a) start the vertical strobe pulse, (b) unlock the stairstep generator, (c) provide the staircase generator with incremental step information.



* Only used when the Blue Time Position Range marker is in a different sector to the Time/cm dot.

INVERTER GAIN

Figure 3-19

INVERTER

The inverter is an operational amplifier (see figure 3-19).

The amplifier has a fixed R_f of 5.1k and one of three timing resistors making up R_{in} .

As the operational gain is designed to be less than one and the measured open loop gain is ≈ 270 , it will be seen that a very close approximation of operational gain can be obtained by taking $\frac{R_f}{R_{in}}$.

For EXAMPLE: "5" Sequence = $\frac{5.1K}{6.81K} = .75$

"2" Sequence = $\frac{5.1K}{17K} = .3$

"1" Sequence = $\frac{5.1K}{34K} = .15$

The actual gain is unimportant but the gain ratios are. Therefore assuming--

A .15 = 1:1

A .3 will = 2:1

A .75 will = 5:1

Time/CM VARIABLE calibrated = 00

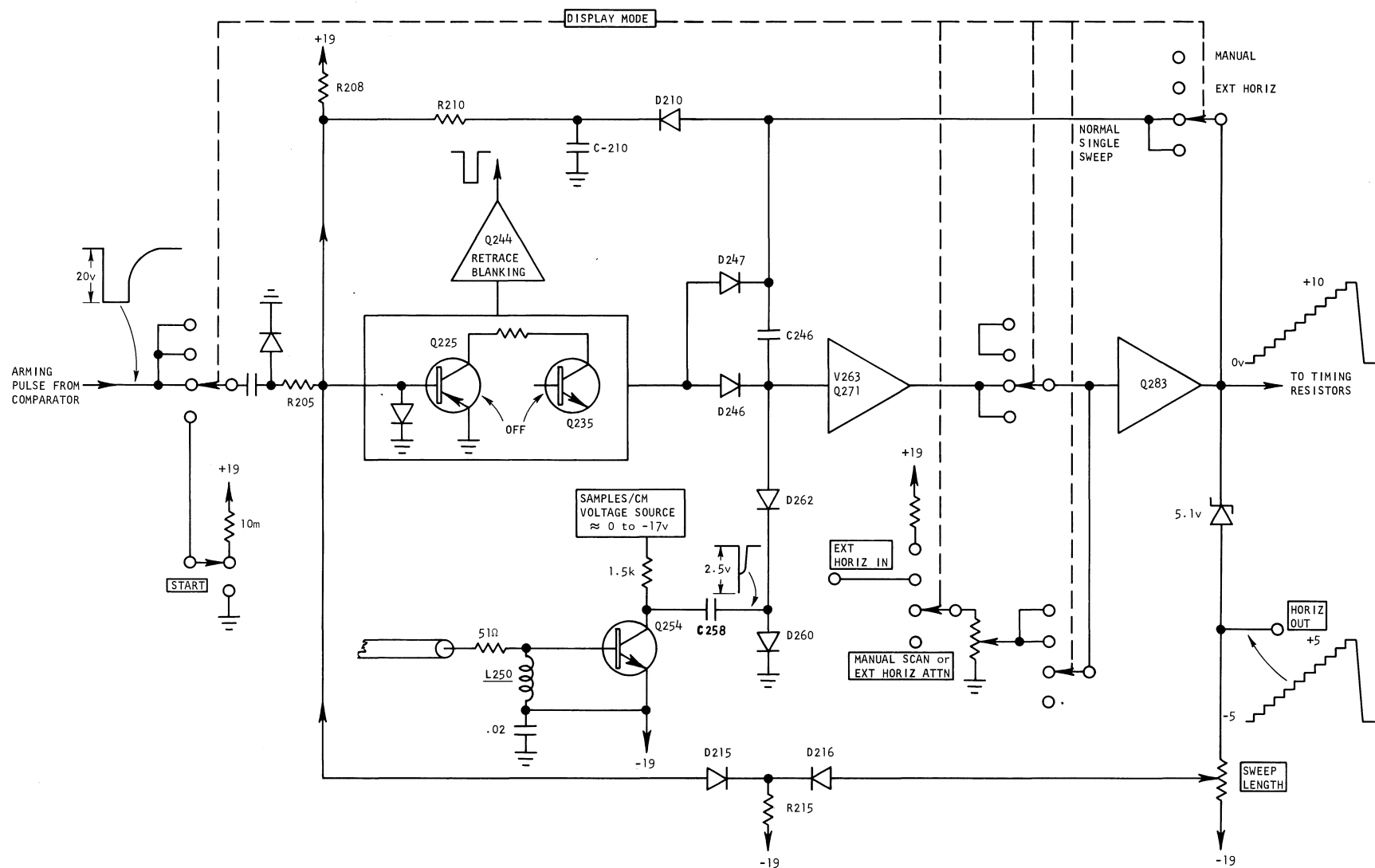
MAGNIFICATION

Normally, R_{in} is driven from a low impedance emitter follower source, however when the next SLOWER ramp is used in conjunction with the same Time/Cm setting it is necessary to reduce the inverter gain by a factor of 10, or by a factor of 100 if the second slower ramp is used.

Reducing the staircase comparison voltage would normally increase the equivalent Time/Cm, assuming all other factors were constant, however in this case, a 10 times or 100 times slower ramp is used, which must be compensated for to ensure correct readout of the TIME/CM switch, this is achieved by inserting a X10 or X100 attenuator between the Staircase generator and the timing resistor.

For the attenuators to divide accurately in conjunction with any timing resistor (R_{in}), the load seen by the attenuators must be constant. Additional resistors are used to ensure constant load impedance under these conditions (equivalent 5.75K, not shown). (See special section on the TIME/CM SWITCH, page 1-15).

NOTES



STAIRCASE GENERATOR

Figure 3-20

STAIRCASE GENERATOR AND SAMPLES DRIVER

The Staircase Generator is based on the proven Miller integrator design used in the conventional solid-state oscilloscope. (See figure 3-20, facing page.)

The generator incorporates these basic building blocks.

1. Miller Integrator

Consisting of a Nuvistor Cathode follower, V263 and a transistor high gain amplifier, Q271--the Miller capacitor is C246 (mylar).

2. Sweep Gating Multi

Consisting of a complementary transistor pair, Q225 and Q235.

3. Disconnect Diodes - D246 and D247

The Miller clamp diode is D246--a low leakage silicon type. D247, a germanium type--performs the sweep start locating function.

4. Sweep Hold-Off

C210 (mylar) and R210 are the hold-off components - in conjunction with D210 - Sweep hold-off is $\approx 200 \mu\text{SEC}$.

5. Retrace Blanking

Q244 is the retrace blanking amplifier. When the staircase is retracing, or in a waiting condition, the Retrace Amplifier applies a negative voltage to pin one of the Blue Ribbon connector via the Vertical Output cathode follower--deflecting the spot downward--off-screen.

6. Output Emitter Follower

Q283 provides the low impedance output to drive the mainframe Horizontal Amplifier (at 1 V/cm).

This output swings $\approx \pm 5\text{v}$. This voltage off-set is provided by a 5.1v zener.

Q283 also drives the timing resistors (R_{in} for the inverter) and the hold-off circuit.

7. Sweep Length vis Timing

During calibration, the staircase output voltage is set to 10v by adjusting the internal SWEEP LENGTH control to display 10 cm. The mainframe horizontal is first calibrated by inserting 5v of Standard Amplitude Calibrator and adjusting the EXT HORIZ ATTEN (mainframe) for 5 cm, this amplitude avoids possible compression errors.

It will be seen that a very close approximation of correct timing may be obtained by simply adjusting the mainframe for a 10 cm display, however, bear in mind the possible accumulative effects of--

- 1) CRT compression at 10 cm.
- 2) ISI Timing resistor tolerance.
- 3) Sweep length vis voltage tolerance.

These effects could add to give an overall tolerance of $\pm 8\%$, for greater accuracy, time marks should be used. (See Calibration section for details.)

8. The Samples Driver and Bucket and Ladle Circuit

These circuits take the place of the timing resistors and voltage source found in conventional oscilloscopes.

The Samples Driver, Q254, is a normally "Off" transistor. The collector load is connected to a Variable Voltage Source controlled by the SAMPLES/CM knob.

When Q254 is non-conducting its collector can be between 0v and $\approx -17\text{v}$ --depending upon the setting of the SAMPLES/CM control.

The incremental step information from the Comparator circuit is applied to the base of Q54, via 50Ω coax. The coax is terminated in $\approx 50\Omega$ to prevent reflections back to the Comparator circuit.

If the collector supply voltage is $\approx 0\text{v}$ with the emitter at $\approx -19\text{v}$ (constant) C258 will have a charge of $\approx 0\text{v}$ (neglecting diode P.D.).

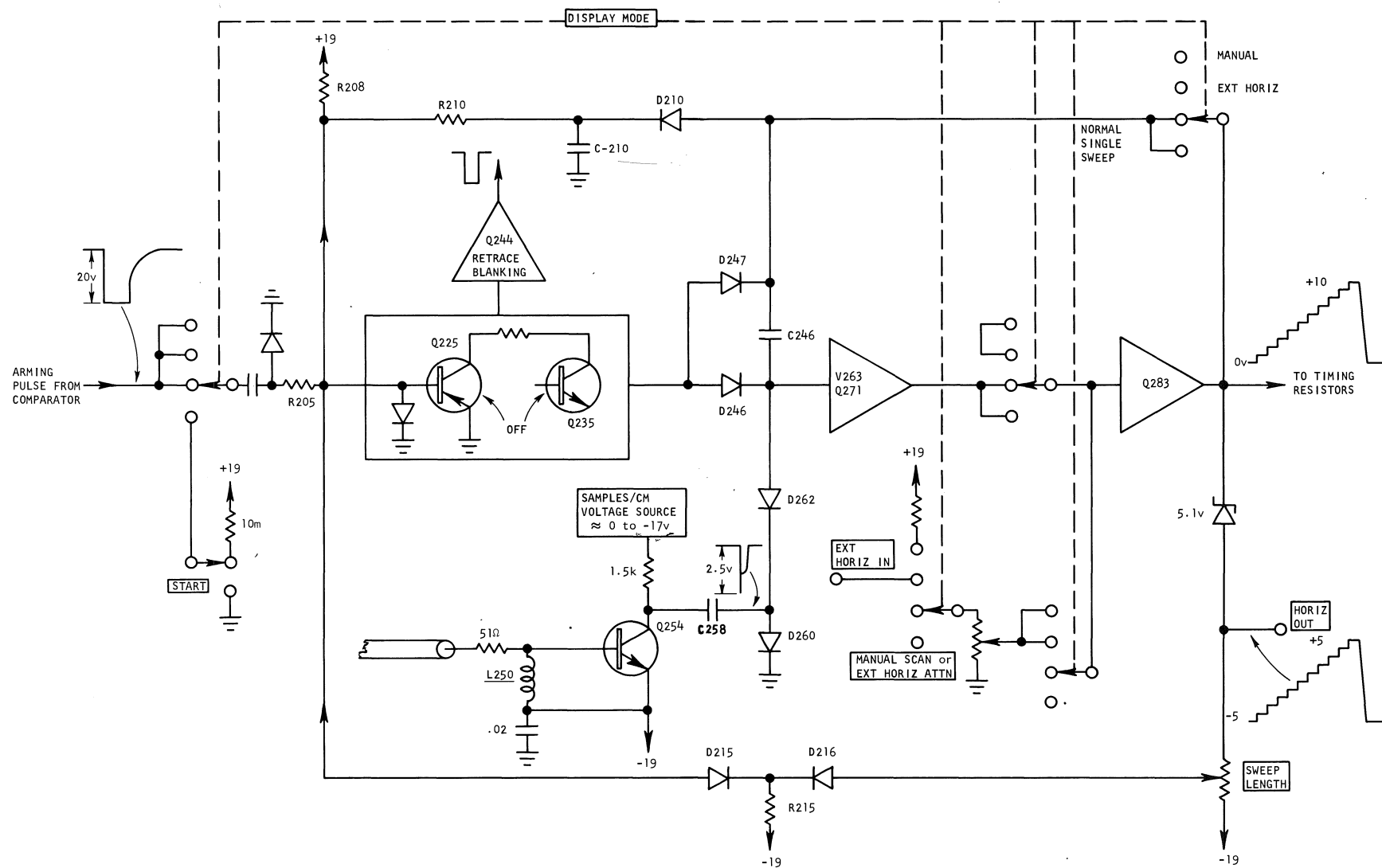
Upon receipt of a positive going pulse from the Comparator, the Samples Driver will saturate and its collector will come down close to the emitter at -19v --this $\approx 19\text{v}$ change, in conjunction with the duration of the pulse, will produce a certain charge on the Miller capacitance via D262 (low leakage Silicon).

This maximum voltage change will produce the longest staircase increments, and therefore less of them will be needed to complete a sweep (≈ 4 to 6 Samples/CM).

If the Samples/cm control is CCW, the Samples Driver Voltage source will be $\approx -17\text{v}$, it will be seen that the maximum change at Q254 collector cannot be more than $\approx 2\text{v}$, the corresponding increments into the Miller capacitance will be smaller, and the Samples/Cm will be at some maximum.

In the SWEEP OFF position (not shown) the Samples Driver voltage supply is disconnected.

NOTES



STAIRCASE GENERATOR

Figure 3-21

SUMMARY OF OPERATION (Staircase Generator) (Figure 3-21)

Remember, the comparator puts out three coincident pulses, one goes to the Vertical strobe circuit and the other two go to the Staircase Generator.

The Multi is a current operated device. The base swing of Q225 is limited to $\pm .6v$ by the grounded emitter configuration and a clamp diode.

The major current determining resistors over the full cycle are-- R209, R205, R215 and R210, however for purposes of explanation these resistors can be looked upon as contributing to, or subtracting from the base current into Q225.

Here's how it works--

1. Q225 and Q235 are off and the Miller is clamped, Q225 is off because the voltage division between R208 and D215-R215 puts the base at $\approx -.1v$ --This condition exists because --
 - (a) D216 is back-biased,
 so $\approx .6$ ma flows through the other current
 switch diode, D215.
 - (b) The hold-off diode, D210, is back-biased.
 - (c) Therefore, the only current flowing is through
 R215 - D215 - R208.

2. A negative going 20v arming pulse is applied to the Sweep Gating Multi via the current determining resistor, R205. The resultant current into the base of Q225 puts it into saturation, Multi action holds it in this condition during sweep run-up.

Further Arming pulses are ineffective during this period.

3. As the sweep runs up--due to incremental inputs from the comparator--D210 will conduct and the sweep will start to contribute current to Q225 base circuit. However, this maximum current--a little over 1 ma--is not sufficient to revert the multi by itself.

A portion of the sawtooth is picked off from the Sweep Length control and applied to the normally-off current switching diode, D216. When D216 conducts, the $\approx .6$ ma flowing via D215 to the base network is suddenly switched to the D216 leg.

The removal of $\approx .6$ ma from the base network of Q225 is sufficient to turn it off.

4. The Miller grid is reclamped and the sweep runs back down. These things happen --
 - (a) The hold-off diode, D210, is disconnected, leaving ≈ 10 v charge on the hold-off cap, C210.
 - (b) D216 disconnects--reapplying the original current path to the base circuit of Q225--however the Arming pulses cannot supply enough current to arm the multi because the stored charge in the hold-off cap is contributing ≈ 1 ma through R210. This is in opposition to the arming pulse current. After $\approx 200 \mu\text{SEC}$ the opposing current reduces to a point where an Arming pulse can re-trip the multi.

Figure 3-21 also shows the Mode Switching, these positions are covered next.

1S1 MODE SWITCH

DISPLAY MODES

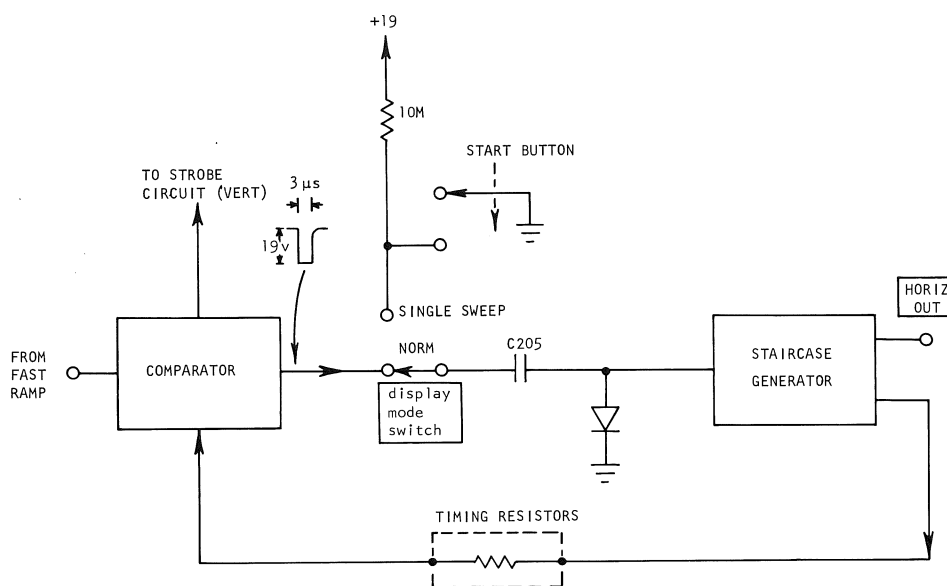
1. Normal 2. Single Sweep 3. Ext. Horiz. 4. Manual

SINGLE SWEEP

This position, in conjunction with the START button, enables a single sweep to be generated -- for purposes of photography, or running an X.Y plotter.

Single Sweep in this instance means single displayed sweep -- the sampler still requires repetitive information.

In the single sweep position the staircase generator is disconnected from the comparator (see figure 3-22).

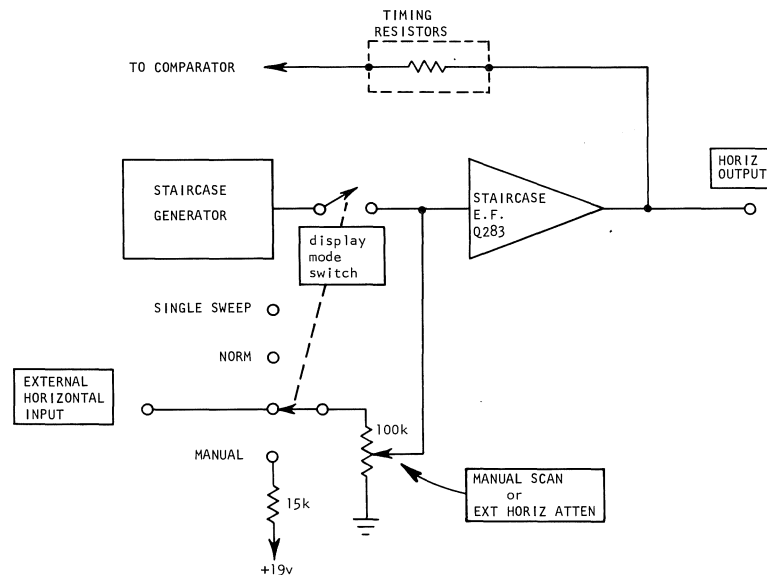


SINGLE SWEEP
Figure 3-22

C205 charges to +19v through the 10 meg resistor and the clamp diodes. When the START button is depressed, the charge on the capacitor is coupled into the staircase generator ($\approx -19v$, differentiated). This pulse unlocks the staircase generator for one sweep only.

EXT. HORIZ.

In the EXT. HORIZ. position of the DISPLAY MODE switch the staircase generator is disconnected from the staircase E.F. (see figure 3-32).



MANUAL SCAN AND EXT. HORIZ.
POSITIONS OF THE DISPLAY MODE

Figure 3-23

Signals can be inserted into the EXT. HORIZ. INPUT (front panel banana jack).

The EXT. HORIZ. sensitivity is continuously variable by the MANUAL SCAN or EXT. HORIZ. ATTEN control.

Max. Sensitivity = 1V/CM \pm 3%

Min. Sensitivity \geq 16V/CM

Input Resistance \approx 20k (CW) to \approx 100k (CCW)

MANUAL SCAN

In the MANUAL SCAN position of the DISPLAY MODE switch the front panel control is connected to a source of voltage (Refer to figure 3-23). The voltage gradient across the front panel control produces a manual scan range of 10.5V \pm .5V (\approx 10.5 CM).

3-55

NOTES

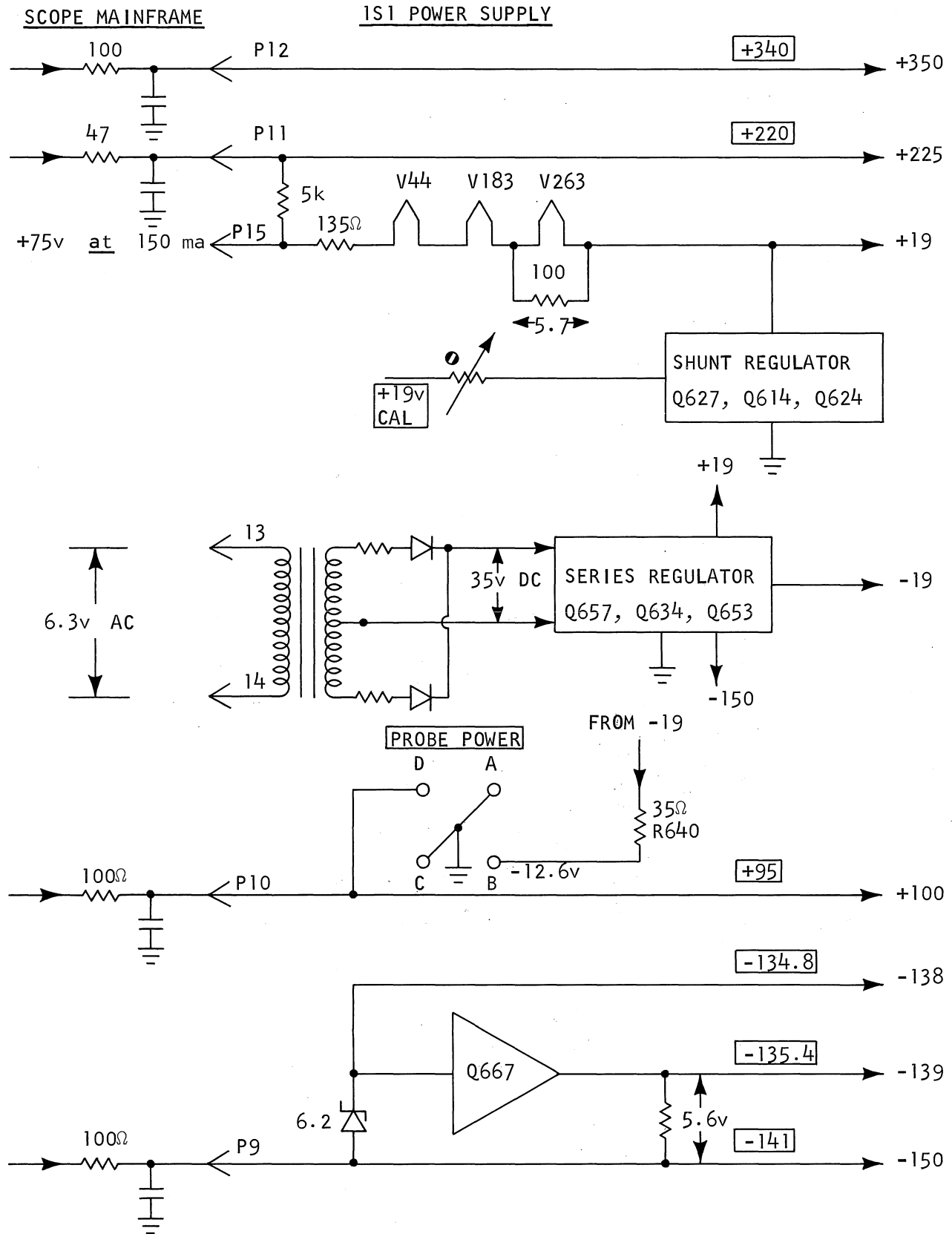


Figure 3-24

POWER SUPPLY

The ISI obtains its power from the oscilloscope main-frame.
(See figure 3-24).

-150, +100, +225 and +350 are used by the ISI in non-critical positions, such as long trailing and collector supplies. These voltages are decoupled in the main-frame so they should all read low when measured in the ISI. Figure 3-24 shows the de-coupling circuits used in a 545A, and some actual voltage reading (boxed figures).

The three vacuum tube heaters are supplied from the 150 ma +75v source (P15). Note that V263, the staircase generator nuvistor, has a 100 Ω shunt to limit the heater voltage to 5.7 volts, the lowered heater voltage reduces the possibility of grid current in this stage. A shunt regulator, consisting of Q627, Q624 and Q614, serves the dual purpose of supplying a regulated +19v output while maintaining the correct current through the filament circuit.

The -19v supply obtains its input from 6.3v AC (pins 13 and 14). A transformer/full-wave rectifier combination presents ≈ 35 v DC to a series regulator consisting of Q657, Q653 and Q634, a 6.2v Zener diode provides the reference.

Both the -19v and +19v supplies are adjustable, however the -19v supply provides the reference for the +19v supply, so it must be adjusted first.

The reason for the -138v and -139v supplies is not voltage requirement but supply isolation.

The 139v supply is taken from emitter follower, Q667, which in turn is referenced to -150 (decoupled) via a 6.2v 10% Zener.

The Zener itself is biased by current drawn by the -138v circuits.

PROBE POWER

+100v (decoupled) and -19v are available at the front panel PROBE POWER connector. The 180 ma drawn by the P6032 heater will drop the -19v down to the required 12.6v (R640).

+19v and -19v SUPPLIES

TOLERANCE $\pm 3\%$ (adjustable)

RIPPLE < 10 mVOLTS

TROUBLESHOOTING HINTS

LOW INTENSITY

The retrace blanking system of the ISI relies on a healthy CRT to function properly. Normal operation--The scope mainframe/CRT is in the "blanked" condition, the ISI display is obtained by turning up the intensity to "override" the mainframe blanking, (Intensity knob at ≈ 3 o'clock). However, if the CRT is gassy and/or has low emission the display may be non-existent, or of insufficient brightness.

Perform standard checks on the CRT/HV. system to determine cause.

COMPONENT LOCATION

The majority of the ISI circuitry is on three etched boards, however due to component density many items are not identified with component numbers, in fact it is a frustrating job to find anything without help.

To overcome this problem, we have included three etched board layouts at the end of the Schematics Section.

1S1 TRAINING CALIBRATION PROCEDURE

1S1

The following calibration procedure is a step by step training device. Specifications listed are customer performance requirements. The 1S1 may be operated in any 530, 540 or 550 series oscilloscope but for this calibration procedure an oscilloscope with a 6 cm vertical scan area should be used.

EQUIPMENT REQUIRED - ISI

1. 530 or 540B Series Oscilloscope (main frame for ISI) (6 cm CRT)
2. 530 or 540 Series Oscilloscope with "L" Plug-in Unit.
 - a. A X10 probe (P6006)
 - b. A X1 probe (P6028)
3. 76 TU Line Voltage Control
4. 530 - 540 Series Flexible Plug-in Extension (012-0038-00)
5. Resistance Bridge (Shasta - Beckman 605) (067-0042-00)
6. 20,000 Ω /v VOM
7. Standard Amplitude Calibrator (067-0502-00)
8. Red patch cord
9. BNC to Binding Post Adapter (103-0033-00)
10. 180A Time Mark Generator
11. 1218-A GR Oscillator (067-0038-00)
12. Mixer Rectifier (067-0081-00)
13. 50 Ω Amplitude Calibrator (067-0508-00)
14. 105 Square Wave Generator
15. 111 Pretrigger Pulse Generator
16. 30 PSEC Tunnel Diode Pulse Generator (067-0513-00)
17. 111 Variable Attenuator (067-0511-00)
18. 3 Female BNC to GR Adapter (017-0063-00)
19. 1 Male BNC to GR Adapter (017-0064-00)
20. A 5X GR Attenuator (017-0045-00)
21. A 10X GR Attenuator (017-0044-00)
22. A 10X BNC Attenuator (011-0059-00)
23. A 70 Ω 5w 5% Resistor.
24. A GR "T" Connector (017-0069-00)
25. BNC cables
26. GR cables

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A. Trigger Jitter Checks (using 180A) 5-46

<u>TRIGGER</u>	<u>SIGNAL</u>	<u>AMPLITUDE</u>	<u>JITTER SPEC</u>
Int	100 kc	50 mv	.7 μ SEC
Ext	100 kc	4 mv	.5 μ SEC
Int	10 mc	50 mv	5 nSEC
Ext	10 mc	8 mv	5 nSEC

B. Trigger Jitter Check (using GR Oscillator). 5-47

Int	1 Gc	50 mv	200 pSEC
Ext	1 Gc	8 mv	200 pSEC

C. Trigger Jitter Check (using 111 Pulse generator.) 5-49

Int	2 nSEC Pulse	40 mv	200 pSEC
Ext	2 nSEC Pulse	7 mv	200 pSEC

D. Trigger Kickout Check (≤ 25 mv P-P) 5-49

E. Display Jitter Check 5-50

<u>TIME POSITION RANGE</u>	<u>JITTER SPEC*</u>
500 μ SEC	100 nSEC
50 μ SEC	10 nSEC
5 μ SEC	1 nSEC
500 nSEC	120 pSEC
50 nSEC	40 pSEC

*Internal trigger with between
.4 and 1 V input.

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Connect a flexible plug-in extension (012-0038-00) from the 545B plug-in amphenol to the 1S1. (See figure 5-1).

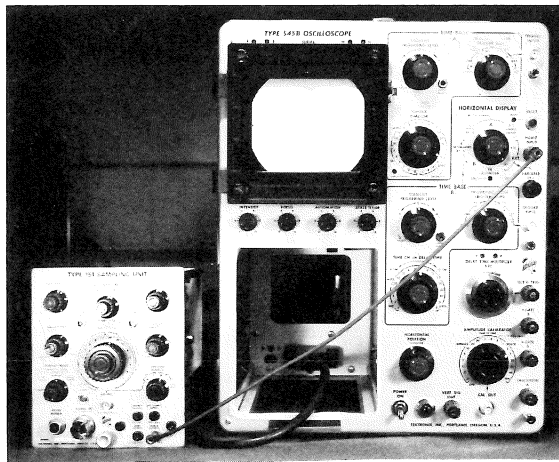


Figure 5-1

Connect a patch cord from the HORIZ INPUT on the scope to the HORIZ OUTPUT on the 1S1. (See figure 5-1).

Apply power to the 545B from 76 TU line voltage control and allow 20 minutes for warmup.

Front Panel Setup

545B (Only applicable controls are mentioned).

HORIZONTAL DISPLAY

VARIABLE 10-1

EXT X1

midrange

HORIZONTAL POSITION }

VERNIER }

midrange

INTENSITY }

FOCUS }

ASTIGMATISM }

Adjust for a sharply defined easily seen trace if visible. If not visible set to midrange.

SCALE ILLUM

Adjust for personal preference.

CRT CATHODE

SELECTOR (on 545B Back Panel)

CHOPPED BLANKING

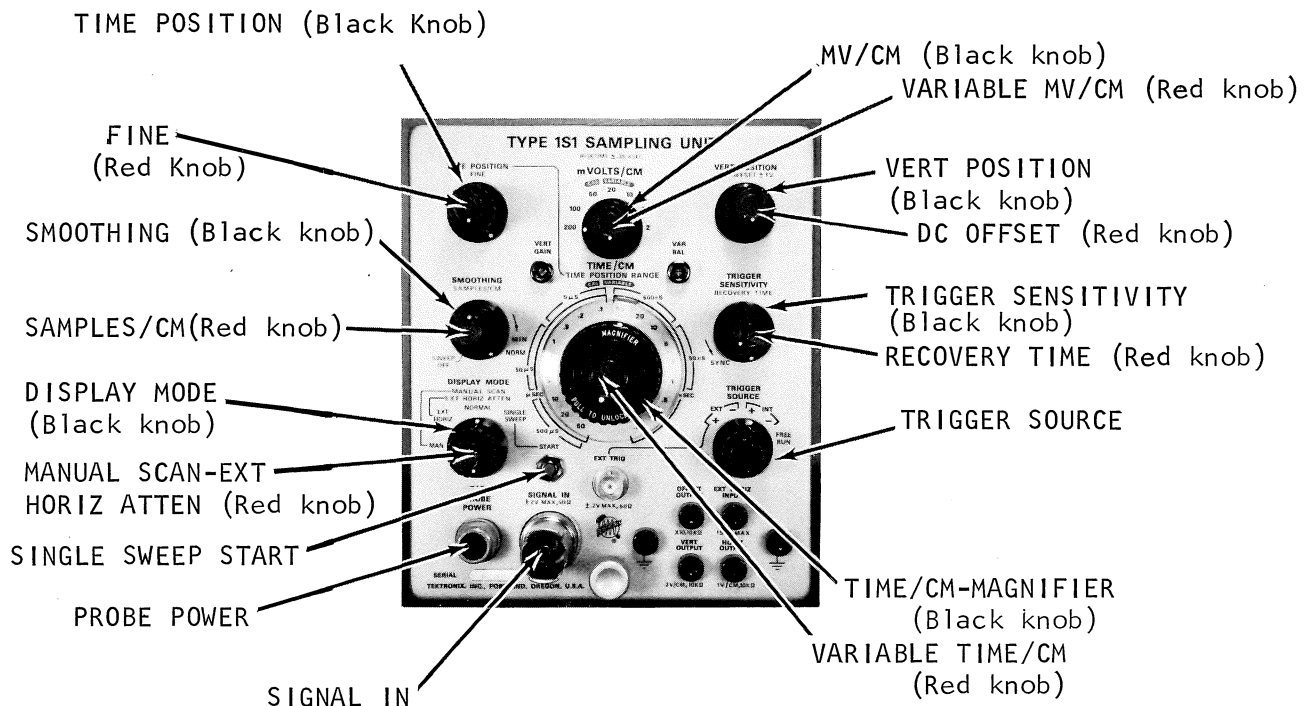


Figure 5-2

1S1

mVOLTS/CM	200
VARIABLE	Calibrated (Detent straight down)
VERT POSITION	midrange
DC OFFSET	midrange (10 turn Pot set 5 turns from one end).
TRIGGER SENSITIVITY	CW
RECOVERY TIME	CCW (not in SYNC detent position)
TRIGGER SOURCE	+ INT
TIME/CM	50 nSEC
VARIABLE	Calibrated (CCW in detent position)
TIME POSITION	CW
FINE	CW
SMOOTHING	CW
SAMPLES/CM	midrange
DISPLAY MODE	NORMAL
MANUAL SCAN-EXT HORIZ ATTEN	CW

I. POWER SUPPLY ADJUSTMENTS and CHECKS

A. SIGNAL IN Input Resistance Check ($49\Omega \pm 1\Omega$).

1. Connect the leads from a resistance Bridge such as the Shasta-Bechman 605 (.2% accuracy) to the inner conductor of the SIGNAL IN GR connector.
2. Measure the input impedance for a DC resistance of $49\Omega \pm 1\Omega$.

B. -19v Adjustment ($\pm 3\%$)

1. Connect a 20,000 Ω/v VOM to measure the -19v supply.
(See figure 5-3).

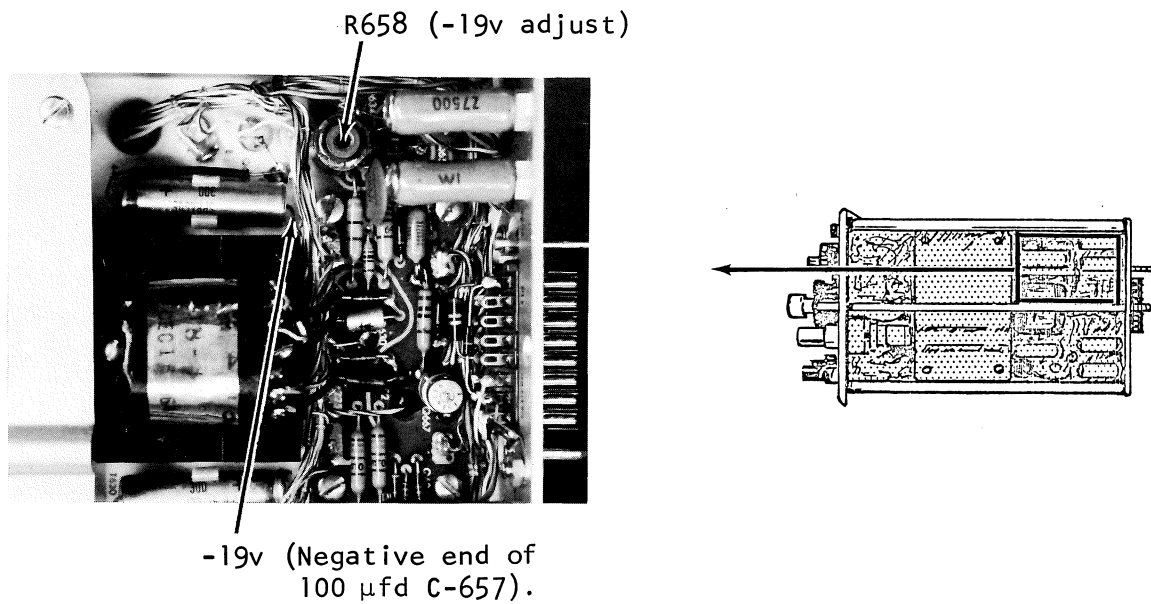


Figure 5-3

2. Adjust R658 (see figure 5-3) for exactly -19v as read on the VOM.

NOTE: VOM accuracy is $\pm 3\%$. By adjusting for exactly 19v, the supply will be $\pm 3\%$.

C. +19v Adjustment ($\pm 3\%$)

1. Connect the VOM to measure the +19v supply (see figure 5-4).

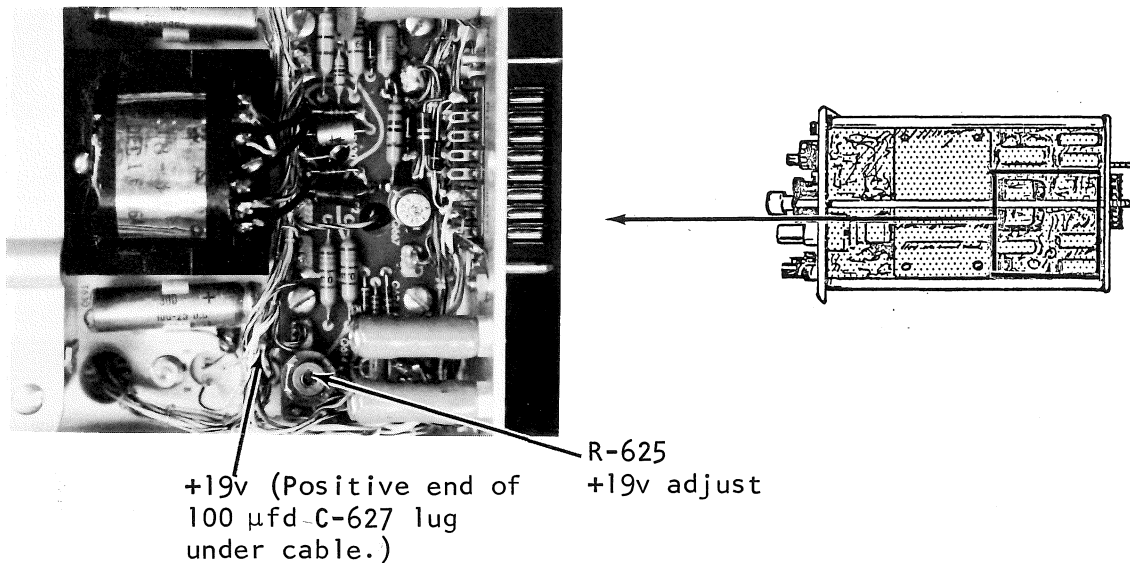


Figure 5-4

2. Adjust R625 (see figure 5-4) for exactly +19v as read on the VOM.

D. Voltage Check across D-662 ($6.2\text{v} \pm 10\%$).

1. Connect the VOM to measure the voltage across D-662. (See figure 5-5.)

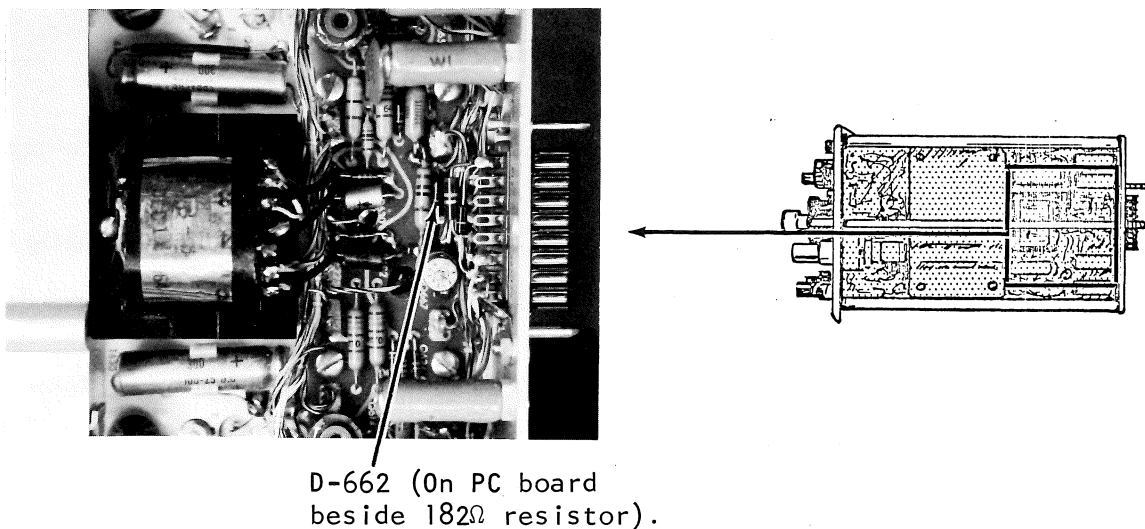


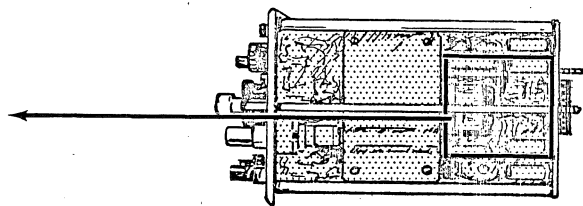
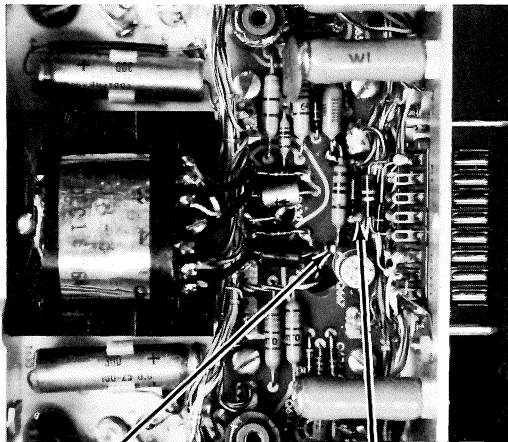
Figure 5-5

- a. Connect the common lead to the top end. (End where 180 Ω and D662 are joined).
- b. Connect the VOM lead to the bottom end.

2. Check the voltage across D-662. It must be between 5.5 and 7 volts.

E. Emitter Base Voltage Check on Q-667.

1. Connect the VOM to measure the emitter base voltage on Q-667 (see figure 5-6).
 - a. Connect the VOM lead to the Base.
 - b. Connect the common lead to the Emitter.



Emitter of Q-667
(End of 182Ω resistor)
(Common lead connected here)

Base of Q-667
(End of D-662)
(VOM lead connected here)

Figure 5-6

2. Check for approximately .6v.
3. Disconnect the meter probes from the 1S1.

F. Probe Power Checks

1. Check for +100v at Pin D of the Probe Power plug on the 1S1 front panel.
NOTE: This 100v is wired directly from the 545B main frame.
2. Connect a 70Ω 5W 5% resistor between pins A and B of the probe power plug.
WARNING: This resistor gets hot enough to burn flesh.
3. With the VOM measure the voltage drop across the 70Ω resistor. It must be 12.6v ±5% (from 12v to 13.2v).
4. Leave resistor connected for the next step.

G. Power Supply Ripple Checks (+19v and -19v <10 mv).

1. Connect a X1 probe from the test scope to the -19v supply (refer to figure 5-3). Set the test scope sensitivity to .005 v/cm.
2. Turn the TRIGGER SENSITIVITY control on the IS1 CCW.
3. Check for less than 10 mv ripple as the 76 TU line voltage control output is varied from 100v to 130v.
4. Remove the 70 Ω resistor from the Probe Power plug.
5. Again check the -19v supply for less than 10 mv ripple as the 76 TU line voltage control output is varied from 100v to 130v.
6. Remove the X1 test scope Probe from the -19v supply and connect it to the +19v supply (refer to figure 5-4).
7. Check the +19v supply for less than 10 mv ripple as the 76 TU line voltage control output is varied from 100v to 130v.
8. Remove the X1 test scope probe from the IS1.

II. TRIGGER CIRCUIT ADJUSTMENTS and CHECKS

A. TD Bias R-460 Adjustment

1. Test scope setup

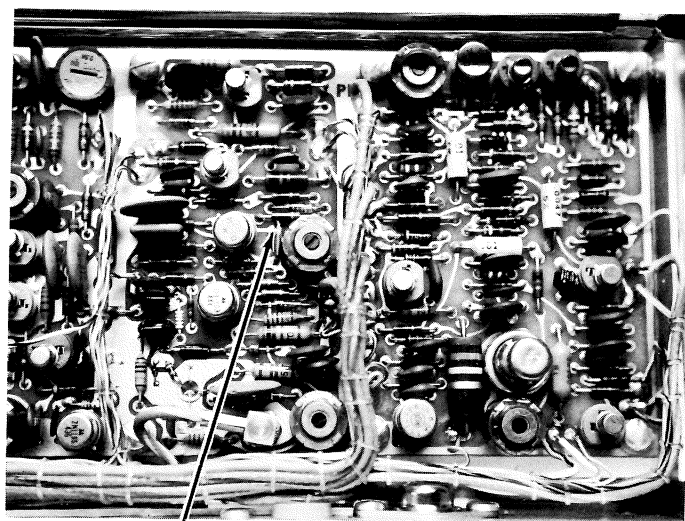
- a. Set the VOLTS/CM switch to .2v.
- b. Set the TIME/CM switch 1 μ SEC.
- c. Set the vertical INPUT SELECTOR switch to DC.

NOTE: If not enough position range is available on DC, AC may have to be used. When AC is used be careful to not turn R460 when the trace is off the CRT.

2. ISI Setup.

- a. Set the TRIGGER SENSITIVITY control to the CW extreme.
- b. The TIME/CM switch should still be set to 50 nSEC.

3. Connect a X10 test scope probe to the collector of Q464 (see figure 5-7).



Collector of Q-464

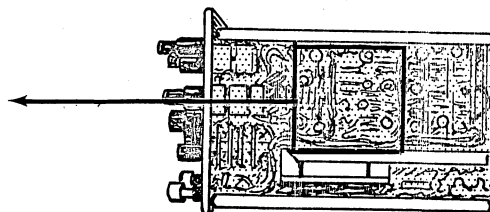


Figure 5-7

4. Adjust the test scope triggering for a stable display (similar to figure 5-8).

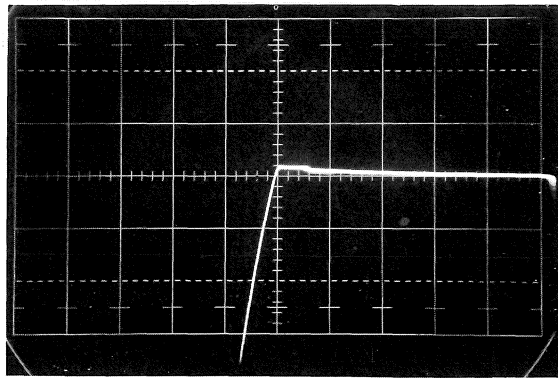
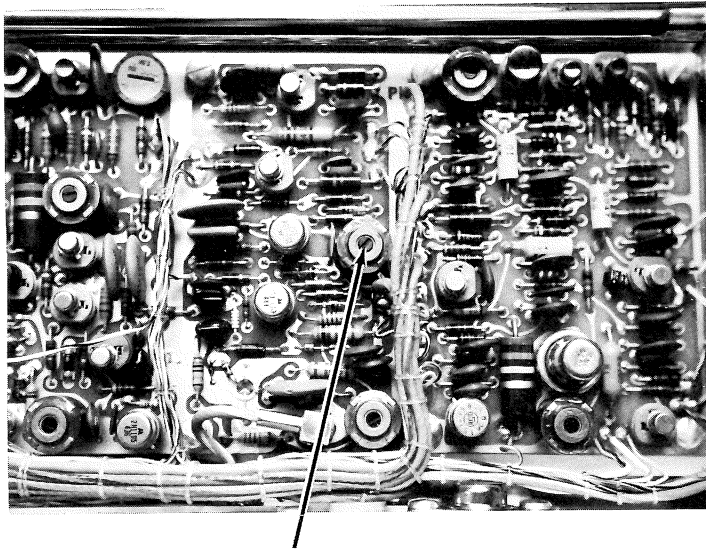


Figure 5-8

5. Adjust R-460 (see figure 5-9) to the point where the display disappears. Note the setting of R460.



TD Bias
R-460

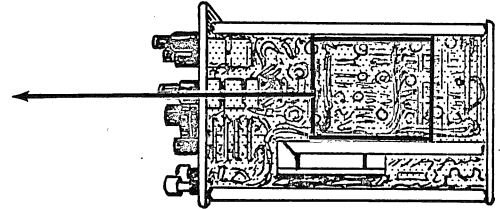
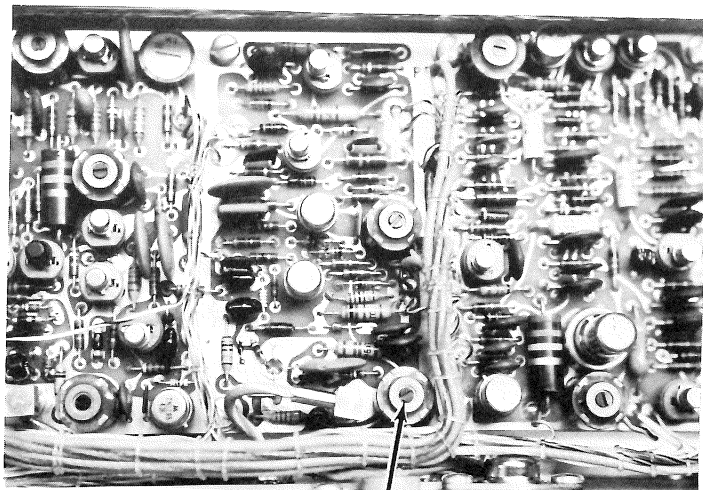


Figure 5-9

6. Set the TRIGGER SENSITIVITY control to the CCW extreme.
7. Adjust R-460 (see figure 5-9) to the point where the display just appears. Again note the setting of R-460.
8. Adjust R-460 to a position halfway between the setting in step 5 and the setting in step 7.
 - a. Leave the probe connected for the next few steps.

B. Internal Triggering Level R-420 Adjustment

1. Set the TRIGGER SENSITIVITY control on the ISI front panel to approximately 2 o'clock.
2. Adjust R-420 (see figure 5-10) CCW until the waveform on the test scope disappears. Bring R-420 CW again until the waveform on the test scope just re-appears.



Internal Trigger Level
R-420

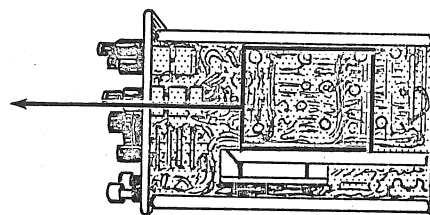


Figure 5-10

3. As the TRIGGER SENSITIVITY on the ISI front panel is turned CCW from 2 o'clock the waveform on the test scope should disappear. As the TRIGGER SENSITIVITY is turned CW from 2 o'clock the waveform on the test scope should remain stationary.

C. Free Run Operation Check

1. ISI Setup

- a. Set the RECOVERY TIME CCW but not in the SYNC detent position.
- b. Set the TRIGGER SOURCE switch to the FREE RUN position.
- c. There should be a waveform similar to figure 5-11 seen on the test scope.

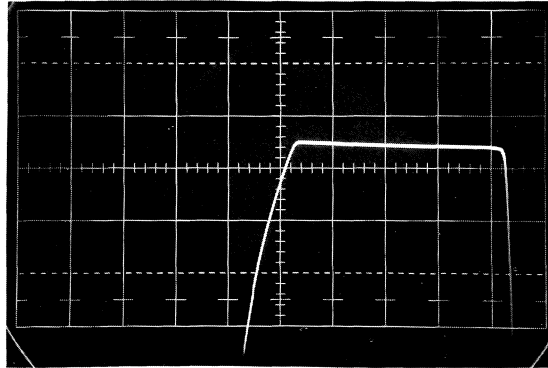


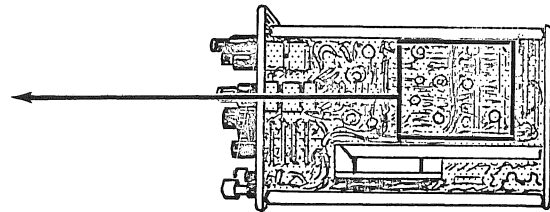
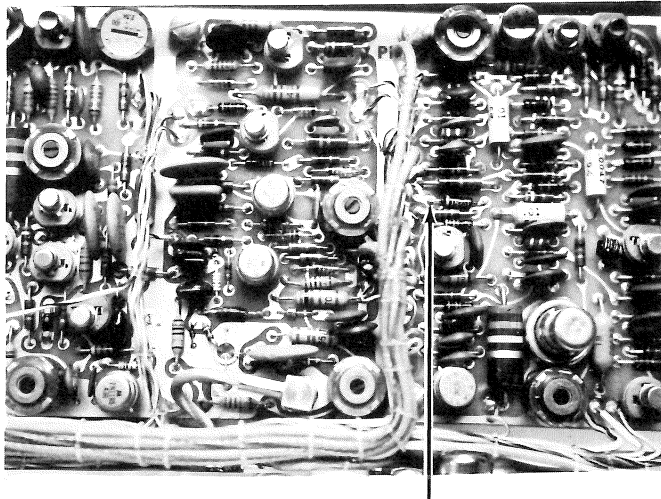
Figure 5-11

- d. As the TRIGGER SENSITIVITY control is turned from the CW extreme to the CCW extreme there should be no effect on the test scope waveform.

III. FAST RAMP and STAIRCASE GENERATOR ADJUSTMENTS

A. Staircase DC Level R-270 Adjustment.

1. Remove the test scope probe from the collector of Q464 and connect it to the emitter of Q283 (see figure 5-12).

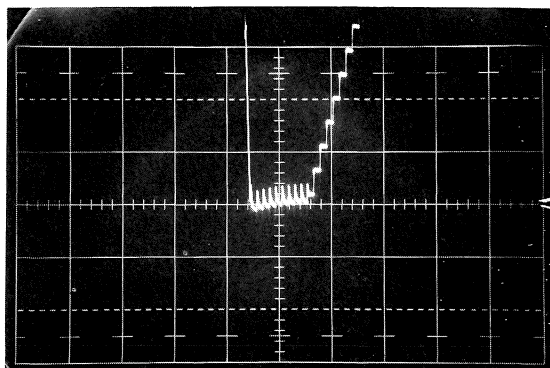


Emitter of Q-283
(Cathode of D285)

Figure 5-12

2. ISI Setup
 - a. Set the SAMPLES/CM to the CW extreme.
 - b. Set the TRIGGER SENSITIVITY to the CW extreme.
3. Test scope setup
 - a. Set the TIME/CM switch to .1 mSEC.
 - b. Set the INPUT SELECTOR to DC.
 - c. Set the VOLTS/CM to .05v.
 - d. Adjust the VERTICAL POSITION control so the center of the graticule is 0v DC.

4. A display similar to figure 5-13 should now be on the test scope.

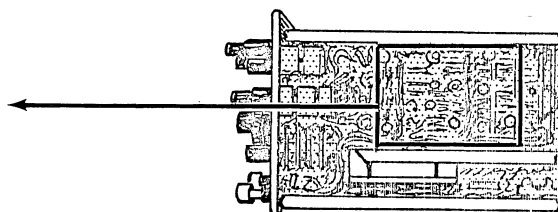
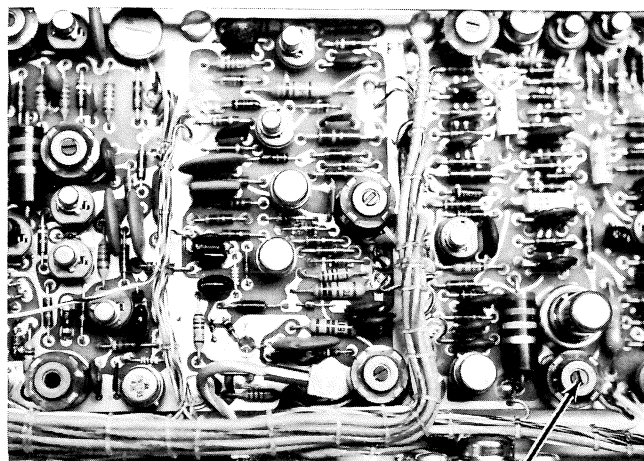


(.05v Vertical Sensitivity
.1 mSEC time/cm).

Graticule Center - 0v

Figure 5-13

5. Adjust R-270 (see figure 5-14) so the most negative part of the staircase foot is 0 volts (graticule center).



R-270
Staircase DC Level

Figure 5-14

B. Inverter DC Zero R-380 Adjustment.

1. Remove the test scope probe from the emitter of Q-283 and connect it to the base of Q-374 (see figure 5-15).

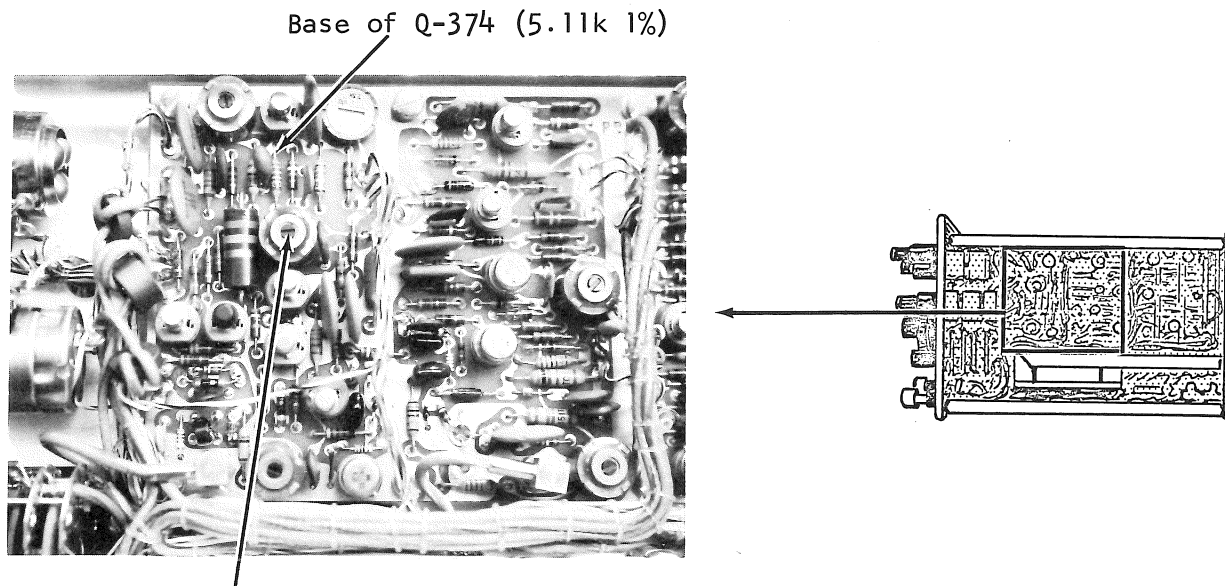


Figure 5-15

2. Test scope Setup

- a. Set the VOLTS/CM switch to .005v.
- b. Adjust the Vertical Position so the center of the graticule represents 0v DC.

- c. Adjust the triggering for a stable display. The display on the test scope should now be similar to figure 5-16.

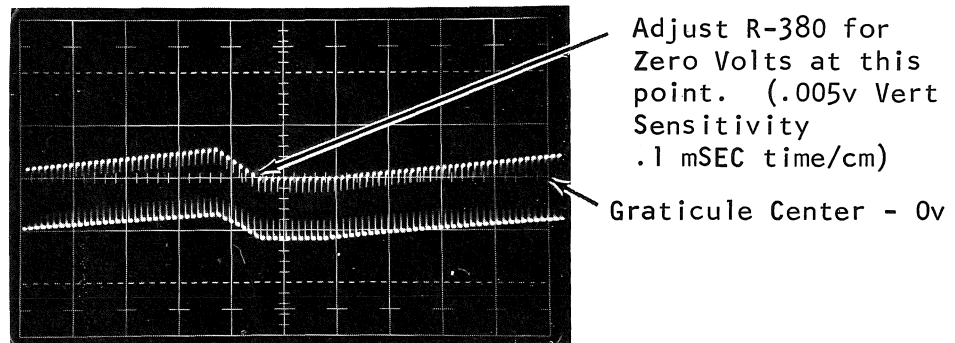


Figure 5-16

3. Adjust R-380 (refer to figure 5-15) so the top of the waveform at the end of the staircase retrace is zero volts (refer to figure 5-16).
 4. Return the SAMPLES/CM control on the 1S1 to midrange.
 5. Remove the test scope probe from the 1S1.
- C. Sweep Length R-290 Adjustment.
1. With the 1S1 VERT POSITION and DC OFFSET controls adjust the trace to the center of the 545B graticule.
 2. Decrease the intensity until the trace is just visible.
 3. Remove the patch cord from the HORIZ INPUT on the 545B.

4. Adjust the HORIZONTAL POSITION control on the 545B to position the CRT spot under the second graticule line (see figure 5-17).
5. Apply 5v from a STANDARD AMPLITUDE CALIBRATOR to the HORIZ INPUT of the 545B.
6. Adjust the VARIABLE 10-1 control on the 545B for exactly 5 cm of deflection between the two spots (see figure 5-17) (1 v/cm sensitivity).

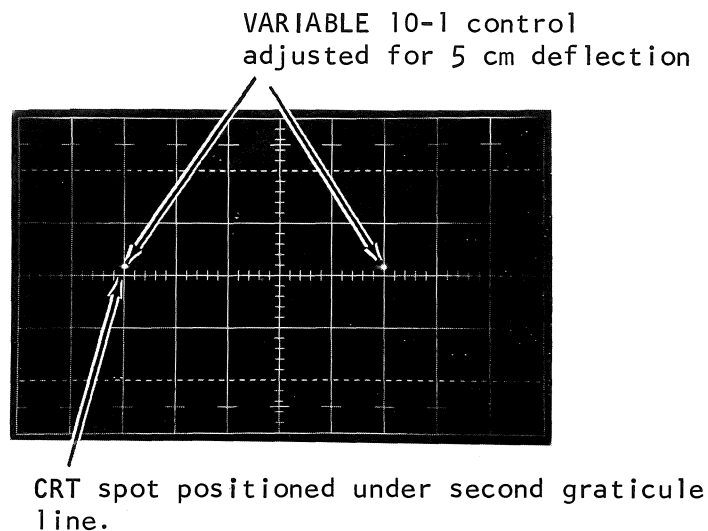


Figure 5-17

7. Remove the STANDARD SQUARE WAVE CALIBRATOR output from the HORIZ INPUT.
8. Return Patch Cord from the HORIZ OUTPUT of the ISI to the HORIZ INPUT on the 545B.

9. Adjust the SWEEP LENGTH R-290 (see figure 5-18) for exactly 10 cm of deflection.

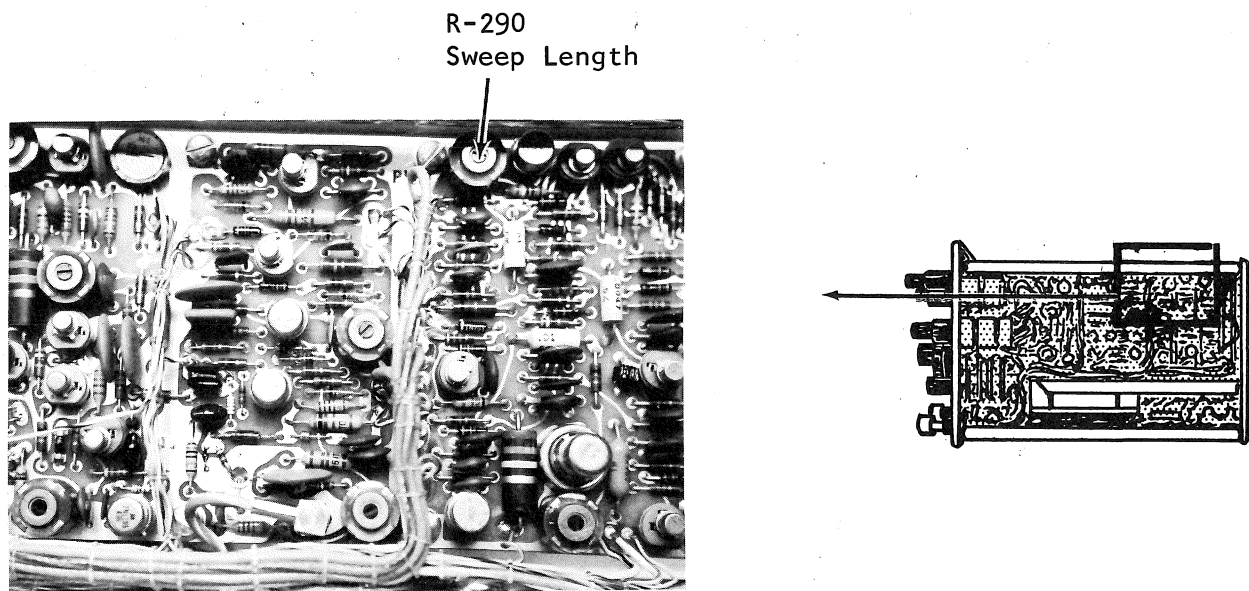


Figure 5-18

D. Timing Cal R-335 Adjustment

1. Set the ISI TIME/CM switch to 5 μ SEC.
2. Apply 5 μ SEC marks from the 180A to the ISI SIGNAL IN through a female BNC to GR adapter (017-0063-00).
3. Adjust the TRIGGER SENSITIVITY for a solid display. (See figure 5-18A). NOTE: The SAMPLES/CM control may have to be adjusted CCW for a well-defined display.

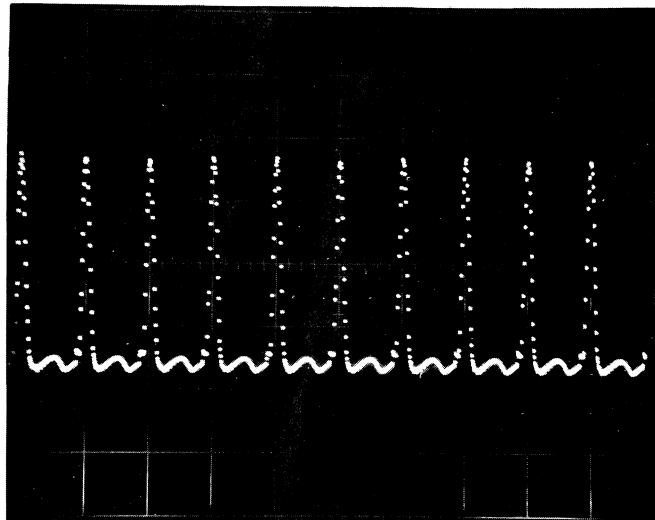


Figure 5-18A

4. Set the TIME POSITION control to midrange.

5. Adjust the TIMING CAL R335 (see figure 5-19) for 1 time mark per division over the middle 8 centimeters.

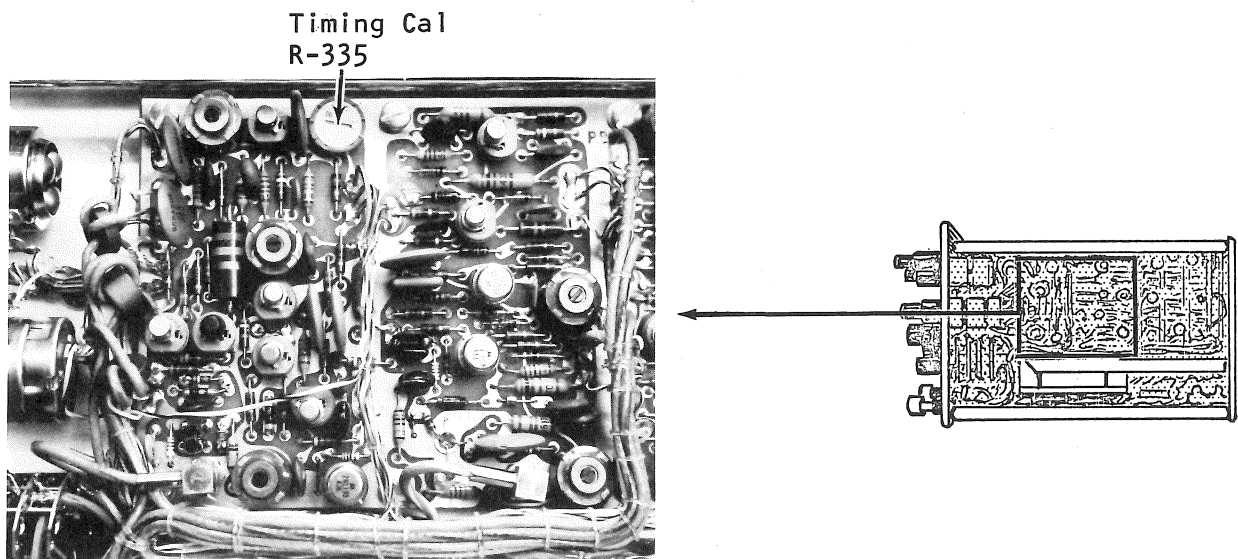


Figure 5-19

6. Check the timing for 1 mark/cm $\pm 3\%$ over the middle 8 centimeters with the TIME POSITION control at CW and CCW.
 7. Return the TIME POSITION control to the CW extreme.
 8. Remove the 180A output from the ISI SIGNAL IN.
- E. Variable Time/cm Range Check ($\geq 2.5:1$)
1. Apply 5 μSEC from the 180A to the ISI SIGNAL IN.
 2. Set the TIME/CM switch on the ISI to 5 μSEC .
 3. Turn the VARIABLE TIME/CM control to the CW extreme.
 4. There must now be at least 2.5 cm between each time mark.
 5. Return the VARIABLE TIME/CM control to the CCW extreme in the CAL detent position.

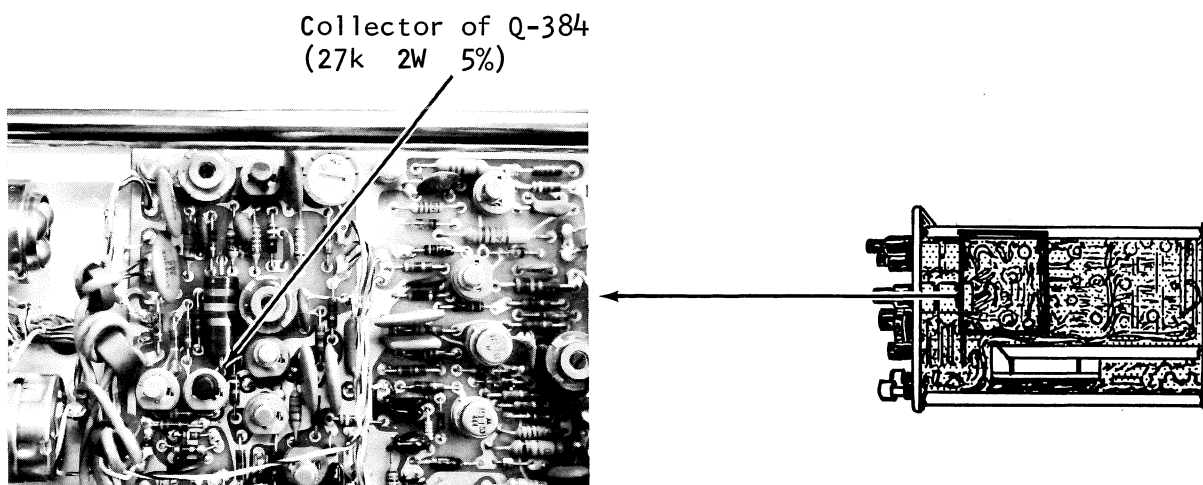
F. Comparator Level R320 Adjustment

1. ISI Setup

- a. Set the TIME POSITION and FINE controls CW.
- b. Decrease the intensity until the trace is just visible.
- c. Set the DISPLAY MODE switch to MAN.
- d. The TRIGGER SENSITIVITY must be CW.
- e. Set the MANUAL SCAN control to position the spot 1 cm from the left edge of the graticule.
- f. Set the TIME/CM switch to 50 μ SEC.

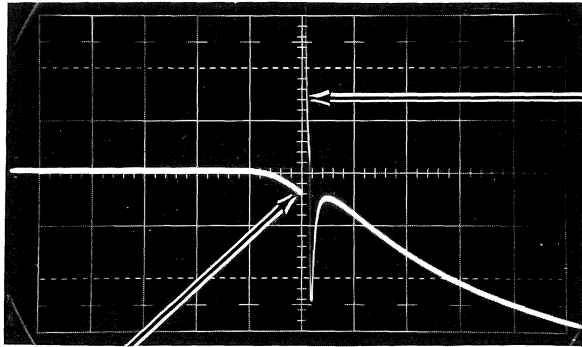
2. Test scope Setup

- a. Set the TIME/CM switch to .1 mSEC.
- b. Set the VOLTS/CM switch to .005v.
- c. Connect a X10 probe from the Vertical input to the emitter of Q384 (see figure 5-20) in the ISI.

Figure 5-20

Test Scope Setup (Con't.)

- d. Set the INPUT SELECTOR switch to AC.
- e. Turn the HORIZONTAL MAGNIFIER on to X5.
- f. Adjust the HORIZONTAL POSITION control to get a display on the CRT similar to the one in figure 5-21.



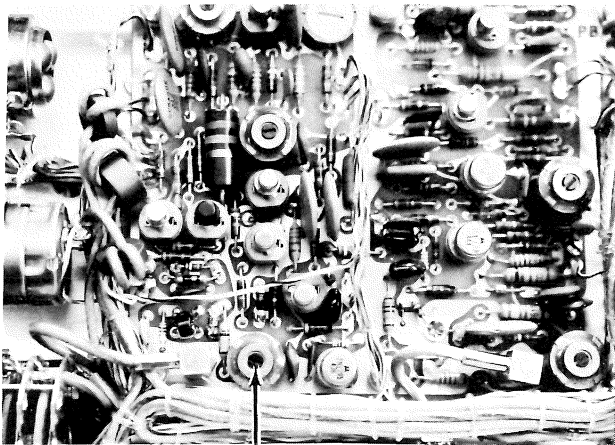
The amplitude of this TD aberration will vary from one unit to the next.

Time/cm .1 mSEC (X5 mag)
Volts/cm .005 v (X10 probe)

Comparator level adjusted so this point is 20 mv (.4 Div) below the positive flat top.

Figure 5-21

3. Adjust the comparator level R-320 (see figure 5-22) so the TD switching aberration starts 20 mv below the positive level (refer to figure 5-21).



Comparator Level
R-320

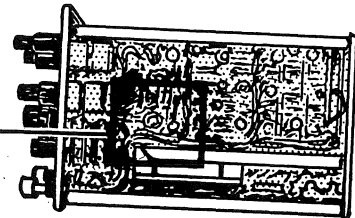


Figure 5-22

4. Remove the X10 Probe from the 1S1.
 5. Return the DISPLAY MODE switch to NORMAL.
- G. Delay Zero R370 Adjustment.
1. Set the 1S1 TIME POSITION RANGE to 500 nSEC and the TIME/CM to 1 nSEC.
NOTE: Go to 50 nSEC/CM, pull the magnifier out and turn to 1 nSEC/CM.
 2. Apply a 111 pulse through a 111 VARIABLE ATTEN and a 5X GR Atten to the 1S1 SIGNAL IN and adjust the 111 VARIABLE ATTEN for approximately 4 cm of signal amplitude.
NOTE: The 111 should have a 4 nSEC charge line connected on the back panel.
 3. Adjust the TRIGGER SENSITIVITY CW from the CCW extreme for a solid display on the 545B.
NOTE: The TRIGGER SENSITIVITY control will have approximately 1 nSEC of control on the delay. It should be adjusted slowly CW from the CCW extreme until the display first becomes solid.
 4. Position the start of the sweep under the left graticule line (see figure 5-23).

Delay Zero adjusted
for 4 nSEC (4 cm)
of delay.

Start of trace
positioned under
left graticule line.

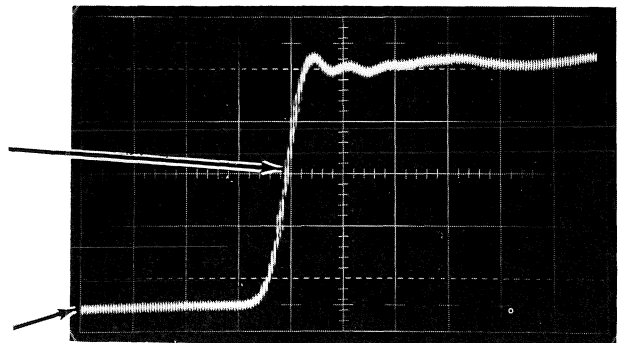


Figure 5-23

5. Adjust delay zero R-370 (see figure 5-24) for 4 nSEC of delay (refer to figure 5-23).

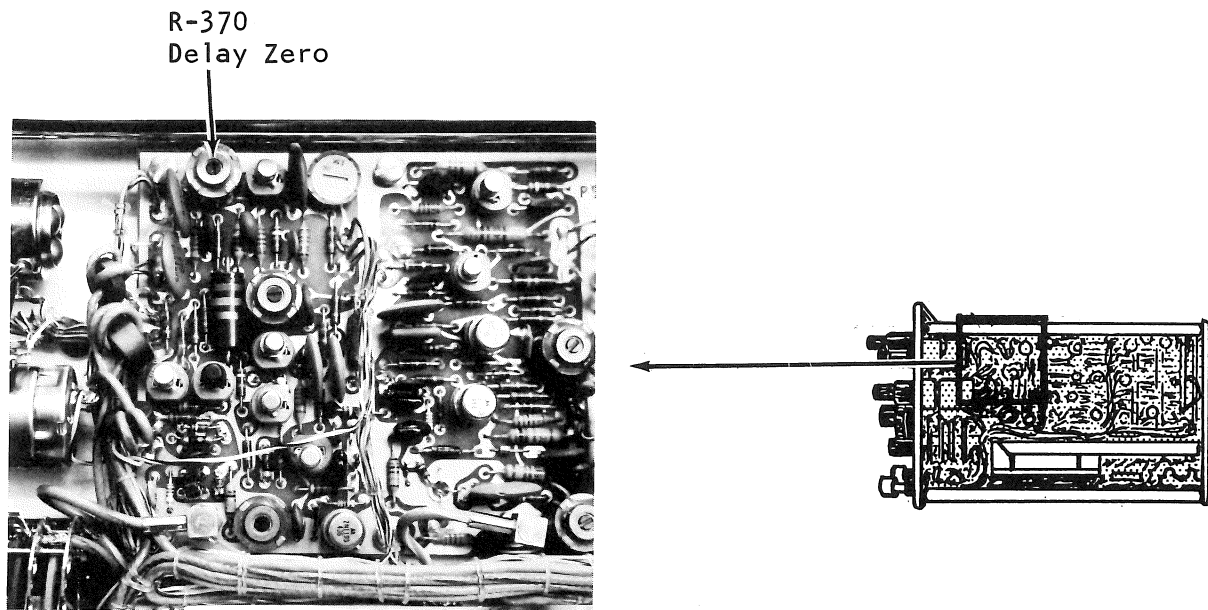


Figure 5-24

6. Remove the 111 signal from the 1S1.
7. Set the 1S1 TRIGGER SENSITIVITY CW.

IV. HORIZONTAL TIMING ADJUSTMENT and CHECK

A. C325 Fast Ramp Cal Adjustment

1. Adjust the frequency accuracy of the GR Oscillator (1218-A) to .01% at 1000 mc following the steps listed below.
 - a. Connect the OUTPUT of a MIXER RECTIFIER (067-0081-00) to the Vertical input of the test scope.
 - b. Set the Vertical VOLTS/CM switch on the test scope to .005v. Set the input selector switch to AC. Set the TIME/CM switch to .1 mSEC. Turn the 5X magnifier OFF.

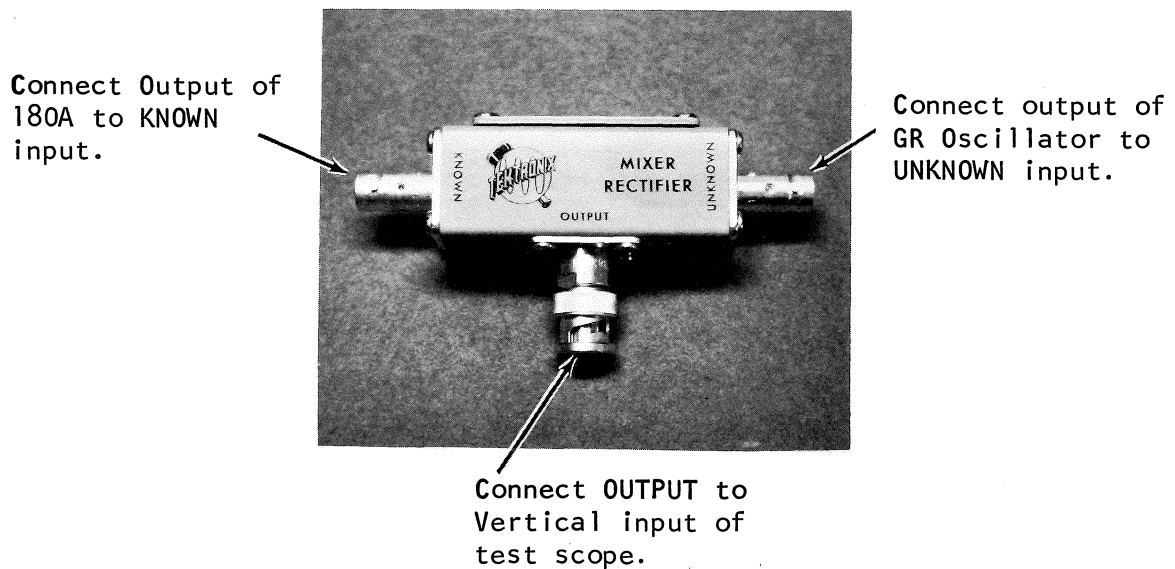
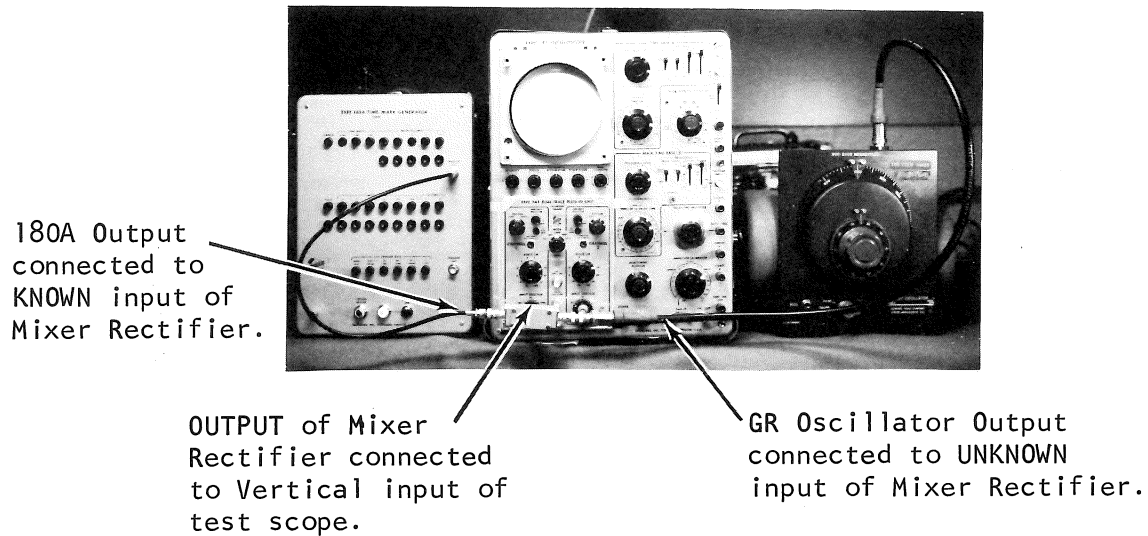


Figure 5-25

- c. Connect the Output of the 1218A GR Oscillator to the UNKNOWN input of the MIXER RECTIFIER (see figure 5-26) through a male BNC to GR Adapter (017-0064-00).
- d. Connect the Output of the 180A TIME MARK GENERATOR to the KNOWN input of the MIXER RECTIFIER (see figure 5-26).

Equipment Setup

Figure 5-26

- e. Apply 50 mc from the 180A.
- f. Adjust the Frequency dial of the GR Oscillator to 1000 mc.
- g. Move the Frequency dial of the GR Oscillator both sides of 1000 mc vary slow by until a beat or difference signal is seen on the test scope.
- h. If the difference signal on the test scope is 10 cycles or less the accuracy of the GR Oscillator is $\leq .01\%$.

2. Remove the Output of the GR Oscillator from the MIXER RECTIFIER and apply it to the SIGNAL IN of the ISI through a 5X GR attenuator. Do NOT change the frequency of the GR Oscillator.
3. Set the TIME Position and FINE controls to midrange.
4. Set the TIME/CM switch on the ISI to 1 NSEC. (TIME POSITION RANGE to 50 nSEC.)

NOTE: The TIME/CM and the TIME POSITION RANGE should be locked together.

5. Adjust C-325 (see figure 5-27) for exactly 1 cycle/cm.

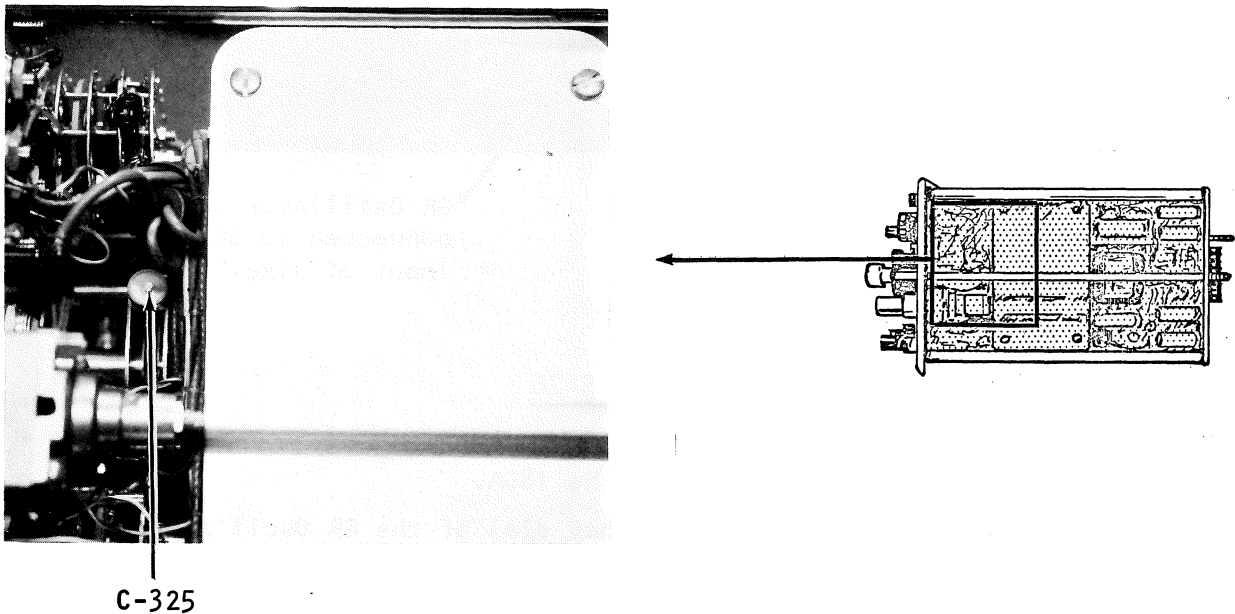


Figure 5-27

6. Check for 1 cycle/cm when the TIME POSITION control is at CW and CCW.
7. Return the TIME POSITION control to midrange.

B. TIME/CM Switch Accuracy Check ($\pm 3\%$)

To check the TIME/CM accuracy, each of the fast ramps are checked for two things. First they are checked for basic timing accuracy. Then they are checked for timing accuracy with each of the 6 magnifier positions. On the first check in each of the 5 charts the TIME POSITION RANGE switch and the TIME/CM switch are together. After the first check the TIME/CM switch should be pulled out and turned separately. Check the timing over the middle 8 centimeters for $\pm 3\%$ timing (± 2.4 mm). When the GR Oscillator is used it must still be calibrated from Step 1v, C.

Set the TIME POSITION RANGE switch to 50 nSEC TIME POS RANGE and the TIME/CM switch to 2 nSEC.

1S1

<u>TIME POS RANGE</u>	<u>TIME/CM</u>	<u>SIGNAL SOURCE</u>	<u>SIGNAL IN</u>	<u>DISPLAY</u>
50 nSEC	2 nSEC	1218-A GR OSC.	1000 mc	2 cycle/cm
"	1 nSEC	"	1000 mc	1 cycle/cm
"	.5 nSEC	"	1000 mc	1 cycle/2 cm
"	.2 nSEC	"	1000 mc	1 cycle/5 cm
"	.1 nSEC	"	1000 mc	1 cycle/10 cm

Set the TIME/CM switch and the TIME POSITION RANGE switch together to the 50 nSEC/CM, 500 nSEC TIME POSITION RANGE position.

1S1

<u>TIME POS RANGE</u>	<u>TIME/CM</u>	<u>SIGNAL SOURCE</u>	<u>SIGNAL IN</u>	<u>DISPLAY</u>
500 nSEC	50 nSEC	180A	10 mc	1 cycle/2 cm
"	20 nSEC	"	50 mc	1 cycle/cm
"	10 nSEC	"	50 mc	1 cycle/2 cm
"	5 nSEC	"	50 mc	1 cycle/4 cm
"	2 nSEC	1218-A GR OSC.	1000 mc	2 cycles/cm
"	1 nSEC	"	1000 mc	1 cycle/cm
"	.5 nSEC	"	1000 mc	1 cycle/2 cm

Set the TIME/CM switch and the TIME POSITION RANGE switch together to the .5 μ SEC/CM, 5 μ SEC TIME POSITION RANGE position.

1S1

<u>TIME POS RANGE</u>	<u>TIME/CM</u>	<u>SIGNAL SOURCE</u>	<u>SIGNAL IN</u>	<u>DISPLAY</u>
5 μ SEC	.5 μ SEC	180A	1 μ SEC	1 mark/2 cm
"	.2 μ SEC	"	5 mc	1 cycle/cm
"	.1 μ SEC	"	10 mc	1 cycle/cm
"	50 nSEC	"	10 mc	1 cycle/2 cm
"	20 nSEC	"	50 mc	1 cycle/cm
"	10 nSEC	"	50 mc	1 cycle/2 cm
"	5 nSEC	"	50 mc	1 cycle/4 cm

Set the TIME/CM switch and the TIME POSITION RANGE switch together to the 5 μ SEC/CM, 50 μ SEC TIME POSITION RANGE position.

1S1

<u>TIME POS RANGE</u>	<u>TIME/CM</u>	<u>SIGNAL SOURCE</u>	<u>SIGNAL IN</u>	<u>DISPLAY</u>
50 μ SEC	5 μ SEC	180A	5 μ SEC	1 mark/cm
"	2 μ SEC	"	1 μ SEC	2 mark/cm
"	1 μ SEC	"	1 μ SEC	1 mark/cm
"	.5 μ SEC	"	1 μ SEC	1 mark/2 cm
"	.2 μ SEC	"	5 mc	1 cycle/cm
"	.1 μ SEC	"	10 mc	1 cycle/cm
"	50 nSEC	"	10 mc	1 cycle/2 cm

Set the TIME/CM switch and the TIME POSITION RANGE switch together to the 50 μ SEC/CM, 500 μ SEC TIME POSITION RANGE position.

1S1

<u>TIME POS RANGE</u>	<u>TIME/CM</u>	<u>SIGNAL SOURCE</u>	<u>SIGNAL IN</u>	<u>DISPLAY</u>
500 μ SEC	50 μ SEC	180A	50 μ SEC	1 mark/cm
"	20 μ SEC	"	10 μ SEC	2 mark/cm
"	10 μ SEC	"	10 μ SEC	1 mark/cm
"	5 μ SEC	"	5 μ SEC	1 mark/cm
"	2 μ SEC	"	1 μ SEC	2 mark/cm
"	1 μ SEC	"	1 μ SEC	1 mark/cm
"	.5 μ SEC	"	1 μ SEC	1 mark/2 cm

V. SAMPLER and MEMORY CIRCUIT ADJUSTMENTS and CHECKS

A. Memory Bal R110 Adjustment.

1. Adjust DC OFFSET so the OFFSET OUTPUT is 0v on the 1S1 following the steps below.
 - a. Turn the INTENSITY on the 545B down until the trace is just visible.
 - b. Remove the patch cord connected to the HORIZ OUTPUT connector on the 1S1.
 - c. Adjust the HORIZONTAL POSITION on the 545B to position the CRT spot under the center Vertical graticule line.
 - d. Connect the patch cord connected to the HORIZ INPUT on the 545B to the OFFSET OUTPUT on the 1S1.
 - e. Adjust the DC OFFSET on the 1S1 until the CRT spot is returned Horizontally to the center Vertical graticule line.

NOTE: If the DC OFFSET is turned very far it may position the spot off the CRT Vertically. In this case return the spot near the center with the VERT POSITION control.

- f. Remove the Patch cord from the OFFSET OUTPUT and return it to the HORIZ OUTPUT connector.
2. Set the TIME/CM on the 1S1 to 50 nSEC.
3. Position the trace to the center of the screen with the VERT POSITION and DC OFFSET.
4. Adjust R110 (see figure 5-28) so that as the SMOOTHING control on the 1S1 front panel is turned from CW to CCW there is no trace shift.

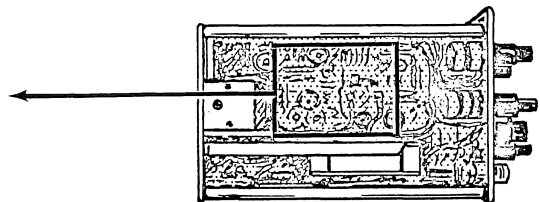
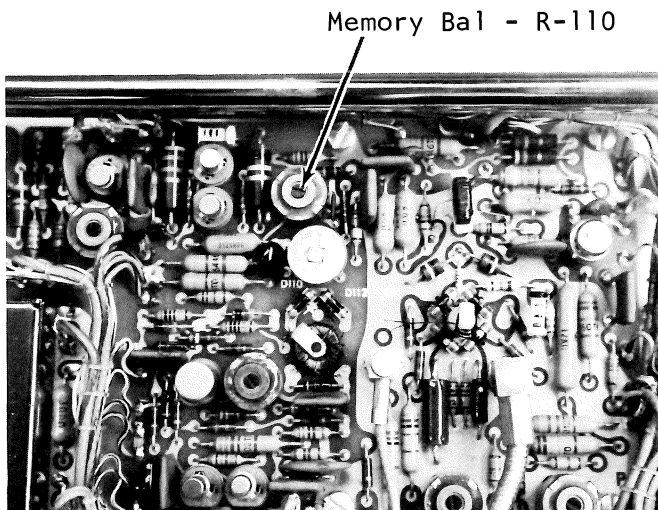
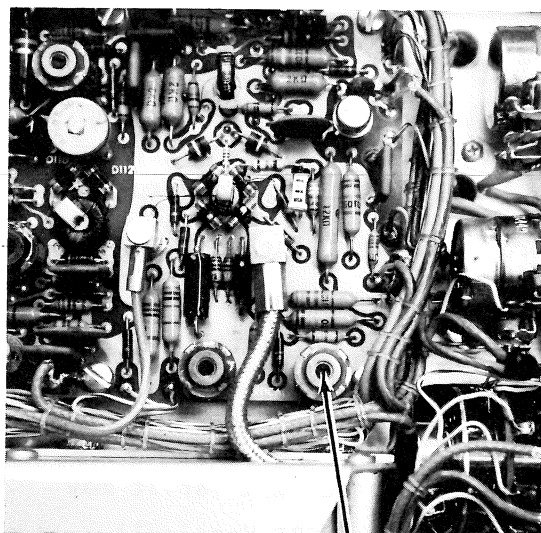


Figure 5-28

B. Bridge Bal R-30 Adjustment

1. Adjust R-30 (see figure 5-29) so that as the mVOLTS/CM switch is switched from 200 mv to 2 mv there is no vertical shift.
2. Return mVOLTS/CM switch to 200.



Bridge Bal.
R-30

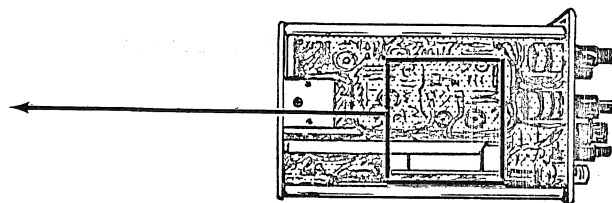


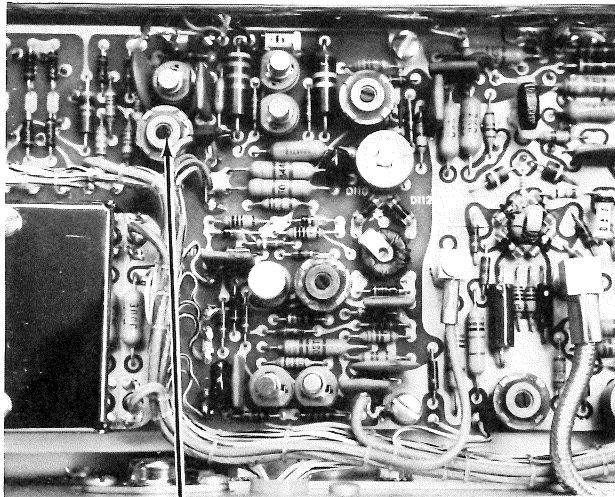
Figure 5-29

C. Variable Bal R-168 (front panel screwdriver) Adjustment

1. Adjust the VAR BAL so that as the VARIABLE m VOLTS/CM control is rotated through its range there is no vertical trace shift.
2. Return VARIABLE mVOLTS/CM control to CAL position.

D. Position Range R-194 Adjustment

1. Adjust the VERT POSITION control on the ISI front panel to midrange (12 o'clock).
2. Adjust R-194 (see figure 5-30) to position the trace to graticule center.



Vertical Position Range
R-194

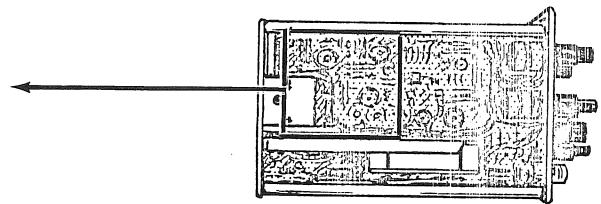


Figure 5-30

E. Vertical Gain R172 (front panel screwdriver) Adjustment

1. Connect the OUTPUT of the 50 Ω Amplitude Calibrator (067-0508-00) to the SIGNAL IN on the IS1.
2. Set the TEST OPERATE switch on the AMPLITUDE CALIBRATOR to the OPERATE position. (See figure 5-31).

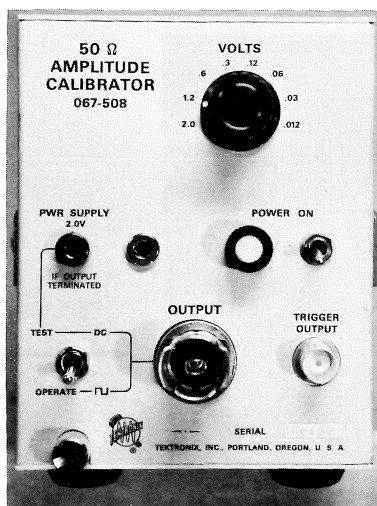


Figure 5-31

3. Set the VOLTS switch on the 50 Ω AMPLITUDE CALIBRATOR to .6.
4. The IS1 mVOLTS/CM switch must still be on 200 mv.
5. Adjust the VERT GAIN (a screwdriver adjustment on the IS1 front panel) for 3 cm of Vertical deflection.

NOTE: To avoid any error introduced by compression do not use either the top or the bottom graticule line for this adjustment.

F. mVOLTS/CM Switch Accuracy Check ($\pm 3\%$).

Check the accuracy of the mVOLTS/CM switch by applying the voltage indicated in column two (2) and observing the display in column three (3) with the mVOLTS/CM switch in the position indicated in column one (1).

<u>mVOLTS/CM</u>	<u>50Ω AMPLITUDE CALIBRATOR VOLTS</u>	<u>DISPLAY</u>
100	.3	3 cm \pm .9 mm
50	.12	2.4 cm \pm .7 mm
20	.06	3 cm \pm .9 mm
10	.03	3 cm \pm .9 mm
5	.012	2.4 cm \pm .7 mm
2	.012	6 cm \pm 1.8 mm

NOTE: Slight adjustment of the TRIGGER SENSITIVITY control may be required to maintain a triggered display.

G. Variable mVOLTS/CM control Range Check (1:4)

1. Return the mVOLTS/CM switch on the ISI to 200.
2. Set the 50 Ω AMPLITUDE CALIBRATOR volts switch to .3.
3. There should now be a display amplitude of 1.5 cm.
4. Turn the VARIABLE mVOLTS/CM control CCW out of its CAL detent position. When the amplitude first increases it should be > 6 cm.
5. Return the VARIABLE mVOLTS/CM control to the CAL detent position.

H. Vertical Output Signal Check

(With 1.2v in, there must be $1.2\text{v} \pm .03\text{v}$ ($\pm 3\%$) out).

1. Set the 50 Ω AMPLITUDE CALIBRATOR VOLTS switch to 1.2v.
2. Set the test scope Vertical VOLTS/CM switch to .05.
3. Connect a X10 probe from the test scope to the VERT OUTPUT connection on the IS1.
4. Check for 2.5 cm (1.2v) $\pm .6$ mm ($.03\text{v}$) Vertical deflection on the test scope.
5. Disconnect the X10 test scope probe and the calibrator signal from the IS1.

I. Memory Gate Width R95 Adjustment

1. Set the SAMPLES/CM control on the IS1 to the CW extreme.
2. Apply a 111 Pulse through a 5X GR attenuator and the 111 VARIABLE ATTENUATOR to the SIGNAL IN connection on the IS1.
NOTE: The 111 should still have a 4 nsec charge line connected on the back.
3. Set the IS1 TIME/CM switch to 2 nSEC.
4. Adjust the TRIGGER SENSITIVITY control for a stable display and the TIME POSITION control to position the leading edge.
5. Adjust the 111 VARIABLE ATTENUATOR for a display amplitude of 5 cm.
6. The SMOOTHING control must be CW.
7. See figure 5-32 for the correct display.

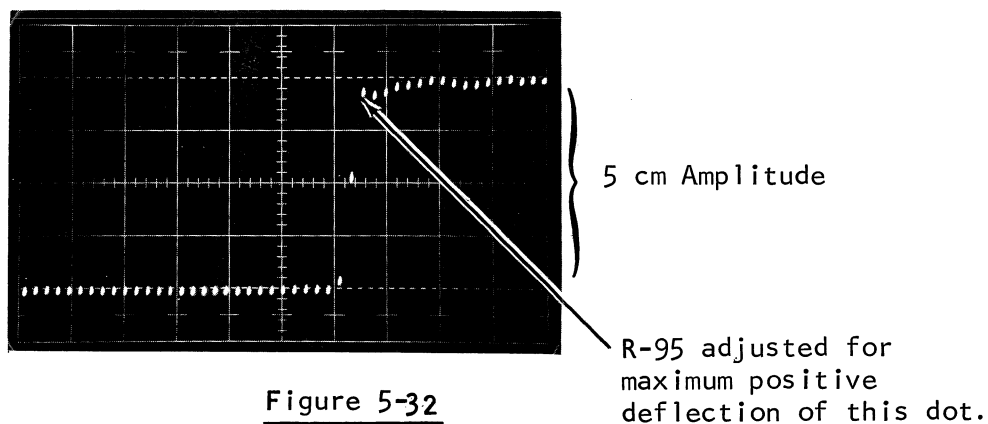
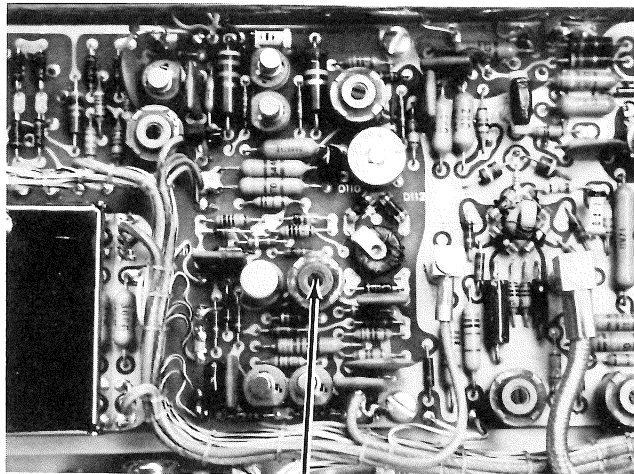


Figure 5-32

6. Adjust R-95 (see figure 5-33) so the first dot at the top of the pulse is at maximum amplitude (most positive deflection) (refer to figure 5-32).



Memory Gate
R-95

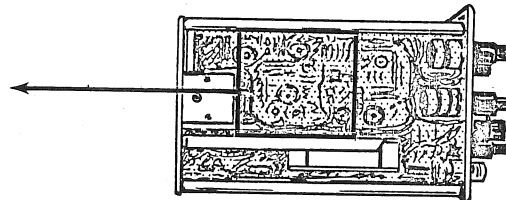


Figure 5-33

7. Remove the OUTPUT of the 111 from the 1S1 SIGNAL IN.
- J. Snap-off Current R85 Adjustment
1. Connect the PULSE OUTPUT of a 30 ps TUNNEL DIODE PULSE GENERATOR to the SIGNAL IN on the 1S1.
 2. Turn ON the TUNNEL DIODE PULSE GENERATOR.
 3. 1S1 Setup
 - a. Set the SAMPLES/CM control to midrange.
 - b. Set the TRIGGER SOURCE switch to - INT.
 - c. With the VERT POSITION control and the TIME POSITION control position the falling edge of the Pulse in the center area of the CRT.
 - d. Adjust the TRIGGER SENSITIVITY control CCW until the trace disappears then adjust it CW until the trace first appears stable.
 - e. Adjust the mVOLTS/CM switch and the VARIABLE mVOLTS/CM control so the fast switching portion of the waveform is 5 cm in amplitude.
 - f. Set the TIME/CM switch to .1 nSEC.
 - g. Adjust the TIME POSITION control to again position the falling edge of the waveform to the center area of the graticule.

4. Check the fall time of the waveform from the 90% amplitude to the 10% amplitude (see figure 5-34). If the fall time is greater than 350 psec (3.5 cm) adjust R85 (see figure 5-35) until the risetime is 350 psec.

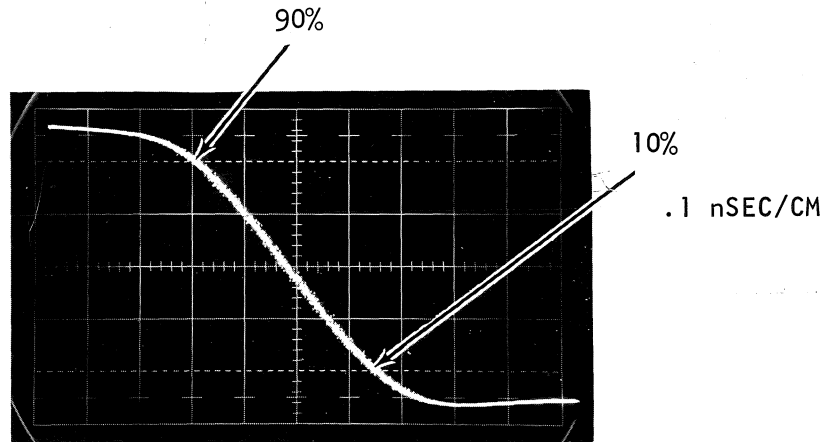
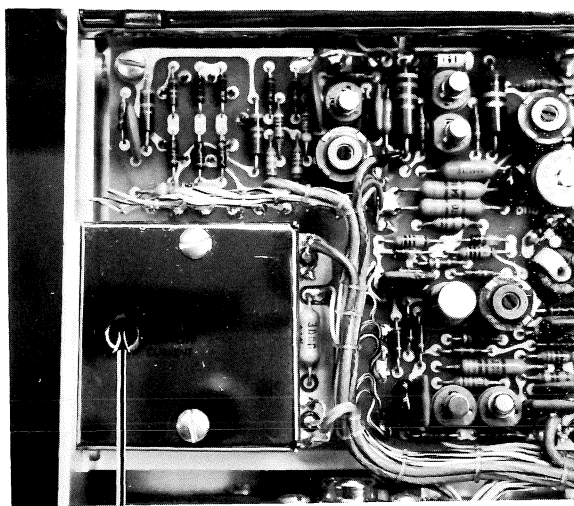


Figure 5-34



Snap-off Current
R-85

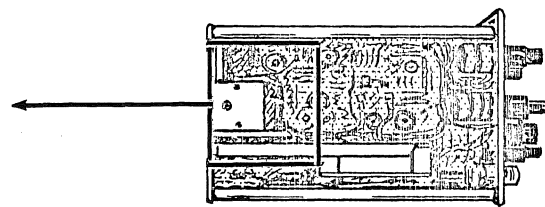


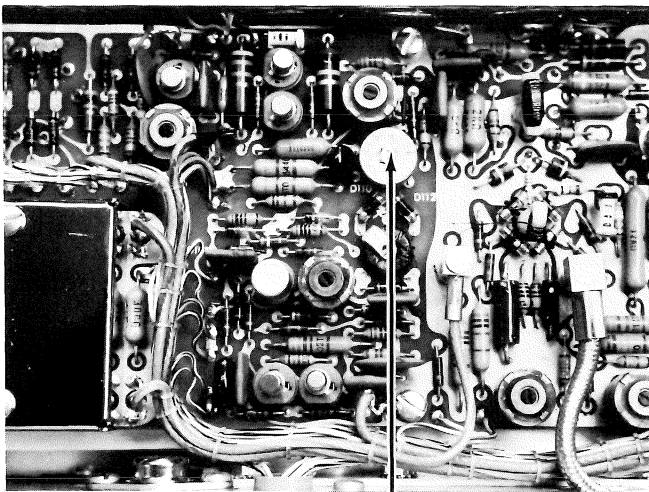
Figure 5-35

5. Remove the OUTPUT of the TUNNEL DIODE PULSE GENERATOR from the ISI SIGNAL IN.
6. Return the mVOLTS/CM switch to 200 and the VARIABLE mVOLTS/CM control to the CAL position.

K. C136 Memory Gain Adjustment

1. Apply the OUTPUT of the 111 to the ISI SIGNAL IN through a 5X GR Attenuator and a 111 VARIABLE ATTENUATOR.
2. ISI Setup
 - a. Set the SAMPLES/CM control to midrange.
 - b. Set the TRIGGER SOURCE switch to + INT.
 - c. Set the TIME/CM switch to 1 nSEC.
 - d. Adjust the TIME POSITION control to position the rising portion of the 111 pulse on the screen and the falling portion off to the right of the screen. (TRIGGER SENSITIVITY may have to be adjusted for a solid display.)
3. Adjust the 111 VARIABLE ATTENUATOR for a display amplitude of 5 cm.
4. Adjust the repetition rate of the 111 to approximately 1 kc following the steps listed below.
 - a. Adjust the REPETITION RATE control to MAX (CW).
 - b. Set the RANGE switch to 100 cps.
5. Adjust C136 (see figure 5-36) so the first dot of the display is flat with the following dots (see figure 5-37, 5-38 and 5-39 next page).

NOTE: The 111 pulse must extend beyond the end of the sweep and the repetition rate must be greater in time than the retrace time to make this adjustment.



C-136

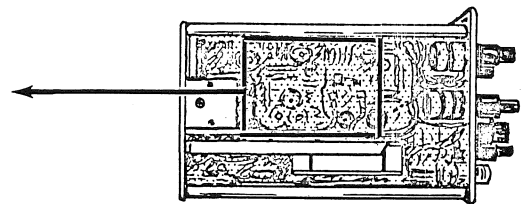


Figure 5-36

NOTE: The adjustment of R85, the snap-off current, will have to be repeated if C136 is adjusted.

C-136 has too much capacitance.

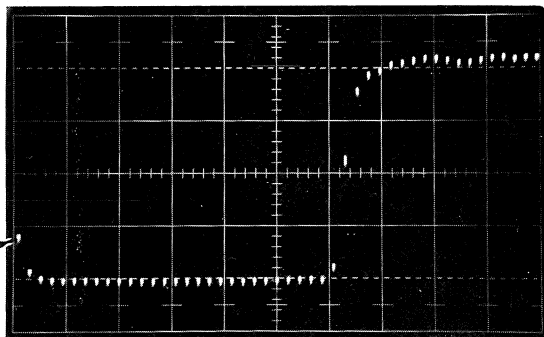


Figure 5-37

C-136 has too little capacitance.

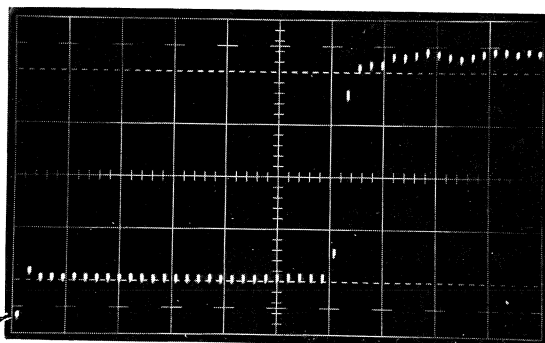


Figure 5-38

C-136 adjusted properly.

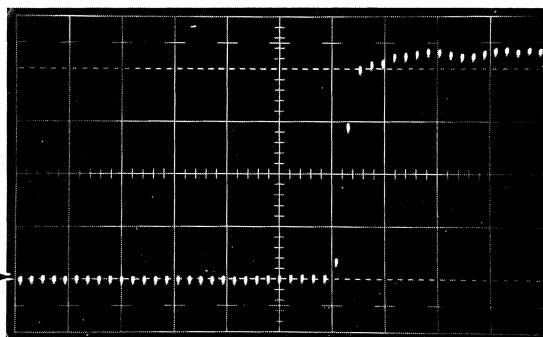


Figure 5-39

6. Switch the OUTPUT POLARITY switch on the 111 to (-).
7. Switch the TRIGGER SOURCE switch on the 1S1 to (-).
8. The first dot on the baseline must not move up or down more than 2 mm from the adjustment made in Step 5.
9. Return the TRIGGER SOURCE switch on the 1S1 to (+) and the OUTPUT POLARITY switch on the 111 to (+).
10. Check the loop gain on each of the mVOLTS/CM switch positions. With a display amplitude of 5 cm the first dot on the baseline must not move up or down more than 6 mm from the adjustment made in Step 5 on any of the mVOLTS/CM switch positions.
11. Remove the 111 signal from the 1S1 SIGNAL IN.
12. Turn off the 545B power, remove the plug-in extension cable from between the 1S1 and the 545B, and install the 1S1 in the 545B plug-in compartment. Turn on the 545B power.

VI. TRIGGER SPECIFICATIONS CHECK

A. Trigger Jitter Checks (with 180A)

Specifications:

<u>TRIGGER</u>	<u>SIGNAL</u>	<u>AMPLITUDE</u>	<u>JITTER SPEC</u>
Int	100 kc	50 mv	.7 μ SEC
Ext	100 kc	4 mv	.5 μ SEC
Int	10 mc	50 mv	5 nSEC
Ext	10 mc	8 mv	5 nSEC

1. ISI Setup

- Set the TIME/CM switch to 50 nSEC.
- Set the TRIGGER SENSITIVITY control CCW.
- Set the TRIGGER SOURCE switch to + INT.
- Set the mVOLTS/CM switch to 10.

- Apply 10 mc from a 180A through a female BNC to GR adapter, a 111 VARIABLE ATTENUATOR and a GR "T" connector to the SIGNAL IN on the ISI. Connect a 10X BNC attenuator and a female BNC to GR adapter between the "T" connector and the EXT TRIG on the ISI. (See figure 5-40).

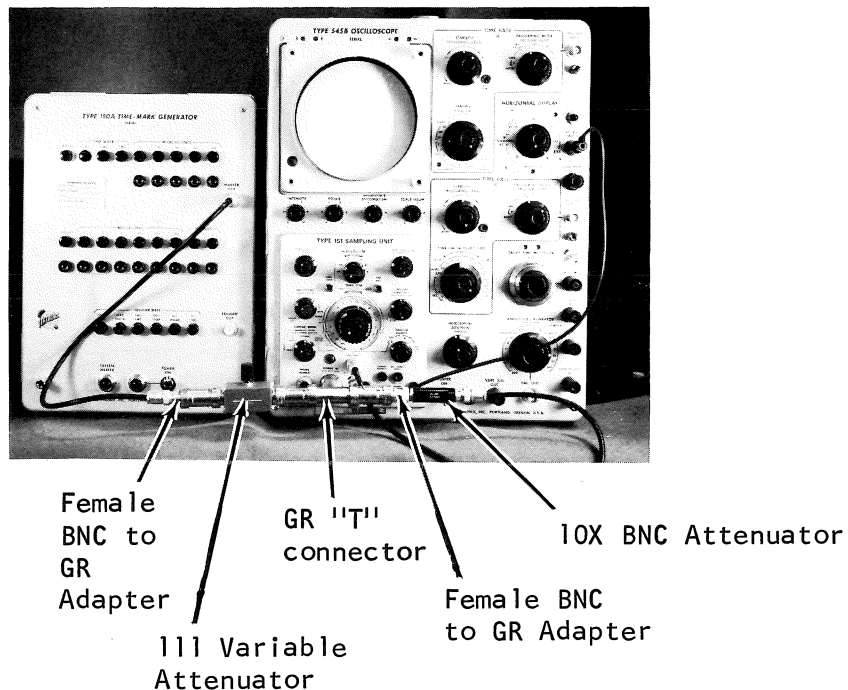


Figure 5-40

3. Adjust the 111 VARIABLE ATTENUATOR to obtain 50 mv (5 cm) at the 1S1 SIGNAL IN.
4. Adjust the TRIGGER SENSITIVITY control for a solid display.
5. Set the TIME/CM switch to 5 nSEC.
6. Measure the trace width of the display (see figure 5-41). There must be less than 1 cm of jitter.

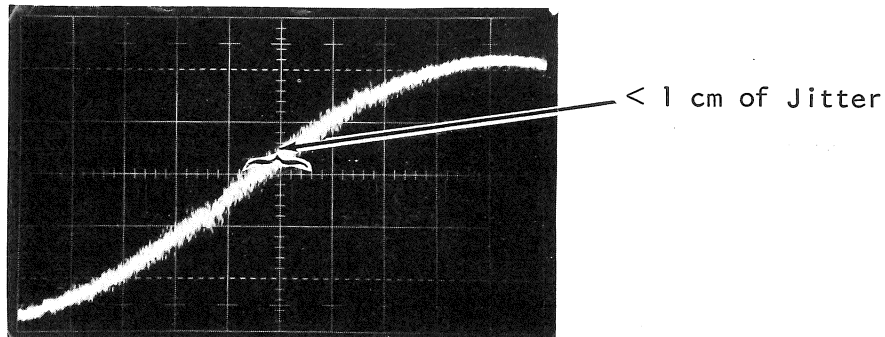


Figure 5-41

7. Switch the TRIGGER SOURCE switch to + EXT. Switch the mVOLTS/CM switch to 20.
 8. Adjust the VARIABLE ATTENUATOR for 80 mv (4 cm).
 9. Check the trace width again for less than 1 cm.
 10. Remove the 180A from the 111 VARIABLE ATTENUATOR.
- B. Trigger Jitter Checks (with 1218-A GR Oscillator)

Specifications:

<u>TRIGGER</u>	<u>SIGNAL</u>	<u>AMPLITUDE</u>	<u>JITTER SPEC</u>
Int	1 Gc	50 mv	200 psec
Ext	1 Gc	8 mv	200 psec

1. Connect the output of the 1218-A GR Oscillator to the 111 VARIABLE ATTENUATOR.
2. Set the mVOLTS/CM switch to 20.

3. By adjusting the VARIABLE ATTENUATOR and the OUTPUT CONTROL on the GR Oscillator obtain 80 mv at the SIGNAL IN of the ISI.
4. Set the TIME/CM switch on the ISI to .1 nSEC.
5. Set the RECOVERY TIME control to the SYNC detent position.
6. Adjust the TRIGGER SENSITIVITY control for a solid display (see figure 5-42).
7. Check for less than 2 cm of jitter.

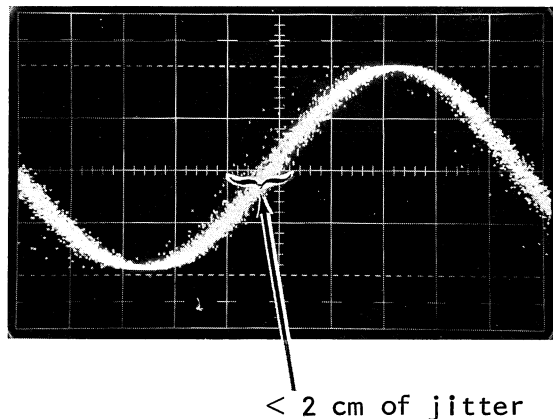


Figure 5-42

8. Switch the TRIGGER SOURCE switch to + INT.
9. Set the mVOLTS/CM switch to 10.
10. Adjust the OUTPUT CONTROL on the GR Oscillator for 50 mv (5 cm).
11. Adjust the TRIGGER SENSITIVITY for a solid display and again check for less than 2 cm of jitter.
12. Remove the output of the GR Oscillator from the III VARIABLE ATTENUATOR.

C. Trigger Jitter Checks (With 111 Pulse Generator.

Specifications:

<u>TRIGGER</u>	<u>SIGNAL</u>	<u>AMPLITUDE</u>	<u>JITTER SPEC</u>
Int	2 nSEC Pulse	40 mv	200 psec
Ext	2 nSEC Pulse	7 mv	200 psec

1. Apply the output of the 111 to the 111 VARIABLE ATTENUATOR.

NOTE: If the 111 has a charge line on the back it should be removed. The repetition rate of the 111 should be approximately 100 kc.

2. Set the TIME/CM switch to 5 nSEC.
3. By adjusting the 111 VARIABLE ATTENUATOR obtain 50 mv (5 cm) at the 1S1 SIGNAL IN.
4. Adjust the TRIGGER SENSITIVITY for a solid display.
5. Set the TIME/CM switch to .1 nSEC and adjust the TIME POSITION control CCW until the rising portion of the 111 pulse is seen on the CRT.
6. Check for less than 2 cm of jitter.
7. Switch the TRIGGER SOURCE switch to + EXT.
8. Switch to mVOLTS/CM switch to 20.
9. Adjust the VARIABLE ATTENUATOR for an amplitude of 80 mv (4 cm).
10. Again check for less than 2 cm of trace width jitter.
11. Remove the GR "T" connector and the X10 BNC attenuator from the SIGNAL IN and EXT TRIG on the 1S1.

D. Trigger Kickout Check (≤ 25 mv P-P)

1. Connect a coax cable from the EXT TRIG on the 1S1 through a female BNC to GR adapter to the SIGNAL IN on the 1S1.
2. Set the TIME/CM switch to 5 nSEC.
3. Set the mVOLTS/CM switch to 10.

4. Adjust the TRIGGER SENSITIVITY control for a stable display.
5. Check for less than 25 mv (2.5 cm) of kickout pulse amplitude (see figure 5-43).

NOTE: The TRIGGER SOURCE switch must still be in + EXT.

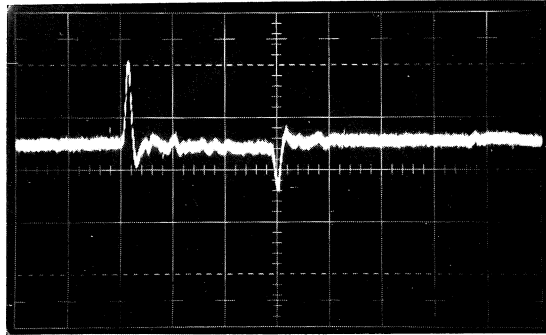


Figure 5-43

6. Switch the TRIGGER SOURCE switch to - EXT.
7. Again check for less than 25 mv (2.5 cm) of trigger kickout amplitude.
8. Remove the cable from between the EXT TRIG and the SIGNAL IN on the ISI.

E. Display Jitter Check

Specifications:

<u>TIME POSITION RANGE</u>	<u>JITTER SPEC</u> (Internal trigger with between .4 and 1 v input).
----------------------------	-------------------------------------------------------------------------

500 μ SEC	100 nSEC
---------------	----------

50 μ SEC	10 nSEC
--------------	---------

5 μ SEC	1 nSEC
-------------	--------

500 nSEC	120 pSEC
----------	----------

50 nSEC	40 pSEC
---------	---------

1. Set the mVOLTS/CM control to 200.
2. Apply 5 mc from the output of the 180A through a 5X BNC attenuator to the SIGNAL IN on the ISI.
3. Set the TIME POSITION RANGE switch to 500 μ SEC and the TIME/CM switch to .1 μ SEC.

NOTE: Set the time/cm to 10 μ SEC, pull it out, then go to .1 μ SEC.

4. Set the TRIGGER SOURCE switch to + INT.
5. Set the RECOVERY TIME control CCW but out of the SYNC detent.
6. Adjust the TRIGGER SENSITIVITY control for a solid display.
7. Check the display trace width for less than 1 cm.

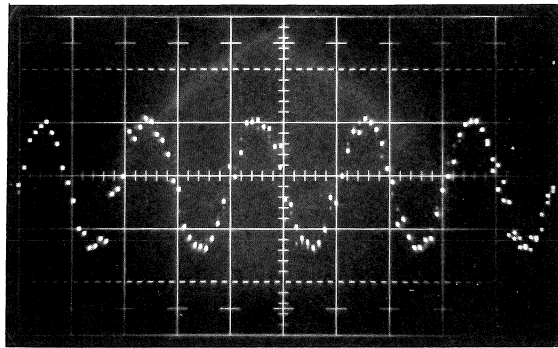


Figure 5-44

8. Apply 50 mc from the 180A to the 1S1 SIGNAL IN.
9. Set the TIME POSITION RANGE switch to 50 μ SEC and the TIME/CM switch to 10 nSEC.
10. Adjust the TRIGGER SENSITIVITY for a solid display.
11. Check for a display trace width of less than 1 cm.

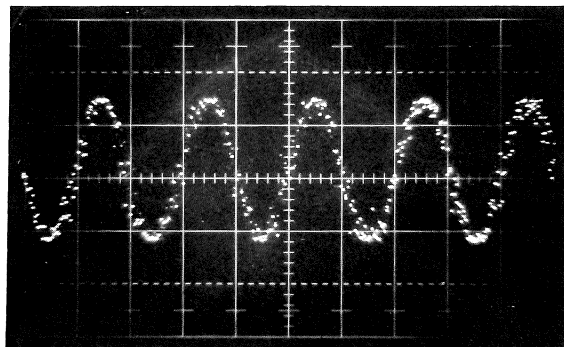


Figure 5-45

12. Set the TIME POSITION RANGE switch to 5 μ SEC and the TIME/CM switch to 1 nSEC.
13. Set the mVOLTS/CM to 50.
14. Adjust the TRIGGER SENSITIVITY for a solid display.
15. Check for a display trace width of less than 1 cm.

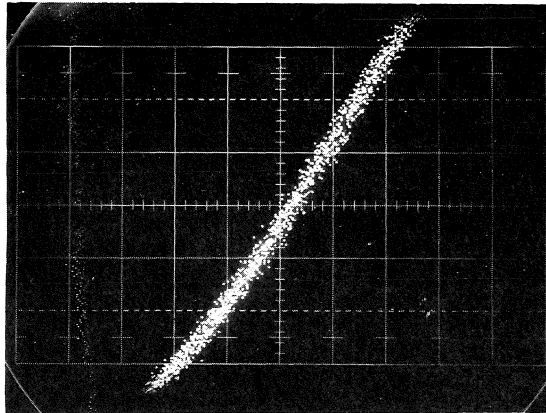


Figure 5-46

16. Set the TIME POSITION RANGE switch to 500 nSEC and the TIME/CM switch to .1 nSEC.
17. Remove the Output of the 180A from the 1S1 SIGNAL IN and apply 1000 mc from the 1218-A GR attenuator.
18. Set the RECOVERY TIME control to the SYNC detent position.
19. Adjust the TRIGGER SENSITIVITY for a solid display.
20. Check for a display trace width of less than 1.2 cm.

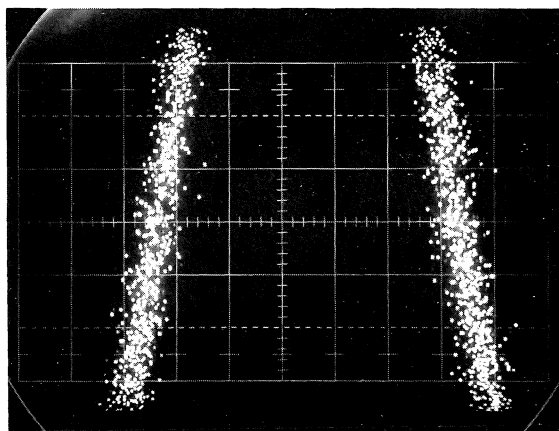


Figure 5-47

21. Set the TIME POSITION RANGE switch to 50 nSEC and the TIME/CM switch to .1 nSEC.

NOTE: Set the TIME/CM switch to 10 nSEC to lock the TIME POSITION RANGE switch to it, switch to 1 nSEC, then pull the TIME/CM switch out and switch to .1 nSEC.

22. Adjust the TRIGGER SENSITIVITY for a solid display.
23. Check for a display trace width of less than .4 cm.

NOTE: It may be easier to make this check with the mVOLTS/CM switch at 100.

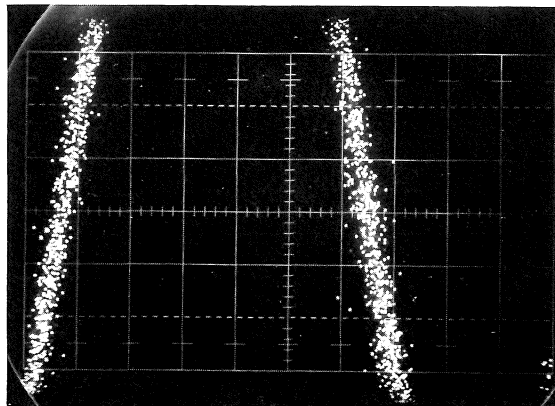


Figure 5-48

24. Remove the Output of the GR Oscillator from the SIGNAL IN connector on the IS1.

VII. SAMPLING CHECKS USING THE 111 PRETRIGGER

A. Smoothing Range Check ($\geq 3:1$) and Amplitude Change With Smoothing ($\pm 3\%$).

1. 1S1 Setup

- a. Set the TIME/CM switch to 1 nSEC (TIME POSITION RANGE to 50 nSEC).
- b. Set the SAMPLES/CM control CW to minimum.
- c. TRIGGER SOURCE set to + INT.

2. 111 Pretrigger Setup

- a. Set the repetition rate to 1 kc.

NOTE: Set the REPETITION RATE control CW to MAX then set the REPETITION RATE RANGE switch to 100 cps.

- b. Connect a 4 nSEC cable to the CHARGE LINE on the 111 back panel.

3. Connect the 111 PULSE OUTPUT to the 1S1 SIGNAL IN through a 5X and a 111 VARIABLE ATTENUATOR.
4. Adjust the TIME POSITION control to position the rising portion of the 111 Pulse near the CRT center area.
5. By adjusting the mVOLTS/CM switch and the 111 VARIABLE ATTENUATOR obtain 5 cm of 111 Pulse amplitude (see figure 5-49).

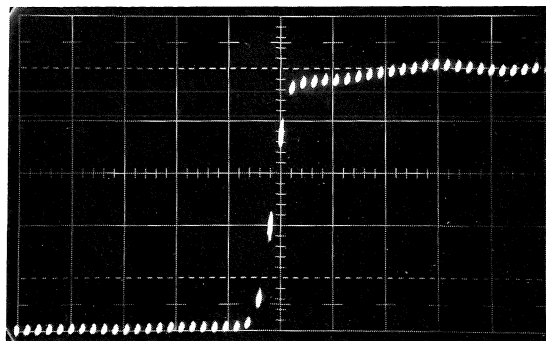


Figure 5-49

6. Turn the SMOOTHING control to the CCW extreme.
7. The amplitude of the waveform must not have changed more than .15 cm. (3%) from step 5 (see figure 5-50).

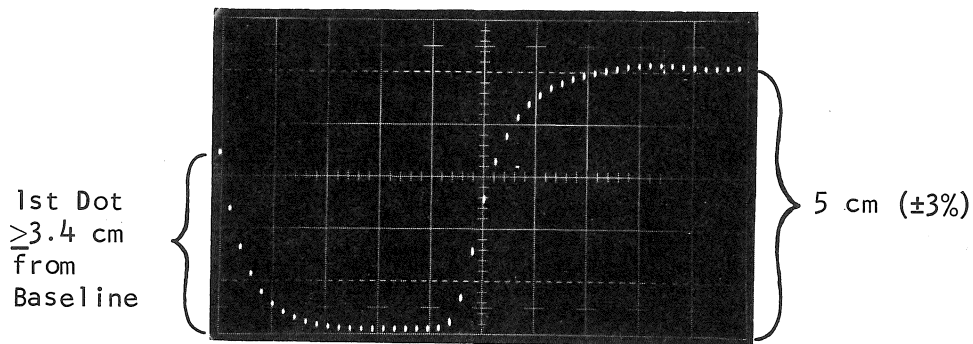
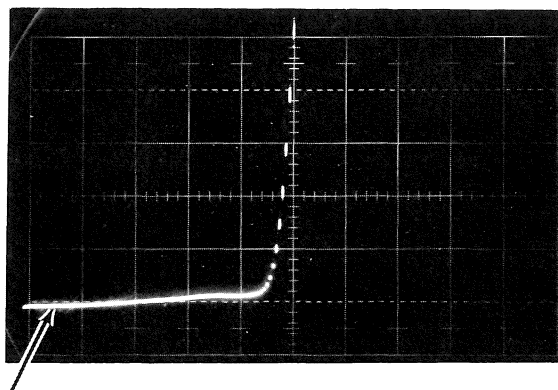


Figure 5-50

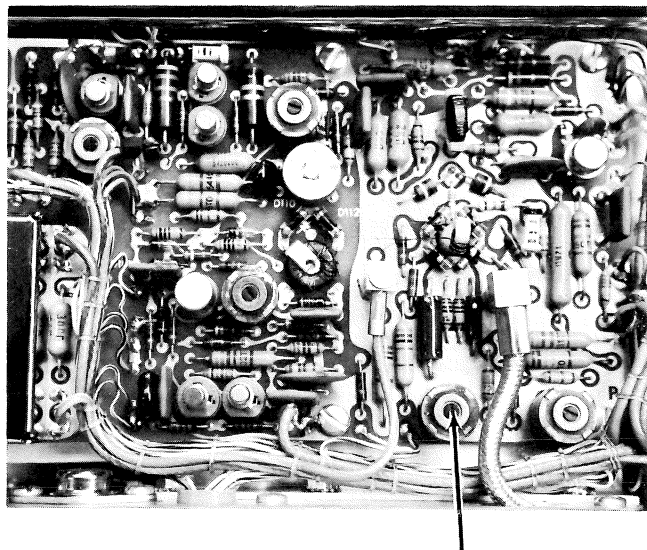
8. With the amplitude of the waveform at 5 cm the first dot must be at least 3.4 cm above the baseline.
 9. Return the SMOOTHING control to the CW extreme.
- B. Maximum Signal In Check ($\geq 2.2v$)
1. Set the mVOLTS/CM switch to 200.
 2. The REPETITION RATE of the I11 must be approximately 100 kc.
 3. Increase the input to the ISI with the I11 VARIABLE ATTENUATOR until the baseline at the left side of the CRT starts to move up.
 4. Insert a 10X GR attenuator between the I11 and the ISI SIGNAL IN.
 5. Measure the signal amplitude and multiply by 10. The result should be $\geq 2.2v$.



Increase I11 input until the baseline starts to move up.

Figure 5-51

5. If the amplitude is less than 2.2v, R-21, the Bridge volts adjustment (see figure 5-52) must be adjusted until the result is 2.2 volts.



Bridge Volts R-21

Figure 5-52

NOTE: If R-21 is adjusted the snap off current, R85, must be readjusted for risetime.

- C. Scaling Shift Check ($\leq \pm 4$ mv from 20 kc to 100 kc) and Low Frequency Shift Check ($\leq \pm 4$ mv from 20 kc to 30 cps).
 1. Adjust the 111 VARIABLE ATTENUATOR for an amplitude of ≈ 200 mv.
 2. Remove the Output of the 111 from the SIGNAL IN on the 1S1 and apply it through a male BNC to GR adapter to the EXT TRIG connection. (Do not apply more than 200 mv.)
 3. Set the repetition rate of the 111 to approximately 20 kc.
 4. 1S1 Setup
 - a. Set the mVOLTS/CM switch to 2.
 - b. Position the top of the trace to graticule center with the VERT POSITION control.
 - c. Set the TRIGGER SOURCE switch + EXT.

- d. Adjust the TRIGGERING LEVEL control CCW until the trace dims a small amount. (This indicates that the sweep is being triggered).
 5. Slowly increase the 111 REPETITION RATE control from 20 kc to 100 kc. The top of the trace must not move more than ± 4 mv (2 cm) from graticule center at any repetition rate.
 6. Return the 111 REPETITION RATE to approximately 20 kc.
 7. Slowly decrease the 111 REPETITION RATE from 20 kc to 30 cps. The top of the trace must not move more than ± 4 mv (2 cm) from graticule center at any repetition rate.
- D. Memory Slash Check (≤ 1 cm at 10 cps)
1. Set the REPETITION RATE of the 111 to 10 cps.
 - a. Set the REPETITION RATE control CCW to MIN.
 - b. Set the REPETITION RATE switch to 10.
 2. Return the mVOLTS/CM switch to 200.
 3. The trace must not fall vertically more than 1 cm between steps.
 4. Remove the Output of the 111 from the 1S1 EXT TRIG and return the TRIGGER SENSITIVITY to the CW position.

VIII. MISCELLANEOUS CHECKS

A. Random Noise Check (≤ 1 mv)

1. Adjust the SAMPLES/CM control to midrange.
2. Set the mVOLTS/CM switch to 2.
3. Set the TIME/CM switch to 50 nSEC.
4. Set the TRIGGER SENSITIVITY control to the CW extreme.
5. Check for not more than 1/2 cm (1 mv) of noise on the trace. (90% of Dots $< 1/2$ cm).

B. Position Range Check ($\geq \pm 5$ cm)

1. Set the mVOLTS/CM switch to 50.
2. Set the VERT POSITION control to the CCW extreme.
3. Adjust the DC OFFSET to position the trace under the bottom graticule line.
4. Position the trace under the top graticule line with the VERT POSITION.
5. Readjust to DC offset to again position the trace under the bottom graticule line.
6. Turn the VERT POSITION control to the CW extreme. The trace must now be positioned at least 4 cm above the bottom graticule line.

C. Offset Range Check ($\geq \pm 1$ v indicated CRT Voltage)

1. Set the mVOLTS/CM switch to 200.
2. Set the DC OFFSET control to the CCW extreme.
3. Position the trace under the bottom graticule line with the VERT POSITION control.
4. Position the trace under the top graticule line with the DC OFFSET.
5. Again position the trace under the bottom graticule line with the VERT POSITION control.
6. Turn the DC OFFSET control to its CW extreme.
7. The trace must be at least 4 cm above the bottom graticule line.

D. Retrace Blanking Check

1. Set both the DC OFFSET control and the VERT POSITION control to the CW extreme.
2. Set the mVOLTS/CM switch to 2.
3. Set the TRIGGER SOURCE switch to FREE RUN.
4. Turn the DC OFFSET in the CCW direction to see that the retrace cannot be positioned on the CRT.

NOTE: As the DC OFFSET is turned CCW the trace will be positioned on the CRT. However, the trace can be distinguished from the retrace by the amount of noise. The trace will have approximately 1/2 cm of noise whereas the retrace will have no noise.

E. Interdot Blanking Check ($\geq 1.5 \mu\text{SEC}$)

1. 545B Setup.
 - a. Set the HORIZONTAL DISPLAY switch to 'A'.
 - b. Set the 'A' TIME/CM switch to 5 μSEC .
 - c. Set the 'A' Triggering mode to AUTO and the TRIGGER SLOPE to + INT.

NOTE: The amplitude of the blanking Pulse is ≈ 12 cm.

If a stable display on AUTO is not easily obtained AC may have to be used.

2. Set the mVOLTS/CM switch on the 1S1 to 200.
3. Adjust the VERT POSITION and the DC OFFSET controls on the 1S1 to position the trace near the center of the graticule.
4. Turn the 5X MAGNIFIER ON on the 545B.
5. Each Blanked area must be at least 1.5 cm long. (1.5 μSEC).
6. Turn the 5X MAGNIFIER OFF and return the HORIZONTAL DISPLAY switch to EXT X1.

F. Single Sweep Operation Check (sweeps once per start--no miss or repetitive sweep).

1. Set the DISPLAY MODE switch to single sweep.
2. Press the SINGLE SWEEP START start button several times. Each time the button is pushed there must be one sweep across the CRT.

- G. MIN and MAX SAMPLES/CM Check (Between 4 and 6 samples/cm at MIN and perceptible trace movement at MAX).
1. Set the TIME/CM control on the ISI to 5 nSEC.
 2. Set the SAMPLES/CM control to MIN (CW).
 3. There must be between 4 and 6 samples/cm displayed on the CRT.
 4. Set the SAMPLES/CM control to MAX (CCW) but not in the SWEEP OFF detent position.
 5. The sweep must have a perceptible movement.
 6. Return the SAMPLES/CM control to midrange.
- H. External Horiz Input Deflection Factor Check (From 1 v/cm \pm 3% to \geq 16 v/cm).
1. Set the DISPLAY MODE switch to EXT HORIZ.
 2. Set the EXT HORIZ ATTEN control to the CW extreme.
 3. Apply 1 v from the STANDARD SQUARE WAVE CALIBRATOR to the EXT HORIZ INPUT on the ISI.
 4. There must be 1 cm \pm 3% of separation between the two CRT spots.
 5. Adjust the EXT HORIZ ATTEN control to the CCW extreme.
 6. Apply 20v from the STANDARD SQUARE WAVE CALIBRATOR to the EXT HORIZ INPUT.
 7. There must not be more than 1 cm of separation between the CRT spots.

NOTE: This step is checking END RESISTANCE on the Pot.

A good pot will show no separation between CRT spots.

TYPE 1S1 NEW PARTS

Following is a list of electrical parts used in the 1S1 that are new to Tektronix, Inc.:

SW215	260-0687-00	262-0718-00	Q485	151-0162-00
R293	311-0531-00		D315	152-0205-00
R295	321-0306-00		D362	152-0211-00
R280	321-0365-00		D304, D345	152-0214-00
R410	120-0399-00		C461	283-0119-00
SW400	260-0685-00	262-0719-00	C342	283-0115-00
SW60	260-0686-00	262-0720-00	C479	283-0116-00
R165	311-0538-00		C302, C446	
SW500 A,B	260-0684-00	262-0721-00	C448	283-0599-00
R500 A	311-0527-00		R334	308-0361-00
T630	120-0400-00		R370	311-0465-00
SW203	260-0689-00		R420	311-0496-00
R606	308-0209-00		R335	311-0540-00
R640	308-0353-00		R478	316-0825-00
R172	311-0449-00		R342	317-0391-00
R475	311-0528-00		R656	323-0149-00
R159	311-0529-00		R657	323-0195-00
R365 A,B	311-0530-00		C480C	283-0114-00
R56	311-0535-00		C480A	285-0683-00
R140	321-0684-00		C480B	290-0269-00
T110	120-0401-00		C326A,B, C,D	295-0087-00
L130	120-0402-00		R520C	321-0662-00
T88	120-0403-00		R510B	321-0664-00
J5, J88	131-0391-00		R510C	321-0667-00
D11A,B,C,D	152-0216-00		R520B	321-0668-00
C136	283-0599-00		R530A	321-0670-00
R86	308-0299-00		R530F	321-0671-00
L10	308-0357-00		R530E	321-0672-00
L11	308-0358-00		R530B	321-0673-00
R30, R194	311-0510-00		R510A	321-0678-00
R185	315-0304-00		R530C	321-0679-00
R109	321-0170-00		R520A	321-0681-00
T340	120-0374-00		R145P	321-0706-00
J410, J320	131-0391-00		R145N	321-0707-00

Type 1S1 New Parts:

R58F	321-0002-00	R42	321-0374-00
R58E	321-0030-00	R190	321-0434-00
R170	321-0215-00	R139	321-0685-00
R60F	321-0654-00	R64	323-0339-00
R60E	321-0655-00	R366	323-0407-00
R60D	321-0656-00	R17	323-0474-00
R58D	321-0657-00	R16	323-0490-00
R60C	321-0658-00		
R60B	321-0659-00		
R60A	321-0660-00		
R58A	321-0661-00		
R145H	321-0663-00		
R145A	321-0665-00		
R145G	321-0666-00		
R145F	321-0669-00		
R145L	321-0674-00		
R145E	321-0675-00		
R145K	321-0680-00		
R145C	321-0682-00		
R145B	321-0683-00		
R440	321-0210-00		
R313	321-0265-00		
R203, R215	321-0267-00		
R495	321-0281-00		
R375	321-0363-00		
R372	321-0401-00		
R483	323-0339-00		
	388-0639-00	EC BOARD HORIZ	
R19, R27	321-0305-00		
R101	321-0307-00		
R32	321-0324-00		
R70	321-0342-00		

TYPE 1S1 ELECTRICAL PARTS

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Description			
Capacitors					
Tolerance $\pm 20\%$ unless otherwise indicated.					
C4*		270 pf			
C5*		470 pf			
C33	281-0578-00	18 pf	Cer	500v	5%
C36	281-0538-00	1 pf	Cer	500v	
C37	281-0538-00	1 pf	Cer	500v	
C39	283-0059-00	1 μ f	Cer	25v	
C42	283-0079-00	0.01 μ f	Cer	250v	
C49	283-0059-00	1 μ f	Cer	25v	
C54	283-0059-00	1 μ f	Cer	25v	
C56	283-0065-00	0.001 μ f	Cer	100v	5%
C66	283-0059-00	1 μ f	Cer	25v	
C68	283-0092-00	0.03 μ f	Cer	200v	
C74	283-0026-00	0.2 μ f	Cer	25v	
C76	283-0594-00	0.001 μ f	Mica	100v	1%
C80	283-0067-00	0.001 μ f	Cer	200v	10%
C81	281-0523-00	100 pf	Cer	350v	
C82	283-0067-00	0.001 μ f	Cer	200v	10%
C83	283-0059-00	1 μ f	Cer	25v	
C84	281-0573-00	11 pf	Cer		10%
C85	283-0067-00	0.001 μ f	Cer	200v	10%
C86	283-0079-00	0.01 μ f	Cer	250v	
C87	281-0572-00	6.8 pf	Cer	500v	10%
C88*		33 pf			
C89*		33 pf			
C93	283-0026-00	0.2 μ f	Cer	25v	
C101	283-0026-00	0.2 μ f	Cer	25v	
C110	283-0051-00	0.0033 μ f	Cer	100v	5%
C115	283-0067-00	0.001 μ f	Cer	200v	10%

* Furnished with Vertical E.C. Board.

Capacitors (cont.)

C122	281-0504-00	10 pf	Cer		500v	10%
C133	283-0026-00	0.2 μ f	Cer		25v	
C135	281-0022-00	8-50 pf	Cer	Var		
C136	283-0599-00	98 pf	Mica		500v	5%
C145	283-0067-00	0.001 μ f	Cer		200v	10%
C157	283-0079-00	0.01 μ f	Cer		250v	
C192	283-0079-00	0.01 μ f	Cer		250v	
C205	283-0077-00	330 pf	Cer		500v	5%
C210	285-0598-00	0.01 μ f	PTM		100v	5%
C220	283-0060-00	100 pf	Cer		200v	5%
C228	283-0000-00	0.001 μ f	Cer		500v	
C232	283-0004-00	0.02 μ f	Cer		150v	
C240	283-0060-00	100 pf	Cer		200v	5%
C246	285-0598-00	0.01 μ f	PTM		100v	5%
C249	283-0095-00	56 pf	Cer		200v	10%
C250	283-0004-00	0.02 μ f	Cer		150v	
C257	283-0004-00	0.02 μ f	Cer		150v	
C258	283-0054-00	150 Pf	Cer		200v	5%
C262	285-0643-00	0.0047 μ f	PTM		100v	5%
C266	283-0004-00	0.02 μ f	Cer		150v	
C269	283-0004-00	0.02 μ f	Cer		150v	
C272	283-0060-00	100 pf	Cer		200v	5%
C276	283-0060-00	100 pf	Cer		200v	5%
C283	283-0004-00	0.02 μ f	Cer		150v	
C298	283-0004-00	0.02 μ f	Cer		150v	
C299	283-0004-00	0.02 μ f	Cer		150v	
C302	283-0599-00	98 pf	Mica		500v	5%
C306	283-0051-00	0.0033 μ f	Cer		100v	5%
C313	283-0081-00	0.1 μ f	Cer		25v	
C315	283-0060-00	100 pf	Cer		250v	5%
C325	281-0061-00	5.5-18 pf	Cer	Var		
C326A	*295-0087-00	0.5 μ f		Timing Capacitor		
C326B		0.05 μ f				
C326C		0.00495 μ f				
C326D		450 pf				

Capacitors (cont.)

C330	283-0081-00	0.1 μ f	Cer	25v	
C335	283-0004-00	0.02 μ f	Cer	150v	
C342	283-0115-00	47 pf	Cer	200v	5%
C357	283-0081-00	0.1 μ f	Cer	25v	
C362	283-0000-00	0.001 μ f	Cer	500v	
C377	283-0076-00	27 pf	Cer	500v	10%
C380	283-0000-00	0.001 μ f	Cer	500v	
C391	283-0004-00	0.02 μ f	Cer	150v	
C397	283-0081-00	0.1 μ f	Cer	25v	
C399	283-0081-00	0.1 μ f	Cer	25v	
C412	283-0079-00	0.01 μ f	Cer	250v	
C413	283-0079-00	0.01 μ f	Cer	250v	
C415	283-0081-00	0.1 μ f	Cer	25v	
C418	283-0069-00	15 pf	Cer	50v	
C420	283-0004-00	0.02 μ f	Cer	150v	
C424	283-0072-00	0.01 μ f	Cer		
C435	283-0004-00	0.02 μ f	Cer	150v	
C446	283-0599-00	98 pf	Mica	500v	5%
C448	283-0599-00	98 pf	Mica	500v	5%
C454	283-0081-00	0.1 μ f	Cer	25v	
C461	283-0119-00	0.0022 μ f	Cer	200v	5%
C462	283-0070-00	30 pf	Cer	50v	10%
C464	283-0059-00	1 μ f	Cer	25v	
C475	283-0000-00	0.001 μ f	Cer	500v	
C479	283-0116-00	820 pf	Cer	500v	5%
C480A	285-0683-00	0.022 μ f	PTM	100v	5%
C480B	290-0269-00	0.22 μ f	EMT	35v	5%
C480C	283-0114-00	0.0015 μ f	Cer	200v	
C487	283-0060-00	100 pf	Cer	200v	5%
C497	283-0004-00	0.02 μ f	Cer	150v	
C614	283-0067-00	0.001 μ f	Cer	200v	10%
C627	290-0215-00	100 μ f	EMT	25v	
C632	290-0122-00	1000 μ f	EMC	50v	
C634	283-0092-00	0.03 μ f	Cer	200v	
C657	290-0215-00	100 μ f	EMT	25v	

Diodes

D11A,B,C,D	*152-0216-00	GaAs, 2 pairs, matched	
D66	*152-0185-00	Silicon	Replaceable by 1N3605
D80	152-0071-00	Germanium	ED 2007
D82	152-0071-00	Germanium	ED 2007
D87	*152-0115-00	GaAs	Tek made
D90	152-0071-00	Germanium	ED 2007
D92	*152-0185-00	Silicon	Replaceable by 1N3605
D101	152-0034-00	Zener	1N753 0.4w, 6.2v, 5%
D103	152-0071-00	Germanium	ED 2007
D107	152-0071-00	Germanium	ED 2007
D109	*152-0185-00	Silicon	Replaceable by 1N3605
D110}	*152-0083-00	GaAs, 1 pair	Tek made
D112}			
D118	*152-0107-00	Silicon	Replaceable by 1N647
D175	*152-0185-00	Silicon	Replaceable by 1N3605
D183	*152-0185-00	Silicon	Replaceable by 1N3605
D185	*152-0185-00	Silicon	Replaceable by 1N3605
D186	*152-0185-00	Silicon	Replaceable by 1N3605
D187	*152-0185-00	Silicon	Replaceable by 1N3605
D188	*152-0185-00	Silicon	Replaceable by 1N3605
D205	*152-0185-00	Silicon	Replaceable by 1N3605
D210	*152-0185-00	Silicon	Replaceable by 1N3605
D215	*152-0185-00	Silicon	Replaceable by 1N3605
D216	152-0141-00	Silicon	1N3605
D237	*152-0185-00	Silicon	Replaceable by 1N3605
D246	*152-0045-00	Silicon	Selected from 1N622A
D247	*152-0075-00	Germanium	Tek Spec
D260	*152-0185-00	Silicon	Replaceable by 1N3605
D262	*152-0045-00	Silicon	Selected from 1N622A
D272	*152-0185-00	Silicon	Replaceable by 1N3605
D285	152-0139-00	Zener	1N751 0.4w, 5.1v, 10%
D292	*152-0185-00	Silicon	Replaceable by 1N3605
D297	*152-0185-00	Silicon	Replaceable by 1N3605
D304	152-0214-00	Tunnel	TD252 4.7 MA
D315	*152-0205-00	GaAs	Tek made
D340	*152-0125-00	Tunnel	Selected TD 3A 4.7 MA

Diodes (cont.)

D345	152-0214-00	Tunnel	TD252	4.7 MA
D362	*152-0211-00	GaAs	Tek made	
D430	152-0177-00	Tunnel	TD253B	10 MA
D432	152-0070-00	Back	BD4	0.1 MA
D449	152-0154-00	Tunnel	TD253	10 MA
D456	152-0008-00	Germanium		
D462	152-0008-00	Germanium		
D464	152-0008-00	Germanium		
D470	152-0008-00	Germanium		
D472	*152-0185-00	Silicon	Replaceable by 1N3605	
D482	*152-0185-00	Silicon	Replaceable by 1N3605	
D490	152-0008-00	Germanium		
D492	152-0008-00	Germanium		
D616	*152-0185-00	Silicon	Replaceable by 1N3605	
D630	152-0066-00	Silicon	1N3194	
D632	152-0066-00	Silicon	1N3194	
D636	*152-0185-00	Silicon	Replaceable by 1N3605	
D638	152-0008-00	Germanium		
D645	152-0034-00	Zener	1N753	0.4w, 6.2v, 10%
D662	152-0034-00	Zener	1N753	0.4w, 6.2v, 10%

Connectors

J1★		
J5	131-0391-00	Coax, Etched Circuit mtg., male
P5★		
P11	131-0017-00	Chassis mtg., 16 contact, male
J88	131-0391-00	Coax, Etched Circuit mtg., male
P88	131-0375-00	Right Angle
J140	*136-0140-00	Socket, Banana Jack Assy.
J145	*136-0140-00	Socket, Banana Jack Assy.
J285	*136-0140-00	Socket, Banana Jack Assy.
J295	*136-0140-00	Socket, Banana Jack Assy.
J320	131-0391-00	Coax, Etched Circuit mtg., male

Connectors (cont.)

P320	131-0375-00	Right Angle
J400	131-0106-00	Chassis Mtg., 1 contact, female
J410	131-0391-00	Coax, Etched Circuit mtg., male
P410	131-0375-00	Right Angle
P640	131-0206-00	Probe Power

Inductors

L1	108-0213-00	2.5 mh
L2	276-0535-00	Core, Toroid
L10	*308-0357-00	4.7 μ h (670 Ω WW resistor)
L11	*308-0358-00	1.4 μ h (1400 Ω WW resistor)
L52	*120-0306-00	Toroid, 40 turns single
L130	*120-0402-00	Toroid, 3 turns
L250	*120-0342-00	Toroid, 10 turns
L302	276-0543-00	Core, Ferrite
L326	276-0549-00	Core, Ferrite
L350	276-0535-00	Core, Toroid
L352	276-0549-00	Core, Ferrite
L354	276-0549-00	Core, Ferrite
L428	*108-0170-00	0.5 μ h
L449	276-0543-00	Core, Ferrite

Transistors

Q54	*151-0134-00	Replaceable by 2N2905
Q64	*151-0108-00	Replaceable by 2N2501
Q74	*151-0151-00	Replaceable by 2N930
Q80	*151-0083-00	Selected from 2N964
Q94	151-0063-00	2N2207
Q634	*151-0151-00	Replaceable by 2N930
Q653	*151-0136-00	Replaceable by 2N3053
Q657	*151-0148-00	Selected (RCA 40250)
Q667	*151-0136-00	Replaceable by 2N3053

Resistors

R1	*308-0224-00	2.45k	1/2w	WW	1%
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Resistors (cont.)

R4*		5 Ω			
R5*		15 Ω			
R7	321-0636-00	100 Ω	1/8w	Prec	1/2%
R8	321-0636-00	100 Ω	1/8w	Prec	1/2%
R13	315-0512-00	5.1k	1/4w		5%
R14	315-0223-00	22k	1/4w		5%
R16	323-0490-00	1.24 meg	1/2w	Prec	1%
R17	323-0474-00	845k	1/2w	Prec	1%
R19	321-0305-00	14.7k	1/8w	Prec	1%
R21	315-0512-00	5.1k	1/4w		5%
R22	311-0497-00	50k		Var	Bridge Volts
R24	323-0469-00	750k	1/2w	Prec	1%
R25	323-0498-00	1.5 meg	1/2w	Prec	1%
R27	321-0305-00	14.7k	1/8w	Prec	1%
R30	311-0510-00	10k		Var	Bridge Bal
R32	321-0324-00	23.2k	1/8w	Prec	1%
R33	321-0452-00	499k	1/8w	Prec	1%
R34	321-0381-00	90.9k	1/8w	Prec	1%
R36	317-0200-00	20 Ω	1/8w		5%
R38	308-0291-00	2k	3w	WW	5%
R39	321-0122-00	182 Ω	1/8w	Prec	1%
R42	321-0374-00	76.8k	1/8w	Prec	1%
R44	308-0310-00	12k	5w	WW	1%
R47	323-0404-00	158k	1/2w	Prec	1%
R49	315-0101-00	100 Ω	1/4w		5%
R51	308-0291-00	2k	3w	WW	5%
R52	321-0247-00	3.65k	1/8w	Prec	1%
R54	315-0101-00	100 Ω	1/4w		5%
R56**	311-0535-00	2.5k		Var	SMOOTHING
R58A	321-0661-00	600 Ω	1/8w	Prec	1%
R58B	321-0126-00	200 Ω	1/8w	Prec	1%
R58C	321-0097-00	100 Ω	1/8w	Prec	1%
R58D	321-0657-00	60 Ω	1/8w	Prec	1%
R58E	321-0030-00	20 Ω	1/8w	Prec	1%

* Furnished with Vertical E.C. Board.

** R56, R254, and SW 254 furnished as a unit.

Resistors (cont.)

R58F	321-0001-00	10 Ω	1/8w	Prec	1%
R60A	321-0660-00	417 Ω	1/8w	Prec	1%
R60B	321-0659-00	139 Ω	1/8w	Prec	1%
R60C	321-0653-00	69.4 Ω	1/8w	Prec	1%
R60D	321-0658-00	21.3 Ω	1/8w	Prec	1%
R60E	321-0655-00	10.3 Ω	1/8w	Prec	1%
R60F	321-0654-00	10.1 Ω	1/8w	Prec	1%
R62	321-0193-00	1k	1/8w	Prec	1%
R64	323-0339-00	33.2k	1/2w	Prec	1%
R66	321-0250-00	3.92k	1/8w	Prec	1%
R67	321-0339-00	33.2k	1/8w	Prec	1%
R68	315-0183-00	18k	1/4w		5%
R69	315-0183-00	18k	1/4w		5%
R70	321-0342-00	35.7k	1/8w	Prec	1%
R72	315-0472-00	4.7k	1/4w		5%
R74	315-0101-00	100 Ω	1/4w		5%
R76	315-0750-00	75 Ω	1/4w		5%
R80	315-0510-00	51 Ω	1/4w		5%
R82	315-0471-00	470 Ω	1/4w		5%
R83	315-0100-00	10 Ω	1/4w		5%
R84	315-0390-00	39 Ω	1/4w		5%
R85	311-0323-00	1.5k		Var	Snap-Off Current
R86	308-0299-00	300 Ω	3w	WW	1%
R87	315-0390-00	39 Ω	1/4w		5%
R88	315-0101-00	100 Ω	1/4w		5%
R89	315-0101-00	100 Ω	1/4w		5%
R92	315-0272-00	2.7k	1/4w		5%
R93	315-0100-00	10 Ω	1/4w		5%
R95	311-0497-00	50k	1/4w	Var	Memory Gate Width
R96	315-0432-00	4.3k	1/4w		5%
R98	315-0102-00	1k	1/4w		5%
R99	315-0392-00	3.9k	1/4w		5%
R101	321-0307-00	15.4k	1/8w	Prec	1%
R103	321-0222-00	2k	1/8w	Prec	1%
R105	323-0353-00	46.4k	1/2w	Prec	1%

Resistors (cont.)

R107	321-0222-00	2k	1/8w		Prec	1%
R109	321-0170-00	576Ω	1/8w		Prec	1%
R110	311-0480-00	500Ω		Var	Memory Bal	
R111	323-0353-00	46.4k	1/2w		Prec	1%
R114	308-0258-00	6k	3w		WW	5%
R115	301-0472-00	4.7k	1/2w			5%
R118	323-0353-00	46.4k	1/2w		Prec	1%
R120	321-0339-00	33.2k	1/8w		Prec	1%
R124	304-0104-00	100k	1w			
R126	315-0101-00	100Ω	1/4w			5%
R128	315-0563-00	56k	1/4w			5%
R130	308-0313-00	20k	3w		WW	1%
R133	315-0101-00	100Ω	1/4w			5%
R139	321-0685-00	30k	1/8w		Prec	1/2%
R140	321-0684-00	15k	1/8w		Prec	1/2%
R145A	321-0665-00	2.16k	1/8w		Prec	1/2%
R145B	321-0683-00	182.5k	1/8w		Prec	1/2%
R145C	321-0682-00	60.83k	1/8w		Prec	1/2%
R145D	321-0677-00	30.4k	1/8w		Prec	1/2%
R145E	321-0675-00	18.25k	1/8w		Prec	1/2%
R145F	321-0669-00	6.08k	1/8w		Prec	1/2%
R145G	321-0666-00	3.04k	1/8w		Prec	1/2%
R145H	321-0663-00	1.07k	1/8w		Prec	1/2%
R145K	321-0680-00	35.3k	1/8w		Prec	1/2%
R145L	321-0674-00	17.4k	1/8w		Prec	1/2%
R145N	321-0707-00	16.5k	1/8w		Prec	1/2%
R145P	321-0706-00	25.5k	1/8w		Prec	1/2%
R153	303-0433-00	43k	1w			5%
R157	315-0201-00	200Ω	1/4w			5%
R159★	311-0529-00	2.5k		Var	DC OFFSET ±1v	
R165	*311-0538-00	7k		Var	VARIABLE (mvolts/cm)	
R167	301-0563-00	56k	1/2w			5%
R168	311-0329-00	50k		Var	VAR BAL	
R170	321-0215-00	1.69k	1/8w		Prec	1%
R172	311-0449-00	1.5k		Var	VERT GAIN	
R174	321-0286-00	9.31k	1/8w		Prec	1%

★R159 and R192 furnished as a unit.

Resistors (cont.)

R175	315-0302-00	3k	1/4w		5%
R177	321-0328-00	25.5k	1/8w	Prec	1%
R180	323-0382-00	93.1k	1/2w	Prec	1%
R183	301-0303-00	30k	1/2w		5%
R185	315-0304-00	300k	1/4w		5%
R190	321-0434-00	324k	1/8w	Prec	1%
R192★	311-0529-00	2.5k		Var	VERT POSITION
R193	321-0392-00	118k	1/8w	Prec	1%
R194	311-0510-00	10k		Var	Position Range
R197	315-0101-00	100Ω	1/4w		5%
R199	301-0303-00	30k	1/2w		5%
R203	316-0106-00	10 meg	1/4w		
R205	315-0103-00	10k	1/4w		5%
R208	321-0267-00	5.9k	1/8w	Prec	1%
R210	315-0303-00	30k	1/4w		5%
R212	315-0101-00	100Ω	1/4w		5%
R215	321-0267-00	5.9k	1/8w	Prec	1%
R220	315-0103-00	10k	1/4w		5%
R225	315-0272-00	2.7k	1/4w		5%
R228	315-0154-00	150k	1/4w		5%
R230	315-0102-00	1k	1/4w		5%
R232	315-0101-00	100Ω	1/4w		5%
R235	315-0154-00	150k	1/4w		5%
R237	315-0123-00	12k	1/4w		5%
R240	315-0333-00	33k	1/4w		5%
R244	315-0272-00	2.7k	1/4w		5%
R246	315-0822-00	8.2k	1/4w		5%
R247	315-0123-00	12k	1/4w		5%
R250	315-0510-00	51Ω	1/4w		5%
R252	315-0101-00	100Ω	1/4w		5%
R254**	311-0535-00	20k		Var	SAMPLES/CM
R255	315-0221-00	220Ω	1/4w		5%
R256	315-0222-00	2.2k	1/4w		5%

★ R159 and R192 furnished as a unit.

** R254, R56, and SW254 furnished as a unit.

Resistors (cont.)

R258	315-0152-00	1.5k	1/4w		5%
R260	315-0183-00	18k	1/4w		5%
R262	315-0390-00	39Ω	1/4w		5%
R264	315-0101-00	100Ω	1/4w		5%
R266	315-0101-00	100Ω	1/4w		5%
R268	315-0101-00	100Ω	1/4w		5%
R269	315-0103-00	10k	1/4w		5%
R270	311-0462-00	1k		Var	Staircase DC Level
R274	306-0184-00	180k	2w		
R276	315-0103-00	10k	1/4w		5%
R280	321-0365-00	61.9k	1/8w		Prec 1%
R283	315-0101-00	100Ω	1/4w		5%
R285	315-0103-00	10k	1/4w		5%
R286	315-0471-00	470Ω	1/4w		5%
R287	201-0202-00	2k	1/2w		5%
R290	311-0480-00	500Ω		Var	Sweep Length
R292	321-0366-00	63.4k	1/8w		Prec 1%
R293	311-0531-00	100k		Var	MANUAL SCAN EXT HORIZ ATTEN
R295	321-0306-00	15k	1/8w		Prec 1%
R297	315-0511-00	510Ω	1/4w		5%
R298	315-0101-00	100Ω	1/4w		5%
R299	315-0101-00	100Ω	1/4w		5%
R305	315-0471-00	470Ω	1/4w		5%
R306	317-0750-00	75Ω	1/8w		5%
R308	315-0202-00	2k	1/4w		5%
R309	315-0163-00	16k	1/4w		5%
R310	315-0330-00	33Ω	1/4w		5%
R313	321-0265-00	5.62k	1/8w		Prec 1%
R320	311-0442-00	250Ω		Var	Comparator Level
R326A	315-0510-00	51Ω	1/4w		5%
R326B	315-0510-00	51Ω	1/4w		5%
R328	315-0101-00	100Ω	1/4w		5%
R330	315-0100-00	10Ω	1/4w		5%
R334	308-0361-00	14.5k	3w		WW 1%

Resistors (cont.)

R335	311-0540-00	2.5k		Var	Timing Cal
R338	321-0085-00	75Ω	1/8w		Prec 1%
R342	317-0391-00	390Ω	1/8w		5%
R344	315-0392-00	3.9k	1/4w		5%
R345	317-0200-00	20Ω	1/8w		5%
R350	315-0122-00	1.2k	1/4w		5%
R352	315-0152-00	1.5k	1/4w		5%
R353	315-0332-00	3.3k	1/4w		5%
R354	315-0682-00	6.8k	1/4w		5%
R356	315-0102-00	1k	1/4w		5%
R357	315-0101-00	100Ω	1/4w		5%
R365A } R365B }	311-0530-00	5k 50k		Var	TIME POSITION FINE
R366	323-0407-00	169k	1/2w		Prec 1%
R367	301-0165-00	1.6 meg	1/2w		5%
R370	311-0465-00	100k		Var	Delay Line
R372	321-0401-00	147k	1/8w		Prec 1%
R375	321-0363-00	59k	1/8w		Prec 1%
R377	321-0261-00	5.11k	1/8w		Prec 1%
R380	311-0442-00	250Ω		Var	Inverter DC Zero
R383	321-0297-00	12.1k	1/8w		Prec 1%
R385	315-0393-00	39k	1/4w		5%
R389	305-0273-00	27k	2w		5%
R391	315-0271-00	270Ω	1/4w		5%
R397	315-0270-00	27Ω	1/4w		5%
R399	315-0270-00	27Ω	1/4w		5%
R401	315-0101-00	100Ω	1/4w		5%
R402	315-0101-00	100Ω	1/4w		5%
R405	315-0101-00	100Ω	1/4w		5%
R406	315-0101-00	100Ω	1/4w		5%
R412	315-0101-00	100Ω	1/4w		5%
R413	315-0101-00	100Ω	1/4w		5%
R415	317-0390-00	39Ω	1/8w		5%

Resistors (cont)

R418	322-0218-00	1.82k	1/4w		Prec	1%
R420	311-0496-00	2.5k		Var	Int Trig Level	
R423	321-0261-00	5.11k	1/8w		Prec	1%
R424	321-0204-00	1.3k	1/8w		Prec	1%
R428	317-0390-00	39 Ω	1/8w			5%
R435*	311-0528-00	10k		Var	TRIGGER SENSITIVITY	
R437	322-0239-00	3.01k	1/4w		Prec	1%
R440	321-0210-00	1.5k	1/8w		Prec	1%
R444	317-0510-00	51 Ω	1/8w			5%
R446	317-0101-00	100 Ω	1/8w			5%
R448	315-0510-00	51 Ω	1/4w			5%
R449	315-0390-00	39 Ω	1/4w			5%
R450	315-0751-00	750 Ω	1/4w			5%
R454	315-0330-00	33 Ω	1/4w			5%
R456	315-0222-00	2.2k	1/4w			5%
R458	315-0102-00	1k	1/4w			5%
R460	311-0462-00	1k		Var	Control TD Bias	
R461	315-0751-00	750 Ω	1/4w			5%
R464	307-0103-00	2.7 Ω	1/4w			5%
R470	315-0102-00	1k	1/4w			5%
R473	301-0823-00	82k	1/2w			5%
R475**	311-0528-00	50k		Var	Recovery Time	
R478	316-0825-00	8.2 meg	1/4w			
R480	316-0475-00	4.7 meg	1/4w			
R483	323-0339-00	33.2k	1/2w		Prec	1%
R487	315-0102-00	1k	1/4w			5%
R489	315-0391-00	390 Ω	1/4w			5%
R493	315-0123-00	12k	1/4w			5%
R495	321-0281-00	8.25k	1/8w		Prec	1%
R497	322-0349-00	42.2k	1/4w		Prec	1%
R499	315-0271-00	270 Ω	1/4w			5%
R500A	311-0527-00	2k		Var	VARIABLE (Time/cm)	
R500B	321-0193-00	1k	1/8w		Prec	1%

* Furnished as a unit with R475 and SW475.

** Furnished as a unit with R435 and SW475.

Resistors (cont.)

R510A	321-0678-00	33.9k	1/8w	Prec	1/2%
R510B	321-0664-00	1.56k	1/8w	Prec	1/2%
R510C	321-0667-00	3.77k	1/8w	Prec	1/2%
R520A	321-0681-00	37.3k	1/8w	Prec	1/2%
R520B	321-0668-00	4.63k	1/8w	Prec	1/2%
R520C	321-0662-00	377Ω	1/8w	Prec	1/2%
R530A	321-0670-00	6.81k	1/8w	Prec	1/2%
R530B	321-0673-00	17k	1/8w	Prec	1/2%
R530C	321-0679-00	34k	1/8w	Prec	1/2%
R530E	321-0672-00	11.4k	1/8w	Prec	1/2%
R530F	321-0671-00	8.51k	1/8w	Prec	1/2%
R601	301-0154-00	150k	1/2w		5%
R603	308-0082-00	3k	5w	WW	5%
R604	308-0003-00	2k	5w	WW	5%
R606	308-0209-00	100Ω	5w	WW	5%
R607	308-0223-00	35Ω	3w	WW	5%
R610	308-0075-00	100Ω	3w	WW	
R614	315-0333-00	33k	1/4w		5%
R616	315-0472-00	4.7k	1/4w		5%
R620	315-0203-00	20k	1/4w		5%
R623	323-0216-00	1.74k	1/2w	Prec	1%
R625	311-0433-00	100Ω		Var	+19v Cal
R626	323-0216-00	1.74k	1/2w	Prec	1%
R630	307-0103-00	2.7Ω	1/4w		5%
R632	307-0103-00	2.7Ω	1/4w		5%
R634	321-0277-00	7.5k	1/8w	Prec	1%
R640	308-0353-00	35Ω	5w	WW	5%
R645	308-0313-00	20k	3w	WW	1%
R650	315-0183-00	18k	1/4w		5%
R653	315-0103-00	10k	1/4w		5%
R656	323-0149-00	348Ω	1/2w	Prec	1%
R657	323-0195-00	1.05k	1/2w	Prec	1%
R658	311-0442-00	250Ω		Var	-19v Cal
R660	308-0267-00	7.5k	5w	WW	5%
R662	323-0122-00	182Ω	1/2w	Prec	1%

Switches

	<u>Unwired</u>	<u>Wired</u>		
SW60	260-0686-00	*262-0720-00	Rotary	MVOLTS/CM
SW203	260-0689-00		Push Button	START
SW215	260-0687-00	*262-0718-00	Rotary	DISPLAY MODE
SW254★	311-0535-00			SWEEP OFF
SW400	260-0685-00	*262-0719-00	Rotary	TRIGGER SOURCE
SW475★★	311-0528-00			SYNC
SW500A } SW500B }	260-0684-00	*262-0721-00	Rotary	TIME POSITION RANGE
				TIME/CM

Transformers

T1	*120-0283-00	Toroid	7T bifilar
T80	*120-0286-00	Toroid	2T bifilar
T82	*120-0241-00	Toroid	2T-3T-4T
T88	*120-0403-00	Toroid	5T bifilar
T110	*120-0401-00	Toroid	20T
T340	*120-0374-00	Toroid	2T-4T
T410	*120-0399-00	Toroid	8T
T630	*120-0400-00	Power	

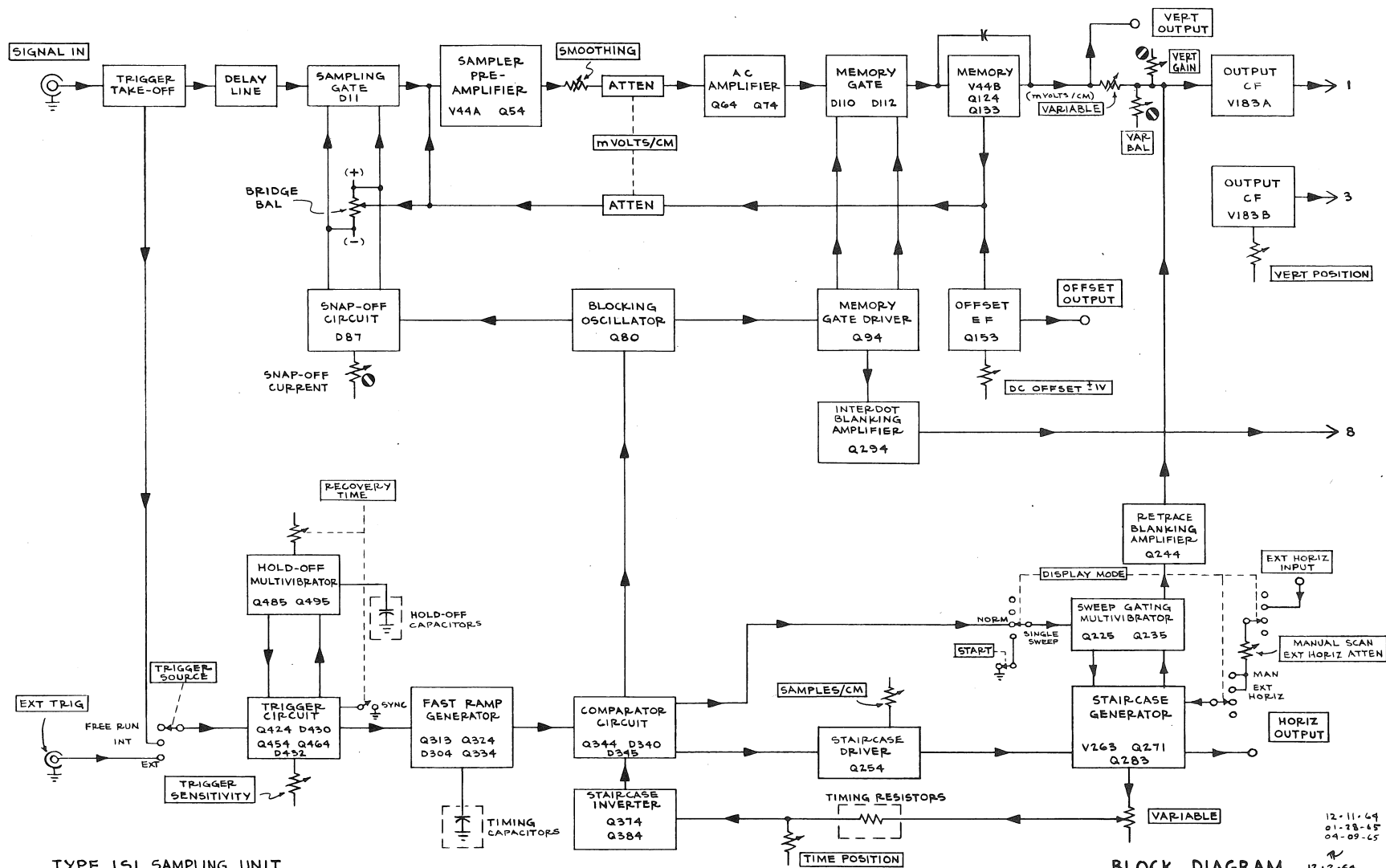
Electron Tubes

V44	154-0413-00	8416
V183	154-0413-00	8416
V263	154-0417-00	8056

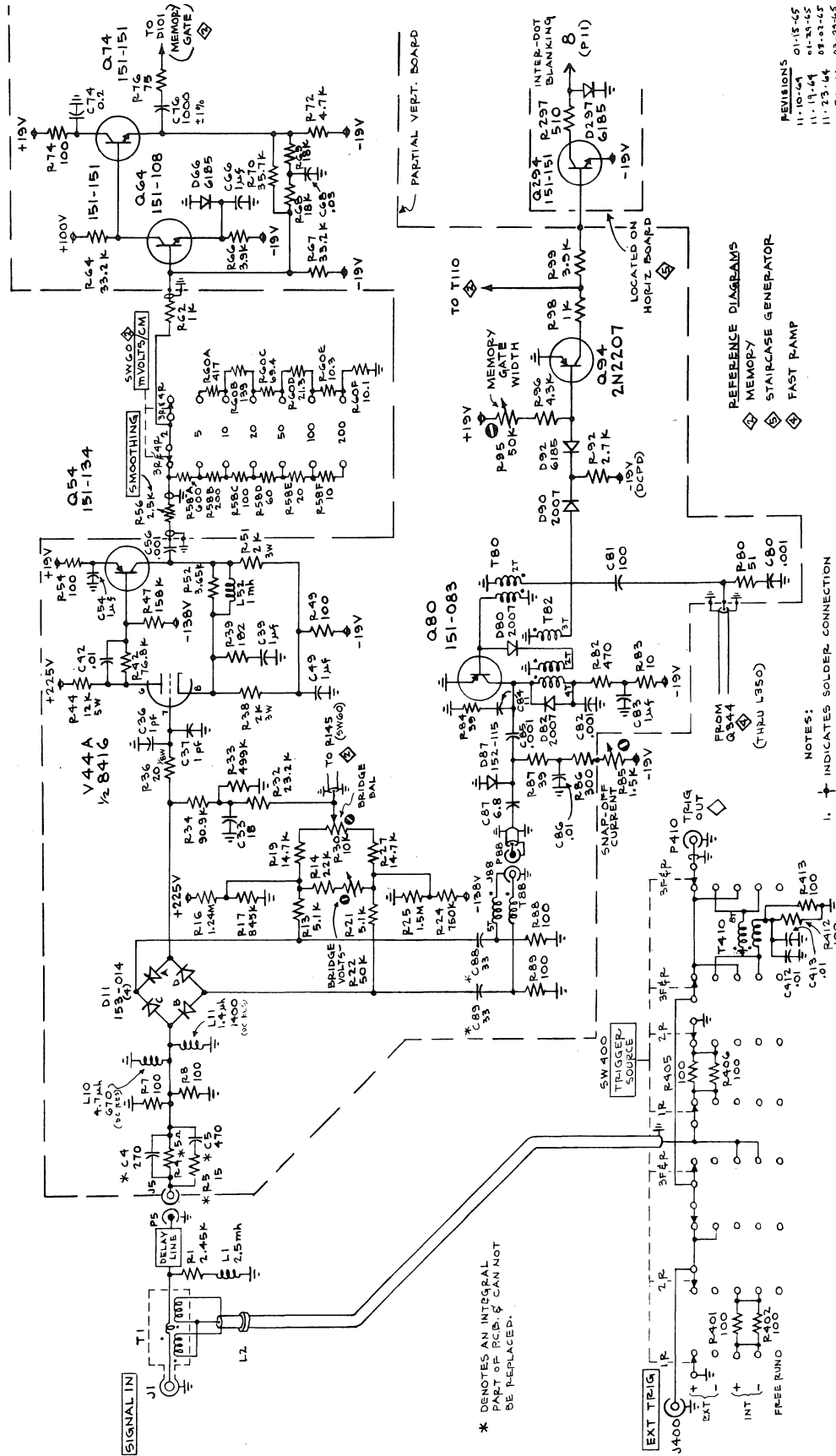
* Tek Made

★SW254, R254, and R56 furnished as a unit.

★★Furnished as a unit with R475 and R435.






BLOCK DIAGRAM
B-ISI-0010





REVISIONS

01-15-65	11-10-64
01-29-65	11-19-64
08-02-65	11-23-64
09-24-65	11-30-64
	12-10-64
	12-11-64
	01-04-65
	01-07-65

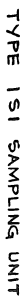
SAMPLER 
08-21-64
C-151-0025

REFERENCE DIAGRAMS
 MEMORY
 STAIRCASE GENERATOR
 FAST RAMP

- NOTES:
1.  INDICATES SOLDER CONNECTION
 2. ALL RESISTORS ARE 1/4W, 5% UNLESS OTHERWISE NOTED
 3. SEE  FOR POWER DISTRIBUTION

* DENOTES AN INTEGRAL PART OF PCB & CAN NOT BE REPLACED.

TYPE 151 SAMPLING UNIT



NOTES:

1. ✚ INDICATES SOLDER CONNECTION
2. ALL RESISTORS ARE 1/4W, 5%
UNLESS OTHERWISE NOTED
3. SEE ③ FOR POWER DISTRIBUTION

REFERENCE DIAGRAMS

- ① SAMPLER
- ⑤ STAIRCASE GENERATOR

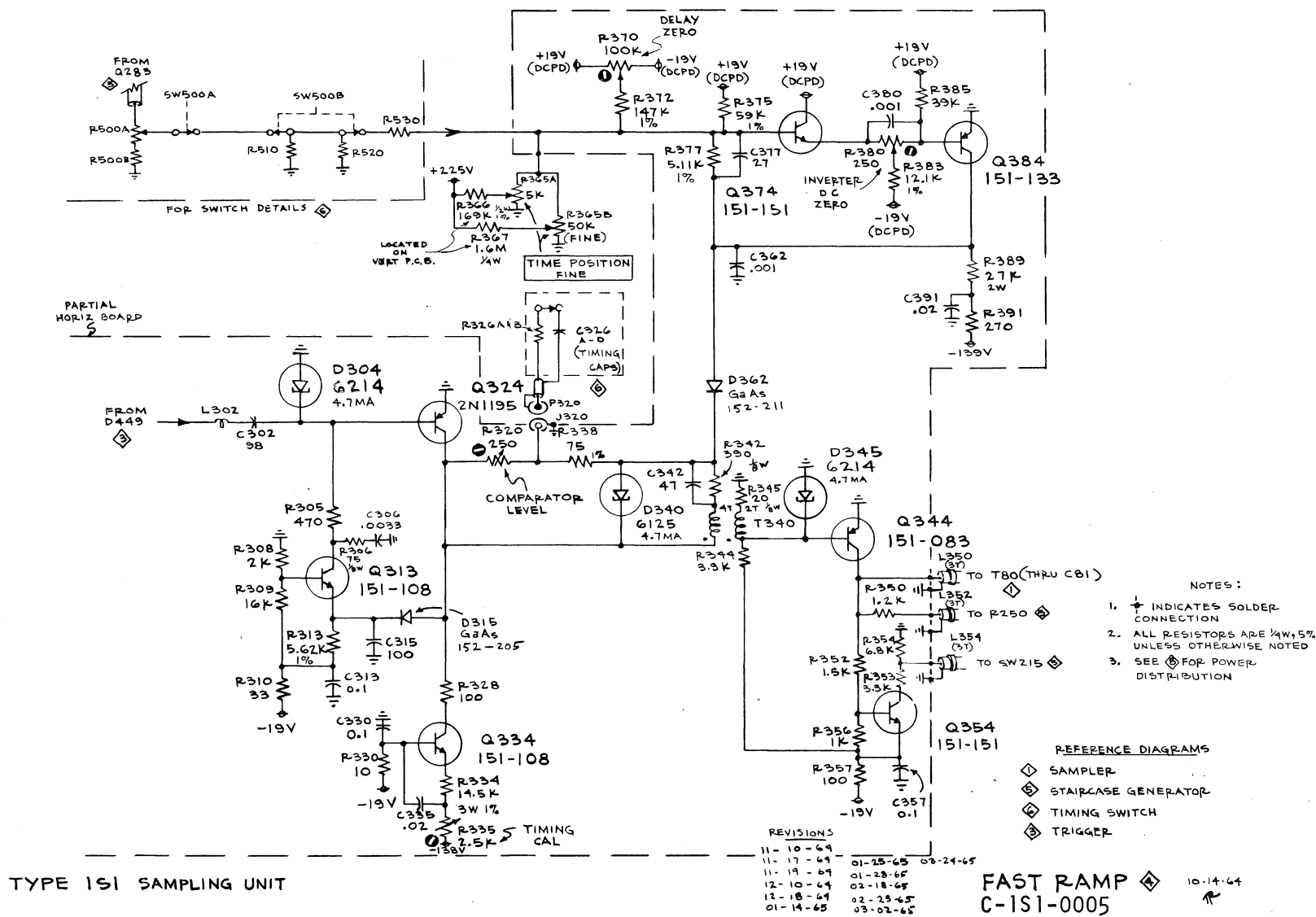
C-151-0010

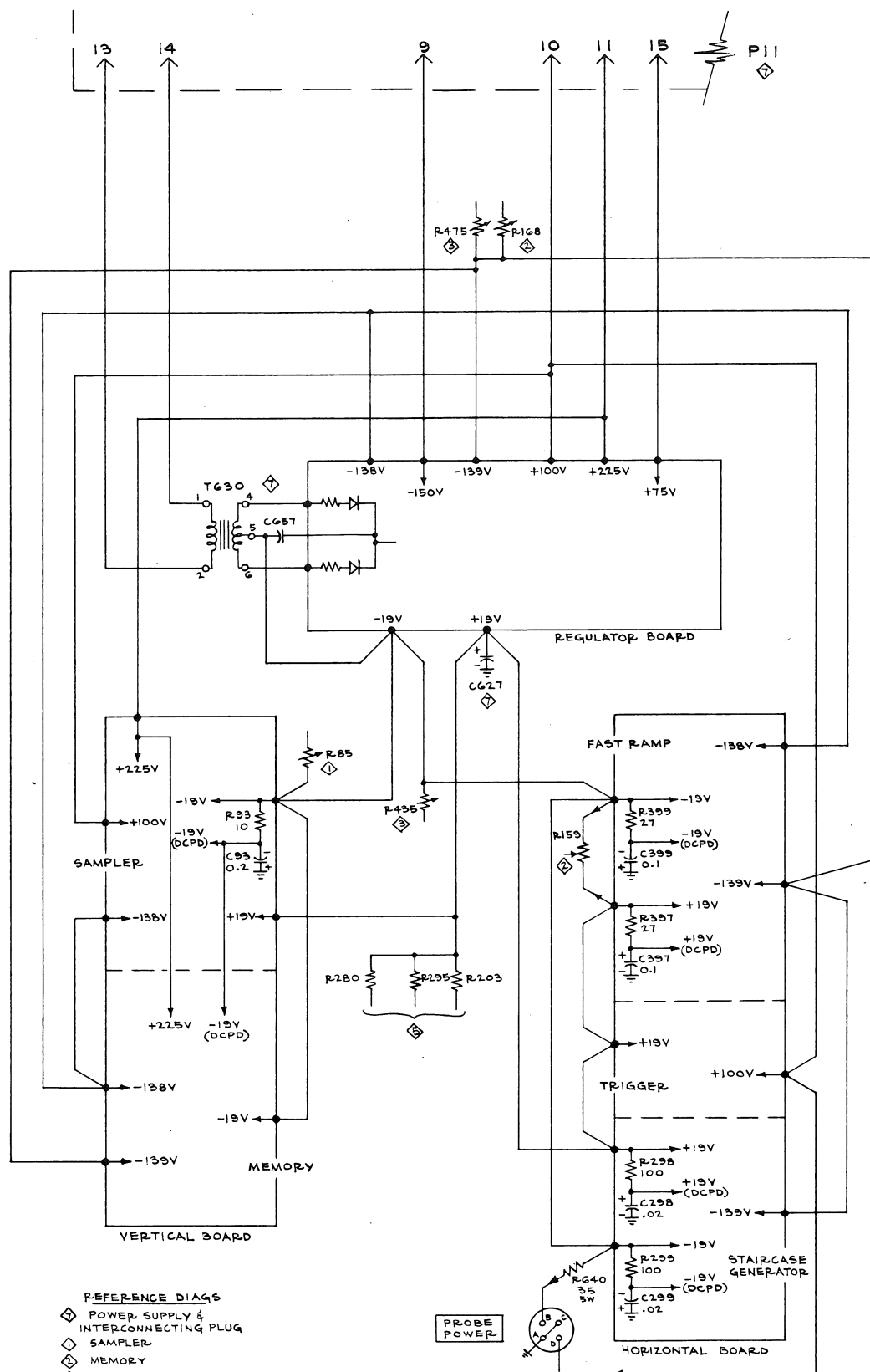
MEMORY 2

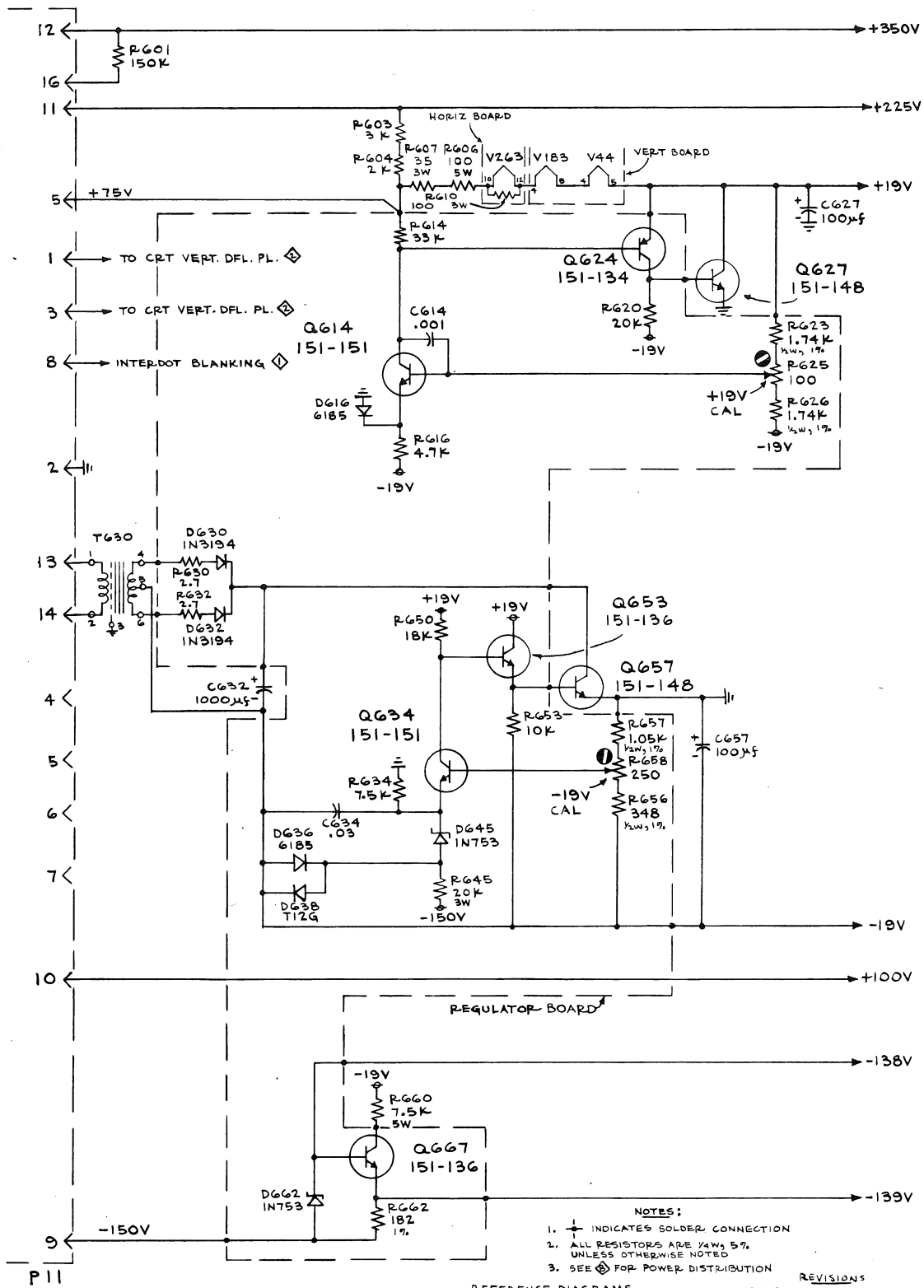
REVISIONS

11-10-64
11-16-64
11-19-64
11-23-64
12-10-64
01-04-65
01-15-65
01-21-65
02-05-65
03-24-65

09-21-64







TYPE 1S1 SAMPLING UNIT

REFERENCE DIAGRAMS

- \odot SAMPLER
- \odot MEMORY

POWER SUPPLY
AND INTERCONNECTING PLUG

C-1S1-0020

