Dept 1B3

INSTRUCTION MANUAL

Serial Number ____________

TYPE 3T6

PROGRAMMABLE SAMPLING SWEEP

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070-0761-00

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WARRANTY

All Tektronix instruments are warranted against defective materials and workmanship for one year. Tektronix transformers, manufactured in our plant, are warranted for the life of the instrument.

Any questions with respect to the warranty mentioned above should be taken up with your Tektronix Field Engineer.

Tektronix repair and replacement-part service is geared directly to the field, therefore all requests for repairs and replacement parts should be directed to the Tektronix Field Office or representative in your area. This procedure will assure you the fastest possible service. Please include the instrument Type and Serial or Model Number with all requests for parts or service.

Specifications and price change privileges reserved.

CONTENTS

Abbreviations and symbols used in this manual are based on, or taken directly from, IEE Standard 260 "Standard Symbols for Units", MIL-STD-12B and other standards of the electronics industry. Change information, if any, is located at the rear of this manual.


TYPE 3T6 PROGRAMMABLE SAMPLING SWEEP
HORIZ POS
HORIZ GAIN
TIME/DIV
TIME/DIV
DECADE
SAMPLES/SWEEP
1
1000
POSITION
DELAY
0 0 0 0
TRIGGER
SENSITIVITY
RECOVERY TIME
MODE
INT
EXT
PROGRAM SELECTOR
INT
EXT
SERIAL
TEKTRONIX
EXTERNAL PROGRAM

SECTION 1
SPECIFICATION

Change information, if any, affecting this section will be found at the rear of the manual.

General Information

The Type 3T6 Programmable Sampling Sweep unit provides a wide range of equivalent and real-time sweep rates. Accurate delay of the equivalent-time time window extends from 0 to 999.9 μs. All sweep rates, samples per sweep and equivalent time sampling sweep-start delay times are controlled either at the front panel or by an external programmer. When using external triggering, use of the automatic triggering feature will maintain proper triggering over a wide range of trigger amplitudes and repetition rates. Special external high-speed programming of the Type 3T6 increases the number of measurements per second that can be made in the system described in Section 2 under High-Speed Programming.

The Type 3T6 is intended for use with the Type 568 Oscilloscope. Any Tektronix 3S-series sampling unit may be used with the Type 3T6, normal use recommended to be with the Type 3S6 Programmable Sampling Unit.

The Type 3T6 and Type 3S6 can be externally programmed from connectors on the rear panel of a Type 568 Oscilloscope. The external program connector at the rear of the Type 568 can be connected to a Tektronix Type 240 Program Control Unit, or the Type 241 Programmer.

The Type 3T6 provides all necessary timing information for making accurate measurements when operated with a Tektronix digital readout system such as the Type 568-Type 230, or the Type 567-Type 6R1A.

With the Type 3T6 PROGRAM SELECTOR set at INT, sweep rate, delay, and samples/sweep (sweep reset) are all manually controlled at the 3T6 front panel. With the PROGRAM SELECTOR at EXT, sweep rate, delay, sweep reset, and dot density may all be externally programmed.

Characteristics

The following characteristics apply over an ambient temperature range of 0° C to +50° C and after a five minute warmup, providing the instrument was calibrated at a temperature between +20° C and +30° C.

Characteristics listed below apply for either front panel operation or external programming only after the Type 3T6 front panel control (HORIZ GAIN) has been properly adjusted for the particular oscilloscope in which the unit is operating.

For particular system warmup requirements, refer to the main-frame oscilloscope instruction manual.

A procedure for mating the Type 3T6 to the oscilloscope can be found in the Operating Instructions section of this manual.

ELECTRICAL CHARACTERISTICS

Characteristic	Performance Requirement

NOTE

In the following trigger section, the amplitudes listed following the Sensitivity Range title are the ranges in which the TRIGGER SENSITIVITY control permits triggering at the low amplitude value, and allows the control to hold off the trigger circuits for signals up to the high amplitude value. However, satisfactory triggering can be obtained for most signals at amplitudes up to the maximum permitted. When using an external trigger signal the maximum trigger input voltage is ±1 V (DC + peak AC).

TRIGGERING	
External Trigger Input	
Input Impedance	Nominally 50 Ω
Maximum Input Voltage	±1 V (DC + Peak AC)
Trigger Requirements	
External SYNC	
Frequency Range	100 MHz to 1 GHz
Sensitivity Range	10 mV to 500 mV P-P
External Sine wave	
Frequency Range	1 Hz to 100 MHz
Sensitivity Range	10 mV to 500 mV P-P
External Pulse	
Frequency Range	DC to 100 MHz
Sensitivity Range	5 mV to 250 mV
Internal Sine wave	
Frequency Range	100 kHz to 100 MHz
Sensitivity Range	100 mV to 2 V P-P
Internal Pulse	
Frequency Range	1 Hz to 100 MHz
Sensitivity Range	100 mV to 2 V
External Auto	
Frequency Range	DC to 100 MHz
Amplitude Range	100 mV to 500 mV
Pretrigger Requirement (lead time required for	

ELECTRICAL CHARACTERISTICS (Cont)

Characteristic	Performance Requirement
3T6 alone to position the triggering edge 1 div from sweep start)	
TIME/DIV	
10 ns	44 ns within 20%
100 ns	141 ns within 20%
1 μs	1 μs within 20%
10 μs	10 μs within 20%
100 μs	100 μs within 20%
500 μs	500 μs within 20%
Trigger Jitter	
Internal	
Sine wave	200 ps or less with 1 V P-P signal at 30 MHz
Pulse	30 ps or less with 500 mV pulse, 2 ns or less wide
External	
Sine wave	200 ps or less with 100 mV P-P signal at 30 MHz
Pulse	30 ps or less with 50 mV pulse, 2 ns or less wide
External Automatic	
Sine wave	200 ps or less with 300 mV P-P signal at 30 MHz
Pulse	30 ps or less with 300 mV pulse, 2 ns or less wide
External Sync	50 ps or less with 100 mV P-P signal at 1 GHz
RECOVERY TIME Range (Reset time)	At least 1.25:1
SWEEP RATES	
TIME/DIV Range	
Real Time	500 ms to 1 ms in 9 calibrated steps, 1-2-5 sequence
Accuracy	Within 3%
Equivalent Time	500 μs to 100 ps in 21 calibrated steps, 1-2-5 sequence.
Accuracy	Within 3% except as noted below
500 μs to 200 μs	Exclude first 150 μs of sweep
100 μs to 20 μs	Exclude first 15 μs of sweep
10 μs to 2 μs	Exclude first 1.5 μs of sweep
1 μs to 200 ns	Exclude first 150 ns of sweep
100 ns to 20 ns	Exclude first 15 ns of sweep
10 ns to 2 ns	Exclude first 15 ns of sweep
1 ns to 100 ps	Exclude first 15 ns of sweep

Characteristic	Performance Requirement
DELAY	
DELAY Range	
TIME/DIV	
500 μs to 2 μs	0 to 999.9 μs in 100 ns increments
1 μs to 1 ns	0 to 9.999 μs in 1 ns increments
500 ps to 100 ps	0 to 999.9 ns in 100 ps increments
DELAY Accuracy (with [A][B][C][D] representing the Delay Window Integers)	Within 3% (see below)
0 to 1 ms	$\frac{[AB] + 3[CD]}{[AB] + [CD]}$ = max error in %
0 to 10 μs	$\frac{[AB] + 3[CD]}{[AB] + [CD]}$ = max error in %
0 to 1 μs	$\frac{[A] + 3[BCD]}{[A] + [BCD]}$ = max error in %
HORIZONTAL DEFLECTION	
Dot Density	
1 SAMPLE/SWEEP	Dot stationary at sweep start
100 SAMPLES/SWEEP	+20%, −0%, at 100 kHz (available only when externally programming, and then only with DECADE set for equivalent time)
1000 SAMPLES/SWEEP	Within 0.5% at 100 kHz, within 3% at 30 Hz
Horizontal Positioning Range	At least 4 divisions
Horizontal Gain Range	At least 1.5:1
Position Indicators	Appropriate indicator on, the other off when trace is positioned 5 divisions from graticule center
PROGRAMMABLE FUNCTIONS	
Auto Calibration Sensitivity	Approximately 1% change in timing for each 75 μA change in timing current.
External Programming	Negative logic
True (logical ONE)	0 V to +2 V
False (logical ZERO)	+6 V to +15 V or open circuit

ENVIRONMENTAL CHARACTERISTICS	
Storage Temperature — $-40°$ C to $+65°$ C	Operating Temperature — As stated above Electrical Characteristics table
Altitude - To 50,000 feet	Altitude — To 15,000 feet

MECHANICAL CHARACTERISTICS	
Dimensions — Height	≈6 1/4 inches
Width	≈ 4 1/4 inches
Length	≈ 14 1/2 inches
Construction	Aluminum alloy chassis with epoxy laminated circuit boards. Front panel is anodized aluminum.
Accessories	An illustrated list of the accessories supplied with the Type 3T6 is at the end of the Mechanical Parts List pullout pages.

NOTES

SECTION 2
OPERATING INSTRUCTIONS

Change information, if any, affecting this section will be found at the rear of this manual.

General Information

This section covers installation, first time operation, function of front panel controls and connectors, general operation and applications of the Type 3T6 Programmable Sampling Sweep Unit

The Type 3T6 is used in the Tektronix Type 568 Oscilloscope, in conjunction with a Tektronix Type 230 Digital Unit and Type 240 Program Control Unit or Type 241 Programmer.

The Type 3T6 can be controlled from the front panel or externally programmed. With the PROGRAM SELECTOR at EXT, the sweep rate, delay and samples per sweep may be programmed through J224 at the rear of the Type 568 Oscilloscope.

Real time sampling is employed at the 3 slower sweep decades and equivalent time sampling at faster rates. An automatic trigger mode is provided to eliminate the need for trigger circuit adjustments over a wide range of trigger amplitudes, repetition rates and wave shapes. A sweep rate indicator readout functions for both front panel and externally programmed operation

The Type 3T6 may be high speed programmed by the Type 230 Digital Unit. This feature is intended primarily for use in applications in which the Type 3T6 and Type 230 are part of a system. More information on high speed programming is provided during the discussion of external programming later in this section.

The Type 3T6 may be used with an automatic calibration system. The automatic calibration feature is useful primarily in systems requiring close tolerance accuracy of readout on the digital unit.

NOTE

When externally programming from the rear panel of the Type 568 be sure that the Circuit Board Connector (See Fig. 2-1) is inserted in J24 at the rear of the Type 3T6. This part provides continuity from pins of J24 on the Type 3T6 to corresponding pins of J24 on the Type 568 Oscilloscope.

Installing the Type 3T6 in the Oscilloscope

The Type 3T6 is designed to drive the horizontal deflection plates of the oscilloscope CRT, and therefore is installed in the right hand compartment of the oscilloscope.

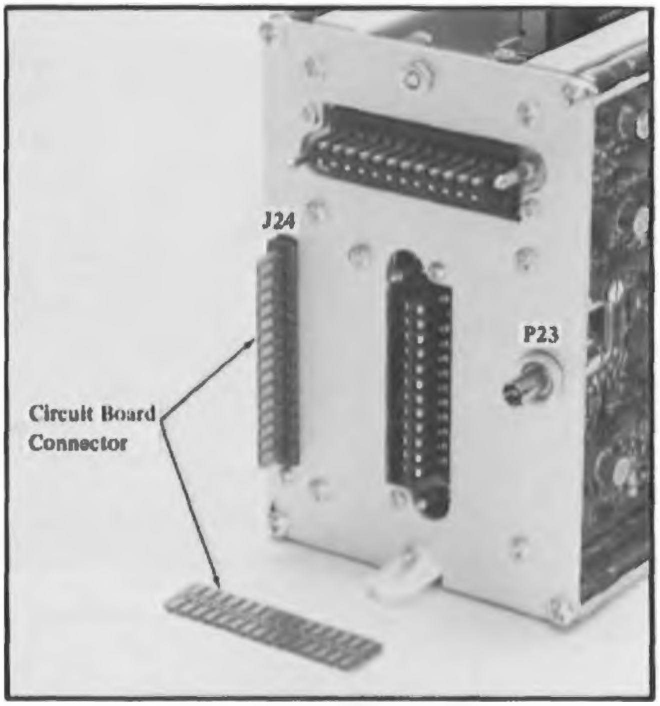


Fig. 2-1. Installation of circuit board connector.

To insert the Type 3T6 into the oscilloscope compartment, turn the knob at the bottom of the front panel counterclockwise several turns until it stops. Then slide the Type 3T6 completely into the compartment. Once the plug-in is seated, turn the knob a few turns clockwise until it is hand tight.

Mating

The Type 3T6 horizontal gain must be matched to the indicator oscilloscope CRT deflection factor for accurate time measurements. The HORIZ GAIN control is a screwdriver adjustment located on the Type 3T6 front panel. The Type 284 Pulse Generator is used as a signal source when adjusting the HORIZ GAIN control in the following procedure for first time operation. Changing the setting of the HORIZ GAIN control will not affect the reading on the digital readout unit.

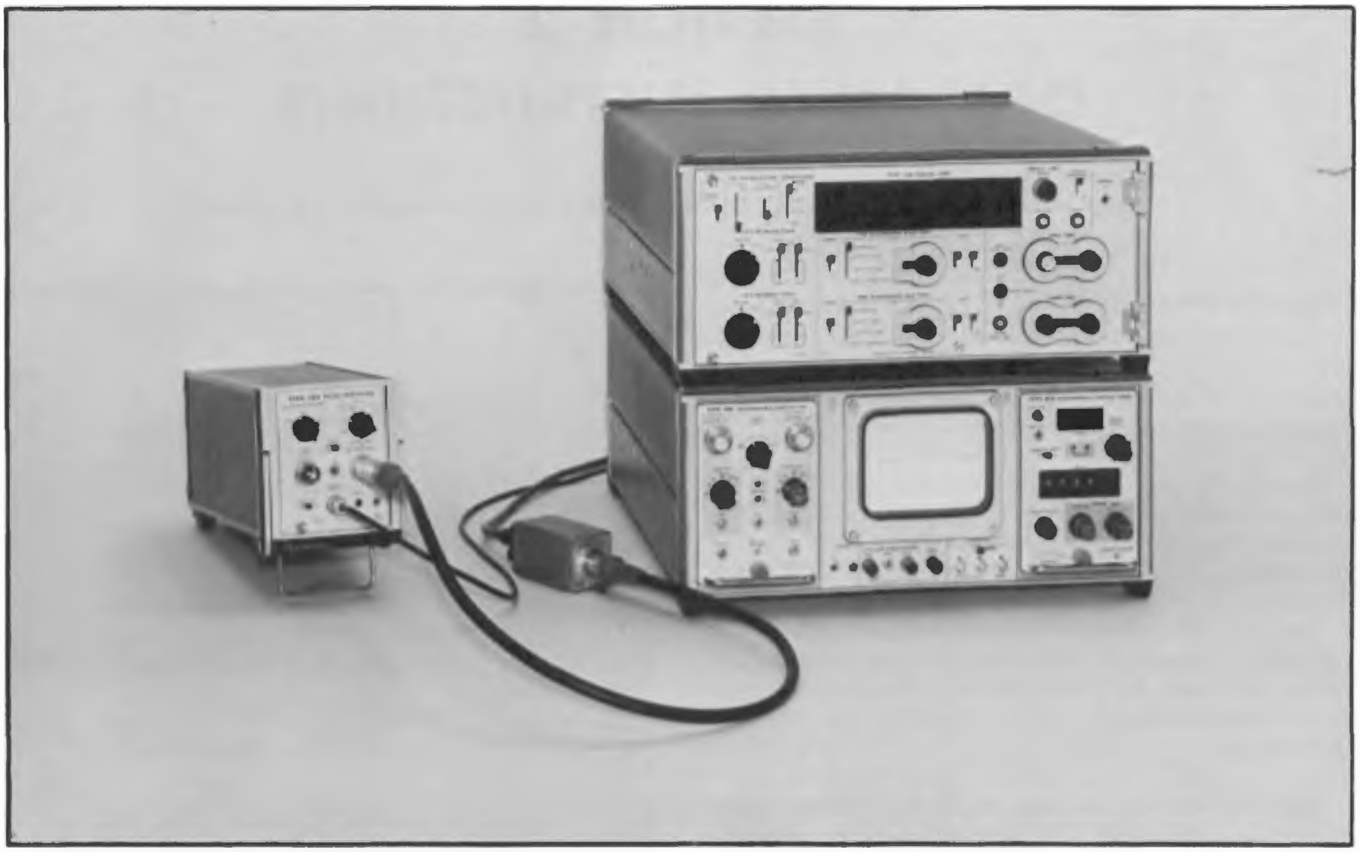


Fig. 2-2. Initial set-up used during first-time operation.

FIRST TIME OPERATION

Control Familiarization

In this procedure for operating the Type 3T6, a Type 3S6 Sampling Unit, Type 568 Oscilloscope, Type 230 Digital Unit, and a Type 284 Pulse Generator are used. Any Tektronix S-series sampling head can be used. Two Type S-2 Sampling Heads were used when making the waveform photographs for the following procedure. See Fig. 2-2.

Initial equipment settings

Type 3T6

HORIZ POS	Midrange
SAMPLES/SWEEP	1000
TIME/DIV DECADE	7 } 500 ns/Div
TIME/DIV MULTIPLIER	5 }
DELAY	0000
PROGRAM SELECTOR	INT
TRIGGER SENSITIVITY	Fully clockwise
RECOVERY TIME	Optional (but not in SYNC)
POLARITY	+
MODE	EXT

Type 3S6

Display Mode	Channel A
Normal Smooth	Normal
DC Offset (both channels)	0.00
Units/Div (both channels)	100
Variable (both channels)	Calibrated (detent)
Invert (both channels)	Push in

Type 230

Measurement Averaging	8
CRT Intensification	Ref Zones and Time Measurement to OFF
Measurement Mode	Time
Ch A Reference Zones	Both at Average
Channel switches	Both at A
Time Measurement Start Point	10% Between Zones
Time Measurement Stop Point	90% Between Zones
Slope	Both at + and 1st
Display Time	Counterclockwise
Triggered Measurement	Off
Limits	Optional

Type 284

Square Wave Amplitude	1.0 V

Period	1 μs
Mode	Square Wave Output
Lead Time	75 ns

NOTE

Type 284 instruments having serial numbers prior to SN B030236 require installation of Field Modification Kit, Tektronix Part No. 040-0487-00 in order to obtain a 75 ns trigger lead time.

Turn on power and allow the equipment to warm up for 5 minutes. Connect a 50 Ω coaxial cable with a 5 ns signal delay and GR 874 connectors to each of the input connectors of the sampling heads. Connect the coaxial cable from the CH A sampling head to the square-wave output of the Type 284 through a 2X attenuator. See Fig. 2-2. Signal applied to the sampling head should not exceed that specified in your sampling head instruction manual.

The unterminated coaxial cable connected to CH B sampling head will delay the reflected strobe kickout signal from this channel until after sampling time has ended.

NOTE

Operating the sampling head without the input connector terminated by a 50 Ω terminator or a coaxial cable will cause a few millivolts vertical shift of the zero signal baseline. For further information on this, and an explanation of operating adjustments of the Type 3S6 and Type S-2, consult the instruction manual for this equipment.

Connect the Trigger Output connector of the Type 284 through a 50 Ω coaxial cable to the Type 3T6 TRIGGER INPUT connector on the Type 568 rear panel.

Adjust the oscilloscope Intensity control and the Type 3S6 DC Offset control for a vertically centered display of normal intensity. Adjust the Type 3T6 HORIZ POS control to set the start of the sweep at the left edge of the graticule. Slowly rotate TRIGGER SENSITIVITY and RECOVERY TIME throughout their range and note the effect on the display. A stable display, as shown in Fig. 2-3 should be obtained. Operate the TRIGGER MODE switch from EXT to INT. Slight adjustment of the TRIGGER SENSITIVITY may be necessary to obtain a stable display. Operate the TRIGGER POLARITY switch from the + to the − position. Note that the trace is now triggered when the input signal is negative-going. Return the TRIGGER MODE switch to EXT position. Return the TRIGGER POLARITY switch to +.

Note the lighted indication in the Type 3T6 TIME/DIV readout window. With the TIME/DIV DECADE set to 7 and the MULTIPLIER at 5, the indicator will show 500 ns (5 X 10^{-7}sec).

Using a small screwdriver, rotate the HORIZ GAIN control throughout its range while observing the displayed square wave. Adjust so that each cycle of the applied 1 μs square wave occupies exactly 2 divisions along the graticule horizontal axis. See Fig. 2-3. This adjustment should be readjusted when using the Type 3T6 in a different oscilloscope, since CRT deflection factors differ between CRT's of the same type. See instructions for setting HORIZ GAIN in the Calibration section.

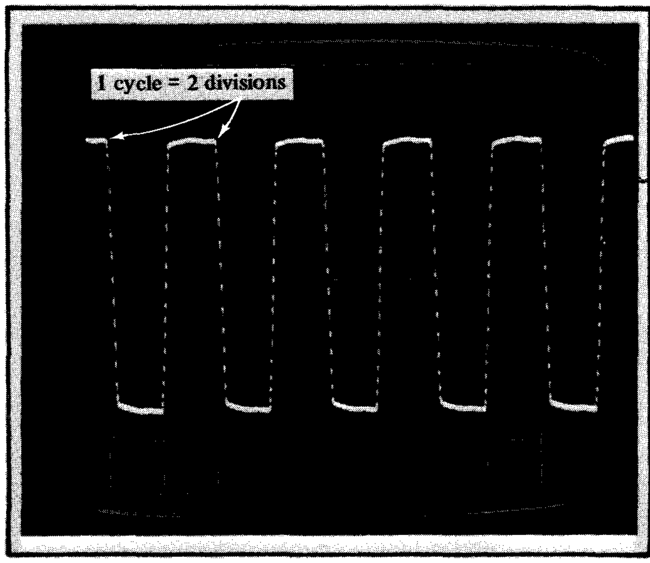


Fig. 2-3. Square wave display suitable for setting horizontal gain.

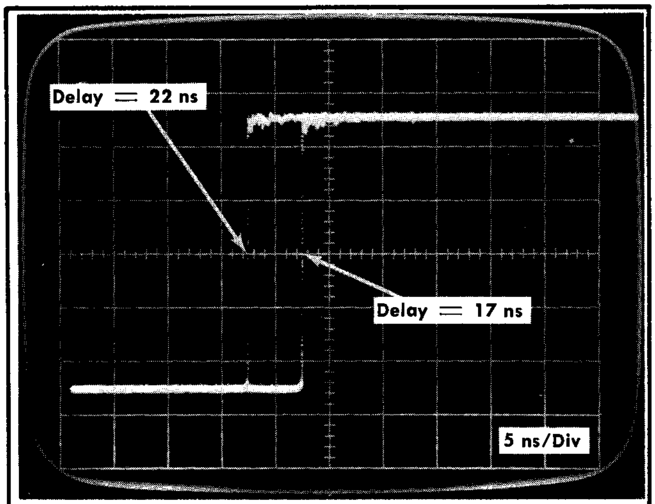
Rotate the TIME/DIV MULTIPLIER from 5 to the 2 and 1 positions while observing the display on the CRT and the lighted indication in the TIME/DIV window. Return the MULTIPLIER switch to 5.

Set the Type 284 for a square wave period of 100 ns and set the Type 3T6 TIME/DIV DECADE to 8. Note the effect on the CRT display and the lighted indication in the TIME/DIV window of switching the DECADE from 7 to 8. Rotate the DECADE switch to all of its other positions and note that the indicated TIME/DIV changes by a factor of ten between each DECADE position. Return DECADE switch to position 8.

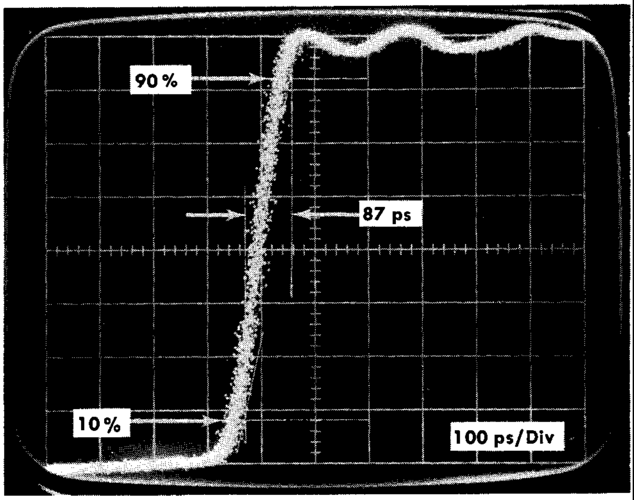
Measuring a Step Signal 10% to 90% Risetime

Connect the coaxial cable from the Channel A sampling head of the Type 3S6 to the Pulse Output connector of the Type 284. Remove the 2X attenuator shown in Fig. 2-2. Set the Type 284 Mode switch for Pulse Output. Set the Type 3S6 Units/Div switch to 50 and the Display Mode switch to CH A. Vertically position the display to mid-screen using the CH A DC Offset control. Set the Type 3T6 TIME/DIV DECADE to 9 and the MULTIPLIER to 5. The TIME/DIV indicator will show 5 ns in the readout window.

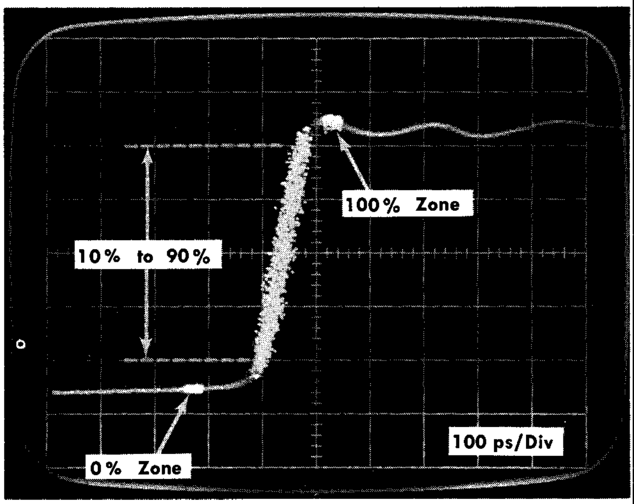
Adjust the Type 3T6 TRIGGER SENSITIVITY for a stable display. Position the display start to the graticule left edge using the HORIZ POS control. Add delay in 1 ns



(A) Effect of increasing sampling sweep delay by 5 ns.



(B) Determining risetime from the CRT display.



(C) Determining risetime from the digitial readout unit.

Fig. 2-4. Fast rise pulse displays.

increments, using the farthest right thumb-wheel switch. Note the effect on the display as DELAY is increased. See Fig. 2-4A.

Continue to add delay until the pulse start is less than 1 division from the graticule left edge. Note the delay reading and set the TIME/DIV DECADE switch to 0 (fully cw). The sweep rate is now 500 ps/div. It should be noted that with the TIME/DIV DECADE turned to the fully cw position a decimal appears in the delay readout area, indicating the delay is now one-tenth of the previous value. Reset the Delay dials to equal the previous value. Change the delay slightly to position the pulse start near the left edge of the graticule. Set the sweep rate to 100 ps/div by placing the TIME/DIV MULTIPLIER at 1. Position the display to the position shown in Fig. 2-4B using the Type 3T6 HORIZ POS control and the Type 3S6 DC Offset control. Read the pulse 10% to 90% rise-time from CRT graticule markings by determining the horizontal distance in divisions between the 10% and 90% amplitude levels of the pulse. Multiply the number of divisions by the sweep rate to determine the pulse risetime. See Fig. 2-4B. Inaccurate measurement of risetime will result if a non-linear portion of the sweep is used. Refer to linearity specifications in Section 1 to determine whether a portion of the sweep must be excluded.

To measure pulse risetime using a digital unit, set the Type 230 Time Measurement switch to On. Set the intensified reference zones to the positions shown in Fig. 2-4C by turning the 0% and 100% Position controls. Read the pulse risetime in the Type 230 readout window.

The function of the Type 3T6 front panel controls and connectors is explained below. See Fig. 2-5.

FUNCTION OF FRONT PANEL CONTROLS AND CONNECTORS

TIME/DIV Indicator — The TIME/DIV indicator is located at the top center of the Type 3T6. The Time/Div selected by the front panel DECADE and MULTIPLIER switches or by an external programmer appears as a lighted display if operating power is applied to the plug-in.

TIME/DIV DECADE — A 10 position switch provides for changing the Type 3T6 sweep rate. Sweep rate increases by a factor of 10 between positions as the switch is rotated clockwise. The TIME/DIV DECADE is used in conjunction with the TIME/DIV MULTIPLIER to select any of 30 calibrated sweep rates. Sweep rates from 100 ps/div to 500 ms/div in a 1, 2, 5 sequence are available. The sweep rate selected is displayed by the TIME/DIV indicator. TIME/DIV in seconds = M times D^{-10} where M is setting of MULTIPLIER switch and D is setting of DECADE

Fig. 2-5. Type 3T6 front panel.

switch. With DECADE at 0 position D = 10.

TIME/DIV MULTIPLIER — A 3 position rotary switch providing multiplication of the sweep rate selected by the DECADE switch by a factor of 1, 2, or 5. The 3 positions of the MULTIPLIER control together with the 10 positions of the DECADE switch provide 30 calibrated sweep rates.

HORIZ POS Control — The horizontal position control is used to position the display horizontally on the CRT of the oscilloscope.

HORIZ GAIN Control — A front-panel screwdriver adjustment that adjusts horizontal gain to match the oscilloscope deflection factor. Also provides a banana-jack ground connection.

POSITION Indicators — Light when CRT electron beam or display is deflected horizontally off screen. Arrow under lamp that is lit shows direction of deflection.

SAMPLES/SWEEP Switch — A 2 position slide-type switch for selecting 1 or 1000 samples per sweep. With the PROGRAM SELECTOR switch at EXT either 1, 100, or 1000 samples per sweep may be programmed.

DELAY Controls and Indicator — The DELAY controls consist of four independent "thumb-wheel" switches accessible through the DELAY window on the front-panel. Each of the thumb-operated controls is numbered, from 0 through 9, around its outer circumference. The numbers visible on these controls indicate the delay programmed when the PROGRAM SELECTOR switch is set at INT. (The ns, μs and decimal lamps do not light during either internal real time operation or external programming.)

TRIGGER SENSITIVITY — This control varies the sensitivity of the triggering circuit. It also provides sine wave sync control when the RECOVERY TIME control is in the SYNC position.

TRIGGER RECOVERY TIME Control — Adjusts holdoff time duration of the trigger circuits to assure stable triggering. It also operates the SYNC switch when turned fully clockwise into detent.

TRIGGER MODE Switch — Provides three positions: INT, EXT, and EXT AUTO. With switch at INT a portion of the signal applied to the sampling head is utilized as the trigger source. With switch set to EXT or EXT AUTO the signal applied to the external trigger INPUT connector on the Type 568 rear panel provides triggering. Use of EXT AUTO position allows external triggering without sensitivity and recovery-time adjustments.

TRIGGER POLARITY Switch — Two-position switch establishes whether triggering takes place with a negative or positive-going trigger pulse. EXT TRIGGER Input is DC coupled so (+) POLARITY refers to a trigger level positive of ground level and (—) POLARITY refers to a trigger level negative with respect to ground.

PROGRAM SELECTOR — A 2 position switch used for selecting INT (front panel) or EXT (external) programming.

EXT PROG Indicator — Lights when PROGRAM SELECTOR switch is set at EXT.

OPERATING INFORMATION

Triggering

Internal triggering of the Type 3T6, from the signal applied to Channel A of the sampling unit, can be used when the signal is a repetitive pulse or sine wave.

When observing a fast risetime pulse using a sampling unit such as the Type 3S6 (which does not have a built-in delay line) an external pretrigger such as supplied by the Type 284 Pulse Generator is required. The amount of pretrigger time required is dependent upon the type of sampling head, sampling head cable length, delay in the sampling unit, and delay in the oscilloscope. A method of determining pretrigger requirements of your system is discussed later in this section.

Two modes of external triggering are available. With the TRIGGER MODE switch set at EXT AUTO, signals of varying amplitude may be rapidly programmed into the system and proper triggering will be maintained automatically. A trigger signal amplitude of 100 mV or more is required at the external trigger input connector when using the EXT AUTO MODE. The maximum external trigger input voltage allowed is ±1 volt. See Section 1 for complete trigger specifications.

NOTE

Earlier models of the Type 568 Oscilloscope require installation of Field Modification Kit, Tektronix Part No. 040-0492-00 to provide a means of externally triggering the Type 3T6. This modification consists of installation of J23 on the Type 568 rear panel and J23 at the rear of the vertical plug-in compartment. Order Kit No. 040-0492-00.

When an external trigger signal of less than 100 mV is used set the TRIGGER MODE switch to EXT. The TRIGGER SENSITIVITY and RECOVERY TIME controls are used in this position as well as in the INT position to obtain proper triggering. If the display appears to jitter, turning the RECOVERY TIME control slightly in either direction and checking the setting of the SENSITIVITY control will eliminate the jitter. The SENSITIVITY control has no effect when TRIGGER MODE is in EXT AUTO position.

Turning the RECOVERY TIME control fully clockwise until it snaps into a detent operates the SYNC switch. The trace now free-runs. Synchronization is controllable with the SENSITIVITY control. The SENSITIVITY control is slowly turned throughout its range until proper triggering is obtained. Trigger SYNC operation is particularly useful at frequencies above 100 MHz where other methods of triggering may be difficult.

AC coupling is provided when TRIGGER MODE is set to INT position, but DC coupling is provided in the EXT and EXT AUTO positions. DC coupling together with the sensitive circuit used in the EXT position may result in unsatisfactory triggering under the conditions discussed below.

If the entire triggering signal is completely positive or completely negative with respect to ground, triggering on only the positive-going or negative-going portion of the triggering signal is possible. With a triggering signal that is entirely positive with respect to ground, set the Type 3T6 POLARITY switch to (+). Triggering will occur during the positive-going leading edge of the triggering signal at a level determined by the setting of the front panel SENSITIVITY control. With a triggering signal that is entirely negative with respect to ground, set the Type 3T6 POLARITY switch to (—). Triggering will occur during the negative going leading edge of the triggering signal.

Triggering on the trailing edge of this type signal may require applying the triggering signal to the Type 3T6 TRIGGER INPUT through a capacitor.

Another case in which triggering may be unsatisfactory in the EXT position is where the duration of a trigger pulse is longer than the recovery time set at the Type 3T6 front panel. If possible, decrease the duration of the trigger pulse or set the RECOVERY TIME control for a longer duration. Recovery time can also be made longer by switching in delay. Applying the trigger signal through a capacitor or switching to EXT AUTO will also correct this difficulty.

Trigger Signal Countdown

The maximum rate at which samples may be taken is limited. Time is required for charging memory circuits, blanking the CRT, moving the spot, unblanking, and other circuit functions. The time required per sample is dependent upon the setting of the TIME/DIV control. See Table 2-1. Readings in the table were taken with the TRIGGER MODE switch set at EXT AUTO and using the 100 ns square wave output of a Type 284 Pulse Generator as the trigger signal.

TABLE 2-1
Time/Sample Rate

TIME/DIV	Time/Sample (approximate)	
100 ps to 1 ns	10 μs	
2 ns to 10 ns	10 μs	
20 ns to 100 ns	12 μs	
200 ns to 1 μs	20 μs	
2 μs to 10 μs	170 μs	
20 μs to 100 μs	1.7 ms	
200 μs to 500 μs	17 ms	
1 ms	10 μs	Real-Time Sampling
2 ms	20 μs	Real-Time Sampling
5 ms	50 μs	Real-Time Sampling
10 ms	100 μs	Real-Time Sampling
100 ms	1 ms	Real-Time Sampling

Since the minimum time per sample shown in Table 2-1 is 10 μs, triggering cannot occur at a rate faster than 100 kHz. If the repetition rate of the triggering signal results in a triggering signal period less than the time required per sample, trigger signal countdown will occur.

As an example, assume a trigger repetition rate of 110 kHz. Period of the trigger signal will be the reciprocal of the frequency, or 1 divided by 110 kHz, or approximately 9 μs. If the time per sample is 10 μs for the sweep rate being used, triggering and sampling will occur every 18 μs. Triggering is occurring only on every other input trigger signal. The triggering signal is being counted down by a factor of 2 to 1, producing a sampling rate of half the repetition rate of the input trigger signal, or 55 kHz.

It should be noted that the time-per-sample values shown in Table 2-1 were determined with a square-wave having a period of 0.1 μs or a repetition rate of 10 MHz. Trigger countdown was at least 100 to 1. The values in the table are, therefore, minimum values. With a low trigger repetition rate, countdown does not occur and each dot is displayed until the next trigger. A triggering signal having a low repetition rate would therefore result in a long Time/Sample.

Assuring Proper Pretrigger or Signal Delay Times for Accurate Sweep Rates

Pretriggering or Signal Delay assures display of the leading edge of a fast-rise pulse. The strobe pulse corresponding to sweep start must reach the sampling bridge before the signal pulse. This means that the signal source must provide

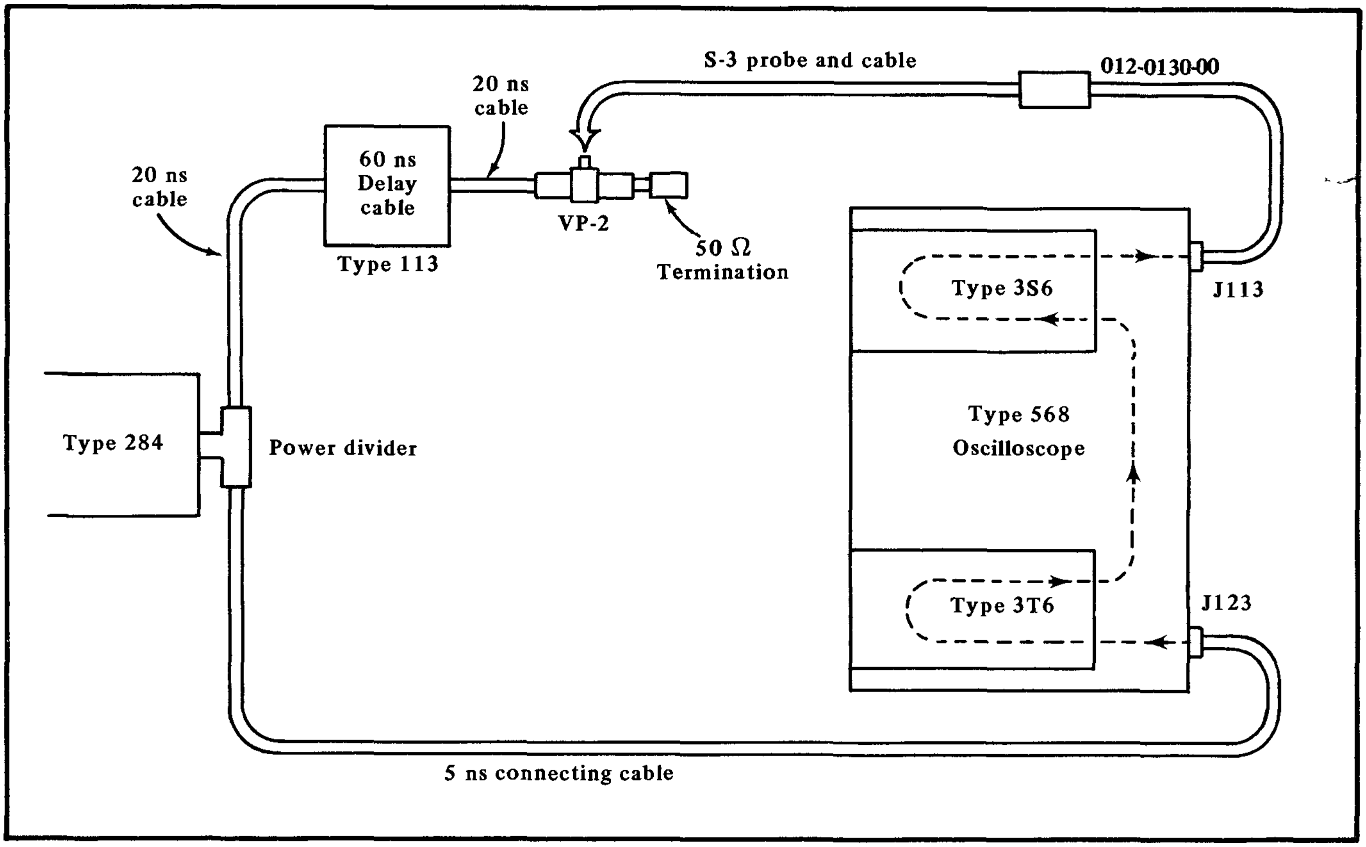


Fig. 2-6. Sampling system delay considerations.

a trigger prior to the signal (pretrigger), or if the signal displayed is also used as the external triggering signal, the signal must be delayed in reaching the sampling bridge. This assures start of the sampling process prior to arrival of the signal at the sampling bridge.

The pretrigger method, using the Type 284 Pulse Generator, was utilized during the discussion of First Time Operation earlier in this section. The Type 284 Lead Time switch was set to provide a pulse at the Trigger Output connector occurring 75 ns before a signal appeared at the Pulse Output connector. The Tektronix Type R116 Programmable Pulse Generator also provides a pretrigger signal that precedes the undelayed pulse output of this instrument. Since the output pulse of the Type R116 may be delayed over a wide range of values, a wide range of signal delay is provided by using the signal from the pretrigger connector for triggering the Type 3T6 and connecting the delayed output pulse of the Type R116 to the sampling unit.

The delay line method will provide time separation of the triggering signal and the signal to be displayed when both of these signals originate as one. When using a sampling unit such as the Type 3S6 without an internal delay line, an external delay such as provided by the Tektronix Type 113 Delay Cable can be utilized. Fig. 2-6 shows an example of the use of this method.

Factors Affecting System Delay are illustrated in Fig. 2-6 using a Type 568 Oscilloscope, Type 3S6 Sampling Unit, Type S-3 Sampling Head, and a Type 3T6 Sampling Sweep.

The Pulse Output of the Type 284 Pulse Generator is connected to a power divider. The 100 mV at one of the connectors of the power divider is applied through a 20 ns length of coaxial cable to the 60 ns Type 113 Delay Cable. The output of the Type 113 Delay Cable is applied through a 20 ns length of coaxial cable to a VP-2 Voltage Pickoff "T" which is terminated in 50 Ω.

Thus, the signal applied to the sampling bridge in the probe head of the Type S-3 Sampling Head lags the pulse at the output of the Type 284 by 100 ns.

Fig. 2-6 and 2-7 also show that the 100 mV at the connector of the power divider is applied through a 5 ns coaxial cable to the external trigger connector on the Type 568 rear panel. The signal at the external trigger connector is therefore leading the signal applied to the probe tip of the Type S-3 Sampling Head by 95 ns. The signal at the probe tip has only a short distance to travel in reaching the sampling bridge in the probe head. However, the signal applied to the trigger input must pass through the path shown, before the strobe pulses are generated and applied to the

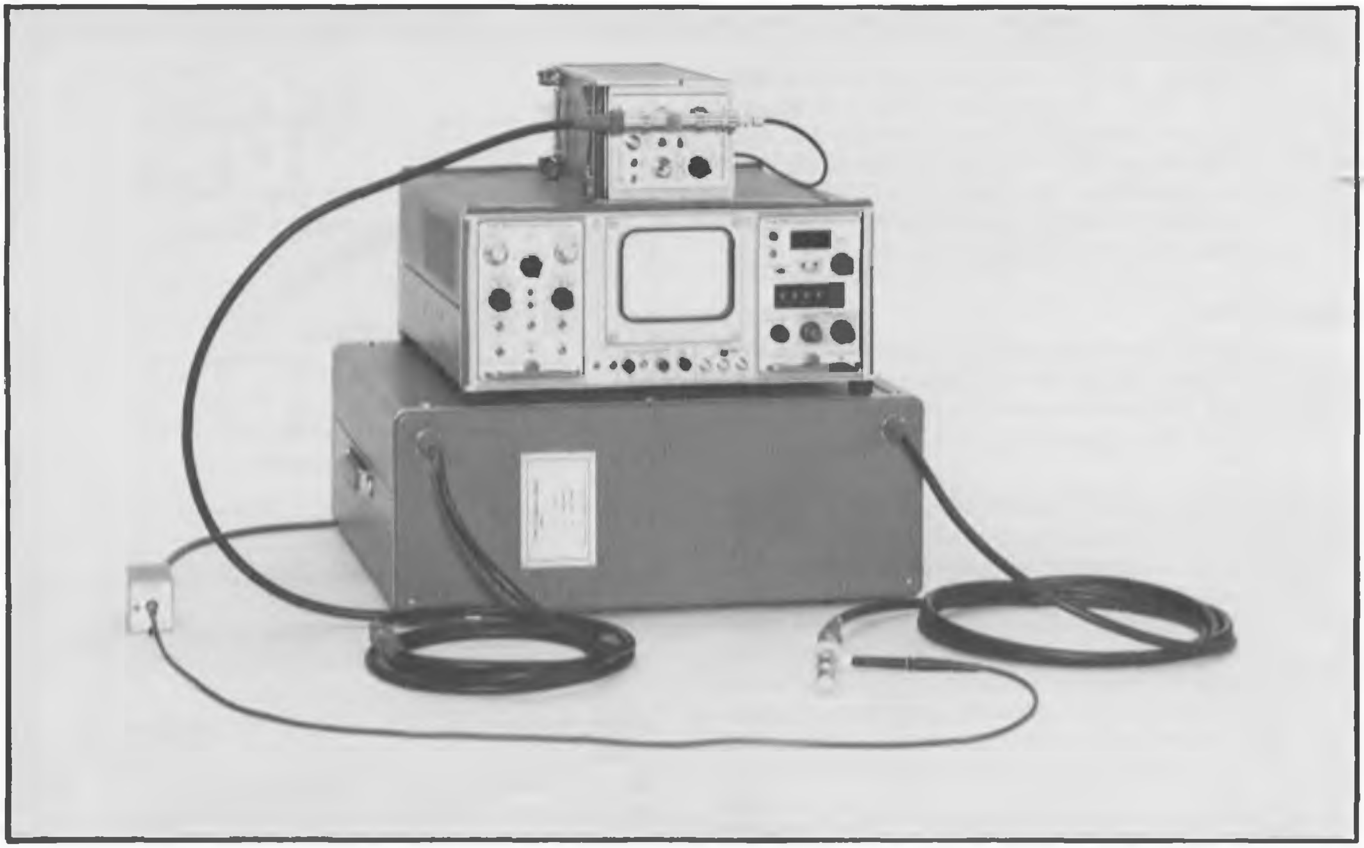


Fig. 2-7. Set up used in determining minimum pretrigger requirements of a typical sampling system.

sampling bridge. The delay between application of the trigger signal to the external trigger connector and arrival of the strobe pulses at the sampling bridge results in a loss of most of the original 95 ns of trigger leadtime.

If a Type S-1 or Type S-2 Sampling Head is substituted for the Type S-3 the trigger path delay will be reduced by approximately 7 ns. This is primarily because the length of the probe cable is eliminated from the strobe path.

Determiniming Minimum Pretrigger or Signal Delay Requirements of a sampling system is discussed below.

Using the setup shown in Fig. 2-7. set the Type 284 Mode switch for Pulse Output. Set the Type 3S6 to Channel A and 20 mV/div. Set the Type 3T6 TRIGGER MODE to EXT AUTO, DECADE to 9 and MULTIPLIER to 1 (1 ns/div). Set sweep start at the left edge of the graticule using the Type 3T6 HORIZ POS control. A vertically centered 5 division display can be obtained by adjusting the Type 3S6 Ch A Offset control and programming delay at the Type 3T6 front panel. The figures given below are typical for a system using the setup shown in Fig. 2-7. The same procedure may be followed with different sampling heads, sweep units or sampling sweeps.

Position the start of the displayed pulse to the left edge of the CRT graticule using the Type 3T6 DELAY controls. With 18 ns of programmed delay, the display is just visible at the left edge of the graticule. The strobe pulse is reaching the sampling bridge only 18 ns before the displayed signal. Since the trigger pulse originally had a 95 ns lead, the difference (95 ns − 18 ns or 77 ns) has been lost in the system. It would appear therefore, that 77 ns of pretrigger would be sufficient instead of the 95 ns we actually have. The start of the pulse will still be visible with a delay cable providing 18 ns less delay, if the 18 ns of delay programmed is removed. While 77 ns of pretrigger would allow the start of the pulse to be observed, the start of the pulse is occurring at the left edge of the graticule. The start of the pulse should occur not closer than 1 division to the left edge of the graticule to allow room for an intensified zone to the left of the displayed pulse. Since we are using a TIME/DIV of 1 ns/div this will add 1 ns to the 77 ns previously determined.

Another consideration is sweep linearity. Reference to TIME/DIV accuracy in Section 1 shows that when using the 1 ns/div setting, the first 15 ns of the sweep should be excluded to assure accuracy within 3%. This 15 ns can be excluded by programming 15 ns of delay. Unless we also increase the pretrigger requirement by 15 ns, the start of the pulse will be occurring during the excluded portion of the sweep. Adding this 15 ns to the previous pretrigger requirement (77 ns + 1 ns) gives a total of 93 ns to provide an accurately timed display, positioned one division from the start of the sweep. Since the trigger pulse at the Type 568 trigger input connector now leads by 95 ns and 93 ns is adequate, the external delay provided in the signal path may be reduced by 2 ns (from 100 ns to 98 ns).

Samples/Sweep

A two position slide-type switch is provided on the front panel of the Type 3T6 for selecting either 1000 or 1 samples per sweep. This switch is effective only when the PROGRAM SELECTOR switch is set at INT.

When the PROGRAM SELECTOR is set at EXT either 1000, 100, or 1 samples per sweep can be programmed. The 100 samples per sweep capability when externally programming is covered later in this section under headings of Dot Density and High-Speed Programming. What is called 1 sample per sweep operation when programming from the Type 3T6 front panel is effectively the same as holding the sweep in the reset position when externally programming sweep reset. Sweep reset is also covered later in this section under the heading of External Programming. In most applications the front panel SAMPLES/SWEEP switch is set at 1000. When the SAMPLES/SWEEP switch is at 1 the Sampling Unit will sample the voltage at the one point on the waveform set by the DELAY switches.

Programming TIME/DIV at Front Panel

The Type 3T6 provides 30 sweep rates. Sweep rate is dependent upon the setting of the DECADE and MULTIPLIER switches. Rotating the MULTIPLIER switch provides 3 sweep rates for each of the 10 positions of the DECADE switch. See Table 2-2.

TABLE 2-2

Determining Sweep Rate TIME/DIV

DECADE Number	MULTIPLIER at 1	2	5
1	100 ms	200 ms	500 ms
2	10 ms	20 ms	50 ms
3	1 ms	2 ms	5 ms
4	100 µs	200 µs	500 µs
5	10 µs	20 µs	50 µs
6	1 µs	2 µs	5 µs
7	100 ns	200 ns	500 ns
8	10 ns	20 ns	50 ns
9	1 ns	2 ns	5 ns
0	100 ps	200 ps	500 ps

Sweep rate for any combination of the DECADE and MULTIPLIER switches can be determined from the table

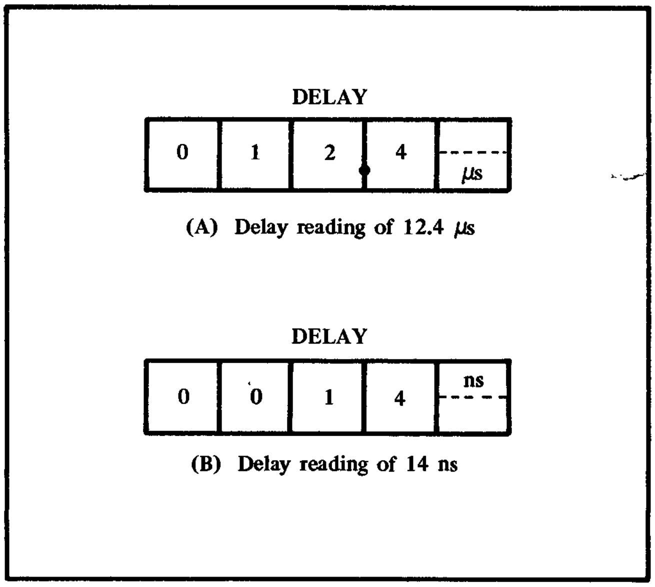


Fig. 2-8. Reading front panel delay.

above. With the DECADE at 7 and the MULTIPLIER at 2, Table 2-2 shows the sweep rate to be 200 ns. Sweep rate can be determined without reference to a table by remembering the relationship shown by the following formula.

$$\text{Time/Div} = M \times 10^{-D}$$

where: Time is in seconds
M is the setting of MULTIPLIER switch
D is the setting of DECADE switch

NOTE

When using formula above with DECADE setting at 0, the value of D is 10.

Programming DELAY at the Front Panel

When the PROGRAM SELECTOR switch is set to INT, the delay of the display window can be changed using the DELAY controls on the Type 3T6 front panel. Any number from 0000 to 9999 can be set in the DELAY window by rotating the four thumb-wheel operated switches. These numbers indicate programmed delay only if the PROGRAM SELECTOR switch is at INT and in equivalent time. In real time (DECADE 1, 2, or 3) no units show in the DELAY window and no delay can be programmed.

In Fig. 2-8A a delay reading of 12.4 µs is shown. Fig. 2-8B indicates that 14 ns of delay has been programmed.

A decimal is present in Fig. 2-8A and the units window shows µs (microseconds) to be the unit of time measurement. In Fig. 2-8B the decimal is not lit and ns (nanoseconds) now appears in the units of measure window. The decimal and units of measure appearing in the readout window depend upon the TIME/DIV setting of the Type 3T6 See Table 2-3. This table shows sweep rates at which the decimal in the delay readout window is lit. Table 2-3 also shows which unit of measure (μs or ns) appears in the units of measure window.

TABLE 2-3
Effect of TIME/DIV switch on DELAY readout

TIME/DIV	Decimal	Units
500 ms to 1 ms	no	none
500 μs to 2 μs	yes	μs
1 μs to 1 ns	no	ns
500 ps to 100 ps	yes	ns

When the TIME/DIV DECADE is set at positions 1, 2, or 3 (500 ms/div to 1 ms/div) sampling is real-time and no delay of display window, with respect to trigger, is available. All other DECADE positions result in equivalent-time sampling.

Time Window Positioning In Relation to the Triggering Event, T_o

Time T_o, the undelayed time window start, occurs slightly after the triggering signal is applied to the Type 3T6. See Fig. 2-9. The amount of time lag between application of the trigger and start of the undelayed sweep (T_o), depends upon the system being used and was discussed earlier in this section under Factors Affecting System Delay.

In Fig. 2-9 the time interval labeled 1 represents the (digitally derived) delay following T_o before starting the timing ramp. This delay is set, when using internal programming, by rotating the two DELAY switches farthest to the left on the Type 3T6 front panel. The maximum value of delay that can be introduced using these two controls is shown, for all equivalent-time sweep rates, in column 1 of Table 2-4. Both of these switches are set at 9 to obtain maximum delay. Time interval 2 of Fig. 2-9 represents the (analog derived) delay in starting of the displayed sweep or (time window) after the start of the timing ramp. See the circuit description for more information on digitally and analog derived delay. This delay is determined by the setting of the 3rd and 4th DELAY switches on the Type 3T6 front panel. The maximum value of delay that can be introduced using these two controls is shown for all equivalent-time sweep rates in column 2 of Table 2-4. Both switches are set at 9 to obtain maximum delay. Examination of columns 1 and 2 of the table shows the sweep rates at which a decimal appears between the 3rd and 4th DELAY switch on the Type 3T6 front panel. Columns 1 and 2 of the table also show the unit of time measurement appearing in the units window of the DELAY indicator.

With a TIME/DIV setting of 100 ps, the 10 divisions of displayed sweep (time window) represents 1 ns of time. Column 3 of Table 2-4 shows the equivalent duration of the time window for all equivalent TIME/DIV sweep rates. If the four DELAY switches on the Type 3T6 front panel are set at 0000 the signals occurring between T_o and 1 ns after T_o will be displayed. See Fig. 2-9. This 1 ns time window may be used to observe signals occurring between T_o and the time shown in column 4 of Table 2-4 by adding the proper delay. Examination of Fig 2-9 shows that time interval 4 is the sum of time intervals 1, 2, and 3. The maximum value for time interval 4 is given in column 4 of Table 2-4.

Reference to Table 2-4, column 3, shows that with a TIME/DIV sweep rate of 100 ns, signals occurring as much as 1 μs after T_o can be observed without using delay. At a samples per sweep rate of 1000 the equivalent-time between samples is 1 ns. This sweep rate will not be satisfactory for observing fastrise or narrow pulses. By using a TIME/DIV of 100 ps, and using DELAY, signals occurring as much as 1 μs after T_o can still be displayed. Using an equivalent time sweep rate of 100 ps/div instead of 100 ns/div provides 1000 samples in a 1 ns equivalent time period. Signals that could not be seen or were inadequately sampled at the slower sweep rate can be displayed using a faster sweep rate together with delay.

At a TIME/DIV of 100 ps the time window can be moved in 100 ps (1 division) increments. If all DELAY switches are set at 9 the time-window will start 999.9 ns or 9,999 divisions after T_o and end 1 ns (equivalent time) later as listed in column 4 of Table 2-4.

Display Rate When Using Equivalent-Time Sampling

Reference to Fig. 2-9 shows that setting both the X1000 and X100 DELAY indicators at ZERO will remove the number 1 delay interval. This results in the timing ramp (interval 5) starting at time T_o.

The minimum time required per sample was given in Table 2-1 during a discussion of trigger countdown earlier in this section. Time per sample is shown in Fig. 2-9 as the sum of time intervals 5, 6, and 7. The duration of the timing ramp and minimum reset time are shown in columns 5 and 6 of Table 2-4. The reset time given in column 6 of the table is the minimum value with the Type 3T6 RECOVERY TIME control fully clockwise. Turning the RECOVERY TIME control counterclockwise will increase the reset time and therefore the real time required to take one sample. Time interval 7 represents trigger circuit arming time and is 1 μs to 3 μs at all sweep rates. Adding time intervals 5, 6, and 7 provides the minimum time per sample as shown in Table 2-1.

The X1000 and X100 delay must be added to time intervals 5, 6, and 7 to determine total time per sample. The maximum sampling rate is the reciprocal of the minimum time per sample given in Table 2-1. With a time per sample

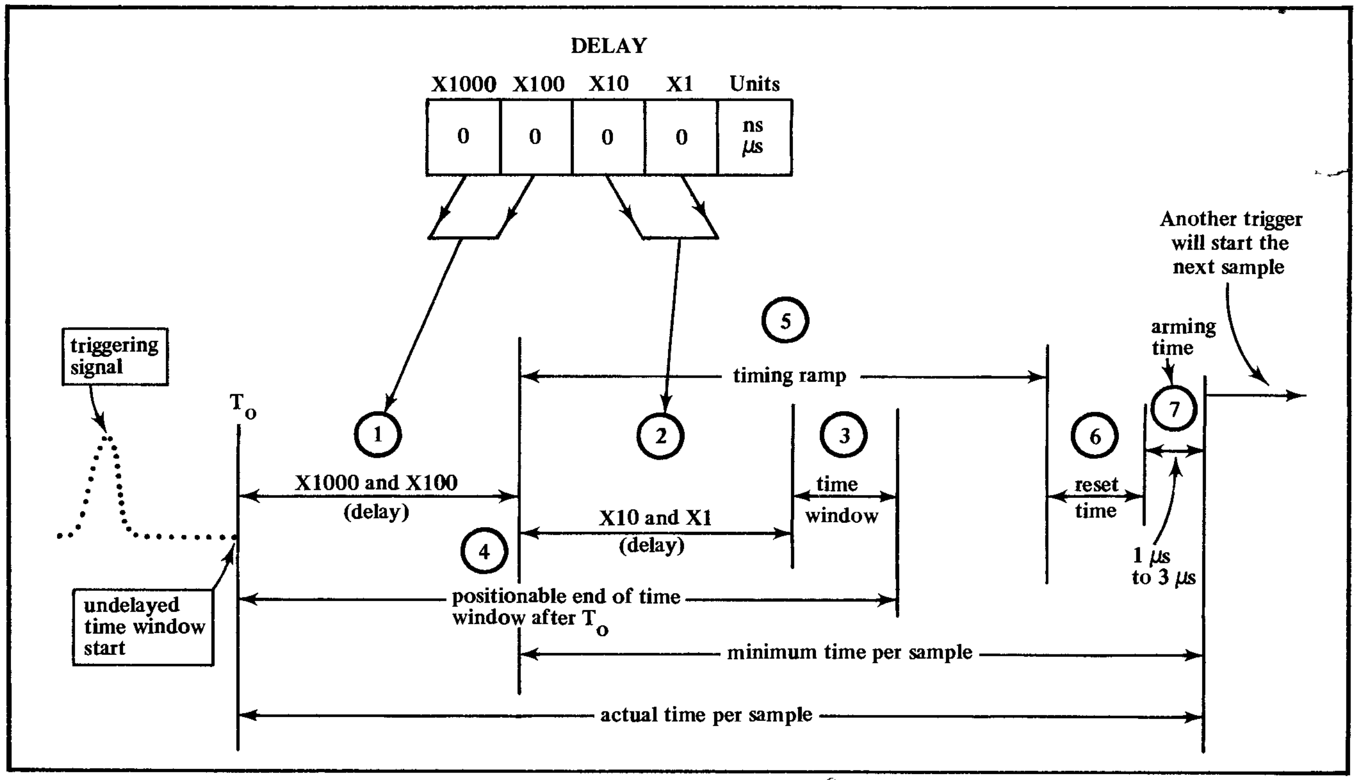


Fig. 2-9. Time segments for full-sweep time-window positioning, and time per sample cycle.

TABLE 2-4
Data for Equivalent Time Sweep Rates of Time Intervals Shown in Fig. 2-9

TIME/DIV	Max. Total X1000 and X100 Delay	Max. Total X10 and X1 Delay	10 Division Time Window	Positionable End of Time Window After T_0	Min. Timing Ramp Length	Min. Reset Time
	(1)	(2)	(3)	(4)	(5)	(6)
500 µs	990.0 µs	9.9 µs	5 ms	5.9999 ms	12 ms	2.5 ms
200 µs	990.0 µs	9.9 µs	2 ms	2.9999 ms	12 ms	2.5 ms
100 µs	990.0 µs	9.9 µs	1 ms	1.9999 ms	1.2 ms	250 µs
50 µs	990.0 µs	9.9 µs	500 µs	1.4999 ms	1.2 ms	250 µs
20 µs	990.0 µs	9.9 µs	200 µs	1.1999 ms	1.2 ms	250 µs
10 µs	990.0 µs	9.9 µs	100 µs	1.0999 ms	120 µs	25 µs
5 µs	990.0 µs	9.9 µs	50 µs	1.0499 ms	120 µs	25 µs
2 µs	990.0 µs	9.9 µs	20 µs	1.0199 ms	120 µs	25 µs
1 µs	9900 ns	99 ns	10 µs	19.999 µs	12 µs	4.5 µs
500 ns	9900 ns	99 ns	5 µs	14.999 µs	12 µs	4.5 µs
200 ns	9900 ns	99 ns	2 µs	11.999 µs	12 µs	4.5 µs
100 ns	9900 ns	99 ns	1 µs	10.999 µs	1.2 µs	7 µs
50 ns	9900 ns	99 ns	500 ns	10.499 µs	1.2 µs	7 µs
20 ns	9900 ns	99 ns	200 ns	10.199 µs	1.2 µs	7 µs
10 ns	9900 ns	99 ns	100 ns	10.099 µs	210 ns	7 µs
5 ns	9900 ns	99 ns	50 ns	10.049 µs	210 ns	7 µs
2 ns	9900 ns	99 ns	20 ns	10.019 µs	210 ns	7 µs
1 ns	9900 ns	99 ns	10 ns	10.009 µs	210 ns	7 µs
500 ps	990.0 ns	9.9 ns	5 ns	1.0049 µs	210 ns	7 µs
200 ps	990.0 ns	9.9 ns	2 ns	1.0019 µs	210 ns	7 µs
100 ps	990.0 ns	9.9 ns	1 ns	1.0009 µs	210 ns	7 µs

of 20 μs the maximum number of samples per second is 50,000. If 50,000 samples per second are taken (depending upon incoming trigger rate) and the SAMPLES/SWEEP is at 1000 the complete display will be repeated 50,000/1,000 or 50 times per second. At slower equivalent-time sweep rates or with a large value of delay (time interval 1 of Fig. 2-9) the time required to produce a display will be much longer. At sweep rates slower than 500 μs, real-time sampling is used since the time required to produce a display would be excessive using equivalent-time.

Time per sample (in seconds) when using real time sampling (TIME/DIV DECADE at 1, 2, or 3) is:

$$\text{time per sample} = \frac{\text{TIME/DIV}}{100}$$

Automatic Calibration

Automatic calibration of the Type 3T6 is primarily intended for use where the Type 3T6 is part of a system requiring close tolerance time measurements.

The Type 3T6 is provided with a lead that may be utilized to control the Type 3T6 timing current. This wire connects to pin 27 of J224 on the rear panel of the Type 568 Oscilloscope. External automatic control of the current through either of these pins permits accurate control of the Type 3T6 timing current, and therefore calibration.

External Programming

Sweep rate, delay, dot density, and sweep reset may be controlled using an external programmer such as the Type 241 or the Type 240 system. The Type 3T6 PROGRAM SELECTOR must be set at EXT when an external program is used.

Dot density may be changed from 100 dots per division to approximately 10 dots per division when using external programming except with TIME/DIV DECADE at positions 1, 2, or 3. This decreases the time required for the Type 230 Digital Unit to make a voltage or time measurement when high speed programming. Dot density of 10 dots per division is not available when using internal (front panel) programming. When taking digital measurements, the dot density must be controlled by the synchronizer of the Type 230.

The external program is applied through an interconnecting cable to J224 on the rear panel of the Type 568 Oscilloscope. The dot density and sweep reset programming lines are also connected to J101 on the rear panel of the Type 568 Oscilloscope. Negative logic is used.

The two logic levels required to program the Type 3T6 can be provided in a number of ways, depending upon the type of programmer used. Each logic line can be controlled using a switch, transistor, or other closure type programming unit. With a negative logic system a logical ONE results when the voltage of a program line is at its less positive level. See Fig. 2-10. A voltage of 0 V to +2 V applied to a program line of the Type 3T6 will provide a logical ONE, while a voltage of +6 V to +15 V results in a logical ZERO. Leaving a programming line open also provides a logical ZERO, while shorting the line to common ground will produce a logical ONE input. Common ground pin number for connector J24 is given in Table 2-7. The common ground lead provides the Type 3T6 and the program unit with the same ground reference. A Program common lead notifies the programming unit whether INT or EXT program has been selected at the Type 3T6 front panel. When INT is selected the programming unit must provide a logical ZERO, to all lines used for external programming.

NOTE

When using connector J224 on the rear panel of the Type 568 Oscilloscope for external programming, be sure that Connector, Circuit Board, Tektronix Part No. 388-0805-00 is inserted in J24 at the rear of the Type 3T6 (See Fig. 2-1).

Accuracy when externally programming TIME/DIV or DELAY is exactly the same as when programming from the front panel, since the system is digital. Accuracy is shown in Section 1.

Truth tables showing logic required by the programmable functions are presented along with examples of their use in the discussion below.

External Programming of TIME/DIV permits selection of any one of 30 sweep rates. The required DECADE and MULTIPLIER may be selected using BCD logic from an external programmer. See Table 2-5. Any of the 10 DECADE numbers may be selected by applying BCD logic to four terminals. With the programmer connected to J224 (rear of the Type 568 Oscilloscope), terminals 1, 2, 3, and 4 are used to program DECADE number.

Assume that the sweep rate to be programmed requires DECADE number 5. Move down the DECADE number column of Table 2-5 to 5. Moving horizontally to the right from 5 shows that logic of ZERO, ONE, ZERO, ONE is required at terminals 1, 2, 3, and 4 respectively of J224. Table 2-5 also shows the TIME/DIV that is obtained at each MULTIPLIER setting. Moving horizontally to the right from 5 in the DECADE number column shows that a TIME/DIV of 10 μs, 20 μs or 50 μs will result, depending upon the MULTIPLIER programmed.

To program a TIME/DIV of 10 μs requires DECADE 5 and MULTIPLIER 1. MULTIPLIER 1 is programmed from J224 by applying a logical ZERO to terminal 6, ZERO to terminal 7, and a logical ONE to terminal 8.

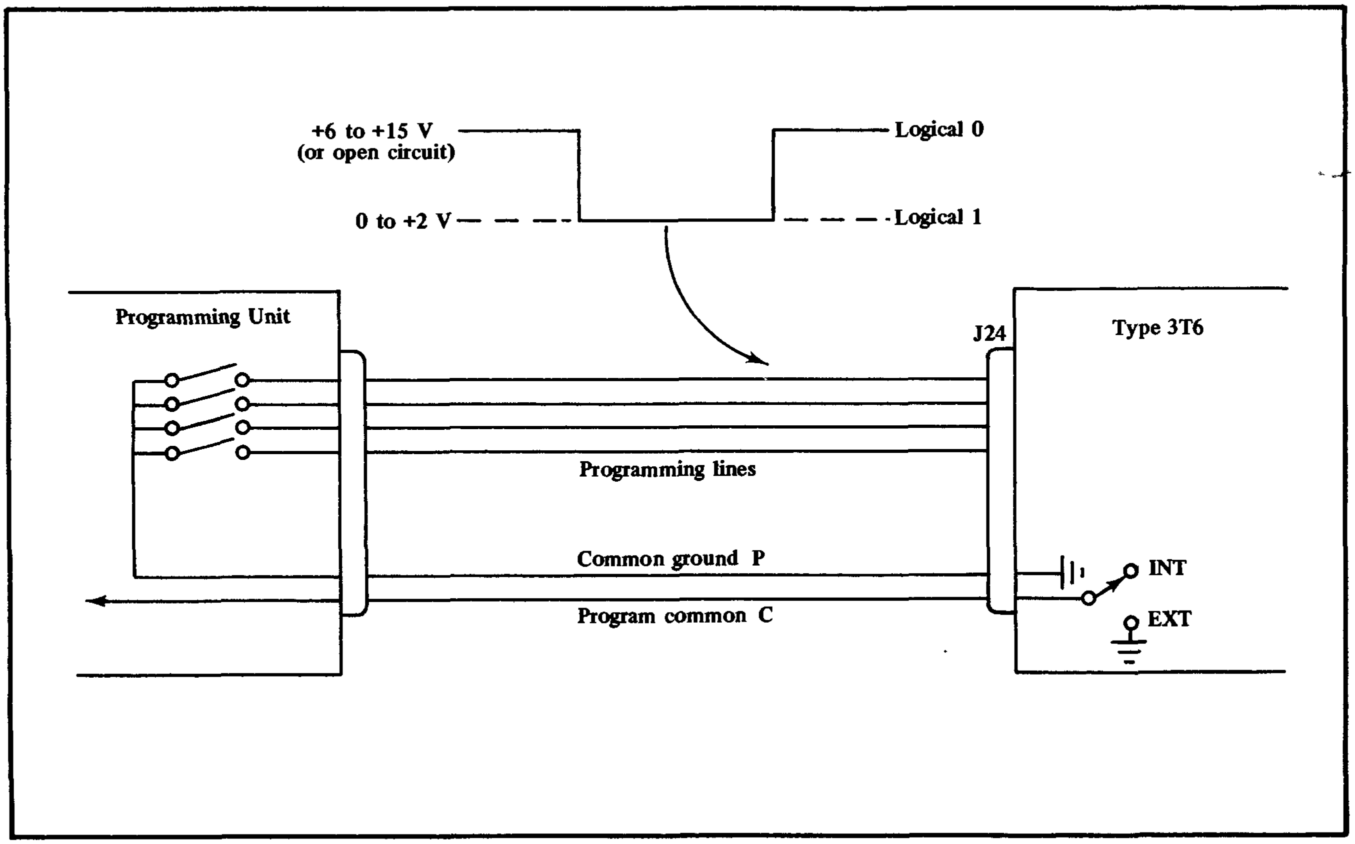


Fig. 2-10. Voltages required from programming unit for proper input logic.

NOTE

The truth table showing logic required to program the TIME/DIV MULTIPLIER (Table 2-5) contains DON'T CARE logic in the center column. The logic level appearing at terminal 7 of J24 or J224 has no effect on the programmed MULTIPLIER setting. Although only two terminals of the Type 3T6 must be connected to the programmer, when externally programming the TIME/DIV MULTIPLIER, three terminals have been provided. Three terminals are provided to ensure ease of operation and compatibility with programmers supplying logic in true BCD form.

Delay Time is programmed using 16 program lines. The same range of delay can be programmed externally as from the front panel. The amount of delay that can be programmed depends upon the sweep rate being used. See Table 2-6 for range of delay that can be programmed.

Delay Factor with PROGRAM SELECTOR at INT is the number visible in the DELAY window on the Type 3T6 front panel. Any value from 0000 to 9999 may be programmed at the front panel or using external programming. The value of the Delay Unit is dependent upon the sweep rate programmed.

Delay Unit and Delay Factor need not be considered when programming from the Type 3T6 front panel. However, discussing internal programming (PROGRAM SELECTOR at INT) will aid in understanding the meaning and use of these terms.

Assume that the PROGRAM SELECTOR switch is set at INT. The TIME/DIV DECADE is at 5 and MULTIPLIER is at 1 resulting in a TIME/DIV of 10 μs/div. Reference to Table 2-6 shows the Delay Unit is 0.1 μs. The DELAY controls are turned until the displayed pulse is in the desired position. The appearance of the DELAY indicator on the Type 3T6 front panel is shown in Fig. 2-11. In Fig. 2-11 a programmed delay of 12.4 μs is indicated. The decimal point and μs which appear on the DELAY indicator at a sweep rate of 10 μs/div indicate that the Delay Unit is 0.1 μs. The Delay Factor of 124 is indicated by numbers on the X1000, X100, X10, and X1 delay controls.

To program this same delay using external programming, follow the procedure below.

1. Set the Type 3T6 PROGRAM SELECTOR at EXT.

TABLE 2-5

Logic and Connections for Externally Programming Sweep Rate

TIME/DIV	Sweep rate DECADE	Sweep rate MULTIPLIER	Program logic DECADE				Program logic MULTIPLIER*		
500 ms		5					1	0	1
200 ms	1	2	0	0	0	1	0	1	0
100 ms		1					0	0	1
50 ms		5					1	0	1
20 ms	2	2	0	0	1	0	0	1	0
10 ms		1					0	0	1
5 ms		5					1	0	1
2 ms	3	2	0	0	1	1	0	1	0
1 ms		1					0	0	1
500 μs		5					1	0	1
200 μs	4	2	0	1	0	0	0	1	0
100 μs		1					0	0	1
50 μs		5					1	0	1
20 μs	5	2	0	1	0	1	0	1	0
10 μs		1					0	0	1
5 μs		5					1	0	1
2 μs	6	2	0	1	1	0	0	1	0
1 μs		1					0	0	1
500 ns		5					1	0	1
200 ns	7	2	0	1	1	1	0	1	0
100 ns		1					0	0	1
50 ns		5					1	0	1
20 ns	8	2	1	0	0	0	0	1	0
10 ns		1					0	0	1
5 ns		5					1	0	1
2 ns	9	2	1	0	0	1	0	1	0
1 ns		1					0	0	1
500 ps		5					1	0	1
200 ps	0	2	0	0	0	0	0	1	0
100 ps		1					0	0	1

Connector	Pin number						
Type 3T6 (rear) J24	1	2	3	4	6	7	8
Type 568 (rear) J224	1	2	3	4	6	7	8

***No internal connections**

TABLE 2-6

Effect of TIME/DIV on Delay Unit and Programmable Delay

TIME/DIV	Programmable Delay	Delay Unit	Delay Factor
500 ms to 1 ms	No delay	No delay	0000
500 μs to 2 μs	0 to 999.9 μs in 100 ns increments	0.1 μs	to
1 μs to 1 ns	0 to 9.999 μs in 1 ns increments	1 ns	9999
500 ps to 100 ps	0 to 999.9 ns in 100 ps increments	0.1 ns	

Programmable Delay = Delay Unit X Delay Factor

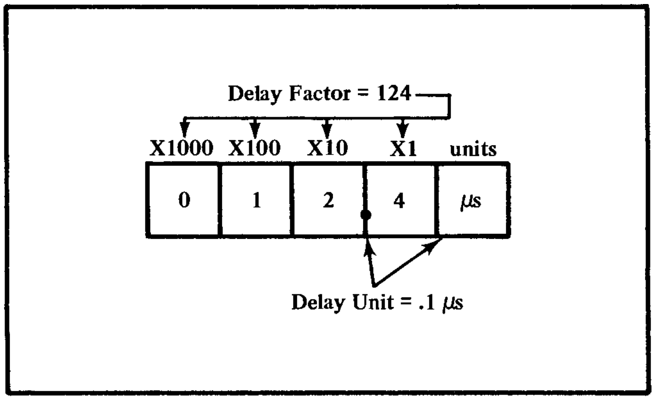


Fig. 2-11. Delay of 12.4 programmed at front panel.

2. Externally program TIME/DIV to 10 µs/div, using the method discussed earlier in this section of the manual.

3. Refer to Table 2-7 to determine logic required by programming lines for X1000, X100, X10, and X1 delay factors. Each of the four truth tables have four lines labeled 1, 2, 4, and 8.

4. To externally program the decimal digits that were previously programmed internally at the front panel window (0124), start with the X1000 digit. Proceed down the left column of the X1000 truth table to the decimal digit and read the binary equivalent in the four columns to the right. The X1000 truth table shows the binary 0000 to the right. Below these digits, at the bottom of the table, the pin numbers to which the four X1000 programming lines connect are given. If J224 is being used for programming, applying a logic ZERO to pins 9, 10, 11, and 12 will program the first decimal digit. Since a potential of +6 V to +15 V or an open circuit provides a logical ZERO an open circuit will be assumed during the remainder of this discussion when a logical ZERO is required. A logical ONE input will be produced by shorting the programming line to common ground.

5. To program the next decimal digit shown on the front panel DELAY indicator follow the same procedure as above. Proceed down the X100 column to the decimal digit 1. The binary equivalent is shown to be 0001. Therefore pins 13, 14, and 5 of J224 are left open and pin 16 is connected to common ground (pin 28 of J224) to provide a logical ONE (0 V to +2 V) on the required programming line. The table shows that connecting pins 16, 21, and 24 of J224 to common ground or a voltage of 0 V to +2 volts will provide the required delay.

Dot Density of either 100 dots/division (1000 samples/sweep) or 10 dots/division may be externally programmed. When real-time sampling (TIME/DIV DECADE at 1, 2, or 3), 10 dots/division cannot be externally programmed. A dot density of 10 dots/div cannot be obtained when the Type 3T6 PROGRAM SELECTOR switch is set at INT.

A logical ONE (0 to +2 V), on the proper programming line, provides a dot density of 10 dots/division while a logical ZERO (+6 V to +15 V or an open circuit) provides a dot density of 100 dots/division. This logic may be applied to pin 17 of J224 at the rear of the Type 568. See Fig. 2-12A.

TABLE 2-7
Truth Tables for Externally Programming Delay

DELAY: 0 1 2 4 µs

X1000	8	4	2	1	X100	8	4	2	1	X10	8	4	2	1	X1	8	4	2	1	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1	0	0	0	1	1	0	0	0	1	1	0	0	0	1	1	0	0	0	1	
2	0	0	1	0	2	0	0	1	0	2	0	0	1	0	2	0	0	1	0	
3	0	0	1	1	3	0	0	1	1	3	0	0	1	1	3	0	0	1	1	
4	0	1	0	0	4	0	1	0	0	4	0	1	0	0	4	0	1	0	0	
5	0	1	0	1	5	0	1	0	1	5	0	1	0	1	5	0	1	0	1	
6	0	1	1	0	6	0	1	1	0	6	0	1	1	0	6	0	1	1	0	
7	0	1	1	1	7	0	1	1	1	7	0	1	1	1	7	0	1	1	1	
8	1	0	0	0	8	1	0	0	0	8	1	0	0	0	8	1	0	0	0	
9	1	0	0	1	9	1	0	0	1	9	1	0	0	1	9	1	0	0	1	
Connector	Pin					Pin					Pin					Pin				Common Ground
J24	9	10	11	12		13	14	5	A		D	E	F	H		J	K	L	M	Pin P
J224	9	10	11	12		13	14	5	16		19	20	21	22		23	24	25	26	Pin 28

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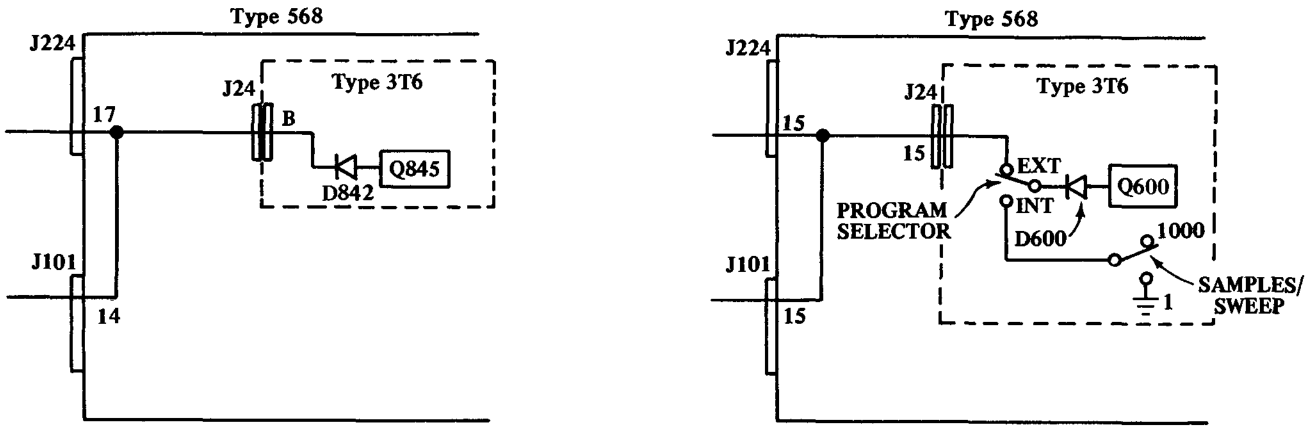


Logic	Program
0	100 dots/division
1	10 dots/division

(A) Programming dot density

Logic	Program
0	Normal sweep
1	Reset sweep

(B) Programming sweep reset

Fig. 2-12. Programming dot density and sweep reset.

Grounding pin 17 of J224 will provide a logical ONE on the proper programming line to change dot density to 10 dots/division. Digital measurements should not be made when a dot density of 10 dots/div is programmed, except when the portion of the sweep during which a dot density of 10 dots/div is programmed, is determined by the Type 230 synchronizer. Fig. 2-12A also shows dot density being controlled by the Type 230 when the program control unit orders high speed programming. High speed programming is discussed later in this section.

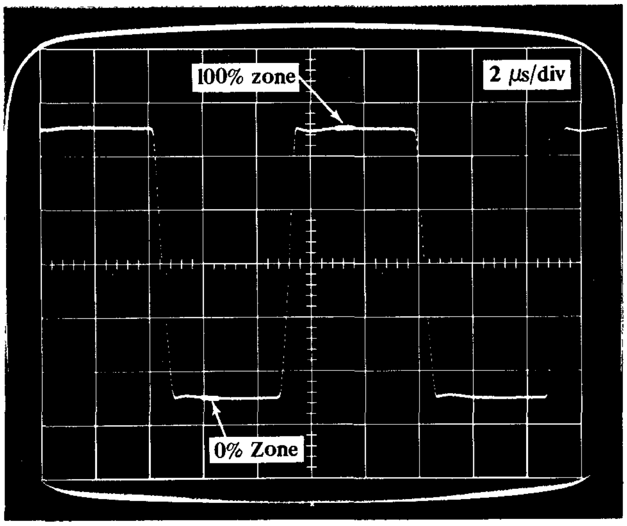
Sweep Reset will return the sweep to its starting position at any time during the sweep that a logical ONE is applied to the proper external programming line and hold the sweep there as long as the logical ONE is there. See Fig. 2-12B. Reset logic is applied to pin 15 of J224 at the rear of the Type 568 Oscilloscope. Fig. 2-12B also shows that positioning the SAMPLES/SWEEP switch on the Type 3T6 front panel to 1, when internal programming is used, is the same as applying a logical ONE to an external program line used for sweep reset.

Reset logic may be applied from the Type 230 Digital Unit to pin 15 of J101. This is covered later in this section during the discussion of high speed programming.

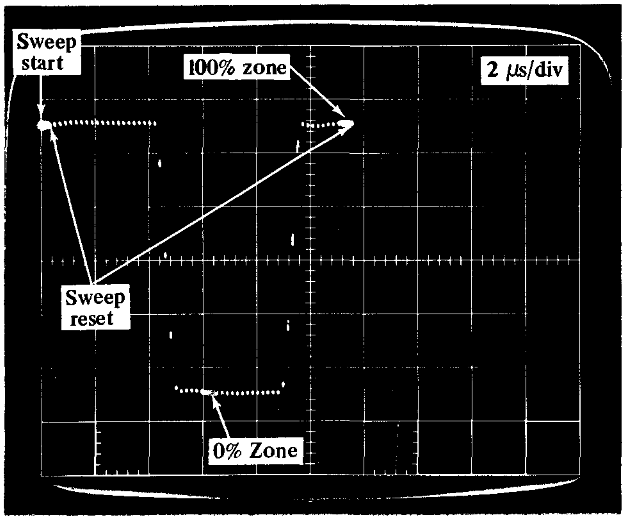
High Speed Programming the Type 3T6 will result in a considerable saving in the time required to make a measurement. This means more measurements per second can be programmed by the system control unit.

During high speed programming, the time required for the Type 230 to make a measurement is reduced by automatically changing the dot density. The number of dots or samples per divison of display is reduced from 100 to 10, except during the reference zones and the measurement sweep. Another factor reducing measurement time is automatic resetting of the sweep. See Fig. 2-13A and Fig. 2-13B for displays when programmed for digital voltage measurements. Fig. 2-13A is a photograph of a display without high-speed programming, while Fig. 2-13B shows the display when the Type 230 is high-speed programmed.

Two sweeps are required for the Type 230 to make a measurement. The first sweep is called the memory charging sweep, while the second sweep is called the measurement sweep. In Fig. 2-13A both sweeps are the same length and consist of 1000 samples each. It is therefore necessary that 2000 samples be taken for each measurement made by the Type 230. However if the program control unit orders high-speed programming, the synchronizer board in the Type 230 Digital Unit will control dot density and sweep resetting of the Type 3T6. See Fig. 2-14. Fig. 2-12B shows

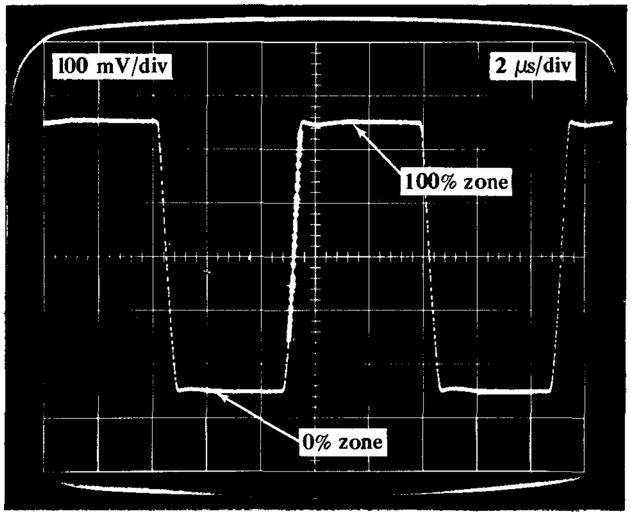


(A) Without high-speed programming.

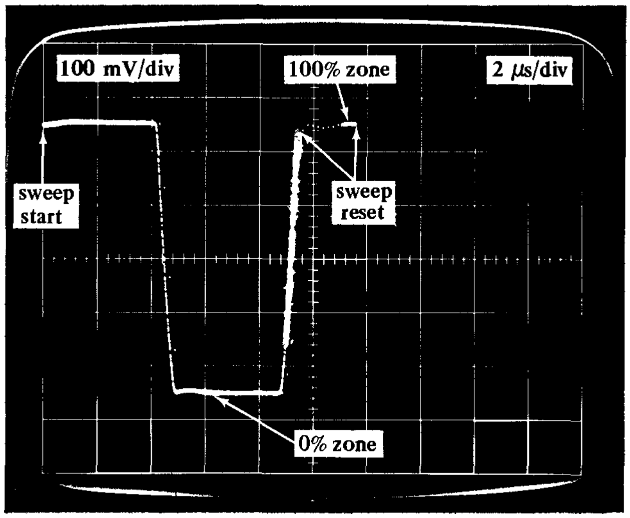


(B) With high-speed programming

Fig. 2-13. Displays when programmed for digital voltage measurements.



(A) Without high-speed programming



(B) With high-speed programming

Fig. 2-15. Displays when programmed for digital time measurements.

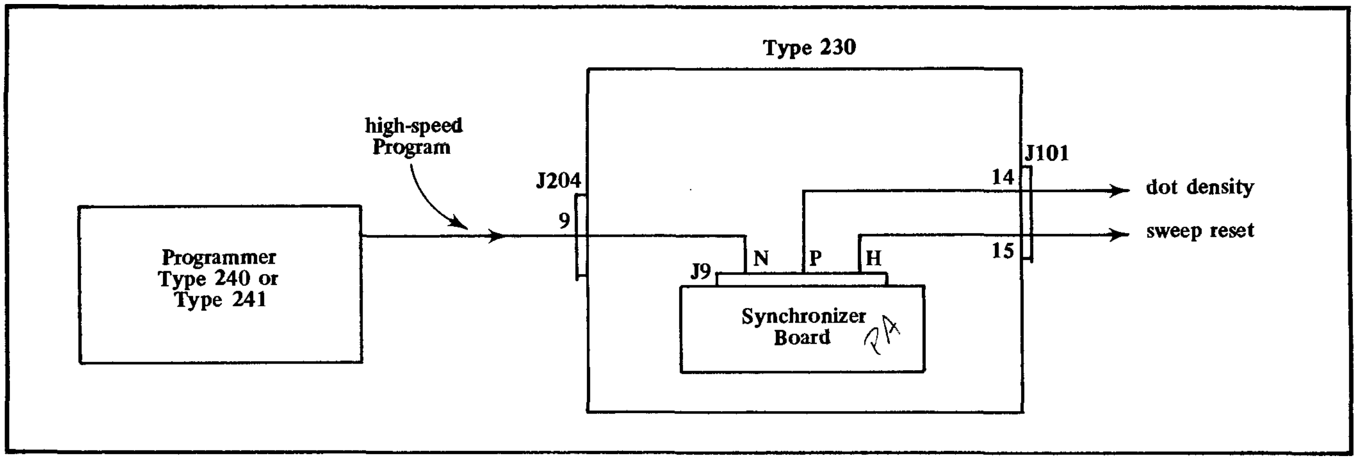


Fig. 2-14. High-speed programming.

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the effect on the Type 568 display of high speed programming. The first sweep ends after the last zone (the 100% zone in this case) and the second sweep is only about 1 mm in length. During the first sweep, dot density will be 10 dots/div except during each of the 3 mm zones when the sample rate is 100 dots/div. Assuming 30 samples for each zone and 52 samples for the remaining 5.2 divisions of the first sweep gives a total of 112 samples instead of the 1000 necessary without high-speed programming. During the second sweep (the measurement sweep) the dot density is 100 dots/division. Since the sweep, in this example, is only about 1 mm in length only 10 samples will be taken during the second sweep before reset occurs. Samples for the two sweeps thus total 122 instead of the 2000 required without high speed programming.

Fig. 2-15 shows displays with and without high-speed programming when making a time measurement using the Type 230. In the example shown, the reduction in samples during the measurement sweep is not as great as when making a voltage measurement. This is due to the second sweep not ending until the end of the time measurement zone. The length of the second sweep and, therefore the number of samples, will be reduced if the measurement zone is kept near the sweep start.

With the Type 3T6 TIME/DIV DECADE set to positions 1, 2, or 3 (the positions in which sampling is real time) high speed programming does not change dot density. The Type 3T6 will, however, respond to commands for trace reset. Measurement time is thus reduced by high-speed programming.

For high-speed programming, the Type 230 Digital Unit must be equipped with a Model 3 or later synchronizer board. Models 1 and 2 cannot be used for high-speed programming the Type 3T6.

NOTES

SECTION 3
CIRCUIT DESCRIPTION

Change information, if any, affecting this section will be found at the rear of the manual.

General

The Type 3T6 Programmable Sampling Sweep unit has two basic modes of operation. The chief difference between them is that one mode constructs an equivalent time display by a conventional (sequential) process requiring that the signal be repeated for each sample, and the other mode presents a real time display of any one signal. Neither mode can display the triggering event itself without a signal delay to the sampling unit, or a pretrigger event to the Type 3T6. The instrument changes modes automatically when the sweep rate is changed from 500 μs/div to 1 ms/div, and vice versa. A fixed range of the signal time region is viewed in either mode. In DECADES 1, 2 and 3 the mode is real time and in DECADES 4 through 0 the mode is equivalent time. Only the equivalent time mode allows the time region to be positioned (delayed) away from (after) the triggering event (T_0) that starts the process for one equivalent time sweep. Time positioning of the sampled time region is referred to as the positioning of a time window. Time window positioning (delay) is not available when the unit is presenting a real time sampling display.

When the Type 3T6 is producing an equivalent time display, the time window can be positioned by the DELAY switches to start just after trigger recognition. The actual minimum delay time after trigger recognition is discussed in the Operating Instructions, as is the maximum delay time.

Another important feature of the Type 3T6 is that its operation can be controlled remotely by special programming equipment. Remote programming is discussed in detail in the Operating Instructions, and later in this section during the Block Diagram description. First, the two modes of sweep generation are discussed.

Sweep Generation

Sweep generation[1] within the Type 3T6 is different for equivalent time than for real time mode of operation. The primary difference is in the operation of the triggering circuits and the method of timing the step drive sent to the staircase generator. Fig. 3-1 shows a simplified representation of sweep voltage vs CRT display dot position for both modes of operation. Real time operation causes the period between staircase step drive pulses to be constant, while the equivalent time operation may present a valid display with considerable variation in time between staircase drive pulses.

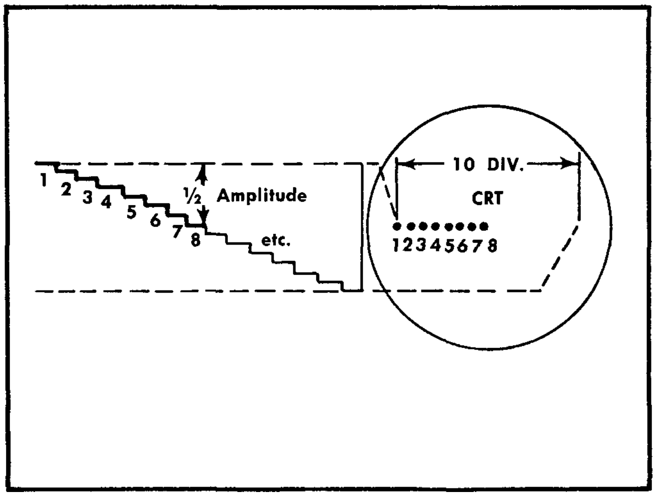


Fig. 3-1. Staircase signal and sequential dot display.

Fig. 3-1 shows a simplified picture of the way in which both equivalent time and real time sweep generation move the dot across the CRT. The figure shows uniform voltage steps and time duration of each part of the staircase signal. Such conditions are true for real time sampling, but equivalent time sampling can require non-uniform time periods for each staircase step.

Equivalent Time Sampling Process

The equivalent time sampling process is shown in basic form in Fig. 3-2. The waveforms represent just two samples in a sequence, such as the fifth and sixth dots of a 1000-dot display. Each waveform is identified with its block, or with interconnections in the adjacent block diagram.

The trigger regenerator circuit is the master programmer of Fig. 3-2. It delivers a positive step pulse at the time of trigger recognition, T_0, to start the process that takes and displays one sample. Immediately after T_0 the trigger circuits lock out any more triggers until the rest of the circuits have operated and the dot has been properly displayed. (The period of time during which triggers are locked out is called the holdoff time, and is made variable by the Type 3T6 front panel RECOVERY TIME control. See the Operating Instructions for RECOVERY TIME control uses.)

[1]Compare this part of the circuit description with the sampling unit (Type 3S5 or 3S6) instruction manual section on Tektronix Sampling Principles for a more complete understanding.

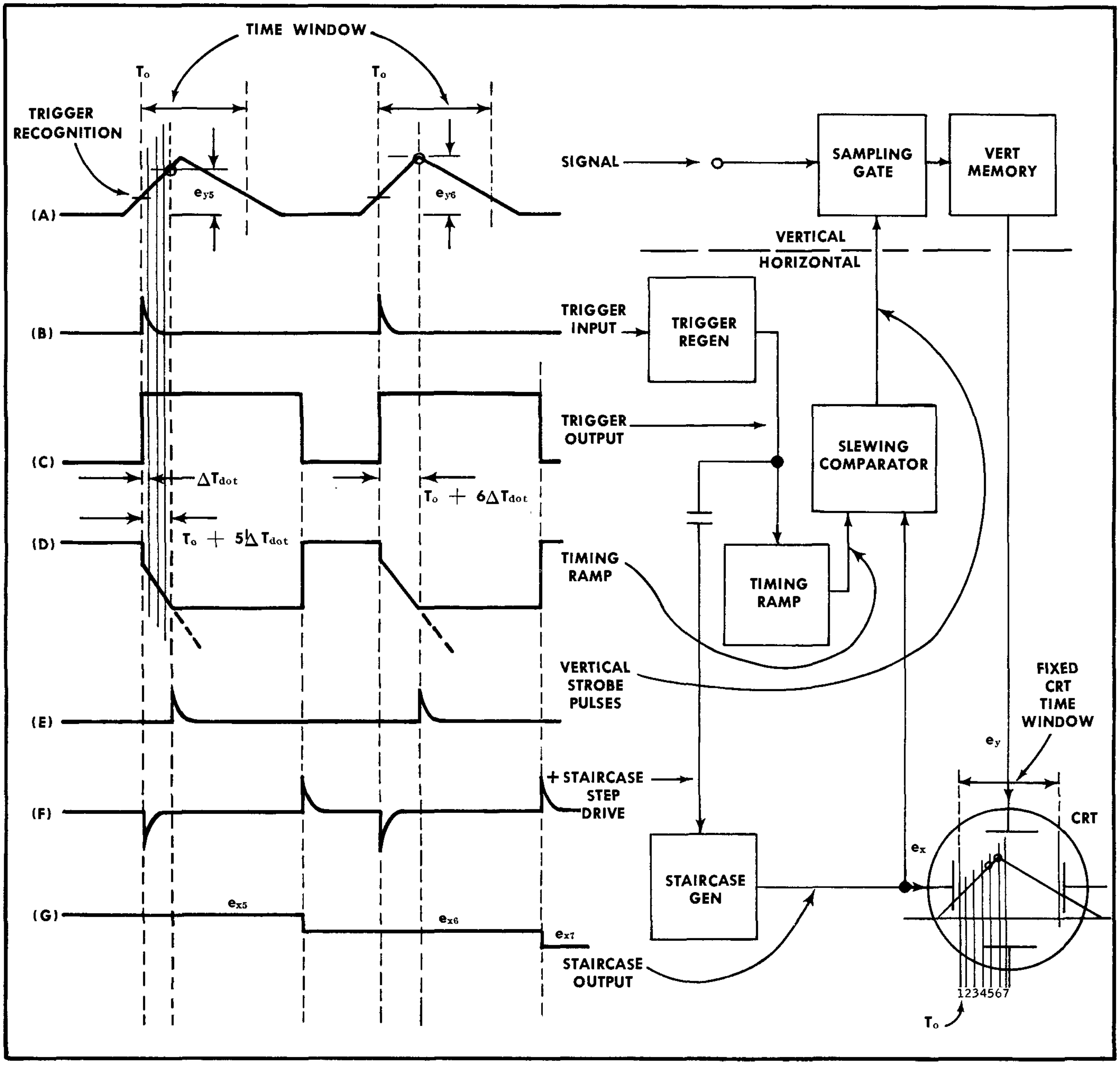


Fig. 3-2. Basic equivalent time sampling oscilloscope.

At T_0, the trigger circuit starts the timing ramp running in a negative direction. The timing ramp "times" the occurrence of the strobe drive pulse sent to the vertical sampling unit as the timing ramp is compared with the voltage of the staircase generator in the Slewing Comparator block. Since the staircase output signal voltage is different for each trigger circuit output pulse, the timing ramp is allowed to run down farther for each successive sample. The result is a time "slewing" of successive sampling times. The slewing increment is identified in Fig. 3-2 as ΔT_{dot} and is a fixed time increment per sample. ΔT_{dot} is set by both the timing ramp slope and the staircase step amplitude.

The waveforms of Fig. 3-2 imply that there can be a CRT dot displayed from the time of the vertical strobe pulse to the time of the timing ramp reset. Actually the CRT blanking is also controlled by the vertical sampling unit. The vertical unit prevents CRT beam current at the time of the vertical strobe pulse and until the vertical memory is stable, typically for 2 to 3 μs.

Adding Sweep Rate and Movable Time Window Controls

The time window (sampled signal time domain) identi-

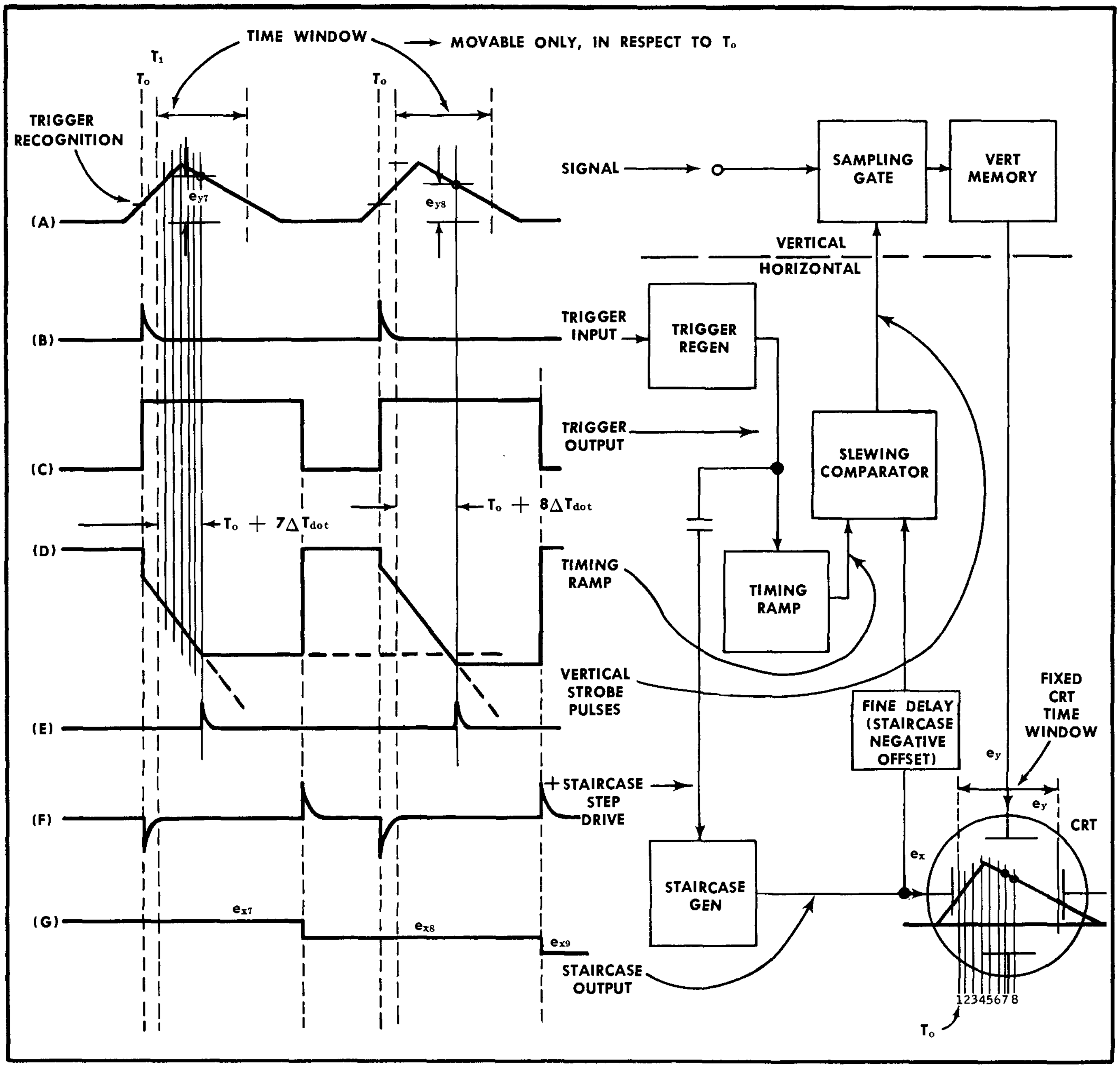


Fig. 3-3. Adding a time-window Delay control to basic block of Fig. 3-2.

fied in Fig. 3-2 can be moved so that a different portion of the signal is displayed. Fig. 3-3 shows a Delay control added between the Staircase Gen block and the Slewing Comparator block. This new circuit allows a negative DC voltage offset to be applied to the staircase signal that is compared with the timing ramp signal. Since the comparator block is a DC coupled comparator, changing the DC level of the staircase signal in a negative direction causes the timing ramp signal to travel farther negative before comparison occurs. Since the timing ramp signal is a ramp, the more negative comparison results in a later comparison and later vertical strobe pulses than before the staircase signal was offset.

The staircase signal sent to the CRT is not altered; thus, the voltages that set the CRT dot positions are not changed, the first dot occurring at the CRT left side. If the Delay control applies a negative offset to the staircase signal that feeds the comparator block, the first displayed dot at the CRT left side will have a vertical voltage related to the signal amplitude at time T_1 (see Fig. 3-3 upper left). The result is an apparent horizontal shift of the displayed signal to the left. The circuits of the Type 3T6 allow only a negative offset to be applied to the staircase signal, thus permitting the movable time window to include only portions of the signal AFTER trigger recognition time, T_o.

Fig. 3-3 does not show any method that will alter the equivalent time sweep rate. Two different controls are used to alter the Type 3T6 sweep rate. One is called the Decade control and the other the Multiplier control. Both controls operate BCD digital logic circuits that change the equivalent time sweep rate thus: the slope of the Timing Ramp is altered and the Staircase signal amplitude is altered before it is sent to the Slewing Comparator block.

To decrease the rate of fall (dV/dt) of the timing ramp is to increase the time assigned to ΔT_{dot} (ΔT_{dot} is the equivalent time between dots). If the staircase signal to the CRT is not altered and the real time presentation of dots is not altered, increasing ΔT_{dot} makes the display have a slower equivalent time sweep rate (more time per CRT division). A slower sweep rate will allow a longer period of the input signal to be displayed.

To increase the rate of fall of the timing ramp is to speed up the equivalent time sweep rate. The Type 3T6 also alters the trigger circuit reset time to avoid display confusion, so the trigger circuits don't recognize the input signal until after the dot has been properly displayed.

To reduce the amplitude of the staircase signal sent to the Slewing Comparator block is to reduce the time assigned to ΔT_{dot}. Since the staircase signal to the CRT is not altered, and the real time presentation of dots is not altered, reducing ΔT_{dot} makes the display have a shorter equivalent time sweep rate (less time per CRT division).

Sweep Generation, Real Time

The real time sampling process is shown in basic form in Fig. 3-4. The waveforms represent two full sweeps, with 7 samples shown for the first sweep. Instead of the Trigger Regenerator initiating all of an individual sample cycle, it starts the cycle for one full sweep, and is then locked out until after the Staircase Generator resets and is ready to start another sweep. The Staircase Generator steps are driven by a Clock and Counter circuit that controls the time between samples and ensures that once started, the samples occur at a precision rate until the end of each sweep.

At T_o, the trigger circuit sends a start pulse to the Clock and Counter circuit. The Clock and Counter circuit delivers pulses to the Strobe Driver, which sends pulses to both the Staircase Generator and the vertical sampling unit. Just as soon as the Staircase Generator starts, the Trigger Lockout circuit inhibits the trigger circuit from responding to any more trigger input signals until after a full sweep has been completed. (The maximum real time Clock and Counter rate is 100 kHz in the Type 3T6.)

The real-time time window cannot be delayed (positioned) with respect to T_o; therefore, the display beginning always occurs at T_o. The dot sequence must include many dots for each vertical signal cycle in order to present a meaningful display. Too few dots per signal cycle cause distortion that may make the display difficult to interpret. It is this characteristic of real time sampling along with the maximum sampling rate, which limits the upper signal frequency that can be properly displayed.

BLOCK DIAGRAM

Two complete block diagrams appear at the back of this manual preceding the main circuit diagrams. The first applies to equivalent time operation, and the second to real time operation. Circuits not used for each of the two modes of operation are shaded to show a visual contrast with the circuits in use.

Central Timing Logic Block (both diagrams)

The three blocks in the upper right corner outline the integrated circuit numbers used to convert the DECADE and MULTIPLIER switches (or external program) binary coded decimal inputs to actuate proper internal circuits and digital unit control lines. (Note that the T2 line of the three Muliplier lines is dashed. That means it is not actually connected internally, but that an external program connector pin is made available so three-line BCD negative logic programmers can be used without confusion.) The sweep rate (both equivalent and real time) is equal to a three line BCD Multiplier binary number multiplied by 10 to the −E power (T X 10^{-E} SEC/div); where E is a BCD Decade (0=10) binary number. These two numbers are read into the Type 3T6 as 3 and 4 Bit BCD numbers respectively. The Central Timing Logic block converts information from the two sets of BCD input lines to proper logic states of all output lines shown leaving the block. Lines going to the Digital Unit Control Logic block and the Sweep Rate Readout Logic block are not individually identified. However, other lines used throughout the other Type 3T6 circuits are identified by either assigned letters or Roman numerals (which are used as Boolean Algebra Symbols) and in most cases with names and pin numbers to show their true function. All lines drawn horizontally to the right of the Central Timing Logic block have the pin numbers of either the Logic One or Logic Two circuit card interconnecting jack included, so that a test oscilloscope can be used to check the output function during maintenance or troubleshooting. The four lines leaving the bottom of the Central Timing Logic block and the one line leaving the left side of the Sweep Rate Readout Logic block all control only the real time sweep rate. Only the bottom two of the fourteen lines leaving the right side of the Central Timing Logic block are used in real time operation. All fourteen lines are used during equivalent time operation.

The Digital Unit Control Logic block does not function until the associated digital unit (Type 230)delivers a logical ONE at the D, U, GND line. When the digital unit grounds the D, U, GND line, the integrated circuits of the Digital Unit Control Logic block control the readout units-of-measure and decimal (including the M, N and μ multipliers)

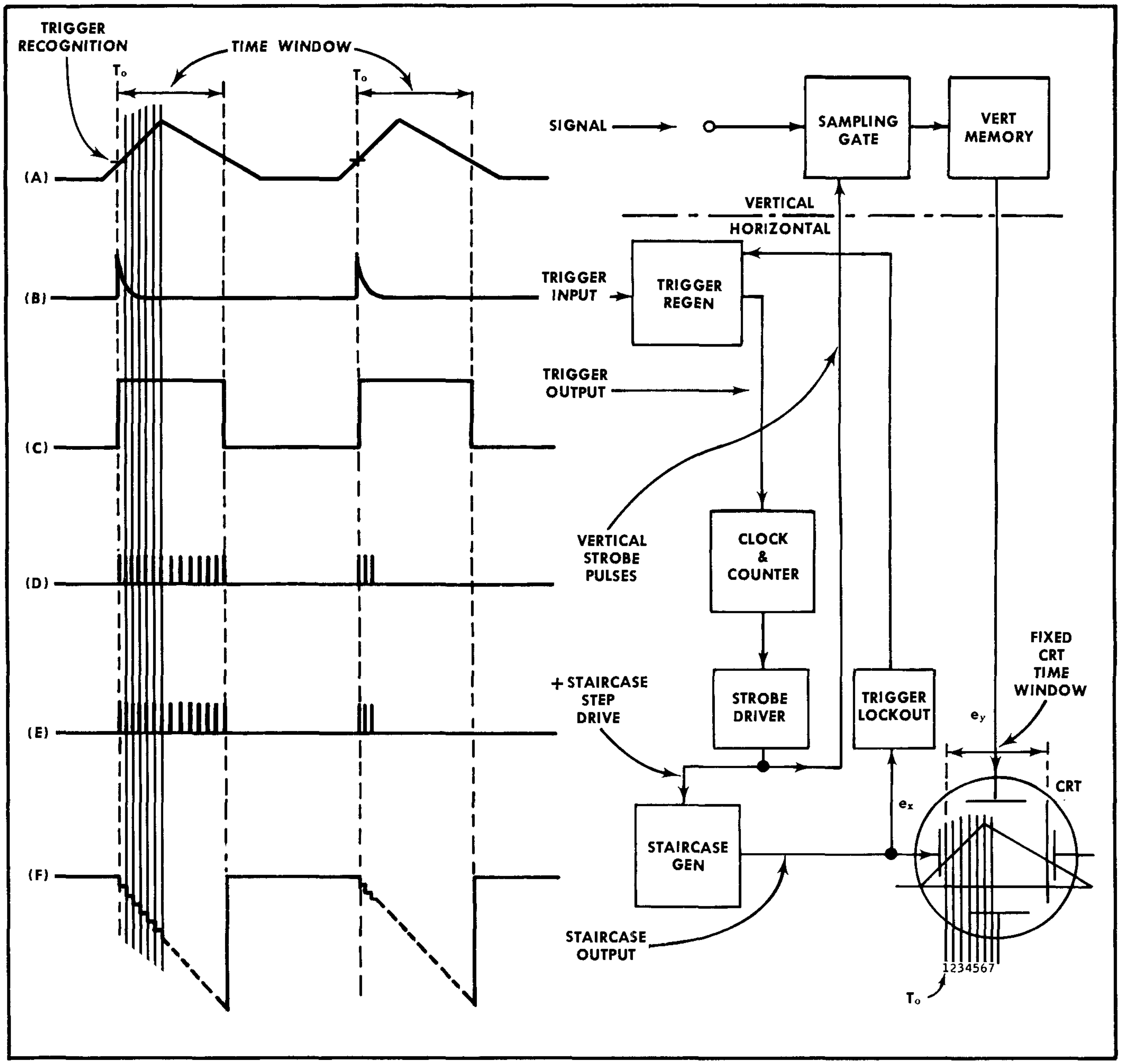


Fig. 3-4. Basic real time sampling oscilloscope.

of the digital unit. Correct output lines are a logical ONE (saturated transistor that grounds the line) for whichever digital unit decimal and unit-of-measure is required by the particular sweep rate in use. The digital unit makes its actual time measurement using the Digital Clock signal diagrammed at the block diagram lower right and leaving the Type 3T6 at P21, pin 13. All Digital Unit Control Logic block output lines are a logical ZERO (up, and at about +8 volts when used with the Type 230) when the digital unit calls for an amplitude (Volts or Amps) measurement and the D, U, GND line is a logical ZERO (up).

The Sweep Rate Readout Logic block operates the Type 3T6 incandescent lamps in the TIME/DIV readout window located on the front panel. (The incandescent lamps of the DELAY switches, ns, µs and the decimal, are all operated directly from the DELAY switch contacts, and are therefore not included in the block diagrams. These lamps are turned off for both real time sweep rates and when the Type 3T6 is externally programmed.)

Equivalent Time Sampling Block

The basic Trigger Regenerator block of Fig. 3-1 is shown at the upper left corner of the main block diagrams as the Trigger and Clock. All of the circuits of schematic diagram

1 are included. The Trigger and Clock circuits start the sampling process for each individual sample trigger recognition, and then automatically reject any more input triggers until reset by other circuits. Reset begins at the end of the Timing Ramp by a signal from the Timing Ramp Reset Comparator. Reset duration is prolonged by the Reset Ramp and Reset Multi until a time when all other circuits have completed their functions and are ready for another sample to be taken.

Assume that all circuits are ready for another sample to be taken, and that only the trigger must arrive to start the process. The conditions and sequence of operation for one sample follow.

Condition

1. D28 and D106 are both at their low voltage state, D106 taking some of the arming current from the Reset Multi through D110. D112 is cut off and D114 and D168 are at their low voltage state. The 10 MHz Oscillator Clock is clamped (and not running) by the Clock Osc Clamp. The Clock Osc Clamp causes the Trigger Inhibit (Q135) to release the Isolation Amp so a trigger can be received at D28.

2. D168 is at its low voltage state with one or two arming currents applied. Initial bias is applied from the Reset Multi block, and arming current may be supplied by U440 via R168. Whether the second arming current is applied depends upon the position of the X100 and X1000 DELAY dials (or external programmed delay). When the X100 and X1000 Delay lines are programmed for a digital zero, U440 applies a steady arming bias to D168. When either set of lines is programmed for other than a digital zero, U440 applies a steady arming bias to D168. When either set of lines is programmed for other than a digital zero, U440 applies its arming current to D168 only after the Clock Counter has made an appropriate count. D168 remains at its low voltage state with both arming biases and holds the Ramp Clamp in a state to hold the Timing Ramp at its starting voltage.

3. The Trigger Reset Multi has set the Counter Reset block to a state that reset the 100/1 Divider and the two decades of the Clock Counter. The two decades of the Clock Counter are reset to zero. If the X100 or X1000 Delay programming is other than zero, U440 removes the arming bias to D168 until a later time.

NOTE

Two arming bias situations have just been described. The first allows D168 to start the sampling process exactly at the time a trigger signal reaches D114. The second delays D168 arming bias from U440 until the Counters have counted out the programmed delay. After the programmed count, U440 arms D168, which can then be tripped to its high state by the next pulse from the Clock Current Pulser to start the sampling process.

4. The Staircase Generator (block diagram lower right) is resting at a fixed DC voltage output. The DC value depends upon whether the next trigger starts the first dot of a full sweep or whether the trigger starts a dot somewhere along the sweep.

Operation Sequence:

1. The trigger signal arrives, passes through the Isolation Amp and causes D28 to switch to its high voltage state. Almost immediately D106 switches to its high voltage state, causing some of the Reset Multi arming bias to go through D112 to D114. D110 is now at cutoff, and thus prevents any Isolation Amp output signal from propagating into D114 via D112. The trigger signal from D28 is also delayed (through a 5 ns Delay Line) and then trips D114 to its high voltage state. As D114 reaches its high voltage state, D110 again conducts, holding D106 at its high voltage state and locking out any more triggers to D114. D114 remains at its high state until reset later.

2. As D114 steps to its high voltage state, a pulse is sent through C118 to D168. D168 may respond if U440 is providing its arming bias. If U440 is not providing arming bias, the pulse through C118 has no effect upon D168.

D114 also starts a pulse through the Clock Start Delay and Clock Osc Clamp blocks that will start the 10 MHz clock oscillator so as to produce the first clock current pulse exactly 100 ns later.

NOTE

Now the two choices of arming D168 by U440 have significance. If the X100 and X1000 Delay lines are both digital zeros, the Timing Ramp is started by D168 when D114 goes to its high voltage state. If either of the X100 or X1000 Delay lines is not a digital zero, D168 is armed later by U440 and then tripped to its high voltage state at the next clock current pulse from Q160. Also, with X100 and X1000 both zeros, D168 starts the Timing Ramp immediately after a trigger pulse. Once D168 is at its high voltage state, only the Reset Multi can reset it to the low voltage state; removing U440 arming bias has no effect upon D168. Thus it can be said that the 100/1 Divider, Clock Counter and both Digital Comparator blocks serve no useful purpose for the special case when both X100 and X1000 Delay lines are digital zeros.

As the 10 MHz Oscillator Clock starts, the Trigger Inhibit block (Q135) takes current away from D28, preventing it from recognizing any more input trigger signals.

3. The 10 MHz clock delivers its signal to both the Clock Current Pulser and the Counter Clock Pulse Shaper. These blocks convert the oscillator sine wave signal to pulses, negative-edge actuating through the Shaper and positive-edge actuating through the Current Pulser.

The total Trigger and Clock circuits remain in the conditions of parts 2 and 3 until the end of the Timing Ramp.

4. As the Timing Ramp runs negative (from about +18 volts) two comparisons are made with it. One is a non-loading comparison at the Slewing Comparator block. The comparison is made between the Timing Ramp voltage and an attenuated staircase voltage that is related to the CRT deflection voltage. When the comparison occurs, a negative-going drive pulse causes the Strobe Driver block Avalanche transistor to deliver two very fast positive-going output pulses, one to the Staircase Stepper, and the other to the vertical channel sampling unit. These actions are described in 6 below.

The second Timing Ramp comparison is made in the Timing Ramp Reset Comparator block. The comparison is made with a fixed DC voltage that stops the ramp from running. (The DC voltage is altered, for the 100 ns Timing Ramp to increase the ramp negative limit. This increases the ramp time to a point that prevents resetting the Trigger circuits too soon, which would be the case if the voltage was not changed for the faster sweep rates.) At the time the ramp is stopped, the Timing Ramp Reset Comparator block sends a negative edge pulse to the Trigger circuit Reset Multi block.

5. The Reset Multi is turned off when the Timing Ramp is stopped. As the multi turns off, all arming current to D106 and D114 is stopped, and most of the arming current to D168 is stopped. D168 drops back to its low voltage state causing the Ramp Clamp to pull the Timing Ramp back up to +18 volts, ready for the next sample. At the same time, the Counter Reset block sends out a positive-going pulse whose leading edge resets the 100/1 Divider and the Clock Counter circuits.

The Reset Ramp runs for a period of time that assures an adequate CRT display of the sample taken a few nanoseconds after the non-loading slewing comparison described in 4 above and all circuits have settled down after reset. The trigger recognition circuits are inactive and cannot respond to any incoming triggers during the Reset Ramp running time. The Reset Ramp running time can be altered by the front panel RECOVERY TIME control to prevent problems in cases where its natural end occurs almost synchronously with a trigger signal arrival. As the ramp ends, the Reset Multi rearms the trigger circuit tunnel diodes and another sample cycle can be made.

6. The Strobe Driver output pulses mentioned in 4 above cause two actions. First, the Staircase Generator output voltage is stepped to place the CRT deflection voltages ready for a new horizontal dot position and for the next slewing comparison. Second, the vertical channel sampling unit receives a strobe command pulse telling it to take a sample of the input signal. Thus the Slewing Comparator and the Timing Ramp and Staircase Inverter are the circuits that assure there is a proper ΔT_{dot} equivalent time between successive samples of each full sweep sampling display.

Sweep Rate Control

The equivalent time sweep rate is changed in two ways. The primary method is to change the rate of the Timing Ramp. The secondary way is to change the amplitude of the staircase fed to the Slewing Comparator. The two methods are combined in a manner that changes ΔT_{dot} out of the Strobe Driver block. This in no way alters the position or number of dots presented in one horizontal scan. The number of samples per sweep is controlled by the Staircase Generator alone.

Changing the sweep rate is accomplished by Central Timing Logic signals sent to the Timing Ramp block, the Staircase Inverter Amp Input Resistors Attenuator block and the 0 Decade X10 Gain Switching block. The last two blocks are part of the Staircase Inverter amplifier which is an (inverting) operational amplifier with its gain set by the ratio of the feedback resistance to the input resistance. Thus, changing the value of either alters the amplitude of the inverted staircase used at the Slewing Comparator.

Changing the rate of the Timing Ramp does not alter the voltage of the slewing comparison, but changes the time after the Timing Ramp is started before the voltage reaches a value that allows the slewing comparison to occur.

Time Window Delay Control

Earlier in the equivalent time sampling sequence of operations, large increment time window delay was mentioned. The delay was stated as controlled by the X100 and X1000 lines fed to the Digital Comparator blocks. The delay was caused by delaying the arming of D168 and thus delaying the start of the Timing Ramp after trigger recognition, T_o.

Small increment time window delay is controlled by the two least significant digits of the DELAY controls (or external program), the Digital To Analog Amp block, and the Fine Delay Atten block. The small increment time window delay information is fed from the Fine Delay Atten block as a DC current into the summing input point of the Staircase Inverter Amp block operational amplifier. The Staircase Inverter Amp output signal staircase is offset by the fine delay information, changing the voltage value of the slewing comparison. This alters the generation of strobe drive in relation to trigger recognition, T_o.

Now the relation between total Timing Ramp length (and duration) and staircase average DC voltage is significant. With the two least significant DELAY dials at 0 (00), the staircase voltage entering the Slewing Comparator starts the first sample (of a sweep) very soon after the Timing Ramp starts. The staircase end comparison is made slightly less than half way down the Timing Ramp total voltage run. With the two least significant DELAY dials at 9 (99), the staircase voltage entering the Slewing Comparator starts the first sample (of a sweep) at a point part way down the Timing Ramp voltage run. The last staircase comparison is made very near the end of the Timing Ramp voltage run, which is almost twice the time delay (slewing) from T_o as was the case for the last sample when the DELAY dials were 00. Refer to the waveforms (D) and (G) of Fig. 3-3 for support of the above statements regarding slewing comparisons and staircase delay offset.

The total of the large increment delay (counter controlled) and the total of the small increment delay (staircase offset controlled) are listed in Table 2-4 in individual columns. The delay times are given for each equivalent time sweep rate. Also in Table 2-4 is a column headed Max. Total X10 and X1 Delay. That column lists the occurrence described above as the last staircase voltage slewing comparison when the two least significant DELAY dials are at 99. The table includes the combined large and small increment delays in the column headed Positionable End of Time Window After T_0. That column includes both kinds of delay and the time duration of the displayed time window for each equivalent time sweep rate.

Special Features, Staircase Generator

The Sweep Reset Tripper block allows either the front panel SAMPLES/SWEEP switch or an external program to reset the Staircase Generator back to its starting voltage. As long as the SAMPLES/SWEEP switch remains at 1, the display will be just one dot located at the sweep start. The circuit is intended primarily for externally programming a sweep reset at the end of a Type 230 measurement or after the last memory zone. It can be used in conjunction with the Sweep Speed-Up Enable block to reduce total measurement time, increasing the number of measurements that can be taken as compared to the number taken if the sweep continues running after the last zone or after the measurement is taken.

The Sweep Speed-Up Enable block allows an external programmer to speed the sweep rate from 100 samples/division to approximately 10 samples/division. When the Type 230 is controlling the sweep speed-up, there are 10 dots/div during non-zone time and 100 dots/div during zone time. The sweep is reset after the last zone. During the measurement sweep, there are 100 dots/div from sweep start to the end of the measurement, and the sweep is reset at the end of the measurement.

The Staircase Stepper block is actually part of the Staircase Generator itself, but is separated to highlight the function. The stepper responds to positive pulses from the Strobe Driver and controls the amplitude of the individual staircase steps. The stepper changes the staircase step amplitude to approximately 10 times as large as normal during the 10 samples/division sweep speed-up function.

The Staircase Reset Multi responds to both the Sweep Reset Tripper and to the staircase output signal. As the output signal reaches approximately +52 volts, the Reset Multi causes the steps to stop advancing the output voltage and quickly returns the output back to zero volts. Actually, samples are taken during the reset time, but the CRT is blanked by Q640 so there is no display evidence of the samples. Sampling during retrace is purposely provided so that the vertical channel memory circuits will never have to respond to full screen changes during retrace. (Full screen changes during retrace could occur if there were no samples taken between the end of a sweep at the graticule top and the next sweep beginning at the graticule bottom.)

Q605, and Q650 blocks provide needed information to the digital unit for digital measurements (in addition to the staircase voltage from the Staircase Generator). The four signals leave the block diagram at the lower right, through P22.

Real Time Sampling Block

Real Time operation uses the Staircase Generator in almost exactly the same manner as just described above. The only difference is that the samples per sweep cannot be altered because of the resultant change in real time sweep rate.

The trigger circuits are used in a manner similar to equivalent time operation. The trigger circuit is armed, then responds to a trigger and locks out other triggers for a definite period. The difference in real time operation is that only one trigger is required for a full sweep, rather than one trigger per sample as in equivalent time. Real time operation does not use D168, to prevent the Timing Ramp blocks (described earlier) from operating, but instead uses just one trigger to start the 10 MHz clock. The 10 MHz clock indirectly drives the Strobe driver and Staircase Generator. Once started, the clock continues to run until the Staircase Generator resets itself. As the Staircase Generator resets, it sends a clock-stop signal through the block labeled Trigger Circuit Control In Real Time to the trigger Reset Multi. As the trigger circuit is reset, the clock stops, one reset ramp runs to allow the staircase generator to fully reset, and then the Reset Multi rearms the trigger circuit, making it ready to receive another trigger and start another real time sweep.

The 10 MHz clock frequency is counted down to 100 kHz by the 100/1 Divider block for the fastest real time sweep rate of 1 ms/div. The Clock Counter block and the Real Time 1, 2, 5 Divider block do not enter into the clock dividing at 1 ms/div, but do operate at slower real time sweep rates. (1 ms/div is true because real time sweep rates always use 1000 samples per sweep. 100 kHz pulses have a 10 μs period. 1000 samples per sweep equals 100 samples/div. Then 100 pulses at 10 μs each equals 1 ms/div.) Note that the 100 kHz line from the 100/1 Divider block to the Clock Pulse Selector block is also labeled Decade 3. 1 ms/div, 2 ms/div and 5 ms/div all require the 100 kHz clock rate to be fed to the Real Time 1, 2, 5 Divider block.

A 10 ms/div sweep rate requires that the clock rate to the Strobe Driver have a 100 μs period. This is done by setting the DECADE switch to 2, and the MULTIPLIER switch to 1. Now the 2nd decade Clock Counter divides the 100/1 Divider 100 kHz signal to 10 kHz, which has a 100 μs pulse period. The same sort of division continues as the real time sweep rate is progressively made slower, including the use of the 1st decade Clock Counter when the DECADE switch is set to 1.

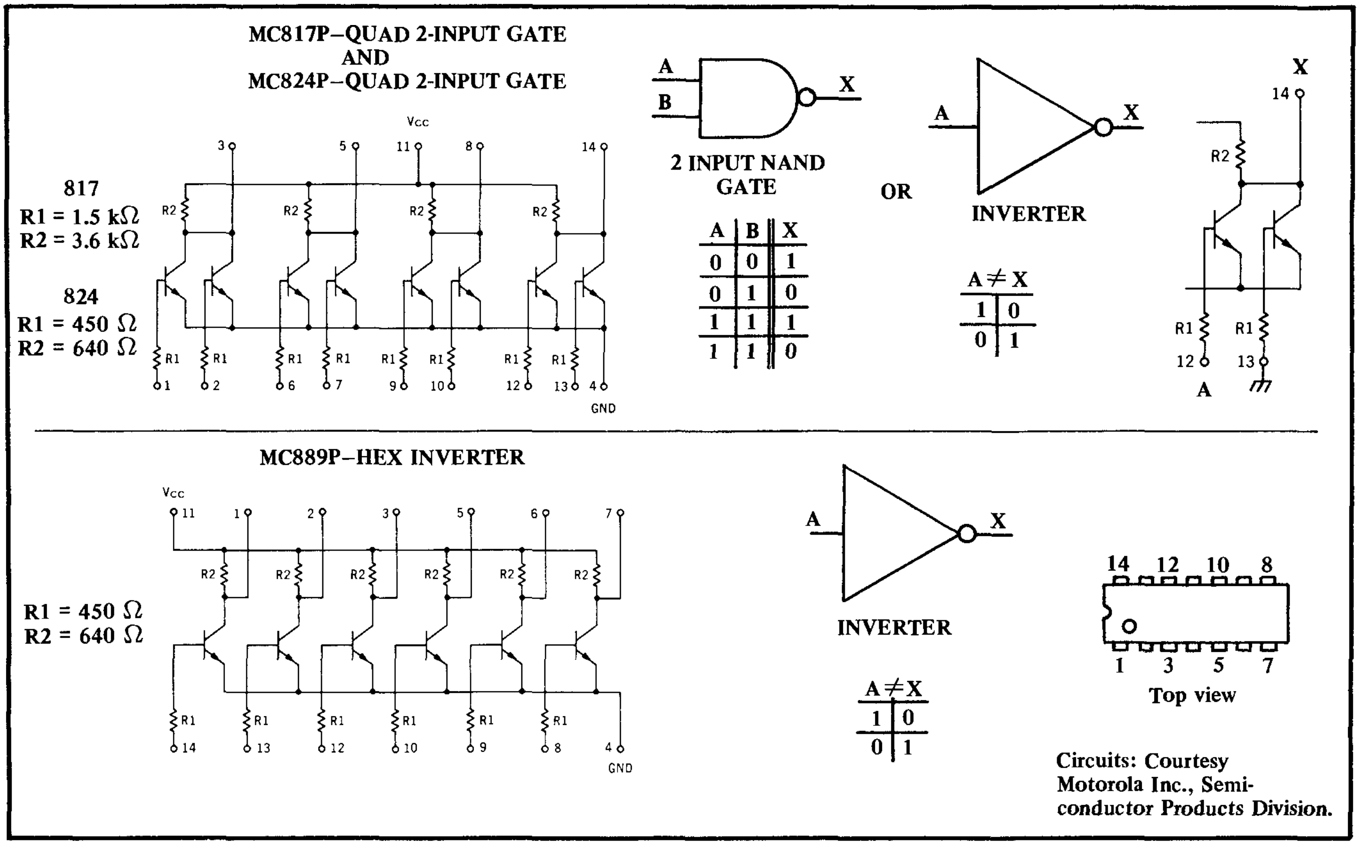


Fig. 3-5. Integrated circuit details. Negative logic symbols.

INTEGRATED CIRCUITS

Several schematic diagrams of the Type 3T6 are drawn using negative logic symbols only. Diagram 1 includes one positive logic OR gate. Internal circuit details, logic symbols and truth tables for all integrated circuits are contained in Figures 3-5 through 3-8. All but U180A are drawn with negative logic symbols, regardless of use within a circuit sequence or chain of events. Logic symbols are based on ASA Y32.14-1962 Standard, adopted as MIL Standard 806-C.

Details of input logic states for external programming are given in the Operating Instructions. Other limited internal logic details are given earlier in this section where a logic function is significant to the block diagram description.

Logic Voltages

Negative logic used internally in the Type 3T6 always means that a logical ONE is a low voltage from 0 V to about +0.2 V. A logical ZERO is basically an "up" voltage of about +1 V for IC's whose input leads do not contain resistors, and up to about +3 V for RTL units. Keeping these voltage limits in mind, defective units can be found using a voltmeter with at least an 11 MΩ input resistance and the truth tables given in Figures 3-5 through 3-8. Troubleshooting should be planned using the block diagram description and classical texts on counters and logic gates. Each logic symbol can be tested for proper function without regard for the rest of the circuits as long as the logic symbols and truth tables are used.

All Motorola 14 pin flat-pack IC's have a top view pin order shown in Fig. 3-5.

CIRCUIT DESCRIPTION

General

The following pages include detailed circuit descriptions of those diagrams that contain transistors and other components in normal schematic form. Diagram pages that include only integrated circuit symbols are not described. See the Block Diagram description for details of the integrated circuit sections of the Type 3T6.

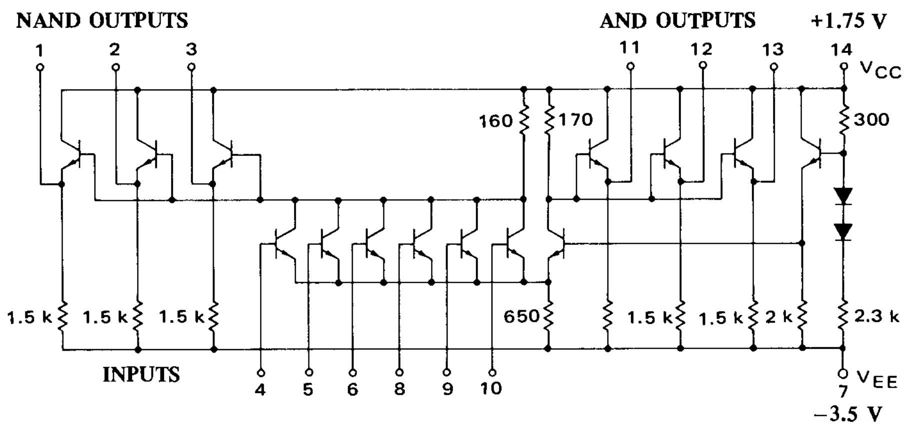
Trigger & Clock Circuits ⟨1⟩

The trigger circuit has an internal input through pins 3 and 4 of P21 and an external input through J5. The internal trigger is AC coupled through C1 to the TRIG MODE switch while L1 grounds the internal trigger input for DC signals. R4-R5 terminate the unused input to prevent noise pickup.

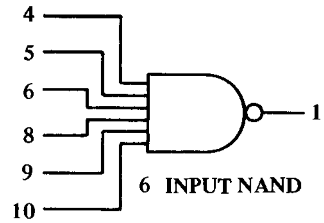
With the TRIGGER POLARITY switch in the plus position, the signal goes through P10 to drive Q20 emitter. In

(A)

6–INPUT GATES
MC1001P CIRCUIT SCHEMATIC



USED AT U440 ONLY



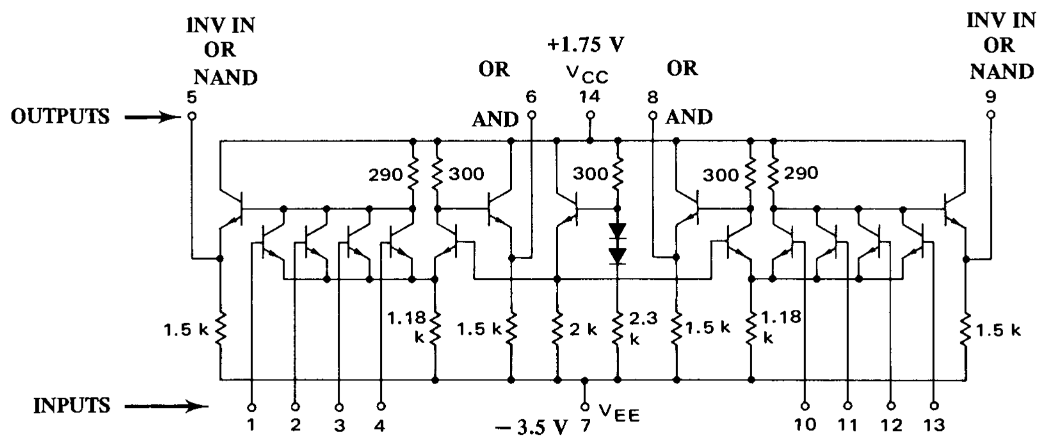
$\overline{1} = 4 \cdot 5 \cdot 6 \cdot 8 \cdot 9 \cdot 10$

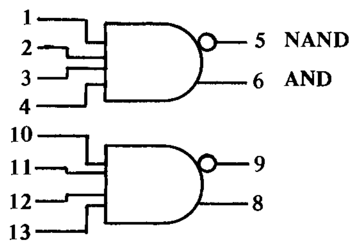
2 INPUT NAND GATE

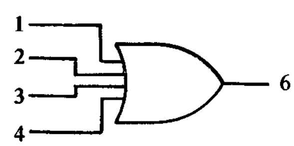
	A	B	X
	0	0	1
	0	1	1
	1	0	1
D168 ARMED →	1	1	0

(B)

DUAL 4–INPUT GATES
MC1004P CIRCUIT SCHEMATIC







Positive Logic OR gate
U180A only

$6 = 1 \cdot 2 \cdot 3 \cdot 4$

2 INPUT AND GATE

A	B	X
0	0	0
0	1	0
1	0	0
1	1	1

$\overline{5} = 1 \cdot 2 \cdot 3 \cdot 4$

2 INPUT NAND GATE

A	B	X
0	0	1
0	1	1
1	0	1
1	1	0

2 INPUT OR TRUTH TABLE

1	2	6
HI	HI	HI
LO	HI	HI
HI	LO	HI
LO	LO	LO

Circuits: Courtesy of Motorola Inc., Semiconductor Products Division.

Fig. 3-6. Integrated circuit details. Negative logic symbols.

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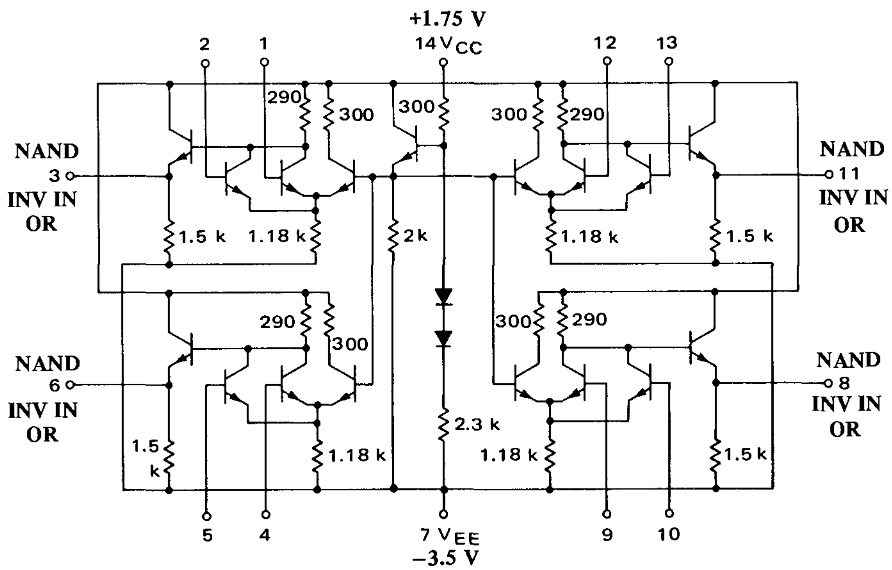
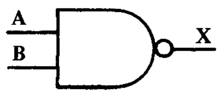
MC1010P QUAD 2 INPUT GATE CIRCUIT SCHEMATIC





2 INPUT AND GATE

Circuit: Courtesy of Motorola Inc., Semiconductor Products Division.

A	B	X
0	0	1
0	1	1
1	0	1
1	1	0

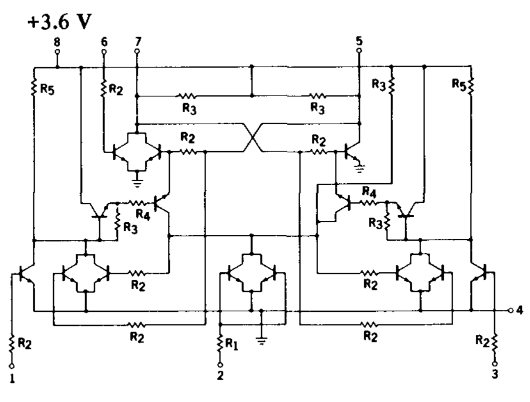
$\overline{3} = 1 \cdot 2$

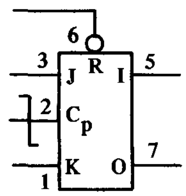
$\overline{6} = 4 \cdot 5$

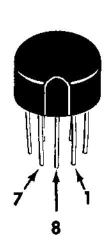
$\overline{8} = 9 \cdot 10$

$\overline{11} = 12 \cdot 13$

TYPE μL 923 (clocked J-K flipflop)







Top view

J	K	P	t^{n+1} 0	1
0	0	0	0	1
0	1	0	0	1
1	0	0	0	1
1	1	0	0	1
0	0	1	Q^n *	
0	1	1	0	1
1	0	1	1	0
1	1	1	$\overline{Q^n}$ *	

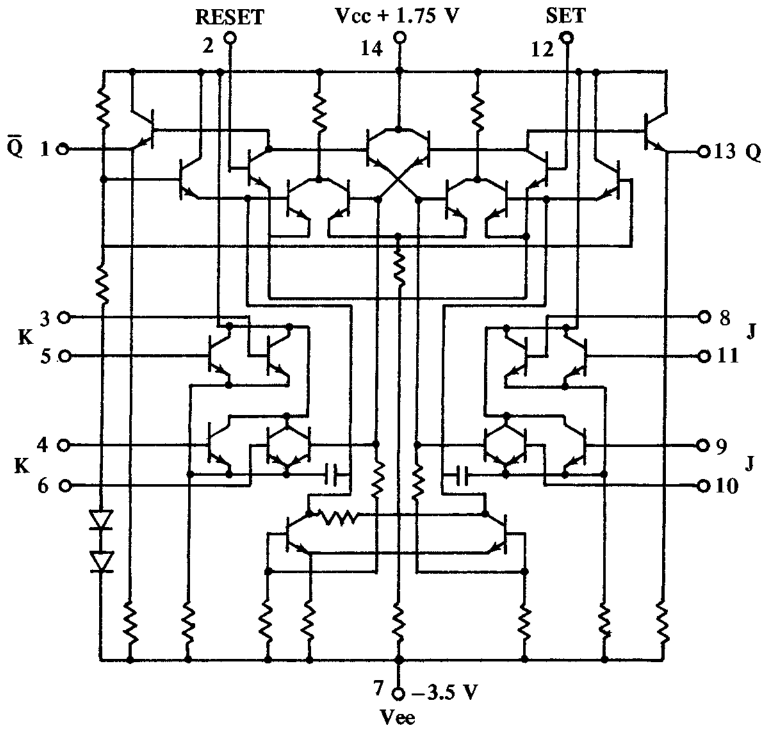
*Q^n = No output changes

$\overline{Q^n}$ = Complement

Data furnished courtesy of Fairchild Camera and Instrument Corporation

Fig. 3-7. Integrated circuit details. Negative logic symbols.

MC1013P AC COUPLED J–K FLIP-FLOP CIRCUIT SCHEMATIC



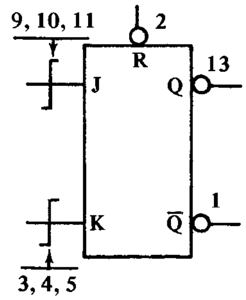
S = SET
R = RESET

S	R	Q	Q̄
0	0	NOT PERMITTED	
0	1	1	0
1	0	0	1
1	1	NO CHANGE	

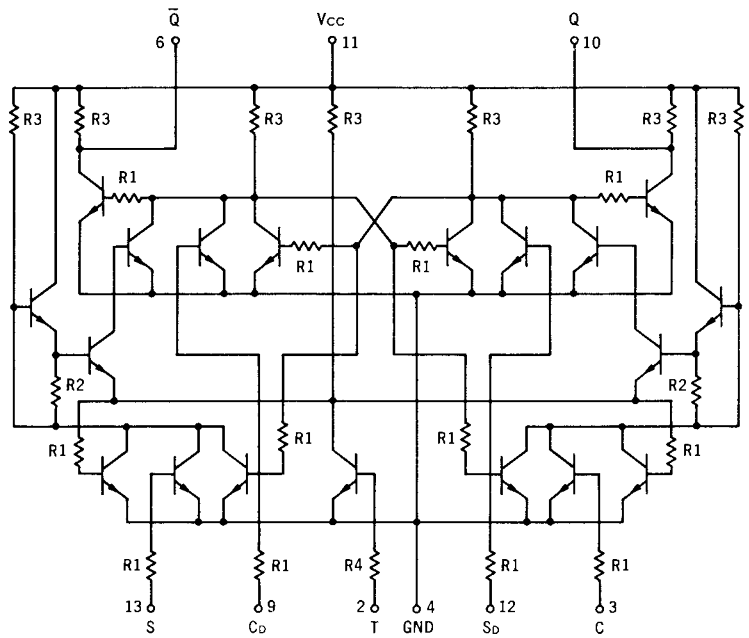
DC OVERRIDES

+ EDGE

J	K	Q	Q
0	0	NO CHANGE	
0	1	0	1
1	0	1	0
1	1	COMPLEMENT	



MC 822P – J-K FLIP-FLOP



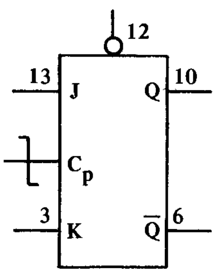
TYPICAL RESISTANCE VALUES
R1 = 1.5 k R3 = 3.6 k
R2 = 2.0 k R4 = 750 Ω

S	R	Q	Q̄
0	0	NOT PERMITTED	
0	1	1	0
1	0	0	1
1	1	NO CHANGE	

DC OVERRIDES

+ EDGE (t^{n+1})

J	K	Q	Q̄
0	0	NO CHANGE	
0	1	0	1
1	0	1	0
1	1	COMPLEMENT	



Circuits: Courtesy of Motorola Inc., Semiconductor Products Division.

Fig. 3-8. Integrated circuit details. Negative logic symbols.

the minus position the high frequency component of the signal goes through transformer T10, which inverts the signal before going to P10. The low frequency portion of the signal goes to Q20 base.

A short summary of the Trigger circuit operation follows. It is assumed that the SENSITIVITY control is adjusted for a properly triggered display (RECOVERY TIME control not at its SYNC position). A trigger signal is received by the Isolation Amplifier Q20; its output switches tunnel diode D28 to its high voltage state, which drives D106 and about 5 ns later, D114 (D114 is driven through a delay line with approximately 5 ns signal delay). The resulting output pulse from D114 sends a signal to D168 and to Q120.

Initial conditions before the trigger sequence can occur require that Q75 and Q72 be conducting. Q75 collector is at approximately +20 V. R100-R102 sets approximately 5.5 mA of bias to D106 (a 10 milliampere tunnel diode). D114 (also a 10 mA TD) is biased through R112-R113 at about the same current. R115 raises D114 slightly positive with respect to D106 voltage; therefore, D112 is reverse biased (cut off) and D110 conducts all of R110 current (3 mA) to D106.

An active cycle begins when Q20 conducts a trigger signal that switches D28 to its high voltage state. A positive pulse is conducted through C58 to trigger D106 to its high state (almost instantly) and thereby reverse bias D110. The 3 mA from R110 is now conducted by D112 to arm D114, so it will switch to its high state when D28 delayed pulse arrives through C50 and the 5 ns Delay Line. As D114 switches high, three events occur: 1) D114 sends a pulse through C118-R118 to D168. (The pulse may or may not be used by D168, depending upon whether D168 is armed from the Digital Comparators through R168). 2) D112 is reverse biased and D110 conducts the 3 mA from R110. D106 is then held at its high state to lock out any more triggers, and D114 remains in its high state until Q75 is turned off at the end of the sample cycle. 3) The Clock Start Delay circuit delays D114 signal from starting the Clock for exactly 50 ns. The next trigger cannot be recognized until the full sampling cycle is complete, and D106 and D114 are reset to their low voltage states by Q72 and Q75 at the end of the Timing Ramp running period (see Block Diagram description).

As the 10 MHz Clock is started by the Clock Start Delay circuit, Q135 is caused to conduct enough Q20 current so that D28 is prevented from responding to any more trigger pulses from Q20.

The Reset Cycle starts after the Timing Ramp has run and been stopped by its Reset Comparator (D538-Q548, as described later in the description of diagram 5), and a negative current pulse is delivered to Q70 base to turn it on. Current from Q70 reverse biases Q75, which then turns off the Reset Multivibrator Q72-Q75, starting the trigger circuit Reset Ramp running.

When the Reset Multivibrator is off, Q90 collector rises to about +1 V from its previous on value of 0 V. Q90 resets the 100/1 Divider, the Clock Counter and Digital Comparators, and the Real Time 1, 2, 5 Divider. D90 clamps Q90 base from going more than −0.6 V negative during its time of non-conduction.

The Reset Multivibrator remains off for the Reset Ramp period, which is determined by one of several capacitors switched into the circuit by saturating transistor switches Q80, Q82, Q84 or Q86. The bases of these switches are controlled from the Type 3T5 Central Timing Logic, which selects the proper reset time for each sweep rate. If 10 μs/div is being used, terminal AQ is at a high level (logical ZERO) and Q84 connects C84 to ground. Note that C74 is in parallel with C84. While the Reset Multivibrator is on, the capacitors are charged to approximately +20 V. When Q72 turns off, the capacitors discharge through R76-R78 to a level of approximately −3.5 V. The time constant is controlled by the RECOVERY TIME control R78. Q72 base is at approximately −3.5 V and the transistor becomes forward biased when the capacitor discharges to a more negative value. When this happens, Q72 turns on Q75 and conducts current to the following four places: 1) C106 via D102. 2) Q90, which turns on. 3) R162 which provides bias to the Timing Ramp Enable TD D168 to help arm it, and 4) To the junction of R112-R110, to rearm D114.

Reset ends when Q75 turns on. Current through D102 causes its junction voltage drop to cut off Q100. As C106 charges through R100-R102-D102, R106 introduces current to D106 slowly to assure that D114 is armed before D106 is armed. When Q75 turns off, D102 no longer reverse biases Q100, which turns on and discharges C106 to −3.5 Volts.

The Trigger SENSITIVITY control circuit includes Q35, which is turned on to saturation for both INT and EXT trigger operation. Q35 conduction forms a monostable multivibrator of D28-L47-L34-R34 and Q35 (Q40 is at cutoff). D28 will step to its high voltage state if it is properly biased and if Q135 is turned off, allowing trigger signals from Q20 to reach D28. D28 bias adjustment control is R30, the SENSITIVITY control; R36 sets the range of control of R30. When D28 switches up, its pulse duration is determined by L34-L47 and the saturation resistance of Q35, as modified by the TRIG SENS ZERO control, R36.

High frequency synchronized operation is possible when the RECOVERY TIME control is placed in its SYNC position. The bias voltage supplied by the SENSITIVITY control is now made more positive to cause the multivibrator to free run. The repetition rate can be altered somewhat by R30, so that D28 can synchronize with Q20 output signal and thereby present a stabilized, synchronized CRT display.

Automatic triggering is obtained when Q40 is turned on and Q35 is turned off by the trigger MODE switch when set to the EXT AUTO position. A bistable multivibrator is formed by D28-L47 and R44. D28 trigger level bias is adjusted during calibration by R32, the AUTO LEVEL control. When a trigger signal of sufficient amplitude arrives from Q20, D28 switches to its high state and remains there until the trigger signal is removed.

Special Trigger Circuit components include R46-R47 and D46 which provide first order temperature compensation for D28. C12-C13-R13 form an all-pass termination to make the trigger circuit input appear as 50 Ω at all frequencies. R23-R24-R26 set Q20 emitter at 0 V for proper external DC triggered operation. D24 temperature compensates the emitter-base junction of Q20. C26 provides a high frequency AC ground for Q20 base. C21-R21 provide frequency compensation to Q20 emitter-base junction, so it always appears resistive to incoming signals. R20 sets the no-signal current of Q20.

Clock Circuit

Initial conditions of the clock circuit (when the Trigger Circuit is armed, ready to be triggered) are such that it is not running. The Clock Start Delay circuit holds the Clock Oscillator Clamp in a condition that prevents the 10 MHz Clock from running. In the Clock Start Delay circuit, D114 holds Q120 in non-conduction, and the voltage divider R121-R122-R124-D124 and R125 holds Q125 in non-conduction. Q130 is off, Q135 is off and Q140-Q145 hold the clock from running.

An operating cycle begins when a trigger signal is recognized by D28 and the output tunnel diode D114 switches to its high state. Then, two things occur: first, C118-R118 conducts a pulse to D168 which, if armed by the Digital Comparator, will switch to its high state and start the cycle for one sample; second, Q120 of the Clock Start Delay circuit (which includes Q125) conducts the current from R122 previously taken by R124, turning on Q125.

When Q120 conducts, D124 is cut off and C124 discharges through R125. Q125 conducts after C124 discharges below −0.6 V and turns on Q130, 50 ns after D114 has switched to its high state.

Before Q130 turns on, L145 conducts some current from Q140 15 mA current and Q150A gate is at approximately ground potential. The inductor current provides magnetic field energy which controls the self-inductance starting characteristics of the Clock when it turns on. The Clock starts when Q130 turns on, and reverse biases D136 and Q145 by −12 V. As Q130 saturates, its collector takes all Q140 current and its −12.2 volts reverse biases D136 and Q145, allowing the self-inductance of L145 to start the clock cycle at the correct amplitude and frequency. Q150A gate voltage starts negative (as L145 maintains the electron flow in the same direction as controlled by Q140) and the Clock starts (described in more detail below).

When Q130 turns on, Q135 is also turned on. Q135 conducts part of the bias current of D28, thereby preventing further trigger pulses from D28.

The Clock is composed of Q150A-Q150B-Q155 and the tank circuit L145-C145-C146. When D136 and Q145 are cut off, L145 magnetic field collapses and charges C145-C146, with C145 and Q150A gate voltage going negative for the first half cycle. Source follower Q150A drives emitter follower Q155. R158 feeds back sufficient energy to maintain self-oscillation. (Incorrect adjustment of R158 will cause the oscillations to increase or decrease in amplitude. D145 and D146 limit the feedback amplitude so the useful adjustment range of R158 is increased.) Q150B is a constant current drain for Q150A. D155 sets the bias for Q150A and B, and temperature-compensates Q155.

The Clock output is at 0 V before the Clock starts. The clock load is Q160 and Q170 emitters through D160 and D171. (D160 and D171 are hot carrier diodes which conduct with about 0.3 V forward voltage drop, whereas Q160 and Q170 have 0.6 V forward voltage drop across their emitter-base junctions before they conduct.) The oscillator output voltage goes negative when the Clock starts. This turns off D171, which has been conducting current from R160-D160 to R172. R172 now conducts current from Q170 emitter, changing Q170 collector voltage from approximately +1 V to 0 V. D160 remains on until the Clock sine wave rises above ground, at which time it turns off and D171 conducts. Q170 collector then rises back to approximately +1 V. As the sine wave goes positive, D160 turns off and Q160 conducts the current of R160. This provides a Clock current pulse into D168 (100 ns after D114 pulses the Clock Start Delay circuit) which lasts until the Clock sine wave amplitude falls below ground.

The Timing Ramp Enable TD, D168 must have three signals coincident at its anode before it will switch positive. The three signals are (with approximate values): 6 mA bias from the Reset Multi through R162-R163, 3 mA arming signal from the Digital Comparator through R168, and 2.6 mA Clock pulse from Q160 through R165 or from D114 through C118-R118. If the arming signal through R168 is absent D168 will receive clock pulses, but will not switch high. When D168 switches, its anode voltage goes positive, generating the Timing Ramp Enable signal that starts the Timing Ramp (diagram 4). D168 remains in its high state until the Reset Multivibrator switches and removes bias current, at which time D168 switches back to its low voltage state.

The operation of U170A and U170B, U180A and U60A is discussed in the Block Diagram description earlier in this section. R164 guarantees D168 will switch to its low state when the bias from the Reset Multi is removed. R175-R178 sets Q170 output to +1 V for the high logic level.

Delay Gating and Digital To Analog Converter 2

The Delay Gating circuit accepts binary information supplied by four decades of binary coded decimal (BCD), to program the CRT display time window Delay. The two most significant decades are fed directly to the Digital Com-

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parators (diagram 3). The two least significant decades are fed directly to the Digital To Analog Converter circuit. The 3rd decade (X100) does feed the Digital To Analog Converter when the TIME/DIV DECADE switch is at 0 (10). The Digital To Analog Converter drives the Staircase Inverter (diagram 5), whose output drives the Slewing Comparator for proper generation of ΔT_{dot} in equivalent time sampling. Output of the Digital To Analog Converter is a DC voltage, used to offset the Staircase Inverter output for time window delay as described in the block diagram description earlier in this section.

Each of the four DELAY switch decades provides four output lines, internally converting the dial decimal number to a BCD number. The output lines connect to the Delay Gating networks through program isolation diodes. The isolation diodes assure there will be no electrical confusion between internal and external programming of the time window delay. The Delay Gating networks convert the input negative logic voltage limits of 0 V to +2 V for a logical ONE, and +6 V to +15 V for a logical ZERO, to narrower circuit related limits.

Following each input isolation diode is a resistor network which standardizes the internal logic voltages to approximately 0 V (or a negative value) for a logical ONE and approximately +1 V or more positive for a logical ZERO. The X100 and X1000 decades have an in-circuit logical ZERO that does not exceed +1.2 V due to the clamping action of diodes D899A through D899I.

The X100 and X1000 decades program the Digital Comparator. The X1, X10 and sometimes the X100 decades program an analog current developed by the operational amplifier Q360-Q370-Q375 to supply the Staircase Inverter Amplifier with a staircase offset current.

The Digital To Analog Converter is an operational amplifier (Q360-Q370-Q375) with FET Q360 the input transistor. Though the input signal to the amplifier summing point (Q360 gate lead) is a current signal, there is a signal voltage at the summing point equal to the amplifier output voltage divided by the open loop gain of the amplifier. A positive signal to Q360A gate makes its source voltage go positive, which decreases the current in Q360B so its drain voltage goes positive. Q360B forward biases Q370 and its collector voltage goes negative. Q375 is an emitter follower, and its emitter voltage also goes negative. R360 feeds back the negative output voltage signal as a current to Q360A gate summing point so that R360 current and the input programming current are equal.

The operational amplifier zero signal DC input is +0.6 V as set by D364 at Q360B gate. This voltage sets the quiescent anode voltage of all the input isolating diodes connected to the common input line (gate of Q360A). The current in the common line is determined by precision resistors that are diode connected by the Delay Gating program. In the X1 decade, the current through D358, D348, D338 or D328 is inversely proportional to the associated series resistor. The values of the series resistors are a binary ratio. The resistors are returned to −10 V which is supplied by the voltage divider R327-R329.

The X10 decade is identical to the X1 decade, except that the four series resistors are connected to −100 V instead of −10 V. The current in each case is increased over the X1 decade by a factor of 10. The X100 decade resistors are one-tenth the value of their counterparts in the X10 decade and the current in each case is increased over the X10 decade by a factor of ten.

Placing a logical ZERO at the Delay X10 decade 4 line (not grounded by either the DELAY switch or external program) causes the voltage divider R292-R294-R296 to place +1 V at D296 anode. D296 cathode is at about +0.4 V due to current in R298. Since the operational amplifier input holds D298 anode at +0.6 V, the 0.2 V forward bias prevents D298 from conducting. Thus R298 current does not affect the amplifier.

Placing a logical ONE at the Delay X10 decade 4 line places D296 anode at about −1 V. The diode is reverse biased and does not conduct. D298 now conducts, placing R298 as an input resistor to the amplifier. R298 current of 0.05 mA is provided by feedback current through R360, causing the amplifier output voltage to change +3 V from its previous value.

When no time-window delay is wanted, there is no input to the operational amplifier and the output voltage at D375 cathode is 0 V. When time-window delay is wanted on sweep rates that include the TIME/DIV DECADE switch positions of 4 through 9, the operational amplifier maximum output voltage is +7.5 V. Those sweep rates use the Delay X100 decade lines in the clocked form of delay only (described with the block diagram). When the TIME/DIV DECADE switch is at 0 (10), then the Delay X100 decade lines are included in the analog form of delay and the operational amplifier maximum output voltage is +75 V. The X100 decade lines are included in the analog delay by the Central Timing Logic placing a logical ONE at pin J (diagrammed connected to the anodes of D247-D257-D267-D277). The line feeding pin J is named "IV' Fine Delay Comp", meaning that there is a compensation of Delay switching for the three fastest sweep rates. The least significant Delay switch now provides 100 ps of delay per step, which amounts to 1 major graticule division at the fastest sweep rate of 100 ps/div.

NOTE

Referring to the Equivalent Time Block Diagram, at the same time the Central Timing Logic makes the IV' line a logical ONE, it makes the γ lst Decade Enable line a logical ZERO to turn off the Clock Counter 1st decade. With the 1st decade off, the Delay X100 lines have no effect upon the clock form of delay. Then the Delay X1000 lines operate the Digital Comparator 2nd decade as if it were a 1st decade, and the total delay operation now uses the most signifi-

cant Delay decade in the clock form of delay and the three least significant Delay decades in the analog form of delay.

The Fine Delay Attenuator converts the voltage at the Analog to Digital Converter output (at D375 cathode) to a current at the summing input to the Staircase Inverter Amplifier (diagram 5). This signal offsets the Staircase Inverter output signal into the Slewing Comparator to delay the time window display away from T_o.

The output current (staircase offset current) magnitude is altered by switching FET's which are programmed by the Central Timing Logic to select one of three values of output resistance. Maximum current output occurs when Q395 conducts. (Its on resistance is less than 30 Ω.) This places R394 in parallel with R377-R378. A current one-tenth of this value is obtained when Q385 conducts. R384 is then in parallel with R377-R378. With both Q395 and Q385 off, the current is reduced to one-hundredth of the maximum value. If Q398 is on (saturated), the output current is one-thousandth of the maximum value since it bypasses about 90% of the current to ground through R398.

Q380 and Q390 serve as signal level converters. Their gain is sufficient to reduce the gate voltages of Q395 and Q385 from −12.2 V to 0 V when +1 V is applied to their emitters. The input signals come from the TIMING LOGIC to these transistors and Q398. When conducting, voltage drops across D382 and D392 reduce the gate voltages to 0 Volt.

Timing Ramp & Staircase Inv Amp. ⑤

The Timing Ramp circuit generates six timing ramps which, together with the staircase signal fed to the Slewing Comparator, provides strobe drive pulses for the vertical channel sampling unit and stepping pulses for the Type 3T6 Staircase Generator.

A separate capacitor is used for each timing ramp. C538-C539 provide the fastest ramp and C503 through C516 provide successively slower rate ramps. The Timing Ramp capacitors are switched in by their respective constant current transistor switches, Q500 through Q516. Each transistor emitter is connected to the common timing current setting resistors R518-R519 and the −100 V supply. Only one switch is on at a time, but C538-C539 are always in the circuit. Timing current is adjusted by R518 and timing accuracy between ranges is assured by the accuracy (error ratios) of timing capacitors C503 through C516.

To obtain a 100 ns/div timing ramp (1 μs ramp), input terminal S is held up at approximately +1 V and Q503 base is at +0.9 V due to the two junction voltage drops of D502 and D514. Q503 conducts, setting its emitter and all of the other common emitters at +0.3 V. The other switches are open because they are reverse biased with their bases at 0 V. D503 through D516 isolate the unused timing capacitors from the one in use. Auto calibration may be provided at terminal K by use of special equipment admitting an increase or decrease to the timing current value set by R518.

Q525-Q530-Q535 form the Ramp Clamp. Q525 and Q530 conduct when the anode of D520 is at 0 V. Q530 collector signal turns on Q535. Q535 collector voltage clamps at approximately +18 V due to feedback to Q530 emitter through D528. The output is then limited to +18 V because R530 and R531 set Q530 base voltage to +18 V. A +0.5 V pulse to D520 from the Timing Ramp Enable diode D168 in the Clock circuit turns off Q525 and stops the current in Q530. R532-D534 set Q535 base voltage 0.6 V above +20 V, turning Q535 off. This allows the timing ramp to begin its rundown from a starting value of +18 V. At the end of a sampling cycle, the anode of D520 is returned to 0 V. Q525 again conducts and Q530 collector voltage drop turns Q535 on to reset the timing ramp voltage back to +18 V.

C525 is a speed-up capacitor that helps start (unclamp) the ramp quickly when D520 gets a positive pulse from the trigger circuit. R501 provides for the I_{CBO} leakage of the Timing Ramp transistors that are cut off.

The Slewing Comparator Q550-Q555 and its constant current drain Q553, compares the Timing Ramp voltage with the Staircase Inverter Amplifier output voltage which is applied to Q555 base. Q555 is normally at cutoff forcing all of Q553 current into Q550. When the voltage at Q550 base becomes less than Q555 base voltage, Q550 turns off. Q555 now conducts all of Q553 current and the negative voltage step at its collector causes Q565 to avalanche. A 20 V positive pulse is produced at Q565 collector and this signal couples through C566 to become the vertical channel sampling unit strobe drive. C567-R567 supplies a similar signal to the Staircase Stepper.

Q548-D538 form the Timing Ramp Reset Comparator. On all ramps except the 100 ns ramp, the Timing Ramp runs negative from about +18 V to about +8 V and stops. It is stopped by current in D538 and Q548. Before the ramp is stopped, Q548 is conducting only about 1/2 mA and its base voltage is set to about +9 V by R547-R549 and the +20-V supply. As the Timing Ramp voltage reaches a value that is about two silicon junction drops (1.2 V) below Q548 base, D538 conducts, causing Q548 to take all the timing current away from the timing capacitor. As the timing current enters Q548, its collector provides a negative step signal to Q70 in the trigger circuit Reset Multivibrator. This initiates reset of both the trigger circuit and the Timing Ramp by returning D520 anode to 0 V.

For the 100 ns ramp only, terminal AD voltage is up, turning Q545 on to saturation. This places R546 in parallel with R549 so that the voltage divider output to Q548 base changes from about +9 V to about +2.5 V. This permits the 100 ns Timing Ramp to run to about +1.5 V before the loading comparison occurs and both the trigger and ramp circuits are reset.

During Equivalent Time operation, the input signal to terminal AV is inhibited by D540 (a germanium diode) whose cathode is at 0 V. During Real Time operation, approximately +1 V is applied to terminal AT and Q540 conducts when a positive signal arrives at terminal AV as the Staircase Generator resets at the sweep end. The voltage at Q70 is lowered and the trigger and timing ramp are reset in the same way as when Q548 turned on.

The method of providing strobe drives in real time is provided by Q560, which is driven from the Clock at a proper rate. For each positive pulse at terminal X, one strobe pulse is produced.

The Staircase Inverter operational amplifier Q590-Q578 gives an inverted output signal at the collector of Q578 for an input signal to Q590A gate. The input signal is composed of a fine delay current from the Digital to Analog converter, the 0 to +7.5 V Staircase signal (converted to a signal current by one or more of the input resistors) and the Delay Zero current, which is adjusted by R591. The output signal is fed directly to the Slewing Comparator at Q555 base and is used to control the equivalent time duration of ΔT_{dot} described near the beginning of this section. Logic control of the staircase signal output amplitude comes from the Central Timing Logic of diagram 7. Input resistors are switched in or out of the circuit (to change the gain) by switching FET's, Q581, Q584 and Q587.

The amplifier input resistance consists of R589 in combination with R582, R585 or R588. When the switching FET Q587 is turned on, R588 is connected in parallel with R589 and the resulting amplifier gain is unity. In like manner, Q584 connects R585 in parallel with R589 for a gain of one-half and Q581-R582 gives a gain of one-fifth. With the three switches open, the input resistance is R589 and the gain is one-tenth.

Each FET switch is turned off with a reverse bias of −12.2 V and is turned on with 0 V gate bias. An input voltage at terminal BT of approximately +1 V turns on Q586 to take all of R587 current which zero biases the FET switch Q587. The slightly positive voltage at Q586 collector is reduced to 0 V for Q587 gate by the D587 junction voltage drop. The remaining FET switches are controlled in the same way at terminals BS and BR and Q583-D584 and Q580-D581.

Terminal BQ receives a voltage of approximately +1 V when the three fastest sweep rates are programmed. Q570, with D571 turn on Q572 and Q575. Q575 places R576 in parallel with feedback resistor R578 to reduce the operational amplifier gain by a factor of 10. Connecting R576 in the circuit causes an unwanted output DC shift that is cancelled by Q572 and R573-R574. The 0 Decade Delay Zero control adjusts the amplifier output to the proper level. Zener diode D573 conducts when Q572 is turned off, otherwise the emitter would follow the base voltage down to −12.2 V and the transistor would not stop conducting. D596 acts as a clamp to prevent base-emitter breakdown of Q578 if Q590 is removed from its socket while the power is on. R579-C579 form an oscillation damping circuit.

Staircase Generator And Horiz Amp ⑥

The Staircase Generator is composed of a Staircase Amplifier Q680, Q685, Q690 and Q695, Staircase Reset Multivibrator Q610, Q630, and Q635, Staircase Stepper Q670 and Q675, Sweep Speed-up Enable Q660, Q840 and Q845 and Sweep Reset Tripper Q600. The output of the Staircase Generator drives the Horizontal Amplifier, the Digital Unit and the Staircase Inverter Amplifier.

The Staircase Generator is an operational amplifier used as a Miller integrator with input at Q680A gate and output at D690 cathode. A negative current pulse to Q680A gate starts to drive Q685 base negative and its output drives emitter follower Q690 positive. C680 feeds back an inverted current pulse to the input of the amplifier. D684 sets the bias and current for both Q680A and B so that Q680A source lead slightly forward biases Q685 when Q680A gate is at 0 V. D690 assures that the collector voltage of Q685 will be at about +1.2 V when the output is at 0 V (thus Q685 does not saturate). Q695 is a constant-current emitter return for Q690 to assure a constant voltage drop across D690 and assure good amplifier linearity. D693 conducts negative signals to the output when Q690 is cut off. This happens when the Staircase is being reduced from +52 V back to 0 V.

The staircase output voltage is changed (made to take a positive step) by input pulses of charge (current X time) from the Staircase Stepper during the 1000 dots/sweep rate. Q690 output current gives C680 a fixed amount of charge (which it retains) each time a pulse from the Staircase Stepper drives Q680A input negative. Hence a staircase of increasing voltage vs time is formed. The staircase is stopped at about +52 V and returned to 0 V. The Reset Multivibrator must turn on again before another staircase can be generated.

During staircase run-up, Q630 and Q635 of the Reset Multivibrator are saturated. To begin the staircase, a positive pulse to terminal BK from the Strobe Driver (Q565 diagram 5) turns on Q670 of the Staircase Stepper, which gives a negative pulse to Q630 base through R605 to turn it on. Q630 drives Q635 into conduction and its collector drops to −12 V. R634 conducts this signal back to Q630 and both transistors are locked on. D680 and D682A are reverse biased and do not conduct.

Q610 base is biased two junction voltage drops below approximately +52 V (which is the top of the staircase). When the staircase exceeds +52 V, D614 conducts a pulse through Q610 to Q630 and turns it off. (R604 is the major current drain, though not the only one, for the several currents that enter the summing point, which is the base of Q630. Only the controlling currents will be mentioned.) Q635 is then reverse biased and its collector goes positive. Q630 is now held off by the positive bias through R634 as clamped by D634, and D682A is biased into conduction.

The positive signal voltage through D682A to Q680A gate results in an amplified negative change to the Staircase Amplifier output, which causes the output voltage to drop to 0 V, at which point, D680 conducts. During this time C625 (which was charged to +52 V) has been discharging through R624-R604, and the cycle begins again when a negative pulse from Q670 through R605 is greater than the diminishing current from R624-C625, turning on Q630.

Q670 and Q675 form the Staircase Stepper. Initial conditions (before each step drive pulse) are: Q670 collector is at +20.6 V, clamped there by D671 and reverse biasing D672. Q675 is conducting about 1.6 mA from +20 V through R672-D678-D668 and D667; Q675 base is at about +4.4 volts as set during calibration by R676 (Samples/Sweep Cal control) and the voltage divider resistors R674-R675; C672 is charged to about +5 volts. The two silicon diode junction drops of +1.2 V across D667-D668 assure that D682B (at the Staircase Amplifier input) is reverse biased and the Staircase Stepper is disconnected from Q680A gate.

A cycle of operation starts when the step drive pulse arrives at Q670 base from the Strobe Driver. Q670 saturates for a very short time, (less than the input pulse duration) and its collector drops to about 0 V. Q670 saturation is intended to, and does, discharge C672 down to about +0.6 V due to the drop across D672. Q670 also takes all the current of R672, placing Q675 at cutoff. D678 disconnects Q675 collector, allowing R668 to forward bias D682B and become the input resistor to the Staircase Generator operational amplifier. (D668 is reverse biased when Q660 is at normal conduction for 1000 samples/sweep. However, should 100 samples/sweep be programmed, D668 remains forward biased and R667 is placed in parallel with R668 as the input to the operational amplifier. See 100 samples/sweep described below.) As long as R668 remains connected to the Staircase Generator (Q680A gate) the output voltage changes in a positive direction. The duration of input current from R668 is very short, controlled by the saturation time of Q670 and the RC charge time of R672-C672. As C672 charges positive, Q675 is caused to conduct again and disconnect R668 from the operational amplifier input, thereby stopping the output voltage change. Each staircase step (output voltage) is the same amplitude because R668 remains as the input resistor for the same amount of time each step. During the time R668 is not the input resistor, D682B remains cut off and the Staircase Amplifier output voltage remains stable. C678 assures that all the charge that should reach the amplifier input does. As R668 is connected, it conducts current out of the amplifier input faster than the amplifier output can follow (and by following, provide an equal current through C680). Therefore, C678 is a temporary current source for R668. Any charge gained by C678 is removed by feedback current through C680 at the end of the stepping time after R668 current has been removed from the amplifier input. R682 develops a small negative feedback signal due to C680 current into C678, helping to prevent overshoot of the operational amplifier output step and "smooth out" the input current pulses from the Staircase Stepper circuit at Q680A gate lead.

Q670 collector also provides drive to the Digital Clock amplifier Q605. Q605 is normally not conducting, its base reverse biased about 0.6 volt by Q670 collector voltage, clamped at +20.6 V by D671. As Q670 saturates, do does Q605, sending a +1.8 V square clock pulse to an associated digital unit.

When 100 samples/sweep is programmed (available by external programming only), additional step current is drawn from the Staircase Generator operational amplifier input by R667 placed in parallel with R668 to make each staircase voltage step 10 times larger than at 1000 samples/sweep. The sweep speed-up program (such as applying a logical ONE at J24 pin B) saturates Q845 to turn off Q660. Initial conditions (at equivalent time sweep rates) for 1000 samples/sweep are: Q840 base is at ground due to the logical ONE signal from the Central Timing Logic $\overline{RT}$ line. Q845 is at cutoff because both the base and emitter return resistors are connected to +3.6 V and the external programming line is at a logical ZERO. Q660 base is held at +3.34 volts by R660-R662; thus, R664 sets the collector current at 2 mA. Nearly I mA passes through R667, 0.134 mA passes through R666 and the rest of the 2 mA passes through D666 and D667. This condition assures that D668 is reverse biased during staircase step times and R667 is isolated from the staircase operational amplifier input.

As the external program applies a logical ONE to J24 pin B, Q845 emitter is taken sufficiently negative that R843 current to Q845 base saturates the transistor. Q845 collector now takes all of R664 current, cutting off Q660. R666 takes Q660 collector to −12.2 V, reverse biasing D666 and placing R667 in parallel with R668 for X10 staircase output voltage steps.

Any sweep can be reset at any time, independent of the staircase output voltage (either real time or equivalent time) by grounding J24 pin 15 (during external programming) or by placing the front panel SAMPLES/SWEEP switch to 1. Either mode of operation grounds pin BN, which turns on Sweep Reset Tripper Q600. Current from R603 turns off Reset Multivibrator Q630-Q635 as long as terminal BN is held down.

The Blanking Amplifier Q640 provides CRT blanking during the reset of the sweep. When the Reset Multivibrator turns off for reset, Q640 base is forward biased to turn it on. This lowers pin 13 of P21 to Zener diode D640 voltage of +43 V from the +125.6 V as set by D641 when Q640 is not conducting. The SAMPLES/SWEEP switch placed in the 1 position actuates the Sweep Reset Tripper, and also grounds out (through D644) any positive signal to Q640. This removes blanking so that the dot can be seen during reset. When 1 sample/sweep is externally programmed (sweep reset) the CRT dot is blanked.

Q650 provides a sweep gate to the Digital Unit when the sweep starts. Turning on Q635 puts a negative bias on Q650 base and it turns off. The voltage at the junction of R651 and R652 increases to +5 V and remains at that value until Q635 turns off at the end of the sweep.

Trigger circuit control for real time sweep rates is synchronized with each sweep by Q540 (included at top of both diagrams 5 and 6). (Q540 is held at cutoff by the $\overline{RT}$ line being a logical ONE for equivalent time sweep rates.) Real time sweep rates place the $\overline{RT}$ line to Q540 at a logical ZERO allowing the Reset Multivibrator to control Q540.

When the Reset Multivibrator turns off at the end of the staircase, Q635 collector goes positive. C626 conducts a positive pulse to Q540 to pulse it on. This produces a negative step to the base of Q70 to initiate trigger circuit reset time. R625 provides a trigger holdoff (only in real time) when terminal BN (drive to Q600 base) is in the reset mode. In equivalent time, terminal AT (the $\overline{RT}$ line) is near ground potential and D540 clamps the base of Q540 at approximately +0.3 V. Q540 then ignores any pulses through C626 or current through R625.

Horizontal Amplifier

The Staircase Amplifier drives an attenuation network R696-R697 which reduces the 0 V to +52 V Staircase to 0 V to +7.5 V. The voltage divider is isolated by emitter followers Q700 and Q705, which provide temperature and offset compensation.

Output Differential Amplifier. The linear output differential amplifier employs two special high voltage transistors Q720-Q730. These transistors have a BV_{CBO} rating of 300 volts, and are used to drive the CRT horizontal deflection plates directly. The emitter circuit is both "long tail" and highly degenerative between transistors, assuring that neither transistor cuts off.

Assume both amplifier bases are at +3.75 volts; R722 and R732 assure that both transistors conduct 2 mA. As Q720 base voltage goes positive, its emitter goes positive, applying a positive turn-off signal to Q730 emitter through R724-R734-R736. Q720 then increases its current, and Q730 decreases its current; Q720 collector goes negative and Q730 collector goes positive. The amplifier thus converts a single input signal to a push-pull output signal. The amount of signal coupled from one emitter to the other emitter is made adjustable by the front-panel HORIZ GAIN control, R736. R736 permits the operator to alter the output stage gain sufficiently to mate the horizontal deflection to the particular oscilloscope in which the Type 3T6 is operated.

The output average voltage value of both Q720 and Q730 is adjustable over a range by the front panel HORIZ POS control, R711. R711 sets the base voltage of emitter-follower Q710, which sets the base voltage of Q730. Total range of voltage at Q710 emitter is from about +1.1 V to +6.6 V, approximately 2 volts less than the total staircase signal amplitude into Q720 base. The differential connection of Q720-Q730 permits the HORIZ POS control to alter the staircase output voltages at Q720 and Q730 collectors without distorting the CRT display time linearity.

Spot Position Indicators

The horizontal spot position indicator lamps are driven by a switching comparator amplifier, Q740-Q745. The comparator is driven by the output amplifier emitter circuit by the voltage across the HORIZ GAIN control. If the CRT driver output amplifier transistor conduction differs enough to cause about 0.5 volt difference at Q740-Q745 bases, the most positive-base transistor saturates and the other transistor is cut off. The long tail resistance in the emitter of the lamp drivers permits the CRT driver emitter circuit to float between 0 V and +7.5 V and still operate the switching comparator properly. Whichever transistor saturates, it then turns on the associated neon lamp in its collector lead. The cutoff transistor assures that its collector circuit lamp has no current and therefore remains dark.

The two series base resistors R740-R746 assure that the pulse caused by neon ignition is not coupled back into the sampling sweep unit circuits. (Without the series base resistors, each time a neon turned on, its effects would be seen on the CRT.) The large resistance between transistor collector leads assures that the off transistor collector voltage does not rise to +125 volts. When a transistor is cut off, its collector voltage is held at about +70 volts by Townsend (dark) current through the associated neon passing through R472 to the other collector. R742 keeps the off transistor collector about +10 to +15 volts from its emitter (the emitter voltage being set by the other neon drop and its saturated transistor). The circuit never operates with both transistors cut off.

Power Supply ⟨11⟩

The low voltage power supply provides the operating power for the Type 3T6 from four regulated supplies to supplement the main frame power supplies. Electronic regulation provides stable low ripple output voltages.

The oscilloscope main frame provides 6.3 VAC to power transformer T901. The primary of the transformer is fused by F900, which is mounted on the rear panel.

The transistors are mounted on the Display circuit board except for Q915 and Q935, which are heat-sinked to the chassis near the rear of the unit.

The +20-Volt power supply *is composed of differential* amplifier Q900-Q905, an error signal amplifier Q910 and a series regulating element Q915.

Zener diode D903 biases Q900 base 9 V below the +20 V output. The bias for Q905 base is set by the voltage divider R907-R908-R909.

The regulator action is as follows: a fast changing output error voltage is fully applied to Q900 base through D903. C908 prevents fast error signals from reaching Q905 base.

Therefore, such errors are applied as an input to only one side of the differential comparator. Q900 emitter then drives Q905 emitter, and Q905 responds as a common base amplifier. Q905 collector voltage change is thus of the same polarity as the error signal that reached Q900 base.

C908 does not prevent very low rate-of-change error signals from reaching Q905 base as attenuated by R907-R908-R909. Thus the low frequency, or DC gain of the comparator is less than the high frequency gain.

Assume a positive error signal arrives at Q900 base. Q905 collector goes more positive and the current in Q910 is decreased. The base of Q915 is driven more negative due to the decrease in the current through R916. Q915 current is also decreased (its internal resistance is increased) increasing the voltage across the transistor. The voltage drop across the load is decreased due to the decrease in current and the normal load voltage is restored. The regulator action is similar for a negative error signal.

Special components serve the following functions: R904, R906, R912, R914 and C912 prevent parasitic oscillation. C908 stabilizes the base voltage of Q905 at high frequencies and C906 is a bypass which reduces the supply high frequency output impedance. R903 sets the Zener diode average current to the proper value. R901 will act as a slow-blowing fuse and protect the rectifier diodes and transformer secondary in the event of a short circuit at the supply output. R908 is adjusted during calibration to obtain the correct output voltage.

The +3.6-Volt power supply regulator action is similar to that in the +20-Volt supply. Q925 is reference biased for proper supply output voltage by the +20-Volt supply through the voltage divider R927-R928. Error signals are applied only to Q920 base through R921.

Special components include C928, R932 and R934, each of which aids in suppressing parasitic oscillations.

The +1.75-Volt supply uses the +3.6-Volt supply as its power source. The regulator action is similar to that in the +20-Volt supply. The reference bias and output voltage are set by R941 and the error signal is applied directly to Q945 base. The output voltage is purposely given a temperature controlled change by D940 and D942 to stabilize the operation of some of the integrated circuits in the Type 3T6.

The series element in the regulator that controls the current to the load is formed by R948 and Q948 in parallel with R949. Maximum resistance exists when Q948 is not conducting and only R949 conducts current. When Q948 is conducting, the resistance is less due to the parallel combination.

The −3.5-Volt supply uses the oscilloscope −12.2-Volt supply as its power source. The regulator action is similar to that in the +20-Volt supply. The oscilloscope −100-Volt supply reference biases Q950 through the voltage divider R951-R952 and also sets the output voltage. The error signal is applied to Q955 base. The series regulating element is formed by Q960-R966 in parallel with R956 and its action is similar to that in the +1.75-Volt supply.

SECTION 4
MAINTENANCE

Change information, if any, affecting this section will be found at the rear of the manual.

Introduction

This section of the manual contains maintenance information for use in preventive maintenance, corrective maintenance or troubleshooting of the Type 3T6.

PREVENTIVE MAINTENANCE

General

Preventive maintenance consists of cleaning, visual inspection, lubrication, etc. Preventive maintenance performed on a regular basis will help prevent instrument failure and will improve reliability of this instrument. The severity of the environment to which the Type 3T6 is subjected will determine the frequency of maintenance.

Cleaning

The Type 3T6 should be cleaned as often as operating conditions require. Accumulation of dirt in the instrument can cause overheating and component breakdown. Dirt on components acts as an insulating blanket and prevents efficient heat dissipation. It also provides an electrical conduction path.

The top and bottom covers of the 560-series instruments into which the Type 3T6 fits, provide protection against dust in the interior of the instrument. Operating without the covers in place will require more frequent cleaning.

CAUTION

Avoid the use of chemical cleaning agents which might damage the plastic used in this instrument. Some chemicals to avoid are benzene, toluene, xylene, acetone or similar solvents. The DELAY switch should be cleaned only with isopropyl alcohol.

Exterior. Loose dust accumulated on the outside of the Type 3T6 can be removed with a soft cloth or small paint brush. The paint brush is particularly useful for dislodging dirt on and around the front-panel controls. Dirt which remains can be removed with a soft cloth dampened in a mild solution of water and detergent. Abrasive cleaners should not be used.

Interior. Dust in the interior of the instrument should be removed occasionally due to its electrical conductivity under high-humidity conditions. The best way to clean the interior is to blow off the accumulated dust with dry, low-velocity air. Remove any dirt which remains with a soft paint brush or a cloth dampened with a mild detergent and water solution. A cotton-tipped applicator is useful for cleaning in narrow spaces on circuit boards.

Lubrication

The reliability of potentiometers, rotary switches and other moving parts can be increased if they are kept properly lubricated. Use a cleaning-type lubricant (such as Tektronix Part No. 006-0218-00) on switch contacts. Lubricate switch detents with a heavier grease (such as Tektronix Part No. 006-0219-00). Potentiometers should be lubricated with a lubricant which will not affect electrical characteristics (such as Tektronix Part No. 006-0220-00). Do not over-lubricate. A lubrication kit containing the necessary lubricants and instructions is available from Tektronix. Order Tektronix Part No. 003-0342-00.

Visual Inspection

The Type 3T6 should be inspected occasionally for such defects as broken connections, improperly seated transistors, damaged circuit boards and heat-damaged parts.

The remedy for most visible defects is obvious; however, care must be taken if heat-damaged parts are located. Overheating is usually only a symptom of trouble. For this reason, it is essential to determine the actual cause of overheating before the heat-damaged parts are replaced; other wise, the damage may be repeated.

Recalibration

To assure accurate measurements, check the calibration of this instrument after each 500 hours of operation or once every six months.

Parts Identification

Identification of Switch Wafers. Wafers of switches shown on the circuit diagram are numbered from the first wafer located behind the detent section of the switch to the last wafer. The letters F and R indicate whether the front or the rear of the wafer is used to perform the particular switching function. For example, the designation 2R printed by a switch section on a schematic identifies the switch section as being on jthe rear side of the second wafer when counting back from the front panel.

The terminals on each decade of the DELAY switch are part of an etched circuit board. The terminals are marked C, 1, 2, 4, or 8.

Wire Color Code. The wiring in the Type 3T6 is color coded to facilitate circuit tracing. In the case of the power-supply leads, the color code indicates the voltage carried, with the widest stripe denoting the first significant figure. Table 4-1 lists the color combinations and the voltages indicated by the colors.

TABLE 4-1
Power Supplies Wire Color Coding

Supply	Color Code
−100 V	Brown Black Brown on Tan
−12.2 V	Brown Red Black on Tan
−3.5 V	Black Blue Black on Tan
+1.75 V	Black Violet Green on White
+3.6 V	Orange Violet Black on White
+20 V	Red Black Black on White
+125 V	Brown Red Brown on White
+300 V	Orange Black Brown on White
6.3 VAC	Blue Brown on White (Terminal 1 of T901)
6.3 VAC	Blue Red on White (Terminal 2 of T901)

Resistor Coding

If the resistor has three significant figures with a multiplier, the resistor will be EIA color coded. If it has four significant figures with a multiplier, the value will be printed on the resistor. For example, a 333 kΩ resistor will be color coded, but a 333.5 kΩ resistor will have its value printed on the resistor body.

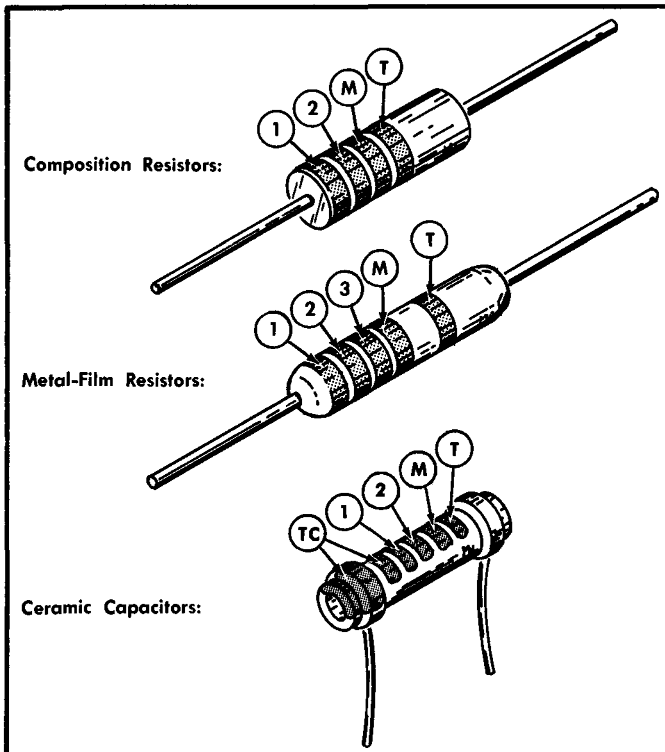
The color-coding sequence is shown in Fig. 4-1.

Capacitor Marking. The capacitance values of common disc capacitors and small electrolytics are marked in microfarads on the side of the component body. The white ceramic capacitors used in the Type 3T6 are color coded in picofarads using a modified EIA code (Fig. 4-1).

Diode Color Code. The cathode end of each glass enclosed diode is indicated by a stripe, a dot or a series of stripes. For normal silicon or germanium diodes the stripes also indicate the type of diode, using the resistor color-code system (e.g., 6185 indicates the type of diode with Tektronix Part No. 152-0185-00). The cathode and anode ends of metal-enclosed diodes can be distinguished by the diode symbol marked on the body or by the flared end of the anode.

Circuit Card/Board Removal and Replacement

Logic 1 and Logic 2. Each card is mounted in the top center of the Type 3T6 and is provided with a plastic handle for removal of the card. As the card is pulled, wiggle the handle to facilitate the card's removal.



(1) (2) and (3) —1st, 2nd and 3rd significant figures;
(M) —multiplier; (T) —tolerance;
(TC) —temperature coefficient.

Resistor and Capacitor Color Code

Color	Significant Figures	Multiplier		Tolerance	
		Resistors	Capacitors	Resistors	Capacitors
Silver	---	10^{-2}	---	±10%	---
Gold	---	10^{-1}	---	±5%	---
Black	0	1	1	---	±20% or 2 pF*
Brown	1	10	10	±1%	±1% or 0.1 pF*
Red	2	10^2	10^2	±2%	±2%
Orange	3	10^3	10^3	±3%	±3%
Yellow	4	10^4	10^4	±4%	+100% −0%
Green	5	10^5	10^5	±0.5%	±5% or 0.5 pF*
Blue	6	10^6	10^6	---	---
Violet	7	---	---	---	---
Gray	8	---	10^{-2}	---	+80% −20% or 0.25 pF*
White	9	---	10^{-1}	---	±10% or 1 pF*
(none)	---	---	---	±20%	±10% or 1 pF*

*For capacitance of 10 pF or less.

NOTE: (T) and/or (TC) color code for capacitors depends upon manufacturer and capacitor type. May not be present in some cases.

Fig. 4-1. Resistor and ceramic capacitor color-code.

Re-insertion of the card requires that it be centered in its three guides and then pressed into its connector with a thumb near each end of the card.

Display Board. The board is held to the Type 3T6 chassis by screws connecting to spring mountings. In removing the board, loosen each screw only one turn at a time so that the circuit board assembly does not spring up at one end and cause damage to the printed circuit or bend the pins. This will equalize the stress caused by the springs.

Check that the pins are straight before replacement. Replace the circuit board with careful alignment of the holes over the pins and with pressure on the area around the screws to overcome spring resistance for the initial screw tightening, then tighten all of the screws gradually, one turn at a time. If difficulty is encountered because of bent pins, position the plastic insulating sheet near the tops of the pins to aid in their alignment. Install the board as instructed above and it will press the plastic sheet into proper position.

Timing Board. Disconnect the three coaxial connectors and then follow the instructions for the Display board removal and replacement. Note the color coding on the wire for correct reconnection.

Parts Replacement

All parts used in the Type 3T6 can be purchased directly through your Tektronix Field Office or Representative. However, replacements for standard electronic items can generally be obtained locally in less time than is required to obtain them from Tektronix. Replacements for the special parts used in the assembly of the Type 3T6 should be ordered from Tektronix, Inc. since these parts are either manufactured or selected by Tektronix, Inc. to satisfy a particular requirement. Before purchasing or ordering, consult the Electrical Parts List to determine the value, tolerance and rating required.

NOTE

When selecting the replacement parts, it is important to remember that the physical size and shape of a component may affect its performance at high frequencies. Parts orientation and lead dress should duplicate those of the original part since many of the components are mounted in a particular way to reduce or control stray capacitance and inductance. After repair, portions of the instrument may require recalibration.

Transformer T901. The transformer is mounted by screws located on each side of the terminals. The transformer is removed through the hole in the left chassis after the Display circuit board and the plastic sheet underneath are removed. Follow the instructions for the Display circuit board removal to prevent damage to the board.

Power Supply Filter Capacitors C902 and C922. To remove a capacitor, unsolder the top lead, lift the capacitor away from the chassis and out of the clamp and then pull the capacitor out to expose the bottom lead which must be unsoldered.

Front Panel Removal. To gain access to components mounted on the back of the front panel, remove the four rails supporting the front panel. The rails are removed by loosening the clamps on the rails near the front panel, removing the four screws in the back end of the rails and then removing the rails from the captive screws in the front panel. To loosen the rails from the captive screws, place an 11/32-inch wrench on the indentations near the end of each rail and turn the rail counterclockwise. Disconnect the connection at J10, which is behind the TRIGGER MODE switch. The front panel may be carefully moved to expose the components mounted on it.

Switch Replacement. Individual parts of either a rotary switch or a lever switch are not normally replaceable. If one section of a switch is defective, the entire unit should be replaced. Replacement switches may be ordered either wired or unwired. Refer to the Electrical Parts List for the appropriate part number. When replacing a switch, tag the leads and switch contacts with corresponding tags. Use the old switch as a sample for wiring the new one, using the *soldering techniques described in this section.*

Circuit Boards. Use ordinary 60/40 solder and a 35- to 40-watt pencil type soldering iron on the circuit boards. The tip of the iron should be clean and properly tinned for best heat transfer to the solder joint. A higher wattage soldering iron may separate the etched wiring from the base material.

All of the components mounted on the Vertical and Control circuit boards can be replaced without removing the boards from the instrument. Observe soldering precautions given under Soldering Techniques in this section.

Replacement of soldered-in diodes. Grasp the diode lead between the body of the diode and the circuit board with a small pair of tweezers. Touch the tip of the soldering iron to the lead where it enters the circuit board. Do not lay the iron tip directly on the circuit board. Gently but firmly pull the diode lead from the hole in the circuit board. If removal of the lead does not leave a clean hole, apply a sharp object such as a toothpick or pointed tool while reheating the solder. Avoid using too much heat.

NOTE

Cleaning of the circuit board hole while the board is mounted in the instrument is not recommended. Solder pushed through the hole toward the back side cannot always be cleared away unless the back side is accessible. Thus, clear the mounting holes only when the board is out of the instrument.

To place the new diode, bend the leads and trim to fit just through the board. Tin each lead while using the tweezers as a heat sink. Place the diode leads in the holes. Observe proper polarity when installing the new diode. Apply a small amount of solder, if necessary, to assure a good bond. Use the tweezers as a heat sink and use only enough heat for a good connection.

Replacement of other soldered-in components. Grip the component lead with long-nose pliers. Touch the soldering iron to the lead at the solder connection. Do not lay the iron directly on the board, as it may damage the board. Refer to Fig. 4-2.

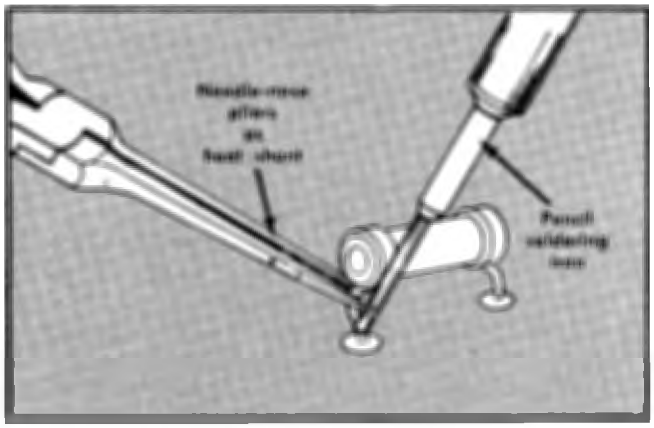


Fig. 4-2. Apply the soldering iron to the heat-shunted lead when removing a component from a circuit card.

When the solder begins to melt, pull the lead out gently. This should leave a clean hole in the board. If not, the hole can be cleaned by reheating the solder and placing a sharp object such as a toothpick or pointed tool into the hole to clean it out.

Bend the leads of the new component to fit the holes in the board. If the component is replaced while the board is mounted in this instrument, cut the leads so they will just protrude through the board.

Pre-tin the leads of the component by applying the soldering iron and a small amount of solder to each (heat-shunted) lead. Insert the leads into the board until the component is firmly seated against the board. If it does not seat properly, heat the solder and gently press the component into place.

Apply the iron and a small amount of solder to the connection to make a firm solder joint. To protect heat-sensitive components, hold the lead between the component body and the solder joint with a pair of long-nose pliers or other heat sink.

Clean the area around the soldered connection with a flux-remover solvent to maintain a good environment characteristics. Be careful not to remove information printed on the board.

Metal Terminals. When soldering metal terminals (e.g., switch terminals, potentiometers, etc.), ordinary 60/40 solder can be used. The soldering iron should have a 40- to 75-watt rating with a 1/8-inch wide chisel-shaped tip.

Observe the following precautions when soldering metal terminals:

1. Apply only enough heat to make the solder flow freely.

2. Apply only enough solder to form a solid connection. Excess solder may impair the function of the part.

3. If a wire extends beyond the solder joint, clip off the excess.

Position Indicator Assembly. Remove the neon holder cover by pushing down on the rear of the cover to release it and then sliding the cover off. Remove the 3/16-inch nut that is exposed and slide the entire assembly from the bolt. Unsolder the two wires underneath the assembly to free it for removal and repair.

Replacing TIME/DIV Readout Lamps. To remove the readout circuit board, use a 1/4-inch wrench to remove the 6-32 nuts from the captive bolts and lift the board free of the bolts.

Lamp removal and replacement requires a pair of tweezers and a small soldering iron. Withdraw the burned-out lamp. To install the new lamp, cut the leads to proper length, and then bend them into the same shape as found in the original lamp. Position the lamp the same as all other lamps in the assembly and solder the leads.

Check that there is no excess solder to short between a hot terminal and ground and then re-assemble the unit.

TROUBLESHOOTING

Introduction

The following information is provided to facilitate troubleshooting of the Type 3T6 if trouble develops. Information contained in other sections of this manual should be used along with the following information to aid in locating the defective component.

Troubleshooting Aids

Diagrams. Circuit diagrams are given on foldout pages in the back of the manual. The circuit number and electrical value of each component in this instrument are shown on the diagrams.

Component Numbering. The circuit number of each electrical part is shown on the circuit diagram. Each main circuit is assigned a series of circuit numbers and the photographs of the circuit boards have the component numbers to aid in locating the parts.

Troubleshooting Techniques

This troubleshooting procedure is arranged in an order which checks the simple trouble possibilities before proceeding with extensive troubleshooting. The first few checks assure proper connections, operation and calibration. If the trouble is not located by these checks, the remaining steps aid in locating the defective component. When the defective component is located it should be replaced following the replacement procedures given in this section.

1. Check Associated Equipment. Before proceeding with troubleshooting of the Type 3T6 check that the equipment used with the Type 3T6 is operating correctly. Check that the signal is properly connected and that the interconnecting cables are not defective. Also, check the power source.

2. Check Control Settings. Incorrect control settings can indicate a trouble that does not exist. For example, incorrect setting of the TRIGGER SENSITIVITY control appears as a defective sweep or trigger circuit. If there is any question about the correct function or operation of any control, see the Operating Instructions section of this manual.

3. Check Instrument Calibration. Check the calibration of the instrument, or the affected circuit if the trouble exists in one circuit. The indicated trouble may only be a result of misadjustment or may be corrected by calibration. Complete instructions are given in the Calibration section of this manual.

CAUTION

It is important not to adjust any power voltage unless a total calibration effort is planned. Changing power supply voltages alters the whole instrument calibration. Other steps of the Calibration Procedure can be performed in any sequence unless otherwise stated.

4. Isolate the Trouble to a Circuit. If the trouble has not been corrected or isolated to a particular circuit with the preceding steps, make the following checks if possible.

a. Check for the correct resistance readings at the interconnecting plug terminals, as indicated in Table 4-2.

If the resistance values at the interconnecting plug are equal or higher than stated in Table 4-2, proceed with the next step.

b. Connect the Type 3T6 to the oscilloscope in which it will normally operate. Use the flexible cable extension, Tektronix Part No. 012-0066-00. Turn on the instrument and allow at least 5 minutes warmup time.

Check the power supply voltages.

Incorrect operation of all circuits often indicates trouble in the power supplies. Check first for correct adjustment of the individual supplies. However, a defective component elsewhere in the instrument can appear as a power-supply trouble and may also affect the operation of other circuits.

The voltages and tolerances of the power supply in the Type 3T6 are given in step 1 of the Calibration Procedure. If a power-supply voltage is within the listed tolerance, the supply can be assumed to be working correctly. If outside the tolerance, the supply may be misadjusted or operating incorrectly. Use the procedure given in the Calibration section to adjust the power supplies.

TABLE 4-2
P21 Interconnecting Plug Resistance Checks Type 3T6 disconnected from Oscilloscope

Pin Number	Resistance to Ground	Meter Leads Reversed
1	100 Ω	100 Ω
2	100 Ω	100 Ω
3	0	0
4	0	0
5	inf	inf
6	35 kΩ	90 kΩ
7	inf	inf
8	inf	inf
9	0	0
10	35 kΩ	90 kΩ
11	inf	inf
12	inf	inf
13	43 kΩ	25 kΩ
14	inf	inf
15	9.4 kΩ	18 kΩ
16	140 Ω	140 Ω
17	12 kΩ	150 kΩ
18	50 Ω	50 Ω
19	0	0
20	9.4 kΩ	18 kΩ
21	7.3 kΩ	150 kΩ
22	4.1 kΩ	4.1 kΩ
23	4.6 kΩ	5.8 kΩ
24	inf	inf

Integrated Circuit Checks

The faulty unit may be located with the aid of the truth tables given in the circuit description by checking the logic output voltages for known input voltages.

Transistor Checks

Transistors should not be replaced unless they are actually defective. Transistor defects usually take the form of the transistor opening, shorting or developing excessive leakage. To check a transistor for these and other defects, use a transistor curve display instrument such as a Tektronix Type 575. However if a good transistor checker is not readily available, a defective transistor can be found by signal-tracing, by making in-circuit voltage checks or by using the substitution method. The location of all transistors is shown in the parts location figures in this section.

To check transistors using a voltmeter, measure the emitter-to-base and emitter-to-collector voltages and determine if the voltages are consistent with the normal resistances and currents in the circuit (see Fig. 4-3).

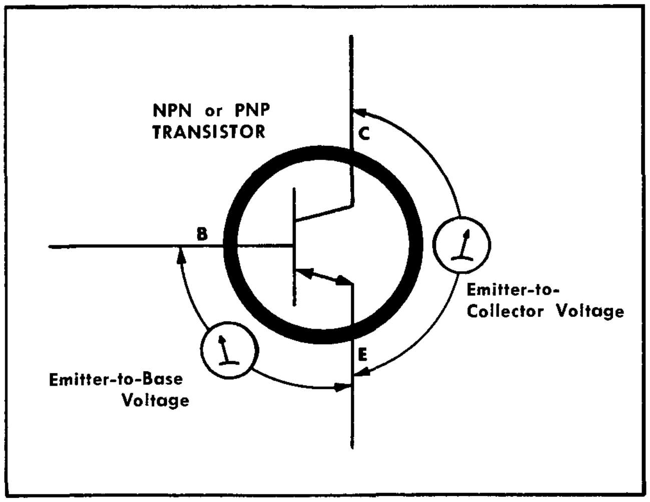


Fig. 4-3. In-circuit voltage checks NPN or PNP transistors.

Diode Checks

A diode can be checked for an open or shorted condition by measuring the resistance between terminals. With an ohmmeter scale having an internal source of about 1.5 volts, the resistance should be very high in one direction and very low when the leads are reversed.

CAUTION

Do not use an ohmmeter scale that has a high internal current. High currents may damage the diode. Do not measure tunnel diodes with an ohmmeter; use a dynamic tester (such as Tektronix Type 575 Transistor-Curve Tracer).

Silicon Controlled Rectifier Checks

The Silicon Control Rectifiers (D824-D836, Tektronix Part No. 151-0503-00) are used for the TIME/DIV lamp drivers (switches). They are readily checked by substituting a good SCR in place of the SCR that is in doubt.

Field Effect Transistor Checks

FET's (Tektronix Part No. 151-1021-00) are used as switches and may be checked with an ohmmeter. They have a resistance between the source and drain terminals of $<30\ \Omega$ for a current that is $\geqslant 1$ mA. The ohmmeter current should not exceed 150 mA during the test. The X10 range of the ohmmeter will usually meet this requirement. The full scale deflection current for the resistance range used should be known so as not to exceed the current limitation of the FET. The meter lead connected to the positive terminal of the internal battery should be connected to the drain and the other lead connected to the source for this test.

FET's (Tektronix Part No. 151-1004-00, single; 151-1007-00 and 151-1011-00, dual) should not be tested with an ohmmeter. If you suspect a dual FET, pull the unit out of the socket, rotate it 180° and re-insert it. If there is no change in the circuit operation, both sections of the dual FET are probably good.

The actual condition of the FET may be checked using a Tektronix Type 575 Transistor Curve Tracer. The dual FET will have to be checked one section at a time. Follow the lead identification of Fig. 4-4 when making connections at the curve tracer sockets. Fig. 4-5 shows the lead identification for the single FET's,

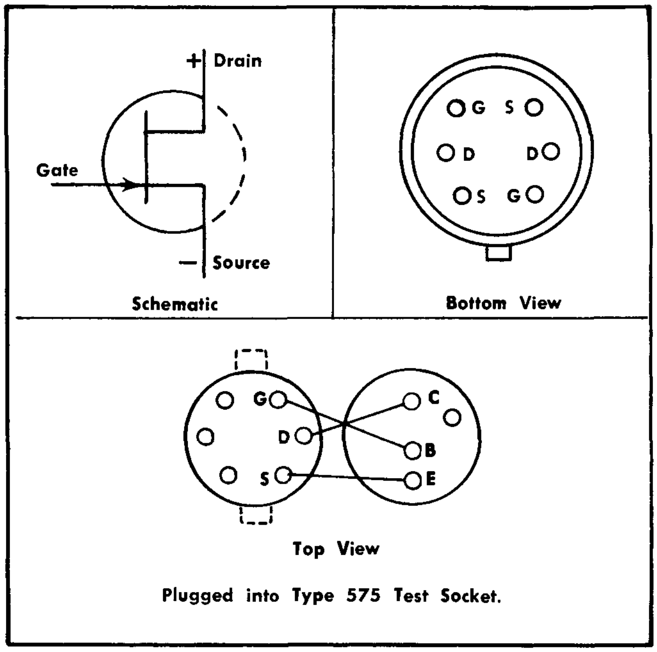


Fig. 4-4. Pin arrangements on dual FET's used in Type 3T6.

Set the curve tracer controls:

COLLECTOR SWEEP Controls	
PEAK VOLTS RANGE	20.0
POLARITY	+ (NPN)
PEAK VOLTS	Fully counterclockwise
DISSIPATION LIMITING RESISTOR	2K
VERTICAL Controls	
CURRENT OR VOLTAGE	1 COLLECTOR MA
POSITION	Spot at lower left corner of graticule

Ⓐ

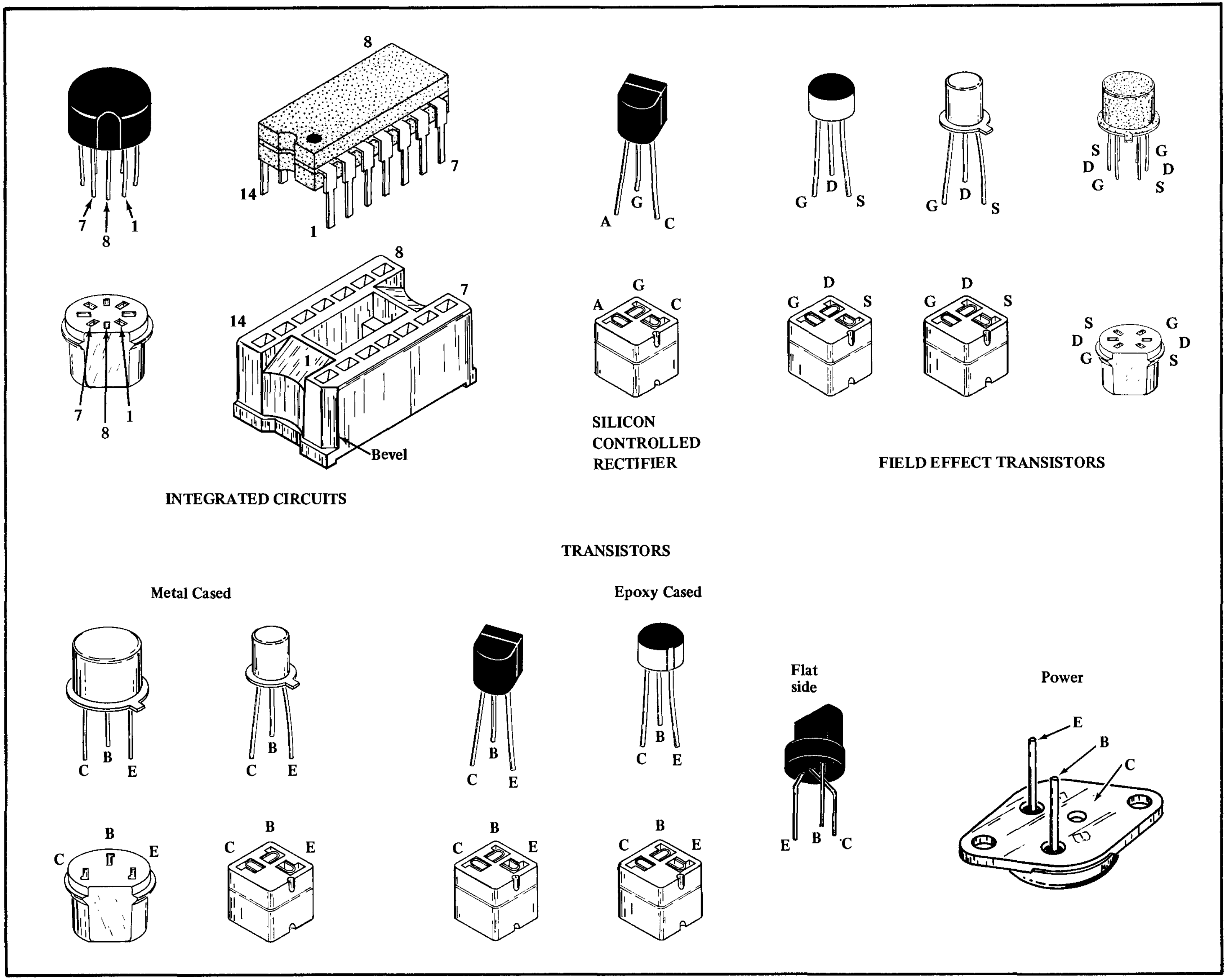


Fig. 4-5. Electrode configuration for socket-mounted transistors and Integrated Circuits, top view.

Ⓐ

HORIZONTAL Controls

VOLTS/DIV	10 COLLECTOR VOLTS
POSITION	Spot at lower left corner of graticule

BASE STEP GENERATOR Controls

REPETITIVE/OFF/SINGLE FAMILY	REPETITIVE
STEPS/FAMILY	Fully counterclockwise
POLARITY	—
STEPS/SEC	120 (up)
SERIES RESISTOR	Optional
STEP SELECTOR	.2 MA PER STEP

Slope Panel Controls

Center rotary switch	EMITTER GROUNDED

Connect a 1000 Ω (1% or 5%) ½-watt resistor between the B and E binding posts on the side of the sloping panel on which you plan to test the FET. This resistor develops a voltage bias for the Gate lead at 1 volt per mA base step current.

Since the leads of the FET are short, you can avoid bending them (with a chance of breakage) by building an adapter out of a spare transistor socket and wire leads to the sloping panel binding posts.

151-1004-00 FET Characteristics

Minimum zero-bias channel current (I_{dss}) is 0.5 mA at V_{dg} of 15 V. Minimum G_m is 1000 μmho at a drain current of 0.5 mA.

151-1007-00 FET Characteristics

Minimum zero-bias channel current (I_{dss}) is 1.5 mA at V_{dg} of 10 V. Minimum G_m is 1000 μmho at a drain current of 1 mA.

151-1011-00 FET Characteristics

Minimum zero-bias channel current (I_{dss}) is 2 mA at V_{dg} of 15 V. Minimum G_m is 2000 μmho at a drain current of 2 mA.

Transistor and Integrated Circuit Replacement. Transistors and ICs should not be replaced unless they are actually defective. Unnecessary replacement or switching of components may affect the calibration of the instrument. If a transistor or integrated circuit is removed during routine maintenance, be sure it is returned to its original socket.

Any replacement component should be of the original type or a direct replacement. Bend the leads to fit the socket correctly and cut off the leads the same length as the original component. Note the electrode configurations shown in Fig. 4-5.

Some of the chassis-mounted power-supply transistors use silicone grease to increase heat transfer. Replace the silicone grease when replacing these transistors.

WARNING

Silicone grease should be handled with care and should be kept away from the eyes. Wash your hands thoroughly after using it.

After any component is replaced, check the operation of that part of the circuit which may be affected.

Major Circuit and Parts Locations

The remainder of this section includes photographs of sections of the Type 3T6. Major circuit areas are identified. All components mounted on circuit boards are identified by circuit numbers. All circuit board connections are identified by pin number or color code.

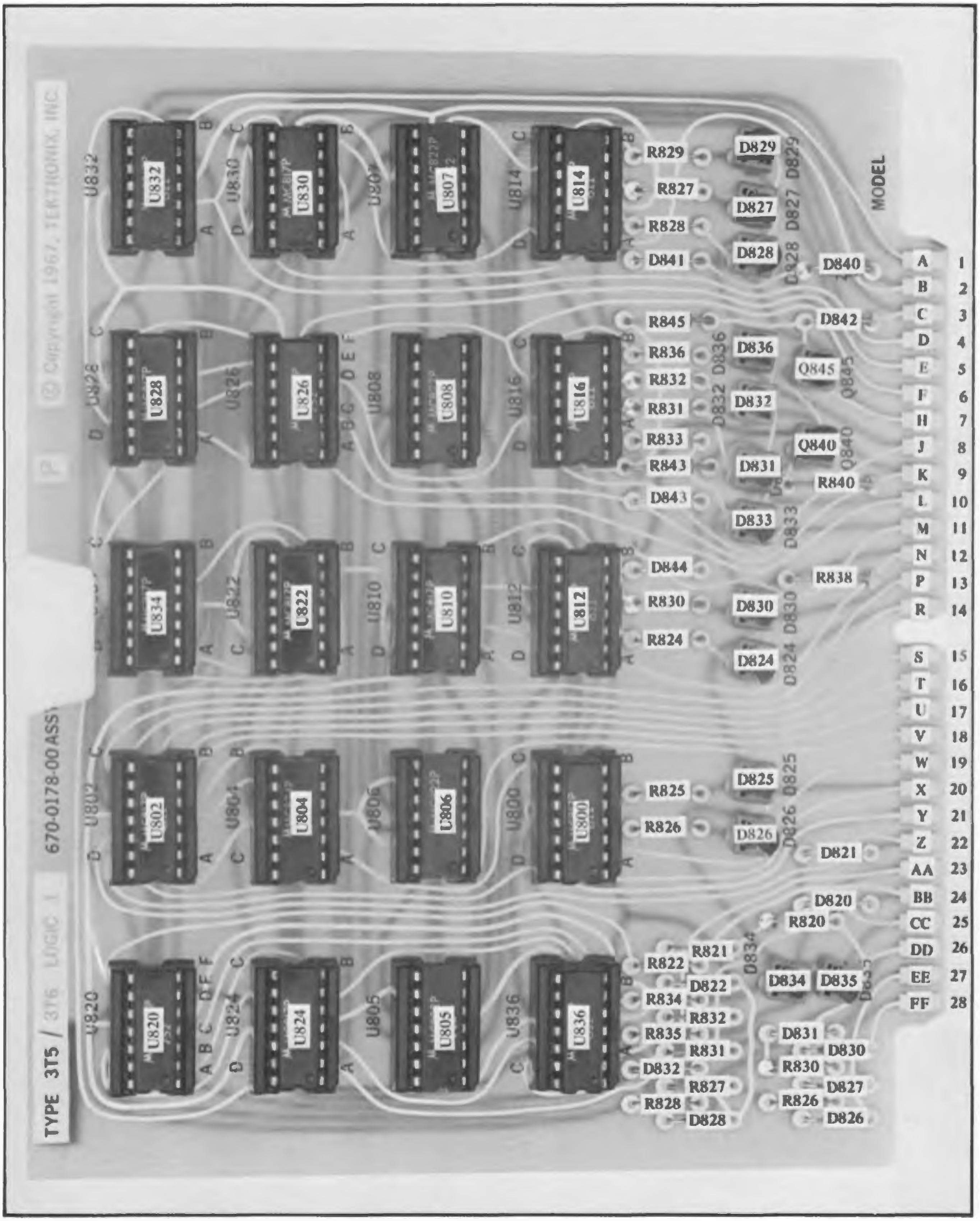


Fig. 4-6. Logic 1 circuit board assembly.

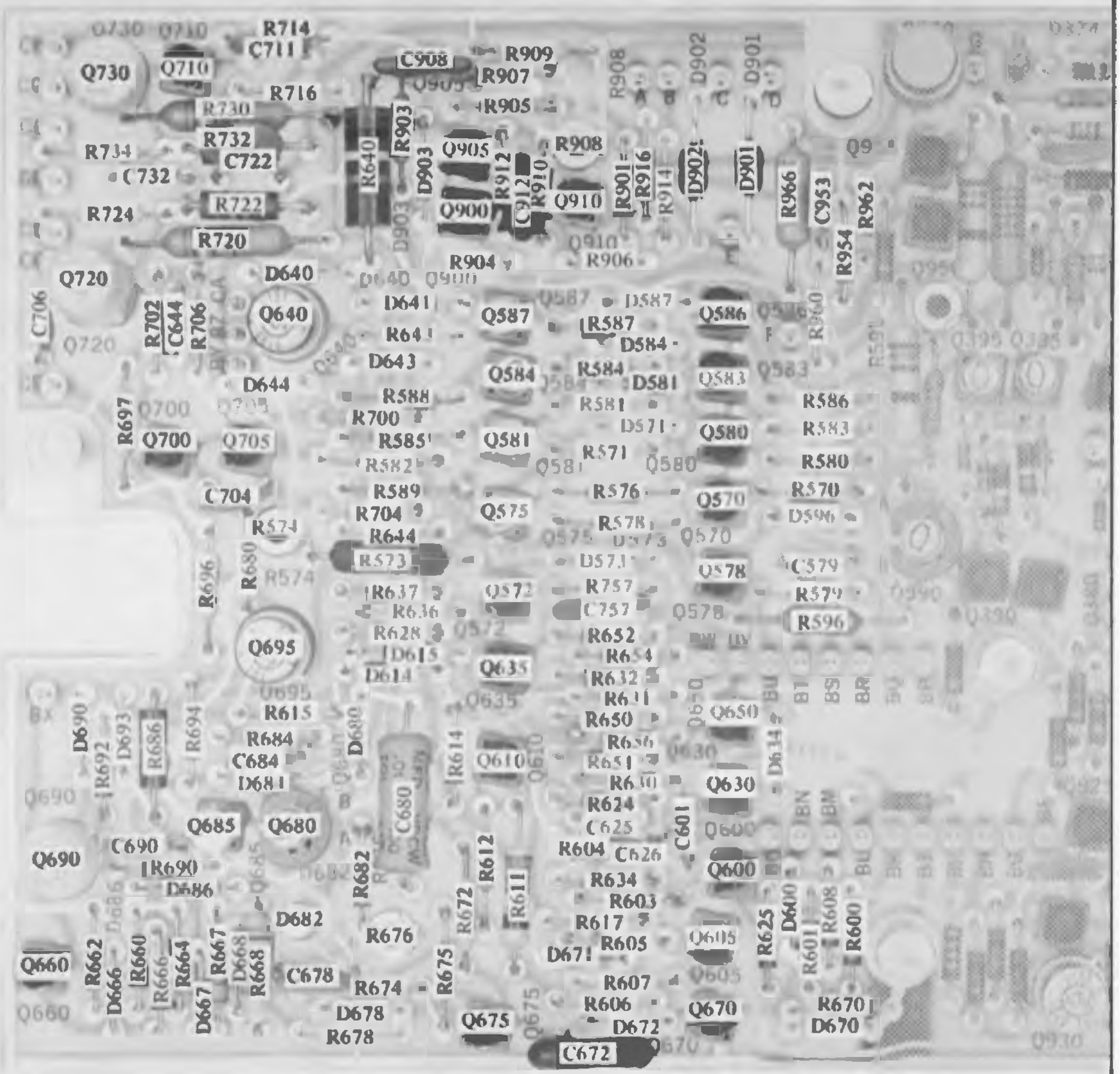


Fig. 4-7A. Display circuit board assembly, left.

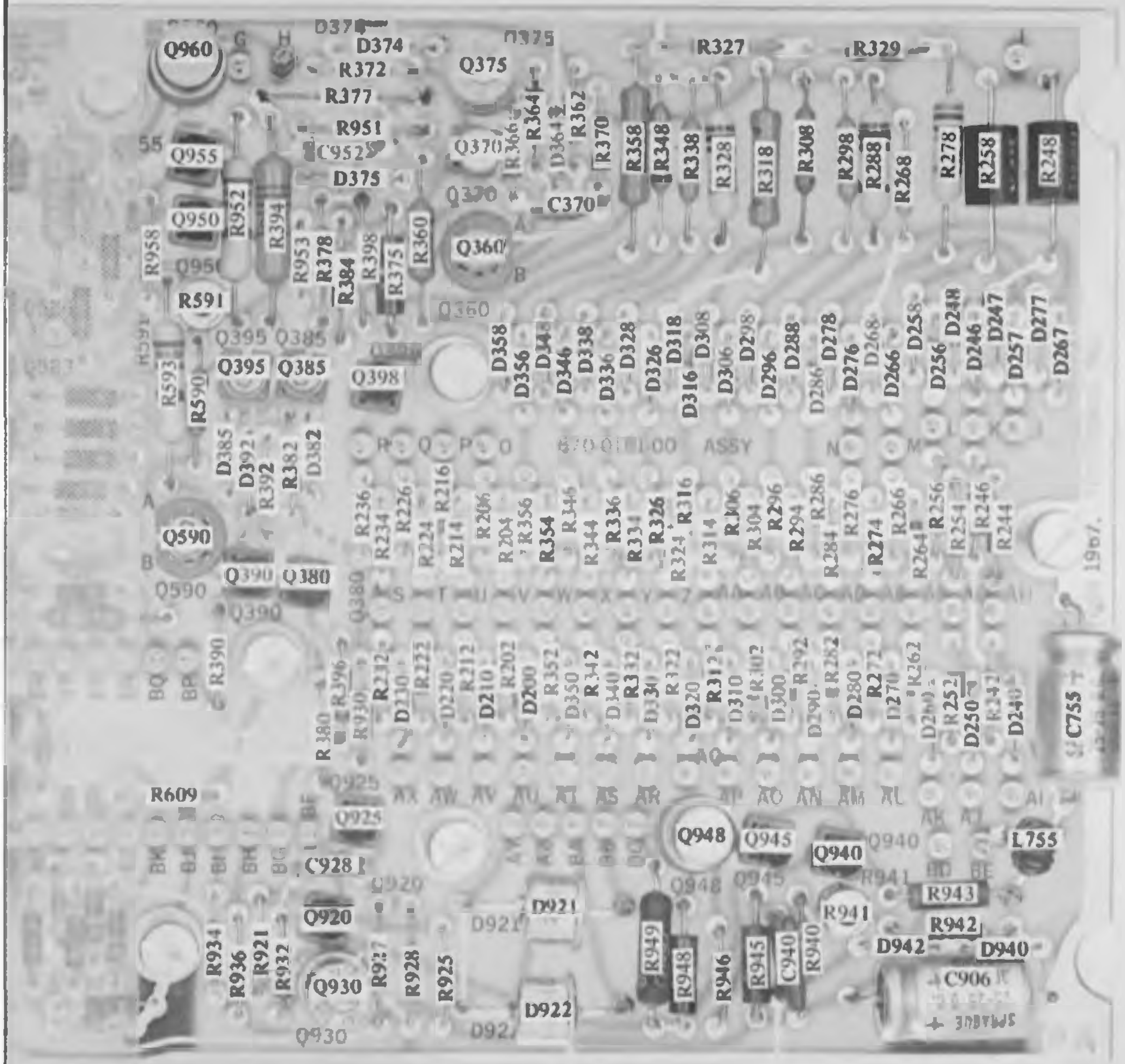


Fig. 4-7B. Display circuit board assembly right.

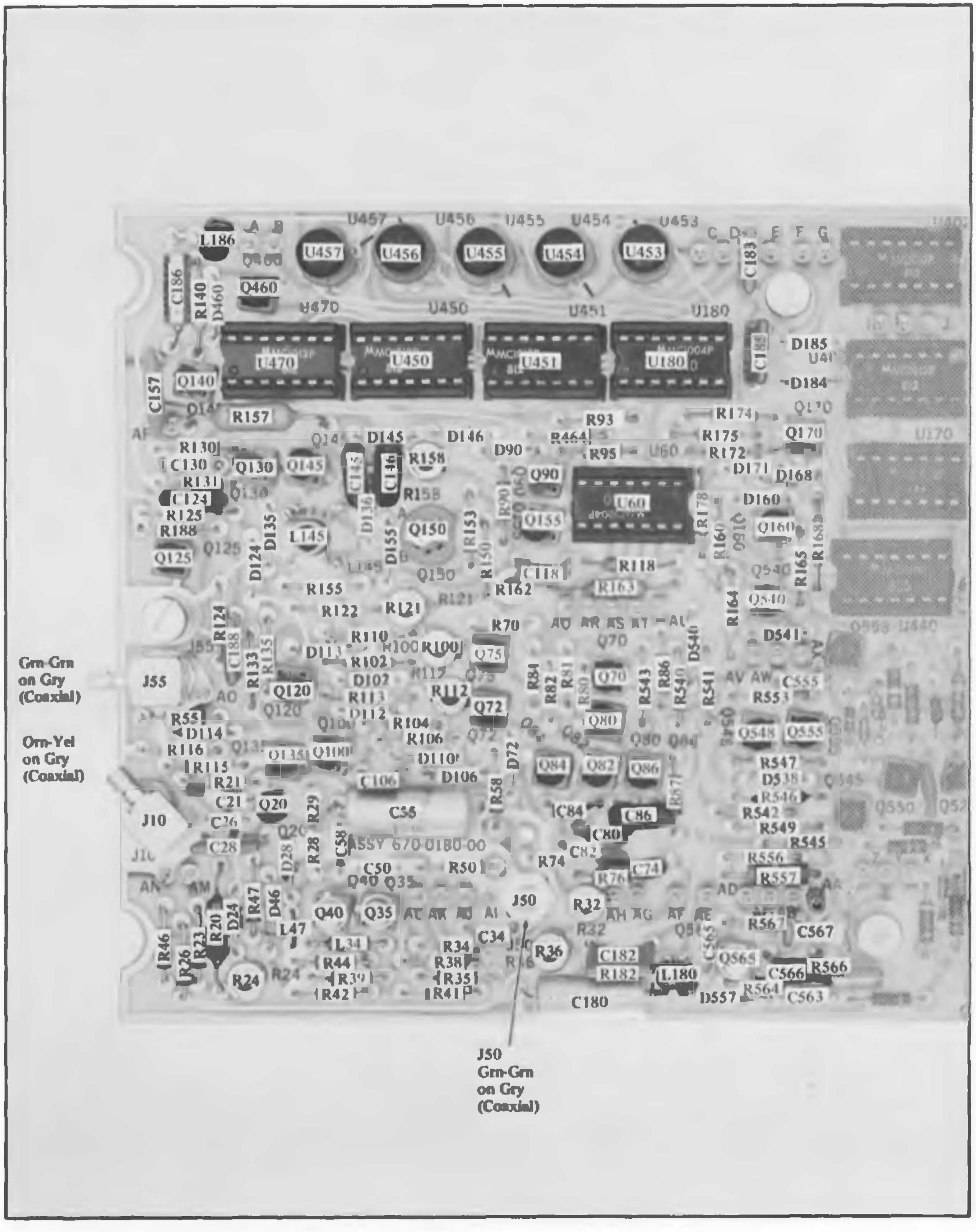


Fig. 4-8A. Timing circuit board assembly, left.

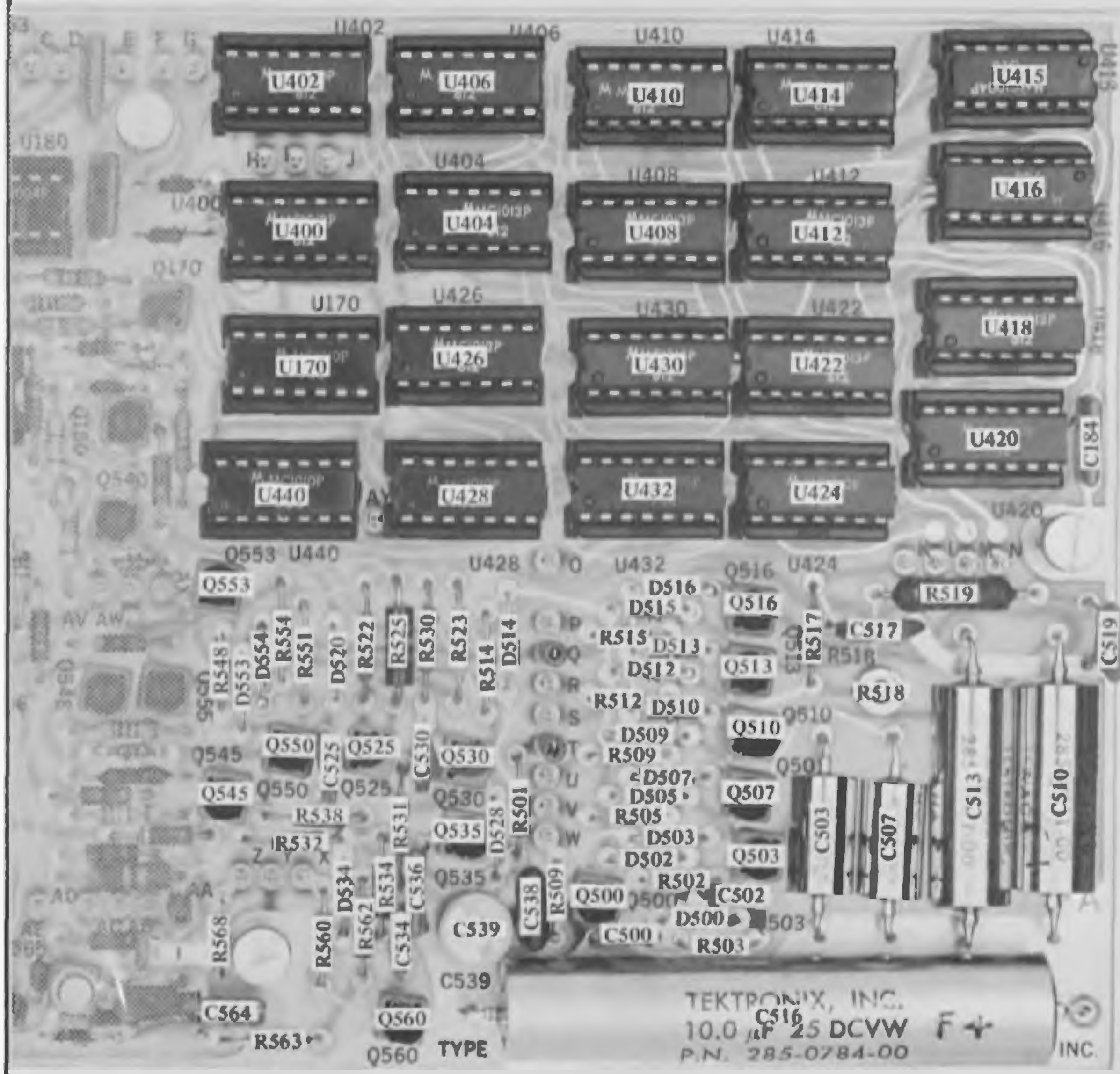


Fig. 4-8B. Timing circuit board assembly, right.

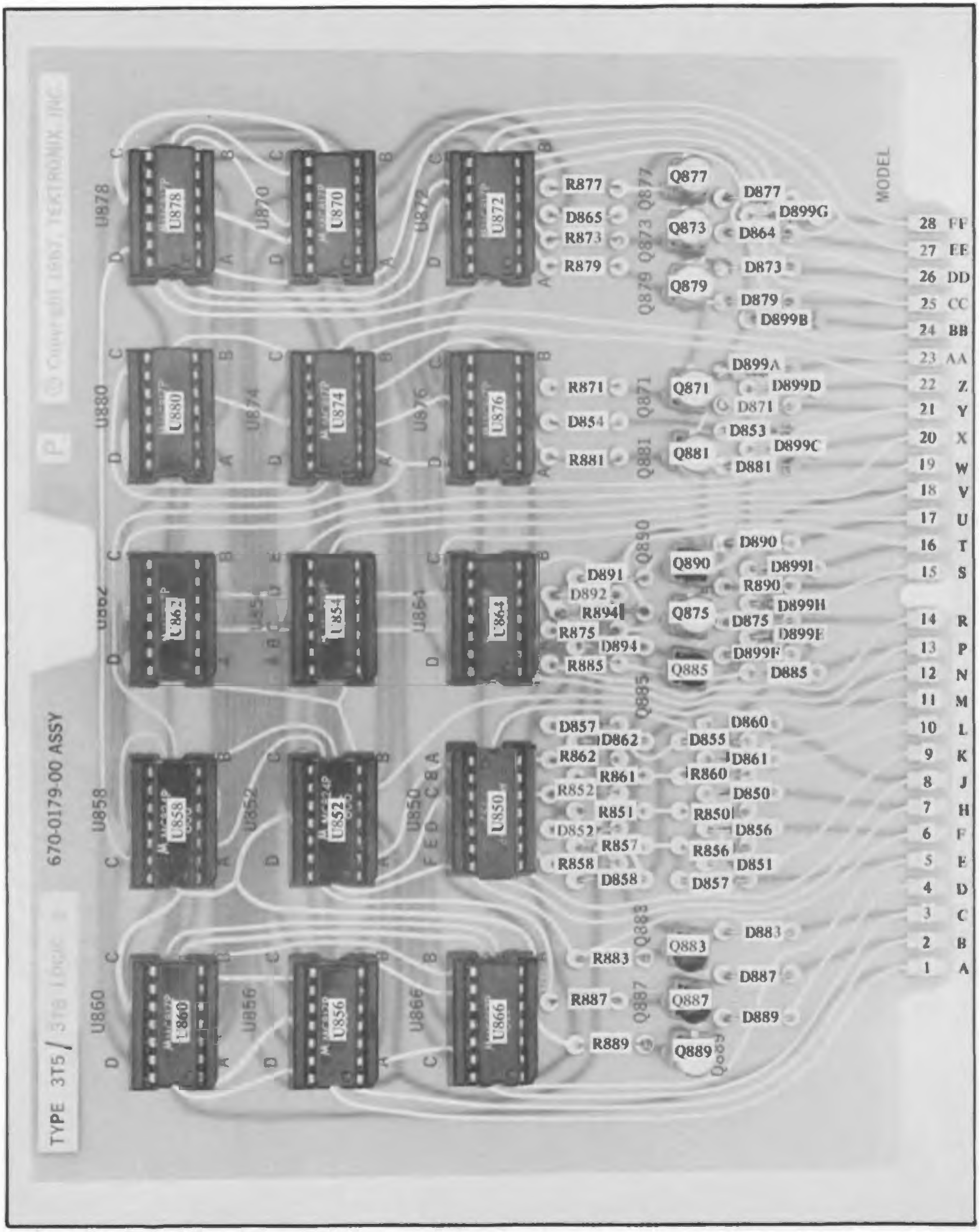


Fig. 4-9. Logic 2 circuit board assembly.

SECTION 5
PERFORMANCE CHECK/CALIBRATION

Change information, if any, affecting this section will be found at the rear of the manual.

Introduction

The following procedure may be used as a front-panel check of the instrument's performance, or as a complete calibration procedure. When only the Performance Check steps are done, the instrument is checked to the "Performance" information given in Section 1. For calibration, limits, tolerances, and waveforms are added to the procedure. Such limits and tolerances should be considered only as calibration guides for these steps, and not as instrument specifications.

The front-panel control names are written in all capital letters, and internal control names are initial capitalized.

Reference to the indicator oscilloscope is to the oscilloscope operating the Type 3T6. The test oscilloscope is the oscilloscope used for observation of internal voltages.

Performance Check steps are those identified in the Type style used in the Introduction sub-heading above. Calibration steps are headlined in the style of the next sub-heading.

Equipment Required

The equipment listed following (see Figs. 5-1 and 5-2), or its equivalent, is required for calibration or checking the performance of the Type 3T6. To ensure accuracy, all test equipment must be calibrated. If other equipment is substituted, it must meet or exceed the limits stated in the description.

1. Indicator oscilloscope in which the Type 3T6 is normally operated, such as the Type 568; equipped with the Type 3S6 Programmable Sampling Unit, with one each Sampling Heads, Type S-1 (for Internal Triggering checks) and Type S-3. Type 230 Digital Unit and one interconnecting cable, Type 230 to Type 568, Tektronix Part No. 012-0119-00, supplied with the Type 230. Interconnecting cable from Type 568 to Sampling Heads, Tektronix Part No. 012-0130-00, supplied with the Type 3S6.

2. Voltage Pickoff, VP-2, Tektronix Part No. 017-0077-01, supplied with the Type S-3, and a 50Ω termination, end-line, Type GR874-W50B, Tektronix Part No. 017-0081-00.

3. Test oscilloscope with vertical risetime of 20 ns, dual-trace, minimum deflection factor of 5 mV/div. Tektronix 540-series oscilloscope, Type 547 with Type 1A1 Dual-Trace Plug-In Unit recommended.

4. 1X probe, P6028 recommended. Tektronix Part No. 010-0074-00.

5. 10X probe, P6006 recommended. Tektronix Part No. 010-0127-00.

6. A precision, non-loading DC voltmeter with the following tolerances; ±0.1% at 20 volts, ±0.5% at 3.5 or 3.6 volts, and ±0.3% at 1.75 volts. A John Fluke Model 801B meets these requirements. The +1.75 volt adjustment requires accurate measurement of the surrounding temperature. 0° to 50° C thermometer, glass-tube Mercury Type, is recommended.

7. Time mark generator. Minimum requirements: Time-mark or sine wave period outputs from 0.5 s through 2 ns; accuracy within 0.5%; output amplitude at least .3 volt into 50 ohms. Tektronix Type 184 recommended.

8. Sine wave generator, Tektronix Type 191 Constant Amplitude Signal Generator. Output frequency variable from 20 MHz through 100 MHz, accurate within 3%; output amplitude variable from approximately 1 volt into 50 ohms.

9. Low-frequency sine wave generator (e.g. General Radio Type 1310-A). Output frequencies of 100 kHz and 30 Hz; output amplitude at least 1 volt into 50 ohms. An adapter is required with this instrument to connect a coaxial cable to its output. Tektronix Part No. 013-0076-00 (clip-lead adapter) may be used.

10. 1 GHz oscillator (e.g. General Radio Type 1361-A Oscillator with Type 1201-B Power Supply). Minimum requirements: Output frequency of 1 GHz within 3%; output amplitude of at least 2 volts into 50 ohms.

11. Signal delay, coaxial cable. Impedance, 50 ohms; delay, 60 ns; GR874 connectors. Tektronix Type 113 Delay cable recommended.

12. Pulse generator. Minimum requirements: Positive-going and negative-going pulse outputs; pulse risetime less than 1 ns; pulse duration 2 ns; repetition rate 100 kHz; pulse amplitude at least 2 volts into 50 ohms. Tektronix Type 111 recommended.

13. Pulse generator. Minimum requirements: Pulse output risetime less than 100 ps; Square wave output amplitude 1 volt, frequency 1 MHz and 10 MHz. Tektronix Type 284 recommended.

14. One 42-inch coaxial cable with BNC connectors.

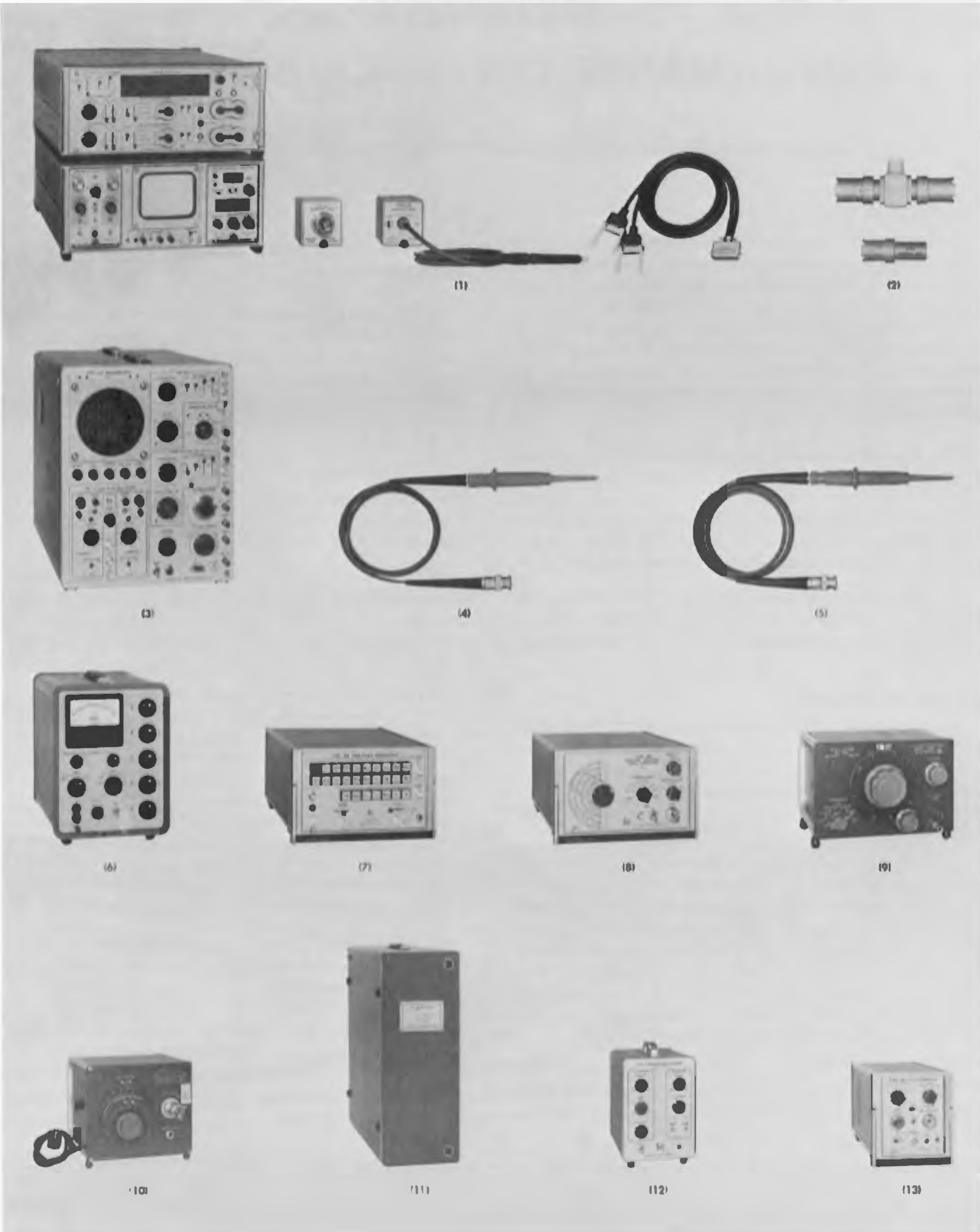


Fig. 5-1. Equipment required for Calibration or Performance Check.

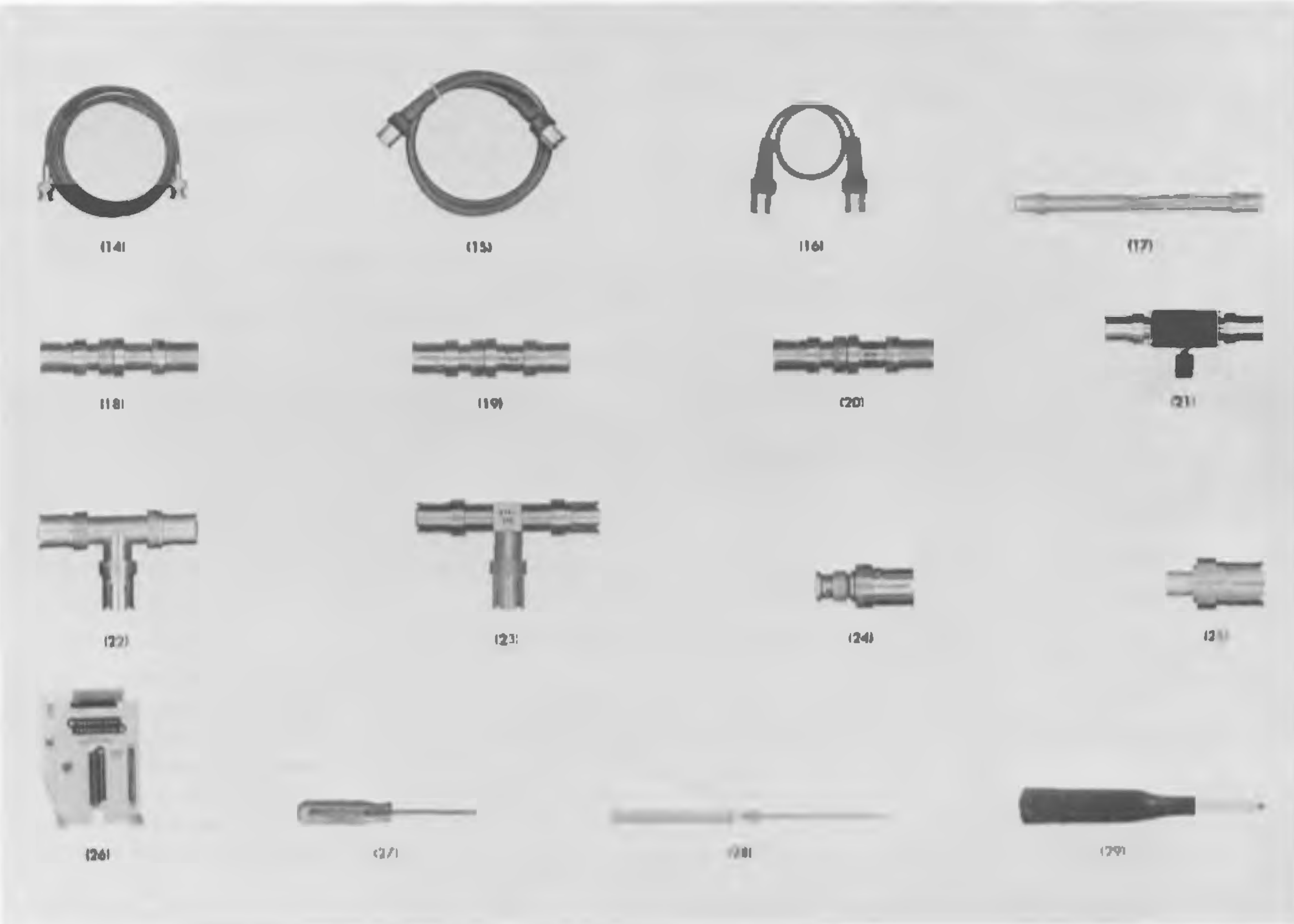


Fig. 5-2. Additional equipment required.

Characteristic impedance approximately 50 ohms. Tektronix Part No. 012-0057-01.

15. 5-ns coaxial cable, type RG213/U, with GR 50 ohm connectors. Tektronix Part No. 017-0502-00, 2 required.

16. 2-ns coaxial cable, type RG58C/U, with GR 50 ohm connectors. Tektronix Part No. 017-0505-00.

17. Air Line; 20 cm or 30 cm length, with GR874 connectors. The 20 cm Air Line is recommended. Tektronix Part No. 017-0084-00.

18. 50-ohm 10X attenuator with GR connectors. Tektronix Part No. 017-0078-00.

19. 50-ohm 5X attenuator with GR connectors. Tektronix Part No. 017-0079-00.

20. 50-ohm 2X attenuator with GR connectors. Tektronix Part No. 017-0080-00, 2 required.

21. Variable attenuator with GR 50-ohm connectors. Tektronix Part No. 067-0511-00.

22. Coaxial T connector with GR 50-ohm connectors. Tektronix Part No. 017-0069-00.

23. Power Divider with GR 50-ohm connectors, 50 Ω GR TPD. Tektronix Part No. 017-0082-00.

24. BNC plug to GR connector adapter. Tektronix Part No. 017-0064-00, 2 required.

25. BNC jack to GR connector adapter. Tektronix Part No. 017-0063-00.

26. Rigid extender, for operating the Type 3T6 outside the indicator oscilloscope; Tektronix Part No. 067-0591-00. A Flexible Extension is required for the digital waveform check (Step 22). Tektronix Part No. 012-0066-00.

27. Pocket-type screwdriver. Blade width less than 1/8 inch.

28. Hexagonal wrench insert tool for inductor adjust-

ment, 5/64 inch tip. Tektronix Part No. 003-0307-00 for handle and Tektronix Part No. 003-0310-00 for insert.

29. Insulated screwdriver, 1 1/2 inch shaft, nonmetallic. Tektronix Part No. 003-0000-00.

PERFORMANCE CHECK AND CALIBRATION RECORD AND INDEX

The following abridged procedure may be used as a guide by the experienced technician for checking and/or calibrating the Type 3T6 Programmable Sampling Sweep. The abridged procedure can also be used as a maintenance record (the procedure may be reproduced without special permission of Tektronix, Inc.). The step numbers and titles are identical to those in the complete procedure.

Type 3T6 Programmable Sampling Sweep, Serial No. ____

Calibration Date ______________

Calibrated By ______________

Checked By ______________

PRELIMINARY PROCEDURE

Performance Check

Install the Type 3S6 3T6 in the right hand opening. Connect the interconnecting cable (Tektronix Part No. 012-0119-00) between J101 on the Type 568 rear panel and J101 on the rear panel of the Type 230 Digital Unit. Connect the Type 3S6 interconnecting cable (Tektronix Part No. 012-0130-00) to J113 on the Type 568 rear panel. Connect the Type S-1 to Channel A and the Type S-3 to Channel B.

Calibration Procedure

Install the Type 3S6 with S-3 Sampling Head in the left hand opening of the Type 568 Oscilloscope, and the Type 3T6 on a rigid extender, Tektronix Part No. 067-0591-00, in the right hand opening. Connect the 36-pin interconnecting cable between J101 of the Type 568 and J101 of the Type 230 Digital Unit. Connect the Type 3S6 interconnecting cable to J113 of the Type 568. Connect the Type S-3 to the Channel A cable.

Both Procedures

Make all power connections. Turn on the power to all equipment. Allow five minutes warm-up time before proceeding. Set the controls as follows:

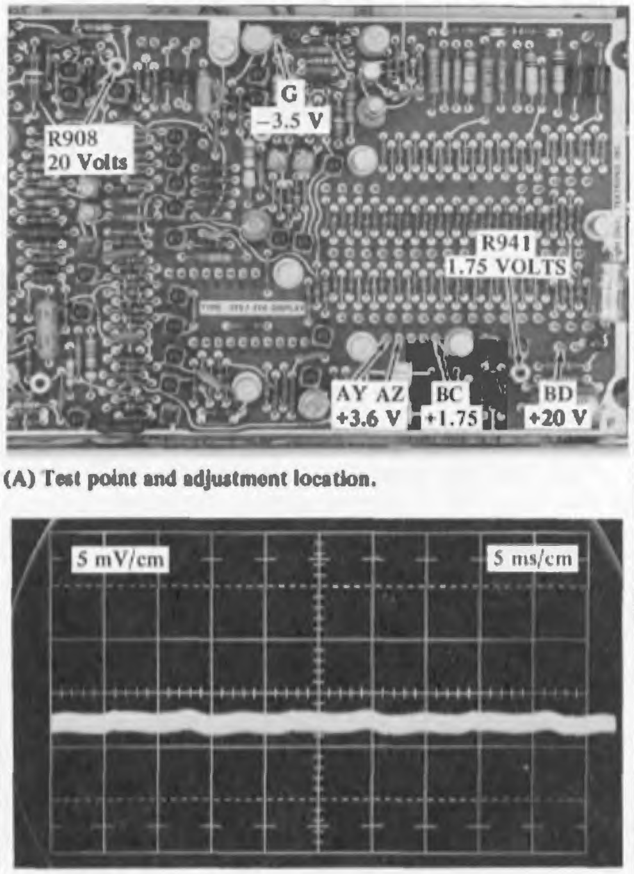
NOTE

If both procedures are performed at the same time, the Type 3T6 must be installed in the oscilloscope for all Performance Check steps.

Control Settings:

Type 3T6

HORIZ POS	Midrange
HORIZ GAIN	As set
SAMPLES/SWEEP	1000
TIME/DIV	
DECADE	6 μs/div
MULTIPLIER	1
DELAY	0000
PROGRAM SELECTOR	INT
TRIGGER	
SENSITIVITY	Fully clockwise
RECOVERY TIME	Midrange
MODE	EXT
POLARITY	+



(A) Test point and adjustment location.

(B) Typical display of ripple.

Fig. 5-3. Power supply checks.

Type 3S6

Mode Switch	CH B
Units/Div	100
Variable	Cal
Invert	Pushed in (both channels) (Normal)
DC Offset	0

Type S-3

Offset	X1

1. Check and Adjust Power Supplies, R908 and R941

a. Refer to Fig. 5-3 to locate the power supply test points and the adjustments for +20 Volts and +1.75 Volts. Locations are on the Display circuit board, instrument left side.

b. Use a precision voltmeter to measure the voltage at each test point in succession. Set the TRIGGER SENSITIVITY control fully counterclockwise. Check the ripple on the test oscilloscope with the 1X probe.

c. CHECK—Power supplies within tolerance listed as follows

Voltage	Tolerance	Ripple
+1.75 V (environment at +25° C ±3° C)	±3%, ±0.0525 V	3 mV
+3.6 V	±5%, ±0.180 V	3 mV
+20 V	±1%, ±0.2 V	3 mV
−3.5 V	±5%, ±0.175 V	3 mV

NOTE

Power supply voltage and ripple tolerances are guides to correct instrument operation, not instrument performance requirements. Actual values may exceed listed tolerances with no loss in measurement accuracy, if the instrument meets the performance requirements in Section 1 as tested in this procedure.

d. ADJUST +20 Volts control, R908, for +20 volts if part c showed the +20 volt supply out of tolerance. Check that the ambient temperature is 25° C ±3° C, then adjust the +1.75 Volt control, R941, if the 1.75 volt supply was more than ±3% out of tolerance.

NOTE

The ambient temperature of the air near the +1.75 V supply with the Type 3T6 on the extender may differ from 25° C by more than 3°. The +1.75 V supply, with a temperature coefficient of −4 mV/° C, can be adjusted despite a few-degree difference from the required 25° C ambient (see Fig. 5-4). For example, at an ambient temperature of 30° C, 5° above 25° C, determine the proper setting of the +1.75 V supply as follows:

(+5° C) (−4 mV/° C = −20 mV = .020 V

1.750 V − .020 V = 1.73 V, the proper setting.

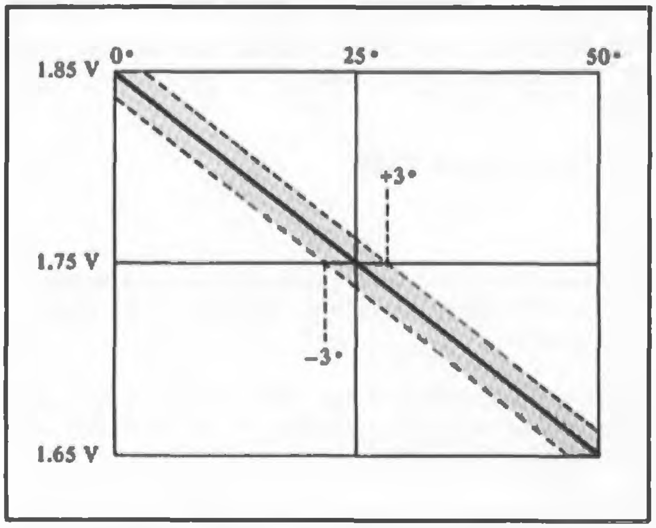


Fig. 5-4. Proper adjustment of +1.75 Volts per degree Centigrade of ambient temperature deviation.

2. Set Horizontal Gain

Requirement—Horizontal gain must match the oscilloscope deflection factor.

a. Apply 1 μs time markers from the time mark generator through a GR to BNC adapter, a 5X attenuator, GR874-T connector and VP-2 with GR874 W50B termination to the Type S-3 probe. Connect a GR to BNC adapter to the T connector and a coaxial cable from the adapter to the Type 568 rear panel connector, J123.

b. Set the DELAY to 0150 ns or more and set the SENSITIVITY control for a stable display.

c. Adjust the HORIZ GAIN control for 1 time mark per division on the CRT; see Fig. 5-5.

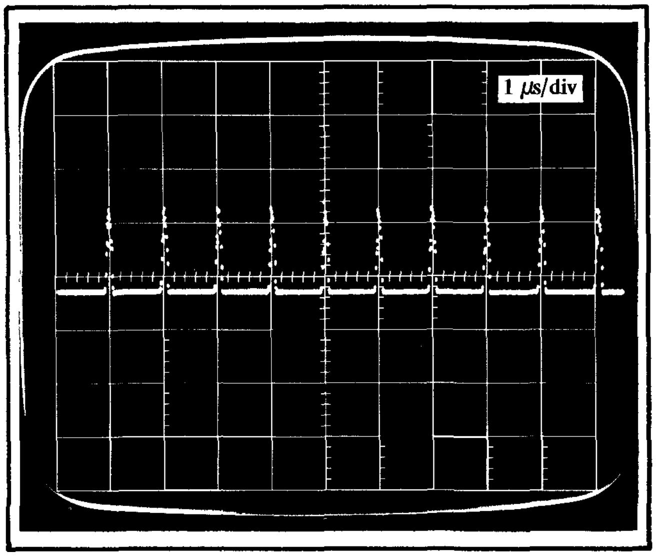


Fig. 5-5. CRT display for setting HORIZ GAIN control.

d. Disconnect the entire hook-up between the time mark generator, sampling head, and Type 568 J123 connector.

3. Check Trigger Jitter

NOTE

Trigger jitter is defined as the horizontal width of the trace when 5% of the dots on each side of the trace are ignored.

Requirement—200 ps or less time jitter on 30 MHz sine waves at peak to peak amplitudes of 1 V INT, 100 mV EXT, 300 mV EXT AUTO;

50 ps or less time jitter on 1 GHz sine waves, peak to peak, 100 mV EXT SYNC;

30 ps or less time jitter on 2 ns wide pulses (500 mV INT, 50 mV EXT, 300 mV EXT AUTO).

Switch the Type 3S6 Mode switch to CH A. Switch the Type 3T6 TRIGGER MODE switch to INT.

NOTE

The Type S-1 Sampling Head is required to check the Internal Triggering (parts a-1 through a-6 and c-1 through c-7).

a. Check Trigger jitter on 30 MHz Sine Wave

a-1. Connect the Type 191 to the Type S-1 with a 5 ns coaxial cable.

a-2. Set the sampling unit Units/Div switch to 200 and the Type 3T6 TIME/DIV to 10 ns (DECADE switch to 8). Set the Type 191 for an output signal of 30 MHz and the amplitude for 5 divisions of display (1 volt; see Fig. 5-6A).

a-3. Obtain a stable display with the SENSITIVITY control set clockwise into free-run operation. Center the display with the DC Offset control.

a-4. Set the TIME/DIV to 100 ps (DECADE switch to 0) and center the rising portion of the display with the DELAY switch. Do not use more than 99.9 ns delay. See Fig. 5-6B.

a-5. Set the Units/Div switch to 5 and re-center the display with the DC Offset control. Readjust SENSITIVITY and RECOVER TIME controls for a stable display.

a-6. Check that the trigger jitter is not greater than 2 divisions (200 ps). See Fig. 5-6C.

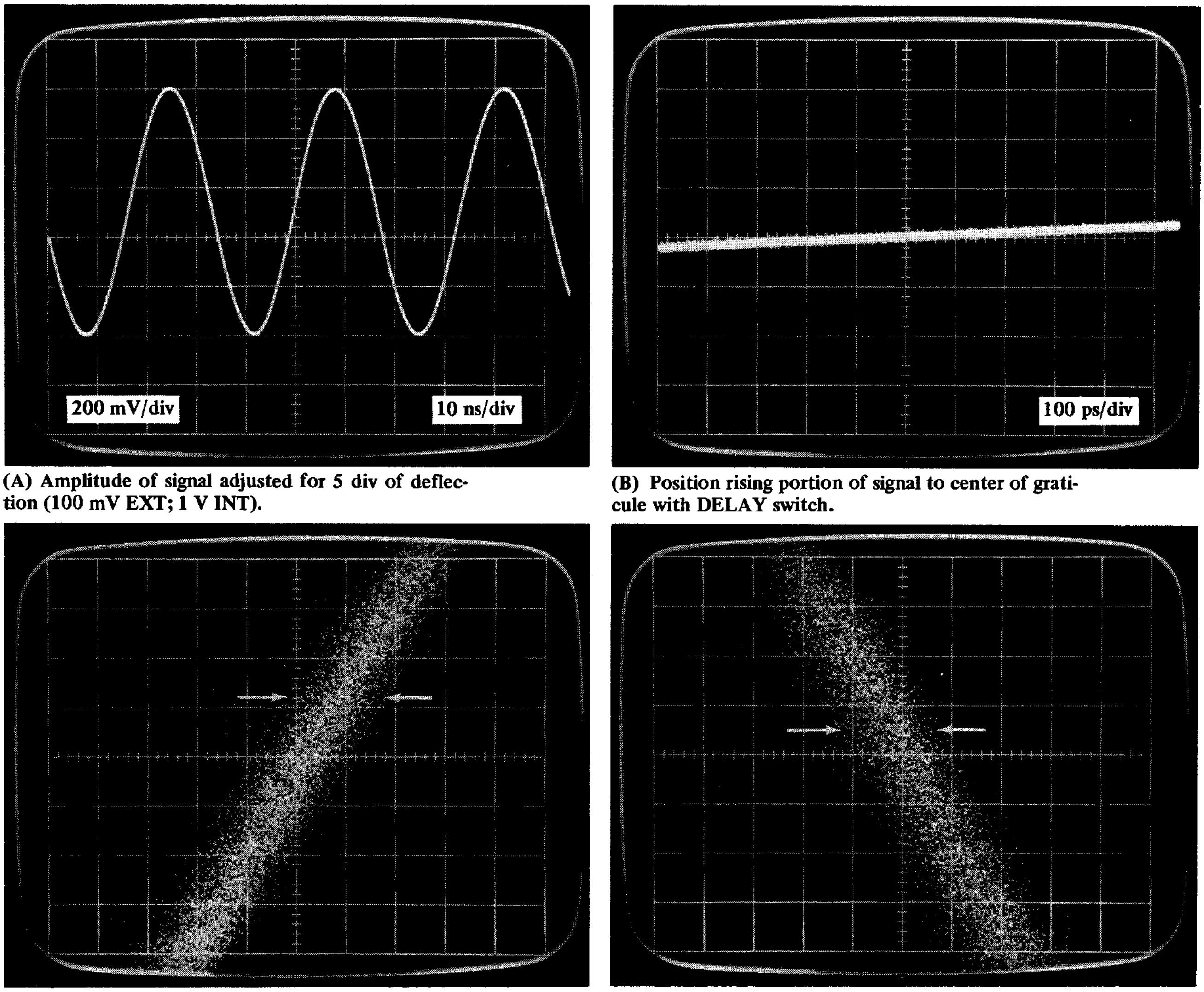
a-7. Disconnect the Type S-1 at the Type 191 Output connector and replace with a GR874 T connector. Connect one side of the T connector to the Type 568 rear panel J123 connector through a 2 ns coaxial cable, a 10X attenuator and a GR to BNC adapter. Connect the T connector to the VP-2 with GR874 W50B termination and to the Type S-3 probe. Switch the Type 3S6 mode to CH B. Set the amplitude as in part a-2.

a-8. Change the MODE switch to EXT and again check that the jitter is within 200 ps. Use the method described in parts a-3 through a-5.

a-9. Set the POLARITY switch to − and check that jitter is not greater than 200 ps, see Fig. 5-6D. Set the SENSITIVITY, RECOVERY TIME, and DELAY as needed.

a-10. Set the POLARITY switch to + and check that jitter is less than 200 ps.

a-11. Set the Type 3T6 TIME/DIV to 1 μs (DECADE



(A) Amplitude of signal adjusted for 5 div of deflection (100 mV EXT; 1 V INT).

(B) Position rising portion of signal to center of graticule with DELAY switch.

(C) Trigger jitter should be 2 div (200 ps) or less, INT + or EXT +.

(D) Trigger jitter should be 2 div or less (200 ps), INT – or EXT –.

Fig. 5-6. Typical displays for checking 30 MHz jitter.

switch to 6), the Units/Div switch to 100 and remove the 10X attenuator from the signal path to J123.

a-12. Set the Type 191 amplitude for a CRT display of 3 divisions of 30 MHz signal (300 mV peak to peak).

a-13. Set the MODE switch to EXT AUTO for a stable display.

a-14. Set the Units/Div switch to 2 the Type 3T6 TIME/DIV to 100 ps (DECADE switch to 0) and re-center the display with the DELAY switch and DC Offset control.

a-15. Check that the trigger jitter is not greater than 2 divisions (200 ps).

a-16. Change the POLARITY to – and check that trigger jitter is not greater than 2 divisions (200 ps).

a-17. Disconnect the GR874-T connector from the Type 191.

b. Check Trigger Jitter on 1 GHz Sine Wave

b-1. Set the Units/Div switch to 100. Set the Type 3T6 TIME/DIV to 200 ps (MULTIPLIER switch to 2) and the MODE switch to EXT.

b-2. Connect the 1-GHz Oscillator to the variable attenuator, 5 ns coaxial cable, 2X attenuator and GR874 TPD power divider. Connect one side of the TPD divider to the S-3 probe through a VP-2 with GP874 W50B termination and connect the other side of the TPD divider to a 5X attenuator, a 2 ns coaxial cable and a GR to BNC adapter to the EXT TRIGGER INPUT connector.

b-3. Set the variable attenuator for a CRT display amplitude of 3.5 divisions.

b-4. Set the RECOVERY TIME control to the SYNC position and obtain a stable display with the TRIGGER SENSITIVITY control.

b-5. Set the Type 3T6 TIME/DIV to 100 ps (MULTIPLIER switch to (1) and use the DELAY switch to center the rising portion of the sine wave.

b-6. Set the Units/Div switch to 10 and use the DC Offset control to center the rising portion of the signal.

b-7. Check that the trigger jitter is not more than 50 ps (0.5 divisions). (Set the POLARITY switch to –, and check for best synchronizing.)

b-8. Disconnect the signal cable from the oscillator.

c. Check Trigger Jitter on 2 ns ± Pulse

c-1. Set the Type 3T6 MODE switch to INT and the POLARITY switch to +. Set the TIME/DIV to 1 ns (DECADE switch to 9).

c-2. Set the sampling unit Units/Div switch to 100.

c-3. Connect the Pulse Generator, set for 100 kHz and + Output, through a 2X attenuator, variable attenuator, 2X attenuator, and GR874 TPD power divider.

Connect one side of the TPD divider to the Type 113 Delay Cable through a 5 ns cable.

Connect the other side of the TPD divider to a 10X attenuator, a 2 ns cable and a GR to BNC adapter to J123.

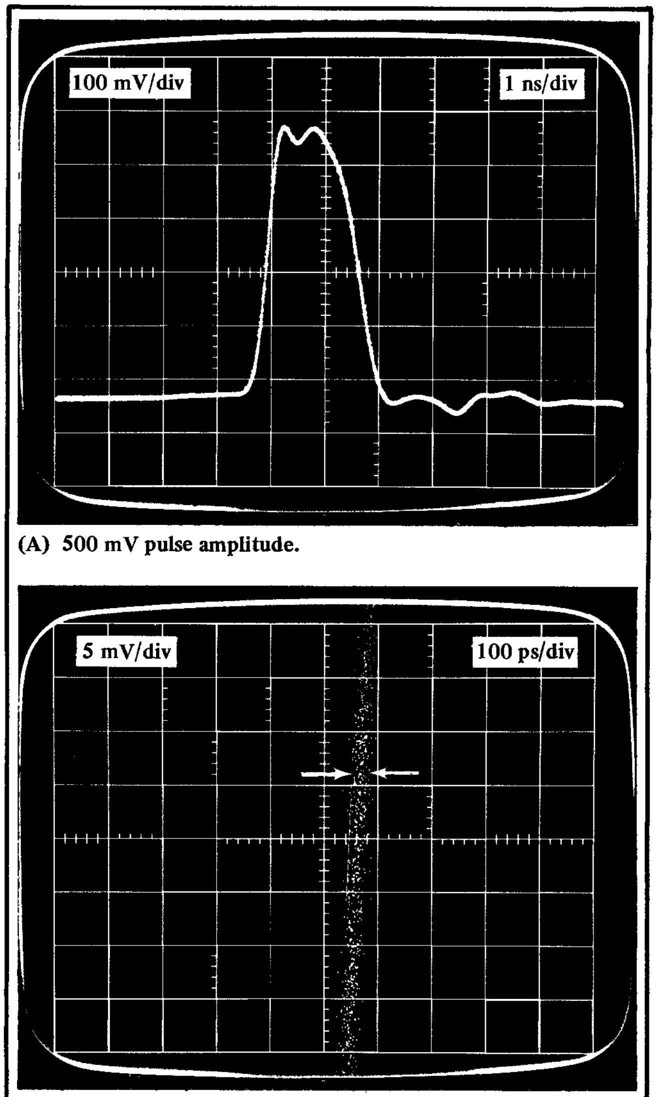
Connect a 5 ns coaxial cable from the Delay Cable to the Type S-1 Sampling Head.

c-4. Center the 2 ns pulse with the DELAY switch. Set the SENSITIVITY control for a stable display and set the variable attenuator for a display amplitude of 5 divisions (see Fig. 5-7A).

c-5. Set the Type 3T6 TIME/DIV to 100 ps (DECADE switch to 0) and use the DELAY switch to set the rising portion of the pulse at the center of the graticule.

c-6. Set the sampling unit Units/Div switch to 10 and use the DC Offset control to center the rising portion of the pulse on the graticule.

c-7. Check for 30 ps or less of time jitter (0.3 division).



(A) 500 mV pulse amplitude.

(B) Time jitter 30 ps or less.

Fig. 5-7. Typical displays of 2 ns pulse trigger jitter.

c-8. Connect the 5 ns coaxial cable from the Delay Cable to the VP-2 with GR874 W50B termination, to the Type S-3 probe.

Set the amplitude as in part c-4. Change the MODE switch to EXT and then repeat parts c-5 and c-6. Check that the jitter is less than 30 ps.

c-9. Set the Type 3T6 TIME/DIV to 1 ns (DECADE switch to 9), the sampling unit Units/Div switch to 100 and set the variable attenuator for a display amplitude of 3 divisions.

c-10. Remove the 10X attenuator from the TPD divider and connect the 2 ns coaxial cable to the TPD divider (no attenuator in the external trigger input, J123, signal path).

c-11. Set the Type 3T6 TIME/DIV switch to 100 ps (DECADE switch to 0), the MODE switch to EXT AUTO and use the DELAY switch to set the rising portion of the pulse at the center of the graticule.

c-12. Set the sampling unit Units/Div switch to 5 and use the DC Offset control to center the rising portion of the pulse on the graticule.

c-13. Check for 30 ps or less of time jitter.

NOTE

The Type 3S6 Dot Response control may require adjustment.

4. Check Triggering

Requirements—The Type 3T6 must trigger satisfactorily on the signals listed when operated in the various modes as follows: External SYNC, frequency range of 100 MHz to 1 GHz with an amplitude range of 10 mV to 500 mV peak to peak.

External sine wave, frequency range of 1 Hz to 100 MHz with an amplitude range of 10 mV to 500 mV peak to peak.

External pulse, frequency range of DC to 100 MHz with an amplitude range of 5 mV to 250 mV.

Internal sine wave, frequency range of 100 kHz to 100 MHz with an amplitude range of 100 mV to 2 V peak to peak.

Internal pulse, frequency range of 1 Hz to 100 MHz with an amplitude range of 100 mV to 2 V.

External Auto, frequency range of DC to 100 MHz with a peak input voltage from 100 mV to 500 mV.

NOTE

The voltages shown for the amplitude ranges give the lowest amplitude of voltage that can be expected to produce a triggered display, and the highest amplitude of trigger signal at which the TRIGGER SENSITIVITY control, when fully counterclockwise, can stop triggering of the sweep. Attempting to set the TRIGGER SENSITIVITY control too far clockwise for trigger signals with amplitudes below the range of the TRIGGER SENSITIVITY control may result in serious trigger jitter or turning the control into the free run region. For signals with amplitudes above the listed ranges, satisfactory triggering can be obtained for most waveforms at amplitudes up to the maximum permitted. See Section 1 for maximum trigger voltage.

The Type S-1 or S-2 Sampling Head is required to check the Internal triggering.

a. Connect the Type 191 to the GR874 T connector through a 5 ns coaxial cable; connect one side of the T connector to the Type S-1 Sampling Head and the other side of the T connector to J123 through a 10X attenuator, a 2 ns coaxial cable and a GR to BNC adapter.

b. Set the sampling unit Units/Div switch to 20 and set the Type 3T6 DELAY switch to 15 ns, the TIME/DIV to 10 ns (DECADE switch to 8), and the TRIGGER MODE switch to INT.

c. Set the Type 191 for an output signal of 100 MHz and 100 mV (5 divisions of display) and check that a stable display is obtained with adjustment of the SENSITIVITY and RECOVERY TIME controls.

d. Set the TRIGGER MODE switch to EXT and check that a stable display is obtained with adjustment of the SENSITIVITY and RECOVERY TIME controls. Remove the 10X attenuator from the external trigger input signal path, for part e, and set the sampling unit Units/Div switch to 100. Set the Sinewave amplitude for 500 mV (5 divisions). (When using the Type S-3 probe for External triggering checks; use with the VP-2 and GR874 W50B termination.)

e. Set the SENSITIVITY control fully counterclockwise and check that no display is obtained.

f. Re-install the 10X attenuator in the external trigger input signal path.

g. Set the RECOVERY TIME control at the SYNC position.

h. Check that a stable display is obtained with adjustment of the SENSITIVITY control and that the display will not shut off at any SENSITIVITY setting.

i. Turn the RECOVERY TIME control out of the SYNC position. Set the sampling unit Units/Div switch to 50 and adjust the Type 191 amplitude for 200 mV (4 divisions). Remove the 10X attenuator from the T connector and connect the 2 ns coaxial cable.

j. Set the TRIGGER MODE to EXT AUTO and scan the Type 191 frequencies from 100 MHz to 20 MHz.

k. Check that the display is triggered at all frequencies.

l. Replace the 10X attenuator between the T connector and the 2 ns coaxial cable to J123. Remove the 5 ns coaxial cable with the GR874 T connector from the Type 191 and connect it to the low frequency oscillator.

m. Set the sampling unit Units/Div switch to 20, the Type 3T6 TIME/DIV to 10 μs (DECADE switch to 5) and the TRIGGER MODE switch to INT.

n. Set the low frequency oscillator for 100 kHz and 100 mV amplitude (5 division display).

o. Check that a stable display is obtained with adjustment of the SENSITIVITY and RECOVERY TIME controls.

p. Set the low frequency oscillator to 30 Hz. Set the Type 3T6 TIME/DIV to 500 ms (DECADE switch to 1 and the MULTIPLIER switch to 5) and adjust the amplitude to 100 mV (5 divisions).

q. Set the Type 3T6 TRIGGER MODE switch to EXT and check that a stable display is obtained with adjustment of the SENSITIVITY and RECOVERY TIME controls.

r. Remove the 5 ns coaxial cable with the GR874 T connector from the low frequency oscillator and connect it to the Square Wave or Sine Wave Output connector of the Type 284. Set the Type 284 Mode switch to Square Wave or Sine Wave Output, Square Wave Amplitude switch to 100 mV and the Period switch to 100 ns.

s. Set the Type 3T6 TIME/DIV to 10 ns (DECADE switch to 8 and MULTIPLIER switch to 1) and the TRIGGER MODE switch to INT.

t. Check that a stable display is obtained with adjustment of the SENSITIVITY and RECOVERY TIME controls.

u. Remove the 10X attenuator from between the GR874 T connector and the 2 ns cable, and connect the 2 ns cable directly to the GR874 T connector.

v. Set the TRIGGER MODE switch to EXT and check that a stable display is obtained with adjustment of the SENSITIVITY AND RECOVERY TIME controls.

w. Install a 2X attenuator between the 5 ns coaxial cable and Type 284 Sine Wave or Square Wave Output connector.

x. Set the sampling unit Units/Div switch to 100 and check for 5 divisions of display amplitude.

y. The 2 ns coaxial cable is connected to J123.Set the TRIGGER MODE switch to EXT and the POLARITY switch to −.

z. Check that the display is not triggered with any setting of the SENSITIVITY control. Triggering that may occur near the free-run position of the SENSITIVITY control is normal.

aa. Set the POLARITY switch to +.

ab. Check that the display will not shut off with any setting of the SENSITIVITY control.

ac. Disconnect the entire hook-up from the Type 284 Output connector.

ad. Connect the 1 GHZ oscillator through a variable attenuator to the GR874 T connector. Connect one side of the T connector to the VP-2 with GR874 W50B termination and thence to the S-3 probe. Connect the other side of the T connector to J123, the external trigger input connector through a 10X attenuator, a 2 ns coaxial cable and a GR to BNC adapter.

ae. Set the Type 3T6 TIME/DIV to 500 ps (DECADE switch to 0 and the MULTIPLIER switch to 5) and set the RECOVERY TIME control in the SYNC position.

af. Set the sampling unit Units/Div switch to 20.

ag. Set the oscillator frequency at 1 GHz and adjust the amplitude for 70 mV (3.5 divisions).

ah. Check that a stable display is obtained with adjustment of the SENSITIVITY control.

ai. Remove the 10X attenuator from the external trigger input signal path.

aj. Set the sampling unit Units/Div switch to 100 and adjust the oscillator amplitude for 350 mV (3.5 divisions).

ak. Check that a stable display is obtained with adjustment of the SENSITIVITY control.

al. Disconnect the entire hook-up from the oscillator output. Set the Type 3T6 TIME/DIV to 10 ns (DECADE switch to 8 and the MULTIPLIER switch to 1) and the RECOVERY TIME control midrange.

5. Check Trigger Sensitivity Range

Requirement—Free-run trigger circuit operation only with the SENSITIVITY control at midrange ±20%.

a. Set the SENSITIVITY control fully counterclockwise, then slowly turn it clockwise.

b. Check that the trace appears within 20° right or left of the midrange position.

6.Check Trigger Kickout

Requirement—Trigger kickout not greater than ±20 mV into 50 Ω.

a. Connect a BNC to GR adapter and 5 ns coaxial cable from J123 to the Type 113 Delay Cable and connect a 5 ns coaxial cable from the Delay Cable to a VP-2 with GR874 W50B termination to the Type S-3 probe.

b. Set the POLARITY switch to +, the MODE switch to EXT and the DELAY switch to 0000. Sweep rate is 10 ns/div.

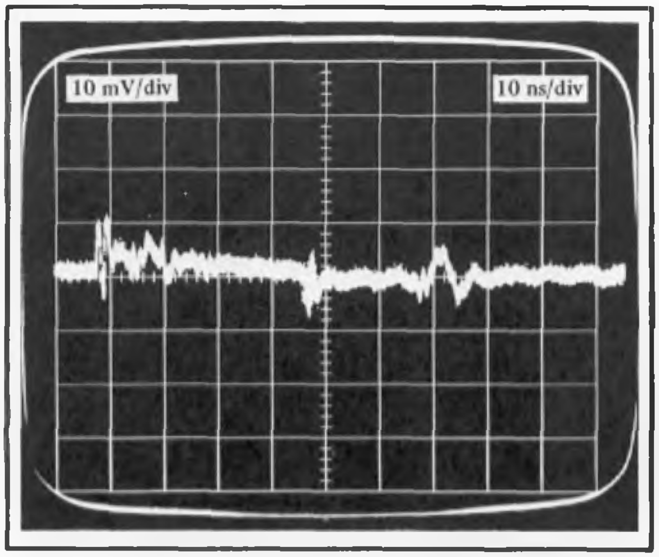


Fig. 5-8. Typical display of trigger kickout.

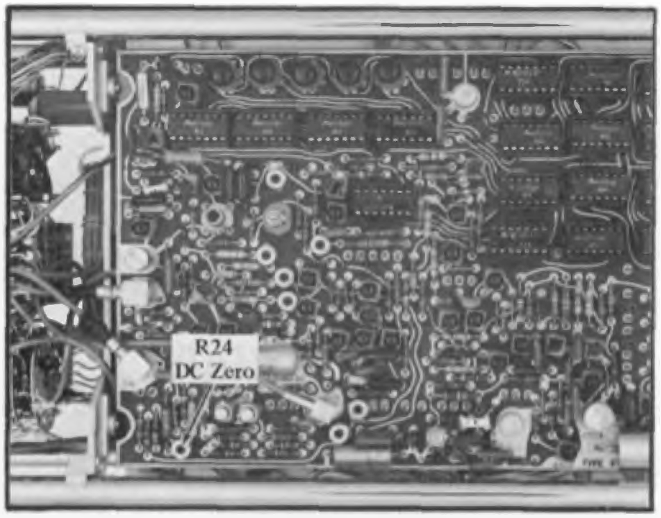


Fig. 5-9. Location of DC Zero, R24, instrument right side.

c. Set the sampling unit Units/Div switch to 10.

d. Set the SENSITIVITY control for a free-running trace and measure the amplitude of the pulse on the Indicator Oscilloscope, Fig. 5-8.

e. Check that the Trigger Kickout Pulse is ±20 mV or less.

f. Disconnect the delay cable and set the Units/Div switch to 100.

7. Adjust DC Zero, R24

a. Connect the BNC to GR adapter, 2X attenuator, VP-2 with GR 874 WOB termination from J123 to the Type S-3 probe.

b. Set the sampling unit Units/Div switch to 5 and the Type 3T6 POLARITY switch to +.

c. Change the TRIGGER MODE switch from EXT to INT and check for no trace shift on the indicator oscilloscope. If there is no trace shift, proceed to part e.

NOTE

Typically 1 mV to 3 mV trace shift may be seen. More shift may cause difficulty in the EXT AUTO TRIGGER MODE.

d. Adjust R24, DC Zero, location shown in Fig. 5-9, for no trace shift as the MODE switch is changed from EXT to INT.

e. Disconnect the entire hook-up between sampling head input and the Type 3T6 trigger input.

NOTES

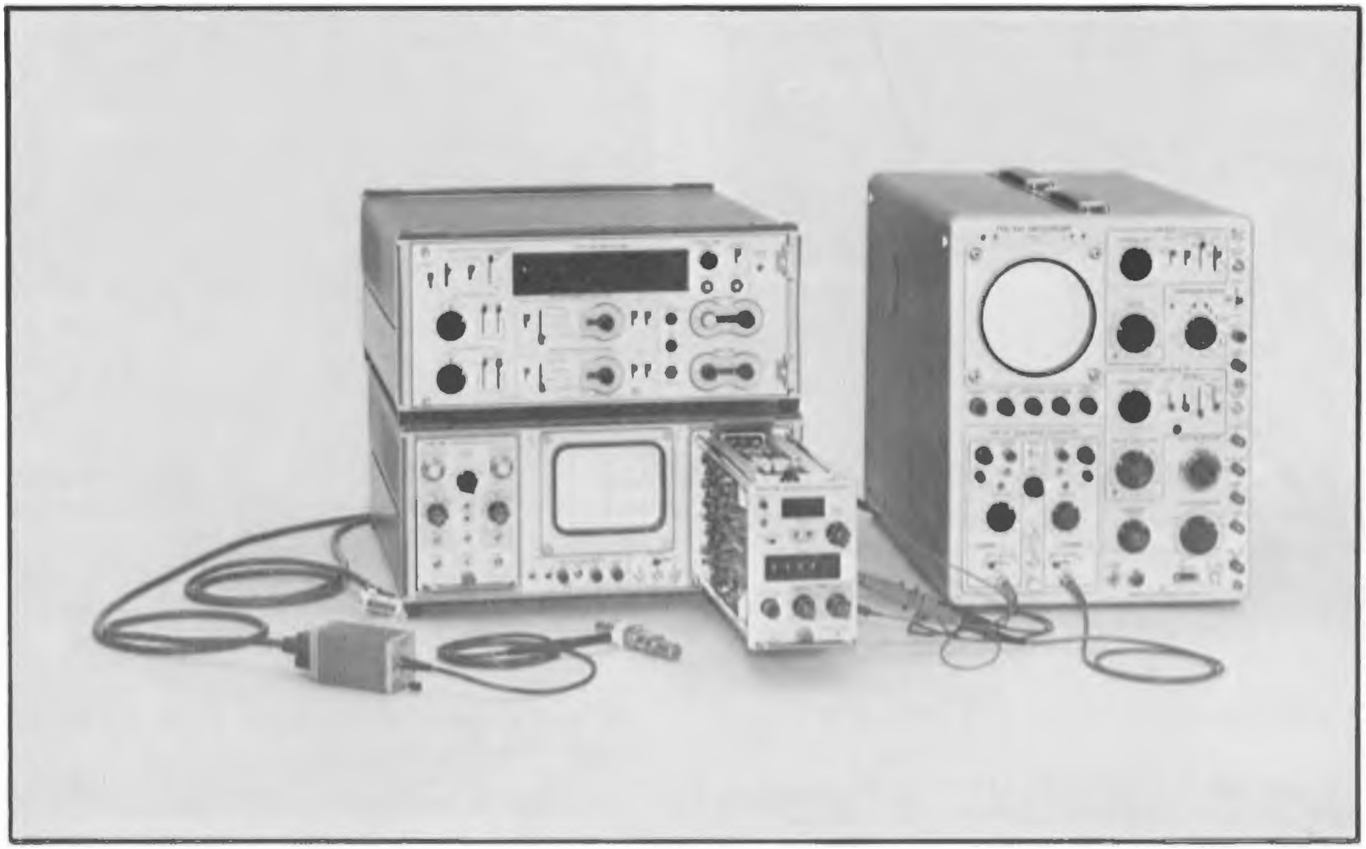


Fig. 5-10. Equipment setup for step 8.

Control Settings

Type 3T6

HORIZ POS	Midrange
HORIZ GAIN	As set
SAMPLES/SWEEP	1000
TIME/DIV	10 ns
DECADE	8
MULTIPLIER	1
DELAY	0000
PROGRAM SELECTOR	INT
Trigger	
SENSITIVITY	Fully counterclockwise
RECOVERY TIME	Midrange
MODE	INT
POLARITY	+
Sampling Unit	
Mode Switch	CH A
Units/Div	200
Variable	Cal
Invert	Pushed in (Normal)
DC Offset	0

Test Oscilloscope and Type 1A1

Time/cm	0.5 µs/cm
Triggering	Auto, Int
Input Coupling	AC
Mode	Dual Trace
Volts/cm Channel 1	.5
Volts/cm Channel 2	.05

8. Adjust Trigger Sensitivity, R112, R100 and R36

a. Use the equipment setup as shown in Fig. 5-10. Connect the Channel 1 1X probe to the Anode of D114 and the Channel 2 10X probe to the Anode of D106. Locations as shown in Fig. 5-11. Trigger the test oscilloscope on the D114 waveform.

b. Turn the SENSITIVITY control fully clockwise and check that the diodes start to switch at midrange setting and continue to switch through the fully clockwise setting. If the diodes operate correctly, proceed to part d then step 9.

c. Adjust R112, Recog TD Bias, R100, Arming TD Bias, and R36, Trig Sens Zero, as follows:

(1) Set R100 and R112 fully clockwise and set the SENSITIVITY control fully counterclockwise.

(2) Initially D106 is not switching to its high state. Turn R112, Recog TD Bias, counterclockwise and note the con-

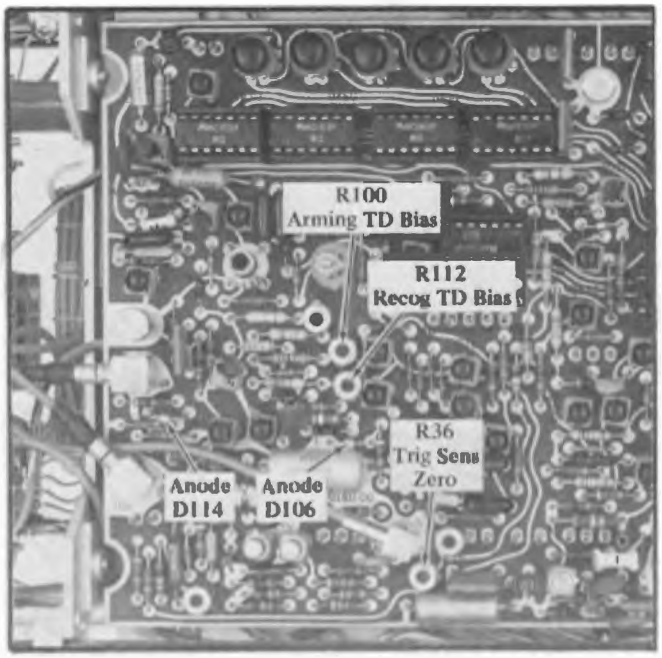


Fig. 5-11. Locations of test points and controls for step 8, instrument right side.

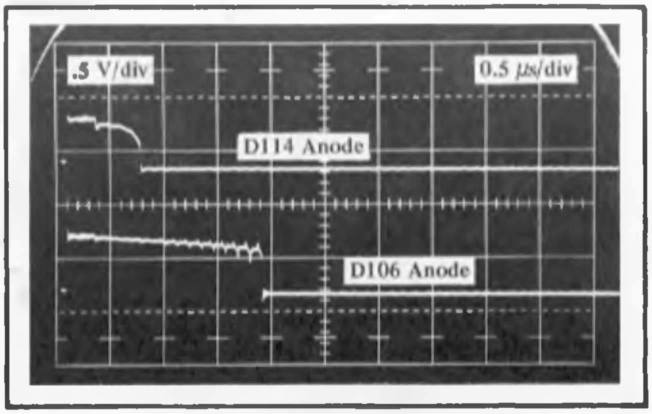


Fig. 5-12. Waveforms for trigger sensitivity adjustment.

trol position when D106 switches, continue turning R112 and note the control position when D114 does not switch.

(3) Set R112 midway between the points of D106 switching and D114 not switching. (Final adjustment of R112 should be made while externally triggering on 100 MHz for least jitter.)

(4) Turn R100, Arming TD Bias, counterclockwise and note the control position when D114 stops switching, turn the SENSITIVITY control fully clockwise, both diodes are switching, then turn R100 counterclockwise until both diodes stop switching and note the position of the control.

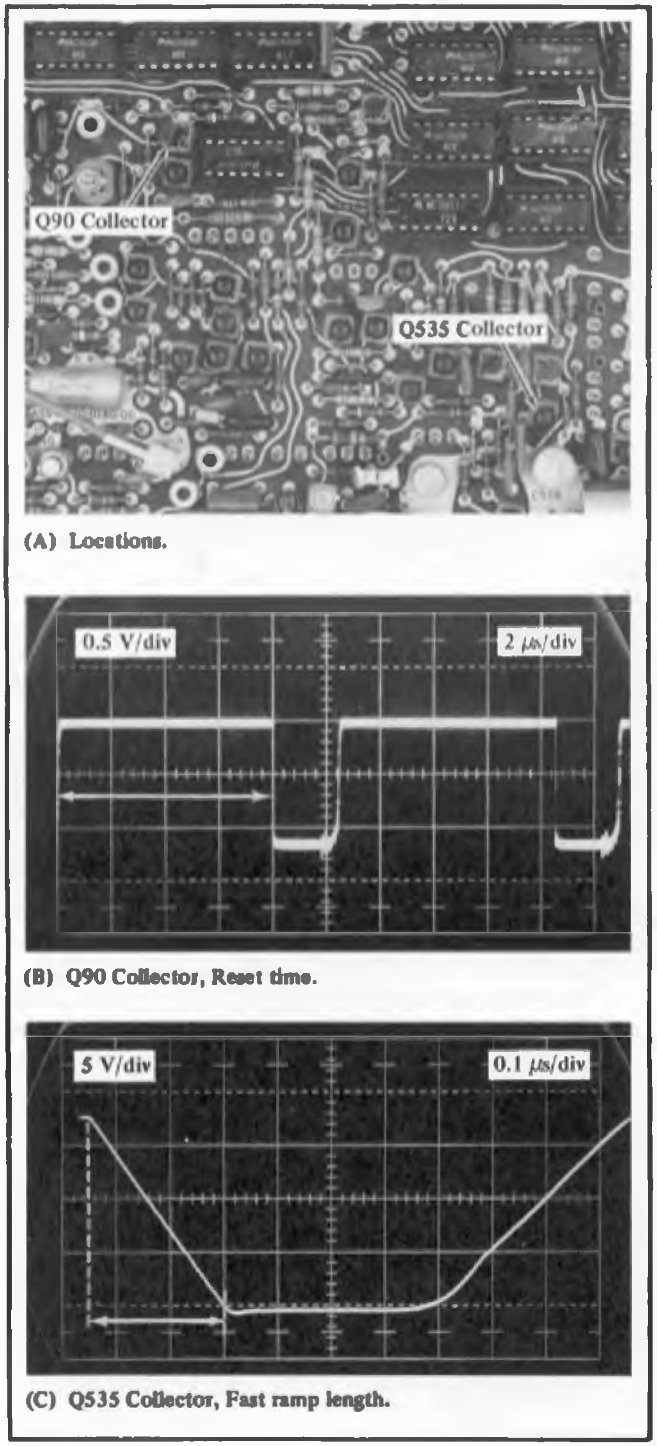
(5) Set R100 midway between the two noted settings.

(6) Set the SENSITIVITY control to midrange, dot straight up, and adjust R36, Trig Sens Zero, to start triggers.

d. Disconnect the probes from the test points.

9. Check Reset Time and Recovery Time Range

a. Set the Type 1A1 Mode switch to CH 1 and the Volts/cm switch to 05. Connect the 10X probe to the collector of Q90, at R93, location shown in Fig. 5-13.



(A) Locations.

(B) Q90 Collector, Reset time.

(C) Q535 Collector, Fast ramp length.

Fig. 5-13. Waveform and test point locations for steps 9 and 10.

b. Set both SENSITIVITY and RECOVERY TIME controls fully clockwise, the MODE switch to EXT and the TIME/DIV to 100 ps (DECADE switch to 0 and MULTIPLIER switch to 1).

c. Set the test oscilloscope Time/cm switch to 2 μs and + Trig.

d. Check the test oscilloscope display for a reset time duration of 7 μs (3.5 cm) or more. Check the reset duration for all sweep rates as listed in Table 5-1.

TABLE 5-1

TIME/DIV	Minimum Reset Time
100 ps to 10 ns	7 μs
20 ns to 100 ns	7 μs
200 ns to 1 μs	4.5 μs
2 μs to 10 μs	25 μs
20 μs to 100 μs	250 μs
200 μs to 500 μs	2.5 ms
1 ms to 500 ms	2.5 ms

e. Set the TIME/DIV to 1 μs (DECADE switch to 6 and MULTIPLIER switch to 1).

f. Set the test oscilloscope Time/cm switch to 1 μs and adjust the Variable Time/cm control to display 4 cm (4 μs) of reset duration.

g. Turn the RECOVERY TIME control fully counterclockwise and check that the test oscilloscope reset time is 5 cm (5 μs) or greater.

h. Set the test oscilloscope Variable to Cal and remove the probe.

10. Check Timing Ramp Length

a. Connect the 10X probe to Q535 Collector and set the test oscilloscope Time/cm switch to 0.1 μs and – Trig polarity.

b. Set both the SENSITIVITY and RECOVERY TIME controls fully clockwise and the TIME/DIV to 100 ps (DECADE switch to 0 and the MULTIPLIER switch to 1).

c. Check the test oscilloscope display for a ramp duration for all sweep rates as listed in Table 5-2.

TABLE 5-2

TIME/DIV	Minimum Ramp Duration
100 ps to 1 ns	210 ns
2 ns to 10 ns	210 ns
20 ns to 100 ns	1.2 μs
200 ns to 1 μs	12 μs
2 μs to 10 μs	120 μs
20 μs to 100 μs	1.2 ms
200 μs to 500 μs	12 ms

d. Disconnect the probe from Q535.

11. Check Dot Density

Requirement—SAMPLES/SWEEP at 1, dot is stationary at the sweep start. With SAMPLES/SWEEP at 1000 there must be 100 dots/div within 0.5% at 100 kHz and within 3% at 30 Hz.

a. Set the SAMPLES/SWEEP switch to 1.

b. Check that only one dot is displayed at the sweep start.

c. Set the SAMPLES/SWEEP switch to 1000 and the TIME/DIV to 1 μs (DECADE switch to 6 and the MULTIPLIER switch to 1).

d. Turn the SENSITIVITY and RECOVERY TIME controls fully clockwise for a free running trace.

e. Set the Type 230 Digital Unit as follows:

Mode	Time
Start	Horiz mm from sweep start at 10 mm
Stop	Horiz mm from sweep start at 90 mm

Other controls should be in the off position.

f. Check that the Digital Unit readout is 8.00 μs ±.04 μs, ±1 count for Type 230 count error.

g. Change the TIME/DIV to 2 μs (MULTIPLIER switch to 2) and check that the Digital Unit readout is 16.00 μs ±.08 μs, ±1 count for Type 230 count error.

h. Change the TIME/DIV to 5 μs (MULTIPLIER switch to 5) and check the Digital Unit readout for 40.00 μs ±.2 μs, ±1 count for Type 230 count error.

12. Adjust Dot Density, R676 ⓘ

a. Set the TIME/DIV to 1 μs (MULTIPLIER switch to 1).

b. Set the Type 230 Digital Unit controls as follows:

Mode	Time
Start	Horiz mm from sweep start 10 mm
Stop	Horiz mm from sweep start 90 mm

Other controls should be in the off position.

c. Adjust R676, Samples/Sweep Cal, for a Digital Unit readout of 8.00 μs. Location is shown in Fig. 5-14.

13. Check Timing Accuracy

Requirement—Correct timing over range of TIME/DIV indicator within ±3% with portion of sweep excluded by the DELAY switch as listed in the fourth column of Table 5-3.

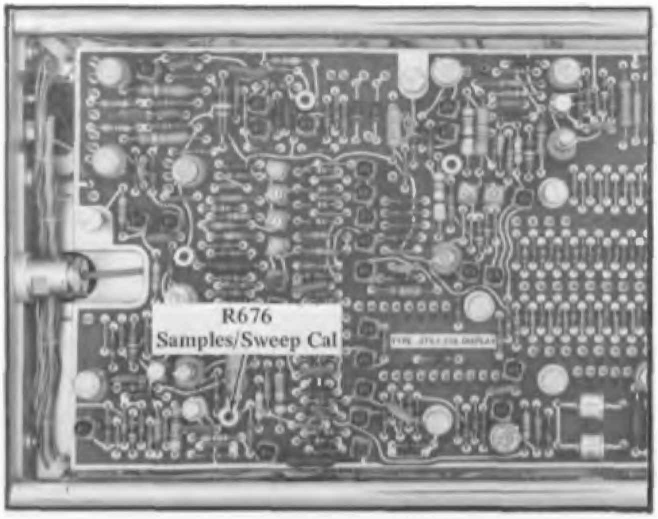


Fig. 5-14. Location of Dot Density adjustment, instrument left side.

a. Set the Type 230 Digital Unit controls as follows:

Mode	Time
Width, 0% Level and 100% Level	10 cm
0% Zone Position	.5 cm
100% Zone Position	.5 cm
Zone Intensity	Off
Start Point Level	% Between Zones 50%
Slope	1st, Negative
Stop Point Level	% Between Zones 50%
Slope	2nd, Negative

The Digital Unit will now read out the period between time marks.

b. Set the Type 3T6 controls as given in the second, third and fourth columns of Table 5-3.

c. Apply the timing signal given in the fifth column of Table 5-3. Connect the time mark generator to a GR to BNC adapter a 5 ns coaxial cable, GR874 T connector, 2X attenuator and VP-2 with GR874 W50B termination to the Type S-3 probe and connect the other connector of the GR874 T to a 2X attenuator, 2 ns coaxial cable and GR to BNC adapter to J123.

TABLE 5-3
TIMING CHECKS

TIME/DIV	DECADE	MULTIPLIER	DELAY	Time Mark Generator	Display	Digital Unit Readout ±3%
500 ps	0	5	0150	2 ns	1 cycle/div	2.00 ns ±.06
5 ns	9	5	0015	20 ns	1 cycle/4 div	20.0 ns ±.6
2 ns	9	2	0015	5 ns	2 cycle/5 div	5.00 ns ±.15
1 ns	9	1	0015	5 ns	1 cycle/5 div	5.00 ns ±.15
10 ns	8	1	0015	50 ns	1 cycle/5 div	50.0 ns ±1.5
20 ns	8	2	0015	.1 µs	1 mark/5 div	.1000 µs ±.003
50 ns	8	5	0015	.1 µs	1 mark/2 div	.100 µs ±.003
500 ns	7	5	0150	1 µs	1 mark/2 div	1.00 µs ±.03
200 ns	7	2	0150	1 µs	1 mark/5 div	1.000 µs ±.03
100 ns	7	1	0015	.5 µs	1 mark/5 div	.500 µs ±.015
1 µs	6	1	0150	5 µs	1 mark/5 div	5.00 µs ±0.15
2 µs	6	2	0015	5 µs	2 marks/5 div	5.00 µs ±0.15
5 µs	6	5	0015	10 µs	1 mark/2 div	10.0 µs ±.3
50 µs	5	5	0015	.1 ms	1 mark/2 div	.100 ms ±.003
20 µs	5	2	0150	.1 ms	1 mark/5 div	.1000 ms ±.003
10 µs	5	1	0015	50 µs	1 mark/5 div	50.0 µs ±1.5
100 µs	4	1	0150	.5 ms	1 mark/5 div	.500 ms ±.015
200 µs	4	2	1500	.5 ms	2 marks/5 div	.500 ms ±.015
500 µs	4	5	1500	1. ms	1 mark/2 div	1.00 ms ±.03
5 ms	3	5	0000	10 ms	1 mark/2 div	10.0 ms ±.3
2 ms	3	2	0000	10 ms	1 mark/5 div	10.00 ms ±.3
1 ms	3	1	0000	5ms	1 mark/5 div	5.00 ms ±.15
10 ms	2	1	0000	50 ms	1 mark/5 div	50.0 ms ±1.5
20 ms	2	2	0000	.1 s	1 mark/5 div	.1000 s ±.003
50 ms	2	5	0000	.1 s	1 mark/2 div	.100 s ±.003
500 ms	1	5	0000	1 s	1 mark/2 div	1.00 s ±.03
200 ms	1	2	0000	1 s	1 mark/5 div	1.000 s ±.03
100 ms	1	1	0000	.5 s	1 mark/5 div	.500 s ±.015

d. Obtain a stable display with the SENSITIVITY and RECOVERY TIME controls. At 2 ns or 5 ns, remove the 2X attenuator to J123 for a stable display.

e. Set the sampling unit Units/Div switch and Variable control for a 6 division display amplitude.

f. Check the indicator oscilloscope displays for correct timing over the center 8 divisions of the graticule within ±3%. The Digital Unit readout should be within ±3% (±1 count) of the number shown in the Digital Readout Unit column of Table 5-3.

g. Check the timing at 200 ps and 100 ps using the Air Line method, explained below in step j, if an accurate frequency source of 1 GHz is not available. Set the TIME/DIV to 200 ps (DECADE to 0 and MULTIPLIER to 2).

h. Connect the Type 284 Pulse Generator Pulse Output to a 5 ns coaxial cable, Type 113 Delay Cable, VP-2 with GR874 W50B termination to the Type S-3 probe. Connect a coaxial cable from the Trigger Output to J123. Set the Type 284 Mode switch to Pulse Output.

i. Set the Delay switch, 15 ns minimum, to position the pulse rising edge on the graticule and obtain the most stable display with the SENSITIVITY and RECOVERY TIME controls. Position the rising edge near the 2nd or 3rd graticule division and note the exact position visually.

j. Remove the 5 ns cable at the Pulse Generator, install either a 30 cm or 20 cm Air Line and reconnect the 5 ns cable.

k. Check that the pulse rising edge moves to the right 1 ns ±3% (5 div ±.15) with a 30 cm Air Line or 0.667 ns ±3% (3.3 div ±0.1) with a 20 cm Air Line.

l. Set the TIME/DIV to 100 ps (MULTIPLIER switch to 1) and remove the Air Line. Reconnect the 5 ns cable.

m. Position the pulse rising edge near the 2nd graticule division and note the exact position.

n. Install the 20 cm Air Line between the Pulse Output and the 5 ns cable.

o. Check that the pulse rising edge moves to the right 0.667 ns ±3% or 6.67 div ±0.2.

p. Disconnect the hook-up at the generator output connector.

14. Adjust Timing, R518, HORIZ GAIN, and C539

a. Connect the time mark generator Marker Output to the Type S-3 probe through a GR to BNC adapter 5 ns coaxial cable, GR874 T connector and VP-2 with GR874 W50B termination. Connect the other terminal of the GR874 T to a 2X attenuator, a 2 ns coaxial cable and a GR to BC adapter to J123.

b. Set the TIME/DIV to 1 μs (DECADE switch to 6 and the MULTIPLIER switch to 1) and set the time mark generator for 5 μs markers.

c. Set the Digital Unit as given in Step 13.

d. Adjust R518, Timing Current, for a readout of 5.00 μs. Location is shown in Fig. 5-15.

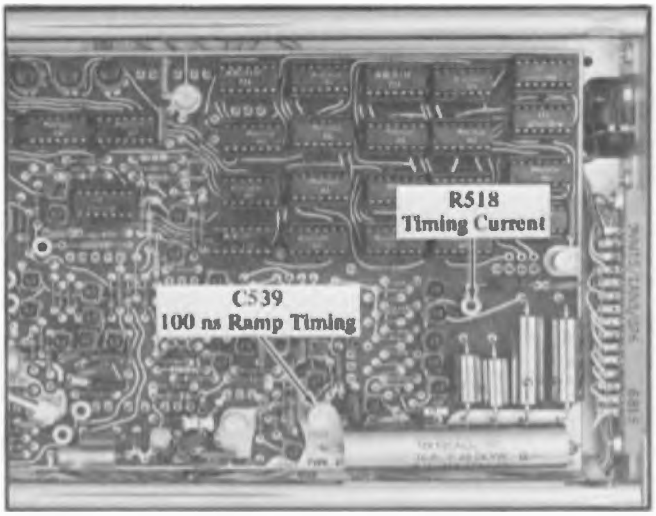


Fig. 5-15. Timing adjustment locations, instrument right side.

e. Set the time mark generator for 1 μs time marks and adjust the front panel HORIZ GAIN control for a CRT display of 1 marker per division; readout should be 1.00 μs.

f. Set the TIME/DIV to 10 ns (DECADE switch to 8) and set the time mark generator to 50 ns, 1 cycle per 5 divisions. Note the Delay listed in Table 5-3.

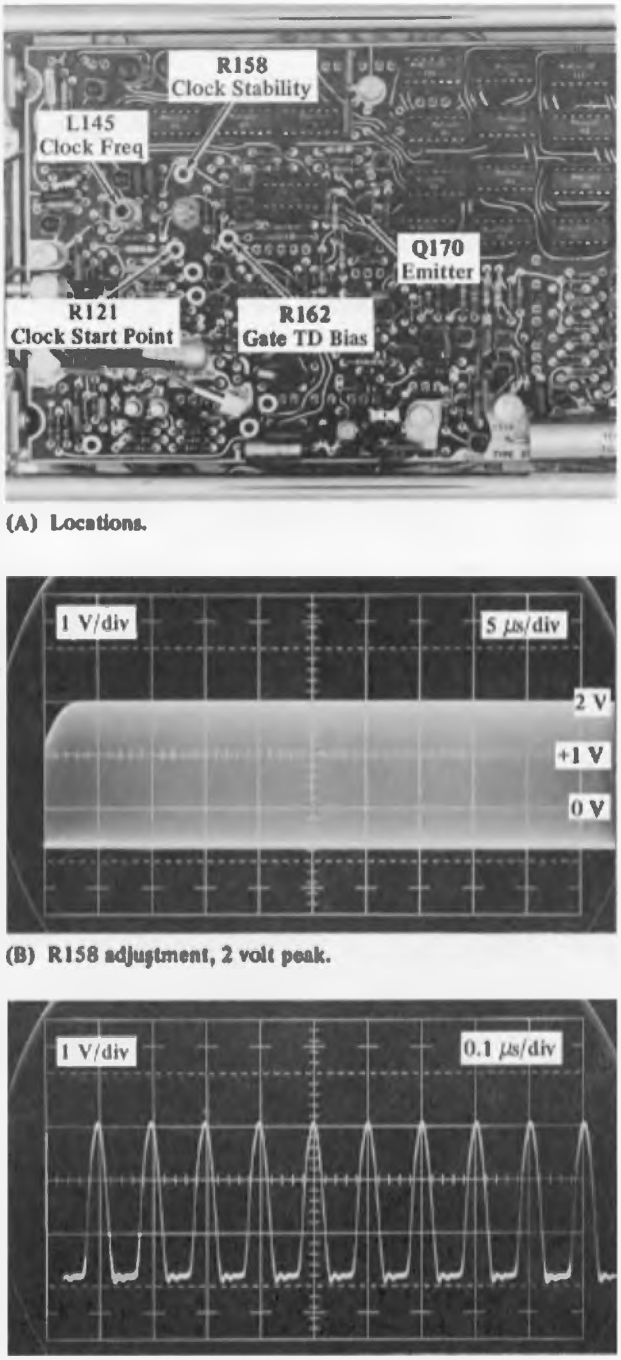
g. Adjust C539, 100 ns Ramp Timing, for a readout of 50.0 ns.

h. Disconnect the hook up from the time mark generator output connector.

Sweep rates of 1 ms through 500 ms will be within tolerance after Clock adjustments have been made; Step 15.

15. Check or Adjust 10 MHZ Clock, R158, R121, L145 and R162

a. Connect the 10X probe from the test oscilloscope to Q170 Emitter, see Fig. 5-1. Set the test oscilloscope sweep rate to 5 μs/cm and the Type 1A1 Volts/cm switch to .1 volts.



(A) Locations.

(B) R158 adjustment, 2 volt peak.

(C) Check of 1 cycle per div.

Fig. 5-16. 10 MHz Clock adjustment, instrument right side, and waveforms.

b. Set the TIME/DIV to 10 µs (DECADE switch to 5 and the MULTIPLIER switch to 1), the SENSITIVITY control fully clockwise for free running trace, and check that the test oscilloscope display is 2 divisions peak (2 volts) from ground reference. Adjust R158, Clock Stability, for +2 volts, see Fig. 5-16B. Check that the first cycle is at least 1 volt peak from ground reference.

c. Set the test oscilloscope Time/cm to 1 µs and observe 1 cycle per division on the test oscilloscope

d Remove the 10X probe.

e. Connect the Type 284 Pulse Generator Square Wave or Sine Wave Output to a 5 ns coaxial cable, GR874 T and the VP-2 with GR874 W50B termination, thence to the Type S-3 probe. Connect a 2X attenuator and 2 ns coaxial cable from the other arm of the GR874 T connector to J123 with a GR to BNC adapter.

f Set the Square Wave Amplitude to 1 V and the Period to 100 ns. Set the TIME/DIV to 10 ns (DECADE switch to 8 and MULITPLIER TO 1) and the DELAY switch to 0000

g. Observe the indicator oscilloscope display while changing the DELAY switch thousands thumbwheel from 0 to 1 and back (changing the delay from 0000 to 1000 and back to 0000) and adjust R121, Clock Start Point, for minimum movement as the DELAY switch is changed.

h. Change the DELAY switch thousands thumbwheel from 0 to 9 (changing the delay from 0000 to 9000 and back to 0000) and adjust L145, Clock Freq, for minimum movement Repeat parts j and k due to interaction.

i Observe the display shift while changing the DELAY switch hundreds thumbwheel so that the delay changes from 0000 to 0100, and then 0200 through 0900. Adjust R162, Gate TD Bias, for minimum display shift. The typical shift is about 1 minor division.

16. Check Delay Accuracy

Requirement—Delay accuracy is within 1% through 3%, based on a combination of 1% clock accuracy and 3% timing accuracy and is determined as follows: the letters A B C D symbolize the four columns of the Delay control, A representing X1000, B X100, C X10 and D X1.

TIME/DIV	Maximum error in %
500 µs to 2 µs	$\frac{1\ AB + 3\ CD}{AB + CD}$
1 µs to 1 ns	$\frac{1\ AB + CD}{AB + CD}$
500 ps to 100 ps	$\frac{1\ A + 3\ BCD}{A + BCD}$

Examples

DELAY Control: A | B | C | D | units

Delay = 2000 ns

$$\frac{20 + 300}{20 + 00} = 1\%$$

1% of 2000 ns = 20 ns

Delay = 0020 ns

$$\frac{00 + 320}{00 + 20} = 3\%$$

3% of 20 ns = 0.6 ns

a. Connect the Type 284 Pulse Generator Square Wave or Sine Wave Output to a 5 ns coaxial cable, GR874 T and the VP-2 with GR874 W50B termination to the Type S-3 probe. Connect a 2X attenuator and 2 ns coaxial cable from the other arm of the GR874 T connector to J123 with a GR to BNC adapter.

b. Set the TIME/DIV to 10 ns (DECADE switch to 8 and MULTIPLIER switch to 1), the MODE switch to EXT, and the DELAY switch to 1000.

c. Set the Type 284 Period switch to 100 ns Square Wave and Square Wave Amplitude to 1 Volt.

d. Change the DELAY switch from 1000 ns to 9000 ns in 1000 ns increments and check for not more than 1 div/1000 ns of trace shift. If trace shift exceeds 1 division when delay is changed 1000 ms see step 15 above.

e. Set the DELAY switch to 0100, add DELAY to position the square wave rising edge in the first graticule division, and set the TIME/DIV to 1 ns (DECADE switch to 9). Set the sampling switch to 20 for a more nearly vertical reference.

f. Change the DELAY switch to 0900 in 100 ns increments and check for not more than 1 div/100 ns of trace shift.

g. Set the TIME/DIV to 10 ns (DECADE switch to 8) and the DELAY switch to 0010.

h. Change the DELAY switch to 0090 in 10 ns increments and check that the signal shifts 1 division per 10 ns change. Changing DELAY from 0010 to 0090 must cause a signal shift of 8 divisions ±0.24 divisions.

i. Set the TIME/DIV to 1 ns (DECADE switch to 9) and the tens thumbwheel of the DELAY switch (2nd from right) to a value X, (00X0) that permits seeing the positive or negative edge of the display.

j. Change the DELAY switch to 00X9 in 1 ns increments and check that the signal shifts 1 division per 1 ns change, 8 divisions ±0.24 division timing error.

k. Disconnect the pulse generator output from the coaxial cable.

17. Adjust Delay Zero, R591 and R574

a. Set the TIME/DIV to 1 μs (DECADE switch to 6 and the MULTIPLIER switch to 1).

b. Connect the time mark generator Marker Output to a GR to BNC adapter, a 5 ns coaxial cable, GR874 T connector and a VP-2 with GR874 W50B termination to the Type S-3 probe and connect the other connector of the GR874 T to a 2X attenuator, 2 ns coaxial cable and GR to BNC adapter to J123.

c. Set the time mark generator for 5 μs time marks.

d. Change the MULTIPLIER switch through 1, 2 and 5 and adjust R591, Delay Zero, for minimum shift of the center time mark. See Fig. 5-17 for location.

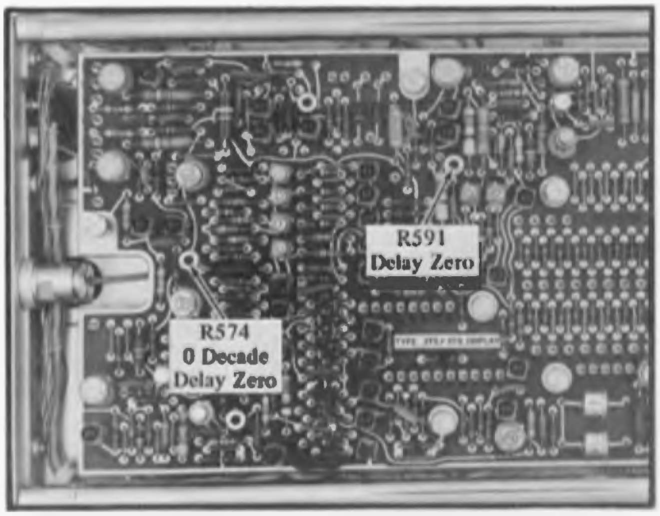


Fig. 5-17. Location of Delay Zero adjustments, instrument left side.

e. Disconnect the hook up to time mark generator output.

f. Connect the Pulse Output of the Type 284 Pulse Generator through a 5 ns coaxial cable to the Type 113 Delay Cable, the VP-2 with GR874 W50B termination to the Type S-3 probe. Connect the Type 284 Trigger Output to J123 through a coaxial cable.

g. Set the TIME/DIV to 1 ns (DECADE switch to 9 and the MULTIPLIER switch to 1) and obtain a stable display with the SENSITIVITY and RECOVERY TIME controls.

h. Use the DELAY switch to place the rising portion of the pulse on the graticule area and center the display with the sampling unit DC Offset control. Note the position from the left graticule edge of the pulse rise 50% amplitude point. For example, with a DELAY setting of 60 ns, the pulse rise is at 7.1 divisions.

i. Change the TIME/DIV to 100 ps (DECADE switch to 0) and set the DELAY switch to that noted in part h above. In the example, the DELAY setting is 067 1 ns.

j. Adjust R574, 0 Decade Delay Zero, so the 50% amplitude point is at the center of the graticule.

k. Disconnect the hook-up to the pulse generator output.

18. Check Delay Zero

Requirement Lead time, due to delay in Type 3T6 alone, required to position a pulse 1 division from sweep start as listed in Type 5-4

TABLE 5-4

TIME/DIV	Lead Time
10 ns	43 ns, ±8 6 ns
100 ns	140 ns, ±28 ns
1 µs	1 µs ±200 ns
10 µs	10 µs, ±2 s
100 µs	100 µs ±20 µs
500 µs	500 µs, ±100 µs

a. Connect the time mark generator Marker Output to a GR to BNC adapter, 5X attenuator, GR874 T, one side of the T connector to a VP-2 with GR874 W50B termination thence to the Type S-3 probe, and the other side of the T to a 2X attenuator 2 ns coaxial cable and GR to BNC adapter to J123.

b. Set the TIME/DIV to 10 µs (DECADE switch to 5) and set the time mark generator for 50 µs time markers

c. Check that the position of the first time mark from the sweep start is as follows

TIME/DIV	Time Mark	Time Mark Position From Sweep Start
10 µs	50 µs	5 div ±.2 div
100 µs	5 ms	5 div ±.2 div
500 µs	1 ms	2 div ± 2 div
100 ns[1]	5 µs	4.2 div ±.28 div
10 ns[1]	1 µs	4 div ±2 div

d. Disconnect the hook-up to the time mark generator.

19. Adjust Auto Level, R32

a. Set the Type 3T6 TIME/DIV to 100 ns (DECADE switch to 7).

b. Connect the Type 191 Sine Wave Generator through a 5 ns coaxial cable, GR874 T connector and VP-2 with GR874 W50B termination Type S-3 probe. Connect a coaxial cable with GR to BNC adapter from the GR874 T connector to J123.

c. Set the sine wave generator for 10 MHz and 200 mV peak to peak. Set the sampling unit Units/Div switch to 50 and the sine wave generator amplitude for 4 divisions.

d. Obtain a stable display and change the MODE switch to EXT AUTO.

e. Check for a stable display while switching the POLARITY switch from + to –, and adjust R32, Auto Level, for a stable display.

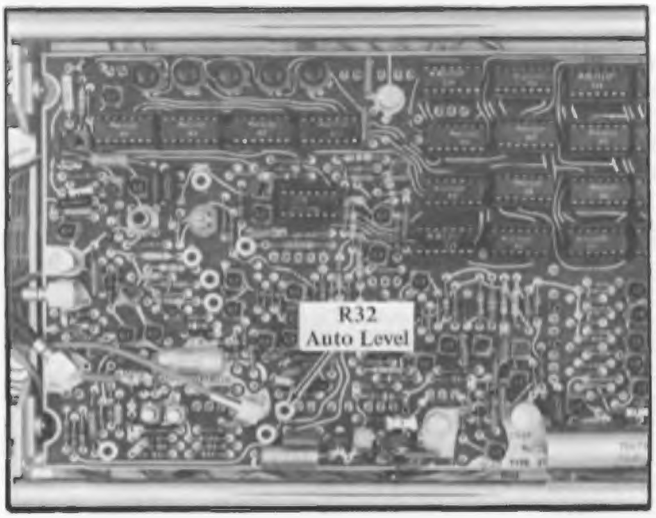


Fig. 5-18. Location of Auto Level control, instrument right side.

f. Disconnect the hook up to the sine wave generator output.

20. Check Horiz Position Range and Position Indicators

Requirement HORIZ POS control must move the trace at least four divisions Position indicator is ON when trace is 5 divisions from the graticule center

a. Connect the time mark generator Marker Output through a GR to BNC adapter, 5 ns coaxial cable, 5X attenuator, GR874 T and VP-2 with GR874 W50B termination to the Type S-3 probe. Connect the T connector to a 2X attenuator, 2 ns cable, GR to BNC adapter to J123. Set the time mark generator for 5 µs markers.

b. Set the Type 3T5 TIME/DIV to 1 µs (DECADE switch to 6) and obtain a stable display.

c. Rotate the HORIZ POS control fully counterclockwise and check that the center time mark moves to the left 2 divisions or more, see Fig. 5-19.

d. Rotate the HORIZ POS control fully clockwise and check that the center time mark moves to the right 2 divisions or more. Disconnect the hook-up from the time mark generator output.

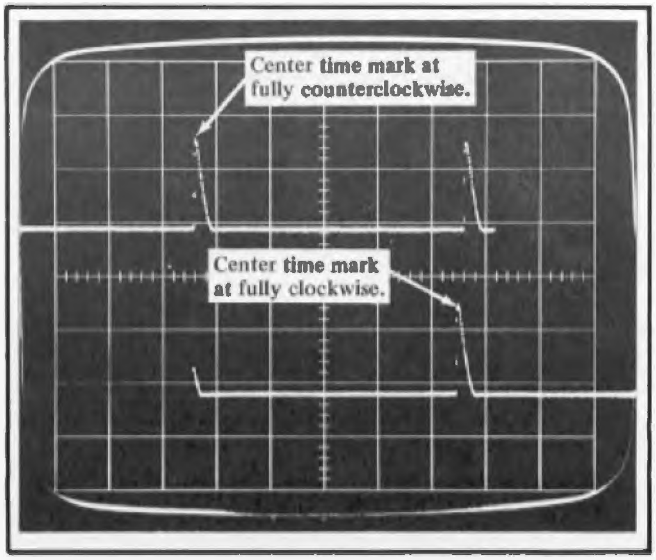
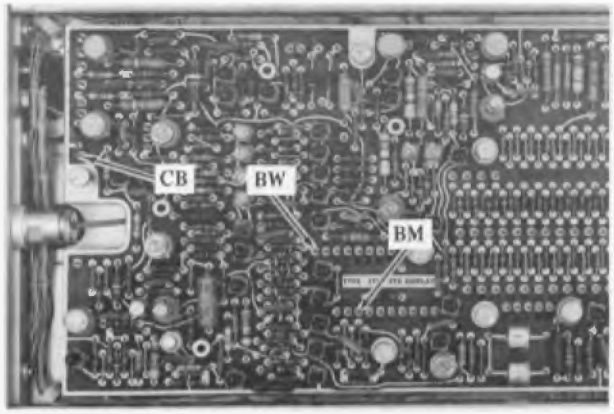


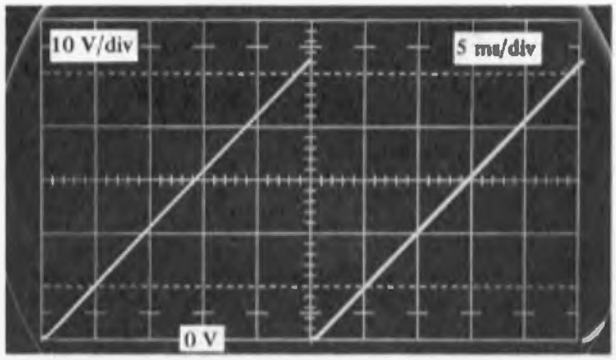
Fig. 5-19. Horizontal Position range check.

TABLE 5-5

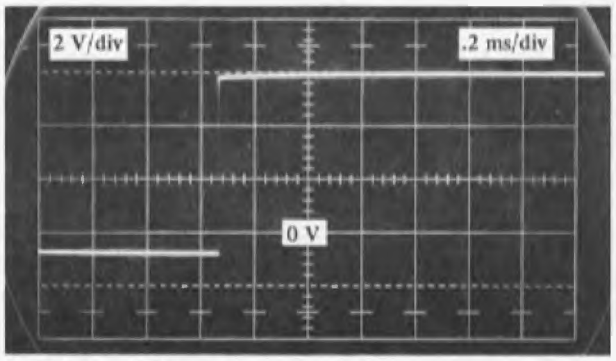
TIME/DIV	DECADE	MULTIPLIER	Type 230 Readout
100 ps	0	1	0.800 ns
200 ps	0	2	1.600 ns
500 ps	0	5	04.00 ns
1 ns	9	1	08.00 ns
2 ns	9	2	16.00 ns
5 ns	9	5	040.0 ns
10 ns	8	1	080.0 ns
20 ns	8	2	1600 µs
50 ns	8	5	0.400 µs
100 ns	7	1	0.800 µs
200 ns	7	2	1.600 µs
500 ns	7	5	04.00 µs
2 µs	6	1	08.00 µs
2 µs	6	2	16.00 µs
5 µs	6	5	040.0 µs
10 µs	5	1	080.0 µs
20 µs	5	2	1600 ms
50 µs	5	5	0.400 ms
100 µs	4	1	0.800 ms
200 µs	4	2	1.600 s
500 µs	4	5	04.00 ms
1 ms	3	1	08.00 ms
2 ms	3	2	16.00 ms
5 ms	3	5	040.0 ms
10 ms	2	1	080.0 ms
20 ms	2	2	1600 s
50 ms	2	5	0.400 s
100 ms	1	1	0.80 s
200 ms	1	2	1.600 s
500 ms	1	5	04.00 s



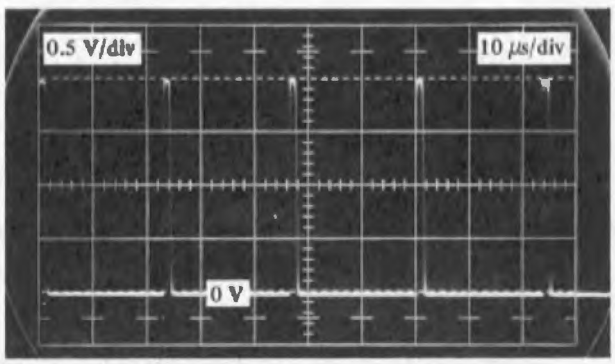
(A) Test point locations, instrument left side.



(B) Display at CB.



(C) Display at BW.



(D) Display at BM.

Fig. 5-20. Digital waveform check.

e. Set the HORIZ POS control to midrange and change the TIME/DIV to 500 μs (DECADE switch to 4 and MULTIPLIER switch to 5) and set the SENSITIVITY control fully clockwise.

f. Observe the Position indicators and the spot as it moves across the CRT. Check that the left indicator lights at the trace start and the right indicator lights at or near the trace end.

21. Check Digital Readout

This is an operational check of the Type 3T6 with the Type 230 Digital Unit. Table 5-5 lists the proper decimal, count the units lamps to be lit, through the tolerances of both the Type 3T6 and the Type 230 are not included here.

Set the Digital Unit Time measurement start point to 10 mm from sweep start and stop point to 90 mm from sweep start. Set the Type 3T6 TIME/DIV to 100 ps (DECADE switch to 0, MULTIPLIER to 1) and the SENSITIVITY control fully clockwise.

Check the readout as listed in Table 5-5.

22. Check Digital Waveforms

Connect the Type 3T6 to the indicator oscilloscope with one flexible extension; digital output is not connected.

a. Set the test oscilloscope Time/cm to 5 ms and the Type 1A1 Volts/cm switch to 1. Set the Type 3T6 TIME/DIV to 1 μs (DECADE switch to 6 and MULTIPLIER switch to 1).

b. Connect a 10X probe from the Type 1A1 input to Pin CB on the Display circuit board (see Fig. 5-20B) and check that the staircase waveform amplitude is 52.5 V ±2.0 V (5.005 div to 5.45 div) and the base is 0 V ±0.5 V.

c. Set the test oscilloscope Time/cm to .2 ms and the Type 1A1 Volts/cm switch to .2.

d. Connect the 10X probe to Pin BW on the Display circuit board and check that the sweep gate waveform amplitude is approximately 5.5 V with the base at approximately −0.8 V (2 V per division).

e. Set the test oscilloscope Time/cm to 10 μs and Type 1A1 Volts/cm switch to .05. Connect the 10X probe to pin BM on the Display circuit board.

f. Check that the clock pulse waveform is +1.8 V ±0.3 V amplitude and the base is at 0 V ±0.2 V (0.5 V per division).

g. Disconnect the probe from the test point on the circuit board.

NOTES

ABBREVIATIONS AND SYMBOLS

A or amp	amperes
AC or ac	alternating current
AF	audio frequency
α	alpha—common-base current amplification factor
AM	amplitude modulation
$\approx$	approximately equal to
β	beta—common-emitter current amplification factor
BHB	binding head brass
BHS	binding head steel
BNC	baby series "N" connector
$\times$	by or times
C	carbon
C	capacitance
cap.	capacitor
cer	ceramic
cm	centimeter
comp	composition
conn	connector
$\sim$	cycle
c/s or cps	cycles per second
CRT	cathode-ray tube
csk	countersunk
Δ	increment
dB	decibel
dBm	decibel referred to one milliwatt
DC or dc	direct current
DE	double end
$^\circ$	degrees
$^\circ$C	degrees Celsius (degrees centigrade)
$^\circ$F	degrees Fahrenheit
$^\circ$K	degrees Kelvin
dia	*diameter*
$\div$	divide by
div	division
EHF	extremely high frequency
elect.	electrolytic
EMC	electrolytic, metal cased
EMI	electromagnetic interference (see RFI)
EMT	electrolytic, metal tubular
ε	epsilon—2.71828 or % of error
$\geq$	equal to or greater than
$\leq$	equal to or less than
ext	external
F or f	farad
F & I	focus and intensity
FHB	flat head brass
FHS	flat head steel
Fil HB	fillister head brass
Fil HS	fillister head steel
FM	frequency modulation
ft	feet or foot
G	giga or 10^9
g	acceleration due to gravity
Ge	germanium
GHz	gigahertz
GMV	guaranteed minimum value
GR	General Radio
$>$	greater than
H or h	henry
h	height or high
hex.	hexagonal
HF	high frequency
HHB	hex head brass
HHS	hex head steel
HSB	hex socket brass
HSS	hex socket steel
HV	high voltage
Hz	hertz (cycles per second)
ID	inside diameter
IF	intermediate frequency
in.	inch or inches
incd	incandescent
∞	infinity
int	internal
$\int$	*integral*
k	kilohms or kilo (10^3)
k Ω	kilohm
kc	kilocycle
kHz	kilohertz
L	inductance
λ	lambda—wavelength
$\gg$	large compared with
$<$	less than
LF	low frequency
lg	length or long
LV	low voltage
M	mega or 10^6
m	milli or 10^{-3}
MΩ or meg	megohm
μ	micro or 10^{-6}
mc	megacycle
met.	metal
MHz	megahertz
mm	millimeter
ms	millisecond
—	minus
mtg hdw	*mounting hardware*
n	nano or 10^{-9}
no. or #	number
ns	nanosecond
OD	outside diameter
OHB	oval head brass
OHS	oval head steel
Ω	omega—ohms
ω	omega—angular frequency
p	pico or 10^{-12}
/	per
%	percent
PHB	pan head brass
ϕ	phi—phase angle
π	pi—3.1416
PHS	pan head steel
+	plus
$\pm$	plus or minus
PIV	peak inverse voltage
plstc	plastic
PMC	paper, metal cased
poly	polystyrene
prec	precision
PT	paper, tubular
PTM	paper or plastic, tubular, molded
pwr	power
Q	figure of merit
RC	resistance capacitance
RF	radio frequency
RFI	radio frequency interference (see EMI)
RHB	round head brass
ρ	rho—resistivity
RHS	round head steel
r/min or rpm	revolutions per minute
RMS	root mean square
s or sec.	second
SE	single end
Si	silicon
SN or S/N	serial number
$\ll$	small compared with
T	tera or 10^{12}
TC	temperature compensated
TD	tunnel diode
THB	truss head brass
θ	theta—angular phase displacement
thk	thick
THS	truss head steel
tub.	tubular
UHF	ultra high frequency
V	volt
VAC	volts, alternating current
var	variable
VDC	volts, direct current
VHF	very high frequency
VSWR	voltage standing wave ratio
W	watt
w	wide or width
w/	*with*
w/o	without
WW	wire-wound
xmfr	transformer

PARTS ORDERING INFORMATION

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

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

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

SPECIAL NOTES AND SYMBOLS

×000	Part first added at this serial number
00×	Part removed after this serial number
*000-0000-00	Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, Inc., or reworked or checked components.
Use 000-0000-00	Part number indicated is direct replacement.
◐	Screwdriver adjustment.
▭	Control, adjustment or connector.

SECTION 6
ELECTRICAL PARTS LIST

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Bulbs			
B740	150-0035-00			Neon A1D T2			
B745	150-0035-00			Neon A1D T2			
B824	150-0057-00			Incandescent #CM8-725			
B825	150-0057-00			Incandescent #CM8-725			
B826	150-0057-00			Incandescent #CM8-725			
B827	150-0057-00			Incandescent #CM8-725			
B828	150-0057-00			Incandescent #CM8-725			
B829	150-0057-00			Incandescent #CM8-725			
B830	150-0057-00			Incandescent #CM8-725			
B831	150-0057-00			Incandescent #CM8-725			
B832	150-0057-00			Incandescent #CM8-725			
B833	150-0057-00			Incandescent #CM8-725			
B834	150-0057-00			Incandescent #CM8-725			
B835	150-0057-00			Incandescent #CM8-725			
B836	150-0057-00			Incandescent #CM8-725			
B890	150-0057-00			Incandescent #CM8-725			
B892	150-0057-00			Incandescent #CM8-725			
B894	150-0057-00			Incandescent #CM8-725			
B896	150-0038-00			Incandescent #680			
				Capacitors			
Tolerance ±20% unless otherwise indicated.							
C1	283-0081-00			0.1 μF	Cer	25 V	+80%—20%
C12	283-0032-00			470 pF	Cer	500 V	
C21	283-0154-00			22 pF	Cer	50 V	
C26	283-0139-01			150 pF	Cer	50 V	
C28	283-0059-00			1 μF	Cer	25 V	+80%—20%
C34	283-0000-00			0.001 μF	Cer	500 V	
C50	283-0069-00			15 pF	Cer	50 V	
C55	290-0138-00			330 μF	Elect.	6 V	
C58	283-0069-00			15 pF	Cer	50 V	
C74	283-0638-00			130 pF	Mica	100 V	1%
C80	283-0167-00			0.1 μF	Cer	100 V	10%
C82	283-0155-00			0.01 μF	Cer	50 V	
C84	283-0065-00			0.001 μF	Cer	100 V	5%
C86	283-0641-00			180 pF	Mica	100 V	1%
C106	283-0051-00			0.0033 μF	Cer	100 V	5%
C118	283-0060-00			100 pF	Cer	200 V	5%

Capacitors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
C124	283-0637-00			20 pF	Mica	100 V	1%
C130	281-0634-00			10 pF	Cer	500 V	
C145	283-0641-00			180 pF	Mica	100 V	1%
C146	283-0594-00			0.001 μF	Mica	100 V	1%
C157	283-0002-00			0.01 μF	Cer	500 V	
C180	290-0162-00			22 μF	Elect.	35 V	
C182	283-0059-00			1 μF	Cer	25 V	+80%—20%
C183	283-0059-00			1 μF	Cer	25 V	+80%—20%
C184	283-0059-00			1 μF	Cer	25 V	+80%—20%
C185	283-0059-00			1 μF	Cer	25 V	+80%—20%
C186	290-0135-00			15 μF	Elect.	20 V	
C188	283-0059-00			1 μF	Cer	25 V	+80%—20%
C370	283-0060-00			100 pF	Cer	200 V	5%
C500	283-0000-00			0.001 μF	Cer	500 V	
C502	281-0634-00			10 pF	Cer	500 V	
C503				900 pF			
C507				0.0099 μF			
C510	*295-0115-00			0.1 μF	(Matched Assembly)		
C513				1 μF			
C516				10 μF			
C517	283-0002-00			0.01 μF	Cer	500 V	
C519	283-0003-00			0.01 μF	Cer	150 V	
C525	283-0060-00			100 pF	Cer	200 V	5%
C530	283-0103-00			180 pF	Cer	500 V	
C534	283-0060-00			100 pF	Cer	200 V	5%
C536	283-0059-00			1 μF	Cer	25 V	+80%—20%
C538	283-0602-00			53 pF	Mica	300 V	5%
C539	281-0092-00			9-35 pF, Var	Cer		
C555	283-0000-00			0.001 μF	Cer	500 V	
C563	283-0060-00			100 pF	Cer	200 V	5%
C564	283-0059-00			1 μF	Cer	25 V	+80%—20%
C565	283-0136-00			10 pF	Cer		5%
C566	283-0115-00			47 pF	Cer	200 V	
C567	281-0510-00			39 pF	Cer	500 V	10%
C579	283-0000-00			0.001 μF	Cer	500 V	
C601	283-0003-00			0.01 μF	Cer	150 V	
C625	283-0051-00			0.0033 μF	Cer	100 V	3%
C626	283-0060-00			100 pF	Cer	200 V	5%
C644	283-0000-00			0.001 μF	Cer	500 V	
C672	283-0626-00			1800 pF	Mica	500 V	5%
C678	283-0003-00			0.01 μF	Cer	150 V	
C680	285-0596-00			0.01 μF	PTM	100 V	1%
C684	283-0060-00			100 pF	Cer	200 V	5%
C690	283-0060-00			100 pF	Cer	200 V	5%
C704	283-0060-00			100 pF	Cer	200 V	5%

Capacitors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
C706	283-0094-00			27 pF	Cer	200 V	10%
C711	283-0003-00			0.01 μF	Cer	150 V	
C722	283-0003-00			0.01 μF	Cer	150 V	
C732	283-0054-00			150 pF	Cer	200 V	5%
C755	290-0107-00			25 μF	Elect.	25 V	
C757	283-0059-00			1 μF	Cer	25 V	+80%—20%
C902	290-0334-00			1250 μF	Elect.	50 V	+75%—10%
C906	290-0107-00			25 μF	Elect.	25 V	
C908	283-0059-00			1 μF	Cer	25 V	+80%—20%
C912	283-0641-00			180 pF	Mica	100 V	1%
C922	290-0403-00			5200 μF	Elect.	10 V	+75%—10%
C928	283-0060-00			100 pF	Cer	200 V	5%
C940	283-0059-00			1 μF	Cer	25 V	+80%—20%
C952	283-0003-00			0.01 μF	Cer	150 V	
C953	283-0000-00			0.001 μF	Cer	500 V	

Semi-conductor Device, Diodes

Ckt. No.	Tektronix Part No.	Eff	Disc	Description	
D24	*152-0185-00			Silicon	Replaceable by 1N4152
D28	152-0177-00			Tunnel	TD 253B 2 pF 10 mA
D46	*152-0075-00			Germanium	Tek Spec
D72	*152-0185-00			Silicon	Replaceable by 1N4152
D90	*152-0185-00			Silicon	Replaceable by 1N4152
D102	*152-0185-00			Silicon	Replaceable by 1N4152
D106	*152-0140-01			Tunnel	Tek Spec
D110	*152-0322-00			Silicon	Tek Spec
D112	*152-0322-00			Silicon	Tek Spec
D113	152-0071-00			Germanium	ED2007
D114	*152-0140-01			Tunnel	Tek Spec
D124	*152-0322-00			Silicon	Tek Spec
D135	*152-0185-00			Silicon	Replaceable by 1N4152
D136	*152-0322-00			Silicon	Tek Spec
D145	*152-0322-00			Silicon	Tek Spec
D146	*152-0322-00			Silicon	Tek Spec
D155	*152-0185-00			Silicon	Replaceable by 1N4152
D160	*152-0322-00			Silicon	Tek Spec
D168	*152-0140-01			Tunnel	Tek Spec
D171	*152-0322-00			Silicon	Tek Spec
D184	*152-0322-00			Silicon	Tek Spec
D185	*152-0322-00			Silicon	Tek Spec
D200	*152-0185-00			Silicon	Replaceable by 1N4152
D202	*152-0185-00			Silicon	Replaceable by 1N4152
D210	*152-0185-00			Silicon	Replaceable by 1N4152

Semi-conductor Device, Diodes *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
D212	*152-0185-00			Silicon	Replaceable by 1N4152
D220	*152-0185-00			Silicon	Replaceable by 1N4152
D222	*152-0185-00			Silicon	Replaceable by 1N4152
D230	*152-0185-00			Silicon	Replaceable by 1N4152
D232	*152-0185-00			Silicon	Replaceable by 1N4152
D240	*152-0185-00			Silicon	Replaceable by 1N4152
D242	*152-0185-00			Silicon	Replaceable by 1N4152
D246	*152-0185-00			Silicon	Replaceable by 1N4152
D247	*152-0185-00			Silicon	Replaceable by 1N4152
D248	*152-0185-00			Silicon	Replaceable by 1N4152
D250	*152-0185-00			Silicon	Replaceable by 1N4152
D252	*152-0185-00			Silicon	Replaceable by 1N4152
D256	*152-0185-00			Silicon	Replaceable by 1N4152
D257	*152-0185-00			Silicon	Replaceable by 1N4152
D258	*152-0185-00			Silicon	Replaceable by 1N4152
D260	*152-0185-00			Silicon	Replaceable by 1N4152
D262	*152-0185-00			Silicon	Replaceable by 1N4152
D266	*152-0185-00			Silicon	Replaceable by 1N4152
D267	*152-0185-00			Silicon	Replaceable by 1N4152
D268	*152-0185-00			Silicon	Replaceable by 1N4152
D270	*152-0185-00			Silicon	Replaceable by 1N4152
D272	*152-0185-00			Silicon	Replaceable by 1N4152
D276	*152-0185-00			Silicon	Replaceable by 1N4152
D277	*152-0185-00			Silicon	Replaceable by 1N4152
D278	*152-0185-00			Silicon	Replaceable by 1N4152
D280	*152-0185-00			Silicon	Replaceable by 1N4152
D282	*152-0185-00			Silicon	Replaceable by 1N4152
D286	*152-0185-00			Silicon	Replaceable by 1N4152
D288	*152-0185-00			Silicon	Replaceable by 1N4152
D290	*152-0185-00			Silicon	Replaceable by 1N4152
D292	*152-0185-00			Silicon	Replaceable by 1N4152
D296	*152-0185-00			Silicon	Replaceable by 1N4152
D298	*152-0185-00			Silicon	Replaceable by 1N4152
D300	*152-0185-00			Silicon	Replaceable by 1N4152
D302	*152-0185-00			Silicon	Replaceable by 1N4152
D306	*152-0185-00			Silicon	Replaceable by 1N4152
D308	*152-0185-00			Silicon	Replaceable by 1N4152
D310	*152-0185-00			Silicon	Replaceable by 1N4152
D312	*152-0185-00			Silicon	Replaceable by 1N4152
D316	*152-0185-00			Silicon	Replaceable by 1N4152
D318	*152-0185-00			Silicon	Replaceable by 1N4152
D320	*152-0185-00			Silicon	Replaceable by 1N4152
D322	*152-0185-00			Silicon	Replaceable by 1N4152
D326	*152-0185-00			Silicon	Replaceable by 1N4152
D328	*152-0185-00			Silicon	Replaceable by 1N4152

Semi-conductor Device, Diodes *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
D330	*152-0185-00			Silicon	Replaceable by 1N4152
D332	*152-0185-00			Silicon	Replaceable by 1N4152
D336	*152-0185-00			Silicon	Replaceable by 1N4152
D338	*152-0185-00			Silicon	Replaceable by 1N4152
D340	*152-0185-00			Silicon	Replaceable by 1N4152
D342	*152-0185-00			Silicon	Replaceable by 1N4152
D346	*152-0185-00			Silicon	Replaceable by 1N4152
D348	*152-0185-00			Silicon	Replaceable by 1N4152
D350	*152-0185-00			Silicon	Replaceable by 1N4152
D352	*152-0185-00			Silicon	Replaceable by 1N4152
D356	*152-0185-00			Silicon	Replaceable by 1N4152
D358	*152-0185-00			Silicon	Replaceable by 1N4152
D364	*152-0185-00			Silicon	Replaceable by 1N4152
D374	152-0265-00			Zener	1N970B 0.4 W, 24 V, 5%
D375	*152-0233-00			Silicon	Tek Spec
D382	*152-0185-00			Silicon	Replaceable by 1N4152
D385	*152-0185-00			Silicon	Replaceable by 1N4152
D392	*152-0185-00			Silicon	Replaceable by 1N4152
D460	*152-0185-00			Silicon	Replaceable by 1N4152
D500	*152-0185-00			Silicon	Replaceable by 1N4152
D502	*152-0185-00			Silicon	Replaceable by 1N4152
D503	*152-0185-00			Silicon	Replaceable by 1N4152
D505	*152-0185-00			Silicon	Replaceable by 1N4152
D507	*152-0185-00			Silicon	Replaceable by 1N4152
D509	*152-0185-00			Silicon	Replaceable by 1N4152
D510	*152-0185-00			Silicon	Replaceable by 1N4152
D512	*152-0185-00			Silicon	Replaceable by 1N4152
D513	*152-0185-00			Silicon	Replaceable by 1N4152
D514	152-0008-00			Germanium	
D515	*152-0185-00			Silicon	Replaceable by 1N4152
D516	*152-0185-00			Silicon	Replaceable by 1N4152
D520	*152-0322-00			Silicon	Tek Spec
D528	*152-0185-00			Silicon	Replaceable by 1N4152
D534	*152-0185-00			Silicon	Replaceable by 1N4152
D538	*152-0185-00			Silicon	Replaceable by 1N4152
D540	152-0008-00			Germanium	
D541	*152-0185-00			Silicon	Replaceable by 1N4152
D553	*152-0185-00			Silicon	Replaceable by 1N4152
D554	*152-0185-00			Silicon	Replaceable by 1N4152
D557	*152-0322-00			Silicon	Tek Spec
D571	*152-0185-00			Silicon	Replaceable by 1N4152
D573	152-0149-00			Zener	1N961B 0.4 W, 10 V, 5%
D581	*152-0185-00			Silicon	Replaceable by 1N4152
D584	*152-0185-00			Silicon	Replaceable by 1N4152
D587	*152-0185-00			Silicon	Replaceable by 1N4152

Semi-conductor Device, Diodes *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
D596	*152-0185-00			Silicon	Replaceable by 1N4152
D600	*152-0185-00			Silicon	Replaceable by 1N4152
D614	*152-0233-00			Silicon	Tek Spec
D615	*152-0233-00			Silicon	Tek Spec
D634	*152-0185-00			Silicon	Replaceable by 1N4152
D640	152-0283-00			Zener	1N976B 0.4 W, 43 V, 5%
D641	*152-0233-00			Silicon	Tek Spec
D643	*152-0185-00			Silicon	Replaceable by 1N4152
D644	*152-0185-00			Silicon	Replaceable by 1N4152
D666	*152-0185-00			Silicon	Replaceable by 1N4152
D667	*152-0185-00			Silicon	Replaceable by 1N4152
D668	*152-0185-00			Silicon	Replaceable by 1N4152
D670	*152-0185-00			Silicon	Replaceable by 1N4152
D671	*152-0185-00			Silicon	Replaceable by 1N4152
D672	*152-0185-00			Silicon	Replaceable by 1N4152
D678	*152-0185-00			Silicon	Replaceable by 1N4152
D680	*152-0333-00			Silicon	High Speed and Conductance
D682	*152-0321-00			Silicon	Dual, Tek Spec
D684	152-0008-00			Germanium	
D686	152-0217-00			Zener	1N756A 0.4 W, 8.2 V, 5%
D690	*152-0185-00			Silicon	Replaceable by 1N4152
D693	*152-0185-00			Silicon	Replaceable by 1N4152
D901	152-0066-00			Silicon	1N3194
D902	152-0066-00			Silicon	1N3194
D903	152-0212-00			Zener	1N936 0.5 W, 9 V, 5% TC
D921	152-0198-00			Silicon	MR1032A (Motorola) 200 V
D922	152-0198-00			Silicon	MR1032A (Motorola) 200 V
D940	*152-0185-00			Silicon	Replaceable by 1N4152
D942	*152-0185-00			Silicon	Replaceable by 1N4152

Fuse

F900	159-0036-00			7A 3AG Slo-Blo

Connectors

J10	131-0265-00			Connector, Coaxial
J24	131-0327-00			Connector, Receptacle 30 pin, female
J50	131-0391-00			Connector, Coaxial, male
J55	131-0265-00			Connector, Coaxial
J800	131-0549-00			Connector, Receptacle, 56 pin, female
J850	131-0549-00			Connector, Receptacle, 56 pin, female
P10	131-0155-00			Connector, Coaxial
P21	131-0149-00			Connector, Receptacle, 24 pin, male
P22	131-0149-00			Connector, Receptacle, 24 pin, male
P23	131-0614-00			Connector, Coaxial, male
P50	131-0375-00			Connector, right angle
P55	131-0155-00			Connector, Coaxial

Inductors

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
L1	*108-0447-00			20 μH
L34	*108-0215-00			1.1 μH
L47	*108-0420-00			60 μ.H
L145	*114-0275-00			1.2-2.4 μH, Var Core 276-0568-00
L180	*120-0382-00			Toroid, 14 turns single
L186	*120-0382-00			Toroid, 14 turns single
L755	*120-0382-00			Toroid, 14 turns single

Transistors

Ckt. No.	Tektronix Part No.	Eff	Disc	Description	
Q20	151-0221-00			Silicon	2N4258
Q35	*151-0108-00			Silicon	Tek Spec
Q40	*151-0108-00			Silicon	Tek Spec
Q70	151-0220-00			Silicon	2N4122
Q72	151-0224-00			Silicon	2N3692
Q75	151-0220-00			Silicon	2N4122
Q80	151-0224-00			Silicon	2N3692
Q82	151-0224-00			Silicon	2N3692
Q84	151-0224-00			Silicon	2N3692
Q86	151-0224-00			Silicon	2N3692
Q90	*151-0198-00			Silicon	Replaceable by MPS-918
Q100	151-0220-00			Silicon	2N4122
Q120	*151-0198-00			Silicon	Replaceable by MPS-918
Q125	151-0221-00			Silicon	2N4258
Q130	*151-0198-00			Silicon	Replaceable by MPS-918
Q135	151-0220-00			Silicon	2N4122
Q140	*151-0216-00			Silicon	Replaceable by MPS-6523
Q145	151-1004-00			Silicon	FET
Q150	151-1011-00			Silicon	Dual FET
Q155	151-0224-00			Silicon	2N3692
Q160	151-0221-00			Silicon	2N4258
Q170	*151-0198-00			Silicon	Replaceable by MPS-918
Q360	151-1007-00			Silicon	Dual FET
Q370	151-0250-00			Silicon	2N5184
Q375	*151-0150-00			Silicon	Replaceable by 2N3440
Q380	*151-0219-00			Silicon	Replaceable by 2N4250
Q385	151-1021-00			Silicon	FET
Q390	*151-0219-00			Silicon	Replaceable by 2N4250
Q395	151-1021-00			Silicon	FET
Q398	151-0224-00			Silicon	2N3692
Q460	151-0220-00			Silicon	2N4122
Q500	151-0224-00			Silicon	2N3692
Q503	151-0224-00			Silicon	2N3692
Q507	151-0224-00			Silicon	2N3692
Q510	151-0224-00			Silicon	2N3692

Transistors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
Q513	151-0224-00			Silicon	2N3692
Q516	151-0224-00			Silicon	2N3692
Q525	151-0190-00			Silicon	2N3904
Q530	151-0190-00			Silicon	2N3904
Q535	151-0220-00			Silicon	2N4122
Q540	151-0224-00			Silicon	2N3692
Q545	151-0224-00			Silicon	2N3692
Q548	151-0224-00			Silicon	2N3692
Q550	151-0224-00			Silicon	2N3692
Q553	151-0224-00			Silicon	2N3692
Q555	151-0224-00			Silicon	2N3692
Q560	151-0224-00			Silicon	2N3692
Q565	151-0083-00			Silicon	Tek Spec
Q570	*151-0219-00			Silicon	Replaceable by 2N4250
Q572	*151-0192-00			Silicon	Replaceable by MPS-6521
Q575	151-1021-00			Silicon	FET
Q578	*151-0219-00			Silicon	Replaceable by 2N4250
Q580	*151-0219-00			Silicon	Replaceable by 2N4250
Q581	151-1021-00			Silicon	FET
Q583	*151-0219-00			Silicon	Replaceable by 2N4250
Q584	151-1021-00			Silicon	FET
Q586	*151-0219-00			Silicon	Replaceable by 2N4250
Q587	151-1021-00			Silicon	FET
Q590	151-1007-00			Silicon	Dual FET
Q600	*151-0219-00			Silicon	Replaceable by 2N4250
Q605	151-0220-00			Silicon	2N4122
Q610	151-0220-00			Silicon	2N4122
Q630	151-0220-00			Silicon	2N4122
Q635	151-0224-00			Silicon	2N3692
Q640	*151-0150-00			Silicon	Replaceable by 2N3440
Q650	151-0224-00			Silicon	2N3692
Q660	*151-0219-00			Silicon	Replaceable by 2N4250
Q670	151-0190-00			Silicon	2N3904
Q675	*151-0219-00			Silicon	Replaceable by 2N4250
Q680	151-1007-00			Silicon	Dual FET
Q685	151-0250-00			Silicon	2N5184
Q690	*151-0150-00			Silicon	Replaceable by 2N3440
Q695	*151-0150-00			Silicon	Replaceable by 2N3440
Q700	*151-0219-00			Silicon	Replaceable by 2N4250
Q705	151-0224-00			Silicon	2N3692
Q710	151-0224-00			Silicon	2N3692
Q720	*151-0150-00			Silicon	Replaceable by 2N3440
Q730	*151-0150-00			Silicon	Replaceable by 2N3440
Q740	151-0179-00			Silicon	2N3877A
Q745	151-0179-00			Silicon	2N3877A

Transistors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
Q900	*151-0219-00			Silicon	Replaceable by 2N4250
Q905	*151-0219-00			Silicon	Replaceable by 2N4250
Q910	*151-0219-00			Silicon	Replaceable by 2N4250
Q915	*151-0148-00			Silicon	Selected from 40250 (RCA)
Q920	*151-0219-00			Silicon	Replaceable by 2N4250
Q925	*151-0219-00			Silicon	Replaceable by 2N4250
Q930	151-0208-00			Silicon	2N4036
Q935	*151-0148-00			Silicon	Selected from 40250 (RCA)
Q940	151-0224-00			Silicon	2N3692
Q945	151-0224-00			Silicon	2N3692
Q948	151-0183-00			Silicon	2N2192
Q950	*151-0219-00			Silicon	Replaceable by 2N4250
Q955	*151-0219-00			Silicon	Replaceable by 2N4250
Q960	151-0136-00			Silicon	2N3053

Resistors

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

Ckt. No.	Tektronix Part No.	Value	Power	Type	Tolerance
R4	315-0101-00	100 Ω	1/4 W		5%
R5	315-0101-00	100 Ω	1/4 W		5%
R13	315-0510-00	51 Ω	1/4 W		5%
R20	322-0603-00	2.51 kΩ	1/4 W	Prec	1%
R21	315-0430-00	43 Ω	1/4 W		5%
R23	315-0103-00	10 kΩ	1/4 W		5%
R24	311-0605-00	200 Ω, Var			
R26	315-0562-00	5.6 kΩ	1/4 W		5%
R28	317-0101-00	100 Ω	1/8 W		5%
R29	317-0101-00	100 Ω	1/8 W		5%
R30[1]	311-0862-00	2 X 20 kΩ, Var			
R32	311-0607-00	10 kΩ, Var			
R34	315-0152-00	1.5 kΩ	1/4 W		5%
R35	315-0332-00	3.3 kΩ	1/4 W		5%
R36	311-0644-00	20 kΩ, Var			
R38	315-0473-00	47 kΩ	1/4 W		5%
R39	315-0103-00	10 kΩ	1/4 W		5%
R41	315-0243-00	24 kΩ	1/4 W		5%
R42	315-0103-00	10 kΩ	1/4 W		5%
R44	315-0300-00	30 Ω	1/4 W		5%
R46	315-0472-00	4.7 kΩ	1/4 W		5%
R47	315-0910-00	91 Ω	1/4 W		5%
R50	315-0470-00	47 Ω	1/4 W		5%
R55	315-0470-00	47 Ω	1/4 W		5%
R58	315-0910-00	91 Ω	1/4 W		5%

[1]Furnished as a unit with R78 and SW78.

Resistors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
R70	317-0103-00			10 kΩ	1/8 W		5%
R74	315-0822-00			8.2 kΩ	1/4 W		5%
R76	315-0303-00			30 kΩ	1/4 W		5%
R78[2]	311-0862-00			2 X 20 kΩ, Var			
R80	317-0511-00			510 Ω	1/8 W		5%
R81	317-0511-00			510 Ω	1/8 W		5%
R82	317-0511-00			510 Ω	1/8 W		5%
R84	317-0511-00			510 Ω	1/8 W		5%
R86	317-0511-00			510 Ω	1/8 W		5%
R87	317-0511-00			510 Ω	1/8 W		5%
R90	315-0103-00			10 kΩ	1/4 W		5%
R93	315-0511-00			510 Ω	1/4 W		5%
R95	315-039-00			390 Ω	1/4 W		5%
R100	311-0633-00			5 kΩ, Var			
R102	321-0641-00			1.8 kΩ	1/8 W	Prec	1%
R104	315-0123-00			12 kΩ	1/4 W		5%
R106	315-0391-00			390 Ω	1/4 W		5%
R110	321-0277-00			7.5 kΩ	1/8 W	Prec	5%
R112	311-0633-00			5 kΩ, Var			
R113	321-0222-00			2 kΩ	1/8 W	Prec	1%
R115	307-0113-00			5.1 Ω	1/4 W		5%
R116	315-0181-00			180 Ω	1/4 W		5%
R118	321-0085-00			75 Ω	1/8 W	Prec	1%
R121	311-0633-00			5 kΩ, Var			
R122	321-0260-00			4.99 kΩ	1/8 W	Prec	1%
R124	315-0102-00			1 kΩ	1/4 W		5%
R125	321-0297-00			12.1 kΩ	1/8 W	Prec	1%
R130	315-0512-00			5.1 kΩ	1/4 W		5%
R131	315-0103-00			10 kΩ	1/4 W		5%
R133	315-0103-00			10 kΩ	1/8 W		5%
R135	315-0103-00			10 kΩ	1/4 W		5%
R140	321-0090-00			84.5 kΩ	1/8 W	Prec	1%
R150	315-0101-00			100 Ω	1/4 W		5%
R153	315-0511-00			510 Ω	1/4 W		5%
R155	315-0511-00			510 Ω	1/4 W		5%
R157	308-0212-00			10 kΩ	3 W	WW	5%
R158	311-0635-00			1 kΩ, Var			
R160	321-0277-00			7.5 kΩ	1/8 W	Prec	1%
R162	311-0634-00			500 Ω, Var			
R163	322-0218-00			1.82 kΩ	1/8 W	Prec	1%
R164	321-0239-00			3.01 kΩ	1/8 W	Prec	1%
R165	315-0510-00			51 Ω	1/4 W		5%
R168	321-0147-00			332 Ω	1/8 W	Prec	1%
R172	321-0256-00			4.53 kΩ	1/8 W	Prec	1%
R174	321-0160-00			453 Ω	1/8 W	Prec	1%

[2]**Furnished as a unit with SW78 and R30.**

Resistors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
R175	321-0097-00			100 Ω	⅛ W	Prec	1%
R178	321-0220-00			1.91 kΩ	⅛ W	Prec	1%
R182	307-0110-00			3 Ω	¼ W		5%
R188	307-0110-00			3 Ω	¼ W		5%
R202	317-0103-00			10 kΩ	⅛ W		5%
R204	317-0432-00			4.3 kΩ	⅛ W		5%
R206	317-0183-00			18 kΩ	⅛ W		5%
R212	317-0103-00			10 kΩ	⅛ W		5%
R214	317-0432-00			4.3 kΩ	⅛ W		5%
R216	317-0183-00			18 kΩ	⅛ W		5%
R222	317-0103-00			10 kΩ	⅛ W		5%
R224	317-0432-00			4.3 kΩ	⅛ W		5%
R226	317-0183-00			18 kΩ	⅛ W		5%
R232	317-0103-00			10 kΩ	⅛ W		5%
R234	317-0432-00			4.3 kΩ	⅛ W		5%
R236	317-0183-00			18 kΩ	⅛ W		5%
R242	315-0272-00			2.7 kΩ	¼ w		5%
R244	315-0122-00			1.2 kΩ	¼ W		5%
R246	315-0472-00			4.7 kΩ	¼ W		5%
R248	308-0505-00			100 kΩ	¼ W	WW	1/20%
R252	315-0272-00			2.7 kΩ	¼ W		5%
R254	315-0122-00			1.2 kΩ	¼ W		5%
R256	315-0472-00			4.7 kΩ	¼ W		5%
R258	308-0506-00			200 kΩ	¼ W	WW	1/10%
R262	317-0512-00			5.1 kΩ	⅛ W		5%
R264	317-0222-00			2.2 kΩ	⅛ W		5%
R266	317-0912-00			9.1 kΩ	⅛ W		5%
R268	321-0781-06			400 kΩ	⅛ W	Prec	¼%
R272	317-0512-00			5.1 kΩ	⅛ W		5%
R274	317-0222-00			2.2 kΩ	⅛ W		5%
R276	317-0912-00			9.1 kΩ	⅛ W		5%
R278	322-0620-01			800 kΩ	¼ W	Prec	½%
R282	317-0163-00			16 kΩ	⅛ W		5%
R284	317-0562-00			5.6 kΩ	⅛ W		5%
R286	317-0203-00			20 kΩ	⅛ W		5%
R288	322-0481-01			1 MΩ	¼ W	Prec	½%
R292	317-0163-00			16 kΩ	⅛ W		5%
R294	317-0562-00			5.6 kΩ	⅛ W		5%
R296	317-0203-00			20 kΩ	⅛ W		5%
R298	322-0510-00			2 MΩ	¼ W	Prec	1%
R302	317-0163-00			16 kΩ	⅛ W		5%
R304	317-0562-00			5.6 kΩ	⅛ W		5%
R306	317-0203-00			20 kΩ	⅛ W		5%
R308	322-0671-00			4 MΩ	¼ W	Prec	1%
R312	317-0163-00			16 kΩ	⅛ W		5%

Resistors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
R314	317-0562-00			5.6 kΩ	1/8 W		5%
R316	317-0203-00			20 kΩ	1/8 W		5%
R318	323-0751-00			8 MΩ	1/2 W	Prec	1%
R322	317-0163-00			16 kΩ	1/8 W		5%
R324	317-0562-00			5.6 kΩ	1/8 W		5%
R326	317-0203-00			20 kΩ	1/8 W		5%
R327	321-0289-00			10 kΩ	1/8 W	Prec	1%
R328	322-0481-01			1 MΩ	1/4 W	Prec	1/2%
R329	321-0381-00			90.9 kΩ	1/8 W	Prec	1%
R332	317-0163-00			16 kΩ	1/8 W		5%
R334	317-0562-00			5.6 kΩ	1/8 W		5%
R336	317-0203-00			20 kΩ	1/8 W		5%
R338	322-0510-00			2 MΩ	1/4 W	Prec	1%
R342	317-0163-00			16 kΩ	1/8 W		5%
R344	317-0562-00			5.6 kΩ	1/8 W		5%
R346	317-0203-00			20 kΩ	1/8 W		5%
R348	322-0671-00			4 MΩ	1/4 W	Prec	1%
R352	317-0163-00			16 kΩ	1/8 W		5%
R354	317-0562-00			5.6 kΩ	1/8 W		5%
R356	317-0203-00			20 kΩ	1/8 W		5%
R358	323-0751-00			8 MΩ	1/2 W	Prec	1%
R360	322-0364-03			60.4 kΩ	1/4 W	Prec	1/4%
R362	315-0104-00			100 kΩ	1/4 W		5%
R364	315-0183-00			18 kΩ	1/4 W		5%
R366	315-0204-00			200 kΩ	1/4 W		5%
R370	315-0101-00			100 Ω	1/4 W		5%
R372	315-0274-00			270 kΩ	1/4 W		5%
R375	301-0104-00			100 kΩ	1/2 W		5%
R377	321-0510-00			2 MΩ	1/8 W	Prec	1%
R378	321-0452-00			499 kΩ	1/8 W	Prec	1%
R380	315-0102-00			1 kΩ	1/4 W		5%
R382	315-0104-00			100 kΩ	1/4 W		5%
R384	321-1427-02			277 kΩ	1/8 W	Prec	1/2%
R390	315-0102-00			1 kΩ	1/4 W		5%
R392	315-0104-00			100 kΩ	1/4 W		5%
R394	323-1327-02			25.2 kΩ	1/2 W	Prec	1/2%
R396	315-0102-00			1 kΩ	1/4 W		5%
R398	321-0356-00			49.9 kΩ	1/8 W	Prec	1%
R464	315-0102-00			1 kΩ	1/4 W		5%
R500	317-0511-00			510 Ω	1/8 W		5%
R501	315-0105-00			1 MΩ	1/4 W		5%
R502	317-0511-00			510 Ω	1/8 W		5%
R503	317-0100-00			10 Ω	1/8 W		5%
R505	317-0511-00			510 Ω	1/8 W		5%
R509	317-0511-00			510 Ω	1/8 W		5%

Resistors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
R512	317-0511-00			510 Ω	1/8 W		5%
R514	315-0163-00			16 kΩ	1/4 W		5%
R515	317-0511-00			510 Ω	1/8 W		5%
R517	321-0126-00			200 Ω	1/8 W		1%
R518	311-0609-00			2 kΩ, Var			
R519	308-0397-00			12.5 kΩ	2 W	WW	5%
R522	321-0317-00			19.6 kΩ	1/8 W	Prec	1%
R523	321-0165-00			511 Ω	1/8 W	Prec	1%
R525	301-0513-00			51 kΩ	1/2 W		5%
R530	321-0222-00			2 kΩ	1/8 W	Prec	1%
R531	321-0314-00			18.2 kΩ	1/8 W	Prec	1%
R532	315-0753-00			75 kΩ	1/4 W		5%
R534	315-0101-00			100 Ω	1/4 W		5%
R538	315-0510-00			51 Ω	1/4 W		5%
R540	315-0104-00			100 kΩ	1/4 W		5%
R541	315-0202-00			2 kΩ	1/4 W		5%
R542	315-0271-00			270 Ω	1/4 W		5%
R543	315-0102-00			1 kΩ	1/4 W		5%
R545	315-0471-00			470 Ω	1/4 W		5%
R546	321-0221-00			1.96 kΩ	1/8 W	Prec	1%
R547	321-0290-00			10.2 kΩ	1/8 W	Prec	1%
R548	317-0514-00			510 kΩ	1/8 W		5%
R549	321-0284-00			8.87 kΩ	1/8 W	Prec	1%
R551	315-0101-00			100 Ω	1/4 W		5%
R553	315-0302-00			3 kΩ	1/4 W		5%
R554	315-0104-00			100 kΩ	1/4 W		5%
R556	315-0101-00			100 Ω	1/4 W		5%
R557	301-0623-00			62 kΩ	1/2 W		5%
R560	315-0471-00			470 Ω	1/4 W		5%
R562	315-0203-00			20 kΩ	1/4 W		5%
R563	315-0222-00			2.2 kΩ	1/4 W		5%
R564	315-0100-00			10 Ω	1/4 W		5%
R566	315-0512-00			5.1 kΩ	1/4 W		5%
R567	315-0102-00			1 kΩ	1/4 W		5%
R568	317-0510-00			51 Ω	1/8 W		5%
R570	315-0102-00			1 kΩ	1/4 W		5%
R571	315-0104-00			100 kΩ	1/4 W		5%
R573	308-0360-00			13.3 kΩ	3 W	WW	1%
R574	311-0633-00			5 kΩ, Var			
R576	321-0235-02			2.74 kΩ	1/8 W	Prec	1/2%
R578	321-0327-02			24.9 kΩ	1/8 W	Prec	1/2%
R579	315-0100-00			10 Ω	1/4 W		5%
R580	315-0102-00			1 kΩ	1/4 W		5%
R581	315-0104-00			100 kΩ	1/4 W		5%
R582	321-0423-02			249 kΩ	1/8 W	Prec	1/2%

Resistors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
R583	315-0102-00			1 kΩ	1/4 W		5%
R584	315-0104-00			100 kΩ	1/4 W		5%
R585	321-0365-02			61.9 kΩ	1/8 W	Prec	1/2%
R586	315-0102-00			1 kΩ	1/4 W		5%
R587	315-0104-00			100 kΩ	1/4 W		5%
R588	321-1331-02			27.7 kΩ	1/8 W	Prec	1/2%
R589	321-0432-02			249 kΩ	1/8 W	Prec	1/2%
R590	321-0395-00			127 kΩ	1/8 W	Prec	1%
R591	311-0614-00			30 kΩ, Var			
R593	323-0355-00			48.7 kΩ	1/2 W	Prec	1%
R596	322-1386-00			104 kΩ	1/4 W	Prec	1%
R600	315-0103-00			10 kΩ	1/4 W		5%
R601	315-0102-00			1 kΩ	1/4 W		5%
R603	315-0362-00			3.6 kΩ	1/4 W		5%
R604	315-0183-00			18 kΩ	1/4 W		5%
R605	315-0363-00			36 kΩ	1/4 W		5%
R606	315-0104-00			100 kΩ	1/4 W		5%
R607	315-0103-00			10 kΩ	1/4 W		5%
R608	315-0103-00			10 kΩ	1/4 W		5%
R609	315-0102-00			1 kΩ	1/4 W		5%
R611	322-0361-00			56.2 kΩ	1/4 W	Prec	1%
R612	321-0324-00			23.2 kΩ	1/8 W	Prec	1%
R614	315-0304-00			300 kΩ	1/4 W		5%
R615	315-0271-00			270 Ω	1/4 W		5%
R617	315-0823-00			82 kΩ	1/4 W		5%
R624	315-0104-00			100 kΩ	1/4 W		5%
R625	315-0512-00			5.1 kΩ	1/4 W		5%
R628	315-0101-00			100 Ω	1/4 W		5%
R630	315-0102-00			1 kΩ	1/4 W		5%
R631	315-0512-00			5.1 kΩ	1/4 W		5%
R632	315-0113-00			11 kΩ	1/4 W		5%
R634	315-0113-00			11 kΩ	1/4 W		5%
R636	315-0112-00			1.1 kΩ	1/4 W		5%
R637	315-0182-00			1.8 kΩ	1/4 W		5%
R640	303-0104-00			100 kΩ	1 W		5%
R643	315-0303-00			30 kΩ	1/4 W		5%
R644	315-0103-00			10 kΩ	1/4 W		5%
R650	315-0912-00			9.1 kΩ	1/4 W		5%
R651	315-0102-00			1 kΩ	1/4 W		5%
R652	315-0123-00			12 kΩ	1/4 W		5%
R654	315-0203-00			20 kΩ	1/4 W		5%
R656	315-0103-00			10 kΩ	1/4 W		5%
R660	315-0183-00			18 kΩ	1/4 W		5%
R662	315-0362-00			3.6 kΩ	1/4 W		5%
R664	315-0822-00			8.2 kΩ	1/4 W		5%

Resistors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
R666	315-0104-00			100 kΩ	1/4 W		5%
R667	321-0383-00			95.3 kΩ	1/8 W	Prec	1%
R668	322-0620-01			800 kΩ	1/4 W	Prec	1/2%
R670	315-0102-00			1 kΩ	1/4 W		5%
R672	321-0286-00			9.31 kΩ	1/8 W	Prec	1%
R674	321-0277-00			7.5 kΩ	1/8 W	Prec	1%
R675	321-0210-00			1.5 kΩ	1/8 W	Prec	1%
R676	311-0634-00			500 Ω, Var			
R678	315-0104-00			100 kΩ	1/4 W		5%
R680	315-0101-00			100 Ω	1/4 W		5%
R682	315-0470-00			47 Ω	1/4 W		5%
R684	315-0101-00			100 Ω	1/4 W		5%
R686	301-0274-00			270 kΩ	1/2 W		5%
R690	315-0242-00			2.4 kΩ	1/4 W		5%
R692	315-0102-00			1 kΩ	1/4 W		5%
R694	315-0162-00			1.6 kΩ	1/4 W		5%
R696	321-0349-00			42.2 kΩ	1/8 W	Prec	1%
R697	321-0277-00			7.5 kΩ	1/8 W	Prec	1%
R700	315-0474-00			470 kΩ	1/4 W		5%
R702	315-0101-00			100 Ω	1/4 W		5%
R704	315-0101-00			100 Ω	1/4 W		5%
R706	315-0103-00			10 kΩ	1/4 W		5%
R710	315-0123-00			12 kΩ	1/4 W		5%
R711	311-0310-00			5 kΩ, Var			
R712	315-0133-00			13 kΩ	1/4 W		5%
R714	315-0101-00			100 Ω	1/4 W		5%
R716	315-0512-00			5.1 kΩ	1/4 W		5%
R720	323-0365-00			61.9 kΩ	1/2 W	Prec	1%
R722	301-0513-00			51 kΩ	1/2 W		5%
R724	321-0222-00			2 kΩ	1/8 W	Prec	1%
R730	323-0365-00			61.9 kΩ	1/2 W	Prec	1%
R732	301-0513-00			51 kΩ	1/2 W		5%
R734	321-0222-00			2 kΩ	1/8 W	Prec	1%
R736	311-0086-00			2.5 kΩ, Var			
R740	317-0473-00			47 kΩ	1/8 W		5%
R742	317-0106-00			10 MΩ	1/8 W		5%
R744	317-0274-00			270 kΩ	1/8 W		5%
R746	317-0473-00			47 kΩ	1/8 W		5%
R757	307-0110-00			3 Ω	1/4 W		5%
R901	307-0103-00			2.7 Ω	1/4 W		5%
R903	321-0209-00			1.47 kΩ	1/8 W	Prec	1%
R904	317-0102-00			1 kΩ	1/8 W		5%
R905	315-0432-00			4.3 kΩ	1/4 W		5%
R906	317-0101-00			100 Ω	1/8 W		5%
R907	321-0215-00			1.69 kΩ	1/8 W	Prec	1%

Resistors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
R908	311-0605-00			200 Ω, Var			
R909	321-0224-00			2.1 kΩ	1/8 W	Prec	1%
R910	315-0123-00			12 kΩ	1/4 W		5%
R912	315-0102-00			1 kΩ	1/4 W		5%
R914	315-0101-00			100 Ω	1/4 W		5%
R916	315-0102-00			1 kΩ	1/4 W		5%
R921	315-0101-00			100 Ω	1/4 W		5%
R925	315-0222-00			2.2 kΩ	1/4 W		5%
R927	321-0310-00			16.5 kΩ	1/8 W	Prec	1%
R928	321-0247-00			3.65 kΩ	1/8 W	Prec	1%
R930	315-0332-00			3.3 kΩ	1/4 W		5%
R932	315-0101-00			100 Ω	1/4 W		5%
R934	307-0104-00			3.3 Ω	1/4 W		5%
R936	315-0101-00			100 Ω	1/4 W		5%
R940	321-0285-00			9.09 kΩ	1/8 W	Prec	1%
R941	311-0605-00			200 Ω, Var			
R942	321-0126-00			200 Ω	1/8 W	Prec	1%
R943	301-0821-00			820 Ω	1/2 W		5%
R945	301-0162-00			1.6 kΩ	1/2 W		5%
R946	315-0100-00			10 Ω	1/4 W		5%
R948	307-0093-00			1.2 Ω	1/2 W		5%
R949	308-0503-00			6.8 Ω	2.5 W	WW	5%
R951	321-0218-00			1.82 kΩ	1/8 W	Prec	1%
R952	323-0355-00			48.7 kΩ	1/2 W	Prec	1%
R953	317-0101-00			100 Ω	1/8 W		5%
R954	315-0910-00			91 Ω	1/4 W		5%
R956	308-0504-00			17 Ω	8 W	WW	5%
R958	315-0101-00			100 Ω	1/4 W		5%
R960	315-0511-00			510 Ω	1/4 W		5%
R962	317-0101-00			100 Ω	1/8 W		5%
R966	308-0223-00			35 Ω	3 W	WW	5%
R972	308-0293-00			4 kΩ	3 W	WW	5%
R975	315-0272-00			2.7 kΩ	1/4 W		5%

Switches

Ckt. No.	Wired or Unwired	Tektronix Part No.	Type	Description
SW5 / SW10	Wired	*262-0847-00	Rotary	MODE / POLARITY
SW5 / SW10		260-0983-00	Rotary	MODE / POLARITY
SW78[3]		311-0862-00		
SW600		260-0816-00	Slide	SAMPLES/SWEEP
SW605	Wired	*262-0846-00	Rotary	PROGRAM SELECTOR
SW605		260-0981-00	Rotary	PROGRAM SELECTOR
SW890[4] / SW892		260-0982-00	Rotary	TIME/DIV DECADE / MULTIPLIER
SW895		260-0932-00	Rotary	DELAY

[3]Furnished as a unit with R78 and R30.

[4]SW890 and SW892 furnished as a unit.

Transformers

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
T10	*120-0491-00			Toroid, 7 turns bifilar
T901	*120-0580-00			H.V. Power

Integrated Circuits

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
U60	156-0024-00			Dual 4-Input Gate Replaceable by Motorola MC1004P
U170	156-0025-00			Quad 2-Input Gate Replaceable by Motorola MC1010P
U180	156-0024-00			Dual 4-Input Gate Replaceable by Motorola MC1004P
U400	156-0022-00			AC Coupled J-K Flipflop Replaceable by Motorola MC1013P
U402	156-0025-00			Quad 2-Input Gate Replaceable by Motorola MC1010P
U404	156-0022-00			AC Coupled J-K Flipflop Replaceable by Motorola MC1013P
U406	156-0025-00			Quad 2-Input Gate Replaceable by motorola MC1010P
U408	156-0022-00			AC Coupled J-K Flipflop Replaceable by Motorola MC1013P
U410	156-0025-00			Quad 2-Input Gate Replaceable by Motorola MC1010P
U412	156-0022-00			AC Coupled J-K Flipflop Replaceable by Motorola MC1013P
U414	156-0025-00			Quad 2-Input Gate Replaceable by Motorola MC1010P
U415	156-0024-00			Dual 4-Input Gate Replaceable by Motorola MC1004P
U416	156-0025-00			Quad 2-Input Gate Replaceable by Motorola MC1010P
U418	156-0022-00			AC Coupled J-K Flipflop Replaceable by Motorola MC1013P
U420	156-0025-00			Quad 2-Input Gate Replaceable by Motorola MC1010P
U422	156-0022-00			AC Coupled J-K Flipflop Replaceable by Motorola MC1013P
U424	156-0025-00			Quad 2-Input Gate Replaceable by Motorola MC1010P
U426	156-0022-00			AC Coupled J-K Flipflop Replaceable by Motorola MC1013P
U428	156-0025-00			Quad 2-Input Gate Replaceable by Motorola MC1010P
U430	156-0022-00			AC Coupled J-K Flipflop Replaceable by Motorola MC1013P
U432	156-0025-00			Quad 2-Input Gate Replaceable by Motorola MC1010P
U440	156-0023-00			6-Input Gate Replaceable by Motorola MC1001P
U450	156-0022-00			AC Coupled J-K Flipflop Replaceable by Motorola MC1013P
U451	156-0022-00			AC Coupled J-K Flipflop Replaceable by Motorola MC1013P
U453	156-0012-00			Clocked J-K Flipflop Replaceable by Fairchild μL923
U454	156-0012-00			Clocked J-K Flipflop Replaceable by Fairchild μL923
U455	156-0012-00			Clocked J-K Flipflop Replaceable by Fairchild μL923
U456	156-0012-00			Clocked J-K Flipflop Replaceable by Fairchild μL923
U457	156-0012-00			Clocked J-K Flipflop Replaceable by Fairchild μL923
U470	156-0022-00			AC Coupled J-K Flipflop Replaceable by Motorola MC1013P

LOGIC #1 CARD

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
	*670-0178-00			Complete Card		

Semi-conductor Device, Diodes

Ckt. No.	Tektronix Part No.	Description	
D800	*152-0185-00	Silicon	Replaceable by 1N4152
D801	*152-0185-00	Silicon	Replaceable by 1N4152
D802	*152-0185-00	Silicon	Replaceable by 1N4152
D806	*152-0185-00	Silicon	Replaceable by 1N4152
D807	*152-0185-00	Silicon	Replaceable by 1N4152
D808	*152-0185-00	Silicon	Replaceable by 1N4152
D810	*152-0185-00	Silicon	Replaceable by 1N4152
D811	*152-0185-00	Silicon	Replaceable by 1N4152
D812	*152-0185-00	Silicon	Replaceable by 1N4152
D824	151-0503-00	Silicon	2N5060
D825	151-0503-00	Silicon	2N5060
D826	151-0503-00	Silicon	2N5060
D827	151-0503-00	Silicon	2N5060
D828	151-0503-00	Silicon	2N5060
D829	151-0503-00	Silicon	2N5060
D830	151-0503-00	Silicon	2N5060
D831	151-0503-00	Silicon	2N5060
D832	151-0503-00	Silicon	2N5060
D833	151-0503-00	Silicon	2N5060
D834	151-0503-00	Silicon	2N5060
D835	151-0503-00	Silicon	2N5060
D836	151-0503-00	Silicon	2N5060
D840	*152-0185-00	Silicon	Replaceable by 1N4152
D841	*152-0185-00	Silicon	Replaceable by 1N4152
D842	*152-0185-00	Silicon	Replaceable by 1N4152
D843	*152-0185-00	Silicon	Replaceable by 1N4152
D844	*152-0185-00	Silicon	Replaceable by 1N4152

Transistors

Ckt. No.	Tektronix Part No.	Description	
Q840	151-0224-00	Silicon	2N3692
Q845	151-0224-00	Silicon	2N3692

Resistors

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

Ckt. No.	Tektronix Part No.	Description		
R800	317-0123-00	12 kΩ	⅛ W	5%
R801	317-0432-00	4.3 kΩ	⅛ W	5%
R802	317-0203-00	20 kΩ	⅛ W	5%
R806	317-0123-00	12 kΩ	⅛ W	5%
R807	317-0432-00	4.3 kΩ	⅛ W	5%

LOGIC #1 CARD *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
				Diodes *(cont)*		
R808	317-0203-00			20 kΩ	⅛ W	5%
R810	317-0123-00			12 kΩ	⅛ W	5%
R811	317-0432-00			4.3 kΩ	⅛ W	5%
R812	317-0203-00			20 kΩ	⅛ W	5%
R824	317-0102-00			1 kΩ	⅛ W	5%
R825	317-0102-00			1 kΩ	⅛ W	5%
R826	317-0102-00			1 kΩ	⅛ W	5%
R827	317-0102-00			1 kΩ	⅛ W	5%
R828	317-0102-00			1 kΩ	⅛ W	5%
R829	317-0102-00			1 kΩ	⅛ W	5%
R830	317-0102-00			1 kΩ	⅛ W	5%
R831	317-0102-00			1 kΩ	⅛ W	5%
R832	317-0102-00			1 kΩ	⅛ W	5%
R833	317-0102-00			1 kΩ	⅛ W	5%
R834	317-0102-00			1 kΩ	⅛ W	5%
R835	317-0102-00			1 kΩ	⅛ W	5%
R836	317-0102-00			1 kΩ	⅛ W	5%
R838	315-0101-00			100 Ω	¼ W	5%
R840	315-0202-00			2 kΩ	¼ W	5%
R843	315-0272-00			2.7 kΩ	¼ W	5%
R845	315-0363-00			36 kΩ	¼ W	5%
				Integrated Circuits		
U800	156-0018-00			Quad 2-Input Gate Replaceable by Motorola MC817P		
U802	156-0018-00			Quad 2-Input Gate Replaceable by Motorola MC817P		
U804	156-0020-00			Quad 2-Input Gate Replaceable by Motorola MC824P		
U805	156-0019-00			J-K Flipflop Replaceable by Motorola MC822P		
U806	156-0019-00			J-K Flipflop Replaceable by Motorola MC822P		
U807	156-0019-00			J-K Flipflop Replaceable by Motorola MC822P		
U808	156-0019-00			J-K Flipflop Replaceable by Motorola MC822P		
U810	156-0018-00			Quad 2-Input Gate Replaceable by Motorola MC817P		
U812	156-0018-00			Quad 2-Input Gate Replaceable by Motorola MC817P		
U814	156-0018-00			Quad 2-Input Gate Replaceable by Motorola MC817P		
U816	156-0018-00			Quad 2-Input Gate Replaceable by Motorola MC817P		
U820	156-0021-00			Hex. Inverter Replaceable by Motorola MC889P		
U822	156-0018-00			Quad 2-Input Gate Replaceable by Motorola MC817P		
U824	156-0018-00			Quad 2-Input Gate Replaceable by Motorola MC817P		
U826	156-0021-00			Hex. Inverter Replaceable by Motorola MC889P		
U828	156-0018-00			Quad 2-Input Gate Replaceable by Motorola MC817P		
U830	156-0018-00			Quad 2-Input Gate Replaceable by Motorola MC817P		
U832	156-0018-00			Quad 2-Input Gate Replaceable by Motorola MC817P		
U834	156-0018-00			Quad 2-Input Gate Replaceable by Motorola MC817P		
U836	156-0018-00			Quad 2-Input Gate Replaceable by Motorola MC817P		

LOGIC #2 CARD

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
	*670-0179-00			Complete Card	

Semi-conductor. Device, Diodes

Ckt. No.	Tektronix Part No.	Eff	Disc	Description	
D850	*152-0185-00			Silicon	Replaceable by 1N4152
D851	*152-0185-00			Silicon	Replaceable by 1N4152
D852	*152-0185-00			Silicon	Replaceable by 1N4152
D853	*152-0185-00			Silicon	Replaceable by 1N4152
D854	*152-0185-00			Silicon	Replaceable by 1N4152
D855	*152-0185-00			Silicon	Replaceable by 1N4152
D856	*152-0185-00			Silicon	Replaceable by 1N4152
D857	*152-0185-00			Silicon	Replaceable by 1N4152
D858	*152-0185-00			Silicon	Replaceable by 1N4152
D859	*152-0185-00			Silicon	Replaceable by 1N4152
D860	*152-0185-00			Silicon	Replaceable by 1N4152
D861	*152-0185-00			Silicon	Replaceable by 1N4152
D862	*152-0185-00			Silicon	Replaceable by 1N4152
D864	*152-0185-00			Silicon	Replaceable by 1N4152
D865	*152-0185-00			Silicon	Replaceable by 1N4152
D871	*152-0185-00			Silicon	Replaceable by 1N4152
D873	*152-0185-00			Silicon	Replaceable by 1N4152
D875	*152-0185-00			Silicon	Replaceable by 1N4152
D877	*152-0185-00			Silicon	Replaceable by 1N4152
D879	*152-0185-00			Silicon	Replaceable by 1N4152
D881	*152-0185-00			Silicon	Replaceable by 1N4152
D883	*152-0185-00			Silicon	Replaceable by 1N4152
D885	*152-0185-00			Silicon	Replaceable by 1N4152
D887	*152-0185-00			Silicon	Replaceable by 1N4152
D889	*152-0185-00			Silicon	Replaceable by 1N4152
D890	*152-0185-00			Silicon	Replaceable by 1N4152
D891	*152-0185-00			Silicon	Replaceable by 1N4152
D892	*152-0185-00			Silicon	Replaceable by 1N4152
D894	*152-0185-00			Silicon	Replaceable by 1N4152
D899A	*152-0185-00			Silicon	Replaceable by 1N4152
D899B	*152-0185-00			Silicon	Replaceable by 1N4152
D899C	*152-0185-00			Silicon	Replaceable by 1N4152
D899D	*152-0185-00			Silicon	Replaceable by 1N4152
D899E	*152-0185-00			Silicon	Replaceable by 1N4152
D899F	*152-0185-00			Silicon	Replaceable by 1N4152
D899G	*152-0185-00			Silicon	Replaceable by 1N4152
D889H	*152-0185-00			Silicon	Replaceable by 1N4152
D899I	*152-0185-00			Silicon	Replaceable by 1N4152

LOGIC #2 CARD *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		

Transistors

Ckt. No.	Tektronix Part No.	Eff	Disc	Description	
Q871	151-0250-00			Silicon	2N5184
Q873	151-0250-00			Silicon	2N5184
Q875	151-0250-00			Silicon	2N5184
Q877	151-0250-00			Silicon	2N5184
Q879	151-0250-00			Silicon	2N5184
Q881	151-0250-00			Silicon	2N5184
Q883	151-0224-00			Silicon	2N3692
Q885	151-0224-00			Silicon	2N3692
Q887	151-0224-00			Silicon	2N3692
Q889	151-0250-00			Silicon	2N5184
Q890	151-0223-00			Silicon	2N4275

Resistors

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

Ckt. No.	Tektronix Part No.	Eff	Disc	Description		
R850	317-0123-00			12 kΩ	1/8 W	5%
R851	317-0432-00			4.3 kΩ	1/8 W	5%
R852	317-0203-00			20 kΩ	1/8 W	5%
R856	317-0123-00			12 kΩ	1/8 W	5%
R857	317-0432-00			4.3 kΩ	1/8 W	5%
R858	317-0203-00			20 kΩ	1/8 W	5%
R860	317-0123-00			12 kΩ	1/8 W	5%
R861	317-0432-00			4.3 kΩ	1/8 W	5%
R862	317-0203-00			20 kΩ	1/8 W	5%
R871	317-0102-00			1 kΩ	1/8 W	5%
R873	317-0102-00			1 kΩ	1/8 W	5%
R875	317-0102-00			1 kΩ	1/8 W	5%
R877	317-0102-00			1 kΩ	1/8 W	5%
R879	317-0102-00			1 kΩ	1/8 W	5%
R881	317-0102-00			1 kΩ	1/8 W	5%
R883	317-0102-00			1 kΩ	1/8 W	5%
R885	317-0102-00			1 kΩ	1/8 W	5%
R887	317-0102-00			1 kΩ	1/8 W	5%
R889	317-0362-00			3.6 kΩ	1/8 W	5%
R890	317-0103-00			10 kΩ	1/8 W	5%
R894	315-0122-00			1.2 kΩ	1/4 W	5%

Integrated Circuits

Ckt. No.	Tektronix Part No.	Eff	Disc	Description	
U850	156-0021-00			Hex. Inverter	Replaceable by Motorola MC889P
U852	156-0020-00			Quad 2-Input Gate	Replaceable by Motorola MC824P
U854	156-0021-00			Hex. Inverter	Replaceable by Motorola MC889P
U856	156-0018-00			Quad 2-Input Gate	Replaceable by Motorola MC817P
U858	156-0020-00			Quad 2-Input Gate	Replaceable by Motorola MC824P

LOGIC #2 CARD *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
				Integrated Circuits *(cont)*
U860	156-0018-00			Quad 2-Input Gate Replaceable by Motorola MC817P
U862	156-0018-00			Quad 2-Input Gate Replaceable by Motorola MC817P
U864	156-0018-00			Quad 2-Input Gate Replaceable by Motorola MC817P
U866	156-0018-00			Quad 2-Input Gate Replaceable by Motorola MC817P
U870	156-0018-00			Quad 2-Input Gate Replaceable by Motorola MC817P
U872	156-0018-00			Quad 2-Input Gate Replaceable by Motorola MC817P
U874	156-0018-00			Quad 2-Input Gate Replaceable by Motorola MC817P
U876	156-0018-00			Quad 2-Input Gate Replaceable by Motorola MC817P
U878	156-0018-00			Quad 2-Input Gate Replaceable by Motorola MC817P
U880	156-0018-00			Quad 2-Input Gate Replaceable by Motorola MC817P

FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations which appear on the pullout pages immediately following the Diagrams section of this instruction manual.

INDENTATION SYSTEM

This mechanical parts list is indented to indicate item relationships. Following is an example of the indentation system used in the Description column.

Assembly and/or Component
  Detail Part of Assembly and/or Component
  mounting hardware for Detail Part
    Parts of Detail Part
    mounting hardware for Parts of Detail Part
mounting hardware for Assembly and/or Component

Mounting hardware always appears in the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation.

Mounting hardware must be purchased separately, unless otherwise specified.

PARTS ORDERING INFORMATION

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

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

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

Change information, if any, is located at the rear of this manual.

ABBREVIATIONS AND SYMBOLS

For an explanation of the abbreviations and symbols used in this section, please refer to the page immediately preceding the Electrical Parts List in this instruction manual.

INDEX OF MECHANICAL PARTS LIST ILLUSTRATIONS

(Located behind diagrams)

SECTION 7
MECHANICAL PARTS LIST

FIG. 1 EXPLODED

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
1-1	366-1035-01			1	KNOB, charcoal—HORIZ POS
-2	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	*mounting hardware: (not included w/resistor)*
	213-0020-00			1	SCREW, set, 6-32 x 1/8 inch, HSS
-3	366-0220-00			1	KNOB, charcoal—PROGRAM SELECTOR
	- - - - - -			-	knob includes:
	213-0020-00			1	SCREW, set, 6-32 x 1/8 inch, HSS
-4	262-0846-00			1	SWITCH, wired—PROGRAM SELECTOR
	- - - - - -			-	switch includes:
	260-0981-00			1	SWITCH, unwired
	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0255-00			1	LUG, solder, 3/8 inch diameter
	210-0978-00			1	WASHER, flat, 3/8 ID x 1/2 inch OD
-5	210-0590-00			1	NUT, hex., 3/8-32 x 7/16 inch
-6	366-0189-00			1	KNOB, red—MULTIPLIER
	- - - - - -			-	knob includes:
	213-0020-00			1	SCREW, set, 6-32 x 1/8 inch, HSS
-7	366-0322-00			1	KNOB, charcoal—TIME/DIV
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
-8	260-0982-00			1	SWITCH, unwired—TIME/DIV
	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0012-00			1	LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
	210-0978-00			1	WASHER, flat, 3/8 ID x 1/2 inch OD
-9	210-0590-00			1	NUT, hex., 3/8-32 x 7/16 inch
-10	366-0319-00			1	KNOB, red—RECOVERY TIME
	- - - - - -			-	knob includes:
	213-0020-00			1	SCREW, set, 6-32 x 1/8 inch, HSS
-11	366-0138-00			1	KNOB, charcoal—SENSITIVITY
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
-12	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
-13	210-0590-00			1	NUT, hex., 3/8-32 x 7/16 inch
-14	366-0189-00			1	KNOB, red—POLARITY
	- - - - - -			-	knob includes:
	213-0020-00			1	SCREW, set, 6-32 x 1/8 inch, HSS
-15	366-0322-00			1	KNOB, charcoaal—MODE
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS

FIG. 1 EXPLODED *(cont)*

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description 1 2 3 4 5
1-16	262-0847-00			1	SWITCH, wired—MODE
	- - - - - -			-	switch includes:
	260-0983-00			1	SWITCH, unwired
	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0012-00			1	LOCKWASHER, internal, $\frac{3}{8}$ ID x $\frac{1}{2}$ inch OD
	210-0978-00			1	WASHER, flat, $\frac{3}{8}$ ID x $\frac{1}{2}$ inch OD
-17	210-0590-00			1	NUT, hex., $\frac{3}{8}$-32 x $\frac{7}{16}$ inch
-18	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
	210-0471-00			1	NUT, hex., $\frac{1}{4}$-32 x $\frac{5}{16}$ x $\frac{19}{32}$ inch long
-19	210-0223-00			1	LUG, solder, $\frac{1}{4}$ ID x $\frac{7}{16}$ inch OD, SE
-20	358-0054-00			1	BUSHING, resistor mounting
-21	367-0075-00			1	HANDLE
	- - - - - -			-	mounting hardware: (not included w/handle)
-22	213-0187-00			2	SCREW, set, 8-32 x $\frac{7}{8}$ inch, HSS
-23	366-0061-00			1	KNOB, plug-in securing
	- - - - - -			-	knob includes:
	213-0005-00			1	SCREW, set, 8-32 x $\frac{1}{8}$ inch, HSS
-24	214-0052-00			1	FASTENER, pawl right w/stop
	- - - - - -			-	mounting hardware: (not included w/fastener)
	210-0004-00			2	LOCKWASHER, internal, #4
-25	210-0406-00			2	NUT, hex., 4-40 x $\frac{3}{16}$ inch
-26	260-0932-00			1	SWITCH, unwired—DELAY
	- - - - - -			-	mounting hardware: (not included w/switch)
	211-0030-00			4	SCREW, 2-56 x $\frac{1}{4}$ inch, 100° csk, FHS
	210-0405-00			4	NUT, hex., 2-56 x $\frac{3}{16}$ inch
-27	260-0816-00			1	SWITCH, slide—SAMPLES/DIV
	- - - - - -			-	mounting hardware: (not included w/switch)
	211-0030-00			2	SCREW, 2-56 x $\frac{1}{4}$ inch, 100° csk, FHS
	210-0405-00			2	NUT, hex., 2-56 x $\frac{3}{16}$ inch
-28	378-0541-00			2	FILTER, lens, neon
-29	352-0064-01			1	HOLDER, neon, dual
	- - - - - -			-	mounting hardware: (not included w/holder)
	211-0109-00			1	SCREW, 4-40 x $\frac{7}{8}$ inch, 100° csk, FHS
	210-0406-00			2	NUT, hex., 4-40 x $\frac{3}{16}$ inch

FIG. 1 EXPLODED *(cont)*

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
1-30	670-0143-00			1	ASSEMBLY, circuit board, neon
	- - - - - -			-	assembly includes:
	388-0842-00			1	BOARD, circuit
	136-0252-00			6	SOCKET, pin connector
-31	200-0534-00			1	COVER, neon holder
-32	333-1053-02			1	PANEL, front
-33	386-1361-00			1	PLATE, readout
-34	214-1019-00			1	HEAT SINK, readout
-35	386-1378-00			1	SUB-PANEL, front
-36	214-0889-00			1	LIGHT DIVIDER, readout
-37	214-0890-00			1	INSULATOR, readout
-38	670-0182-00			1	ASSEMBLY, circuit board—READOUT
	- - - - - -			-	assembly includes:
	388-0711-01			1	BOARD, circuit
	- - - - - -			-	mounting hardware: (not included w/assembly)
	210-0586-00			2	NUT, keps, 4-40 x 1/4 inch
-39	- - - - - -			1	BULB ASSEMBLY, w/hardware
-40	386-1360-00			1	SUPPORT, chassis
	- - - - - -			-	support includes:
-41	211-0094-00			4	SCREW, 4-40 x 1/2 inch, THS
-42	358-0215-00			1	BUSHING, plastic, horseshoe
-43	348-0149-00			1	GROMMET, plastic, "U" shaped
-44	348-0158-00			1	GROMMET, plastic, "U" shaped
-45	- - - - - -			1	RESISTOR
	- - - - - -			-	mounting hardware: (not included w/resistor)
-46	211-0544-00			1	SCREW, 6-32 x 3/4 inch, THS
	210-0805-00			1	WASHER, flat, 0.204 ID x 0.438 inch OD
-47	210-0478-00			1	NUT, resistor mounting
-48	211-0507-00			1	SCREW, 6-32 x 5/16 inch, PHS
-49	343-0089-00			7	CLAMP, cable, plastic, large
-50	343-0088-00			3	CLAMP, cable, plastic, small
-51	441-0775-00			1	CHASSIS, display
	- - - - - -			-	mounting hardware: (not included w/chassis)
-52	211-0504-00			5	SCREW, 6-32 x 1/4 inch, PHS
-53	441-0776-00			1	CHASSIS, timing
	- - - - - -			-	mounting hardware: (not included w/chassis)
-54	211-0504-00			5	SCREW, 6-32 x 1/4 inch, PHS
-55	129-0162-00			2	POST, metal
	- - - - - -			-	mounting hardware for each: (not included w/post)
-56	211-0007-00			2	SCREW, 4-40 x 3/16 inch, PHS
-57	131-0549-00			2	CONECTOR, 56 pin
	- - - - - -			-	mounting hardware for each: (not included w/connector)
-58	211-0014-00			2	SCREW, 4-40 x 1/2 inch, PHS

FIG. 1 EXPLODED *(cont)*

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
1-59	129-0152-00			2	POST, metal
	- - - - - -			-	mounting hardware for each: (not included w/post)
-60	211-0504-00			2	SCREW, 6-32 x 1/4 inch, PHS
-61	- - - - - -			1	TRANSFORMER
	- - - - - -			-	mounting hardware: (not included w/transformer)
-62	211-0021-00			2	SCREW, 4-40 x 1 1/4 inches, RHS
-63	210-0004-00			2	LOCKWASHER, internal, #4
-64	344-0016-00			2	CLIP, capacitor mounting
	- - - - - -			-	mounting hardware for each: (not included w/clip)
-65	213-0044-00			1	SCREW, thread forming, 5-32 x 3/16 inch, PHS
-66	344-0152-00			2	CLIP, circuit board
	- - - - - -			-	mounting hardware for each: (not included w/clip)
-67	211-0503-00			2	SCREW, 6-32 x 3/16 inch, PHS
68	214-1039-00			1	PLATE, insulator
-69	214-1040-00			1	PLATE, insulator
-70	131-0513-02			137	CONNECTOR, feed-thru
	- - - - - -			-	mounting hardware for each: (not included w/connector)
-71	358-0329-00			1	BUSHING, plastic
-72	214-1042-00			11	SPRING, helical compression
-73	670-0181-00			1	ASSEMBLY, circuit board—DISPLAY
	- - - - - -			-	assembly includes:
	388-0970-00			1	BOARD, circuit
-74	136-0183-00			9	SOCKET, transistor, 3 pin
-75	136-0220-00			38	SOCKET, transistor, 3 pin
-76	136-0235-00			3	SOCKET, transistor, 6 pin
-77	136-0257-00			1	SOCKET, transistor, 4 pin
78	136-0263-01			86	SOCKET, connector pin
-79	200-0385-00			4	COVER, transistor
-80	211-0610-00			7	SCREW, 6-32 x 3/8 inch, PHB
-81	361-0182-00			7	SPACER, sleeve
82	670-0179-00			1	ASSEMBLY, circuit card—LOGIC #2
	- - - - - -			-	assembly includes:
	388-0968-00			1	CARD, circuit
-83	136-0220-00			11	SOCKET, transistor, 3 pin
-84	136-0269-00			15	SOCKET, integrated circuit, 14 pin
-85	367-0090-00			1	GRIP, plastic
-86	210-1062-00			1	WASHER, recessed, plastic
-87	213-0082-00			1	SCREW, thread cutting, 4-40 x 1/2 inch, PHS

FIG. 1 EXPLODED *(cont)*

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
1-88	670-0178-00			1	ASSEMBLY, circuit card—LOGIC #1
	- - - - - -			-	assembly includes
	388-0967-00			1	CARD, circuit
-89	136-0220-00			15	SOCKET, transistor, 3 pin
-90	136-0269-00			20	SOCKET, integrated circuit, 14 pin
-91	367-0090-00			1	GRIP, plastic
-92	210-1062-00			1	WASHER, recessed, plastic
-93	213-0082-00			1	SCREW, thread cutting, 4-40 x 1/2 inch, PHS
-94	670-0180-00			1	ASSEMBLY, circuit board—TIMING
	- - - - - -			-	assembly includes:
	388-0969-00			1	BOARD, circuit
-95	131-0265-00			2	CONNECTOR, coaxial, male, right angle
-96	131-0391-00			1	CONNECTOR, coaxial, male
-97	136-0220-00			38	SOCKET, transistor, 3 pin
-98	136-0235-00			1	SOCKET, transistor, 6 pin
-99	136-0237-00			5	SOCKET, transistor, 8 pin
-100	136-0252-01			2	SOCKET, connector pin
-101	136-0263-00			51	SOCKET, connector pin
-102	136-0269-00			25	SOCKET, integrated circuit, 14 pin
-103	211-0610-00			4	SCREW, 6-32 x 13/8 inch, PHB
-104	361-0182-00			4	SPACER, sleeve
-105	- - - - - -			2	TRANSISTOR
	- - - - - -			-	mounting hardware for each: (not included w/transistor)
-106	211-0507-00			2	SCREW, 6-32 x 5/16 inch, PHS
-107	210-0457-00			2	NUT, keps, 6-32 x 5/16 inch
-108	384-0615-00			4	ROD, spacing
-109	131-0149-00			1	CONNECTOR, 24 pin, male
	- - - - - -			-	mounting hardware: (not included w/connector)
-110	210-0586-00			2	NUT, keps, 4-40 x 1/4 inch
	166-0032-00			2	TUBE, spacer
-111	211-0016-00			2	SCREW, 4-40 x 5/8 inch, PHS
-112	131-0149-00			1	CONNECTOR, 24 pin, male
	- - - - - -			-	mounting hardware: (not included w/connector)
	211-0008-00			2	SCREW, 4-40 x 1/4 inch, PHS
-113	210-0586-00			2	NUT, keps, 4-40 x 1/4 inch
-114	352-0031-00			1	HOLDER, fuse, single
	- - - - - -			-	mounting hardware: (not included w/holder)
-115	211-0510-00			1	SCREW, 6-32 x 3/8 inch, PHS
-116	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch

FIG. 1 EXPLODED *(cont)*

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
1-117	210-0202-00			1	LUG, solder, SE #6
	- - - - - -			-	mounting hardware: (not included w/lug)
-118	211-0504-00			1	SCREW, 6-32 x 1/4 inch, PHS
-119	210-0407-00			1	NUT, hex., 6-32 x 5/16 inch
-120	131-0327-00			1	CONNECTOR, 30 pin, female
	- - - - - -			-	mounting hardware: (not included w/connector)
-121	211-0014-00			2	SCREW, 4-40 x 1/2 inch, PHS
-122	210-0586-00			2	NUT, keps, 4-40 x 1/4 inch
-123	351-0037-00			1	GUIDE, plug-in
	- - - - - -			-	mounting hardware: (not included w/guide)
-124	211-0013-00			1	SCREW, 4-40 x 3/8 inch, PHS
-125	210-0586-00			1	NUT, keps, 4-40 x 1/4 inch
-126	386-1362-00			1	PANEL, rear
	- - - - - -			-	mounting hardware: (not included w/panel)
-127	212-0023-00			4	SCREW, 8-32 x 3/8 inch, PHS
-128	179-1298-00			1	WIRING HARNESS, chassis
	- - - - - -			-	wiring harness includes:
	131-0512-00			89	CONNECTOR
-129	179-1296-00			1	WIRING HARNESS, display
	- - - - - -			-	wiring harness includes:
	131-0512-00			56	CONNECTOR
-130	179-1301-00			1	WIRING HARNESS, switch
-131	179-1302-00			1	WIRING HARNESS, delay line, w/connectors
-132	175-1010-00			1	CABLE ASSEMBLY, connector
	- - - - - -			-	cable assembly includes:
	131-0155-00			1	CONNECTOR, coaxial, 50 Ω
	175-1011-00			1	CABLE ASSEMBLY, connector
	- - - - - -			-	cable assembly includes:
-133	131-0614-00			1	CONNECTOR
	- - - - - -			-	mounting hardware: (not included w/cable assembly)
-134	361-0192-01			1	SPACER, ring
-135	358-0172-00			1	BUSHING, connector

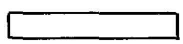
STANDARD ACCESSORIES (not shown)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description
	388-0805-00			1	BOARD, circuit, connector
	070-0761-00			2	MANUAL, instruction

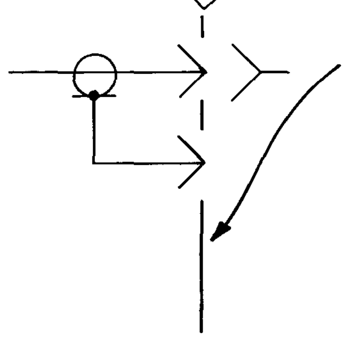
SECTION 8
DIAGRAMS

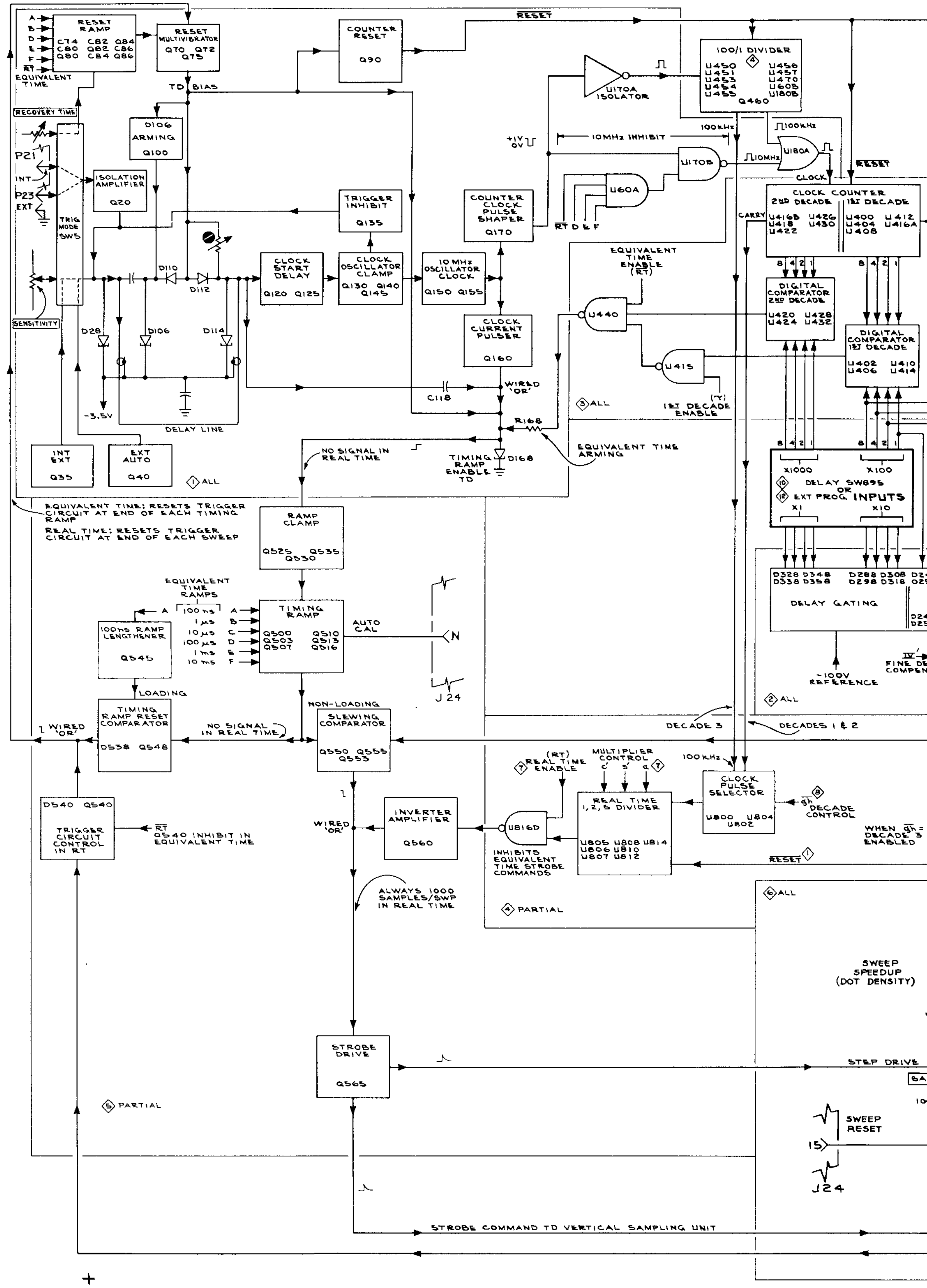
The following symbols are used on the diagrams:


Screwdriver adjustment

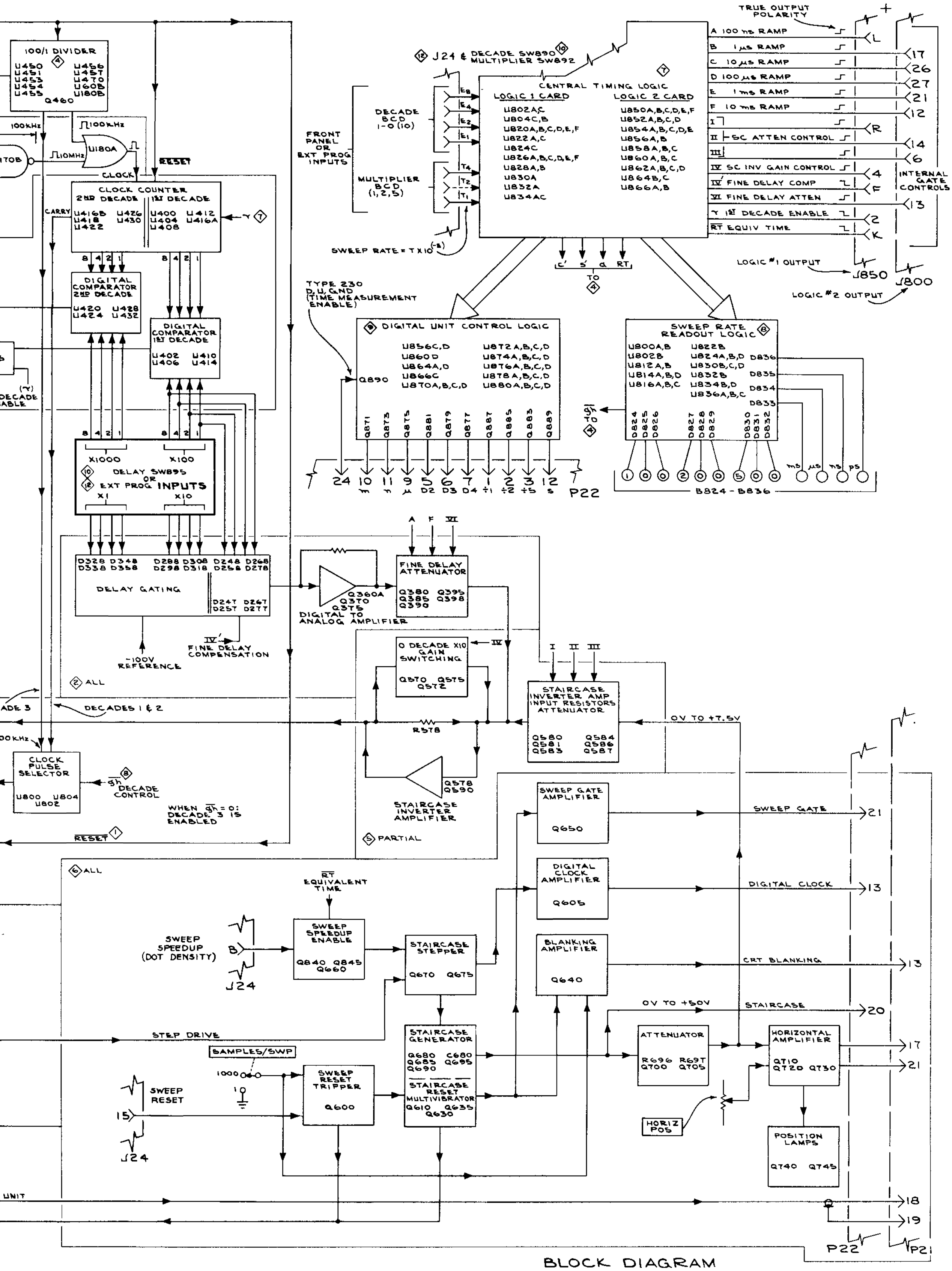

Front panel control or connector

Refer to indicated diagram


Blue line encloses components located on circuit board

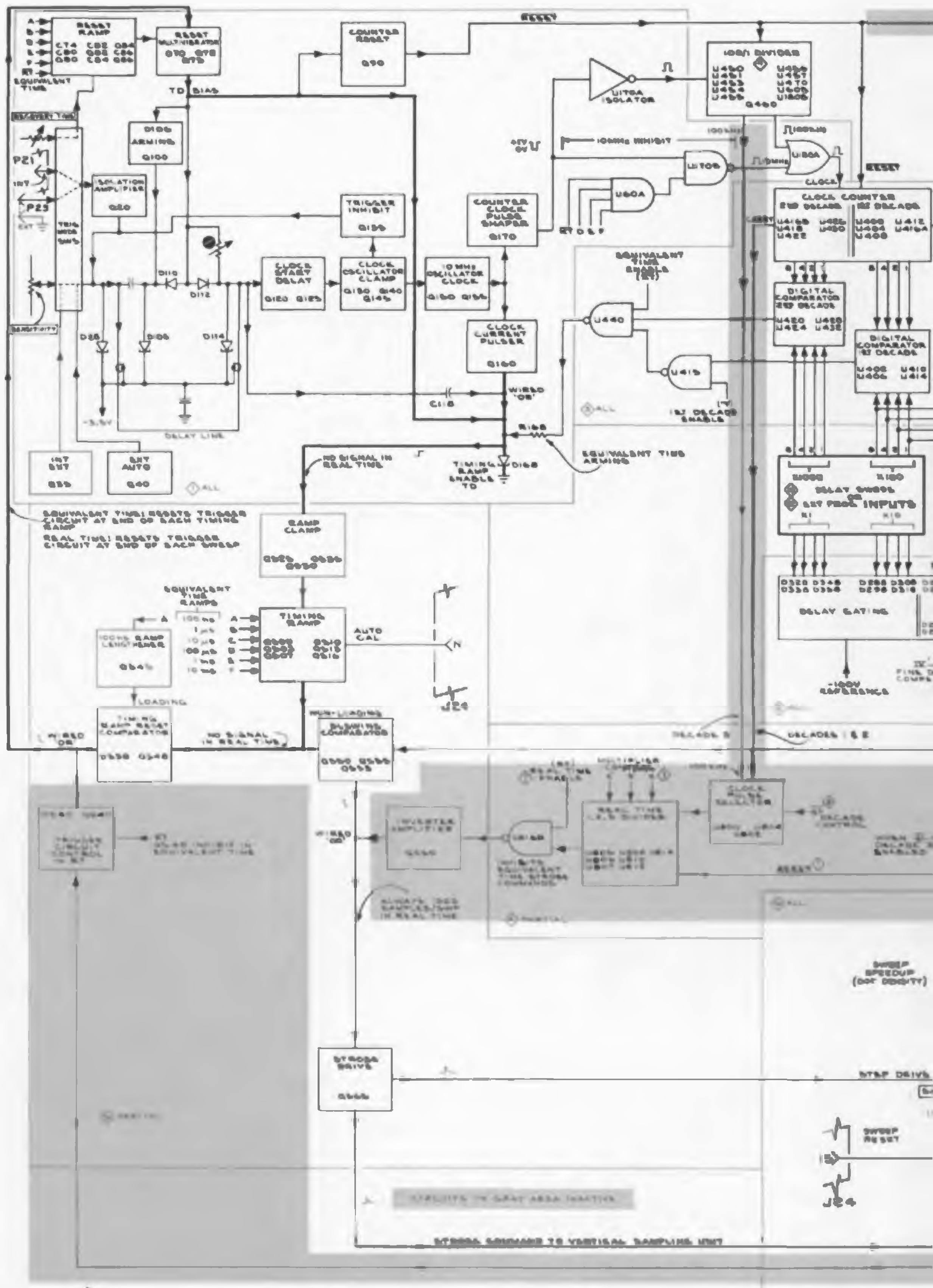


TYPE 3T6

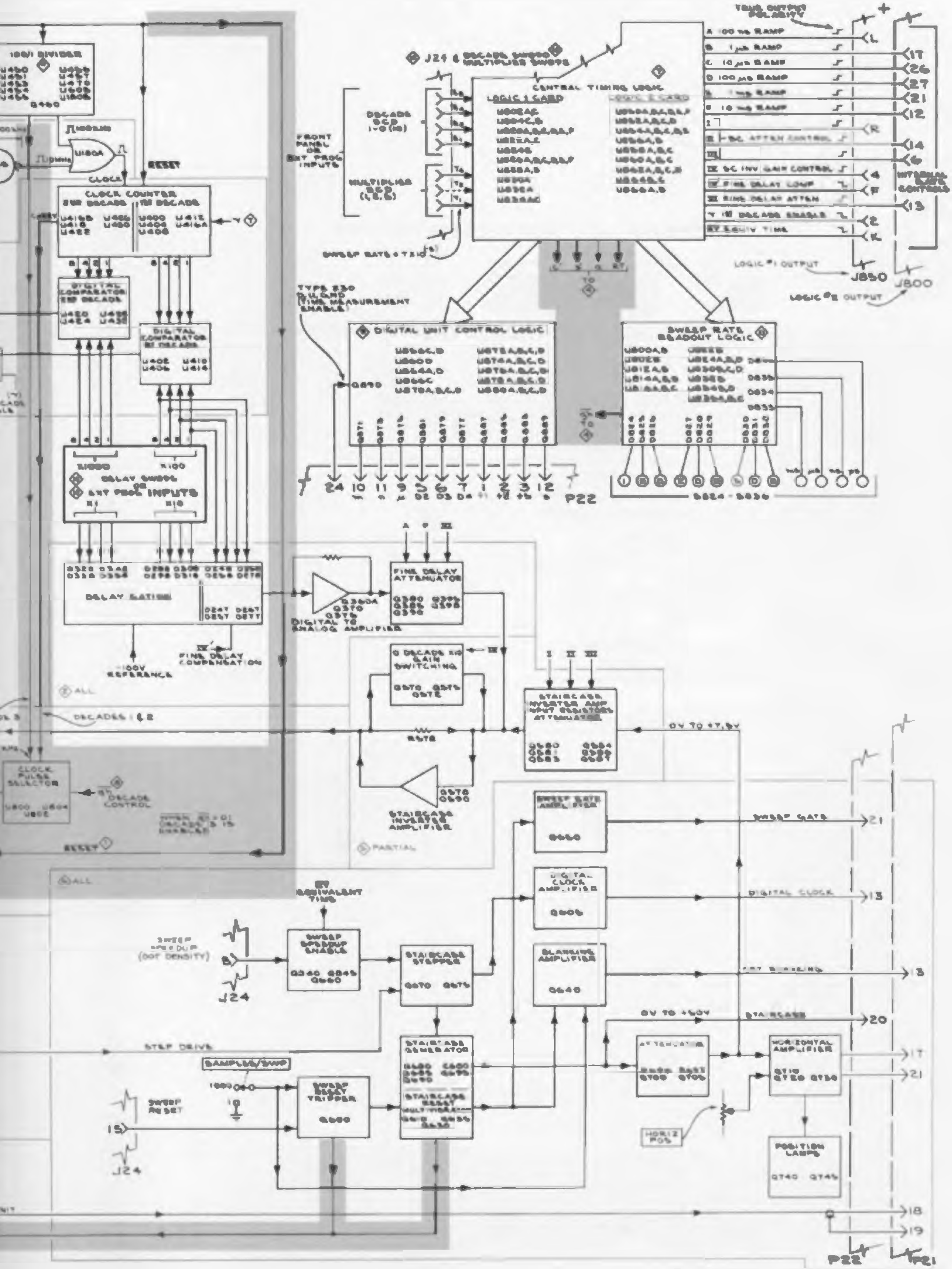


BLOCK DIAGRAM

1168

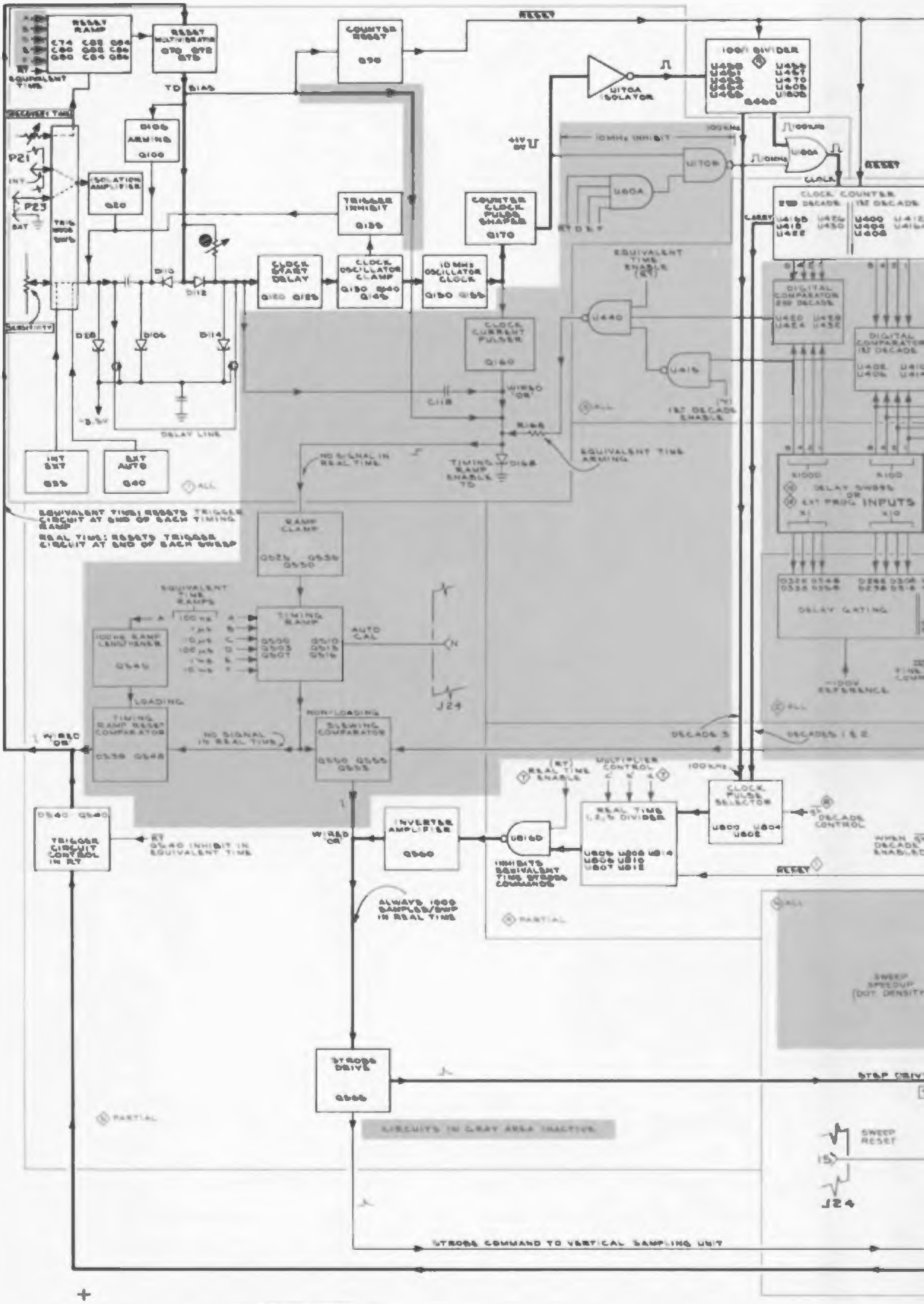


TYPE 3T6 EQUIVALENT TIME

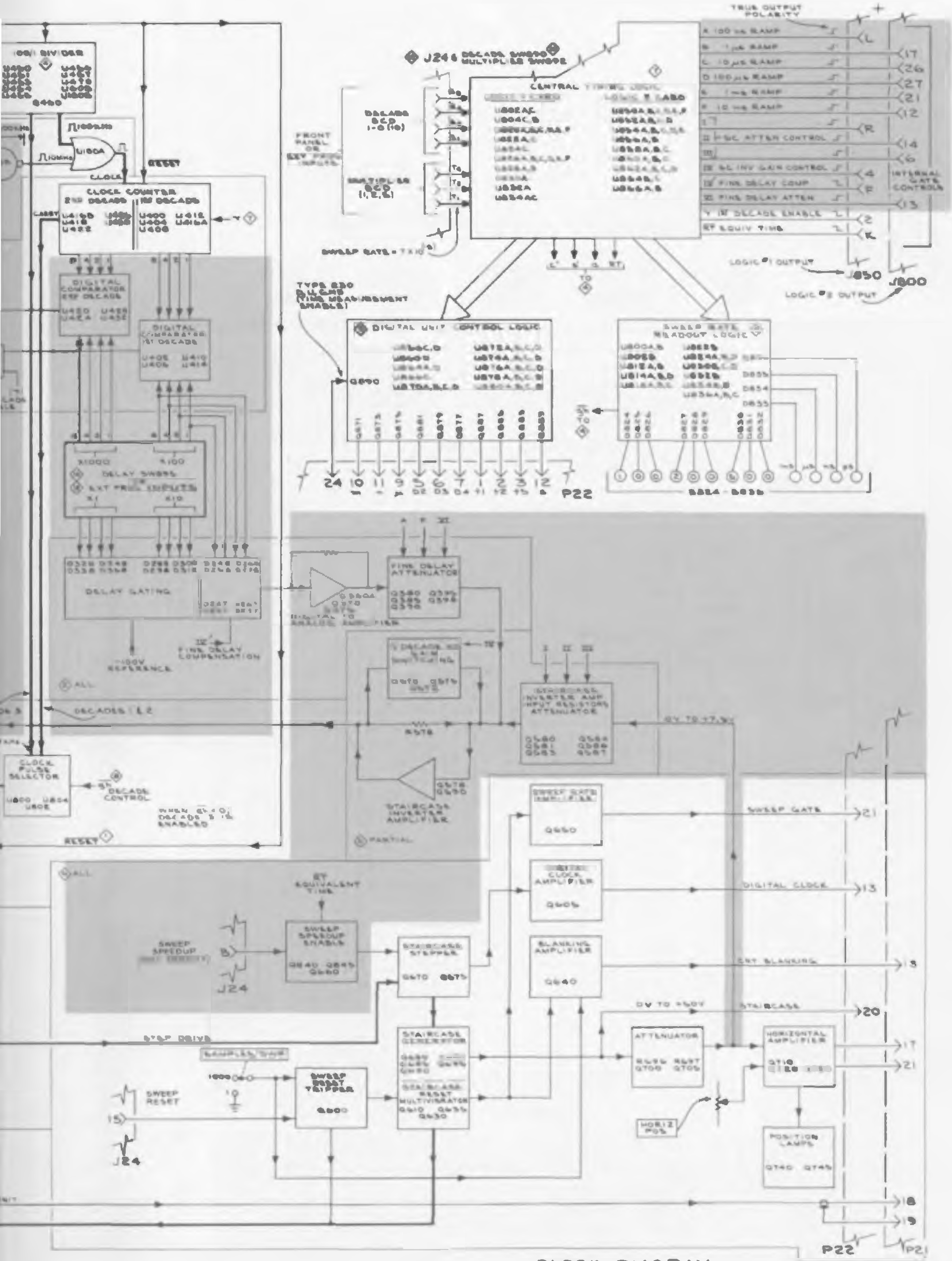


BLOCK DIAGRAM

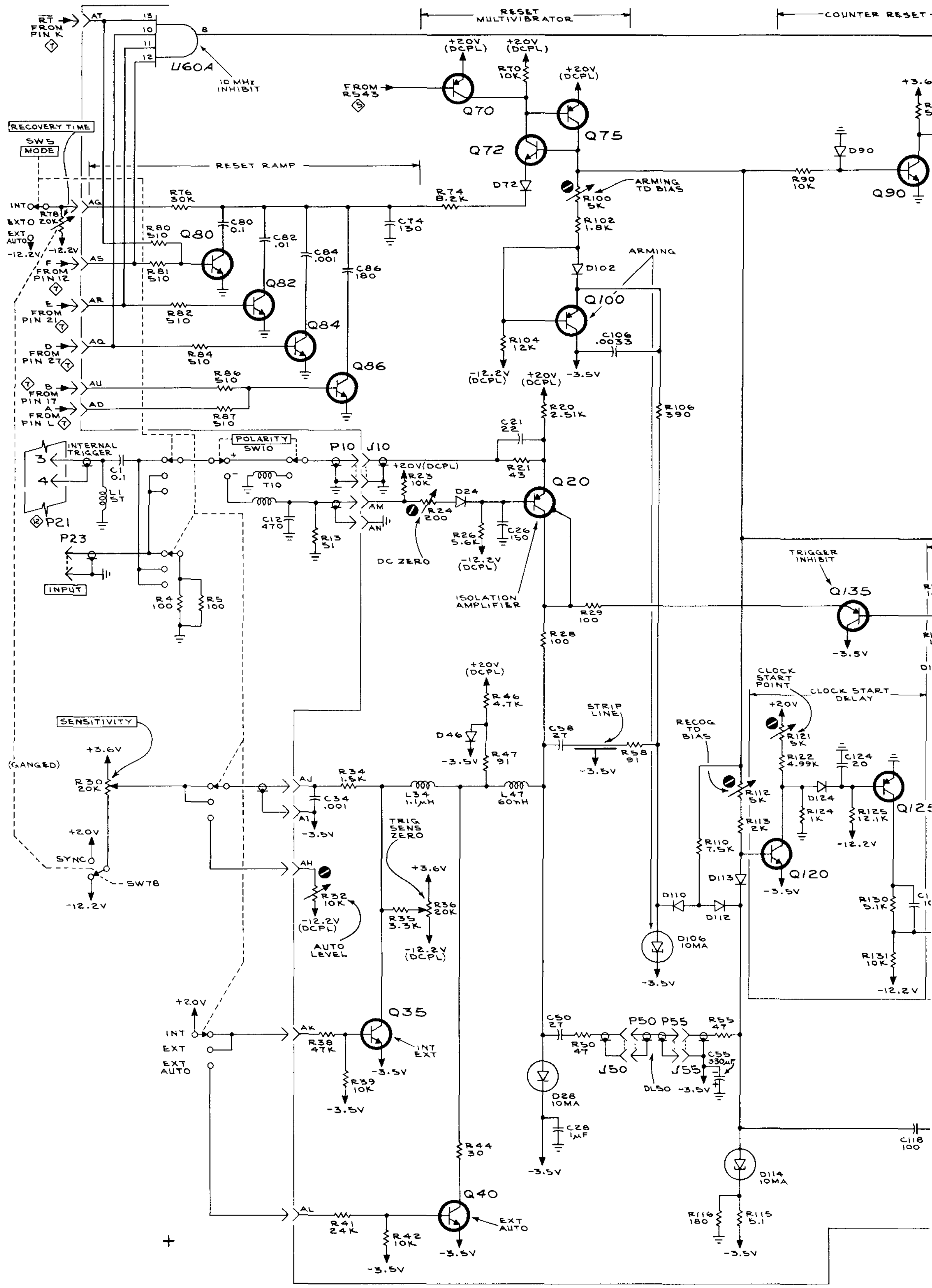
1168



TYPE 3T6 REAL TIME

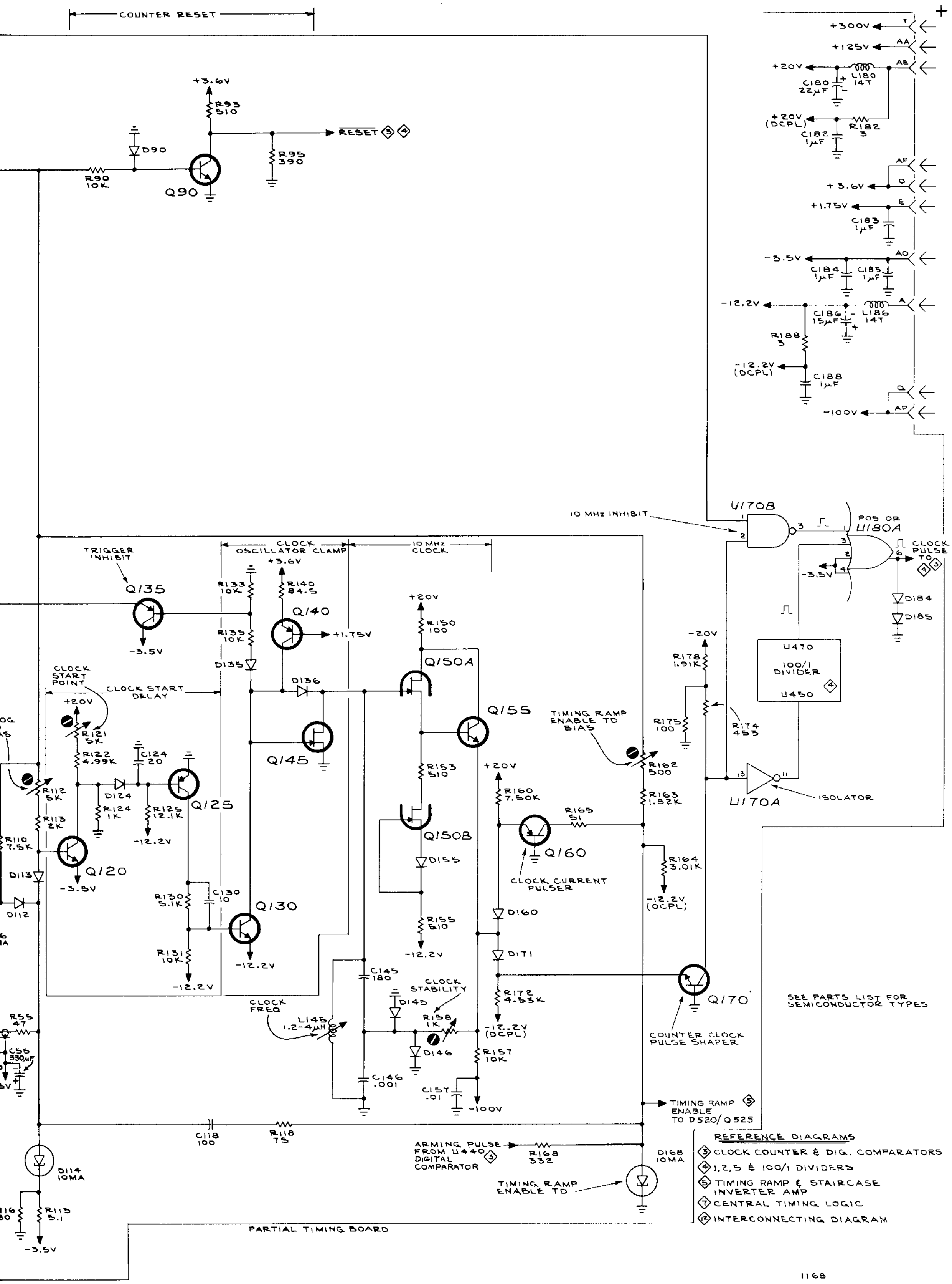


BLOCK DIAGRAM


RESET MULTIVIBRATOR
COUNTER RESET
U60A
10 MHz INHIBIT
FROM R543
Q70
Q72
Q75
RESET RAMP
RECOVERY TIME
SW5
MODE
ARMING TD BIAS
R100 5K
ARMING
Q80
Q82
Q84
Q86
Q100
Q90
Q20
ISOLATION AMPLIFIER
DC ZERO
INTERNAL TRIGGER
POLARITY SW10
P10
J10
P21
P23
INPUT
TRIGGER INHIBIT
Q135
CLOCK START POINT
CLOCK START DELAY
SENSITIVITY
(GANGED)
STRIP LINE
RECOG TD BIAS
TRIG SENS ZERO
AUTO LEVEL
Q120
Q35
Q40
INT EXT
EXT AUTO
SW7B
SYNC
P50 P55
J50
J55
DL50

TYPE 3T6

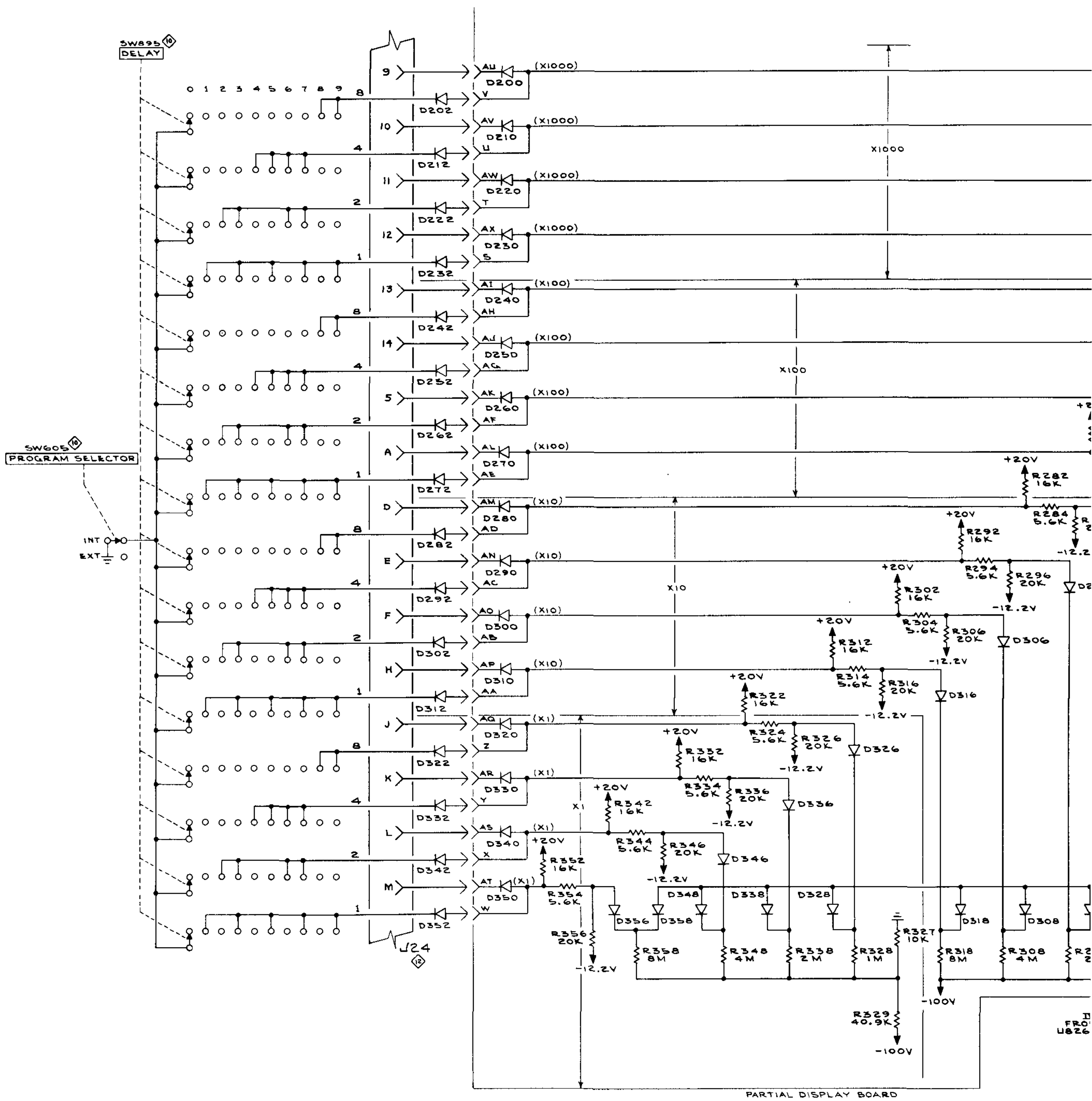
A



1168

A

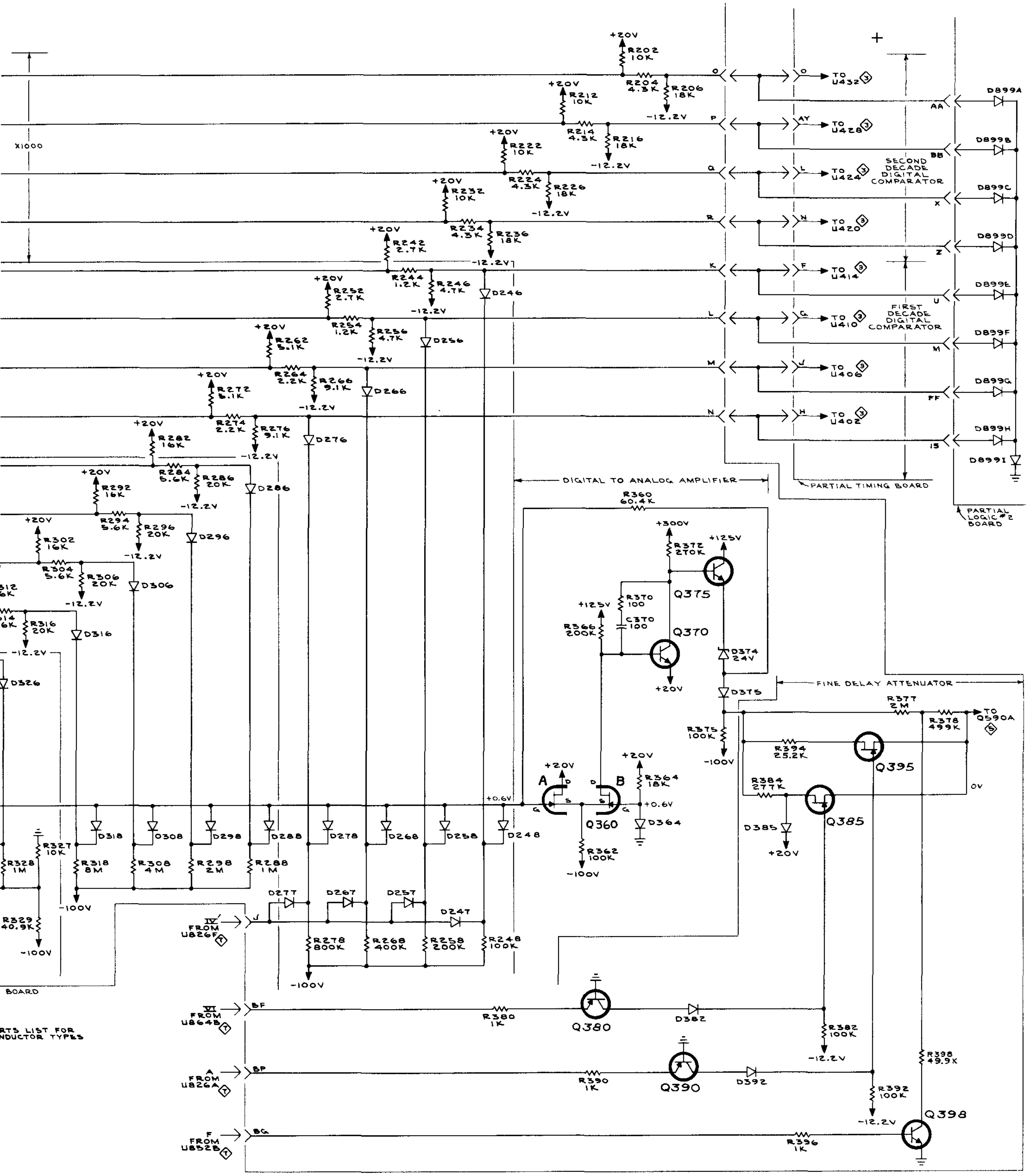
TRIGGER & CLOCK ①



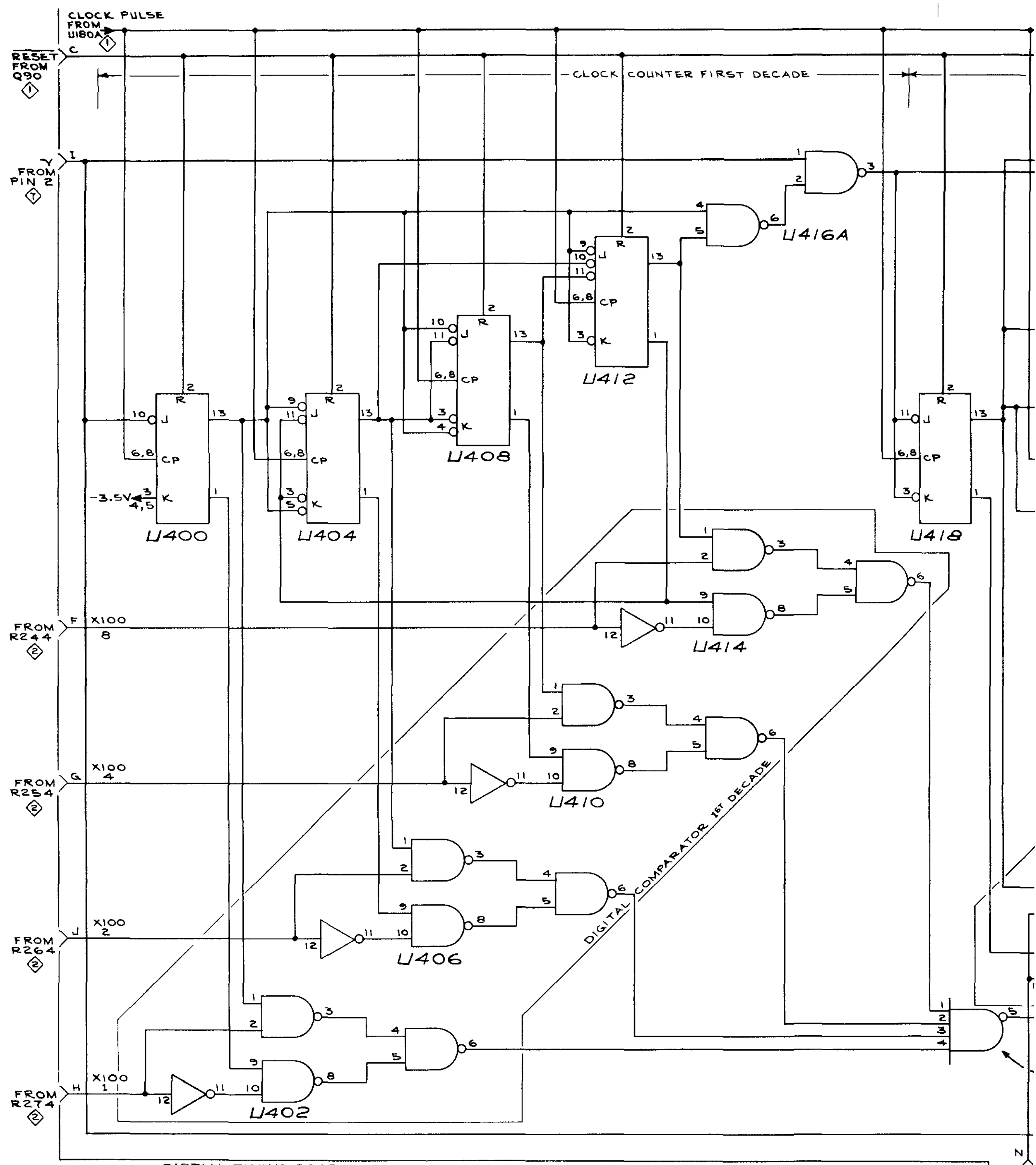
REFERENCE DIAGRAMS

- ③ CLOCK COUNTER & DIG. COMPARATORS
- ④ 1,2,5 & 100/1 DIVIDERS
- ⑤ TIMING RAMP & STAIRCASE INVERTER AMP
- ⑦ CENTRAL TIMING LOGIC
- ⑩ SWITCHING & DELAY READOUT
- ⑯ INTERCONNECTING DIAGRAM

SEE PARTS LIST FOR SEMICONDUCTOR TYPES



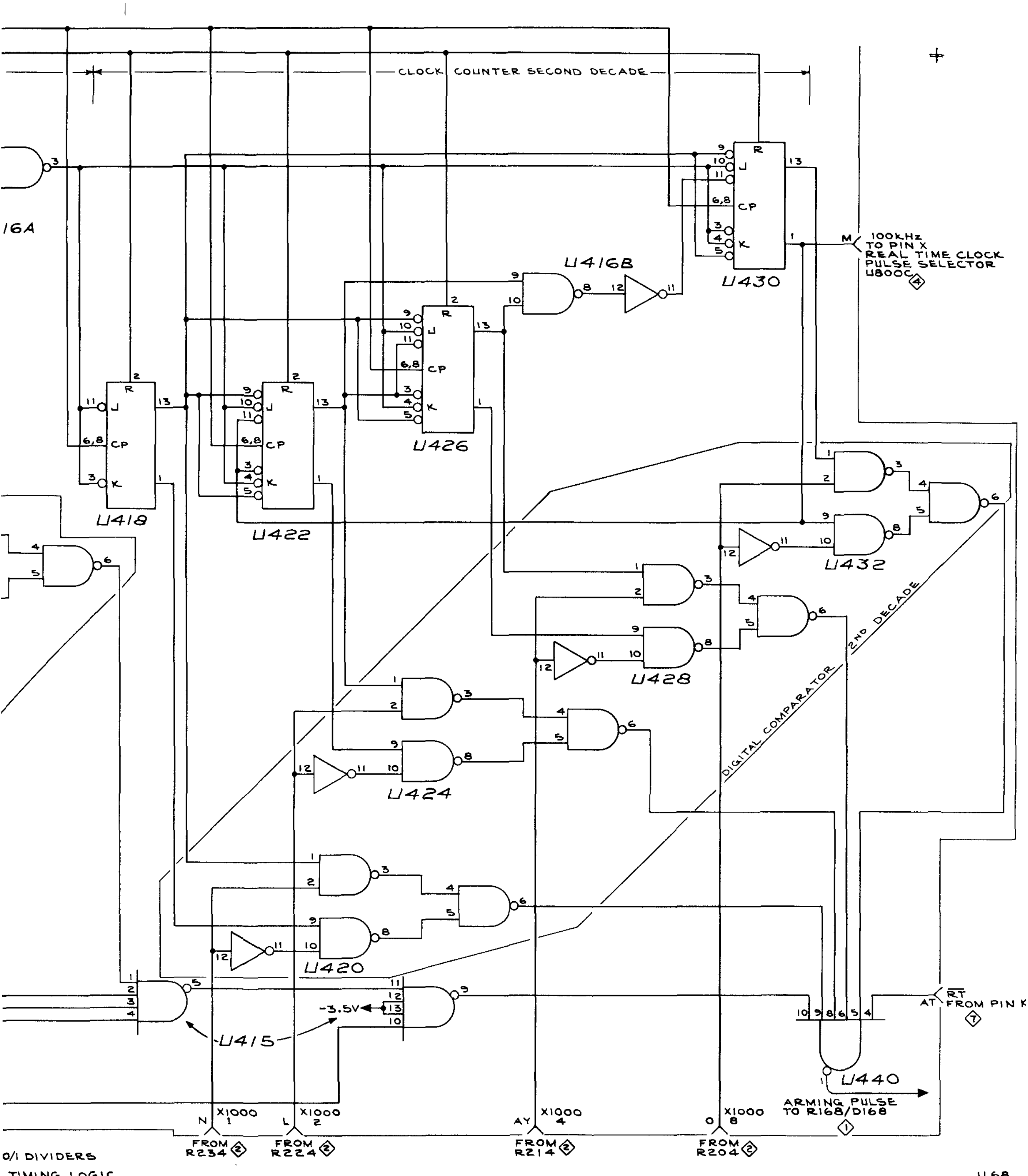
DELAY GATING &
DIG. TO ANALOG CONVERTER ② 1168



REFERENCE DIAGRAMS
1 TRIGGER & CLOCK
2 DELAY GATING & DIG. TO ANALOG CONVERTER
4 1, 2, 5 & 100/1 DIVIDERS
7 CENTRAL TIMING LOGIC

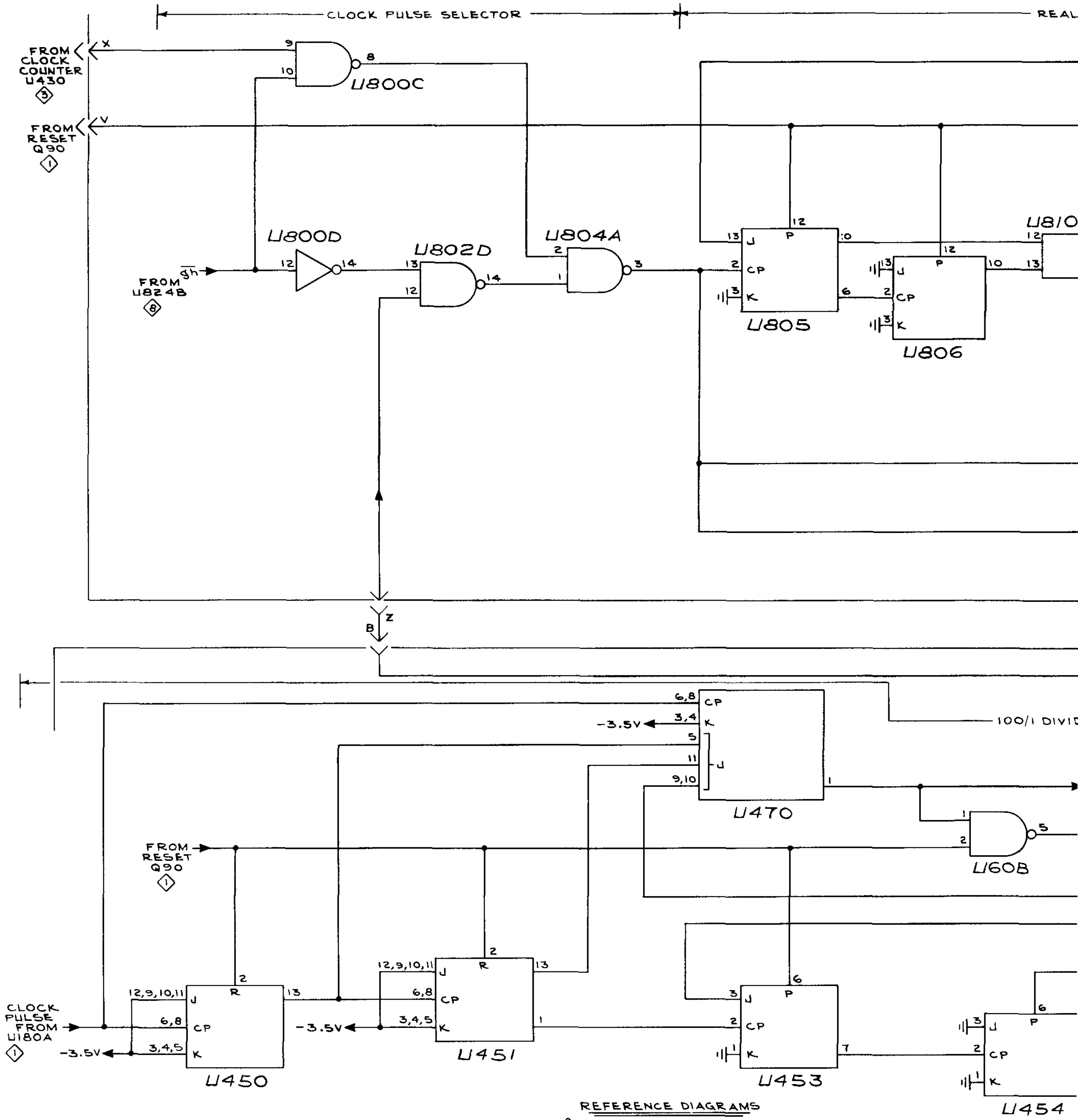
TYPE 3T6

A



1168

CLOCK COUNTER & DIG. COMPARATORS 3

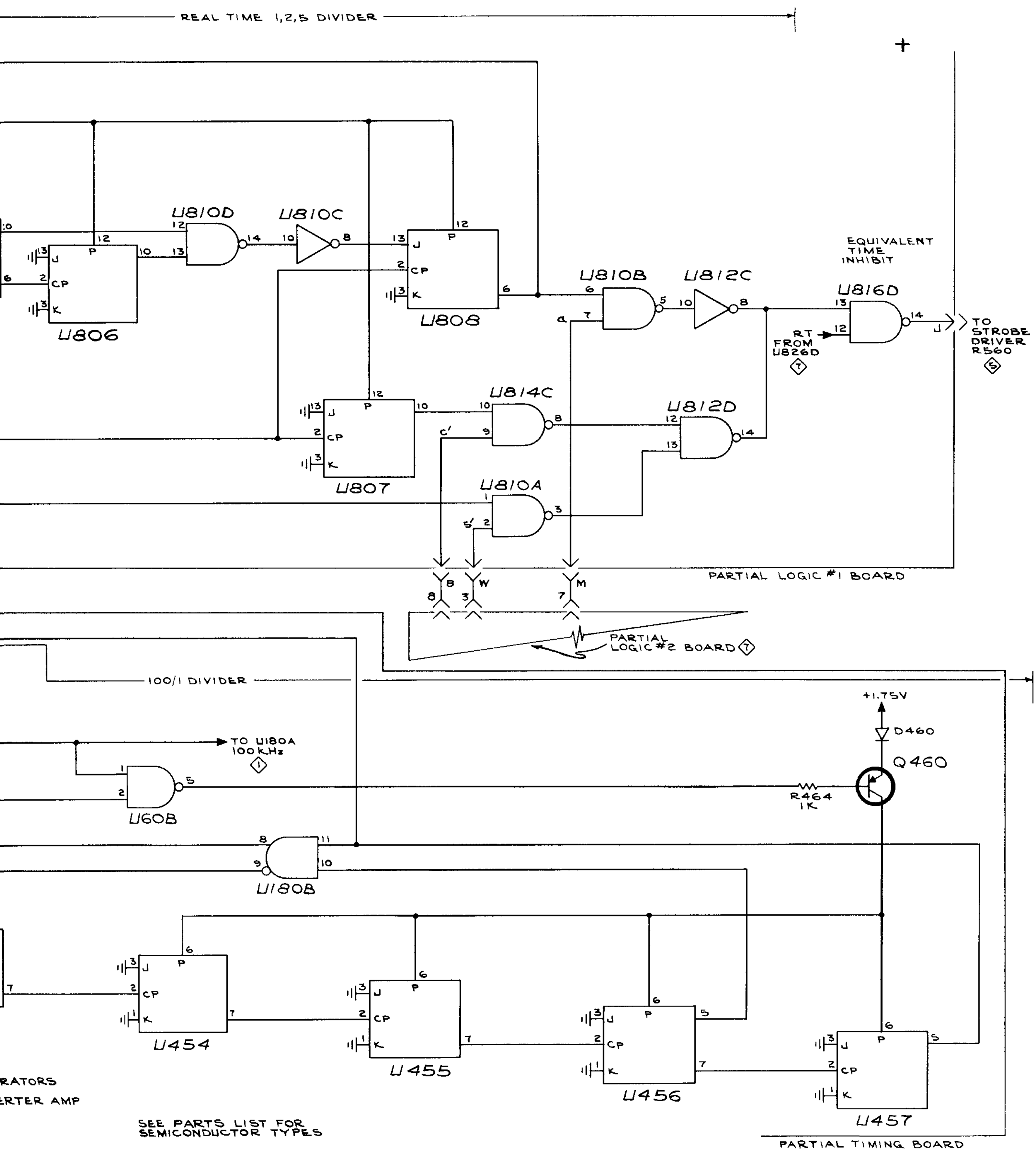


REFERENCE DIAGRAMS
① TRIGGER & CLOCK
③ CLOCK COUNTER & DIG. COMPARATORS
⑤ TIMING RAMP & STAIRCASE INVERTER AMP
⑦ CENTRAL TIMING LOGIC
⑧ SWEEP RATE READOUT LOGIC

SEE PARTS
SEMICONDU

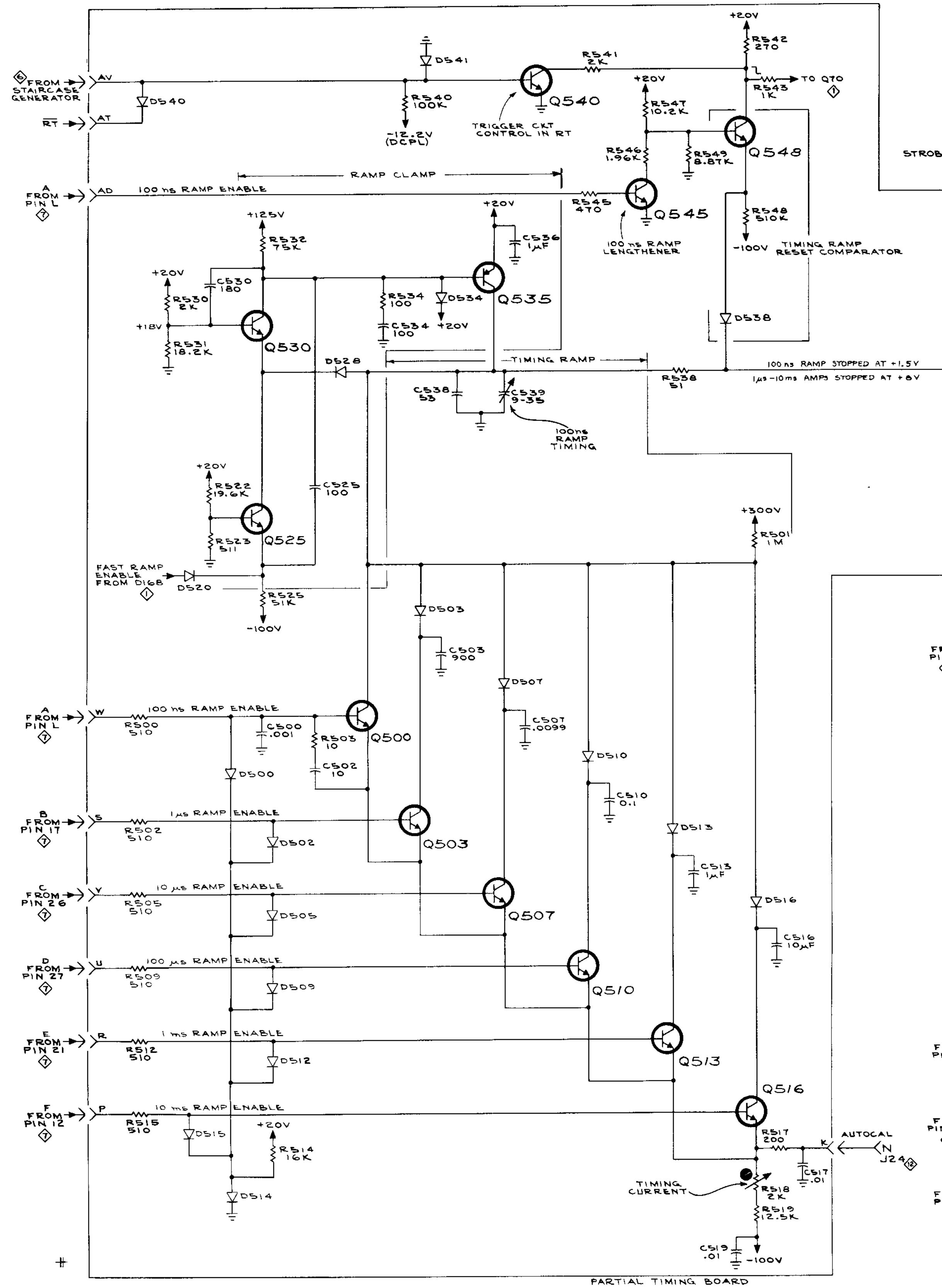
TYPE 3T6

A



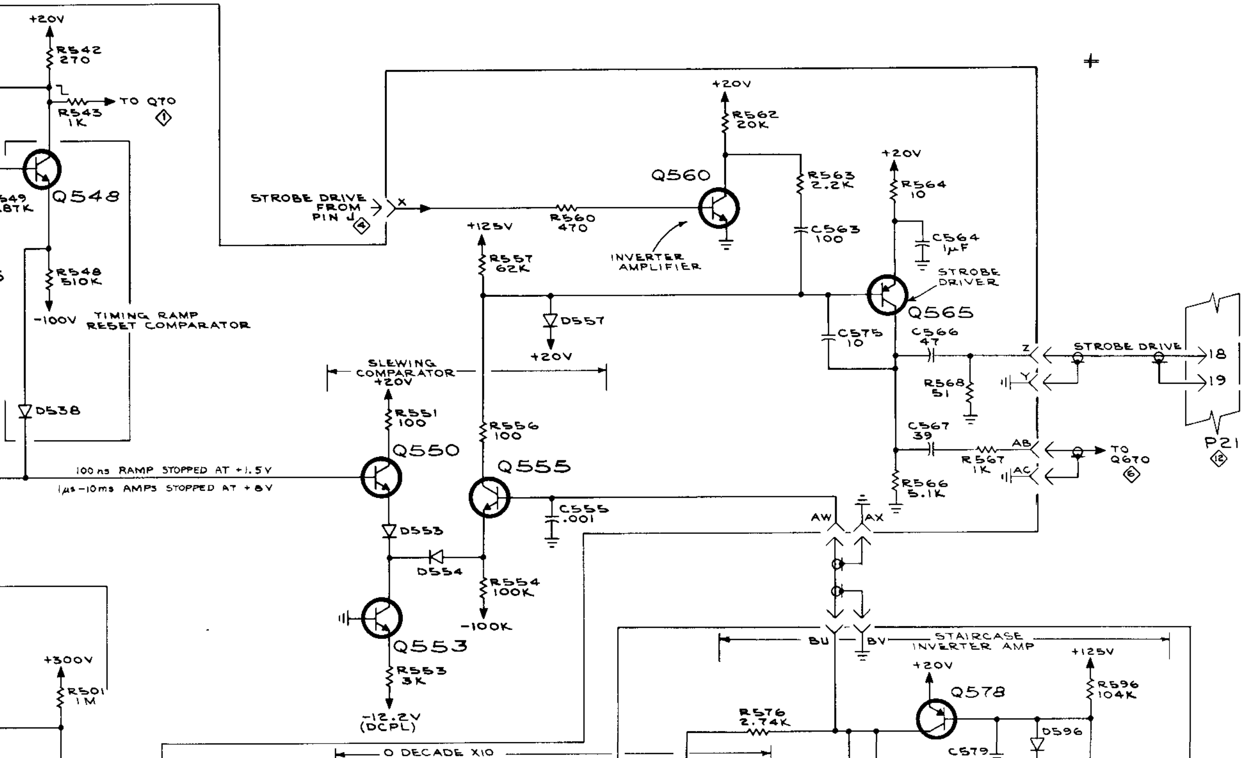
A

1, 2, 5 & 100/1 DIVIDERS ④ 1168

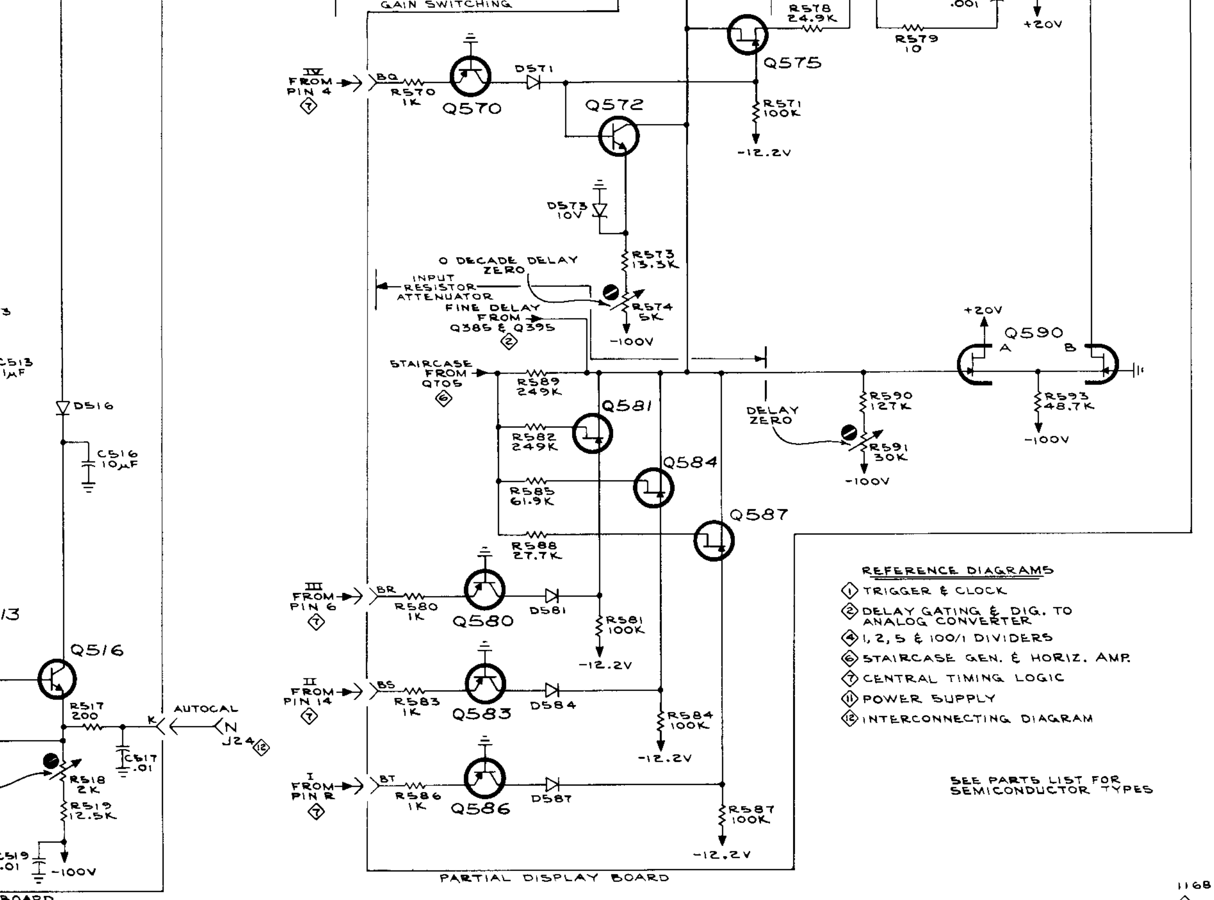

FROM STAIRCASE GENERATOR
RT
FROM PIN L
FROM PIN 17
FROM PIN 26
FROM PIN 27
FROM PIN 21
FROM PIN 12
TRIGGER CKT CONTROL IN RT
RAMP CLAMP
100 ns RAMP ENABLE
100 ns RAMP LENGTHENER
TIMING RAMP RESET COMPARATOR
TIMING RAMP
100 ns RAMP STOPPED AT +1.5V
1µs-10ms AMPS STOPPED AT +8V
100ns RAMP TIMING
FAST RAMP ENABLE FROM D168
1µs RAMP ENABLE
10µs RAMP ENABLE
100µs RAMP ENABLE
1ms RAMP ENABLE
10ms RAMP ENABLE
TIMING CURRENT
AUTOCAL
TO Q70
STROB
PARTIAL TIMING BOARD

TYPE 3T6

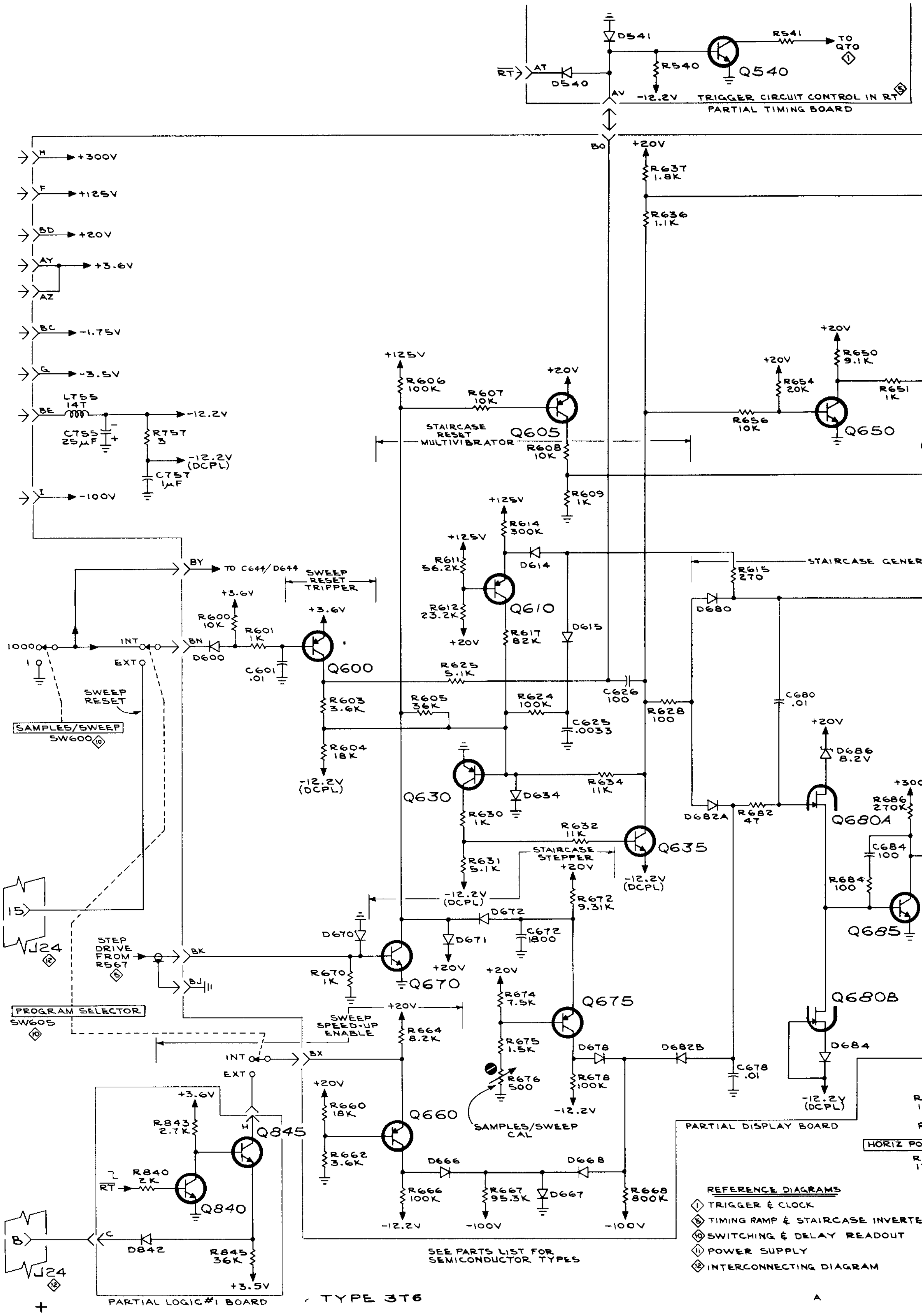
A



+20V
R542 270
TO Q70
R543 1K
Q548
R548 510K
-100V
TIMING RAMP RESET COMPARATOR
D538
100 ns RAMP STOPPED AT +1.5V
1μs-10ms AMPS STOPPED AT +8V
STROBE DRIVE FROM PIN J
Q560
R562 20K
R560 470
INVERTER AMPLIFIER
R563 2.2K
C563 100
+125V
R557 62K
D557
SLEWING COMPARATOR +20V
R551 100
Q550
R556 100
Q555
D553
D554
R554 100K
-100K
Q553
R553 3K
-12.2V (DCPL)
C555 .001
R564 10
C564 1μF
STROBE DRIVER
Q565
C575 10
C566 47
R568 51
C567 39
R567 1K
R566 5.1K
STROBE DRIVE
P21
TO Q670
STAIRCASE INVERTER AMP
Q578
R596 104K
D596
C579
R576 2.74K
+300V
R501 1M
0 DECADE X10

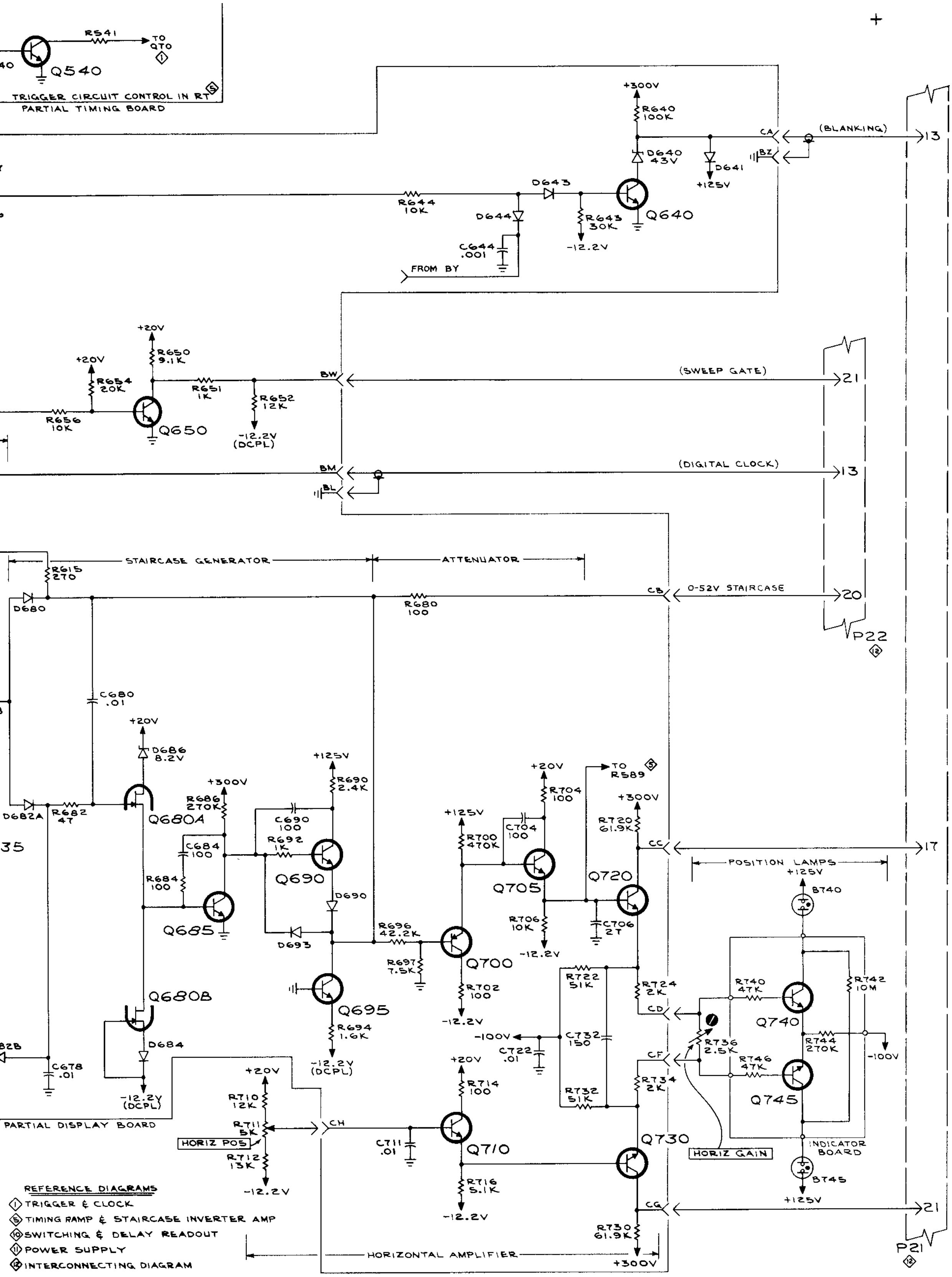


TIMING RAMP & STAIRCASE INVERTER AMP ⑤

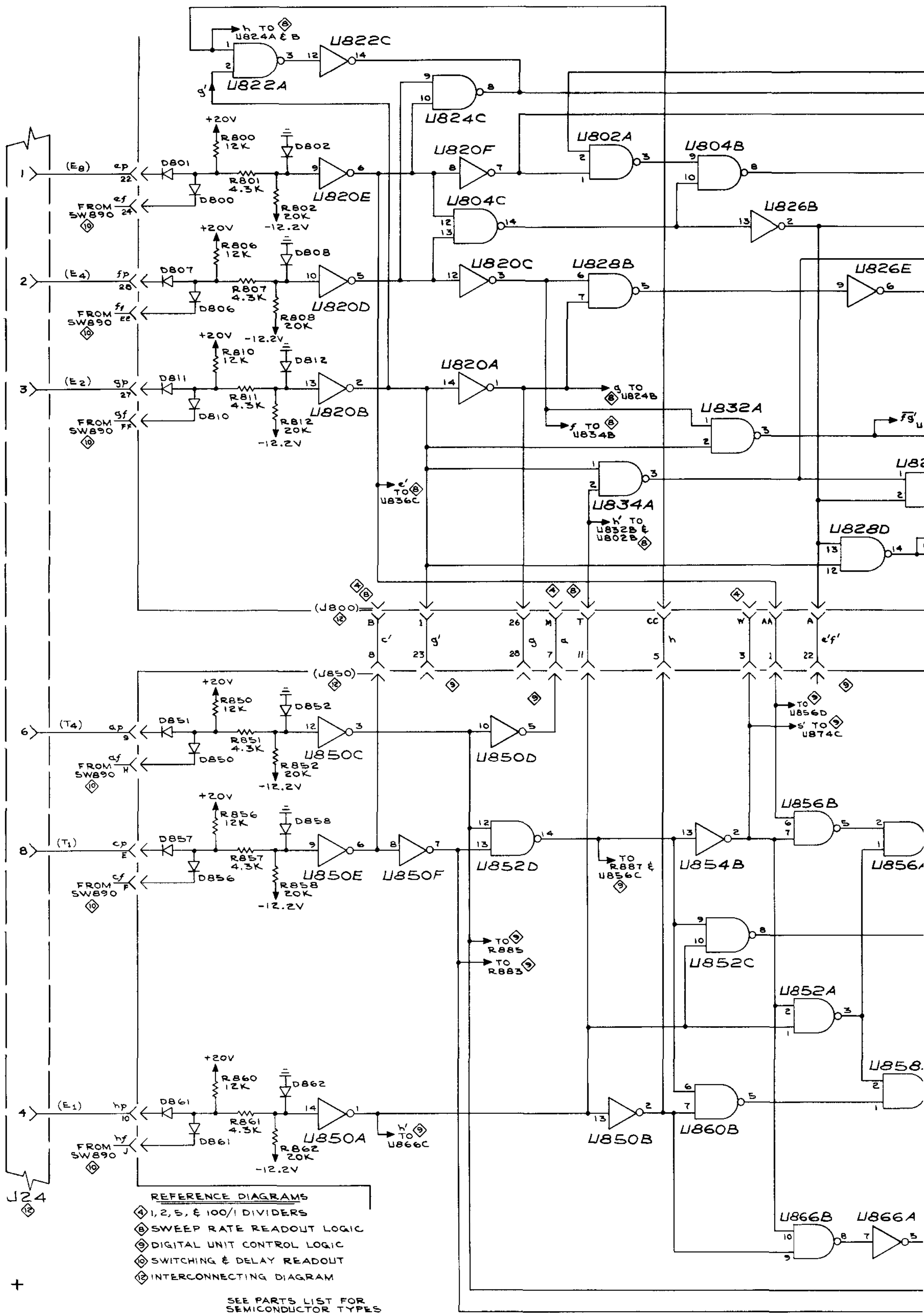


TRIGGER CIRCUIT CONTROL IN RT
PARTIAL TIMING BOARD
STAIRCASE RESET MULTIVIBRATOR
SWEEP RESET TRIPPER
STAIRCASE GENERATOR
SAMPLES/SWEEP
SW600
SWEEP RESET
STEP DRIVE FROM R567
PROGRAM SELECTOR
SW605
STAIRCASE STEPPER
SWEEP SPEED-UP ENABLE
SAMPLES/SWEEP CAL
PARTIAL DISPLAY BOARD
PARTIAL LOGIC #1 BOARD
SEE PARTS LIST FOR SEMICONDUCTOR TYPES
REFERENCE DIAGRAMS
1 TRIGGER & CLOCK
5 TIMING RAMP & STAIRCASE INVERTE
10 SWITCHING & DELAY READOUT
11 POWER SUPPLY
12 INTERCONNECTING DIAGRAM

TYPE 3T6



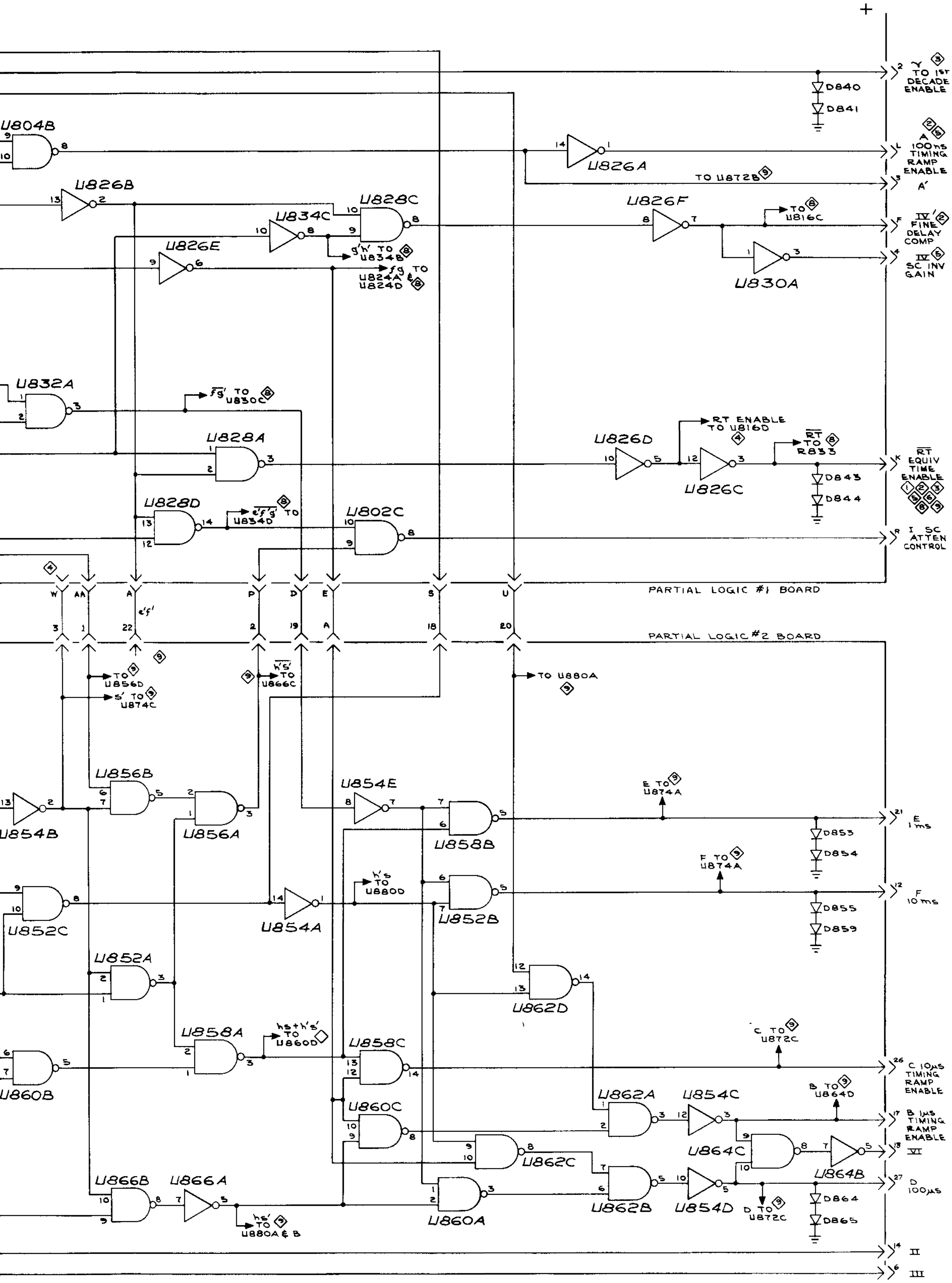
STAIRCASE GEN & HORIZ. AMP. 6 1168



REFERENCE DIAGRAMS
4 1, 2, 5, & 100/1 DIVIDERS
8 SWEEP RATE READOUT LOGIC
9 DIGITAL UNIT CONTROL LOGIC
10 SWITCHING & DELAY READOUT
12 INTERCONNECTING DIAGRAM

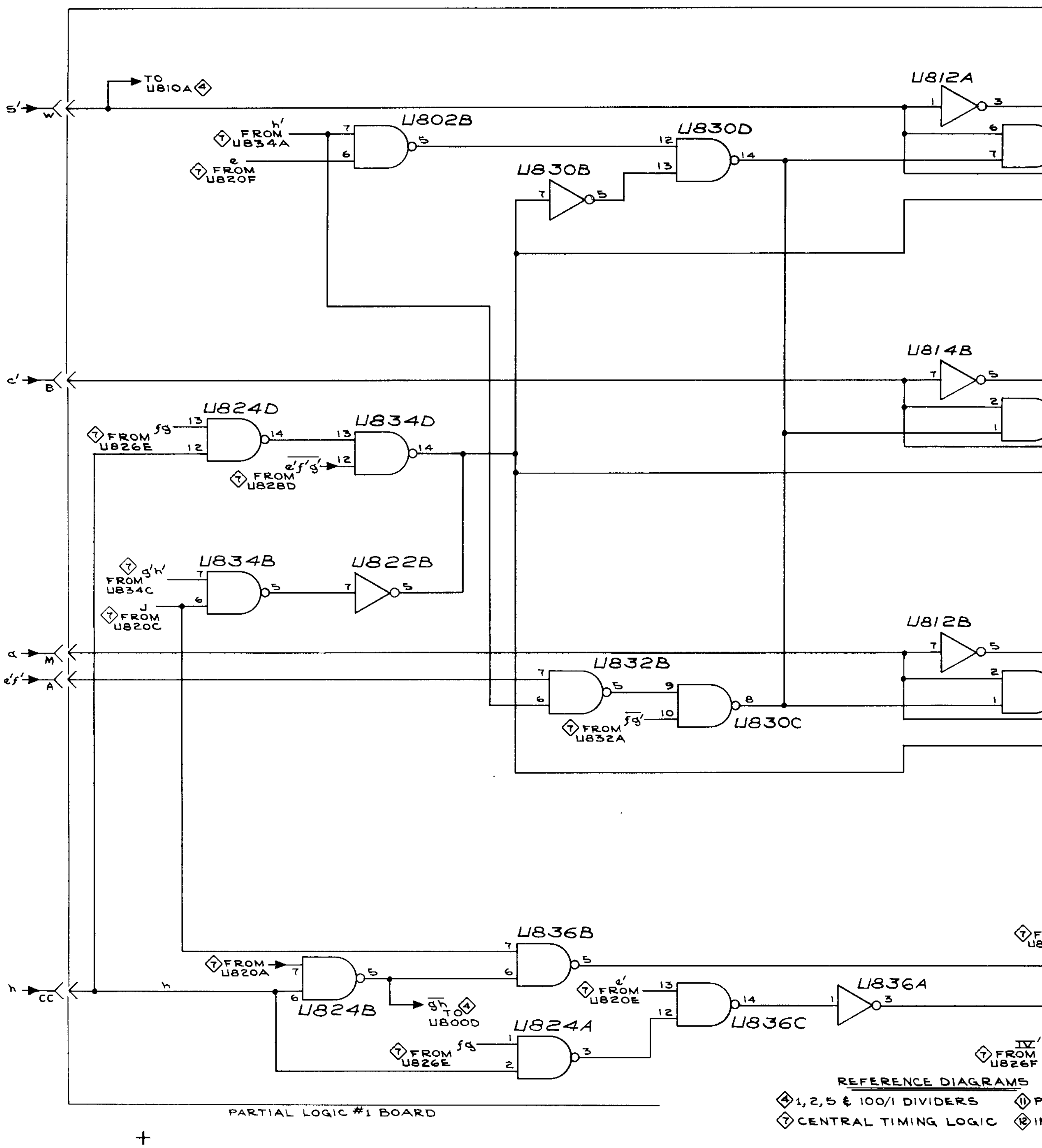
SEE PARTS LIST FOR SEMICONDUCTOR TYPES

TYPE 3T6



CENTRAL TIMING LOGIC 7

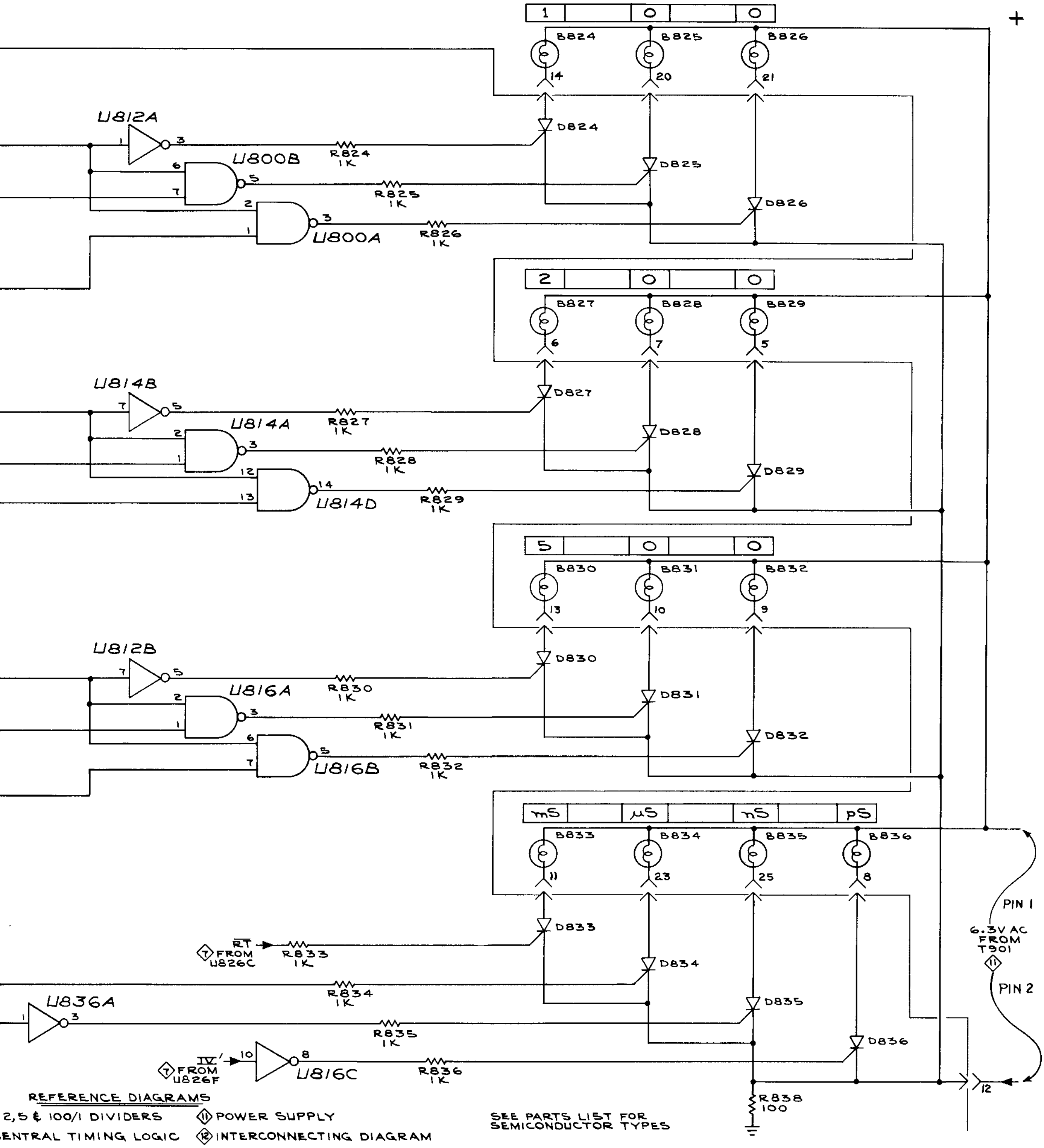
1168



PARTIAL LOGIC #1 BOARD

TYPE 3T6

A



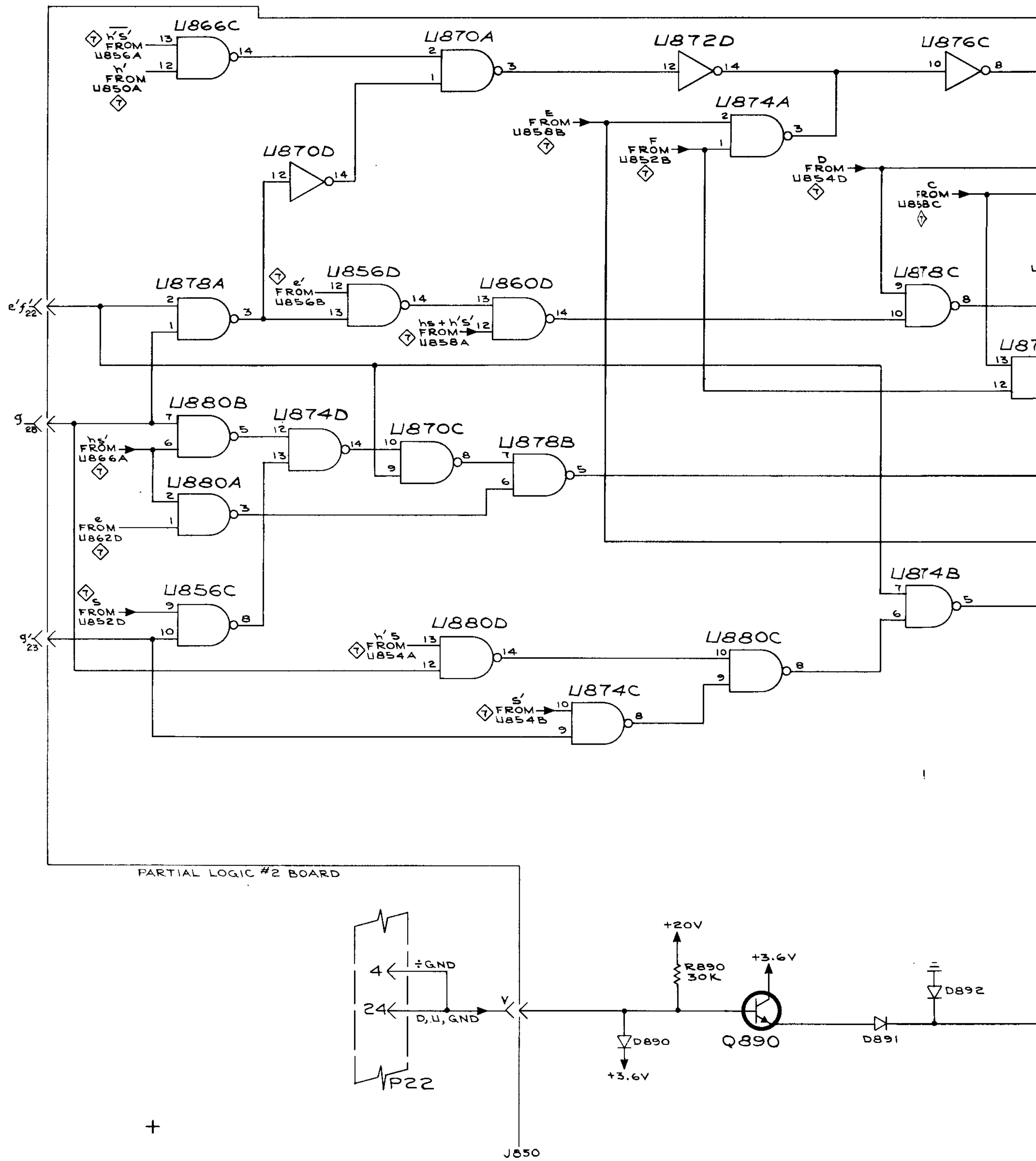
REFERENCE DIAGRAMS
2,5 & 100/1 DIVIDERS
ENTRAL TIMING LOGIC
⑪ POWER SUPPLY
⑫ INTERCONNECTING DIAGRAM

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

A

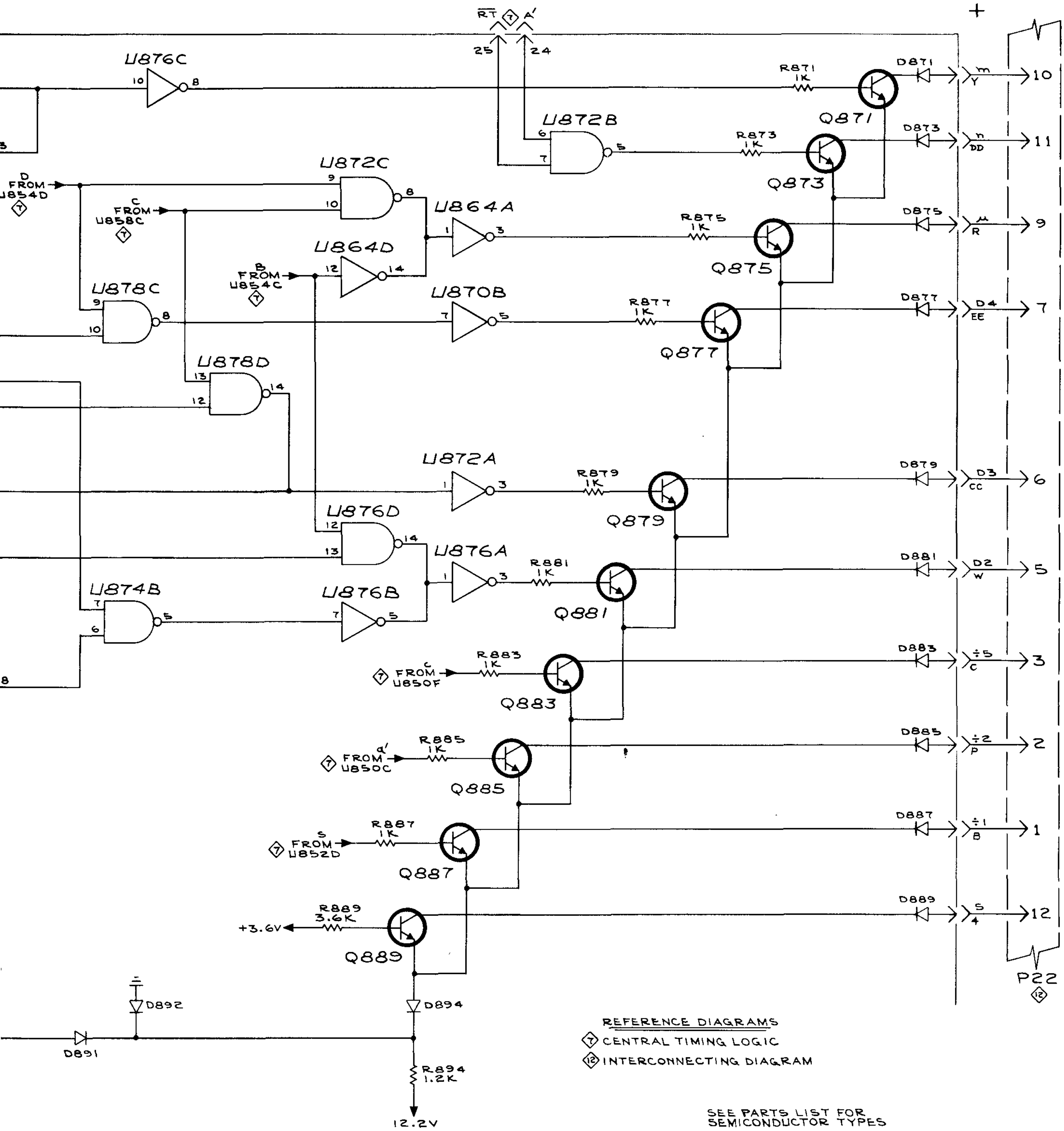
SWEEP RATE READOUT LOGIC ⑧

1168


U866C
U870A
U872D
U876C
U874A
U870D
U878C
U878A
U856D
U860D
U880B
U874D
U870C
U878B
U880A
U874B
U856C
U880D
U880C
U874C
PARTIAL LOGIC #2 BOARD
+20V
R890
30K
+3.6V
D892
D890
Q890
D891
P22
J850

TYPE 3T6

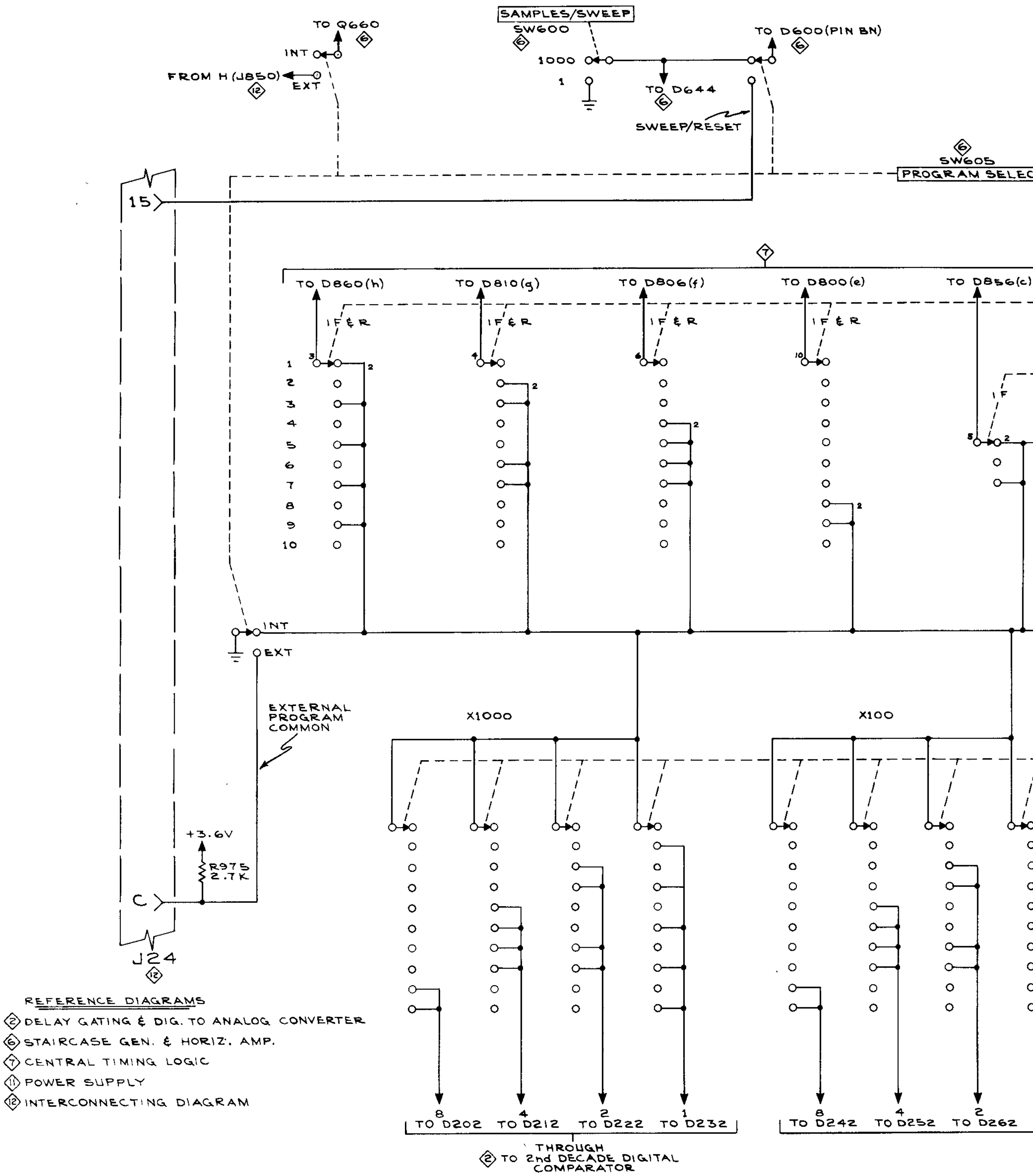
A

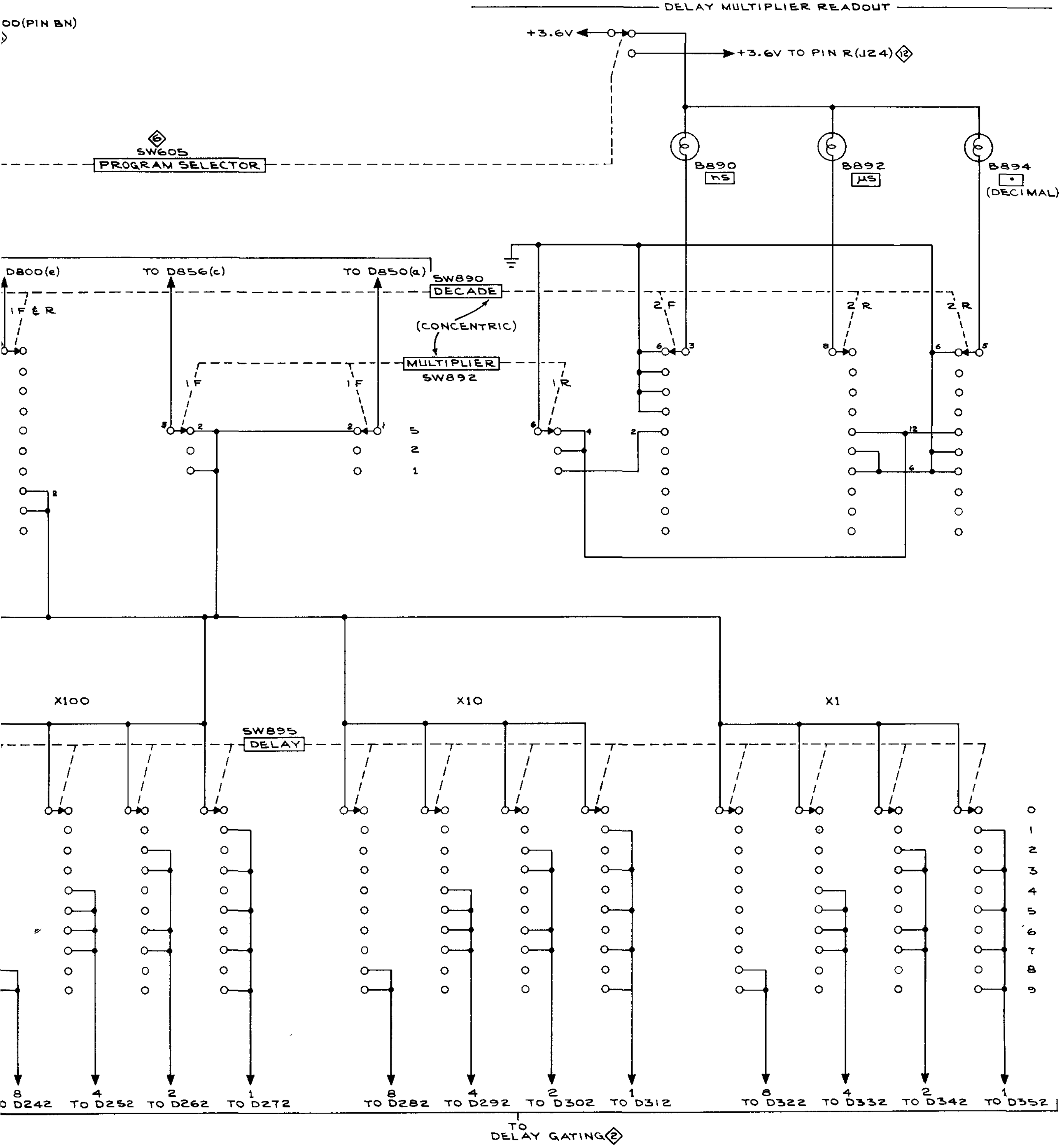


A

DIGITAL UNIT CONTROL LOGIC 9

1168


SAMPLES/SWEEP
SW600
1000
1
TO Q660
INT
EXT
FROM H (J850)
TO D600 (PIN BN)
TO D644
SWEEP/RESET
SW605
PROGRAM SELEC
15
TO D860(h)
TO D810(g)
TO D806(f)
TO D800(e)
TO D856(c)
IF & R
IF
INT
EXT
EXTERNAL PROGRAM COMMON
X1000
X100
+3.6V
R975 2.7K
C
J24
8 TO D202
4 TO D212
2 TO D222
1 TO D232
8 TO D242
4 TO D252
2 TO D262
THROUGH
TO 2nd DECADE DIGITAL COMPARATOR
REFERENCE DIAGRAMS
2 DELAY GATING & DIG. TO ANALOG CONVERTER
6 STAIRCASE GEN. & HORIZ. AMP.
7 CENTRAL TIMING LOGIC
11 POWER SUPPLY
12 INTERCONNECTING DIAGRAM



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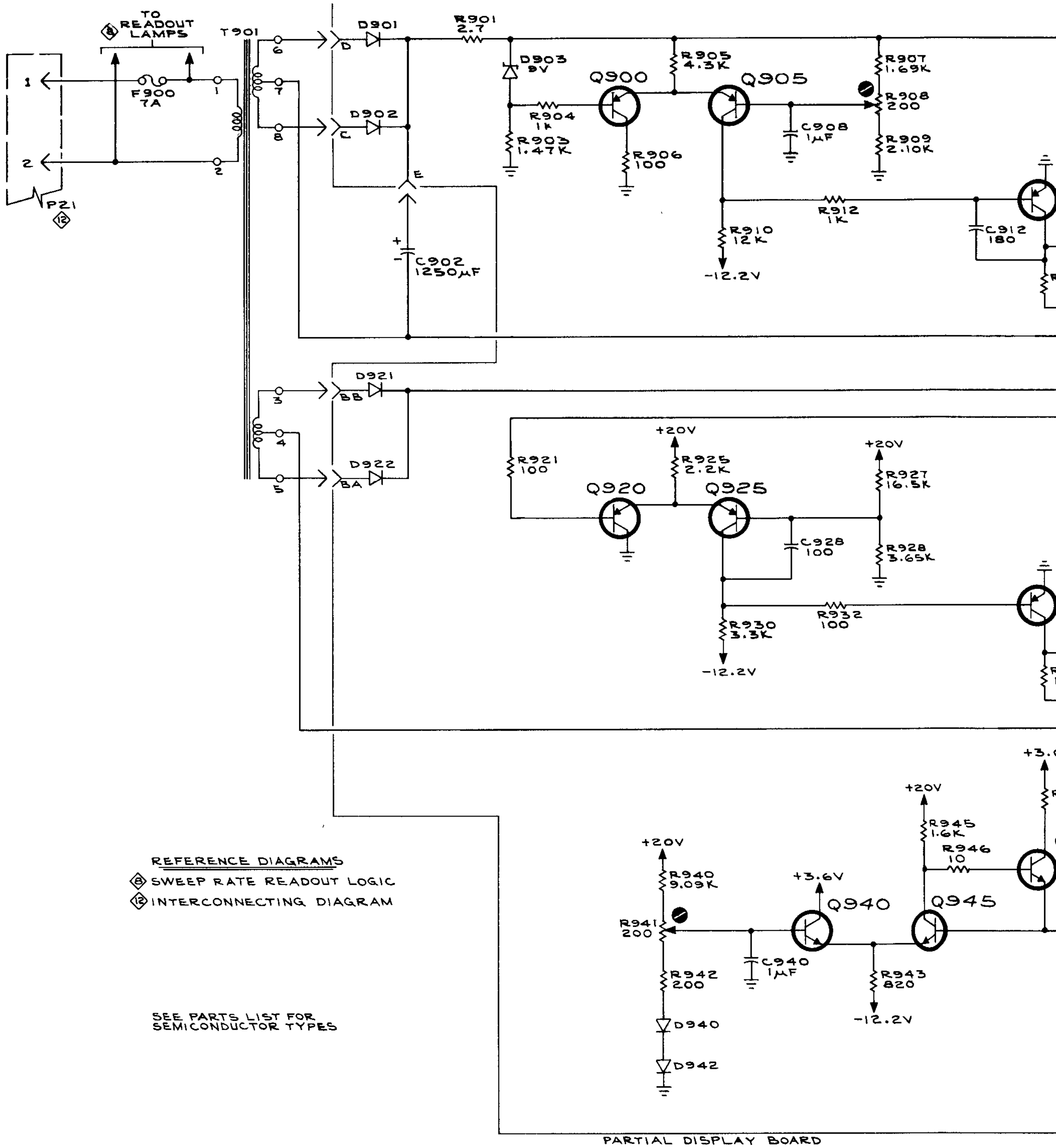
SWITCHING & DELAY READOUT ⑩ 1168

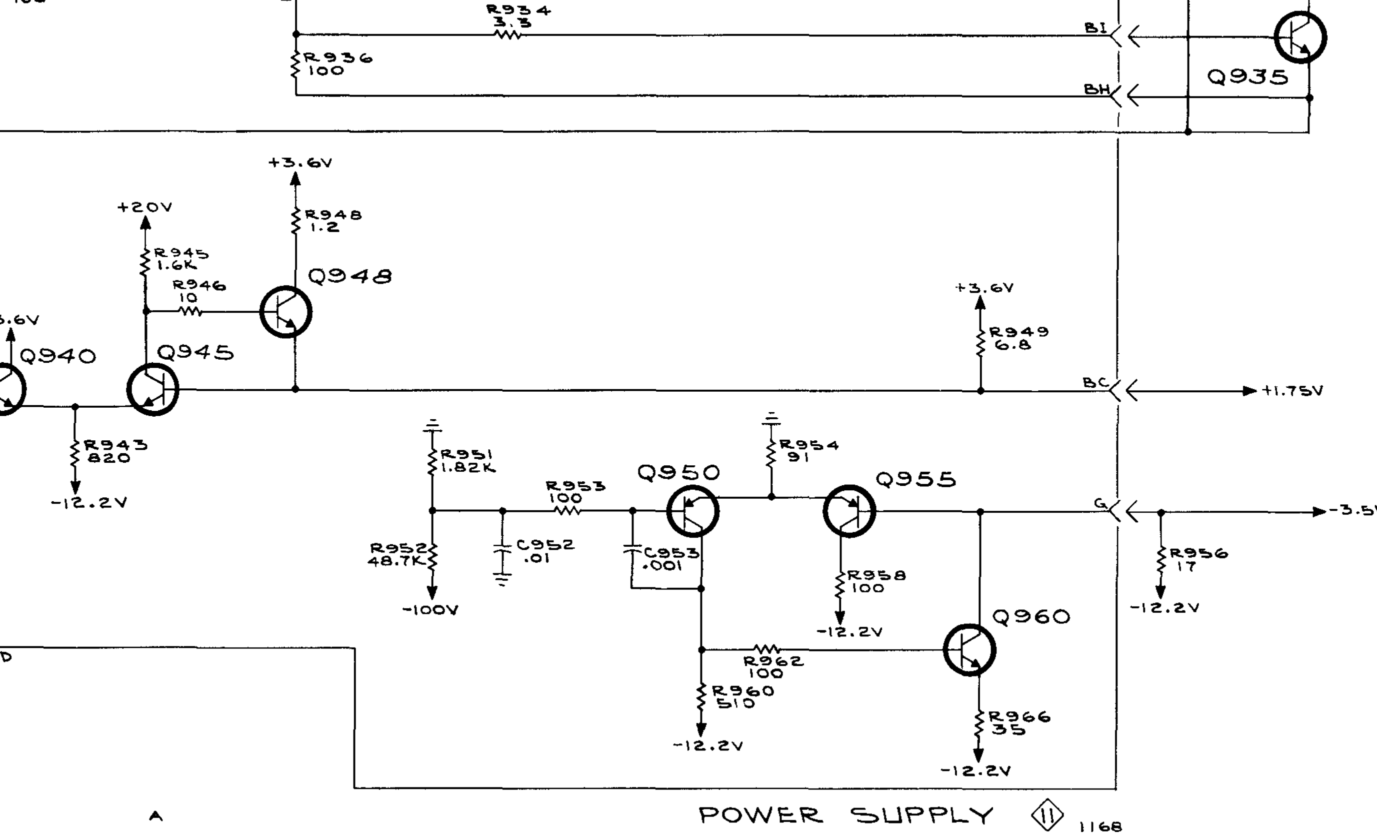


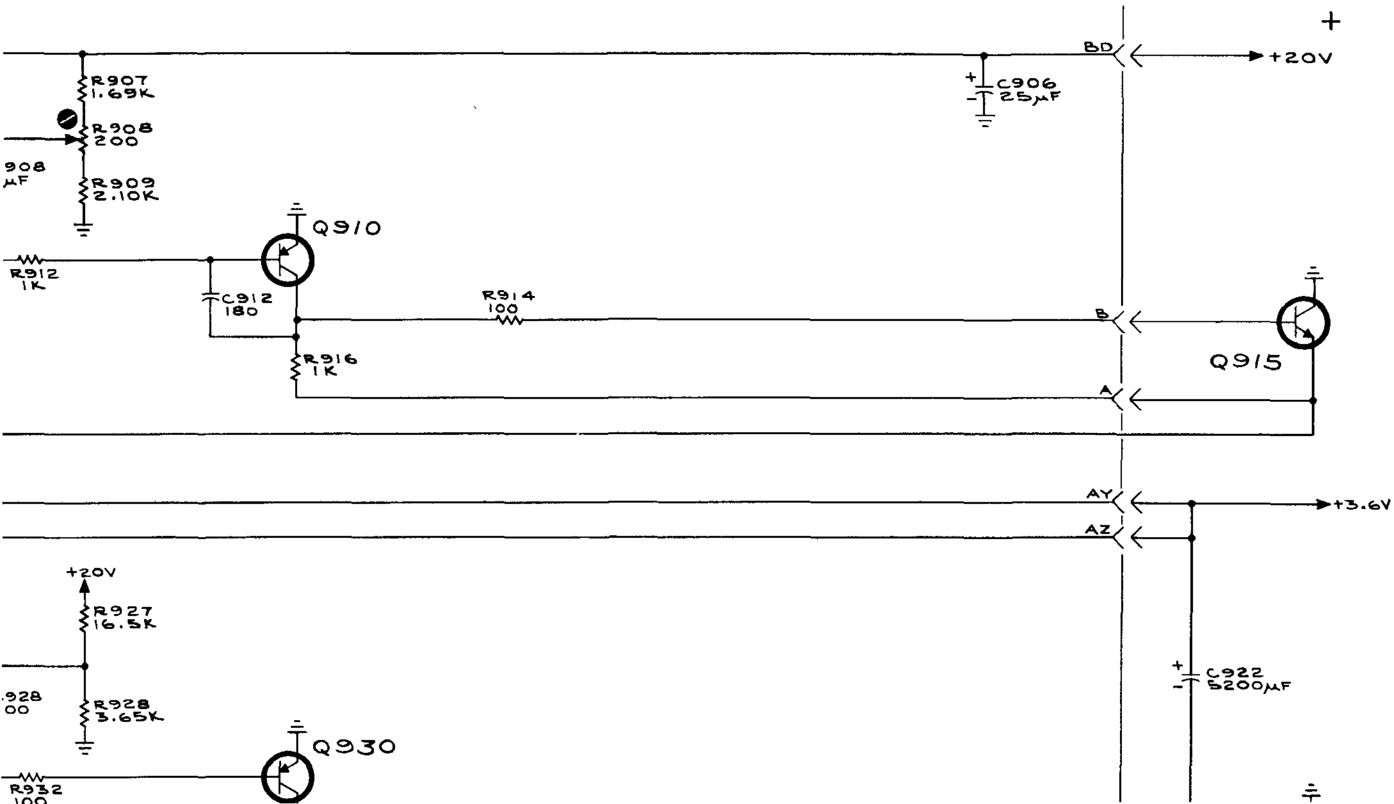
REFERENCE DIAGRAMS

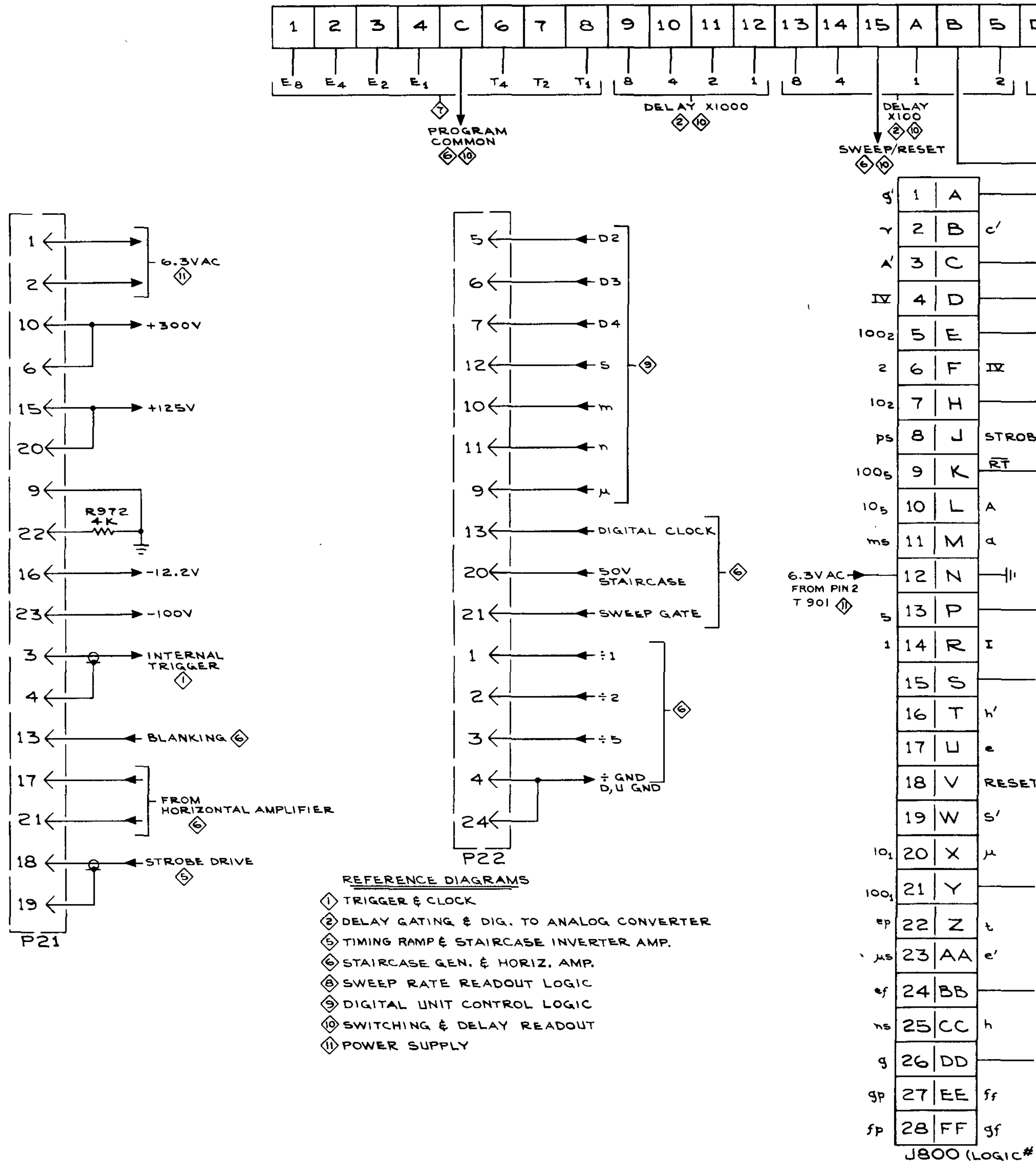
⑧ SWEEP RATE READOUT LOGIC

⑫ INTERCONNECTING DIAGRAM

SEE PARTS LIST FOR SEMICONDUCTOR TYPES


R934
3.3
R936
100
BI
BH
Q935
+3.6V
R948
1.2
+20V
R945
1.6K
R946
10
Q948
Q940
Q945
R943
820
-12.2V
+3.6V
R949
6.8
BC
+1.75V
R951
1.82K
R953
100
Q950
R954
91
Q955
G
-3.5V
R952
48.7K
-100V
C952
.01
C953
.001
R958
100
-12.2V
R956
17
-12.2V
Q960
R962
100
R960
510
-12.2V
R966
35
-12.2V
A
POWER SUPPLY
11
1168


R907
1.69K
R908
200
908
µF
R909
2.10K
Q910
R912
1K
C912
180
R914
100
R916
1K
BD
+20V
C906
25µF
B
A
Q915
AY
+3.6V
AZ
+20V
R927
16.5K
.928
00
R928
3.65K
Q930
R932
100
C922
5200µF


E8 E4 E2 E1 T4 T2 T1
PROGRAM COMMON
DELAY X1000
DELAY X100
SWEEP/RESET
6.3VAC
+300V
+125V
R972 4K
-12.2V
-100V
INTERNAL TRIGGER
BLANKING
FROM HORIZONTAL AMPLIFIER
STROBE DRIVE
P21
D2
D3
D4
DIGITAL CLOCK
50V STAIRCASE
SWEEP GATE
÷1
÷2
÷5
÷ GND D,U GND
P22
6.3V AC FROM PIN 2 T 901
STROBE
RESET
J800 (LOGIC#
REFERENCE DIAGRAMS
1 TRIGGER & CLOCK
2 DELAY GATING & DIG. TO ANALOG CONVERTER
5 TIMING RAMP & STAIRCASE INVERTER AMP.
6 STAIRCASE GEN. & HORIZ. AMP.
8 SWEEP RATE READOUT LOGIC
9 DIGITAL UNIT CONTROL LOGIC
10 SWITCHING & DELAY READOUT
11 POWER SUPPLY

TYPE 3T6

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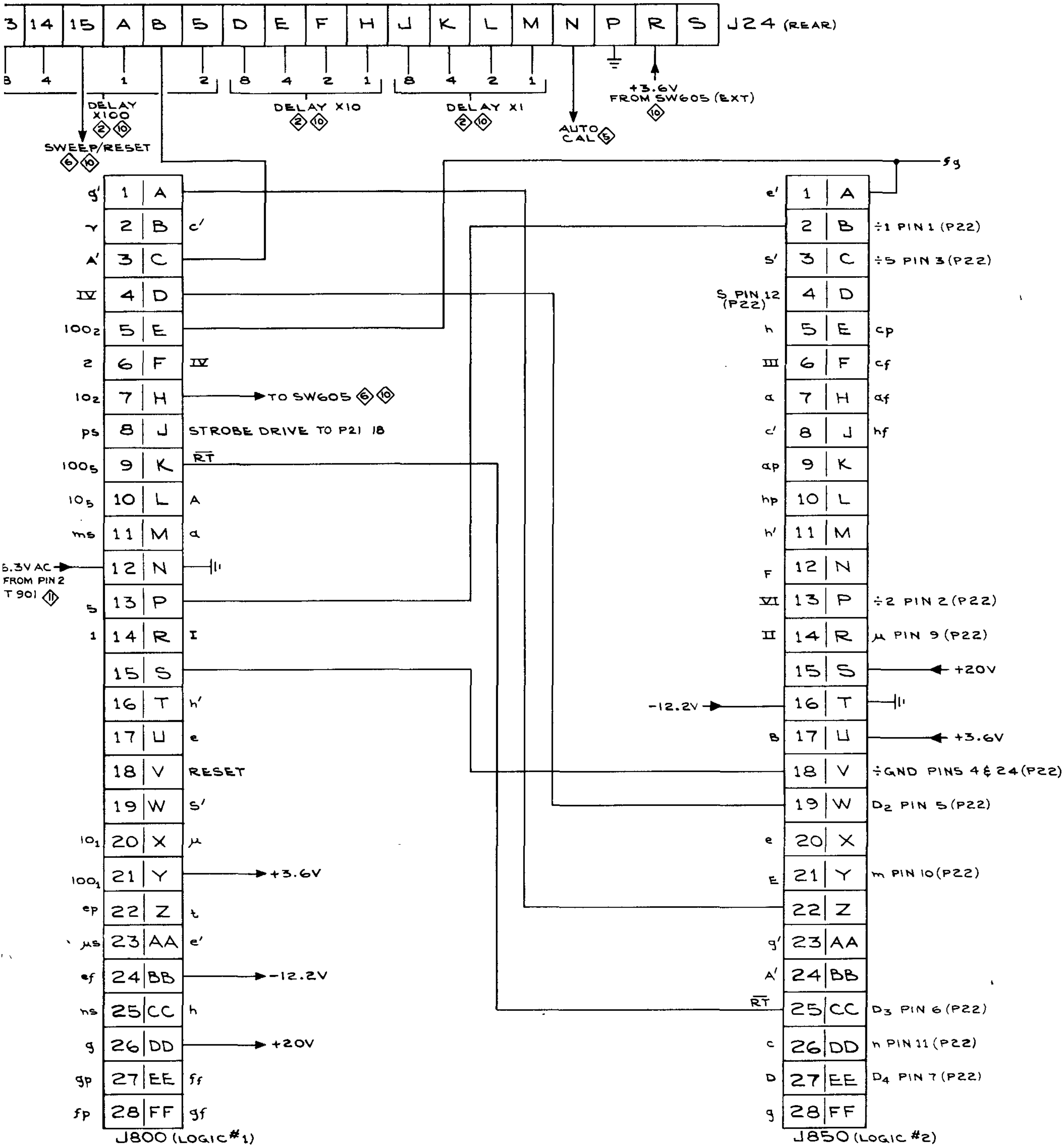


INTERCONNECTING DIAGRAM 12 1168

A

FIG. 1 EXPLODED

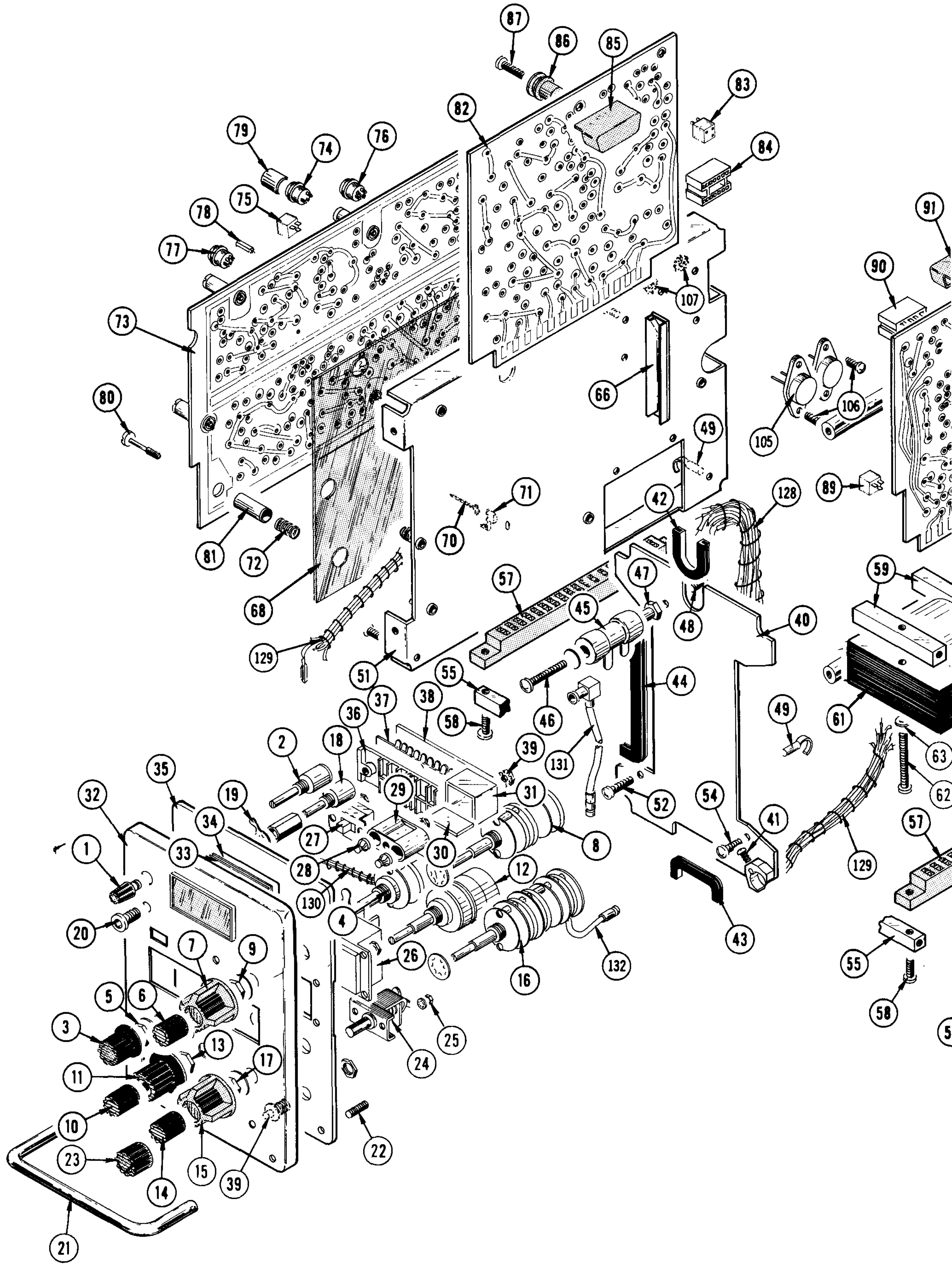
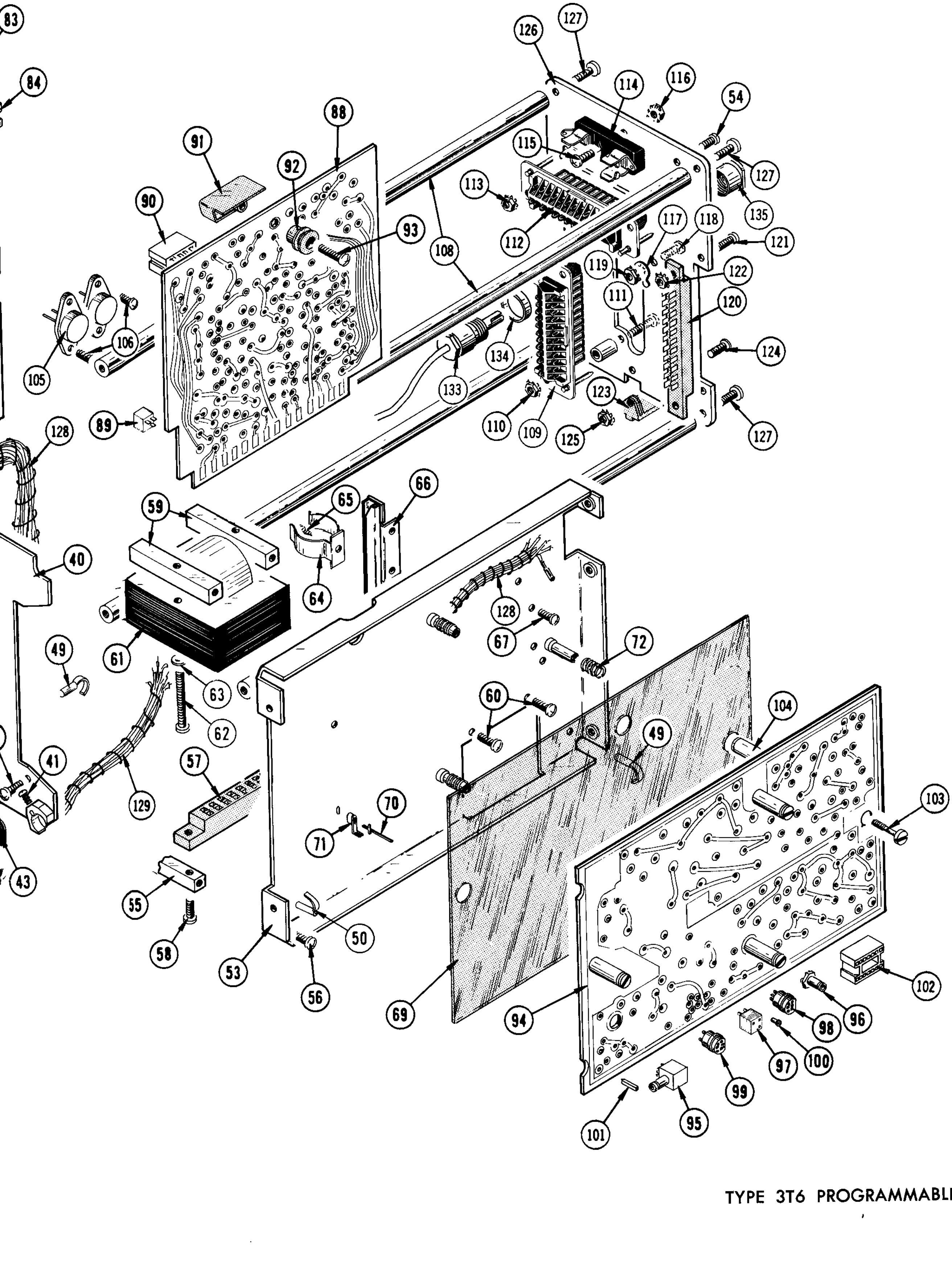
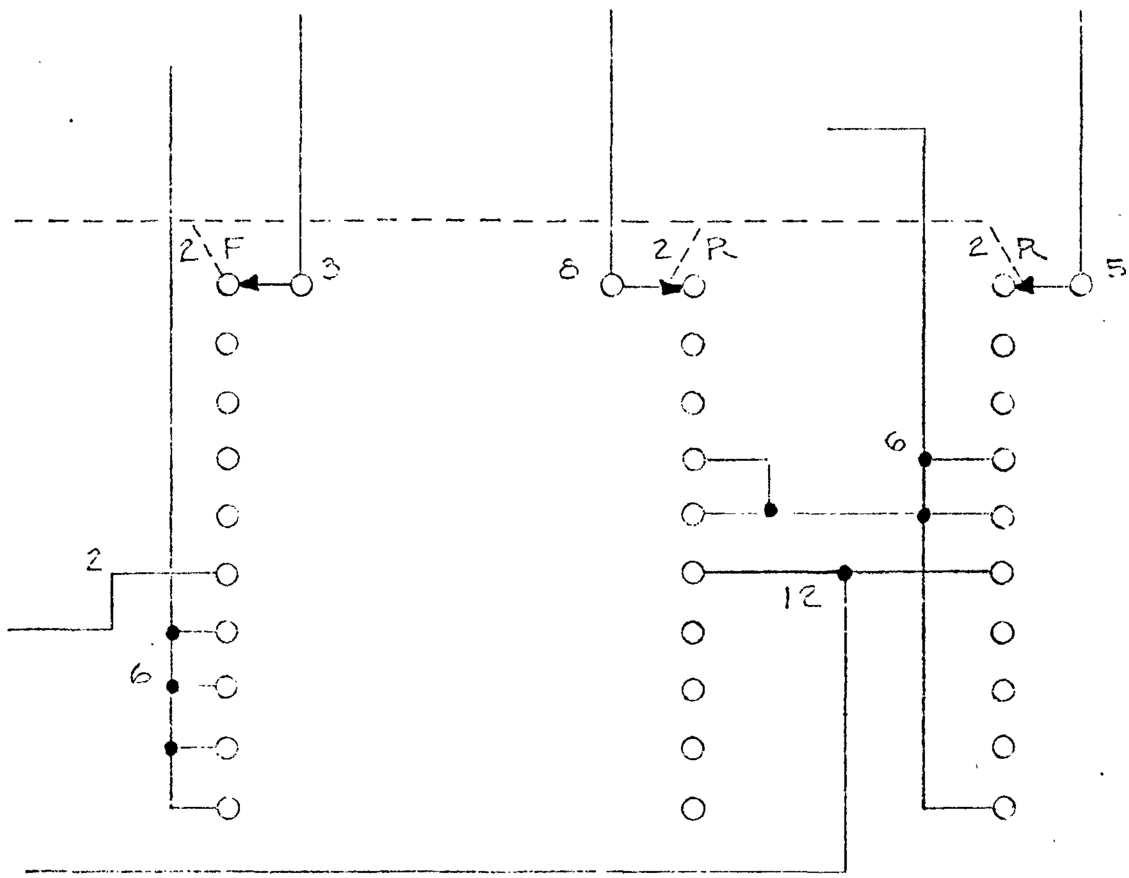


FIG. 1 EXPLODED



TYPE 3T6 PROGRAMMABLE SAMPLING SWEEP

SCHEMATIC CORRECTION



PARTIAL SWITCHING & DELAY READOUT

10

C1/1168

General Information

This modification changes circuits that affect the External Automatic triggering mode of operation and the required time per sample at some of the equivalent-time sweep rates.

TEXT CORRECTION

Section 1 Specification

Page 1-1

CHANGE: Electrical Characteristics under External Auto, change Amplitude Range to the following:

Signal Voltage	
POLARITY Sw. +	
Positive Peak	Between +100 mV and +500 mV
Negative Peak	Between +10 mV and -500 mV
POLARITY Sw. -	
Positive Peak	Between -10 mV and +500 mV
Negative Peak	Between -100 mV and -500 mV

Page 1-2

CHANGE: the last two lines of the left column to read:

10 ns to 1 ns	Exclude first 15 ns of sweep
500 ps to 100 ps	Exclude first 15 ns of sweep NOTE: Accurate within 5%

Section 2 Operating Instructions

Page 2-6

ADD: immediately under the Triggering heading, right column:

Three basic modes of triggering are available in the Type 3T6, as controlled by the trigger MODE switch. The modes are: Internal, External and External Automatic. Internal triggering is AC coupled only, and both external modes are DC coupled. The external mode (not automatic) can be altered from a normal triggering function to be Synchronized with high frequency information above 100 MHz. (Synchronized operation is not recommended for the Internal mode because internal trigger pickoff circuits and connections do not allow sine wave signals above about 100 MHz to reach the trigger circuits.)

Each Basic triggering mode causes the triggering event to occur on only the positive or the negative signal slope as controlled by the POLARITY switch. Both the External and External Auto modes require the triggering signal to have a voltage component positive with respect to ground for +POLARITY triggering, and have a voltage component negative with respect to ground for -POLARITY triggering. Section 1 lists the minimum and maximum signals required for each mode of operation.

CHANGE: first two words, Internal Triggering under present Triggering heading, underline them to delineate that following text is a discussion of internal triggering only.

CHANGE: beginning with third paragraph under Triggering, replace remainder of triggering text with the following:

External triggering (not automatic) must be selected when the pretrigger signal amplitude is less than 100 mV peak to peak. The POLARITY switch must be set to equal the polarity of the triggering signal. If the trigger signal peaks are at ground and +50 mV, set the POLARITY switch to + to obtain proper displays. If the trigger signal peaks are at ground and -50 mV, set the POLARITY switch to - to obtain proper displays. (In some cases, a triggered display can be obtained when the POLARITY switch is incorrectly set, but at that time, removal of the triggering signal will reveal a free running trigger circuit. This is not considered normal or proper triggering.)

NOTE

> Earlier models of the Type 568 Oscilloscope require installation of Field Modification Kit, Tektronix Part No. 040-0492-00 to provide a means of externally triggering the Type 3T6. This modification consists of installation of J23 on the Type 568 rear panel and J23 at the rear of the vertical plug-in compartment.

External Auto triggering is desirable when the triggering signal is known to be greater than 100 mV peak to peak with one peak at ground. Then the operator need not make any control adjustments to obtain proper displays. The External Auto triggering mode is of particular advantage when the Type 3T6 is used in an automatically programmed system where the triggering signal can be planned to always have sufficient amplitude. The primary limitation of EXT AUTO triggering is that the signal must always have one peak within 10 mV of ground. Signals that are offset from ground more than 10 mV in the direction that the POLARITY Switch is set, may not permit the external automatic circuit to operate, thereby preventing a display. If it is not possible to obtain a triggering signal with one peak near ground, place an AC coupling capacitor in series with the trigger cable. If the trigger signal has a duty factor near 50%, then the signal received by the trigger circuit will pass through zero, but the total amplitude will have to be $\geq$ 200 mV peak-to-peak in order to obtain a display.

Use of the SENSITIVITY and RECOVERY TIME controls. These two controls must be properly adjusted when the triggering mode is either Internal or External (not automatic). The SENSITIVITY control has a range of control over the various trigger signals as listed on page 1-1 in the Electrical Characteristics table. Full counterclockwise rotation of the control will assure there is no sweep when the triggering signal maximum value is less than the maximum value for the particular sensitivity range listed. Turning the control clockwise past its midpoint will cause the trigger circuits to free run and provide a display when there is no triggering signal.

The RECOVERY TIME control should be adjusted whenever the display is confused, even though the SENSITIVITY control is adjusted in the proper region. The RECOVERY TIME control must be adjusted any time a trigger pulse duration is longer than the sampling cycle recovery time, or when the trigger signal period is harmonically related to the trigger circuit countdown rate (discussed below). (Choose a slower sweep rate if the trigger period is longer than the numbers in the right column of Table 2-1.) Both controls should always be adjusted when first obtaining a display from a new signal, with the goal that proper setting assures minimum displayed time jitter. In cases where the display is a pulse chain, the recovery time can be made longer by switching in more clock controlled DELAY (Defined in the left column of page 3-6). This method does not apply when only one step function is displayed and to add delay would only place the desired signal portion out of sight off the CRT left side.

CHANGE: lines 1, 2 and 4 of TABLE 2-1 to read:

100 ps to 1 ns	12 μs
2 ns to 10 ns	12 μs
20 ns to 100 ns	12 μs
200 ns to 1 μs	22 μs

Page 2-11 second column, 3rd paragraph

CHANGE: last line to read:

..as listed in column 3 of Table 2-4.

second column, 2nd paragraph under Display Rate When Using Equivalent-Time Sampling

CHANGE: the 12th line to read:

..as is 3 μs to 6 μs at all sweep rates. Adding time intervals...

Page 2-12 Table 2-4, 6th column

CHANGE: lines 9 through 11 to read 4 μs and lines 12 through 21 to read 6 μs.

Fig. 2-9

CHANGE: the arming time, 7th time zone to read:

"3 μs to 6 μs"

Section 3 Circuit Description

Page 3-6 second column, 2nd paragraph

CHANGE: lines 7 and 8 to read:

D114 via D112. The trigger signal from D28 is also delayed (through a 3.75 ns Delay Line, DL50) and then trips D114 to...

Page 3-13 left column, 2nd paragraph

CHANGE: line 5 through the end of the paragraph to read:

by the Isolation Amplifier Q20; its output through L20-R28 (D20 is reverse biased) switches tunnel diode D28 to its high voltage state, which drives D106 and about 4 ns later, D114 (D114 is driven through DL50). The resulting output pulse from D114 sends a signal to D168 and to Q120.

left column, 4th paragraph

CHANGE: line 7 to read:

arrives through C50 and the 4 ns Delay Line, DL50.

left column, 5th paragraph

CHANGE: line 2 to read:

circuit, Q135 and D20 are caused to conduct enough Q20 current so...

right column, 3rd paragraph

CHANGE: the last sentence to read:

When Q75 turns off, D102 no longer reverse biases Q100, which turns on and discharges C106 to -3.5 volts.

Page 3-14 left column, Special Trigger Circuit

ADD: 2 sentences into line 7 of Special Trigger Circuit as follows:

compensates the emitter-base junction of Q20. D20 isolates Q20 collector circuit from Q135 emitter circuit when Q135 is at cut-off. L20 prevents Q20 from oscillating while Q135 is conducting. C26 provides...

Page 3-16 Q530-Q535 form the Ramp Clamp

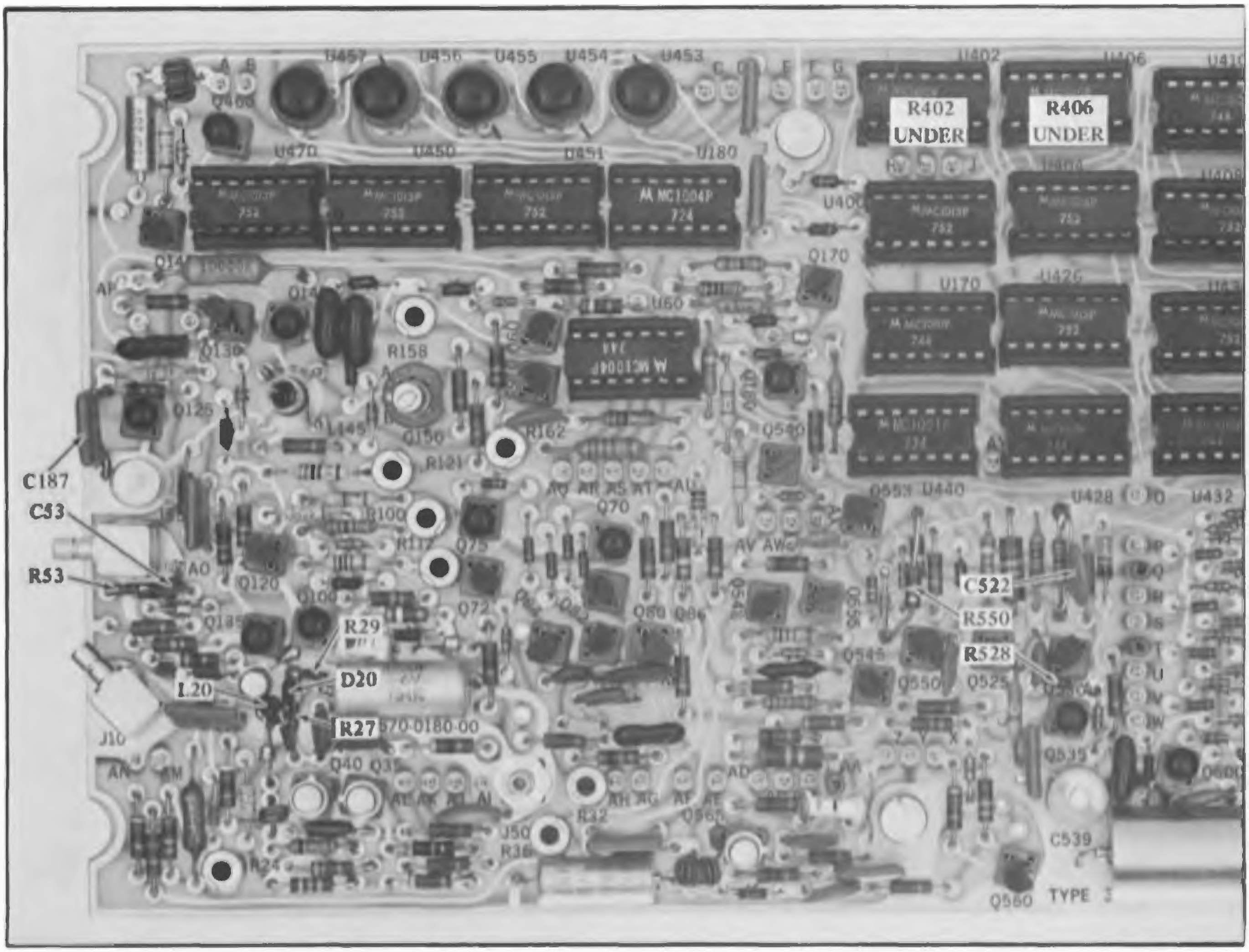
ADD: the following sentences to the 2nd paragraph under Q520-Q530 for the Ramp Clamp:

C522 holds Q525 base impedance low so the drive pulse through D520 stops Q525 conduction rapidly. R528 pulls up on Q525 collector to aid in rapidly clearing the carriers out of the transistor junction region as the drive pulse stops conduction.

The Slewing Comparator

ADD: the following sentence after the 3rd sentence under The Slewing Comparator:

R550 assures that D553 junction carriers are cleared out rapidly at the time it turns off, aiding to make the comparison occur as rapidly as possible.



New parts location on the Timing Circuit board due to M14,392/1268.

Section 5 Performance Check/Calibration

Page 5-4 left column.

ADD: to the Equipment Required List:

30. A 1.5 Volt size D Dry cell (not shown).
31. A 2.5 kΩ potentiometer, 2 watt, such as Tektronix Part No. 311-0395-00. (Not shown.)
32. A 47 Ω 1/2 watt carbon composition resistor (not shown).

Page 5-19 left column, Step 18 (d) and Step 19

REPLACE: the text with the following:

d. Disconnect the signal generator and cables.

19. Adjust Auto Level, R32

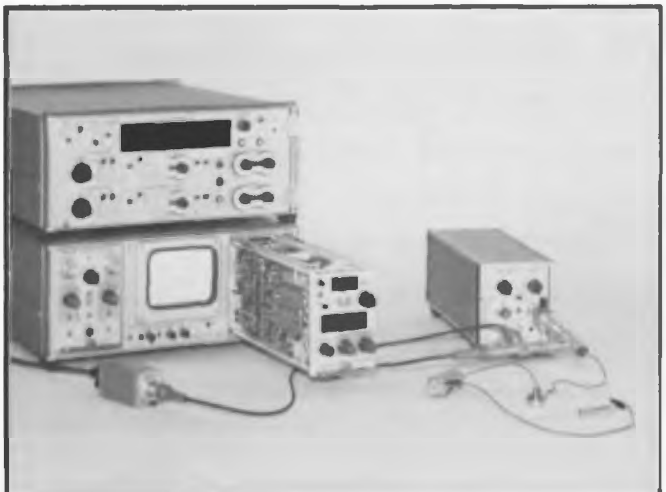
a. Set the Type 3T6 TIME/DIV to 1 μs (DECADE switch to 6, MULTIPLIER switch to 1). Trigger switches for + External triggering, and the DELAY controls all to zero.

b. Make connections between the Type 284 and both the sampling head input and the Type 3T6 external trigger INPUT connector. The equipment includes:

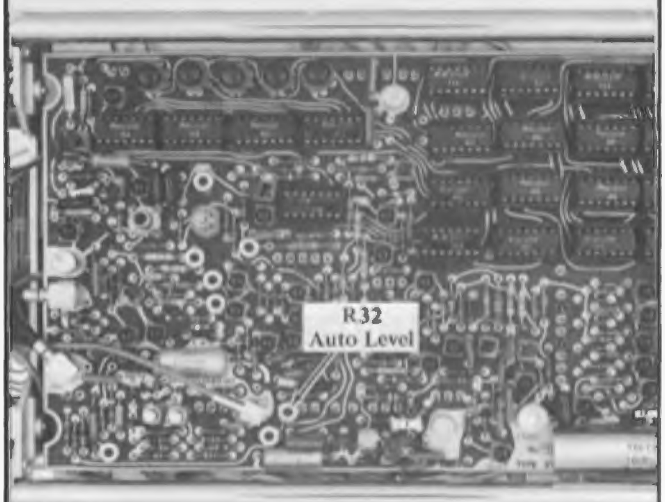
Variable Attenuator (item 21).
2X Attenuator (item 20).
GR 874-T, Coaxial tee (item 22).
GR 874-TPD, Power Divider Tee (item 23).
Two 5 ns signal delay cables with GR 874 connectors (item 15).
GR to BNC male adapter (item 24).
1.5 volt dry cell battery (item 30).
2.5 kΩ potentiometer, 2 watt (item 31).
47 Ω, 1/2 watt carbon resistor (item 32).

Leads that place the battery, potentiometer and 47 Ω resistor in series to be clipped to the open port of the tee connector, see Fig. 5-18A.

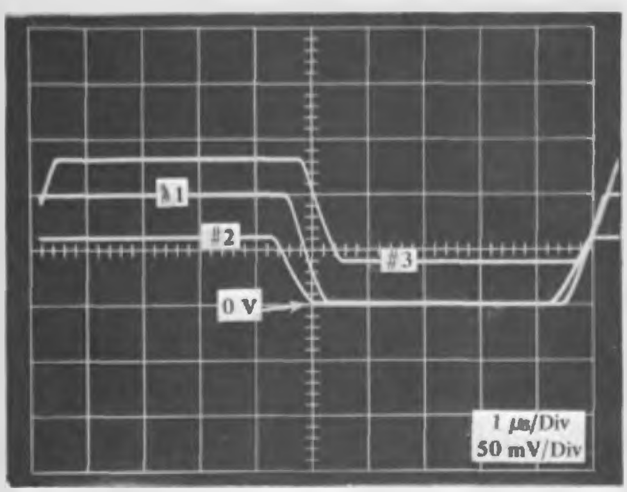
REPLACE: the existing Fig. 5-18 with the following:



(A) Equipment connections.



(B) R32 location.



(C) Multiple exposure waveforms.

Fig. 5-18. Auto level adjust, step 19.

Install the Variable Attenuator (with the arrow pointing outward) to the Type 284 Square Wave Or Sine Wave Output connector. Install, in order, to the Variable Attenuator, a GR Tee, a GR TPD to one port of the Tee, and the two coaxiable cables to the two remaining ports of the GR TPD. This leaves one port of the Tee open for connecting a DC offset current from the battery and potentiometer. Connect one of the cables to the sampling head input, and the other cable to a GR to BNC adapter and then to the Type 3T6 external trigger INPUT connector. See Fig. 5-18A.

c. Set the sampling unit vertical deflection factor to 50 mV/Div. Set the Type 284 controls:

Square Wave Amplitude	1.0 V
Period	10 μs
Mode	For Square Wave

Set the Variable Attenuator control fully clockwise. Adjust the Type 3T6 Trigger SENSITIVITY and RECOVERY TIME controls for a stable CRT display. Use the sampling unit DC Offset control to position the signal zero-volt point one major division below graticule center. Reduce the signal amplitude to 100 mV peak to peak by adjusting the Variable Attenuator control. The display will be like waveform number 1 of Fig. 5-18C.

If the display disappears before the signal amplitude reaches 100 mV, turn R32 (location shown in Fig. 5-18B) a few degrees clockwise. Clockwise rotation of R32 may ultimately produce a free running trace because D28 is oscillating. The final adjustment includes only a few degrees of the total rotation of R32.

d. Waveforms 2 and 3 of Fig. 5-18C are operations that check the hysteresis gap of the Schmidt type Trigger Recognition circuit and D28. The final hysteresis gap must center around +55 mV, and have a magnitude that is either $\geq$ 20 mV or $\leq$ 90 mV. When the hysteresis gap is 20 mV, the display will remain triggered by a signal with a positive excursion that exceeds +65 mV and with a negative excursion that is less positive than +45 mV. The Specification section states only the maximum hysteresis gap of 90 mV, which means there will be a triggered display when the signal maximum positive excursion is $\geq$ 100 mV and the negative excursion is less positive than +10 mV. The same hysteresis gap limits apply for negative signals below ground with the limits between ≥ -100 mV and ≤ -10 mV.

Waveform number 2, produced by reducing the signal amplitude to be less than +100 mV, checks the Trigger Recognition circuit hysteresis gap positive voltage. Slowly reduce the signal amplitude (using the Variable Attenuator control) until the trace disappears. Note the signal positive value at the point that just restores the display.

Waveform number 3 is obtained by applying a positive offset to the 100 mV peak to peak signal. Offset is applied by connecting the 1.5 volt dry cell, 47 ohm resistor and clip leads to the Tee open port; see Fig. 5-18A. Before making connections, place the variable resistor for maximum resistance of 2.5 kΩ. Connect the positive lead to the Tee center conductor, and the negative lead to the outer conductor.

Now increase the offset voltage until the trace disappears. Note the signal negative excursion positive voltage value at the point that just restores the display.

If the two signal voltages that permit a triggered display are +90 mV and +50 mV, then R32 must be turned slightly clockwise to lower the hysteresis gap to be centered around +55 mV. The Specification has been met if the hysteresis gap limits are 90 mV, centered around +55 mV.

e. Reverse the offset leads so the signal can be offset negative, and set the Type 3T6 Triggering POLARITY switch to -. It may be necessary to change the Trigger MODE switch to EXT in order to properly offset the signal, and then return it to EXT AUTO once the 100 mV peak to peak display is centered around -55 mV. (The 47 Ω resistor limits the battery current to about 21 mA when the variable resistance is zero, preventing damage to the 2X attenuator and/or the GR 874-TPD.)

Check that the Trigger Recognition circuit negative triggered hysteresis gap limits are the same as the positive limits, but centered around ≈ -55 mV. It is not required that the negative gap center be precisely at -55 mV, but it is important that there be a trace when the trigger signal DC peak values are at -100 mV (or more negative) and at -10 mV (or less negative).

In the event R32 does not move the hysteresis gap center voltage, but instead only affects the positive voltage at which the trace stops (part d above), then D28 is oscillating and must be replaced by a new tunnel diode. Use only a tunnel diode and R44 purchased from Tektronix, because they have been specially checked to operate in this particular circuit.

In the event the hysteresis gap is less than 20 mV, change Q40. A too narrow hysteresis gap means that Q40 saturation resistance is too high. A too wide hysteresis gap is very unlikely.

(In an emergency, R44 may be changed. However, it must be a precision metal film resistor. Change it to be larger if a larger hysteresis gap is needed, at a value rate of approximately 1 Ω for an additional 9 mV of gap voltage limits.)

f. Disconnect the hook-up and the Type 284.

ELECTRICAL PARTS AND SCHEMATIC CORRECTIONS

REMOVE:

C130	281-0634-00	10 pF	Mica	100 V	1%
C157	283-0002-00	0.01 µF	Cer	500 V	
C534	283-0060-00	100 pF	Cer	200 V	5%
R534	315-0101-00	100 Ω	1/4 W		5%

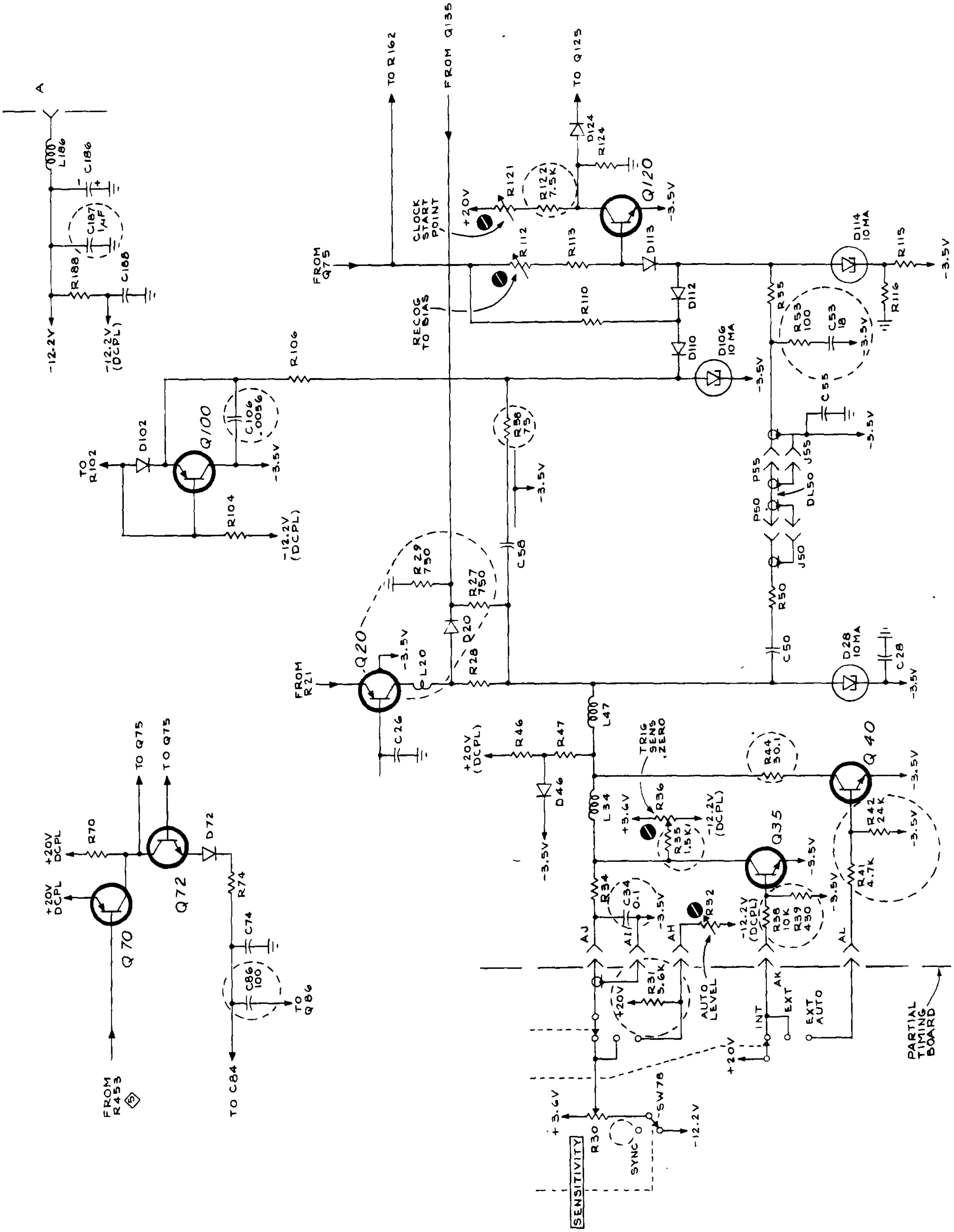
CHANGE TO:

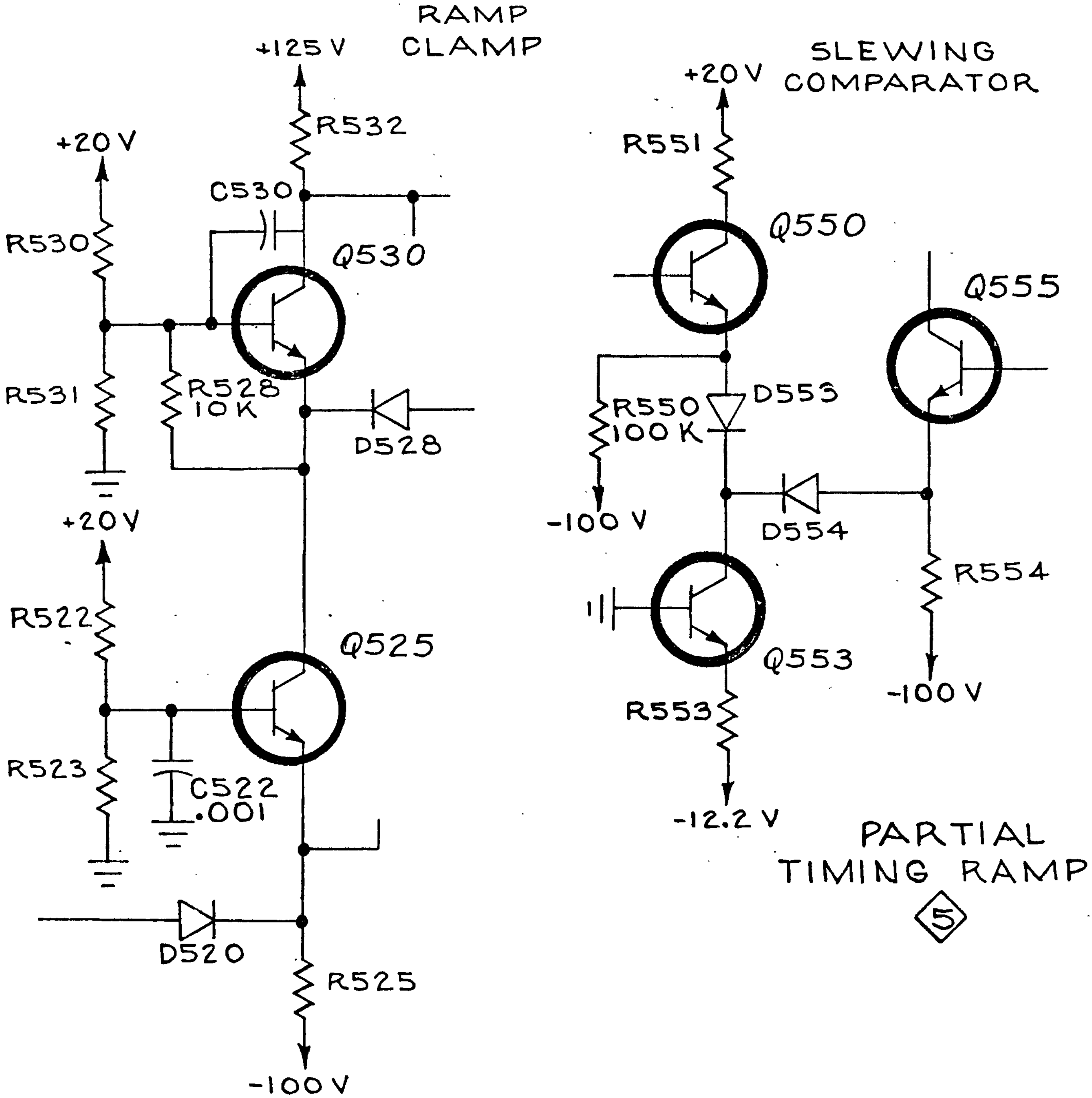
C34	283-0023-00	.1 µF	Cer	10 V	
C50	283-0094-00	27 pF	Cer	200 V	5%
C58	283-0094-00	27 pF	Cer	200 V	5%
C86	283-0128-00	100 pF	Cer	500 V	10%
C106	281-0591-00	5600 pF	Cer	200 V	
C625	281-0591-00	5600 pF	Cer	200 V	
D28/R44	*153-0042-00	Tunnel diode and resistor pair			
DL50	179-1302-00	30 inch (3.75 ns) Delay Line			
Q20	151-0202-00	Silicon	2N4261		
Q40	151-0190-01	Silicon	2N3904		
Q72	151-0190-01	Silicon	2N3904		
Q500	151-0190-01	Silicon	2N3904		
Q550	151-0190-01	Silicon	2N3904		
Q555	151-0190-01	Silicon	2N3904		
R29	317-0751-00	750 Ω	1/8 W		5%
R35	315-0152-00	1.5 kΩ	1/4 W		5%
R38	315-0103-00	10 kΩ	1/4 W		5%
R39	315-0431-00	430 Ω	1/4 W		5%
R41	315-0472-00	4.7 kΩ	1/4 W		5%
R42	315-0243-00	24 kΩ	1/4 W		5%
R44	321-0047-00	30.1 Ω	1/8 W	Prec	1%
R58	315-0750-00	75 Ω	1/4 W		5%
R122	321-0277-00	7.5 kΩ	1/8 W	Prec	1%

ADD:

C53	283-0159-00	18 pF	Cer	50 V	
C187	283-0059-00	1 µF Cer		25 V	
C522	283-0078-00	0.001 µF	Cer	500 V	
D20	152-0322-00	Silicon	Tek Spec		
L20	276-0507-00	Ferramic Suppressor			
R27	317-0751-00	750 Ω	1/8 W		5%
R31	315-0562-00	5.6 kΩ	1/4 W		5%
R53	317-0101-00	100 Ω	1/8 W		5%
R402	315-0152-00	1.5 kΩ	1/4 W		5%
R406	315-0152-00	1.5 kΩ	1/4 W		5%
R528	317-0103-00	10 kΩ	1/8 W		5%
R550	315-0104-00	100 kΩ	1/4 W		5%

SCHEMATIC CORRECTION





PARTIAL
TIMING RAMP
5