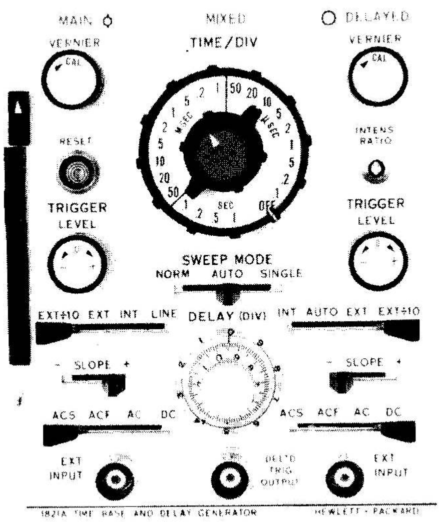
HP 1821A

TIME BASE AND DELAY GENERATOR

1821A



HEWLETT hp PACKARD

HP 1821A

OPERATING AND SERVICE MANUAL

MODEL 1821A
TIME BASE AND DELAY GENERATOR

SERIALS PREFIXED: 809

See Section VII For Instruments
With Other Prefixes

1900 GARDEN OF THE GODS ROAD, COLORADO SPRINGS, COLORADO, U. S. A.

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SECTION I
GENERAL INFORMATION

1-1. INSTRUMENT DESCRIPTION.

1-2. The Hewlett-Packard Model 1821A Time Base And Delay Generator (shown in Figure 1-1) is a sweep generating plug-in unit for the hp Model 180-series Oscilloscope. Main sweep speeds are selectable in 22 ranges from 0.1 μsec/div to 1 sec/div. A vernier provides continuous adjustment between ranges and will extend the slowest sweep to at least 2.5 sec/div. The Magnifier switch on Model 180-series Oscilloscopes can expand the fastest sweep to 10 nsec/div. Delayed sweep speeds can be selected with 18 ranges from 0.1 μsec/div to 50 msec/div; the delayed vernier provides continuous adjustment between ranges and extends the slowest sweep speed to at least 125 msec/div. The main and delayed sweeps can be used either separately or combined to obtain a dual sweep-speed display.

1-3. The delayed sweep feature of the Model 1821A permits accurate time measurement between a reference signal and a point of interest on a complex waveform or pulse train; it also allows for exact time interval measurement between consecutive pulses in a pulse train or burst. The length of time before the delayed sweep starts is adjustable. The mixed sweep feature permits viewing simultaneously the character of an entire complex waveform and an expanded portion of the same waveform.

1-4. Single sweep operation is possible for any type of display. This feature may be used with any sweep speed to facilitate transient waveform photography. Normal triggering of the Model 1821A main sweep and delayed sweep may be selected to occur on an internal signal from the vertical plug-in or on an external signal up to 90 MHz (requires 0.5v pk-pk up to 50 MHz, increasing to 1v at 90 MHz). For the main sweep, automatic triggering provides a bright base line in the absence of an input signal; for the delayed sweep, automatic triggering starts this sweep at the end of the delayed period set. Trigger slope level, and coupling are controlled from the front panel for both the main and delayed sweeps. Table 1-1 provides complete specifications for the Model 1821A and Figure 1-2 illustrates typical displays obtainable with the plug-in.

1-5. SCOPE OF MANUAL.

1-6. This manual provides operating and service information for the hp Model 1821A Time Base And Delay Generator. This manual supplements the information presented in the Operating and Service Manual for the hp Model 180-series Oscilloscope. For specific information about any plug-in for the Model 180-series Oscilloscope, refer to the manual for that plug-in.

1-7. INSTRUMENT IDENTIFICATION.

1-8. Hewlett-Packard uses a two-section eight-digit serial number to identify instruments. The first three digits (preceding the dash) are the serial prefix which identifies a series of instruments; the last five digits identify a particular instrument in the series. The serial number appears on a plate located on the rear panel. All correspondence with a Hewlett-Packard Sales/Service Office in regard to an instrument should reference the complete serial number.

1-9. MANUAL CHANGES.

1-10. This manual provides complete information for any Model 1821A with a serial number prefixed (see Paragraph 1-7) by the three digits indicated on the title page. If the serial prefix of the instrument is different from that on the title page, a "Manual Changes" sheet supplied, or Section VII of this manual, will describe changes which will adapt this manual to provide correct coverage. Technical corrections (if any) to this manual, due to known errors in print, are called Errata and are shown on the change sheet. For information on manual coverage of any hp instrument, contact the nearest hp Sales/Service Office (addresses are listed at the rear of this manual).

Table 1-1. Specifications (Cont'd)

External: 0.5 v pk-pk from DC to 50 MHz (depending on Trigger Coupling) increasing to 1 v pk-pk at 90 MHz.

Slope: selectable, positive or negative.

Trigger Point: adjustable ±3 v over selected trigger signal (±30 v in EXT ÷ 10).

DELAY:

Time: continuously variable from 0.1 μsec to 10 sec; accuracy ±1%; linearity ±0.2%; time jitter is less than 0.005% of maximum delay of each range (1 part in 20,000).

Trigger Output (at end of delay time): approximately 1.5 v pulse with rise time less than 50 nsec from 1k ohm impedance.

MIXED SWEEP:

Dual sweep display in which main sweep drives first portion of display and delayed sweep completes display at speeds up to 1,000 times faster.

INTENSIFIED SWEEP:

The intensified section of the main sweep shows the time of the delayed sweep. It indicates the portion of the main sweep to be expanded full screen in delayed operation.

SINGLE SWEEP:

Front panel controls permit single sweep operation.

WEIGHT:

Net, 3-3/4 lbs (1,7 kg). Ship, 6-1/4 lbs (2,8 kg).

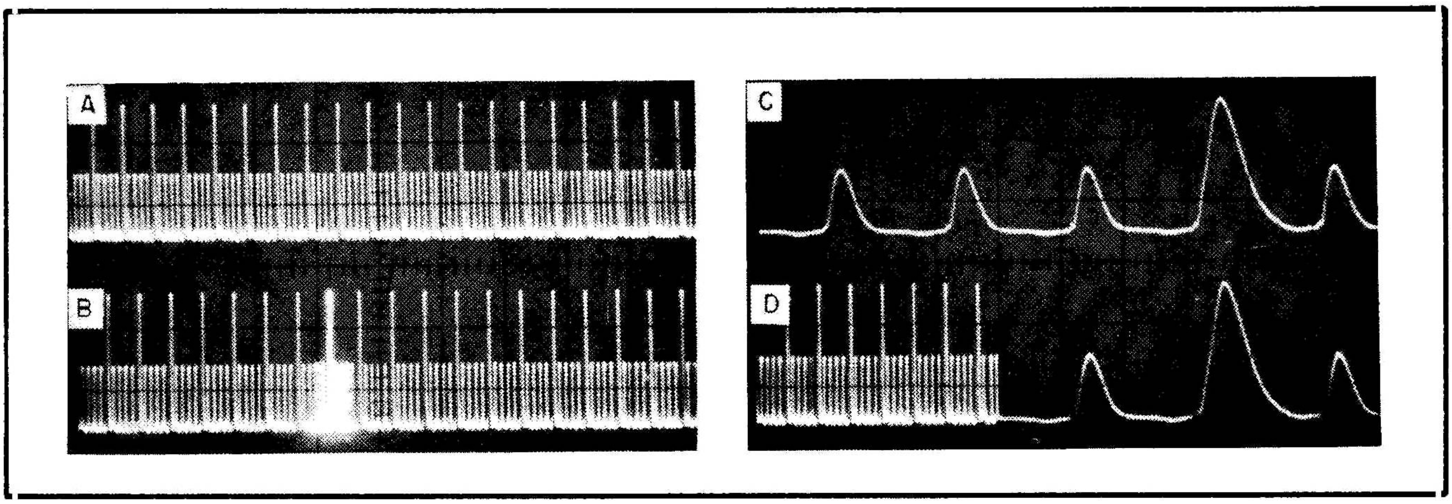


Figure 1-2. Waveforms illustrating sweep combinations using Model 1821A: (A) normal sweep; (B) intensified sweep (portion covered by delayed sweep is brightened); (C) delayed sweep (intensified portion of B is expanded to full 10 div); (D) mixed sweep (faster delayed sweep drives right portion of display).

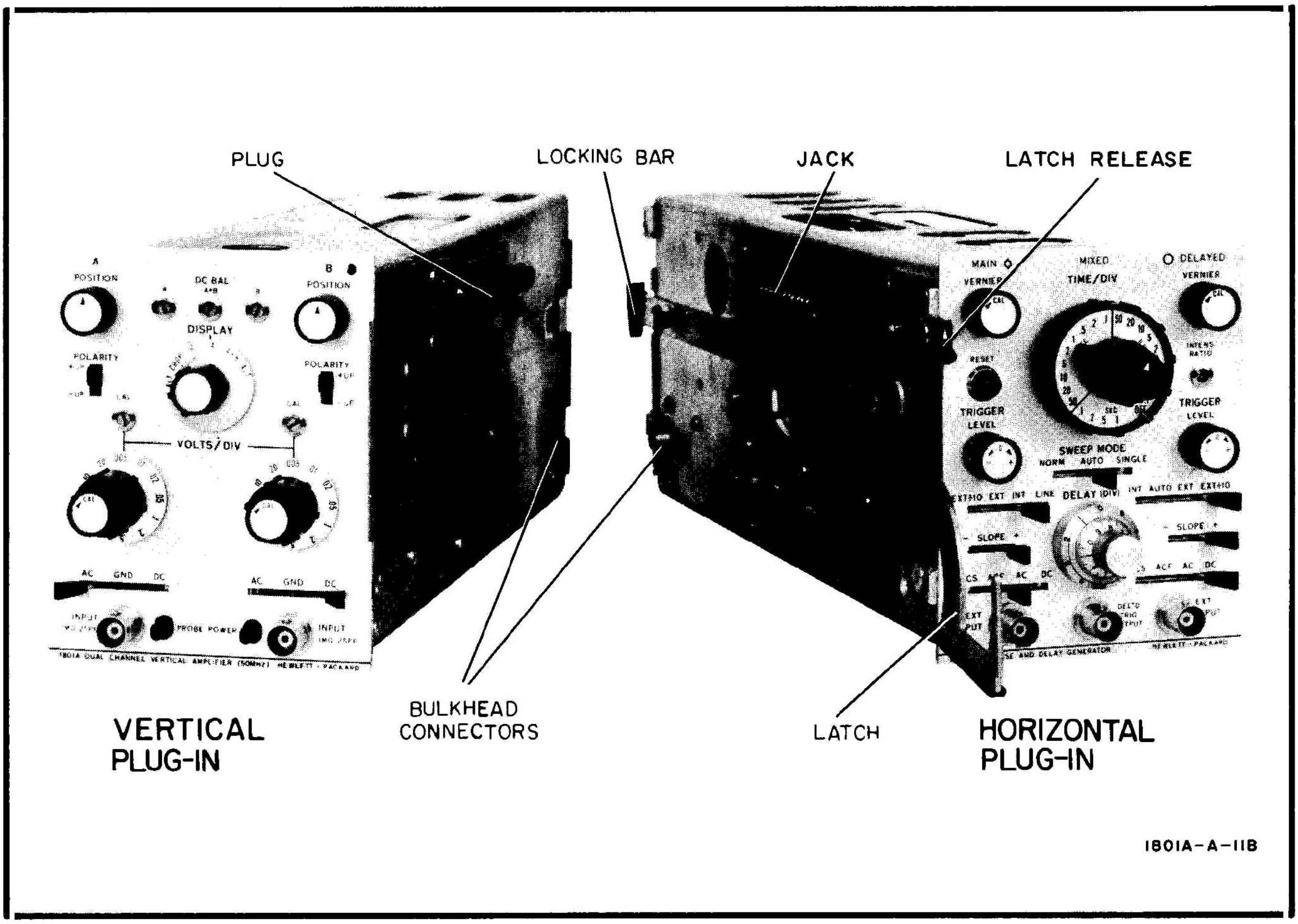


Figure 2-1. Plug-In Mating

SECTION IV
PRINCIPLES OF OPERATION

4-1. INTRODUCTION.

4-2. The Model 1821A Time Base and Delay Generator produces two linear sweeps for use as time bases in the Model 180-series Oscilloscopes. Either sweep, or a combination of both, may be selected by front panel controls. The selected sweep is applied to the Oscilloscope to drive the horizontal amplifier. Figure 4-1 is an over-all block diagram that shows the principal circuits of the Model 1821A and their relationship to each other.

4-3. The trigger generators each produce a fast-rise negative pulse at some point on the trigger signal. The gate generators are "fired" by these pulses and produce negative gates that are coupled to the integrators. Each integrator generates a positive sweep during the time it is unclamped by the gates.

4-4. The sweep comparator generates a positive pulse at some time after the start of the main sweep. This pulse "resets" the delayed gate generator to a pre-trigger condition. Since the delayed gate generator can not be fired until it is reset, the delayed gate and sweep always start after the main gate and sweep.

4-5. The main and delayed gates from the gate generators, and the main and delayed sweeps from the integrators are applied to the Sweep Display switch. This front panel control couples the main and delayed signals, in various combinations, to the Model 180-series Oscilloscope.

4-6. MAIN SWEEP.

4-7. The main sweep circuit is explained in the following paragraphs. The Block Diagram Description is a general explanation of circuit function while Circuit Details provides more complete information.

4-8. BLOCK DIAGRAM DESCRIPTION.

4-9. A block diagram of the main sweep circuit is shown in Figure 4-2.

4-10. NORMAL. Setting the SWEEP MODE switch to NORM disables the auto circuit and allows the main sweep circuit to operate normally. The selected trigger signal is applied to the trigger generator which produces a fast-rise negative pulse at some point on the trigger signal. The gate generator is "fired" by this pulse and produces a negative signal that is applied to the Sweep Display switch and to the integrator. When unclamped by this signal, the integrator begins to generate the main sweep. This linear positive-going sweep is applied to the Sweep Display switch and

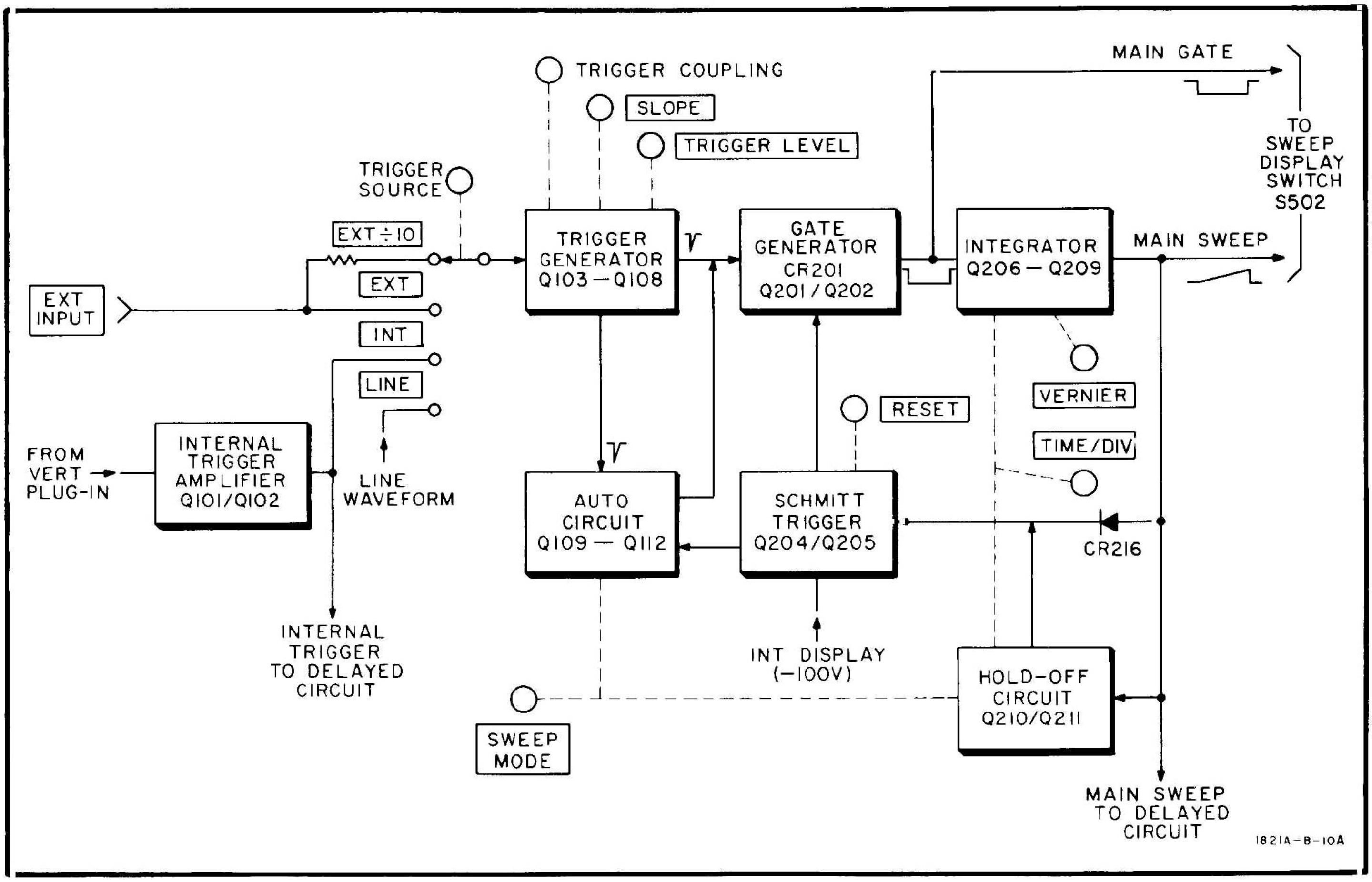


Figure 4-2. Main Sweep Circuit Block Diagram

to the Schmitt trigger. When the ramp (the positive-going portion of the sweep signal) reaches a predetermined amplitude, the Schmitt trigger changes state, causing the gate generator to turn off, terminating the main sweep. After a brief delay from the end of the sweep, the hold-off circuit generates a negative signal that switches the Schmitt trigger back to the pretrigger state. This action "resets" the gate generator. The next negative pulse from the trigger generator "fires" the gate generator again and the cycle repeats.

4-11. AUTO. Selecting AUTO with the SWEEP MODE switch activates the auto circuit. However, if a trigger signal greater than about 40 Hz is present, the signal from the trigger generator "locks out" the auto circuit. With the auto circuit "locked out", the main sweep circuit operates as it did in NORM. If the trigger signal drops below 40 Hz, or is removed, the auto circuit turns on. It is triggered by the Schmitt trigger at the same time the gate generator is "reset" and supplies the current necessary to "fire" the gate generator. This action causes the main sweep circuit to free-run -- its rate determined by the sweep speed.

4-12. SINGLE. Setting the SWEEP MODE switch to SINGLE disconnects the hold-off circuit from the Schmitt trigger. The gate generator must now be "reset" by depressing the RESET push button at the end of each sweep, manually switching the Schmitt trigger to the pretrigger state.

4-13. CIRCUIT DETAILS.

4-14. The following paragraphs provide more information about the main sweep circuit. Refer to the schematic diagram in Figures 7-4 and 7-6.

4-15. NORMAL. The trigger signal is obtained from one of three sources as determined by the Trigger Source Switch, S101. The external signal is obtained from a front-panel BNC connector; the line signal from the Model 180-series Oscilloscope; and the internal signal from the Vertical Plug-In through the internal trigger amplifier, Q101/Q102. Voltage divider R103/R104 attenuates the external signal by a factor of 10 when EXT÷10 is selected. Voltage divider R101/R102 attenuates the line signal to 10 v pk-pk. The selected trigger signal is coupled through the Trigger Coupling switch S102 to source follower Q103. Trigger Coupling switch S102 selects between direct coupling (DC) capacitive coupling (AC) a low-pass filter (ACS) and a high-pass filter (ACF). CR103 protects Q103 from excessive negative voltage. Q103 provides a high input impedance to the trigger signal and couples the signal to the trigger comparator, Q104/Q105.

4-16. The trigger comparator switches tunnel diode CR106 to a high-voltage state at a selected point on the trigger signal. Setting the SLOPE switch to + turns off CR104 and turns on CR105. Tunnel diode CR106 is connected through CR107 to the collector of Q104. The positive slope of the trigger signal, applied to the base of Q104, causes Q104 to eventually conduct hard enough to switch CR106 to a high-voltage state. The TRIGGER LEVEL control determines the base voltage of Q105 and therefore affects the bias on Q104. Adjusting the TRIGGER LEVEL control determines the voltage required to switch the tunnel diode. Diodes CR109 and CR110 protect Q104 and Q105 from reverse breakdown, base to emitter.

4-17. Setting the SLOPE switch to - turns off CR105 and turns on CR104. Tunnel diode CR106 is connected through CR108 to the collector of Q105. The trigger signal is coupled through Q104 to the emitter of Q105. Eventually the negative slope of the trigger signal turns on Q105 hard enough to switch CR106 to a high-voltage state. Since the TRIGGER LEVEL control determines the bias on Q105, it also determines the voltage required to switch the tunnel diode.

4-18. The negative-going rectangular wave produced by CR106 is differentiated by C118 and the emitter circuit of Q107. The resulting signal is coupled to Q108. Since Q108 is biased below cut-off, only the positive pulses are amplified and inverted. The fast-rise negative pulses from the collector of Q108 are coupled to the auto circuit "locking it out" and to the tunnel diode, CR201 (Figure 8-6). The current provided by the first negative pulse, combined with the current from Q204 is sufficient to switch CR201 to a high-voltage state. After the trigger pulse ends, the current from Q204 alone is sufficient to keep CR201 in this high-voltage state. The negative signal produced by CR201 is amplified and inverted by Q201 and Q202. Diodes CR202 through CR204 keep Q201 from saturating. The negative signal at the collector of Q202 is coupled to three places: (1) to P1 pin 14 and through the Model 180-series Oscilloscope to the rear panel, (2) to S502 as an intensity signal to unblank the CRT, and (3) to the Miller integrator circuit where it opens diode switch CR211/CR215.

4-19. When the diode switch opens, the timing capacitor (C501 through C510) begins charging through the timing resistor (R502 through R510) to the negative voltage on the wiper of R235. The TIME/DIV switch determines the slope of the negative-going ramp at the gate of Q207 in two ways: (1) by selecting various RC time constants; (2) by selecting the base voltage on Q206 which determines the charging voltage at R235. The VERNIER control, R235, adjusts the charging voltage between the calibrated steps of the TIME/DIV control. The positive-going linear ramp at the output of the Miller integrator is coupled to P1 pin 11 and through the Model 180-series Oscilloscope to a rear-panel connector, to R460 to arm the delayed sweep circuit, and to S502 for horizontal deflection.

4-20. The positive-going ramp is also picked off the wiper of R251 and applied to CR216. As the ramp goes positive, CR216 turns on and connects the ramp to the base of Q205. The ramp continues going positive until it reaches the upper hysteresis limit of the Schmitt trigger, when Q205 turns on, turning Q204 off. The current from Q204 through CR201 is removed, and the tunnel diode switches to a low-voltage state. The negative gate ends; the diode switch (CR211/CR215) closes and terminates the ramp. Disconnect diode CR216 opens when the ramp ends, disconnecting the sweep voltage from the Schmitt trigger. The base voltage of Q205 returns to a quiescent level and the Schmitt trigger remains in this new state. CR201 is now in a "no-trigger" condition and incoming negative trigger pulses have no effect.

4-21. As the main sweep was being generated, the positive-going ramp was also applied to the hold-off emitter followers, Q210 and Q211. The positive-going signal at the emitter of Q210 was coupled through CR218 and CR219 and discharged the selected hold-off capacitor (C514 through C520). When the ramp ended, CR218 turned off and the hold-off capacitor began to charge negatively. As the capacitor charges, CR217 turns on and connects the hold-off capacitor to the base of Q205. When the charge on the hold-off capacitor reaches the lower hysteresis limit of the Schmitt trigger, Q205 turns off, turning on Q204. Q204 now supplies current to CR201 "resetting" it to a pretrigger condition. The time between the end of one sweep and the turn-on of Q204 is called hold-off. A new sweep cannot be started until this time has elapsed. Hold-off is varied slightly as the Main TRIGGER LEVEL control is adjusted by varying the voltage at R254. This provides a stable display of certain discrete high frequency signals.

4-22. SINGLE. When SINGLE is selected with the SWEEP MODE switch, the output from the hold-off circuit is clamped to about 0 v by CR220. S201 must be depressed to provide the negative signal that turns off Q205, switching the Schmitt trigger to a pretrigger state and resetting CR201. At this time, Q203 is turned on, shorting R217 and lighting front-panel indicator DS201. RESET lamp DS201 therefore indicates that CR201 is "reset". The next trigger pulse will switch CR201 to a high-voltage state and the previous cycle will repeat.

4-23. AUTO. At the time Q205 is turned off, a positive pulse from the collector of Q205 is applied to the base of Q109 (Figure 8-4). If the SWEEP MODE switch is set to either NORM or SINGLE, the monostable multivibrator, Q110/Q111, is disabled, causing CR117 to open. Q112 is then biased into conduction, turning off Q109. The auto trigger from Q205 is blocked by Q109 and has no effect on the circuit.

4-24. If however, AUTO is selected (no trigger signal applied) Q110 turns on, turning off Q111. The negative voltage from the collector of Q111 turns off Q112. The relatively positive voltage from the collector of Q112 is blocked by CR114, and Q109 conducts when the auto trigger from Q205 is applied. The current from Q109 triggers CR201, and the main sweep circuit free-runs — CR201 being fired by the current from Q109 each time it is reset by the current from Q204.

4-25. When a trigger signal is applied, the negative pulses from the collector of Q108 are coupled to the base of Q111, switching the monostable multivibrator to its non-stable state (Q110 off — Q111 on). If the frequency of the trigger signal is above approximately 40 Hz, the multivibrator does not return to its stable state. The relatively positive voltage from the collector of Q111 is blocked by CR117 and Q112 is biased into conduction. The negative signal from the collector of Q112 turns off Q109, blocking the auto trigger. The next pulse from Q108 will fire the gate circuit and start a sweep. If the frequency of the trigger signal drops below 40 Hz, the sweep circuit will be alternately triggered and free-run, providing an unstable display.

4-26. DELAYED SWEEP.

4-27. A block diagram of the delayed sweep circuit is shown in Figure 4-3. The delayed sweep circuit is similar to the main sweep circuit. There are, however, three main differences: (1) the hold-off circuit is replaced by the sweep comparator; (2) there is no auto circuit; (3) triggering from the power-line waveform is replaced by automatic triggering.

4-28. BLOCK DIAGRAM DESCRIPTION.

4-29. The sweep comparator generates a positive pulse at a point on the main sweep, determined by the setting of the CM DELAY control. The pulse from the sweep comparator switches the delayed Schmitt trigger to a pretrigger state, resetting the gate generator. Setting the delayed Trigger Source switch to AUTO allows this same pulse to generate a trigger that fires the gate generator. In AUTO, the delayed sweep starts immediately at the end of the delay. Selecting either INT or EXT with the delayed Trigger Source switch, allows the selected trigger signal to produce the pulse that fires the gate generator. Using internal or external trigger signals cause the delayed sweep to start on the first trigger signal after the delay.

4-30. The negative output from the gate generator (when fired) is applied to the sweep display switch and to the integrator. The integrator, when unclamped by this signal, generates a positive-going ramp that is applied to the sweep display switch and to the Schmitt trigger. When the sweep reaches a preselected amplitude, the Schmitt trigger changes state, turning off the gate generator, terminating the sweep.

4-31. The sweep comparator will again generate a positive pulse at some time during the next main sweep and the previous cycle will repeat.

4-32. CIRCUIT DETAILS.

4-33. The following paragraphs contain more detailed information about the delayed sweep circuits. Refer to the schematic diagram in Figures 8-7 and 8-8.

4-34. The positive-going main sweep, applied to the base of Q411 (Figure 8-8) eventually causes the transistor to conduct hard enough to switch tunnel diode CR423 to a high-voltage state. Since the DELAY (DIV) control determines the gate voltage of Q412 it also determines the bias on Q411. As the DELAY (DIV) control is varied, Q411 switches the tunnel diode, CR423, to a high-voltage state at various times during each sweep. The negative signal generated by CR423 is inverted by Q410 and coupled to the base of Q403. The positive signal turns on Q403, switching the Schmitt trigger to a pretrigger state, resetting CR401. The positive signal from Q410 is also differentiated by C422 and R459 and coupled to the base of Q409. Since Q409 is normally cut-off, only the positive-going pulses are applied to the front-panel BNC connector, J401.

4-35. If AUTO is selected with the delayed Trigger Source switch (Figure 8-7) the positive pulse from Q410

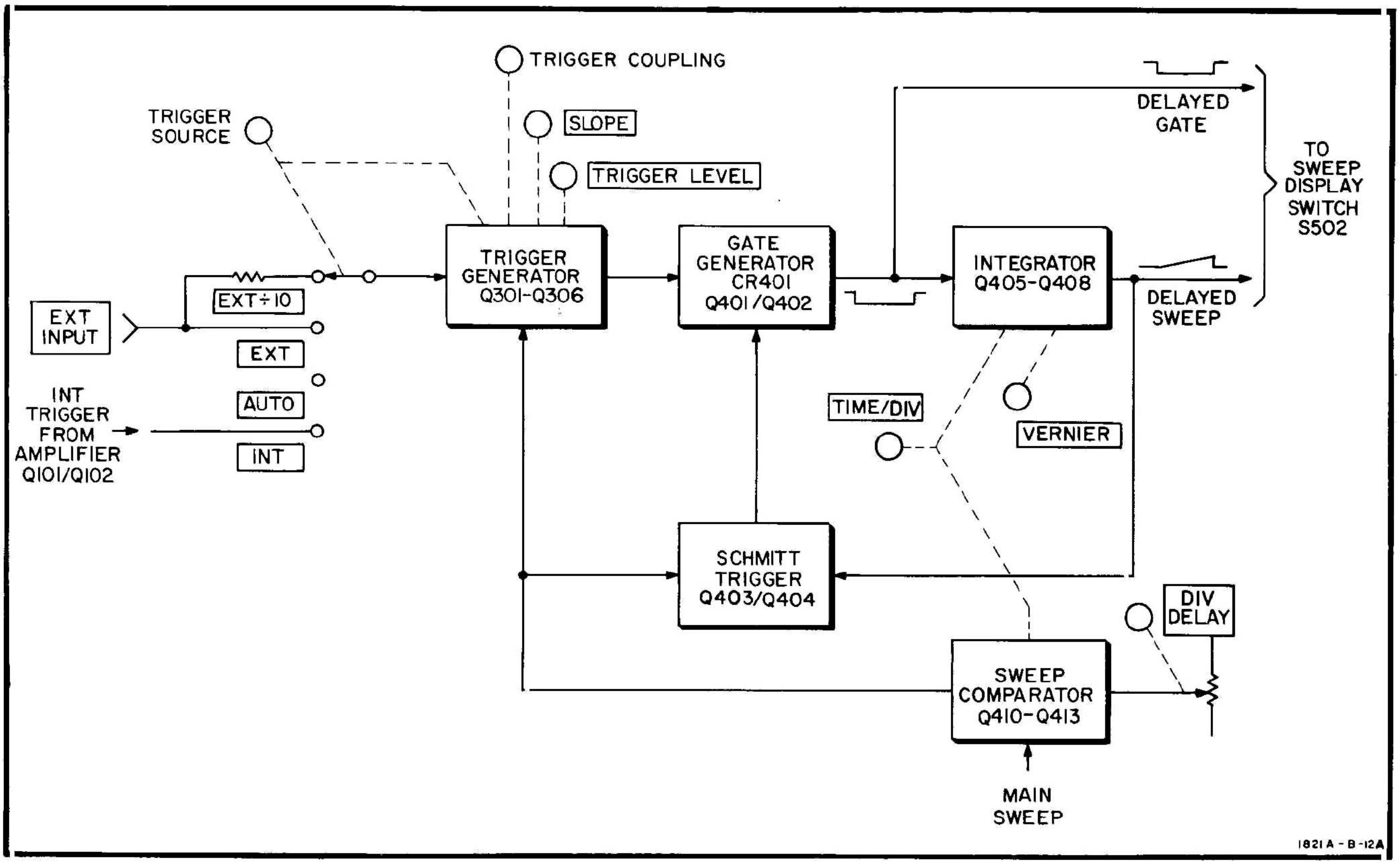


Figure 4-3. Delayed Sweep Circuit Block Diagram

is also coupled through CR309 to the base of Q306. The negative pulse from the collector of Q306 fires CR401 starting the delayed gate. In AUTO, therefore, the delayed gate and the delayed sweep start immediately after the delay.

4-36. Setting the delayed Trigger Source switch to either EXT, EXT÷10 or INT, reverse biases CR309. The auto trigger from Q410 is blocked and the gate circuit is not fired until the selected trigger signal produces a negative trigger pulse. In EXT, EXT÷10 or INT the delayed gate and sweep start on the first trigger signal after the delay.

4-37. The delayed trigger generator, gate generator, and integrator operate similarly to the main sweep circuits which are explained in Paragraph 4-13 to 4-20.

4-38. When the main sweep ends (Figure 8-8), Q411 turns off, switching CR423 to a low-voltage state. The negative output from the collector of Q410 turns off Q403, switching the Schmitt trigger to its pretrigger state. The current to CR401 is removed, the gate ends, and the delayed sweep is terminated. This action insures that the delayed sweep ends with the main sweep, preventing the main sweep from being triggered again while the delayed sweep is being generated.

4-39. SWEEP DISPLAYS.

4-40. The main and delayed gates and the main and delayed sweeps are applied to the Sweep Display switch. As the switch is rotated between the MAIN, MIXED, and DELAYED positions, various combinations of the applied signals are coupled to the Model 180-series Oscilloscope. A schematic diagram of the Sweep Display switch, S502, is given in Figure 8-10.

4-41. Figure 4-4 shows the displays obtained in the three positions of the Sweep Display switch. For illustration purposes, the vertical input signal is shown to be a repetitive series of six pulses. The first pulse has some minimum amplitude and each successive pulse is larger. The main gate and sweep start on the first pulse. The delayed gate and sweep are 2.5 times faster than the main, and start (at end of delay) just before the second pulse.

4-42. MAIN. Setting the Sweep Display switch to MAIN, couples the main sweep to the Oscilloscope for deflection. The main and delayed gates are combined and coupled to the Oscilloscope for intensity. The portion of the display that occurs during the delayed gate time is intensified. Diode CR502 limits the maximum amplitude of the delayed gate to a voltage selected by R525.

4-43. MIXED. Selecting MIXED, combines the main and delayed sweeps and applies them to the Oscilloscope. CR501 prevents the main sweep from feeding back into the delayed circuit. The delayed sweep however, couples through when it exceeds the amplitude of the main sweep. The main gate is coupled to the Oscilloscope for intensity. The first part of the display is on main sweep time and the last part on delayed sweep time. The display is an even intensity except for the difference caused by the different speeds of the main and delayed sweeps. When the delayed sweep

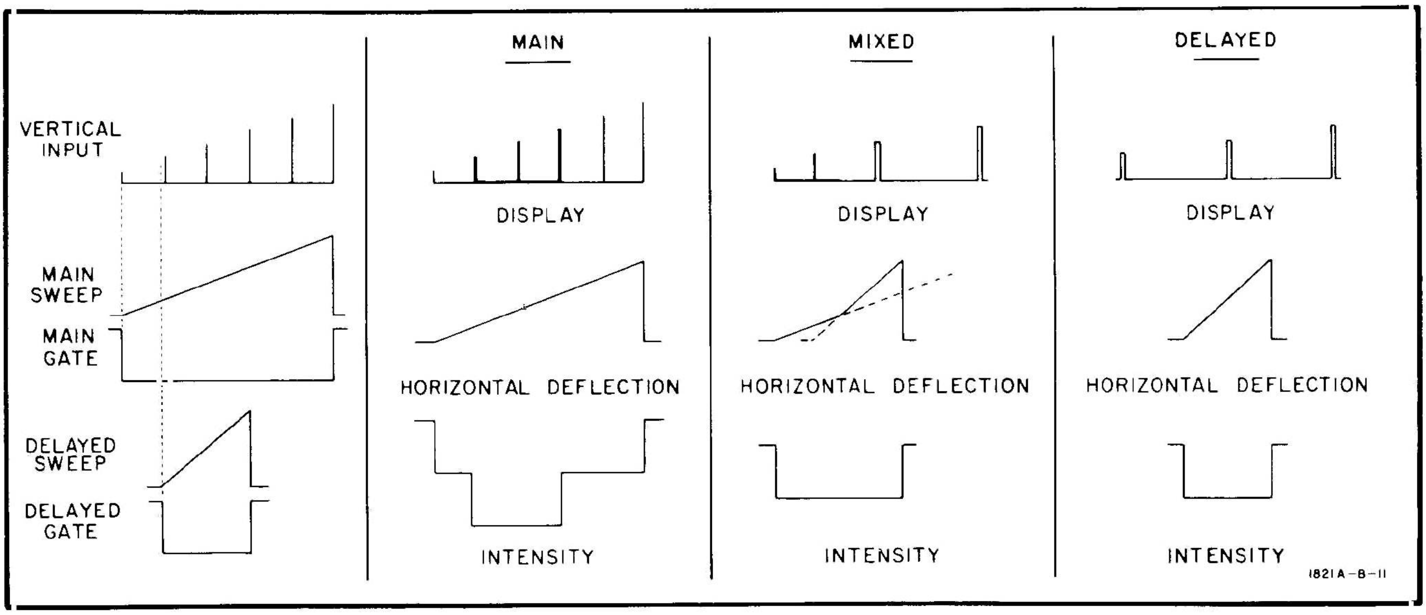


Figure 4-4. Sweep Displays

reaches maximum amplitude before the main sweep, the delayed sweep signal, feeding back into the main sweep circuitry, terminates the main sweep. This action insures that both sweeps terminate at the same time.

4-44. DELAYED. Selecting DELAYED, couples the delayed gate and sweep to the Oscilloscope. The portion of the vertical input signal that was intensified in MAIN, is now displayed at the delayed sweep speed.

Table 5-1. Required Test Equipment

Recommended Instrument: Type	Recommended Instrument: Model	Required Characteristics	Par Ref.	Required for
Signal Generator	hp Model 608 C/E or hp Model 3200 B	50 MHz & 90 MHz @ 1 v pk-pk	5-12	Triggering Check
Oscillator	hp Model 200 CD	40 Hz & 100 kHz @ 6 v pk-pk	5-13 5-31 5-32 5-33	Trigger Point & Slope Check Trigger Symmetry Check Main Sweep Length Adj Delayed Sweep Length Adj
Time Mark Generator	Tektronix Type 184	0.1 μsec to 1 sec @ 3 v pk-pk	5-14 5-15 5-16 5-17 5-18 5-19 5-20 5-21 5-22 5-23 5-34 5-35 5-36	Main Sweep Time Check Main Sweep Vernier Check Magnified Sweep Check Delayed Sweep Time Check Delayed Sweep Vernier Check Delay Time Accuracy Check Delay Time Linearity Check Jitter Check Delayed Trigger Output Check Mixed Sweep Check Main Sweep Time Adj Delayed Sweep Time Adj Sweep Comparator Adj
Oscilloscope	hp Model 140A w/1402A and 1423A	Sensitivity 0.1 v/cm sweep speed 50 nsec/cm	5-22	Delayed Trigger Output Check
10:1 Divider Probe	hp Model 10001A or hp Model 10004A	3% accuracy	5-22	Delayed Trigger Output Check
RF Voltmeter	hp Model 411A	0.5 v pk-pk @50 MHz 1 v pk-pk @90 MHz	5-12	Triggering Check
DC Voltmeter	hp Model 412A	1 v range 3% accuracy	5-30	Output Level Adj

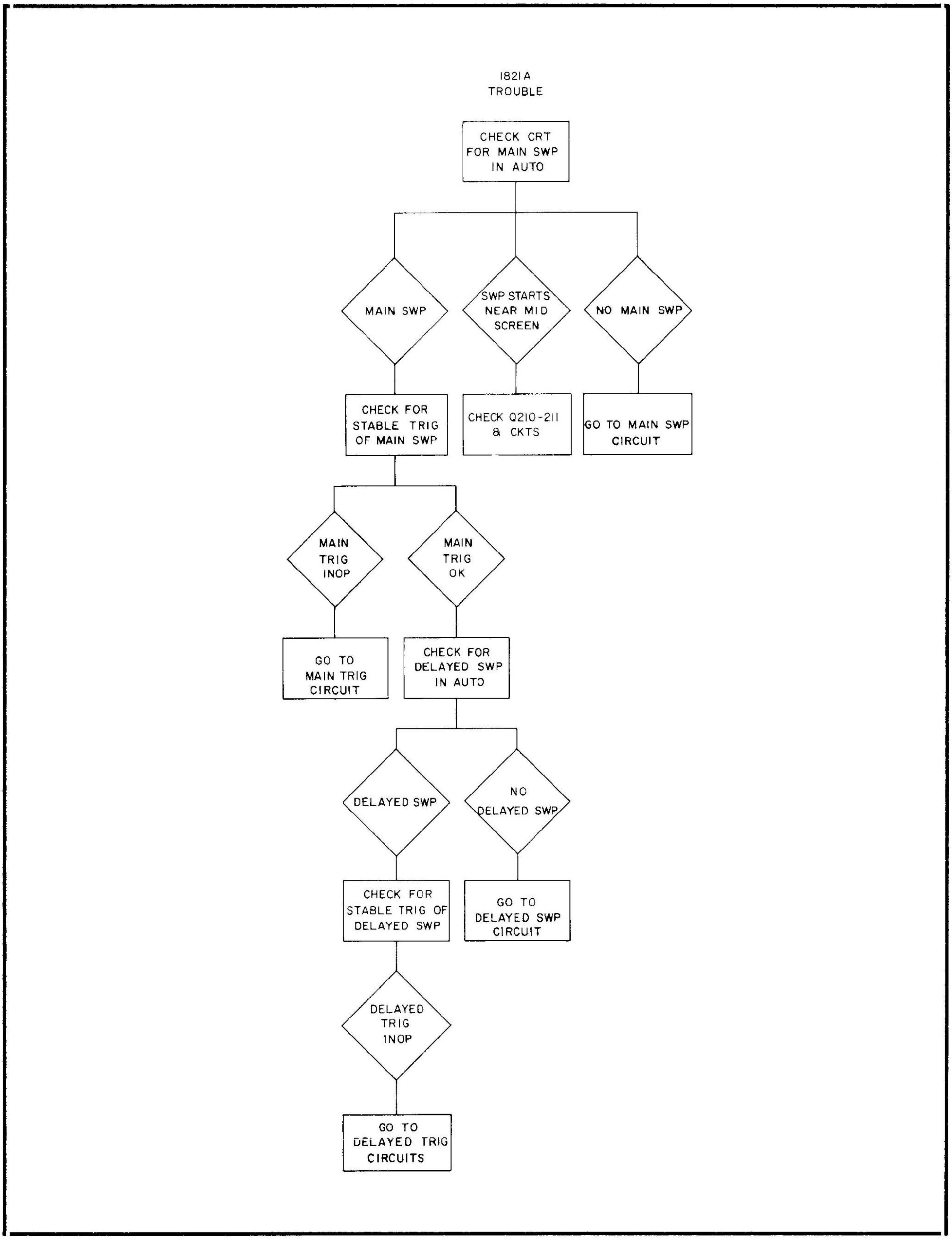


Figure 8-1. Over-all Troubleshooting Tree

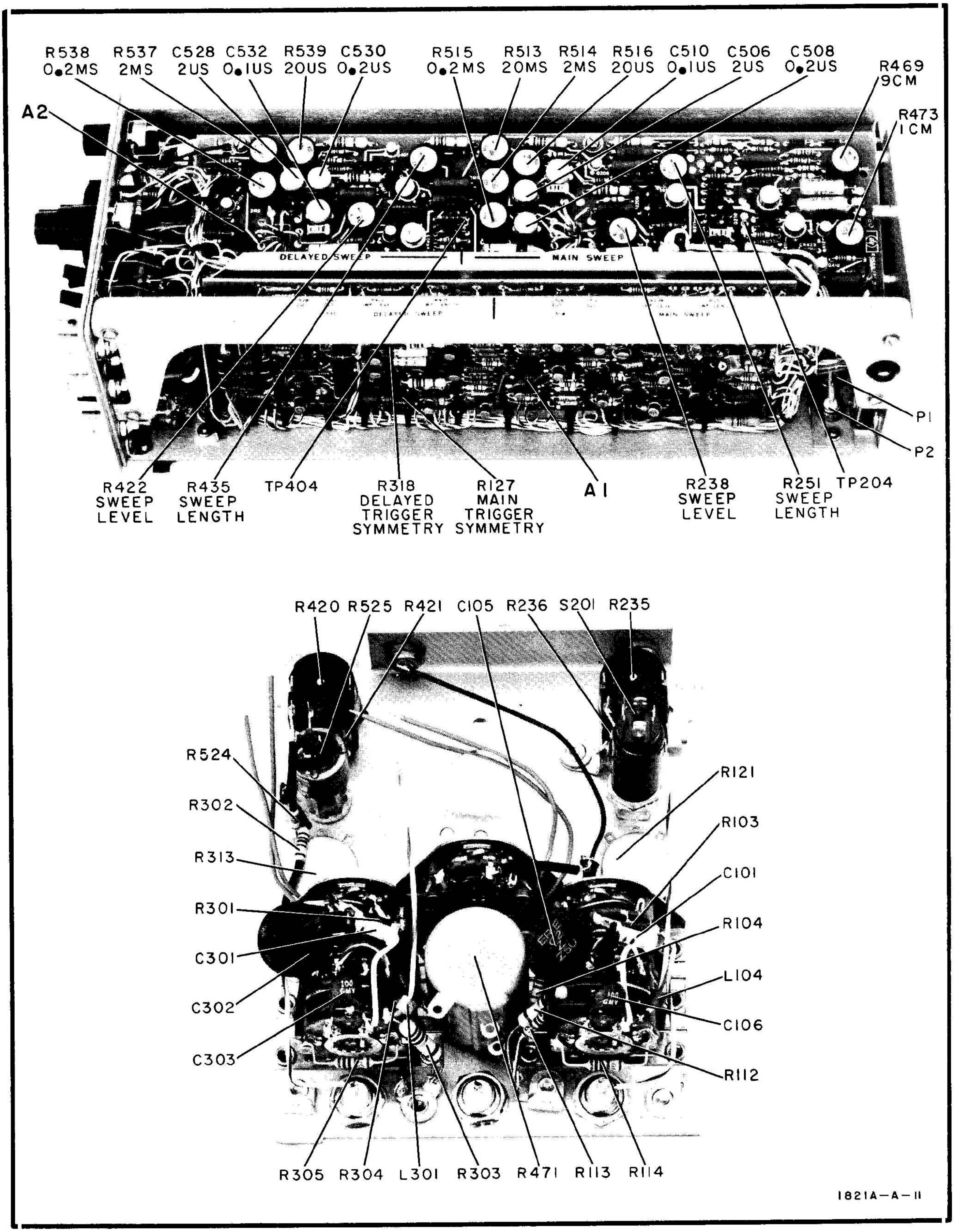
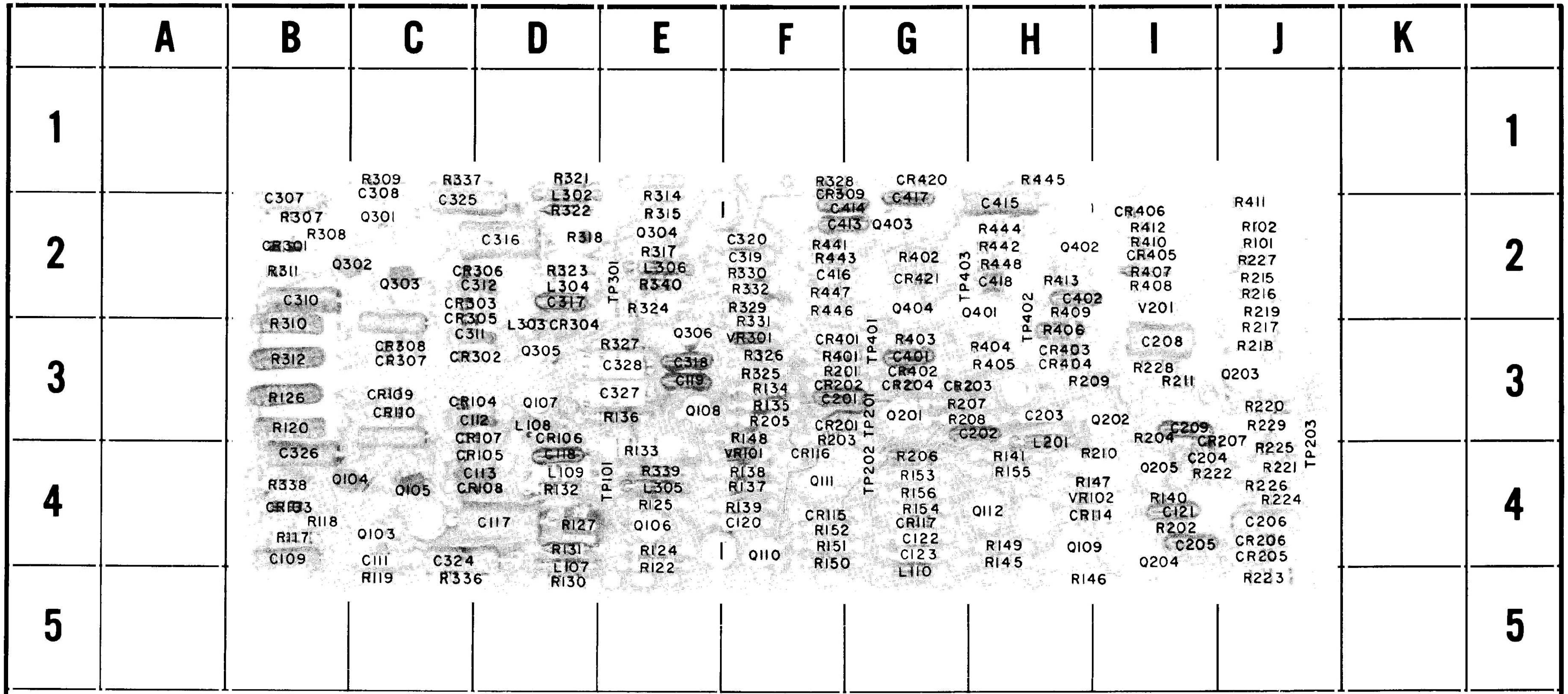


Figure 8-2. Adjustment Location and Component Identification.



REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC
C109	B-4	C312	C-2	CR107	C-3	CR309	F-1	Q107	D-3	R117	B-4	R147	H-4	R217	J-3	R321	D-1	R409	H-2
C111	C-4	C316	D-2	CR108	C-4	CR401	F-3	Q108	E-3	R118	B-4	R148	F-3	R218	J-3	R322	D-2	R410	I-2
C112	C-3	C317	D-2	CR109	C-3	CR402	G-3	Q109	H-4	R119	C-5	R149	H-4	R219	J-2	R323	D-3	R411	J-2
C113	C-4	C318	E-3	CR110	C-3	CR403	H-3	Q110	F-4	R120	B-3	R150	F-4	R220	J-3	R324	E-2	R412	I-2
C117	D-4	C319	F-2	CR114	H-4	CR404	H-3	Q111	F-4	R122	E-5	R151	F-4	R221	J-4	R325	F-3	R413	H-2
C118	D-4	C320	F-2	CR115	F-4	CR405	I-2	Q112	H-4	R124	E-4	R152	F-4	R222	I-4	R326	F-3	R441	F-2
C119	E-3	C324	C-4	CR116	F-4	CR406	I-2	Q201	G-3	R125	E-4	R153	G-4	R223	J-5	R327	E-3	R442	H-2
C120	F-4	C325	C-2	CR117	G-4	CR420	G-1	Q202	I-3	R126	B-3	R154	G-4	R224	J-4	R328	F-1	R443	F-2
C121	I-4	C326	B-4	CR201	F-3	CR421	G-2	Q203	J-3	R127	D-4	R155	H-4	R225	J-4	R329	F-2	R444	H-2
C122	G-4	C327	E-3	CR202	F-3	L107	D-5	Q204	I-4	R130	D-5	R156	G-4	R226	J-4	R330	F-2	R445	H-1
C123	G-4	C328	E-3	CR203	G-3	L108	D-3	Q205	I-4	R131	D-4	R201	F-3	R227	J-2	R331	F-3	R446	F-2
C201	F-3	C401	G-3	CR204	G-3	L109	D-4	Q301	C-2	R132	D-4	R202	I-4	R228	I-3	R332	F-2	R447	F-2
C202	H-3	C402	H-2	CR205	J-4	L110	G-5	Q302	B-2	R133	E-4	R203	F-3	R229	J-3	R336	C-5	R448	H-2
C203	H-3	C413	F-2	CR206	J-4	L201	H-3	Q303	C-2	R134	F-3	R204	I-3	R307	B-2	R337	C-1	TP101	E-4
C204	I-4	C414	F-2	CR207	I-3	L302	D-1	Q304	E-2	R135	F-3	R205	F-3	R308	B-2	R338	B-4	TP201	G-3
C205	I-4	C415	H-2	CR301	B-2	L303	D-3	Q305	D-3	R136	E-3	R206	G-4	R309	C-1	R339	E-4	TP202	G-4
C206	J-4	C416	F-2	CR302	C-3	L304	D-2	Q306	E-3	R137	F-4	R207	G-3	R310	B-3	R340	E-2	TP203	J-4
C208	I-3	C417	G-2	CR303	C-2	L305	E-4	Q401	H-2	R138	F-4	R208	G-3	R311	B-2	R401	F-3	TP301	E-2
C209	I-3	C418	H-2	CR304	D-3	L306	E-2	Q402	H-2	R139	F-4	R209	H-3	R312	B-3	R402	G-2	TP401	G-3
C307	B-2	CR103	B-4	CR305	C-3	Q103	C-4	Q403	G-2	R140	I-4	R210	I-4	R314	E-2	R403	G-3	TP402	H-3
C308	C-1	CR104	C-3	CR306	C-2	Q104	B-4	Q404	G-2	R141	H-4	R211	I-3	R315	E-2	R404	H-3	TP403	G-2
C310	B-2	CR105	C-4	CR307	C-3	Q105	C-4	R101	J-2	R145	H-4	R215	J-2	R317	E-2	R405	H-3	V201	I-2
C311	C-3	CR106	D-3	CR308	C-3	Q106	E-4	R102	J-2	R146	H-5	R216	J-2	R318	D-2	R406	H-3	VR101	F-4
																R407	I-2	VR102	H-4
																R408	I-2	VR301	F-3

1821A-B-2B

Figure 8-3. Component Identification, A1

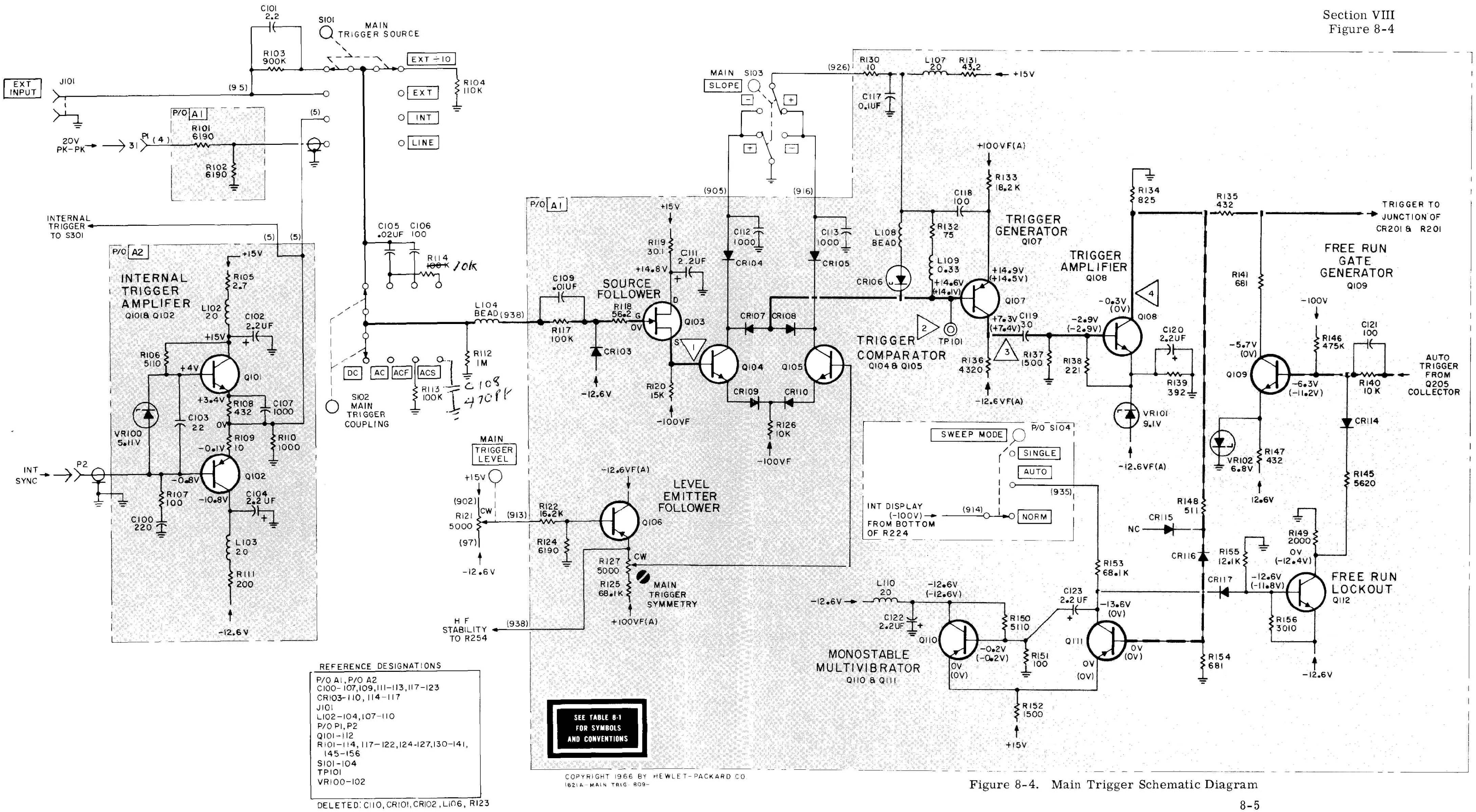


Figure 8-4. Main Trigger Schematic Diagram

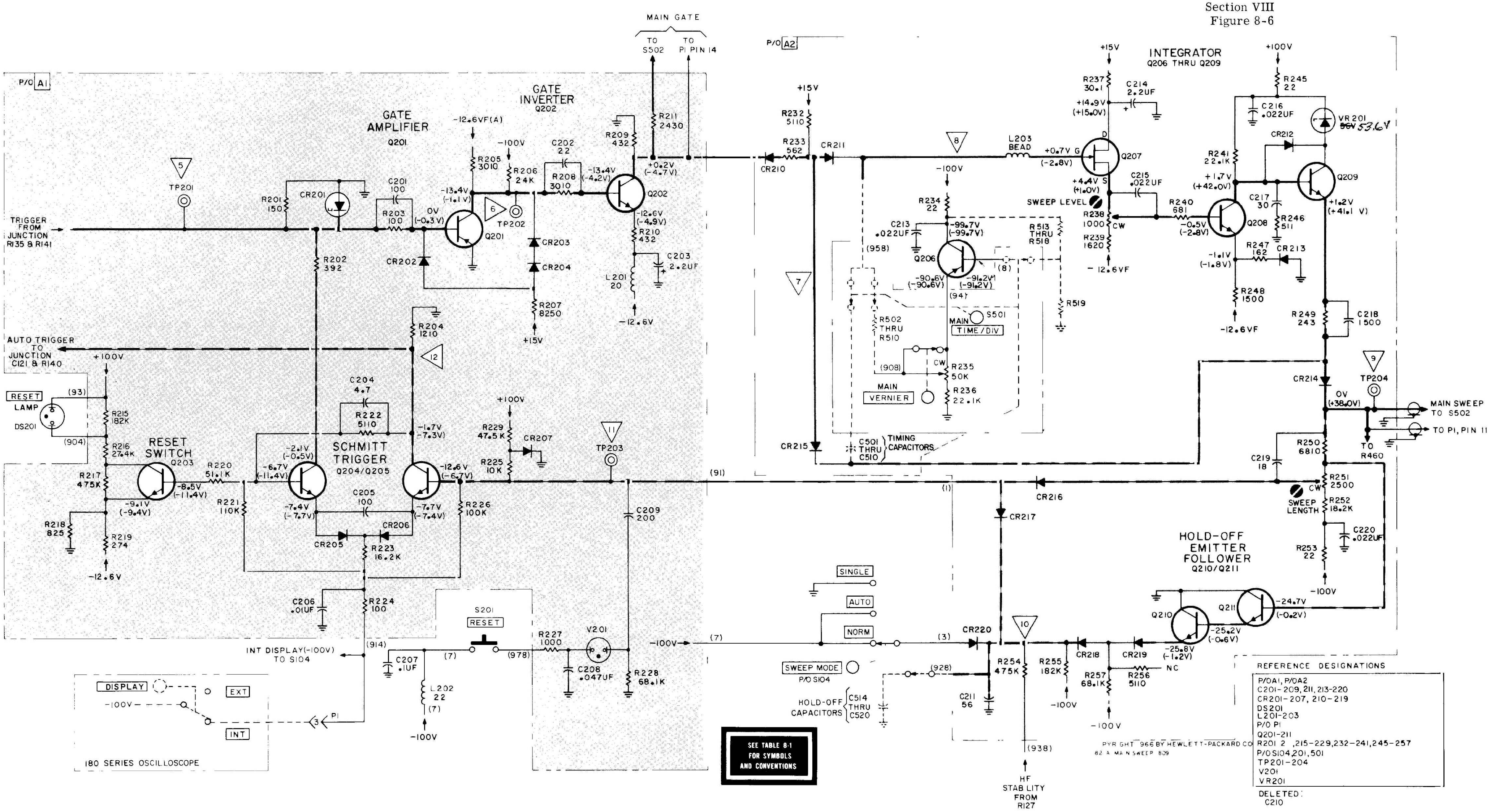


Figure 8-6. Main Sweep Schematic Diagram

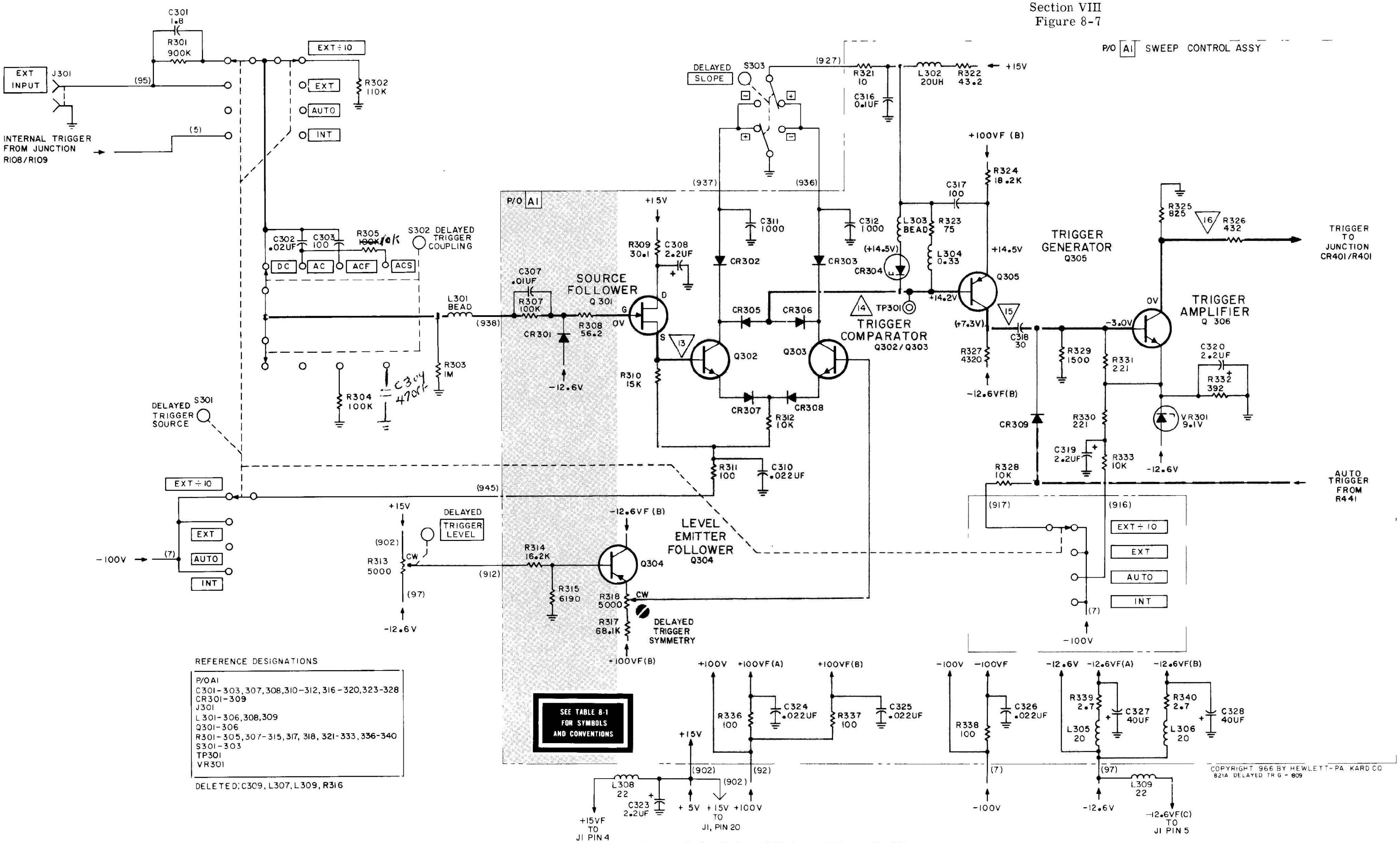


Figure 8-7. Delayed Trigger Schematic Diagram

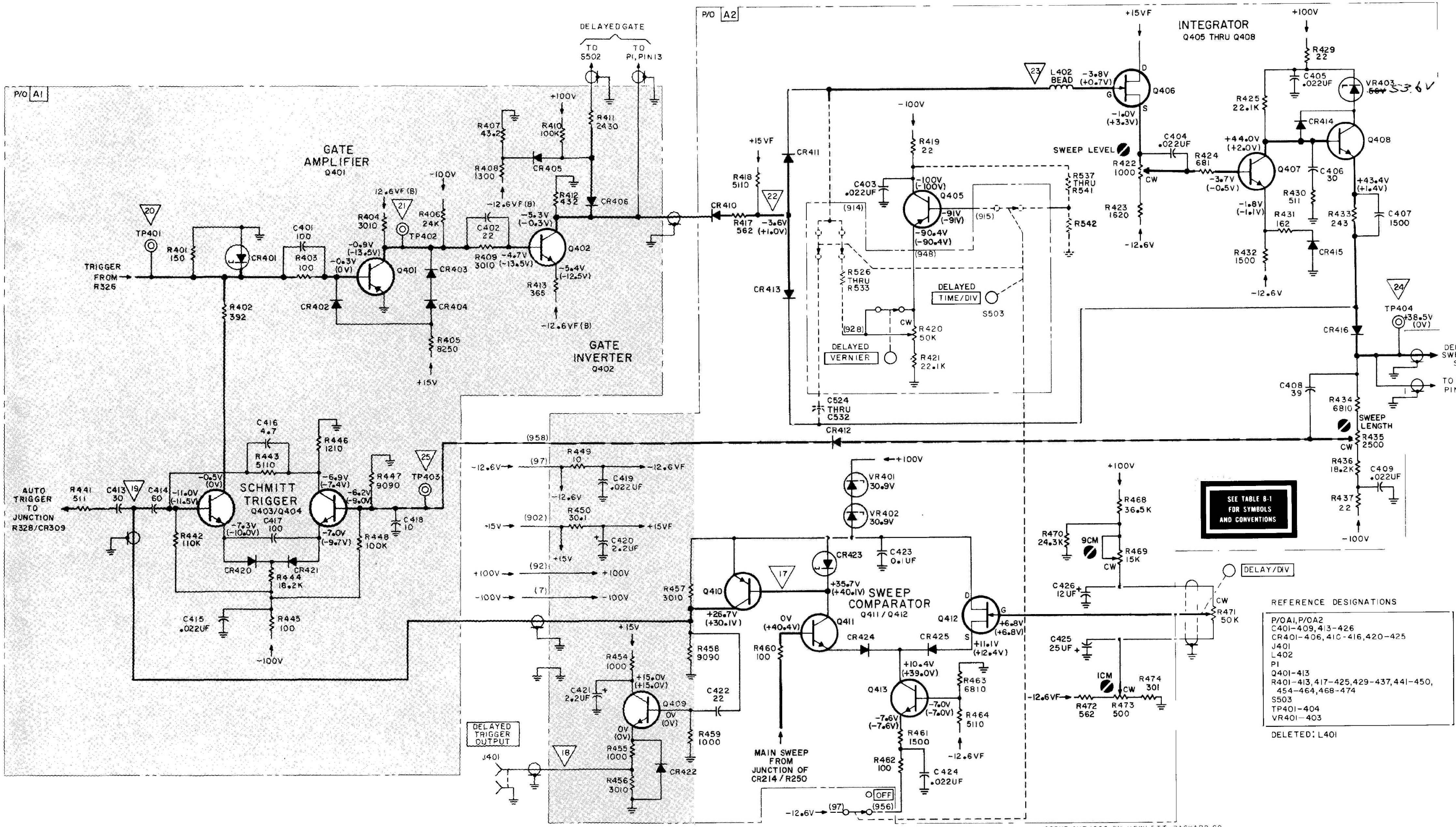


Figure 8-8. Delayed Sweep Schematic Diagram

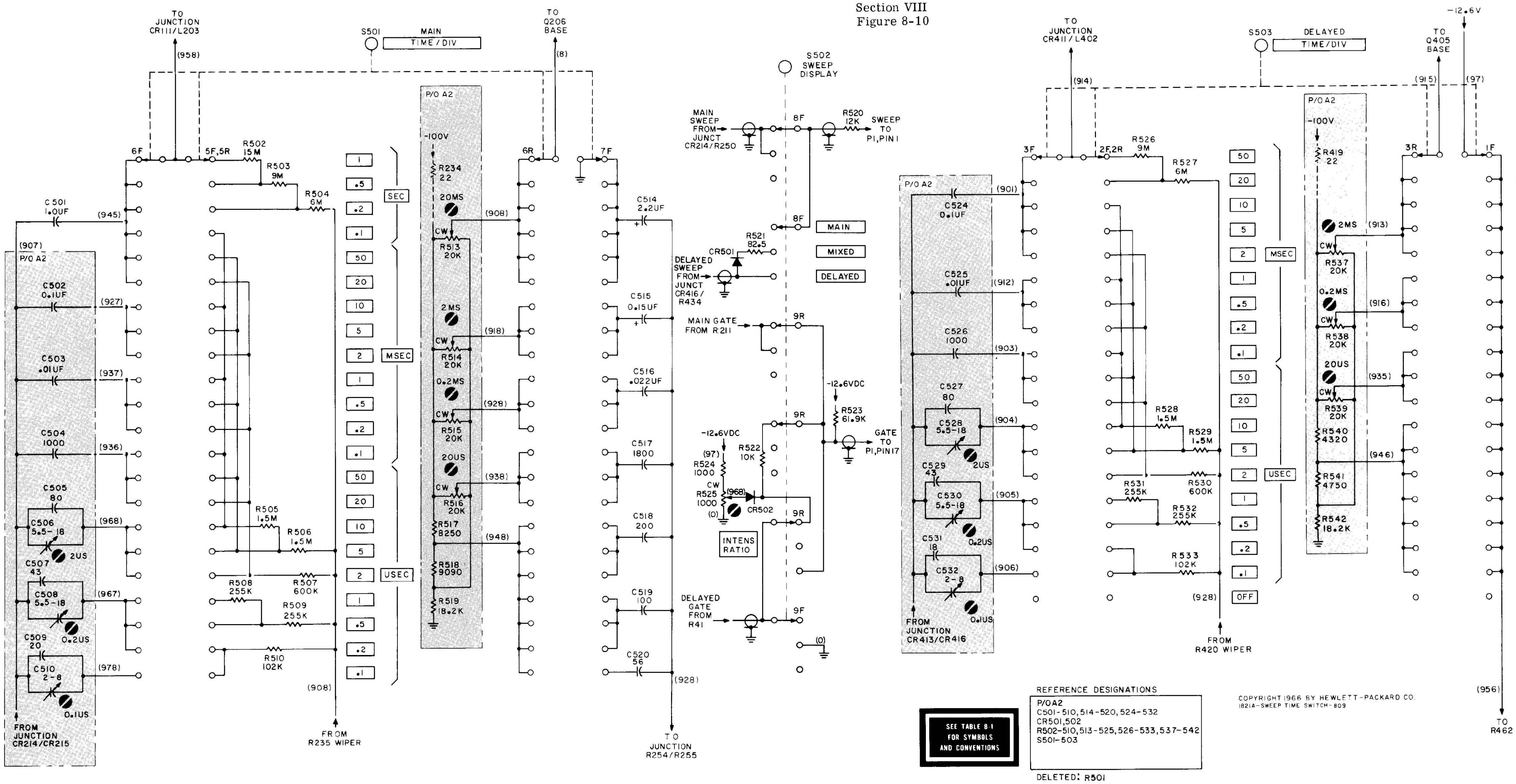


Figure 8-10. Sweep Time Switch Schematic Diagram 8-13