INTRODUCTION

This manual supplement describes the special features of OPTION 5 as installed in the 465 Oscilloscope. It adds a TV Sync Separator, providing stable sweep triggering from composite video waveforms. With sync separator mode selected, A Sweep is automatically triggered at the field rate and TV line rate triggering is added to the signal source selecting the sweep B. The sync separator accepts sync-positive or sync-negative video, from Channel 1, Channel 2 or external input. Recognition circuits are optimized for 405-525-625 line 50 or 60 Hz field rate broadcast systems, and are compatible with closed circuit systems up to 1201 line 60 Hz field rate.

TEKTRONIX®

465
OPTION 5
SUPPLEMENT

INSTRUCTION MANUAL

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Serial Number _____

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SPECIFICATION

General Information

The Option 5 Sync Separator provides for front-panel selection of additional processing for triggering signals, to facilitate observation and measurement of composite video and related television waveforms. Added circuits provide amplification, selectable polarity inversion, clipping and vertical-sync recognition with output of vertical (field-rate) triggers to Sweep A and horizontal (line-rate) triggers to the Sweep B Triggering SOURCE switch.

The source of signals to be processed in the Sync-Separator is selected by the Sweep A Triggering SOURCE switch: Norm (Composite vertical signal); CH1, CH2, Ext, Ext ÷ 10.

The separator circuit may be operated from normal sync-negative composite video (A-Sweep Triggering SLOPE switch at -)or inverted video (SLOPE switch set to +), for most standard broadcast systems from 405 to 819 lines, 50 or 60 Hz field rates, or for closed-circuit systems up to 1201 lines, 60 Hz, though internal adjustment may be necessary for consistent operation with systems having very narrow sync pulses.

When the A-Sweep Trigger COUPLING switch is set to Sync Sep, the Vertical Sync output of the Sync Separator is automatically applied to the A Sweep triggering circuits, and only this signal may be used for triggering Sweep A. The Horizontal Sync (line-rate sync) from the Separator is fed only to an added position on the B Sweep Triggering SOURCE switch, and it may be selected or not for B Sweep Triggering, as the operator may wish. No horizontal sync is fed to the B Sweep Triggering SOURCE switch unless A Sweep has been set to Sync Sep.

To facilitate video measurements, the Vertical Amplifier input coupling capacitors for the AC mode have been increased from .02 to 0.2μF. The larger physical size of these capacitors has increased the input shunt capacitance, which has been normalized at 24pF.

This supplement describes the characteristics, operation and maintenance of the added features of the Type 465 Option 5 Oscilloscope. Except as noted below, most parts of the standard Type 465 operators' and service manuals remain applicable.

Characteristics

Standard Type 465 Oscilloscope characteristics are applicable, except as noted below:

Input Shunt RC Characteristic: 1MΩ ± 2%, 24pF ± 2%, time-constant 24µs ± 2%

AC Input Coupling:

Low Frequency -3dB Direct	≤ 1 Hz
via 10X passive probe	≤ 0.1 Hz
Tilt, 10ms wide pulse: Direct	≤ 2.5%
via 10X passive probe	≤ 0.25%
Maximum Input Voltage	400 V (DC + peak AC)

Triggering:

Sync Separator: Stable video rejection and sync separation from sync-positive or sync-negative composite video, 405 to 819-line 50 or 60 Hz field rate.

		Amplitude Requirement (p-p) Min	Max
Internal:	Composite video (nominal)*	2 cm	20 cm
	Composite sync	0.7 cm	20 cm
External:	Composite video (nominal)	225 mV	4 V
	Composite sync	75 mV	4 V
Ext ÷ 10:	Composite video (nominal)	2.25 V	10 V
	Composite sync	750 mV	10 V

*Peak video ≈ 7/3 sync amplitude.

Furnished Accessories (See page 27 for complete listing)

Includes:

1 NTSC (CCIR System M) graticule, p/n 337-1674-02
-40 to +100 units, with 7.5 unit setup line; horizontal divisions along "0" line

1 CCIR (CCIR System B) graticule, p/n 337-1674-03
0 to +100 units, 35 unit setup line; horizontal divisions along "30" line

Operation

The following instructions pertain primarily to use of the 465 Option 5 in TV applications. For general operating and application information, see the standard Type 465 Operator's Manual.

1. Installation of Video Graticule.

To install a video graticule, loosen (about 6 turns) the four captive screws holding the CRT bezel in place, and remove the bezel. Snap the standard (clear or blue) light filter from the two bosses on the bezel, and install the desired graticule on these bosses, with the marking on the outside.*

The extended tab at the bottom of the graticule belongs at the slightly wider (bottom) margin of the graticule cover.

The graticule can be moved slightly horizontally to line up the external graticule and mask with the CRT graticule and viewing area. Reinstall the bezel.

When the video graticule is installed, the ten horizontal divisions along the "0" line correspond to the internal graticule divisions, and the TIME/DIV calibration of the oscilloscope is correct. However, the vertical divisions represent only proportions of the 100-unit (CCIR) or 140-unit (NTSC) video waveform, and the vertical "VOLTS/DIV" calibration is inapplicable. The 100 or 140 units occupy 6.67 cm.

To set up calibration for a standard 1V (nominal) studio video signal, apply the 300 mV CALIBRATOR waveform to the Vertical input and adjust the VOLTS/DIV and VARIABLE controls so that the displayed waveform occupies just 30 units (CCIR graticule) or 42 units (NTSC graticule). This adjustment may be performed with a free-running sweep.

*Early production 465 Option 5 instruments were shipped with a thin light-filter/graticule requiring reinstallation of the clear light filter between the graticule and CRT, to hold the graticule in place. These thinner graticules have no bottom tab, and mount in a rectangular recess in the bezel rather than on the bosses. These graticules cannot be used at the same time as the EMI/contrast mesh filter, which mounts in the same space.

2. Operation of the Sync Separator.

Basic operation of the Sync Separator requires the following three steps:

(1) Setting the A Sweep COUPLING switch to Sync Sep.

(2) Providing the Separator circuit with a suitable Composite Sync or Composite Video Waveform[1]. For special considerations in Dual Trace modes (Alt., Chop), see 4 below. For internal triggering, the sync portion of the displayed waveform should be at least 0.7 cm high (10 units, or 1/2 division on the CCIR graticule; 14 units, or about 3/4 division on the NTSC graticule). For external triggering, the sync portion of the waveform should be at least 75mV in amplitude, or 0.75 V in the "Ext ÷ 10" mode. Care should be excerised not to exceed the indicated maximum amplitudes (20 div for internal triggering, 10 V for external triggering), to avoid circuit overloads and partial or complete loss of sync.

(3) Proper polarity selection for the video waveform applied. For normal video with sync at the negative peak and picture information positive-going, the A Sweep Triggering SLOPE switch should be set to "-"; for inverted video having sync at the positive peaks and peak video (white) at the negative peaks, the SLOPE switch should be set to "+". The A Sweep SLOPE switch in the Sync Sep mode controls an inverting/non-inverting signal preamplifier ahead of the sync separator.

3. Triggering the Sweep.

The output of the Sync Separator is fed directly to the A Sweep Trigger circuit; all that is required for triggering is the proper setting of the A Sweep Triggering LEVEL control, to about "ten o'clock" (about 60° counterclockwise from "0"). In 405-line and comparable systems, the level control may need to be further counterclockwise to avoide some line-rate artifacts on the Vert Sync signal.

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1. Composite Sync is combined Vertical and Horitzontal sync as a single waveform, but without video (picture) waveforms; Composite Video is the picture waveform complete with Vertical and Horizontal blanking and sync.

Trigger View

Note: The injection point of Vertical Sync signals from the Sync Separator is not the same as for normal triggering modes, and in some instruments, the Trigger View amplifier may show the signal as positive-going, of incorrect amplitude, or distorted. The Trigger View display should be ignored when using the Sync Separator.

For B Sweep Triggering from the Sync Separator Line-rate trigger output, four conditions must be met:

(1) The A Sweep COUPLING switch must be set to Sync Sep and A Sweep must be running[1].

(2) The B Sweep triggering SOURCE switch must be set to TV line.

(3) The B Sweep Triggering SLOPE switch must be set to "-".

(4) The B Sweep Triggering LEVEL control must be set counterclockwise from "0" -- about 10 or 11 o'clock is recommended.

4. Vertical Operating Modes - Special Considerations.

(1) Dual Trace Modes.

The Sync Separator is not capable of correct processing of the switched (composite vertical deflection) waveforms present on the Norm bus in the Alternate and Chopped modes; for dual trace operation, the Sync Separator input must be taken from CH1, CH2 or an external source. (When only one trace is displayed, the Norm position of the A Sweep SOURCE Switch may be used.) It is therefore not possible to obtain stable simultaneous displays of two independent video displays that are not gen-locked together.

(2) Single Channel Triggering.

When triggering from Channel 1 or Channel 2, the waveform fed to the Sync Separator is the same (except for positioning) as that displayed on-screen when the channel is turned on. If the VARIABLE control is used to reduce displayed amplitude, the signal to the Sync Separator is also reduced. When the Channel 2 INVERT switch is pushed in, the CH2 signal to the Sweep A Triggering SOURCE switch is also inverted. Therefore, in selecting the position of the A Sweep SLOPE switch in Internal triggering, it is only necessary to note the polarity

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1. B Sweep cannot be operated independently and cannot run more than once per operation of A sweep. For "Composite line" displays, see Para 7(2) below.

of the displayed waveform, disregarding its actual polarity as applied to the Vertical INPUT connector. For external triggering, the actual applied polarity will determine the necessary SLOPE setting.

It is not necessary to display Channel 1 or Channel 2 to obtain CH1 or CH2 triggering. So long as the AC-GND-DC switch for the channel is not in GND, the input amplifier and trigger channel are active, regardless of the selection of VERT MODE pushbuttons.

(3) Add mode.

A single-channel triggering signal amplitude is not affected by the contribution of the other channel to an Add mode display. Where the Add mode with CH2 inverted is used to compare two video waveforms by subtraction, the CH1 or CH2 signal to the Sync Separator will be adequate for stable triggering so long as the individual channel signal (when displayed alone) meets the signal requirements.

Where the Add mode is used to display a "full-sized" signal from two sides of a balanced line, the Norm (Composite vertical) A Sweep SOURCE switch position may be used if it happens that neither Channel signal alone is of sufficient amplitude for stable sync separation and triggering.

5. Typical Operation.

The typical operating mode for which the Type 465 Option 5 circuits are designed use A Sweep to establish a basic field and frame-related cycle, with B Sweep used for detail observations and measurements on various parts of the video waveform.

To obtain stable displays free of interlace jitter (for systems have 2:1 interlace), the A Sweep TIME/DIV switch should be set to display an odd number of fields plus a fraction of a field, in the unmagnified display. For 50 and 60 Hz field rates, the 2 ms/div setting is usually selected, though for some PAL system observations, a setting of 5 ms/div (approx. 2 1/2 field display) with the A TRIGGER HOLDOFF control set to approximately 4 o'clock (additional 1 field holdoff) may be desirable to maintain a stable display relationship to the four-field PAL burst-blanking sequence. All detail measurements are then made with B Sweep, using the B Dly'd or Mix mode, with the B Sweep SOURCE switch set to either Starts After Delay (continuously variable B Sweep start

point) or to TV Line (B Sweep starts after the leading edge of the next horizontal sync pulse following the delay interval set by the DELAY TIME POSITION control and the A Sweep TIME/DIV setting).

Because the leading edge of the sync pulse will not itself be displayed, the typical B TIME/DIV setting for width measurements on front porch, back porch and horizontal blanking intervals, horizontal sync, serration and equalizing pulses will be made at a B Sweep setting of 10µs/div, to display two consecutive pulses, and using the 10X Magnifier to display the second pulse at 1µs/div.

For rise and fall time measurements on blanking and sync waveforms, triggering of B Sweep directly from the displayed waveform (avoiding the processing delay of the sync separator) is recommended, in order to view the triggering edge at sweep rates from .5 to .05µs/div.

6. Selecting An Individual Line.*

The Sync Separator circuit does not differentiate between the two fields of an interlaced frame, or among the four fields of the PAL color frame sequence. However, using a 1 1/2 or 3 1/2 field basic A Sweep cycle, the sweep will remain stably locked to a given display until the signal is interrupted.

(1) One Frame Cycle.

To display an entire vertical blanking interval and locate a specific line (e.g. , one of the lines containing a specific VIT waveform) set A Sweep to 2 ms/div and the B Sweep TIME/DIV control (pull to unlock from A) to 10µs/div. Use the POSITION control to center the second vertical blanking interval to center-screen, and depress the 10X MAG pushbutton, providing sufficient resolution to identify the field. Be sure the A TRIGGER HOLDOFF is at Normal (counterclockwise).

If the field is not the desired one, flick the A Sweep SLOPE position momentarily to the opposite polarity and back again until the start of the desired field is displayed.

Press A INTEN, and use the DELAY TIME POSITION control to position the intensified zone (Sweep B) to encompass the desired line. Pressing the B DLY'D button will then display the desired line.

*For field and line identification systems, see appendix.

(2) Two-Frame Cycle.

If PAL burst blanking is to be checked, an A Sweep 3 1/2 field cycle (5 ms/div, with the A TRIGGER HOLDOFF at about 4 o'clock) is required, using B Sweep (Mix mode recommended) to identify fields and lines. At 5 ms/div, only two and a fraction fields will be displayed, with a full field covered by the trigger holdoff interval. To put a specific field on-screen in a particular location will typically require several operations of the SLOPE switch.

7. Special Measurements.

(1) Overscanned Displays.

For various video measurements, it may be desirable to magnify the video waveform vertically beyond the limits of the screen. Under these circumstances, the trigger amplifiers or Sync Separator may be overloaded, blocking out some sync pulses in the vicinity of strong video transitions, or losing sync pulses altogether. To avoid overload problems, use External sync, or use the other vertical channel to supply a constant amplitude signal to the Sync Separator while the overscanned observations are being made. Note, however, that transient-response aberrations in the 465 main vertical amplifier will be increased when the signal is driven offscreen, becoming relatively serious if the amplifier is driven to saturation and cutoff.

(2) Horizontal Sync Pulse Measurements.

Measurements of the rise and fall times and width of horizontal sync pulses typically do not require use of the Sync Separator except when only certain lines or groups of lines appear to be abnormal. A bright display of all horizontal sync pulses is obtained when Sweep A is triggered on the appropriate slope using LF REJ coupling and an A Sweep rate of 5µs/div (for 525 or 625 line systems). Stability of triggering may be affected by sharp luminance transitions at the right side of the picture, but typically a careful setting of the LEVEL control will permit accurate measurements. Use of the 5µs/div basic rate locks out most of the video from triggering A Sweep, using B Sweep and/or the X10 MAG to obtain the required Time/Div rate for the time resolution required.

(3) RF Interference.

Operation in the vicinity of some FM and TV transmitters may show objectionable amounts of RF signal energy in the display, even when coaxial input connections are used. The front-panel 20 MHz BW Switch will usually

eliminate such interference from the display, but will not affect the signal reaching the Sync Separator. Where the RF interferes with Sync Separator operation, external filters will be required. Use of probes designed for 10-30 MHz oscilloscopes will provide 6 to 10dB attenuation in the 50-100 MHz range, and may be beneficial in reducing interference.

APPENDIX

Indentifying Fields, Frames & Lines in 525/60 and 625/50 TV Systems.

NTSC (CCIR System M).

Field 1 is defined as the field whose first equalizing pulse is one full H interval (63.5μs) from the preceding horizontal sync pulse. The Field 1 picture starts with a full line of video.

Field 1 lines are numbered 1-263, starting at the leading edge of the first equalizing pulse. The first regular horizontal sync pulse after the second equalizing interval is the start of line 10.

Field 2 starts with an equalizing pulse a half-line interval from the preceding horizontal sync pulse. The Field 2 picture starts with a half line of video.

Field 2 lines are number 1-262, starting at the leading edge of the second equalizing pulse. After the second equalizing interval, the first full line is line 9.

CCIR System B and Similar 625/50 Systems (including PAL)

In most 625-line, 50Hz field-rate systems, identification of parts of the picture relies primarily on continuous line numbering rather than on field-and-line identification, except for PAL systems.

The CCIR frame starts with the first (wide) vertical sync pulse following a field which ends with a half-line of video. The first line after the second equalizing interval is line 6; the first picture line is line 23 (half-line of video). The first field of the frame contains lines 1 through the first half of line 313, the picture ending with a full line of video (line 310).

The second field of the frame commences with the leading edge of the first (wide) vertical sync pulse (middle of "line" 313), and runs through line 625 (end of equalizing interval). The first full line after the equalizing interval is line 318; the picture starts on line 336 (full line).

The first field is referred to as "odd," the second field as "even." Note that the identification systems for System M and System B are opposite.

In the four-field PAL sequence with Bruch Sequence Color-burst blanking, the fields are identified as follows:

Field 1: Field which follows a field ending in a half-line of video, and which preceding field has color burst on the last full line. Field 1 lines are 1 through 312 and half of line 313. Color burst starts on line 7 of Field 1; a half-line of video appears on line 23.

Field 2: Field which follows a field ending in a full line which does not carry color burst. Field 2 lines are the last half of line 313 through line 625. Color burst starts on line 319 (one line without burst following the last equalizing pulse); a full line of video appears at line 336.

Field 3: Field which follows a field ending in a half line and which preceding field has no color burst on its last full line. Field 3 lines are 1 throught the first half of line 313. Burst starts on line 6 (immediately following the last equalizing pulse); a half-line of video appears on line 23.

Field 4: Field which follows a field ending in a full line carrying color burst. Field 4 lines are the second half of line 313 through line 625. Color burst for Field 4 starts on line 320 (two full lines without burst follow the last equalizing pulse); video starts with a full line on line 336.

CIRCUIT DESCRIPTION

1. Block Diagram & Switching (Fig 1). The Option 5 Sync Separator consists of three principal circuit elements, with added switching facilities, as shown in Fig 1:

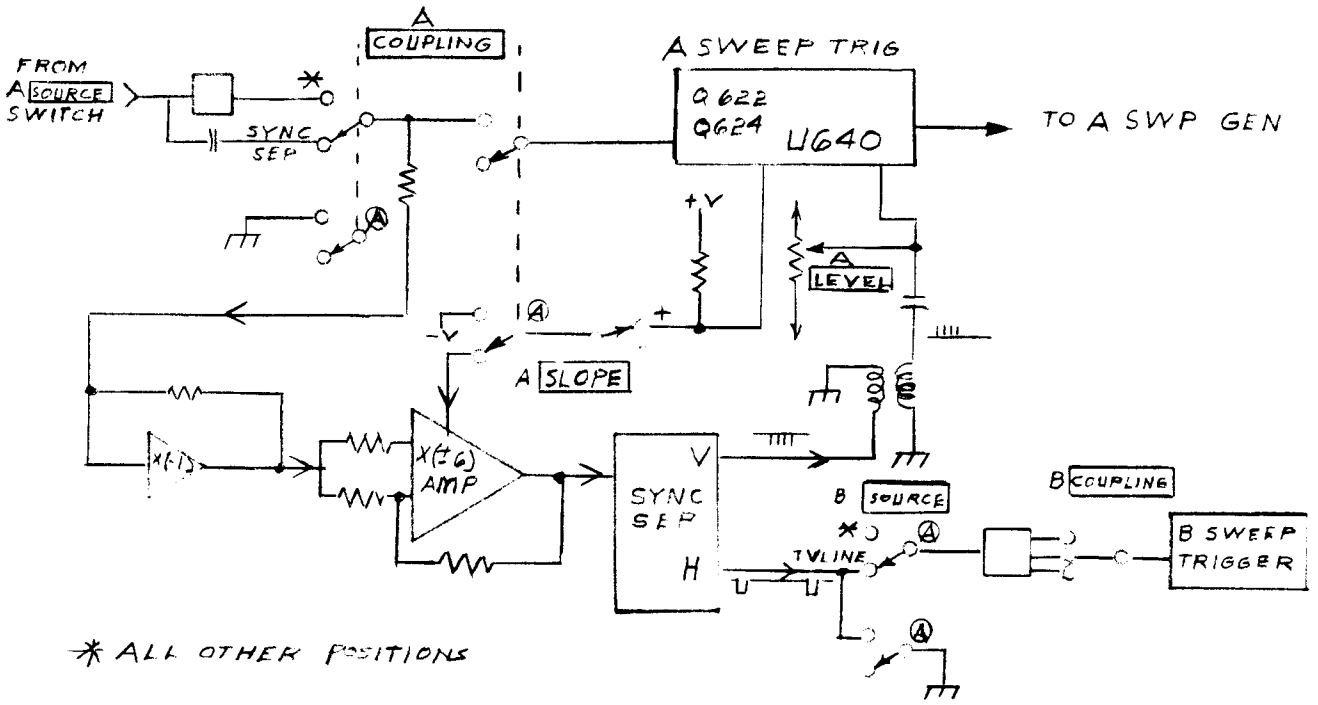


FIG 1 SWITCHING & BLOCK DIAGRAM
Switching is done by existing contacts, except at points A , by added microswitches.
**Switching done by existing contacts.

(a) Switching. An additional Sync Sep position on the A sweep Trigger COUPLING switch provides input to the Sync Separator, disabling of the normal A Sweep trigger input, and conversion of the SLOPE switch to control the inverting/non-inverting amplifier U1930, rather than the normal trigger amplifier U640. An added TV Line position on the B Sweep Triggering SOURCE switch allows triggering of B Sweep from the Horizontal (line) rate triggers from the Sync Separator when the latter has been activated by the A Sweep Coupling switch.

(b) Input Amplifier. The Sync Separator input amplifier extracts triggering signals from the "bottom" of the 1.1MΩ resistor which sets the normal trigger circuit input impedance, and provides wide-band, low impedance drive to the inverting/non-inverting amplifier. Gain of the input amplifier is -1.

(c) Inverting/Non-Inverting Amplifier. The operational amplifier U1930 provides a voltage gain of 6, to provide adequate drive the the Sync Separator from the low-level internal (25mV/div) and attenuated external input signals. The output of this amplifier may be electronically switched by the SLOPE switch via Q1922 and Q1926 to provide the proper

**Effective B14---- and up.

polarity signal to the Sync Separator from either sync-negative or sync-positive composite video. In the "-" position of the SLOPE switch, the amplifier inverts the signal from the input Amplifier; in the "+" position, the amplifier is non-inverting.

(d) Sync Separator. The input stage of the sync separator clamps the negative peaks of the input waveform, and strips the video from the sync, providing a composite sync output for use as horizontal (TV line) sync by Sweep B. This composite sync signal is also processed to produce a Vertical sync output signal (a burst of narrow pulses for systems having serrated sync pulses, otherwise a single narrow pulse at the end of the vertical sync pulse). The vertical sync pulse is inverted by a transformer and applied directly to the A Sweep Triggering circuit, at the LEVEL control input.

2. INPUT AMPLIFIER.

2.1 Functional Description (Fig 2). The input Amplifier extracts triggering information (composite sync or video) from the internal and external triggering signal sources with minimum interference with the wideband triggering capabilities of the Type 465 triggering circuits in normal modes, and provide a low-impedance drive to the following stage.

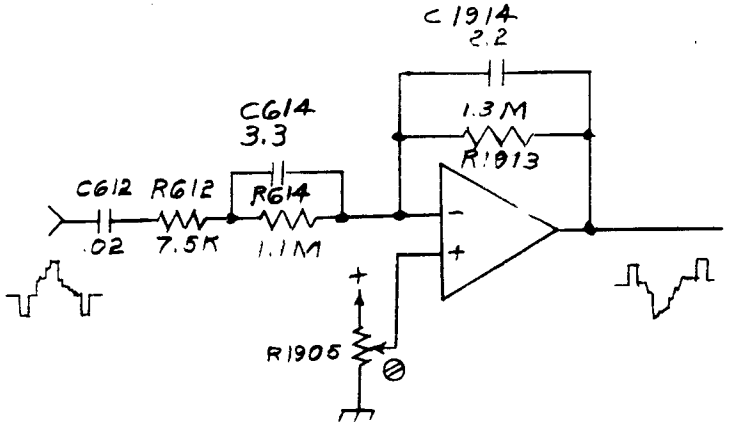


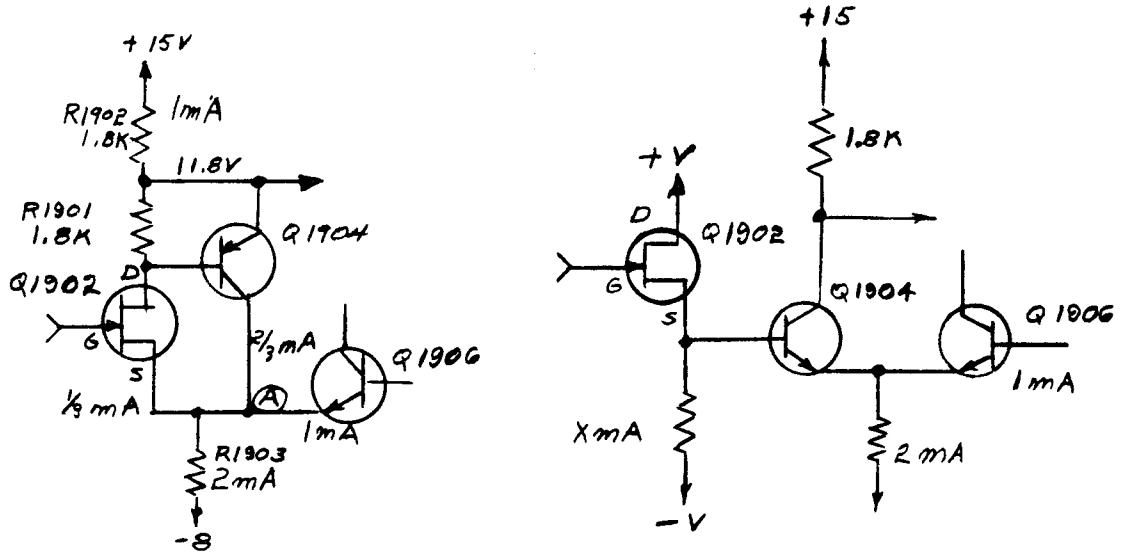
FIG 2. INPUT AMPLIFIER
FUNCTIONAL DIAGRAM
Input is slightly overcompensated to correct for cable losses between switching and amplifier.

Q1902 (FET), Q1904, Q1906, Q1910 and Q1912 form a wideband operational amplifier (Fig 2) with R1913 and C1914 as the principal feedback elements. Open loop gain is approximately -3300. With input via R614, R612 and C614,

the closed-loop gain is -1, with a -3dB bandwidth of approximately 6MHz. The signal is AC-coupled to these input elements via C612, providing a low-frequency cutoff of about 8Hz, and preventing any DC offset in the input signal from affecting the amplifier dynamic range.

Transient response of the amplifier alone is relatively clean*. Because of the losses in the coaxial cable between the switching circuits and the amplifier board, the amplifier is deliberately undercompensated by a small amount, to optimize overall response.

*Because of transient feedback from the sync separator, some ringing may be observed after one of the transitions. This effect is separately identified by disconnecting the sync separator cable.



(1) ACTUAL CIRCUIT. Feedback from Q1904 provides low impedance at A to drive Q1906.

(2) FUNCTIONAL EQUIVALENT (DC). (Wideband performance with feedback is limited by greater signal delay in amplifier)

FIG 3A INPUT AMPLIFIER - INPUT CIRCUIT.

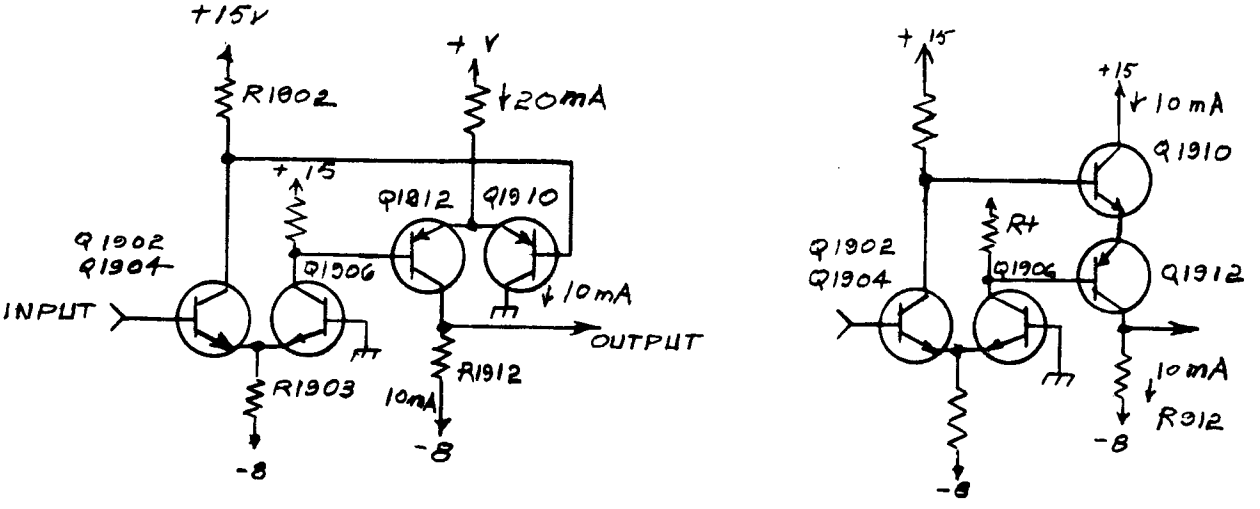
FET Q1902 provides required high input impedance; transistor Q1904 corrects for high source-impedance of FET.

2.2 Input Amplifier - Detail. Q1902, a Field Effect Transistor, provides the high DC input resistance and low (essentially zero) input current required for operation with high input and feedback resistances. Q1904 (See Fig 3A) samples the drain current of Q1902 by means of the drop across R1901, and supplies current to the FET source circuit to maintain

the Q1902 bias essentially constant - in effect, forcing the source to follow the gate signal, and making Q1902 appear as a very low impedance for driving the very low emitter inpedance of Q1906.

In the quiescent state, a constant current of 2mA is provided via R1903 to the input paraphase stage. When R1905 is correctly set (approx. +1V), this current is equally shared by Q1906 and the Q1902-Q1904 pair. The value of R1901 is selected to provide 1/3mA to Q1902 and 2/3mA to Q1906. The current variation with input signals is almost entirely handled by Q1904, with the current in Q1902 remaining essentially constant.

The effective load resistor for Q1902/1904 is R1902, in the quiescent state providing a source of +13.2V behind 1.8kΩ to the base of Q1910. The higher value of R1909 (collector load of Q1906) provides a quiescent source of +11.7V behind 3.3kΩ to the base of Q1912. The difference in source voltages provides the necessary turn-on bias for Q1910-Q1912, the output stage.

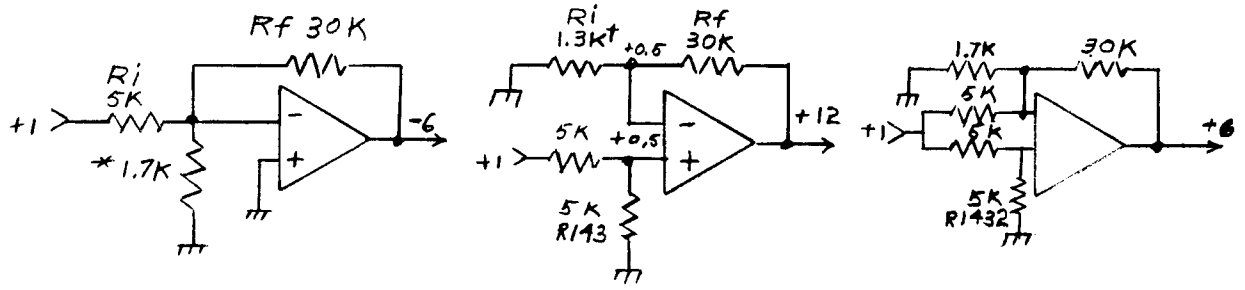


(1) EQUIVALENT CONVENTIONAL AMPLIFIER. (Q1910 output current is unused).

(2) NPN/PNP OUTPUT. Output transistors share single current.

FIG 3B. INPUT AMPLIFIER - OUTPUT STAGE.

The NPN/PNP output stage is equivalent to a conventional emitter-coupled pair (See Fig 3B). However, since only one output is used, the power demand is reduced by using a single quiescent and signal current for both transistors. Quiescent current, when the output voltage (TP1912) is set to 0V by R1905, is approximately 10mA.



A. GAIN FROM -INPUT.
-Rf/Ri = -6.
*Shunt resistor has negligible effect on gain from -input.

B. GAIN FROM +INPUT
(Rf + Ri)/Ri = X24
Input divider makes overall gain 0.5 X 24 = X 12.
+1.7k in parallel iwth 5kΩ.

C. COMBINED GAIN is X (12-6) =X6

FIG 4. OPERATIONAL AMPLIFIER WITH INPUT TO BOTH + AND - INPUTS. Gain from each signal source is evaluated by considering the opposite source to be grounded. "Voltages" shown are for illustration only.

3. Inverting/Non-Inverting Amplifier.

3.1 Functional Description (Fig 4). The Sync Separator itself requires sync-negative video with the sync portion at least 30 to 100mV in amplitude (value varies somewhat with line rate, presence of color burst, etc., and setting of the Clipping Level adjustment). The differential-input operational amplifier U1930 provides a voltage gain of 6 and selectable polarity inversion to provide the necessary drive to the Sync Separator from the 25mV/div internal triggering signals and from the attenuated external trigger inputs.* Polarity switching is provided from the front-panel A-Sweep Triggering SLOPE switch, via Q1922 and Q1926.

*External triggering signals are attenuated by 4 in the Ext mode and by 40 in the Ext ÷10 mode, to allow a more usefule LEVEL control range in normal triggering.

3.2 Detail Description. Integrated circuit U1930 is a wideband, differential-input operational amplifier. The associated components C1936-7-8, R1936 and R1938 provide interstage phase correction and rolloff tailoring to optimize response and stability for the overall feedback configuration used.

Field-effect transistor Q1926 is a "switching" FET, appearing as a very low value resistance (typically 50 to 80Ω) at zero bias, but as a very high value (>MΩ) when the gate is biased a few volts negative from the source. The "open" condition is maintained even for negative drain voltages so long as the gate bias is several volts negative from the peak negative drain excursion.

When Q1926 is biased off (Q1922 off and diode CR1922 conducting), the

signal from Q1912 is provided via C1918 and C1919 to both + and - inputs of U1930. Under these conditions (See Fig 4), the gain via R1933 is approximately -6 and the gain via R1931 is +12, for a net gain of +6. This mode is used when the original input waveform is "sync-positive", and the SLOPE switch is set to "+"; the necessary inversion having been performed by Q1902-1912. The SLOPE switch provides a +1 V level to pin N of the board connector, keeping Q1922 turned off in this mode. CR1921 and C1921 protect Q1922 against switching transients.

When the original waveform is sync-negative, the inversion introduced by Q1902-1912 must be reversed in the signal to the Sync Separator. This is done by switching the SLOPE switch to "-" which releases pin N and allows R1921 to provide base current to Q1922 via R1922. The current is sufficient to saturate Q1922, pulling R1923 to near 0 V and disconnecting CR1922. R1926 provides a slight positive bias to Q1926* to assure a minimum drain impedance. Q1926 shunts nearly all the signal current in R1932 to ground, changing the effective configuration of the operational amplifier from that of Fig 4C to that of Fig 4A, a simple inverting amplifier with a gain of -6.

*Q1926 is a junction FET; forward gate current limits positive bias to about +600 mV.

4. Sync Separator

4.1 Functional Description. The Sync Separator (Fig 5) (a) strips off the video (picture) information from the incoming sync-negative video from U1930, (b) amplifies the resulting composite sync for use as horizontal (TV line) sync by B Sweep, and (c) processes the composite sync to provide Vertical (Field Rate) sync to the Sweep A trigger circuits.

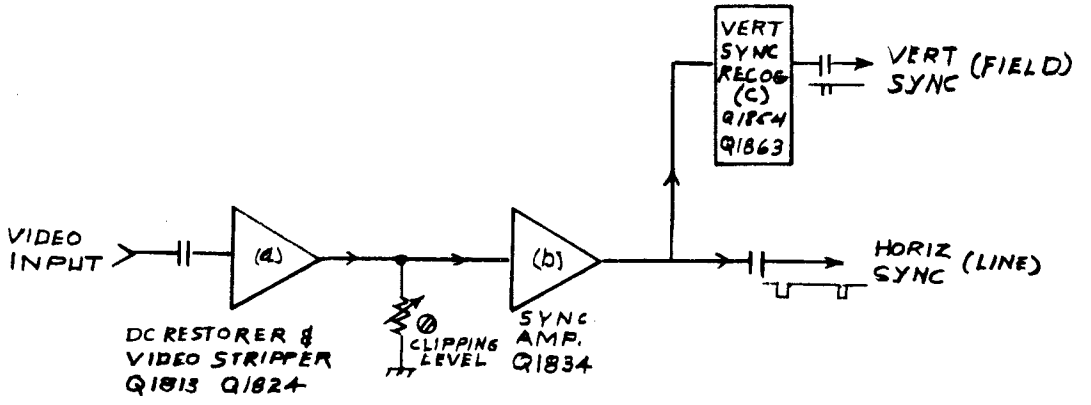
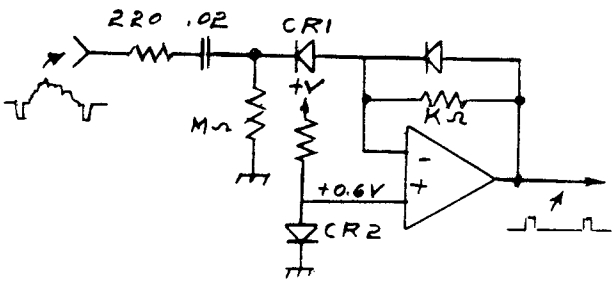


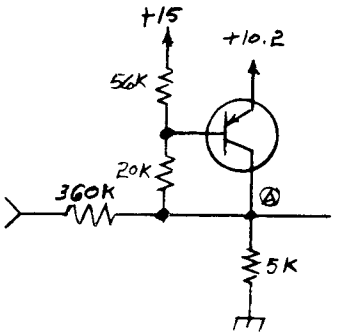
FIG 5 SYNC SEPARATOR - BLOCK DIAGRAM

4.2 Detail Description

(a) Video Stripper. Q1813 and Q1814 from a limited-swing feedback amplifier which amplifies only the negative peaks of the incoming waveform. A functional equivalent is shown in Fig. 6A.



(A) SYNC STRIPPER, FUNCTIONAL EQUIVALENT. CR1 and CR2 are equivalent of biased-on Q1813.



(B) EFFECTIVE Q1824 CIRCUIT WHEN Q1813 IS CUT OFF. Point A has very low impedance, unaffected by input currects through 360k feedback resistor.

FIG 5 SYNC SEPARATOR-INPUT STAGE

In the quiescent state, the base of Q1813 rests at approximately +9.0 V, its base-current supplied by R1812 and feedback current via R1818, which combine to set the quiescent equilibrium point for the amplifier. This equilibrium point is affected slightly by the Clipping Level adjustment R1826. The emitter of Q1824 is held at approximately +10.1 V by the +10.1 V supply (4.3 V and 5.1 V Zener diodes VR1827 and VR1832 and CR1826 carrying approximately 7 mA current from the +15 V supply via R1827). In the quiescent state, the collector of Q1824 rests at approximately +9 V, the same as the input base 1813.

With sync-negative video applied via C1812, the negative-going peaks (sync) are clamped at the +9 V level by the feedback current via CR1818 and the low forward impedance of the Q1813 base. The positive-going portions of the input waveform generate increasing amounts of feedback current via R1818 only until Q1824 reaches its negative-swing limit. Beyond this point, further positive input cuts off Q1813, and has negligible effect on the output.

The positive-going peaks, as noted before, cut off Q1813. When Q1813 is driven positive, the negative excursion at the collector of Q1824 is stopped at approximately +7.6 V by the network consisting of R1814, R1816, R1820, and the clipping-level divider R1824-6 to ground, and by the current through Q1824 established by this network (Fig 6B). By not permitting Q1824 to be cut off when Q1813 is cut off, the network provides an output to Q1834 relatively unaffected by input video excursions, since feedback to the base of Q1824 via R1820 establishes a very low impedance at its collector, not much affected by the small signal currents injected via R1818 while Q1813 is cut off.

The maximum signal swing at the Q1824 collector for any magnitude of input signal above about 100mV p-p is then +9.6 to +7.6V, or about 2V p-p, with active response confined to the most negative parts of the input signal.

Capacitor C1824 provides high-frequency stabilization of the Q1813-Q1824 loop, and attenuates any color-subcarrier peaks which may penetrate the sync region.

The divider R1824-5-6 sets the DC level of the Q1824 output signal, to cross the turn-on level of Sync Amplifier Q1834, approximately +5.6 to +5.8V. Diodes CR1824-1825 provide thermal compensation for the temperature coefficient of Q1834, and do not participate in the basic circuit operation.

(b) Sync Amplifier. Q1834 provides output of composite sync via CR1834, R1533-4 and C1866 to the Sweep B Triggering SOURCE switch* to serve as TV Line sync, and drive to the Vertical Sync Recognizer Q1854-Q1863.

In the quiescent state, Q1834 is cut off, its emitter held at +5.1V by the current through VR1832 and its base at something below the turn-on level of +5.7V by the Clipping Level divider. The collector is at +10.1V, prevented from rising further above the 9.6V supply by CR1828.

When negative-going sync pulses arrive at Q1813, they are inverted by Q1824 and provide sufficient base current to Q1834 via R1824 to saturate the transistor (Q1834 is a very high Beta transistor--generating a minimum of 300μA collector current for each microampere of base current through much of its operating range, and requiring only about 30 to 50μA base current for saturation at 10mA collector current).

In being driven between saturation (collector at approx. 5.2V) and cutoff (10.1V), Q1834 generates approximately 4.9V p-p of sync signal, with output via CR1834, attenuated by the divider R1833-R1834 to approximately 0.2 to 0.3V, suitable for B Sweep triggering, and AC coupled to B Sweep via C1866.

(c) Vertical Sync Recognizer. Q1854 and Q1863 recognize the various forms of TV Vertical (Field-rate) sync pulses by providing an output signal proportional in amplitude to the duration (width) of a preceding negative-going pulse. The output signal occurs on the trailing edge of the input pulse.

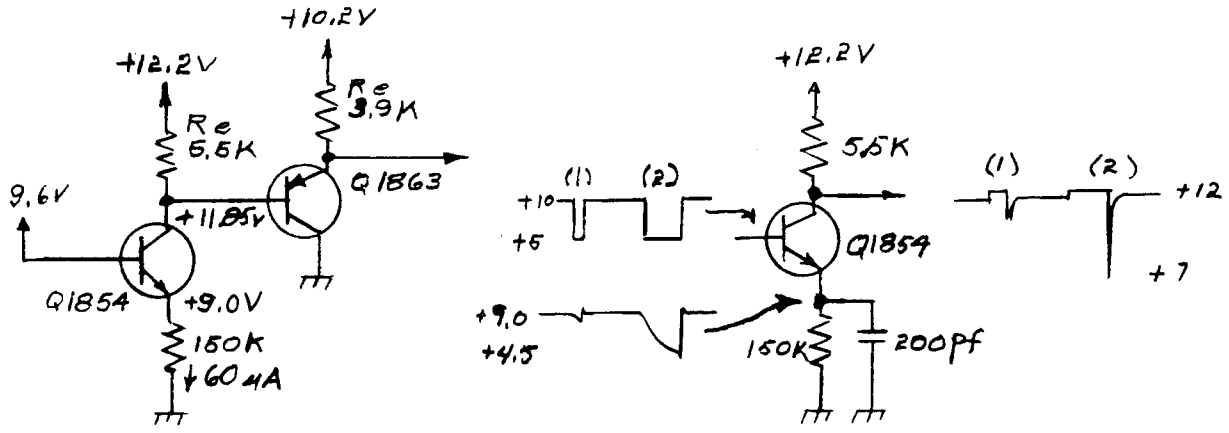
In most TV systems, a Vertical sync pulse consists of a train of negative-going**pulses some 5 times wider than horizontal sync pulses, and separated by narrow intervals ("serrations") of about the same width as horizontal sync pulses. In these systems, the recognizer produces a train of narrow output pulses, one for each serration of the sync pulse.

*NOTE When the Sweep B Triggering SOURCE switch is set to any position except TV Line, the Horizontal Sync output line from the Sync Separator is grounded, and no signal appears at TP1866.

In some 405/50 and 819/50 broadcast systems and in many closed-circuit TV systems, the vertical sync pulse is a single negative-going**pulse having a duration of several full horizontal lines. In these systems, the recognizer puts out a single narrow pulse at the end of the sync pulse.

Q1854 is driven by The Q1834 Sync Amplifier with a 4.9V signal between +10.1 and +5.2V, with the negative portion of the signal representing the sync portion of the incoming waveform.

**When the waveform polarity is "sync-negative".



(A) QUIESCENT-STATE (DC) EQUIVALENT OF VERTICAL SYNC RECOGNIZER. Q1863 is cut off by about 2V.

(B) Q1854 RECOGNIZER ACTION. When transistor is cut off, emitter runs down on 30μs (150k x 200 pF) time-constant toward 0V. For narrow pulse (1), rundown is less than for wide Vertical Sync pulse (2).

FIG. 7 VERTICAL SYNC RECOGNIZER

In the quiescent state between sync pulses (Fig 7A), the collector of Q1834 is high and CR1831 holds the base of Q1854 at approximately +9.6V. The output stage network of R1854-R1860-R1861 and D1865-R18 sets the emitter of the output emitter follower Q1863 at about +10.2V, and provides Q1854 with an effective collector supply voltage of +12.2V and an effective collector load resistor of 5.5k. The 60μA collector current of Q1854 (set by the approximately 9.0V voltage across the 150kΩ emitter resistor R1856) generates approximately 0.35V drop in the equivalent 5.5K collector load, setting the base voltage of Q1863 at +11.9 volts (nominal value) -- assuring that Q1863 is cut off.

When the Q1834 collector steps negative with a sync pulse, CR1831 disconnects and R1850 pulls the base of Q1854 negative, cutting off Q1854, its emitter being held positive by the charge in C1856. The collector of Q1854 steps positive by about 350mV when the quiescent collector current is cut off.

With Q1854 cut off, the only conducting connection to C1866 is the 150K resistor R1856, which discharges C1856 toward ground on a 30 microsecond time-constant, starting out at a rate of about -300mV per microsecond (Fig 7B). For the duration of 2 to 6 microsecond wide horizontal sync or verticl equalizing pulses, the run-down amounts to only -0.5 to -2 volts; for the longer-duration vertical sync pulses, the amount of rundown is -4 (typical for 819/50 system with serrations) to -5.5 volts (rundown stops at this time, ''caught'' at 4.2V by the base which is at about +4.7V).

When the collector of the Q1834 Sync Amplifier steps positive at the end of the pulse, a negative-going output pulse is generated at the Collector of Q1854 which is proporional to the amount of emitter rundown. The exact magnitude of this output pulse is a complex function of the rate-of-rise of the positive transition from Q1834, the value of C1856 the collector-to-base capacitance (including C1854) of Q1854 (Miller effect) and the collector-to-ground capacitance of Q1854 (including C1860). The output pulse at the Q1854 collector is designed to be approximately 80% of the amount of emitter run-down.

An anomalous overshoot occurs at the base of Q1854, driving the base about 1.5V above the quiescent level at the end of a Vertical sync pulse (this overshoot does not appear on the Q1834 collector bus). The cause is the positive-going trailing edge of the differentiated Q1854 collector output pulse being coupled back to the base by C1854 and the Q1854 collector capacitance. The collector waveform stays negative during the time the base is being driven positive; when the base stops at the quiescent level, the collector voltage rises rapidly, coupling an apparent overshoot into the base waveform The phenomenon tends to reduce the amount of usable rundown for Vertical serrations following the first one, but is not otherwise significant.

The output stage bias network, keeping Q1863 cutoff in the quiescent mode, inhibits the output of Q1854 collector pulses of less than about 2V peak (negative) amplitude. The larger pulses corresponding to the trailing edtes of vertical sync pulses are large enough to turn on Q1863, and provide output signals of 1 to 2.5V at the input end of C1865. Because of the short risetime of the generated pulses, the output stage does respond a samll amount even during cutoff, due to base-emitter capacitance in Q1863, a phenomenon particularly noticeable when the load is removed.

With the load disconnected, the negative-going output pulses are 2 to 2.5V in amplitude (somewhat smaller in 819/50 systems with serrated sync pulses), with a risetime of about 25ns and a width of about 150ns. Because they are so narrow, with a low repetition

rate, they are hard to locate in an oscilloscope display, and are frequently misinterpreted as to their presence or absence, their amplitude, and even polarity (a small trailing-edge overshoot is often mistaken for the pulse itself).

The output stage level-setting network R1854-R1860-R1861 is diode-connected to the output, to limit positive-going peaks in the output. C1861 provides a low AC impedance for this clamp.

Output coupling capacitor C1865 attenuates the signal to about -0.7V peak when driving its normal load (T1940 primary). The signal is inverted by T1940 (located on the Sync Amplifier board) for insertion into the inverting input (LEVEL control input) of the A-Sweep Triggering integrated circuit U640, at a level of about 0.6V peak, and a width of about 35ns. Because this is an inverting input, the effect is the same as applying a negative-going signal via the normal input path; the correct position for the A Sweep LEVEL control is therefore in the "-" range for triggering on the leading edge of the pulse.

465 OPTION 5

(Changes from Standard 465)

A1 CH 1 Attenuator Circuit Board Assembly

670-2863-00	B010100	B169999
672-0416-01	B170000	

CAPACITORS				
C2	281-0627-00	B010100	B169999	1.0 pF, Cer, 500 V
C2	281-0610-00	B170000		2.2 pF, Cer, 200 V
C3	285-1055-00			0.2 µF, Plastic, 400 V
RESISTORS				
R3	Delete			

A2 CH 2 Attenuator Circuit Board Assembly

670-2863-00	B010100	B169999
672-0416-01	B170000	

CAPACITORS				
C52	281-0627-00	B010100	B169999	1.0 pF, Cer, 500 V
C52	281-0610-00	B170000		2.2 pF, Cer, 200 V
C53	285-1055-00			0.2 µF, Plastic, 400 V
RESISTORS				
R53	Delete			

A8 Trig Gen & Sweep Logic Circuit Board Assembly

670-2234-03	B010100	B139999
670-3283-00	B140000	B251094
670-3283-02	B251095	

CAPACITORS				
C501	281-0659-00	B010100	B139999	4.3 pF, Cer, 500 V, ±0.25 pF
C501	281-0572-00	B140000		6.8 pF, Cer, 500 V, ±0.5 pF
C602	281-0659-00	B010100	B139999	4.3 pF, Cer, 500 V, ±0.25 pF
C602	281-0709-00	B140000		7 pF, Cer, 500 V, ±0.1 pF
C607	281-0515-00	B010100	B139999	27 pF, Cer, 500 V, ±1.35 pF
C607	281-0552-00	B140000		25 pF, Cer, 500 V
C614	281-0626-00	B010100	B139999	3.3 pF, Cer, 500 V,
C614	281-0610-00	B140000		2.2 pF, Cer, 200 V, ±0.1 pF
C640	283-0004-00	XB140000		0.02 µF, 150 V, +80-20%
C676	281-0540-00	B010100	B139999	51 pF, Cer, 500 V, ±5%
C676	281-0602-00	B140000		68 pF, Cer, 500 V, ±5%
RESISTORS				
R602	316-0470-00	B010100	B139999	47 Ω, 1/4 W, 10%
R602	315-0910-00	B140000		91 Ω, 1/4 W, 5%
R612	315-0752-00			7.5 kΩ, 1/4 W, 5%
R613	316-0473-00			47 kΩ, 1/4 W, 10%
R614	321-1485-00			1.11 MΩ, 1/8 W, 1%
R616	316-0106-00			10 MΩ, 1/4 W, 10%
R671	316-0100-00	B010100	B139999	10 Ω, 1/4 W, 10%
R671	315-0750-00	B140000		75 Ω, 1/4 W, 5%
R681	316-0100-00	B010100	B139999	10 Ω, 1/4 W, 10%
R681	315-0750-00	B140000		75 Ω, 1/4 W, 5%

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A8 Trig Gen & Sweep Logic Circuit Board Assembly

SWITCHES

S510	105-0400-00			Actuator Assy B TRIGGER SOURCE
S510A	260-1309-00	B010100	B139999X	Switch, Push, Lever
S615	105-0447-00	B010100	B139999	Actuator Assy A TRIGGER SOURCE
S615	105-0583-00	B140000		Actuator Assy, A TRIGGER COUPLING
S615A	260-1309-00	B010100	B139999X	Switch, Push, Lever
S615B	260-1309-00	B010100	B139999X	Switch, Push, Lever

A12 TV Sync Separator Circuit Board Assembly

670-0648-02	B010100	B139999
670-0648-03	B140000	

CAPACITORS

C1808	290-0415-00			5.6 µF, EMT, 35 V
C1812	283-0239-00			0.022 µF, Cer, 50 V
C1824	281-0549-00			68 pF, Cer, 500 V, 10%
C1827	290-0530-00			68 µF, Elect., 6 V, 20%
C1832	290-0530-00			68 µF, Elect., 6 V, 20%
C1854	281-0562-00	B010100	B139999	39 pF, Cer, 500 V
C1854	281-0632-00	B140000		35 pF, Cer, 500 V, ±1%
C1856	281-0605-00			200 pF, Cer, 500 V
C1860	281-0511-00			22 pF, Cer, 500 V, 10%
C1861	283-0010-00			0.05 µF, Cer, 50 V
C1865	281-0550-00			120 pF, Cer, 500 V
C1866	283-0010-00			0.05 µF, Cer, 50 V

DIODES

CR1818	152-0141-02	Silicon, replaceable by 1N4152
CR1824	152-0141-02	Silicon, replaceable by 1N4152
CR1825	152-0141-02	Silicon, replaceable by 1N4152
CR1826	152-0141-02	Silicon, replaceable by 1N4152
VR1827	152-0395-00	Zener, 1N749A, 4.3 V, 5%, 0.4 W
CR1828	152-0075-00	Germanium, Tek Spec
CR1831	152-0141-02	Silicon, replaceable by 1N4152
VR1832	152-0195-00	Zener, 1N751A, 5.1 V, 5%, 0.4 W
CR1834	152-0075-00	Germanium, Tek Spec
CR1865	152-0075-00	Germanium, Tek Spec

TRANSISTORS

Q1813	151-0188-00	Silicon, 2N3906
Q1824	151-0188-00	Silicon, 2N3906
Q1834	151-0192-00	Silicon, replaceable by MPS 6521
Q1854	151-0192-00	Silicon, replaceable by MPS 6521
Q1863	151-0188-**01**	Silicon, replaceable by 2N3251

RESISTORS

R1811	315-0221-00	220 Ω	1/4 W	5%
R1812	315-0914-00	910 kΩ	1/4 W	5%
R1814	315-0563-00	56 kΩ	1/4 W	5%
R1816	315-0471-00	470 Ω	1/4 W	5%
R1818	315-0364-00	360 kΩ	1/4 W	5%

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465 OPTION 5

(Changes from Standard 465)

A1 CH 1 Attenuator Circuit Board Assembly

670-2863-00	B010100	B169999
672-0416-01	B170000	

CAPACITORS				
C2	281-0627-00	B010100	B169999	1.0 pF, Cer, 500 V
C2	281-0610-00	B170000		2.2 pF, Cer, 200 V
C3	285-1055-00			0.2 μF, Plastic, 400 V
RESISTORS				
R3	Delete			

A2 CH 2 Attenuator Circuit Board Assembly

670-2863-00	B010100	B169999
672-0416-01	B170000	

CAPACITORS				
C52	281-0627-00	B010100	B169999	1.0 pF, Cer, 500 V
C52	281-0610-00	B170000		2.2 pF, Cer, 200 V
C53	285-1055-00			0.2 μF, Plastic, 400 V
RESISTORS				
R53	Delete			

A8 Trig Gen & Sweep Logic Circuit Board Assembly

670-2234-03	B010100	B139999
670-3283-00	B140000	B251094
670-3283-02	B251095	

CAPACITORS				
C501	281-0659-00	B010100	B139999	4.3 pF, Cer, 500 V, ±0.25 pF
C501	281-0572-00	B140000		6.8 pF, Cer, 500 V, ±0.5 pF
C602	281-0659-00	B010100	B139999	4.3 pF, Cer, 500 V, ±0.25 pF
C602	281-0709-00	B140000		7 pF, Cer, 500 V, ±0.1 pF
C607	281-0515-00	B010100	B139999	27 pF, Cer, 500 V, ±1.35 pF
C607	281-0552-00	B140000		25 pF, Cer, 500 V
C614	281-0626-00	B010100	B139999	3.3 pF, Cer, 500 V,
C614	281-0610-00	B140000		2.2 pF, Cer, 200 V, ±0.1 pF
C640	283-0004-00	XB140000		0.02 μF, 150 V, +80-20%
C676	281-0540-00	B010100	B139999	51 pF, Cer, 500 V, ±5%
C676	281-0602-00	B140000		68 pF, Cer, 500 V, ±5%
RESISTORS				
R602	316-0470-00	B010100	B139999	47 Ω, 1/4 W, 10%
R602	315-0910-00	B140000		91 Ω, 1/4 W, 5%
R612	315-0752-00			7.5 kΩ, 1/4 W, 5%
R613	316-0473-00			47 kΩ, 1/4 W, 10%
R614	321-1485-00			1.11 MΩ, 1/8 W, 1%
R616	316-0106-00			10 MΩ, 1/4 W, 10%
R671	316-0100-00	B010100	B139999	10 Ω, 1/4 W, 10%
R671	315-0750-00	B140000		75 Ω, 1/4 W, 5%
R681	316-0100-00	B010100	B139999	10 Ω, 1/4 W, 10%
R681	315-0750-00	B140000		75 Ω, 1/4 W, 5%

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A8 Trig Gen & Sweep Logic Circuit Board Assembly

SWITCHES

S510	105-0400-00			Actuator Assy B TRIGGER SOURCE
S510A	260-1309-00	B010100	B139999X	Switch, Push, Lever
S615	105-0447-00	B010100	B139999	Actuator Assy A TRIGGER SOURCE
S615	105-0583-00	B140000		Actuator Assy, A TRIGGER COUPLING
S615A	260-1309-00	B010100	B139999X	Switch, Push, Lever
S615B	260-1309-00	B010100	B139999X	Switch, Push, Lever

A12 TV Sync Separator Circuit Board Assembly

670-0648-02	B010100	B139999
670-0648-03	B140000	

CAPACITORS

C1808	290-0415-00			5.6 µF, EMT, 35 V
C1812	283-0239-00			0.022 µF, Cer, 50 V
C1824	281-0549-00			68 pF, Cer, 500 V, 10%
C1827	290-0530-00			68 µF, Elect., 6 V, 20%
C1832	290-0530-00			68 µF, Elect., 6 V, 20%
C1854	281-0562-00	B010100	B139999	39 pF, Cer, 500 V
C1854	281-0632-00	B140000		35 pF, Cer, 500 V, ±1%
C1856	281-0605-00			200 pF, Cer, 500 V
C1860	281-0511-00			22 pF, Cer, 500 V, 10%
C1861	283-0010-00			0.05 µF, Cer, 50 V
C1865	281-0550-00			120 pF, Cer, 500 V
C1866	283-0010-00			0.05 µF, Cer, 50 V

DIODES

CR1818	152-0141-02	Silicon, replaceable by 1N4152
CR1824	152-0141-02	Silicon, replaceable by 1N4152
CR1825	152-0141-02	Silicon, replaceable by 1N4152
CR1826	152-0141-02	Silicon, replaceable by 1N4152
VR1827	152-0395-00	Zener, 1N749A, 4.3 V, 5%, 0.4 W
CR1828	152-0075-00	Germanium, Tek Spec
CR1831	152-0141-02	Silicon, replaceable by 1N4152
VR1832	152-0195-00	Zener, 1N751A, 5.1 V, 5%, 0.4 W
CR1834	152-0075-00	Germanium, Tek Spec
CR1865	152-0075-00	Germanium, Tek Spec

TRANSISTORS

Q1813	151-0188-00	Silicon, 2N3906
Q1824	151-0188-00	Silicon, 2N3906
Q1834	151-0192-00	Silicon, replaceable by MPS 6521
Q1854	151-0192-00	Silicon, replaceable by MPS 6521
Q1863	151-0188-01	Silicon, replaceable by 2N3251

RESISTORS

R1811	315-0221-00	220 Ω	1/4 W	5%
R1812	315-0914-00	910 kΩ	1/4 W	5%
R1814	315-0563-00	56 kΩ	1/4 W	5%
R1816	315-0471-00	470 Ω	1/4 W	5%
R1818	315-0364-00	360 kΩ	1/4 W	5%

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A12 TV Sync Separator Circuit Board Assembly

RESISTORS

R1820	315-0203-00		20 kΩ	1/4 W	5%
R1824	315-0182-00		1.8 kΩ	1/4 W	5%
R1825	315-0182-00		1.8 kΩ	1/4 W	5%
R1826	311-1226-00		2.5 kΩ	Var	
R1827	315-0681-00		680 Ω	1/4 W	5%
R1830	315-0112-00		1.1 kΩ,	1/4 W	5%
R1833	315-0303-00		40 kΩ	1/4 W	5%
R1834	315-0162-00		1.6 kΩ	1/4 W	5%
R1850	315-0274-00		270 kΩ	1/4 W	5%
R1854	315-0102-00		10 kΩ	1/4 W	5%
R1856	315-0154-00		150 kΩ	1/4 W	5%
R1860	315-0822-00		8.2 kΩ	1/4 W	5%
R1861	315-0123-00		12 kΩ	1/4 W	5%
R1863	315-0822-00		8.2 kΩ	1/4 W	5%

TEST POINTS

TP1811	214-0579-00	Test Point
TP1854	214-0579-00	Test Point
TP1865	214-0579-00	Test Point
TP1866	214-0579-00	Test Point

A13 Trigger Pickoff Circuit Board Assembly

670-2682-00 B010100 B139999
670-2682-01 B140000

CAPACITORS

C1907	283-0177-00		1 μF, Cer, 25 V
C1914	281-0557-00		1.8 pF, Cer, 500 V
C1916	281-0064-00		0.25 - 1.5 pF, Var
C1918	290-0512-00		22 μF, Elect., 15 V
C1919	290-0512-00		22 μF, Elect., 15 V
C1921	283-0024-00		0.1 μF, Cer, 30 V
C1936	281-0650-00		18 pF, Cer, 200 V, 10%
C1937	283-0197-00		470 pF, Cer, 100 V
C1938	281-0650-00		18 pF, Cer, 200 V, 10%
C1940	283-0000-00		0.001 μF, Cer, 500 V
C1947	283-0177-00		1 μF, Cer, 25 V
C1949	283-0177-00		1 μF, Cer, 25 V

DIODES

CR1921	152-0141-02		Silicon, replaceable by 1N4152
CR1922	152-0141-02		Silicon, replaceable by 1N4152
CR1949	152-0141-02	XB140000	Silicon, replaceable by 1N4152

CONNECTORS

J1901	131-1003-00	Receptacle, coaxial cable

A13 Trigger Pickoff Circuit Board Assembly

TRANSISTORS

Q1902	151-1005-00	Silicon, FET, N-channel
Q1904	151-0188-00	Silicon, PNP, 2N3906
Q1906	151-0192-00	Silicon, NPN, Replaceable by MPS 6521
Q1910	151-0190-00	Silicon, NPN, 2N3904
Q1912	151-0134-00	Silicon, PNP, 2N2905
Q1922	151-0188-00	Silicon, PNP, 2N3906
Q1926	151-1022-00	Silicon, FET, N-channel

RESISTORS

R1901	316-0182-00	1.8 kΩ 1/4 W	10%
R1902	316-0182-00	1.8 kΩ 1/4 W	10%
R1903	321-0256-00	4.53 kΩ 1/8 W	1%
R1905	311-1164-00	50 kΩ Var	
R1906	316-0273-00	27 kΩ 1/4 W	10%
R1907	316-0822-00	8.2 kΩ 1/4 W	10%
R1909	316-0332-00	3.3 kΩ 1/4 W	10%
R1912	304-0821-00	820 Ω 1 W	10%
R1913	321-0486-00	1.13 MΩ 1/8 W	1%
R1918	316-0104-00	100 kΩ 1/4 W	10%
R1921	316-0274-00	270 kΩ 1/4 W	10%
R1922	316-0273-00	27 kΩ 1/4 W	10%
R1923	316-0393-00	39 kΩ 1/4 W	10%
R1926	316-0394-00	390 kΩ 1/4 W	10%
R1931	321-0260-00	4.99 kΩ 1/8 W	1%
R1932	321-0260-00	4.99 kΩ 1/8 W	1%
R1933	321-0260-00	4.99 kΩ 1/8 W	1%
R1934	321-0216-00	1.74 kΩ 1/8 W	1%
R1935	316-0274-00	270 kΩ 1/4 W	10%
R1936	316-0221-00	220 Ω 1/4 W	10%
R1938	316-0221-00	220 Ω 1/4 W	10%
R1939	321-0338-00	32.4 kΩ 1/8 W	1%

TRANSFORMERS

T1940	120-0550-00	Toroid

TEST POINTS

TP1912	214-0579-00	Test Point

INTEGRATED CIRCUITS

U1930	156-0136-00	Oper. Amp. CA 3030

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465 OPTION 5

MECHANICAL PARTS LIST

(Changes from Standard 465)

333-1635-01			1	PANEL, front
386-2534-00	B010100	B139999	1	PLATE, lever mounting
386-2376-00	B140000		1	PLATE, lever mounting
441-1150-00			1	CHASSIS, sync separator
441-1151-00			1	CHASSIS, trigger pickoff
103-0051-01			2	ADAPTER, 6-32
337-1674-02			1	LIGHT FILTER/TV graticule, NTSC
337-1674-03			1	LIGHT FILTER/TV graticule, CCIR
337-1829-00			1	SHIELD, trigger pickoff
131-1031-00	XB140000		4	CONTACT, High Frequency, top mounting
131-1030-00	XB140000		1	CONTACT, High Frequency, bottom mounting
131-0608-00	XB140000		6	TERMINAL PIN

465 Option 5

CALIBRATION PROCEDURE

EQUIPMENT REQUIRED

All Tektronix test equipment must be calibrated to factory calibration specifications. Howevever, equivalent test equipment may be used.

1	Type 106 Square-Wave Generator	
1	Television Test Signal Generator	(067-0601-00)
10	Program cards	
	067-5001-00	(405/50)
	067-5002-00	(525/60)
	067-5003-00	(625/50)
	067-5004-00	(819/50)
	067-5005-00	(819/50)
	067-5006-00	(729/60)
	067-5007-00	(875/60)
	067-5008-00	(945/60)
	067-5009-00	(1029/60)
	067-5010-00	(1201/60)

1	465 Oscilloscope	(referred to as Bench Scope)
1	P6065 X10 Probe	
1	Adapter	017-0063-00
1	50 Ω Termination	011-0049-01
1	75 Ω Termination	011-0055-00
1	50 Ω Coaxial Cable	012-0057-01
1	75 Ω Coaxial Cable	012-0074-00
1	1 MΩ X 24 pF Input RC Normalizer	067-0539-00

FACTORY TEST LIMITS

Factory Test Limits are qualified by the conditions specified in the main body of the Calibration Procedure. The numbers to the left of the limits correspond to the procedure steps where the check or adjustment is made. Steps without Factory Test Limits (setups, presets, etc.) are not listed. Instrument may not meet Factory Test Limits if calibration or checkout methods and test equipment differ substantially from those in this procedure.

TRIGGERS

(4.) a. Trigger Amplitude: 2 div (1 volt) of Composite video made up of .286 volts of Sync Pulses and .714 volts Picture Information.

(4.) b. Line Pulses: ≥.2V negative sync pulses.

(6.) c. Delayed Sweep Triggering: Stable triggering throughout entire vertical blanking interval.

(4.) d. Triggering Ramge: ≤ 2.0 div to ≥ 20 div.

(7.) e. Line Rates: Line rates 405/50 through 1201/60 will trigger from ≤ 2.0 div to ≥ 20 div.

SHORT FORM PROCEDURE

1. PRESETS

2. TRIGGER PICKOFF DC LEVEL

   Adjust Trigger Pickoff DC Level Control: (R1905) ±100mV

3. TRIGGER PICKOFF HIGH FREQUENCY COMPENSATION

   Adjust Compensation: (C1917)

4. SYNC SEPARATOR CLIPPING LEVEL

   Adjust clipping level: (R1826) 18 stable Sync Pulses ≥200mV

5. FIELD RATE PULSES

   Check for at least 6 pulses at TP1865: ≥200mV

6. LINE AND FIELD RANGE

   Check Triggering Range: ≤2.0 div to ≥ 20 div

7. LINE RATES

   Check Line Rates: Check for stable triggering from ≤2.0 div to ≥20 div line rates from 405/50 through 1201/60.

CALIBRATION

SPECIAL 465 PROCEDURE CHANGE for Option 5. CH 1 and CH 2 LF compensating are to be adjusted with a 24pf normalizer. (Regular 465's use 20pf input)

1. PRESETS

Set the 465 controls as follows:

CH 2 VOLTS/DIV	20mV
MODE (VERTICAL)	CH 2
INPUT COUPLING	DC
A & B T/D	20µsec
HORIZ MODE	A
TRIG MODE	AUTO
A TRIGGERING	
LEVEL	MIDRANGE
SLOPE	+
COUPLING	SYNC SEP
SOURCE	NORMAL
B TRIGGERING	
LEVEL	MIDRANGE
SLOPE	-
COUPLING	AC
SOURCE	TV LINE

Install 525/60 Program Card into TV Test Signal Generator.

2. TRIGGER PICKOFF DC LEVEL ±100mV

DISCONNECT: Sync Separator by removing green plug (P1920) from Pickoff Board.

CONNECT: X10 probe from Bench Scope to TP1912 on Pickoff Board.

SET: Bench Scope sensitivity 5 mV; Input DC.

ADJUST: R1905 for 0 volts on Bench Scope.

CALIBRATION

3. TRIGGER PICKOFF HIGH FREQUENCY COMPENSATION

CONNECT: 50Ω terminated cable from Type 106 SQUARE-WAVE GENERATOR to CH 2 input BNC.

SET: TYPE 106 to FAST RISE, 10KC.

ADJUST: TYPE 106 for 6 div of display on Test Scope.

SET: Test Scope "A" COUPLING - SYNC SEP.

SET: Bench Scope TIME/DIV to 20 µs and adjust triggers for stable display.

ADJUST: C1917 for the best flat top.

RECONNECT: Green Plug (P1920)

4. SYNC SEPARATOR CLIPPING LEVEL

SET: 465 Test Scope as follows:

CH 2 VOLTS/DIV	.1
A & B TIME/DIV	.2ms
A TRIGGERING	
SLOPE	-
SOURCE	CH 2

CONNECT: 75Ω terminated cable from Composite Video Output jack on 067-0601-00 (Television Test Signal Generator) to CH 2 input.

ROTATE: AVERAGE PICTURE LEVEL CCW on 067-0601-00.

ADJUST: COMPOSITE VIDEO AMPLITUDE control 067-0601-00 for 2.86 div (.286 volts) of signal on the Test Scope.

SET: CH 2 VOLTS/DIV to .2.

ADJUST: AVERAGE PICTURE LEVEL control on 067-0601-00 for 5 div (1 volt) p to p signal on Test Scope.

SET: CH 2 VOLTS/DIV to .5.

SET: Bench Scope as follows:

VERTICAL MODE	CH 1
INPUT	DC
SENSITIVITY	.1V
HORIZONTAL DISPLAY	A
TIME/DIV	.1m sec

4. CONT.

TRIG MODE	AUTO
"A" TRIGGERING	
SLOPE	-
COUPLING	AC
SOURCE	EXT

CONNECT: Bench Scope EXT input BNC to FIELD RATE OUT BNC of 067-0601-00 with an unterminated cable.

CONNECT: X10 probe from Bench Scope CH 1 input BNC to TP1866 Sync Separator Board.

ADJUST: R1826 (CLIPPING LEVEL) until 18 stable Sync Pulses are displayed on the Bench Scope. (18 Sync Pulses consist of 6 narrow negative pulses, 6 wide negative pulses, followed by 6 more narrow negative pulses.)

CHECK: Amplitude of the 18 Sync Pulses $\geq$200mV.

SET: Test Scope CH 2 VOLTS/DIV to 50mV.

CHECK: Bench Scope for 18 stable Sync Pulses (Readjust R1826 if necessary.)

CHECK: Test Scope for stable triggering.

SET: Test Scope CH 2 VOLTS/DIV to .5; INVERT IN: "A" Trigger SLOPE to +.

CHECK: Bench Scope for 18 stable Sync Pulses.

ROTATE: AVERAGE PICTURE LEVEL on 067-0601-00 slowly CCW.

CHECK: Bench Scope for 18 stable Sync Pulses.

CHECK: Test Scope for stable triggering.

SET: Test Scope INVERT OUT; "A" Trigger SLOPE to -.

ROTATE: AVERAGE PICTURE LEVEL slowly CW until the amplitude of Composite Video Signal is 1 volt.

CHECK: Bench Scope for 18 stable Sync Pulses.

CHECK: Test Scope for stable triggering.

CALIBRATION

5. FIELD RATE PULSES

CONNECT: X10 probe of Bench Scope to TP1865.

CHECK: that at least 6 negative Field Rate Pulses are present and that their amplitude is ≥200mV.

REMOVE: X10 Probe.

6. LINE AND FIELD TRIGGERING RANGE

SET: 465 Test Scope as follows:

MODE (VERTICAL)	ADD
CH 2 VOLTS/DIV	.5
INPUT COUPLING	AC
A TIME/DIV	2ms
B TIME/DIV	.1msec
HORIZONTAL DISPLAY	A INTEN

ADJUST: "A" Trigger LEVEL for stable triggering on Field Pulses.

ADJUST: "B" Trigger LEVEL for stable triggering on Line Pulses.

SET: The DELAY TIME POSITION so the intensified portion is on the second vertical blanking interval.

SET: Horizontal display to B DLY'D.

ROTATE: The DELAY TIME POSITION through the vertical blanking interval and check for stable triggering on the negative-going portion of each Sync Pulse.

SET: CH 2 VOLTS/DIV to 50mV.

CHECK: for stable Field and Line triggering; use CH 1 and CH 2 POSITION pots to position bottom of signal to check for proper triggering.

SET: CH 2 VOLTS/DIV to .5.

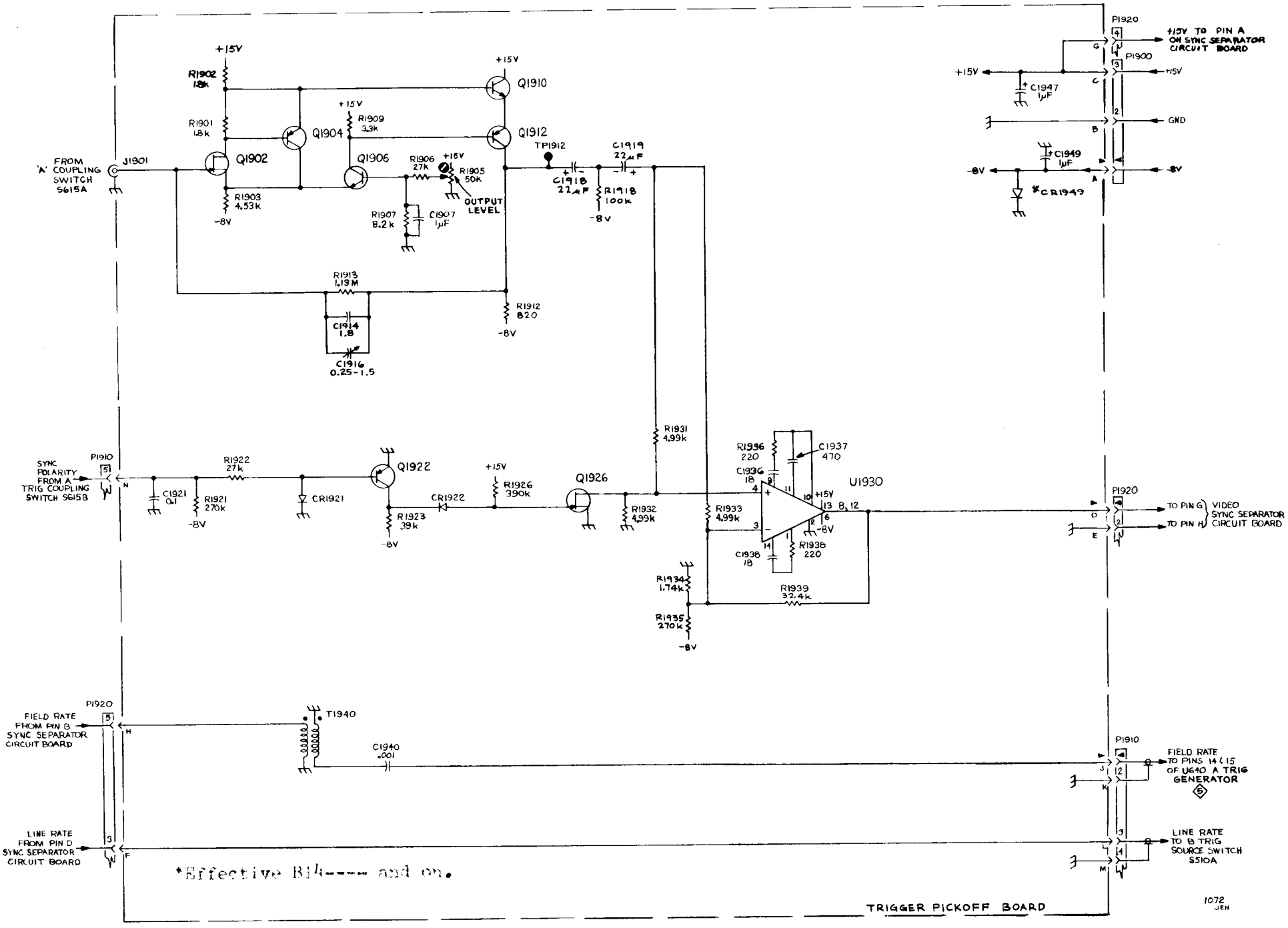
LINE RATES

Using the following chart check for stable triggering on Field and Line Pulses for the various Program Cards. Repeat Step 6 for each Program Card. if necessary, readjust R1826 but reset for 525/60 operation.

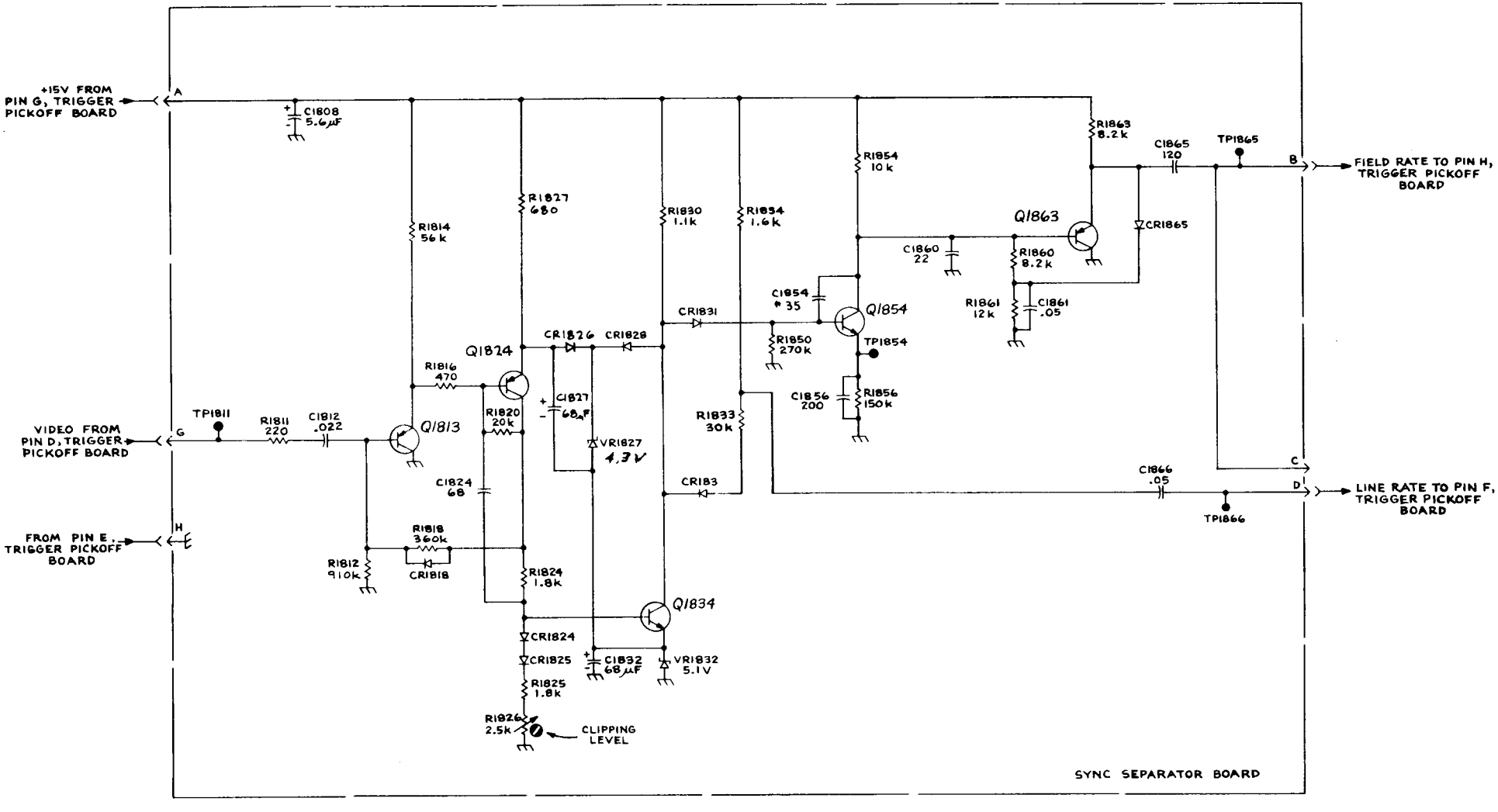
7. CONT.

System	Line Rate	Amplitude
A	405/50*	≤2 div to ≥20 div
M	525/60	≤2 div to ≥20 div
B	625/50*	≤2 div to ≥20 div
E	819/50*	≤2 div to ≥20 div
F	819/50*	≤2 div to ≥20 div
EIA STANDARD	729/60	≤2 div to ≥20 div
EIA STANDARD	875/60	≤2 div to ≥20 div
EIA STANDARD	945/60	≤2 div to ≥20 div
EIA STANDARD	1029/60	≤2 div to ≥20 div
EIA STANDARD	1201/60	≤2 div to ≥20 div

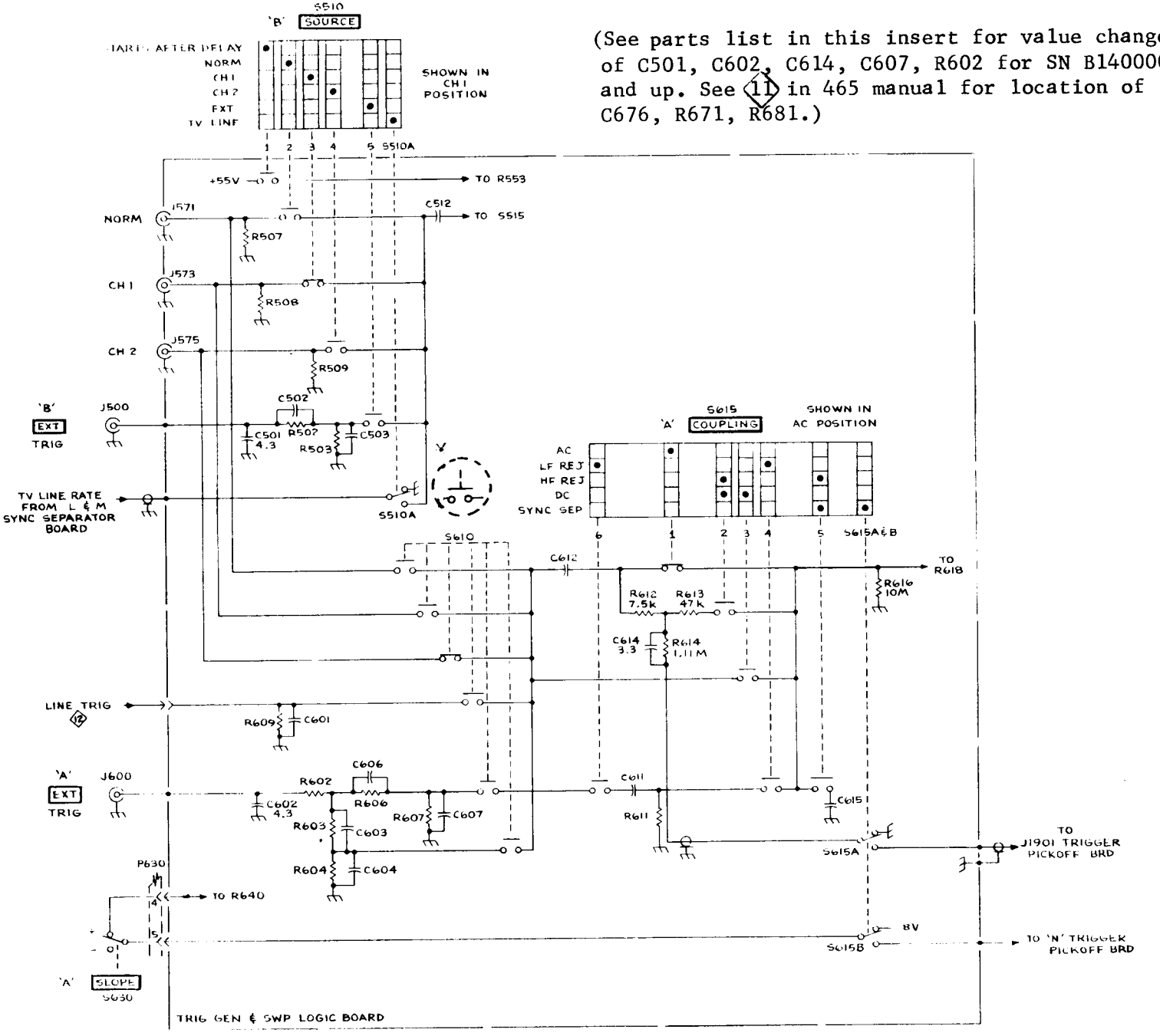
* To see the second vertical blanking interval; "A" sweep variable will have to be adjusted for 50Hz program cards.



TRIGGER PICKOFF



*See parts list in this insert.

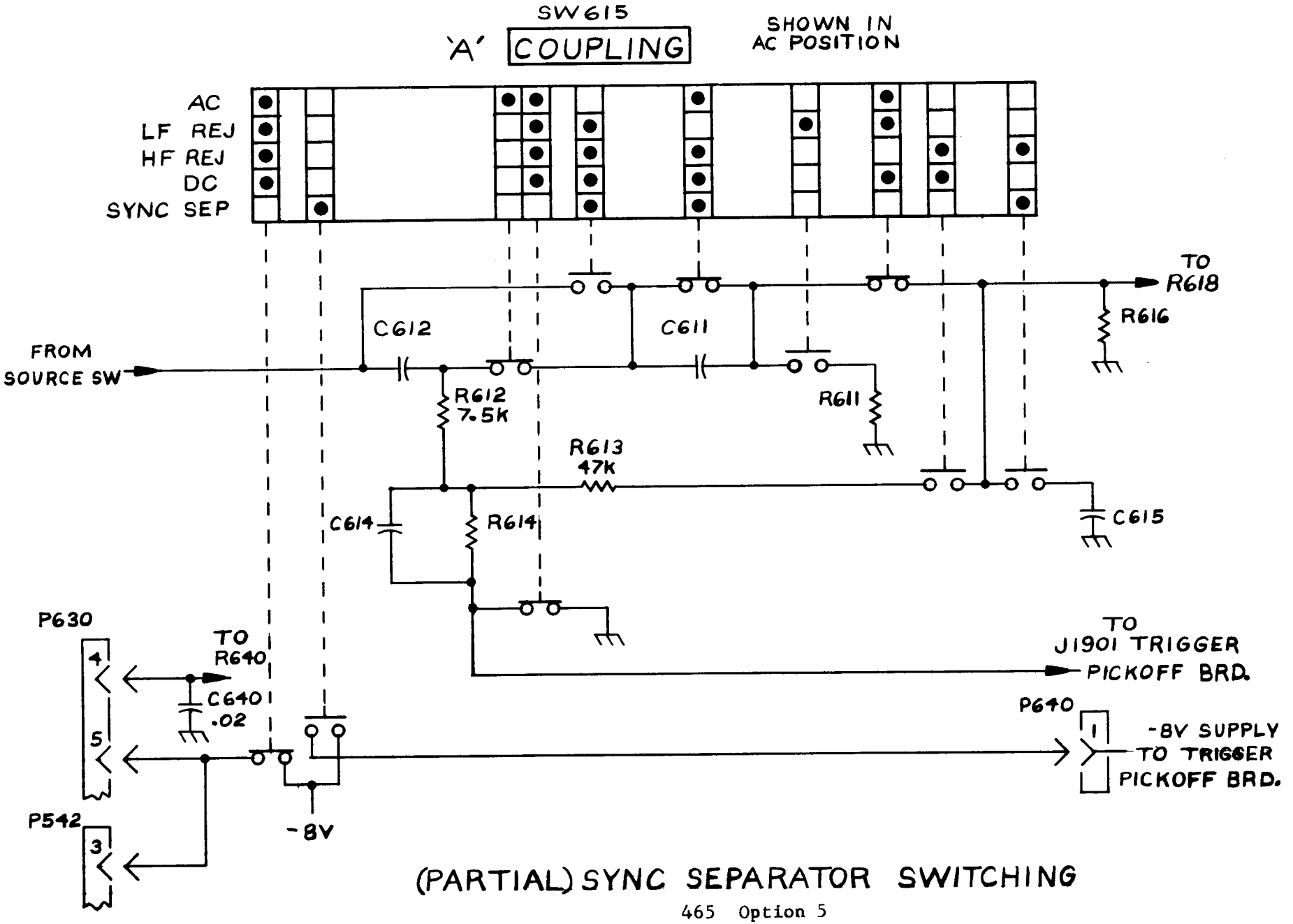


(See parts list in this insert for value changes of C501, C602, C614, C607, R602 for SN B140000 and up. See 11 in 465 manual for location of C676, R671, R681.)

*S510A replaced by a board-mounted switch B14---- and up.

SYNC SEPARATOR SWITCHING

(See partial for B140000-up for other changes.)



(PARTIAL) SYNC SEPARATOR SWITCHING

465 Option 5

Effective B14---- and up.