SECTION 11

PULSE AND BAR TRIGGER AND CALIBRATING GENERATORS GE4/502 AND GE4/502A

Introduction

Function

The GE4/502 and GE4/502A are auxiliary units used in pulse and bar waveform testing. The GE4/502 is intended for 405-line operation; the GE4/502A is similar to the GE4/502, but is switchable at the rear between 405 and 625 lines. These units have two functions:

1. To provide a means of calibrating the timebase of an oscilloscope to be used in pulse and bar tests;

2. To facilitate the display on the oscilloscope of a sine-squared pulse and bar signal obtained at the output of the apparatus under test.

requires flexible and stable control of the position and size of the oscilloscope display combined with a bright and well-defined trace; further, in order to measure the duration of some effect on the received signal when the signal transmitted is not available for comparison, it is necessary that the oscilloscope timebase scale in μsec/cm shall be accurately known. All these requirements may be satisfied conveniently if a GE4/502 or GE4/502A is incorporated in the display and triggering arrangements of the oscilloscope.

The generator provides two alternative outputs synchronised to the pulse and bar signal. One of these outputs is a timing waveform which can be displayed to calibrate the oscilloscope time-

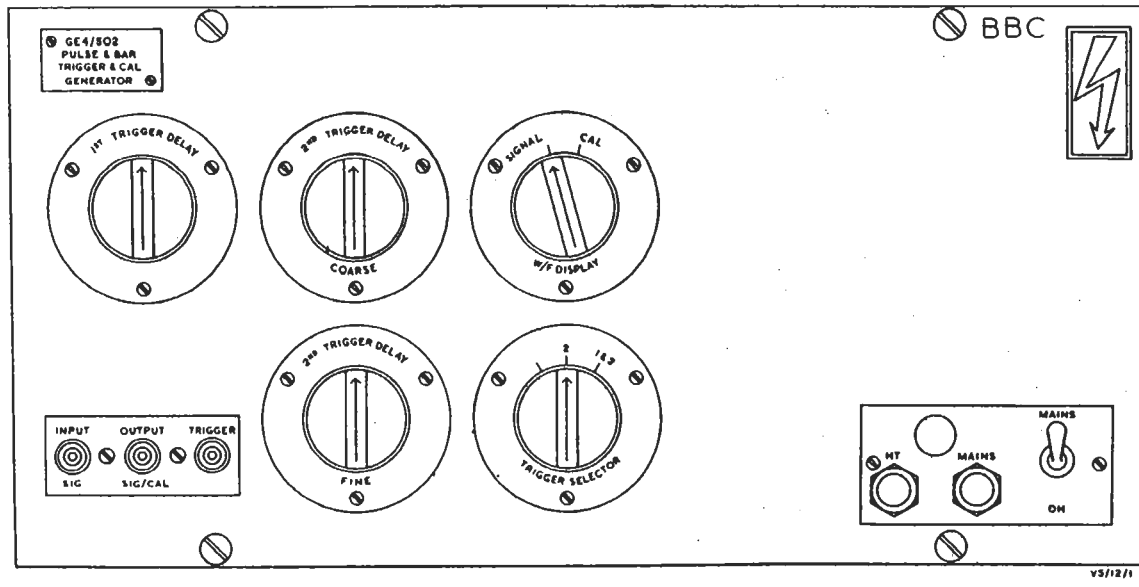


Fig. 11.1. Generator GE4/502: Front Panel
Drawing No. DK 5746

Pulse and Bar Testing Technique

In pulse and bar testing the 1T or 2T pulse waveform is displayed on an oscilloscope and compared with a graticule so that the waveform, which is the output signal from the apparatus under test, may be assessed by deciding within which set of limit lines the pulse most closely fits. (A pulse and graticule are shown in Fig. 11.3a.) Other parameters of the pulse and bar waveform are inspected in a similar way. This procedure

base. The other output is an oscilloscope-triggering signal comprising two differently-delayed positive-going triggering pulses during each pulse and bar period.

The amount of delay between each trigger pulse and the reference is variable, being adjustable by controls on the front panel of the generator. This delay allows any part of the pulse and bar waveform to be displayed at the fastest timebase speeds.

General Description (Fig. 11.1)

Operational Controls

All operational controls and coaxial connectors are on the front of the unit. (Fig. 11.1.) In operation, the pulse and bar waveform under examination is applied to the *Input* connector, the waveforms appearing at the *Output* and *Trigger* connectors being then selected by the *W/F Display* switch. For 405-line operation, using either generator, with this switch set at *Cal.* a 3-Mc/s calibrating waveform of amplitude 0·5 volt peak-to-peak appears at the *Output* connector, which is loaded by 75 ohms, with the same waveform but a somewhat higher voltage at the (unloaded) *Trigger* connector. If the *W/F Display* switch is set to *Signal*, the input pulse and bar waveform appears in parallel at the *Output* connector and 8-volt trigger pulses appear at the *Trigger* connector. A pulse with (1) short and (2) long delay is available, and either or both pulses can be chosen via the *Trigger Selector*

With the GE4/502, the timing of the pulses is adjustable between 6 and 9 μsec and 30 and 85 μsec respectively by means of the three *Trigger Delay* controls shown in Fig. 11.1.

With the GE4/502A on 405 lines the position of the first of the delayed trigger pulses is variable between 9 and 12 μsec and the position of the second is variable between 38 and 82 μsec. On 625 lines the position of the pulses is variable between 26 and 52 μsec; for this mode of operation a 0·5-volt p-p 5-Mc/s calibrating waveform is available at the *Output* connector when the *W/F Display* switch is on *Cal.*

Generators GE4/502 and GE4/502A

In what follows, the method of operation of either generator on 405 lines is given, followed by a circuit description of the GE4/502 only and test specifications for both types. Operation of the GE4/502A on 625 lines is not covered separately, but can be inferred from the instructions given for 405 lines. The circuit of the GE4/502A, which includes a 405/625 *Line Standard* switch and additional capacitors, is given in Fig. 34.

Method of Operation (405 Lines)

Oscilloscope Timebase Calibration

Calibration of the oscilloscope timebase consists in determining the time in microseconds represented by each centimetre of horizontal deflection on the tube. The procedure is as follows:

1. Place the testing graticule in position on the oscilloscope.
2. Connect the equipment as shown in Fig. 11.2a and switch on. Set the GE4/502A to 405.
3. Set the *W/F Display* switch to *Cal.* With the pulse and bar signal under test applied to the *Input* connector of the generator, a 3-Mc/s calibrating waveform will now appear at the *Signal* and *Trigger* connectors as indicated in Fig. 11.2b. This 3-Mc/s waveform occurs as a burst locked to the line sync pulse included in the pulse and bar input signal. (Fig. 11.3b.)

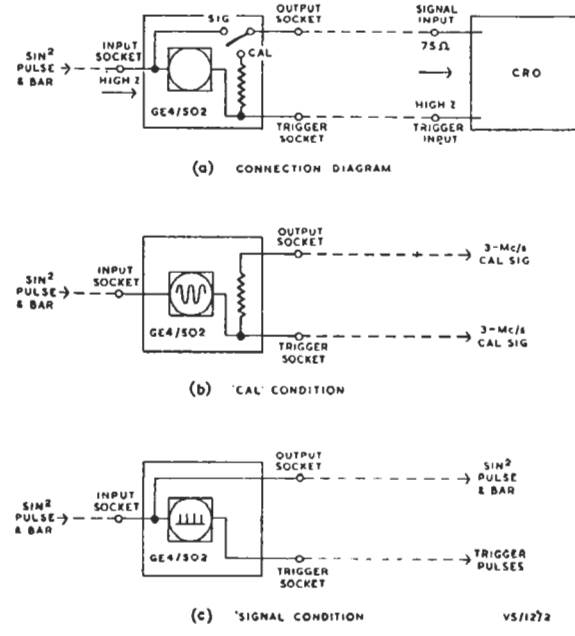
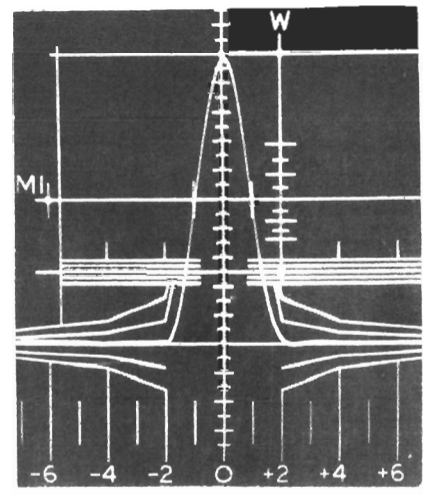


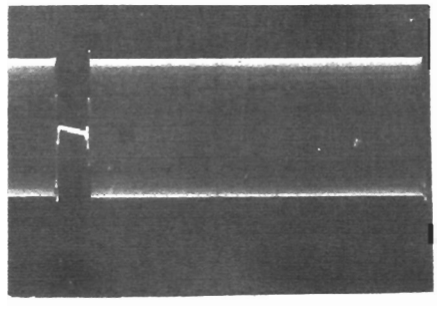
Fig. 11.2. Generator GE4/502: Connections

4. Adjust the oscilloscope timebase controls so that the successive tips of the displayed waveform, which occur at 0·33-μsec intervals, coincide with the 2T marked intervals of the graticule. The time-scale of the oscilloscope display will then be the same as that of the graticule, because for the 405-line system the time interval T is by definition equal to 0·167 μsec. (See Section 10.) The 2T intervals on the graticule are 1 cm apart and the timebase controls should therefore indicate a setting of about 0·33 μsec/cm. Fig. 11.3c shows the display with the timebase correctly set up.

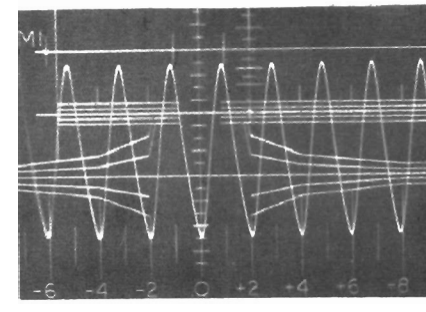
NOTE:—No timebase sweep expansion (magnification) need be used. This facility frequently gives rise to 'jitter' on the displayed signal.



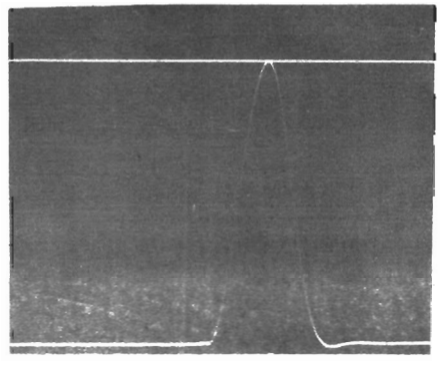
(a) Testing Graticule with Sine-squared Pulse



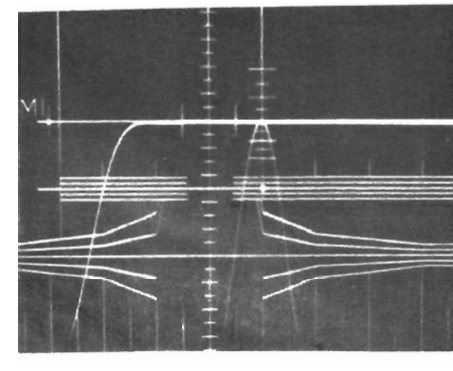
(b) Synchronised Burst of 3-Mc/s Waveform



(c) 3-Mc/s Calibrating Waveform Correctly Adjusted on Graticule



(d) Superposition of Sine-squared Pulse and 40-μsec Bar



(e) Superposition of Pulse and Bar Displayed with the Graticule

Fig. 11.3. Generator GE4/502: Oscillograms
Drawing No. DSKA 6575

Test Signal Measurement

The amplitude transitions in the pulse and bar waveform have durations of the order of 0·1 to 0·5 μsec. The most effective display of the transitions is obtained when the total scan time of the oscilloscope timebase is in the range between 2 and 5 μsec. The timebase must therefore be triggered less than 2 μsec before the occurrence of the event it is required to display.

When the generator is used as an aid to test signal measurement it is connected in the same way as for timebase calibration (Fig. 11.2a), but the *W/F Display* switch is set to the *Signal* position. Under these conditions, when the pulse and bar signal to be examined is applied to the *Input* connector, this signal also appears at the *Output* connector, but triggering pulses appear at the *Trigger* connector. (Fig. 11.2c.)

The triggering pulses are locked to and delayed by a variable amount from the back edge of the synchronising pulse of the pulse and bar waveform. Triggering pulses with a short delay and a long delay are available either separately or together as already stated. The first of these pulses, with a delay variable in the range between 6 and 9 μsec, is used to enable the sine-squared pulse to be set correctly for reference to the limit lines of the graticule. (Fig. 11.3a.)

The second triggering pulse, with a delay variable in the range between 30 and 85 μsec, may be used for detailed examination of the 40-μsec bar.

The main use of the second trigger, however, is in conjunction with the first, i.e., with the *Trigger Selector* switch set to *1 and 2*, when a twice-line-frequency trigger is obtained. By adjustment of the timebase controls, two timebase scans can be obtained within the duration of one period of the pulse and bar waveform, and subsequently by adjustment of the *Trigger Delay* controls the sine-squared pulse may be superimposed on the bar. In this way, very accurate setting of the pulse-to-bar ratio to 1 : 1 is possible at the test signal source; however, the most important use of the method of superposition is to display the pulse and bar when the pulse-to-bar ratio is being measured on the graticule. These two applications are indicated in Figs. 11.3d and 11.3e.

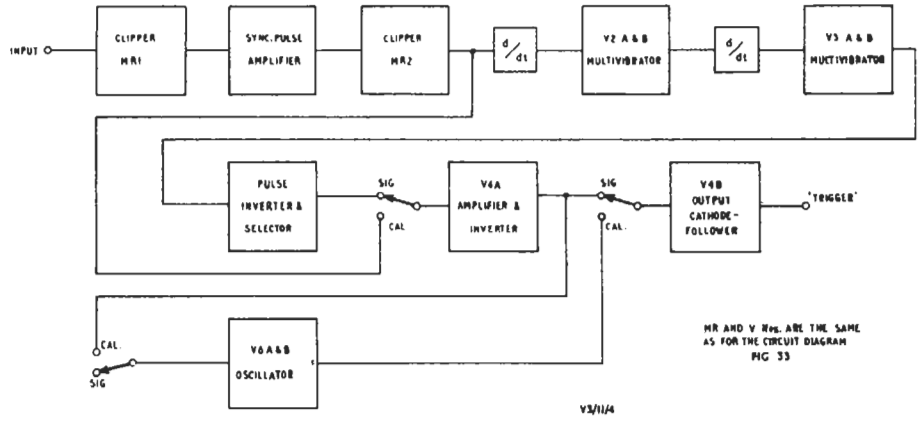


Fig. 11.4. Generator GE4/502: Block Diagram
Drawing No. DSKA 6576

Circuit Description: GE4/502

General

A block diagram of the GE4/502 is given in Fig. 11.4; the *Output* connector switching is omitted from this diagram, but is indicated in Fig. 11.2. The complete circuit is shown in Fig. 33. Details of the waveforms obtained at each stage appear in Fig. 11.5. The amplitude of the sine-squared pulse and bar input signal is 1 volt peak-to-peak.

In both the *Cal.* and *Signal* conditions of the generator, the pulse and bar waveform applied to the *Input* connector has its bar component reduced by crystal diode MR1, which conducts only within approximately ±0·3 volt about the black level of the signal. After amplification and inversion by V1, the signal is clipped by crystal diode MR2, which is biased by a pre-set resistor R11, and only the 10-μsec line-sync pulse component of the original waveform then remains. The sync pulse

may be used in either one of two ways, according to the circuit function selected by the *W/F Display* switch.

Calibrating Signal Generation

This mode of operation is established by setting the *W/F Display* switch to *Cal.* as shown in Figs. 11.2b and 33. Under these conditions, the sync pulse output from MR2 is switched to V4A, by which it is further amplified and inverted and afterwards applied to the grid of V6A, which is thus cut off for 10 μsec.

The two sections, A and B, of V6 comprise an *LC* oscillator in which positive feedback is applied via V6B grid and R46 and common cathode coupling resistor R47, the output being available at V6B anode. In the absence of an input to V6A grid, the tuned circuit L1-C18 oscillates continuously. Thus the oscillator is started at the end of each 10-usec cut-off period and a steady display of the oscillatory waveform is obtained when the output of the generator is viewed on the oscilloscope, since the timebase is triggered by the start-up of the oscillation envelope. The output voltage of the oscillator is controlled by the pre-set variable resistor R46, which varies the feedback fraction and gain of V6A.

Trigger Pulse Generation

This mode of operation is established by setting the *W/F Display* switch to *Signal*, as shown in Figs. 11.2c and 11.4. Under these conditions the sync pulse component of the sine-squared pulse and bar waveform is differentiated after leaving MR2 and the resultant negative-going spike is used to trigger V2, a monostable multivibrator, into its unstable state. The duration of this state is adjustable by the *First Trigger Delay* control, RV1, the resistance setting of which enters into the expression for the multivibrator time constant, C6(RV1 + R17). The output of V2 is differentiated and the negative-going spike triggers V3 via diode V5A. V3 is another monostable multivibrator, the unstable state of which is adjustable in duration by the *Second Trigger Coarse* and *Fine* controls, RV2 and R27, the resistance settings of which enter into the time constant, C9(RV2 + R27 + R28); the maximum or minimum delay obtainable with RV2 and R27 can be set by R23, which operates independently of the front panel controls.

The anode load of V3B is T1 primary winding. This offers a low impedance at line frequency, and therefore the output waveform consists of positive- and negative-going spikes corresponding to the switching off and on of V3B.

The output from T1 secondary is applied to T2 via crystal diodes MR5 and MR6, by the action of which the currents due to the differently delayed pulses of opposite polarity in T1 secondary give

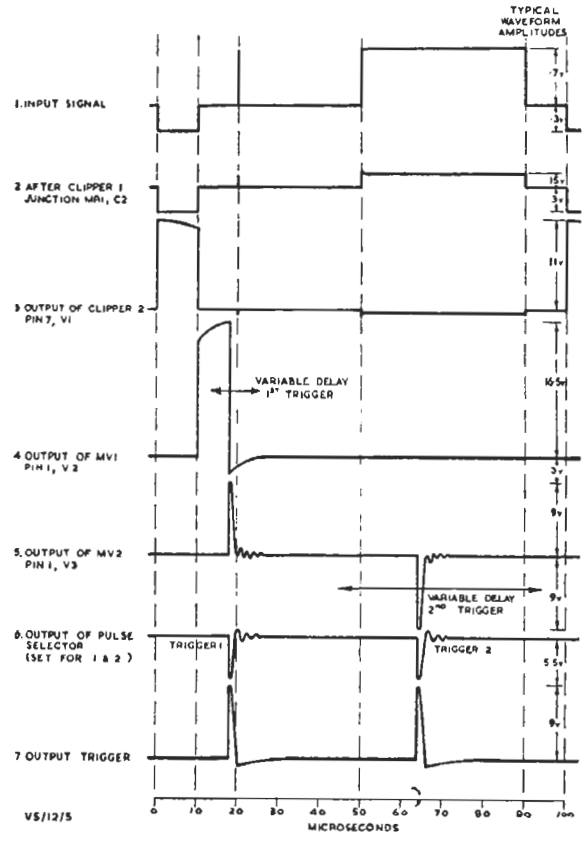


Fig. 11.5. Generator GE4/502: Waveforms
Drawing No. DSKA 6557

rise to unidirectional current pulses in T2 primary. The arrangement of MR5, MR6 and T2 provides a means of selecting the required pulse or pulses by choice of transformer connections, for which the *Trigger Selector* switch is used.

The selected pulse or pulses are amplified and inverted by V4A, and subsequently appear at the *Trigger* connector of the generator via cathode follower V4B at an output impedance such that the pulses are unaffected by the input capacitance of an oscilloscope trigger connection.

Power Supplies

The generator has a built-in mains unit incor-

porating T3 and V7 to V11. The h.t. is supplied via rectifier V7 and a conventional series stabilising circuit using V9, V10 and the neon V11, the output voltage being controlled by R44. The heater circuits of V2 and V3 are supplied via the barretter V8 to minimise changes in valve parameters resulting from variations in the voltage of the heater supply due to mains voltage variations. The total power consumption is 50 watts.

Test Procedure*: GE4/502 Only

Equipment Required

Avometer Model 8
Tektronix oscilloscope Type 524AD
Pulse and bar generator
Wavemeter Type BC221
Change-over box
Wattmeter

Power Supply

1. Ensure that the mains-selector link of the GE4/502 is in the appropriate position and switch on.
   WARNING:—Never apply power to the unit with *one* of the two valves V2 and V3 removed from its socket, because the heater of the other is then liable to damage owing to the rise in voltage across barretter V8.
2. Check that all valve heaters are alight. Measure the h.t. voltage at pin 2 of V9 and adjust if necessary to 150 volts by means of R44.
3. Display the ripple on the h.t., using the maximum-gain condition of the oscilloscope Y amplifier, and estimate the ripple amplitude. An accurate measurement is not possible because this amplitude, which should not exceed 2 mV peak-to-peak, is of the same order as the noise present on the h.t. output.

Sync Separator

1. Terminate the *Output* connector of the GE4/502 in 75 ohms and apply the pulse and bar signal to the *Input* connector.
2. Monitor pin 7 of V1, using the x10 probe on the oscilloscope.
3. Adjust R11 so that the pulse and bar are clipped from the signal, obtaining the maximum amplitude of sync pulse with this condition. This amplitude should be 12 $\pm$1·75 volts.

Delayed Trigger Pulses

1. Set the *W/F Display* switch on the GE4/502 to *Signal* and the *Trigger Selector* to *1 and 2.*
2. Apply the pulse and bar signal to the *Input* connector.
3. Take the *Trigger* connector output to the oscilloscope signal input, so as to display the trigger pulses. The oscilloscope should be triggered from the pulse and bar signal available at the *Output* connector of the GE4/502, preferably using the trailing edge of the line sync pulse.
4. Set the pre-set control R23 to its mid point.
5. Turn the *1st Trigger Delay* control fully clockwise to minimum delay. Observe the delay of the first trigger pulse, which should be less than 9·0 µsec from the trailing edge of the line sync pulse.
6. Turn the *1st Trigger Delay* fully anticlockwise to its maximum position. The delay should now be greater than 10·5 µsec.
7. Turn the *2nd Trigger Delay* coarse and fine controls fully clockwise to minimum delay. The delay of the second trigger pulse from the trailing edge of the line sync pulse should not be greater than 38 µsec.
8. Turn the *1st Trigger Delay* control fully clockwise to minimum and the *2nd Trigger Delay* coarse and fine controls fully anticlockwise to maximum. The second trigger pulse should now have a delay of not less than 80 µsec. If necessary, change the value of R28 to achieve the stipulated delay.

Oscillator

1. Apply a pulse and bar input to the GE4/502, set the *W/F Display* switch to *Cal.* and display the signal.
2. Adjust R46 so that the oscillation envelope fills the complete line period and is symmetrical about the zero signal line of the sync pulse period.
3. Adjust the position of the dust-iron core of L1 to bring the oscillation frequency to 3 Mc/s.
   (a) During the initial stages of the adjustment the 1-Mc/s marker pips on the oscilloscope should be used. In the line waveform envelope the difference in period of the two waveforms gives rise to a progressive phase difference which is visible as a sinusoidal brightness modulation.
   (b) For the final adjustment, connect the oscillator output to the BC221 wavemeter,

*These tests are comprehensive. Partial testing may often suffice. Adjustments should not be disturbed unnecessarily.

by taking the *Antenna* lead to the oscilloscope input terminal. Beat conditions occur at 10-kc/s intervals; the centre frequency and two strongest sidebands may thus be located, both aurally and by observing the oscilloscope display (timebase scale about 1 msec/cm). The most distinct pattern is at the centre frequency, and this should be set to 3 Mc/s; the sidebands will then be located at 2·990 Mc/s and 3·010 Mc/s.

Test Procedure*: GE4/502A Only

Equipment Required

Avometer Model 8
Tektronix oscilloscope Type 515 or 545
405-line pulse and bar generator
625-line pulse and bar generator
Frequency counter covering 3 to 5 Mc/s
Change-over box
Variable attenuator

Power Supply

Proceed as already indicated for GE4/502.

Sync Separator

1. Set the *Line Standard* switch on the rear of t' unit to *625*. Connect the pulse and bar signal, which should be set up accurately to 1 volt peak-to-peak, to the input and terminate at the output.
2. Monitoring pin 7 of V1 using the x10 probe on the oscilloscope, adjust R11 so that the pulse and bar are clipped from the signal, and obtain maximum amplitude of sync pulse with this condition. The amplitude should be not less than 11 volts.
3. Using the 405-line signal, and without further adjustment of R11, check that the amplitude is still not less than 11 volts.

Delayed Trigger Pulses (*See Table 1*)

(*a*) *General*

NOTE:—Maximum trigger delay is obtained with the controls fully anticlockwise.

1. Set the *W|F Display* switch to *Signal* and the *Trigger Selector* switch to *1 and 2*.
2. Trigger the oscilloscope externally from the rear edge of the sync pulse of the pulse and bar waveform.
3. Connect the oscilloscope input to the GE4/502A *Trigger* output in order to display the trigger pulses.
4. Set C24 to mid position. Insert a 680-kilohm resistor as R28.
   The setting of V3 stability control R23 should now be checked. The two possible limiting conditions are:
   (i) If the d.c. potential at pin 7 of V3 is too low, at low values of delay V3A may not be properly triggered on by V2.
   (ii) If the d.c. potential is too high, at high values of delay V3A may not be properly cut off during its quiescent period.
5. Check, by monitoring pin 1 of V3B, that R23 is set well past the position where V3 for minimum delay ceases to operate correctly.
6. Then check that for maximum delay V3A anode is at h.t. potential during the rest of the multivibrator sequence when V3A is nonconducting.

(*b*) *To Check 405-line Delays*

1. Apply the 405-line pulse and bar input, and set the *Line Standard* switch to *405*.
2. Set the *1st Trigger Delay* control to maximum (fully anticlockwise). Measure this delay, which should be within the range 10·5 to 12 μsec, taking the rear edge of the sync pulse as reference.
3. Turn the *2nd Trigger Delay* controls fully clockwise. Measure the resultant delay, which should not exceed 38 μsec.
4. Turn the *1st Trigger Delay* control fully clockwise and the *2nd Trigger Delay* controls fully anticlockwise. The resultant second delay should be not less than 82 μsec.

(*c*) *To Check 625-line Delays*

1. Repeat the tests under (*b*), using a 625-line pulse and bar input and with the *Line Standard* switch set to *625*.
2. Check that the maximum first trigger delay is in the range 6·5 to 7·5 μsec.
3. Check that the minimum second trigger delay is not greater than 26 μsec and the maximum not less than 53 μsec.

(*d*) *To Adjust Delays*

If the required delays cannot be obtained, alter the setting of trimmer C24 and/or change the value of R28.

1ST DELAY.—The maximum or minimum first delay may be varied in both the *625* and the *405* position by use of trimmer C24.

*See footnote on page 11.6.

2ND DELAY:—The maximum or minimum second delay may be varied in both the *625* and the *405* position by changing the value of fixed resistor R28.

TABLE 1: GE4/502A TRIGGER DELAY RANGES

	1st Trigger Delay			*2nd Trigger Delay*		
Line Standard	*Normal Position of sin^2 Pulse*	*Range of Delay*	*Max.*	*Normal Position of Bar Edges*	*Min.*	*Max.*
625	6·5	2	<7·5	27 52	<26	>52
405	10	3	<12	40 80	<38	>82

All waveform timings are nominal, and relative to the rear edge of the sync pulse. The units are microseconds. The ranges between minimum and maximum second delay may be extended by making use of the first delay.

NOTE:—If it should be necessary to check the trigger pulse delays, this should be done by reference to the rear edge of the sync pulse and not by reference to the pulse and bar waveform.

(*e*) *Output Amplitude*

The amplitude of the output trigger pulses should be not less than 8 volts.

Oscillator

1. Set the *W/F Display* switch to *Cal.* and disconnect the input signal so that the oscillator is free-running.
2. Connect the frequency counter to the *Output*, which should remain terminated in 75 ohms. Switch to *405*.
3. Set C18 and C26 to their mid positions and adjust the oscillator frequency to 3 Mc/s by means of the dust iron core of L1.
4. Switch to *625* and set to 5 Mc/s using C18.
5. Return to *405* and adjust C26 so that the frequency is again 3 Mc/s.
6. Connect the 405-line input signal and adjust R46 so that the oscillation envelope fills the line period. The waveform should be as symmetrical as possible about the zero signal line of the sync pulse period.
7. Repeat operation 6 for 625 lines.
8. Continue switching between 405 and 625 lines, and set R46 for the best compromise on symmetry.
9. Check that the waveform peak-to-peak amplitude, measured at pin 6 of V6B, is not less than 10 volts. The output signal amplitude will then be about 0·5 volt peak-to-peak terminated.
10. Observe the change in frequency in the blanked mode of operation. Retune C18 to correct this for 625-line operation, and retune C26 to correct for 405-line operation.
11. Check that R46 is still in the optimum position, and adjust if necessary.
12. If R46 has to be altered, check the frequencies again.

Test Procedure*: GE4/502 and GE4/502A

Power Consumption

1. Disconnect the long lead from pin 2 of V9. Switch on and measure the h.t. current. This should be between 52 and 57 mA. Switch off and re-connect the lead.
2. Measure the mains power consumption of the equipment using any suitable wattmeter. The consumption should be about 50 watts.

Effect on Input Signal

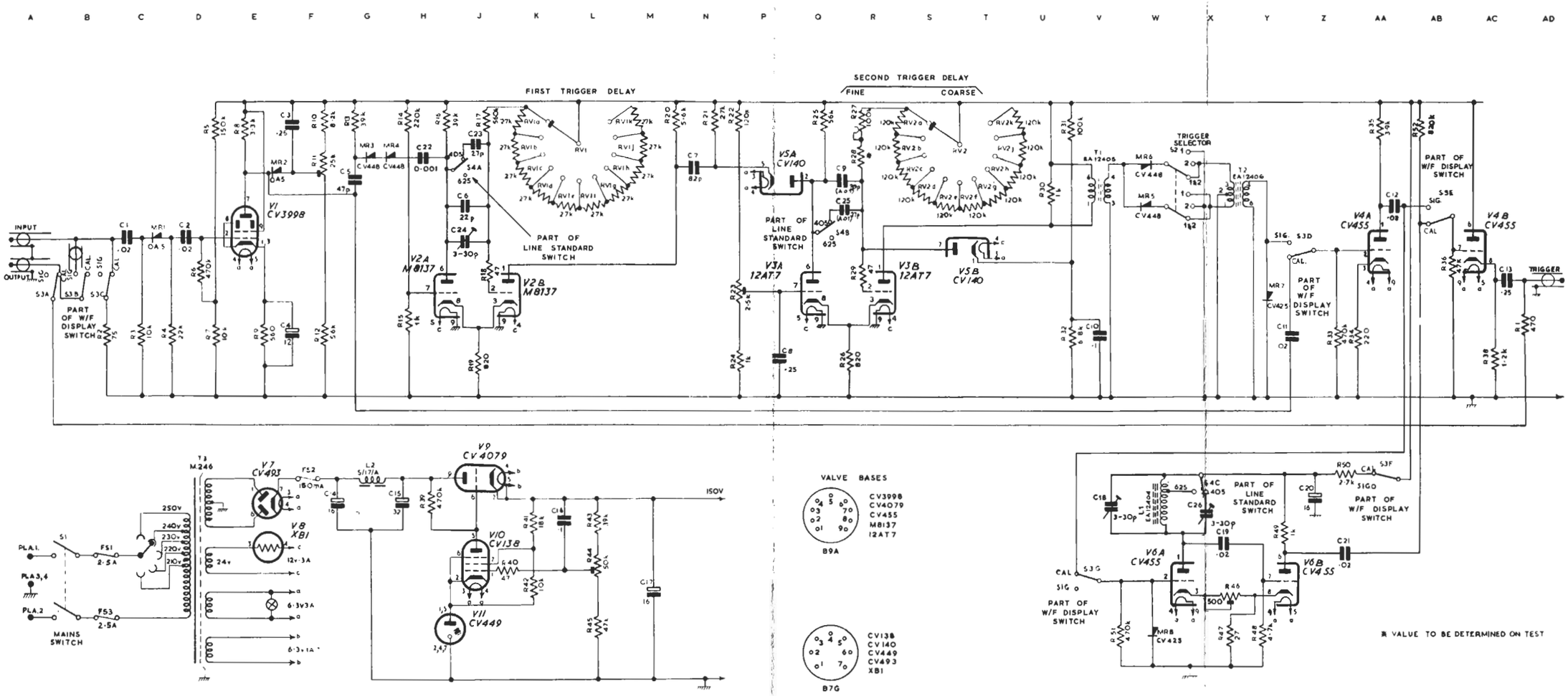
Check by means of a change-over method that the process of feeding the pulse and bar signal to the oscilloscope using the GE4/502 does not result in additional waveform distortion.

Stability of Trigger Pulses

1. Select *Trigger 1* and display the 1T pulse on the 0·1-μsec/cm range, using a suitable graticule to define the pulse position. The display should be completely free from instability, which may take any of the following forms:
   (a) Thickening of the trace on nearly vertical parts of the waveform.
   (b) Gradual drift of the pulse from some set position.
   (c) Fast erratic changes in pulse position.
2. Select *Trigger 1 and 2* and display the back edge of the bar adjacent to the 1T pulse. The following conditions should apply:
   (a) There should be no apparent thickening of the trace on nearly vertical parts of the waveform.
   (b) There should be no fast erratic changes in the position of the bar with respect to the pulse.
   (c) While fluctuations of the bar edge about a mean position are permissible, over a period of two minutes the maximum excursion should not exceed 20 mμsec, although for much longer periods the delay may drift as much as 0·2 μsec from the original setting.

*See footnote on page 11.6.

PARTS LIST DA5744



* VALUE TO BE DETERMINED ON TEST

PULSE AND BAR TRIGGER AND CALIBRATING GENERATOR GE4/502A : CIRCUIT

GE4/502A