# SECTION 6

## NON-LINEARITY TEST SIGNAL GENERATORS GE4/505 AND GE4/505A

### Introduction

The GE4/505 generates test signals for measuring the non-linearity of the voltage transfer characteristic of all television apparatus which accepts a video-frequency 405-line waveform; type GE4/505A is a modified version for the 625-line standard. For test work the generator is used in conjunction with a filter, an amplifier and an oscilloscope.

Further description deals particularly with the parent equipment and is followed by supplementary information about the modified type.

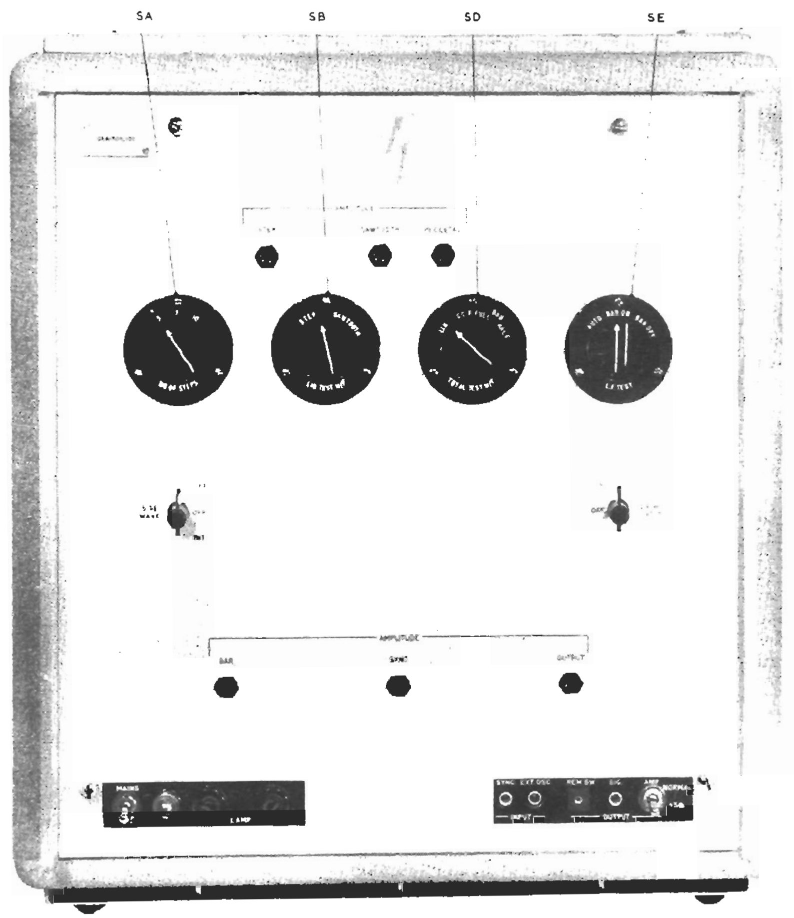



*Fig. 6.1 Non-linearity Test Signal Generator GE4/505*

### Mechanical Arrangement

Fig. 6.1 is a front view of the GE4/505. The generator consists of two chassis mounted in a portable case (carrying case type CS2/7B) of dimensions 17 in. wide, $19\frac{1}{2}$ in. high and $14\frac{1}{2}$ in. deep. The unit weighs 38 lb and its power consumption is approximately 160 watts.

At the front of the unit are the switches for waveform selection, pre-setting controls for waveform amplitudes, signal input and output plugs, and a mains switch with associated indicator lamp and fuses. The front panel can be removed, without taking off the control knobs, after releasing four coin-slotted screws. This reveals the component side of the vertically-mounted signal chassis.

The mains-input plug is at the rear of the unit. The back panel can be removed by releasing two coin-slotted fasteners, to expose the horizontally-mounted power-supply chassis and the valve side of the signal chassis. The remaining pre-set controls on the signal chassis and the pre-set controls on the power-supply chassis are accessible when the rear panel is removed.

Care should be taken to avoid altering the positions of components and wiring, because the performance of the generator may be affected. A replacement component should be placed in the position that was occupied by the faulty component and any disturbed wiring should be returned to its original position.

**Facilities**

The generator has an output impedance of 75 ohms and should be terminated in 75 ohms. It supplies a l-volt waveform which can be either free running or synchronised to line-trigger pulses. The table below gives a summary of the various waveforms which can be generated and the appropriate settings for four rotary switches on the front panel; the switch codes are those of Fig. 13.

Fig. 6.2 shows several examples of the output waveforms that are available. Additionally a 0.1-volt p-p sine waveform can be superimposed on any of these signals by moving a *Sine Wave* key-switch to *Int.*, at which an internal 600-kc/s oscillator is connected. Alternatively the *Ext.* setting of the switch provides for superimposition of a sine-wave signal from an external source. Other features are as follows:—

*Lin. W/F Attn. Key-switch*

Placing this switch to *On* causes the sawtooth or staircase component of any test waveform to be reduced by approximately 10 dB.

*Amp. Switch*

When set to *+3 dB* the output is increased by the stated value, with no change in distortion.

*Switch SE*

This has *Bar On* and *Bar Off* settings where the bar waveform is connected and disconnected, respectively. An *Auto* setting gives automatic operation such that the bar waveform is inserted and removed at intervals of about 5 seconds.

*Remote-switching Socket*

This provides for connection of an external switch by which the bar waveform can be inserted and removed.

| | *Waveform* | *Switch Settings* | | | |
|---|---|---|---|---|---|
| | | *SA* | *SB* | *SD* | *SE* |
| (a) | A staircase from blanking level to peak white on each line, the number of steps being 5, 7, or 10. | *5, 7* or *10* | *Step* | *Lin.* | — |
| (b) | A sawtooth from blanking level to peak white on each line. | — | *Sawtooth* | *Lin.* | — |
| (c) | Either of waveforms (a) and (b) on every fourth line, the other three lines being either blanking level or peak-white bars. | *5, 7* or *10* | *Step*<br>*Sawtooth* | *CCIR* | { *Bar Off*<br>*Bar On* |
| (d) | A peak-white bar on each line. | — | — | *Full Bar* | *Bar On* |
| (e) | A bar of 50 per cent. peak white on each line. | — | — | *Half Bar* | *Bar On* |
| (f) | Syncs only. | — | — | *Full Bar*<br>*Half Bar* | *Bar Off* |

**Non-Linearity Distortion Measurements**

The GE4/505 generates test waveforms which traverse at line frequency the voltage transfer characteristic of the apparatus under test. Non-linearity of the characteristic is measured by analysing the test waveform at the output of the apparatus.

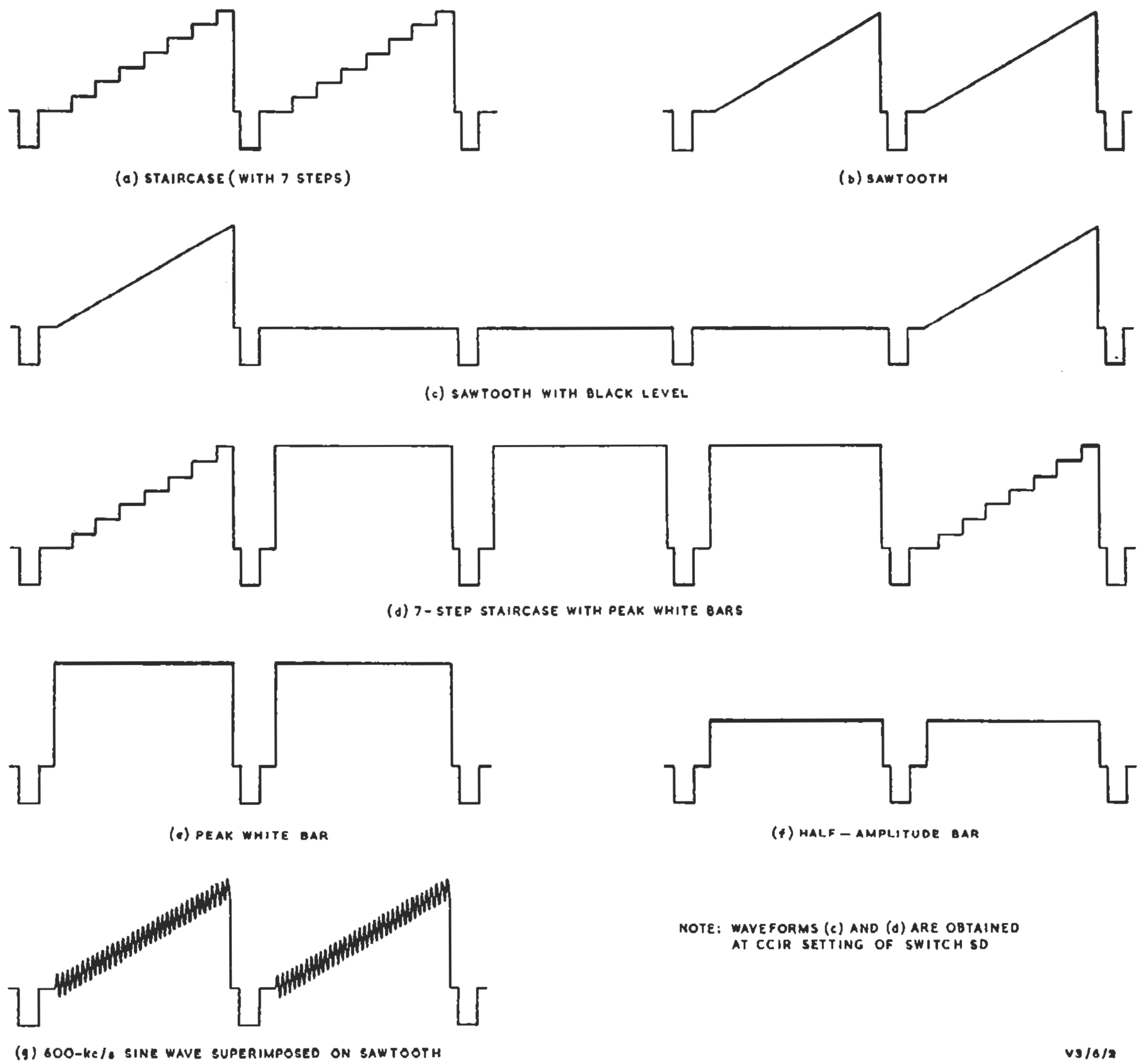



*Fig. 6.2 Some Examples of Output Waveforms available from GE4/505*

To compare non-linearities and quote values for equipment specifications, it is necessary to use test waveforms which have an agreed shape and from which quantitative results can be obtained. These requirements are met by the staircase waveform and by the sawtooth waveform with a superimposed sine wave.

Differences in the amplitudes of the steps of a staircase waveform at the output of the apparatus under test indicate the nature and degree of non-linearity distortion and this is measured by using the arrangement shown in Fig. 6.3. The pulse-shaping network, FL1/509A, acts on the step waveform to produce pulses of virtually sine-squared form and the amplitude of the pulses is proportional to the amplitude of the steps. Non-linearity distortion is calculated as a percentage

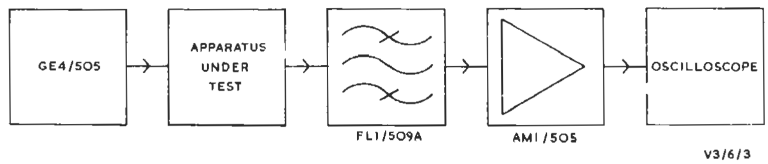



*Fig. 6.3 Block Diagram showing Arrangement of Equipments for Measuring Non-linearity Distortion*

using the expression 100 (1—$a/b$), where $a/b$ is the ratio of the smallest-pulse amplitude to the largest-pulse amplitude; see Fig. 6.4. For record purposes the amplitude of each pulse can be measured.

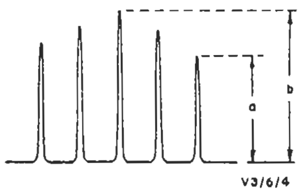



*Fig. 6.4 Example of Oscilloscope Display when using 5-step Staircase Waveform to Measure Non-linearity Distortion*

Pulses at the output of the filter have half the amplitude of the steps from which they are formed, that is, 0.35 volts divided by the number of steps. To achieve greater accuracy of measurement the pulses are amplified before display on an oscilloscope. For this purpose there is a special amplifier (type AM1/505) using transistors and incorporating a peak clipper. Alternatively use can be made of any video amplifier which has a gain of 15 dB and is free from hum. Because the pulses are of the same order of amplitude, non-linearity distortion in the amplifier and oscilloscope has little effect on accuracy of measurement.

scope) and then measure the amplitude difference ($b$ — $a$) with the gain of the oscilloscope increased.

If a sawtooth waveform is mixed with a relatively small amplitude sine waveform and the result applied to the apparatus under test, the sawtooth traverses the transfer characteristics and the small-amplitude sine wave explores the incremental gain at successive points across the characteristic. Ordinarily for BBC test purposes the step waveform is preferred to this alternative.

At the output of the apparatus under test the sawtooth is removed by a band-pass filter type FL2/521A (type FL2/521B for 625 lines) and non-linearity distortion is revealed as a variation in the amplitude of the sine waveform. This is expressed in the same form as the results of tests with the step waveform. The ratio $a/b$ is now the ratio of minimum to maximum amplitudes, as shown in Fig. 6.5.

The generated C.C.I.R. waveforms are of the same general form as the waveform specified by the Comité Consultatif International des Radiocommunications. The addition or removal of the bar component of these waveforms alters the mean level of the signal, and thus simulates large and rapid changes in the average brightness of a transmitted scene. With a.c. coupled equipments this alters the position of the test waveform on the transfer characteristic and enables a greater range

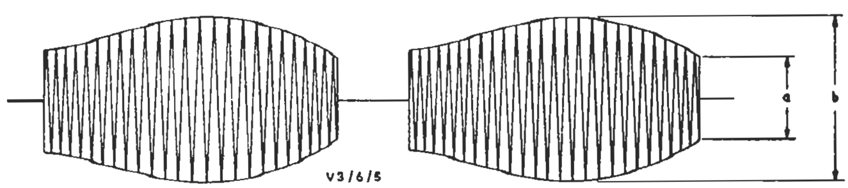



*Fig. 6.5 Example of Oscilloscope Display when using Sine-wave-on-Sawtooth Waveform to Measure Non-linearity Distortion*

Since 100 (1 — $a/b$) can be expressed as 100 ($b$ — $a$)/$b$, a convenient way to measure accurately the non-linearity distortion is to measure $b$ (using the calibrated gain control of the oscillo-

of characteristics to be examined than that normally occupied by the p-p waveform. Measurements of non-linearity distortion are usually made with the C.C.I.R. waveforms.

The test waveform which gives a peak-white bar on each line enables the transient effects of sudden changes of mean picture level to be assessed. Low-frequency non-linearity distortion tests, known colloquially as bump tests, are carried out by insertion and removal of the bar component. This can be done automatically, but alternatively an external switch can be connected to the generator to permit hand control. The waveform at the output of the apparatus under test is observed on an oscilloscope.

Sudden changes of mean picture level cause mean signal level to shift position on the transfer characteristic, and this may result in alteration of non-linearity distortion. To check for such alteration the display of a C.C.I.R. waveform is observed while its bar component is being alternately inserted and removed.

The 10-dB attenuation of the sawtooth or staircase component of a test waveform enables a more detailed examination to be made of that part of the transfer characteristic where the signal is near blanking-level.

The 3-dB increase in the amplitude of the output of the generator enables overload tests to be made above the standard level (1 volt).

**General Description of Circuit**

Fig. 6.6 is a block diagram of the GE4/505. In Figs. 6.7 and 6.8 are diagrams of waveforms, with their relative timing, at various points in the circuit.

*Generation of Master Trigger Pulses*

Master trigger pulses are generated by blocking oscillator V2, which is triggered by multivibrator V1. The multivibrator can be locked by small-amplitude input pulses and provides good frequency stability when free-running.

The line-frequency output pulses from V2 are used to trigger five separate pulse generators; V3, V7, V9, V11 and V17.

*Blanking Generator*

V9 generates a blanking waveform and is triggered by master pulses from V2. The output of V9 is used to insert blanking into the sawtooth and step waveforms, and also for triggering three gating circuits.

*Production of Pulses for Staircase Generator*

The pulse amplifier V3 is driven from the output of V2, and its anode load is a band-pass tuned circuit selected from three available as determined by the setting of the *Number of Steps* switch (SA in Fig. 13). These circuits have pass bands in which lie the 6th, 9th and 13th harmonics of the line-frequency pulses from V2, and they apply a sine waveform, at the selected harmonic frequency, to V4.

The blocking oscillator V4 is triggered by each cycle of the selected harmonic. The output of V4 consists of a train of short-duration pulses at either 6, 9 or 13 times the line frequency, as shown in Fig. 6.7. With the *Lin. Test W/F* switch (SB in Fig. 13) at *Step*, the pulses initiate generation of the steps in the staircase waveform from V5. For the duration of line blanking the action of V5 is arrested by suppressing the output pulses from V4 in a gating circuit operated by pulses from V10a. In turn V10a is driven from the blanking generator V9. During blanking periods the output of V2 triggers the discharging circuit V7.

*Staircase and Sawtooth Generator*

V5 is a cascode amplifier with a capacitive load, and its function is to integrate the waveform applied to the input grid. With switch SB at *Step*, the pulses from the gating circuit are integrated at V5 anode to provide the steps in the staircase waveform. With switch SB at *Sawtooth*, a steady potential is applied to the input grid of V5 to produce the linearly-falling voltage of the sawtooth waveform. In the sawtooth condition the line-blanking pulses from V10a are also fed to V5. Discharge of the anode capacitor is achieved by the action of V7.

*V14 Gating Circuit*

The output of V5 is transferred by the cathode-follower V6 to the gating circuit V14. The gate output is taken from V14 to the mixing circuit at the grid of V18.

For the *Lin.* position of switch SD, the gating circuit operates to give either a sawtooth or step waveform on every line. In either the *Full Bar* or *Half Bar* condition these waveforms are not required, and therefore the gate is closed. For the *CCIR* condition, either the sawtooth or staircase waveform is required in every fourth line, for which purpose V14 is pulsed from V12 via V13a.

V14, a double-triode, is connected as a long-tailed pair. Operation of the gating circuit causes d.c. changes at the common cathode, such that rise and fall of voltage forms a pedestal which, for both staircase and sawtooth waveforms, has the same phase as the gating pulses from V13.

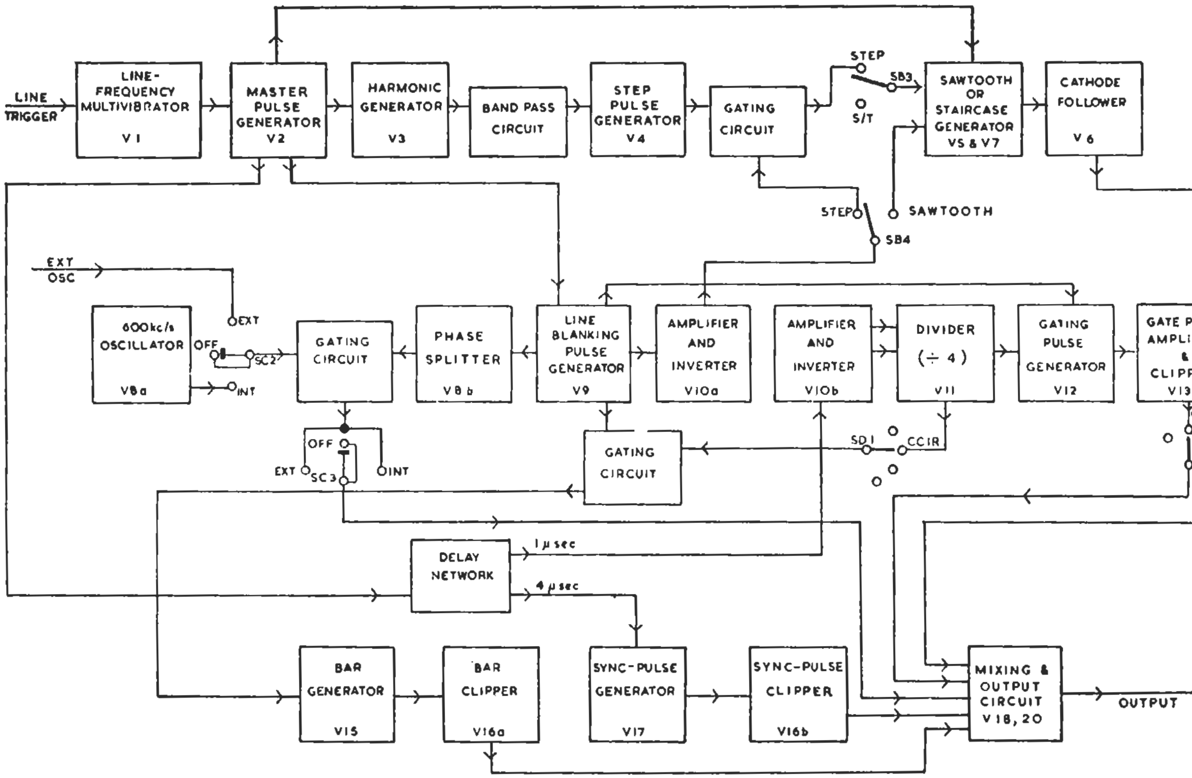



*Fig. 6.6 Block Diagram of Stage Interconnection in GE4/505*

*Gating Pulse Generator*

The gate is required to provide an output on every fourth line, and so the divider circuit V11 is used to produce one output pulse for every four master trigger pulses received from V2 through the delay network X1. The output pulses of V11, together with blanking pulses from V10a, trigger V12 to produce a correctly-timed gating pulse.

*Pulse Clipper V13b*

The pulse amplifier V13 also provides an output in antiphase to the gating pulses applied to V14, and it is fed to the mixing circuit through the output waveform switch. The pulse amplitude for this opposed output is variable, such that correct adjustment gives cancellation of the pedestal generated by V14.

*Bar Generator*

The bar generator V15 is triggered by the output of the blanking generator. The bar waveform is selected and fed to the mixing circuit by switch SE and a relay which affords the remote- and automatic-switching facilities.

*Sync Pulse Generator*

The sync pulse generator V17 is triggered by master trigger pulses delayed by 4 μs in the delay line X1. The waveform is clipped by V16b; an output is taken from the cathode by d.c.-coupling to the mixing circuit.

*600-kc/s Oscillator*

V8 is used in a conventional Hartley oscillator circuit, the output from which is blanked in a gating circuit driven from the blanking generator. The functions of switch SC are to stop the oscillatory condition as it connects the *Ext.* plug (PLB) to the input of the gate. The output of the gate is connected to the mixing and output circuit at both the *Ext.* and *Int.* positions of SC.

*Mixing and Output Circuit*

The several contributions to various output waveforms are resistively mixed at the grid of V18. Blanking level is established by the sync output, and the other portions of the total waveforms do not affect this. The output amplifier has d.c. coupling, with both a.c. and d.c. negative feedback. An output-amplitude control is provided.

**Detailed Description of Circuit Fig. 13**

A circuit diagram of the GE4/505 is given in Fig. 13 and the circuit of the power supply chassis, is given in Fig. 14.

The GE4/505 uses several forms of multivibrator circuit. These and operation of the blocking oscillator circuit are fully detailed in Television Engineering, Vol. 3.

*Generation of Master Triggering Pulses*

The master triggering pulses, from which all waveforms are timed, are generated by the blocking oscillator V2b.

V2 is triggered by positive-going pulses from the anode-coupled astable multivibrator V1. The frequency of oscillation is controlled by RV1, which sets the aiming potential for the grid circuit of V1b. To enable the circuit to be triggered, the waveform period is adjusted to 99 μs approximately. The output from V1a anode is differentiated by C6 and R13, with MR2 employed to suppress negative-going spikes.

V1 can be locked to an external source connected through PLA. Externally-derived pulses are differentiated by C1 and R3, supplemented by MR1 which suppresses positive-going spikes.

*Blanking Generator*

An output from the cathode of V2 is fed via C65 to the blanking generator V9. This valve is in a cathode-coupled monostable multivibrator circuit, the relaxation time of which is controlled by RV7. Positive-going blanking pulses are produced at the anode of V9b, and their half-amplitude width is nominally 20·5 μs.

*Production of Pulses for Staircase Generator*

The pulses that are applied to the grid of V5 to generate the steps of the staircase waveform are produced by the blocking oscillator V4. This valve is triggered by a sine wave which is harmonically related to the line frequency.

The anode load of V3 is a band-pass tuned circuit, set up for any of three conditions by switch SA. A band-pass characteristic is necessary to allow for variations in the repetition frequency of the V1 waveform when a synchronising input is applied to plug PLA. The circuits are adjusted to select the 6th, 9th and 13th harmonics of the line-frequency pulses applied to V3 grid.

There is a practical limit to the rejection of adjacent harmonics and the presence of these in the output of V3 results in modulation of the waveform. For a given percentage variation in the frequency generated by V1, the frequency deviation increases

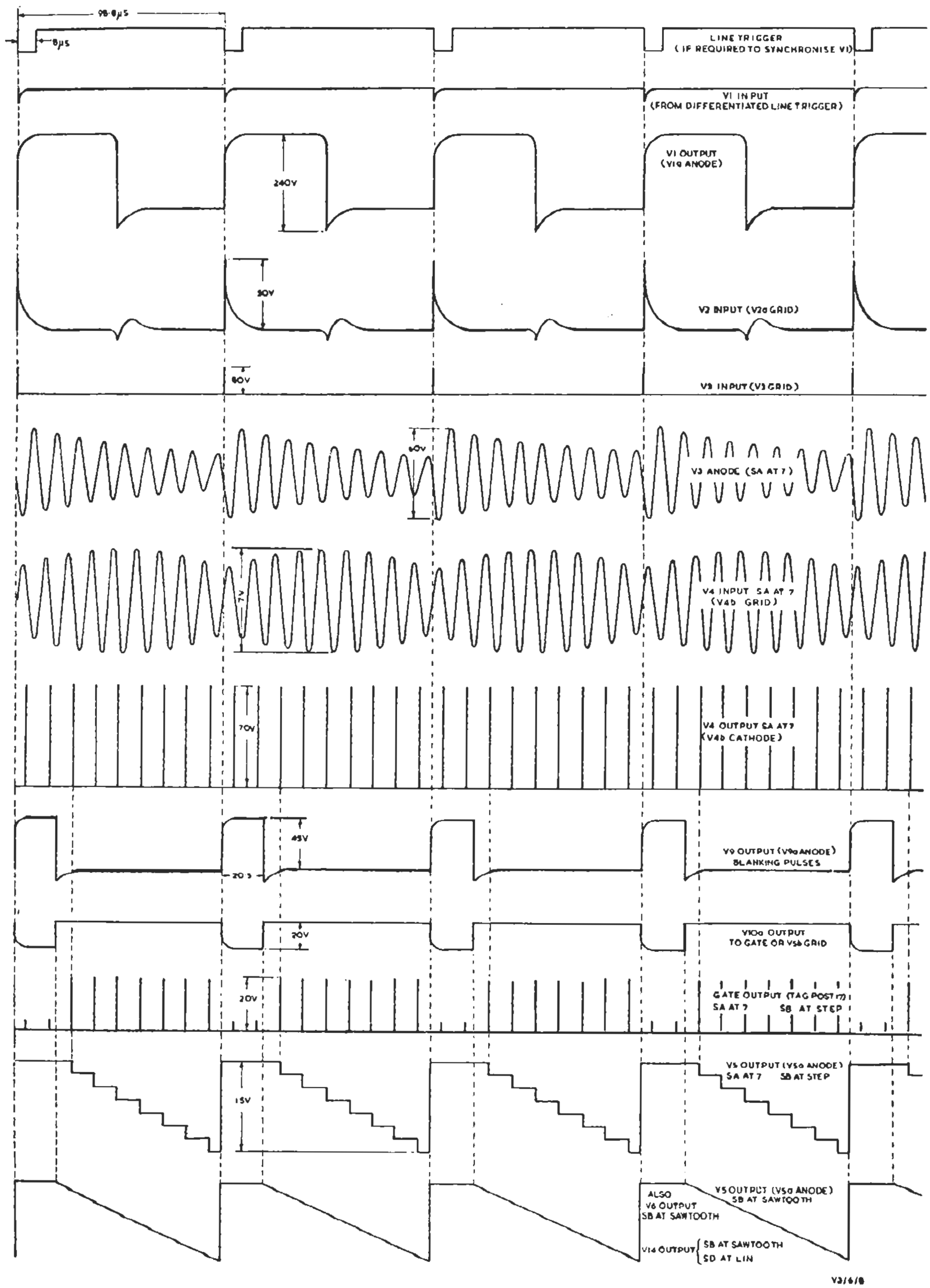



*Fig. 6.7 Relative Timing of Waveforms Generated in GE4/505; to Horizontal Scale as in Fig. 6.8*

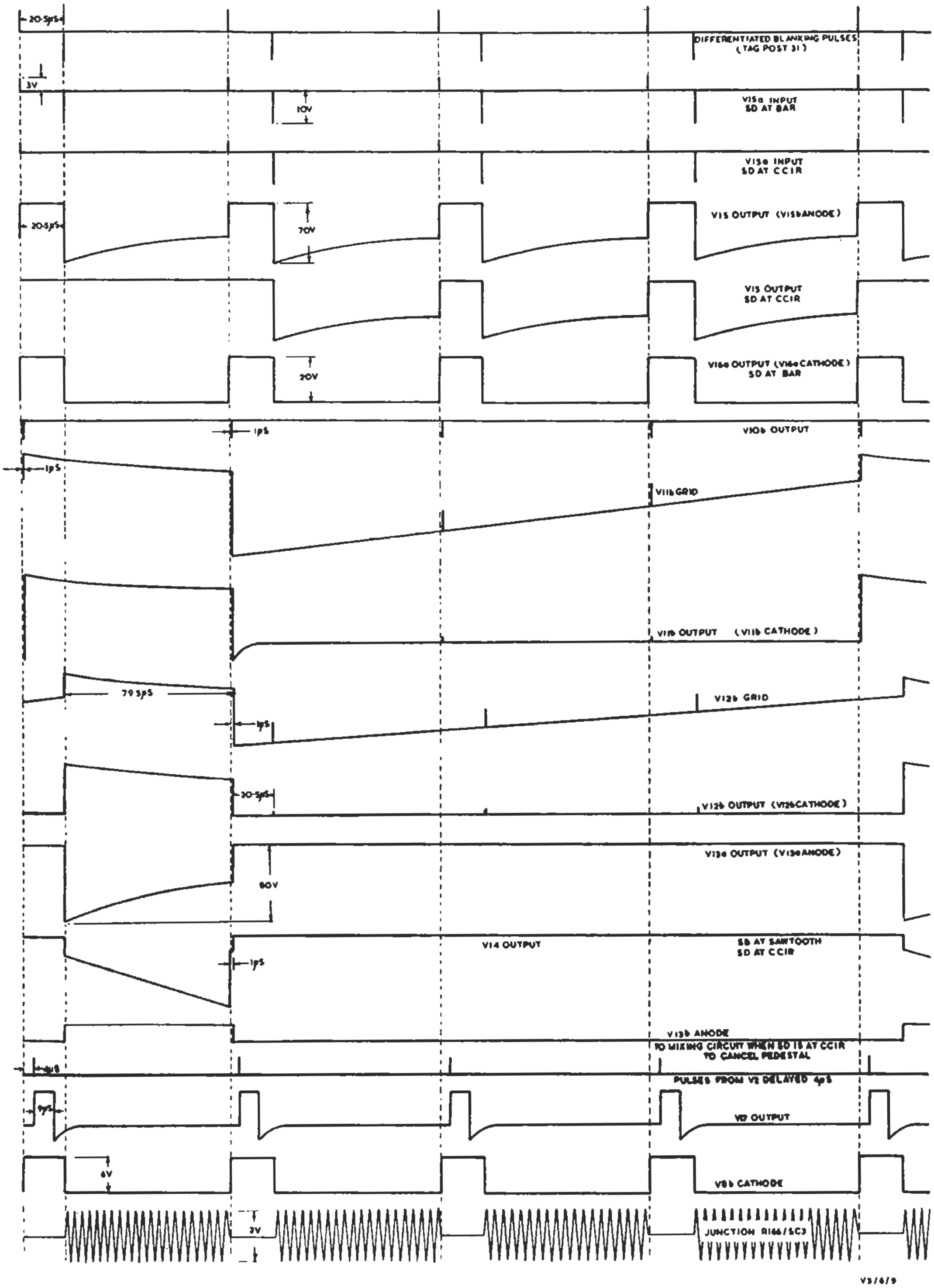



*Fig. 6.8 Relative Timing of Waveforms Generated in GE4/505; to Horizontal Scale as in Fig. 6.7*

with the order of the harmonic, and the pass band of V3 anode circuit must be proportionately wider. The resultant increase in the amplitude of adjacent harmonics increases the depth of the modulation.

Because only the positive-going peaks of the waveform from V3 fall within the grid base of V4, the full modulation amplitude would be included in the drive if the full voltage across L4 were to be applied to V4. To avoid this, the modulated sine-wave input is reduced in amplitude by using a tap on L4. Thus the effective modulation is reduced.

Steps are not required during line-blanking periods and the unwanted driving pulses are removed by the gating action of diode MR3. Normally reverse bias is applied to MR3 through R41, and positive-going pulses from V4 cathode pass to the grid of V5. The cathode of MR3 is fed also with a blanking waveform from V10a anode. Negative-going blanking pulses drive the diode into conduction, and so R94 (220 ohms) is shunted across R44 (47 kilohms). During this period therefore the pulses from V4b are reduced in amplitude by the voltage divider R33, R94.

*Staircase and Sawtooth Generator*

V5 is a double-triode connected as a cascode amplifier. The behaviour of such a stage is similar to that of a pentode in that the anode current is nearly independent of the anode voltage, and depends only on the potential between the control grid and the cathode of the lower valve (V5b). The anode load is the capacitor C43, shunted by C44 and alternatively by either C42 or C40. When a constant voltage is applied to V5b grid, a constant current flows into the anode capacitive load, giving a linear increase in charge and voltage across the load. This forms the sweep part of the sawtooth waveform. To obtain a repetitive waveform an anode-coupled monostable multivibrator V7 is arranged to discharge the anode load of V5 during the line blanking period. The stable state for this circuit is with V7b conducting. A positive trigger pulse from the master pulse generator V2 is applied to the cathode of V7b, momentarily cutting it off and initiating the change of state. The cathode of V7a is connected to V5a anode and C43 is discharged through V7a. As its cathode voltage rises towards h.t. potential, V7a becomes cut off and the circuit returns to the stable state.

Operation of switch SB from *Step* to *Sawtooth* results in:

(a) Increase of bias for V4b, sufficiently for oscillation to cease. (Wafer SB1)

(b) Connection of C39 across C43, the V5 anode capacitor. (Wafer SB2)

(c) Transfer of V5b grid from the output of the gating diode MR3 to a steady negative voltage derived from RV4. This alteration introduces the restoring diode MR5 into the V5b grid circuit. (Wafer SB3)

(d) Switching of the negative-going blanking waveform from the MR3 cathode to the V5b grid, and so the valve is non-conductive during line blanking. (Wafer SB4)

The object in switching MR5 to V5b grid circuit, where it will d.c.-restore the blanking waveform, is to avoid the fluctuations of mean signal level that would otherwise result from changes of blanking-pulse width. In turn, this ensures constancy of sawtooth amplitude. The bias control RV4 determines the anode current of V5 during conduction and is the *Sawtooth Amplitude* control.

When the grid of V5 is pulsed, current pulses of equal amplitude and duration increase the charge on C43 in discrete steps so that a staircase voltage waveform is developed.

The input pulses to V5b have the same amplitude for the 5-, 7- and 10-step conditions, and the amplitude of the output waveform would vary unless compensation were made. Compensation is achieved by increasing the anode capacitance, using switch-wafer SA4 to shunt C43 with either C40 or C42. For a given charge the voltages developed on the larger values of capacitance are smaller, and consequently the total staircase amplitude is reduced.

In the *Step* condition, RV3 determines the standing bias on V5b grid, and consequently the voltage by which the driving pulses exceed the grid cut-off potential of V5b. Thus RV3 controls the amplitude of current pulses flowing into C43. C44 is the *Step Amplitude* control and provides for a final adjustment.

*V14 Gating Circuit*

V14 is a double-triode with both sections used as cathode-followers having a common load resistor R138. V14b provides a signal path from the staircase-and-sawtooth generator to the mixing and output stage. V14a serves as a d.c. path and acts as a switch operating on V14b.

When the positive voltage on the grid of V14a rises, the voltage of the strapped cathodes also rises to a value slightly greater than that on the grid. This rise carries the cathode voltage above that on V14b grid, V14b is cut off and the signals from V5 do not reach the mixing circuit. For completely effective action the cathode voltage must exceed that of V14b grid by a value which is at least equal to the sum of the V14b grid base and half the p-p amplitude of the applied signal.

When the V14a grid voltage is driven negative the cathode voltage falls, but only to a value a few volts more than that of V14b grid, which is connected to the junction of R141 and R142. V14a becomes cut off by the pulse while V14b is conductive and passes the signal to the mixing circuit. Operation of the gating circuit necessarily produces a pedestal waveform at the cathode of V14, and this is superimposed on the output signal from this valve.

The conditions with switch SD at its several positions are:—

(a) *Lin.* V14a grid is returned to earth, so that V14b is continuously conducting.

(b) *CCIR* V14a grid has a standing bias from the junction of R133 and RV12, together with the signal from the pulse generator V12. RV12 is for adjusting V14a bias so that V14b is completely cut off even for peaks of the input waveform.

(c) *Full Bar* V14a grid is biased from the junction of RV12 and R134, so that V14b is continuously cut off.

(d) *Half Bar* As for (c).

*Gating Pulse Generator*

The pulses that operate the gate, with switch SD at *CCIR*, are generated by V12. V12 is driven by pulses from the divider circuit V11, which produces one output pulse for every four master trigger pulses from V2.

An input for V11 is provided from a tapping on the delay line X1 so that closing of the gate occurs 1 μs after completion of the sawtooth or staircase waveform.

The delayed master pulses, inverted by V10b, are applied to both anodes of V11, which is an asymmetrical monostable multivibrator.

V11a is normally cut off, because its cathode is earthed and its grid is held at a negative voltage when V11b conducts. This condition is the stable state, owing to the connection of grid resistor R106 to h.t. positive.

One microsecond after the beginning of line blanking, a negative-going pulse is applied from V10b to the grid of V11b through MR12 and C76. Consequently the V11b anode current is reduced and the multivibrator assumes the unstable state. This change generates a large negative voltage on the V11b grid, whereby the unstable condition is maintained. There follows an exponential decay of this grid voltage, the time constant of C76 and R106 being such that the next two pulses do not reset the circuit. By the time the fourth pulse arrives, via MR13 and C77, the V11b grid voltage has risen sufficiently for the circuit to be switched back to the stable state.

During the periods of conduction in V11a and V11b, the diodes MR12 and MR13 respectively are reverse-biased. Therefore these diodes ensure that the pulses are only applied to the grid of the valve in which conduction is occurring.

RV8 sets the bias for V11a, and so controls the amplitude of the positive-going pulses applied to V11b during the periods when it is cut off. In this way it controls the division ratio of the circuit.

An output taken from V11b cathode for the gating circuit of the bar generator is referred to later. The output from V11a anode is differentiated by C79 and R114, and applied through gating diode MR14 to the anode of V12a. The circuits of V11 and V12 are identical, but V12 is triggered from a different source. While V12a is cut off, MR14 is unbiased and passes negative-going pulses through C81 to V12b grid. These pulses cause the circuit to transfer to its unstable state, where MR14 is reverse-biased and blocks any further pulses. V12b is cut off and MR15, which has become unbiased, passes negative spikes of differentiated blanking pulses to the grid of V12a. Resetting of the circuit to the stable state occurs after an interval determined by the time-constant elements at V12b grid.

The control RV9 operates in a similar manner to RV8 and is adjusted so that the positive-going pulses from V12b cathode recur at every fourth line, with the leading edge of each pulse coincident with the end of line blanking. Triggering V12 from V11 ensures coincidence between the pulses from these two valves.

The signal from V12b cathode is inverted by V13a before passing through switch-wafer SD3 to the gating circuit V14.

*Pulse Clipper V13b*

The unwanted pedestal waveform at V14 cathode (in the *CCIR* mode) is removed in the mixing circuit by cancellation with a waveform of opposite sense to that taken through C102 from V14. V13b is cathode-coupled to V13a so that the input to V13a appears inverted at V13b anode. When the anode voltage of V13b rises, MR16 conducts at a voltage determined by the setting of RV10, and consequently C83 is connected in parallel with the anode load. The resulting long time-constant provides for clipping of the pulses and control of the output amplitude.

D.C. coupling to V13a grid, and the positive bias from RV11 on V13b grid, cause V13a to cut off at the negative extremes of the waveform. The output of V13b is thus of rectangular form and is selected by switch-wafer SD2 for connection via C103 to the mixing circuit.

*Bar Generator*

V15 is a cathode-coupled monostable multivibrator. The input is taken from the line blanking generator V9, after being differentiated by C68 and R90 to produce spikes which are applied through MR10. The purpose of this diode is to pass only negative-going spikes to the grid of V15a, which is normally conducting, and these spikes trigger the multivibrator to its unstable state.

This circuit is unusual in that the timing components C91 and R168 are connected in the grid circuit of the valve which, in the unstable state, is conducting. To stabilise the pulse width, restoration to the stable condition is initiated by small positive spikes applied to V15a grid through C70, which is connected in parallel with MR10. This arrangement is used so that a waveform with short rise and fall times, and of required polarity, can be obtained using the negative triggering pulse that is available.

The waveform at the grid of V15b is d.c.-restored by MR19 to stabilise conditions when operating in the *CCIR* mode.

V15 is not triggered under the *Lin.* condition. Triggering under the *CCIR* condition occurs in three lines of every four, and for either the *Full Bar* or *Half Bar* condition there is triggering on every line. These alternatives result from various switched conditions of MR11.

With switch SD at *Lin.*, the anode of MR11 is earthed through wafer SD1 and thus the negative-going spikes are suppressed.

For the *CCIR* setting, SD1 connects the anode of MR11 through C78 to the cathode output of the gating pulse generator V11. The signal taken from this point is a positive-going pulse with one-line duration, starting and finishing 1 μs after the beginning of line blanking. Each pulse drives MR11 into conduction, by which R90 (10 kilohms) becomes shunted by R111 (1 kilohm) and the cathode input impedance of V11b. This reduces the spike amplitude at tag 31 to a value below that necessary for triggering of V15.

Use of either the *Full Bar* or *Half Bar* settings of switch SD leaves the diode MR11 reverse-biased from the junction of R103 and R104.

The output from V15b anode is clipped by MR18 to remove triggering spikes. As the anode voltage rises to that at the junction of R69 and R170, MR18 conducts and C92 holds the anode voltage steady until the diode is once more cut off.

The negative-going bar waveform is applied to the control grid of V16a, connected as a cathode follower.

V16a is biased beyond cut off from the 50-volt negative supply, and because the positive peaks of the bar waveform drive the valve into conduction, the bottoms of the pulses are clipped.

In the *CCIR* condition, a bar is generated on three out of four lines. This shifts the mean signal level and alters the conditions at V16a grid. Compensation is provided through switch-wafer SD4 operating to reduce the bias so that the waveform at V16a cathode is clipped correctly. Wafer SD4 also effects the change to *Half Bar* by a further change of the bias for V16a.

The bar waveform is routed to the mixing circuit by switch SE and the relays RLA and RLB, according to the setting of the switch SE. With SE at *Bar Off*, both relays are de-energised and the bar waveform is isolated from the mixing circuit. Provision of an earth via the remote-switch socket SKTA, energises RLA and provides a signal path to the mixing circuit, via RLA2.

With SE at *Auto*, wafer SE1 makes an energising supply for RLB, which operates after a delay imposed by C95 and the current-limiting resistor R178. The single contact of RLB provides an earth for RLA, which operates after C96 has charged. RLA2 passes the bar signal to the mixing circuit, and RLA1 removes the earth from RLB. Release of RLB is delayed for about three seconds while C95 discharges through the relay coil, and the delay is ensured by short-circuiting R175. Then RLB1 opens to de-energise RLA, which releases after the delay caused by discharge of C96, after which the cycle of action is repeated.

*Sync Pulse Generator*

The sync pulse generator V17 is a cathode-coupled monostable multivibrator, triggered by positive-going master pulses from V2. The pulses are delayed by 4 µs in delay line X1, to correct for the advance of standard studio line-trigger pulses.

The stable state is with V17b conductive owing to the grid being returned to h.t. positive. A positive pulse to V17a grid gives the change to the unstable state, for a period determined by the time constant of C98 and R189. Reversion to the initial condition takes about 9 µs, and a positive-going sync pulse is produced at V17b anode.

When V17a conducts, its cathode voltage is determined by the voltage taken from the slider of RV17. This control is used to determine the anode current of V17a during conduction and so enables the relaxation time of the circuit to be adjusted. It is set for a half-amplitude pulse width of 9 µs at the V16b cathode.

The diode MR23 is used to stabilise the grid voltage of V17b during periods of conduction. Without this diode the output-pulse amplitude would be considerably influenced by valve characteristics.

The V17b output is clipped by MR20 in conjunction with C100. V16b is in a clipper circuit, identical with the V16a circuit, and clips the negative-going part of the signal.

*600-kc/s Oscillator*

V8a is used in a series-fed Hartley oscillator circuit. The output is taken from a tap on the tuned-circuit capacitor and connected through switch-wafer SC2 to the gating circuit comprised of R73, R74, MR8 and MR9. The function of the gating circuit is to insert blanking in the oscillator signal.

Blanking pulses from V9 are applied to the phase-splitter incorporating V8b, outputs from anode and cathode of which are used to switch the two diodes of the mixing circuit. When the diodes are in the high-impedance condition the oscillator output is effectively disconnected from the mixing circuit.

When switch SC is set to *Ext.*, SC2 transfers the input of the gate from the oscillator to plug PLB as SC1 switches R68 (100 kilohms) into the anode circuit of the oscillator. Consequently the oscillator stops functioning, but anode current still flows to prevent deterioration of the cathode.

Setting switch SC to the *Off* position causes disconnection of both the input and output of the gating circuit, and the connection of R68 into the h.t. supply.

*Mixing and Output Circuit*

The connections to the mixing circuit are a.c.-coupled, with the exception of that from the sync pulse clipper V16b whereby blanking level is established. To prevent changes of blanking level on switching the bar component, this waveform is d.c.-restored to the voltage developed across the zener diode MR22.

The *Lin. W/F Attn.* switch (SF) short-circuits R198 and R199 when set to the *Off* position. When these resistors are in circuit (SF to *On*) the amplitude of the sawtooth, or staircase, component of the waveform is reduced by 10 dB.

When the *Amp.* switch (SG) is placed at *+3 dB*, removal of the L-type attenuator, R214 and R215, increases the amplitude of the total output waveform.

The low-frequency test signal has components down to d.c. and therefore a d.c.-coupled output amplifier (V18 and V20) is used. This has both d.c. and a.c. negative feedback. The feedback is adjustable over a limited range by RV20, the *Output Amplitude* control.

The screen grid of V18 is connected to the stabilised 250-volt supply through a stabiliser V19.

**Power Supplies Fig. 14**

The power supply unit incorporates two transformers with input-voltage tappings which are adjusted by a common selector.

*50-volt Negative Supply*

This bias supply is derived from a 100-volt winding on T302 and a full-wave rectifier comprising germanium diodes MR304 and MR305. Stabilising is provided by a standard circuit arrangement using V301 as the series stabiliser and V302 as the shunt amplifier; see Instruction V.4. A stabiliser reference-voltage is obtained through two zener diodes MR313 and MR314.

*250-volt Stabilised Supply*

This is derived from a 270-volt winding on T301 and a full-wave rectifier using eight germanium diodes. The diodes are bridged by 56-kilohm resistors to equalise their peak-inverse voltages during non-conductive periods. Without the resistors the voltage developed across a diode with unduly high back-resistance could cause breakdown of the diode and rapid destruction of the circuit.

The series stabiliser has two valves in parallel, V303 and V304, and the shunt amplifier V305 is a cascode amplifier. The gain of a cascode is given by the product of the mutual conductance of the lower triode and the anode load of the upper triode. The lower triode can have its $g_m$ increased by increasing the current flowing through it, for which reason R321 is used to bleed extra current from the 250-volt rail. The connection of this resistor has negligible effect on the circuit as the cathode of V305a, to which it is connected, is a point of low impedance.

The reference voltage is not taken from a neon stabiliser as is usual. Instead, the cathode of V305b is connected to earth and the lower end of the feedback resistor chain is taken to the stabilised —50 volt supply.

*200-volt Supply*

This supply is produced through a straightforward half-wave rectifier circuit fed from the 160-volt winding on T301. The two GJ5M diodes are fitted with equalising resistors and smoothing is provided by a single capacitor C301A.

Three of four heater-supply windings on T302 are used with valves in the test generator. One winding provides an unbalanced supply at pins 5 and 6 of SKTM, for all valves except those enumerated below. The balanced supply on pins 8 and 9 of the same socket is used with V2, V3 and V4; individual feeds are filtered at each valve base. The supply on pins 7 and 10 of SKTM is maintained at approximately 50 volts positive, by use of R309 and R324, and fed to V5, V6, V7 and V14.

**Valve Data**

The following tables give voltages measured on d.c. ranges, 250 volt and 100 volt as appropriate, of an Avometer Model 8 instrument. Most of the figures are average values computed from readings taken on several GE4/505 equipments; individual readings were within 10 per cent of the quoted figure in each instance. Otherwise the least and greatest readings are given to show the probable spread of voltages.

The table includes valve-pin numbers particularly to remove ambiguity about the half-sections of the many double-triodes. For certain stages the operating condition while readings were taken is indicated by footnotes.

**Operational Stages (Fig. 13)**

| *Valve* | *Anode* | *Pin* | *Grid* | *Pin* | *Cathode* | *Pin* |
|---|---|---|---|---|---|---|
| V1a | 132 | 6 | −11·25 | 7 | 1·8 | 8 |
| CV2492 | | | | | | |
| V1b | 141 | 1 | −27·5 | 2 | 1·6 | 3 |
| V2a | | 6 | 2·9 | 7 | 10 | 8 |
| CV2492 | 212 | | | | | |
| V2b | | 1 | −28/−46 | 2 | | 3 |
| V3a | H.T.+ | 5 | −25·2 | 1 | | 2 |
| CV138 | | | | | | |
| | | | 245 (Scr.) | 7 | | |
| V4a | 132 | 6 | | 7 | 5·0 | 8 |
| CV2492† | | | | | | |
| V4b | 230 | 1 | −12/−18 | 2 | | 3 |
| V5a | 197 | 6 | 104 | 7 | As pin 1 | 8 |
| CV2492 | | | | | | |
| V5b | 110 | 1 | −9·5 | 2 | | 3 |

† 10-step condition

| *Valve* | *Anode* | *Pin* | *Grid* | *Pin* | *Cathode* | *Pin* |
|---|---|---|---|---|---|---|
| V6 | | 6 | | 7 | | 8 |
| CV5042 | H.T.+ | | As V5, pin 6 | | 203 | |
| | | 1 | | 2 | | 3 |
| V7a | 249 | 1 | 145 | 9 | As V5, pin 6 | 8 |
| ECF80 | | | | | | |
| V7b | 169 | 6 | | 2 | 5·0 | 7 |
| | | | 218 (Scr.) | 3 | | |
| V8a | H.T.+ | 1 | | 2 | | 3 |
| CV4004 | | | | | | |
| V8b | 243 | 6 | −9·6 | 7 | 1·5 (approx.) | 8 |
| V9a | 145 | 6 | 37·5 | 7 | As pin 3 | 8 |
| CV4024 | | | | | | |
| V9b | 228 | 1 | 18·6 | 2 | 38·5 | 3 |
| V10a | 245 | 6 | −22·2 | 7 | 12 | 8 |
| CV5042 | | | | | | |
| V10b | 234 | 1 | −14·7 | 2 | | 3 |
| V11a | 114 | 1 | −3/−25 | 2 | 0 | 3 |
| CV5042 | | | | | | |
| V11b | 188 | 6 | −49·5 | 7 | 5·0 | 8 |
| V12a | 160 | 6 | −3/−40 | 7 | 0 | 8 |
| CV4024 | | | | | | |
| V12b | 204 | 1 | −28·6 | 2 | 5·0 | 3 |
| V13a | 230 | 1 | As V12, pin 3 | 2 | 7·8 | 3 |
| CV4004 | | | | | | |
| V13b | 220 | 6 | 4·5 | 7 | As pin 3 | 8 |
| V14a | | 6 | 0‡ | 7 | 105‡ | 8 |
| CV2492 | H.T.± | | 96* | 7 | 115* | 8 |
| | | | 150** | 7 | 160** | 8 |
| V14b | | 1 | 94 | 2 | As pin 8 | 3 |
| V15a | 236 | 6 | 2·0* | 7 | 2 0* | 8 |
| M8137 | | | | | | |
| V15b | 194 | 1 | 4·5 | 2 | As pin 8 | 3 |
| V16a | | 1 | −11 | 2 | 13·8 | 3 |
| CV2492 | H.T.+ | | | | | |
| V16b | | 6 | −16·5 | 7 | 1·75 | 8 |

‡ Lin. condition  * CCIR condition  ** Bar condition

*Previously issued as page 6.15 of Instruction V.3, Section 6.*

| *Valve* | *Anode* | *Pin* | *Grid* | *Pin* | *Cathode* | *Pin* |
|---|---|---|---|---|---|---|
| V17a | 222 | 1 | 2·4 | 2 | 9·5 | 3 |
| CV4024 | | | | | | |
| V17b | 143 | 6 | 8·0 | 7 | As pin 3 | 8 |
| V18 | 78 | 7 | −1·7 | 2 | | 1 |
| CV3998 | | | | | 0 | |
| | | | 164 (Scr.) | 9 | | 3 |
| V20* | H.T.+ | 7 | −4·5 | 2 | 2.47 | 3 |
| EL822 | | | Scr. as pin 7 | 8 | | |

* CCIR condition

**Power Supplies (Fig. 14)**

| *Valve* | *Anode* | *Pin* | *Grid* | *Pin* | *Cathode* | *Pin* |
|---|---|---|---|---|---|---|
| V301 | 76 | 9 | −11·3 | 6 | 0 | 2 |
| CV4079 | | | | | | |
| V302 | As V301, pin 6 | 5 | −39 | 1 | −36·6 | 7 |
| 6AU6 | | | | | | |
| | | | 0 (Scr.) | 6 | | |
| V304† | 324 | 9 | 247 | 6 | 256 | 2 |
| CV4079 | | | | | | |
| V305a | As V304, pin 6 | 6 | 100 | 7 | 103 | 8 |
| CV4004 | | | | | | |
| V305b | As pin 8 | 1 | −0·4 | 2 | 0 | 3 |

† Parallel with V303

Power Supply Details

250-volt stabilised supply at 180 mA ± 20 mA
50-volt stabilised supply at 52 mA ± 5 mA

**Maintenance Notes**

There should be no need for adjustments, other than by controls on the front panel, if the generator is allowed a period of 10 minutes to warm up.

After switching between the sawtooth and staircase waveforms, and also after changing the number of steps in a staircase waveform, readjustment of the *Pedestal Amplitude* control may be necessary.

Non-linearity distortion present in the output waveform is normally between 0.75 and 1.0 per cent.

The components and wiring of the generator must not be disturbed. When maintenance is necessary the position and wiring of a faulty component should be noted before removal is effected. Cross-talk and spurious effects may be encountered if this precaution is ignored.

The replacement of valves V1, V9, V11, V12, V15 and V17 may necessitate readjustment of the associated controls RV1, RV7, RV8, RV9, RV15 and RV17 respectively. After changing valve V10, waveforms should be checked in the associated circuits as detailed in the Test Specification. If the requirements of paragraph 22, relative to blanking periods, cannot be met another valve should be selected for the V10 position.

The pre-set controls L2, L4, C20, C21, C25, C27 and C30 which are associated with V3 should not be adjusted. In the unlikely event of component failure in this stage the generator should be returned to Equipment Department for realignment.

The following list indicates those pre-set controls that may be adjusted, when necessary, without the need for special equipment. There follows a description of the function of each control and the method of its adjustment. In case of difficulty Equipment Department should be consulted.

| | *Stage* | *Control(s)* |
|---|---|---|
| V1 | Master Oscillator | RV1 |
| V4 | Step-pulse Generator | RV2, C35, C37, RV3 |
| V9 | Blanking Generator | RV7 |
| V11 | Frequency Divider | RV8 |
| V12 | Gating-pulse Generator | RV9 |
| V13 | Gating-pulse Clipper | RV11, RV12 |
| V15 | Bar Generator | RV15 |
| V17 | Sync-pulse Generator | RV17 |
| V18 V20 | Mixing and Output Circuit | RV19 |

*V1 Master Oscillator*

RV1 is used to adjust the output frequency of this stage. The control can be set by the method outlined in items 16 and 47 of the Test Specification but adjustment is best made using equipment available at Equipment Department. This stage is very stable and, because its output affects all other circuits, adjustment of RV1 should not be attempted until all other possibilities have been eliminated.

*V4 Step-pulse Generator*

Stability controls for the staircase waveforms are:

| | |
|---|---|
| 10-step | RV2 |
| 7-step | C37 |
| 5-step | C35 |

Adjustment of these controls should only be carried out when V1 and V9 are operating correctly as specified in items 16 and 7, respectively, of the Test Specification. RV2, C35 and C37 affect the timing of the staircase steps and the capacitors have a secondary effect on the amplitudes of the 5- and 7-step waveforms.

RV3 is an auxiliary control for all staircase amplitudes.

*V9 Blanking Generator*

RV7 is set for a specified pulse-duration as detailed in item 7 of the Test Specification.

*V11 Frequency Divider*

The setting of RV8 controls the division ratio and the stability of this circuit. This control must be correctly set before adjustment of RV9 is attempted; see under V12.

*V12 Gating-pulse Generator*

RV9 is a division-ratio and stability control. If the output waveform shows an incorrect sequence of bars and staircase (or sawtooth), RV8 should be adjusted first as detailed in item 12 of the Test Specification, after which RV9 is set as detailed in item 13. This last adjustment is facilitated by monitoring the generator output-waveform on an oscilloscope.

*V13 Gating-pulse Clipper*

RV11 provides control of the level at which gating pulses are clipped and the setting of RV12 determines the voltage at which the gating valve V14 operates. The correct settings are obtained by the procedure described in items 37 and 38 of the Test Specification. Other settings of RV10 (*Pedestal Amplitude*), RV11 and RV12 may provide zero pedestal in the output waveform but those obtained by following the Specification give optimum performance.

*V15 Bar Generator*

RV15 is a triggering and stability control, the wrong adjustment of which may result in the bar waveform having a duration less than one line; see item 10 of the Test Specification.

*V17 Sync-pulse Generator*

Sync-pulse duration can be adjusted using RV17; see items 8 and 9 of the Test Specification.

*V18 and V20 Mixing and Output Circuit*

RV19 controls the amplitude of inserted sine-wave; its adjustment is described in item 41 of the Test Specification. The capacitor C108, which controls the frequency response of the output amplifier, should not require adjustment.

## Test Specification

*Warning: This specification is given as an aid to fault-finding and the procedures detailed should not be carried out in normal use of the equipment.*

Negative-going line-frequency pulses with an amplitude of about 50 volts are available at the *Sync Output* plug. When the generator is operated in the free-running condition these pulses can be used to synchronise an oscilloscope.

The following apparatus is required for setting up and testing the generator:

Avometer Model 8.
Tektronix Oscilloscope type 515A with 10 Meg-ohm, 8 pF probe, type P410.
Wayne Kerr Video Oscillator type 022B.
Filter type FL1/509A
Filter type FL2/521A (405 lines) or type FL2/521B (625 lines)
Video Amplifier type AM1/505 (15-dB gain).
Pulse and Bar Generator GE4/504
Variable Attenuator (75 ohms).
Bendix Crystal Calibrated Frequency Meter type BC221.

The measurements referred to in following operations are made with the oscilloscope and probe, except where stated otherwise. Further, there is no need to allow for the effect of measuring equipment on circuits under test provided the test apparatus is of the specified grade.

*Power Supply Chassis*

Check that the mains voltage selector is in the appropriate position.

1. Connect the Avometer across the 50-volt negative supply at the paxolin tag strip on the signal chassis end of the power cableform and adjust RV302 on the power supply chassis to give a reading on the meter of 50 volts.
2. Measure the h.t. positive voltage at the same tag strip and adjust RV303 to give a meter reading of 250 volts.
3. Measure the positive voltage at tag 19. It should be 220 volts ± 10 volts, with switch SE at the *Bar On* position.

*Signal Chassis*

4. Set the lever switches at their middle positions, the rotary switches SA, SB, SD, SE fully clockwise and the toggle switch SG at *Normal*.
   Note: The setting of RV1 should not be disturbed unless a valve or component has been changed; see reference to V1 Master Oscillator under Maintenance Notes.
   Monitor the junction of C6 and R13 and set RV1 to give a waveform period of about 99µs. Check that an increase of 2µs is available and reset RV1 to give approximately 99 µs.
5. Remove V1. Monitor the junction of R16 and R17 and check that the free-running frequency of the blocking oscillator V2 is in the range 7 — 8·5 kc/s. If necessary select R18 to bring the frequency within this range.
6. Replace V1. Check that the displayed pulse amplitude is 18 — 20 volts and, if necessary, adjust this amplitude by selecting R17. The half-amplitude pulse duration should be 0·3 µs.
7. Monitor pin 6, V9. Set RV7 to give a half-amplitude pulse duration of 20·5 µs. The pulse amplitude should be 40 volts ± 5 volts.
8. Monitor pin 2, V17 and check that the positive-going spurious reflections, from the delay line X1, which follow the pulse are less than 15 per cent of the pulse amplitude.
9. Monitor pin 8, V16. Set RV17 to give a half-amplitude pulse duration of 9 µs. The pulse amplitude should be 19 volts ± 1·5 volts.
10. Monitor pin 3, V15. Set switch SE to *Bar On* and switch SD to *Full Bar*. Adjust RV15 until the trailing edge of the positive-going pulse locks to the triggering spike. Set SD to *Lin.*, which should cause the pulse to disappear. If necessary, adjust RV15 to a point just past that at which the pulse is removed.
    Reset SD to *Full Bar* and confirm that the pulse is still locked to the triggering spike.
11. Monitor pin 3, V16 where the pulse amplitude should be 24 volts ± 2 volts.
12. Monitor tag 42. Set switch SD to *CCIR* and adjust RV8 so that the negative-going pulses have maximum amplitude obtainable with both edges triggered. The pulses should recur every 4th line. Reset RV8 so that pulse amplitude is 5 per cent less than maximum.
    Monitor pin 8, V11. The positive transitions of displayed pulses should be not less than 22 volts and the negative transitions not less than 15 volts.

13. Monitor tag 62. Set RV9 in the manner described for RV8 (see item 12).
Monitor pin 3, V12. The half-amplitude duration of the displayed pulses should be 79·5 μs. with positive-going and negative-going transitions of 30 volts and 20 volts respectively.

14. Monitor the junction of C70 and R91 (tag 36). The amplitude of the negative-going spikes should be not less than 7 volts.

15. Monitor pin 3, V16. The negative-going pulses should be present for three lines in every four lines, with an amplitude of 21 volts ± 2 volts.

16. Set the frequency of multivibrator V1 (see Maintenance Notes) as follows:
   (a) Set switch SA to *10*.
   (b) Monitor pin 8 of V4. The repetition frequency of the displayed pulses should be the 13th harmonic of the frequency of V1.
   Adjust the video oscillator to 131·6 kc/s by beating its output against the Bendix crystal-calibrated frequency meter.
   Connect the oscillator output, at a level of +10 dB, to pin 8 of V4 through a resistor of value 18 kilohms.
   (c) Adjust RV1 so that the oscilloscope display indicates zero beat.
   (d) Disconnect the video oscillator.

17. Monitor pin 7, V4. The modulated sine wave should have a p-p amplitude of not less than 15 volts.

18. Check the free-running frequency of the blocking oscillator V4 as follows:—
   (a) Remove V3 and monitor pin 3 of valve V4.
   (b) Set switch SA to *10* and switch SB to *Step*.
   (c) Adjust RV2 to check that both 11 and 12 pulses can be obtained within a period of 100 μs.
   (d) Replace V3.

19. *Adjust RV2 to give 13 pulses in each line period at pin 3, V4. The pulse amplitude should be not less than 50 volts.

20. *Set SA to *7*. Adjust C37 to give 9 pulses in each line period.

21. *Set SA to *5*. Adjust C35 to give 6 pulses in each line period.

22. Monitor the junction of C41 and MR3 (tag 17).
Set SA to *10* and check that, during line blanking, three pulses are rejected in each train of 13 pulses. Pulse amplitude should be not less than 15 volts with maximum variation of 0·5 per cent. If, during blanking periods, pulse amplitude is not reduced to 20 per cent, select a replacement valve for V10.

23. Set SA to *7* and check that 2 pulses are rejected in every 9 pulses.

24. Set SA to *5* and check that one pulse is rejected in every 6 pulses.

25. †Monitor pin 8, V6. Set SA to *10*.
Readjust RV2 so that the final step has a duration of 3·5 μs.

26. †Set SA to *7* and readjust C37 to make the final step 6 μs in duration.

27. †Set SA to *5*. Readjust C35 to give a duration of 8 μs for the final step.

28. Set SB to *Sawtooth*. Set the *Sine Wave* switch SC to *Int*. Monitor at tag 23. The amplitude of the waveform during the flat 80-μs period should be 5 volts p-p. It is adjusted, if necessary, by selection of R72.

29. Monitor the junction of R166 and the rotor of switch wafer SC3. The sine wave should be set symmetrically about zero, and the balance of the gating circuit should be adjusted, if necessary, by selecting R76. The rejection during blanking should be greater than 30 dB.

30. Measure the frequency of the output from V8a, by beating with the video oscillator. Connect the oscillator output and the oscilloscope probe to the junction of R166 and the switch wafer SC3.
Adjust L6 to give a frequency of 600 kc/s ± 50 kc/s.

31. Put switch SC to *Ext*. Set the video oscillator to 600 kc/s and connect it to plug PLB. With the oscillator output at zero level, the amplitude of the sine wave displayed on the oscilloscope should be 1·4 volts p-p, ignoring the transient conditions during the first 3 cycles. Reset SC to *Off*.

32. Set SD to *Lin.*, SA to *10* and SB to *Step*.
Monitor pin 8, V14. Set the *Step Amp.*

* For 19, 20 and 21 the controls should be set to the centre of the range giving stable pulse trains.

† The adjustment required in 25, 26 and 27 to achieve the stated figures should be of the order of 1μs. If larger adjustment is necessary, recheck the frequency of multivibrator V1.

control (C44) to the mid-position. Adjust RV3 to give the displayed waveform an amplitude of 15 volts. Check that there is no slope on the horizontals of the step waveform.

33. Set switch SB to *Sawtooth*. Adjust the *Sawtooth Amplitude* control RV4 to make the displayed waveform amplitude 16 volts.
34. Monitor pin 2, V7. The duration of the displayed pulse, measured between the vertical edges, should be 1 μs ± 20 per cent.
35. Monitor at the pin-7 position of V7, with the valve removed. The amplitude of the displayed pulses should be not less than 12 volts. Replace V7.
36. Monitor pin 2, V5 without using the probe. The deviation from zero slope of that part of the displayed waveform between blanking pulses should be less than 0·5 per cent. This measurement is difficult to make and care must be taken that the oscilloscope is not overloaded.
37. Monitor pin 8, V14. Place switch SD at *CCIR*, switch SB to *Step* and set C44, the *Step Amplitude* control, to minimum capacitance. Adjust RV12 to make the amplitude of the pedestal preceding the first step 3·5 volts.
38. Monitor pin 6, V13. Set the *Pedestal Amplitude* control (RV10) fully clockwise and adjust RV11 to give a displayed pulse amplitude of 3 volts.
39. Set C108 and RV20 to their mid-position. SA should now be set at *10*, SB at *Step*, SD at *CCIR* and SE at *Bar On*. Terminate the output in 75 ohms and monitor the output waveform with the oscilloscope.

    Adjust the front-panel controls so that the test waveform components of the display are of 0·7 volts p-p amplitude, the sync pulses are of 0·3 volts amplitude and there is zero pedestal amplitude under the staircase waveform.
40. Set SB to *Sawtooth* and adjust the *Sawtooth Amplitude* and *Pedestal Amplitude* controls to give a sawtooth waveform of 0·7 volts amplitude with no pedestal.
41. Set the *Sine Wave* switch SC to the *Int.* position and adjust RV19 to give a sine-wave amplitude of 0·1 volts p-p. Reset SC to the *Off* position.
42. Check the stability of the output amplifier as follows:
    (a) Set *Amp.* switch SG to + *3 dB* and remove the 75-ohm termination from the output.
    (b) Set C108 to minimum capacitance and RV20 for maximum output.
    There should be no high-frequency ringing on or after edges in the displayed waveforms. Other indications of instability are changes in amplitude at some low frequency and the intermittent appearance of random forms on or just after the pulse edges.
43. Set up the high-frequency response of the amplifier as follows:
    (a) Set SD to *Half Bar* and SE to *Bar Off*.
    (b) Remove V16 and set RV20 to the mid-position.
    (c) Connect the output of the video oscillator to the junction of RV18 and R197.
    (d) Terminate the output in 75 ohms and display the waveform on the oscilloscope.
    Using the oscilloscope to measure the output amplitude, check the frequency response of the amplifier. Adjust C108 so that the response is flat to within ± 0·5 dB between 300 kc/s and 4·5 Mc/s. There should be no peak in the characteristic between 5 Mc/s and 10 Mc/s.
44. Connect the video oscillator to the *Ext. Osc.* plug PLB and set the lever switch SC (*Sine Wave*) to *Ext*; the sine wave will be displayed with blanking and syncs. Adjust C121 to give a frequency response that is flat from 300/kcs to about 4 Mc/s. The response should be not more than 3 dB down at 5 Mc/s.
    Replace V16 and reset SC to *Off*.

*Final Adjustments*

45. Set switch SD to *CCIR*.
    Connect the oscilloscope input, without the probe, to the 250-volt positive h.t. line; this connection must be at the paxolin tag panel on which the cableform terminates. Connect the oscilloscope earth to the signal chassis adjacent to the tag strip.

    Adjust RV301 to give zero amplitude of 100-c/s component in the displayed waveform, using the maximum gain of the oscilloscope. Other components in the waveform should have an amplitude less than 50 mV p-p with the exception of narrow spikes which should be less than 100 mV p-p amplitude.
46. Measure the negative bias and positive h.t. voltages and, if necessary, RV302 and RV303 should be reset in their stated order.

47. Monitor the junction of C6 and R13.
Adjust RV1 to give an increase in the period of the waveform of about 0·5 µs. (i.e. from 98·8 µs to 99·3 µs). This adjustment is made by reference to the *change* in the period and not by measuring the time interval between pulses.

**Checking Procedures**

*Power Consumption*

1. Connect the Avometer in series with the 250-volt supply lead at the paxolin tag strip on the signal chassis. The current should be 180 mA ± 20 mA.

2. Connect the Avometer in series with the 50-volt negative supply lead. The current should be 52 mA ± 5 mA.

*Measurement of the Non-Linearity Distortion of the Output Waveform*

Set up the equipment as shown in Fig. 6.9

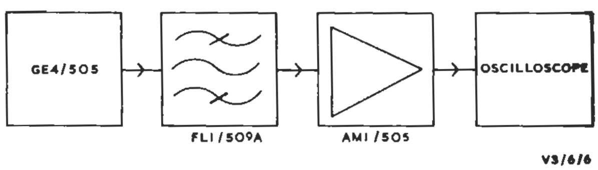



*Fig. 6.9 Block Diagram showing Arrangement of Equipments for Checking Tolerances of GE4/505 Output Waveforms*

1. Set switch SA to 5, switch SB to *Step*, switch SD to *Lin*. Set up the front panel controls to give a correct waveform of 1V p-p amplitude.

2. Measure the amplitudes of the largest and smallest spikes and calculate the non-linearity distortion as explained on page 80.
The non-linearity distortion should be less than 1 per cent and is commonly between 0·75 per cent and 1·0 per cent.

3. Repeat measurement (2) with switch SA at *7* and at *10*.

4. Set switch SD to *CCIR* and repeat the measurement with switch SE at the *Bar Off* and *Bar On* positions.
The total non-linearity distortion should be less than 1 per cent with switch SE at either *Bar On* or *Bar Off* and the change in distortion should be less than 0·5 per cent when switching between these two conditions.

5. Replace the filter FL1/509A by the filter FL2/521A (type FL2/521B for 625 lines).
Set SB to *Sawtooth*, SD to *Lin*. and the *Sine Wave* switch to *Int*.
Measure the non-linearity distortion as explained on page 80.

6. Set SD to *CCIR* and repeat the measurement. For both tests 5 and 6 the non-linearity distortion should be less than 1 per cent and is commonly within the range 0·75 per cent to 1·0 per cent.
The transient conditions of the first and last 5 µs of the sine waveform must be neglected.

*Measurement of L.F. Test Signals*

Disconnect the filter and amplifier from the output of the GE4/505.

1. Set the *Sine Wave* switch to *Off* and switch SD to *Half Bar*. Terminate the output in 75 ohms and display the waveform on the oscilloscope. The bar amplitude should be 0·35 volts ± 10 per cent.

2. Set switch SD to *Full Bar* and switch the oscilloscope for d.c. measurement. The bar amplitude should be 0·7 volts ± 10 per cent. The change in blanking level voltage when the bar is removed should be less than 20 mV.

3. Set the oscilloscope time base speed to 0·5 sec/cm. and observe the low-frequency transient behaviour of the signal when switch SE is moved between the *Bar On* and *Bar Off* positions. A slow change in level may occur (as measured in 2) but there should be no high-frequency transient effects.

4. Set switch SE to *Auto*. The relays should operate to give automatic removal and replacement of the bar component. The on and off periods should be in the range from 2 to 5 seconds and adjustment is made by selecting R178.

5. Trigger the oscilloscope time-base with a signal from the junction of R178 and RLB. Examine the waveform during the transition from blanking level to peak white. This transition must be completed and stable in less than 300 µs. The effect of relay contact bounce will be seen on the make transition.

*Miscellaneous Facilities*

1. Operate the *Amp.* switch (SG) and check that the output changes by 3 dB. The tolerance specified is 5 per cent.

2. Set switch SD to *CCIR*. Operate the *Lin. W/F Attn.* switch (SF) and confirm that the amplitude of the sawtooth waveform changes by 3 : 1; tolerance ± 5 per cent. Check that the *Pedestal Amplitude* control does not require more than a small readjustment when switch SF is operated.

3. Apply a feed of standard 2-volt negative-going line trigger pulses to the *Sync Input* plug PLA and check that the generator locks to them satisfactorily.

*Detailed Examination of Waveform Transitions*

Examine the various output waveforms and verify that the rise and fall times are as follows:

(a) For any one-step riser the rise time should be from 0·1 to 0·5 μs.
(b) The transition from peak white to blanking level after the staircase or sawtooth waveform should be from 0·5 to 1·0 μs.
(c) The bar rise-time is adjusted by selecting C94 to give minimum overshoot consistent with a rise time between 0·2 and 0·8 μs.
(d) The bar fall-time should be from 0·2 to 0·8 μs
(e) The sync pulse rise-time is adjusted by selection of C101 to give minimum overshoot consistent with a rise time between 0·1 and 0·25 μs.
(f) The sync pulse fall-time should be within the range 0·1 to 0·25 μs.

*Cross-talk Effects*

1. Set switch SD to *Lin.* and SB to *Sawtooth.* Examine the output waveform on a slow time-base and check that there is no 100-c/s modulation.

2. Set SA to *10* and SB to *Step.* Verify that the steps are free from 130-kc/s sine-wave modulation. Check that the waveform is free from 2·5-kc/s modulation and that there are no spurious transients in the post-sync suppression period.

3. Display the various output signals from the GE4/505 and check that there are no other transient effects. There should be no 50-c/s, 100-c/s or 2·5-kc/s additive components present in the waveform.

Various small transients are present in the waveform and the following typical figures are taken from Equipment Department Test Report Number 5/61.

*Switch SD at Lin.*

(a) 2·5 kc/s transient at an amplitude from 3 to 10 mV p-p.
(b) Pedestal edge transient from 2 to 5 mV p-p.
(c) Disturbance of sync-pulse bottoms between 3 and 5 mV.

*Switch SD at CCIR*

(a) Pedestal edge transient from 18 to 20 mV p-p.
(b) Pedestal edge transient on sawtooth 15 mV p-p.
(c) On the fall edge of sawtooth and 5-step wave-forms a transient from 70—90 mV p-p.

*Switch SD to Full Bar, SE at Bar Off*

(a) 2·5 kc/s transient at 8 mV d.a.p.
(b) Transient on pedestal at an amplitude of 5 mV d.a.p.

*Switch SD at Half Bar, SE at Bar On*

The leading edge of the bar waveform has an overshoot of between 1 and 2 per cent.

On all waveforms there is a disturbance of about 30-mV amplitude at the junction between peak white and the falling edge.

**Supplementary Information for GE4/505A**

The two versions of the non-linearity test-signal generator are basically similar but the GE4/505A contains several small modifications to suit operation on 625-line standards.

Changes in component values, made necessary by the scaling-up of frequency, are detailed in Fig. 13A; other alterations are described below.

*Generation of 5-step Staircase Waveform*

With 625-line operation a longer back porch period is required to accommodate a colour-signal reference burst and this entails shortening the duration of the steps. The anode circuit of the harmonic generator V3 is adjusted to resonate at the 7th harmonic of the line frequency, instead of the 6th, and this produces a step-duration of 9 μs. The top step is terminated by the line-blanking period after about 5·5 μs.

The 7-step and 10-step waveforms remain unchanged apart from scaling.

*Gating Circuit V14*

Because of the short duration of the front porch it is desirable that no transients should appear in it and the gate timing is modified to eliminate a spurious pulse that is present in the 405-line version. The driving pulse to the divider stage (V11) is obtained from the input to the delay line instead of from the 1-μs tapping point.

*Sync-pulse Generator V17*

With 625-line standards, studio line-drive pulses are advanced relative to line-sync pulses by 1·5 μs instead of the 4 μs used with 405 lines. Master-triggering pulses for the sync-pulse generator are injected therefore at a tapping on the delay line, instead of at the input. The new input tag is numbered 11 and the normal input (tag 1) is terminated with a 2·2 kilohm resistor.

Output from the delay line consists of a main pulse followed by a decaying train of pulses that are unwanted. Owing to the relatively short duration of the 625-line standard line-sync pulses, these echos have appreciable amplitude when V17 reaches the end of its relaxation period and false triggering is likely to occur. To obviate this the trigger pulse is fed via a diode which is biased to pass only the large-amplitude initial pulse.

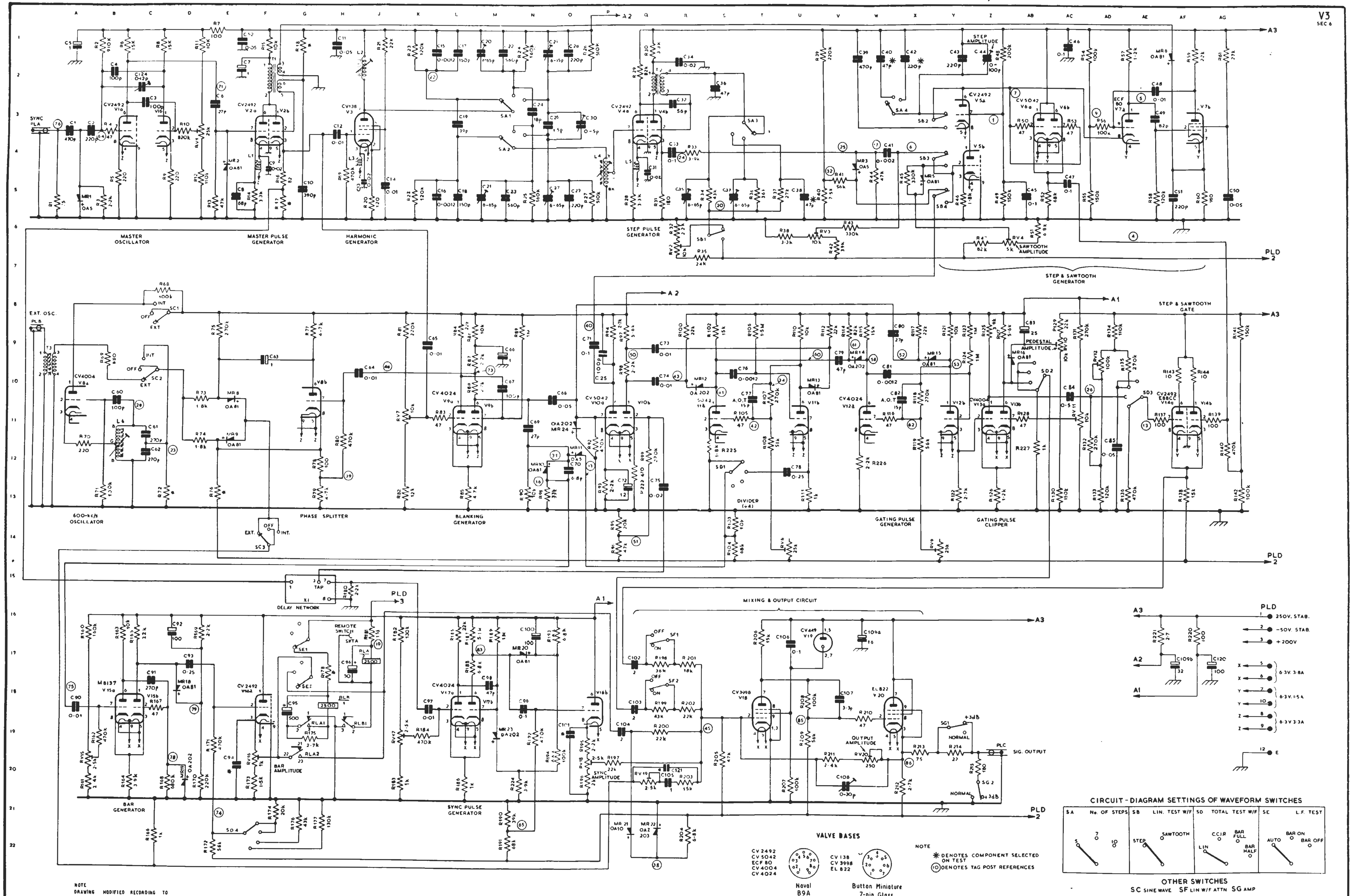
KHG/0162

GI/JBB/202
EK 10697
ISS 8

Parts List EA10696



V3
SEC 6




NOTE
DRAWING MODIFIED RECORDING TO DD CF 9813 SEE DD TECH MEM 9-76 (67)

# NON-LINEARITY TEST SIGNAL GENERATTOR GE4/505: CIRCUIT DIAGRAM

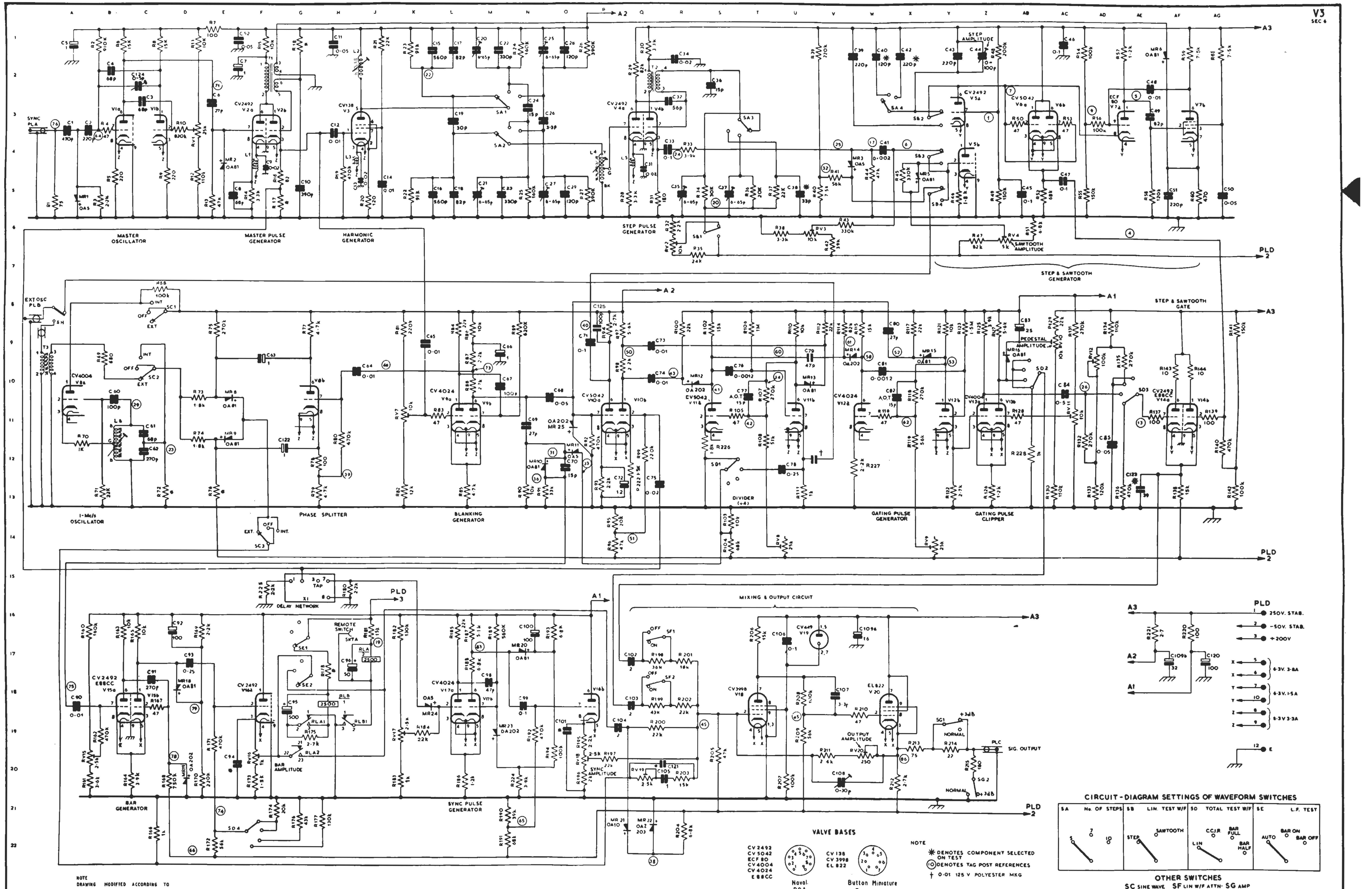
405-LINE VERSION

FIG.13
ISSUE 4 (JAN69)
GE4/505

62/KHG/112
EK 11269
ISS 4
(DEC 63)

Parts List EA11268





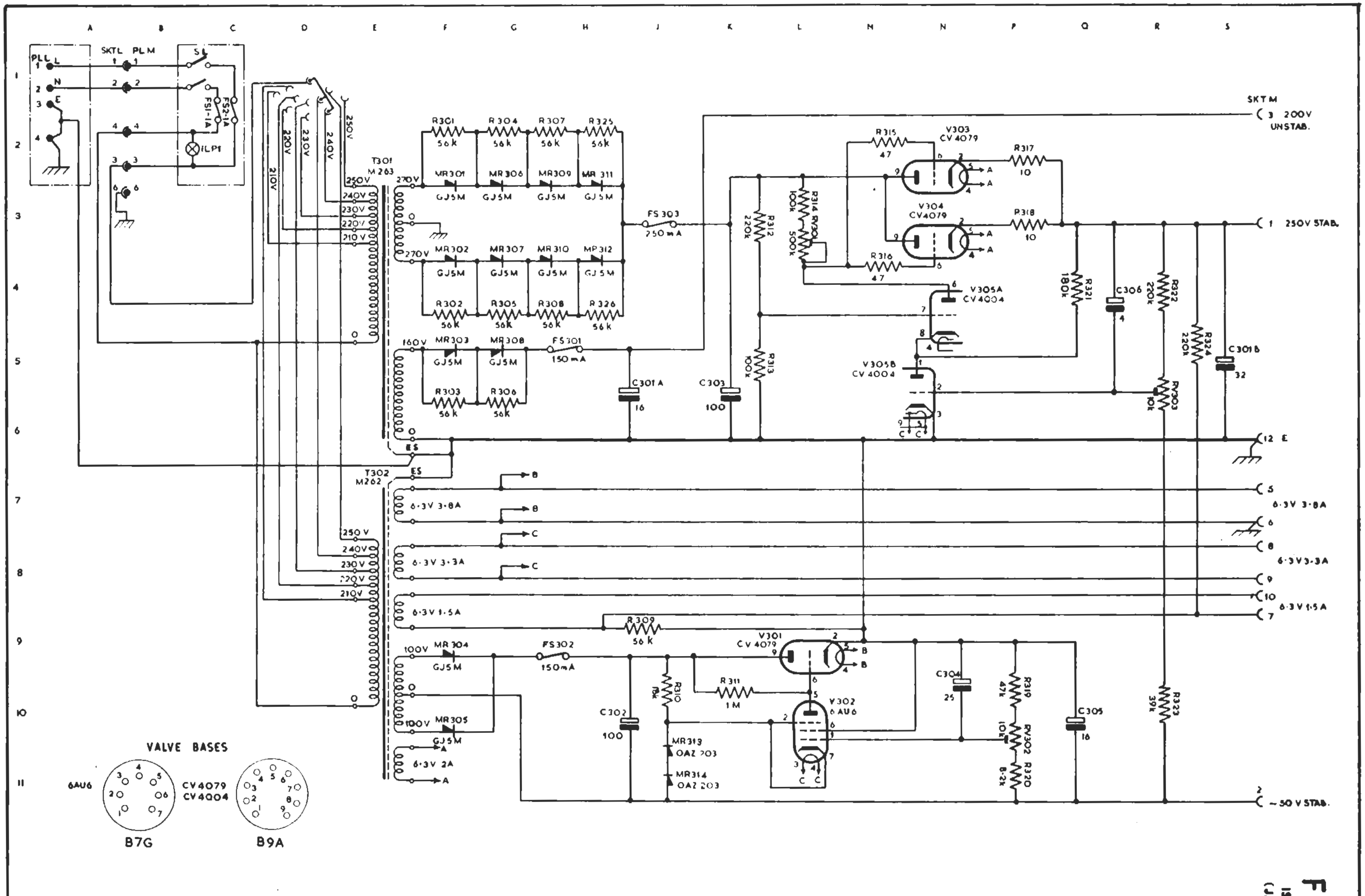

NON-LINEARITY TEST SIGNAL GENERATOR GE4/505A: CIRCUIT DIAGRAM

625-LINE VERSION

FIG.13A
ISSUE 4 (JAN 69)
GE4/505A

EC

61/JBB/103
EC10698
ISSUE 7.




GE4/505 POWER SUPPLIES: CIRCUIT

V3
FIG14
ISSUE 2
(JAN 69)