SECTION 10

SINE-SQUARED PULSE AND BAR TESTING METHODS

AND

TEST SIGNAL GENERATORS

Part 2: Generators: GE4/504 Series

Introduction

Generators GE4/504 and GE4/504A to D provide the pulse-and-bar and 50-c/s waveforms for the tests described in Part 1 of this Section. Each generator provides the following test signals:

(a) 1T pulse and bar,
(b) 2T pulse and bar, and
(c) 50-c/s waveform.

The GE4/504, GE4/504C and GE4/504D also provide a line-sawtooth waveform for linearity testing. All the test signals have an amplitude of one volt p-p and are delivered from a source of 75 ohms. Each waveform includes line sync pulses but has no field sync pulses or field blanking. The 405-line-standard pulse-and-bar waveform and the 50-c/s pulses.

The GE4/504 and GE4/504A are 405-line-standard generators. The GE4/504A provides a line-sawtooth waveform whereas the GE4/504 (no longer supplied) does not.

The GE4/504B and GE4/504C were designed as 625-line-standard equivalents of the GE4/504 and GE4/504A respectively although no GE4/504B generators were ever made.

The GE4/504D was developed for O.B. use. It only occupies the space of a single generator but provides test signals, including line-sawtooth waveforms, for both line standards. As the design is a compromise, its performance is not as good as the GE4/504A or GE4/504C.

The GE4/504D is not free-running and requires

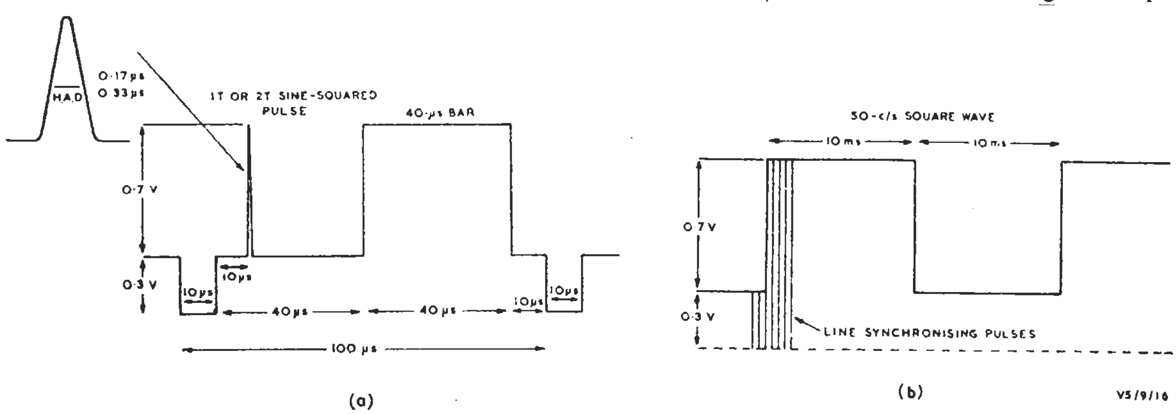


Fig. 10.12. Sine-squared Pulse Test Waveforms
(a) Pulse and Bar (b) 50-c/s Square Wave

waveform are shown in Fig. 10.12.

All the generators except the GE4/504D provide two triggering outputs in addition to the main video output. These consist of negative-going line sync pulses with an amplitude of one volt p-p when fed into a 75-ohm load, and positive-going pre-pulses which occur just before the pulse signal of the pulse-and-bar waveform. The pre-pulses are for triggering an oscilloscope when the pulse is to be examined. The GE4/504D provides only sync a feed of line-trigger pulses at the standard amplitude of two volts p-p. All the other generators will operate in a free-running condition but can be synchronised by negative-going line-trigger pulses, line sync pulses or mixed sync pulses of the standard amplitude. Synchronisation is maintained with pulses down to an amplitude of 0·3 volt.

All models of the generator include their own mains unit. Each generator is contained in a standard portable case CS2/7.

Generator GE4/504

General Description

The complete output signal is derived by mixing together independently generated sections of the waveform. The selection of the appropriate waveform components is controlled by the selector *Waveform* position, two components are mixed directly in a common output resistor.

A block schematic diagram of the generator is shown in Fig. 21, and a simplified diagram for each position of the selector switch is shown in Fig. 10.13.

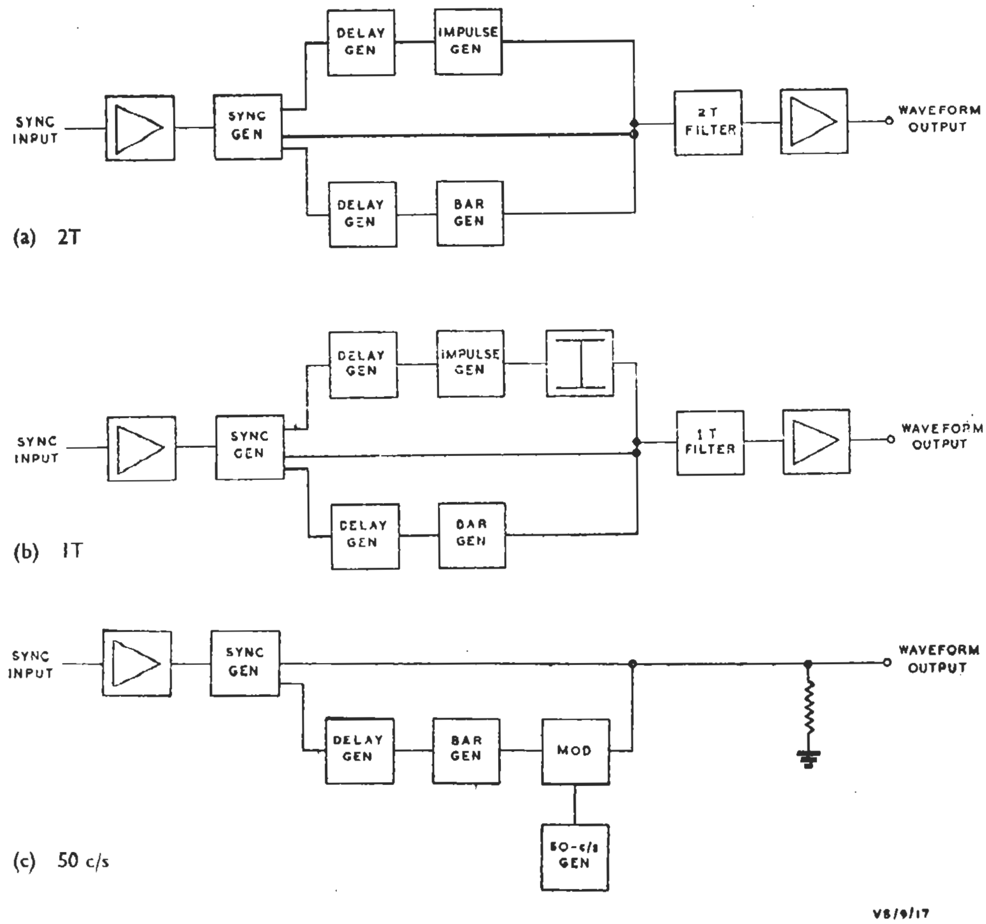


Fig. 10.13. Simplified Block Schematic

switch which has three positions, *1T*, *2T* and *50-c/s Waveform*. In the *1T* and *2T* positions, three components are selected, and fed via a filter network to an output amplifier. In the *50-c/s*

When line sync or line trigger pulses are used to lock the generator, these are differentiated and amplified in stage V1. The output from V1 comprises a series of positive-going spikes, coincident with

V6 provides the pre-pulse output, while V8 triggers the blocking oscillator V7 which produces the pulse of the pulse and bar waveform. The output from V5A is fed to V11; this valve triggers the stage V10 which produces the 40-microsecond line bar waveform in the pulse and bar condition and the 80-microsecond line bar waveform in the *50-c/s Waveform* condition.

Pre-pulse Generator

The pre-pulse generator comprises a double-triode valve V6 which is connected as a window stage with positive feedback applied from the anode of V6B to the grid of V6A. In the quiescent state, V6B is conducting and V6A is cut off. The grid of V6B is fed with the sawtooth waveform generated at the anode of V5B. At the beginning of a line sync period, when the anode of V5B falls to a low potential, the current in V6B falls; the anode potential of V6B rises and the common cathode potential falls. When V6A commences to conduct, the cathode potential falls more slowly, while the anode potential rises more rapidly. There is then a rapid transition to the state when V6A is conducting and V6B is cut off. During the run-up period of the sawtooth at the anode of V5B, V6B remains non-conducting until the anode potential of V5B rises to the point where current again commences to flow in V6B. When this happens the anode potential of V6B falls, and this fall in potential is communicated by C22 to the grid of V6A. This is followed by a rapid transition to the initial state where V6B is conducting. Further rise in the anode potential of V5B is then prevented by grid current in V6B. The precise instant of transition to the non-conducting state in V6A can be varied within narrow limits by adjustment of RV 2, which is labelled *Pre-pulse Position;* this control determines the common cathode potential when V6A is conducting, and hence the time at which V6B re-commences to conduct. The output from V6A is fed via the short time-constant network C23, R45 to the *Pre-pulse Output* plug. C23 and R45 serve to differentiate the waveform at the anode of V6A and provide alternate negative-going and positive-going spikes. The negative-going spike is coincident with the leading edge of the line sync pulse, and the positive-going spike occurs just before the pulse of the pulse and bar waveform. When the output is terminated in 75 ohms the pre-pulse output is approximately 0·3 volt d.a.p.

Impulse Generator

The sawtooth waveform generated at the anode of V5B is fed to the grid of V6A and also to the grid of V8A. V8 is a double triode, connected in a circuit arrangement similar to that of valve V6. At the commencement of the line sync pulse period, when the anode potential of V5B falls abruptly, the current in V8A is cut off and current commences to flow in V8B.

When the anode potential sawtooth of V5B has risen to the point where V8A conducts, a further transition occurs, and current in V8B ceases abruptly. Thus a negative-going pulse, of duration approximately 20 microseconds, is produced at the anode of V8B. This pulse is fed to the grid of V7A by C31 and R54. The time constant of the network is short, and the pulse is differentiated; the diode MR 4 serves to suppress the negative-going spike, which is produced by the leading edge of the pulse and is thus coincident with the beginning of the line sync pulse. The positive-going spike at the trailing edge of the pulse occurs about 10 microseconds after the trailing edge of the line sync pulse, and the spike causes a pulse of current to flow in valve V7A, which is biased to a point near anode-current cut-off. A negative-going spike is thus produced at the anode of V7A and is fed by C26 to the anode of V7B, the impulse-generating blocking oscillator.

The blocking oscillator utilises transformer T1 as the frequency controlling element. The transformer parameters are such that, with the circuit and stray capacitances involved, its resonance frequency is about 15 Mc/s. The coupling between the anode and grid winding is tight, and when valve V7B commences to oscillate, only one half-cycle of anode current flows before grid current charges C25 to a voltage at which the valve is biased to a point so far beyond cut-off that further cycles of conduction cannot occur.

In the circuit arrangement employed standing bias is applied to the grid of V7B via resistor R48 from the bleeder chain R90, R91, RV 6 across the stabilised −85 volt supply. The value of R48 is a compromise between that which gives minimum sawtooth voltage at the grid of V7B and that which gives the required operating frequency of 10 kc/s. The standing bias is such that V7B is normally non-conducting. When a negative-going spike is applied at the anode from the anode of V7A, the grid of V7B is driven positive, thus developing a spike of anode current in the valve. Because C25 is connected to cathode, the resistor

R49 is outside the grid-cathode circuit, and hence may be considered a normal load resistor fed from a high impedance. The value of R49 is equal to that of two resistors in parallel, one of 150 ohms and one of 452 ohms. The 150-ohm resistor is the load resistance of the stage V7B, while the 452-ohm resistor is the input resistance of the symmetrical π attenuator, the other components of which are R55, R56. The π attenuator introduces 6 dB of attenuation of the signal, and serves to isolate the generator from the load circuit. The image impedances of the attenuator are 150 ohms, and hence the attenuator is matched at its input.

The signal from the output attenuator is taken to one pole of the selector switch, from which it is fed to either the 1T or the 2T network, according to the switch setting.

Fine control of the pulse amplitude is achieved by means of RV 3 and RV 4 in the 1T and 2T positions of the selector switch respectively; the control is effected by varying the standing voltage at the anode of V7B. The voltage dropping chain is decoupled by C30 and C24. The chain is of high resistance, the mean anode current in V7B being low because of the small mark/space ratio of the impulse waveform. This high resistance in turn ensures stability of pulse amplitude, because any variation produces a corresponding variation of mean anode current; this in turn produces a variation in standing anode voltage which tends to minimise the change.

In order to ensure maximum pulse amplitude stability, the heater of V7 is fed with a stabilised d.c. supply.

Line Bar Generator and Window Stage

The sawtooth waveform at the anode of V5A is fed to the grid of V11B which is a delay-pulse generator. Under quiescent conditions V11B is conducting and V11A is cut off. With the commencement of each line synchronising pulse, current in V11B is cut off and V11A conducts. Conduction in V11B is re-initiated by the rising sawtooth waveform fed to the grid; when conduction recommences there is a rapid transition to the initial state with V11B conducting. Thus a negative-going pulse is generated at the anode of V11A, the leading edge of which is coincident with the leading edge of the line sync pulse and the trailing edge of which occurs some 40 microseconds after the trailing edge of the line sync pulse in the *1T* and *2T* positions of the selector switch, and 8 microseconds in the *50-c/s Waveform* position. These pulses are fed by C41 and R78 to the grid of V10B. The time constant of this network is short, and the pulses are differentiated, producing alternate negative-going and positive-going spikes. The negative-going spikes, coincident with the leading edges of the line sync pulses, are removed by the action of the diode MR 5.

V10 is a double-triode stage connected as a monostable multivibrator. Under quiescent conditions V10A is conducting and V10B is cut off. At the occurrence of the positive-going spikes at the grid of V10B, anode current flows in this valve and the anode voltage falls. The voltage fall is fed via C38 and C39 to the grid of V10A, causing its anode current to fall. This fall of anode current produces a drop in the common cathode voltage which serves to increase the current in V10B, thus providing regenerative action. As the grid of V10A is driven negative, current ceases to flow in diode V16.

After the rise in current in V10B is completed, the grid voltage of V10A commences to rise towards h.t. potential through current flowing in R72. This rise in voltage continues until V10A again commences to conduct, when the common cathode voltage starts to rise. V10B anode current starts to fall, and consequently the anode voltage starts to rise. This rise in voltage is communicated to the grid of V10A via C38 and C39 and a regenerative action occurs, with a rapid transition to the initial state where V10B is cut off and V10A conducting. The rise in voltage at the grid of V10A is checked when V16 re-commences to conduct, clamping the voltage of the grid to that existing at the junction of R80 and R81. The relaxation time of V10A is determined by the values of C38, C39, R72 and the h.t. voltage. In the *1T* and *2T* pulse positions of the selector switch the relaxation time is approximately 40 microseconds. In the *50-c/s Waveform* position of the switch additional resistance, comprising R116 and R142, is introduced in series with R72; this reduces the relaxation period to give a longer bar waveform. With the switch set to *50-c/s Waveform,* the positive-going pulse at the anode of V11A occurs about 8 microseconds after the trailing edge of the line sync pulse, and the line bar commences at this time. The relaxation time of V10A is about 80 microseconds.

The line-bar output is fed from the anode of V10A to the grid of V9B. This is a conventional window stage of the type described in *Television Engineering Volume 3.* It is used to improve the line bar waveform, to reduce the rise times of bar edges and to stabilise the output amplitude against changes of input amplitude.

The amplitude of the line-bar output can be adjusted by means of RV 5 (*Line Bar Amp.*) which controls the current flowing in the output stage of V9A when the pulse occurs. The output of V9A is fed to one pole of the selector switch, and at the *1T* and *2T* positions it is mixed with the line sync and pulse waveforms and fed to the appropriate 1T or 2T network. In the *50-c/s Waveform* position of the switch the line bar is fed to the grid of the modulator stage V14B, whence it is fed to the output and suppressed for alternate 10-millisecond periods.

Mixing Circuits, 1T and 2T Filters

In the *1T* and *2T* positions of the selector switch, the line sync, line bar and pulse waveforms are combined and fed to the appropriate 1T or 2T filter network. Both networks have a characteristic impedance of 150 ohms, and the impulse generator is designed to have an output impedance of this value. The line sync bar generators are both of high internal impedance, and it is only necessary to match the impulse generator to the filter network; the effect of the slight mismatch which results when the line sync and line bar generators are connected in parallel has been eliminated by modifying one of the resistor values in the attenuator.

The circuit diagrams of the 1T and 2T network filters are shown in Fig. 23. As mentioned in Part I of this Section, the response of these filters approximates closely to the sine-squared-pulse spectrum. The output from the filter network in use is fed to the grid of the input stage of the output amplifier V12B. Correct termination for the network is provided by R115, which has a resistance of 150 ohms. An additional network with an attenuation of 6 dB and comprising R139, R140 and R141 is introduced into circuit between the output of the impulse generator and the input of the 1T network. This additional attenuation is necessary to equalise the heights of the 1T and 2T pulses which, as pulse height is proportional to filter bandwidth, would otherwise differ by 6 dB.

In the *50-c/s Waveform* position of the selector switch, the line sync pulses are fed directly to the resistor R117, which is connected directly to the output plug. This resistor is also fed with the picture signal waveform from the cathode of V14B. The generation of this latter waveform is discussed later. As the output amplifier is not used in the *50-c/s Waveform* position, its h.t. supply is broken.

Output Amplifier

The output amplifier comprises stages V12 and V13. V12B is a conventional amplifying stage feeding the cascode-connected double triode V13. This cascode stage in turn feeds the cathode-follower stage V12A. A feedback connection is taken from the output of V12A to the cathode of V12B, the feedback resistor being R103. The values of R103 and R113 are such that the overall gain from the grid of V12B to the junction of R96 and C47 is four. The output impedance at this point is very low, because of the high degree of negative feedback employed. To give the required output impedance of 75 ohms, resistor R96 is connected in series with the waveform output plug. With a load resistance of 75 ohms connected, the overall gain from the grid of V12B to the load resistor is then two, i.e., 6 dB.

Capacitor C51 is connected in parallel with R103 to provide a fine adjustment of the high-frequency response of the output amplifier.

The output amplifier is surrounded by a shield, to prevent pick-up of spurious signals. The h.t. and l.t. supplies are filtered by lead-through capacitors C56, C45 and C46.

50-c/s Waveform Generator and Modulator Stage

At the *50-c/s Waveform* position of the selector switch, a waveform is generated which comprises alternate 10-millisecond periods of line bar followed by 10-millisecond periods of blanking level. The basic 50-c/s square-wave is generated in the astable multivibrator V15. The action of V15 is as follows.

Consider initially the conditions where V15A is conducting and V15B is cut off. V15A grid is then at zero bias, grid current being maintained by the bleeder chain from the h.t. supply comprising R137 and RV 9. The grid of V15B is at a low voltage because of a charge on C64. The grid voltage of V15B then rises as capacitor C64 discharges through the bleeder chain R132, R131 and RV 8 connected between h.t. positive and chassis. When the grid potential of V15B rises to the point at which current commences to flow in this valve, the common cathode voltage commences to rise. As the common cathode voltage rises, grid current ceases to flow in V15A because the grid voltage cannot rise rapidly in the presence of C65, and the anode current of V15A falls. The anode voltage of V15A then rises, and this voltage rise is communicated by C64 to the grid of V15B thus providing a regenerative action. A rapid transition of state then occurs, until V15B is fully conducting and V15A cut off.

The grid voltage of V15A commences to rise as capacitor C65 charges through R137 and RV 9. This action continues until current commences to flow in V15A, producing a rapid fall in V15A anode voltage. This fall in voltage is communicated by C64 to the grid of V15B and the anode current in V15B falls. The common cathode voltage then falls, accentuating the transition. The regenerative action continues causing the anode voltage of V15A to bottom and grid current to flow, partly discharging C65. The complete cycle is then repeated.

Resistors RV 8 and RV 9 affect the periods during which valves V15B and V15A respectively are non-conducting. Each resistor controls the duration of one portion of the waveform, and therefore, the total duration of the waveform. These controls must be adjusted in conjunction to produce a unity mark space ratio and a waveform of the appropriate total duration (20 ms).

The square wave generated at the anode of V15B is fed via C63 to the grid of V14A. This stage is normally biased beyond cut-off by the standing bias fed via R130 from the chain comprising R92, R93 connected across the stabilised negative supply.

When the pulses at the anode of V15B are positive-going, V14A is driven into conduction, producing negative-going pulses at its anode.

The 80-microsecond positive-going line-bar pulses from V9 are also fed to the anode of V14, and a combination of negative-going 10-millisecond pulses and the line bars is fed via C61 to the grid of V14B.

V14B is a cathode-follower stage, biased to a point near cut-off by the bias fed via R120 from the chain R94, RV 7 and R95 connected across the stabilised negative supply. When V14A is conducting, the negative-going pulse developed at its anode carries the grid of V14B to a point well beyond cut-off, and the line-bar waveform does not appear at the cathode. When V14A is non-conducting, V14B is fully conducting, and the line-bar pulses appear at its cathode. These are fed via R123 to the output resistor R117. Waveform distortion occurring due to the time-constant of the coupling circuit R120, C61 is eliminated by the network (R127 + R128)C62 in the anode circuit of V14A.

R117 is also fed with the output of the line sync window stage V3, and a composite waveform is formed in R117 comprising line syncs and alternate periods of line bars and blanking level. At this position of the selector switch the output amplifier is not used, and its h.t. supply is removed by the selector switch. The output impedance at V12A cathode is consequently high, and the impedance shunted across the waveform output plug by the output amplifier comprises this output impedance and R96 in series. These provide a negligible shunt across R117.

Power Supply Unit (*Fig. 24*)

The power supply unit is on a separate sub-chassis at the bottom rear of the unit. A circuit diagram is given in Fig. 24. A stabilised supply at 250 volts is generated using the diodes MR 8, MR 9 and MR 14 to MR 17 and the series stabiliser V21. The control grid of V21 is connected to the anode of V22B, which is a cascode-connected double-triode valve. The input grid of V22A is fed from the potential divider connected between the h.t. positive line and the stabilised negative supply. Under normal conditions the grid is at a voltage slightly negative with respect to earth, to which the cathode of V22A is returned. Any change in the output voltage produces a change in the grid voltage of V22A, and this change is amplified and communicated to the grid of V21 in such a sense that the output voltage fluctuation is minimised. The design of the unit is conventional, and reference should be made to Instruction V.4 for the operating principles of this type of regulated supply.

A further stabilised supply, at −85 volts, is derived utilising the diodes MR 10 and MR 11. This supply is stabilised by the gas-filled stabilising valve V23, and is used for biasing purposes. Heater supplies at 6·3 volts a.c. are obtained from two windings of transformer T3. One of these windings supplies heater current for the valves in the stabilising circuit; the other supplies heater current for all valves except V7 and V9 in the generator circuit and this supply is biased about 80 volts positive with respect to earth (by R46 and R47) to avoid exceeding the maximum cathode-heater rating of the valves. A further supply at 6·3 volts d.c. is derived by rectifying the 12·6-volt output from transformer T3 by the rectifier MR 13; this supply is smoothed and fed to the transistor VT 1, which is connected in an emitter-follower circuit. The base of the transistor is held at a stabilised voltage by the action of the Zener diode MR 18; the supply to this diode is derived independently by the metal rectifier MR 12. Because the base voltage is stabilised the output voltage of the emitter of VT 1 is stable. The output impedance at this point is very low because of emitter-follower action, and hence regulation is good. The value of the series resistor R166 is adjusted on test to give an output voltage of precisely 6·3 volts d.c. This supply is used to feed the heater of the impulse-generator valve V7 and also that of V9, to stabilise the heater operation against changes in mains voltage.

Connections between Power Supply Unit and Generator

The connections between the power supply unit and the generator are made by means of a 12-way connector. The circuits between the various pins are as follows:

Pin	*Circuit*
1	H.T. +
2	—85 V
7, 10	6·4 V a.c.
10, 11	6·4 V d.c.
12	Chassis earth

Mechanical Construction

The generator is fitted in a portable carrying case Type CS2/7. The framework of the case is assembled from standard alloy channel, to which the face panels are attached.

The components of the generator are mounted on a single panel attached to the framework of the case by tapped alloy angle. The power unit is mounted on the floor of the case, at the rear. The controls project through the front panel of the unit, as shown in Plate XI. The 1T and 2T filter units are mounted in an enclosed box at the rear of the main generator panel, from which they are separated by stand-off posts. The interior of the equipment can be seen in Plates XII and XIII. (Note that in all three plates the generator shown is a GE4/504A).

Lining-up Procedure

The lining-up procedure entails adjustment of the various sections of the waveform to their correct amplitudes. This adjustment must be carried out using an oscilloscope which does not in any way visibly distort an applied pulse and bar signal. A suitable instrument for this purpose is a Tektronix oscilloscope Type 545 with a pre-amplifier Type 53/54 K.

Proceed as follows:

1. Set the selector switch to the *1T* position, and terminate the *Waveform Output* in 75 ohms. Switch on power supplies, and allow 10 minutes to elapse for the unit to warm up. Display the output waveform. Adjust the *Sync Pulse Amp.* control until the sync pulse is precisely 0·3 volt d.a.p. Adjust the *Line Bar Amp.* control until the line bar amplitude is 0·7 volt d.a.p. Adjust the *T Pulse Amp.* control until the 1T-pulse height is precisely equal to the line-pulse height. (If a double triggering facility is available, this is most accurately done by displaying the pulse in the centre of the line bar.) Adjust the *T Pulse Amp.* control until a bright spot is observed on the line bar trace, indicating that the tip of the pulse is coincident with the line bar.
2. Set the selector switch to *2T* and adust the *2T Pulse Amp.* control until the pulse height is equal to that of the line bar.
3. Set the selector switch to 60-*c/s Waveform*, and using the calibrated sweep time facility of the oscilloscope, adjust the 50-c/s waveform frequency and duration controls until the periods of line bars and blanking level are both equal to 10 milliseconds. Check that the sync pulse amplitude is still approximately 0·3 volt d.a.p. and that the picture signal amplitude is 0·7 volt d.a.p. If the picture signal amplitude is not precisely 0·7 volt d.a.p., adjust the settling of RV 7 (50-*c/s Waveform Amp.*).

GENERATOR GE4/504A

General

The GE4/504A is similar to the GE4/504 but gives a line-sawtooth output in addition to the pulse and bar. Also in later models the impulse forming circuit associated with V 7 (Fig. 22) is replaced by a three-transistor circuit. A complete circuit diagram of a GE4/504A with transistor impulse forming circuit is shown in Fig. 25.

Sawtooth Generator (Fig. 25)

The sawtooth is generated in the circuit associated with V 17. It is fed to the generator output when the main switch is in the *Aux. W/F* position and an auxiliary switch, labelled 50-*c/s Waveform* and *Line Sawtooth*, is in the *Line Sawtooth* position. With the auxiliary switch on *Line Sawtooth*, the h.t. supply to the output stage of V 14 is interrupted, and valve V 17 is energised instead. V 17 is a double triode connected as a 'bootstrap' stage* (V 17B) and a discharge valve (V 17A). The action of the circuit is as follows. At the beginning of the period of the 80-micro-second line bar generated in V10, V17A is biased to a point beyond cut-off. The grid of V17B is at a low voltage, and the grid voltage commences to rise as C80 and C81 in parallel charge through R 198 and MR 19. As the grid voltage rises, the cathode voltage also rises by cathode-follower action. This rise is communicated by C83 to the junction of MR 19 and R 198, and after a short period, current in MR 19 ceases as its cathode voltage rises above that of its anode. Since the voltage rise at the junction of R 198 and MR 19 is approximately equal to the rise in voltage at the junction of R 198 and C80, C81, a substantially

* See *Television Engineering, Volume* 3.

constant voltage is maintained across R 198. Thus approximately constant current flows in R 198, producing a linear rise in voltage across C80, C81. The corresponding rise in cathode current is also substantially linear, and this is fed via R 196 to the common load resistor R 117; C82 eliminates some unwanted spikes from the waveform.

At the end of the 80-microsecond line bar generated at the cathode of V10, the grid of V17A is driven positive, and anode current flows, discharging C80 and C81 and thus providing the trailing edge of the sawtooth. V17A remains conducting until the beginning of the next line bar, when the cycle re-commences. Diode MR 20 at the grid of V17A serves to clamp the tips of the positive-going portions of the waveform at earth potential, and R220 isolates the input capacitance of V17A from the cathode of V10.

The rate of voltage rise at the grid of V 17B is determined by the time-constant R198(C80 + C81); as the duration of the sawtooth is fixed, the values of C80 and C81 determine the amplitude of the sawtooth. C81 is variable to permit control of the sawtooth amplitude.

Transistor Impulse Generator (Fig. 25)

The impulse is generated in the blocking oscillator circuit of TR23. The trigger for the blocking oscillator is derived from the output of V8B. The waveform at V8B anode is differentiated by C31 and R229, forming negative pulses coincident with the leading edge of line syncs and positive pulses which occur about 10 microseconds after the trailing edge of line syncs. These pulses are applied to the base of TR24, an npn transistor which is normally in a state of low conduction because its base is connected to chassis potential through R229. The negative pulses on TR24 base have thus little effect, but the positive-going pulses drive the transistor into conduction, generating a positive pulse across R228. This pulse is applied to the base of TR23.

TR23, also an npn transistor, is normally in a state of low conduction because its base is connected to chassis potential through R228. The positive pulse on its base starts it conducting. The rising current through the transformer winding in its collector circuit induces a voltage across the winding in its emitter circuit which drives the emitter negative. This increases the emitter-to-base voltage, causing the current in TR23 to increase further.

The effect is cumulative, and the increase in current is very rapid. As soon as the current approaches its maximum value and the rate of increase in current starts to fall, the induced voltage in the transformer winding in the emitter circuit decreases. This tends to reduce the current in the transistor, and once the current starts to decrease, the induced voltage in the emitter winding reverses and the current is cut off by cumulative action. The impulse from TR23 drives TR22 heavily into conduction, causing it to discharge C86. The voltage change on this capacitor determines the voltage and duration of the output pulse.

The power supply for the transistors is obtained from the generator h.t. supply. It is reduced from h.t. potential across R71 and the voltage reference tube V18 and is stabilised by the zener diodes MR22, MR23 and MR24.

The pulse amplitude is controlled by controlling the standing collector voltage by means of RV3 for the 1T pulse and RV4 for the 2T pulse.

Lining-up Procedure

The lining-up procedure is the same as for the GE4/504, except that an additional adjustment of line sawtooth amplitude is required. This adjustment is made by displaying the line sawtooth waveform, and adjusting the setting of C81 until the line sawtooth amplitude is precisely 0·7 volt d.a.p.

†† Test Specification; GE4/504 & GE4/504A

1. Apparatus Required

- **Tektronix oscilloscope Type 545 with pre-amplifier 53/54K, pre-amplifier 53/54G and Tektronix × 10 probe (8-pF, 10-megohm)
- Pulse and bar trigger and calibrating waveform generator GE4/502
- **Pulse and bar generator (405-line system)
- Avometer Model 8
- Wayne Kerr B.221 universal bridge (or any equivalent bridge)
- Wayne Kerr video oscillator Type 022B
- CR100 receiver or similar amplifier detector
- †Linear sawtooth generator (e.g., TV/TG/1 or GE4/505)
- Frequency calibrating unit (e.g., crystal meter BC.221)
- 6-dB attenuator (e.g., S.T. & C. 74600A)

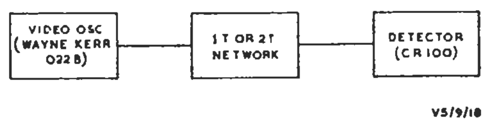


Fig. 10.14. Schematic for Test 3(b)

2. Electrical Tests

General

Set the mains transformer primary tap to the correct voltage. Solder a wire bridge in place of the adjust-on-test resistors R128, R142 and R166. Connect the plug (PL F) connecting the main chassis to the power supply chassis. Connect the unit to the mains and switch on. Allow one minute for warming up before commencing next check.

** The pulse and bar generator used must produce a waveform that is known to be correct and in accordance with the specification for the waveform. As the oscilloscope is used to assess the pulse and bar waveform critically, the instrument must not in any way visibly distort an applied pulse and bar signal. This applies particularly to all tests in Section 6 of this specification. Should any doubts exist as to the performance of either of the above instruments, Designs Department should be consulted.

† Used for GE4/504A only.

††See footnote on page 10.31.

Power Supply

Check that the following voltages appear at the socket PL F. This can be done by removing base panel.

Between pins:

1 and 12	Adjust RV 15 for 250 volts
2 and 12	85 volts ± 2 volts
10 and 11	6·4 ± 0·1 volts (select R166*)
7 and 10	6·4 ± 0·2 volts a.c.

All readings given are for the Model 8 Avometer on the appropriate range.

Hum Level

Remove valve V2. Using the oscilloscope, measure the hum level on the 250-volt h.t. line. This should not exceed 10 mV. Check that this level is maintained for a change in input voltage of at least ± 10 volts.

Stabilised Supplies

Measure the change in stabilised heater voltage between pins 10 and 11 for a change of ± 8 per cent in the mains voltage. The heater supply should change by no more than ± 1·0 per cent.

3. Sine Squared Networks

Remove the network boxes. The network box contains two networks which shape the impulse and produce 1T or 2T sine-squared pulses. To align the networks the following procedure must be adopted.

(a) In each network the two shunt capacitors with trimmers in parallel should be removed from the box and adjusted to the values given below.

Network	*Total Capacitance*
1T	C100/C101 = 26·8 pF C105/C106 = 74·5 pF
2T	C107/C108 = 67·5 pF C111/C112 = 156·5 pF

These capacitors must be adjusted within the limits of the Wayne Kerr B.221 bridge (i.e., ± 0·25 per cent).

* If necessary use two MV 1 resistors in parallel.

(b) The remaining adjustments can be carried out using the circuit shown on page 10.22 in Fig. 10.14.

Use screened leads, with a minimum of open lead at the connection between Wayne Kerr video oscillator network and detector.

Two high-grade silvered mica capacitors having the following values must be obtained:

$$C_{1T} = 500 \text{ pF} \pm 0{\cdot}25\%$$
$$C_{2T} = 1000 \text{ pF} \pm 0{\cdot}25\%$$

NOTE:— The suffix indicates the network to which the capacitor belongs.

The setting up procedure is as follows. With the apparatus connected as shown, tune the receiver to the video oscillator frequency, making sure the receiver is not overloaded. Set each frequency setting of the signal generator with the BC.221 crystal calibrator. Using the appropriate test capacitor, connect the signal generator across each of the series inductors in turn (the capacitor lead lengths should be about half an inch). Adjust the coil to give a minimum response on the receiver at the frequency given in the table. When the three series inductors have been resonated, tune the shunt resonant circuit for minimum response at the frequency given in the table. The test capacitor is not used for the shunt circuits. L9 and L11 have two dust iron cores each.

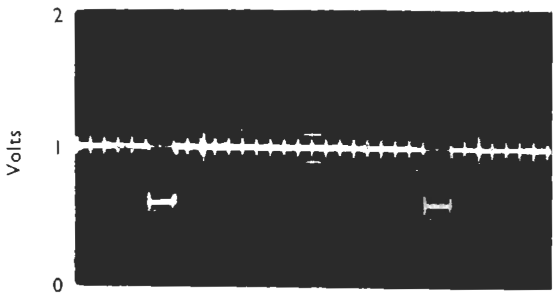
Network	*Component Number*	*Resonance Frequency f (Mc/s)*
1T	L1 L2 L4 L3	3·850 2·864 2·890 6·156
2T	L8 L9 L11 L10	1·925 1·432 1·445 3·078

4. Waveform Generator

Test Procedure

With the shaping networks re-connected to the generator, apply power to the unit, and after waiting at least 20 minutes conduct the tests listed below. The waveforms numbered 1 to 23 should be obtained, using the Tectronix oscilloscope and the × 10 probe. The voltages are approximate, and may vary from the indicated values by up to ± 20 per cent.

Voltages of waveforms marked * depend upon control settings. Except where otherwise instructed, set all variable controls to their mid positions and the function switch to 1T pulse.



* *Waveform 1: V3, Pin 1 (or Tag 10)*

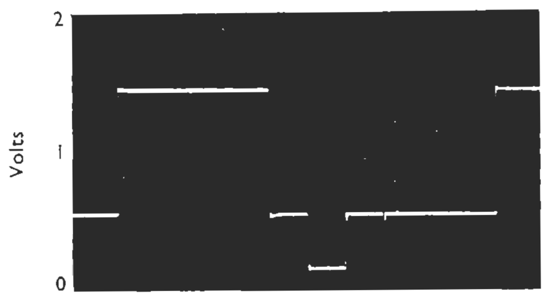
Remove V9 and adjust C5 and C8 to give a sync-pulse width of 10 μs with a pulse-repetition rate of 10 kc/s. Amplitude, excluding fast impulse, 0·4 volt.

Waveform 2: V2, Pin 1 (Tag 5)

Amplitude of pulse, 100 volts.

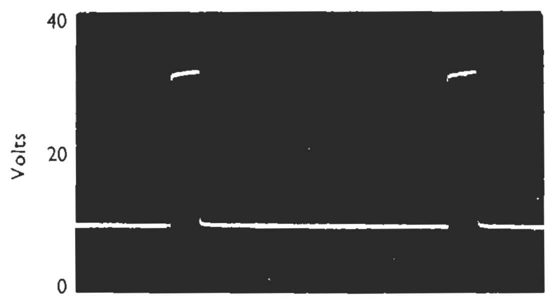
Waveform 3: V1A, Pin 6

Apply two volts of line-sync pulse to the *Sync Input* socket and adjust the *Fine Frequency* control to give the maximum pulse. Amplitude of positive pulse, 60 volts.



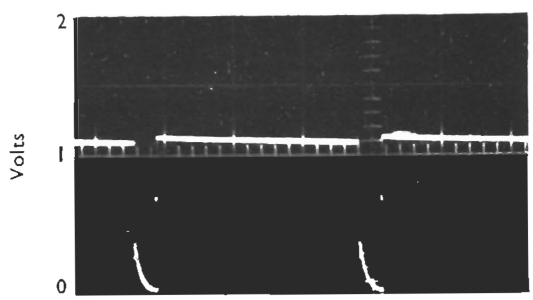
**Waveform 4: V3, C11 (Tag 10)*

Replace V9, remove line triggers and reset *Fine Frequency* control centrally. Amplitude, excluding fast impulse, 1·2 volts.



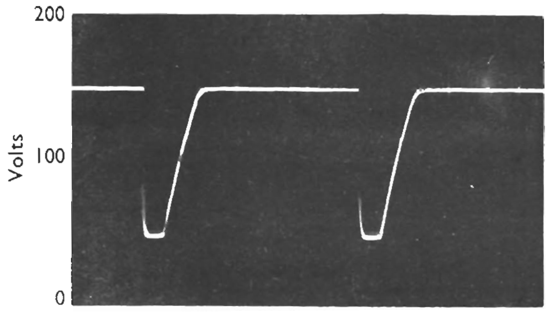
Waveform 5: V4, Pin 1 (or Tag 17)

Amplitude of pulse, 24 volts.

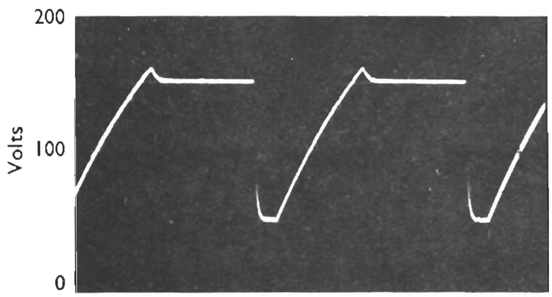


Waveform 6: V4, C16 (Tag 15)

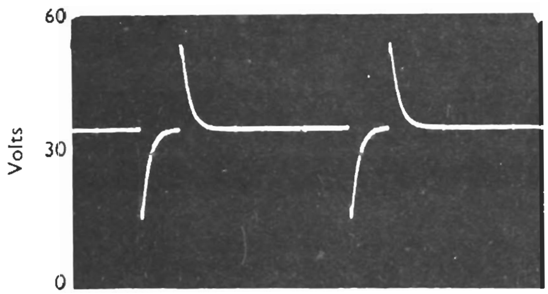
Terminate the *Line Sync* output socket in 75 ohms. Amplitude of pulse, 1·2 volts.



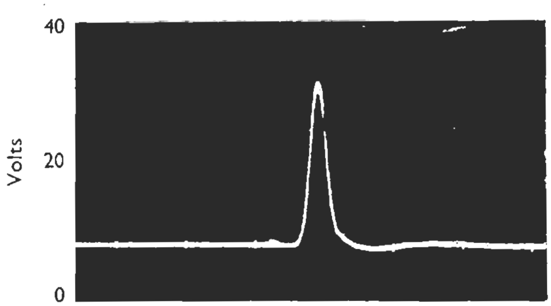
Waveform 7: V5, Pin 6 (Tag 18)
Amplitude of pulse, 100 volts.



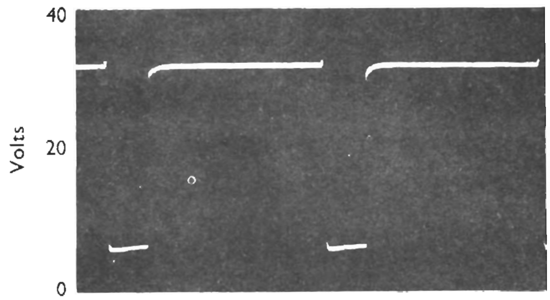
Waveform 8: V5, Pin 1
Amplitude of pulse, 100 volts.



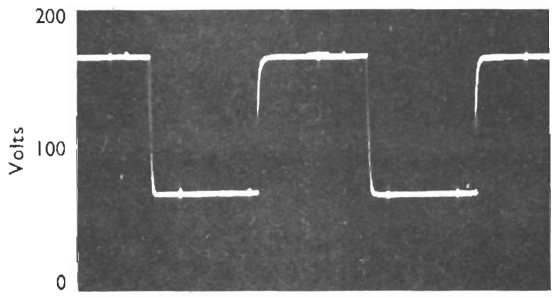
Waveform 9: V6, C23 (Tag 22)
Amplitude of positive pulse, 17 volts.



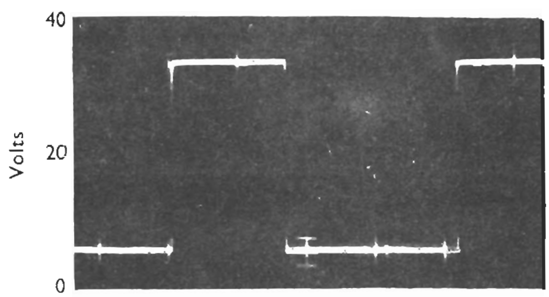
**Waveform 10: V7, Pin 8*
Oscilloscope time-base speed, 0·1 μs/cm. Amplitude of pulse, 24 volts.



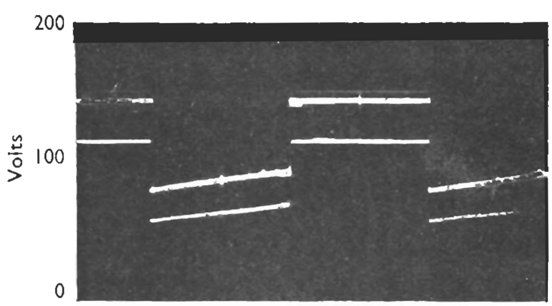
Waveform 11: V8, Pin 6
Amplitude of pulse, 25 volts.



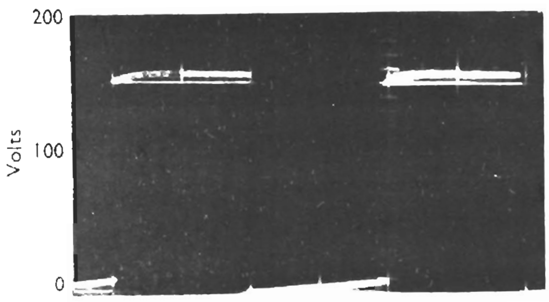
Waveform 12: V11, Pin 1
Amplitude of pulse, 100 volts.



Waveform 13: V10, Pin 1
Adjust C38 to give a positive pulse width of 40 μs. Amplitude of pulse, 25 volts.

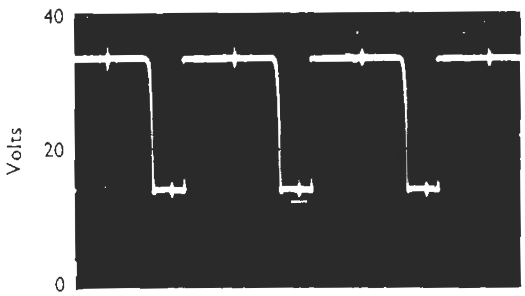


Waveform 14: V9, Pin 1
Set the function switch to *50-c/s Waveform*. D.A.P. value of waveform, 70 volts.



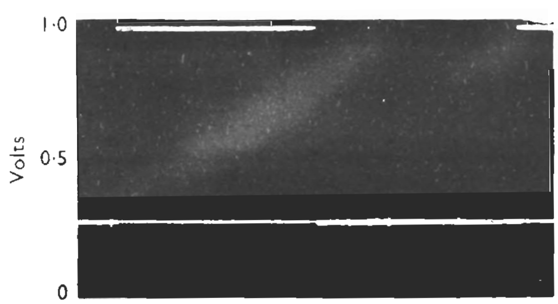
Waveform 15: V15, Pin 6

Set the function switch to *50-c/s Waveform* and adjust RV 8 and RV 9 to give equal mark-space times of 10 ms. Amplitude of waveform, 150 volts.



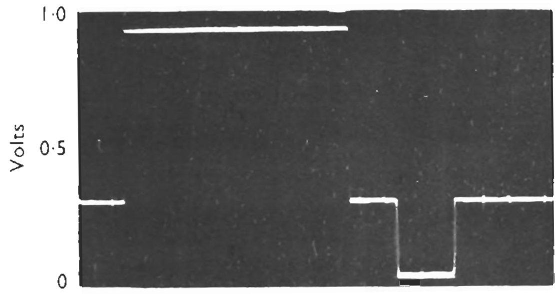
Waveform 16: V10, Pin 8

Connect a 500-kilohm variable resistor in place of R142 and adjust it to give a negative pulse width of 80 μs half-amplitude duration. Measure the resistance at the setting found and select the nearest value of Erie Type 109 for use as R142. Amplitude of waveform, 20 volts.



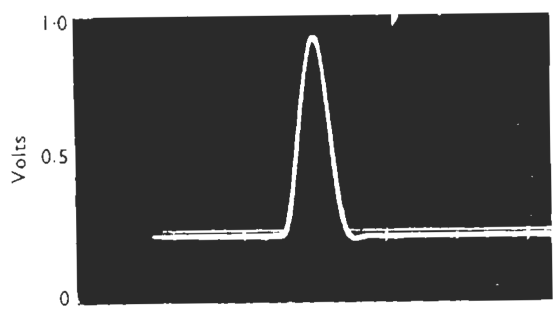
Waveform 17: Generator Output

Set the function switch to *50-c/s Waveform* and terminate the generator in 75 ohms. Adjust RV 7 to give a 50-c/s square wave, without sync pulses, of 0·7 volt.



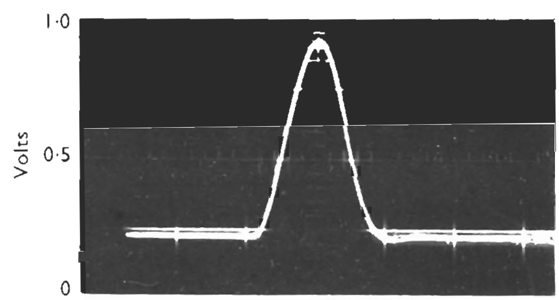
**Waveform 18: Generator Output*

Set the function switch to 1T or 2T and terminate the generator. The waveform should appear substantially as shown, although the pulse amplitude may need final adjustment. Amplitude of waveform, 1 volt.



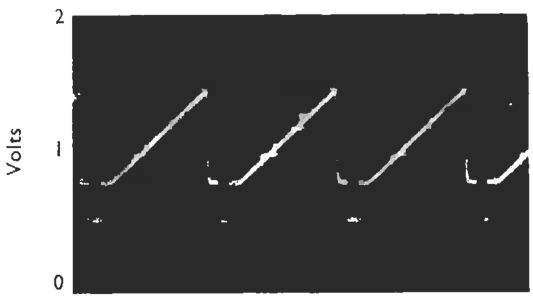
* *Waveform 19: Generator Output*

Set the function switch to 1T pulse and terminate the generator in 75 ohms.



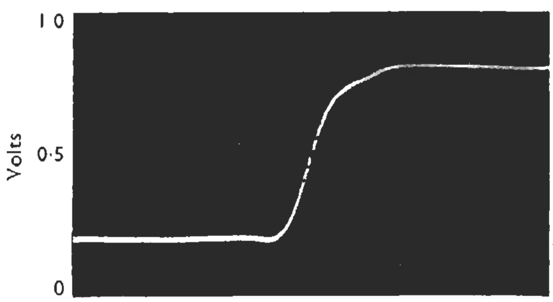
* *Waveform 20: Generator Output*

Set the function switch to 2T pulse and terminate the generator in 75 ohms.



Waveform 21: Generator Output (GE4/504A Only)

Set the function switches to *Line Sawtooth* and adjust C81 to give a sawtooth amplitude, excluding sync pulses, of 0·7 volt.



Waveform 22: Positive Bar Edge

See instructions below next waveform.

Waveform 23: Negative Bar Edge

Disconnect C59 at position G on SA6 and connect a 75-ohm Erie Type-108 resistor between the free end of C59 and earth. Terminate the oscillioscope input in 75 ohms and, using the full expansion of the oscilloscope, measure the voltage across the Type-108 resistor.

5. Output Amplifier

(*a*) *V12 and V13*

These valves form the output amplifier and are tested together as described below.

With the oscilloscope terminated in 75 ohms ±1 per cent, connect its input to the output socket of the pulse and bar generator called for in the list of test equipment by means of a short coaxial lead. Set the pulse and bar heights for both 1T and 2T waveforms to be equal as accurately as possible. The bar height should be measured in the centre of the bar.

Disconnect the input to V12B at point D on the main circuit diagram and connect a 150 ohms ±1 per cent resistor across R115. Connect the pulse and bar generator which has just been aligned through a 6-dB 75-ohm attenuator to point D and chassis, by means of a short coaxial lead *. Now move the oscilloscope input to the output of V12A. Set the generator to the 1T-pulse position and observe the pulse and bar heights. By carefully adjusting C51 make the pulse height precisely the same as that of the bar. Having carried out this adjustment, observe the 2T waveform. This also should show no difference in pulse and bar heights.

(*b*) *Overload Test*

Set the video oscillator output to 1 Mc/s at −4·0 dB with respect to 1 volt d.a.p., and apply the signal to the input of the amplifier, in place of the pulse and bar input. Display the output waveform; no distortion of the sine wave should be visible.

6. Final Setting-up Procedure

If the generator has passed all previous tests, then the final setting up procedure should be carried out. Allow twenty minutes warm-up period before commencing tests.

With the oscilloscope (terminated in 75 ohms ± 1 per cent) connected to the generator output, carry out the following operations:

(a) Check sync pulse width and spacing. These should be 10 μs and 90 μs respectively. If necessary, adjust C5 and C8.
(b) Adjust RV 10 to give a sync pulse amplitude of 0·3 volt peak-to-peak as closely as possible.
(c) Check the bar width and position. This should be 40 μs wide starting 40 μs from the back edge of the line-synchronising pulse. Adjust C38 and C57 if necessary.
(d) Set bar amplitude to 0·7 volt using control RV5.

* When the pulse and bar generator is connected to point D, it is essential that the connecting leads are as short as possible.

(e) Set function switch to *50-c/s Waveform*. Adjust RV8 and RV9 if necessary to give correct width and a 1 : 1 mark-to-space ratio.

(f) Display the 50-c/s waveform on the oscilloscope in the d.c.-connected condition.
Adjust RV 7 to give 0·7 volt d.a.p. excluding sync pulses. Connect a 10-kilohm variable resistor in place of R128 and adjust for minimum tilt on the top of the 50-c/s waveform. Measure the variable resistor and select R128 from the Erie Type-109 range nearest to this value.
Adjust RV 7 to give 0·7 volt d.a.p. of 50-c/s waveform excluding sync pulses.

(g) Set the function switch to 1T pulse. Trigger the oscilloscope with the pre-pulse output; set the triggering slope switch to external, positive. Set the oscilloscope to display the sine-squared pulse on a time base of 0·1 μs/cm. Rotate RV 2 over its complete range. This control should move the pulse from a position just after the start of the sweep to a position at least 0·5 μs later.

(h) Connect line trigger pulses to generator. Adjust RV 1 until the generator locks to these pulses. The generator should remain locked over the major part of the rotation of the RV 1 control. Use the generator GE4/502 to display the pulse at maximum expansion and observe the jitter on the trace. This should be of the order of 2 mμs and should be substantially the same whether the generator is locked or unlocked.

(i) Display the 1T pulse and bar waveform on the oscilloscope and turn RV 6 fully clockwise. Increase the setting of RV 6 until the pulse occurs every line, and continue increasing the setting until the 1T pulse amplitude is equal to that of the bar. Switch the function switch to *2T* and adjust RV 4 until the 2T pulse amplitude is equal to that of the bar. (With some impulse generator valves it may not be possible to obtain an equal 1T pulse-to-bar ratio by increasing RV 6; in these circumstances RV 6 should be turned back from the point of maximum pulse amplitude to a point giving 0·95 maximum amplitude. Controls RV 3 and RV 4 should then be adjusted so that 1T and 2T pulse heights are the same as the amplitude of their respective bars. This adjustment is most easily made by double triggering the oscilloscope, causing the pulse to sit in the middle of the bar),

NOTE:—One method of checking that the top of the pulse is exactly in the middle of the bar trace width is as follows. Display the pulse in the centre of the bar (i.e., double triggered condition), using a time-base speed of 0·5 μs/cm. Adjust tube brightness until the pulse is just visible and focus display to obtain minimum trace width. Now if the pulse height is varied it will be observed that when the top of the pulse meets the bar trace a small bright spot appears, indicating that the two traces are exactly superimposed.

(j) Measure the tilt over the duration of the 40-μs bar and the 50-c/s waveform, ignoring the first and last 1 μs. If this tilt is not well below 1 per cent of the bar amplitude, a fault condition exists.
NOTE:—It is important to check the oscilloscope against an impeccable waveform at each sweep speed and at each attenuator setting to be used for the measurement. If it is impossible to avoid a very small residual tilt, due to the oscilloscope, the measurement may be made by taking the difference of the tilts.

(k) Measure the impulse across R49 using the × 10 probe. The amplitude of the pulse should be about 20 volts and the half-amplitude duration should be less than 35 mμs.

(l) Disconnect C59 at position G on the switch and connect a 75-ohm resistor between the earthy end of C59 and earth. Measure the waveform across this resistor using a short length of coaxial cable terminated in 75 ohms at the oscilloscope end. The rise and fall times of the bar should be 25 mμs. Reconnect C59.

(m) The sine-squared pulse should be positioned 10μs from the back edge of the synchronising pulse. Adjust C21 to achieve this condition.

(n) GE4/504A only. Set the function switches to *Line Sawtooth*. Adjust C81 to give a line sawtooth amplitude, excluding sync pulses, of 0·7 volt. Use the Tektronix 545 oscilloscope with pre-amplifier 53/54G to compare the line sawtooth waveform with a similar waveform known to be linear from either the TV/TG/1 or the GE4/505. The difference between the two signals over the coincident parts of the sawtooth waveforms should be less than 0·015 volt. To compare the two waveforms it will be necessary either to lock the GE4/505 to the GE4/504A using the line sync output or to lock the GE4/504A to the TV/TG/1 signal. Check that the back edge of the sawtooth does not distort the front edge of the line synchronising pulses.

7. Final Check of Generator Output

This final check is a critical appraisal of the 1T and 2T pulses. The following points should be checked:

(a) Each pulse should have a first overshoot 0·9% ± 0·5% of the peak pulse amplitude.

(b) Each pulse should have a second overshoot 0·5% ± 0·4% of the peak pulse amplitude.

(c) Any other disturbances before, during or after the pulse should have amplitudes not greater than 0·2 per cent.

(d) Display the bar and examine the corners. No appreciable exponential distortion should be visible.

(e) The sync pulse should be well shaped.

(f) Set pulse and bar amplitudes to be exactly equal after a warm-up period of at least twenty minutes. Then check the pulse-to-bar amplitude ratio at the end of a subsequent minimum period of six hours continuous operation. The change in pulse-to-bar amplitude ratio should be less than 1 per cent.

G.G.J. 10/60

GENERATOR GE4/504C

General

The 625-line-standard generator GE4/504C provides the following test signals:—

(a) 1T pulse-and-bar waveform,
(b) 2T pulse-and-bar waveform,
(c) 50-c/s waveform, and
(d) line-sawtooth waveform.

The pulse-and-bar waveforms are shown in Fig. 10.15. The 50-c/s waveform consists of line sync pulses with a 50-μs line bar switched alternately off and on at 10-ms intervals. The duration of the line-sawtooth waveform is 50 μs.

The generator also provides two triggering outputs. These consist of negative-going line sync pulses of one volt p-p when fed into a 75-ohm load, and positive-going pre-pulses which occur just before the pulse signal of the pulse-and-bar waveform. The pre-pulses are for triggering an oscilloscope when the pulse is to be examined.

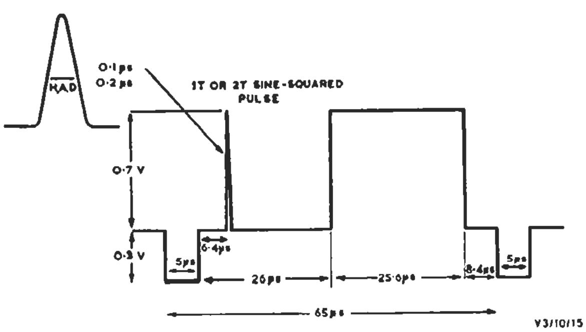


Fig. 10.15. Generator GE4/504C: Pulse-and-bar Waveforms

Circuit Description (Figs. 26 and 27)

The generator circuit of the GE4/504C is shown in Fig. 26. The circuit is a modified version of the GE4/504A circuit. The modifications are merely component changes which are required because of the differences in timing between the 625 and 405-line-standard waveforms. The GE4/504C functions in the same way as the GE4/504A.

The 625-line-standard filter circuits required for the GE4/504C are shown in Fig. 27. The GE4/504C uses the same power-supply circuit (Fig. 24) as the earlier generators.

Lining-up Procedure

The lining-up procedure, in which the various sections of waveforms are adjusted to their correct amplitude, is similar to that for the GE4/504A.

TEST PROCEDURE*: GE4/504C

General

The procedure for testing and setting up the GE4/504C is similar to that for the GE4/504A. Points of difference are dealt with below.

Sine Squared Networks

Capacitance Values

Network	*Total Capacitance*
1T	C100/C101 = 11 pF C105/C106 = 38 pF
2T	C107/C108 = 34 pF C111/C112 = 88 pF

The capacitance values must be adjusted to be within ±0·25 per cent of the quoted values.

Inductance Values

Network	*Component Number*	*Resonance Frequency (Mc/s)*
1T	L1	3·616
	L2	2·613
	L3	2·637
	L4	10·260
2T	L8	3·502
	L9	2·613
	L11	2·637
	L10	5·130

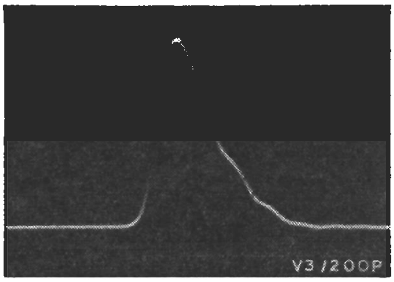
* Certain parts of this Test Procedure, e.g., the determination of correct values for a.o.t. resistors, can normally be left out unless other associated components have been disturbed.

Waveform Generator

The waveforms shown on pages 10.24 to 10.27 give a guide to the waveforms to be expected at the various points in the GE4/504C. The GE4/504C waveforms will of course have timings appropriate to 625-line working.

Transistor Impulse Generator

The transistor impulse generator in the later models of the GE4/504C may be tested either mounted in the generator chassis or as a separate unit apart from the generator. The procedure for testing as a separate unit is given below.



Waveform 24: Transistor Impulse Generator at TR22 Emitter
Timebase speed 20 mμs/cm.
Amplitude about 8 volts.

1. Connect together the three terminal pins which are situated at the right-hand side and near the upper edge of the card.
2. Connect a 45-kilohm Painton Type-302 resistor between the common connection and the 250-volt positive h.t. supply.
3. Connect the earth side of the power supply to the earth terminal pin on the card.
4. Apply to the trigger input terminals on the card a feed of positive trigger pulses of amplitude 2·5 volts and half-amplitude duration (H.A.D.) of about 0·3 μs. (Suitable trigger pulses can be obtained from the output of V8 in a GE4/504 series generator.)
5. Connect a 150-ohm resistor between the output of the card and earth.
6. Measure the amplitude of the signal at this point and check that the appearance is similar to that shown in Waveform 24.

Output Amplifier

The output amplifier section formed by V12 and V13 should be checked in the same way as in the GE4/504 and GE4/504A, but using a 625-line-standard pulse-and-bar generator instead of a 405-line-standard generator.

Final Setting-up Procedure

If the generator has passed all previous tests, then the final setting-up procedure should be carried out. Allow 20 minutes warm-up period before commencing tests.

Terminate the oscilloscope in 75 ohms ±1 per cent and connect it to the generator output. Carry out the following operations:—

(a) Check sync pulse width and spacing. These should be 5 μs and 65 μs respectively. If necessary, adjust C5 (spacing) and C8 (width).
(b) Adjust RV10 to give a sync pulse amplitude of 0·3 volt p-p as closely as possible.
(c) Check the bar width and position. The bar should be 25·6 μs wide starting 26 μs from the back edge of the line sync pulse. Adjust C38 (width) and C57 (position) if necessary.
(d) Set the bar amplitude to 0·7 volt using RV5.
(e) Set the function switch to *50-c/s Waveform*. Adjust RV8 and RV9 if necessary to give a 1 : 1 mark-to-space ratio and correct width.
(f) Display the 50-c/s waveform on the oscilloscope in the d.c.-connected condition. Then:
   1. Adjust RV7 to give 0·7 volt p-p excluding sync pulses. Connect a 25-kilohm variable resistor in place of R128 and adjust for minimum tilt on the top of the 50-c/s waveform. Measure the variable resistor and reconnect in position R128 an Erie Type-109 resistor as near as possible to this value.
   2. Adjust RV7 to give 0·7 volt p-p of 50-c/s waveform excluding sync pulses.
(g) Set the function switch to *IT* pulse. Trigger the oscilloscope using the pre-pulse with the triggering slope switch set to external positive. Set the oscilloscope to display the sine-squared pulse on a time base of 0·1 μs/cm. Rotate RV2 over its complete range. This control should move the pulse from a position just after the start of the sweep to a position at least 0·4 μs later.
(h) Connect line trigger pulses to the generator. Adjust RV1 until the generator locks to these pulses. The generator should remain locked over the major part of the range of RV1. Use the generator GE4/502 to display the pulses at maximum expansion and observe the jitter on the trace. This should be of the order of 2 mμs and should be substantially the same

whether the generator is locked or unlocked.

(i) Check that RV6 is fully anticlockwise. Display the 1T pulse-and-bar waveform on the oscilloscope. Set RV3 about a third of its rotation clockwise and select an Erie Type-108 resistor for R206 so that the amplitudes of the bar and pulse are almost equal. (If necessary, the value of R63 may be reduced.) Adjust RV3 to make the amplitudes exactly equal. Set the function switch to *2T* and adjust RV4 so that the amplitude of the 2T pulse is exactly equal to that of the bar. (These adjustments are most easily made by double-triggering the oscilloscope, thereby causing the pulse to sit in the middle of the bar.

NOTE:—One method of checking that the top of the pulse is sitting exactly in the middle of the bar trace width is as follows:—

Display the pulse sitting in the centre of the bar (i.e., double-triggered condition), using a time base speed of 0·5 μs/cm. Adjust the tube brightness so that the pulse is just visible and focus the display to obtain minimum trace width. Now if the pulse height is varied, it will be observed that when the top of the pulse meets the bar trace a small bright spot appears, indicating that the two traces are exactly superimposed.

(j) Measure the tilt over the duration of the 25·6-μs bar and the 50-c/s waveform, ignoring the first and last 1 μs. If this tilt is not well below 1 per cent of the bar amplitude, a fault condition exists.

NOTE:—It is important to check the oscilloscope at each sweep speed and at each attenuator setting to be used for measurement, against a waveform known to be impeccable. If it is impossible to avoid a very small residual tilt due to the oscilloscope, the measurement may be made by taking the difference of the tilts.

(k) Measure the impulse across V7, pin 8, using the x10 probe. The amplitude of the pulse should be about 15 volts and the half-amplitude duration should be less than 25 mμs.

(l) Disconnect C59 at position G on the switch and connect a 75-ohm resistor between the earthy end of C59 and earth. Measure the waveform across this resistor using a short length of coaxial cable terminated in 75 ohms at the oscilloscope end. The rise and fall times of the bar should be less than 25 mμs. Reconnect C59.

(m) The sine-squared pulse should be positioned 6·4 μs from the back edge of the sync pulse. Adjust C21 to achieve this condition.

(n) Set the function switches to *Line Sawtooth.* Adjust C81 to give a line-sawtooth amplitude excluding sync pulses of 0·7 volt. Use the Tektronix 545 with pre-amplifier 53/54G to compare the line-sawtooth waveform with a similar waveform known to be linear, e.g., from the GE4/505A. The difference between the two signals over the coincident parts of the sawtooth waveforms should be less than 0·015 volt. To compare the two waveforms it will be necessary to lock the GE4/505A to the GE4/504C using the line-sync output. Check that the back edge of the sawtooth does not distort the front edge of the line sync pulses.

Final Check of Generator Output

Proceed as given for the GE4/504 and GE4/504A.

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GENERATOR GE4/504D

General

The GE4/504D provides both 405- and 625-line 1T and 2T pulse-and-bar waveforms. Its performance is a compromise, however, and although adequate falls below that of the GE4/504A and GE4/504C.

The GE4/504D also provides a 50-c/s square waveform consisting of line sync pulses with a 50-microsecond line bar waveform switched off and on at 10-millisecond intervals. The line bar in the waveform is 30 microseconds short for 405-line working, and if the reading of the 50-c/s bar waveform tilt is not corrected, an optimistic result will be obtained; the correction factor is 1·6.

A line sawtooth waveform is also provided; this has a duration of 50 microseconds, and its amplitude can be adjusted to be correct on either line standard but not on both simultaneously. The output is normally set to the correct amplitude for 625 lines and is then about 1 dB high on 405 lines.

The only triggering pulses provided by the GE4/504D are an output of line syncs.

Circuit Description

General

All the waveform components except the 2T pulses for both line standards are formed in the main generator circuit (Fig. 28) which is a modified version of that of the GE4/504A. The GE4/504D version of the circuit has been modified to generate a 1T 405-line-standard pulse-and-bar waveform and a 1T 625-line-standard pulse-and-bar waveform instead of a 1T and a 2T waveform for the same line standard.

Separate circuits using transistors generate the 405-line-standard 2T pulse and the 625-line-standard 2T pulse. These circuits (Fig. 29) also include a mixing amplifier for each line standard.

The 2T pulse-and-bar waveforms are obtained by suppressing the 1T pulse in the 1T pulse-and-bar waveform and inserting a 2T pulse in its place. Each 2T pulse is fed to the appropriate mixing amplifier, and the 1T pulse-and-bar waveform from the output of the appropriate 1T filter (Fig. 30) is also fed to the mixing amplifier. When the 2T pulse is suppressed, the output is the 1T pulse-and-bar waveform. When the 1T pulse is suppressed, the output is the 2T pulse added to the bar of the 1T pulse-and-bar waveform. An auxiliary switch is provided labelled *1T* and *2T*. With the switch in the *1T* position, the 12-volt negative supply is disconnected from the 2T impulse generator, and the mixing amplifier output is the 1T pulse-and-bar waveform. With the switch in the *2T* position, the 12-volt negative supply is restored to the 2T impulse generator and the trigger to the 1T impulse generator is short-circuited. The mixing amplifier output is then the 2T pulse and T bar waveform.

Fig. 10.16 is a block diagram showing how 1T and 2T pulse-and-bar waveforms for either line standard are generated. The 1T impulse waveform, the bar and the sync waveforms are fed to the 1T filter input. The output of the 1T filter is fed to the mixing amplifier in the 2T generator and mixing circuit, where it is mixed with the 2T pulse waveform. The output of the mixing amplifier is fed to the output amplifier in the main generator.

Generator Circuit (Fig. 28)

The generator circuit of the GE4/504D, shown in Fig. 28, is a modified version of the GE4/504A generator circuit. One of the modifications is that the sync generator V2 is a monostable multivibrator and not an astable multivibrator, and thus needs line-frequency trigger pulses to operate it.

In the absence of trigger pulses, the right-hand half of V2 conducts heavily because its grid is connected to h.t. potential through R13, R14 and RV1. The grid of the left-hand half of V2 is connected to the potential divider formed by R8 and R220, and is held at a sufficiently low potential to cut the left-hand half of V2 off. A positive pulse on the left-hand grid of V2 causes this half to conduct, its anode potential falls and this fall in potential is transmitted to the right-hand grid through C7 and C8. This reduces the current in the right-hand half and the cathode potential falls. The fall in cathode potential increases the current in the left-hand half. Cumulative action thus changes the state to the left-hand half conducting and the right-hand half cut off.

C7 and C8 now start to discharge through R14 and RV1. The grid of the right-hand half of V2 therefore starts to rise towards h.t. potential. When the right-hand half starts to conduct, the cathode potential rises. This reduces the current in the left-hand half and its anode potential rises. The rise in potential is transmitted to the grid of the right-hand half through C7 and C8 re-enforcing the current rise in the right-hand half. The action of the circuit is cumulative and the state reverts to the right-hand half conducting and the left-hand half cut off. The duration of the pulse which is initiated by the trigger pulse is determined by the settings of C8 and RV1. The control RV1 (the left-hand control on the front of the unit) is used operationally to set the syncs to the correct width for the line standard to be used.

The pre-pulse signal is not available as a trigger output as it is on the GE4/504A. Instead, it is fed

the 625-line standard in the normal way. When the main switch is set to 405, an additional resistor, R222, is inserted between the grid of the left-hand side of V10 and h.t. This resistor, shown attached to the switch in Fig. 28, has a value chosen to provide the correct bar width. The start of the bar is 25 microseconds after the trailing edge of line syncs for both line standards.

The 50-c/s waveform and the line-sawtooth waveform are generated in the same way as in the GE4/504A.

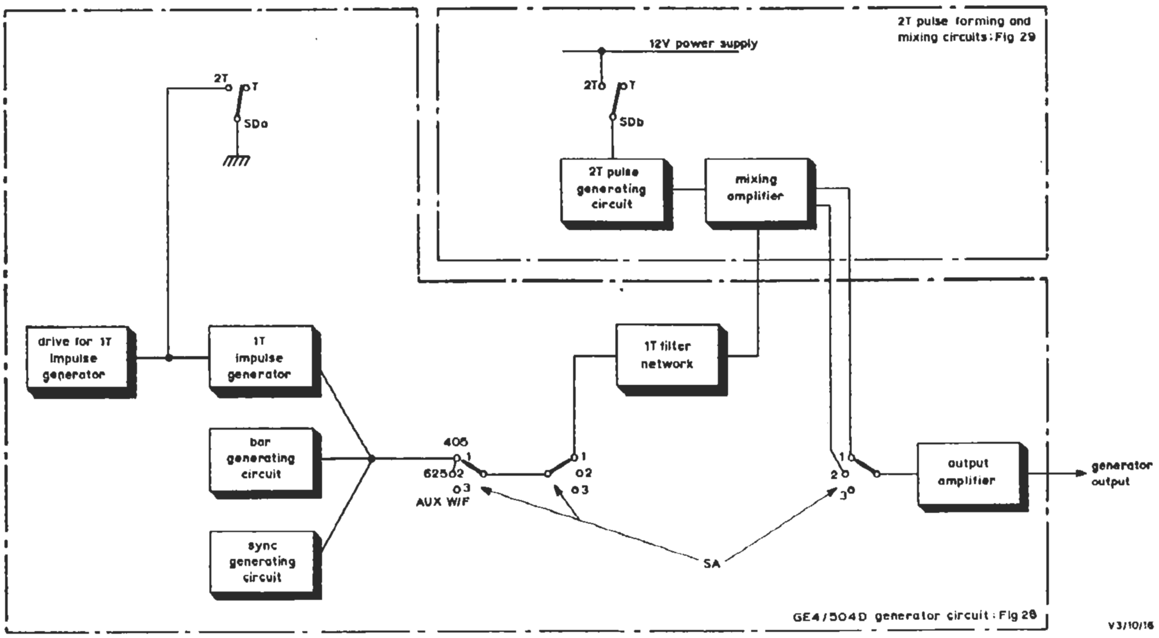

Fig. 10.16. Generator GE4/504D: Method of Producing 1T and 2T Pulse-and-bar Waveforms

to the 2T pulse generator and is used as a trigger pulse for this generator.

Earlier models of the GE4/504D used a valve impulse generator similar to that in the GE4/504 but later models use a transistor circuit as in the GE4/504A and GE4/504C.

The trigger pulses to the impulse generator board are shorted out when a 2T pulse-and-bar output is required. This is done by switching a diode across the anode load of the output side of V8.

Because this generator provides both 405- and 625-line-standard bar waveforms, the duration of the bar has to be altered from one line standard to the other. This is achieved by the method used to increase the bar duration for the 50-c/s waveform in the GE4/504A. C38 adjusts the bar duration for

2T Pulse Forming and Mixing Circuits (*Fig. 29*)

In the following account, the 405-line circuits only are described. The 625-line circuits are similar.

The purpose of the circuits is to generate the 2T pulses for both line standards and add them to the output waveform when required. The circuit diagram is shown in Fig. 29. The pulses are generated in a similar way to the 1T pulses. An impulse waveform is generated in a blocking oscillator, TR5, and is fed through a filter to produce a sine-squared pulse; this pulse is then fed via TR6 to the base of TR3. The 1T pulse-and-bar waveform is fed to the base of TR2. TR2 and TR3 have a common collector-resistor R3 and the combined output from TR2 and TR3 is fed to the final amplifier TR1.

The pre-pulse signal from the right-hand anode of V6 in the main generator circuit is fed to the trigger input for the 2T pulses. The signal is differentiated by C23 in the main generator circuit and R13 in the 2T pulse forming circuit. The signal at the trigger input terminal is therefore a series of negative-going pulses coincident with the leading edge of line syncs and positive-going pulses some 9 microseconds after the trailing edge of line syncs.

These pulses are amplified in TR4 and applied to the base of the blocking oscillator TR5. The polarity of the pulses is reversed in the amplification process and the pulses on the base of TR5 are positive-going coincident with the leading edge of line syncs and negative-going 9 microseconds after the trailing edge of line syncs.

Because the base of TR5 is connected to chassis potential through R18, this transistor is already in a state of low conduction and the positive pulses have little effect. The negative pulses make TR5 conduct more heavily. The rising current through the transformer winding in the collector circuit of TR5 induces a voltage across the winding in its emitter circuit which drives the emitter positive. This increases the emitter-to-base voltage, causing the current in the transistor to increase. The effect is cumulative, and the increase in current is very rapid.

As soon as the current approaches its maximum value, and its rate of increase starts to fall, the induced voltage in the transformer winding in the emitter circuit decreases. This tends to reduce the current in the transistor. Once the current starts to decrease, the induced voltage in the emitter winding reverses, and the current is cut off by cumulative action. The diode D1 removes any unwanted overshoots in the waveform. C8 tunes the transformer to the resonant frequency which provides pulses of the correct half-amplitude duration.

The impulse is transmitted to the base of the npn transistor TR6, an emitter-follower which feeds into the 2T filter. This filter is the same as the 2T filter used in the GE4/504 and GE4/504A, except for the values of the π-type loss-pads at the output and the input. The pulse at the filter output is fed to the base of TR3.

TR3 and TR2 are common-emitter amplifiers with a shared collector resistor in which the 1T pulse-and-bar and 2T pulse are added. The collectors of TR3 and TR2 are directly coupled to the output transistor TR1. The output amplitude is controlled by RV1 in TR1 collector circuit.

Power Supply for 2T Pulse Forming and Mixing Circuits (Fig. 29)

The power supply for the 2T pulse forming and mixing circuits is fed with 240-volt mains from the generator power supply. It provides two stabilised outputs, one at 12 volts positive, for TR6 and TR16, and one at 12 volts negative for the rest of the circuit. Bridge rectification is used for both outputs.

The 12-volt positive supply is smoothed by C41, C42 and R72 and then stabilised by zener diodes ZD1 and ZD2.

The 12-volt negative supply is a conventional series-stabilised circuit including TR21, TR22 and TR23 with ZD3 as the reference element.

Power Unit for GE4/504D (Fig. 31)

The unit providing power for the generator GE4/504D itself is shown in Fig. 31.

TEST PROCEDURE*: GE4/504D

General

The main generator circuit of the GE4/504D is tested and set up in a similar way to that of the GE4/504A. Data and tests specific to the GE4/504D follow.

Sine Squared Networks

Networks provided

The GE4/504D contains four sine-squared networks as follows:

1. 1T-network for 405-line standard,
2. 1T-network for 625-line standard,
3. 2T-network for 405-line standard,
4. 2T-network for 625-line standard.

The appropriate capacitance and inductance values for these four networks are given in the tables overleaf.

Transistor Impulse Generator

Test in the same way as for GE4/504C.

Waveform Generator

1. Apply a feed of 405-line trigger pulses to the sync input of the GE4/504D.
2. Check that the sync control knob has been positioned symmetrically on the potentiometer.
3. Rotate the control so that the index line is about

* Certain parts of this Test Procedure, e.g., the determination of correct values for a.o.t. resistors, can normally be left out unless other associated components have been disturbed.

TABLES OF CAPACITANCE AND INDUCTANCE VALUES FOR GE4/504D SINE SQUARED NETWORKS (SEE PAGE 10.37)

Capacitance Values

Network	*Total Capacitance*
405 1T	C100/C101 = 27 pF C105/C106 = 68 pF
625 1T	C108 = 11 pF C111/C112 = 38 pF
405 2T	C30/C31 = 94 pF C35/C36 = 41 pF
625 2T	C10/C11 = 160 pF C15/C16 = 72 pF

The capacitance values must be adjusted to be within ±0·25 per cent of the quoted values.

Inductance Values

Network	*Component Number*	*Resonance Frequency (Mc/s)*
405 1T	L1 L2 L4 L3	3·850 2·864 2·890 6·156
625 1T	L8 L9 L11 L10	3·616 2·613 2·637 10·260
405 2T	L1 L2 L3 L4	1·445 3·078 1·432 1·925
625 2T	L11 L12 L13 L14	2·637 5·130 2·613 3·502

in the centre of the escutcheon line adjacent to the *405 Line* engraving.

4. Adjust C8 to obtain a sync pulse width of 10 μs as observed at tag 10 using a x10 probe.
5. Replace the 405-line trigger pulse feed by a feed of 625-line trigger pulses and rotate the pulse width control until a sync pulse width of 5 μs is obtained. The index line on the knob should fall within the segment engraved on the escutcheon adjacent to the *625 Line* engraving.

The waveforms already given for the GE4/504 provide a guide to the shapes of the waveforms to be expected at the various points in the GE4/504D.

Output Amplifier

The output amplifier section formed by V12 and V13 should be checked in the same way as for the GE4/504 and GE4/504A, but using a 625-line-standard pulse-and-bar generator instead of a 405-line-standard generator.

Final Setting-up Procecure

When the GE4/504D has passed all previous tests the final setting-up procedure should be carried out. Allow 20 minutes warm-up period and then proceed as follows:—

(a) Apply a feed of 405-line trigger pulses to the sync input of the generator. Set the left-hand control to *405 Lines*, the centre control to *405 Lines* and the right-hand control to *T*. Connect the output of the generator to the input of a UN1/511 and the output of the UN1/511 to the input of the oscilloscope terminated in 75 ohms. Set the UN1/511 to *Signal* and observe the waveform on the oscilloscope.

(b) Adjust C57 (V5) so that the start of the bar occurs 25 μs after the back edge of the line sync pulse.

(c) Connect a 1-megohm variable resistor in place of R222 and adjust this to obtain a pulse width of 40 μs. Measure the value of the variable resistor and select an Erie Type-108 resistor with the nearest preferred value as R222.(The value should be about 330 kilohms.)

(d) Set the UN1/511 to *Measure Syncs*, operate the function switches to *Auxiliary Waveform* and *Line Sawtooth*, adjust the *Sync Pulse Amp.* control to obtain 0·3 volt, switch the function control to *405 Lines* and adjust RV1 on the 405-line card to obtain 0·3 volt of sync pulse.

(e) Operate the centre function switch to *625 Lines*, and adjust RV11 to obtain 0·3 volt of sync pulse. If either RV1 or RV11 does not have sufficient range of adjustment, then adjust the sync pulse amplitude so that the correct pulse amplitude can be obtained on both 625 and 405 positions simultaneously. The amplitude of the line sawtooth sync pulse will then be incorrect. Check that the error is less than 1·0 dB, i.e., that on the sawtooth waveform the sync pulse amplitude is within the range 0·27 to 0·33 volt approximately.

(f) Set the UN1/511 to *Measure Picture* and adjust the *Line Bar Amplitude* control to obtain a bar amplitude of 0·7 volt. (If it is not possible to adjust the bar amplitude to exactly 0·7 volt on both standards, then the best compromise should be adopted, i.e., the bar should be above 0·7 volt on one standard by the same amount as it is below it on the other standard. The difference value should not exceed 0·2 dB.)

(g) Set the generator function switch to *50-c/s Waveform* and the UN1/511 to *Signal.* Observe the waveform and adjust RV8 and RV9 to obtain a 50-c/s (20-ms) waveform with 1 : 1 mark-to-space ratio. (To adjust RV8 and RV9 it is necessary to remove the right-hand side cover of the GE4/504D.)

(h) Display the 50-c/s waveform on the oscilloscope in the d.c.-connected condition.

(i) Adjust RV7 to give 1·0 volt p-p of signal as measured using the UN1/511.

(j) Display the signal only. Connect a 250-kilohm variable resistor in place of R128 and adjust for minimum tilt on top of the 50-c/s waveform. Measure the variable resistor and select as R128 an Erie Type-109 resistor with the nearest nominal value.

(k) Check the waveform amplitude and if necessary adjust RV7 to obtain 1·0 volt of signal.

(l) Set the function switch to *Line Sawtooth* and measure the signal amplitude. Adjust C81 to obtain +0·5 dB with respect to 1 volt.

(m) Display a 405-line 2T pulse-and-bar signal on the oscilloscope, i.e., use 405-line triggers and set the switches to *405 Lines* and *2T* where appropriate. By means of C21, adjust the position of the sine-squared pulse to occur 9 μs from the back edge of the sync pulse. Using the GE4/502, display the pulse-and-bar signal and adjust RV2 to obtain unity pulse-to-bar ratio. Observe the pulse shape; this should have a first overshoot of 0·9 ±0·5 per cent and a second overshoot of 0·5 ±0·4 per cent. The trigger crosstalk which is apparent at the start of the pulse has an amplitude of about 2 per cent; the frequency components of the crosstalk aie extremely high, and will normally be eliminated by the band restriction of the circuit under test. To check that this is so, display the pulse on a Tektronix 515A oscilloscope. The crosstalk should have a displayed amplitude of less than 0·5 per cent.

(n) Display a 625-line 2T pulse. Adjust RV12 on the 625-line card to obtain unity pulse-to-bar ratio. The remarks in (m) above about the *405*-line 2T pulse also apply to the *625*-line 2T pulse waveform.

(o) Connect a 5-kilohm variable resistor in place of R206. Display a 625-line 1T pulse-and-bar waveform and check the bar amplitude. Set RV3 to the middle of its range of control and adjust the 5-kilohm resistor to obtain unity pulse-to-bar ratio. Measure the variable resistor and make R206 an Erie Type-N6A with the nearest preferred value. Readjust RV3 to obtain unity pulse-to-bar ratio. Connect a 5-kilohm variable resistor in place of R221 and repeat the above procedure for a 405-line 1T pulse. Exceptionally, the pulse amplitude may be insufficient; in this event, change the a.o.t. zener diode MR24 to obtain a higher supply voltage to the impulse generator card.

(p) Measure the tilt over the 40-μs duration of the 405-line bar waveform, ignoring the first and last 1 μs. The line tilt should be less than 0·25 per cent of the bar amplitude.

(q) Set the function switches to *625 Lines* and *Line Sawtooth.* Lock the frequency of the GE4/505A waveform to the GE4/504D waveform using the line sync output waveform. Use the Tektronix 545 with pre-amplifier 53/54G or Type G to compare the GE4/504D sawtooth with a similar waveform from the GE4/505A. The difference between the coincident parts of the waveforms should be less than 0·015 volt. Check that the slow back edge of the sawtooth waveform from the GE4/504D does not distort the front edge of the line sync pulses.

Final Check of Generator Output

Proceed as given for the GE4/504 and GE4/504A. Paragraph (c) should be qualified by the addition shown below in italics.

(c) Any other disturbances before, during or after the pulses should have amplitudes not greater than 0·2 per cent, *except to the extent already mentioned immediately before the 2T pulses.*

The following extra paragraph also applies:—

(g) Trigger the generator with 405-line pulses and observe the 405-line 1T pulse-and-bar waveform, the 2T pulse-and-bar waveform, the line-sawtooth waveform and the 50-c/s waveform in order. Trigger the generator with 625-line pulses and observe the corresponding set of 625-line waveforms. The waveforms should be free from significant defects, although the signal amplitude will change slightly between 625 and 405 lines on the *Auxiliary Waveform* position. No pre-set adjustments should be necessary on changing from 625 to 405 lines or in the reverse direction.

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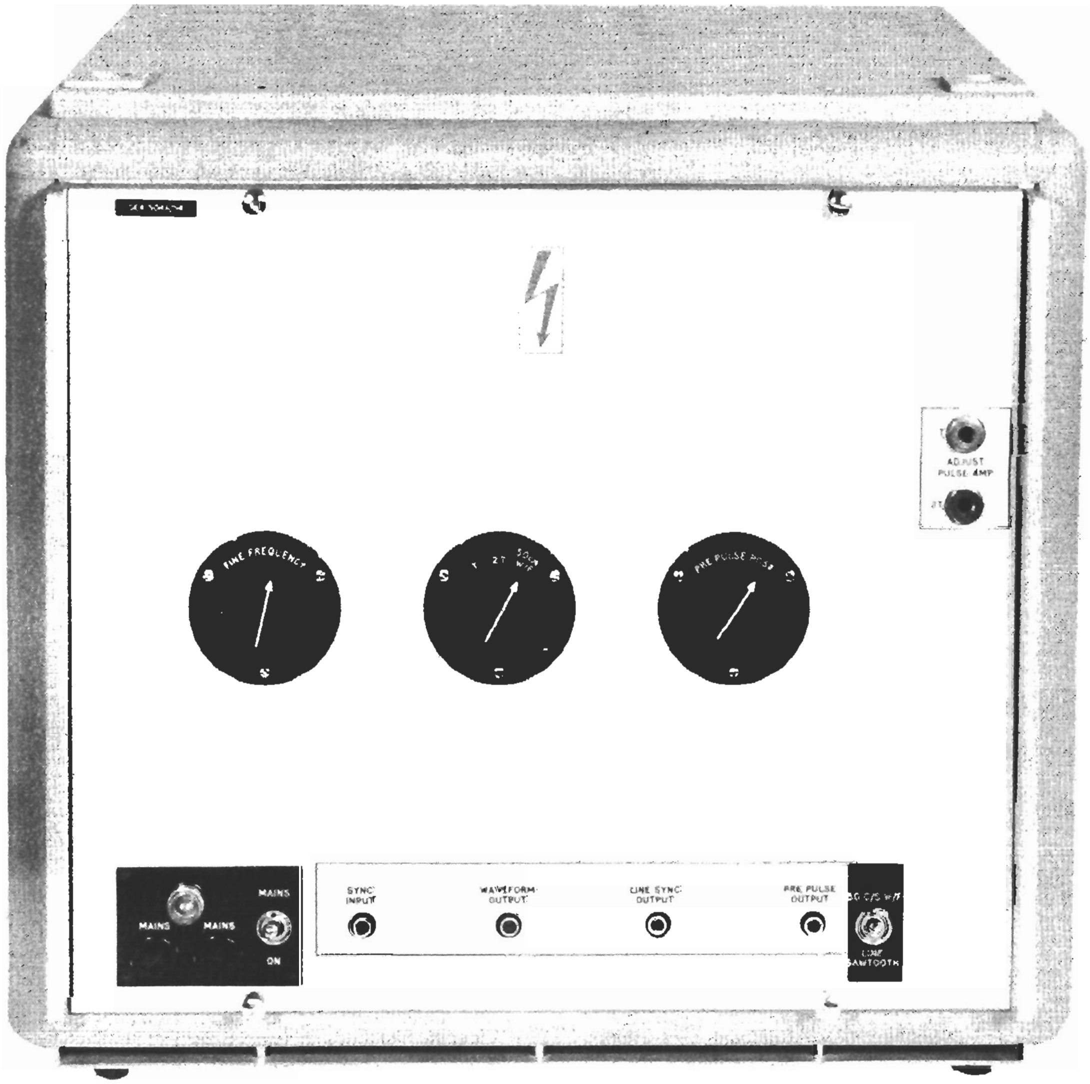


Plate XI. GE4/504A: Front View

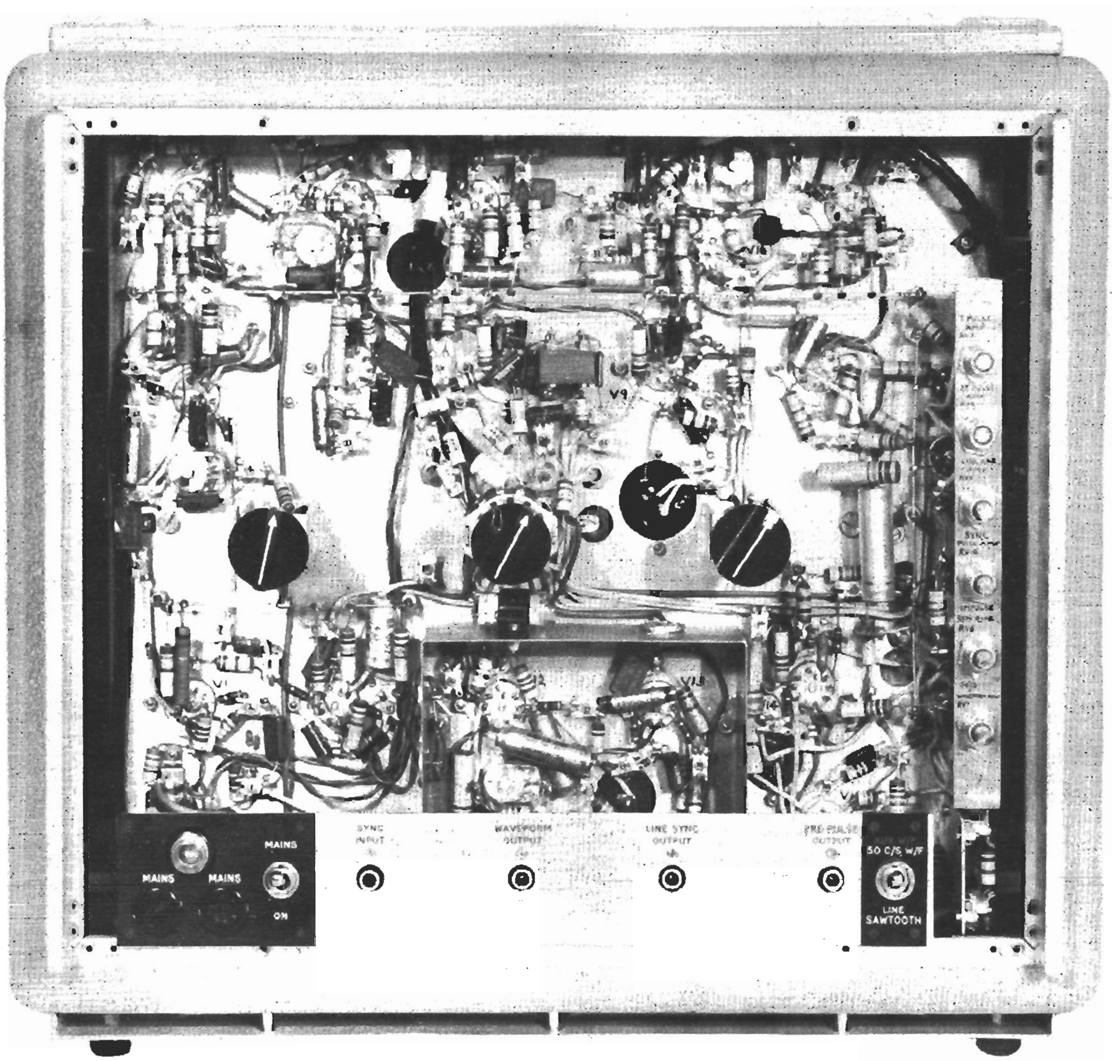


Plate XII. GE4/504A: Internal Front View

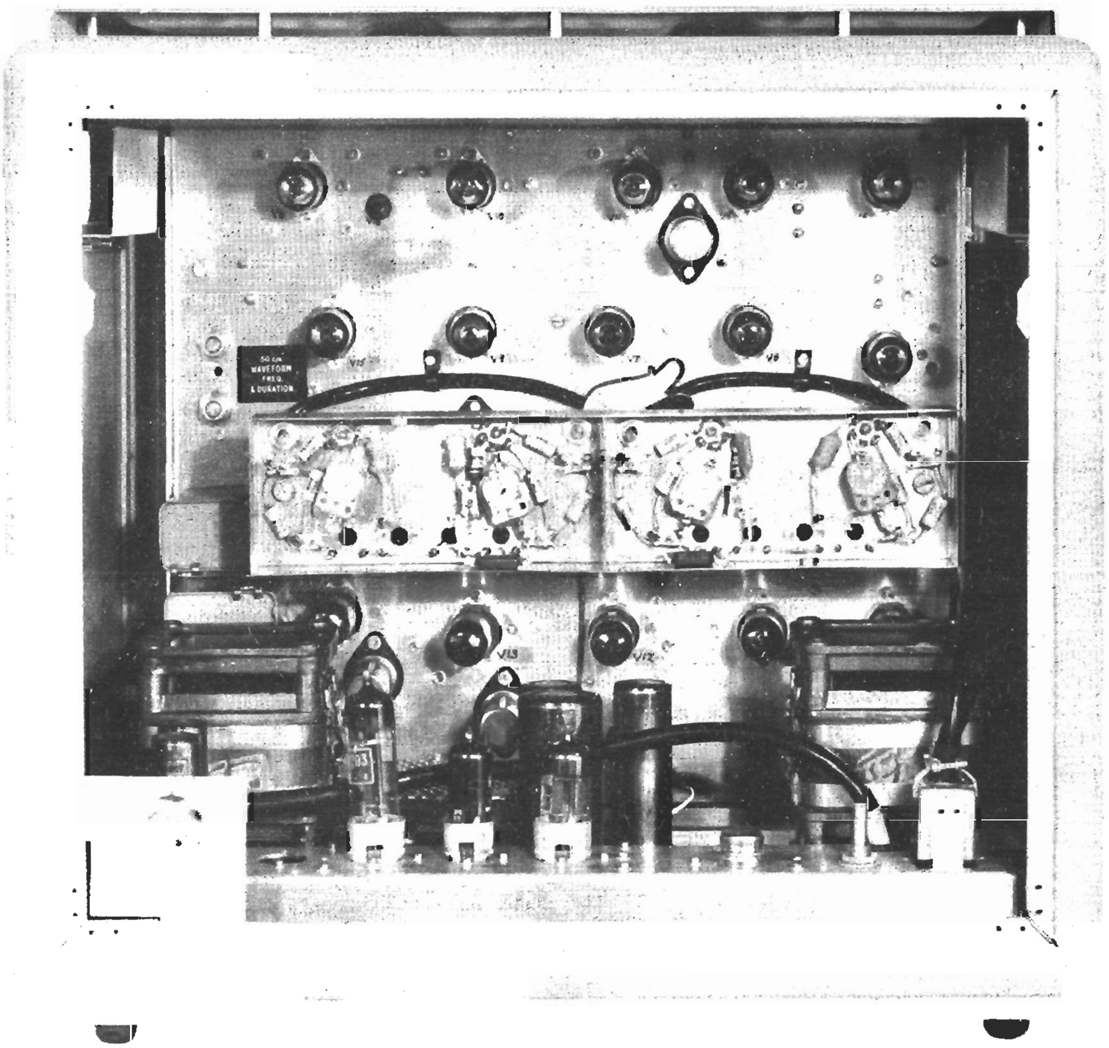
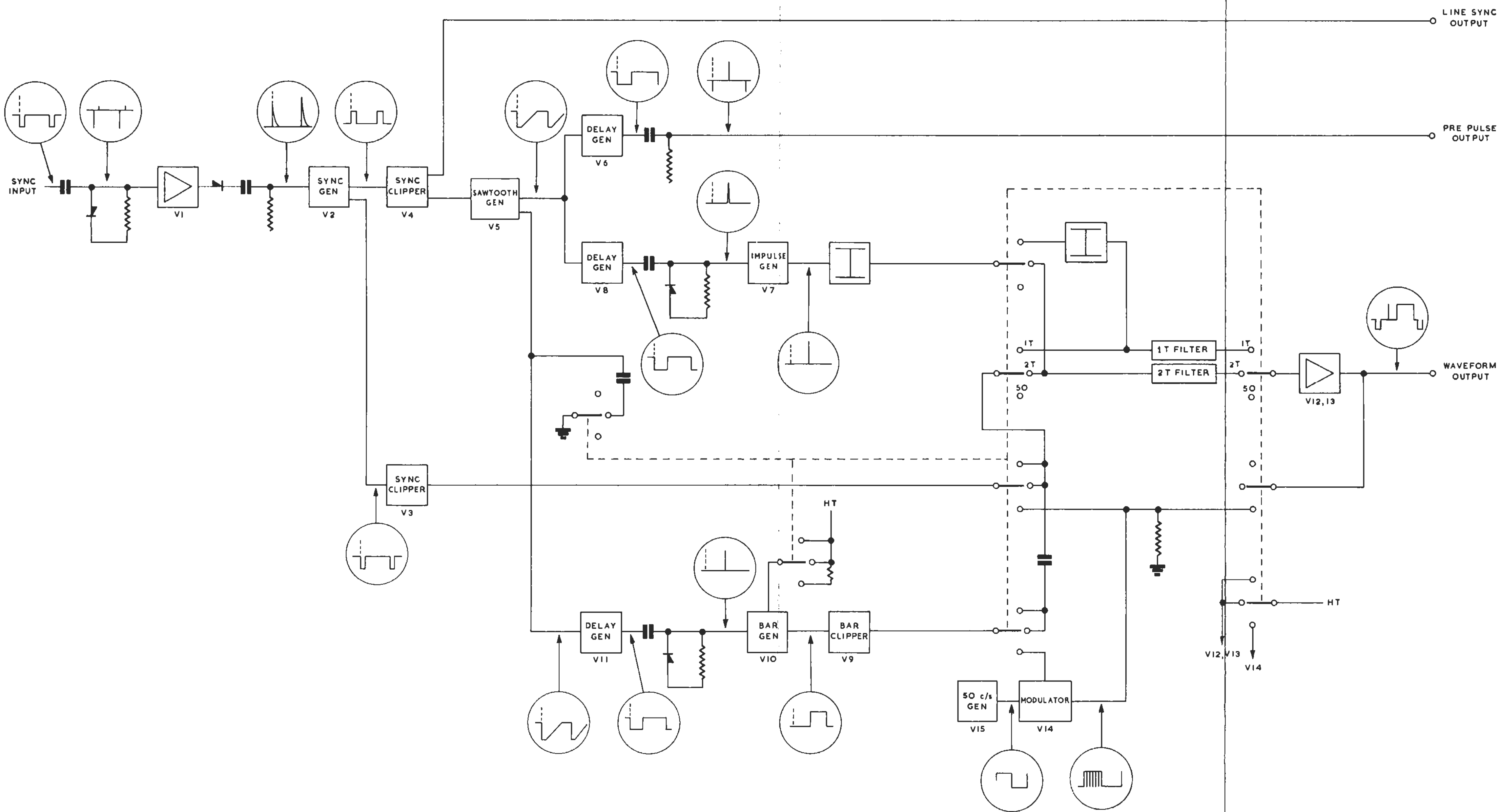


Plate XIII. GE4/504A: Internal Rear View



SINE-SQUARED PULSE AND BAR WAVEFORM TEST GENERATOR GE4/504: SCHEMATIC

COMPONENT TABLE: FIG. 22

PAGE I

Comp.	Loc.	Type	Tolerance per cent	Comp.	Loc.	Type	Tolerance per cent
C1	B4	T.C.C. CSM20N		C50	G20	T.C.C. CSM20N	
C2	C6	Plessey CE19/1		C51	G22	Oxley A7/18D	
C3	E4	Hunt B810		C52	I20	Hunt B810	
C4	H3	T.C.C. CSM20N		C53	J15	Hunt B810	
C5	H3	Oxley A7/65D		C54	J18	T.C.C. CP35N/PVC	
C6	I3	T.C.C. CSM20N		C55	K16	Plessey CE809/1	
C7	K4	T.C.C. CSM20N		C56	L15	S.T. & C. 455/LWA/2A	
C8	L4	Oxley A7/18D		C57	V5	Oxley A7/65D	
C9	M5	Erie NO30AD		C58	V5	T.C.C. CSM20N	
C10	M2	Hunt B810		C59	U18	T.C.C. SCE79PE/PVC	
C11	O2	T.C.C. SCE79PE/PVC		C60	W18	Plessey CE809/1	
C12	O6	Hunt B810		C61	X18	Dubilier B209	
C13	P4	Plessey CE809/1		C62	Z15	Dubilier B211	
C14	P6	Hunt B500K		C63	Z18	T.C.C. CP37N/PVC	
C15	Q6	T.C.C. CP32N/PVC		C64	AB17	G.E.C. Polyester 250 V	2
C16	R2	Hunt A311		C65	AD20	G.E.C. Polyester 250 V	2
C17	S3	T.C.C. CP32N/PVC					
C18	S6	Hunt B810		MR1	B5	CV 425	
C20	W6	T.C.C. CSM20N		MR2	G2	CV 425	
C21	X6	Oxley A7/30D		MR3	U6	CV 425	
C22	Z3	T.C.C. CP32N/PVC		MR4	E13	CV 425	
C23	AB3	T.C.C. CSM20N		MR5	S12	CV 425	
C24	C10	Hunt B810					
C25	C12	G.E.C. Polystyrene 125 V	2	R1	A5	Erie 109	
C26	D10	Hunt B810		R2	C5	Erie 9	
C27	C12	Hunt B847		R3	C4	Erie 16	
C28	D12	Hunt B847		R4	D1	Erie Type 8	
C29	D13	Plessey CE19/1		R5	D6	Erie 109	
C30	E10	Hunt B810		R6	E1	Erie 108	
C31	G10	T.C.C. CSM20N		R7	E6	Erie 109	
C32	H10	T.C.C. CP32N/PVC		R8	H2	Erie 109	
C33	M12	Hunt B847		R9	I4	Erie 16	
C34	N12	Hunt B847		R10	J1	Erie 108	
C35	N10	Plessey CE821/1		R11	J6	Painton P306A	
C36	O13	Plessey CE821/1		R12	J1	Painton P306A	
C37	O9	T.C.C. CP35N/PVC		R13	K4	Erie 16	
C38	P10	Oxley A7/65D		R14	L1	Erie 109	
C39	P10	T.C.C. CSM20N		R15	M4	Erie 109	
C40	R13	Hunt B500K		R16	M6	Erie 109	
C41	S10	T.C.C. CSM20N		R17	M4	Erie 16	
C42	S13	Hunt B500K		R18	N1	Erie 9	
C43	U10	T.C.C. CP32N/PVC		R19	N6	Painton P306A	
C44	U13	Hunt B500K		R20	N1	Erie 108	
C45	B17	S.T. & C. 455/LWA/2A		R21	O4	Erie 16	
C46	B17	S.T. & C. 455/LWA/2A		R22	O1	Erie 108	
C47	D19	Plessey CE1222/1		R23	O6	Erie 108	
C48	D20	Plessey CE809/1		R24	P1	Erie 108	
C49	G16	T.C.C. CP32N/PVC		R25	Q5	Erie 9	

COMPONENT TABLE: FIG.22

PAGE 2

Comp.	Loc.	Type	Tolerance per cent	Comp.	Loc.	Type	Tolerance per cent
R26	Q6	Erie 109		R74	P8	Erie 8	
R27	Q4	Erie 16		R75	Q13	Painton P306A	
R28	R1	Erie 8		R76	Q8	Erie 108	
R29	R6	Painton P306A		R77	Q11	Erie 16	
R30	R1	Erie 8		R78	R12	Erie 109	
R31	S4	Erie 9		R79	Q13	Erie 109	
R32	T6	Erie 9		R80	S11	Erie 109	
R33	T4	Erie 9		R81	S12	Erie 109	
R34	U1	Erie 109		R82	T11	Erie 16	
R35	U1	Erie 109		R83	U8	Erie 108	
R36	V4	Erie 9		R84	U13	Painton P306A	
R37	X4	Erie 16		R85	U8	Erie 108	
R38	Y1	Erie 108		R86	V11	Erie 16	
R39	Y6	Erie 108		R87	V12	Erie 9	
R40	Y1	Erie 8		R88	V13	Erie 109	
R41	Z4	Erie 16		R89	V8	Erie 108	
R42	Z4	Erie 9		R90	W12	Erie 109	
R43	AB1	Erie 109		R91	W13	Erie 109	
R44	AB6	Erie 109		R92	X12	Erie 109	
R45	AB6	Erie 9		R93	X13	Erie 109	
R46	AD2	Erie 109		R94	Y12	Erie 109	
R47	AD3	Erie 109		R95	Y13	Erie 109	
R48	B13	Erie 9		R96	C20	Erie 109	
R49	C13	Erie 109	1	R97	E15	Painton P306A	
R50	D10	Erie 8		R98	E20	Erie 109	
R51	D13	Erie 9		R99	F18	Erie 16	
R52	D9	Erie 9		R100	F19	Erie 9	
R53	E11	Erie 9		R101	F20	Erie 109	
R54	F13	Erie 9		R102	E17	Erie 109	
R55	F12	Erie 109	1	R103	G21	Erie 109	
R56	F13	Erie 109	1	R104	H15	Erie 108	
R57	G13	Erie 57		R105	H20	Erie 109	
R58	H11	Erie 16		R106	H16	Erie 16	
R59	H8	Erie 9		R107	I15	Erie 108	
R60	H13	Painton P306A		R108	I20	Erie 108	
R61	I8	Erie 8		R109	I18	Erie 16	
R62	I11	Erie 16		R110	I20	Erie 9	
R63	K8	Erie 108		R111	K15	Erie 100	
R64	L11	Erie 16		R112	K16	Erie 100	
R65	M8	Erie 108		R113	K20	Erie 109	
R66	N13	Painton P306A		R114	K18	Erie 16	
R67	M8	Painton P306A		R115	L20	Erie 109	
R68	N11	Erie 16		R116	T16	Erie 108	
R69	N12	Erie 9		R117	T20	Erie 109	
R70	N13	Erie 109		R118	V19	Painton P306A	
R71	O8	Erie 109					
R72	O9	Erie 109		R120	X20	Erie 108	
R73	P11	Erie 16		R121	X18	Erie 16	

COMPONENT TABLE: FIG. 22

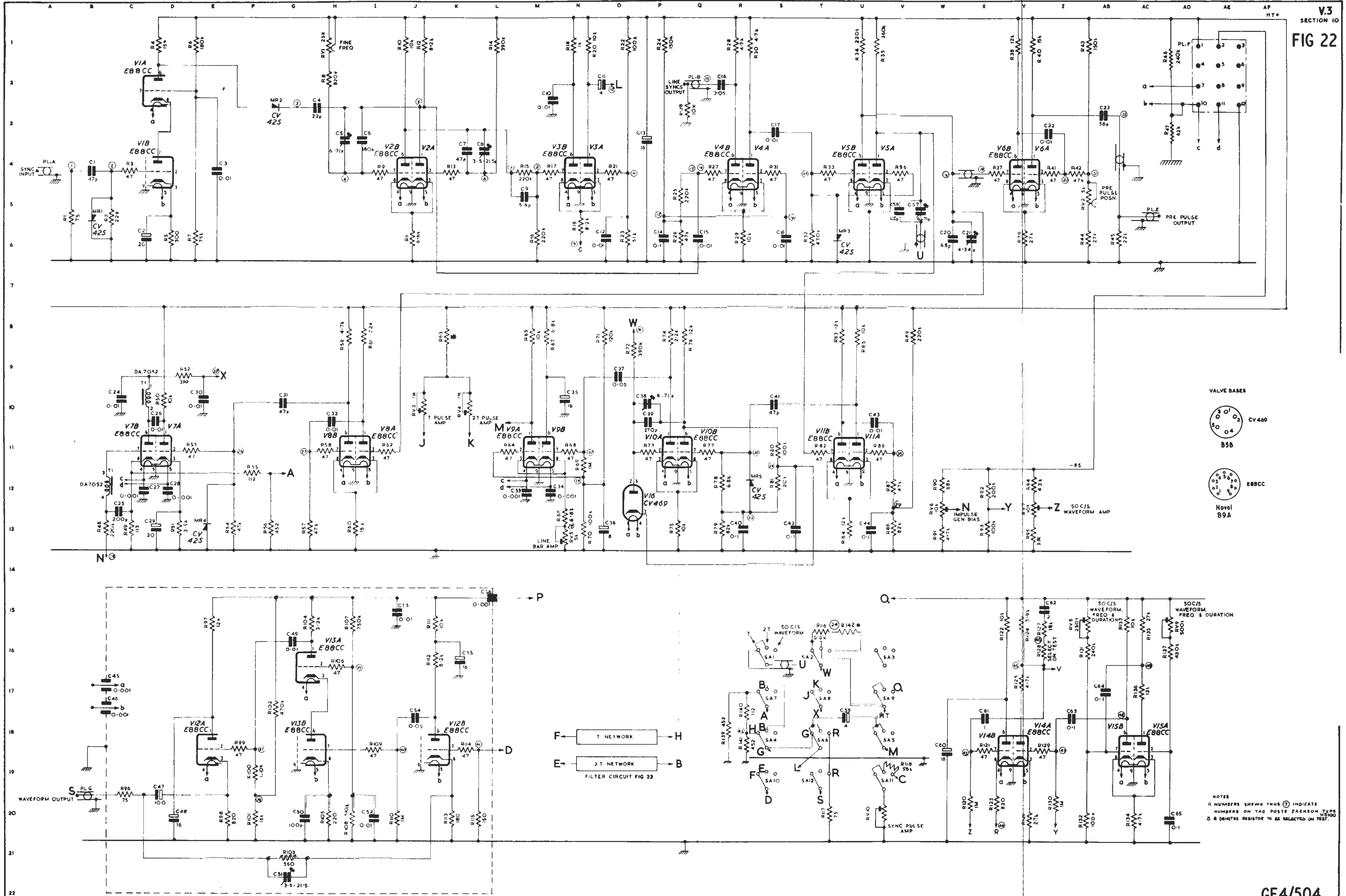
PAGE 3

Comp.	Loc.	Type	Tolerance per cent	Comp.	Loc.	Type	Tolerance per cent
R122	Y15	Erie 8		R139	R18	Erie 109	1
R123	X20	Erie 8		R140	R18	Erie 109	1
R124	Y15	Painton MV1A		R141	R18	Erie 109	1
R125	Y17	Painton MV1A		R142	U16	Erie 108	
R126	Y20	Erie 8					
R127	Z15	Erie 109		RV1	H1	Plessey MH2 CP161100/513	
R128	Z16	Erie 109		RV2	AB5	Colvern CLR1132/15S	
R129	Y18	Erie 16		RV3	J10	Plessey MH CP161100/509	
R130	Z20	Erie 8		RV4	K10	Plessey MH CP161100/509	
R131	AB16	Erie 108		RV5	N13	Colvern CLR1132/15S	
R132	AB20	Erie 108		RV6	W12	Colvern CLR1132/15S	
R133	AC15	Erie 100		RV7	Y12	Colvern CLR1132/15S	
R134	AC20	Painton MV1A		RV8	Z15	Plessey MH2 CP161100/507	
R135	AC15	Erie 108		RV9	AC15	Plessey MH CP161100/509	
R136	AC17	Erie 108		RV10	V20	Colvern CLR1132/15S	
R137	AC16	Erie 108					
				T1	C12	DA 7052	

60/GGJ/202/DE
DK 7051
ISSUE 3

V.3
SECTION 10

FIG 22

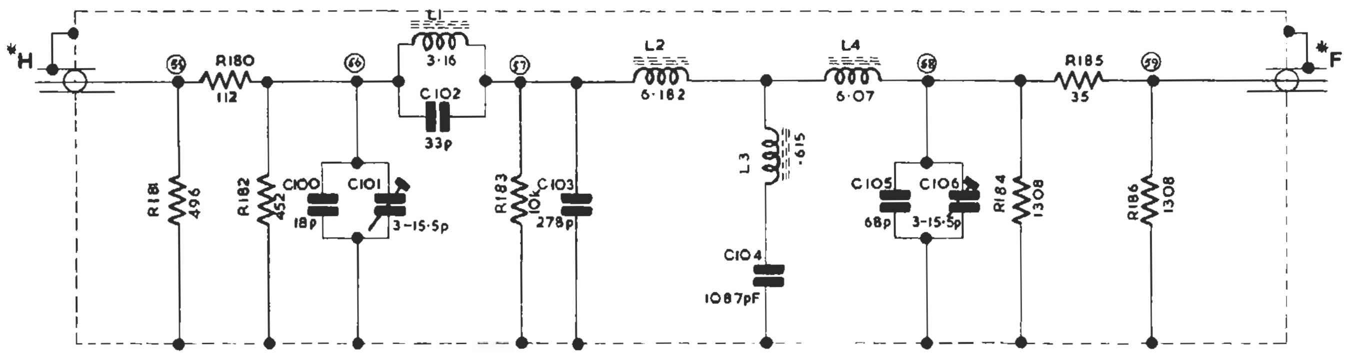


SINE-SQUARED PULSE AND BAR WAVEFORM TEST GENERATOR GE4/504 : CIRCUIT

GE4/504
CIRCUIT

COMPONENT TABLE: FIG. 23

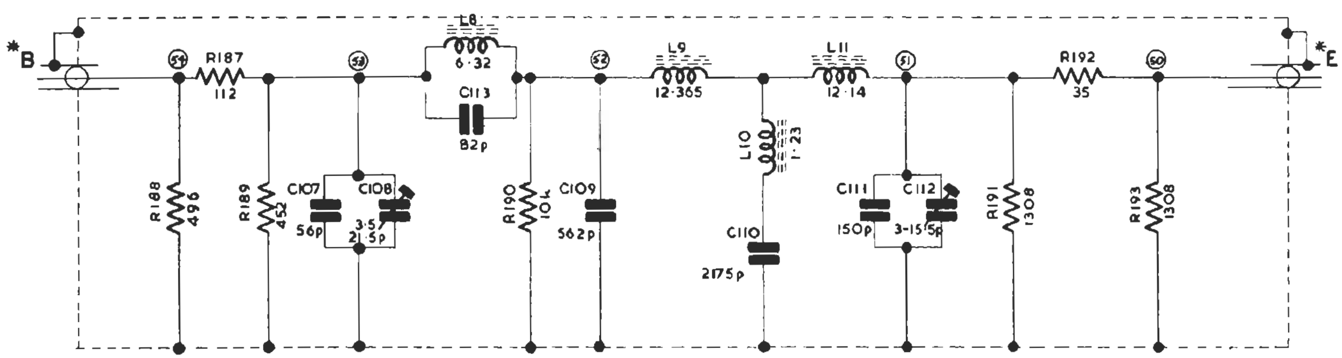
Comp.	Loc.	Type	Tolerance per cent	Comp.	Loc.	Type	Tolerance per cent
C100	C3	T.C.C. CSM20N		L8	D2		
C101	C3	Oxley A7/12·5D		L9	F6		
C102	D2	T.C.C. CSM20N		L10	F7		
C103	E3	Johnson Matthey A22 350 V	5	L11	G7		
C104	F3	Johnson Matthey A22 200 V	5				
C105	G3	T.C.C. CSM20N		R180	B2	Erie 109	1
C106	H3	Oxley A7/12·5D		R181	B3	Erie 109	1
C107	C8	T.C.C. CSM20N		R182	B3	Erie 109	1
C108	C8	Oxley A7/18D		R183	D3	Erie 109	
C109	E8	Johnson Matthey A22 200 V	5	R184	J3	Erie 109	1
C110	F8	Johnson Matthey A22 200 V	5	R185	J2	Erie 109	0·5
C111	H8	G.E.C. Polystyrene 125 V		R186	K3	Erie 109	1
C112	H8	Oxley A7/12·5D		R187	B6	Erie 109	1
				R188	B8	Erie 109	1
				R189	B8	Erie 109	1
L1	D1			R190	D8	Erie 109	
L2	F2			R191	H8	Erie 109	1
L3	F2			R192	J7	Erie 109	0·5
L4	G2			R193	K8	Erie 109	1



1T 0·167 μs SIN² NETWORK & PADS

NOTE:- 1 POINTS SHOWN THUS *B INDICATE CONNECTIONS OF CORRESPONDING LETTERING ON GE4/504 & GE4/504A CIRCUITS (FIGS 22 & 25)

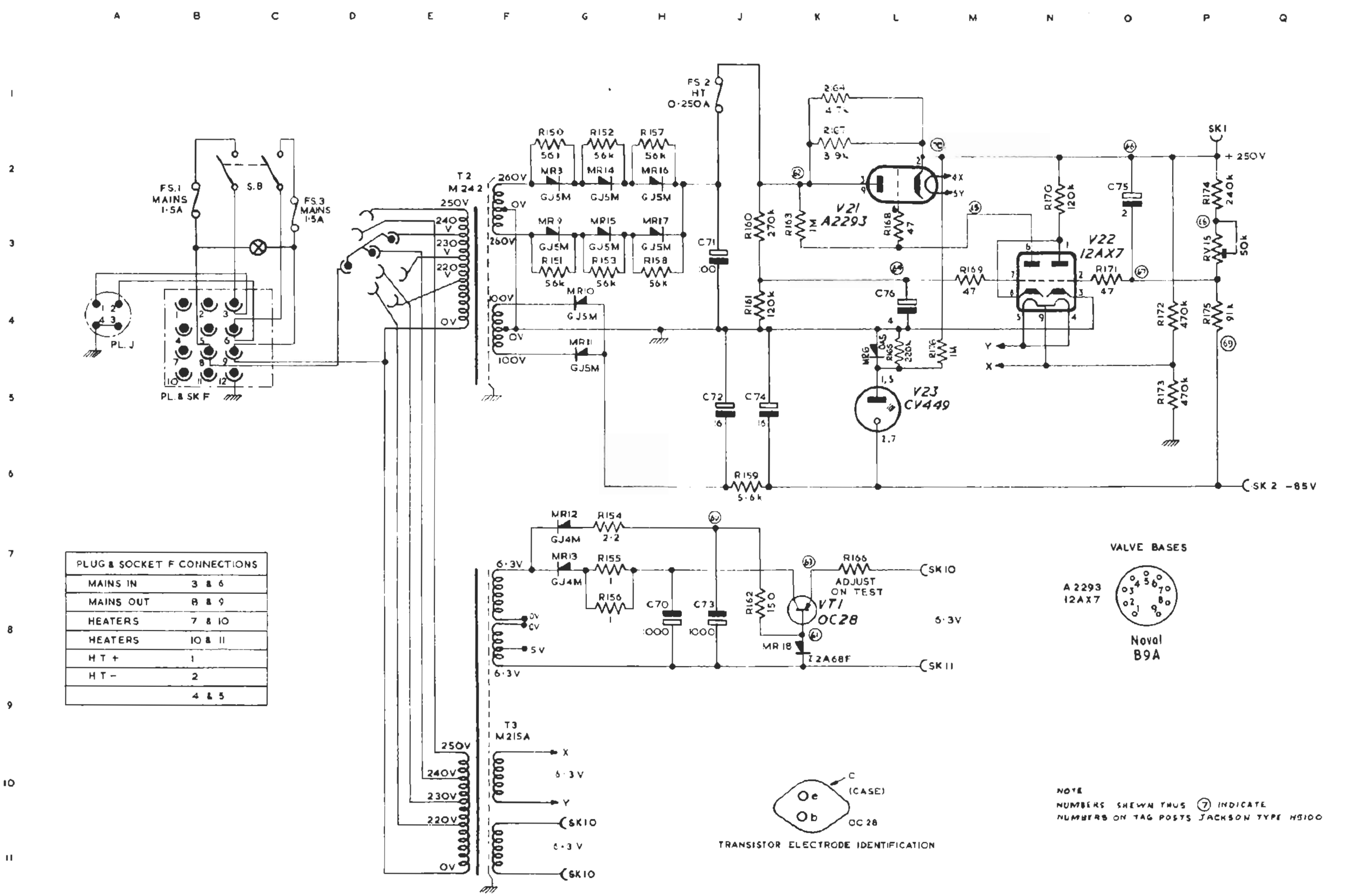
2 NUMBERS SHOWN THUS (7) INDICATE NUMBERS ON TAG POSTS JACKSON TYPE H5100



2T 0·33μs SIN² NETWORK & PADS

FIG 23

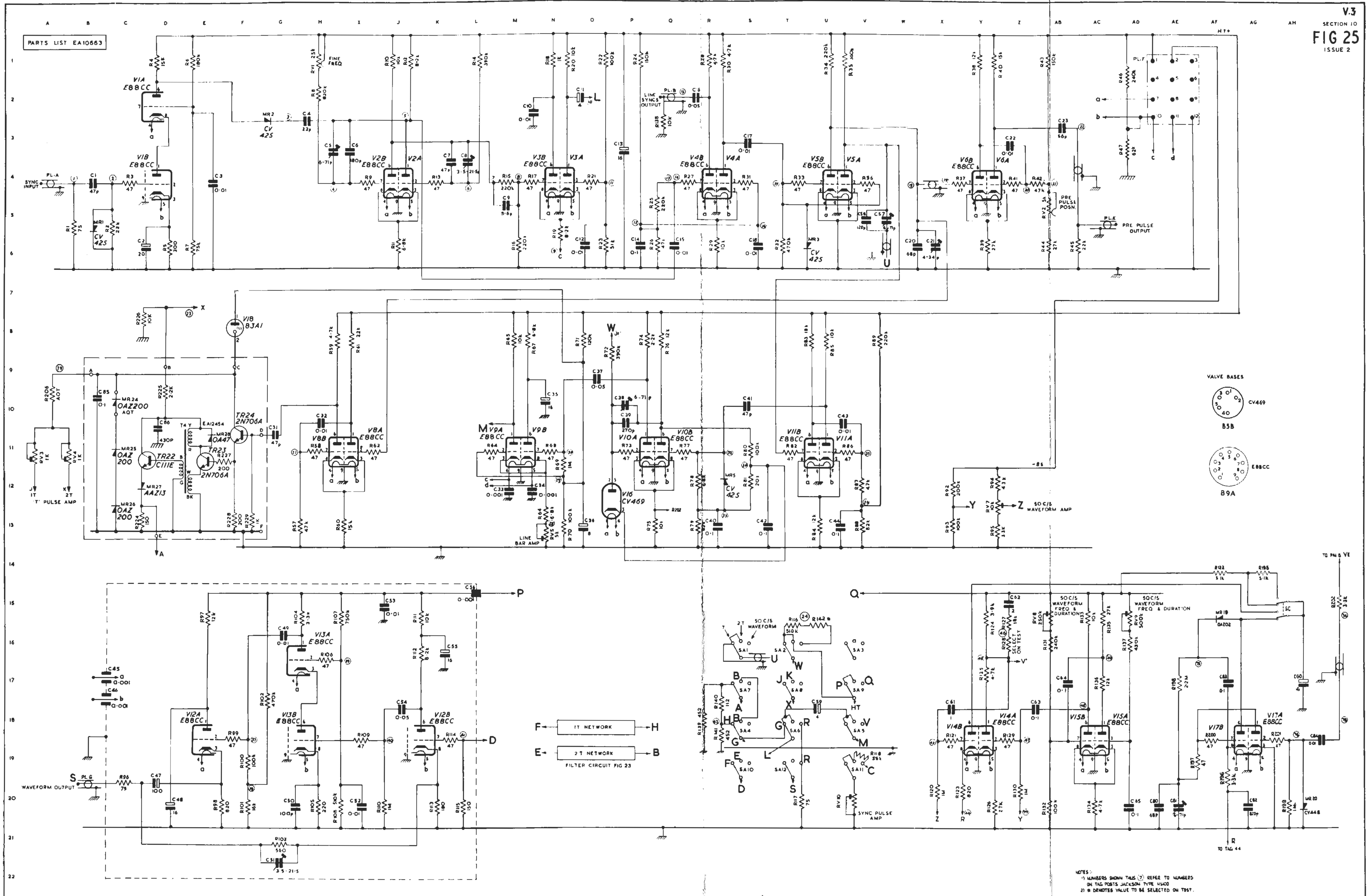
1T AND 2T FILTER CIRCUITS FOR GE4/504 AND GE4/504A



PLUG & SOCKET F CONNECTIONS	
MAINS IN	3 & 6
MAINS OUT	8 & 9
HEATERS	7 & 10
HEATERS	10 & 11
H T +	1
H T −	2
	4 & 5

FIG 24

POWER UNIT FOR GE4/504 AND GE4/504A : CIRCUIT

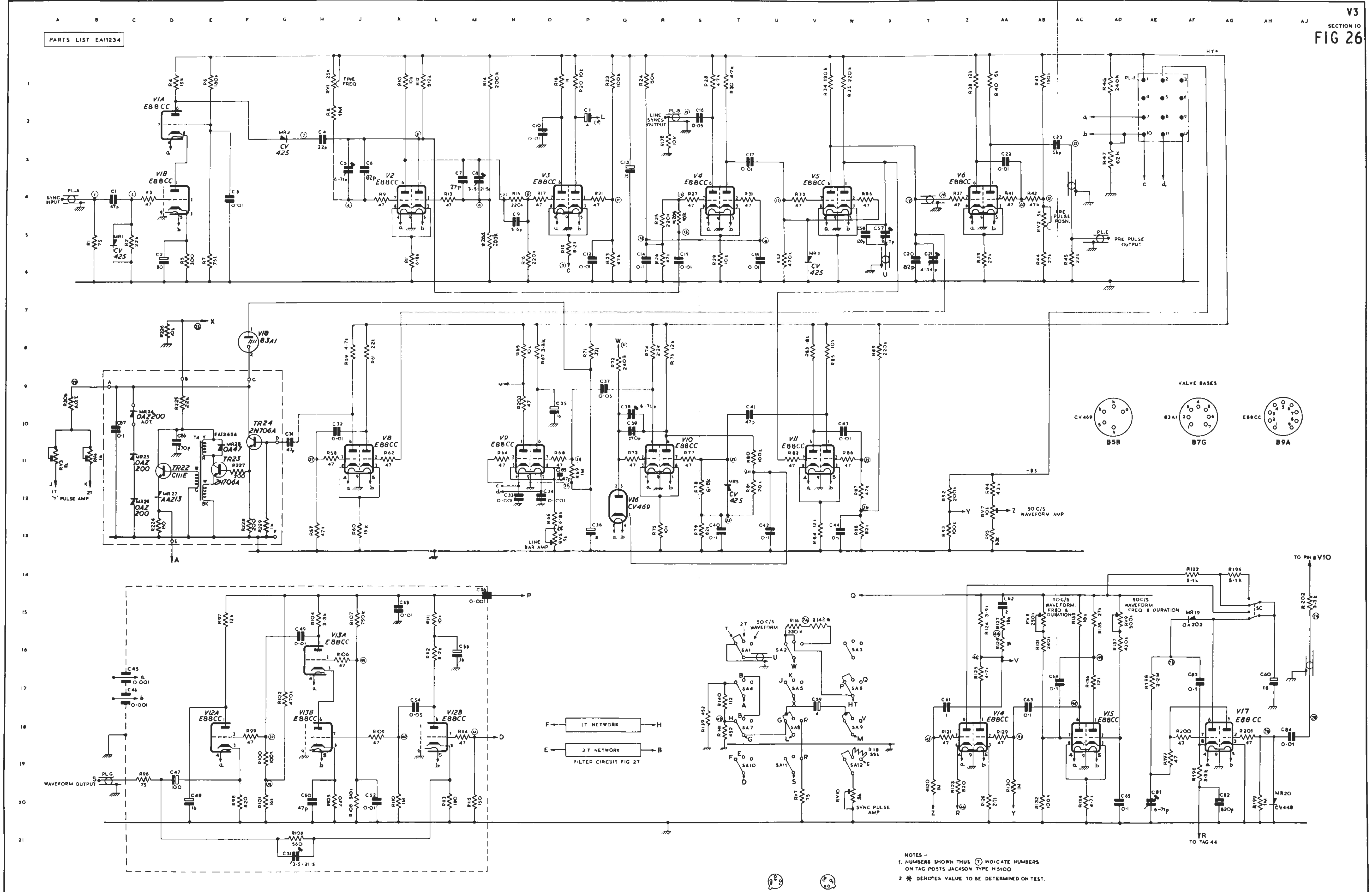


SINE-SQUARED PULSE AND BAR WAVEFORM TEST GENERATOR GE4/504A (MODIFIED VERSION): CIRCUIT

GE4/504A
CIRCUIT

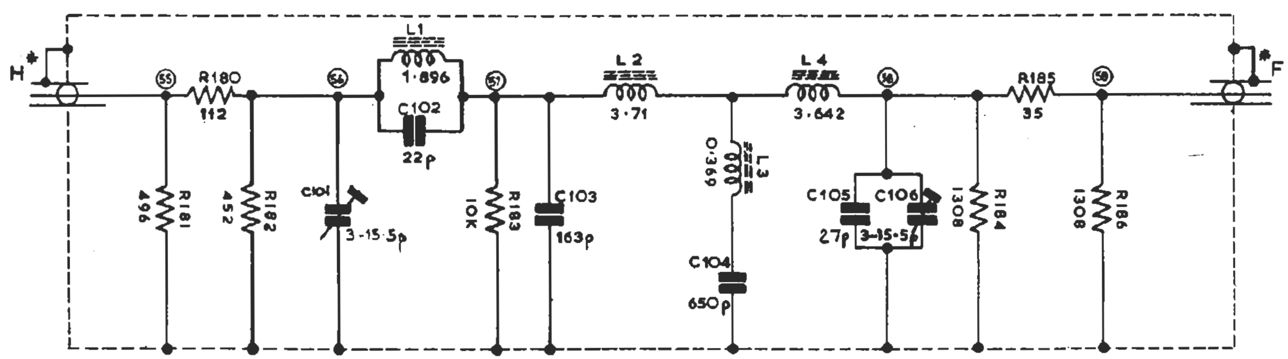
65/JW/009/BK
EK11306
ISSUE 5

V3
SECTION 10
FIG 26



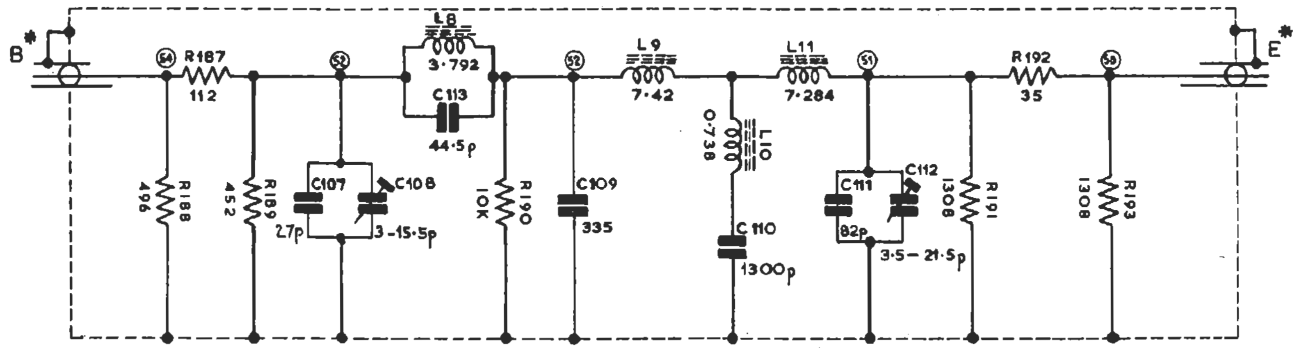
SINE-SQUARED PULSE AND BAR WAVEFORM TEST GENERATOR GE4/504C: CIRCUIT

GE4/504C
CIRCUIT



1T 0·1 μs SIN² NETWORK & PADS.

NOTE
POINTS SHOWN THUS B* INDICATE CONNECTIONS OF CORRESPONDING LETTERING ON GE4/504C CIRCUIT (FIG 26)
NUMBERS SHOWN THUS (50) INDICATE NUMBERS ON TAG POSTS JACKSON TYPE HS100

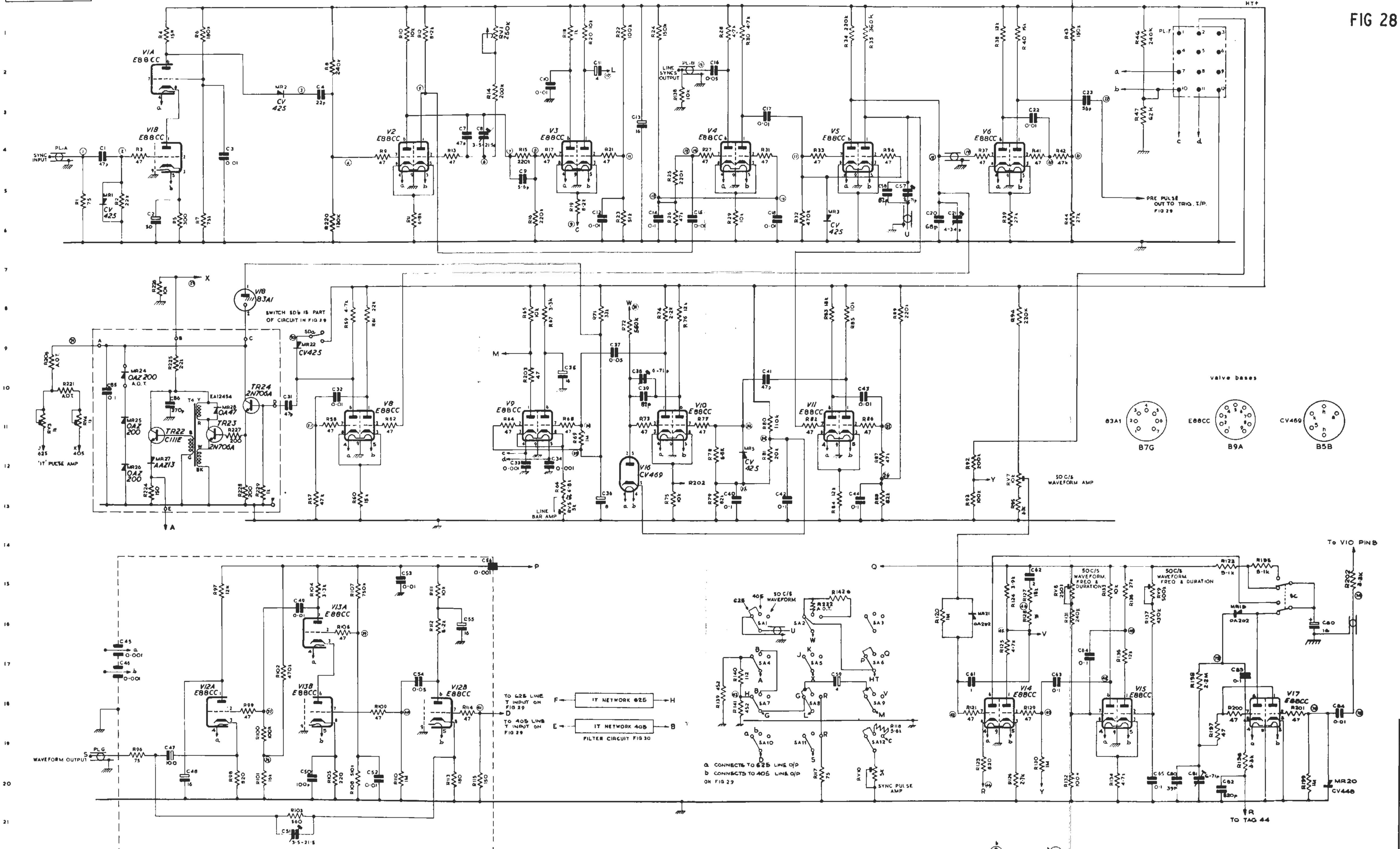


2T 0·2 μs SIN² NETWORK & PADS.

1T AND 2T FILTER CIRCUITS FOR GE4/504C

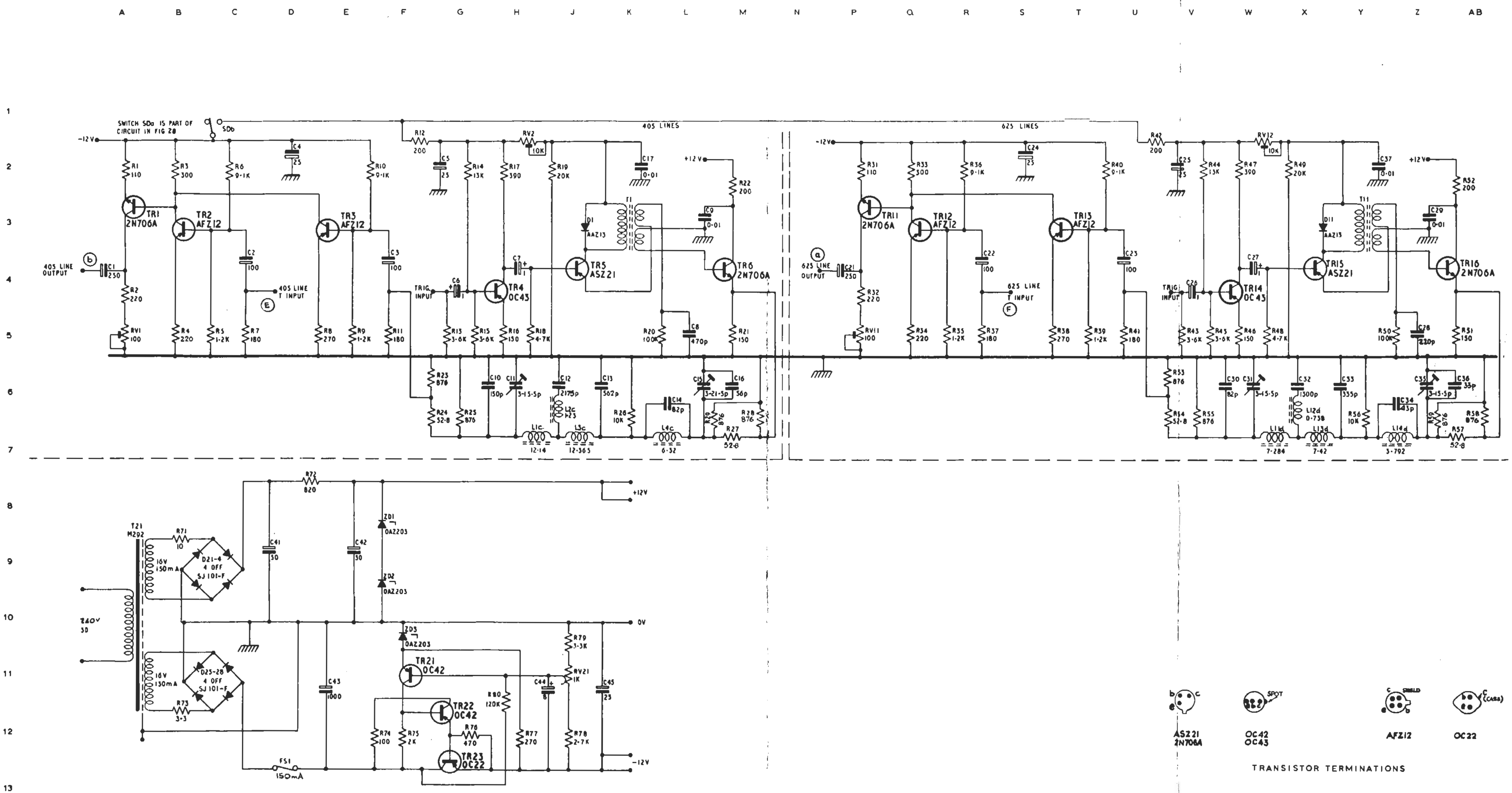
PARTS LIST DA11816

FIG 28



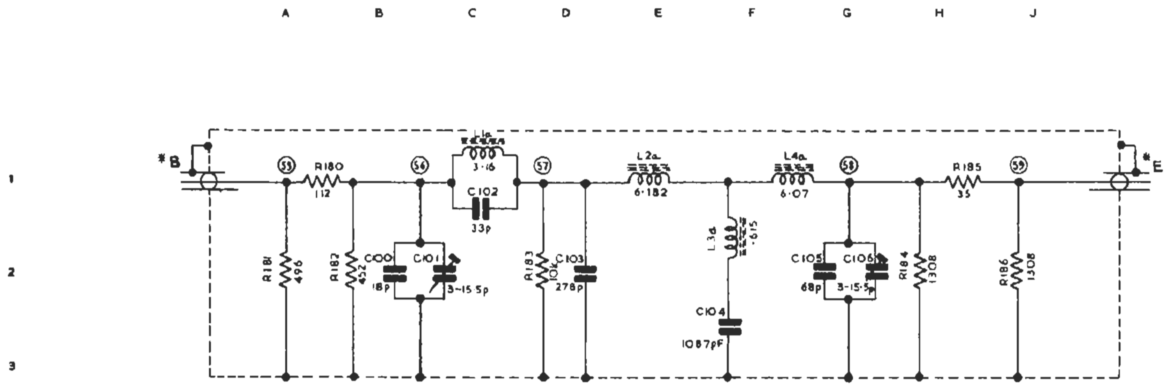
SINE-SQUARED PULSE AND BAR WAVEFORM TEST GENERATOR GE4/504D: CIRCUIT.

GE4/504D
CIRCUIT



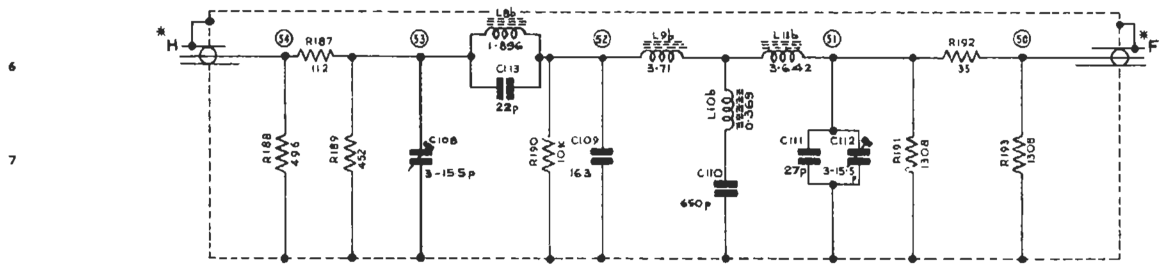
2T PULSE FORMING AND MIXING CIRCUITS OF GE4/504D

2T PULSE
CCTS OF
GE4/504D



IT 0·167µs SIN² NETWORK & PADS

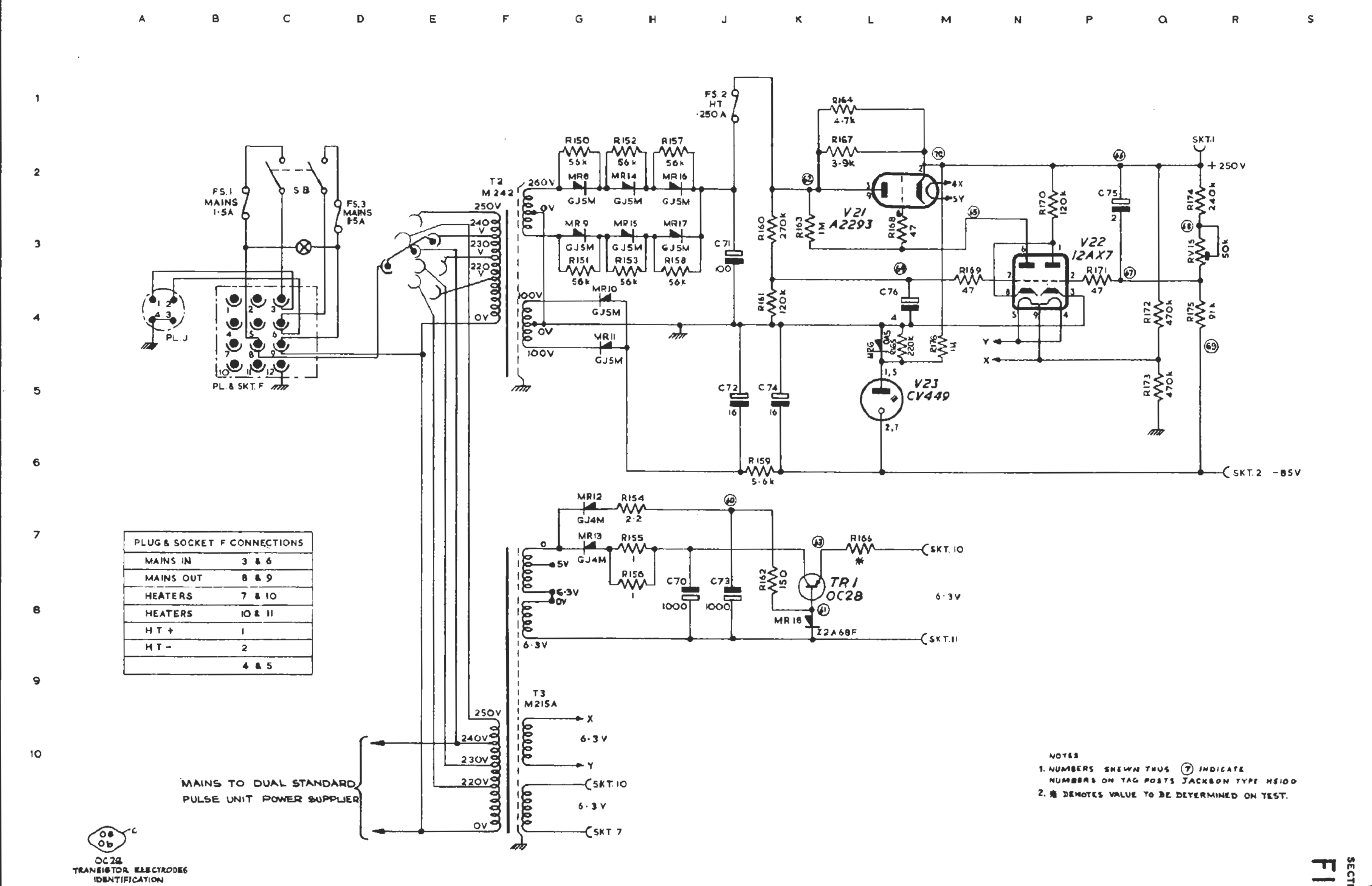
POINTS SHOWN THUS *B INDICATE POINTS OF CORRESPONDING LETTERING IN FIG 29



IT 0·10µs SIN² NETWORK & PADS

IT FILTER CIRCUITS FOR 405 AND 625 LINE STANDARDS IN THE GE4/504D

65/JW/616
DC11813
ISS.2



PLUG & SOCKET F CONNECTIONS	
MAINS IN	3 & 6
MAINS OUT	8 & 9
HEATERS	7 & 10
HEATERS	10 & 11
HT +	1
HT −	2
	4 & 5

NOTES
1. NUMBERS SHEWN THUS (7) INDICATE NUMBERS ON TAG POSTS JACKSON TYPE HS100
2. * DENOTES VALUE TO BE DETERMINED ON TEST.

POWER UNIT FOR GE4/504D

V3
SECTION 10
FIG 31