PULSE GENERATOR SET CT500

GENERAL AND TECHNICAL INFORMATION
AND
SCALE OF SERVICING SPARES

ROYAL AIR FORCE

Prepared by the Procurement Executive, Ministry of Defence

CONTENTS

LEADING PARTICULARS

P.R.F.	Continuously variable in three ranges as follows:- ÷10: 100 p.p.s. to 1200 p.p.s. x1: 1000 p.p.s. to 12000 p.p.s. x5: 5000 p.p.s. to 60000 p.p.s.
Output pulse width	Over recurrence frequency ranges ÷10 and x1, the output pulse width may be switch-selected from the following values:- 0·5, 1·0, 2·0, 3·0, 4·0, 5·0, 7·0 µS Over recurrence frequency range x5, only the 0·5 µS pulse width is available.
Pulse width accuracy...	±10% of half amplitude.
Output pulse amplitudes	60V output: 0 to 60V positive-going, continuously variable; output impedance not greater than 200 ohms at full amplitude. +5/20V output: 5V to 20V positive-going, continuously variable, into a resistive load of 90 ohms. ±0.1mV/10V output: 100 µV to 10V positive or negative-going, continuously variable; output impedance 90 ohms ± 5% when MULTIPLIER switch is set to 0·1, 1, 10 or 100. In each case, the maximum amplitude has a tolerance of ±10%.
Rise and fall times	+5/20V and ±0·1mV/10V outputs: not greater than 0·15 µS or 5% of the pulse width, whichever is the larger. 60V output: not greater than 0·2 µS or 5% of the pulse width, whichever is the larger.
Overshoot and undershoot	Not greater than 7½% of maximum pulse amplitude.
Sync. pulse output	Positive-going pulses of 60V ±10% amplitude and 7·0 µS ±10% width at half amplitude; output impedance not greater than 200 ohms.
Delay	The output pulse may be delayed with respect to the trailing edge of the sync. pulse over a range of 5·0 µS to 1·5ms. The delay time is given as one fixed delay of 5·0 µS and four continuously variable ranges as follows:- 5 µS to 30 µS 25 µS to 150 µS 50 µS to 300 µS 250 µS to 1500 µS
External trigger	The instrument may be triggered by a pulse of either polarity, amplitude 5V to 10V and p.r.f. between 100 p.p.s. and 12000 p.p.s., applied from an external source. The width of the

Prelim.

	trigger pulse must not be less than 2·0 µS.
Modulation	The pulse generator output over the recurrence frequency range 6000 p.p.s. to 12000 p.p.s. may be frequency modulated to a maximum deviation of ±10% by a signal of approximately 5V amplitude applied from an external source.
Power supplies	110V to 125V or 200V to 250V, 50 Hz to 60 Hz, or 200V, 400Hz.
Dimensions and weight	

Height (mm)	Width (mm)	Depth (mm)	Weight (Kg)
222	445	356	10

Chapter 1

INTRODUCTION AND GENERAL DESCRIPTION

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INTRODUCTION

1. The pulse generator set CT500 6625-99-952-9168 (fig. 1) is a general-purpose pulse generator. The output pulse repetition rate is continuously variable from 100 p.p.s. to 60000 p.p.s. and the pulse width variable in seven discrete steps between 0·5 μs and 7·0 μs at repetition rates up to 12000 p.p.s.; between 12000 p.p.s. and 60000 p.p.s., the pulse width is fixed at 0·5 μs. A sync. pulse output, of a fixed pulse width of 7·0 μs, is provided and the delay between this and the main pulse output is continuously variable from 5 μs to 1500 μs. The main pulse output may be taken from any one of three output sockets, each of which has an independent amplitude control. Provision is made for externally triggering the instrument by a pulse of either polarity, and for the application of a modulating signal which frequency modulates the output, over the range 6000 p.p.s. to 12000 p.p.s., up to a maximum deviation of ±10%.

2. The pulse generator is self-contained, and is supplied complete with a power cable and two connector assemblies (normally stowed in the case cover). Thus only adjustment of the power-supply selector to suit the local supply, and connection of this supply to the instrument, is required to bring it into operation.

GENERAL DESCRIPTION

Principles of operation

3. A simplified block diagram of the pulse generator is shown in fig. 6. The instrument may be triggered internally (from the p.r.f. generator) or from an external source (via the EXT TRIGGER input socket), the particular mode of triggering desired being selected by means of the TRIGGER switch. The p.r.f. generator provides a continuous square-wave output signal at a repetition rate set by the PULSE RECURRENCE FREQUENCY kc/s controls. When it is required to modulate the instrument, the modulating signal is passed via the MOD input socket to the p.r.f. generator circuit, where it causes the p.r.f. generator output repetition rate to deviate either side of the rate set at the front panel controls. External triggering pulses may be either positive or negative-going, the circuits being arranged so that the trigger input to the sync. pulse generator is always positive-going.

4. The function of the sync. pulse generator circuit is to generate trains of square pulses of a constant preset duration and at the same repetition rate as that of the trigger pulses applied to the circuit input. Complementary outputs are provided. One of these outputs is passed to the

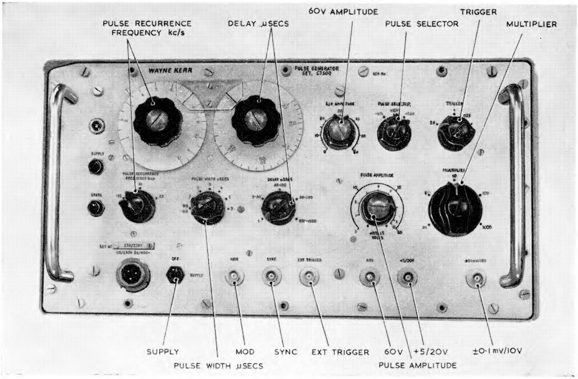

Fig. 3. Pulse generator: front panel

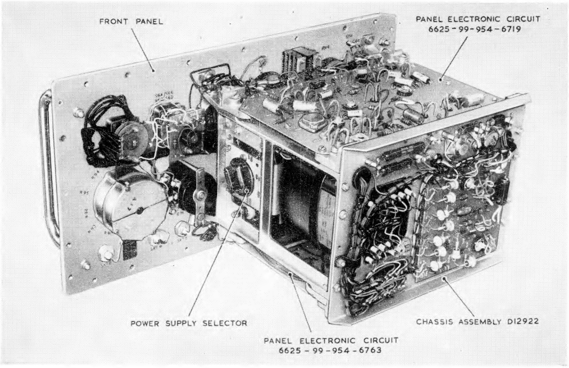

Fig. 4. Pulse generator: general view of interior

sync. pulse output circuit, where it is amplified and connected to the SYNC output socket as a positive-going pulse of some 60V peak amplitude and 7·0 μs half-amplitude width. The second sync. pulse generator output is conected to the input of a delay generator.

5. The delay generator produces a square pulse which has its leading edge coincident with the leading edge of the sync. pulse input and a duration determined by the setting of the DELAY μSECS controls. This pulse is passed to the main pulse generator circuits to generate the switching input for an artificial line pulse-forming circuit. The square pulse generated by this circuit, in response to the delay generator output, has a leading edge which is coincident with the trailing edge of the delay generator output. Thus the delay between the leading edges of the sync. and main pulses set at the DELAY μSECS switch is brought into being. The duration of the pulse-forming circuit output is set, on the ÷10 and x1 repetition rate ranges, by the PULSE WIDTH μSECS switch. On the x5 range (12000 p.p.s. to 60000 p.p.s.), this switch is overridden by contacts of the PULSE RECURRENCE FREQUENCY kc/s switch and the pulse width restricted to 0·5 μs over the complete range.

6. The formed main pulse is applied to a trigger circuit, which reshapes the pulse and accurately defines the signal levels, and then passed to the +5V/20V, ±0·1mV/10V output circuits. A complementary output of the trigger circuit is also provided and connected to the 60V output circuit.

7. The PULSE SELECTOR switch enables either +5V to +20V, +0·1mV to +10V, or −0·1mV to −10V, to be selected as the output of the +5V/20V, ±0·1 mV/10V circuit. In the +20v position of the switch, the main pulse is routed to the +5v/20v output socket at an amplitude determined by the setting of the PULSE AMPLITUDE control (indicated by the outer scale of this control). In the +10v or −10v position of the switch, the main pulse is routed to the ±0·1mv/10v output socket at the polarity indicated. The output pulse amplitude is now determined by the position of the PULSE AMPLITUDE (inner scale) and the MULTIPLIER controls. The 60V output is unaffected by the

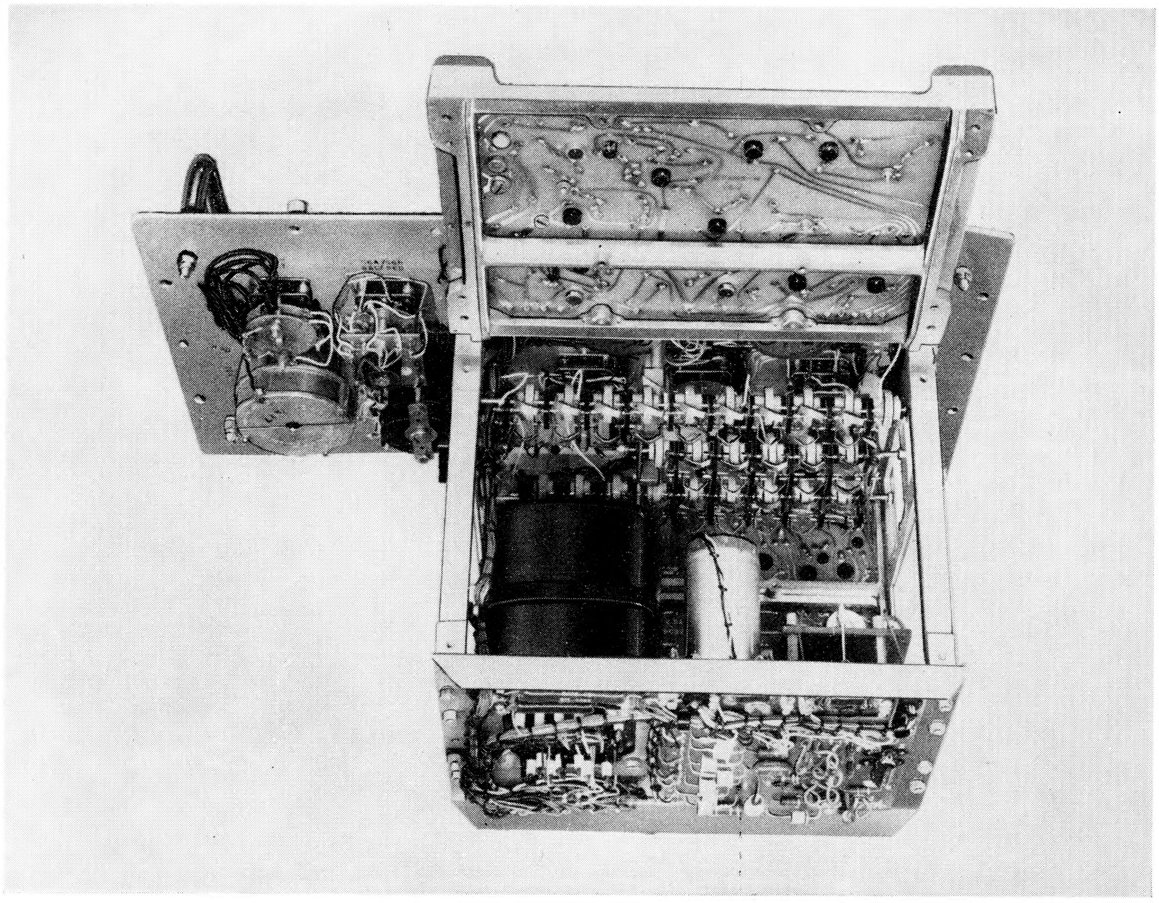

Fig. 5. Pulse generator: interior, showing artificial line

PULSE SELECTOR switch, a pulse (at an amplitude determined by the setting of the 60v AMPLITUDE control) being present at the 60V output socket at all times.

Construction

8. The complete instrument is contained in a conventional, services-pattern, metal case, complete with carrying handles and measuring some $8\frac{3}{4}$ in. × $17\frac{1}{2}$ in. × 14 in. overall. The front cover of this case is held in position by ten captive screws, and releasing these enables the cover to be removed, revealing the front panel of the pulse generator (fig. 3) and the power and signal connectors stowed in the cover (fig. 2). The pulse generator is secured in the main body of the case by the fourteen 2BA screws around the periphery of the front panel. Removal of these screws permits the instrument to be withdrawn from the case to give access to the interior.

9. A general view of the pulse generator with the case removed is shown in fig. 4. All user controls, together with the various input and output sockets, are mounted on the front panel. Also mounted on the front panel are the preset resistors and other components immediately associated with these controls and sockets. Three sub-assemblies (chassis assembly D12922, panel electronic circuit 6625-99-954-6763, panel electronic circuit 6625-99-954-6719), on which the majority of the remaining circuits are located, are carried on a frame chassis mounting on the rear face of the front panel.

10. The chassis assembly D12922 carries the d.c. power supply circuits for the instrument, the associated power supply selector socket and link plug being mounted between a pair of the frame-chassis side members. The panels electronic circuit take the form of printed circuit panels, and these are carried on hinged frames at the top and bottom of the frame chassis. The circuits on these panels divide between the two main functional groups forming the pulse generator circuit proper, those on the panel 6625-99-954-6763 being concerned with the generation of the sync. pulse (including the delay generator) and those on the panel 6625-99-954-6719 with the generation of the main pulse.

11. The frames carrying the two electronic circuit panels are secured at the rear edge of the frame chassis by captive screws. With these screws released, the panels may be hinged back to allow access to the printed wiring on the underside of the panels and to components of the chassis assembly and the artificial line (fig. 5).

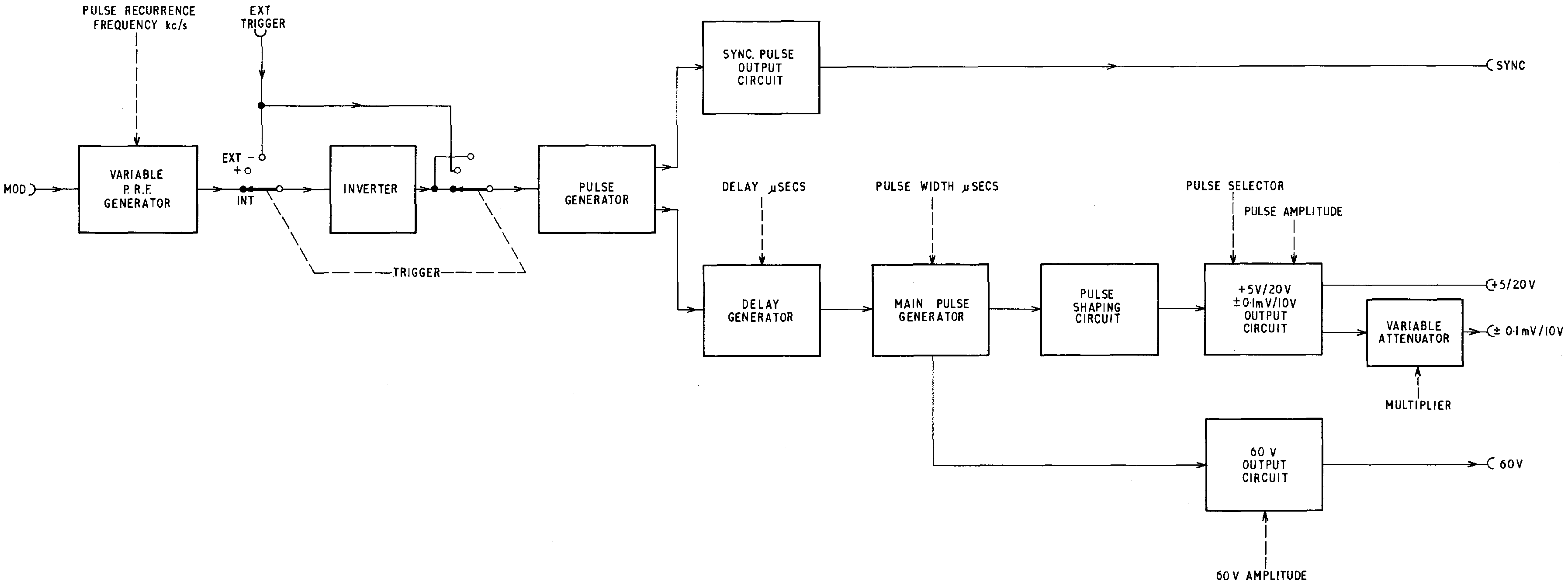

Fig. 6 Pulse Generator Set CT500 6625-99-952-9168 : simplified block diagram Fig. 6

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Chapter 2

OPERATING INSTRUCTIONS

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Preparation

1. To bring the pulse generator into service, proceed as follows:—

(1) Ascertain that the voltage of the supply from which the instrument is to be operated is within the range given on the plate above the power input plug on the instrument's front panel. If this is not so, the power transformer connections must be reset as follows:

(a) Remove the fourteen 2 B.A. screws round the periphery of the front panel and withdraw the instrument from its case. Stand the instrument on its front panel handles.

(b) The power-supply selector plug can now be seen at the approximate centre of the instrument, beside the power transformer. Remove the plug and re-insert it into the socket so that the engraved arrow points to the power supply range nearest to the voltage of the supply to be used.

(c) Return the instument to its case and refit and tighten the securing screws removed in operation (a).

(d) Remove the two 6 B.A. screws securing the supply-voltage indicating plates and re-arrange the plates so that they indicate the voltage range to which the power-supply selector plug is now set.

(e) Refit the plates and the securing screws.

(f) Confirm that the SUPPLY fuse is correctly rated for the voltage range set, i.e., 500mA for supplies within the 200V to 250V ranges and 1A for supplies within the 110V to 125V ranges.

(2) Connect the a.c. mains supply to the pulse generator by means of the 3-way connector supplied with the instrument.

(3) Set the SUPPLY switch to the on position. The indicator lamp located above the SUPPLY fuse should now be lit.

(4) The instrument is now ready for use.

Operation

2. With the instrument prepared for use as detailed in the section above, proceed as follows:

(1) Set TRIGGER switch to the mode of triggering required. If EXT+ or EXT− is selected, the trigger signal from the external source should be connected at the EXT TRIGGER socket and must have the following characteristics:

polarity: either
amplitude: 5V to 10V,
p.r.f.: 100 p.p.s. to 12000 p.p.s.,
width: not less than 2·0 μs.

(2) Select the required output at the PULSE SELECTOR switch. If the output is to be taken from the +5/20v socket, set the switch to +20v. If the output is to be taken from the ±0·1mv/10v socket, set the switch to +10v or −10v, as dictated by the output pulse polarity required. The 60v output is not switched.

(3) Set the PULSE RECURRENCE FREQUENCY kc/s, PULSE WIDTH μSECS and DELAY μSECS controls to give the desired pulse characteristics. The DELAY μSECS control should not be set to a value which is greater than the period of the output pulse, as this causes difficulty in synchronizing the output.

(4) Set the PULSE AMPLITUDE control, or (if the 60v output is used) the 60V AMPLITUDE control, to give the required output pulse amplitude. If the output is to be taken from the +5/20v socket, the output pulse amplitude is as indicated by the red (outer) scale of the PULSE AMPLITUDE control. In the latter instance, the MULTIPLIER switch must be set to the appropriate multiplying factor.

(5) Connect the appropriate output to the circuit under test. Note that when using the +5/20v output, an external resistor of 90 ohms must be connected in parallel with the load to give the correct pulse shape and amplitude. Since the output pulses contain very high frequency components, it is essential that the connecting leads used are of a type designed for high frequency use if the output pulse shape is to be preserved.

Chapter 3

FUNCTIONAL TESTS

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INTRODUCTION

1. Normally, unserviceable instruments will be returned to the manufacturers for repair and/or recalibration. No setting-up instructions, other than those forming an integral part of the operating instructions (Chap. 2), are therefore included in this Publication. The need is recognized, however, for some procedure by which a check of the pulse generator's calibration may be performed and which enables the incorrect operation of a suspect instrument to be confirmed. This chapter sets out a series of tests of various facilities offered by the pulse generator CT500. All the tests may be performed without removing the instrument from its case.

TEST EQUIPMENT

2. A complete list of the test equipment required for the performance of the tests is given below.

(1) Oscilloscope with a 'Y' amplifier having a bandwidth of 50 Mc/s and a rise time $\not>$ 7ns. (Oscilloscope CT536 or equivalent.)

(2) Pulse generator providing a 20μs pulse, 5V to 10V in amplitude, positive- or negative-going, at a p.r.f. of 100 p.p.s. to 12000 p.p.s. (Pulse generator CT434 or equivalent.)

(3) Audio oscillator to cover frequency range 6 kc/s to 12 kc/s, output amplitude range OV to 10V r.m.s., output impedance without the range 100 ohms to 10 kilohms. (Signal generator CT416 or equivalent.)

(4) Carbon resistor, 200 ohms ±2%, $\frac{1}{4}$W.

(5) Carbon resistor, 91 ohms ±2%, $\frac{1}{4}$W.

POWER SUPPLIES

3. The following power supplies are required for the performance of the tests:

(1) Single-phase a.c. mains supply, 200V to 250V, 50 c/s, at 1A.

FUNCTIONAL TESTS

General

4. Before conducting any tests, the following points should be noted:-

(1) The test figures quoted are true values. The degree of accuracy and influence of the measuring instruments used should, therefore, be taken into consideration when assessing the performance of the equipment under test.

(2) Throughout the tests, it is assumed that the test equipment will be switched on and off as required and that it is adjusted as appropriate to the test undertaken.

P.R.F. GENERATOR

5. With the pulse generator prepared for normal use as detailed in Chap. 2, proceed as follows:

(1) Set the PULSE SELECTOR switch to +10.

(2) Set the PULSE AMPLITUDE potentiometer to 10 (on the inner scale) and the MULTIPLIER switch to 1000.

(3) Connect the ±0·1mV/10V output socket to the input of the oscilloscope (Item 1).

(4) Set the PULSE RECURRENCE FREQUENCY kc/s switch to ÷ 10.

(5) Set the PULSE RECURRENCE FREQUENCY kc/s dial to each of its major calibrated points in turn and, adjusting the oscilloscope controls as necessary, note the time interval between the leading edges of successive pulses of the oscilloscope display at each setting.

(6) Convert the time intervals noted in (5) into pulse repetition rates. For example:

Time interval = 10ms

Number of pulse per second = $\frac{1}{0\cdot 01}$

= 100 p.p.s.

At no point checked should the difference between the indicated and the measured p.r.r. exceed ±10% of the dial calibration at that point.

(7) Set the PULSE RECURRENCE FREQUENCY kc/s switch to the X1 and X5 positions in turn, repeating sub-para. (5) and (6) at each position.

±0·1mV/10V output

6. With the pulse generator prepared for normal use as detailed in Chap. 2, proceed as follows:

(1) Set the PULSE RECURRENCE FREQUENCY kc/s switch and the associated dial for a p.r.r. of 5000 p.p.s.

(2) Set the PULSE SELECTOR switch to +10.

(3) Set the PULSE AMPLITUDE potentiometer to 10 (on the inner scale) and the MULTIPLIER switch to 1000.

(4) Connect the ±0·1mV/10V output socket to the input of the oscilloscope (Item 1).

(5) Measure the amplitude of the pulse displayed on the oscilloscope at all settings of the PULSE WIDTH µ SECS switch. This amplitude should be 10V ±10%.

(6) Measure the half-amplitude width of the pulse displayed on the oscilloscope at all settings of the PULSE WIDTH µ SECS switch. These widths should be 0·5, 1·0. 2·0. 3·0, 4·0, 5·0 and 7·0µs, ±10%.

(7) Set the PULSE WIDTH µ SECS switch to 0·5 and measure the time taken for the displayed pulse to rise from 10% to 90% of its final amplitude. This time should not exceed 0·15µs.

(8) Measure the time taken for the displated pulse to fall from 90% to 10% of its maximum amplitude. This time should not exceed 0·15µs.

(9) Measure the amplitude of the overshoot and undershoot at the maximum amplitude of the displayed pulse. These two amplitudes should each not exceed 7½% of the pulse amplitude.

(10) Check the calibration of the PULSE AMPLITUDE potentiometer at each major calibration point of the inner scale. The calibration error at any point should not exceed 5% of the maximum amplitude.

(11) Set the PULSE SELECTOR switch to -10V and the PULSE AMPLITUDE potentiometer to 10 (inner scale).

(12) Repeat sub-paras. (5), (8) and (9).

(13) Set the PULSE SELECTOR switch to +10V and the MULTIPLIER switch to 100. Set the PULSE AMPLITUDE potentiometer to 10 and measure the amplitude of the displayed pulse.

(14) Load the pulse generator output with the 91-ohm resistor (Item 5). The pulse amplitude should now be halved to an accuracy of ±10%.

+5V/20V output

7. With the pulse generator prepared for normal use as detailed in Chap. 2, proceed as follows:

(1) Set the PULSE RECURRENCE FREQUENCY kc/s switch and the associated dial to give a p.r.r. of 5000 p.p.s.

(2) Set the PULSE SELECTOR switch to +20V and the PULSE AMPLITUDE potentiometer to 20 (outer scale).

(3) Connect the +5V/20V output socket, loaded by the 91-ohm resistor (Item 5), to the input of the oscilloscope (Item 1).

(4) Measure the amplitude of the pulse displayed on the oscilloscope at all settings of the PULSE WIDTH SECS switch. This amplitude should be 20V ±10%.

(5) Measure the half-amplitude width of the pulse displayed on the oscilloscope at all settings of the PULSE WIDTH µ SECS switch. These widths should be 0·5, 1·0, 2·0, 3·0, 4·0, 5·0 and 7·0µs, ±10%.

(6) Set the PULSE WIDTH μ SECS WIDTH switch to 0•5 and measure the time taken for the displayed pulse to rise from 10% to 90% of its final amplitude. This time should not exceed 0•15μs.

(7) Measure the time taken for the displayed pulse to fall from 90% to 10% of its maximum aplitude. This time should not exceed 0•015μs.

(8) Measure the amplitude of the overshoot at the maximum amplitude of the displayed pulse. These two amplitudes should not exceed $7\frac{1}{2}$% of the pulse amplitude.

(9) Confirm that with counter-clockwise rotation of the PULSE AMPLITUDE potentiometer, the amplitude of the displayed pulse smoothly reduces to 5V ±10%.

60V output

8. With the pulse generator prepared for normal use as detailed in Chap. 2, proceed as follows:-

(1) Set the PULSE RECURRENCE FREQUENCY kc/s switch and the associated dial to give a p.r.r. of 5000 p.p.s.

(2) Set the 60V AMPLITUDE potentiometer fully clockwise.

(3) Connect the 60V output socket to the input of the oscilloscope (Item 1).

(4) Measure the amplitude of the pulse displayed on the oscilloscope at all settings of the PULSE WIDTH μ SECS switch. This amplitude should be 60V ±10%.

(5) Measure the half-amplitude width of the displayed pulse at all settings of the PULSE WIDTH μ SECS switch. These widths should be 0•5, 1•0, 2•0, 3•0, 4•0, 5•0 and 7•0μs, ±10%.

(6) Set the PULSE WIDTH μ SECS switch to 0•5 and measure the time taken for the displayed pulse to rise from 10% to 90% of its final amplitude. This time should not exceed 0•15μs.

(7) Measure the time taken for the displayed pulse to fall from 90% to 10% of its maximum amplitude. This time should not exceed 0•15μs.

(8) Measure the amplitude of the overshoot and undershoot at the maximum amplitude of the displayed pulse. These two amplitudes should not exceed $7\frac{1}{2}$% of the pulse amplitude.

(9) Confirm that with counter-clockwise rotation of the 60V AMPLITUDE potentiometer, the amplitude of the displayed pulse smoothly reduces to zero.

External trigger

9. With the pulse generator prepared for normal use as detailed in Chap. 2, proceed as follows:

(1) Set the TRIGGER switch to EXT +.

(2) Connect the EXT TRIGGER input socket to the output of the pulse generator (Item 2). Set the pulse generator (Item 2) to give a 2 s, 5V positive-going pulse, at a p.r.r. of 1000 p.p.s.

(3) Connect the 60V output socket to the input of the oscilloscope (Item 1) and confirm that a pulse generator CT500 output is present.

(4) Increase the p.r.r. of the pulse generator (item 2) to 12000 p.p.s. and confirm that a pulse generator CT500 output is still present.

(5) Set the TRIGGER switch to EXT - and adjust the pulse generator (Item 2) to give a 2 s, 5V negative-going pulse. Confirm that a pulse generator CT500 output is still present.

(6) Reduce the p.r.r. of the pulse generator CT500 output is still present.

Modulation

10. With the pulse generator prepared for normal use as detailed in Chap. 2, proceed as follows:-

(1) Set the TRIGGER switch to INT and the PULSE RECURRENCE FREQUENCY kc/s switch and the associated dial to give a p.r.r. of 10000 p.p.s.

(2) Set the PULSE WIDTH SECS switch to 5•0 and the DELAY μ SECS switch to 5-30.

(3) Connect the 60V output socket to the input of the oscilloscope (Item 1).

(4) Adjust the oscilloscope controls so that two pulses of pulses of pulse genera- output are displayed, the second pulse in the centre of the display.

(5) Connect the audio oscillator (Item 3) output to the MOD input socket and adjust the aduio oscillator controls to give an output frequency of 1 kc/s.

(6) Adjust the audio oscillator output level until the width of the overlapping pulse on the display is 25μs. The audio oscillator output level for this condition should be approximately 5V r.m.s.

Sync. output

11. With the pulse generator prepared for normal use as detailed in Chap. 2, proceed as follows:

(1) Set the PULSE RECURRENCE FREQUENCY kc/s switch and the associated dial to give a p.r.r. of 1000 p.p.s.

(2) Set the TRIGGER switch to INT and connect the SYNC output socket to the input of the oscilloscope (Item 1).

(3) Measure the half-amplitude width of the pulse displayed at the oscilloscope. This should be 7·0 s ± 10%.

(4) Measure the amplitude of the displayed pulse. This should be 60V ±10%.

(5) Adjust the PULSE RECURRENCE FREQUENCY kc/s switch and the associated dial to give a p.r.r. of 50000 p.p.s.

(6) Repeat sub-paras. (3) and (4).

(7) Load the sync. output with the 200-ohm resistor (Item 6). The amplitude of the leading edge of the displayed pulse should now be greater than 30V.

CHAPTER 4

CIRCUIT INFORMATION

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Introduction

1. The circuit of the pulse generator CT500 may be divided into four main sections roughly corresponding to the main sub-assemblies of the instrument:

(1) Panel electronic circuit 6625-99-954-6763.

(2) Panel electronic circuit 6625-99-954-6719.

(3) The power supplies, (chassis assembly D12922).

(4) The front panel and frame assembly D12921.

2. The paragraphs which follow contain a detailed description of the operation of the pulse generator circuit in terms of the operation of each of the sections of that circuit listed above. The components and circuits carried by the front panel and frame assembly are all effective in one or other of the other three sections. For convenience, the circuits of this assembly are not described separately but in the paragraphs dealing with the circuits which they influence. The locations of the various circuits are indicated in the appropriate circuit diagrams.

Panel electronic circuit 6625-99-954-6763 (fig. 1)

P.R.F. generator

3. Transistors VT1, VT2, VT3 and VT4 are used in an emitter-coupled multivibrator, generating a square-wave output the repetition frequency of which may be varied by means of switch S1 (PULSE RECURRENCE FREQUENCY kc/s) and RV4, or by means of an externally connected signal.

4. The multivibrator circuit has two stable states, VT2 on and VT4 off, and VT2 off and VT4 on. Constant-current transistors VT1 and VT3 conduct continuously throughout the circuit's cycle of operation. Assume initially that switch S1 is set to position 1 (÷ 10), and that VT2 is hard on and VT4 has just come into conduction (i.e. a transition from the first stable state to the second has just started). As soon as transistor VT4 begins to conduct, its collector voltage rises (from approximately 0V) and this rise is coupled by Zener diode MR3 to VT2 base, tending to cut off VT2. The voltage at VT2 collector thus falls towards 0V and this fall is coupled by Zener diode MR2 to VT4 base, bringing this transistor further into conduction and causing its collector voltage to rise even more. At the same time, emitter-follower action causes a rise in VT2 emitter voltage and this rise is coupled by capacitors C2 and C4 in parallel to VT4 emitter increasing the forward biassing of the VT4 emitter-base junction. By a cumulative action, therefore, the circuit is rapidly brought to the second stable state (VT2 off and VT4 on).

5. With VT2 cut off, the base voltage of VT4 is held at approximately +5V by the action of Zener diode MR2. The transistor thus passes a constant current, holding the emitter, and hence one electrode of each of the capacitors, at a constant voltage. The capacitors selected (C2, C4) now start to charge linearly towards +25V via VT1 and resistor R3, the charging rate being determined by the current flowing through transistor VT1, i.e. the positions of the rotor of switch wafer S1a and potentiometer RV4 slider (this slider is coupled to the calibrated dial associated with switch S1). As the capacitors charge, the emitter voltage of VT2 rises. The emitter-junction of this transistor is thus increasingly forward-biased until, eventually, the transistor conducts. Simultaneous with this occurring, the capacitors discharge through VT2, causing VT2 collector voltage (and hence VT4 base voltage) to fall. This initiates a second switching action similar to that already described, which culminates in VT2 being fully on and VT4 off. The capacitors now proceed to charge in the opposite direction (via VT3 and R5) until VT4 is brought into conduction, when the cycle repeats.

6. Positive-going signals at the collectors of VT2 and VT4 are limited to 6.8V by the Zener action of Zener diodes MR1 and MR4, and the use of a balanced multivibrator circuit ensures that the waveforms at these collectors have a mark : space ratio of 1 : 1. Thus the output of the circuit, at VT4 collector, is essentially a square wave of approximately 6.8V amplitude (from 0V) and with a pulse repetition rate (p.r.r.) determined by the settings of switch S1 and potentiometer RV4. Preset variable resistors (RV1-3; RV5-7) enable the voltage gradient across the RV4, R84 potential divider to be adjusted for each repetition rate range, during calibration, to accommodate component tolerances in the multi-vibrator circuit.

7. Over a certain range of repetition rates, the pulse generator output may be frequency modulated by application of a suitable signal (see Leading Particulars and Chap. 3) at socket SKT1 (MOD). As can be seen from the circuit diagram, the modulation signal is superimposed upon the d.c. level at RV4 slider. This causes the current passed by transistors VT1 and VT3, and hence the repetition rate of the waveform generated by the multivibrator, to vary in sympathy with the signal.

Sync. pulse generators (VT5-VT9)

8. The sync. pulse generator consists of an input inverter (VT5), a monostable (VT6, VT7), and a bistable (VT8, VT9). The function of the circuit is to generate trains of pulses of a predetermined width and at the same repetition rate as that of the trigger pulses applied at the input of the circuit.

9. In the INT or EXT- positions of switch S2 (TRIGGER), the output of the p.r.f. generator (para. 3), or a negative-going trigger input from an external source connected via socket SKT2 (EXT TRIGGER), is coupled to VT5 base, via contacts of switch wafer S2a and capacitor C5. Transistor VT5 is connected as a common-emitter with a gain of approximately unity. The stage thus acts as an inverter, producing a signal at its collector (and hence at contacts 1 and 3 of switch wafer S2b) which is similar in amplitude, but in phase opposition, to the signal at its base. Signals at VT5 base are clamped at OV by the action of diode MR30. In the EXT+ position of switch S2, the inverter stage is by-passed and the external trigger input connected directly to contact 2 of switch wafer S2b. Irrespective of the triggering mode selected, therefore, a positive-going pulse appears at the rotor of S2b.

10. Transistors VT6 and VT7 are operated in a monostable circuit the output pulse width of which may be varied, over a limited range for calibration purposes, by adjustment of preset variable resistor RV8. The pulse at S2b is coupled via capacitor C7 and diode C7 and diode MR5 to VT6 base. The capacitor differentiates the waveform and the negative-going pulses so produced are blocked by the diode. The signal at the transistor base is therefore a positive-going,short-duration pulse the leading edge of which is coincident with the leading edge of the trigger pulse at S2b rotor.

11. In the quiescent condition, VT7 is conducting steadily due to a positive bias applied to the base from the junction of MR7, R16, while VT6 is cut off by the low voltage at VT7 collector, connected via Zener diode MR6. When the positive pulse output of MR5 is applied to VT6 base, VT6 starts to conduct and its collector voltage falls sharply. This fall is coupled via C8 and C9 to VT7 base. The current in VT7 is thus reduced and its collector voltage rises. This rise is coupled by MR6 to VT6 base, causing a further fall in VT6 collector voltage. The base voltage of VT7 also falls, therefore, taking the transistor further towards cut off. At the same time, MR7 becomes increasingly reverse biased and the standing voltage at VT7 base is reduced. Hence by a rapid cumulative action, the circuit switches to a quasistable state in which VT7 is off and VT6 on. In this state, VT7 collector stands at +12V. Zener diode MR6 is thus heavily reverse biased and the resulting Zener effect holds the base voltage of VT6 constant at approximately +6.8V. Thus the transistor collector voltage is also constant, and capacitor C8 commences to charge towards +12V via R15 and RV8.

12. As the capacitor charges, the voltage at the junction of the capacitor and MR7 rises at a rate determined by the C8/R15, RV8 time constant, until, eventually, MR7 is forward biased and starts to conduct. With the diode conducting, a positive voltage appears at VT7 base and brings the transistor into conduction, initiating a second cumulative action which returns the circuit to the quiescent condition. The output of the circuit, at VT7 collector, is thus a train of positive-going pulses. The pulse width is determined by the setting of RV8 and they are at the same repetition rate as the trigger input at S2b rotor.

13. The monostable output is coupled by capacitor C10 to VT8 base. The capacitor differentiates the waveform, causing positive and negative-going short-duration pulses, coincident with the positive and negative-going edges respectively of the monostable output pulses, to appear at VT8 base.

14. Transistors VT8 and VT9 are operated in a conventional bistable circuit which is normally in the stable state VT8 off and VT9 on. With the application of the positive-going pulse to its base, VT8 is brought into conduction. The collector voltage of VT8 falls causing, via R19, a fall in VT9 base voltage. Transistor VT9 thus tends towards cut off and its collector voltage starts to rise, this rise being coupled to VT8 base to bring it further into conduction. Thus by a rapid cumulative action, the circuit switches to the stable state VT8 on and VT9 off.

15. With the application of the negative-going pulse to VT8 base, the transistor is taken towards cut off. The collector voltage of VT8, and hence VT9 base voltage, rises. Transistor VT9 is therefore brought into conduction and its collector voltage falls. Hence a second cumulative action takes place which rapidly returns the circuit to the original stable state. Capacitors C11 and C12 are included in the circuit to improve the h.f. response and hence the switching time, of the device.

16. The outputs of the bistable, at the transistor collectors, are complementary, square pulse trains at the same repetition rate as the triggering waveform at S2b rotor. The output at VT9 collector is passed directly to the input of the delay generator (para. 17), while the output at VT8 collector is connected to the input of the sync. pulse amplifier (para. 19).

Delay generator (VT10 - VT11)

17. Transistors VT10 and VT11 and their associated components form a monostable circuit similar to that in which VT6 and VT7 operate. In this circuit, however, the pulse width may be selected from amongst one fixed and four variable values by means of switch S3 (DELAY μSECS). Adjustment of the delay at the variable ranges is provided by RV9. Preset variable resistors RV10-14 permit adjustment, during calibration, of the range of delay covered at each switch position, and of the value of the fixed delay.

18. The output of the delay generator, at VT11 collector, is a positive-going square pulse at the same repetition rate as the triggering waveform at S2b rotor. The width of this pulse is dependent upon the settings of switch S3 and variable resistor RV9. This output is connected, via board pin 15, to the input of the panel electronic circuit 6625-99-954-6719 (para. 21).

Sync. pulse output circuit (VT12-VT14)

19. The pulse output of VT9 in the sync. pulse generator circuit (para. 8) is connected, via R32 and C19 in parallel, to the base of common-emitter amplifier VT12. The capacitor is included in the connection to improve the h.f. response of the input circuit, thereby helping to preserve the waveform shape. Effectively connected across the input of the amplifier are the stray capacities of the input circuit. These include the base-emitter capacitance of the VT12 and, in a conventional amplifier circuit having a high-impedance collector load, this capacitance would be increased by the Miller Effect, resulting in serious degradation of the output waveform shape. In this circuit, the collector load of VT12 is the comparatively low emitter impedance of common-base transistor VT13. This low-impedance load considerably reduces the Miller Effect and hence the waveshape degradation.

20. The waveform developed across VT13 collector load, R34, is coupled by Zener diode MR14 to the base of emitter follower VT14. The sync. pulse output is developed across the emitter load of this transistor (resistors R37A-C in parallel) and a.c. coupled (C21) to the output socket, SKT3 (SYNC). This output is a positive-going pulse, 60V in amplitude and at a repetition rate determined by the setting of S1 and RV4, or by the repetition rate of the input at SKT2 (EXT TRIGGER), of a width (normally 7.0µS) determined by the setting of RV8.

Panel electronic circuit 6629-99-954-6719 (fig. 2)

Main pulse generator (VT15-VT18)

21. The output of the delay generator (para. 17) is connected via board pin 9 and capacitor C22 to the base of VT15. Transistors VT15 and VT16 are used in a bistable circuit, the operation of which is similar to that of the bistable in the sync. pulse generator. Appearing at VT16 collector, therefore, is a positive-going square pulse. The repetition rate of this square pulse is determined by the settings of switch S1 (PULSE RECURRENCE FREQUENCY kc/s) and RV4, or by the repetition rate of a trigger pulse connected from an external source, and the width is identical to that of the monostable output pulse.

22. The output of bistable VT15, VT16 is coupled by R44 and C75 in parallel to the base of common-emitter amplifier VT17. The capacitor improves the h.f. response of the coupling arrangement to ensure the sharp trailing edge to the pulse input to VT17 necessary for correct pulse formation in VT17 circuit. The collector load of VT17 is a pulse-forming circuit consisting of resistors R46, R47 and an artifical transmission line (L1-L26, C73 and C26-C50). The line is terminated by R51, and the values of R46 and R47 are selected to give a total value equal to the characteristic resistance of the line. With switch S1 (PULSE RECURRENCE FREQUENCY kc/s) at position 1 (÷ 10) or 2(x1), a short circuit is connected across the line at a point determined by the setting of switch S4 (PULSE WIDTH µSECS). In position 3(x5) of switch S1, switch S4 is overridden and a permanent short circuit connected across the line at the junction of L3 and L4.

23. Normally, VT17 is cut off by a negative bias from the junction of R44 and R45. The positive-going pulse from the bistable brings the transistor into conduction and it remains in this condition for the duration of the pulse. By preserving the sharp trailing edge of the pulse, it is ensured that the transistor cuts off abruptly at the end of the pulse. Due to the presence of the artifical line in VT17 collector circuit, as the transistor

cuts off a positive-going pulse appears across R46. The leading edge of this pulse is thus coincident with the trailing edge of the pulse at VT17 base and the duration of the pulse is the two-way travel time of the section of line up to the short circuit, connected across the line by the contacts of switch S4.

24. Because of the characteristics of the VT17 circuit and its controlling waveform, the output pulse of the circuit at the junction of R46 and R47 will have finite rise and fall times, giving a pulse width reducing in value from the base to the peak of the pulse. The width of the output pulse is specified to within close limits, and if no precautions are taken to compensate for the variation in pulse width, or differing component characteristics in subsequent circuits, it could be possible to reach a condition in which it is impossible to attain the required limits. The output of the pulse forming stage is connected via emitter follower VT18. In addition to the pulse, this transistor has a negative bias applied to its base derived from the R48, R49, RV16 potential divider, connected between the +12V d.c. and -6V d.c. supply lines. The operating point of VT18 can thus be moved up and down between the maximum and minimum amplitudes of the pulse applied to its base by adjustment of RV16. The pulse developed across the emitter load therefore has a maximum and minimum width determined by the setting of RV16. During setting up, RV16 is adjusted to give an output pulse half-amplitude width of 0.5 µS with switch S4 set to position 1 (0.5). The amplitude of the VT18 output pulse is maintained constant over the normal range of operation by the action of thermistor TH1. The output of the pulse forming circuit is, therefore, a train of positive-going pulses of constant amplitude, with a width determined by the setting of switch S4 and preset potentiometer RV16, at a repetition rate determined by the settings of switch S1 (PULSE RECURRENCE FREQUENCY kc/s) and RV4 or the repetition rate of the trigger pulse connected from an external source.

Pulse shaping circuit (VT19-VT22)

25. The positive-going pulse output of VT18 is applied directly to the base of VT19. Transistors VT19 and VT20 are operated in a Schmitt trigger connection the quiescent condition of which is VT19 off and VT20 on. The pulse input brings VT19 into conduction and VT19 collector voltage falls. This fall is coupled via R54 and C72 in parallel to VT20 base, taking this transistor towards cut off. By emitter-follower action, the emitter voltage of VT20 also falls, causing, due to the emitter coupling, a fall in VT19 emitter voltage. The base-emitter junction of VT19 is thus further forward-biased, bringing this transistor further into conduction. Thus a rapid cumulative action occurs which culminates in VT19 being fully on and VT20 off.

26. The circuit remains in this condition until the end of the positive pulse at VT19 base. Transistor VT19 then starts to cut off, the resultant rise in its collector voltage switching on VT20. A second cumulative action is initiated, therefore, which returns the circuit to the quiescent condition. The points in the cycle of operation at which VT20 switches on and off are determined by the standing bias applied to its base. Thus while at VT19 collector there appears a negative-going pulse of the same width as the pulse forming circuit output, the pulse at VT20 collector is positive-going and the width is determined, within limits, by the setting of preset variable resistor RV17.

27. The collector supply for VT20 is obtained from the emitter circuit of constant-current transistor VT21, connected between the +25V d.c. and OV supply lines. With the ±0.1 mv/10V output selected (switch S6 (PULSE SELECTOR) at position 1 (-10V) or 2 (+10V)) the current in transistor VT21, and hence the collector voltage of VT20 and the maximum amplitude of the pulse at VT20 collector, is defined by the voltage at the junction of preset variable resistor RV24 and resistor R97, connected in series between the +25V d.c. and OV supply lines. With the 20V output selected (switch S6 at position 3 (+20V)) the base voltage of VT21 is dependent upon the setting of variable resistor RV25b (PULSE AMPLITUDE). The voltage across RV25b, and hence the current in VT21, is defined by the setting of preset variable resistor RV18 and the current in constant-current transistor VT22. As the current in the transistor is itself set by the value of preset variable resistor RV20, it follows that in position 3 of switch S6, the collector voltage of VT20 is determined by the settings of RV18, RV25b and RV20.

+5V/20V, ±0.1 mV/10V output circuit (VT23-VT25)

28. The positive-going pulse at VT20 collector is directly coupled to the base of emitter-follower VT23. A preset variable capacitor, C53, at VT23 base provides additional shunt capacitance to degrade the h.f. response of the circuit, thus bringing the overshoot and undershoot on the output signal to within acceptable limits. The pulse developed across the emitter load of the transistor (R61) is directly coupled to the bases of transistors VT24 and VT25.

29. NPN transistor VT24 and PNP transistor VT25 are connected as a complementary emitter-follower. The purpose of this circuit and its operation is best appreciated by considering first the effect of omitting this stage and connecting capacitor C54 directly to VT23 emitter. Coincident with the leading edge of the positive-going pulse at VT23 base, the transistor conducts and C54 charges via the emitter-base junction resistance. This resistance is in the order of a few ohms and thus the capacitor charges rapidly, preserving the fast trailing edge of the pulse passed to the output. On the trailing edge of the pulse at the base, VT23 cuts off and C54 discharges via resistor R61. The value of this resistor is such as to give a much longer discharge than the charge time constant. This results in the fast trailing edge required in the output pulse being lost.

30. In the complementary emitter-follower circuit, biasing of the transistors is arranged so that as one transistor cuts off, the other cuts on. This changeover point is at approximately half-amplitude of the applied pulse. Initially, VT25 is on and C54 draws charging current through VT25 emitter-base junction resistance. At the half-amplitude point of the leading edge of a positive-going pulse of VT23 output, VT25 cuts off and VT24 comes into conduction. The capacitor discharges through VT24 emitter-base junction resistance, charging in the opposite polarity via the same path. At the half-amplitude point of the trailing edge of VT23 output, the transistors again change over, to bring VT25 on and switch VT24 off. This causes the capacitor to discharge via VT25 base-emitter junction and recharge via the same path in the original polarity. All the time constants are very short, due to the low resistance component involved in each case, and thus the rise and the fall times of the output pulse are short.

31. The output of the complementary emitter follower is connected by C54 to the centre tap of transformer T2 primary winding. In position 1 (-10V) of switch S6 (PULSE SELECTOR), a fraction of the waveform developed across one secondary winding of the transformer, determined by the value of R89 and the

setting of RV25a (PULSE AMPLITUDE), is passed to the input of a switched, 90-ohm, decade attenuator. The multiplying factor of this attenuator is determined by the setting of switch S7 (MULTIPLIER) and the attenuated signals passed, via the rotor of this switch, to output socket SKT6 (±0.1mV/10V) at an output impedance of 90 ohms. Position 2 (+ 10V) selects the other secondary winding of T2. This secondary is wound in the opposite direction to that selected at position 1, also being positioned on the 'high' side of the primary centre tap. The waveform developed across this secondary is thus in antiphase to that across the winding previously selected. The waveform is connected to output socket SKT6 via the path already described. At position 3 of the switch (20V), both secondary windings of the transformer are open-circuited and the primary winding connected as an auto-transformer to output socket SKT4 (+ 5V/20V). The amplitude of the output waveform at this socket is determined by the setting of RV25b, as described in para. 27.

+60V output circuit (VT32 - VT34)

32. The negative-going pulses appearing at VT19 collector (para. 26) are connected to the input of the 60V output circuit via R79 and C69 in parallel. This output circuit is identical in operation to the sync. pulse output circuit, and thus no detailed description is necessary here. In this case, however, the fixed emitter load of the output emitter-follower is replaced by potentiometer RV19 (60V AMPLITUDE), the output waveform being connected from the slider of this potentiometer via C71 to output socket SKT5 (60V).

Chassis assembly D12922 (fig. 3)

Input circuit

33. The a.c. mains supply is connected by the poles of plug PLA, the contacts of switch (S5) and fuse-link F1 to the power-supply selector socket. The poles of the power-supply selector plug then route the supply to the primary windings of transformer T1 appropriate to the input voltage. A neon indicator lamp (N1) is connected across the outers of T1 primary to give a "supply on" indication. The transformer has three secondary windings and these are connected, as shown in the diagram, to the rectifier circuits from which the instrument's d.c. supplies are obtained.

+25V supply

34. The 43V a.c. output developed across a secondary winding of T1 is applied to the input of the bridge-rectifier circuit formed by diodes MR16-MR19. The unsmoothed d.c. output of the bridge is smoothed by R66, C63, and then passed via a series regulator (VT26, VT29, VT31) and further filtering (C67, C68) to the pulse generator circuits as a regulated, 25V d.c. supply.

35. In the regulator circuit, transistors VT29 and VT31 are connected in a differential amplifier configuration. The base of VT29 is referenced to 5.6V by Zener diode MR27, and a fraction of the output voltage determined by the setting of potentiometer RV21, connected in series with R76 and TH2 in parallel, R77 and R78 across the power supply output, is applied to VT31 base. The collector supply for VT31 is derived from a half-wave rectifier circuit (MR23, MR24, C56, C58) the a.c. input of which is also the a.c. input to the main circuit. Due to the emitter-follower action of VT29 and the common emitter connection of the two transistors, VT31 emitter voltage is held at a constant value. The current in VT31 is, therefore, determined by the power supply's d.c. output voltage and a.c. mains input voltage, and thus the

voltage at VT31 collector is directly proportional to these voltages. This proportional voltage is directly connected to the base of VT26, the first transistor of the series-control element.

36. Transistors VT26-VT28 are connected as cascaded emitter-followers to form a compound series-control element. The current in these transistors, and hence the current in the load and the voltage drop across it (i.e. the voltage at the power supply output), is controlled by the input from VT31. Initially, RV21 is set so that with a correct a.c. input to the circuit and the optimum value of external load connected, the output voltage is +25V. Subsequent changes in the a.c. input voltage, or the d.c. output voltage, result in a change in VT31 output and, consequently, a change in the current passed to the load by the series elements. For example, if the output voltage rises, then VT31 base voltage also rises, causing the transistor to conduct more heavily with a consequent fall in its collector voltage. This means that the voltage at VT26 base, and (by emitter-follower action) the voltage at VT27 and VT28 bases, also falls. Transistors VT26-VT28 therefore pass less current and the voltage drop across the load i.e. across the power supply output lines, falls, stabilizing at +25V. Compensation for changes in output voltage due to the effect of temperature changes upon circuit components is provided, over the normal operating temperature range, by thermistor TH2.

+12V supply

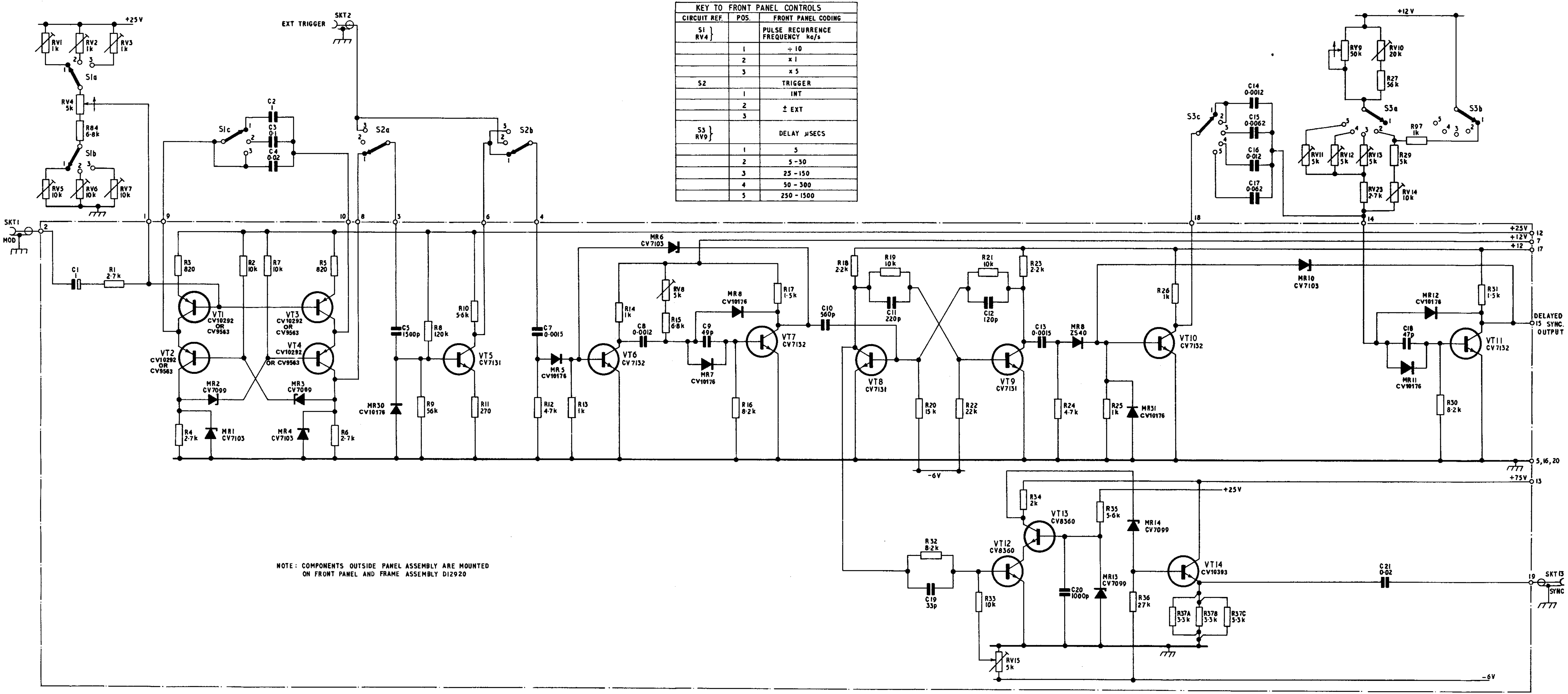
37. Potentiometer RV22 is connected in series with R72 and R71 and TH3 in parallel, between the +25V d.c. and 0V supply lines. The voltage at the wiper of the potentiometer is connected directly to the base of constant-current transistor VT30. The voltage developed across the emitter load of this transistor is decoupled by C65 and fed to the pulse generator circuits as a +12V d.c. supply. Temperature compensation is again provided by a thermistor (TH3).

+75V supply

38. The 137V-0V-137V a.c. voltage developed across a centre-tapped secondary of transformer T1 is coupled to the anodes of diodes MR20, MR21. These diodes are used in a full wave rectifier connection, the output of which is first passed through a smoothing circuit formed by resistors R64, R65 and capacitors C60, C61. It is then stabilized by the action of Zener diode MR26 and passed to the external circuits as a +75V d.c. supply.

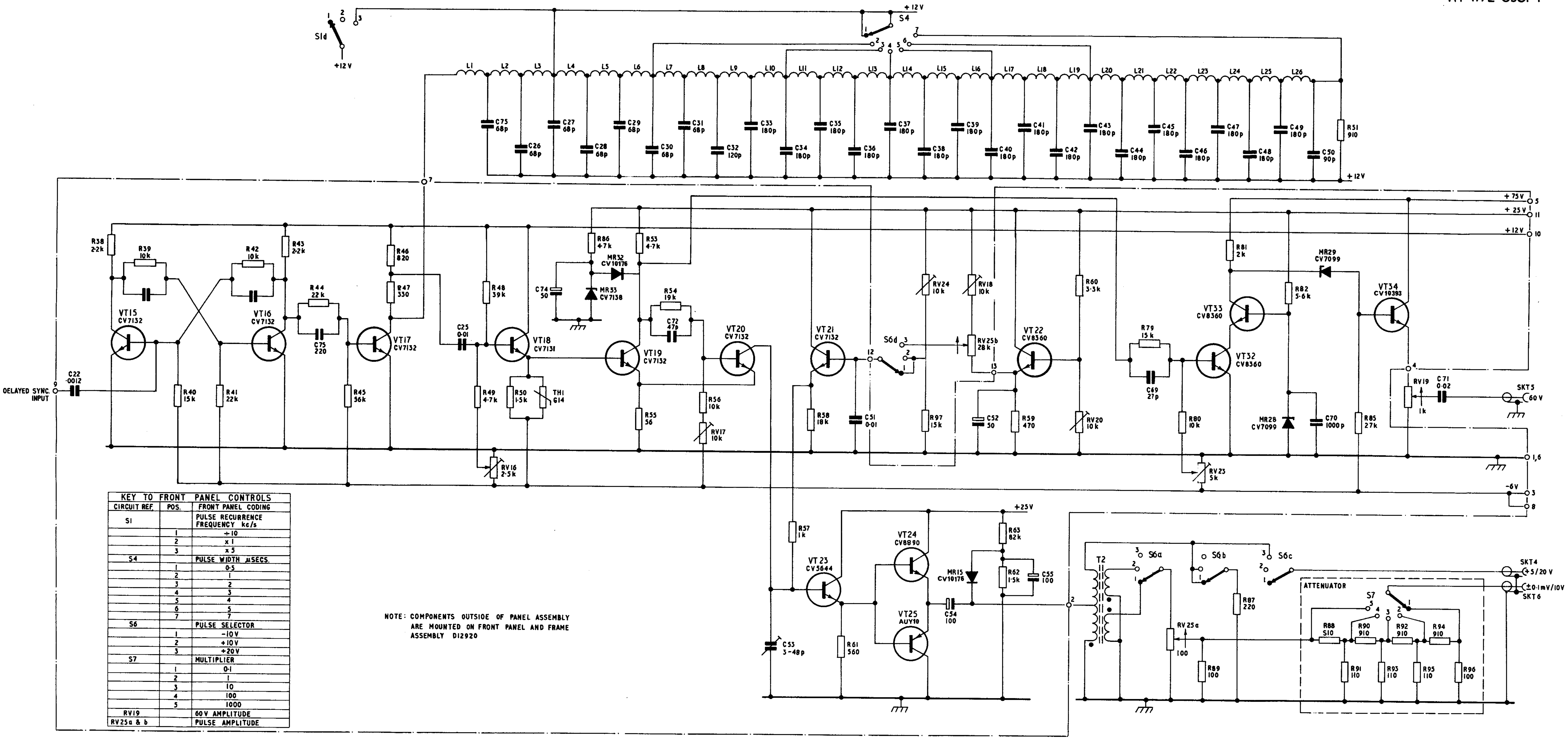
-6V supply

39. The -6V supply is derived from a 12V a.c. output of the mains transformer by half-wave rectifier diode MR22 and smoothing circuit R83, C57, C59. The supply is stabilized by Zener diode MR25 before its connection to the external circuits.



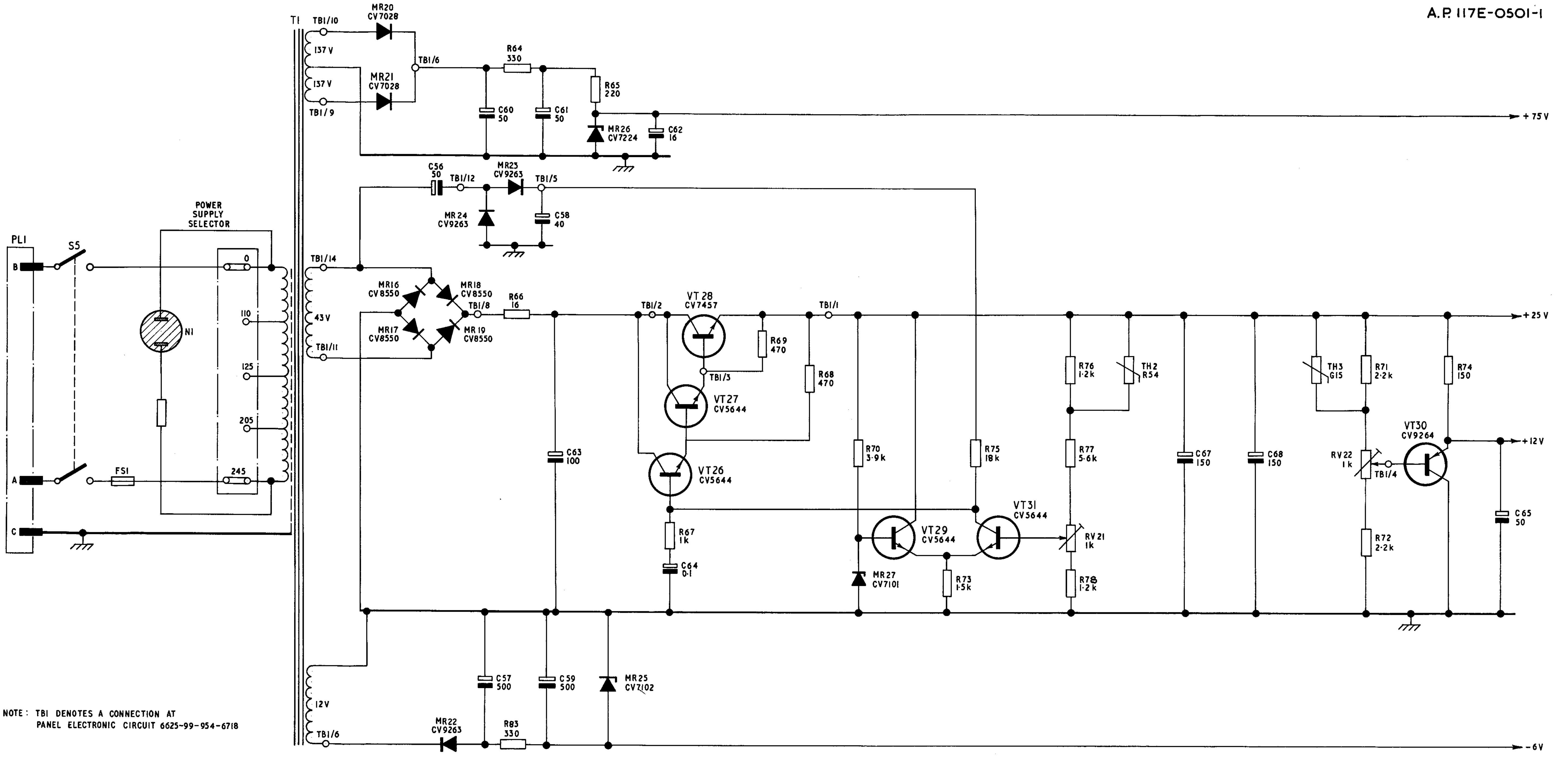
KEY TO FRONT PANEL CONTROLS		
CIRCUIT REF.	POS.	FRONT PANEL CODING
S1 } RV4 }		PULSE RECURRENCE FREQUENCY kc/s
	1	÷ 10
	2	x 1
	3	x 5
S2		TRIGGER
	1	INT
	2	± EXT
	3	
S3 } RV9 }		DELAY μSECS
	1	5
	2	5 - 30
	3	25 - 150
	4	50 - 300
	5	250 - 1500

Fig.1 Panel Electronic Circuit 6625-99-954-6763 : circuit Fig.1



KEY TO FRONT PANEL CONTROLS		
CIRCUIT REF.	POS.	FRONT PANEL CODING
S1		PULSE RECURRENCE FREQUENCY kc/s
	1	÷10
	2	x 1
	3	x 5
S4		PULSE WIDTH µSECS.
	1	0·5
	2	1
	3	2
	4	3
	5	4
	6	5
	7	7
S6		PULSE SELECTOR
	1	-10V
	2	+10V
	3	+20V
S7		MULTIPLIER
	1	0·1
	2	1
	3	10
	4	100
	5	1000
RV19		60V AMPLITUDE
RV25a & b		PULSE AMPLITUDE

Fig. 2 Panel Electronic Circuit 6625-99-954-6719 : circuit



NOTE: TB1 DENOTES A CONNECTION AT PANEL ELECTRONIC CIRCUIT 6625-99-954-6718

Fig. 3

Chassis Assembly D12922 : circuit

TOPIC 3D

PULSE GENERATOR SET, CT500
10S/6625-99-952-9168)

SCALE OF SERVICING SPARES

Introduction

This Scale of Servicing Spares is based on the most up-to-date information available at the time of printing. Any aspect of the scale thought to be unsatisfactory is to be reported in accordance with AP 100B-01, Order 0504 to the Ministry of Defence (ADSM 25) RAF via Command Headquarters.

COLUMN HEADINGS AND SPECIAL NOTES

COL 1 - Section and Reference number

COL 2 - Nomenclature

COL 3 - Qty off per equipment

COL 4 - 4 months station holding to support one equipment. (Note 1 and 2)

COL 5 - 4 months station holding to support two equipments. (Note 1)

COL 6 - 4 months station holding to support three equipments. (Note 1)

COL 7 - 6 months 3rd Line test equipment repair unit holding. Items marked with an asterisk are to be demanded on a one-for-one basis as required.

COL 8 - Items marked ∅ affect calibration of the equipment. (Note 3)

COL 9 - Circuit reference, part number or other reference.

Note 1... Quantities scaled in Cols 4, 5 and 6 are maximum station holdings.

Note 2... Items marked with an asterisk (*) in Col 4 may be demanded on a one-for-one basis by user units.

Note 3... Where more than one circuit reference appears in Col 9, and the calibration symbol ∅ appears in Col 8, this symbol applies to underlined circuit references only.

1	2	3	4	5	6	7	8	9
5K								
9457900	Clip,electrical,alligator type	2	*			*		For cable
10AC								
1006437	Ring,retaining,3/16 in bore dia.	10	*			*		For case cover
1018359	Screw,machine;6BA, $\frac{3}{4}$in lg	2	*			*		For 10AK/ 9546141
1070402	Screw,machine;8BA,1$\frac{1}{4}$ in lg	4				*		
1220036	Screw,externally relieved body,2BA,4.1/64 in lg	10	*			*		For case cover
9018887	Screw,machine;8BA,5/16 in lg	4				*		For 10H/ 1074576
9018889	Screw,machine,8BA,7/16 in lg	10				*		For RV10 to RV14
9018894	Screw,machine;6BA,$\frac{1}{4}$ in lg	11				*		
9138582	Washer,non metallic,rubber	10	*			*		For case cover
9156281	Nut,plain,hexagon,4BA	15				*		
9417070	Nut,plain,hexagon,2BA	10	*			*		For case cover
9418907	Screw,machine,2BA,$\frac{1}{2}$ in lg	14	*			*		Front panel
9436075	Washer,spring tension,8BA	26				*		
9436076	Washer,spring tension,6BA	58	*			*		
9436077	Washer,spring tension,4BA	26				*		
9436079	Washer,spring tension,2BA	4				*		
9438009	Nut,precision	6				*		For RV4,RV9, RV19,RV25
9447144	Screw,machine,4BA,$\frac{1}{4}$ in lg	3				*		For S7
9447146	Screw,machine,4BA,$\frac{3}{8}$ in lg	16				*		
9447148	Screw,machine,4BA,$\frac{1}{2}$ in lg	3				*		
9447156	Screw,machine,2BA,$\frac{1}{2}$ in lg	4				*		
9447162	Screw,machine,6BA,$\frac{1}{4}$ in lg	28				*		
9482288	Screw,machine,4BA,$\frac{3}{8}$ in lg	4				*		For T1
9484141	Nut,plain,hexagon,8BA	26				*		
9484142	Nut,plain,hexagon,2BA	4				*		
9484143	Nut,plain,hexagon,6BA	8	*			*		
9507578	Washer,non metallic,ptfe	10	*			*		For case cover
9706224	Nut,plain,hexagon,4BA	4				*		
10AE								
9546718	Panel,electronic circuit, 33 components	1				*		D12757
9546719	Panel,electronic circuit, 68 components	1				*		D12751
9546763	Panel,electronic circuit, 82 components	1				*		D12754
9717707	Light,indicator,with red lens	1	*			1		N1
10AK								
0970183	Insert,control dial-knob	6	*			*		
0970184	Cap,electrical	6	*			*		
0970185	Knob,1$\frac{3}{4}$ in od,w/skirt	1	*			*		For S7
0970186	Knob,1$\frac{1}{8}$ in od,w/o skirt	5	*			*		
9428675	Knob,1$\frac{5}{8}$ in od,w/o skirt	2	*			*		For RV4,RV9

1	2	3	4	5	6	7	8	9
<u>10AK</u>								
9428683	Knob,1⅛ in od,w/o skirt	2	*			*		For RV19,RV25
9428697	Insert,control dial-knob	4	*			*		
9546141	Cursor,indicator,plastic, 29/32 in long	1	*			*		
9546712	Dial,control:marked 1 to 12	1				*		
9546715	Dial,control:marked 5 to 30, and 25 to 150	1				*		
<u>10AP</u>								
9010703	Cover insulating, electrical clip red	1	*			*		For cable
9010704	Cover insulating, electrical clip black	1	*			*		For cable
<u>10AS</u>								
9138580	Retainer packing 13/64 in id.	10	*			*		For case cover
9138583	Spring,helical compression	10	*			*		For case cover
9456168	Retainer,semi-conductor device;black beryllium copper,13/16 in by ⅞ in lg	1				*		
9996277	Seal,rubber channel	1				*		For case cover
<u>10B</u>								
5800112	Insulator,stand off; ceramic	11				*		
9450578	Insulator,bowl,⅛ in dia	4				*		
9546220	Insulator,bead,11/64 in dia	8				*		
<u>10C</u>								
0124918	Capacitor,fixed,100 µF + 50%-20%,350V	1				1	ϕ	C63
1070401	Capacitor,fixed,50 µF + 100%-20%,50V	3	*	(C68)		1	ϕ	<u>C56</u>,<u>65</u>,68
1070403	Capacitor,fixed,220 pF ± 10%,500V	1				1	ϕ	C11
1074091	Capacitor,variable, 48 pF MAX	1				1	ϕ	C53
2235902	Capacitor,fixed,16 µF + 100%-20%,100V	1				1	ϕ	C62
5800991	Capacitor,fixed,50 µF + 100%-20%,6V	1				1	ϕ	C74
9113713	Capacitor,fixed,120 pF ± 2.5%,750V	3				1	ϕ	C12,23,24
9451868	Capacitor,fixed,1 µF ± 2%,150V	1				1	ϕ	C2
9463263	Capacitor,fixed,500 µF + 100%-20%,15V	1				1	ϕ	C59
9463613	Capacitor,fixed,500 µF + 100%-20%,25V	1				1	ϕ	C57
9466644	Capacitor,fixed,50 µF + 100%-20%,150V	1				1	ϕ	C61
9516574	Capacitor,fixed,0.1 µF ± 20%,200V	1				1	ϕ	C64

1	2	3	4	5	6	7	8	9
10C								
9520734	Capacitor,fixed,40 μF + 100%-20%,100V	1				1	ϕ	C58
9529995	Capacitor,fixed,33 pF ± 5%,750V	1				1	ϕ	C19
9546207	Capacitor,fixed,47 pF ± 2%,750V	3				1	ϕ	C9,18,72
9546208	Capacitor,fixed,0.0012 μF ± 10%,500V	2				1	ϕ	C8,22
9546209	Capacitor,fixed,0.0015 μF ± 10%,500V	3				1	ϕ	C5,7,13
9546210	Capacitor,fixed,0.001 μF ± 10%,500V	2				1	ϕ	C20,70
9546211	Capacitor,fixed,560 pF ± 10%,500V	1				1	ϕ	C10
9546213	Capacitor,fixed,27 pF ± 5%,750V	1				1	ϕ	C69
9546214	Capacitor,fixed,50 μF ± 50%-20%,275V	1				1	ϕ	C60
9546215	Capacitor,fixed,1 μF + 100%-20%,150V	1				1	ϕ	C1
9546216	Capacitor,fixed,0.062 μF ± 2%,50V	1				1	ϕ	C17
9546217	Capacitor,fixed,0.012 μF ± 2%,50V	1				1	ϕ	C16
9546218	Capacitor,fixed,0.0062 μF ± 2%,50V	1				1	ϕ	C15
9546219	Capacitor,fixed,0.0012 μF ± 2%,50V	1				1	ϕ	C14
9546248	Capacitor,fixed,100 μF + 50%-20%,4V	2				1	ϕ	C54,55
9546249	Capacitor,fixed,50 μF + 50%-20%,10V	1				1	ϕ	C52
9546251	Capacitor,fixed,0.02 μF ± 2%,150V	3	*	(C71)		1	ϕ	C4,21,71
9546252	Capacitor,fixed,0.1 μF ±2%,150V	1				1	ϕ	C3
9546641	Capacitor,fixed 0.01 μF ± 20%,250V	2				1	ϕ	C25,51
9727313	Capacitor,fixed,150 μF + 100%-20%,50V	1				1	ϕ	C67
10CV								
0372047	Valve,electronic;CV7028	2				2	ϕ	MR20,21
0372199	Valve,electronic;CV7099	6				4	ϕ	MR2,3,13,14 28,29
0372201	Valve,electronic;CV7101	1				1	ϕ	MR27
0372202	Valve,electronic;CV7102	1				1	ϕ	MR25
0372203	Valve,electronic;CV7103	4				3	ϕ	MR1,4,6,10
0372379	Valve,electronic,CV7131	4				2	ϕ	VT5,8,9,18
0372380	Valve,electronic;CV7132	10				3	ϕ	VT6,7,10,11 15,16,17,19 20,21

1	2	3	4	5	6	7	8	9
10CV								
0372388	Valve,electronic,CV7138	1				1	ϕ	MR33
0372631	Valve,electronic;CV7224	1				1	ϕ	MR26
0373553	Valve,electronic;CV8360	5				2	ϕ	VT12,13,22 32,33
0373780	Valve,electronic;CV8550	4				3	ϕ	MR16 to 19
0374485	Valve,electronic;CV9263	3				2	ϕ	MR22,23,24
0374486	Valve,electronic;CV9264	1				1	ϕ	VT30
0374864	Valve,electronic;CV9762	1				1	ϕ	VT28
0375150	Valve,electronic;CV10176	10				5	ϕ	MR5,7,8,9, 11,12,15,30, 31,32
1180426	Valve,electronic; transistor (AUY10)	1				1	ϕ	VT25
1081532	Transistor CV8890	1				1	ϕ	VT24
10D								
9546714	Delay line	1				*	ϕ	D12527
9546716	Delay line	1				*	ϕ	D12763
9546717	Delay line	1				*	ϕ	D12528
10F								
1074029	Switch,rotary,wafer,4 pole 3 positions, 1 wafer	1				*	ϕ	S6
9546134	Switch,rotary,wafer,4 pole, 3 positions, 2 wafer	1				*	ϕ	S1
9546135	Switch,rotary,wafer,single pole,7 positions,single wafer	1				*	ϕ	S4
9546136	Switch,rotary,wafer,3 pole 5 positions,2 wafer	1				*	ϕ	S3
9546140	Switch,rotary,wafer,2 pole, 3 positions, 2 wafer	1				*	ϕ	S2
9546260	Switch,toggle	1	*			1		S5
10H								
0120236	Plug,electrical,coaxial	3	*			1		For cables
0130538	Plug,electrical,3 pole	1	*			1		PL1
0590170	Fuseholder	1	*			1		
0590171	Carrier,fuse link.	1	*			1		
1074028	Socket,electrical,coaxial	6	*			1		SKT1 to 6
1074576	Terminal board,6 pin type terminals	1				*		
1074626	Terminal board,9 lug terminals	1				*		D14213
9138305	Fuse link,electrical 500mA	1	1	2	3	4		FS1
9546300	Terminal board,9 post type	1				*		
9553094	Terminal board,9 lug type terminals	1				*		D14057
9553095	Terminal board,7 lug type terminals	1				*		D14055
9553096	Terminal board,7 lug type terminals	1				*		D14058
9703092	Plug,electrical,free,3 pole	1	*			*		Voltage selector
9703093	Socket,electrical,9 pole	1				*		Voltage selector

1	2	3	4	5	6	7	8	9
10HS								
9459896	Cable assembly,power, electrical	1	*			1		
9546137	Cable assembly,radio freq; plug 1st end, 2 clips, 2nd end;4 ft lg.	1	*			1		
9546138	Cable assembly,radio freq. free plug both ends,4 ft o/a lg	1	*			1		
10K								
9546139	Transformer,power,step-down	1				1	ϕ	T1
9546762	Transformer pulse	1				1	ϕ	T2
10L								
1074575	Attenuator,variable 0-80db	1				*		S7
10W								
0113277	Resistor,fixed,16 ohms ± 5%,6W	1				1	ϕ	R66
0113300	Resistor,fixed,150 ohms ± 5%,6W	1				1	ϕ	R74
0113327	Resistor,fixed 2K ohms ± 5%,6W	2				1	ϕ	R34,81
0113385	Resistor,fixed 330 ohms ± 5%,12W	1				1	ϕ	R64
0113471	Resistor, fixed,220 ohms ± 5%,9W	1				1	ϕ	R65
0118259	Resistor,variable,1K ohms ± 20%,0.25W	2				1	ϕ	RV21,RV22
0118260	Resistor,variable,2.5K ohms ± 20% 0.25W	1				1	ϕ	RV16
0118261	Resistor,variable,5K ohms ± 20%,0.25W	3				1	ϕ	RV8,RV15,RV23
0118262	Resistor,variable,10K ohms ± 20%,0.25W	2				1	ϕ	RV17,RV20
0124671	Resistor,fixed,100 ohms ± 5%,0.5W	1	*			1		R89
0128560	Resistor,fixed,100 ohms ± 1%,0.125W	1				1	ϕ	R96
0128561	Resistor,fixed,110 ohms ± 1%,0.125W	3				1	ϕ	R91,93,95
0128583	Resistor,fixed,910 ohms ± 1%,0.125W	4				1	ϕ	R88,90,92,94
0215231	Resistor,fixed,820 ohms ± 5%,0.25W	2				1	ϕ	R3,5
0215241	Resistor,fixed,1K ohms ± 5%,0.25W	1				1	ϕ	R97
0215281	Resistor,fixed,2.2K ohms ± 5%,0.25W	4				1	ϕ	R18,23,38,43
0215291	Resistor,fixed,2.7K ohms ± 5%,0.25W	1				1	ϕ	R28
0215321	Resistor,fixed,4.7K ohms ± 5%,0.25W	1				1	ϕ	R29

1	2	3	4	5	6	7	8	9
10W 0215341	Resistor,fixed,6.8K ohms ± 5%,0.25W	2				1	ϕ	R15,84
0215351	Resistor,fixed,8.2K ohms ± 5%,0.25W	1				1	ϕ	R32
0215520	Resistor,fixed,330 ohms ± 2%,0.25W	1				1	ϕ	R47
0215620	Resistor,fixed,820 ohms ± 2%,0.25W	1				1	ϕ	R46
0215740	Resistor,fixed,2.7K ohms ± 2%,0.25W	2				1	ϕ	R4,6
0215800	Resistor, fixed,4.7K ohms ± 2%,0.25W	1				1	ϕ	R53
0215860	Resistor,fixed,8.2K ohms ± 2%,0.25W	2				1	ϕ	R16,30
0216001	Resistor,fixed,10K ohms ± 5%,0.25W	2				1	ϕ	R33,80
0216021	Resistor,fixed,15K ohms ± 5%,0.25W	1				1	ϕ	R79
0216091	Resistor,fixed,56K ohms ± 5%,0.25W	1				1	ϕ	R27
0216211	Resistor,fixed,10K ohms ± 2%,0.25W	6				1	ϕ	R2,7,19,21 39,42
0216251	Resistor,fixed,15K ohms ± 0.25W	3				1	ϕ	R20,40,54
0216291	Resistor,fixed,22K ohms ± 2%,0.25W	3				1	ϕ	R22,41,44
0216390	Resistor,fixed,56K ohms ± 2%,0.25W	1				1	ϕ	R45
0221079	Resistor, fixed,56K ohms ± 10%,0.25W	1				1	ϕ	R55
0221151	Resistor,fixed,220 ohms ± 10%,0.25W	1				1	ϕ	R87
0221163	Resistor,fixed,270 ohms ± 10%,I,25W	1				1		R11
0221174	Resistor,fixed,330 ohms ± 10%,0.5W	1				1	ϕ	R83
0221193	Resistor,fixed,470 ohms ± 10%,0.25W	3				1	ϕ	R59,68,69
0221205	Resistor,fixed,560 ohms ± 10%,0.25W	1				1	ϕ	R61
0222004	Resistor,fixed,1K ohms ± 10%,0.25W	6				1	ϕ	R13,14,25,26 57,67
0222016	Resistor,fixed,1.2K ohms ± 10%,0.25W	2				1	ϕ	R76,78
0222025	Resistor,fixed,1.5K ohms ± 10%,0.25W	5				1	ϕ	R17,31,50,62 73
0222046	Resistor,fixed,2.2K ohms ± 10%,0.25W	2				1		R71,72
0222067	Resistor,fixed,3.3K ohms ± 10%,0.25W	1				1	ϕ	R60

1	2	3	4	5	6	7	8	9
10W								
0222069	Resistor,fixed,3.3K ohms ± 10%,0.5W	3				1	ϕ	R37A,R37B, R37C
0222079	Resistor,fixed,3.9K ohms ± 10%,0.25W	1				1		R70
0222088	Resistor,fixed,4.7K ohms ± 10%,0.25W	4				1	ϕ	R12,24,49,86
0222100	Resistor,fixed,5.6K ohms ± 10%,0.25W	4				1	ϕ	R10,35,77,82
0222121	Resistor,fixed,8.2K ohms ± 10%,0.25W	1				1	ϕ	R63
0222130	Resistor,fixed,10K ohms ± 10%,0.25W	1				1	ϕ	R56
0222151	Resistor,fixed,15K ohms ± 10%,0.25W	2				1	ϕ	R52,97
0222163	Resistor,fixed,18K ohms ± 10%,0.25W	2				1	ϕ	R58,75
0222184	Resistor,fixed,27K ohms ± 10%,0.25W	3				1	ϕ	R1,36,85
0222205	Resistor,fixed,39K ohms ± 10%,0.25W	1				1	ϕ	R48
0223007	Resistor,fixed,56K ohms ± 10%,0.25W	1				1	ϕ	R9
0223049	Resistor,fixed,120 ohms ± 10%,0.25W	1				1	ϕ	R8
1018743	Resistor,thermal,10K ohms at 20°C	1				1	ϕ	TH1
1069270	Resistor,variable,1K ohm ± 20%,2W	1				1		RV19
1070405	Resistor,variable,5K ohm ± 5%,5W	1				1		RV4
1074625	Resistor,variable,100 ohms/ 25K ohms ± 5%,3W	1				1		RV25A,RV25B
5803169	Resistor,variable,50K ohms ± 5%,5W	1				1		RV9
5803169	Resistor,variable,50K ohms ± 5%,5W	1				1		RV9
9332924	Resistor,variable,10K ohms ± 10%,½W at 70°C	5				1		RV5,RV6,RV7, RV18,RV24
9447126	Resistor,thermal,50K ohms at 20°C	1				1	ϕ	TH2
9488173	Resistor,variable,1K ohms ± 10%,½W at 70°C	3				1		RV1
9532178	Resistor,variable,10K ohms ± 10%,½W at 70°C	1				1	ϕ	RV14
9546247	Resistor,thermal,100K ohms at 20°C	1				1	ϕ	TH3
9546873	Resistor,variable,20K ohms ± 10%,1W	1				1	ϕ	RV10
9727192	Resistor,variable,5K ohms ± 10%,at 70°C,½W	3				1	ϕ	RV11,RV12, RV13

1	2	3	4	5	6	7	8	9
10W								
9727193	Resistor,variable,10K ohms ± 10%,½W at 70°C (alternative for 10W/9532178 when that item is no longer available)	1				*	ϕ	RV14
28F								
9429636	Washer,seal,flat rubber/steel	14	*			*		Front panel
28FP								
1004892	Stud,turnlock fastener	3				*		For case cover
1004893	Bushing,rubber	3				*		For case cover
9993392	Receptacle,positive lock	3				*		For case cover
28W								
1200071	Washer flat; 2BA	10	*			*		For case cover
9437455	Washer flat; 4BA	10				*		
9995407	Washer flat;⅛ in id, 15/16 od	3				*		
110CV								
7303284	Transistor,CV10393	2				1	ϕ	VT14,34
7520150	Valve,electronic,CV5644	5				2	ϕ	VT23,26,27,29,31
8413218	Transistor,CV9563 (see note)	4				2	ϕ	VT1 to VT4
	Note: CV9563 is a replacement for CV10292 (10CV/5961-99-037-5240)							

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