AIR PUBLICATION

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PULSE GENERATOR
CT 321

GENERAL AND TECHNICAL INFORMATION

BY COMMAND OF THE DEFENCE COUNCIL

[signature]

Ministry of Defence

FOR USE IN THE
ROYAL AIR FORCE

(Prepared by the Ministry of Technology)

A.L.6 May 67

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PART 1

LEADING PARTICULARS
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GENERAL INFORMATION

LEADING PARTICULARS

Nomenclature and	*Generator pulse CT*321
Ref. No.	6625-99-943-7371
Sinewave	50 c/s to 50 kc/s at 15 V r.m.s.
Squarewave	50 c/s to 50 kc/s at 50 V peak-to-peak
Pulse	0·1, 0·2, 0·5, 1·0, 2·0, 5·0, 10 and 20 μs. positive or negative, at 60 V, 50 c/s to 50 kc/s p.r.f.
Sync pulse	1·0, 5·0 and 20 μs positive or negative, at 15, 25, 50 and 100 V
Trigger	The pulse may be triggered from any one of the following:— (1) Internal from main oscillator (2) Sinewave (3) Positive or negative pulse (4) Single stroke 12 V d.c.
Attenuated outputs	
Sinewave	1 V to 1 μV r.m.s. in 1 dB steps
Squarewave	1 V to 1 μV peak-to-peak in 1 dB steps
Pulse	10 V to 10 μV peak in 1 dB steps
Power supplies	110-120 V and 200-250 V a.c. 50-60 c/s

Dimensions	*Height (in.)*	*Width (in.)*	*Depth (in.)*	*Weight (lb.)*
Pulse generator sub-assembly	14	19	18	42
Power supply	10½	19	15½	49

Chapter 1.—GENERAL DESCRIPTION

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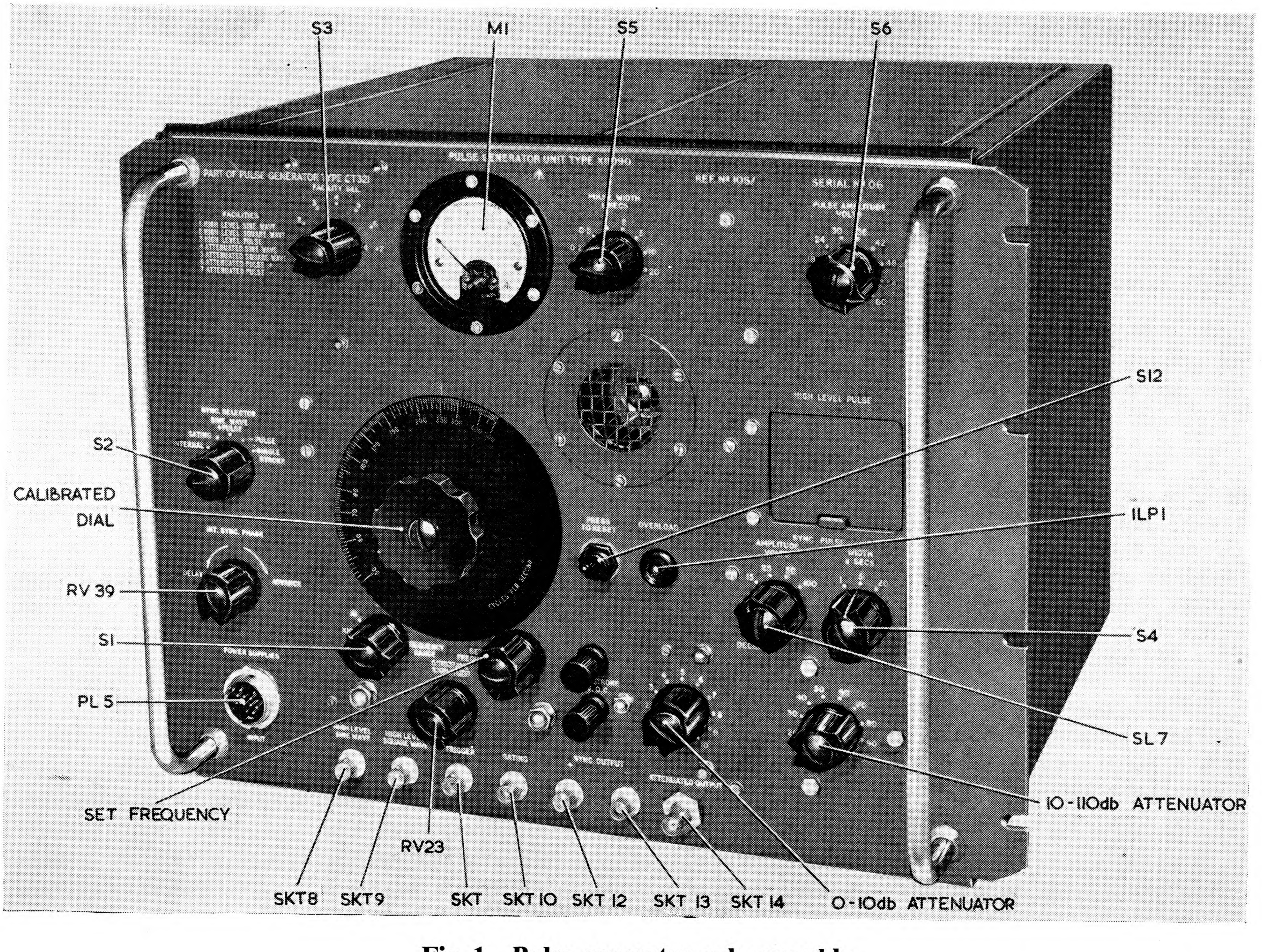


Fig. 1. Pulse generator sub-assembly

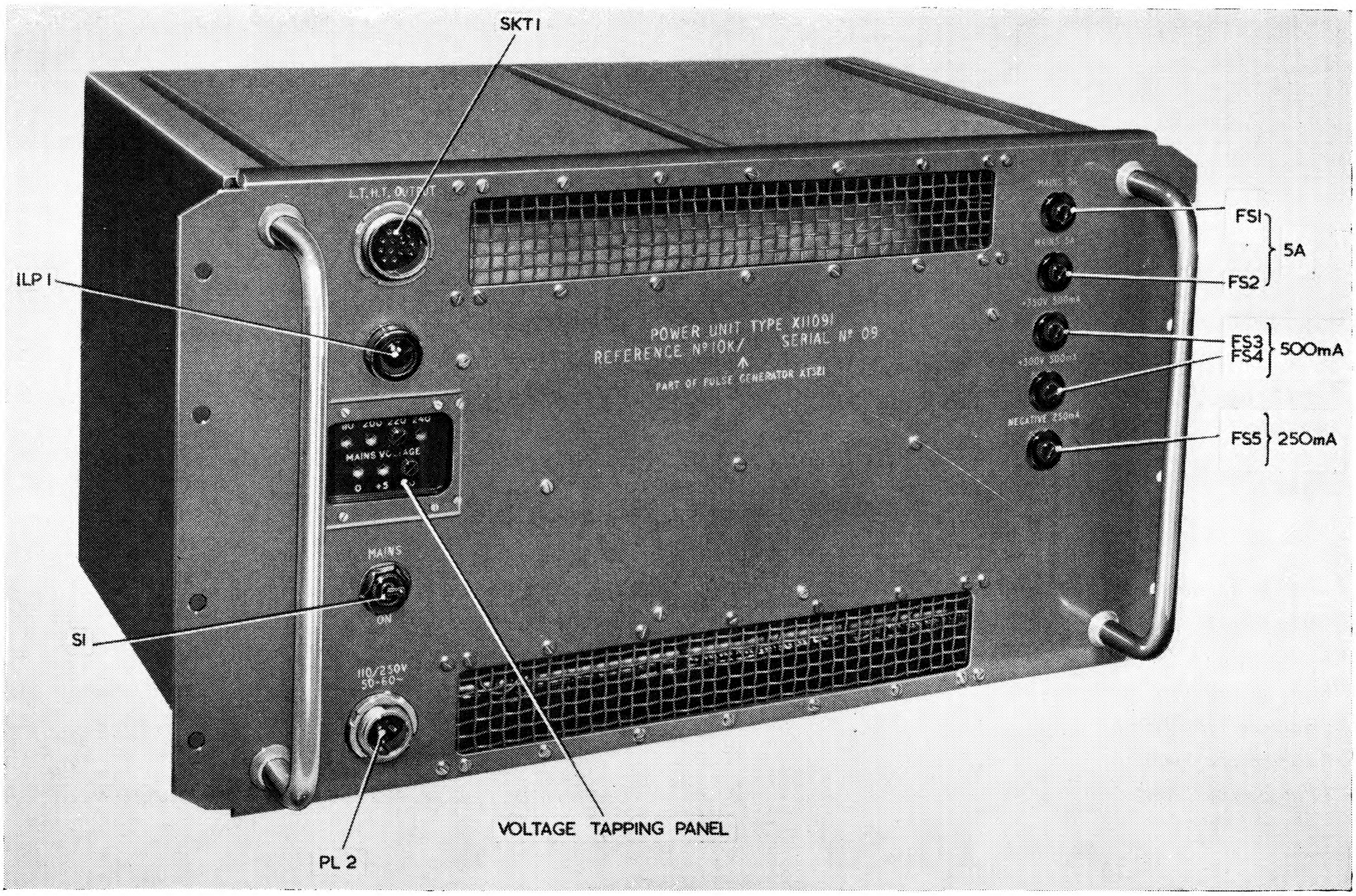


Fig. 2. Power supply

INTRODUCTION

1. The pulse generator CT321 has been developed for use in the servicing of electronic equipment, particularly high-gain video amplifiers. It consists of two units (shown in *fig.* 1 *and* 2, respectively) as follows:—

(1) Generator, pulse, sub-assembly (*Ref. No.* 6625-99-943-7370)

(2) Power supply (*Ref. No.* 6625-99-943-7372)

The units are interconnected by a 12-way connector supplied with the equipment. Both units may be rack mounted.

2. Sine wave, square wave and pulse facilities are provided over a frequency range of 50 c/s to 50 kc/s. Each facility is available at a relatively high output level or at a lower (attenuable) level. The HIGH LEVEL outputs are separate and have specified output impedances; the ATTENUATED OUTPUT is common to all facilities and has an output impedance of 75 ohms.

3. The generator may be triggered internally (free-running) or externally, and may also be gated. It provides positive or negative synchronizing pulses of variable amplitude and width which can be advanced or delayed with respect to the generated signal.

4. The nominal mains power supply requirement is 110-120 V or 200-250 V at 50-60 c/s. A mains connector is supplied with the equipment.

Pulse generator sub-assembly

5. A more detailed assessment of the CT321 may be obtained from the front panel of the pulse generator sub-assembly. The controls, and their functions, are as follows:—

(1) FACILITY SEL. Enables selection of any one of the seven facilities inscribed on the front panel adjacent to the switch:—

1. HIGH LEVEL SINE WAVE. Open-circuit amplitude 15 V ± 5 per cent. Output taken from HIGH LEVEL SINE WAVE socket. Output impedance not greater than 5000 ohms.

2. HIGH LEVEL SQUARE WAVE. Open-circuit amplitude 50 V peak-to-peak ± 5 per cent. Output taken from HIGH LEVEL SQUARE WAVE socket. Output impedance not greater than 5000 ohms.

3. HIGH LEVEL PULSE. Maximum open-circuit amplitude 60 V peak ± 5 per cent. Output taken from HIGH LEVEL PULSE − or + socket. Output impedance not greater than 230 ohms.

4. ATTENUATED SINE WAVE. Maximum amplitude 1 V r.m.s. when terminated by 75 ohms.

5. ATTENUATED SQUARE WAVE. Maximum amplitude 1 V peak-to-peak when terminated by 75 ohms.

6. ATTENUATED PULSE +. Maximum amplitude 10 V peak when terminated by 75 ohms.

7. ATTENUATED PULSE −. Maximum amplitude 10 V peak when terminated by 75 ohms.

(2) DECIBELS. Relates to the graduations of the two step attenuators which permit attenuation of the low level signals from 0 to 120 dB in 1 dB steps.

(3) FREQUENCY RANGE. The positions of this switch multiply, in effect, the sweep of the tuning dial (50 c/s to 500 c/s) by 1, 10 and 100 times. The range corresponding to each position is therefore: —

× 1 50 c/s - 500 c/s

× 2 500 c/s - 5 kc/s

× 3 5 kc/s - 50 kc/s

(4) SET FREQUENCY. A slow motion friction drive for the tuning dial.

(5) SET SINE WAVE LEVEL. Adjusts the output level of the sine wave generator as indicated by the meter. The correct level is 50 microamperes.

(6) PULSE WIDTH. Selects pulse width of 0·1, 0·2, 0·5, 1, 2, 5, 10 and 20 μs.

(7) PULSE AMPLITUDE. Selects pulse amplitudes from 6 V to 60 V in 6 V steps.

(8) PRESS TO RESET. Restores the pulse when the overload relay has tripped. (The maximum pulse duty cycle is 10 per cent; this can be exceeded by selecting wide pulses at a high p.r.f. but the generator is then protected by the operation of the overload relay. Indication of the overload condition is given by the OVERLOAD neon).

(9) SYNC. SELECTOR. This switch has five positions, corresponding to the five ways in which the generator can be synchronized, as follows: -

(a) INTERNAL — free running.

(b) GATING — free running but pulse output available only for the duration of a gating pulse. The gating pulse, which must have an amplitude of at least 25 V and a width greater than 20 μs, is applied to the GATING socket.

(c) SINE WAVE / + PULSE. Synchronized externally, via the TRIGGER socket, by either a sinewave of 3 V to 30 V r.m.s. at 50 c/s to 50 kc/s or a positive pulse of 3 V to 30 V peak amplitude with a minimum width of 2 μs and a p.r.f. of 1 c/s to 50 kc/s.

(d) PULSE. Synchronized externally, via the TRIGGER socket, by a negative pulse of 3 V to 30 V peak amplitude with a minimum width of 2 μs and a p.r.f. of 1 c/s to 50 kc/s.

(e) SINGLE STROKE. One pulse only is given when 12 V d.c. is applied between the two SINGLE STROKE terminals.

(10) SYNC. PULSE AMPLITUDE VOLTS / WIDTH μSECS. Sets the amplitude and width of the sync. pulses (available at the SYNC. OUTPUT + and – sockets) to 15, 25, 50 or 100 V and 1, 5 or 20 μs.

(11) INT. SYNC. PHASE. Advances or delays the phase of the sync. pulses with respect to the generated signal.

The interconnection with the power supply unit is effected through the POWER SUPPLIES INPUT plug.

Power supply

6. This unit provides all the power supplies for the generator sub-assembly through the L.T. H.T. OUTPUT socket on the front panel. These supplies are: —

350 V d.c. stabilized	fused — 500 mA
300 V d.c. stabilized	fused — 500 mA
– 150 V d.c. stabilized	common fuse —
– 300 V d.c. stabilized	(NEGATIVE) 250 mA
12·9 V a.c. ...	for valve heaters
230 V a.c.	for blower motor.

7. The mains input supply is brought in at the 3-pole plug marked 110/250V 50-60~ on the front panel. Also on the front panel are a MAINS on/off switch and indicating lamp, a MAINS VOLTAGE tapping panel and two MAINS 5A fuses.

FUNCTIONAL DESCRIPTION

8. For a brief functional description of the generator unit reference is made to the block diagram shown in fig. 14. A more detailed description of the circuit is given in Part 4 of this volume.

9. When the SYNC. SELECTOR is in the INTERNAL or GATING positions the frequency of operation is governed by the sinewave oscillator, *i.e.* as shown by the position of the main tuning dial. The oscillator has two outputs, one low level and the other at a high level. The low-level output is fed via relay RL2/1 (controlled by the FACILITY SEL.) and step attenuators to the ATTENUATED OUTPUT socket. The high-level output is taken direct to the HIGH LEVEL SINE WAVE socket and to the squarewave unit.

10. In the squarewave unit, the sinewave is used to control the squarewave generator and to develop a trigger pulse for the sync. pulse generator. The phase of the sync. trigger may be advanced or delayed with respect to the squarewave trigger by the INT. SYNC. PHASE control.

11. The squarewave generator provides the squarewave outputs and also initiates the pulse facilities. The high-level output is taken direct to the HIGH LEVEL SQUARE WAVE socket and the low-level output via relay RL3/1 (controlled by the FACILITY SEL.) and step attenuators to the ATTENUATED OUTPUT socket. A third output is fed to the pulse-former unit, either direct or via the gating amplifier, depending on the position of the SYNC. SELECTOR switch.

12. There are two pulse generators in the pulse-former unit, one for short duration pulses, 0·1-1 μs, and the other for long pulses, 2-20 μs.

13. The outputs from the pulse-former unit are fed to the pulse-squarer unit which shortens the rise and fall times of the long duration pulses and sets the amplitude of all pulses. Either the short- or long-duration pulses are selected for amplification by the output valve of this unit to form the low-level and the high-level output pulses. The low-level pulses, which are taken to the step attenuators and thence to the ATTENUATED OUTPUT socket, will be positive or negative according to whether the FACILITY SEL. switch is in position 6 or 7, but positive and negative pulses may be taken simultaneously from the HIGH LEVEL PULSE – and + sockets when the FACILITY SEL. switch is in position 3.

14. In this initial survey of the circuit the switch functions have, for the most part, been ignored. The switch functions for control of the pulse widths and amplitudes consist merely of changing the circuit constants. The functions of the FACILITY SEL. and SYNC. SELECTOR switches, however, are interdependent and warrant more detailed description.

15. When generating pulses, the CT321 may be synchronized with other equipment in two ways. Either it provides the necessary sync. pulses, and thus determines the frequency of operation, or it is triggered externally, the frequency then being decided by the equipment supplying the trigger. This trigger may be a sinewave or a positive or negative pulse (*para.* 5 (9)).

16. External triggering cannot be used for generating sine or square waves. For these facilities, therefore, the frequency is governed by the sinewave oscillator and synchronization with other equipment is attained through the CT321 sync. pulses.

17. Pulse output can also be gated, *i.e.* generated at the frequency of the sinewave oscillator, for the duration of an external pulse fed to the GATING socket. The limits of the gating pulse are given in para. 5 (9).

18. Summarizing paragraphs 15, 16 and 17, the FACILITY SEL. and SYNC. SELECTOR switches ensure

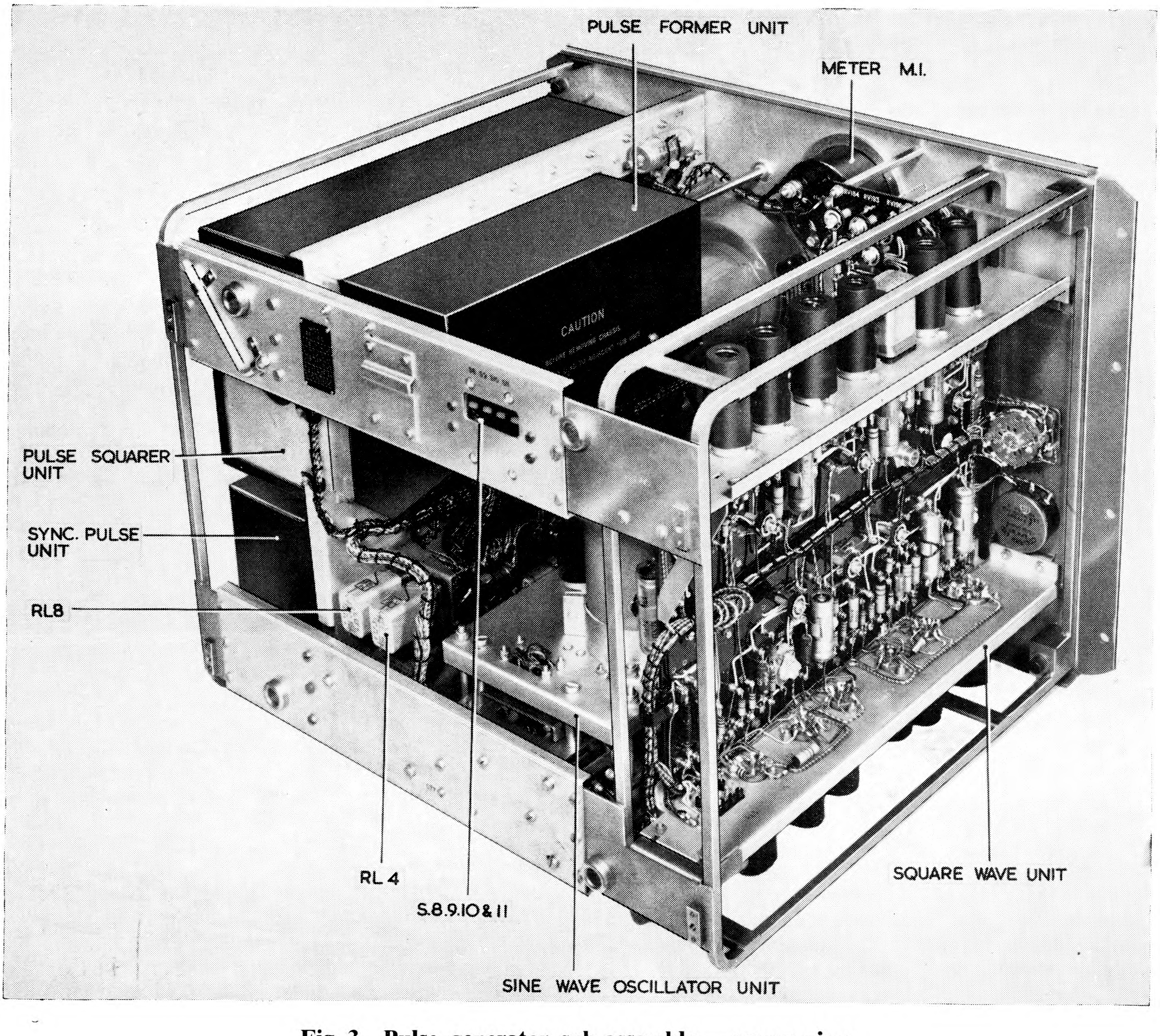


Fig. 3. Pulse generator sub-assembly — upper view

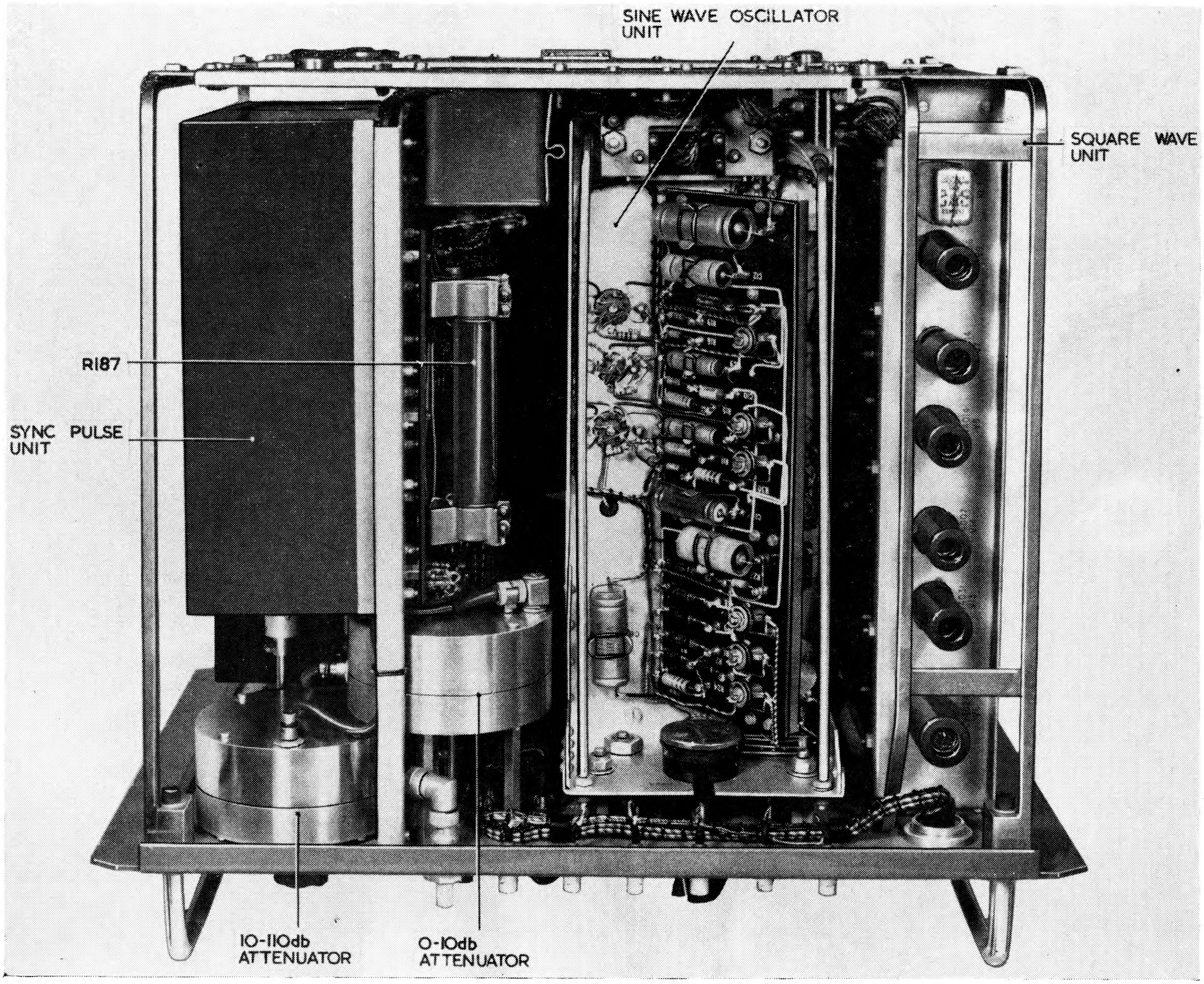


Fig. 4. Pulse generator sub-assembly — lower view

that: —

(1) Sync. pulses are provided by the generator in all positions of the FACILITY SEL. switch when the SYNC. SELECTOR is set to the INTERNAL and GATING positions.

(2) The generator can be triggered externally only when the FACILITY SEL. switch is in positions 3, 6 or 7 (pulse output) with the SYNC. SELECTOR switch in the SINE WAVE / + PULSE, – PULSE or SINGLE STROKE positions.

CONSTRUCTION

Pulse generator sub-assembly

19. Views of this sub-assembly with the rear cover removed are shown in fig. 3 and 4. The sub-assembly breaks down into six units which, although not referenced by the Services as interchangeable items, are more easily serviced by their removal. These units are identified in this publication as follows: —

	Fig.
Sinewave oscillator ...	5
Squarewave oscillator ...	6
Pulse-former unit	7
Pulse-squarer unit ...	8
Sync. pulse generator ...	9
Main chassis framework ...	10

20. The procedure for removing these units is described in the subsequent para. 21 to 27.

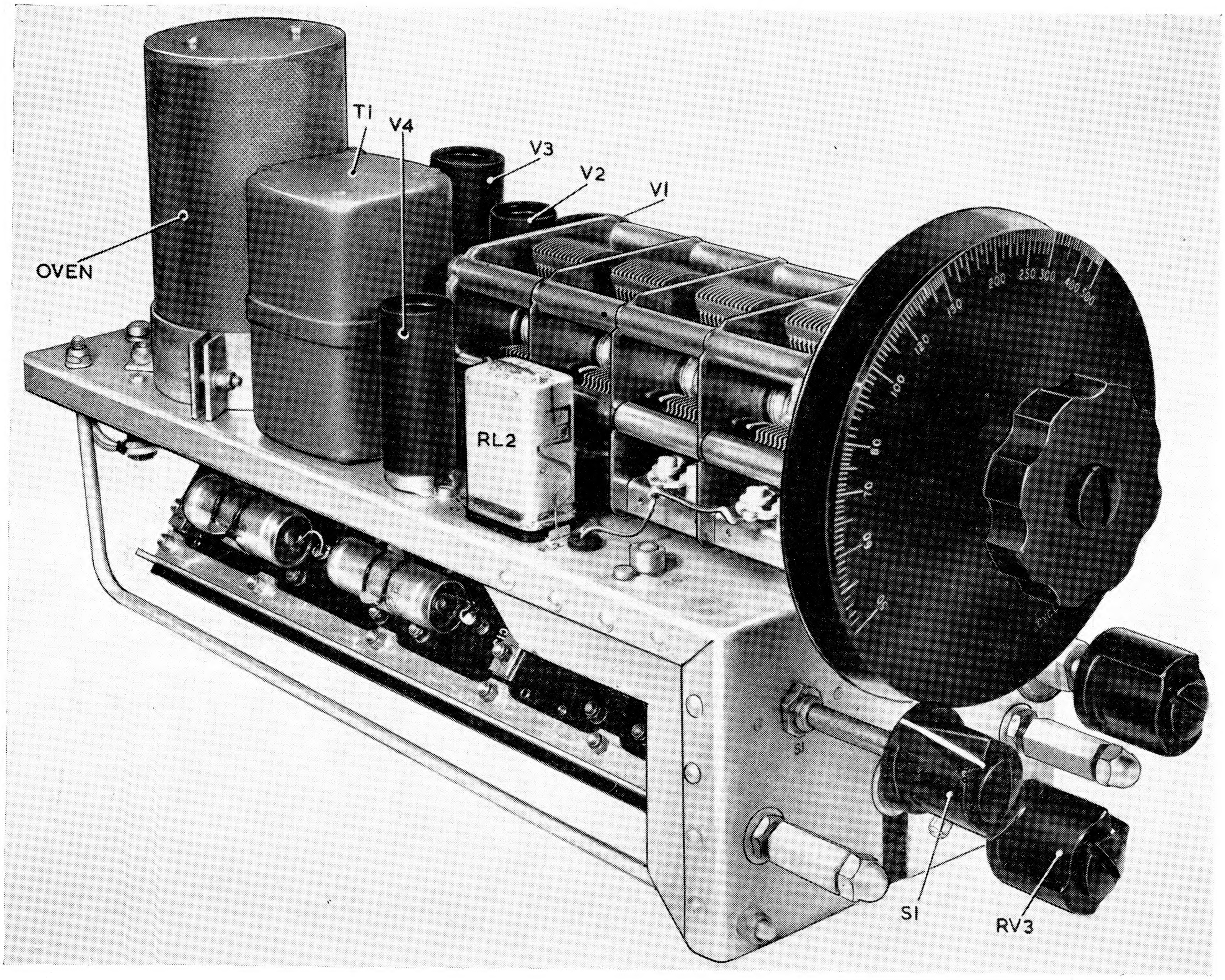


Fig. 5. Sinewave oscillator

Sinewave oscillator

21. Detach the knobs from the FREQUENCY RANGE, SET SINE WAVE LEVEL and SET FREQUENCY controls. Remove the two dome-headed nuts holding the unit to the front panel and release the two 4 B.A. captive screws holding it to the rear mounting bracket.

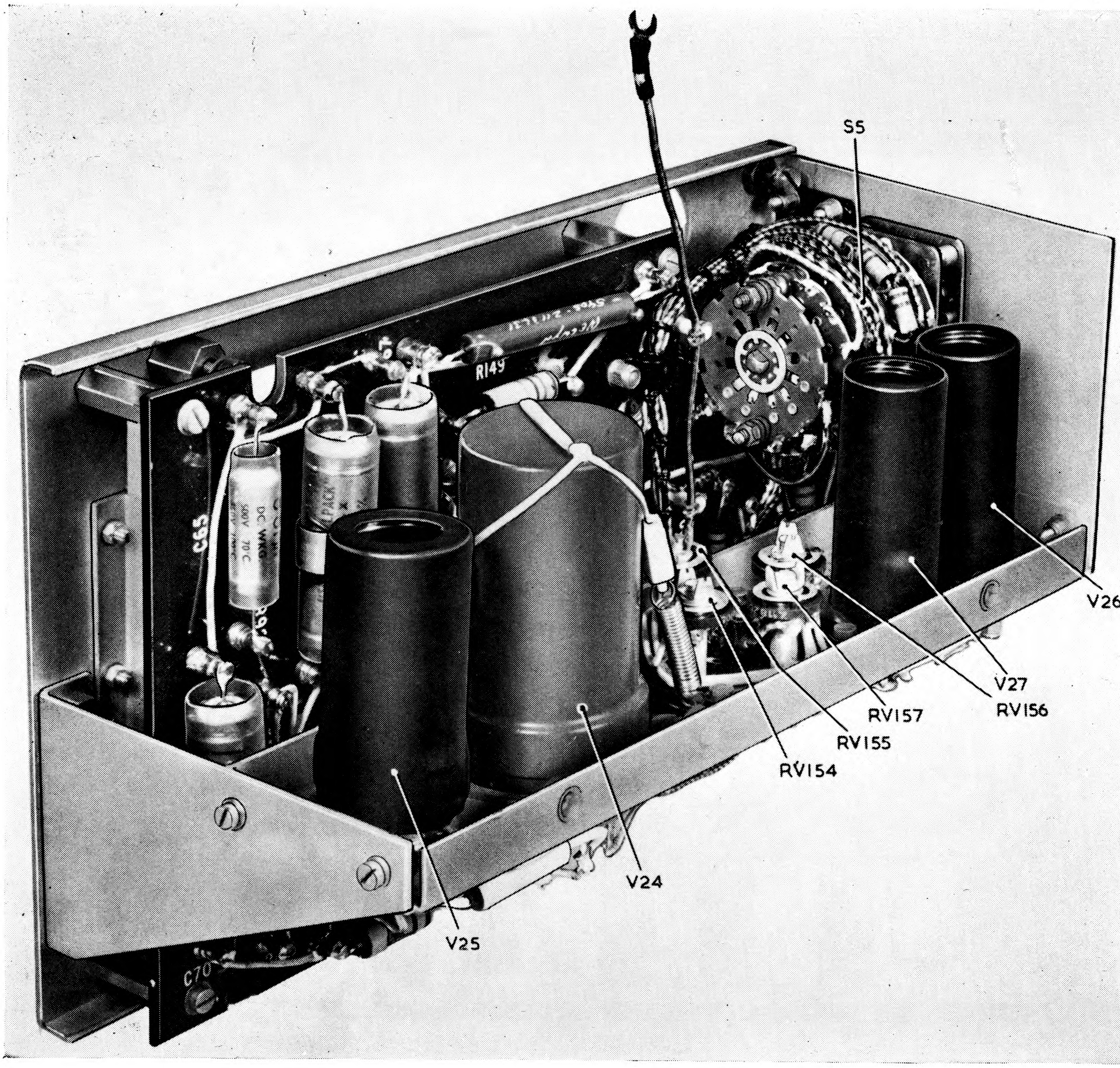


Fig. 7. Pulse-former unit

Pulse-former unit

23. Remove the cover held in position by two hexagon-headed bolts. Release the PULSE WIDTH switch coupler and the lead to the pulse-squarer unit. Release the four captive 4 B.A. bolts holding the unit to the main chassis. The delay line of this unit is assembled on an insulating board which is held in a recess in the unit by four 4 B.A. screws. When these screws are removed, the delay line hinges out on the cable-form.

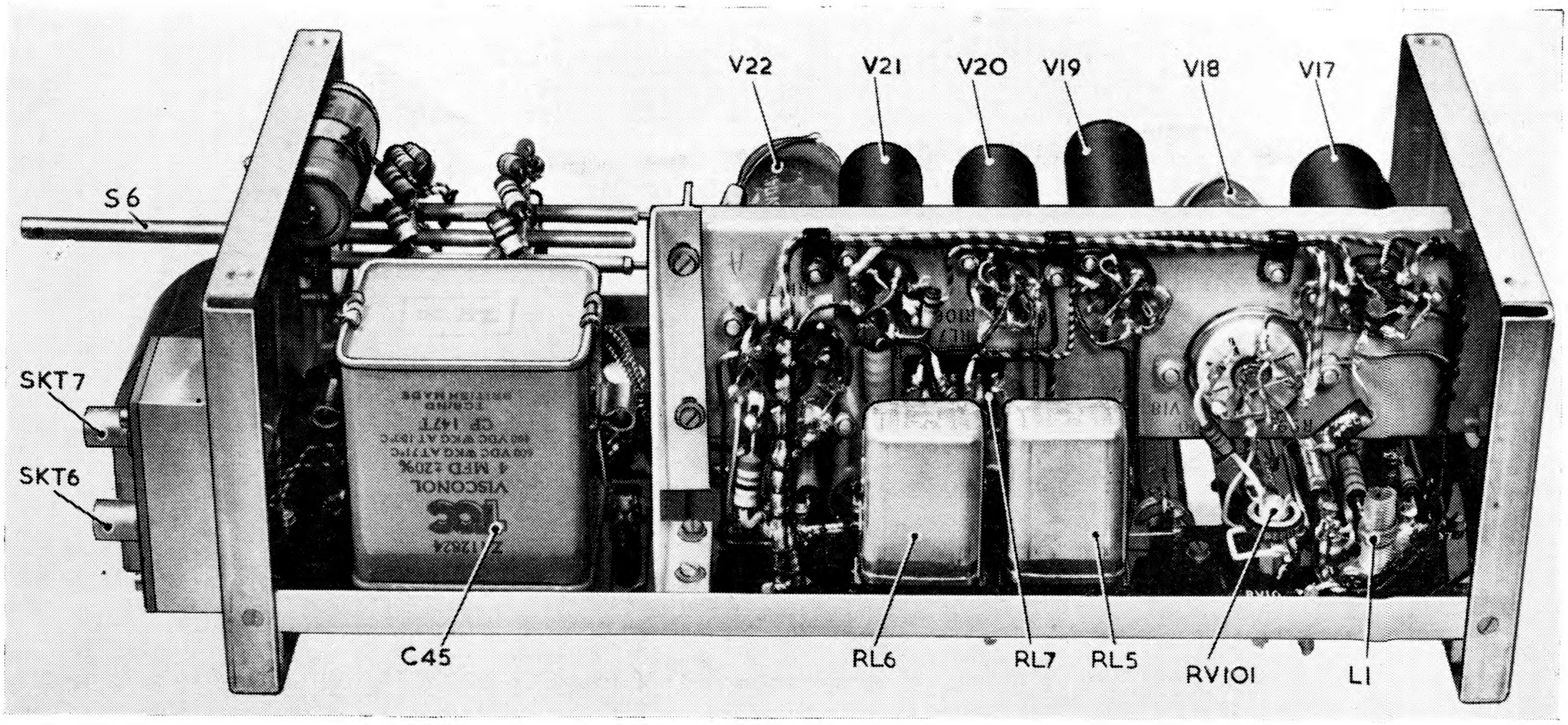


Fig. 8. Pulse-squarer unit

Pulse-squarer unit

24. Take off the knob of the PULSE AMPLITUDE VOLTS control. Remove the cover held in position by four 4 B.A. hexagon-headed bolts. Release the lead to the pulse-former unit and the four captive 4 B.A. bolts holding the unit to the chassis.

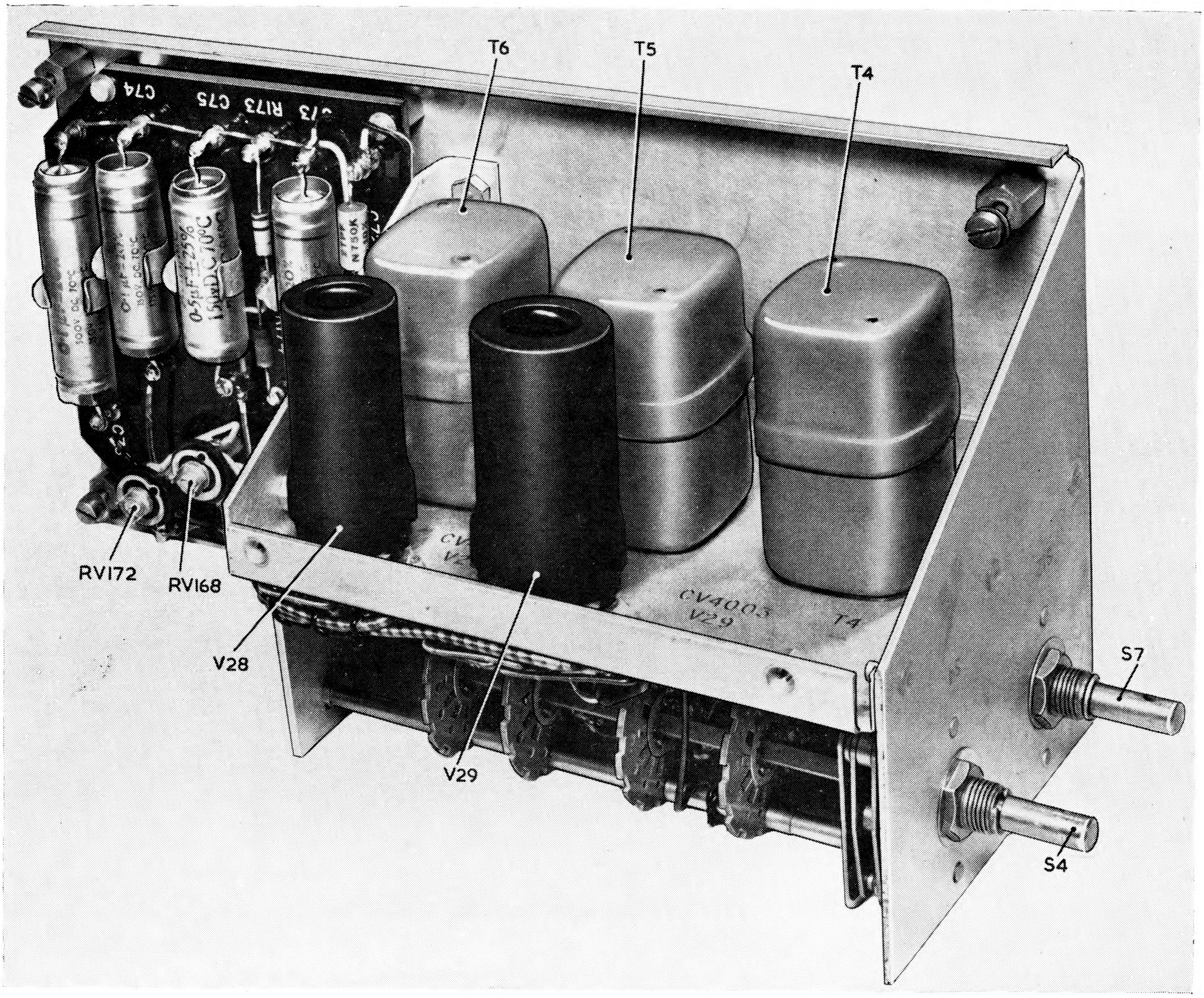


Fig. 9. Sync.-pulse generator

Sync. pulse generator

25. Detach the knobs from the SYNC. PULSE AMPLITUDE and WIDTH controls. Remove the cover held in position by two 4 B.A. hexagon-headed bolts. Release the four captive 4 B.A. bolts holding the unit to the main chassis.

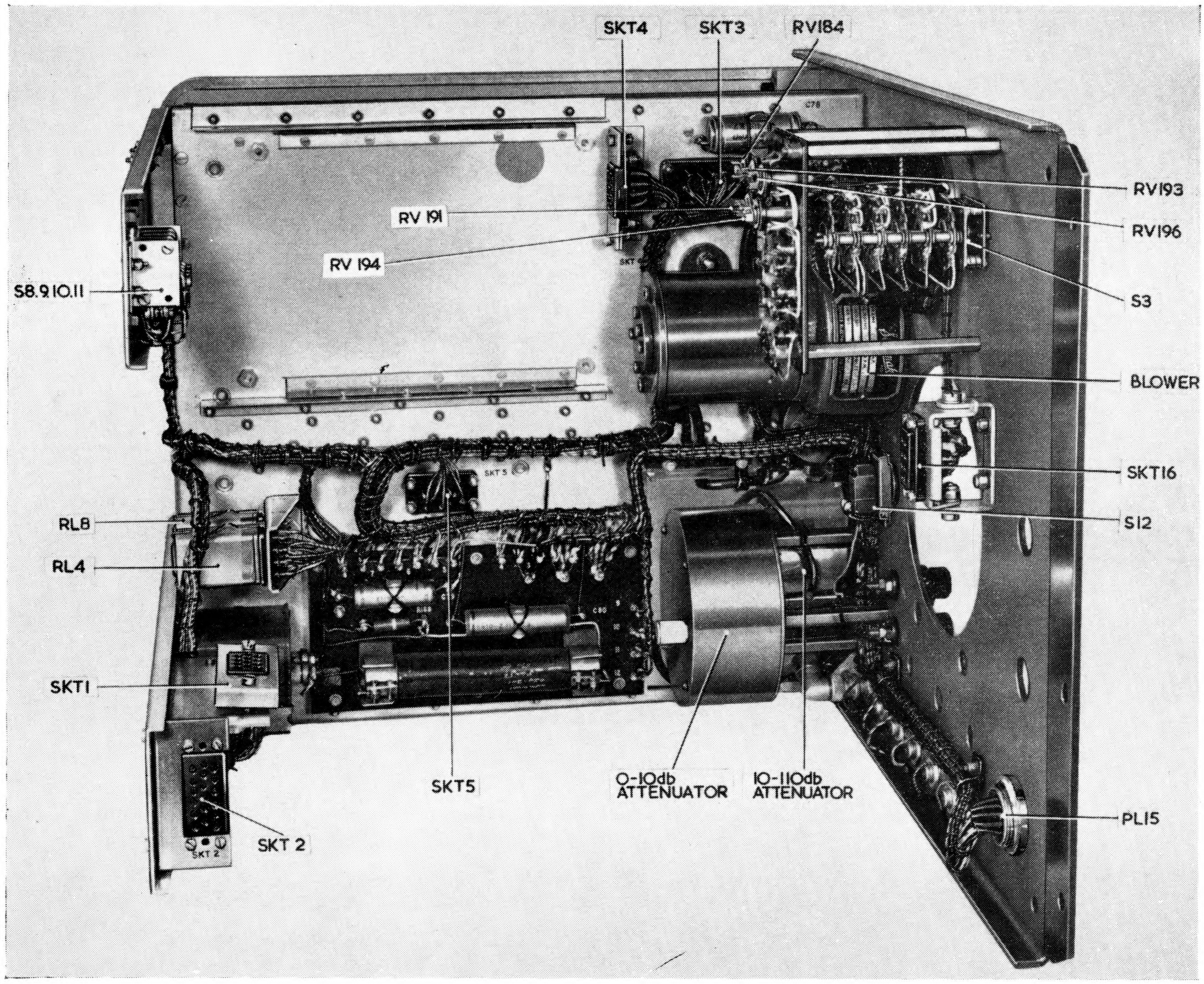


Fig. 10. Main chassis framework

26. A tool is provided to adjust the small pre-set potentiometer. It is stowed, together with the Allen key mentioned in para. 22, on the rear top framework of the main chassis. Also screwed to this framework is a plate which can be removed and screwed in the reverse position over the micro-switches to actuate them when it is necessary to operate the generator sub-assembly with the rear cover removed.

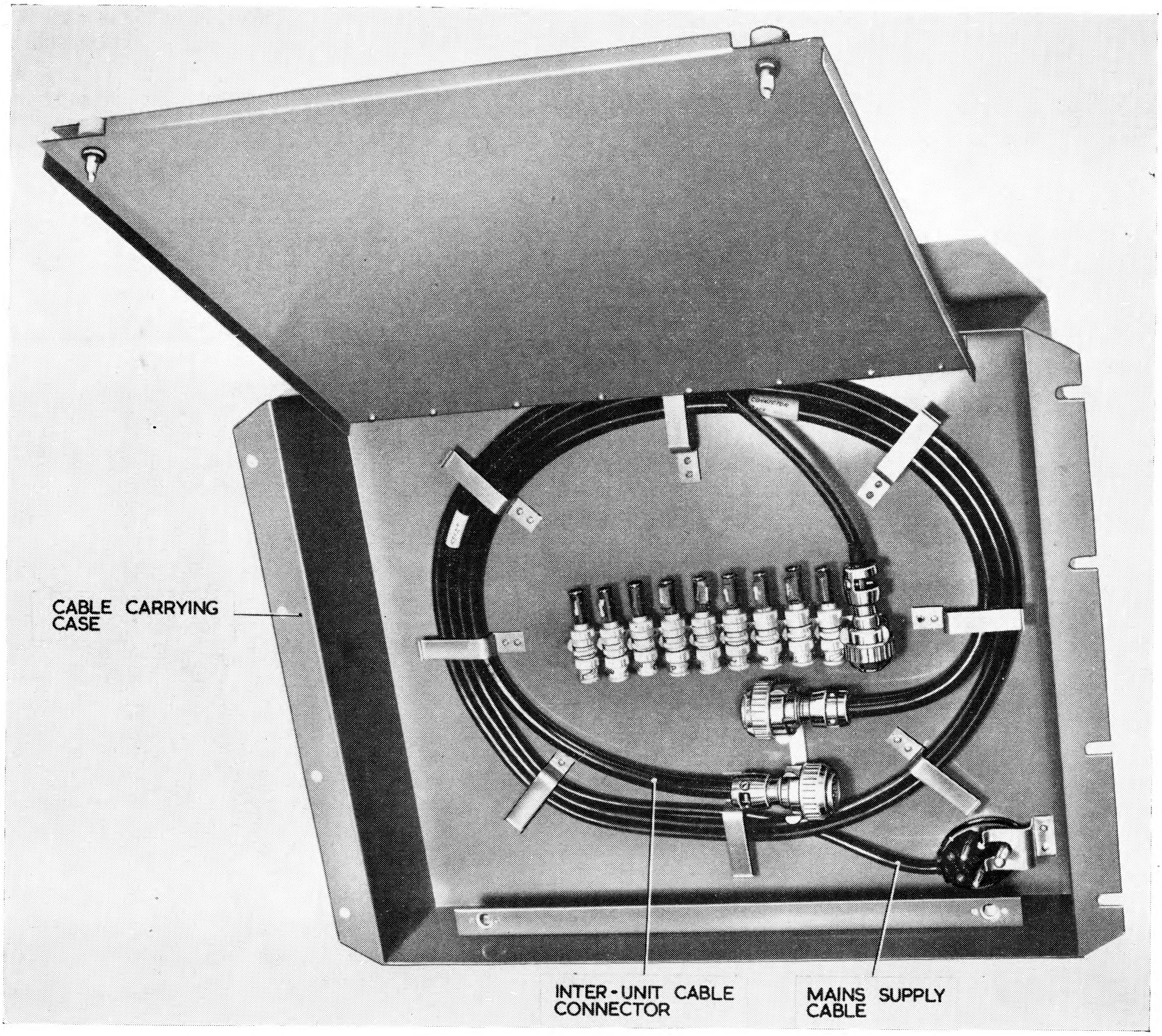


Fig. 11. Pulse generator sub-assembly — front cover

27. Stowed in the front cover are the mains lead, the twelve-way interconnecting lead and nine co-axial-output plugs. Output leads can therefore be made up for specific requirements. A view of the front cover is shown in fig. 11.

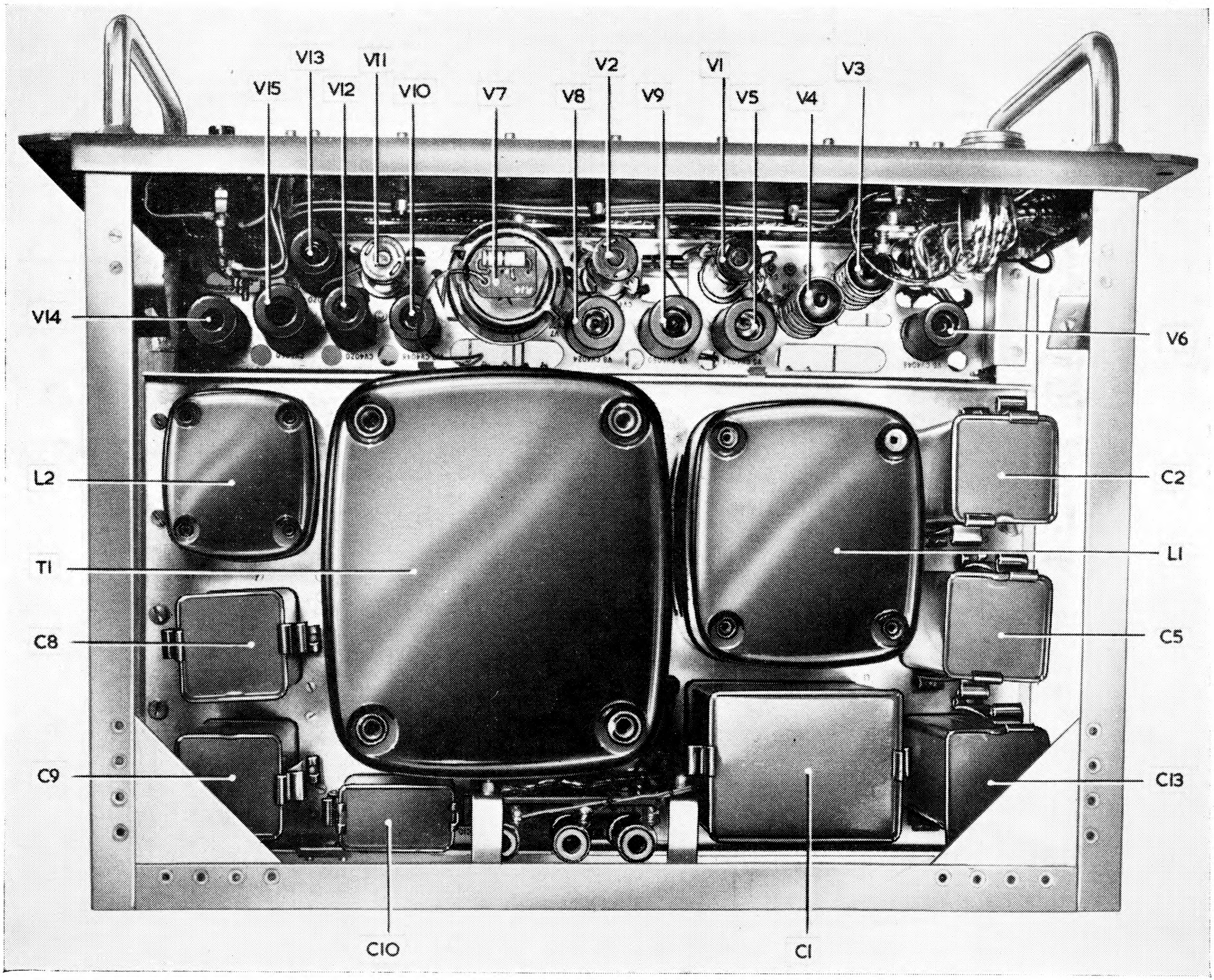


Fig. 12. Power supply — upper view

Power supply

28. Views of the top and underside of the power supply unit, with the dust cover removed, are given in fig. 12 and 13, respectively. To the front of the unit is a sub-chassis, bearing the valves of the unit, with the main chassis, bearing the transformer and the smoothing inductors and capacitors at the rear. The spare fuses, and also the plate for actuating the microswitch when the unit is to be operated with the rear dust cover removed, are mounted on the rear of the chassis.

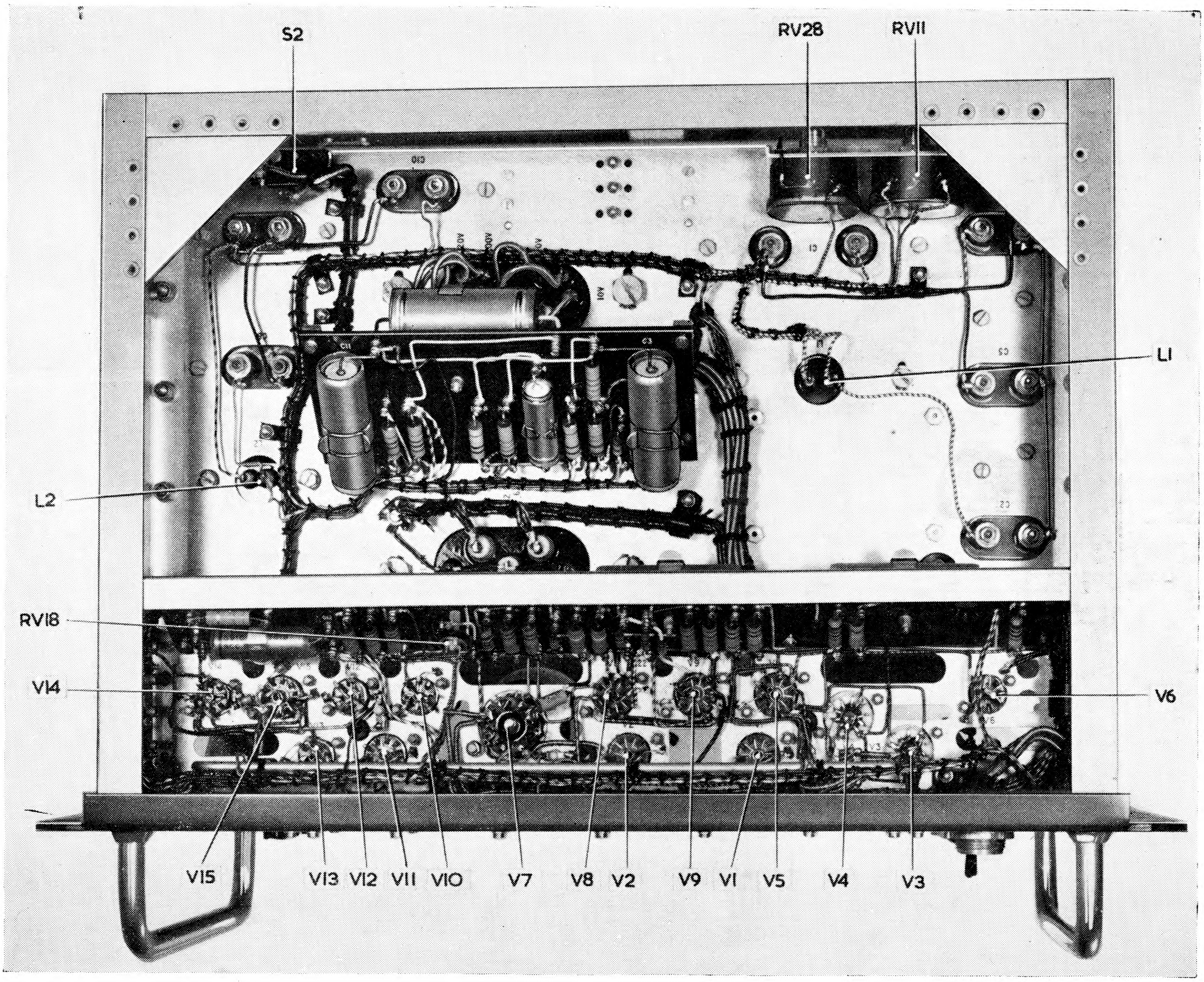
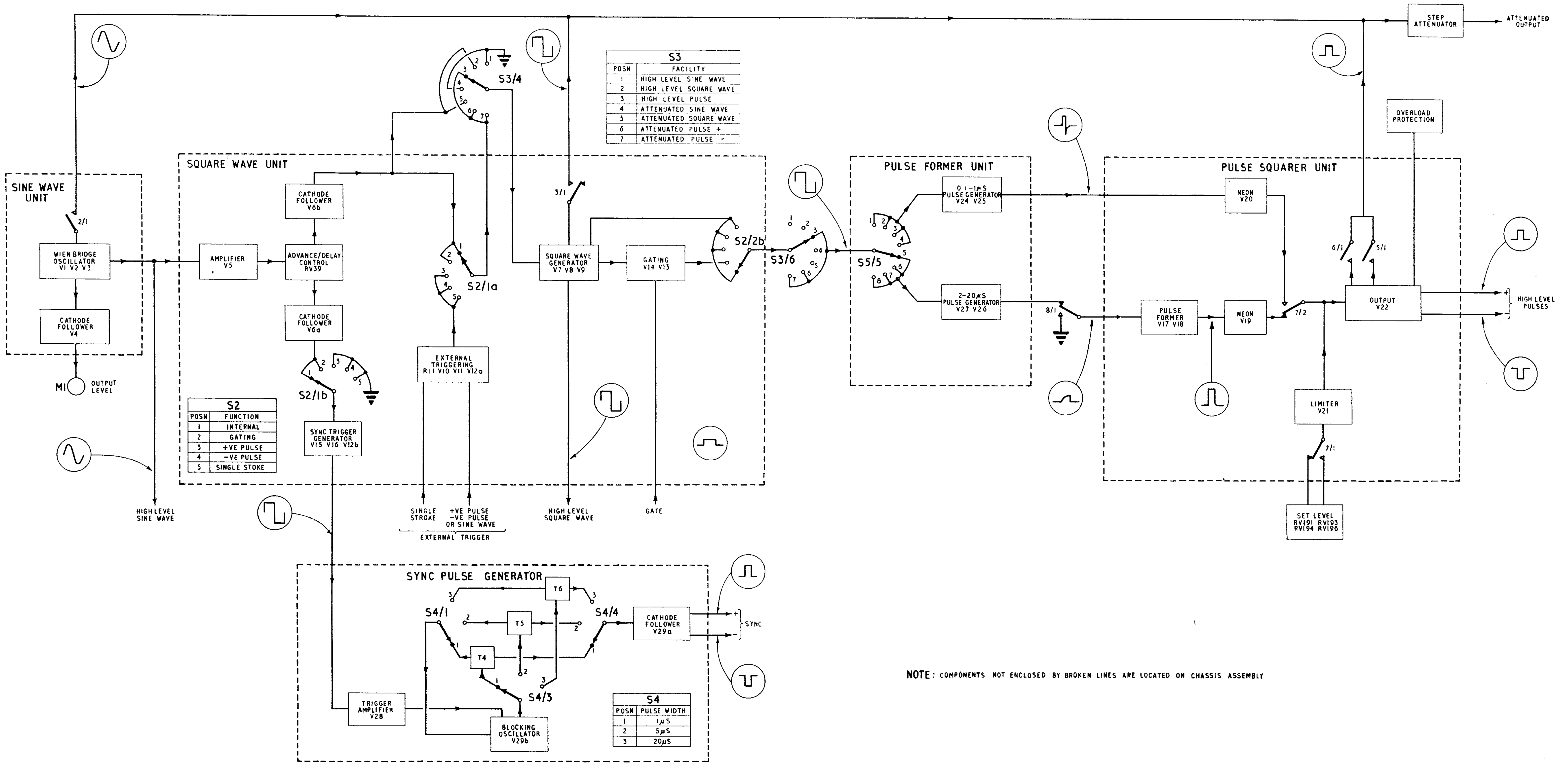


Fig. 13. Power supply — lower view



S3

POSN	FACILITY
1	HIGH LEVEL SINE WAVE
2	HIGH LEVEL SQUARE WAVE
3	HIGH LEVEL PULSE
4	ATTENUATED SINE WAVE
5	ATTENUATED SQUARE WAVE
6	ATTENUATED PULSE +
7	ATTENUATED PULSE −

S2

POSN	FUNCTION
1	INTERNAL
2	GATING
3	+VE PULSE
4	−VE PULSE
5	SINGLE STOKE

S4

POSN	PULSE WIDTH
1	1µS
2	5µS
3	20µS

Fig. 14 Generator pulse CT321 : block diagram Fig. 14

Chapter 2.—OPERATING INSTRUCTIONS

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Preparation

1. From the front cover of the pulse generator sub-assembly, remove the 3-way mains connector, the 12-way connector and such of the r.f. plugs as are required to make up signal output connectors. The correct cable to use for the output connectors is UR.70.

2. Connect the pulse generator to its power supply unit by means of the 12-way connector.

3. Ensure that the tappings of the MAINS VOLTAGE panel on the power supply are set correctly for the available supply. Connect the power supply unit to the mains supply by means of the 3-way connector.

4. Put the MAINS switch to the ON position and note that the indicator lamp now glows. Allow a warming-up period of at least 30 minutes from switching on before bringing the equipment into use.

5. When the FACILITY SEL. switch is in positions 3, 6 or 7 the OVERLOAD neon may light, indicating that the overload relay has tripped due to the duty cycle being exceeded. Should this happen, either the pulse recurrence frequency or the pulse length should be reduced and the PRESS TO RESET switch depressed. (The p.r.f. is the frequency of operation as shown by the tuning dial unless the generator is being triggered externally).

OPERATION

High-level sinewave

6. Set the FACILITY SEL. switch to position 1 and the SYNC. SELECTOR switch to the INTERNAL position. Select the FREQUENCY RANGE required. The frequency of operation can be set approximately with the tuning dial and accurately with the slow motion drive SET FREQUENCY control. Adjust the SET SINEWAVE LEVEL control for a reading of 50 microamperes on the meter. The output is taken from the HIGH LEVEL SINE WAVE socket.

Attenuated sinewave

7. Turn the FACILITY SEL. switch to position 4 and set the other controls as in para. 6. The output is taken from the ATTENUATED OUTPUT socket at a level controlled by both of the step attenuators.

High-level squarewave

8. Turn the FACILITY SEL. switch to position 2 with the other controls as in para 6. The output is taken from the HIGH-LEVEL SQUARE WAVE socket.

Attenuated squarewave

9. Set the FACILITY SEL. switch to position 5 and the other controls as in para. 6. The output is taken (as in *para.* 7) from the ATTENUATED OUTPUT socket.

High-level pulse

10. Turn the FACILITY switch to position 3 and set the SYNCH. SELECTOR switch in the position appropriate to the method of synchronization as follows:—

INTERNAL	—triggered internally by sinewave oscillator
GATING	—triggered internally but gated by external pulse
SINEWAVE / + PULSE	—triggered externally by sinewave or positive pulse
– PULSE	—triggered externally by negative pulse.
SINGLE STROKE	—triggered externally by 12V d.c.

11. If the generator is triggered internally, the tuning controls are to be set as in para. 6. If the generator is also gated the gate must be a positive pulse with a peak amplitude of 25 volts, or greater, and exceeding 20 μs in length. It is fed into the GATING socket.

12. If an external trigger is used this is connected to the TRIGGER socket or, with the 12 V d.c. trigger, to the two terminals marked SINGLE

STROKE 12V D.C. The trigger must consist of either:—

(1) A sinewave of 3 to 30 volts r.m.s. at 50 c/s to 50 kc/s.

or

(2) A positive or negative pulse of 3 to 30 volts peak, of 2 μs minimum length and at a p.r.f. of 1 c/s to 50 kc/s.

For single-stroke operation, the frequency of the strokes should not exceed 10 c/s otherwise the relay may be damaged.

13. The output is taken from the positive or negative HIGH LEVEL pulse sockets.

Attenuated pulse

14. Set the FACILITY SEL. switch to position 6 or 7 according to whether a positive or negative output pulse is required. Set the remaining controls as in para. 10. The output is taken as in para. 7.

15. For pulse output the maximum duty cycle is 10 per cent, *i.e.* the duration of the pulse must not exceed one tenth of the time of the duration of one cycle. This limits the repetition frequency at which pulses of various lengths may be generated as follows:—

20 μs—up to 5 kc/s

10 μs—up to 10 kc/s

5 μs—up to 20 kc/s

2, 1·0, 0·5, 0·2, and 0·1 μs—up to 50 kc/s.

Should this duty ratio be exceeded, the overload protection circuit will operate (*para.* 5).

16. To preserve the sharp rise and fall characteristic of the pulse, capacity loading of the output should be kept as low as possible.

Sync. pulses

17. Positive and negative sync. pulses are obtainable at the SYNC. OUTPUT sockets when the generator is operated with the SYNC. SELECTOR switch in the INTERNAL or GATING positions. The phase of the sync. pulse with respect to the main pulse can be advanced or delayed by the INT. SYNC. PHASE control up to 10 per cent of one complete cycle (*i.e.* the time between the commencement of one pulse and the next).

PART 2

TECHNICAL INFORMATION (SERVICING)

Chapter 1

SERVICING, PULSE GENERATOR SUB-ASSEMBLY

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Introduction

1. The amount of servicing permissible by service personnel on this equipment is restricted to renewing those items which have been provided as spares and to the adjustment of the preset controls. The spare items referred to are listed under the heading of the pulse generator CT321 in Vol. 3 of A.P.2276F. No special equipment is required to renew these items which are, in the main, valves and their associated circuit components, but the performance of the pulse generator should afterward be tested as some readjustment of the preset controls may then be necessary.

2. The preset controls may also have to be adjusted from time to time to compensate for the natural ageing of the components but it is emphasized that any adjustments made must be in accordance with the tests described in this chapter as otherwise the parameters of the output may not be as designated by the various switch positions on the front panel. The function and location of each of the preset controls is given in Table 1.

3. Apart from their purpose of setting up the preset controls, the tests given in this chapter can also be used to gauge the performance of the equipment and to assist in the location of faults. To this end reference should be made to the circuit description of the generator given in Part 4, Chap. 1.

4. The tests are performed with the pulse generator connected to its associated power unit (power supply 6125-99-943-7372) after allowing for a warming up period of ten minutes. Since the rear cover of the unit has to be removed to adjust the preset controls, the microswitch locking plate (*fig.* 1) must be fitted in position to actuate the switches S8-11.

5. A special tool is provided with each unit to adjust the open type potentiometers. It is held in clips at the back of the main chassis framework. After the completion of each test, the lock-nuts of the preset potentiometers affected should be tightened.

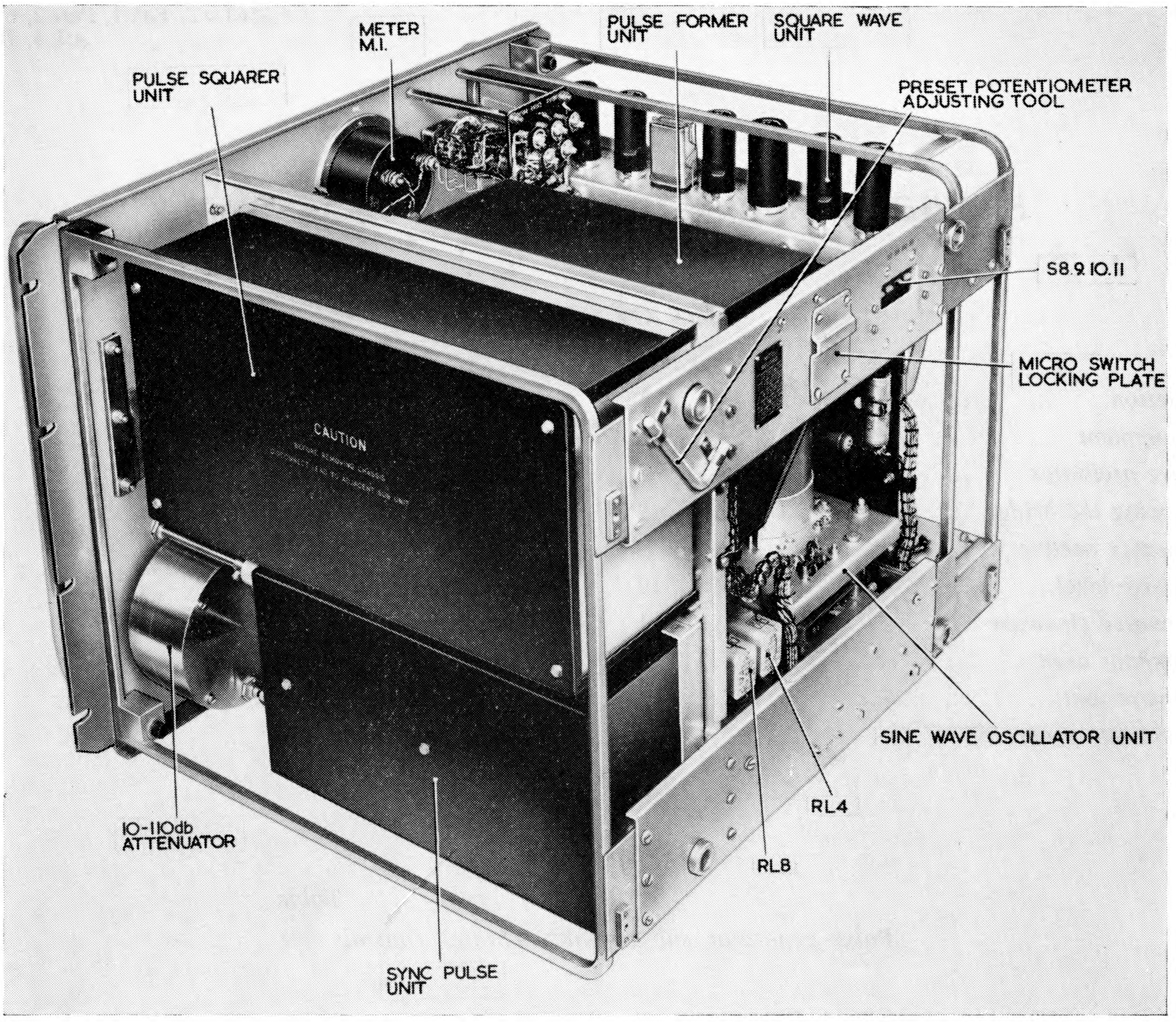

Fig. 1. Pulse generator sub-assembly

Test equipment

6. The following equipment, or its equivalent, will be required to carry out the tests described in this chapter:—

(1) Multimeter (6625-99-943-1524).

(2) Oscilloscope CT380 (6625-99-943-6737).

(3) Bridge universal (*Ref. No.* 10*S*/17635). A.F. three terminal bridge.

(4) Bridge resistance CT375 (6625-99-943-2242). To measure 3 megohms to an accuracy of $\pm 1\%$.

(5) Counter electronic CT463 (6625-99-943-1419). Frequency meter 50 c/s to 50 k/s to an accuracy of $\pm 0{\cdot}2\%$.

(6) Valve voltmeter Type 9483 (*Ref. No.* 10*S*/16828). To measure 1 to 15V r.m.s. at 50 c/s to 50 kc/s to an accuracy of $\pm 2\%$.

(7) Signal generator Type 65B (*Ref. No.* 10*S*/16499). To provide a sinewave trigger at 50 c/s to 50 kc/s.

(8) Signal generator Type 16727 (*Ref. No.* 10*S*/17702). To provide a pulse trigger at lc/s to 50 kc/s.

(9) Tester insulation resistance Type E (*Ref. No.* 5*G*/427). To measure resistances up to 100 megohms at 500V.

Sinewave oscillator

7. The component references referred to in the following sub-paragraphs are those of the circuit diagram (*Part* 4, *Chap.* 1, *fig.* 1). Views of the sinewave oscillator are shown in fig. 2 of this chapter and in fig. 5 of Part 1, Chap. 1.

Balancing the bridge

8. (1) Set the FACILITY SEL. switch to HIGH LEVEL SINEWAVE at the SYNC SELECTOR switch to INTERNAL.

(2) Adjust RV20 until the potential measured across R24 is 25V d.c.

(3) Connect the oscilloscope to the HIGH LEVEL SINEWAVE socket and check that the output is undistorted throughout the range of the generator.

(4) Set the FREQUENCY RANGE switch to $\times 10$ and the tuning dial fully counter-clockwise (maximum frequency, minimum capacity).

(5) Connect the a.f. bridge as follows:—

(*a*) Neutral lead to the wiper of S1/2 (FREQUENCY RANGE switch).

(*b*) "E" lead to chassis.

(*c*) "I" lead to the wiper of S1/1 (using a low capacitance clip).

(6) Balance the bridge and note the capacitance reading.

(7) Reconnect the bridge as follows:—

(*a*) Neutral lead to chassis.

(*b*) "E" lead to the wiper of S1/2.

(*c*) "I" lead to the wiper of S1/1 (using a low capacitance clip).

(8) Set the "C" dial on the bridge to the value previously noted (*sub-para.* (6)) and adjust C6 to balance the bridge.

(9) Use the resistance bridge to measure the actual value of R1 and then adjust RV4 to obtain the same measurement for the joint value of R7 and RV4.

(10) RV5 and R8 should be balanced against R2, and RV6 and R9 balanced against R3 as in sub-para. (9).

Table 1

Pulse generator sub-assembly—preset controls

Circuit (Part 4, Chap. 1) Ref.	Fig.	Location	Illustration (*these figures appear in Part 1, Chap. 1) Fig.	Function	Para.
C6	7	Trimmer capacitor for C4 and 5	* 5	Balances C4 and 5 against C2 and 3	8
C21	8	V7 anode to V8 grid	* 6	Squarewave contour corrector	14
C31	8	V15 anode to V16 grid	* 6	Sync pulse contour corrector	15
C83	9	V27 anode to V26 grid	6	Pulse width capacitor	21
L1	10	V17 anode	* 8	Pulse rise-time inductor	22
RV4	7	Bridge circuit	2	X1 range corrector	8
RV5	7	Bridge circuit	2	X2 range corrector	8
RV6	7	Bridge circuit	2	X3 range corrector	8
RV20	7	V3 grid return	2	Sinewave output level	8
RV26	7	V3 anode circuit	2	Sinewave attenuated level	11
RV29	7	V4 cathode circuit	2	Meter calibration	10
RV34	8	V5 anode	* 6	Sets range of advance/delay (RV39)	19
RV42	8	V6 grid negative return	* 6	V6 bias	8
RV45	8	V7 grid return	* 6	External trigger	17
RV54	8	V8 grid negative return	* 6	Squarewave amplitude	14
RV72	8	V12a grid negative return	* 6	External trigger	17
RV83	8	V13b grid negative return	* 6	Gate amplifier	20
RV90	8	V16 grid negative return	* 6	Sync. pulse mark/space	15
RV101	10	V18 grid return	* 8	Long-duration pulse amp.	22
RV154	9	V26 grid return	* 7	20μs pulse width	22
RV155	9	V26 grid return	* 7	10μs pulse width	22
RV156	9	V26 grid return	* 7	5μs pulse width	22
RV157	9	V26 grid return	* 7	2μs pulse width	22
RV167	11	V29b grid return	4	20μs sync pulse width	18
RV168	11	V29b grid return	4	5μs sync pulse width	18
RV172	11	V29b grid return	4	1μs sync pulse width	18
RV184	12	V6b grid return	*10	Squarewave mark/space	14
RV189	12	RL4 shunt resistor		Overload sensitivity	24
RV191	12	V21a grid return	*10	High level short-pulse limiter	22
RV193	12	V21a grid return	*10	High level long-pulse limiter	22
RV194	12	V21a grid return	*10	Attenuated short-pulse limiter	23
RV196	12	V21a grid return	*10	Attenuated long-pulse limiter	23

Frequency accuracy

9. Connect the pulse generator to the CT463 and check the frequency calibration of the generator at as many points as possible. The accuracy should be such that in the frequency ranges 50-200 c/s and 10 000-50 000 c/s the error does not exceed 5% and in the frequency range 200-10 000 c/s the error does not exceed 2%.

Note . . .

In the absence of a CT463, other methods of frequency calibration may be used provided that the resulting accuracy of the generator is not thereby impaired.

Sinewave level

10. (1) Connect the valve voltmeter to the HIGH LEVEL SINEWAVE output socket and adjust the SET SINEWAVE LEVEL control until the output is 15V r.m.s.

(2) Adjust the preset potentiometer RV29 until the meter on the front panel of the generator reads 50μA.

Attenuated sinewave

11. (1) Set the FACILITY SEL. switch to ATTENUATED SINEWAVE.

(2) Set both attenuators to 0dB.

(3) Set the frequency to 1000 c/s.

(4) Adjust the SET SINEWAVE LEVEL control until the meter reads 50μA.

(5) Connect the ATTENUATED OUTPUT loaded by a 75 ohm ±1% resistor to the valve voltmeter and adjust RV26 to obtain a reading of 1V r.m.s.

Thermistor oven

12. To ensure that the oven is being maintained at a constant temperature by the thermostat, connect a 12V lamp across pins 1 and 2 of the oven. The lamp will indicate when the supply is connected to the oven. After the instrument has been running for approximately one hour the oven should be cycling.

Squarewave unit

13. The component references referred to in the following sub-paragraphs are those of the circuit diagram (*Part* 4, *Chap*. 1, *fig*. 2). Views of the squarewave unit are shown in fig. 3 of this chapter and in fig. 6 of Chap. 1, Part 1.

Squarewave generator

14. (1) Set the generator frequency to 1000 c/s and the SET SINEWAVE LEVEL control to give a reading of 50μA on the front panel meter (an output of 15V r.m.s.).

(2) Connect the oscilloscope to the HIGH LEVEL SQUARE WAVE socket.

(3) Set the FACILITY SEL. switch to HIGH LEVEL SQUARE WAVE, and the SYNC. SELECTOR switch to INTERNAL.

(4) Set the preset potentiometer RV184 to its mid position and adjust RV54 to obtain a 50V peak-to-peak squarewave on the oscilloscope.

(5) Adjust RV184 for unity mark/space ratio.

(6) Adjust the C21 for minimum rise and fall time of the squarewave without overshoot.

(7) With the multimeter set to the 100V d.c. range, measure and record the voltage between the cathode of V6b and earth (volts across R43).

Sync.-trigger generator

15. (1) Set the pulse generator frequency to 1000 c/s, the FACILITY SEL. switch to HIGH LEVEL PULSE and the SYNC. SELECTOR switch to INTERNAL.

(2) Connect the multimeter between the cathode of V6a and the chassis.

(3) Adjust the INT. SYNC. PHASE control until the multimeter reads the same voltage as that recorded between V6b and the chassis (*para.* 14 (7)).

(4) Connect the oscilloscope to the cathode of V12b and adjust the preset RV90 until the mark/space ratio of the squarewave display is unity.

(5) Adjust C31 for minimum rise and fall without overshoot.

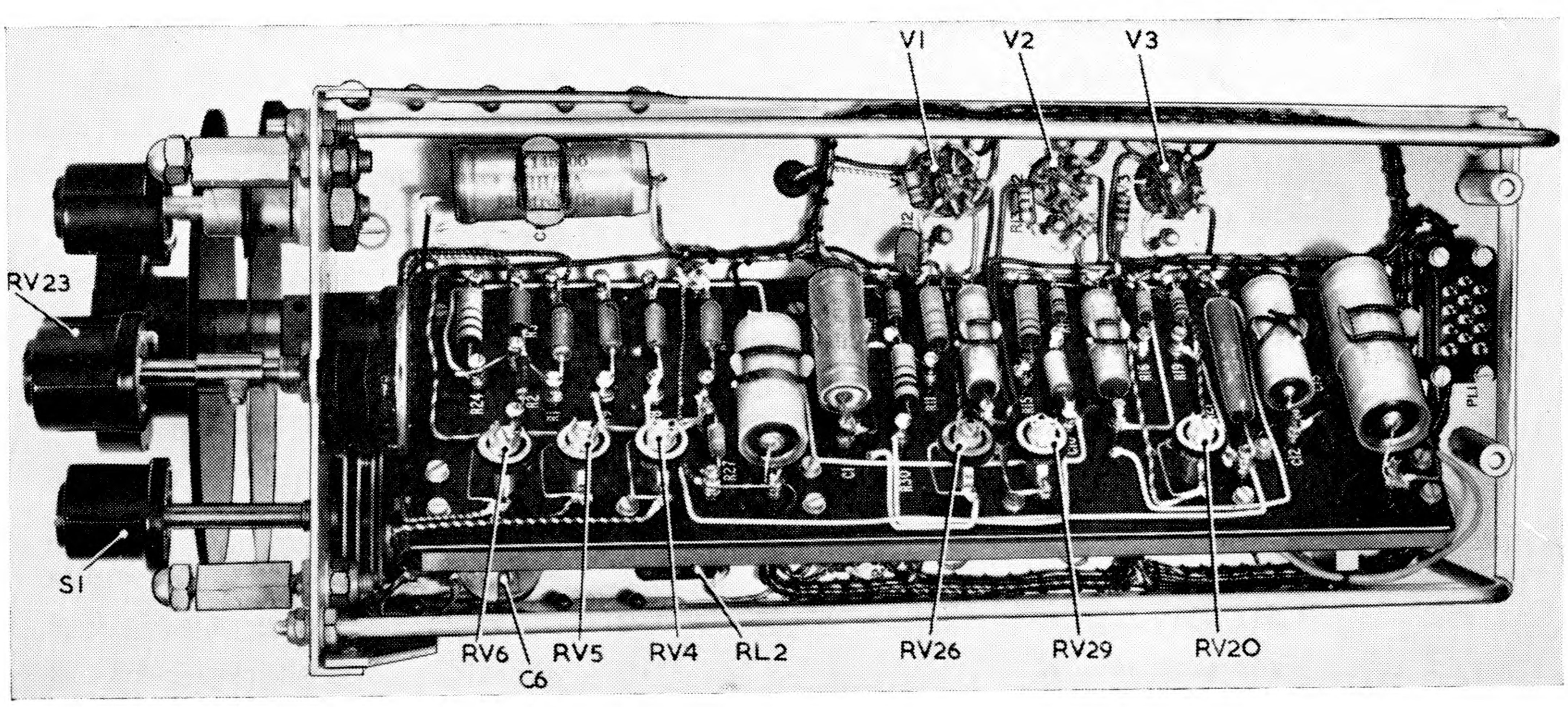

Fig. 2. Sinewave oscillator

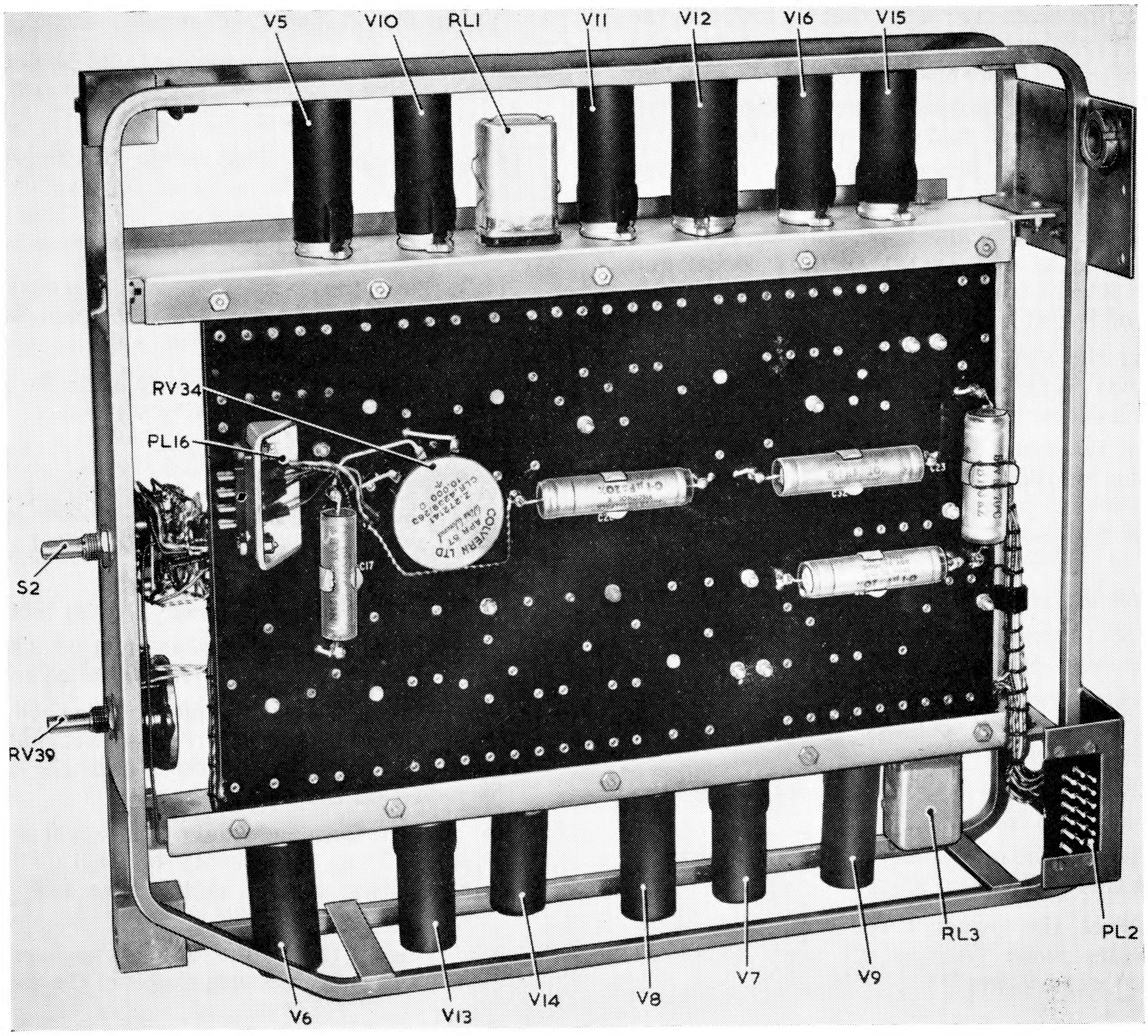

Fig. 3. Squarewave unit

External trigger (sinewave)

16. (1) Set the FACILITY SEL. to HIGH LEVEL PULSE and the SYNC. SELECTOR to SINEWAVE/ +PULSE.

(2) Connect the TRIGGER socket to the sig. gen. Type 65B set to give a sinewave output of 3V r.m.s. at a frequency of 1000 c/s.

(3) Connect the oscilloscope to the anode of V12a.

(4) Adjust the preset RV72 so that a squarewave is displayed on the oscilloscope (the squarewave should have an amplitude of approximately 50V peak-to-peak).

(5) Ensure that the generator can be triggered satisfactorily over the range 50-50 000 c/s.

External trigger (pulse)

17. (1) Connect the signal generator Type 16727 to the TRIGGER socket in place of the signal generator Type 65B.

(2) Set the signal generator Type 16727 to give a 5μs positive pulse of 3V peak amplitude at a p.r.f. of 1000 c/s. It may be necessary to adjust RV72 slightly to obtain a pulse at the anode of V12a which remains connected to the oscilloscope.

(3) Set the SYNC. SELECTOR to −PULSE and the trigger unit to give a 3V peak negative pulse of 5μs. Again a slight adjustment to RV72 may be necessary to obtain a pulse at the anode of V12a.

(4) Ensure that the generator can be triggered over a p.r.f. range of 1-50 000 c/s.

(5) If RV72 has been adjusted for this test, repeat the sinewave trigger test (*para.* 16) and this test until a setting for RV72 is found satisfactory to both triggers.

(6) Reconnect the oscilloscope to the HIGH LEVEL SQUAREWAVE socket and adjust RV45 until a pulse is displayed on the oscilloscope for both sinewave and pulse trigger inputs.

Sync-pulse generator

18. It is necessary to insert here the setting up instructions for the sync-pulse generator as sync. pulses derived from it are required for the remaining tests on the squarewave unit. Views of the sync-pulse generator are shown in fig. 4 of this chapter and in fig. 9 of Part 1, Chap. 1.

(1) Set the main frequency dial to 1000 c/s, the FACILITY SEL. switch to HIGH LEVEL PULSE and the SYNC. SELECTOR switch to INTERNAL.

(2) Set the preset potentiometers RV167, RV168 and RV172 to their mid-point positions.

(3) Set the SYNC. PULSE AMPLITUDE and WIDTH switches to the 100V and 1μs positions.

(4) Connect the oscilloscope, with the time base set to 10μs to the +SYNC. OUTPUT socket and adjust RV172 so that displayed pulse has a width of 1μs at half amplitude.

(5) Set the SYNC. PULSE WIDTH switch to 5μs and adjust RV168 until the pulse has a width of 5μs at half amplitude.

(6) Set the SYNC. PULSE WIDTH switch to 20μs and the oscilloscope timebase to 100μs and adjust RV167 until the pulse has a width of 20μs at half amplitude.

Advance/delay

19. (1) Set the FACILITY SEL. to HIGH LEVEL PULSE and the SYNC. SELECTOR to INTERNAL.

(2) Connect the multimeter set to the 100V d.c. range, between the cathode of V6a and the cathode of V6b.

(3) Adjust the INT. SYNC. PHASE control until the multimeter reads zero.

(4) Connect the multimeter between the cathode of V6b and ground.

(5) Adjust the preset RV42 until the meter reads the same voltage as was measured previously (*para.* 14 (7)).

(6) Connect the direct input to the oscilloscope, Y1, to the positive HIGH LEVEL PULSE socket.

(7) Connect the direct input to the oscilloscope, Y2, to the positive SYNC. OUTPUT socket.

(8) Set the generator frequency to 1000 c/s, the PULSE WIDTH switch to 5μs and the SYNC. PULSE WIDTH switch to 5μs.

(9) With the time base of the oscilloscope, set to 1-10 milliseconds, the main pulse and the sync-pulse should be displayed on the oscilloscope with both leading edges commencing at the same time.

(10) Turn the INT. SYNC. PHASE control fully clockwise, which should result in the main pulse commencing before the sync pulse.

(11) Adjust the preset RV34 to make the interval between the two leading edges 100μs.

Gating amplifier

20. (1) Set the FACILITY SEL. switch to HIGH LEVEL PULSE and the SYNC. SELECTOR switch to INTERNAL.

(2) Turn the main frequency dial to 1000 c/s.

(3) Set the SYNC. PULSE AMPLITUDE switch to 50V and the SYNC. PULSE WIDTH switch to 5μs.

(4) Connect the trigger input of the oscilloscope to the positive SYNC. OUTPUT socket and adjust the INT. SYNC. PHASE control until the pulse is displayed on the oscilloscope.

(5) Set the frequency dial of the signal generator Type 16727 to a frequency of 1000 c/s and the other controls on this unit to give a 30μs pulse at an amplitude of 30V.

(6) Connect the output of the signal generator Type 16727 to the GATING socket of the generator.

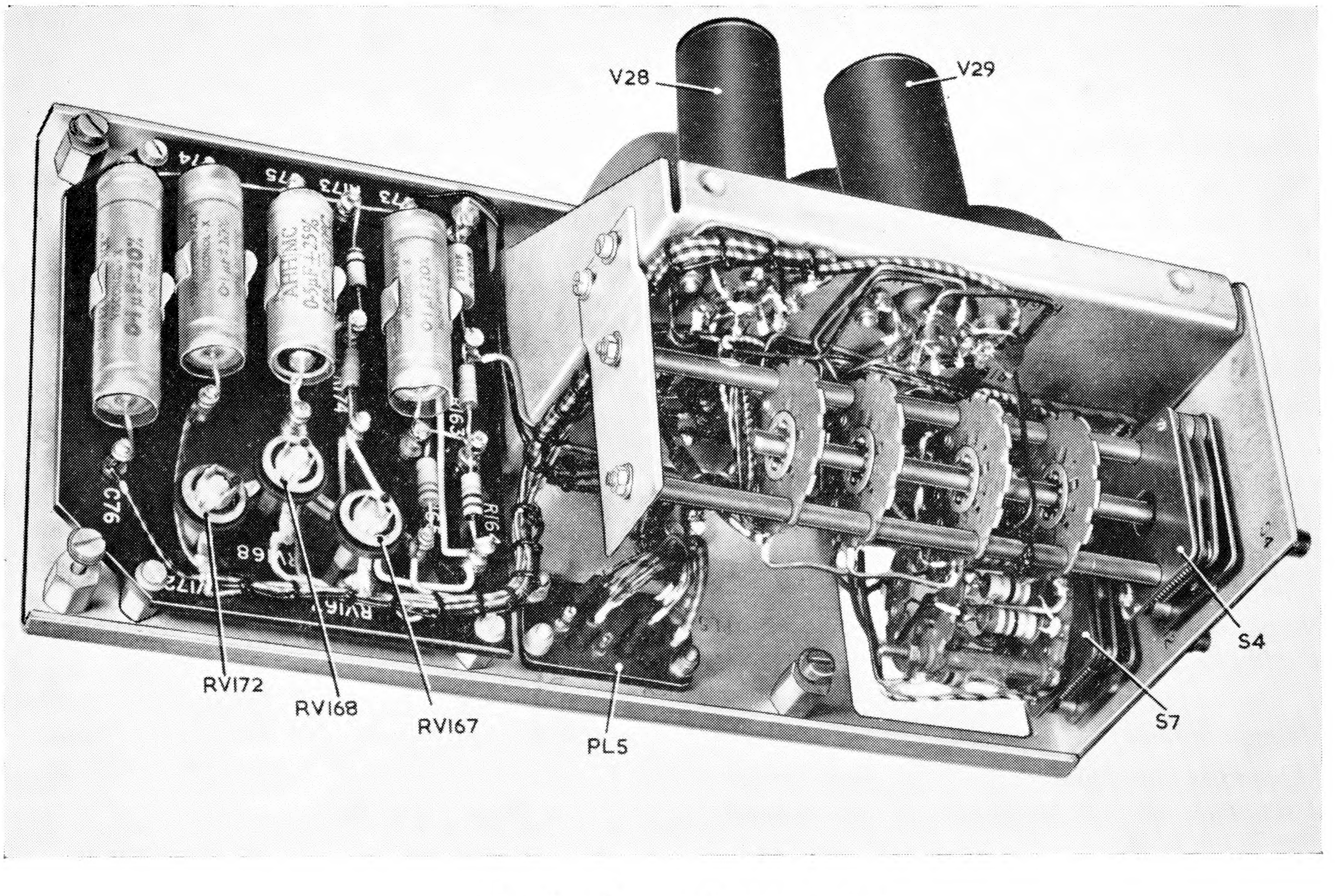

Fig. 4. Sync-pulse generator

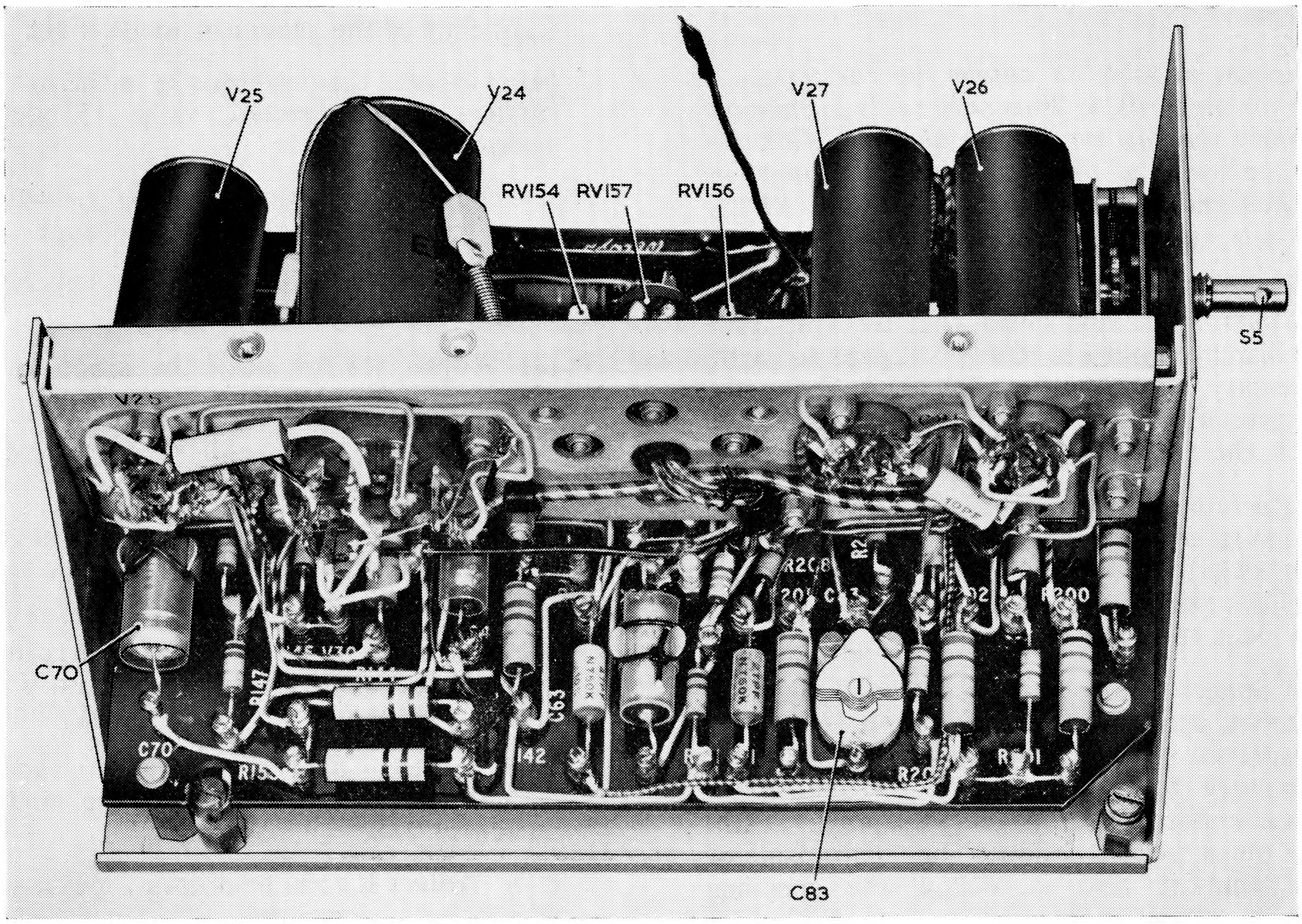

Fig. 5. Pulse-former unit

(7) Put the SYNC. SELECTOR switch to the GATING position and adjust RV83 until a pulse is again displayed on the oscilloscope.

Note . . .

It is important for this test that the frequencies of the pulse generator and signal generator are the same.

Pulse-former unit

21. Views of the pulse-former unit are shown in fig. 5 of this chapter and in fig. 7 of Part 1, Chap. 1.

(1) Set the FACILITY SEL. switch to HIGH LEVEL PULSE and the SYNC. SELECTOR switch to INTERNAL.

(2) Set the PULSE WIDTH switch to the 1μs position.

(3) Connect the oscilloscope to the anode of V25 (the interconnecting link between the pulse former and pulse squarer units) and check that a 1μs pulse is displayed on the oscilloscope.

(4) Putting the PULSE WIDTH switch successively to the 0·5, 0·2 and 0·5μs positions should result in pulses of corresponding widths being displayed on the oscilloscope.

(5) Disconnect the oscilloscope from the anode of V25 and connect it to the junction of R201 and R204.

(6) Set the PULSE WIDTH switch to the 2μs position and RV157 to its mid-position. Adjust C83 to make the displayed pulse width approximately 2μs.

Pulse-squarer unit

22. Views of the pulse-squarer unit are shown in fig. 6 of this chapter and in fig. 8 of Part 1, Chap. 1.

(1) Set the generator frequency to 1000 c/s, the FACILITY SEL. switch to HIGH LEVEL PULSE and the SYNC. SELECTOR switch to INTERNAL.

(2) Set the PULSE AMPLITUDE switch to the 60V position and the PULSE WIDTH switch to give a 2μs duration pulse.

(3) Set RV189 fully counter-clockwise.

(4) Connect the oscilloscope to the positive HIGH LEVEL PULSE output socket and the trigger input of the oscilloscope to the appropriate SYNC. OUTPUT socket.

(5) Connect the multimeter between the cathode of V22 and earth and adjust RV101 until the meter reads zero.

(6) Adjust RV193 until the amplitude of the displayed pulse is 60V peak to earth.

(7) Set RV157 to its mid-position and adjust C83 until the displayed pulse is 2μs wide at half amplitude.

(8) Set the PULSE WIDTH switch to the 5μs position and adjust RV156 until the displayed pulse is 5μs wide at half amplitude.

(9) Set the PULSE WIDTH switch to the 10μs position and adjust RV155 until the 10μs pulse is 10μs wide at half amplitude.

(10) Set the PULSE WIDTH switch to the 20μs position and adjust RV154 until the displayed pulse is 20μs wide at half amplitude.

Note . . .

If it is not possible to obtain the correct pulse widths for the 5, 10, or 20μs pulses it is permissible to slightly readjust the setting of C83. This will affect the width of the 2μs pulse which must be rechecked and any adjustment made with RV157 (previously set to the mid-point position).

(11) Connect the oscilloscope to the negative HIGH LEVEL PULSE and check that the amplitude of the displayed pulse is 60V ±5% peak to earth. If necessary, slightly adjust RV193 to bring the amplitude within the required limits and then recheck the amplitude of the positive pulse.

(12) Reconnect the oscilloscope to the positive HIGH LEVEL PULSE output socket, set the PULSE WIDTH switch to the 1μs position and adjust RV191 until the displayed pulse has an amplitude of 60V peak to earth.

(13) Connect the oscilloscope to the negative HIGH LEVEL PULSE output socket and check that the displayed pulse is 60V peak to earth. If it is necessary to adjust RV191 to obtain the required amplitude within ±5%, the positive HIGH LEVEL pulse output should be rechecked to ensure that it also is within the specified tolerance.

(14) Connect the positive HIGH LEVEL PULSE output to the direct input terminals of the oscilloscope. Put the PULSE WIDTH switch to 2μs set the timebase of the oscilloscope to 1-10μs and adjust L1 for minimum rise time without measurable overshoot.

Attenuated pulse output

23. (1) Set the FACILITY SEL. switch to ATTENUATED PULSE + and the SYNC. SELECTOR switch to INTERNAL.

(2) Set the SYNC. PULSE WIDTH switch to 5μs and the SYNC. PULSE AMPLITUDE switch to 50V.

(3) Set the PULSE WIDTH switch to 1μs and the frequency of the generator to 1000 c/s.

(4) Connect the oscilloscope to the ATTENUATED OUTPUT socket loaded by a 75 ohm ±1% resistor.

(5) Connect the positive SYNC. OUTPUT to the sync./trigger input of the oscilloscope.

(6) Ensure that both attenuator switches are set to zero.

(7) Adjust RV194 until the amplitude of the displayed pulse is 10V peak-to-ground.

(8) Advance the FACILITY SEL. switch to ATTENUATED PULSE –.

(9) Measure the amplitude of the negative pulse which should be 10V ±5% peak-to-ground.

(10) If it necessary to readjust RV194 to obtain the correct amplitude for the negative pulse, recheck the amplitude of the positive pulse to ensure that it is still ±5% of 10V.

(11) Return the FACILITY SEL. switch to ATTENUATED PULSE + and set the PULSE WIDTH switch to 2μs.

(12) Adjust RV196 to obtain a pulse amplitude of 10V peak-to-ground.

(13) Advance the FACILITY SEL. switch to ATTENUATED PULSE – and check the amplitude of the negative pulse, if necessary readjusting RV196 and then rechecking the positive pulse to ensure that its amplitude is still within ±5% of 10V.

Overload protection

24. (1) Set the FACILITY SEL. switch to HIGH LEVEL PULSE and the SYNC. SELECTOR switch to INTERNAL.

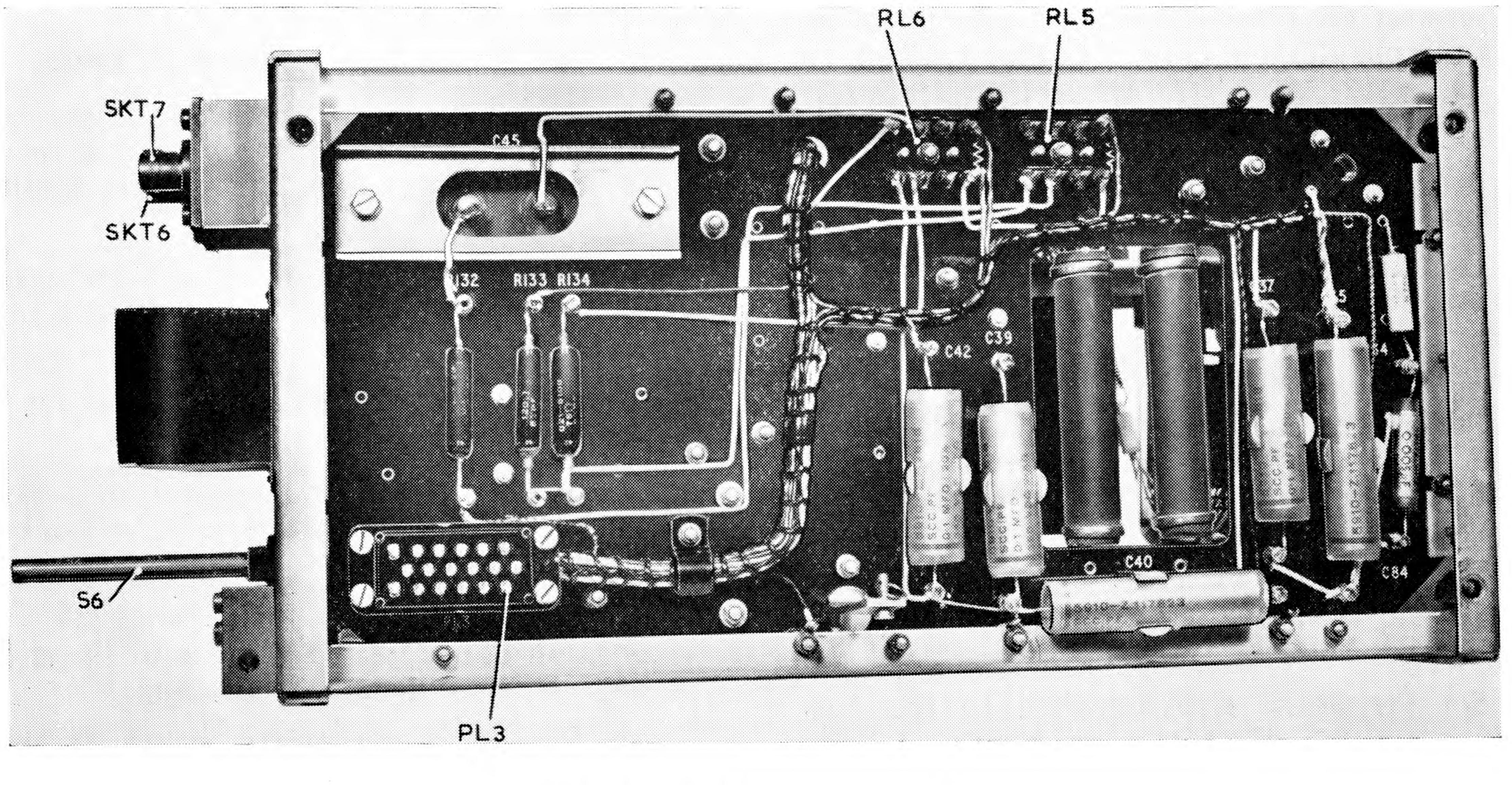

Fig. 6. Pulse-squarer unit

(2) Set the PULSE AMPLITUDE switch to the 60V position and the PULSE WIDTH switch to give a 20μs pulse.

(3) Turn the main frequency dial to 5500 c/s.

(4) Set the SYNC. PULSE AMPLITUDE switch to 25V and the SYNC. PULSE WIDTH switch to 5μs.

(5) Connect the oscilloscope to the positive HIGH LEVEL PULSE output.

(6) Adjust RV189 until the pulse just disappears and the OVERLOAD neon glows.

(7) Reduce the frequency of the generator to 5000 c/s and operate the PRESS TO RESET switch. The pulse should be restored and the OVERLOAD neon extinguished.

(8) Increase the frequency again and observe that the pulse disappears when the frequency is approximately 5500 c/s.

(9) Turn the PULSE WIDTH switch to the 10μs position and increase the frequency of the generator. The pulse should now disappear when the frequency is advanced slightly in excess of 10 000 c/s. If satisfactory, reduce the frequency and operate the PRESS TO RESET switch.

(10) Turn the PULSE WIDTH switch to the 5μs position and increase the frequency of the generator until it again overloads which should happen when the frequency is slightly above 20 000 c/s.

Chapter 2

SERVICING, POWER SUPPLY

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LIST OF ILLUSTRATIONS

Introduction

1. The tests described in this chapter are based on those given in the production test specification for the power supply and can therefore be used to assess the serviceability of the unit. They also enable the preset potentiometers to be correctly adjusted and will give an indication of the probable location of faults. For this latter purpose, reference should also be made to the circuit description of the unit given in Part 4, Chap. 2. Spare items obtainable for the unit are listed under the heading of the pulse generator CT321 in Vol. 3 of A.P.2276F.

Test equipment

2. The following equipment, or its equivalent, will be required to carry out the tests described in this chapter:—

(1) Multimeter (6625-99-943-1524).
(2) Oscilloscope CT.386 (*Ref. No.* 10*S*/17003).
(3) Voltage adjusting transformer. Input 230V 50 c/s with output variable between 212V and 244V. Suitable instrument, Claude Lyons Type V5H.
(4) Tester insulation resistance Type E (*Ref. No.* 5*G*/427).

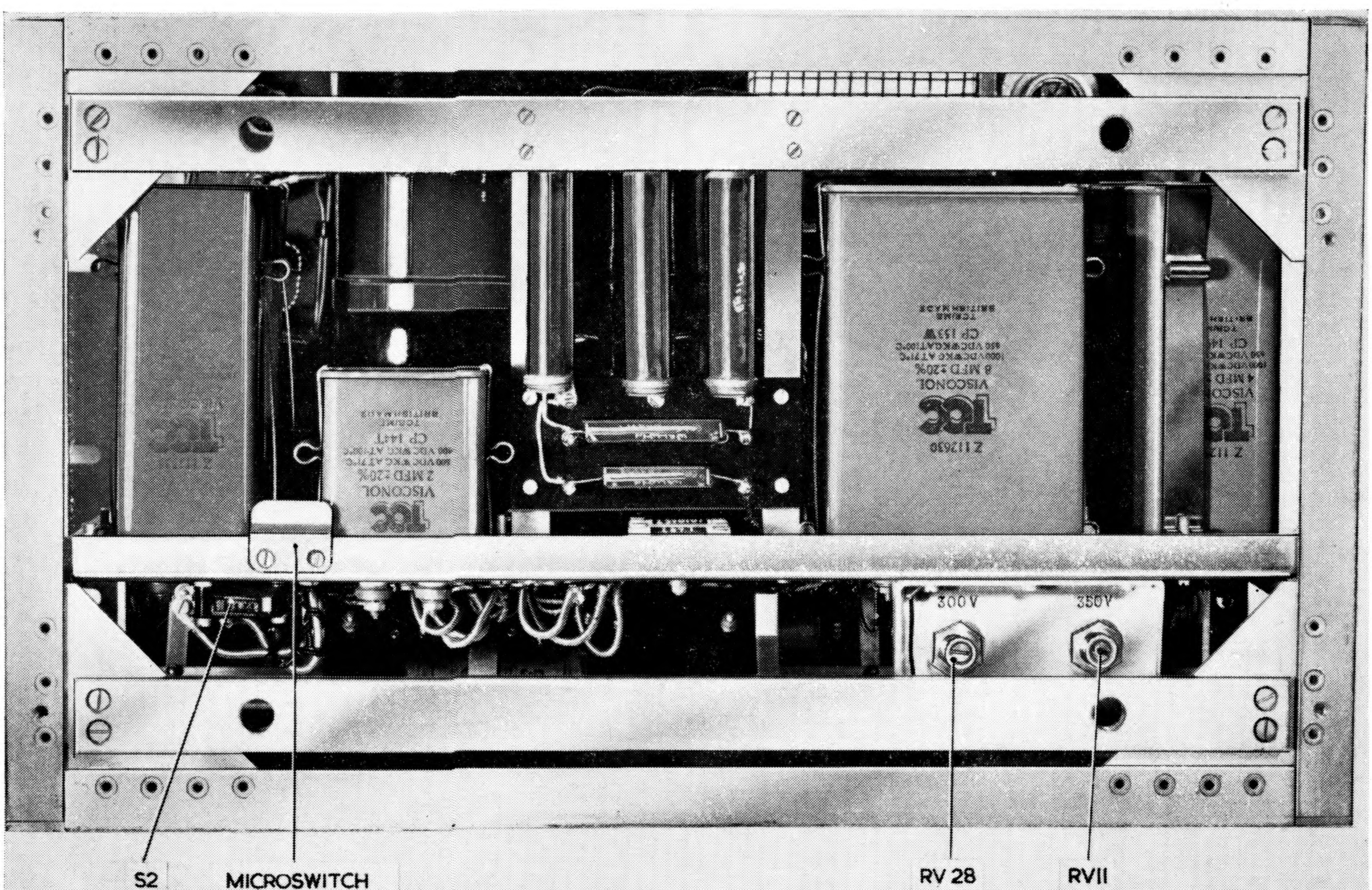

Fig. 1. Power supply

Insulation

3. The insulation resistance at 500V d.c. between all parts not intended to be electrically connected should not be less than 40 megohms.

Functional tests

4. In order to make the following functional tests it is necessary to remove the power unit from its case and to position the microswitch locking plate so that it actuates S2 (*fig.* 1). The unit should then be connected either to the pulse generator sub-assembly or to an equivalent dummy load. If the pulse generator is used as the load, the SYNC. SELECTOR switch should be put to one of the external trigger positions. (Were the unit allowed to generate, the resulting fluctuations of the load would invalidate the ripple measurements.) Ensure that the voltage selector tap in use agrees with the voltage of the available mains supply before connecting the unit to the supply via the voltage adjusting transformer. Put the MAINS switch to ON and adjust the transformer until the supply voltage to the unit is the same as the mains voltage to the transformer. Allow the unit ten minutes to warm up before proceeding with the tests.

Positive 350V supply

5. Monitor the 350V output at poles K and L of SKT1 with the multimeter and adjust RV11 to obtain a reading of 350V. Using the voltage adjusting transformer, vary the mains input to the unit by plus and minus 6%. The 350V output reading should remain constant.

6. Connect the oscilloscope across the 350V output and measure the ripple voltage which should not exceed 20mV peak-to-peak.

Positive 300V supply

7. Disconnect the multimeter lead from pole K and reconnect it to pole F to monitor the 300V output. Adjust RV28 for a reading of 300V. Vary the mains input by plus and minus 6% and ensure that the meter reading remains constant.

8. Connect the oscilloscope across the 300V output and adjust RV18 for indication of minimum hum. Measure the ripple voltage to ensure that it does not exceed 20mV peak-to-peak.

Negative 300V supply

9. Connect the multimeter to poles M and L of SKT1 and measure the −300V supply which should be between 286V and 312V. Varying the mains input by plus and minus 6% should not result in the meter reading moving outside the limits stated.

10. Connect the oscilloscope across the −300V output and measure the ripple voltage which should not exceed 250mV peak-to-peak.

Negative 150V supply

11. Connect the multimeter to poles J and L of SKT1 and measure the −150V supply. The meter reading should be between 146V and 156V. Vary the mains input by plus and minus 6% and note that the meter reading stays within the limits stated.

12. Connect the oscilloscope across the negative 300V supply and measure the ripple voltage which should not exceed 50mV peak-to-peak.

PART 4

CIRCUIT THEORY

Chapter 1

CIRCUIT DESCRIPTION, PULSE GENERATOR SUB-ASSEMBLY

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LIST OF ILLUSTRATIONS

Introduction

1. As the circuit diagram of the generator is rather large, it is more convenient, for the purpose of circuit description, to have a separate circuit diagram for each unit. Each of these diagrams should be read in conjunction with the circuit diagram for the main chassis framework (*fig.* 12) which shows how the units are interconnected. These diagrams will be found at the end of the chapter. Other diagrams, showing waveforms, are interspersed in the text.

2. The units will be described in the order in which they appear in the block diagram (*Part* 1, *Chap.* 1, *fig.* 14). All their power supplies are drawn from the power supply unit via the main chassis framework.

Sinewave oscillator (*fig.* 7)

3. This unit generates a sinewave at an amplitude of either 15V or 1V r.m.s. in the frequency range of 50 c/s to 50 kc/s through the medium of a Wein bridge oscillator consisting of V1 and V2 with V3 operating as a cathode-follower output stage.

4. The frequency-determining components are the series-parallel networks R1 to R9 and C2 to C6. Since the component values in the series and parallel arms are approximately equal, the frequency of operation is given by:—

$$f = \frac{1}{2\pi RC}$$

R and *C* being the amount of resistance and capacitance in either the series or parallel arms.

5. One of three fixed values of resistance are selected in each arm by the FREQUENCY RANGE switch, S1. These resistors correspond to the three ranges:—

3 megohms — X1 — 50 c/s to 500 c/s
300 kilohms — X10 — 500 kc/s to 5 kc/s
30 kilohms — X100 — 5 kc/s to 50 kc/s

Fine adjustment is allowed for on each range by the variable preset resistors RV4, RV5 and RV6.

6. Within each range the frequency is controlled by the continuously variable and ganged capacitors C2, C3 and C4, C5. The trimming capacitor, C6, compensates for the additional stray capacitance present in the parallel leg.

7. The gain of the amplifier is limited by the negative feedback loop to an amount sufficient to overcome the attenuation of the Wein bridge network and give the required output. A thermistor is used to control the feedback loop and, since its resistance varies with temperature, it is kept in a temperature-controlled oven at approximately 75°C. It is necessary to stabilize the oven at such a high figure because the complete equipment is designed to operate in ambient temperatures up to 55°C.

8. In order to limit phase distortion, V2 is directly coupled to V3. This is made possible by returning the grid of V3 to the −300V line. Part of the grid return, RV20, is variable allowing the working point of V3 to be adjusted so that it passes 25 mA.

9. The output level of the oscillator is adjusted by RV23, the SET SINEWAVE LEVEL control. From the circuit it may appear that this control only determines the proportion of the output used as feedback to the bridge network. This is true, but, as the action of the thermistor-controlled bridge maintains the amount of feedback at this point constant for all positions of the control, the output at V3 cathode must increase or decrease as the control is varied. The advantage of this form of control is that the output impedance of V3 remains the same at all output levels.

10. Monitoring of the output level is by the cathode-follower detector, V4, and indication is given on the meter M1. RV29 is adjusted by the manufacturer so that the meter reads 50 μA when the sinewave level at the cathode of V3 is 15V r.m.s. Subsequent adjustment of RV29 is necessary only after renewing V4 or its associated components.

11. The high-level output (15V) is taken from the cathode of V3 via C15 and pole 3 of PL1 to the main chassis framework and from there to both the front panel socket, SKT8, and the squarewave unit.

12. The low-level output (1V) is taken from the anode of V3 via the auto-transformer T1, the necessary switching being carried out by the relay RL2 which is operated when the FACILITY SEL. switch, S3, is in position 4. The preset variable resistor, RV26, is provided to set the required low-level output to be 1V r.m.s. when the output is loaded by 75 ohms. This output is taken via pole 7 of PL1 to the step-attenuators, and from there to SKT14, the ATTENUATED OUTPUT socket, on the front panel.

Squarewave unit (*fig.* 8)

13. The signal from the sinewave unit is fed into the grid of the amplifier, V5. The gain of this pentode is stabilized by negative feedback through C16 and R32 and the output level varied by means of the preset potentiometer RV34.

14. After being amplified by V5, the sinewave is taken to the grids of the two cathode-follower triodes, V6a and V6b. The grid voltage of each valve is determined by the potential-divider networks R38, RV39, R41 and RV42, and R40, RV39 R41 and RV42 respectively. It will be seen that RV39 either balances the two grids or makes one more positive or negative with respect to the other. The output from each valve is therefore a sinewave, the mean level of which depends on the position of RV39; as the output level of one is increased, that of the other is decreased. When S3, the FACILITY SEL. switch, is in position 2 or 5 however the grid of V6b is returned via S3/2 to a positive potential determined by the preset resistor RV184. The reason for this is explained in para. 19.

15. The sinewave output from the cathode of V6b is passed via S2/1a and S3/4 to the square-wave generator V7 and V8. Together these valves form a Schmitt trigger circuit, *i.e.* a mono-stable flip-flop circuit. There are two forms of coupling between the valves; one by R51, from the anode of V7 to the grid of V8, and the other by the common cathode resistor, R52. When the potential at the grid of V7 is raised above a certain level (*point x in* (*m*) *of fig.* 1) V7 conducts, causing a fall in potential at the anode. This fall in potential is passed to the grid of V8 reducing the valve current and, therefore, the potential across R52. The effect of this is to increase still further the current through V7 and the cycle is cumulative until V8 is cut off causing the anode potential to rise to that of the h.t. ((*n*) *of fig.* 1). When the input to V7 is reduced below the aforementioned level (*y in* (*m*) *of fig.* 1), the reverse action takes place and the circuit returns to the quiescent state.

16. The preset variable capacitor, C21 is provided to reduce the attenuation at high frequencies. RV54, by setting the level at which V8 operates, sets the amplitude of the squarewave.

17. Similarly the sinewave output from V6a is fed via S2/1b to the sync-trigger generator, V15 and V16. This circuit is identical to that of the squarewave generator (*para.* 15) with C31 compensating for the attenuation at high frequencies and RV90 setting the mark/space ratio of the sync-trigger.

18. It should be apparent from para. 15 and fig. 1 that changing the level of the waveform fed to the grid of V7 or V15 will advance or delay the point in time at which the pulse developed at the anode of either V8 or V16 commences and that, since the level fed to one circuit varies inversely with respect to the level fed to the other, the pulses produced by each will be out of phase by the amount represented in fig. 1 as ($t_2 - t_1$).

19. It will also be noticed that the mark/space ratio of the squarewave is affected by the advance/delay action. This is unimportant when pulses are being generated since the squarewave is then only a trigger for the pulse (the pulse parameters being set by the pulse-former and pulse-squarer units) but it would assume relevance for a squarewave output and, for this reason, V6b grid is returned to RV184 when S3 is in positions 2 or 5. In those positions, the mark/space ratio of the squarewave can be set to unity by RV184.

20. From the anode of V8 the squarewave is fed to the grid of V9, the cathode-follower output stage. The full output from this stage is taken via C23 and PL2 to SKT9, the HIGH LEVEL SQUARE WAVE socket, on the front panel. For the attenuated output the relay contact 3/1 disconnects R60 from the cathode

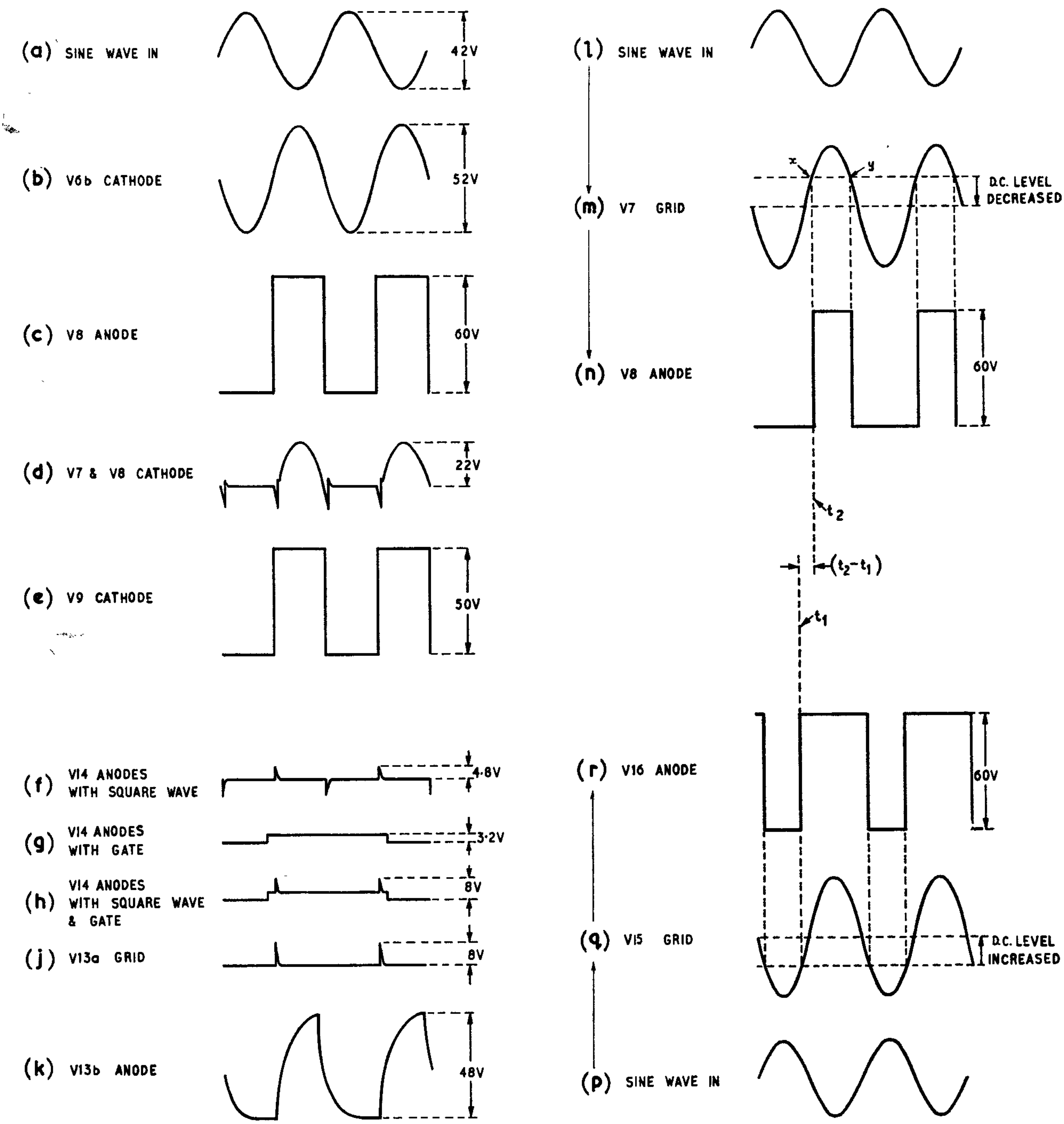


Fig. 1. Squarewave unit: waveforms

load of V9 and connects in its place the input circuit to the step-attenuators. The output from the attenuators goes to SKT14, the ATTENUATED OUTPUT socket on the front panel. The output to the pulse-former unit is taken from the cathode of V9 either direct or via the gate amplifier, according to the position of S2/2b.

Gate amplifier

21. The gate amplifier consists of V13 and V14. The double diode, V14, acts as the actual gate switch and is followed by the double triode, V13, connected in a Schmitt circuit. The amplifier responds to a gating pulse lasting longer than 30 μs and with a minimum peak amplitude of +25V.

22. The anodes of V14 are held below the potential required to operate the Schmitt circuit by returning the cathode of V14b to the junction of R75 and R76, a point negative with respect to earth. As the cathode of V14a is at earth potential, this valve is cut off. The squarewave from the cathode of V9 is differentiated by C28 and R73 but the positive peaks ((*f*) *of fig.* 1) are not of sufficient amplitude to overcome the standing bias on V14b. When a positive gating pulse is applied (via C30) to the cathode of V14b, however, this diode is cut off and V14a is then able to conduct each time the positive peak of a differentiated squarewave is applied to its anode ((*h*) *of fig.* 1).

23. As V14a conducts, its cathode potential rises sufficiently to trigger V13a. This initiates the sequence of events associated with a Schmitt circuit (*as described in para.* 15) resulting in the development of a strong positive pulse at the anode of V13b ((*k*) *of fig.* 1). The amplitude of this pulse is governed by the setting of RV83.

External trigger

24. When the generator is triggered externally by a positive pulse or sinewave, the SYNC. SELECTOR switch is in position 3 and S2/2a connects the trigger to the grid of V11. The valves V11 and V12a constitute a Schmitt trigger circuit which will produce a positive-going pulse at the anode of V12a, when triggered by a positive pulse of between 3V and 30V peak amplitude, or will produce a squarewave when triggered by a sinewave between 3V and 30V r.m.s.

25. For a negative-pulse-input trigger (of between 3V and 30V peak amplitude) the SYNC. SELECTOR switch is set to position 4. S2/3b then connects the trigger to the grid of V12a which acts as an inverting amplifier and again produces a positive-going pulse at its anode.

26. If the generator is to be triggered using the single stroke facility, the SYNC. SELECTOR should be set to position 5. A pulse is then given each time 12V d.c. is applied to the two SINGLE STROKE terminals on the front panel. This trigger energizes the relay RL1 causing the relay contact 1/1 to connect C24 across V10 and R63 in series. The charge held by C24 ionizes the neon, V10, and the capacitor discharges rapidly through the resistor R63; the pulse thus developed across R63 is applied via S2/2a, to the grid of V11 and operates the Schmitt circuit.

27. Between "strokes", when RL1 is de-energized, C24 is charged to 300V through R62. The time constant of C24 and R62 is such that there is a comparatively long wait period before the charge on C24 is sufficient to fire the neon.

28. For each type of external trigger, therefore, a positive pulse is developed at the anode of V12a; this pulse output is applied, via C20, S2/1a and S3/4, to the squarewave generator, V7.

Pulse-former unit (*fig.* 9)

29. This unit uses separate circuits to form the long- and the short-duration pulses. A secondary-emission valve produces the 0·2, 0·5 and 1 μs pulses and a multivibrator those of the 2, 5, 10 and 20 μs duration. The trigger pulse from the squarewave unit is fed to either circuit by S5/5, the PULSE WIDTH switch.

Short-duration pulse (0·1–1 μs)

30. A simplified circuit of the principal components in the pulse-former and pulse-squarer units that are involved in the development of the short-duration pulse is shown in fig. 2. Sketches of the waveforms which obtain at various points in the circuit are given in fig. 3.

31. The secondary-emission valve, V24, is normally cut-off by the control grid being returned to a lower potential than the cathode. It is made to conduct by feeding a positive trigger pulse to the grid ((*b*) *of fig.* 3).

32. The dynode is held at a positive potential of 30V (160V with respect to the cathode) by returning the load resistor R144 to the potential divider R148 and R149. Electrons from the cathode strike the sensitized surface of the dynode and cause secondary emission from the dynode to the anode; the resulting anode current is approximately four times greater than the cathode current. As soon as the valve starts to conduct, the anode potential falls and positive feedback from anode to cathode by means of the capacitor, C64, will cause the cathode to be driven negative. In effect, this is the same as driving the grid more positive and the cathode current is thus increased. The action is rapidly cumulative until the valve saturates.

33. As the anode falls, a wave-front is launched down the delay line L3 to L17 and C47 to C60. The delay line is terminated by a short-circuit at one of four points, depending on the pulse length selected by S5/6, and the wave-front is

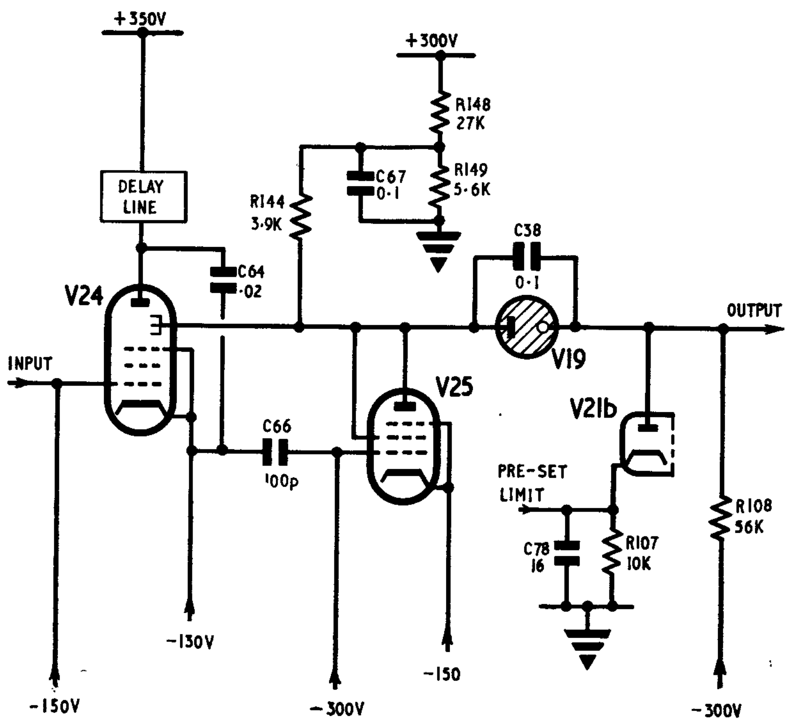


Fig. 2. Development of short-duration pulse: simplified circuit

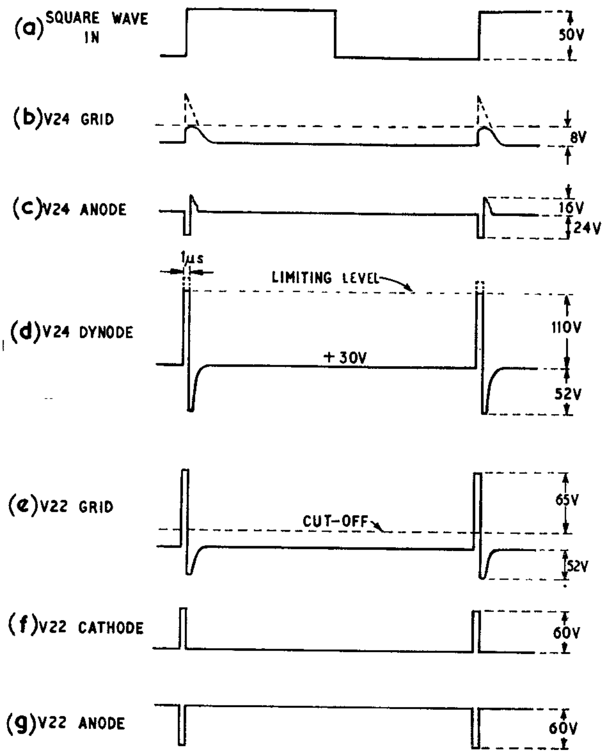


Fig. 3. Development of short-duration pulse: waveforms

therefore reflected back to the anode in opposite phase, that is with a positive-going leading edge. This positive-going signal, passed to the cathode of V24 by C64, cuts off the valve.

34. The output pulse is developed by the dynode current across the load resistor R144. The dynode current is derived mainly from the charge on C67, but as the loss of charge for the short period that V24 is conducting is comparatively small, the potential at the junction of C67 and R144 remains almost constant whilst the potential at the dynode rises rapidly to the upper-limiting level (*para.* 44).

35. When V24 is cut off, the dynode potential falls but, due to stray capacities in the dynode circuit, the fall would be exponential were it not for V25 which acts as a discharge valve. V25 is normally cut off and is made to conduct by the reflected positive-going edge from the delay line which is coupled to its grid by C66. The dynode load resistor, R144, is also the anode load of V25 and, as V25 conducts, the voltage drop across R144 takes the dynode below its quiescent potential thereby counteracting the exponential decay and producing a fast fall-time ((*d*) *of fig.* 3).

36. The diode V23 is provided in the grid circuit of V24 to pass the large grid current which flows when V24 is triggered. The diode V30 is used to d.c. restore the signal fed to the grid of V25.

37. The output pulse from the dynode is directly coupled to the output valve V22 in the pulse-squarer unit via the neon V20.

Long-duration pulse (2–20 *µs*, *fig.* 4)

38. The long-duration pulse is produced by the mono-stable multivibrator, V26, and V27. In the quiescent state, *i.e.* in the absence of trigger pulses, V27a and V27b are cut off and V26 is conducting. V27a will conduct, and the common anode potential fall, upon the arrival of a positive trigger pulse at the grid of V27a. The fall in anode potential is passed, via C83, to the grid of V26 reducing the anode and screen currents through that valve. The resultant rise in screen potential is passed back to the grid of V27b via R207 and C85, causing that valve to conduct and reduce still further the common anode potential. This action, which is cumulative, rapidly cuts off V26. C83 then commences to discharge through the grid-return network selected by the PULSE WIDTH switch wafers S5/3 and S5/2, the time taken for it to discharge sufficiently to allow V26 to conduct again being governed by the amount of grid-return resistance in circuit and the potential to which that resistance is returned.

39. When V26 starts to conduct, the fall in screen potential is passed to the grid of V27b and once again there is a rapid change from one state to the

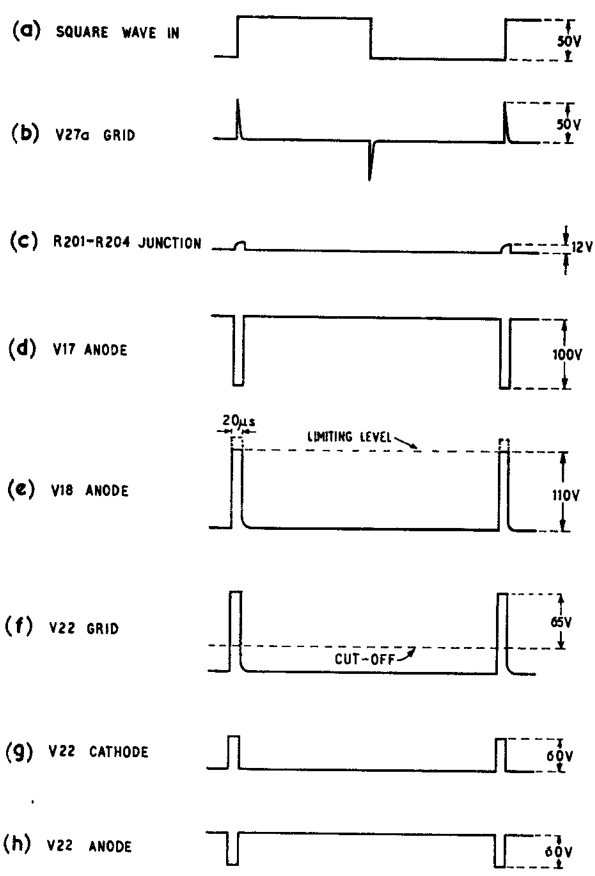


Fig. 4. Development of long-duration pulse: waveforms

other. The circuit is now quiescent and remains so until the arrival of another trigger pulse.

40. Adjustment of the four pulse lengths is made separately with the individual preset resistors RV154 and RV157.

41. The output is taken from the anode circuit of V26 to the pulse-squarer unit via pole 3 of PL4.

Pulse-squarer unit (*fig.* 10)

42. This unit improves the shape of the pulse by reducing the rise- and fall-times of the long-duration pulse and by limiting the upper level and the lower level of both long- and short-duration pulses. (This action is illustrated in fig. 4 which depicts the development of a 20 μs pulse from a 2 kc/s squarewave).

Limiting

43. A standing bias of approximately −50V at the grid of the pulse output valve V22 prevents the valve from responding to that part of the pulse which falls below 50V amplitude, the region in which distortion at the trailing edge occurs, ((*e*) *of fig.* 3 *and* (*f*) *of fig.* 4). The biasing current flows from the −300V line through R108 and either V19 and the anode circuit of V18 to the +350V line, or V20 and the anode circuit of V25 to the +300V line, depending on whether long- or short-duration pulses are being generated.

44. Upper limiting is achieved by V21 and either V19 or V20. The upper-limit level is set by one of four preset resistors RV191, RV194, RV193 and RV196. The first two fix respectively the amplitude of high-level output and the amplitude of the attenuated output of the short-duration pulse, and the latter two act similarly for the longer pulse.

45. The setting of the upper limit resistor determines the current through V21a and, thereby, the voltage across the cathode resistor R107. Since the cathode of V21a is connected to the cathode of V21b, the anode of V21b cannot rise above this preset potential. It follows, therefore, that the potential at the anode of V18 or at the dynode of V24, cannot exceed the potential at the cathode of V21b plus the potential across the corresponding neon (V19—150V, V20—85V).

46. Apart from improving its shape, limiting the pulse in this manner also enables the maximum amplitude of the output pulse to be adjusted.

Short duration pulse

47. The short-duration pulse is connected from the pulse-former unit to the pulse-squarer unit by a separate lead. This prevents the build up of stray capacities which would occur were it routed via the main chassis framework cableform. The impedance of C41 is negligible and the pulse should be considered as applied direct through the contact 7/2 to the grid of V22.

Long-duration pulse

48. The long-duration pulse is brought into the unit through pole 2 of PL3. It is d.c. restored by the diode V31 and, when applied to the grid of V17, overcomes the cathode bias (derived from the steady flow of current through V18 and the common-cathode resistor R99) and causes V17 to conduct. The resulting fall in potential at the anode of V17 is passed, via C36, to the grid of V18 reducing the current flow through that valve and the bias across R99. (The change in current through V18 is greater than the change in current through V17). As the bias is reduced, the current through V17 increases and the cumulative action ensures a rapid change from one state to the other, *i.e.* V17 conducting and V18 cut off. This state obtains until the end of the pulse when the trailing edge initiates rapid cumulative action in the reverse direction.

49. The pulse-lengthening effects of stray capacities appearing in shunt with the anode load of V17 are offset by the inductor, L1, which thereby assists in keeping the rise- and fall-times of the pulse to a minimum.

50. To sum up, when a pulse is fed to the grid of V17, a pulse of the same duration but of greater amplitude and improved shape is produced at the anode of V18.

51. The pulse is passed via C38 and contact 7/2 to the grid of V22.

Pulse output

52. A positive high-level pulse, at an amplitude of 60V peak, is developed at the cathode of V22 and a negative pulse of the same amplitude is developed at the anode. R111–R131 and the PULSE AMPLITUDE switch, S6, enable the amplitude of both the negative and positive pulses to be reduced in steps of 6V.

53. To make the amplitude of the positive and negative pulses the same, the cathode network, R122–R131, which also passes the screen current, is shunted by R109.

54. For attenuated output of the positive pulse, relay RL5 (contact 5/1) connects the step attenuators, in series with R133, across the cathode load. This reduces the maximum amplitude of the pulse output from the step-attenuator to the required 10V.

55. For attenuated output of the negative pulse, relay RL6 (contact 6/1) connects the step attenuators via R132 and C45 to the anode load of V22. The maximum output from the step-attenuator is again 10V. To make the operating conditions of V22 the same as for the attenuated positive pulse output, contact 6/2 connects R133 and R134 in series (the resistance of R134 being equivalent to the input impedance of the step-attenuators) across the cathode load.

Sync-pulse generator (*fig.* 11)

56. This unit, using valves V28 and V29, produces both positive and negative sync. pulses of 1, 5 and 20 μs duration at amplitudes of 15, 25, 50 and 100V. V28 operates as a trigger amplifier and buffer stage, V29b is arranged as a blocking oscillator and V29a is the output valve. Fig. 5 shows the development of a 5 μs sync. pulse.

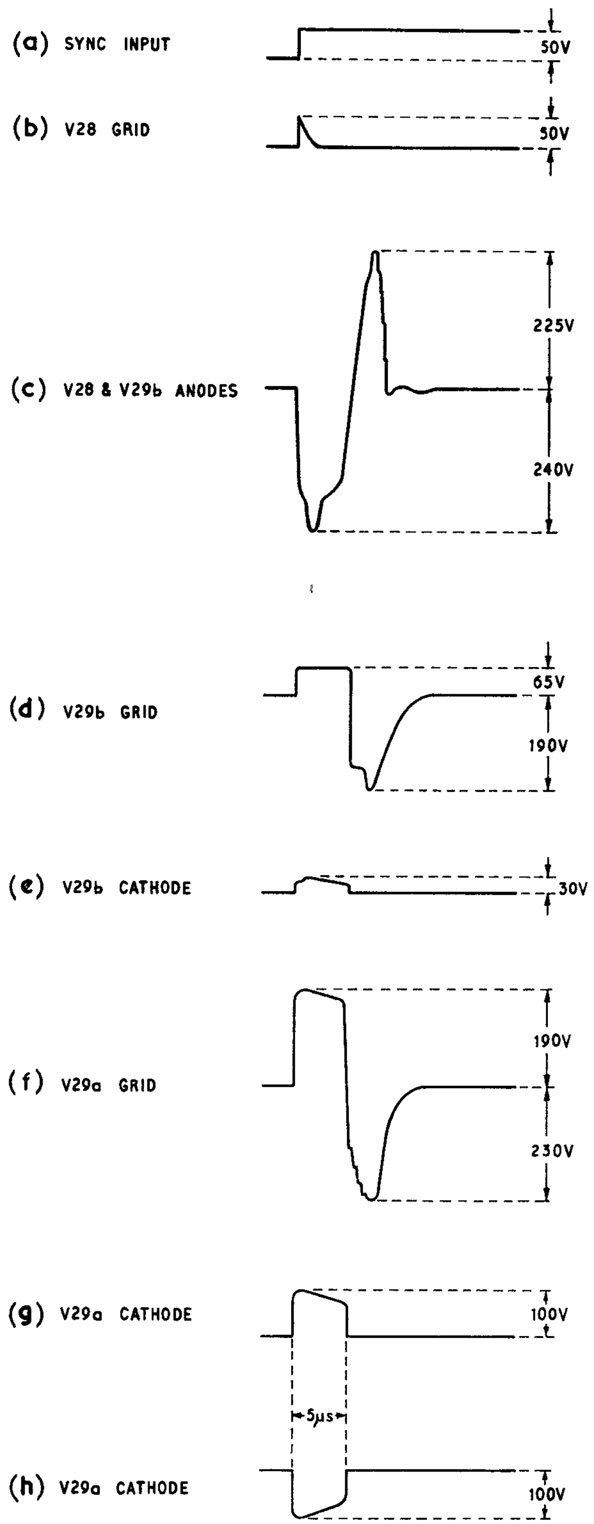


Fig. 5. Development of sync-pulse: waveforms

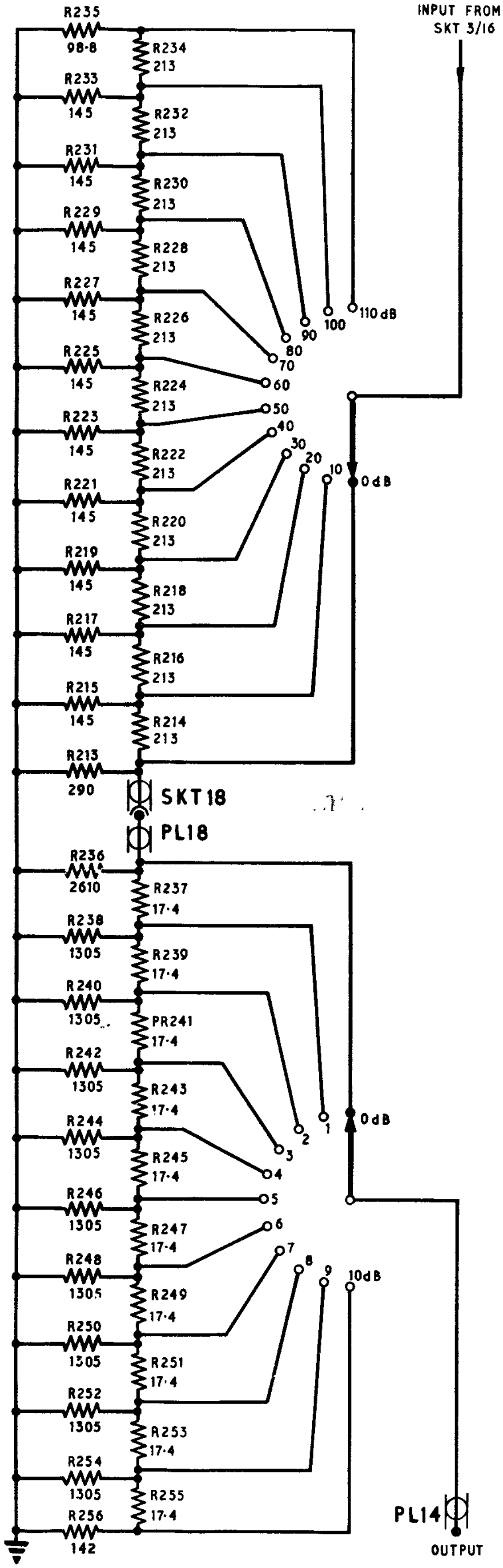


Fig. 6. Step attenuators

57. The grids of V28 and V29 are returned to potentials that are negative to their cathodes and, in the quiescent state, the valves are cut off. The sync. trigger is fed to the unit via pole 2 of PL5 and is differentiated by the short time-constant of the input circuit to V28. This produces a sharp positive spike at the grid of V28 ((*b*) *of fig.* 5), the valve then conducts and the potential at the anode, and also at the anode of V29b to which it is connected, falls. One of the transformers T4, T5 and T6 is switched into the common anode circuit of V28 and V29b, according to the length of pulse required. The transformers are connected to produce positive feedback at the grid of V29b so that a fall in anode potential results in the grid being driven positive and, the action being cumulative, the valve quickly saturates. After a period, related to the impedance of the transformer and the potential to which the grid is returned, the valve current will fall and start a reverse cumulative action, *i.e.* rise in anode potential, fall in grid potential, fall in anode current, until V29b is cut off. V28 and V29b remain in this state until the receipt of a further trigger pulse.

58. Adjustment of each sync. pulse length is controlled by the preset resistors RV167, RV168 and RV172.

59. A third winding on each transformer takes the output from the blocking oscillator to the grid of the output stage V29a. At this point the output consists of a high-amplitude positive pulse of defined length followed by a higher amplitude negative overshoot ((*f*) *of fig.* 5). In the quiescent state, V29a is cut off by a bias of approximately −80V obtained from the junction of R173 and R174 with the result that V29a conducts only for the upper portion of the positive pulse. The negative sync. pulse is developed across the tapped anode load, R175–R178 and the positive sync. pulse across the tapped cathode load, R179–R182. The maximum amplitude of both pulses is 100V but the taps enable selection by S7/1 and S7/2 of alternative outputs of 15, 25 and 50V.

Overload protection

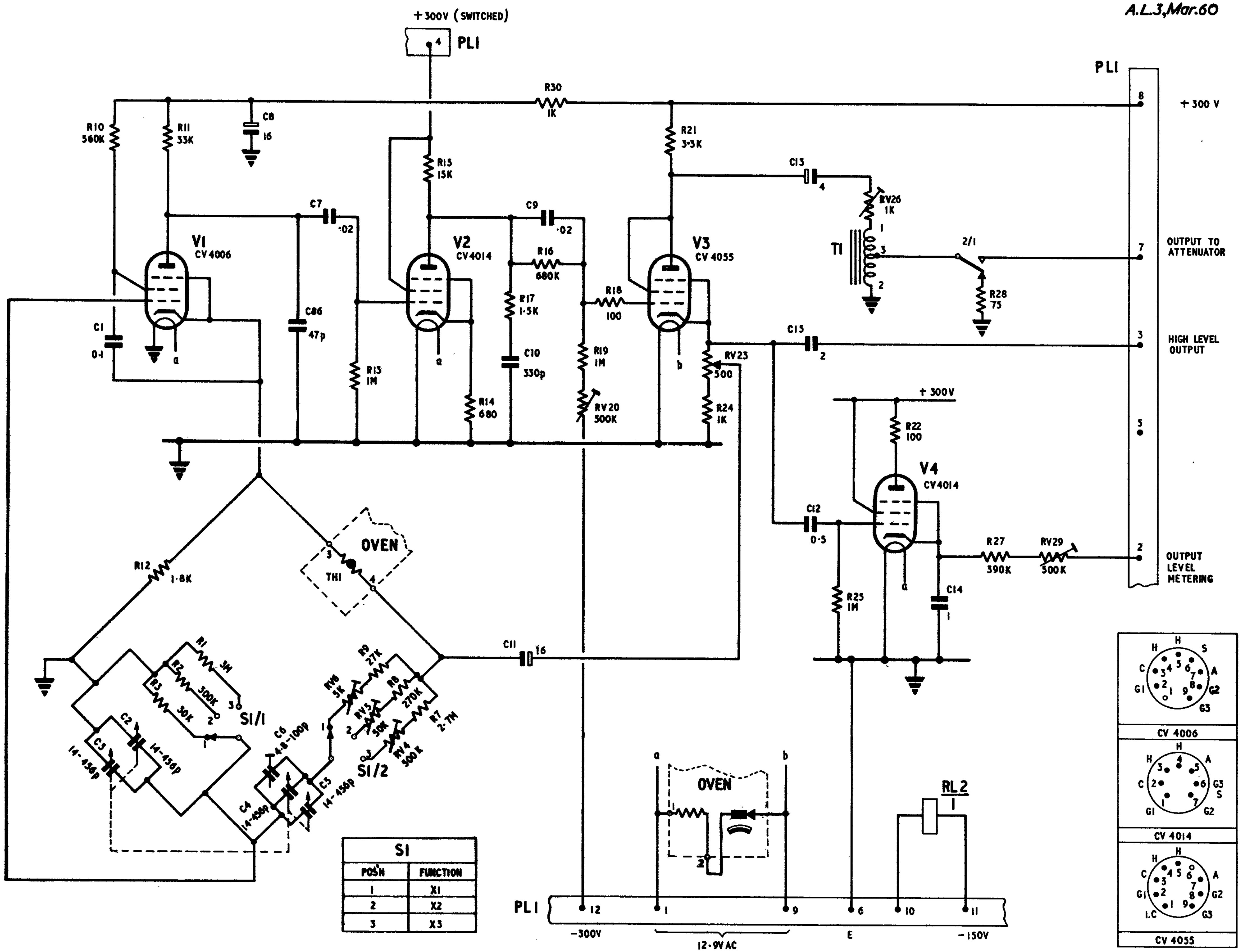
60. The maximum pulse duty cycle is 10% and provision is made to stop the pulse automatically if the duty cycle is exceeded. Indication of when the protection circuit operates is given by the illimination of ILP1. Before the pulse can be restored, it is necessary to reduce either the pulse length or the pulse recurrence frequency. Normal operation can then be resumed by depressing the PRESS TO RESET switch on the front panel.

61. The circuit operates by including the relay RL4 in the 350V supply lead to the pulse output valve V22 (*fig.* 12). The sensitivity of the relay is adjusted by the preset shunt resistor, RV189, so that it operates if the current through V22 exceeds the amount pertaining to the maximum duty cycle.

62. The relay contact 4/1 connects the supply via R188 to the OVERLOAD neon, ILP1, and via R187 to the relay RL8. The 2–20 μs pulse input to the pulse-squarer unit is disconnected by the relay contact 8/1 (the shorter-duration pulses cannot overload the generator) and, consequently, V22 is cut off. However, RL4 remains energized through the contact 4/1 until it is short-circuited by the PRESS TO RESET switch, S12.

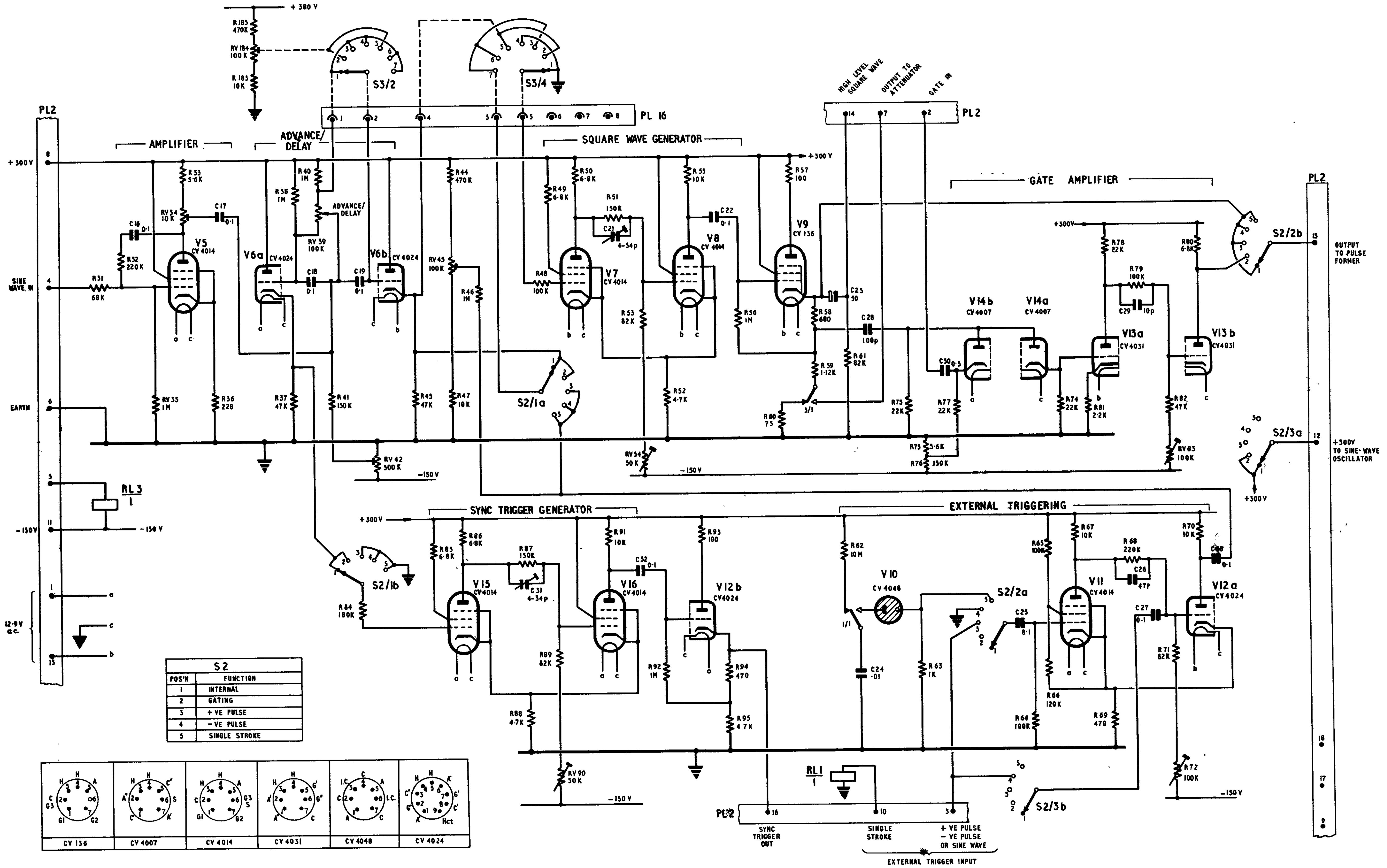
Attenuated output

63. The attenuated output circuit consists of two step-attenuators (*fig.* 6). One provides a total attenuation of 10 dB in steps of 1 dB and the other a total of 110 dB in steps of 10 dB. The attenuators are connected in series making the total range of attenuation 0–120 dB in steps of 1 dB The input and output impedance is 75-ohms.



S1	
POSN	FUNCTION
1	X1
2	X2
3	X3

Fig. 7 Sine-wave oscillator unit: circuit Fig. 7



S2	
POS'N	FUNCTION
1	INTERNAL
2	GATING
3	+ VE PULSE
4	− VE PULSE
5	SINGLE STROKE

Fig.8 Square-wave unit: circuit Fig.8

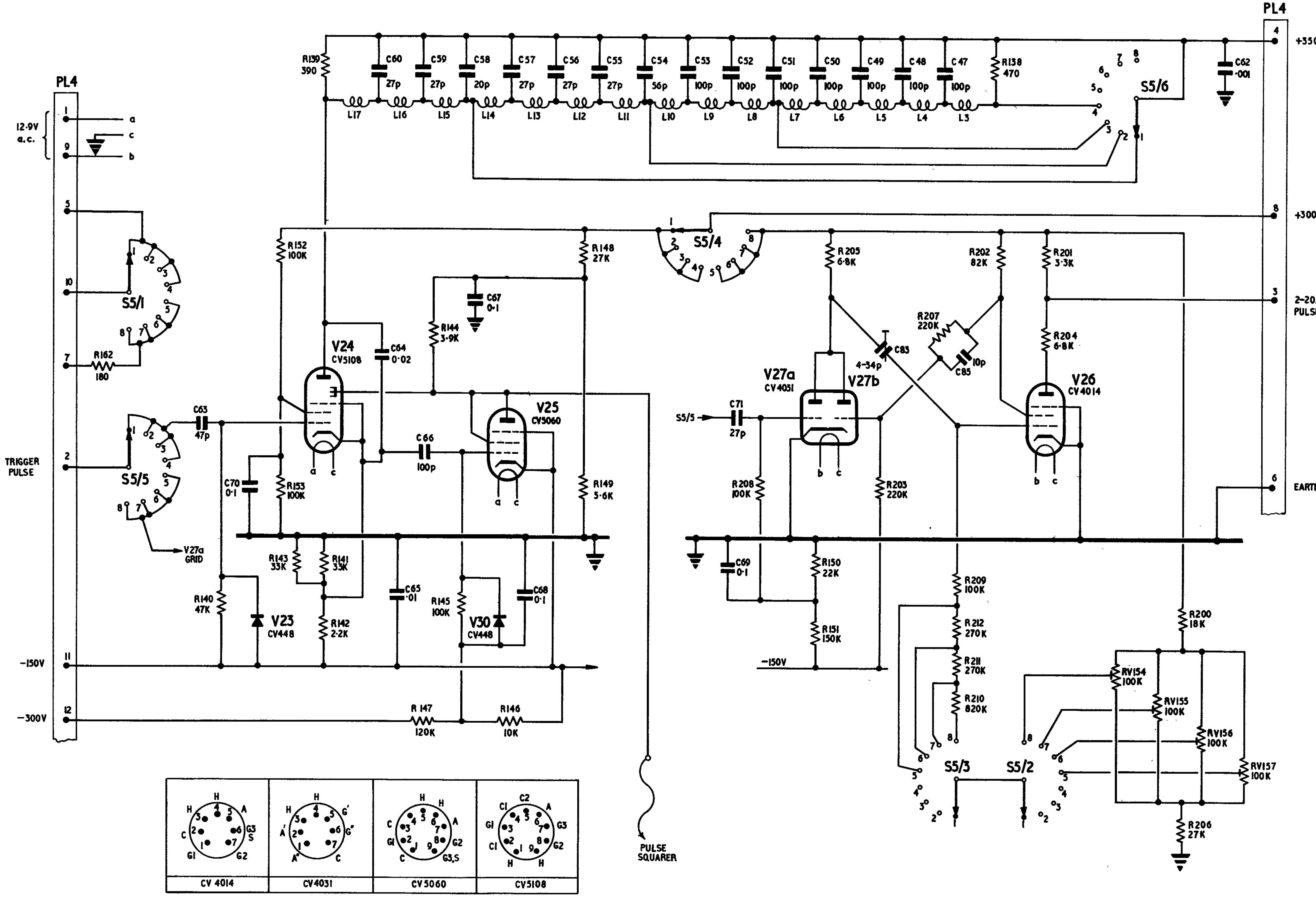


Fig. 9 Pulse-former unit: circuit Fig. 9

RELAY	FUNCTION
RL5	+VE PULSE OUTPUT TO ATTENUATOR
RL6	-VE PULSE OUTPUT TO ATTENUATOR
RL7	C/F INPUT SWITCHING

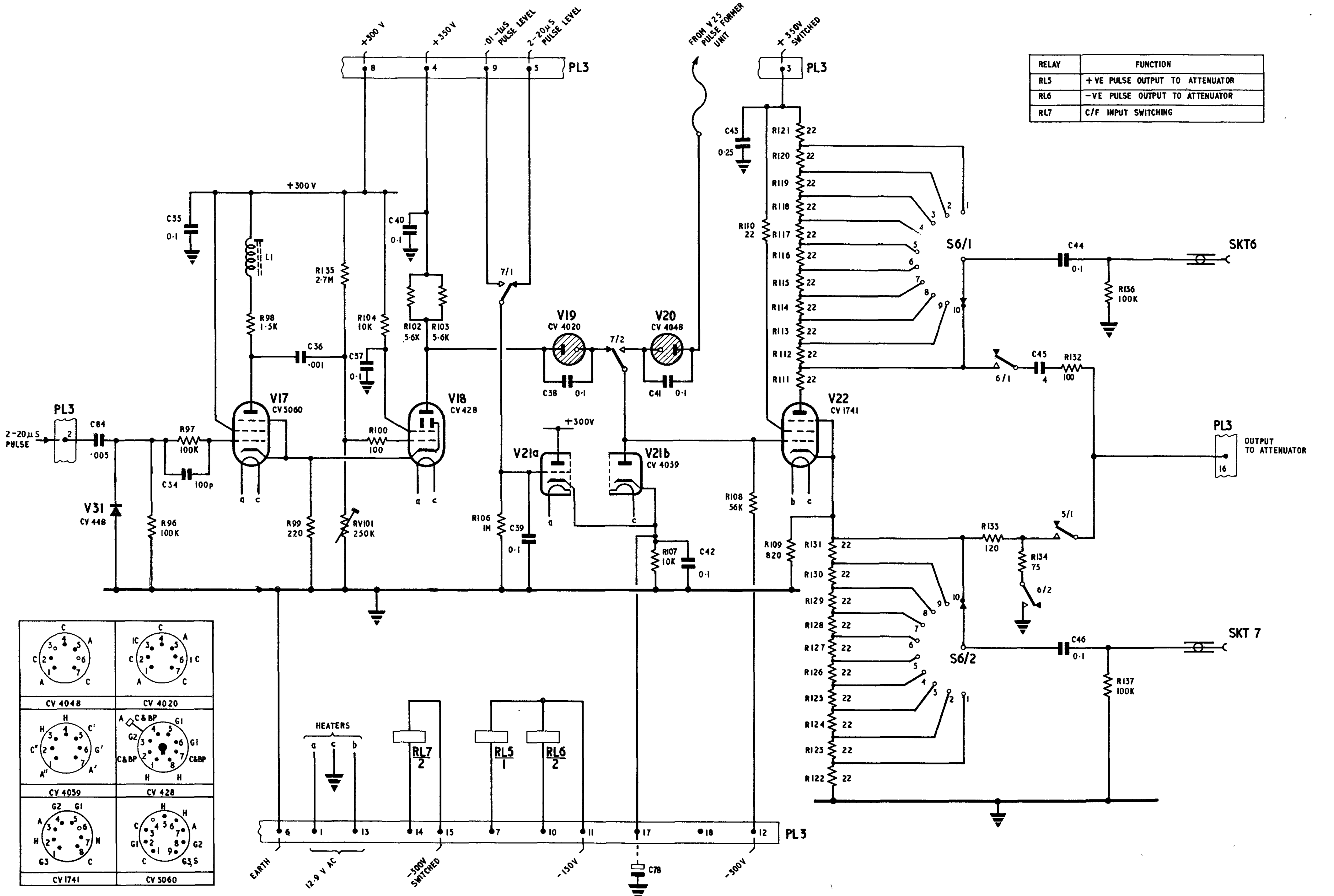


Fig. 10 Pulse-squarer unit: circuit Fig. 10

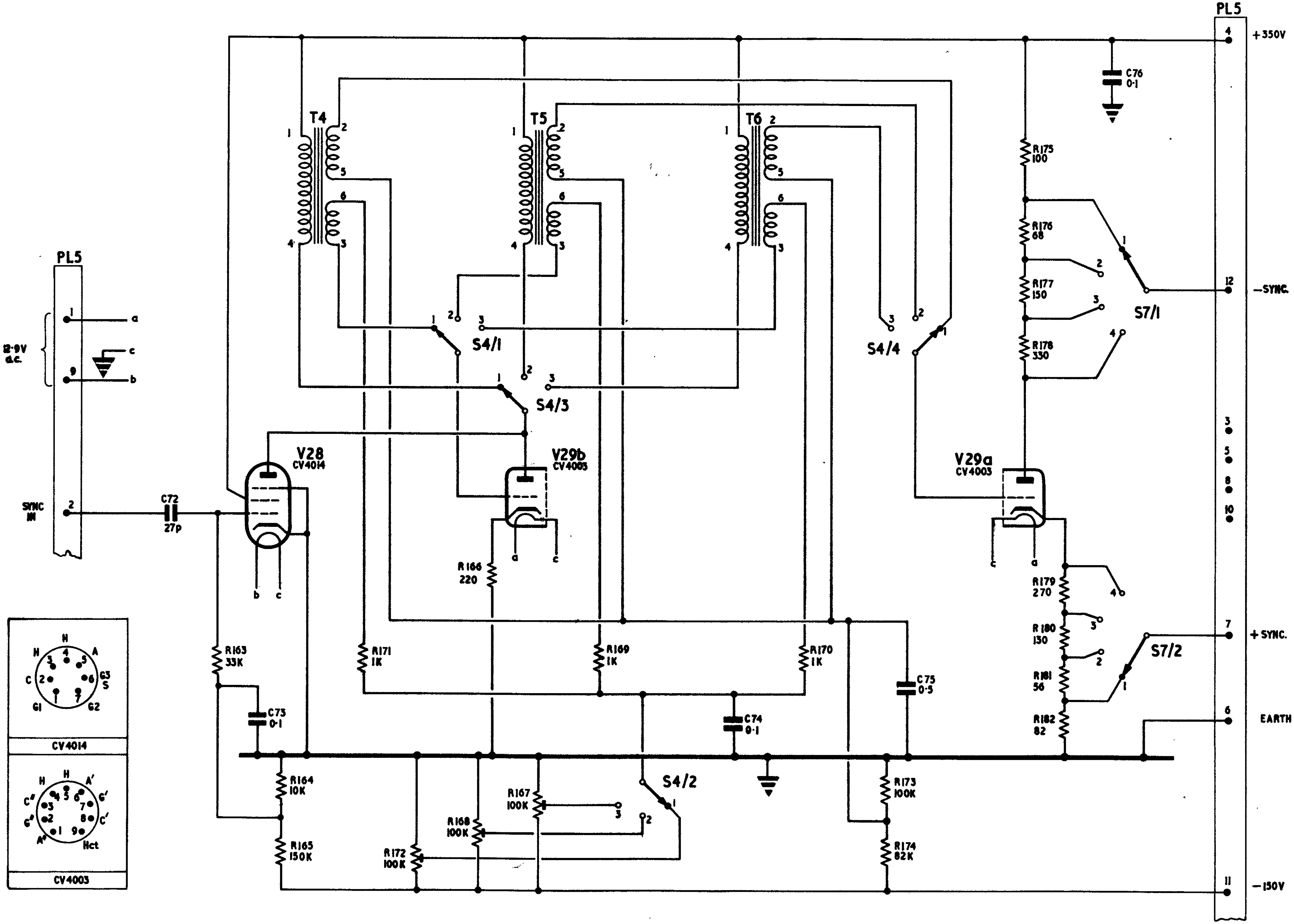
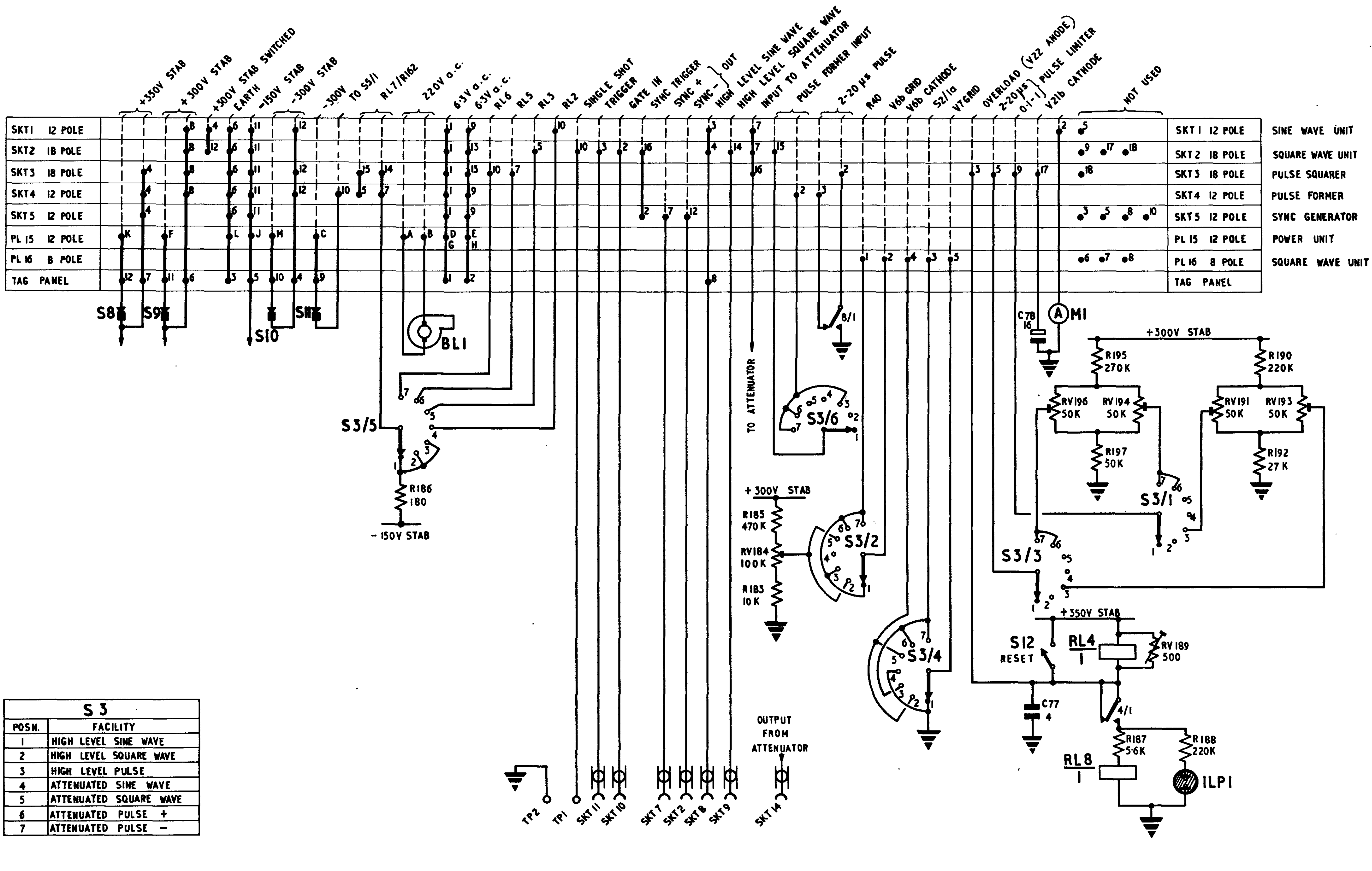


Fig.11 Sync-pulse generator: circuit Fig.11



S3	
POSN.	FACILITY
1	HIGH LEVEL SINE WAVE
2	HIGH LEVEL SQUARE WAVE
3	HIGH LEVEL PULSE
4	ATTENUATED SINE WAVE
5	ATTENUATED SQUARE WAVE
6	ATTENUATED PULSE +
7	ATTENUATED PULSE −

Fig. 12 Main chassis framework : circuit Fig. 12

Chapter 2

CIRCUIT DESCRIPTION, POWER SUPPLY

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

Introduction

1. This unit provides all the a.c. and d.c. supplies for the pulse generator unit. These are:—

(1) +350V d.c. stabilized
(2) +300V d.c. stabilized
(3) −150V d.c. stabilized
(4) −300V d.c. stabilized
(5) 12·6V a.c. heater supply
(6) 230V a.c. for fan.

2. A circuit diagram of the power supply is shown in fig. 1. From the mains input plug, PL2, the supply is taken via the MAINS ON switch S1, the fuses FS1 and FS2, the microswitch S2, and the voltage selection panel, to the mains transformer T1. This transformer has four secondaries as follows:—

(1) 500–0–500V h.t. for full-wave rectifiers V1 and V2
(2) 6·3V, 5·5A heater supply for V1, V2, V3, V4 and V7
(3) 6·3V, 1·5A heater supply for V11
(4) 12·9V, a centre-tapped winding supplying all other valve heaters in the power supply and pulse generator unit (this allows for 0·3V drop in the inter-unit wiring).

Positive supplies

3. The +350V and +300V supplies are derived from a full-wave rectifier circuit using two CV4044 valves, V1 and V2. The output is smoothed by the network C1, L1 and C2 and then divided so that the two supplies may be staoilized independently.

4. The stabilizing of the +350V line is effected by the valves V3, V4, V5 and V6. Valves V3 and V4 are parallel-connected triodes in series with the h.t. supply; their joint resistance to the h.t. current is proportional to their grid/cathode potential, which is controlled by the amplifier V5. V5 is a double triode connected as a cascode amplifier. The cathode of V5b is held at +85V by the neon valve V6. The grid of V5b is returned to a potential on the divider network R8, R9, RV11 and R12 depending on the setting of RV11. This setting determines the level at which the amplifier functions and, consequently, the level at which the h.t. is stabilized.

5. If the potential at V3/V4 cathode rises, V5b grid rises and V5a anode falls. Since the anode of V5a is directly coupled to the grid of V3/V4, the grid/cathode potential of V3/V4 is thus increased. This increases the impedance of V3/V4 to the h.t. current and so reduces the potential at the common cathodes.

6. For the +300V supply a single tetrode, V7, is used as the series valve. The principle of the circuit is the same as that used for the 350V supply but, since the response to variations of the load must be much faster, the control amplifier is more complex.

7. The +300V supply control amplifier employs a pentode, V9 and a twin triode, V8. The cathode of V9 is held at 85V by the reference neon, V10, and the grid is returned to a potential determined by the setting of RV28. Variations of the load are amplified by V9, which is directly coupled to V8b. V8a and V8b are connected as a "long tail" pair and therefore the signal at the anode of V8a will be in phase with that fed to the grid of V8b. There is thus the required 180° phase change between the variations at the grid of V9 and those which subsequently appear at the grid of V7.

8. Negative feedback is applied to the control amplifier by R17 and R18 to offset the hum developed across the reference neon, V10. The amount of feedback can be adjusted by RV18.

Negative supplies

9. The negative supplies are obtained by connecting a half-wave rectifier in the inverse direction across one half of the h.t. secondary winding of T1. C8 is the reservoir capacitor and L2 and C9 the smoothing filter. An amplified shunt circuit consisting of V13, V14 and V15 is used to stabilize the −150V supply while the 150V neon, V12, connected in series with the 150V supply, stabilizes the −300V supply.

10. When considering the function of this stabilizing circuit, it should be remembered that there is a current path between poles C and J of SKT1 consisting of RL7 or R162 in series with one of the following RL2, RL3, RL5, RL6 or R186.

11. The cathode of the pentode amplifier, V14, is held at −150V by the reference neon, V13, and the anode is taken to the +300V line via the load resistor R34. The grid of V14 is connected to the −150V line so that, for example, an increase in negative potential on the line results in a fall at V14 grid, a rise at V14 anode and a rise at V15 grid to which V14 is directly coupled. This increases the current through V15 and the voltage drop across R32 (through which V15 current flows (*para.* 10)) and so reduces the potential on the −150V line to the equilibrium value.

Blower motor supply

12. The a.c. supply for the blower motor in the pulse generator unit is taken from the 230V tap on the primary of T1 to poles A and B on SKT1.

P30279 533401/6558 9/60 250 C & P Gp 375

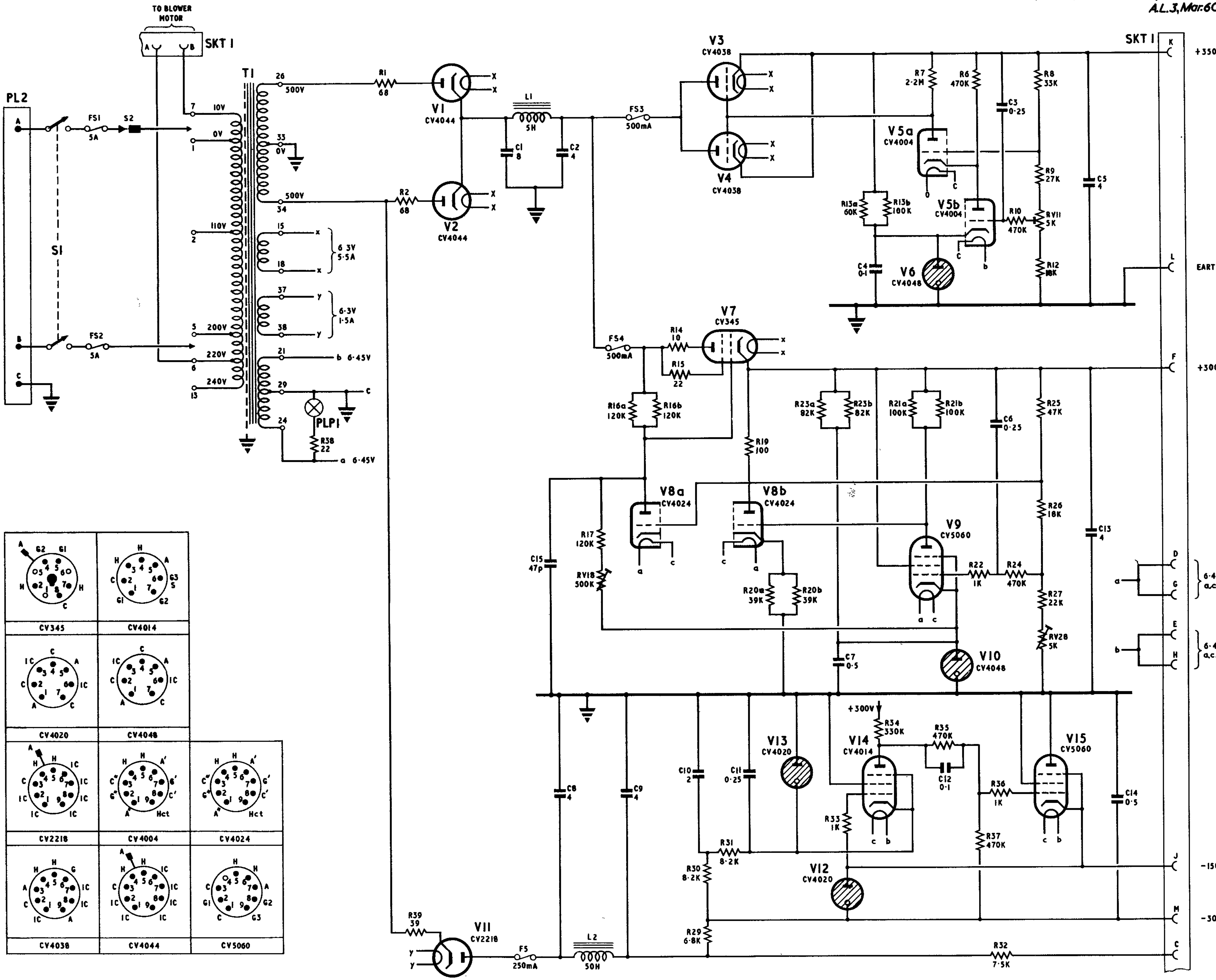


Fig. I Power supply 6625-99-943-7372: circuit Fig. I

PP8697 533402/6659 5/60 255 C & P Gp. 924 (4)