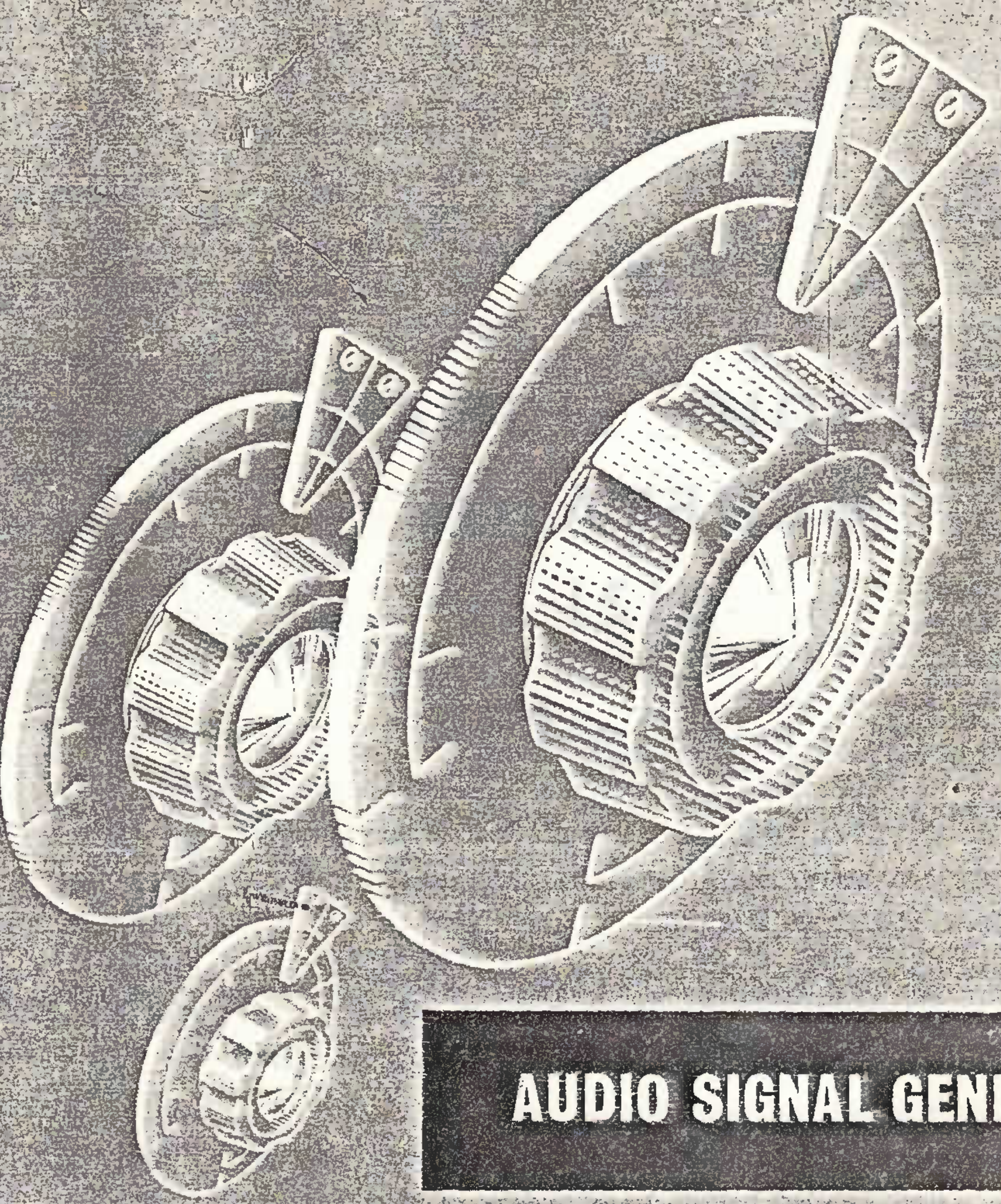

AUDIO SIGNAL GENERATOR S121

INSTRUCTION MANUAL

WAYNE KERR

AUDIO SIGNAL GENERATOR S121

THE WAYNE KERR LABORATORIES LIMITED
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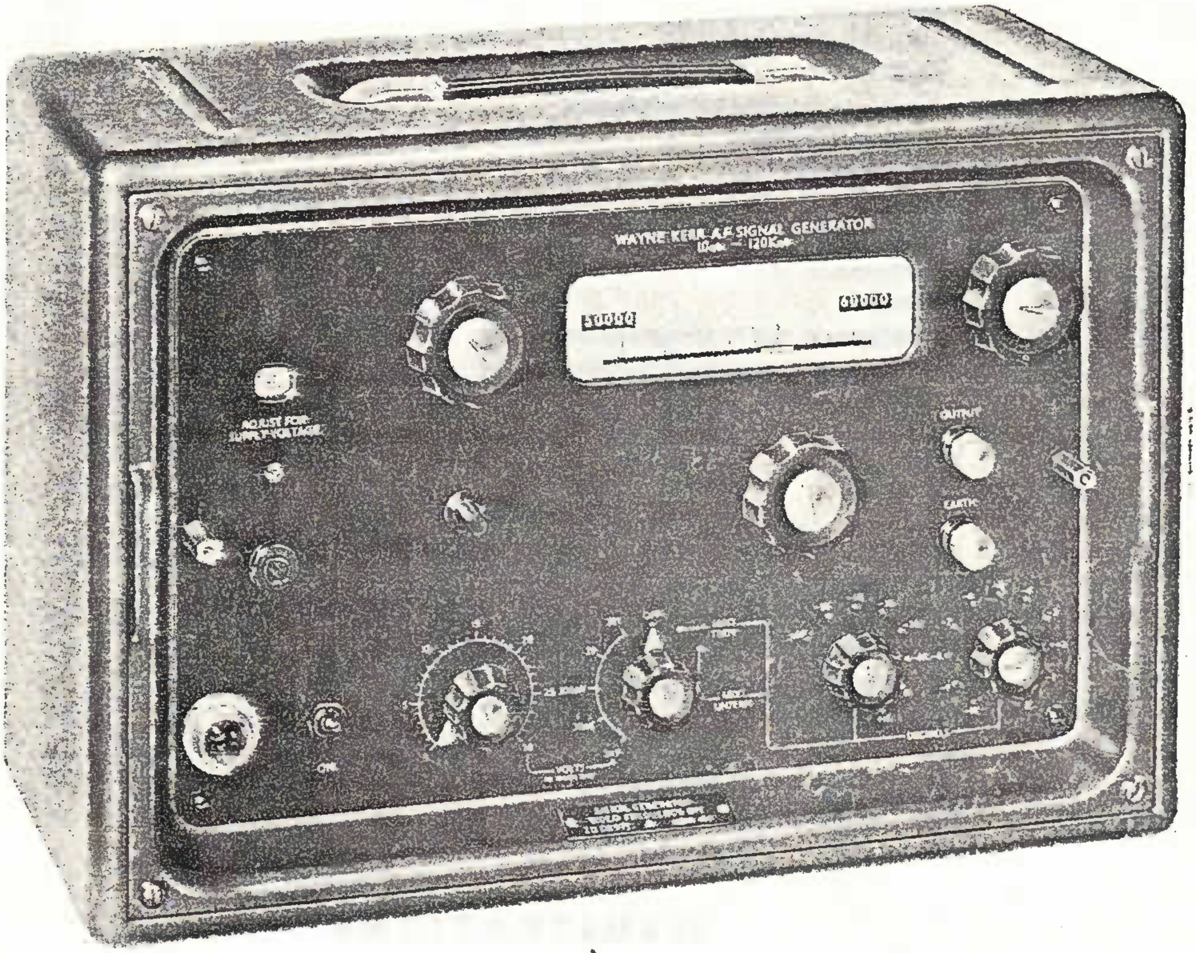
CONTENTS

TABLES

ILLUSTRATIONS


WAYNE KERR A.F. SIGNAL GENERATOR
50000
69000
ADJUST FOR SUPPLY VOLTAGE
OUTPUT
EARTH
ON
VOLTS

INTRODUCTION

The Audio Signal Generator S121 is a high grade laboratory oscillator providing an extremely stable output in the frequency range 10c/s to 120kc/s. The unique dial display provides direct readings of frequency with a discrimination of 1% over the entire frequency range. The frequency control system permits the selection of major intervals in the frequency range, for measurements on filters etc., and the continuous adjustment of the output frequency.

Two output arrangements are incorporated; one providing a high impedance output of 0 to 30V in five ranges, with continuous adjustment from zero in each range, and the other providing 600-ohm outputs (terminated or unterminated) from +10dB to −70dB (reference 0dB = 1 mW into 600 ohms) in 1dB steps.

The instrument utilizes a Wien Bridge oscillator, arranged to cover the frequency range with a minimum number of standard components, and has been designed for ease of operation.

SPECIFICATION

FREQUENCY COVERAGE	10c/s to 120kc/s	
FREQUENCY ACCURACY	±1% or ±0·5c/s, whichever is the greater, over the whole band on both 600Ω outputs. On the high-level output this accuracy is maintained up to at least 20kc/s.	
FREQUENCY PULLING		
600-ohm outputs	Up to 20kc/s	less than 0·05%
	50kc/s	less than 0·1%
	100kc/s	less than 0·3%
	with 600Ω external load switched on and off.	
High-level outputs	Up to 10kc/s	less than 0·05%
	20kc/s	less than 0·1%
	50kc/s	less than 0·2%
	100kc/s	less than 0·5%
	measured at 30V for all external loads from 3kΩ to 100kΩ.	
FREQUENCY STABILITY	One part in 10^4 over short periods	
WAVEFORM DISTORTION (600Ω terminated)	*Frequency*	*Harmonic content* (with respect to fundamental)
	16c/s	Better than −34dB (2%)
	32c/s	Better than −40dB (1%)
	64c/s	Better than −45dB (0·6%)
	100c/s	Better than −50dB (0·31%)
	300c/s to 10kc/s	Better than −54dB (0·2%)
	30kc/s	Better than −52dB (0·25%)
	50kc/s	Better than −50dB (0·31%)
	100kc/s	Better than −48dB (0·4%)
OUTPUT LEVEL ACCURACY (Ambient temperature 20°C ±3°C)		
600-ohm outputs	Better than ±0·5dB	
High-level outputs	Below 20kc/s	Better than ±0·5dB
	50kc/s	Better than −1dB
	100kc/s	Better than −3dB
OUTPUT LEVEL STABILITY		
600-ohm outputs	Better than 0·2dB	
High-level outputs (0 to 30V)	Below 10kc/s, better than 0·2dB Between 10kc/s and 20kc/s, better than 0·3dB	
Short-term	Allowing half-an-hour warming up period, short-term stability of output level is better than 0·2dB.	
OUTPUT IMPEDANCE ACCURACY *(600-ohm outputs)*	±2%	
ATTENUATOR ACCURACY	Better than ±0·2dB	
HUM LEVEL	Better than 60dB below signal level	
POWER SUPPLY	100V to 115V or 190V to 250V, 40c/s to 60c/s single phase. Power consumption approximately 25 Watts.	
DIMENSIONS	17 in. × 11½ in. × 7½ in. (43·2cm × 29·2cm × 19cm)	
WEIGHT	17 lb (7·7 kg)	

OPERATING PRINCIPLES

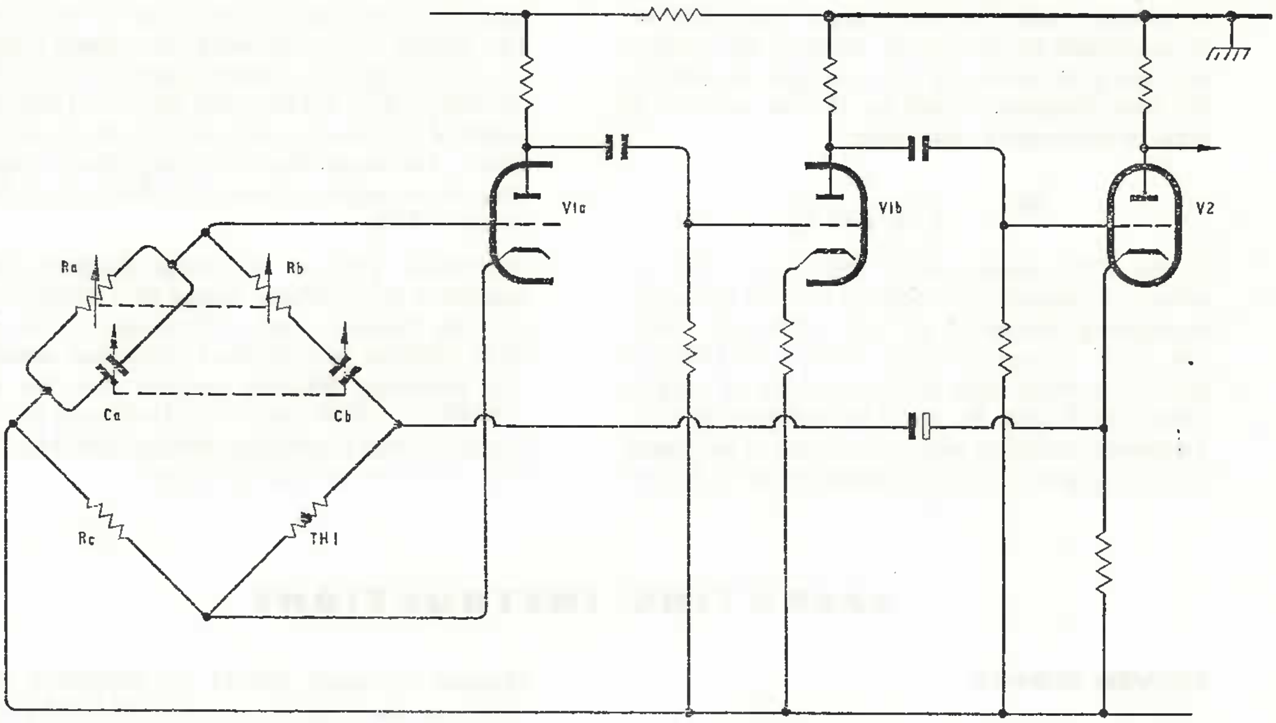


Fig. 1 Basic Wien Bridge Oscillator

The S121 utilizes a Wien Bridge oscillator, the basic circuit of which is shown in figure 1. V1a is the oscillator valve, V1b an amplifier and inverter, and V2 the output amplifier and feedback cathode follower. The circuit oscillates at a frequency determined by the set values of the bridge components, the frequency being that which

a develops a voltage across R_a in phase with the output of V2, and

b develops a positive feedback voltage greater than the negative feedback voltage.

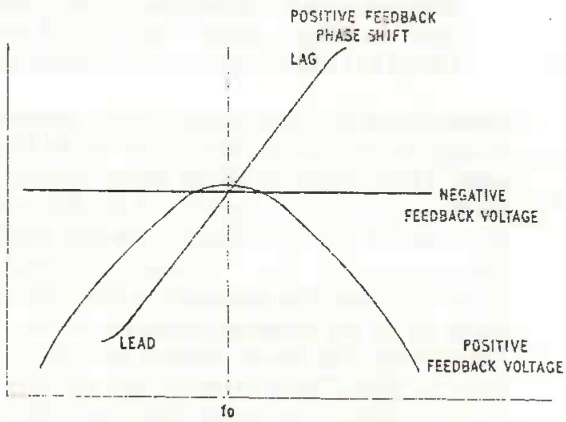


Fig. 2 Conditions for Oscillation

Positive feedback from V2 cathode is developed across bridge arms R_a, C_a and R_b, C_b, negative feedback being developed across bridge arms TH1 and R_c. For given values of the bridge components, the positive feedback voltage is a maximum at one frequency only, while the negative feedback is constant at all frequencies. Figure 2 illustrates the relative magnitudes of the feedback voltages about the frequency of oscillation, and shows also the phase relationship between the positive feedback (developed across R_a) and the output at the anode of V2. The feedback and output voltages are in phase when $\omega R_b C_b = 1/\omega R_a C_a$,* which gives the frequency of oscillation

$$f_o = \frac{1}{2\pi\sqrt{R_a R_b C_a C_b}}$$

In the S121, R_a always equals R_b, and C_a always equals C_b, hence the equation can be re-written

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

where $R = R_a = R_b$
and $C = C_a = C_b$

* Derived from the 'imaginary' parts of the formula for the condition of balance in a Wien bridge circuit.

For a given value of C, the value of R can be varied to provide a basic frequency range. This range can be multiplied by any factor required by suitably decreasing the value of C. For example, to multiply the basic frequency range by 10, the value of C must be decreased to one tenth.

$$10f_o = \frac{1}{2\pi R\ (10^{-1}\ C)}$$

In the S121, values of C_a and C_b (i.e. 'C') are selected by switching circuits to provide frequency multiplying factors of x1, x10, x100 and x1000. The basic frequency range of 10c/s to 120c/s is covered in 10c/s steps by the selection of suitable values for R_a and R_b, again by switching circuits. Frequency variation within each step is facilitated by making part of the appropriate value of R_a and R_b variable, so that continuous coverage over the basic frequency range is provided in 10c/s bands. The variable parts of R_a and R_b are ganged together. For each range of frequencies (10c/s to 120c/s, 100c/s to 1·2kc/s, 1kc/s to 12kc/s and 10kc/s to 120kc/s) the width of the bands is increased by the multiplying factor. The range 1kc/s to 12kc/s (basic range × 100), for example, is covered in eleven 1kc/s bands (10c/s × 100).

Thermistor TH1 in the bridge feedback circuit maintains the oscillator output at a constant level over the frequency range. The output circuit of the S121 includes two switched attenuator networks, one providing 600-ohm outputs over the range +10dB to −70dB (relative to 1mW) and the other providing high impedance outputs from 0 to 30V in five continuously variable ranges.

OPERATING INSTRUCTIONS

POWER SUPPLY

The instrument operates from 40c/s to 60c/s supplies of 100V to 115V, 190V to 220V or 220V to 250V, adjustment to suit the supply voltage being provided by a screwdriver-operated switch on the left side of the front panel. Indication of the range to which the input voltage selector switch is set is given by a small scale located directly above the switch. When the instrument is to be used with 100V to 115V supplies, fuse FS1 (located directly below the input voltage selector switch) must be changed to 2A rating; a 1A fuse is normally fitted.

The power supply is connected to the instrument via the front panel. It is essential that all the power supply connexions are made correctly, the wires being identified as follows:

Red—Live Black—Neutral Green—Earth

Note: The positive of the h.t. supply is connected to the chassis, the return circuit being at h.t. negative.

CONTROLS

The function of each control located on the front panel, and its method of use, is as follows:

Frequency Selection Controls

The oscillator output is set to the required frequency in the range 10c/s to 120kc/s by means of three controls. Two of the controls are selector switches (located one each side of the frequency scale), which are used together to select the band covering the required frequency, while the third control provides continuous frequency variation within the limits of the selected band.

Frequency band selectors: The frequency band selector and the major frequency range selector controls are located to the left and right respectively of the frequency scale. The band selector control facilitates selection of eleven bands in each of the major frequency ranges, the width of each band depending upon the particular range selected. The ranges covered and the width of the bands within each range are

10c/s to 120c/s: eleven bands 10c/s wide
100c/s to 1.2kc/s: eleven bands 100c/s wide
1kc/s to 12kc/s: eleven bands 1kc/s wide
10kc/s to 120kc/s: eleven bands 10kc/s wide

Operation of the band selector switch automatically changes the dial figures at each end of the frequency scale, while operation of the range selector switch masks or reveals the cyphers of the dial readings. (Each of the major ranges is a decade multiple or sub-multiple of the 'adjacent' ranges). The frequency scale thus represents a band between the limits set by the frequency controls. In the 10c/s to 120c/s range, the bands covered are 10c/s to 20c/s, 20c/s to 30c/s, 30c/s to 40c/s and so forth up to 110c/s to 120c/s, and in the 100c/s to 1.2kc/s range the bands covered are 100c/s to 200c/s, 200c/s to 300c/s etc.

Frequency scale and fine frequency control: The frequency scale, which is approximately logarithmic, has ten major divisions each sub-divided into five minor divisions. The frequency coverage of the scale is indicated by the dial figures at each end, the figures being changed by operation of the frequency band and major range selector controls. Adjustment of frequency within a band is provided by the variable control located immediately below the scale panel, a fine pointer indicating the selected frequency. A frequency overlap is provided between each of the major ranges. Where a frequency is required within the overlap section, the setting is obtained more accurately in the lower range.

A frequency overlap is also provided between adjacent bands, by extending the frequency scale each side of the first and last major markers. The major scale and the extension divisions are underlined in black; a further marker, not underlined, is provided at each extreme limit of the scale for setting-up purposes. The frequency extensions are given for each of the four major ranges in table 1.

TABLE 1

Frequency Scale — Extensions

Major Frequency Range	Width of Each Band	Scale Extensions		
		Left Side	Right Side	
			Per Division	Total
10c/s to 120c/s	10c/s	0·1c/s	0·2c/s	0·8c/s
100c/s to 1·2kc/s	100c/s	1c/s	2c/s	8c/s
1kc/s to 12kc/s	1kc/s	10c/s	20c/s	80c/s
10kc/s to 120kc/s	10kc/s	100c/s	200c/s	800c/s

Thus, on the 300c/s to 400c/s band (100c/s to 1.2kc/s range), the frequency scale is extended to cover from 299c/s to 408c/s.

Output Selector Control

This is an eight position switch (including one 'off' position) for the selection of a 600Ω terminated or unterminated output, or one of five 'high-level' outputs. In the '600Ω' positions the precision attenuator is connected in circuit, while in the 'high-level' positions, the continuously variable voltage control is connected in circuit; the front panel is engraved to indicate which controls are related to specific positions.

The output impedance on the voltage ranges depends upon the range selected; with the variable control fully clockwise the impedance for each range is:

30V range:	3·3kΩ
3V range:	950Ω
300mV range:	100Ω
30mV range:	10Ω
3mV range:	9Ω

In the OFF position, the output selector control short circuits the OUTPUT and EARTH terminals, and isolates both output circuits from the oscillator. The oscillator still operates, however, so that a stable signal is available when the selector is set to an output position.

Voltage Output Control

This control, calibrated from 0 to 30, enables the level of the output voltage to be adjusted within the range selected by the output selector control.

600-ohm Output Attenuators

Two controls are incorporated to provide attenuation from +10dB to −70dB (relative to 1mW in 600 ohms), one control covering from +10dB to −60dB in 10dB steps, and the other covering from 0 to −10dB in 1dB steps. The approximate equivalent voltage output for any given dB setting is given in table 2.

TABLE 2

Decibels and Equivalent Voltages

(0dB = 0.775V)

dB	Voltage	dB	Voltage	dB	Voltage	dB	Voltage
+10	2·5V	−10	0·25V	−30	25mV	−50	2·5mV
+9	2·2V	−11	0·22V	−31	22mV	−51	2·2mV
+8	1·95V	−12	0·195V	−32	19·5mV	−52	1·95mV
+7	1·73V	−13	0·173V	−33	17mV	−53	1·7mV
+6	1·55V	−14	0·16V	−34	15·5mV	−54	1·6mV
+5	1·38V	−15	0·14V	−35	14mV	−55	1·4mV
+4	1·23V	−16	0·12V	−36	12mV	−56	1·2mV
+3	1·1V	−17	0·11V	−37	11mV	−57	1·1mV
+2	0·98V	−18	98mV	−38	9·8mV	−58	980μV
+1	0·87V	−19	87mV	−39	8·7mV	−59	870μV
0	0·775V	−20	77·5mV	−40	7·8mV	−60	780μV
−1	0·69V	−21	69mV	−41	6·9mV	−61	690μV
−2	0·62V	−22	62mV	−42	6·2mV	−62	620μV
−3	0·55V	−23	55mV	−43	5·5mV	−63	550μV
−4	0·49V	−24	49mV	−44	4·9mV	−64	490μV
−5	0·44V	−25	44mV	−45	4·4mV	−65	440μV
−6	0·39V	−26	39mV	−46	3·9mV	−66	390μV
−7	0·35V	−27	35mV	−47	3·5mV	−67	350μV
−8	0·31V	−28	31mV	−48	3·1mV	−68	310μV
−9	0·28V	−29	27·5mV	−49	2·8mV	−69	275μV
						−70	245μV

SETTING-UP THE OSCILLATOR

Switching On

For accuracy of frequency and output level, the instrument should be switched on half-an-hour before use (or an hour, if extreme accuracy is required) in order that it may reach thermal equilibrium. Note that, when in use, the output can be switched off by the output selector control without disturbing the operation of the oscillator; the output will then be available when required without the necessity for a waiting period.

Output Selection

The oscillator output is available at the two terminals on the right-side of the front panel. It should be noted that the positive h.t. line is connected to the chassis and consequently the return circuits, which are at h.t. negative, are isolated; a good earth connexion is desirable.

Three types of output are available: high-level, 600Ω terminated and 600Ω unterminated. The required output and level is set up by the output selector and associated attenuator controls. Three controls are associated with frequency selection; further details of these are given under the heading 'Controls'.

APPLICATIONS

The range of facilities provided and the accuracy of the S121 oscillator make it eminently suitable for innumerable applications. The availability of a stable high-level output, for example, makes it an ideal instrument for use as a bridge source (e.g. for use with the Wayne Kerr B221).

The oscillator can also be used as the source in a transmission measuring set; Wayne Kerr Transformer Type T121 and A.F Voltmeter Type M121 are available to complete the set.

The transformer (shown in figure 3) provides a balanced 600Ω or 150Ω output from an unbalanced 600Ω input. By connecting a 300Ω or 75Ω resistor between the centre-tap and appropriate output terminal, a 300Ω or 75Ω unbalanced output is also available, developed across the centre-tap and appropriate 'unconnected' terminal. Note that the balanced outputs are not 'floating', but are 'centre-tapped' to earth.

When using the transmission measuring set equipment, it is advisable, if possible, to set the output level of the oscillator and make the measuring adjustments by means of the 'Range' control on the A.F. Voltmeter Type M121.

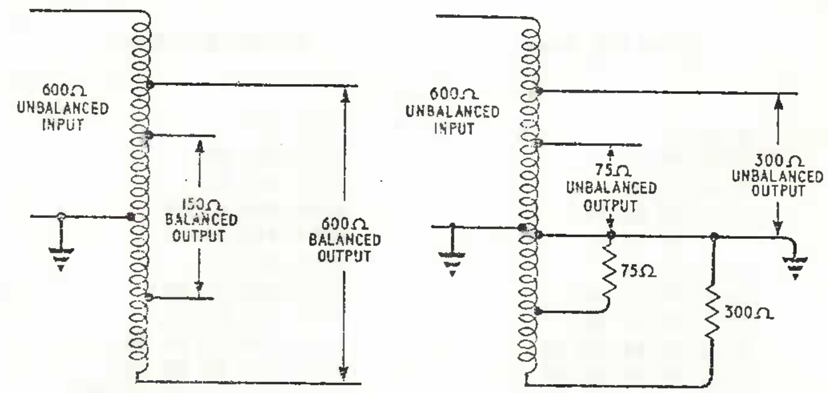


Fig. 3 Transformer T121

TECHNICAL DESCRIPTION

GENERAL

The oscillator circuits are constructed on an aluminium alloy chassis, on the reverse of which is fitted the front panel mask. The chassis is secured vertically in a mild steel case, the rear of the case being fitted with a panel which can be readily removed to reveal the major components. The power supply circuits are screened from the oscillator circuits. Figure 8 illustrates the location of the major components.

The frequency band selector knob operates through a bevel gear to drive the associated rotary wafer switch (S2), the drums carrying the scale 'limit' figures being mounted on the same spindle as the switch. The frequency band multiplier knob operates the switch S1 direct, a rack and pinion device being fitted to the shaft of the switch to operate the scale 'limit' figure shutter mechanism. A similar rack and pinion device is fitted to the variable frequency control (RV1) to operate the frequency scale marker.

The operation of a Wien Bridge circuit, which forms the basis of S121, is described briefly in the section headed 'Operating Principles'. Figure 4 shows the circuit arrangement of the S121 in a simplified form, the complete circuit diagram being given in figure 9 at the end of this book.

FREQUENCY DETERMINING COMPONENTS

Frequency-ranges

The basic frequency band steps are provided by the selection of resistors R1 to R4 and R5 to R8, adjustment of frequency within each step being provided by the ganged variable controls RV1a and RV1b. Selection of the appropriate 'band' resistors is made by the rotary wafer switch S2, S2a selecting from resistors R1 to R4 (series r.c. bridge-arm) and S2b selecting from R5 to R8 (parallel r.c. bridge-arm). The resistors selected, and the effective resistance of the series r.c. and parallel r.c. bridge-arms (including the parallel-connected fixed and variable components R9, RV1a and R10, RV1b) are given in table 3.

TABLE 3

Effective Resistance Values in R.C. Bridge Arms

Range	Resistors Selected: Series R.C. Arm	Resistors Selected: Parallel R.C. Arm	Resistive Values of each R.C. Arm (Ω)
10–20	RV1a, R9	RV1b, R10	102·5k–47·5k
20–30	RV1a, R9, R4	RV1b, R10, R8	50·6k–32·2k
30–40	RV1a, R9, R3	RV1b, R10, R7	33·6k–24·4k
40–50	RV1a, R9, R3, R4	RV1b, R10, R7, R8	25·9k–19·5k
50–60	RV1a, R9, R2, R3	RV1b, R10, R6, R7	20·1k–16·4k
60–70	RV1a, R9, R1	RV1b, R10, R5	16·4k–14·1k
70–80	RV1a, R9, R1, R4	RV1b, R10, R5, R8	14·3k–12·3k
80–90	RV1a, R9, R1, R3	RV1b, R10, R5, R7	12·5k–10·9k
90–100	RV1a, R9, R1, R3, R4	RV1b, R10, R5, R7, R8	11·1k–9·9k
100–110	RV1a, R9, R1, R2, R3	RV1b, R10, R5, R6, R7	10·0k–9·0k
110–120	RV1a, R9, R1, R2, R3, R4	RV1b, R10, R5, R6, R7, R8	9·1k–8·3k

The resistors used in the bridge are of high stability to ensure accuracy and reliability of the frequency calibration.

Frequency multiplying

The frequency multiplying factors of 1, 10, 100 and 1000 are obtained by the selection from capacitors C1 to C6 and C7 to C12, in the series and parallel r.c. arms of the bridge respectively. Selection is made by the rotary switch S1, of which S1a selects the capacitors in the series r.c. arm, and S1b the capacitors in the parallel r.c. arm. The capacitors employed for each factor are detailed in table 4.

Capacitors C4, C5, C6, C10, C11 and C12 are each formed by two components connected in parallel, one having a fixed value, and the other being selected during test to provide the desired total capacitance. C3, C9 and C1, C7 are trimmer capacitors for the x100 and x1000 factors respectively.

TABLE 4

Multiplying Factor Capacitors

Factor	Series R.C. Bridge Arm	Parallel R.C. Bridge Arm
X1	C6	C12
X10	C5	C11
X100	C3, C4	C9, C10
X1000	C1, C2	C7, C8

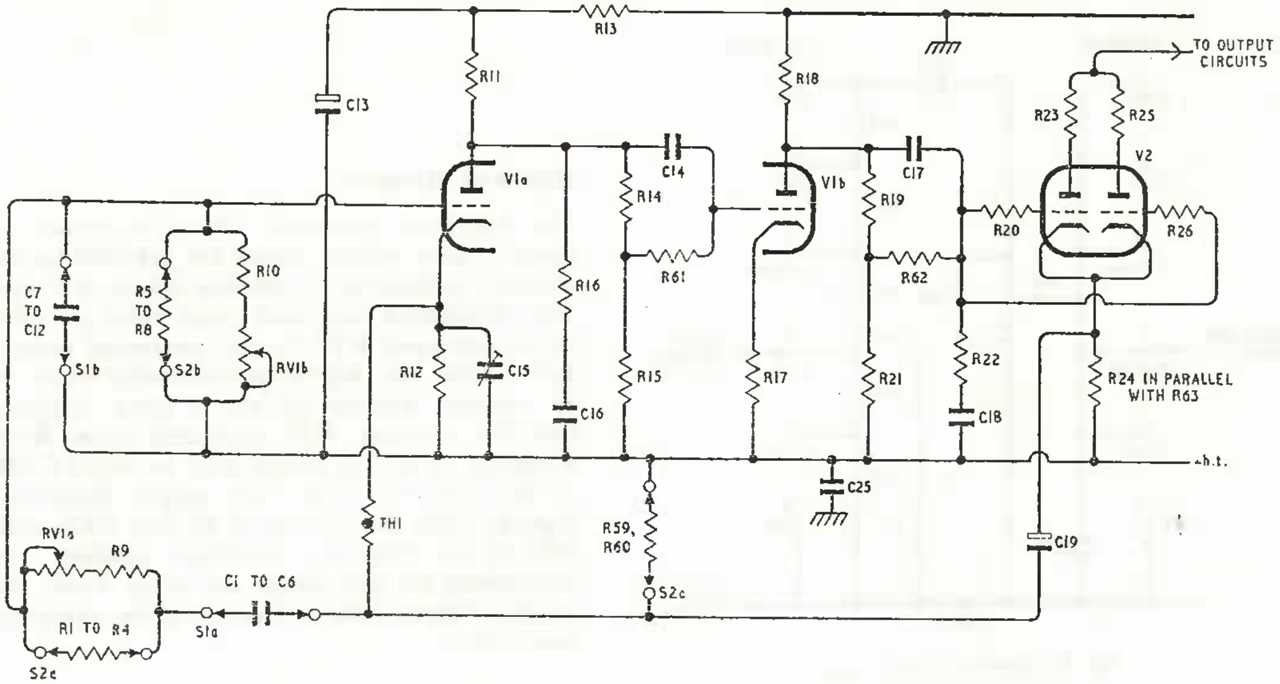


Fig. 4 Oscillator Circuit — Simplified

OSCILLATOR / AMPLIFIER

The oscillator/amplifier circuit utilizes two double triode valves V1 and V2. V1a and V1b form a high gain amplifier, while V2 operates as a cathode follower in the amplifier circuit and as a high-impedance constant-current output stage.

The cathode output of V2, developed across R24, is applied via C19 to thermistor TH1 and resistor R2 to develop the negative feedback voltage, and to the series and parallel r.c. bridge arms to develop the positive feedback voltage. Negative feedback is applied to the cathode of V1a, and positive feedback to the grid of V1a. The feedback voltage applied from V2 is maintained at a constant level irrespective of frequency by the operation of the thermistor TH1, and by the suitable selection of load compensating resistors R59 and R60. The thermistor is mounted on the outer face of the front panel, to prevent its characteristic being affected by temperature rise within the case.

The amount of feedback required to sustain oscillations in the Wien bridge circuit is about 9.5 dB only; all the excess gain of the amplifier V1a and V1b provides negative feedback at the cathode of V1a to stabilize the output level, and to reduce distortion in the generated waveform. Undesired phase shifts near and above 100kc/s, caused by stray capacitance, are minimized by C15 connected across R12.

The anode output of V1a is coupled to the grid of V1b via R14, R15, C14 and R61, and the anode output of V1b is coupled to the grids of V2 via C17, R19, R21 and R62. These coupling networks together with components R16, C16 and R22, C18 are provided to ensure an adequate stability margin at the upper and lower frequencies.

OUTPUT CIRCUITS

The oscillator output, developed across the resistive anode load of V2, is applied via switch S4 (wafer b) to either the high-level attenuator circuit or the 600-ohm attenuator circuit. V2 acts as a constant current generator since the voltage across the cathode resistor is maintained at a constant level.

In position 6 of S4, the anode of V2 and the output terminal are connected directly to the chassis (earth). The output is thus switched off although the power supply is not interrupted and the oscillator continues to operate.

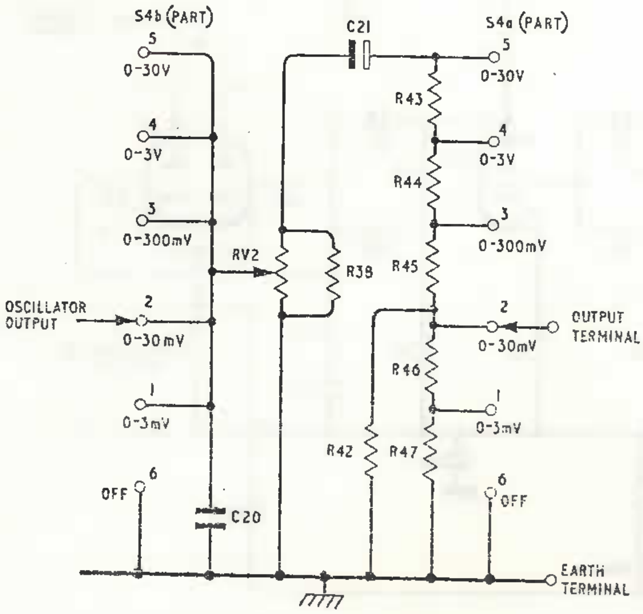
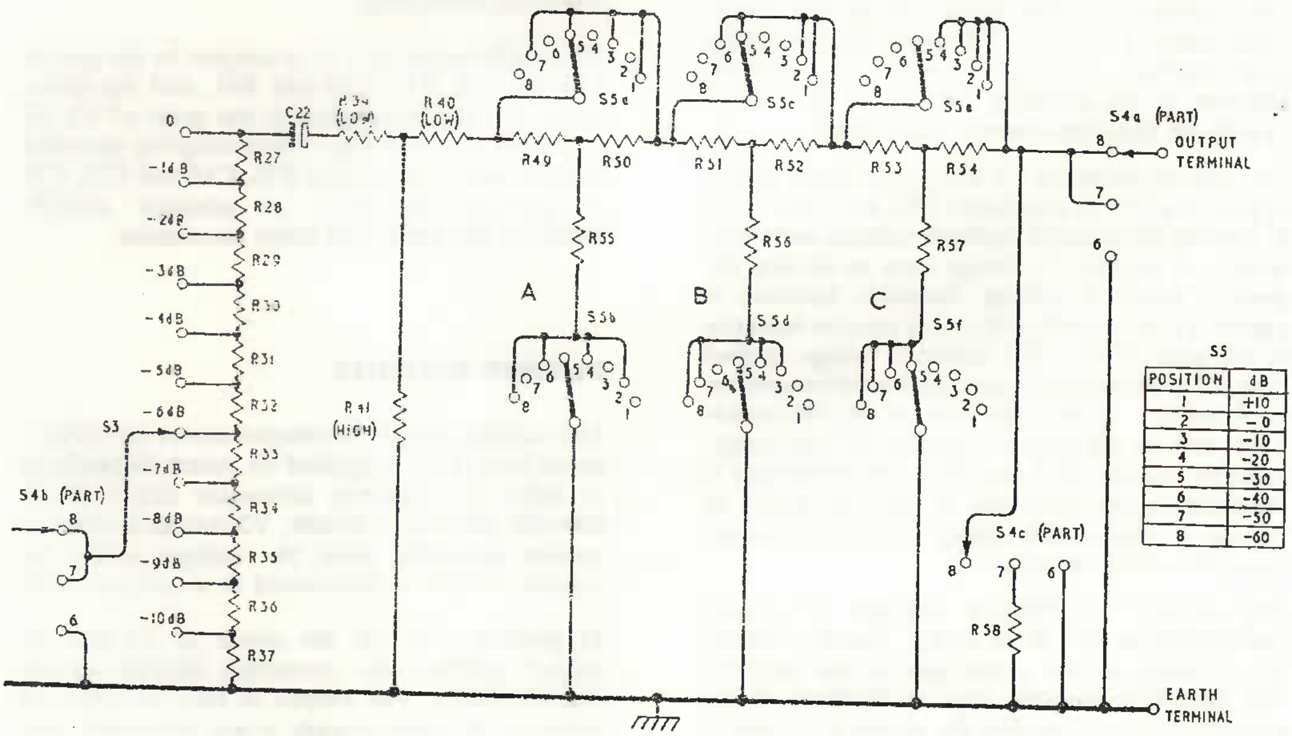


Fig. 5 High-level Attenuator

High-level Attenuator

The high-level attenuator circuit is shown in figure 5. Five voltage ranges are provided by the switched potentiometer network R43 to R47 and R42, adjustment over each range being provided by potentiometer RV2. Parallel connected resistor R42 enables the desired potentiometer ratio to be obtained without the use of close tolerance low-value resistors. R38, connected across RV2, is selected to set the output level to within 0·5dB of the calibrated scale. The output impedance depends upon the settings of S4 and RV2; with RV2 at its maximum clockwise position, the impedances for each range are given under the heading Output Selector Control in the operating instructions.



S5

POSITION	dB
1	+10
2	− 0
3	−10
4	−20
5	−30
6	−40
7	−50
8	−60

Fig. 6 600Ω Attenuator

TABLE 5

600Ω Attenuators

Range	Switch Position	Attenuators Selected (Fig. 5)	Total Attenuation of Networks
+10dB	1	None	0
0	2	A	10dB
—10dB	3	B	20dB
—20dB	4	A, B	30dB
—30dB	5	C	40dB
—40dB	6	A, C	50dB
—50dB	7	B, C	60dB
—60dB	8	A, B, C	70dB

600Ω Attenuators

The step attenuators are shown in figure 6. The oscillator output is connected via S4b to the 0 to −10dB potentiometer chain R27 to R37, and is then routed to the OUTPUT terminal via a combination of T-attenuators and S4a. All the resistors utilized have a high stability and a tolerance of ±0·5%.

The absolute level of the output is set to within 0·5dB by T-attenuator R39, R40 and R41. The characteristic impedance of all the T-attenuators is 600Ω; network A has an attenuation of 10dB, network B an attenuation of 20dB and network C an attenuation of 40dB. The A, B and C attenuator networks are selected by operation of switch S5 to provide a range of −60dB to +10dB in 10dB steps, as detailed in table 5.

The attenuator earth leads are arranged to reduce earth currents to a minimum. Care has also been taken to reduce currents between the EARTH terminal and the power supply lead, an important precaution where the oscillator is to be used as a source for bridge measurements or attenuator testing.

A 600Ω resistor, R58, is connected across the output when S4 is set to position 7 (600Ω TERM).

POWER SUPPLY

The a.c. power supply input is connected to the primary of T1 via the on/off switch S6, fuse FS1 and the voltage tap selector switch S7 (fig. 7). S7, located on the front panel, is a preset control enabling transformer taps to be selected to suit

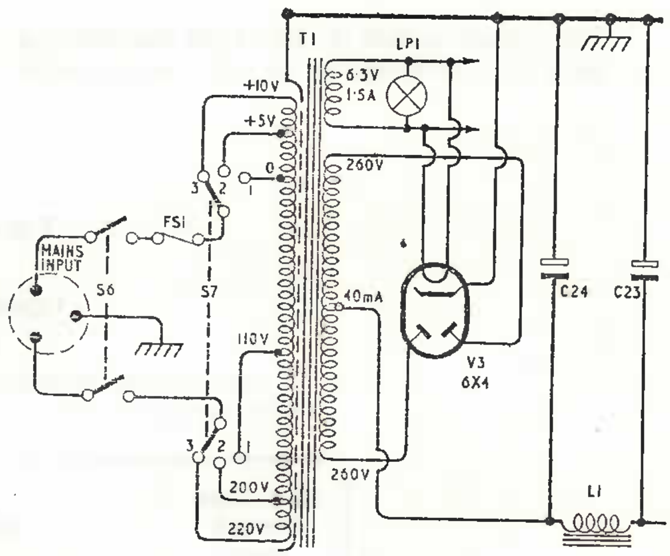


Fig. 7 Power Supply

input supplies between 100V and 115V, 190V and 220V or 220V and 250V.

The 260-0-260V secondary output of T1 is full-wave rectified by double diode V3, and smoothed by capacitive input filter C24, L1 and C23 to provide the h.t. supply. V3 cathode is connected to chassis, hence the 'positive' h.t. line is at earth potential, the negative h.t. line being at approximately −290V with respect to earth.

The heaters of valves V1, V2 and V3 are supplied from the 6·3V 1·5A secondary, which also supplies the pilot lamp LP1, used for lighting the scale of the voltage selector panel.

MAINTENANCE

PERFORMANCE TEST

The performance of the S121 can be checked by any of the standard methods for measuring frequency and a.f. voltages. A recommended series of tests, together with notes on any adjustments which may be necessary, are given in the 'Re-alignment and re-adjustment procedures'.

VOLTAGES

The voltages quoted in table 6 are intended as a guide only; deviations up to ±20% can be caused by variations of component values within their tolerances. The measurements were obtained with an AVOmeter Model 8, with the oscillator operating under the following conditions:

a Output selector control set to the 600Ω TERM position

b All attenuators set to their zero positions

c Frequency set to 1000 c/s

d Power supply input maintained at its nominal value.

TABLE 6

Typical Voltages

All measurements are taken with the negative lead connected to the negative h.t. line.

AVOmeter Model 8 Range	Test Points			Reading
100V d.c.	V1a	Anode	pin 1	91V
2·5V d.c.		Cathode	pin 3	1V
250V d.c.	V1b	Anode	pin 6	166V
25V d.c.		Cathode	pin 8	11V
100V d.c.		Grid	pin 7	9V
1000V d.c.	V2	Anode	junction R23/24	270V
100V d.c.		Cathode	pin 3 or pin 8	75V
250V d.c.		Grid	junction R20/R62	50V
1000V d.c.	V3	Cathode	chassis	290V
250V d.c.		Junction R11/R13		240V

H.T. Current	33mA
Power Consumption	25VA

RE-ALIGNMENT AND RE-ADJUSTMENT PROCEDURES

General

Re-adjustment and re-alignment should not be contemplated unless it is proved to be absolutely necessary, and the procedure should be adopted only by skilled technicians. Given with the procedures are details enabling the performance of the oscillator to be checked. The equipment required is:

a Frequency standard, 10c/s to 100kc/s, 0·1% accuracy.

b Oscilloscope (e.g. Cossor Type 1035).

c Valve Voltmeter, 1% accuracy (e.g. Wayne Kerr M121).

d Waveform Analyser (e.g. Wayne Kerr A321).

e Distortion factor meter, to cover from 16c/s to 64c/s.

f Universal Bridge (e.g. Wayne Kerr B221) or Wheatstone Bridge, 0·1% accuracy.

g AVOmeter Model 8.

Fine Frequency Control (RV1a and RV1b)

Before checking the accuracy of the frequency output, it is advisable to check the setting of the fine frequency control, which is formed by ganged potentiometers RV1a and RV1b. If the control has been replaced, care should be taken to ensure that in its fully counter-clockwise position, the red pointer on the frequency scale aligns with the extreme left hand marker. Then:

a Set the frequency band selector controls to give the 10c/s to 20c/s band, and adjust the fine frequency control to align the scale pointer to the 10c/s marker. Using a Bridge instrument, check that the the combined series resistance of R9 and RV1a is 100kΩ ±0·3%. Re-alignment of RV1 relative to the scale pointer may be necessary to achieve this result. Check that the combined series resistance of R10 and RV1b is 100kΩ ±0·5%. Ensure that the potentiometer spindle is locked with grub-screws.

b Adjust the fine frequency control to align the scale pointer to the 20c/s marker, and check that the combined series resistance of R9 and RV1a and of R10 and RV1b is 50kΩ ±1%.

Frequency and Level Alignment

General: Set the power supply to within 5% of 230V or 110V, and set the input tap selector switch (located on the front panel) to the appropriate corresponding position.
Switch on the S121 and, using an oscilloscope, ensure that a pure sine-wave output is obtained at all frequencies, on both '600 ohm terminated' and '30 volt' outputs.
Set the output selector control to the 600Ω TERM position.

10c/s to 120c/s range: Using a frequency standard and an oscilloscope, ensure that each decade step in the range 10c/s to 120c/s is accurate to within 1% or ±0.5c/s. Check, with a valve voltmeter, that the output stays constant to within ±1% over the entire range.

100c/s to 1·2kc/s range: Check that the frequency at each step in the 100c/s to 1·2kc/s range is within 1%. If necessary C5 and C11 may be increased in value by the addition of parallel capacitors, to adjust the frequency to within the required limits. Check that the output voltage over the range is within 1% of the level measured over the 10c/s to 120c/s range.

10kc/s to 120kc/s range: Set the frequency band selectors to give the 10kc/s to 20kc/s band, and adjust the fine frequency control to align the scale pointer with the 10kc/s marker. Check that the output is within ±1% of 10kc/s, adjusting trimmers C1 and C7 if necessary. By increasing the adjusted setting of one trimmer and reducing the adjusted setting of the other, obtain an output level within 1% of that obtained on the first two ranges. Lock the trimmers with solder, and re-check the frequency accuracy at 10kc/s.
Adjust the fine frequency control and the band selectors to give a scale indication of 100·5kc/s in the 10kc/s to 120kc/s range. Check that the output frequency is within ±0·1% of 100kc/s, adjusting C15 if necessary. Check that the frequency at each step in the range 10kc/s to 120kc/s is accurate to within ±1%.

1kc/s to 12kc/s range: Set the frequency band selectors to give the 1kc/s to 2kc/s band, and adjust the fine frequency control to align the scale pointer with the 1kc/s marker. Check that the frequency is within 1% of 1kc/s, adjusting C3 and C9 if necessary. By increasing the adjusted setting of one trimmer and reducing the adjusted setting or the other, obtain an output level within 1% of that obtained on the previous ranges. Lock the trimmers with solder, and check that the frequency at each step in the range 1kc/s to 12kc/s is within ±1%.

Scale Accuracy: Select the 1kc/s to 2kc/s band, and adjust the fine frequency control to the 1·1kc/s, 1·2kc/s, 1·3kc/s, 1·4kc/s, 1·5kc/s, 1·6kc/s, 1·7kc/s, 1·8kc/s, 1·9kc/s and 2·0kc/s markers, checking that the output frequency is within ±1% of the indicated value.

Setting-up Output Level

Connect a valve voltmeter to the output terminals and set the output selector control to the 600Ω TERM position. Check that the output level at 50c/s, 500c/s, 5kc/s and 50kc/s is constant to within ±1%.

Set the attenuators to give +10dB and the frequency controls to give a frequency of 1kc/s. The output voltage must be between 2·33V and 2·57V; R39, R40 and R41 can be adjusted as indicated in table 7 to set the output between the required limits, if necessary. (Note that the characteristic impedance of the T-attenuator formed by R39, R40 and R41 is 600Ω).

Set the output selector control to the 30V position, and check that the output level is constant to within ±3% over the frequency range 10c/s to 20kc/s. Check that rotation of the output selector control to the 3V, 300mV, 30mV and 3mV positions produces accurate reductions in the output level by a factors of ten (±1%).

Select 1kc/s by means of the frequency controls, set the output selector control to the 3V position, and the voltage level control to 30. Check that the output level lies between 3V and 3.15V, adjusting the value of R38 if necessary. (Suitable values of R38 are 39k, 47k, 56k, 68k, 82k and 100k).

Distortion

Set the output selector control to the 600Ω TERM position, connect a waveform analyser to the output and check that the amplitudes of the second and third harmonics do not exceed the figures quoted in table 8.

TABLE 7

Values of R39, R40 and R41

Output	Select R39 and R40	Select R41
2·57V	16Ω	10kΩ
2·7V	33Ω	5·6kΩ
2·9V	51Ω	3·6kΩ
3·1V	68Ω	2·7kΩ
3·3V	82Ω	2·0kΩ
3·5V	100Ω	1·5kΩ
3·7V	120Ω	1·2kΩ
3·9V	130Ω	1·1kΩ

TABLE 8

Second and Third Harmonic Levels

Frequency	Second Harmonic	Third Harmonic
100c/s	52 dB down	50 dB down
200c/s	52 dB down	53 dB down
500c/s	52 dB down	60 dB down
1kc/s	52 dB down	63 dB down
5kc/s	54 dB down	64 dB down
10kc/s	54 dB down	—

Set the output selector and voltage level controls to give 3V output, and set the frequency to 1kc/s. Check that with the waveform analyser switched to '600Ω unterminated' the second harmonic does not exceed −48dB.

Using a distortion factor meter, check that the distortion at 16c/s does not exceed −34dB; at 32c/s, −40dB; and at 64c/s, −45dB.

Frequency Stability

Connect an oscilloscope to the output terminals, and set the oscillator to give an output of 30V at 101kc/s (100kc/s to 110kc/s band). Using the frequency standard, check that when the voltage selector switch is changed to the 3V output, the change in frequency is less than 505c/s.

Set the output selector control to the 600Ω TERM position, the attenuators to give +10dB, and the frequency controls to give 101kc/s. Check that when the output selector is re-set to the 600Ω UNTERM position, the frequency change is less than 303c/s.

Residual Hum

Disconnect the lead connected to the wiper of switch wafer S1a and short the grid of V1a to the negative h.t. line. Connect the valve voltmeter and oscilloscope to the output terminals, and set the oscillator frequency to 1kc/s. Observe on the oscilloscope that the output consists mainly of 100c/s sine-wave, and check that the output level does not exceed 6mV on the 600Ω terminated output and 20mV on the 30V output.

Attenuators

Unless a reliable standard attenuator is available, it is better to check that each resistor in the various T-attenuator networks is within ±0·5% of its nominal value.

Valve Replacement

Replacing V1, V2 or V3 should effect no change in the performance of the S121.

Thermistor Replacement

When the thermistor TH1 is replaced it will generally be necessary to reset the output level by changing the values of R38, R39, R40, and R41. Notes regarding the selection of these resistors are given in this section of the book.

REMOVAL AND REPLACEMENT PROCEDURES

In order to perform either electrical or mechanical servicing it may be necessary to remove certain parts of the oscillator. The procedures to be adopted are given in the following paragraphs.

Potentiometers RV1a and RV1b

Removal. To remove the fine frequency control potentiometers from the unit:

a Remove the three medium size knobs from the frequency controls, and remove the unit from the case by releasing the four screws at the corners of the front panel. Place the unit face down, and disconnect at the main tag board the four leads from the power unit and the single lead from switch S4b (to R23 and R25).

b Slacken the two nuts securing the end bracket at the left of the unit, and remove the four bolts which fix the cast unit to the panel. The end bracket can then be pushed to one side to allow the cast unit to be removed.

c Remove the connexions to the potentiometer by unscrewing the nuts anchoring the terminating tags.

d Displace the 'Groverlock' pin positioned on the potentiometer side of the flexible coupler, slacken the grub-screws, and unscrew the four retaining screws. The potentiometer can now be removed.

Replacement. The procedure to be adopted for the replacement of a potentiometer is the reverse of that detailed for removal. It will be necessary to drill a 1/16 in. diameter hole in the potentiometer shaft to repin the flexible couplers. To ensure that this hole is drilled on the correct centres:

a Fit the potentiometer securely in position by means of the four retaining bolts.

b Adjust the pointer of the front panel scale so that it is aligned with the extreme right-hand marker when the potentiometer is set to its maximum clockwise position.

c Tighten the grub-screws on the coupler, which is then rotated until the hole in the coupler is in a convenient position to use as a location for the 1/16 in. drill.

d Drill the hole and fit a 1/16 in. diameter x3/8 in. pin.

The cast unit can be re-fitted once the potentiometer has been pinned. Notes on the setting-up of a new potentiometer are given in the re-adjustment and re-alignment procedures, under the heading 'Fine Frequency Control'.

Glass Scale

Removal. First remove the cast unit, as detailed in sub-paragraphs a and b of the 'Potentiometers RV1a and RV1b' removal procedure. Then slacken the bolts retaining the brackets at each end and top centre of the scale, and remove the scale.

Replacement. When re-fitting a glass scale, ensure that the scale apertures coincide with the drum engraving before tightening the retaining bolts. Re-fit the cast unit and replace the unit in the case.

Pointer and Pinion Wheel

Removal. Remove the cast unit, as detailed in sub-paragraphs a and b of the 'Potentiometers RV1a and RV1b' removal procedure. Slacken the two bolts retaining the guide rack, slacken the two grub-screws in the drive pinion wheel, and remove the pinion wheel.

Replacement. Fit the new pointer, and re-fit the pinion wheel. Set the pointer to the extreme right-hand scale marker with the potentiometer in its maximum clockwise position, and tighten the grub-screws in the pinion wheel. Check the travel of the pointer over scale length.

Front Panel Mask

Removal. To remove the front panel mask:

a Remove all knobs fitted to the front panel controls.

b Disconnect the leads to the rear of the output terminals, and remove the output terminals.

c Remove the cover retaining pillars (where fitted).

d Disconnect the leads to the thermistor, and remove the thermistor housing.

e If fitted, remove retaining ring on the power supply input socket, and drop the socket back.

f Remove the retaining nut on the power supply on/off switch and drop the switch back.

g Disconnect the leads to the fuse holder, and remove the holder.

h Unscrew the bolt situated at each corner of the panel mask, and remove the mask.

Replacement. The procedure to be adopted when re-fitting the front panel mask is the reverse of that detailed for its removal.

Power Supply Chassis

Removal. First remove the front panel mask (detailed in the previous paragraphs), then:

a Disconnect the four leads from the cast unit to the main tag panel.

b Remove the retaining bolts and release the power supply chassis.

Replacement. To re-fit the chassis, reverse the procedure adopted for its removal.

Switches S1a and S1b

Removal. First remove the cast unit, as detailed in sub-paragraphs a and b under the heading 'Potentiometers RV1a and RV1b', then:

a Disconnect the leads from the tag panels.

b Remove the pinion wheel.

c Slacken the switch fixing nut, and remove the switch.

Replacement. To re-fit the switch, reverse the procedure adopted for its removal.

Valve Chassis

Removal. First remove the cast unit as detailed in sub-paragraphs a and b under the heading 'Potentiometers RV1a and RV1b', then:

a Disconnect the leads from 'drum-switch' S2a and S2b.

b Disconnect the lead to the side bracket.

c Slacken the bolts through the brackets and board, and remove the valve chassis.

Replacement. To re-fit the chassis, reverse the procedure adopted for its removal.

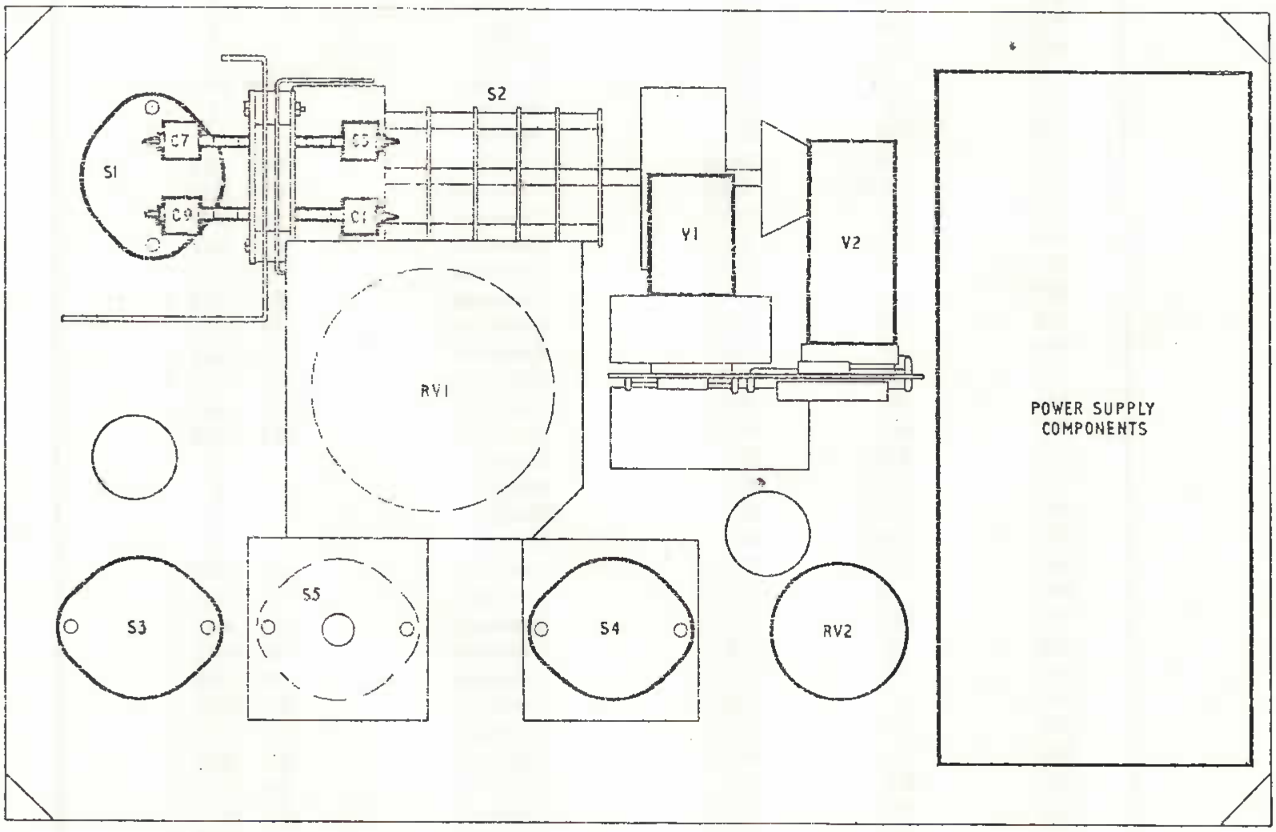


Fig. 8 Location of Major Components

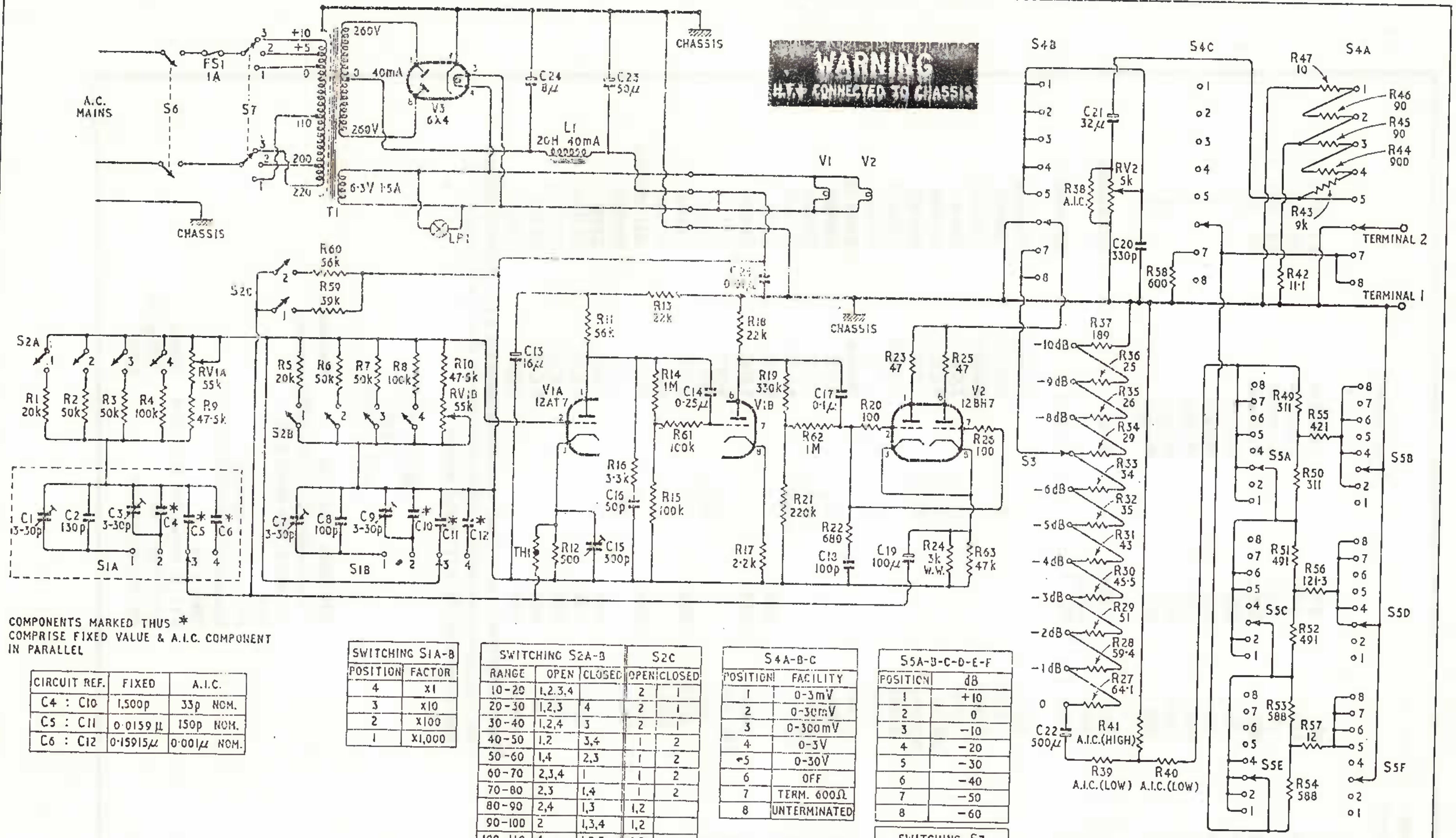
COMPONENT LIST

Circuit Reference	Description			
R1	20k	0·5%	Constanta	0·5 1012 1
R2	50k	0·5%	Constanta	0·5 1012 1
R3	50k	0·5%	Constanta	0·5 1012 1
R4	100k	0·5%	Constanta	0·5 1012 1
R5	20k	0·5%	Constanta	0·5 1012 1
R6	50k	0·5%	Constanta	0·5 1012 1
R7	50k	0·5%	Constanta	0·5 1012 1
R8	100k	0·5%	Constanta	0·5 1012 1
R9	47·5k	0·5%	Constanta	0·5 1012 1
R10	47·5k	0·5%	Constanta	0·5 1012 1
R11	56k	10%	Morgan	T
R12	500	1%	Erie	108
R13	22k	10%	Erie	RMA 8
R14	1M	10%	Morgan	T
R15	100k	10%	Morgan	T
R16	3·3k	10%	Morgan	T
R17	2·2k	10%	Morgan	T
R18	22k	10%	Erie	RMA 8
R19	330k	5%	Morgan	T
R20	100	20%	Morgan	T
R21	220k	5%	Morgan	T
R22	680	10%	Morgan	T
R23	47	20%	Morgan	T
R24	3k	5%	Welwyn	AW 3111
R25	47	20%	Morgan	T
R26	100	20%	Morgan	T
R27	64·1	0·5%	Constanta	0·5 1012 1
R28	59·4	0·5%	Constanta	0·5 1012 1
R29	51	0·5%	Constanta	0·5 1012 1
R30	43·5	0·5%	Constanta	0·5 1012 1
R31	43	0·5%	Constanta	0·5 1012 1
R32	35	0·5%	Constanta	0·5 1012 1
R33	34	0·5%	Constanta	0·5 1012 1
R34	29	0·5%	Constanta	0·5 1012 1
R35	26	0·5%	Constanta	0·5 1012 1
R36	25	0·5%	Constanta	0·5 1012 1
R37	139	0·5%	Constanta	0·5 1012 1
R38	A.I.C.	10%	Morgan	T
R39	A.I.C.	10%	Morgan	T
R40	A.I.C.	10%	Morgan	T
R41	A.I.C.	10%	Morgan	T
R42	11·1	0·5%	Constanta	0·5 1012 1
R43	9k	0·5%	Constanta	0·5 1012 1
R44	900	0·5%	Constanta	0·5 1012 1
R45	90	0·5%	Constanta	0·5 1012 1
R46	90	0·5%	Constanta	0·5 1012 1
R47	10	0·5%	Constanta	0·5 1012 1
R48	10	0·5%	Constanta	0·5 1012 1
R49	311	0·5%	Constanta	0·5 1012 1
R50	311	0·5%	Constanta	0·5 1012 1
R51	491	0·5%	Constanta	0·5 1012 1
R52	491	0·5%	Constanta	0·5 1012 1
R53	588	0·5%	Constanta	0·5 1012 1
R54	588	0·5%	Constanta	0·5 1012 1

Circuit Reference	Description				
R55	421	0·5%		Constanta	0·5 1012 1
R56	121·3	0·5%		Constanta	0·5 1012 1
R57	12	0·5%		Constanta	0·5 1012 1
R58	600	0·5%		Constanta	0·5 1012 1
R59	39k	10%		Morgan	T
R60	56k	10%		Morgan	T
R61	100k	10%		Morgan	T
R62	1M	10%		Morgan	T
R63	47k	10%		Morgan	T
RV1a	55k	M-10-62		Berco	1% Linearity
RV1b	55k	2 Gang			
RV2	6k	Tw		Reliance	5% Linearity
C1	3/30pF			Mullard	E7864–01
C2	130pF		5	T.C.C.	SMP401
C3	3/30pF			Mullard	E7864–01
*C4	1500pF		0+2%	T.C.C.	SMP401
*C5	0·0159μF		+0–1%	T.C.C.	SM1006
*C6	0·1591μF		+0–1%	T.C.C.	SM1007
C7	3/30pF			Mullard	E7864–01
C8	100pF		5%	T.C.C.	SMP401
C9	3/30pF			Mullard	E7864–01
*C10	1500μF		+2%	T.C.C.	SMP401
*C11	0·0159μF		+0–1%	T.C.C.	SM1006
*C12	0·1591μF		+0–1%	T.C.C.	SM1007
C13	16μF	350V		T.C.C.	CE19L
C14	0·25μF	350V		T.C.C.	CP48N
C15	50/300pF			Bulgin	CP3
C16	50pF		10%	Erie	N750K
C17	0·1μF	350V		T.C.C.	CP37N
C18	100pF		10%	Erie	N750K
C19	100μF	150V		Hunt	JEN 159 HNN
C20	330pF		20%	T.C.C.	SMP101
C21	32μF	150V		T.C.C.	CE19F
C22	500μF	25V		T.C.C.	CE25CE
C23	50μF	350V		T.C.C.	CE171LE
C24	8μF	450V		T.C.C.	CE19P
C25	0·01μF	350V		T.C.C.	CP32N

*These components have the fixed values shown above and A.I.C. (Adjust in Calibration) capacitors connected in parallel, which are: C4, C10 33pF nominal; C5, C11 150pF nominal and C6, C12 0·001μF nominal

Circuit Reference	Description	
V1	12AT7 or ECC81	
V2	12BH7	
V3	6X4 or EZ90	
L1	20H 40mA, Type C230	Gardeners
T1	Primary—10–5, 0, 110, 200, 220V Sec. 260–0–260V 40mA, 6·3V 1·5A Ministry Type 6000/57 Commercial Type 6005/57 Open Core	Parmeko
LP1	6·3V ·11 Amp Lamp Type OS76	Osram
FS1	Fuse 1 Amp L1055	Belling Lee
TH1	50k 10% A5412/100	S.T.C.



COMPONENTS MARKED THUS *
COMPRISE FIXED VALUE & A.I.C. COMPONENT
IN PARALLEL

CIRCUIT REF.	FIXED	A.I.C.
C4 : C10	1,500p	33p NOM.
C5 : C11	0·0159μ	150p NOM.
C6 : C12	0·15915μ	0·001μ NOM.

SWITCHING S1A-B	
POSITION	FACTOR
4	X1
3	X10
2	X100
1	X1,000

SWITCHING S2A-B			S2C	
RANGE	OPEN	CLOSED	OPEN	CLOSED
10-20	1,2,3,4		2	1
20-30	1,2,3	4	2	1
30-40	1,2,4	3	2	1
40-50	1,2	3,4	1	2
50-60	1,4	2,3	1	2
60-70	2,3,4	1	1	2
70-80	2,3	1,4	1	2
80-90	2,4	1,3	1,2	
90-100	2	1,3,4	1,2	
100-110	4	1,2,3	1,2	
110-120		1,2,3,4	1,2	

S4A-B-C	
POSITION	FACILITY
1	0-3mV
2	0-30mV
3	0-300mV
4	0-3V
5	0-30V
6	OFF
7	TERM. 600Ω
8	UNTERMINATED

S5A-B-C-D-E-F	
POSITION	dB
1	+10
2	0
3	-10
4	-20
5	-30
6	-40
7	-50
8	-60

SWITCHING S7		
POS.	V RANGE	T1 TAPS
1	100-110	0 & 110
2	190-220	+5 & 200
3	220-250	+10 & 220

AUDIO OSCILLATOR Type S121	The Wayne Kerr Laboratories Ltd.	DRG No. 3870/L

NOTE: RV2 is now 6kΩ.

Fig. 9 Circuit Diagram

WAYNE KERR

TELEPHONE: MALden 2202

TELEGRAPH: WAYNKERR, NEW MALDEN

SALES AND SERVICE

44 COOMBE ROAD, NEW MALDEN, SURREY

TELEPHONE: LOcust 8-6820

TELEGRAPH: WAYNKERR, PHILADELPHIA

WAYNE KERR CORPORATION

1633 RACE STREET, PHILADELPHIA 3, PENNSYLVANIA

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