Oscillator PTS/13

Introduction

The PTS/13 is a portable oscillator designed primarily for lines testing. The frequency range covered is from 40 c/s to 10 kc/s and the output level is adjustable to certain definite values required in lines work. These are 0 and + 4 db (for normal transmission measurements) and + 10, + 12, + 14 and + 20 db for special tests and overload measurements.

1. The oscillator section which includes valves V1 and V2.
2. The section including the components R1, C1, R4, C2; these represent the main frequency-determining elements.
3. The amplifier section consisting of the valve V3.
4. The final section including the output-impedance and output-level switching.

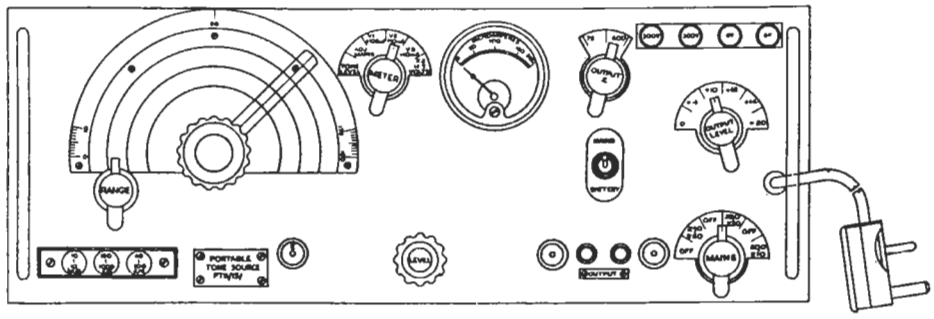


Fig. 9.7. Portable Tone Source PTS/13 : Face Panel

Two alternative output impedances, 75 ohms or 600 ohms, can be selected by means of a switch. The tone source can be operated from 50-c/s mains using a built-in mains unit or from external h.t. and l.t. batteries.

The oscillator is contained in a wooden box measuring approximately 16½ in. × 6 in. × 9 in. and fitted with a carrying handle. The weight is 25 lb.

A spare for each type of valve used in the oscillator is carried inside but no spare special resistance lamp is provided because if this fails the oscillator will require adjustment when the lamp is replaced.

General Description of the Circuit

Very briefly the PTS/13 consists of a two-valve RC oscillator with amplitude stabilisation by a negative* lamp, the output of the oscillator being amplified by a third valve. For the purpose of explanation the simplified circuit diagram shown in Fig. 9.8 can be conveniently divided into the following four sections which will be separately considered.

* Feedback circuit which includes a special resistance,

The Oscillator Section

The oscillator section consists of the two valves V1 and V2 which are conventionally RC-coupled; both are pentodes but V2 is strapped as a triode. Oscillation occurs due to positive feedback obtained by coupling the anode of V2 to the grid of V1 via one of the frequency-determining networks, e.g., R1, C1, R4, C2. Oscillation occurs at the frequency at which the network gives zero phase shift and at this frequency the network has a minimum loss of 10 db; hence the amplifier must give more than 10 db gain to maintain oscillation. The amplifier section is capable of giving about 70 db gain but this is reduced to the required value by negative feedback, obtained by coupling the anode of V2 to the cathode of V1 by the components C3, R17, the feedback voltage appearing across the lamp in the cathode circuit of V1. This lamp carries the steady cathode current of V1, about 1 mA, which provides grid bias; it also carries about 5 mA a.c. when the amplifier is oscillating normally, and provides about 60 db negative feedback making the amplifier output-input characteristic practically straight and reducing waveform distortion to a low level.

The lamp filament has a large thermal coefficient of resistance and if, for any reason (for example an increase in h.t. voltage), the output of V2 tends to increase, the current in the lamp also tends to increase; the resulting increase in lamp resistance causes an increase in the negative feedback voltage and a decrease in amplifier gain. In this way the lamp tends to maintain the output of V2 at a constant level irrespective of the frequency generated; it also keeps the output independent of changes in supply voltages and of changes in valves. The component values are so chosen that the signal level maintained at the anode of V2 is within the power-handling capacity of V2.

Limitation of output is an important feature in an oscillator required to give an undistorted waveform; without this circuit or some other form of external amplitude limitation, the oscillations would build up until the valves overloaded and introduced harmonic distortion, i.e., amplitude would be limited by non-linearity of the valve characteristics.

The Frequency-determining Network

The frequency-determining network is fundamentally an L-type, the series arm consisting of resistance and capacitance in series, and the shunt arm of resistance and capacitance in parallel (Fig. 18). Zero phase-shift occurs at the frequency for which

$$f = \frac{1}{2\pi\sqrt{(R_s C_s R_p C_p)}}.$$

In the PTS/13, $R_s = R_p$ and $C_s = C_p$

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

where $R = R_s = R_p$ and $C = C_s = C_p$.
The frequency of oscillation is thus inversely proportional to R and C. Two similar variable capacitors ganged by an insulated coupling are used for C_s and C_p and, for a fixed value of R, the capacitors are trimmed to give a 10 : 1 change in frequency. The frequency range is further extended by changing the value of R and the circuit constants of the PTS/13 are chosen to give the following ranges:—

Range	*Frequency*	*Value of R*
A	1-10 kc/s	330 kΩ
B	100 c/s-1 kc/s	3·3 MΩ
C	40-100 c/s	4·7 MΩ

The restricted coverage on range C is obtained by putting fixed capacitors in parallel with C_s and C_p.

The operation of this oscillator circuit can also be explained by regarding the components R1, C1, R4, C2, R17 and the lamp as constituting a Wien bridge; this explanation is given in an article by Clifford.* (See also *Appendix* A, page A.1.)

The Amplifier Stage

The oscillations at the anode of V2 are applied to the grid of V3 via a potentiometer R18, the *level* control, and a series resistor R20 is included to isolate the output stage from the oscillator section. A large amount of negative voltage feedback is applied to V3 to enable it to deliver the maximum desired output (+ 20 db) with little distortion. The feedback is applied in two ways: by returning the cathode circuit to a tertiary winding on the output transformer T1 and by direct coupling by C9 and R23 between anode and grid circuits. This large amount of feedback causes V3 to have a very low effective anode a.c. resistance; the output load has therefore a very small effect on the a.c. potential at the anode and the output level measuring meter can be left in circuit irrespective of the output load.

Output Impedance and Output Level Switching

The secondary winding of T1 is in two sections which are connected in series in one position of the output impedance switch and give an output impedance at the secondary winding of about 180 ohms. This is raised to 600 ohms by the components R31, R32, and R33. The series capacitors C20 and C21 are included to minimise the high-frequency loss caused by leakage inductance in the output transformer. The 600-ohm output across R33 is connected to a 600-ohm balanced attenuator, the output of which is connected to the output terminals and output jack in parallel.

At the second position of the output-impedance switch the secondary windings are connected in parallel to give an output impedance of about 50 ohms. This is increased to 75 ohms by resistors R29 and R30, which are followed by a 75-ohm attenuator ganged with the 600-ohm attenuator and inserting the same loss as the 600-ohm attenuator at the same position of the output-level switch.

* F. G. Clifford "A Bridge-stabilised Resistance-capacitance Oscillator" *Electronic Engineering, June 1945, page 50*

Metering Facilities

The front panel of the oscillator carries a 200-μA meter, the resistance of which is built out to 1 kilohm by R34. By operating the six-position meter switch the meter can be used to give the following measurements :—

H.T. Volts

The meter is connected in series with R16 and across the h.t. supply. The reading should be multiplied by 2 to give the h.t. voltage.

Cathode Current V3

The meter is connected across R28 in the cathode circuit of V3. The reading should be divided by 10 to give the cathode current in milliamps.

Cathode Current V2

The meter is connected across R15 in the cathode circuit of V2. The reading should be divided by 10 to give the cathode current in milliamps.

Cathode Current V1

The meter is connected across R11 in the cathode circuit of V1. The reading should be divided by 10 to give the cathode current in milliamps.

Mains Voltage Adjustment

The meter is connected across the d.c. side of a bridge-type rectifier M2, the a.c. side of which is connected across the valve heater supply. The resistor R36 in series with the rectifier source input is so adjusted that the meter reads mid-scale when the tapping switch at the mains transformer primary is correctly set.

Tone Level

The meter is connected across the d.c. side of a bridge-type rectifier M1, the a.c. side of which is connected between the anode of V3 and earth. The resistor R25 in series with the a.c. side is so adjusted that the meter reads 175 when the oscillator is delivering the power indicated by the level switch.

Power Supply

When the mains-battery switch is set for mains operation, h.t. is obtained from a UU6 rectifier and smoothing circuit and l.t. from a winding on the mains transformer T2. There are a number of primary tappings on T2 and the correct one can be selected by a switch which has intermediate off positions between the various tappings ; these should be used for *on-off* switching.

When the mains-battery switch is set for battery operation, a supply of 20 milliamps at 300 volts is required at the h.t. terminals and 1·5 A at 6 volts at the l.t. terminals. The mains-battery switch should be used for *on-off* switching.

Operation

1. *On Mains.* Set *meter* switch to ADJ. MAINS and adjust mains switch to give the highest meter reading nearest to 100.
   On Batteries. Connect the batteries to the appropriate terminals and set the *mains-battery* switch to BATTERY.
2. Set the range switch to the desired frequency range and the frequency control to the desired frequency.
3. Set the meter switch to TONE LEVEL and adjust the *level* control until the meter reads 175. The meter switch can be left in this position.
4. Set the *output impedance* switch to the desired value.
5. Set the *output level* switch to the desired value.

Valve Data

Valve	*Type*	*Cathode Current*
V1	EF54	1·0 mA
V2	EF55	10·5 mA
V3	EF54	5·5 mA
V4	UU6	—

Total h.t. feed : 17 mA at 290 volts.

General Data

Output Impedance

With output switch set to 600 *ohms*, 600 ohms ± 10 ohms over the whole output-level attenuator range.

With output switch set to 75 *ohms*, 75 ohms ± 5 ohms over the whole output-level attenuator range.

Amplitude Characteristic

Within ± 0·25 db of the 1 kc/s value from 50 c/s to 10 kc/s.

Accuracy of Measured Output Level

Within ± 0·5 db of the level indicated by the meter and level switch from 50 c/s to 10 kc/s.

Meter Error due to Load

Negligible at all settings except + 20 where a maximum error of + 0·2 db occurs with a 100-ohm load.

Harmonic Distortion

(measured at zero level)

Frequency	600-*ohms output*	75-*ohms output*
50 c/s	< 2%	< 2%
100 c/s	< 1%	< 1%
1 kc/s	< 1%	< 1%

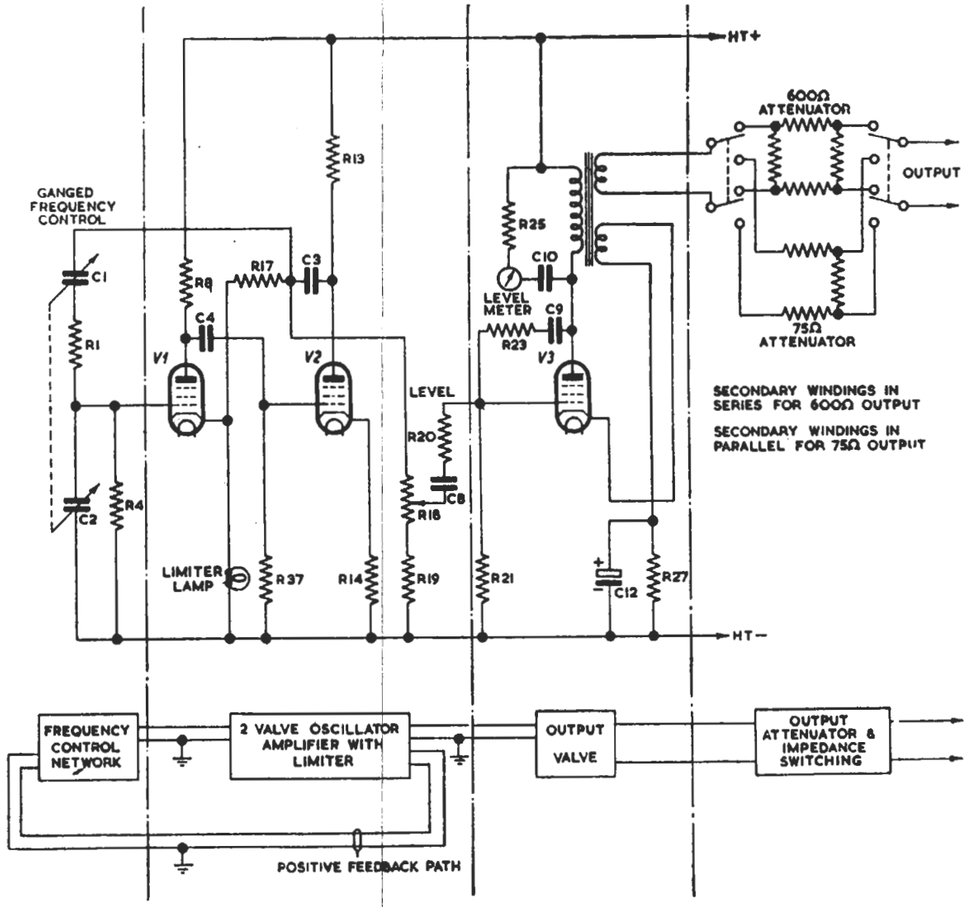
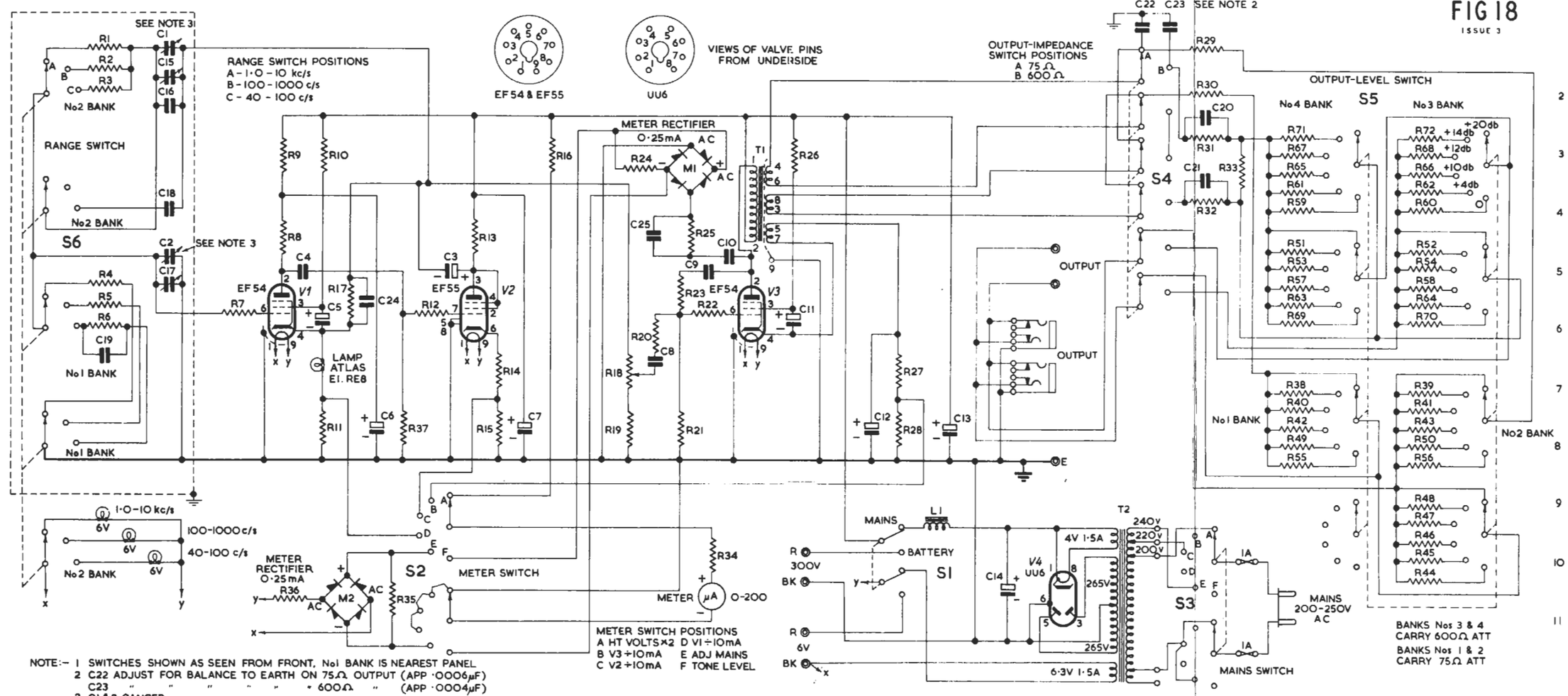


Fig. 9.8 Portable Oscillator PTS/13 : Simplified Circuit

S4

FIG 18
ISSUE 3



NOTE:- 1 SWITCHES SHOWN AS SEEN FROM FRONT, No1 BANK IS NEAREST PANEL
2 C22 ADJUST FOR BALANCE TO EARTH ON 75Ω OUTPUT (APP ·0006μF)
C23 " " " " " 600Ω " (APP ·0004μF)
3 C1 & 2 GANGED

COMP	LOCATION	VALUE	TYPE
C1	B1	MAX 533 μμF	PLESSEY TYPE E
C2	B5	" 533 "	" " "
C3	G5	16 μF	BEC 500V Wkg
C4	D5	0·5 "	TCC TYPE 345 350V
C5	E6	16 "	BEC 500V Wkg
C6	F8	16 "	" - " "
C7	H8	16 "	" " "
C8	K7	0·1 "	TCC TYPE 345 350V
C9	L5	0·1 "	" - M2N
C10	M5	0·1 "	" " 345 350V
C11	N6	16 "	BEC 500V Wkg
C12	O8	250 "	" 12V Wkg
C13	P8	16 "	" 500V Wkg
C14	Q10	8 "	TCC TYPE CE25P
C15	B2	2-25 μμF	PLESSEY TYPE A3
C16	B2	15 "	TCC TYPE SCT1
C17	B5	2-25 "	PLESSEY TYPE A3
C18	B4	0·00025 μF	TCC TYPE SCT3 ±2%
C19	A7	0·00025 μF	" " " "
C20	U2	·02 μF	UIC TYPE SM1007 ±1%
C21	T4	·02 μF	" " " "
C22	T1	500μμF	TCC TYPE M2N
C23	T1	500 "	" " "
C24	E6	10 "	TCC TYPE SCT1
C25	K4	10 pF	
L1	P9	20 H	BULGIN TYPE LF40

COMP	LOCATION	VALUE	TYPE
R1	A1	0·33MΩ	2W TYPE A3635 ±1%
R2	A1	3·3 "	" " " "
R3	A2	4·7 "	" " " "
R4	A5	0·33 "	" " " "
R5	A5	3·3 "	" " " "
R6	A6	4·7 "	" " " "
R7	C6	4700 Ω	½W ERIE TYPE 9 ±5%
R8	D5	0·1 MΩ	" " " " "
R9	D3	47000 Ω	" " " " "
R10	E3	1·0MΩ	" " " " "
R11	E8	10 Ω	½W ERIE TYPE 100 ±5%
R12	G6	4700 "	½W ERIE TYPE 9 ±5%
R13	G4	15000 "	2W ERIE TYPE 13 ±5%
R14	H7	330 "	½W " TYPE 100 ±2%
R15	H8	10 "	½W " " ±5%
R16	J3	2MΩ	½W ERIE TYPE 9 ±5%
R17	E6	2500 Ω APPROX	SELECTED ON TEST
R18	K7	0·1MΩ	L HAP 10410-24000
R19	K8	0·1 "	½W ERIE TYPE 9 ±5%
R20	K6	0·1 "	" " " "
R21	L8	0·1 "	" " " "
R22	L6	4700 Ω	" " " "
R23	L5	1·5MΩ	" " " "
R24	K3	2000 Ω	" " " "
R25	L4	480kΩ	½W TYPE A3622 ±1%
R26	N3	33000 Ω	½W ERIE TYPE 9 ±5%
R27	P7	220 Ω	½W ERIE TYPE 9 ±5%
R28	P8	10 "	½W ERIE TYPE 100 ±5%
R29	U1	16 "	" " " "
R30	U2	16 "	" " " "
R31	U3	257 "	½W TYPE A3622 ±2%
R32	U4	257 "	" " " "
R33	U3	3900 "	½W ERIE TYPE 108 ±2%
R34	M10	+METER RES=1000Ω	½W " " 8
R35	F11	600 "	½W " " 108 ±2%
R36	D11	20000Ω APPROX	SELECTED ON TEST
R37	F8	1·0MΩ	½W ERIE TYPE 108 ±1%
R38	V7	37 Ω	" " " "
R39	X7	37 "	" " " "
R40	V7	56 "	" " " "
R41	X7	56 "	" " " "
R42	V8	81 "	" " " "
R43	X8	81 "	" " " "
R44	X10	83 "	" " " "
R45	X10	89 "	" " " "
R46	X10	110 "	½W TYPE A3622 ±1%
R47	X9	125 "	" " " "
R48	X9	152 "	" " " "
R49	V8	200 "	" " " "
R50	X8	200 "	" " " "
R51	V5	224 "	" " " "
R52	X5	224 "	" " " "

COMP	LOCATION	VALUE	TYPE
R53	V5	317 Ω	½W TYPE A3622 ±1%
R54	X5	317 "	" " " "
R55	V8	337 "	" " " "
R56	X8	337 "	" " " "
R57	V5	427 "	" " " "
R58	X5	427 "	" " " "
R59	V4	733 "	" " " "
R60	X4	733 "	" " " "
R61	V4	826 "	" " " "
R62	X4	826 "	" " " "
R63	V6	923 "	" " " "
R64	X6	923 "	" " " "
R65	V3	1154 "	" " " "
R66	X3	1154 "	" " " "
R67	V3	1393 "	" " " "
R68	X3	1393 "	" " " "
R69	V6	1485 "	" " " "
R70	X6	1485 "	
R71	V3	1807 "	
R72	X3	1807 "	
T1	M3		AL/6/RA
T2	T10		M158

PORTABLE TONE SOURCE PTS/13 CIRCUIT