OSCILLATOR TS/9

Introduction

The TS/9 is a rack-mounted RC oscillator intended primarily for use in test rooms and control rooms. The frequency range extends from 40 c/s to 40 kc/s and is continuously covered in three ranges, but the third range is regarded as satisfactory only up to 20 kc/s. The output level can be adjusted between − 50 db and + 20 db by two variable attenuators, one operating in 10-db steps and the other in 1-db steps, and a continuously variable control with a range of 6 db which, in conjunction with an output meter calibrated in 0·1-db divisions, can be used to give accurate output settings. The output impedance is 600 ohms.

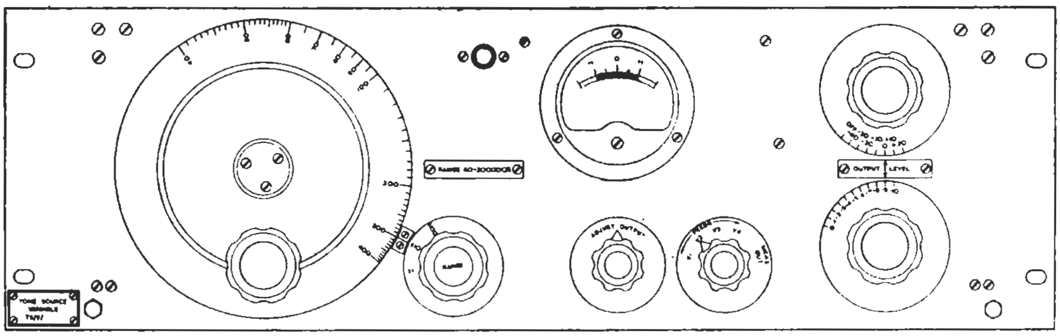


Fig. 8.3. Tone Source TS/9 : Face Panel

Mechanical Design

The oscillator is built on a 6¾-inch standard panel 22 inches wide which carries the *frequency* control, *range* control, *adjust output* control, *output level* attenuators, *feed-measuring* switch, output meter and indicator lamp. (Fig. 8.3). The valves and most of the components are mounted on a conventional horizontal chassis which extends for about two-thirds of the panel width, leaving a space at one end for the variable capacitor (frequency control), the range switch and other components in the frequency-determining network, all of which are totally enclosed in a rectangular screening box.

An external mains unit is required and the oscillator output, h.t. and l.t. connections are made via a tag strip behind the panel and at one end.

Electrical Design (Fig. 19)

The TS/9 consists of two parts, the oscillator-amplifier section V1, V2, and an amplifier section, V3, V4. The oscillator-amplifier section is designed on Wien-bridge principles, with amplitude limitation by a negative-feedback circuit, employing a special resistance lamp, connected in the cathode circuit of the first valve. This circuit operates in the same way as that of valves V1 and V2 in the PTS/13 and reference should be made to p. 9.15 for further details of the circuit.

The output of V2 is coupled by the variable gain-control to an amplifier section comprising valves V3 and V4. This section has considerable negative feedback to give good linearity and the output is connected to the two variable attenuators, one having 10-db and the other 1-db steps. (Fig. 8.4.)

Circuit Description

Oscillator-amplifier Section (*Fig.* 19)

This section consists of an EF50 (V1) conventionally RC-coupled to an EF55 (V2), both valves being connected as pentodes. These two valves are capable of considerably more than the 10-db voltage gain necessary to overcome the attenuation of the frequency-determining network and to maintain oscillation. The gain is, however, reduced to the required amount by the negative-feedback circuit connected between V2 anode and V1 cathode and consisting of R11 and the resistance lamp. The resistance of this lamp increases greatly with increase of the current through it ; in this way, the lamp limits the amplitude of oscillation built up by positive feedback before this limitation is imposed by the curvature of the oscillator valve characteristic. In addition to the voltage feedback V2 also has about 6-db current feedback due to the bias resistor R15 which is not decoupled. The large amount of total feedback gives this oscillator-amplifier section linearity of amplitude/frequency characteristic and output waveform, and minimises harmonic distortion of the signal generated at V2 anode.

quency sweep over each range. On each range, C is trimmed to give a 10 : 1 change in capacitance (and hence in frequency) and the values of R also decrease in 10 : 1 steps as the range switch is advanced towards the higher frequencies. By careful trimming of the variable capacitors and by use of close-tolerance resistors, a single scale on the tuning dial holds accurate for all three ranges. The range switch is calibrated as a multiplier and values of R for individual ranges are as below.

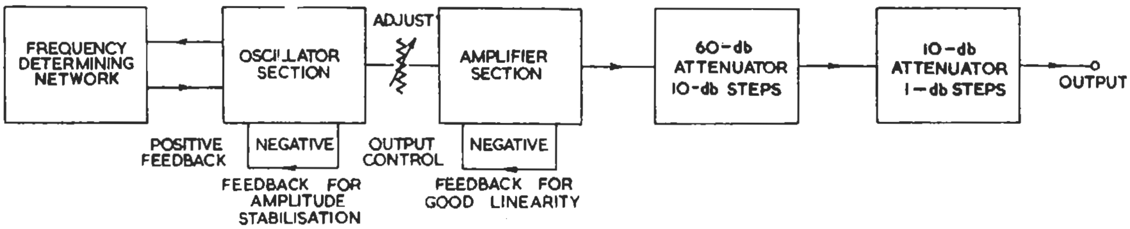


Fig 8.4. Tone Source TS/9 : Block Schematic

Frequency-determining Network

The basic form of the frequency-determining network is shown in Fig. 8.5. Each of the capacitors, C1, C2, consists of two 500-$\mu\mu$F variable capacitors ; i.e., C1 = C2 = 0·001μF max, and the whole four units are ganged to form the main frequency control.

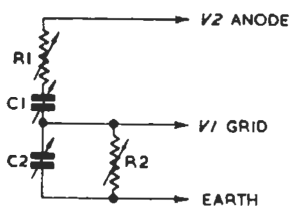


Fig. 8.5. Tone Source TS/9 : Basic form of Frequency-determining Network

The resistors, R1, R2, are used for frequency range control ; each has three different values, selected by the range switch, but for all positions of the switch, R1 = R2.

There are, therefore, two circuits, each having similar component values, and in the explanation that follows, C and R apply to both circuits.

The oscillation frequency f is that for which the network gives zero phase-shift between the anode of V2 and the grid of V1 ; it is given by

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

Frequency may thus be varied by altering the value of either C or R, or of both C and R. The circuit diagram, Fig. 19, shows that R is variable in three steps to give three frequency ranges, and that C is continuously variable to give the frequency sweep over each range.

Switch Setting	*Range*	*Value of R*
x1	40 c/s — 400 c/s	3·3 M Ω
x10	400 c/s — 4kc/s	330 k Ω
x100	4kc/s — 40 kc/s	33 k Ω

In the Wien-bridge circuit (Fig. 8.5) the frame of the variable capacitor must be connected to the grid of V1. Thus the frame must be insulated from chassis and the inevitable frame-chassis capacitance appears in parallel with C2, i.e., between grid and earth, upsetting the equality between C1 and C2. This difficulty could be overcome by trimming C1 but this might so reduce the ration of maximum to minimum capacitance that the 10 : 1 frequency ratio could not be obtained. To avoid this, the frame chassis capacitance is considerably reduced by use of an electrostatic screen, consisting of two 16 s.w.g. conductors in the shape of a V placed between the capacitor frame and the chassis and connected to the cathode of V1 which is, of course, at signal potential. *Note. The theory of this circuit is analysed on page* A.1.

Amplifier Section

The amplitude of the signal at the anode of V2 is of the order of 20 volts, too large to be applied directly to the grid of V3. It is therefore attenuated by the 47-kΩ resistor R18, the fixed 1-kΩ resistor R17 and the 1-kΩ continuously variable gain-control R16. These resistor values ensure that the signal fed to V3 is not too large and that the range of R16 is limited to approximately 6 db.

V3 is an EF50, used as a pentode, and has a high value of anode load (100 kΩ) to give high voltage gain. V3 is coupled by C16 and R21 to the output pentode V4, an EF55, the output of which is choke-capacitance coupled to the output transformer T1. Voltage feedback is applied over the amplifying section by means of the resistors R28 (100 kΩ) and R22 (1 kΩ), R22 also functioning as bias resistor for V3. To keep the value of the feedback voltage correct down to zero frequency, no capacitance is included in the feedback loop, and a small direct current therefore flows through the loop from the h.t. supply; the steady p.d. produced by this current in passing through R22 is used to bias V3. To make good certain losses at the high frequencies R22 is shunted by a 0·001μF capacitor C17 which reduces the effective value of β at high frequencies and maintains a level response over the wanted frequency range. Some current feedback is applied to V4 by the bias resistor R29 which is not decoupled.

The output of V4 is coupled to a bridge-type copper-oxide meter rectifier W1 via an RC network comprising C20, R32, C21, R33, C22 which is necessary to ensure accuracy in the meter readings at the higher frequencies.

Attenuator Section

The secondary winding of the transformer T1 is in two equal parts connected to provide a balanced source for the attenuator which follows it. The two halves of the winding are connected together via a parallel network R31, C23, the values of which are chosen to offset the high-frequency loss due to the leakage inductance of the transformer. This loss is not corrected by negative feedback because the transformer is not included within the feedback loop.

The two attenuators are of the bridged-H type, having a constant and balanced input and output impedance of 600 ohms. The first attenuator, A1, has 8 studs giving 0-60-db attenuation in 10-db steps and a position of infinite attenuation. The second attenuator, A2, has 11 studs giving 0-10-db attenuation in 1-db steps. Thus by use of both attenuators, the attenuation can be varied in 1-db steps over a range of 70 db.

Meter Facilities

The oscillator is fitted with a milliammeter which by operation of the meter switch, S2, can be used for measuring output level or h.t. feeds of any of the four valves. The meter scale is calibrated in 0·1-db intervals from − 1 db to + 1 db, with a mid-scale zero. The meter switch is normally left at the *measure output* position and the values of R32, R33, R34 are chosen so that when the *adjust output* control is set to give a mid-scale reading on the meter, the output of the oscillator is at zero level. A 250-μF capacitor C11 is connected across the meter to make the readings steady at low frequencies.

In position 1, *V1 feed*, the feed-measuring switch connects the meter across R10 in the h.t. feed to V1, and the value of R10 is chosen to give a mid-scale reading when the feed is normal. Similarly the feeds of the other valves are measured by operating S2 to connect the meter across other feed-measuring resistors, the values of which are chosen in each case to give mid-scale reading for a normal feed.

When the meter is reading d.c. feeds, R35 is connected across the rectifier; this is to keep the total anode resistance of the last valve constant, and thus prevent a high voltage occurring across the rectifier.

Valve Data

Valve	V1	V2	V3	V4
Type	EF50	EF55	EF50	EF55

Power Supplies Required

H.T. 300 v at 50 mA.
L.T. 6·3 at 2·6 A.

General Data

Output Impedance

Output Level	Output Impedance
+ 20 db	600 ± 60
+ 10 db	600 ± 18
zero	600 ± 6

Amplitude Characteristic Referred to 1,000 *c/s*

40 c/s to 10 kc/s, within ± 0·3 db.
10 kc/s to 20 kc/s, within ± 1·0 db.

Harmonic Distortion

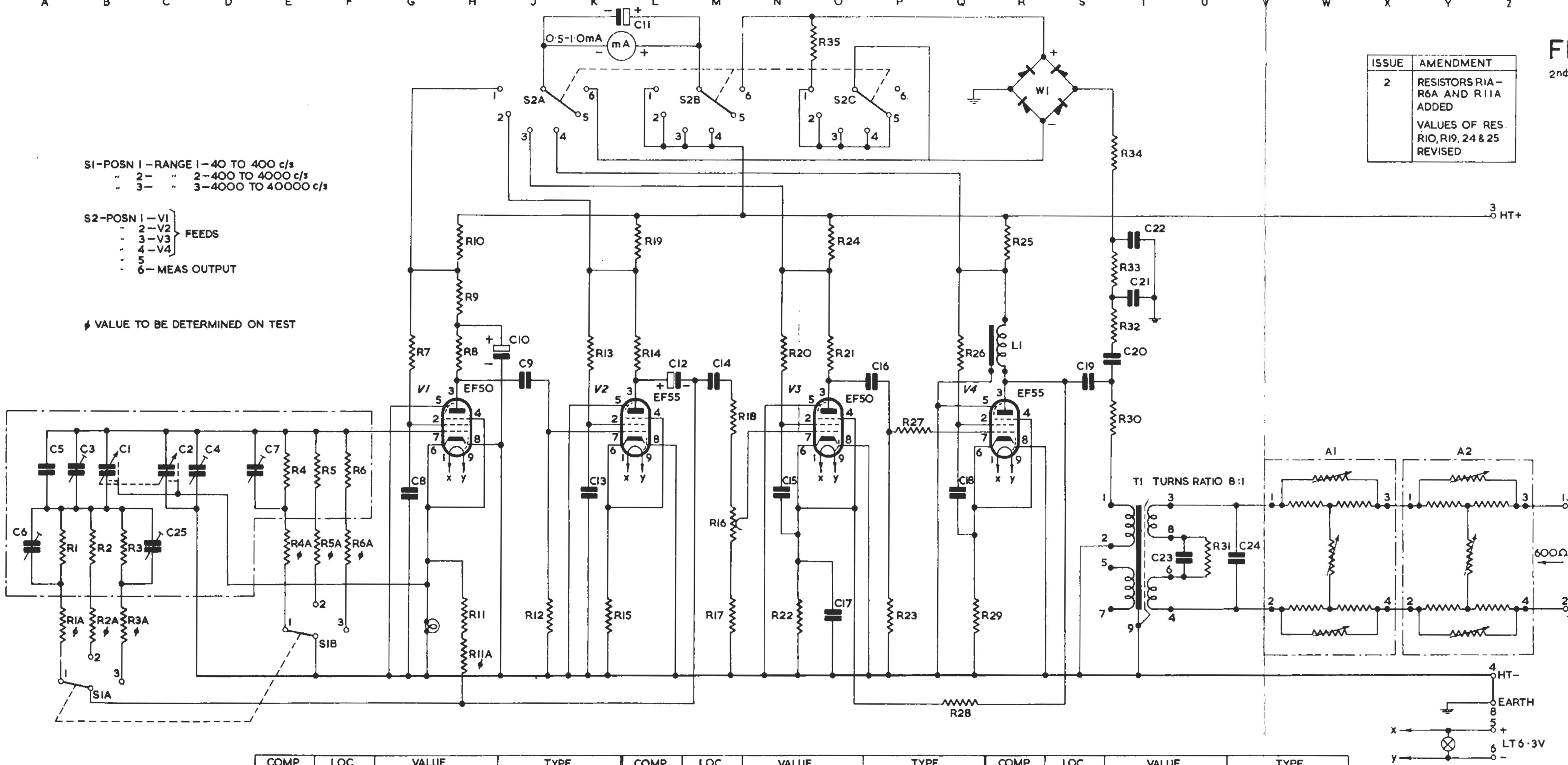
Frequency c/s	Total Harmonic Distortion
40	1%
60	0·5%
100	0·3%
1-20 kc/s	0·2%

See also page A.1.

FIG 19

2nd ISSUE

ISSUE	AMENDMENT
2	RESISTORS R1A–R6A AND R11A ADDED VALUES OF RES. R10, R19, 24 & 25 REVISED



COMP	LOC	VALUE	TYPE
C1	B8	·001 ±1%	WINGROVE C6004/1
C2	C8	·001 ±1%	" "
C3	B8	50p	EDDYSTONE 582
C4	D8	50p	" "
C5	A8	20p±20%	TCC SCD4
C6	A9	8p	MULLARD E7850
C7	E8	8p	" "
C8	G8	1±10%	MUIRHEAD 39AT
C9	J6	0·1±5%	UIC SM1007
C10	H6	16	BEC CE511/15
C11	L1	250	TCC CE 26C
C12	L6	16	BEC CE511/15
C13	K8	2±10%	MUIRHEAD 39AT
C14	M6	1±10%	" "
C15	N8	1±10%	" "
C16	P6	0·2±5%	UIC SM1007
C17	O10	·001±15%	TCC M2N
C18	Q8	2±10%	MUIRHEAD 39AT
C19	S6	1±10%	" "
C20	S6	0·1±5%	TCC 545
C21	T5	20p±20%	" SCD4
C22	T4	20p±20%	" "
C23	U9	·015±10%	" M3N

COMP	LOC	VALUE	TYPE
C24	V9	·005±10%	TCC M3N
C25	C9	8p	MULLARD E7850
L1	R6	200H±15%	R/1
R1	A9	3·3M±2%	WELWYN A3634
R2	B9	330k±2%	" "
R3	B9	33k±2%	" "
R4	E8	3·3M±2%	" "
R5	F8	330k±2%	" "
R6	F8	33k±2%	" "
R7	G6	470k±10%	ERIE 9
R8	H6	100k±10%	" 9
R9	H5	47k±10%	" 9
R10	H4	230±1%	WELWYN A3622
R11	H10	4·1k±1%	WELWYN A3623
R12	J10	1M±10%	ERIE 9
R13	K6	39k±10%	" 8
R14	L6	10k±1%	PAINTON 401 7W
R15	K10	100±10%	ERIE 9
R16	M9	1k	MNAP 10250 36000

COMP	LOC	VALUE	TYPE
R17	M10	1k±1%	WELWYN A3622
R18	M7	47k±5%	" "
R19	L4	6·2±1%	PAINTON P401
R20	N6	330k±10%	ERIE 9
R21	O6	100k±10%	" 9
R22	N10	1k±2%	WELWYN A3622
R23	P10	470k±10%	ERIE 9
R24	O4	270±1%	WELWYN A3622
R25	R4	7·2±1%	PAINTON P401
R26	Q6	47k±10%	ERIE 8
R27	P7	4·7k±10%	" 9
R28	Q11	100k±5%	WELWYN A3634
R29	R10	220±10%	ERIE 8
R30	T7	15k±2%	WELWYN A3622
R31	U9	205±1%	" "
R32	T5	82k±5%	" "
R33	T4	30k±10%	ERIE 9
R34	T3	30k±10%	" 9
R35	O1	390±10%	" 9
T1	T9		AL/33R

TONE SOURCE TS/9