TF 144H (Series II)

TF 144H *(Series II)*

Standard Signal Generator

OPERATING AND MAINTENANCE HANDBOOK

MARCONI INSTRUMENTS LIMITED
ST. ALBANS HERTFORDSHIRE ENGLAND

MANUAL CHANGE

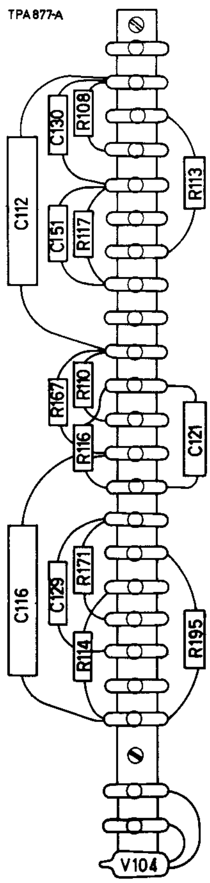
for

TF 144H (Series II)

STANDARD SIGNAL GENERATOR

A modified tag strip has been fitted to the a. l. c. and modulation amplifier. This has involved the relocation of some components.

A drawing of the new arrangement is given below, this replaces fig. 4.5 on page 33 of the handbook.



A. L. C. and modulation amplifier tag strip.

TF 144H/4

TF 144H/4S

OPERATING AND MAINTENANCE HANDBOOK No. OM 144H (II)

for

Standard Signal Generator
TF 144H *(Series II)*

Types TF 144H/4, TF 144H/4R, TF 144H/4S and TF 144H/6S

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CONTENTS

I GENERAL INFORMATION

1.1 FEATURES

The TF 144H series of signal generators give c.w. and a.m. outputs suitable for the standard measurements and tests on equipment operating in the m.f., h.f., and lower v.h.f. bands. Their good frequency stability and high-discrimination tuning are of particular advantage in testing narrow-band communication receivers.

Each generator covers 10 kc/s to 72 Mc/s in twelve ranges. Eight of these ranges follow a straight-line frequency law and have a frequency cover of 2:1; the remaining four have a slightly greater range and one of them covers the medium-wave broadcast band. A large effective scale length is provided on the main tuning dial which has separate hand-calibrated scales for each range. Its discrimination is such that a 2% frequency change on any band occupies more than a quarter of an inch of scale length. Frequency accuracy is ±1%, but for greater accuracy there is a built-in crystal calibrator which gives at least 90 crystal check points throughout the twelve ranges.

An 8:1 reduction drive from the main tuning control enables easy and precise adjustment to be made, and a linear logging scale with 100 divisions attached to the main tuning control facilitates interpolation between any of the main-scale divisions. In addition to the logging scale, a fine tuning control is provided which is operative above 80 kc/s and enables incremental frequency adjustments to be made, with complete freedom from backlash, up to ±0.5% of the frequency in use.

Modulation can be applied from an internal 400-c/s to 1000-c/s oscillator or from an external source. In both cases, depth is variable up to 80% over most of the frequency range.

There are two r.f. signal outlets. One supplies an output e.m.f. switchable between 2 and 2.75 volts (monitored by the meter) at very low impedance while the other supplies a variable e.m.f. between 2 µV and 2 volts via coarse and fine 50-ohm attenuators; the output range may be extended down to 0.2 µV by using the 20-dB Attenuator Pad accessory. A system of automatic level control keeps the carrier level constant throughout wide frequency changes.

Designed for operation from either a.c. mains or battery supplies the instrument is available in forms suitable for bench or rack mounting, as detailed below.

1.2 STANDARD AND SERVICES VERSIONS

TF 144H/4 and TF 144H/4R are the standard bench- and rack-mounting models. The versions with suffix 'S' are Services types which are distinguished from the standard models by a sealed round meter, a Plessey Mk. IV mains supply plug, and accessories supplied.

Standard Models

TF 144H/4 : Bench mounting
TF 144H/4R : Rack mounting

Services Models

TF 144H/4S : Bench mounting. No accessories. Joint-Service Ref. No. CT 452A.

TF 144H/6S : Bench mounting. With accessories. Ref. No. CT 452A Set.

The accessories supplied and available are described in Section 1.4.

1.3 DATA SUMMARY

FREQUENCY

Range:	10 kc/s to 72 Mc/s, in 12 bands.
Main Tuning:	Straight-line frequency law on 8 bands. Linear logging scale on slow-motion drive divides the main scale into nearly 400 divisions per band.
Calibration Accuracy:	±1%.
Fine Tuning:	Calibrated directly in % frequency change. Discrimination: 1 division = 0.01%. Total cover: 1%. Accuracy: ±10% of scale reading for carrier frequencies below 16 Mc/s; 15% of scale reading for higher frequencies. For use at carrier frequencies above 80 kc/s only.
Crystal Check:	400-kc/s and 2-Mc/s crystals selected automatically by band switch. Accuracy: ±0.005%.
Stability:	±0.002% in a ten-minute interval after warm-up.

OUTPUT

Impedance:	50 Ω at calibrated output; v.s.w.r. better than 1.25:1.
Calibrated Output:	2 μV to 2 V e.m.f. Low outputs down to 0.2 μV using 20 dB Pad TM 5573.
Direct Output:	Normal: approximately 2V. High: 2.75V into 75Ω, directly monitored to an accuracy of ±0.5dB on ranges A to K or ±1.0dB on range L.
Coarse Attenuator:	Eleven 10-dB steps.
Fine Attenuator:	Ten 1-dB steps; interpolation by carrier-level control and meter.
Attenuator Accuracy:	Within ±0.7 dB to 30 Mc/s; within ±1 dB to 72 Mc/s.
Level Monitor:	Protected-thermocouple voltmeter. Accuracy: ±0.5 dB absolute.
Stray Radiation:	Negligible; permits full use of lowest output.

MODULATION

Internal A.M.:	400 c/s and 1 kc/s, switch selected.
Depth:	0 to 80% (dependent upon modulating frequency at low carrier frequencies - see table under External A.M.); monitored by carrier-level meter and calibrated control.

1.3 DATA SUMMARY (continued)

Accuracy of r.m.s. modulation: ±5% modulation (i.e. 6.25% of full scale) at carrier frequencies where 80% modulation is obtainable with low distortion - see table under External A.M.

External A.M.: Minimum modulation frequency: 20 c/s. The maximum modulating frequency and depth which can be obtained at low distortion, when the ratio of modulating frequency to carrier frequency is small is, typically, as shown in the following table :-

Carrier Frequency	Max. Mod. Frequency		
	0-30%	30-50%	50-80%
10 kc/s	1 kc/s	400 c/s	200 c/s
100 kc/s	5 kc/s	2 kc/s	1 kc/s
1 Mc/s	20 kc/s	14 kc/s	8 kc/s
10 Mc/s	20 kc/s	17 kc/s	15 kc/s
72 Mc/s	20 kc/s	20 kc/s	20 kc/s

Input requirements: approximately 6 volts into 25 kΩ for 80% modulation.

Spurious A.M. on C.W.: Less than 0.1% depth.

Spurious F.M. on C.W.: Deviation less than ±0.0001% of the carrier frequency.

Spurious F.M. on A.M.: At frequencies below 30 Mc/s, deviation with 30% a.m. is less than ±0.01% of the carrier frequency or ±100 c/s, whichever is the higher.

POWER SUPPLY
(A.C. Mains or external batteries)

A.C. Mains: 200 to 250 volts or 100 to 130 volts, adjustable at plug-type supply-mains tapping panel. Frequency range, 40 to 100 c/s; consumption, 80 watts.

Batteries: L.T.: 6 volts, 2 amps. H.T.: 240 volts, up to 50mA depending on setting of controls.

DIMENSIONS & WEIGHT (in bench case):

Height	Width	Depth	Weight
$13\frac{1}{2}$ in	$20\frac{1}{2}$ in	11 in	65 lb
(34 cm)	(52 cm)	(27.9 cm)	(29.5 kg)

2 OPERATION

2.1 INSTALLATION

Take off the transparent plastic cover, if one is supplied with the instrument. If the cover is not completely removed when the instrument is operated overheating may occur. Position the instrument so that the ventilating louvres at the rear and underneath are not obstructed.

Unless otherwise specified, the instrument is despatched with its mains input circuit adjusted for immediate use on 240 volts within the frequency range 40 to 100 c/s. It may also be adjusted for operation from other a.c. supply mains in the range 100 to 130 and 200 to 250 volts, or from 6-volt l.t. and 240-volt h.t. external batteries.

2.2 CONNECTIONS

For a.c. mains operation, first check or alter the mains transformer tappings as shown in Section 4.2 Connect the instrument to the power socket by means of the mains lead and plug in the r.f. lead to the R.F. OUTPUT socket. These leads are normally stowed in the two case handle recesses. A 20-dB Attenuator Pad for use with the r.f. lead when required, is clipped inside the right-hand recess.

When the instrument is supplied for Services use, an adaptor Type TM 6263 is fitted into the front panel supply plug. This provides the necessary circuit linkages, and also an entry for the standard Plessey MkIV Services power lead.

For battery operation, connect up the special battery lead Type TM 6122 available as an optional accessory If the instrument is to be used in a vehicle, use a separate l.t. battery, or alternatively, check that the vehicle wiring employs a negative earth return system. Since there is no Services equivalent for the lead Type TM 6122 the Adaptor mentioned above should be removed to make way for the McMurdo Type socket on the end of the battery lead.

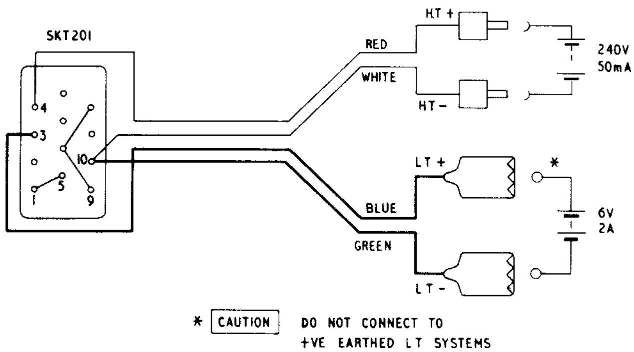


Fig. 2.1 Battery Supply Lead

2.3 WARMING UP

The specified stability of 0.002% in a 10-minute period is not attained until a warm-up period of about 3 hours has elapsed. After switching on, and with the function switch set to any position other than CARRIER OFF, the initial drift will be of the order of 0.01% of any selected frequency per 10-minute period. This higher order of drift will of course diminish with time. and you should therefore leave the instrument switched on during periods of intermittent use - preferably switched to the frequency range required. When changing from one frequency range to another, a period of 15 minutes or more should be allowed for maximum stability.

During the warm-up period however, you can still be assured of a high order of accuracy provided that frequency checks are made using the crystal calibrator. This particularly applies in the case of battery operation when it is undesirable to leave the instrument switched on for long periods.

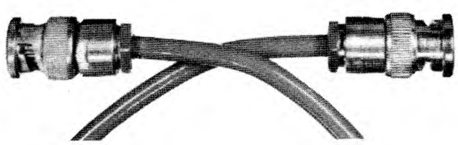
1.4 ACCESSORIES

1. STANDARD MAINS LEAD
Type TM 2560CA: 6 ft long; for a.c. mains operation of TF 144H/4 and TF 144H/4R only.

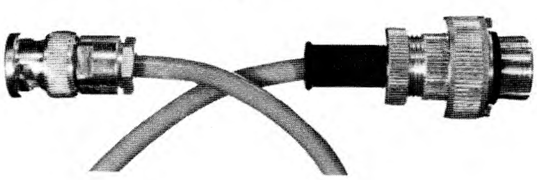
2. SERVICES MAINS LEAD - Connector Type 3429/1 (A. M. Ref. 10HA/8359); Admiralty Ref. A. M. 67384): 5 ft long; for a.c. mains operation of 'S' versions only.

3. BATTERY LEAD Type TM 6122: 6 ft long; for battery operation of all models.

4. OUTPUT LEAD Type TM 4969/3: 50 ohms; BNC plug - BNC plug; 5 ft long (Joint Service Ref. No. 5995-99-580-0513).

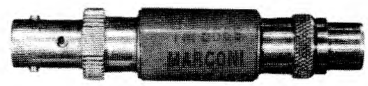


5. OUTPUT LEAD Type TM 4726/152: 50 ohms; BNC plug - Belling-Lee L788FP plug; 5 ft long. (Joint Service Ref. No 5995-99-580-0512).

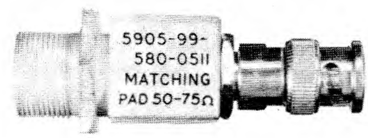


6. 20 dB PAD Type TM 5573: 50 ohms; BNC plug - BNC socket; (Joint Service Ref. No. 5905-99-580-0510).

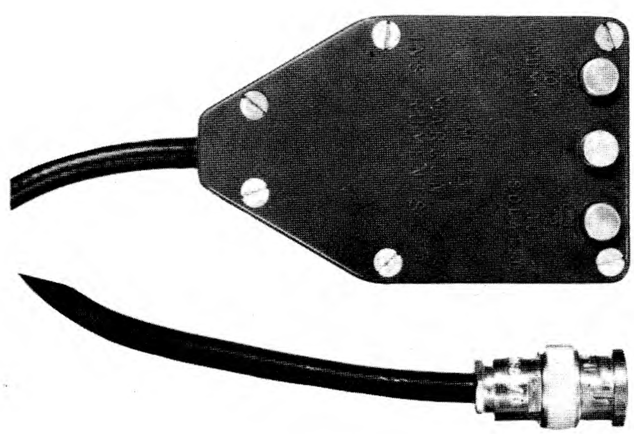
7. MATCHING PAD Type TM 5569: 50 to 75 ohms; BNC socket - Belling-Lee L734/P plug.



8. MATCHING PAD Type TM 6599: 50 to 75 ohms; BNC plug - Burndept PR4E plug. (Joint Service Ref. No. 5905-99-580-0511).



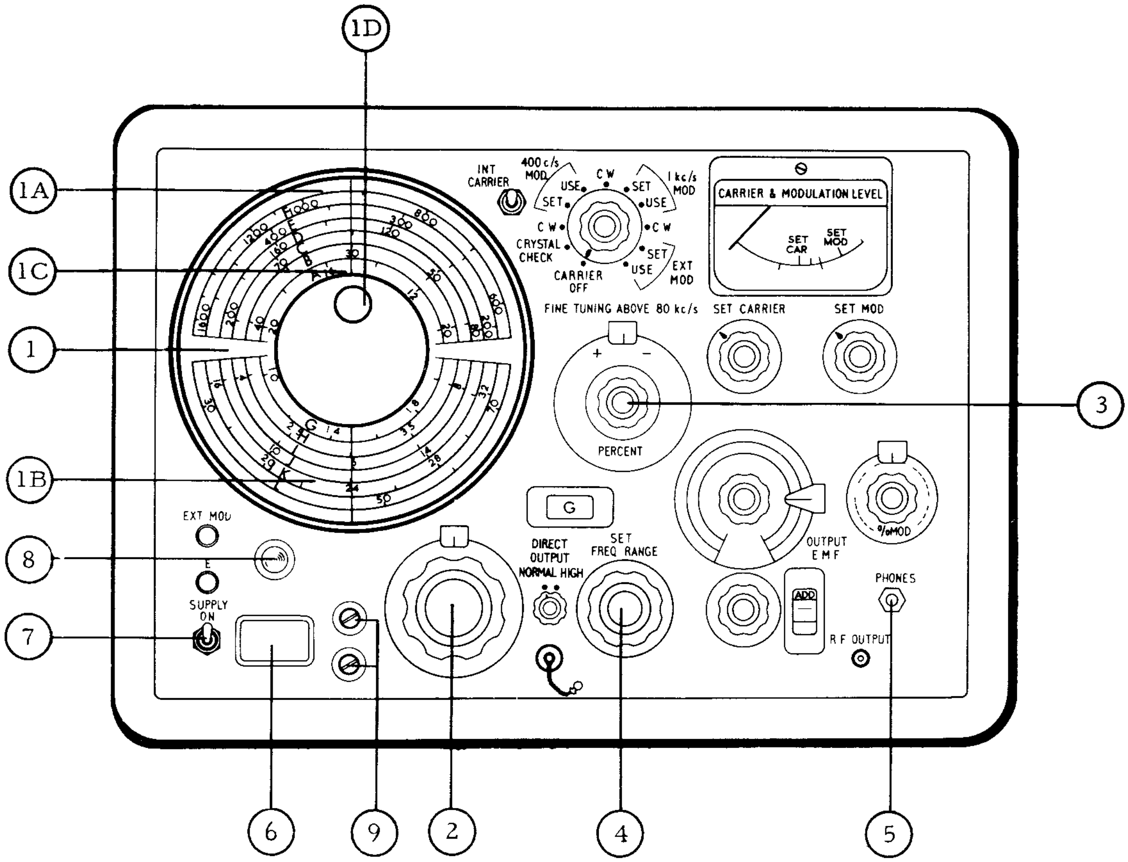
9. DUMMY AERIAL & D.C. ISOLATING UNIT Type TM 6123: Input, BNC plug on 3 ft lead; output, spring-loaded terminals. For general receiver testing or for use on circuits with d.c. potentials up to 350 volts. (Joint Service designation: COUPLER SIG. GEN.; Ref. No. 6625-99-913-9483).



Accessories supplied with each version are as follows :-

TF 144H/4 and TF 144H/4R : 1, 4, 6.
TF 144H/4S : None
TF 144H/6S : 2, 4, 6, 9.

2.4 CONTROLS: SUPPLY AND TUNING



(1) MAIN TUNING DIAL

(1A) Cursor for ranges A-F (10-1,605 kc/s).

(1B) Cursor for ranges G-L (1- 72 Mc/s).

(1C) Arrow Reference Mark. Align upper cursor with this when not using crystal calibrator.

(1D) Set Cursor Control. Allows either cursor to be adjusted for standardizing scale against crystal check points - see Table in Section 2. 8.

(2) MAIN TUNING CONTROL. For logging scale calibration see Section 2. 9.

(3) FINE TUNING CONTROL. Gives ±0.5% incremental tuning on ranges D to L. Each scale division represents 0. 01%.

(4) RANGE CONTROL. 12-position. Identification and frequency of range selected is shown in the window.

(5) PHONES JACK. Insertion of telephone plug, with Function Selector set to CRYSTAL CHECK, switches on crystal calibrator.

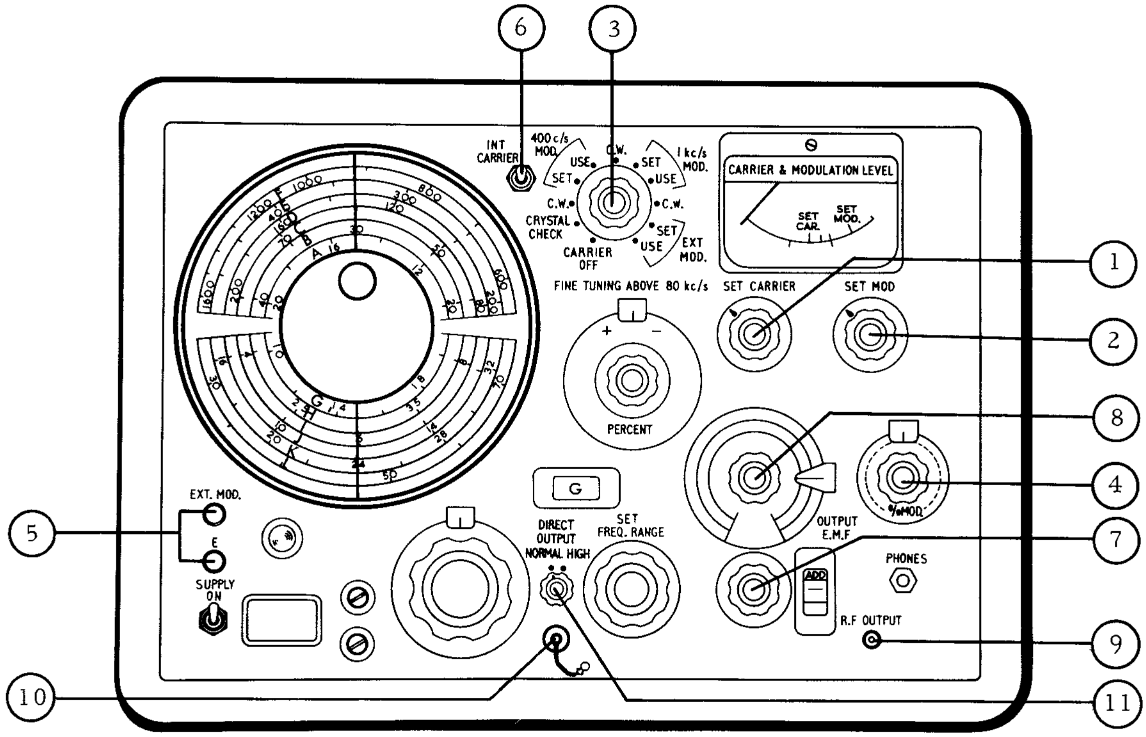
(6) SUPPLY PLUG. Connect lead TM 2560 CA or 3429/1 for a.c. mains operation, or TM 6122 for battery operation.

(7) SUPPLY SWITCH. For mains or battery operation.

(8) PILOT LAMP. Indicates valve heaters are on.

(9) FUSES. Supply: 2A, H. T. : 500 mA.

2.5 CONTROLS: MODULATION AND OUTPUT



(1) C. W. MONITORING. Adjust to SET CARRIER mark, or to 0.5 dB marks for attenuator interpolation.

(2) MOD. MONITORING. Adjust to SET MOD. mark with MODULATION SELECTOR at a SET position.

(3) MODULATION SELECTOR. Carrier Off position removes h.t. from r.f. oscillator.

(4) % MOD. Controls internal and external modulation.

(5) EXT. MOD. TERMINALS. 25 kΩ impedance. About 6 volts input gives 80% modulation.

(6) INTERRUPT CARRIER. For temporarily switching off carrier without affecting output impedance or stability.

(7) COARSE ATTENUATOR. 11 steps of 10 dB.

Figures in window show :-

Black : dB relative to 1 μV, to be added to figure on dial.

Red or Green: Voltage range covered by same-coloured scale on dial.

(8) FINE ATTENUATOR. 10 steps of 1 dB.

Scales read :-

Black : dB relative to 1 μV, to be added to figure shown by Coarse Attenuator.

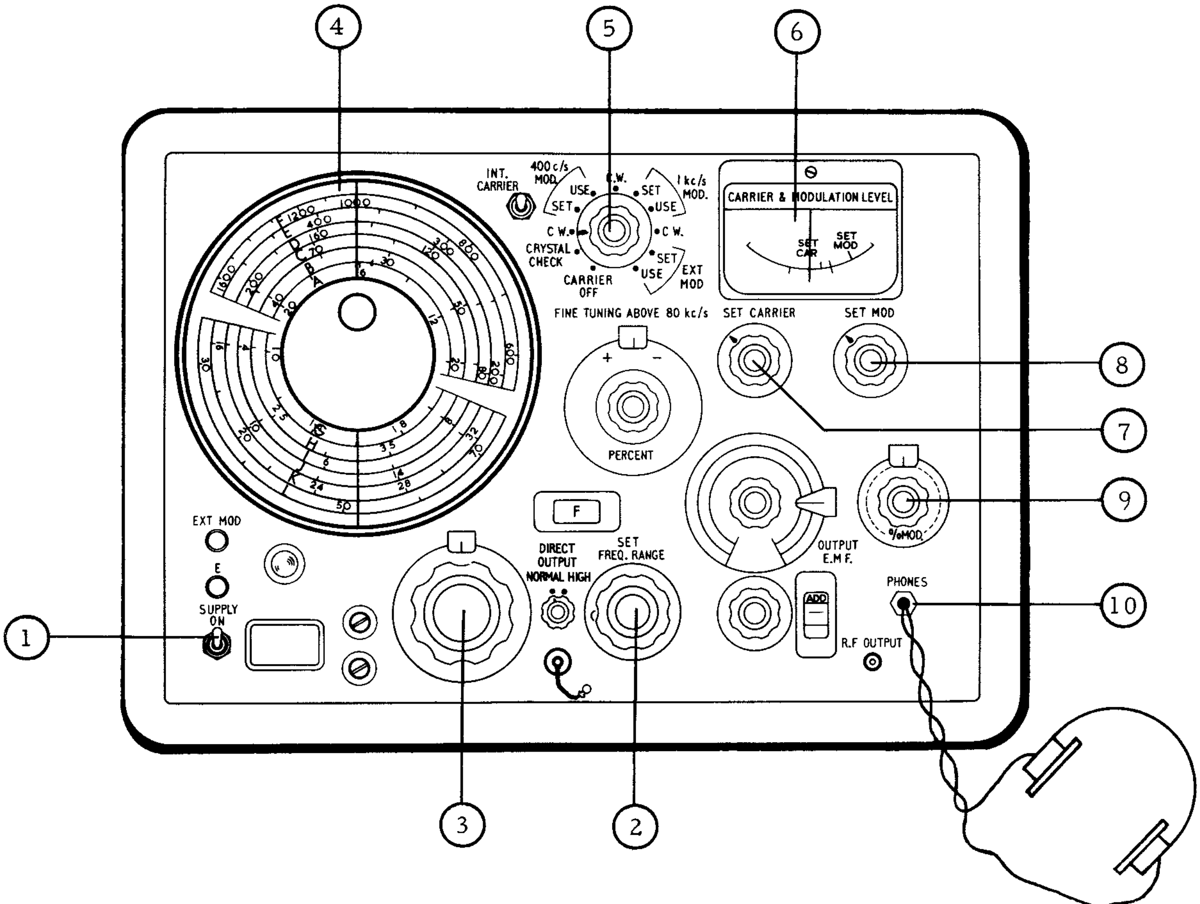
Red or Green : Output voltage. Multiply by factor depending on range shown by Coarse Attenuator.

(9) R. F. OUTPUT. Open-circuit e.m.f. shown by attenuator controls. 50 ohms source impedance. Connector: BNC type UG291/U.

(10) DIRECT OUTPUT. 2 volts output variable only by SET CARRIER control. Connector: BNC type UG290/U.

(11) DIRECT OUTPUT SWITCH. Selects direct output level; in the NORMAL position 2 V, in the HIGH position 2.75 V With the switch at HIGH there is no output from the R. F. OUTPUT socket.

2.6 QUICK OPERATIONAL CHECK



The following sequence of operations will enable you to get the feel of the controls and to check that the r.f. oscillator, modulation circuits, monitor and crystal calibrator are working.

(1) Switch to SUPPLY ON.

(2) Turn the SET FREQ. RANGE switch to F - 535 to 1605 kc/s.

(3) (4) Adjust the main tuning control for an indication of 1000 kc/s against the upper cursor.

(5) Set the function selector to one of the C. W. positions.

(6) (7) Bring the meter pointer to the SET CARRIER mark by adjusting the SET CARRIER control, and note that the control is within, say, the middle third of its travel.

(5) Turn the function selector to 400 c/s MOD - SET.

(6) (8) Bring the meter pointer to the SET MOD mark by adjusting the SET MOD control.

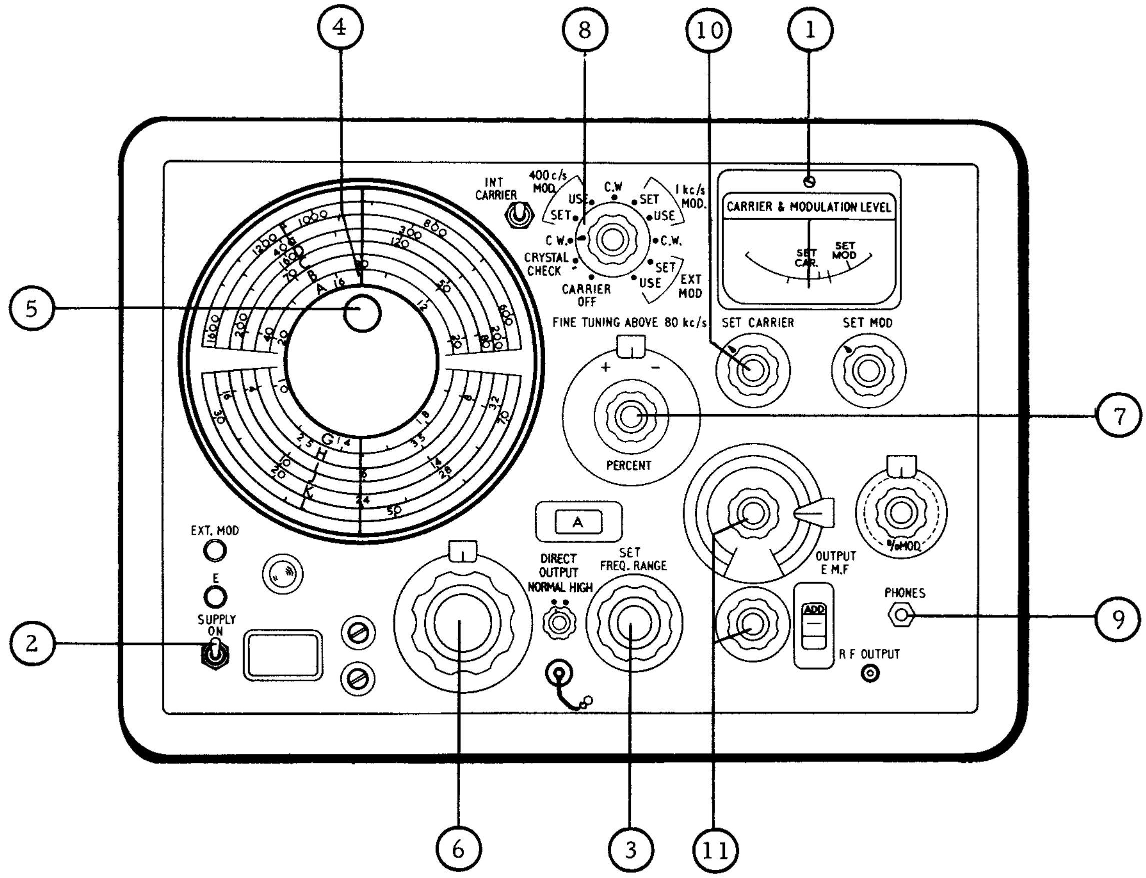
(5) Turn the function selector to 400 c/s MOD - USE.

(9) Rotate the % MOD control and check that the modulation depth readings on the control scale and the meter agree.

(5) Turn the function selector to CRYSTAL CHECK.

(10) Plug headphones into the PHONES jack and check that a beat note can be heard as the main tuning dial is rocked through one or two divisions about the 1000 kc/s mark.

2.7 C.W. OPERATION



(1) Check the mechanical zero setting of the meter and adjust if necessary.

(2) Switch to SUPPLY ON and allow time to warm up.

(3) Turn the SET FREQ RANGE control to the required range.

(4) (5) (6) Bring the upper cursor line to the arrow mark by means of the SET CURSOR control. Adjust the main tuning control to bring the main dial reading to the approximate frequency required.

(7) Turn the FINE TUNING control to 0.

(8) (9) For maximum accuracy switch to CRYSTAL CHECK and plug headphones into the PHONES jack. Readjust the main tuning control for zero beat at the nearest crystal check point (see Section 2.8 for check point frequencies) and reset the cursor to correct the dial reading.

(6) Tune to the exact required output frequency by adjusting the main dial to the nearest calibrated mark and interpolating by means of the logging scale on the main tuning control (see Section 2.9 for logging scale calibration).

(8) (10) Switch to C.W. and adjust the SET CARRIER control to bring the meter pointer to the SET CARRIER mark.

(11) Adjust the OUTPUT E.M.F. controls for the required output voltage.

NOTE: Watch the meter when making large frequency changes - it may be necessary to readjust the SET CARRIER control.

2.8 USE OF CRYSTAL CALIBRATOR

To use the crystal calibrator, plug headphones into the PHONES jack and switch to CRYSTAL CHECK. Adjust the main tuning dial to obtain zero beat at the nearest check point to the wanted frequency. Then use the SET CURSOR control to align the cursor with the check point frequency indication on the dial.

Crystal check point frequencies occur as follows :-

Ranges A to D at submultiples of 400 kc/s,
Ranges E and F at submultiples of 2 Mc/s,
Ranges G and H at multiples of 400 kc/s,
Ranges I to L at multiples of 2 Mc/s.

The actual frequencies are tabulated below.

TABLE 2.1

CRYSTAL CHECK POINT FREQUENCIES

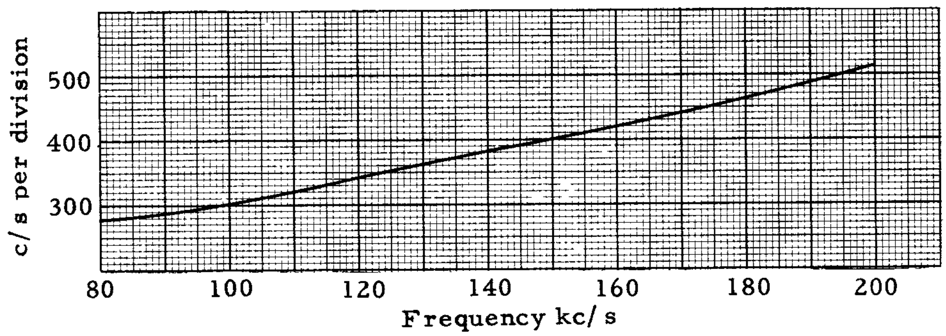
Range A 10-20 kc/s	Range B 20-40 kc/s	Range C 40-80 kc/s	Range D 80-200 kc/s	Range E 200-535 kc/s	Range F 535-1605 kc/s
10	20.00	40.00	80.00	200.00	666.66
10.26	21.05	44.44	100.00	222.22	1000.00
10.53	22.22	50.00	133.33	250.00	1333.00
10.81	23.53	57.14	200.00	285.71	1500.00
11.11	25.00	66.66		333.33	
11.43	26.66	80.00		400.00	
11.76	28.57			500.00	
12.12	30.77				
12.5	33.33				
12.9	36.36				
13.33	40.00				
13.79					
14.29					
14.81					
15.38					
16.00					
16.66					
17.39					
18.18					
19.05					
20.00					

Range G 1-2 Mc/s	Range H 2-4 Mc/s	Range I 4-8 Mc/s	Range J 8-16 Mc/s	Range K 16-32 Mc/s	Range L 30-72 Mc/s
Check points every 400 kc/s		Check points every 2 Mc/s			

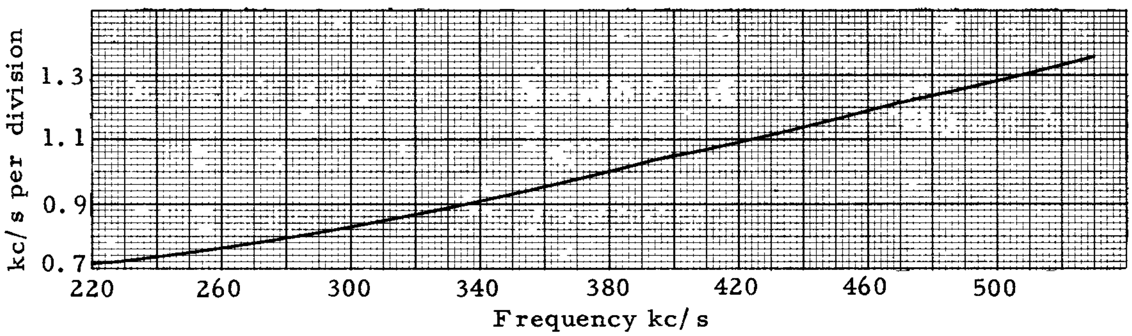
2.9 TUNING CONTROL LOGGING SCALE

RANGE A : 30 c/s per division
RANGE B : 60 c/s per division
RANGE C : 120 c/s per division

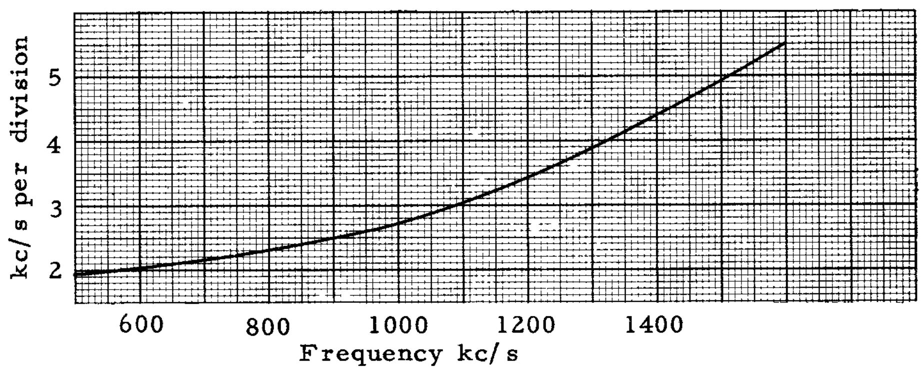
RANGE D



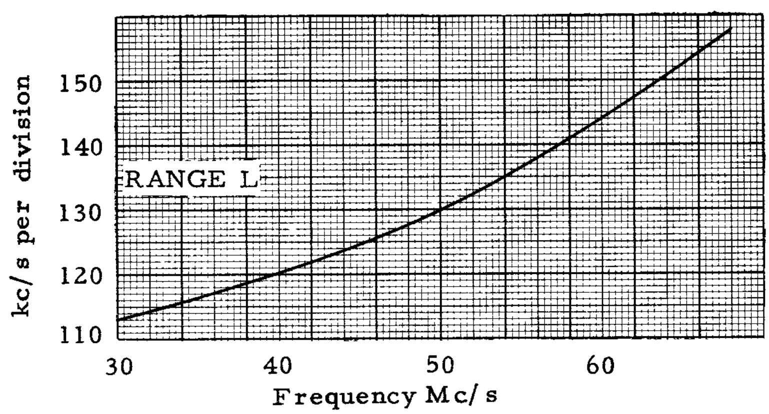
RANGE E



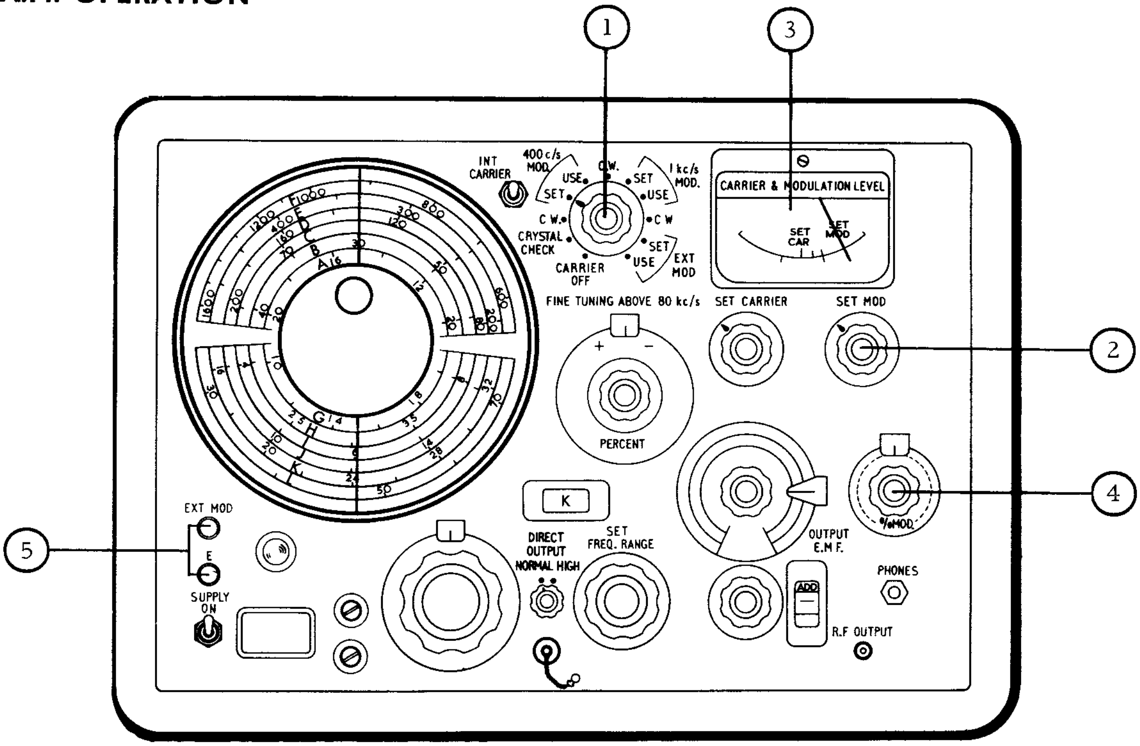
RANGE F



RANGE G : 3 kc/s per division
RANGE H : 6 kc/s per division
RANGE I : 12 kc/s per division
RANGE J : 24 kc/s per division
RANGE K : 48 kc/s per division



2.10 A.M. OPERATION



INTERNAL

Switch on, tune, and set output as for C. W. (see Section 2. 7).

(1) (2) (3) Switch to 400 c/ s MOD-SET or 1 kc/ s MOD-SET and adjust the SET MOD control to bring the meter pointer from the SET CARRIER mark to the SET MOD* mark.

(1) (4) Switch to the adjacent USE position and set the % MOD control to indicate the required percentage modulation on its dial.

EXTERNAL

Switch on, tune, and set output as for C. W. (see Section 2. 7).

(5) Connect the external modulating source to the EXT MOD and E terminals (about 6 volts for 80% modulation).

(1) (2) (3) Switch to EXT MOD-SET and adjust the SET MOD control to bring the meter pointer from the SET CARRIER mark to the SET MOD* mark.

(1) (4) Switch to EXT MOD-USE and set the % MOD control to indicate the required percentage modulation on its dial.

* Except at low carrier and high modulation frequencies. The maximum depth for low-distortion modulation is limited when the modulation frequency exceeds a certain percentage of the carrier frequency (about 2% at 10 kc/ s carrier to about 0. 1% at 10 Mc/ s). The maximum modulation frequencies for different carrier frequencies and modulation depths are shown in the table in Data Summary - Modulation, Section 1.3. When using a combination of carrier and modulation frequency that puts a limitation on the modulation depth, the 50% or 30% mark on the meter is used instead of the SET MOD mark.

For example : at 10 kc/ s carrier, 400 c/ s modulation, set to the 50% mark;
at 10 kc/ s carrier, 1000 c/ s modulation, set to the 30% mark;
at 1 Mc/ s carrier, 14 kc/ s modulation, set to the 50% mark.

2.11 R.F. OUTPUT ARRANGEMENTS

The R. F. OUTPUT circuit of the Signal Generator should be regarded as a zero-impedance voltage source in series with a resistance of 50 ohms. This is shown in Fig. 2.8 where :

E is the indicated source e.m.f.,
Ro is the source resistance,
R_L is the external load resistance

V_L, the voltage developed across the load, is given by

$$V_L = E.\frac{R_L}{R_o + R_L}$$

Note: if the load is not predominantly resistive the reactive component must be taken into account and ±jX added to R_L.

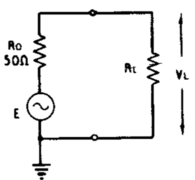


Fig. 2.8
Equivalent output circuit

Table 2.2 shows the conversion factors for obtaining the load voltage from the indicated e.m.f. at different load impedances.

When using a correctly matched, i.e. 50-ohm, output lead its output end can be regarded as an extension to the output socket on the Generator and wide variations in load impedance do not seriously affect the calculated load voltage obtained from Table 2.2. Standing waves produced by the mismatched load can, for most purposes, be ignored.

For greatest accuracy - if the additional attenuation can be tolerated - use the 20-dB Attenuator Pad Type TM 5573 between seriously mismatched loads and the output lead. This ensures that the lead is correctly terminated, and also attenuates any extraneous noise induced in the lead.

TABLE 2.2

LOAD ohms	To find load voltage: Multiply E.M.F. by	or	Subtract dB
10	0.167		15.5
20	0.286		10.9
30	0.375		8.5
40	0.445		7.0
50	0.50		6.0
60	0.55		5.2
70	0.58		4.7
75	0.60		4.4
80	0.62		4.2
90	0.64		3.8
100	0.67		3.5
120	0.71		3.0
150	0.75		2.5
200	0.80		1.9
300	0.86		1.3
500	0.91		0.8
600	0.92		0.7
800	0.94		0.5
1000	0.95		0.4
2000	0.98		0.2
4000	0.99		0.1

OUTPUTS INTO 50-OHM LOADS

The voltage developed across a 50-ohm load is equal to half the e.m.f. indicated on the voltage scales of the Generator output controls, or 6 dB less than dBμV indication.

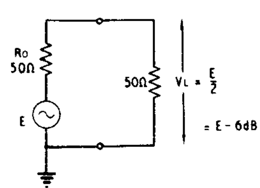
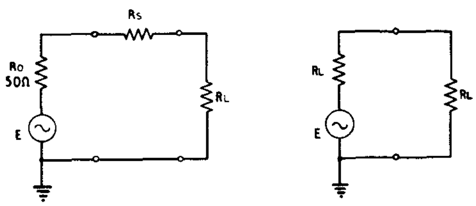


Fig. 2.9
50-ohm load

MATCHING TO HIGH IMPEDANCE LOADS

To present a load that is greater than 50 ohms with a signal derived from a matched source, a resistor Rs is added in series with the Generator output. The value of Rs is given by the difference between the load and Generator impedances, that is,

$$R_s = R_L - R_o$$



Series resistor in circuit — Equivalent circuit

Fig. 2.10 High-impedance matching

The voltage across the load, V_L, is given by

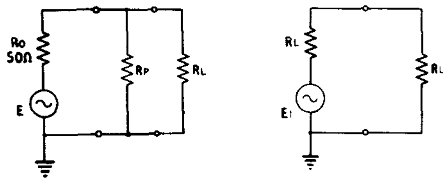
$$V_L = \frac{E}{2}$$

For the special case of a 75-ohm load a Matching Pad, Type TM 5569 or TM 6599, is available as an accessory and consists basically of a 25-ohm resistor with coaxial connectors for insertion in series with the output lead.

MATCHING TO LOW-IMPEDANCE LOADS

To present a load that is less than 50 ohms with a signal derived from a matched source, a resistor Rp is added in parallel with the Generator output. The value of Rp is given by

$$R_p = \frac{R_o R}{R_o - R}$$



Parallel resistor in circuit — Equivalent circuit

Fig. 2.11 Low-impedance matching

The effective source e.m.f., E_1, is now different and is given by

$$E_1 = E \cdot \frac{R_p}{R_p + R_o}$$

and the voltage across the load, V_L, is given by

$$V_L = \frac{E_1}{2}$$

MATCHING TO BALANCED LOADS

Equipment whose input circuit is in the form of a balanced winding can be fed from the Generator by using two series resistors as shown in Fig. 2.13. This method makes use of the auto-transformer effect of the centre-tapped windings and is <u>not</u> suitable for resistive balanced loads.

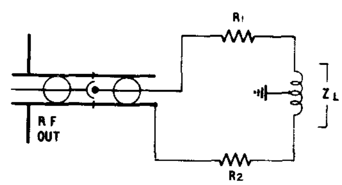


Fig. 2.12 Balanced load matching

The values of R_1 (for use in the live lead) and R_2 (for the earth lead) are given by

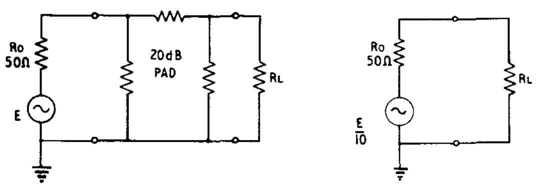
$$R_2 = \frac{Z_L}{2}$$

$$\text{and } R_1 = \frac{Z_L}{2} - 50$$

2.12 USE OF 20-dB ATTENUATOR PAD

It is recommended - provided that the reduced output e.m.f. can be tolerated - that the 20-dB Attenuator Pad TM 5573 should be permanently connected to the output end of the r.f. lead. Terminated in this way, the extraneous noise pick-up in the lead is attenuated by a factor of ten before being applied - together with the signal - across the load. This arrangement is particularly advantageous when making signal-to-noise tests on receivers at low voltage level.

With the Pad in circuit, the possibility of errors in apparent e.m.f. or output impedance, due to the presence of standing waves at the higher frequencies, is avoided since it is now impossible to seriously mismatch the r.f. lead. In fact, variations in load impedance between zero and infinity cause the effective value to depart from the correct value by as little as 1 ohm.



Pad in circuit

Equivalent circuit

Fig. 2.13 Effect of 20-dB Pad

The Pad reduces the effective source e.m.f. by a factor of 10: therefore, the figures for load voltage obtained from Table 2.2 must be divided by 10 or reduced by 20 dB. The load voltage, V_L, is given by

$$V_L = \frac{E}{10} \cdot \frac{R_L}{R_o + R_L}$$

When matching to loads other than 50 ohms, the matching resistor must be inserted on the output side of the Pad; the expressions given in Section 2.11 then become :-

For series matching, $V_L = \frac{E}{20}$

For parallel matching,

$$V_L = \frac{E_1}{20} = \frac{E}{20} \cdot \frac{R_p}{R_p + R_o}$$

2.13 USE OF DUMMY AERIAL AND D.C. ISOLATOR

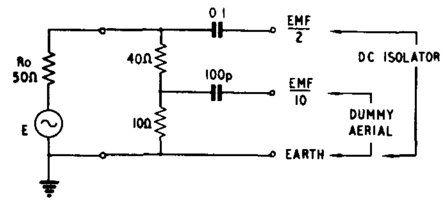


Fig. 2.14 Generator output using TM 6123

To use this dual-purpose unit as a dummy aerial, connect the EMF/10 and E terminals to the receiver under test. The unit then simulates the impedance of a typical aerial for broadcast receivers in the l.f., m.f. and h.f. bands, and provides an open-circuit e.m.f. of one-tenth of that indicated by the Generator.

To use it as a 350-volt d.c. isolator connect the EMF/2 and E terminals to the equipment under test. This allows the Generator output to be applied to circuits having a standing d.c. potential up to 350 volts. The open-circuit e.m.f. is half of that indicated by the Generator.

2.14 DIRECT OUTPUT

Two r.f. levels are available at the DIRECT OUTPUT socket; with the DIRECT OUTPUT switch at NORMAL an e.m.f. of 2 V is provided and with the switch at HIGH an output, which is preset during manufacture at 2.75 V (100 mW into a 75 Ω load), is available. The source impedance with the switch in either position is virtually zero.

As with the R.F. OUTPUT the stated level depends on the SET CARRIER control having been adjusted to bring the pointer of the CARRIER AND MODULATION LEVEL meter to the SET CARRIER mark, but you will notice that adjustment to the SET CARRIER control is not usually necessary when switching from NORMAL to HIGH.

The minimum load impedance which may be presented to the DIRECT OUTPUT when switched to NORMAL is 200 Ω and when switched to HIGH is 50 Ω. If, for any reason, the impedance of the load is lower than these figures add a series resistor between the DIRECT OUTPUT and the cable to bring the effective impedance seen by the generator up to the minimum value.

NOTE: At high frequencies the connecting cable may amount to a quarter wavelength and then, if terminated with a high impedance this will appear as a very low impedance to the Signal Generator.

The R.F. OUTPUT is disconnected when the DIRECT OUTPUT is switched to HIGH.

3 TECHNICAL DESCRIPTION

It is intended that the description given in the CIRCUIT SUMMARY below should be read in conjunction with the Functional Diagram. Reference should be made to the Circuit Diagrams at the back of the handbook when reading the more detailed information in the subsequent sections.

3.1 CIRCUIT SUMMARY

Output from the r.f. oscillator stage, V101, is applied direct to the HIGH OUTPUT socket, and also to the R.F. OUTPUT socket via the coarse and fine attenuators. The oscillator output is also applied to the thermocouple meter for carrier level monitoring, to the grid of V102b via the a.l.c. diodes for automatic level control, and to the crystal calibrator V103.

The double-triode stage V103 acts as a crystal oscillator and mixer; its beat note output is used - after amplification by V204a - to provide calibration markers for checking and calibrating the dial. Output to the PHONES jack is taken from the cathode-follower triode V204b which also provides a.g.c. voltage for application to the grid of V204a via the a.g.c. diode.

Valve sections V204a and V204b, when switched for internal modulation, are arranged as a bridge-connected R-C oscillator. Output from the oscillator at the anode of V204b is applied via the cathode-follower V202b to the amplifier V102b. Output from this amplifier is then applied to a further cathode-follower V102a which screen-modulates the r.f. oscillator.

3.2 R.F. OSCILLATOR

All the components associated with the oscillator stage, V102, are contained within a completely screened R.F. Box, although valves V101 to 103 are accessible from outside the R.F. Box. Range selection and appropriate circuit changes are made by means of turret switched components as described in Section 3. 3.

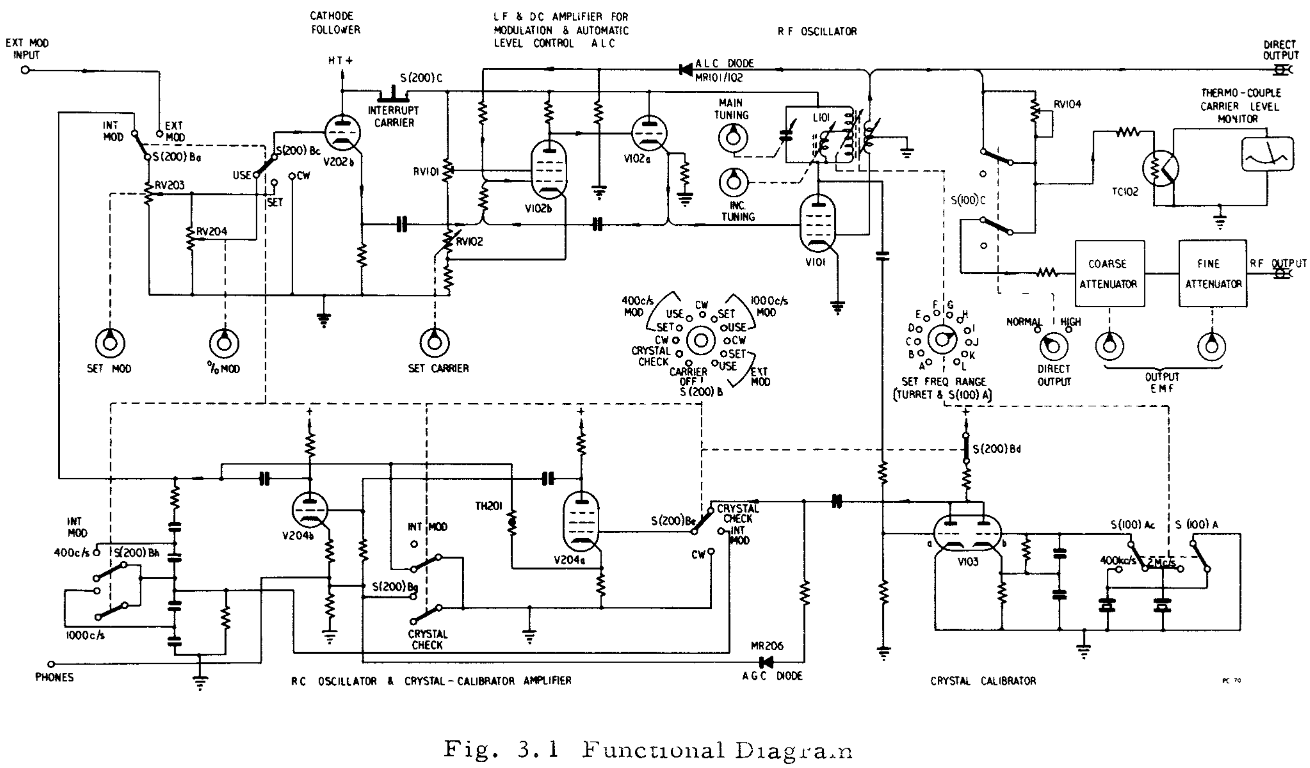


Fig. 3.1 Functional Diagram

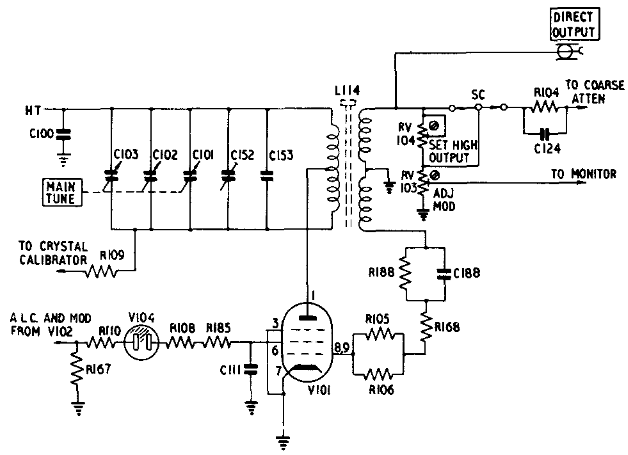


Fig. 3.2 R.F. Oscillator - Range A
(Ranges B and C are basically similar)

On ranges A to K, (see Figs. 3.2 and 3.3) V101 is connected as an r.f. oscillator using a tuned-anode circuit with an inductively coupled feed-back winding connected into the grid circuit. On the highest-frequency range, L, the circuit is changed to that of a Colpitts oscillator (see Fig. 3.4).

The level of the r.f. output is determined by the value of the oscillator screen potential. This potential - which is derived from the cathode of V102a - depends on (i) the potential on the grid of the audio amplifier and a.l.c. valve, V102b, which in turn depends upon the adjustment of the SET CARRIER control RV102, preset resistor RV101, and the automatic level control voltage and (ii) the position of the SET FREQ RANGE switch, section S(100)Ah, which selects the amount of series resistance between the oscillator screen and

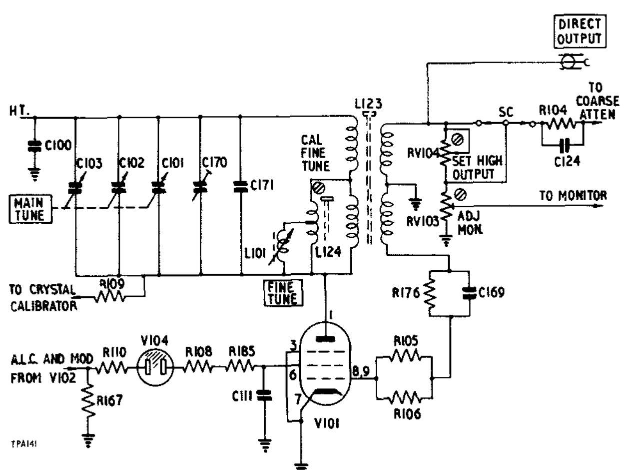


Fig. 3.3 R.F. Oscillator - Range G
(Ranges D to K are basically similar)

the cathode of V102a. On ranges A to H, this potential is limited by the series resistors, R110, R108, R185 and the neon tube V104; on ranges I, J, and K by R110, R108; and on range L, by R110 and R185.

3.3 RANGE SWITCHING

Range switching is accomplished by selecting any one of twelve turret-mounted inductors and associated components by means of the SET FREQ RANGE control; Figs 3.2 to 3.4 show the three principal circuit arrangements. Contacts which provide the connections between the selected components and the main part of the circuit also serve to short-circuit, and earth, the tuning inductor of the next lower section not in use - this being a precaution against the production of spurious resonances.

Switch S(100)A, comprising seven separate sections, is ganged to the SET FREQ RANGE control and performs the following functions :-

S(100)Af and S(100)Ae :

Select the beat note output and switch the h.t. supply of the crystal calibrator V103.

S(100)Ac and S(100)Ad :

Switch the 2,000-kc/s and 400-kc/s oscillator crystals appropriate to the frequency range selected.

S(100)Ab and S(100)Ai :

Route the modulating a.f. output from the cathode follower V202a to the grid of the amplifier V102b as described in Section 3.7. For ranges A, B, and C, the filter network which includes L110 and L111 is used; for the remaining ranges, the filter network which includes L108 and L109 is used.

S(100)Ah :

Provides a coarse adjustment to the screen potential applied to the r.f. oscillator, V101. This maintains the oscillatory voltage at a constant level irrespective of the range in use.

3.4 MAIN TUNING

The main tuning dial control rotates the ganged variable capacitors C101, C102, and C103 via an 8:1 reduction gear. Capacitors C101 and C102 are permanently connected in parallel with one another, and are connected in parallel with the selected tuning inductor as the SET FREQ RANGE control is operated. On ranges A to J, all three capacitors are connected in parallel (C103 is connected in parallel with C101/C102 via the turret contacts 3 and 4). On range K, C101/C102 are disconnected, leaving only C103 connected in parallel with the tuning inductor L132. On range L, all three capacitors are connected in a series/parallel arrangement.

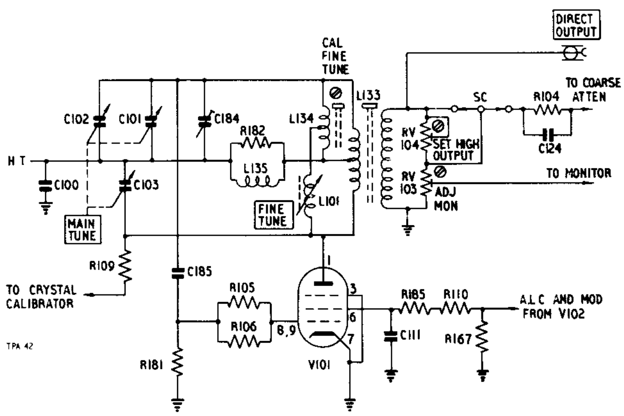


Fig. 3.4 R.F. Oscillator - Range L

3.5 INCREMENTAL TUNING

A small variable inductor (L101) placed effectively in parallel with part of each main tuning inductor via turret contacts 3 and 5 provides an electrical incremental tuning facility. The inductance of L101 is varied by means of the FINE TUNE control which operates a rising cam attached to the inductor core. The actual connection of L101 is across part of the fixed inductor (L118, L120, L122 etc.) associated with each turret section; this in turn is connected in parallel with part of the main tuning inductor. On range C and below the incremental tuning is inoperative.

3.6 MODULATION OSCILLATOR AND CATHODE FOLLOWER

When the function selector switch S(200)B is set to the INT MOD SET and USE positions, the triode-pentode valve V204 functions in a Wien Bridge oscillator circuit. Fig. 3.5 shows the circuit switched for 400-c/s modulation. When 1,000 c/s modulation is selected, capacitor C213 is added in series with C212, and capacitor C214 in series with C215 by means of switch section S(200)Bh.

Level-stabilizing negative feedback is applied to the cathode of V204a from the anode of V204b via the thermistor TH201; positive feedback to the grid of V204a from the junction of C212/C215 (junction C213/C214 for 1,000 c/s) via S(200)Be maintains oscillation.

When the valve is used in this way as a modulation oscillator, the cathode resistor R224 is short-circuited by the contacts of the switch wafer S(200)Bg. When CRYSTAL CHECK is selected, this resistor is restored into the circuit; V204a then functions as an audio amplifier, and V204b as a cathode follower output stage.

In the SET (internal or external modulation) switch positions, the a.f. is applied to the grid of the cathode-follower connected triode V202a via switch wafers S(200)Ba and S(200)Bc, and the uncalibrated SET MOD

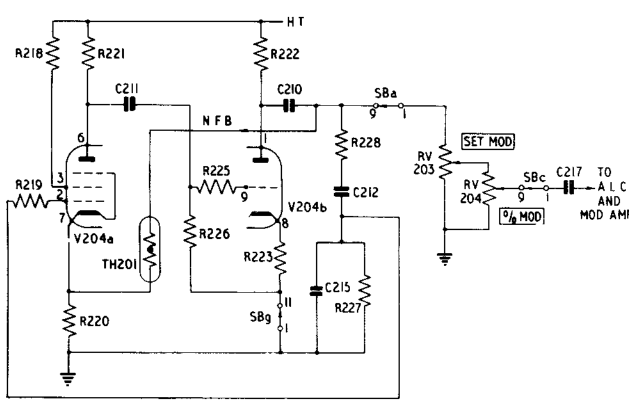


Fig. 3.5 Modulation Oscillator Switched to 400 c/s - USE

control RV203. At this switch setting, and regardless of the setting of the calibrated % MOD control RV204, RV203 provides a means of setting up the modulation level in conjunction with the SET MOD reference mark on the meter. When the switch is moved to the USE position, the modulating voltage is then derived from the slider of the % MOD control.

3.7 A.L.C. AND MODULATION AMPLIFIER

The valve V102 combines the functions of audio amplifier, automatic level control (a.l.c.), and cathode follower output for screen modulating the oscillator valve, V101. The circuit arrangement is shown in Fig. 3.6.

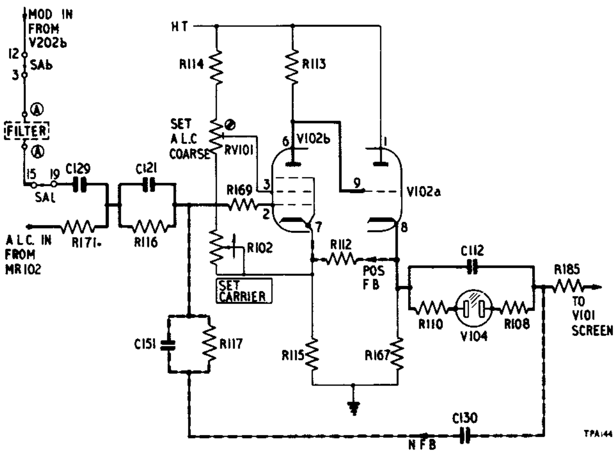


Fig. 3.6 A. L. C. and Modulation Amplifier

Modulating voltages are applied to the grid of V102b from V202b via either of two filter networks and the additional feed and filter components C129, C121 and R116. D.C. coupling is employed between the anode of V102b and grid of the cathode follower V102a - the r.f. output carrier being then modulated by the variation in voltage output at the cathode of V102a.

A. L. C. is obtained by rectifying part of the oscillator output (via C104 and MR102), and applying the resultant d.c. to the grid of V102b, where it is compared with the reference potential set up across R115. For any change in r.f. output, a difference voltage appears at the anode of V102b, and hence the grid of V102a. The level at which the a.l.c. operates depends upon the adjustment of the SET CARRIER control RV102, and the setting of the preset resistor RV101. The SET CARRIER control can be considered as a fine control adjustment to the output carrier level. Since its range of adjustment is small, there is no risk of damage to the thermocouple in the meter monitoring circuit when using the instrument, provided, of course, that the preset resistor RV101 has been previously correctly adjusted.

The heater of V102 (together with the heaters of V101 and V103) is supplied with 6.3 volts d.c. from the stabilized l.t. supply.

3.8 CRYSTAL CALIBRATOR

The purpose of the calibrator is to provide accurate audio calibration markers for standardizing the main tuning dial calibration, and hence the carrier frequency.

Double triode V103 functions as a crystal oscillator/mixer which combines a small portion of the main oscillator output with the oscillations produced by a 400-kc/s or 2-Mc/s crystal. The beat-note output from this valve is then applied via V204 to the PHONES jack.

Triode section V103b is connected in a Colpitts oscillator circuit arrangement;

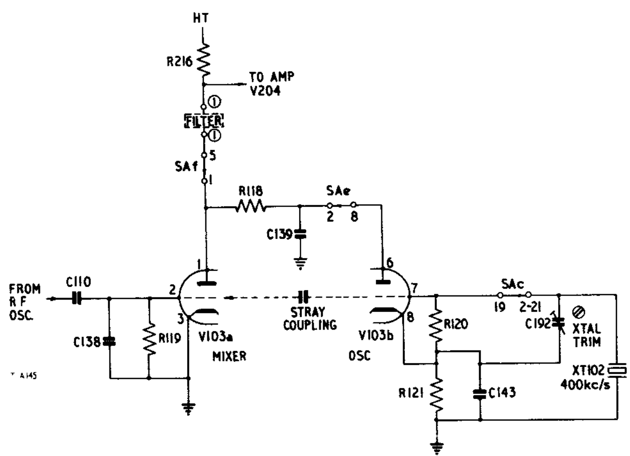


Fig. 3.7 Crystal Calibrator - Ranges A to D

switch section S(100)Ac (SET FREQ RANGE) control) selects the crystal frequency appropriate to the selected frequency range, while section S(100)Ad short circuits the out-of-use crystal.

On ranges A to D, as shown in Fig. 3.7, the 400 kc/s crystal is in circuit; on ranges E and F the 2-Mc/s crystal is used. On all these six ranges, switch wafers S(100)Ae and S(100)Af connect the anode load R216 to the anode of V103a. The h.t. voltage for V103b is obtained via R118 which bridges the two anodes on these ranges. Signal mixing takes place as a result of the stray coupling from triode section V103b.

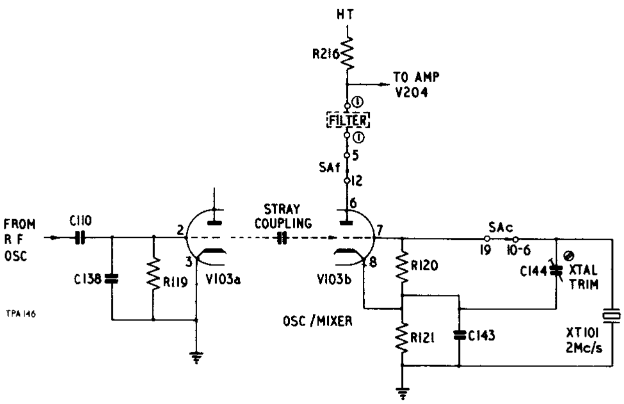


Fig. 3.8 Crystal Calibrator - Ranges I to L

On ranges G and H, the 400-kc/s crystal is in circuit; on ranges I, J, K, and L, as shown in Fig. 3.8, the 2-Mc/s crystal is selected. On these six ranges, resistor R216 is connected to the anode of V103b. The triode section V103a is not energized but provides stray coupling for mixing to take place in V103b.

Switch section S(200)Bd breaks the h.t. supply to the crystal calibrator circuit in all positions other than CRYSTAL CHECK.

3.9 CRYSTAL CALIBRATOR AMPLIFIER

When the function selector is set to CRYSTAL CHECK, output from the crystal calibrator is applied to V204 now functioning as an audio amplifier and cathode follower as shown in Fig. 3.9.

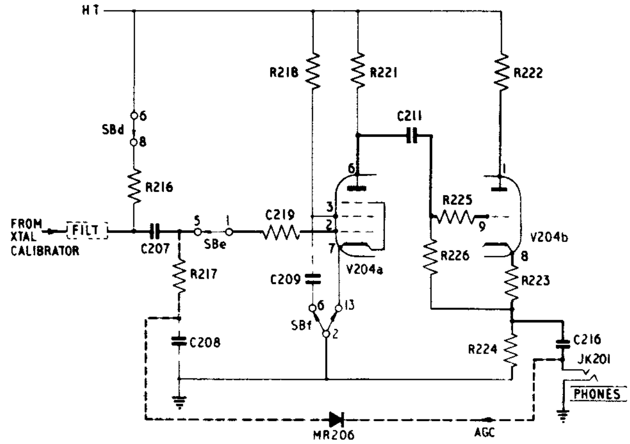


Fig. 3.9 V204 switched as Crystal Calibrator Amplifier

The PHONES jack is connected across the cathode follower (V204b) output at the junction of R224/223, while the signal at this junction is also rectified and applied as a.g.c. to the grid of V204a, via C216 and the a.g.c. diode, MR206. The use of a.g.c. in this circuit arrangement ensures that the level of the audio beat note, used when checking the main tuning dial calibration, remains reasonably constant over the wide frequency coverage of the Generator.

The switch sections, and associated circuit changes, are as follows :-

S(200)Be :

Transfers the grid of V204a to the output of the crystal calibrator at C207.

S(200)Bf :

Connects V204a screen decoupling capacitor C209 to earth, and short-circuits the cathode resistor R220.

S(200)Bg :

Restores the cathode follower resistor R224 to the circuit. Makes the a.g.c. operative by breaking the earth connection. Earths the junction C210/TH201.

3.10 OUTPUT ATTENUATORS

Series connected coarse and fine attenuators between the r.f. oscillator and the R.F. OUTPUT socket provide adjustment of the e.m.f. from the Generator between 2 μV and 2 volts in 1-dB steps. A plug-on 20-dB attenuator pad accessory extends the range down to 0.2 μV. Of the two R.F. OUTPUT controls, the lower knob controls the coarse attenuator, in 10-dB steps, while the dial above it provides a fine interpolation adjustment between 0 and 10 dB. When switched for c.w. working, a fine interpolation between the 1-dB steps of the attenuator can be made by making use of the ±0.5 dB marks on the meter in conjunction with adjustment to the SET CARRIER control.

For any movement of the attenuators, the voltage range covered by the dial, and the number of dB's to be added to those indicated, are shown in the window adjacent to the coarse control knob.

The coarse attenuator consists of a conventional ladder network giving a stepped attenuation while at the same time maintaining a 50-ohm output impedance. A bridged T-network is used for the fine attenuator - both ends of the series resistors being switched to provide a good v.s.w.r. The capacitors C146 to C150 connected across the shunt resistors associated with the five highest attenuation switch positions, compensate for the inductive effect exhibited by these resistors.

When the controls are moved to correspond with 126 dB, both attenuators are switched out of circuit thereby avoiding any shunting effect.

3.11 DIRECT OUTPUT

A connection between pin 7 of the turret and the DIRECT OUTPUT socket provides, in conjunction with the setting of switch S100c, two levels of output.

In the NORMAL position of the switch the output e.m.f. is the same as at the R.F. OUTPUT socket with both attenuators out of circuit. When S100c is turned to HIGH, RV104 is connected in series with the feed to the a.l.c. monitor and the level monitor, thus reducing the a.l.c. voltage and the sensitivity of the level monitor by corresponding amounts.

3.12 METER MONITORING

A panel meter continuously monitors the output from the oscillator via a thermocouple (TC102). Both c.w. and modulation reference levels are marked on the scale for use in conjunction with the SET CARRIER and SET MOD controls, in addition to the ±0.5 dB marks referred to in Section 3.10.

Fixed resistors R100, R186 and R198 set the approximate heater current flowing through the thermocouple, while RV103 provides a 'set carrier' preset adjustment. Protection of the thermocouple from possible overload damage is afforded by a limiting circuit comprising MR103, MR104 and C196 which prevents the voltage across the thermocouple exceeding 6.3 volts.

3.13 POWER SUPPLIES

The instrument is designed to operate from either a.c. mains, or external h.t. (240 volts) and l.t. (6 volts) batteries.

The internal power supplies are provided by a mains transformer whose primary windings may be connected in series/parallel for 100- to 130-volt operation, or in series for 200- to 250-volt operation. Tappings on these windings permit connections to be made to suit intermediate voltages within each range.

The secondary windings LT2 and LT3 provide a.c. heater current for the valves V201, V202, V204 and also the pilot lamp PLP201; winding LT1 supplies the valves V101, V102 and V103 via full-wave rectifier MR205 and its associated smoothing and regulating circuits.

H.T. supply is obtained from the secondary winding of the mains transformer; full-wave rectification is employed using eight bridge-connected rectifiers MR201 to MR204 and MR207 to MR210, while resistance-capacitance smoothing is effected by means of reservoir capacitor C201 and the regulator circuit.

Removing the mains input socket SKT 202 from the front panel plug PL201, and replacing it with the battery connector socket SKT 201, automatically adjusts the circuit connections to suit the d.c. inputs. The circuit adjustments are as follows :-

(1) The h.t. circuit from the cathode of V201 via pins 1 and 2 of PL201 is broken. The battery supply h.t. positive is connected to pin 1.

(2) The d.c. l.t. supply to V101, V102 and V103 is broken at pins 11 and 12, and the 6-volt battery positive supply is connected to pin 12.

(3) The earth connection is removed from the bottom of the LT3 heater winding, but remains connected to pin 10 so as to provide the common l.t./h.t. connection from the batteries. The 6-volt battery supply is applied to the heaters of V202 and V204 via the LT3 secondary winding - the voltage drop due to the resistance of the winding being negligible.

The same front panel switch S(200)A is used for both main and battery operation. The fuse FS201 protects the rectified h.t. supply only.

H. T. Regulation

The h.t. is stabilized by means of a conventional series regulation valve (V201), and an error amplifier (V202).

Error voltages are sampled at the grid of V202 via the preset resistor RV201 which forms part of a potentiometer connected across the regulated h.t. supply. The reference potential for the cathode of V202 is obtained from the tapping at the junction of R209 and the voltage reference tube V203.

A degree of forward control is effected by means of the V202 screen voltage connection via R204 to the unregulated h.t. supply, thus ensuring maximum stability against changes in mains input supply.

L. T. Regulation

The l.t. stabilizing circuit is similar in operation to the h.t. circuit, using a series element as the main regulator.

The transistor VT201 functions as the series element between the negative side of the rectifier MR101 and the common heater/chassis return circuit. Error signals are amplified by VT203 and applied to VT201 via the emitter follower VT202. Positive feedback forward control is applied to VT202 via R211; the thermistor BR201 compensates for changes in temperature, while C204 prevents instability occurring round the feedback loop.

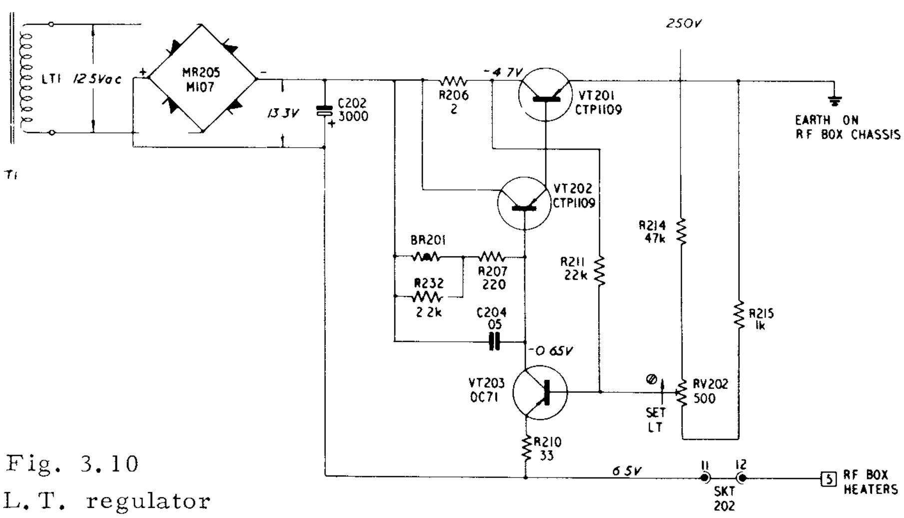


Fig. 3.10
L. T. regulator

4 MAINTENANCE

.1 GENERAL

The maintenance information in this nstruction book enables you to carry out nost of the setting up, testing and repairing nat may be required on this instrument.

For routine inspection of the instrument ollow the instructions given in Section 4.7 - 'erformance Checks.

For fault location, first refer to Section .6 - Valve Failure and Replacement, since alves are the most likely source of trouble; ection 4.4 - Static Voltages, will also help locate a fault, as will the routine check-ut in Section 4.7. Where performance is narginal, the source of trouble can often be dentified by moving to a higher primary apping on the mains transformer, which ffectively decreases the supply voltage; nis may exaggerate the weakness and make easier to trace.

Always look out for obvious signs of ailure, such as cold valves, burnt-out esistors and other overheating symptoms, lash-over marks and blown fuses. Inspect or bad soldering and dry joints by noting hanges in performance caused by gently apping the joints with an insulated prod - but e careful of high voltages.

In case of difficulties that cannot be leared by means of this instruction book, or or general advice on servicing the instru-nent, please write or phone our Service epartment or nearest Area office. Always nention the type number and serial number f your instrument. (For addresses, see ear cover.)

If the instrument is being returned for epair please indicate clearly the nature of ne fault or the work you require to be done.

4.2 MAINS INPUT ARRANGEMENT

The Generator is fitted with a mains transformer which has a double wound primary winding. The two sections may be connected either in series-parallel, or in series, depending on whether the instrument is to be used for 100- to 130-volt, or 200- to 250-volt operation. Each primary section is tapped, and the connections brought out to a voltage adjustment panel available through an aperture at the rear of the case.

Mains input adjustments are made by means of four two-pin plugs which make contact with the connections to the transformer through a reversible masking plate. This plate is annotated on one side with voltages applicable to 100- to 130-volt range, and on the other side with voltages applicable to the 200- to 250-volt range. All the possible plug combinations to suit the input voltage range covered by the instrument are shown.

The instrument is normally despatched with its mains input adjusted for 240-volt operation. To alter the input to suit the voltages within the 100- to 130-volt range, it is merely necessary to remove the four two-pin plugs, reverse the cover plate, and then replace the plugs so that their positions correspond to the appropriate diagram in Fig. 4.1.

Switch off the supply before making an adjustment. The two fixing screws that secure the tapping panel to the sub chassis are at the potential of VT201 collector which is about -5 volts d.c. relative to the main chassis.

If the plugs are stiff to remove, lubricate the pins with a thin smear of petroleum jelly.

SUPPLY VOLTAGE PANEL

Masking plate and links must be positioned according to supply voltage, as shown :-

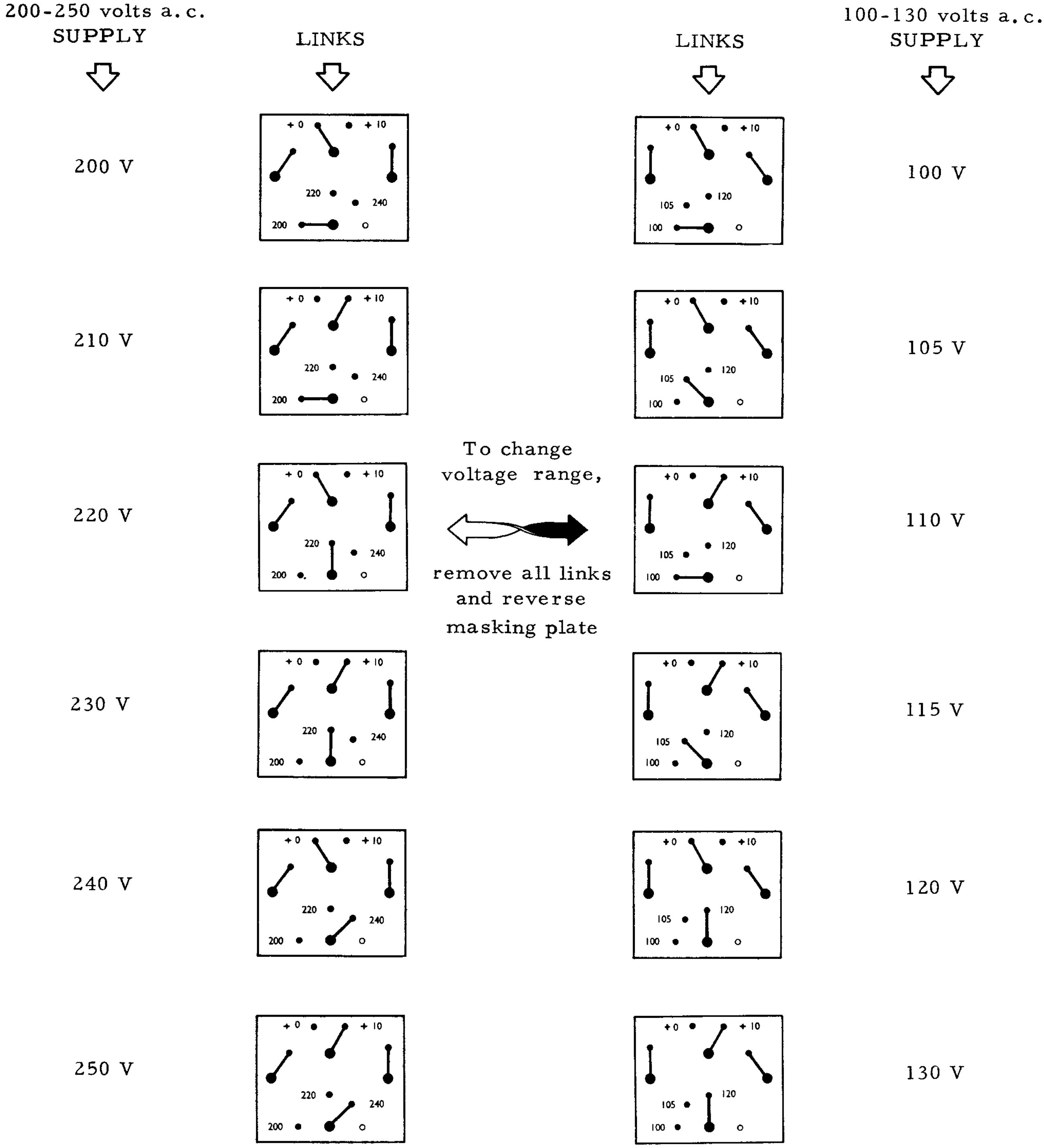


Fig. 4.1 Supply Voltage Plug Settings

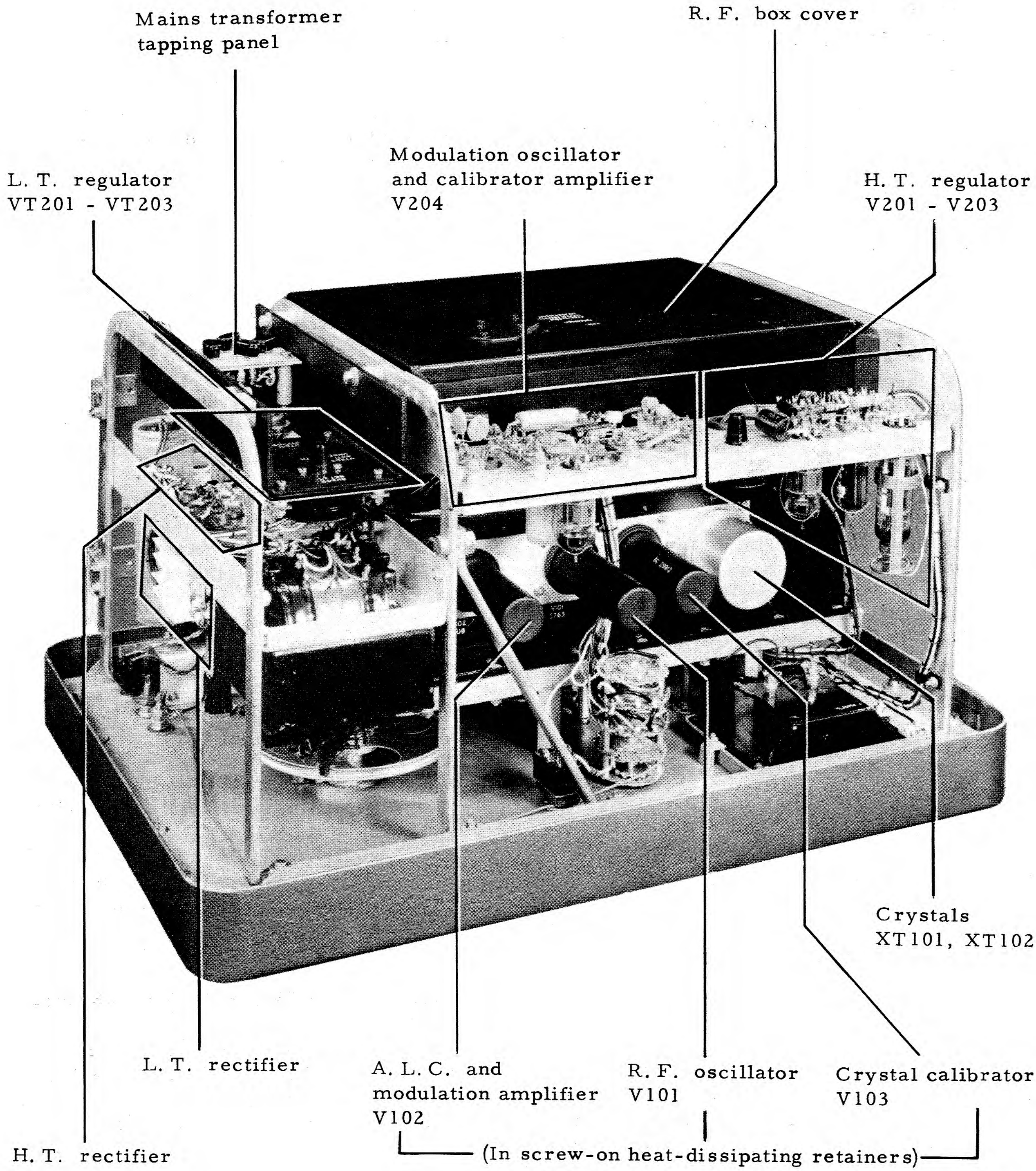


Fig. 4.2 General Arrangement of TF 144H/4

4.3 REMOVAL OF CASE —ACCESS TO COMPONENTS

To remove the case, stand the instrument face downwards, and take out the four screws at the back and the four at the bottom of the case. Lift the case clear, complete with the aluminium trim.

All valves are now accessible, and their location is shown in Fig. 4.2. All presets can be adjusted without removing the r.f. box cover; RV101, RV103 and RV104 through holes in the bottom of the cover, C144 and C192 through holes inside the crystal screening can.

R. F. BOX

To open the r.f. box remove the four cover fixing screws, two on each side, and lift off the cover. To get at many of the components it may also be necessary to remove the coil turret which can be done quite easily as follows :-

(1) Turn the turret to a position between two ranges to disengage the contacts beneath the turret. Be careful not to disturb any of the coil windings or preset controls.

(2) Undo the three screws around the drive shaft.

(3) Lift off the coil turret, watching out for the side thrust exerted by the detent spring.

To replace the turret, first make sure the drive is still between two ranges. Locate the turret so that the spigot in the shaft plate engages in the hole near the 'L' segment of the turret.

FINE ATTENUATOR

To remove the Fine Attenuator assembly :-

(1) Slacken the set-screw in the fine attenuator knob.

(2) Remove the four fixing screws of the R. F. OUTPUT socket.

(3) Remove the six fixing screws from the attenuator housing inside the r.f. box and withdraw the assembly far enough to allow its input coaxial connector to be unplugged.

(4) Completely withdraw the assembly with the output lead attached.

(5) Take off the housing after removing the four hexagon-headed screws near the rim of the housing.

When replacing the assembly note that the input lead is at the 6 o'clock position. Before tightening the set screw make sure that the dial reads 6.4 on the red scale when the switch is fully counter-clockwise.

COARSE ATTENUATOR

Replacement of resistors in the coarse attenuator is not practical. Although it is possible to get at the resistors by removing the spur gears and rear cover plate, the spring mechanism inside the attenuator will be released and can only be re-set by a procedure beyond the scope of this handbook.

4.4 STATIC VOLTAGES AND CURRENTS

The voltages on the circuit diagrams are representative of those obtained with a 20 kΩ/volt multi-range meter, such as an Avometer Model 8, set to its highest convenient range.

R. F. Box Voltages and Currents

Valve electrode voltages for V101 and V102 in the r.f. box are difficult to obtain since the presence of the test meter influences both the oscillatory conditions and the level of the a.l.c. voltage. Therefore, it is better to rely on the current measurements given in the table below. The r.f. oscillator screen and modulator cathode voltages, however, can conveniently be checked by measuring the voltage to chassis from each side of capacitor C112. Checking the currents and voltages against the values given in the table provides a guide to the efficiency of the oscillator over any band and will help to locate discrepancies and variations in range coils.

Range	Frequency	C112 +ve	C112 -ve	R.F. Box current† (c.w. condition)
A	10 kc/s	90 V	30 V	8 mA
	20 kc/s	82 V	25 V	7 mA
B	20 kc/s	82 V	24 V	6.65 mA
	40 kc/s	75 V	20 V	5.9 mA
C	40 kc/s	86 V	29 V	7.2 mA
	80 kc/s	86 V	30 V	7.05 mA
D	80 kc/s	86 V	28 V	8 mA
	200 kc/s	80 V	24 V	7.45 mA
E	200 kc/s	76 V	18 V	6.3 mA
	535 kc/s	70 V	15 V	5.4 mA
F	535 kc/s	82 V	22 V	7.4 mA
	1605 kc/s	68 V	10 V	5.5 mA
G	1 Mc/s	89 V	31 V	8.5 mA
	2 Mc/s	86 V	21 V	6.8 mA
H	2 Mc/s	94 V	36 V	10 mA
	4 Mc/s	78 V	21 V	8.2 mA
I	4 Mc/s	125 V	62 V	13.0 mA
	8 Mc/s	100 V	30 V	9.5 mA
J	8 Mc/s	81 V	71 V	17 mA
	16 Mc/s	41 V	37 V	11.3 mA
K	16 Mc/s	81 V	71 V	19 mA
	32 Mc/s	80 V	37 V	12.8 mA
L	30 Mc/s	120 V	110 V	22 mA
	50 Mc/s	87 V	70 V	17.5 mA
	72 Mc/s	71 V	68 V	16.5 mA

† Measured by connecting a milliameter across the contacts of the CARRIER INTERRUPT switch and opening the switch.

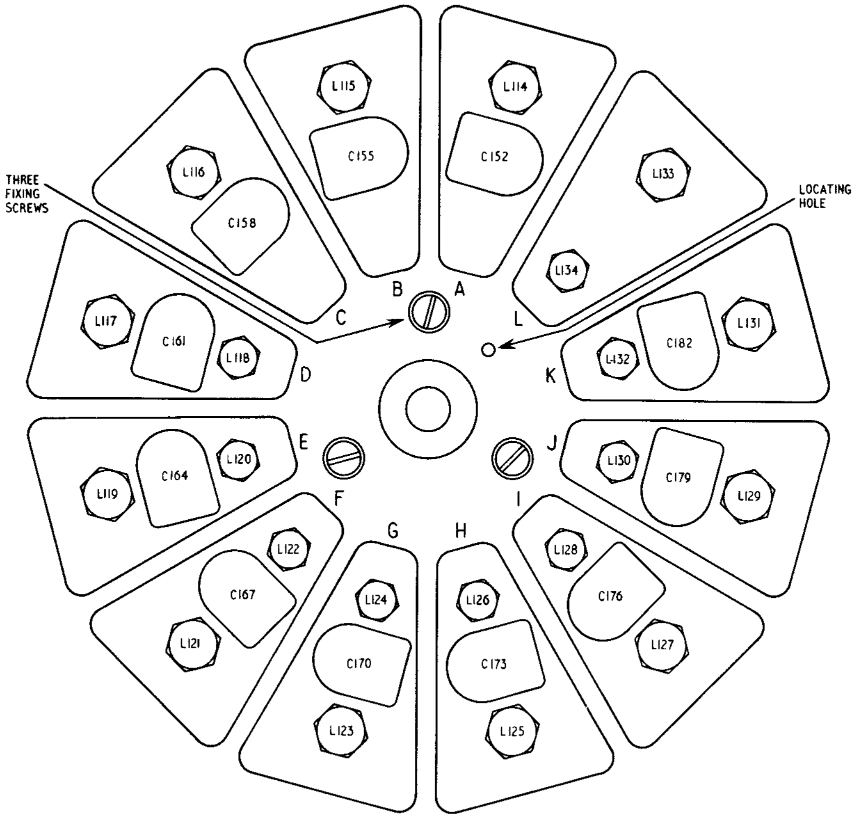


Fig. 4.4 Coil turret

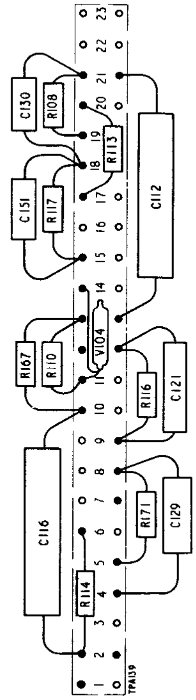


Fig. 4.5 A.L.C. & Mod. Amp. tagstrip

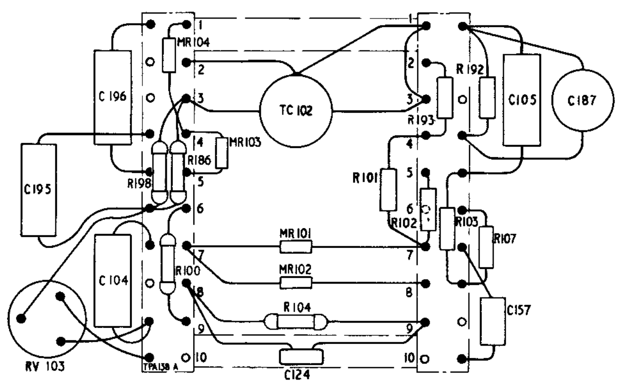


Fig. 4.6 Monitor tagstrip

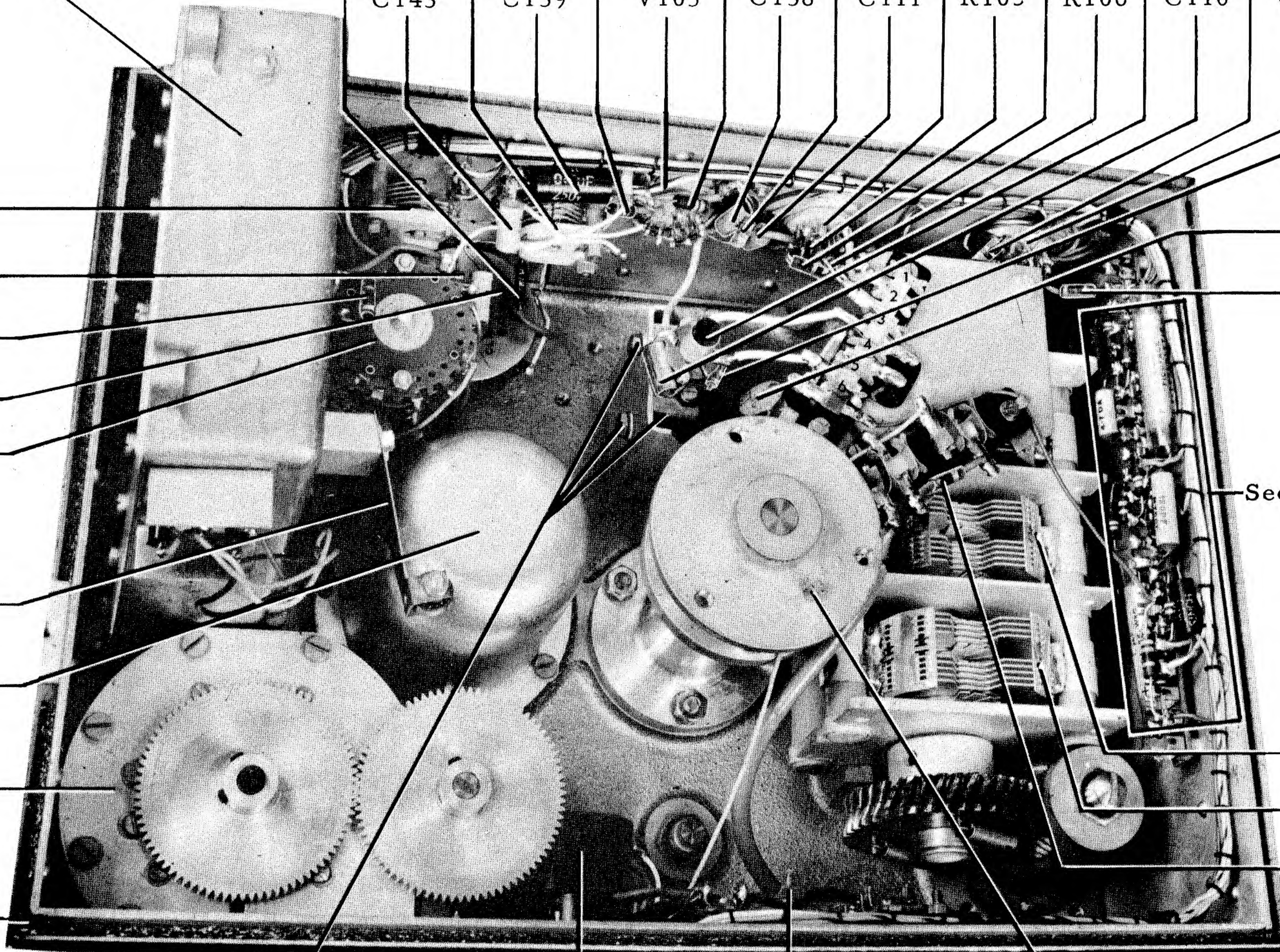


Fig. 4.3 R.F. Box interior

4.5 VALVE FAILURE AND REPLACEMENT

If the instrument becomes faulty, valve failure is the most likely cause; to help you locate a faulty valve, the main failure symptoms for each are included in the following table. Failure of a dual-purpose valve such as V102 and V204 can be readily diagnosed if faults are noted in both of its functions. For example: absence of crystal check points would indicate failure of either V103, the crystal oscillator, or V204, the crystal calibrator amplifier; but if modulation was also absent, this would definitely point to V204 since this valve is also the modulation oscillator.

When a valve is replaced, it is advisable to use the same type as the original fitted in the instrument: this is normally, but not necessarily, the type listed in the fourth column. If the original type is not available one of the equivalent types listed should be suitable. After fitting the new valve, carry out the performance check indicated in the last column.

Do not overlook the fact that the valve-failure symptoms and readjustments required may also apply to certain of the components associated with the valve.

After replacing any of the transistors, VT201 to VT203, carry out performance check No. 1B.

Valve No.	Function	Symptom of Failure	Type	Equivalents	Check Ref.
V101	R.F. oscillator	Low output	QV03-12	5763 CV2129	2C, 4A
V102	A.L.C. and mod. amplifier	Unstable output, low or distorted modulation	6U8	ECF82 CV5065	2D
V103	Crystal oscillator	Crystal check points weak	12AU7	ECC82 B329 6067 CV491 CV4003	3A, 3B
V104	Voltage Stabilizer	Low output, ranges A - H only	3L		2C
V201	H.T. Regulator	Unstable frequency, low output	6CJ6	EL81 CV2721	1A, 1C
V202	Regulator control and mod. cathode follower	Unstable frequency, low output	6U8	ECF80 ECF82 CV5065	1A, 5B
V203	Regulator reference tube	Unstable frequency, low output	5651	85A2 QS83/3 CV2573 CV449	1A
V204	Mod. oscillator and cal. amplifier	Low modulation, crystal check points weak	6U8	ECF80 ECF82 CV5065	5B, 3C

4.6 ADJUSTMENT OF PRESETS

Many of the operating parameters are brought within close limits by means of preset controls. These controls will not normally require adjustment except following the replacement of a valve or other component. When adjustment is necessary, it must be done in accordance with the performance check specified in the table.

Circuit Ref.	Function	Check Ref. (Section 4.7)
RV101	Adjust a.l.c. voltage. WARNING: Incorrect setting can burn out thermocouple.	2D
RV103	Standardize level meter indication.	2A
RV104	Set HIGH OUTPUT	2E
RV201	Set h.t. voltage.	1A
RV202	Set d.c. heater voltage to r.f. box.	1B
L114 L115 L116 L117 L119 L121 L123 L125 L127 L129 L131 L133	Standardize main tuning dial calibration at l.f. end of each range.	4A
L118 L120 L122 L124 L126 L128 L130 L132 L134	Set frequency coverage of FINE TUNING control.	4B
C144	Set 2000 kc/s crystal frequency.	3A
C152 C155 C158 C161 C164 C167 C170 C173 C176 C179 C182 C184	Standardize main tuning dial calibration at h.f. end of each range.	4A
C192	Set 400 kc/s crystal frequency.	3A

4.7 PERFORMANCE CHECKS

The following tests cover the setting-up of all circuits in the Signal Generator and the verification of the main points of performance.

Although a setting-up procedure is included for preset components in the r.f. oscillator coil turret such adjustments require a high degree of specialized experience for satisfactory results; you are therefore recommended not to make these adjustments unless it is strictly necessary. For advice on this and other servicing matters please consult Marconi Instruments Service Department or your local Area office - the addresses are given on the back cover.

(a) Multi-range volt-ammeter, 20 kΩ/volt; such as Avometer Model 8.

(b) Variable transformer, to suit supply voltage; such as Variac.

(c) D.C. supply, standardized at 2 and 2.3 volts.

(d) Frequency meter, 400 kc/s to 2 Mc/s, 0.002% accuracy; such as Marconi Instruments TF 1417, TF 1345, TME2.

(e) Valve voltmeter, a.f. to 2 Mc/s; such as Marconi Instruments TF 1100, TF 1300, TF 1041.

(f) Audio oscillator, 100 c/s to 10 kc/s, 100 mV to 20 volts monitored; such as Marconi Instruments TF 1101, TF 1370.

(g) Oscilloscope, a.f. to at least 30 Mc/s; such as Marconi Instruments TF 1330.

(h) A.F. Attenuator, continuously variable; such as Marconi Instruments TF 338.

REF & OPERATION	TEST EQUIPMENT - CONNECTIONS	CONTROL SETTINGS - CONDITIONS	MEASURE - TEST	IF INCORRECT ADJUST OR CHECK
1 POWER SUPPLY				
1A Set h.t.	(a)	Check T201 primary tap agrees with supply voltage.	Measure voltage at C206 +ve: 250 V d.c.	Adjust RV201.
1B Set l.t.	(a)	Check T201 primary tap agrees with supply voltage.	Measure voltage at Pin 5 of r.f. box tag-strip: 6.5 V d.c.	Adjust RV202.
1C H.T. and l.t. regulation.	(a) (b): connect in mains supply.	Check T201 primary tap agrees with supply voltage.	Vary supply voltage ±6%: check h.t. variation within ±0.5 V, l.t. variation within ±0.05V.	H.T.: check V201 (low emission) MR201 to MR210. L.T.: check VT201, VT202, MR205.
2 LEVEL MONITOR				
2A SET CARRIER calibration.	(c): connect 2.0 V to DIRECT OUTPUT.	RANGE control between two ranges. DIRECT OUTPUT switched to NORMAL.	Check meter reads at SET CARRIER mark.	Adjust RV103.
2B SET MOD calibration.	(c): connect 2.3 V to DIRECT OUTPUT.	RANGE control between two ranges. DIRECT OUTPUT switched to NORMAL.	Check meter reads at SET MOD mark.	Check TC102.
2C Output.	-	Select C.W., RANGE A.	Check SET CARRIER control can deflect meter reading beyond +0.5 dB mark. Repeat on all ranges.	Check V101. Check setting of RV101.

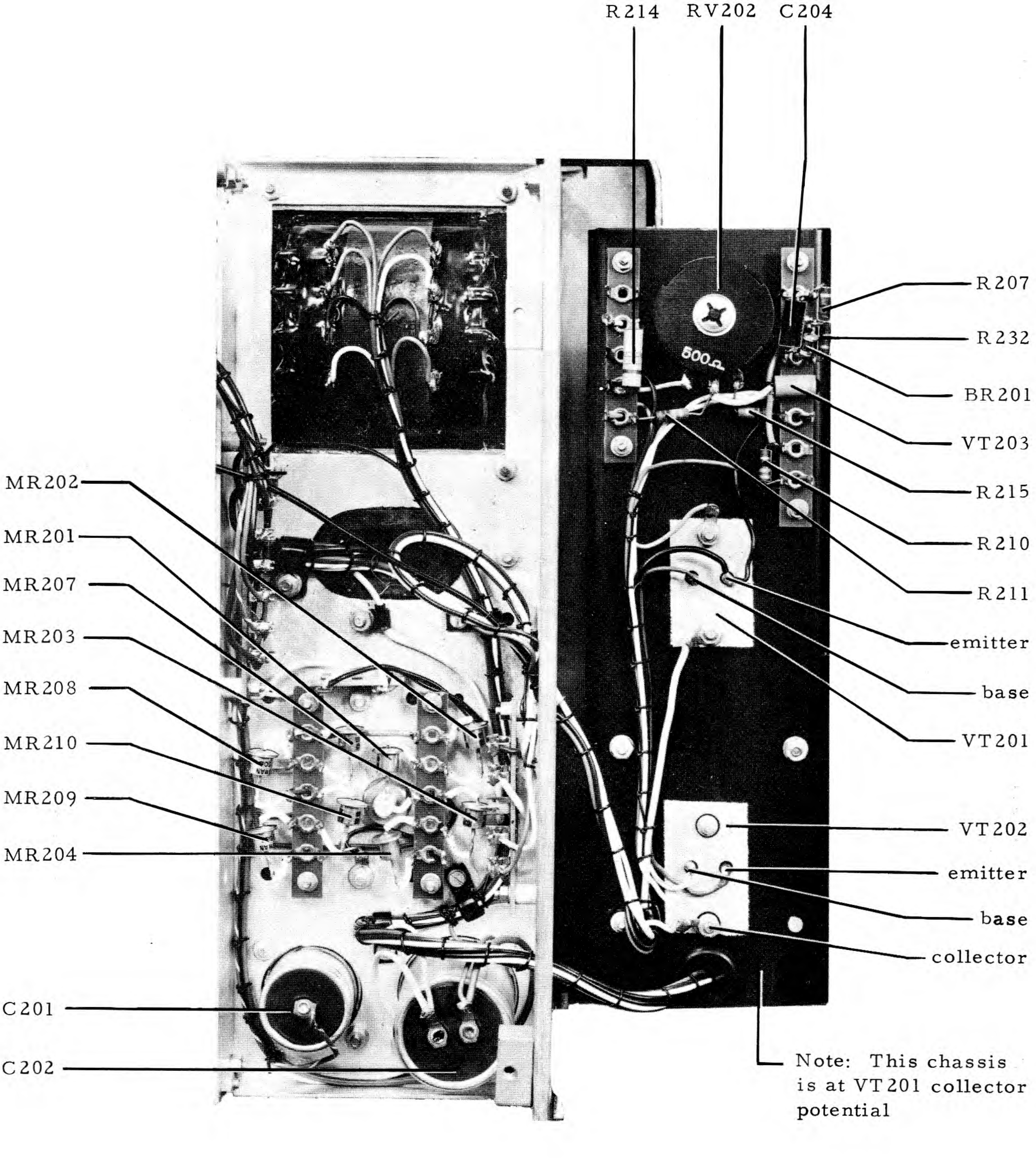


Fig. 4.7 H.T. Rectifier and l.t. regulator

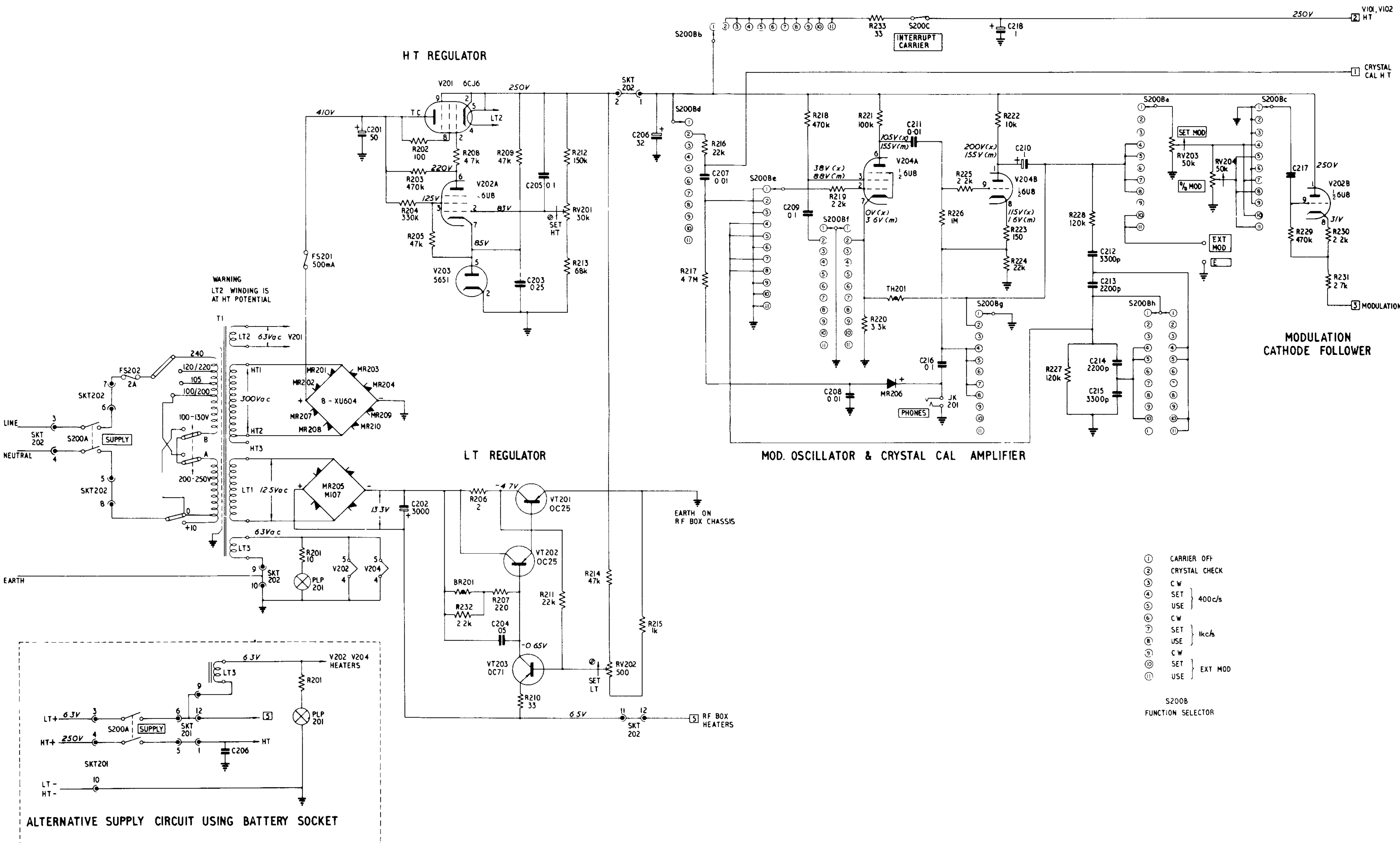


Fig 4·9 POWER SUPPLY AND MODULATION OSCILLATOR

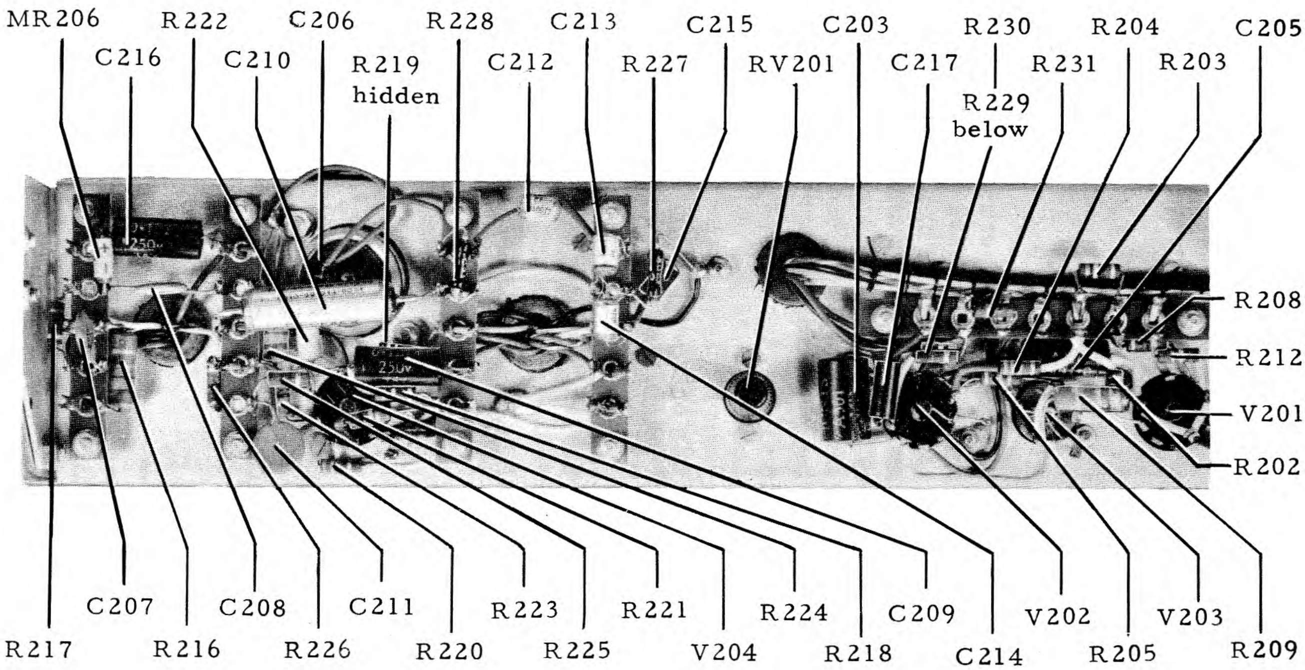
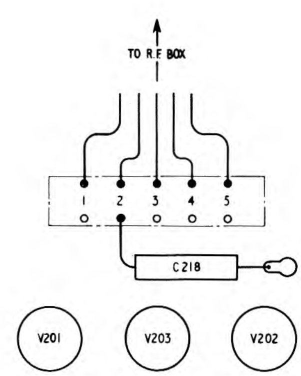


Fig. 4.8 H.T. regulator and V204 circuit



R.F. box tagstrip mounted on top of chassis

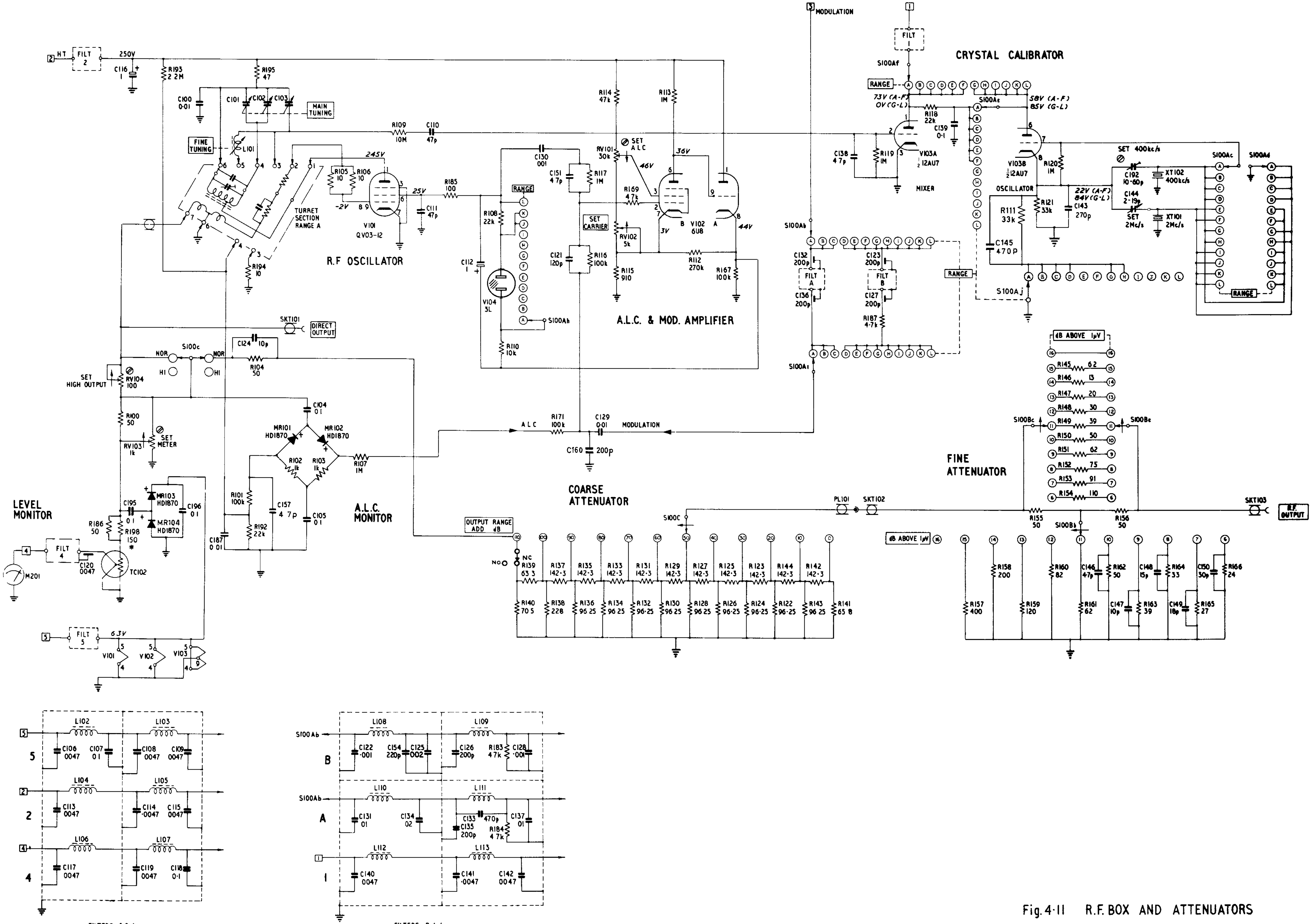


Fig. 4·11 R.F. BOX AND ATTENUATORS

REF & OPERATION	TEST EQUIPMENT - CONNECTIONS	CONTROL SETTINGS - CONDITIONS	MEASURE - TEST	IF INCORRECT ADJUST OR CHECK
2 LEVEL MONITOR (continued)				
2D A. L. C. action	-	Select C. W., RANGE D, main tuning to mid-scale. Meter to SET CARRIER.	Tune through all ranges; check meter variation within ±0.5 dB over any range and within 0.75 dB between ranges and that meter can be brought to SET CARRIER mark.	Adjust RV101 slightly.* Repeat Ref. 2C. *Turning RV101 too far clockwise may burn out thermocouple TC102.
2E Set HIGH OUTPUT	(c): connect 2.75 V to DIRECT OUTPUT.	RANGE control between two ranges. DIRECT OUTPUT switched to HIGH.	First check section 2A. Check meter reads at SET CARRIER mark.	Adjust RV104.
3 CRYSTAL CALIBRATOR				
3A Frequency	(d): couple to crystal circuit by looping wire round V103.	Select CRYSTAL CHECK (i) RANGE E (ii) RANGE A	(i) Measure frequency: 2000 kc/s. (ii) Measure frequency: 400 kc/s.	(i) Adjust C144. (ii) Adjust C192.
3B Crystal volts	(e)	Select CRYSTAL CHECK (i) RANGE E (ii) RANGE A	(i) Measure volts across XT101: 2.5 - 16 V. (ii) Measure volts across XT102: 2.5 - 16 V.	Check crystal, V103.
3C Cal. Amplifier A. G. C.	(f): apply 1 kc/s via capacitor to pin 1 of r.f. box tag-strip. (e): connect to plug in PHONES jack.	Select CRYSTAL CHECK RANGE control between two ranges.	Vary oscillator from 100 mV to 20 V and measure output at PHONES jack: 2 to 20 V.	Check MR206, V204, C208.

REF & OPERATION	TEST EQUIPMENT - CONNECTIONS	CONTROL SETTINGS - CONDITIONS	MEASURE - TEST	IF INCORRECT ADJUST OR CHECK
4 TUNING CONTROLS				
4A Main Tuning		Leave case on and allow 2 hour warm-up. Select C. W., CRYSTAL CHECK, and plug into PHONES jack. FINE TUNING to 0, SET CURSOR to bring cursor to arrow mark.	Tune to selected crystal check points on each range in turn and check dial accuracy is within ±1%.	At l.f. end of any band adjust appropriate coil: L114, L115 .... L133. At h.f. end adjust appropriate trimmer: C152, C155 .... C184.
4B Fine Tuning	(d): connect to R.F. OUTPUT.	Select C. W., main tuning to mid-scale.	On ranges D to L in turn check FINE TUNING control cover and accuracy.	If total cover wrong adjust appropriate coil: L118, L120 .....L134. If error asymmetric relative to 0 mark, adjust L101 mechanical setting (see Fig. 4.3).
5 MODULATION				
5A Frequencies	400 c/s (g): Y input to S200 Ba tag 1. (f): connect to X input.	Select 400 c/s MOD-SET.	Adjust a.f. source for Lissajous zero beat. Check frequency is 400 c/s ±5%.	Check C212, C215, R227, R228.
	1000 c/s (g): Y input to S200 Ba tag 1. (f): connect to X input.	Select 1000 c/s MOD-SET.	Adjust a.f. source for Lissajous zero beat. Check frequency is 1000 c/s ±5%.	If 400 c/s is correct, check C213, C214.

REF & OPERATION	TEST EQUIPMENT - CONNECTIONS	CONTROL SETTINGS - CONDITIONS	MEASURE - TEST	IF INCORRECT ADJUST OR CHECK
5 MODULATION (continued)				
5B Mod. Depth	(g): connect to HIGH OUTPUT.	Select C.W., 400 c/s MOD-SET.	Check SET MOD control can give meter reading at SET MOD mark on ranges C to L without apparent distortion.	Check a.f. voltage across RV203 is 15 V ±10%. Check V204, V202, C210.
5C Ext. Mod. Bandwidth	(f), (h): connect oscillator via attenuator to EXT. MOD terminals. Set oscillator to 1000 c/s 10 V; attenuator to 10 dB. (e): connect to C112 +ve.	Set % MOD for convenient voltmeter reading.	Keep oscillator output constant; vary frequency from 20 c/s to 20 kc/s and note that attenuator adjustment needed to keep voltmeter reading constant does not exceed ±1.2 dB.	Check filter response by transferring voltmeter to junction C127/R128.

SPARES ORDERING SCHEDULE

When ordering replacement parts, always quote the TYPE NUMBER and SERIAL NUMBER of the instrument concerned.

To specify the individual parts required, state for each part the QUANTITY required and the appropriate SOS ITEM NUMBER.

For example, to order replacements for the 1 kΩ resistor, R102, and the 0.1μF capacitor C104, quote as follows :

Spares required for TF 144H/4, Serial Number 000000

1 off, SOS Item 3
1 off, SOS Item 140

If the part required is not listed please state its location, function and description.

SOS No.	Circuit Ref.	Type	Value	Tolerance	Rating W at 55°C	Works Ref.
FIXED RESISTORS						
1	R100	Carbon filament	50 Ω	2%	1/4	10-TM 6714/1
2	R101	Deposited carbon	100 kΩ	10%	1/4	7-TM 6714/1
3	R102	" "	1 kΩ	10%	1/4	8-TM 6714/1
4	R103	" "	1 kΩ	10%	1/4	8-TM 6714/1
5	R104	Carbon filament	50 Ω	2%	1/4	70-TM 5993A/1
6	R105	Deposited carbon	10 Ω	10%	1/4	19-TM 6712/1
7	R106	" "	10 Ω	10%	1/4	19-TM 6712/1
8	R107	" "	1 MΩ	10%	1/4	9-TM 6714/1
9	R108	" "	22 kΩ	10%	1/4	8-TM 67`5
10	R109	" "	10 MΩ	10%	1/4	70-TM 6077
11	R110	" "	10 kΩ	10%	1/4	6-TM 6715
11/1	R111	" "	33 kΩ	10%	1/4	23-TM 6712/2
13	R112	" "	270 kΩ	10%	1/4	18-TM 6712/1
14	R113	" "	1 MΩ	10%	1/4	7-TM 6715
15	R114	" "	47 kΩ	10%	1/4	4-TM 6715
16	R115	" "	910 Ω	5%	1/4	69-TM 5993A/1
17	R116	" "	100 kΩ	10%	1/4	5-TM 6715
18	R117	" "	1 MΩ	10%	1/4	7-TM 6715
19	R118	" "	22 kΩ	10%	1/4	22-TM 6712/1

SOS No.	Circuit Ref.	Type	Value	Tolerance	Rating W at 55°C	Works Ref.

FIXED RESISTORS (continued)

20	R119	Deposited carbon	1 MΩ	10%	1/4	20-TM 6712/1
21	R120	" "	1 MΩ	10%	1/4	20-TM 6712/1
22	R121	" "	33 kΩ	10%	1/4	23-TM 6712/1
23	R122	Carbon filament	96.25 Ω	1%	1/8	36-TM 5990
24	R123	" "	142.3 Ω	1%	1/8	37-TM 5990
25	R124	" "	96.25 Ω	1%	1/8	36-TM 5990
26	R125	" "	142.3 Ω	1%	1/8	37-TM 5990
27	R126	" "	96.25 Ω	1%	1/8	36-TM 5990
28	R127	" "	142.3 Ω	1%	1/8	37-TM 5990
29	R128	" "	96.25 Ω	1%	1/8	36-TM 5990
30	R129	" "	142.3 Ω	1%	1/8	37-TM 5990
31	R130	" "	96.25 Ω	1%	1/8	36-TM 5990
32	R131	" "	142.3 Ω	1%	1/8	37-TM 5990
33	R132	" "	96.25 Ω	1%	1/8	36-TM 5990
34	R133	" "	142.3 Ω	1%	1/8	37-TM 5990
35	R134	" "	96.25 Ω	1%	1/8	36-TM 5990
36	R135	" "	142.3 Ω	1%	1/8	37-TM 5990
37	R136	" "	96.25 Ω	1%	1/8	36-TM 5990
38	R137	" "	142.3 Ω	1%	1/8	37-TM 5990
39	R138	" "	228 Ω	1%	1/8	41-TM 5990
40	R139	" "	63.3 Ω	2%	1/8	39-TM 5990
41	R140	" "	70.5 Ω	2%	1/8	40-TM 5990
42	R141	" "	65.8 Ω	2%	1/8	38-TM 5990
43	R142	" "	142.3 Ω	1%	1/8	37-TM 5990
44	R143	" "	96.25 Ω	1%	1/8	36-TM 5990
45	R144	" "	142.3 Ω	1%	1/8	37-TM 5990
46	R145	" "	6.2 Ω	2%	1/8	11-TM 5991
47	R146	" "	13 Ω	2%	1/8	12-TM 5991
48	R147	" "	20 Ω	2%	1/8	13-TM 5991
49	R148	" "	30 Ω	2%	1/8	16-TM 5991
50	R149	" "	39 Ω	2%	1/8	17-TM 5991
51	R150	" "	50 Ω	2%	1/8	19-TM 5991

SOS No.	Circuit Ref.	Type	Value	Tolerance	Rating W at 55°C	Works Ref.
FIXED RESISTORS (continued)						
52	R151	Carbon filament	62 Ω	2%	1/8	20-TM 5991
53	R152	" "	75 Ω	2%	1/8	21-TM 5991
54	R153	" "	91 Ω	2%	1/8	23-TM 5991
55	R154	" "	110 Ω	2%	1/8	24-TM 5991
56	R155	" "	50 Ω	2%	1/8	19-TM 5991
57	R156	" "	50 Ω	2%	1/8	19-TM 5991
58	R157	" "	400 Ω	2%	1/8	27-TM 5991
59	R158	" "	200 Ω	2%	1/8	26-TM 5991
60	R159	" "	120 Ω	2%	1/8	25-TM 5991
61	R160	" "	82 Ω	2%	1/8	22-TM 5991
62	R161	" "	62 Ω	2%	1/8	20-TM 5991
63	R162	" "	50 Ω	2%	1/8	19-TM 5991
64	R163	" "	39 Ω	2%	1/8	18-TM 5991
65	R164	" "	33 Ω	2%	1/8	17-TM 5991
66	R165	" "	27 Ω	2%	1/8	15-TM 5991
67	R166	" "	24 Ω	2%	1/8	14-TM 5991
68	R167	Deposited carbon	100 kΩ	10%	1/4	5-TM 6715
69	R168	" "	22 kΩ	10%	1/4	23-TM 6086
70	R169	" "	4.7 kΩ	10%	1/4	21-TM 6712/1
71	R170	" "	10 kΩ	10%	1/4	22-TM 6086
72	R171	" "	100 kΩ	10%	1/4	5-TM 6715
73	R172	" "	10 kΩ	10%	1/4	22-TM 6086
74	R173	" "	4.7 kΩ	10%	1/4	21-TM 6086
75	R174	" "	4.7 kΩ	10%	1/4	4-TM 6144/4
76	R175	" "	4.7 kΩ	10%	1/4	4-TM 6144/5
77	R176	" "	4.7 kΩ	10%	1/4	4-TM 6144/6
78	R177	" "	4.7 kΩ	10%	1/4	4-TM 6144/7
79	R178	" "	4.7 kΩ	10%	1/4	2-TM 6144/8
80	R179	" "	4.7 kΩ	10%	1/4	2-TM 6144/9
81	R180	" "	3.9 kΩ	10%	1/2	3-TM 6144/10
82	R181	" "	4.7 kΩ	10%	1/4	21-TM 6086
83	R182	" "	1 MΩ	10%	1/4	31A-TM 6144/11

SOS No.	Circuit Ref.	Type	Value	Tolerance	Rating W at 55°C	Works Ref.
FIXED RESISTORS (continued)						
84	R183	Deposited carbon	4.7 kΩ	10%	1/4	8-TM 5992
85	R184	" "	4.7 kΩ	10%	1/4	8-TM 5992
86	R185	" "	100 Ω	10%	1/4	17-TM 6712/1
87	R186	Carbon filament	50 Ω	2%	1/4	10-TM 6714/1
88	R187	Deposited carbon	4.7 kΩ	10%	1/2	66-TM 5993A/1
89	R188	" "	47 kΩ	10%	1/4	5-TM 6144
90	R189	" "	22 kΩ	10%	1/4	6-TM 6144/1
91	R190	" "	22 kΩ	10%	1/4	6-TM 6144/2
92	R191	" "	10 kΩ	10%	1/4	7-TM 6144/3
93	R192	" "	22 kΩ	10%	1/4	6-TM 6714/1
94	R193	" "	2.2 MΩ	10%	1/4	5-TM 6714/1
95	R194	" "	10 Ω	10%	1/4	67-TM 5993A/1
96	R195	" "	47 Ω	10%	1/2	68-TM 5993A/1
97	R196	" "	100 Ω*	10%	1/2	24-TM 6086
97/1	R197	Carbon filament	1 kΩ	10%	1/2	25-TM 6086
97/2	R198	" "	150 Ω*	10%	1/2	11-TM 6714/1
98	R201	Composition	10 Ω	10%	1/2	10-TM 6083
99	R202	Deposited carbon	100 Ω	10%	1/4	7-TM 6084
100	R203	" "	470 kΩ	10%	1/4	20-TM 6084
101	R204	" "	330 kΩ	10%	1/4	19-TM 6084
102	R205	" "	47 kΩ	10%	1/4	14-TM 6084
103	R206	Wire-wound	2 Ω	5%	9/70°C	25126-702
104	R207	Deposited carbon	220 Ω	10%	1/4	4-TM 6085
105	R208	" "	4.7 Ω	10%	1/4	11-TM 6084
106	R209	" "	47 kΩ	10%	1	13-TM 6084
107	R210	" "	33 Ω	10%	1/4	3-TM 6085
108	R211	" "	22 kΩ	10%	1/4	6-TM 6085
109	R212	" "	150 kΩ	10%	1/4	18-TM 6084
110	R213	" "	68 kΩ	10%	1/4	15-TM 6084
111	R214	Metal oxide	47 kΩ	10%	2	7-TM 6085
112	R215	" "	1 kΩ	10%	1/4	5-TM 6085

* Nominal value; actual value selected during test.

SOS No.	Circuit Ref.	Type	Value	Tolerance	Rating W at 55°C	Works Ref.
FIXED RESISTORS (continued)						
113	R216	Deposited carbon	22 kΩ	10%	1	12-TM 6084
114	R217	" "	4.7 MΩ	10%	1/4	24-TM 6084
115	R218	" "	470 kΩ	10%	1/4	20-TM 6084
116	R219	" "	2.2 kΩ	10%	1/4	9-TM 6084
117	R220	" "	3.3 kΩ	10%	1/4	6-TM 6084
118	R221	" "	100 kΩ	10%	1/4	16-TM 6084
119	R222	" "	10 kΩ	10%	1	22-TM 6084
120	R223	" "	150 Ω	10%	1/4	8-TM 6084
121	R224	" "	22 kΩ	10%	1	12-TM 6084
122	R225	" "	2.2 kΩ	10%	1/4	9-TM 6084
123	R226	" "	1 MΩ	10%	1/4	23-TM 6084
124	R227	Carbon filament	120 kΩ	2%	1/2	17-TM 6084
125	R228	" "	120 kΩ	2%	1/2	17-TM 6084
126	R229	Deposited carbon	470 kΩ	10%	1/4	20-TM 6084
127	R230	" "	2.2 kΩ	10%	1/4	9-TM 6084
128	R231	" "	2.7 kΩ	10%	1/4	10-TM 6084
129	R232	" "	2.2 kΩ	10%	1/4	11-TM 6085
130	R233	" "	33 Ω	10%	1/4	57-TF 144H/4

SOS No.	Circuit Ref.	Type	Value	Tolerance	Rating W at 70°C	Works Ref.
VARIABLE RESISTORS						
131	RV101	Wire-wound	30 kΩ		2	24-TM 6712/1
132	RV102	Wire-wound	5 kΩ		3	65-TM 5993A/1
133	RV103	Composition	1 kΩ		1/4	25-TM 6712/1
133/1	RV104	Composition	100 Ω		1/4	26-TM 6712/1
134	RV201	Wire-wound	30 kΩ		2	25-TM 6084
135	RV202	Wire-wound	500 Ω		2	9-TM 6085
136	RV203	Wire-wound	50 kΩ		3	58-TF 144H/4
137	RV204	Wire-wound	50 kΩ		3	58-TF 144H/4

SOS No.	Circuit Ref.	Type	Value	Tolerance	Rating Volts d.c.	Works Ref.
CAPACITORS						
38	C100	Ceramic	0.01 μF	+80% -20%	350	75-TM 5993A/1
	C101		200 pF			
39	C102	3-gang variable	200 pF			74-TM 5993A/1
	C103		200 pF			
40	C104	Paper	0.1 μF	20%	250	13-TM 6714/1
41	C105	"	0.1 μF	20%	250	13-TM 6714/1
42	C106	Lead-through	4,700 pF	Min	350	17-TM 5992
43	C107	Paper	0.1 μF	10%	250	22-TM 5992
45	C108	Lead-through	4,700 pF	Min	350	17-TM 5992
46	C109	Ceramic	4,700 pF	Min	500	18-TM 5992
47	C110	"	47 pF	10%	750	7E-TM 6077
48	C111	"	47 pF	10%	750	27-TM 6712/1
49	C112	Electrolytic	1 μF	20%	275	16-TM 6715
50	C113	Lead-through	4,700 pF	Min	350	17-TM 5992
51	C114	"	4,700 pF	Min	350	17-TM 5992
52	C115	Ceramic	4,700 pF	Min	500	18-TM 5992
53	C116	Electrolytic	1 μF	20%	275	16-TM 6715
54	C117	Lead-through	4,700 pF	Min	350	17-TM 5992
55	C118	Paper	0.1 μF	20%	250	22-TM 5992
56	C119	Lead-through	4,700 pF	Min	350	17-TM 5992
57	C120	Ceramic	4,700 pF	Min	500	18-TM 5992
58	C121	"	120 pF	10%	750	14-TM 6715
59	C122	Paper	1,000 pF	10%	400	23-TM 5992
60	C123	Lead-through	200 pF	20%	500	21-TM 5992
60/1	C124	Ceramic	10 pF	0.5 pF	750	76-TM 5993A/1
61	C125	Paper	2,000 pF	10%	350	25-TM 5992
62	C126	Lead-through	200 pF	20%	350	20-TM 5992
63	C127	"	200 pF	20%	350	20-TM 5992
64	C128	Paper	1,000 pF	10%	400	23-TM 5992
65	C129	"	0.01 μF	20%	400	15-TM 6715
66	C130	"	1,000 pF	20%	400	13-TM 6715
67	C131	"	0.01 μF	10%	150	24-TM 5992

SOS No.	Circuit Ref.	Type	Value	Tolerance	Rating Volts d.c.	Works Ref.

CAPACITORS (continued)

SOS No.	Circuit Ref.	Type	Value	Tolerance	Rating Volts d.c.	Works Ref.
168	C132	Lead-through	200 pF	20%	350	20-TM 5992
169	C133	Ceramic	470 pF	20%	500	28-TM 5992
170	C134	Paper	0.02 μF	10%	150	26-TM 5992
171	C135	Lead-through	200 pF	20%	350	20-TM 5992
172	C136	"	200 pF	20%	500	21-TM 5992
173	C137	Paper	0.01 μF	10%	150	24-TM 5992
174	C138	Ceramic	4.7 pF	10%	750	28-TM 6712/1
175	C139	Paper	0.1 μF	20%	250	31-TM 6712/1
176	C140	Lead-through	4,700 pF	Min	350	17-TM 5992
177	C141	"	4,700 pF	Min	350	17-TM 5992
178	C142	Ceramic	4,700 pF	Min	500	18-TM 5992
179	C143	"	270 pF	10%	500	29-TM 6712/1
180	C144	Trimmer	2-19 pF		500 V pk	32-TM 6712/1
180/1a	C145	Ceramic	470 pF	10%	500	26361-031
182	C146	"	4.7 pF	10%	750	36-TM 5991
183	C147	"	10 pF	10%	750	37-TM 5991
184	C148	"	15 pF	10%	750	38-TM 5991
185	C149	"	18 pF	10%	750	39-TM 5991
186	C150	"	30 pF	10%	750	40-TM 5991
187	C151	"	4.7 pF	10%	750	12-TM 6715
188a	C152	Trimmer	4-20.5 pF		500 V pk	9-TM 6144
189	C153	Ceramic	82 pF	5%	750	31-TM 6086
190	C154	Paper	220 pF	20%	600	29-TM 5992
191a	C155	Trimmer	4-20.5 pF		500 V pk	9-TM 6144/1
192	C156	Ceramic	91 pF	5%	750	32-TM 6086
193	C157	"	4.7 pF ±0.5 pF		750	26321-052
194a	C158	Trimmer	4-20.5 pF		500 V pk	9-TM 6144/2
195	C159	Ceramic	82 pF	5%	750	31-TM 6086
195/1	C160	Paper	200 pF	20%	600	26174-116
197a	C161	Trimmer	4-20.5 pF		500 V pk	9-TM 6144/3

SOS No.	Circuit Ref.	Type	Value	Tolerance	Rating Volts d.c.	Works Ref.

CAPACITORS (continued)

SOS No.	Circuit Ref.	Type	Value	Tolerance	Rating Volts d.c.	Works Ref.
198	C163	Ceramic	1,000 pF	+40% -20%	500	8-TM 6144/4
199a	C164	Trimmer	4-20.5 pF		500 V pk	12-TM 6144/4
200	C166	Ceramic	1,000 pF	+40% -20%	500	8-TM 6144/5
201a	C167	Trimmer	4-20.5 pF		500 V pk	12-TM 6144/5
202	C169	Ceramic	1,000 pF	+40% -20%	500	8-TM 6144/6
203a	C170	Trimmer	4-20.5 pF		500 V pk	12-TM 6144/6
204	C171	Ceramic	91 pF	5%	750	32-TM 6086
205	C172	"	1,000 pF	+40% -20%	500	8-TM 6144/7
206a	C173	Trimmer	4-20.5 pF		500 V pk	12-TM 6144/7
207	C174	Ceramic	91 pF	5%	750	32-TM 6086
208	C175	"	220 pF	+40% -20%	500	8-TM 6144/8
209a	C176	Trimmer	4-20.5 pF		500 V pk	12-TM 6144/8
210	C177	Ceramic	82 pF	5%	750	31-TM 6086
211	C178	"	220 pF	+40% -20%	500	8-TM 6144/9
212a	C179	Trimmer	4-20.5 pF		500 V pk	12-TM 6144/9
213	C180	Ceramic	100 pF	5%	750	33-TM 6086
214	C181	"	470 pF	+40% -20%	500	9-TM 6144/10
215a	C182	Trimmer	4-20.5 pF		500 V pk	12-TM 6144/10
216	C183	Ceramic	10 pF	5%	750	29-TM 6086
217	C184	Trimmer	2-11 pF		500 V pk	36-TM 6086
218	C185	Polystyrene	150 pF	5%	350	30-TM 6086
219	C187	Ceramic	.01 μF	+80% -20%	350	15-TM 6714/1
220	C188	"	0.01 μF	20%	400	10-TM 6144
221	C189	"	0.01 μF	20%	400	10-TM 6144/1
222	C190	"	0.01 μF	20%	400	10-TM 6144/2
223	C191	"	0.005 μF	20%	400	11-TM 6144/3
224	C192	Trimmer	10-60 pF		350	33-TM 6712/1
225	C193	Ceramic	10 pF	5%	750	29-TM 6086
226	C194	"	10 pF	5%	750	29-TM 6086
227	C195	Paper	0.1 μF	20%	250	13-TM 6714/1
228	C196	"	0.1 μF	20%	250	13-TM 6714/1

SOS No.	Circuit Ref.	Type	Value	Tolerance	Rating Volts d.c.	Works Ref.
CAPACITORS (continued)						
229	C201	Electrolytic	50 μF	+50% -20%	500	21-TM 6083
230	C202	Electrolytic	3,000 μF	+100% -20%	25	22-TM 6083
231	C203	Paper	0.25 μF	20%	150	38-TM 6084
232	C204	"	0.05 μF	20%	150	18-TM 6085
233	C205	"	0.1 μF	20%	250	37-TM 6084
234	C206	Electrolytic	32 μF	+50% -20%	450	41-TM 6084
235	C207	Ceramic	0.01 μF	10%	350	36-TM 6084
236	C208	"	0.01 μF	10%	350	36-TM 6084
237	C209	Paper	0.1 μF	20%	250	37-TM 6084
238	C210	Electrolytic	1 μF	20%	275	39-TM 6084
239	C211	Ceramic	0.01 μF	10%	350	36-TM 6084
240	C212	Polystyrene	3,300 pF	2%	125	35-TM 6084
241	C213	"	2,200 pF	2%	125	34-TM 6084
242	C214	"	2,200 pF	2%	125	34-TM 6084
243	C215	"	3,300 pF	2%	125	35-TM 6084
244	C216	Paper	0.1 μF	20%	250	37-TM 6084
245	C217	Paper	0.05 μF	20%	250	40-TM 6084
246	C218	Electrolytic	1 μF	20%	275	39-TM 6084

'OS No.	Circuit Ref.	Description	Works Ref.
TRANSFORMERS & INDUCTORS			
247	T201	Mains Input Transformer	1-TM 6083
248	L101	Fine Tuning Coil	7-TM 6077
249	L102	Filter Coil	42-TM 5992
250	L103	"	42-TM 5992
251	L104	"	38-TM 5992
252	L105	"	38-TM 5992
253	L106	"	39-TM 5992
254	L107	"	39-TM 5992
255	L108	"	40-TM 5992
256	L109	"	40-TM 5992
257	L110	"	37-TM 5992
258	L111	"	37-TM 5992
259	L112	"	41-TM 5992
260	L113	"	41-TM 5992
261	L114	Range A Tuning Coil	12-TM 6144
262	L115	Range B "	20-TM 6144/1
263	L116	Range C "	21-TM 6144/2
264	L117	Range D "	22-TM 6144/3
265	L118	Filter Coil	23-TM 6144/3
266	L119	Range E Tuning Coil	15-TM 6144/4
267	L120	Filter Coil	18-TM 6144/4
268	L121	Range F Tuning Coil	26-TM 6144/5
269	L122	Filter Coil	18-TM 6144/5
270	L123	Range G Tuning Coil	27-TM 6144/6
271	L124	Filter Coil	18-TM 6144/6
272	L125	Range H Tuning Coil	31-TM 6144/7
273	L126	Filter Coil	18-TM 6144/7
274	L127	Range I Tuning Coil	15-TM 6144/8
275	L128	Filter Coil	18-TM 6144/8
276	L129	Range J Tuning Coil	27-TM 6144/9
277	L130	Filter Coil	18-TM 6144/9

SOS No.	Circuit Ref.	Description	Works Ref.

TRANSFORMER & INDUCTORS (continued)

278	L131	Range K Tuning Coil	29-TM 6144/10
279	L132	Filter Coil	18-TM 6144/10
280	L133	Range L Tuning Coil	30-TM 6144/11
281	L134	Filter Coil	32-TM 6144/11
282	L135	"	31-TM 6144/11

VALVES & VALVE HOLDERS

283	V101	Tetrode, type QV03-12	47-TM 6712/1
284		B9A holder for V101, with screw-on screening can	36-TM 6712/1
285		Earthing gasket, to fit under V101 can	TB 38141
286	V102	Triode pentode, type 6U8 (ECF82)	46-TM 6712/1
287		B9A holder for V102, with screw-on screening can	35-TM 6712/1
288		Earthing gasket, to fit under V102 can	TB 38141
289	V103	Double triode, type 12AU7 (ECC82)	48-TM 6712/1
290		B9A holder for V103, with screw-on screening can	35-TM 6712/1
291		Earthing gasket, to fit under V103 can	TB 38141
291/1	V104	Neon, type 3L	19-TM 6715
292	V201	Pentode, type 6CJ6 (EL81)	75-TM 6084
293		Holder for V201, type B9A	57-TM 6084
294		Retainer for V201, including spring	60-TM 6084
295		Top cap connector for V201	61-TM 6084

SOS No.	Circuit Ref.	Description	Works Ref.
		VALVES & VALVE HOLDERS (continued)	
296	V202	Triode pentode, type 6U8 (ECF82)	76-TM 6084
297		Holder for V202, type B9A	57-TM 6084
298		Retainer for V202	58-TM 6084
299	V203	Voltage reference tube, type 5651	77-TM 6084
300		Holder for V203, type B7G	56-TM 6084
301		Retainer for V203	59-TM 6084
302	V204	Triode pentode, type 6U8 (ECF82)	76-TM 6084
303		Holder for V204, type B9A	57-TM 6084
304		Retainer for V204	58-TM 6084
		CRYSTALS, HOLDERS & SCREENING CANS	
305	XT101	Crystal, 2,000 kc/s	38-TM 6712
306		Holder for XT101	40-TM 6712
307		Clip, to retain XT101	41-TM 6712
308	XT102	Crystal, 400 kc/s	39-TM 6712
309		Holder for XT 102	40-TM 6712
310		Clip, to retain XT102	41-TM 6712
311		Screening can for crystals	TB 36644

SOS No.	Circuit Ref.	Description	Works Ref.

TRANSISTORS

312	VT201	Germanium Power, type OC 25	28-TM 6085
313	VT202	Germanium Power, type OC 25	28-TM 6085
314		Mica washer and two nylon bushes for VT202	30-TM 6085
315	VT203	Germanium A.F., type OC71	29-TM 6085

SEMICONDUCTOR DIODES

316	MR101	Gold-bonded, type HD 1870	16-TM 6714
317	MR102	" "	16-TM 6714
318	MR103	" "	16-TM 6714
319	MR104	" "	16-TM 6714
320	MR201	Silicon, type XU 604 (1N 540)	32-TM 6083
321	MR202	" " "	32-TM 6083
322	MR203	" " "	32-TM 6083
323	MR204	" " "	32-TM 6083
324	MR205	Selenium, type M107	31-TM 6083
325	MR206	Germanium general purpose, CV 425	52-TM 6084
326	MR207	Silicon, type XU 604 (1N 540)	32-TM 6083
327	MR208	" " "	32-TM 6083
328	MR209	" " "	32-TM 6083
329	MR210	" " "	32-TM 6083

SOS No.	Circuit Ref.	Description	Works Ref.
		THERMISTORS & THERMOCOUPLE	
330	TH201	Bead-type A15	51-TM 6084
331	BR201	Rod-type CZ3	10-TM 6085
332	TC102	V.H.F. Thermocouple	10-TM 6712
		LAMP & HOLDER	
333	PLP201	Pilot Lamp, 6.3 V, 0.15 A	68-TF 144H/4
334		Lamp holder, with bezel and lens	TB 5073
		FUSES & HOLDERS	
335	FS201	H.T. fuse, 500 mA	23411-256
336		Fuse-holder for FS201	TB 24330/1
337	FS202	Mains fuse, 2 A	91-TF 144H/4
338		Fuse-holder for FS202	TB 24330/1
		METER	
339	M201	Meter, rectangular, for TF 144H/4 or H/4R	TM 3970/99
340	M201	Meter, round, sealed, for TF 144H/4S or -H/6S	1-TM 6294

SOS No.	Circuit Ref.	Description	Works Ref.
JACK, PLUGS & SOCKETS & TERMINALS			
341	JK201	PHONES jack	73-TF 144H/4
342	PL101	BNC plug for coarse attenuator	2-TM 6027
343	SKT102	BNC socket for fine attenuator	2-TM 4726/95
344	PL201	12-pin SUPPLY plug	72-TF 144H/4
345	SKT201	12-pin battery socket	1-TM 6122
346	SKT202	12-pin mains socket	2-TM 4726/77
347		Supply adaptor for PL201, for TF 144H/4S, TF 144H/6S	TM 6263
348	SKT101	BNC socket, DIRECT OUTPUT	84-TM 5993A/1
349		Cap and chain for SKT101	77-TF 144H/4
350	SKT103	BNC socket, R.F. OUTPUT	2-TM 6096
351	TP201	EXT. MOD. terminal	112-TF 144H/4
352	TP202	E. terminal	71-TF 144H/4
SWITCHES			
353	S(100)A	Wafer switch, FREQ. RANGE	18-TM 5993A/1
354	S(100)B	Wafer switch, OUTPUT E.M.F. (fine)	49-TM 5991
354/1	S(100)C	Wafer switch, DIRECT OUTPUT	110-TM 5993A/1
355	S(200)A	Switch, SUPPLY	69-TF 144H/4
356	S(200)B	Wafer switch, function selector	2-TM 6084
357	S(200)C	Switch, INTERRUPT CARRIER	66-TF 144H/4
KNOBS DIALS & DRIVES			
		Main Tuning Control	
358		Tuning dial ($7\frac{1}{2}$ inch dia.) blank	TC 30580
359		Range cursor	TB 29973
360		Window for tuning dial	TB 29974
361		Knob	TB 31044
362		Logging scale dial	TB 31391
363		Cursor for logging scale	TB 25273/9
364		Earthing spring, for tuning dial spindle	TA 12731A
365		Wire drive assembly, complete with end ferrules	TB 35165

SOS No.	Circuit Ref.	Description	Works Ref.
		KNOBS, DIALS & DRIVES (continued)	
		<u>Fine Tuning Control</u>	
366		Dial, blank	TB 31390
367		Cursor	TB 25273/9
368		Knob	TB 17848/4
		<u>Frequency Range Control</u>	
369		Knob	TB 17848/13
370		Chain drive	87-TM 5993A/1
		<u>Output E.M.F. Controls</u>	
371		Dial	TB 31042
372		Cursor	TB 25273/1
373		Knob, for fine attenuator	TB 23920/9
374		Knob, for coarse attenuator	TB 17848/4
375		Function selector knob	TB 17848/3
376		SET CARRIER knob	TB 17848/3
377		SET MOD knob	TB 17848/3
		<u>% MOD Control</u>	
378		Dial	TB 31516
379		Cursor	TB 25273/9
380		Knob	TB 23920/9

SOS No.	Circuit Ref.	Description	Works Ref.
MISCELLANEOUS			
381		Turret contact strip assembly (with 6 spring fingers)	TB 36672
382		Turret contact strip assembly (with 4 spring fingers)	TB 36673
383		Turret detent spring	TB 29926
384		Ball-race for detent spring	80-TM 5993A/1
385		Earthing gasket, monel-metal mesh, for r.f. box cover	113-TM 5993A/1
386		Mains tapping panel assembly, with plugs	TC 32089
387		Insulating spacer, supporting l.t. regulator chassis	TB 25002/146
388		Insulating washer, for l.t. regulator chassis screws	TB 2706/153
389		Instrument case, for TF 144H/4, -H/4S, -H/6S	TE 26860/1
390		Front panel surround, for TF 144H/4	TC 37819/1
390/1		Front panel surround for TF 144H/4S and TF 144H/6S	TC 37819/2
391		Aluminium trim, to fit between case and surround, for TF 144H/4, -H/4S, -H/6S	TD 23713/8
392		Dust cover, for TF 144H/4R	TE 31517
393		Cover plate, for access to transformer tapping panel	TB 30875
394		Plastic cover	98 TF 144H/4
395		Panel rail, for TF 144H/4R	TC 32885
396		Panel pillar, for TF 144H/4S, -H/6S	TB 33086
397		Case foot	TA 11420

NOTES

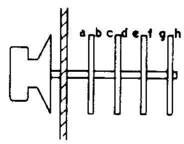
1. COMPONENT VALUES
Resistor : No suffix = ohms. K = kilohms. M = megohms.
Capacitors : No suffix = microfarads. p = picofarads.
* Value selected during test; nominal value shown.

2. VOLTAGES
These are d.c. and relative to chassis except where otherwise indicated.
Voltmeter : 20 kΩ/V model on highest convenient range
(X) : switched to CRYSTAL CHECK
(M) : switched to any MOD position

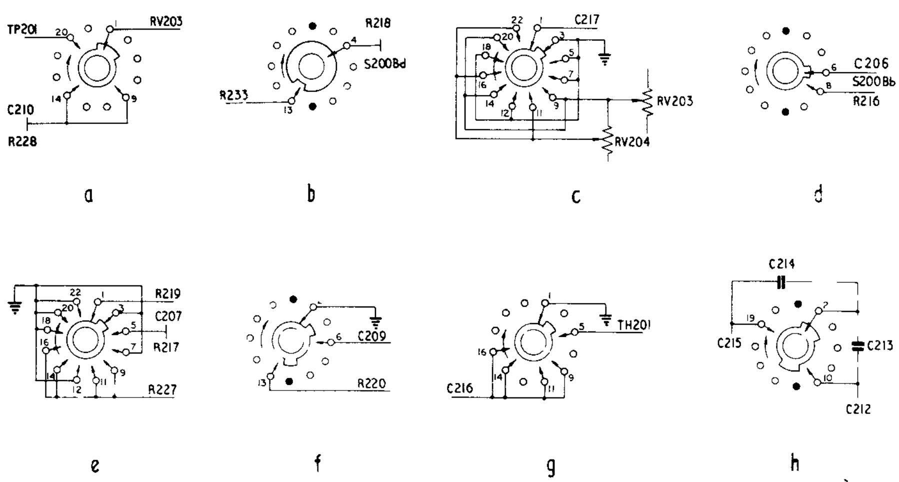
3. SYMBOLS
- preset component
- arrow indicates clockwise rotation of knob
- EXT panel marking
- connections on r.f. box tagstrip
- supply plug and socket connections.
  SKT201 : battery socket
  SKT202 : a.c. mains socket

4. SWITCHES
Rotary switches are drawn schematically. Numbers indicate control knob setting.

S200B



Sequence of sections



Plan of sections viewed from knob end with knob fully counter-clockwise.

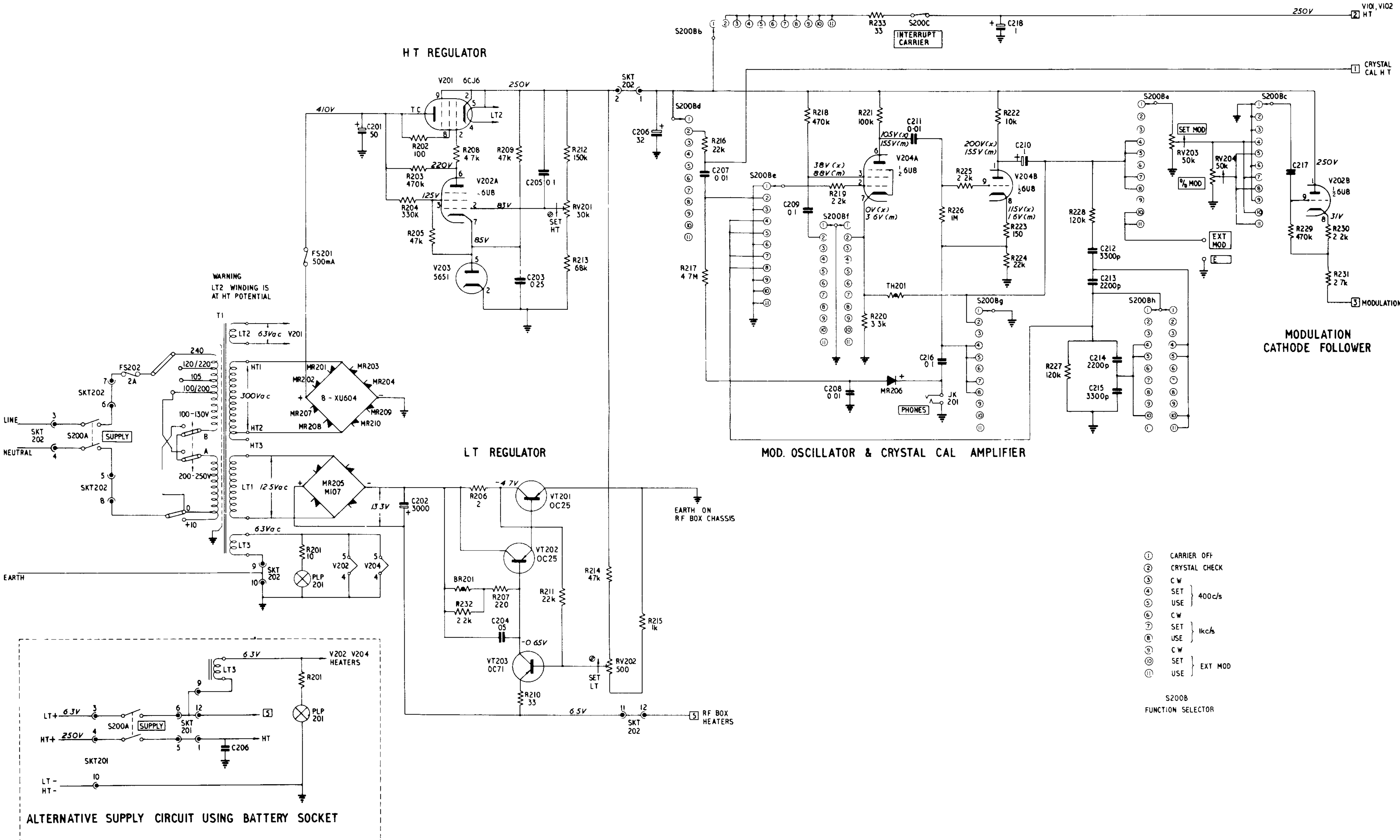


Fig 4·9 POWER SUPPLY AND MODULATION OSCILLATOR

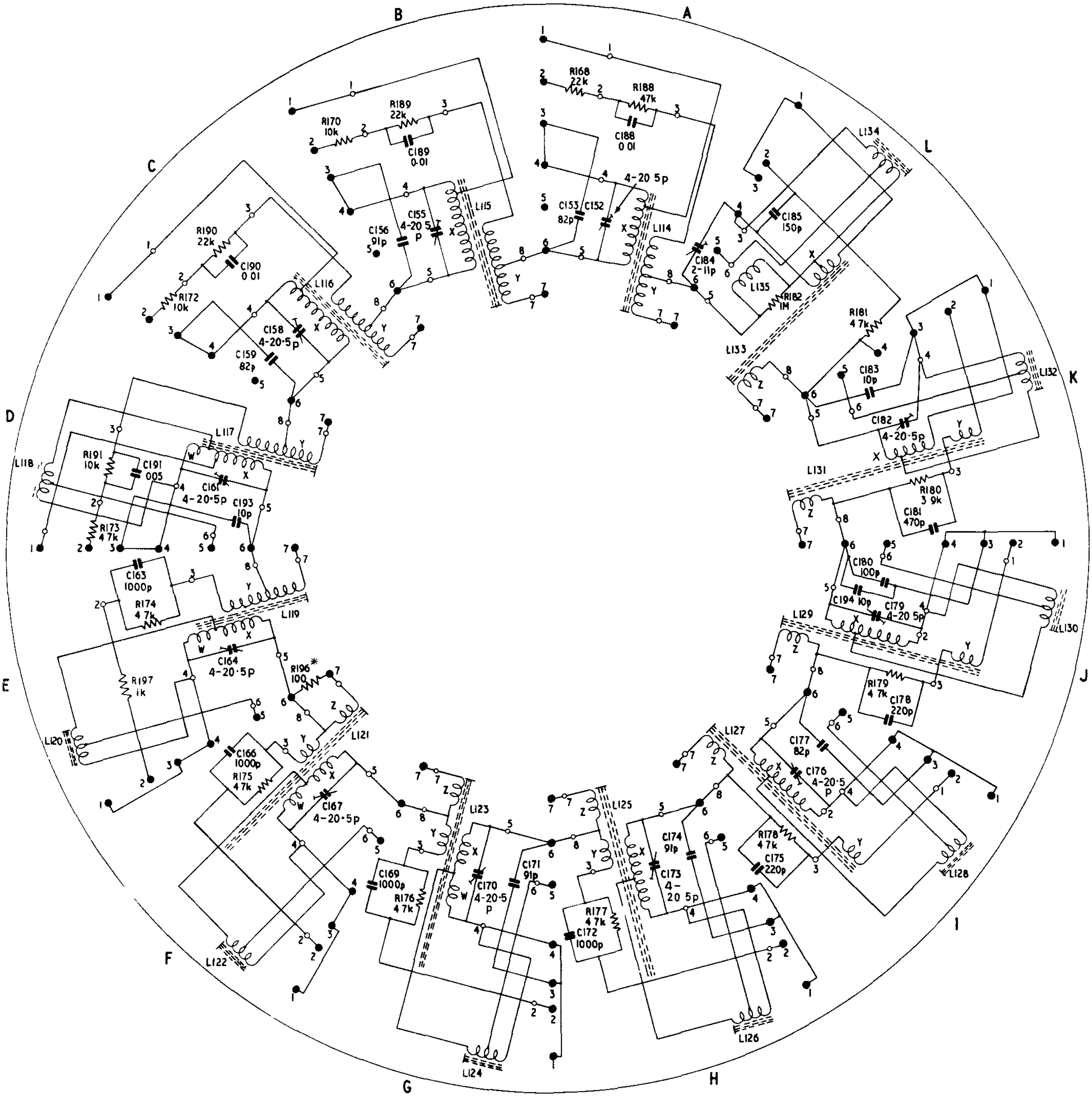


Fig. 4·10 COIL TURRET

NOTES

1. COMPONENT VALUES

   Resistors : No suffix = ohms. k = kilohms. M = megohms.
   Capacitors : No suffix = microfarads. p = picofarads.
   *Value selected during test; nominal value shown.

2. VOLTAGES

   These are d.c. and relative to chassis except where otherwise indicated.
   Voltmeter : 20 kΩ/V model on highest convenient range
   (A) : Range A with meter at SET CARRIER
   (A-F) : Ranges A - F.
   (G-L) : Ranges G - L.

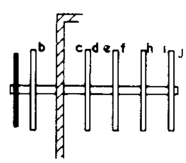
3. SYMBOLS

   ⊘ preset component
   ↑ arrow indicates clockwise rotation of knob
   [EXT] panel marking
   [1] connections on r.f. box tagstrip

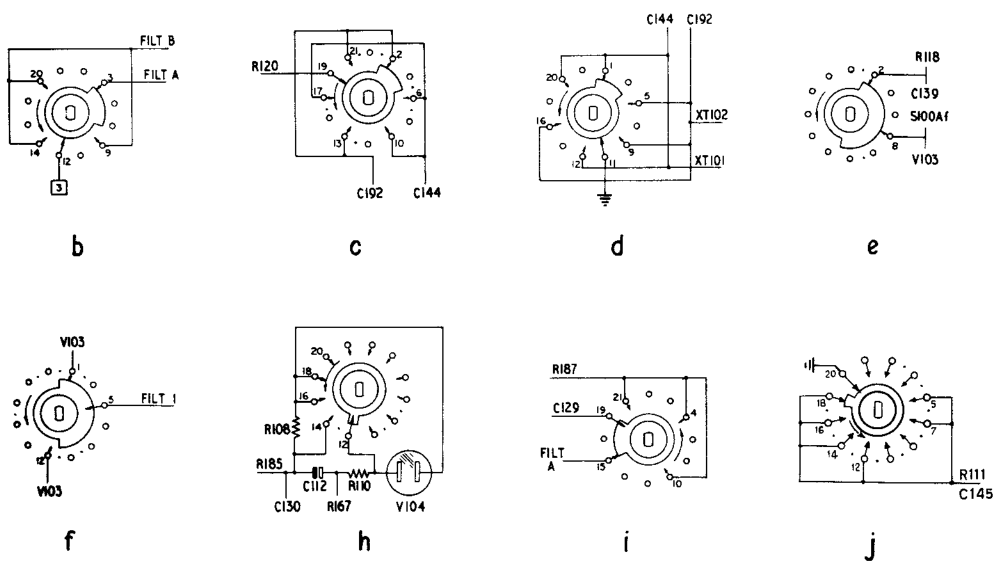
4. SWITCHES

   Rotary switches are drawn schematically. Numbers or letters, indicate control knob setting.

S100A



Sequence of sections.



Plan of sections viewed from knob end with knob fully counter-clockwise.

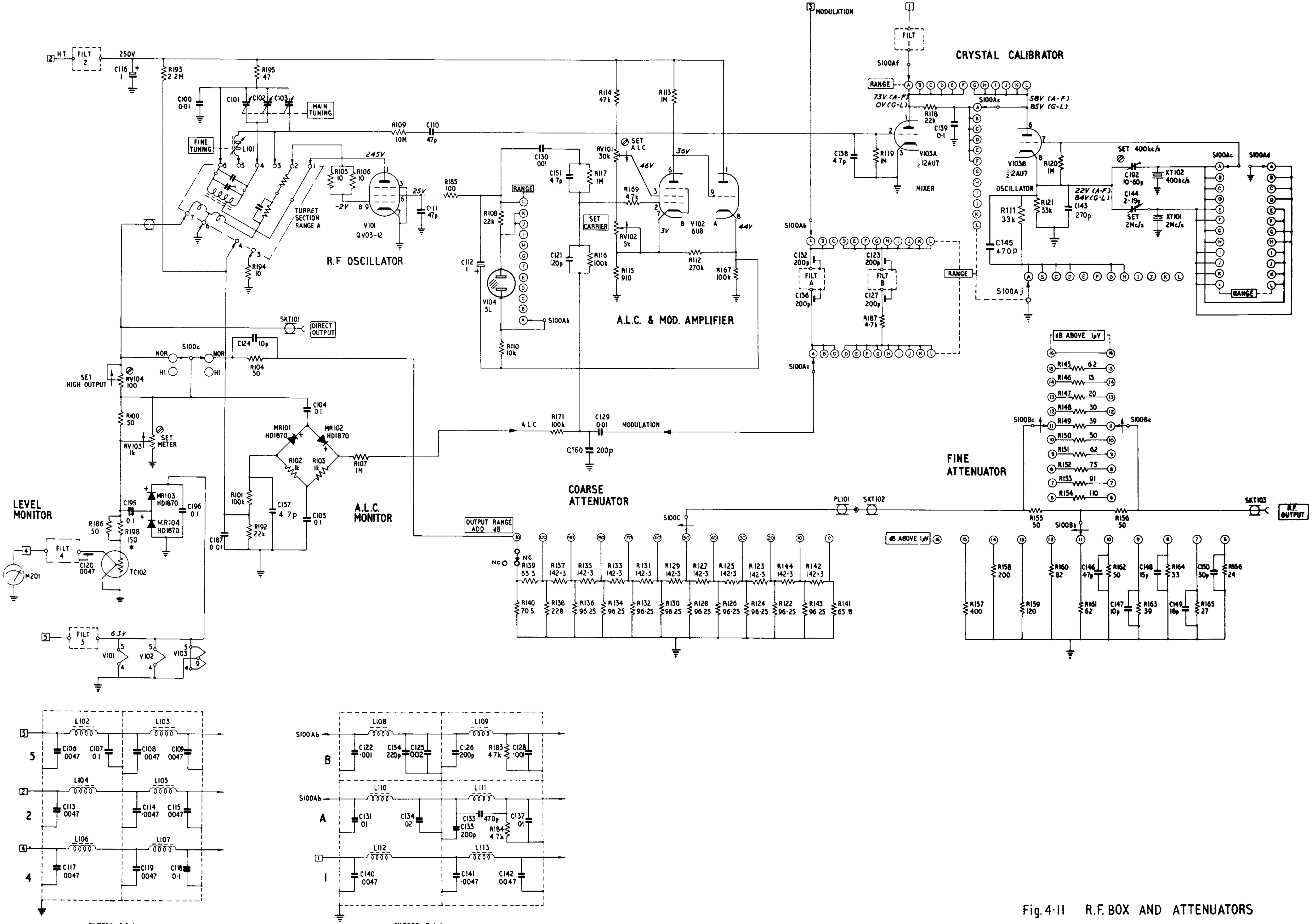


Fig. 4·11 R.F. BOX AND ATTENUATORS

DECIBEL CONVERSION TABLE

Ratio Down			*Ratio Up*	
VOLTAGE	*POWER*	*DECIBELS*	*VOLTAGE*	*POWER*
1·0	1·0	**0**	1·0	1·0
·9886	·9772	**·1**	1·012	1·023
·9772	·9550	**·2**	1·023	1·047
·9661	·9333	**·3**	1·035	1·072
·9550	·9120	**·4**	1·047	1·096
·9441	·8913	**·5**	1·059	1·122
·9333	·8710	**·6**	1·072	1·148
·9226	·8511	**·7**	1·084	1·175
·9120	·8318	**·8**	1·096	1·202
·9016	·8128	**·9**	1·109	1·230
·8913	·7943	**1·0**	1·122	1·259
·8710	·7586	**1·2**	1·148	1·318
·8511	·7244	**1·4**	1·175	1·380
·8318	·6918	**1·6**	1·202	1·445
·8128	·6607	**1·8**	1·230	1·514
·7943	·6310	**2·0**	1·259	1·585
·7762	·6026	**2·2**	1·288	1·660
·7586	·5754	**2·4**	1·318	1·738
·7413	·5495	**2·6**	1·349	1·820
·7244	·5248	**2·8**	1·380	1·905
·7079	·5012	**3·0**	1·413	1·995
·6683	·4467	**3·5**	1·496	2·239
·6310	·3981	**4·0**	1·585	2·512
·5957	·3548	**4·5**	1·679	2·818
·5623	·3162	**5·0**	1·778	3·162
·5309	·2818	**5·5**	1·884	3·548
·5012	·2512	**6**	1·995	3·981
·4467	·1995	**7**	2·239	5·012
·3981	·1585	**8**	2·512	6·310
·3548	·1259	**9**	2·818	7·943
·3162	·1000	**10**	3·162	10·000
·2818	·07943	**11**	3·548	12·59
·2512	·06310	**12**	3·981	15·85
·2239	·05012	**13**	4·467	19·95
·1995	·03981	**14**	5·012	25·12
·1778	·03162	**15**	5·623	31·62

DECIBEL CONVERSION TABLE (continued)

Ratio Down			*Ratio Up*	
VOLTAGE	*POWER*	*DECIBELS*	*VOLTAGE*	*POWER*
·1585	·02512	**16**	6·310	39·81
·1413	·01995	**17**	7·079	50·12
·1259	·01585	**18**	7·943	63·10
·1122	·01259	**19**	8·913	79·43
·1000	·01000	**20**	10·000	100·00
·07943	$6{\cdot}310 \times 10^{-3}$	**22**	12·59	158·5
·06310	$3{\cdot}981 \times 10^{-3}$	**24**	15·85	251·2
·05012	$2{\cdot}512 \times 10^{-3}$	**26**	19·95	398·1
·03981	$1{\cdot}585 \times 10^{-3}$	**28**	25·12	631·0
·03162	$1{\cdot}000 \times 10^{-3}$	**30**	31·62	1,000
·02512	$6{\cdot}310 \times 10^{-4}$	**32**	39·81	$1{\cdot}585 \times 10^{3}$
·01995	$3{\cdot}981 \times 10^{-4}$	**34**	50·12	$2{\cdot}512 \times 10^{3}$
·01585	$2{\cdot}512 \times 10^{-4}$	**36**	63·10	$3{\cdot}981 \times 10^{3}$
·01259	$1{\cdot}585 \times 10^{-4}$	**38**	79·43	$6{\cdot}310 \times 10^{3}$
·01000	$1{\cdot}000 \times 10^{-4}$	**40**	100·00	$1{\cdot}000 \times 10^{4}$
$7{\cdot}943 \times 10^{-3}$	$6{\cdot}310 \times 10^{-5}$	**42**	125·9	$1{\cdot}585 \times 10^{4}$
$6{\cdot}310 \times 10^{-3}$	$3{\cdot}981 \times 10^{-5}$	**44**	158·5	$2{\cdot}512 \times 10^{4}$
$5{\cdot}012 \times 10^{-3}$	$2{\cdot}512 \times 10^{-5}$	**46**	199·5	$3{\cdot}981 \times 10^{4}$
$3{\cdot}981 \times 10^{-3}$	$1{\cdot}585 \times 10^{-5}$	**48**	251·2	$6{\cdot}310 \times 10^{4}$
$3{\cdot}162 \times 10^{-3}$	$1{\cdot}000 \times 10^{-5}$	**50**	316·2	$1{\cdot}000 \times 10^{5}$
$2{\cdot}512 \times 10^{-3}$	$6{\cdot}310 \times 10^{-6}$	**52**	398·1	$1{\cdot}585 \times 10^{5}$
$1{\cdot}995 \times 10^{-3}$	$3{\cdot}981 \times 10^{-6}$	**54**	501·2	$2{\cdot}512 \times 10^{5}$
$1{\cdot}585 \times 10^{-3}$	$2{\cdot}512 \times 10^{-6}$	**56**	631·0	$3{\cdot}981 \times 10^{5}$
$1{\cdot}259 \times 10^{-3}$	$1{\cdot}585 \times 10^{-6}$	**58**	794·3	$6{\cdot}310 \times 10^{5}$
$1{\cdot}000 \times 10^{-3}$	$1{\cdot}000 \times 10^{-6}$	**60**	1,000	$1{\cdot}000 \times 10^{6}$
$5{\cdot}623 \times 10^{-4}$	$3{\cdot}162 \times 10^{-7}$	**65**	$1{\cdot}778 \times 10^{3}$	$3{\cdot}162 \times 10^{6}$
$3{\cdot}162 \times 10^{-4}$	$1{\cdot}000 \times 10^{-7}$	**70**	$3{\cdot}162 \times 10^{3}$	$1{\cdot}000 \times 10^{7}$
$1{\cdot}778 \times 10^{-4}$	$3{\cdot}162 \times 10^{-8}$	**75**	$5{\cdot}623 \times 10^{3}$	$3{\cdot}162 \times 10^{7}$
$1{\cdot}000 \times 10^{-4}$	$1{\cdot}000 \times 10^{-8}$	**80**	$1{\cdot}000 \times 10^{4}$	$1{\cdot}000 \times 10^{8}$
$5{\cdot}623 \times 10^{-5}$	$3{\cdot}162 \times 10^{-9}$	**85**	$1{\cdot}778 \times 10^{4}$	$3{\cdot}162 \times 10^{8}$
$3{\cdot}162 \times 10^{-5}$	$1{\cdot}000 \times 10^{-9}$	**90**	$3{\cdot}162 \times 10^{4}$	$1{\cdot}000 \times 10^{9}$
$1{\cdot}000 \times 10^{-5}$	$1{\cdot}000 \times 10^{-10}$	**100**	$1{\cdot}000 \times 10^{5}$	$1{\cdot}000 \times 10^{10}$
$3{\cdot}162 \times 10^{-6}$	$1{\cdot}000 \times 10^{-11}$	**110**	$3{\cdot}162 \times 10^{5}$	$1{\cdot}000 \times 10^{11}$
$1{\cdot}000 \times 10^{-6}$	$1{\cdot}000 \times 10^{-12}$	**120**	$1{\cdot}000 \times 10^{6}$	$1{\cdot}000 \times 10^{12}$
$3{\cdot}162 \times 10^{-7}$	$1{\cdot}000 \times 10^{-13}$	**130**	$3{\cdot}162 \times 10^{6}$	$1{\cdot}000 \times 10^{13}$
$1{\cdot}000 \times 10^{-7}$	$1{\cdot}000 \times 10^{-14}$	**140**	$1{\cdot}000 \times 10^{7}$	$1{\cdot}000 \times 10^{14}$