NOTES ON RECEPTION SET R109.

1. GENERAL DESCRIPTION.

The Reception Set R109 is a general purpose wireless receiver suitable for use as a vehicle station or as a portable ground station. The inclusion of a beat frequency oscillator provides for the reception of C.W. signals as well as R/T and M.C.W.

The frequency range is 1.8 to 8.5 Mc/s covered in two bands. The set will therefore receive signals from any No.19 or 22 Set within range.

As a vehicle station the set, which is contained, complete with Power Unit, in a metal case, is mounted in a rubber suspended carrier which is bolted inside the vehicle. By releasing two catches the set may be removed from its carrier and set up as a ground station.

Those familiar with the No.21 Set will notice the similarity in construction and appearance between it and the set under discussion. Later, similarity in circuit details will be noted.

Aerials.

When operated as a vehicle station the set will be used with a vertical aerial comprising three 4' tapered rods which fit into one another (Antennae Rods F Sections 1, 2 and 3). The whole is mounted in a flexible rubber base (Aerial Base No.10) on the outside of the truck. Protection from overhead power lines is provided by a fixed condenser in the aerial lead, (Condenser X5, 5 KV Mk II). Four 4' rods may be used with a stationary vehicle. The receiver is earthed on the vehicle chassis by connecting one of the earth terminals to the carrier.

For ground station operation a self-supporting vertical aerial as described above may be used. Four sections, giving a total length of 16', are mounted in an Aerial Base No.11, the latter being clamped to a spike hammered into the ground.A counterprise earth should be used with this arrangement (Leads Counterprise No.2 Mk II). It may be noted, however, that in some circumstances satisfactory results may be obtained without an earth connection.

Two aerial terminals are provided marked 80 ohms and 500 ohms respectively. Aerials of the Marconi variety which are an odd number of 1/4 λ in length are connected to the low impedance (80 ohm) terminal on the set. The vertical aerials are connected to this terminal. The alternative terminal provides for matching the set to a high impedance Hertz type of aerial, the total length of which, i.e. horizontal portion + down lead, will be adjusted to 1/2 the wavelength of the received signal.

Power is derived from a 6 volt 40 A.H. accumulator, high-tension voltage being obtained by the use of a vibrator and selenium rectifier. L.T. current consumption is approximately 1.2 Amps.

The receiver employs an eight valve superheterodyne circuit consisting of an R.F. amplifier, mixer with separate local oscillator, two stages of I.F. amplification, combined signal detector A.V.C. diode and 1st A.F. amplifier followed by an output stage. A B.F.O. which may be switched on for the reception of C.W. signals completes the circuit.

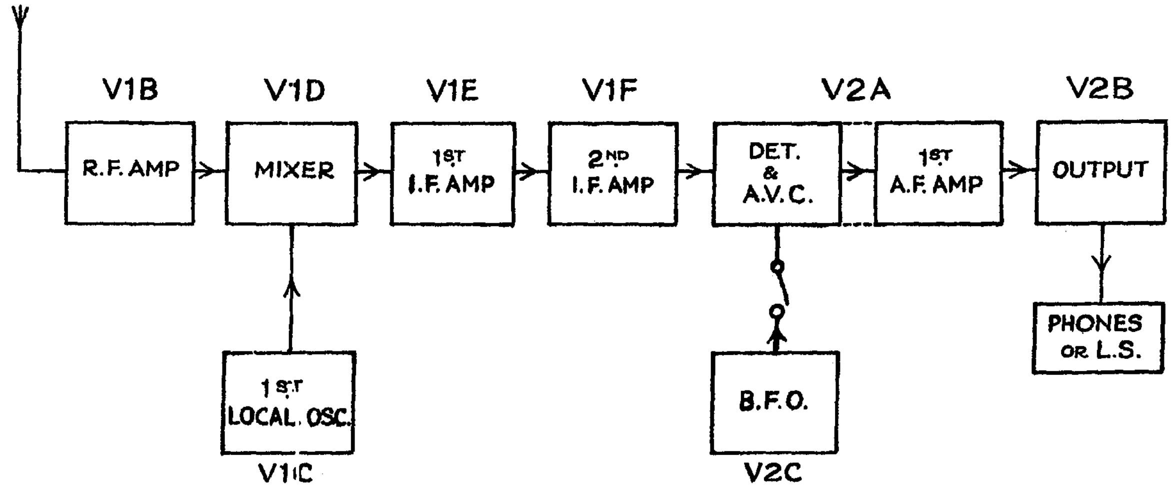


Figure 1. Block Diagram of R109.

2. DETAILED DESCRIPTION OF CIRCUITS.

(i) The R.F. Amplifier Stage.

The signal frequency R.F. valve V1B is a 2 volt directly heated R.F. pentode, type ARP12. The two tuned circuits associated with this valve provide sufficient selection before the frequency changer to prevent serious 2nd channel interference

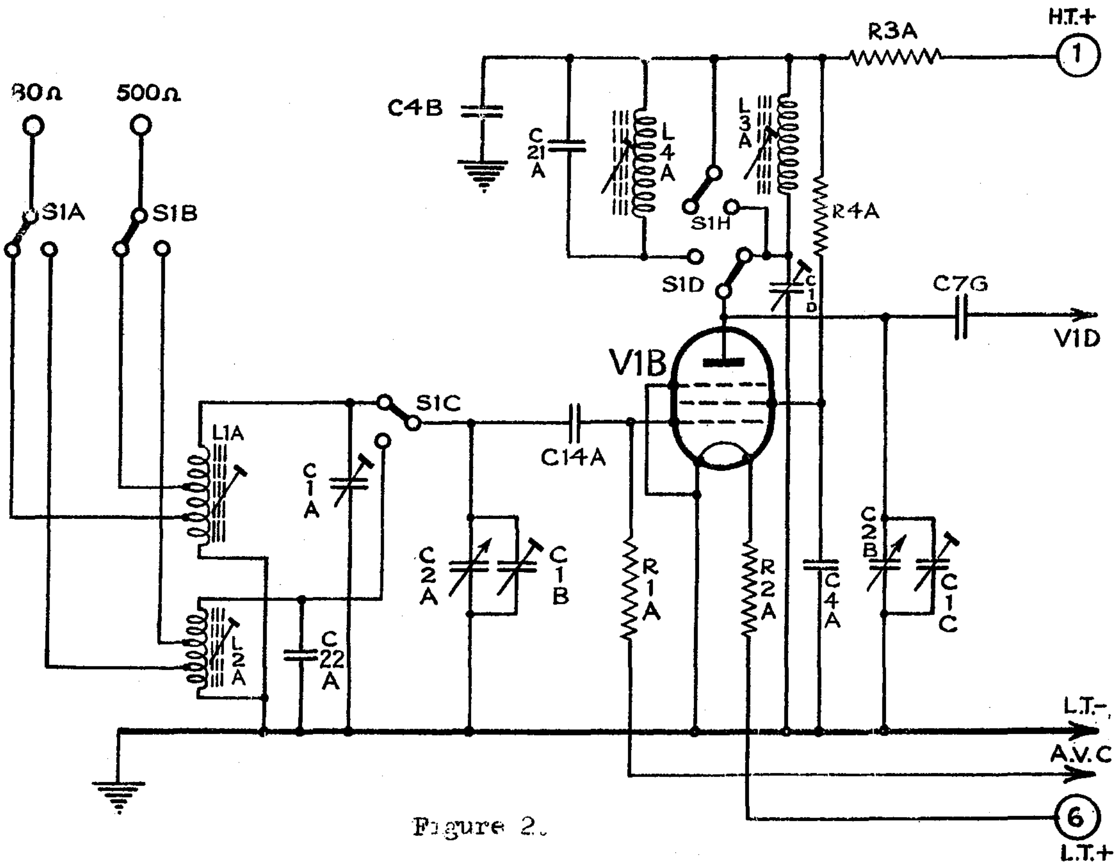


Figure 2.

The received signal is auto-coupled to the grid circuit comprising the dust-iron cored inductance L1A or L2A tuned by C2A, one section of a 3-gang tuning condenser. C1B (5/35 μμF) is a trimming condenser located on the 3-gang assembly which in conjunction with C22A (22 μμF) enables the R.F. stage to be aligned on the 3.9/8.5 Mc/s band C1A (5/35 μμF) is an additional trimmer operative on the 1.8/3.9 Mc/s band only.

The grid condenser C14A (.0003μF) enables grid bias of minimum value - 2.5V to be applied via the grid leak R1A (1 MΩ) and the A.V.C. line. Filament voltage is adjusted to its correct value by the filament resistance R2A (71Ω).

Tuned anode coupling is employed between this and the mixer stages. The dust-iron cored anode inductance L3A or L4A is tuned by C2B another section of the 3-gang condenser. Trimming on the higher frequency band is accomplished by C1C in conjunction with C21A. C1D is an additional trimmer for the other band. The anode circuit is decoupled by C4B (.01 μF) in conjunction with R3A (5000Ω) while R4A (.25 MΩ) and C4A serve a similar purpose for the screen grid of this stage.

R.F. output at signal frequency is taken from the anode to the control grid of the mixer V1D via the coupling condenser C7G (150 μμF).

(ii) The Mixer Stage and Local Oscillator.

Frequency changing is carried out by applying the output from the oscillator V1C to the suppressor grid of the mixer valve V1D. V1C is an R.F. pentode type ARP12 functioning as a tetrode in a series-fed tuned anode oscillator. Note that while screen grid and anode are strapped together the suppressor grid is earthed. This affords an increased R.F. output. This is tuned to a frequency 465 Kc/s above that of the incoming signal by means of C2C the remaining section of the 3-gang tuning condenser. Minimum tracking error is maintained by means of the padders C5A (.0015 μF) and C6A (.002 μF) in series with the tuning inductances L5A (1.8/3.9 Mc/s) and L6A (3.9/8.5 Mc/s) respectively. Control grid bias for the valve is applied by means of the grid-leak and

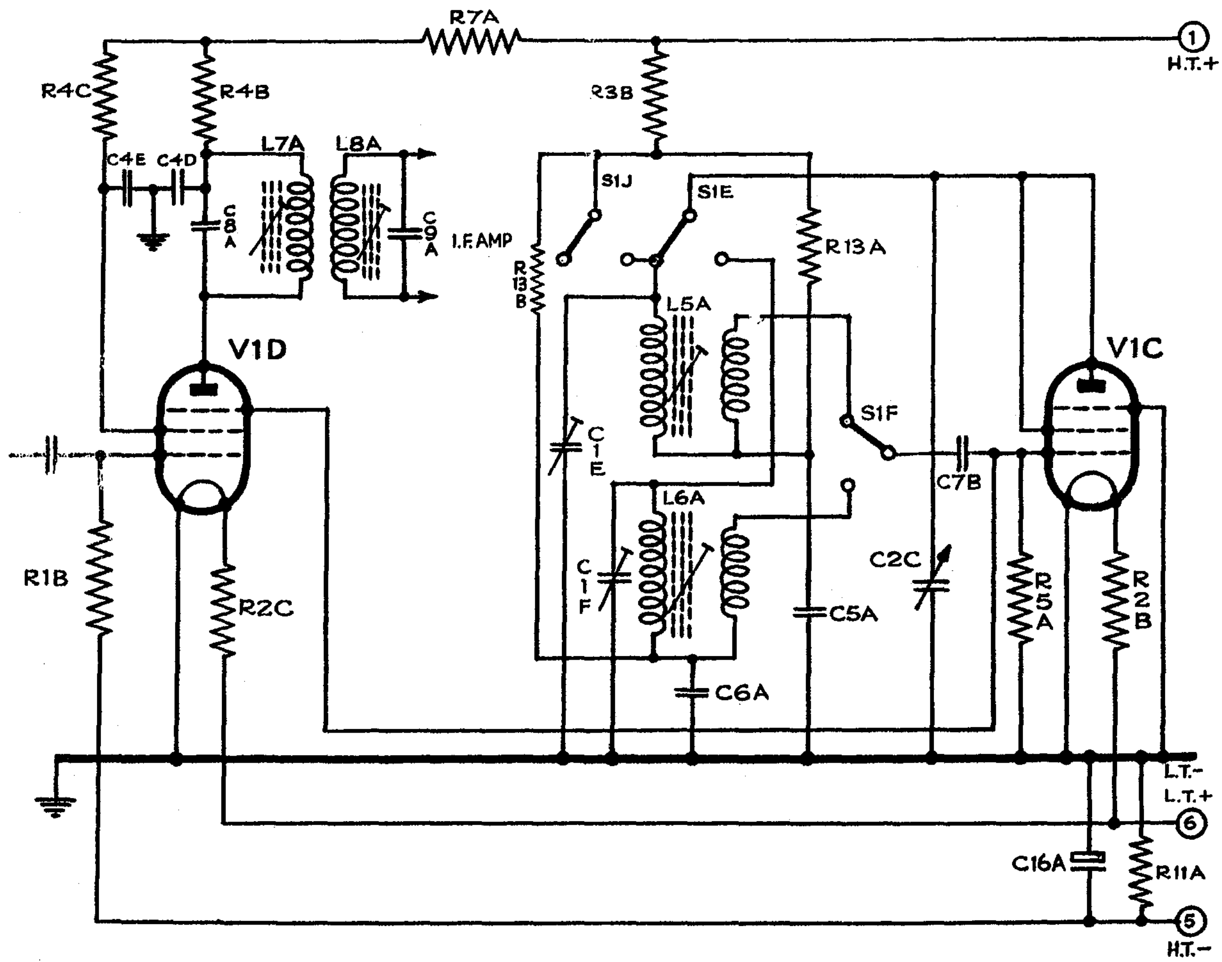


Figure 3.

condenser C7B and R5A (150$\mu\mu$F and 25,000Ω) respectively.

On the higher frequency band L5A is shorted by R13B, the anode feed resistance used on the other band. This is to prevent loss of efficiency on this frequency band due to absorption by the 1.8/3.9 Mc/s coil.

L7A, the primary winding of the 1st I.F. transformer, in conjunction with C8A (150$\mu\mu$F) form the anode load of the mixer valve V1D. This tuned circuit has a natural frequency of 465 Kc/s (I.F.) & selects this frequency difference between the incoming signal and the output from the local oscillator. Tuning adjustment to the I.F. coils is carried out by means of the movable slug inside each coil.

A steady negative bias of 2.5 volts is applied to V1D by returning the control grid via R1B (1 MΩ) to H.T.-.

R7A (10,000Ω) and R3B (5,000Ω) provide convenient means of testing the cathode current of V1D & V1C respectively by measuring the voltage drop across them.

(iii) The Intermediate Frequency Amplifier.

This comprises two R.F. pentodes, type ARP12, employed in a two stage amplifier. The two valves V1E and V1F are coupled by I.F. bandpass transformers permeability tuned to the intermediate frequency 465Kc/s. Coupling to the signal diode detector stage is via another band-pass transformer.

The I.F. component of the output from V1D passes to the 1st I.F. valve V1E via the bandpass filter consisting of L7A & L8A with their associated condensers C8A (150$\mu\mu$F) and C9A (160$\mu\mu$F) respectively.

V1E is coupled to V1F by means of a similar filter consisting of L7B and L8B and their associated condensers C8B and C9B. Note. All complete circuit diagrams supplied with the set show an unused secondary winding in the 1st and 2nd I.F. transformers. These components were originally designed for the No.21 Set.

Anode and screen grid decoupling & control grid biasing arrangements are similar for both stages. Both suppressor grids are taken down to chassis. H.T. to anodes and screens is supplied by way of the test resistances R7B and R7C (10,000Ω) decoupled by C4H and C4L (.01μF) respectively. Further decoupling for the screens is provided by C4G and C4K (.01μF) in conjunction with the voltage dropping resistances R4D and R4E (.25 MΩ).

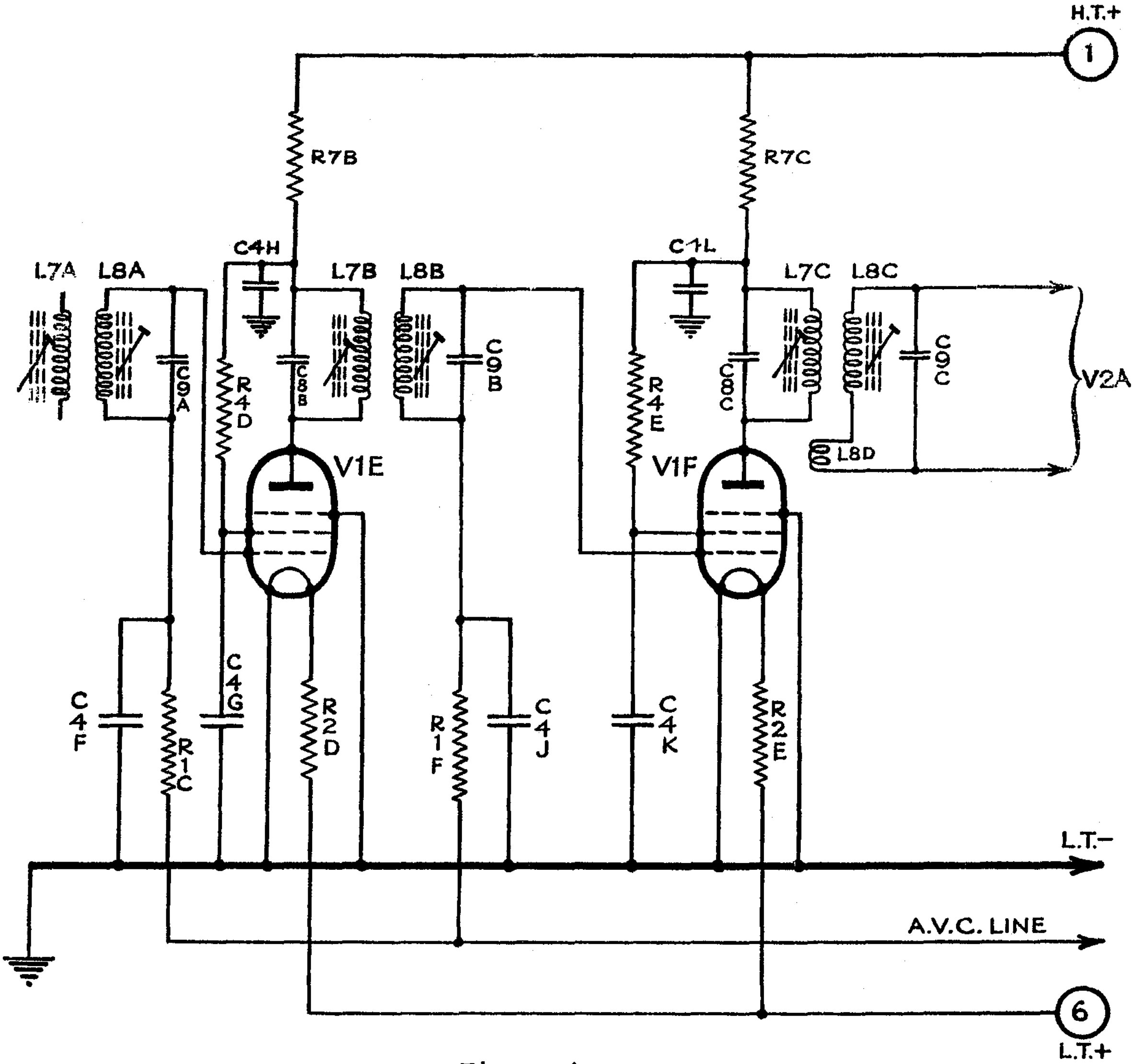


Figure 4.

Full A.V.C. is supplied to both valves by returning the control grid to the A.V.C. diode via the filter secondary and a 1 MΩ decoupling resistance (R1C and R1F) in each case. C4F and C4J (.01 μF) provide a low impedance path for I.F. between the earthy end of the filter secondaries and filament.

R2D and R2E are filament resistances.

The I.F. filter coupling V1F to the signal diode and comprising L7C, L8C, C8C and C9C is slightly modified by the inclusion of the extra coupling coil in series with the secondary. This provides a broader frequency response compared with that of the previous stages.

(iv) Signal Detector.

One diode of V2A, a double-diode triode valve, type AR8, functions as signal detector in a series diode circuit. R1D (1 MΩ) and C3B (100 μμF) are the load resistance and condenser respectively. R8A (.1 MΩ) in conjunction with C7D (150 μμF) and C3B form an I.F. filter. A.F. voltages across the load R1D are applied to the triode portion of V2A for amplification via the blocking condensers C11A (.002 μF).

(v) 1st Audio Frequency stage.

As inferred above the triode section of V2A functions as an A.F. amplifier. This stage is resistance capacity coupled to the output stage V2B, the anode load resistance being R9A (50,000 Ω) and the coupling condenser C11B (.002 μF). H.T. to the anode is decoupled by the electrolytic condenser C13A (2 μF) in conjunction with the test resistance R3C (5000 Ω).

A steady negative grid bias of 2.5 volts is applied by returning the control grid to H.T.- via the grid leak R1G (1 MΩ) and the decoupling resistance R1H (1 MΩ). C12A the decoupling condenser has a capacity of .1 μF. Note the I.F. stopper R4F (.25 MΩ) in the grid lead. The action of this component has been dealt with in Notes on W/S No.21.

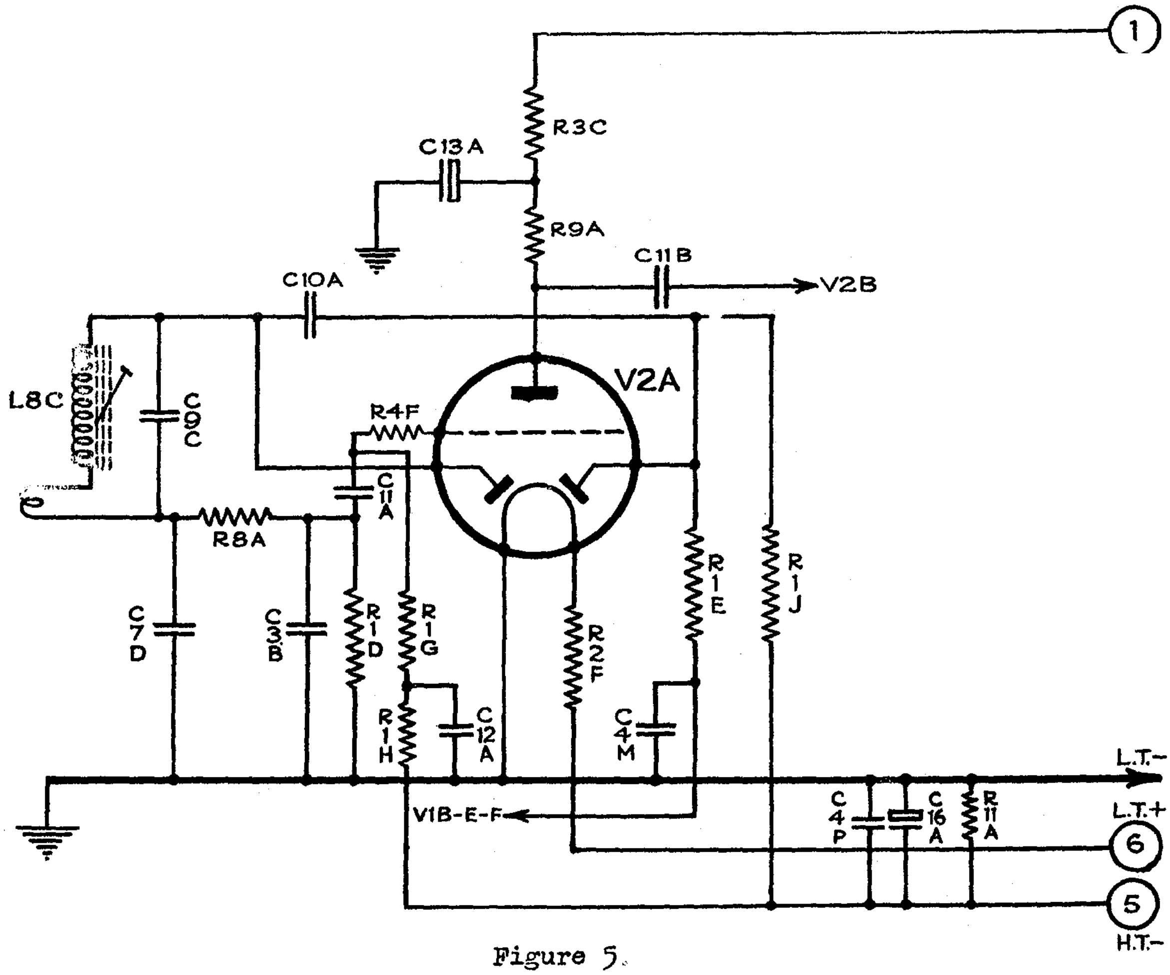


Figure 5.

(vi) Automatic volume control.

The remaining diode portion of V2A operates in a parallel diode circuit to provide extra grid bias on V1B - E - F when receiving strong signals. It should be noted that there is no R.F. gain control on this set.

I.F. input to this circuit is taken from the secondary of the last I.F. band-pass filter via the condenser C10A (200$\mu\mu$F). R1J (1 MΩ) between anode and H.T.- provides the load and the anode will of course receive a 2.5 volt negative bias due to R11A (250Ω) in the H.T.- lead. This bias acts as A.V.C. delay voltage so that the diode is inoperative on weak signals. The rectified signal causes a negative potential to develop at the anode proportional to the strength of the received carrier. This voltage is applied to the controlled valves as bias through the filter comprising R1E (1 MΩ) and C4M (.01μF).

(vii) The Output Stage.

The output stage comprises a double diode triode valve type AR8 functioning as a triode A.F. amplifier, the two diodes being strapped to filament. This valve works into an output transformer T1 which has two secondaries. One secondary is associated with two phone jacks while the other feeds a small loudspeaker. The switch S2A enables the receiver to be operated with either the loudspeaker OR phones.

The A.F. output from the previous stage is applied via the coupling condenser C11B to the receiver volume control R10A (1 MΩ variable). A.F. voltage is tapped off the latter and passed to the grid of V2B via the grid stopper R8B (.1 MΩ). Control grid bias is obtained by returning the volume control resistance to H.T.-. The anode circuit is decoupled by means of the electrolytic C13B (2μF) in conjunction with the test resistance R3D (5000Ω).

A crash limiter may be switched across the phone secondary of T1 by means of the switch S3A and consists of a metal rectifier unit W1A. This comprises two rectifiers in parallel but with polarities reversed the whole functioning as an A.C. resistance the value of which decreases rapidly with increase in applied voltage. The result is that for ordinary signal voltage, the resistance is high and has little effect, but on reception of transients such as atmospherics it becomes low and forms an effective short across the secondary winding of T1. C14B (.003μF) a condenser between anode and earth limits the high- note response of the set and overcomes shrillness in reproduction.

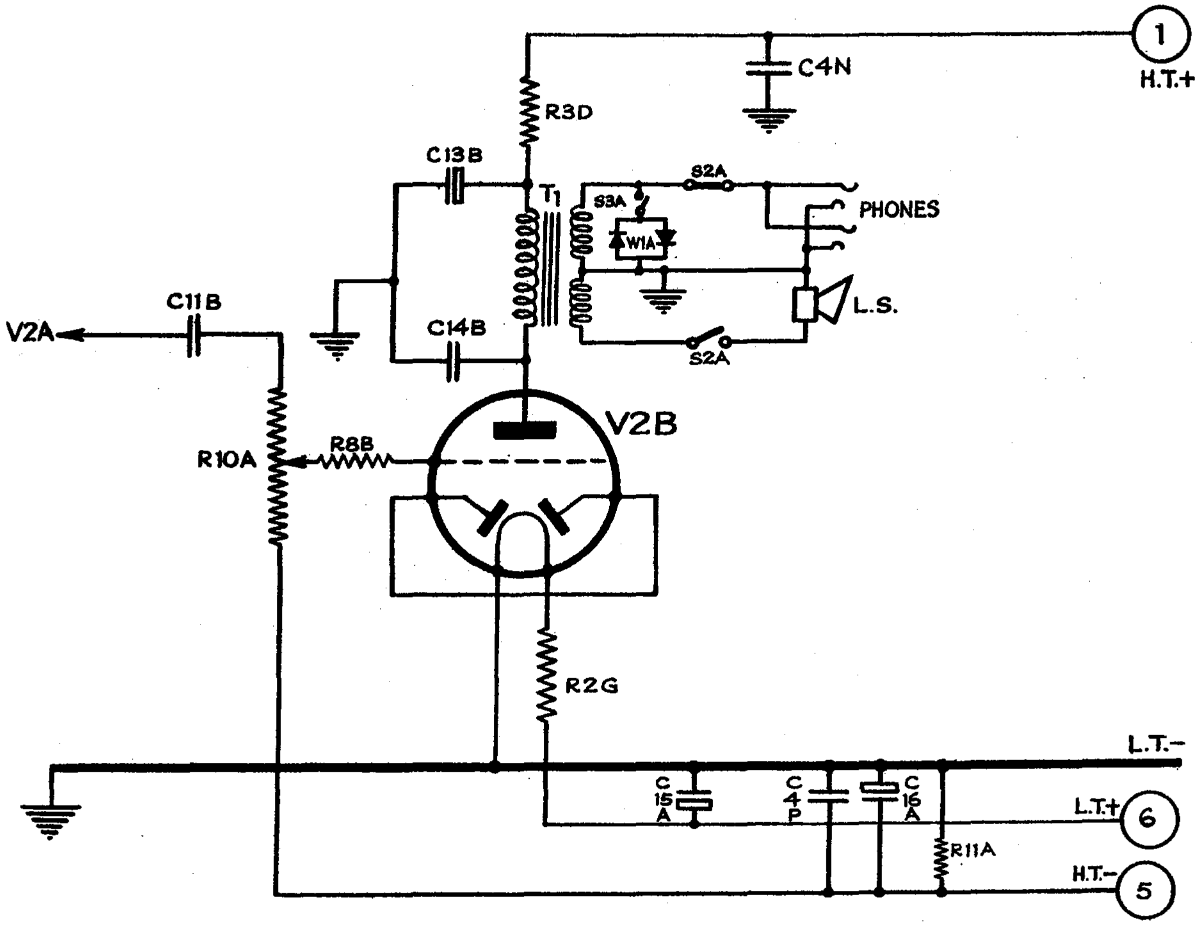


Figure 6.

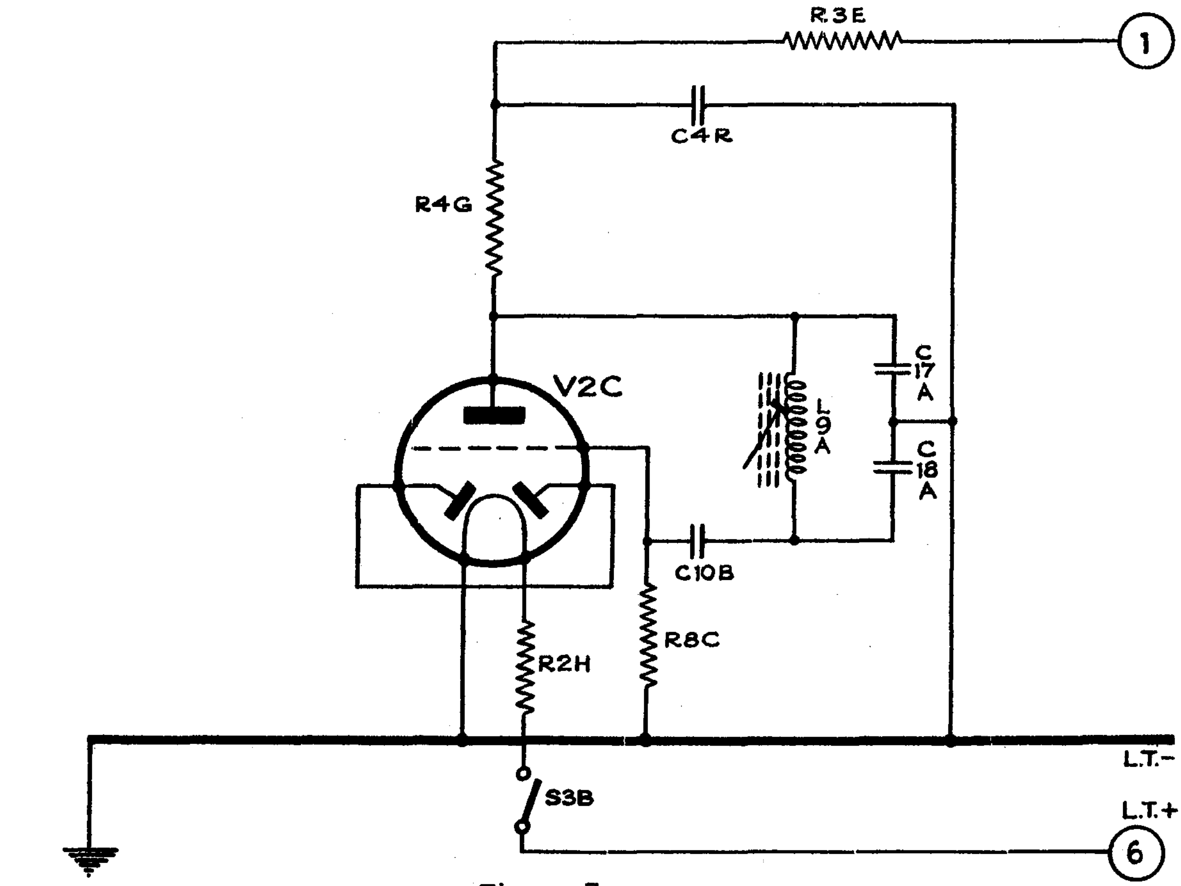


Figure 7.

(viii) Beat Frequency Oscillator.

The beat frequency oscillator V2C is a double diode triode with diode anodes strapped to filament as in V2B, operating as a triode in a parallel-fed Colpitts circuit. The oscillatory circuit consisting of the permeability tuned inductance L9A and the condensers C17A (.0004 μF) and C18A (.0012 μF) functions at approximately the intermediate frequency. Output is taken from the anode and applied to the signal detector via the small capacity of a short piece of twin flex. Self-bias is obtained from the grid leak R8C (1 MΩ) in conjunction with C10B (.0002 μF). H.T. to anode is supplied from the H.T. line via the test resistance R3E (5000 Ω) and the load R4G (.25 MΩ). The oscillator maybe switched on or off by means of the RT/CW switch S3B which breaks the filament cct. on R/T.

(ix) The Wave Change Switch.

Switching from one frequency band to the other is accomplished by means of a Yaxley type switch. This latter is a two position switch arranged in three banks which are mutually screened.

The rear bank (S1A - B & C) is associated with the aerial tuning inductances L1A and L2A, while the R.F.A. tuned anode inductances L3A and L4A are dealt with by the centre bank (S1D & H). The remaining disc (S1E, F & J) in front of the switch assembly selects the appropriate local oscillator coil L5A or L6A.'

3. TECHNICAL DESCRIPTION OF THE POWER SUPPLY UNIT.

H.T. and L.T. current is derived from the self-contained power pack located on the left side of the set, and energised by a 6 volt accumulator. The H.T. output is 160 volts at 10 mA.

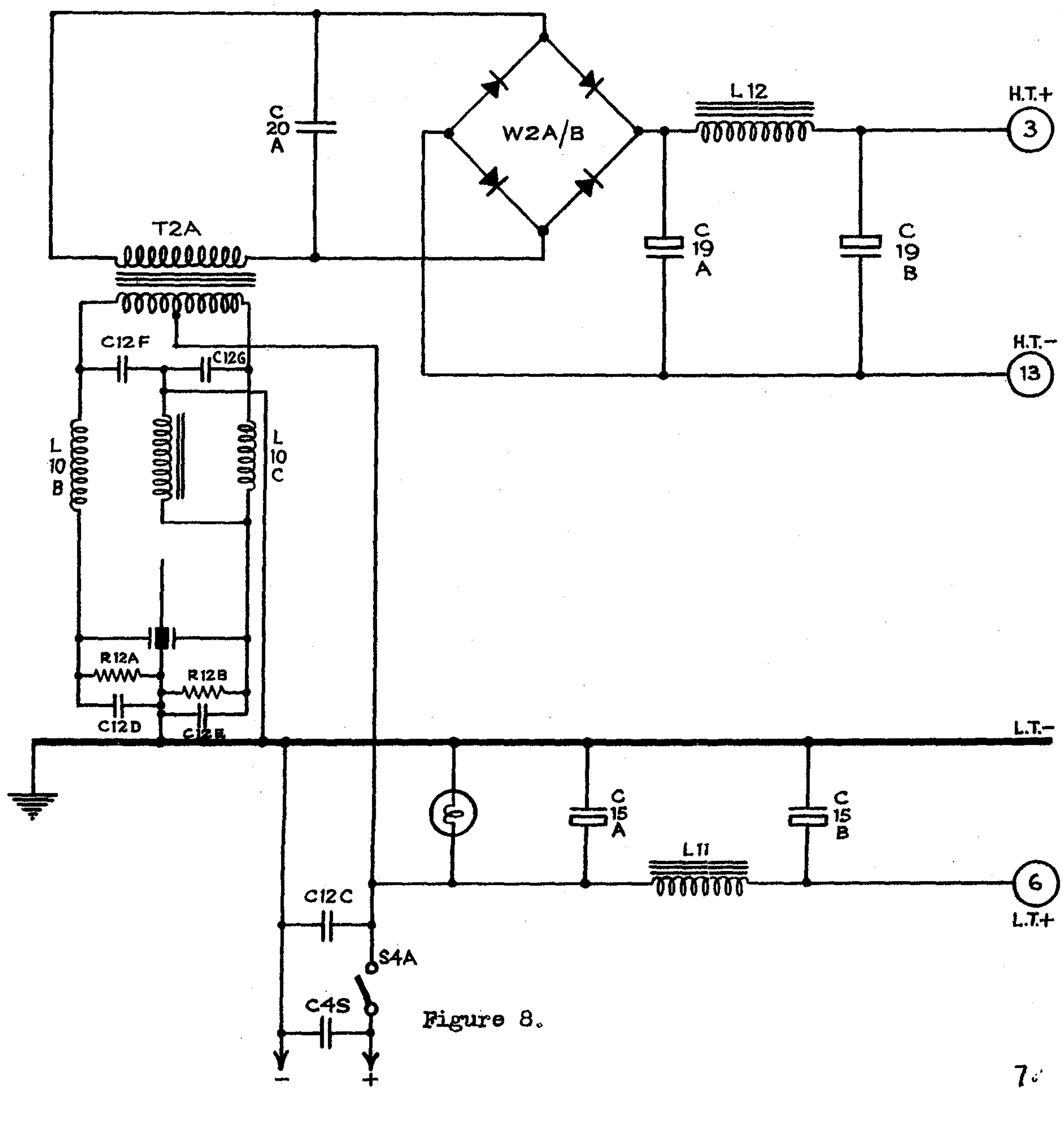


Figure 8.

The low voltage from the accumulator is stepped up by means of a Vibrator No.2 (Mallory Type 650) and a suitable iron-cored transformer T2A. The former is of the non-synchronous type and the transformer output is therefore applied to a separate bridge-connected selenium rectifier W2A/B. H.T. smoothing is accomplished by means of the choke L12 and condensers C19A & B (4μF)

Vibrator action is as follows:- When the battery is first switched on by means of S4A the vibrator reed is drawn over to the right by the electromagnet and a pulse of current traverses the right hand half of the primary winding of T2A. The magnet coil is now short-circuited by the right-hand vibrator contacts and becomes de-energized, the reed rebounding on to the left-hand contacts. A pulse will now pass through the remaining half of the primary of T2A. The electromagnet is again energised and the cycle of operations repeated. We thus obtain an A.C. input to T2A the frequency of which depends upon that of the vibrator reed.

C20A (.025μF) connected across the secondary of T2A absorbs surges of current in the latter, & thus forms a protection for the rectifier and smooths its input. The R.F. chokes L10B and L10C in conjunction with condensers C12F - G (1μF) form effective R.F. filters to prevent R.F. interference from reaching the receiver. Condensers C12D - E shunted by R12A - B (150Ω) across the vibrator contacts reduce arcing at these points. Smoothing in the filament circuits of the directly heated valves is provided by the choke L11 and condensers C15A - B (75μF).

Circuit Modifications.

To meet special requirements modified versions of the Reception Set R109 have been produced with a consequent improvement in C.W. reception and an extension in frequency range. A summary of these modifications follows.

Reception Set R109 A.

1. The ARP12 in the R.F. stage is replaced by a 6 volt indirectly heated pentode (V3A) type ARP36. A separate L.T. line from power pack to receiver has been included.
2. A.V.C. is not included but there is an I.F gain control operated manually. V3A is biased by means of a cathode resistor R11B (270Ω) connected to H.T. -.
3. Bias for V1E and V1F is obtained from an additional rectifier circuit in the Supply Unit. See diagram below. Minimum bias is derived from R11A and control is obtained by means of a variable resistor R10A.

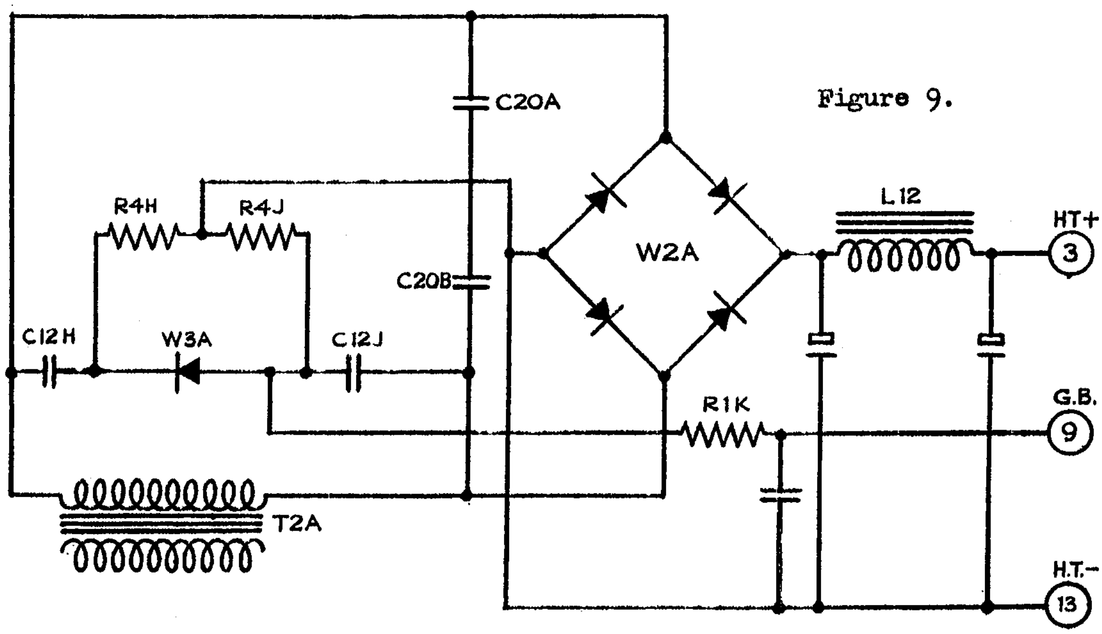


Figure 9.

4. Different values of variable condenser gangs and R.F. tuning coils have been used to give an extended frequency range, i.e. 2.0 - 4.9 Mc/s and 4.9 - 12.0 Mc/s.
5. Tuned secondary transformer coupling is used between V3A and V1D.

Reception Set R109 B.

Modifications as for R109A except that the frequency range covered is 2.5 - 5.5 Mc/s and 5.5 - 12 Mc/s, values of condenser gangs and tuning inductances being adjusted accordingly.

Reception Set R109 C.
These sets have been modified to improve C.W. reception only, the frequency range remaining as for R109.
1. A.V.C.is dispensed with & a manual control operates in the I.F. and R.F. stages.
2. Bias supply & control is provided by similar means to those detailed for R109 A & B.

4. FAULT FINDING.

To remove the chassis from its metal case, loosen the two captive fixing bolts marked ⊗ on the front panel and withdraw. Without further stripping tests may be made on all valves. A test tag panel located at the rear of the receiver chassis enables a rapid check on valve emission to be taken with a pocket voltmeter by measuring the voltage drops across the test resistances referred to in the text. The meter (Voltmeters pocket 250 V No.2) is connected between each of the points marked V1B etc. in turn and the point marked +. There is a separate + point for V2B.

The following table while typical of the readings obtainable is for illustration only, each set should have its own set of readings for comparison when faults appear.

VALVE.	PANEL ENGRAVING.	FUNCTION.	APPROX. VOLTS.
ARP 12	V1B	R.F. Amp.	4
"	V1C	1st L.O.	8.
"	V1D	MIXER	2.5
"	V1E	1st I.F.A.	4.5
"	V1F	2nd I.F.A.	4.5
AR 8	V2A	Det A.V.C.& A.F.	1.5
"	V2B	OUTPUT	4
"	V2C	B.F.O.	1 Switch to C.W.

The following tests will be made if no valve readings are obtainable :-

(i) H.T.input to the set(160V) can be tested across tags 3 & 13 on the panel.

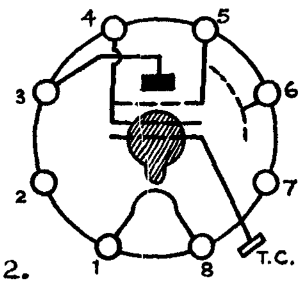
(ii) Testing across tag 5 and chassis will prove L.T. input.

(iii) The voltage between tag 3 & chassis should be slightly lower than in (i) - no reading here with (i) normal will indicate the bias resistor R11A dis.

Voltage tests at the valve holders can be made with the aid of the diagrams below. The readings given should prove a useful guide.

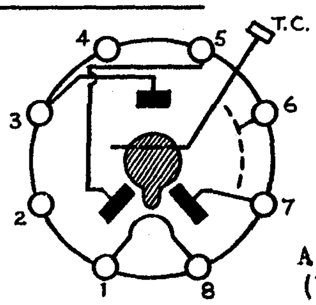
Readings obtained with an Avometer Model 7 (400 V range).

Between Chassis and	V1B	V1C	V1D	V1E	V1F	V2A	V2B	V2C
Anode	140	65	40	140	140	100	140	35
Screen	50	65	50	50	150	-	-	-



A.R.P.12.
(V1B-F)

Valve Base connections viewed from under side of Chassis



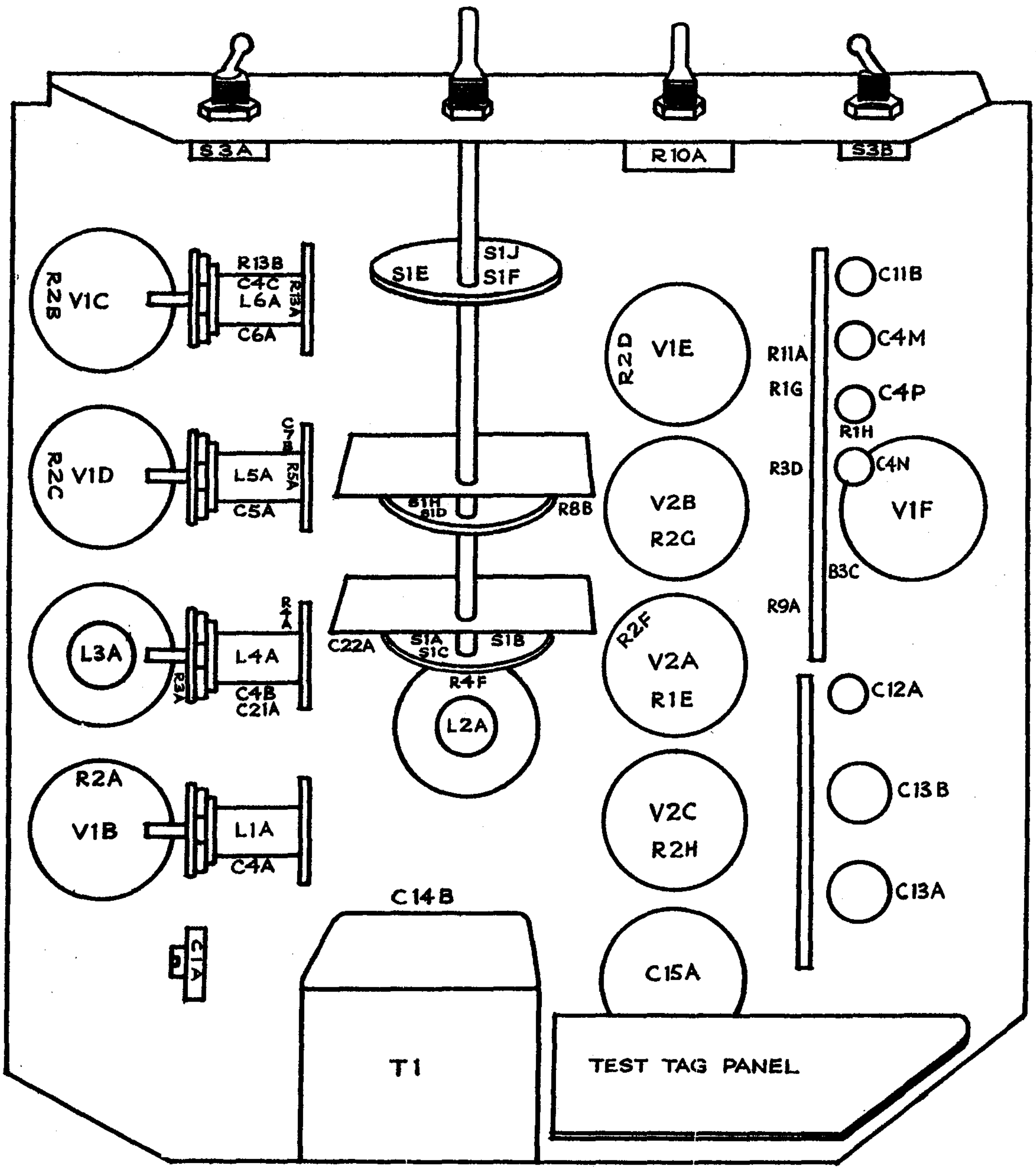
A.R.8.
(V2A-C)

Figure 10.

Figure 11.

DRAWING OF LEFT SIDE OF RECEIVER CHASSIS

SHOWING APPROX.LOCATION OF COMPONENTS.



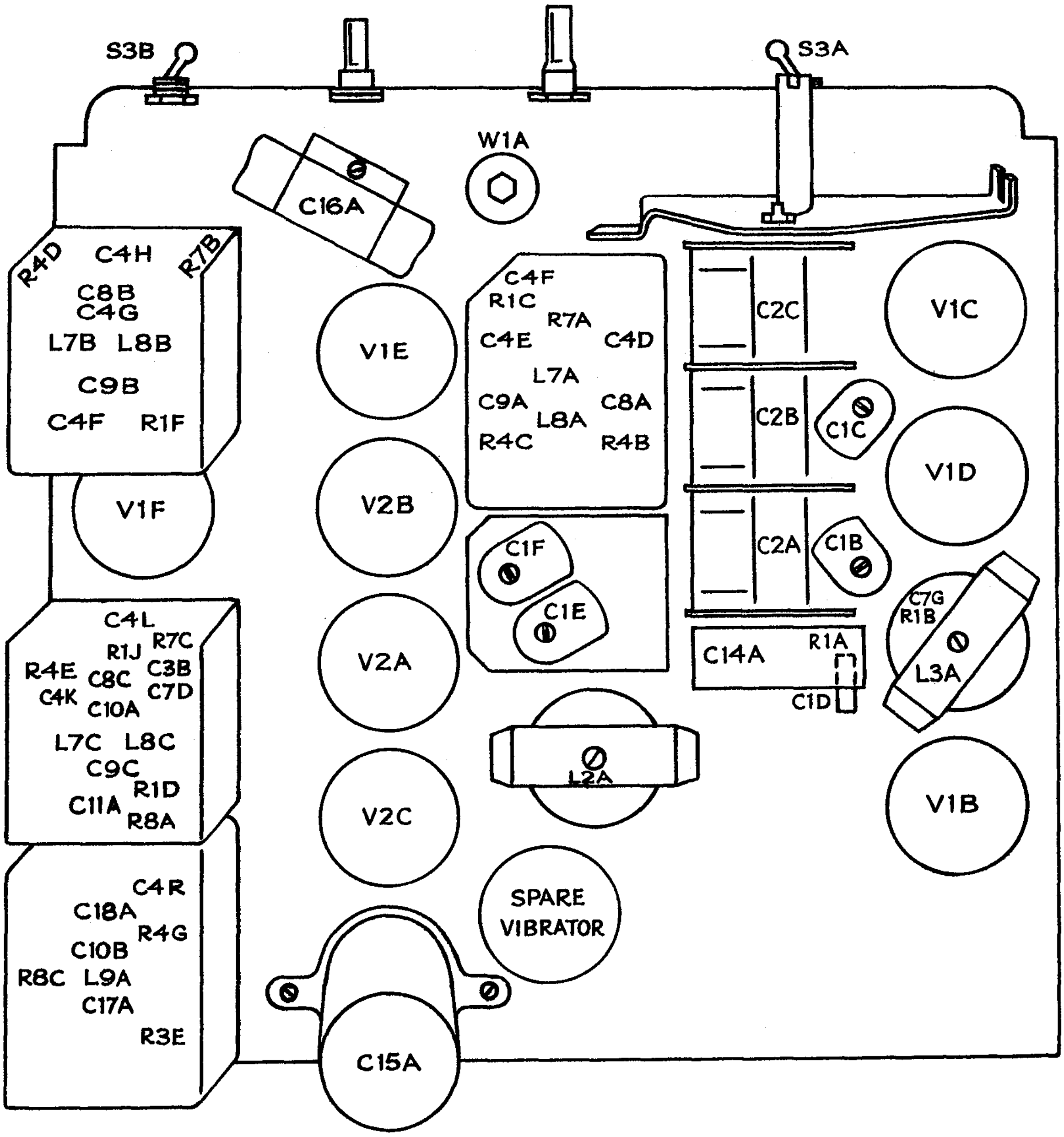
CONDENSERS

C1 5/35 µµF	C2 14/368 µµF	C4 .01 µF
C5 .0015 µF	C6 .002 µF	C7 150 µµF
C8 150 µµF	C9 160 µµF	C10 220 µµF
C11 .002 µF	C12 .1 µF	C13 2 µF
C14 300 µµF	C15 75 µF	C16 25 µF
C17 400 µµF	C18 .0012 µF	C19 4 µF
C20 .025 µF	C21 15 µµF	C22 20 µµF
	C25 100 µµF	

Figure 12.

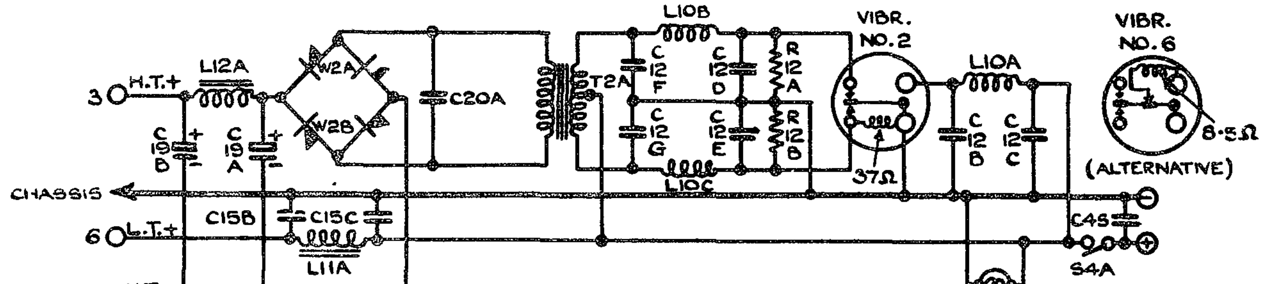
DRAWING OF RIGHT SIDE OF RECEIVER CHASSIS

SHOWING APPROX. LOCATION OF COMPONENTS.



RESISTORS

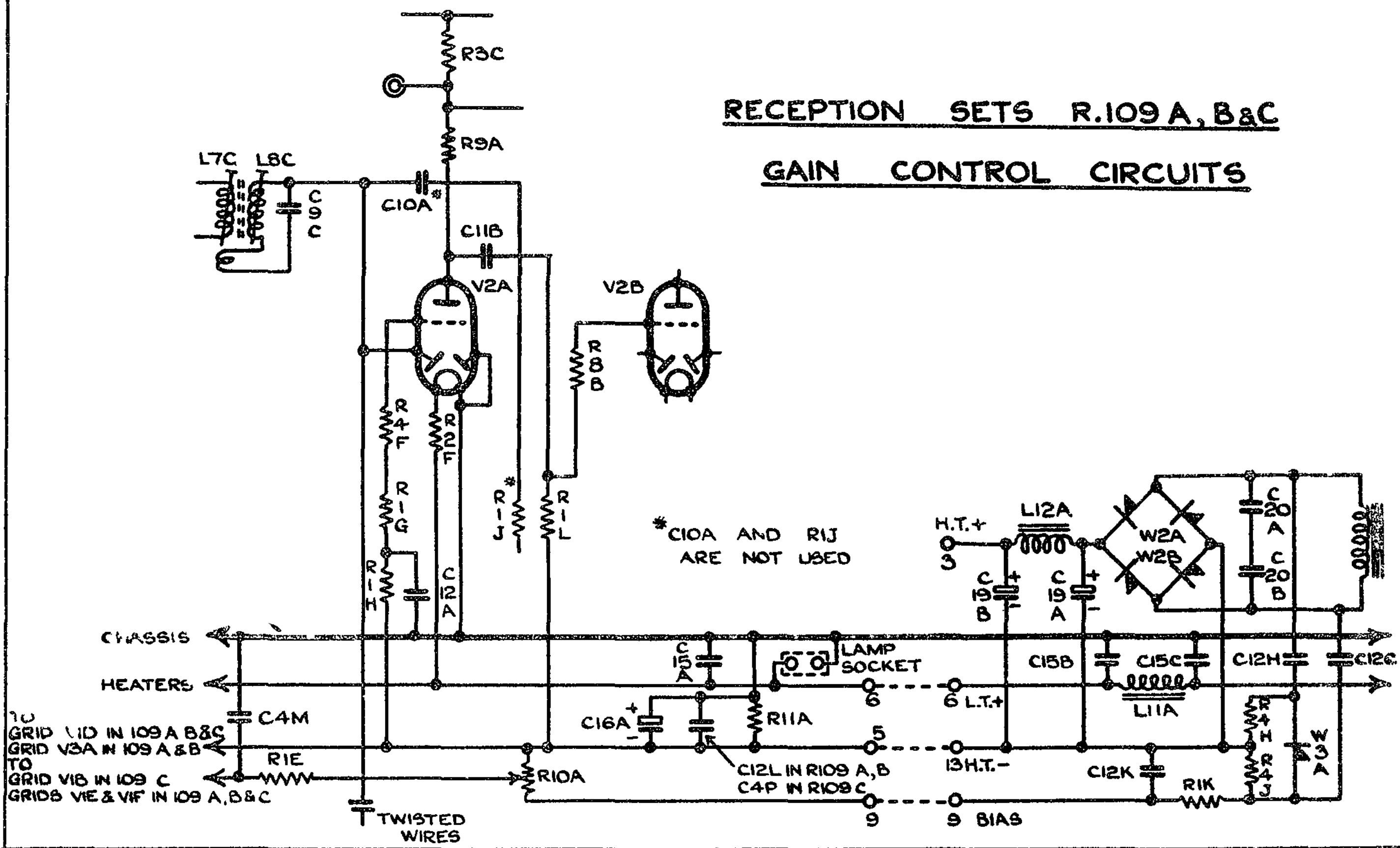
R1 1 MEG OHM	R2 71 OHMS	R3 4,700 OHMS
R4 .22 MEG OHMS	R5 22,000 OHMS	R7 10,000 OHMS
R8 100,000 OHMS	R9 47,000 OHMS	R10 1 MEG OHM
R11 270 OHMS	R12 150 OHMS	



R.109 SUPPLY UNIT

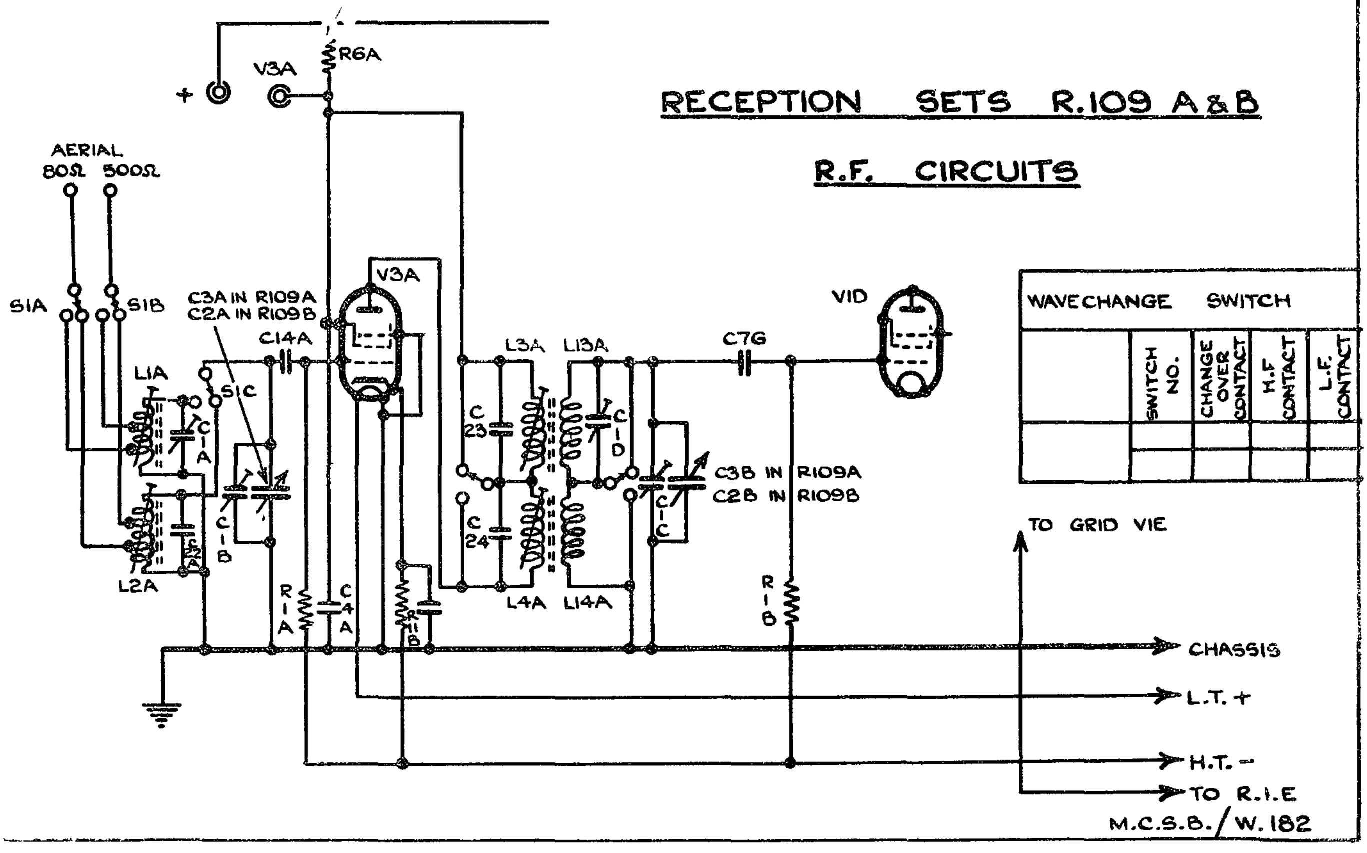
RECEPTION SETS R.109 A, B&C

GAIN CONTROL CIRCUITS

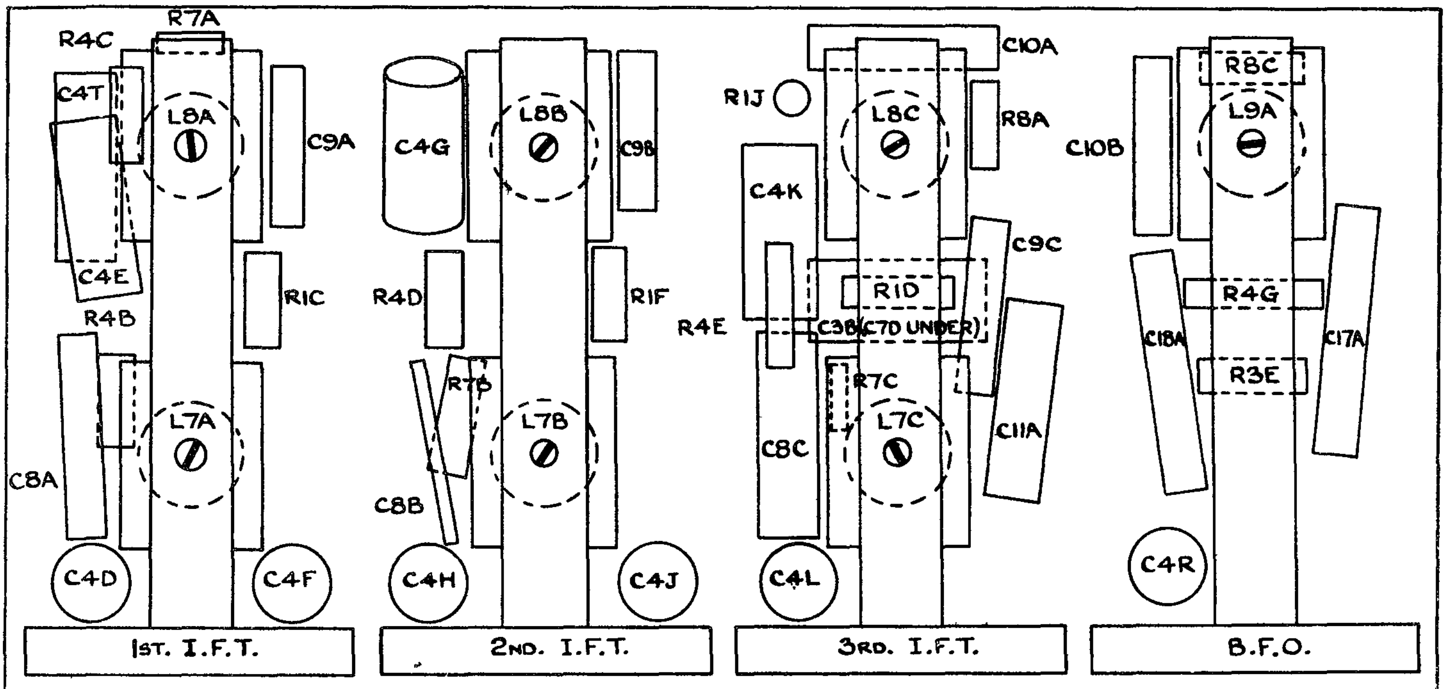


RECEPTION SETS R.109 A&B

R.F. CIRCUITS



WAVECHANGE SWITCH	SWITCH NO.	CHANGE OVER CONTACT	H.F. CONTACT	L.F. CONTACT



RECEPTION SET R109. INTERNAL LAYOUT I.F.T. AND B.F.O. SCREENING CANS.

CONDENSERS

REF.	EQUIP'T	VALUE	REMARKS
C1	ALL	5/35µµF	SEMI-FIXED
C2	109,109B&C	14/368µµF	GANGED VARIABLE
	109A	14/530µµF	
C3	109A	14/440µµF	VARIABLE
C4	ALL	·01µF	±25% TUBULAR
C5	109,109C	·0015µF	± 10%
	109A, B	·002µF	
C6	109,109C	·002µF	± 10%
	109A, B	·0025µF	
C7	ALL	150µµF	± 10%
C8	ALL	150µµF	± 3%
C9	ALL	160µµF	± 3%
C10	109	200µµF	± 10%
	109A,B,C	220µµF	
C11	ALL	·002µF	±25% TUBULAR
C12	ALL	·1µF	±20% TUBULAR
C13	ALL	2µF	350V.POLARISED
C14	ALL	300µµF	±20%
C15	ALL	75µF	12 V. REV.
C16	ALL	25µF	12V.POLARISED
C17	ALL	400µµF	± 5%
C18	ALL	·0012µF	± 20%
C19	ALL	4µF	350V.POLARISED
C20	109	·025µF	±20% TUBULAR
	109A,B,C	·05µF	
C21	109,109C	15µµF	± 10%
C22	109	20µµF	± 10%
	109A,B,C	22µµF	
C23	109A, B	33µµF	± 10%
C24	109A, B	47µµF	± 10%
C25	ALL	100µµF	± 10%

RESISTORS

REF.	EQUIP'T	OHMS	REMARKS
R1	ALL	1M	± 20%
R2	ALL	71	±5% WIREWOUND
R3	109	5K	± 20%
	109A,B,C	4·7K	
R4	109	250K	± 20%
	109A,B,C	220K	
R5	109	25K	± 20%
	109A,B,C	22K	
R6	109A, B	2·2K	± 20%
R7	ALL	10K	± 20%
R8	ALL	100K	± 20%
R9	109	50K	± 20%
	109A,B,C	47K	
R10	ALL	1M	VARIABLE LINEAR
R11	109	250	± 10%
	109A,B,C	270	
R12	ALL	150	± 20%
R13	109	20K	± 20%

VALVES

NO.	EQUIP'T	TYPE	REMARKS
V1	ALL	ARP 12	
V2	ALL	AR 8	
V3	109A, B	ARP 36	

INDUCTANCES

L1	L.F. AERIAL COIL
L2	H.F. AERIAL COIL
L3	L.F. ANODE COIL
L4	H.F. ANODE COIL
L5	L.F. OSC. COIL
L6	H.F. OSC. COIL
L7	I.F. PRIMARY COIL
L8	I.F. SECONDARY COIL
L9	B.F.O. COIL
L10	VIBRATOR CHOKE
L11	L.T. CHOKE
L12	H.T. CHOKE
L13	L.F. GRID COIL
L14	H.F. GRID COIL

SWITCHES

S1	WAVE - CHANGE
S2	L.S. / TELEPHONE
S.3A	CRASH - LIMITER
S.3B	SYSTEM
S4	ON - OFF

RECTIFIERS

W1	TYPE M.3
W2	SELENIUM NO. 13
W3	TYPE J.25

TRANSFORMERS

T1	O/P TRANSFORMER
T2	POWER TRANSFORMER

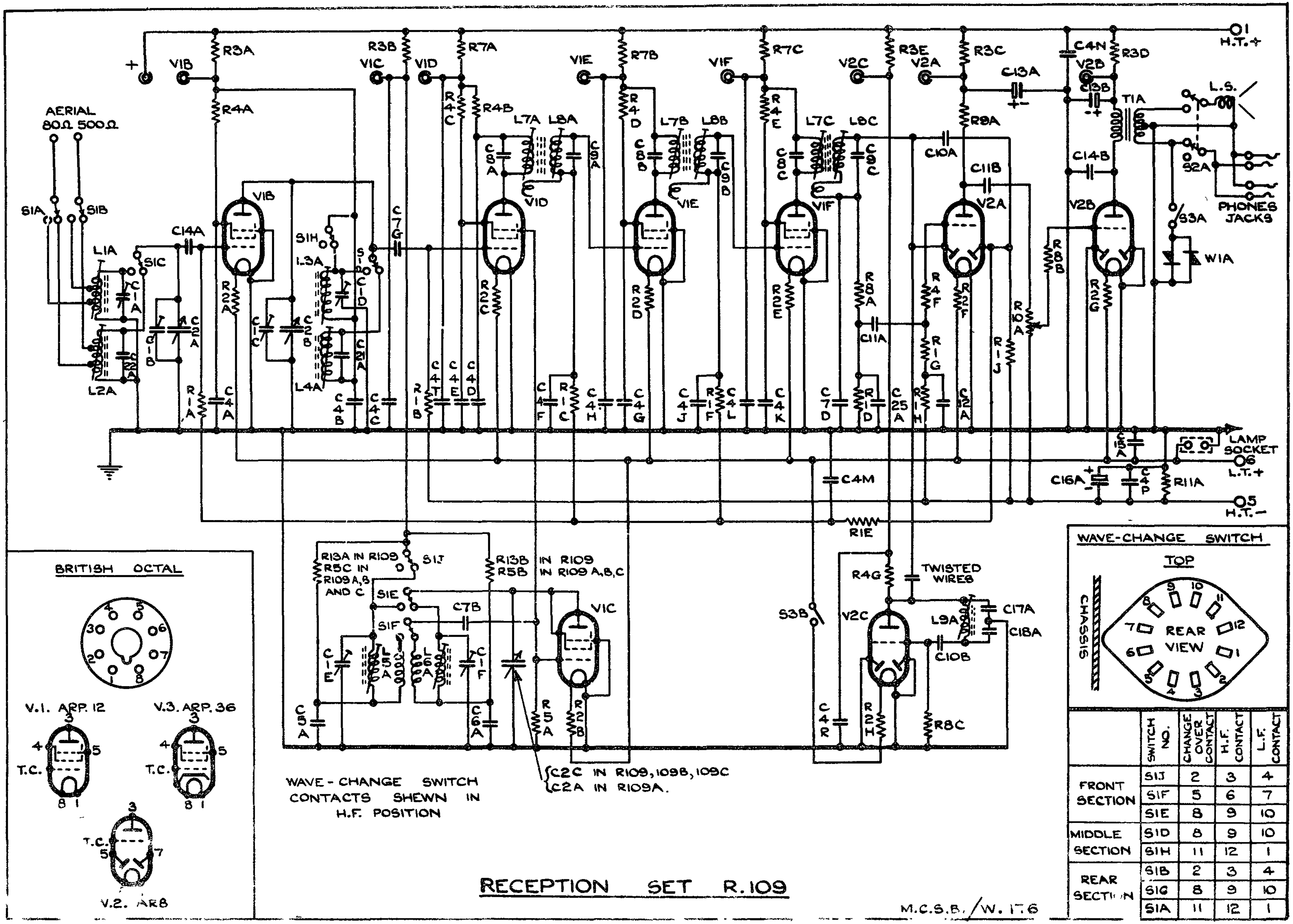
COMPONENT LIST

RECEPTION SETS R109, A, B & C

RECEPTION SETS R109, 109A, 109B, 109C. SUMMARY OF DIFFERENCES.

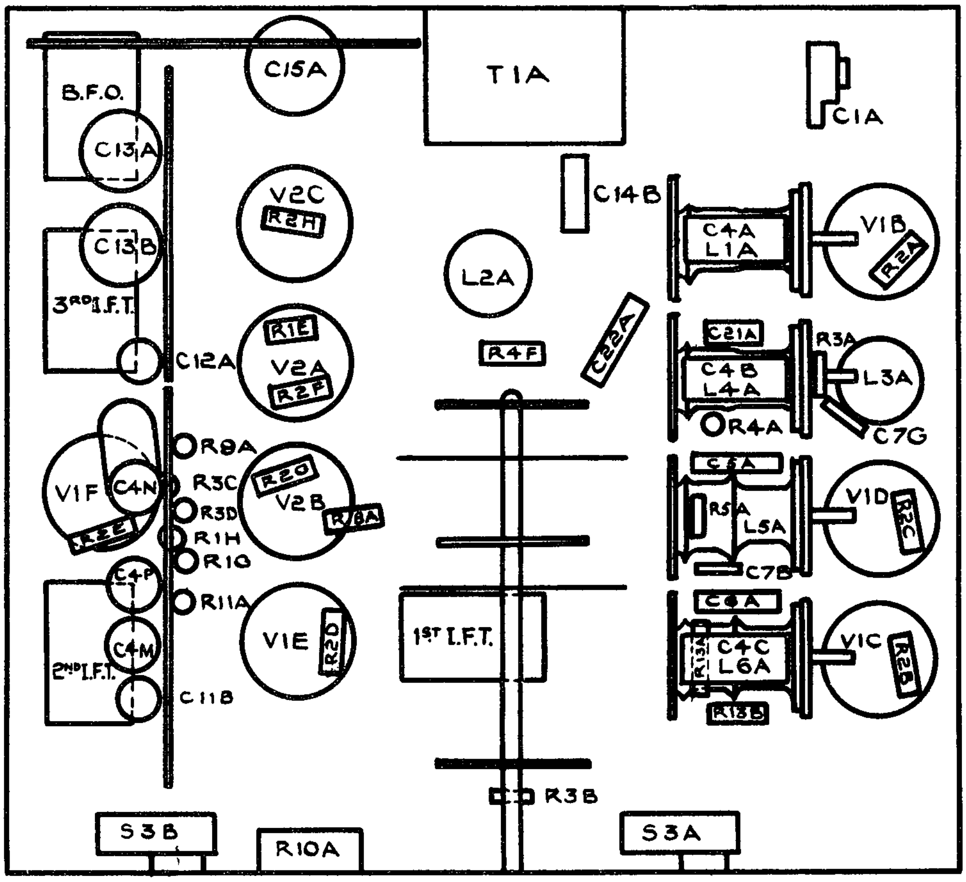
TYPE	FREQUENCY RANGE Mc/s	VOLUME CONTROL	R.F. AMPLIFIER	ALIGNMENT FREQUENCIES IN Mc/s H.F. BAND		L.F. BAND	
R109	1·8–3·9–8·5	A.V.C ON R.F. AND I.F. STAGES MANUAL CONTROL ON A.F. STAGE	A.R.P. 12 DIRECTLY HEATED	8·2	4·1	3·8	1·9
R109 A	2·0–4·9–12·0	NO A.V.C. MANUAL CONTROL ON ON I.F. STAGES ONLY	A.R.P. 36 INDIRECTLY HEATED	11·8	5·0	4·7	2·1
R109 B	2·5–5·5–12·0	NO A.V.C. MANUAL CONTROL ON I.F. STAGES ONLY	A.R.P. 36 INDIRECTLY HEATED	11·8	5·6	5·4	2·6
R109 C	1·8–3·9–8·5	NO A.V.C. MANUAL CONTROL ON R.F. AND I.F. STAGES	A.R.P. 12 DIRECTLY HEATED	8·2	4·1	3·8	1·9
I.F. ALL MODELS 465 Kc/s				C1F. C1C. C1B.	L6A. L4A. L2A	C1E. C1D. C1A.	L5A. L3A. L1A.

M.C.S.B./W. 184

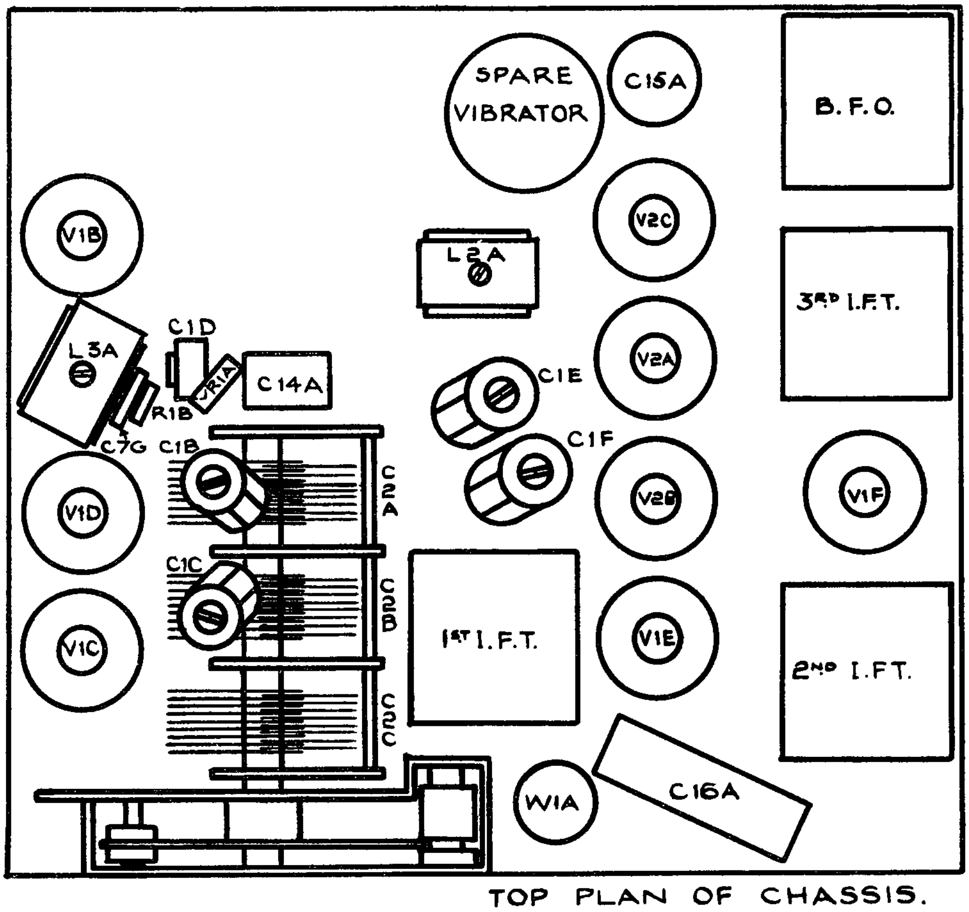


	SWITCH NO.	CHANGE OVER CONTACT	H.F. CONTACT	L.F. CONTACT
FRONT SECTION	S1J	2	3	4
	S1F	5	6	7
	S1E	8	9	10
MIDDLE SECTION	S1D	8	9	10
	S1H	11	12	1
REAR SECTION	S1B	2	3	4
	S1G	8	9	10
	S1A	11	12	1

RECEPTION SET R.109



UNDERNEATH PLAN OF CHASSIS



FOR INTERNAL LAYOUT OF THE I.F.T. AND B.F.O. SCREENING CANS, SEE M.C.S.B./W.184.

TOP PLAN OF CHASSIS.

RECEPTION SET R.109.

M.C.S.B/W.183.