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STR. 18-C

AIRBORNE H.F. RADIO COMMUNICATION EQUIPMENT

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DRAWINGS (Cont'd.)

ILLUSTRATIONS

CHAPTER 1

GENERAL DESCRIPTION

1.0 GENERAL MAKE UP OF EQUIPMENT

1.1 The STR.18C equipment comprises a 100 channel crystal controlled Transmitter/Receiver for airborne use. Full remote control is provided from a small control box, but local control at the equipment for use by a radio operator is also available. One crystal is required for each channel in use.

It operates without restriction in the frequency band 2.8 Mc/s to 18.1 Mc/s providing C.W., M.C.W. and R/T facilities from the local control position but R/T only when remotely controlled.

The equipment is designed to be as versatile as possible in its utilization and installation, there being no restriction on the relative positioning of the units.

The 100 preset channels which can be selected at will after being "set up" are distributed in 24 bands each being ± 1% of a nominal frequency. These bands can be set up in any part, in any sequence within the frequency range of the equipment and any number of suitable channels allocated to a band.

This banding procedure applies only to the transmitter Unit and the Aerial Coupling arrangements, the receiver and transmitter drive stages being automatically tuned for each of the 100 channel frequencies selected. A "speech clipping" modulator is standard.

Transmission and reception are on the same frequency but provision is made for fine tuning the receiver ± 7kc/s from a nominal channel on local control only.

1.2 The equipment conforms to the requirements of B.C.A.R. Section R with known proposed amendments and to relevant paragraphs of British Standard Specification (B.S.) No. G100. The equipment conforms in general to B.S. R1 for recommendations as to sizes, weights, finishes and installation in Standard (S.B.A.C.) rack mountings.

All units are designed to operate generally in large civil aircraft where pressurized accommodation is available for the units and non-acrobatic flight intended.

1.3 Definitions

To clarify certain terms used later in this handbook the following definitions are made.

"Local Control"

Control (by a radio operator) of the equipment from its main units in their mounting racks.

"Remote Control"

Control of the equipment from the Remote Control Unit (R.C.U.) normally mounted in the cockpit for Pilot or Co-pilot operation.

"Setting Up"

The initial tuning-up of the equipment into bands and channels on local control to allow normal channel/band selection on its completion.

"Wire or Fixed Aerial"

An aerial of open wire of fixed length normally from the nose to tail of an aircraft. Uses the fixed wire aerial coupling unit 24-LRU.52.

"Suppressed Aerial"

In this case the main plane, or tail plane of a large aircraft, is excited by means of a coupling unit mounted in a cut away portion of the trailing or leading edge of the plane. The plane structure then is excited to radiate. (e.g. Coupling Unit 24-LRU.58.)

2.0 TYPICAL INSTALLATIONS

Two typical installations are given as an example in Table I which lists the equipment units required.

At the Receiver/Drive Unit Fig. 2 (3-LRU. 111A)

The following controls are present when Local/Remote Switch S11 is in "Local" position. This unit mounts all the controls necessary for setting up and operating the equipment. Thus remaining units can be mounted in not readily accessible positions if required.

(1) OFF	-	All equipment off.
(2) RX ON	-	Receiver operating, drive circuit available, heaters on.
(3) STD/BY	-	Remaining Transmitter heaters on, transmitter circuits tune to band selected.
(4) TX	-	Transmitter rotary starts, ready for sending.
(5) C.W.	-	Operation on C.W., C.W. oscillator on in receiver, modulator valves cut off.
(6) M.C.W. Operation	-	Carrier modulated by tone oscillator.
(7) R/T.	-	Microphone input to modulator.
(8) Selection of Transmitter Band labelled A-Z	-	This tunes the Transmitter and Aerial to any one of 24 bands.
(9) Selection of Channel - 00 - 99	-	Two knob (concentric) control of channel frequency by selecting channel crystal.
(10) Metering of Transmitter Drive	-	P.A. Stage grid current and cathode current, and aerial excitation.
(11) Fine Tuning Control for Receiver	-	Varies I.F. filter.
(12) Muting ON/OFF Switch	-	Cuts out receiver muting.
(13) Note filter ON/OFF Switch	-	Allows a narrow band audio filter to be used for C.W. reception.
(14) Local/Remote Switch	-	Enables control of the equipment to be passed to Remote Control Unit which then overrides the controls on this unit and enables R/T operation only.
(15) A.G.C. ON/OFF switch	-	Enables receiver A.G.C. to be switched off.
(16) R.F. Gain Control	-	Operates on the receiver.

30-LRE.50A See Fig. 22.

For use on a large aircraft with a Suppressed Aerial and with local or remote control.

30-LRE.50B See Fig. 21.

For use on a large aircraft with a Wire Aerial and with local or remote control.

2.2 Table I

Unit	Code	30-LRE.50A	30-LRE.50B
Power and Modulator Unit	404-LRU.4B	1	1
Transmitter Unit	4-LRU.50D	1	1
Receiver/Drive Unit	3-LRU.111A	1	1
Control Unit (Remote)	402-LRU.11A	1	1
Aerial Coupling Unit (Wire)	24-LRU.52C or E		1
Aerial Coupling Unit (Suppressed)	24-LRU.58C	1	

Note: The Receiver/Drive Unit can be changed quickly from wire to Suppressed aerial operation by reversal of a plug.

2.3 A Typical Installation (30-LRE.50B Suppressed Aerial)

2.3.1 This now briefly described to list the facilities available at each Unit.

The units are mounted in the normal aircraft radio racks except for the Remote Control Unit assumed to be mounted in the cockpit and the Suppressed Aerial coupling unit in its appropriate position which would be inaccessible from the main equipment or the interior of the aircraft.

2.3.2 Local Control

On local control the following facilities are available.

(17) Tune/Test Switch - This is used in conjunction with (10) above and (18) below to tune up any of the 24 bands possible by remote control from this unit.

(18) Band Setting Controls - These comprise (1) 4 x 24 setting knobs for the potentiometers controlling the setting positions of the transmitter and aerial tuning elements, (2) Two 24 way plug boards to allocate the band information to the transmitter and receiver.

At the Transmitter (4-LRU.50D) Fig.3

Manual control of this unit is possible under emergency conditions, two crystals may be inserted in the front panel to give emergency transmission, the transmitter rotary being controllable from here. Valve stages can be monitored at the front panel.

At the Aerial Coupling Unit (Wire) (24-LRU.52C) Fig.5

Manual operation of this unit is available for initial setting up trials, and for emergency use if accessible. Aerial excitation can also be monitored at the front panel under these conditions.

2.3.3 Remote Control See Fig.1.

When control is transferred to the Remote Control Unit 402-LRU.11A the following facilities on R/T operation only are present.

(1) OFF, RX ON, STD/BY and TX switch (see 1-4 in 2.3.2).
(2) Channel Selection 00 - 99 (see 9 in 2.3.2).
(3) Band Selection A-Z (see 8 in 2.3.2).
(4) Receiver muting ON/OFF switch.
(5) Meter-Aerial excitation.
(6) R.F. Gain - Controls receiver.
(7) Illumination dimmer control.
(8) Tune Lamp. This illuminates whenever a channel is being tuned.

3.0 BRIEF DESCRIPTION OF UNITS

Receiver/Drive Unit (3-LRU.111A) Fig.2.

This contains the receiver and the drive stages of the transmitter,

the crystals, setting-up controls and all controls necessary for channel selection and operation of the equipment. All these controls are accessible on the front panel, the setting-up controls being enclosed by a suitable cover during normal operation.

The removal of the rotary transformer and blower unit and its subsequent re-fitting is made as simple as possible.

The receiver/drive unit is directly operated from a standard 28V D.C. supply with a regulated 19V supply.

When a particular channel crystal is selected this unit auto-tunes to the required condition. The R.F. Unit, I.F. Unit, Front panel, Band Selector, Crystal selector (Turret) and Relay Unit are readily unplugged from the Mounting Unit for maintenance purposes.

The low impedance aerial change-over relay is mounted in this Unit.

The receiver is fitted with a noise limiter against impulsive noise.

Power and Modulator Unit (404-LRU.4B) Fig.4

This unit contains the Rotary Transformer for the H.T. supplies of the Transmitter circuits, and its associated control relays and filter circuits. A sub-chassis mounts the push-pull audio amplifier which drives the modulator for the final R.F. amplifier in the Transmitter Unit. A simple form of V.O.G.A.D. is incorporated in the amplifier which is also fitted with "speech clipping" circuits which can be preset at several levels.

Transmitter Unit (4-LRU.50D)

This unit mounts 3 ganged coil tuned r.f. amplifiers, the final being the P.A. stage and operated from one control. The input and output impedances are 70 ohms.

Aerial Coupling Unit (Wire) (24-LRU.52C) Fig.5 or
(24-LRU.52E) Fig.9A

This unit provides a pi-network to match the transmitter 70 ohm output to the complex impedance of a wire aerial. It contains two variable inductances and a selection of fixed condensers operated by three remote control elements. A vacuum relay is also fitted.

Aerial Coupling Unit (Suppressed) (24-LRU.58)

This consists of a coupling loop for suppression in the aircraft structure. This loop inductance is variable to resonance with one of 12 fixed capacitors mounted in the switch unit behind it. Both are selected by remote control. The unit can take several mechanical forms.

Interconnection of Units

All units have rear mounted plugs and sockets which engage with corresponding plugs and sockets on the ends of the interconnection cables. The cable ends are mounted on back plates fixed to the standard aircraft racking which carry spigots to register with their respective units.

4.0 THE REMOTE CONTROL SYSTEM

This brief description is elaborated in Chapter III section 2.0. The control is basically in two divisions.

4.1 Channel Selection

Operation of the "Tens" and "Units" switches on the channel knobs causes the crystal turret to rotate and to stop in one of 25 positions using the continuity path over a 10 wire system. As the turret has 4 banks of 25 crystals, this presents 4 crystals to the crystal contacts. Extra switches on the channel knobs operate 3 relays which connect one of these four crystals as required to the crystal oscillator. This frequency together with band information from the band selector enables the auto-tune circuit of the Receiver/Drive unit to search and stop on the peak drive in the transmit condition. On receive the same tuned circuits are used and thus the Receiver is fully tuned.

4.2 Band Selection

The remote control of the 3 or 4 tuning elements is carried out by a self-balancing resistance bridge system (Wheatstone Servo). In this a small D.C. motor at the driven (tuning element) and of the circuit is coupled mechanically to a potential divider resistance which forms a bridge with another potential divider at the Drive Unit. Relays detect the "out of balance" current, and turn the motor so that balance is obtained. Variation of the resistance on the Drive Unit thus causes the tuning element to follow and allows remote control of this during setting up. Change of a band selects the appropriate resistance ratio previously chosen when setting up and causes the tuning element to run to the required position. This procedure can take place while the circuits are on "Stand by" and prevents radiation of a tuning signal, and also occurs at the same time as the auto-tune drive circuit is operating.

In the case of the wire aerial four remote tuning elements each requiring 24 setting positions are necessary at the Drive Unit; these are supplied by 8 special potentiometers. In these one resistance element can provide 12 independent resistance ratios, one of which can be selected by turning the element to the correct position.

The 24 bands are selected on a 12 x 2 basis. The selector motor turning the selector potentiometers and associated band selector switches to one of 12 positions by means of the loss of continuity over a 6 wire system to the Band Switch. A relay operated when the Band Switch changes from the range A-M to N-Z transfers the stopping positional information to a second set of potentiometers and switches.

4.3 The change to a channel frequency which can fit into one of the 24 bands already set up, i.e. within $\pm$ 1% of the nominal frequency of the band merely requires the insertion of the new crystal in the turret and selecting its channel number with the appropriate band. This could easily be done in flight in a few moments.

4.4 The Transmitter and the fixed wire aerial coupling unit, if accessible, may be tuned manually. In the event of an emergency, the transmitter may be started from the Transmitter Unit, when one of two crystals plugged into its front panel gives the required drive, thus allowing the use of the transmitter in the event of Remote Control System failure.

CHAPTER 2

PERFORMANCE AND PHYSICAL DETAILS

1.0 GENERAL

1.1 The equipment is designed to work as an entity. It is possible, however, to operate the wire aerial version using a manually tuneable receiver of some type and utilizing the high impedance changeover aerial relay in the Aerial Coupling Unit.

1.2 The general conditions under which the equipment is expected to operate are:-

With regard to climatic and mechanical conditions of operation the equipment is intended to comply with the British Civil Airworthiness requirements of the Air Registration Board.

Altitude Rating

Suppressed aerial coupling unit	-	40,000 ft.
Main items of equipment	-	20,000 ft.

Vibration

Suppressed aerial coupling unit	-	Grade 2
Main items of equipment	-	Grade 3 with suitable anti-vibration mountings on racks.

Acceleration

All equipment - Grade 3.

Climatic Conditions

All equipment - Category I

2.0 TRANSMITTER/RECEIVER

The following performance details are typical and may vary slightly between installation and installation.

2.1 Transmitter/Receiver

2.1.1 Frequency Range

2.8 - 18.1 Mc/s with no limitations. 100 channels in any order in 24 1% bands set anywhere in range.

Note: The Atlantic City frequency bands allocated to H.F. Air Mobile Service can be covered completely in 23 Bands.

2.1.2 Susceptibility to ripple

Every possible endeavour is made to minimise the effect of ripple on the D.C. supply due to inefficient smoothing on the aircraft supply.

2.2 Transmitter

2.2.1 Power Output

Not less than 100 watts into a non-reactive load of 70 ohms measured at the centre frequency of each pre-set band. At the edges of these bands the power output does not fall by more than 2 db relative to that at the centre frequency. Further attenuation due to the aerial is kept to a minimum.

2.2.2 Modulation

With the peak clipping circuits out of operation, the modulator is capable of modulating the carrier to a depth of 100% with an input of -20 db with respect to the nominal input voltage. The latter is defined as an input of 20 millivolts $\pm$ 3 db balanced to earth within 1% having a source impedance of 300 ohms.

2.2.3 Distortion

Between the limits of 500 c/s and 3,000 c/s the total R.M.S. distortion below the clipping level will not exceed 15%.

2.2.4 V.O.G.A.D.

The A.G.C. commences to operate at an input of -6 db with reference to the nominal input voltage. Up to 18 db of peak clipping at 90% modulation can be obtained. The degree of peak clipping will be maintained within 2 db for input levels between -6 db and +20 db.

2.2.5 Side Tone

The level of side tone on R/T when the transmitter is fully modulated with a 1,000 c/s tone, is adjustable by tappings of the transformer to give the equivalent of 225 mW or less into a resistive load of 33 ohms.

2.2.6 Frequency Tolerance

The frequency tolerance including the long and short term stability is better than .01% or 1 kc/s whichever is the greater.

2.2.7 Spurious and Harmonic Radiations

These conform to the requirements of the C.C.I.R. Atlantic City regulations.

2.3 Receiver

2.3.1 Sensitivity

C.W. not more than 6 db down from the standard output for an input of 3 μV.

R.T. not more than 6 db down from the standard output for an input of 3 μV modulated 50% at 1,000 cycles.

Note: Standard output is taken as resulting from a receiver input of 50 μV modulated 50% at 1,000 c/s.

2.3.2 Signal/Noise Ratio

C.W. - The Signal/Noise ratio is better than 16 db when measured with an R.F. input of 3 μV.

R.T. - The Signal/Noise ratio is better than 10 db when measured with an R.F. input of 3 μV modulated 50% at 1,000 c/s.

2.3.3 A.G.C.

The output does not rise by more than 6 db for inputs between 5 μV and 0.1 of a volt.

2.3.4 Image Suppression

The second channel suppression is greater than 45 db.

2.3.5 Fine Tuning

It is possible to adjust the tuning of the receiver by ± 7 kc/s about each preset frequency, with an accuracy of better than ± 1 kc/s. When operating from the remote control unit, the fine tuning control on the receiver drive unit will be reset, such that the overall frequency tolerance will be met.

2.3.6 Muting

The muting is capable of being preset so that it opens at any input up to 50 μV. The amount by which the audio output is reduced when the muting circuit is in operation may be preset to either greater than 50 db or within the range 15 to 20 db.

2.3.7 Frequency Tolerance

The frequency tolerance including the long and short term stability is better than .01% or 1 kc/s whichever is the greater.

2.3.8 Overall bandwidth

6 kc/s ± 1 kc/s at 465 kc/s (6db)
24.5 kc/s ± 1.5 kc/s at 465 kc/s (60 db).

2.3.9 I.F. Breakthrough

Not worse than 50 db.

2.3.10 Audio Characteristic

Relative to 1000 c/s the response will be between 0 and -3 db between 300 and 3000 c/s.

Outside this band the response will fall continuously by at least 4 db per octave, the audio response being obtained by the introduction of the audio signal at the final detector output.

2.3.11 Audio Output Power

(i) Output Power

The receiver is capable of supplying an output power of 225 mW when supplied with a signal modulated at 1,000 c/s to a depth of 100% into a resistive load of 33 ohms. Where the modulation is sinusoidal the total harmonic content of the output does not exceed 10% of the total output for modulation depths below 90%. Under no condition is the receiver capable of delivering an output in excess of 675 mW into a resistive load of 33 ohms.

(ii) Regulation with Changes of Supply Voltage

Under the conditions of (i) above, but with the 28V supply to the receiver reduced to $22\frac{1}{2}V \pm \frac{1}{2}V$ and 19V supply remaining constant, the output does not fall by more than 2 db below 225 mW.

(iii) Regulation with Changes of Output Impedance

Under the conditions of (i) above, but with a resistive load of 100 ohms, the output is not greater than 150 mW. Under these conditions where the modulation is sinusoidal, the total harmonic content does not exceed 15% of the output.

2.3.12 Noise Limiter

A circuit will limit the effect of impulsive noise pulses to a level approximately that of the received signal with 100% modulation.

3.0 POWER REQUIREMENTS

3.1 The power supply required is 28V D.C. with a regulated supply of 19V D.C.

3.2 Power Input

The power input to the equipment is as follows:- (Typical Values)

Condition	28V D.C.	19V D.C.	Watts
RX ON	2.7	8.85	154
Standby	2.8	8.25	315
C.W. Space	12.0	8.25	510
C.W. Mark	21.8	8.25	840
R/T (P.T.T. open)	12.5	8.25	580
R.T. Normal speech (unclipped)	24.0	8.25	900
M.C.W.	26.0	8.25	960
M.C.W. Space	15.0	8.25	650
R.T. (Clipped Speech)	27.0	8.25	990

NOTES: The figures given above are approximate.

When a channel is being selected there is an increase of 10W.

It should be noted that the power figures given in the last column above are for the total power consumed from the 28V supply and, therefore, include the losses in the regulator.

4.0 DIMENSIONS AND WEIGHTS

Does not include cabling.

	Size In.	Weight lb.	kg.
(a) Transmitter Unit 4-LRU.50D	8 x 8 x 12½ deep	16.0	7.3
(b) Power and Modulator Unit 404-LRU.4B	8 x 10 x 12½ deep	34.0	15.4
(c) Receiver/Drive Unit 3-LRU.111A	8 x 16 x 12½ deep	49.0	22.3
(d) Remote Control Unit 402-LRU.11A	6 x 6 x 2½ deep	2.25	1.0

(e) Aerial Coupling Unit 24-LRU.52C	8x9x12½ deep	17.0	7.7
(f) Aerial Coupling Unit 24-LRU.58C	8x9x12½ deep	13.0	5.9
(g) Aerial Coupling Unit 24-LRU.52E	6.5x7.5x17	19.75	9.0
Back Plate for (a) L.100946/20	8" wide	0.31	0.14
Back Plate for (b) L.100946/21	10" wide	0.38	0.17
Back Plate for (c) L.114650/1	16" wide	1.5	0.7
Back Plate for (d) L.101059/2	6" wide	0.25	0.11
Back Plate for (e) L.100946/22	9" wide	0.44	0.2

Total Weight of Installation 30-LRE.50A = 124 lb.
Total Weight of Installation 30-LRE.50B = 128 lb.

Less racking details, aerial and cables.

5.0 VALVES USED

This list includes glass enveloped electronic valves only and not any germanium or selenium rectifiers used as diodes.

5.1 Transmitter/Receiver complete

CV. Code	Commercial Code	A	B	C	Total
CV. 136	6AM5 (6516)	-	2	1	3
CV. 138	6AM6 (6064)	-	-	7	7
CV. 140	6AL5 (6058)	-	1	-	1
CV. 428	5B/254M	1	4	-	5
CV. 454	6BA6 (5749)	-	-	5	5
CV. 455	12AT7 (6060)	-	2	2	4
CV. 491	12AU7 (6067)	-	1	-	1
CV. 2127	6CH6 (6132)	1	-	1	2
CV. 2135	6BR7 (6059)	-	2	-	2
CV. 2208	G50/1G	-	-	3	3
CV. 2519	4H/135M SV-4X/150A	2	-	-	2

A = Transmitter Unit 4-LRU.50D
B = Modulator Unit 404-LRU.4B (28-LRU.362C)
C = Receiver/Drive Unit 3-LRU.111A
The code in Brackets refers to BRIMAR "Trustworthy" Valves.

5.2 "Line up" of Valves

5.2.1 Receiver/Drive Unit 3-LRU.111A

Valves used in Receive Condition		Position
1st R.F. Amplifier	1 - CV.454	D
2nd R.F. Amplifier	1 - CV.454	D
1st Frequency Changer	1 - CV.138	D
Local Oscillator (Xtal)	2 - CV.138	D
1st I.F. Amplifier	1 - CV.454	E
2nd I.F. Amplifier	1 - CV.454	E
3rd I.F. Amplifier	1 - CV.454	E
C.W. Oscillator	1 - CV.138	E
Squelch Valve	1 - CV.455	E
1st Audio Amplifier	1 - CV.138	E
Audio Output Stage	1 - CV.136	E
Valves used only in Transmitter Drive Circuits		
465 kc/s Xtal Osc.	1 - CV.455	D
Aperiodic Amplifier	1 - CV.2127	D
Valves used in Auto Tune Circuit		
Differentiating Amplifier	1 - CV.138	F
Relay Driver	1 - CV.138	F
Overshoot Correction	3 - CV.2208	F

Position reference D = R.F. Unit 28-LRU.420A
E = I.F. Unit 28-LRU.421A
F = Mounting Unit 395-LRU.62A

5.2.2 Power and Modulator Unit 404-LRU.4B (Amplifier 28-LRU.362C).

Push Pull Microphone Amp.	2 - CV.2135
Push Pull 1st Amplifier	1 - CV.455
V.O.G.A.D. Detector	1 - CV.140
Tone Oscillator and Phase Splitter	1 - CV.455
Push Pull 2nd Amplifier	2 - CV.136
Cathode follower Drive	1 - CV.491
Parallel Push Pull Modulator	4 - CV.428

5.2.3 Transmitter Unit 4-LRU.50D.

Buffer Amplifier	1 - CV.2127
Driver Amplifier	1 - CV.428
Power Amplifier	2 - 4H/135M in parallel.

CHAPTER 3

DESCRIPTION

Section 1.0, 2.0 and 3.0 of this Chapter cover the systems of control and frequency selection in the complete equipment. Section 4.0 deals in detail with the circuits of the Transmitter and Receiver Units, Section 5.0 covers the details of Aerial Coupling Units. The latter two sections also contain a brief mechanical description of each unit to emphasize the construction adopted. The technical description of the Remote Control Unit 402-LRU.11A is included in Section 4.0.

1.0 THE OVERALL R.F. CIRCUITS

(See Fig. 20)

Fig. 20 is an explanatory block schematic of the complete STR.18-C equipment. Assume that the set is to operate (send and receive) on a frequency of f_o kc/s and that in the Receiver/Drive Unit a crystal of $f_o + f_2 = f_1$ is presented to the 1st Oscillator by the remotely controlled XTAL TURRET. Then at the same time the Receiver/Drive Unit only is placed in the TRANSMIT condition by the relays shown. The band selection circuits place the three r.f. tuned circuits of the R.F. Amplifier on the correct band; $f_o + f_2$ is mixed in a balanced crystal mixer with a frequency of f_2 from the Xtal Oscillator (465 kc/s) and the resulting sum and difference frequencies taken to the r.f. circuits by the relay in Transmit position. end of this selection the start signal causes the tuning condenser of the r.f. circuits to be turned by its auto-tune motor to the l.f. position, reverse and rotate to the h.f. end of the band. The tuning condenser is stopped on the peak of the first signal reached, i.e. $f_o + f_2 - f_2 = f_o$, by means of an amplitude discriminator, thus leaving the tuned circuits in a position to select and amplify f_o.

At the conclusion of this auto-tune operation, the Receiver/Drive Unit returns to the Receive condition automatically.

1.1 Equipment on "Receive"

A signal of f_o at the aerial passes through the aerial coupling unit

which is tuned to $f_o \pm 1\%$, through the r.f. tuned circuits tuned to f_o as above, thence to the mixer (6AM6) where the crystal frequency of $f_o + f2$ is used to modulate. The resultant i.f. of f_2 (465 kc/s) is amplified and selected by the i.f. amplifier chain, detected and taken to the phones by means of Transmit/Receive relay. The centre frequency of the band pass filters is manually variable $\pm$ 7 kc/s thus allowing reception of frequencies within this range of f_o the r.f. circuits being able to accept this deviation.

1.2 Equipment on "Send"

When the key is depressed the relays change to the Transmit positions, the drive at f_o passes through the "receiver" r.f. tuned circuits as in the original auto-tune operation, and thence to the 6CH6 (CV.2127) aperiodic amplifier and a wideband transformer which delivers approximately 2V R.M.S. into 70 ohms. This drive is applied to the Transmitter Unit by a coaxial cable, and amplified by the ganged tuned circuits which have been tuned to $f_o \pm 1\%$ to leave the Transmitter Unit at a 70 ohm 100 watt level, and thence to the aerial coupling unit. The input speech signal is amplified by the clipper modulator and anode modulates the P.A. stage of the Transmitter Unit. Sidetone from this audio amplifier is switched to the phones in place of the received signal by the relay in the Transmit position.

Thus, break-in working is achieved.

It should be noted that:-

(a) When a channel is selected the Receiver/Drive Unit always auto-tunes to the selected channel frequency, thus the $\pm$ 1% band operation does not apply to the receiver proper or to the drive generation circuits on Send.

(b) The $\pm$ 1% band tuning is confined to the later stages of the transmitter on send, and to the aerial coupling circuits on send and receive.

(c) A channel frequency at the mid-point of each band is used in the send position to align the transmitter circuits and aerial coupling units to this frequency by means of the band setting controls on the Receiver/Drive Unit.

As the "receiver" tuned circuits and the transmitter circuits cover the total frequency range in 2 or 3 ranges, the bands being

set up have to be assigned to one of these ranges by means of the Uniplug system on the front of the unit. The correct range is then always chosen whenever that band is selected.

(d) The Transmitter ranges are (1) 2.8 - 7.0 Mc/s
(2) 7.0 - 18.1 Mc/s
Receiver ranges are (1) 2.8 - 5.2 Mc/s
(2) 5.2 - 10.1 Mc/s
(3) 10.1 - 18.1 Mc/s

The correct crystal is of a frequency such that if f_o kc/s is the required send/receive frequency the crystal frequency $f_1 = f_o +$ 465 kc/s.

The crystal should be to the Inter-service (International) Specification ZDH, or equivalent specification i.e. S.T.C. RL.7065-146N.

2.0 THE REMOTE CONTROL SYSTEM OF FREQUENCY SELECTION

(See Figs. 1, 2, 24 and 25)

This description is best divided into three sections.

2.1 Covers the selection of the correct channel, i.e. positioning of the channel crystal by means of remote selection.

2.2 Covers the bridge system used to tune the band circuits by remote control from the Drive Unit during the initial setting up of the bands.

2.3 Covers the selection of the band tuning positions from the Remote or Local position after they have been set up.

The auto-tune circuits though they operate from 2.1 are described in more detail in 4.1 of this Chapter.

2.1 Channel (Crystal) Selection Circuits (See Fig. 24)

The turret of the channel selector when rotating turns also the wipers of two 25 way switches S1A, S1B, thus marking one of the 25 contacts on each bank. In Fig. 24A these switches are shown developed. Relay RL4/2 is connected between the wiper contacts and effectively moves up and down the banks shown.

The "Units" switch S3B marks 5 positions spaced 5 apart on S1B while "Tens" switch S2B marks groups of 5 positions in turn on S1A. In the position shown, there is a 28 volt circuit through RL4 from S2B to S3B to earth. RL4 then operates to stop the motor geared to the turret and to S1 by removing its 19V supply and shorting its armature to act as brake. At the same time the removal of earth from the "start" line signals the auto-tune circuit to commence operation.

Relay RL4 can only operate in one of the 25 positions thus positioning the turret such that 4 of its crystals engage the fixed contacts by means of their pins. It will be seen that there are four combinations of the positions of S2B and S3B which will cause the motor to stop in this position, i.e. 04 (shown) 09, 59 and 54. The table on the right shows the channel positions for each of the 25 stopping positions of the turret. The ambiguity of these four channel positions is resolved by S2A and S3A ganged to S2B and S3B. In the position shown relays RL3, RL2 and RL1 are unoperated and reference to their contacts shows that the 00-44 bank of crystals is connected to the crystal oscillator via contacts 1B and 3B, the remaining three crystals selected being shorted by the other contacts. Thus crystal 04 only is selected to control the crystal oscillator.

A further example; assume that the "Tens" switch S2 is in position 5 and Units Switch is in position 9, i.e. channel 59 chosen. The turret still stops with RL4 in position shown but now RL3 is earthed by S2A and operates, RL2, RL1 are also earthed and operate. The 55-99 crystal bank is now selected by 2A and 3B to the crystal oscillator, i.e. 59 is connected. The other banks are again shorted by 2B and 3A.

In the complete equipment the channel switches S2, S3, are mounted on the front panel of the Receiver/Drive Unit in the case of Local control, or on the Remote Control Unit when Remote Control is selected. The Local/Remote switch being used in the transfer. This complete operation is described in section 3.5 following in this Chapter.

2.2 The Remote Control Bridge System (See Fig. 25)

The circuit used to drive the tuning motors has two functions. Firstly, to turn the motors by remote control to tune-up the equipment from the Drive Unit and Receiver. Secondly, to provide a means of returning to these chosen tuning conditions when selection of a frequency channel is made. The circuit can be described as a "Wheatstone Servo" and is fundamentally a self-balancing resistance bridge. Refer to Fig. 25D. The bridge

circuit consists of a potential divider R2 representing a setting on one of the 12 way potentiometers. This is connected by a cable as shown to the remote unit and to potentiometer R1 of the tuning motor assembly. These form a Wheatstone Bridge as shown in sketch, energised from the 19 volt supply, and having relay DR/2 as a detector. The wiper of R1 is mechanically driven from the motor M. When the bridge is unbalanced the relay operates due to out of balance current and the two contacts DR1 and DR2 close, on the bottom contacts for instance. The motor then starts and turns the wiper of R1 such that it moves towards the balance position. When this is reached and out-of-balance currents fall below that needed to operate the relay, the contacts DR1 and DR2 return to the centre position and the motor stops. If the wiper had been initially on the other side of the balance point, DR1 and DR2 would have closed to the upper position reversing the motor direction and obtaining balance as before.

Thus shifting the position of wiper on R2 (i.e. moving the channel knob on a 12-way potentiometer) causes the bridge to unbalance and the motor to drive to the new balance condition.

The travel of the wiper of R2 over the full length of the resistance winding will therefore cause the motor to rotate through a definite number of revolutions and this is used to drive the necessary tuning elements to any corresponding position.

In the practical case the circuit needs to be elaborated. The circuit used on all the tuning motors is shown in Fig. E and will now be explained.

Pot. A represents the setting potentiometer coupled by cables (pins 2 and 3) to the motor balancing potentiometer RVA. These are both 230 ohms approx. The bridge is supplied with 19 volts except when equipment is in the MANUAL condition and when the Selector motor is running. A separate earth wire on the bridge is used, earthed at one end only, to avoid other D.C. earth currents affecting the bridge detector. The wiper of Pot. A is taken through pin 4, through relay 3A to the sensitive detector relay RL4/1 on its 110 ohm winding and thence to the wiper of RVA driven by gearing from motor MG. When the bridge is unbalanced RL4/1 operates closing 4A. The contacts of this relay cannot handle the motor current thus 4A operates slave relays RL1/2 is operated, 1A and 1B close. The +28 volt supply is then taken via 2B, 1A to one side of the motor MG which being earthed on its other pole via 2A and 1B then starts to rotate.

At balance 4A returns to centre position releasing RL1/2. Contact 1B then short-circuits the motor armature providing a braking action to prevent over-running of the motor. The motor has a permanent magnet field. If RL2/2 operates then 1A and 2B apply the + 28V to the motor and the direction of rotation is reversed.

Detector relay RL4/1 operates on 200 microamps approx. and due to this sensitivity the 110 ohm winding must be protected against the currents due to the bridge being well out of balance. In such a condition the non-linear resistance W5 in series with safety relay RL3/2 across the 110 ohm winding falls to a low value, RL3/2 operates opening 3A and placing RB in series with the sensitive winding to protect it. Near balance conditions 3A closes, thus restoring the detector to its full sensitivity. The contacts 4A are protected by spark quench rectifiers W1, W2, which also slow the release of the slave relays RL1/2 and RL2/2. W3 and W4 are spark quench rectifiers across the motors to protect 1A, 1B, 2A, 2B.

Such a system described above will, unless the mechanical device driven by the motor MG has a particular stiffness, tend to "overshoot" the balance point and then hunt before coming to rest. This is prevented by an "anti-hunt" circuit using a second winding on sensitive relay RL4/1. This will be described as the "feedback" circuit although the action is not as is generally understood by this term. Assume that the motor is moving towards the balance point, contact 1A being closed, the + 28 volts from the motor pole at 1A is applied through a second winding of 45 ohms on RL4/1 through feedback resistance RA to earth at 1B. The mode of action of the 45 ohm winding is in opposition to that of the detector winding so that RL4/1 will reach its neutral position to stop the motor before the actual balance point is obtained. When this occurs, the feedback winding no longer has any effect as the +28V is removed by 1A, but the out-of-balance current still remains in the 110 ohm winding of RL4/1 as the balance point has not yet been reached. RL4A thus closes again to operate 1A, but as the effect of the 45 ohm winding is now greater, RL4A is immediately thrown off. This repeats until the unbalance current falls below the operating value of the 110 ohm winding of RL4/1 and thus equilibrium is reached.

Had the motor been operating due to 2B being closed, the feedback direction would then be 2B to 2A, still in opposition to the action of the 110 ohm winding. In practice this causes the slave relays to run the motor until just before balance and then "tick" into the rest position. If any

overshoot does occur due to varying load on the motor, this circuit greatly reduces the duration of hunting.

"Hash" filters L, CA are fitted to each pole of the motor and are enclosed in a screened box. Either of contacts 2A or 1B of the slave relays operate when the motor is running and earth the tune line taken to pin. 6. This indicates by illumination of the tune lamp that a tuning motor is operating and normally prevents the key placing the transmitter on "mark". This latter function is amplified in section 3.0 of this Chapter.

To prevent this control system driving the motors such that the mechanical rotation limit stops are reached on the associated driven components it is necessary to arrange electrical stops "inside" them. This is done by limiting the wiping length of the 12-way setting potentiometers so that a small portion of the resistance is always left in circuit (Pot. A). The balancing potentiometer RVA therefore will always reach balance before the end of its travel.

The components used on these bridge circuits are tabulated against the function of the Tuning motors concerned in Table I.

TABLE I

Function of Tuning Meter		Component Reference					
		12 way Potentiometer	Motor	Balancing Potentio-meter	Slave Relay	Detector Relay	Safety Relay
Fixed Aerial Coupling Unit	Input Coil	7 Pot.3 (A-M) 7 Pot.4 (N-Z) on 3-LRU.111A	8MG1	8RV5	8RL3 8RL4	8RL6	8RL5
	Con-denser Switch	7 Pot.5 (A-M) 7 Pot.6 (N-Z) on 3-LRU.111A	8MG2	8RV4	8RL7 8RL8	8RL10	8RL9
	Output Coil	7 Pot.7 (A-M) 7 Pot.8 (N-Z) on 3-LRU.111A	8MG3	8RV3	8RL11 8RL12	8RL14	8RL13
Suppress-ed Aerial Coupling Unit	Con-denser Switch	7 Pot.5(A-M) 7 Pot.6 (N-Z) on 3-LRU.111A	5MG2	5RV2	7(1)RL1* 7(1)RL2	7(1)RL4*	7(1)RL3*
	Loop Tuning	7 Pot.3(A-M) 7 Pot.4 (N-Z) on 6-LRU.189C	5MG1	5RV1	1RL15* 1RL16	1RL14*	1RL3*
Trans-mitter Any Aerial	R.F. Stages	7 Pot.1(A-M) 7 Pot.2(N-Z)	2MG1	2RV1	2RL8 2RL9	2RL6	2RL7

* On Relay Unit 82-LRU. 116C mounted on 3-LRU.111A when suppressed aerial is used.

2.3 The Band Selection Circuits (See Figs. 24, 25)

2.3.1 There are 24 bands to be selected in the equipment. These are designated A-Z (I and O omitted) and grouped in two sets of 12, i.e. A-M, N-Z, the change from one group to the other being effective by the AM-NZ switch which is operated by pulling or pushing the band switch knob. Thus we have a 12 x 2 system. To economise in the number of wires used to switch this information a wire saving technique is used. 6 wires being used for the 12 positions and one for the AM-NZ selection. In Fig. 24B the Band Selector switch has a symmetrical set of wipers which earth up to four of the six wires joining this switch to the finder switch (S4) on the selector unit. This switch is turned mechanically by the selector motor and in one position only, fails to make an earth via the 6 wires causing the relay RL5/2 to release and stop the selector motor by contacts 5A and 5B, 5B removes the +19 volt supply and 5A short circuiting the motor to provide braking action. Contact 5A also removes the earth from the Start Line thus sending a start signal to the auto tune circuit. Briefly then the motor rotates the selector bank until the latter fails to find an earth.

Rotating the Band selector switch to any other position causes the selector switch to turn to the corresponding position before stopping. In the diagram, S4 is shown in the stopping position equivalent to the position set by the Band switch, i.e. on position 8.

2.3.2 Selection of Bands by the Band Selector Motor

The shaft turning the finder (stopping)switch has other switches ganged to it and in addition is geared to 6 or 8 special 12-way potentiometers. For each band selected they provide an independent resistance ratio for Tuning Motor circuit involved which then functions as described in section 2.2 (Remote Control Bridge System). This is done by the rotation of the 12 ratio potentiometers sketched in Figs. A and B of Fig. 25. The potentiometer consists of a resistance winding R woundon a former which is a rod of pear cross-section, mounted between ball bearings and rotated on the axis of the circle forming the larger radius of the cross section as shown in A. The small radius, on which the resistance wire is uninsulated, can then touch each of the 12 contacts C in turn when the winding R is rotated. These contacts C are each mounted on a tapped nut through which passes the start lead screw L. S. Thus turning knob R will cause the contact to move along the lead screw, and if this is in contact with the winding R, it will vary the resistance ratio of contact lead 2 in respect to end 1 and 3 of the winding. All the 12 lead screws are moving in guides holding them radially and they are electrically commoned, but insulated from the

winding R. As the selector motor moves R to touch only one lead screw to correspond to the channel chosen, this potentiometer is therefore equivalent to 12 separate 3-watt potentiometers, the wipers of which would be selected by a single pole 12-way switch.

Auxiliary contacts on the motor relay disconnect the 19 volt supply to these potentiometers while the selector motor is operating thus preventing hunting of the Tuning motors as the potentiometers move over the various lead screw contacts prior to arriving at the chosen channel.

For each motor circuit there are two 12-way potentiometers, one for Band A-M and the other for Band N-Z.

The switches ganged to the selector shaft comprise (a) an extra stopping bank used from the Remote Control Unit, (b) two pairs of 12-position switches used to set the Transmitter and Receiver to their correct frequency ranges for the selected band, using the position of the Uniplugs lettered A-Z. One switch in each pair covers plug positions A-M and the other N-Z.

The change from the A-M potentiometers and switches to those associated with bands N-Z is accomplished by the A-M/N-Z switch which being operated to the N-Z position, operates the band relays as shown in Fig. 24B. As previously mentioned, this switch is operated by pushing or pulling the Band Switch knob which in addition to controlling these relays also changes the lettering of the 12-position switch.

Further details of the interconnection of the units using this band selection circuit are given in Section 3.0 of this Chapter.

3.0 INTERCONNECTION OF UNITS AND CONTROL CIRCUITS

It is necessary in describing some of the following circuits which involve several of the units of the complete equipment to have an abbreviated component reference to shorten this text. Each main unit of the equipment has a code number allocated, which is boldly marked, in a circle, on the unit schematic, and on the sections of the simplified schematics. The same number is used in the cable termination codes.

The numbers allocated are as follows:-

2 - Transmitter Unit 4-LRU.50D
3 - Power and Modulator Unit 404-LRU.4B
5 - Suppressed Aerial Unit 24-LRU.58
7 - Receiver/Drive Unit 3-LRU.111A
7(1) - Relay Unit 82-LRU.116C on (7)
7(2) - The R.F. Unit 28-LRU.420A on (7)
7(3) - The I.F. Unit 28-LRU.421A on (7)
8 - Aerial Coupling Unit 24-LRU.52C
9 - Remote Control 402-LRU.11A

As an example:-

Relay RL3/2 on the Receiver Drive Unit 3-LRU.111A is referred to as 7RL3/2. Switch S2A on the Remote Control Unit will be 9S2A. Resistance R55 on the Power and Modulator Unit will be 3R55.

On all schematics an encircled 19 or 28 indicates the voltage line where all such points on the unit concerned are interconnected, this procedure is adopted to remove confusing lines on the schematics.

This Section is divided into the following sub-sections:-

3.1 Inter-unit Cabling

Interconnection between the units of the equipment is made by engaging the plugs and sockets at the rear of each unit with the respective sockets and plugs of the cables which are mounted on the back plates of the mounting racks. The back plates carry two locating spigots which align the units to the back plates.

The multi-way cables consist of separate polythene insulated wires contained in a thin polythene tube, rubber grommets being used at the clamping glands of the terminations, or of standard aircraft multi-way cables.

Each cable is given a designation letter (number/number) marked on the cable. The cable ends are marked with a number and the cable letter, the number indicates the unit to which the end of cable is to be connected. The numbers agree with the Unit Numbers given in the preface to this Chapter. The cut outs in the back plates are similarly marked with the cable-end designations to indicate the correct position of each cable when installed.

Examples Cable A/18/2 is terminated by socket 7A and plug 3A and is used between the Receiver/Drive Unit (1) and Modulator Unit (3). The figure 2 describes the length and plug/socket orientation used on a particular aircraft installation.

Table II lists the normally used cables (See Figs. 21, 22).

TABLE II

Cable	Termination	Use
A/18/x	3A (Power & Mod. Unit) to 7A (Receiver/ Drive Unit)	Multi-way control
B/18/x	2B (Transmitter Unit) to 7B (Receiver/ Drive Unit)	Co-axial r.f. drive
C/18/x	2C (Transmitter Unit) to 7C (Receiver/ Drive Unit)	Co-axial r.f. output
D/18/x	2D (Transmitter Unit) to 3D (Power & Modulator Unit)	Multi-way control
E/18/x	2E (Transmitter Unit) to 3E (Power & Modulator Unit)	Co-axial 600V
F/18/x	Intercomm. Unit to 3F (Power & Modulator Unit)	Multi-way control
G/18/x	5G (A.C.U. Suppressed) to 7G (Receiver/Drive Unit)	Multi-way control
H/18/x	9H (Remote Control Unit) to 7H (Receiver/Drive Unit)	Multi-way control
J/18/x	3J (Power/Modulator Unit) to External Transmitter	Multi-way control
J/18/P	3J (Power/Modulator Unit) alternative to J/18/x	Multi-way control
K/18/x	5K (A.C.U. Suppressed) to 7K (Receiver/ Drive Unit)	Co-axial aerial
M/18/x	Aircraft Battery to 7M (Receiver/Drive Unit)	3-way
N/18/x	3N (Power/Modulator Unit) to 7N (Receiver/Drive Unit)	Multi-way audio
P/18/x	3P (Power/Modulator Unit) to Aircraft Battery	3-way
Q/18/x		

R/18/x	8R (A.C.U. Wire) to 7R (Receiver/ Drive Unit)	Co-axial aerial
S/18/x	8S (A.C.U. Wire) to 7S (Receiver/Drive Unit.	Multi-way control
T/ 18/x		

3.2 The Stand-By RX-ON Circuit (see Fig. 23 centre)

RX ON Circuit

The receiver may be switched on at either the Receiver Drive Unit or at the Remote Control Unit.

Local Control

Switch 7S8A in the "RX ON" position places an earth via socket SK13/17 and switch S11F/(L) on relay 7RL19/2 the other side of which is connected to the 19 volt aircraft supply at plug 7PL7/3 through Fuse 7F2. This relay starts the 180V H.T. rotary machine by connecting the 19 volt supply to relay 7RL18/1 and to the Receiver heaters. 7RL18/1 then connects the +28 volt supply from 7PL4 to the rotary. The Receiver is then fully operational.

Remote Control

Switch 7S11F is now in the R position and substitutes 9S5A for 7S8A above, thus providing control from the Remote Control Unit.

STD/BY Circuit

The transmitter can be switched on at either the Receiver/Drive Unit, Transmitter Unit or at the Remote Control Unit.

Local Control

With 7S8A in the "STD/BY" position, an earth is placed via 7S11G(L) 7PL2/1, and 3SK2/1 on to 3RL6/1. This relay is connected on its other side to the +19 volt supply at 3F5 from the aircraft battery. Relay 3RL6/1 operates and by operation of 3LRL7/1 switches the +19 and +28 volt supplies to the Transmitter control circuits and to the heater of the valves in those circuits.

The "Emergency" switch 2S3C on the Transmitter, can perform an identical function via 3SK1/3 and 2PL1/3.

On "Remote Control" 7S11G(R) allows 9S5A via 7PL1/15 and 9PL1/15 to operate in place of the Local Control 7S8A.

3.3 The "H.T. ON" Circuit Send (Refer to Fig. 23 top)

The Transmitter may be switched to "Send" in three positions, at the Receiver/Drive Unit by Switch 7S8B, at the Remote Control Unit by 9S5B and at the Transmitter, under Emergency Conditions, by Switch 2S3B. In the simplified circuit given, the equipment is shown on "Local" control, Transmitter on "AUTO" and in the "OFF" condition. Placing 7S8B in the "SEND" position, +19V is applied through switch 7S11H through 2S3B to contacts of time delay relay RL10A. These are closed if the set has been on "Stand-by" for 30 seconds passing the circuit through the external equipment interlock contacts to the relays 3RL8/1 and 3RL9/1 which operate to start the H.T. machine. At the same time, the H.T. ON lamp 7LP3 indicates the time delay has allowed the circuit to operate. Contacts 3RL9B open when the machine starts and can be used to prevent another transmitter being used. On "Remote" operation 7S11H and 7S11Q replace 7S8B by the remote switch 9S5.

On "EMERGENCY" operation, switch 2S3B disconnects the start circuit from plug 2PL1/8 in the XTL1 and XTL2 positions (last two positions shown and supplies + 28 volts to start the machine in its place. Should the interlock contacts be open due to external apparatus in use, the machine cannot start under any condition. Except under emergency conditions, failure of the 19 volt supply will cause the machine to stop.

3.4 The Key Circuit (See Fig. 23 bottom)

The normal aircraft requirement is that the equipment should be placed on "mark" when a single key line is earthed. This line enters the set from the Intercom system at socket 3SK5/5 on the Power and Modulator Unit. The circuit is shown in the equipment "OFF" condition, when relays 3RL12A and 7RL21B being unmade, present an open circuit to the incoming (and thus external) key line. With "RX ON", this condition remains unchanged, but during the auto-tune operation of the Receiver (which is done under "send" conditions) relay 7RL117B closes to earth, operating the keying relays in the R.F. Unit and 7RL16/2. This provides the internal "send" condition required, the contacts of 7RL16/2 being used to place the receiver r.f. stages (now part of the drive circuit) to maximum gain independent of the manual r.f. gain controls 7RV1, or 9RV1. The other contacts of 7RL16/2 mute the I.F. Unit, a requirement during normal "mark".

When the transmitter is on "STD/BY", relay 7RL21B closes connecting the extreme key line.

Now on "mark", in the Receiver/Drive Unit the same relays operate as above and additionally, the aerial changeover relay 7RL20/2 operates connecting the transmitter output to the aerial. With the transmitter on "Send", i.e. when its H.T. machine starts, 3RL12A closes to allow operation of 3RL2/2 and 2RL4/2 on "mark". Rectifiers W2, W3 slow the operation of 2RL4/2 and 3R42 delays the release of 3RL2/2.

The key line may be earthed in the "Tune" condition of the Transmitter by switch 2S4 via 2S2C. The Test/Tune 7S6 switch on the Receiver/Drive Unit used in setting up also keys the transmitter in both conditions. When the Aerial Coupling Unit (Wire) is used, socket SK20 is positioned to link pins 37 and 20 thus allowing operation of the keying circuit 8K1, 8RL1, 8RL2 via 7SK2/11 and 8PL2/11.

3.5 The Channel (Xtal) Selection Circuit (See Figs. 27, 24)

This circuit operates as soon as the "RX ON" condition is made and is not changed in any way by the STD/BY or SEND conditions, as its function is purely to select the correct channel crystal. The basic operation of this circuit has been covered in Section 2.1 of this Chapter. Fig. 27 shows the interconnection of the Local and Remote controls of this circuit. Dealing first with the Receiver/Drive Unit (7). On the Selector Unit (Xtal) 7S7A and 7S7B are the stopping switches mounted on the turret spindle, 7RL4/2 is the motor stopping relay, causing the motor 7MG1 to stop when operated to close 7RL4A and 7RL4B.

The linked contacts of switch 7S7 are connected in common by 10 wires on "Local Control" to the Channel Switch 7S1/S2 on the Front Panel via socket 7SK12 and plug 7PL12, and when the Remote Control Unit is to be used, to 9S1/S2 via 7SK11, 7PL11, 7PL1 and 9PL1 (pins 1.10).

The changeover of control from "Local" to "Remote" is carried out by Local Remote Switches 7S11D and 7S11Q which change the Earth and + 18 volt supplies to the channel switches.

The Crystal Selector relays 7RL1/2, 7RL2/2, 7RL3/2 are commoned in a similar manner to 7S1/S2 and 9S1/S2.

Rectifiers 7W7, 7W8, 7W9, 7W12, 7W13, 9W1 and 9W2 are added to prevent false earth paths due to the channel switch, not in use in some positions, causing a wrong stopping portion of 7S7. The switches on this simplified schematic are numbered as in the wiring diagram, the translation of these contact numbers on the channel switches being shown at Note A. The switches are shown on Channel 64.

3.6 The Band Selection Circuit (See Figs. 13, 24, 26)

This circuit again operates in the "RX ON" condition and its positioning is not changed by STD/BY or SEND. The function of the circuit is to select the positioning of the potentiometers and switches on the Band Selector Unit from either the Front Panel of the Receiver Drive Unit or from the Remote Control Unit. The basic operation of the 7 wire system used has been described with reference to Fig. 24 in section 2.3.2 of this Chapter.

Referring now to Fig. 26 which shows the Local/Remote connections of the units in the "Remote" position. Selection of a band on Band Switch 9S3A on the Remote Control Unit causes motor 7MG2 to rotate Remote Stopping Switch 7S5E to rotate to the "no earth" position when the motor is stopped by the release stopping relay 7RL14/2. Similarly, operation of remote AM-NZ switch 9S3B causes the AM-NZ relays to operate.

On "Local" control the Local Remote switch 7S11 is placed in the Local (L) position when:-

7S11A switches 7RL14/2 from 7S5E to 7S5F via plug 7PL10/14-15-16.
7S11B switches AM-NZ relays from 9S3B to 7S4.
7S11D removes the earth from 9S3A.

Thus 7S5F is now the stopping switch being controlled in position by switch 7S3 on the Front Panel.

The use of independent stopping switches for the Local and Remote positions obviates the chance of false earths and is chosen to avoid the complications that arise if two wire-saving systems of this type are commoned. All the switches are numbered as in the wiring data, the circular diagram in the top left showing the relation between the switch numbers and the Band letters. The switches are shown in position of Band G. The position of the switch shafts is also shown as an aid in fault tracing. The operation overall is summarized in Table III below.

TABLE III

	Local Control	Remote Control
Selector Stopping Switch	7S5F	7S5E
AM-NZ Switch	7S4	9S3B
Band Switch A-M or N-Z	7S3	9S3A
AM-NZ relays	7RL11/2, 7RL12/2, 7RL13/2	7RL11/2, 7RL12/2 7RL13/2
Motor Stopping Relay	7RL14/2	7RL14/2
Position of 7S4 or 9S3B	AM	NZ
	Components Selected	
12-way Potentiometers	Pot. 1, Pot. 3, Pot. 5, Pot. 7	Pot. 2, Pot. 4, Pot. 6 Pot. 8
Receiver Range Selector Uniplugs	PL16 A-M through S5A	PL16 N-Z through S5B
Transmitter Range Selector Uniplugs	PL17 A-M through S5C	PL17 A-M through S5D

NOTE: Pot. 7 and Pot. 8 may not be present in the Suppressed Aerial Case as they are not used. All above components are on Selector Unit (Band) and thus can be prefixed by 7.

3.7 The 19V Circuit (See Fig. 29 top)

The + 19 volt regulated supply enters the equipment at two points, on the Receiver/Drive Unit at plug 7PL3/3 and on the Power and Modulator Unit at plug 3PL1/11-12. The negative pole is earthed. Starting from 7PL3/3 this supply allows the operation of the Receiver/Drive Unit as a complete unit, should it be required to act as a receiver only. Relay 7RL19/2 is connected directly to switch 7PL3/3 through fuse 7F2. When the set is in "RX ON" position at switch 9S5 (Remote) or 7S8A (Local) this relay is earthed closing RL19A nd connecting the 19 volt supply to the equipment as follows:-

(a) To the Selector Unit (Turret) at socket 7SK11/15
(b) To the Auto-tune valve heaters 7V1, 7V2
(c) To the Front Panel at socket 7SK13/6
(d) To the R.F. and I.F. Unit heaters at sockets 7SK14/13 and 7SK15/9 respectively.

(e) To relay 7RL18/1 which operates to put on the + 28 volt supply.
(f) To the Selector Unit (Band) motor 7MG2 at socket 7SK8/13.

The supply to the bridge circuits of the remote tuning system of the aerial varies with the type of aerial used.

Suppressed aerial operation (shown on Fig. 29)

The + 19 volt on socket 7SK20/18 is linked to 7SK20/2 and thence to the bridge supply at the Selector Unit (Band) socket 7SK8/2, being interrupted by relay 7RL15A which opens when motor 7MG2 operates to prevent "chattering" of the tuning motors. The supply to the condenser switch bridges 7POT5, 7POT6 is broken in the "Test" and "Tune" positions of 7S6 to prevent this being used on "mark".

Wire aerial operation

The + 19 volt supply from socket 7SK20/36 is now linked to 7SK20/19 and is taken through 7SK2/1 and plug 8PL2/1 to the Aerial Coupling Unit. In the "Auto" position of switch 8S1B it is taken back to the bridge circuits via 8PL2/7, 7SK2/7, 7SK20/23 and 7SK20/40.

Starting now from the Power and Modulator Unit at plug 3PL1/11-12, the STD-BY relay 3RL6/1 operates in that condition through fuse 3F1. This relay closes 3RL6A (lower schematic) to place +28 volts on relay 3RL7/1 which closes 3RL7A and connects the 19 volt supply from 3F1 to the Transmitter Units as follows:-

(g) The Audio Amplifier valve heaters at socket 3SK6/4
(h) The P.A. stage heaters via dropping resistance 3R41, sockets 3SK1/24 and 2SK1/2 to valves 2V3 and 2V4 in series.
(j) The remaining heaters in the Transmitter Unit via socket 3SK1/7 to valves 2V1 and 2V2, 2RL10/1 is the heater of the time delay relay with its contacts in the H.T. ON circuit. The dial lamp 2LP1 and the motor relays via 2S3B are also connected.
(k) The Bridge supply of the Transmitter tuning motor through fuse 3F2, 3SK2/14, 7PL2/14 and 7SK10/14 on the Selector Unit (Band). This supply being broken by relay 7RL15B as in the case of the aerial bridge supplies described above.

3.8 The + 28 Volt Supply Circuit (See Fig. 29 bottom)

The + 28 volt supply again enters at two points from the aircraft supply on the Receiver/Drive Unit at plug 7PL7/4 and on the Power and Modulator Unit at plug 3PL1/13-20.

Starting at 7PL7/4 for the Receiver/Drive Circuits. Relay 7RL18A is closed by the 19 volt supply in the "RX ON" condition (see 3.7) and connects the + 28 volt supply to the circuits and to the Rotary Transformer 7MG3 to give the H.T. supply. The "hash" filter for this machine is X1. The supply is connected in particular to the following points.

(a) The intertune circuit via switch 7S6 to the Transmitter at plug 7PL2/3.
(b) The Selector Unit (Band) at socket 7SK8/1.
(c) The time delay relay heater 7RL22/1 which does not allow the autotune to operate until the heaters of the R.F. unit are at normal emmission.
(d) The auto-tune relays 7RL7, 7RL8, 7RL9, 7RL10 and thence through 7RL19B (closed by the "RX ON" relay) to the R.F. Unit relays at socket 7SK14/3.
(e) To the Channel switches, on "Local" from 7S11Q to 7S2A via socket 7SK11/14 and plug 7PL12/14 and on "Remote" from switch 7S11Q to the 28 volt supply in the Remote Control Unit.
(f) To the keying relays 7RL16/2, 7RL20/2 (AE c/o)
(g) To the I.F. Unit note filter relay at socket 7SK15/10 and also to the relays of the Selector Unit (Turret) at socket 7SK11/16.

Again there are alternative connections depending on the kind of aerial in use.

Suppressed Aerial Case

Socket 7SK20 is in position shown and connects the motors of the Aerial coupling unit to the 28 volt supply switched by the motor relays in Relay Unit which is supplied at socket 7SK9/1.

Wire Aerial Operation

In this case the connections above are broken by Socket 7SK20 and by linking 7SK20/26 to 7SK20/43 the 28 volt supply is taken to the Wire Aerial Coupling Unit keying relays and its tuning motor relays 8RL3, 4, 7, 8, 11, 12.

At the Transmitter, the + 28V supply when the SEND relay 3RL8A is closed, starts the H.T. machine 3MG1 through the starting circuit described in section 3.3 of this chapter. Another branch circuit connects the supply through the 28V control fuse 3F1 to relay contact 3RL6A, which is closed in the STD.BY condition by operation from the + 19V circuit, and energises the remaining + 28V circuits of the Transmitter.

On the Modulator Unit, there are the relays 3RL2, 7 and 11 with their associated resistance 3R42, and the bias supply of the Modulating valves 3V5-V6-V7-V8 the cathodes of which are connected to the + 28 volt supply by relay 3RL3A.

The + 28V supply enters the Transmitter Unit via socket 3SK1/11 to (a) Operate the blower motor 2MG2, (b) Provide bias for the P.A. valves 2V3 and 2V4 by connection to their cathodes via bias resistor 2R7, (c) Supply the band change relays 2RL1, 2RL2 and 2RL3 via band switches 2S1 and 2S3B, (d) Supply the Motor Tuning Circuit in the "Auto" position of 2S3B via 2SK2/5.

A connection is also taken from 3SK2/2 to the Receiver/Drive Unit at 7PL2/2 and thence to operate relay 7RL21/2 which connects the Tune and Key Lines when the Transmitter is in use, and also to the Meter circuit 7M1 via 7SK13/3 for use as the return for the Cathode Current metering of the Transmitter PA stage.

3.9 The 180 Volt Circuit (See Fig. 28 Middle left)

This circuit is normally confined to the Receiver/Drive Unit (7). The 180V positive supply from the machine is taken through a two stage "hash" filter to the front panel fuse F3. An auxiliary fuse F4 is used at a higher value than F3 and is employed to protect the filter. From F4 the supply is filtered by choke L1 and C1 against ripple on the aircraft supply and thence to:-

(a) The I.F. Unit at socket SK15/4
(b) The R.F. Unit at socket SK14/4
(c) The auto-tune circuit relay RL5 etc.
(d) The C.W. circuit. The H.T. to the C.W. beating oscillator is taken to the C.W. switch S10 via SK13/19 and through S10 to SK13/18 and to the Local/Remote switch S11L. This is used to remove the C.W. condition when remote control is selected. On Local Control the H.T. supply is carried on to the C.W. oscillator at SK15/7

(e) A supply is taken to the Intercom socket 3SK5/8 via 7PL6/4 for use if an external audio amplifier is used.

3.10 The 300 Volt Circuit (See Fig. 28 Top)

This circuit is confined to the transmitter.

The negative pole of the 300V winding of the H.T. machine 3MG1 in the Power and Modulator Unit is earthed. The positive pole is earthed. The positive pole is protected by fuse 3F4 and filtered by r.f. hash filter 3L5, 3C28, 3L4, 3C27, and by the ripple filter 3L8, 3C22. The supply then splits as follows:- (a) To provide the modulated screen supply of the P.A. valves 2V3, 2V4, through resistor 3R43, the secondary of the modulator transformer 3T3 and thence by 3SK1/22, 2PL1/22. 3R43 is short circuited by 3RL11A except when equipment is in the TUNE position of 1S5 for setting up a channel. (b) To the anodes and screen grids of the Audio Amplifier via 3SK6/12. (c) To the keying relay 2RL4A via 3SK1/25 and thence to the anodes of 2V1 and 2V2 and via 2PL1/17, 3RL1A. A branch from this latter keyed supply is taken to the anodes of the tone (M.C.W.) oscillator 3V8 via 3SK6/11.

3.11 The 600 Volt H.T. Circuit

See Fig. 28 (centre and right).

The negative pole of the 600 volt winding of the machine is earthed. The positive pole, through the fuse 3F3 is filtered for r.f. "hash" by 3L3, 3C30, 3L2, 3C29 and for ripple by 3C24.

It then supplies the anodes of the modulating valves in push pull 3V9, 3V10, 3V11 and 3V12 through the centre tapped primary winding of 3T3, and also the anodes of the P.A. valves through the secondary winding of 3T3.

A separate cable from plug 3PL2 to 2PL3 is used for this modulated 600 volt supply.

3.12 The Manual/Tune Circuit (See fig. 28 bottom)

It is advisable to define the purpose of this circuit before a detailed description is attempted. It can be sub-divided as follows:-

The "TUNE" line

Earthing this line:-

(a) Lights the "Tune" lamps on the Remote Control Unit (9LP2) and on the Drive Unit (7LP4) whenever any of the selector motors or tuning motors are operating.
(b) Puts the transmitter in the TUNE condition, i.e. key up condition except for the Crystal circuit.
(c) Mutes the receiver.
NOTE: Condition (b) allows the key to be on mark with safety while a channel is being selected.

The "MANUAL" Line

Earthing this line lights the "Tune" lamps as long as either the Transmitter or Aerial Coupling Unit is in MANUAL condition. Thus if the tune lamps remain alight an indication is given that one or more units have to be put into the manual condition and thus remote control is not possible.

To avoid spurious operation of relays etc., when part of the equipment is in the OFF condition the two circuits above are automatically isolated in sections as required.

The action is best described by an explanation of operation in particular cases.

3.12.1 "RX ON" Condition (Transmitter OFF)

As drawn the circuit is for Suppressed Aerial operation. When either of the Selector Units is operating during a band/channel change, or auto-tuning is in progress either relay 7RL9B or 7RL10B has operated to provide an earth through rectifiers W1 or W2 for the Tune Lamps 7LP4 through 7W5 (and mutes the receiver I.F. Unit by 7RL16B operated by 7RL17B).

If Remote control is selected lamp 9LP2 is also connected to the Tune line by 7S11Q. Similarly operation of the motor relays of the aerial coupling unit in Relay Unit (4(1)RL1, 4(1)RL2, 4(1)RL5, 4(1)RL6) also earths the Tune line.

If the Wire Aerial Coupling Unit is used socket 7SK20 is now such that 7SK20/47 joins to 7SK20/30 and 7SK20/48 to 7SK20/31 thus connecting the Manual and Tune lines of that unit to the circuit, Should any of the tuning-motor-relays (8RL3 etc.) operate, the tune line is again earthed. If the Unit is placed on "Manual" the Manual line via 8PL2/18 is earthed causing the Tune Lamps to light. Note that W5 isolates the two circuits.

3.12.2 Transmitter on STD/BY or SEND

If the +28 volt supply from the transmitter closes 7RL21A, thus connecting the Transmitter Tune Line by 7PL2/10, 3SK2/10, when the transmitter tuning motor is operating, this line is earthed by 2RL8B and 2RL9A.

Closing switch 2S3C to the MANUAL condition earths the manual line.

The earthing of the Tune Line now the transmitter is connected:-

(a) Operates relay 2RL5 which removes the + 300 volt supply from the first two stages of the Transmitter (2RL5A) and biases back the P.A. stage by 2RL5B.

(b) Operates relay 3RL1 to cut off the modulator valves by 3RL1B.

The supply to these relays 2RL5 and 3RL1 is derived from 7S6 the Test/Tune Key, and is removed in the "Tune" condition to allow the Transmitter to operate normally during the tuning necessary when setting up. If this was not arranged the rotation of any of the tuning motors should effectively put the transmitter on Space.

4.0 THE TRANSMITTER/RECEIVER UNITS

This section is divided into the following sub-sections:-

4.1 Receiver/Drive Unit 3-LRU.111A
4.2 Transmitter Unit 4-LRU.50C
4.3 Power and Modulator Unit 404-LRU.4B
4.4 Remote Control Unit 402-LRU.11A

Each section will comprise of a short mechanical description of the unit followed by a description of the electrical circuit.

4.1 Receiver Drive Unit 3-LRU.111A

(See Figs. 2, 11, 12, 13, 14, 15, 16, 17, Plates 1, 2, 3)

4.1.1 This unit which is completely auto-tuned provides the drive to the transmitter and is also the complete receiver. It mounts the setting up controls for the rest of the equipment and the low impedance aerial change-over relay. The front panel mounts all the controls necessary for operation of the equipment.

4.1.2 Mechanical Layout

This unit is 16" wide, 8" high and 12½" deep and consists basically of a front panel mounted on a shallow tray chassis as the base. On this Mounting Unit the remaining items of the unit are fitted. A loose dust cover which may be withdrawn to the rear encloses the whole equipment when in use.

The unit has been designed to allow a considerable breakdown into sub-units by use of a screw-driver only, each sub-unit can then be serviced separately.

This breakdown can be summarized as follows:-

By removal of dust cover only the following units can be withdrawn.

(a) The R.F. Unit 28-LRU.420A
(b) The I.F. Unit 28-LRU.421A
(c) The Relay Unit 82-LRU.116C
(d) The H.T. Machine RL.7001-81A
(e) All relays (except 7RL20), these being of the plug-in type.

Valves V1, V2 and RL22 may be removed without disturbing the other units.

By additionally removing the Front Panel (400-LRU.121A) the remaining sub-units may be withdrawn:-

(f) The Selector Unit (Band) 165-LRU.28A
(g) The Selector Unit (Xtal) 165-LRU.29A

and from the Front Panel:

(h) Switch Unit 112-LRU.95A (Channel Switch S1, S2)
(j) Switch Unit 112-LRU.92A (Band Switch S3, S4)

In general any further servicing will require the use of a soldering iron.

The underside of the Mounting Unit contains all the inter-connection wires between sub-unit, the control relays, and the components associated with the auto-tune circuit, and allows circuit tracing with the equipment in operation as almost all connections are readily accessible.

Access to the machine filters is obtained by removing the screening cover.

The Front Cover (See Fig. 2) mounts, at the top, the controls used for Local operation. The extra controls used in setting-up are on the right. Two removable covers on the front panel give access, on the left, to the potentiometer and plugs on the Selector Unit (Band) and on the right, to the crystals in the crystal turret. About 1/5th of the crystals can be removed at any one position of the turret.

The two side handles of the panel allow it to be placed face down on the bench without damage to the controls.

The rear plate of the mounting unit mounts the plugs and sockets for connection to the rack mounted back plate when the unit is in position. These are:-

PL1 - 28-way Plug connecting with cable to the Remote Control Unit.
PL2 - 20-way Plug connecting with cable to the Modulator Unit.
PL3 - Co-ax Plug connecting with cable to the Aerial Coupling Unit.
PL4 - Co-ax Plug connecting with cable to the Transmitter (R.F.)
PL5 - Co-ax Plug connecting with cable to the Transmitter (Drive).
PL6 - 4-way Plug connecting with cable to the Modulator Unit
PL7 - 4-way Plug connecting with cable to the Aircraft battery.
SK2 - 28-way Socket connecting with cable to the Aerial Coupling Unit.

Behing the front panel, the two selector units mount into the chassis base. A bracket on the right carries the "Test Tune" switch (S6), the "Local/Remote" Switch (S11), and the knob of the "Fine Tuning" control.

This latter turns the I.F. tuning shaft on the I.F. Unit by means of gearing and universal joints, and is interlocked mechanically with S11 so that "Remote control" cannot be chosen without returning this knob to its centre position.

Also directly behind the front panel is mounted the multilamp socket PL5 used to record switch position in the Aerial Coupling Unit.

The rear space behind the two Selector Units is occupied by the R.F. Unit and I.F. Units mounted across the chassis on brackets on each side of the unit which raise these units to occupy the top half of the rear space.

Below them and bridged by them is the Relay Unit, the Control relays and the H.T. machine fixed directly to the Mounting Unit.

The aerial changeover relay RL20 is mounted directly behind PL3 and PL4 at the rear in a screened compartment, one side of which can be removed for inspection.

The Unit is cooled by a fan on the H.T. machine which draws air through a filter plate in the dust cover, over the mainly heated units and expels it through a vent at the rear.

The sub-units will now be described in detail with that of Mounting Unit taken last.

4.1.3 The R.F. Unit 28-LRU.420A

(See Fig. 16, Plate 2)

This sub-unit is a tray chassis 14-1/8" long, $4\frac{1}{4}$" wide and $3\frac{3}{4}$" high overall. It mounts the tuneable r.f. amplifier which acts either as the r.f. stage on "receive " or as the drive selection amplifier on "send". This amplifier is tuned by a three ganged-condenser driven by a small motor and is tuned to resonance, on transmit by the autotune circuit (see Section 1.0 of this Chapter).

(Circuits on "Send" (i.e. when auto-tuning)

The Selector Unit (Crystal) presents a crystal (fo kc/s) to the oscillator valve V7 at the bottom right of the schematic.

V7 (CV.4014) is a pentode connected anode coupled Pierce-Colpitts oscillator, the crystal being connected across grid and anode at PL4. The feedback capacitance divider providing the necessary feedback is formed from the "stray" (turret) capacities from PL4/1 and PL4/2 to earth. Limitation of crystal voltage is controlled by grid leak R35 through choke L7, and provides the correct crystal dissipation and sinusoidal output.

The potential on grid of V7 is connected by C36, R44 to the grid V6 (CV.138) which is a normal cathode follower with a wideband transformer T5 as cathode load. Approx 1-2 volts r.f. appears at TP.6.

The low impedance output from V6 is taken from the cathode by the wideband transformer T5 and the balanced secondary connected to the crystal Mixer (147-LRU.30A). This is a Cowan modulator using four germanium diodes W2, W3, W4, W5, receiving its second input from the 465 kc/s oscillator V5, CV.455, C42 and C43 are preset trimmers which provide an initial capacity balance.

The primary of the r.f. transformer T6 is tuned slightly below 465 kc/s and is joined to the anode of V5A and grid of V5B. The harmonic mode crystal XL1 (Type ZCA.465) is joined by C9 to the anode of V5B and to the grid of V5A and in a series mode provides the feedback path for oscillation. The seondary of the transformer T6 is roughly tuned by C17 and connected to the Cowan modulator through the low pass filter formed symmetrically by C19, L8, C20, C21, L9, C22 which rejects higher harmonics of 465 kc/s. This filter is terminated by R21 and R22.

The output from the Cowan modulator is developed across R23, R24, R25 in series and is predominantely f_o + 465 kc/s and f_o - 465 kc/s in frequency, the carrier f_o being normally at a low level and still further reduced by adjustment of the balancing potentiometer RV2.

A part of this output across R24 is taken to relay contacts 1B (closed on Send) and to input of the r.f. amplifier. This is a conventional 2 valve 3 tuned circuit amplifier, V1 and V2 (CV.454's) being the amplifier valves and covers the 2.8 to 18.1 Mc/s in 3 ranges, viz. 2.8 - 5.7, 5.7 - 10.1 and 10.1 - 18.1 Mc/s.

The input transformers T1, T2 and T3 and the coils of the succeeding stages L1, L2, L3 and L4, L5, L6, are selected for each range by ganged

switches S1A, S1B, S1C, S1E and the circuits tuned by the ganged condenser C1A, C1B, C1C. This condenser is motor driven by MG1 from its low frequency value and is stopped by the auto-tune circuit at the peak of the first tuning response in the range, i.e. at f_1 - 465 kc/s. This action is dealt with in more detail in para. 4.1.9C.

Thus the output of the tuned amplifier through C26 across R31 is at the operating frequency f_o, i.e. $f_o = f_1 - 465$ kc/s, and is applied to the grid of the mixer valve V3 (CV.138) and to the grid of the aperiodic amplifier valve V4 (CV.2127). The mixer V3 is biased past cut-off by the positive potential from the heater chain at R32 through contact 2A in the "Send" condition. The anode load of V4 is a wideband transformer, the secondary of which delivers approx. 2 volts into 70 ohms at PL2, thence to 7PL5 the Transmitter Drive plug. Contact 2B in "send" condition has opened to remove the earth on this line.

The secondary of T4 also joins to the voltage doubler rectifier using W7, W8 Germanium diodes, the D.C. output of which, from junction of W7 and C40 through R45, is taken to PL5/22 and thence to the autotune circuit where it provides the stopping signal. The action of this circuit is detailed in 4.1.9(c) of this Chapter.

The gain of the r.f. amplifier is controlled on "send" in two ways
(a) the gain of each range is pre-selected by the cathode resistors R16, R17 of the second stage V2. These are selected by the range switch S1F.
(b) The gain tilt on each range is corrected by cathode bias resistor RV1 on stage V1 which is ganged mechanically to the tuning condenser C1.
(c) The A.G.C. bias from the I.F. Unit at plug PL5/11 is applied to V1 by R2 C4, and V2 by R15 and C14, but this is removed by earthing this line in the "send" condition by relay contact 2B, thus placing the amplifier at full gain.

Range selection is effected by the rotary solenoid MG2 which is stopped in the range position by S1D. This is stepped continuously until S1D receives an earth from the Receiver/Range Uniplugs 7PL16.

The stepping of MG2 is controlled by RL3 in the following way.
+28V is applied to the solenoid MG2 through contact 3A in position shown, causing it to operate and hold (one step). W6 is a spark quench.
+ 28V is applied to RL3/2 in parallel with the large condenser C3 through R3 and after a period controlled by the time constant of R_3, C_3, the

potential across relay RL3/2 to ground through contact 3B rises to operate the relay. Contact 3A then removes the supply to MG2 which releases, 3B removes the earth from RL3/2 which does not release until the potential across C3 falls to the release voltage of the relay which is lower than the operate voltage. At its release, 3A steps MG2 once more, and 3B allows RL3/2 to operate again after a delay, and the stepping action continues with approximately equal operate and release times on RL3/2.

The connection from C3/3B is taken to PL5/23, thence through 7W6 to the start line of the auto-tune circuit and thus as long as this line is earthed, i.e. while the Selector Units are operating, no range selection can commence. As soon as the range switch S1D finds an earth on PL5/5-6-7 this same point is earthed holding RL3/2 in the operate position to finally release(and stop) MG2 at the selected range.

The Circuits on Receive

The received signal f_o from the aerial change-over relay 7RL20 enters the unit on a screened cable from 7PL/18 at PL1 and through 1A and 1B in position shown to the r.f. amplifier which has, as described, just previously been auto-tuned to f_o. The amplified signal from the anode of V2 in C26 is applied to the grid of the triode connected mixer which is operating, now cathode biased by R33 (2A in position shown). Note the output from the Amplifier V4 is now earthed by 2B so that no signals can be received by the autotune circuit, or the Transmitter stages. The crystal oscillator V6 and V7 at f_o + 465 kc/s is applied to the mixer at the cathode from 2A and C31 and the resultant i.f. from the anode is passed by SK1 to the I.F. Unit.

The auto-tuning motor MG1 is driven by relays in the autotune circuit in the mounting unit connected to PL5/16, PL5/17. S1A and S2A are the limit switches on the tuning condenser shaft that cause MG1 to reverse before the mechanical stops on this condenser are reached.

The two send/receiver relays RL1/2 and RL2/2 connected to the +28 volts supply are operated by the Keying relay 7RL16 earthing PL5/25 and PL5/18 respectively. This duplicated connection is used only when this unit is being tested.

The h.f. connections to this unit are made by coaxial plugs or sockets SK1, PL1, PL2, the d.c. connections by a 25-way plug PL5 at the rear, which engages with socket 7SK14 on the main chassis, and the crystal

connections by two sprung contacts on the Selector Unit (Xtal) bearing on two contacts PL4 on the side of the R.F. Unit.

The cathode currents of all valves can be checked by measuring the potentials at the chassis test points TP.

4.1.4 The I.F. Unit 28-LRU.421A

(See Fig. 15, Plate 2)

This sub-unit is a tray chassis 14-1/8" long, 2-2/3" wide and 3-3/4" high overall. The i.f. connection is made by a coaxial socket SK1 at the front of the unit, the D.C. and audio connections being made by a 12-way plug PL1 at the rear which engages with 7SK15 on the main chassis. The i.f. from the H.F. Unit enters at SK1 and thence to the first pair of i.f. tuned circuits L1, C1, L2, C5. These two circuits are capacitively-link-coupled by C2, the two coupling windings and C4, giving a symmetrical bandpass. L2 is connected to the grid of the first I.F. valve V1 (CV.454).

A similar pair of tuned circuits C9 L3, C13 R33, L4-couple this valve to the 2nd I.F. valve V2 (CV.454) and a further pair of circuits C17, L5, C22, L6 couple V2 to the 3rd I.F. valve V3 (CV.454).

The anode circuit of V3 is tuned by C24, L7 coupled to a further tuned circuit L8, C27. The potential across L8 is applied to the voltage doubling detector formed by germanium diodes W1, W2. R20 C30 is the load for W1 and that for W2 is C36, R25, R26.

Semi-Conductor diodes W3, W4 are used as a normal series/shunt limiter for impulsive noise peaks. A positive bias equivalent to the carrier level is applied to W4 through R29 from the detector. Half the audio signal is applied to W3 from potential divider R25, R26, so that when a signal greater than 100% modulation is received the potential across W3 falls to zero and W3 ceases to conduct.

Normally the audio signal from the detector is taken by W3, R27 and V6B to Audio Level potentiometer RV2 and thence at the selected level to the grid of the 1st Audio stage V7 (CV.138). This valve is resistance-capacity-coupled by R42, C45 to the grid of the Audio output valve V8 (CV.136), the anode of which is transformer-coupled to the Telephone

output at PL1/2. Negative feedback is applied over V7 and V8 from the junction of R45 R46 across the output. This allows a relatively constant output into any one pair of phones when up to three pairs are used. The positive delay bias for the A.G.C. is supplied from the potential divider R22, R21 from the H.T. line from PL1/4. Thus at "no signal" condition the junction of R29, R30 can be positive to earth. This potential is held off from the A.G.C. line by the selenium blocking rectifier W5. When a signal above the delay bias is received the above potential falls to zero and then becomes negative and the A.G.C. line becomes effective applying a control bias to the grid of V1 by R2 filtered by C6, C27, to the grid of V2 by R8 and to the R.F. stages by connection at PL1/11. A selonium rectifier W6 from the A.G.C. line to earth ensures that the latter can never rise positive even if W5 fails and so protects the controlled valves, the delay bias being applied after rectification ensures the A.G.C. being unaffected by the modulation.

A double triode V6 (CV.455) is a muting circuit arranged to reduce the receiver output until the incoming signal reaches a pre-set level. This is operated by the A.G.C. bias being allowed to remove the muting at a chosen value.

The audio signal from R27, through C40, is applied to the grid of V6B which is biased past cut off, as explained below, and thus cannot pass to RV2.

In the "MUTE ON" position RV1 is connected to earth via plug PL1/6 either by 7S12 or 9S4. RV1 being of low value, a small positive bias from H.T. path R36, R33, RV1 to ground is applied to the cathode of V6a. The grid of this valve is connected to the A.G.C. line which is approximately at earth under "no signal" conditions. Thus the grid being only slightly negative to its cathode, allows the valve to conduct, and the drop across R34 which is a high resistance, places a high negative potential on the grid of V6B and thus "cuts it off".

When a signal is received such that the A.G.C. negative potential adds to the bias due to RV2, valve V6A cuts off and the grid potential of V6B relative to its cathode rises allowing V6B to conduct and act as a cathode follower coupling the audio signal to RV2 and on the audio amplifier. RV1 is thus the adjustment to set the muting level.

In the "MUTE OFF" condition, RV1 is removed from earth and the larger resistance R32 applies such a bias to V6A that it is always cut

off, thus the mute cannot be affected by a fall in the A.G.C. bias to zero. A small audio signal is always applied from R27 through R28 to RV2 and supplies a low audio level which remains when the mute is operative. This can be removed if complete muting is required, being mounted on a separate tag strip, or it can be changed in value to give any desired degree of muting.

Relay RL1 when operated by the Note Filter switch 7S14 via PL1/8 closes contact 1A and connects the parallel resonant circuit L10, C43 tuned to 1000 c/s ± 10% to ground from the audio line to act as a note filter for C.W. reception. In the Off position R39 is connected as a substitute impedance to the tuned circuit to avoid change of level.

C.W. reception is provided by the oscillator stage V4 (CV.138) which is a cathode coupled Colpitts oscillator the tuned circuit being L9, C31, C32, C33. The 465 kc/s signal from this is taken from the anode load R16 and injected through a level controlling condenser C29 to the grid of V3.

All the i.f. coils and the above oscillator coil L9 are mounted in screened compartments in an aluminium block. The coils each have dust iron cores which are fixed to a common mounting bar allowing individual adjustment for initial alignment of the i.f. amplifier. This bar can be moved up and down by a cam action controlled by a shaft which is turned by the "Fine Tuning Control" on the Front Panel of the Receiver/Drive Unit. Connection between the camshaft and the linkage to this front panel is made by a socket device (SK2) which allows I.F. unit to be removed. Thus the movement of the cam shaft alters the tuning of each i.f. coil and thus the i.f. pass band may be shifted ± a few kilocycles, to allow Fine Tuning. The C.W. oscillator is also varied by the same amount allowing variation of beat note on C.W. reception.

The cathodes of V1 and V2 are brought out to PL1/12 and are normally earthed on "receive" by a keying relay 7RL16A. This earth is removed on "send", R6 then providing a large bias to cut off these valves thus rendering the receiver inoperative.

4.1.5 <u>The Selector Unit (Band) 165-LRU.28A</u>

See Fig. 13, 24, 26 and Plate 2.

This unit provides the band selection information for the equipment, its basic method of operation having been previously described in section 2.3 of this Chapter.

The unit is approximately $6\frac{1}{2}$" long x $8\frac{1}{2}$" wide x $5\frac{1}{2}$" high and plugs into the Mounting Unit by means of two 18-way connectors PL8, PL10.

The front and bottom of the unit mounts eight 12-way potentiometers which are held in place by their mounting plates at the front, and by their spindles at the rear. The spindles carry a forked arm which is set in a particular (Band M) position.

When the potentiometer is in the unit this forked arm engages with a pin fixed to a wormwheel through the centre bush of which passes the spindle of the potentiometer. The wormwheel can rotate on a ball race. This allows a potentiometer to be replaced in position without disturbing the ganging of the others and at the same time aligns it to its correct initial rotation, from the front of the Receiver/Drive Unit. Three contact springs make electrical contact with each potentiometer.

The 8 potentiometers are driven by a common transverse shaft at the rear, mounting 4 worms which each engage two of the worm gears on the potentiometer spindles. Thus the backlash is equal on each.

The shaft revolves at 1/12th of the potentiometer speed and has also upon it a contact drum which breaks once per revolution and a further worm gear driven by the worm on the permanent magnet motor. Above the potentiometers, transversely across the top of the unit, are six 12 position switches, the centres of which are turned at the same speed as the potentiometers by a train of gears.

At the top front of the unit are the 24-position plug boards which allow the range selection of the Transmitter and Receiver.

Referring now to Fig. 13.

Switch S5E and S5F are the wire saving stopping banks for the 12-position selection.

Switch S5E connected via PL10/1-6 is controlled by the Remote Control Unit Band switch 9S3A. S5F is connected through PL18/1-6 to the Band Switch 7S3 on the Front Panel.

Switch S5A and S5B, S5C, S5D are the range Uniplug selectors, the former pair covering the Receiver and the latter pair the Transmitter.

The AM-NZ relays are RL11/2, RL12/2, RL13/2 have contacts 11B which select either S5A or B and 11A which deal similarly with S5C or D.

Of the remaining contacts, 12A, 12B, 13A change over the Aerial Coupling potentiometers, 13B being used for the two transmitter potentiometers.

The motor stopping relays RL14/2, RL15/2 which release to stop the motor MG2, act as follows:-

Contact 14A removes the +19V supply to MG2.

Contact 14B short circuits the motor to provide quick stopping by eddy current braking in the armature. 14A in the operated (running) position earths PL10/12 which is connected to the Auto-tune "start" line.

S5G is the contact which breaks accurately at the 30° positions of the stopping banks of S5 and thus removes errors due to the rather wide angles of contact on the type of switches used.

15B breaks the positive supply to the potentiometer Pot. 1 and Pot. 2; and 15A that to Pot. 3, Pot. 4, Pot. 7, Pot. 8, when the motor MG2 is selecting. This renders the bridge circuits quiescent during selection.

The similar supply to Pot. 5, Pot. 6 (condenser switches) is broken by 7S6 in the Tune or Test position by connection at PL8/9.

Separate earth wires are brought out from each group of potentiometers to avoid stray earth currents affecting the bridges near balance, i.e. at PL8/12 and PL10/8. All the relays on this unit are of the plug in type.

4.1.6 The Selector Unit (Crystal) 165-LRU.29A

See Fig. 14, 24, 27 and Plate 2.

This unit mounts up to 100 crystals and on channel selection presents the correct crystal to the oscillator on the R.F. Unit. The method of operation has been described in sections 2.1 and 3.5 of this chapter. The unit is approximately $6\frac{1}{2}$" long x $5\frac{1}{2}$" wide x 5" high. A horizontal shaft mounted in ball bearings is driven by a small permanent magnet motor.

The shaft carries the light alloy crystal drum and the wipers of two 25 position switches. The crystal drum has four rows of 25 sockets in which the crystal cases can be placed and retained by a spring catch, the crystal pins then projecting around the periphery. A set of 8 contacts engage each horizontal row of four crystals at the rear of turret as this rotates. 4 relays are mounted immediately above the crystal contacts, three of these relays being used to connect the crystal contacts to the two spring loaded contacts at the rear of the turret frame which engage with the contact bosses on the r.f. unit, i.e. to the crystal oscillator stage. The fourth relay is the motor stopping relay. The four relays and the crystal contacts can be hinged back for inspection and to allow the crystal turret to be withdrawn.

When this unit is mounted on the Mounting Unit, the crystal drum projects partly through the front panel to allow easy change of crystals.

Connections to this unit are made by plug PL11 at the base and at socket SK12 on the top left to the front panel channel switch.

In Fig. 14 switch S7A and S7B are the 25 position stopping switches, RL4/2 being the relay which stops motor MG1. Relays RL1/2, RL2/2, RL3/2 are the crystal selector relays, W13, W14 are the reverse path blocking rectifiers. The function of these has already been described relative to Fig. 27 in section 3.5.

4.1.7 Relay Unit 82-LRU.116C

(See Fig. 17 and Plate 2)

This removable unit is used with the Suppressed Aerial only. It consists of the relays etc. of the bridge circuits controlling the positioning of the Switch motor and Loop Tuning motor on the Suppressed Aerial Coupling Unit 24-LRU.58C. The unit is 7-1/8" long, $2\frac{1}{2}$" wide and $2\frac{3}{4}$" high and carries one plug which connects it to the Mounting Unit when in position. All the relays are of the plug-in type.

The circuit which is shown of Fig. 17 is basically a pair of circuits described in section 2.2 of this chapter, less the controlling potentiometers, the motors and their balancing potentiometers.

The function of the components are summarised as follows:-

	Switch Motor Circuit	Loop Motor Circuit
Detector Relay	RL4/1	RL8/1
Relay Protection Circuit	RL3/1	RL7/1
Motor Relays	RL1/2, RL2/2	RL5/2, RL6/2
Path of Detector Current	PL9/6 to PL9/10	PL9/9 to PL9/11
Motor Connections	PL9/4, PL9/5	PL9/7, PL9/8

All the references can be prefaced by 7(1).

When in place in the Mounting Unit, the Detector relays are accessible at the side of this unit.

4.1.8 The Front Panel Unit 400-LRU.121A (See Fig. 2, 12 and Plate 2)

By removing the handles and three knobs this front panel may be unplugged from the remainder of the unit, a 25 way plug and socket being used.

It mounts all the controls necessary for Local Operation except the Local Remote Switch 7S11, the Test/Tune Switch 7S6 and the Fine Tuning Control.

The panel carries two detachable covers removed when setting up. The larger, covering the Selector Unit (Band), bears a 100 channel frequency chart to record the Channel/Band allocations, the smaller giving access to the crystals. The covers are held in position by spring catches. Refer to Fig. 12.

The wiring from plug PL13 connects to all components except

(a) Band Switch S3, S4 which connects direct, by the cable, ended by PL18 to SK18 on the Selector Unit (Band). This switch can be removed from the front panel by screw driver use only and is coded:

Switch Unit 112-LRU.92A

The action of this switch is described in 3.6 of this chapter. Turning the knob rotates S3 into any one of 12 positions displaying band letters A-M in sequence on the front. Pulling the knob outwards operates S4 and allows

the knob to be rotated again into twelve position, the band letters displayed now being N-Z. PL2 is a dial illumination lamp.

(b) Channel Switch S1, S2 which connects direct by the cable, ended by PL12 to SK12, on the Selector Unit (Crystal). This switch can also be removed by the use of a screwdriver only and is coded Switch Unit 112-LRU.95A.

This unit mounts two pairs of 10 position switches, the shaft of S2A and S2B being mounted inside concentrically with that of S1A, S1B.

Thus turning the smaller knob operates "Tens" switches S2A, S2B displaying numbers 1-10 in turn; turning the larger outer knob moves "Units" switches S1A, S1B also displaying numbers 1,10 in sequence. The action of this switch is dealt with in section 3.5 of this Chapter.

The remaining controls have the following function, generally covered by section 3.0 of this chapter.

ON/OFF Switch S8A-B has four positions, on one bank

OFF - S8A wiper to Earth, S8B wiper to + 19V.
RX-ON - S8A Earths PL13/17 - puts on Receiver/Drive Unit.
STD/BY - S8A adds an earth to PL13/9 and switches on + 19, +28V control circuit at the transmitter. Transmitter valves heated.
TX - S8A places +19V on PL13/13 and starts Transmitter Rotary Transformer.

Meter Switch S9 has four positions on one bank. This connects microammeter M1 to transmitter circuits for setting-up procedure.

D - Connects M1 through R20 to PL13/21 and thence to 8SK14/22 to act as a voltmeter to read the rectified DRIVE output of the R.F. Unit. The other pole of M1 is earthed.

I_C - Connects M1 to read Cathode Current of the P.A. valves, acting as a voltmeter across 2R7 in the Transmitter to the + 28V supply to which the cathodes of 2V3 and 2V4 are returned. R2 is the series meter resistance.

I_g – Connects M1 to read Grid Current (Drive) of P.A. valves, acting as a voltmeter across the metering resistance 2R24 in the grid return to earth. R3 is the series meter resistance.

A_E – M1 is connected as a microammeter to read the AERIAL EXCITATION by connection to PL13/1 and PL13/20. A separate earth on PL13/1 is connected for this purpose to avoid change of the reading of M1 due to D.C. earth currents in the equipment. PL13/20 connects to the excitation detectors in either type of Aerial Coupling Unit.

Service Switch S10 – 3 positions on one bank.

This switch selects the type of transmission.

RT – Places an earth from PL13/8 to PL13/5 which operates R.T/M.C.W. relay 3RL3 on the Modulator Unit which allows the Modulator final stage to operate by cutting out the biasing-back resistance 3R40 in their cathodes.

M.C.W. As R.T. condition, but an earth added to PL13/7 which operates the MCW/CW relay 3RL4 on the Modulator Unit, which disconnects the microphone amplifier stages and connects the Tone oscillator to provide modulation and sidetone.

C.W. Earth now only on PL13/7, i.e. on 3RL4. 3RL3 is released, biasing off the modulator valves. The Tone oscillator still provides sidetone. In addition the unit H.T. supply from PL13/19 is connected to PL13/18 and thence to 7SK15/7 to put on the C.W. injection oscillator on the I.F. Unit (See Section 4.1.4 above).

S12 – MUTE ON-OFF Switch

This in the ON position, places an earth on PL13/15 via S13 and allows the receiver to be muted until a set signal level is reached. See 4.1.4 above for operation. In the OFF position this earth is removed. This switch is inoperative if S13 is in the A.G.C. OFF position.

S13 - A.G.C. ON/OFF Switch - A double pole changeover switch.

In the OFF position this earths the A.G.C. line via PL13/12 and 7SK15/11 and at the same time disconnects S12 as this circuit operates off the A.G.C. voltage.

S14 - NOTE FILTER Switch

This in the ON position operates the relay RL1 on the I.F. Unit by the earth placed on PL13/11, thus connecting the 1000 c/s filter on the audio circuit.

RV1 - R.F. Gain Control

This varies the r.f. gain of the receiver and acts as explained in section 4.1.2 of this chapter.

LP1 - is the dial light illuminating S8 and S10. Note S9 is not illuminated as it is only used during setting up procedure.

4.1.9 The Mounting Unit 395-LRU.62A

(See Fig. 11 and Plate 2)

This unit provides the means of interconnection of all the previous units in this section as listed in 4.1.1. It consists of a shallow chassis on which are mounted brackets, the H.T. machine, and sockets for control relays. Looking from the front of the unit.

(A) A shelf bracket at the back right provides support for the I.F. and H.F. Units and mounts SK15 and SK14 which provide connections to the units. Three 6-way r.f. filters surround SK14 to filter the leads passing to the R.F. Unit. The bracket also carries the bearings and bevel gears to the mechanical socket which couples the Fine Tuning control to the I.F. Unit.

This bracket is extended toward the front left where it provides the method of attachment and connection to the front panel by means of a sub-panel.

This carries S11, S6, the fine-tuning knob and SK13 which connects the front panel. A bracket on the right front provides

the front panel fixings in that side. At the rear is a back plate bracket mounting the plugs and sockets connecting the Receiver/Drive Unit to the rest of the equipment. The machine is mounted in a containing cover so that the efflux air from its fan escapes through a cut-out in this panel. In the centre front, is mounted the 12 lamp holder LP5 used for switch position signalling.

The front lower edge carries the fixing handles of the front panel, the 3 fuses F1, F2, F3 and lamps LP3, LP4. All connections to relays, sockets and plugs, except those mentioned just above, are beneath the chassis together with all the components associated with the auto-tune circuit.

(B) Refer to Fig. 11. The components will now be described functionally in turn.

Local Remote Switch S11. This mounts on the front side bracket and transfers control of the equipment from "Local" to "Remote". It is interlocked mechanically by means of a bolt action with the Fine Tuning Knob mounted just above it, so that "Remote" cannot be selected unless the latter is returned to its centre frequency position. S11 has 15 changover switches mounted on 4 banks and performs the operations listed below:-

Switch position	Changes Over	Connection	
		Local	Remote
S11A	Band stopping relay 7RL14/2	7S5F via 7SK8/14	7S5E via 7SK8/15
S11B	AM-NZ Relays at 7SK10/10	7S4 via 7PL18/8, 7SK10/15	9S3B via 7PL1/28
S11C	Receiver Mute at 7SK15/8	7S13 via 7SK13/15	9S4 via 7PL1/19
S11D	Local Remote Earth	Earth to 7SK11/13	Earth to 7PL1/18
S11E	R.F. Gain Control at 7SK14/10	7RV1 via 7SK13/22	9RV1 via 7PL1/22
S11F	RX ON relay 7RL19/2	7S8A via 7SK13/17	9S5 via 7PL1/14
S11G	STD/BY relay 3RL6/1	7S8A via 7SK13/9	9S5A via 7PL1/15
S11H	TX/ON relay 3RL8/1	7S8B via 7SK13/13	9S5 via 7PL1/16
S11J	AE indicator from 7SK2/6	7M1 via 7SK13/20	9M1 via 7PL1/13

Switch Position	Changes Over	Connection Local	Connection Remote
S11K	Service Switch Earth at 7S6A	7S10 via 7SK13/8	TX on RT by 3RL3 via 7PL2/4
S11L	RX C.W. H.T. supply at 7SK15/7	7S10 via SK13/18	Connection to SK13/18 broken i.e. RX cannot be on C.W.
S11M	Note filter relay 4(3)RL1/1	7S14 via 7SK13/10	Connection to 7SK13/10 broken i.e. i.e. RX note filter removed
S11N	Tune Line	No connection	Tune Line to 7LP2 via 7PL1/17
S11P	A. G. C. Earth	7S14 via 7SK13/23	Connection to 7SK13/23 broken i.e. AGC always ON
S11Q	+ 28V channel selection	7S2A via 7SK11/14 and 7SK12/14	9S2A via 7PL1/21

Test/Tune Switch S6. This key switch has 3 positions. Test-Operate-Tune, and is used during setting up. In the "Test" position it places the transmitter on "Mark" by earthing the key line. On "Tune", in addition, it removes the supply to the "Tune" relays so allowing the tuning motors to operate without "keying" the transmitter and also connects a series resistor in the P. A. stage screen circuit using the "safe" relay. The "Test" and "Tune" positions are spring loaded so that when the key is not being actuated it returns to the "Operate" (central condition).

The contacts function as follows:-

Switch Contacts	Test	Operate	Tune
S6A	As operate	Applies Service Switch earth to S11K	Earth safe relay 3RL11 via 7PL2/19, removes earth to S11K, i,e. TX now on R. T.

Switch Contacts	Test	Operate	Tune
S6B-C	Disconnects Switch Bridge Supply	Connects Condenser Switch Bridge Supply in A.C.U's from 7SK8/10 to 7SK8/9 and 7SK2/13	Disconnects Switch Bridge Supply.
S6D	As operate	Connects + 28V to Tune Relays 3RL1, 2RL5 via 7PL2/2	Breaks supply to 7PL2/2 disabling Tune relays
S6E-F	Earths key line S6F	No earth on key line	Earths key line S6E

LP5 - 12 lamp-holder (219-LRA.11B)

This is mounted at the front of the unit and provides sockets for 12 lamps all commoned on one side to the 19V supply through 7R23. The other side of the lamps are taken to the position signalling switches on the Aerial Coupling Units, i.e. 8S3A using 6 lamps and 5S1 using 12 lamps. The choice of these connections is made by SK20 (see below). The switches apply an earth one lamp at a time.

Aerial Changeover Relay 7RL20

This relay is mounted in a screened compartment at the rear left of the unit. In the "space" receive condition the "low impedance" aerial input from the Aerial Coupling Unit enters at 7PL3 and through 20A to PL19 and thence by a detachable coaxial lead to the R.F. Unit input 7(2)PL1.

On "mark" the aerial at 7PL3 is connected directly to 7PL4 the output from the Transmitter Unit (2PL4), by 20A. The receiver input now being earthed by 20B. The key line to the coil of RL20/2 is filtered by C7/L3 and C8/L2 to prevent R.F. passing back.

SK20 Aerial Coupling Unit Control Change-over Point

This 50-way socket is mounted on the underside of the chassis and

acts as a 14-way change-over switch to change the connections of 7SK2 from those suitable for the Suppressed Aerial Coupling Unit 24-LRU.58 (position shown in Fig. 11) to those required for the Wire Aerial Coupling Unit 24-LRU.52. The linking is effected by a detachable plug with contacts joined as shown. When the alternative connections are required this plug is removed and replaced by the alternatively linked plug, mounted adjacently in spring clips.

The changes made by this socket can be seen from the index against 7SK2 in the schematic.

H.T., 19V and 28V Circuits

These are described functionally in sections 3.9, 3.7, 3.8 respectively of this chapter.

The H.T. machine has two stage "hash" filters (8-LRU.332A) on its input and output, the ripple filter L1, C1 being mounted above the chassis.

Relays, Fuses and Signal Lamps

These are best tabulated as to use.

F1 - 28V circuit fuse - through front panel.
F2 - 19V circuit fuse - through front panel.
F3 - H.T. circuit fuse - through front panel.
LP4 - Tune Lamp - through front panel, signals tuning operation in progress or, a Unit left on MANUAL control.
LP3 - H.T. ON Lamp - is lit by the Transmitter H.T. rotary start circuit by 7PL2/6.
RL5/1 - Auto-tune relay (Sensitive relay)
RL7/2 - Auto-tune relay
RL8/2 - Auto-tune relay
RL9/2 - Auto-tune relay (Motor relay)
RL10/2 - Auto-tune relay (Motor relay)
RL16/2 - Keying relay, on "mark" 16A "cuts off" the Receiver by removing earth from SK15/12 and returns r.f. again to maximum by earthing SK14/10. 16B applies H.T. to SK14/5.
RL17/2 - Auto-tune relay.
RL18/1 - 28V ON relay
RL19/2 - 19V ON relay - 19B is a protective contact on the auto-tune.

RL20/2- Keying Relay Aerial Change-over (see above)
RL21/2 - Operated by the Transmitter + 28V supply from PL2/3, 21A breaks the Tune Line, 21B breaks the key line from the Transmitter Units.
RL22/1 - Time delay relay - auto-tune circuit.
RL23/2 - Auto-tune relay.

(The relays ascribed to the auto-tune circuit are dealt with below.)

RV2 - Aerial Indicator level adjustment - in series with indicator current from SK2/6 and meter M1.
RV3 - Overshoot Correction Adjustment on auto-tune circuit.

(C) The Auto-tuning Circuit Operation (See Fig. 11)

The components of this circuit, apart from the relays listed above and valves V1 and V2 are mounted below the chassis.

Basic operation

The purpose of this circuit is to stop the rotation of the tuning motor 7(2) MG1 on the R.F. Unit when its ganged condenser has reached the tuning position such that the maximum output voltage appears at SK14/22 (see section 4.1.3 of this Chapter). This motor is driven at constant speed through resonance and the resulting output rectified by 7(2)W7 and W8 and appears at SK14/22. This positive voltage relative to ground is differentiated by C3, R4 so that the grid of V1 (CV.138) receives a signal that passes rapidly towards zero in a negative direction at substantially the instant the output from 7SK14/22 reaches its maximum. (Contact 17A is assumed operated, i.e. no earth on grid of V1).

After amplification and inversion in V1 the waveform is applied to the grid of V2 (CV.138) which is biased below cut off by the positive potential on its cathode from the divider R15, R12, R18 to earth through 17A from the H.T. line.

While the grid of V1 is being driven positive, that of V2 is being made more negative, but at the resonance point when the grid of V1 commences to fall rapidly negative, the grid of V2 rises sharply positive and allows V2 to conduct and operate RL5/1 on one winding in its anode. Contact 5A operating "stops" the motor. The operation of RL5/1 thus

occurs at the same instant as the output at SK14/22 reaches peak resonance. The coupling between V1 and V2 by C5, R9 acts as a slight phase advance.

Typical waveforms and voltages of valves V1 and V2 are shown in Fig. 55, page 3/30, Vol.2.

Although 7(2) MG1 is braked by its armature being short circuited by the stopping relay, its overrun plus the operate times of the motor relays allows 7(2)MG1 to stop after the peak resonance has been reached. This error is corrected as follows: When 5A operates the motor is actually reversed, and at the same instant C4 commences to charge-up from the H.T. line at a rate depending on the time constant of RV3, R11, R10, C4. When the potential C4 reaches the triggering potential of the small gas discharge tube V3 (CV.2208), this conducts and the sudden discharge through C6 operates RL5/1 again through its second winding (2, 3) to reset and finally stop 7(2)MG1.

When operating on reduced voltage i.e. 22V, the H.T. is lowered and thus the charging time of C4 will vary. This is corrected by biasing the cathode of V3 from the potential divider formed by V4, V5, R21, R22. The stabilising effect of gas tubes V4, V5 (CV.2208) corrects this bias to compensate for the drop in H.T. V4 and V5 also illuminates V3 and prevents the uneven triggering associated with neon tubes in the dark.

This "turn back" of 7/2)MG1 thus corrects the over-shoot. This overshoot correction can be adjusted by RV3 which allows the controlling time constant.

The actual control of the motor by 5A through its auxiliary relays is described below.

Motor Control Relays

It is best to attempt to describe the action of these relays in stages.

7(2) SW1 and SW2 are limit switches on the gang condenser SW1 at the maximum (l.f.) capacity and SW2 at the h.f. and and are operated by a cam when those positions are reached.

STAGE I. Receiver placed in RX ON Condition

The + 19 and + 28 volts appear at points shown. In particular 19B closes applying + 28V to SK14/3 and to RL23/1 which operates through R24 and R25. Contact 23A thus closes and earths the Start Line. This Start Line will be repeatedly mentioned and is basically a point from which the removal of an earth starts the auto-tune operation. The start line being earthed, allows RL9/2 to operate through W4 and RL10/2 through SK14/2, 7(2)SW1, SK15/15 and W3. Contacts 9A, 9B, 10A, 10B close earthing both sides of 4(2)MG1 at SK14/16, and SK14/17 preventing its start. The heater of the time delay relay RL22/1 is already in circuit.

STAGE II Time delay RL22/1 operated

Contact 22A now closes, connecting the junction of RL23/1 and R24 through SK14/24 to 7(2) RL3A which has closed and thus this point is connected to the + 28 volt supply from SK14/3. RL23/1 then releases, slowed by slug resistor R19 and removes the earth from the Start Line at 23A.

The removal of the earth on the Start Line and thus from SK14/23 allows the range selector solenoid 7(2)MG2 to step to its correct position (See 4.1.3 of this Chapter) and thus the r.f. amplifier is ready for tuning.

Relay RL10/2 does not release as it is latched in by the path from earth through 10B, 10A, 8B, 7(2)SW1; RL9/2 releases and 7(2)MG1 thus has + 28 volts at SK14/16 via 9A, and earth at SK14/17 via 10B. It rotates in the direction turning the condenser towards the l.f. end, i.e. towards 7(2) SW1. Note that RL17/2 across the motor leads cannot operate due to blocking action of W10. Thus during this "back-stroke" of 7(2)MG1 the auto-tune valves are inoperative as the grid of V1 is earthed by 17A and the bias on V2 is increased by the resistor R13 to a large value.

As soon as the motor operates 7(2) SW1, RL10/2 is released, RL9/2 operates via 8A, 10 B to earth. Thus the motor receives an earth on SK14/16 via 9B and +28V on SK14/17 via 10A, it therefore reverses its rotation (c.f. case above) and starts to drive the condenser towards the h.f. end of the range. The polarity across RL17/2 is now

such that it operates when 17A allows V1 and V2 to operate normally, 17B operates RL16/2 and 7(2)RL1/2, 7(2)RL2/2 through SK14/18 and 25. This action places the r.f. unit in the "local" send condition as explained in Section 1.0 of this chapter.

STAGE III. Action when auto-tune stops on reaching resonance

The condenser now tuning towards its h.f. end reaches the resonance at the applied signal frequency and is "stopped" by V1, V2, RL5/1. This is described in 4.1.9(c) above which, however, does not fully explain the action of the relays.

When 5A closes its earths RL7/2 which operates. 7A closes and connects the Tune Line to RL10/2 via 7(2)SW1, 7B closes to connect 8A to the Tune Line.

The Tune Line, however, is earthed through W1 and 9B, therefore RL10/2 operates, and is latched up as before by earth from 10B, 10A, 8B and 7(2)SW1.

Contact 10B also removes the earth from RL9/2 which releases.

7(2)MG1 thus reverses as long as 5A is closed, the earth on the Tune Line being now through W2 and 10B.

RL8/2 now operates from +28V line through 9A, 9B, and 7B to earth on the Tune Line, 8B opens unlatching RL10/2 which however is still operated through 7A.

When the V3 "fires" 5A is released, releasing RL7/2, 7A then releasing RL10/2 to stop the motor, braked as before, by the short circuit from SK14/17 to SK14/16 through 9A and 10A. 7B also releases, but as the release time of RL8/2 is lengthened by "slug" R14, 10B has released before RL8/2 has started to release. RL8/2 is therefore latched up by earth from 10B through 8A, and only releases when auto tune operates on the next auto tune cycle.

This is the end of the auto-tune cycle.

STAGE IV

When it is necessary to re-auto-tune, (reset) the final phase takes place.

This can occur either:-

(a) When a new crystal is presented to the Xtal oscillator, that is, whenever the Selector Unit (Xtal) moves as a CHANNEL change is made.

(b) When a change of BAND is made, i.e. whenever the Selector Unit (Band) operates.

(c) Whenever the equipment is switched ON and the initial time delay has operated.

In any of these conditions an earth is placed on the Start Line, this causes RL10/2 and RL9/2 to operate as in Stage I and thus 10B removes the latching earth from RL8/2 through 8A and thus this relay releases. The condition is now that of the beginning of Stage II, the same sequence following when the start signal, i.e. removal of the earth from the Start Line, occurs.

Protective Circuits on the Auto-Tune circuits

Some of these have already been partly mentioned by are now listed for clarification.

(a) "Back-stroke" protection relay RL17/2. This relay in its unoperated condition renders the whole circuit inoperative, and as it only operates when the condenser is being tuned from the l.f. to the h.f. ends, prevents spurious operation on the backstroke. (See Stage II).

(b) Rectifier W11. This connected to earth from the grid of V1 prevents any spurious negative going pulses due to relay circuits etc., from being amplified and passed to V2 as a stopping pulse. W11 ensures that the grid cannot become more negative than earth, W14, in series, acts as limiter to reject low amplitude spurious signals.

(c) RX ON protecting contacts 19B. Contacts 19B break the supply to RL/23 and to 7(2) MG2 every time the 19V supply is interrupted; this ensures the auto-tune resets when this occurs.

(d) Time Delay Relay RL22/1. This delays the commencement of the auto-tune operation (see Stage II) so as to prevent a false stopping

point due to the anode current variations that would occur if the circuit were to operate while the valve cathodes were heating.

(e) D.C. Blocking Rectifiers. W1, W2 from the Tune Line allow current to flow to the Tune Line from the relays (RL9/2, RL10/2), but preclude flow in the opposite direction. W6, W3, W4 have analogical purposes.

(f) Reversing Limit Switch 7(2) SW2. If a channel has been selected but no crystal has been placed in the appropriate position on the Crystal Turret, or if for some other reason the auto-tune circuit does not stop the tuning motor 7(2)MG1, this will rotate in the forward direction until the h.f. end of the condenser travel is reached. The condenser would thus reach its mechanical stop and its clutch would slip continuously. This is prevented by 7(2)SW2 closing just before the limit stop, this operates RL10/2 through 7(2)SW1, 10B releasing RL9/2 (see Stage II) and reversing the motor to run again on its backstroke. The tuning motor will reverse at the l.f. end again using 7(2)SW1 and "try again". If no stopping signal is obtained (i.e. no crystal) this cycling action will continue indefinitely, but the Tune Lamp will remain alight at either operating position as an indication of this.

(g) Band change protection relay RL23/1. If the AM-NZ switch operation only is made on the Band Change Switch (that is knob pushed in or out) no rotation of either selector motor occurs, but the change say from Band C to Band Q may result in a change of the Receiver Range selection, i.e. a change of the earthed position on 7(2)S1D, the stopping band of 7(2)MG2. In this case the earth is removed from 7(2)RL3/2 which releases 7(2)RL3A and the +28 volt supply to the junction of R24 and RL23/1. This then operates and 23A earths the Start Line and thus the autotune resets.

4.2 Transmitter Unit 4-LRU.50D

(See Figs. 3, 7 and Plates 4 and 5)

4.2.1 Mechanical Layout

The complete unit consists of a composite chassis on which is mounted a front panel 8" x 8" bearing the controls necessary for

Manual and Emergency operation. A removable dust cover encloses the whole unit and is fixed by means of a quick release fastener at the rear. The unit is $12\frac{1}{2}$" deep.

The main portion of the equipment is the cast aluminium chassis of the Valve Unit 19-LRU.14D to which is attached the front panel. Beside this unit is bolted the Coil Unit 2-LRU.37C, a cast chassis mounting the 3 coil cans containing the variable inductances tuning the amplifier stages. The coils are ganged by means of a shaft running under the centre line of the coils below the chassis and having a chain sprocket wheel on the front end. A further unit, the Drive Unit Mechanical 327-LRU.15B, plugs and bolts on the right-hand front of the Valve Unit. This mounts the motor and its associated gears, potentiometer and relays that constitute the remote controlled tuning head. Connection is made between this unit and the drive shaft of the Coil Unit by means of a silver-nickel chain running on special sprocket wheels.

From the front of the valve unit, on its top surface behind the Drive Unit, are the input valve and time delay relay RL10/1 mounted on a valve base. Then follow two relays, RL4/2, and RL5/2, and on the raised step the driver valve and its screen, behind the screen are mounted the two output valves on a raised cast box which leads the air from below through the valve anodes. This box is directly above the air blower which is attached to the underside of the chassis and draws the cooling air, through the air filter, to discharge it directly into the box.

The air blower, the valve box, the filter housing and the three main units may all be separated using a screw driver, all the electrical connections being made by plugs and sockets.

The front panel controls are described in the following section.

The rear of the combined units mount four plugs for connection to the rest of the Transmitter. They are:-

PL1 - 28-way plug - Control and Power supplies.
PL2 - Coaxial plug - R.F. Input.
PL3 - Coaxial plug - 600 volt H.T.
PL4 - Coaxial plug - R.F. Output.

4.2.2 Electrical Description

Radio Frequency Circuits

The function of this unit as a whole is to amplify the input from the oscillator in the Control and Drive Unit, from a level of 2V R.M.S into 70 ohms to the output level of 100 watts into 70 ohms, at fundamental frequency. The input from plug PL2 through C1 and S3C is connected to the grid of the input pentode valve V1. R1 is the terminating resistance of the input cable. The 300 volt H.T. line supplies the screen directly from R11. The anode is shunt fed by choke L14 and decoupling R11 and C8. The anode circuit isolated by means of C3 is a variable inductance L2 tuned by C6 and stray capacity. Electrical trimming is done by an iron-cored coil L1 and C6. The valve is mainly cathode biased by R4 and R6. R8 is a damping resistance across the tuned circuit.

Coupling to the next stage is direct by C9, R15, to the grid of the bean tetrode V2 which is the Driver stage. The 300 volt H.T. supply is taken to screen grid by R16, C11, and to the anode by shunt feed through R14 and L6. This valve operates in Class A B, and is biased by grid leak R15 and cathode resistances R22, R23. The anode is tuned by circuit L4, C17, similar to the preceding stage, and is trimmed by L3 and C17.

The Power Amplifier stage has two air-blast cooled beam tetrodes V3 and V4, operating in parallel in Class C. The grids are driven from driver stage through C13. The screen grid potential and the anode potential are obtained direct from the Power and Modulator Unit from the 300 volt and 600 volt supplies respectively. When the Transmitter is modulated in the R/T and M.C.W. conditions these two supplies are modulated by output transformer 3T3 in that unit. The screen potential is taken through R30 and R31 decoupled by C20 but is decreased by a further resistance 3R43 switched in series in SAFE condition by 3RL11.

The anodes are shunt fed by chokes L10 - L13. L7 and L8 are anti-parasitic chokes on the grids. The bias of the stage is obtained as fixed bias from the + 28 volt battery supply, to which the cathode return is connected as grid leak bias through L9 and R27, R24, and from cathodes bias resistors R25, R26 and R7. C7 is added to prevent keying surges at the anodes.

The anode circuit is matched to the low impedance output by means of the pi-circuit C22, L5, and C25, C26, C27. L5 is variable and ganged to the preceding stages.

The transmitter covers the frequency range in two ranges 2.8 - 7.0 Mc/s and 7.0 - 18 Mc/s. The transmitter is normally on the higher of these ranges. When range change relays RL1/1, RL2/1 and RL/3 operate extra condensers are switched in. These are C4 and trimmer C5 on first stage by 3B; C15 and trimmer C16 on second stage by 2B, while on the output circuit both the input and output shunt elements of the pi-circuit are increased by C24 and C28, C29, respectively by 1A and 1B. RL1/1 is a special high voltage relay 60-LRU.90.

Keying Circuit

When the key line is earthed, RL4/2 operates, 4A closes and connects the 300V D.C. supply to the first two stages and also via pin 17 on PL1 to the Tone oscillator in the Modulator Unit via 3SK1. R13 in the cathode of the P.A. stage normally biases this nearly to cut off; when 4B closes this is short circuited and the P.A. stage is then able to operate normally. When the intertune line is earthed RL5/2 operates and by means of 5A and 5B has the function of putting this unit in the "space" condition.

Valve Heaters

V1 and V2 are heated in series from the 19 volt supply from pin 27 on PL1. R19 is in parallel with V1. The heaters of the P.A. valves V3 and V4 are in series off a nominal 12.6 volt supply obtained from series dropping resistance 3R41 in the Power and Modulator Unit. The blower motor MG2 starts at the same time as the heaters are connected.

The thermal type Time delay relay, RL10/1 is connected in series with heater of V1 and after 30 seconds, closes 10A allowing H.T. to be applied. R20 is in parallel with RL10/1 to provide with it, the correct series resistance.

Function of Front Panel Controls

Band Switch S1

When S3 is on any position other than AUTO, S1 operates range-change relays when in 2.8 - 7.0 Mc/s position.

Meter Switch S2A-B

In I_1 position S2B connects meter M1 across R6 to earth in the cathode return of the first stage such that M1 through R6 reads cathode current of this stage. (Meter reading X 10 = cathode current in mA approx.).

In I_2 position S2B connects M1 across R23 to earth in cathode return of the second stage such that M1 through R21 reads cathode current of this stage (Meter reading X 20 = cathode current in mA approx.).

In Ig position S2B connects M1 across R24 to earth in the grid lead of the P.A. stage such that M1 through R18 reads grid current of that stage. (Meter reading X10 = grid current in mA approx.).

In I_c position S2B connects M1 across R7 to the +28V supply in the cathode lead of the P.A. stage such that M1 through R10 reads cathode current of that stage. (Meter reading X 100 = cathode current in mA approx.).

Positions I_1 and I_2 are grouped under condition OPERATE, S2 should be left finally in these positions when operating the transmitter manually.

Positions I_g and I_c are grouped under condition TUNE. S2 in this condition is used for tuning the transmitter manually and in both position (1)S2A connects Test Key S4 to earth so that using this the transmitter can be keyed, (2)S2A puts the transmitter in the SAFE condition through S3A when this is in any other position than AUTO, i.e. S2 can be left in any position when transmitter is on AUTO.

Auto-Manual-Emergency Switch S3 A-C

AUTO Position (Operate)

(1) R.F. input from PL2 is connected to grid of V1 via S3C. Cathode resistance of V1 is then R4, R5 and grid leak R2, R39.

(2) Band relays are connected to range switches 1S8 via pin 6 on PL1 (S3B).

(3) H.T. start circuit is connected between pin 8 and pin 4 on PL1 allowing remote control. (S3B).

(4) S3A connects the control detector circuit from pin 14 to the detector contact on the potentiometer RV1 of the Transmitter remote control head.

MANUAL Position (Operate)

(1) Circuit is as in auto position on S3C.

(2) S3B connects range relays to local range switch S1. H.T. on circuit as AUTO position.

(3) S3A removes control detector circuit from tuning head, and allows S2A to connect SAFE line to earth.

EMERGENCY Position STD-BY

(1) S3C Circuit condition as in AUTO and MAN.

(2) S3B connects range switch S1 as before, and disconnects H.T. ON circuit.

(3) S3A connects the STD-BY circuit at pin 3 on PL1 to earth and thus puts on the heaters.

EMERGENCY Position XTL1 (Similar action for position XTL2)

(1) S3C connects XTL1 between grid of V1 and earth, C1 is disconnected, R38 replaces R4 as the cathode bias resistor. R39 is now cathode

load resistance and stage becomes an aperiodic crystal oscillator of Colpitts type, C32 and C33 providing the feedback path.

(2) The range change switch S1 is connected as before, but the H.T. ON circuit is connected to +19 volts by S3B and starts the H.T. machine.

(3) S3A operates as in STD-BY position.

Test Key S4

This when pressed, puts the transmitter on mark condition for tuning manually when S2 is in Tune positions.

Switch S5

This illuminates the meter and frequency dial.

The front panel also displays a dial calibrated in the two frequency bands and is ganged to the tuning circuits. This is used to aid manual tuning.

The Remote Control Head

This is all on Drive Unit Mechanical 327-LRU.15B and is connected to pins 10, 12, 14 and 16 of PL1. It is described in Section 1 of this chapter.

4.3 Power and Modulator Unit 404-LRU.4B (See Figs. 4.8 and Plate 6)

4.3.1 Mechanical Layout

The complete Unit consists of a main chassis on which is mounted the front panel 8" x 10" bearing the air intake dust filter. A removable dust cover encloses the whole Unit and is fixed at the rear by means of a quick release fastener. The unit is $12\frac{1}{2}$" deep.

The main chassis is $2\frac{1}{2}$" deep open at the bottom and covers the whole base of the unit. On its top surface are mounted the motor Generator (left-hand side), the Audio Amplifier Chassis 28-LRU.362C

(on right-hand side front) and to the rear of this the modulating transformer. The rear H.T. brushes of the generator are covered by a bracket which carries a valve heater dropping resistance R41 and can be swung clear for access to the brushes.

On the underside of the chassis there is a group of control relays in the front left. The centre is occupied by a screened compartment which contains the generator connections, the "noise" suppression filters, and the second relay of the machine start circuit.

The remainder of the chassis mounts the machine start relay, and components of the H.T. smoothing circuits.

The interconnection of this unit with others is made by seven plugs and sockets fixed to the rear face of the chassis.

These are:-

PL1 - 20-way plug	-	Power supply input
PL2 - Coaxial plug	-	600V H.T. modulated output
SK1 - 28-way socket	-	Control and power supplies(to Tx)
SK2 - 20-way socket	-	Control and power supplies (to D.U.)
SK3 - 4-way socket	-	Transmitter Interlock
SK4 - 4-way socket	-	Receiver connections
SK5 - 8-way socket	-	Connections to Intercommunication Equipment (sidetone, key and microphone circuit).

PL2 and SK3 are mounted on a bracket above the chassis.

Cooling air for this unit is drawn through the filter box on the front panel by the fan on the L.T. (front) end of the machine. Some air is then passed through the machine and some taken directly from the fan through a slot in the cowl and directed across the output valves by a deflector duct. The air exhausts through louvres in the rear top of the dust cover.

Two quick release fasteners allow the two air filters to be removed, and a further four fasteners allow removal of the baffle plate behind the filters. This permits the fan cowl of the machine to be withdrawn for inspection of the L.T. brushes.

A sliding cover beside the air filter on the front panel allows access to three pre-set adjustments on the audio amplifier.

The machine is held in position by means of two clamp bands on a saddle. When these and the air duct are released, the electrical quick release connections freed, and the bracket previously mentioned raised, the machine can be removed.

The audio amplifier is held on to the main chassis by means of four captive screws. Input connections are made by plug and socket (PL3, SK6), the output connections by top caps of the modulator valves.

4.3.2 Electrical Description

Audio frequency circuits

These comprise the audio amplifier chassis 28-LRU.362C and the modulating transformer T3.

The balanced microphone input enters at pins 3 and 4 on SK5 and thence via 1 and 2 on SK6 to the input winding of transformer T1. The secondary winding is connected to the input stage V1 and V2 operating in push-pull. The anode supply of these valves is obtained from relay contact 4A in the R/T position only. These valves (CV.2135) act as the microphone amplifier and also as the controlled stage in the V.O.G.A.D. circuit. With zero input signal the valves are biased by cathode resistor R69, the screens being supplied from the potential divider R4, R5. The anodes of V1 and V2 are coupled by C17, R62, C18, R63 to the grids of the push-pull 1st audio amplifier valve V3, a double triode (CV.455). This is cathode biased by R9. The output from the anode loads of this stage R10, R11 is coupled directly to the cathodes, through C3 and C4, of the double diode rectifier V4 (CV.140) which acts as the control source of the V.O.G.A.D.

The Gain Adjusting Circuit (V.O.G.A.D.)

Valves V4a and V4b act as a normal push-pull rectifier coupled by C3 and C4, the load being R1 and R2 in the first stage. A delay bias from R16, R24, RV1 supplied from the +300 volt line at PL3 pin 12 is applied to the cathodes and thus when an audio level greater than this delay is applied, the negative potential from the anodes is applied to the junction of R1, R2.

The V.O.G.A.D. action on the gain of stage V1, V2 is due to two related circuits. The above rectified negative potential is applied to the grids via R1, R2. At the same time a current will flow from earth through the selenium rectifiers (Unistors) W1 and W2, depending on this potential. Depending on the magnitude of this current, W1 and W2 in series will act as a decreasing load resistor across the secondary of T1 and will act as a means of reducing the audio signal on the grids. The potential developed across R3 will also increase the negative grid bias. These two effects act to provide a relatively constant audio level on the cathodes of V4.

This controlled signal may be attenuated in six steps by the balanced network formed by R12 and one of the four resistors R80, R70, R71, R72, R73, and R13 also one of R81, R74, R75, R76, R77. These resistors are selected by switch S1 mounted on the chassis top.

The selected audio level is coupled by C5 and C6 to a push-pull series limiter used to provide "speech clipping". This in effect "squares off" the tops of the modulation to enable a higher average level of modulation to be achieved with the resulting improved intelligibility under weak signal conditions, particularly in the presence of noise.

The limiter comprises the selenium rectifiers (Unistors) W3, W4, and W5, W6, together with resistors R17, R19, R21 and R18, R20, R22 respectively. The Unistors are biased positively through junction of R19, R20 from the potential divider RV1 off the +300 volt supply. Consider one half of the limiter only: assume that the bias from RV1 is E volts and that W3 and W4 act as "perfect" diodes and that R19 has a value of R ohms. R17 is R/2 ohms and R21 R ohms. Then with current flowing through both W3 and W4, E/4 volts appear across R17 and E/4 across R21. The incoming audio signal is superimposed due to C5 on this value of E/4.

When the positive swing takes the potential across R17 above E/2 volts W3 ceases to conduct leaving a potential of E/2 across R21. On the negative swing W3 conducts continuously and the potential appears across R21. If, however, it falls below zero, W4 ceases to conduct and potential across R21 cannot fall below zero. Thus no matter what the input to the limiter, the potential across R21 is limited to E/2 on positive swings and zero on the negative.

RV1 is used to adjust this value of E/2 to correspond to approximately 100% modulation. S1 then allows, by control of the input, a choice of amount of clipping:- 3, 8, 11, 14, 16 or 19 db nominally.

The clipped audio signal is then directly coupled to the push-pull second amplifier V5, V6 (2 x CV.136), the screen supply is from the +300V line through R25. A low pass filter X1 is placed between the clipper circuit and the grids of V5, V6 to limit the "sideband splash".

Across the anodes is connected a phase correction network R26, R28, C9, R27, R29, C10 which partly compensates for distortion that occurs in the output transformer T3.

The anodes of V5, V6 are resistance-capacity coupled by C7, R31 and C8, R32 to the grids of the push-pull cathode follower driver stage V7 (CV.491), the anodes of which are supplied through R30.

The cathode load of this stage is an iron-cored choke (the primary of T2), and the potential across this is applied to the grids of the final modulator stage.

A secondary winding on T2 supplies sidetone to PL3/10. The final modulator stage uses 4 tetrode valves (CV.428) is parallel push-pull working in Class AB. The bias is obtained partly by cathode resistor R39, decoupled by C11 but mainly by the + 28 volts at SK/3 via PL3/8 or 9 and relay contacts 4B, 2B, 1B, 3A.

When the +28 volt bias is removed, R40 acts as an extra cathode bias resistor which biases the stage to cut off. This occurs as described below. The anodes of V9, V10, and V11, V12 are joined to the primary of the output transformer T3, the anode supply being obtained at the centre tap from the 600 volt supply. This transformer is not part of the Audio Amplifier chassis 28-LRU.362C but is mounted at the rear of this on the main unit. C19 across R40 limits the transient appearing on the output valves when 4B opens.

The secondary windings of T3 are used as follows:-

Winding 5-6 is the main secondary supplying the 600 volt modulated supply to the Transmitter Unit P.A. valve anodes via PL2.

Winding 7-8 provides the 300 volt modulated supply to the P.A. valve screen grids via SK1/22.

All valves on this Unit are in series/parallel on the 19V stabilized supply at PL3/4.

The Tone Oscillator

This uses a double triode V8 (CV.455). V8A is a type of phase shift oscillator at 1000 c/s approximately. It is a cathode follower with a twin Tee network C12, R59, C14 and R55, C13, R58. This network has a gain of slightly greater than unity, and as the cathode follower to which it is connected has a corresponding gain of slightly less than unity, oscillation can take place.

The cathode load is relatively high (RV2) and allows a proportion of the output to be directly coupled to V8B, a conventional phase splitting stage to give a symmetrical output across its anode and cathode.

This output is taken through C15, R64 and C16, R65 to the grids of the second audio amplifier stage V6, V5. This coupling is of a relatively high impedance to avoid any effect on the operation of the clipping circuit.

RV2 acts as a M.C.W. level control of modulation.

4.3.3 R/T, M.C.W. C.W. operation

C.W. SK2/13 is earthed operating RL4/2. The 300 volt H.T. from PL3/11 (the keyed supply from SK1/17) is connected to the anodes of V8 the tone oscillator which therefore operates.

Contact 4A also removes the H.T. from V1, V2, V3 thus disabling the speech input stages. 4B closes connecting the cathodes of the modulator valves through PL3/8, 1B to 3A which however, remains open.

These valves then remain "cut off" by R40. On "mark" the tone signal from V8 is passed normally from V5, V6 to V7 where the sidetone is derived from T2 via PL3/10, 2A to the Telephone + at SK5/1. The operation of 2B has no effect.

4.3.4 M.C.W.

Socket SK2/13 and SK2/4 are now earthed, operating RL4/2 and RL3/2, 3A now closes connecting the Modulator cathodes to + 28 volts at SK2/3 and allowing this stage to operate. Sidetone is derived as in C.W. case, but 2B is inoperative being short circuited by 4B, i.e. the modulator stage is not keyed on M.C.W.

Thus M.C.W. is provided as 100% modulation with no "clipping". Sidetone again is provided and it is similarly derived as in the R/T case.

4.3.5 R/T

Socket SK2/4 only is earthed, i.e. RL3/2 only is operated. 4A now disconnects the tone oscillator and allows V1, V2, V3 to operate. 4B having released, the cathodes of the modulator stage are now connected through PL3/9, 2B, 1B, and 3A to the + 28 volt supply when the Press-to-Talk Switch (Key) is closed and thus the keying relay 2b is closed. Speech modulation is then possible, sidetone being taken from T2 as before.

When the P.T.T. switch is released 2B opens when R40 "cuts off" the modulator valves as an economy measure. This also occurs when the Tune relay RL1/2 is operated under TUNE conditions.

4.3.6 Relay and Control Circuits

These are in general covered in Section 3.0 of this Chapter where the various simplified schematics are discussed.

4.3.7 Power Supply Circuits

The power supply to the whole of the Transmitter Units (but not to the drive generation stages in the Receiver/Drive Unit) enter on PL1. + 28V on PL1/13-20, + 19V regulated on PL1/11-12, and the common earth (negative) on PL1/1-10. When the equipment is on STD/BY RL6/1 is operated, 6A connecting the + 28V supply to the control circuits and in particular to RL7/1. 7A then closes and connects the +19V supply to the control circuits and to all valve heaters of the equipment.

Fuse F1 protects the + 28V control circuits.
Fuse F2 protects the + 19V control circuits.
Fuse F5 protects all the 19V circuits.

These three fuses are mounted on the front panel of the Unit.

In the H.T. ON (Send) condition RL9/2 and RL8/1 operate, 8A makes and connects the + 28V supply to the motor side of the H.T. generator MG1 through the low resistances R44, R45. When the machine speed rises and back E.M.F. builds up to approximately 20-24 volts RL10/1 operates, 9A being made, 10A then short circuits the above starting resistances. Contact 9B breaks connection between pins 3 and 4 on SK3 and is used to break the circuit of any other equipment as required.

Immediately RL8/1 is opened, 9A breaks, causing R44 and R45 to be brought back into start circuit ready for any immediate re-start.

The negative side of the motor winding is earthed, the two stage filter L6, C25, L7, C26 mounted in a screened box is the "noise" suppressor on the positive side.

The + 300V output from the machine is taken through "noise" filters L5, C28, L4, C27, and then through a one stage filter of L8, and C22, C23 which acts as a ripple filter.

The + 600V output from the machine is taken through noise filters L3, C30, L2, C29, to the secondary winding of T3, C24 giving some ripple suppression.

F3 and F4 protect the H.T. circuits and the "noise" filters. They are mounted inside the equipment to avoid bringing dangerous voltages to the front panel.

R43 in the + 300V connection the screen winding of T3 is brought into circuit when set is in the "SAFE" condition by breaking of 11A-B and thus limits the screen potential of the P.A. stage.

5.0 DESCRIPTION OF AERIAL COUPLING CIRCUITS

5.1 Aerial Coupling Unit 24-LRU.52C (for sixed wire aerial)

See Figs. 5, 9 and Plate 7.

5.1.1 Mechanical Layout

The complete unit consists of a rectangular aluminium alloy angle framework mounted on a shallow chassis base. The front panel 8" x 8" carrying the necessary manual controls is attached to the forward end, and a panel mounting cable connector at the back. A removable dust cover encloses the whole unit and is fixed by a quick release fastener at the rear. The Unit is $12\frac{1}{2}$" deep.

On the left and right-hand sides of the rear of the base chassis are mounted the variable inductance coils at the input and output of the Unit. These coils are connected through "anti-inertia" couplings to the front panel controls and to the driving motors. Above these coils on the centre line, are mounted the fixed condenser and the associated switch.

The space between the coils is occupied by the relays of the bridge circuits operating the motors.

A sub-panel 327-LRU.19A on which the front panel is mounted, bears the three balancing potentiometers of the remote control circuits with the gearing between these and their respective manual control knobs and motors. The latter are mounted at the bottom of the unit below the gearing and are jointly disengaged from the gear trains when the "AUTO-MAN" switch is on "MAN" position. The motors are held in cylindrical housings and can be removed by withdrawal from the underside.

The front panel has the following controls, all for use on manual operation:-

Three tuning knobs and the associated dials.
Two switches - AUTO-MAN and OPERATE-TUNE.

A Test Key.
A Meter giving indication of aerial excitation.
Two variable resistances for adjustment of aerial excitation monitor.

At the rear of the unit a sub-panel carries the vacuum relay used as the "send-receiver" aerial changeover, a relay earthing the receiver line on "send", and an aerial excitation monitor circuit.

The rear panel has the following connectors mounted thereon:-

PL1 -	Coaxial plug	-	Transmitter R.F. input
PL2 -	28-way plug	-	Control circuits
PL3 -	High voltage plug	-	to Aerial
PL4 -	Coaxial plug	-	to Receiver
SK1 -	4-way socket	-	to control and external relay

The underside of the base chassis displays the control relay connections and mounts the associated components.

5.1.2 Electrical Description

R.F. Circuit

The unit employs a pi-network to match the 70 ohm output from the transmitter to the coupled impedance presented by a wire aerial. L1 is the input shunt element, one of condensers C1 to C6 the series element, and L2 the output shunt element. The transmitter output is connected to PL1 and the aerial to PL3.

The mode of operation of the Aerial relay is governed by connections on Tag Strip T.S.A. at left-hand rear of Unit.

For "Low Z c/o" of aerial from send to receive, TSA.2 is linked to TSA.3 and TSA.4 to TSA.5, RL1/1 and RL2/2 are then connected between the +28 volt supply to the unit and earth when either the transmitter is switched to "Standby" or the receiver is ON and in "tuned" aerial position. 1A then connects the aerial at PL.3 to the Transmitter output (as to the Low Z c/o) relay in the Drive Unit via the coupling circuit. 2A earths PL4. When all the equipment is in OFF condition, 1A connects the aerial to PL4, and since this is not being used for Low Z c/o, it is earthed by its socket on the back plate.

For "High Z c/o", TSA.2 is linked to TSA.1 and TSA.5 to TSA.6 and RL1/1, RL2/2 are operated by the Key circuit.

In the "space" condition relay 1A connects the receiver via PL4 to the aerial at PL3, on "mark" relay RL1/1 makes and connects the output of the pi-network at L2 to aerial at PL3. At the same time RL2/2 makes and receiver lead is earthed by 2A.

S3B selects one of the six condensers C1-C6 as required. L1 and L2 are variable over their whole range.

Monitoring of Aerial Excitation

A toroidal coil wound on an iron dust core and mounted in a screen acts as an aerial current transformer T1, the aerial lead being a "single turn" primary. The secondary output shunted by R1 is rectified by germanium rectifier W2 and the current in the load consisting of R3, RV1 in series with the meter M1, is measured.

A capacitance potential divider formed by the insulated coil screen and C7 connects a fraction of the aerial potential to a second germanium rectifier W1, the rectified current then being measured again by M1 in series with R2 and RV2. The meter M1 will read as an indication of aerial current plus aerial potential. Thus on a low impedance aerial the meter will give an indication mainly of aerial current, while on a high impedance aerial an indication mainly of aerial voltage is obtained. This ensures that a good indication of aerial excitation is given no matter what the aerial impedance.

RV1 and RV2 allow the circuit to be adjusted for a particular aerial. Generally these will be set so that the meter scale represents amps and kilovolts. The indication is either given on pin 26 on PL2 to avoid interference with the indication due to any earth currents due to the control circuits flowing in a common earth line.

Control Circuits

The three motors MG1, MG2 and MG3 are remotely tuned by the settings of the associated potential dividers in the Control and Drive Unit (see 3.1 of this chapter). The relay circuits of these motors are as described in section 1.2 of this chapter. The + 19 volt supply for

the motor relays is obtained from PL2/1. Motor MG2 operates 3 ganged switches S3A, S3B and S3C. S3B selects the series condenser, S3A indicates to the Control and Drive Unit which condenser is selected by earthing one of the six signal wires of pins 20-25 on PL2, and S3C renders test key K1A inoperative except when the contact of S3B is on a condenser position. This avoids S3B making or breaking r.f. potentials.

Switch S1A-D has two positions. In the "AUTO" position the Unit is remotely controlled. S1A connects the output of the aerial monitor circuit to remote meters via pin 6 on PL2, S1B connects the + 19 volt supply to the remote control bridge circuits of this unit, S1C opens the "Manual" line. S1D breaks the "safe" line earth in case S2A is left on "TUNE". In the "MANUAL" positions the functions of the switch are reversed, S1A now connecting meter M1 to aerial monitoring circuit to assist in manual tuning.

Switch S2A-B has two positions. In the "Operate" condition the key line of pin 11 on PL2 is removed from test key K1A by S2A while S2B removes the earth from the safe line to allow the transmitter to operate at full output.

In the "TUNE" position which is only used when tuning this unit manually, S2B brings K1A into circuit to allow the transmitter to be put to "mark" for tuning, and S2A earths the "safe" line bringing into circuit the extra screen grid resistor in the transmitter P.A. stage as a precaution while manually tuning.

Socket SK1 has the transmitter + 28V supply on pin 1, pin 3 is earthed by the X-Y switch on the Control and Drive Unit. This is intended to be used for instance, should an external relay be required near the aerial on some installations.

5.2 Aerial Coupling Unit 24-LRU.58 (for suppressed aerial operation)

(See Fig. 10)

5.2.1 General

The purpose of this unit is to provide a method of coupling between the 70 ohm output impedance of the Transmitter Unit and the metal surfaces of an aircraft, the latter being thus excited as a "drag free" antenna.

For this purpose a coupling loop is placed at a point of relatively large curvature of the aircraft external covering. For aircraft of 90 - 130 ft. wing span this is normally the leading edge of the main plane adjacent to the fuselage. For aircraft of the 220 ft. wing span class the leading or trailing edges of the tailplanes are normally used.

The coupling unit is a simple tuned circuit and is constructed in two sections, a condenser unit and a loop unit. These may be arranged in two ways forming two slightly different groups of the Coupling Unit.

5.2.2 Mechanical

The Loop Unit (Coil Tuning 20-LRU.241) consists of a large air spaced coil mounted forward of a metal frame on polythene supports. The coil is of 3 turns, 1" apart made of $\frac{1}{2}$" copper tubing. Each loop is 15" x $4\frac{1}{2}$". The bottom turn is variable, being formed by a bridge piece between two parallel bars. The movement of this bridge, by means of the motor drive lead screw through its centre, provides the variation of inductance necessary for tuning the unit to a specific frequency. The mounting frame of the loop carries the driving motor and the gearing to its associated setting potentiometer.

The Condenser Unit (276-LRU.36A) consists of a bank of condensers and a selecting switch mounted on a frame 11" - $7\frac{1}{2}$". A removable cover 6" high encloses the unit. The switch is motor driven by the normal bridge circuit and is of suitable construction for operation at high altitudes. A six-way cable joins this unit to the Loop Unit.

The Loop and Condenser Unit mounted separately with heavy flexible connectors between them to carry the r.f. current, forms Coupling Unit 24-LRU.58A or B and it is suitable for tail plane mounting, the coil unit being in the tail plane and the Condenser Unit adjacent in the fuselage. Alternatively the Loop and Condenser Unit can be mounted on a common frame, the Condenser Unit behind the Loop Unit, with some saving in overall dimensions. This mode is suitable for main plane mounting in a diaphragm forward of the main spar. This version is coded 28-LRU.58C.

5.2.3 Electrical Description

Referring to Fig. 10, the schematic of the two Units, and to position of S2 shown. L1 is taken to earth via L12, L11 and the wiping arm of S2. Across L1 is C11 and C12 forming a parallel tuned circuit. This circuit is excited, by a low impedance tap on the inductance element, from the 70 ohm cable from the transmitter entering at P1. L12 and L11 forming the coupling inductance.

The loop is tuned to resonance by the mechanical variation of L1 by motor MG1.

As frequency decreases, condenser switch S2 is moved to the left adding further condensers C10 to C1 as required, and at the same time increasing the coupling inductance by addition of L9 to L1 successively. S2 is rotated by gearing from MG2 and is set to position by means of the balancing potentiometer RV4.

The relatively small variation of L1 possible, requires that the range 2.8 to 18.1 Mc/s be covered in 12 bands. These are shown in Chapter V (3) Table III, and require 12 values of condenser needing twelve positions of S2. The position of S2 is recorded by the contact of lamp signal switch S1 which is ganged mechanically to it. The angle of make of a contact on S1 being smaller than the corresponding angle required by S2, and thus the signal lamp on the Drive Unit lit by the earth on S1 indicates the setting position for an appropriate value of capacity.

The excitation of the loop is metered by means of a small pick-up coil and rectifier W1, the output being taken to the meter on the Drive Unit via P2/F. P2/L is a separate earth for this circuit.

The control connections between the Condenser Unit and Loop Unit are made by plug and socket P1/SK1.

RV3, RV4, RV5, and RV6 provide "electrical stops" in the bridge circuits and can compensate for different lengths of control wiring.

5.3 Aerial Coupling Unit 24 LRU 52E (for fixed wire aerial)

See Schematic Sht. 7.5, (Fig. 9A), S.R.I.S. 18 Sht. 4.27 (Fig. 9B)

5.3.1 General. This Coupling Unit is an alternative version of the basically similar units 24 LRU 52 Groups A, B, BC, C, D and F used on the STR 18 Equipments. It is mechanically modified to allow fitting in an aircraft close to the skin and in particular between the skin and the trim line on the centre line of the aircraft. This imposes a height limitation on the unit which necessitates the mechanical re-design. Special mountings obviate the normal aircraft racking, thus there is no backplate required.

5.3.2 Mechanical Layout. The complete Unit consists of a rectangular, 17" long aluminium alloy angle framework mounted between two endplates 7.5" wide 6.5" high. These end plates each carry special hooked brackets with captive screw fasteners which are used to secure the unit rigidly to the shockmounted adaptor plates fixed to the aircraft. The unit is enclosed by a two part dust cover. The arrangement is shown in Fig. 9B).

The adaptor plates L/122091 are normally supplied with 6 lb (Medium) shock mounts, and are attached to the airframe. The unit is then placed in position as follows:- The hooked brackets at one end of the Coupling Unit are placed over the stirrups of one mount, the other (free) end of the Unit is then raised until the hooked brackets at that end are also engaged with the stirrups of the remaining mount. The unit is safely supported during this stage, but is only loosely restrained. The four captive screws on the Unit are then screwed into the mounts, making these and the Unit one rigid assembly. The cables are then attached at one end.

So mounted, the underside of the Unit can be as close as 7.25" from the aircraft skin.

The mechanical sub-division of the Unit is as follows:-

5.3.2 Mechanical Layout (Cont'd)

At the end remote from the incoming cable connections, (back) the lower half of the Unit contains the Mechanical Drive Unit (327 LRU 19E). This comprises the motors, balancing potentiometers and gearing associated with the variable inductances L1 and L2. Above this assembly is plugged the Relay Unit (82 LRU 116E) carrying all the relays associated with the motor circuits.

Forward of these units, parallel to the centre line, are the two inductances L1 and L2 coupled by bevel gears to the Drive Unit mentioned above. Above these are the high voltage aerial relay (RL1) and the aerial earthing contactor (RL2). At the front of the unit is the second Mechanical Drive Unit (327 LRU 17F). This is a horizontal motor driven switch, on and above which, are the 6 condensers C1 to C6 used as the series element of the matching circuit.

The rear of the unit carries 4 plugs and sockets for external connections. The high voltage terminal on the side is normally provided with a snatch-off connector. As there can be no normal access to this unit, there are no manual controls, but 3 dials showing the position of each of the tuning elements are visible from the underside. This is an aid to servicing and for use in workshops when pre-setting the band control potentiometer in an associated Drive Unit.

The external connectors are:-

PL1 - Coaxial Plug - Transmitter R.F. Input.
PL2 - 28 way Plug - Remote Control Circuits.
PL3 - High Voltage Plug - To Aerial.
PL4 - Coaxial Plug - To high impedance receiver.
SK1 - 6 way Socket - To aerial switching circuits.

5.3.3 Electrical Description
R.F. Circuit

The matching circuit is a pi-network coupling the 70 ohm input from the transmitter to the coupled impedance of the aerial.

L1 is the input shunt element, one of condensers C1 to C6 is the series element, and L2 the output shunt element. Both L1 and L2 provide D.C. paths to earth thus providing protection. The input is connected at PL1 and the output taken from PL3.

5.3.3 Electrical Description (Cont'd)

L1 and L2 are continuously variable, while the series element is selected by means of S3B. Depending on installation requirements, RL1/2 and RL2/1 may or may not be present. This description will assume both are present.

RL1/2 is a vacuum relay which plugs in position. When inoperative, the aerial at PL3 is connected via 1A to the high impedance receiver plug PL4. When operated, the aerial is connected to L2 by 1A and at the same time any receiver at PL4 is grounded by 1B. This relay can work at 20 bauds, and thus permits break-in working if a seperate receiver is in use.

RL2/1 is a high voltage contactor. When operated it disconnects the aerial from the r.f. network and grounds it. It is used in dual installations to obviate the pick-up from another adjacent aerial. RL1/2 and RL2/1 if present, can be selected and controlled in several ways allowing a very flexible range of installations. Switch S1 provides this, giving the following basic selections:-

Position 1. Single Installation - Low Impedance Send/Receive Switching.

RL1/2 is operated as soon as the equipment is switched on, earth being supplied by S1B, S1C and 28 volts by S1A. RL2/1 can be operated if + 28 volts is applied to SK1/A. Send/Receive switching at 70 ohms in Receiver Drive Unit.

Position 2. Single Installation - High Impedance Send/Receive Switching.

RL1/2 is now operated from the key line at PL2/11 via S1B. This only occurs when main Equipment is in Transmit condition when +28 volts is available from PL2/27 via S1A. RL2/1 is available as in Position I.

Position 3. Dual Installation - Low Impedance Send/Receive Switching.

RL1/2 is operated from 28 volt line when an earth is applied to SK1/C either from an external source or by a link on a plug joining PL2/C to PL2/F. RL/2 may be operated by application of + 28 volts at SK1/A.

Position 4. Dual Installation - High Impedance Send/Receive Switching.

RL1/2 is now operated by the key line, allowing break in working on a receiver at PL4. RL2/1 is operated by +28 volt applied at SK1/A normally obtained as soon as the second equipment is placed in the transmit condition. The aerial of this unit is then disconnected and earthed.

Monitoring of Aerial Excitation.

The connection from these relays to the aerial terminal PL3 passes through the Aerial Monitor Circuit which using the toroidal transformer T1 allows an indication substantially the sum of the voltage and current at this point. This is described in 5.1.2 of this chapter.

Control Circuits.

These are identical in operation to those of other groups of 24 LRU 52.

The three motors MG1, MG2 and MG3 are remotely controlled by the setting of the associated potential dividers in the Receiver/Drive Unit. (See 3.1 of this chapter). The relay circuits of these motors are as described is section 1.2 of this chapter. The supply at 19V to the potentiometer circuits in the Drive Unit is passed directly from PL2/1 to PL2/7.

MG2 operates 2 ganged switches S3A and S3B, S3B selects the series condenser (one of C1 to C6) while S3A indicates which condenser is selected by earthing one of the indicator wires at PL2/20-25.

The Tune line is earthed when any of the motors are operating and is connected to the rest of the equipment at PL2/19. MG1 controls coil L1, and MG3 coil L2.

It should be noted that no local manual operation of these circuits is possible on these units. However, a small unit (101 LRU 172A) connected in series with the 28 way cable entering at PL2, allows a local control of all the circuits, if needed for servicing or for initial tuning experiments when the unit is used for the first time on a particular aerial installation.

CHAPTER 4

INSTALLATION DETAILS

1.0 EQUIPMENT SCHEDULE

The following is a complete schedule of equipment necessary for forms of installation of STR.18-C equipment. This is covered generally in Chapter I, Sections 1 and 2.

Items 1 to 11 and 19 list under the two headings, those supplied as a Standard Equipment. Items 30-34 cover valves and crystals for these headings and items 12-28, 35-41 should be ordered to suit particular requirements. Items 6 and 19 are required only if Remote Control is used.

Column I covers Installation 30-LRE.50A (See Chapter I)
Column II covers Installation 30-LRE.50B

These are for typical installations, some changes in the schedule are necessary if variations are made.

The cables are designated for example A/18/5, meaning Cable A for STR.18 Equipment, the final figure 5 being used for a particular aircraft installation and defining the length of the cable and the orientation of its terminations.

All references to item numbers in this chapter refer to the Schedule that follows below:-

Item	Description		Quantity I	Quantity II
1	Transmitter Unit	4-LRU.50D	1	1
2	Modulator and Power Unit	404-LRU.4B	1	1
3	Receiver/Drive Unit	3-LRU.111A	1	1
4	Aerial Coupling Unit (Wire)	24-LRU.52C or E	1	
5	Aerial Coupling Unit (S)	24-LRU.58A, B or C		1
6	Remote Control Unit	402-LU.11A	1	1
7	Back Plates for Item 4 (C)	L.100946/22		1
8	Back Plates for Item 3	L.114650/1	1	1

Item	Description	Code	Quantity I	Quantity II
9	Back Plates for Item 4 (C)	L. 100946/20	1	1
10	Back Plates for Item 2	L. 100946/21	1	1
11	Back Plates for Item 6	L. 101059/2		1
	Cables (see Chapt. 3 Sect. 3.1)			
12	Cable from items 2 to 3	A/18/-	1	1
13	Cable from items 1 to 3	B/18/-	1	1
14	Cable from items 1 to 3	C/18/-	1	1
15	Cable from items 1 to 2	D/18/-	1	1
16	Cable from items 1 to 2	E/18/-	1	1
17	Cable from items 2 to Intercom.	F/18/-	1	1
18	Cable from items 3 to 5	G/18/-	1	
19	Cable from items 6 to 3	H/18/-	1	1
20	Cable from items 5 to 3	K/18/-	1	
21	Cable from items 3 to Battery	M/18/-	1	1
22	Cable from items 3 to 2	N/18-	1	1
23	Cable from items 2 to Battery	P/18/-	1	1
24	Cable from items 3 to 4	R/18/-		1
25	Cable from items 3 to 4	S/18/-		1
26	Cable from items 4 to Aerial	W/18/-		1
27	Cable from item 2 to second Transmitter (Interlock)	J/18/-	1	1
28	Cable (plug) on item 2 if 27 is not used	J/18P	1	1
29	Handbook	HB. 1070-C1	1	1
30	Valves			

Commercial "Trustworthy"						
CV Code	Code	Type	CV			
CV. 136	6AM5	6516		These valves	3	3
CV. 138	6AM6	6064	4014	are supplied	7	7
CV. 140	6AL5	6058		with the	1	1
CV. 428	5B/251M			equipment	5	5
CV. 454	6BA6	5749	4009		5	5
CV. 455	12AT7	6060	4024		4	4
CV. 491	12AU7	6067	4003		1	1
CV. 2127	6CH6	6132			2	2
CV. 2135	6BR7	6059	4006		2	2
CV. 2208	G50/1G				3	3
CV. 2519	4H/135M				2	2

Item	Description	Code	Quantity I	Quantity II
31	Time Delay Relay	LS. 730	1	1
32	Time Delay Relay	S103/1K	1	1
33	Crystals Type 4046	ZDH	1-100	1-100
34	Crystal Type 4019 Gp.7 465 kc/s	ZCA. 465	1	1
35	Voltage Regulator	A. 1202	1	1
36	S. B. A. C. Standard Packing	To customers requirements	1	1
37	Mic. /Tel. Headset with leads and plug	ES. 7728 Sht. 1	1	1
38	Mic. /Tel. Socket with leads	Type 359 Ref. 10H/2206	1	1
39	Terminal Block 2-way No. 1	Type B ref. 5C/430	3	3
40	Press-to-Talk Switch	Ref. 5D/534	1	1
41	Telegraph Key	Type 5KK Mk.IV	1	1
42	Junction Box for Item 35	154-LU. 66A	1	1

2. 0 CONSTRUCTION OF THE RACKING SYSTEM

This will normally be carried out by the aircraft constructor. The racking used is that covered by the British Standards Institution publication "Sizes and Forms of Civil Aircraft Radio Equipment" BS. R1 . This in general follows the practice of the S. B. A. C. /R. C. E. E. A. earlier racking system.

The layout of the rack will of course also depend on other equipment that may be required to be installed in the same racking as this equipment.

Standard Radio Installation Schedule S. R. I. S. 18C gives full installation information and includes the sizes of the STR. 18-C equipment, and shows the position of the Unit Locking Devices required on the rack for each unit. It also shows the clearance required behind the back plates to accommodate the plugs or cable ends and any cable radii. The approximate position of the centre of gravity of each unit is also shown to enable the rack weight distribution to be estimated. The dimensions of the Remote Control Unit and its back plate are also mentioned.

Each rack requires to be mounted on anti-vibration mountings (A.V.M.). These should cover, if possible, the full vibration range expected, but a compromise must normally be made. A mean deflection per A.V.M. of 0.062 - 0.093" under static load as a general figure.

The figure of rack loading of 2.5 lbs/inch run can be taken as satisfactory. It may be necessary to place additional A.V.M. other than at the ends of the rack when several heavy units are mounted on the same rack.

3.0 INSTALLATION

3.1 General

The STR.18-C can be arranged in almost any manner, there being no requirement as to length of leads between units.

In general the Receiver/Drive Unit should be accessible but the remaining units can be stowed in a closed crate or in racking beneath flooring if required.

If the emergency and manual control facilities are required the Fixed Aerial Coupling Unit and the Transmitter Unit should be readily accessible to an Operator.

The Modulator and the Receiver/Drive Unit being the heaviest units can with advantage be mounted at the end of a rack to be closest to the A.V.M.

The A.V.M. on the rack should all be deflected the same amount when the rack is full and should not "bottom" under normal vibration conditions.

The cable run P/18 to the Modulator from the Battery isolators on the aircraft wiring should be kept shorter than 12 feet approximately to avoid excessive volt drop. The corresponding distance for the Receiver cable M/18 is 18 feet. The racking should be adequately earthed both to D.C. and to radio frequency.

3.2 The Remote Control Unit (Item 6)

The back plate for this (item 11) should be mounted either on a standard console or on a suitable copy of this in a position to give the remote operator (Pilot) clear access to the R.C.U. in flight without excessive movement. The Remote Control Unit may then be plugged into the cable end, and fixed by the four red painted screws at the corners.

The cable (H/18) between the back plates and the main units should be kept under 50 feet if possible.

3.3 Aerial Coupling Unit Fixed (Wire) (Item 4) See also 3.9.

This should be mounted as close as possible to the base of the aerial lead-through insulator to obviate long internal leads at the high r.f. potential of the aerial.

Cables to this unit R/18 and S/18 can be up to 120 feet in length without any serious loss of r.f. output.

3.4 Wire Aerial

This will depend on size and type of aircraft. A 50 - 65' wire from just aft of the pilot's position to a point about 10-15 feet up on the fin is given as a typically suitable aerial.

3.5 Suppressed Aerial Coupling Unit (Item 5)

Each case of installation of this unit must be considered on its merits. The general remarks of Chapter 3, Section 5.2.1 apply and it is essential that for a new design of aircraft, consultation with S.T.C. should take place as early as possible as the fitting on this unit may require special fixing arrangements that affect the aircraft structural detail.

The cabling to this unit G/18, K/18 should be less than 120 feet.

3.6 Altitude limitation

In the case of aircraft normally operating above 20,000 feet all units except item 5 should be installed in the pressurized portion of the

aircraft. In cases where this is not possible S. T. C. should be consulted, as higher altitude operation is possible with certain limitations.

3.7 Stabilized D.C. Supply 19 ± 1V

The equipment requires this supply in addition to the unregulated 28V D. C. supply for the H. T. machines. This may be supplied from a general regulated supply used for several different types of equipment if available or from a separate Voltage Regulator A. 1202 (Item 42) which is suitable for rack mounting.

3.8 Cabling

When the location of each unit of the STR. 18-C equipment has been fixed, the cable lengths required should be measured less terminal plugs and sockets.

A suffix to the cable codes will then be allocated by S. T. C. which will define this information for future ordering.

Cables should be cleated at intervals to avoid relative movement, sharp bends should be avoided and sufficient slack left at the ends to enable cables to be released from the Back Plates or units.

Where cables may chafe on the aircraft structure they should be bound with a suitable protecting tape.

Cable bends should not be of smaller radius than 4 inches except for those covered below:-

B/18, L/18, Q/18	- 2.5 inches minimum
C/18, E/18, K/18, R/18	- 5 inches minimum

Finally, all cable ends should be secured to the units and back plates in the marked positions.

Racking Check

If possible check the positioning of the back plates in the racking by using a jig for each unit to ensure that the cable end terminations are correctly mounted to engage the units when inserted.

Supply Check

Switch on the aircraft supplies and check that:-

	Back Plate L.114650/1 Socket 7M	Back Plate L.100946/21 Socket 3P
+28V appears on	Pin 4	Pins 13-20
+19V appears on	Pin 3	Pins 11 and 12
Earth appears on	Pins 1 and 2	Pins 1-10
Check continuity between		Pins 1 and 2 on Plug 3J

Note: All plugs and sockets when correctly mounted have pin 1 at the top.

Caution: Do not use a probe greater than 0.04" dia. in the Pye sockets otherwise damage will occur.

NOTE: In cases of Dual Installations an additional series of back plates is available to differentiate between the equipment. A colour band is the only difference. The codes are:-

Red Band (Port)	Green Band (Starboard)
L.100946/20	L.100946/120
L.100946/21	L.100946/121
L.100946/22	L.100946/122
L.101059/2	L.101059/102
L.114650/1	L.114650/101

3.9 Aerial Coupling Unit 24 LRU 52E Fixed (Wire)

This unit is mounted on Adaptor Plates L/122091 as shown in Fig.9B. The aerial terminal PL3 should be as close to the base of the aerial mast as possible, and the connection should be as well spaced from earth as practical. A good earth connection should be taken from the base of the aerial mast to the clamps on L/122091. Preferably this connection should be from the outside of the aircraft skin adjacent to the base of the mast.

Cables to this unit should be arranged so that when the unit is released from the end remote from the cables and swung down, the cables can hinge freely from the nearest point of cleating.

When installed, the unit should be capable of being moved to the full limits of the shock mounts without fouling any adjacent structure.

CHAPTER 5

INITIAL ADJUSTMENTS AND SETTING UP

It is assumed in the following instructions that the equipment has been checked on a bench test, that the cabling has been installed in the manner of Chapter 4 and that the power supplies are connected.

Insert all units except the Receiver/Drive Unit in the racking push well home, and secure.

1.0 ADJUSTMENT OF THE RECEIVER/DRIVE UNIT AND AERIAL COUPLING UNIT FOR FIXED WIRE.

1.1 The Receiver Drive Unit 3-LRU.111A (See Fig. 2)

A simple change enables this unit to be used either with a Wire or Suppressed aerial. Normally the unit will be received from the works adjusted specifically to one of these alternatives. It may happen however that one user organization may be using both types of aerial and in this case the Unit may require change.

Remove the dust cover from the Unit and examine the plug engaged with SK20 at the rear.

This may be labelled "Fixed Wire Aerial", in which case the corresponding plug marked "Suppressed Aerial" will be in the "stowed" position. Place the requisite plug on SK.20.

Check that :-

(a) Suppressed Aerial: That Relay Unit 82-LRU.116C (beneath the R.F. Unit) is present.

(b) Wire Aerial: That 8 12-way potentiometers are present in the Band Selector.

Note: (a) is not required in case of (b). Only 6 potentiometers are needed in case (a).

Replace the dust cover and inset unit in the rack and secure.

The GREEN coloured labels in the centre of the 12-way potentiometer should now be checked. These should read:-

	POT. 3 POT. 4	POT. 5 POT. 6	POT. 7 POT. 8
Suppressed Aerial	LOOP S	CONDENSER S	BLANK
Wire Aerial	INPUT FW	SERIES FW	OUTPUT FW

(The upper bank read A-M, the lower N-Z.)

If these are not correct they may be removed by unscrewing the centre knurled nut, reversing the label and refixing.

1.2 Wire Aerial Coupling Unit 24-LRU.52C (See Fig.5) See also 2.3.

This unit can either be used in (a) the "High Z c/o" condition when the vacuum relay in it is used for send/receive switching to a manually tuned high impedance receiver connected directly to the aerial or (b) the "Low Z c/o" condition where the send/receive relay is at the 70 ohm impedance of the feeder to the Aerial Coupling Unit.

The "Low Z c/o" is always used with the STR.18-C. The unit leaves the Works in that condition. This is signified by the small disc on the front panel which should show Yellow and be marked "Low Z".

Any change (needing a soldering iron) is made as below to the links on TSA inside the unit.

	Low Z c/o	High Z c/o
24-LRU.52A	On TSA link 2 to 3, 5 to 4	On TSA link 2 to 1, 5 to 6
Change Panel Disc to	Yellow	Blue

1.3 Wire Aerial Coupling Unit 24 LRU 52 E

Aerial switching arrangements on this unit are selected by screwdriver alotted switch S1 on the unit. This selection should be made on installation.

Position	1	- "Low Z c/o"	-	Single Installation
"	2	- "High Z c/o"	-	" "
"	3	- "Low Z c/o"	-	Dual "
"	4	- "High Z c/o"	-	" "

Connections to SK1 on the unit will depend on the particular requirements of an installation.

2.0 PREPARATION FOR SETTING UP A FREQUENCY ON THE RECEIVER/DRIVE UNIT 3-LRU.111A

(Refer to Fig. 2 and Plate 1)

2.1 Remove the front covers form the Selector Unit potentiometers and the Crystal Turret. Obtain the necessary crystals type ZDH.

2.2 Arrangement of crystals in Channels and Bands

2.2.1 The following method is suggested, but variations can be made. Using a proforma of the layout of Table I arrange all the desired frequencies in numerical order starting with channel 00 as shown.

It now remains to group these frequencies into bands of ± 1% or less depending on the frequencies to be used, and having decided the bands, to decide which channel in each band will be used to align the transmitter and Aerial Coupling Units.

See over for Table I.

Tune	Band	Send Frequency kc/s	Chan.	Insert Xtal Freq.kc/s
	A	2868	00	
T	A	2875	01	
	A	2889	02	
	B	2910	03	
T	B	2931	04	
	B	2945	05	
	B	2952	06	
	C	2966	07	
T	C	2987	08	
	C	3001	09	
T	D	3105	10	
T	E	3404.5	11	
	E	3411.5	12	
	F	3432.5	13	
T	F	3446.5	14	
	F	3467.5	15	
	F	3481.5	16	
T	G	4575	17	
	H	4654.5	18	
T	H	4689.5	19	
	H	4696.5	20	
	H	4703	21	
	J	5491.5	22	
T	J	5499	23	
	K	5551.5	24	
T	K	5566.5	25	
	K	5581.5	26	
	L	5604	27	
	L	5611.5	28	
	L	5619.5	29	
	L	5626.5	30	
T	L	5641.5	31	
	L	5649	32	
	L	5671.5	33	
	M	6510	34	
	M	6537	35	
T	M	6552	36	
	M	6582	37	
T	M	6597	38	
	N	6612	39	
T	N	6627	40	
	N	6645.5	41	
	N	6651	42	
	P	8820	43	
	P	8837	44	
	P	8845.5	45	
	P	8854	46	
	P	8862.5	47	
	P	8871	48	
	P	8879.5	49	
T	P	8888	50	
	P	8913.5	51	
	P	8930.5	52	
	P	8937	53	
	P	8939.	54	
	P	8947.5	55	
T	Q	10021	56	
T	R	11299.5	57	
	S	13264.5	58	
	S	13274.5	59	
	S	13284.5	60	
	S	13294.5	61	
T	S	13314.5	62	
	S	13324.5	63	
	S	13334.5	64	
	S	13344.5	65	
	S	13354.5	66	
	T	17916.5	67	
	T	17926.5	68	
T	T	17946.5	69	
	T	17966.5	70	
			71	
			72	
			73	
			74	
			75	

These frequencies are now to be allocated bands such that all frequencies in a band do not differ from its "Tuning" frequency by more than 1%.

The Tuning frequency being the channel on which the band is aligned and ideally is at the mid-point of the Band.

Depending on the number of channels to be set up these bands may be made less than the 1% figure, thus allowing less decrease from the nominal power output of the equipment.

In the examples quoted, which are representative of most of the 1954 allocation of H. F. air frequencies, the bands are in general less than $\pm$ 1%.

A typical method of choosing the bands and tuning frequencies is given.

If the frequencies generally fall inside the Atlantic City Air Frequency Allocations then it it can be assumed that the number of single channel bands will not be large (all these frequencies may be covered in 23 $\pm$ 1% bands) and thus it will be safe to make the bands smaller where convenient.

Starting at the lowest frequency 2868 kc/s, 1% of this is 28 kc/s, i.e. 2% is 56 kc/s.

Thus approximately the first band A could cover 2868 to 2868 + 56 = 2924 kc/s.

This would cover the first four frequencies, but there follow several more frequencies 2931, 2945, etc.

See over for Table II.

TABLE II

Tune	Band	Send Frequency kc/s	Chan.	Insert Xtal Freq.kc/s	Tune	Band	Send Frequency kc/s	Chan.	Insert Xtal Freq.kc/s
	A	2868	00	3333	T	N	6627	50	7092
T	A	2875	01	3340		N	6645.5	51	7110.5
	A	2889	02	3354		N	6651	52	7116
			03					53	
	B	2910	04	3375		P	8820	54	9285
T	B	2931	05	3396		P	8837	55	9302
	B	2945	06	3410		P	8845.5	56	9310.5
	B	2952	07	3417		P	8854	57	9319
			08			P	8862.5	58	9327.5
			09			P	8871	59	9336
	C	2966	10	3431		P	8879.5	60	9344.5
T	C	2987	11	3452	T	P	8888	61	9353
	C	3001	12	3466		P	8913.5	62	9378.5
T	D	3105	13	3570		P	8930.5	63	9395.5
T	E	3404.5	14	3869.5		P	8937	64	9402
	E	3411.5	15	3876.5		P	8939	65	9404
	F	3432.5	16	3897.5		P	8947	66	9412
T	F	3446.5	17	3911.5				67	
	F	3467.5	18	3932.5				68	
	F	3481.5	19	3946.5	T	Q	10021	69	10486
			20		T	R	11299.5	70	11764.5
T	G	4575	21	5040				71	
	H	4654.5	22	5119.5				72	
T	H	4689.5	23	5154.5		S	13264.5	73	13729.5
	H	4696.5	24	5161.5		S	13274.5	74	13739.5
	H	4703	25	5168		S	13284.5	75	13749.5
			26			S	13294.5	76	13759.5
	J	5491.5	27	5956.5	T	S	13314.5	77	13779.5
T	J	5499.5	28	5964.5		S	13324.5	78	13789.5
			29			S	13334.5	79	13799.5
	K	5551.5	30	6015.5		S	13344.5	80	13809.5
T	K	5566.5	31	6031.5		S	13354.5	81	13819.5
	K	5581.5	32	6046.5				82	
			33					83	
	L	5604	34	6069				84	
	L	5611.5	35	6076.5				85	
	L	5619.5	36	6084.5		T	17916.5	86	18381.5
	L	5626.5	37	6091.5		T	17926.5	87	18391.5
T	L	5641.5	38	6106.5	T	T	17946.5	88	18411.5
	L	5649	39	6114		T	17966.5	89	18431.5
	L	5671	40	6136				90	
			41					91	
			42					92	
	M	6510	43	6975				93	
	M	6537	44	7002				94	
T	M	6552	45	7017				95	
	M	6582	46	7047				96	
	M	6597	47	7062				97	
			48					98	
	N	6612	49	7077				99	

Inspection shows these could easily be covered in 3 bands. Therefore 2868, 2875, 2889 are allocated the first band, say A. 2875 is chosen as the Tuning frequency and is marked by T as shown.

This method is carried on throughout the list, each group of frequencies being marked with Band letters as shown.

When choosing the T channel, the nearest channel to the mid-band is chosen, but preference can well be given, where two such frequencies are available, to A3 frequencies as A1 frequencies can better withstand power reduction. Although this process seems a little complicated, a little practice enables a quick allocation to be made. Some channels, e.g. 4575 are so removed from adjacent channels that a band has to be allocated to it alone, on examining the completed list it is seen that 70 channels are covered in 18 bands.

A revised allocation could then be made using all 24 bands, or the remaining bands left "spare" for future frequency changes.

In this example, typical bandwidths as a percentage about the T channel are:-

3 channels A = +0.5	-0.25%	4 channels N = +0.36	-0.23
2 channels E = +0.2	-0%	13 channels P = +0.67	-0.77
4 channels H = +0.3	-0.7%	9 channels S = +0.3	-0.38
7 channels L = +0.53	-0.65%	4 channels T = +0.13	-0.17

2.2.2 Having arranged the band allocation, it is suggested that the list be re-copied (Table II) leaving spare channels between bands as shown.

This will enable the addition of frequencies to be made to existing bands without the necessity of band rearrangement.

It is probable that a new frequency can then be added simply by inserting the requisite crystal, e.g. 13304.5 kc/s can be added to Band S at Channel 82

2.2.3 Next add in the (Insert Xtal) column the crystal frequencies, i.e. f + 465 kc/s; this is helpful as the crystals are marked only with this frequency.

2.2.4 Copy the Band/Channel allocation on to the Label on the front cover of the Band Selector. These labels can be typed, copies are available under ref: 2-LRU.111A Det.5

2.2.5 Arrange the crystals in channel order on a convenient space close to the Drive Unit.

2.3 Inserting the Xtals into the Drive Unit

(a) With S11 on "Local" put S8 to RX "ON".

(b) Turn Channel Switch S1 or S2 until Xtal sockets 00, 05 etc. appear in the turret aperture.

(NOTE: In general the "Tens" Switch S2 moves the turret 5 positions and the "Units" Switch S1, 1 or 5 positions for one digit change).

A simple rule enables any particular crystal (channel) socket to be brought to the front. Add 30 to the channel number required and select this on S1. The crystal socket will then appear in the second row of the visible portion of the turret, e.g. For channel 26 select 56, for channel 80 select 10, i.e. 110 neglecting the first figure.

Approximately one fifth of the crystals may now be inserted, these can either be inserted in channel sequence, or as the sockets become visible in the turret, Table II should be used as guidance.

Accuracy is essential in putting these crystals in the noted channel sockets to avoid future incorrect operation, the crystal frequency is not visible when the crystal is in position.

The crystals are inserted with the pins projecting from the outside of the turret, pushed down slightly and the spring retainer clipped on the crystal rim.

CAUTION: Keep fingers etc. well away from the turret when this rotates as there is a considerable torque and they may be trapped between the turret and panel.

2.4 Setting the Transmitter and Receiver Ranges (See Fig.2)

When all crystals areinserted, the Uniplugs on PL16 and PL17 have now to be chosen correctly at the top of the Band Selector Unit on the left.

2.4.1 The Receiver Range

This is chosen on PL16 which has 3 sockets against each of the 24 band letters. The rows of sockets are numbered to correspond to the receiver ranges viz:-

Range 1	2800	to 5200 kc/s
Range 2	5200	to 10100 kc/s
Range 3	10100	to 18100 kc/s

From Table II note the frequency of the "T" channel in each band and place a Uniplug in the range row corresponding, e.g. T channel for Band H is 4689.5 kc/s and is thus in Range 1, T for N is 6627 in Range 2, etc. Complete this operation for all the bands all cated. LEAVE UNIPLUGS IN THE REMAINING UNUSED BAND SOCKETS. This is important as the range selector will operate continuously if one of these bands is selected and there is no Uniplug in any of the 3 positions. A small tool is provided in the cover to remove individual Uniplugs.

2.4.2 The Transmitter Range.

This is chosen on PL17 which has two sockets against each of the 24 band letters. These rows are numbered to correspond to the two Transmitter ranges, viz:

Range 1	2800 kc/s to 7000 kc/s
Range 2	7000 kc/s to **18100 kc/s**

As in 2.4.1 above the "T" " channel frequency for each band is noted from Table II, compared with the above ranges and the Uniplug inserted in the correct row, e.g. T for S band is 13314.5 kc/s, thus Uniplug is inserted in row 2 for Range 2.

2.5 The Receiver/Drive Unit is now fully set up and will operate to provide the required drive to the Transmitter or as a Receiver.

3.0 TO SET UP THE BANDS ON THE TRANSMITTER

3.1 On the Transmitter Unit (Fig. 3)

(a) Put S2 to NORMAL (either position)

(b) Put S3 to AUTO

NOTE: If the transmitter is in such proximity to the Drive Unit that the meters on both can be observed easily, it is advantageous in tuning to leave S2 above on "Tune I_c" so that the cathode current of the P.A. stage can be noted continuously, and thus obviating some switching on the Drive Unit.

On the Receiver Drive Unit (Fig. 2)

Decide which band is to be set up, select on S1/S2 and S3/S4 the Band and "T" channel for that band from Table II, e.g. 01A for Band A.

The Drive output at this unit is now checked by putting S9 to "D" position and S6 to "Tune" when a reading of 1.5 - 3.0 approx. on the scale will be obtained when the auto-tuning has ceased. (This latter is normally also indicated by the extinguishing of LP4 the Tune lamp.)

4.0 SETTING UP THE TRANSMITTER ON A FIXED WIRE AERIAL

NOTE: Aircraft should be clear of hangars for this operation.

4.1 From Drive Unit by Remote Control

4.1.1 At the Aerial Coupling Unit (Fig. 5)

(a) Place S1 in "Auto" Position.
(b) Place S2 in "Operate" Position.

4.1.2 At the Drive Unit (Fig. 2)

(a) Place S8 to STD BY.

If Band switches S3 and S4 have been shifted since last switching to "Standard-by" the transmitter tuning head will rotate to reach this setting position. The TUNE lamp will glow while this is occurring and will then extinguish. (If it remains alight, this indicates that either Aerial Coupling Unit or Transmitter have been left on "MANUAL", or that a fault has occurred on one of the tuning motor circuits.)

Now for each of the bands to be set up, the potentiometers must be adjusted. These are labelled A-M and N-Z to correspond to the channels. The potentiometer knobs (pot knobs) are tuned by means of the small tool provided. This requires slight pressure to produce the frictional torque to turn the knob and will slip when the end stops are reached. 25 turns traverse the slider from one end to the other.

The tuning tools LP.182272 are stored in the removable cover.

NOTE: When adjusting SERIES control until one of the Coupling Lamps (LP5) indicate, it will be found that these glow

over approximately 1 turn of knob. Knob should be set in the approximate mid-position of the "glow arc". The Red label distinguishes the Transmitter Pots from those used with the Aerial which are Green.

4.1.3 Adjustment when Aerial Tuning is known

The three controls on the Aerial Coupling Unit now require to be set. The aerial impedance varies widely over the frequency band and thus the adjustment of these controls can be tedious if no other information is available.

The settings for any one type of aircraft, are however, resonably constant for particular frequencies.

Thus it can be assumed that the settings of Table III following are known.

The Drive Unit potentiometers can thus be set on STD/BY in the Workshop to produce these figures on a "slave" Aerial Coupling Unit, or by means of a voltage test jig.

When the Drive Unit is installed, it then only remains to check and trim these settings.

If a frequency different from thos recorded is required, the nearest frequency is generally a good starting point.

When in an aircraft, the Drive Unit is installed without the above pre-setting, then if the Aerial Coupling Unit is visible, the potentiometers can be adjusted to the figures of Table III.

It is recommended that pre-adjustment in this manner is adopted as time is saved.

TABLE III

MANUAL SETTINGS ON AERIAL COUPLING UNIT FIXED

Band	Freq Mc/s.	Input	Coupling	Output
A	2.800	280	3	240
B	4.600	260	3	70

Band	Freq Mc/s	Input	Coupling	Output
C	7.000	26	4	125
D	12.000	20	4	20
E	18.000	52	2	45
F				
G				
H				
J				
K				
L				
M				
N				
P				
Q				
R				
S				
T				
U				
V				
W				
X				
Y				
Z				

4.1.4 Assuming the above pre-adjustment is possible, then the final settings are made as follows:-

(a) During this adjustment S9 is used to check on the meter, Aerial Excitation (AE), and grid and cathode currents of the P.A. stage, (Ig and Ic respectively).

(b) Turn TRANSMITTER potentiometer knob ANTI-CLOCKWISE until the stop is reached (POT.1, POT.2).

(c) Put S8 to SEND, the machine will now start. If the set has not been at STD/BY for 30 seconds, wait until this time has elapsed before switching to SEND. The starting of the machine is signalled by the H.T. ON lamp.

Each time a meter reading is required, raise key S6 to the TUNE, position.

Send Ic = 0.5 - 1.0 approximately.

Now turn the TRANSMITTER potentiometer knob CLOCKWISE, watching the meter reading Ig, until the FIRST maxima is reached. Adjust to maximum value.

(NOTE: If the transmitter unit is visible, (b) above can be omitted, the dial on the transmitter being turned by use of the potentiometer knob to approx the correct frequency.)

(d) It now remains to complete the Aerial Tuning. Read the aerial excitation AE which should indicate owing to the initial pre-adjustment.

Slightly adjust OUTPUT until AE is a maximum, then check adjustment of INPUT. Check value of Ic which should be approx. 3.5 in TUNE position. If so, check that it does not exceed 4.25 in the TEST position.

Alternate the adjustment of INPUT and OUTPUT until the maximum value of AE consistent with a loading under 4.25 on TEST is obtained.

If Ic is too great it can normally be reduced by lowering the OUTPUT reading, i.e. by ANTICLOCKWISE movement of the pot knob.

If preadjustment is carried out properly only a few channels will require much adjustment.

Repeat for all remaining bands, selecting the "T" Channel/Band each time. After adjustment of all bands, alter Table III if necessary for the particular aircraft as there might be slight differences in aerial characteristics.

These figures can then be used to set the Aerial Coupling Unit manually as described later.

4.1.5 Adjustment when Aerial Tuning is NOT known

(a) Set the knobs concerned in the band in question:-

Turn TRANSMITTER pot knob ANTICLOCKWISE until the stop is reached (Pot. 1, Pot. 2).

Turn INPUT pot knob ANTICLOCKWISE until the stop is reached (Pot. 3, Pot. 4)
Turn SERIES pot knob ANTICLOCKWISE until lamp 1 glows (Pot. 5, Pot. 6)
Turn OUTPUT pot knob ANTICLOCKWISE until the stop is reached (Pot. 7, Pot. 8)

Now alter the SERIES pot knob until the condenser number is in agreement with that given for the frequency in Table IV. Table IV will either have been obtained for a particular aerial by experiment, or calculated approximately by the method of Appendix A to this chapter.

(b) Then reading Ic, and with Key S6 on TUNE, turn the INPUT pot knob CLOCKWISE until the first "dip" is noted in Ic. Refer to AE, and turn OUTPUT knob clockwise until a reading is obtained. Then readjust INPUT to "dip" on Ic and repeat input to output until the maximum value of AE is obtained consistent with the loading limits of 4.1.4(d) above.

If it is not possible to load fully, select the next highest condenser, if overloaded, the next lowest.

(c) It is not always possible to find the "dip" in Ic, at some lower frequencies. In this case the following method can be tried.

Select condenser as before. Then turn INPUT approx 5 turns CLOCKWISE. Turn OUTPUT carefully CLOCKWISE, reading AE, until some output is obtained.

Adjust INPUT and OUTPUT until correctly loaded, or repeat using adjacent condensers as before.

TABLE IV

Column C is the value of series element as indicated by lamp number. Aerial No. 1 is given as a typical example.

Aerial Ref:	No. 1 - 45		No. 2 -		No. 3 -		No. 4 -	
	Range Mc/s	C		C		C		C
	2.8 - 3.5	3						
	3.5 - 4.5	4						
	4.5 - 5.3	5						
	5.3 - 7.5	3						
	7.5 - 8.0	2						
	8.0 - 8.3	1						
	8.3 - 9.5	2						
	9.5 - 10.5	3						
	10.5 - 11.5	4						
	11.5 - 12.5	3						
	12.5 - 14.5	4						
	14.5 - 15.5	3						
	15.5 - 18.0	2						

4.1.6 Adjustment of Aerial Coupling Unit 24 LRU 52 E

If the adjustment of the Aerial Tuning Unit is known for a particular type of aircraft installation then the procedure of 4.1.3 previous is identical for use with this unit.

The Drive Unit potentiometers can now be set using the 3 dials on the underside of this GpE unit.

Similarly the method of 4.1.5 can be used to set up initially an unknown aerial, and the dials of the GpE unit noted for inclusion in Table III as each band is satisfactorily tuned.

As the Gp.E unit may be some distance from the Receiver/Drive Unit, this may be tedious, particularly if match conditions and aerial current measurements are being made at the aerial base.

Test Unit 101 LRU 172A can be inserted in the control cable to and will then allow, by use of its controls, the equivalent of Manual tuning of the Gp. E unit and allow much more rapid experimenting with its settings.

The Test Unit is shown in Fig. 9CA and the method of connection in Fig. 9CB. When in use the three tuning controls are used in conjunction with the dials of the Unit. The lamps indicate the "Coupling" condenser selected. The Test key on the right, keys the transmitter on "SAFE" when in the "Tune" position, and is used while setting up. With the key in the "Test" position, the transmitter is keyed in the normal full power condition. The Meter reads aerial excitation.

The Tune lamp also functions whenever any of the tuning heads are operating.

4.2 Setting Transmitter and Aerial Coupling Unit Manually, selecting the Channel on the Receiver/Drive Unit

4.2.1 At the Aerial Coupling Unit (Fig. 5)

(a) Put S1 to MAN position, S2 to OPERATE

(b) If the information of Table III is available set the INPUT, COUPLING and OUTPUT controls to the values shewn for the frequency designed (or to nearest shewn.) (A pencil is a convenient aid to turning these dials.)

4.2.2 At Transmitter Unit (Fig. 3)

(a) Put S2 to Ig (TUNE).
(b) Put S3 to MAN.
(c) Put S1 to band covering frequency required.
(d) Turn Tuning control fully CLOCKWISE, i.e. to lowest frequency on dial.

4.2.3 At the Receiver/Drive Unit (Fig. 2)

(a) Select crystal frequency required on S1/S2.
(b) Put S8 to SEND.

Tuning can now be completed.

4.2.4 At Transmitter Unit and Aerial Coupling Unit

On Transmitter Unit, Press Test Key (S4) and turn TUNING control ANTI-CLOCKWISE until meter records first peak in Ig. Leave at peak Ig. At the Aerial Coupling Unit turn the three controls to the settings given in Table III for the frequency desired. If frequency is not recorded, turn to settings of nearest given. Put S2 to TUNE, and press K1 to get a meter reading. Adjust controls to give maximum aerial indication on meter. Return S2 to OPERATE, and check I_C on Transmitter. This should not exceed 3.5.

Mutually adjust both Transmitter and Aerial Coupling Unit until this is so. Then with S2 on Aerial Coupling Unit, and S2 on Transmitter at NORMAL press either an external telegraph key or S5 on Drive Unit to TEST and check that I_C recorded on Drive Unit does not exceed 4.25.

If the centre T frequency of a band is set-up in this way all the remaining channels in that band may be used without any further manual adjustment. That is, Manual retuning is only required when a band change is needed.

4.3 Setting Transmitter and Aerial Coupling Unit using EMERGENCY facilities on Transmitter

4.3.1 On emergency conditions the transmitter will operate on the service selected on S10 on Drive Unit, or under fault conditions on whichever service is then possible. Thus on Drive Unit, select service on S10, put S8 to RX to allow the keying circuit to operate.

4.3.2 Adjust Aerial Coupling Unit as in 4.2.1 above. On Transmitter Unit set as in 4.2.2. Place Crystal to be used in Socket I by lifting flap labelled "Emergency Crystal". Put S3 to STD BY and wait 30 seconds. Then turn to XTL1, machine will start.

The equipment is then tuned as in 4.2.4.

The equipment is then tuned as in 4.2.4.

A second Crystal can be placed in Socket 2 but in this case S3 must be put in XTL2 position for tuning.

The crystals to be used should be S.T.C. Type 4044 to Spec. RL.7065-144A or A.M. Type 10XJ of a frequency equal to that required for transmission.

5.0 SETTING UP THE TRANSMITTER WITH SUPPRESSED AERIAL

In this instance the Receiver/Drive Unit 3-LRU.111A is used with the wing or tail plane mounted Aerial Coupling Unit (Suppressed) 24-LRU.58A. No access is needed to this latter unit. (See Figs. 2 and 3) for tuning.

(a) Proceed as in Section 1.0 of this Chapter for preliminary adjustment to the Transmitter and Drive Units.

5.1 Tuning operation from Receiver/Drive Unit (Fig. 2)

(a) Select crystal of frequency channel desired on S1/S2.
(b) Put S8 to STD BY (See Section 4.12).
(c) Turn XMITTER pot knob ANTI-CLOCKWISE until stop is reached.
Pot 1, Pot 2.
Turn LOOP pot knob ANTI-CLOCKWISE until stop is reached.
Pot 3, Pot 4.
Turn COND pot knob (Pot 5, Pot 6) until the Condenser Number given in Table V indicates on the lamp panel on right-hand top front of Unit. Adjustment should be in the centre of the "glow arc" as in 3.1.2(b). Table V following gives the correct Condenser Number against frequency. Where a frequency falls in two bands, choose condenser number of the band in which it most easily fits.
(d) Put S8 to SEND, and tune transmitter to maximum I_g as in 4.1.2(c).
(e) It now remains to tune the Aerial Coupling Unit. Put S6 to Tune and turn LOOP pot control CLOCKWISE until meter reads a maximum on AE selected by S9.
Check that I_c then does not exceed 3.5 as before or 4.25 when S6 is on TEST.

Adjust both LOOP and XMITTER pot knobs until the correct loading of I_c is reached consistent with maximum indication on AE.

(f) It is assumed that this operation has taken place with aircraft clear of hangar. The first opportunity should be taken during test flight to check and adjust the loop tuning in 5.1(e) above.

TABLE V

Condenser Settings for Suppressed Aerial Coupling Unit

Frequency Range Mc/s	Condenser Number
2.8 - 3.2	12
3.1 - 3.7	11
3.65 - 4.4	10
4.3 - 5.15	9
5.0 - 6.0	8
5.85 - 7.0	7
6.9 - 8.25	6
8.0 - 9.65	5
9.4 - 11.3	4
11.0 - 13.2	3
12.8 - 15.4	2
15.1 - 18.1	1

NOTE: Should it be found that a "true" peak is not reached on AE indication, release S6 and select the next condenser number and retune.

5.2 Manual Tuning of Transmitter with Suppressed Aerial

The Transmitter may be tuned manually as in the manner of section 4.2.4, 4.2.3 and 4.2.4 preceding. The Coupling Unit can only be tuned by remote control as in 5.1 above from the Receiver/Drive Unit.

APPENDIX A TO CHAPTER V OF HB. 1070-C

If the Series impedance of the aerial is known at a particular frequency and is R+jX ohms where X is +ve or -ve. Then this can be expressed as Rp in parallel with Xp, as $Rp = \frac{R^2 + X^2}{R} = \frac{X^2}{R}$ where X is much greater than R.

Evaluate Rp and F $\sqrt{Rp}$, f in Mc/s.

Then: If f $\sqrt{Rp}$ is

greater than 1900 use Condenser 1
between 1900 - 760 use Condenser 2
between 760 - 316 use Condenser 3
between 316 - 127 use Condenser 4
between 127 - 47.5 use Condenser 5
between 47.5 - 19 or less use Condenser 6

These methods will allow the compilation of Table IV, to act as the starting point in adjustment of the Aerial Coupling Unit.

In cases where a figure for f $\sqrt{Rp}$ is obtained say of 340 which is close to one end of the range i.e. 316 of 760 - 316 it may be better to choose the next lowest rnage i.e. 316 - 127 for a first trial.

CHAPTER 6

OPERATING INSTRUCTIONS

It is assumed that the equipment has been set up in accordance with the procedure of Chapter 5.

1.0 "LOCAL" OPERATION AT THE EQUIPMENT ON RECEIVER/ DRIVE UNIT 3-LRU.111A

(See Fig. 2, 3 and 5.)

Check that Tune Lamp LP4 is out, if not one or more of the units is left on MANUAL. In which case put S1 on the A.C.U. (Fig. 5 to AUTO and S3 on the Transmitter Unit (Fig. 3) to AUTO.

1.1 To Receive (Fig. 2)

(1) See that S11 is on Local.
(2) Switch S8 to RX ON.
(3) Select Channel and Band on S1/S2 and S3/S4 after approx. 60 sec. the auto-tune operation will take place.

If "constant readiness" to receive is required S8 should always be left in "RX ON" position.

(4) Select R/T, M.C.W., or C.W. as required. The receiver is then operating.
(5) Fine Tuning of the receiver is possible on f knob on top left. This should normally be left in the centre position to pick up a signal for the first time. This is also used for C.W. beat note control.
(6) On C.W. additional selectivity can be obtained by switching in the Audio Note Filter. (S14 to IN) and adjusting the beat note to maximum aural output.
(7) The R.F. Gain Control RV1 is normally left at maximum, but can be used to reduce the signal.
(8) The A.G.C. may be removed (S13 to OFF) but on strong signals the r.f. gain must be reduced to avoid "blocking".

(9) The Mute circuit can be switched ON at S12. In which case the RV1 should then be adjusted until noise peaks just break through. The receiver will then be nominally quiet but will accept any readable signal.

In very quiet locations it may not be possible to "open" the mute even with RV1 at maximum.

(10) To change a channel in a band, simply change S1/S2 and wait until LP4 goes out.

(11) To change band and channel both S1/S2 and S3/S4 must be used.

IT IS IMPERATIVE THAT BOTH BAND AND CHANNEL BE CORRECTLY SELECTED.

1.2 To Transmit (on same channel as 1.1)

(1) Turn S8 to STD/BY.
(2) Select Service required on S10, i.e. C.W., M.C.W. or R/T. After approx. 30 seconds after (1) above.
(3) Turn S8 to SEND and transmission can now commence.

If the Transmitter is required to be at "Instant Readiness" S8 should be left at STD/BY.

S8 should normally only be placed on SEND during an actual transmission to increase the life of the H.T. machine. It should not be left on during a listening watch.

(4) To change frequency, use S1/S2, S3/S4 as in 1.1 and wait until Tune Lamp LP4 goes out before keying or closing the P.T.T. switch.

(No damage results if this latter is forgotten but the transmission will not "go out".)

1.3 Manual Operation of Transmitter

Proceed as in section 4.2 or 4.3 of Chapter V.

1.4 Emergency Operation of Transmitter

Proceed as in section 4.3 of Chapter V.

2.0 OPERATION ON REMOTE CONTROL

2.1 On the Receiver/Drive Unit (See Fig. 2)

Place S11 in REMOTE position. This is only possible when fine Tuning control is returned to near zero position.

S8 can well be left on RX/ON or STD/BY in case re-transfer is needed, say by an operator handing over to the Pilot's position.

2.2 On the Remote Control Unit 402-LRU.11A (See Fig. 1)

2.2.1 To receive

(1) Put S5 to RX.
(2) Select channel on S1/S2 and Band on S3.
(3) Put RV1 to maximum gain, i.e. fully clockwise.
(4) Put S4 to MUTE OFF.

Then when the Tune Lamp LP2 goes out, the receiver is ready. (There may be a 60 second delay if the equipment was "cold" prior to transfer of control.)

2.2.2 To Transmit (on the same channel as 2.2.1)

(1) Put S5 to STD/BY, wait 30 seconds, then switch to TX. When the Tune Lamp goes out transmission can start. The remarks of 1.1.2(3) and (4) also apply.

2.2.3 RV2 controls the illumination of S1/S2, S3 and S5.

If Mute facility is required, put S4 to ON, and adjust RV1 until noise peaks can just be heard.

If signals are expected comparable with the existing noise level S4 should be in the OFF position.

CHAPTER VII

ROUTINE FIRST LINE MAINTENANCE

1.0 GENERAL

This chapter covers Routine Maintenance and such fault location that can be carried out in an aircraft without the use of extra test equipment. Section 2.0 and 3.0 cover Routine Maintenance, and Section 4.0, covers Fault Location in a simple manner. Further details of Equipment Alignment and Workshop Maintenance are given in Volume II to this Handbook.

2.0 ROUTINE INSPECTION (Units remaining in Rack)

(a) Check connections to the battery supply from both Transmitter and Receiver.
(b) Examine the aerial connections and the aerial earthing switch if fitted. Examine microphone, telegraph key and phone leads as these items are liable to minor damage.
(c) Check the output voltage of the voltage regulator with the equipment running.
(d) Check that all units are securely clamped in their racks and that the retainers on the front are securely fastened.
(e) Check that the remote control unit is firmly held against its back plate by its four corner screws.

3.0 OPERATIONAL CHECK

As there may be 100 channels on 24 bands in use, a full check on each of these is undesirable due to the time taken. It is suggested that any 6 channels at random, 3 in bands A-M and 3 in bands N-Z, will provide a good statistical check on the equipment.

For operating instructions see Chapter VI.

3.1 Receiver

Switch Receiver into 'local control' position. Set control switch to RX. Select the channel on which signals can be obtained. After 45 seconds when the time delay has operated check:

(a) That tune lamp goes out when a channel is selected, and the auto tune mechanism has functioned.
(b) That the operation of the gain control is normal when receiving a signal.
(c) That the fine tuning control is operating.
(d) Check action of 'A.G.C.' switch on a strong signal with full R.F. gain, 'A.G.C. Off' should show signs of Receiver blocking.
(e) With A.G.C. switch ON and Mute Switch ON check the operation of the mute switch by tuning the R.F. gain control whilst listening to a signal, until the signal just fails to open the muting. Switch mute switch to 'OFF' and note the increase in signal.
(f) Check the Xtal selection, auto tune and band switching circuits by selecting channels and bands and noting the drive reading on the meter (switch set to D) in each case when the test key is operated after tuning ceases.
(g) That the receiver is muted when the test key is operated.
(h) Switch to Remote and check the operation of the selected switches. R.F. gain control mute switch and tune lamp at the Remote Control Unit.

3.2 Transmitter

(Fixed Aerial)

Put Receiver Drive Unit to 'local control' switch to 'Standby' and select a switch channel.

(a) If the unit is not already warm from previous tests note that after 45 seconds the time delay and auto tune mechanism operate and that the tune lamp goes out.
(b) Check that Drive is indicated on the meter when the test key is operated (switch to D).
(c) Switch to 'Send' and note that the 'H.T. ON' lamp lights and machine (3MG1) starts. A separate time delay is incorporated in the transmitter operating 30 seconds after switching to 'Standby'
(d) Return to 'Standby' position, and change the channel noting that all tuning heads rotate and that the condenser indicator lamps on the drive unit light.
(e) Check the resetting of the tuning dials on the Aerial Coupling Unit and the Transmitter Unit (if accessible). Put each to 'Manual' then in turn rotate each manual tuning knob one quarter of a turn and

and return switch to 'Auto'. Each tuning drive should move slightly back to its original setting. Failure to do this probably indicates an insensitive moving coil relay.

(f) Select a channel, turn to 'Send', press test key and check drive (D) Grid Current (Ig) cathode current (Ic) and aerial excitation (IA_e) on the meter on the Drive Unit. Using phones listen to sidetone on C.W. and M.C.W., and to voice on R.T. when the microphone is used.

(g) Repeat on several channels in both bands.

(h) Some typical meter readings are given in Table II following (Section 4.1.3). Aerial currents vary between different types of aircraft and Aerial and can best be checked by average figures taken from a number of indentical installations.

(j) Check manual operation at the Transmitter and Aerial Coupling Units if accessible using the test keys at these positions with the respective switches in the tune position. Note that AE current can be read on the ACU meter and Ig on the transmitter. Return switches to AUTO after test.

3.3 Receiver and Transmitter

(a) As a final check listen out and if possible work a station on 'Send'.

4.0 FAULT LOCATION

The purpose of this section is to enable the operator to assess, by inspection in the aircraft and without extra test gear, some of the fault conditions and decide which major unit is the cause.

Before investigating any fault, ensure that all controls are in the correct operating positions. (See Chapter VI) e.g. check that units are not on manual when auto operation is required.

The following is a limited list given as a simple guide only of some faults in terms of their symptoms.

Many major faults result in the blowing of one or more fuses. Table I lists these for convenience and section 4.1 deals with fuse faults.

FUSE LIST, TABLE I

Unit	Fuse Ref.	Function	Fuse Belling Lee	Rating
Power and Modulator Unit	F1 (3F1)	28V Control Cct	L.1055/3	3 amp
	F2 (3F2)	19V Control Cct	L.1055/2	2 amp
	* F3 (3F3)	600V Circuit	L.1055/750	750 mA
	* F4 (3F4)	300V Circuit	L.338/500	500 mA
	F5 (3F5)	19V Supply Circuit	L.1055/10	10 amp
Receiver Drive Unit	F1 (7F1)	28V Supply Circuit	L.562/7	7 amp
	F2 (7F2)	19V Supply Circuit	L.562/7	7 amp
	F3 (7F3)	H.T. 180V Circuit	L.562/250	250 mA
	** F4 (7F4)	H.T. (machine)	L.562/500	500 mA

* Inside the unit and accessible at the left hand side when dust cover is removed.

** Inside the machine filter unit.

4.1 Fuse Faults

WARNING: Switch off before replacing a fuse.

Symptoms resulting from failure of any particular fuse – Local operation

Failure	Effect
Fuse 3F1 (28V Control on Modulator Unit)	Receiver Drive Units normal. Tx unit does not operate on auto. A.C.U Operates on Auto. H.T. rotary in Modulator inoperative. Ic Ig Il I2 IAe read Zero. Tx Dead Power Valve blower inoperative
Transmitter fuse 3F2 19V Control on Modulator Unit	Receiver Drive Unit normal. Tx unit inoperative on auto. Power Valves blower operates. H.T. Rotary Operates. Tx operates on manual and emergency

Transmitter fuse (3F5) (19V on Modulator Unit)	Receiver Drive Unit normal. Tx Unit inoperative on Auto. Tx Dead ACU operates on Auto. H.T. Rotary inoperative.
Transmitter fuse 3F3 (600V on Modulator Unit)	Receiver Drive Unit normal. Tx - No output - IAE Zero 11 12 on Tx Normal. Ig normal. Ic low and is reduced when test key is in Tune position.
Transmitter fuse 3F4 300V on Modulator Unit	Receiver Drive Unit normal. Tx no output. No meter reading except Ic which reads low and is not reduced when test key is in tune position.
Receiver Drive Unit fuse 7F1 28V Supply	Xtal Turret does not stop and can be heard rotating in phones. Tune lamp does not light. ACU inoperative on Auto. Tx operates on Auto. Tx H.T. Rotary operates. Key is permanently down No.D, Ig IAE readings 11, 12 normal.
Receiver Drive Unit fuse 7F2 19V Supply	Receiver Drive Unit. Completely dead. ACU inoperative on Auto. Tx operates on Auto. Tx Rotary inoperative. H.T. on lamp does not light. Tx blower motor operates.
Receiver Drive Unit 7F3 and 7F4 H.T. 180V fuses	Tune lamp remains alight as R.F. tuner continues to hunt. Selection circuits normal. Receivers completely dead in phones. No D reading. Tx and ACU normal on auto but no Ig or IAC, but I1 I2 normal. Ic only readable with test key at tune

4.1.2 Supply Failure (Transmitter)

Should either the 19V or 28 volt supply fail, the symptons are the same as for 3F1 and 3F5. Receiver normal.

4.1.3 Supply failure (Receiver)

Should either the 19V or 28 volt supply fail, the symptoms are the same as for 7F1 and 7F2.

Typical Meter Readings TABLE II

Frequency Mc/s	Meter Readings					
	D	I1	I2	Ig	Ic	IAE*
2.8 Band I	3.0-4.0	4.5-5.0	2.2-2.4	4.0-5.0	3.5-4.5	1.0-3.0
5.0 "	3.0-4.0	"	"	3.0-4.0	"	"
7.0 "	2.0-3.0	"	"	2.5-3.0	"	"
7.0 Band II	2.0-3.0	"	"	3.0-4.5	"	"
11.0 "	1.5-3.0	"	"	3.0-4.0	"	"
16.0 "	1.5-3.0	"	"	1.5-3.0	"	"
Meters to be used	1M1	2M1	2M1	1M1	1M1	1M1
				2M1	2M1	9M1
						8M1

Meter 1M1 is on the Receiver Drive Unit
Meter 2M1 is on the Transmitter Unit
Meter 8M1 is on the Aerial Coupling Unit (Fixed)
Meter 9M1 is on the Remote Control Unit

* The aerial current readings vary with the aerial used and the frequency and should be compared with those known for the particular installation.

NOTE: The meter multipliers are:-

Ig mA = scale x 10
Ic mA = scale x 100
I1 mA = scale x 10
I2 mA = scale x 20

Meter on Drive unit reads "sluggishly"

4.2 Faults on Control Circuits

This section is intended to cover possible faults in the Control Circuits, and to indicate the units which may be affected. Remedial action is indicated where possible. Before taking any action ascertain that units are all securely mounted in their racks to eliminate faulty backplate connections.

4.2.1 Receiver Drive Unit or Transmitter fails to switch on

(a) Check D.C. Supplies. Voltage Regulator, and fuses.

Try remote operation. Failure at local only, indicates front panel switching circuits. If fuses do not cure the trouble RL6 and RL7 in the modulator may be faulty in the case of the transmitter and RL.18, RL.19 in the receiver drive unit in the receiver case.

(b) Crystal turret rotates continuously

Check 28V supply fuse. Check remote operation to eliminate front panel switching circuits. Check turret switch and adjustment.

(c) Transmitter and Aerial Coupling Unit will not run on auto

This may be due to a fault common to all the Bridge servo-mechanisms. e.g. Loss of supply - Check 19V control fuse on Power and Modulator Unit.

Faulty Plug connections at rear of the units.

Inoperative potentiometer unit in receiver drive unit, due to faulty driving motor or tight gearing.

Potentiometer unit stopping so that the connecting elements are between channels. Units left with switches on manual instead of auto.

It is advisable to try several channels on both bands (A-M) and (N-Z) to try to locate the fault to either group of potentiometers

(d) One particular tuning head fails to operate on auto

This is due to a break or fault in the respective bridge circuit which is not common to other bridge circuits.

Likely cause is a faulty sensitive relay (S. 115), faulty lead-screw potentiometer, or the potentiometer at the head end.

Check rear plug connections of units, try channels on both (A-M) and (N-Z) groups to locate the leadscrew potentiometer.

A suspected potentiometer may not be properly ganged with the other potentiometers, may not be making to its wipers or may be making faulty connection to the spring contacts when it is fitted into the main unit.

(e) One particular head will not rotate on auto on a particular channel (e.g. Channel A)

This is due to the respective leadscrew potentiometer not making connection on that channel.

(f) Tuning head runs to one end of travel and drives against clutch or end stop

This is normally due to an incomplete bridge circuit caused by disconnection at the leadscrew or the remote potentiometer or in the interconnecting cables. The common cause is due to bad connections in the rear plugs and sockets. These should be examined for faulty pins and all units should be pushed firmly home in the racks.

(g) Excessive ticking as tuning motor reaches balance

This may be due to tight goaring or to an oversensitive S. 115 bridge detector relay. This is not serious unless the head fails to set accurately the increased time taken for the head to settle being generally within the limits allowed.

(h) Tuning head hunts before stopping

This is due to a faulty detector relay S. 115 (i.e. open circuit

feedback winding) or otherwise in the feedback circuit on the unit in question.

(j) Tuning heads do not reset accurately

This may be caused by intermittent and varying connections at the leadscrew potentiometers especially if the effect is confined to particular channels. Insensitive detector relays have similar effects and can be checked by a $\frac{1}{4}$ turn test as follows:-

Place the unit on 'Manual'. Turn the manual tuning wheel $\frac{1}{4}$ turn clockwise. Return switch to auto and check that the dial resets to its original position. Repeat in an anticlockwise direction. If no resetting takes place exchange relay.

(k) No Condenser indicator lamps

If units are serviceable when a condenser is selected manually by means of the dial indicator the fault may lie in the supply to the lamps at the receiver drive unit or in the earthing contact switch in the aerial coupling unit. Should a condenser not be selecting (i.e. A.C.U. unserviceable) a mechanical fault in the A.C.U. is probable.

4.2.2 Faults on Tune/Manual Circuits

The manual line serves to indicate that auto control is not possible by illumination of the 'tune' lamps when any unit is set to manual operation.

The tune line provides a similar indication when any selector or tuning motors are in motion or before the receiver drive unit time delay has operated.

(a) Tune lamp remains illuminated

This may be due to (1) Units being set to 'manual'
(2) Time delay not operated
(3) Heads revolving or crashing) see clutch and end stops) 4.2.1

(4)	Turret revolving continuously)	
(5)	Potentiometer unit revolving)	See 4.2.1
	continuously)	
(6)	R.F. Amplifier tuner hunting continuously	See 4.2.3

4.2.3 Auto tune faults

(a) R.F. Amplifier hunting continuously

This normally results from failures in the Xtal oscillator circuit or in the band selection circuits such that no signal is available to trigger the autotune mechanism or because the autotune circuits are failing to operate.

A failure in the oscillator may be due to a faulty Xtal, (i.e. on one particular channel) to the fact that there is no Xtal in the turret, or to the Xtal pins not making proper connection to the Contact fingers.

Band failures can result from wrongly positioned plugs in the 'Uniplug' panel, no operation of the Ledex switch to the R.F. amplifier unit, or to the band switch (AM-NZ) which can be eliminated by operation from the remote control box.

If a uniplug is placed in a higher frequency band that that required the tuner will be searching at a much higher frequency than the desired channel and it is possible for the autotune mechanism to stop on the second or third harmonic. The drive reading D is very little reduced by unrecognisable signals should be received in the phones.

In any case of suspected wrong frequency check both the Xtal and the band setting remembering that the Xtal frequency is 465 kc/s above the channel frequency. With a uniplug placed in a lower band than that required, no harmonics are found, and the R.F. tuner continues to hunt.

Provided the correct band is selected, the Xtal oscillator signal can be checked by setting the meter switch to D, placing the key to 'test' and observing the upper and lower sideband signals appearing

on the meter, as the R.F. tuner sweeps through the tuning points. When a signal is present but the auto tune fails to trigger, the fault lies in the receiver drive unit mounting chassis and may be located to V1, V2, RL.5 (Carpenter relay) or associated circuits.

(b) Other Auto tune faults

Symptom - low drive (D). In general this would point to a faulty R.F. amplifier but it can also be caused by the autotune step back control (RV.3) in the base of the mounting unit being incorrectly set. This can be ascertained by observing the meter D deflection (key on test) as the autotune triggers. If the deflection is large and the final steady D reading (key on test) is small the step back control needs slight adjustment.

No appeciable loss in transmitter drive results however unless this reading is below 1.0 and adjustment should not be attempted except in the workshop (See Vol.II section 3.4.3(2) for adjustment procedure).

4.2.4 'H.T. ON' and Service Selection

(a) Transmitter H.T. rotary fails to operate when switch is set to Tx

If the H.T. on lamp operates the fault is in the Power and Modulator Unit and may be due to RL.8, RL.9, the rotary itself or associated connections.

If the H.T. on lamp does not light, check that the time delay valve in the transmitter unit has operated and that the interlock circuit is complete.

In the case of a dual installation the second power and modulator unit must be in position to complete the connection to pins 1 and 2 on SK.3 and furthermore it should be remembered that one rotary will not start if the other one is already running.

In the event of complete interlock circuit failure the 4 way Plugs 3J may be removed from the power and modulator back plates and pin 1 joined to pin 3 on SK.3 in the power and modulator Unit. The rotaries will then start independently.

It is advisable to examine the interlock plugs and sockets SK.3 for faulty contacts and ensure that both modulators are well fitted in their racks before taking this action.

Operation from 'local, 'remote' and 'emergency' should all be attempted to eliminate their respective switching circuits. If the rotary starts in any of these cases the interlock circuit is not at fault.

(b) Loss of Transmitter 'R.T.' 'MCW' 'CW' Services

Check from local and remote to eliminate switching circuits. All associated relays are in the Power and Modulator Unit and operate when a service is selected as follows:

CW:	RL.4
MCW:	RL.3 and RL.4
RT:	RL.3

In general faults will allow operation on C.W. to be continued.

(c) Loss of services CW, MCW, RT, R.F. Gain. Note filter A.G.C. and mute, on receiver

In general a loss of any of these services will be associated with faults in the sub units of the receiver drive unit.

CW	- I.F. unit V.4 (CV.138)
MCW & RT	- Try remote operation
R.F. Gain	- Try remote operation and if unsatisfactory fault is probably in the R.F. amplifier - V1 or RV.1.
Note filter	- I.F. Amplifier RL.1
A.G.C.	- Mounting Unit local/remote switch S.11K or I.F. Amplifier
Mute	- I.F. Unit - V6

4.2.5 The Key Circuit - Fig.23

(a) Key will not operate

The key line enters all units and keying is possible from several test points all of which should be tried in order to localise the fault.

Faults peculiar to the external key normally lie in the intercomm switching circuits or possibly at the power and modulator unit.

Failure to key at the receiver drive unit (i.e. no D indication on the meter) would point to the key switch itself, RL.16 or the R.F. Amplifier. If Drive is present but the transmitter fails to key the fault lies in the transmitter and in such a case that Ig is present but the transmitter output will not key the aerial changeover relays (Lo Z in the receiver drive unit or Hi Z in the wire aerial coupling unit are suspect.

It should be remembered when carrying out the tests that the transmitter and wire aerial coupling units can only be operated by their respective test keys when switches are set to 'Manual' and 'Tune' and further in the case of the Aerial Coupling Unit this is still not possible if a condenser is not selected. Keying is not possible during selection and tuning procedure as indicated by illumination of the tune lamp, so that any fault which produces an earth on the tune line will normally be accompanied by apparent keying difficulties. (See (a) above.)

(b) Key permanently down

This may be caused by an earth on the key line in any unit or in the external key line via the intercomm circuits. The transmitter A.C.U. and modulator Units can be removed and the receiver drive unit operated alone using the test/tune key to localise the fault.

Failure of the 28V fuse in the receiver drive unit also produced key down effects.

4.2.6. Other transmitter faults

(a) Low Ig D normal – faulty V1, V2, or possible V3 or V4 in the transmitter unit. Wheels off or making bad contact to transmitter tuning coils.

(b) No. IAE, Ig normal – faulty brush contact on transmitter output coil or aerial disconnected.
600V fuse broken

Aerial changeover relays faulty (Hi Z in A.C.U.
Lo Z in Receiver
Drive Unit)
Faulty indicator circuit (i.e. radiation possible
without indication on meter).

(c) No. I_1 I_2 Ic I_{AE}, D normal - 300V fuse broken

(d) Low Ic no I_1 I_2 - 600V fuse broken

(e) Drive D and Tx normal. Rx dead - I.F. Amplifier Unit faulty
Telephone output circuit via
SK.4/SK.5 in Power and
Modulator, and intercomm
circuit faulty

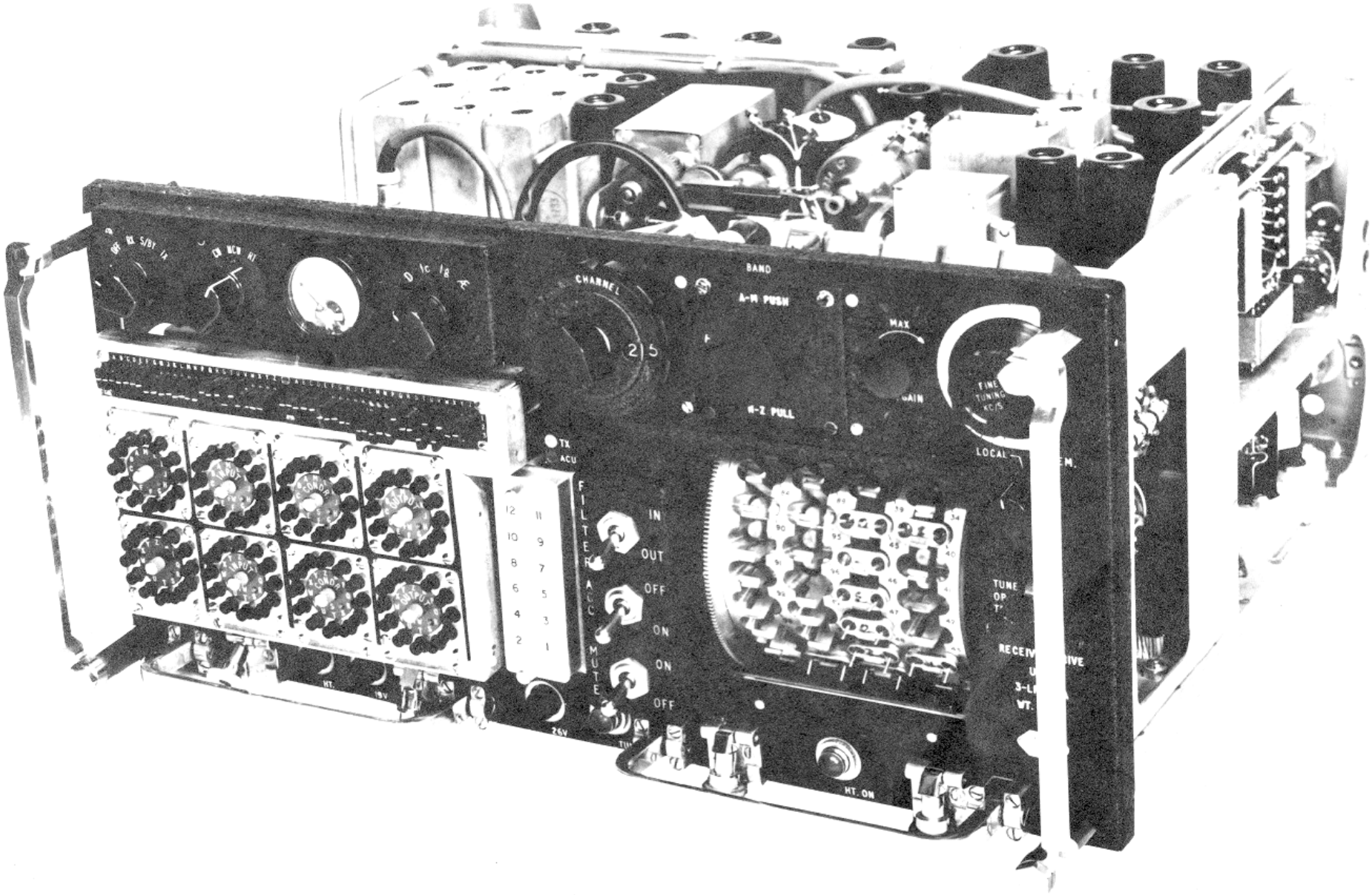


PLATE 1

RECEIVER/DRIVE UNIT COVER REMOVED

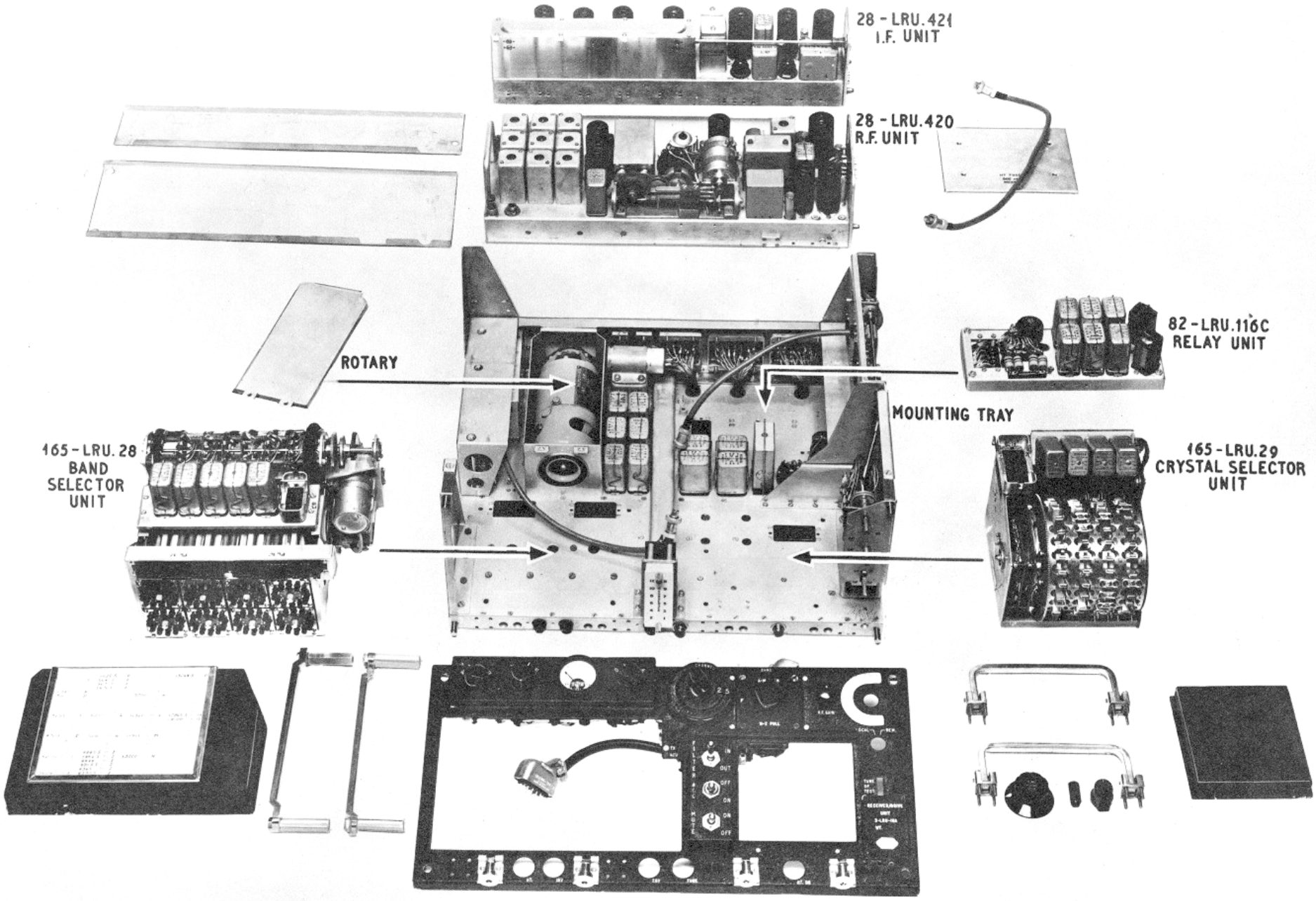
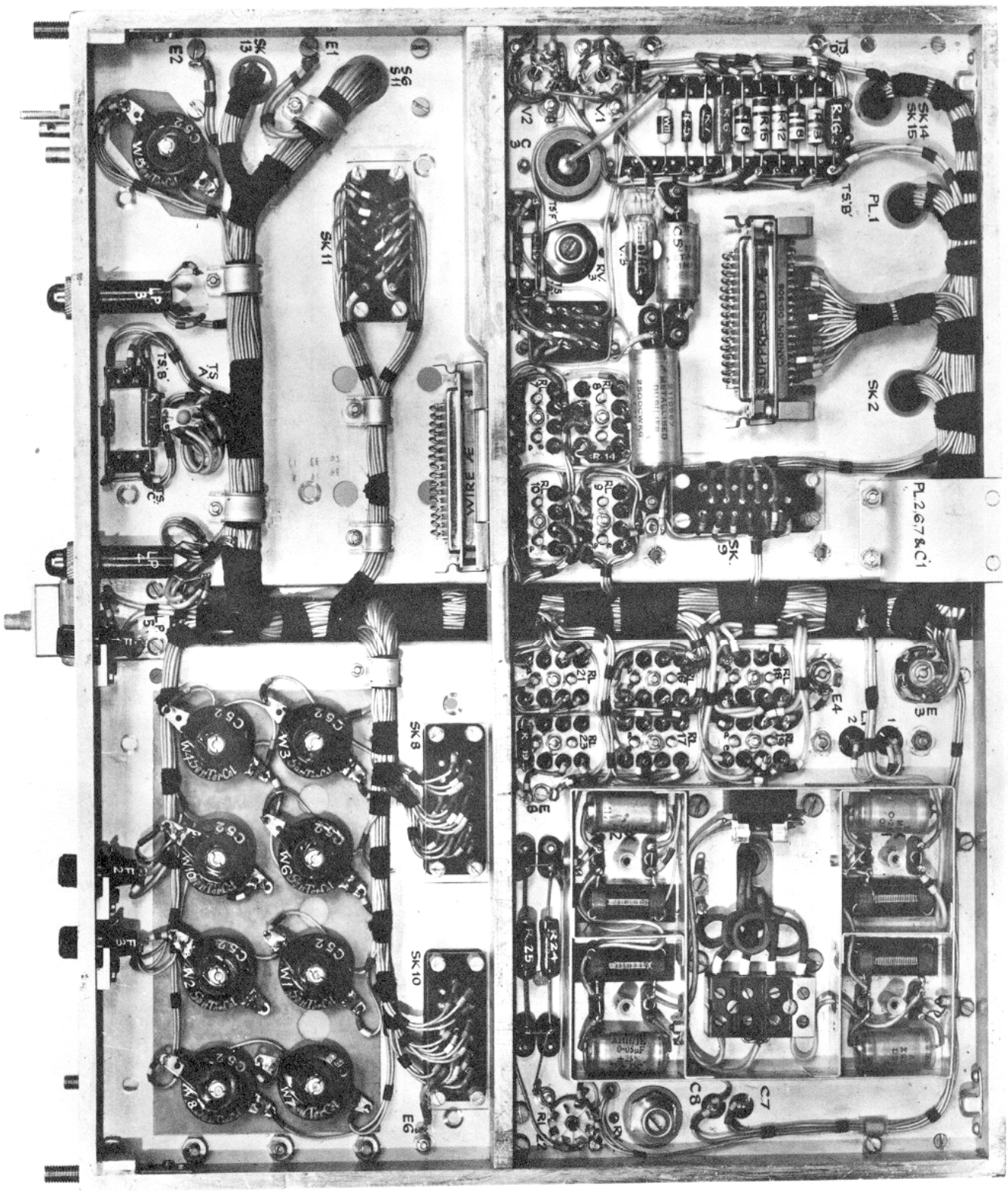


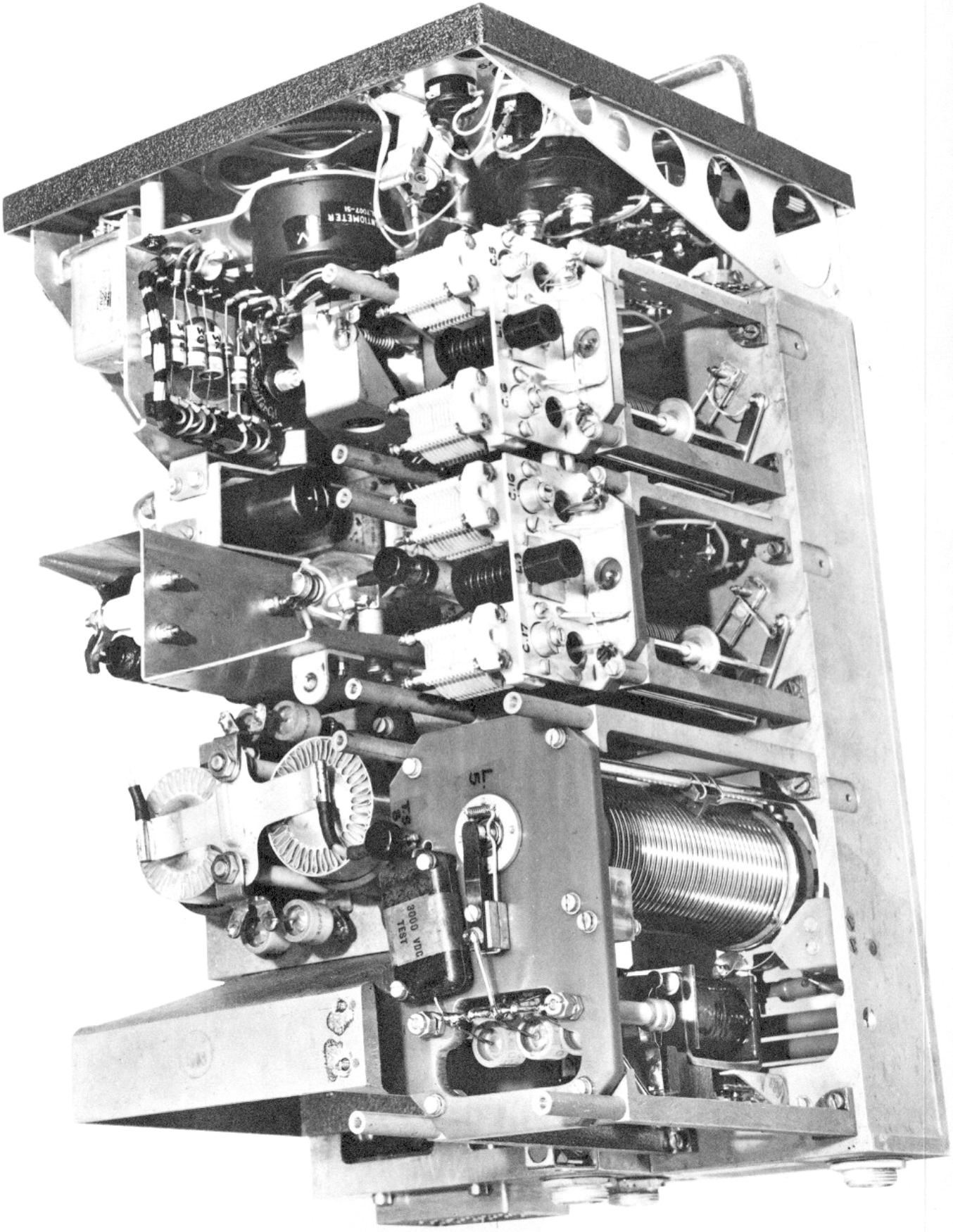
PLATE 2

RECEIVER/DRIVE UNIT EXPLODED VIEW



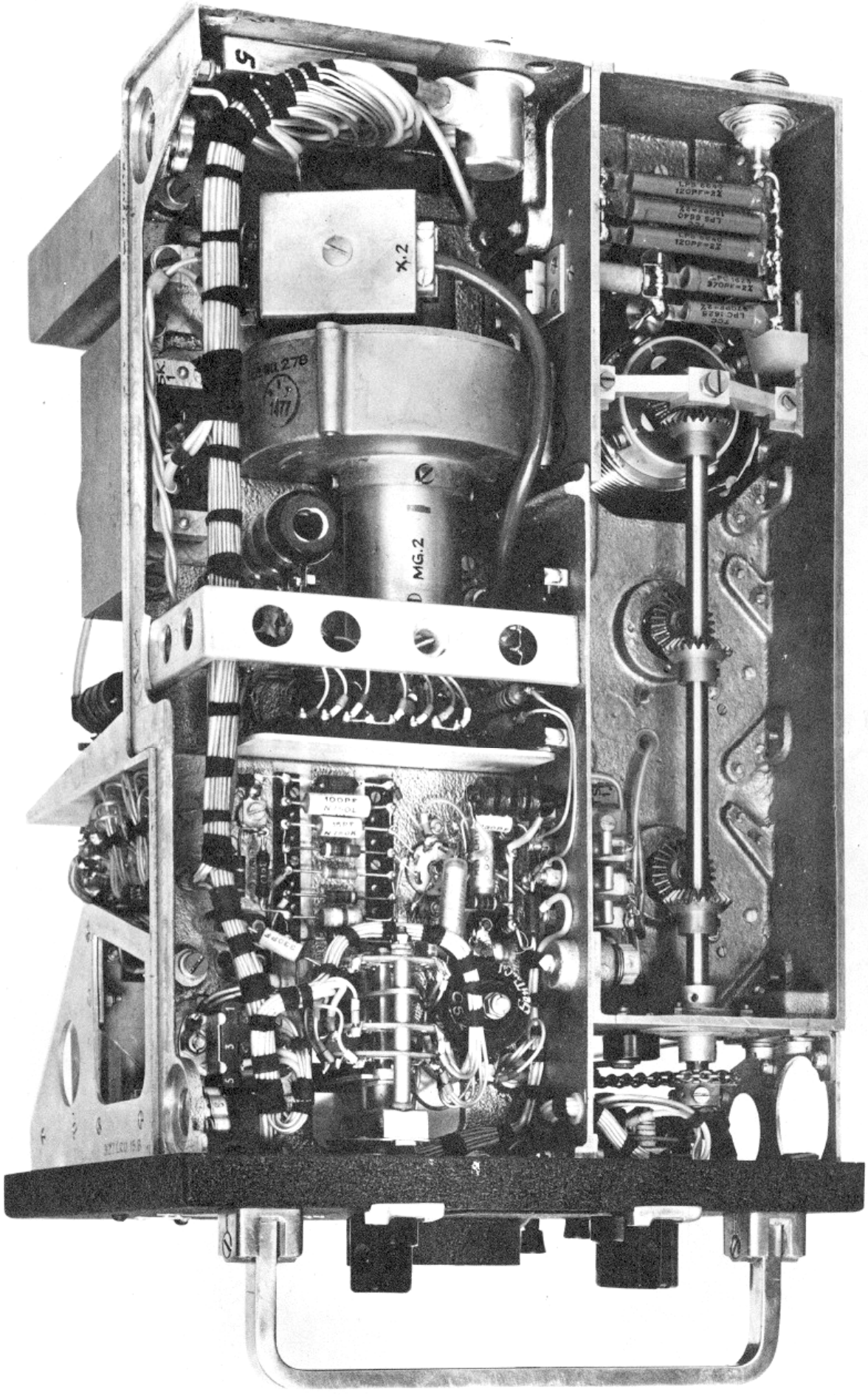
RECEIVER/DRIVE MOUNTING UNIT, UNDERSIDE

PLATE 3



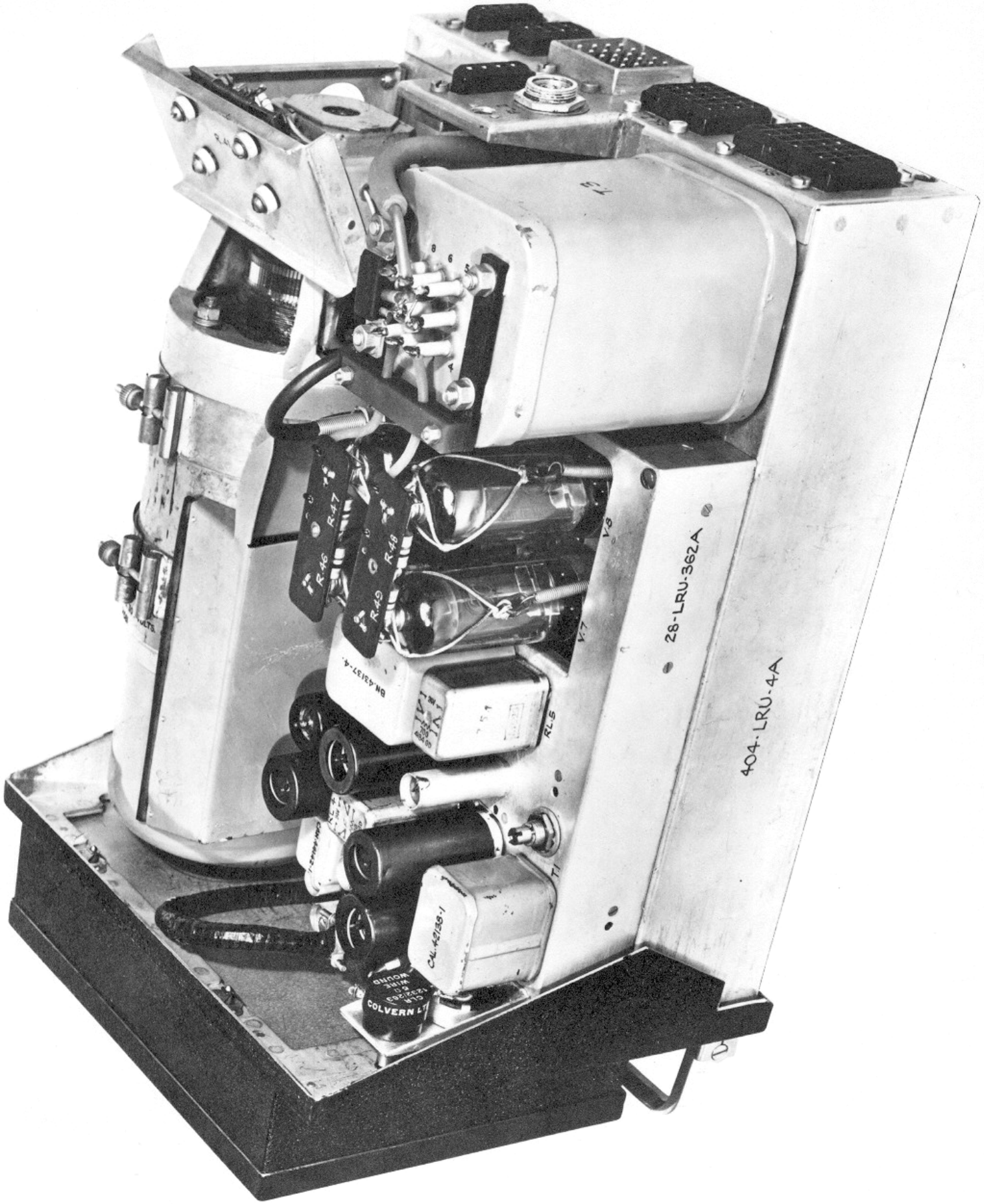
TRANSMITTER UNIT COVER & COIL CANS REMOVED

PLATE 4



TRANSMITTER UNIT UNDERSIDE VIEW

PLATE 5

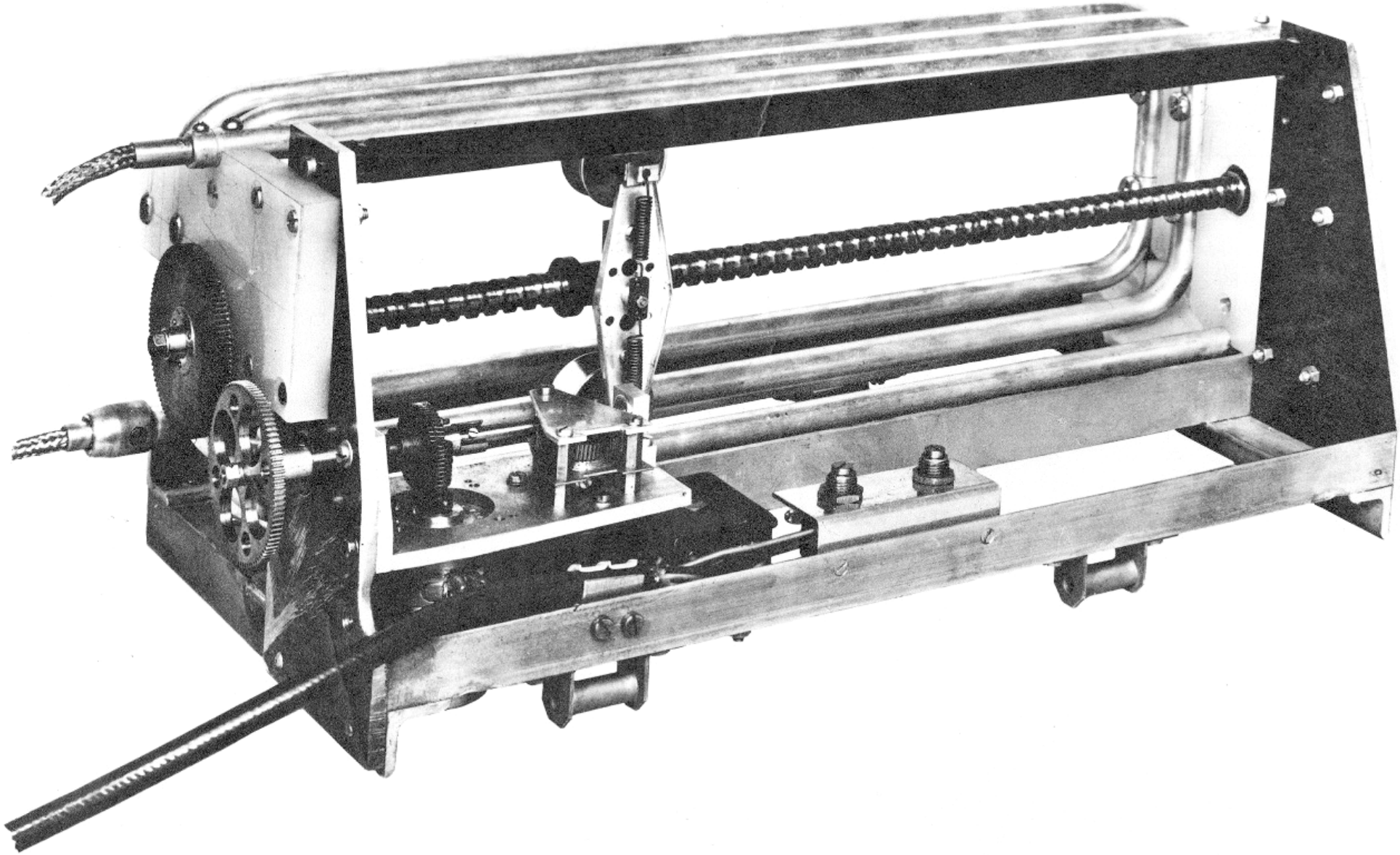


POWER & MODULATOR UNIT

PLATE 6

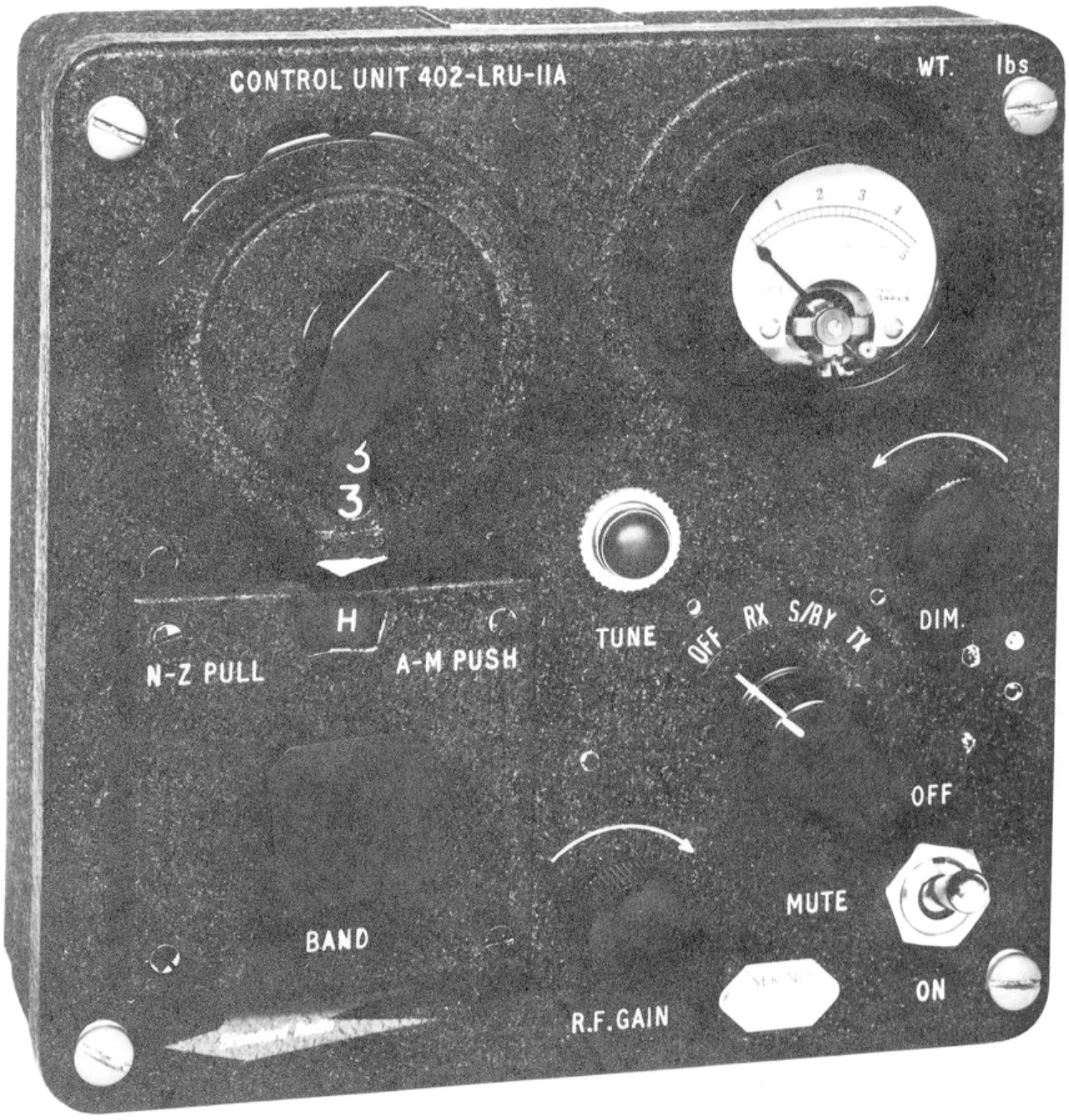
AERIAL COUPLING UNIT (WIRE)

PLATE 7



AERIAL COUPLING UNIT (SUPPRESSED)

PLATE 8



OPERATOR'S CONTROL UNIT

PLATE 9