B.R. 222

THE USER'S GUIDE TO WIRELESS EQUIPMENT

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THE USER'S GUIDE TO WIRELESS EQUIPMENT

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CHANGE NO. 2

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MARCH, 1970

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SECTION 1

GENERAL

1.1. SAFETY PRECAUTIONS

Risk of Electric Shock.

1. The operation of wireless equipment involves the use of high voltages which are dangerous to life and users must therefore exercise care in their duties.

2. In modern design the whole of the equipment is within a shielding enclosure provided where necessary with access doors or drawers generally fitted with safety interlock switches which act to shut off dangerous voltages within the enclosures when the doors or drawers are open.

3. Interlocks are, however, provided only on normal access doors, and side, back and top screens can be removed without operating the interlocks, and will thereby allow access to circuits carrying voltages dangerous to life.

4. Furthermore, interlocks are provided as an additional safety precaution in case the operator forgets to switch off power before making an internal adjustment. They are not there to be relied on. Some interlocks are physically opened by the action of opening the door, but many rely on a spring to open the switch when the retaining pressure of the door is removed, with the consequent unreliability.

5. Although every practicable safety device is incorporated in modern equipment, the following rules must always be observed:

a. Never make any internal adjustments or handle any part of the equipment without first switching off power supplies or seeing that the interlocks have operated. In some circuits dangerous potentials may still exist with power switched off due to charges retained by capacitors. These circuits must be earthed before being touched, preferably by means of an earthing stick which should be provided in every transmitter room.

b. Do not remove, short circuit or tamper with safety interlock switches in any way except when necessary for servicing or testing the equipment, nor place reliance upon them to remove voltages from the equipment.

c. When servicing or adjusting equipment, have an assistant or some other person capable of rendering immediate aid in the event of an accident.

6. To summarize:

SWITCH OFF POWER SUPPLIES, AND EARTH THE CIRCUITS BEFORE TOUCHING THEM.

DO NOT TAMPER WITH INTERLOCKS.

Fire Risk.

7. There is always some potential fire risk involved in the use of radio equipment. All ratings should be fully aware of this danger and of the need for prompt action on discovering a fire inside a radio panel or cabinet.

8. Carbon dioxide extinguishers only should normally be used for fires in radio equipment, but water extinguishers may also be used, *provided all power supplies are switched off first.* Foam extinguishers are *not* to be used for electrical fires.

9. General information on the operation of all electronic equipment and precautions against fire risk are contained in current D.C.I.s. Main points covered are:

a. Equipment not in continuous use should be switched on for a few hours daily, with both H.T. and L.T. supplies on. Certain valves may be damaged if operated with only L.T. supplies on.

b. Equipment not required for 6 hours should be switched off.

c. Unattended radio compartments should be left with the doors wide open and air conditioning switched off. These offices should be inspected every 30 minutes, but this interval may be extended if fire risk is small.

d. A.C. supplies to radio offices should be checked regularly as certain valves can be damaged by wide fluctuations in supply voltage.

FIRST AID TREATMENT AFTER ELECTRIC SHOCK

10. The greatest effect of an electric shock is caused, not by the voltage involved but by the current which that particular voltage can pass through your body. A comparatively weak current can cause death and it is therefore essential that you should avoid making your body a conductor when handling electrical equipment.

The following precautions should be taken to reduce any possibility of severe electric shock:

Avoid standing on bare metal decks. If necessary, wear rubber-soled shoes.

Avoid all contact with water, particularly at the hands and feet.

Switch off all power supplies whenever possible.

Handle equipment or tools with one hand only whenever possible.

Always regard all electrical equipment as potentially dangerous, irrespective of the voltages used.

11. **Types of Injury.** There are two main types of injury following electric shock:

a. Temporarily suspended animation (apparent death),

b. Burns.

In the first type of injury, it is *essential* to start and continue artificial respiration immediately and to continue it sometimes for over two hours. Life can thus be saved, in the vast majority of cases.

12. **Artificial Resuscitation.** The aim of artificial resuscitation is to re-establish the flow of air to and from the lungs as soon as possible, so as to avoid damage to the vital centres in the brain by 'oxygen starvation'. The primary method of resuscitation is the Mouth to Mouth method, popularly known as the 'Kiss of Life'. This method is particularly effective in certain service situations as it can be carried out in confined spaces or awkward positions, i.e. in a small compartment or on a life raft. Another method is the 'Holger Nielson' method.

PROCEDURE WITH APPARENT DEATH

13. **Mouth to Mouth Resuscitation.**

a. Remove the body from contact with live equipment (switch off if possible). This should be done with a stick or other non-conductor. The clothes of the patient will be non-conductive as long as they are dry.

b. Send someone for the Medical Officer.

c. Start artificial resuscitation as follows:

(1) The patient should be placed on his back or supported on his back in some convenient position (Fig. 1a).

(2) Extend the head backwards so that the mouth, throat and nose are in a straight line. In this position the mouth will usually fall open (Fig. 1b).

(3) The operator fills his lungs, places his mouth widely opened over that of the patient and exhales forcibly, thus inflating the patient's lungs. The nose is closed by the operator's cheek or thumb and forefinger (Fig. 1c).

(4) The operator raises his head well clear of the patient and turns to observe the falling of the chest as it empties. At the same time air may be heard to escape from the patient's mouth and nose (Fig. 1d). While the patient's chest is emptying, the operator refills his own lungs and then repeats the procedure in (2) and (3). The method is repeated until natural breathing is restored or hope abandoned.

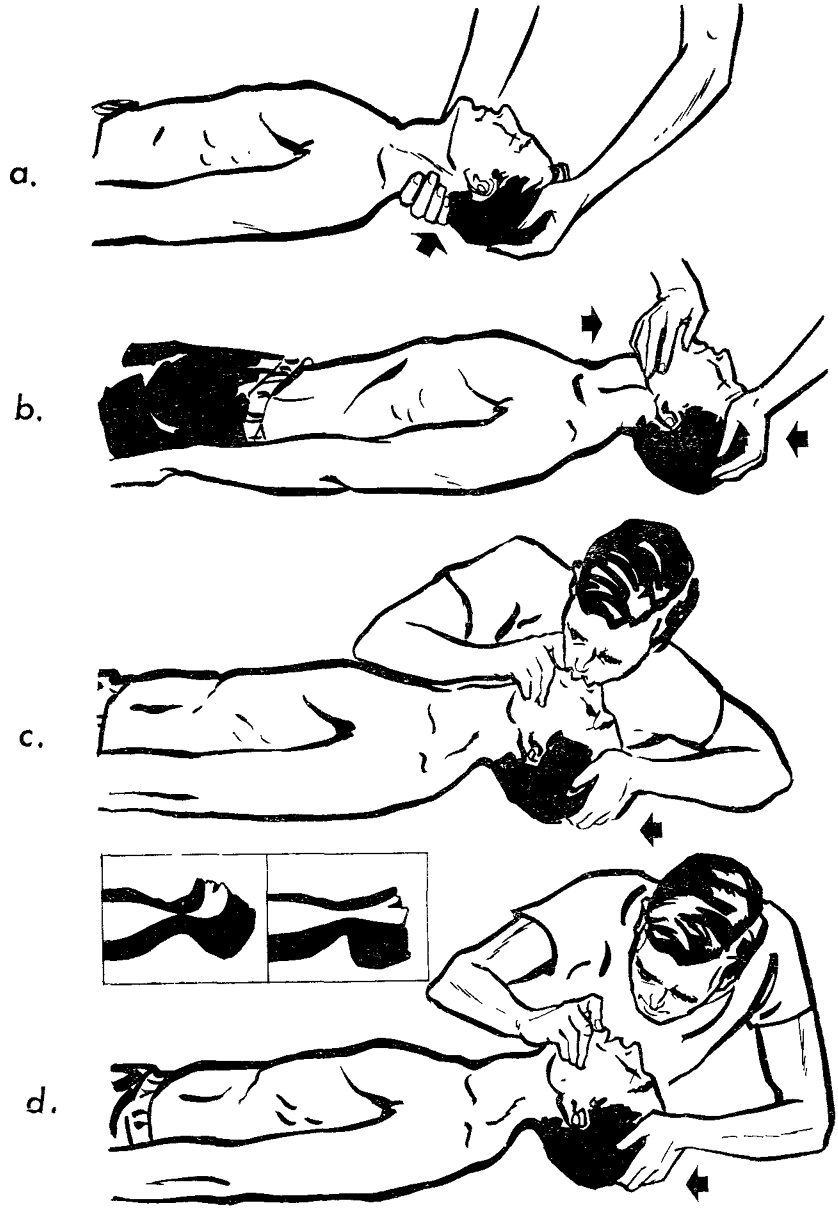
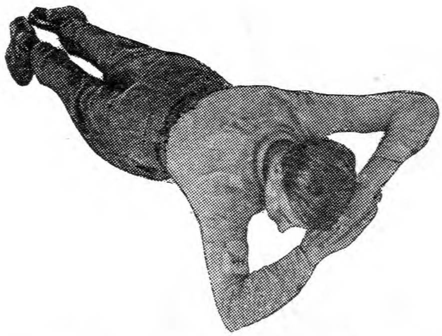
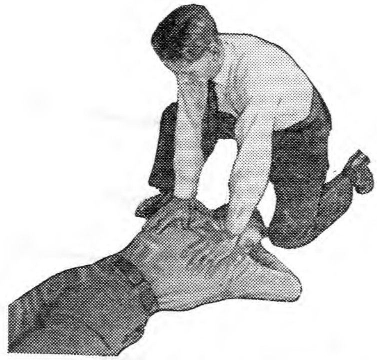


FIG. I. MOUTH TO MOUTH RESUSCITATION

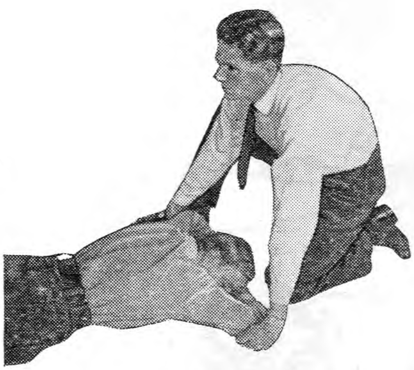
14. **Holger-Nielson Method**



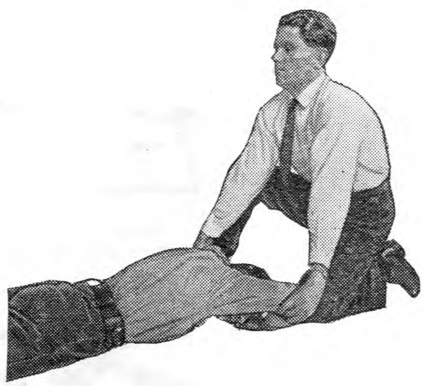
(1) Place the patient prone in the position shown, and make sure the airway is clear, by putting a finger in the patient's mouth and removing false teeth or any other obstruction.



(2) Kneel at the head of the patient as shown and place the spread hands on the patient's back. Rock forward until the arms are vertical and exert pressure down through the arms on to the back of the patient.



(3) Rock backwards slowly so as not to cause any sudden release of pressure; remove hands from back and grasp arms above the elbow, lifting them until slight resistance is felt. Then lower them.



(4) Repeat the cycle, starting from (2).

FIG. 2.

This cycle should be repeated twelve times per minute with as smooth a rhythm as possible, and continued until normal breathing has been established.

As soon as artificial respiration has been started, an assistant should loosen all clothes and the patient should be kept warm. No drugs or drinks should be given until the patient is conscious.

When the patient revives, keep him lying down to avoid strain on the heart. In any case the patient should be kept in bed for 24 hours in order to avoid the danger of a hypostatic pneumonia developing.

15. **Procedure with Burns.** If the patient is only suffering from burns, wrap him in any dry clean dressings before medical attention is received. Keep the patient warm (as for shock treatment) and send someone else for the Medical Officer. Stay with the patient until the Medical Officer arrives.

1.2. INTRODUCTION

1. **Details of Radio Equipment.** A summary of information not covered in BR 222 may be found in the following publications:

BR 333(1)	Ships
BR 333(2)	Naval Aircraft
BR 333(3)	Mobiles
BR 333(4)	Shore Stations

2. **Abbreviations used in BR 222.** The following abbreviations are in common use, but are non-standard.

AE	Aerial
A.F.C.	Automatic Frequency Control
A.G.C.	Automatic Gain Control
A.T.U.	Aerial Tuning Unit
B.F.O.	Beat Frequency Oscillator
C.A.W.	Common Aerial Working
COMIST	Communications Improvements In the Short Term
C.C.R.	Communications Control Room
EVOS	Electronic Voice Operated Switching
F.S.T.	Frequency Shift Telegraphy
ICS	Integrated Communications System
L.O.	Local Oscillator
M.C.O.	Main Communications Office
M.O.	Master Oscillator
N.F.	Note Filter
N.L.	Noise Limiter
P.C.C.	Partial Crystal Control
R.C.U.	Radio Control Unit
Rx	Receiver
T.C.U.	Transmitter Control Unit
Tx	Transmitter
V.F.O.	Variable Frequency Oscillator
V.O.G.A.D.	Voice Operated Gain Adjusting Device
XL	Crystal

3. **Frequency Bands**

a. The following designations and authorised abbreviations are approved for combined use throughout the British and U.S. Services.

DESIGNATION OF FREQUENCY	AUTHORIZED ABBREVIATION	FREQUENCY
Very Low	VLF	Below 30 kHz
Low	LF	30–300 kHz
Medium	MF	300–3000 kHz
High	HF	3–30 MHz
Very High	VHF	30–300 MHz
Ultra-High	UHF	300–3,000 MHz
Super-High	SHF	3,000–30,000 MHz (3–30 G Hz)
Extremely High	EHF	30,000–300,000 MHz (30–300 G Hz)

b. By common usage within the Royal Navy the following definitions of frequency bands usually apply. When reference to a frequency band is made in this book (e.g. HF common aerial working) these definitions are intended (see overleaf):

ABBREVIATED DESIGNATION	FREQUENCY
MF	200–600 kHz
HF	1.5–24 MHz
VHF(1) (Military)	23–76 MHz
VHF(2) (Military)	100–156 MHz
VHF (Commercial)	156–162 MHz
UHF	225–400 MHz

c. The following sub-band designations are agreed for British Joint use only.

LETTER DESIGNATION	FREQUENCIES IN MHz	APPROX. MIDBAND WAVELENGTH
L2	300–1,000	60 cm
L1	1,000–2,500	20 cm
S	2,500–4,100	9 cm
C	4,100–7,000	6 cm
X	7,000–11,500	4 cm
J	11,500–18,000	$2\frac{1}{4}$ cm
K	18,000–25,000	$1\frac{1}{4}$ cm
Q	25,000–40,000	9 mm
V	50,000–74,000	6 mm

4. Basic Definitions

a. ASSIGNED FREQUENCY (ITU 85). The centre of the frequency band assigned to a station.

b. ASSIGNED FREQUENCY BAND (ITU 89). The frequency band the centre of which coincides with the frequency assigned to the station and the width of which equals the necessary bandwidth plus twice the absolute value of the frequency tolerance.

c. CHARACTERISTIC FREQUENCY (ITU 86). A frequency which can be easily identified and measured in a given emission.

d. REFERENCE FREQUENCY (ITU 87). A frequency having a fixed and specified position with respect to the assigned frequency. The displacement of this frequency with respect to the assigned frequency has the same absolute value and sign that the displacement of the characteristic frequency has with respect to the centre of the frequency band occupied by the emission.

e. FREQUENCY TOLERANCE (ITU 88). The maximum permissible departure by the centre frequency of the frequency band occupied by an emission, from the assigned frequency or, by the characteristic frequency of an emission from the reference frequency. The frequency tolerance is expressed in parts in 10^6 or in Hertz.

f. FREQUENCY OFFSET (JSP2 except *Note*). The difference between the Assigned Frequency and the Dial Setting.

Note: In certain receiving equipments in the Royal Navy, the Frequency Offset is the sum of the difference between the Assigned Frequency and the Dial Setting, plus the internal (built-in) offset of the equipment.

g. DIAL SETTING (JSP2). The frequency setting shown on the frequency indication display of an equipment (e.g. tuning scale of a receiver or window setting on a control unit). This indication is usually, but not always, the carrier frequency.

h. AUDIO BASEBAND. In the process of modulation, the audio frequency band occupied by all the transmitted signals which modulate the carrier.

i. OCCUPIED BANDWIDTH (ITU 90). The frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5% of the total mean power radiated by a given emission. In some cases, for example multi-channel frequency-division, the percentage of 0.5% may lead to certain difficulties in the practical application of the definitions of occupied and necessary bandwidth; in such cases a different percentage may prove useful.

j. NECESSARY BANDWIDTH (ITU 91). For a given class of emission, the minimum value of the occupied bandwidth sufficient to ensure the transmission of information at the rate and with the quality required for the system employed, under specified conditions. Emissions useful for the good functioning of the receiving equipment as, for example, the emission corresponding to the carrier of reduced carrier systems, shall be included in the necessary bandwidth.

k. SIDEBAND (ACP 167). A sideband is the frequency band, above or below the carrier, produced by the process of modulation.

l. SINGLE-SIDEBAND (SSB) (ACP 167 except *Note*). That system of carrier transmission in which one sideband is transmitted and the other sideband is suppressed. The carrier wave may be either transmitted or suppressed.

Note: When using certain modern equipments in the Royal Navy and requiring to simulate a DSB transmission, it is necessary to transmit SSB (lower sideband suppressed) with full carrier transmission.

m. DOUBLE-SIDEBAND (DSB) (ACP 167). That method of communication in which the frequencies produced by the process of modulation are symmetrically spaced both above and below the carrier frequency and are all transmitted.

n. INDEPENDENT SIDEBAND (ISB) (ACP 167). Independent sideband transmission is that method of communication in which the frequencies on the opposite sides of the carrier, produced by the process of modulation, are not related to each other but are related separately to two sets of modulating signals. The carrier frequency may be transmitted, suppressed, or partially suppressed.

o. CIRCUIT (ACP 167)

(1) *Communication term.* An electronic path between two or more points capable of providing a number of channels.

(2) *Engineering term.* A number of conductors connected together for the purpose of carrying an electrical current.

p. POWER (ITU 94). Whenever the power of a radio transmitter, etc., is referred to, it shall be expressed in one of the following forms:

—peak envelope power (Pp)
—mean power (Pm)
—carrier power (Pc)

For different classes of emissions, the relationships between peak envelope power, mean power and carrier power, under the conditions of normal operation and of no modulation, are contained in Recommendations of the C.C.I.R., which may be used as a guide.

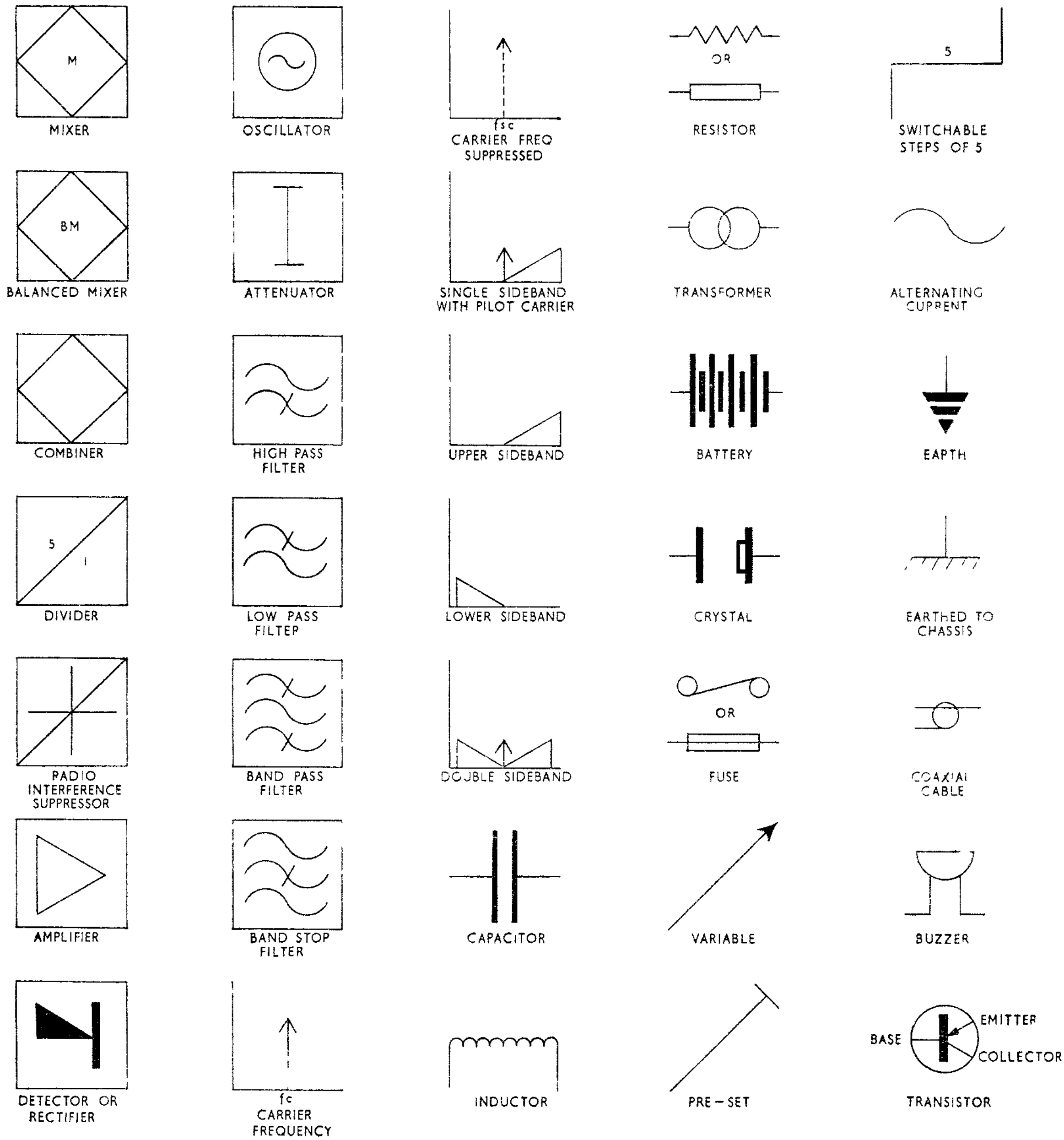
q. PEAK ENVELOPE POWER OF A RADIO TRANSMITTER (ITU 95). The average power supplied to the antenna transmission line by a transmitter during one radio frequency cycle at the highest crest of the modulation envelope, taken under conditions of normal operation.

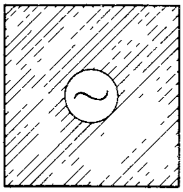
r. MEAN POWER OF A RADIO TRANSMITTER (ITU 96). The power supplied to the antenna transmission line by a transmitter during normal operation, averaged over a time sufficiently long compared with the period of the lowest frequency encountered in the modulation. A time of $\frac{1}{10}$ second during which the mean power is greatest will be selected normally.

s. CARRIER POWER OF A RADIO TRANSMITTER (ITU 97). The average power supplied to the antenna transmission line by a transmitter during one radio frequency cycle under conditions of no modulation. This definition does not apply to pulse modulated emissions.

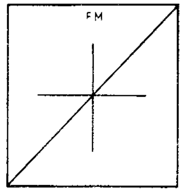
t. EFFECTIVE RADIATED POWER (ITU 98). The power supplied to the antenna multiplied by the relative gain of the antenna in a given direction.

5. Inter-services Standard Graphical Symbols for use in Telecommunication Engineering

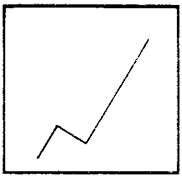




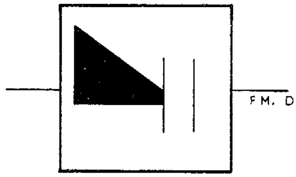
BLOCKING OSCILLATOR



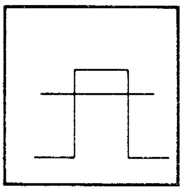
F.M. LIMITER



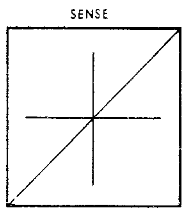
SQUARE ROOTING UNIT



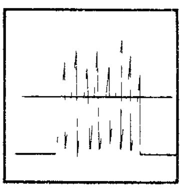
F.M. DISCRIMINATOR



AMPLITUDE CLIPPING UNIT



SENSE LIMITER



MUTING

NOTE THE SYMBOLS ILLUSTRATED ABOVE ARE MORE COMMONLY USED IN BLOCK DIAGRAMS OF ELECTRONIC WARFARE EQUIPMENT (UA3 ETC)

1.3. NOMENCLATURE

1. **RN Nomenclature.** A summary of the more common RN radio type numbers and outfit letters is given below. It is not a complete list.

a. TYPE NUMBERS

86	VHF transceiver
89	HF transmitter
262–293	Radar
405–410	Warning telephone sets
431–443	Hailing equipments
451–458	S.R.E.
601–605	Medium power HF/MF transmitters
609	Submarine marker buoy/transmitter
612	Transportable transmitter/receiver
615	VHF portable
617	Shore Station medium power HF transmitter
618–619	Low power HF/MF transmitter
620–622	Portable sets
623	Medium power HF transmitter (submarines)
625–629	Portable sets
633	Low power SSB transceiver
634–638	Portable sets
640–641	Medium power HF/MF SSB Transmitter
681–689	Low power UHF/VHF sets for radio telephone purposes
691–693	UHF transmitters
696	UHF transceiver
900–999	Radar sets

b. DF OUTFIT LETTERS

AH 4 etc.	Shore HF DF – Fixed aerials
FH 4 etc.	Shipborne HF DF – Fixed aerials
FM 12 etc.	Shipborne MF DF – Fixed aerials
FU 1 etc.	Shipborne UHF DF – Commutated aerial array
FU 3 etc.	Shore UHF DF – Commutated aerial array

c. EQUIPMENT OUTFITS

ACA–AZZ	Aerial outfits
BAc–BCz	Battery outfits
CAA–CUZ	Receiver outfits
DDA–DDZ	a.c. supply outfits
EA–EZ	Aerial exchange outfits
EAA–EAZ	Common aerial working outfits
ETA–ETC	Aerial Base Tuner outfits
FAZ	SSB Adapter for B40/B41
FSA–FSB	Frequency standard outfits
GAA	Two tone keyer
JA–JZ	Radar indicator units
KHA–KHZ	W/T and Voice control systems
KKA	Speech converter equipment
KMM–KMP	Control systems
QA–QZ	Special receivers
REA–REZ	Recording outfits
RWA	RATT outfit

TA–TZ	Trunk outfits
TDA	Transmitter Drive Unit
TEA–TFZ	Tool outfits
TGA–TGE	Teleprinter outfits
THA–THZ	Tool outfits
WBA–WBZ	Wide Band amplifier outfits
YAA–YAZ	E.W. Office Accessory outfits
Group OA	Deck insulator

Note: A receiver CDW is a B40 plus additional equipment as laid down in its associated ‘E’ list. This equipment consists of certain spares and other components necessary for installing this receiver in a ship.

d. Suffix Letters to Transmitter Type Numbers

GROUP	SUFFIX LETTER	MEANING
Type of power supply	E	Battery supply available when main power fails
Portions of set	H L	HF portion only fitted LF MF portion only fitted
Major modifications	No letter M P Q	Original Set *Set after first major modification *Set after second major modification *Set after third major modification
Miscellaneous description	S T	A ship set adapted for shore use Transportable version of a normal transmitter

*A major modification is defined as a modification necessitating the provision of new drawings and ‘E’ Lists.

Note: The only suffix letters likely to be met with at present are those listed above. In certain older ships other suffix letters may be found but these are rapidly disappearing.

2. Army Nomenclature

a. Army personnel may refer to their equipments by leaving out the first few letters in type references. For instance, it is common to refer to the SR A43 as the A43. Much of the vehicle mounted equipment can be operated remotely. For example, vehicle mounted equipment can be operated from a remote control unit sited inside a building while the vehicle is standing in a field outside. In Army nomenclature the first letter immediately preceding the figures denotes power consumption and also gives some indication of the size of the equipment.

LETTER	POWER ~~OUTPUT~~ INPUT	SIZE OF EQUIPMENT
A	0–10 watts	Manpack
B	10–100 watts	Transportable
C	100–1,000 watts	Vehicle mounted/transportable
D	1–10 kW	Mobile or transportable
E	In excess of 10 kW	Static or transportable

b. The two figures denote the frequency range within which the equipment operates.

FIGURES	FREQUENCY BAND
10–39	300 kHz–30 MHz
40–69	30 MHz–3,000 MHz
70–99	Above 3,000 MHz

c. In addition one or two letters in front of the above letter and figures broadly describes the equipment.

LETTERS	MEANING
SR	Station Radio
T	Transmitter
TR	Transceiver
RR	Radio Relay

For example: SR A43 – Station Radio set, Manpack with a power input of between 0 and 10 watts and frequency range in the 30 to 3,000 Megahertz band.

TABLE 1 ARMY EQUIPMENT

TYPE	POWER OUTPUT (Watts)	FREQUENCY RANGE (Megahertz)	TYPE OF EMISSION	POWER SUPPLY	BATTERY LIFE (Hours)	USED BY	AERIALS	RANGE (Miles)	NAVAL EQUIVALENT	REMARKS
SR A13	LP 1½ HP 8 R/T 16 CW	2–8 2–8	Voice CW	12 volt battery	8	Infantry Amphibious and Airborne Forces	8 ft rod Wire. 100 Yards Ground AE	5 LP 12 HP		
SR A14	See Type 635					Infantry and Amphibious Forces			635	Channelization may be different to 635
SR A40	See Type 625					Infantry			625	Channelization may be different to 625
SR A41	0.75W	38–55	Voice(Fm)	135/ 67.5/ 61 11.5V DRY Battery		Infantry		1½–10	626	
SR A43	See Type 634					Air supported Operations			634	Channelization may be different to 634
SR B47	0.5	38–56	Voice	12 or 24 volt battery	Trickle charged	Vehicle radio Army Air Corps Tanks	8 ft rod	3		181 Channels
SR B48	0.5	26–38	Voice	12 or 24 volt battery	Trickle charged	Vehicle radio Artillery	8 ft rod	3		121 Channels
SR C11	50	2–16	Voice CW FST	24 volt battery	Trickle charged	Vehicle radio Divisional and Brigade Command	8 ft rod Dipole	25 200		Uses R210 receiver SSB version also available
SR C13	16	1.5–12	Voice CW	12 or 24 battery	Trickle charged	Vehicle radio Armoured Corps Engineers	12 ft rod Dipole	40 200		200 Watt output model also available

SR C14	50 CW 100 SSB	3–18	DSB SSB CW MCW	24 volt battery	Trickle charged	Formation and Rear Link use	Dipole Rod Wire	300 50 300		4 Spot Frequencies Crystal controlled 4 USB 4 LSB
SR C15	400 SSB 100 CW 100 FST	2–30	DSB SSB CW FST	27.5 volt battery/ Generator		General Air portable roles	15–23 ft rod wire	 60 500		Frequency Shift 850 Hertz (Collins 618T)
SR C42	0.25	36–60	Voice	12 or 24 volt battery	Trickle charged	Vehicle radio General Purpose Tanks	8 ft rod	3–4	631	High power version available
SR C45	0.25	23–28	Voice	12 or 24 volt battery	Trickle charged	Artillery	8 ft rod	3–4	636	High power version available
SR D11	350	2–22	DSB LSB SSB FST CW Voice	100–250 volts a.c. (Generator)		Vehicle mounted Divisional and Brigade Nets	16 ft rod 27–42 ft rod	60 100		Receivers R230 or R234 may be used Normally mounted in a 1 ton vehicle High power version available

3. **USN Nomenclature.** Equipment provided from USN sources can be identified by the system indicator AN/followed by a series of letters and numbers which show what the equipment is capable of and any modifications that have been made to it, e.g. AN/SGC – 1A.

The following table will enable this equipment to be identified more fully.

TABLE 2. IDENTIFICATION OF USN EQUIPMENT

SET OR EQUIPMENT INDICATOR LETTERS			MODEL NUMBER	MODIFICATION LETTER	MISCELLANEOUS IDENTIFICATION
1st Letter INSTALLATION	2nd Letter TYPE OR EQUIPMENT	3rd Letter PURPOSE			
A–Airborne (installed and operated in aircraft) B–Underwater mobile, submarine C–Air transportable (inactivated, not in use) D–Pilotless carrier F–Fixed G–Ground, general ground use (includes two or more ground installations) K–Amphibious M–Ground mobile (installed as operating unit in a vehicle which has no function other than transporting the equipment) P–Pack or portable (animal or man) S–Water surface craft T–Ground transportable U–General utility (includes two or more general installations classes, airborne, shipboard and ground) V–Ground vehicular (installed in vehicles designed for functions other than carrying electronic equipment e.g. tanks) W–Water surface and underwater	A–Invisible light, heat radiation B–Pigeon C–Carrier D–Radiac E–Nupac F–Photographic G–Telegraph or teletype I–Interphone and public address J–Electro-mechanical (not otherwise covered) K–Telemetering L–Countermeasures M–Meteorological N–Sound in air P–Radar Q–Sonar and underwater sound R–Radio S–Special types, magnetic, etc., or combinations of types T–Telephone (wire) V–Visual and visible light W–Armament (peculiar to armament not otherwise covered) X–Facsimile or television	A–Auxiliary assemblies (not complete operating sets) B–Bombing C–Communications (receiving and transmitting) D–Direction finder E–Ejection and/or release G–Fire control or searchlight directing H–Recording and/or reproducing (graphic, meteorological and sound) L–Searchlight control (inactivated, G will be used) M–Maintenance and test assemblies (including tools) N–Navigational aids (including altimeters, beacons, compasses, racons, depth sounding approach and landing) P–Reproducing (inactivated, not in use) Q–Special or combination of purposes R–Receiving, passive detecting S–Detecting and/or range and bearing T–Transmitting W–Control X–Identification and recognition	1 2 3 4 etc	A B C D etc	X) Change Y) in supply Z) voltage, phase or frequency T-Training

Note: Specific experimental indicators have been established to identify previous-to-production equipment made by certain US Government laboratories. These indicators consist of the letter X and one other letter.

e.g. XA–Communications Navigation Laboratory, WADC, Dayton, Ohio.

XN–Department of Navy, Washington DC.

4. **UK Joint Nomenclature for Communication Equipment**

a. Agreement has now been reached on a UK Joint System for the nomenclature of communication equipment to ensure that the three Services use the same title to identify equipment in common use. The method selected allows the title to give some indication of the characteristics and use of the equipment and in this respect is based on the system used hitherto by the US Forces.

b. The system will eventually be applied to all basic communication equipments including EW equipments, but not to COMSEC equipments and installations or to ancillary outfits, since these are very often single service additions to the basic set.

c. It is not intended to use this nomenclature in retrospect (1967) except in the case of CLANSMAN and SKYNET earth station equipments. Future common use equipments will be titled in accordance with the Joint nomenclature.

d.

(1) The nomenclature of an item of equipment consists of:
- (a) National identification
- (b) Type of installation
- (c) Type of equipment
- (d) Purpose
- (e) Identity number

(2) The national identification letters are UK.

(3) Type of installation, type of equipment and purpose indicators are taken from the following table:

1st Letter TYPE OF INSTALLATION	2nd Letter TYPE OF EQUIPMENT	3rd Letter PURPOSE
A – piloted aircraft	C – carrier	A – auxiliary assemblies
B – underwater mobile, submarine	G – telegraph or teleprinter	C – communications (RX & TX)
D – pilotless carrier	T – interphone and public address	D – direction finder
F – fixed ground	J – electromechanical	H – recording and/or reproducing
G – general ground use	K – telemetry	K – computing
K – amphibious	L – countermeasures	M – maintenance and/or test assemblies
M – ground, mobile (special signal vehicle)	M – meteorological	R – receiving
P – man portable	R – radio	T – transmitting
S – surface craft/ships or buoys	S – special types or combination of types	
T – ground transportable	X – facsimile or television	
U – general utility	T – [illegible]	
V – ground, vehicular (any vehicle)		
W – surface craft and underwater craft combination		

(4) Identity numbers are taken from the following blocks:

RN	001 to 300
ARMY	301 to 600
RAF	601 to 999

The numbers will be taken in sequence from each block by the sponsoring service.

(5) *Example.* UK/PRC–334 would be a man-portable radio communication transmitter/receiver sponsored by the Army, and allocated number 334.

1.4. RN COMMUNICATION EQUIPMENT

1. The COMIST (Communications Improvement in the Short Term) programme introduced SSB equipment into ships which were not ICS fitted, to give the Fleet a SSB capability as quickly as possible. As a result, ships were fitted with a wide variety of equipments. This variety of fits has now been standardised as shown in table 1. All ships will become Standard 3 in due course.

TABLE 1. RN COMMUNICATION STANDARD FITS

NEW TITLE	EQUIPMENT	OLD TITLE	TYPE OF SHIP
STANDARD 2	640 and CJK Phases A, B, C, D RWA included in later Phases Most ships have had their final numbers of SSB receivers made up by CJAs instead of more CJKs	COMIST	Most ships in commission in 1963
STANDARD 3A	ICS: KMM: RWA	STANDARD 3	All new construction 1965–1969
STANDARD 3B	640 and base tuned whips ICS reception; KMP: RWA	STANDARD 3 MIXED	Type 12, 41, 61 and 81 at first long refit after 1966
STANDARD 3C	As for 3A except:- TDC vice TDA CJM vice CJA EY(2) vice EY (better connections) FSA3 vice FSA1 EZ(2) vice EZ (contains L.F/M.F Adaptor) CJN vice B40/41/FAZ and CJC Modified TCU (1 per Tx for both USB and LSB)	NONE	New construction 1969 onwards (Some items only may be fitted in earlier ICS Ships)
STANDARD 3D	As for STANDARD 3B but with ICS reception to STANDARD 3C	NONE	Types 12, 41, 61 and 81 whose next long refit is 1969 or later

Note:—The fitting shown above omits that STANDARD 3A has been retrospectively fitted in *Eagle Hermes*, and *Ark Royal*, and that *Leanders* 1–4 and *DLGs* 1–4 will be fitted with STANDARD 3C.

1.5. SUBMARINE COMMUNICATION EQUIPMENT

1. Introduction

a. Notwithstanding that most of the communications equipment fitted in submarines is similar to that fitted in surface vessels, the necessary limitations in size, weight, ventilation and performance have meant that some equipment, or units of equipment have had to be extensively modified or specially designed to fulfil submarine requirements.

b. The actual composition of the equipment fitted in any submarine will depend to a very great extent on the modernisation programme and the role a particular vessel is designed to fulfil.

c. Submarines in use today are grouped into three main types, as follows:

Fleet Ballistic Missile Submarines (SSBN)

(*Resolution* class) referred to within the Royal Navy as Polaris submarines.

Fleet Submarines (SSN)

A general purpose submarine capable of sustained submergence at fleet speed or greater and equipped to act in close support of a surface force when so required. (*Dreadnought*, *Valiant*, *Warspite*, *Churchill*).

Patrol Submarines (SS)

A general purpose submarine not capable of sustained submerged speed at fleet speed and not therefore capable of acting in close support of surface forces. (*Oberon*, *Porpoise*, A and T class).

d. Summaries of the more common equipments fitted in submarines are given hereunder. Fuller information will be found in the relevant sections of this publication, or the equipment handbooks.

2. UHF Equipment

a. Type 696

Frequency range	225–400MHz
Frequency determination	Frequency synthesis
Channel Change	Dial selection
Emission	Voice or MCW
Power output	14W

3. HF Transmission

a. ICS Outfit TDA/WBC

Frequency range	1.5–24MHz
Frequency determination	Frequency synthesis from highly accurate and stable frequency standard outfit FSA2
Emission	DSB, ISB, SSB – Voice, FST, CW or MCW
Power output	Up to 1kW (PEP)

b. Type 623

Frequency range	1.5–24MHz
Frequency determination	VFO or crystal
Emission	CW only
Power output	400W

c. Type 619H

Frequency range	1.5–16MHz
Frequency determination	VFO or crystal
Emission	CW, MCW or Voice
Power output	40W

d. Type TCS

Frequency range	1.5–12MHz
Frequency determination	VFO or crystal
Emission	CW or Voice
Power output	40/20W

4. **HF Reception**

a. ICS receiver outfit CJA, providing reception of DSB, ISB, SSB - Voice, FST, CW or MCW between 2 and 30MHz, employing free tuning or unattended synthesised reception.

b. Receiver outfit CDW (B40), providing DSB reception of Voice, CW or MCW between 640kHz and 30MHz.

5. **VLF Reception**

a. ICS receiver outfit CJD, providing CW, MCW, Voice or FST reception from 10 to 200kHz, employing free tuning or unattended synthesised reception.

b. Receiver outfit CFA, providing CW ~~reception from 14 to 22.5kHz.~~

c. Receiver outfit CDY (B41), providing DSB reception of Voice, CW, MCW, from 15kHz to 700kHz.

6. **RATT Facilities**

a. Broadcast Reception

TTVF(B)	Converts audio tones from the broadcast receiver into a keyed tone.
TT 11	Changes keyed tone into a D.C. voltage as the keying function for the teletypewriter.
TGB(3)	Model 12, Mk3, teletypewriter, 50 or 75 bauds.

b. Transmission and Reception

TTVF(T)	Converts the audio signal from the receiver into tone on/off keying function when in the receive condition. In the transmit condition it acts as a tone generator on one of two channels, either 500/700Hz or ~~2125/2975Hz~~. 1275 2125 Hz
TT10	Changes DC teletypewriter functions into tone on/off for transmission and vice versa for reception. It incorporates lamp indication and a CW facility.
TGB(3)	Model 12, Mk3, teletypewriter, 50 or 75 bauds.
6S6	Provides tape-reading keying functions at 50 bauds, or 75 bauds
SUR	A Switch Unit Radio, which permits the DC voltages necessary for control of the transmitter to be outside the area of the teletypewriter terminal, as well as converting tone on/off into DC for keying the transmitter.

7. **On Line Equipment.** Details of the equipment associated with the outfit RWA are given in the relevant publication. On line equipment for both reception and transmission may be fitted.

8. **Submarine Indicator Buoy (Type 609).** One buoy is stowed forward and one aft in the submarine casing. They can be released from inside the submarine to float to the surface as a visual indication of the submarine's position. Each buoy contains a battery powered transmitter which radiates SUBSUNK distress calls and transmissions for direction finding purposes on 4340kHz.

9. Summary of Equipment Fitted

OUTFIT	FLEET	PATROL
696	one fitted, one spare	one fitted, one spare
ICS	two TDA/WBC	
623		one
619H	one	one
TCS		one may be fitted in lieu of 619H
CJA	two	
CDW	one	two
CJD	one	
CDY		two
CFA	two	one of each of CDY and CFA ONLY if aerial outfit ALK is fitted

10. Summary of Submarine Communication Aerials

OUTFIT	FORM	CLASSIFICATION AND FREQUENCY RANGE	POWER	USED WITH	REMARKS
ALE	Periscopic/Telescopic	HF TX 1.5–24MHz VHF TX/RX 100–156MHz	400W HF	623/86M	
ALF	Two fin-mounted loops	VLF/LF RX 15–550kHz		B41	via special loop coupling unit
ALG	Periscopic/Telescopic	HF TX 1.5–24MHz UHF 225–400MHz	400W HF	623/696	Identical to ALE but UHF
ALJ	Stub	UHF 225–400MHz	20W	696	Only 3 units made
ALK	Buoy (Ferrite)	VLF RX 15–25kHz		CFA	Control unit built into CFA
ALL	Fin mounted ALK	VLF RX 15–25kHz		CFA	Control unit built into CFA
ALM	Fin mounted (Ferrite)	VLF/LF RX 10–200kHz		CJD	Separate VLF exchange reqd.
ALN	Periscopic/Telescopic	HF TX 1.5–24MHz UHF TX/RX 225–400MHz	400W ~~HF~~ 1kW	~~696~~	~~Modified ALQ~~
ALO	Fin mounted (Ferrite)	VLF/LF RX 10–200kHz		CJD	Separate ae exchange reqd.
ALP	Buoy (Ferrite)	VLF/LF RX 10–200kHz		CJD	Separate ae exchange reqd.
ALQ	Buoy	~~VLF/HF/UHF~~ HF TX 2-30 MHz	1kW	~~WBA~~	Currently under development
AMK1	Buoy	UHF TX/RX 225–400MHz	20W	696	Mounted on outfit AYG
AMK2	Stub	IFF			Mounted on own pedestal mast
AWJ	Emergency whip	HF TX/RX ~~1.5–24~~ 2-30 MHz	400W	623/619	
AWO	Hinged whip	HF TX/RX 1.5–24MHz	400W	623/619	
AWU	Special purpose whip	Navigational aid			Mounted on AN/BRA mast
ALT	Floating wire	VLF RX			Includes winding gear
ALU	Floating wire	HF RX 2-30			Includes winding gear
AN/BRA	Periscopic/Telescopic	HF TX/RX ~~1.5–24~~ MHz	1kW	~~WBA~~	Mast outside pressure hull

1.6. AIRCRAFT EQUIPMENTS

1. **General.** This Section summarises the various equipments fitted in Fleet Air Arm and some FRU aircraft.

2. **Nomenclature.** The majority of aircraft equipments are known by an ARI number and another alternative; these are listed below. For the purpose of reference in subsequent paragraphs the ARI nomenclature has been used.

ARI NUMBER	OTHER TITLE
5489	TR1936
	TR16440
5491	TR1934
	TR1935 + relay
18032	HF
18124/1	ARC 52 UHF DC version
18124/2	ARC 52 UHF AC version
18179/1	SSB HF (Mullard)
18197/1	PTR 170 Light-weight UHF without Homer
18197/2	PTR 170 Light-weight UHF with Homer PV 141
23057	Stand-by UHF
23090	Type 618T Collins HF TR
23117	Marconi 60 VHF

HF EQUIPMENTS

3. **Fitting Policy.** It is the current policy to fit all aircraft in the Fleet Air Arm with improved HF equipment to provide a significant improvement in voice ranges. The fitting programme concerns the following types:

a. Buccaneer Mk I — ARI 18179/1

b. Buccaneer Mk II — ARI 23090

c. Wessex Mk I — ARI 18032 (being changed to ARI 23090)

d. Wessex Mk I & III — ARI 23090

e. Wessex Mk V — ARI 23090

f. Gannet AEW Mk III — ARI 23090

4. **ARI 23090 (Collins 618T)**

a. WHERE FITTED:

(1) Buccaneer Mk II — 618 T2
(2) Wessex Mk I & III — 618 T3
(3) Wessex Mk V — 618 T3
(4) Gannet AEW Mk III — 618 T3

b. FREQUENCY RANGE (in whole number of kHz steps only)

(1) 2 to 30 MHz
(2) 2 to 25 MHz when antenna tuner 180 – 3A is in use

c. FREQUENCY DETERMINATION. Synthesiser, tuning to the suppressed carrier frequency. Any whole number of kHz within the frequency range can be selected on the cockpit control unit. This means that aircraft fitted with this equipment can only man SSB voice circuits whose assigned frequency ends in 0.5 kHz.

d. STABILITY 1 in 10^6

e. POWER OUTPUT

(1) SSB Voice	400W (PEP)
(2) DSB (AM) Voice	100W
(3) CW	100W

f. POWER SUPPLIES AND POWER CONSUMPTION

(1) 618 T2

(a) 27.5V DC Transmission and Reception draws 100W

(b) 115V 400Hz Transmission draws 650VA (SSB) or 700VA (DSB)
3 phase AC Reception draws 550VA

(2)

(a) 115V 400Hz Single phase AC drawing 100W

(b) 27.5V drawing 950W

g. EMISSION

(1) SSB Voice – Upper or Lower sideband

(2) DSB (AM) Voice

(3) CW (This facility is not normally connected in aircraft)

h. WEIGHT

UNIT	WEIGHT	
Transreceiver	50 lb	
Control Unit	2 lb	
Antenna tuner	18 lb	4 oz
Transreceiver mounting tray	5 lb	
Antenna tuner mounting tray	1 lb	4 oz
Total	76 lb	8 oz

5. ARI 18179 (Mullard SSB)

a. WHERE FITTED:

(1) Buccaneer Mk I

(2) Some Wessex Mk I

b. FREQUENCY RANGE

2 to 20 MHz

c. FREQUENCY DETERMINATION. 12 preset crystal controlled channels in 3 ranges:

(1) Range 1 – 2.5 to 5 MHz

(2) Range 2 – 5 to 10 MHz

(3) Range 3 – 10 to 20 MHz

d. STABILITY. 1 part in 10^8

e. POWER SUPPLIES AND POWER CONSUMPTION

(1) 28V DC – Transmission and reception draws 270W

(2) 200V 400 Hz – Transmission draws 685VA
3 phase AC – Reception draws 190VA

f. Emission. Upper sideband Voice (controlled carrier)

g. Weight

(1) Transreceiver

UNIT	WEIGHT	
Generator	35 lb	
Power Supply	26 lb	8 oz
Amplifier	13 lb	8 oz
Transmitter/Receiver	29 lb	8 oz
Interconnector Box	2 lb	
Control Radio Set	–	
Total	106 lb	8 oz

(2) Aerial System

UNIT	WEIGHT	
Tuner Radio Frequency	15 lb	5 oz
Network Impedance Matching	2 lb	7 oz
Selector Unit	10 lb	7 oz
Connector RF	1 lb	8 oz
Mounting	2 lb	1 oz
Total	31 lb	12 oz

6. **ARI 18032 (HF DSB Set).** Still fitted in some AEW aircraft, Wessex Mk 1 and Whirlwind helicopters, 4 channel VFO control. This equipment will be replaced by ARI 23090 in AEW and Wessex in due course.

V/UHF EQUIPMENTS

7. **General.** All naval and FRU aircraft are UHF fitted. The current policy has been to fit all rotary wing and a limited number of second line fixed wing aircraft with a lightweight 12 channel crystal UHF set (ARI 18197). This set has known limitations but now works up to its designed performance. It is to remain in service for some time. The majority of fixed wing aircraft and all front line fixed wing aircraft carry ARI 18124, with 1750 channels, which are available through the operation of a manual dial control on a separate unit.

8. The replacement set for existing UHF equipment is under consideration and will probably provide UHF and VHF coverage in one set, the same size and weight of the ARI 18124, with 50 kHz channel spacing.

9. The need for a lightweight equipment to cover the band from 30 MHz to 400 MHz is known. This is especially necessary for the co-operation by helicopters and ground attack aircraft with forward Army units which do not use UHF. The Army front line units operate on VHF frequencies between 40 and 60 MHz. This equipment is the subject of a Joint requirement.

VHF EQUIPMENT

10. **ARI 5489 (Type 1936 series).** There are now three versions of the original TR1936 equipment: TR1936, TR1936B and TR16440. The differences are shown below:

a. WHERE FITTED
(1) TR1936 & TR1936B. Whirlwind SAR aircraft and Sea Prince (T).
(2) TR16440. Sea Devon, Sea Heron and Sea Prince communication aircraft.

b. FREQUENCY RANGE. 115 to 145 MHz

c. FREQUENCY DETERMINATION AND CHANNEL SPACING
(1) TR1936. 10 crystal controlled channels – 180 kHz spacing.
(2) TR1936B. 10 crystal controlled channels – 50 kHz spacing.
(3) TR16440. 44 channel version of TR1936.

d. STABILITY. ±0.005% of the crystal in use.

e. POWER OUTPUT. 8 to 10W.

f. POWER SUPPLY AND POWER CONSUMPTION. 27.5V DC – Transmitter draws 220W and Receiver draws 180W.

g. EMISSION. Voice.

h. PERFORMANCE. 100 miles air to ground at 10,000 ft.

i. Weight

	UNIT	WEIGHT
	Transreceiver	26 lb 8 oz
	Control Unit	10 oz
Total		27 lb 2 oz

UHF EQUIPMENT

11. ARI 18124 (AN/ARC 52)

a. WHERE FITTED. All fixed wing front line aircraft and the majority of second line aircraft.

b. FREQUENCY RANGE. 225 to 399.9 MHz.

c. FREQUENCY DETERMINATION AND CHANNEL SPACING. 20 channels of which 18 may be preset to any of 1750 frequencies. 1 Guard (243 MHz), 1 Manual. Channel spacing 100 kHz.

d. STABILITY. + or — 10 kHz.

e. POWER OUTPUT. Minimum 12W, average 18W.

f. POWER SUPPLY AND POWER CONSUMPTION. 27.5V DC – Transmitter and channel change draws 467W. Receiver draws 343W.

g. EMISSION. Voice, Tone (in Emergency).

h. PERFORMANCE. 200 miles air to air – ground to air (with aircraft at 45,000 ft).

i. WEIGHT.

	UNIT	WEIGHT	
	Transreceiver	50 lb	
	Control Unit	3 lb	
Total		53 lb	(including mounting tray, control receiver Manual and Interconnecting box)

Notes: 1. Set is pressurised.

2. The transreceiver incorporates an additional, self contained receiver set up on 243 MHz. This enables the operator to monitor 'guard' simultaneously with manual reception of the channel in use, provided the control unit switch is to T/R + Guard.

3. The control unit has 4 positions:
   1. OFF
   2. T/R
   3. T/R + Guard
   4. ADF*

*ADF applies power to the Violet Picture Homer which operates when the ADF switch is made.

12. **ARI 18197 (PTR 170)**

a. WHERE FITTED. All Wasps, some other rotary wing and some fixed wing second line aircraft.

b. FREQUENCY RANGE. 225 to 399.9 MHz.

c. FREQUENCY DETERMINATION AND CHANNEL SPACING. 12 preset crystal channels from any 1750 in the frequency range, there is no dialling facility. Channel spacing 100 kHz.

d. STABILITY. + or ± 10 kHz.

e. POWER OUTPUT. Nominal 2W.

f. POWER SUPPLY AND POWER CONSUMPTION. 27.5V DC – Transmitter and channel change draws 4.5W. Receiver draws 3.5W.

g. EMISSION. Voice, Tone (in emergency).

h. PERFORMANCE. Approximately 50 miles Air to Air, Air to Ground (above radio horizon).

i. WEIGHT.

UNIT		WEIGHT	
Transreceiver		23 lb	
Control Unit		$1\frac{1}{4}$ lb	
	Total	$24\frac{1}{4}$ lb	Includes mounting tray

Note: When aircraft also carries Homer PB141 the UHF installation is given number ARI 18187/2.

13. **ARI 23057 (Standard UHF set)**

a. WHERE FITTED. All fixed wing and larger rotary wing aircraft.

b. FREQUENCY RANGE. 238 to 248 MHz.

c. FREQUENCY DETERMINATION. 2 crystal controlled channels one set to 243 MHz and the second one not more than 1 MHz above or below this.

d. POWER OUTPUT. 3W.

e. POWER CONSUMPTION. 85W.

f. POWER SUPPLIES. 24V DC either from mains or battery.

g. EMISSION. Voice, Tone (in emergency).

h. PERFORMANCE. 100 miles over radio horizon.

i. WEIGHT. Transreceiver 11 lb.

Notes: 1. Can provide audio side tone for use on Intercom when transreceiver is to RECEIVE.

2. Control switches which are under pilot's control give:
   1. Main/Stand by UHF.
   2. Guard/Alternate frequency (on stand by set).
   3. Normal/Emergency power (for stand by set).

3. Power unit may be transistorised in different makes in which case weight is reduced to 8 lb 5 oz.

OTHER EQUIPMENT

14. UHF homing facilities are provided in all UHF fitted aircraft except for some joint V/UHF fitted second line aircraft who carry, either a radio compass, or a VHF homer. Two UHF homers are in current use, each associated with the UHF set carried in the aircraft.

15. **ARI 11820 (Violet Picture)**

a. WHERE FITTED. All front line aircraft equipped with ARI 18124.

b. FREQUENCY RANGE. 225 to 400 MHz.

c. Will operate with CW, MCW or Voice transmissions on the frequency selected from the ARI18124.

d. POWER SUPPLIES. 225V HT from ARI 18124
28V LT from ARI 18124
28V LT from aircraft supply.

e. PERFORMANCE. 100 n.m. ground to air, 200 n.m. air to air, above radio horizon.

f. WEIGHT.

UNIT	WEIGHT
RF Unit	10 lb 12 oz
AF Unit	5 lb 4½ oz
Indicator	1 lb 7 oz
Aerial	1 lb 8 oz
Total	18 lb 15½ oz

g. HOMING INDICATION. In azimuth 'Left or Right'.
In elevation 'Up or Down'.

Notes: 1. ARI 18120 is suffixed with '1 to 4' to indicate modification necessary to adapt it to various aircraft, e.g. Homer in Buccaneer is 18120/4
Homer in Vixen is 18120/1

2. Homer is blanked by a muting switch from own aircraft transmissions.

16. **ARI 18197/2 (PV141)**

a. WHERE FITTED. All ARI 18197 fitted aircraft except Hillers.

b. FREQUENCY RANGE. 225 to 399.9 MHz.

c. Will operate with CW, MCW and Voice transmissions on the frequency selected by the ARI 18197.

d. POWER SUPPLY. 28V DC.

e. As for reception by ARI 18197.

f. WEIGHT. 4 lb 11 oz including mounting tray.

g. Homing Indication. In azimuth only 'Left or Right'.

Note: Homer is blanked by a muting switch from own aircraft transmissions.

UHF PERSONNEL BEACONS (SEARCH AND RESCUE (TYPE 958))

17. Beacon equipments (SARBE) are provided for aircrew and are fitted inside Mae West life jacket. This equipment is also being fitted in liferafts carried in ships.

18. **ARI 23157 (SARBE Mk III)**

a. Where Fitted. Mae Wests of air crews.

b. Frequency. 243 MHz.

c. Frequency Determination. Single crystal control for transreceiver.

d. Emission. Voice or beacon.

e. Stability. + or − 15 kHz.

f. Power Output.

(1) Beacon 0.4W AF modulated pulses.

(2) Transmit Voice 100 mW.

g. Power Supply. Kalium battery unit. 150V/6V/1.34V.

h. Modulation. Beacon PRF 0.25 – 0.5 Hz.
Beacon modulation 1020 + or − 250 Hz.
Modulation depth not less than 40%.

i. Performance. Beacon – greater than 60 miles sea to air.
Voice – 10 miles sea to air, optical range sea to sea.
Battery life – 8 to 20 hours dependent on mode.

j. Weight.

UNIT	WEIGHT	
Speech and T/R unit	2 lb	1 oz
HT/LT battery	3 lb	7 oz
LT battery pack including microphone convertor	2 lb	15½ oz
Total	8 lb	7½ oz

k. Beacon. Beacon operation is achieved as soon as the aerial is released from its holding container. When the beacon is operating a distinctive pip pip noise is emitted from the speech unit.

Note: The set is built to withstand pressure of ejection from aircraft at 70,000 ft and immersion to a depth of 30 ft in water.

SARBE WITH TRANSISTORISED BEACON

19. A fully transistorised Beacon is being fitted to replace the older type with the following improvements.

a. Modulation Depth. 100% (Carrier reduced to zero between pulses).

b. Operation Range. Greater than 60 n.m. sea to air (at 10,000 ft)
Greater than 40 n.m. sea to air (at 5,000 ft)
Greater than 15 n.m. sea to air (at 500 ft)

c. Power Output. 400 mW PEP nominal.

d. Power Supply. 10.7V plus 1.34V Bias Kalium battery.

e. WEIGHT.

UNIT		WEIGHT	
Beacon			$10\frac{1}{2}$oz
Battery		1 lb	6 oz
	Total	2 lb	$\frac{1}{2}$oz

20. **ARI 23099 (Centralised Audio Selection System (C.A.S.S.)).** The Centralised Audio Selection System made by Ultra Electronics and designated ARI 23099 is fitted in the Wessex Mk V and Buccaneer Mk II aircraft. C.A.S.S. provides complete facilities for the control of all radio installation within the aircraft. Each crew member has a 'station box' which permits him to select whichever facilities are required quite independently of the other crew members, while at all times retaining a common intercom.

21. **Procedure for the supply of crystals.** When an A/S helicopter flight consisting of Wasp and Wessex helicopters fitted with ARI 18197 is formed for a small ship, the signal officer of the air station at which this takes place will demand one set of ARI 18197 crystals to cover the channelisation given in the A/S helicopter table in RNCP 4. At the earliest opportunity the ship must demand crystals for:

a. The duplicate set of the RNCP 4 A/S helicopter table channelisation.

b. Two of each crystal laid down in RNCP 13 under Group 34A, which are not included in the RNCP 4 A/S helicopter table.

1.7. MERCHANT SHIP AND R.F.A. EQUIPMENTS

1. **International Rules and Requirements.** The Merchant Shipping (Radio) Rules, 1965 which came into force in May of that year, outline the rules and equipment requirements for merchant ships to a scale dependent on type and tonnage.

2. **Classification of Merchant Ships**

a. Class 1. Steamers licensed to carry more than 250 passengers.

b. Class 2.

(1) Passenger steamers other than those of class 1.

(2) Cargo ships of 1600 tons and upwards.

c. Class 3. Cargo ships of between 500 and 1,600 tons.

d. Class 4. Cargo ships of between 300 and 500 tons.

e. Classes 1 and 2 are subject to the rules for radio-telegraph ships, classes 3 and 4 to those for radio-telephone ships.

3. **Requirements.** The following are the general minimum requirements for merchant ships:

a. Auto Alarm	Obligatory to classes 1 and 2
b. Alarm Generating Device	Obligatory in all classes
c. Emergency Installations	Transmitter and receiver separate from the main installations are obligatory in classes 1 and 2
d. Loudspeaker Watch Facilities	Obligatory in all classes. May be provided by the reserve or auto-alarm receiver in radio-telegraph ships
e. Direction Finding Equipment	Obligatory in ships over 1,600 tons
f. Main Radio Telegraph Installation	Transmitter and receiver, obligatory in classes 1 and 2
g. Main Radio Telephone Installation	Obligatory in classes 3 and 4
h. VHF (FM) Equipment	Not obligatory for any category, but is widely fitted in large merchant ships

4. **Types of Equipment.** The performance specifications of the equipment used are required to include the following facilities:

a. Main Radio Telegraph Transmitter	MF, CW and MCW on 500 kHz and at least four other spot frequencies in the range 405 to 525 kHz. Normally covers MF/HF 365 to 540 kHz and 3 to 23 MHz, e.g. Worldspan, Oceanspan, Globespan
b. Reserve Radio Telegraph Transmitter	MF CW on 500 kHz
c. Reserve Radio Telegraph Receiver	Frequency coverage 405 to 535 kHz, 1,605 to 3,800 kHz and through maritine mobile bands between 4 and 23 MHz
d. DF Equipment	Frequency coverage 255 to 525 kHz
e. VHF Equipment	Frequency coverage 156 to 162 MHz

5. **Merchant Shipping War Requirements.** The minimum requirements listed above are laid down in statutory regulations issued by the Ministry of Transport. Technical specifications are issued by the GPO. In addition to the statutory regulations, MOD (Navy) lays down certain wartime requirements. Although it would be ideal if ships conformed to these regulations in peacetime, it is not practicable to order them to do so. By close co-operation between all concerned the requirements are fulfilled as far as possible, and space left for the necessary equipment to be quickly fitted on the outbreak of war.

6. **MOD (Navy) Desired Additional Radio Communication Equipment.** The following radio equipment is desired by the MOD (Navy) to be fitted in time of war. This equipment is additional to that required by statutory regulations.

a. SHIPS ABOVE 1600 GROSS TONS.

(1) *HF*

(a) Main Transmitter
Power output – minimum – 100 watts
aim – 200 watts or more
See notes (i) and (ii)

(b) Emergency and Secondary Transmitters
HF frequency range need not extend above 13 MHz
Frequency range up to 23 MHz desirable
Power Supply – batteries of same endurance as required for emergency (Rescue) MF transmitter
See notes (i), (ii), (iii) and (iv)

(c) Receiving Equipment
Receiving equipment corresponding to the frequency range of the HF main transmitter
See notes (i) and (ii)

(d) Emergency Receiving Equipment
Emergency receiving equipment corresponding to the frequency range of the HF Emergency transmitter
See notes (i), (ii), (iii) and (iv)

Notes

(i) This equipment may be combined with the MF equipment required by International regulations

(ii) Where ship owners do not feel justified in fitting such equipment in peacetime, it is strongly urged that space be allocated and reserved for installation during war.

(iii) This equipment shall be fitted in a compartment sited as far as practicable from the ship's radio office, and in such a position as is afforded as much protection as possible.

(iv) This equipment shall use an aerial or aerials other than those used for the ship's normal equipment.

(2) *VHF/FM Equipment.* In time of war, VHF/FM transmit and receive equipment is a requirement for Convoy Tactical Communications and, therefore, should be fitted in all Allied Merchant Ships. VHF/FM has a world-wide peacetime application and, ideally, merchant ships of all nations should eventually be so fitted. NATO nations should encourage their shipping authorities to fit VHF/FM in all ships. This equipment should be located as near the bridge as possible.

b. SHIPS BELOW 1600 GROSS TONS (other than harbour craft). VHF/FM Equipment. In the event of war, such of these ships as are detailed to proceed in convoy will require VHF/FM transmit and receive equipment for Convoy Tactical Communications. This equipment should be located as near the bridge as possible.

c. OTHER SHIPS. If vessels in this class are required to proceed more than 300 miles from land, National Naval Ministries should arrange to fit such additional radio communications equipment as may be thought necessary for the vessel's safety.

7. **Capabilities of MF/HF Transmitter Equipments**

a. OCEANSPAN: MARCONI MARINE RADIO TRANSMITTER NS301

Frequency range: 410 to 512 kHz, 4 to 22 MHz with 37 preset frequencies.

Facilities MF CW/MCW
HF CW/Voice

Power output 100 to 120 watts
Frequency stability MF 0.02%
HF 0.005%

b. Globespan: Marconi Marine Radio Transmitter NT302

Frequency range: 405 to 525 kHz (7 preset channels)
1.6 to 3.8 MHz
4, 6, 8, 12, 16 and 22 MHz maritime bands with 5 preset channels in each band

Facilities: MF – CW/MCW
IF – CW/MCW/Voice
HF – CW/Voice

Power output: MF – 275 watts
IF – 100 watts
HF – 400 watts

Frequency stability: MF – .02%
HF – .001%

c. Worldspan: Marconi Marine Radio Transmitter

Frequency range: 365 to 540 kHz
3 to 23 MHz

Facilities: CW/MCW/Voice

Power output: Medium

d. DS9B: International Marine Radio Transceiver

Frequency range: 2.5 to 22 MHz

Facilities: General purpose SSB transceiver

Power output: Low

e. Transarctic: Marconi Marine Transceiver

Frequency range: Transmitter: 375 to 500 kHz and 1.5 to 13 MHz
Receiver: 180 to 520 kHz and 600 kHz to 13 MHz

Facilities: CW/MCW/Voice

Power output: 45 to 70 watts according to emission

Frequency stability: MF – 0.1%
HF – 0.02%

8. **Capabilities of MF/HF Receiver Equipments**

a. Mercury: Marconi Marine Radio Receiver NS601

Frequency range: 15 to 40 kHz and 100 kHz to 4 MHz

b. Electra: Marconi Marine Radio Receiver NS301

Frequency range: 250 to 520 kHz and 1.5 to 25 MHz

c. Atlanta: Marconi Marine Radio Receiver NS702

Frequency range: 15 kHz to 28 MHz

d. Lodestone: Marconi Marine Radio Receiver ND101

Frequency range: 250 to 550 kHz

9. **Capabilities of VHF Equipments**

a. Argonaut: Marconi Marine VHF Transceiver NTS403

Frequency range: Transmitter: 156 to 158.8 MHz

	Receiver:	156 to 163.4 MHz (available in 40 channels with provision for 7 to 10 extra channels if required)
Power output:	20 watts	

10. **Capabilities of Emergency Equipments**

a. Reliance: Marconi Marine Emergency Radio Transmitter NT102

Frequency range: 365 to 525 kHz
Facilities: CW/MCW
Power output: 120 watts

b. Lifeline: Marconi Portable Emergency Transmitter Type 600

Frequency: 2182 kHz
Facility: Voice or two-tone alarm
Power output: 1.4 watts

c. Salvita: Marconi Marine Lifeboat Transmitter Type NTS303

Frequencies: Transmitter: 500 kHz crystal controlled
8364 kHz crystal controlled
500 kHz crystal controlled
Facility: MCW
Power output: 3.5 watts

d. Autokey: Marconi Marine Automatic Sender NM102. Fitted to key either an alarm or distress signal automatically.

e. Vigilant: Marconi Auto Alarm Receiving Apparatus NS102. A receiver for 500 kHz, incorporating a bell alarm operated on receipt of the full automatic alarm. This equipment is now being superseded by SAFEGUARD.

f. Seaguard: Marconi Automatic Alarm Receiving Apparatus NS703. A later model receiver to VIGILANT covering the frequency range 487 to 512 kHz, incorporating a bell alarm operated on receipt of the first dashes of the automatic alarm.

g. Alert: Marconi Marine Emergency Guard Radio Receiver NS101. An emergency receiver operable only on 500 kHz.

11. **Royal Fleet Auxiliaries**

a. Equipment. The required standards of equipment for R.F.A.s are laid down in current D.C.I.s. They are at present similar to the statutory regulations for merchant ships with the following additions:

(1) Facility for Continuous Tuning on the Main Transmitter. VFO attachments are being fitted to the normal commercial transmitters.

(2) UHF Transceiver. Type 691/CUH, and/or Type 692/CUJ, are fitted in R.F.A.s of over 1000 tons for short range communication with H.M. ships in peace and war.

(3) VHF Transceiver, a wartime requirement only. Type 689, for communication within a convoy.

(4) Low Power HF Transmitter and Receiver. With voice facilities and emergency power arrangements. For communication on tactical and command nets.

(5) Ratt. A Broadcast Bay and a Tactical Bay in R.A.S. – fitted ships only.

b. Personnel. All R.F.A.s carry a civilian radio officer. In addition some of the larger and more modern R.F.A.s carry naval personnel permanently and have extra equipment. The majority of R.F.A.s, however, have no naval communication ratings as complement but some are normally drafted for exercise periods.

1.8. SHORE STATION EQUIPMENTS

1. **Shore Station Transmitters.** The following table shows the principal types of transmitter in use at R.N. Shore Stations.

TYPE NO. OR NAME	MAKER	FREQUENCY RANGE	POWER OUTPUT	REMARKS
SWB 8	Marconi	3–27 MHz	2–4 kW	Widely fitted
SWB 11	Marconi	3–27 MHz	4–7 kW	High power version of SWB 8
DS 13	Standard Telephone	4–27.5 MHz	22 kW on C.W. I.C.K. F.S.T. 40 kW on S.S.B	
HS 31	Marconi	4–27.5 MHz	3.5 kW	Replacing SWB 8
HS 51	Marconi	4–27 MHz	20 kW on C.W. F.S.T. 40 kW on S.S.B	Alternative to DS 13
HS 71	Marconi	4–27.5 MHz	7 kW on C.W. F.S.T. 10–12 kW on S.S.B.	Replacing SWB 11
HS 81	Marconi	70–160 kHz	40 kW	
TFL 761	Marconi	40–150 kHz	40 kW on C.W. 28 kW on F.S.T.	
CM 8A	Standard Telephone	60–500 kHz	10 kW on C.W.	
632S	Racal	1.5–25 MHz	1 kW	C.W., F.S.T., Voice, (Choice of D.S.B. or S.S.B. (Suppressed or Re-inserted carrier))
R 20A	Standard Telephone	60–500 kHz	5 kW	

2. **Shore Station Receivers**

TYPE NO.	FREQUENCY RANGE	REMARKS
CGH	650 kHz–30.6 MHz	Dual diversity outfit
CGK/CGL	3–27.5 MHz	Triple diversity outfit
CGN	73 kHz–30.5 MHz	
CGP	3–27.5 MHz	Dual diversity outfit
CGR	1–30 MHz	Dual diversity outfit
CHA	3–25 MHz	FST with FAE
CHB	12.5 kHz–30 MHz	FST or SSB with ancillary equipment
CHC	980 kHz–30 MHz	

1.9. LAYOUTS

1. Layouts of an aircraft carrier, a D.L.G., an I.C.S. fitted frigate and a part Standard 3 Mix frigate, together with details of the equipment fitted in each type of ship, are shown in the diagrams on the following pages. It is emphasised that these layouts and lists of equipment fitted are typical only and will not be precisely correct for all ships. Even ships of the same class may vary slightly in particular equipments fitted.

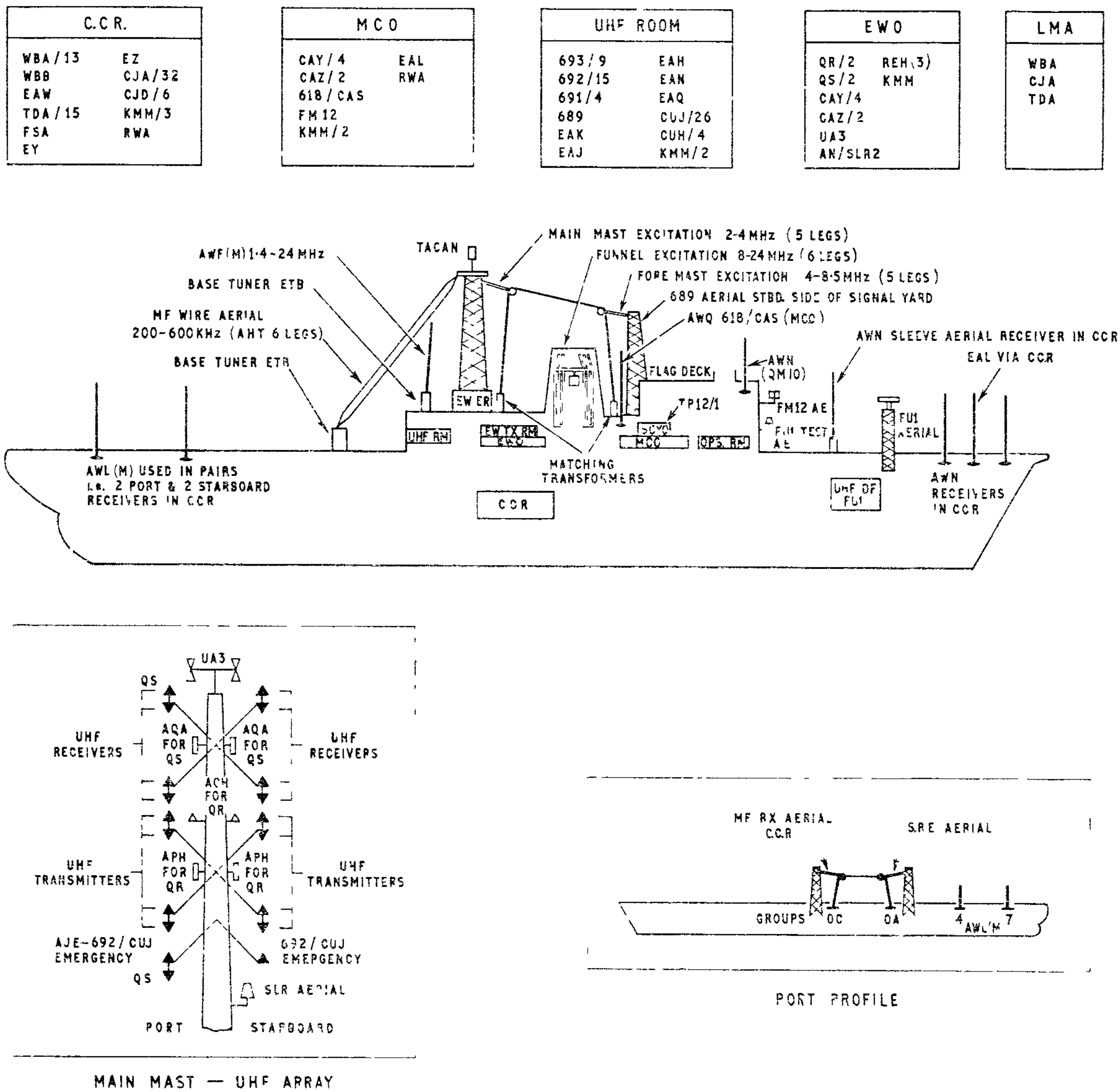


FIG. 1. ~~I.C.S. FITTED CARRIER~~ STANDARD 3M CARRIER

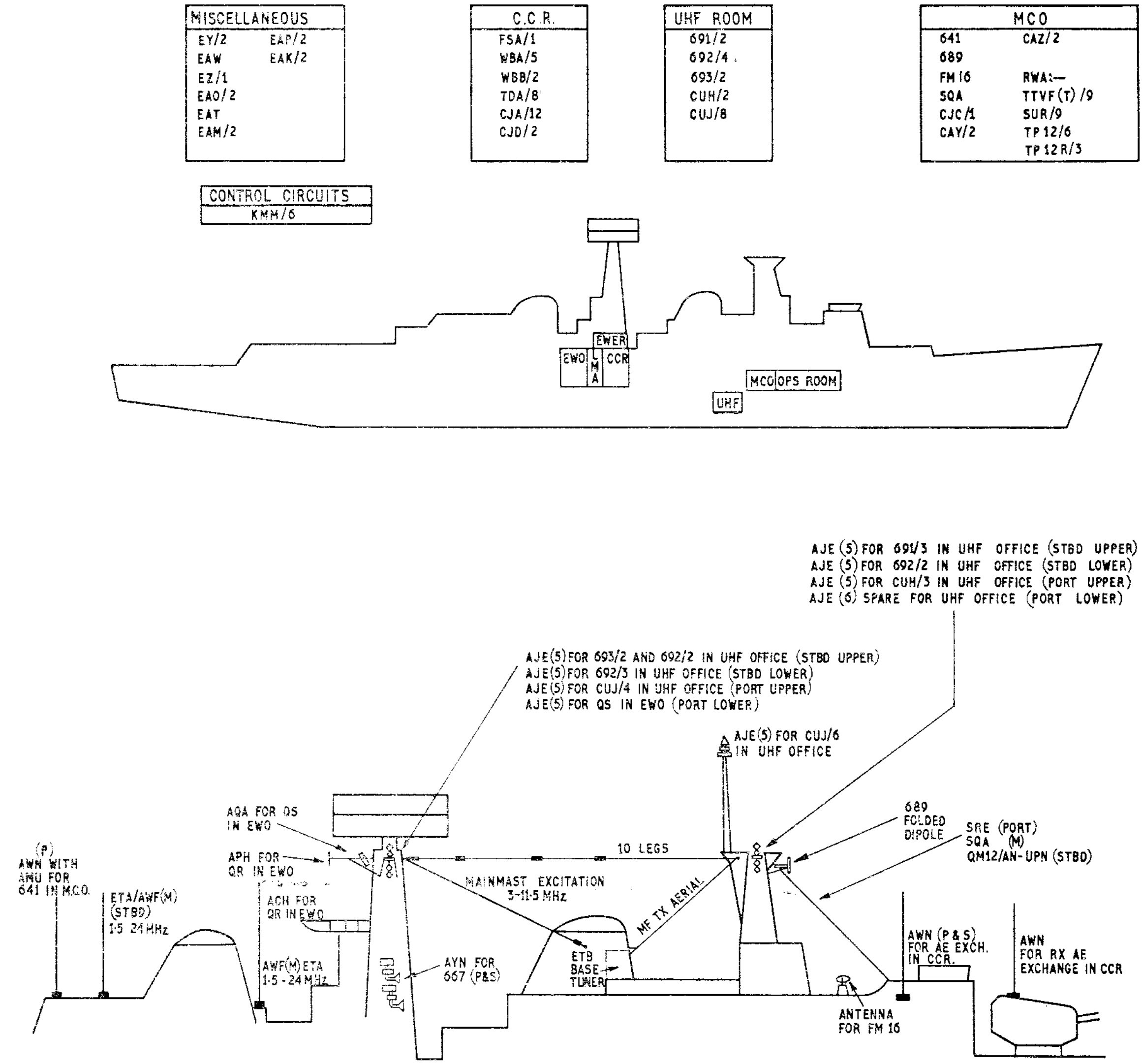


FIG. 2. TYPICAL STANDARD 3P [redacted] D.L.G.

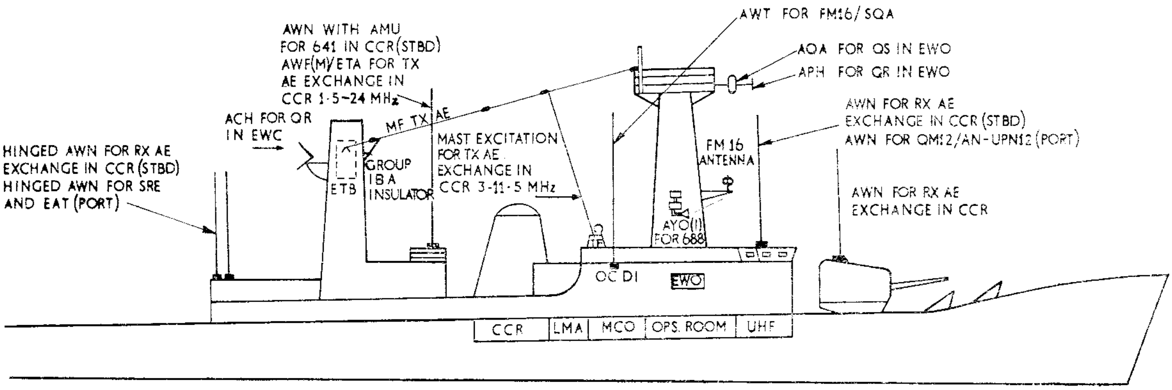
Ch 4

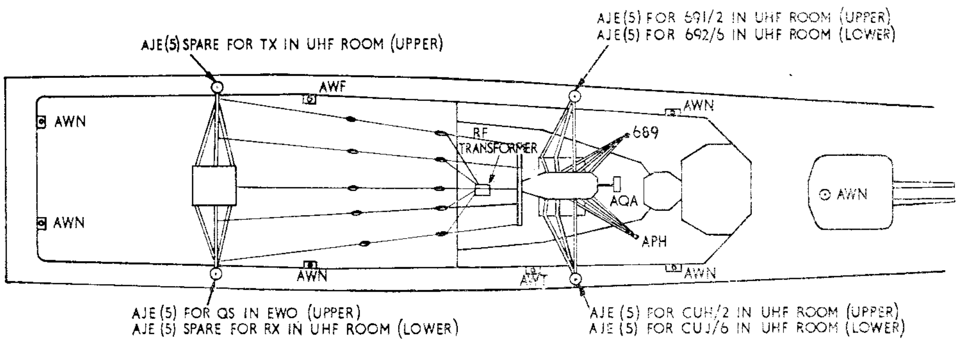
MCO	
FM 16	TGA (2)
SQA	TGB (2)
CAY/FAZ	TGB (3)
CAY	KMM
RWA :—	
TGA (4)	
TGB (4)	

CCR	
WBA/3	TDC/6
WBB	CJM/B
EY (2)	CJD/2
ETA (1)	EZ
ETB	FSA
EAW (6)	KMM
641	TGA

UHF	
691/2	689
692/6	
EAJ	
EAK	
CUH (2)	
CUJ (6)	

EWO
REH (3)
CJL
QR
QS
UA8
UA9





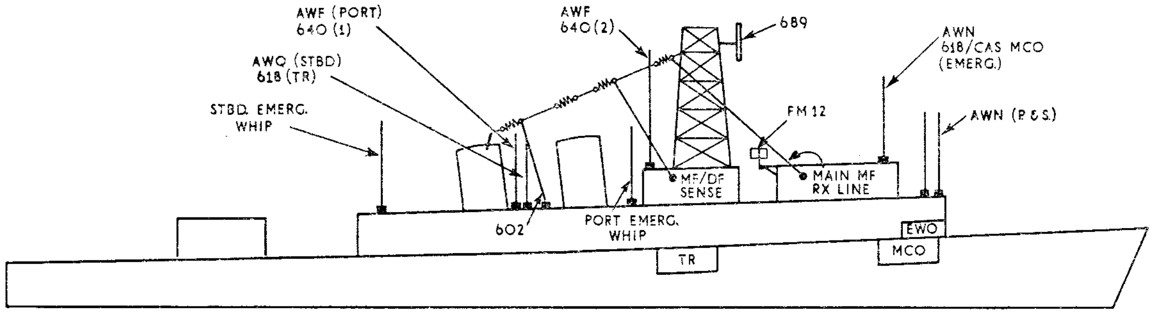
STANDARD 3A

FIG. 3. TYPICAL ~~I.C.S. FITTED~~ LEANDER CLASS FRIGATE

TRANSMITTER ROOM	
640 (2)	692 (3)
602	691 (3)
618 H	689

E. W. O.
B 40
UA 3
REH 5

M. C. O.	
618 / CAS	B 41 (2)
692	FM 12
CUH (3)	TGB (2)
CUJ (4)	TGA (3)
CJA (4)	TTVF (T)(3)
B 40 (2)	FSB (2)
B 40 + FAZ (2)	RWA



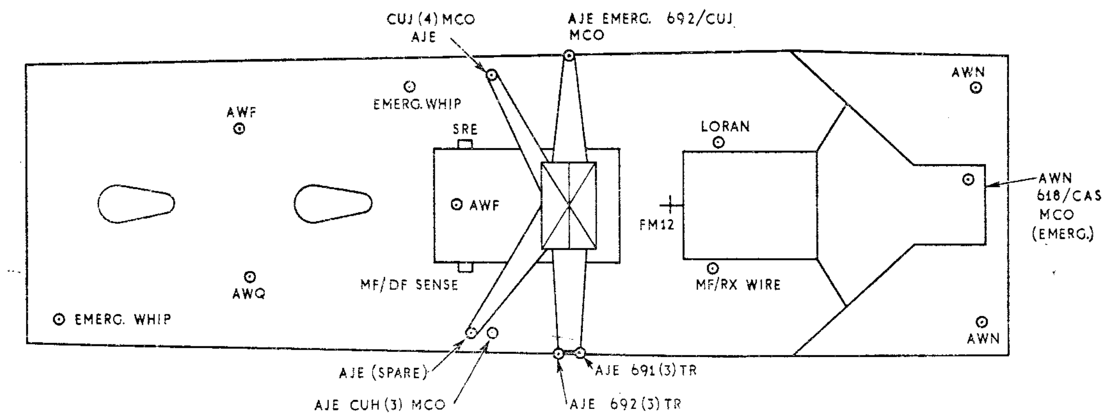


FIG. 4. ~~TYPICAL TRIBAL CLASS FRIGATE – PART STANDARD 3 MIX~~
TYPICAL STANDARD 3B (Part Fit) TRIBAL CLASS FRIGATE

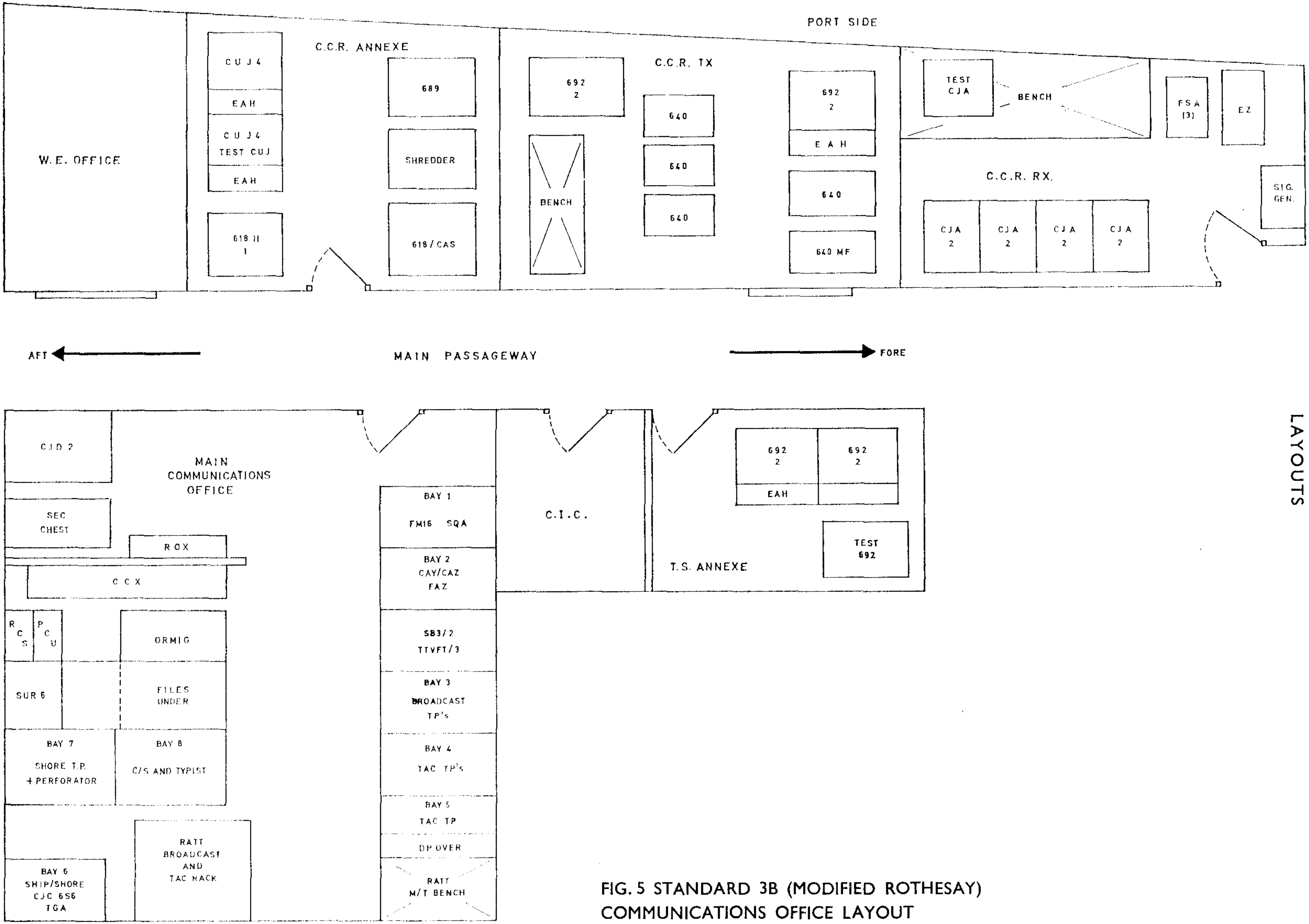


FIG. 5 STANDARD 3B (MODIFIED ROTHESAY) COMMUNICATIONS OFFICE LAYOUT

1.10. POWER SUPPLIES

1. Arrangements for power supplies can be broadly divided into those fitted in a.c. ships and those fitted in d.c. ships.
Within these two classifications, classes of ships vary considerably, and even individual ships, within the divisions of class, may differ.

2. The generators in a.c. ships feed each its own panel of a switchboard. Normally the panels of two generators are sited in one switchboard. Thus in a frigate the 'after switchboard' may be composed of a panel from each of two turbo-generators, and the 'forward switchboard' of a panel from each of two diesel generators. In a carrier, there might be two diesel panels for'ard, two aft, two T/Gs on the starboard and two on the port. The panels of generators which feed into one switchboard are separated by bus-bar linking switches so that one generator can supply both panels. Similarly, each switchboard is joined to the other by interconnecting cables with switches. Thus in the event of damage, to for example, the boiler room, resulting in loss of steam, the diesel generators can be made to supply the services normally fed from the T/G supply. This arrangement can also be used in harbour when the boilers are not flashed up. From each panel, supplies are led, through a number of breakers, into the 'tree' system which breaks down available supplies into the various services as required throughout the ship.
Alternative supplies, which are additional to emergency supplies, are available in some cases for compartments containing radio equipment. These supplies are obtained from a separate switchboard and generator and are brought into use by means of a changeover switch in the M.C.O.

3. Older types of destroyers and frigates normally have two generators only. D.C. supply from either port or starboard ring main is selected at a control board in the M.C.O. by means of a Changeover switch. The a.c. output of the two generators is fed through the same control board. Either output can be selected to feed the two distribution boards, through the necessary transformers.

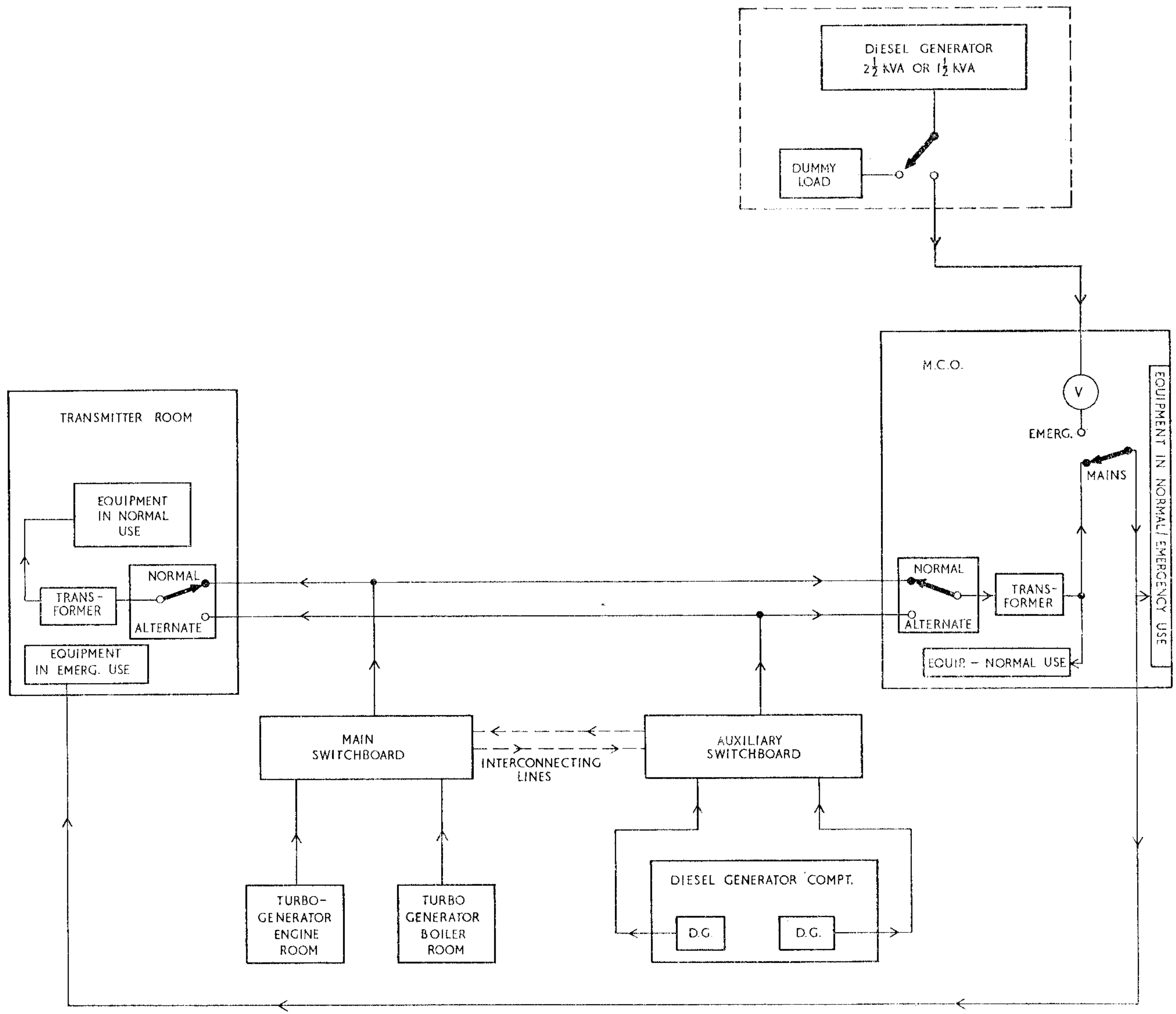


FIG. 1. POWER SUPPLY ARRANGEMENT IN MODERN a.c. DESTROYERS AND FRIGATES

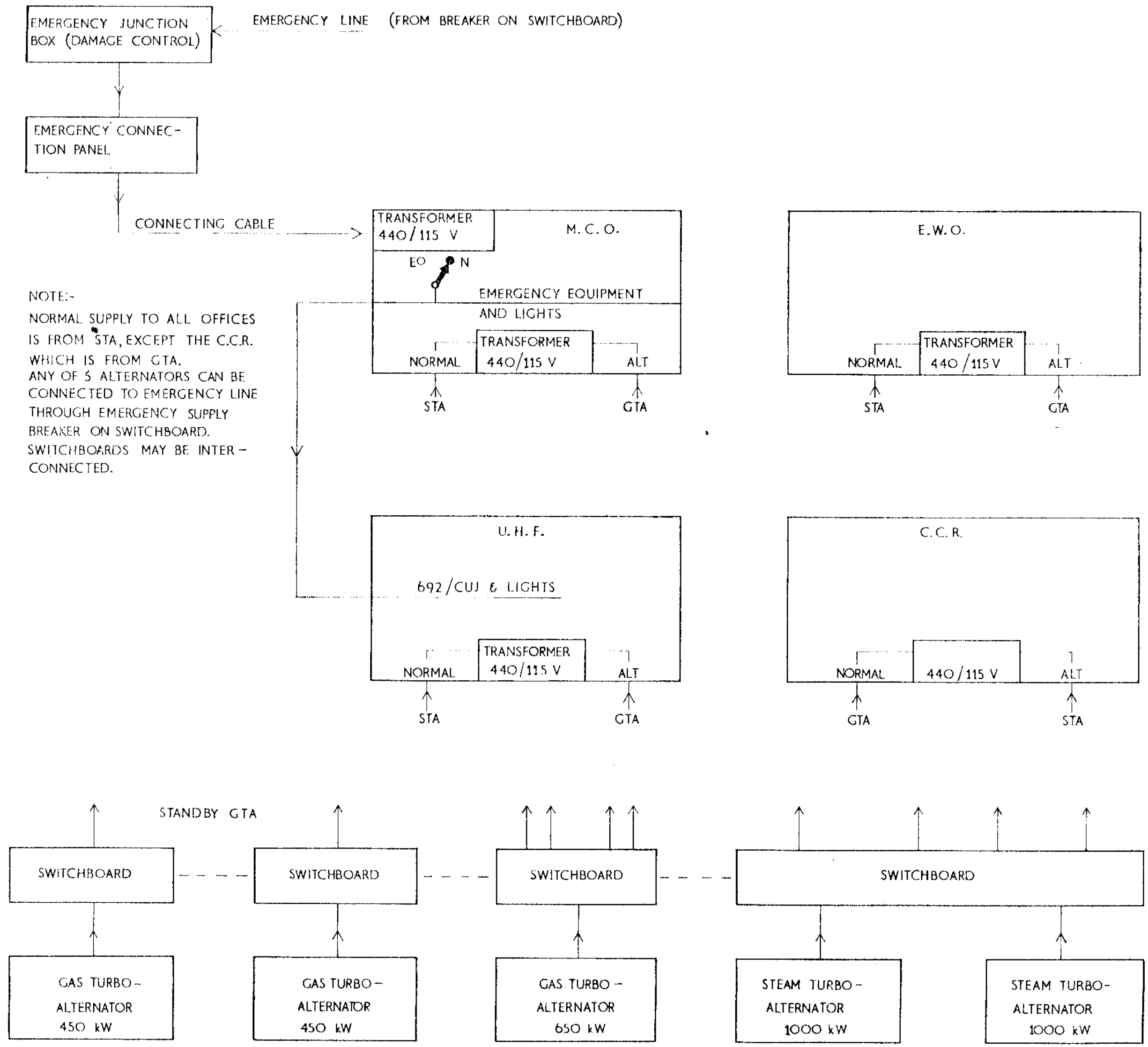


FIG. 2. POWER SUPPLY ARRANGEMENTS – D.L.G.

Emergency Power Supplies

4. In most cases, ships are supplied with alternative main supply from the electrical department. In a real emergency, however, when there is no way of supplying power from main generators, certain equipment can be used with a supply from a small diesel generator.

5. Standard 1, 2 and 3B ships are fitted with $2\frac{1}{2}$ kVA or $1\frac{1}{2}$ kVA diesel generators to provide all emergency power supplies to the communication department when the ship's normal power supply fails. These diesels have replaced all battery outfits and emergency a.c. supply outfits. Aircraft carriers are fitted with two diesel generators, one to supply lighting and selected equipment in the M.C.O. (and, if required, the V/UHF TR) and the second to supply lighting and selected equipment in the C.C.R. Standard 1, 2 and 3B destroyers and frigates are fitted with one diesel generator only. This is sited adjacent to the M.C.O. and is used to supply emergency lighting and selected equipment in the M.C.O. and Transmitting Room. In some ships this supply is available in the M.C.O. only.

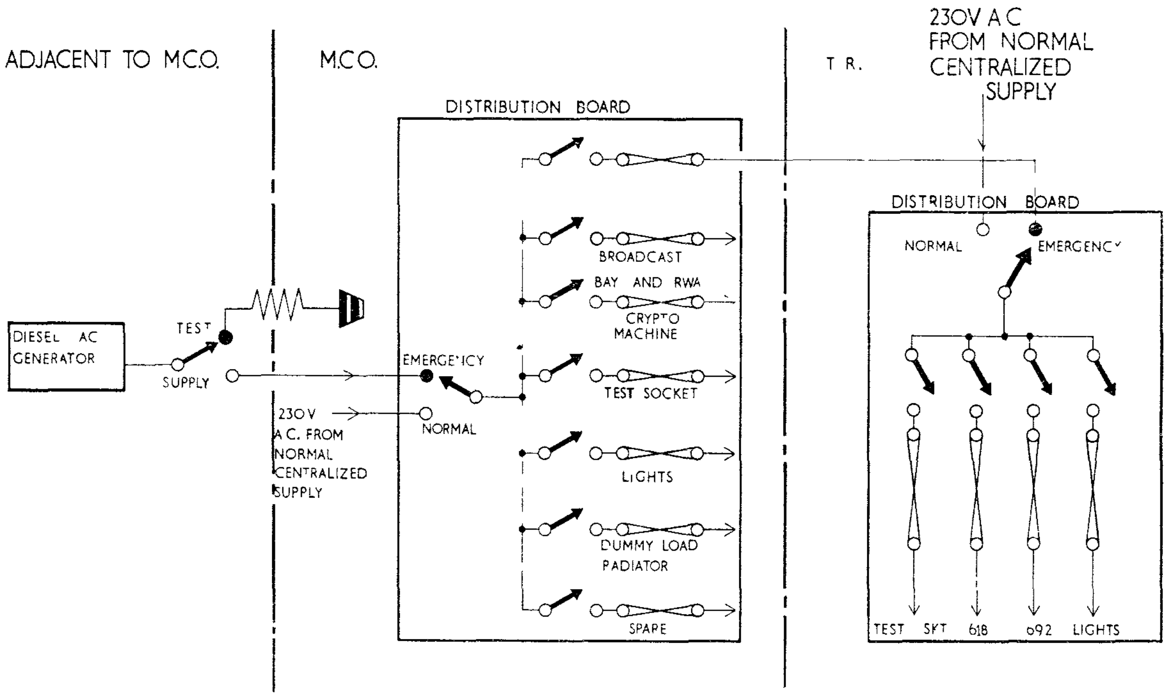


FIG. 3. TYPICAL EMERGENCY SUPPLY ARRANGEMENTS, STANDARD 1, 2 OR 3B FRIGATE

6. The diesel is started by a manually operated starting handle and is fitted with a TEST/SUPPLY changeover switch. This allows the generator to be run on a dummy load for test purposes. In the supply position the output of the generator is fed to the changeover switch on the distribution board.

7. The equipment required to be operated from the emergency supply is fed from a separate distribution board. A changeover switch on the distribution board allows 230V a.c. to be taken from the normal supply source or from the diesel generator. Slight variations in wiring of the emergency supply will be found in different ships.

8. Emergency power arrangements in a D.L.G. differ from other ships in that there is no emergency diesel generator fitted. Lighting and selected equipment are supplied during an emergency power failure from a separate transformer sited in the M.C.O. This transformer can be connected by cable to an emergency connection box and then to an emergency junction box, both situated near the M.C.O. Any one of the five alternators may then be connected, via the emergency supply breaker on the switchboard, to the emergency line and hence to the emergency junction box.

1.11. RADIO HAZARDS (RADHAZ)

1. **General.** Ships are now fitted with a large number of high power transmitting equipment, radio communications, radar and sonar. These high power transmissions constitute a threat to:

a. Human life – because of the effects of radiation on the human body.

b. The Ship and Human life – radiation can cause the untimely ignition of explosive devices and combustible material.

Radio Hazards also includes certain other side effects which originate in the same area as the true radio hazard, e.g. the danger from rotating aerials and aural shock from the use of sirens.

2. **Organisation.** The orders for Radhaz are detailed and complex but when fully understood and correctly applied will not normally adversely affect the operational capacity of a ship; for example, by planning the route, and using only this route, for the embarkation and disembarkation of SEACAT missiles, restrictions on the use of transmissions can be minimised, and applied to the minimum amount of equipment. Therefore each ship must have a comprehensive and clear organisation to prevent hazards to men, equipment and material whilst retaining maximum operational efficiency.

3. **Responsibilities.** The Commanding Officer is responsible for the Radio Hazard Organisation but delegation or responsibility should be:

a. The S.C.O. for overall co-ordination and promulgation of the Ship's Radhaz orders. He should co-ordinate the advice to the Command on the operational aspects of Radio Hazards.

b. The W.E. Officer to advise on all technical aspects of Radio Hazards and in consultation with the Medical Officer advise on Safety Distances and Durations. Also to state what relaxations of normal precautions are required for W.E. personnel involved in maintenance and fault finding.

c. The O.O.W. (O.O.D.) to be responsible for the implementation of the Radhaz organisation and for the custody and correct use of the ship's Radio Hazard Board.

d. O.R.O., Sonar Controller, Lt Cdr(F). Provided that the Command is fully informed, the users of equipment should be allowed to apply restrictions to equipment under their control direct.

e. All Ships Officers and Departmental Heads for having a good understanding of the Radhaz orders so that they are aware when any of their men are subject to Radio Hazards and to ensure that any hazardous situations in their department is correctly described in the ships Radhaz Orders and for their correct application within their departments. They are responsible for applying to the O.O.W. for clearance in using equipment in a manner other than described on the Ship's Radhaz Board.

4. **Written Orders and Instructions in a Ship**

a. CAPTAIN'S STANDING ORDERS. These should include:

(1) The responsibility delegated to officers.

(2) A broad outline of where radio hazards exist, e.g. the ship's man aloft line, above which a man cannot go without permission.

(3) Where the Radhaz organisation is to be laid down in ships and in departmental orders.

b. SHIP'S RADIO HAZARD ORDERS. To contain the detailed orders for the correct application of the ship's Radio Hazard organisation. In some ships these are now produced separately from the Ship's Orders and distributed to all departments and interested authorities under the signature of the Executive Officer.

c. SHIP'S HAZARD BOARD. This board should be portable and displayed near the compass platform at sea and near the Q.M.'s harbour position in harbour. The Hazard Board should contain sufficient information to allow the O.O.W. to control the Hazard Organisation.

Duplicate Board to be kept in departmental offices with only that departments equipment shown. This board is not required for control but only for indicating what precautions are required for each situation affecting the equipment within the department.

5. **Restrictions Applied Direct by an Operational Officer.** There may be occasions when immediate action is needed to render equipment inoperative, e.g. operation of aircraft. On such occasions the Operational Officer must be authorised to order equipment to cease operation and to order the resumption of transmissions. This procedure is intended for situations where quick reactions are needed in order to maintain operational efficiency.

Should there be a conflict of requirements; for example, the rearming of a strike aircraft with electrically initiated missiles when there is a high precedence signal being transmitted on ship-shore, reference must be made to the Command.

6. **Production of Radhaz Orders.** The distinction between two possible types of precautionary action should be made.

a. If the equipment causing a hazard is operated frequently or is needed at short notice and without warning, the area it endangers should be permanently closed (i.e. made a 'Man Aloft Area') and entered only by permission of the O.O.W.

b. If the equipment is used very occasionally, or is used frequently but rarely pointed at an area of the ship, then the onus to take action is on the user or maintainer. He must request permission from the O.O.W. and thus ensure that the area has been cleared for the required time. These two arrangements can best be laid down by establishing a 'Normal' state for all equipment and areas concerned in the RADHAZ organisation, and then declaring what precautions must be taken when any one wishes to break the 'Normal' state. In the case of high power radars which can affect parts of the upper deck only when operated below a certain elevation or on certain bearings, it may well be possible under harbour or cruising conditions to ensure that the equipment is only operated on 'safe' elevations or bearings. If this is so the equipment when 'safe' can be termed to be in the 'Normal' state and it would then be the responsibility of the user department to produce such orders as to ensure that the O.O.W. is informed in good time when required to break the 'Normal' state. Once so informed the O.O.W. is then responsible for clearing and keeping clear those parts of the upper deck rendered 'unsafe'.

c. CHECK OFF LIST. The following is recommended as a 'Check Off' list for ships commissioning or for ships which have undergone structural or equipment changes:

(1) List all transmitting equipment (Radio, Radar and Sonar) with their frequency bands and emitted power.

(2) Check 'Horizontal Safety Distances' in areas in the vicinity of emitters within which a physical shock hazard exists.

(3) Establish 'safety distances and durations', boundaries, and an overall 'Man Aloft Boundary'. Check that permanent boundaries are marked and the necessary notices produced and posted. Ensure these notices can be read when it is dark.

(4) Establish the 'Normal' situation for high power radars (paragraph *b* above).

(5) Establish causes of physical, radiation and sonar hazards.

(6) Note special procedures for certain jibs (e.g. crane jibs must be handled with rubber gloves).

(7) List all inflammable and combustible material likely to be handled on board.

(8) List all Electrically Initiated Explosive Devices (EIED) normally handled on board.

(9) Establish which radiating equipment can affect the items in 7 and 8.

(10) Establish normal stowage and methods of embarkation of 7 and 8.

(11) List precautions necessary for normal stowed state and additional precautions when normal state is broken.

(12) Check the devices (keys, fuses) for ensuring silence of equipment.

(13) Design the Ship's Radhaz Board.

(14) Check individual department's check board.

Having completed the 'Check Off List' the Ship's Radhaz Orders can be compiled. On completion, ensure that the Ship's Book contains a copy.

Finally the Radhaz section in the Captain's Standing Orders should be written.

7. **The Ship's Radhaz Board**

a. It is important that any officer using the Radhaz Board should be familiar with its use. To facilitate this it is important that all Radhaz Boards should be similar in design.

b. Construction of the Board

Part A
A table in which the circumstances leading to the restriction should be placed on the left hand side and titles of equipment at the head of columns at the top.

Part B
The stowage for the safety devices and keys.

Part C
Ship Silhouette. A Silhouette or outline of the ship with guide lines from aerials to a key which matches with the aloft position on the left hand side of the table.

Part D
The board can be made as one complete unit or in parts but the part which contains the safety devices should be lockable and the key should be retained by the O.O.W./O.O.D.
A diagram of the principles explained above for a DLG is given in Fig. 1.

8. **Hazards to Personnel – Radar**

a. Radiation. Personnel exposed to radiation from radar equipment can suffer deep burns of the body or at least superficial burning of the skin. The type of burns suffered depends on frequency emitted but it is most important to note that a person being subjected to deep body burns may not be aware that this is taking place. The great danger is from the main beam. Provided the aerial is functioning correctly the side lobes do not constitute a danger. A table of 'Safe Distances' has been established for radar equipment. These distances are calculated for the main beam. Similarly a table of 'Maximum Times' a person can spend exposed to the main beam has been worked out. The 'Maximum Time' may be 1 second or 5 minutes, depending on the type of equipment.

b. Safety Procedures. Commanding Officers are responsible that the necessary orders cover the following:

(1) Man Aloft instructions must be applied when personnel climb aloft and are in danger of entering the main beam or when any visual examination is made of radiators, reflector, waveguides, cones or any other device emitting R.F. energy.

(2) During transmission periods these aerials are not depressed to illuminate normal working spaces.

(3) Precautions are taken when alongside or when adjacent ships are transmitting.

c. Mechanical Danger. This arises from rotating aerials.

d. R.F. Burns and Shock. Physical contact with aerials, adjacent materials and structures can cause physical shock or burns.

9. **Communication Equipment.** The dangers are similar to those produced by radar equipment:
Radiation
R.F. burns and shock.

a. Radiation Area. The extent of the hazardous radiation area depends on frequency being used and the emitted power. The radiation hazard is not as dangerous as that from radar transmitters but personnel are not to be exposed for long periods. Each area in which this hazard exists is to be clearly indicated by a red line painted on the deck. This line is to have red arrows pointing from it to the source of the hazard. The extent of danger areas surrounding different emitters is laid down in detail in paragraph 15. On or near the source of danger is to be displayed a notice in red letters on a white background consisting of the following:

WARNING
DO NOT REMAIN WITHIN AREA SHOWN BY RED ARROWED LINE ON DECK FOR MORE THAN 2 MINUTES IN EVERY 20

As these notices cannot be illuminated in darken ship conditions the ship's Radhaz Orders should include regulations governing the access to these areas with particular emphasis on the danger during hours of darkness.

b. R.F. BURNS AND SHOCK

(1) Induced voltage may exist in wires, ropes, stanchion stays, etc., when these are close to transmitting aerials. Warning notices stating:

DANGER HIGH VOLTAGE DO NOT TOUCH

may have to be displayed on the outer framework of Base Tuner Outfits and the base pedestals of whip aerial outfits AWF(M) and AWL(M) depending on the type of earths fitted. Again details are in current DCIs.

(2) I.C.S. ships use the masts, funnels or superstructure as broadband aerials and because of the high power of transmissions used, any wire, rope, etc., hanging vertically in the vicinity of these structures is particularly dangerous.

(3) Sleeving – The sleeving of wires, etc., should be of PVC with a wall thickness of $\frac{1}{16}$ inch. This also applies to shackles and blocks of running stages, etc.

(4) Rubber Gloves – Rubber gloves must be worn by personnel when working with jibs and wires, hooks of cranes or on whip aerials when these are close to radiating aerials.

(5) Damage to equipment – I.C.S. Ships – Alterations to the ship's rigging can change the radiation pattern of the mast or structure to which the rigging is coupled and thus cause a mismatch in tuning which will result in damage to the transmitting equipment. No alteration is to be made to the rigging without reference to MOD (NAVY).

10. **Ships Fitted with Gas Turbo Generators.** When the turbine is running the funnel becomes charged with static electricity which can amount to 18,000 volts. Therefore personnel must not touch the funnel when the turbines are running.

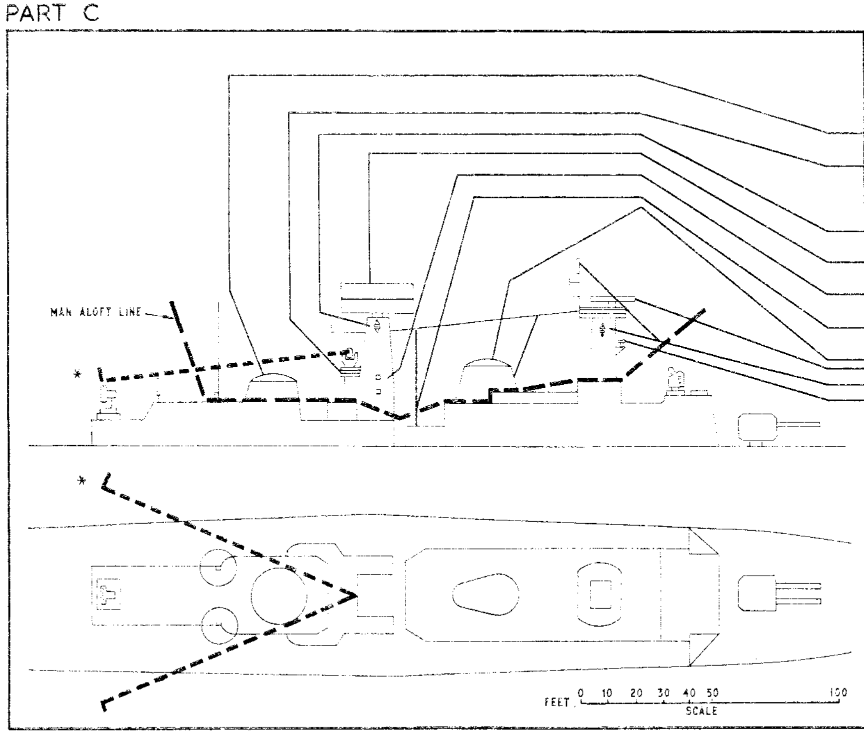
11. **Steam and Noise.** A sudden loud noise can cause a man to lose his grip when aloft or he may be scalded by exhausting steam. Whenever a man goes aloft the engine room or other departments must be informed and the man must wear a lifeline.

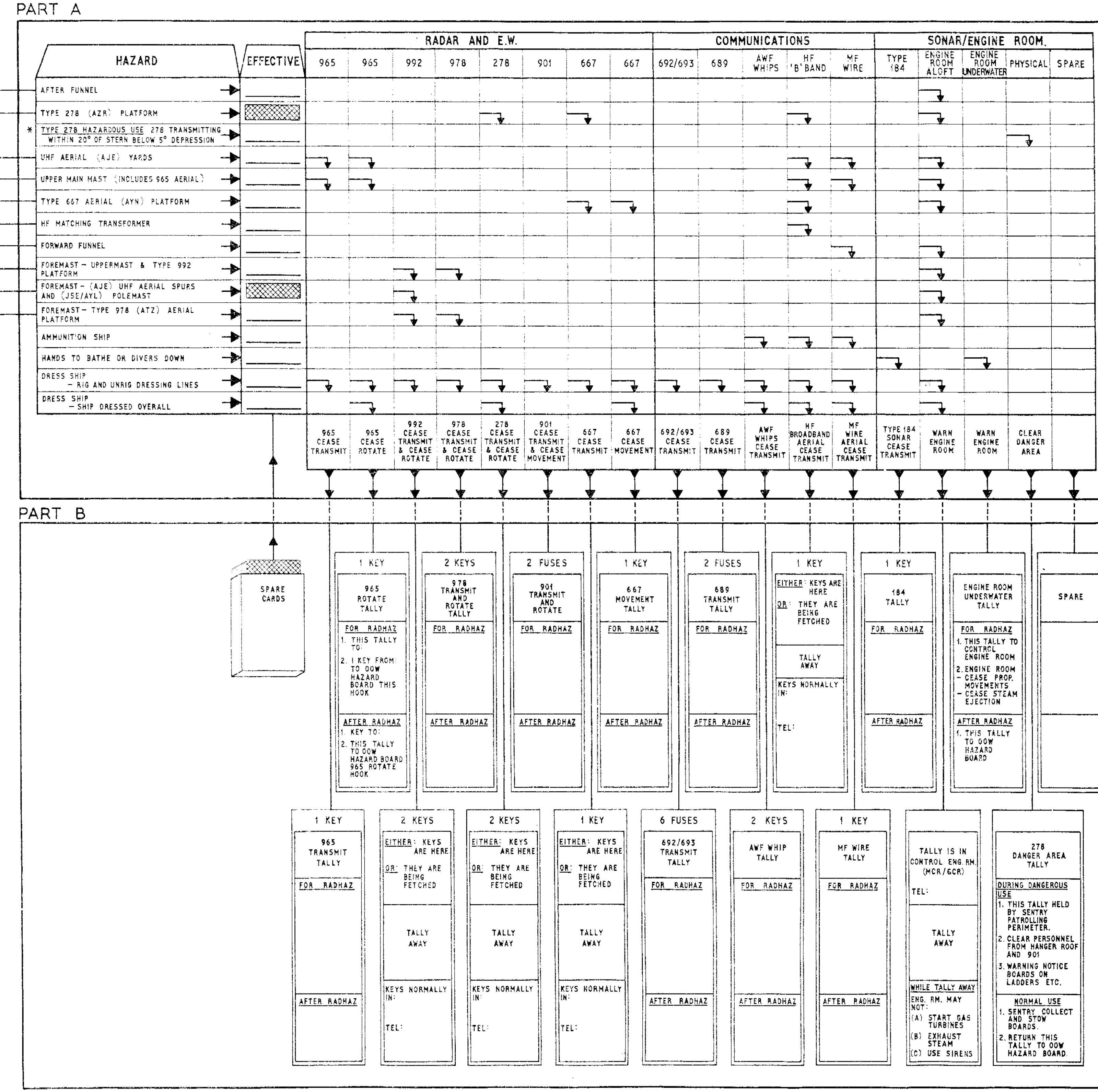
12. **Dressing ship**

a. WIRELESS. Transmissions on equipments with outputs of 500W and more must not take place if the aerial is within a certain distance of the dressing lines. These distances are laid down in DCIs.

b. RADAR. Transmissions should be avoided from radar sets using open wire feeders which may be adjacent to dressing lines and downhauls. The use of rotatable aerials which may foul dressing lines or flags must be prevented. Where possible dressing lines and downhauls should be bonded to earth if wireless transmitters, whose aerials are within the safe distance of the dressing lines, with outputs exceeding 50W, are likely to be used.

13. **Hazards to Divers.** If a diver is subjected to a very loud or unexpected noise under water his hearing may be impaired or he may become disorientated. Modern sonar sets operate on audible frequencies and make a very loud noise.





NOTE:–
(1) EXAMPLE SHOWN IS FOR GMD CLASS OF SHIP A DESIGN FOR EACH CLASS OF SHIP WILL BE REQUIRED.
(2) INTENTION IS FOR THE FINAL DESIGN TO BE IN COLOUR.

FIG. 1. RADIO HAZARDS (GMD CLASS)

a. ACTION BY COMMANDING OFFICER

(1) He should request the Port Authorities to promulgate the periods during which the set is operating.

(2) Ensure that diving in diving suits, including standard diving equipment does not take place within 40 feet of any part of a submarine when its set is switched on.

(3) Prohibit skin diving, or bathing within 50 yards of the ship or 100 feet of the submarine, when its set is switched on.

(4) Ensure that the Diving Officer is informed when a ship or submarine fitted with audible sonar equipment is present in harbour.

(5) Ensure that the Diving Officer has read relevant instructions on diving in the vicinity of ships and submarines.

b. DIVING OFFICER

(1) He is to ensure that any hazard restrictions necessary in his own ship are known by the O.O.W. before any diver enters the water.

(2) He is to be aware of the dangers from other ships as well as his own and ensure that the divers are informed of them.

14. **Hazards to Weapons and Explosive Devices**

General – As already stated in the introduction the second major hazard is that to both personnel and to the ship by the unintentional ignition of Electrically Initiated Explosive Devices or combustible material by radar or radio emissions. The range of sources of danger in this category covers most modern weapons and a number of fuels and has led to a considerable amount of detailed regulations.

The following E.I.E.D. are subject to Hazard regulations which must be consulted in formulating a ship's Radhaz Organisation:

a. SEASLUG Missiles.

b. SEACAT Missiles.

c. 2,000 lb, 1,000 lb and 500 lb bombs.

15. **Safety**

a. There are two types of hazard which may be encountered from HF wireless transmissions, RF Radiation Hazard and RF Shock and Burn Hazard.

(1) *RF Radiation Hazard.* An electric field exists in the vicinity of the transmitting aerial associated with Types 89Q, 603, 605, 640 and Outfits WBA and WBB. The extent of the field varies with the frequency to which the transmitter is tuned and the point along the vertical axis of the aerial from where the measurement is being taken. Tables 1, 2 and 3 below give the safe distances, measured horizontally from the centre line of the aerial, for the combinations of transmitter, aerial and frequency indicated in the tables.

TABLE 1. TYPE 640 – WHIP AERIAL

HEIGHT ABOVE DECK ON WHICH BASE TUNER IS MOUNTED (*ft*)	FREQUENCY		
	2 MHz	*4 MHz*	*6 MHz & above*
	Safe distance in feet from centre line of the aerial		
5	1	Less than 1	Less than 1
6	2	1	Less than 1
8	3	2	Less than 1
12 or more	4	3	Less than 1

TABLE 2. TYPES 603, 605, 89Q, 640, WBA AND WBB – WHIP AND WIRE AERIALS

DECK	TRANSMITTER	603/5 89Q	640	640	WBA	WBB
	Base Tuner	ETA1 Exposed	ETC Exposed	ETC Enclosed	ETA1 Exposed	ETB Exposed
	Aerial	Whip Aerials AWF(M) and AWL(M)				Cage or Roof
—	*Frequency Range*	*Safe distance in feet*				
Deck on which base tuner is mounted	2 MHz & below	$1\frac{1}{2}$	$1\frac{1}{2}$	2	3	1
	3 MHz	1	1	$1\frac{1}{2}$	2	1
	4 MHz & above	1	1	1	1	—
Decks $7\frac{1}{2}$ or more feet above base tuner deck	2 MHz & below	4	4	4	5	4
	3 MHz	3	3	3	4	3
	4 MHz	2	2	2	3	—
	6 MHz & above	1	1	1	$1\frac{1}{2}$	—

Notes

1. The safe distance is given for a height of 6 feet (the height of a man) above the deck.
2. The radius of the red circle painted on the deck would be the greatest of the distances shown above in the column for that transmitter.

TABLE 3. OUTFIT WBA – BROAD BAND AERIALS

DECK	FREQUENCY BAND	TRANSMITTER AERIAL	WBA FOLDED MONOPOLE STRUCTURE FOREMAST	MAINMAST	FUNNEL	BICONICAL
—	—	*Number of Transmitters*	*Safe distance in feet*			
7 feet above deck on which transformer is mounted (*see Note*)	1.5 to 5 MHz	8	—	2	—	—
	3 to 11 MHz	4	1	—	—	—
	5 to 11 MHz	8	1	—	—	—
	8 to 24 MHz	8	—	—	2	2

Note

The transformer is normally mounted on a 5 foot pedestal thus making the feed point 7 feet above the deck; if the transformer is mounted directly on the deck the distances given above should be doubled.

(2) *RF Shock and Burn Hazard.* An RF voltage may be induced in metal structures from a transmitter aerial. The size of the induced voltage will depend on the frequency and power of the transmitter, the height of the structure and the distance between the aerial and the structure. Table 4 gives the estimated minimum separation required between various transmitter aerials and ship structures to ensure that no danger to personnel exists from induced voltages.

TABLE 4. 500/1000W TRANSMITTERS – ALL TYPES OF AERIALS

AERIAL	WHIP OR WIRE		BROAD BAND			
	—		MAST			FUNNEL OR BICONICAL
FREQUENCY BAND MHZ	1.5 to 24		1.5 to 11	1.5 to 7	5 to 11	8 to 24
NUMBER OF TRANSMITTERS	1		4	8	8	8
POWER	500 W	1000 W	1000 W			1000 W
SHIP STRUCTURES	*Minimum Separation between Aerial and Structure (Feet)*					
Guardrails and stanchions	3	3	6	7	7	7
Awning wires and stanchions. Boat davit stays	6	7	12	12	15	15
Boat davits	8	10	20	20	30	30
Torpedo davits	6	7	12	12	15	15
Crane jibs of H feet in height	H	H	3H	4H	4H	4H
Receiver aerials. Mast and funnel stays of H feet in height	H	H	2H	3H	3H	3H
Upper deck structures and fittings of less than 6 feet in height	H	H	H	H	H	H

16. **Instructions Concerning Radio Hazards**

a. Details and instructions concerning radio hazards are promulgated in BR 2924, *Handbook for Radio Hazards*, and in current DCIs.

b. Ships' and Departmental orders should also contain details and instructions on RADHAZ.

1.12. STORES AND CRYSTALS

1. **Responsibility of Stores.** The Signal Communication Officer has portable radio equipment, crystals, headsets and microphones in use in his department on his charge. This responsibility may be delegated to the senior communication ratings of the V/S and W/T departments who may hold and sign their own S.1099 and S.156. All other equipment, which may be portable fittings or Naval stores, including aerials and control outfits, are on charge of the Weapons and Radio Engineer Officer.

2. **Portable Fittings.** This includes transmitters, receivers, control outfits, etc., which are secured to the ship's structure but can be removed if necessary.

3. **Naval Stores.** These are divided into:

a. PERMANENT STORES. Items of a valuable or lasting nature, e.g. crystals. They may become defective and require replacement.

b. CONSUMABLE STORES. Items of little value or which are expendable, e.g. cleaning gear, light bulbs, etc. A fixed quarterly allowance per ship is laid down which should not be exceeded except in special circumstances.

4. **Lists**

a. LIST OF PORTABLE FITTINGS AND SPARE PARTS. Contains a list of all portable fittings on charge to the Weapons and Radio Engineer Officer.

b. PERMANENT LOAN LIST. Contains a list of all permanent stores on charge to the Signal Communication Officer.

c. 'E' LIST. An 'E' list is produced for each equipment or outfit, e.g. transmitter Type 605. It contains a list of all items which form part of the particular outfit. A column is completed showing the quantity of each item supplied to the ship.

5. **Books of Reference**

B.R. 4, *Naval Storekeeping Manual.* General instructions on storekeeping procedure.

B.R. 320, *Catalogue of Naval Stores.* Contains description, pattern number, subhead and cost of all permanent and consumable stores. In several volumes.

6. **'S' Forms.** The following is a list of the 'S' Forms likely to be met:

S.156. Demand note for naval stores from the supply dept.

S.1091. Return note for naval stores to the supply dept.

S.1092. Temporary Loan Book, used when drawing items for a short period.

S.1099. Permanent Loan List forms.

S.149. Counter Book. Certain consumable stores can be drawn by authorized personnel by signing this book. It is countersigned by the Head of Department or senior ratings at intervals.

S.145. Demand Note for single items from ship's supply dept. to dockyard/store depot.

S.145a. Demand note for many items from ship's supply dept. to dockyard/store depot. Transposed in dockyard for computer action.

S.331. Return/Survey note between ship and dockyard/store depot.

S.549. Transfer of stores between ships.

CRYSTALS

7. **General.** Crystals are permanent stores and of considerable value. They must be treated carefully, kept locked up and mustered frequently. Details of crystals available and allowed are given in a current 'S' series publication.

8. **Frequencies for which Crystals may be drawn.** The 'S' series publications lists frequencies for which crystals are allowed in specific areas (e.g. Worldwide, Home, Far East, etc.) and also some allowed for specific purposes (e.g. Ships commissioning for trials only). It is emphasized that the lists give the crystals allowed as opposed to required, and it is not essential to draw crystals for all frequencies listed. For instance, a ship with 601 series transmitters only does not need HF transmitter crystals.

9. **Musters of Permanent Loan Lists**

Loan Clothing 6 monthly.
Attractive items (crystals, portables, etc.) 6 monthly.
Items rigged (office clock, etc.) 18 monthly.

1.13. THE IMPORTANCE OF ACCURACY IN THE ADJUSTMENT OF EQUIPMENT

1. **Congestion in Communications.** It may not be generally realized that extreme congestion of the frequency spectrum exists on all frequencies below approximately 10 MHz, and to a lesser degree to all those above. Many medium and high frequencies are shared by 20 or 30 different users. To help relieve this congestion, and in particular to allow the lower power users to communicate at all, a complicated series of international plans are in existence, which segregate particular classes of users to certain sections of the spectrum. These users are roughly divided into ships, aircraft, coast stations, broadcasting and fixed. Around 1 to 3 MHz these different users often share sections of the spectrum; above about 3.5 MHz their use of certain sections becomes exclusive. The exclusive plans are further divided into specific channels which are allocated internationally and nationally to individual users. The R.N. allocations in the spectrum are contained in D.C.I.s 'S' series. They should be rigidly adhered to, except in emergency or as specially directed.

2. **Interference.** The vast majority of interference complaints are traced to users departing from their assigned frequencies, primarily as a result of maladjustment of equipment. It should be remembered that all interference is usually mutual. If as a result of incorrect tuning of a transmitter a ship is 10 kHz low, she will not only cause interference to the legitimate users of that frequency, but will herself suffer interference from these users. As ships and aircraft are in the lower powered category it is to their great advantage to be tuned accurately to their assigned frequency.

3. **Accuracy of Transmitter and Receiver Adjustment.** Due to the congestion previously mentioned frequency accuracy, particularly in the exclusive bands, is of prior importance. Correct choice of frequency also helps considerably in reducing interference. The following short examples illustrate the point:

a. All ship broadcast and ship answering frequencies are segregated into certain exclusive bands previously mentioned, and are further channelled into specific frequencies all of which are shared by several stations on a geographical sharing basis. If a ship at the far end of a certain station's service area attempts to read that station on other than the optimum frequency, she may suffer interference from another station sharing that frequency who is putting down a greater field strength in that particular location than the wanted signal.

b. The channel spacing for 4 MHz components of ship broadcasts is only 4 kHz. So if a ship's receiver is adjusted at too wide a bandpass or generally incorrectly adjusted, interference may be experienced from adjacent channel stations on either side of the wanted signal. This type of interference becomes more serious when RATT is being used as the actual transmissions themselves occupy a bandwidth of 1 kHz or less.

c. Excessive harmonic radiation, or maladjustment of the older type of transmitter which produces the wrong multiplication factor will invariably cause trouble. For example, the 4th harmonic of the 12 MHz ship-shore calling or working frequencies falls within the B.B.C. TV band. A transmitter incorrectly adjusted so that it doubles in the output stage, instead of radiating the intended fundamental of, say, 2800 kHz will cause serious interference in the aircraft route band, which is used by long distance civil airlines for communication and navigation. Safety of aircraft may then be endangered.

d. MF frequencies travel a long distance at night, this distance being primarily proportional to power used. If you are communicating over a distance of a few miles with MF, use only sufficient power to serve your purpose, bearing in mind that at the same time in different parts of the world a hundred or more stations may all legitimately be using the same frequency for various purposes.

e. Remember you usually stand a better chance of maintaining communication if you remain on your assigned frequency. An odd 100 Hz high or low can sometimes make the difference between good communication and none at all.

4. **Aerials.** Normally transmissions to ships from shore take place using omnidirectional aerials, or aerials of a type designed to cover a certain service area. Transmissions from ships must, of necessity, also be from omnidirectional aerials, but these aerials can produce most erratic polar diagrams, due to the ship's structure, fittings, the termination of adjacent aerials, etc. This irregularity of directivity should always be borne in mind as it often contributes to some of the unusual communication results obtained in, and by, ships. A certain receiver aerial may have the reputation of being the best one to receive on a particular frequency band. It should be remembered that the probable reason for this in certain locations may be that this aerial is so inefficient to signals received from certain other directions that it virtually rejects this interference, making the wanted signal seem louder. Equally under changed circumstances this same aerial may effectively reject the wanted signal.

5. **Crystals.** Crystals are used in the communication world primarily to obtain frequency accuracy and stability of transmitters and receiver. Crystals are, however, not 100 per cent accurate and are processed to certain tolerances which are laid down in current D.C.I.s. These tolerances may vary from as much as 0.02 per cent between 0–60 degrees Centigrade down to 0.0015 per cent between finer limits of temperature. The majority of ordinary crystals used by ships are of the order of 0.02 to 0.01 per cent tolerance for MF, HF, and VHF. It will be seen that if a net is crystallized on the same frequency, it does not follow that they will all come up at exactly the same point on a receiver; often the acceptance bandpass of the receiver will take care of this, but if the receiver is being used in the highly selective state, it may be possible to reject or distort stations' transmissions using crystals near the limits of tolerance, particularly at the higher frequencies.

6. **Testing and Tuning.** Excessive testing and tuning, especially with the key clamped down without listening out, can be one of the most exasperating as well as one of the most dangerous practices in the communications world. Well-constructed and clearly defined adjustment cards will normally obviate all excessive tuning, and testing should be confined to the minimum required on authorized frequencies.

7. **Conclusion.** It should always be remembered that the low-powered users – ships and aircraft in particular – are the most susceptible to interference, because in addition to their low power the transmitting and receiving aerials used have to be omnidirectional. The shore station invariably has more power available, and if operating a fixed service can concentrate on directivity, which enables the station when transmitting to concentrate its radiated field strength into the right area, and when receiving, to reject signals from unwanted directions. Correct and accurate use of assigned frequencies, which is essential to good communication, is only possible by correct and accurate adjustment of all equipment.

1.14. RADIO RELAY

1. GENERAL

a. Radiation hazards and ICS frequency separation are at present imposing limitations on the use of medium powered HF transmitters by high capacity ships (DLG's and above), particularly aircraft carriers.

b. To overcome the effect of these limitations the most suitable ship in the vicinity of the high capacity ship may be detailed to act as relay ship for a given type of circuit. When so detailed the relay ship should prepare the necessary changes in equipment tuning and plugging so that, when desired, the relay can be implemented with the minimum delay.

c. In certain instances the high capacity ship may have to close down for reasons of radio hazard before the relay can be set up or when no relay ship is available. In such cases the word RADHAZ may be used by the high capacity ship to give warning of her intentions or to explain why she has stopped transmitting.

d. The 10 per cent frequency separation restrictions at present affecting ICS ships (which may be as much as $22\frac{1}{2}$ per cent between certain frequencies in triple drive fitted ships) may prevent an ICS ship setting watch on a given circuit. In such cases the ICS ship may indicate her inability to set watch by the word FREQSEP. The use of a relay ship should, under normal circumstances, only be considered if the ICS ship experiencing the difficulty is a high capacity ship.

e. Relays may also be used to overcome equipment defects, mutual interference and other problems.

2. Terminology

a. There are six basic types of circuit which may be relayed; the type of relay is known by a letter dependent on the emission used on that circuit, as follows:

(1) Relay ALFA – A RATT task force or group broadcast.

(2) Relay BRAVO – A Voice Simplex circuit.

(3) Relay CHARLIE – A RATT Simplex circuit.

(4) Relay DELTA – A CW Simplex circuit.

(5) Relay ECHO – Re-radiation of the on-line broadcast in its encrypted mode.

(6) Relay FOXTROT – Re-radiation of a mobile fixed service which may be employing on-line equipment. Relay FOXTROT indicates relay of both IN and OUT channels; relay FOXTROT ONE the OUT channel only; relay FOXTROT TWO, the IN channel only.

b. Throughout this chapter the following terms are used:

(1) CIRCUIT FREQUENCY – The (HF) frequency in use on a circuit before relay working is considered and that used by the relay ship for the retransmission.

(2) LINK FREQUENCY – The frequency used solely for contact and relaying between the high capacity ship and the relay ship.

3. Method of relay

a. The method by which each relay is achieved depends on the equipment fits of both the high capacity ship and the relay ship and on the control arrangements fitted on the relay ship. The decision as to which method is to be employed for a given relay rests with the high capacity ship and must be stated at the outset. To simplify this decision and to ensure that there is an unambiguous way of stating which method is to be employed, the various methods have been given designators which have been set out in table 1 in *c.* below. The number in each designator refers specifically to what the high capacity ship must do.

The second letter in each designator is the key to what the relay ship must do, but because the detailed arrangements in the relay ship depend on what is coming from the high capacity ship, they can only be deduced from consideration of the whole method designator.

b. The high capacity ship, knowing her own equipment fit, must first find out the equipment and control arrangements fitted in the ship under consideration for relay. Table 1 then shows the method designator appropriate to that combination. Material arrangements for both the high capacity ship and the relay ship for the method designator can then be found in paragraphs 4 and 5 respectively.

c. Relay Method Designators. These are as indicated in the table:

TABLE 1 RELAY METHOD DESIGNATORS

TYPE OF RELAY	RELAY SHIP / HIGH CAPACITY SHIP	OUTFIT KH AND RATT 2/2A	OUTFIT KH AND RWA	OUTFIT KMM AND RWA	OUTFIT KMP AND RWA
Relay ALFA	RATT 2/2A	M1A	M1B	M1B OR M4E	M15
	Outfit RWA	M2A	M3C	M3D OR M4E	M3D
Relay CHARLIE	RATT 2/2A	M1A	M1B	M1B OR M4E	M1B
	Outfit RWA	M2A	M3C	M3D OR M4E	M3D
Relay DELTA	RATT 2/2A	Not Possible*	M6G	M5F OR M8H	M5F OR M6G
	Outfit RWA	Not Possible*	M7G	M5F OR M8H	M5F OR M7G
Relay BRAVO	Any Fit	Not Possible*	Not Possible	M9J OR M10K	M9J
Relay ECHO	RATT 2/2A OR RWA	Not Possible	M11L	M11L OR M11M	M11L OR M11M
Relay FOXTROT ONE	RATT 2/2A	Not Possible	Not Possible	Not Possible	Not Possible
	Outfit RWA	Not Possible	M3C	M3C OR M3D	M3C OR M3D
Relay FOXTROT TWO	RATT 2/2A OR Outfit RWA	Not Possible	M11L	M11L OR M11M	M11L OR M11M

*It has been decided that interim ships staff modifications to equipment previously issued in RN Signal Orders to permit this relay cannot be issued as an official modification in BR 1917 and are therefore cancelled.

d. For some relay methods using outfit RWA, a specially prepared relay link is required. This link consists of a standard double ended connector pattern no. 5995–AP 181048 modified as follows:

PLUG "A"		PLUG "B"
PIN A	CONNECT TO	PIN D
PIN D	CONNECT TO	PIN A
PIN B	CONNECT TO	PIN E
PIN E	CONNECT TO	PIN B

The modified connector should be painted red or bound in red adhesive tape, to distinguish it from the standard type.

4. Material arrangements in High Capacity Ships

a. M1

(1) The Link Frequency is UHF.

(2) Set up Type 691 or 692 to the Link Frequency.

(3) Connect the ANSGC–1A to this transmitter. (Relay Alfa, ANSGC–1A to TRANSMIT: Relay Charlie to AUTO).

(4) Plug TTY into the two-tone T/T socket of the teleprinter Distribution Panel.

(5) A2 RATT using 200 Hz shift is thus transmitted on the UHF Link Frequency.

(6) If Relay Charlie, continue reception of the Circuit Frequency as before during the relay.

b. M2

(1) The Link Frequency is UHF.

(2) Set up a Type 691 or 692 to the Link Frequency.

(3) Connect a TTVF (TACTICAL) set to Channel 1 (500 Hz=A: 700 Hz=Z) via a SUR to this transmitter. (Relay ALFA, TTVF(T) to TRANSMIT: Relay Charlie to AUTO).

(4) A2 RATT using 200 Hz shift is thus transmitted on the UHF Link Frequency.

(5) If Relay Charlie, continue reception of the Circuit Frequency as before during the relay.

c. M3

(1) The Link Frequency is UHF.

(2) Set up a Type 691 or 692 to the Link Frequency.

(3) Connect a TTVF (TACTICAL) set to Channel 2 (2125 Hz=A: 2975 Hz=Z) via SUR to this transmitter. (Relay Alfa, TTVF(T) to TRANSMIT: Relay Charlie to AUTO: Relay Foxtrot one to TRANSMIT).

(4) A2 RATT using 850 Hz shift is thus transmitted on the UHF Link Frequency.

(5) If Relay Charlie, continue reception of the Circuit Frequency during the relay.

d. M4

(1) The Link Frequency is HF.

(2) Set up an SSB transmitter in such a way as to transmit FST 850 Hz shift Arrangement 1 on the Link Frequency, ensuring that the power output of this transmitter is not more than 50 watts. (Relay Alfa, TTVF(T) to TRANSMIT: Relay Charlie to AUTO).

(3) If Relay Charlie, continue reception of the Circuit Frequency as before during the relay.

e. M5

(1) The Link Frequency is UHF.

(2) Set up a Type 691 to the Link Frequency. It is important that the MCW oscillator of the type 691 chosen produces within 100 Hz of 1 kHz.

(3) Key this transmitter on MCW.

(4) MCW is thus made on the UHF Link Frequency.

(5) Continue to receive the Circuit Frequency as before during the relay.

f. M6

(1) The Link Frequency is UHF.

(2) Set up a Type 691 or 692 to the Link Frequency.

(3) Connect the ANSGC–1A to this transmitter. (ANSGC–1A to TRANSMIT).

(4) Plug a morse key fitted with a two-pole red plug into the two-tone T/T socket of the Teleprinter Distribution Panel. (The key used must be one that ensures the D.C. loop is completed when the key is up and broken when the key is down).

(5) Two-tone morse on the Link Frequency is thus made, using the ANSGC–1A 700 Hz tone when the key is up and the 500 Hz tone when the key is down.

(6) Continue to receive the Circuit Frequency as before during the relay.

g. M7

(1) The Link Frequency is UHF.

(2) Set up a transmitter to the Link Frequency.

(3) Key a TT 10 switched to MORSE from its associated morse key to its parent TTVF (TACTICAL) switched to TRANSMIT and Channel 1 (700 Hz tone when key is up and 500 Hz tone when key is down) and RATT. Connect the TTVF (TACTICAL) via the SUR switched to RATT to the transmitter.

(4) Two-tone morse (200 Hz shift) is thus made using the TTVF(T) tones on the UHF Link Frequency.

(5) Continue to receive the Circuit Frequency as before during the relay.

h. M8

(1) The Link Frequency is HF.

(2) Set up a transmitter to the Link Frequency ensuring that the power output is not more than 50 watts.

(3) Key the transmitter on CW in the normal way.

(4) Continue to receive the Circuit Frequency as before during the relay.

i. M9

(1) The Link Frequency is UHF.

(2) Tune a transmitter to the Link Frequency.

(3) Connect this transmitter to the positions manned by Circuit Frequency users.

(4) Transmit DSB Voice on the UHF Link Frequency.

(5) Continue to receive the Circuit Frequency as before during the relay.

j. M10

(1) The Link Frequency is HF.

(2) Tune a transmitter to the Link Frequency ensuring that the power output is not more than 50 watts. (If the emission is to be SSB Voice this must be made clear by the designator chosen for the Link Frequency in the initial signal (see paragraph 6)).

(3) Transmit voice on the HF Link Frequency.

(4) Continue to receive the Circuit Frequency as before during the relay.

k. M11

(1) The Link ship will transmit A2 RATT 850 Hz shift on the UHF Link Frequency.

(2) Set up a Type CUH/CUJ on the Link Frequency.

(3) Plug the receiver to a Broadcast Selector Unit and thence through the converter and decryption equipment to the broadcast bay.

5. Material Arrangements in the Relay Ship

a. M1A

(1) The high capacity ship will transmit A2 RATT 200 Hz shift on the UHF Link Frequency.

(2) Set up a UHF receiver to the Link Frequency.

(3) Connect the output of the UHF receiver to the ANSGC–1A, set to RECEIVE, at the RATT bay.

(4) Set up an HF transmitter in such a way as to transmit FST 850 Hz shift Arrangement 1 on the Circuit Frequency. (Note that the Lower Sideband of the transmitter must be used).

(5) Set the Teletypewriter Distribution Panel as shown on page 10–2–27, Fig. 14.

b. M1B

(1) The high capacity ship will transmit A2 RATT 200 Hz shift on the UHF Link Frequency.

(2) Set up a UHF receiver to the Link Frequency.

(3) Connect the output of the UHF receiver to a TTVF(T) switched to RECEIVE and to Channel 1 (500 Hz=A: 700 Hz=Z). 2125 1275

(4) Set up an SSB transmitter to the Circuit Frequency and connect it via a SUR to a second TTVF(T) switched to Channel 2 (2975 Hz=A: 2125 Hz=Z) in such a way as to transmit FST 850 Hz shift Arrangement 1. In relay Alfa the TTVF(T) must be to TRANSMIT: Relay Charlie to AUTO.

(5) Connect the output of the TTVF(T) set to Channel 1 to the input of the TTVF(T) set to Channel 2 at the Distribution Panel (Tactical). The RELAY link must be used.

c. M2A

As for M1A

d. M3C

(1) The high capacity ship will transmit A2 RATT 850 Hz shift on the UHF Link Frequency.

(2) Set up a UHF receiver to the Link Frequency.

(3) Connect the output of the UHF receiver to a TTVF(T) switched to RECEIVE and to Channel 2
2775 (2125 Hz=A: 2975 Hz=Z). 2125 1275

(4) Set up an SSB transmitter to the Circuit Frequency and connect it via a SUR to a second TTVF(T) set to Channel 2 (2975 Hz=A: 2125 Hz=Z) in such a way to transmit FST 850 Hz shift Arrangement 1. In Relay Alfa the TTVF(T) must be set to TRANSMIT: In Relay Charlie to AUTO: In Relay Foxtrot one to TRANSMIT. 2125

(5) Connect the output of the receive TTVF(T) from the UHF receiver to the input of the transmit TTVF(T) at the Teletype Distribution Panel (Tactical). The RELAY link must be used.

e. M3D

(1) The high capacity ship will transmit A2 RATT 850 Hz shift on the UHF Link Frequency.

(2) Set up a UHF receiver to the Link Frequency.

(3) Set up an SSB transmitter to the Circuit Frequency in such a way as to transmit FST 850 Hz shift Arrangement 1. (Note that the Lower Sideband of the transmitter must be used).

(4) Transfer the output of the UHF receiver to the input of the HF transmitter via the direct relay facilities provided in Outfit KMM or KMP.

f. M4E

(1) The high capacity ship will transmit FST 850 Hz shift Arrangement 1 on low power on the HF Link Frequency.

(2) Set up an HF receiver to the Link Frequency.

(3) Set up an SSB transmitter on Medium Power (up to 0.7kW) to the Circuit Frequency in such a way as to transmit FST 850 Hz shift Arrangement 1.

(4) Transfer the output of the HF receiver to the input of the HF transmitter via the direct relay facilities provided in Outfit KMM.

g. M5F

(1) The high capacity ship will transmit MCW on the UHF Link Frequency.

(2) Set up a UHF receiver to the Link Frequency.

(3) Set up an HF SSB transmitter to the Circuit Frequency in such a way that when modulated in the carrier suppressed mode by the 1 kHz output of the UHF receiver, it will radiate on the Circuit Frequency.

(4) Transfer the output of the UHF receiver to the input of the HF transmitter via the direct relay facilities provided in Outfit KMM or KMP.

h. M6G

(1) The high capacity ship will transmit two-tone morse 200 Hz shift on the UHF Link Frequency.

(2) Set up a UHF receiver to the Link Frequency.

(3) Set up an HF SSB transmitter in such a way that when modulated in the carrier suppressed mode by a 1 kHz tone it will radiate on the Circuit Frequency.

(4) Connect the UHF receiver to a TTVF(T) switched to RATT, RECEIVE and Channel 1 (500 Hz and 700 Hz tones).

(5) Connect a second TTVF(T) switched to MORSE via a SUR switched to MORSE to the HF transmitter.

(6) Connect the two TTVFs(T) together at the Distribution Panel (Tactical) by using the RELAY link.

i. M7G

As for M6G

j. M8H

(1) The high capacity ship will transmit CW on low power on the HF Link Frequency.

(2) Set up a receiver to the Link Frequency ensuring that the audio output is 1 kHz.

(3) Set up an HF SSB transmitter in such a way that when modulated in the carrier suppressed mode by the 1 kHz output of the Link Frequency receiver, it will radiate on the Circuit Frequency.

(4) Transfer the output of the HF Link Frequency receiver to the input of the HF Circuit Frequency transmitter via the direct relay facilities provided on Outfit KMM.

k. M9J

(1) The high capacity ship will transmit DSB Voice on the UHF Link Frequency.

(2) Set up a receiver to the UHF Link Frequency.

(3) Set up an HF transmitter on SSB or DSB Voice, as appropriate, to the Circuit Frequency, being particularly careful, if SSB Voice, to note whether the Circuit Frequency has a 3 kHz or 6 kHz assigned bandwidth.

(4) Transfer the output of the UHF receiver to the input of the HF transmitter via the direct relay facilities of Outfit KMM or KMP.

l. M10K

(1) The high capacity ship will transmit voice on low power on the HF Link Frequency. Whether she intends to use DSB or SSB Voice should be clear from the designator in the initial signal (see paragraph 6).

(2) Set up an HF receiver to the Link Frequency.

(3) Set up an HF transmitter on SSB or DSB Voice, as appropriate, to the Circuit Frequency, being particularly careful, if SSB Voice to note whether the Circuit Frequency has a 3 kHz or 6 kHz assigned bandwidth.

(4) Transfer the output of the HF Link Frequency receiver to the input of the HF Circuit Frequency transmitter via the direct relay facilities of Outfit KMM.

m. M11L

(1) The Link Frequency is UHF.

(2) Set up a Type 691 or 692 to the Link Frequency.

(3) Connect reception of the Circuit Frequency to a TTVF(T) switched to RECEIVE and Channel 2.

(4) Connect a second TTVF(T) switched to TRANSMIT and Channel 2, via a SUR to the UHF transmitter.

(5) Connect the output of the RECEIVE TTVF(T) to the input of the TRANSMIT TTVF(T) by means of the RELAY link.

n. M11M

(1) The Link Frequency is UHF.

(2) Set up a Type 691 or 692 to the Link Frequency.

(3) Connect reception of the Circuit Frequency via the control unit radio relaying to the UHF transmitter.

6. **Detailing Ships for Relay Duties**

a. The relay ship will be detailed by the OTC or high capacity ship concerned in the following form:

(1) The word RELAY followed by:

(a) the high capacity ship requiring relay facilities;

(b) the relay ship;

(c) the type of relay (Alfa, Bravo, Charlie, Delta);

(d) the method of relay (from paragraph 3 table 1);

(e) the circuit designator of the circuit to be relayed;

(f) the Link Frequency, followed for Relay A and C, by the baud speed if other than 75 bauds. For Relay B, Method M10K, the designator used for the link Frequency must make it clear whether the Link Frequency is DSB or SSB Voice and, if SSB, clearly show both the centre of the emitted bandwidth and the suppressed carrier frequency;

(g) the Circuit Frequency (this may be omitted if the frequency is self-evident from (e) above).

(h) for relay Foxtrot, the circuit designator of the engineering circuit.

b. Examples

1. Relay – c/s EAGLE – c/s KENT – ALFA – M2A – 19G2 – 65D1 – 50
2. Relay – c/s FEARLESS – c/s YARMOUTH – DELTA – M5F – 20G2 – 65D1
3. Relay – c/s VICTORIOUS – c/s GALATEA – BRAVO – M10K – 18G1 – FREQ 1/50/3*
4. Relay – c/s HERMES – c/s GALATEA – FOXTROT – H32B6/U47W – H32A3/U43Z – U42W.

*Shows SSB Voice on 4134.5 (4133) with 3 kHz assigned bandwidth from appropriate RN Signal Order.

c. For Relay Foxtrot the high capacity ship is to order the Relay ship to set watch on a UHF Voice circuit to be used as an engineering circuit for passing steerage instructions, synthesiser settings, etc.

7. **Preliminary Arrangements**

a. As soon as possible after the initial signal has been made, action as follows is to be taken:

(1) In the high capacity ships:

(a) Prepare equipment as listed for the appropriate method in paragraph 4.

(b) Copy the Circuit Frequency in the MCO/BWO in addition to other internal users for monitoring purposes.

(c) Warn internal users of the Circuit Frequency that while the change to and from relay working is being implemented their ability to transmit will be temporarily interrupted.

(d) For relay B, method M10K

(i) In ICS ships. Switch off the side-tone facility at the C and M Desk on the Link Frequency TCU. (Warn users of the Link Frequency that they will not hear their own transmissions until they are being relayed by the relay ship).

(ii) In 640 fitted ships. Since side-tone cannot be switched off, warn users of the Link Frequency that once relay working starts the fact that they can hear their own transmissions in their headsets will not be an indication that their signal is being retransmitted and being received by them from their Circuit Frequency receiver.

(e) When convenient, make a test transmission to the relay ship on the Link Frequency.

(2) In the relay ship:

(a) Prepare equipment as listed for the appropriate method in paragraph 5.

(b) Copy the Circuit Frequency in the MCO/BWO if not already doing so.

(c) Parallel reception of the Link Frequency to a bay in the MCO/BWO.

(d) Be prepared to receive a test transmission on the Link Frequency from the high capacity ship.

8. **Drill for Transferring from the Normal to the Relay State**

a. The high capacity ship transmits on the Circuit Frequency to the relay ship, information to all units on the Circuit Frequency, the procedure message STANDBY START RELAY.

b. The relay ship closes up an extra operator (the relay operator) who sets listening watch on the Link Frequency.

c. The high capacity ship stops transmitting on the Circuit Frequency and starts transmitting on the Link Frequency (call tape or long test transmission).

d. In the relay ship, as soon as the relay operator hears the high capacity ship's transmission on the Link Frequency he switches on the SUR to the Circuit Frequency transmitter which relays automatically. This is not necessary when the direct relay facilities of outfit KMM or KMP are being used.

e. As soon as the high capacity ship hears her call being retransmitted she can commence passing traffic on the Link Frequency. In Relay Bravo, Method M10K, using a Type 640 in the high capacity ship, since the circuit operator will be hearing his own side-tone from the HF Link Frequency transmitter, initially he will have to be informed by the MCO as soon as he is being retransmitted.

f. In Relay Foxtrot, if difficulty is experienced in relaying an on-line fixed service, the high capacity ship will shift to plain working and order the relay ship to provide monitor teleprinters on the IN and OUT channels by transmitting the word "MONITOR" on the engineering circuit. Subsequent information provided by the relay ship should help to diagnose the cause of the difficulty.

9. **Drill for Transferring from the Relay to the Normal State**

a. The high capacity ship transmits on the Circuit Frequency (via the Link Frequency) to the relay ship, information to all units on the Circuit Frequency, the procedure message STANDBY STOP RELAY.

b. The high capacity ships stops using the Link Frequency.

c. The Relay ship switches off her Circuit Frequency transmitter (unless required for her own use). This is not necessary when the direct relay facilities of KMM or KMP are being used.

d. The high capacity ship recommences transmitting on the Circuit Frequency.

1.15. THE RULES FOR PLANNING, ORDERING AND SETTING-UP SINGLE-SIDEBAND VOICE CIRCUITS

1. **Planning the Circuits**

a. THE GROUND RULES. For all SSB voice circuits the Upper sideband is to be used.

b. 3kHz AND 6kHz ASSIGNMENTS. The amount of frequency spectrum necessary for an SSB voice circuit is about 3kHz. At the planning stage, frequencies with 3kHz bandwidth may be available, or it may be necessary to make use of frequencies with 6kHz bandwidth, provided for emissions such as DSB voice. The following rules govern what must be written into frequency publications or complans in both these cases, and included in correspondence and messages referring to frequency assignments.

c. In this context it is assumed that the centre of the emitted bandwidth coincides exactly with the assigned frequency and that the suppressed carrier frequency is exactly 1.5kHz below it.

d. When writing the circuit into frequency publications, complans, etc., the assigned frequency must be followed in brackets by the suppressed carrier frequency and the emission designator specifically described. Thus a 3kHz SSB voice assignment on 4842.5kHz would be written as: A3J (or SSB Voice) 4842.5 (4841).

2. **When 3kHz Bandwidth is Available for Assignment.** For intra-RN circuits involving type 633 or Collins 618T, and for all Joint circuits, the centre of the assigned bandwidth (the assigned frequency) MUST END IN .5kHz. Following from paragraph 1. *c.* above, the suppressed carrier frequency will then be a whole number of kHz.

3. **When 6kHz Bandwidth is Available for Assignment**

a. In this case, the frequency listed will be the centre of the bandwidth available and is thus both the assigned frequency and the carrier frequency for a circuit on which it is required to use DSB voice.

b. When this frequency is used for SSB voice, only the upper 3kHz are used. Thus the suppressed carrier frequency is made to coincide with the listed frequency and the centre of the emitted bandwidth – or the new assigned frequency for SSB voice working – is 1.5kHz above it.

c. When writing the circuit into the frequency publications, complans, etc., the new assigned frequency for SSB voice must be followed in brackets by the suppressed carrier frequency and the emission specifically described. Therefore, from an original assignment of 4841kHz with 6kHz available, the new assignment would be written as: A3J (or SSB Voice) – 4842.5 (4841).

d. Since most 6kHz assignments are listed as whole numbers of kilocycles, it follows that when they are used for SSB voice, the suppressed carrier frequency will also be a whole number of kHz. Compatibility is thus assured between the various types of equipment that may be employed and no special rules are necessary. 6kHz assignments not ending in a whole number of kHz must be used with discretion. (See para. 2).

4. **Use of a 3kHz or 6kHz Assignment for other than its Listed Emission**

a. The situation will often arise when a frequency assigned and listed for a specific mode of emission, is required to be used for another emission. An example of this has already been described in para. 3*a.* to *d.* above. In every case where a misunderstanding could occur the new emission designator must be accompanied by the frequency on which it is intended that the new emission should be centred.

b. A typical example of such a case is when an assignment is made for Joint circuits, or for intra-RN circuits employing either type 633 or Collins 618T, in the SSB voice mode when it is required to change to morse or FST mode of operation. Such a circuit will appear for SSB voice as 4842.5 (4841) tailored specially so that the suppressed carrier frequency is a whole number of kHz. Therefore, when employing these equipments, FST or morse operation is precluded on assigned frequencies ending in .5kHz.

c. In this case the emitted bandwidth for morse and for FST is to be centred on the nearest whole number of kHz below the frequency assigned for SSB voice operation. For example quoted above this would be for morse A1 or A2 4842kHz or FST F1 4842kHz.

d. It will now be seen that if misunderstandings are to be prevented, frequency publications and complans will in most instances have to show, for each basic assignment of frequency spectrum, a different assigned frequency and designator or line number for different types of emission.

e. This point is illustrated in the following table:

TABLE 1

EXAMPLE	CIRCUIT TITLE	CIRCUIT DESIGNATOR	EMISSION OR MODE	FREQUENCY
With 6 kHz band-width available	Air Defence	16G1A	A3 (DSB Voice)	6482
	Net	16G1B	A1 (CW)	6482
		16G1C	A3J (SSB Voice)	6483.5 (6482)
With 3 kHz band-width available (fass=0.5 kHz)	Carrier'JOC	202J3A	A3J (SSB Voice)	4213.5 (4212)
		202J3B	A1 (CW)	4213
		202J3C	A2 (MCW)	4213
		202J3D	F1 (FST)	4213
With 3 kHz band-width available (fass=whole number)	Tactical	Line 12	A3J (SSB Voice)	2790 (2788.5)
		Line 13	A1 (CW)	2790
	Secondary	Line 14	F1 (FST)	2790
See limitations in paragraph 2.				

5. **Ordering the Circuit**

a. The order to set up an SSB voice circuit must always make it clear what both the assigned frequency and the suppressed carrier frequency are. If this can be done by reference to a recognised circuit designator or line number this is perfectly satisfactory.

b. If, however, a ship or authority has to use a DSB assignment, it must be first converted into the SSB voice form, in accordance with the rules in paragraphs 3*a.* to *d.* above, and it follows that the normal designator or line number for the 6kHz assignment cannot be used to order the circuit.

6. **Setting up the Circuit**

a. From paragraph 5 it will be seen that units setting up their equipment will be provided with the assigned frequency followed in brackets by the suppressed carrier frequency whether the original assignment was 3kHz or 6kHz. They will also be given an emission designator to signify that the emission is SSB voice.

b. On SSB voice circuits, voice is to be used throughout. The initial call is not made on CW, nor is CW automatically reverted to if SSB voice communications are lost.

7. **Changing from SSB Voice to Another Mode of Emission**

a. If for a special reason it is necessary to change from SSB voice to another mode of emission, the following rules are to apply.

b. The authority ordering the change must quote the recognised line number or circuit designator which applies to the new mode of emission. Thus from example in line 1 of table 1, when a change to CW is required, the necessary order would be: "QSW – 16G1B".

c. If no such line number or designator exists, the unit ordering the change must then include with the new emission designator, the centre of the emitted bandwidth as follows:

(1) When the SSB voice assigned frequency ends in .5kHz. The new morse or FST assigned frequency must be the nearest whole number of kilocycles below the SSB assigned frequency. For example if the assigned frequency for SSB voice is 4314.5 (4313), then the frequency to be assigned for FST must be 4314, when the necessary order would be: "QSW 4314 F1".

(2) When the SSB voice assigned frequency ends in whole kilohertz. The new morse or FST assigned frequency must coincide with the SSB assigned frequency. For example, if the assigned frequency for SSB voice is 6824 (6822.5), then the frequency to be assigned for CW must be 6824, when the necessary order will be: "QSW 6824 A1".

8. **Setting up Equipment.** The dial settings appropriate to RN equipment for SSB voice circuits are shown below.

a. TRANSMITTERS

TDA	Synthesiser set to suppressed carrier frequency USB/carrier suppressed Vogad IN (on TCU)
640	Synthesiser set to suppressed carrier frequency System to ISB (SC) Use CHANNEL A Vogad IN
633	The channel crystal is used to derive the suppressed carrier frequency which must be a whole number of kilohertz Sideband to UPPER Carrier to OFF
Collins 618T	Synthesiser set to the suppressed carrier frequency, which must be a whole number of kilohertz System to USB

b. RECEIVERS

CJA	Synthesiser set to suppressed carrier frequency Modulation to SSB – ISB/EXT Auto/Manual gain to PAUSE Output switch to USB Synthesised/Free Running to SYNTHESISED
CJK	Synthesiser set to centre of emitted bandwidth Sideband selector to USB (Clockwise) BFO down Bandwidth to 3kHz AVC to LONG Output 1 or 2 to USB
B40/FAZ	B40 tuned to centre of emitted bandwidth Bandwidth to 3kHz FAZ to USB and VOICE

1.16. INTRODUCTION TO SINGLE-SIDEBAND

1. The technique of Single-Sideband has been known since 1914, but its general application has been delayed by the need for exceptional stability in both transmitters and receivers. With the introduction of frequency standards and synthesisers this requirement has now been met. Two additional advantages gained as a result of this stability are that equipment may be used unattended for long periods with much more critical tolerances for filters and bandwidths than were previously considered possible.

2. **Audio Frequencies.** The human voice and all musical instruments produce audible sound waves, known collectively as audio frequencies, in a range that extends from about 15 Hertz to 18,000 Hertz. If any frequency, or group of frequencies, in this range is fed into a good quality microphone, the output will be alternating voltages of the same frequency or frequencies as the sound waves that produced them. For ordinary communication purposes, it has been found that intelligible speech communication can be carried out by limiting this range to a group or audio baseband between about 300 and 3,000 Hertz.

3. **Radio Frequencies.** Any conductor carrying current has a magnetic field surrounding it. If the current is made to vary, so will the magnetic field. If the current is made to vary or alternate at a frequency greater than about 12,000 Hertz (Hz), the resulting variations in the magnetic field will be radiated outwards in a form known as radio waves. The word used to describe this phenomenon is propagation. Because about 12kHz is the lowest frequency able to cause propagation, it is necessary to raise the frequency of the audio band if radio communication is to take place. This is done in a radio transmitter in which a radio frequency or carrier is added to the audio baseband, in effect raising the audio baseband into the radio frequency spectrum. Until recently, this addition process in the transmitter had to be carried out in a mixer whose output consisted of a central carrier corresponding to the frequency chosen to be added and two bands of radio frequencies, one above and the other below the carrier, called sidebands.

Because the output produced is the result of addition and subtraction, the frequencies used will determine the amount of space the emission will occupy in the frequency spectrum.

4. **Bandwidth.** While it is true that a wider range of transmitted audio frequencies will produce better fidelity, this can only be achieved by a corresponding increase in the bandwidth. Because of increasing congestion in the HF portion of the frequency spectrum, present efforts are concentrated on using the narrowest possible bandwidth consistent with intelligibility.

Bandwidth then is dependent upon the mode of emission and on the upper and lower limits of the frequencies in the audio baseband. Despite considerable effort, international agreement has not yet been achieved as to just what these limits shall be. This means that it is highly probable that for identical classes or types of emission made by other nations slightly different bandwidths will be necessary. The audio baseband chosen for the modern naval equipments extends from 350Hz to 3050Hz (these figures being agreed standards for modern equipments in the USN, RCN and RN) and represent an effective compromise between bandwidth and intelligibility.

5. **Double-Sideband**

a. From Fig. 1, it should be apparent that a double-sideband voice emission consists of the radio frequency carrier and two bands of radio frequencies located either side of it. These represent the original audio baseband and are identified as the upper sideband or the lower sideband.

An important feature of DSB voice is that while the upper sideband has the higher voice frequencies of the audio baseband as the highest radiated frequencies, the lower sideband being a mirror image of the upper, has the higher voice frequencies as the lower radiated frequencies. This is known as sideband inversion, and occurs because the upper sideband is produced by the addition (r.f. + a.f.) of the two frequencies whereas the lower sideband is the product of their subtraction (r.f.–a.f.).

b. Careful study of Fig. 1 will reveal two of the principal reasons why double sideband transmissions have been supplanted by more efficient techniques, namely:

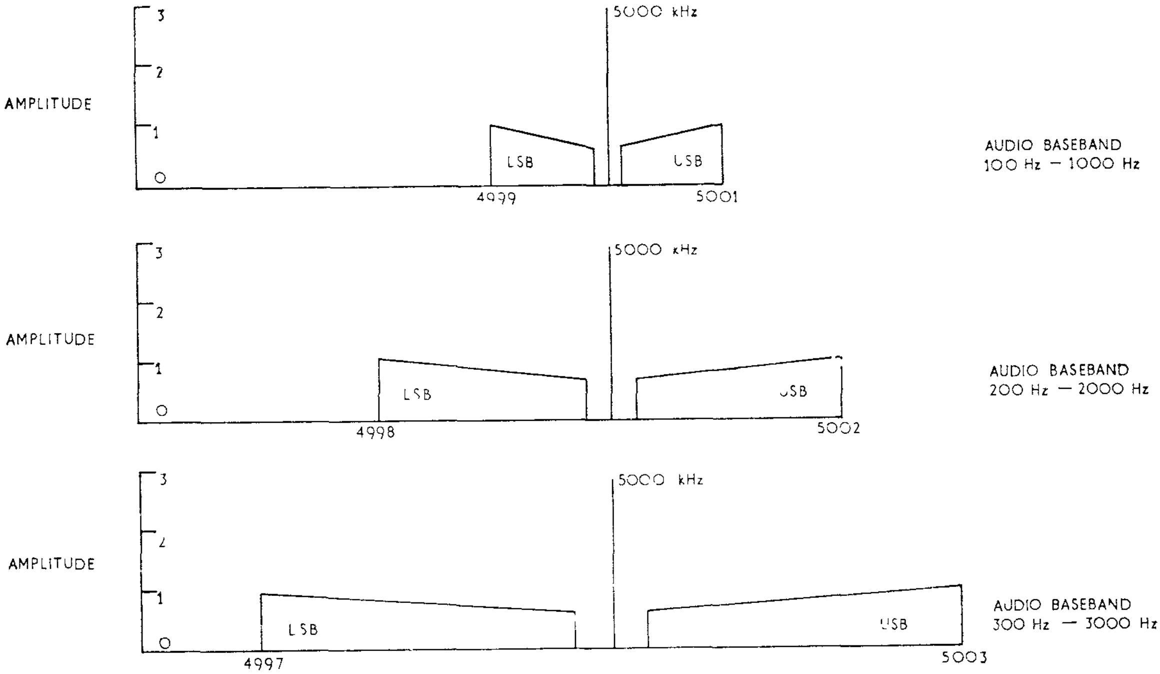


FIG. 1. BASEBAND – BANDWIDTH RELATIONSHIP

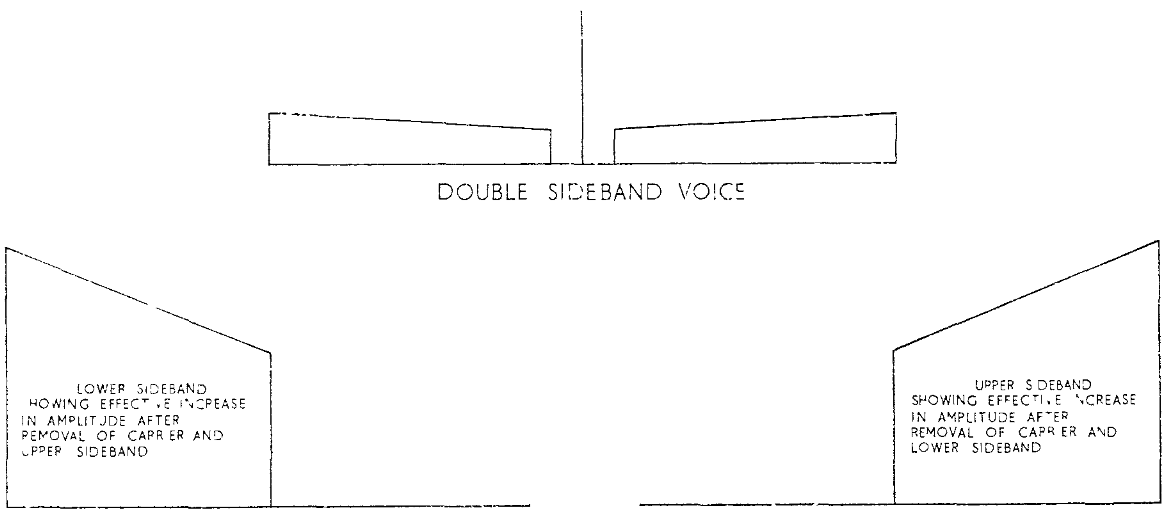


FIG. 2. POWER RELATIONSHIP

(1) Although the intelligence is limited to a relatively narrow band of frequencies, the double sideband transmission requires a bandwidth of twice the highest audio frequency.

(2) As the amplitude of the carrier represents 66% of the total power output, only the remaining 33% is available to be shared between the two sidebands, each of which contains the identical information or intelligence which originated in the one audio baseband. Thus only $\frac{1}{3}$ of the power available at the transmitter is devoted to the all important intelligence.

Therefore it should be clear that if the power contained in the carrier and the duplicated (and unwanted) sideband could be eliminated or suppressed, the total power of the transmitter can be used for the remaining sideband, thereby resulting in a 5 or 6 fold increase in amplitude (and power) with a corresponding increase in performance. If this were done, it would, concurrently, also halve the amount of the radio frequency spectrum necessary to transmit the same intelligence. The effect of this would be to reduce the transmission to a single-sideband.

6. **Single Sideband.** In general the term single-sideband refers to the method more accurately described as single-sideband suppressed carrier (SSB (SC)) where only one sideband is transmitted and the carrier is suppressed to the point of non-existence. The actual degree of carrier suppression is variable and is generally expressed as a power ratio (measured in decibels) relative to the peak level of the wanted sideband. With 50 decibels (db) of carrier suppression, a transmitter with a nominal output of 1000 watts will have a carrier power of 0.01 watt.

Briefly then a single-sideband signal is a normal amplitude modulated double sideband signal from which the non-essential elements have been removed or reduced to the level where their effect on the output power and output waveform are negligible.

7. **Performance of Single-Sideband**

a. While the principal advantages of SSB are the reduction in bandwidth coupled with the increase in effective sideband power, other factors contribute to the preference for this mode of emission. Under ideal propagating conditions, an SSB transmitter will perform as well as a double-sideband transmitter of three times the power rating. With long distance (multi-hop) sky-wave communication, double-sideband is subject to deterioration because all three components of the transmitted signal (upper-sideband, carrier and lower-sideband) must be received exactly as transmitted to achieve fidelity and optimum signal strength. The most common fault of communication by means of the ionosphere is selective fading, where the carrier level is reduced (or attenuated) more than the sidebands. This causes the r.f. envelope to lose its original shape and thereby produce distortion. Selective fading can also cause a phase shift between the carrier and the sidebands with a consequent loss of intelligibility in the received signal. Because only one sideband is transmitted, an SSB transmission will give equal performance to a DSB transmission at least four times more powerful, this advantage increasing markedly as conditions become more unfavourable.

The calculated ratio of relative performance is shown in Fig. 3.

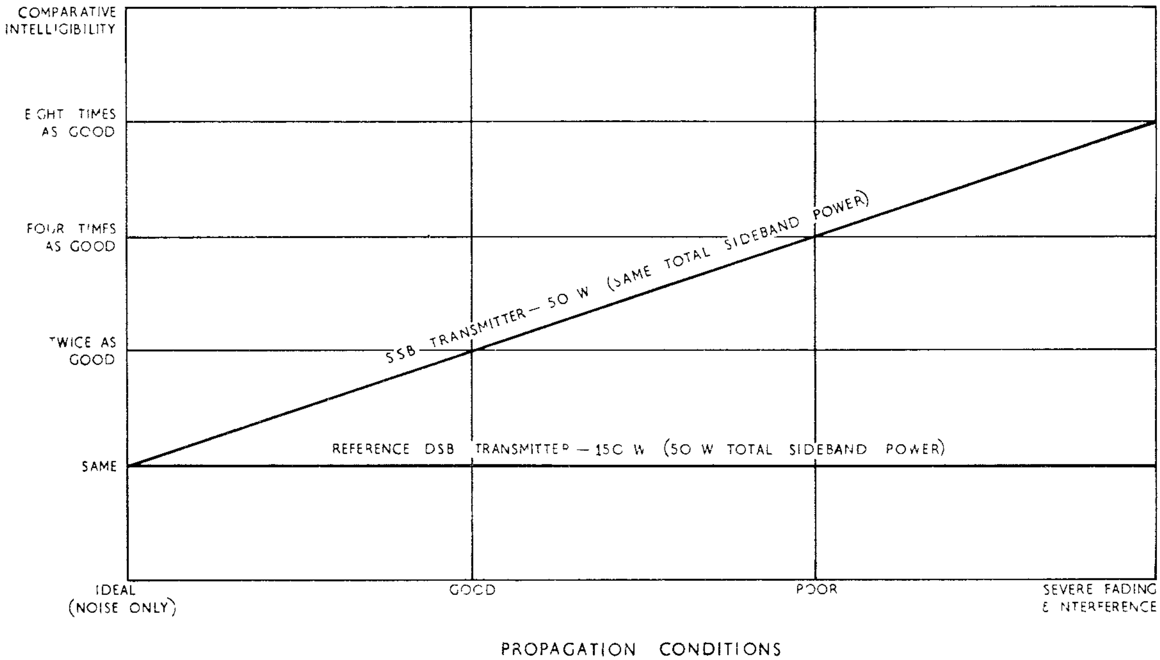


FIG. 3. COMPARISON OF INTELLIGIBILITY OF COMMUNICATION BETWEEN SSB VOICE AND DSB VOICE WITH TRANSMITTERS RADIATING SAME TOTAL SIDEBAND POWER UNDER VARYING PROPAGATION CONDITIONS

8. **Assigned Bandwidth and Frequency.** A station using a specified mode of emission, is given or *assigned* a portion of the radio frequency spectrum for a specific circuit. For ease of reference the centre of this assigned bandwidth is defined as the assigned frequency. With DSB equipment the carrier frequency and the assigned frequency are the same. This is because the DSB transmission is centred on the carrier frequency and it is this frequency that is set on any transmitter or receiver.

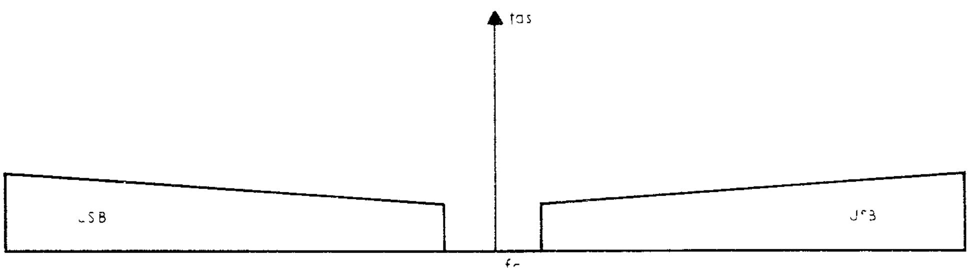


FIG. 4a

Because in the search for greater efficiency, the carrier frequency and one of the side-bands have been removed or suppressed, the balanced nature of the DSB emission has been upset. The transmitter is not now radiating equally about its (suppressed) carrier frequency or dial setting.

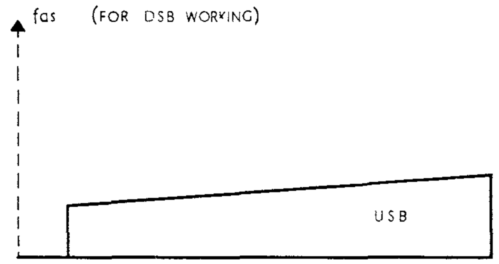


FIG. 4b

This means that the remaining sideband is *offset* and is no longer centred on the assigned frequency which was established for double sideband working.

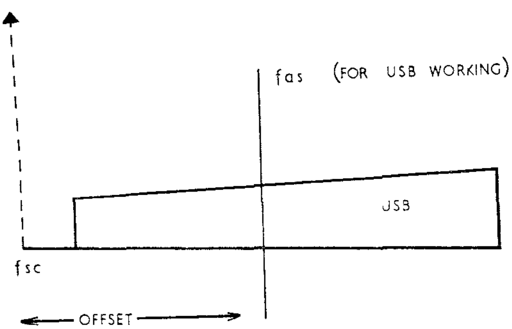


FIG. 4c

9. **Offsetting.** The frequency specified in a complan is the centre of the bandwidth that may be used on that circuit for the stated mode of emission. It is essential that the emission made *is centred* on this assigned frequency. To achieve this when using SSB techniques, a way must be found of moving the emission in a direction that will bring it to the point where it *is centred.* For the DSB emission, the reference point was the carrier frequency which corresponded to the setting placed on the transmitter or receiver because it was from the carrier that the sidebands extended up and down.

Even though the carrier has been suppressed, IT IS STILL THE REFERENCE OR CONTROLLING POINT FOR THE SIDEBANDS.

The question is, if you use upper-sideband, is the suppressed carrier frequency above or below the centre of the sideband? Unless you can see the answer to this question quite clearly, you should, before reading further, return to paragraph 8 and study it until you can see this very important feature of using a transmitter in the single-sideband mode.

10. **Direction**

a. The rule of course is:

Transmitter in the SSB mode radiating USB – suppressed carrier is *below* the assigned frequency.

Transmitter in the SSB mode radiating LSB – the suppressed carrier is *above* the assigned frequency.

The question as to which sideband should be used for SSB voice at first caused some doubt, but over the years general convention has tended to favour the upper sideband and this has now been officially recognised by all UK and NATO services.

b. The difference between the centre of the sideband and the suppressed carrier frequency is known as the *offset*. Having discovered the direction of this offset for upper or lower sideband voice, the next thing to find is its value.

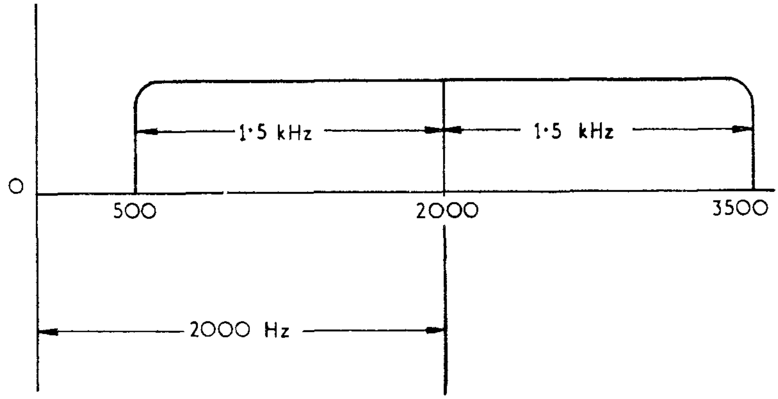
11. **Basebands.** In paragraph 4 it was shown that the bandwidth was dependent upon the mode of emission and on the upper and lower limits of the frequencies in the audio baseband. The three examples in Fig. 5, each using different audio baseband limits, illustrate how any variation in bandwidth will affect the excursion (or difference) between the centre of the emitted sideband and the suppressed carrier (dial) setting.

12. **Accuracy Requirements.** The intelligence (i.e. the audio frequency) at any one moment of time in voice can be regarded as a definite tone value with respect to the carrier frequency and this tone can only be recovered at the receiver if the carrier (which was suppressed at the transmitter) is re-inserted in exactly the same relative position by the receiving station. This means that if the transmitter has added a radio frequency of 5000 kHz to the original audio baseband, exactly 5000 kHz must be subtracted by any receiver requiring to receive that transmission. Any difference between the frequency added by the transmitter and that subtracted by the receiver will, by altering the relationship of the carrier to the baseband introduce distortion with a consequent reduction in readability.

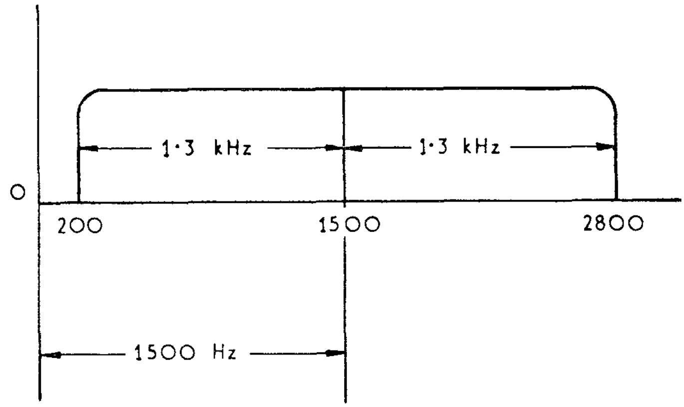
As an indication of the degree of accuracy necessary, a difference of 50 Hz is sufficient to produce slight speech distortion while 100 Hz will result in considerable loss of intelligibility. From this it should be evident that while the requirements for accuracy and stability are essential at both the transmitting and receiving terminals of a circuit, it is equally necessary for identical settings to be applied to each. This necessity for accuracy precludes the use of individual offsets for transmitters having different audio basebands. This would necessitate each receiving station knowing what audio baseband was being used by each transmitting station in order to determine the actual value of offset to be placed on the receiver to restore the critical relationship of carrier to audio baseband.

13. **Standard Voice Offset.** It was pointed out in para. 4 that it has not yet been possible to obtain international agreement on just what the limits of the audio baseband will be. As a compromise, an artificial value of 1.5 Hz has been chosen to represent the amount by which the (suppressed) carrier frequency will differ from the centre of the emitted sideband when radiating SSB voice. By agreeing within NATO to this artificial value we can all set the same suppressed carrier frequency for a given assigned frequency and thereby ensure intelligibility over nearly all the different audio basebands we use.

Example A. Audio baseband 500–3500 Hz
Range = 3000 ÷ 2 = 1500 plus the distance from lower edge of audio baseband = 500
Total 2000 Hz



Example B. Audio baseband 200–2800 Hz
Range = 2600 ÷ 2 = 1300 plus the distance from lower edge of audio baseband = 200
Total 1500 Hz



Example C. Audio baseband 350–3050 Hz
Range = 2700 ÷ 2 = 1350 plus the distance from lower edge of audio baseband = 350
Total 1700 Hz

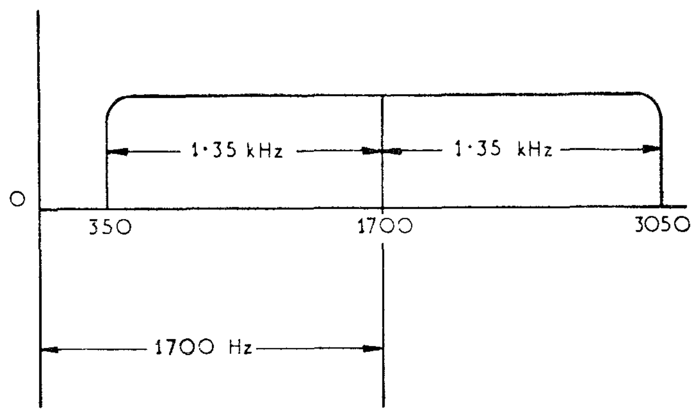


FIG. 5

Fig. 6 shows the effect of this offset with an audio baseband of 350 to 3050 Hz. It should be noted that there is a 50 Hz excursion outside the assigned bandwidth of 3 kHz. Having agreed on this value, anyone planning or ordering an SSB voice circuit is now in a position to specify what the suppressed carrier frequency (and hence the figure to be set on the synthesiser or tuning dial) will be for any assigned frequency, i.e. when using USB voice:– fsc = fass – 1.5 kHz, or fass = fsc + 1.5 kHz.

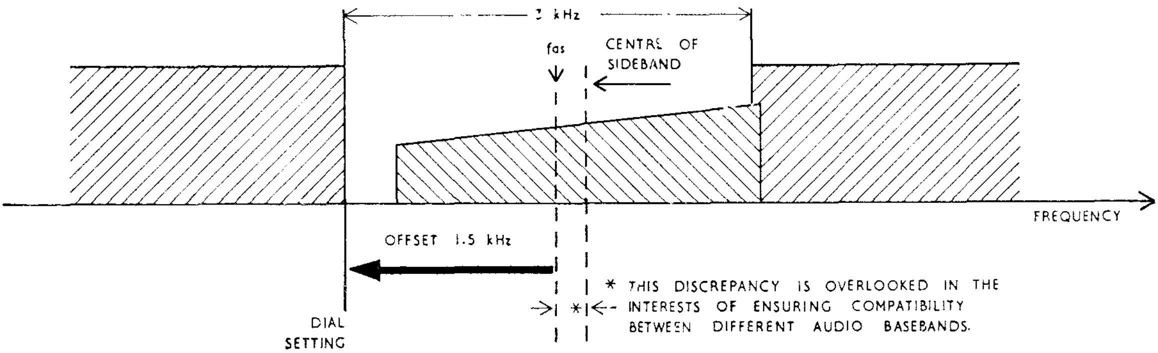


FIG. 6

14. **Frequency Promulgation.** In order to further decrease any possibility of error, every assignment made for the transmission of SSB voice will be described initially by its assigned frequency followed by the suppressed carrier frequency in brackets. Thus the operator will find in the frequency column for his complan for every SSB circuit, both the assigned frequency and the suppressed carrier frequency.
For example:

DESIGNATOR	TITLE	MODE OF EMISSION	FREQUENCY
19G1A	Air Defence Net	A3J	4212.5 (4211)

This means, set 4211 on the synthesiser dials and use the upper sideband. If you have an audio baseband which is centred 1.5 kHz above the suppressed carrier you will then radiate equally about 4212.5 kHz.

SECTION 2

TRANSMITTERS

'DRIVE UNITS, POWER AMPLIFIERS'

2.1. NOTES ON TUNING TRANSMITTERS

1. The following points should be borne in mind when tuning transmitters.

a. No switches of any description should be moved with H.T. on and the key pressed.

b. No power transfer switch – for example, HF/MF or C.W./M.C.W. change-over switches – should be moved with H.T. on.

c. Always tune on C.W., with power as shown in guides, switching to other types of emission as required after tuning.

d. Remember that on some transmitters the maladjustment of some controls by the odd degree may reduce power output by as much as a quarter.

e. After shifting frequency on a transmitter it may be necessary to re-adjust the aerial tuning of any other transmitters whose aerials are adjacent.

f. When an overload relay trips it does so because of excessive current usually caused by faulty tuning. Before resetting the overload relay re-adjust whichever control it was that caused this excessive current and/or reduce power. The latter is always the safer but usually takes a little longer.

g. The power amplifier anode current meter normally provides the correct final tuning point. Aerial current or aerial tuning indicator meters usually provide only a secondary indication. Some MF transmitters are tuned for maximum aerial current, but even in these cases there is almost always a maximum P.A. anode current figure which must not be exceeded.

h. Do not exceed meter markings. They are provided for guidance and to exceed them, particularly in output stages, may damage the transmitter.

i. Do not start generators or alternators on load. For example, do not start 602E emergency machine with power supply switch to EMERGENCY and H.T. on.

j. Finally, never rely on safety interlocks breaking power supplies. **If it is necessary to make internal adjustments to transmitters always see that the power supply is SWITCHED OFF.**

2.2. AERIAL TUNING

1. The problem of matching the output of a transmitter to an aerial system is in general governed by the following factors:

a. The aerial and trunking will present a different impedance with different frequencies. This impedance will consist of a resistive component made up of the radiation resistance and any loss resistance present and of a reactive component which may be inductive or capacitive and consequently out of phase with the resistive component.

b. The output valves in the transmitter will only deliver maximum power when the load into which they work is purely resistive and of a value equal to the effective internal resistance of the valves under the chosen working conditions.

c. The transmitter output power must be concentrated on the single desired frequency and not wasted on a large range of harmonics. The anode circuit of the P.A. stage and the aerial tuning unit, which together with the aerial forms a tuned circuit, must therefore be sufficiently selective to enable this to occur and must, at the same time, prevent unwanted harmonics from reaching the aerial. Unwanted harmonics are suppressed by the design of these tuned circuits which firstly should minimize the amount of harmonics generated and, secondly, may present a low impedance path to earth for those harmonics already present. This latter function is only achieved in full by a Pi filter.

2. Transmitter aerial tuning units are therefore designed:

a. To tune out the reactive component of the aerial impedance.

b. To transform the remaining resistive component to a value suitable to load the output valves.

c. To maintain purity of output waveform by tuning the aerial to resonance, and by suppressing harmonics.

3. All these factors are interdependent. Thus tuning the aerial tuned circuit to resonance automatically involves tuning out the reactive component of the aerial impedance. Adjusting the coupling, i.e. matching the aerial to the load, alters the resonant frequency of both the aerial and P.A. tuned circuit. Thus it is essential that for every alteration of coupling, the aerial and P.A. tuned circuits should be ~~retuned~~. This retun is applicable to the majority of service transmitters, notable exceptions being Type 601 and Type 602 HF, whose aerial tuning circuits are entirely separate from their P.A. tuned circuits.

2.3. STANDARD AERIAL TUNING DRILL

1. The term Standard Aerial Tuning Drill is used to describe the normal method of tuning a transmitter's aerial circuits. This standard method, notes on which are given below, holds good for the majority of service transmitters, notable exceptions being Types 601 and 602 HF, whose aerial circuits must be tuned strictly in accordance with their tuning guides. In fact, all transmitters should be tuned in accordance with their tuning guides, but in some cases these merely state that Standard Aerial Tuning Drill is to be used.

2. The object of Aerial Tuning is to transfer the correct amount of energy at r.f. from the power amplifier stage via the aerial tuning unit to the aerial. This transfer is indicated when the P.A. anode current meter reads the correct loading figure and the P.A. stage *is still exactly in resonance at the required output frequency.*

3. Three major controls are always used. They are:

a. Power Amplifier Tuning

b. Coupling

c. Aerial Circuit Tuning.

These three controls may be complicated by the addition of various input tapping, aerial tapping, condenser and range switches, but once the correct settings for these auxiliary controls have been found, either by reference to charts or by trial and error, the final tuning is carried out by the three major controls. Some coupling is always required and an initial setting is usually given, but if one is not given the control should be set just off minimum (on most sets the coupling control must be used with caution as the position giving optimum coupling is often critical).

4. **The Drill.** With the P.A. anode circuit in tune and coupling as above, tune the aerial circuit for a rise in the P.A. anode current meter. Having obtained this, retune the P.A. anode circuit for minimum anode current (i.e. resonance). Now use the coupling to increase or decrease P.A, anode current and after *every* adjustment of coupling retune the P.A. anode circuit for minimum and the aerial circuit for maximum anode current. Continue this process until the correct loading condition is reached, that is to say the correct reading in the P.A. anode current meter with P.A. anode tuning at MINIMUM and aerial tuning at MAXIMUM.

2.4. TUNING GUIDES

1. In order that a transmitter or any other piece of radio equipment with variable controls may function at its maximum efficiency, it is essential that the correct tuning drill be always carried out. These tuning drills are established for all equipments as they are accepted into service, and printed copies or 'Tuning Guides' are then made available for use on board ships fitted with these equipments.

2. Tuning Guides are therefore intended to enable an operator, once he has received basic instruction on a particular equipment, to tune and operate it at its maximum efficiency in the shortest possible time.

3. Tuning Guides are now being printed in a form suitable for insertion in a stiff cover (S.1680). All future revisions of Tuning Guides will be printed in this form.

4. The Cover and the Tuning Guides for the particular equipments fitted in a ship should be demanded from the R.N. Store Depot, Deptford.

5. Finally it is stressed that it is absolutely essential to follow the correct tuning drill implicitly at all times and that Tuning Guides should be available in all ships, particularly in small craft where the operators may be inexperienced and lack necessary supervision.

6. The following Tuning Guides are available:

S.1680	Cover for Tuning Guides
S.1681	601/602 (HF)
S.1682	602 (MF)
S.1683	603/605 (HF)
S.1685	605 (MF)
S.1690a	I.C.S. Tuning Guide—Preliminary Drill
S.1690b	I.C.S. Tuning Guide—Check-off List for starting system
S.1690c	I.C.S. Tuning Guide—Outfit WBA/WBB
S.1690d	I.C.S. Tuning Guide—Tuning Drill
S.1690e	I.C.S. Tuning Guide—Broadband Aerial, Normal Line
S.1690f	I.C.S. Tuning Guide—Broadband Aerial, Triple Drive Line
S.1690g	I.C.S. Tuning Guide—HF Base Tuned Whip Aerial
S.1690h	I.C.S. Tuning Guide—MF Base Tuned Wire Aerial
S.1690i	I.C.S. Tuning Guide—When Necessary Plugging Has Been Completed
S.1691	CJA/CJC
S.1692	CJD
S.1693	Band Suppression Filter
S.1695	89Q
S.1700	619 (MF)
S.1701	619 (HF)
S.1702	618 (MF)
S.1703	618 (HF)
S.1704	640
S.1705	CJK

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2.5. 'RED LINE' READINGS ON TRANSMITTER METERS

These tables of RED LINE markings for important meters in wireless transmitters have been prepared to assist operators in producing the optimum from their equipment. Ships' staffs should mark these red lines on the glass of the meters concerned in *red paint.*

TABLE 1

TYPE OF TRANSMITTER AND METER TO BE MARKED	RED LINE TO BE MARKED AT	THESE READINGS WILL BE OBTAINED AFTER TUNING WITH:			
		TRANSMITTER SWITCHED TO	ASSOCIATED METER OR CONTROL SWITCH IN POSITION	TUNE-OPERATE SWITCH IN POSITION	KEY OR PRESSEL SWITCH DOWN/UP
TCS					
Plate Current	80-90 mA	Voice			Down
	170-180 mA	C.W.			Down
89Q					
Filament Voltage	10 V				Up
P.A. Plate current	200 mA	C.W.		Tune	Down
	440 mA	C.W.		Operate	Down
	360 mA	F.S.T.		Operate	Down
601					
5AB P.A. anode current	165 mA	C.W.		Operate	Down
5AB/A.P.A. anode	180 mA	C.W.		Operate	Down
602					
4AD Tuning	Between 0·55 and 0·63 mA	C.W.	Tune amp	Operate	Down
5AB P.A. anode current	165 mA	C.W.		Operate	Down
5AB/A P.A. anode current	180 mA	C.W.		Operate	Down
603					
a.c. supply	230 V				
Final Amp H.T.	1100 V	Low Power C.W./M.C.W./R.T.			Down
	1550 V	Full power M.C.W./R.T./F.S.K.			Down
	2000 V	Full power C.W.			Down
Modulator H.T.	2000 V	M.C.W. and R.T. only			Up
Modulator Cathodes					
V1 and V2	150 mA	M.C.W. and R.T. only			Up
V3 and V4	150 mA	M.C.W. and R.T. only			Up
5AB P.A. anode current (Note 1)	165 mA	C.W.		Operate	Down
5AB/A.P.A. Anode current (Note 1)	180 mA	C.W.		Operate	Down
HF Final Grid	30 mA	C.W.		Operate	Down
HF Final Amp Anode	540 mA	C.W.		Operate	Down
HF Final Amp Anode (Note 2)	300 mA	Low Power C.W.		Operate	Down

(*Table* 1 *continued on page* 2–5–2)

(*Table* 1 *continued*)

TYPE OF TRANSMITTER AND METER TO BE MARKED	RED LINE TO BE MARKED AT	THESE READINGS WILL BE OBTAINED AFTER TUNING WITH:			
		TRANSMITTER SWITCHED TO	ASSOCIATED METER OR CONTROL SWITCH IN POSITION	TUNE-OPERATE SWITCH IN POSITION	KEY OR PRESSEL SWITCH DOWN/UP
Modulation (Note 3)	600 V	M.C.W. and R.T. Low Power Peak when modulated M.C.W. and R.T. High Power Peak when modulated			Down
605					
a.c. Supply	230 V				Down
Final Amp H.T.	1100 V	Low Power C.W./M.C.W./R.T.			Down
	1550 V	Full power			
	2000 V	Full Power C.W.			
Modulator H.T.	2000 V	M.C.W. and R.T. only			Up
Modulator Cathodes V1 and V2	150 mA	M.C.W. and R.T. only			Up
V3 and V4	150 mA	M.C.W. and R.T. only			Up
Modulation (Note 3)	600 V	M.C.W. and R.T. Low Power Peak when modulated			Down
	1000 V	M.C.W. and R.T. High Power Peak when modulated			Down
4AD tuning (Note 1)	Between 0·55 and 0·63 mA	C.W.	Tune amp	Operate	Down
LF Final Amp Grid	25 mA	C.W.		Operate	Down
LF Final Amp Anode (M89)	540 mA	C.W.		Operate	Down
5AB Anode current	165 mA	C.W.		Operate	Down
5AB/A Anode current	180 mA	C.W.		Operate	Down
HF Final Grid (M.88)	30 mA	C.W.		Operate	Down
HF Final Amp Anode (M.88)	540 mA	C.W.		Operate	Down
HF Final Amp Anode (Note 2)	300 mA	Low Power C.W.		Operate	Down
612					
P.A. anode current	130 mA	M.C.W. and R.T.	Position 3	Operate	Down
	170 mA	C.W.	Position 3	Operate	Down
86M					
Tuning Meter	Between 0·6 and 0·63 mA		Position 3		Down
87M					
P.A. anode current	80 mA		A1 and A2	Full power	Down

(*Table* 1 *continued on page* 2–5–3)

(*Table* 1 *continued*)

TYPE OF TRANSMITTER AND METER TO BE MARKED	RED LINE TO BE MARKED AT	THESE READINGS WILL BE OBTAINED AFTER TUNING WITH:			
		TRANSMITTER SWITCHED TO	ASSOCIATED METER OR CONTROL SWITCH IN POSITION	TUNE-OPERATE SWITCH IN POSITION	KEY OR PRESSEL SWITCH DOWN/UP
87P and Q P.A. anode current	70 mA		A1 and A2	Full power	Down
618 HF Tx P.A. anode current MF Tx P.A. anode current	 200 mA 220 mA	 C.W. C.W.			 Down Down
619 HF Tx Monitor Meter MF Tx Monitor Meter	 250-300 mA 300-400 mA 200-250 mA	 M.C.W. or Voice C.W. C.W.	 P.A. Total P.A. Total P.A. Total		 Down Down Down

1. These readings will not necessarily be obtained, but must not be exceeded, meters should be marked for standardization with 601 and 602.
2. Used for initial tuning point only, and not an indication of the working point.
3. 601 Series transmitters are normally modulated at 70 per cent, for voice and 90 per cent for M.C.W. These readings are ones which whould not be exceeded.

Note.—Transmitters are tuned on C.W. (where applicable) and, provided correct readings are obtained, most other readings for M.C.W. and Voice will follow approximately and automatically when the transmitter is switched as shown in column 3.

2.6. TYPE 86M

DATE OF DESIGN. 1940

HANDBOOK. B.R. 1401

ESTABLISHMENT LIST. E604

FREQUENCY RANGE. 100–156 Mc/s

FREQUENCY DETERMINATION. Crystal Oscillator

EMISSION AND POWER OUTPUT.
VOICE – 6 to 8 W

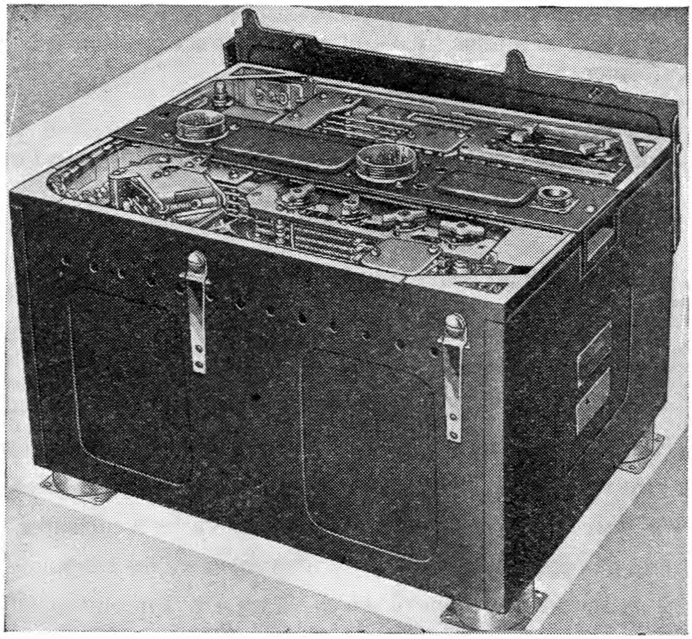


FIG. 1

GENERAL

1. A VHF Transmitter/Receiver of U.S. design originally fitted in aircraft. It was fitted in nearly all ships and submarines as the standard emergency VHF set. There are four pre-set automatically tuned frequency channels.

2. **Power Supplies.** The transceiver may operate from:

a. 230 V, 50 c/s a.c. supply which feeds rectifier unit SE8, or

b. 24 V d.c. battery supply which feeds a dynamotor unit

TRANSMITTER

3. **Frequency Build-up**

a. Crystal frequency $= \frac{\text{Signal frequency}}{18}$

b. Crystal Grid	Oscillator Anode	1st Harm. Amp.	2nd Harm. Amp.	P.A.
1	$\times 2$	$\times 3$	$\times 3$	
e.g. 8·040 Mc/s	16·08 Mc/s	48·24 Mc/s	144·72 Mc/s	144·72 Mc/s

4. **Crystal Oscillator.** A pentode with 4 separate crystal grid circuits. The anode circuit is tuned by a coil and variable capacitor to the crystal's 2nd harmonic and is capacity coupled to the 1st harmonic amplifier.

5. **1st Harmonic Amplifier.** Trebles. A beam tetrode with the output circuit tuned by a coil and variable capacitor to the crystal's 6th harmonic and capacity coupled to the 2nd harmonic amplifier.

6. **2nd Harmonic Amplifier.** Trebles. A double beam tetrode in push-pull with the output tuned to the crystal's 18th harmonic by a coil and variable capacitor, and capacity coupled to the P.A.

7. **Power Amplifier.** A double beam tetrode in push pull, anode modulated, with output tuned to the crystal's 18th harmonic by a coil and variable capacitor, it is coupled to the aerial circuit by a variable transformer.

8. **Voice Input Circuit.** The microphone feeds into the primary of the microphone input transformer, the secondary being coupled to the speech amplifier via a potentiometer.

9. **Speech Amplifier.** A pentode transformer coupled to the modulator.

10. **Modulator.** Two beam tetrodes in push-pull with the output circuit transformer coupled to the P.A. H.T.

11. **Transmitter Controls**

CRYSTAL OSCILLATOR. The left hand of four controls. Varies a capacitor.

1ST HARMONIC AMPLIFIER. Control second from the left. Varies a capacitor.

2ND HARMONIC AMPLIFIER. Control third from the left. Varies a capacitor.

POWER AMPLIFIER. The right hand control. Varies a capacitor.

ANTENNA COUPLING. A screwdriver control or milled knob on the right of the set. A variable transformer.

GAIN. A screwdriver control which varies a potentiometer adjusting the input to the speech amplifier.

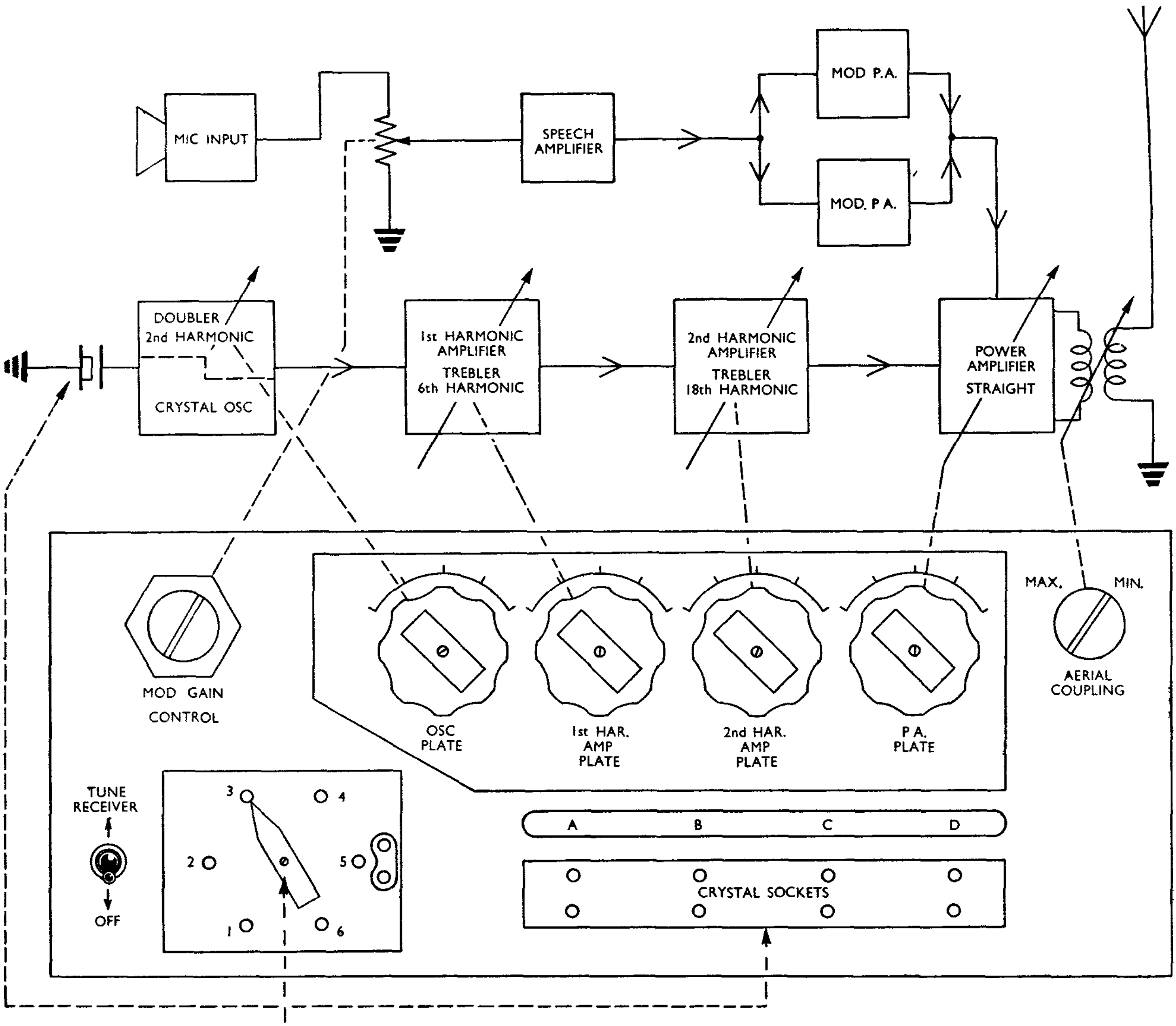
METER SWITCH. Has 6 positions:

a. 1st Harmonic Amp. Anode current
b. 2nd Harmonic Amp. Anode current
c. P.A. Anode current
d. Aerial Current – an indication only – not used
e. P.A. Grid Current
f. Blank.

TUNE-RECEIVER switch. In the Tune-Receiver position, applies H.T. to the crystal oscillator valve only. Used when tuning the receiver.

12. **Tuning Instructions for Transmitter**

a. The transmitter must be tuned before the receiver.
b. Insert the appropriate crystals ($\frac{1}{18}$ of signal frequency).
c. Check TUNE REC switch is off.
d. Plug meter into socket adjacent to meter switch.
e. Make mains switch, press button D, channel release button (in receiver section), loosen locking nuts, and press button A.
f. Set tuning controls to approximate frequency.
g. With meter switch in position 1, tune first tuning control for maximum reading in meter (using T on auto. controller or pressel switch to key transmitter).
h. With meter switch in position 2, tune 2nd tuning control for maximum.
i. With meter switch in position 3, tune 3rd tuning control for maximum, and without delay tune 4th tuning control for minimum (note meter reading) and partially lock all tuning controls, being careful not to upset tuning adjustments.
j. Tune remaining channels as for A, pressing appropriate buttons B, C and D in that order.



CRYSTAL FREQUENCY =
1/18th OF TRANSMITTING FREQ

SWITCH POSITION	TUNE FOR	NORMAL READING	TROUBLE
1 (1st HAR AMP PLATE)	MAX	0·4	MORE THAN 0·75
2 (2nd HAR. AMP. PLATE)	MAX	0·5	MORE THAN 0·75
3 (P.A. PLATE)	3rd CONTROL MAX 4th CONTROL MIN	0·63	MORE THAN 0·75
4 (R.F. INDICATOR)	NOT USED FOR TUNING	FULL SCALE	LESS THAN 0·5
5 (P.A. GRID)	NOT USED FOR TUNING	OFF	———
6 BLANK			

FIG. 2. TYPE 86M TRANSMITTER

k. Adjust the common coupling control (knurled knob in transmitter section), 4th tuning control (on the frequency that gave the highest recorded meter reading), to read as near as possible to 0·63, with meter switch in position 3 and 4th tuning control adjusted to a minimum. Finally press channel release and lock locking nuts by carefully tightening against cam pile.

TUNING A SINGLE CHANNEL. Press channel button preceding the channel it is desired to tune and channel release. Loosen locking nuts, press desired channel button and proceed with normal channel tuning. It may be necessary to check *k* above.

TUNING CHECK. With meter switch in position *c*, rotate first 3 controls slightly against positioning indent. There should be no *increase* in meter. Likewise with control 4 there should be no *decrease*.

RECEIVER

13. **Frequency Build-up.**

$$\text{Crystal frequency} = \text{Signal Frequency} \begin{cases} -12 \div 11 \text{ for } 100 \text{ to } 108 \text{ Mc/s} \\ -12 \div 12 \text{ for } 108 \text{ to } 116 \text{ Mc/s} \\ -12 \div 13 \text{ for } 116 \text{ to } 124 \text{ Mc/s} \\ -12 \div 14 \text{ for } 124 \text{ to } 132 \text{ Mc/s} \\ -12 \div 15 \text{ for } 132 \text{ to } 140 \text{ Mc/s} \\ -12 \div 16 \text{ for } 140 \text{ to } 148 \text{ Mc/s} \\ -12 \div 17 \text{ for } 148 \text{ to } 156 \text{ Mc/s} \end{cases}$$

14. **1st R.F. Amplifier.** A variable mu pentode whose grid and anode circuits are tuned by capacitors which are ganged to the r.f. Tuning Control. The anode output is transformer coupled to the grid of the Mixer.

15. **Crystal Oscillators and Audio Squelch.** A double triode; one triode has a crystal controlled grid circuit connected to one of four crystals. The frequency range of crystals to be used is 8 to 8·72 Mc/s. The anode output circuit is broadly tuned by screwdriver adjustable coil cores, and capacity coupled to the harmonic generator. The other triode acts as a squelch or noise suppressor valve.

16. **Harmonic Generator.** A triode with the output circuit tuned to appropriate crystal harmonic (i.e. Fs – 12 Mc/s). The output circuit is tuned by a variable capacitor which is ganged to the Oscillator tuning control, and is capacity coupled to the harmonic amplifier.

17. **Harmonic Amplifier (Buffer).** A pentode which amplifies the harmonic generator output. The output circuit is tuned by a capacitor which is ganged to the Oscillator tuning control and is transformer coupled to the mixer.

18. **Mixer.** A pentode with the grid circuit tuned by a capacitor ganged to the r.f. Tuning Control. The oscillator output is always lower than the signal frequency by the amount of the i.f. (12 Mc/s). The mixer output is tuned transformer coupled to the 1st i.f.

19. **I.F. Stages.** These consist of three pentodes, the first two being variable mu, all with tuned transformer coupled inputs tuned to the i.f. (12 Mc/s). The output of the 3rd i.f. is transformer coupled to the Detector.

20. **Detector, 1st A.F. Amplifier and A.G.C.** A double diode pentode, the two diode anodes being strapped together and working as a single diode.

a. DETECTOR. The A.F. output is fed to the grid of the 1st a.f. via a noise limiter valve and a.f. Gain potentiometer which is screwdriver controlled.

b. A.G.C. Negative bias is applied to the grids of the 1st r.f. and 1st and 2nd i.f. via the second triode of the Crystal Oscillator which provides a delayed a.g.c.

c. 1ST A.F. AMPLIFIER. This comprises the pentode of the valve and the output is capacity coupled to the grid of the 2nd a.f. (output valve).

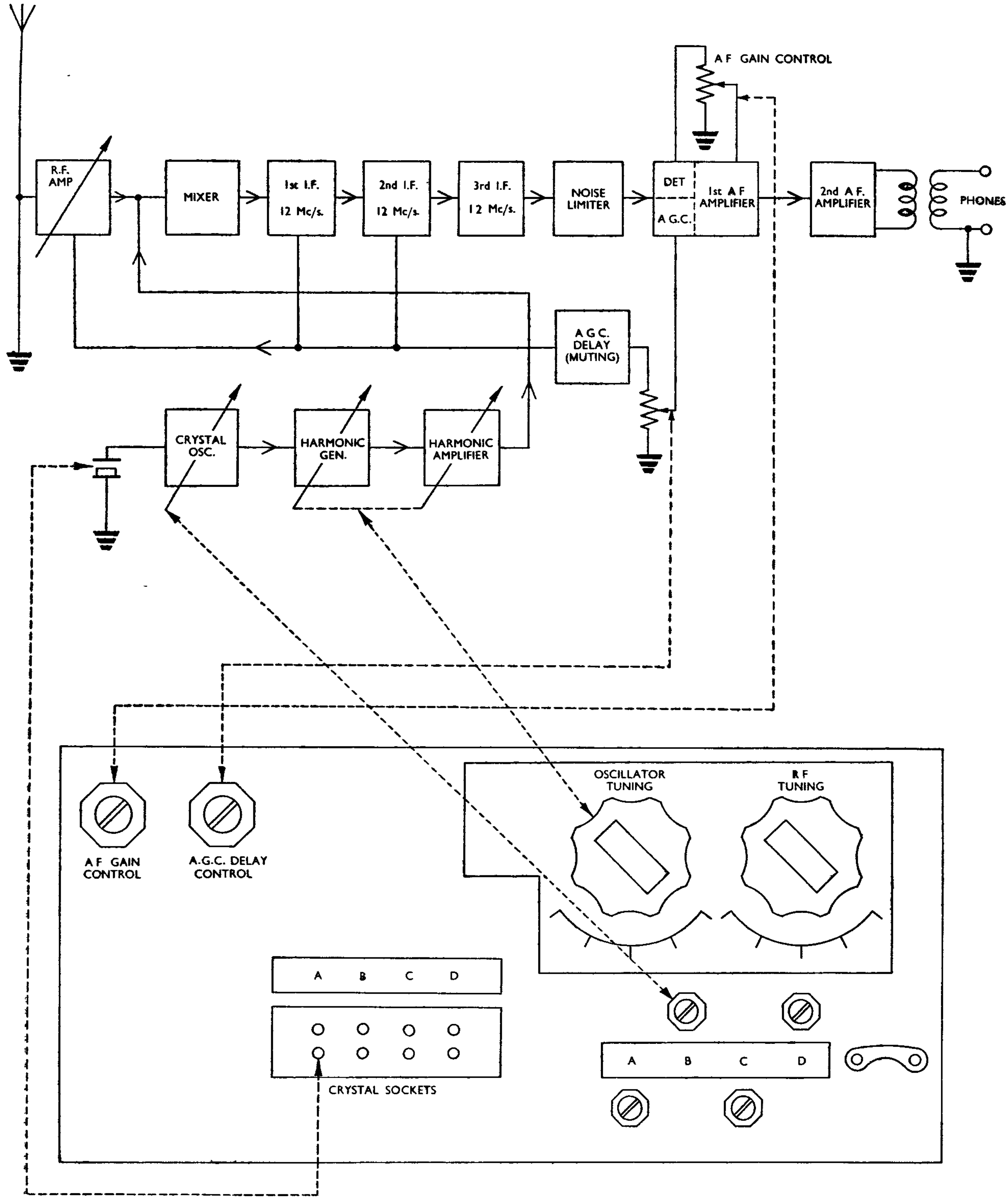


FIG. 3. TYPE 86M RECEIVER

21. **2nd A.F. Amplifier (output).** The anode load acts as the primary of the output transformer which has three tappings of its secondary supplying impedances of 8,000, 6,000 and 50 ohms.

22. **Receiver Controls.**

AUDIO. A.F. gain. Screwdriver control. Adjusts a potentiometer in the input of the 1st a.f.

RELAY. This control:

a. In certain modified receivers adjusts the voltage level at which the a.g.c. delay valve functions.

b. In certain receivers adjusts the cut-off level of the muting (squelch) circuit when fitted.

CHANNEL RELEASE. A push button on the left of the receiver. Frees the ratchet system.

OSCILLATOR PLATE TUNING. Four screwdriver controls, one for each channel, adjust the coils in the crystal anode circuit.

OSCILLATOR TUNING. Adjusts the ganged variable capacitors in the harmonic generator and harmonic amplifier output circuits.

R.F. TUNING. Adjusts the ganged variable capacitors in the r.f. input and output and mixer input circuits.

METER. A separate piece of equipment used for tuning.

23. **Tuning Instructions for Receiver**

a. The transmitter must be tuned before the receiver.

b. Insert appropriate crystals. Crystal Frequency $= \dfrac{\text{Signal Frequency} - 12}{\text{Harmonic}}$

c. Transfer meter to receiver socket, set relay control fully clockwise and audio control almost fully clockwise.

d. Press button D, channel release, loosen locking nuts and press button A.

e. Check key on controller electric to R.

f. Place Tune Receiver switch to Tune Receiver.

g. Set both receiver controls to approximate frequency and unscrew oscillator plate tuning control until 5 or 6 threads are showing.

h. Adjust the two tuning controls alternately for minimum meter reading.

i. Screw in the oscillator plate tuning control until there is an increase in meter reading and a pronounced click in the phones, then screw O.P.T.C. anticlockwise until meter reading drops again and continue approximately $\frac{3}{4}$ of a turn in the same direction.

j. Slightly readjust tuning controls for minimum meter reading.

k. Tune remaining channels as for A, pressing buttons B, C, and D as required in that sequence.

l. Press channel release and lock locking nuts.

m. Press each channel button in turn and check that meter readings have been maintained.

n. Place Receiver switch to OFF.

TUNING A SINGLE CHANNEL. Press channel button preceding the channel it is desired to tune and channel release. Loosen locking nuts, press desired channel button and proceed with normal channel tuning.

TUNING CHECK. Before *n* above, rotate tuning controls against positioning indent. There should be no decrease in meter readings.

2.7. TYPE 89Q

DATE OF DESIGN. 1942

HANDBOOK. B.R. 1426 and R.C.A. (Radio Corporation of America) Handbook

ESTABLISHMENT LIST. E.875

FREQUENCY RANGE. 1·5–20 Mc/s

FREQUENCY DETERMINATION. VFO. or Crystal Oscillator

EMISSION and POWER OUTPUT. C.W. 350 W
Voice 250 W

1. **General.** A compact, medium powered transmitter of American design with British modifications. ~~It is very widely fitted in all types of ship, including submarines~~.
It consists basically of three units, the transmitter itself, a speech amplifier and a British control unit, the speech amplifier and control unit normally being mounted together.
The Crystal oscillator and master oscillator are also separate units one of which must be plugged into the front of the transmitter depending on the type of frequency determination required.

2. **Power Supplies.** The transmitter contains its own power pack consisting of a transformer and associated rectifier for all d.c. voltages and a second transformer for all valve heaters and filaments. The supply required is any voltage between 190 and 250 V, 50–60 c/s, single phase a.c. and taps on the input transformers must be selected to suit the voltage in use. Four diode valves (in two parallel pairs) act as a full wave rectifier and provide all H.T. and bias voltages.
Main H.T. is approximately 2000 V on c.w. and 1500 V on Voice. Maximum power consumption reached with 100 per cent modulation on voice, is 1850 watts.

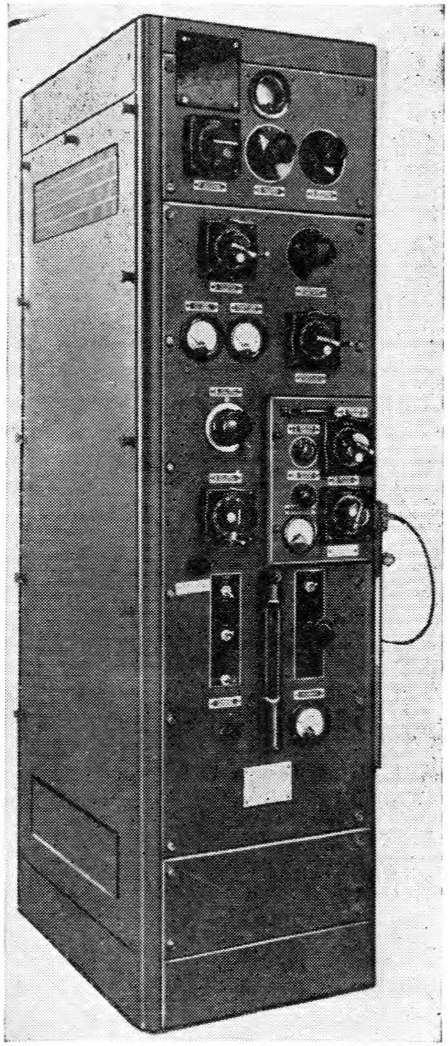


FIG. 1

DESCRIPTION

3. **Frequency Build-up** (all figures in Mc/s).

CRYSTAL OSCILLATOR	INTERMEDIATE AMPLIFIER	POWER AMPLIFIER
1·5–6·7	1·5–6·7 (Straight)	1·5–6·7
	6·7–13·4 (Doubles)	6·7–13·4
	13·4–20 (Trebles)	13·4–20

Block Diagram

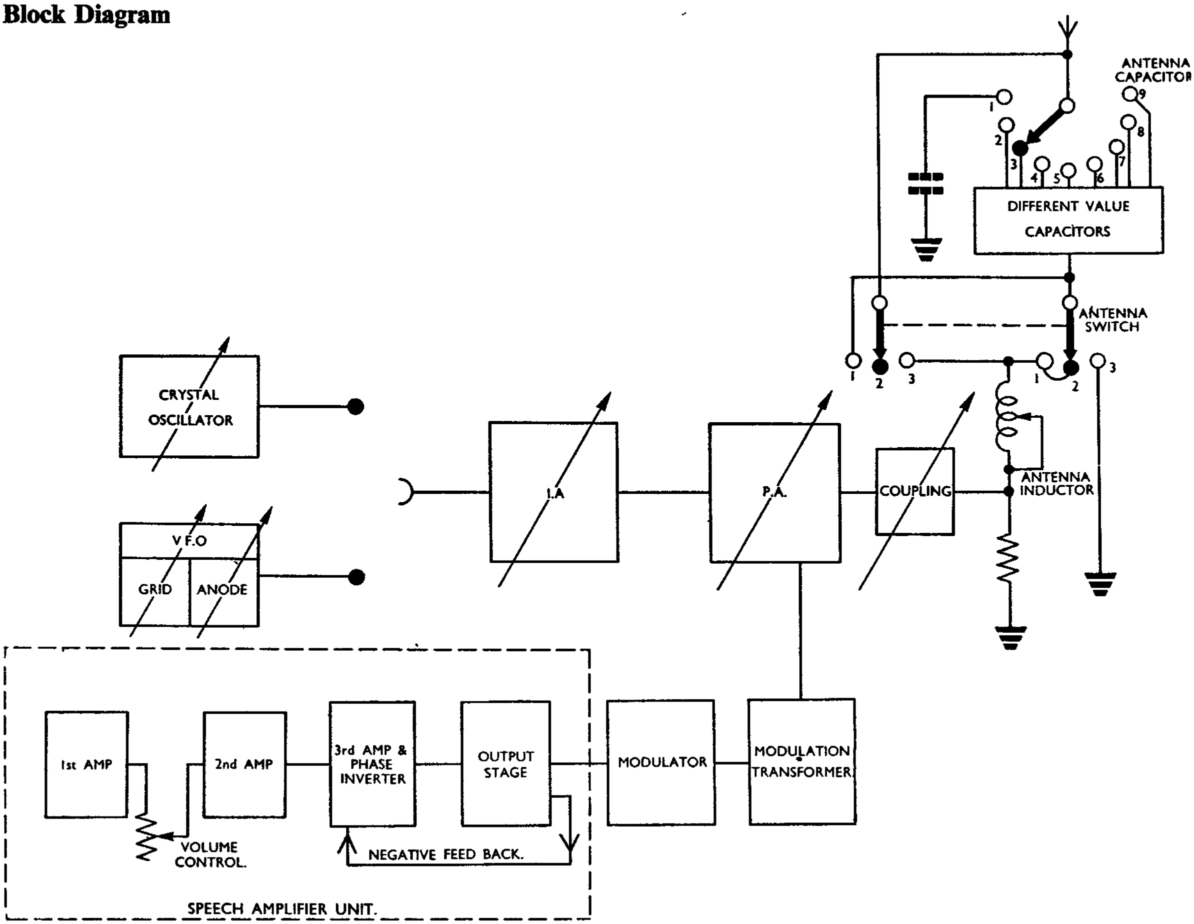


FIG. 2. TYPE 89 Q

(*Frequency Build-up continued*)

VARIABLE FREQUENCY OSCILLATOR		INTERMEDIATE AMPLIFIER	POWER AMPLIFIER
GRID	ANODE		
0·75–5	1·5–10 (Always doubles)	1·5–10 (Straight)	1·5–10
		10–20 (Doubles)	10–20

4. R.F. Circuits

a. Crystal Oscillator. This is contained in a separate plug-in unit and consits of a beam tetrode with the crystal in the grid circuit and the anode circuit tuned by a switched coil and a variable capacitor. The circuit will tune from 1·5 to 6·7 Mc/s only and is capacitively coupled to the grid of the Intermediate Amplifier.

b. Variable Frequency Oscillator. Also contained in a separate plug-in unit. A beam tetrode with the oscillatory circuit between grid and cathode. The frequency band of this circuit which is tuned by switched capacitors and a variable coil is from 0·75 to 5 Mc/s only. The anode circuit, called the multiplier circuit, and also tuned by switched capacitors and a variable coil, is always tuned to the second harmonic (that is, it always doubles) and is again capactively coupled to the grid of the Intermediate Amplifier.

c. Intermediate Amplifier. A beam tetrode whose anode circuit covers the whole frequency range of 1·5 to 20 Mc/s. The circuit is tuned by a variable coil and a variable capacitor, additional fixed capacitors being brought in by the range switch for 1·5 to 2 Mc/s only. Thus in crystal control the I.A. may act as a straight amplifier, a doubler, or a trebler while in v.f.o. control it may act as a straight amplifier or a doubler only. The output is capacitively coupled to the power amplifier.

d. Power Amplifier. Two beam tetrodes in parallel with the output circuit tuned by switched capacitors and a variable coil.

e. Aerial Circuit. Matches the Power Amplifier to the Aerial by means of variable coupling and a series or parallel arrangement of a bank of switched capacitors and a variable coil. Alternatively the capacitors can be shorted out and the coil used on its own. The coupling consists of a variable coil which forms part of the P.A. Anode circuit and it must therefore be used with great caution as a small alteration of coupling throws the P.A. anode circuit completely off tune. An indication of aerial current is given by the Antenna ammeter.

Note. – The correct position of the aerial circuit switches for tuning the earlier stages of the transmitter is the Antenna Switch to 2 and the Antenna Capacitor Switch to 1. In this position the aerial is virtually disconnected from the transmitter, as can be seen from the block diagram, because there is no capacitor in position 1 of the Antenna Capacitor Switch. There is, however, the 'stray' capacitance of the switch represented by the dotted capacitor.

5. **A.F. Circuits**

a. Speech Amplifier. The separate speech amplifier unit contains the microphone input transformer and three a.f. amplifier stages (all pentodes). The third a.f. Amplifier, which is also a phase splitter supplies the drive for the push-pull output stage which consists of two beam tetrodes and is transformer coupled to the grids of the two modulator valves contained inside the transmitter. The purpose of the phase splitter is merely to enable a single valve, the third a.f. amplifier, to provide the input for a push-pull stage. A volume control consisting of a potentiometer in the grid of the second a.f. amplifier provides control of overall gain and therefore of depth of modulation. Negative feed-back is applied from a secondary winding on the output transformer to the cathode of the third a.f. valve and forms an automatic means of keeping the output of the amplifier steady and of improving the quality of modulation. The unit contains its own power pack consisting of an input transformer with taps for a 50 c/s single phase a.c. supply of between 190 and 250 V (the same as the transmitter power supply) with a double diode full wave rectifier valve and separate windings from the transformer for filament supplies.

b. Modulator. Two triodes in push-pull which, together with the modulation transformer, are contained inside the transmitter. The drive to the grids is via a transformer from the output stage of the separate speech amplifier unit. The output circuit is the primary of the modulation transformer the secondary of which is in the H.T. line to the anodes and screens of the P.A. stage. Separate grid bias adjustment for each valve is provided to minimize distortion.

6. **Keying.** Keying is achieved by changing the potential applied to the screen grids of the Intermediate and Power Amplifier Valves. When the keying is open a negative voltage is applied thus shutting the valves down. When the relay is closed the correct positive voltage is applied and the valves are allowed to function. By the adjustment of an internal link the oscillator also (either crystal or v.f.o., whichever is in use) may be keyed by means of keying anode and screen H.T.

7. Controls

OSCILLATOR SWITCH.

a. In the crystal oscillator unit, selects fixed coils in the anode circuit.

b. In the v.f.o. Unit, selects fixed coils and capacitors in the grid circuit.

OSCILLATOR TUNING.

a. In the crystal oscillator unit, adjusts a variable capacitor in the anode circuit.

b. In the v.f.o. Unit, adjusts a variable coil in the grid circuit.

MULTIPLIER SWITCH. Present in v.f.o. Unit only. Selects fixed capacitors in the anode circuit of the oscillator.

MULTIPLIER TUNING. Present in v.f.o. Unit only. Adjusts a variable coil in the anode circuit of the oscillator.

NORMAL – F.S.T SWITCH. Present in crystal oscillator only. In F.S.T position the transmitter is driven by an external Frequency shift keyer.

'A' INT. AMP. INDUCTOR. Adjusts a variable coil in the Intermediate Amplifier anode circuit.

'B' INT. AMP. CAPACITOR. Adjusts a variable capacitor in the Intermediate Amplifier anode circuit.

INT. AMP. RANGE SWITCH. Has two positions – 1·5 to 2 Mc/s and 2–20 Mc/s. In the 1·5 to 2 Mc/s position brings extra capacitors into the I.A. anode circuit.

'C' POWER AMP. INDUCTOR. Adjusts a variable coil in the P.A. anode circuit.

'D' POWER AMP. BAND SWITCH. Selects fixed capacitors in the P.A. anode circuit.

'E' ANTENNA COUPLING. Adjusts a variable coupling coil in the P.A. anode circuit.

'F' ANTENNA INDUCTOR. Adjusts the variable coil in the aerial circuit.

'G' ANTENNA SWITCH. Has three positions:

(1) Aerial coil only in aerial circuit

(2) Series position. Aerial coil and capacitors in series.

(3) Parallel position. Aerial coil and capacitors in parallel.

'H' ANTENNA CAPACITOR SWITCH. Has nine positions. Selects fixed capacitors in the aerial circuit. Capacitors are short circuited when Antenna Switch is to position 1.

LINE ON/OFF SWITCH. Completes a.c. supply to transmitter and British Control Unit.

FILAMENT INCREASE. Varies a potentiometer in the a.c. supply to the primary of the filament transformer. Should be adjusted to read 10 V in the filament meter.

TUNE/OPERATE SWITCH. In Tune position inserts two resistors in the a.c. supply to the primary of the H.T. transformer.

PHONE/C.W. SWITCH. In c.w. the modulator valves are not supplied with H.T. and the secondary of the modulation transformer is short circuited. In phone H.T. is applied to the modulator valves and the short circuit acrosss the secondary of the modulation transformer is removed.

PLATE ON/OFF SWITCH. TEST ON/OFF SWITCH. Have no function in the British version of the transmitter.

VOLUME Control (on Speech Amplifier Unit). Adjusts depth of modulation by varying a potentiometer in the grid circuit of the second a.f. amplifier.

NEON TUBE. On Voice the neon tube gives a rough indication of depth of modulation. For example, threequarters of the tube glowing indicates 75 per cent modulation. On c.w. the tube glows when the transmitter is keyed and therefore it merely indicates keying.

8. **British Control Unit.** The main purpose of the control unit is to prevent the anode supply to the rectifiers being made until 70 seconds after the filament supply has been completed. This is arranged automatically by means of a thermal delay relay inside the unit.

In addition the unit permits the transmitter to be operated from a remote position as well as locally.

Note. – An additional control unit, Design 8, is required to adapt this transmitter for use with KH series control systems.

9. **Control Unit – Controls**

A.C. ON/OFF SWITCH. Completes a.c. supply to the Control unit provided Line Switch on the transmitter is already made.

C.W./R.T. SWITCH. Changes over control circuits for type of emission required.

LAMP. Indicates that power is on to the control unit.

10. **Tuning Instructions**

a. V.F.O. Operation

(1) Set dials and switches from appropriate tuning curves and switch to c.w. on transmitter and British Control Unit. Switch to TUNE.

(2) Make line switch on transmitter and mains switch on control unit and wait 70 seconds.

(3) Adjust Multiplier tuning for maximum in I.A. grid meter.

(4) Adjust Int. Amp. Inductor for minimum in I.A. plate meter.

(5) Adjust Power Amp. Inductor for minimum in P.A. plate meter. This reading is not to exceed 200 mA. If it does, coupling is to be reduced and Power Amp Inductor re-adjusted.

(6) As dials were set from approximate tuning curves, oscillator tuning should now be re-adjusted to frequency standard being used (receiver or wavemeter), repeating (3), (4) and (5) as necessary.

(7) Place Antenna Switch to position 1. Carry out standard aerial tuning drill using Antenna Inductor, Antenna Coupling and Power Amp. Inductor controls to obtain a reading of 200 mA in P.A. plate meter.

(8) Switch to operate and check that reading of P.A. plate meter is 440 mA (360 mA if FST). If it is not, repeat aerial tuning drill for this reading.

Notes. (i) If no tuning point is obtained with the Antenna switch in position 1 try position 2, progressively decreasing the Antenna Capacitor Switch from 9 to 1 with a full rotation of the Antenna Inductor from 0000 to maximum for each step. Finally repeat the procedure with the Antenna Switch in position 3, if necessary. (ii) Antenna Coupling should be adjusted with great care and should always be approximate to the curve setting.

b. Crystal Operation

(1) Plug in appropriate crystal as follows:

Output Frequency	*Crystal Frequency*
1·5–6·7 Mc/s	Equals out frequency
6·7–13·4 Mc/s	Equals $\frac{1}{2}$ output frequency
13·4–20 Mc/s	Equals $\frac{1}{3}$ output frequency

(2) Carry out (1) and (2) of v.f.o. operation.

(3) Adjust Oscillator tuning for maximum I.A. grid meter, increasing dial reading by one or two degrees to ensure stability of crystal. (That is, tune to SLOW side of crystal.)

(4) Continue from (4) of v.f.o. operation, omitting (6).

c. FST Operation Using GK 185A

(1) Switch Normal – F.S.T. switch to F.S.T.

(2) Carry out (1) and (2) of V.F.O. operation.

(3) Adjust oscillator tuning for maximum in I.A. grid meter.

(4) Adjust R.E. output switch on GK 185A to give reading of between 30 and 40, in I.A. plate meter.

(5) Continue from 4 of V.F.O. operation omitting (6).

2.8. 601 SERIES

1. There are five transmitters in this series, brief details of which are shown in the following table 1.

TABLE 1

TYPE	DESCRIPTION	FREQUENCY RANGE	TYPE OF EMISSION	POWER OUTPUT
601	Low Power HF	1·5 to 24 Mc/s	C.W. M.C.W. Voice	50 W
602	Low Power HF	1·5 to 24 Mc/s	C.W., M.C.W., Voice — Mains Supply C.W., I.C.W. — Emergency Supply	50 W
	and			
602E	Low Power MF	200 to 500 kc/s	C.W., M.C.W. — Mains Supply C.W., I.C.W. — Emergency Supply	50 W
603	Medium Power HF	1·5 to 24 Mc/s	C.W. M.C.W. Voice	450 to 650 W 400 to 500 W 400 to 500 W
605	Medium Power HF	1·5 to 24 Mc/s	C.W. M.C.W. Voice	450 to 650 W 400 to 500 W 400 to 500 W
	and			
	Medium Power MF	200 to 500 kc/s	C.W. M.C.W.	500 W 400 W

2. The five transmitters have been developed together, on the unit principle. A standard range of units has been produced, combinations of which form the required transmitter.

3. The advantage of this scheme lies in the standardization of units; many of these are used in more than one of the five transmitters and are thus interchangeable. For example the transmitter unit for Type 601 is used to drive an amplifier in Type 603. The smaller units which are technically more intricate, and thus more liable to break down, are fitted on ball bearing runners for easy removal or interchange. The larger units are also easily removed but they are not fitted on runners. Supplies are taken via contact blocks at the rear of the units and patching cords are provided to carry supplies to any unit withdrawn for servicing.

4. The following table 2 shows the units and their names and indicated their functions.

TABLE 2

UNIT NO.	FULL NAME	SHORT TITLE	COMPONENT OF	REMARKS
1	Rectifier Unit S.E. 13	Rectifier S.E. 13	All 601 Series	Provides H.T., Heaters and bias supplies for Low Power Transmitters and screen supplies for Amplifier M.88 or M.89 in Medium Power Transmitters.

(Table 2 continued)

UNIT NO.	FULL NAME	SHORT TITLE	COMPONENT OF	REMARKS
2	Modulator and Rectifier Unit Design A	50 W Modulator	All 601 Series	Modulates Low Power Transmitters or drives Main Modulator in Medium Power Transmitters.
3	Transmitter 5AB	Transmitter 5AB	601, 602, 602E, 603, 605	50 W HF Transmitter. Drives Amplifier M.88 in Medium Power HF Transmitters.
4	Aerial Tuning Unit for Transmitter 5AB	HF A.T.U.	601, 602, 602E	Matches the aerial to Transmitter 5AB.
5	Transmitter 4AD	Transmitter 4AD	602, 602E, 604, 605	50 W MF Transmitter and A.T.U. Drives Amplifier M.89 in Medium Power MF Transmitters.
6	Framework with control panel for Type 601	Type 601 Cabinet	601	Houses units comprising Type 601.
7	Framework with control panel for Type 602	Type 602 Cabinet	602, 602E	Houses units comprising Type 602.
8	Amplifier M.88	Amp. M.88	603, 605	650 W HF Amplifier.
9	Aerial Tuning Unit for Amplifier M.88	HF A.T.U.	603, 605	Matches the aerial to Amplifier M.88.
11	Framework for 400 W HF panels	HF Cabinet	603, 605	Houses the HF Units and Aerial C.O.S. for Medium Power HF Transmitters.
12	Dual Transformer United Design 1	Dual Transformer	603, 604, 605	Main H.T. transformers for Dual Rectifier.
13	Dual Rectifier and Smoothing Unit Design 45	Dual Rectifier	603, 604, 605	Provides anode H.T. for Main Modulator and Amplifier M.88 or Amplifier M.89.
14	Modulator Unit 400 W	Main Modulator	603, 604, 605	Modulates Amplifier M.88 (m.c.w. or Voice) or Amplifier M.89 (m.c.w.)
15	Contactor Unit Design 3	Contactor Unit	603, 604, 605	Contains relays and contactors for Medium Power Transmitters.
16	Bias and Control Supply Unit	Bias Unit	603, 604, 605	Provides bias to Main Modulator and Amplifier M.88 or M.89 and provides control circuit power in Medium Power Transmitters.
17	Framework for Modulator and Rectifier Units	Power Cabinet	603, 604, 605	Houses the Modulator and rectifier units, etc., of Medium Power Transmitters.
18	Amplifier M.89	Amp. M.89	604, 605	500 W MF Amplifier.
19	Aerial Tuning Unit for M.89	MF A.T.U.	604, 605	Matches the aerial to Amplifier M.89.
20	Framework for MF Panels	MF Cabinet	604, 605	Houses the MF Units in the Medium Power Transmitters.

(Table 2 continued)

UNIT NO.	FULL NAME	SHORT TITLE	COMPONENT OF	REMARKS
21	Switch Aerial changeover for Types 601 and 602	Aerial C.O.S.	601, 602, 602E	External to the Transmitters.
22	Switch Aerial changeover for Type 604	Aerial C.O.S.	604	A separate cabinet alongside Transmitter.
23*	Battery Outfit BBY	(Battery) Outfit BBY	602E	Equipment for emergency operation of Type 602E.
24	Emergency Power Unit	E.P.U.	602E	a.c. generator and starter driven by Unit 23.

* Unit 23 is also used for equipment other than the 601 series.

5. Transmitters of this series are designed to fit into any type of control outfit.

6. A more detailed description of the transmitters of the 601 series is given under separate headings.

7. When Type 601 and Type 603 are used with HF Transmitter Common Aerial Working they are known as Type 601(2) and Type 603(2) respectively. The main differences are that the aerial tuning units of these transmitter are not used, the ventilation system (blower) has been modified and modified control panels are employed. (See Section 6, Aerials.)

8. **601** *series modifications*

Suffix numbers are used to identify the various modifications made to the series.

601 *and* 603

601(1), 603(1)	Original fitting
601(2), 603(2)	Modified for working with CAW outfit EAM.
601(3), 603(3)	Original fitting but 5 AB replaced by 5AB/A.
601(4), 603(4)	Modified for EAM. 5 ABA fitted
601(5), 603(5)	Modified for working with HF base tuner. 5 AB/A fitted.
603(6)	Modified to include 5AB/C

602 *and* 605

602(1), 605(1)	Original fitting
602(2), 605(2)	5AB replaced by 5 AB/A
602(3), 605(3)	Modified for working with MF base tuner. 5AB/A fitted.
605(4)	Modified to include 5AB/C

9. 5AB and 5AB/A Series.

The original HF transmitter in the 601 series has been modified to give improved performance and to provide remote frequency changing from calling to working frequency when used on Ship/Shore working.

NOMENCLATURE	OLD PATT. NOS.	NEW PATT. NOS.	REMARKS
5AB Series			
5AB	W 8360/a	W8360/A	Basic HF Transmitter.
5AB/B	A.P. 164731	A.P.164731	5AB with Remote Call/Working Frequency Change facility. (See Note iii).
5AB/A Series.			F.S.T. Facility.
5AB/A	A.P.164322 Tx. complete with Oscillator Unit A.P.164420	A.P.164322 TX. Drawer. A.P.164855 Oscillator Unit	
5AB/AB	A.P.164322 Mod. 1 with Oscillator Unit A.P.164420 Mod. 1	A.P.164732 Tx. A.P.164855 Oscillator Unit	See Note i.
5AB/AC	—	A.P.164732 Tx. A.P.164759 Oscillator Unit	See Notes i, ii and iii.
5AB/C	—	A.P.164732 Tx. A.P.164759 Oscillator Unit	5AB/AC with Remote Call/Working Frequency Change facility. See Notes i, ii and iii.

Notes. (i) The transmitter drawer A.P. 164732 is capable of taking either oscillator A.P. 164485 or A.P. 164759 without modification. (ii) The oscillator A.P. 164759 is similar to the A.P. 164855 but has two additional crystal units to give the frequency change facility – see Note iii. (iii) The transmitter 5AB/AC is identical to the 5AB/C except that the latter has the remote wiring and remote switch to provide the remote frequency change facility for C.W. Ship/Shore. The running of this wiring (B.R. 1917 Mod. 27 to the 601 Series, which covers the conversion of 5AB to 5AB/B and 5AB/AC to 5AB/C) is by A and A action only, but it is also possible to achieve the facility by ship's staff additions to existing wiring.

2.9. TYPE 601

DATE OF DESIGN. 1943–1945.

HANDBOOK. B.R. 1466(1);

B.R. 1466(2).

ESTABLISHMENT LIST. E.696.

FREQUENCY RANGE. 1·5 to 24 Mc/s.

FREQUENCY DETERMINATION. V.O. and P.C.C.

EMISSION AND POWER OUTPUT.

C.W. }
M.C.W. } 50 W.
Voice }

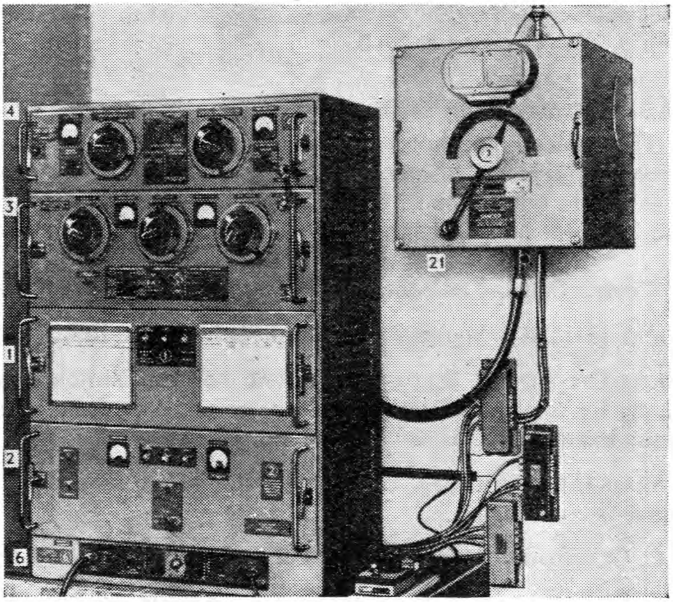


FIG. 1

GENERAL

1. **Block Diagram**

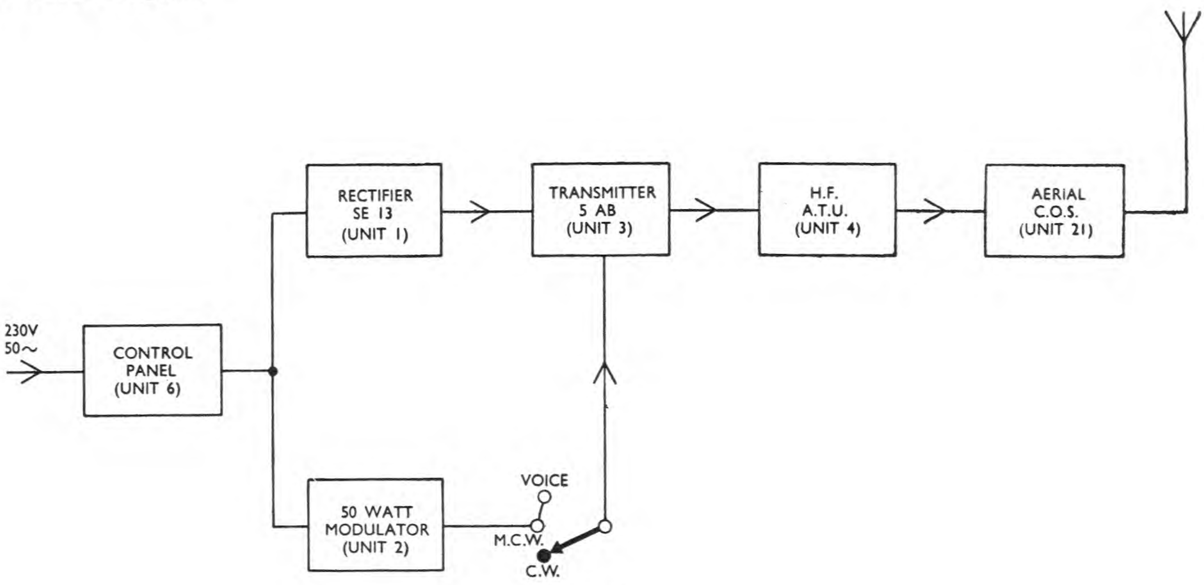


FIG. 2

2. Type 601 is a general-purpose low power HF transmitter. It obtains its supply of 230 V 50 c/s from the ship's standard a.c. supply.

3. Type 601 consists of the following units:

Unit 1.	Rectifier S.E.13	Unit 4.	HF A.T.U.
Unit 2.	50 W. modulator	Unit 6.	Type 601 cabinet
Unit 3.	Transmitter 5AB	Unit 21.	Aerial C.O.S.

CABINET AND CONTROL PANEL

4. **The Cabinet.** This houses all the units of the transmitter with the exception of the aerial C.O.S., which is mounted externally. Inter-unit cabling is fitted on the framework inside the back. The cabinet in addition contains the control panel which mounts the various switch controls, fuses, microphone and key sockets, and indicator lamps. Behind this are the associated relays and other components.

5. **Control Panel.** The controls, reading from left to right, are:

LOCAL HANDSET. Socket for local microphone and headset, for operation on voice in local control.

LOCAL-OFF-REMOTE SWITCH. In LOCAL position, switches on H.T. supplies. In REMOTE position H.T. supply for the transmitter can only be switched on from a remote position. When the transmitter is not in use it should be in the OFF position.

VOLUME (LOCAL PHONE). Controls volume of output in local handset from any receiver to which transmitter is connected.

A.C. OUT FUSES. 5-amp fuses in a.c. supply to an external rectifier for lamp indication.

A.C. SUPPLY LAMP. Glows when a.c. is switched on.

A.C. IN FUSES. 5-amp fuses in a.c. supply to transmitter.

A.C. SUPPLY SWITCH. Switches on a.c. supply to the transmitter and supplies all valve heaters.

C.W.–M.C.W.–R/T SWITCH. Selects type of transmission.

LOCAL KEY JACK. For tuning or operating in local control.

UNITS

6. All the units comprising Type 601 are described under Type 602.

TUNING INSTRUCTIONS

7. See under Type 602.

2.10. TYPE 602

DATE OF DESIGN. 1943–1945

HANDBOOK. B.R. 1467(1);
B.R. 1467(2)

ESTABLISHMENT LIST. E.696

FREQUENCY RANGE. HF. 1·5 to 24 Mc/s
MF. 200 to 500 kc/s

FREQUENCY DETERMINATION

HF { 1·5 to 3 Mc/s V.O.
3 to 24 Mc/s P.C.C.

MF – V.O.

EMISSION AND POWER OUTPUT.

HF { C.W.
M.C.W.
Voice
I.C.W.* } 50 W

MF { C.W.
M.C.W.
I.C.W.* } 50 W

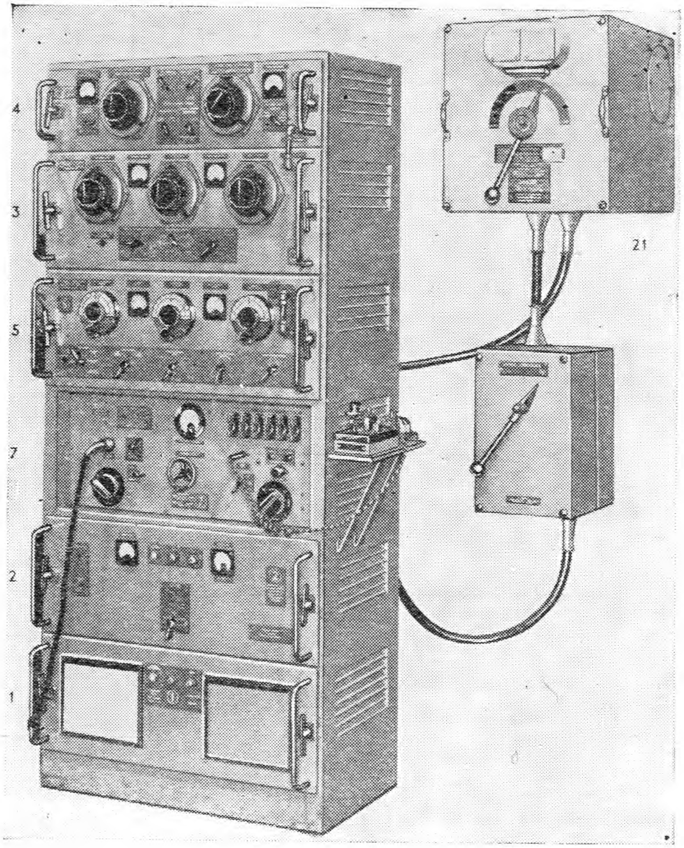


FIG. 1

GENERAL

1. Type 602 is a general-purpose low power MF/HF transmitter. When fitted with an emergency power unit it is referred to as Type 602E. Type 602E normally obtains its supply of 230 V 50 c/s from ship's standard a.c. supply, but can be switched to an emergency supply in the event of power failure. The emergency power unit which is fed from Battery Outfit BBY provides this supply.

2. Type 602 consists of the following units:

Unit 1.	Rectifier S.E. 13	Unit 7.	Type 602 cabinet	
Unit 2.	50 watt modulator	Unit 21.	Aerial C.O.S.	
Unit 3.	Transmitter 5 AB	Unit 23.	Battery outfit BBY	Fitted with Type 602E only.
Unit 4.	HF A.T.U.	Unit 24.	E.P.U.	
Unit 5.	Transmitter 4AD			

* When using emergency supply 602E only.

Block Diagram

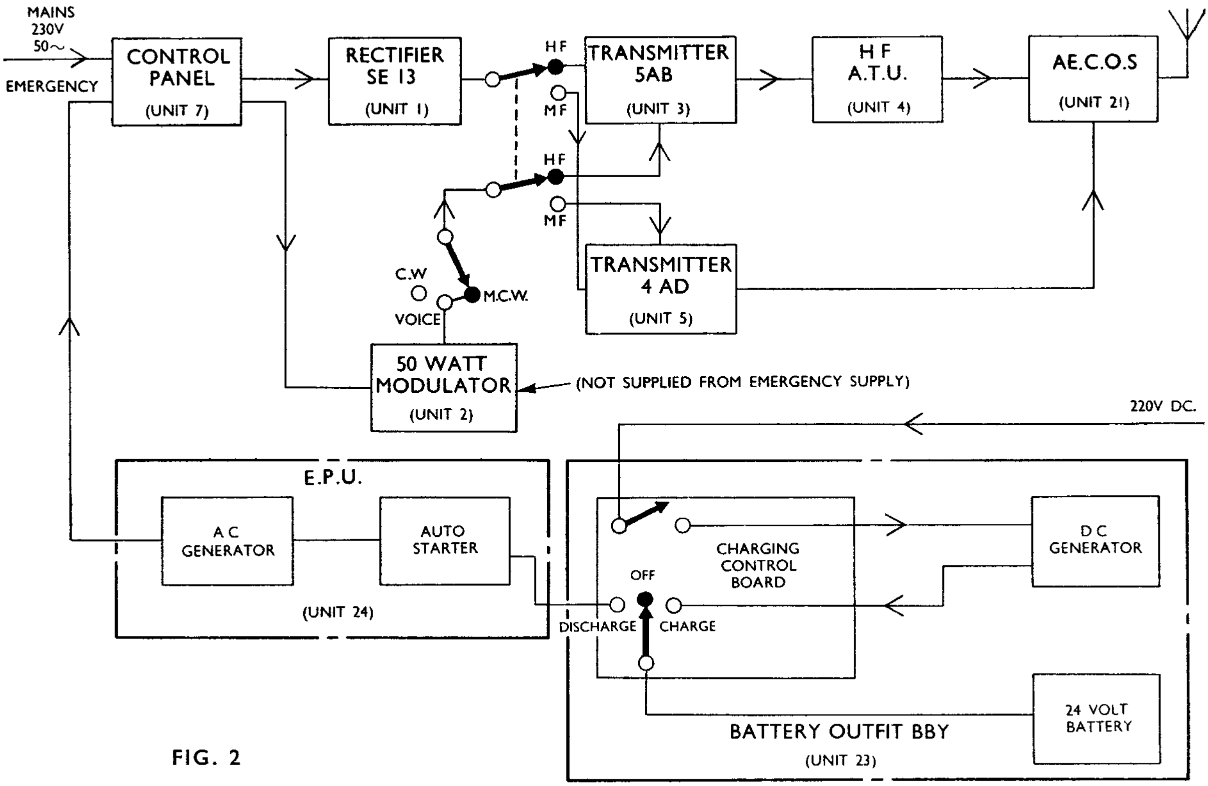


FIG. 2

CABINET AND CONTROL PANEL

3. **The Cabinet.** This houses the Rectifier S.E. 13, 50 watt Modulator, Transmitters 4 AD and 5AB and the HF Aerial Tuning Unit. The aerial C.O.S., E.P.U., Battery Outfit and associated equipment are external to the cabinet. In addition the cabinet contains the control panel which mounts the various switch controls, fuses, microphone and key sockets, voltmeter and indicator lamps. Behind this are the associated relays and other components.

4. **Control Panel.** The controls, reading from left to right are:

HF – MF SWITCH. Switches supplies either to transmitter 5AB or to transmitter 4AD.

LOCAL HANDSET. Socket for local microphone and headset, for operation on voice in local control.

LOCAL – OFF – REMOTE SWITCH. In LOCAL position switches on H.T. supplies. In REMOTE position, H.T. supply for the transmitter can only be switched on from a remote position. When transmitter is not in use it should be in the OFF position.

VOLUME (LOCAL PHONE). Controls volume of output in local headset from any receiver to which transmitter is connected.

INCREASE VOLTAGE. (Used with emergency supply only.) A field regulator controlling the output voltage of the emergency a.c. generator.

A.C. SUPPLY VOLTMETER. Indicates voltage from a.c. mains or voltage from emergency a.c. generator. Latter voltage can be adjusted by field regulator.

C.W. – M.C.W. – R.T. SWITCH. Selects type of transmission.

LOCAL KEY JACK. For tuning and operating in local control.

A.C. SUPPLY SWITCH. A four-position switch.

Position 1. OFF

Position 2. Emerg. C.W. } Switches transmitter to a.c. supply from emergency a.c. generator and arranges H.T. supply for c.w. or i.c.w. transmission.

Position 3. Emerg. I.C.W. }

Position 4. Mains. Switches the transmitter to a.c. supply from mains.

START – STOP PRESS BUTTONS. Alternative positions for controlling emergency a.c. generator (other position is on external automatic starter). The neon lamp indicator immediately below the buttons lights when the emergency a.c. generator is running. The press buttons and indicating lamp are inoperative when working from mains supply.

FUSES. Three sets, as follows:

a. A.C. In – 5 amp fuses in a.c. supply to transmitter.

b. Voltmeter – 1 amp fuses in supply to voltmeter.

c. A.C. Out – 5 amp fuses in a.c. supply to an external rectifier or transformer for lamp indication circuits.

RECTIFIER UNIT S.E. 13

5. Block Diagram

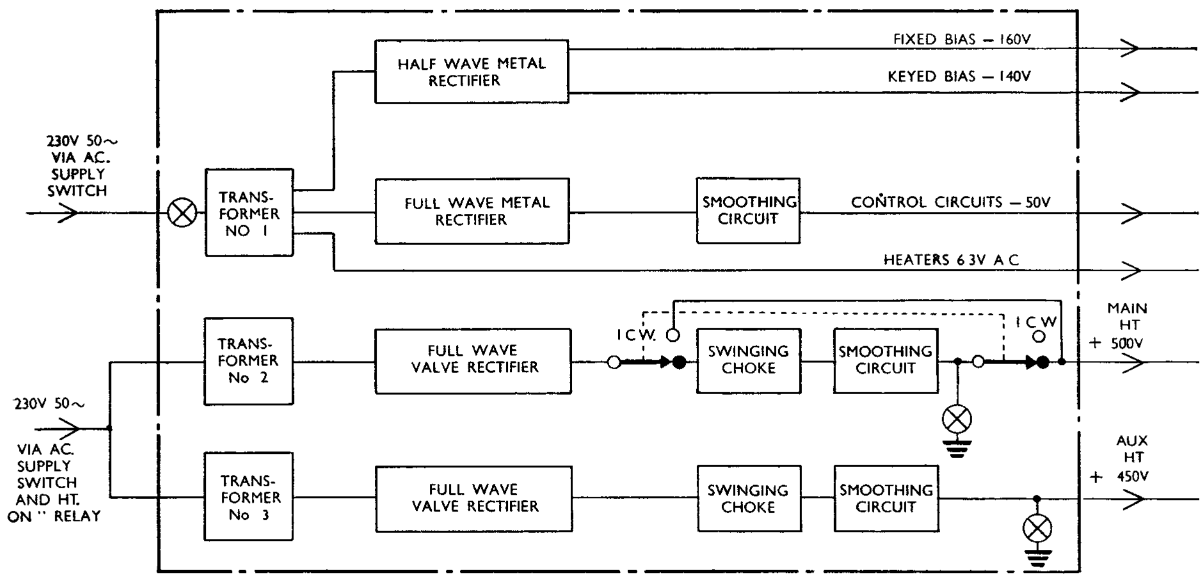


FIG. 3

6. This unit provides d.c. and a.c. supplies for the operation of transmitter 5AB or 4AD. 230 V, 50 c/s feeds three transformers which supply various rectifier circuits as shown in the block diagram.

7. **First Transformer.** The supply to the first transformer is completed when the a.c. supply switch is made to the MAIN, EMERG. C.W. or EMERG. I.C.W. positions. With its associated rectifiers it provides control circuit and bias voltages and also the heater supply.

8. **Second and Third Transformers.** The supply to the remaining transformers is completed when the H.T. ON relay is made. The operation of this relay is described under Operation of Interlock and H.T. ON Relays (paras. 51–53). Swinging chokes are fitted in the output of the Main and Auxiliary H.T. rectifiers. Briefly, the function of this type of choke is to keep the output voltage at a steady level.

9. **Indicating Lamps.** There are three neon indicating lamps on the front panel. They are marked HEATERS, BIAS AND CONTROL, 450 V and 500 V. The first of these lamps glows immediately the a.c. supply is completed to the Heater, Bias and Control circuits transformer. The other two lamps glow when the 450 V 500 V d.c. supplies are produced by their appropriate transformers and their associated rectifier and smoothing circuits. This will occur when the H.T. ON relay is made. When the a.c. supply switch is in the EMERG. I.C.W. position the 500 V lamp will not glow as the lamp is across the output of the smoothing circuit which is by-passed in this position of the switch.

TRANSMITTER 5AB

10. **Block Diagram.** (See page 2–10–6.)

11. This transmitter has been designed as a self-contained r.f. unit capable of delivering 50 W output into a tuned aerial over the frequency range 1·5 to 24 Mc/s. An aerial matching and tuning device (the HF A.T.U.) matches any combination of aerial or trunk to the transmitter's output.

12. **Frequency Determination.** There are two distinct methods of frequency determination in this transmitter. On the two lower ranges (1·5 to 2 Mc/s and 2 to 3 Mc/s) a variable oscillator is used. On the three remaining ranges, partial crystal control is employed.

13. **Transmitter Stages.** The transmitter consists of the following stages:

a. VARIABLE OSCILLATOR covering 0·5 to 1 Mc/s by a variable coil.

b. CRYSTAL OSCILLATOR using 0·5 Mc/s crystal.

c. TWO HARMONIC SELECTOR STAGES (H.S.1 and H.S.2) selecting 5th, 6th, 7th, 8th, 9th and 10th harmonics of the C.O. frequency, as necessary, by means of a six position CRYSTAL HARMONIC SELECTOR switch.

d. BALANCED MIXER STAGE which on the lower ranges (1·5 to 3 Mc/s) acts as a buffer stage between V.O. and Amplifier 1 and on the remaining ranges (3 to 24 Mc/s) acts as a mixer producing a resultant frequency which is the sum of C.O. harmonics and the V.O. frequency (giving 3 to 6 Mc/s).

e. AMPLIFIER 1 STAGE is ganged to the Mixer and tuned to the same frequency (3 to 6 Mc/s) for output frequencies above 3 Mc/s. It is tuned to the second or third harmonic of the V.O. for frequencies from 1·5 to 3 Mc/s.

f. AMPLIFIER 2 STAGE which performs any one of the following four functions:

(i) Amplifies – 1·5 to 6 Mc/s output.
(ii) Doubles – 6 to 12 Mc/s output.
(iii) Trebles – 12 to 18 Mc/s output.
(iv) Quadruples – 18 to 24 Mc/s output.

g. POWER AMPLIFIER STAGE ganged to Amplifier 2. This stage amplifies the finally selected output frequency to the required power level.

14. The following summarizes the stages in frequency determination:

Range	*V.F.O.*	*Crystal*	*Harm. Seltr.*	*Mixer*	*1st Amp.*	*2nd Amp.*	*P.A.*
1	0·75–1	—	—	0·75–1	1·5–2	1·5–2	1·5–2
2	0·667–1	—	—	0·667–1	2–3	2–3	2–3
3	0·5–1	0·5	2·5–5	3–6	3–6	3–6	3–6
4	0·5–1	0·5	2·5–5	3–6	3–6	6–12	6–12
5	0·5–1	0·5	2·5–5	3–6	3–6	12–24	12–24

Note. All values in Mc/s.

15. **Keying.** Four stages of the transmitter are keyed – H.S.1, H.S.2, V.O. and P.A. stages. In the SPACE condition the keyed bias of — 140 V (obtained from rectifier S.E.13) is applied to the control grids of H.S.1, H.S.2, V.O. and P.A. stages. This is sufficient to close down the valves of these stages. In the MARK condition the keyed bias is connected to earth and H.S.1, H.S.2, V.O. and P.A. stages operate. The transfer of the keyed bias is effected on c.w. and m.c.w. by the keying relay which is contained in Rectifier S.E.13 and on voice by the operation of the R/T relay situated in the control panel.

16. **Controls.** The front panel of 5AB mounts the following controls and instruments (left to right):

a. Tuning Controls

VARIABLE OSCILLATOR. A variable inductance which tunes the V.O. over the range 500 kc/s to 1 Mc/s.

MIXER TUNING. Two ganged variable inductances, one in the mixer stage, the other in the first amplifier On the two lower ranges (1.5 to 3 Mc/s) the mixer stage operates as a buffer amplifier flatly tuned to approximately 1·1 Mc/s and the variable tuning of this stage is not in circuit.

AMPLIFIER TUNING. Two ganged variable inductances, one in the second amplifier and the other in the power amplifier stage.

b. Switches

CRYSTAL HARMONIC SELECTION SWITCH. Selects one of the six preset circuits in both harmonic selectors. It is calibrated for simplicity in terms of output frequencies.

TUNING METER SWITCH. Enables tuning meter to be switched to measure current or voltage at various points in the circuit for checking and tuning. Also in all positions except the OPERATE position, this switch inserts a resistance in series with the 500 V H.T. supply to the P.A. valves to prevent damage to these valves during tuning.

OUTPUT FREQUENCY RANGE SWITCH. This switch has various functions dependent on the output frequency required. On the lower ranges (1.5 to 3 Mc/s) fixed bias of — 160 V is applied to the C.O., H.S.1 and H.S.2 stages putting them out of circuit, and the tuned circuit of the Mixer stage is altered to a fixed flatly tuned circuit, thus arranging this stage to work as a buffer amplifier. On all frequency ranges, from the mixer stage onwards, it alters fixed capacitors in all tuned circuits dependent on frequency range.

c. Meters

TUNING METER. This meter reads the current in the following circuits: V.O. grid, Mixer grid, Amplifier 1 grid, Amplifier 2 anode and P.A. grid. In the sixth position it also reads P.A. grid current but with full H.T. applied to the P.A. valves.

P.A. ANODE CURRENT METER. Reads the sum of the anode current of both P.A. valves.

d. Jacks

PHONES FOR V.O. CALIBRATION. This is connected in the mixer cathode circuit. It provides a means of checking the calibration of the V.O. against the crystal fitted in the C.O.

> *Note.* When checking calibration of V.O. the Output Frequency range switch must be on one of the higher ranges (3 to 24 Mc/s), or the C.O. will be out of circuit.

17. **Crystals.** Two types of crystal both of 500 kc/s frequency are available for use with the transmitter. They are easily recognizable by the spacing of the pins.

a. Marconi Type. Wide-spaced pins.

b. Salford Type. Narrow-spaced pins. A slightly more stable crystal that is physically more fragile than than the Marconi type. Each transmitter is provided with one crystal of each type, a spare holder being provided for the one not in use. The Marconi crystal is normally used.

18. **Calibration Book.** A calibration book is provided with each transmitter 5AB and should remain with the transmitter throughout its service. Complete instructions for the use of the calibration charts are provided in the front of the book.

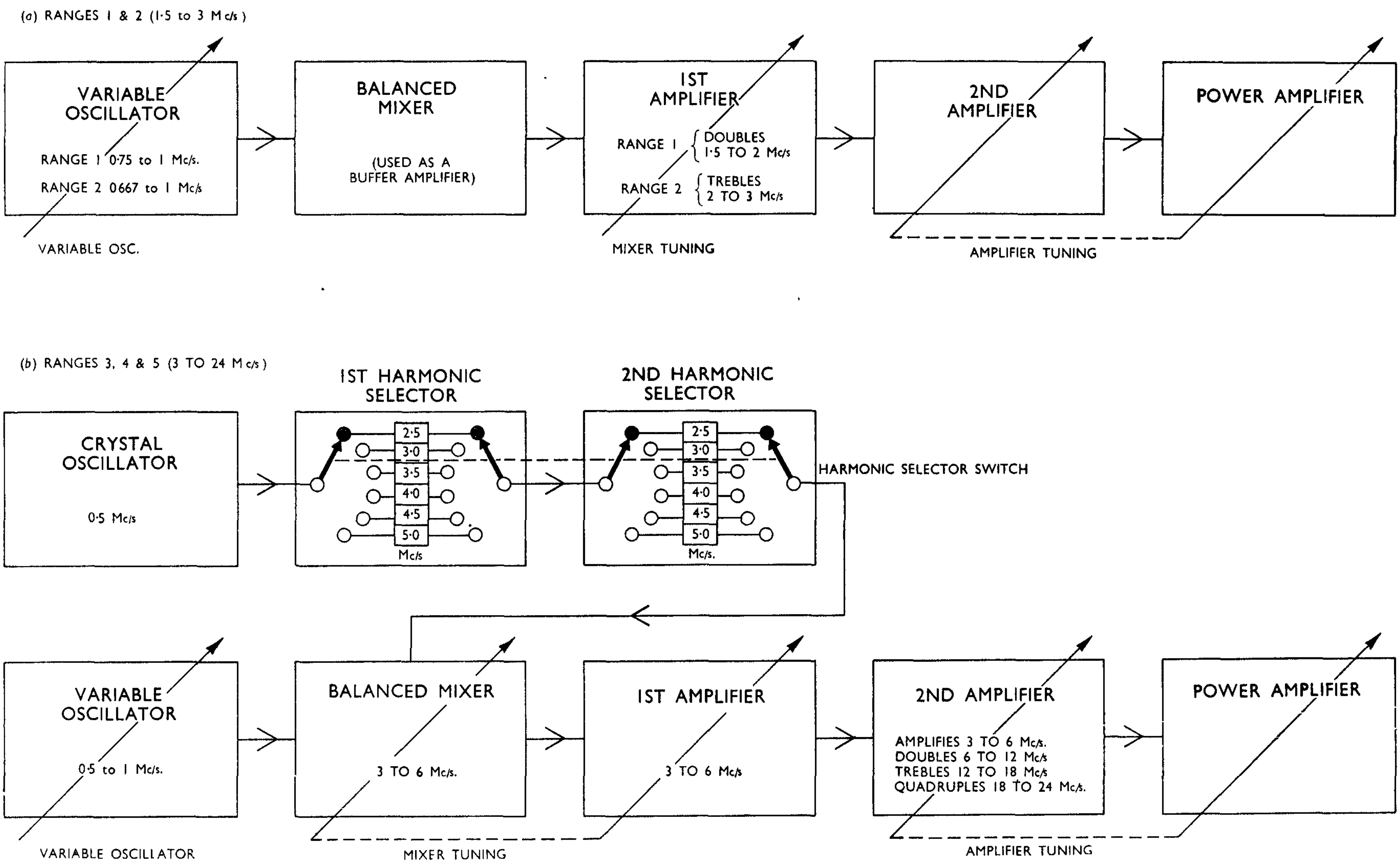


FIG. 4. TRANSMITTER 5 AB

19. **Application of F.S.T.** The use of the 5AB for Frequency Shift operation has necessitated a small modification to the transmitter.
The modification consists primarily of fitting a switch for NORMAL or F.S.T operation. When to F.S.T. the Partial crystal control circuits of the 5AB are inoperative and the controlling frequency with the required deviation is applied to the first amplifier from an external Frequency Shift Keyer.
The operation of 5AB when switched to F.S.T. is as follows:

a. Frequencies of from 1·5 to 6·7 Mc/s from the Keyer Unit are applied to the grid of the first amplifier via the input socket.

b. The second amplifier acts as a straight amplifier for frequencies 1·5 to 6·7 Mc/s, doubles from 6·7 to 13·4 Mc/s, trebles from 13·4 to 20·1 Mc/s and quadruples 20·1 to 24 Mc/s.

c. The P.A. stage, which is ganged to the second amplifier, acts as a straight amplifier throughout.

d. The first amplifier, which is controlled by the Mixer dial, has a nominal top frequency of 6·0 Mc/s, but it will tune easily to 6·7 Mc/s. It is therefore necessary to depart from the normal tuning procedure for frequencies 6·0 to 6·7 Mc/s and multiples.

e. The deviation of the frequency shift in the Keyer Unit will alter according to the multiplication factor of the transmitter. Provision for this correction is contained in the keyer unit.

f. The transmitter must be in the C.W. condition for F.S.T. operation.

20. **H.F. Transmitter** 5AB/A. Designed as a replacement for the 5AB series where F.S.T. operation is required.
This unit has additional circuits which cater for F.S.T. and Facsimile operation as well as normal operation on C.W., M.C.W., and R/T.

21. **Major Differences Between 5AB/A and 5AB.**

a. This unit has been completely re-valved.

b. Power output 40 watts.

c. V.F.O. tunes between 1 and 1·25 Mc/s.

(1) Crystal Oscillator contains 9 crystals, the required one being selected by a 9 position crystal switch on the front panel. The crystals cover frequencies between 2·75 and 4·75 Mc/s at intervals of 0·25Mc/s.

(2) Output frequency range switch has 6 positions as follows:

1	1·5–2·0	4	6·0–12·0
2	2·0–3·0	5	12·0–18·0
3	3·0–6·0	6	18·0–24·0

(3) Partial Crystal Control (P.C.C.) is used over the entire range of the transmitter. The Mixer stage is tuned to either the *Sum* or *Difference* of V.F.O. and Crystal frequencies depending on the output frequency. (*See* Fig. 5.)

(4) The frequency determining circuits are contained in a temperature controlled oven working at 75 deg. C. This oven requires a separate 230 V a.c. supply, which will normally be left permanently switched on. The frequency stability of the 5AB/A is 0·003 per cent of the output frequency, but this will only be achieved if the oven supply is on for at least 3 hours prior to using the transmitter.

(5) The separate 230 V a.c. supply is also used to supply a heater transformer which produces 6·3 V for the heaters of the valves in the frequency determining circuits. This was found necessary as the extra current required is not available from the rectifier S.E.13.

(6) A periodic Voltage Amplifier. An untuned buffer stage between Mixer and Amp. 1. It is designed to provide an equal level of amplification of frequencies between 1·5 and 6 Mc/s.

(7) The following stages are keyed from the Keyed bias line (— 140 v):

Crystal Oscillator (Suppressor grid only).
Amplifier 1.
Power Amplifier.

(8) The V.F.O. is not now keyed, and this further improves frequency stability.

(9) The final loading figure for the P.A. stage is 180 mA (5AB-165 mA).

(10) No phone jack for V.F.O. calibration. This procedure is now carried out using the tuning meter with Meter Switch in the CAL position.

22. F.S.T. Operation

Brief description. The keying signal is applied to a trigger circuit, the square wave output of which is used to operate the Reactance Stage. The input to this stage is controlled by a limiter. The Reactance stage, which is connected across the V.F.O. tuned circuit, is used to shift the V.F.O. frequency in one direction for IDLE and in the opposite direction for ACTIVE. The total shift is variable between 0–1000 c/s. Thus, for an assigned frequency of 5 Mc/s, the output frequency will be:

$$\left.\begin{array}{ll}\text{IDLE/MARK} & 5000{\cdot}425 \text{ kc/s.} \\ \text{ACTIVE/SPACE} & 4999{\cdot}575 \text{ kc/s.}\end{array}\right\} \text{Using 850 c/s shift.}$$

When the second amplifier is being operated as a frequency multiplier on ranges 4, 5 and 6, the output from the Limiter is automatically divided by 2, 3 or 4 depending on the position of the range switch. It is important therefore to remember to set the cycle shift control to the cycle shift actually being used. This will normally be, by NATO agreement, 850 c/s.

23. Keying speed. Up to 100 bauds normally, but may be used at speeds up to 250 bauds by removing a small capacitor from the limiter range.

24. Service Switch. A 7 position switch marked as follows:

1. TEST ± (Red + Black —).
2. TEST 0 (See Note 2 below).
3. TEST ± (Red — Black +).
4. FAX.
5. F.S.K. ± (Red — Black +).
6. F.S.K. ± (Red + Black —).
7. C.W.M.C.W.R.T. (Emission switch on transmitter control panel also in appropriate position).

Positions 1 to 3 are only used when setting up the frequency shift circuits (Internal adjustments).
The + positions are used then the IDLE signal applied to the trigger circuits is positive with respect to the ACTIVE signal. This is the normal application in ships.
The black and red symbols are used as follows:

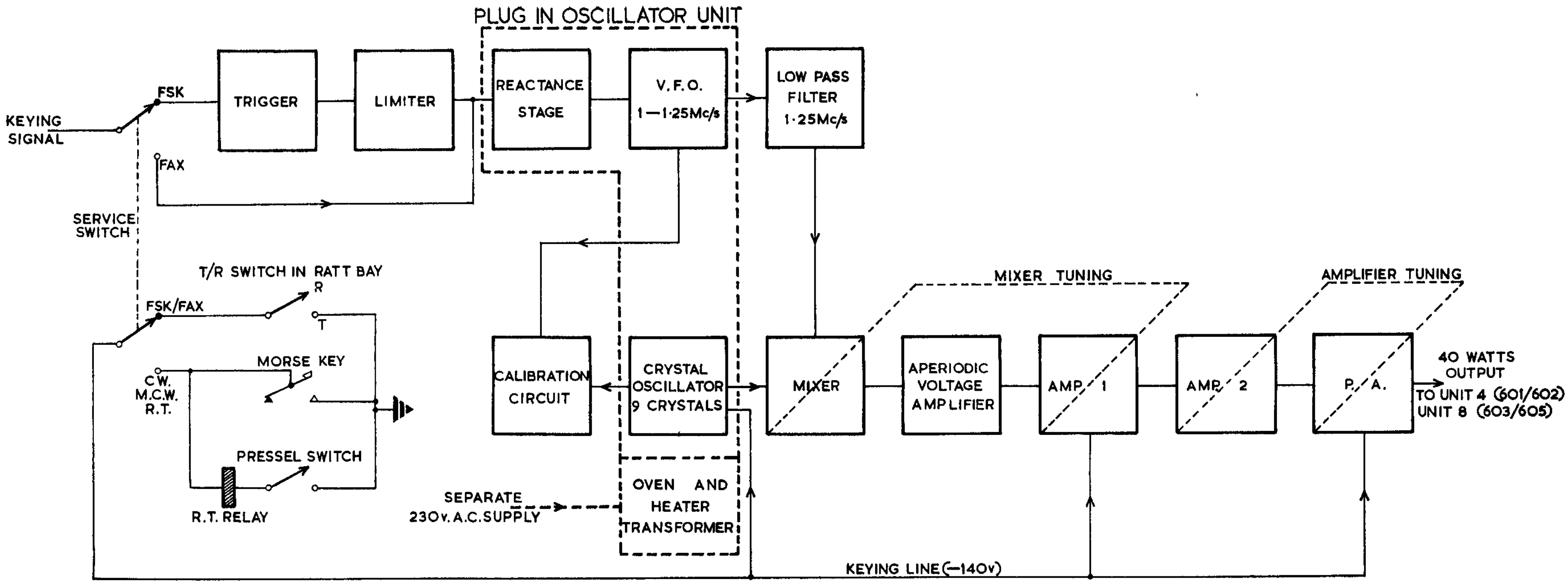
Black	Mixer tuned to *sum* of V.F.O. and crystal frequencies.
Red	Mixer tuned to *difference* of V.F.O. and crystal frequencies.

Notes. (i) The crystal oscillator is only connected to the Calibration Circuit in the first three positions on this switch. (ii) Positions 2 and 7 are identical as regards circuit arrangements. Position 2 could be used therefore for C.W., M.C.W. and R.T. if position 7 was defective.

25. Tuning of 5AB/A. Full instructions for the tuning of the unit are contained in the Calibration Book which is fitted inside the hinged door covering the V.F.O. tuning dial.

Note. If the *exact* output frequency is given in Table 1 of the Calibration Book, then the settings for this frequency must be used and *not* the settings for the nearest frequency below the output frequency.

The tuning instructions for the remaining units of Types 601/2/3/5 remain the same.



V.F.O.	CRYSTAL OSCILLATOR No.	FREQ.
1 TO 1·25	1	2·75
	2	3·00
	3	3·25
	4	3·50
	5	3·75
	6	4·00
	7	4·25
	8	4·50
	9	4·75

IN USE	MIXER AND AMP. 1		AMP. 2		P. A.	RANGE SWITCH
1/2	DIFF	1·5–2	X1	1·5–2	1·5–2	1·5–2
3/4/5/6	DIFF	2–3	X1	2–3	2–3	2–3
7/8/9	DIFF	3–3·75	X1	3–3·75	3–3·75	3–6
ALL	SUM	3·75–6	X1	3·75–6	3·75–6	
7/8/9	DIFF	3–3·75	X2	6–7·5	6–7·5	6–12
ALL	SUM	3·75–6	X2	7·5–12	7·5–12	
ALL	SUM	4–6	X3	12–18	12–18	12–18
ALL	SUM	4·5–6	X4	18–24	18–24	12–24

FIG. 5. H.F. TRANSMITTER 5AB/A

HF AERIAL TUNING UNIT

26. Block Diagram.

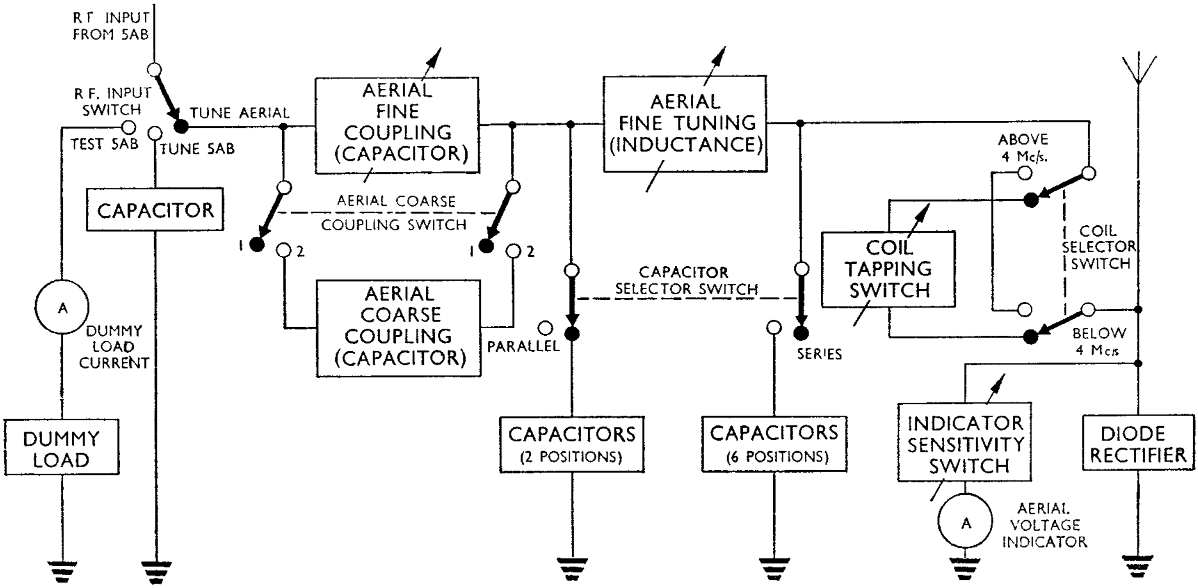


FIG. 6

27. The purpose of this unit is transfer as much power as possible from the power amplifier valves of transmitter 5AB to the aerial. This is done by neutralizing the reactance of the aerial until it matches the output of the P.A. valves of the 5AB.

28. The A.T.U. consists of the following:

A variable capacitor which adjusts the coupling between the 5AB and the main circuits of the A.T.U.

An inductance consisting of a continuously variable coil and *a capacitance* consisting of a bank of switchable fixed capacitors forming a tuned circuit.

Additional coils and capacitors which can be switched into circuit to vary the components mentioned above.

In addition, a dummy load is provided so that the 5AB output can be tested without breaking radio silence. An aerial indicator shows when there is an r.f. voltage at the output terminal.

29. CONTROL.

The following controls reading from right to left, are mounted on the front panel.

Tuning Controls

AERIAL FINE COUPLING. This adjusts the variable capacitor which controls coupling from 5AB to main circuits of the A.T.U.

AERIAL FINE TUNING. This adjusts the variable coil in the A.T.U.

Switches

R.F. INPUT SWITCH. This switch has three positions: Test 5AB (DUMMY LOAD). Switched r.f. current from 5AB to the dummy load via dummy load current meter.

Tune 5AB. Switches r.f. current from 5AB through a small value capacitor to earth. The value of this capacitor is equivalent to the capacitance of the connection between the r.f. Input Switch and the aerial coupling capacitor so that when 5AB is tuned in this position its amplifier tuning point is the same as for the tune aerial position.

Tune Aerial. R.F. current from 5AB is connected to the A.T.U. circuit.

Condenser Selector Switch. Has two functions. It provides a choice of capacity for the tuned circuit. It is also used to connect the selected capacity in series or parallel with the aerial.

Aerial Coarse Coupling Switch. In position 2 adds an extra Capacitor in parallel with Aerial fine coupling capacitor.

Coil Selector Switch. This adds a number of fixed coils in series with the fine tuning on the 1·5–4 Mc/s position of the switch.

Coil Tapping Switch. This switch selects the coils to be used which have been brought into circuit by the coil Selector Switch on the 1·5–4 Mc/s range.

Indicator Sensitivity Switch. This connects the meter circuits to a monitor diode via switched resistance so that a convenient indication can be obtained.

METERS

Dummy Load Current. Measures r.f. current in the dummy load when the r.f. Input Switch is set to Test 5AB.

Aerial Voltage Indicator. Indicates that there is r.f. voltage at the output terminal.

Monitor Phone Jack. This is supplied from the monitor diode to enable the quality of modulation to be checked at the transmitter when using voice or M.C.W.

TRANSMITTER 4AD

30. Block Diagram

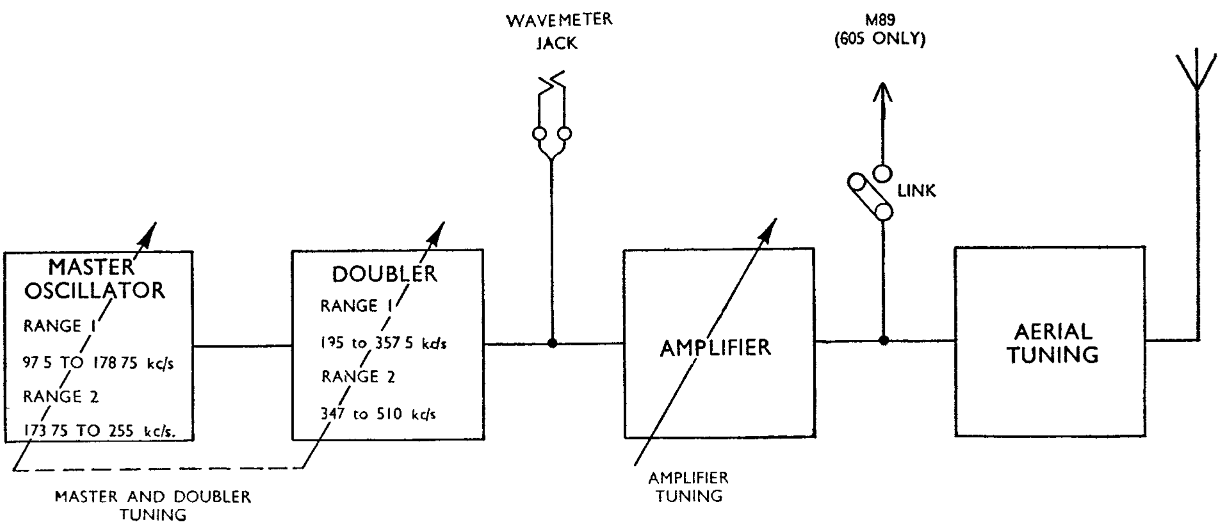


FIG. 7

31. This transmitter has been designed as a low-power MF unit covering the frequency band 200 to 500 kc/s. In Type 602 this unit is used as a self-contained transmitter housed immediately below transmitter 5AB. Voice is not normally used with this transmitter.

32. The transmitter has four stages as follows:

a. Master Oscillator. This is a self-oscillating circuit having two continuously tunable ranges controlled by a range switch. Tuning of each is effected by a variable capacitor which is ganged to a similar capacitance in the doubler stage.

Range 1. 97·5 to 178·75 kc/s.

Range 2. 173·75 to 255 kc/s.

b. Doubler. On both ranges the anode circuit of this stage doubles the frequency of the M.O. stage. It is tuned by a capacitor ganged to the M.O. capacitor.

Range 1. 97·5 to 357·5 kc/s.

Range 2. 347·5 tp 510 kc/s.

c. Amplifier. This consists of two valves in parallel which raise the power to the required level. This circuit is tuned by a variometer in the anode circuit.

d. Aerial Tuning. This consists of a tapped aerial loading coil with a variometer for fine tuning. A bank of switched capacitors provide coupling from the amplifier stage.

33. **CONTROLS.**

The following controls and meters are provided reading from left to right on the panel.

Tuning Controls

Master and Doubler Tuning. Varies ganged capacitor in M.O. and Doubler circuits.

Amplifier Tuning. Tunes a variometer in the anode circuit of the Amplifier stage.

Aerial Fine Tuning. A variometer in the aerial tuning circuit.

Switches

Meter Switch. A six-position switch enabling the tuning meter to be used to measure current in different parts of the circuit. Used for checking and tuning.

Tune-Operator Switch. This switch has two positions, Tune Master and Amplifier and Tune Aerial and Operate. In the latter position it short circuits an extra cathode biasing resistor in the cathode supply to the amplifier valves. This resistor is in circuit in the Tune Master and Amplifier position of the switch to prevent excessive current flowing in the amplifier valves during initial stage of tuning.

Frequency Range Switch. A two-position switch which alters the inductance and capacity in the M.O. Doubler and Amplifier Stages for each range.

Aerial Coupling. This is an eight-position switch which selects the necessary capacitor for coupling.

Aerial Coarse Tuning. An eight-position switch which selects the Tapping on the aerial loading coil. The inductance between each adjacent tap is varied by the Aerial Fine Tuning.

METERS

Tuning Meter. Reads current in various parts of the circuit as controlled by the meter switch.
Aerial Current Meter. Reads current in the aerial.

JACKS

Wavemeter Jack. As the M.O. is not calibrated it may be necessary to tune the transmitter by wavemeter. A wavemeter jack is provided for this purpose on the left of the panel. This jack is coupled to the anode circuit of the doubler thus enabling output frequency to be determined.

34. Two-Position Link. Fitted inside the set. In one position the link is idle and plays no part in the circuit. This is used when the transmitter is part of Type 602. In the other position it connects the output of the amplifier stage to an r.f. output plug on the outside of the panel. This output plus is used in Type 604 and 605 only and is connected to the input plug on Amplifier M.89.

35. Send-Receive Link. Two terminals are provided also at the top right of the panel which can be connected to send-receive circuits if required. Normally they are linked together.

MODULATOR AND RECTIFIER UNIT

36. Power Supplies – Block Diagram

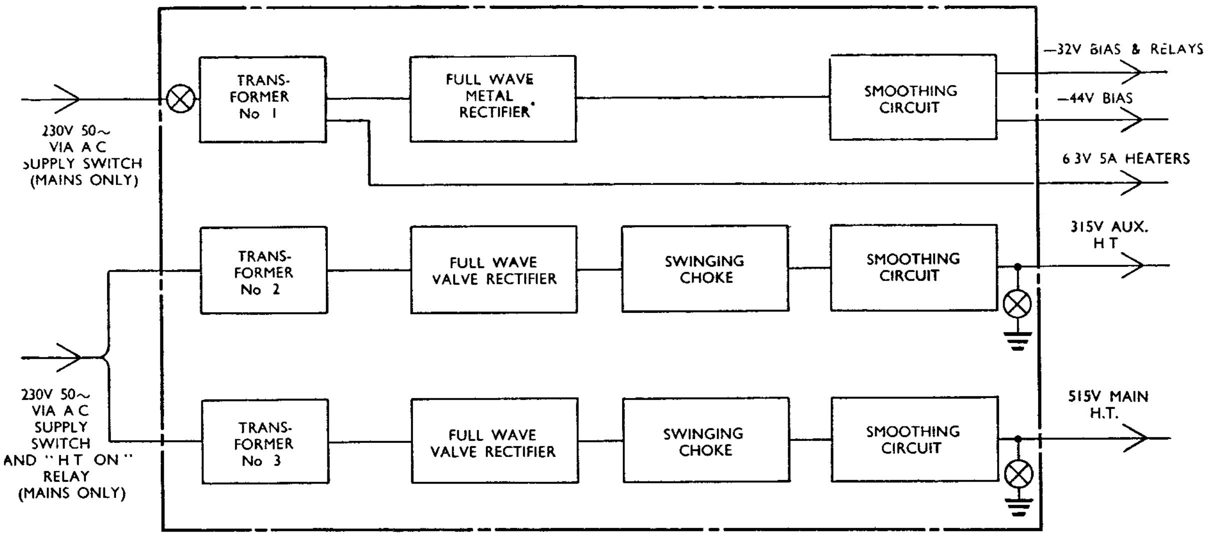


FIG. 8

37. **Power Supplies – General.** The power supplies for the 50 W modulator are self-contained, apart from −140 V keyed bias required on m.c.w. The supplies are somewhat similar to those provided by Rectifier S.E.13 to the transmitter units. 230 V 50 c/s feeds three transformers which supply various rectifiers, as shown in the block diagram. The supply to the first transformer, which, with its associated rectifiers, provides bias supplies and supplies for the C.W., M.C.W. and R/T relays, is completed when the a.c. supply switch is made to the Mains position. When operating from the Emergency Power Unit the 50 W modulator is not supplied and emergency operation on voice and m.c.w. is not possible. The supply to the remaining transformers is completed when the H.T. On relay is energized, provided that the emission switch on the Control panel is either to R/T or M.C.W.

38. **Modulator – General.** This unit is designed to modulate the anode and screen supplies of either the P.A. valves of the 5AB in m.c.w. or Voice, or the amplifier valves of the 4AD in m.c.w. only. The modulator is not used when the 602E is being supplied from the Emergency Power Unit. Carbon microphones are used.

39. The audio chain on R/T is as follows:

a. Microphone Transformer. The microphone output is fed into the microphone transformer via a two-position switch. The position of this switch depends on the type of microphone and audio lines in use. The switch is set up on installation and should not be altered. The output of the microphone transformer can be varied by a three-position switch (marked Low, Med. and High) which alters the audio voltage applied to the first amplifier stage.

Modulator – Block Diagram

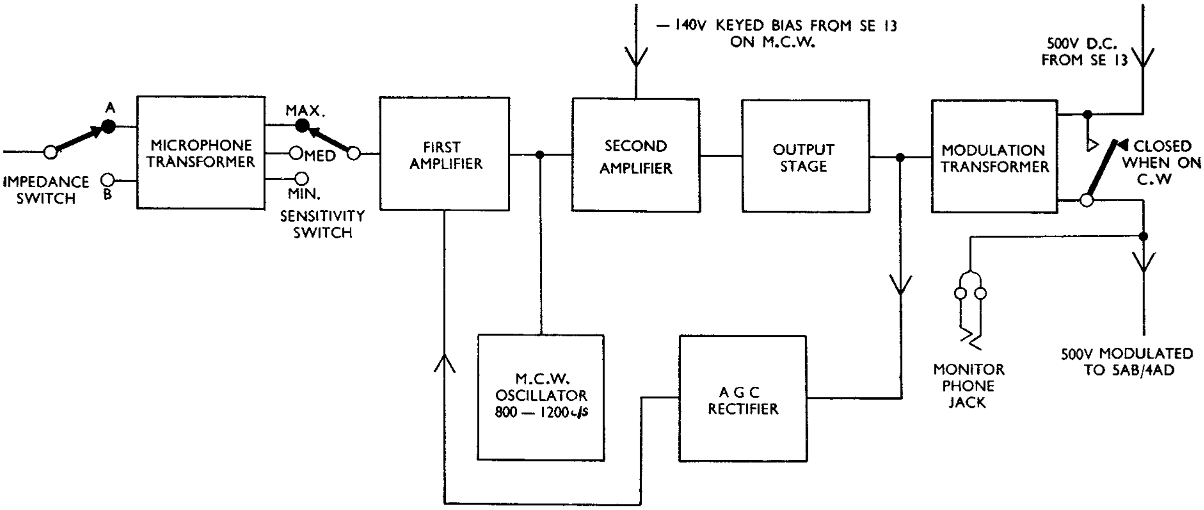


FIG. 9. MODULATOR – BLOCK DIAGRAM

b. First Amplifier. Two valves in push-pull.

c. Second Amplifier. Two valves in push-pull.

d. Output Stage. Two valves in push-pull, feeding the modulation transformer.

e. Modulation Transformer. The 500 V d.c. supply, which is to be modulated is fed into the secondary of the modulation transformer. When using c.w. the secondary of the modulation transformer is short-circuited by the operation of the c.w. relay.

40. **A.G.C. Rectifier.** From the output stage, voltage is fed to an a.g.c. rectifier. When the a.g.c. rectifier operates it feeds back a negative voltage on to the grids of the first amplifier valves thus reducing their amplification. The rectifier does not operate until voltages above a certain level are received. This level can be altered by a screwdriver control on the front panel, marked A.G.C. Delay, which therefore alters the depth of modulation in voice (for m.c.w., see next paragraph).

41. **M.C.W.** When using m.c.w., the output from the m.c.w. oscillator is fed into the second amplifier stage, the first amplifier not being used. This is achieved by the operation of the m.c.w. relay. As the first amplifier stage is not used, the a.g.c. circuit will not be effective. Depth of modulation is varied in m.c.w. by altering the H.T. supply to the m.c.w. oscillator by means of a variable resistance. This is done by a screwdriver control marked M.C.W.

42. **Checking Modulation.** An output from the secondary of the modulation transformer is taken to a phone jack on the front panel to enable a check to be made of the quality of modulation.

43. **Controls.** The following are mounted on the front panel, reading from left to right:

Sensitivity Switch. A three-position switch marked Low, Med. and High, selected by screwdriver control. After being set up on installation should not normally be altered.

M.C.W. Note Frequency. Varies iron core coil (choke) in m.c.w. oscillator, enabling selection of any note frequency between 800 and 1200 c/s by screwdriver control.

Anode Current Meter. Measures anode current in various stages as controlled by Anode Current Meter Switch.

NEON LAMPS. These lamps only light when using *Mains* supply.

a. Heaters Bias and Control. Glows when a.c. supply is switched on.

b. 300 *V.* Glows when H.T. ON relay makes and emission switch is in m.c.w. or R/T positions.

c. 500 *V.* Glows when H.T. ON relay makes and emission switch is in m.c.w. or R/T positions.

MONITOR PHONES. A telephone jack which provides a means of checking quality of modulation in m.c.w. and Voice.

ANODE CURRENT METER SWITCH. Switches in meter to read anode current in various circuits.

MODULATION METER. Measures output voltage (R.M.S.) from the Modulator.

MODULATION DEPTH CONTROLS. On removing the cover two screwdriver controls are revealed.

a. R.T. (a.g.c. Delay). Controls a.g.c. delay voltage and thus depth of modulation. Preset on installation to give 70 per cent modulation which is approximately equivalent to 130 V on modulation meter.

b. M.C.W. Controls voltage output from m.c.w. oscillator. Preset on installation to give 90 per cent modulation which is equivalent to about 160 V on modulation meter.

44. **Input Impedance Switch.** Selects correct tapping on microphone line input transformer. Situated inside the unit at the left hand side. It is set up correctly on installation and should not be altered.

AERIAL CHANGE-OVER SWITCH

45. This unit is sited near to the transmitter at the foot of the aerial trunk. It is connected to the aerial via an insulator assembly and to the transmitter by a length of coaxial polythene cable.

46. The aerial C.O.S. consists of two main portions:

a. THE MAIN R.F. SWITCH. This switch can be placed by hand in any one of six positions.

(1) MF
(2) HF
(3) Earth through Resistance
(4) Isolate
(5) Receive
(6) Earth

These positions indicate to what the aerial is connected. In the ISOLATE position the aerial is not connected to anything.

b. AUXILIARY SWITCHES. These are for various interlocking purposes and will be dealt with under Interlocks (paras. 51–53).

47. **Man Aloft.** A Man Aloft Tablet is provided on the front panel of the C.O.S. When it is removed the C.O.S. cannot be put in the MF or HF positions.

48. **Emergency Use.** The switch is designed to facilitate a number of emergency conditions. The aerial can be connected to a receiver, or to another transmitter of the 601 series. The transmitter can also be connected to another aerial via the aerial change-over switch belonging to another 601 series transmitter. These changes are made by means of a link, situated behind the front panel.

OPERATION OF INTERLOCK AND 'H.T. ON' RELAYS

49. **Interlock Circuits.** These are provided to ensure that the transmitter cannot be operated remotely unless:

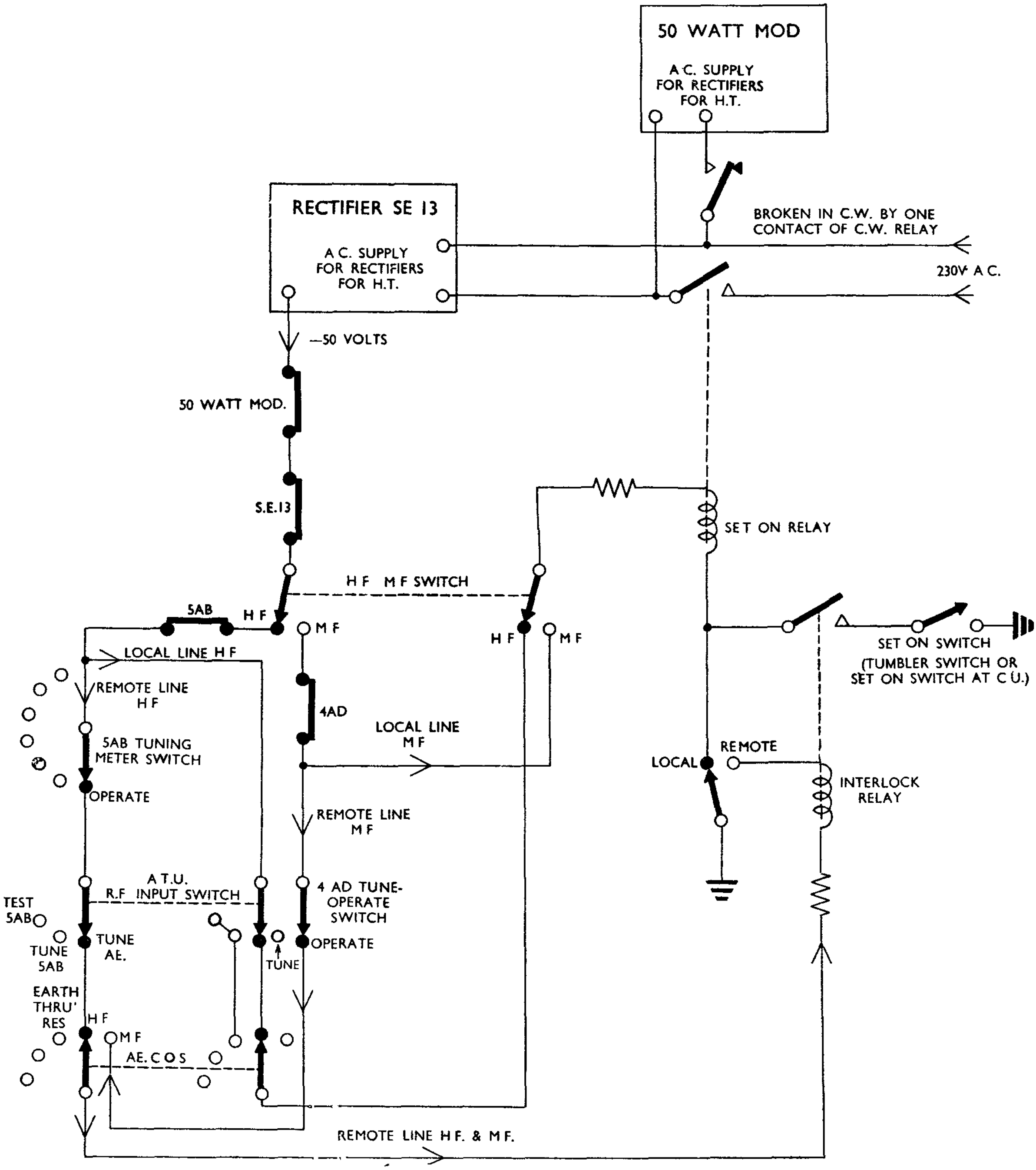


FIG. 10. INTERLOCK AND 'H.T. ON' RELAYS – BLOCK DIAGRAM

On HF the 5AB is to Operate, the A.T.U. to Tune Aerial and the Aerial C.O.S. to HF.

On MF the 4AD is to Operate and the Aerial C.O.S. to MF.

The transmitter can be operated locally on HF whatever the Tune-Operate condition of the 5AB, provided the following conditions are fulfilled:

a. If the A.T.U. is to TEST 5AB or TUNE 5AB, the Aerial C.O.S. must be to EARTH THROUGH RESISTANCE.

b. If the A.T.U. is to TUNE AERIAL, the Aerial C.O.S. must be to HF.

The transmitter can be operated locally on MF whatever the positions of the TUNE-OPERATE and Aerial Change-over Switches may be, but for remote control these must be to OPERATE and MF respectively.

50. **Interlock Relay.** By reference to the diagram it will be seen that the interlock relay is only in the circuit when the Local/Remote switch is to REMOTE.

EMERGENCY POWER UNIT

51. The E.P.U. consists of an a.c. generator and automatic starter operated from Battery Outfit BBy. It provides 450 W single phase a.c. at 230 V when normal supply for 602E fails.

52. **Control.** Three links in the starter determine whether control of the machine shall be from the starter or from the transmitter control panel. On the latter the a.c. supply switch selects the E.P.U. output, which should then be adjusted by the alternator field regulator to 236 V with the transmitter switched on but the key not pressed.

BATTERY OUTFIT BBy

53. Battery Outfit BBy provides a 24 V d.c. supply which may be used to drive the E.P.U. when normal supplies are not available.
The principal components are:

BATTERY. A single 24 V 250 ampere-hour battery.

D.C. GENERATOR. Supplied from ship's mains for charging the battery.

COMBINED CHARGING AND CONTROL BOARD. For regulating the charging rate of the battery and controlling the charging generator.

TUNING INSTRUCTIONS

54. **Types 601 and 602 HF Tuning Guide**

601	*a*. Switch to c.w.	602HF	(1) Switch to c.w. and HF.
	b. Make a.c. Supply switch.		(2) Switch to main.

c. Aerial C.O.S. to EARTH THROUGH RESISTANCE.

d. Set 5AB switches and dials from Calibration Book.

e. R.F. input switch to TUNE 5AB.

f. A.T.U. Controls to starting positions viz:
Aerial Fine tuning to min.
Fine coupling as stated on set.
Coil tapping switch to 1.
Coil selector switch to 4 to 24 Mc/s (irrespective of output frequency).
Coarse coupling to 1.
Condenser switch to SERIES on appropriate frequency.

g. Local/Remote switch to LOCAL.

h. 5AB tuning meter switch to TUNE MIXER. Press the key and tune mixer tuning dial for max. in tuning meter.

i. 5AB tuning meter switch to TUNE AMP. and tune amp. tuning dial for min. in P.A. anode meter.

j. 5AB tuning meter switch to OPERATE and test tuning of 5AB through dummy load with R.F. input switch to TEST 5AB. (Dummy load meter should read about 0·6 amp.)

k. R.F. input switch to TUNE Aerial and Aerial C.O.S. to HF.

l. *For Output Frequencies above or below 4 Mc/s.*

Tuning of A.T.U. Correct tuning results in the following conditions:

Rocking of Aerial Tuning results in *fall* in P.A. Anode current.

Rocking of Fine coupling results in *fall* in P.A. Anode current.

Rocking of 5AB Amp Anode results in *rise* in P.A. Anode current.

In drill below, the expression 'Tune' is to mean—

A full rotation of the aerial tuning control from min. to max. together with the necessary adjustment of Fine and Coarse coupling to achieve the conditions noted above, with a loading figure of 165 mA P.A. anode current. (See Note (ii) below.)

'Tune' with all controls at starting points. If this does not produce the correct tuning point, carry out (*a*) or (*b*) below.

a. *Above* 4 Mc/s.

(1) Condenser switch to parallel 5 and 'Tune'.

(2) Condenser switch to parallel 1, 2, 3, 4 and 6. 'Tune' at each in turn.

b. *Below* 4 Mc/s.

(1) Coil Selector switch 1·5 to 4 Mc/s and 'Tune' for each position of the Coil Tapping Switch from 1 to 10.

(2) Coil Selector switch to 4 to 24 Mc/s condenser switch to parallel 3 and 'Tune.'

(3) Condenser switch remaining at parallel 3, coil selector switch to 1·5 to 4 Mc/s, 'Tune' for each position of coil tapping switch. (From 1 to 10.)

(4) Coil Selector switch remaining at 1·5 to 4 Mc/s, condenser switch to parallel 1, 'Tune' for each position of coil tapping switch from 1 to 10, repeating this drill for all remaining parallel positions of condenser switch 2, 4, 5 and 6.

Notes. (i) The dividing line of 'above' or 'below' 4 Mc/s is not rigid, and the border line frequency which fails to tune correctly should be treated as if it were the other side of the prescribed dividing line. (ii) In this set, correct coupling is obtained with anode current at a maximum of 165 mA. If not, reset aerial tuning and readjust coupling till correct tuning conditions apply.

If any case occurs where all correct tuning indications are not fulfilled, the coupling provides the final setting, i.e. max. at 165 mA anode current.

55. Type 601(2) HF Tuning Guide (HF Transmitter C.A.W.)

a. Ensure that the common aerial working exhaust fans are running.

b. Before switching on transmitter ensure that—

On the appropriate Filter Unit:

(1) Tune/Operate switch is to TUNE.

(2) Aerial selector switch is to TUNE TRANSMITTER.

(3) SAFE TO TRANSMIT key is in lock and turned clockwise.

(4) Auto transformer switch is in position 5.

(5) The TUNE/TEST switch key is set to neutral (central position).

On the Transmitter.

(6) Local/Remote switch to H.T. OFF.

(7) C.W./M.C.W./R/T switch to C.W.

(8) The relevant Tune/Test key switch is in the neutral position.

(9) Tuning meter switch is to TUNE MIXER.

c. Switch on Mains switch at Control Panel.

d. Proceed to tune as follows.

Framework HF Type C.A.W.3 and 5AB

(1) Move Local/Remote switch to LOCAL.

(2) Ascertain settings of switches and dials from calibration curves. Set switches and dials to settings given.

(3) Lock V.F.O. dial.

(4) Put appropriate key switch to TUNE. This acts as a local key.

(5) Offset Amplifier Tuning Dial by one turn and tune Mixer tuning dial for maximum in tuning meter. Re-set amplifier tuning dial.

(6) Tuning meter switch to TUNE AMP. Tune Amplifier tuning dial for maximum in tuning meter. (This should correspond to a minimum on P.A. anode current meter.)

(7) Tuning meter switch to OPERATE.

(8) Lock all 5AB dials.

The transmitter is now tuned. Release Tune/Test key.

Filter Cabinet

(9) Tune/Test key-switch to TUNE. The wattmeter should now read between 30 and 50 W.

(10) Aerial selector switch to TUNE FILTER position corresponding to frequency in use, i.e. to TUNE FILTER ONE for frequencies between 2 and 5 Mc/s, to TUNE FILTER TWO for frequencies between 4·5 and 17·5 Mc/s and to TUNE FILTER THREE for frequencies between 17·5 and 24 Mc/s.

(11) Tune appropriate filter to maximum power as indicated by wattmeter.

(12) Move Aerial Selector switch one further stop clockwise, i.e. on to corresponding aerial position

(13) Retune filter to maximum power and adjust Auto Transformer switches until reading of about 160 to 170 mA is obtained on 5AB output stage anode meter. This will mean trying several positions of the Auto Transformer switch and slight retuning of the filter.

(14) Put Tune/Operate switch to OPERATE.

The filter Channel is now tuned.

Framework Type C.A.W.4

(15) Turn the Local/Remote switch to H.T. OFF.

(16) Put System switch to M.C.W. or 'R/T' as required.

(17) Turn Local/Remote switch to REMOTE and transmitter is ready for operation through KH control system.

56. **Type 602 MF Tuning Guide**

a. Switch to C.W. MF and Mains.

b. Aerial C.O.S. to MF.

c. Set Frequency range switch to appropriate range.

d. Set Meter switch to TUNE AMP.

e. Set 'TUNE/OPERATE' switch to TUNE MASTER AND AMPLIFIER.

f. Set Aerial Tuning Controls to starting positions as follows:
Aerial Coupling to 1
Aerial Coarse Tuning to 1
Aerial Fine Tuning to zero.

g. Plug wavemeter in Wavemeter Coupling Socket (wavemeter should be set to output frequency required). A calibrated receiver may be used in lieu of a wavemeter.

h. Remote/Local switch to LOCAL.

i. Tune MASTER AND DOUBLER for maximum in wavemeter indicator or for zero beat in receiver.

j. Tune AMPLIFIER for minimum in tuning meter.

k. Set Tune/Operate switch to TUNE AERIAL AND OPERATE.

l. Rotate Aerial Fine Tuning for maximum in tuning meter.

m. If no rise occurs, all positions of aerial coarse tuning should be tried with *l* until rise is found.

n. If rise is less than 0·55 in tuning meter increase coupling one step, detune aerial circuit by setting aerial coarse tapping clockwise or anti-clockwise and repeat *d*, *j* and *k*.

o. Reset aerial coarse tuning and repeat *l*, progressively repeat *n* and *l* until maximum occurs between 0·55 and 0·63 in tuning meter.

2.11. TYPE 603

DATE OF DESIGN. 1943–1945

HANDBOOK. B.R. 1468(1);
B.R. 1468(2)

ESTABLISHMENT LIST. E696

FREQUENCY RANGE.

1·5 to 24 Mc/s

FREQUENCY DETERMINATION.

1·5 to 3 Mc/s V.O.
3 to 24 Mc/s P.C.C.

EMISSION AND POWER OUTPUT

C.W. 450–650 W
M.C.W. 400–500 W
Voice 400–500 W

1. **Block Diagram**
(See page 2–11–2)

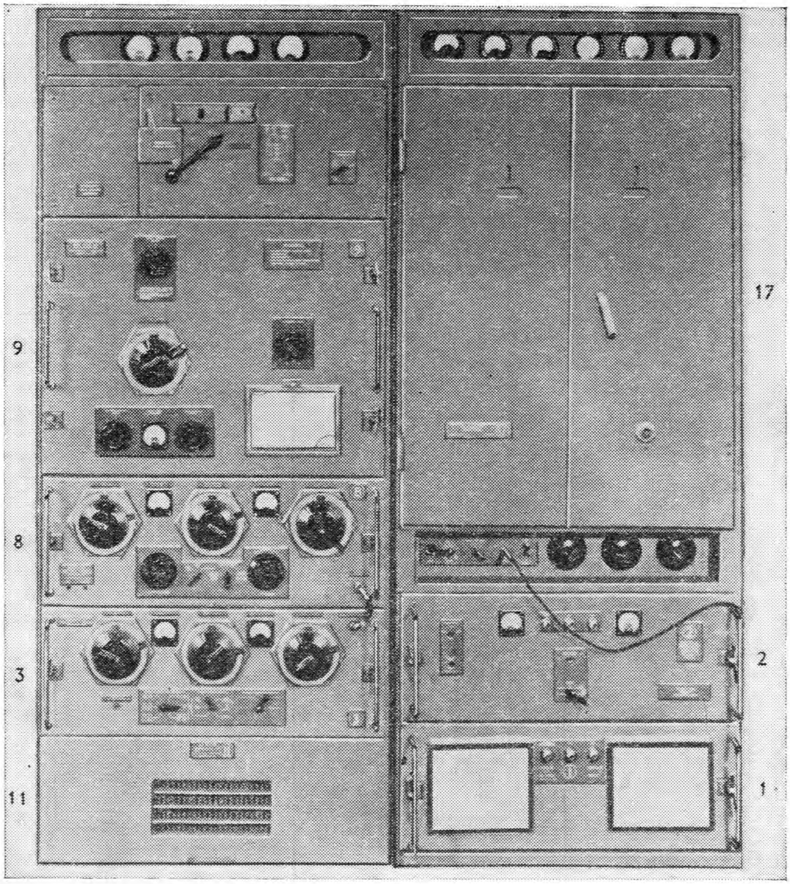


FIG. 1

2. Type 603 is a general-purpose medium-power HF transmitter fitted as the main HF transmitter in destroyers and above. This transmitter is supplied with 230 V 50 c/s single phase or three phase. Two links in the contactor unit must be set to either the single phase or three phase position.

3. Type 603 consists of the following units.

Unit 1. Rectifier S.E.13 – see Types 602 and 605
Unit 2. 50 W modulator – see Types 602 and 605
Unit 3. Transmitter 5AB – see Types 602 and 605
Unit 8. Amplifier M.88 – see Type 605
Unit 9. HF Aerial Tuning Unit – see Type 605
Unit 11. HF Cabinet – see Type 605
Unit 12. Dual Transformer – see Type 605
Unit 13. Dual Rectifier – see Type 605
Unit 14. Main Modulator – see Type 605

(*continued on page* 2–11–3)

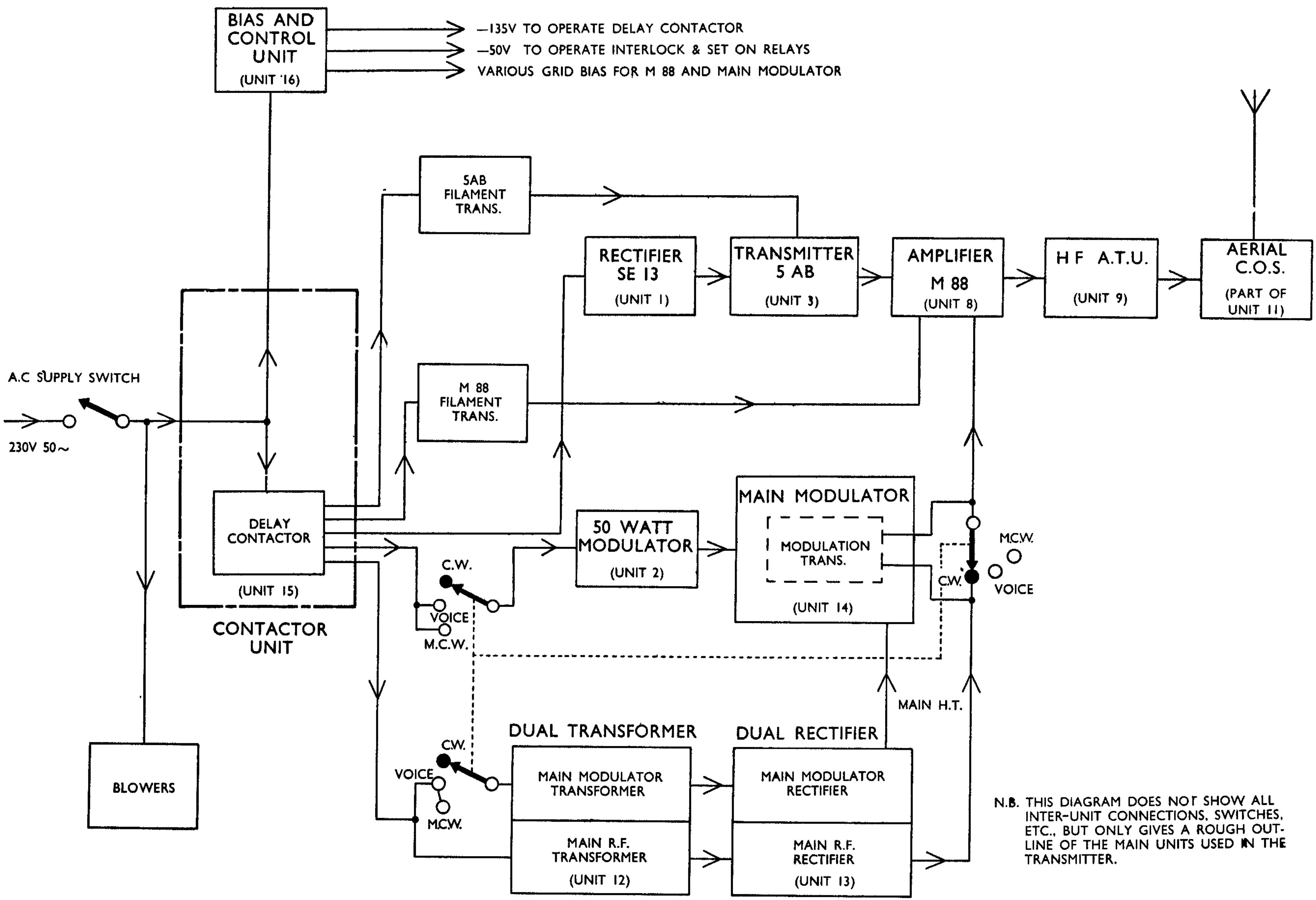


FIG. 2. TYPE 603 – BLOCK DIAGRAM

(*continued from page* 2–11–1)

Unit 15. Contactor Unit – see Type 605
Unit 16. Bias Unit – see Type 605
Unit 17. Power Cabinet – see Type 605

4. **Aerial C.O.S.** Similar to Type 605 but positions tallied differently. No. 18 in. trunk fitted.

5. **Operation of Interlock and Set on Relays.** See Type 605.

6. **Tuning Instructions.** See Type 605.

2.12. TYPE 603(5)

HANDBOOK B.R. 2216

Establishment List E.1321

General

1. Type 603(5) is a modified Type 603 (with transmitter 5AB/A) for working with Base Tuner Outfit ETA. Description of Outfit ETA is contained in the Aerial section. Type 603(5) is the same as the 603 except for the modified units below.

2. Units

a. Control and Power Supply Unit. Replaces the HF Aerial Tuning in Type 603 (see Outfit ETA).

b. Directional Coupler. Used for measuring V.S.W.R. in the transmission line. Measurements are fed to the two meters in the Control and Power Supply Unit. The Directional Coupler is housed in the left hand side of the Aerial C.O.S. Compartment.

c. Aerial Change Over Switch.

(1) Earth – aerial connected to earth.

(2) Tune MF Base Tuner – connects MF transmitter to MF aerial.

(3) Operate MF Base Tuner – as for (2) but Base Tuner controls inoperative.

(4) Tune HF Base Tuner – HF transmitter connected to aerial.

(5) Operate HF Base Tuner – as for (4) but Base Tuner controls inoperative.

(6) Isolate – contact arms of switch not engaged.

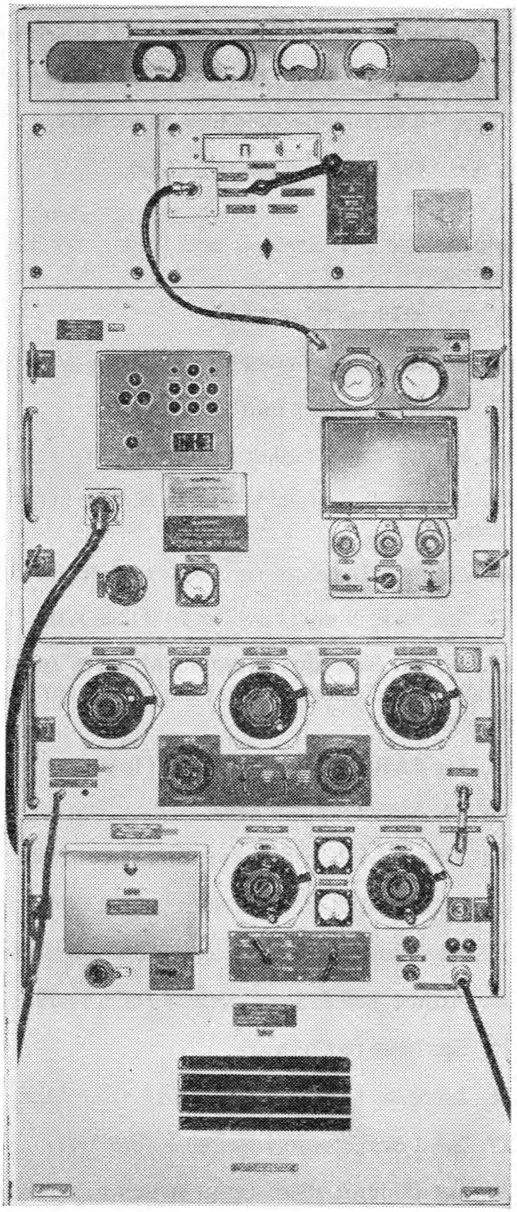


FIG. 1

Type 603(5) HF Tuning Guide with Base Tuning Outfit ETA(1)

1. Switch to HF, CW, LOW POWER.
2. Switch Local/Remote switch to SET OFF.
3. Plug key into M88 key jack, the local key position on power cabinet must *not* be used.

4. Set Dummy load/Aerial switch to DUMMY LOAD (DL).

5. Set Aerial switch to EARTH through resistance.

6. Set O.F.R.S. on 5AB/A and M88 to setting obtained from calibration curves.

7. Set 5AB/A VFO, Mixer and PA dials to settings obtained from booklet in VFO dial cover.

8. Set 5AB/A meter switch to TUNE MIXER.

9. Set M88 coupling control to 00.

10. Set M88 grid and anode tuning circuit controls to settings obtained from BR1468(2) Part 2. These settings are not essential and tuning can be achieved by rotating both controls clockwise from a zero setting.

11. Set M88 to Tune 5AB.

12. Set M88 meter switch to either of the screen current positions.

13. Set ETA power unit switch to ON

14. Set main a.c. supply switch to ON.

15. Set Local/Remote switch to SET ON. (After a delay of 30 seconds all supplies are applied via the delay contactor.)

16. Adjust Mixer tuning dial for MAXIMUM in tuning meter.

17. Set 5AB/A meter switch to TUNE AMP.

18. Adjust Amplifier tuning control for MAXIMUM in tuning meter. This will approximately coincide with a fall in P.A. anode current meter, but for tuning other than Type 602 the anode current meter should be disregarded.

19. Set 5AB/A meter switch to OPERATE.

20. Set M88 to TUNE M88.

21. Adjust M88 grid circuit tuning control for MAXIMUM in tuning meter.

22. Adjust M88 anode circuit tuning control for MAXIMUM in tuning meter.

23. Re-adjust M88 grid control for MAXIMUM.

24. Adjust grid current control for a reading of 30 mA in Final Amp grid current meter.

25. Set M88 to OPERATE.

26. Increase M88 coupling and retune M88 Anode for a loading of 300 mA in Final Amp anode meter.

27. Set Local/Remote switch to SET OFF.

28. Set Dummy load/Aerial switch to AERIAL.

29. Set Aerial change over switch to TUNE HF base tuner.

30. Set Tune/Operate switch on CONTROL and power supply unit to M88.

31. Set controls A, B, C and Mode switch to settings obtained from calibration curves.

32. Set Local/Remote switch to SET ON.

33. Press Tune switch on control and power supply unit until Tuning-in process lamp is extinguished and Tuning completed lamp stays on.

34. Key the transmitter, depending upon the accuracy to which controls A, B, and C have been set, the VSWR meter should show a deflection into the Green and the Forward power meter should show a reading of approximately 450 mA. Slight adjustment of the controls may be necessary to achieve this.

a. Adjustment of controls for L Mode (Positions 1–7) Rotate control A slightly clockwise, adjust control C in both directions for the best deflection of the VSWR meter. Should this prove unsatisfactory rotate control A slightly anti-clockwise adjusting control C in both directions for the best deflection in VSWR meter.

It should be noted that VSWR reading will deteriorate with rotation of control A, improvement being apparent only after adjustment of Control C.

b. Adjustment of controls for Pi Mode (Position)

Adjust control B in conjunction with controls A and C as in *a* endeavouring to use the minimum amount of capacitance (Control B) to obtain satisfactory VSWR reading.

35. Set Local/Remote switch to SET OFF.

36. Set Tune/Operate switch on control and power supply unit to OPERATE.

37. Set Aerial change over switch to Operate HF base tuner.

38. Set Tune/M88/Operate switch to OPERATE.

39. Set transmitter Low/Full power switch to FULL.

40. Set Local/Remote switch to LOCAL or REMOTE as required.

2.13. TYPE 605

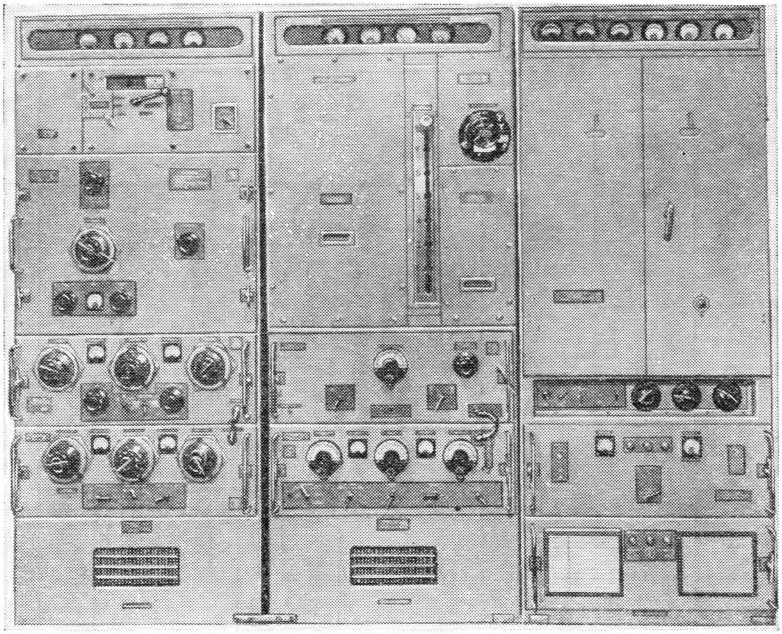


FIG. 1

DATE OF DESIGN. 1943–1945

HANDBOOK. B.R. 1470(1); B.R. 1470(2); B.R. 1470(3).

ESTABLISHMENT LIST. E696

FREQUENCY RANGE	HF 1·5 to 24 Mc/s MF 200 to 500 kc/s
FREQUENCY DETERMINATION	HF 1·5 to 3 Mc/s – V.O. 3 to 24 Mc/s – P.C.C. MF V.O.
EMISSION AND POWER OUTPUT HF	C.W. 450 to 650 W M.C.W. 400 to 500 W Voice 400 to 500 W
MF	C.W. 500 W M.C.W. 400 W

GENERAL

1. **Block Diagram** (see following page).

2. Type 605 is a general purpose medium power HF/MF transmitter fitted in cruisers and above. This transmitter is supplied with 230 V, 50 c/s a.c. single phase or three phase. Two links in the contactor unit must be set to either the single phase or three phase position.

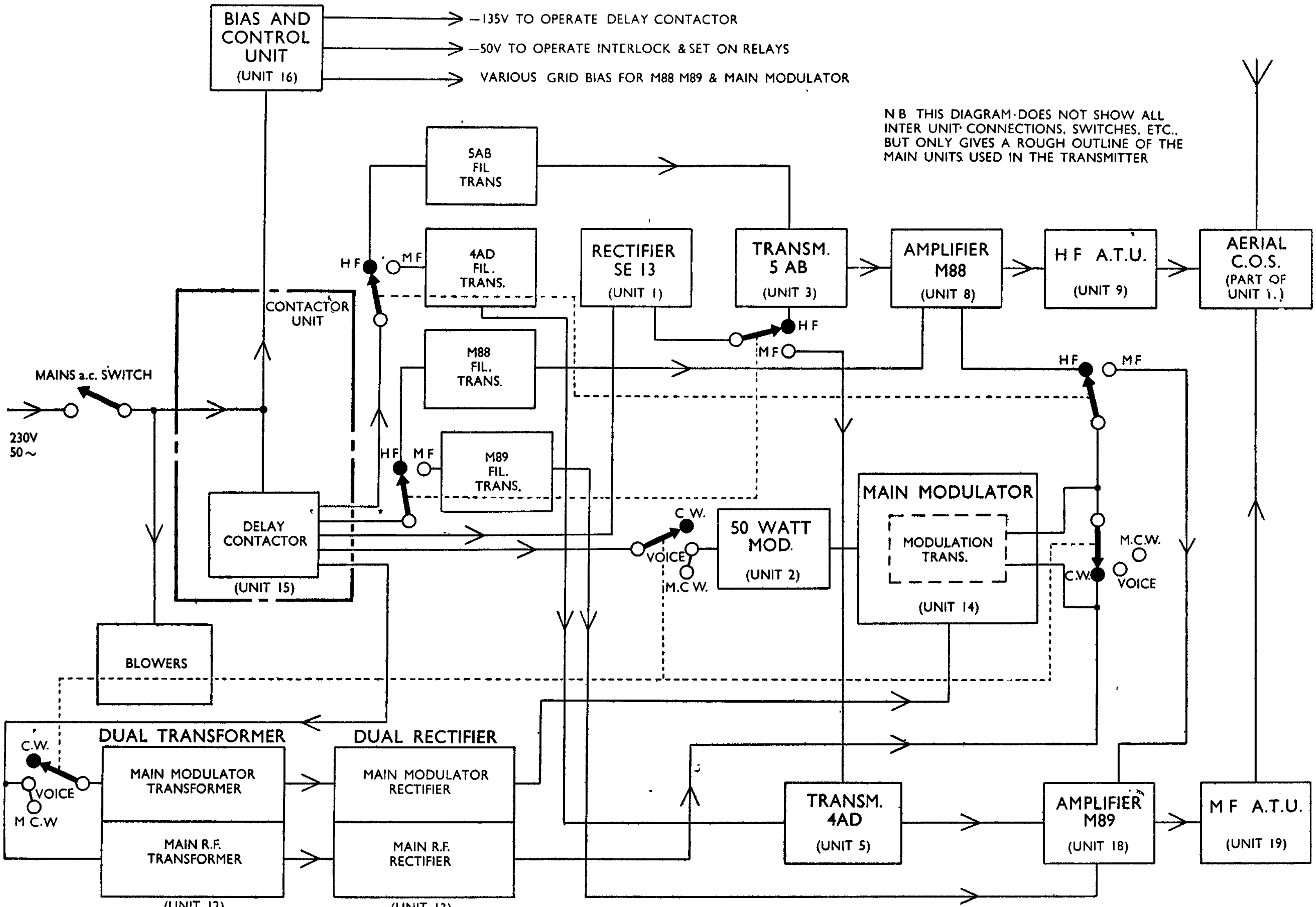


FIG. 2. TYPE 605 – BLOCK DIAGRAM

3. Type 605 consists of the following units:

Unit 1. Rectifier SE13.
Unit 2. 50 W Modulator.
Unit 3. Transmitter 5 AB.
Unit 5. Transmitter 4AD.
Unit 8. Amplifier M88.
Unit 9. HF A.T.U.
Unit 11. HF Cabinet.
Unit 12. Dual Transformer.
Unit 13. Dual Rectifier.
Unit 14. Main Modulator.
Unit 15. Contactor Unit.
Unit 16. Bias Unit.
Unit 17. Power Cabinet.
Unit 18. Amplifier M89
Unit 19. MF A.T.U.
Unit 20. MF Cabinet.

CABINET AND CONTROL PANEL

4. The power cabinet framework houses the following detachable units:

Main Modulator
Contactor Unit
Bias Unit
Dual Rectifier
Dual Transformer
Rectifier SE13
50 W Modulator.

The two latter units may be withdrawn on Roneo runners. They occupy the lower part of the cabinet. Access to the Main Modulator, Dual Transformer, and Contactor Unit is made through panel doors which automatically open safety contacts when the doors are opened. To gain access to the Bias Unit the 50 W modulator must first be removed. Likewise the Contactor Unit must be removed to reach the Dual Transformer.

5. A Meter Panel and Control Panel form part of the cabinet. The meter panel occupies a position above the Main Modulator and contains the following instruments, together with their associated resistors, two bias potentiometers and three illumination lamps:

Modulation Meter
Main Modulator Cathode Meter VI and V2
Main Modulator Cathode Meter V3 and V4
Modulator H.T. Voltmeter
Final Amplifier H.T. Voltmeter
A.C. Supply Voltmeter.

6. **Controls.** The following controls are provided on the control panel.

LOCAL HANDSET. This is the socket for local microphone and head-set, for operation on Voice in local control.

VOLUME (LOCAL PHONE). Controls the volume of output in local headset from any receiver to which the transmitter is connected.

LOCAL-SET OFF-REMOTE SWITCH. In the LOCAL position this closes the contactor energizing circuit and supplies a.c. to all circuits via the Delay Contactor. In REMOTE position it places the transmitter in readiness for the contactor to be operated from a remote position via the C.C.X. The switch therefore controls all supplies (except those to the Bias Unit) via the Delay Contactor.

LOCAL KEY SOCKET. For tuning or operating morse in local control.

A.C. SUPPLY SWITCH. This switches on the external a.c. supply to the transmitter through the contactor unit. It also switches on the Power Cabinet blower and either the MF or HF Cabinet blower.

HF–MF SWITCH. An 18 pole two-way switch which transfers all power supplies to either the HF or MF Cabinet.

MODULATION SWITCH. Selects the type of transmission required. The R/T position is not used on MF and the supplies to the Main and 50 W Modulators are broken when on c.w.

POWER CONTROL SWITCH. Alters power by selecting different tappings on Main r.f. transformer. It also inserts additional resistors in the Main Modulator input potentiometer and in screen H.T. supplies to the R.F. amplifiers when in LOW position.

F.S.K.–C.W. SWITCH. Alters power by selecting different tappings on main r.f. transformer. When switched to F.S.K. the power output from the transmitter will be approximately three-quarters of the output on C.W. Full Power.

BIAS AND CONTROL UNIT

7. This unit is contained in the Power Cabinet immediately behind the 50 W modulator. It provides the d.c. voltages used to:

a. Operate the Interlock and Set on relays;

b. Operate the Delay Contactor in the Contactor Unit;

c. Provide a fixed grid bias for Amplifier M88 or M89;

d. Provide a variable grid bias for the Main Modulator.

8. **Supplies.** The unit is supplied with 230 V single phase a.c. from the Contactor Unit as soon as the main a.c. supply switch is made. Two full-wave metal rectifiers with associated smoothing circuits provide output voltages of —50, —125 and —135 V. The Interlock and Set On relays are operated from the —50 V supply. The —135 V is provided for operation of the delay contactor in the Contactor Unit. The —125 V supply is used via a potentiometer to provide —70 V bias supply for amplifier M88 or M89. This —125 V supply also provides variable bias of any value between —95 and —125 V to each pair of valves of the Modulator push-pull stage. This bias can be varied by two screwdriver controls at each end of the meter panel, tallied MOD. BIAS.

RECTIFIER S.E. 13

9. For details of this unit see Type 602. There are several minor differences when this unit is used as part of Types 603, 604 and 605.

a. The —50 V supply is now only used to operate the keying relay, not the Interlock and H.T. on relays as in Types 601 and 602. The reason for this is that the S.E. 13 does not receive its supply until the delay contactor starts its cycle of operation. As the supply to the delay contactor is not made until the interlock circuit is complete, —50 V must therefore be available as soon as the transmitter is switched on. Thus —50 V for this purpose is obtained from the bias and control unit as explained in paragraph 8 above.

b. The S.E.13 does not provide the filament supplies for the 5AB or 4AD when used as part of Types 603, 604 and 605. Separate filament transformers are provided for this purpose.

c. The 500 V H.T. supply for the P.A. valves of the 5AB is fed to the 5AB via a variable resistance situated in amplifier M88. The control for this variable resistance is marked GRID CURRENT. By varying this control the H.T. supply to the P.A. valves of the 5AB is varied and thus the drive from 5AB to M88 (grid current) is varied. Similarly the 500 V supply to the Amplifier valves of the 4AD is via a variable resistance situated in amplifier M89.

d. The 450 V supply is used to feed the screens of the valves in amplifiers M88 or M89.

DUAL TRANSFORMER

10. Diagram.

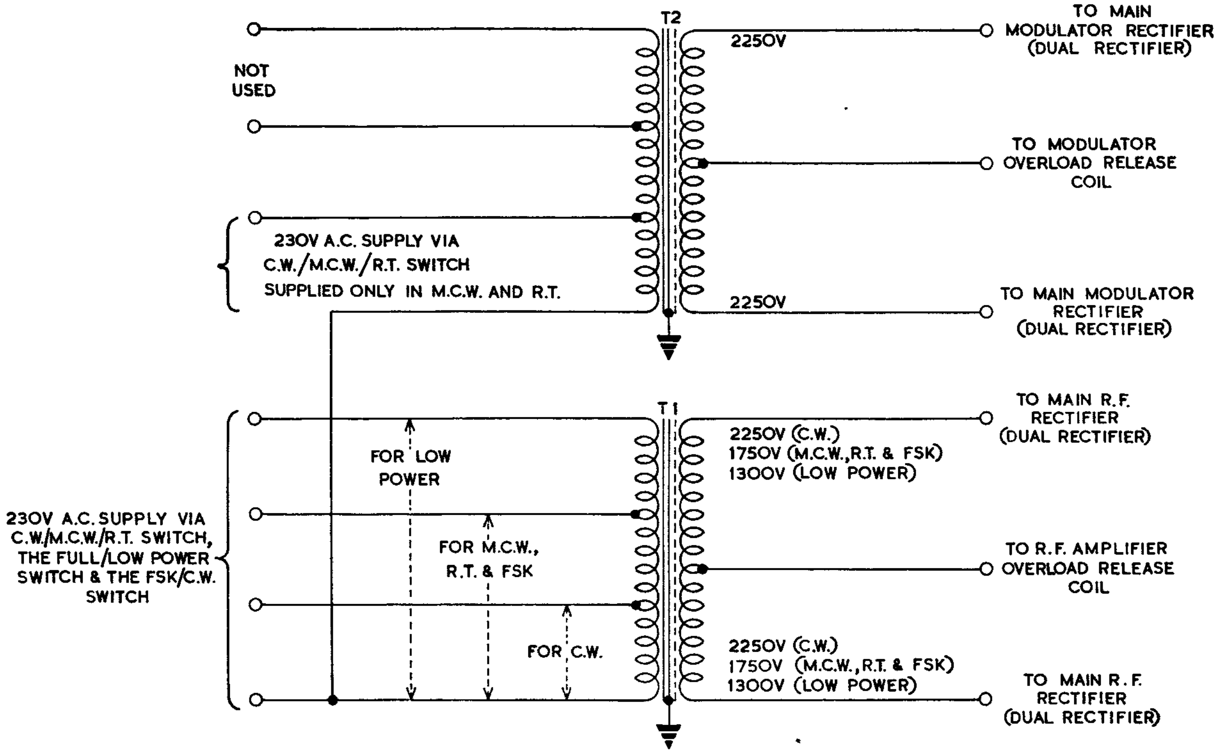


FIG. 3

11. This unit provides the power for the Dual Rectifier and is housed in the Power Cabinet behind the Contactor Unit. There are two transformers in the unit, one supplying the Main r.f. Rectifier and the other the Main Modulator Rectifier.

12. **Supplies.** The primary winding of the Main r.f. transformer (T1) is supplied with 230 V a.c. via the Delay Contactor Unit. The primary is tapped in three positions as shown on the diagram and the 230 V supply is applied between three different sections of the primary according to the output required. The output varies for the following conditions of the transmitter; C.W. (Full Power), M.C.W. or R/T (Full Power) and Low Power. Selection of the requisite primary tapping point is automatically carried out by a combination of the Modulation and Power Control Switches. To enable the transmitter to be used under the continuous Key Down condition required for F.S.T. it is necessary to reduce the H.T. voltage. This is done by the F.S.T.–C.W. switch, which when set to F.S.T. selects the same primary tapping as is used for M.C.W. and R/T (Full Power). The primary winding of the main modulator transformer is also supplied with 230 V a.c. via the delay contactor provided that the modulation switch is to M.C.W. or R/T. The primary is tapped in one position only and thus gives one output only irrespective of the position of the power control switch.

DUAL RECTIFIER

13. This unit is housed in the Power Cabinet behind the double doors, below the Main Modulator and above the Contactor Unit. It contains two similar valve rectifier circuits, each having two pairs of diodes operating as a full wave rectifier system. The eight rectifier diodes are mounted in the front of the unit and are readily accessible when the Power Cabinet doors are open.

14. **Main R.F. Rectifier.** The anodes of the diodes of this rectifier are supplied with 2250, 1750 or 1300 V from the R.F. transformer dependent upon the position of the Modulation and Power Control switches. The rectified voltage is smoothed and supplied to the M88 or M89. Its value is approximately:

1950 V d.c. on c.w. full power
1550 V d.c. on c.w. or R.T. full power
1100 V d.c. on low power
1550 d.c. on F.S.T. full power.

15. **Main Modulator Rectifier.** The anodes of the diodes of this rectifier are supplied with 2250 V from the Modulator transformer when the transmitter is in the m.c.w. or R/T condition only. The rectified voltage is partially smoothed and supplied to the Main Modulator. Its value is approximately 1950 V d.c.

TRANSMITTER 5AB

16. For details of this transmitter see Type 602. In Types 603 and 605 the output is fed to amplifier M88 instead of to the HF A.T.U. as in Types 601 and 602. Also in Type 603 and 605 the anode and screen supplies of the P.A. valves are *not* modulated when using m.c.w. and voice and filament supplies are obtained from a separate transformer instead of from Rectifier SE13.

AMPLIFIER M88

17. Amplifier M88 is a single stage push-pull HF amplifier. It is used to step up the output of the 50 W transmitter 5AB, to the output power of the transmitters. Four valves are used, arranged as two parallel pairs in push-pull. The output of transmitter 5AB is fed into Amplifier M88 by means of the primary winding of the M88 grid transformer. The 5AB output is amplified in the M88 and passed to the HF A.T.U. by a variable coupling coil.

18. **Power Supplies.** The supplies are obtained from the following sources:

Anode – Dual Rectifier Unit
Screen – Rectifier SE13
Bias – Bias and Control Unit
Filament – Transformer in HF Cabinet.

19. **Frequency Range.** The frequency range 1·5 to 24 Mc/s is covered by six bands as follows:

Band	*Frequency Mc/s*	*Band*	*Frequency Mc/s*
1	1·5–2·0	4	6·0–12.0
2	2·0–3·0	5	12·0–18·0
3	3·0–6·0	6	18·0–24·0

A front panel control (Output Frequency Range) selects the band in use. The control is ganged to two turrets, one carrying the grid coils and the other the anode coils and coupling coils. Rotation of this range switch also selects auxiliary tuning capacitors in the grid and anode circuits, their object being to maintain efficiency over the whole of the tuning range.

20. **Tune-Operate Switch.** To enable transmitter 5AB to be tuned without being affected by the Amplifier M88, a switch is provided by means of which the 5AB output can be shunted into a dummy load. This switch, the TUNE-OPERATE SWITCH, is a control on the front panel of the M88. It also has a position for tuning the M88 in which a resistance is put in the cathode circuit of the amplifying valves, which reduces the current passed and subsequently the power output of the amplifier.

21. **Monitor Circuit.** A small monitor circuit using a diode and its associated circuits is provided in the M88 for checking modulation quality and to assist in fault finding. The output of this monitor is fed to a phone jack on the front panel.

22. **Local Key Jack.** A local key jack is provided on the front panel for convenience in tuning when the HF Cabinet is not adjacent to the Power Cabinet (*e.g.* Type 605).

23. **Meters.** Two meters with a switch enable the individual currents in the cathode and screen circuits to be measured. These meters are used when tuning M88. Meters at the top of the HF Cabinet read the combined final amplifier grid, screen and anode currents.

24. **Controls.** The following controls are fitted on the front panel.

OUTPUT COUPLING. A variable coil which varies coupling to HF A.T.U.

OUTPUT FREQUENCY RANGE Mc/s. Turret switch which controls two turrets, one carrying grid coils, the other anode and coupling coils. Selects output frequency range.

FINAL AMPLIFIER ANODE TUNING. Controls a variable capacitor in the anode tuned circuit.

FINAL AMPLIFIER GRID TUNING. Controls a variable capacitor in the grid tuned circuit.

TUNE-OPERATE SWITCH. A three-position switch:

a. Tune 5AB. Output of 5AB shunted into dummy load.
b. Tune M88. Resistance inserted in cathode circuit of amplifier valves.
c. Operate. Resistance removed from cathode circuit of amplifier valves.

TUNING METER SWITCH. Enables tuning meters to be switched as required.

GRID CURRENT. A variable resistance in the H.T. line to P.A. valves of transmitter 5AB. Thus by varying this control the drive from the 5AB to the M88 is altered.

HF AERIAL TUNING UNIT

25. **Diagram** (*See* page 2–13–8)

26. The H.F. Aerial Tuning Unit is designed to match the aerial to Amplifier M88 at all frequencies covered by the set. Its size is due to its ability to withstand very high power with a good margin of safety.

27. The main components of the A.T.U. are an inductance and a bank of capacitors. The inductance is varied by a wiper which is controlled from the front panel by a control marked AERIAL TUNING COIL. Further tuning is effected by selecting appropriate capacitors by means of the Condenser Switch. The output from the M88 is tapped into the aerial coil at the correct spot by means of the r.f. Input Tapping Switch. In a similar manner the aerial is tapped to the coil by means of the Aerial Tapping Switch. At the higher frequencies the top of the Aerial coil will be shorted out by the wiper contact and to prevent these shorted turns from forming resonant frequencies within the band of the set, sections of the shorted turns can be shorted again by means of the Coil Shorting Switch. One position of the r.f. Input tapping switch enables the output of M88 to be fed into a dummy load with associated meter. This provides a means of tuning the M88 without breaking Radio Silence.

28. **Controls**

AERIAL TUNING COIL. Wiper control of HF Aerial Tuning Coil.

CONDENSER SWITCH. Selects the capacitors for tuning the HF Aerial Tuning Coil.

R.F. INPUT TAPPING SWITCH. Matches coil to output of Amplifier M88. Provides for tuning into a dummy load.

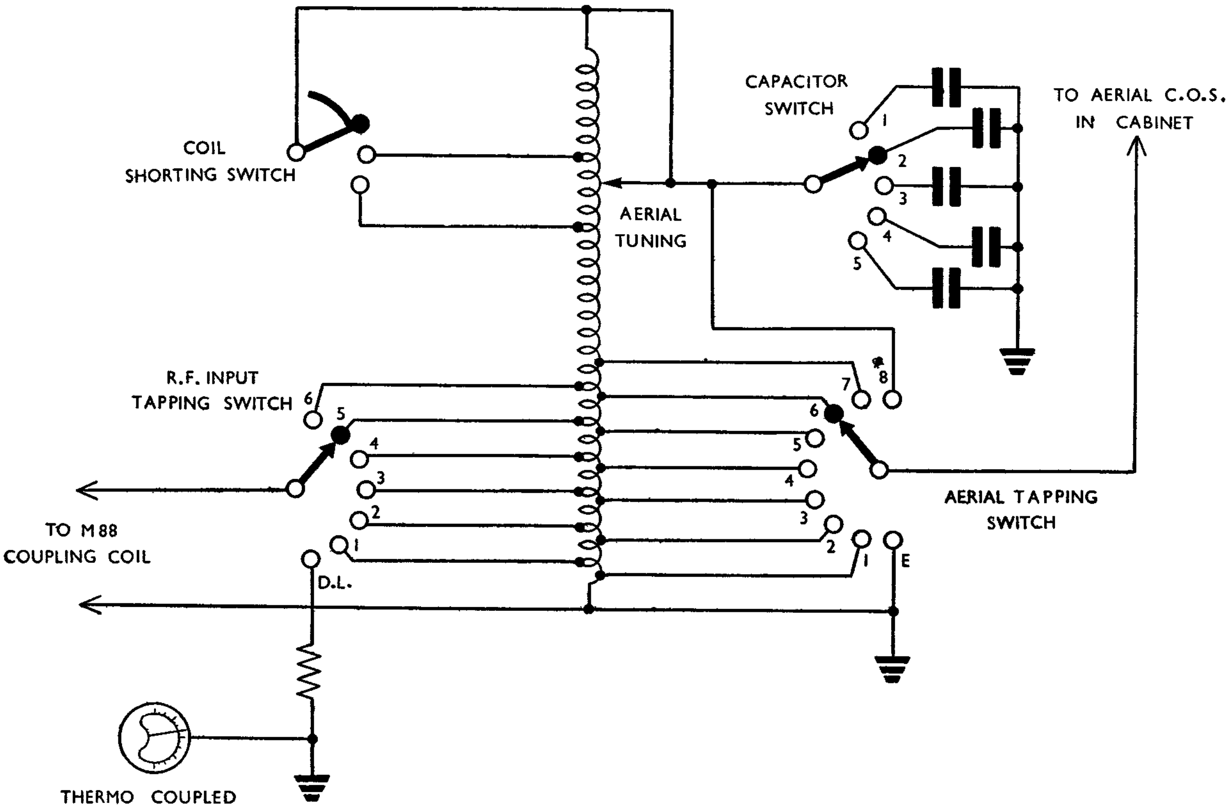


FIG. 4. H.F. AERIAL TUNING UNIT

AERIAL TAPPING SWITCH. Matches coil to aerial.

COIL SHORTING SWITCH. Short circuits portions of the coil not in use.

TRANSMITTER 4AD

29. For details of this transmitter see Type 602. In Types 604 and 605 the output from the amplifier stage of the 4AD is taken via a link to a socket on the front panel, and the A.T.U. of the 4AD is by-passed. However the aerial coupling and the aerial tuning coil are not disconnected from the Amplifier circuit so they should be left in their minimum position (i.e. anti-clockwise) when 4AD forms part of Types 604 and 605. The anode and screen supplies are not modulated when using m.c.w. and filament supplies are obtained from a separate transformer instead of from Rectifier SE13.

AMPLIFIER M89

30. M89 raises the power output of Transmitter 4AD from 50 to approximately 500 W. Facilities are provided for reducing the power output to 200 W. Three valves in parallel are used. The output voltage from the 4AD is fed to the grids of these valves via a fixed potentiometer which reduces the voltage to the correct value required by the valves. The anode circuit of the valves is a filter arrangement consisting of capacitors and a variometer. The capacitors in the output side of the Pi filter may be varied by an arrangement of links which are set up on installation. (The links correspond to the aerial coupling control on transmitter 4AD.)

31. **Power Supplies.** The supplies are obtained from the following sources:

Anode. Dual Rectifier Unit
Screen. Rectifier SE13
Bias. Bias and Control Unit
Filament. Transformer in MF Cabinet.

32. **Frequency Range.** The frequency range 200 to 500 kc/s is covered in two ranges:

Range 1 – 200 to 350 kc/s.

Range 2 – 350 to 500 kc/s.

33. **Monitor Circuit.** A small monitor circuit, inductively coupled to the output variometer, consisting of a metal rectifier and associated circuits, is provided in M89 for checking quality of modulation on m.c.w. The output of this monitor circuit is fed to a phone jack on the front panel.

34. **Local Key Jack.** This jack is provided on the M89 front panel for convenience in tuning. It is an alternative to the one provided on the Power Cabinet Control Panel.

35. **Controls.** The following controls are fitted on the front panel of M89, reading from right to left:

FINAL AMPLIFIER TUNING. Tunes the output circuit by rotating a variometer.

TUNE – OPERATE SWITCH. This has two positions:

a. Tune Final Amp. and Aerial. In this position cathode bias is automatically increased.

b. Check Aerial Tuning and Operate. In this position bias is reduced to normal and interlock circuit is completed.

FREQUENCY RANGE SWITCH. Selects the required frequency range by altering capacitors in the anode circuit of the amplifier valves.

LOCAL KEY JACK. See para. 34.

JACK FOR V3. For grid current measurement.

JACK FOR V2. For grid current measurement.

JACK FOR V1. For grid current measurement.

MONITOR PHONES. See para. 33.

GRID CURRENT. A variable resistance in the H.T. line to Amplifier valves of transmitter 4AD. By varying this control the drive from the 4AD to the M89 is altered.

AERIAL CHANGE-OVER SWITCH

36. The Aerial C.O.S. is housed in the top part of the HF cabinet framework. It provides arrangements for the use of an 8-in. and an 18-in. trunk aerial. Connections between the aerials and the C.O.S. are made through insulator assemblies.

37. The Aerial C.O.S. consists of two main portions:

a. THE MAIN R.F. SWITCH. This switch can be placed by hand in any one of seven positions:

(1) *Earth through Resistance*

(2) *Type* 601/2. This position is used in conjunction with the emergency link board.

(3) *HF* 8-*in. Trunk.* 8-in. trunk connected to HF transmitter. 18-in. trunk isolated.

(4) *Isolate.* Both 8-in and 18-in. trunks isolated.

(5) *MF.* 18-in. trunk connected to MF. Transmitter 8-in. trunk isolated.

(6) *Receive.* 18-in. trunk normally connected to receiver aerial jack box adjacent to the local bay. 8-in. trunk isolated.

(7) *HF* 18-*in. Trunk.* 18-in. trunk connected to HF transmitter. 8-in. trunk isolated.

b. AUXILIARY SWITCHES. These are for various interlocking purposes and will be dealt with under interlocks (paras. 44–46).

38. **Man Aloft.** A Man Aloft Tablet is provided on the front panel of the C.O.S. When it is removed the C.O.S. cannot be put to any of the transmit positions.

39. **Emergency Link Board.** This board is situated to the left of the main r.f. switch. There are four terminals on the board which provide for various aerial arrangements. By means of these links the transmitter can be operated using an emergency aerial or another transmitter can use the 8-in. trunk. Full instructions for the arrangement of the links are found in B.R. 1470(3).

50 W MODULATOR

40. For details of this unit see Type 602. When used with Types 603, 604 and 605 the output is used to drive the main modulator and not to modulate the transmitters 5AB or 4AD as in the Types 601 and 602. When the Power Control Switch on the Control panel is to LOW one of its functions is to reduce the output from the 50 W Modulator to the Main Modulator by inserting a resistance in the output.

MAIN MODULATOR

41. This unit is an amplifier for the a.f. output from the 50 W modulator. It is the top removable unit in the power cabinet framework. There is no front panel on the unit, access being obtained by opening the doors in the top half of the power cabinet. The unit contains two pairs of valves operating in push-pull. The input circuit is an a.f. transformer which steps up the output voltage from the 50 W Modulator. The output is taken from the filaments to the primary of the modulation transformer. The secondary of the Modulation transformer has two windings, one through which the anode supply to the M88 or M89 passes and the other through which the screen supply to the M88 or M89 passes. Thus when using m.c.w. or Voice on HF the anodes and screens of the M88 valves are modulated and when using m.c.w. on MF the anodes and screens of the M89 valves are modulated.

42. **Power Supplies**

a. H.T. Dual Rectifier

b. Filament. Own filament transformer

c. Grid Bias. Bias and Control Unit. The H.T. and filament supplies are not provided when the modulation switch is to c.w.

43. **Controls.** There are two screwdriver controls situated one at each side of the meter panel on the power cabinet. These controls are for varying the grid bias supply to each pair of valves in the Main Modulator. They should be adjusted so that the two cathode current meters on the meter panel read approximately 150 mA.

44. **Operation of Interlock and Set on Relays** (See Fig. 5)

INTERLOCK CIRCUITS

45. These are fitted to ensure that the transmitter cannot be operated remotely unless:

a. ON H.F. The 5AB is to OPERATE, the r.f. Input Switch on A.T.U. is to any position other than DUMMY LOAD, the Aerial C.O.S. is to HF 8 or HF 18 and the Amplifier M.88 to OPERATE.

b ON MF. The 4AD is to OPERATE, the Aerial C.O.S. is to MF and the Amplifier M.89 is to OPERATE.

The transmitter can be operated locally on HF whatever the Tune-Operate condition of the units, but if the r.f. Input Switch on the A.T.U. is to DUMMY LOAD the Aerial C.O.S. must be in the EARTH THROUGH RESISTANCE position. If the r.f. Input Switch is in any position other than DUMMY LOAD the Aerial C.O.S. must be to HF 8 or HF 18. On MF the transmitter may be operated locally irrespective of the position of the Tune/Operate switches on the units.

46. **Interlock Relay.** By reference to the diagram it will be seen that the interlock relay is only in the circuit when the Local/Remote switch is to REMOTE.

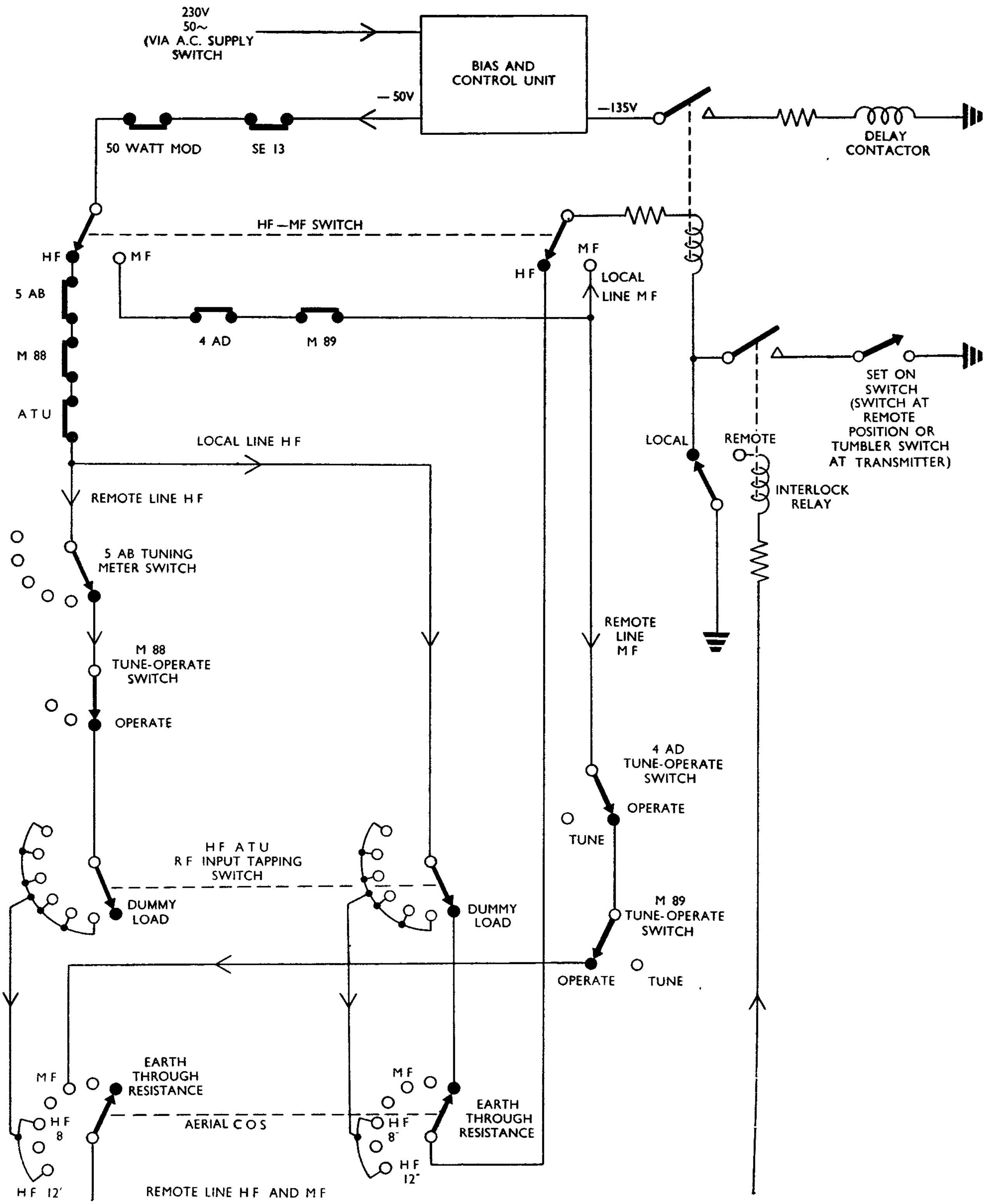


FIG. 5. INTERLOCK AND SET ON RELAYS

OPERATION OF DELAY CONTACTOR

47. Diagram Fig. 6 (overleaf) is applicable to a single-phase supply.

48. **Functions.** The delay contactor performs the following functions:

a. Permits control of supplies from either local or remote positions.

b. Provides required delay before full voltage is applied to certain circuits.

c. Ensures the correct cycle of switching operations is always carried out.

49. **Operation.** By reference to the diagram and the following Table 1 the cycle of operation of the delay contactor may be followed.

TABLE 1

OPERATION	TIME IN SECS.	REDUCED VOLTAGE SUPPLIED TO	FULL VOLTAGE SUPPLIED TO
A.C. Supply Switch To ON	—	—	Bias Unit. a.c. Voltmeter. a.c. Out terminals. Blowers.
Set on Relay energized	—	—	—135 V from Bias Unit to Delay Contactor Solenoid.
	1	Filaments of M.88/M.89, Dual Rectifier, Main modulator and lamps to illuminate modulation meters	S.E.13. Bias transformer, 5AB Heater transformer or 4AD Heater transformer. Heaters and Bias Transformer of 50 W modulator and lamp to illuminate a.c. voltmeter.
	6	—	Filaments of M.88 or M.89, Dual Rectifier, Main Modulator and lamps to illuminate Modulation Meters.
	25	Dual Transformer	H.T. Contactor Solenoid energized S.E. 13 H.T. Transformers, 50 W Modulator H.T. Transformers.
	30	—	Dual Transformer.

The above table is applicable when using Voice and m.c.w. On c.w. H.T. supplies to the 50 W Modulator and Main Modulator are not completed.

TUNING INSTRUCTIONS

50. **Type 603 and 605 HF Tuning Guide**

a. Switch to HF, C.W. and low power.

b. Set up 5AB with appropriate calibration book.

c. Set M.88 to appropriate frequency (approximate dial settings are given in handbook) with coupling at zero, grid currents control to maximum and switched to TUNE 5AB.

d. Aerial to EARTH THROUGH RESISTANCE.

e. R. F. input switch to D.L.

f. Set aerial tapping switch to position 1.

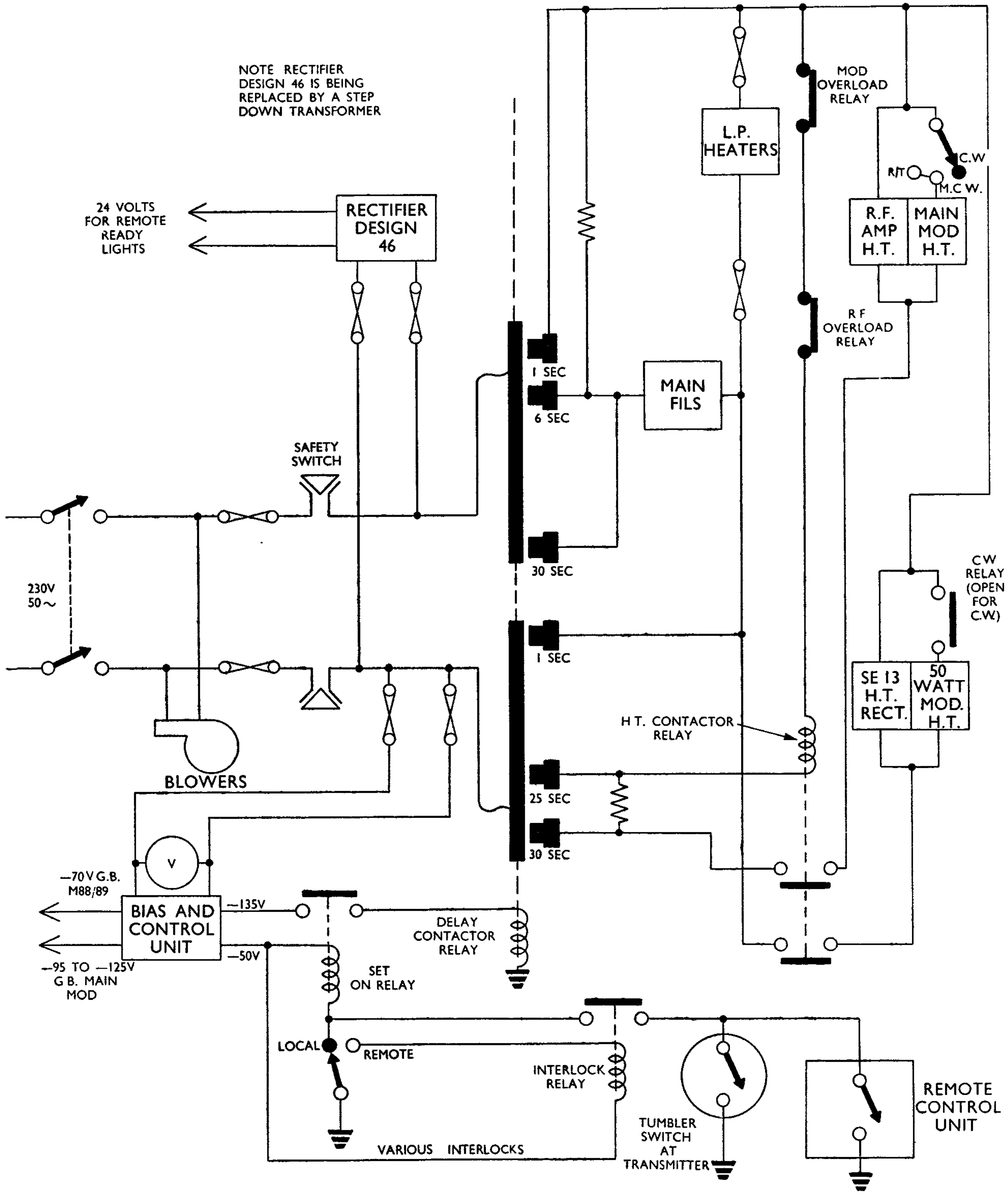


FIG. 6. OPERATION OF DELAY CONTRACTOR

g. Set condenser switch, coil shorting switch and aerial tuning coil of A.T.U. to starting positions given in the table of settings.

h. Make a.c. switch.

i. Set Local/Remote switch to LOCAL (wait for delay contactor sequence as indicated by neons).

j. Tune 5AB in the normal way (see 602HF) with the exception of the amplifier tuning which should be tuned for a max. in the tuning meter with the switch in the P.A. GRID (TUNE) position.

k. Switch 5AB to OPERATE.

l. SWITCH M.88 to TUNE M.88.

m. Tune M.88 grid and anode controls for max. screen current.

n. Adjust GRID CURRENT control to read 30 mA in FA grids meter.

o. Switch M.88 to OPERATE.

p. Advance the coupling on M.88 until FA anodes meter reads 300 mA, maintaining the dip in the meter by means of the FA anode control.

q. Aerial C.O.S. to HF 8 or HF 18 (in Type 605) or HF (in Type 603).

r. Set r.f. input tapping switch to table setting.

s. Set aerial meter sensitivity switch to position 3.

t. Tune aerial tuning coil to max. in the aerial meter. Note reading. Repeat for the other positions of the aerial tapping switch until the position which gives maximum reading in the aerial meter is obtained.

u. Shift position of the r.f. input tapping switch above and below that given in the table of settings starting on the next lower position and readjusting the Aerial Tuning coil to max. in the aerial meter each time. Select an r.f. input switch position which brings FA anodes meter nearest to 300 mA when aerial tuning coil is at max. in the aerial meter.

v. Readjust the coupling until FA anodes meter reads 300 mA maintaining dip in the meter by means of the FA anode control.

w. Local/Remote switch to OFF.

x. Switch to FULL POWER.

y. Local/Remote switch to LOCAL (wait for delay).

z. FA anode meter should read 540 mA. If not, adjust coupling as necessary, maintaing dip in the meter by means of the FA anode control. Check that FA grids meter is reading 30 mA: if not adjust grid current control as necessary.

51. **Type 603(2) HF Tuning Guide** (HF Transmitter C.A.W.).

a. Ensure that the Common Aerial Working exhaust fans are running.

b. Before switching on transmitter ensure that:

On the Aerial Switch Unit in the Filter Channel

(1) Tune/Operate switch is to TUNE.

(2) Aerial Selector switch is to TUNE TRANSMITTER.

(3) SAFE TO TRANSMIT key is in the lock and turned clockwise.

(4) Auto transformer switch is in position 5.

(5) The Tune/Test switch keys are set to neutral (central position).

On the Power Cabinet

(6) Local/Remote switch to H.T. OFF.

(7) HF/MF switch is to HF (it should never be necessary to have it in any other position).

(8) C.W./M.C.W./R/T switch to C.W.

(9) Low/Full power switch to LOW.

On the H.F. Framework

(10) The relevant Tune/Test key switch is in the neutral position.

5AB

(11) Tuning meter switch is to TUNE MIXER.

*M.*88

(12) Tune/Operate switch is to TUNE 5AB.

(13) Grid Current Control is turned fully clockwise.

(14) Meter switch is set to SCREENS.

(15) Switch on Mains Switch on Power Cabinet.

(16) Proceed to tune transmitter as follows:

Power Cabinet

(1) Move the Local/Remote switch to LOCAL.

(2) Ascertain settings of switches and dials from Calibration Curves, and then set accordingly.

(3) Lock V.F.O. dial.

(4) Put appropriate key switch to TUNE. This acts as local key.

5AB

(5) Offset Amplifier Tuning dial by one turn and tune mixer tuning dial for maximum in tuning meter. Reset amplifier tuning dial.

(6) Tuning meter switch to TUNE AMP. Tune Amplifier tuning dial for Maximum in tuning meter. (This should correspond to a minimum on P.A. anode current meter.)

(7) Tuning meter switch to OPERATE.

(8) Lock all 5AB dials.

*M.*88

(9) Set range switch to required range and coupling control to minimum.

(10) Tune/Operate switch to TUNE M.88.

(11) Tune Amplifier grid control for maximum in screen meters. Tune anode tuning control also for Maximum.

(12) Tune/Operate switch to OPERATE.

(13) Advance coupling control and tune Anode Control by the Amplifier Anode Current Meter to a loaded dip of 300 mA (i.e. advance coupling and rock anode Tuning Control until the point of dip rises to 300 mA).

(14) Check grid current. Set to 30 mA by grid current control.

(15) Release Tune/Test switch and switch to Full Power. Press Tune/Test switch and check that the anode current rises to about 540 mA.

(16) Check that the wattmeter on filter cabinet reads between 500 and 600 W. The transmitter is now tuned.

(17) Put power switch to Low POWER. The wattmeter should now read between 125 and 150 W.

Filter Cabinet

(18) Move aerial selector switch to the TUNE FILTER position corresponding to the frequency in use.

(19) Tune appropriate filter to maximum power as indicated by wattmeter (approximate setting can be obtained from calibration curve).

(20) Switch the aerial selector switch to the next clockwise position, TUNE AUTO TRANSFORMER. In this position recheck filter tuning. Adjust auto transformer taps until wattmeter reads again between 125 and 150 W and the Anode Current meter reads nearest to 300 mA.

(21) Check M.88 coupling and anode control as in (13).

(22) Put the tune operate switch to OPERATE. This locks all switches on the Aerial switch unit and the lamps marked SET OPERATING should now glow.

(23) Return to the Power Cabinet, put the Local/Remote switch to H.T. OFF, switch the system switch to m.c.w. or R.T. if required and switch to Full Power.

(24) Put Local/Remote switch to REMOTE and Transmitter is ready for operation through KH control system.

52. **Type 604 and 605 MF Tuning Guide**

a. Switch to MF, C.W. and Full Power.

b. Switch to Tune on 4AD and M.89 and select appropriate frequency ranges.

c. Place grid control on M.89 to mid position. Aerial C.O.S. to MF. A.T.U. controls to starting positions (Coarse position 1 – Fine fully anti-clockwise). In Type 604 Aerial C.O.S. to MF Condenser IN or MF Condenser OUT.

d. Make a.c. switch.

e. Place Local/Remote switch to LOCAL and wait for completion of delay contactor sequence as indicated by neons.

f. Tune 4AD omitting aerial section (see 602 MF).

g. Tune M.89 Final Amplifier for dip in FA anode meter.

h. Tune A.T.U. When tuning point is found (by correct combination of Fine and Coarse tuning controls, indicated by increase in FA current), switch 4AD and M.89 to operate and readjust A.T.U. and M.89 as necessary to obtain loading figure of 540 mA.

i. Adjust grid current control on M.89 for 25 mA.

Note. Maximum aerial current together with loading figure of about 540 mA with P.A. in resonance is correct final tuning position, assuming M.89 coupling links are set correctly.

53. **Type 603 and 605 HF F.S.T. Operation**

Note. The first amplifier (Mixer Tuning) is always adjusted to the same frequency as the Keyer Unit output. The second amplifier and P.A. (Amplifier Tuning) is always adjusted to the output frequency.

a. With the Normal – F.S.T. Switch to NORMAL tune the transmitter to the required output frequency as laid down in para. 50 *a* to *j*.

b. Open the key, switch off H.T. and set the Tuning Meter Switch to Tune Mixer.

c. Plug the output of the keyer unit unit into the F.S.K. socket, and set up the unit to the required frequency in accordance with the instructions for that particular unit.

d. Set the Normal–F.S.K. switch to F.S.T., switch on H.T., press the key and adjust the Mixer dial for a maximum reading in the tuning meter.

Note. Only slight adjustment will normally be necessary, but when the Keyer Unit output frequency exceeds 6·0 Mc/s the mixer dial must be turned in a clockwise direction until the maximum is found. This will be above 20·00 degrees in most transmitters. Output frequencies so effected:

6·0 to 6·7 Mc/s
12·0 to 13·4 Mc/s
18·0 to 20·1 Mc/s.

e. Switch to OPERATE, check that P.A. tuning is correct (to 'DIP' in P.A. anode current meter) and adjust the output of keyer unit so that the reading in meter is 0·4 mA.

f. Continue from (*k*) to (*w*) of normal tuning instructions.

g. Switch C.W.–F.S.K. switch to F.S.T.

h. Switch to full power.

i. Local/Remote to local, wait for delay.

j. FA Anode should read 500 mA. If not, adjust coupling as necessary, maintaining dip in FA meter by means of FA anode control. Check that FA grid reads 30 mA. If not adjust grid current control as necessary

Note. Under no circumstances must the keyer unit drive be removed while H.T. is on and the key is pressed. Failure to observe this precaution will result in damage to the P.A. valves of the transmitter 5AB.

2.14. TYPE 618

DATE OF DESIGN. 1953

HANDBOOK. B.R. 1565

ESTABLISHMENT LIST. E. 1049

FREQUENCY RANGE. HF Transmitter: 1·5–16 Mc/s
MF Transmitter: 330–550 kc/s
Receiver: 59–555 kc/s
1·47–30 Mc/s

FREQUENCY DETERMINATION. VFO or Crystal Oscillator

EMISSION AND POWER OUTPUT.

HF Transmitter: C.W., M.C.W., Voice – 40 W
MF Transmitter: C.W., M.C.W. – 15 W

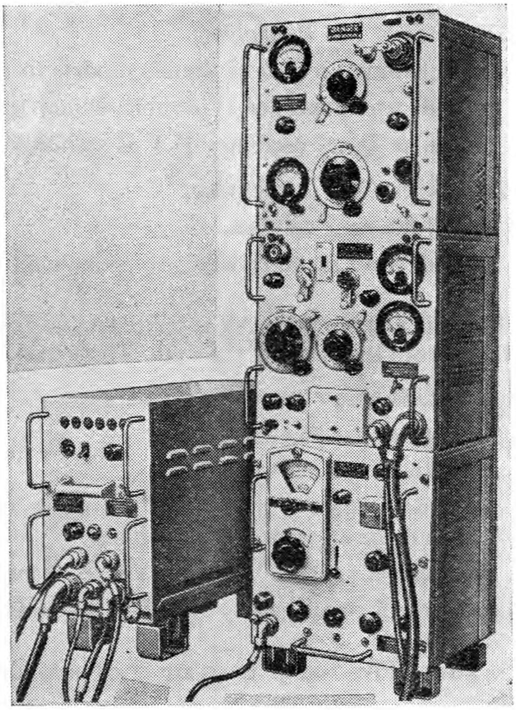


FIG. 1

GENERAL

1. The equipment consists of separate HF and MF Transmitters, together with a power pack, which also provides power for an associated Receiver Outfit CAS when this is fitted. When the HF Transmitter only is fitted the equipment is referred to as Type 618H. The items below show which of the four main units each equipment includes:

618. Power Pack, HF Transmitter, MF Transmitter

618H. Power Pack, HF Transmitter

CAS. HF MF Receiver.

Note. Receiver outfit CAS cannot operate without the power pack, but at present is unlikely to be supplied except with Types 618 or 618H which already include the power pack. It is possible, however, that a separate power pack may be developed to supply Receiver Outfit CAS only, so that this may be fitted on its own.

2. **Power Supplies**

110–120 V or 220–245 V } 50 c/s single phase a.c. (maximum consumption 600 W (key down m.c.w.))

Taps on the input transformers in the power pack must be adjusted to suit the supply voltage in use. In most ships the normal 230 V a.c. supply will be used, but the following a.c. power supply outfits are designed to work with Type 618 and Receiver Outfit CAS either in emergency or, in certain light craft, for normal operation.

Outfit	*Input*	*Output*
DWH	24 V d.c.	230 V a.c.
DWJ	110 V d.c.	230 V a.c.
DWK	220 V d.c.	230 V a.c.

POWER PACK

3. This unit provides the necessary H.T., filament, bias and control voltages for the operation of the receiver and either the HF transmitter or the MF transmitter by means of:

Transformer No. 1 *supplying:*

a. Full wave rectifier (2 double diodes) to provide main H.T. for transmitter P.A. (400 V).

b. Full wave rectifier (1 double diode) to provide transmitter auxiliary H.T. and all receiver H.T. (Receiver Local oscillator H.T. is stabilized by Neon Stabilizer.)

Transformer No. 2 *supplying:*

a. All filament voltages.

b. Full wave metal rectifiers to provide all bias and relay (control) voltages.

4. **Plugs and Sockets.** All supplies to and from the power pack are via external plug and socket connections from the front of the unit. These are:

a. Mains plug – for main a.c. supply

b. Transmitter Filament socket *c.* Transmitter Power socket	Filaments, H.T. and Control supply to HF or MF Transmitter.

Note. There is no HF/MF change-over switch. Change over is effected by plugging supply leads into the appropriate transmitter.

d. Receiver socket – filaments and H.T. supply to receiver

e. Control circuits plug – All control circuits to C.C.X. for remote control.

5. **Fuses.** Five 5-amp. fuses are fitted in holders at the top of the front panel and are in circuit as follows:

F1 F2	a.c. leads to primary of transformer 1	220/245 volt supply 3 amp. anti-surge 110/120 volt supply 5 amp. anti-surge
F3 F4	a.c. leads to primary of transformer 2	220/245 volt supply 1·5 amp. anti-surge 110/115 volt supply 3 amp. anti-surge

F5 400 V H.T. 1 amp.

F6 300 V H.T. 500 mA.

6. **Controls and Facilities.** The following controls and facilities are provided:

MAINS SWITCH. Completes a.c. supply to primaries of both transformers.

STAGE SWITCH. This switch has three positions which complete supplies as follows:

REC – All receiver voltages.

STANDBY – All receiver voltages and transmitter heaters.

TRANS READY – All receiver and transmitter voltages.

INDICATOR LAMP. This lamp is across the primary of transformer No. 2 and therefore indicates that a.c. supply is on and fuses 3 and 4 are intact.

Note. It is possible for a.c. to be supplied to transformer No. 1 even though lamp is not glowing (lamp defective or F3 or F4 blown).

LOCAL/REMOTE SWITCH. Transfers control of transmitter from Local position to Remote position via CCX.

MICROPHONE SOCKET. A seven-pin socket is provided so that a microphone or headset may be used at local position.

KEY JACK. For local keying.

7. **Relays.** Three relays are contained in the power pack as follows:

Relay A. The H.T. relay. Operates in Local and Remote. Contacts in main H.T. rectifier circuit.

Relay B. The Lamp relay. Operates in Remote only. Closes Ready lamp circuit and one contact in Busy lamp circuit.

Relay C. The Voice relay. Operates only in voice, when pressel switch is closed. Removes H.T. from m.c.w. oscillator, completes Busy lamp circuit, and completes the circuit through the two keying relays. The action of closing the pressel switch also energizes the microphone.

HF TRANSMITTER

8. Frequency Range 1·5–16 Mc/s.

Frequency Determination: V.F.O. or Crystal Oscillator.

Emission and Power Output $\begin{cases}\text{C.W. – 40 W.}\\ \text{M.C.W. – 40 W.}\\ \text{Voice – 40 W.}\end{cases}$

9. **Block Diagram** (See following page)

10. **Frequency Build-up** (all figures in Mc/s).

Range	*Master Oscillator*	*Buffer Grid*	*Buffer Anode*	*Power Amplifier*
1	1·5–3·5	Untuned	1·5–3·5	1·5–3·5
2	1·75–4	Untuned	3·5–8 (Doubles)	3·5–8
3	2–4	4–8 (Doubles)	8–16 (Doubles)	8–16

11. **R.F. Circuits**

a. MASTER OSCILLATOR. A beam tetrode with the tuned circuit between grid and cathode for v.f.o. working, the tuning being done by a capacitor connected to the ganged M.O. and Buffer tuning control. In crystal oscillator working this tuned circuit is disconnected and the selected crystal inserted between grid and earth. To ensure frequency stability of the circuit stabilized H.T. is supplied.

b. BUFFER STAGE. A beam tetrode which serves to isolate the frequency determing stage from the Power Amplifier and also acts as a frequency multiplier on Ranges 2 and 3.

On Range 1 the anode circuit is tuned to M.O. frequency by a capacitor ganged to M.O. tuning control. (Stage acts as a buffer.)

On Range 2. As for Range 1 except that the anode circuit is tuned to twice M.O. frequency. (Stage now acts as a buffer and frequency doubler.)

On Range 3. A tuned circuit is inserted in the grid by the Range Switch. This is tuned to twice M.O. frequency by a capacitor ganged to the M.O. tuning control. The anode circuit is now tuned to twice the grid frequency. (Stage now acts as a buffer and frequency quardupler.)

c. POWER AMPLIFIER. Three beam tetrodes in parallel with their anode circuit tuned by a capacitor operated by the P.A. Anode Control. Anode and screen H.T. is applied via the secondary of the modulation transformer giving high level modulation on Voice and m.c.w. with a power output comparable to that on c.w.

d. AERIAL CIRCUIT. A series/parallel arrangement. The circuit consists of a variable aerial loading coil, which can be used connected to the aerial alone, or with either of two combinations of fixed capacitors

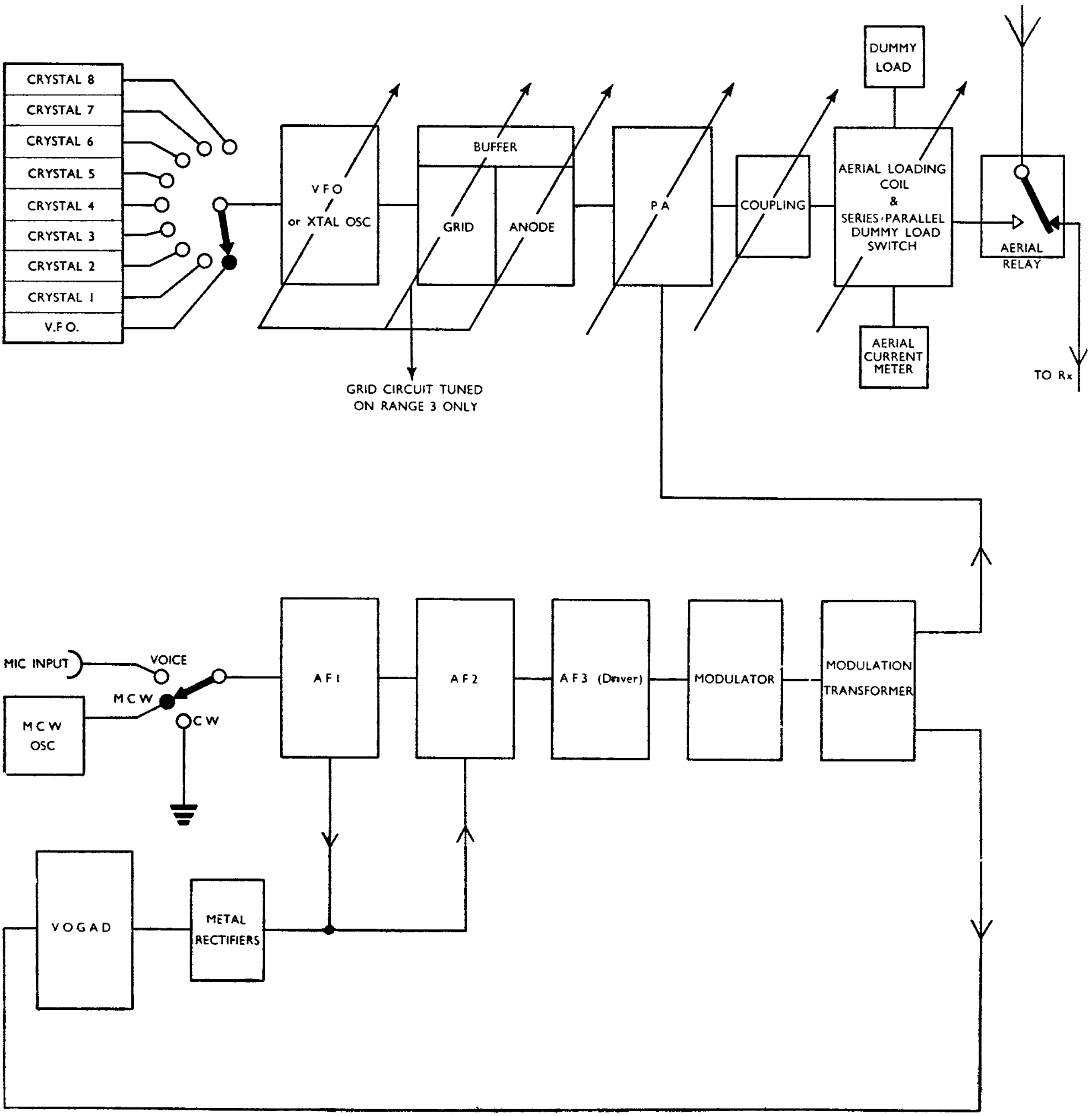


FIG. 2. H.F. TRANSMITTER – BLOCK DIAGRAM

connected in series or parallel with it. Coupling from the P.A. stage is by means of a variable coupling transformer. An indication of r.f. voltage in the aerial circuit is given by a meter with its associated rectifier circuit.

12. A.F. Circuits

a. First A.F. Amplifier. A pentode amplifier, whose grid is fed from the secondary of the microphone transformer, and which is capacitively coupled to the *b.* Second Amplifier. This is a similar pentode amplifier capacitively coupled to the

c. Third Amplifier. A beam tetrode working as a driver for the modulator valves which it feeds via a transformer. A filter network in the driver anode circuit restricts the audio response to 2500 c/s.

d. Modulator. Two beam tetrodes in push-pull working through the modulation transformer, the secondary of which is in the H.T. line to the anodes and screens of the P.A. valves.

e. M.C.W. Oscillator. A pentode oscillator producing a frequency between 800 and 1200 c/s. When the emission switch is to m.c.w. the output is capacitively coupled to the grid of the first a.f. amplifier which is then disconnected from the microphone transformer.

f. Voice-Operated Gain Adjusting Device. The VOGAD circuit, which has a similar function to an a.g.c. circuit, is designed to control the amplification of the audio stages of the transmitter so as to provide a modulation depth of between 85 and 90 per cent.

The circuit operates as follows. A proportion of the modulator output is tapped off the modulation transformer secondary and fed back to a triode-connected pentode amplifier. After amplification the signal is rectified and then applied to the grids of the first and second a.f. amplifiers, thus providing a negative bias proportional to the modulator output and therefore keeping that output constant.

13. **Keying.** The transmitter is keyed by the combined action of two relays, one being a high speed relay and the other a slow relay whose contacts take about 20 milliseconds to move. The action is as follows:

When the key is pressed the high speed relay operates at once and

a. Removes a negative bias from the M.O. grid,

b. Reduces a negative bias on P.A. grid,

c. Removes an earth from the grid of the driver valve in the modulator.

The M.O. therefore begins to oscillate immediately. 20 milliseconds later the slow relay operates and:

d. Applies a positive voltage to a potentiometer in the buffer grid to restore the valve to its working point.

e. Mutes the receiver Outfit C.A.S. by removing anode and screen H.T. from the first r.f. stage and screen H.T. from the second r.f. stage.

f. Transfers the aerial from the receiver to the transmitter.

g. Provides a hold-on supply for the high speed relay so that even when the key is raised it does not open until the slow relay does.

At this point the transmitter transmits, but, since the M.O. has had 20 milliseconds to get into operation, a pulse with a sharp leading edge is transmitted. When the key is released the transmitter continues to transmit for 20 milliseconds and then all conditions above are reversed, the transmitter shuts down suddenly and gives a sharp trailing edge to the pulse. This is the object of this arrangement, but the presence of the slow relay also makes high speed keying impossible and maximum keying speed is approximately 36 w.p.m. In voice, no hold-on supply for the high speed relay is provided by the slow relay, but this is immaterial in this condition as the carrier is made continuously and is not keyed as in c.w. or m.c.w. The transmitter is controlled by the pressel switch and, as before, the radiated carrier is delayed 20 milliseconds after the making of the switch.

14. **Controls**

C.W./M.C.W./Voice Switch. Selects the type of emission.

Frequency Range Switch. Selects components in the tuned circuits appropriate to the required range.

Oscillator Selector Switch. Selects v.f.o. or one of eight crystals in M.O. circuit. The eight crystals are housed under a cover plate on the front of the transmitter.

MASTER OSCILLATOR. Adjusts the ganged tuning capacitors in v.f.o. and buffer stages.

P.A. ANODE. Adjusts the tuning capacitor in Power Amplifier anode circuit.

AERIAL COUPLING. Varies the coupling between the P.A. anode and aerial circuits.

AERIAL LOADING COIL. Provides fine tuning of the aerial circuit for maximum power output.

AERIAL CONDENSER AND DUMMY LOAD SWITCH. Inserts the dummy load or provides a series or parallel arrangement of the aerial circuit as required. It has six positions which arrange the aerial circuit as follows:

a. Dummy Load.	Connects Aerial Loading Coil to dummy load. Aerial disconnected.
b. Parallel 1.	Coil to aerial in parallel with capacitance.
c. Parallel 2.	Coil to aerial in parallel with smaller value capacitance.
d. OFF.	Coil to aerial – no capacitance connected.
e. Series 1.	Coil to aerial in series with capacitance.
f. Series 2.	Coil to aerial in series with smaller value capacitance.

AERIAL METER SWITCH. Adjusts the sensitivity of the aerial current meter.

PHONES VOLUME. Adjusts the volume of reception from the Receiver Outfit CAS at the Local Phones socket.

15. **Tuning Instructions.**

PREPARING FOR TRANSMISSION

Adjust the controls listed below to the following starting positions:

a. H.T. Supply Switch on power unit to REC.

b. Main Supply switch to ON and note the indicator lamp lights.

c. H.T. supply switch to STANDBY.

d. REMOTE/LOCAL switch to LOCAL.

e. Aerial loading coil to ZERO.

f. Aerial coupling control to midway position.

g. Aerial meter switch to position 1.

h. Aerial condenser switch to DUMMY LOAD.

i. C.W./M.C.W./VOICE switch to c.w. After a delay of about 30 seconds set the H.T. supply switch to TRANS READY.

j. Plug a morse key into the key jack and press the key as required for tuning adjustments below.

V.F.O. Operation

k. Frequency range switch to required range.

l. Oscillator selector switch to M.O.

m. M.O. dial to frequency required from calibration curve provided.

n. P.A. anode control to same setting as for M.O. control.

o. Adjust M.O. control to frequency standard being used (wavemeter or receiver). Lock dial.

p. Adjust P.A. anode control until P.A. anode meter indicates a dip. (Note that the dial reading is of roughly the same order as that of the M.O. control, if not readjust until such a point is obtained.)

q. Check that there is a reading in the aerial current meter. If there is not, turn the aerial meter switch one stop at a time towards maximum until a SMALL reading is obtained. Do not turn further than necessary or meter will be damaged.

r. Adjust aerial loading coil for a peak reading in aerial current meter, reducing aerial meter switch as necessary.

s. Set aerial condenser switch to Off position.

t. Readjust aerial loading coil for a peak reading in aerial current meter.

u. Readjust P.A. anode control for a dip in P.A. anode meter.

v. Readjust aerial loading coil for a peak reading in aerial current meter, increasing coupling and dipping P.A. anode current as necessary until aerial current is at maximum or P.A. anode meter reads 200 mA, whichever occurs first.

w. If no loading position is achieved with aerial condenser switch to Off position repeat *t*, *u* and *v* with switch first in series 1 and 2 positions then parallel 1 and 2 positions until optimum output is achieved.

x. C.W./M.C.W./Voice switch to type of emission required.

Crystal Operation

k. Frequency range switch to required range.

l. Oscillator selector switch to desired crystal position.

m. M.O. dial to frequency required from calibration curve provided.

n. P.A. anode control to same setting as for M.O. control.

o. Adjust M.O. control for maximum in P.A. anode meter. Lock dial.

p. Proceed as in *p* to *x* of V.F.O. operation.

Notes. 1. Crystal fundamental frequencies must be kept within the following limits:

Range 1. – 1·5 to 3·5 Mc/s.

Range 2. – 1·75 to 4 Mc/s.

Range 3. – 2 to 4 Mc/s.

The transmitter operates by frequency multiplication as shown below:

Range 1 (1·5 to 3·5 Mc/s).	C.O. or V.F.O. = Output frequency.
Range 2 (3·5 to 8 Mc/s)	C.O. or V.F.O. = $\frac{1}{2}$ Output frequency.
Range 3 (8 to 16 Mc/s)	C.O. or V.F.O. = $\frac{1}{4}$ Output frequency.

The initial stages of tuning (up to *r* above) may be carried our during radio silence because up to this point the Aerial Condenser Switch is to 'Dummy Load.'

MF TRANSMITTER

16. Frequency range: 330–550 kc/s.

Frequency determination: V.F.O.

Emission and Power Output $\begin{cases}\text{C.W. – 15 W.}\\ \text{M.C.W. – 15 W.}\end{cases}$

17. **Block Diagram** (See following page)

18. **Frequency Build-up.**

Master Oscillator	*Buffer*	*Power Amplifier*
330–550 kc/s	330–550 kc/s	330–550 kc/s

19. **R.F. Circuits**

a. Master Oscillator. A beam tetrode with the tuned circuit between grid and cathode, the tuning being carried out by a capacitor varied by the Master Oscillator Control. To ensure frequency stability of the circuit stabilized H.T. is supplied from a stabilovolt inside the set.

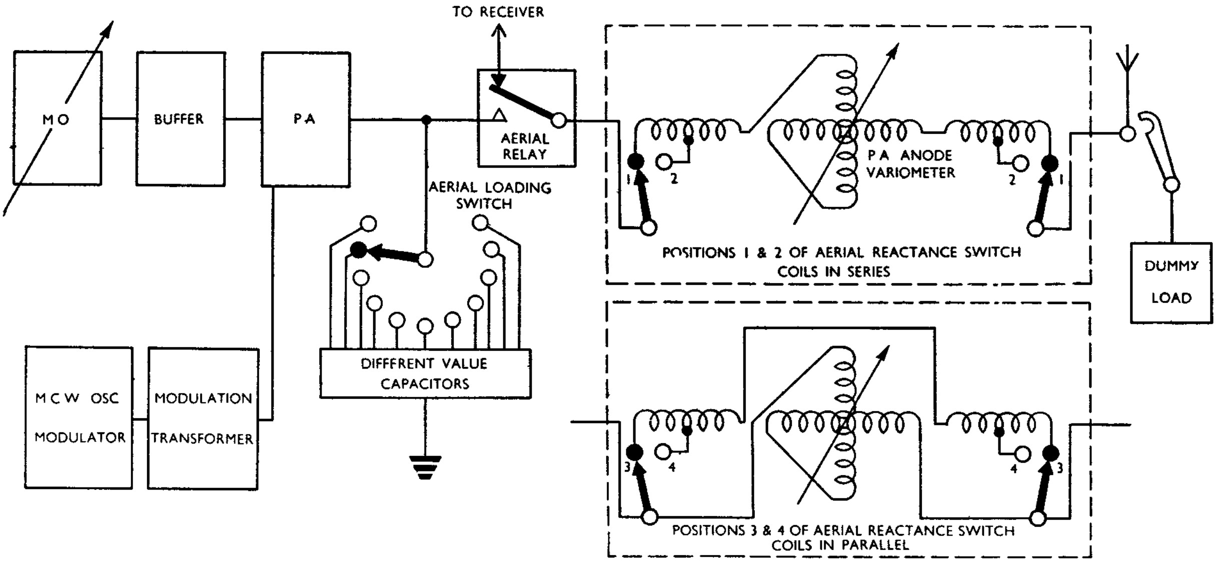


FIG. 3. MF TRANSMITTER – BLOCK DIAGRAM

b. Buffer. A beam tetrode acting as a buffer to isolate the M.O. stage from the Power Amplifier. The stage has no variable tuning, but the tuned circuits in the anode and grid together with that in the M.O. anode are heavily damped by resistors so that the system has a flat response over the whole band.

c. Power Amplifier and Aerial Circuit. Three beam tetrodes in parallel, anode and screen H.T. being applied in m.c.w. via the secondary of the modulation transformer giving high level modulation and power output comparable to that on c.w. The anode circuit is in fact the aerial circuit as well, so that both P.A. and Aerial are tuned together. It is made up of a bank of switched capacitors to earth controlled by the Aerial Loading Switch and performing a function identical to that of a coupling control, followed by the P.A. anode variometer consisting of one coil rotating within another. These coils are tapped and can be switched in series or parallel with one another by the Aerial Reactance switch.

20. **A.F. Circuits**

M.C.W. Oscillator and Modulator. Two beam tetrodes form a push-pull audio oscillator with a frequency of 800–1200 c/s and are also the modulator valves. The oscillatory circuit consists of a capacitor and the primary of the modulation transformer. On c.w. working the m.c.w. relay is not energized laps its two contacts short out the secondary of the modulation transformer to avoid surge effects and remove anode and screen H.T. from the valves. On switching to m.c.w. the relay is energized, the short circuit is removed and anode and screen H.T. is supplied.

21. **Keying.** The transmitter is keyed by the action of a single relay having two contacts and operating as follows.

When the key is pressed the relay is energized and the first contact transfers the aerial from the receiver to the transmitter. The second contact applies anode and screen H.T. to the Master Oscillator and at the same time mutes the Receiver Outfit CAS by removing anode and screen H.T. from the 1st r.f. stage and screen H.T. from the 2nd r.f. stage. When the key is released the aerial is re-connected to the receiver, M.O. Anode and screen H.T. is broken and receiver H.T. is replaced.
The maximum keying speed is approximately 36 w.p.m.

22. Controls

C.W./M.C.W. SWITCH. Selects the type of emission by the action of the m.c.w. Relay.

MASTER OSCILLATOR. Adjusts the tuning capacitor in M.O. Stage.

P.A. ANODE. Adjusts the P.A. Anode variometer for fine tuning of P.A. and aerial.

AERIAL REACTANCE SWITCH. Taps and switches P.A. Anode variometer coils into series or parallel for coarse tuning of P.A. and aerial.

AERIAL LOADING SWITCH. Selects capacitors to earth in P.A. Anode and aerial circuit. Performs the function of a coupling control.

PHONES VOLUME. Adjusts the volume of reception from the Receiver outfit CAS at the Local Phones socket.

23. Tuning Instructions

a. H.T. supply switch on power unit to REC.

b. Main supply switch to ON and note indicator lamp lights.

c. H.T. supply switch to STAND BY.

d. Remote/Local switch to LOCAL.

e. C.W./M.C.W. switch to c.w.

f. Connect aerial to glass insulator terminal.

g. M.O. control to required frequency.

h. Aerial reactance switch and aerial loading switch to position 1.

i. H.T. supply switch to TRANS READY.

j. Plug morse key into key jack and press key for each of tuning adjustments below.

k. Adjust M.O. control to frequency standard being used (wavemeter or receiver). Lock dial.

l. Adjust P.A. anode control in conjunction with aerial reactance switch for minimum reading in P.A. anode current meter.

m. Adjust aerial loading switch for maximum reading in aerial voltage meter, dipping anode current by adjustment of P.A. anode control for each step of aerial loading switch. P.A. anode current should not exceed 220 mA.

n. C.W./M.C.W. switch to type of emission required.

Notes. (i) Under certain conditions when using the high positions of the Aerial Reactance Switch at low frequencies, the transmitted frequency may double the indicated frequency. Care must be taken that this does not occur by starting with the Aerial Loading and Aerial Reactance Switches anti-clockwise and working on the first P.A. anode current dip obtained by the above procedure. (ii) The transmitter will radiate even when the dummy load is in use and cannot therefore be tuned at all during radio silence.

24. **Type 618A.** An improved version of the Type 618 has been produced. Apart from keying circuit changes the differences are mainly confined to improvements to various components and mechanical features which have given trouble since the introduction of these transmitters.

25. **Keying Circuit Changes.** Complaints of excessive key click interference from Type 618 transmitters have called for a complete re-design of the keying circuits. As a result the keying is now accomplished by the removal of a negative bias from the grids of the first (and second in the HF transmitter) stages by a high speed relay. A second high speed relay, operated in parallel with the keying relay, mutes the receiver by inserting an 100 ohm resistor across its telephone output. The send/receive relay transfers the aerial from receiver to transmitter and earths the receiver input.

2.15. TYPE 619

DATE OF DESIGN. 1953

HANDBOOK. B.R. 2169

ESTABLISHMENT LIST. E. 1065.

FREQUENCY RANGE

HF Transmitter: 1·5–16 Mc/s
MF Transmitter: 330–550 kc/s
Associated Receiver CAT: 60 kc/s–30 Mc/s

FREQUENCY DETERMINATION

HF Transmitter: V.F.O. or Crystal Oscillator
MF Transmitter: V.F.O.

EMISSION AND POWER OUTPUT

HF Transmitter: C.W., M.C.W., Voice – 40 W
MF Transmitter: C.W., M.C.W. – 15 W

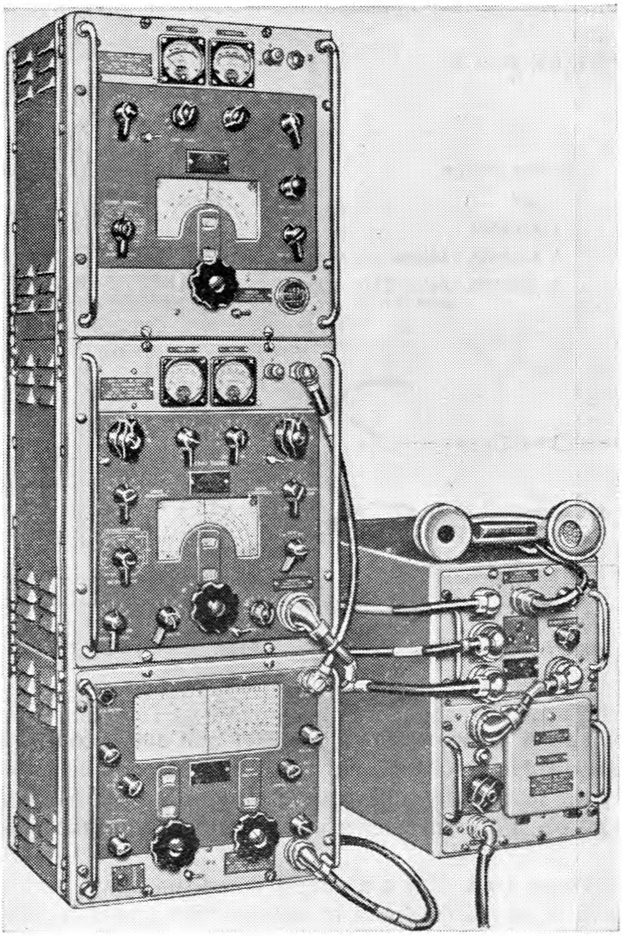


FIG. 1

GENERAL

1. **Units.** The equipment consists of separate HF and MF Transmitters, a Power Unit capable of supplying either the HF or MF transmitter and an associated Receiver Outfit CAT. The equipment may be fitted as an all-wave transmitter or as an HF transmitter, with or without the receiver outfit as follows:

619. Power Unit, HF Transmitter. MF Transmitter.

619H. Power Unit, HF Transmitter.

CAT. Receiver.

2. **Outfit CAT.** The receiver outfit CAT cannot at present be supplied separately as it relies for its power supplies on the transmitter power unit. However, an independent power unit is being developed to supply the receiver only.

3. **Fitting of Type 619.** Type 619 together with CAT is widely fitted in small ships (*e.g.* Coastal and Inshore Minesweepers) as their main transmitter and receiver outfit. It is also widely fitted in all types of ships as the emergency all wave transmitter and receiving outfit. 619H is fitted in all classes of ships as a low power HF transmitter and as an emergency HF transmitter. The suffix letter 'E' is not normally used with this outfit.

4. **Power Supplies.** The equipment can be operated from 100 to 125 or 200 to 250 V a.c. For naval use it will normally be operated from a standard 230 V a.c. supply outfit or centralized a.c. supplies.

When fitted as an emergency outfit it is operated from emergency a.c. supply outfit DWH and Battery outfit BBy. Power consumption is approximately 450 W.

POWER PACK

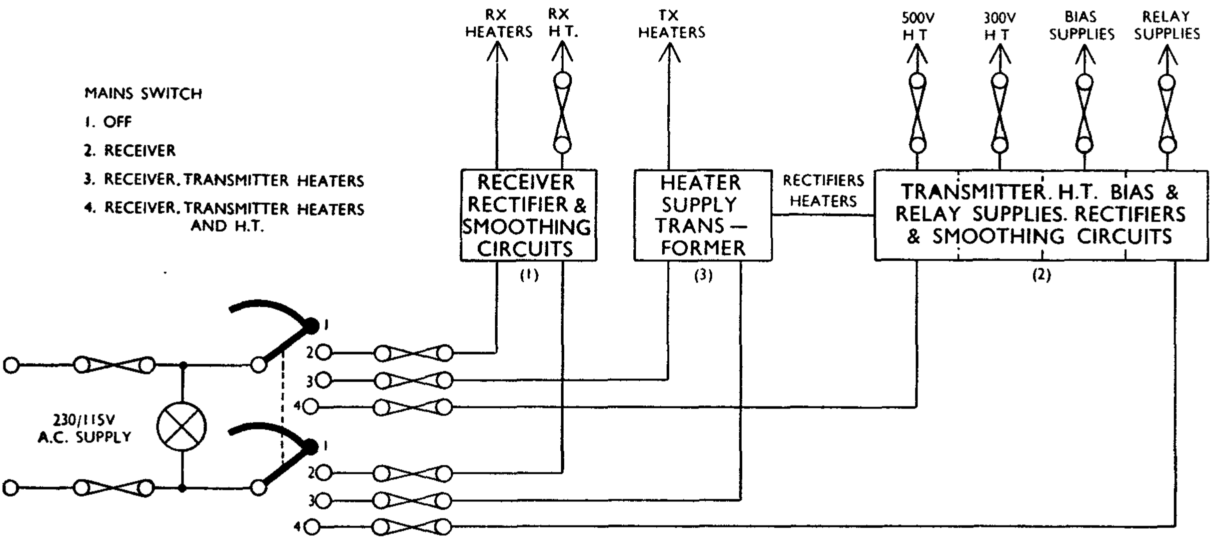


FIG. 2. TYPE 619 - POWER SUPPLIES

5. This is in two sections, a power unit and a control unit. The lower section (power unit) contains the transformer, rectifiers and smoothing circuits necessary to provide the a.c. and d.c. supplies required by the transmitter and receiver. The upper section contains the control units, relays and local operating controls. For convenience all the outputs from the power unit are fed through the control unit.

6. **Power Unit.** The a.c. supply is fed through a pair of main fuses to a 4-position switch. An indicator lamp is across the input to indicate that power is on to the power unit. The 4-position switch operates as follows:

POSITION 1. All supplies broken

POSITION 2. A.c. supply is fed through a pair of fuses to transformer No. 1, whose three secondary windings are used to supply the heaters of all valves in the receiver and the heater and anode supplies to the receiver rectifier. The rectified output of 250 V is fed through a single fuse and smoothing circuit to provide all receiver H.T. supplies.

POSITION 3. In addition to receiver supplies, as for position 2, a.c. supply is fed through a pair of fuses to transformer No. 3. The three secondary windings of the transformer are used to supply all heaters of the rectifiers for the Relay supplies, bias supplies, auxiliary H.T. and main H.T.

POSITION 4. Supplies are completed as for positions 2 and 3 and in addition a.c. supply is fed through a pair of fuses to transformer No. 2, whose four secondary windings are used to provide the anode supplies of four rectifiers as follows:

a. Relay Supplies Rectifier, whose output is fused by a single fuse and is used to supply —50 V to operate most of the relays.

b. Bias Supplies Rectifier, whose output is fused by a single fuse and is used to supply —50 V bias.

c. Auxiliary H.T. Rectifier, whose output is fused by a single fuse and is used to supply 300 V H.T. to driver stages and screens of transmitter and modulator.

d. Main H.T. Rectifier, whose output is fused by a single fuse and used to supply H.T. to the transmitter P.A. stage and the Modulators.

The primary of each transformer is provided with taps and shorting strips to allow for the various a.c. supplies which may be used.

7. **Fuses.** All the fuses are contained in a fuse panel on the front of the power unit.

8. **Output.** All the outputs from the power unit are fed through a single 18-core cable to the control unit, from where they are fed via three separate cables to:

a. The Receiver.

b. Either the HF or MF Transmitter.

c. The Remote Control Position, via the Control system.

All the cables are connected by plug and socket connections. Transfer from the HF to the MF transmitter is achieved by transferring the plug from the socket on the HF transmitter to the socket on the MF transmitter.

9. **Control Unit.** In addition to the output cables mentioned in para. 8 above, the Control unit contains:

a. The Local/Remote switch which changes over the microphone and keying from local positions to remote positions.

b. Local key jack.

c. Local microphone socket.

d. Local phone jack and volume control, which is always in circuit and not affected by Local/Remote switch.

e. Local loudspeaker jack.

f. Five relays which enable the transmitter to be switched on, and operated from a remote position, and for changing modulation and providing lamp indication.

HF TRANSMITTER

10. **R.F. Circuits.**

a. V.F.O. OR CRYSTAL OSCILLATOR. A nine-position switch selects one of eight crystals or in position nine makes the circuitry changes for v.f.o. operation. When a crystal is employed the crystal is connected between grid and earth and the anode circuit tuned by a variable capacitor operated by the Main tuning control and an inductance selected by the range switch. The anode circuit is tuned to the crystal frequency and fed to the grid of the frequency doubler stage.

For V.F.O. working the same tuned circuit is employed as the frequency determining circuit connected between grid and anode. For v.f.o. or crystal working this circuit is always operating at half the output frequency. To assist frequency stability, HT supply to this stage is stabilized.

b. DOUBLER STAGE. The tuned anode circuit of the doubler stage is tuned to twice the frequency of the v.f.o. or crystal oscillator and fed to the Buffer Amplifier. Tuning is by a variable capacitor, ganged with the v.f.o. or crystal oscillator and doubler to the main tuning control, and one of the three inductances selected by the range switch.

c. BUFFER AMPLIFIER. This stage which acts as an isolating stage between V.F.O. and doubler and P.A. has a tuned anode circuit. Tuning is by a variable capacitor ganged with v.f.o. or crystal oscillator and doubler stage to the main tuning control, and one of three inductances selected by the range switch. The output is fed to the grids of the P.A. stage.

d. Power Amplifier. The P.A. stage employs three valves in parallel with the output fed into the pi filter matching unit. The H.T. supply to the P.A. valves passes through the secondary of the modulation transformer to provide anode and screen modulation for voice and m.c.w. working.

e. Clamp Valve. This is fitted as a safety device to prevent the P.A. valves passing too much current, particularly during tuning, and takes the place of a tune/operate switch and overload relays.

f. Pi Filter. Aerial matching is achieved by the use of a pi filter, the input side of which may be regarded as P.A. Anode tuning and the output side as Aerial tuning. To enable the transmitter to be tuned into any aerial six variable controls are provided as follows:

(1) *Anode Coarse.* Selects the fixed capacitor on input of pi filter.

(2) *Anode fine.* Variable capacitor for anode tuning.

(3) *Coil Switch.* Selects one of three inductances. Normally required in the same numbered position as the range switch.

(4) *Coil Tapping.* Selects the anode tap on the coil selected by the coil switch. Is varied in conjunction with Anode Fine control for obtaining the dip in the anode current.

(5) *Aerial Condenser Coarse.* Selects the fixed capacitor for aerial tuning. Also includes the dummy load position used for testing.

(6) *Aerial Condenser Fine.* Variable capacitor for aerial tuning.

g. Aerial Metering Circuit. To ensure a good reading in the aerial meter over the whole frequency range on any type of aerial used, two tuned circuits are provided consisting of one of three inductances selected by the range switch and a variable capacitor ganged to the Main tuning control.

h. Aerial Relay. When a common aerial is used for transmitter and receiver the Aerial relay connects the aerial to the transmitter and earths the receiver input when the morse key or pressel switch is pressed; when the key is released the relay connects the aerial to the receiver.

11. **A.F. Circuits.**

a. M.C.W. For m.c.w. working a 1000 c/s oscillator is employed feeding into a limiter stage.

b. Voice. The microphone input is fed through an a.f. filter to the grid of the microphone preamplifier stage. The feed on to the grid is varied by the Modulation level control which is used to alter the depth of modulation. The output of this stage is fed to the limiter when the modulation switch is to voice.

c. Limiter. This stage is employed in place of an a.g.c. or VOGAD and prevents distortion or over modulation due to shouting into the microphone by controlling the feed to the phase splitter.

d. Phase Splitter. The input to a push-pull stage is normally by transformer which allows the grids of the two valves to be 180 degrees out of phase, i.e. one is positive when the other is negative. A phase splitter serves exactly the same purpose and is used in lieu of a transformer to couple the input to the Modulators.

e. Modulators. A push-pull stage providing anode modulation of the P.A. stage of the transmitter.

12. **Controls.**

Range Switch. Three-position switch. Selects the inductance in the tuned circuit of:

a. V.F.O./Crystal Oscillator
b. Doubler Stage
c. Buffer Amplifier
d. Aerial Metering circuit.

Crystal Switch. Nine-position switch. Selects one of eight crystals or adjusts circuitry for v.f.o. operation.

Main Tuning Control. Adjusts the variable capacitor in the tuned circuit of

a. V.F.O./Crystal Oscillator
b. Doubler Stage
c. Buffer Amplifier
d. Aerial Metering Circuit.

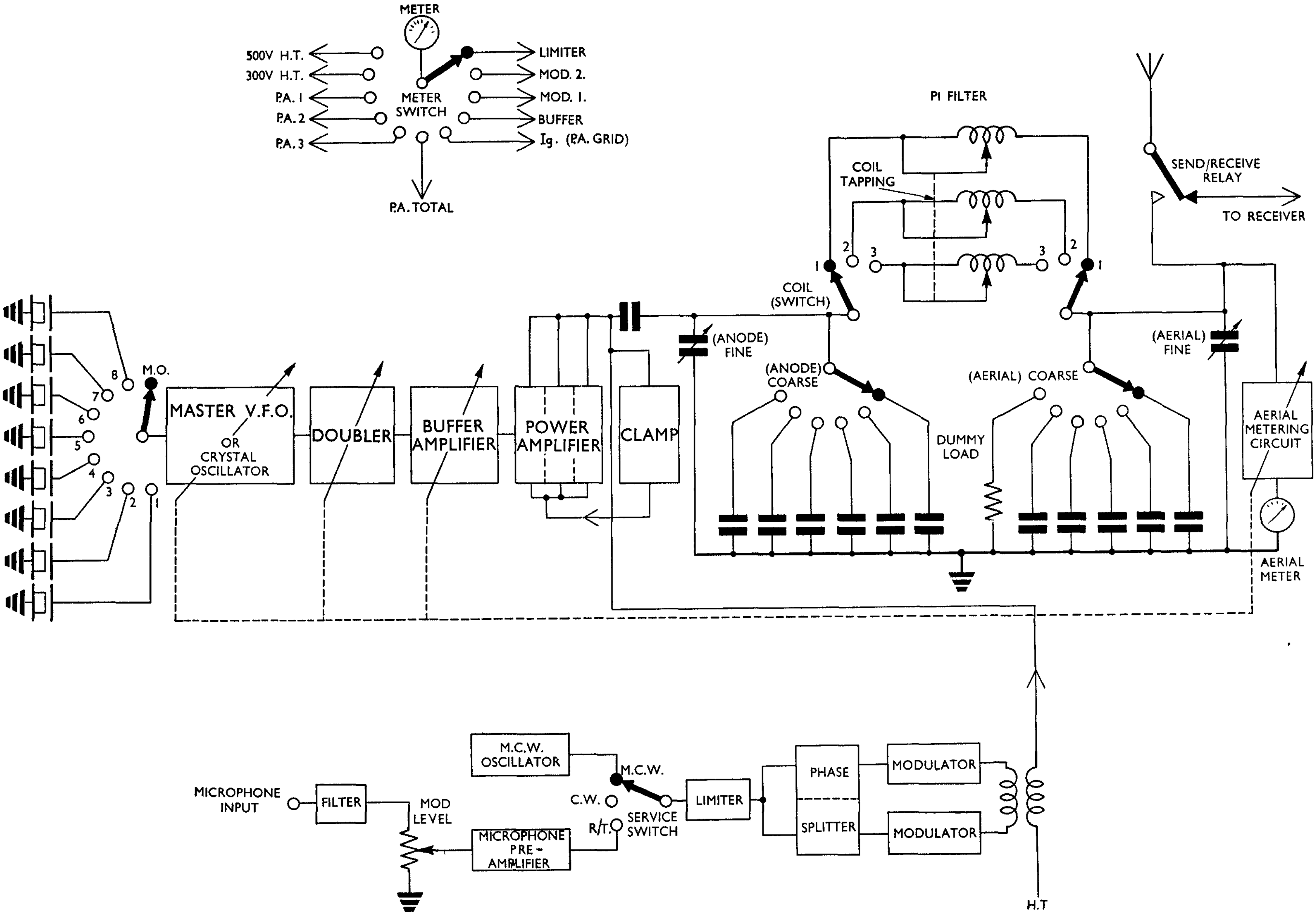


FIG. 3. TYPE 619 – HF TRANSMITTER

SERVICE SWITCH. Three-position switch, C.W., M.C.W., and R/T. Conditions the transmitter for c.w., m.c.w. or voice working.

ANODE (COARSE)
ANODE (FINE)
COIL (COARSE)
COIL TAPPING (FINE)
AERIAL CONDENSER (COARSE)
AERIAL CONDENSER (FINE)
} Pi Filter matching (see para. 10 *f* above).

MODULATION LEVEL CONTROL. Control the input to the microphone preamplifier.

MONITOR METER SWITCH. Eleven-position switch. Reads H.T. voltages and cathode and grid currents of stages as shown on the meter switch label. The primary positions for the user are:

a. P.A. Total Positions. For tuning P.A. and Aerial stages.

b. Ig (P.A. Grid position). For tuning the crystal oscillator.

c. Limiter position. For setting the Mod. level control.

13. **Keying.** Pressing the morse key or pressel switch operates three relays (G, F and K)

a. 'G' relay simultaneously disconnects the anode circuit of the oscillator from earth and connects the cathode circuits of the buffer amplifier and power amplifiers to earth.

b. 'F' relay changes over the aerial from the receiver to the transmitter.

c. 'K' relay (which is situated in the receiver CAT) applies a negative bias to the grids of the valves of the receiver r.f. and i.f. stages thus muting the receiver.

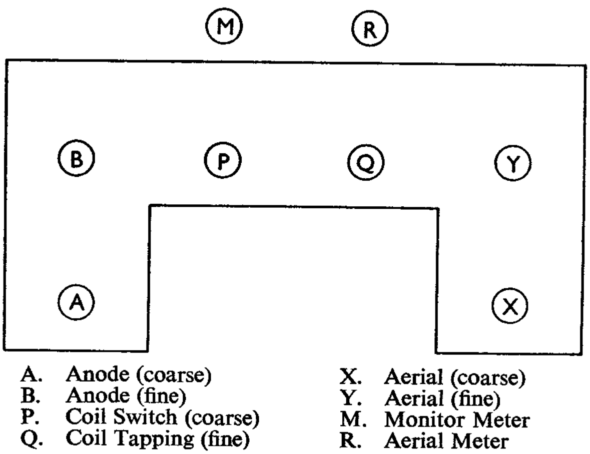
14. **Change-over Between HF and MF Transmitters**

a. Switch off mains on power unit. Change over the power supply plug from the socket on HF transmitter to the socket on MF transmitter.

b. Change over aerial lead from Aerial terminal on HF transmitter to Aerial terminal on MF transmitter.

c. Change over receiver aerial lead from socket on HF transmitter to socket on MF transmitter.

15. **Tuning Instructions**



A. Anode (coarse)
B. Anode (fine)
P. Coil Switch (coarse)
Q. Coil Tapping (fine)

X. Aerial (coarse)
Y. Aerial (fine)
M. Monitor Meter
R. Aerial Meter

Note. There are only three controls, but each has Coarse and Fine tuners.

FIG. 4. LAYOUT OF TUNING CONTROLS

To Tune the Transmitter

a. With the Power Supply Switch to Off, see that the Aerial, Receiver Connection and Power Supply Plug are connected to the HF Transmitter.

b. Local/Remote Switch on Power Unit to Local.

c. Make the Power Supply Switch on Power Unit to position marked Rx and Tx Heaters and Tx H.T.

d. Put Service Switch to c.w.

e. Put Range Switch to required range.

f. Put main Tuning Control to required frequency.

g. Put P to postion 1 for frequencies 1·5 to 3 Mc/s.
„ „ 2 „ „ 3 to 7 Mc/s.
„ „ 3 „ „ 7 to 16 Mc/s.

h. Put A, B, Q, X and Y fully anti-clockwise.

For M. O. Control

i. Put Crystal Switch to M.O.

j. Put Meter Switch to P.A. Total.

For Crystal Control

(Crystal frequency is half the Output frequency)

i. Put Crystal Switch to appropriate position.

j. Put Meter switch to Ig.

k. Press key and adjust Main Tuning Control for maximum reading of Meter M, detuning slightly anti-clockwise from the peak.

l. Put Meter Switch to P.A. Total.

To Match the Aerial to the Transmitter

Step One – To find the Point of Resonance

a. Press the key and swing B slowly right round to search for a dip in the meter M. (The dip should be a minimum reading of about 100 which rises on both sides.)

b. If no dip, turn Q clockwise, one step at a time, repeating *a* at each step, until dip is found.

c. If there is no dip when Q is fully clockwise, turn Q back fully anti-clockwise, turn P one step clockwise and repeat *a* and *b* until dip is found.

Note. During Step Two or Step Three it may be found impossible to regain the dip with B.

If B is hard over clockwise, move A one step at a time clockwise, resuming the search for dip with B on each step of A.

If B is hard over anticlockwise, move Q one step at a time anti-clockwise, resuming the search for dip with B on each step of A.

Step Two – To load the Transmitter

d. Turn Y clockwise until reading of Meter M rises to about 400.

e. If it does not rise to 400 when Y is fully clockwise, turn Y back fully anti-clockwise, turn X one step clockwise and repeat *d.*

f. When Meter M has risen to 400, retune to dip by turning B clockwise.

g. Repeat *d* to *f* until the dip reading of Meter M has increased to:

C.W. Transmissions	300 to 400
R/T/M.C.W. Transmissions	250 to 300

h. Turn Service Switch to m.c.w. or R/T if necessary for the transmission.

If Step Two is continued until X is at position 6 and Y fully clockwise, but the dip reading of M is still too low, then carry out Step Three.

Step Three

i. Leave X in position *f.* Turn Y fully anti-clockwise. Retune to dip with B (anti-clockwise).

j. Increase Q one step clockwise. (If Q is already fully clockwise, turn P one step clockwise and turn Q fully anti-clockwise).

k. Retune to dip with B (clockwise).

l. Attempt to load to the correct loading conditions with small clockwise alterations of Y, maintaining the dip with B.

m. If correct loading conditions still not achieved, leaving X in position 6 repeat *i* to *l* above until correct loading conditions are reached.

Note 1. The correct matching condition is *maximum* reading in aerial meter for correct *Dip* reading of monitor meter.

Note 2. If the set is being used on c.w. and it is desired to use m.c.w. or R/T carry out the following:

a. Leave the Service Switch to c.w.

b. Move Y anti-clockwise, maintaining dip in Meter M with B (Anti-clockwise) until dip reading of M is 250–300.

c. Normally *b* will be sufficient, but it may be necessary also to move X and/or A one step anti-clockwise.

d. Put Service Switch to m.c.w. or R/T as desired.

Note 3. If the set is being used on m.c.w. or R/T and it is desired to use c.w. carry out the following:

a. Put the Service Switch to c.w.

b. Carry out Step Two and/or Step Three until correct loading figure for c.w. is achieved.

Note 4. To set MOD. Level control, having tuned transmitter, and put Service Switch to R/T,

a. Put Meter Switch to Limiter position, and Mod. Level control fully clockwise.

b. Speak into microphone a continuous steady 'AH.'

c. Turn Mod. level control Anti-clockwise until meter reading starts to fall.

d. Leave Mod. level control in position where meter reading first started to fall.

MF TRANSMITTER

16. R.F. Circuits

a. V.F.O. Employs a tuned grid circuit with a fixed inductance and variable capacitor controlled by the Main tuning control.

b. BUFFER AMPLIFIER. The output of the v.f.o. is fed to an untuned buffer amplifier. This stage acts as an isolating stage between the v.f.o. and P.A. stages to improve frequency stability.

c. P.A. STAGE. The output of the Buffer Amplifier is fed to the P.A. Stage which employs two valves in parallel. The output of the P.A. stage is fed into the Pi Filter matching circuit. The H.T. supply to the P.A. valves passes through the secondary of the Modulation transformer to provide anode and screen modulation for m.c.w. working.

d. CLAMP VALVE. The clamp valve is connected across the P.A. Stage. This is a safety device to prevent the P.A. valves passing too much current particularly during tuning and takes the place of a tune/operate switch and overload relays.

2-15-9

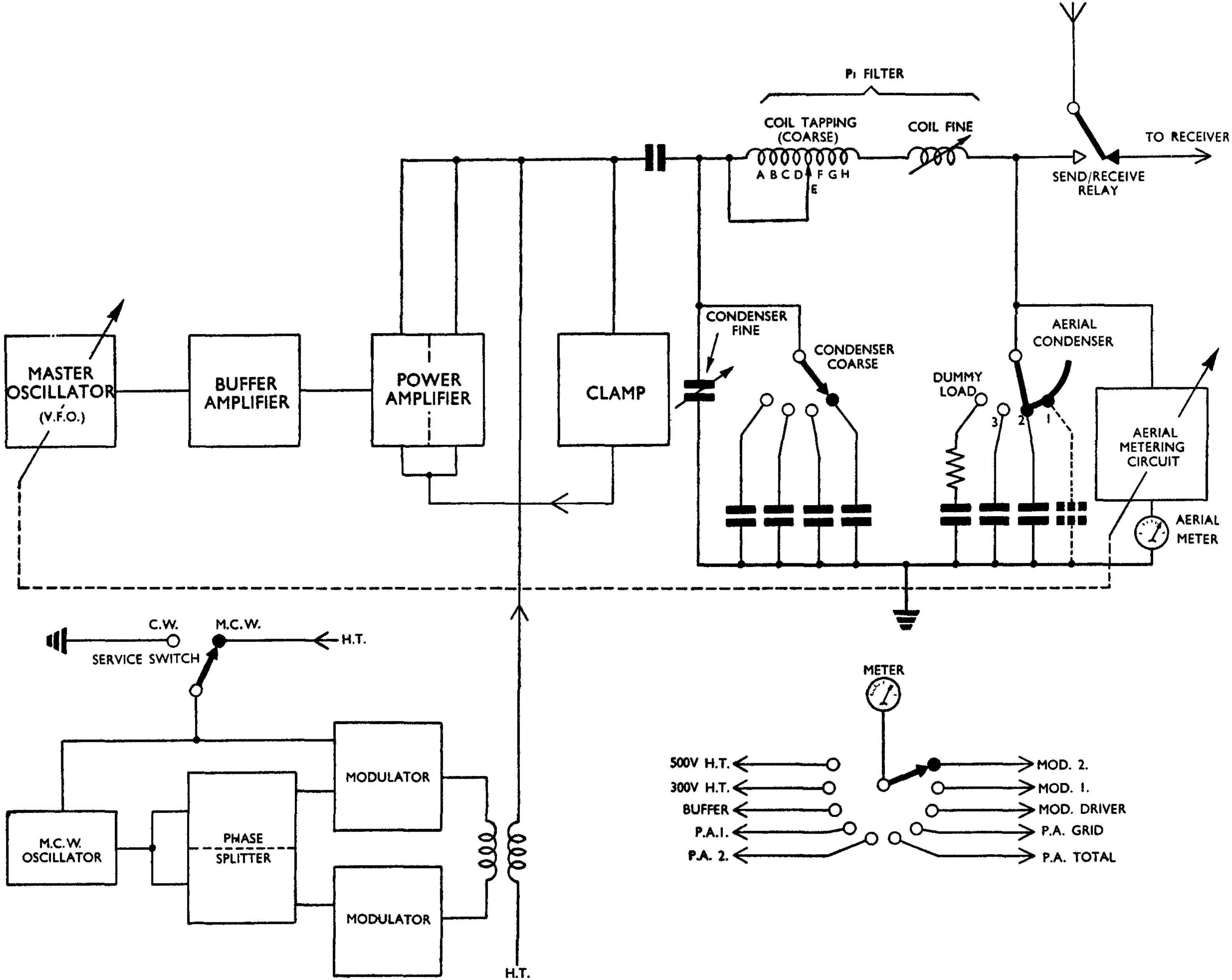


FIG. 5. TYPE 619 – MF TRANSMITTER

e. PI FILTER. Aerial matching is achieved by the use of a Pi filter circuit the input side of which may be regarded as P.A. anode tuning and the output side as aerial tuning. To enable the transmitter to be tuned into any type of aerial, five variable controls are provided as follows:

(1) *Condenser* (*Coarse*). Selects the fixed capacitor on the input side of the pi filter.

(2) *Condenser* (*Fine*). Fine tuning control for input of pi filter.

(3) *Coil Tapping* (*Coarse*). The Coarse Inductance tapping.

(4) *Coil* (*Fine*). Fine variometer tuning control for the inductance.

(5) *Aerial Condenser*. Selects the fixed capacitor for aerial tuning. Also includes the Dummy load position for testing.

f. AERIAL METERING CIRCUIT. To ensure a good reading in the Aerial meter regardless of the type of aerial used a tuned circuit is employed consisting of a fixed inductance and a variable capacitor which is ganged to the main tuning control.

g. AERIAL RELAY. Changes over the Aerial from the receiver to the transmitter when the key is pressed.

17. **A.F. Circuits**

a. M.C.W. OSCILLATOR. A 1000 c/s oscillator is used to provide the modulation for m.c.w. working.

b. PHASE SPLITTER. The output of the 1000 c/s oscillator is fed to a phase splitter. This stage is used instead of a transformer ensuring that the feed to the grids of the push-pull modulator stage are 180 degrees out of phase with each other.

c. MODULATORS. A push-pull stage providing anode modulation of the P.A. stage of the transmitter.

18. **Controls**

MAIN TUNING CONTROL. Adjusts the variable capacitor in the v.f.o. and metering circuit.

SERVICE SWITCH. Two-position switch, c.w. and m.c.w. Conditions the transmitter for c.w. or m.c.w. working.

CONDENSER (COARSE) CONDENSER (FINE) COIL TAPPING (COARSE) COIL (FINE) AERIAL CONDENSER	} Pi Filter matching (see para. 16 *e* above).

MONITOR METER SWITCH. Ten-position switch. Reads H.T. voltages, cathode and grid currents of stages as shown on the meter switch label. The primary position for the user is the P.A. TOTAL position, used for tuning the Pi Filter.

19. **Keying.** Pressing the morse key or pressel switch operates three relays (H, J and K).

a. 'H' relay completes H.T. supply to the oscillator valve and alters bias on the grid of clamp valve.

b. 'J' relay changes over the aerial from the receiver to the transmitter.

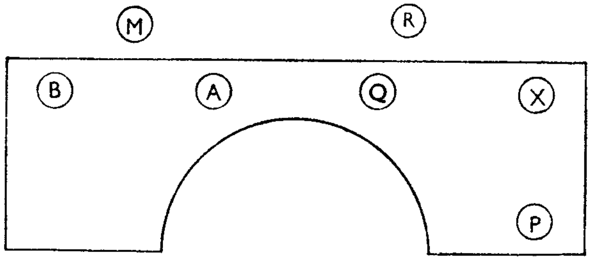
c. 'K' relay (which is situated in the receiver CAT) applies a negative bias to the grids of the receiver r.f. and i.f. stages thus muting the receiver.

20. **Change-over between HF and MF Transmitter.** (See para 14.)

21. **Tuning Instructions**

a. TO TUNE THE TRANSMITTER

(1) With the Power Supply Switch to OFF, see that the aerial, Receiver Connection and Power Supply Plug are connected to the MF Transmitter.



A. Condenser (coarse)
B. Condenser (fine)
P. Coil Tapping (coarse)
Q. Coil (fine)
X. Aerial Condenser
M. Monitor Meter
R. Aerial Meter

Note. There are only three controls, but two have Coarse and Fine tuners.

FIG. 6. LAYOUT OF TUNING CONTROLS

(2) Local/Remote Switch on Power Unit to LOCAL.

(3) Make Power Supply Switch on Power Unit to position marked RX AND TX HEATERS AND TX H.T.

(4) Put Service Switch to c.w.

(5) Put Main Tuning Control to required frequency.

(6) Put A to position 2, and B fully clockwise.

(7) Put P and Q fully anti-clockwise.

(8) Put X to position 3.

(9) Put Monitor Meter Switch to P.A. Total.

b. To match Aerial to Transmitter

Step One – To find the point of Resonance

(1) Press the key and swing Q slowly right round to search for a dip in the meter M. Sometimes the dip is large and easy to see, but sometimes it is small and hard to see. On these latter occasions, a peak in the Meter R can easily be seen at the same point.

(2) If no dip, repeat (1) on positions B and C of Switch P.

(3) If no dip, turn P back to position A and put X in position 2.

(4) Repeat (1) for each position of Switch P as far as position G, or until dip is found.

(5) If still no dip, turn P back to position A and put X to position 1, and repeat (1) for all positions of Switch P.

Step Two – To load the Transmitter. The transmitter is correctly loaded when the dip reading of M is between 200 and 250, and Meter R reads a maximum. Carrying out Step One may produce a dip reading too low or too high.

If the dip reading is below 200:

(6) Turn A one step clockwise and retune to dip by turning B anti-clockwise.

(7) Turn B clockwise until M reads nearly 300. Remove to dip by turning Q clockwise.

(8) If Q becomes fully clockwise, turn P one step clockwise, and retune by turning Q anti-clockwise. Similarly if B becomes fully clockwise repeat (6).

(9) Continue (7) until dip reading of M is between 200 and 250. Note the reading of R at the dip point, and choose settings for the maximum in R, maintaining the dip in M between 200 and 250.

If dip reading is above 250:

(6) Turn B anti-clockwise about three divisions and retune to dip by turning Q anti-clockwise.

(7) If Q becomes fully anti-clockwise, turn P one step anti-clockwise and then retune by turning Q clockwise.

(8) Repeat (6) and (7) until dip reading of M is between 200 and 250, and select setting as in (9). If B becomes fully anti-clockwise, turn A one step anti-clockwise and retune by turning B clockwise.

M.C.W. Switch to m.c.w. if required.

22. **Type 'A' Power Pack.** A modified power pack has been produced which differs from the original as follows:

a. All H.T., Bias and control supplies are now supplied from full wave metal rectifier circuits.

b. Eight in numbers fuses are mounted on the front of the unit and provide protection as shown below. None of the d.c. outputs are fused.

FS1 and FS2	A.C. Supply.
FS3 and FS4	A.C. Receiver.
FS5 and FS6	A.C. transmitter Bias and control and H.T.
FS7 and FS8	A.C. transmitter heaters.

2.16. TYPE 623

DATE OF DESIGN. 1952

HANDBOOK. B.R. 2181

ESTABLISHMENT LIST. E. 1100

FREQUENCY RANGE. 1·5 to 24 Mc/s (V.F.O.)
2 to 24 Mc/s (C.O.)

FREQUENCY DETERMINATION. V.F.O. or Crystal Osc.

EMISSION AND POWER OUTPUT. C.W. 400 W.

1. **Description.** Type 623 is a medium power HF transmitter with an output of 400 W, specifically designed for use in submarines. The transmitter is designed for operation from 115 V 60 c/s or 230 V 50 c/s single phase a.c. supplies. In addition 220 V d.c. supply is required for relay, master oscillator oven and anti- condensation heater operation.

The transmitter uses either v.f.o. or crystal for frequency determination. The frequency range of 1·5 to 24 Mc/s is covered in four bands by a variable frequency oscillator tuning over the basic range of 1·5 to 3 Mc/s followed by amplifying or multiplying stages, according to the output frequency. The transmitter is also capable of operation on any one of nine spot frequencies, determined by crystals within the range 2 to 24 Mc/s with no restrictions of the

(*continued on page 2–16–2*)

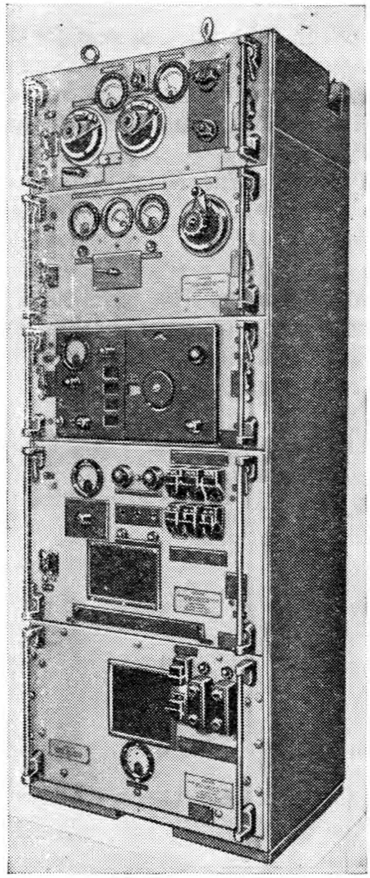
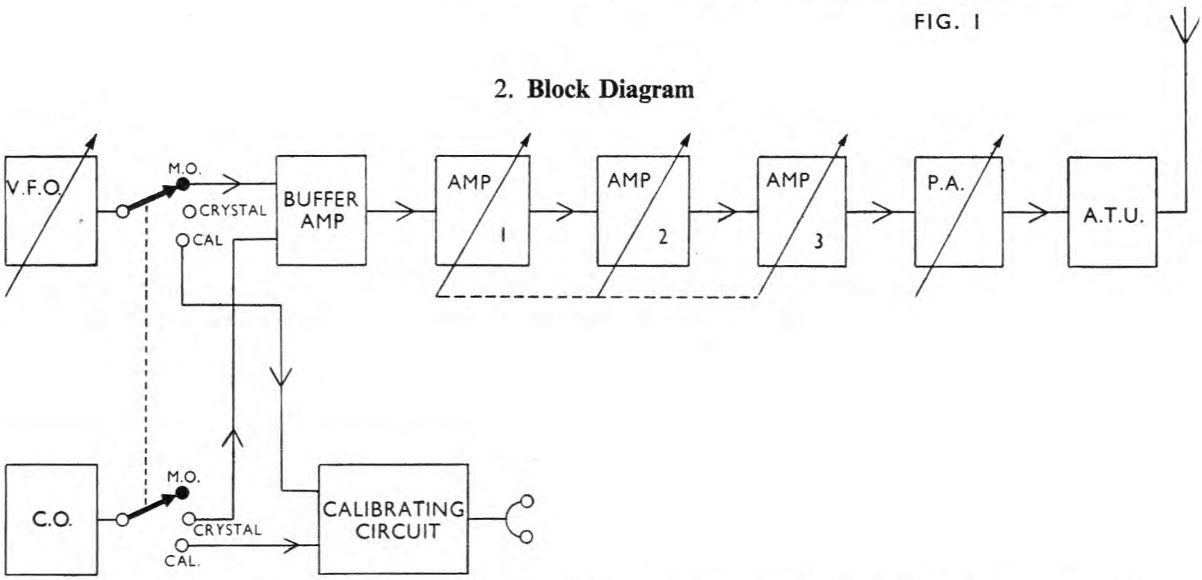


FIG. 1

2. Block Diagram



N.B. THERE ARE 9 CRYSTAL POSITIONS

FIG. 2. ~~60 WATT SSB~~ TRANSMITTER – TYPE 623

distribution of the frequencies within this band. The operating frequencies of the crystals employed all lie between 2 and 4 Mc/s and the frequency multiplying stages are again utilized as required.

A built-in calibration system for the v.f.o. is provided by the inclusion of a 100 kc/s crystal capable of being switched into the grid circuit of the crystal oscillator. Calibration is achieved by tuning the v.f.o. to zero beat with harmonics from the 100 kc/s crystal oscillator. The v.f.o. stage and the 100 kc/s crystal are both enclosed in a thermostatically controlled oven to provide stable operating conditions.

3. **Power Amplifier Stage.** The power amplifier stage covers the frequency range in six bands and employs two tetrodes connected in parallel, to feed a pi network designed for operation into an impedance of 90 ohms.

4. **Aerial Tuning.** The aerial tuner housed in the top drawer of the transmitter is essentially a matching transformer to convert the impedance of the aerial system to the requisite 90 ohms. A dummy load having a resistance of 90 ohms is built into the cabinet assembly of the transmitter to provide a load for the output stage during tuning.

5. **Frequency Build-up.** The following tables indicate the functions of the various stages when using v.f.o. or crystal:

a. V.F.O.

Range	*V.F.O. Frequency*	*Multiplication Factor*			*Output Frequency*
	Mc/s	*Amp* 1	*Amp* 2	*Amp* 3	*Mc/s*
1	1·5 to 3	×1	×1	×1	1·5 to 3
2	1·5 to 3	×2	×1	×1	3 to 6
3	1·5 to 3	×2	×2	×1	6 to 12
4	1·5 to 3	×2	×2	×2	12 to 24

b. CRYSTAL OSCILLATOR

Range	*Crystal Frequency*	*Multiplication Factor*			*Output Frequency*
	Mc/s	*Amp* 1	*Amp* 2	*Amp* 3	*Mc/s*
1	2 to 3	×1	×1	×1	2 to 3
2	3 to 4	×1	×1	×1	3 to 4
2	2 to 3	×2	×1	×1	4 to 6
3	3 to 4	×1	×2	×1	6 to 8
3	2 to 3	×2	×2	×1	8 to 12
4	3 to 4	×1	×2	×2	12 to 16
4	2 to 3	×2	×2	×2	16 to 24

6. **Keying.** The Buffer Amplifier and Amplifier 1 stages are keyed. In the SPACE condition the control grids of the valves of these stages have a heavy negative bias. In the MARK condition this bias is removed and the control grids are connected to earth.

2.17. TYPE 633

DATE OF DESIGN. 1959

HANDBOOK. B.R. 1188

ESTABLISHMENT LIST

FREQUENCY RANGE. E. 1278

Channel 1 and 2: 3 to 6·7 Mc/s
Channel 3 and 4: 6·7 to 15 Mc/s

FREQUENCY DETERMINATION.

Crystal Oscillator
Crystal frequency = Output frequency + 1800 kc/s.

EMISSION.

(*a*) SSB, suppressed carrier
(*b*) SSB, full carrier
(*c*) C.W.
(*d*) SSB, keyed tone

POWER OUTPUT

Telephony – 60 W (PEP)
C.W. – 60 W.

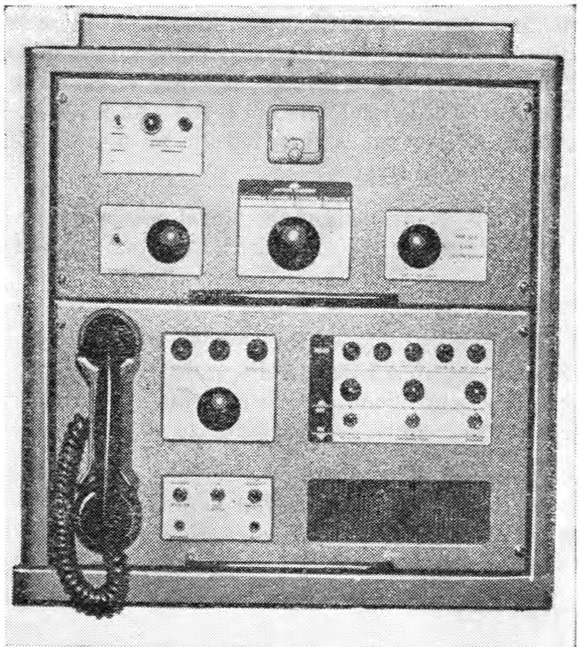


FIG. 1

GENERAL

1. A single sideband transmitter and receiver designed to cover medium distances using simplex voice working on any one of four pre-tuned frequencies.

TRANSMITTER

2. The a.f. input is first amplified, then passed via the limiter switch or through a second amplifier to the amplifier limiter, the purpose of which is to clip the speech waveform, thus avoiding distortion in the final transmitter stage. The limiter a.f. output is fed to a modulator which is also fed from a 100 kc/s crystal oscillator. The 100 kc/s carrier is suppressed in the modulator and the upper sideband is suppressed by a filter, which passes the lower sideband (97–100 kc/s). This is passed to the second modulator.

3. The second modulator, which consists of two triodes, is also fed with a crystal oscillator frequency of either 1700 kc/s (upper) or 1900 kc/s (lower) depending on the sideband selected. The output of the modulator is fed to an amplifier tuned to the resulting 1800 kc/s sideband. The unwanted sideband is rejected: the 1700 kc/s or 1900 kc/s carrier is balanced out in the modulator. The third modulator works in a manner similar to the second, except that the oscillator frequency is selected by the four-position channel switch which connects the desired crystal.

4. The output of the third modulator is fed to the first P.A. stage. The final P.A. stage delivers a peak power of 60 W to the aerial.

5. For Morse operation a 1 kc/s a.f. amplifier is switched in at the limiter grid, and keyed via a jack at the front of the supply unit.

RECEIVER

6. Double-superheterodyne receiver using crystal oscillators common with the transmitter section. The signal is connected from the common aerial via the send-receive relay to a r.f. amplifier, thence to the first mixer. This is fed with the output from the channel crystal in use. The second mixer is fed with either 1700 kc/s or 1900 kc/s depending on the sideband in use. The signal (now at 100 kc/s) passes through a crystal filter which selects the lower sideband in the 100 kc/s band which is amplified by a two-stage amplifier. The crystal detector is fed with a 100 kc/s carrier generated by the common 100 kc/s oscillator, and the a.f. output is then fed via an a.f. amplifier, cathode follower, and a second a.f. amplifier, to the a.f. output stage.

7. On c.w. transmissions the signal comprises a single frequency removed from the nominal carrier by 1 kc/s. Hence no B.F.O. is used, and the final audio signal emerges as a 1 kc/s tone.

AERIAL MATCHING UNIT

8. This unit is designed to provide correct matching of the transmitter into a 16-ft. whip aerial. The unit is contained in a hermetically sealed weather-proof aluminium box containing silica gel crystal and is remotely controlled from the transmitter. It consists of an 'L' section filter employing various combinations of inductance and capacitance which are selected for each channel when setting up.

9. In operation, the required circuits are selected by the channel switch, which is driven by a Ledex motor controlled by the Aerial Tuning Selector Switch on the front panel of the transceiver. A neon light at the switch burns when the correct selection is made. The aerial tuning selector is then released and the drive stops.

CONTROLS

10. *a.* CARRIER ON/OFF.	Switches the transmitter carrier as required. In ON position the a.f. drive is automatically reduced to give 60 W PEP output from the transmitter.
b. TUNE.	Fine adjustment of working frequency. Range of ± 60 c/s, transmit and receive frequencies are corrected simultaneously.
c. CHANNEL.	Selection of one of four operating frequencies.
d. RECEIVER GAIN.	Adjusts gain of receiver. Set for convenient volume from handset or loudspeaker.
e. OUTPUT CURRENT (Meter).	Normally measures total P.A. cathode current. May be switched (internally) to measure P.A. grid current for tuning.
f. SIDEBAND UPPER/LOWER.	Selects either the U.S.B. or L.S.B. operation.
g. AERIAL TUNING SELECTOR.	Selects the correct matching for the frequency in use. Applies H.T. to the Ledex motor in the Aerial Tuning Unit. Note. This switch is held in the ON position until the adjacent indicating lamp lights indicating that the correct circuits are set up.
h. LOCAL/REMOTE.	Selection of operating positions.
i. RECEIVER ON/OFF.	Switches receiver and oscillator heaters, 200 V and 150 V H.T. for transmitter and receiver.
i. TRANSMITTER ON/OFF.	Switches transmitter P.A. H.T. and transmitter valve heaters. This switch is operative only when RECEIVER and POWER switches are set to ON.
k. POWER ON/OFF	Switches mains supply to all sections of the equipment. Oven heaters are controlled by this switch.
l. C.W. TRANSMIT–RECEIVE.	The receive position is used for every operation except c.w. transmit; in this position the switch replaces the pressel switch.

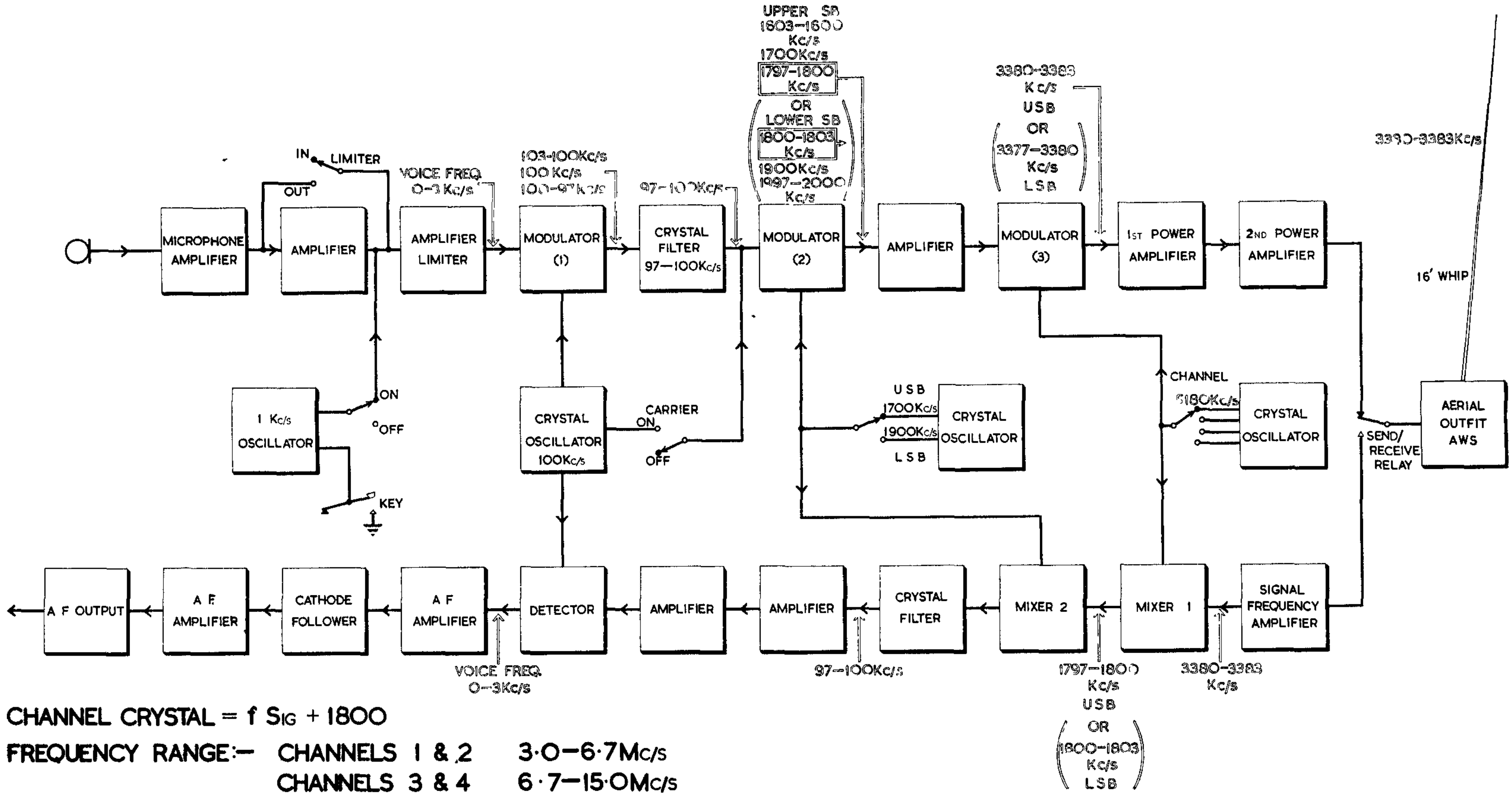


FIG. 2. TYPE 633 – SSB TRANSMITTER/RECEIVER

m. PHONES–SPEAKER.	Connects either phones or speaker to a.f. output.
n. LIMITER IN/OUT	Connects or disconnects a speech clipper in the a.f. circuits. This is used to improve reception under poor conditions.

OPERATING INSTRUCTIONS

GENERAL

11. *a.* Set the Power and Receiver switches to ON.

b. Set the Transmitter switch to ON and allow 2 minutes for the equipment to warm up.

c. Set the Channel switch to the required channel and if the aerial matching unit is being used with a whip aerial, press Aerial Tuning Selector Switch until the indicating lamp lights.

d. Set the Local/Remote switch as desired, enabling the equipment to be used at the Transmitter–Receiver or at a remote position via the KH control system.

TELEPHONY

12. *a.* Set the C.W. Transmit/Receive switch to RECEIVE, and the Upper/Lower Sideband switch as required.

b. Set the PHONES/SPEAKER switch as required and insert phones into phones jack if required; in either position the receiver a.f. output may be monitored on the handset.

c. Set the Carrier ON/OFF switch as required. When working to a normal D.S.B. receiver the Carrier switch must be set to ON.

d. Set the RECEIVER GAIN control to produce a convenient output level in the phones, speaker or handset.

e. Press the handset pressel switch to SPEAK and release to receive.

Note. When the pressel switch is pressed, speak into the handset and note that the OUTPUT CURRENT meter reading varies from 55 mA–65 mA or 160 mA–170 according to the sideband in use.

f. Once communication has been established adjust the TUNE control, at one end of the link only, to a point where the distant operators' speech sounds most natural.

g. If a more accurate method of netting is required, proceed as follows:

(1) At one end of the link arrange to send c.w. by setting the TRANSMIT C.W./RECEIVE switch to TRANSMIT C.W. and pressing the key.

(2) At the other end of the link adjust the TUNE control until a pure tone is heard in the earpiece. If the receiver is off tune, a number of tones will be heard and as the receiver is tuned in, these disappear, leaving the 1 kc/s tone.

h. In conditions of low signal to noise ratio, i.e. under poor propagation conditions or at a station with high site noise levels, set the LIMITER switch to IN at both ends of the link. Although this leads to a certain amount of speech distortion, the average power transmitted is greater and hence reception is improved.

C.W.

a. Insert the key plug in the key jack.

b. To receive, set the c.w. TRANSMIT/RECEIVE switch to RECEIVE.

c. To transmit, set the c.w. TRANSMIT/RECEIVE switch to c.w. TRANSMIT and operate the key.

Note. When the key is operated, the OUTPUT CURRENT meter should read approximately 160–170 mA according to the sideband in use.

2.18. TYPE 640

HANDBOOK. B.R. 2328, 2344–2347

ESTABLISHMENT LIST.

FREQUENCY RANGE

MF 240 kc/s to 3 Mcs

HF 1·3 to 24 Mc/s

EMISSION. C.W.

M.C.W.

D.S.B.

I.S.B. Suppressed Carrier

I.S.B. pilot carrier

External modulation at 100 kc/s (*e.g.* F.S.T.)

POWER OUTPUT. 500 watts P.E.P.

FREQUENCY TOLERANCE. On each multiple of 1 kc/s.

a. Short term over temperature range – 150° C to + 55° and + 6 per cent Supply Voltage variation better than $\pm 3 \times 10^8$

b. Long term ageing.
Better than 5 parts in 10^8 per month with provision for adjustment.

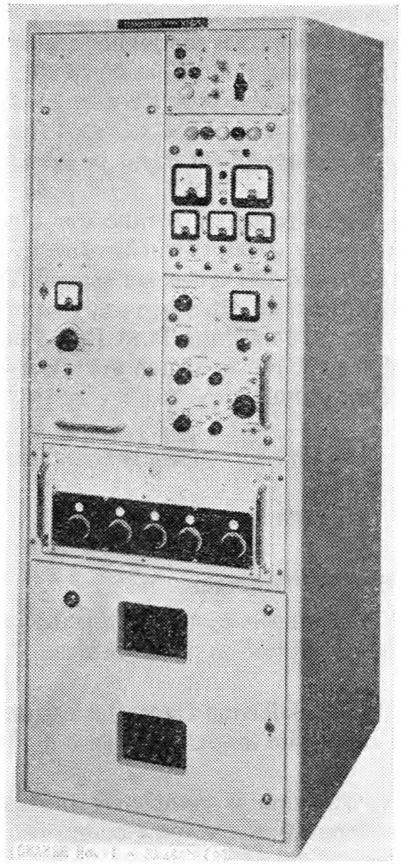


FIG. 1

DESCRIPTION

Cabinet and General Layout

1. The cabinet housing Type 640 is of steel construction and is intended for plinth mounting on Admiralty Pattern shock mounts. Air inlet and exhaust connections are located on the cabinet top, the left-hand side of the cabinet being encased internally to form an air duct to the various levels.

2. The upper section of the cabinet contains the Control Unit, Sideband Generator, Drive Amplifier and Final Stage Amplifier. The centre and lower sections of the cabinet contain the Frequency Synthesizer and Power Supply Units respectively.

3. The units in the upper section of the cabinet and those behind the door on the lower section are maintained in position by Yale key power interlocks which operate in conjunction with the main full power safety interlocking.

Power Section

4. This section consists of three units, H.T. Transformer, Assembly, H.T. Supply Unit and Auxiliary Supplies Unit. These units provide the necessary H.T. screen grid and grid bias supplies plus low voltage supplies for relay and contactor heaters, microphone circuits, aerial matching unit control motors and indicating lamp circuits. Silicon rectifiers are utilized throughout. The power supply circuits are fully fuse protected and have associated blown fuse indicator lamps.

Frequency Synthesizer

5. This unit is mounted immediately above the Ancillary Supplies Unit. It is self-contained and self-powered and is withdrawable on runners. It accepts an input of 1 Mc/s from the external Crystal Oscillator and a composite modulated signal centred on 100 kc/s from the A.F. Unit. By processes of frequency division and multiplication of the 1 Mc/s control frequency, and by subsequent selection and synthesis of the resultant products along with the intelligence-bearing 100 kc/s signal the unit produces an output signal at the required radiated frequency bearing the desired modulation for delivery at 10 mW/P.E.P. level to subsequent linear power-amplifying stages. A full description is given in late paragraphs.

6. The Frequency Synthesizer Unit carries on its front panel only five controls, these being rotary frequency selector switches directly calibrated in terms of radiated frequency in steps of 1 Mc/s, 100 kc/s, 10Kc 1 kc/s and 100 cycles per second. These switches incorporate an interlock which attenuates transmission by at least 40 dBs when any one or more of the switches is operated, and thereafter transmission cannot commence until the TUNE DRIVE position of the system switch and the MEDIUM or LOW power positions of the r.f. power switch are selected. Warning that the switches have been moved is given by illumination of the TUNE lamp.

7. The unit is completely transistorized, and is divided into seven sub-units for ease of servicing.

8. The unit also delivers a 100 kc/s carrier to modulators contained in the A.F. Unit.

Sideband Generator

9. This unit is mounted, together with the r.f. Amplifier and Control Units, on the right-hand side of the upper section of the cabinet.

10. The Sideband Generator operates in conjunction with the Frequency Synthesizer for which it provides a composite modulated signal at 100 kc/s.

11. The unit is completely transistorized and contains two separate audio channels A and B, each incorporating a volume compressor (or V.O.G.A.D.) followed by a speech clipper. Either channel may operate on telegraphy or telephony, but in C.W., M.C.W., and D.S.B. working only Channel A is operative. In I.S.B. Channel A corresponds to the upper sideband and Channel B to the lower.

12. Each audio channel is also fitted with a sidetone amplifier, the input for which is derived from the output of the clipper.

13. Following the V.O.G.A.D. and clipper the audio output from each channel is applied to a 100 kc/s balanced modulator. The 100 kc/s side-band output from this is routed via the appropriate upper or lower side-band filter for I.S.B. working (or via a suitable attenuator for D.S.B.) to a combining unit where it is combined with the output from the other channel. The combined signal is applied to a 100 kc/s buffer amplifier, giving an output sufficient to provide 'intelligence' drive to the frequency synthesizer at 100 kc/s.

14. A carrier rejector circuit is included in the buffer amplifier so that the carrier level on I.S.B. working can be suppressed to lower than —60 dB relative to normal working P.E.P.

15. Arrangements are also made in this amplifier for re-inserting the carrier as suitable for C.W., M.C.W., D.S.B. and I.S.B. PILOT CARRIER conditions.

16. Two headphone jacks are provided to allow the modulating signals in Channels A and B to be monitored individually.

Drive Amplifier

17. This unit comprises a two-stage tuned valve amplifier and is intended to accept a modulated input of about 10 mW P.E.P. from the Frequency Synthesizer and to amplify this signal to a level of about 5 watts P.E.P. to feed directly to the final stage broad-band amplifier.

18. The total frequency range of 0·1 to 28 Mc/s is covered in nine tuning ranges. On the lowest frequency range, 0·1 to 1 Mc/s no tuning is employed, but on the remaining eight ranges three tuned circuits are used, tuned by a 3-gang variable capacitor with front panel control. The correct range is automatically selected by a Ledex driven range switch controlled by the Megacycles selector switch in the Synthesizer. A front panel meter is provided to monitor the r.f. output level so that the tuning operation is simply one of adjusting for maximum output.

19. A drive level control is fitted for precise adjustment of output level, and for the compensation of variation in gain of the Frequency Synthesizer or tuned amplifier over the frequency range. In addition a Power Reduction Switch provided for reduction of output level in three steps of approximately 5 dB. (Full, High, Medium and Low.)

Control Unit

20. This unit incorporates the Load V.S.W.R. and Forward Peak Power meters, control buttons and meter indicators for the aerial matching units, transmitter control switches and also indicator lamps showing the 'state' of the system.

Final Stage

21. This unit is mounted on two heavy duty runners and occupies the top left-hand side of the cabinet

22. It incorporates both MF and HF directional couplers for V.S.W.R. detection and forward r.f. power indications.

23. The Final amplifier stage proper uses six pairs of air-cooled tetrodes arranged in a push-pull distributed amplifier circuit working under class AB1 conditions.

24. Grid and anode circuits consist of balanced transmission lines systems driven by, or fed into, ferrite transformers. Separate output transformers for MF and HF operation are incorporated automatically with the appropriate Aerial Matching Unit.

25. Valve feed metering switches are provided together with a test instrument, which can also be switched to meter the more important of the supplies.

26. A switch is included in the unit to enable a reduced value of H.T. to be applied for test purposes. This switch is accessible when the unit is drawn slightly forward, and is automatically returned to its working position when the unit is pushed fully home.

27. Switches are included in the final amplifier H.T. supply and air interlock circuit to enable drive to be applied to this final stage during testing and maintenance without the application of main H.T. These switches are automatically operated by the removal of the cover to the grid chamber of the final amplifier chassis.

Local Control Unit

28. This unit normally is mounted on top of the cabinet at the front, and is connected to the transmitter via an 11-way socket in the cabinet top. The unit carries a standard MIC-TEL socket and two headphone jacks. The unit also includes a non-locking morse key for local testing and a send/receive switch. The

receiving circuit incorporates a volume control. The whole circuit is arranged for paralleling on to the main receiver-output/transmitter-sidetone circuit and to accept from it receiver and sidetone signals.

Anti-Condensation Heaters

29. Two heating resistors are incorporated with means for presetting their connections for 230 V or 115 V supplies. This circuit is brought to two independent terminals and it is assumed that the electrical supply will be separate from the main supply. A lamp indicator shows when this circuit is energized.

Operation

30. The system switch incorporated in the sideband generator has eight positions:

TUNE DRIVE

a. In this position the power amplifier is disabled while the drive equipment is being set to frequency. Simultaneously a c.w. signal at 100 kc/s is applied to the Synthesizer. The synthesizer decade controls having been set to the required frequency, the r.f. amplifier can be tuned and the drive level control adjusted for correct output. This position is interlocked with Medium and Lower Power positions of the r.f. power reduction switch.

TUNE AERIAL

b. In this condition the power amplifier and aerial matching unit controls motors are energized, and the A.M.U. may be tuned for minimum V.S.W.R. progressing in power from the Low or Medium power positions of the power reduction switch. The Drive Level control is finally adjusted for correct P.E.P. as indicated on the Peak Power Output Meter.

C.W.

c. In this position, an external send/receive switch as selected by the Channel A Input/Switch is routed so as, when closed, to operate the transmitting send/receive relay and thereby to close the two receiver desensitizing and input protection loops, energize the IN USE lamp and put the selected telegraph key into circuit. Pressure on the key then keys the transmitter at three points, namely the 100 kc/s output from the Sideband Generator one stage of the tuned r.f. Amplifier Unit and the Final Stage. By being thus keyed at three points, output from the transmitter on KEY-UP is extremely low.

M.C.W.

d. The same conditions apply as for position 3 above, but the carrier power is reduced to 6 dB below rated P.E.P. and a 1 kc/s tone is keyed on Channel A and set to give 80–90 per cent D.S.B. modulation of the keyed carrier.

D.S.B.

e. The control of the transmitter send/receive system is now taken to a local or remote send/receive toggle switch or Pressel switch as determined by the Channel A Input Switch. The receiver de-sensitizing and input circuit protection loops are closed on SEND to give SIMPLEX operating. However, if separation between transmitting and receiving aerials and between frequencies is sufficient to permit DUPLEX working the circuits can be deliberately disabled for this by external means.

f. Channel A only is operative and its input switch selects the required operation position.

I.S.B. SUPPRESSED CARRIER

g. In the two I.S.B. conditions, both channels are operative and their respective input switches may be set as required independently for local or remote operation, speech or keyed tone, or either channel may be switched off to give S.S.B. working on the other channel. When only one channel is in use SIMPLEX operation is obtained as on D.S.B. When both channels are in use, the send/receive switches associated with the two signal sources are paralleled. Thus the closing of either will bring the drive send/receive system to the SEND condition.

(*continued on page* 2–18–5)

RESTRICTED

2-18-4A

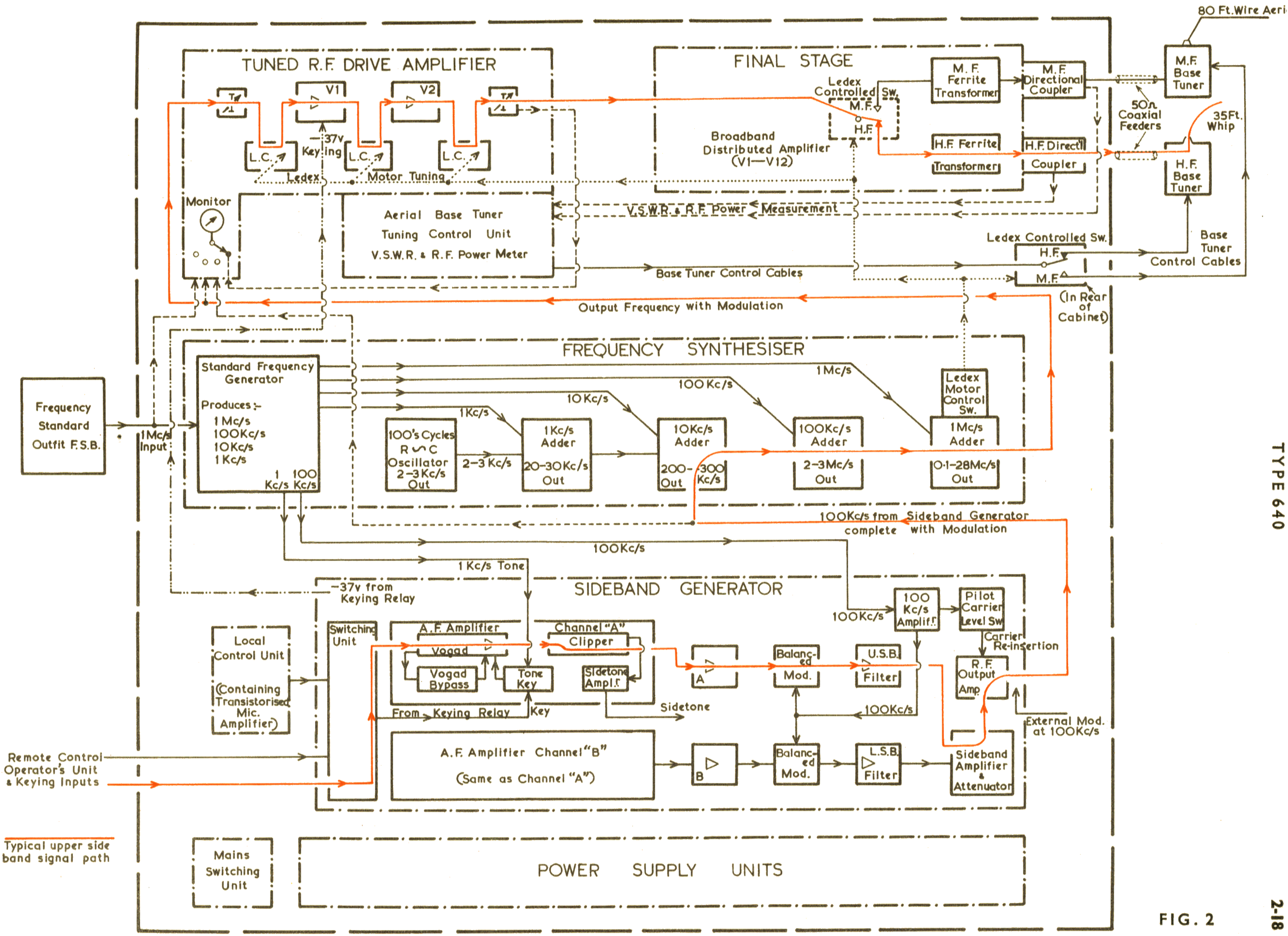


FIG. 2

TYPE 640 TRANSMITTER. BLOCK DIAGRAM

ORIGINAL
(reverse blank)

(*continued from page* 2–18–4)

h. When speech is used on both channels the full P.E.P. may be obtained on both sidebands, but when either channel is set for keyed tone operation the peak power on both sidebands is automatically dropped to 6 dB below normal P.E.P.

j. In the suppressed carrier condition, carrier suppression of at least 60 dB is obtained by balance with the rejection in the modulators together with the rejection in the sideband filters and carrier rejection.

Note. Single channel working only is available at present in the R.N. due to limited control wiring.

I.S.B. PILOT CARRIER

k. All conditions apply as for I.S.B. SUPPRESSED CARRIER, but in this case a pilot carrier is reinserted after the sideband filters at a level between —6dB and —26dB relative to P.E.P. by means of an internal switch in steps of 5 dB.

EXTERNAL MOD

l. In this condition both a.f. Channels are rendered inoperative and the 100 kc/s input to the synthesizer is connected to an external socket so that any other type of modulated 100 kc/s signal may be applied to the system from an external unit, *e.g.* an F.S.T. telegraph generator. The send/receive control is then routed to a separate external send/receive circuit.

m. Each of the two channels A and B is provided with a seven-position (including OFF) input switch. In the local mic and key positions the input and send/receive circuits are connected to the local control unit which may be fitted either on top of the cabinet or adjacent to the transmitter. The remote Line and Key positions are intended for use with a remote operator's control unit which may form part of a Naval KH or KMM or similar control outfit.

THE FREQUENCY SYNTHESIZER (TYPE 640)

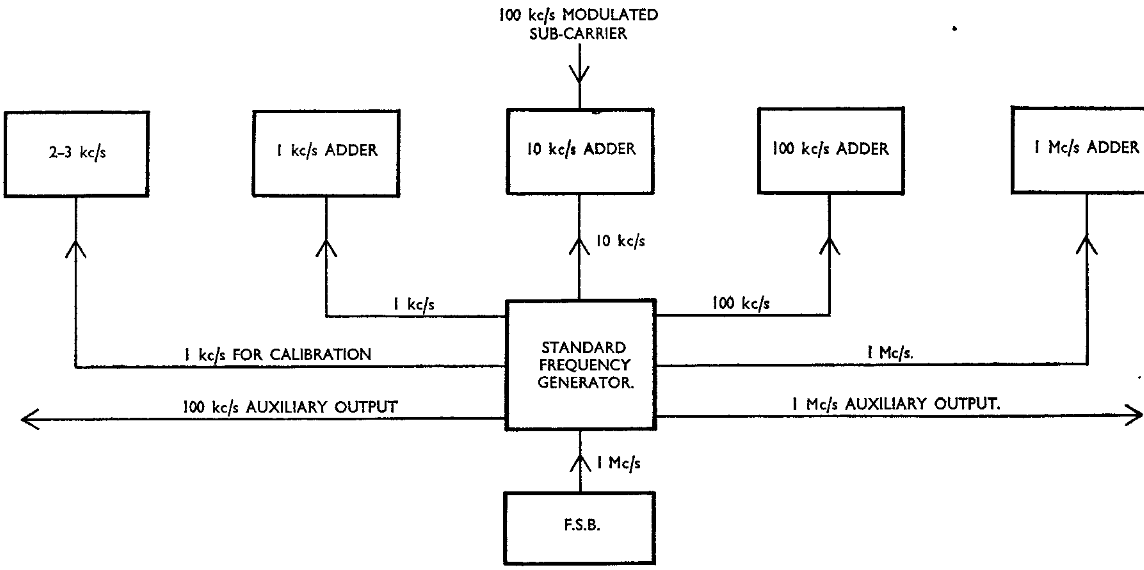


FIG. 3. FREQUENCY SYNTHESIZER (640)

1. The Frequency Synthesizer provides high frequency stability for the Transmitter. 5 decade controls provide the frequencies in steps of Mc/s, 100 kc/s, 10 kc/s, 1 kc/s and 100 cycles.

2. All these frequencies except the 100 cycles are obtained from the Master Oscillator Unit F.S.B. and have its stability. The 100 cycles is obtained from a free running oscillator which can increase any error by $\pm$ 3 cycles. All stages are transistorized.

3. **The Standard Frequency Generator.** This component contains only dividers and buffer amplifiers. The input from the F.S.B. of 1 Mc/s is converted to give outputs from this unit of 1 Mc/s, 100 kc/s, and 1 kc/s. These frequencies are fed to the appropriate adder circuits. In addition to these frequencies the Standard Frequency Generator provides two outputs for auxiliary purposes.

4. **The 2 to 3 kc/s Oscillator.** Control Switch for Fraction of kc/s.

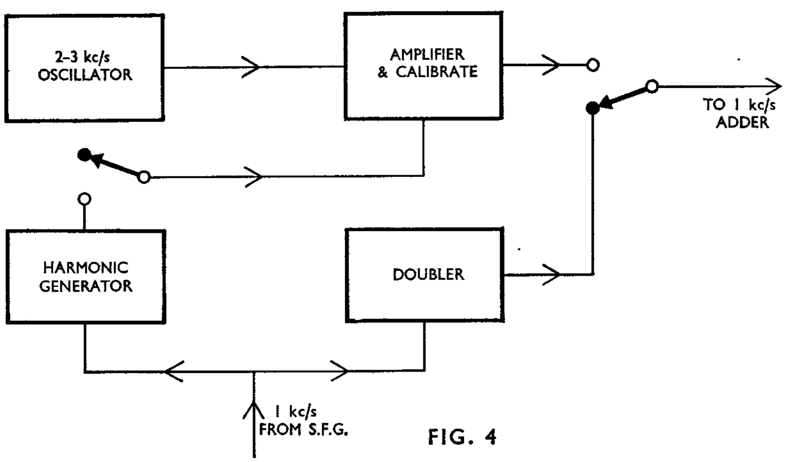


FIG. 4

Position	*Frequency*
0	Oscillator inoperative
1	2·1 kc/s
2	2·2 kc/s
3	2·3 kc/s
Etc.	Etc.
8	2·8 kc/s
9	2·9 kc/s
T1	Test 3 kc/s
T2	Test 2 kc/s

Note. Only 10 positions are marked on the switch. The two test positions on the switch are not marked but are provided for test purposes.

As the control is moved from 0 to 9 output frequency is increased in 100 cycle steps between 2·1 and 2·9 kc/s by selecting different capacitors. In the 0 position the oscillator is inoperative and the standard frequency of 1 kc/s is doubled and at 2 kc/s is used as the output when the transmitter output is an exact number of kc/s, i.e. no hundreds.

The harmonic Generator provides a 2 and a 3 kc/s output for calibration purposes. When the control is on T1 the 3rd harmonic of the 1 kc/s input is heterodyned with the oscillator output (on T2 the 2nd harmonic). The 2 kc/s is used to produce a beat at the beginning of the range and the 3 kc/s at the end. By adjusting a trimming capacitor at each end of the range the beat note can be reduced to zero to correct the frequency.

5. The 1 kc/s Adder

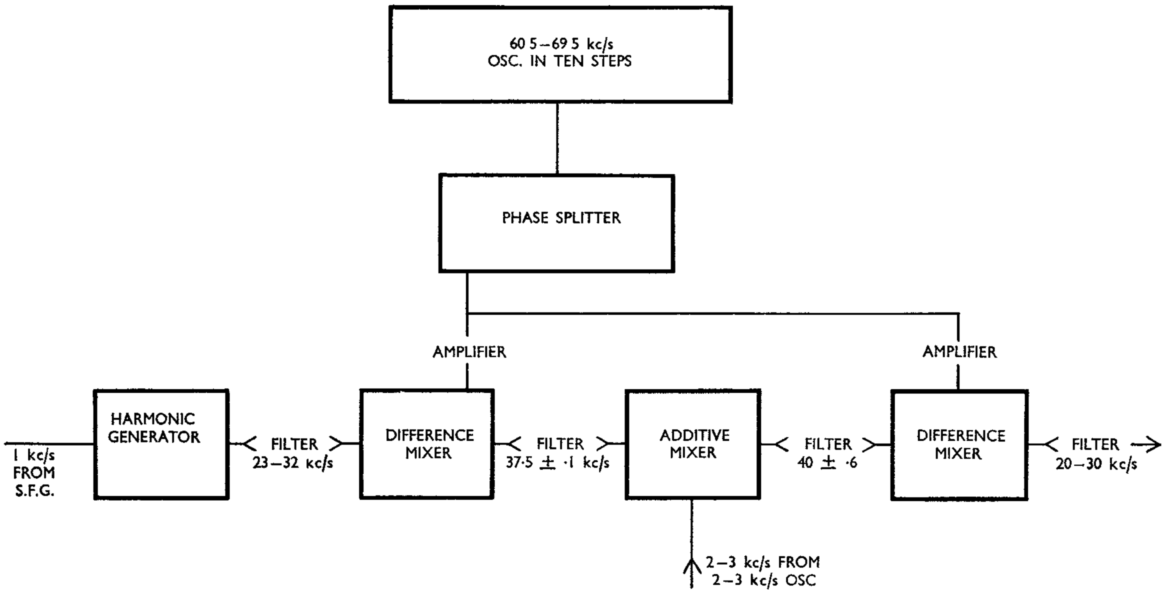


FIG. 5. 1 Kc/s ADDER

Oscillator kc/s	Harmonic Generator kc/s	Mixer Output kc/s
60·5	23	37·5
61·5	24	37·5
Etc.	Etc.	37·5
69·5	32	37·5

a. The Harmonic Generator is fed with 1 kc/s from the Standard Frequency Generator and provides harmonics of 23 to 32 kc/s. The 10 step oscillator is switched to produce one of 10 frequencies between 60·5 and 69·5 in 1 kc/s steps. The mixer input is the Oscillator Frequency plus or minus 23 to 32 kc/s and the Mixer output is 37·5±cycles selected by the Filter, *e.g.*

$$65{\cdot}5 - 28\text{th harmonic} = 37{\cdot}5 \pm 0{\cdot}1 \text{ kc/s.}$$

b. The inputs to the 2nd Mixer are:

(1) 37·5±0·1 kc/s from 1st Mixer.

(2) 2 kc/s from 2–3 kc/s oscillator – OR –

(3) 2·1 to 2·9 kc/s stepped output from the 2–3 kc/s oscillator.

The 2nd mixer is an additive mixer and the frequencies passed by this mixer are

$$37{\cdot}4+2 = 39{\cdot}4 \text{ kc/s}$$

to

$$37{\cdot}6+3 = 40{\cdot}6 \text{ kc/s}$$

That is a pass-band of 40±6 kc/s.

c. The inputs to the 3rd Mixer are:

(1) 40±0·6 kc/s from 2nd Mixer.

(2) The selected frequency (60·5–69·5) from the oscillator.

The 3rd Mixer is a difference mixer, so the output passed by this mixer is 20 to 30 kc/s (60·5—40·6 = 19·9 and 69·5—39·4 = 30·1).

Example: This example also shows on the right hand column the effect of drift in the stopped oscillator assuming this oscillator drifts 50 cycles high; note that this drift does not appear in the output.

Oscillator	66.5 kc/s	66·55
Harmonic Generator	29 „	29
1st Mixer (Difference)	37·5 „	37·55
100's (Cycles)	2 „	2
2nd Mixer (Additive)	39·5 „	39·55
Oscillator	66·5 „	66·55
3rd Mixer (Difference)	27 „	27

The output of the 1 kc/s Adder is taken to the next stage – the 10 kc/s Adder.

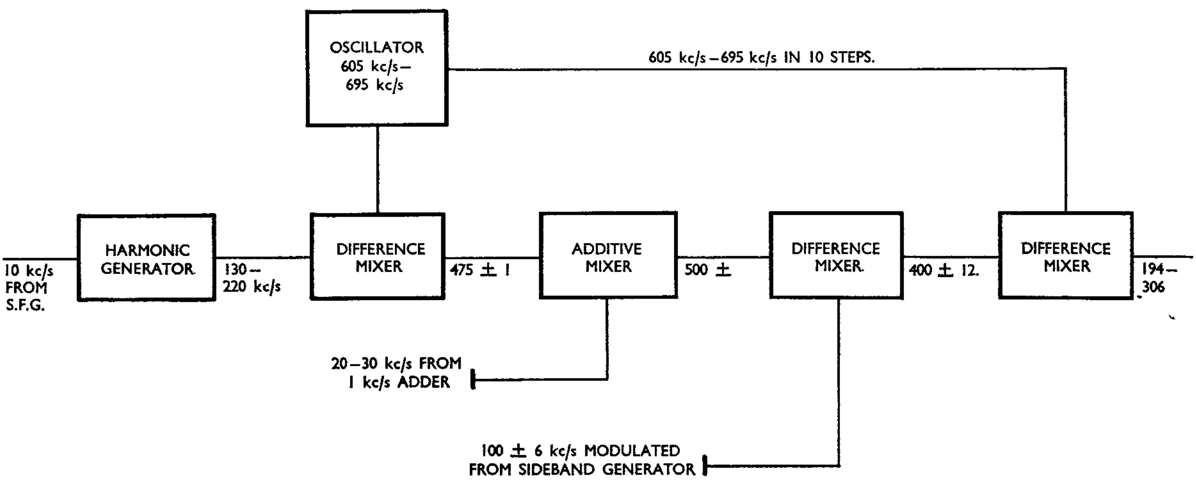


FIG. 6

6. **The 10 kc/s Adder.** The basic mixing action is as described previously, but there is an extra mixer to cater for Modulated Sub-Carrier of 100 kc/s with its 12 kc/s bandwidth. If there is no modulation the output of this stage is 209 to 300 kc/s, that is 10 times that of the previous Adder.

7. **The 100 kc/s Adder.** This is similar to the 1 kc/s Adder, except that all frequencies are multiplied 100 times to give an output of 2 to 3 Mc/s.

8. **The Megacycles Adder.** This is similar to the 1 kc/s Adder, but frequencies are different as follows:

	Frequency
Stepped Oscillator	40·5 to 67·5 Mc/s (in 28 steps).
Harmonic Generator	3 to 30 Mc/s (from 1 Mc/s F.S.B.).
1st Filter	All frequencies above 33 Mc/s attenuated.
1st Mixer	Difference Frequency.
2nd Filter	37·5—0·1 Mc/s.
2nd Mixer	Additive 2 to 3 Mc/s from 100 kc/s Adder.
3rd Filter	40±·6 Mc/s.
3rd Mixer	Difference.
4th Filter	0·1 to 28 Mc/s.

The output of the Synthesizer at 10 mW is fed into the set drive of the transmitter. A fault in the Synthesizer circuits results in weak or no output and this will show up on the drive level meter on the transmitter.

TRANSMITTER TYPE 640 – TUNING GUIDE

1. Complete the external supplies to the transmitter and the fan motor.

2. Switch on the transmitter a.c. Power Supply. It is not possible to operate this switch until all safety keys are in position and locked.

3. Set the required frequency on the synthesizer (having taken into account any offsetting required).

4. Check the frequency standard is being fed from the FSB by pressing the 1 Mc/s button between the drive controls and observing a deflection in the drive meter.

5. Switch both Channel A and Channel B switches to:

(i) Local/Remote to OFF.
(ii) Vogad/Clipper to OUT.

6. System switch to TUNE DRIVE.

7. Power Output switch to LOW.

8. V.S.W.R. meter sensitivity switch to REDUCED.

9. Make the start switch. There will be a ninety seconds delay between making this switch and the burning of the READY LIGHT.

10. When the Ready Light is burning tune the TUNE DRIVE control for a maximum in the Drive Meter. This control has a fast and slow mechanical drive. The fast drive gives the appearance of being stiff.

11. Set the SET DRIVE control to the Red Line indication in the DRIVE METER.

12. Place the System Switch to the TUNE AERIAL position.

Note. The following steps are carried out to produce a minimum standing wave ratio in the V.S.W.R. meter by altering the Capacitative (C) and Inductive (L) components, situated in the base tuned whip, by means of button controls which drive motors forward or in reverse and in turn alter the L and C components. The direction of the motors is indicated in the drawing (Fig. 7). It will be noted that each set (L and C) has a centre control for increasing the speed of the motors, but it is found that these are not normally necessary except in the initial setting up.

WHEN TUNING FOR A MINIMUM IN THE V.S.W.R. METER, SHOULD THE NEEDLE INDICATION EXCEED THE HALFWAY POSITION ON MEDIUM POWER OR ABOVE, REDUCE POWER AND RETUNE.

13. Set Aerial Tuning buttons as follows:

a. Capacitance to Zero.

b. Range as indicated on tuning settings. (The switch above this control governs the direction of range settings.)

c. Inductance to approximately 25.

14. Commence tuning aerial by increasing C and searching for a minimum in V.S.W.R. Meter. When found note the reading.

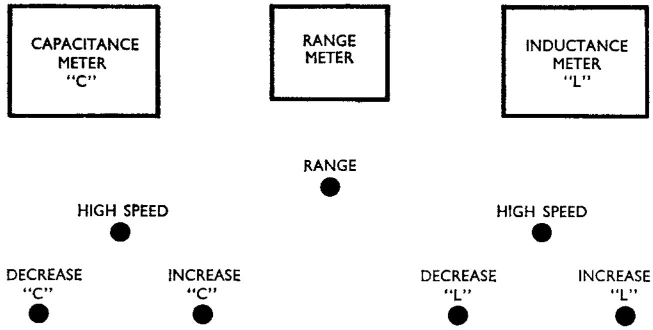


FIG. 7. LAYOUT OF AERIAL TUNING CONTROLS

15. Increase L and retune C into a minimum. Should this reading be higher than that noted before, decrease L and retune C.

16. Sensitivity switch to NORMAL.

17. Increase or decrease L retuning C until the reading nearest 1 is obtained in the V.S.W.R. Meter

18. Should a reading of 1 not be found when:

a. L is at a minimum, then decrease range one position.

b. L is at a maximum, then increase range one position and carry out tuning drill from (13) again.

19. Switch to MEDIUM power and retune – V.S.W.R. Meter nearest 1 or in the green belt.

20. Switch to HIGH power and carry out same procedure.

21. Switch to FULL power and adjust SET DRIVE to bring power output meter to '500' watts P.E.P. The V.S.W.R. Meter should not be above the green belt reading. If it is then reduce power and retune.

22. The equipment is now tuned.

23. Switch to Low Power and select REMOTE/LOCAL and EMISSION as required.

Note. Should the OVERLOAD RELAY trip, indicated by a loss of drive and overload Relay Lamp burning (usually because of mismatch), reduce power to Low, reset OVERLOAD RELAY and retune.

24. Set Power Output Switch to required power.

Selection of Emission

25. C.W., M.C.W., and D.S.B. can only be selected on Channel A. When either of these emissions are selected Channel B is to be switched OFF.

26. I.S.B.(S.C. or I.S.B.(P.C.) may be selected on either channel, but at present only one channel may be used at a time.
When using these emissions Channel A indicates UPPER SIDE BAND and Channel B indicates LOWER SIDE BAND.

Miscellaneous

27. Aerial tuning buttons are inoperative when switched to:

a. TUNE AERIAL – FULL POWER or

b. When System Switch is on other than TUNE AERIAL.

28. Should the synthesizer be altered even by point one of a kilocycle the transmitter will revert to TUNE and the correct procedure by switching to LOW POWER – TUNE DRIVE – RETUNING must be carried out again.

29. The 640 was designed for use on I.S.B. and therefore the frequency setting dials display the frequency of the Carrier on C.W. as the centre frequency on I.S.B. There is, therefore, a requirement to offset the dial readings when working in S.S.B. Voice or F.S.T., since it is mandatory that the radiated output should straddle the Assigned Frequency~~. Full explanation is given in Section 9-1~~. Full explanation is given in Sections 1.15 and 1.16

2.19. TYPE 641

HANDBOOK: B.R. 4144(2)

ESTABLISHMENT LIST: S.1555

1. General Description

a. Purpose. Type 641 is designed as a 100 W self-tune HF transmitter/receiver outfit suitable for fitting as the emergency HF equipment in frigates and above.

b. Capabilities:

(1) FREQUENCY RANGE:

1.5 to 24 MHz	As simplex transmitter/receiver outfit.
240 to 525 kHz	Additional frequency range covered by receiver only.
1 to 27.9 MHz	

(2) TYPES OF EMISSION.—Type 641 is designed as a s.s.b./i.s.b. transmitter and is capable of the following:

c.w.	(A1)
m.c.w.	(A2H—compatible with A2)
f.s.t.	(F1)
s.s.b.	(A3A, A3J)
i.s.b.	(A3B, A9B)
d.s.b.	(A3H—compatible with A3)

(3) OUTPUT POWER.—100 W maximum (variable in 1 dB steps).

(4) INPUT POWER.— 100 to 130 V or 200 to 250 V 50/60 Hz, 1230 W (maximum, when tuning).

(5) FREQUENCY ACCURACY.—Equal to that of the external frequency standard on integral 1 kHz steps, less than ±0.25 Hz on intermediate 100 Hz steps.

(6) KEYING SPEED (c.w.).—Maximum 30 bauds (40 w.p.m.).

(7) ASSOCIATED AERIAL OUTFITS:

Either AWF—35 ft. whip
or AWN—30 ft. whip
or AWH—24 ft. whip

} Below 3 MHz the percentage efficiency corresponds very roughly to the aerial length. Above 4 MHz this is roughly doubled.

2. Description of Units (Fig. 1).

a. Type 641 consists of the units tabulated below. Brief details of them are given in paragraphs 3 to 8:

UNIT NO.	TITLE/DESCRIPTION	PATTERN NUMBER
1	2	3
1	Synthesizer Electrical Frequency	5820-99-519-7000 (Marconi 3786F)
2	Modulator—Tuning Unit	5820-99-519-6983 (Marconi M30 1071 01)

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UNIT NO.	TITLE/DESCRIPTION	PATTERN NUMBER
3	Control and Power Supply Unit	5820–99–519–7005 (Marconi M30 1069 01)
4	Amplifier Radio Frequency	5820–99–519–7014 (Marconi N1050)
5	Antenna Matching Unit	5820–99–519–7033 (Marconi N7100)
6	Receiver Radio Frequency	5820–99–519–7019 (Marconi N2020)

b. Some of the above units are used to make up other outfits as follows:

(1) Units 1 and 6.—Receiver Outfit CJM.

(2) Units 1 and 2.—Transmitter Drive Outfit TDC.

c. *Brief Functional Description of Units:*

(1) The frequency synthesizer which is common to both transmitter and receiver is fed with a 1-MHz input from an external frequency standard from which is derived all other frequencies employed in the system. For the transmit path the frequency synthesizer feeds 100 kHz to the modulator tuning unit where it is modulated by 1 or 2 inputs to produce a s.s.b./i.s.b. modulated sub-carrier. This 100-kHz sub-carrier is fed back to the synthesizer where it is raised to the required output frequency which is then applied to the tuning unit section of the modulator tuning unit where it is amplified to provide an r.f. output of 100 mW. This 100 mW r.f. signal is fed via a wide-band preamplifier to the final single valve r.f. amplifier (PA) stage. Matching between the PA and the whip antenna is achieved by means of an automatically selected LC network which is located in the amplifier r.f. unit and the antenna matching unit. During transmit periods the receiver is earthed to prevent damage from the break-through of the transmitter output.

(2) For the receive path, as in the transmit path, the synthesizer provides all the frequencies employed in the receiver; 2 to 3 MHz, 37·5 MHz, 40 to 67·5 MHz and 100 kHz. The receiver may be used for the reception of frequencies outside the range of the transmitter in which case the antenna matching unit circuits will not be matched and reception may be slightly degraded. The r.f. signal is fed from the whip aerial through the antenna matching unit and then to the receiver where an overload protection device guards against excessive r.f. voltages. The r.f. signal is changed to two or three intermediate frequencies, dependant upon the frequency range, which is then detected and the resultant audio frequency is fed via a.f. amplifiers to headphones or loudspeaker system.

(3) TRANSMITTER STATE.—This is indicated by five lamps mounted on the modulator tuning unit as follows:

1 .. Unready ..	ORANGE	4 .. Tune ..	YELLOW
2 .. Ready ..	GREEN	5 .. Overload ..	RED
3 .. In use ..	WHITE		

(4) RECEIVER STATE.—This is indicated by two lamps on the receiver front panel as follows:

1 .. Tuning ..	YELLOW	2 .. Cutout ..	RED

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(5) TUNING.—The transmitter and receiver are tuned by an automatic tuning system which is controlled by the setting of the synthesizer decade selector switches. The setting of the MHz selector controls the supply to a Ledex motor which operates the range switching. Fine tuning is carried out by servo motors which are controlled by the setting of all five of the decade selector switches.

3. The Synthesizer

a. The purpose of the synthesizer which is shared by the transmitter and receiver is to:

(1) provide the frequency or frequencies required for the transmitter and receiver, based on the extremely accurate frequency standard. The accuracy (or nearly so) of the frequency standard is maintained by the synthesized frequency;

(2) provide control for the automatic tuning system.

b. Frequency range.—The frequency range of the synthesizer is 0.24 MHz to 27.999 MHz. The usable frequency when used with Type 641 is:

Transmitter—1.5 MHz to 24 MHz.

Receiver—240 kHz to 525 kHz.
1.06 MHz to 27.999 MHz.

c. Front panel controls:

(1) Five controls, as given below, are used to set on the required frequency of the transmitter and/or receiver:

Control	*Position*	*Control*	*Position*
MHz	0–27	1 kHz	0–9
100 kHz	0–9	.1 kHz	0–9
10 kHz	0–9		

(2) CAUTION.—These controls should not be set to frequencies outside the range of the transmitter or receiver nor should they be set to a blank dial setting.

4. The Modulator Tuning Unit (Figs. 1, 2, 3)

a. Purpose.—The modulator is required to convert the a.f. intelligence to a s.s.b. or i.s.b. input suitable for feeding to the synthesizer for synthesizing the selected r.f. frequency. The tuning unit is required to increase the output of the synthesizer to 100mW (P.E.P.) to drive the P.A. stages.

b. The modulator-tuning cabinet contains:

The Modulator
The Tuning Unit (Drive Amplifier)

c. Front Panel Controls/Indicators/Switches.—Details of the controls, indicator lamps, meters and fuses fitted on the front panel are given in the following sub-paragraphs:

(1) CONTROLS (Fig. 1):

SWITCH/CONTROL	POSITIONS	FUNCTION
1	2	3
Supply	On/Off	Completes the power supply to the modulator tuning unit, control power supply unit, r.f. amplifier, and antenna matching unit.
Tune	Pressed/Released	Pressed to start the transmitter tuning sequence.
Reset	Pressed/Released	Pressed to reset the transmitter overload.

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SWITCH/CONTROL	POSITIONS	FUNCTION
R.F. Interlock	On/Off	Completes the r.f. keying lines.
Drive Attenuator	0–30 dB	Controls the output of the transmitter in 2 dB steps.
0–1 dB	0–1 dB	In conjunction with drive attenuator controls the output of the transmitter in 1 dB steps.
Metering	Various	Permits metering of the various circuits.
USB Input Selector	Loc/Rem 1/Rem 2	Selects the position from which the u.s.b. is to be operated (keyed).
USB System Selector	Off/SSB SC/SSB PC/ DSB/CW/MCW	Selects the emission to be used on the u.s.b.
LSB Input Selector	Loc/Rem 1/Rem 2	Selects the position from which the l.s.b. is to be operated (keyed).
LSB System Selector	Off/SSB SC/SSB PC	Selects the emission to be used on the l.s.b.
Volume	—	Controls the volume in the monitor headphones and loudspeaker.
Monitor	Rem 1/Rem 2	Permits monitoring at the local position of either the Rem 1 or 2 positions.
Test Key	—	Permits the radiation of a c.w. test signal.

(2) TRANSMITTER STATE LAMPS.—The following lamps, labelled as shown, are used to indicate:

Equipment not ready for use .. .. UNREADY
Equipment ready for use .. .. READY
Equipment is in use .. .. IN-USE
Equipment is in process of tuning .. .. TUNE
The PA stage is drawing excess current or the PA valve cooling system has failed OVERLOAD

(3) METERS.—The antenna indicator meter and a universal test meter are fitted on the front panel.

(4) FUSES.—The following fuses and fuse warning lamps are fitted on the front panel:

Modulator Tuning Unit
Control Power Supply Unit, HT and LT Supplies

d. Other Controls.—Control switch, −16 −26 dB which controls the level of the radiated pilot carrier is mounted behind the front panel on the top right-hand side. To obtain access the drawer must be opened. The −16 dB position gives a pilot carrier of approximately 2.5 W and the −26 dB position a pilot carrier of approximately .25 W.

5. **Control Power Supply Unit.** (Fig. 4).

a. Purpose.—To provide the power supplies required by the pre-amplifier and PA stage and for keying, control and tuning.

b. Front Panel Controls/Indicators/Switches:

(1) CONTROLS:

(a) Metering.—Permits metering of the various outputs of the power supply unit.

(b) Overload Reset.—To reset the transmitter overload.

(c) Overload Trip Calibration and Test Trip.—These 2 controls are for use in testing the overload relay.

(2) INDICATOR LAMPS.—HT indicator lamp to indicate the HT and SG supplies are on.

(3) METERS.—The universal test meter.

(4) FUSES.—Fuse indicator lamps for the +30V and −30V control voltage.

6. **The Radio Frequency Power Amplifier.** (Fig. 4)

a. Purpose.—To provide an output of 100 W into a 50-ohms transmission line over the frequency range 1.5 to 24 MHz from an input signal of about 1 W (P.E.P.)

b. Front Panel Controls.—Nil.

7. **The Antenna Matching Unit.** (Fig. 4).

a. Purpose.—To provide the coupling between the 50-ohms feeder of the PA stage and the antenna and to allow for correct impedance matching over the full frequency range for the particular antenna.

b. Front Panel Controls.—Nil.

8. **The Receiver Radio Frequency.** (Figs. 5 and 6)

a. Purpose.—To provide an i.s.b. receiver with automatic tuning capable of receiving all modes of telegraphy or telephony transmissions.

b. Frequency Range:

MF 240—525 kHz	Full performance.
HF 1.06—1.499 MHz	Slightly degraded performance.
HF 1.5—27.5 MHz	Full performance.
HF 27.6—27.999 MHz	Slightly degraded performance.

c. Frequency Stability:

On exact multiples of 1 kHz	Stability as for external frequency standard in use.
On exact multiples of .1 kHz	Stability ±.25 Hz over the full temperature range.
On exact multiples of 10 Hz	Stability ±5 Hz over the full temperature range. (±1 Hz on constant ambient temperature).

d. Power Supplies.—100 to 130 V or 200 to 250 V 50/60 Hz 150 W.

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e. Front Panel Controls/Indicators/Switches.—Details of these are given in the following sub-paragraphs:

(1) CONTROLS:

SWITCH/CONTROL	POSITION	FUNCTION
1	2	3
Supply	On/Off	Completes the power supply to the receiver and synthesizer units.
Fine Tuning	−50 to +50 Hz	Varies the 100 kHz oscillator from −50 to +50 Hz in 10 Hz steps.
R.F. Gain	—	Manual control of the gain of the r.f. and i.f. stages via the A.G.C. line.
Mute	On/Off	Control of the receiver muting.
Metering	Various	Permits metering of supplies and test points.
USB System Selector	Off/SSB/DSB/MCW CW/FST/Data	Selects the filters, A.G.C. time constants etc. appropriate to the mode selected.
LSB System Selector	Off/SSB/Data	
USB Output Selector	Loc/Rem 1/Rem 2	Connects the appropriate sideband output to the output channel selected.
LSB Output Selector	Loc/Rem 1/Rem 2	
USB Squelch	On/Off	Controls the squelch circuit for each sideband output.
LSB Squelch	On/Off	
Monitor Headset	USB/Off/LSB	Connects the selected output to the monitor headset and monitor loudspeaker.
Monitor Loudspeaker	USB/Off/LSB	
Monitor Volume		Controls the volume in the monitor headset and loudspeaker.

(2) INDICATOR LAMPS.—The following lamps, labelled as shown, are used to indicate:

Receiver or transmitter is in process of tuning .. .. TUNE

R.F. protection circuit has operated.
Ledex motor supply has failed. .. .. CUTOUT
Ledex motor has jammed.

(3) METERS.—A universal test meter is fittted and used in conjunction with the metering switch.

(4) FUSES.—The following fuses and fuse warning lights are fitted:

Synthesizer	Receiver	HT	FIL

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TUNING AND OPERATING INSTRUCTIONS

9. General

a. The transmitter.—The frequency range of the transmitter is 1.5 to 24 MHz. On no account should the TUNE switch be depressed when the synthesizer is set to frequencies outside this range. If this should be done accidentally a maintainer will be required to free the automatic tuning controls.

b. The receiver.— The receiver may be set to any frequency within the range 240 to 525 kHz and 1 MHz to 27.999 MHz. It is not necessary to depress the TUNE switch to tune the receiver. Frequencies outside this range must not be set on the synthesizer.

c. After the tuning sequence has been completed any alteration of the decade switches on the synthesizer will require the tuning sequence to be carried out again.

d. Frequencies.—The frequency set on the synthesizer is the frequency of the carrier. The necessary offset must be made to ensure that the centre of the radiated bandwidth coincides with the *assigned frequency*.

(1) For c.w. working.—The frequency set on the synthesizer is to be 1 kHz below the assigned frequency.

(2) For d.s.b. and m.c.w. working.—The frequency set on the synthesizer is to be the assigned frequency.

(3) For s.s.b. voice working.—When using u.s.b. the frequency set is to be 1.5 kHz below the assigned frequency. When using the l.s.b. the frequency set on the synthesizer is to be 1.5 kHz above the assigned frequency.

(4) For f.s.t. working.—The centre of the 2 tones must coincide with the assigned frequency.

10. Tuning

a. A Tuning Guide showing the manual actions required for setting up the equipment and the sequence of the automatic tuning action is contained in para. 12.

b. Procedure for Setting Receiver Controls.—The following procedure should be used:

(1) R.F. GAIN CONTROL (SQUELCH TO BE USED).—Set the meter switch to Position 16 or 17, adjust the r.f. gain control until the meter starts to rise, set the gain control a further 20 dB above the point at which the meter started to rise. The gain control is calibrated in dBs and is marked from 0 to 120.

(2) R. F. GAIN CONTROL (SQUELCH NOT REQUIRED). Set control fully clockwise, i.e., in the silver-coloured zone.

(3) SQUELCH CONTROLS. After setting the r.f. gain control, switch the u.s.b. and l.s.b. squelch controls ON. The receiver output will be attenuated whenever the signal output drops by more than 20 dB. The r.f. gain control may be adjusted up or down if squelch is required to operate at a level above or below 20 dB.

(4) MUTE SWITCH. This will normally be made to ON whenever the transmitter is being used.

(5) FINE TUNE CONTROL. This is normally set to 0. It may be adjusted as required to improve the clarity of the signal either by ear for voice transmissions, or by monitor instrument for f.s.t. or data transmissions.

11. Operating.

a. Procedure for Resetting the Transmitter Overload and Receiver Cutout:

(1) Transmitter Overload. Press the overload RESET button on the modulator tuning unit or the control power supply unit. If overload continues to operate send for a maintenance mechanic.

(2) Receiver Cutout. Switch off the receiver power supply, pause for 30 seconds and then remake the power supply. If cutout continues to operate send for a maintenance mechanic.

b. Lamp Indicator State. The details in (1) and (2) below give the key to the various combinations of these lamps.

(1) Transmitter (Modulator Tuning Unit):

STATE LAMP						INDICATION
Supply	Unready	Ready	In Use	Tune	Overload	
1	2	3	4	5	6	7
ON	ON					HT has not been applied to PA because of 30 sec. warm up delay.
ON		ON		ON		Supplies complete. Ready to tune.
ON			ON	ON		Equipment is being tuned. (Not yet complete).
ON		ON				Equipment tuned and ready for use.
ON		ON	ON			Equipment in use.
ON	ON				FLASHING	Overload has operated because cooling system in PA stage has failed.
ON	ON				ON	Overload has operated because PA valve is drawing excessive current.

(2) Receiver:

STATE LAMP			INDICATION
Supply	Tuning	Cutout	
1	2	3	4
ON	ON		Receiver or transmitter is being tuned.
ON		FLASHING	Ledex switching motor has jammed.
ON		ON	Aerial overload has operated or auxiliary supplies have failed.

c. Overload Trip Calibration Control and Test Trip Control:

(1) These controls are for testing the operation of the HT overload. The test trip control switch is pressed and the calibration control turned clockwise until the overload operates. Release of the test trip switch resets the overload.

(2) These controls are for maintainer and not user operator use.

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12. TUNING GUIDE AND SEQUENCE OF EVENTS

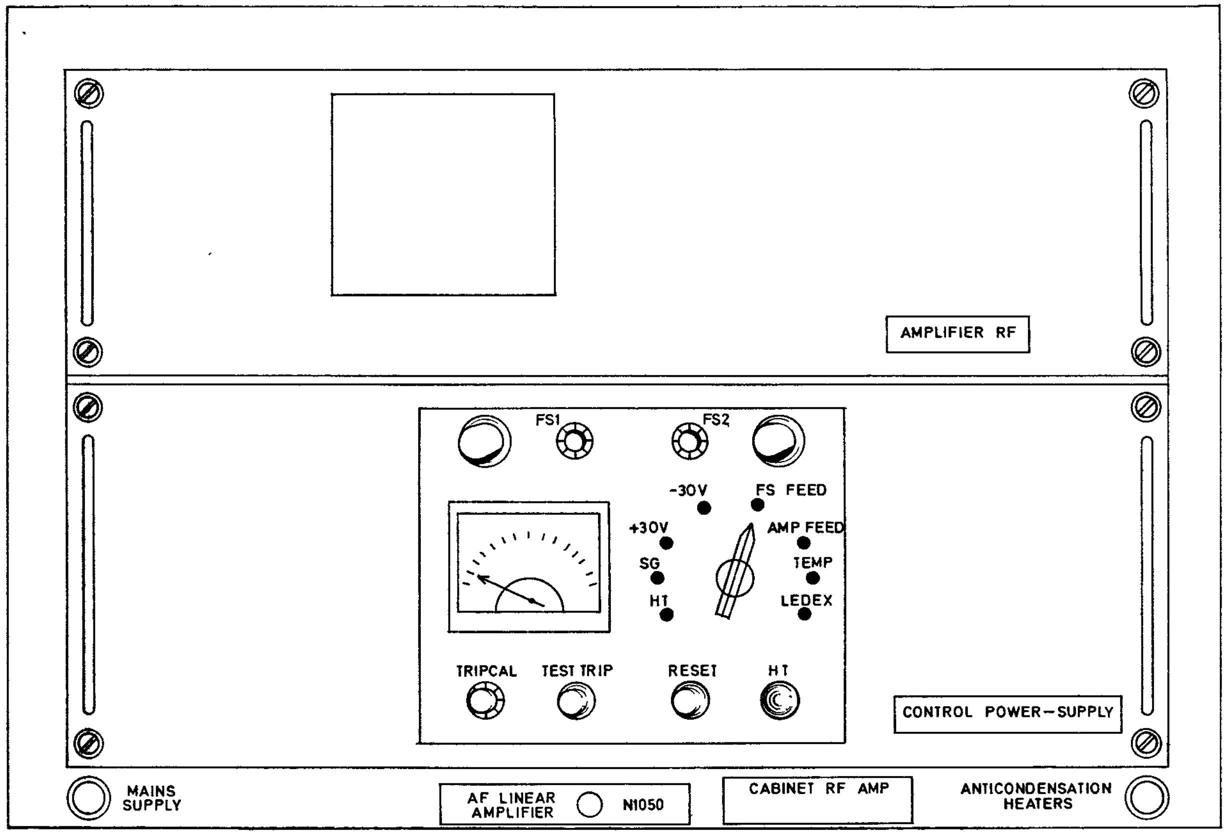
1. The table below shows the manual actions required for setting up Type 641 and the sequence of events in the automatic tuning process.

2. The times indicated in Column 2 are the maximum times. Tuning will normally be quicker than this.

EVENT NO.	TIME (Seconds)	MANUAL ACTION	AUTOMATIC ACTION	LAMP INDICATION				REMARKS
				UNREADY	READY	TUNE	IN USE	
1	2	3	4	5	6	7	8	9
1		PUT main supply switch to ON						r.f. amplifier cabinet light on.
2	Zero	PUT modulator tuning unit supply switch to ON		ON	OFF	OFF	OFF	Drive cabinet modulator tune unit lights on.
3		PUT r.f. interlock switch to ON						Key must be in lock
4		PUT receiver supply switch to ON						Receiver supply light and synthesizer dial lights on.
5		SET receiver upper and lower sideband system switch to system required						
6		SET receiver output switches to LOC/REM 1/REM 2 as required						
7		SET receiver L/S and H/SET switches as required						
8		SET the frequency required on the synthesizer	Receiver tunes to the synthesizer frequency			ON		Receiver TUNE light on whilst tuning.
9		SET the receiver r.f. gain control						See paragraph 10 *b*.
10		ADJUST receiver fine tuning control						
11		SET receiver squelch switches to ON						
12		SET receiver MUTE switch to ON						Receiver is now ready for use.
13	+30		HT delay contactor ON	OFF	ON	ON	OFF	HT lamp on.
14		DEPRESS the TUNE switch		OFF	OFF	ON	ON	Supply to tuning motors completed.
15			Range switches operate. PA output to dummy load					
16	+31		r.f. amplifiers and PA grid circuits tune					
17	+40		PA anode circuit coarse tunes. AMU band switches operate					

(continued overleaf)

EVENT NO.	TIME (Seconds)	MANUAL ACTION	AUTOMATIC ACTION	LAMP INDICATION				REMARKS
				UNREADY	READY	TUNE	IN USE	
1	2	3	4	5	6	7	8	9
18	+44		AMU capacitor to minimum. PA anode fine tunes. r.f. output from dummy load to AMU. AMU coil coarse tunes					
19	+49		AMU coil and capacitor fine tune					
20	+50		Tune off	OFF	ON	OFF	OFF	Supply to tuning motors broken.
21		PRESS test key and observe antenna meter reads between 200 and 300						
22		SET the drive attenuator for output power required						
23		SET the upper and lower sideband switch to system required						
24		SET the input switches to the LOC/REM 1/REM 2 position required						EQUIPMENT IS NOW READY FOR USE.



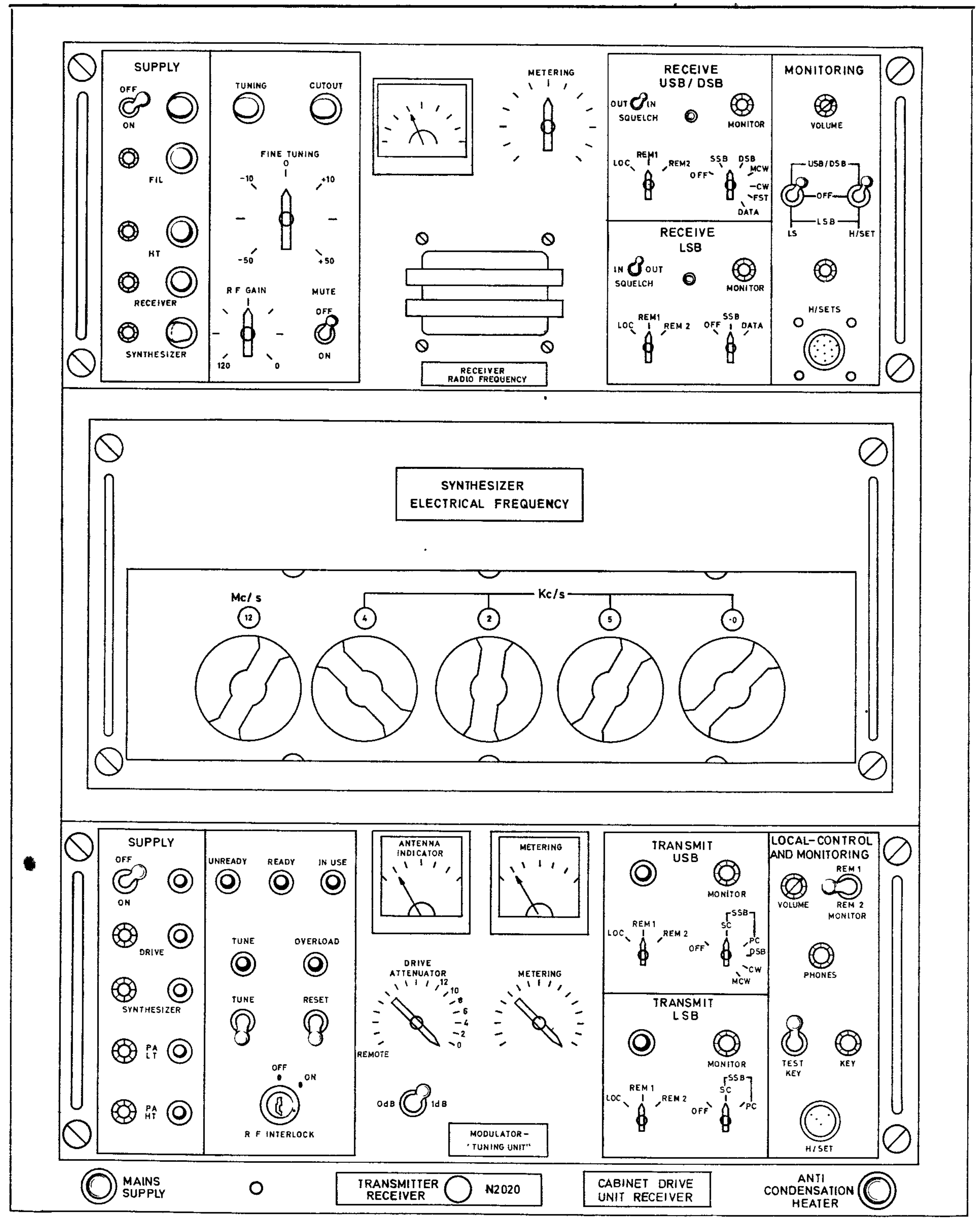


FIG. 1. TRANSMITTER/RECEIVER TYPE 641

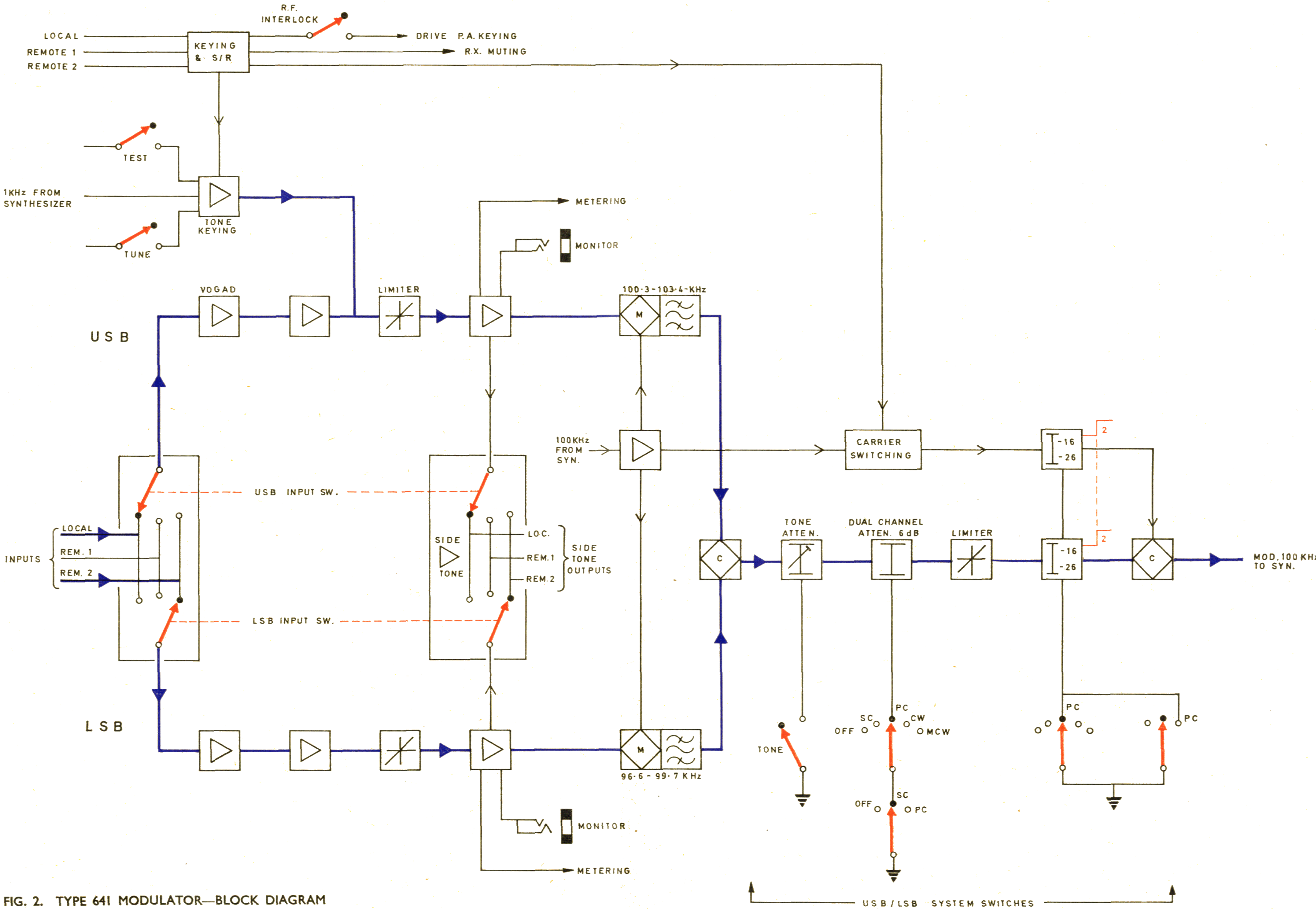


FIG. 2. TYPE 641 MODULATOR—BLOCK DIAGRAM

169471—25-26

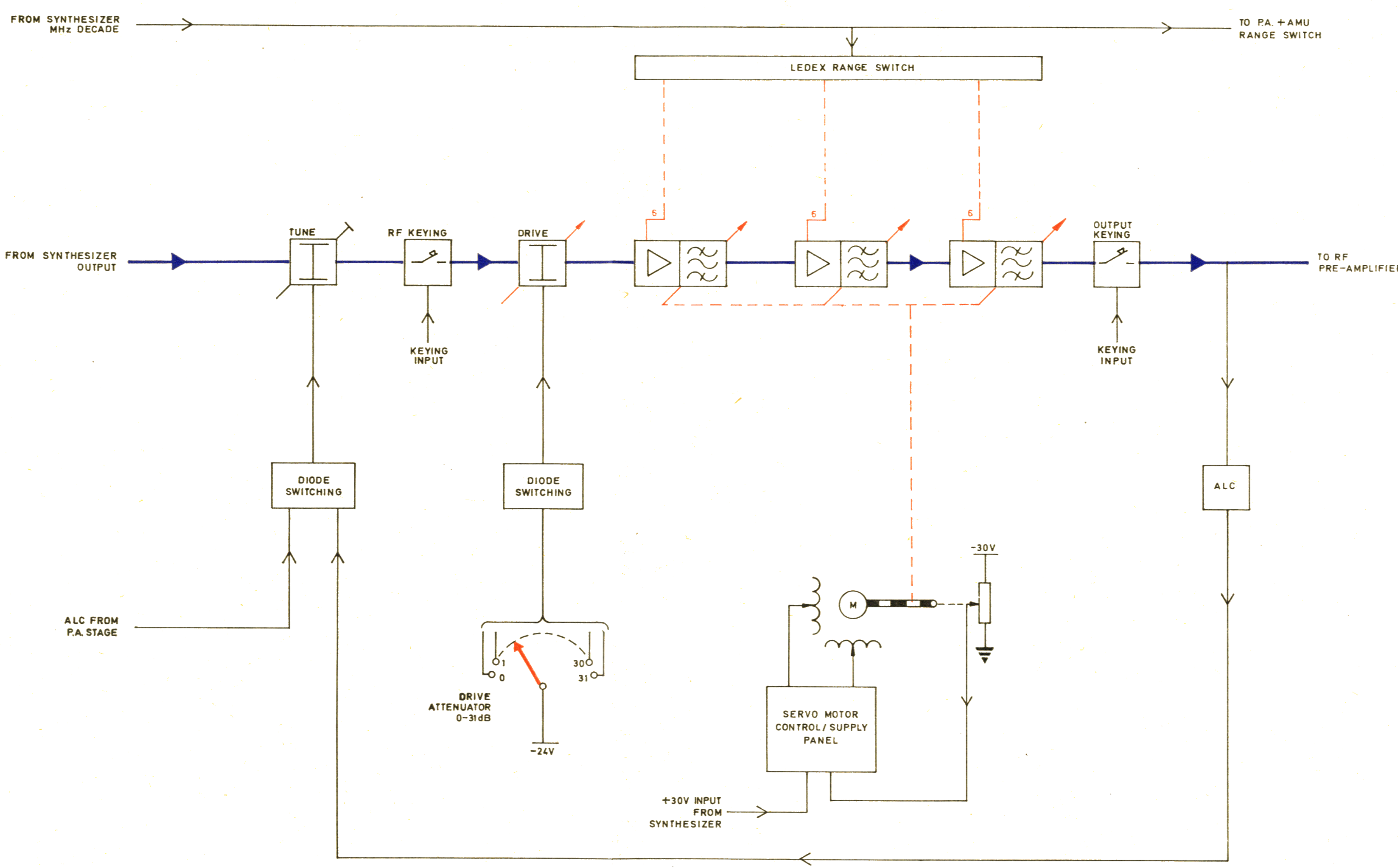


FIG. 3. TYPE 641 DRIVE UNIT—BLOCK DIAGRAM

169471—27–28

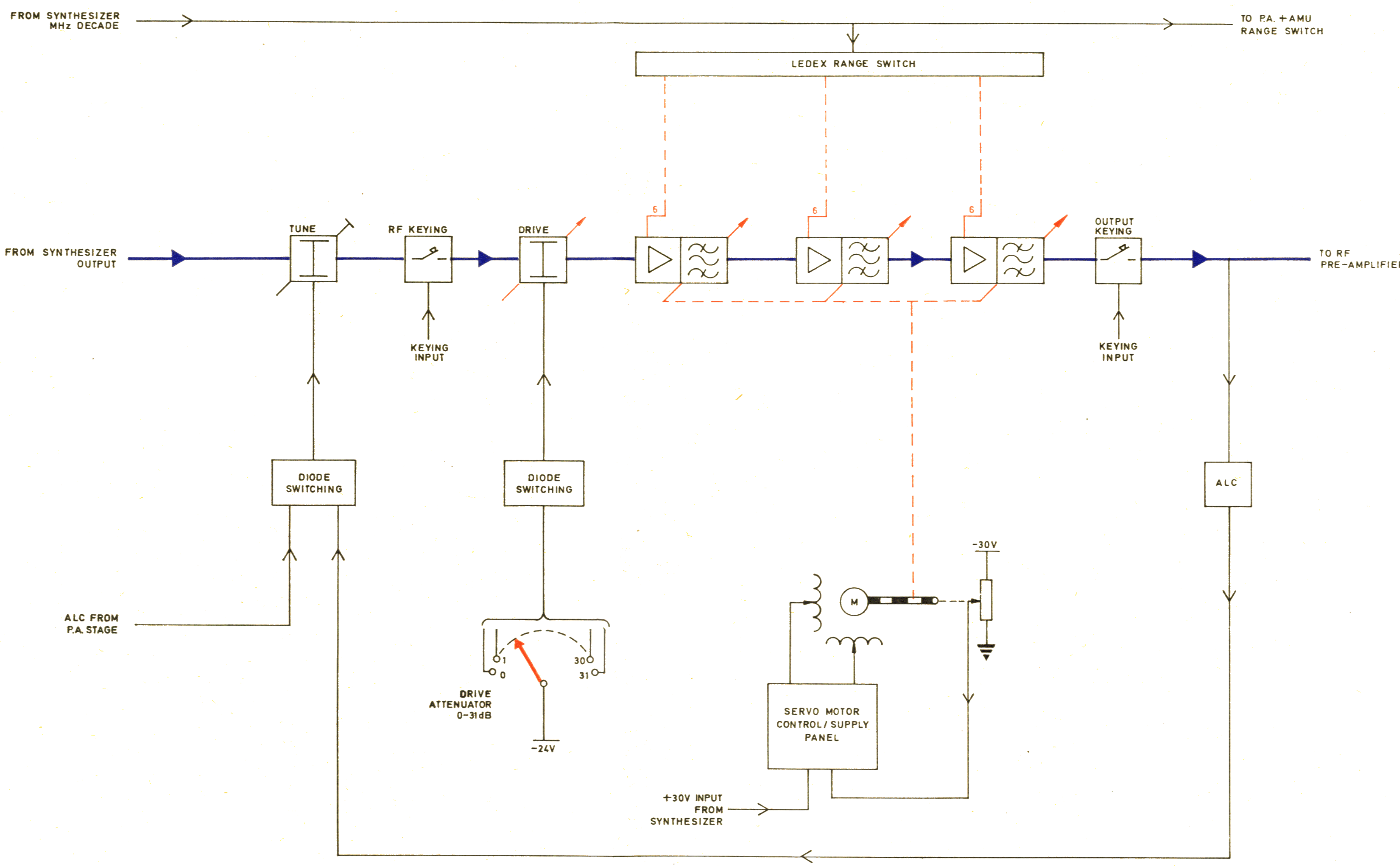


FIG. 3. TYPE 641 DRIVE UNIT—BLOCK DIAGRAM

169471—27–28

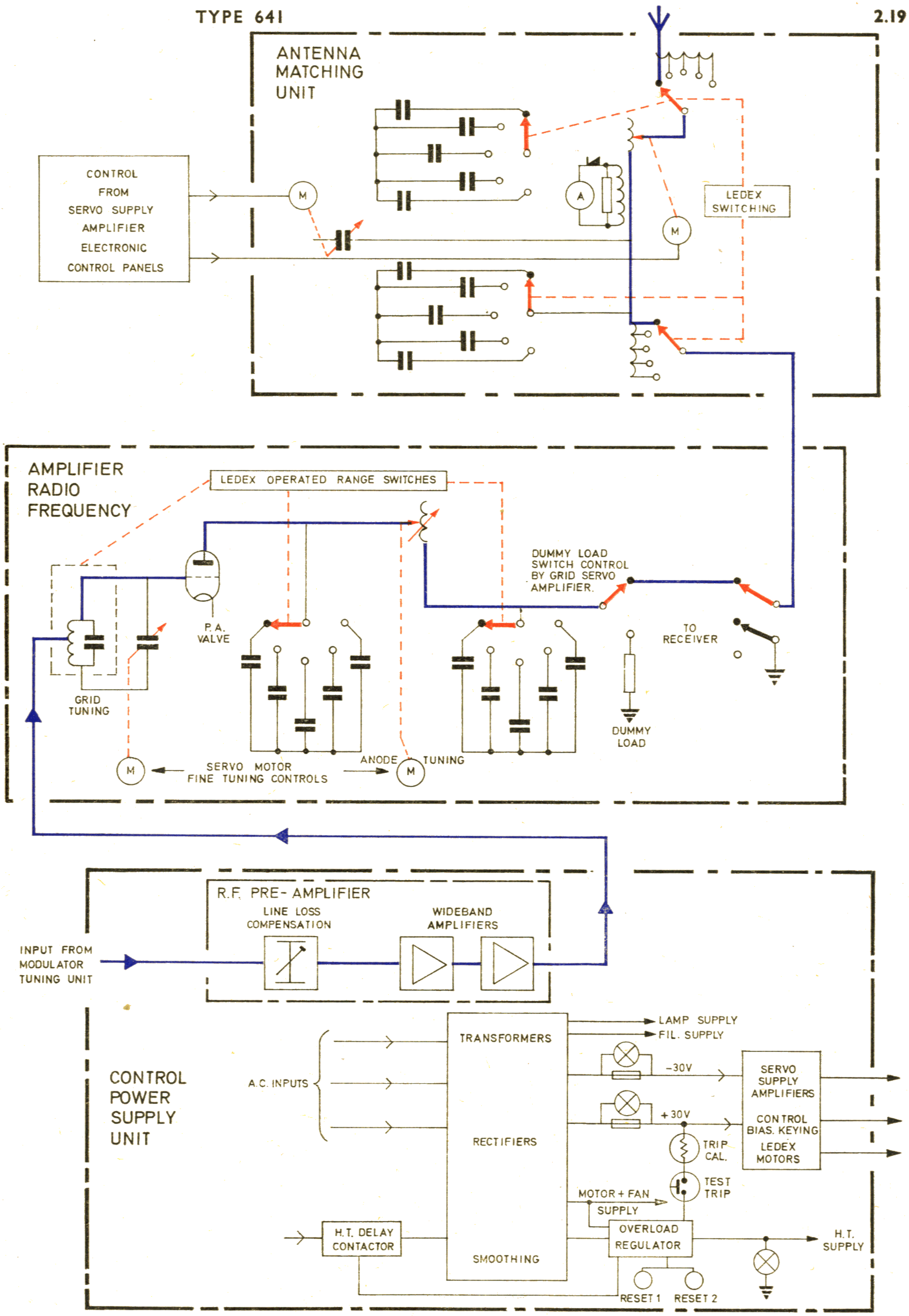


FIG. 4. TYPE 641
CONTROL PS, R.F. AMP AND AMU

169471—29–30

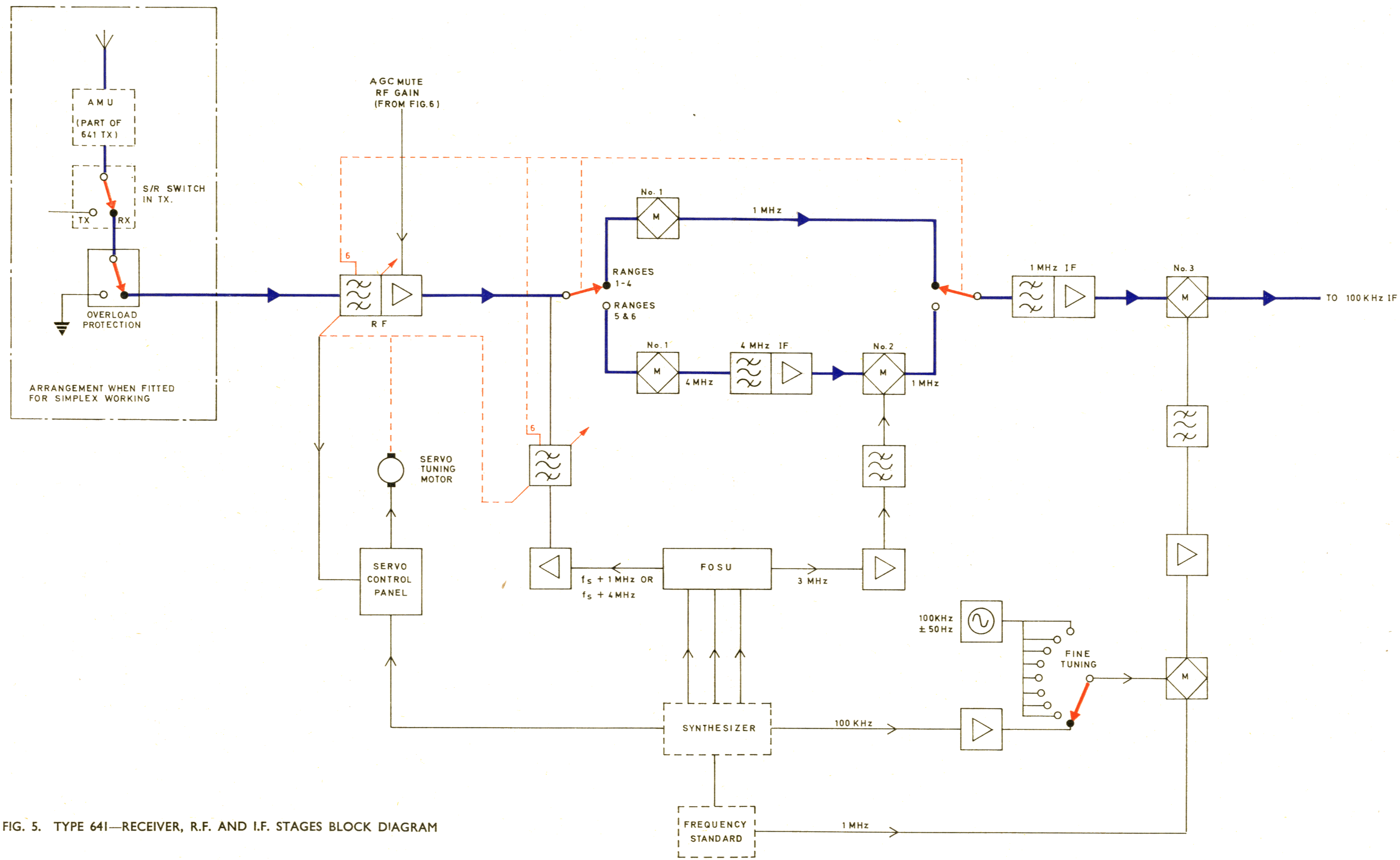


FIG. 5. TYPE 641—RECEIVER, R.F. AND I.F. STAGES BLOCK DIAGRAM

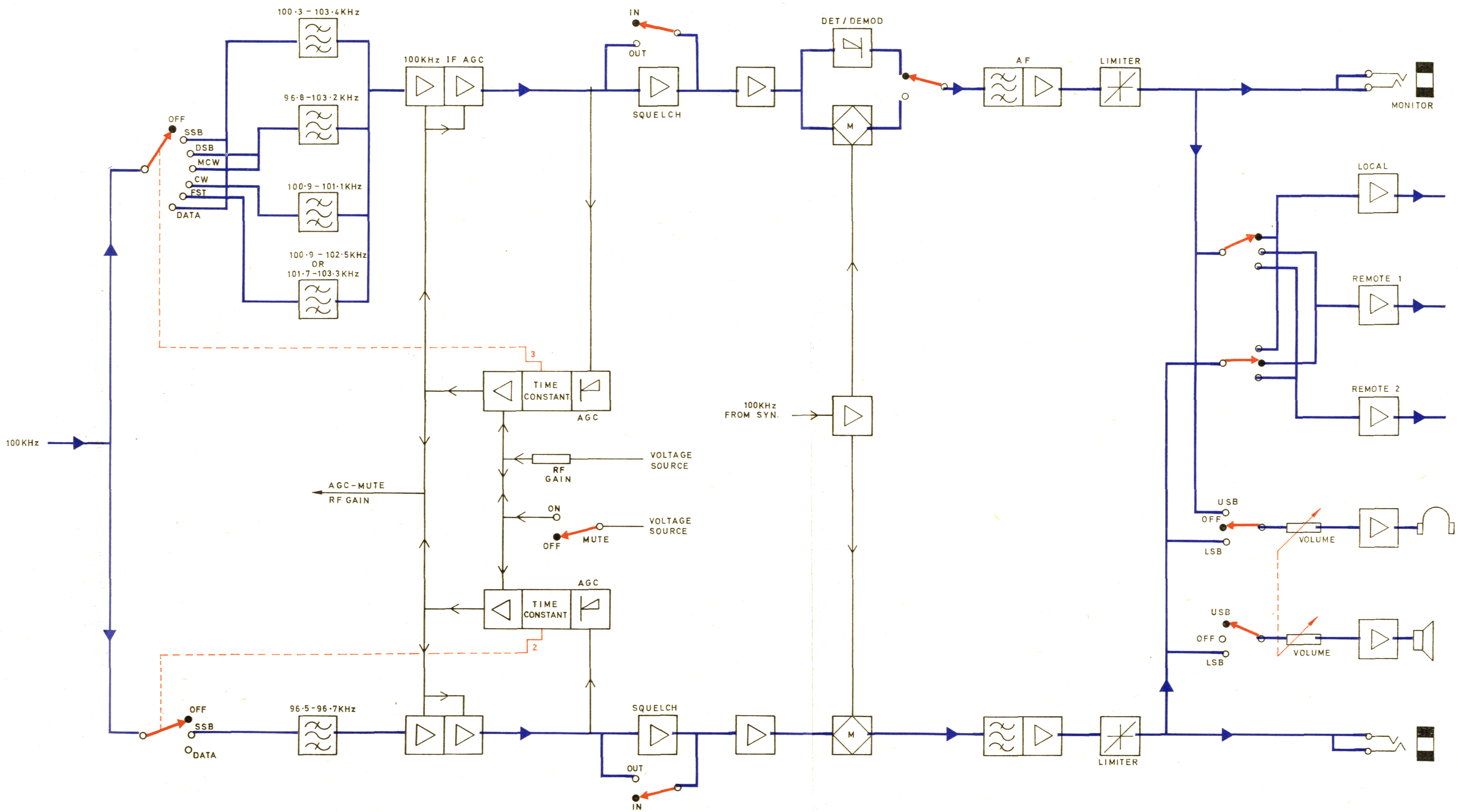


FIG. 6. OUTFIT CJM—RECEIVER, I.F. AND A.F. STAGES—BLOCK DIAGRAM

169471—33—34

2.20. TYPE 689

HANDBOOK. B.R. 2305

ESTABLISHMENT LIST. E 1326

FREQUENCY RANGE. 28 channels in the Band 156–162 Mc/s

RECEIVER. Simplex. 156·3–156·8 Mc/s
Duplex. 160·65–162·0 Mc/s

TRANSMITTER. 156·05–157·4 Mc/s
(A separate transmitter having a frequency coverage similar to that of the Duplex receiver must be used when working on Duplex channels.)

FREQUENCY DETERMINATION. Synthesizer

CHANNEL SPACING. 50 kc/s

EMISSION. F3 (Telephony)

RECEIVER INTERMEDIATE FREQUENCIES.
1st IF 10·701 Mc/s (Simplex)
15·301 Mc/s (Duplex)
2nd IF 2 Mc/s

AERIAL SYSTEM. FOLDED DIPOLE

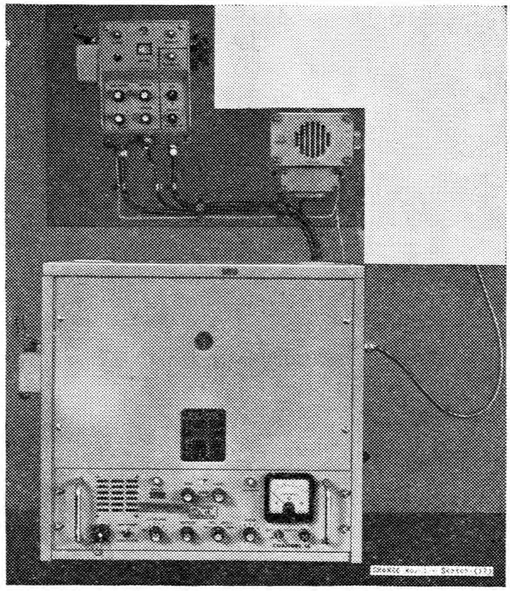


FIG. 1

Details of use of channels in Admiralty List of Radio Signals, Volume 1 and R.N. Signal Orders.

CHANNEL FREQUENCIES

Channel	*Transmitter*	*Receiver*
1	156·05	160·65
2	156·10	160·70
3	156·15	160·75
4	156·20	160·80
5	156·25	160·85
6	156·30	156·30
7	156·35	160·95
8	156·40	156·40
9	156·45	156·45
10	156·50	156·50
11	156·55	156·55
12	156·60	156·50
13	156·65	156·65
14	156·70	156·70
15	156·75	Guard Band (156·725–156·775)
16	156·80	156·80 (Calling and Safety)
17	156·85	Guard Band (156·825–156·875)

CHANNEL FREQUENCIES (*continued*)

Channel	*Transmitter*	*Receiver*
18	156·90	161·50
19	156·95	161·55
20	157·00	161·60
21	157·05	156·05 or 161·65
22	157·10	161·70
23	157·15	156·15 or 161·75
24	157·20	161·80
25	157·25	161·85
26	157·30	161·90
27	157·35	161·95
28	157·40	162·00

Note. Channels 6 and 8 to 17 are Simplex Channels. These are the only channels available for inter-ship use.

GENERAL

1. Type 689 is a VHF FM marine radiotelephone specifically designed for shipborne operation and suitable for international marine use. It will provide direct inter-ship communication and communication between ship and harbour, docking or pilot services. Calls can be made to any telephone subscriber via the public correspondence service.

2. **Power Supplied.** 100–150 V/190–240 V, 40–60 c/s.

3. **Power Output.** 10–12 watts with single aerial and duplexer.

14–20 watts with separate simplex and duplex aerial.

4. **Power Consumption.**

	Receiver	*Transmitter*
	150 watts (approx.)	200 watts (approx.) LOW POWER
		270 watts (approx.) HIGH POWER

5. A LOW POWER/HIGH POWER switch enables the transmitter output to be reduced to approximately 200 mW for short range harbour working and alignment purposes.

6. Facilities are provided for operation on 28 channels in the international marine VHF band, nine for single frequency simplex working, 17 for duplex working and two guard channels. Facilities are also provided for automatic reversion to Channel 16 and local or remote operation. Remote control can be carried out from either of two remote positions over lines up to 300 ft. in length, depending upon loop resistance. Telephone handsets are supplied for both local and remote use. Remote control boxes are designed for bulkhead mounting and carry all the essential operation controls.

Synthesizer

7. The synthesizer provides the fifth oscillator injection frequencies for the receiver by mixing the output of a tens oscillator with that of a common units oscillator. The resultant frequency is amplified and multiplied in the following stages before injection into the receiver first mixer stages. The synthesizer also provides drive for the transmitter by mixing the output of a further tens oscillator with that of the common units oscillator. The resultant frequency is fed to the transmitter input amplifier. Also mounted on the synthesizer chassis are the channel selection Ledex motors and associated switches.

Transmitter

8. The transmitter employs 11 valves, 9 in the r.f. section and 2 in the a.f. section. Three valves (two crystal oscillators and a mixer) in the synthesizer are followed by a double triode, the first section operating as an amplifier and the second as a phase modulator. Modulated output is taken through a pentode buffer stage, followed by two pentode multipliers and a double beam tetrode, the two halves of which function in further multiplier circuits. The total multiplication of the synthesizer output frequency is 36. The final multiplier drives the power amplifier stage, a double beam tetrode operating in a push-pull circuit. Audio frequency input from the microphone is fed to a double triode operating as a two-stage amplifier, the output from which is fed a double diode clipper and a 3 kc/s low-pass filter to the phase modulator.

Receiver

9. The complete 28-channel receiver employs 24 valves, mounted on 4 chassis, in a double superheterodyne circuit. The basic receiver has 10 valves and provides 9 channels for simplex working. Two r.f. amplifiers are followed by two mixers, three i.f. amplifiers and a discriminator. The output from the discriminator is fed to a three-valve squelch and a.f. amplifier circuit and returned to the basic receiver chassis for final amplification. The r.f. head which is similar to the r.f. and mixer stages of the basic receiver, employs 5 valves and, in conjunction with the basic receiver i.f. and succeeding stages, provides 17 channels for duplex working. Six valves in the synthesizer provide the first oscillator frequencies for the receiver and the r.f. head, two crystal oscillators being followed by a mixer, an amplifier and two multipliers.

Duplexer

10. The duplexer enables the equipment to operate with a single aerial system. The aerial is connected directly to the duplexer, one output from which is connected to the aerial change over relay via the aerial filter and the other to the r.f. head for duplex reception. The connection to the aerial change over relay is used for both transmission and reception on simplex channels and for transmission only on duplex channels.

Power Supply Unit

11. The main power supply unit provides the requisite H.T. and heater supplies for the transmitter, receiver, r.f. head and synthesizer and also the Ledex motor and relay energizing supplies. The transmitter H.T. supply is derived from a full-wave valve rectifier, while the receiver, r.f. head and synthesizer H.T. supply is derived from a half wave silicon rectifier. Two further silicon rectifiers provide the Ledex motor and relay energizing supplies. Also mounted on the main power supply unit chassis are the squelch circuit components, the a.f. output transformer for the remote loudspeaker and the transmit/receive and low power/high power relays. A separate sub-chassis (50 V power supply unit) contains the mains switching relay and its associated power supply.

Operating Instructions

12. *Receive and Transmit*

Receive

a. Turn the OFF/LOC/REM 1/REM 2 switch to select the required operating position.

b. When operating from either of the remote positions turn the OFF/HIGH POWER/LOW POWER switch on the remote control box to the LOW POWER position and adjust the DIMMER control until the required brightness is obtained from the indicator lamps.

c. Select the required channel by means of CHANNEL SELECTION switches.

d. Adjust loudspeaker output to required level by means of LS VOLUME control.

e. Adjust SQUELCH control so that the receiver will operate with the weakest required signal.

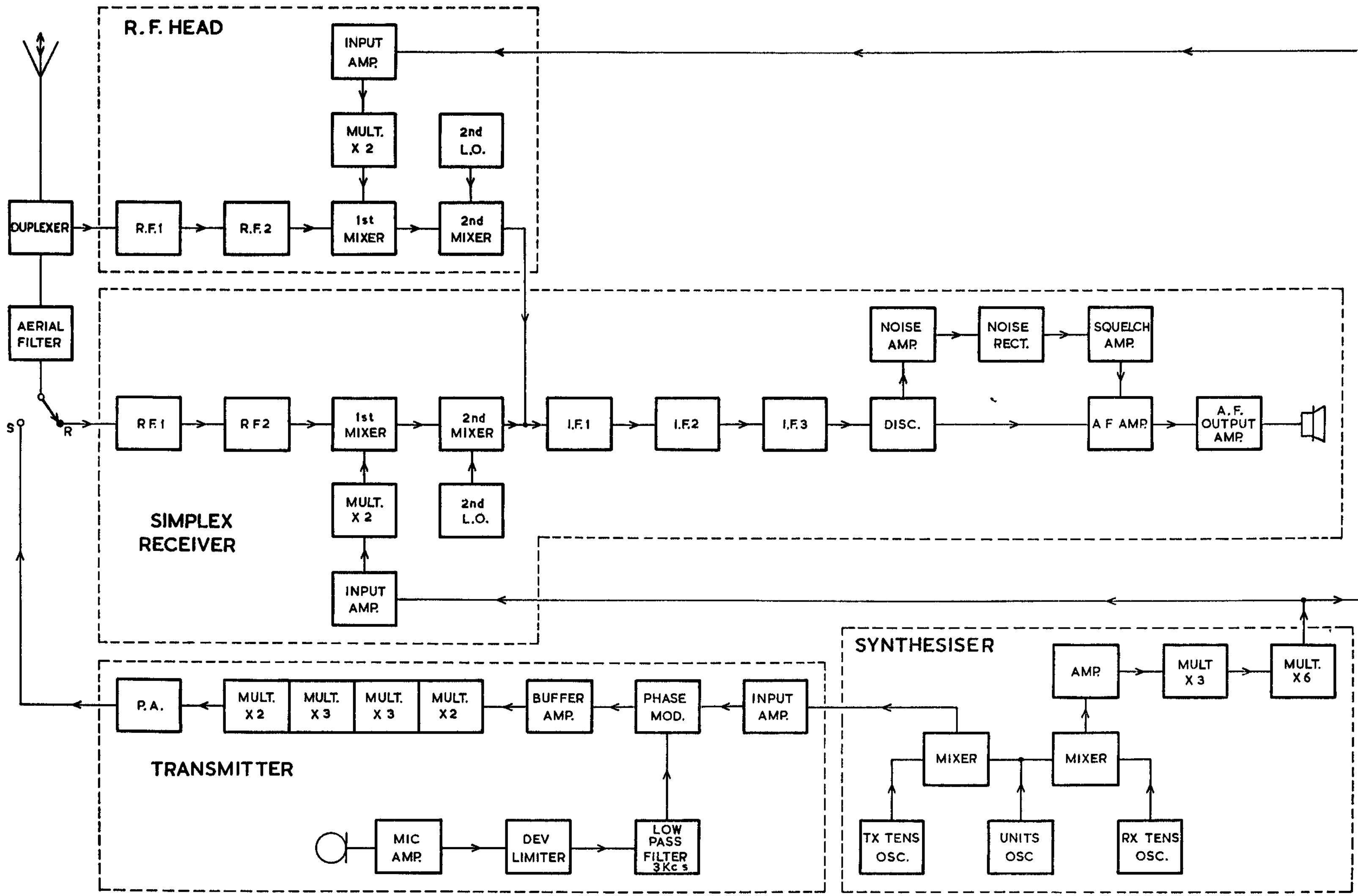


FIG. 2. TYPE 689 TRANSCEIVER

Transmit

f. Switch on the equipment and select the required channel as described in *a* to *c* above.

g. For short range working switch to LOW POWER and for normal working switch to HIGH POWER.

h. Lift the telephone handset from its rest, operate the pressel switch and speak into the microphone. It should be noted that the loudspeaker is inoperative when the equipment is transmitting and that in this condition incoming signals can only be heard in the telephone handset earphone (duplex channels only).

Channel 16 Reversion

13. When the CHANNEL 16 OUT/IN switch is in the OUT position, reception on Channel 16 can only be obtained by selecting this channel with the CHANNEL SELECTION switches.

14. When the CHANNEL 16 OUT/IN switch is in the IN position the equipment automatically selects Channel 16 after replacement of the telephone handset on its rest. Reversion to the indicated channel is obtained by pressing the CHANNEL 16 RELEASE button. The equipment then remains on the indicated channel until the telephone handset is lifted and replaced on its rest, when Channel 16 is again automatically selected.

2.21. TYPE 691 AND 691 EF

DATE OF DESIGN. 1953

HANDBOOK. B.R. 2061(1)

ESTABLISHMENT LIST. E. 1033

FREQUENCY RANGE.

277 to 283 Mc/s
10 Preset channels with Normal Frequency Plan.
9 Preset channels with Alternative Frequency Plan.

EMISSION AND POWER OUTPUT.

Voice and m.c.w. 10 W. Amplitude or Frequency Modulated.

FREQUENCY DETERMINATION. Crystal

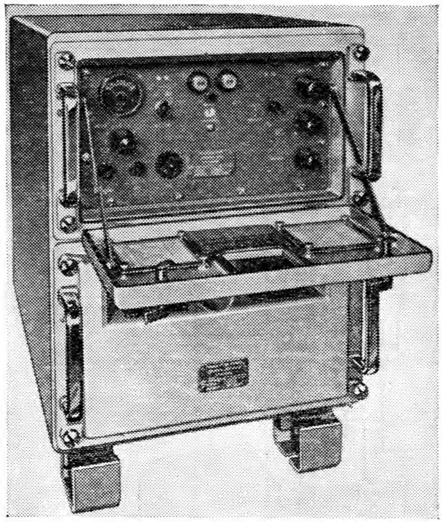


FIG. 1

GENERAL

1. Type 691 is a low-power ship/ship, ship/shore UHF transmitter with 10 preset crystal-controlled channels in the frequency band 277 to 283 Mc/s. An alternative 5 crystals can be used with the alternative frequency plan, but this provides 9 channels only and Channel 4 becomes inoperative. The crystals are contained in small glass holders, in appearance like miniature valves; each 'valve' holds two, except when using the alternative set when one of the holders has only one. Each holder has a letter identity.

2. **Crystallization**

NORMAL			ALTERNATIVE		
CRYSTAL HOLDER IDENTITY	OUTPUT FREQUENCY	CHANNEL NUMBER	CRYSTAL HOLDER IDENTITY	OUTPUT FREQUENCY	CHANNEL NUMBER
A	277·8	2	A	277·8	2
	279·4	5		279·4	5
B	281·2	8	B	281·2	8
	282·8	10		282·8	10
C	277·1	1	C.A	277·0	1
	278·3	3		278·4	3
D	278·9	4	D.A	Not used	4 (Inoperative)
	280·1	6		280·0	6
E	280·6	7	E.A	280·7	7
	282·1	9		281·9	9

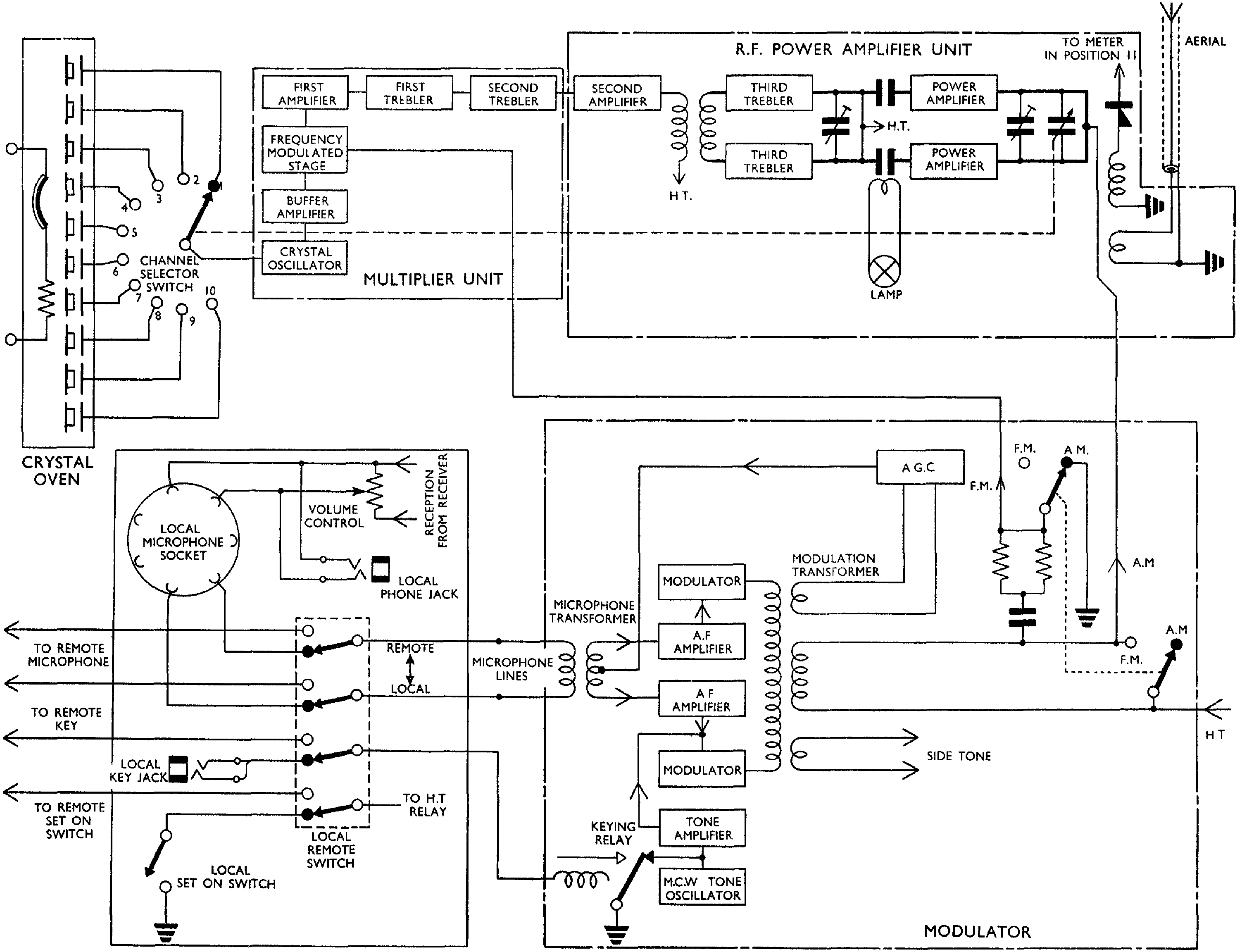


FIG. 2. TYPE 691 TRANSMITTER

3. **Channel 4.** Channel 4 is not used in the alternative frequency plan as it is exactly midway between the frequency of Channel 3 and Channel 5 (RUSTY BOLT effect). When set up to the alternative frequency plan the transmitter should not be left switched to Channel 4 as this may cause damage to the Crystal Oscillator valve.

4. **Transmitter Cabinet.** The transmitter is housed in a metal cabinet with two sliding drawers. The lower drawer contains the Power Unit and the upper drawer contains the Transmitter and Modulator. The power supply switch and fuses are mounted on a cabinet panel on the front, separating the two drawers. A blower is used to provide forced ventilation for the transmitter.

5. **Power Supplies.**

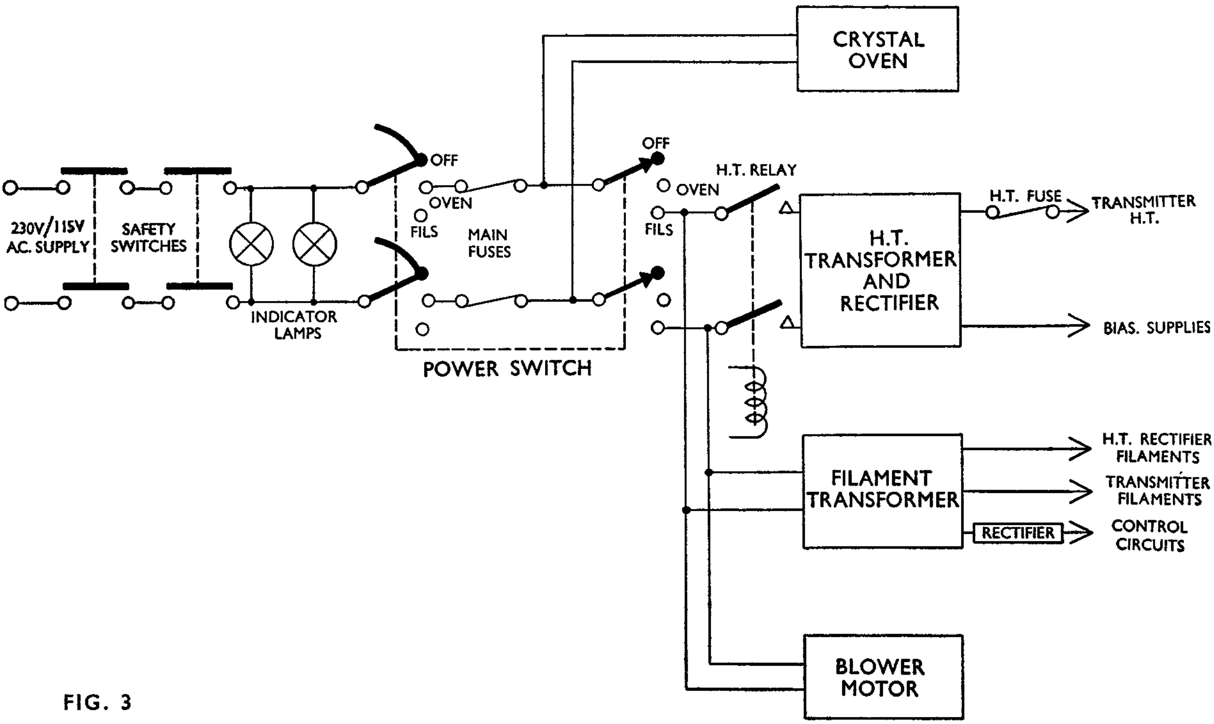


FIG. 3

Type 691 operates from a 230 or 115 V, 50 c/s a.c. supply. With 691EF an emergency a.c. supply outfit DWH is provided to supply 230 V when the normal ship's supply fails. The 230/115 V supply is fed through two safety switches, one on the power unit drawer, and a second on the transmitter drawer. Either of these will break the supply when the drawer is opened. A pull-out contact on these switches enables the power supply to be restored with the drawer open to assist maintenance. Two lamps fitted inside the power drawer indicate that power is on. The a.c. supply is fed through a 3-position switch and a pair of mains fuses. The switch has the following positions:

OFF. Breaks the supply.

OVEN. Completes the supply to the temperature-controlled crystal oven, which requires approximately 15 minutes to reach its operating temperature.

FILS. The supply is completed to the blower motor (fitted in the back of the Power drawer) to the filament transformer and, via the H.T. relay, to the H.T. transformer.

The H.T. relay is operated, in LOCAL by putting the SET ON switch on the transmitter drawer to M.C.W./VOICE, or to VOICE and pressing the pressel switch. In remote it is operated by the tumbler switch fitted alongside the transmitter or by the on/off switch on the KH control unit Design 5 if switched to M.C.W./

VOICE. If switched to VOICE the pressel switch must also be pressed. The change over from 230 to 115 V supply is effected by means of change-over links. These connect the Primaries of the H.T. and filament transformers which are in two halves; in series for 230 V supply or in parallel for 115 V supply. The filament transformer supplies the filaments of the transmitter and rectifier valves and through a metal rectifier the d.c. control circuit voltage. The H.T. transformer supplies, through valve rectifiers, the H.T. and bias supplies for the transmitter. The H.T. supply is fused with a single fuse.

DESCRIPTION

6. **R.F. Circuits.** These consist of a crystal oscillator stage with the crystal selected by the CHANNEL SELECTOR switch connected between grid and earth. This is followed by a Buffer Amplifier stage whose function is to prevent any interaction between the crystal oscillator stage and the a.f. voltages fed to the frequency modulated stage when using F.M. When using amplitude modulation, the frequency modulated stage acts as a normal amplifier stage having little gain.

The output of the F.M. stage is fed to the First Amplifier which is used to ensure that there is sufficient drive for the First and Second Trebler Stages. Both trebler stages, as their description implies, multiply their input frequency three times so that the output of the Second Trebler is nine times the crystal frequency. The output of the Second Trebler is fed to the Second Amplifier stage which ensures sufficient drive for the Third Trebler. The Third Trebler produces a frequency 27 times the crystal frequency and feeds into into the P.A. stage. All stages up to and including the Third Trebler are fixed tuned to Channel 6.

The bandwidth of each circuit is sufficient to ensure that each stage performs its function on all channels and gives sufficient output to provide satisfactory communication. It is obvious, however, that channels nearest to the middle of the band will give slightly better results. Trimming capacitors are provided for lining these circuits up to Channel 6 when the set is first installed and after any component changes. A pea-lamp is provided for lining up the Third Trebler.

The Crystal Oscillator and buffer stages are untuned. The P.A. stage has a fixed tuned grid circuit (tuned to Channel 6) and an anode tuned circuit whose tuning is preset to each channel frequency. The presetting of the tuning capacitor is selected by the CHANNEL SELECTOR switch. The Aerial feeder is inductively coupled to the P.A. Anode tuned circuit.

A meter is provided on the transmitter panel with an 11-position switch which reads as follows:

Position 1. Anode Current of Crystal Oscillator
Position 2. Anode Current of Buffer Amplifier
Position 3. Anode Current of First Amplifier
Position 4. Anode Current of First Trebler
Position 5. Anode Current of Second Trebler
Position 6. Anode Current of Second Amplifier
Position 7. Grid Current of Third Trebler
Position 8. Anode Current of Third Trebler
Position 9. Grid Current of P.A. Stage
Position 10. Anode Current of P.A. Stage
Position 11. Transmitter Output Power.

7. **A.F. Stages (Modulator).** The output from either the local or remote microphone is fed through the microphone input transformer to the grids of the amplifier stage. The amplifier stage output is fed to the modulator stage, which for amplitude modulation is used to modulate the H.T. and Screen stage.

The output to the frequency modulated stage is earthed by the action of the A.M./F.M. switch. When in the F.M. position the H.T. supply to the P.A. stage does not pass through the modulation transformer. The a.f. output of the modulator is fed to the frequency modulated stage. A second winding of the modulator transformer is used to provide a.g.c. which is fed to the a.f. amplifier stage. A third winding is provided for sidetone, but is not wired to a telephone jack.

For m.w.c. transmissions, a 900 c/s tone oscillator, whose output is amplified by the tone amplifier, is fed to the grid of one modulator valve only. Either A.M. or F.M. may be used for voice or m.c.w. transmission. No changeover switch is required for changing from VOICE to m.c.w. The action of pressing the morse key removes the earth from the output of the tone oscillator and it is then fed into the tone amplifier and thence to the modulator.

Lamp indication is provided on the front of the transmitter drawer to indicate whether the A.M./F.M. switch is to A.M. or F.M.

8. **Controls.** The controls fitted on the front of the transmitter drawer and their functions are as follows: PHONE JACK. A monitoring position fed from the receiver output.

VOLUME CONTROL. Controls the level of reception from the receiver.

KEY JACK. For plugging in a morse key for m.c.w. transmission.

A.M./F.M. SWITCH. Conditions the transmitter for frequency or amplitude modulation of the carrier. The A.M./F.M. indicator lamps indicate the position of the switch.

READY LAMP. Indicates that the transmitter is ready for operation. Depressing the microphone pressel switch or the morse key will bring on the carrier.

MICROPHONE SOCKET. For plugging in a microphone for local operation.

SET-ON SWITCH. Makes the H.T. relay and lamp ready circuits when switched to M.C.W./VOICE. When switched to VOICE completes the lamp ready circuits and allows pressel switch to operate the H.T. relay. M.C.W. cannot be used in this position. Overheating of the transmitter will occur if the H.T. supply is completed for long periods and the M.C.W./VOICE position should only be used when operational requirements call for mixed M.C.W. and VOICE transmissions.

CHANNEL SWITCH. Selects the crystal and the output tuning for the particular channel. An indicator lamp is used to illuminate the number of the channel in use.

LOCAL REMOTE SWITCH. Changes over the following circuits from the front panel controls to corresponding controls at the remote position.

a. Morse key jack.
b. Microphone socket.
c. Set on switch.

METER AND METER SWITCH. For switching meter to check correct functioning of each stage as indicated in para. 6.

9. **Resonators.** These are used with common aerial working and are described in Section 6 – Aerials. In addition, a single resonator is normally fitted with a type 691/CUH using send/receive working, in order to provide added selectivity for the receiver.

2.22. TYPE 692

DATE OF DESIGN. 1955.

HANDBOOK. B.R. 1492A

ESTABLISHMENT LIST. E 1162

FREQUENCY RANGE. 225 to 399·9 Mc/s

EMISSION AND POWER OUTPUT.

Voice – 10 W. Amplitude Modulation

FREQUENCY DETERMINATION

MASTER OSCILLATOR: Built in Crystal Reference System tunes M.O. to required frequency and maintains it on frequency.

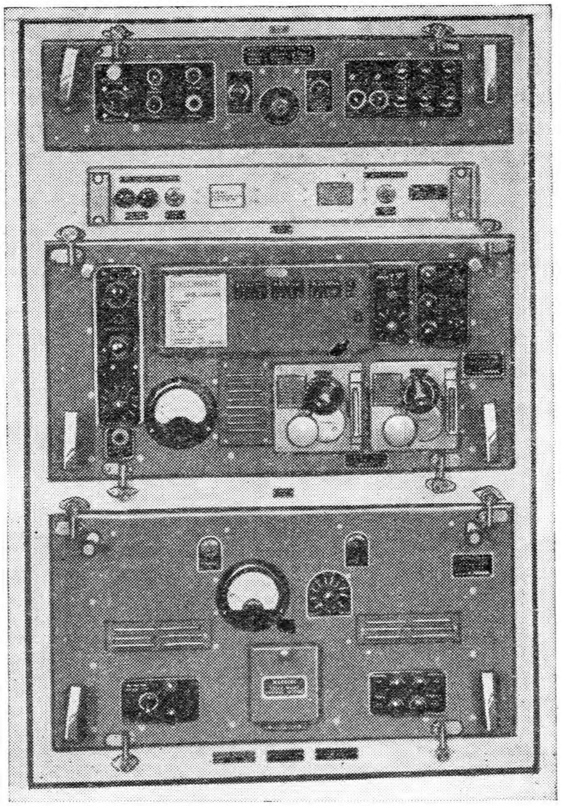


FIG. 1

GENERAL

1. Type 692 is a Ministry of Supply designed low power UHF transmitter adapted for Naval use. It provides 1750 channels from 225 to 399·9 Mc/s inclusive, with 100 kc/s channel separation. Any 10 of these channels can be preset and then selected either locally at the Transmitter, or, if Remote Control Selection units are fitted, from a remote position.

2. The transmitter consists of the following drawers:

a. CONTROL DRAWER. Mains supply switches, fuses, relays and local control facilities.

b. TRANSMITTER UNIT. R.F. Circuits, frequency control arrangements and Modulator.

c. POWER UNIT. Transformers and rectifiers providing necessary power supplies.

3. **Power Supplies.** Designed to operate from 115 V or 230 V a.c. Input voltage may be varied in 5-volt steps around these figures if necessary.

4. **Power Unit.** Provides the following supplies as shown in the Block Diagram:

a. 375 V Main Transmitter H.T.

b. 300 V Main Modulator H.T.

c. 275 V Auxiliary H.T.

d. 110 V for Crystal Oven and Blowers.

e. —150 V Bias.

f. —48 V for Relays, etc.

g. 6·4 V, 6·7 V and 7 V for Heaters.

A 60-second thermal delay device prevents the H.T. supplies (*a*, *b* and *c* above) being made before the

Crystal ovens have reached operating temperature. *a* and *b* are only completed on switching to TRANSMIT and pressing the pressel switch, or on switching to TUNE.

TRANSMITTER

5. **R.F. Circuits.** The basic transmitter consists of a Master Oscillator, tunable from approximately 37 Mc/s to 66 Mc/s in nine ranges, Doubler, Driver, Trebler and P.A. stages. The M.O. frequency is therefore multiplied by six and amplified. There is no crystal oscillator, the crystals in the transmitter being used to get the Master Oscillator on to the correct frequency and to help keep it there.

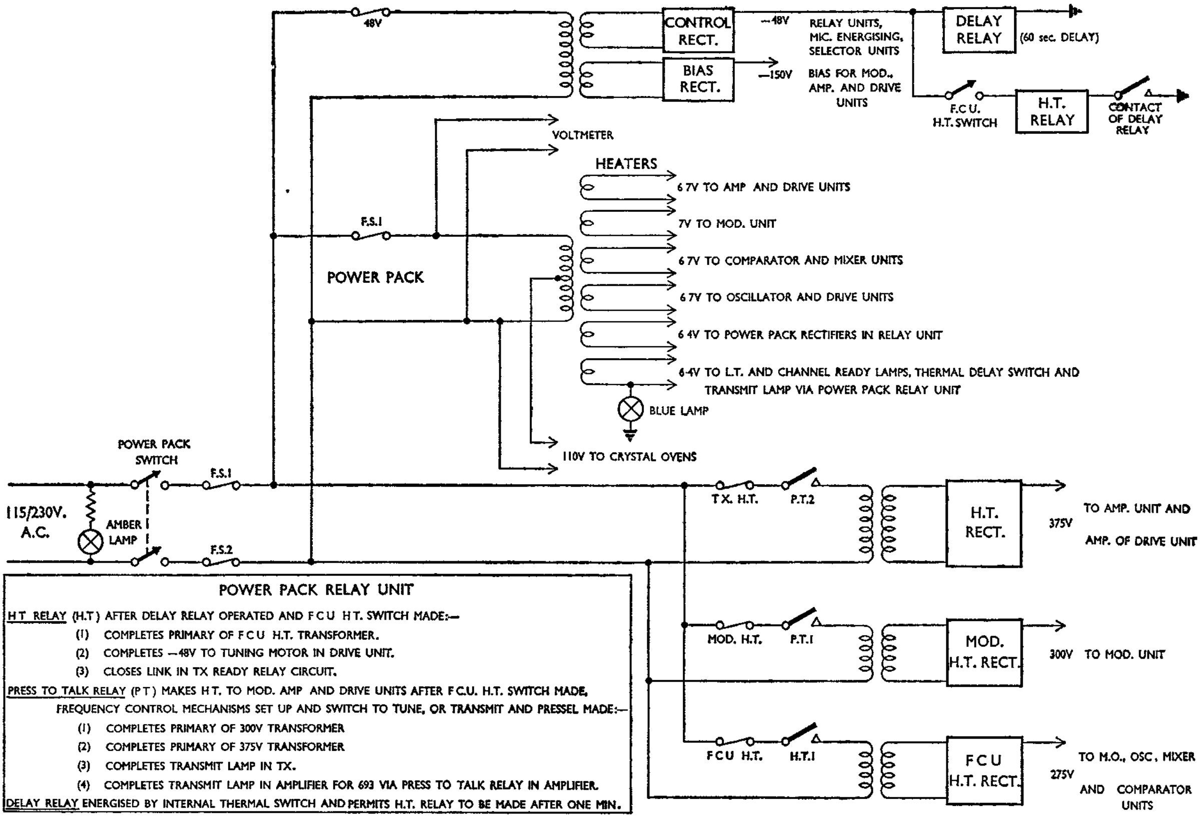


FIG. 2. TYPE 692 – POWER UNIT AND RELAY UNIT

6. Frequency Selection and Control

a. Each frequency corresponds to four letters as shown on the hinged flap protecting the frequency setting sliders.

The four sliders are set to the appropriate letters for a particular frequency.

b. The first slider selects the correct range for the Master Oscillator and the correct crystal for the 100's Oscillator. The remaining three sliders select the correct crystal for the 10's Oscillator, the Units Oscillator and the Reference crystal Oscillator respectively.

c. The output of the M.O. is fed to the First Mixer together with the output of the 100's oscillator Harmonic Selector. The M.O. is made to hunt through about 3 Mc/s in the selected range. The difference frequency produced by the first Mixer is therefore variable and when it comes within the tolerance of Filter A a voltage output is applied to the Second Mixer. The output of the Second Mixer is the difference between the variable frequency coming from Filter A and the 10's oscillator. When this difference comes within the tolerance of Filter B, a voltage output is applied to the Third Mixer. The difference between the frequency of this output and the Units Oscillator passes through Filter C when the required tolerance is achieved. The output finally passes through Filter D to the Comparator, where it is compared with one of two Reference Crystals, depending on whether the original frequency set on has an odd or even decimal point.

d. Filter D has a bandpass of $\pm$150kc/s and will therefore allow through frequencies from 2·35 to 2·65 Mc/s. This occurs when the M.O. is approaching the correct frequency and an output taken off

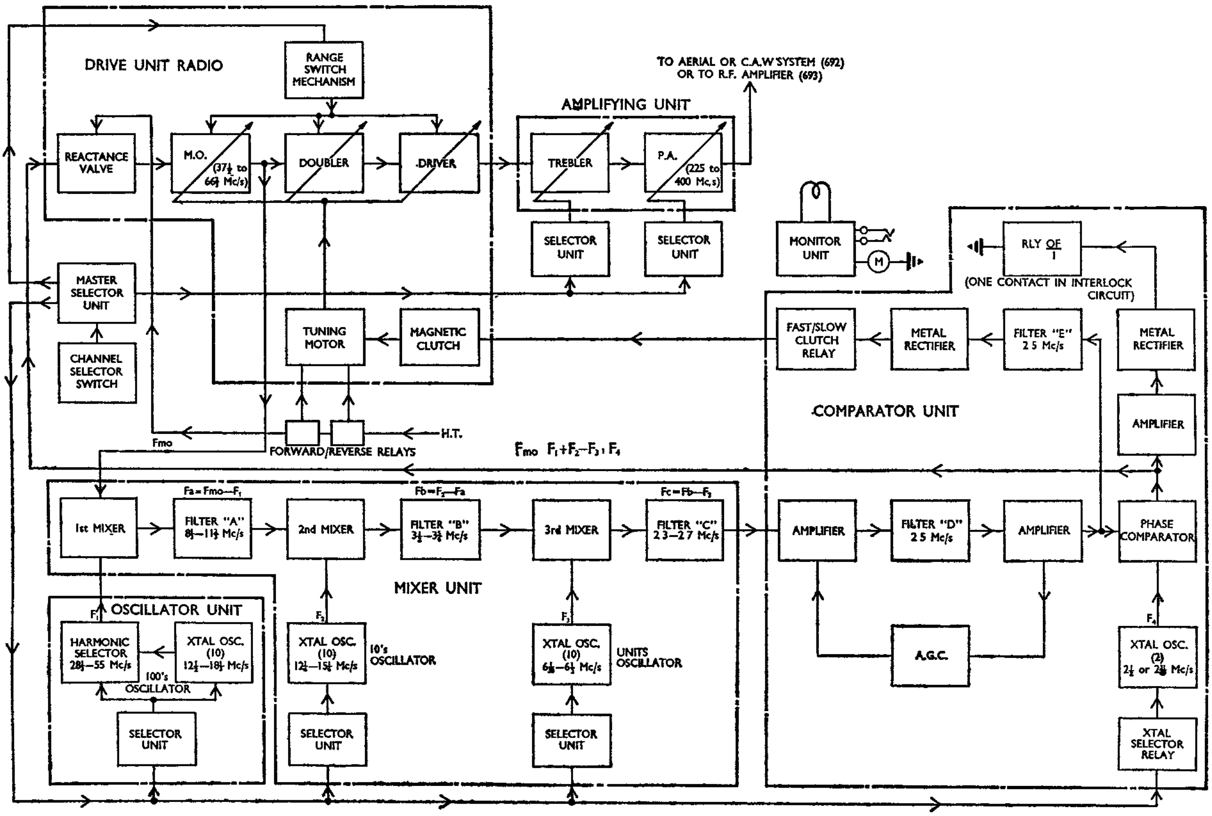


FIG. 3. TYPE 692 – TRANSMITTER (See Fig. 6)

before the Comparator is then fed through another Filter E to the Fast/Slow clutch relay, which slows down the tuning motor to $\frac{1}{25}$ of its normal speed.

e. There are two outputs from the Comparator. One supplies bias to the Reactance Valve which ensures that the M.O. is kept on tune. The other output controls a relay. When this relay operates, which happens when the M.O. is on frequency, the tuning motor stops and the Forward and Reverse tuning motor relays are brought under the control of the Reactance Valve, to enable it to keep the M.O. on tune.

7. Modulator Unit. The function of this unit is to amplify the microphone input and use it to modulate the H.T. supply to the P.A. stage of the transmitter. The microphone input goes through a high pass filter, which cuts off frequencies below 500 c/s, and then through three stages of amplification followed by an output stage.

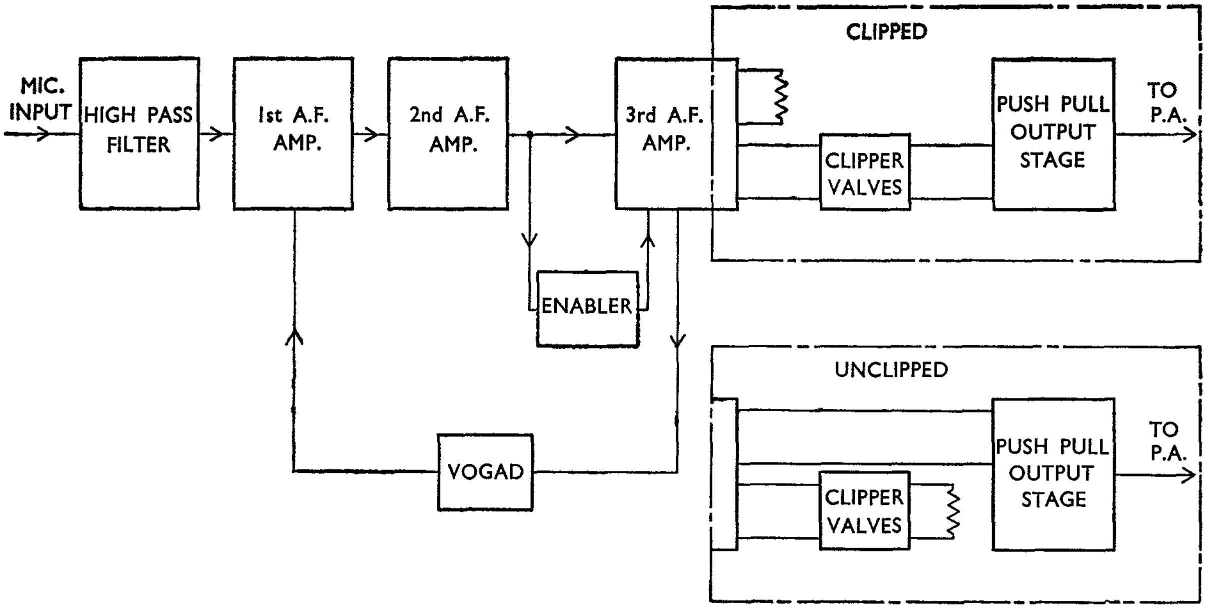


FIG. 4. TYPE 692 – MODULATOR UNIT

The following features are incorporated:

a. ENABLER.	This prevents the modulator being actuated by noise and can be compared with the muting valve in a receiver.
b. VOGAD.	Voice Operated Gain Adjusting Device. This is a form of automatic gain control which can be shorted out of circuit if not required. A portion of the output of the 3rd a.f. Amplifier is taken off, rectified and fed back to the 1st a.f. Amplifier as negative bias.
c. CLIPPER VALVES.	These can be put in and out of circuit by an alteration inside the Modulator. They 'clip' the peaks off the a.f. signal to reduce distortion to a minimum and may be useful at extreme range.
d. EVOS.	Electronic Voice Operated Switch. This enables the set to be switched on as soon as someone speaks into the microphone and switched off when the speech stops. It is not normally used in ships.

8. Transmitter Drawer Controls

F.C.U. H.T. SWITCH

a. switches on H.T. to Master Oscillator, Oscillator, Mixer and Comparator units provided delay switch has operated.

b. Lights Amber lamp.

REMOTE–OPERATE–LOCAL SET SWITCH

a. In LOCAL SET position prevents F.C.U. H.T. being applied during setting up of channel (i.e. breaks an interlock circuit).

b. In OPERATE allows control of transmitter in local position.

c. In REMOTE allows control of transmitter from Remote position *only.*

TUNE-OFF-TRANSMIT SWITCH

a. In TUNE position reduces P.A. screen voltage to allow transmitter to be tuned in approximately half power. Applies a MARK to transmitter.

b. In TRANSMIT position transfers control to either local or remote operating position dependent upon position of REMOTE-OPERATE-LOCAL SET switch. MARK now applied by pressel switch of microphone.

c. Lights Red lamp in TUNE position and in TRANSMIT when pressel is made.

CHANNEL SELECTION SWITCH

Switches Selector unit mechanism to appropriate channel for tuning and operation of set in association with Remote-Operate-Local Set switch, e.g.:

Channel 1, Local set – Allows frequency settings to be made on Selector unit.

Channel 1, Operate – Allows selected frequency to be tuned, or operated locally.

METER AND METER SWITCH

A twelve-position meter switch allows metering of various parts of transmitter and F.C.U. as indicated on cover plate inside transmitter, dependent upon position of wandering test lead associated with meter and five test sockets.

MONITOR SWITCH

A five-position switch which, when Meter switch is to position 9, has the following functions:

a. POWER. Connects meter to a probe unit to give an indication of radiated r.f. power.

b. CAL. In conjunction with Calibrate control allows meter to be calibrated for full scale deflection.

c. R. COEFF. Connects meter to a probe unit to give an indication of any reflected r.f. along aerial feeder, thus providing a check on efficiency of aerial or feeder.

d. MODULATION %. Allows meter to provide a check on percentage modulation.

e. MONITOR Meter disconnected. Allows aural check of modulation in phones plugged into MONITOR OUTPUT socket.

Note: When phones plugged in meter is always disconnected.

TREBLER TUNING CONTROL

Adjusts anode circuit of Trebler stage.

P.A. TUNING CONTROL

Adjusts anode circuit of P.A. stage.

CHANNEL READY (GREEN LAMP)

Indicates Transmitter ready for completion of tuning (i.e. adjustment of Trebler and P.A. controls), or if already tuned – ready for operation.

MICROPHONE INPUT SOCKET

Not used in R.N.

9. **Control Drawer.** This drawer controls the switching on of power to the set and enables the set to be controlled locally.

The following controls are mounted on the front:

TRANSMITTER ON/OFF SWITCH

Completes mains supply to Power unit. Blower motor and primaries of 24V transformer via Control Drawer Mains ON/OFF Switch.

Lights Amber lamp on Power Drawer.

Amplifier On/Off Switch

Completes mains supply to Amplifier Power Drawer in Type 693.
Lights Amber lamp on Amp. Power unit.

Control Drawer Mains On/Off Switch

Completes mains supply to primaries of 24V transformer which provides 24V a.c. for remote lamp indication and 24V rectified for certain control circuits (e.g. Send/Receive Relay).
Lights CONTROL DRAWER MAINS amber lamp, and 24V a.c. Amber lamp and 24V d.c. Amber lamp.

Fuses

2 Mains Supply (3 amp).

2 24V (2 amp).

2 24V a.c. (2 amp).

Microphone Socket

For local control of set.

Phone Jack and Volume Control

For reception from associated receiver.

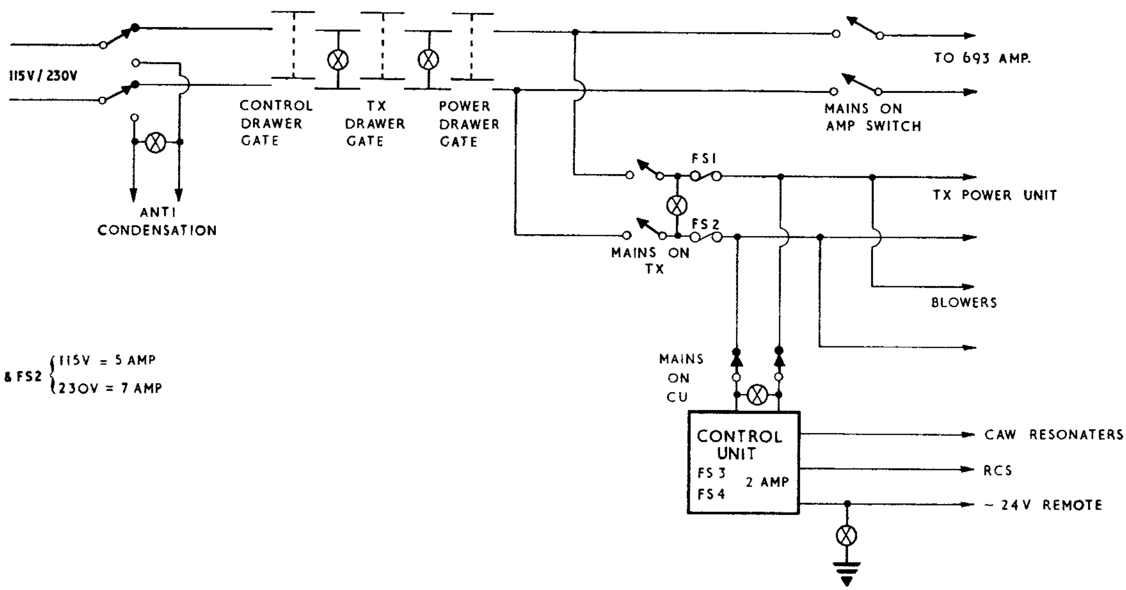


FIG. 5. TYPE 692 – CONTROL DRAWER

COMMON AERIAL WORKING WITH TYPE 692, TYPE 693 AND RECEIVER CUJ

10. Where Common Aerial Working is used it is necessary to employ resonators (see Section 6). With Type 692, Type 693 and CUJ, various outfits, embodying either 2, 4, or 6 aerial resonators, with either manual or automatic control, are used. At the frequency to which it is tuned, each resonator represents a ¼-wave transmission line which acts as a highly selective filter, accepting the wanted signal and offering an effective resistance to the passage of all others.

The transmitter or receiver is connected to its associated resonator which is tuned to the frequency in use. It therefore rejects frequencies from other sources. All the resonators in one drawer are joined by channel connectors of equal length to a central r.f. Junction box, from which the aerial lead is taken. Transmitters and receivers which share a common aerial must be spaced at least 1 Mc/s apart in frequency.

METHODS OF OPERATION

11. Transmitters Type 692 and 693 and their associated receiver CUJ can be operated in one of four different ways, depending on the installation. The system at *d* below is the only one normally used with Type 693.

a. SEND–RECEIVE WORKING. A single aerial is used for both transmission and reception, with a Send–Receive Relay. A hand-tuned resonator is fitted on the receiver side only. Manual channel changing locally at the transmitter and at the receiver.

b. RELAY UNIT DESIGN 90 NOT FITTED. In this case hand-tuned resonator outfits are used for both transmitters and receivers. Manual channel changing locally at the transmitter and at the receiver.

c. RELAY UNIT DESIGN 90 FITTED. Auto-tuned resonators are installed. A receiver and its associated aerial resonator outfit can be set to the same channel as a transmitter and its resonator outfit by means of a control at the transmitter; alternatively the transmitter can be aligned by a control at the receiver. This is known as the partial Remote Channel Selection facility.

d. REMOTE CHANNEL SELECTION UNIT ADDED TO SYSTEM *c*. The transmitter, receiver and their resonators are all changed from channel to channel by means of the R.C.S. unit at the remote position. This is known as the full Remote Channel Selection facility.

TYPE 692

12. **Tuning Instructions**

a. Switch ON Control Drawer mains.

b. Switch ON Transmitter mains. Blowers start – amber lamp lights.
Mains On Lamp (amber) lights.
24 V supplies – amber lamp lights.
Power Unit supplies – amber lamp lights.

c. Switch ON Transmitter Power unit mains. L.T. supplies – blue lamp lights. Set meter switch to position 1. Check reading 75 approx. (Selector mechanism may not operate correctly if voltage too high or too low.)

d. Set channel selector switch to required channel.

e. REMOTE–OP–LOCAL Set switch to LOCAL SET.

f. Set cams as indicated by frequency tote.

g. Set REMOTE–OP–LOCAL SET switch to OP. Selector mechanism will operate briefly. Check channel reading and window and setting of flags.

h. Connect aerial feeder into power meter CT 214.

i. Switch F.C.U. H.T. switch to ON. Thermal delay operates. Amber lamp lights on completion. After –10–15 seconds, green CHANNEL READY lamp lights.

j. Set TUNE–OFF–TRANSMIT switch to TUNE. Red lamp lights.

k. Set meter switch to position 8 (P.A. anode), and monitor switch to POWER.

l. Tune Trebler for maximum.

m. Set meter switch to position 9 (r.f. power).

n. Tune P.A. for maximum.

o. Set TUNE–OFF–TRANSMIT switch to TRANSMIT. Red lamp goes out.

p. Press pressel switch. Red lamp lights. Compare meter reading with watts output graph.

Tuning the Aerial Resonator with a Hand-tuned System.

q. Disconnect CT 214. Plug aerial feeder into resonator.

r. From tuning calibration card obtain approximate setting of numerical indicator for frequency in use and apply. Ensure that all other resonators in drawer are set more than 45-digits away from resonator being tuned.

s. Set resonator monitoring probe switch to position corresponding to resonator being tuned.

t. At transmitter drawer set F.C.U. H.T. switch to H.T. ON and the TUNE–OFF–TRANSMIT switch to TUNE.

u. Tune resonator for maximum. It is important that final adjustment be made turning handle in a clockwise direction. Return RESONATOR MONITORING PROBE to OFF.

In an Auto-tuned System

v. After completing *p* above, disconnect CT 214 power meter and plug aerial feeder into resonator.

w. Ensure that channel indicator dial of resonator agrees with CHANNEL SELECTOR switch indication. From resonator calibration card obtain approximate reading for frequency in use and apply. Check that all other resonators in drawer are set more than 6 divisions away from resonator being tuned.

x. Set RESONATOR MONITORING PROBE switch to position corresponding to resonator being tuned.

y. At transmitter drawer set F.C.U. H.T. switch to H.T. ON and TUNE–OFF–TRANSMIT SWITCH to TUNE.

z. Tune resonator for maximum in meter. After obtaining maximum reading turn vernier drive knob anti-clockwise 5 divisions and then re-tune in a clockwise direction for a maximum. Return RESONATOR MONITORING PROBE switch to OFF.

Testing Aerial Feeder

13. The efficiency of the aerial and feeder system can be tested by measuring the Reflection Coefficient using the montoring unit. This should be done every time a new channel is set up.

a. Set METER SWITCH to position 9 (position 5 in Type 693). Set Monitor switch to Cal. Set F.C.U. H.T. switch to H.T. ON and TUNE–OFF–TRANSMIT switch to TRANSMIT.

b. Operate pressel switch and adjust CALIBRATE control so that meter reading is 100.

c. Turn Monitor switch to R. Coeff. The meter will indicate value of the reflected wave at transmitter. If aerial and feeder connections are in good condition meter reading should be less than 20. If the reading is greater than 25 the system should be examined for possible faults.

Modulation Testing

14. *a*. Set Monitor switch to Cal, and, with pressel switch pressed, adjust CALIBRATE control for a reading of 100 on the meter.

b. Set Monitor switch to Mod. % and observe meter reading while speaking into microphone. Meter should flick upwards to a reading greater than 50.

Using the Transmitter

15. *Relay Unit Design* 90 *not fitted*

a. Set REMOTE–OP–LOCAL SET switch to REMOTE or OP as required.

b. Set F.C.U. H.T. switch to H.T. On and TUNE–OFF–TRANSMIT switch to TRANSMIT. F.C.U. H.T. (amber) and CHANNEL READY (green) lamps should burn.

c. To change to another channel set REMOTE–OP–LOCAL switch to Op, and CHANNEL SELECTOR switch to required channel. When green CHANNEL READY lamp burns tune resonator to new frequency.

d. After tuning resonator, return REMOTE–OP–LOCAL SET switch to REMOTE if required.

Relay Unit Design 90 fitted

16. *a.* Ensure that 24 V REMOTE (amber) lamp on control drawer is alight, thus indicating that 24 V supply at the Receiver is on.

b. Set REMOTE–OP–LOCAL SET switch to REMOTE, F.C.U. H.T. SWITCH TO H.T. ON, and the TUNE–OFF–TRANSMIT switch to TRANSMIT. Ensure that F.C.U. H.T. (amber) and CHANNEL READY (green) lamps are burning.

c. When it is required to change channel the operation will normally be done at the receiver. However, it can be done from the transmitter if required. Set REMOTE–OP–LOCAL Set switch to OP and Channel Selector switch to required channel.

d. After automatic timing of transmitter is completed, as indicated by lighting of CHANNEL READY (green) lamp, operate PRESS TO TUNE RECEIVER switch on control drawer.

e. Receiver and its resonator will tune to same channel as transmitter. When tuning is completed return REMOTE–OP–LOCAL SET switch to REMOTE. TUNED (green) lamp on transmitter control drawer lights.

17. *Remote Channel Selection (R.C.S.) Unit fitted.*

a. Ensure that 24 V REMOTE (amber) lamp on control drawer is alight, thus indicating that 24 V supply at the receiver is on.

b. Set REMOTE–OP–LOCAL SET switch to REMOTE, F.C.U. H.T. switch to H.T. ON, and TUNE–OFF–TRANSMIT switch to TRANSMIT. Ensure that F.C.U. H.T. (amber) and CHANNEL READY (green) lamps are burning.

c. To prevent two or more of the transmitters serving one resonator drawer from being switched to the same frequency, an interlock is provided on channels 3 to 7 inclusive., Frequencies which are common to a number of transmitters must be set up on these channels, and the terminal board inside the C.A.W drawer set up as appropriate.

d. To change channels at R.C.S. unit, set CHANNEL SELECTOR switch to required channel and press RETUNE button.

c. When tuning of transmitter and resonator is complete the TX READY FOR RETUNE (green) lamp will light. Likewise, when receiver and its resonator are tuned, RX READY FOR RETUNE (green) lamp will light.

f. When transmitter, receiver and resonators are all set up on the new channel CHANNEL READY (green) lamp will light.

g. If transmitter, receiver, and resonators do not set up on same channel, the RETUNE (amber) lamp will light, indicating faulty channel selection. Press RETUNE button again.

h. If in a C.A.W. system an attempt is made to select a frequency already in use by another transmitter on same system, TX READY FOR RETUNE (green) lamp will flash about four times during resonator tuning. When tuning is complete RETUNE (amber) lamp burns indicating that this frequency is already in use.

Circuit arrangements are such that in these circumstances resonator will have tuned beyond the frequency range of the equipment and it will not be possible to transmit.

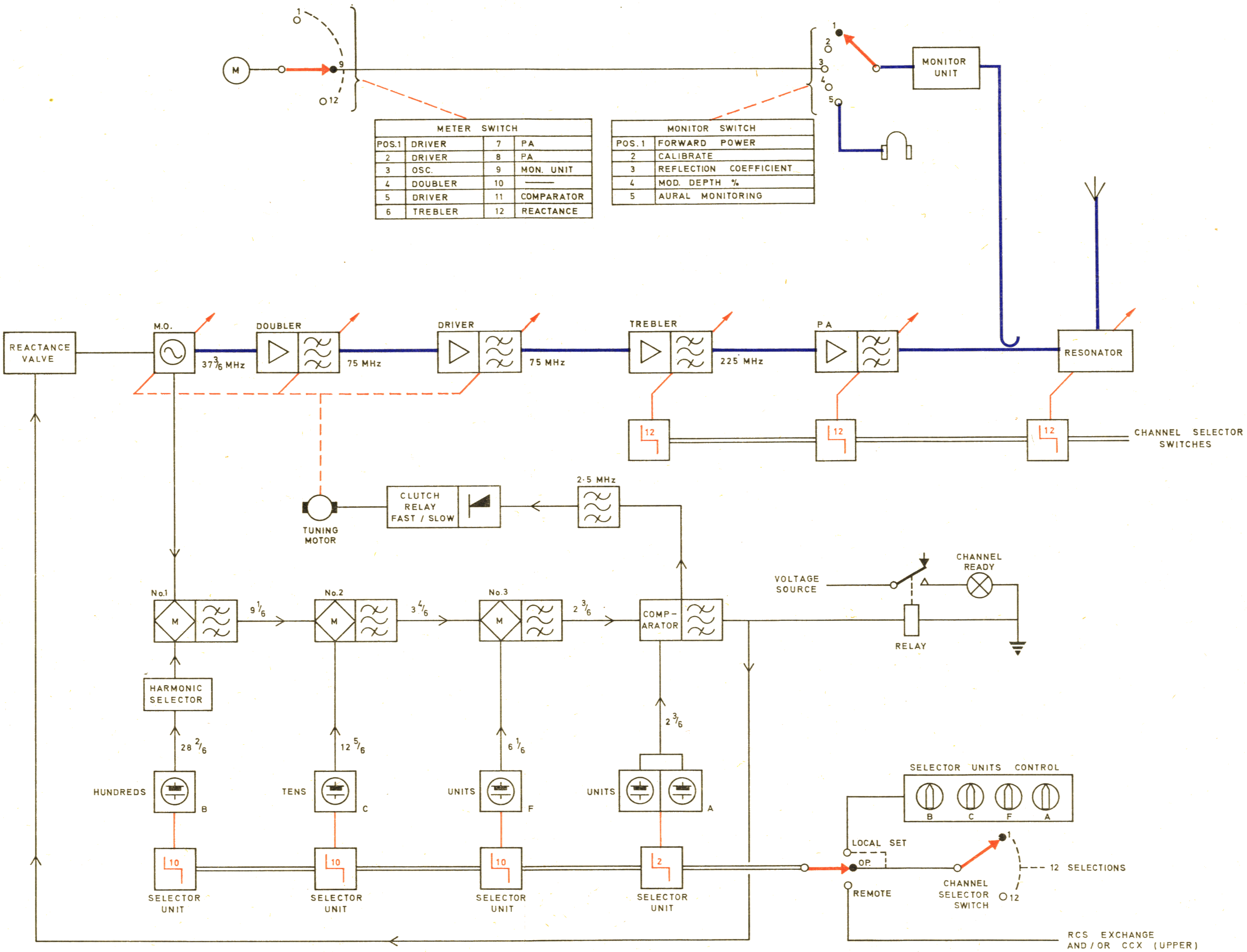


FIG. 6. TRANSMITTER TYPE 692—BLOCK DIAGRAM (FREQUENCY SETTING 225·0MHz)

169471—35–36

2.23. TYPE 693

DATE OF DESIGN. 1955

HANDBOOK. B.R. 1492A

ESTABLISHMENT LIST. E 1162.

FREQUENCY RANGE. 225–399·9 Mc/s

EMISSION AND POWER OUTPUT. Voice. Approx. 100–150 W

FREQUENCY DETERMINATION. As for type 692

GENERAL

1. The transmitter Type 693 is basically a transmitter Type 692 with an additional amplifying unit, with which is associated a power unit (Type 9202). Otherwise the transmitter's drawers are the same for the Type 692, i.e. a Control drawer, a Transmitter drawer, and a Power drawer (Type 7097).

POWER UNIT (TYPE 9202)

2. This contains two assemblies. The chassis contains all the power supply arrangements, with two exceptions, for the amplifying unit and the metering circuits for test purposes. The exceptions are the negative 150 V and negative 48 V supplies which are obtained from the power unit (Type 7097). The relay unit includes a thermal delay system which prevents the mains supply from being applied to the H.T. transformers until the valve heaters have been switched on for approximately one minute. It also includes a system of overload relays which operate in the event of either the Buffer Amplifier or the P.A. valves of the amplifying unit becoming overloaded.

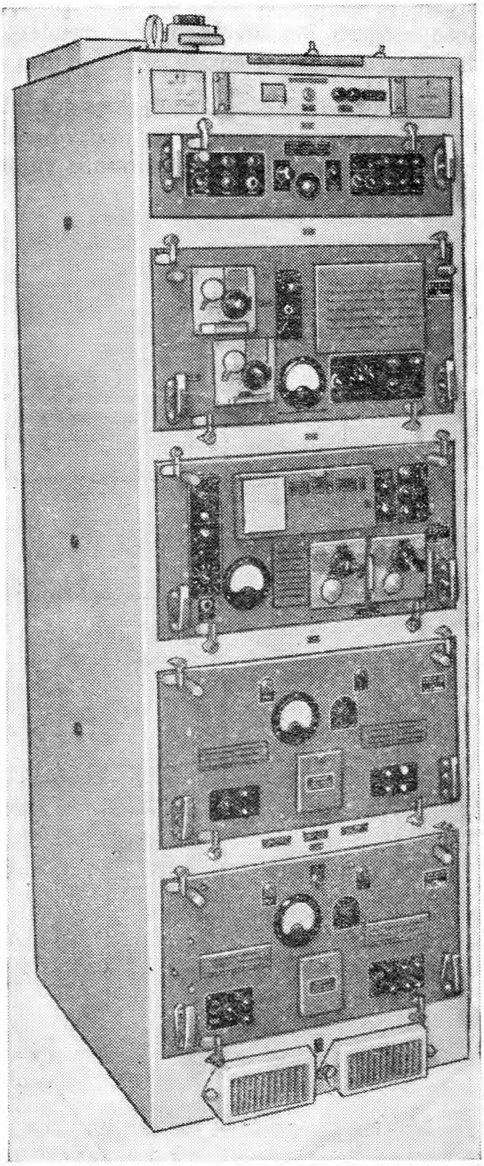


FIG. 1

3. **Controls**

Mains.	Completes a.c. Supply to the primaries of the transformers. Blue lamp lights. Thermal delay starts. All heaters supplied. Main fuses alongside.
Mains Tapping Panel.	Enables adjustments to be made to allow for power supplies between 105 V and 130 V and 200 V and 250 V.
H.T. Off and Overload Reset.	Used to restore H.T. after overload has occurred and to reset overload relays.
Meter Switch.	Ten fixed points for readings.

AMPLIFYING UNIT

4. This consists of two stages, a buffer amplifier followed by a push-pull output stage. The grid and anode circuits of the buffer stage are hand-tuned when setting up a channel, using the 'GRID TUNING' control. Both controls are driven by the frequency selection drive from the Transmitter Unit when changing channels. The anode circuit of the output stage is similarly tuned using the ANODE TUNING control.

In the Type 693M modulation does not take place in the Transmitter Unit. The a.f. output of the modulator is taken to the amplifier unit where a transformer is included in the anode circuit of a push-pull modulator. Amplitude modulation is employed in the anode and screen circuits of the amplifier output stage.

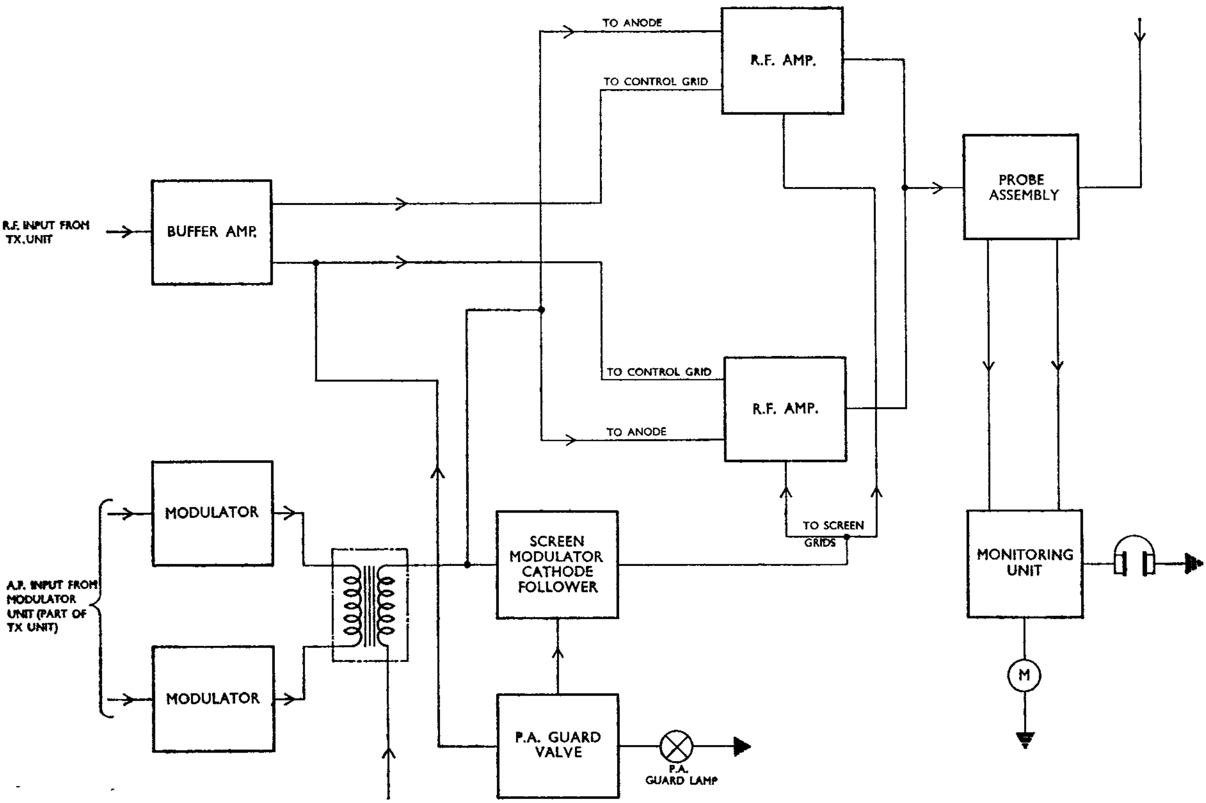


FIG. 2. TYPE 693 POWER AMPLIFIER

The bias on the grids of the output stage valves is dependent upon the r.f. drive. It is therefore necessary to protect these valves from damage due to any failure of this drive. This is achieved by the use of a P.A. Guard valve which is so arranged as to conduct only when the r.f. drive fails. Such an action causes a reduction in the output of the screen modulator valve, which in turn reduces the voltage at the screen grids of the P.A. stage. This keeps the anode current within safe limits.

The P.A. guard lamp is normally alight at low brilliance. In the event of failure of the Guard valve the lamp will burn brightly. To assist comparison, a DEPRESS TO SIMULATE BRIGHT switch is provided.

5. Controls

a. Meter Switch. Five positions. Position 5 brings in Monitor Switch.

b. Monitor Switch. Controls the Probe unit, which consists of two TOWERS containing inductance loops so arranged that the FORWARD loop provides a measure of power going up the aerial, while the REVERSE loop indicates the power reflected.

There are 5 positions:

c. POWER.	Meter gives indication of power output (FORWARD TOWER).
d. CAL.	Connects calibrating potentiometer (see *Calibrating* control below).
e. R. COEFF.	Connects REVERSE TOWER, via calibrating circuit, to meter. Provides indication of percentage power reflected in aerial system due to mismatching, faulty connections, etc.
f. MOD %	Provided CALIBRATING control has been adjusted so that full scale deflection of the meter represents amplitude of r.f. power, percentage modulation will be indicated in this position.
g. MON.	Disconnects meter, for use when using monitoring jack and telephones. This is necessary to avoid the phones shunting the meter, so giving rise to erroneous readings. Telephone jack should *always* be removed except when switched to MON, as this always disconnects meter.
h. Grid Tuning.	Controls grid and anode circuit of buffer stage.
i. Anode Tuning.	Controls anode circuit of output stage.
j. Calibrate.	With Monitor Switch to CAL, used to adjust metering circuit to obtain a fullscale deflection of meter (a reading of 100) for whatever power output may be at frequency in use.
k. Transmit/Tune.	In TUNE position reduces voltage to screen grids of P.A. valves.
l. Depress to Stimulate Bright.	To assist comparison between the actual brilliance of the P.A. guard lamp and the bright condition which would indicate failure of the Guard valve.
m. Indicating lamps.	TRANSMIT (red). Burns when H.T. is applied to P.A. stage. P.A. GUARD (amber) Burns low normally. Bright if P.A. guard valve heater fails.

TUNING INSTRUCTIONS

6. *a.* Switch on Transmitter Mains on Control Drawer – Amber lamp Tx Power Unit Lights.

b. Switch on Control Drawer Mains – Amber lamp (Mains on Control drawer) lights. Amber lamp (24 V) lights.

c. Switch on AMP MAINS on Control Drawer – Amber lamp (Amp Power unit) lights.

d. Switch on Mains on Transmitter Power Unit – Blue Lamp (L.T) lights

e. Switch on Mains on Amp Power Unit – Blue Lamp (L.T.) lights.

f. Set up Selector Unit on Transmitter.

g. Disconnect Aerial feeder at top of cabinet and plug CT 214 to socket.

h. On Amp Drawer TRANSMIT–TUNE switch to TUNE.

i. On Transmitter drawer F.C.U. H.T. switch to ON – Amber lamp (F.C.U. H.T.) lights; Green lamp (Channel ready) lights.

j. TUNE–OFF–TRANSMIT switch to TUNE – Red lamp lights.

k. On Amp Drawer H.T. OFF and OVERLOAD RESET switch to ON – Red lamp (Amp Drawer) lights.

l. On Transmitter Drawer METER switch to 8 – Tune Trebler for maximum.

m. On Transmitter Drawer METER switch to 9 – MONITOR switch to POWER – Tune P.A. for maximum.

n. On Amp Drawer METER switch to 3 – tune GRID for maximum.

o. On Amp drawer METER switch to 5 – MONITOR switch to POWER – Tune anode for maximum. Check CT 214 for Power Output.

p. On Transmitter Drawer TUNE–OFF–TRANSMIT switch to TRANSMIT. On Amp Drawer TRANSMIT–TUNE switch to TRANSMIT.

q. On Control Drawer – plug handset into Mic input and press pressel switch.

Repeat *l* to *o* (using meter in Amp in switch position 3 (or 4) for Transmitter Trebler and P.A.).

Do not tune for maximum in CT 214.

If Overload occurs:

On Amp Drawer – TRANSMIT–TUNE switch to TUNE.

On Amp Power Unit – Switch OFF H.T. OFF and OVERLOAD RESET then return to ON.

On Transmitter – TUNE–OFF–TRANSMIT switch to TUNE and repeat from *l*.

Tuning the Aerial Resonator

A hand-tuned system will not normally be used with Transmitter Type 693.

In an auto-tuned system, the procedure is the same as that described for Type 692.

On completion of *n* above.

r. Disconnect CT 214 and plug aerial feeder into resonator. Then proceed as for Type 692.

TESTING AERIAL FEEDER AND MODULATION TESTING

7. The methods of testing the efficiency of the aerial and feeder system and testing for modulation are the same as those for Type 692, *Except* that the monitor switch, monitor jack plug, CALIBRATE control, and meter to which the Type 692 instructions refer are those in the amplifier drawer, and not the Transmitter drawer.

USING THE TRANSMITTER

8. *Operation.* Is not affected by installation differences such as whether or not Relay Unit Design 90 is fitted, or whether R.C.S. Unit is installed. The only differences are:

a. Set TUNE–TRANSMIT switch on amplifier drawer to TRANSMIT.

b. Set power unit H.T. OFF and OVERLOAD RESET switch to ON. Transmit (red) lamp on amplifier drawer lights.

Changing Channels. Is accomplished in the same way, depending on the installation, as for Type 692.

Note. Type 693 is normally installed with the full R.C.S. facility provided.

Emergency Operation as Low Power Transmitter

9. If a fault in either the amplifier drawer or the amplifier power drawer of a Type 693 transmitter, the transmitter can be used in low power. The amplifier drawer must remain connected inside the cabinet.

a. On control drawer set TRANSMITTER MAINS and AMPLIFIER MAINS switches to OFF.

b. Change over the HIGH/LOW power plug inside the transmitter drawer to the LOW POWER position,

c. Undo the hinged cover in the top of the transmitter cabinet and change over the connections by inserting socket 1 SKK into plug 1 PLT and socket 1 SKL into plug 1 PLK.

d. Set the TRANSMITTER MAINS switch to ON and retune trebler and P.A. controls.

Note. The AMPLIFIER MAINS switch must be left to OFF.

2.24. TYPE 696

HANDBOOK. B.R. 2304

ESTABLISHMENT LIST. E1293

FREQUENCY RANGE. 225–399·9 Mc/s

FREQUENCY DETERMINATION. CRYSTAL CONTROLLED FREQUENCY SYNTHESIZER

EMISSION AND POWER OUTPUT:

VOICE
M.C.W.
HI FI
} NOT LESS THAN 14 WATTS INTO 75 OHMS.

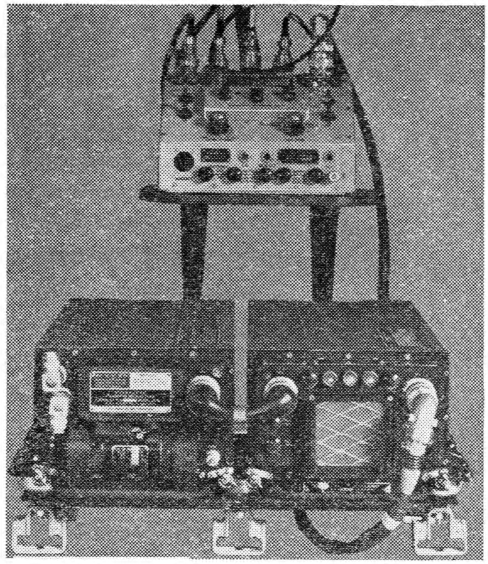


FIG. 1

GENERAL

1. An extremely compact general purpose multi-channel U.H.F. transceiver to replace Type 86M. There are 1,750 channels at 100 kc/s intervals between 225 and 399·9 Mc/s. Ship version of AN/ARC–52.

2. The HI FI facility gives extended bandwidth and can be utilized for data transmission.

3. Three major units are mounted on vibration isolating trays:

a. POWER SUPPLY UNIT

b. CONTROL UNIT

c. TRANSCEIVER

4. The transceiver incorporates forced cooling and a heat exchanger system.

5. Power supplies 115 or 230 V 45–65 c/s.

6. Associated aerials AJE SURFACE CRAFT
ALG OR AMK SUBMARINES

7. Duty Cycle. Nominally 5 minutes transmission in any 15 minute period.

8. **Interconnection of units** (*See* Fig. 2)

9. **Power Supply Unit**

a. This unit provides all d.c. requirements of the transceiver and serves as a junction box between transceiver and control units. Valve heater supplies are obtained from a sub-unit on the transceiver chassis.

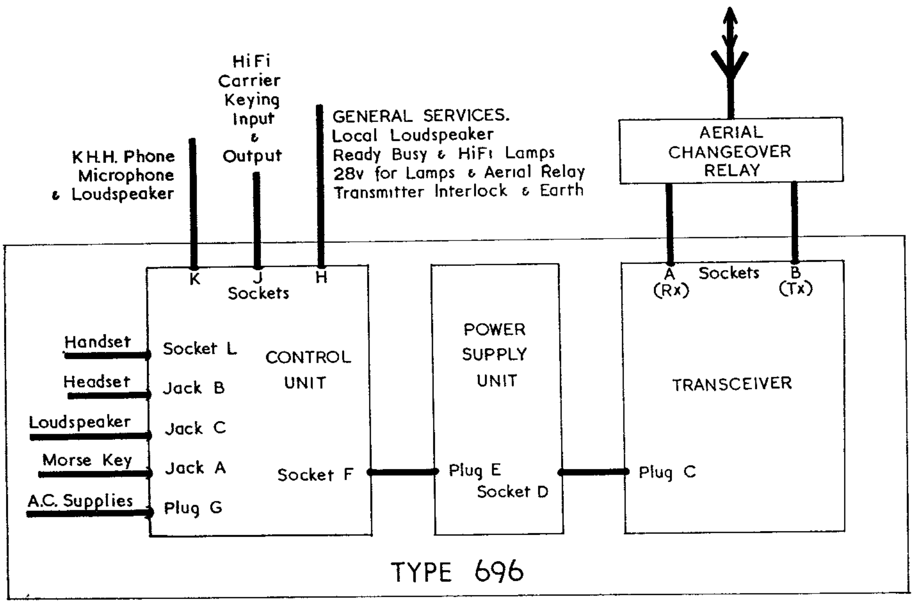


FIG. 2. TYPE 696 – INTERCONNECTION OF UNITS

b. Three front panel lamps provide indication for the following supplies:

(1) A.C. Mains

(2) Heaters

(3) 28 V

c. Three neon lamps are mounted within the case as warnings of the existence of high potentials.

d. Two mains voltage selector panels are provided at the rear of the unit.

e. The unit produces the following d.c. supplies:

(1) 440 V H.T.

(2) 155 V H.T.

(3) 130 V H.T.

(4) 28 V Control Circuits.

10. Control Unit

a. The control unit, which may be situated up to ~~40 ft~~ 10ft from the receiver, provides complete control of the equipment including the selection of any one of the 1750 channels.

b. A Thermal delay system ensures that transmission cannot take place until approximately 50 seconds after initial switching on.

c. A Thermal overload system causes the READY and BUSY lamps to flash alternately if the temperature of the transceiver case rises above approximately 85 degs C.

d. Controls

The following controls appear on the control unit and are explained under 'OPERATING INSTRUCTIONS'.

(1) FUNCTION switch, which has the following positions:

REMOTE }
[redacted] } VOICE
LOCAL

HI FI

RECEIVE }
TRANSMIT } M.C.W.

(2) FREQUENCY SELECTOR switches. These switches are calibrated direct in frequency and there is no requirement for charts or graphs.

(3) LOCAL PHONE GAIN

(4) MUTING ON–OFF switch

(5) LOUDSPEAKER ON–OFF switch

(6) MAINS ON–OFF switch

(7) R.I.S. ON–OFF switch.

Two preset controls located beneath a hinged flap are for HI FI and voltage adjustment.

e. Jacks

(1) Phones. (2) Loudspeaker. (3) Key. (4) Headset.

f. Indicator Lamps

(1) Supply. (2) 28 V. (3) Heaters. (4) Ready. (5) Busy. (6) HI FI.

g. Fuses

Fuses on the front panel are in the following circuits:

(1) A.C. supply. (2) Heaters. (3) 28 V.

11. Transceiver

a. General. The Block Diagram of Type 696 shows that certain frequency generation circuits in the transceiver serve both transmitter and receiver. Relays in the variable i.f. amplifier and H.T. switching, condition these circuits as appropriate for transmission or reception. Crystal selection and adjustment of tuned circuits is carried out by a mechanical tuning unit.

b. Transmitter Section

The following explanation should be followed with reference to the block diagram.

(1) Unit 8 houses two crystal oscillator banks, each containing 10 crystals.

BANK A provides outputs in 1 Mc/s steps between 24·9 and 33·9 Mc/s.

BANK B provides outputs in 0·1 Mc/s steps between 3·05 and 2·15 Mc/s.

(2) Unit 5 houses crystal oscillator BANK C which contains 15 crystals.

The output of BANK C is multiplied to provide one of 18 output frequencies, in 10 Mc/s steps between 200 and 370 Mc/s at the SPECTRUM AMPLIFIER.

(3) The selected outputs from BANK A and BANK B are mixed to provide an input to the INJECTION AMPLIFIER between 21·85 and 31·75 Mc/s. The resultant signal is taken to the 1st TRANSMITTER MIXER together with an output from the 1·85 Mc/s Oscillator.

(4) The resultant 20·0 to 29·9 Mc/s output of the 1st TRANSMITTER MIXER is taken via the VARIABLE IF AMPLIFIER to the second TRANSMITTER MIXER. Also fed to the second TRANSMITTER MIXER is the signal from the SPECTRUM AMPLIFIER. (200 to 370 Mc/s as explained in (2) above.)

(5) The output of the second TRANSMITTER MIXER is the final frequency of the transmitter between 225 and 399·9 Mc/s and is applied to the modulated r.f. P.A. stage via the TRANSMITTER PREAMPLIFIER.

(6) The MODULATOR UNIT can accept signals from a microphone or an associated HI FI UNIT. The Modulator unit contains a 1000 c/s tone oscillator for M.C.W. operation.

(7) Sidetone is provided on voice or M.C.W. by rectification of the r.f. carrier.

c. Receiver Section

The receiver is a double superhet which uses a variable first i.f. between the limits 20 to 29·9 Mc/s. The first i.f. for a given signal frequency is the unit and decimal of that frequency plus 20 Mc/s, *e.g.* for a signal frequency of 277·8 Mc/s, the first i.f. would be: 7·8+20 Mc/s = 27·8 Mc/s.

The second i.f. is fixed at 1·85 Mc/s.

The following explanation should be followed with reference to the block diagram.

(1) The input signal is fed via an r.f. amplifier to the first RECEIVER MIXER.

The SPECTRUM GENERATOR provides the L.O. signal for this mixer.

(2) The output of the first RECEIVER MIXER is the difference between the two applied frequencies and lies between 20 and 29·9 Mc/s. This signal is taken via the VARIABLE I.F. AMPLIFIER to the second RECEIVER MIXER.

(3) The second Receiver Mixer has an input from the INJECTION AMPLIFIER of between 21·8 and 31·7 Mc/s and the result is a signal at the second i.f. of 1·85 Mc/s.

(4) The second i.f. signal is filtered and fed to the DETECTOR, AVC, and NOISE LIMITER stages.

(5) The audio stages include a MUTING CIRCUIT, HI FI AMPLIFIER and a LOUDSPEAKER AMPLIFIER.

12. **Operating Instructions**

a. Prior to making the SUPPLY switch the following Setting of controls should be carried out.

(1) FUNCTION switch to VOICE LOCAL

(2) LOCAL PHONE to MID POSITION

(3) L.S. switch ON

(4) MUTE switch OFF

(5) R.I.S. switch OFF

(6) FREQUENCY SELECTOR switches to desired channel frequency

(7) HI FI TX GAIN (beneath access flap) MIDWAY

(8) RECEIVER RF GAIN (beneath access flap) *fully clockwise*

b. Function Switch

(1) When this switch is in the VOICE LOCAL position all remote circuits are disconnected.

(2) In the VOICE REMOTE position of the switch limited control of the equipment is available via the KHH control system.

(3) HI FI. . . . In this case an input to the transmitter may be taken from an external HI FI Unit.

(4) M.C.W. RECEIVER. Transmission circuits are isolated and local loudspeaker disconnected. Tone output to local handset and headset only.

(5) M.C.W. TRANSMIT. The (red) BUSY lamp indicates that the equipment is permanently in the transmit condition. Keying is available up to 30 W.P.M. using a nominal 1000 c/s tone.

c. Frequency Control

The first of three switches selects the frequency in *ten megacycle* steps, the second in steps of 1 *megacycle* and the third in steps of 100 *kc/s*. Any of the 1750 channels can thus be selected by this method; ~~no other tuning is necessary~~.

When changing channel the READY and BUSY lamps are extinguished.

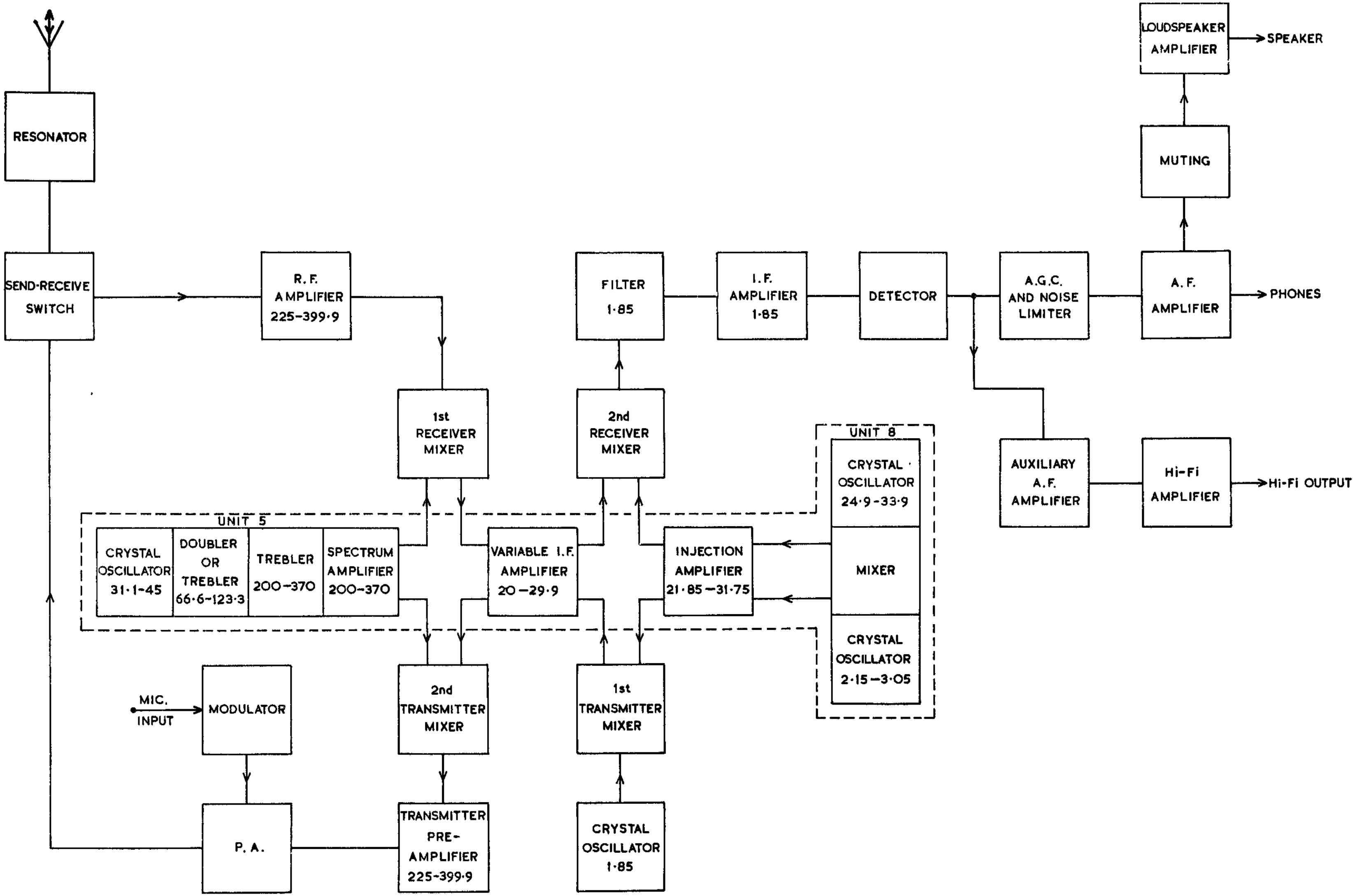


FIG. 3. TYPE 696 TRANSCEIVER 255 – 399.9 MC/S

d. Mute Control

Controls a circuit which mutes the rceiver output until a signal of predetermined strength is received.

e. Receiver R.F. Gain Control

This control is located beneath the access flap and is used when measuring the receiver noise factor using a CT 207.

f. The Duty Cycle and Thermal Overload Lamp Indications should be borne in mind when operating the equipment.

g. Resonators.

Hand-tuned resonators, where fitted are to be set up to the tuning adjustment graph reading and tuned as necessary.

2.25. TYPE TCS

DATE OF DESIGN. 1941

HANDBOOK. U.S.N.

ESTABLISHMENT LIST. AE2

FREQUENCY RANGE. 1·5 to 12 Mc/s

FREQUENCY DETERMINATION. V.F.O. or Crystal Oscillator

EMISSION AND POWER OUTPUT. C.W. 40 W
Voice 20 W

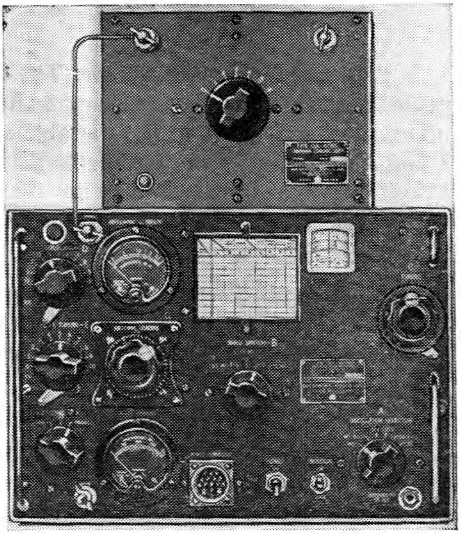


FIG. 1

1. **General.** Type TCS is an American transmitter and receiver outfit fitted as a low power transmitter and/or emergency outfit in some ships and as the main HF transmitter in some small craft. It is being replaced by Types 618 and 619. The receiver is not widely fitted and on account of its radiating properties should not be used during periods of wireless silence. The transmitter only is described here.

2. **Power Supplies.** There are basically three separate power supply units available, only one of which is provided with each transmitter.

A.C. POWER PACKS. A rectifier unit which operates from 115 or 230 V a.c. or from 115 V a.c. only, two designs being available.

BATTERY POWER PACKS. A dynamotor unit which operates from a 12 or 24 V Battery outfit or from 12 V only, two designs being available.

UNIVERSAL POWER PACK. A motor generator unit. The motor generators are interchangeable and may be supplied to operate from any of the following supplies:

a. 24 V d.c.
b. 32 V. d.c.
c. 115 V d.c.
d. 230 V d.c.
e. 115 V a.c.

3. **Frequency Build-up.**

RANGE	V.F.O. (M.O.) OR CRYSTAL OSCILLATOR	DOUBLER TUNED CIRCUIT (BUFFER GRID)	BUFFER (DOUBLER) AMPLIFIER	POWER AMPLIFIER
1 1·5 to 3 Mc/s	1·5 to 3 Mc/s	Out	1·5 to 3 Mc/s	1·5 to 3 Mc/s
2 3 to 6 Mc/s	1·5 to 3 Mc/s	Out	3 to 6 Mc/s	3 to 6 Mc/s
3 6 to 12 Mc/s	1·5 to 3 Mc/s	3 to 6 Mc/s	6 to 12 Mc/s	6 to 12 Mc/s

4. **Crystal Frequency.** When using crystal oscillator control the frequency of the crystal will be:

Range 1 = Output Frequency   Range 2 = $\frac{\text{Output Frequency}}{2}$ Range 3 = $\frac{\text{Output Frequency}}{4}$

5. **V.F.O. and Crystal Oscillator.** The transmitter may be v.f.o. or crystal controlled depending on the position of the Oscillator Selector Switch. In the M.O. positions a v.f.o. stage is employed which tunes between 1·5 and 3 Mc/s. The variable capacitor tuning is ganged to the TUNING control. In the CO1, 2, 3 and 4 positions of the Oscillator Selector Switch a separate crystal oscillator stage is employed. The 4 positions allow for selection of any one of four crystals to be connected to the grid of the crystal oscillator valve. The output of the v.f.o. or crystal oscillator is fed to the Buffer Amplifier stage.

6. **Doubler Tuned Circuit.** This is a tuned circuit to the Buffer stage which is brought in by the range switch on range 3 only. It is tuned to twice the frequency of the v.f.o. or crystal oscillator stage by a variable capacitor which is ganged to the TUNING control.

7. **Buffer Amplifier.** The Buffer Amplifier, whose tuned circuit consists of one of three inductances selected by the range switch and a variable capacitor ganged to the TUNING control, acts as a straight amplifier on range 1. On range 2 it is tuned to twice the frequency of the v.f.o. or crystal oscillator. On range 3 it is tuned to twice the frequency of the Doubler tuned circuit, i.e. four times the frequency of the v.f.o. or crystal oscillator. Its output is fed to the grid of the P.A. stage.

8. **Power Amplifiers.** The P.A. stage employs two valves in parallel for c.w. working, whilst only one of these valves is employed on voice. The tuned circuit consists of a tapped inductance and fixed capacitors both of which are selected by the range switch and a variable capacitor for fine tuning controlled by the PLATE TUNING control. The P.A. stage is inductively coupled to the aerial by means of the variable coupling control. For voice transmission the anode and screens of the P.A. stage are modulated.

9. **Aerial Circuit.** A series-parallel arrangement whereby a fixed capacitor may be connected in series or in parallel with a variable inductance (Antenna Loading) or in the OFF position the inductance may be used alone. To allow better matching on the lower frequencies, an additional antenna loading coil fitted external to the transmitter can be used in series with the aerial, and provides an additional inductance with six tapping positions (marked 0 to 5) selected by the Antenna Loading Coil Switch. Position 6 of this switch shorts the coil out for use on the higher frequencies.

10. **Modulator.** A single push-pull modulator stage is employed for voice transmission. The microphone output is connected to the grids of the modulator via the input transformer and the output of the modulator used to modulate the H.T. and screen supply to the P.A. stage.

11. **Controls**

A – OSCILLATOR SELECTOR. Enables the use of four crystals or M.O. Also has a M.O. Test psoition. In this position H.T. is applied, without keying, to the oscillator and buffer stages only and enables the transmitter to be tuned to the dead space of the receiver frequency.

B – BAND SWITCH. Selects the appropriate tuned circuits in the Buffer amp and P.A. stages and on band 3 brings in the Doubler tuned circuit.

C – TUNING. Tunes the ganged variable capacitors in the M.O. Buffer amp. and Doubler tuned circuits.

D – COUPLING. Adjusts the coupling of the P.A. stage to the aerial circuit.

E – PLATE TUNING. Adjusts variable capacitor in the P.A. output circuit.

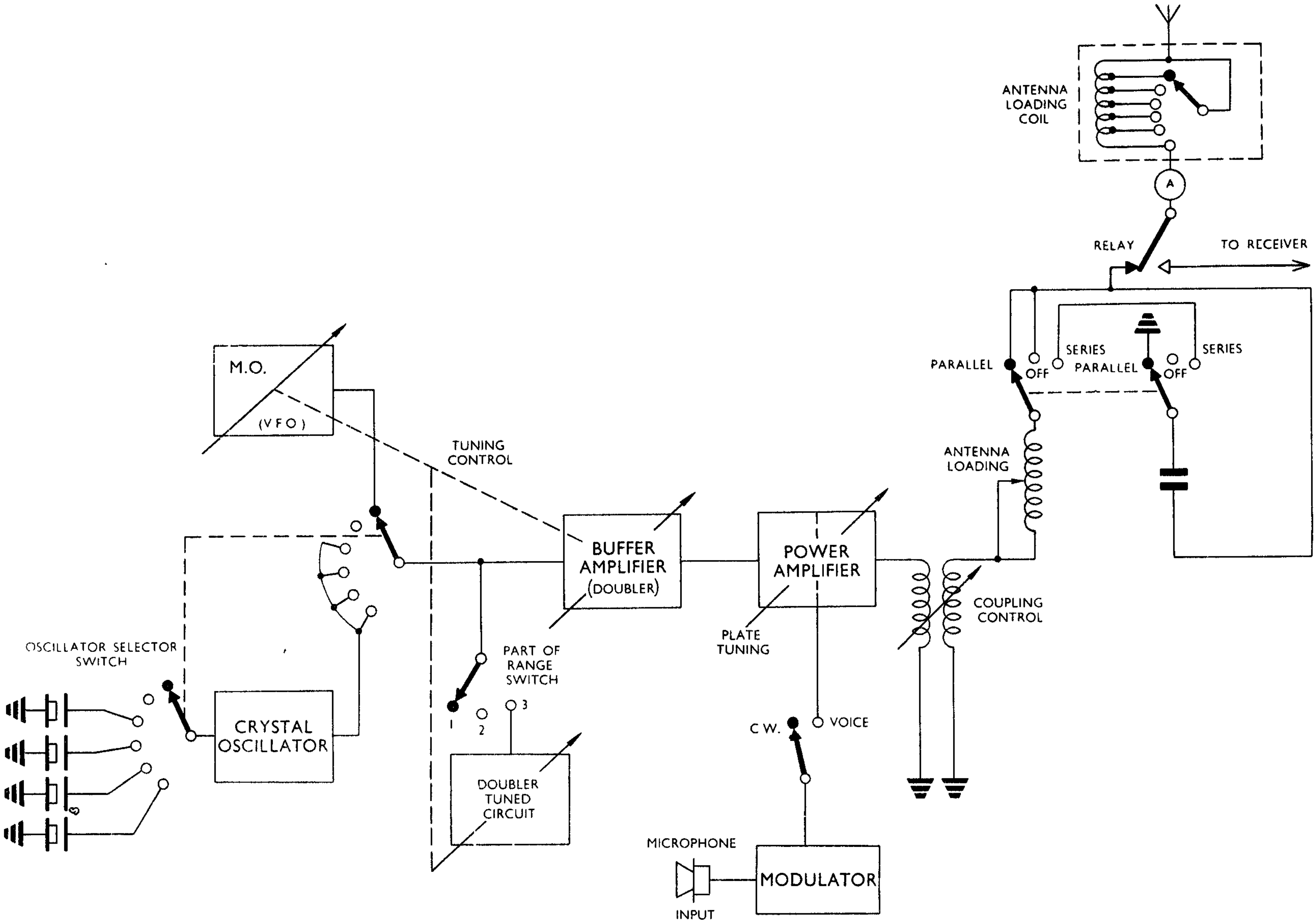


FIG. 2. TYPE TCS TRANSMITTER

F – Antenna Condenser. A fixed capacitor which can be switched either:

a. Out of the circuit.

b. In series, or

c. In parallel with aerial inductance.

G – Antenna Loading. Adjusts variable inductance in the aerial circuit.

H – Aerial Current and P.A. Anode Current Meters. Standard loading marks are painted on the P.A. meter for voice and c.w. The aerial ammeter reads a maximum aerial current of 3 amps.

I – Emission Switch.

a. *On c.w.* it brings in both P.A. valves in parallel and breaks the filament supply to the modulators.

b. *On Voice* it breaks the filament supply to the second valve in the P.A. and makes the filament supply to the modulators (30 seconds should be allowed for the modulator filament to heat up).

J – Antenna Loading Coil. An external tapped coil in series with the aerial circuit used for matching the aerial on Range 1.

12. V.F.O. Operation

a. Set the following controls to starting positions as below:

Oscillator Selector Switch to M.O. (see note below).

Band switch to the appropriate band.

Tuning control to the appropriate frequency.

Plate tuning to 1.

Coupling to 0.

Antenna loading to 0.

Antenna Condenser switch to OFF.

Antenna Loading coil switch to 6.

Switch to c.w.

b. Make power switch and wait about one minute.

c. Check the setting of the Tuning Control against frequency standard being used (see note below).

d. Adjust the Plate Tuning control for minimum in the Plate current meter.

e. Increase the coupling slightly, and carry out standard aerial tuning drill using coupling, plate tuning, and antenna loading. Positions SERIES and PARALLEL of the Antenna Condenser switch should be tried if no correct tuning is achieved.

13. Crystal Operation

a. Insert appropriate crystals.

b. Set the oscillator selector switch to the crystal position required and remaining controls as for *a* of para. 12.

c. Make power switch and wait about one minute.

d. Adjust the tuning control for just off MAXIMUM in the Plate current meter.

e. Carry out *d* and *e* of para. 12.

Notes. It is possible to set the transmitter to a frequency already set up on the receiver as follows:

(1) Set the Oscillator Selector switch to M.O. Test. (2) Adjust tuning control for dead space in receiver phones. (3) Carry out *d* and *e* as for v.f.o. operation.

2.26. OUTFIT TDC

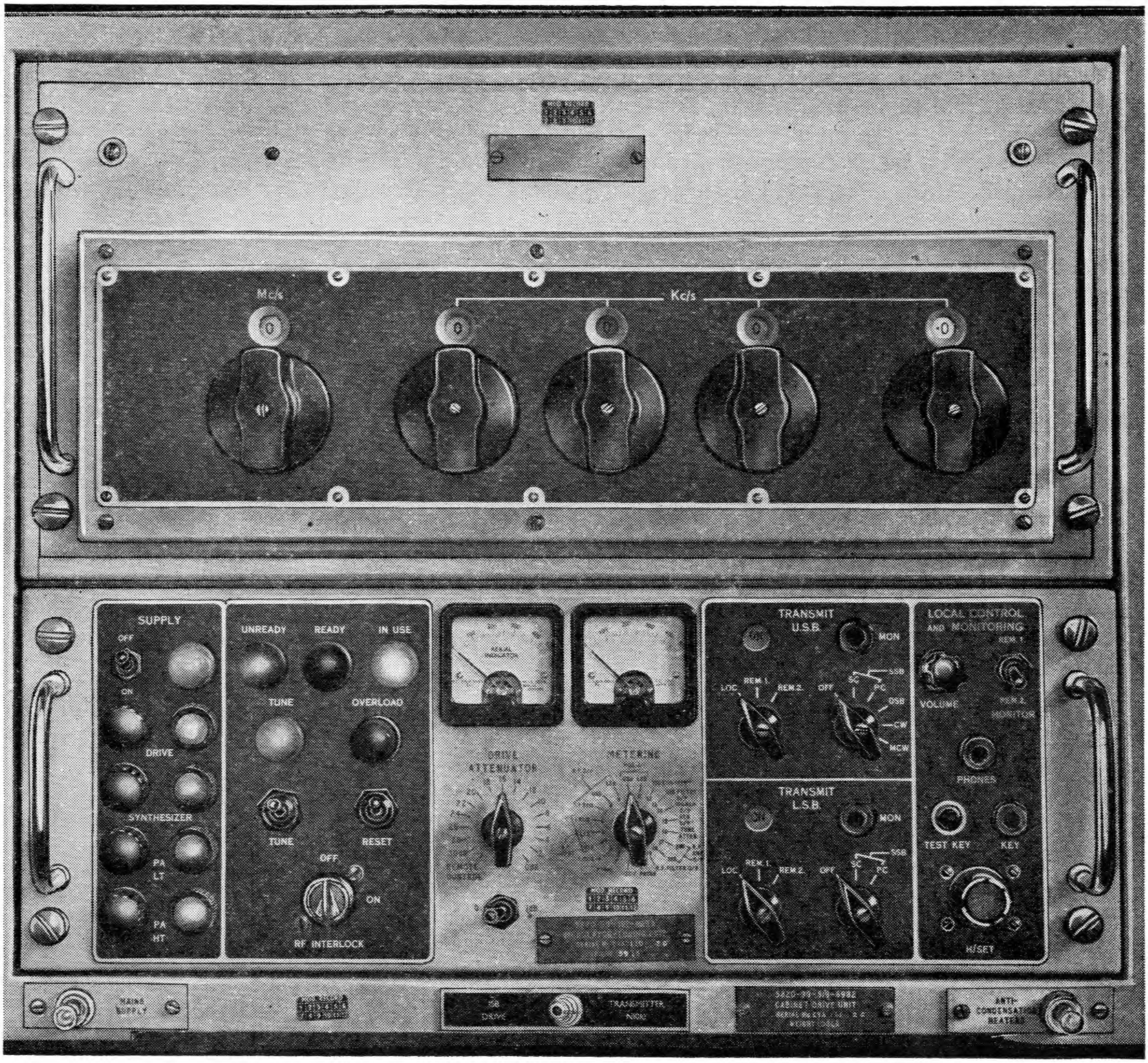


FIG. 1. OUTFIT TDC

HANDBOOK

E LIST

FREQUENCY RANGE 240 – 525 kHz, 1 – 27.5 MHz } In 100 Hz steps

POWER OUTPUT 100mW

POWER SUPPLIES 100 – 130V, 200 – 250V A.C. 50/60 Hz

General

1. Outfit TDC comprises the following units:
Synthesiser, Electrical Frequency (Marconi Type 3786F), Modulator – Tuning Unit.

2. The outfit is designed to provide a low level drive to a linear type amplifier operating in either the MF band of 240 – 525 kHz, or the HF band of 1 – 27.5 MHz. The drive system operates on the principle of frequency synthesis; accepting a 1 MHz input from a frequency standard and translating this to spot frequencies at 100Hz intervals throughout the bands, according to the frequency selected at the set of front panel dials. At the same time, the drive signal is modulated in accordance with the mode of operation selected.

3. Depending upon the design of the associated power amplifier, Outfit TDC may also be used to control the application of supplies to the power amplifier and to monitor its functioning. Outputs such as side tone and muting are available if required to provide these services to an associated receiver (used in Type 641).

Frequency Synthesiser

4. The frequency synthesiser is designed to give the required output for Drive Outfit TDC and also to give the required output for the mixers when associated with receiver outfit CJM. The synthesiser will therefore be considered here in its application to both these outfits.

5. A stable 1 MHz is fed to the synthesiser from an external frequency standard. Sub multiples of 100 kHz, 10 kHz and 1 kHz are obtained by frequency division in the Frequency Divider. Separate tuned buffer amplifiers feed these outputs to the Decade Generating Units, comprising the AF Oscillator, which provides 100 Hz decade, and the four Frequency Multipliers which provide 1 kHz, 100 kHz and 1 MHz decades.

6. The AF Oscillator provides an output of 2.0 to 2.9 kHz switched in 100 Hz steps by the .1 kHz decade switch. At 2.0 kHz, the output is derived from the reference frequency by multiplication, but the 2.1 to 2.9 kHz frequencies are generated by an internal crystal oscillator.

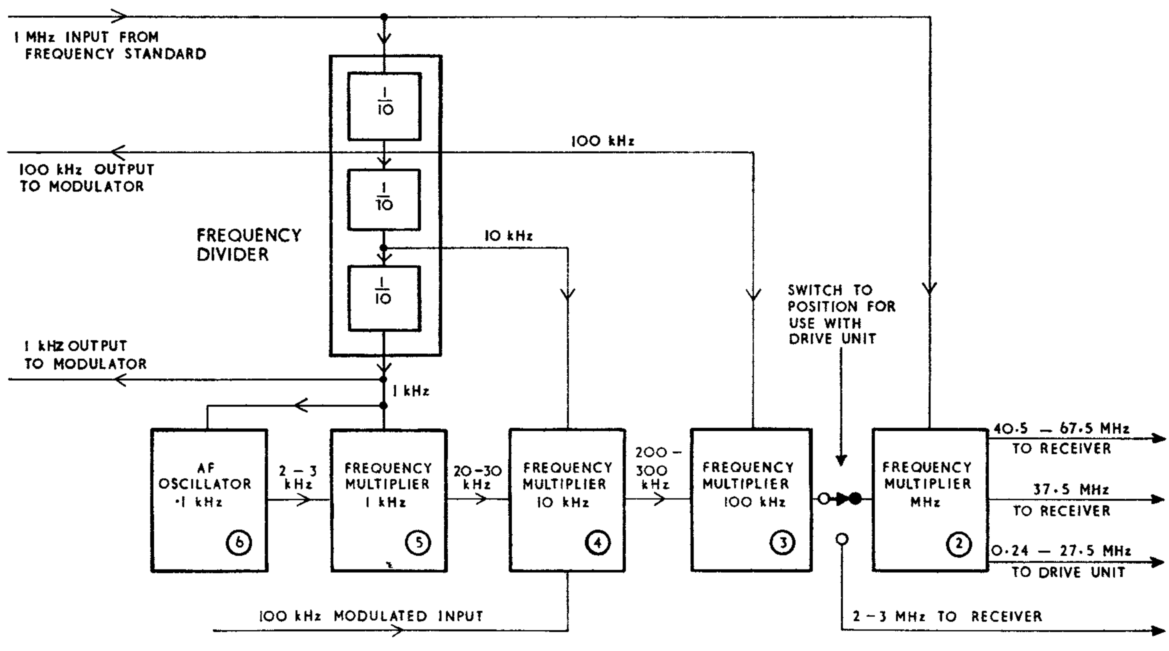


FIG. 2. FREQUENCY SYNTHESISER – BLOCK DIAGRAM

7. The Frequency Multipliers employ the triple mix system using variable oscillators, balanced modulators and highly selective filters to select the required multiple of the sub harmonic frequency, which in each case is added to the input frequency to produce the required final frequency. Thus the required signal is progressively synthesised as each multiplier contributes its respective increment.

8. In the receiver application, two of the mixing processes in the MHz multiplier are omitted, thereby giving the required output for receiver mixers.

9. Auto Tuning Circuits. The Synthesiser contains a precision potential divider network associated with the decade switches. When this network is supplied with 30V from an associated drive or receiver it provides a D.C. output proportional to the frequency set on the decade switches. This output is the reference for the automatic tuning servo circuits of both the drive and the receiver.

10. Interlock circuits are provided in each decade control and these form part of the time relay circuit in the associated drive unit.

Modulator – Tuning Unit

11. The Modulator-Tuning Unit forms a comprehensive drive equipment when used with a frequency synthesiser. The drive features automatic tuning and level control whilst the output from the unit is 100mW p.e.p. for driving a linear power amplifier.

12. The modulator circuits provide for one or two audio frequency inputs to give a SSB/ISB output at 100 kHz which is fed to the frequency synthesiser. The frequency synthesiser then translates this to the final output frequency. The signal is then applied to the Tuning Unit Drive in which it is filtered and amplified to provide the final output of 100mW.

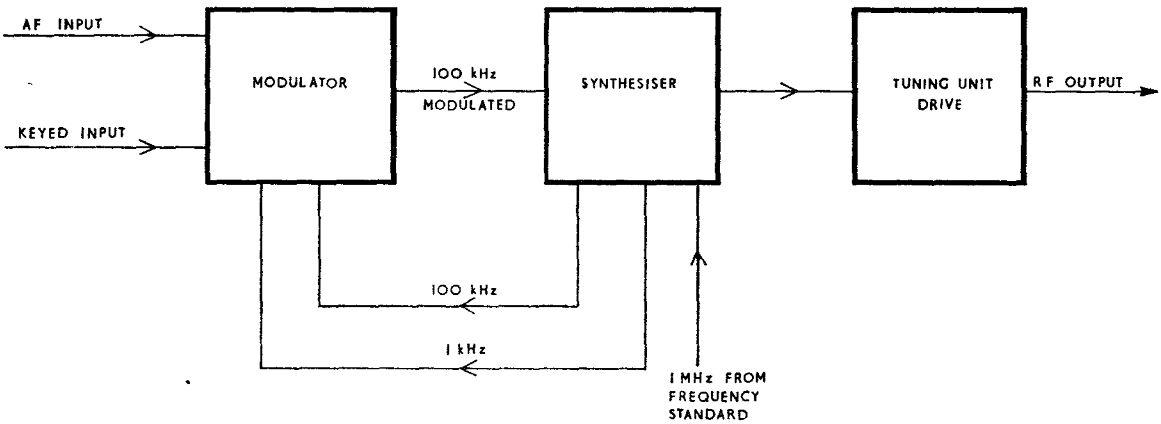


FIG. 3. BASIC MODULATOR – TUNING UNIT BLOCK

Brief Description

13. Front panel switches (SA and SB) enable line and keying inputs to be selected from any of three operating positions designated LOCAL, REMOTE1 and REMOTE2 to provide the following types of transmission:

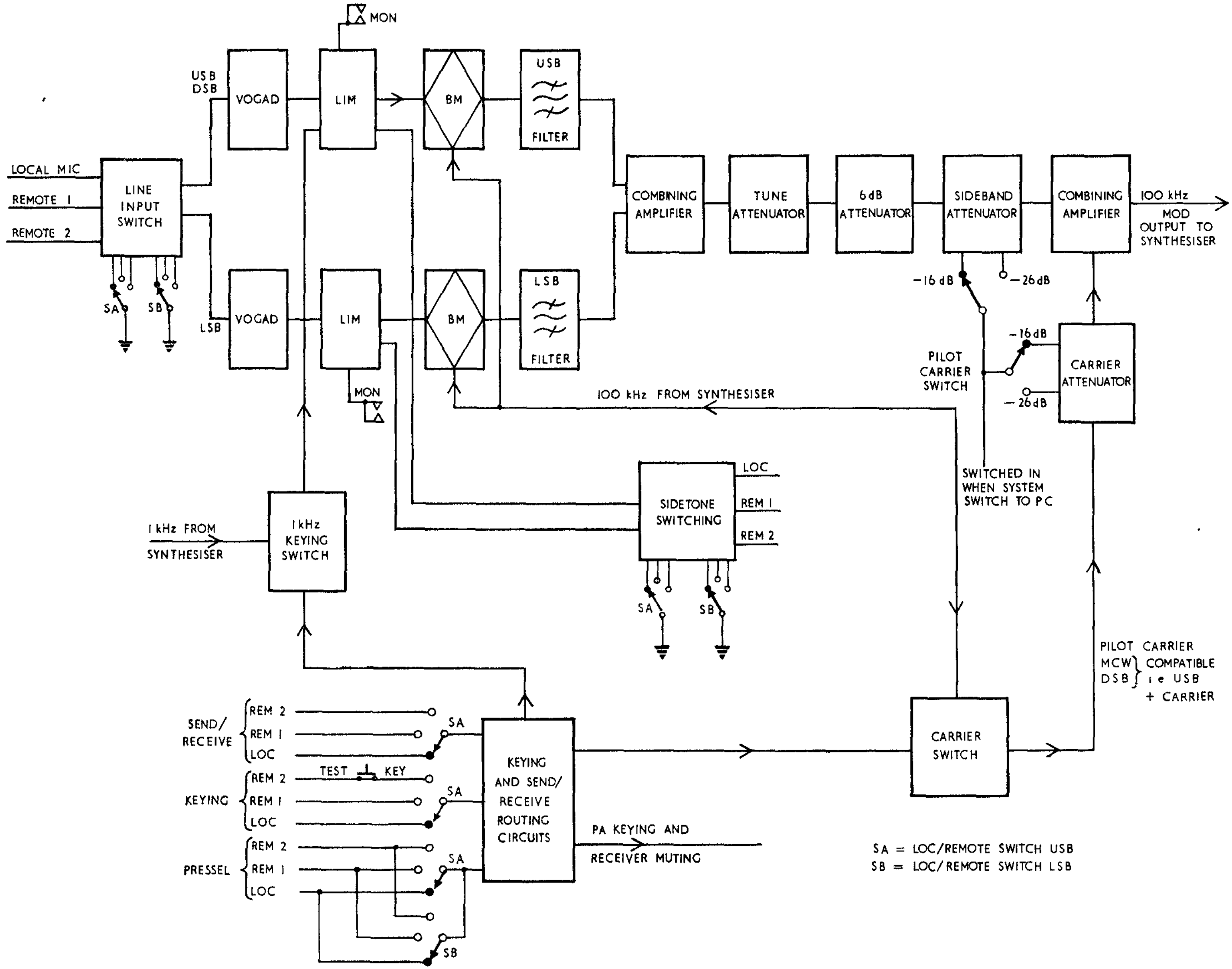
a. SSB or ISB with suppressed carrier.

b. SSB or ISB with pilot carrier.

c. Compatible DSB (carrier and upper sideband only).

d. CW (1kHz tone keyed in upper sideband only).

e. MCW (1kHz tone keyed in upper sideband plus keyed carrier).


MON
USB
DSB
VOGAD
LIM
BM
USB
FILTER
LOCAL MIC
REMOTE 1
REMOTE 2
LINE INPUT SWITCH
SA
SB
COMBINING AMPLIFIER
TUNE ATTENUATOR
6dB ATTENUATOR
SIDEBAND ATTENUATOR
COMBINING AMPLIFIER
100 kHz
MOD OUTPUT TO SYNTHESISER
−16 dB
−26 dB
LSB
VOGAD
LIM
BM
LSB
FILTER
MON
PILOT CARRIER SWITCH
−16 dB
−26 dB
CARRIER ATTENUATOR
100 kHz FROM SYNTHESISER
SWITCHED IN WHEN SYSTEM SWITCH TO PC
LOC
REM 1
REM 2
SIDETONE SWITCHING
1 kHz FROM SYNTHESISER
1 kHz KEYING SWITCH
SA
SB
PILOT CARRIER
MCW
DSB
COMPATIBLE i e USB + CARRIER
SEND/ RECEIVE
REM 2
REM 1
LOC
SA
KEYING
REM 2
TEST KEY
REM 1
LOC
SA
PRESSEL
REM 2
REM 1
LOC
SA
SB
KEYING AND SEND/ RECEIVE ROUTING CIRCUITS
PA KEYING AND RECEIVER MUTING
CARRIER SWITCH
SA = LOC/REMOTE SWITCH USB
SB = LOC/REMOTE SWITCH LSB

14. The front panel LOC/REMOTE switches select the required AF input to be fed to the USB or LSB channel. In each channel, the audio signal passes through a VOGAD and LIMITER circuit which are permanently in the circuit. In the USB channel only, an alternative input is a 1 kHz tone from the keying switch, which is fed to the LIMITER when the upper sideband is switched to CW or MCW. In each channel, a front panel monitor phone socket is also available at the local or remote line selected by the appropriate LOCAL/REMOTE switch.

15. The audio signal in each channel then passes to a balanced modulator where a 100 kHz radio frequency from the synthesiser is also fed. The outputs of the balanced modulators will contain the modulated sideband and a considerably reduced 100kHz carrier in each channel. These outputs pass through appropriate sideband filters which further reduce the carrier frequency, after which the modulated sidebands are combined.

16. Following the combining of sidebands, a number of attenuator circuits are employed as follows:

a. Tune Attenuator. Attenuation is available at 0dB, –3dB, 6dB or –9dB preselected by link in the setting up of the equipment in order to provide a low level output for reduced power tuning if required.

b. 6dB Attenuator. Brought into circuit in the DSB and MCW position of the USB System Switch and also when the LSB is used in any ISB mode, i.e. in conjunction with the SC, PC or CW position of the USB system switch.

c. Sideband Attenuator. Switched into circuit in the PC position of either sideband system switch. Introduces –16dB or –26dB attenuation dependent on the position of an internal pilot carrier switch.

17. After the attenuator circuits, the modulated sidebands pass through a combining amplifier where the full carrier can be re-inserted in the MCW or DSB mode by the keying of the carrier switch, or an attenuated carrier can be re-inserted in either of the pilot carrier modes.

18. The 100 kHz modulated output of the modulator is passed to the synthesiser where it is combined in the 10 kHz frequency multiplier.

19. The synthesiser will provide an output at the chosen radio frequency modulated as selected at the modulator and this RF output is passed to the tuning unit drive.

Tuning Unit Drive

20. The input to the tuning unit drive is from the synthesiser and the output is fed to the associated power amplifier.

21. The tune attenuator provides attenuation of the signal in steps of $\frac{3}{8}$dB from 0dB to 23$\frac{5}{8}$dB automatically controlled by feedback from the ALC detector to ensure that the final output is always 100mW during the tuning process.

22. The RF switch and output switch form part of the normal keying functions of the equipment.

23. The RF attenuator provides attenuation in 1dB steps from 0dB to 31dB and is switched by front panel controls to give a power reduction facility.

24. The signal from the R.F. attenuator is amplified in the Wideband Amplifier coupled to tunable bandpass filters. The correct filters for the frequency required are chosen by the Range Control on setting the MHz decade of the synthesiser. An output from the Range Control is also available to feed the range control of the associated power amplifier. The chosen filters are fine tuned by a servo mechanism which takes up a position decided by the voltage received from the synthesiser decade control potential dividers.

25. When automatic tuning has been completed, the RF output, at a level decided by the Drive Attenuator Switches (up to 100mW), is available to feed a power amplifier.

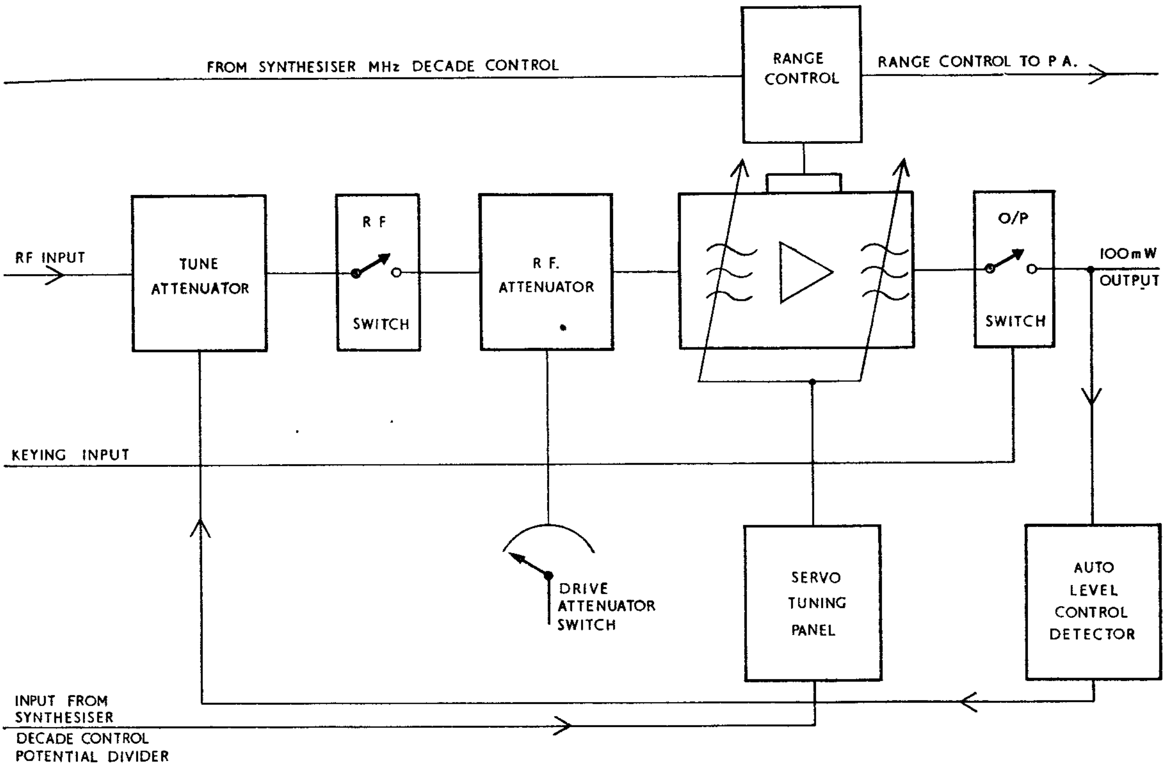


FIG. 5. TUNING UNIT DRIVE – BLOCK DIAGRAM

Modulator – Tuning Unit. Front Panel Controls

26.

SWITCH OR CONTROL	POSITION	EFFECT
Supply off/on	ON	Connects mains supply.
TUNE	Pressed	Commences the tuning sequence.
RESET	Pressed	Resets mains supply if OVERLOAD has tripped. Mains must first be switched OFF to allow smoothing capacitors to discharge.
RF Interlock off/on	OFF	Open circuits keying lines.
Drive attenuator	0 – 30dB	Varies degree of attenuation or drive output in steps of 2dB.
	0 – 1dB	Inserts 1dB in addition to that set on 0 – 30dB switch.
Metering	20 Steps	Selects built in circuit metering positions displayed on meter.
USB and LSB Input Switches	LOCAL	All circuits controlled at front panel.
	REM1	All circuits controlled at REM1 operating position.
	REM2	All circuits controlled at REM2 operating position.
USB System Switch	SSB { OFF, SC, PC	Partial carrier at –16dB or –26dB as set on internal switch.
	DSB	Upper sideband only and full carrier.
	CW	1 kHz keyed tone in upper sideband, suppressed carrier.
	MCW	1 kHz keyed tone in upper sideband and full keyed carrier.
LSB System Switch	SSB { OFF, SC, PC	Partial carrier at –16dB or –26dB as set on internal switch.
Volume		Controls audio level of signal available in phones or headset.
Monitor	REM1	Allows monitoring of transmission in USB or LSB if respective input switch is to REM1.
	REM2	As above if input switch set to REM2.
Test Key	Pressed	Simulates a local key to check functioning of equipment.

27. In addition to the controls listed above, the front panel also carries a number of fuse sockets, indicator lamps, phone, local key and headset/handset sockets.

Tuning

28. Outfit TDC may be used as a drive for a variety of amplifiers. For this reason, instructions for the use of the controls in three arrangements to cover all possible applications will be shown. These arrangements are:

a. When the associated amplifier is not designed for auto tuning (e.g. Outfit TDC only, auto tuning).

b. When used in a transmitter with auto tuning capability (e.g. Type 642).

c. When used in a transceiver with auto tuning capability (e.g. Type 641).

29. Modulator-Tuning Unit as outfit TDC. Transmitter not fitted for auto tuning.

a. The READY, IN USE and OVERLOAD lamps are inoperative.

b. Set SUPPLY switch to ON. This also energises the Synthesiser.

c. Insert key and ensure R.F. INTERLOCK is ON.

d. Observe (1) The SUPPLY lamp is alight.
(2) The Synthesiser dial lamps are alight.
(3) The TUNE lamp is alight.

e. Select the required frequency on the synthesiser.

f. Depress TUNE switch to initiate tuning sequence.

g. After approximately 1 second the TUNE lamp is extinguished, indicating that the tuning sequence is complete.

h. Set the system and input switches to the type of transmission required. This may be done before step *f.*

i. If any frequency change is made on the synthesiser, the TUNE lamp will light and the tuning sequence must again be initiated as in *f.*

30. Modulator – Tuning Unit in transmitter with auto tuning capability.

a. Set SUPPLY switch to ON. This also energises the synthesiser.

b. Insert key and ensure R.F. INTERLOCK is ON.

c. Observe (1) The SUPPLY lamp is alight.
(2) The synthesiser dial lamps are alight.
(3) The UNREADY lamp is alight, and, after approximately 30 seconds –
(4) The UNREADY lamp is extinguished.
(5) The READY and TUNE lamps are alight.

d. Select the required frequency on the synthesiser.

e. Set the system and input switches to the type of transmission required.

f. Depress the TUNE switch.

g. Observe (1) The READY lamp is extinguished.
(2) The IN USE and TUNE lamps are alight, and, after approximately 20 seconds –
(3) The IN USE and TUNE lamps are extinguished.
(4) The READY lamp is alight indicating tuning sequence is complete.

h. Observe that the appropriate channel lamp indication is shown for the channel selected and that the IN USE lamp is lit by the pressel or key line from the operating position selected.

31. Modulator – Tuning Unit in Transceiver with auto tuning capability.

a. Set SUPPLY switch to ON. This energises the Modulator – Tuning Unit only.

b. Insert key and ensure RF INTERLOCK is ON.

c. Set RECEIVER SUPPLY switch to ON. This also energises the synthesiser.

d. The sequence is now as described in para. 30 *c.* to *h.* above.

2.27. 100W HF POWER AMPLIFIER (MARCONI TYPE N1050) AND AERIAL MATCHING UNIT (MARCONI TYPE N7100)

HANDBOOK		
E LIST		
FREQUENCY RANGE	1.5 to 24 MHz	
POWER OUTPUT	1.5 to 20 MHz	120W p.e.p.
	20 to 24 MHz	Greater than 75W p.e.p.
POWER SUPPLY	115V or 230V AC 50/60 Hz	

General

1. The 100W HF Power Amplifier and the Aerial Matching Unit have been designed for operation in all emission modes. When used in conjunction with Outfit TDC, they form a complete 100W ISB transmitting system (Type 642). The Power Amplifier accepts a drive of approximately 100mW from outfit TDC and produces an output of approximately 100W p.e.p. The equipment feeds back information to Outfit TDC when tuning has been carried out and the correct RF level established. Overload indication and resetting facilities are also fed back to outfit TDC.

2. The Aerial Matching Unit will operate with whip aerials of 16, 24 or 35 feet in length, but preset adjustments are required for any particular aerial. The aerial circuit is automatically set to resonance and the coupling optimized under the control of the frequency synthesiser and automatic monitoring circuits.

3. A change over aerial relay system is incorporated for simplex operation, e.g. as fitted in Type 641.

Brief Description

4. The RF drive input to the HF Power Amplifier is fed to a transistorised wideband penultimate linear amplifier, the output of which is approximately 500mW. This output is passed to the tuned grid circuit of the final linear amplifier valve. The RF voltage at the grid is monitored and fed back to the remote Tuning Unit Drive as DC for automatic level setting purposes.

5. The final amplifier valve has a 'pi' section RF output circuit matching down to 50 ohms. This circuit comprises a number of fixed parallel input and output capacitors with tuning accomplished by a continuously variable inductors. The 50 ohm point is used for the inclusion of the "send – receive" relay and for the insertion of phase and magnitude detectors for use in auto tuning.

6. The output of the HF Power Amplifier is fed via a 50 ohm co-axial cable to the Aerial Matching Unit where it is transformed up to 820 ohms. The aerial matching section employs a continuously variable tuning coil as a series element which can be augmented with a fixed loading coil or a number of fixed values of series capacitance. A parallel leg consists of variable capacitance with the addition of switched values of capacitance.

7. The tuning sequence operates in the following manner:
When the TUNE button on the drive unit is pressed, the P.A. grid circuit seeks resonance following the drive tuning. Simultaneously, the anode circuit "rough tunes" at the cessation of which the Ledex range switch selects all the correct components for the frequency to be transmitted. Fine tuning into a 50 ohm load then automatically takes place, and simultaneously, rough aerial coil positioning is proceeding. When anode fine tuning has ceased, RF power at approximately 100W is dissipated in the 50 ohm termination and evidence of this power appears on the RF output meter of the Tuning Unit Drive. At this stage, the anode circuit is correctly tuned and loaded and the second phase of the tuning operation begins.

8. The load/aerial circuit now operates, removing the 50 ohm load and switching the output into the wideband R.F. transformer. The aerial coil will have previously reached its rough tuning position and therefore is in a state to "fine tune" direct from phase detector instructions. The presence of RF will also

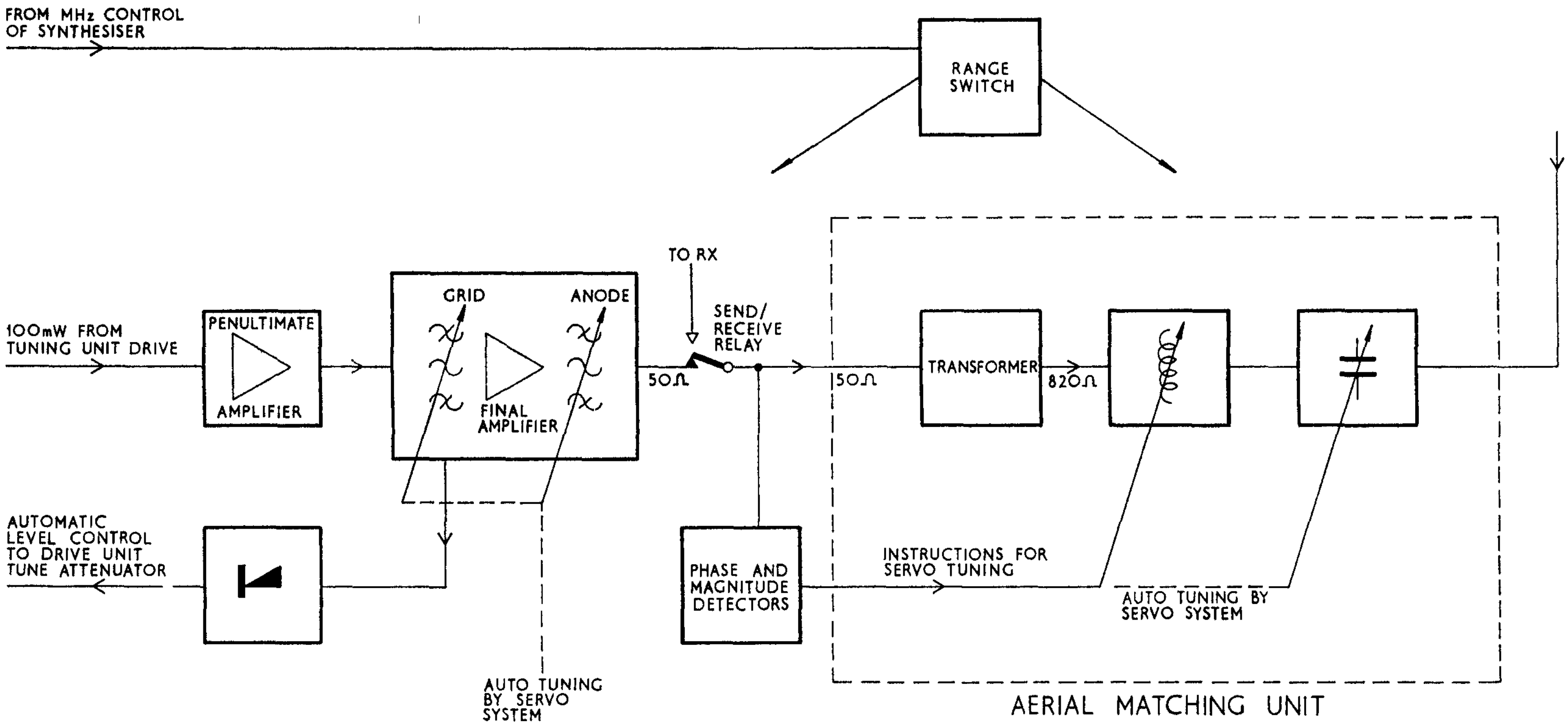


FIG. 1. HF POWER AMPLIFIER AND AERIAL MATCHING UNIT – BLOCK DIAGRAM

cause the magnitude detector to run the variable capacitor through its range to a tuning point. Both these systems operate mutually until no further movement dictates the closing down of circuits initially made by the TUNE circuit. When this has been completed, servo amplifiers and motors switch off.

9. The tuning process will take approximately 15 seconds if the change involves maximum excursion of variable circuits, but a normal tuning time would be approximately 8 seconds.

10. Should the tuning sequence be interrupted in any way, e.g. power failure or decade control movement, then the tuning operation must be re-started.

SECTION 3

RECEIVERS

3.1. GENERAL NOTES ON RECEIVER CONTROLS

1. **Switching On.** Receivers should normally be switched on 15 minutes or more before required for use, enabling valves to warm up, thereby improving frequency stability.

2. **Use of A.G.C.**

a. A.G.C. is the normal operating position and should be used on all occasions except when an interfering station is causing so great an A.G.C. action as to make the wanted signal unreadable.

b. A.G.C. should be switched off:

(1) When the strength of a local transmission causes so great an A.G.C. action that the receiver is blocked.

(2) When initially tuning in a wanted signal when strong interference is being experienced.

3. **Noise Limiter** Normally left in the Off position and is switched on when an operator experiences heavy interference from atmospherics, or from own ship's radar transmissions.

4. **Anti-Cross Modulation.** Normally left in a fully clockwise position and should be adjusted when cross modulation is experienced. This form of interference can be recognized as it occurs only when the wanted station is actually transmitting, and consists of the modulation of the interfering station being superimposed on the carrier of the wanted signal.

5. **Bandwidth Switch.** This should be in the widest position when receiving Voice. For C.W. it should be reduced from this position when searching and should be further reduced to clear interference from stations whose frequencies are near that of the wanted signal. It may also be necessary to increase the gain if the bandwidth is reduced, although this is automatically carried out in modern receivers.

6. **Aerial Trimmer.** This must be adjusted for each frequency to ensure the best performance from the receiver.

7. **R.F. Gain.** This should never be increased beyond the point where the noise or mush suddenly becomes very pronounced. It should normally be kept just below this point when using A.G.C. in receivers where R.F. Gain and A.G.C. are operative at the same time. In most modern receivers the R.F. Gain Control is inoperative when using a.g.c.

8. **Audio or A.F. Gain.** With a.g.c. on, the a.f. Gain is normally adjusted for comfortable noise level, but with A.G.C. off it should normally be left at maximum, volume being controlled by the r.f. Gain.

9. **B.F.O.** Is provided for the reception of C.W. signals, the b.f.o. frequency being made variable by a small amount on either side of the intermediate frequency so that the beat note is adjustable. Adjacent channel interference may be avoided by rotating the b.f.o. control. Receivers fitted with High and Low positions to their system switch do not have a separate b.f.o. control. In this case the frequency of the b.f.o. is fixed tuned to 1 kc/s above and 1 kc/s below the i.f. In receivers designed for FST working there are also positions for 2·55 kc/s above and below the i.f. Adjacent channel interference is cleared by shifting from High to Low or vice versa.

10. **Noise Suppressor or Squelch.** In some receivers [redacted] this can be switched in, in others [redacted] the noise suppressor is in all the time. This eliminates loud mush and receiver noise (not pulse transmissions) when no signal is being received and may also eliminate very weak signals. It should not be used if received signals are likely to be very weak. The term 'muting' is sometimes used for noise suppression.

11. **Aerial Filters.** Should normally be plugged in to reduce interference, but they may weaken signals. They are designed to cut out interference from frequencies outside the frequency range of the receiver, i.e. above 30 Mc/s for specifically B40.

12. **Band Switch (Range Switch).** Normally varies the inductance coils and brings in Capacitors as necessary in the r.f., Mixer, and Local Oscillator stages.

13. **Main Tuning Control.** Provides continuous tuning over the whole of any particular range by ganged variable capacitors normally in the R.F., Mixer, and Local Oscillator stages.

14. **Logging Scale.** Most receivers have a logging scale on the main tuning control and it is important that operators keep an accurate log of the readings for frequencies they have used, as it makes it easier to identify a station again. (This is especially important with Receiver CAT.)

15. **Crystal On-Off Switch.** In HF Receivers the local oscillator is normally a v.f.o. but may be crystal controlled by switching the Crystal On-Off Switch to ON and inserting the appropriate crystal. Crystal to be used is stated under the individual receiver notes. The Crystal On-Off switch also arranges the local oscillator circuit for v.f.o. or crystal oscillator working.Crystal control of the local oscillator considerably assists the stability of the receiver when reading a broadcast or fixed station transmission, but should not be used for the reception of signals from a station whose transmitter is known to be unstable or when reading several stations whose transmitters are not exactly on the same frequency.

3.2. CDW/CAY (B40)

DATE OF DESIGN. 1946

HANDBOOK. B.R. 1617

ESTABLISHMENT LIST. F.E.935

FREQUENCY RANGE. 650 kc/s–30 Mc/s

POWER SUPPLIES. 115 V or 230 V 50 c/s a.c.

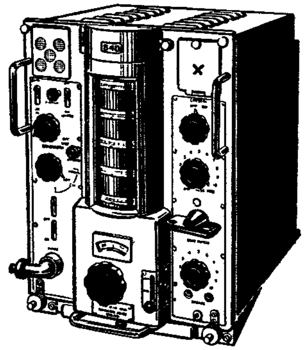


FIG. 1

GENERAL

1. A superheterodyne receiver consisting of three basic units:

a. R.F. Unit. *b.* I.F. Unit *c.* A.F. and Power Unit.

The B40 series was designed to replace receiver B28. There are four models: B40(A), B40(B), B40(C) and B40(D). The B40(D) is described in this section and the differences between this and the other models are listed later. A B40(D) fitted for Common Aerial Working is known as an Outfit CAY: if not so fitted it is Outfit CDW.

DESCRIPTION

2. **R.F. Unit**

a. Aerial Circuit

In outfit CAY the r.f. input arrives from either of the HF lines which run to each receiver in turn, depending on the position of the aerial selector switch (*see* Section 6 – Aerials). A micro-switch in the frequency range turret control ensures continuity of the aerial lines when changing over frequency ranges; this switch is fitted in both CAY and CDW.

The r.f. input transformer effectively forms the filter network required for the receiver's use in common aerial working. The secondary of this transformer forms part of the r.f. grid circuit and is tuned by a variable capacitor ganged to the main tuning control.

b. First r.f. Amplifier

A high slope pentode. In the CAL position of the system switch, the H.T. supply to this valve is broken. This prevents any signals from the aerial getting through the receiver, and prevents any oscillation from calibrating circuit from being radiated.

Anti-cross modulation. Controlled by a variable resistor adjusting the grid bias, which shifts the working point on the valve characteristic curve to a straighter portion thus reducing rectification of any strong but unwanted signal which would otherwise impose its modulation on to the wanted signal. A resistor and a crystal rectifier ensure that the grid of the r.f. amplifier remains negative with respect to the cathode. Without this safeguard it would be possible, in certain positions of the anti-cross modulation control, for the grid to pass current, reducing selectivity and increasing cross modulation.

c. Second r.f. Amplifier

A variable mu pentode. Its grid circuit consists of the tuned secondary of the input transformer and fixed capacitors selected by the turret switch, and a variable capacitor ganged to the main tuning control.
Gain. Controlled by either a.g.c. which adjusts the grid bias or by manual control which adjusts the cathode bias.

CAL position. When the system switch is in the CAL position, the crystal harmonics from the b.f.o. are fed into the output circuit of the first r.f. and hence the input circuit of the second r.f.

d. MIXER. A triode-heptode valve, of which the triode is not used. The local oscillator output is fed to the injector grid and the r.f. output to the control grid.

e. LOCAL OSCILLATOR. A pentode which can be operated by the Crystal ON–OFF switch either as:
Crystal Oscillator. Electron-coupled to the anode circuit which is tuned to the required harmonic of the crystal (see table under Crystal Compartment), or as

V.F.O. Tuned by main tuning control as 500 kc/s above the incoming signal (the crystal terminals being short-circuited).

A small variable capacitor in the oscillator circuit, operated by the OSC TRIM control, permits fine tuning which, since the range of the a.f. discriminator on the F.S.T. Convertor is only from 2025 c/s to 3075 c/s, is particularly necessary at frequencies above about 9 Mc/s.

3. **I.F. Unit**

a. THREE STAGE I.F. AMPLIFIER. Three variable mu pentodes with fixed transformer coupled inputs tuned to the I.F. of 500 kc/s.

Bandwidth Arrangements. The bandwidth switch alters the coupling between primary and secondary of the I.F. transformers. It also inserts a crystal gate filter between the first and second i.f. stages when in the 1 kc/s position of the switch. The three positions of the bandwidth switch are as follows:

8 kc/s Tight coupling – wide bandwidth.
3 kc/s Loose coupling – narrow bandwidth.
1 kc/s Loose coupling – very narrow bandwidth with crystal filter in circuit between first and second I.F. stages.

Gain Arrangements. A.G.C. adjusts the grid bias of the first and second i.f. stages. Manual gain adjusts the cathode bias of the first, second and third i.f. stages.

b. DETECTOR AND A.G.C. STAGE. Consists of a double diode.

Detector. One half of the double diode acts as a detector. The a.f. output is fed to first a.f. via a variable resistor controlled by a control marked a.f. GAIN.

A.G.C. Stage. The other half of the double diode is fed from the primary of the third i.f./Detector transformer. Negative bias is applied to the grids of second r.f., first and second i.f. stages and a reduced bias to the first a.f. stage.

Note. The a.g.c. time constant is automatically set to allow for a quick build-up but slow decay.

c. NOISE LIMITER. A double diode. One diode is a series limiter. At normal signal level it conducts and is in the a.f. path between detector and first a.f. stage. A short pulse of relatively great amplitude will close this diode down for the duration of the pulse, thereby breaking the a.f. output to the first a.f. stage. As these pulses are of such very short duration, the intelligibility of a.f. output is not seriously impaired. Any pulse, which is strong enough to break through the inter-electrode capacity of the first diode, is shunted by the second diode.

d. B.F.O. A pentode oscillator which can produce five output frequencies as follows:

Position	*Frequency Kc/s*	*Position*	*Frequency Kc/s*
1	497·45	4	501
2	502·55	5	500
3	499		

Further details are given in the operation of the system switch.

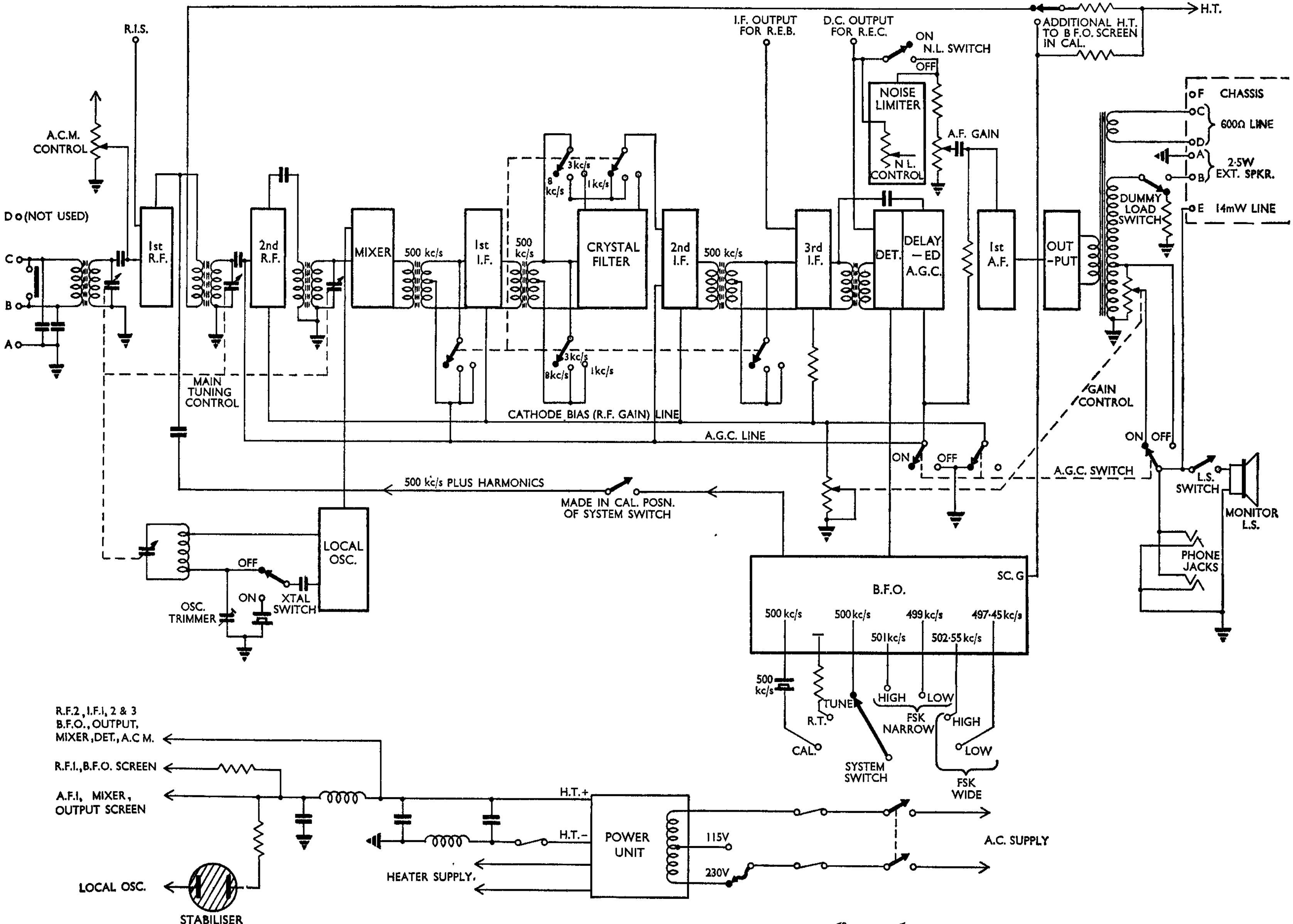


FIG. 2. RECEIVER B40D

See Fig. 4.

CL4

4. A.F. and Power Unit

a. First A.F. Amplifier. A variable mu pentode whose input is controlled by a variable resistor (A.F. Gain Control). Reduced a.g.c. is fed to this stage.

b. Second A.F. Amplifier and Output Stage. A power pentode. It feeds the output transformer from which the following outputs are taken:

Remote Outputs (1) 600 ohm 35 mW line (to control system).
(2) 600 ohm 2·5 W line (to remote loudspeaker in R.I.C. bay when C.A.W. outfit EAL not fitted).

Local Outputs (1) Local phone jacks in receiver.
(2) Internal loudspeaker.
(3) External phone line (not normally used).

Notes. (i) All the above outputs are available simultaneously. (ii) The remote loudspeaker output can be switched from its line to a dummy load by means of the dummy load switch at the back of the receiver.

c. Gain Arrangements.

A.F. Gain Control. Affects all the a.f. outputs.

Gain Control. With a.g.c. switched Off the Gain Control affects All outputs. With a.g.c. switched On this control varies only the local outputs (see para. 6).

d. Power Unit.

Mains Transformer. This has two mains fuses (2 amps) in the input to the primary, and tappings on the primary for 115 V and 230 V a.c. supply. These are marked and situated at the rear of the receiver which must be withdrawn to gain access. It has three secondaries for valve heaters, rectifier heaters and main H.T. which is also fused (500 mA).

–Two Double Diodes. The two anodes are strapped together, the whole forming a full-wave rectifier circuit with a valve at each end of the mains transformer H.T. winding. H.T. is provided for the first R.F., for the local oscillator (using a voltage stabilizer) and for all other stages.

5. Frequency Shift Telegraphy

Active Inactive

In a Frequency Shift system the [redacted] signal is transmitted on one radio frequency and the [redacted]signal on a different radio frequency. The difference between these two frequencies, known as the 'shift,' is established, at present, as 850 c/s for HF working. Thus for a nominal frequency of, for example, 5000 kc/s, the [redacted] and [redacted] signals are radiated on 5000·425 kc/s and 4999·575 kc/s respectively.

ACTIVE INACTIVE

In the Frequency Shift Convertor unit, the a.f. discriminator works in the Wide shift condition over the range 2025 c/s–3075 c/s: the centre frequency is therefore 2550 c/s. In the Narrow shift condition the centre frequency is 1000 c/s: this condition is normally only used for L.F., when the shift is normally 85 c/s. In the B40(D) therefore it is necessary to be able to produce as required two separate outputs for F.S.k. operation, one centred on 2550 c/s and the other on 1000 c/s. The first is achieved by either the 497·45 kc/s (LOW) or 502·55 kc/s (HIGH) outputs of the b.f.o., and the second by either its 499 kc/s (LOW) or 501 kc/s (HIGH) outputs.

The last two outputs are also used for c.w. reception.

6. Controls.

System Switch. A seven-position switch.

F.S.K. Wide Low. B.F.O. operates at 497·45 kc/s.

F.S.K. Wide High. B.F.O. operates at 502·55 kc/s.

F.S.K. Narrow Low. B.F.O. operates at 499 kc/s.

F.S.K. Narrow High. B.F.O. operates at 501 kc/s.

Tune. B.F.O. oscillates at 500 kc/s, i.e. in tune with the i.f. System switch should be in this position when tuning in a c.w. station. Receiver is tuned for zero beat, indicating that 500 kc/s passing through i.f. stages is beating with 500 kc/s from b.f.o. at detector. r.f. and i.f. stages of receiver must then be at maximum efficiency.

R/T. The b.f.o. cathode is earthed through a high resistance and does not oscillate.

Calibrate. The H.T. to the first r.f. is broken, and screen supply to the b.f.o. valve is increased to provide a strong oscillation. b.f.o. is controlled by a 500 kc/s crystal and the output (500 kc/s plus harmonics) is fed to the output circuit of the first r.f. and hence the input of the second r.f. b.f.o. continues to feed 500 kc/s to the detector stage.

GAIN CONTROL. Adjusts two potentiometer on the same spindle.

a. In the cathode circuit of the second r.f. and all i.f. stages.

b. Across the a.f. output transformer secondary supplying the internal loudspeaker and local phones.

Note. Only one potentiometer is in circuit at a time depending on whether a.g.c. is switched ON or OFF.

A.G.C. ON–OFF Switch. In the OFF position the a.g.c. line is earthed. In the ON position the r.f. gain potentiometer is earthed.

RANGE SWITCH (TURRET SWITCH). Controls turret and changes the tuned circuits of the r.f. stages, Mixer and Local Oscillator.

CRYSTAL COMPARTMENT. A gauze electrostatic screen is fitted on the door (note earthing plunger). A pilot light indicates when crystal switch is to ON. The crystal frequency is always 500 kc/s above the signal frequency modified as shown in the following table, where Fs is the signal frequency.

Signal Frequency	*Crystal Frequency*	*Signal Frequency*	*Crystal Frequency*
650 kc/s to 7 Mc/s	Fs+500 kc/s	14·5 Mc/s to 22 Mc/s	$\frac{\text{Fs}+500\text{ kc/s}}{3}$
7 Mc/s to 14·5 Mc/s	$\frac{\text{Fs}+500\text{ kc/s}}{2}$	22 Mc/s to 30 Mc/s	$\frac{\text{Fs}+500\text{ kc/s}}{4}$

CRYSTAL SWITCH. This has two positions.

OFF. Local Oscillator is a v.f.o.

ON. Local Oscillator is crystal controlled.

ANTI-CROSS MODULATION. Alters the grid bias hence the working point of the first r.f. stage.

TUNING KNOB. Tunes ganged capacitors in the first and second r.f., Mixer and Local Oscillator circuits.
It also turns the scale drum and logging scale.

DIAL LOCK. Locks tuning drum and is spring held.

TUNING DRUM. The frequency scale has special markings to indicate.

a. Calibration Points: Denoted thus: ●

b. R.F. Lining-up Points: Denoted thus: +

MONITOR LOUDSPEAKER SWITCH. Controls receiver monitor loudspeaker.

NOISE LIMITER SWITCH. Brings in noise limiter to reduce interference caused by radar and other pulse transmissions.

LIMITER CONTROL. A potentiometer which is used to determine the level at which limiting action commences.

BANDWIDTH SWITCH. This has three positions:

a. 8 kc/s. *b.* 3 kc/s. *c.* 1 kc/s.

A.F. GAIN. Controls input to first a.f. and hence all audio outputs.

DUMMY LOAD SWITCH. Normally left in the OFF position (toggle towards the rear of the receiver) whether or not external loudspeaker is connected. This has been found necessary when receiver is operated in conjunction with K.H. series in ships not fitted with EAL.

DIAL LAMPS BRILLIANCE CONTROL. Controls a variable resistor, in series with one of the five dial lamps as selected by the turret switch.

AERIAL INPUT. There are four pins marked A, B, C, and D.

A – Earth.

B and C – Low impedance input.

D – Not connected.

R.I.S. Input. Not used.

D.C. Socket. Output from detector for disc recording (not now used).

I.F. SOCKET. Output from third i.f. for photographic analysis of transmission characteristics (REB).

DIFFERENCES

7. The principal differences between the B40(D) and other receivers in this series are summarized below:

a. Differences between B40(D) and (C). The B40(C) has:

(1) No OSC. TRIM control.

(2) No crystal rectifier or resistor as safeguard in the anti-cross modulation arrangements.

(3) No F.S.k. positions on the system switch, which only has five positions. The first two are LOW and HIGH, which correspond to the F.S.T. Narrow positions of the B40(D) switch: the others are TUNE, CAL and R/T, and have the same characteristics as those in the B40(D).

(4) Only one rectifier valve in the power unit.

(5) Different type of valve throughout.

b. Differences between B40(C) and (B). The B40(B) has:

(1) No facility for common aerial working, and therefore minor differences in aerial input circuits. No aerial change-over [illegible]. switch

(2) Two aerial inputs – 1 Low impedance – as in B 40(D).

2 High impedance – capacitor coupled to secondary of input transformer. Used for short aerial leads.

(3) No micro-switch in the turret-switch arrangements.

(4) No earthing of main turret switch.

c. Differences between B40(B) and B40/B40(A). The B40/B40(A) have:

(1) No A.G.C. switch. The system switch has an additional position marked MANUAL. In this position the a.g.c. is switched off and the b.f.o. is oscillating at the frequency of the i.f. (500 kc/s). In all other positions of the system switch the a.g.c. is in circuit. The disadvantage is that if a.g.c. is not required (i.e. when reading a very weak signal) the receiver must be slightly detuned in order to obtain a beat note, and as a result its efficiency is somewhat reduced.

(2) Screwdriver controls for limiter and a.f. gain.

(3) No window shewing the frequency range in use.

(4) Different markings for the Bandwidth switch. These are: (*Continued on page* 3.2.8)

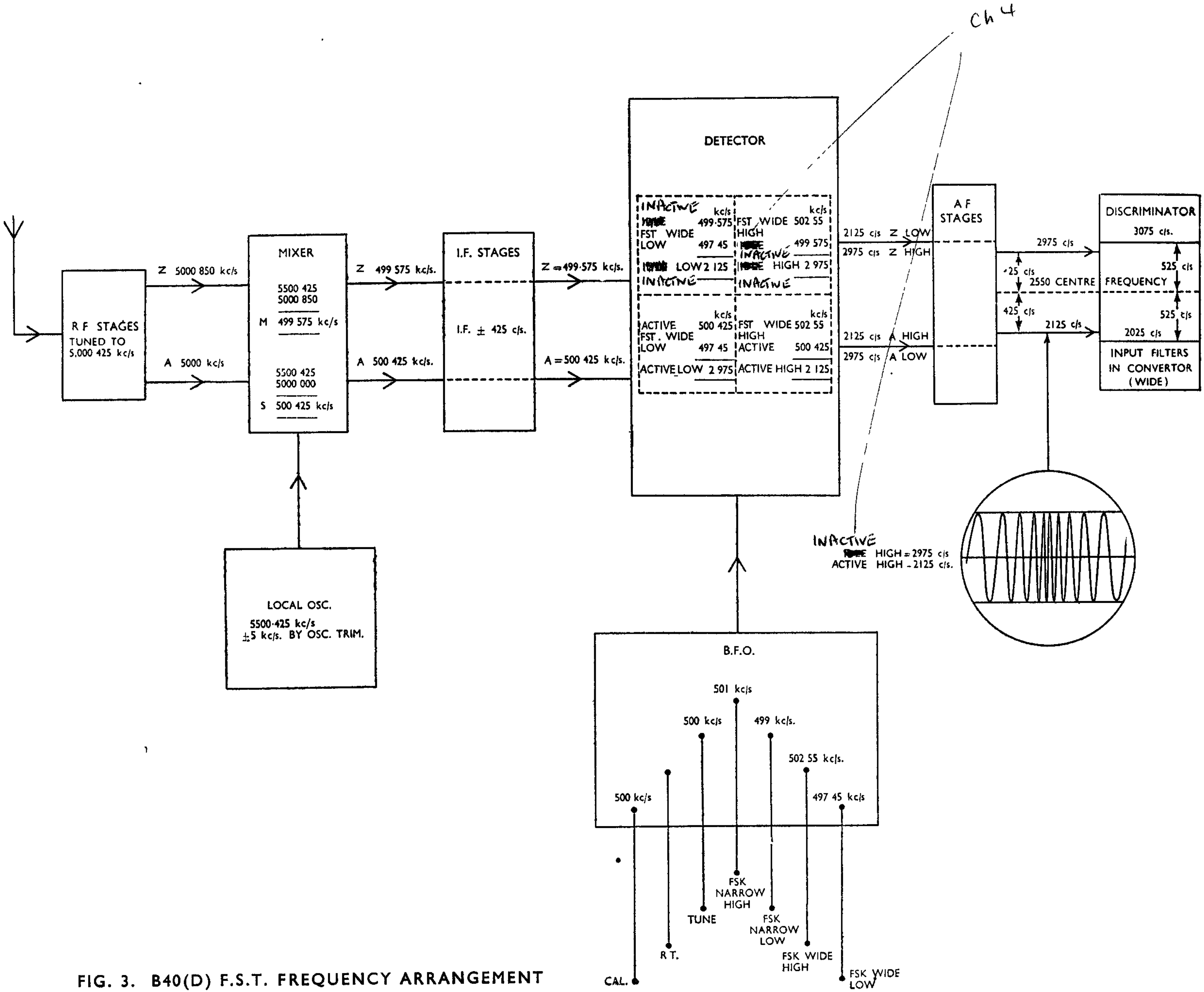


FIG. 3. B40(D) F.S.T. FREQUENCY ARRANGEMENT

(*Continued from page* 3–2–6)

WIDE – 8 kc/s on B40(D). In addition, the screen supply to the b.f.o. is broken in this position.

NARROW – '3 kc/s' in B40(D).

NOTE FILTER – '1 kc/s' in B40(D). There is a 1000 c/s filter with a bandpass of 200 c/s instead of a crystal filter.

(5) Aerial input pins marked 1, 2, 3 and 4 instead of A, B, C, and D.

8. **Operating Instructions For B40/B41**

a. Switch on receiver for at least 15 minutes before being required for use.

b. Switch off LIMITER, CRYSTAL and A.G.C. switches.

c. Turn Anti-cross Mod control to fully clockwise.

d. Set Range Switch to appropriate frequency band.

e. Adjust Gain Control for three-quarters of its travel clockwise.

f. Switch on Monitor loudspeaker.

g. Set bandwidth switch to NARROW or 3 kc/s position.

h. Set system switch to CALIBRATE.

i. Adjust A.F. gain control for three-quarters of its travel clockwise.

j. Tune the receiver by the main tuning control to the calibration mark nearest the frequency at which it is desired to work. A beat note should be produced. Slowly rock main tuning control for zero beat.

k. Adjust cursor by means of knurled wheel behind curved door until arrow in in line with calibration spot.

l. Set system switch to TUNE.

m. Switch on a.g.c. Adjust Gain Control to comfortable noise level.

n. Tune in to signal, adjust a.f. gain for comfortable noise level, and further tune for signal's zero beat.

o. (1) C.W. Reception. Set system switch to LOW or HIGH. Set Bandwidth switch to '1 kc/s' if necessary to clear interference, and readjust gain control as requisite.

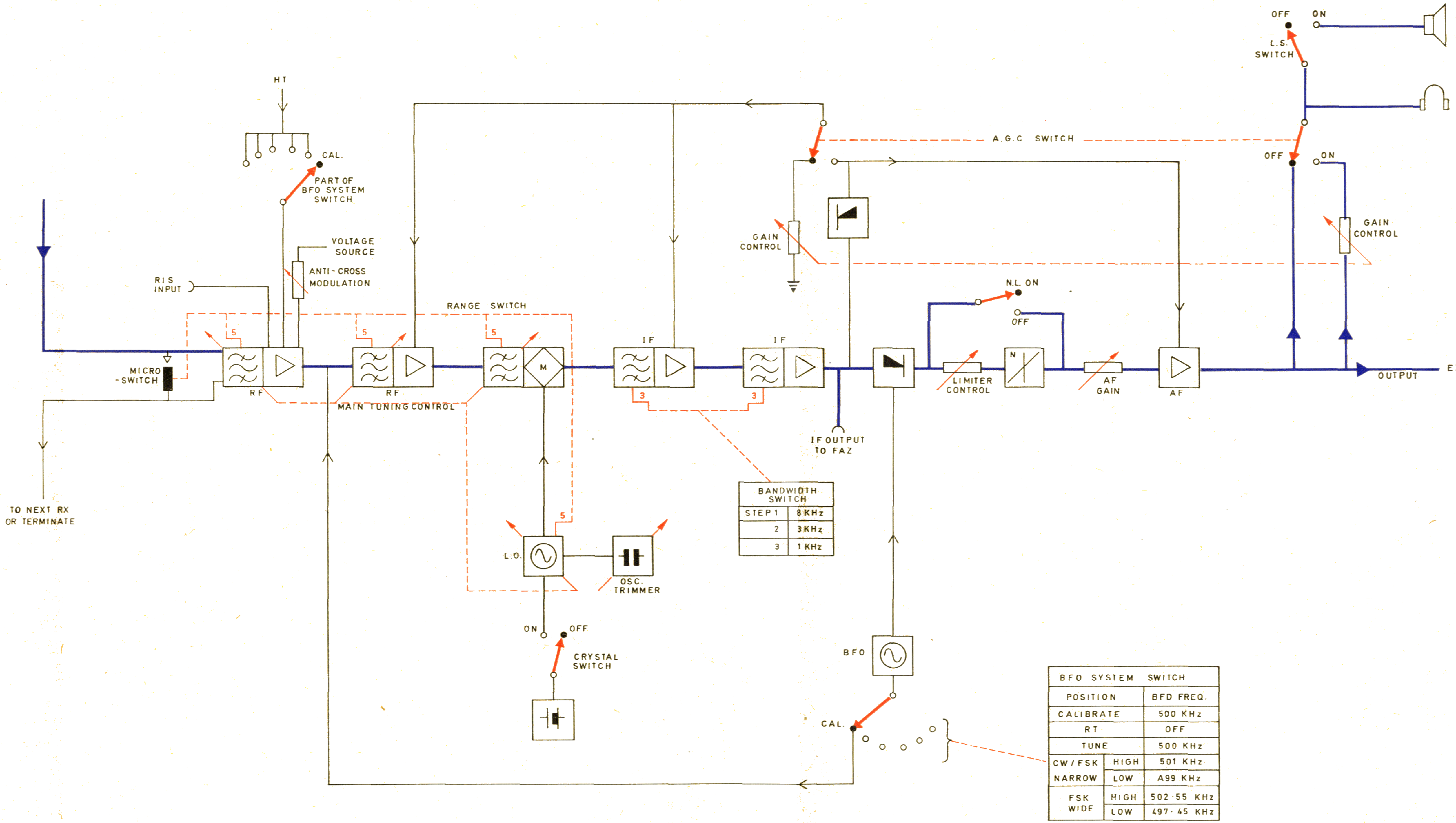
(2) Voice Reception. Set system switch to R/T. Set bandwidth switch to WIDE or '8 kc/s' position.

p. For Crystal Oscillator working insert appropriate crystal and put crystal switch to ON.

q. Adjust main tuning control for maximum signal output.

r. If cross modulation interference is experienced, adjust anti-cross mod control to eliminate it.

s. If experiencing interference from atmospherics or pulse transmissions, switch on limiter and adjust limiter control for best reception.



BANDWIDTH SWITCH	
STEP 1	8 KHz
2	3 KHz
3	1 KHz

BFO SYSTEM SWITCH		
POSITION		BFO FREQ.
CALIBRATE		500 KHz
RT		OFF
TUNE		500 KHz
CW/FSK NARROW	HIGH	501 KHz
	LOW	A99 KHz
FSK WIDE	HIGH	502·55 KHz
	LOW	497·45 KHz

FIG. 4. RECEIVER B40.D—BLOCK DIAGRAM

169471—37-38

3.3. RECEIVER OUTFIT CDY/CAZ (B41)

DATE OF DESIGN. 1946

HANDBOOK. B.R. 1618

ESTABLISHMENT LIST. F.E. 935

FREQUENCY RANGE. 15 kc/s to 700 kc/s

POWER SUPPLIES. 115 V or 230 V, 50 c/s a.c.

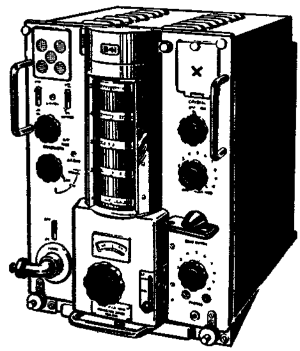


FIG. 1

GENERAL

1. A superheterodyne receiver consisting of three basic units:
   a. R.F. Unit.
   b. I.F. Unit.
   c. A.F. and Power Unit.

There are three models of B41. The type to which this section refers is B41(C). Differences are described later. All types can be fitted for Common Aerial Working. When this is done the outfit is known as outfit CAZ instead of CDY.

DESCRIPTION

2. The description of the B41 is the same as for the B40 with the exceptions listed below.

3. **R.F. Unit.**

AERIAL CIRCUIT. An additional tuned circuit is introduced into the input of the first r.f. There is no micro-switch. There are two aerial inputs.

R.F. STAGES.

a. There is only one r.f. amplifier, with its own tuned circuit: a.g.c. is not applied to this stage.

b. The low-impedance aerial lead is transformer-coupled, and the high impedance lead is capacitor-coupled, to the r.f. amplifier tuned circuit.

LOCAL OSCILLATOR. Operates at 800 kc/s above the signal frequency. There is no OSC. TRIM control.

4. **I.F. Unit.**

I.F. STAGES. The i.f. is 800 kc/s.

B.F.O. Has three outputs, at 800 kc/s, 801 kc/s or 799 kc/s.

In the CAL position of the system switch, extra H.T. is applied to the screen of the oscillator which under these circumstances has a resonant frequency of 100 kc/s. The output, rich in harmonics, is fed to the grid of the mixer. It is possible to calibrate on frequencies below 100 kc/s, and other than multiples of 100 kc/s, by beating harmonics of the crystal with harmonics of the local oscillator. The eighth harmonic of the 100 kc/s crystal is fed to the detector to beat with the i.f. signal.

5. **A.F. Output and Power Unit.** Three output channels:
   a. 2·5 W Remote loudspeaker line.
   b. 35 mW line, to control system.
   c. Local phone and internal loudspeaker.

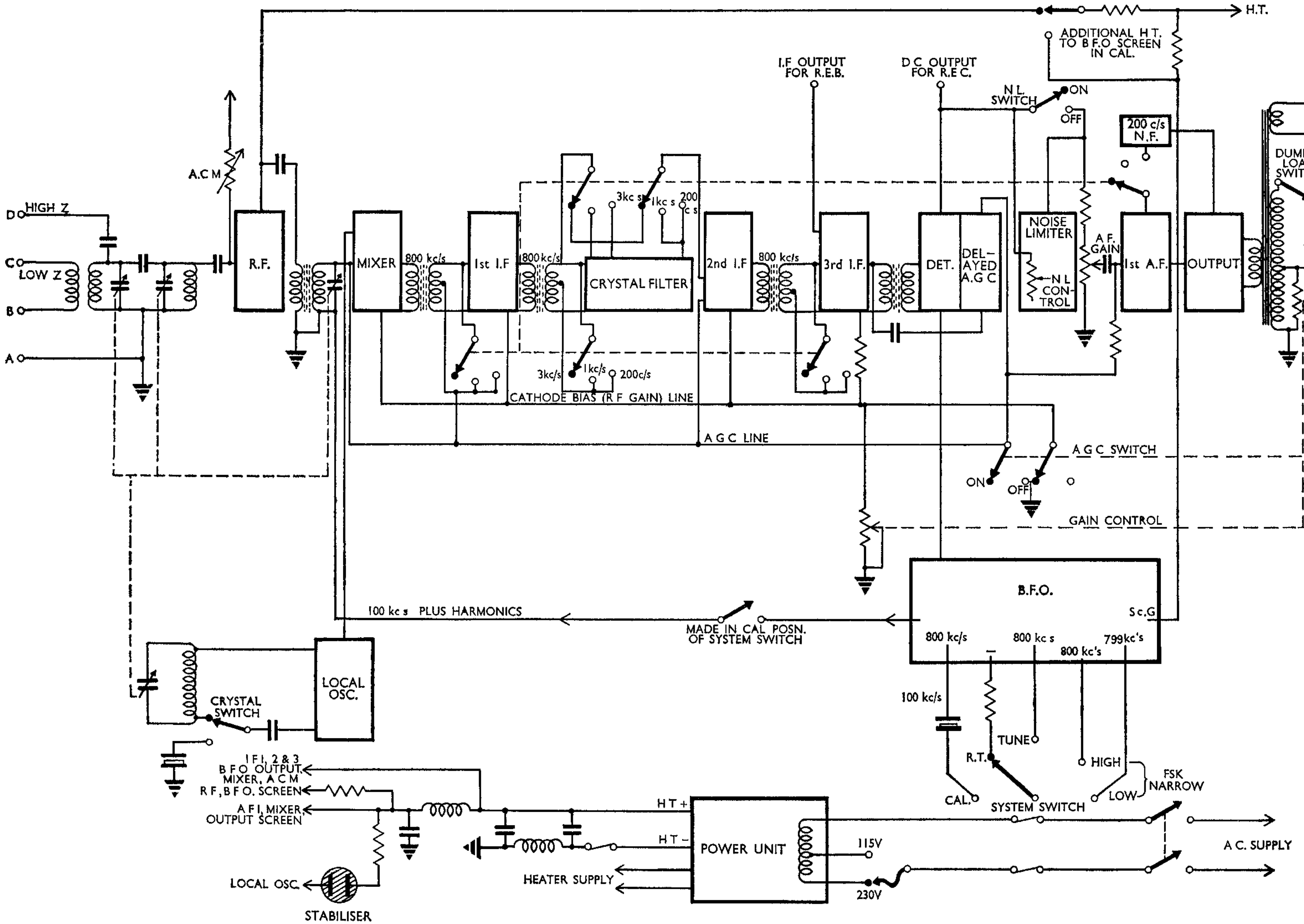


FIG. 2. RECEIVER B 41

6. **Controls.**

SYSTEM SWITCH. A five-position switch.

Low. B.F.O. oscillates at 799 kc/s. Used in this position for normal c.w. reception as an alternative to HIGH, to assist in clearing adjacent channel interference.

High. B.F.O. oscillates at 801 kc/s.

Tune. B.F.O. oscillates at 800 kc/s, i.e. in tune with the i.f.

R/T. B.F.O. does not oscillate.

Calibrate. B.F.O. is controlled by 100 kc/s crystal.

BANDWIDTH SWITCH. Three positions, marked '200 c/s,' ' 1 kc/s,' and '3 kc/s.'

AERIAL INPUT. There are four pins, marked A, B, C and D.

A – earth.

B and C – low impedance.

D – high impedance.

DIFFERENCES

7. The principal difference between the B41(C) and (B) is that the former is fitted throughout with valves which have been agreed for joint-service use, whereas the older type is not.

8. The principal differences between the B41(B) and (A) are as follows. The B41(A) has:

a. Different bandwidth switch – Wide (8 kc/s).
Narrow (3 ks/c).
Note Filter.

In the last, the bandwidth remains at 3 kc/s, but the note filter, with an audio bandwidth of approximately 200 c/s, is introduced. In Wide position, b.f.o. circuit is inoperative.

b. System switch with six positions. CAL as in B41(C). A.G.C. is applied in the TUNE, LOW, HIGH, and R/T positions, and is inoperative in the MANUAL position. This should only be used when strong interference is experiences in reception of weak signals. In this position, the b.f.o. is at 800 kc/s: the receiver must therefore be detuned slightly to ensure an audible note.

c. No a.g.c. switch.

d. Screwdriver controls for Limiter and R.F. Gain control.

e. Aerial input markings 1, 2, 3 and 4.

OPERATING INSTRUCTIONS

9. See instructions for B40.

3.4. RECEIVER OUTFIT CAS

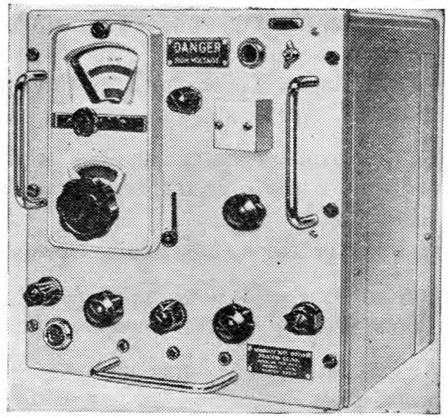


FIG. 1

DATE OF DESIGN. 1953

HANDBOOK. B.R. 1565

ESTABLISHMENT LIST. E.1049

FREQUENCY RANGE. 59 kc/s to 555 kc/s
1·47 Mc/s to 30 Mc/s

POWER SUPPLY. 110 V or 230 V a.c., 50 c/s

POWER CONSUMPTION. 75 W

GENERAL

1. A superheterodyne receiver requiring a separate power pack. Used in conjunction with associated transmitter type 618 or 618H. In most cases the functions of the circuits re similar to those of receiver B40.

2. **Units.** The receiver consists of three basic units:

R.F. Unit I.F. Unit A.F. Unit.

DESCRIPTION

3. **Aerial Input Circuit.** May use a high or low impedance aerial.

High Impedance Aerial. Connected to Pin D of aerial plug, which is connected to Pin C via an I.F. rejector circuit and transformer coupled to the grid of the first R.F.

Low Impedance Aerial (80 OHMS). Pins B and C may have balanced or unbalanced feeder. Transformer coupled to the grid of the first r.f.

> *Note.* When using the same aerial as the transmitter, one wafer of the slow (send/receive) relay enables the operator to listen through.

4. **1st R.F. Amplifier.** A pentode whose grid circuit is tuned by a capacitor ganged to the main tuning control. The anode output is transformer coupled to the grid of the second r.f. The H.T. to the anode and screen grid is via the muting relay to prevent overloading during transmissions. In the CAL position of the b.f.o. switch, H.T. supply is broken, which prevents any signals from the aerial getting through the receiver.

5. **2nd R.F. Amplifier.** A variable mu pentode whose grid circuit is tuned by a capacitor ganged to the main tuning control. The anode output is transformer coupled to the control grid of the mixer. The H.T. to the screen grid is via the muting relay to prevent overloading during transmissions.

6. **Mixer.** A heptode whose screen supply is via a stabilizer. The local oscillator output is fed to the injector grid.

7. **Local Oscillator.** A pentode with a stabilized H.T. supply, which can be operated by the screw-type crystal OFF–ON control either as –

V.F.O. Always tuned by main tuning control at 800 kc/s (the i.f.) above the incoming signal (Crystal Oscillator short circuited); or as:

CRYSTAL OSCILLATOR. Electron coupled to the anode circuit which is tuned to the required harmonic of the crystal (see table under Crystal Compartment).

8. **I.F. Stages.** These consist of three variable mu pentodes, with fixed transformer coupled inputs tuned to the i.f. (800 kc/s).

BANDWIDTH ARRANGEMENT. The bandwidth switch alters the coupling between the primary and secondary of the i.f. transformers. (See function of Bandwidth switch for method of varying coupling.)

9. **Detector and A.G.C. Stage.** Consists of a double diode.

DETECTOR. One half of the double diode acts as a detector. The a.f. output is fed to the first a.f. via a noise limiter, which is always in the circuit, and an a.f. Gain control.

A.G.C. STAGE. The other half of the double diode is fed from the primary of the third i.f./Detector transformer. Negative bias is applied to the grids of second r.f., first i.f., and second i.f. stages. Half the a.g.c. voltage is also applied to the first a.f. The a.g.c. time constant is automatically adjusted by the b.f.o. control to allow for a quick build-up but slow decay for C.W. (interrupted carrier) and to make the build-up and decay time the same for R/T (constant carrier).

10. **Noise Limiter.** A double diode. Prevents radar pulses from being passed on to the a.f. stages. (See Noise Limiter para. under B40.)

11. **B.F.O.** A pentode oscillator which can produce three output frequencies:

a. 1 kc/s above the i.f. (801 kc/s).

b. On tune to the i.f. (800 kc/s).

c. 1 kc/s below the i.f. (799 kc/s).

Further details are given under the operation of the b.f.o. switch.

12. **1st A.F. Amplifier.** A variable mu pentode whose input is controlled by a variable resistor (a.f. Gain). There is a choice of two outputs to the grid of the second a.f. either capacity coupled or via a note filter depending upon the position of the Bandwidth switch.

13. **2nd A.F. Amplifier.** A pentode capacity coupled to the third a.f. (output).

14. **3rd A.F. Amplifier.** A pentode. It feeds the output transformer which has 100 ohm and 500 ohm outputs for loudspeaker or phones. In the phone output there is a separate manual volume control.

15. **Controls**

BAND CHANGE SWITCH. Switches in the appropriate circuits in the r.f., Mixer and Local Oscillator stages.

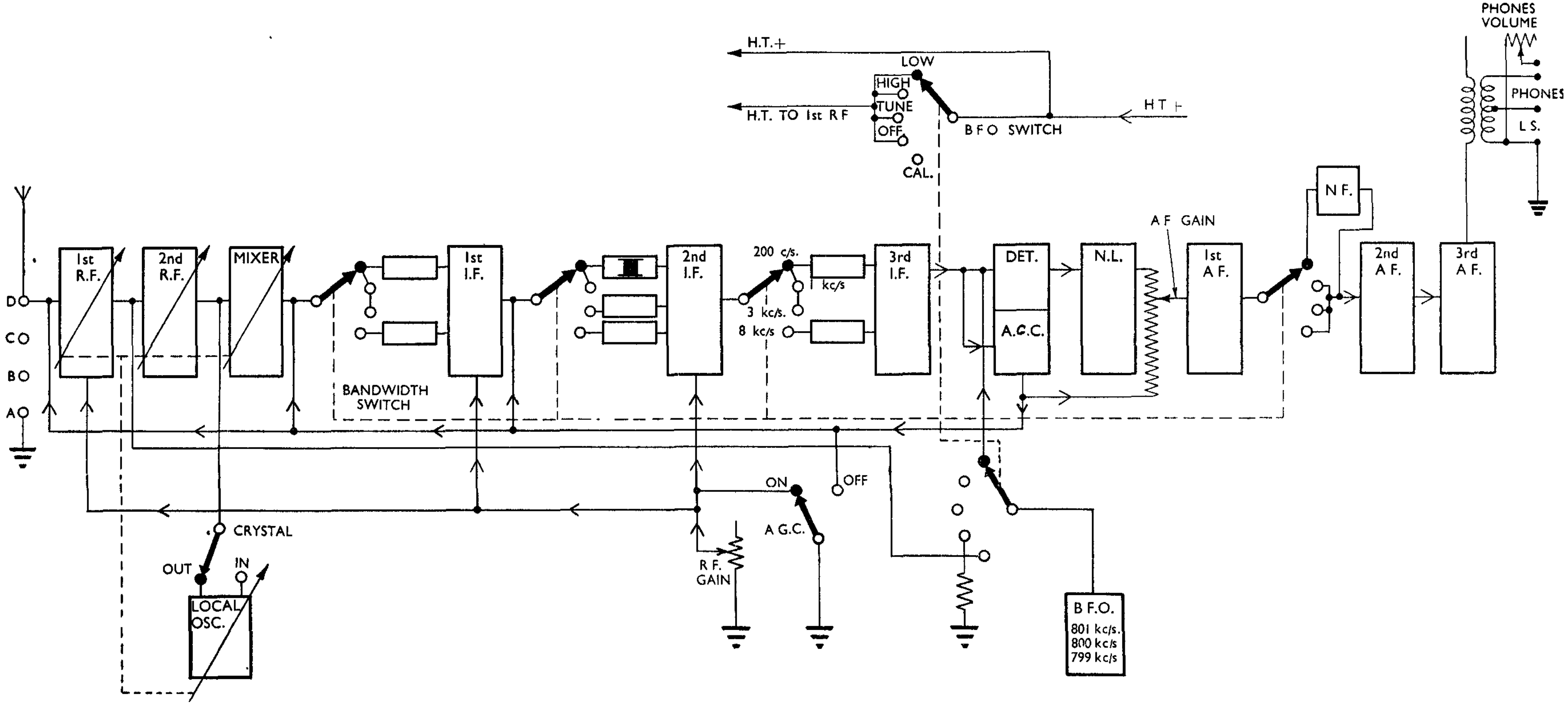
TUNING CONTROL. Varies the tuning for each wave band.

Calibration points denoted thus: ●

R.F. lining-up point denoted thus: +

CRYSTAL SWITCH. By rotating this control the spindle which is screw threaded causes the local oscillator circuit to function as a V.F.O. or Crystal Oscillator.

DIAL LOCK. Locks tuning drum and is spring held.



FREQUENCY RANGE {59 kc/s. – 555 kc/s.
1·47 Mc/s. – 30 Mc/s.

I.F. 800 kc/s.

FIG. 2. RECEIVER OUTFIT CAS

R.F. Gain. Is operative when the a.g.c. switch is in the off position. Varies the bias on the cathodes of the second r.f., first i.f. and second i.f. stages.

A.F. Gain. Always in the circuit. Varies the output of the detector to the first a.f. stage.

Phones Volume. Varies a potentiometer across the secondary transformer of the third a.f. which controls output to phone sockets only.

A.G.C. On–Off. Two-position switch:

On. Makes a.g.c. stage operative which controls the grid bias on the second r.f., first i.f. and second i.f. stages.

Off. A.G.C. earthed. Gain arrangements as in r.f. Gain. Used in this position while listening to signals from a weaker station when a stronger station is transmitting on nearly the same frequency, and when working a station on a direct net.

Bandwidth. Alters the coupling between the primary and secondary of the i.f. transformers (between mixer and first i.f., first i.f. and second i.f., second i.f. and third i.f.). There are four positions:

8 *kc/s.* Tight coupling between above stages by introduced additional coupling coil.

3 *kc/s.* Normal coupling between above stages. Additional coupling coil disconnected.

1 *kc/s.* Brings in a 1 kc/s crystal filter between first i.f. and second i.f. Adjusts cathode bias on second i.f. and third i.f. to maintain constant gain.

200 *c/s.* In addition to the 1 kc/s arrangements an audio filter network is brought in between first a.f. and second a.f.

B.F.O. Switch. A five-way switch.

Cal. The H.T. to the first r.f. is broken and H.T. to b.f.o. increased. B.F.O. is controlled by an 800 kc/s crystal and the output (800 kc/s plus harmonics) is fed to the input circuit of the second r.f.

Off. B.F.O. earthed through a high resistance and does not oscillate. Used in this position for the reception of Voice.

Tune. B.F.O. in tune with the i.f. (800 kc/s). Switch should be in this position when tuning in a C.W. station. Receiver is tuned for zero beat which indicates 800 kc/s is passing through the i.f. stages and beating with 800 kc/s of the b.f.o. at the detector. As the optimum frequency of the i.f. stages is 800 kc/s the receiver must be working at maximum efficiency.

High. B.F.O. is 1 kc/s above the i.f. (801 kc/s). Used in this position for normal c.w. reception or as an alternative Low to clear any unwanted signals.

Low. As for High except b.f.o. is 1 kc/s below i.f. (799 kc/s).

Crystal Compartment. A rectangular detachable metal cover is placed over the crystal sockets which will take A or C type crystal. The frequency of the crystal is shown below, where Fs is the signal frequency.

Signal Frequency	*Crystal Frequency*	*Signal Frequency*	*Crystal Frequency*
59 kc/s to 7 Mc/s	Fs+800 kc/s	14·5 Mc/s to 22 Mc/s	$\frac{\text{Fs}+800\text{ kc/s}}{3}$
7 Mc/s to 14·5 Mc/s	$\frac{\text{Fs}+800\text{ kc/s}}{2}$	22 Mc/s to 30 Mc/s	$\frac{\text{Fs}+800\text{ kc/s}}{4}$

Aerial Input. There are four pins marked A, B, C and D.

A – Earth.

B and C – Low impedance input.

D -- High impedance input.

POWER INPUT. An eleven-pin plug adaptor for connecting the appropriate outputs from the Power Pack described under Transmitter Type 618.

16. **OPERATING INSTRUCTIONS**

a. Switch on main power supply on power pack unit.

b. Switch on power to receiver by means of control on power pack.

c. Range switch to appropriate range.

d. Turn crystal switch to fully anti-clockwise position (Crystal OFF).

e. Bandwidth switch to 3 kc/s.

f. A.G.C. off.

g. A.F. gain and r.f. gain to approximately midway position.

h. System switch to CALIBRATE.

i. Turn main tuning control to calibration spot nearest the frequency required, tuning for zero beat.

j. Adjust cursor knob until the cursor line is directly over the calibration spot.

k. System switch to TUNE and switch on A.G.C.

l. Adjust main tuning control to zero beat of signal required.

m. *C.W. Reception.* Put system switch to HIGH or LOW. Set bandwidth switch to '1 kc/s' if necessary to clear interference, and readjust gain controls as requisite.

n. *Voice Reception.* Put system switch to OFF and bandwidth switch to '8 kc/s'.

o. Adjust A.F. gain control for comfortable noise level.

l. For C.W. signals bandwidth switch may be switched to '200 c/s' for increased selectivity.

q. For crystal oscillator working, turn crystal control fully clockwise and insert appropriate crystal as shown in para. 15 under 'Crystal Compartment.'

r. Tune main tuning control for maximum signal output disregarding cursor reading on main tuning dial.

s. Adjust system and bandwidth switches as necessary for selectivity.

3.5. RECEIVER OUTFIT CAT

DATE OF DESIGN. 1952

HANDBOOK. B.R. 2169

ESTABLISHMENT LIST. E.1065

FREQUENCY RANGE. 60 kc/s to 32 Mc/s

POWER SUPPLY. 100–125 V, or 200–250 V a.c., 50 c/s

POWER CONSUMPTION. 50 W (approx.)

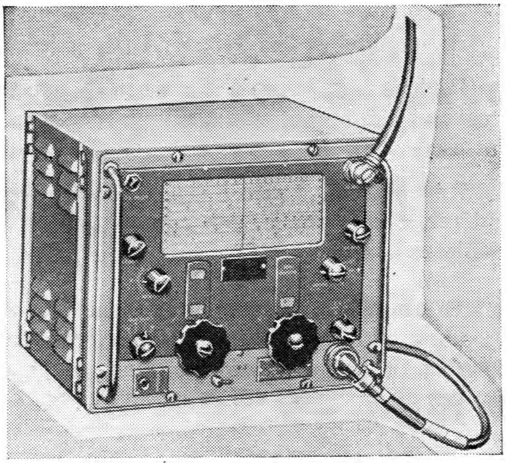


FIG. 1

GENERAL

1. The receiver operates as a single or double superheterodyne requiring a separate power pack. Used in conjunction with associated transmitter type 619 or 619H.

2. **Frequency Range**

Range 1.	– 60–125 kc/s	i.f. 460 kc/s.
„ 2.	– 100–260 kc/s	i.f. 460 kc/s.
„ 3.	– 260–660 kc/s	i.f. 1·4 Mc/s and 460 kc/s.
„ 4.	– 0·66–1·5 Mc/s	i.f. 460 kc/s.
„ 5.	– 1·5–3·4 Mc/s	i.f. 460 kc/s.
„ 6.	– 3·4–7·0 Mc/s	i.f. 1·4 Mc/s and 460 kc/s.
„ 7.	– 7·0–15 Mc/s	i.f. 1·4 Mc/s and 460 kc/s.
„ 8.	– 15–32 Mc/s	i.f. 1·4 Mc/s and 460 kc/s.

DESCRIPTION

3. **Aerial Input Circuit.** The aerial is capacity coupled on ranges 1–5 and inductively coupled on ranges 6–8 to the grid of the r.f. amplifier. A filter tuned to 460 kc/s is connected in series with the aerial, except on ranges 3 and 5, to minimize i.f. breakthrough. When using the same aerial as the associated transmitter the send/receive relay enables the operator to listen through.

4. **R.F. Amplifier.** A pentode valve, transformer coupled to the first mixer stage. A filter tuned to 1·4 Mc/s is inserted in parallel with the primary of the r.f. transformer, to attenuate i.f. signals on ranges 3 and 6. The grid circuit is tuned by a capacitor ganged to the main tuning control.

5. **First Mixer.** The heptode portion of a triode heptode valve. The grid circuit is tuned by a capacitor ganged to the main tuning control. The range switch selects the anode tuned circuit appropriate to the i.f. for that range (460 kc/s on Ranges 1, 2, 4 and 5; 1·4 Mc/s on Ranges 3, 6, 7 and 8).

6. **1st Local Oscillator.** A triode valve. The range switch arranges that the oscillator frequency is the appropriate i.f. above the signal frequency. The anode circuit is tuned by a capacitor ganged to the main tuning control. The output is fed to the injector grid of the mixer via the crystal ON-OFF switch, which also makes and breaks the H.T. supply to the 1st local oscillator.

7. **Crystal Oscillator.** The triode portion of the triode heptode mentioned under '1st Mixer'. It is brought into the circuit by means of the crystal switch, which in the ON position connects a stabilized H.T. supply to the crystal oscillator. The crystal frequency is always the appropriate i.f. above the desired frequency.

8. **1st Amplifier or 2nd Mixer.** A triode heptode valve.

ON RANGES 1, 2, 4 AND 5 (i.e. when the receiver is operating as single superhet.) The heptode portion is a normal I.F. amplifier stage, with the anode circuit tuned to 460 kc/s; in this case the triode portion is not used.

ON RANGES 3, 6, 7 AND 8 (i.e. when the receiver is a double superhet). The heptode portion acts as a 2nd mixer with the output circuit tuned to 460 kc/s as before. The triode portion operates as a 2nd oscillator at 1·86 Mc/s.

9. **I.F. Amplifiers.** Two pentodes, the first one being a variable mu. These stages act as 2nd and 3rd i.f. or 1st and 2nd i.f. amplifiers respectively, depending upon whether the receiver is operating as a superhet or double superhet. Their anode circuits are tuned to 460 kc/s. The transformer couplings between all i.f. stages are varied by the Selectivity Switch, which has four positions. (See para. 16.)

10. **Detector and A.G.C. Stage.** Consists of a double diode.

DETECTOR. One half of the double diode acts as a detector. The a.f. output is fed to the 1st a.f. amplifier via a Noise Limiter (which is always in the circuit) and an A.F. Gain control.

A.G.C. STAGE. The other half of the double diode is fed from the primary of the last i.f. stage transformer. Full negative a.g.c. bias is fed to the grids of the i.f./2nd mixer and 1st i.f. amplifier. Half the a.g.c. bias is fed to the grid of the r.f. amplifier. A.G.C. is only operative when the a.g.c. switch is to ON.

11. **Noise Limiter.** A double diode. Prevents radar pulses from being passed on to the a.f. stages. (See Noise Limiter para. under B40.)

12. **B.F.O.** A pentode operating as an electron coupled oscillator at 460 kc/s, which can be varied ± 5 kc/s by the b.f.o. tuning control. Output is capacity coupled to the detector anode.

13. **1st A.F. Amplifier.** A variable mu pentode whose input is controlled by a variable resistor (a.f. gain). The output is resistance capacity coupled to the 2nd a.f. amplifier (output stage).

14. **2nd A.F. Amplifier (Output Circuit).** A beam tetrode. A large negative feedback from the anode of this stage is applied to the cathode of the 1st a.f. amplifier, thus keeping the output in the secondary of the output transformer constant with varying loads. The output transformer has 100 ohm and 600 ohm outputs for loudspeaker or phones.

15. **Muting Relay.** This operates when the transmitter key is pressed and applies a preset bias to the cathodes of the r.f. amplifier, i.f. amplifier/mixer, and the 1st i.f. amplifier.

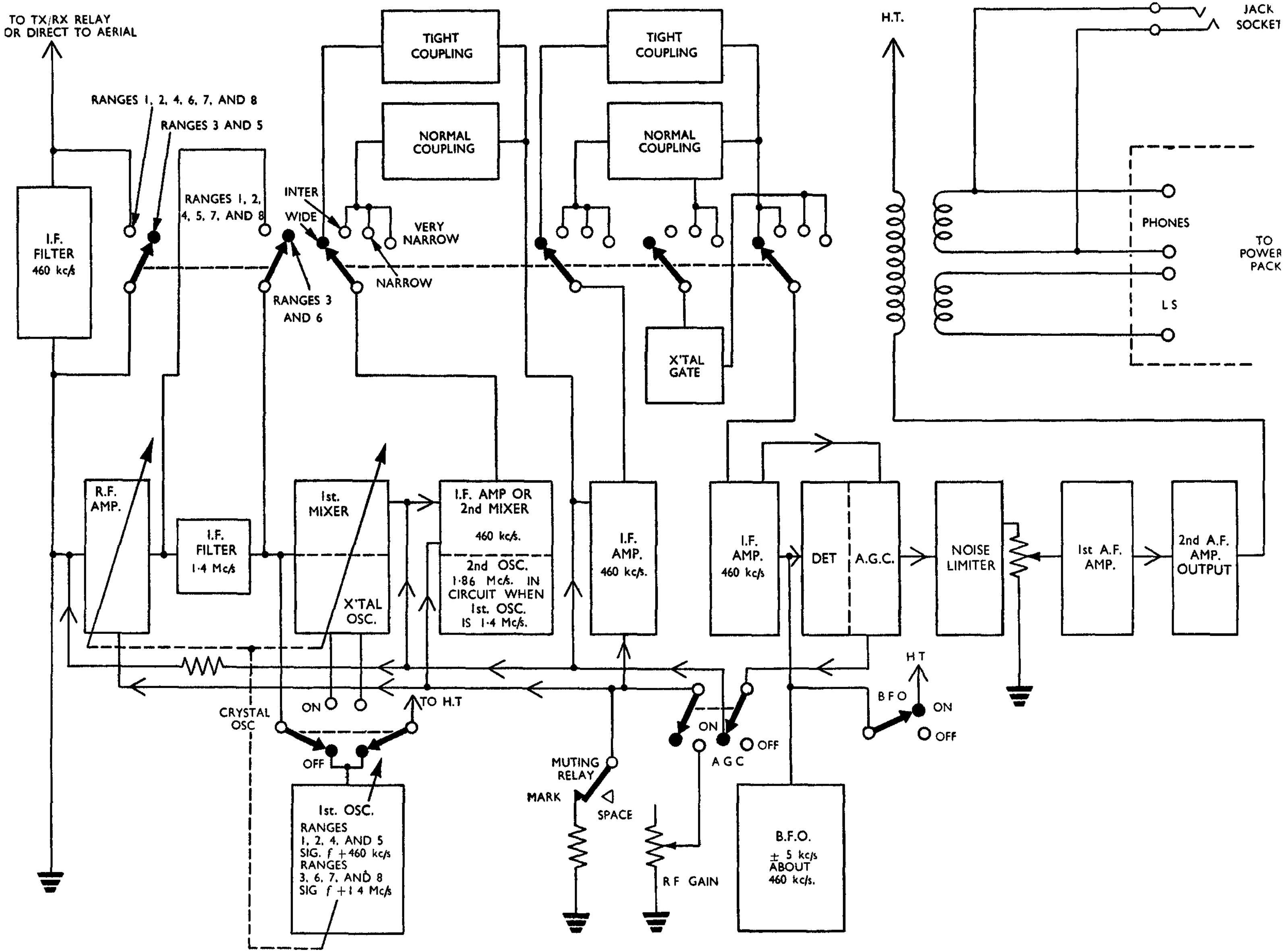
16. **Controls**

BAND CHANGE SWITCH. Switches in the appropriate circuits in the r.f., mixer, and 1st local oscillator stages, arranges the receiver to operate as a single or double superhet by bringing in the 2nd oscillator, and switches in or out one or other of the two i.f. filters.

TUNING CONTROL. Varies ganged capacitors in the r.f. mixer, and 1st local oscillator stages.

CRYSTAL ON-OFF SWITCH. Arranges the circuit for crystal or V.F.O. control; it has two functions:

On. Connects stabilized H.T. to the crystal oscillator anode and completes the crystal oscillator circuit. Breaks the H.T. supply to the 1st local oscillator.



FREQUENCY RANGE 60 kc/s.—32 Mc/s.

FIG. 2. RECEIVER CAT

Off. Connects stabilized H.T. to the 1st local oscillator and connects the output from the 1st local oscillator to the mixer. Breaks the H.T. supply to the crystal oscillator anode.

To insert a crystal the receiver must be drawn out of its chassis and metal cover of crystal holder removed. Socket will take a type A or B crystal.

The crystal frequency is 460 kc/s on ranges 1, 2, 4 and 5 and 1·4 Mc/s on ranges 3, 6, 7 and 8 above the signal frequency, modified as shown in the following table, where Fs is the signal frequency:

Signal Frequency	*Crystal Frequency*	*Signal Frequency*	*Crystal Frequency*
60–260 kc/s	Fs+460 kc/s	14·5–22 Mc/s	$\frac{\text{Fs}+1\cdot4\text{ Mc/s}}{3}$
260–660 kc/s	Fs+1·4 Mc/s		
0·66–3·4 Mc/s	Fs+460 Mc/s	22–30 Mc/s	$\frac{\text{Fs}+1\cdot4\text{ Mc/s}}{4}$
3·4–7·0 Mc/s	Fs+1·4 Mc/s		
7·0–14·5 Mc/s	$\frac{\text{Fs}+1\cdot4\text{ Mc/s}}{2}$	30–32 Mc/s	$\frac{\text{Fs}+1\cdot4\text{ Mc/s}}{5}$

DIAL LOCK. Locks tuning control.

R.F. GAIN. Is operative when the a.g.c. switch is in the off position. Varies the bias on the cathodes of the r.f. amplifier, 2nd mixer/i.f. amplifier and 1st i.f. amplifier.

A.F. GAIN. Always in the circuit. Varies the input to the 1st a.f. stage.

A.G.C. ON-OFF. Two-position switch.

On. Makes a.g.c. circuit operative which feeds bias as stated in para. 10.

Off. A.G.C. output is disconnected.

SELECTIVITY SWITCH. Alters the coupling between primary and secondary of the i.f. coupling transformers. There are four positions:

a. Wide. Arranges overcoupling of the primaries and secondaries of the inter stage i.f. transformers.

b. Intermediate. Normal coupling is used between primaries and secondaries of the inter stage i.f. transformers.

c. Narrow. Connects a crystal filter circuit and a balanced split tuned circuit in the secondary of the 2nd I.F. transformer.

d. Very Narrow. As for narrow but only half of the secondary of the 2nd i.f. transformer is used.

B.F.O. SWITCH. Makes or breaks the H.T. supply to the anode of the b.f.o. as required.

B.F.O. TUNING. A variable capacitor in the grid circuit of the b.f.o. which enables the b.f.o. frequency to be altered from 455 to 465 kc/s approximately to clear interference from stations on nearly the same frequency as the wanted signal.

PHONE SOCKET. Is fed from the 100 ohm tapping of the output transformer. A parallel tapping of the 100 ohms along with the 600 ohm tapping is taken via a cable to the power unit where there are sockets for phones (via a potentiometer) and loudspeaker.

AERIAL INPUT TERMINAL. When receiver is not fitted with associated transmitter, the aerial may be connected direct on to the terminal. When fitted with an associated transmitter, the aerial is connected via a terminal on the transmitter.

17. **Operating Instruction**

(1) Switch on main power supply to power pack unit.

(2) Switch on power to receiver by means of control on power pack.

(3) Set band indicator to appropriate range.

(4) Crystal switch to OFF.

(5) Selectivity switch to 'I' (Intermediate).

(6) A.G.C. ON.

(7) A.F. gain and r.f. gain to approximately three-quarters travel clockwise.

(8) b.f.o. ON.

(9) b.f.o. tuning control to zero.

(10) Adjust main tuning control to zero beat of signal.

(11) *a. c.w. Reception.* Adjust b.f.o. control above or below zero position to give comfortable beat note, and set selectivity switch to 'N' (Narrow).

b. Voice Reception. Switch off b.f.o. and set selectivity switch to 'W' (Wide).

(12) Adjust a.f. gain as necessary for comfortable noise level.

(13) For reception of C.W. signals, selectivity switch may be switched to 'V.N.' (Very Narrow) to clear interference. Adjust main tuning control and gain controls as necessary.

(14) For crystal oscillator working set crystal switch to ON and insert the appropriate crystal as shown in para. 16, Controls – Crystal ON/OFF Switch.

(15) Tune main tuning control for maximum signal output.

3.6. RECEIVER OUTFIT CJK

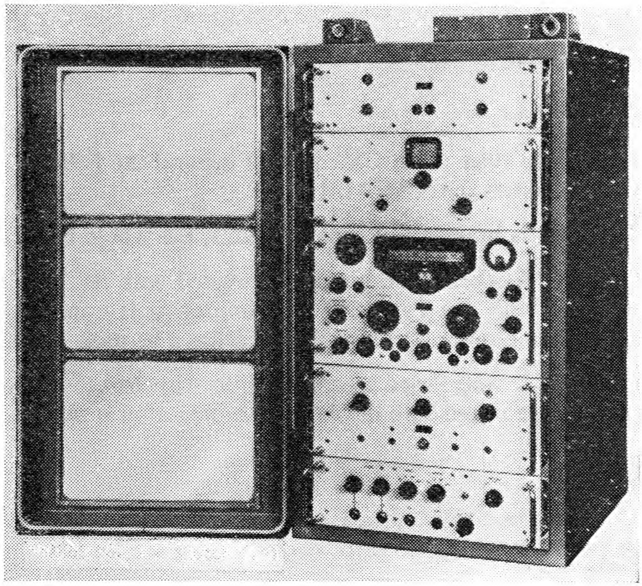


FIG. 1

Receiver CJK Comprising:

RA 117. Receiver Unit.

MA 150E. Synthesizer Unit.

MA 150. Power Unit and Internal
100 kc/s Frequency Standard.

RA 218. S.S.B. Converter Unit.

1. **Frequency Range.** 1–30 Mc/s in six range steps.
   I.F. Output. 100 kc/s.
   B.F.O. ±8 kc/s.

2. **Frequency Stability.** Either ±5 parts in 10^7 when connected to own internal 100 kc/s standard: or ±3 parts in 10^8 when connected to External Frequency Standard.

3. **Selectivity.** Six i.f. bandwidths selected by the SELECTOR Switch giving bandwidths of 13, 6·5, 3 and 1·2 kc/s 300 c/s and 100 c/s.

4. **Calibration.** A 100 kc/s signal derived from a 1 Mc/s crystal oscillator, with check points at 100 kc/s intervals.

5. **Noise Limiter.** A noise limiter can be switched into operation to provide limiting modulation levels exceeding 30 per cent.

6. **Meter.** Switched to read Signal Carrier Level, a.f. output level, or 'S' Meter indication to measure R.F. level at 100 kc/s during calibration.

7. **Modes of Operation.** *a.* C.W.
   b. D.S.B. – M.C.W., Voice.
   c. I.S.B./S.S.B. (U.S.B. or L.S.B.)
   Voice/F.S.T. (Two Tone) RATT.

8. **Power supplies.** 100–125 V and 200–250 V, 45–65 c/s.
   Power Consumption 100 W.

9. **Aerial System.** C.A.W. outfit EAL.

10. **Dimensions.**	Height 3 ft 2 ins. Width 1 ft 10 ins. Depth 2 ft.
11. **Weight.**	400 lb.

GENERAL

12. The receiver outfit CJK is built around the RACAL RA17 D.S.B. receiver which when modified for CJK becomes the RACAL 117.

The CJK is built in five separate units, the whole being contained in a forced air ventilated cabinet.

Outfit CJK when fitted alone is provided with its own 100 kc/s frequency standard. When fitted in conjunction with the Type 640 Transmitter, it is controlled from the external frequency standard F.S.B., which being more accurate should always be used if available.

Outfit CJK when used in conjunction with MA150E Synthesizer unit is designed for unattended reception, the required stability being attained after a two-hour warm up period.

Controls.

13. These controls on the front panel of receiver RA117 are listed in the order in which they will normally be used for setting up prior to use.

POWER.	Makes supply to mains transformer.
RF RANGE Mc/s.	Selects any one of 5 antenna ranges plus 2 wideband positions (75 ohms and 2000 ohms input impedances).
MEGACYCLES.	Selects Mc/s frequency.
SYSTEM.	Selects for Standby, Manual, A.V.C., CAL, Check B.F.O.
BANDWIDTH.	Two crystals filters determine bandwidth so that centre frequency of each is within 50 c/s avoiding necessity to retune receiver. Six positions.
A.F. GAIN.	Controls Audio Output (but not when operating S.S.B.).
KILOCYCLES.	Selects kc/s frequency. Calibration may be checked at 100 kc/s intervals by setting system switch to CAL. This control is inoperative when the V.F.O. EXTERNAL–INTERNAL switch is set to EXTERNAL.
b.f.o.	Makes or breaks the H.T. to the b.f.o. The b.f.o. is by-passed when CJK is operated on S.S.B.
b.f.o. NOTE kc/s.	The b.f.o. is exactly tuned to a central point when the b.f.o. Note kc/s control is set to zero beat with calibration. Having standardized the b.f.o. the frequency of an incoming signal may be accurately measured, by setting the KILOCYCLES control to a zero beat position. Retune for reception of c.w.
R.F. TUNE.	If maximum sensitivity is not required the antenna need not be tuned unless strong unwanted signals are present. Unless aerial is tuned strong unwanted signals may cause cross modulation.
R.F./I.F. GAIN.	Operative in both MAN and A.V.C. in MAN position setting should always be at a minimum consistent with a satisfactory a.f. level. On A.V.C. the r.f./i.f. Gain should be set to maximum position unless receiver noise is troublesome during periods when no carrier is being received.

(*continued on page* 3–6–3)

(*continued from page* 3–6–2)

A.V.C. Has two time constants. Long. Used for Voice.
Short. Voice or High Speed Telegraphy.
For hand speed c.w. the MAN position of the System switch should be used.

A.F. LEVEL. Is unaffected by position of main a.f. Gain control. *Do not turn this control to maximum unless* the 10 mW, 600 ohms winding is suitably terminated.

LIMITER. Reduces noise peaks above 30 per cent modulation level.

SPEAKER. A1 watt internal loudspeaker, controlled by the Speaker ON/OFF control. The speaker is automatically disconnected when a headset is inserted in one of the two telephone jacks on the receiver.

V.F.O. Has two positions marked INTERNAL and EXTERNAL. On INTERNAL the receiver operates as a conventional superhet. The synthesizer and frequency Standard being disconnected. On EXTERNAL the receiver is operated in conjunction with the synthesizer and the frequency Standard F.S.B. On this position the Kilocycles control is inoperative.

OUTPUTS.
a. Internal Loudspeaker. 1 watt.
b. Three separate outputs of 3 mW 600 ohms at rear of receiver chassis.
c. One 10 mW output at 600 ohms independent of a.f. Gain.
d. One 1 watt at 3 ohms.

TELEPHONE JACKS. Two parallel sockets at front panel, connected across one of the 3 watt outputs.

UNITS

14. **Power Unit MA150**

FUNCTION: To provide power to the synthesizer and to maintain the Internal Frequency standard (100 kc/s) at its correct operating temperature.

15. **General Description**

a. The unit contains rectifying and smoothing circuits to provide the H.T., bias and filament voltages to the synthesizer.

b. Internal Frequency Standard (100 *kc/s*)

This consists of an extremely stable crystal which provides the synthesizer with 100 kc/s in the following circumstances:

(1) When CJK is fitted without transmitter 640.

(2) On failure of the External Frequency Standard (Outfit F.S.B.).

Changeover is effected by a screwdriver control inside the unit.

c. Controls

(1) POWER SWITCH. Applies a.c. mains to the unit.

(2) STANDBY/OPERATE SWITCH. On standby filament supplies to synthesizer only are made.

On Operate. The H.T. and Bias supplies to the synthesizer are made.

(3) LAMPS. Power. Indicates a.c. supplies are made.

Oven. Indicates voltage at the oven heaters. Lamp will 'cycle' in time with the oven thermostat relay.

16. **The Preselector and Protector Unit**

a. Function. The Preselector Unit enables the CJK to be operated in adverse conditions of local interference, such as high static or strong local interference, with little effect of overall performance. The preselector provides an r.f. input in the range 1·5 to 30 Mc/s to the receiver. The selectivity is such that signals 5 per cent off tune are attenuated by at least 100 dB.

b. Description. The r.f. input is fed via the Aerial Selector Switch to one of 6 tuned circuits depending on the frequency being received. The tuned circuits consist of coils and capacitors. Tuning of each range being carried out by the variable capacitors. Except on ranges 1 and 6 the output of the tuned circuit selected is fed on to a two valve r.f. amplifiers tage. The output of the Preselector Unit is then fed into the r.f. stage of the receiver.

c. Common Aerial Working. Several CJK outfits may be operated from one aerial. The Preselector switches are of the 'make and break' type so that on changing ranges continuity is maintained in the other receivers.

When the CJK is not connected to a C.A.W. system, the socket marked AE OUT (at the top of the cabinet) is earthed. Under these conditions, frequency response in the 24–30 Mc/s range may be slightly reduced.

d. Power Supplies. The unit contains its own power supplies. The unit contains two transformers and a rectifier circuit which supply H.T. to the two r.f. valve amplifiers and the filament supplies.

e. Controls and Switches

RANGE SWITCH.	Selects one of six tuned circuits.
TUNER.	Variable capacitors which provide continuous tuning within the range selected by the range switch.
A.C. SWITCH.	Applies a.c. mains to the unit.
LAMP.	Connected across valve heater winding of mains transformer and indicates power completed.

17. **Receiver RA117**

a. The RA117 is a general purpose superhet receiver with a very high standard of stability and selectivity which, combined with other units, forms outfit CJK. Receiver RA117 is similar to receiver RA17 but has an additional i.f. STAGE. The frequency range of the receiver is 1 to 30 Mc/s.

b. General Description. Fig. 4 shows the block diagram of the receiver RA117.

c. Aerial Circuit. The aerial is connected to the tuned r.f. amplifier through a 30 Mc/s low-pass filter and a five-position attenuator. The switch marked r.f. Range Mc/s selects a wideband 75 ohm aerial or a wideband (high impedance aerial) or any one of the five tuned aerial coils for tuned operation. The aerial is tuned by two ganged condensers which is done by the control marked r.f. TUNE. This control is switched out of circuit when the r.f. RANGE Mc/s switch is on either of the wideband positions.

d. R.F. Amplifier. The incoming signal is fed to the grid of the r.f. amplifier which is a variable-mu, low noise double triode. A delayed A.V.C. is applied to the grid of one of the triodes. The output of the R.F. amplifier is taken through a 30 Mc/s low-pass filter on to the control grid of the first mixer valve.

e. First Variable Frequency Oscillator. This is a cathode coupled Hartley oscillator continuously tunable over the frequency range 40·5 to 69·5 Mc/s. Tuning is a variable capacitor which is coupled to the Mc/s dial which is calibrated from 0 to 29 Mc/s. The First v.f.o. is coupled to the signal grid of the first mixer stage and to the control grid of the harmonic mixer.

f. First Mixer. The incoming signal and the output of the First v.f.o. are fed to the signal grid of the first mixer which produces a signal at 40 Mc/s. This output is then fed into the 40 Mc/s filter which has a pass-band of 40 Mc/s plus or minus 650 kc/s. This filter is provided with this band pass to allow for possible drift of the First V.F.O. The output is then taken to the second mixer stage via the First I.F. Filter.

g. One Mc/s Crystal Oscillator/Amplifier. The crystal oscillator is controlled by a 1 Mc/s crystal between the control and screen grids. The anode coil resonates at 1 Mc/s. The 1 Mc/s output is fed to the Harmonic

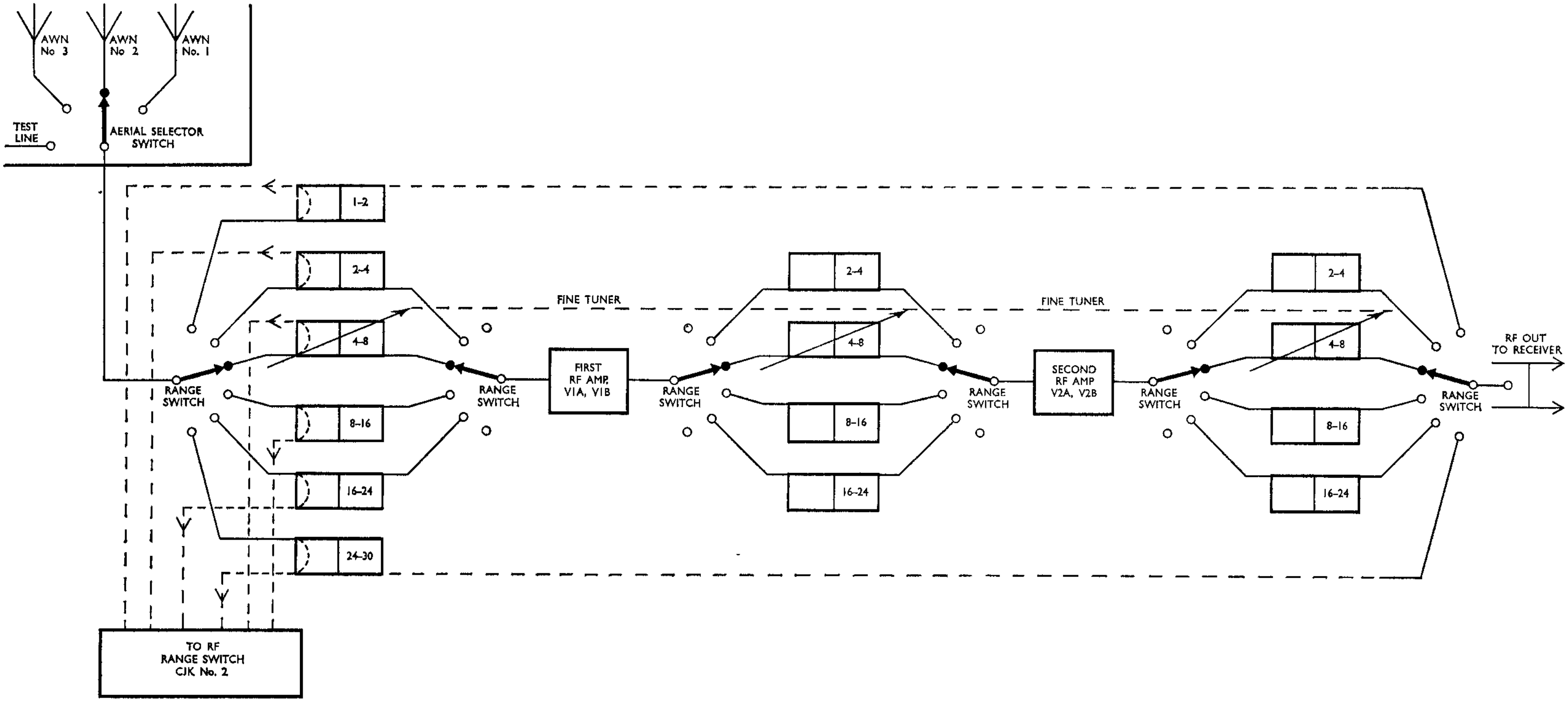


FIG. 2. PRESELECTOR/PROTECTOR WITH RANGE SWITCH AT 4 – 8 Mc/s

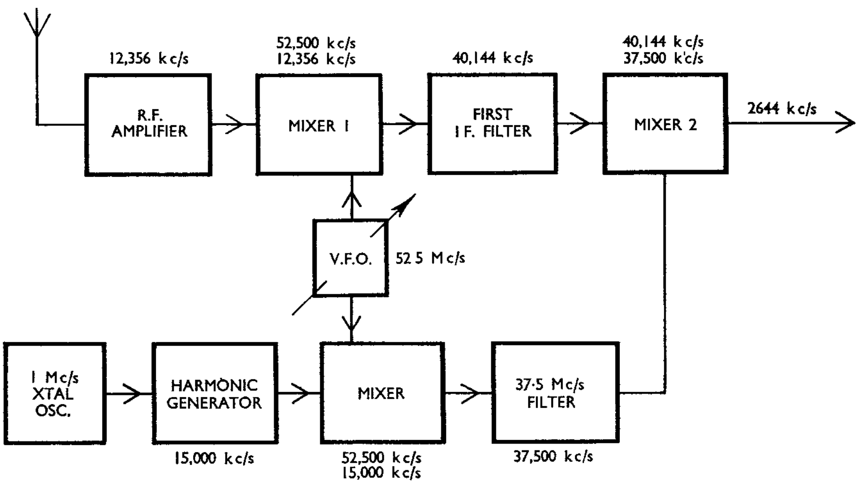
Ch 4

Generator. The crystal oscillator can be fed with a 1 Mc/s signal from the synthesizer by setting the INTERNAL–EXTERNAL screwdriver control to the EXTERNAL position. When fed with the 1 Mc/s source from the synthesizer the crystal oscillator operates only as an amplifier and not as an oscillator. When the INTERNAL–EXTERNAL control is on the internal position the 1 Mc/s signal is also fed to the control grid of the mixer valve in the calibrate stage of the receiver.

h. Harmonic Generator. The 1 Mc/s signal from the crystal oscillator is fed to the control grid of the harmonic generator which produces harmonics which are fed to the 32 Mc/s low-pass filter. The purpose of this filter is to prevent harmonics other than those required from passing to the Harmonic Mixer.

i. Harmonic Mixer. The outputs from the Harmonic Generator (via the 32 Mc/s filter) and the First V.F.O. are applied to the suppressor and control grids respectively. The output of the Harmonic Mixer is always 37·5 Mc/s. This output is fed through a 2 valve amplifier stage and a 37·5 Mc/s filter to the second mixer.

j. The Second Mixer. The second mixer produces the second i.f. of 2–3 Mc/s by mixing the 37·5 Mc/s signal and the first I.F. of 40 Mc/s. The operation of the receiver can be summarized so far as follows: The incoming signal is converted to the band 2–3 kc/s by mixing with a selected harmonic of the 1 Mc/s crystal oscillator. Thus an incoming signal of 12356 kc/s when mixed with the 15th harmonic of 1 Mc/s



[illegible]. FIRST STAGES OF CJK

FIG. 3

Ch.4

is converted to 2644 kc/s, whilst an incoming signal of 6583 kc/s mixed with the 9th harmonic of 1 Mc/s is converted to 2417 kc/s. The method of selecting the required harmonics of the crystal standard is as follows:

In tuning the V.F.O. over its frequency range there will be outputs through the filter at megacycle intervals, e.g.:

V.F.O. FREQ.	HARM. GEN.	FILTER
40·5 Mc/s	3rd	37·5 Mc/s
41·5 ,,	4th	37·5 ,,
etc. ,,	etc.	37·5 ,,
45·5 ,,	8th	37·5 ,,
46·5 ,,	9th	37·5 ,,
47·5 ,,	10th	37·5 ,,
etc. ,,	etc.	37·5 ,,
52·5 ,,	15th	37·5 ,,
etc. ,,	etc.	37·5 ,,
69·5 ,,	32nd	37·5 ,,

By injecting the filter outputs of 37·5 Mc/s into the second mixer whilst the V.F.O. output is injected into the First Mixer, it is possible to utilize the megacycle output harmonic, appropriate to the incoming signal for the purpose of converting the signal to the band 2–3 Mc/s. This method of using three mixers is known as the Wadley Triple Mix.

The V.F.O. dial is calibrated in megacycle steps so that for receiving 12356 kc/s the dial setting would be 12 Mc/s and for 6583 it would be 6 Mc/s.

Note that with this system—

(i) The V.F.O. output is self-cancelling so that it does not affect the receiver stability. (ii) The receiver has an output only when a megacycle component is selected so that tuning over a wide range is accompanied by 'rising noise' at megacycle intervals. (iii) The selected harmonics of the standard is always 3 Mc/s above the V.F.O. dial setting while the i.f. of 2–3 Mc/s is calibrated at 0–1 Mc/s.

k. Third Mixer. The output of the second mixer of 2–3 Mc/s is taken through a 2–3 Mc/s filter on to the signal grid of the Third Mixer stage. A second input of 3·6–4·6 Mc/s from the Second v.f.o. amplifier is also fed into the Third Mixer. These two inputs produce an output of 1·6 Mc/s which is the third i.f. This third i.f. is then taken through a 1·6 Mc/s filter which has a bandwidth of 13 kc/s.

l. Second V.F.O. The second v.f.o. covers the frequency range of 3·6–4·6 Mc/s. Tuning is by a variable capacitor to which is coupled the Kilocycles scale which is calibrated between 0 and 100 kc/s. When the V.F.O. switch is set to INTERNAL the output of the second v.f.o. is fed to the Second v.f.o. Amplifier.

When this switch is set to EXTERNAL the Second v.f.o. Amplifier is fed with the 3·6–4·6 Mc/s output from the Synthesizer.

m. Fourth Mixer. The 1·6 Mc/s output from the Third Mixer and filter is fed to the Fourth Mixer signal grid. On to the oscillator grid is also fed the 1·7 Mc/s output from the 1·7 Mc/s crystal oscillator/ amplifier. These two inputs give an output from the fourth mixer of 100 kc/s.

n. 1·7 *Mc/s Crystal Oscillator/Amplifier.* This is a crystal controlled oscillator when the receiver is used as the RA17, but when the receiver is used as the RA117 (CJK) this stage is supplied with a 1·7 Mc/s signal from the S.S.B. adaptor and acts only as an amplifier.

o. 100 *kc/s Filter.* The 100 kc/s output from the fourth mixer is fed into the Filter stage which by switching enables the bandwidth to be selected. The filter stage consists of two types of filters, a crystal filter and a L–C filter, selected by the BANDWIDTH Switch.

The bandwidths available are:

$$\left.\begin{matrix}100\text{ c/s}\\300\text{ c/s}\end{matrix}\right\}\text{ Crystal Filter}\qquad\left.\begin{matrix}1{\cdot}2\text{ kc/s}\\3{\cdot}0\text{ kc/s}\\6{\cdot}5\text{ kc/s}\\13{\cdot}0\text{ kc/s}\end{matrix}\right\}\text{ L–C Filter.}$$

p. First 100 *kc/s i.f. Amplifier.* The output from the Filter Stage is fed to the control grid of the First 100 kc/s i.f. Amplifier. The control grid is also returned to the A.V.C. line.

q. Second 100 *kc/s i.f. Amplifier.* The First 100 kc/s i.f. Amplifier is transformer coupled to the Second 100 kc/s Amplifier. The signal is fed on to the control grid of this valve which by transformer coupling feeds the signal on to the anode of the Diode Detector.

r. Diode Detector and Noise Limiter. This is a double diode valve. One diode operates as a detector and the other as a noise limiter. When the Monitor Meter is switched to r.f. LEVEL the meter indicates the detector diode current. The Noise Limiter operates at 30 per cent modulation and is switched in or out by the Limiter Switch.

s. A.V.C. and Time Constant. The signal at the anode of the second 100 kc/s i.f. Amplifier is taken on to the anode of the A.V.C. anode. A resistance network provides a delayed voltage to the cathode of this diode. When the A.V.C. switch is set to the SHORT position and the SYSTEM switch is set to A.V.C., CAL or CHECK b.f.o., the anode of the A.V.C. diode is connected to the A.V.C. line via a coil and a resistance. When the A.V.C. switch is on the LONG position decoupling capacitors are introduced and are charged through the Time Constant Diode. When the system switch is set to MANUAL the A.V.C. line is connected to the r.f./i.f. GAIN control so that the gain of the 100 kc/s amplifiers can be varied by adjusting the potential applied to the A.V.C. line. The A.V.C. potential is also taken to a tag strip at the rear of the receiver for external use if required.

t. Audio Output. The audio frequencies are applied to the grid of one half of the a.f. amplifier (double triode) via the a.f. GAIN control. The output is taken on to the output transformer which has four separate outputs. One output is used for the internal loudspeaker, one for the local phones and the other two are taken to the rear of the receiver. The audio frequencies are also applied to the grid of the other half of the a.f. amplifier via the a.f. GAIN LEVEL control which presets the level from the output transformer in the anode circuit of this half of the valve. This output is taken to feed the remote reception lines. When the monitor meter is switched to a.f. LEVEL the meter indicates the a.f. level in the remote reception line.

u. Beat Frequency Oscillator. The Beat Frequency Oscillator is tuned to 100 kc/s, but tuning can be adjusted to 8 kc/s either side by varying the variable condenser attached to the 'B.F.O. Note kc/s' control. When this control is set to zero the output frequency is exactly 100 kc/s. The B.F.O. output is fed to the diode detector anode.

When the SYSTEM switch is in the CAL or STANDBY positions H.T. is not supplied to the B.F.O.

v. 100 kc/s i.f. Output. The output of the First i.f. 100 kc/s Amplifier is also fed to the i.f. output valve. A.V.C. is also applied to this valve. The anode load consists of an auto-transformer which supplies an output of the i.f. of 100 kc/s which is for external requirements. In the CJK outfit this 100 kc/s output is taken into the S.S.B. adaptor.

w. Crystal calibration. The crystal calibrator valves are controlled by the 1 Mc/s crystal or by the 1 Mc/s external input to the 1 Mc/s crystal oscillator/amplifier. Signals at 100 kc/s intervals are fed to the signal grid of the Third Mixer to provide calibration points. Calibration can only be carried out when the V.F.O. switch is set to the INTERNAL position.

The calibrator valves consist of two valves. The 1 Mc/s signal is fed to the first grid of the first calibrator whose anode is tuned to 100 kc/s and is coupled to the control grid of the second calibrator. The anode of the second calibrator is tuned to 900 kc/s in turn is coupled back to the third grid of the first calibrator. A difference frequency of 100 kc/s is thus produced. The arrangement of this circuit is self-regenerative.

18. The Sideband Converter/Adaptor

a. The Sideband Converter enables outfit CJK to be operated in conjunction with Independent sideband, Single Sideband (upper or lower), Double Sideband or C.W. The 100 kc/s output from the fourth mixer in the receiver is fed into the sideband Converter which converts the i.f. into its upper and lower sideband components.

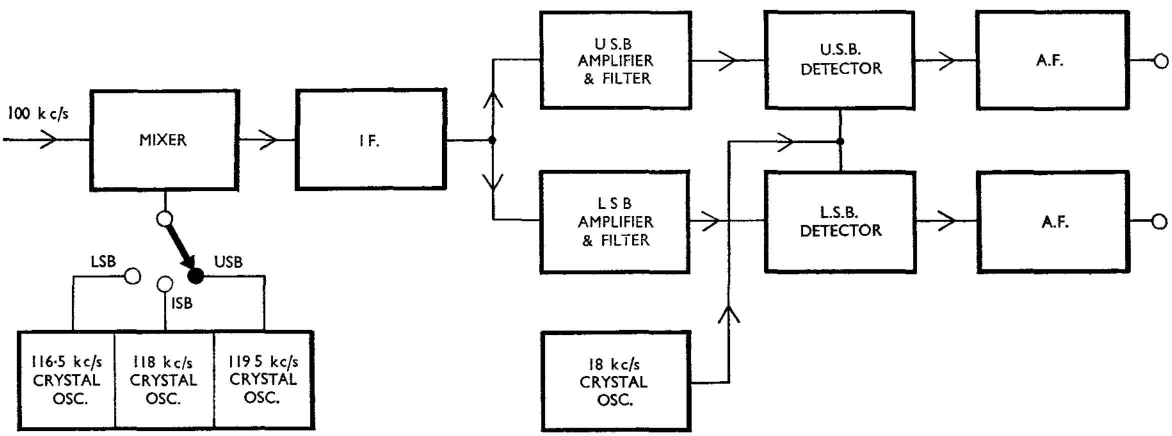


FIG. 4 SIDEBAND CONVERTOR (CJK) (SHOWING SSB OUTPUTS ONLY)

Ch 4

b. The 100 kc/s i.f. is fed into the mixer stage which is also fed with the selected outputs from a crystal oscillator. These selected outputs are 116·5 kc/s, 118 kc/s and 119·5 kc/s which enable the required sideband to be selected and full use of the receiver selectivity. The crystal oscillator is contained in a thermostatically controlled oven.

c. The output from the Mixer consists of upper and lower sideband frequencies centred on an i.f. of 18 kc/s. This is passed through a band pass filter and to the upper and lower sideband channels via a low pass filter which attenuates the 118 kc/s frequency appearing on the grids of the sideband amplifiers. Because of the use of an oscillator frequency which is above that of the i.f., inversion of the sideband frequencies occurs.

d. Sideband Amplifiers. The output from the band pass filter is passed to the upper and lower sideband amplifiers, the control grids and cathodes of which are connected in parallel. The anode resistors of each are equal so that identical outputs to the U.S.B. and L.S.B. filters are provided.

e. Band Pass Filters and Detectors. The 18 kc/s i.f. is passed through the U.S.B. filter and on to the U.S.B. Detector. The U.S.B. Filter attenuates the 18 kc/s by 15 dB and attenuates the L.S.B. by 38 dB. A second input to the U.S.B. Detector is provided by the 18 kc/s oscillator. The output of the detector consists of an a.f. of up to 3 kc/s, the Upper Sideband. The function of the lower sideband circuits are identical to the U.S.B. circuits except that the filters have a different band pass.

A.F. Amplifiers. The outputs of the detectors are fed via the a.f. Gain to the grid of the a.f. amplifiers whose outputs are taken via output transformers on to the monitoring and line sockets.

f. 18 kc/s Oscillator. This oscillator is crystal controlled and has a resonant frequency of 18 kc/s. The output is fed via cathode followers to the detectors.

g. Fine Tuning Unit. The Fine Tuning Unit consists of two oscillators and a Mixer.

The first oscillator is crystal controlled at 5·1 Mc/s whose anode circuit is tuned to double this frequency. The 10·2 Mc/s output is fed to the control grid of the Mixer.

The second oscillator is crystal controlled at 4·25 Mc/s whose anode circuit doubles, giving an output of 8·5 Mc/s which is also fed on to the control grid of the Mixer.

The anode circuit of the Mixer which is tuned to 1·7 Mc/s is taken to feed the Fourth Mixer in the receiver. A variable capacitor tuning control 'Fine Tuning kc/s' varies the tuning from 0 to 1 kc/s and provides an accuracy of 10 c/s.

h. Output Switching and Monitoring. Two independent switched outputs are provided, Output 1 and Output 2. Upper, Lower or Double sideband outputs or Off may be selected.

19. Synthesizer MA 150E

a. Function. To provide:

(1) A 1 Mc/s output to the Harmonic Generator in the RA117.

(2) A variable frequency of very high accuracy to the third mixer stage of the RA117. In effect when the Synthesizer is used in CJK, it replaces the kilocycles control of the RA117. The changeover of the kc/s control is effected by adjusting the INTERNAL–EXTERNAL control at the front of the receiver.

b. Frequency Range. 3601–4600 kc/s.

c. General Principles. The synthesizer utilizes the technique, whereby a V.F.O. covering a range of 3601–4600 kc/s is controlled by the harmonics of a very highly stable crystal source of 100 kc/s from the F.S.B. (external source) or from an internal source. The technique enables this output frequency to be automatically locked, both in frequency and phase, to whole and fractional multiples of the frequency source.

d. The Decade System. The Decade System is used with the 100 kc/s output frequency range (3601–4600) subdivided into divisions of 100, 10, and 1 kc/s. The 100 kc/s from the crystal source is transformed by a pulse generator into a series of short impulses with a repetition frequency of 100 kc/s. The harmonic content of these impulses are the synchronizing source for each decade, viz. 100, 10, and 1.

e. 100 *kc/s Decade.* Comprises a harmonic selector multiplier which develops an output utilizing the 33rd to the 42nd harmonic (3300–4200 kc/s) in steps of ten.

f. 10 *kc/s Decade.* This output utilizes the 27th to the 36th harmonics of the 100 kc/s source, which then being divided by 10 gives an output in the range 270–360 kc/s, depending on the setting of the 10's switch.

g. 1 *kc/s Decade.* Here the harmonics selected are the 31st to the 40th (3100–4000 kc/s) which is subdivided by 10 to give an output of 31–40 kc/s in steps of 1 kc/s.

The output from the 10 kc/s decade (270–360 kcs) is then mixed with the output of an interpolation oscillator working in the range 301–400 kc/s. This will produce a beat frequency of between 31 and 40 kc/s, which is compared and locked with the 31–40 kc/s output from the 1 kc/s decade. The output from the 100 kc/s decade 3300–4200 kc/s is mixed with the Master oscillator output 301–400 kc/s, which is in turn compared and locked with the 301–400 kc/s output from the interpolation oscillator. Thus the master oscillator is harmonically phase locked to the frequency source (100 kc/s) in subdivisions of 100, 10, and 1 kc/s, and therefore will have the stability and accuracy of that same frequency source.

h. Power Supplies. The supplies are obtained from the Power Unit situated at the top of the CJK.

Filaments. From the a.c. on Switch.

H.T. From the Operate Position of the Tune/Operate switch.

i. Lamp. When lit indicates that the selected frequency has 'locked on' and the Synthesizer is operational.

j. Decade Switches. 3 switches; 100, 10, and 1 kc/s. Select the necessary components of the wanted signal. (The Mc/s component is selected by the Mc/s control at the Receiver RA117.) Fractions of kc/s are obtained by adjusting the 'Fine Tuning Control' at the S.S.B. Converter Unit.

k. Frequency Meter. The Frequency Meter output enables the synthesizer to be used with a digital counter to check the frequency of the receiver v.f.o., and for test purposes.

20. **Setting up CJK using Synthesizer.**

The CJK may be operated using one of two frequency sources:

a. An External source of 1 Mc/s (suitably subdivided) from Frequency Standard F.S.B. . . . 3 parts in 10^8. or . . .

b. An internal source of 100 kc/s from a crystal inside the power unit . . . 5 parts in 10^7.

An EXTERNAL–INTERNAL switch situated inside the Power Unit makes the necessary selection.

For normal purposes *a* will be used. *b* should be used in the event of failure of F.S.B. or in the unlikely case of a CJK not being fitted with F.S.B.

(1) Mains switch from CONDENSATION HEATERS to POWER ON.

(2) Check that cooling fan at top of chassis is running – *IMPORTANT.*

(3) Select appropriate aerial from switch at top of chassis.

(4) Make following a.c. switches at, Power Unit . . . Preselector Unit . . . Racal 117 . . . and S.S.B. Adaptor Unit.

(5) Standby/Operate switch on Power Unit to OPERATE. (If the Internal source is being used, a warm up time of 2 hours should be allowed before making this switch, although ten minutes will give reduced stability performance.)

(6) Adjust the 100's . . . 10's . . . and 1 kc/s settings at Synthesizer.

(7) Select appropriate range at Preselector Unit.

(8) R.F. range switch at receiver to appropriate range.

(9) R.F. attenuator to minimum.

(The two impedance positions of the r.f. range switch should only be used when searching over a band of frequencies. CJK with Synthesizer is not convenient for this function.)

(10) External–Internal switch at front of Racal 117 to External.

(11) Limiter Off.

(12) System switch to A.V.C.

(13) R.F./I.F. Gain to nearly maximum (it may be necessary to reduce this control as convenient).

(14) A.F. Gain to give reasonable signal or noise level.

(15) B.F.O. to 0.

(16) A.V.C. time constant to Long for voice or Short for C.W., etc.

(17) Meter switch to a.f. Level (r.f. Gain may be reduced to protect this meter . . . at a.f. level meter will indicate maximum a.f. output . . . at r.f. level will indicate maximum detector output. And is therefore a helpful tuning guide.)

(18) Adjust Mc/s control to correct frequency in logging scale at receiver.

(19) Adjust tuner control at r.f. preselector/Protector Unit for maximum signal or noise input.

(20) Adjust r.f. tuner control at receiver for maximum signal or noise input.

(21) Repeat 18, 19 and 20 until signal is correctly tuned.

(22) Select required output from S.S.B. Convertor Unit.

(23) Switch muting control (at bulkhead) on, if CJK is to be operated on a frequency which will also be used from the ship's main transmitters.

C.W. D.S.B. Operation

B.F.O. On.

B.F.O. control offset to give a readable c.w. note.

(B.F.O. is inoperative when using CJK in any S.S.B. mode.)

Bandwidth switch to 3 kc/s.

Voice–M.C.W.–2 tone (500–700 c/s active/idle operation)

B.F.O. switch – Off.

Bandwidth switch to 6·5 kc/s.

Output 1 switch at S.S.B. Convertor to D.S.B.

FST (Carrier Shift) Operation. At present, RN Broadcasts are operated in 'Arrangement 1' on HF (see BR 222 RATT section). This entails using CJK in Lower Sideband. 'Arrangement 2' will necessitate using Upper Sideband. It is necessary therefore to operate L.S.B. by offsetting 2·55 kc/s. By switching to Lower Sideband results in an offset of 1·5 kc/s, therefore the Synthesizer must be offset by *adding* a further 1·05 kc/s.

e.g. To receive FST Broadcast HNR at 6362 kc/s

Mc/s control to	6
Synthesizer to	363
Fine Tuner (at S.S.B. Convertor)	·05 kc/s.

Sideband switch to L.S.B.

Output 1 switch to L.S.B.

Adjust gain control immediately beneath as required.

Note. If it is ever required to Operate an 'Arrangement 2' then 1·05 kc/s must be subtracted from the Synthesizer and the Sideband and Output 1 switches put at U.S.B.

SSB Voice Operation

Sideband and Output 1 switches at S.S.B. Converter to required sideband.

Adjust fine tuner control to obtain maximum clarity.

It cannot be emphasized too strongly that for S.S.B. operation accurate tuning and adjusting is essential.

> *Notes.* Operation of Limiter . . . A.G.C. controls, etc., should be in accordance with the instructions laid down in the general chapter on receiver controls in B.R. 222.

CJK WITHOUT THE SYNTHESIZER. Internal–External switch at RA117 to Internal (the kc/s control is now operative and the Synthesizer Inoperative).

To calibrate RA117. (Facility available every 100 kc/s.)

B.F.O. to 0.
System switch to Cal.
Adjust kc/s control to zero beat.
Adjust curser to align zero beat with nearest 100 kc/s setting.
Switch off cal.

Check BFO. System switch to Check B.F.O. Phones at D.S.B. output at S.S.B. convertor. Rotate B.F.O. control for zero beat. This should coincide with O position of the control.

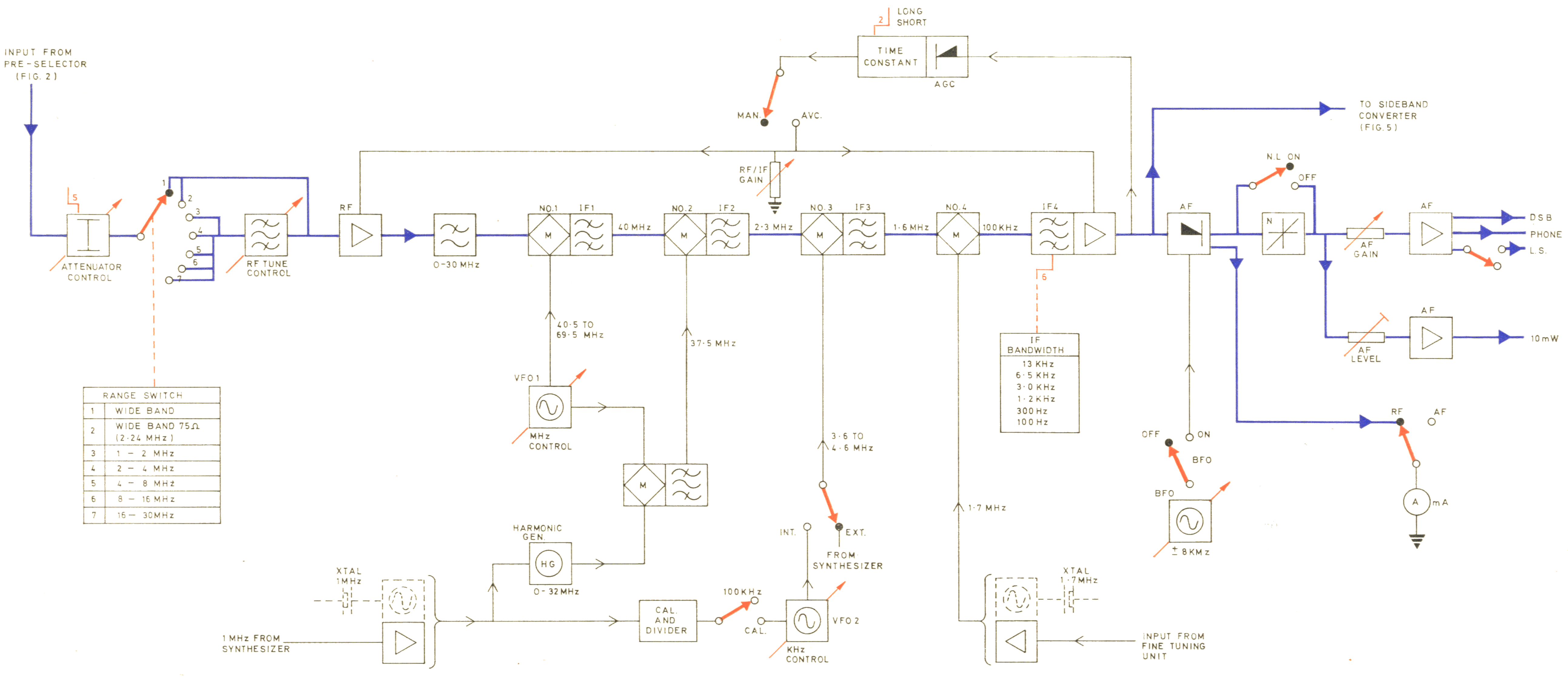
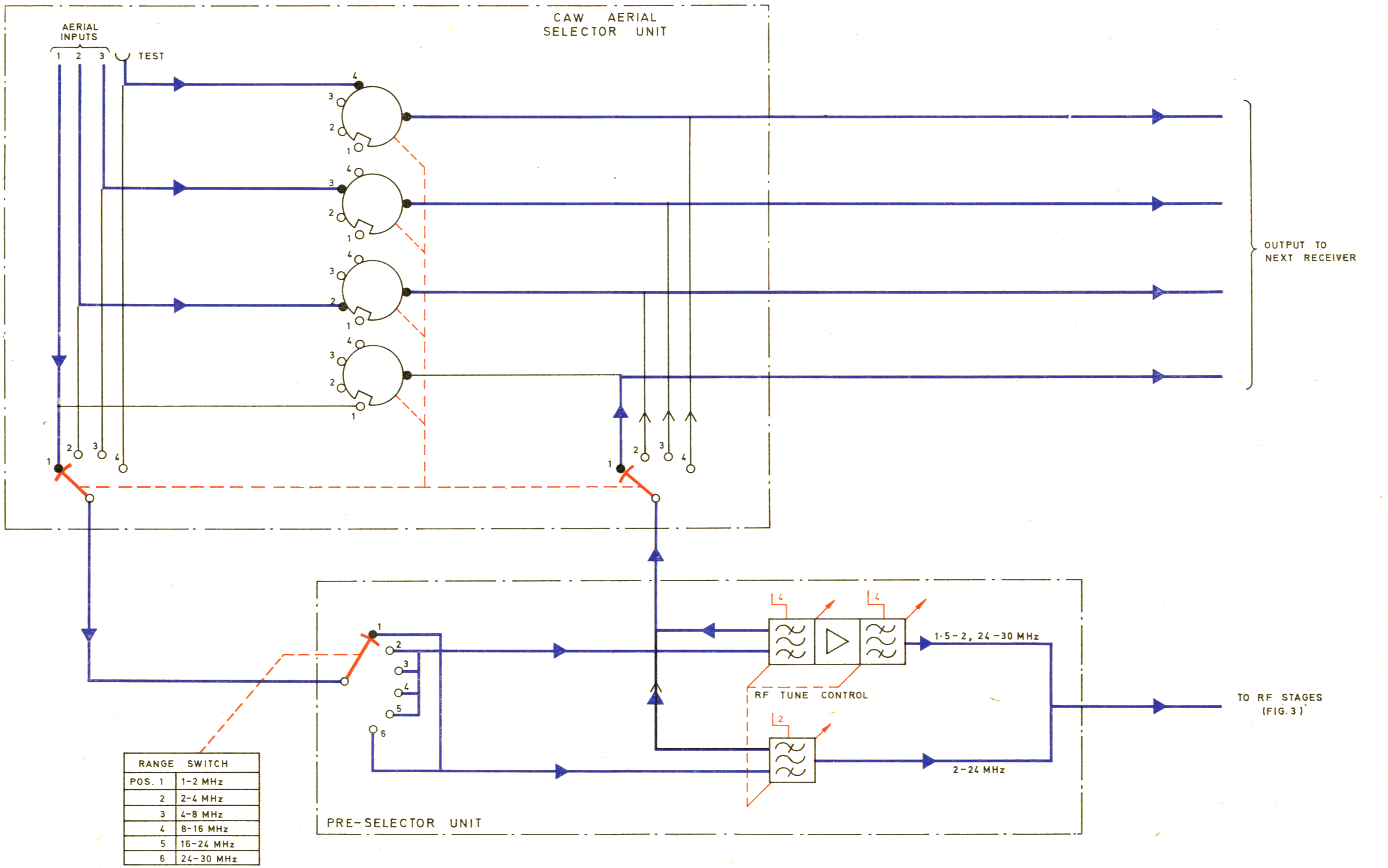


FIG. 5. RECEIVER OUTFIT CJK—BLOCK DIAGRAM

169471—39—40



RANGE SWITCH	
POS. 1	1–2 MHz
2	2–4 MHz
3	4–8 MHz
4	8–16 MHz
5	16–24 MHz
6	24–30 MHz

FIG. 6. RECEIVER OUTFIT CJK—AERIAL AND PRE-SELECTOR STAGES

3.7. RECEIVER OUTFIT CHC

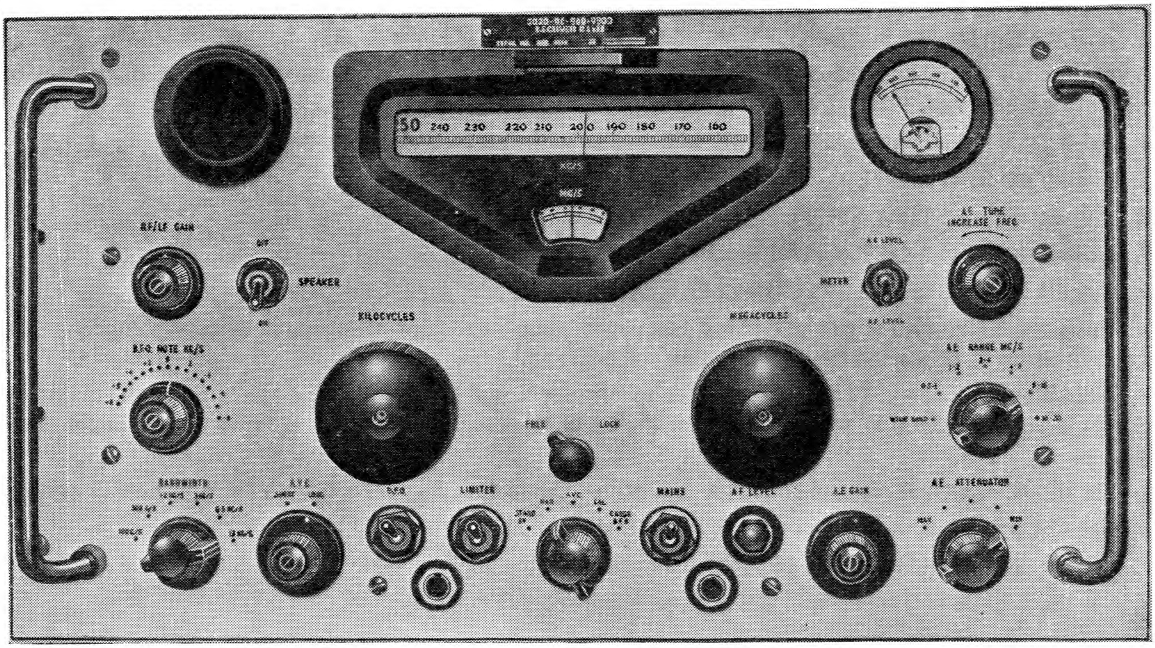


FIG. 1

DATE OF DESIGN	1958
HANDBOOK	BR 1171
E LIST	E 1212
FREQUENCY RANGE	980 kHz to 30 MHz
MAIN INTERMEDIATE FREQUENCY	100 kHz
POWER SUPPLIES	100 – 125V or 200 – 250V 45 – 65 Hz
POWER CONSUMPTION	90W
PLANNED MAINTENANCE SCHEDULE	Daily user check schedule not yet formulated

General

1. Outfit CHC is formed by the receiver Racal RA–17, which is a treble superhet employing the Wadley Loop principle. The final intermediate frequency for amplification is 100 kHz. Tuning is accurate to within 500 Hz. The system can either be cabinet or rack mounted. This receiver is currently replacing the CDW/CDY series of receivers.

2. **Operating Instructions**

a. Set the mains switch to ON.

b. Set the AERIAL RANGE selector switch to the desired frequency band.

c. Set the AERIAL ATTENUATOR switch to MINIMUM.

d. Set the MHz control to the appropriate number of MHz. (An increase of receiver noise will indicate the correct setting).

e. Set the SYSTEM SWITCH to CAL.

f. Set the BANDWIDTH selector to 3 kHz.

g. A.F. GAIN to mid position.

h. Adjust the kHz control to give a zero beat at the 100 kHz frequency nearest to that of the desired operating frequency.

i. Adjust the milled cursor slide setting to coincide with this frequency on the kHz dial.

j. Switch the BFO to ON.

k. Adjust the SYSTEM SWITCH to CHECK BFO.

l. Adjust the BFO NOTE control to indicate zero beat.

m. Adjust the SYSTEM SWITCH to MANUAL.

n. Tune the kHz control to the desired frequency, and on receipt of a signal, critically tune for zero beat, in order to centralise the signal within the passband.

o. Adjust the AERIAL TUNE control for maximum signal (or, in the absence of a signal, maximum noise). For optimum CW reception adjust the BFO to produce an acceptable audio note in the headphones.

p. Set the A.F. GAIN control to MAX and adjust the output signal level with the I.F. GAIN control.

q. For the reception of MCW or DSB VOICE signals switch the BFO to OFF.

r. Set the SYSTEM SWITCH to AVC if required.

s. Set the BANDWIDTH SWITCH for optimum reception.

3. Use and Protection of the Meter

a. With the meter switch in the R.F. level position, the meter reads the signal current. In the A.F. Level position, the A.F. LINE OUTPUT is indicated.

b. In order to prevent damage to the meter, it is advisable to operate controls during tuning as follows:

(1) With the meter switch set to R.F. Level, before switching the system switch from AVC to MAN, ensure that the IF Gain Control is fully anti-clockwise. Gain may thereafter be increased as required.

(2) Similarly, before switching the meter from RF Level to AF Level, ensure that the AF Level control is set to minimum. Gain may then be increased as required.

(3) If traffic permits, the A.F. Level control should be set to minimum before operation of the meter switch, after which the A.F. Level may be advanced to the level required.

4. Additional Information

a. The BFO is arranged to be exactly on the IF Amplifier response when the BFO control is set to zero beat with the calibrator.

b. Aerial Tuning. If maximum sensitivity is not required, the aerial need not be tuned except where strong unwanted signals are present. The presence of very strong signals anywhere within the spectrum may cause cross-modulation unless the aerial is tuned. Under these conditions, care must be taken to avoid tuning the input to the interfering signals instead of the signal required. Familiarity with the tuning controls will obviate this.

c. The Aerial Attenuator Control is intended to enable an operator to reduce the level of all incoming signals. This may be desirable when strong unwanted signals are present that cannot be rejected sufficiently by tuning the aerial, or when the required signal is causing overloading in the early stages of the receiver.

d. Spurious Channel Interference. If high level unwanted signals cause interference with the desired signal, the spurious response may be eliminated by slight resetting of the MHz control without disturbing the desired signal.

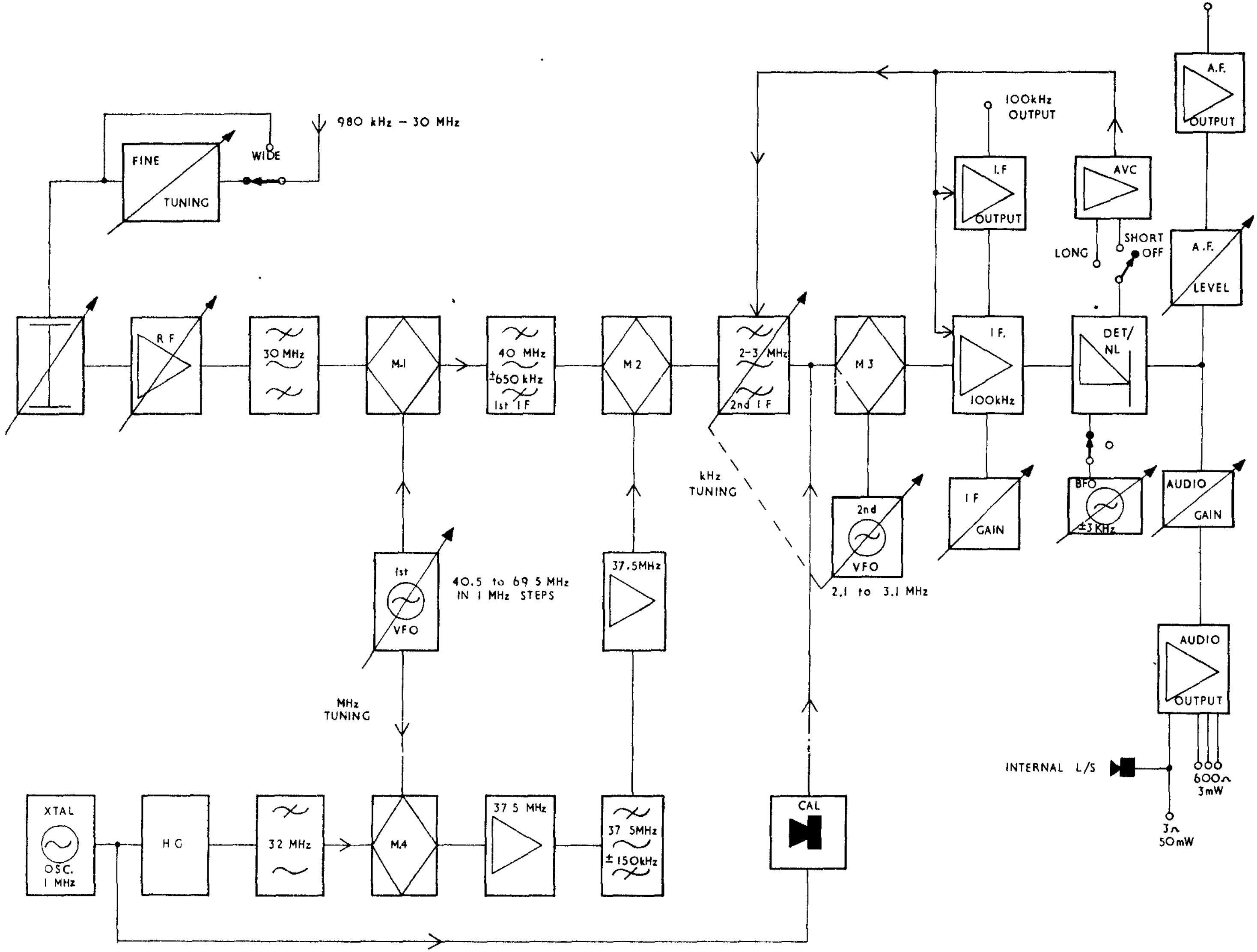


FIG. 2. RECEIVER TYPE RACAL–17(CHC) – BLOCK DIAGRAM

e. The MHz Scale should be checked occasionally to ensure that its setting is central with respect to the crystal controlled band in use. This is indicated by a decrease of signal, or noise, each side of the correct setting.

f. The calibration of the kHz scale may be checked at 100 kHz intervals by turning the system switch to CAL.

g. The overall tuning accuracy of the receiver is better than 500 Hz.

h. Stability. The average receiver, after warm-up time of 1 to 2 hours will remain tuned to within 50 Hz of the selected frequency under conditions of constant supply voltage and ambient temperature.

i. Indicator Lamp on the front panel indicates that the filaments are on.

j. Mains Fuse. One, situated at the rear of the chassis.

3.8. RECEIVER OUTFIT CUH (P. 116)

DATE OF DESIGN. 1953

HANDBOOK. B.R. 2062(1)

ESTABLISHMENT LIST. E. 1033

FREQUENCY RANGE. 277 to 283 Mc/s. 10 preset channels with normal crystallization.
9 preset channels with alternative crystallization.

POWER SUPPLIES. 115 V or 230 V, 50 c/s, a.c.

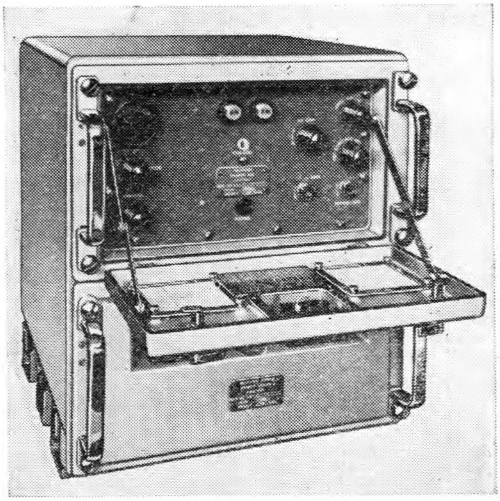


FIG. 1

1. **General.** Receiver outfit CUH is the associated receiver with transmitter outfit 691. It is a double superheterodyne receiver employing a crystal controlled first local oscillator stage controlled by 10 switched crystals when the normal crystallization plan is used and nine switched crystals when on the alternative crystallization plan. Channel 4 is inoperative in the alternative plan. The crystals are contained in small glass holders, in appearance like miniature valves. Each 'valve' holds two crystals except when using the alternative set when one of the holders has only one crystal. Each holder has a letter identity.

2. **Crystallization**

NORMAL			ALTERNATIVE		
CRYSTAL HOLDER IDENTITY	INPUT SIGNAL FREQUENCY	CHANNEL NUMBER	CRYSTAL HOLDER IDENTITY	INPUT SIGNAL FREQUENCY	CHANNEL NUMBER
A	277·8	2	A	277·8	2
	279·4	5		279·4	5
B	281·2	8	B	281·2	8
	282·8	10		282·8	10
C	277·1	1	C.A	277·0	1
	278·3	3		278·4	3
D	278·9	4	D.A	Not used	4 (inoperative)
	280·1	6		280·0	6
E	280·6	7	E.A	280·7	7
	282·1	9		281·9	9

3. **Receiver Cabinet.** The receiver is housed in a metal cabinet with two sliding drawers. The upper drawer contains the receiver and the lower drawer the power unit. The power supply switch and fuses are contained on a cabinet panel separating the upper and lower drawers. A blower fitted in the power drawer provides forced ventilation.

4. **Power Supplies**

The 230 V/115 V a.c. supply is fed from the normal a.c. supply system or when fitted as the Emergency UHF receiver from a.c. supply outfit DWH. The supply is fed through safety switches, which break the a.c. supply when the power or receiver drawers are withdrawn. A pull-out contact on these switches

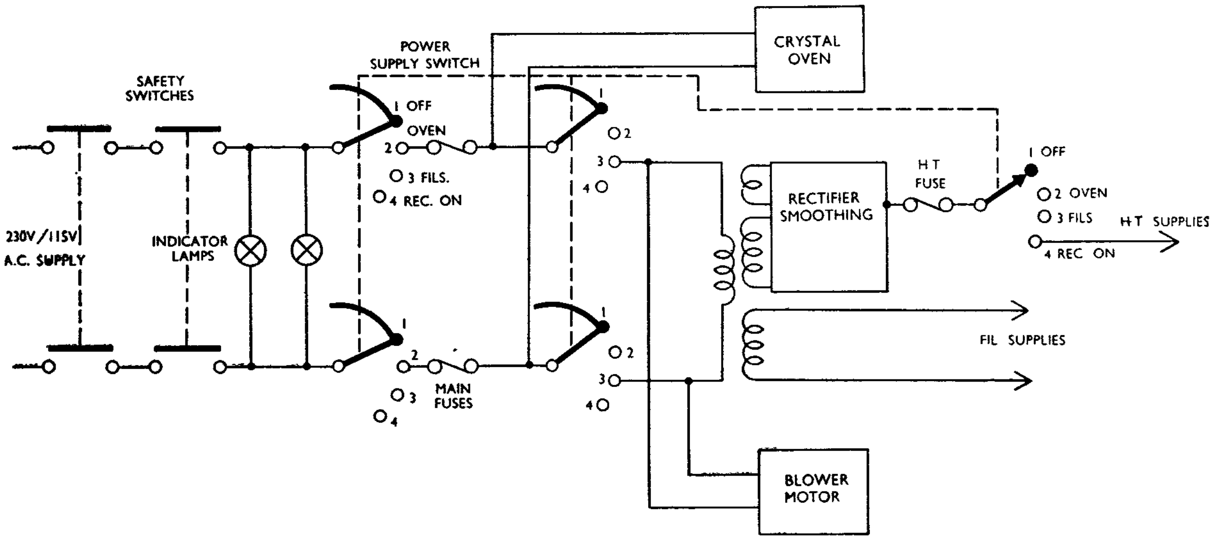


FIG. 2

enables the supply to be restored with the drawers withdrawn to assist maintenance. Two indicator lamps fitted inside the power drawer indicate that power is on to the unit. From the safety switches and lamps the supply is fed to the four-position power switch. The four positions of this switch complete supplies as follows:

Off. All supplies broken.

Oven. 230 V supply is completed through the main fuses to the crystal oven. The crystal oven requires approximately 15 minutes to reach its normal operating temperature.

Fils. 230 V supply is completed to the blower motor for forced ventilation, and to the primary of a transformer. The three secondaries of the transformer supply:

a. The filaments of all valves in the receiver.

b. The filaments and anodes of the rectifier.

H.T. This completes the H.T. from the rectifier and smoothing circuits to all stages in the receiver.

The H.T. supply is separately fused. The change-over from 230 to 115 V a.c. supply is arranged by two links in the power drawer. These connect the primary of the transformer, which is in two parts, in series or in parallel.

5. **R.F. Amplifier.** A single r.f. amplifier stage is employed with a tuned anode circuit, flatly tuned to the mid frequency of 280 Mc/s,but providing adequate response over the frequency band 277 to 283, Mc/s, so that no adjustment is required when changing channels.

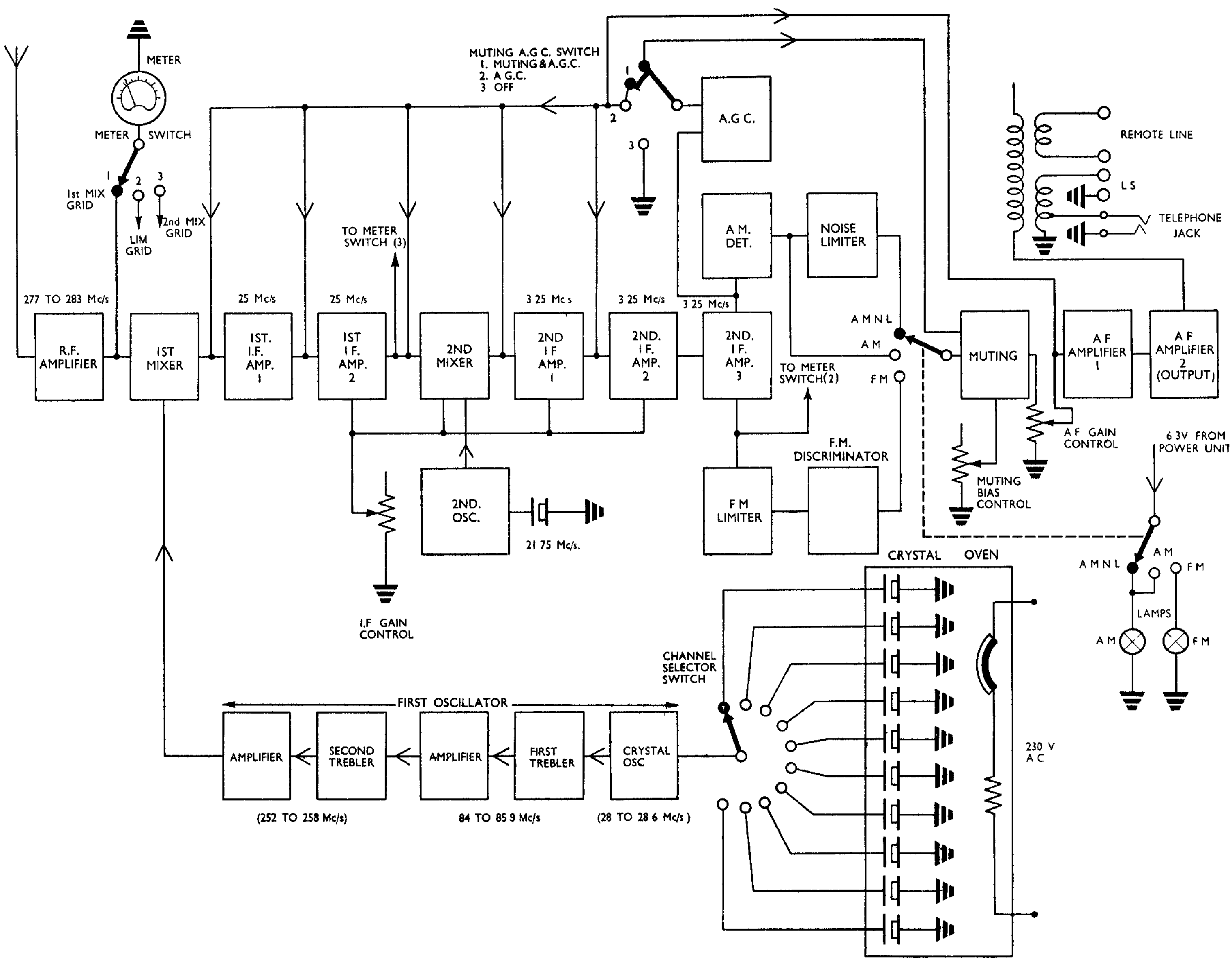


FIG. 3. RECEIVER OUTFIT CUH (P.116)

6. **First Mixer.** The output of the r.f. stage and the output of the first oscillator are fed into the first mixer stage. The tuned anode circuit of the first mixer selects the difference frequency component of 25 Mc/s. For example on channel 1:

Signal Frequency 1st r.f. 277·1 Mc/s.

Frequency Output of first Oscillator. 252·1 Mc/s.

Frequency Output of first Mixer. 25 Mc/s.

7. **First Oscillator Stage.** The frequency output of the first oscillator stage is controlled by one of 10 crystals selected by the channel selector switch and connected between grid and earth of the crystal oscillator valve. The output of the crystal oscillator is fed into the first trebler stage whose anode circuit is tuned to three times the crystal frequency. The first trebler output is fed to an amplifier stage to ensure sufficient drive to a second trebler stage whose anode circuit is tuned to nine times the crystal frequency. The second trebler output is fed through a second amplifier stage to the mixer. The anode circuits of the second trebler and second amplifier are fixed tuned to the mid frequency of the band (Channel 6). It follows that the output of the first oscillator will fall off slightly on other channels, but circuits are so designed that sufficient output is ensured on all channels to provide adequate feed to the mixer.

8. **First i.f. Amplifiers.** Two stages of i.f. amplification at the first i.f. of 25 Mc/s are provided. The total bandwith of these stages is fixed at approximately 450 kc/s. Manual and automatic gain are provided on these two stages.

9. **Second Mixer.** The outputs of the first I.F. amplifier and the second oscillator are fed to the second mixer stage, whose output circuit selects the difference frequency component of 3·25 Mc/s. For example:

Output of first i.f. Amplifiers. 25 Mc/s.

Output of second Oscillator. 21·75 Mc/s.

Frequency output of second Mixer. 3·25 Mc/s.

10. **Second Oscillator.** Consists of a single valve crystal controlled oscillator employing a crystal of 21· 75 Mc/s.

11. **Second i.f. Amplifiers.** Three stages of amplification at the second i.f. of 3·25 Mc/s with a total bandwidth of approximately 90 kc/s. Manual and automatic gain are provided on the first two stages only. The output of the second I.F. amplifiers is fed to the A.M. detector for amplitude modulated signals and to the F.M. limiter for frequency modulated signals.

12. **A.M. Detector.** One half of a double diode is used as a conventional detector, the other diode being used for a.g.c. The feed to the muting and a.f. stages is via the noise limiter, with the system switch in the A.M.N.L. position, or direct to the muting stage when the system switch is in the A.M. position. The output from the A.M. detector is broken when the receiver is switched to the F.M. position.

13. **Noise Limiter.** The noise limiter, which is switched in when the system switch is in the A.M.N.L. position, is used to prevent bursts of noise from electrical storms, radar and other pulse transmissions being passed on to the a.f. stages.

14. **A.G.C.** Automatic gain control is effective in positions one and two of the Muting and A.G.C. switch. The a.g.c. is applied to the two first i.f. amplifier stages, the second mixer and the first two stages only of the second i.f. amplifier. Reduced a.g.c. is applied to the first a.f. amplifier. In position three of the switch the output of the a.g.c. diode is earthed.

15. **Muting.** Muting is provided to silence the receiver when no signal is being received and to open up the receiver as soon as a signal is received. A screwdriver muting bias control is provided to determine

the strength of signal required to open up the receiver. Once set up in accordance with the instructions contained in the handbook it should not normally be touched. If very weak signals are expected, the muting should be switched off. The output of the a.g.c. stage is used to operate the muting, so it can only be used with a.g.c.

16. **F.M. Limiter and Discriminator.** The output of the second i.f. amplifiers is fed to the F.M. limiter stage and with the system switch in the F.M. position the output of the F.M. discriminator is fed to the a.f. stages. The action of the F.M. discriminator is to transform frequency variations into a.f. voltage variations for passing on to the a.f. stages.

17. **A.F. Stages.** The input to the first a.f. stage is controlled by the a.f. Gain control. Three outputs are are provided from the a.f. output stage.

a. A 2-watt output for feeding a single loudspeaker.

b. A local monitoring phone jack tapped off the L.S. winding.

c. A separate winding giving approximately 10 mW output to remote reception lines.

18. **Controls**

POWER SUPPLY SWITCH. A four-position switch.

Off. Power broken.

Oven. Completes 230 V a.c. to crystal oven.

Fils. Completes filament supplies and supply to blower motor.

H.T. Completes H.T. supplies.

SYSTEM SWITCH. A three-position switch.

A.M.N.L. For amplitude modulated signals. Noise limiter in.

A.M. For amplitude modulated signals. Noise limiter out.

F.M. For frequency modulated signals.

MUTING AND A.G.C. SWITCH. A three-position switch.

Muting and a.g.c. Normal position for use with UHF Ratt. Muting and a.g.c. on.

A.G.C. Normal position for use with voice. No muting.

Off. Used only for testing.

CHANNEL SELECTOR SWITCH. A 10-position switch. Selects the crystal for the first oscillator, thereby selecting the channel of reception.

METER SWITCH. A three-position switch for testing.

a. Reads grid current of first mixer.

b. Reads grid current of F.M. limiter.

c. Reads grid current of second mixer.

I.F. GAIN CONTROL. Controls the gain of the i.f. stages. Should normally be operated in the maximum gain position.

A.F. GAIN CONTROL. Controls the level of input to the first a.f. stage. Should be adjusted to give the desired level in the headphones.

MUTING BIAS CONTROL. Set up in accordance with instructions contained in the handbook and should not be touched by the operator. If considered unsatisfactory it should be switched off, and eventually reset by the electrical department.

PHONE JACK. For monitor headphones.

INDICATORS.

A.M./F.M. Indicator Lamps. Operated by the system switch, and indicates whether receiver is set for reception of A.M. or F.M. signals.

Channel Indicator. Operated by the power switch and channel selector switch and illuminates the number of the channel in use.

3.9. RECEIVER OUTFIT CUJ

DATE OF DESIGN. 1955

HANDBOOK. B.R. 1492B

ESTABLISHMENT LIST. E. 1157

FREQUENCY RANGE. 225–399·9 Mc/s

POWER SUPPLIES. 230 V or 115 V a.c.
45–65 c/s

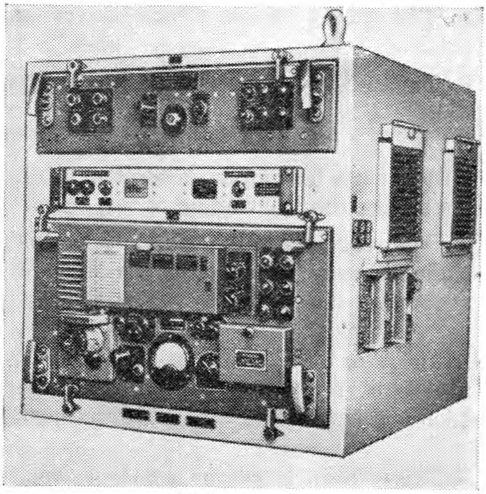


FIG. 1

GENERAL

1. A double-superheterodyne receiver which can be pre-set to 10 frequencies of the 1750 available.

DESCRIPTION

The receiver consists basically of three units:

a. r.f. amplifying unit. *b.* i.f. amplifying unit. *c.* a.f. amplifying unit.

2. Associated with these units are four others which contain the arrangements for frequency selection and tuning. These are:

a. Radio Drive Unit. *b.* Oscillator Unit. *c.* Mixer Unit. *d.* Comparator Unit.

3. **R.F. Amplifying Unit.** This consists of three stages, of which the first two amplify the signal input. The third is a mixer with an output at the first i.f. which is 24 Mc/s. The tuning circuits for all three are ganged to the selector unit on the front panel.

4. **I.F. Amplifying Unit.** The output of the r.f. Unit is passed through one stage of i.f. amplification and thence to a second local oscillator which operates 22·025 Mc/s. The result is the second i.f. of 1·975 Mc/s which undergoes three further successive stages of amplification. The final stage has two outputs:

a. Taken through a cathode follower stage for use in direction finding equipment.

b. Passed through detector, noise limiter, and audio cathode follower stages to the a.f. amplifying unit.

5. All i.f. stages (except cathode follower) are controlled by an a.g.c. voltage derived from the detector and applied via an A.G.C. amplifier and gate circuit.

6. **A.F. Amplifying Unit.** Two stages of amplification and two outputs, one for monitor purposes and one to line. A muting circuit is incorporated, which is operated by the A.G.C. amplifier stage, and which conducts only when no signal is being received, in such a way as to cut out noise in headphones.

7. **Frequency Selection.** The frequency selection arrangements are essentially the same as those in the Type 692 transmitter, with the difference that the various selective processes control not a Master Oscillator but the local oscillator in the Radio Drive Unit, or 'First Local Oscillator'.

8. **Radio Drive Unit.** This contains:

a. The first local oscillator, which operates over any one of nine ranges, as selected.

b. The tuning motor, which 'drives' the oscillator over the range until the correct tuning point is reached.

c. The doubler, which doubles the oscillator output and passes to the r.f. mixer a signal at the frequency $\frac{\text{f sig} \pm 24}{3}$. The sign is +ve for r.f. inputs of between 296 Mc/s and 343·9 Mc/s for reasons connected with certain harmonics generated in the unit, and is —ve for all other frequencies. In fact the mixer selects the third harmonic of this signal to provide the correct first i.f. which is 24 Mc/s.

d. The reactance valve, which, once the correct tuning point has been reached, assumes control of the tuning motor. Thereafter it maintains a watching brief and operates the motor, in forward or reverse, at the first sign of a drift of frequency.

9. **Oscillator Unit.** Contains the 'hundreds' oscillator. Its control is ganged to the oscillator in the Radio Drive Unit (see 8 *a* above), but in this case it is the appropriate crystal, and not a range of frequencies, which is selected. One stage of amplification is provided.

10. **Mixer Unit.** Contains the three mixer units, with their associated filters, and two further oscillators, the 'tens' and the 'units,' which are used, as in the transmitter, to produce the correct difference frequency to pass to the reference circuit in the comparator unit.

11. **Comparator Unit.**

Its functions are:

a. To complete the process of frequency selection by 'comparing' the output from the final filter with that of the reference crystal oscillator, and to turn over control of the tuning motor to the reactance valve in the drive unit as soon as the correct tuning point has been reached.

b. To provide warning to the reactance valve of any subsequent imperfect balance between these outputs, signifying a drift off frequency, so that the reactance valve can correct it.

The unit contains two amplification stages and two filters. As the oscillators in the drive unit approach the correct frequency and the various selective processes begin to pass the correct signals, their amplitude increases and at a certain point the second of these filters (E) allows an escape through a rectifier to operate a d.c. relay which changes the tuning motor speed to 'slow.'

The comparator outputs are the same as for the Transmitter Type 692 (see Transmitter Section) and operate in precisely the same way.

12. **Resonators.** See under 'Type 692' in Section 2.

13. **Methods of Operation.** See under 'Type 692' in Section 2.

14. **Tuning**

a. Switch on 'Mains.' Blowers start – amber lamp lights.
Mains receiver light – amber lamp lights.

b. Switch on Control drawer mains. 230 V to Control drawer – amber lamp lights.
24 V supplies – amber lamp lights.

c. Switch on Receiver mains. L.T. supplies – blue lamp lights.

d. Set up receiver as for Transmitter Type 692. Note that the Code is different.

e. Switch H.T. on. Thermal delay in relay circuit operates. Red lamp lights. After 10–15 seconds, green lamp lights.

f. Switch OFF–AGC–DF switch to OFF.

g. Switch MUTING switch to OFF.

h. Turn r.f. GAIN control fully clockwise.

i. Set METER switch to position 2. The meter now shows Detector Anode current.

j. Tune for a maximum using fine control of r.f. stage tuning dial, starting from setting indicated on the metal plate alongside. If full scale deflection occurs, reduce r.f. gain. Note peak reading.

k. Switch to next channel and then return to the one being tuned. The peak reading should be the same as before. If it is not, retune and repeat.

l. Switch OFF–AGC–DF switch to AGC.

m. Switch MUTING switch to ON. The receiver is now ready for local operation.

n. Turn r.f. GAIN control fully clockwise, then reduce gain until noise cuts off. (Muting circuit now operating.)

o. Turn LINE GAIN control to half way.

15. **Tuning Resonators**

Hand-Tuned System.

p. Set OFF–AGC–DF switch to OFF. Set LINE GAIN control fully clockwise. Set METER switch to position 2. Adjust r.f. gain to obtain meter reading between 50 and 70.

q. From the resonator tuning card, take the approximate numerical setting for the selected frequency, and set it in the window alongside the tuning handle. Ensure that all other resonators in the system are set at more than 45 digits from one being tuned.

r. Set the RESONATOR MONITORING PROBE switch to required resonator.

s. Operate DEPRESS TO TUNE switch, readjust resonator tuning to obtain maximum resonator meter reading. It is important to reach maximum reading while *turning the handle clockwise*. Release DEPRESS TO TUNE switch and switch probe switch to OFF.

In an AUTO-TUNED System.

Proceed as far as *p* above. Then:

t. Ensure that the channel indicator dial on resonator agrees with that of channel selector switch on receiver, and obtain, from the tuning calibration card for resonator, the approximate dial reading for selected frequency. Set dial to reading given. If receiver is being used with C.A.W. system, ensure that all other resonators in system are set at more than 6 divisions on main scale from their being set.

u. Set RESONATOR MONITORING PROBE switch to position corresponding to resonator being tuned. Insert vernier drive knob into guide hole. Operate appropriate DEPRESS TO TUNE switch and readjust resonator tuning to obtain maximum reading in the meter.

v. Having obtained the maximum reading, turn the vernier drive knob anti-clockwise about 5 divisions and then retune in a clockwise direction from maximum reading. Release DEPRESS TO TUNE switch, lock thumb screw and remove vernier drive knob.

w. Set RESONATOR MONITORING PROBE switch to OFF.

COMMON AERIAL WORKING and METHODS OF OPERATION

See particulars of Transmitter Type 692.

16. **Using the Receiver**

Relay Unit Design 90 not fitted.

a. Switch to AGC. r.f. GAIN control should be set fully clockwise. LINE GAIN control should be set half way between maximum and minimum. Switch to REMOTE.

b. To change to another channel, switch to OP and set channel switch to the required channel number. When green CHANNEL READY lamp comes on, tune resonator to new frequency (see para. 15*q*). When resonator has been tuned switch to REMOTE.

> *Note. At the Remote Operating Position the Ready Lamp will light when both transmitter and receiver are set up on a channel. For this lamp to light the transmitter and receiver* need not *be on the same channel.*

Relay Unit Design 90 *fitted.*

c. Adjust receiver controls as in para. *a.*

d. To change to another channel switch from REMOTE TO OP. Set channel selector switch to required channel. When automatic tuning is completed, green CHANNEL READY lamp will light and, when the resonator has set up on the new channel the green TUNED lamp on control drawer will light. Operate. PRESS TO TUNE TRANSMITTER switch on control drawer: transmitter and its resonator will then change to same channel as receiver. Switch to REMOTE after 15 seconds.

Remote Channel Selection (*R.C.S.*) *Unit fitted.*

e. Receiver controls should be adjusted as in para. *a.*

f. To prevent two or more receivers being switched to the same frequency when a C.A.W. system is in use, an interlock is provided. The interlock operates only on channels 3 to 7 and common frequencies should always be set up on these channels.

g. To change to another channel, set channel selector switch of R.C.S. Unit to new channel and press RETUNE button. When tuning of receiver and its resonator is completed the green RX READY FOR RETUNE lamp will light. Similarly, when transmitter and its resonator are tuned the green TX READY FOR RETUNE lamp will light. When receiver, transmitter and resonators are set up on the same channel, the green CHANNEL READY lamp will light. The system is then ready for operation on new channel.

h. If receiver, transmitter and resonators do not set up on same channel, amber RETUNE light will burn. Operate RETUNE button again. Persistent failure to line-up indicates a fault.

i. If, when the receiver is being used with a C.A.W. system, the frequency selected is already in use on another equipment, the amber RETUNE lamp will flash four times. After tuning is completed the RETUNE lamp will remain alight indicating this frequency is already in use. Under these conditions the receiver is rendered inoperative by automatic tuning of the resonator to beyond the frequency range of the equipment.

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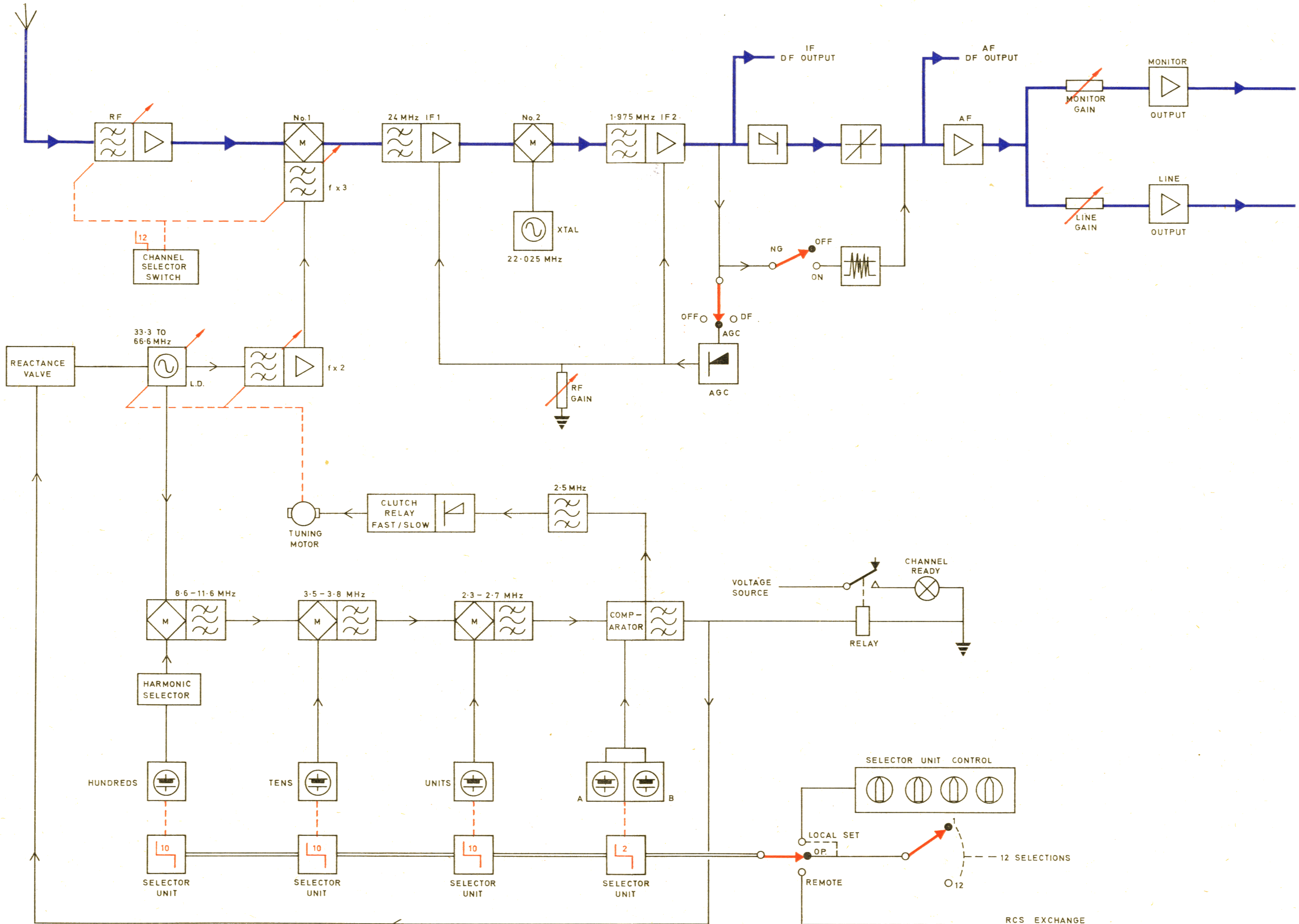

FIG. 2. RECEIVER OUTFIT CUJ
BLOCK DIAGRAM

3.10. RECEIVER OUTFIT QR

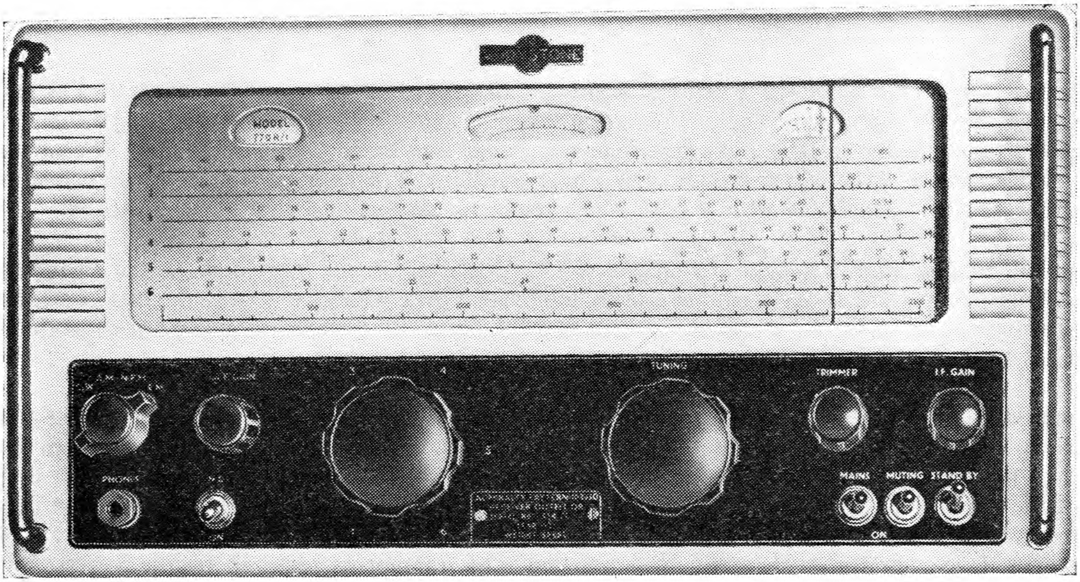

FIG. 1

DATE OF DESIGN. 1956

HANDBOOK. B.R. 1147

ESTABLISHMENT LIST. E. 1205

FREQUENCY RANGE. 19 Mc/s to 165 Mc/s (in 6 bands)

POWER SUPPLIES. 110 V, 200 V or 230 V 40 to 60 c/s

POWER CONSUMPTION. 90 VA

ASSOCIATED AERIALS. ACH APH

PURPOSE. For reception of V.H.F. A.M. and F.M. signals.
PLANNED MAINTENANCE SCHEDULE – R·17/5

GENERAL

1. The receiver outfit QR is the Eddystone receiver model 770R and is fitted in ships as a part of the 'Standard Search Bay'; the QR can also be found fitted in shore stations.

The receiver is a conventional superheterodyne consisting of the following basic units.

1 r.f. Stage. 4 i.f. Stages. 3 a.f. Stages.

Type of reception C.W. and A.M. Voice.
F.M. and N.F.M. Voice.

DESCRIPTION

2. **Aerial Circuit.** The receiver is designed for use with a dipole aerial feeding through a 72 or 75 ohm coaxial cable to a socket at the rear chassis. Filter Unit design 18 could be employed as required. (Details of which can be found in Handbook.)

3. **The R.F. Unit.** One r.f. Stage which is a pentode and ganged to the Local Oscillator and Mixer, the three stages have a Stabilized Supply. Frequency range selection is by means of switched L and C in 6 bands and tuning is by variable capacitance in r.f., Mixer and Local Oscillator Stages. The i.f. of 5·2 Mc/s is selected from the Mixer Anode. The Local Oscillator Tracks 5·2 Mc/s above the signal input frequency. The r.f. valve is fed with A.G.C. The signal now passes to the first i.f. transformer.

4. **The I.F. Stages.** Four conventional stages of i.f. Amplification are provided. Tertiary windings in the i.f. transformers are brought into circuit by the System Switch to give various degrees of selectivity. Gain compensating resistors, i.f. Gain Control and the Stand By Switch are incorporated in this unit. A.G.C. is applied to the first three i.f. stages.

5. **Bandwidth.** The bandwidth of the receiver is determined in the i.f. Stages by means of the SYSTEM Switch; by adding L and R in the anode tuned circuits, the bandwidth of F.M. is increased from 15 kc/s (N.F.M.) to 75 kc/s (F.M.). The i.f. gain of the receiver is effected by means of controlling the cathode bias of i.f. 1 and i.f. 2, thus the overall gain of the receiver. This control (the i.f. GAIN) should be used at almost maximum to allow good signal control with the a.f. gain. The output from i.f.4 is fed either to the crystal detector for A.M. and C.W. or to the F.M. Limiter as required by the SYSTEM Switch. In the F.M. position anode load is added to i.f.4 and output fed to the F.M. Limiter Grid. The SYSTEM Switch also decides where the a.f. input is taken from – either detector anode or discriminator cathode.

6. **Controls**

MAINS ON–OFF SWITCH. Completes the supply to the receiver. The dial lamps should light immediately this switch is made, otherwise suspect failure of mains fuses.

SYSTEM SWITCH. A four-position switch marked C.W., A.M., N.F.M. and F.M. which controls the type of transmission acceptable.

Circuit arrangements for each mode are as follows.

C.W. TELEGRAPHY. B.F.O. on, i.f. selectivity adjusted to narrow, crystal diode for A.M. detection brought into circuit, F.M. circuits inoperative.

A.M. TELEPHONY. As for C.W. Telegraphy but B.F.O. is inoperative. The tuning meter functions as a 'S' meter (reading black characters) and a signal should be tuned for maximum deflection.

NARROW-BAND F.M. TELEPHONY. Selectivity of i.f. circuits adjusted to ±15 kc/s, A.M. detector inoperative, discriminator circuits operative, tuning meter indicates F.M. on-tune position (red mark).

WIDE-BAND F.M. TELEPHONY. Gain and bandwidth of i.f. circuits adjusted for a deviation of ±75 kc/s, otherwise as for N.F.M.

WAVE-CHANGE SWITCH. Marked 1–6, representing the six ranges of the receiver. A positive lock ensures that the turret contacts are in the correct position and movement of the know automatically disenagges the locking mechanism.

TUNING CONTROL. Six scales are marked directly in frequency to an accuracy within 1 per cent on Ranges 1 and 2 and within one-half of 1 per cent on the other ranges. The logging scale is supplemented by a vernier dial which effectively expands the scale length to 32 ft.

For A.M. signals, tune to one maximum deflection and then in the other. The centre position between the two peaks and with the pointer coincident with the red mark is the correct tuning point.

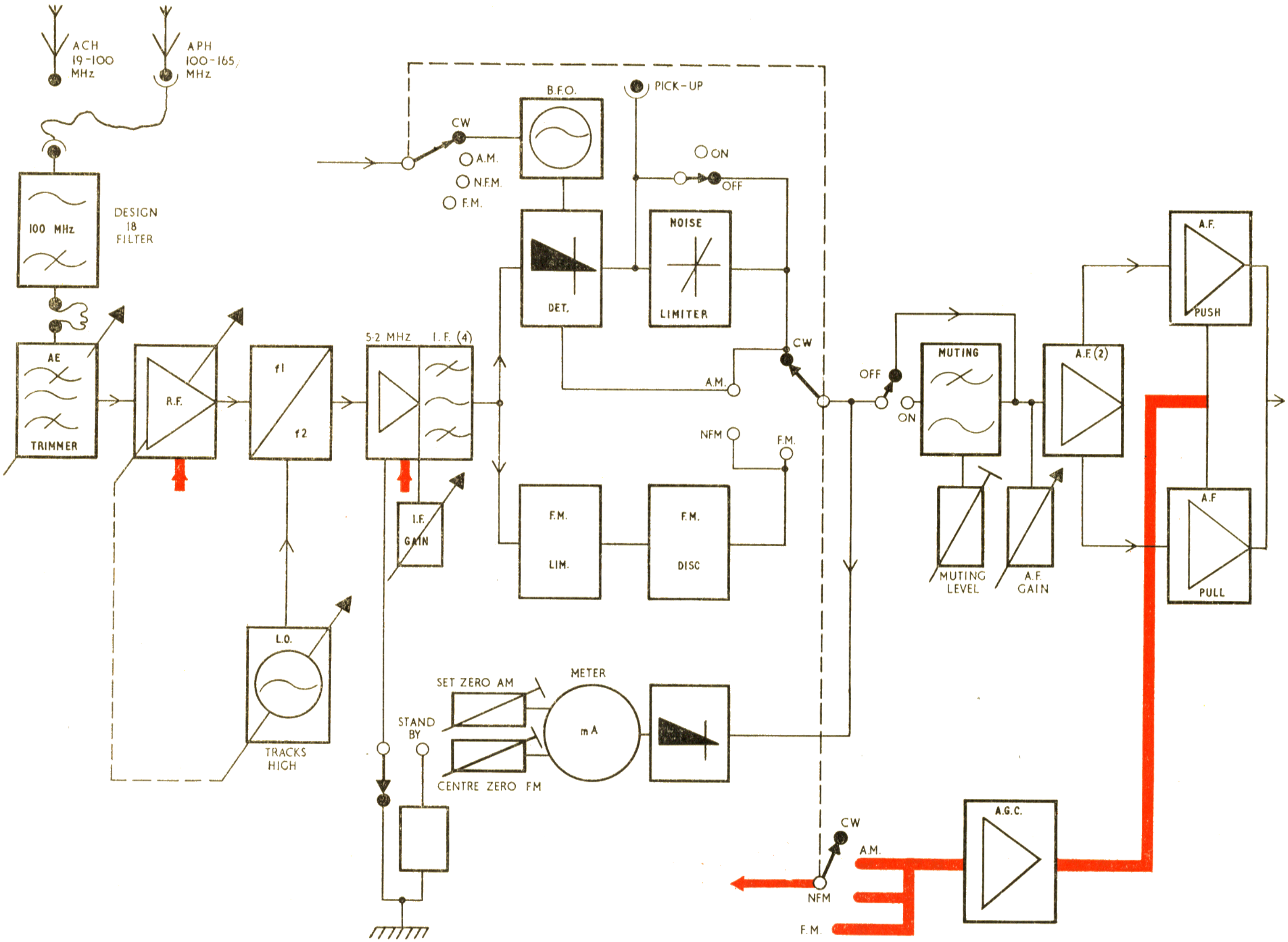

FIG. 2. OUTFIT QR – BLOCK DIAGRAM

TRIMMER. Permits correction to be made for variations in aerial and feeder reactance. Only minor adjustment normally required to achieve correct tuning point of signal.

I.F. GAIN. Adjusts gain of i.f. stages. Normally this control should be kept well advanced, except on strong c.w. signals.

A.F. GAIN. Adjusts gain of a.f. stages in the usual way.

N.L. SWITCH. The noise limiter is effective against transient interference which may be experienced when the receiver is set to C.W. or A.M.

MUTING SWITCH. With the switch in the OFF (UP) position the receiver performs normally. When the switch is set to ON, the receiver is silent until a signal is received of sufficient strength to overcome the bias delay. The delay is adjustable for signals of 5 microvolts or greater.

STANDBY SWITCH. When the switch is set to STANDBY (UP) the receiver is desensitized. Normally, this switch will be left in the down position.

PHONES (JACK SOCKET). Permits connection of high resistance headphones. Details of the facilities provided on the Rear Chassis (Fuses, etc.) can be found in the Handbook.

7. **Position of Controls for Intercept Search**

All signals are to be tuned in with the System Switch in the A.M. position (Muting Switch OFF), for maximum in the meter. Then the trimmer is to be rotated for a further maximum to ensure aerial feed to the r.f. amplifier.

If the signal is pulsed, these controls are not to be altered.

If the signal is modulated the System Switch should then be placed to F.M. If the signal is in fact A.M. no signal will be received, and the operator must now go back to A.M. and the muting switch can be used if desired. If the signal is still received in F.M. position of the System Switch, then it is F.M. and must be tuned to centre zero and muting switch used as desired.

8. Daily User Check. (In accordance with P.M.S. R17/5).

a. Check reception of both AM and FM signals via both aerials.

b. Check correct metering of AM and FM signals.

c. Check the muting and Standby functions.

d. Check arrival of audio signals at the audio exchange.

3.11. RECEIVER OUTFIT QS(1)

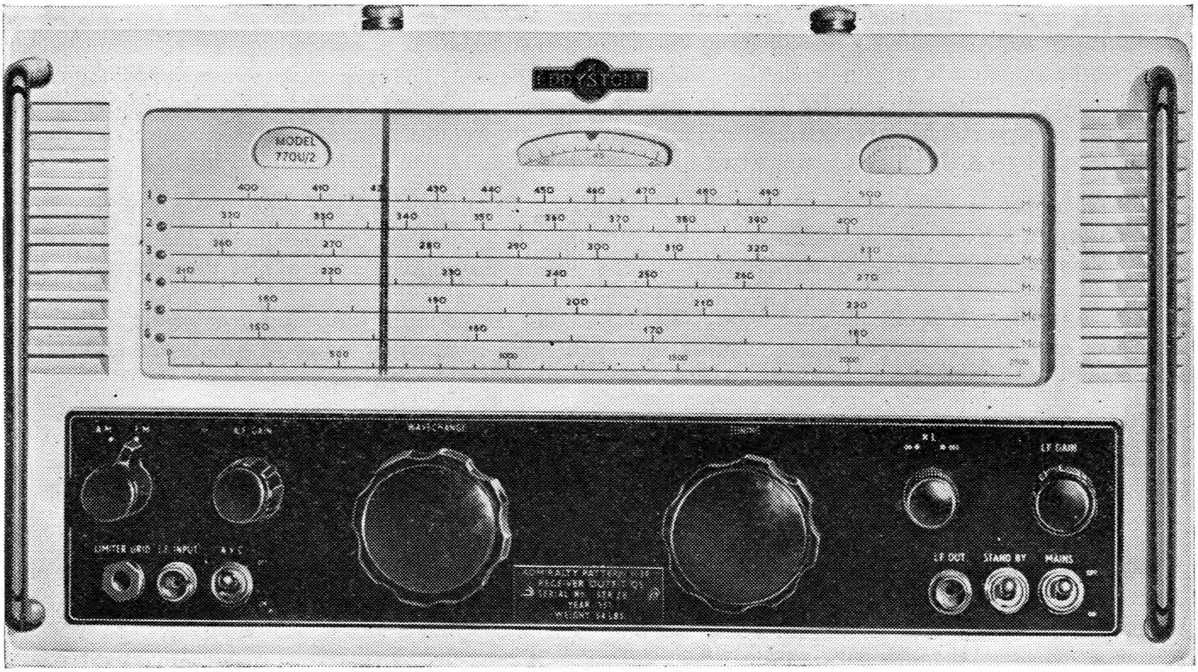

FIG. 1

DATE OF DESIGN. 1956

HANDBOOK. B.R. 1153

ESTABLISHMENT LIST. E. 1205

FREQUENCY RANGE. 150 Mc/s to 500 Mc/s. (In six bands.)

POWER SUPPLIES. 100 V to 125 V to 250 V 40 to 60 cycles
(Selected by transformer tapping, see handbook.)

POWER CONSUMPTION. 90 VA

ASSOCIATED AERIALS. AQA – for use 150 to 210 Mc/s (Broadband bi-conical dipole)
AJE – for use 210 to 500 Mc/s (Broadband end fed full wave dipole)

PURPOSE. Reception of UHF A.M. and F.M. signals.

PLANNED MAINTENANCE SCHEDULE – R.18/3 Ch

GENERAL

1. The receiver outfit 'QS' is the Eddystone receiver model 770U. This receiver is part of the Standard search bay and can be fitted either in ships or on shore establishments. It is conventional double superheterodyne, comprising the following basic units:

a. 1 r.f. stage. *b.* 3 i.f. stages. *c.* 2 a.f. stages.

DESCRIPTION

2. **Aerial.** Two aerial outfits are allocated for use with this receiver. They are:

Outfit AQA, for frequencies up to 210 Mc/s, and outfit AJE for frequencies between 210 and 500 Mc/s. Aerial outfit AQA employs a Broad Band biconical array, which is connected via an r.f. transformer unit (whose function is to unbalance the balanced output given by the type of aerial employed, to match the unbalanced input required for this receiver) to the office bulkhead, where a filter unit (design 18, a high pass filter at 100 Mc/s) is fitted. When this facility is not required, the aerial can be connected direct to the receiver by a through adaptor fitted to a filter unit case.

The AJE, which is a Broad Band End fed full wave dipole, is fed into the office via a junction box, terminating in a fixed socket, which is in close proximity to the socket termination of the aerial system AQA. This facilitates the aerial change-over necessary for the frequency coverage of the receiver.

3. **R.F. Amplifier.** A grounded grid triode. The advantage of having a grounded grid triode is that the grid acts as a screen and reduces the noise level which exists in other types of amplifiers at V/UHF frequencies.

4. **Crystal Mixer.** A germanium diode, is fed by the r.f. Amplifier and the Local Oscillator, operating in the fundamental mode over the whole frequency coverage of the receiver, and is gang-tuned along with the r.f. and Mixer tuned circuits. The 1st i.f. of 50 Mc/s is extracted by transformer coupled tuned circuits, and fed to the input of a 50 Mc/s Cascade Amplifier.

5. **50 Mc/s Cascode Amplifier.** This operates on a low impedance and gives a high impedance output. The advantage of employing a Cascode Amplifier at this stage is to overcome the damping of r.f. which would otherwise occur. This amplifier also operates with a low noise factor, which enables the receiver to give good signal to noise ratio in operation. A facility is provided at this stage by employing a tertiary winding on the transformer coupled grid input to this stage, for an input at 50 Mc/s to be injected into the Cascode Amplifier at 75 ohms, for use by an auxiliary r.f. unit. The Cascode Amplifier output is then fed to a normal 50 Mc/s i.f. Amplifier.

6. **50 Mc/s i.f. Amplifier.** A Pentode. The i.f. gain of the receiver is effected on this Amplifier, in the form of cathode bias variation. A much reduced voltage from the H.T. line is taken from a resistor and fed to the cathode of this stage. This voltage feed line also contains an additional resistor, which when switched into circuit by the Stand By switch raises the cathode voltage sufficiently high to stop this stage conducting and thus desensitizes the receiver. The output of this stage is then fed to a mixer to reduce the 50 Mc/s i.f. to one of 5.2. Mc/s.

7. **Mixer.** A Double Triode. Has a fixed oscillator at 55·2 Mc/s in one grid circuit, which supplies the grid circuit of the mixer half of the triode via coupling capacitor. The signal is supplied at 50 Mc/s by a coupler, the difference of 5·2 Mc/s is extracted at the anode of mixer triode by transformer coupled tuned circuits and fed to the 2nd i.f. amplifier stages in the conventional manner.

8. **2nd I.F. Stages.** Two stages of i.f. amplification at 5·2 Mc/s are employed. The output of the 2nd i.f. stage is fed to a 5·2 Mc/s cathode follower circuit, the crystal diode demodulator, and to the F.M. Limiter input circuit.

9. **Cathode Follower Circuit.** This circuit functions to give an i.f. output at 5·2 Mc/s for viewing purposes on an oscilloscope. The cathode follower is employed to obtain a high impedance input, giving a low impedance output. This output is brought via a d.c. blocking capacitor to a jack socket at the front panel of the receiver.

10. **F.M. Limiter and Discriminator.** The i.f. output of 5·2 Mc/s is fed to the F.M. Limiter via a capacitor. The limiter stage ensures a constant amplitude level output which is essential to feed the F.M. Discriminator. For correct function of the stage, the limiter works as follows: Initially, there is a zero bias in

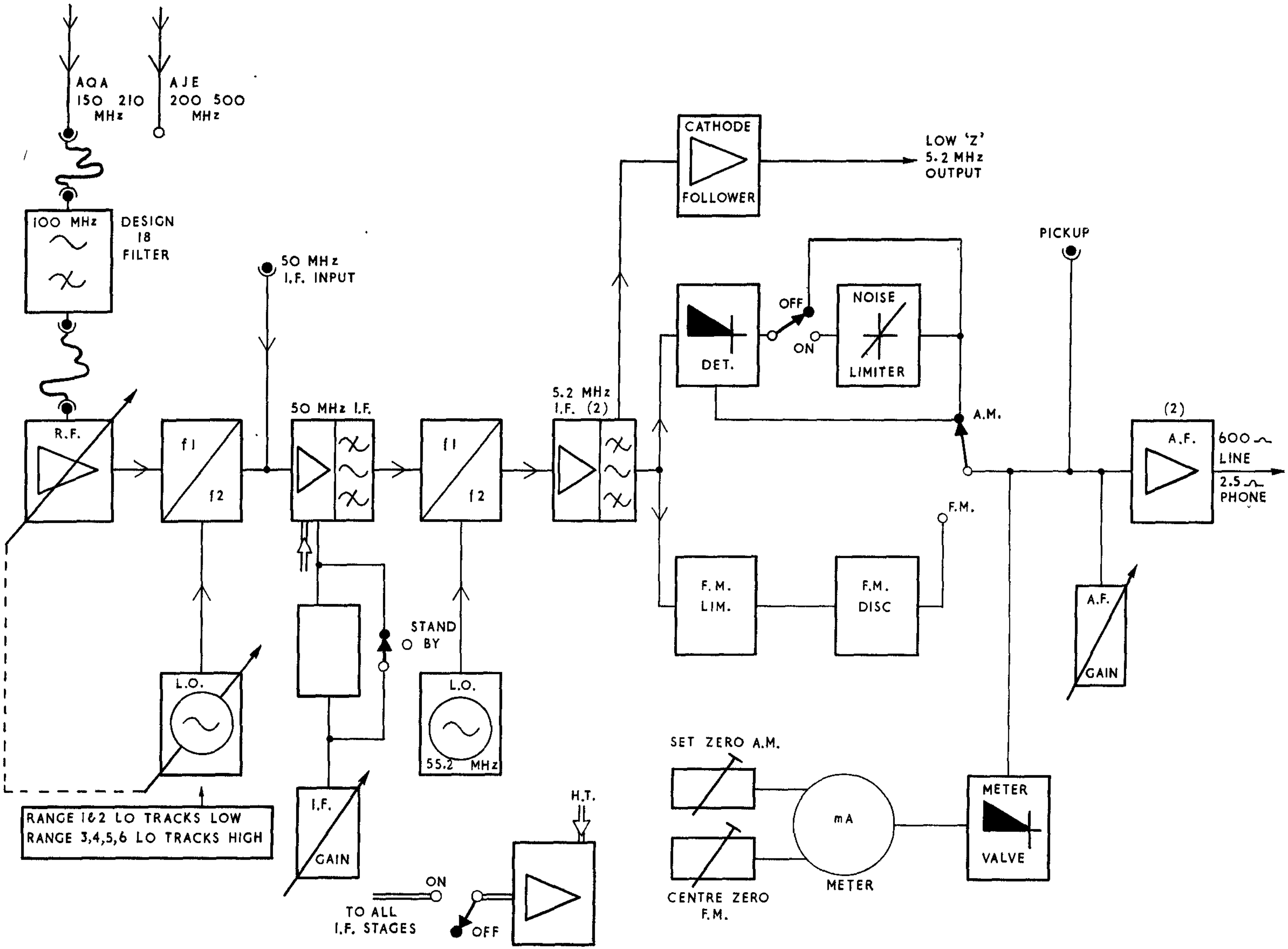

FIG. 2. OUTFIT QS – BLOCK DIAGRAM

the limiter valve, but the first few cycles of a signal input cause grid current to flow and charge the right plate of the capacitor, to a negative potential, which since the signal input at this stage is large, is sufficient to drive the valve to class "C" operation. The time constant of the resistor and capacitor is long compared to the oscillator period at 5.2 MHz and thus maintains a steady bias condition.

The anode and screen voltages are low so that saturation of the valve occurs on the positive half cycles of the operation, thus effectively limiting the maximum output and maintaining a constant level output, with which to supply the discriminator input. The discriminator is the normal Foster-Seely type and the output feeds to the F.M. contact on the AM/FM switch. The discriminator gives narrow band F.M. Operation at 15 kHz deviation.

11. **Tuning Meter.** This is connected to the cathode circuit of the meter control valve. When the mode switch is set to A.M. the correct tuning point is maximum deflection clockwise in the meter. In F.M. the meter acts as an "S" meter. The meter circuit is basically similar to that when in A.M. but the centre F.M. now follows the discriminator output, the correct tuning point now being zero F.M.

12. **Audio Stage.** A double triode and a pentode output valve. The 1st a.f. Amplifier is now a two stage double triode which drives the pentode output. The a.f. gain control is in the grid circuit of the a.f. Amplifier valve.

13. **Power Supplies.** The mains transformer has primary tappings to permit operation from 100/125V or 200/250V 40–60 Hz supplies. The total consumption being approximately 90 VA. A conventional H.T. rectifier and smoothing circuit is used and a 150V stabilized supply is provided by the voltage stabilizer, for the r.f. Amplifier L.O., 50 MHz i.f. Amplifier and F.C. Supplies to the r.f. Compartment enter by way of feed through capacitors and r.f. Chokes.

14. **Controls**

MODE SWITCH. A two position switch marked A.M. and F.M. which controls the type of transmission acceptable.

WAVE CHANGE SWITCH. This has six positions for selecting the desired range. An indicator lamp lights up opposite the selected range scale.

TUNING CONTROL. Six scales are marked directly in frequency to an accuracy within 0.2 per cent on all ranges. The logging scale is supplemented by a vernier dial which effectively expands the scale length to 32 feet.

N.L. SWITCH. The noise limiter switch is effective against transient interference which may be experienced when receiving A.M. signals.

STANDBY SWITCH. This switch reduces the sensitivity of the receiver. Normally this switch is left inoperative.

A.V.C. SWITCH. When on, applies delayed A.V.C. to the i.f. Amplifiers and F.C.

A.F. GAIN. Adjusts gain of a.f. stages.

I.F. INPUT SOCKET. Enables an external 50 MHz signal to be fed into the receiver at an impedance of 75 ohms.

I.F. OUTPUT SOCKET. Provides an i.f. output at 5.2 MHz which permits a signal to be displayed on an oscilloscope.

LIMITER GRID SOCKET. A Milliameter connected in the limiter grid circuit can be used in the alignment of the i.f. circuits.

PHONES JACK SOCKET. Permits connection of high resistance phones.

AUDIO OUTPUTS. A Jack for high impedance phones at left front of receiver, when phones plugged in the L.S. output at rear chassis is muted.

2.5 ohm output for external L.S.

600 ohms external line output at rear chassis.

A facility is also provided for external audio signals to be injected to grid input of 1st a.f. stage, thus enabling the a.f. Amplifiers to be used for further amplification of REH inputs or from a record player. Terminals are at rear chassis.

15. **Operating Instructions**

Switch on power to receiver, indicator and dial lights should come on.

Set wave change switch to appropriate range.

Select appropriate aerial for frequency coverage.

Set standby switch to down, Mode switch to A.M., A.V.C. switch to off, N.L. switch to off.

I.F. Gain to Maximum. A.F. Gain control as required.

Tune to maximum deflection in meter for correct A.M. tuning.

For tuning F.M. signals tune meter to centre zero.

16. **Daily User Checks** (in accordance with R 18/3)

a. Check reception of both AM and FM signals using each aerial in turn.

b. Check correct functioning of meters in AM and FM.

c. Check the STANDBY function.

d. Check arrival of audio signals at audio exchange.

3.12. RECEIVER ADAPTOR OUTFIT FAZ

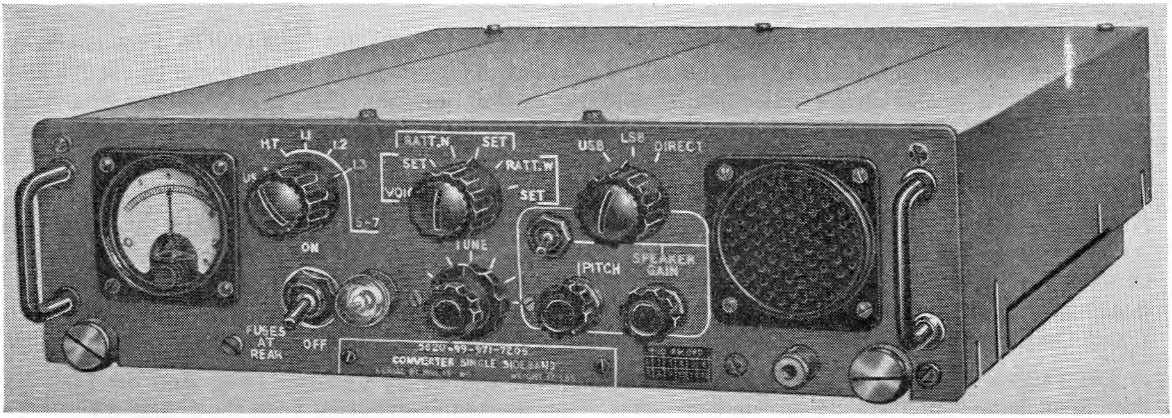

FIG. 1

HANDBOOK	BR2431 BR 2432
ESTABLISHMENT LIST	E1449
POWER SUPPLIES	115V or 230V a.c., 40–60 Hz

1. General

a. Outfit FAZ is designed to adapt the B40 and B41 receivers for single side-band operation. It provides for attended or nominally unattended reception by the B40 or B41 of the following types of signal:

Wide-Shift RATT (850 Hz shift).

Narrow-Shift RATT (85 Hz shift).

S.S.B. Voice.

b. The instability of the Local Oscillator of the B40 and B41 is the limiting factor of the overall stability of the combined receiver and adaptor. Though no attempt has been made to improve the stability of the B40 and B41 Local Oscillator, the fitting of the Adaptor has made it possible, by a system of Automatic Frequency Control in the adaptor, to ensure the correct audio output, even though the receiver Local Oscillator may drift slightly off frequency. When FAZ is fitted, the B40 and B41 may still be used as normal receivers if required.

c. The adaptor should be mounted in a tray directly above its associated B40 or B41 or, if there is insufficient space, on a nearby shelf or bracket.

2. Brief Circuit Description

a. OUTFIT FAZ contains four printed circuit boards

Board No. 1: Mixer Stage R.F.

Board No. 2: Amplifier I.F. Signal.

Board No. 3: Amplifier A.F. Loop

Board No. 4: Corrector A.F.

b. FREQUENCY CHANGER. The input signal from the B40 or B41 I.F. Stage is fed to the Frequency Changer which forms part of the Mixer Stage R.F. (Board No. 1). The input signal is mixed with the amplified output from the Local Oscillator to produce the i.f. The i.f. stages are designed to operate at 21.5 kHz but the frequency of the signal through the i.f. will be offset from 21.5 kHz by an amount which varies with the type of signal being received. The Local Oscillator frequency is tunable from 19 kHz to 24 kHz above the input frequency for upper side band operation and 19 kHz to 24 kHz below the input frequency for lower side band operation.

The Local Oscillator frequency is switched from USB to LSB by the USB, LSB DIRECT Switch on the front panel. The Local Oscillator frequency is also switched for either B40 or B41 input by the B40/B41 selection switch located on the back-plate. If switched to B40 operation the Local Oscillator produces a frequency of 500 kHz + or — 19 to 24 kHz (depending on the position of the USB, LSB DIRECT Switch). If switched to B41 operation the Local Oscillator produces a frequency of 800 kHz + or — 19 to 24 kHz (depending on the position of the USB, LSB DIRECT Switch).

Automatic control and stabilization of the Local Oscillator frequency is accomplished by means of a d.c. control voltage fed from the Corrector A.F. Stage and applied to a pair of reactance diodes which are connected across the Local Oscillator tuned circuit. When the FUNCTION Switch is to any of the "Set" positions, the output from the reactance diodes is removed from the Local Oscillator tuned circuit. The Local Oscillator is not therefore subject to automatic frequency control while the set is being tuned.

c. I.F. FILTER. The I.F. Filter is connected between the Frequency Changer Stage and the First I.F. Amplifier. It accepts the i.f. signal and removes all unwanted frequencies from the frequency changer output. It has a fixed bandwidth of 4.8 kHz.

d. I.F. AMPLIFIER AND DEMODULATOR. The two-stage I.F. Amplifier circuit forms part of the Amplifier I.F. Signal Board (Board No. 2) which also includes the detector, known as a ring demodulator, and a low pass filter. The I.F. Amplifier output is converted to audio by mixing it with the output of a crystal controlled 20 kHz re-insertion oscillator (on the Amplifier A.F. Loop Board) in the ring demodulator. The required audio output is always the difference between the i.f. and the re-insertion oscillator signal. It should be noted that the re-insertion signal is always below the i.f. The audio output passes through a 0 – 3 kHz low pass filter before going to the A.F. Amplifier on the Amplifier A.F. Loop (Board No. 3).

e. A.F. AMPLIFIER. The A.F. Amplifier and a 20 kHz crystal controlled re-insertion oscillator comprise the Amplifier A.F. Loop (Board No. 3). The audio output from the Low Pass Filter is fed to the A.F. Amplifier, the gain of which is preset. After amplification the signal is fed to a phase splitter and then to the output stage which drives the audio output transformer.

The audio output transformer provides:

(1) Output to the monitor speaker and phones via the local gain control.

(2) Line output (Voice/RATT Wide/RATT Narrow).

(3) Feed-back for Local Oscillator frequency control.

The output for teleprinter operation is switched for Wide or Narrow RATT operation by the FUNCTION Selector switch. The Wide RATT signal is switched direct to a 600-ohm line output and the Narrow RATT through a 200 Hz tone filter, then to the same 600-ohm line output.

f. AUTOMATIC FREQUENCY CONTROL

(1) Automatic frequency control is accomplished by detecting deviations in the a.f. frequency response, caused by local oscillator or incoming signal instability, and translating these deviations to an equivalent d.c. voltage which is fed to two reactance diodes connected across the Outfit FAZ local oscillator tuned circuit.

(2) For voice modulation the feed-back signal from the output transformer is connected to a cross-over network which is tuned to the mid-point of the audio frequency response. Under normal conditions the cross-over network outputs are equal and opposite and the resulting control voltage is therefore zero. In the event of frequency drift occurring the network will produce a voltage the polarity of which is determined by the direction of the frequency drift.

(3) For Narrow RATT operation one discriminator circuit is tuned to 1037.5 Hz just below the upper RATT output frequency limit of 1042.5 Hz and the other 962.5 Hz just above the lower limit of 957.5 Hz.

(4) For Wide RATT operation the discriminator has to be adjusted to accept signal shift of 850 Hz.

RESTRICTED

3-12-3

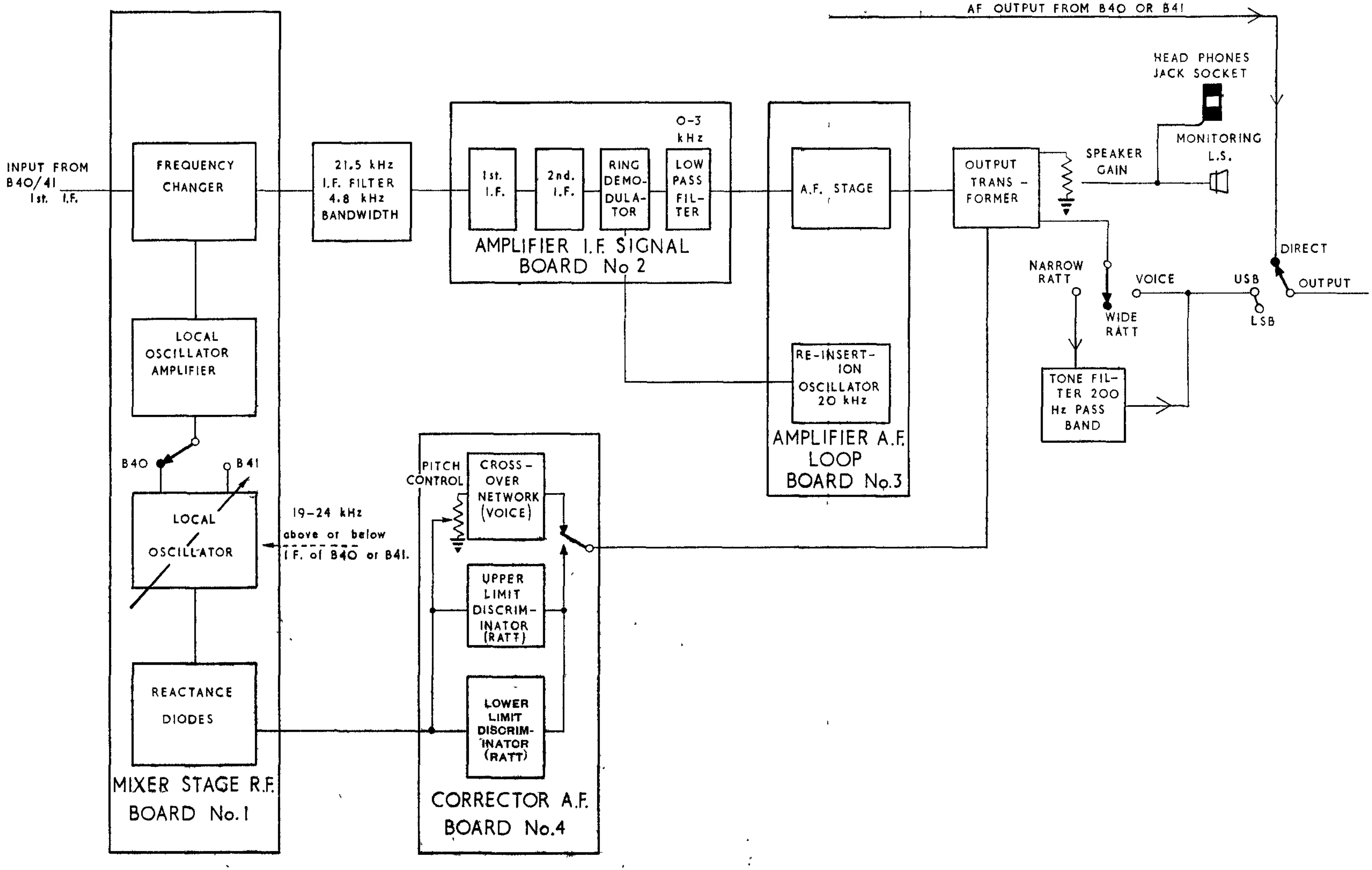

FIG. 2, ADAPTOR FAZ–BLOCK DIAGRAM

CHANGE NO. 4

One discriminator circuit is tuned to 2950 Hz just below the upper RATT output frequency limit of 2975 Hz and the other to 2150 Hz just above the lower limit of 2125 Hz. Frequency drift produces a d.c. voltage, the polarity of which is determined by the direction of frequency drift.

TABLE 1

EXAMPLES OF FAZ FREQUENCIES FOR THE RECEPTION OF DIFFERENT EMISSIONS

(1) MODE OF TRANSMISSION		(2) INPUT FROM B40 (kHz)	(3) FAZ LOCAL OSC (kHz)	(4) FAZ I.F. (kHz)	(5) A.F. OUTPUT (Hz)
Wide-shift RATT	Arrgmt. 2	500 ± .425	522.550	22.550 ± .425	2550 ± 425
	Arrgmt. 1	500 ± .425	522.550		
Narrow-shift RATT	Arrgmt. 2	500 ± .0425	521.000	21.000 ± .0425	1000 ± 42.5
	Arrgmt. 1	500 ± .0425	521.000		
Voice	USB LSB	501.35 to 498.65 498.65 to 501.35	521.65 478.35	20.3—23.0	300—3000

Note: For B41 receiver add 300 kHz to all frequencies in columns (2) and (3).

3. **Operating Instructions**

a. Setting up receiver for SSB voice:

(1) ON/OFF switch to ON.

(2) System switch to R/T.

(3) Bandwidth switch to 3 kHz.

(4) AGC ON/OFF switch to ON.

(5) Oscillator Trimmer control to ZERO.

(6) Tune receiver for maximum volume of noise from loudspeaker or headphones. As the signal is SSB it will not, at this stage, be intelligible.

b. Setting up SSB adaptor for SSB voice:

(1) ON/OFF switch to ON.

(2) Meter switch to USE.

(3) Tune control to about the mid point of its travel.

(4) Pitch control to about the mid point of its travel.

(5) USB/LSB/DIRECT switch to USB or LSB as required or directed.

(6) System switch to VOICE SET.

(7) Speaker gain control adjust for comfortable output level.

(8) Tune control adjust for undistorted signal output.

(9) System switch to VOICE.

c. SETTING-UP THE RECEIVER FOR RATT SIGNALS

850 Hz Shift RATT

(1) SYSTEM switch to TUNE.

(2) BANDWIDTH switch to 3 kHz.

(3) LOUDSPEAKER ON/OFF switch to ON.

(4) Tune the receiver midway between the two tones. This centres the two tones in the i.f. band-pass.

(5) LOUDSPEAKER ON/OFF switch to OFF.

(6) SYSTEM switch to RT.

85 Hz Shift RATT

(1) SYSTEM switch to TUNE.

(2) BANDWIDTH switch to 1 kHz.

(3) LOUDSPEAKER ON/OFF switch to ON.

(4) Tune the receiver midway between the two tones. This centres the two tones in the i.f. band-pass.

(5) LOUDSPEAKER ON/OFF switch to OFF.

(6) SYSTEM switch to RT.

d. SETTING-UP THE SSB ADAPTOR FOR RATT SIGNALS

(1) FUNCTION switch to RATT N Set or RATT W Set.

(2) USB, LSB DIRECT to USB.

(3) Turn the SPEAKER GAIN control clockwise for reasonable level of output from the loudspeaker or headphones.

(4) Adjust the TUNE control so that the meter reads Ø.

(5) FUNCTION switch to RATT N or RATT W and check that the teleprinter is working.

(6) SPEAKER GAIN control fully counter-clockwise.

Note: During the reception of signals, receiver drift will be indicated by the meter pointer becoming offset from Ø, this is remedied by readjusting the TUNE control to return the meter reading to Ø.

e. USING B40 OR B41 WITHOUT FAZ

(1) USB, LSB DIRECT switch to DIRECT. In this position the B40/B41 is operating as a normal receiver.

(2) FAZ may be switched off.

3.13. OUTFIT CJM

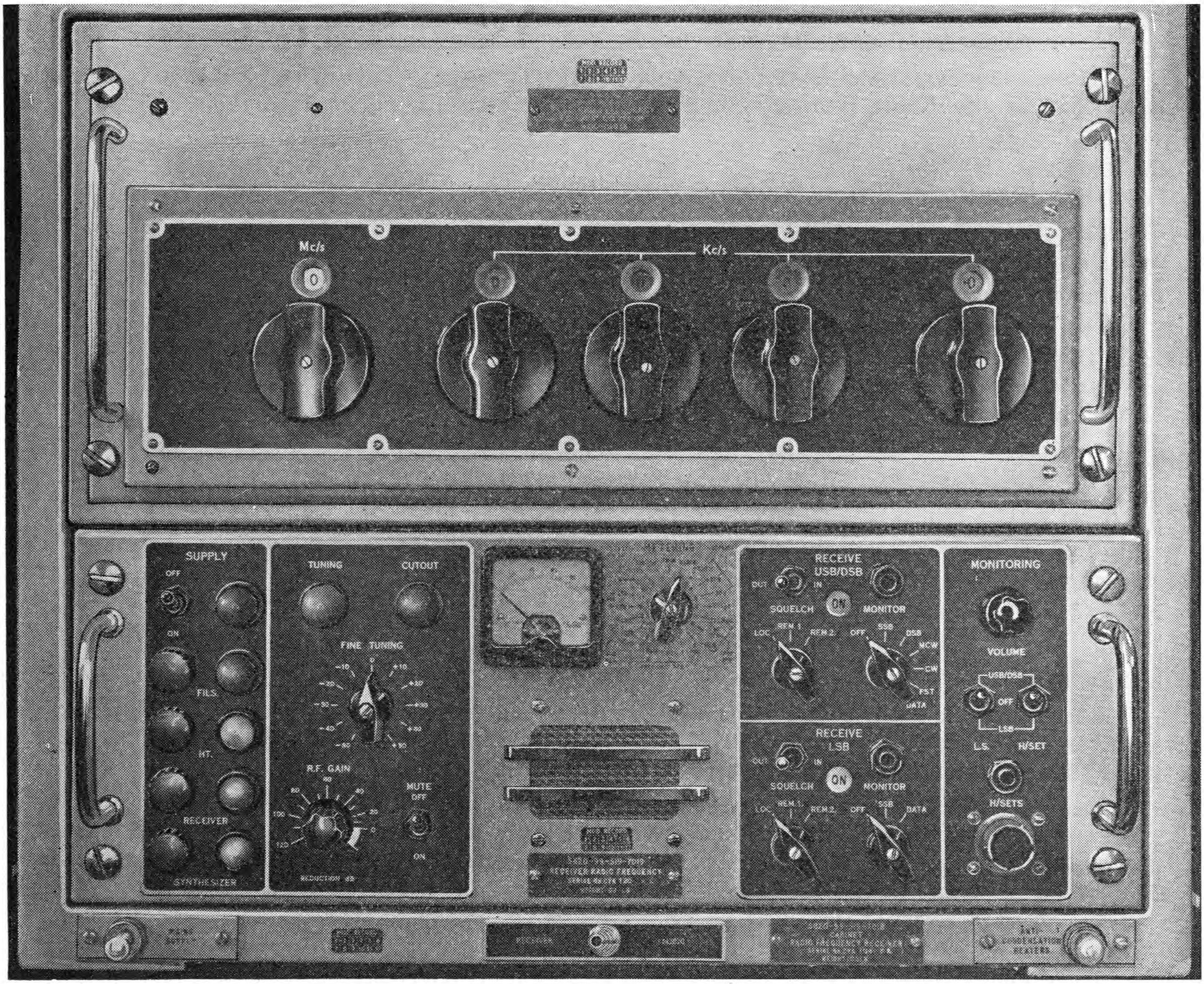

FIG. 1

HANDBOOK

ESTABLISHMENT LIST

FREQUENCY RANGE: 240 – 525 kHz
1.0 – 27.999 MHz

POWER SUPPLIES: 100 – 130V 50Hz A.C.
200 – 260V 50Hz A.C.

General

1. Outfit CJM comprises the following units:
Synthesiser, Electrical Frequency (Marconi Type 3786F).
Receiver, Radio Frequency.

2. The outfit forms a complete receiving equipment suitable for telegraphy or telephony reception in the M.F. and H.F. bands and will accept c.w., m.c.w., d.s.b., s.s.b., i.s.b., and f.s.t. signals. The receiver uses a double or triple superheterodyne circuit with dual final i.f. stages, demodulators and a.f. amplifiers for i.s.b. operation. Aerial input circuits are automatically protected against large r.f. voltages.

3. The Frequency Synthesiser is described under Outfit TDC (page 2–26–2) and will not be further described in this sub-section. It provides the required receiver oscillator frequencies as follows:

100 kHz
2 to 3 MHz } dependent on synthesiser dial settings.
40.5 to 67.5 MHz }
37.5 MHz

The synthesiser also provides a d.c. voltage directly related to dial settings which is passed to the receiver for automatic tuning purposes.

4. Provision is made in the receiver for the following types or reception:
On the USB/DSB channel
SSB with Suppressed or Pilot Carrier (3 kHz bandwidth)
DSB (6 kHz bandwidth)
MCW
CW
FST (850 Hz shift with 1700 Hz centre frequency)
DATA (3 kHz bandwidth)
On the LSB channel
SSB with Suppressed or Pilot Carrier (3 kHz bandwidth)
DATA (3 kHz bandwidth).

Brief Description

5. The aerial input is fed from the HF Power Amplifier and Aerial Matching Unit when the receiver forms part of Type 641 (see page 2–27–1). In other applications, the normal Common Aerial Working system gives a choice of aerials by external changeover switch.

6. The aerial input to the receiver is first fed to the Overload Prevention Unit. A relay within this unit operates to close down the receiver if the aerial voltage exceeds approximately 5V. A front panel 'cutout' lamp will indicate operation of the O.P.U. and in order to reset, it is necessary to switch the receiver Mains supply OFF and ON again.

7. Following the O.P.U., the signal is passed through a filter network in which the range setting and fine tuning is automatically carried out, governed by the decade dial settings of the synthesiser. The signal is then amplified and passed to the first frequency changer (Balanced Modulator). The second input to this frequency changer is derived from the synthesiser by way of the Frequency Off-set Unit ('local oscillator'). Since the synthesiser is the same as that used on the transmitter drive (as in Type 641), its normal output must be at the frequency indicated on the decade dial controls. In order to produce the receiver first i.f. of 1 MHz on ranges 1 to 4 or 4 MHz on ranges 5 and 6, the synthesiser frequency must be offset by 1 MHz or 4 MHz. The output from the F.O.S.U. is passed through an automatically tuned filter before being applied to the frequency changer.

8. On ranges 5 and 6, the first i.f. of 4 MHz is passed through a crystal filter to the second frequency changer where it is mixed with 3 MHz to produce i.f. of 1 MHz. On ranges 1 to 4, the 1 MHz output from the first frequency changer is routed directly to the input of the 1 MHz amplifier. Routeing of the signal is effected by diode switches controlled by the range switch. The output from the 1 MHz amplifier is applied to the third frequency changer where it is mixed with 1.1 MHz to produce the final i.f. output of 100 kHz.

9. The 3 MHz input for the second frequency changer is obtained by direct multiplication of the 1 MHz standard frequency. The 1.1 MHz input for the third frequency changer is produced by mixing the 1 MHz standard frequency with the 100 kHz from the synthesiser. A fine frequency control is incorporated here,

when required, by replacing the 100 kHz from the synthesizer by the output of a crystal oscillator nominally at 100 kHz but which may be pulled ±50 Hz in steps of 10 Hz as required. When the front panel FINE TUNING control is set to 0, the 100 kHz from the synthesizer is used. In any other position of the FINE TUNING control, the crystal oscillator provides the input.

10. The 100 kHz i.f. output from the third frequency changer is applied to each of two amplifiers, one for USB/DSB and the other for LSB. The output of the USB/DSB amplifier is applied to any one of four crystal filters which are for USB, DSB, CW and FST. The output of the LSB amplifier is applied to the LSB filter. The mode of reception is selected by the system switch on the receiver front panel and this will automatically select the appropriate filter.

11. After the sideband filters, a squelch circuit is incorporated in each channel and this can be switched in or out by front panel control. A front panel R.F. GAIN control sets the i.f. and consequently the a.f. output of both channels and the level set on the control is maintained by A.G.C. circuits in each channel. The A.G.C. circuits provide for varying time constants automatically selected by the mode of reception chosen at the system switches.

12. In each channel, the 100 kHz i.f. signal carrying the appropriate sideband intelligence is fed to the demodulator, together with a 100 kHz signal from the synthesiser. The resulting a.f. output in each channel passes through limiting amplifiers which give a closely controlled output level for each channel.

13. Each channel output is routed by front panel switches to the LOCAL, REM1 or REM2 operating positions. A headset monitor socket on the front panel may be connected to any one of the line outputs by the USB/DSB–OFF–LSB headset monitor switch. The loudspeaker may also be connected in the same way.

Operating Instructions

14. The setting of the synthesizer dials initiates the automatic tuning sequence. It is therefore only necessary for the operator to set the required frequency on the synthesizer dials and select the sideband, emission mode and remote output required.

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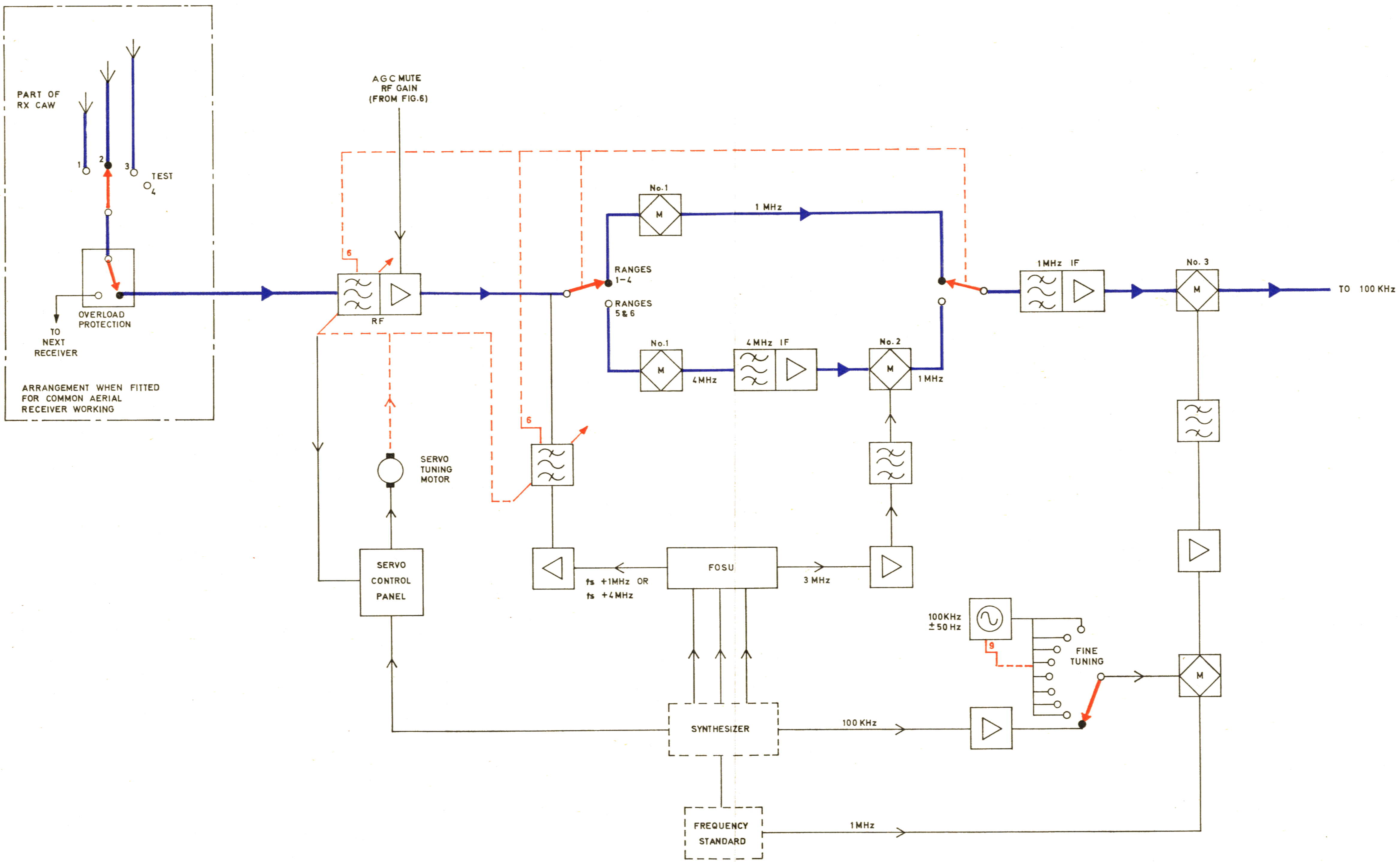


FIG. 2. OUTFIT CJM—RECEIVER; R.F. AND I.F. STAGES—BLOCK DIAGRAM

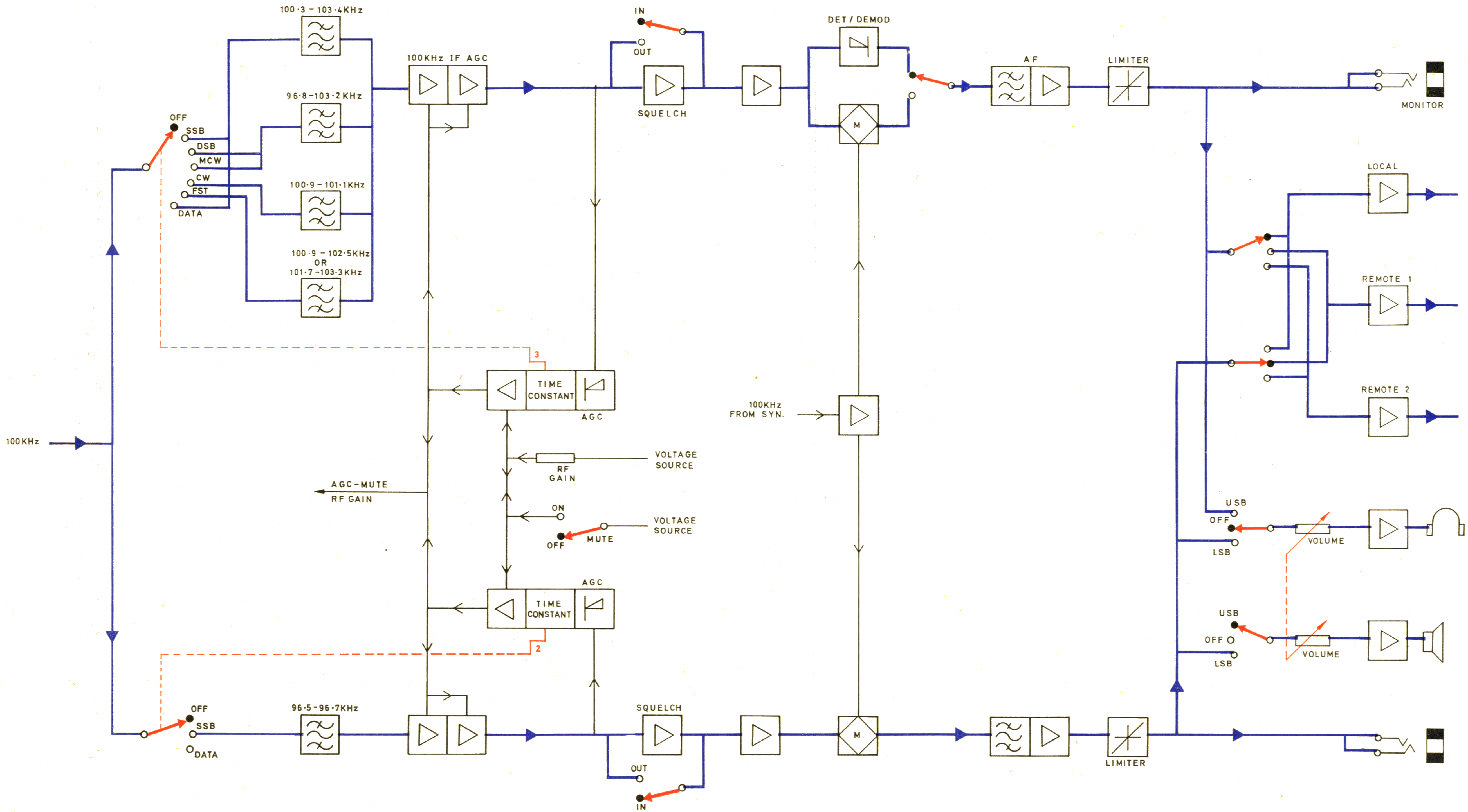


FIG. 3. OUTFIT CJM—RECEIVER, I.F. AND A.F. STAGES—BLOCK DIAGRAM

SECTION 4

D.F., AUTO ALARM

[redacted] AND RECORDER OUTFITS

4.1. DIRECTION FINDING

D.F. ERRORS

1. All systems of D.F. are liable to certain errors which may be considered under two headings.

Errors due to the Peculiarities of the Wave being Received. These cannot be corrected but their presence can sometimes be detected by the operator.

Errors due to the Ship and the Equipment fitted in the Ship. These may be corrected or avoided to a certain extent.

2. **Errors due to the Wave**

Night Effect. Caused by changes in ionization of the layers. Is most pronounced and may be expected at dusk and dawn. Its effect is to give a blurred zero, similar to semi-circular error (see below). If adjustment of the semi-circular corrector has no effect, night effect should normally be suspected. Errors may vary from 3 to 30 degrees.

Land Effect (or Shore Effect). Results in changes in the direction of the radio wave when passing from land to sea and *vice versa.* It is usually greater when the land is high. It is also greater when the wave crosses the coastline at a narrow angle (i.e. least when the wave crosses the coastline at right angles). No correction can be applied.

Aeroplane Effect. This may be experienced when a D.F. bearing is being taken of a high flying aircraft. It produces exactly the same results as land effect. No correction can be applied.

3. **Errors due to the Ship.** The ship's structure, including mast, stays and rigging, can act as a re-radiator, so that, in addition to the direct wave from the transmitter, re-radiated waves from the ship's structure are also present. These can be broadly divided into those in phase with the incoming wave and those out of phase. The in-phase component causes quadrantal error and the out-of-phase component causes semi-circular error. Both of these can be corrected.

QUADRANTAL ERROR. This is corrected by:

a. The Construction of the Loops. The fore and aft loop is made smaller than the port and starboard loop.

b. The Setting of the Inductance Corrector. This has the effect of altering yet further the size of the fore and aft loop. Its setting is determined during calibration.

c. The Correction Obtained from Calibration Curves. The visual and wireless bearings are obtained during calibration and the errors plotted to produce the correction. This may be applied by reading off the calibration curves or cams may be cut and fixed to the gonio to apply the correction automatically.

SEMI-CIRCULAR ERROR. Corrected by the use of the semi-circular corrector. This is designed to induce into the D.F. loops input circuits a signal from the sense aerial that is of equal amplitude but of opposite phase to that induced by the out-of-phase re-radiated component. This out-of-phase component causes blurring of the zero. The semi-circular corrector is adjusted by trial and error until a well-defined zero is obtained.

D.F. CALIBRATION

4. **Instructions for D.F. Calibration.** B.R. 2357, *Instructions for D.F. Calibration,* gives detailed instructions for the calibration of Naval D.F. equipment. This should be consulted before any D.F. calibration is carried out. Advice may be obtained from 'X' Section *H.M.S. Mercury.*

5. **Responsibility for D.F. Calibration.** Carried out by ships' electrical and base staff, except on the following occasions:

a. Initial calibration of ships which have been newly constructed, modernized or converted.

b. Initial calibration of a new type of D.F. equipment after fitting in existing ships.

In the above cases, the calibration will be done by a representative of the Captain Superintendent, A.S.W.E., unless the ship has been constructed, modernized or converted in a naval dockyard, in which case the calibration should be carried out by an officer on the staff of the Admiral Superintendent of the Dockyard.

6. **Notes on Calibration**

Berth. Special berths are normally given in local orders. These berths must be clear of traffic and such that the transmitting vessel can circle the ship at a radius of not less than 7·5 cables.

Equipment in Normal Seagoing Position. It is important that boats, cranes, guns, etc., particularly those in the vicinity of the aerials, are in their normal seagoing position.

Aerials. Transmitter aerials are normally earthed and receiver aerials connected in the usual way. After calibration, if particularly accurate bearings are required the aerials must be put in the same condition as they were during the calibration.

Visual Bearings. During calibration, visual bearings from which deviations of the outfit are deduced are taken from a position in the vicinity of the D.F. aerial, so that errors due to parallax are reduced to a minimum. Where the aerial is remote from the bridge, a portable bearing indicator should be used.

7. **Occasions for D.F. Calibration.** D.F. equipments should be calibrated on the following occasions:

a. On completion of a newly constructed, modernized or converted ship.

b. When a new type of D.F. set is fitted.

c. When the whole or any major part of an existing equipment is replaced.

d. If the position of the frame coil is changed.

e. When alterations are made to the ship's structure in the vicinity of D.F. aerial.

f. When about to take part in operations which involve the use of HF or UHF frequencies on which the equipment has not previously been calibrated.

8. **Check Calibrations.** Carried out to check existing calibration curves as follows:

MF. At intervals not exceeding 12 months.

HF. At four-monthly intervals.

UHF. A check of test angles should be made quarterly (see B.R. 1437).

A check calibration should be ordered if any alteration is made to the stowage of gear or to rigging in the vicinity of DF aerials.

9. **Time taken for Calibrations**

MF

Initial calibration: 3 hours (six frequencies).

Check calibration: 1½ hours (three frequencies).

HF and UHF

Initial calibration: 2 working days.

Check calibration: 1 working day.

10. **Calibration Curves and Cams.** As a result of a D.F. calibration a calibration chart is produced which shows the corrections to be applied for quadrantal error. With certain D.F. outfits metal cams are provided which can be cut by the ship's electrical staff to apply the corrections automatically. Photostat copies of the calibration charts can be made at H.M.S. *Collingwood.*

4.2. D.F. OUTFIT FM12 (RECEIVER FMB)

DATE OF DESIGN. 1942

HANDBOOK. B.R. 1370

ESTABLISHMENT LIST. E550

FREQUENCY RANGE. 42 to 1060 kc/s.

POWER SUPPLIES. 230 V, 50 c/s, a.c.

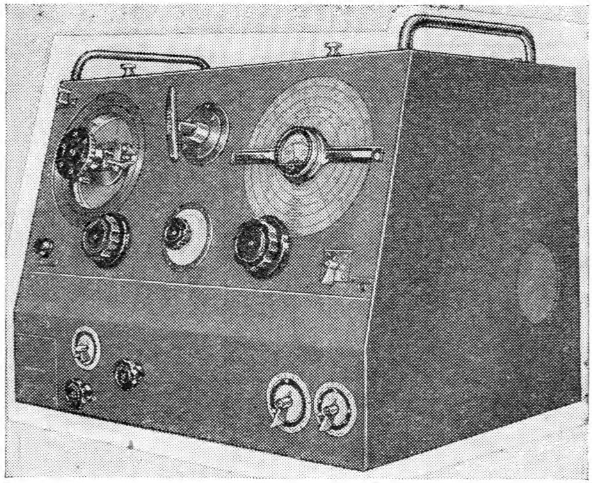


FIG. 1

1. **General.** FM12 is a direction finding outfit fitted in all types of ship. The goniometer, receiver and power supply unit are all mounted together in one cabinet. A fixed frame coil is used, S22 in destroyers, frigates and smaller ships, and S19 in cruisers and above.

2. **Power Supplies.** The equipment operates from 230 V a.c. supply. The a.c. supply is fed through an ON/OFF switch, a pair of mains fuses and a safety switch, to the primary of a transformer. The safety switch is operated by the hinged lid on the cabinet, a.c. supply being broken when the lid is opened. The transformer has three secondary windings. Two windings supply the heater and anode of the rectifier whose output is smoothed and provides the H.T. to all stages in the receiver. The third winding supplies the heaters of all stages in the receiver and also supplies the dial lamps, which are selected by the range switch and illuminate the dial for the frequency range in use.

RECEIVER

3. The Receiver FMB is a straight (TRF) receiver, employing three stages of r.f. amplification, a detector, a het. oscillator (for c.w. reception) and one stage of a.f. amplification. Tuning of the r.f. detector and het. oscillator stages is achieved by a five-position range switch. This switch revolves a drum, on which are mounted the coils for each of the five stages, and it selects the coils for the appropriate range. All five tuned circuits are tuned by the five ganged tuning capacitors controlled by the main tuning control.

4. **Volume Control.** The gain of the receiver is adjusted by means of the volume control fitted on the front of the receiver which controls the cathode bias of the 2nd and 3rd r.f. stages. The 2nd r.f. stage is also fitted with an R.I.S. control which is not now used.

5. **Het. Oscillator.** The het. oscillator is provided with a three-position switch:

Off. Breaks the H.T. supply to the het. oscillator for the reception of M.C.W. and voice.

Het. 1. The normal operating position for c.w. signals.

Het. 2. Reduces the H.T. supply and so reduces the output of the het. oscillator for the reception of very weak c.w. signals.

A second contact of this switch earths the output of the het. oscillator in the OFF position, and in position Het. 1 and 2 connects the output of the oscillator to the detector.

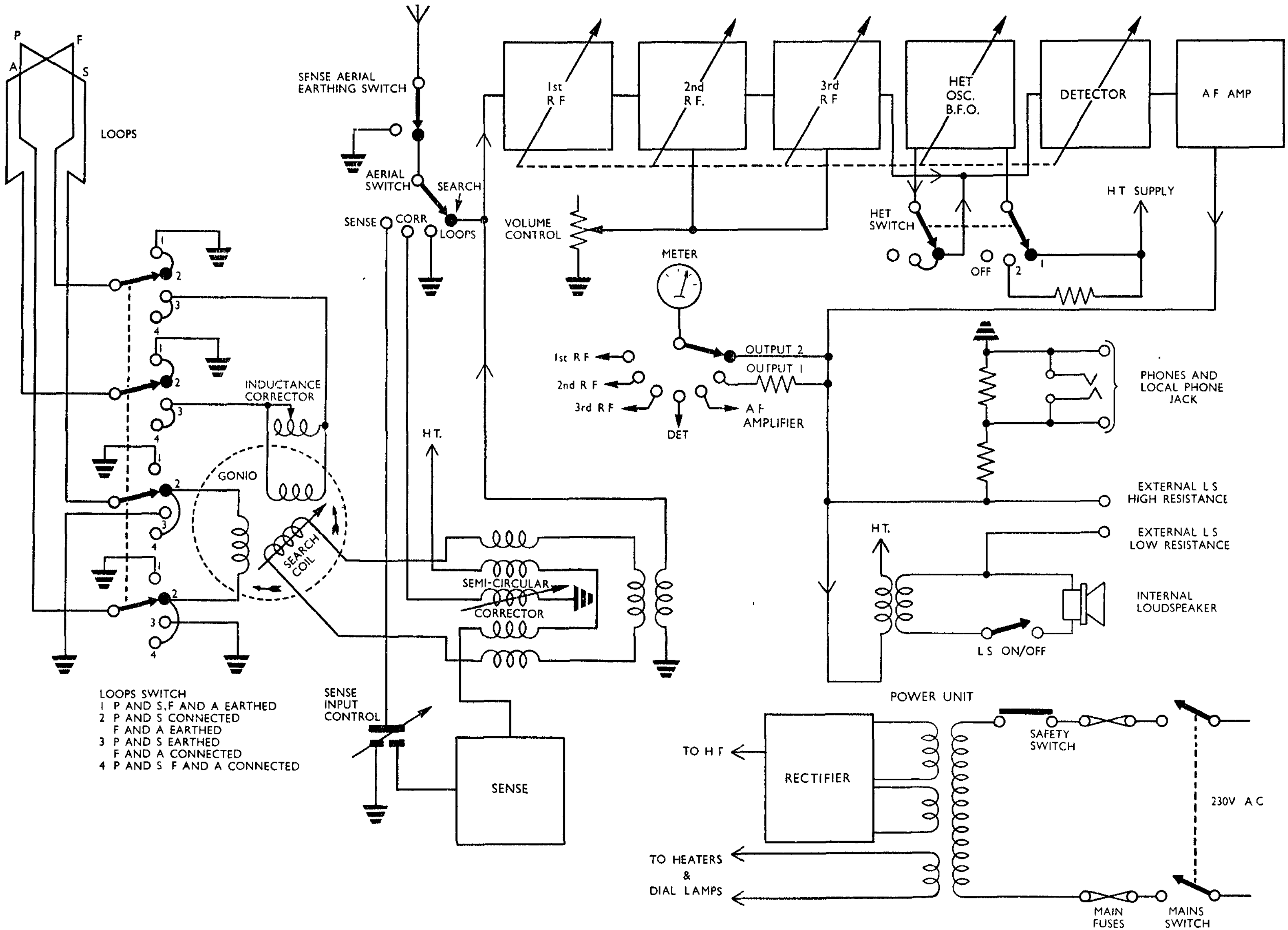


FIG. 2. DF OUTFIT FM 12

6. **Outputs.** The following outputs are provided:

Built-in loudspeaker, with an ON/OFF switch fitted on top of the cabinet.

External loudspeaker, of low or high resistance type, from terminals on the output terminal block. (Not normally used.)

Phone outputs, to local headphone jackbox, and to external phones via output terminal block.

7. **Meter.** A meter is provided on the front of the receiver, with a seven-position switch for testing purposes, and as an output meter for visual indication of bearing.

Positions 1 *to* 5. Read the anode current of the following stages:

1st r.f.	Detector
2nd r.f.	a.f. Amplifier.
3rd r.f.	

These positions are for test purposes only.

Positions 6 *and* 7, marked 'Output 1' and Output 2,' read the rectified a.f. output. 'Output 1' is the normal position for visual indication. 'Output 2' provides greater sensitivity for a very weak signal by removing a resistor from the output line.

AERIAL INPUTS

8. **Frame Aerial.** The port and starboard and the fore and aft loops are fed into the goniometer through a four-position loops switch. The four positions connect the loops as follows:

Position 1. P and S loop earthed
F and A loop earthed

Position 2. P and S loop connected
F and A loop earthed

Position 3. P and S loop earthed
F and A loop connected

Position 4. P and S loop connected
F and A loop connected

Positions 1 to 3 are used for test purposes only, Position 4 being the operating position. The input from the loops is inductively coupled to the 1st r.f. stage by means of the search coil and the coupling transformer to which the search coil is permanently connected. The input from the loops is determined by the position of the search coil which revolves around the F and A and the P and S inductances. The bearing or reciprocal of the transmission being received is thus indicated by the position of the search coil.

(*continued on page 4–2–4*

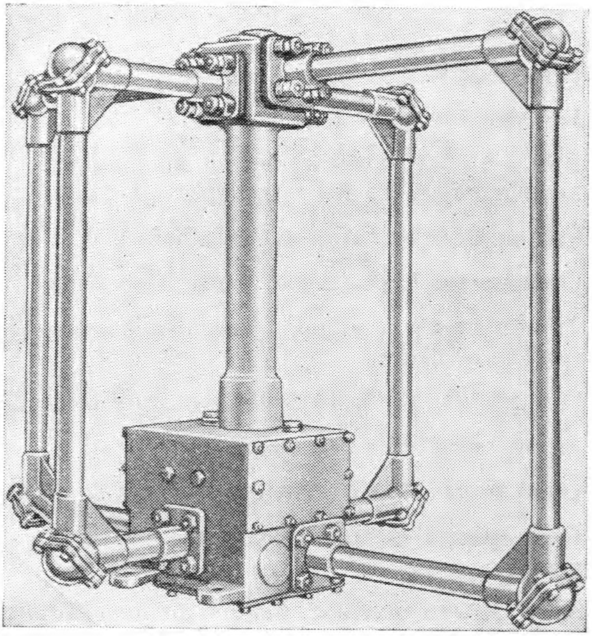


FIG. 3

9. **Aerial Switch.** The arrangement and function of the input circuits is determined by the position of the aerial switch, which has four positions as follows:

SEARCH. The sense aerial is connected directly to the grid of the 1st r.f. stage. The loop aerial is connected in the normal way but the input from the loops is very small in comparison with that of the sense aerial. This input can therefore be disregarded and the outfit operates as an ordinary receiver. Used for searching and for maintaining normal listening watch.

LOOPS. The sense aerial is disconnected and earthed and only the input from the loop aerial is connected. The bearing or reciprocal of the station will thus be determined by the position of the search coil.

CORR. The sense aerial is connected through the semi-circular corrector inductance. The loops are connected in the normal way. By revolving the semi-circular corrector, a signal equal but in opposite phase to that produced by the re-radiated out-of-phase component is induced into the loops input circuit and cancels out to a large extent the re-radiated out-of-phase component picked up by the loops.

SENSE. The sense aerial is connected via the sense output control to the grid of the sense valve. The output of the sense valve is inductively coupled to the loops input. The output of the sense valve will either be in phase or anti-phase with the input from the loops and will therefore determine the sense or direction of the signal.

10. **Sense Output Control.** This is used to ensure that the input from the sense aerial is of the same value as the input from the loops. (See operating instructions for procedure for setting this control.)

11. **Bearing Indicator.** The bearing indicator consists of a pointer which moves around two graduated scales. The outer scale is graduated in true bearings from 0 to 360 degrees and is driven by the ship's master gyro. The inner scale gives relative bearings and is graduated 0 to 180 degrees Red and 0 to 180 degrees Green. Two pointers are provided; a black pointer which indicates the uncorrected bearing (i.e. correction from the calibration chart must be applied to this) and a white pointer which indicates the corrected bearing when cams have been cut and fitted which automatically apply the correction.

12. **Sense Aerial.** A vertical 30 foot aerial is used as the sense aerial. This may be specially rigged and used only as a sense aerial or it may be fed to an aerial exchange board for normal reception. Alternatively, any 30 foot whip or wire aerial may be fed from the aerial exchange board to the FM 12.

CONTROLS

13. AERIAL SWITCH. (See para. 9.)

RANGE SWITCH. Switches in coils for the tuned circuits in the r.f. stages, detector and het. oscillator, and illuminates the dial range light.

VOLUME CONTROL. Adjusts the cathode bias of the 2nd and 3rd r.f.s.

GONIOMETER. Indicates true or relative bearing.

TUNING CONTROL. Adjusts ganged variable capacitors in the tuned circuits of the r.f. stages, detector and het. oscillator.

HET. SWITCH. A three-position switch for controlling the het. oscillator. (*See* para. 5.)

METER AND SWITCH. (See para. 7.)

GYRO SUPPLY ON/OFF SWITCH. Switches on the Gyro motor.

GYRO RESET CONTROL. Revolves the true bearing scale to allow the gyro to be aligned with ship's master gyro.

SENSE OUTPUT CONTROL. Adjusts the sense valve output to equal that of the loops input.

SEMI-CIRCULAR CORRECTOR. Controls the input from the sense aerial when in the Corr. position. (See para. 9.)

INDUCTANCE CORRECTOR. Set up from calibration chart. Minimizes quadrantal error by altering the inductance in the F and A loop. (In certain ships this inductance may be in the P and S loop.)

LOOPS SWITCH. A four-position switch for earthing loop aerial. (See para. 8.)

A.C. SUPPLY ON/OFF SWITCH. Completes 230 V a.c. supply to rectifier transformer.

R.I.S. CONTROL. Not used.

SENSE AERIAL EARTHING SWITCH. Earths the sense aerial when testing or set not in use.

SENSE AERIAL RELAY SWITCH. Not normally connected. Completes supply to relay which earths the sense aerial when a high-powered MF transmitter is keyed.

LOUDSPEAKER SWITCH. Switches on the internal loudspeaker.

OPERATING INSTRUCTIONS

14. Switching on and Searching

(1) Make Mains supply switch.

(2) Put meter switch to any one of first five positions.

(3) Switch on sense aerial.

(4) Loops switch to position 4 (F and A, P and S connected).

(5) Inductance corrector to stop indicated on calibration chart.

(6) Aerial switch to SEARCH.

(7) Het. switch to position Het. 1.

(8) Range switch and main tuning control to correct frequency.

(9) Volume control to about $\frac{3}{4}$ of full rotation.

(10) Semi-circular corrector control upright (midway).

(11) Search for signal with main tuning control. Move het. switch to position het. 2 if signal is very weak.

15. To Take a Bearing

(1) Put meter switch to OUTPUT 1 (Output 2 if signal is very weak).

(2) Adjust volume until meter reads approximately 75 per cent of scale.

(3) Put aerial switch to LOOPS. Readjust meter reading to 75 per cent if necessary.

(4) Rotate gonio for dip in the meter and for minimum signal in phones. Two dips will be observed, 180 degrees apart on gyro scale. Note relative and gyro bearings.

(5) Put aerial switch to SENSE. Reduce meter reading to 75 per cent by volume control.

(6) Rotate gonio clockwise for 90 degrees. Meter reading and signal strength should fall if on correct bearing, or rise if on the reciprocal. If reciprocal bearing, switch back to LOOPS. Turn gonio 180 degrees, obtain dip, switch to SENSE and again rotate gonio 90 degrees clockwise. Signal and meter reading should now fall.

(7) If, during (4) above, zero is blurred, carry out (5) and (6) to determine sense, then switch to CORR. Return to tune bearing, adjust semi-circular corrector and gyro until a well-defined zero is obtained.

(8) Read off bearings, relative and gyro, from black pointer, and apply corrections from calibration curve if cams are not fitted. Report corrected bearings. If cams are fitted, read off bearings from white pointer and report.

16. **Applying Corrections.** To avoid confusion when applying corrections to true and relative bearings the following rule should always be followed. Positive corrections are applied clockwise, negative corrections are applied anticlockwise; if red bearing, first reverse the sign.
Example 1. True bearing, 315. Relative bearing, R 94. Correction from chart, +3 deg. Corrected bearing – True, 318, Relative, R 91.

Example 2. True bearing, 120. Relative bearing, G 160. Correction from chart, —2 deg. Corrected bearing – True, 118, Relative G 158.

17. **To set up Sense Output Control**

(1) Obtain bearing of a known station (i.e. sense must be known).

(2) Leave aerial switch in SENSE position.

(3) Rotate gonio 90 degrees clockwise from true bearing.

(4) Adjust volume control to give 70 per cent meter reading.

(5) Adjust sense output control for a dip in the meter. Leave sense output control in this position.

This control once set up need not be reset except for a large increase or decrease in frequency, a change of sense aerial or change of sense valve.

4.3. HF DF SYSTEM FH4

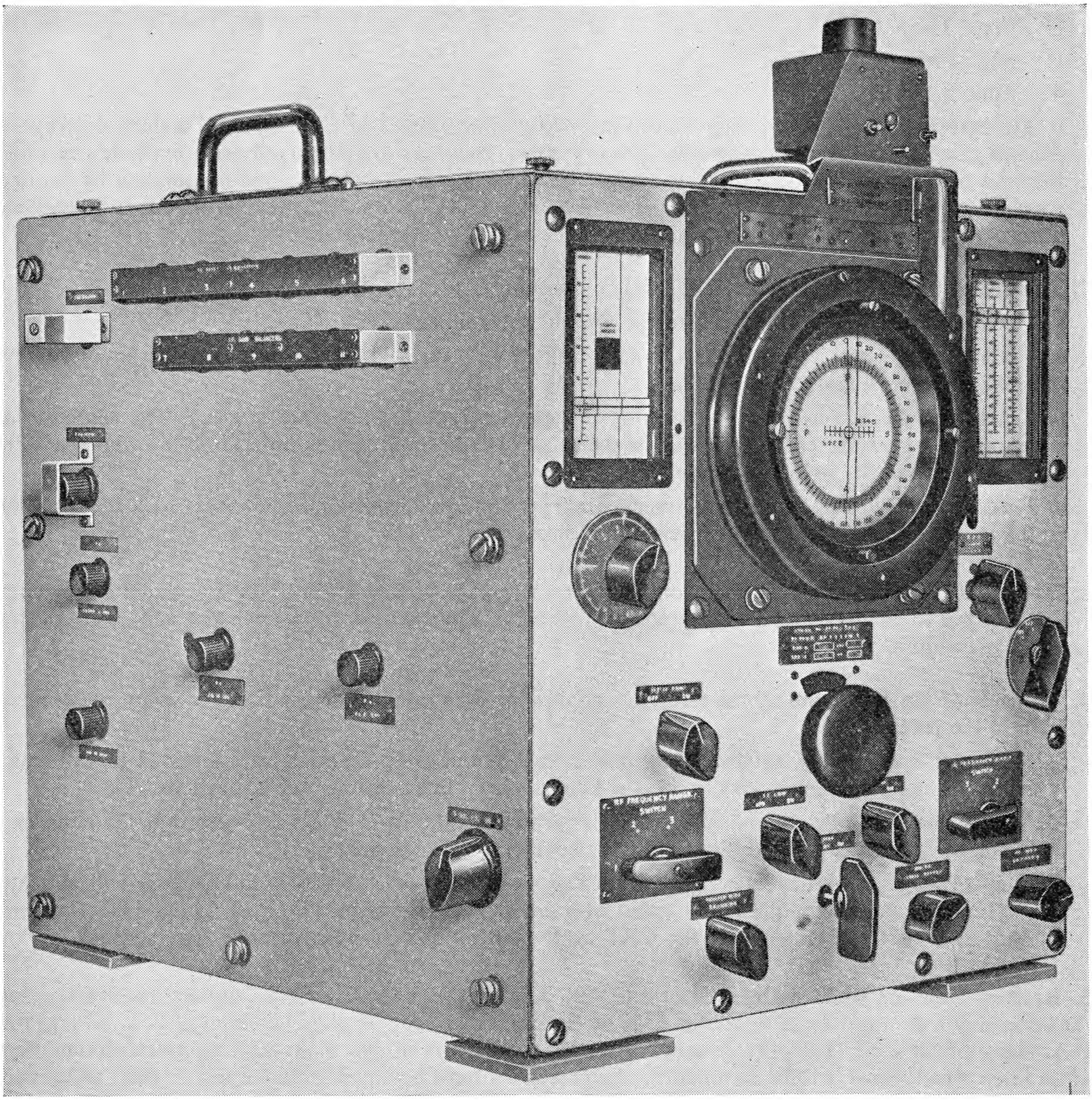


FIG. 1

DATE OF DESIGN	1942
HANDBOOK	BR 1613
ESTABLISHMENT LIST	E 551
PLANNED MAINTENANCE SCHEDULE	R22/1C
FREQUENCY RANGE	1 to 24 MHz
INTERMEDIATE FREQUENCY	450 kHz
POWER SUPPLIES	230V 50/60Hz Single Phase

1. **General**

a. System Designation

F – Fixed Loop Aerial

H – High Frequency

4 – Fourth Model

b. Description. A high frequency direction finding system fitted in Commando Carriers, destroyers, general purpose frigates and anti-submarine frigates. Bearings are displayed on a cathode ray tube. Because of limitations with shipborne aerials, accurate bearings of emissions propagated by ground wave only are possible. Direction finding can be accurate to within $\pm 2°$. Sky wave emissions produce a trace on the cathode ray tube which is generally constantly changing bearing.

2. **Aerial Outfit (Framecoil S25B).** The aerial comprises:

a. Crossed, Fixed Loops – in the fore and aft and port and starboard planes.

b. First Loop – set at 45° in the Green 45° and Red 135° direction. It is used to emit a low level test signal for receiver alignment purposes.

c. Sense Aerial – a vertical whip forming the upper structure of the aerial array. The sense aerial is connected to associated components in the sense chamber and to a counterpoise in order that this aerial is electronically balanced to the loop.

d. Feeders – heavy armoured twin screened cables connect the aerial components to a transformer coupling unit situated close to the receiver and display unit.

3. **Voltage Regulator.** Permits manual control of regulating the voltage input to the associated power unit, which requires to be 200V and is registered in a voltmeter. The mains on/off switch and mains input fuses are sited in this unit.

4. **Power Unit.** This provides all the essential supplies for the operation of the CRT, receiver and control of gain in the receiver unit.

a. Final audio amplifiers, internal loudspeaker and phone output sockets are situated in this unit. A switch in the phone socket disconnects the loudspeaker when a phone plug is inserted.

b. A stabilised grid bias neon strike switch is located on the front panel in order that the neon can be struck to ensure a stabilised bias supply for control of receiver gain.

c. Main HT fuse and Grid Bias fuse are located on front panel. Loss of grid bias fuse will indicate as maximum signal on the CRT and audio with a complete loss of gain control. Loss of HT fuse will indicate as a spot of brilliance at the CRT centre but no signals, regardless of gain settings.

5. **Receiver Unit and Dial Bearing Indicator (FHB).** The receiver consists of two superhet receivers under the control of a common local oscillator. One receiver is used to convey signal content of F.A. loop to the F.A. plates of the CRT. The other is used for the P.S. channel in similar manner. If the trace presentation of an intercepted signal is to be accurate the two receivers must be equal at all stages for gain, phase and selectivity. The output of the final stages of I.F. of each receiver are coupled to the appropriate plates of the receiver.

a. Audio. An output from each final I.F. amplifier is fed to the detector to provide an audio output. The audio unit contains a radar interference limiter so that heavy pulsed interference on voice signals may be reduced, and an audio filter to reduce background noise with CW signals by reducing the audio bandwidth to 600 to 1000 Hz.

b. Test Facilities. To allow the operator to check that there is no imbalance between the two receivers, a test signal may be produced at any Rx tuned frequency. This test signal may be injected internally or radiated by the test loop and intercepted by the DF loops, as a signal from Green 45.

c. Sensing. All signals will be displayed as a diametral trace on the CRT. Thus there is ambiguity of bearing. This is resolved by the provision of a sense system under control of the operator. This allows the operator to determine the quadrant in which the true bearing of the emitter exists.

6. **Operator's Check.** This is designed to allow the operator to use the external test signal to achieve an overall balance of the system on the frequency to which the receiver is tuned. This check is to be carried out hourly when on a task frequency or if receiver frequency is altered by more than one rotation of the tuning control. Diagrammatic illustration of this check is shown in Fig. 2.

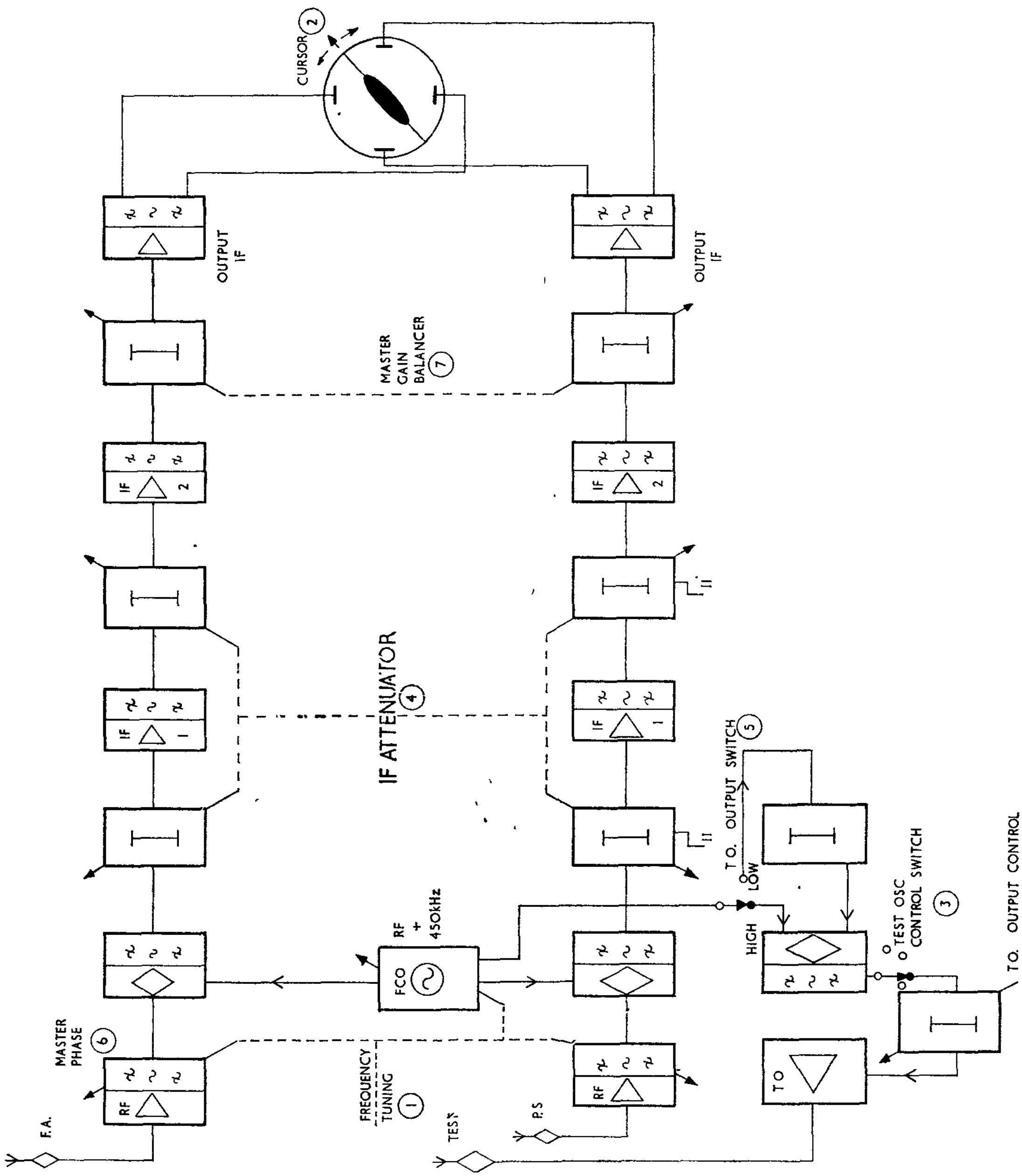


FIG. 2. HF DF SYSTEM FH4 – CONTROLS USED FOR OPERATOR'S CHECK – BLOCK DIAGRAM

It is assumed that the equipment has been switched on for at least six hours, with all checks of CRT setting up and alignment completed.

1. Switch both Range switches to the appropriate frequency range and tune the receiver to the required frequency.

2. Place the dial bearing indicator cursor to lay across 45 – 135 degrees.

3. Switch Test Oscillator control switch to TAe position.

4. Set the I.F. Attenuator to position 6 if on range 1
position 4 if on range 2 or 3
position 3 if on range 4.

5. Check that the T.O. output switch is in high position, turn the T.O. output control till test signal trace is at full scale deflection.

6. Using the Master Phase control, remove any ellipse in the test signal trace.

7. Using the Master Gain control, set the test signal trace to lie across 45 – 135 degrees.

8. Switch the T.O. control switch to either BFO or OFF, as required by the search task being undertaken.

Note: When this check is being carried out during the process of taking a bearing, the I.F. attenuator is to be left in the position determined by achieving full scale deflection of the signal trace. The test oscillator output control only being used to control the Test Signal. This simplifies the process and decreases the time taken, which is of primary importance as the signal duration may be very short.

7. **Taking a Bearing.** Fig. 3 shows diagrammatically the units of the receiver which are controlled and adjusted during this process.

1. Tune the receiver accurately to the maximum length of trace.

2. Using the I.F. attenuator, set signal trace to full scale deflection.

3. Adjust the Dial Bearing indicator cursor to lie over the trace.

4. Move the sense switch to both FA and PS positions to determine in which quadrant the bearing is indicated.

5. If time permits and the search task dictates that written record of intercepted traffic is to be kept, use the BFO control to produce suitable signal pitch (do not detune), and set the audio gain control for desirable audio level (do not use the I.F. attenuator).

Note: It may be necessary to do an operator's check during this process. If so, and the signal is of keyed or intermittent voice it will not be necessary to detune, as the test signal will show on the CRT during non signal conditions. Until further information is available, or if not otherwise directed, the bearing from the dial bearing indicator is to be recorded and reported. For further detailed information consult BR 1613 Ch 5 part 2B, taking note that calibration curves are not to be used unless specifically ordered.

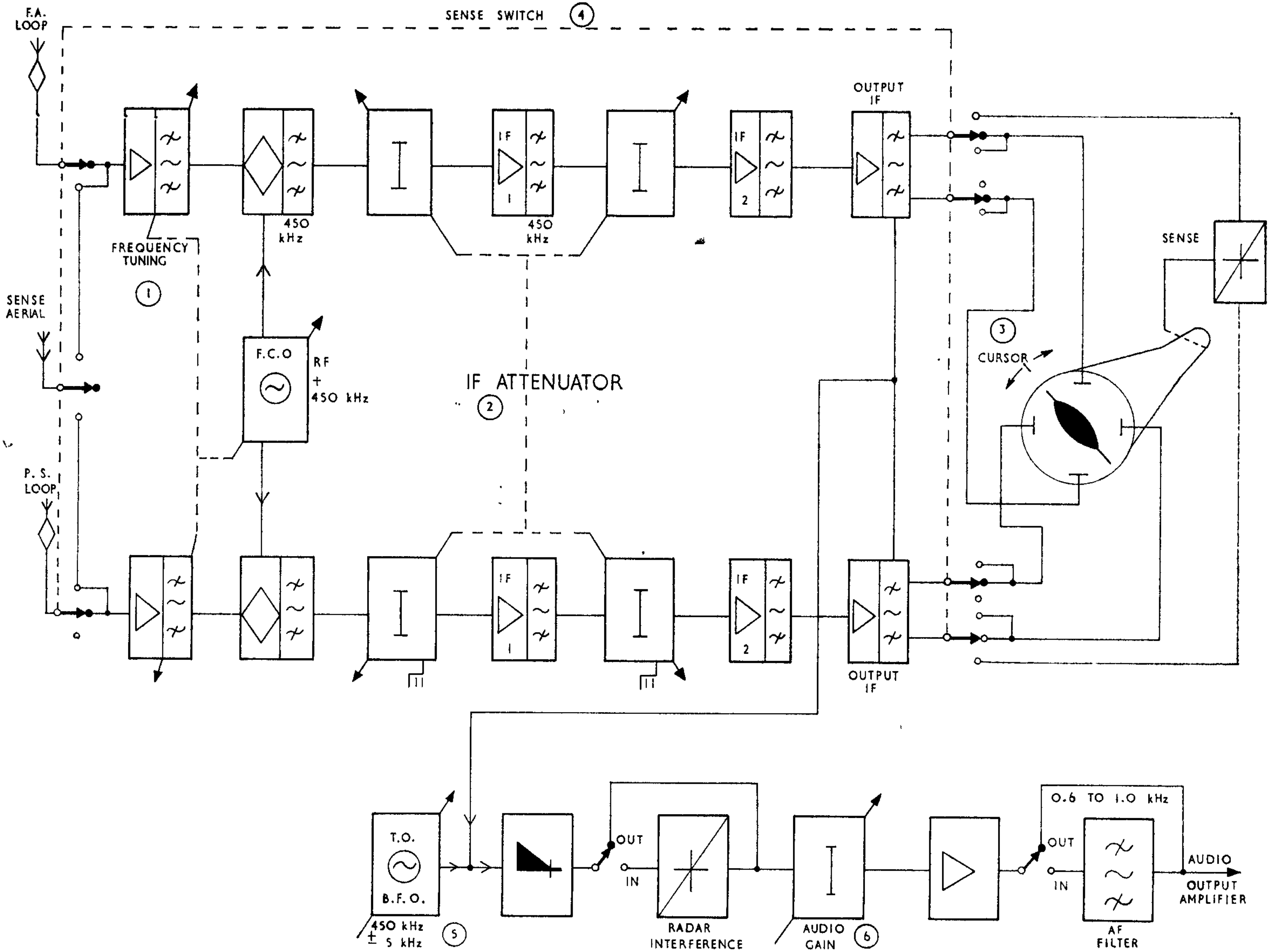


FIG. 3. HF DF SYSTEM FH4 – CONTROLS USED TO TAKE A BEARING – BLOCK DIAGRAM

8. **Alignment Check.** This check is to be carried out at least every four hours or on any occasion when the operator check does not produce the specified result. The equipment must be switched on for a minimum period of six hours prior to checks or use. Fig. 4 shows the units of the receiver which are used and adjusted during this process.

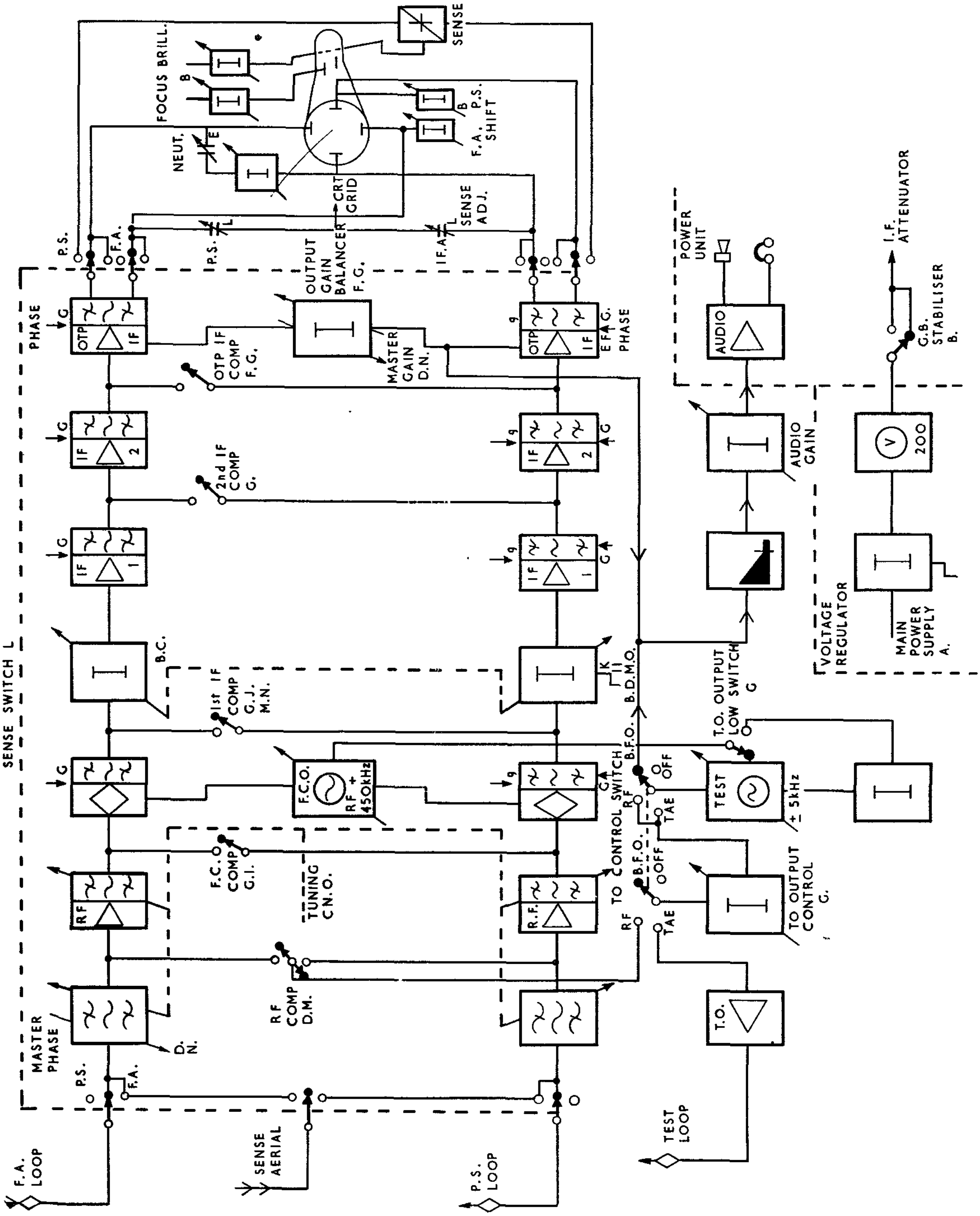


FIG. 4. HF DF SYSTEM FH4 – ALIGNMENT CHECK – BLOCK DIAGRAM

1. Check that the Voltage Regulator is adjusted so that voltmeter reads 200V and that the grid bias neon stabiliser has struck.

2. Set the T.O. control switch to off, and turn the I.F. attenuator to position 11 and check that the spot is correctly centred, focussed and at a reasonable level of brilliance. On completion set the I.F. attenuator to position 3.

3. Tune the receiver to 6 MHz, detune from any signal interference and then set I.F. attenuator to position 6.

4. Set the T.O. control switch to RF and turn on the RF comparator switch. Ensure that the BFO, master phase controls are upright.

5. Check CRT neutralising by switching the P & S switch to OFF and by rotating the PS output I.F. phase control. If all is correct there should be no trace movement from the vertical and no ellipsing should be induced. If all is not well, note it and inform your senior rate on completion. Switch on the PS switch.

6. Switch on the I.F. output comparator, and, using the PS, FA phase controls peak the FA signal and with the PS, bring the trace to a straight line at approx. 45 degrees. Using the output gain balancer bring the trace to 45 degrees. Switch off the output I.F. comparator.

7. Switch on the FC comparator. Check the phase alignment of the second, first and FC amplifiers in turn using the appropriate comparator switch and associated phase controls. On completion only the RF and FC comparators should be switched on.

8. Check selectivity balance ('Q') of the amplifiers by rotating the BFO and noting appearance of any ellipsing, which should not exceed 1mm. If severe ellipsing occurs, note it and inform your Senior Rating on completion.

9. Switch OFF the FC comparator switch.

10. Switch ON the First IF comparator switch.

11. Check the IF attenuator gain balance by rotating it over the full travel, maintaining full scale trace at each of the numbered graduations. If the trace departs from 45 degrees by more than 2 degrees at any point, correct this by the procedure laid down in BR 1613 Ch 4 part 2 section B12. On completion set the IF attenuator to position 6.

12. Check the sense output phasing by use of the sense switch and the FA and PS sense adjustors.

13. Switch OFF the first IF and RF Comparator switches. Switch the T.O. control switch to TAe position.

14. Check the overall HF phase and gain tracking of the system. This is carried out on each of the four frequency ranges in turn. Tune the receiver through its total frequency range coverage maintaining full scale trace and checking that the test signal can be controlled at all points to give a straight line at 45 degrees, by use of the master gain and master phase controls. If this cannot be achieved, the system is not in correct balance and will require correction by all or some of the sections of the Full Alignment.

15. Set the T.O. control switch to either BFO or OFF as determined by your search task, tune to designated frequency, complete the operators check and observe for task signals.

9. **Daily User System Check.** This is to be carried out daily in accordance with planned maintenance schedule R22/1C, and consists:

a. Alignment Check to be carried out.

b. Operators Check must be effected over all the four frequency bands.

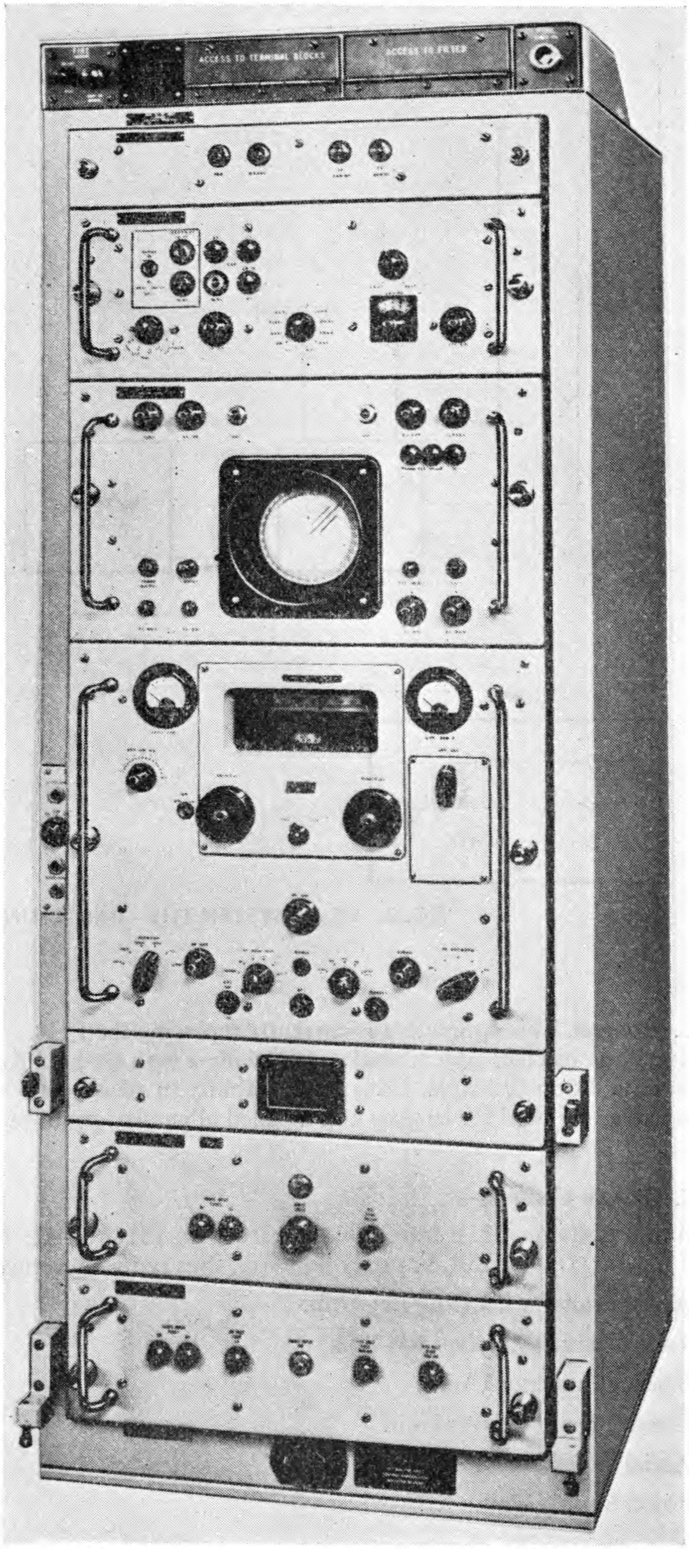
c. Check reception of external signals on all four frequency bands.

d. Check correct function of gyro repeater.

e. Check arrival of audio signals at phone socket and at the audio exchange (if fitted).

10. **Calibration.** Details in BR 2357.

4.4. HF DF SYSTEM FH5



DATE OF DESIGN 1964

HANDBOOKS

BR 2465(1) – Technical Description
BR 2465(2) – Maintenance

ESTABLISHMENT LIST

(To be issued)

FREQUENCY RANGE

1 to 30 MHz

INTERMEDIATE FREQUENCY

100 kHz

POWER SUPPLIES

100 – 125V or 200 – 250V at 50Hz

PLANNED MAINTENANCE SCHEDULE

(To be issued)

FIG. 1

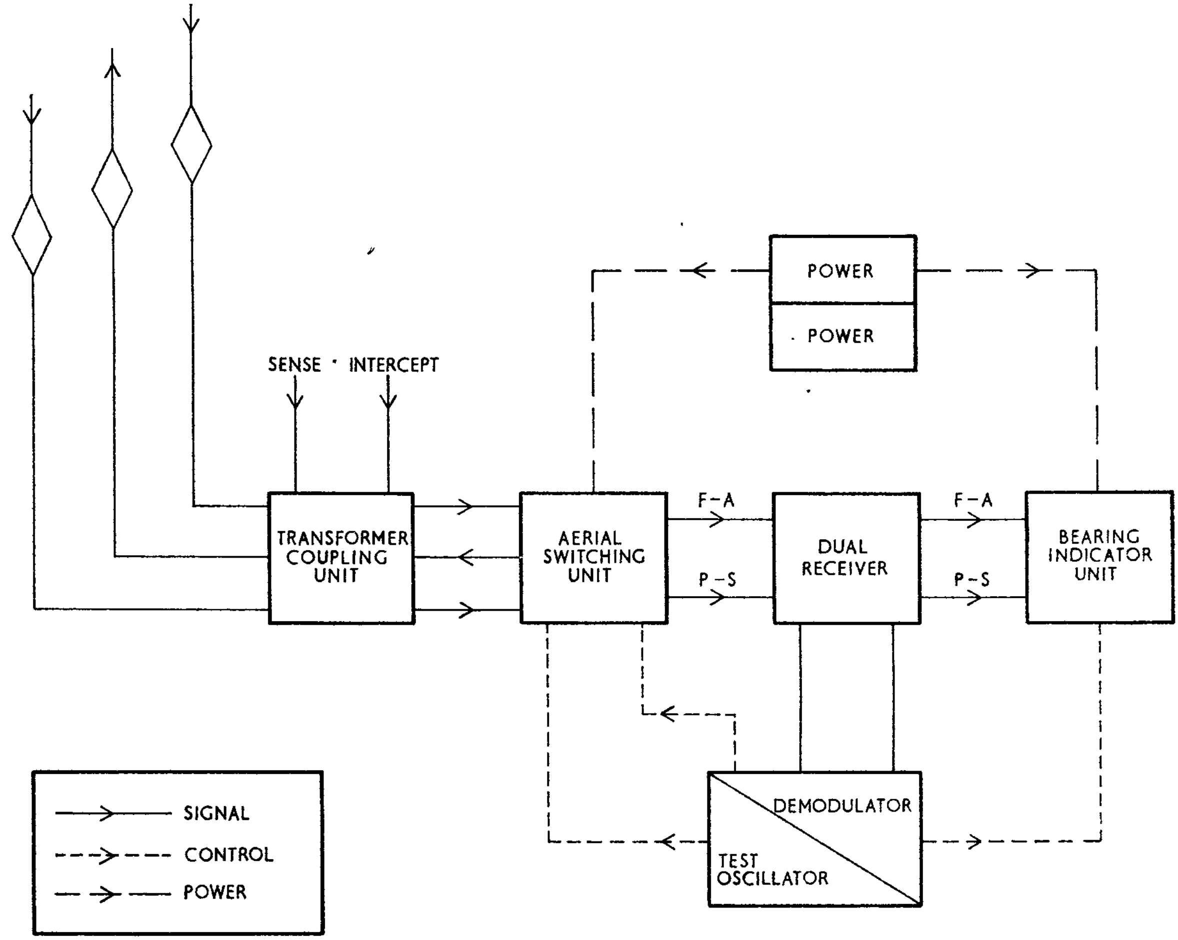


FIG. 2. HF DF SYSTEM FH5 – BASIC UNIT – BLOCK DIAGRAM

1. **General.** This equipment is currently replacing the FH4.
The basic receiver system used is essentially a twin channel Racal RA–153, based on the RA–17, using the Wadley Loop principle. Long term stability in phase, gain and selectivity of the two receiver channels removes the need for lengthy and detailed alignment procedures.

2. **System Components**

Aerial System – S25B framecoil (as used with FH4) or AE 701 (Racal) which is similar in design to the S25B, but only half size, thus reducing topweight and wind resistance.

Aerial Transformer Coupling Unit.

Twin Channel Receiver RA–153.

Bearing Indicator Unit.

Control Demodulator Unit.

Aerial Switching Unit.

Power Supply Unit.

3. **Twin Channel Receiver (RA153).** Converts the received signal frequency to an I.F. of 100 kHz which is then made available at the Bearing Indicator Unit for bearing presentation and at the Control Demodulator Unit for necessary conversion to provide an audio output. User controls are similar to the CHC (RA–17). Each channel of the receiver is fed by the appropriate loop of the aerial system.

4. **Bearing Indicator Unit.** Contains the deflection and sensing amplifiers to provide drive for cathode ray tube presentation of bearings and sense indication. Facilities are provided for channel reversal, which permits rapid assessment of phase and gain balance of the system.

5. **Control Demodulator Unit.** This unit comprises three primary sections:

a. The system switch which selects one of the following modes of operation:
Intercept 1. Intercept 2. Test Indicator. Test Receiver. Test Aerial. D.F.

b. The test oscillator which operates in conjunction with the system switch in any one of the three test modes on one of ten pre-selected frequencies.

c. Essential units and user controls for the reception of SSB and FM signals.

6. **Aerial Switching Unit.** Switches the necessary units at 10Hz, so as to select the appropriate modes for sensing and assessment of channel alignment in the three Test modes and the D.F. mode.

7. Provision is made for a blown air supply and CO_2 injection.

8. The transformer coupling unit may be bulkhead mounted or mounted on top of the cabinet assembly.

9. **Procedure for Setting Up on a Task Frequency**

1. Set the SYSTEM SWITCH to TEST RECEIVER.
2. Select the appropriate frequence on the TEST OSCILLATOR SELECTOR.
3. Switch the R.F. RANGE switch to WIDEBAND.
4. Tune the receivers to the Test Oscillator frequency by means of the MHz and kHz controls.
5. Set the BANDWIDTH SELECTOR to 3 kHz.
6. Select the appropriate R.F. Range frequency setting.
7. Switch the R.F. ATTENUATOR to MAX.
8. Adjust the R.F. TUNE control for maximum amplitude signal indication on the cathode ray tube.
9. Depress the CHANNEL REVERSAL switch and remove any apparent Gain of Phase imbalance with the P–S GAIN or PHASE controls.
10. Select the TEST AERIAL mode of operation on the SYSTEM SWITCH and observe that no phase of gain imbalance is indicated. (If the signal amplitude is low, adjust by means of the R.F. ATTENUATOR control).
11. Depress the SENSE switch and check for correct sense indication (F and S quadrant).

10. **Procedure for Taking a Bearing on the Task Frequency**

1. Set the R.F. ATTENUATOR to MINIMUM and the RF/IF GAIN control to MAXIMUM.
2. Set the SYSTEM SWITCH to D.F.
3. Tune for maximum signal amplitude on the cathode ray tube using the kHz and R.F. TUNE controls.
4. Adjust the Dial Bearing Indicator cursor over the signal direction.
5. Adjust the RF/IF GAIN for maximum CRT signal amplitude, increasing the RF Attenuation as required.
6. Depress the SENSE SWITCH to assess signal direction quadrant.

7. Read off the bearing from the tune bearing gyro indicator ring and depress the CHANNEL REVERSAL switch to check Phase and Gain balance of the two receivers.

8. Adjust the bandwidth as required and select the appropriate modulation mode to read the signal.

11. **Snap Bearing Procedure When Shifting to a Frequency not Known in Advance.** The system will be in use on some task frequency and all primary controls will, therefore, be in the correct modes for D.F. search. On being ordered to investigate some other frequency for D.F. purposes, the following procedure is recommended:

1. Set the R.F. ATTENUATOR to minimum and the RF/IF GAIN control to maximum.
2. Set the R.F. RANGE switch to WIDEBAND.
3. Tune to the signal frequency using the MHz and kHz controls.
4. Lay the dial bearing indicator cursor across the signal trace.
5. Depress the SENSE SWITCH, read off the bearing.

IF TIME PERMITS:

6. Select the appropriate R.F. RANGE setting.
7. Set the R.F. TUNE control for maximum signal and re-adjust the R.F./I.F. GAIN control as necessary for full scale deflection of signal on the CRT.
8. Realign the cursor as necessary and amend assessment of bearing.
9. Select the appropriate bandwidth and read signal if this is required.

4.5. D.F. OUTFIT FU1

DATE OF DESIGN. 1960

HANDBOOKS. B.R. 2303 (1) Technical Description and Maintenance
B.R. 2303 (2) Receiver Cabinet
B.R. 2303 (3) DF Cabinet
B.R. 2303 (4) Azimuth Indicator

ESTABLISHMENT LIST. E 215

FREQUENCY RANGE. 225 to 399·9 Mc/s

POWER SUPPLY. 115 or 230 V 45–65 c/s single phase a.c.

POWER CONSUMPTION. 1·3 kW

DESCRIPTION

1. FU1 is a shipborne automatic UHF D.F. equipment operating on single or two channel installation providing instantaneous visual presentation, on up to four display units in parallel, of the bearing of any signal received on one of ten switched preset frequencies.

It is fitted in Aircraft Carriers, Air Direction Frigates and Destroyers for aircraft safety and homing to replace VHF D.F. Outfit FV11. The Main Equipment is normally fitted in a separate UHF D.F. Office with remote indicators in the Aircraft Direction Room and Carrier Controlled Approach Room. A dotted line trace may also be presented on Radar P.P.I.s or C.D.S.

2. **Power Supplies.** The a.c. supply is fed to the Power Supply Panel via a bulkhead mounted mains ON/OFF switch. The panel provides power switching to anti-condensation heaters or via auto-voltage regulator to separate power units in Receiver and D.F. cabinets and Display Units.

3. **Aerial Systems**

a. D.F. Array. Two in number which consist of:

(1) Twelve unipoles mounted on a counterpoise for Aircraft Carriers.

(2) Eighteen dipoles arranged around a mast for Air Direction Frigates and Destroyers.

b. The Commutated Aerial D.F. System consists of a 1 kc/s Master Oscillator unit controlling the electronic switching of a ring of 12 or 18 aerials in cyclic order every milli-second giving 12 or 18 samples of the phase comparison between being fed through a Resonator to the D.F. Receiver.

c. Auxiliary Aerial. An outfit AJE which provides the UHF input through a second Resonator to the Auxiliary Receiver.

Note. In two channel equipments the Cabinets are duplicated with each Resonator providing two outputs.

4. **Main Units.** These are:

a. Receiver Cabinet consisting of Control Drawer, D.F. Receiver Auxiliary Receiver, Blower Unit and Resonator Drawer.

b. D.F. Cabinet with front panel consisting of Delay, Discriminator and bearing Resolution circuits. Rear panel consisting of Master Oscillator and Pulse Generation circuits and associated amplifiers.

c. Local and Remote Display Unit(s) incorporating C.R.T., associated circuits and Power unit.

5. Control Drawer provides

a. Local Line output reception from Auxiliary Receiver.

b. Voltages to operate Auto-Tuned Resonator motors and give Lamp indication.

c. Relay Unit Design 90 which allows remote channel selection.

6. **Receivers.** Both d.f. and Auxiliary receivers are similar to Receiver Outfit CUJ except:

a. They share common first and second local oscillators.

b. Frequency Selection is controlled from the Auxiliary Receiver.

c. Frequency control of first local oscillator takes place in Auxiliary Receiver.

d. I.F. Output only is required from d.f. receiver to d.f. Cabinet.

e. Two outputs are required from Auxiliary Receiver:

(1) I.F. Output to d.f. Cabinet.

(2) A.F. Output for local monitoring or remote reception.

The Auxiliary receiver has three main purposes:

(1) To stabilize the centre frequency of the d.f. signal to control the phase modulation.

(2) To prevent phase discontinuation on incoming signal.

(3) To provide audio monitoring.

7. DF Cabinet

a. The R.F. Output from the D.F. Aerial Array consists of a phase modulated signal directly related to the bearing of the transmitter station. This output is fed via a resonator to the d.f. Receiver, where, in order to demodulate the signal satisfactorily to extract the bearing information, an i.f. Output at 1 975 kc/s is provided for application to the d.f. Cabinet. The r.f. Output from the Auxiliary Aerial AJE is fed a second resonator to the Auxiliary Receiver where an i.f. Output at 1975 kc/s is also applied to the D.F. Cabinet.

COMBINING MIXER

b. The i.f. output from the Auxiliary Receiver is mixed with the output from a 130 Mc/s crystal oscillator and the resultant beat frequency at 1845 kc/s is then combined with the i.f. output from the D.F. Receiver, thus the 130 kc/s beat obtained carriers all of the original D.F. Receiver modulation and has the stability of the 130 kc/s oscillator regardless of receiver tuning, any phase discontinuations on the incoming signal occur virtually simultaneously at the d.f. and Auxiliary aerials and do not appear on the 130 kc/s beat.

c. Secondly the discriminator can only accept a phase excursion of ± 180 degrees, therefore the phase excursion is reduced from a possible ± 360 degrees at certain radio frequencies by applying the signal to Time Delay Circuit.

TIME DELAY CIRCUIT

d. This circuit changes the 130 kc/s beat to 80 kc/s by mixing with the output from a 50 kc/s crystal oscillator and then applies a one millisecond (the time for which one aerial in the d.f. Array is connected to the d.f. Receiver) time delay on the 80 kc/s signal, before combining with the 130 kc/s and undelayed voltage and the beat at 50 kc/s selected. This 50 kc/s signal now bears the difference in phase between two adjacent aerials in the array.

PHASE DISCRIMINATOR (DEMODULATOR)

e. Accepts the phase modulated 50 kc/s signal and un-modulated 50 kc/s output (from 50 kc/s crystal oscillator) and demodulates the signal to provide a low frequency amplitude waveform from the phase difference of the two inputs.

RESOLVER

f. Compares the phase of the low frequency amplitude waveform with standard or reference waveforms from a Reference Generator giving four d.c. waveforms proportional to the bearing information, and applied after amplification to the Bearing Display cathode ray tube producing the bearing of the incoming signal visually relative to true North.

8. **Display Unit**

a. The Local Display consists of a Power Unit, C.R.T. and facilities for audio monitoring. The Remote Display has additional facilities of Remote Channel Selection whereby the operator may select any of ten pre-set channels.

b. The Remote C.R.T. is in parallel with the Local C.R.T. and bearings displayed are:

(1) On inner scale, true (QTE) relative to true North.

(2) On outer scale, driven from the ship's gyro system true or reciprocal bearings relative to ship's gyro system, true or reciprocal bearings relative to ship's heading. A manually operated cursor facilitates reading.

c. Bearings of transmission may be obtained beyond the range of audible speech. The response time of one-fifth second is sufficient to give bearing indication.

d. In Emergency – Bearings can be taken two minutes following the switching on of the equipment.

Note. (1) At the Local Display a switch is provided to select either channel for presentation. (ii) At the Remote position, displays are duplicated, different channels being presented on each display.

9. **Operating Instructions**

a. Switch Bulkhead supply switch to ON. (Equipment requires a warming up period of 30 minutes for accurate bearings.)

b. On Power Supply Panel

(1) Switch Equipment/Heaters C.O.S. to Equipment.

(2) Switch Normal/Standby C.O.S. to Normal. Check Green Indicator lamp illuminated.

c. On Receiver Cabinet Control Drawer

(1) Switch Mains ON. Check Blower running and Blower indicator lamp (amber) illuminated. Check air blowing through exhaust ports. Check Mains indicator lamp (amber) on both receivers illuminated.

(2) Switch Mains on Control Drawer ON. Check control Mains indicator lamp (amber) illuminated. Check 24 V lamp (amber) illuminated.

d. On Receivers. (D.F. Receiver is tuned similarly to Auxiliary Receiver where appropriate.)

(1) Switch Mains ON (both receivers). Check LT indicator lamp (blue) illuminated.

(2) Switch H.T. ON (both receivers). Check that after thermal delay (60 secs.) has elapsed the H.T. indicator lamp (red) illuminated. After 15 to 30 secs. Channel Ready indicator lamp (green) is illuminated on Auxiliary Receiver.

(3) Turn Remote/OP/Local Set switch on Auxiliary Receiver to OP.

(4) Turn Channel Selector switch on Auxiliary to appropriate channel. Check that windows on Main Selector Unit on Auxiliary Receiver, the r.f. Selector Units on D.F. and Auxiliary Receiver and number on channel indicator dial on each Resonator indicate that channel selection has been followed.

(5) Switch to Local Set. Check that H.T. lamp goes out. Set up the four sliders on horizontal bar to code letters for the frequency required. (Local Set channel is indicated on left of Selector.) Return to OP. Check flags correspond with code set up, in right window. (The operating channel is now indicated on Selector Unit.)

(6) To tune r.f. stages. Switch A.G.C. Off. Muting Off and turn r.f. Gain fully Clockwise. Set Meter Switch to Position 2 (Detector Current). Unlock r.f. Selector Unit and insert tuning key. Set

r.f. Selector Unit to approximate setting from calibration chart. Turn tuning key for maximum indication in meter. (Approach peak clockwise.) (If meter indication exceeds full scale, reduce r.f. Gain.) Lock dial, remove tuning key to stowage.

(7) Switch Channel Selector Switch to next channel, after auto tuning cycle has completed return to original channel.

When Channel Ready lamp illuminated, check meter indication is as before, if not repeat tuning procedure.

e. To Tune Resonators

(1) Turn Resonator switch to appropriate resonator. Unlock appropriate resonator, insert vernier drive knob and set dial to approximate setting given on calibration graph.

(2) To produce target signal:

(*a*) Key 692 on low power (Tune) using same frequency or

(*b*) Depress Buzzer switch on Resonator, then:

With A.G.C. Off, Muting Off and r.f. Gain set to give half scale deflection in meter on Auxiliary Receiver,

If (*a*), Adjust Resonator tuning for maximum Auxiliary Receiver meter indication, adjusting r.f. Gain to prevent overloading.

If (*b*), Adjust Resonator for maximum resonator meter reading. (Approach maximum indication clockwise.)

(3) Lock the thumbscrew on resonator and remove vernier drive knob.

(4) Switch A.G.C. ON, Muting ON and r.f. Gain fully clockwise. The Line Gain control should be left at mid-scale position.

f. To set audio output from Auxiliary Receiver

With no signal imput, adjust r.f. Gain Control until the receiver noise just falls below audible level with headphones plugged into Control Drawer and its volume control fully clockwise.

g. To switch on power supplies to DF Cabinet

(1) Open front panel door and reset gate switch. Neon indicator lamp should illuminate.

(2) Switch Mains ON.

(3) Switch 6·3 a.c. switch ON.

(4) Switch Blower switch ON. Check exhaust fan functions.

(5) Switch 350 V H.T. and 250 V H.T. switches on.

(6) Check meter indications for each switch position is as indicated.

Note. The power unit is normally left ON and cabinet doors closed.

h. To set up Display Units

(1) For Local Display the a.c. Supply is provided direct from bulkhead Mains C.O.S. For Remote Display the S.C. supply may be switched to Anti-Condensation heaters or the Display Unit.

(2) Switch STAB. H.T. switch on Power Unit to ON.

(3) Turn BRIGHTNESS control on Azimuth Indicator (C.R.T.) a small amount clockwise (thus operating the Mains On/Off switch). Check that when equipment has warmed up 280 V (stabilized) indicated in meter.

(4) After 30 minutes warming up period, switch external Test Signal. (692 or other suitable signal source.) Adjust BRIGHTNESS and FOCUS controls for maximum sharpness of trace. Memorize the setting of BRIGHTNESS control.

(5) Remove the Test Signal by pressing the D.F. CENTRE CHECK button.

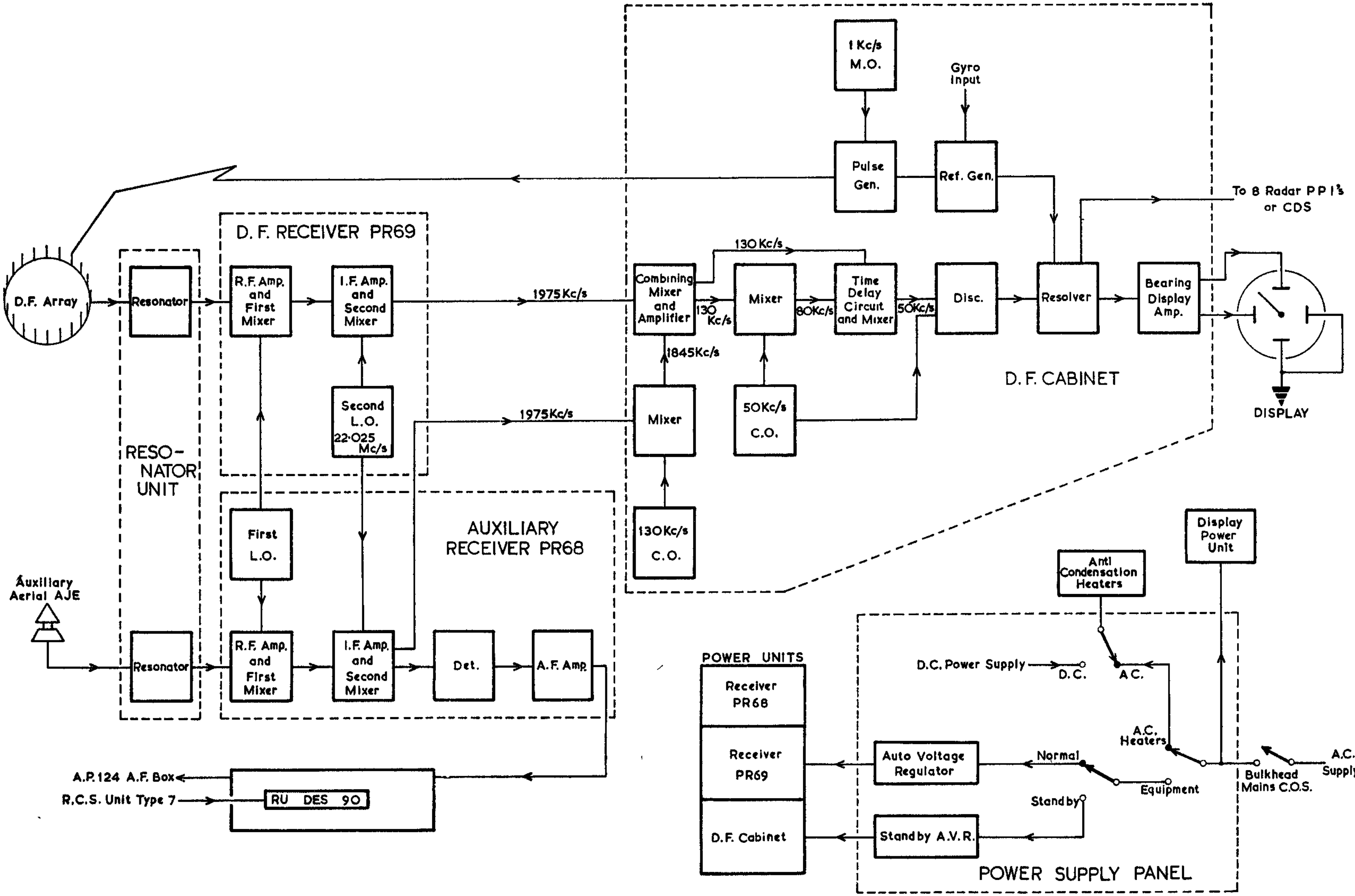


FIG. 1. DF OUTFIT FU1

(6) Check that centre marking spot on Indicator is concentric with scale on the face of C.R.T. If it is not, adjust SPOT SHIFT controls. If spot shift controls are reset, repeat (4).

(7) Increase the brilliance of the display by adjusting BRIGHTNESS control, and if necessary, adjust ZERO BALANCE controls to reduce any residual trace to a minimum level.

Reset the BRIGHTNESS control to original memorized setting.

Note. Use Minimum BRIGHTNESS compatible with a readable display to conserve the life of the C.R.T.

(8) Restore the D.F. equipment to normal by releasing the CENTRE CHECK button. Adjust the TRACE LENGTH control as appropriate and adjust the scale illumination by means of the SCALE BRIGHT/DIM control.

(9) Switch Off the 692 or other r.f. signal source.

(10) To obtain QUJ (True Reciprocal) bearings depress QTE/QUJ spring-loaded switch to QUJ position.

If required the cursor may be rotated by means of the thumbwheel on the side of the hood to:

(*a*) enable accurate bearings to be taken when trace is too short;

(*b*) store and indication due to signal of short duration;

(*c*) estimate the mean position of a fluctuating trace.

4.6. D.F. OUTFIT FU3

DATE OR DESIGN. 1960

HANDBOOKS. B.R. 1175 (1) Operating Instructions and Technical Description and Maintenance
B.R. 1175 (2) Block layout and Circuit Diagrams
B.R. 1175 (3) Remote D.F. Indicator

ESTABLISHMENT LIST. E 1204

FREQUENCY RANGE. 225 to 399·9 Mc/s

POWER SUPPLY. 115 or 230 V 45 to 65 c/s. Single phase a.c.

POWER CONSUMPTION. 1·2 kW

GENERAL

1. FU 3 is a modified shore installation similar to D.F. Outfit FU1, the principal difference between the outfits being:

a. Two independent channels are available, one functioning on either of two pre-selected frequencies and the other on any one of five pre-selected frequencies, outputs from the receiver i.f. stages being switched to their respective i.f. stages as required.

b. Outputs are provided from each display for feeding into the UHF Triangulation Fixer network.

c. The D.F. Array consists of the 18 unipole system only.

d. The Receivers' first and second i.f.s are 15 Mc/s and 2 Mc/s respectively with the second local oscillator crystal controlled at 17 Mc/s.

e. On a Naval Air Station, a D.F. Building houses the main equipment, the remote control and display being available in the airfield control tower.

f. For description see D.F. Outfit FU1 details.

4.7. SHF DF SYSTEM UA3

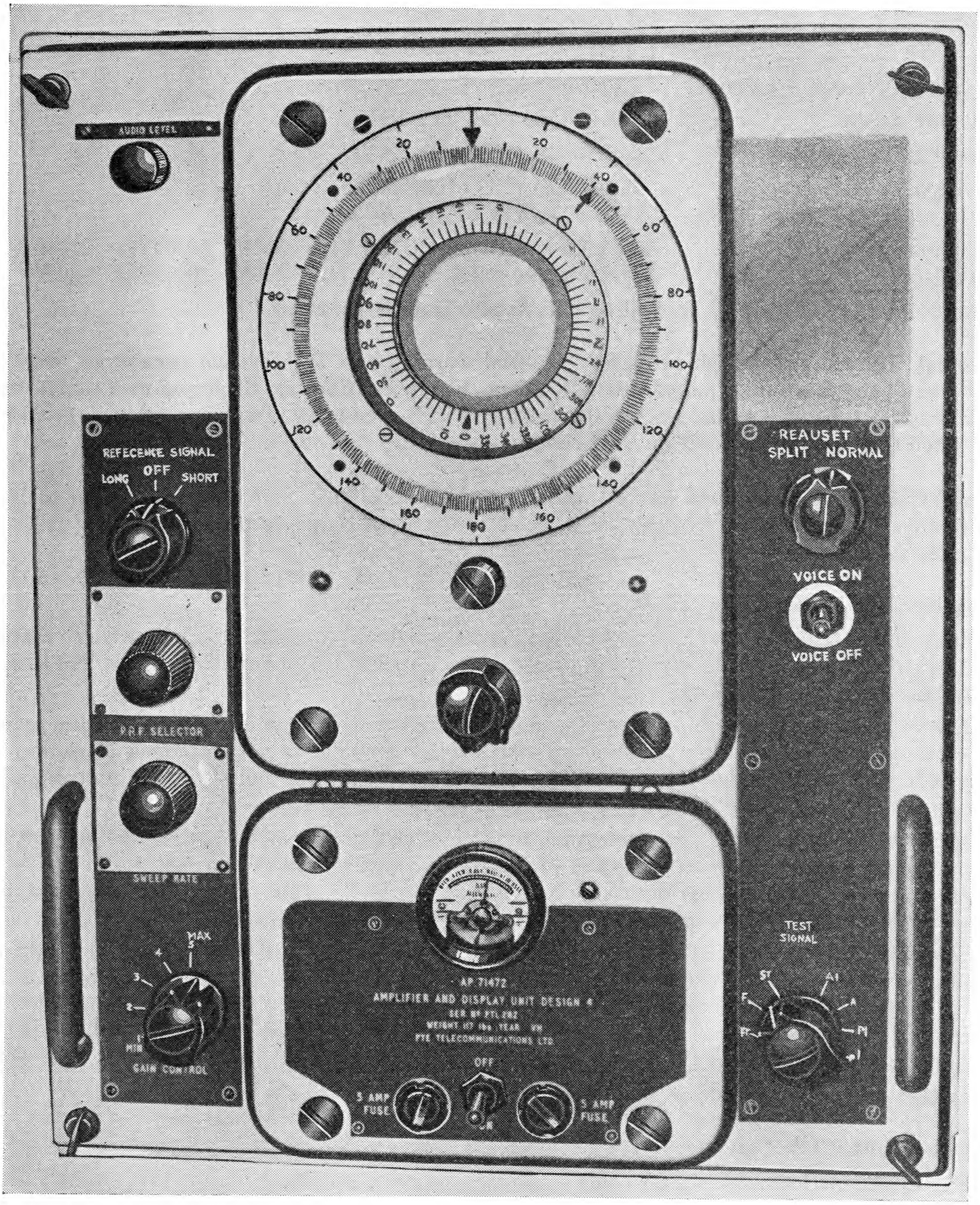


FIG. 1

For details see over

DATE OF DESIGN	1959
HANDBOOK	BR 2349 (Office Equipment) BR 2354 (Aerial Outfits)
E LIST	E 1231
PLANNED MAINTENANCE SCHEDULE	R22/60
FREQUENCY RANGE	2500 – 11500 MHz in 3 Bands
FREQUENCY BAND DIVISION AND AERIAL OUTFIT	'S' 2500 to 4100 MHz AYC 'C' 4100 to 7000 MHz AYD 'X' 7000 to 11500 MHz AYE
POWER SUPPLIES AND CONSUMPTION	Amplifier and Display Unit 115 – 230V 50/60 Hz 250W Switching and R.I.S. Unit 110 – 250V 50/60 Hz 70W
RECEPTION	Pulsed R.F. signals from target radar

1. **General.** The UA3 is a high probability tactical warning and D.F. system capable of surveillance in any one of the previously quoted radar frequency bands. Bearings are displayed as a radial trace on the cathode ray tube with an accuracy better than $\pm 10°$. No frequency tuning is employed, the whole of the selected frequency band being covered continuously.

2. **Aerial Outfit.** Comprises three sets of four horn aerials. Fore, Port, Starboard and Aft for each of the three frequency bands. Radio frequency is detected in the aerial outfits to produce a pulsed D.C. which suffers less attenuation.

3. **Amplifier and Display Unit**

a. Each of the four channels (F, P, S, A) is fed via the aerial selector switch to the four video amplifiers, each controlled in gain by a ganged, five position selector switch. The amplifiers are wideband type so that pulse shape is maintained at a minimum distortion.

b. The amplified signal is then passed to the output amplifiers which comprise four deflection amplifiers which drive CRT for bearing presentation and a mixer amplifier which combines a portion of all four deflection amplifier outputs to provide a common audio output and a pulse brightening output. The input to the audio amplifier is variable by the audio gain control.

c. The UA3 signal audio output is presented to the left hand phone socket and can be made available at the right hand phone socket when the phone selector switch is in the normal position. The radio communication receiver audio output (via KH) is made available at the right hand socket, and may be temporarily disconnected by depression of the spring loaded Voice ON – OFF switch.

d. The pulse brightening output is used to trigger the CRT cathode in such a way that brilliance is applied by signal presence. This allows the CRT brilliance control to be reduced and so reduce operator eye strain to a minimum during no signal conditions. The intensity of CRT presentation is dependent upon the P.R.F. of the signal and therefore provides a facility for visual assessment of signal P.R.F.

e. Brilliance, Focus, P–S and F–A shift controls are provided for initial setting up of the CRT. On completion, the brilliance may be reduced so that no spot appears on the CRT.

4. **Switching and R.I.S. Unit**

a. To reduce interference from own ship's radars, sync pulse outputs from the ship's radars are connected into the R.I.S. and Switching Unit, amplified and used to provide a gating pulse which is used to remove interfering signals from the CRT. Audio breakthrough from own ship's radars will occur.

b. To reduce interference from consort radars a portion of all signal inputs is fed to four amplifiers in the R.I.S. and Switching Unit and via the blanking level control to further stages to produce a gating pulse. The blanking level control will decide the minimum signal level necessary to produce a gating pulse. Signals below this level will not initiate a blanking pulse and will indicate on the CRT normally.

5. **Internal Test Signal.** To enable the operation of video amplifiers and output amplifiers to be checked, a common test signal source is available. Overall gain of the test signal is by means of the Test Level control. The test signal may be fed to each amplifier in turn or to adjacent pairs of amplifiers in order to observe octantal bearing presentation. P.R.F. of the test signal is variable between approximately 200 and 2500 Hz, by use of the P.R.F. selector control.

6. **Reference Signal.** A reference signal is also available for audio familiarisation and operates in either the long or short duration mode which simulates broad or narrow beam radars respectively. A variable sweep rate control allows for speeds of 0.4 to 2.5 S.P.R. to be selected. P.R.F. is controlled in a similar manner to that of the test signal.

7. **Detection Crystals for Aerial Outfit**

a. Because of attenuation problems, the detection crystals in the aerial system AYE are placed in the horn aerial. Crystals for aerial systems AYC and AYD are placed in the R.F. Units. The RF units are necessary to filter unwanted strong signals outside the design frequency limits so that only those within the band will appear on the CRT.

b. Due to the differences in crystals, aerial feeders, etc., it is essential that an overall balance of the system can be achieved to give best bearing accuracy consistent with reasonable sensitivity.

c. To ease balancing problems, crystals are to be matched before fitting in aerials or RF units in accord with BR 2349 Part 2 Chapter 5 para. 6. Test sets design 15 (AYC), 19 (AYD) and 21 (AYE) are available for crystal matching and overall balancing.

d. To obtain best performance from AYE (X band) the aerial lines have no balancing facilities – balance being achieved by use of the Output Amplifier gain balancers. Then, leaving these controls as set up for X Band, the AYC and AYD are balanced by use of the aerial line attenuators, situated on top of the R.I.S. and Switching Unit.

8. **Passive Crystal Protection in Aerial Outfit AYC.** The crystals in the AYC RF Unit are provided with protection against unduly high signal levels by the provision of passive protection cells. A priming voltage for these cells is controlled from a switched unit in the EW office. It is to be noted that these cells have an optimum life of 1500 hours and therefore should only be used when it is expected that strong signal environment will be of short duration, e.g. during R.A.S., etc. For prolonged periods in harbour the crystals should be removed. See BR 2354 Page 19 and Page 8 para. 15.

9. **System Checks**

a. Daily – User check in accordance with planned maintenance schedule R 22/6C.

b. Weekly – (If mast availability permits). Overall channel balance check in accordance with BR 2349 Part 2 Chapter 5 para. 7.

c. Three Monthly – Check of office equipment, aerials and feeders in accordance with BR 2349 Part 2 Chapter 5 para. 8.

d. Before making large alterations when gain balancing, the considerations, bearing accuracy versus sensitivity should be taken into account – guidance is given in BR 2349 Part 2 Chapter 4.

10. **Live Checks.** It is important that every opportunity be taken to check the system against live radars for both bearing accuracy and maximum intercept range performance. This is the only really valid check that the system is operating satisfactorily at best sensitivity. Bearings can be compared with those available in the Ops Room and should at all times be better than $\pm 10°$. Maximum intercept range should at least equate with the figures given in BR 2349 Part 2 Chapter 4.

11. **Check of Pulse Blanking**

a. In addition to the method detailed in BR 2349 Part 2 Chapter 5 para. 9, the operation of pulse blanking may be checked by the operator without the need for additional test equipment.

b. The test signal is fed to the video amplifier and to the RIS Switching Unit. The test signal output level is linked to the gain control of the video amplifiers. When the video amplifier gain control is at minimum, the test signal output is at maximum. As the video amplifier gain is increased, the test signal output is reduced by an equal amount. This is in order to maintain equal trace length from the test signal under all positions of the gain control.

c. With the gain control at minimum, the high level test should be blanked and thus removed from the CRT by a small clockwise movement of the blanking level control. Leaving the blanking level control at the position where blanking has occurred, the gain control can now be increased, thus reducing the test signal output, to an amount less than is necessary to activate a blanking pulse – the test signal trace should now re-appear. Further movement of the blanking level control should blank the test signal – *et seq.*

12. **Care of Aerials.** The aerial units and R.F. units must be kept free from dirt and paint (other than that applied in manufacture) at all times and the surface cleanliness of bare metal surfaces around access panels must be checked at least weekly. The ingress of dirt or damp will quickly and adversely affect overall performance.

13. **Crystals.** The current type to be used are the CV 7181/2/3 series, which have a forward bias applied to increase the sensitivity of the system.

14. **Information available from UA3 Intercept**

Radar Frequency Band

A.R.P. (SPR) by stop watch measurement

P.R.F. by audio or visual assessment

Mode of operation of radar – intermittent, etc.

Bearing of emitter to within ± 10°.

15. **Operation of UA3.** The UA3 must be operated in gain position 5 in order that maximum intercept range may be achieved. To reduce operator fatigue, when a group of UA3 fitted ships are in company, the Standby and Alert methods may be employed. There is no point in putting this type of equipment to the Loudspeaker state of operation. RNCP 10 805 & 2019 refers.

16. **Intercept Range.** This is difficult to indicate in average figures, because conditions vary and so do output power of radar types. But a guide can be given for specific examples of radars, under normal propagation conditions.

UA3 in Frigate – 992 in DLG	Intercept 40 – 45 miles
UA3 in Frigate – ASV 21 Shackleton (at 1000 ft)	65 – 70 miles
UA3 in Frigate – 978 in frigate	25 – 30 miles
UA3 in Frigate – 1000 in S/M (S/M dived)	10 – 14 miles

Note: The above figures do not take into account the possibility of operation in a dense radar environment, in which case the signal at maximum intercept range, although indicating on the CRT may well be masked by other signals and not be recognised until a significant signal increase lifts it above the interference – thus giving a reduced first detection range.

17. **Calibration.** Full details in BR 2357.

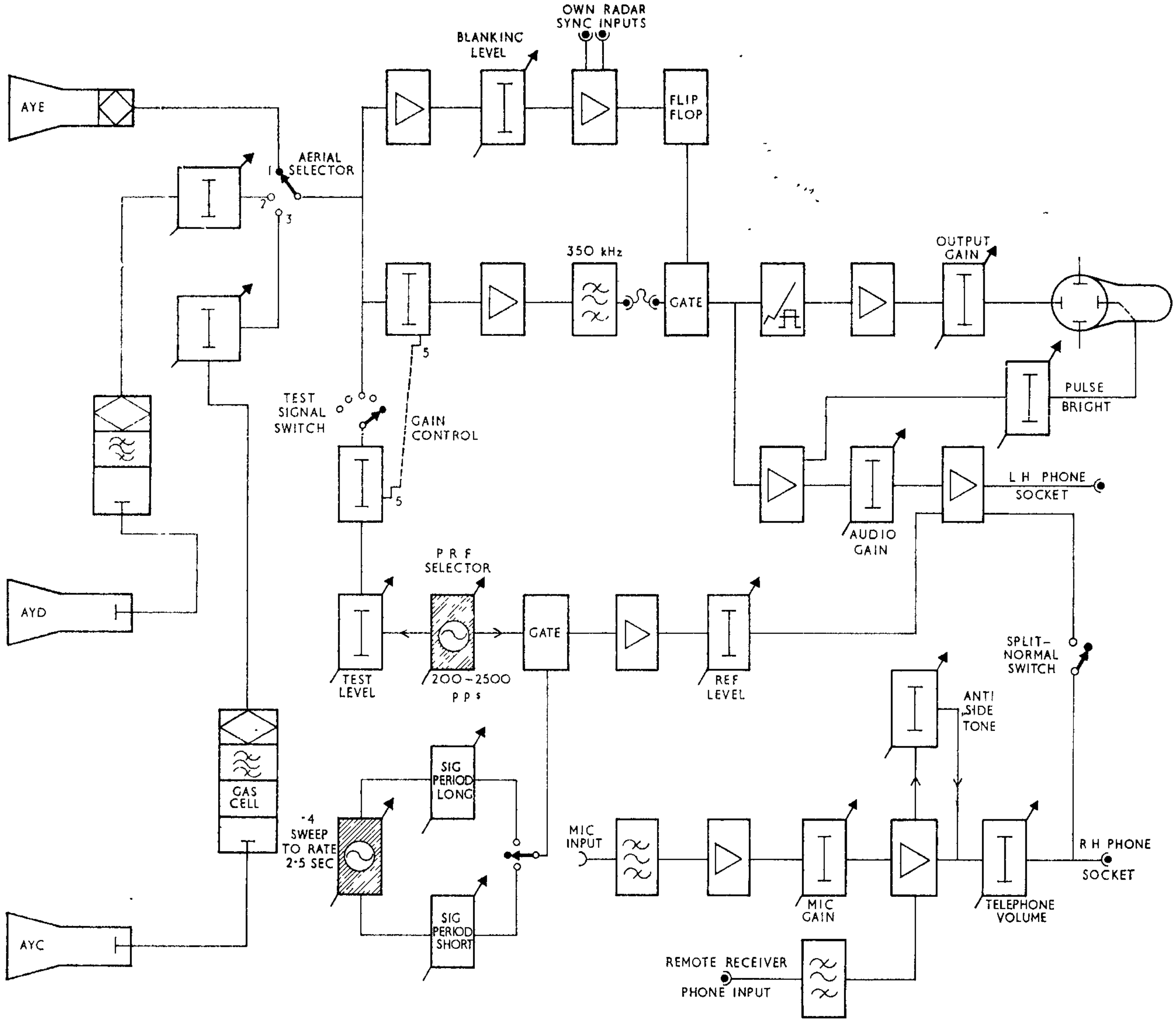


FIG. 2. SHF DF SYSTEM UA3 – BLOCK DIAGRAM

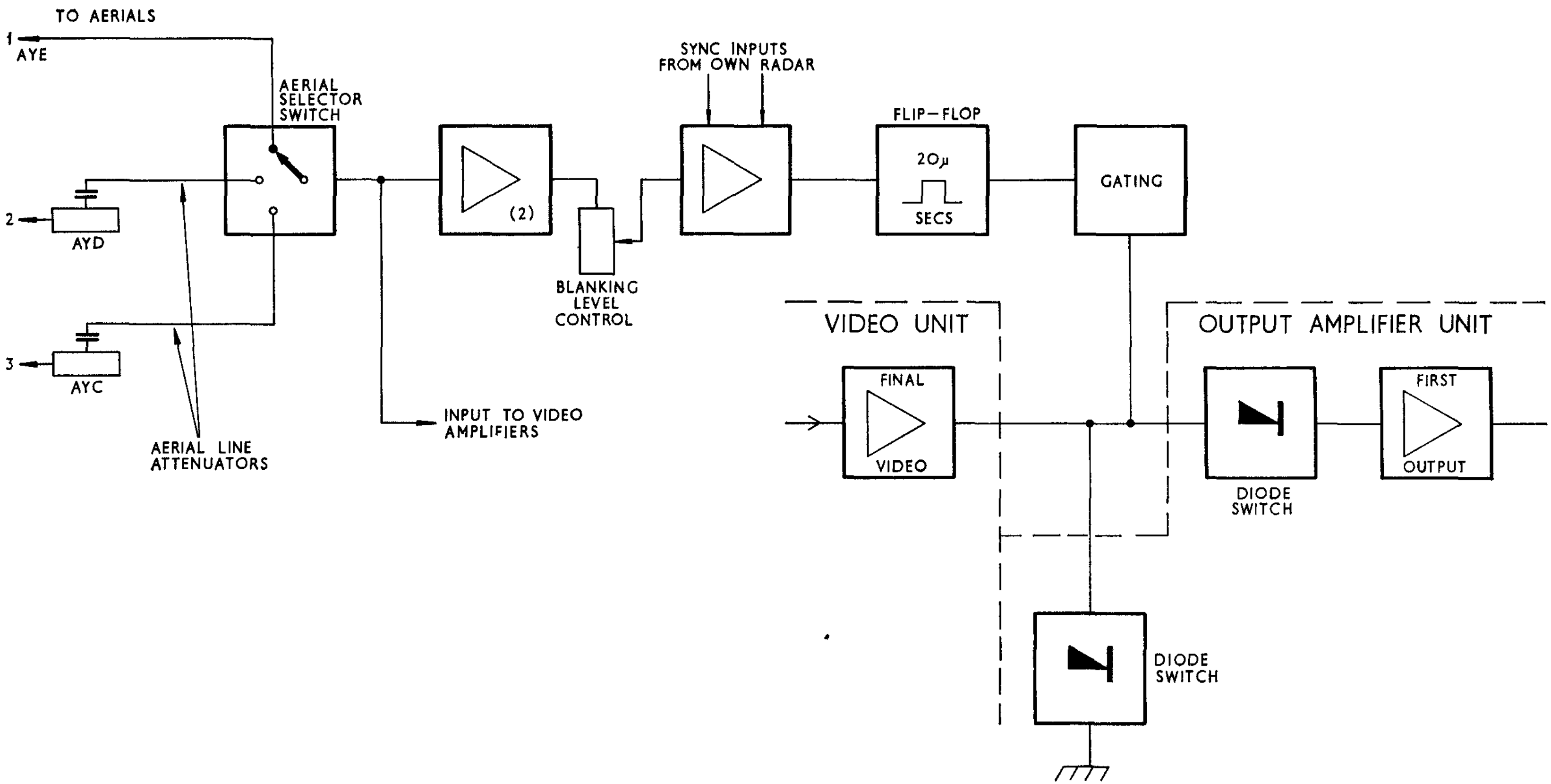


FIG. 3. UA3 – SWITCHING AND R.I.S. UNIT – BLOCK DIAGRAM

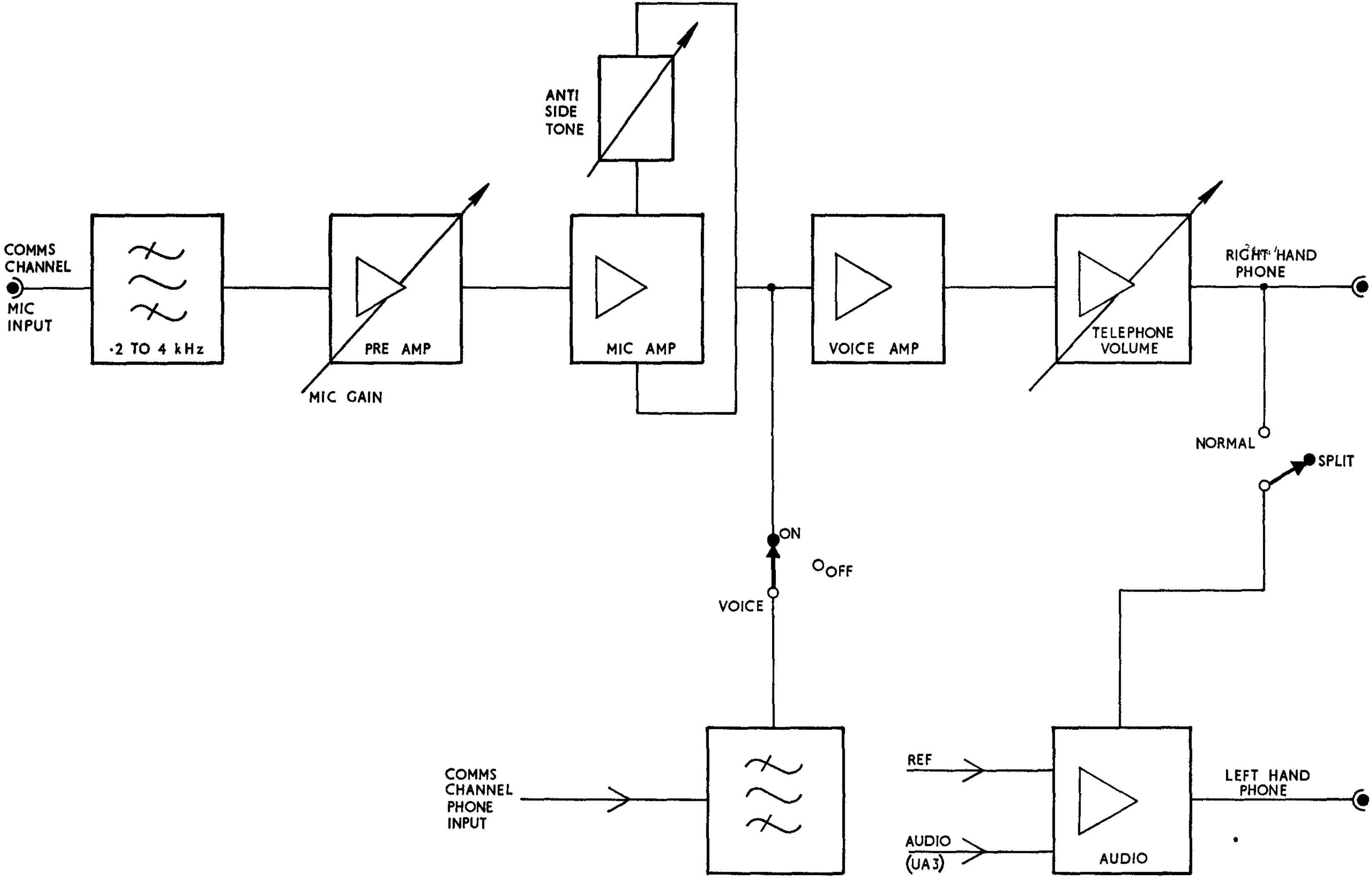


FIG. 4. UA3 AUDIO SYSTEM – BLOCK DIAGRAM

4.8. MAGNETIC TAPE RECORDING OUTFITS REH 3 AND REH 4

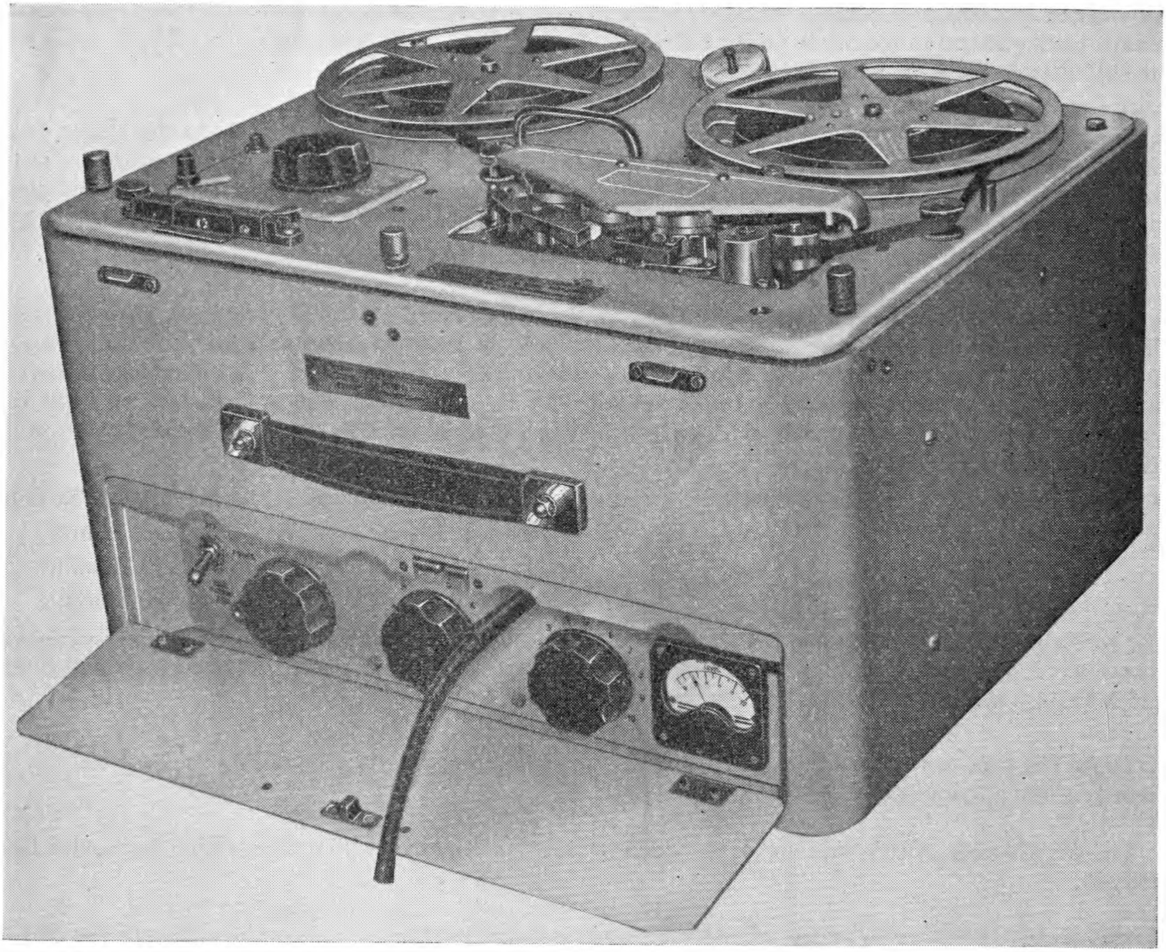


FIG. 1

DATE OF DESIGN	1959
HANDBOOK	BR 1174
ESTABLISHMENT LIST	E 1191
POWER SUPPLIES	100–200V or 200–250V at 50Hz. (If a 60Hz supply is to be used, the capstan pulley must be changed to maintain the correct tape speeds).
PLANNED MAINTENANCE SCHEDULE	R21/5C
PURPOSE	Various monitoring purposes and training.

General

1. **General.** In both recording outfits REH3 and REH4, the tape deck and amplifier units are similar. The REH3 is designed for table mounting and the REH4 is designed for mounting in a standard 19 inch rack. In the rack mounting the tape deck and amplifier units are mounted separately with the tape deck mounted at a steep angle to permit easy access to the tape spools.

The REH will permit recordings to be made and played back with no requirement for processing and the recordings can easily be stored for future reference or use for long periods without appreciable loss in response or reproduction quality. WIND ON and WIND BACK facilities are available for speedy transfer of tape from one reel to the other. Outfit REH3 will be described, although some outfits REH1 and REH2 are still fitted in the R.N. (but are basically similar in operation).

2. **Inputs and Outputs.** The tape recorder requires inputs to the amplifier which feeds the record head. In the playback mode of operation the output from the playback head is fed through the amplifier to the required outputs. The REH is designed to record from either a 600 Ohm line input or a high impedance microphone input. In the playback mode, outputs are available at a 600 Ohm line output socket, a 2.5V telephone output or to an internal loudspeaker at 500mW.

3. **Speed Control (Tape Deck).** Three speeds are available for recording and playing back, thus providing three bands of frequency response for recording, making the recorder adaptable for processing various forms of signal. Control of speed is effected by a slide and drop gear change which dictates the correct dimensioned pulley to be engaged in operation with the capstan motor. The pulley is a long triple diametered type. (A spare being provided for use with 60Hz input mains frequency). The three speeds and the relevant data are as follows.

Recorder Speed	Tape Speed	Response	Play Time Per Track
FAST	$7\frac{1}{2}$"/Sec.	60 – 10,000Hz	30 Minutes
MEDIUM	$3\frac{3}{4}$"/Sec.	60 – 5,000Hz	60 Minutes
SLOW	$1\frac{7}{8}$"/Sec.	60 – 2,000Hz	120 Minutes

For recording hand speed morse the slow speed will provide sufficient fidelity to cover the frequencies encountered. For speech or high speed morse the medium speed may be used. Pulse signals and others which require maximum fidelity, the fast speed must be used.

4. **Tape.** The tape normally used is in 1200 ft lengths on 7″ reels with two recording tracks available, the recording and playing back effected on the upper track.

5. **Logging Counter.** A turns counter is provided for logging purposes with a zero setting and scaled from 0 to 999.

6. **Bias Switch.** At the rear of the recorder a switch is provided for normal and low bias to the record/playback head. When using interservice tapes a low bias is to be used as indicated on the tape leader, for all other tapes switch left in BIAS NORMAL.

7. **Meterswitch.** Adjacent to the bias switch. In the READ BIAS position the bias to the Record/Playback head is shown on the meter. In the READ LEVEL the meter shows signal level being recorded. In both cases the meter is only in the circuit in the record mode.

8. **Tape Splice.** To facilitate tape joining, splicer is fitted on the tape deck.

9. **Meter.** Reading signal level, set by manufacturers to peak at 8 with only 5 per cent distortion and in circuit only in record mode. A zero setting control is also provided to accurately set the meter with no signal input.

10. **Modes of Operation.** The tape recorder will operate in any one of four modes, as selected by the system switch mounted on the tape deck, these are:

RECORD WIND ON WIND BACK PLAYBACK

a. RECORD MODE. Recordings can be made either from a 600 Ohms line or a microphone input via a matching transformer. The microphone input is passed through three stages of amplification before

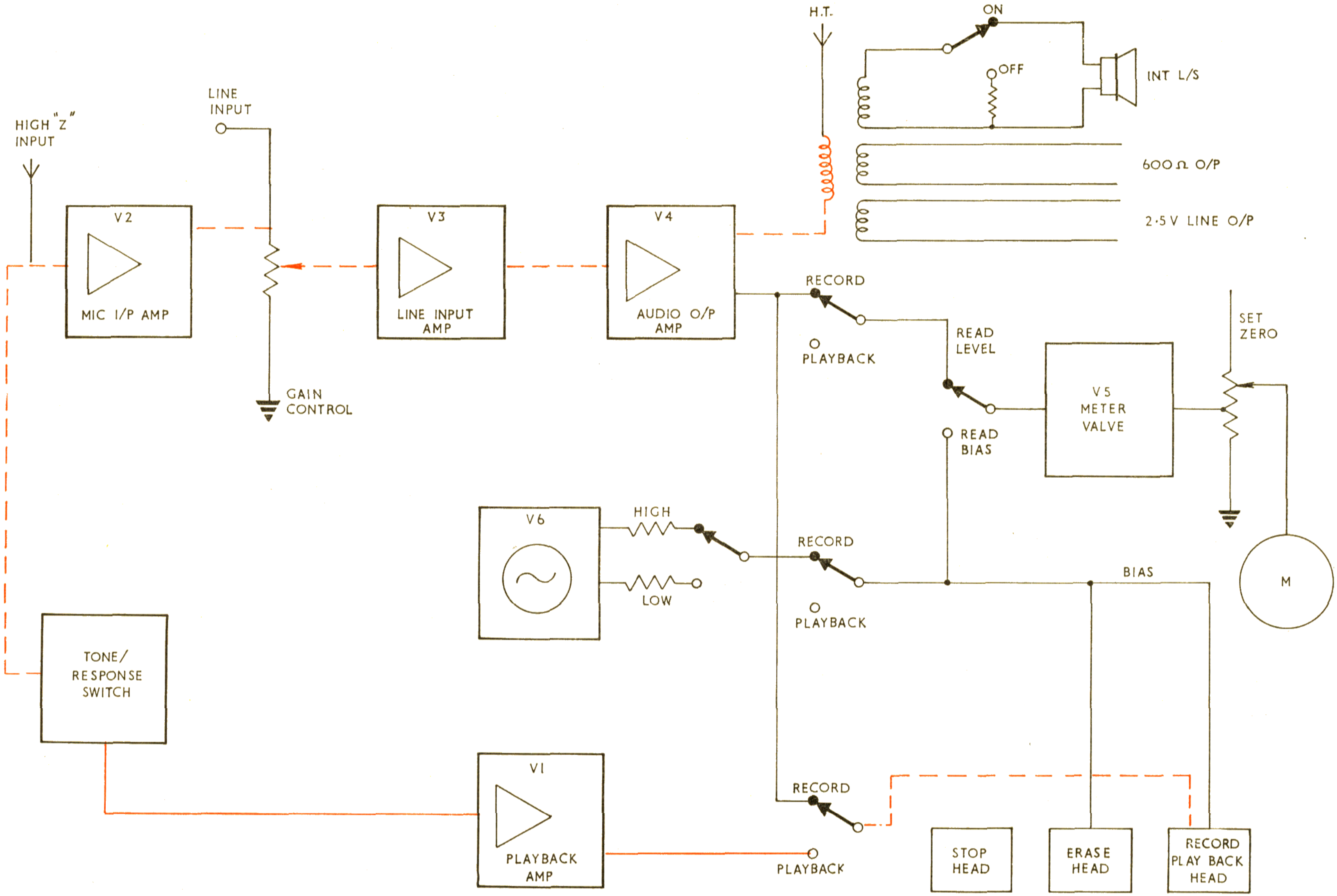


FIG. 2. R.E.H. 3/4 – BLOCK DIAGRAM

application to the recording head. The line input at 600 Ohms is usually from a companion receiver and thus at much greater amplitude than the microphone and easily variable, so this is passed only through two stages of amplification before application to the record head.

The input gain control in the recorder in both cases of input is effected on the second amplifier stage by means of the gain control. The signal is passed from the final amplifier to the record head via the system switch, when in the record position. The system switch also applies H.T. to the oscillator valve and the meter valve. The oscillator gives an approximate output of 51 kHz, used in the erase head to ensure that any previous recording is erased before the present recording is applied to the tape. A portion of this oscillator output is also applied as a bias to the record head to avoid any interference which may be caused by the oscillator valve and the meter valve. The oscillator can be varied to overcome any variations of the iron dust core in the oscillator circuit, the control of which is situated at the rear of the chassis. The system switch also energizes the capstan and take-up motors, via the start switch.

b. PLAYBACK MODE. In this position of the system switch the source of audio reproduction is the record/playback head and the tape. The voltage pick-up on the tape as a result of the magnetic field cutting the playback head coils is very small, so this voltage is passed through a pre-amplifier before passing through three stages of amplification. The anode circuit of the pre-amplifier contains a switched R.C. circuit, controlled by the response switch, which enables the recording to be played back at the same sound level as the signal recording, but at much greater amplitude. The positions of the response switch are marked A to F and give various frequency response ranges.

"D" level response ± 3dB from 60 to 10,000 Hz at fast speed.

"E" as for "D" but with some attenuation at high frequency end.

"F" as for "D" but with more severe high frequency attenuation than "E".

"C" as for "D" but with bass attenuation.

"A" level response to 5,000 Hz at medium speed.

"B" as for "A" but with bass attenuation.

In playback, the system switch also removes the H.T. from the oscillator and meter valves and thus the bias from the record head, and energizes the capstan and take-up motors. Any input plug used during record must be removed to allow the amplifiers to function.

c. WIND ON AND WIND BACK MODES. The motors now run at a very high speed to facilitate rapid positioning of the tape to its desired position, and as the machine is under local supervision, the auto stop is not functioning, but held off. In the wind on position the system switch energizes the capstan and take-up motors, and in the wind back position energizes the capstan and rewind motor.

11. **Electronic Voice Operated Switching Unit (E.V.O.S.).** This is an externally fitted unit and found on the right hand side of the recorder. It is designed to extend the usefulness of the REH. It finds its greatest usefulness in situations where intelligence to be recorded arrives in the form of short passages followed by long no-signal intervals. By switching the recorder on only when a signal is present, the traffic of many hours can be recorded on a reel of tape that would have a continuous running of one hour or less. In order to provide for remote-control and voice operation, the capstan motor lead is broken and the connections taken to the 8 pin octal socket at the rear of the recorder. For the same reason the oscillator H.T. feed is also broken and taken to two points of the same socket. Before the recorder can be used therefore, in the absence of the voice-operation unit, it is necessary to insert the dummy octal plug provided, which has shorting links, to bridge these broken connections. This unit consists of a three position system switch as follows; voice operation, remote and off/playback. A jack for use with the remote position and a sensitivity level control for use with voice operation.

a. VOICE OPERATION. In circuit only in the record mode. Incoming signal activates capstan motor and oscillator H.T. A delay relay will keep the recorder running approximately 10 seconds after the incoming signal has ceased. Sensitivity control should be set at "0" (Min) and a steady tone signal equal to the weakest signal it is desired to record should be fed into the recorder unit, then by rotating sensitivity control slowly clockwise the recorder will start to record. This is the position the sensitivity control should remain at. If the signal intended for recording is too weak the background noise will activate recorder and the tape will just keep recording.

b. REMOTE. In circuit in record/playback positions. The tape mechanism can be started and stopped via octal socket at rear of the equipment. Makes or breaks feed to the capstan motor and oscillator H.T. when switched on or off from the remote position. Remote operation is secured by keying the relay of a simple switch connected through the jack on the front panel of the E.V.O.S. unit.

c. OFF/PLAYBACK. The recorder is in normal state for local use as the H.T. is supplied continuously throughout the relay system.

12. Differences between REH3, 4 and 1, 2 can be found in the relative handbooks.

13. **Stop and Start Switches.** In all the described modes the start switch has to be made to complete the selected motor circuits and consists of a hold on relay. In the record and playback modes this is controlled by the auto stop spring loaded switch, held in the off position by the tape. When the tape has passed by the sprung arm, the arm drops into a recess and cuts off the start switch, thus stopping the recorder. To stop recorder a small press button is provided near the start switch.

14. **Operation**

RECORD (LOCAL)

1. Switch on MAINS switch and green light will indicate power is supplied to the recorder.
2. System switch to WIND ON or WIND BACK.
3. Insert tape into "V" with dull side inwards (shiny side towards you).
4. Meter switch to read LEVEL adjust zero control to read ZERO.
5. BIAS switch to read BIAS NORMAL or as indicated on tape leader.
6. Select desired speed by use of bar speed control.
7. E.V.O.S. system switch to OFF/PLAYBACK. If E.V.O.S. not fitted check dummy octal plug is inserted in rear of recorder.
8. Select appropriate input, HIGH "Z" for microphone and 600 OHMS for receiver, etc.
9. System switch to RECORD and adjust VOLUME control to peak meter at 8 when signal is being received.
10. Switch on START switch.

RECORD (REMOTE)

1 to 6.

7. E.V.O.S. system switch to REMOTE and plug in remote switch jack plug.

8–10.

11. Switch on from a remote position.

RECORD (VOICE OPERATION)

1 to 6.

7. E.V.O.S. system switch to VOICE OPERATION and adjust SENSITIVITY control with a tone equal to the weakest signal it is desired to record.

8–10.

PLAYBACK

1 to 3.

4. Insert desired speed.

5. E.V.O.S. switch to OFF/PLAYBACK. If E.V.O.S. unit not fitted check dummy octal plug.
6. Select appropriate output.
7. RESPONSE switch to position D or as required.
8. System switch to PLAYBACK.
9. Switch on START switch.
10. Adjust VOLUME control to desired level.

15. **To Erase Tape.** To erase a recording the recorder is set in the record mode and volume level is set to minimum to avoid a whistle being recorded due to the instability of the amplifiers as no signal is present.

16. **Monitoring Recording.** The signal being recorded can be monitored at the recorder as the audio outputs are active during recording. It is, however, desirable to have the loudspeaker off to avoid any possible feed-back from any local microphones, and to use the phone outputs.

17. **Planned Maintenance Schedule. R21/5(C). Daily Checks.** Check the correct functioning of playback and record in local and remote modes of operation. Check record function in E.V.O.S. mode.

4.9. DF OUTFIT FM16 (MARCONI LODESTAR)

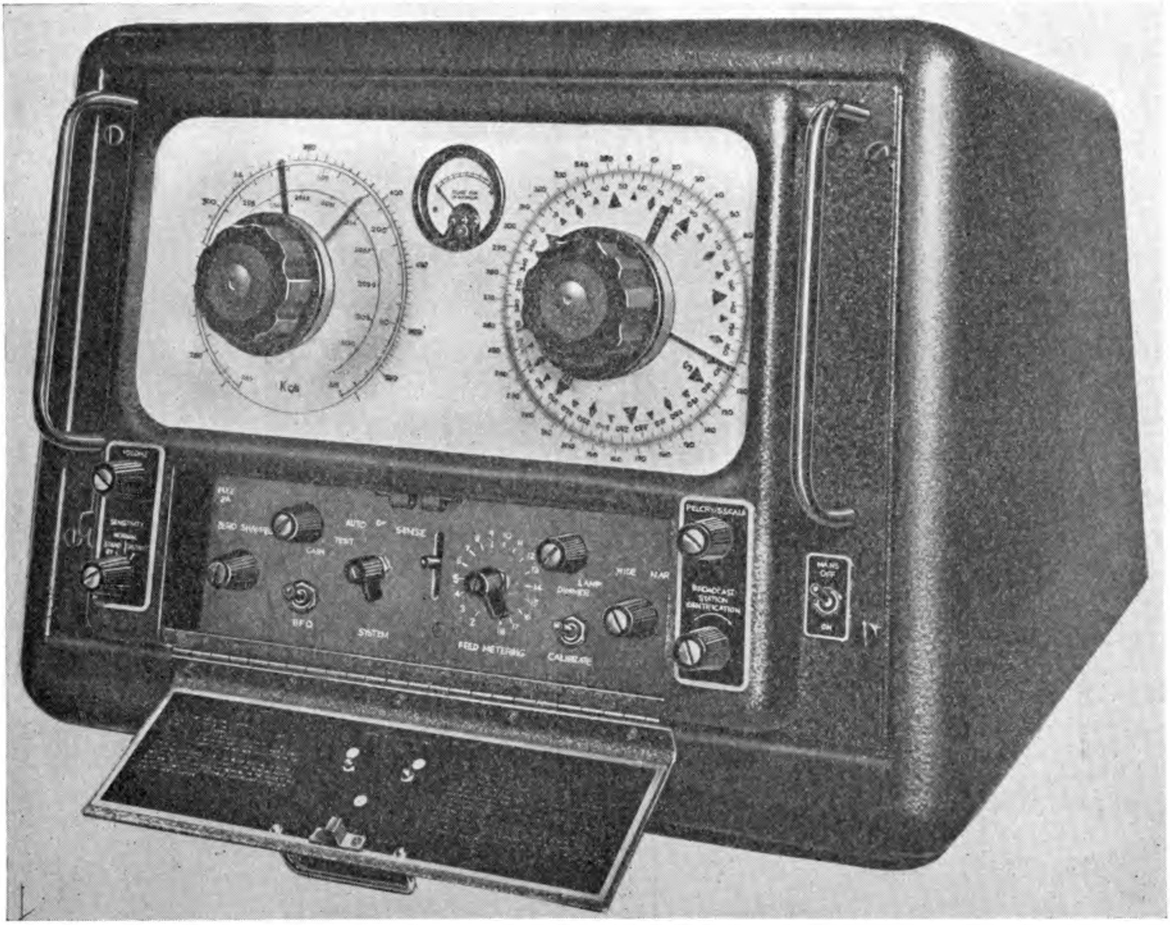


FIG. 1

DATE OF DESIGN	1960
HANDBOOK	BR 2494
ESTABLISHMENT LIST	E 1571
FREQUENCY RANGE	250–550kHz (285–315kHz displayed over inner scale in red)
INTERMEDIATE FREQUENCY	110 kHz
POWER SUPPLIES	110/220V d.c. 115/230V 50/60 Hz a.c.

1. **General.** The FM 16 is an automatic direction finder with switching facilities for instant reversion to manual operation. The equipment uses the Bellini-Tosi fixed-loop aerial system, with a rotatable servo-driven goniometer coil, operating on the null-signal method. In addition to the main tuning scale, which covers the whole frequency range, there is a bandspread scale, expanding the range allocated to radio beacons (285–315 kHz).

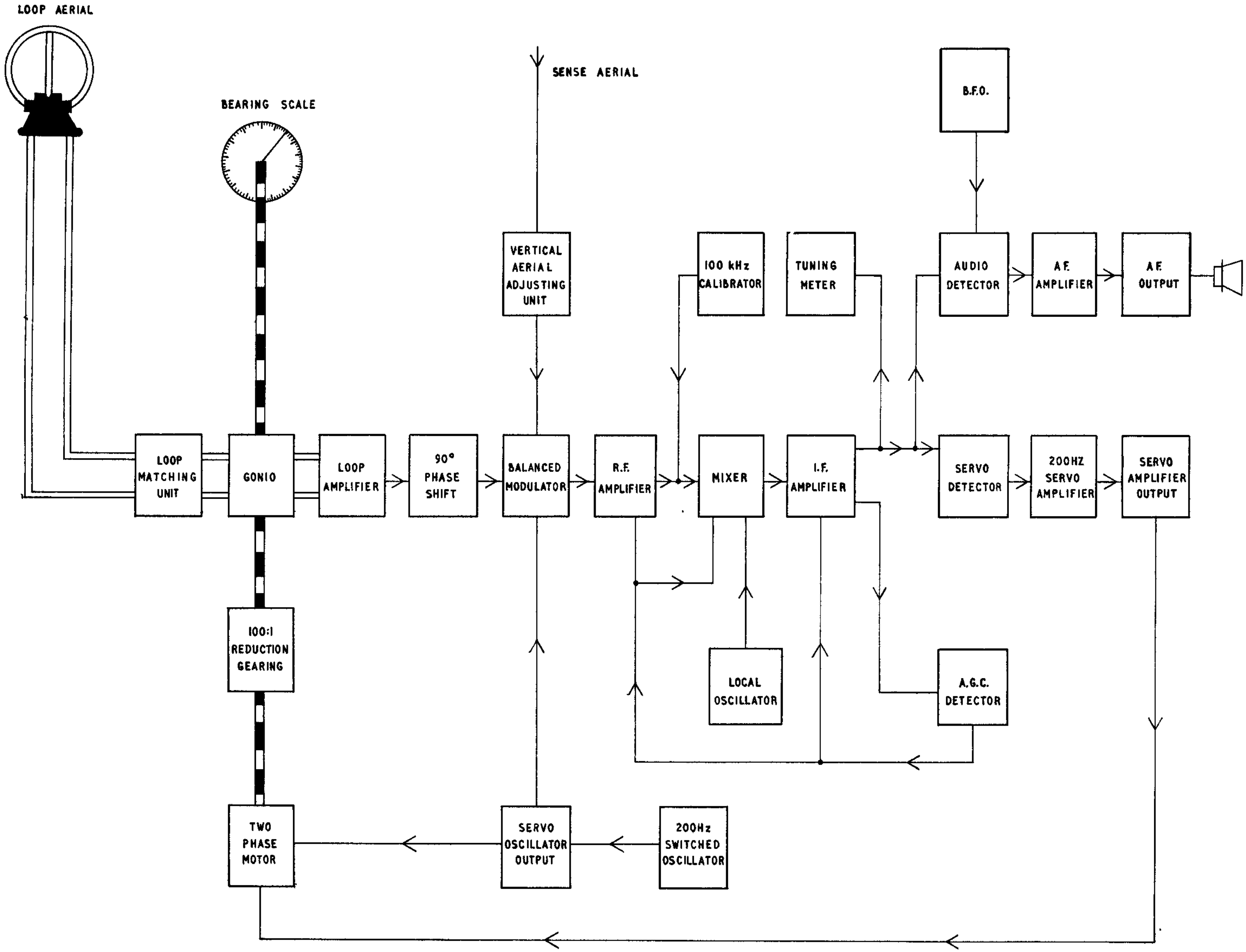


FIG. 2. D.F. OUTFIT FM16 – BLOCK DIAGRAM - (See Fig.3)

Ch 4

2. Basic Principles of Automatic Operation

a. AERIAL INPUT CIRCUITS. The signal output from the loop aerial is much smaller than the signal from the vertical (Sense) aerial. It also leads (or lags) by 90 degrees on the sense aerial signal, the actual direction being dependent upon the offset of the goniometer from the null point.

The loop signal is amplified and phase-shifted before being made equal in amplitude with the signal from the sense aerial when the goniometer is 90 degrees off the bearing. Although the amplitudes of the loop and sense signal will now be equal, they may be either in or out of phase.

b. SERVO-MOTOR INPUT. The loop signal is made alternately in phase then out of phase with the sense signal by means of an electronic switch. This switching is carried out at 200 Hz and produces a carrier modulated to a depth of 100%. The main modulated signal is meanwhile amplified by a conventional superheterodyne receiver and demodulated in the usual manner. The output from the servo detector is fed to an amplifier tuned to 200 Hz which eliminates noise and signal modulation components before supplying power in the form of a 200 Hz signal to one winding of a two-phase servo-motor, identified as the signal drive.

The second winding of the servo-motor is continuously energised at 200 Hz by the reference drive output of the switched oscillator, the motor supplies being fed 90 degrees out of phase to ensure maximum torque.

c. PHASE SENSING. The servo-motor is connected to the goniometer and overall phasing is such that the signal drive results in the goniometer moving towards the null point; when this point is reached there is no loop signal and the operation of adding and subtracting the voltages of the loop and sense signals leave the sense signal unaltered. The 200 Hz modulation is absent so that there is no output from the servo detector, no signal drive to the 200 Hz servo amplifier and hence no torque at the motor to move the goniometer.

d. SENSE REVERSAL. There will always be a second null 180 degrees from the true bearing. The phase reversal of loop signals when the goniometer is turned through 180 degrees causes the overall phasing to be reversed and the signal drive moves the goniometer away from the ambiguous or false null. It is possible for the goniometer to rest on the false null thereby producing no drive to move it away. This is an unstable condition and the slightest disturbance, either electrical or mechanical, will produce a drive sending the goniometer towards the true null.

3. Front Panel Controls

a. ON-OFF SWITCH. Provides double-pole switching of the mains input. The input circuit incorporates two-pole fusing and a rectificer to prevent damage should the mains input (if d.c.) be inadvertently reversed.

b. TUNING CONTROL. A main tuning capacitor driven by a gear-type reduction drive having negligible backlash. There are two tuning scales – outer and inner. The outer scale characters are in black and cover the frequency range 250–550 kHz. The portion of the range covering 285–315 kHz is marked in red. On the inner scale, this radio beacon band of 285–315 kHz is bandspread for ease of operation, with all inner figures also being marked in red. Both dials incorporate provision for calibration against an internal crystal calibrator.

c. DF GONG. A push switch which actuates a remote single-stroke gong to facilitate the accuracy of simultaneous bearings.

d. GONIOMETER DRIVE. This control is for use on MANUAL operation. The sense pointer plays no part in automatic operation.

e. VOLUME CONTROL. This control, in the a.f. stage of the receiver, has a full range of control on AUTO but is restricted to 35db when on MANUAL.

f. SENSITIVITY. This control is only operative on AUTO. In the Normal position, the sensitivity is such that a signal of 40uV/m produces full pointer torque. It enables the gain to be increased progressively to give operation on signal levels of the order of 1uV/m in the distant position. The use of the normal position in areas of reasonable signal strength reduces the fluctuation of the goniometer pointer due to noise. The tuning meter enables the correct setting of the sensitivity control to be selected and facilitates accurate tuning.

g. NORMAL/SPEECH SWITCH. Controls the receiver bandwidth and the BFO when on AUTO. In the SPEECH position the bandwidth is increased and the BFO is inoperative.

h. PELORUS SCALE. Used for manually aligning the Gyro repeater and ship's head.

4. Controls Beneath Hinged Cover

a. SYSTEM SWITCH. Provides changeover from AUTO to MANUAL operation.

(1) Test	Meter switched to measure valve feeds and performance.
(2) Auto	Switches automatic bearing facility on.
(3) DF	In this position both DF and non-locking sense positions are provided.
(4) Sense	Sensitivity switch inoperative. RF gain control in circuit.

b. ZERO SHARPEN. This control is used to 'sharpen' the null signal point to overcome a 'blurred zero' and is operative in the MANUAL DF position only.

c. BFO SWITCH. Switches on the BFO for CW operation when the equipment is switched to MANUAL operation.

d. WIDE/NARROW SWITCH. Provides two degrees of bandwidth for MANUAL operation, 2.5 kHz and 850 Hz.

e. FREQUENCY CHECK. Switches on a 100 Hz calibration check oscillator and removes HT from the loop amplifier and r.f. stages.

f. RF GAIN. This replaces the sensitivity switches when the equipment is set for MANUAL operation. On AUTO, gain is controlled by a.g.c.

g. SCALE LAMP DIMMER. Provides range scale illumination.

h. 300 kHz SET. Used for accurate alignment of the bandspread scale against the crystal calibrator oscillator.

i. FEED METERING SWITCH. Used with the SYSTEM SWITCH in the TEST position to check the HT line and valve feeds throughout the equipment.

5. Operating Instructions

a. AUTOMATIC. Switch ON and allow 30 seconds for valve heaters to function.

Set	SYSTEM SWITCH to AUTO. SENSITIVITY to NORMAL. NORMAL/SPEECH to NORMAL. VOLUME CONTROL to approximately midway position.

Tune to required frequency, when signal is heard tune for maximum deflection in the tuning meter. If the meter reading is below the RED mark, advance the SENSITIVITY CONTROL until a meter reading of between 3 and 4 is obtained. Adjust the VOLUME CONTROL to provide suitable loudspeaker output.

b. MANUAL. Switch ON and allow 30 seconds for valve heaters to function.

Set	SYSTEM SWITCH to DF. BFO to ON or OFF as required. WIDE/NARROW to required bandwidth.

Move TUNING POINTER to the required frequency and when signal is heard, tune carefully for maximum deflection on the tuning meter, adjusting RF gain to give a meter reading of approximately 5. Rotate GONIOMETER and note the two bearings at which the meter reading is a minimum, keeping RF GAIN and ZERO SHARPENING controls adjusted as required.

Rotate SENSE POINTER to one of the bearings noted above, then re-adjust RF GAIN to provide a meter reading of 5.

Move SYSTEM SWITCH to SENSE and note meter reading.

Rotate SENSE POINTER to the other bearing and again note the meter reading. The CORRECT bearing is that giving the LOWEST reading.

6. **Setting Bandspread Scale**

Set SYSTEM SWITCH to DF.

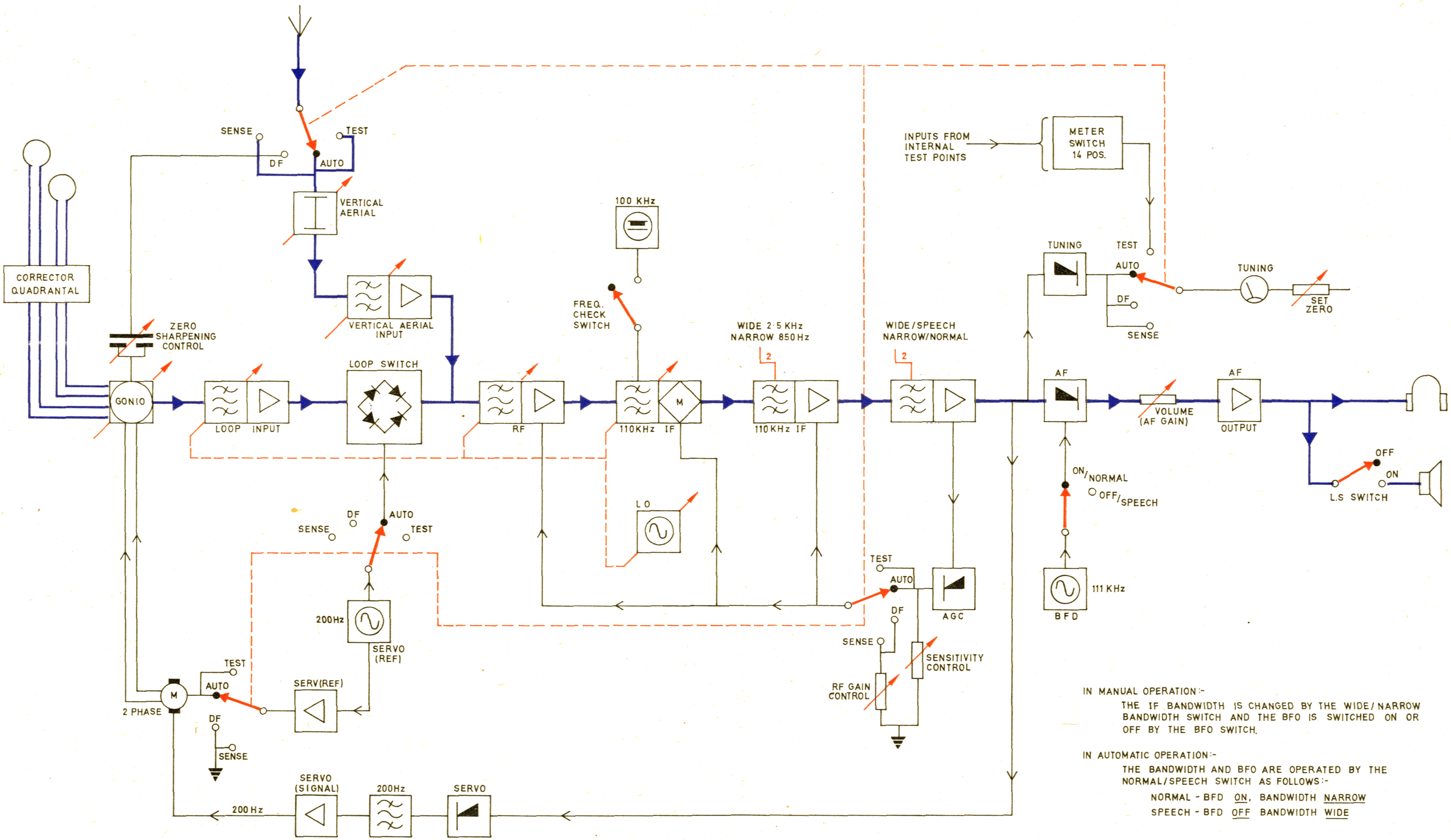
Set WIDE/NARROW SWITCH to NARROW.

Set RF GAIN to mid point.

Operate FREQUENCY CHECK switch and search for a clear strong signal in the region of 300 kHz.

Tune the signal carefully, reducing the RF GAIN as necessary to maintain mid-scale meter deflection.

Loosen BANDSPREAD SET clamping screw and move the bandspread scale until the 300 kHz pointer is under the RED pointer, then re-clamp.



IN MANUAL OPERATION:-
THE IF BANDWIDTH IS CHANGED BY THE WIDE/NARROW BANDWIDTH SWITCH AND THE BFO IS SWITCHED ON OR OFF BY THE BFO SWITCH.

IN AUTOMATIC OPERATION:-
THE BANDWIDTH AND BFO ARE OPERATED BY THE NORMAL/SPEECH SWITCH AS FOLLOWS:-
NORMAL - BFO ON, BANDWIDTH NARROW
SPEECH - BFO OFF BANDWIDTH WIDE

FIG. 3. DF OUTFIT FM 16—BLOCK DIAGRAM

4.10. AUTO ALARM OUTFIT SQA

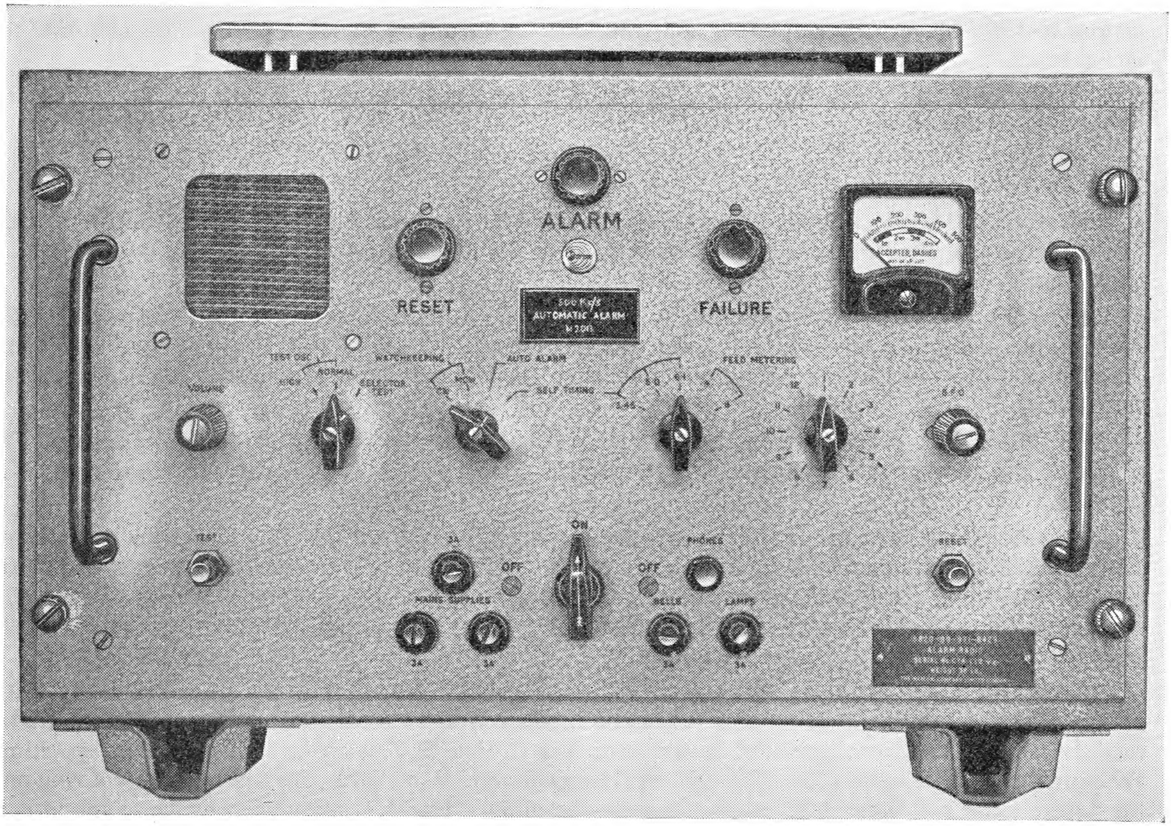


FIG. 1

HANDBOOK	BR 2446
E LIST	E 1507
FREQUENCY RANGE	496 – 504 kHz Preset-Wideband CW or MCW
POWER SUPPLIES	110/220V D.C. 115/230V 50Hz A.C. 24V D.C. for lamps and bell

General.

1. Outfit SQA is designed to give an audible warning of an automatic alarm signal received on 500 kHz by ringing up to 3 alarm bells and lighting a lamp on the front panel. It will normally be fitted in the MCO in the same bay as the M/F D/F outfit. A continuous watch ship will have only one alarm bell fitted in the MCO, whilst a non-continuous watch ship will have a second alarm bell fitted on the bridge.

2. The equipment can conveniently be considered in two parts:

a. The signal stages, comprising a T.R.F. receiver tuned to 500 kHz ± 4kHz which provides an audio output to loudspeaker or headphones and translates the incoming signal into an on/off action of the signal relay.

b. The selector stages which time the on/off action of the signal relay and, if they constitute an alarm signal, operate the alarm.

3. **Brief Circuit Description**

a. R.F. STAGES. The aerial input passes through a 500 kHz bandpass filter with a bandwidth of 8 kHz. The signal is amplified in these stages, the third of which incorporates a pre-set gain control, set on installation.

b. DETECTORS. The output of the 3rd R.F. Stage is fed to the AGC and signal detectors. The output of the AGC detector controls the bias and hence the gain of the 1st and 2nd R.F. amplifiers. The signal detector output passes to the AF amplifier through the AF gain control and also feeds the selector stages.

c. BFO. The BFO is a 500 kHz oscillator which can be varied ±3 kHz by a front panel control. The output is fed to the signal detector only when the system switch is in the "Watchkeeping C.W." position.

d. SELECTOR STAGES. The output of the detector is passed through a 100Hz low pass filter (smoothing circuit) which only allows the D.C. component of the AF signal to pass to the timing trigger and alarm circuits. Providing these D.C. components are of the correct length and are correctly spaced, the equipment will go to the alarm condition. A minimum of four consecutive pulses of the requisite length and space are required to operate the alarm.

e. ALARM AND LAMP CIRCUITS. The alarm and lamp circuits are supplied by an external 24V D.C. switched by the mains on/off switch. When the mains on/off switch is switched to OFF, the alarm relay will be in the 'down' position as shown in Fig. 2. The H.T. relay will be in the 'up' position. When mains is switched on, the 24V D.C. will immediately be available, the alarm bells will ring and the failure lamp will light. After approximately one minute, the H.T. relay will change to the 'down' position (Fig. 2), the failure lamp will be extinguished, the alarm lamp will light and the alarm bells will continue to ring. In this condition, the reset button (Fig. 3) may be pressed which will change the alarm relay to the 'up' position. The bells will cease to ring, the alarm lamp will be extinguished and the reset lamp will light. If the 24V D.C. can be switched externally, switching on can be delayed until after the reset button has been pressed to avoid the alarm bells ringing.

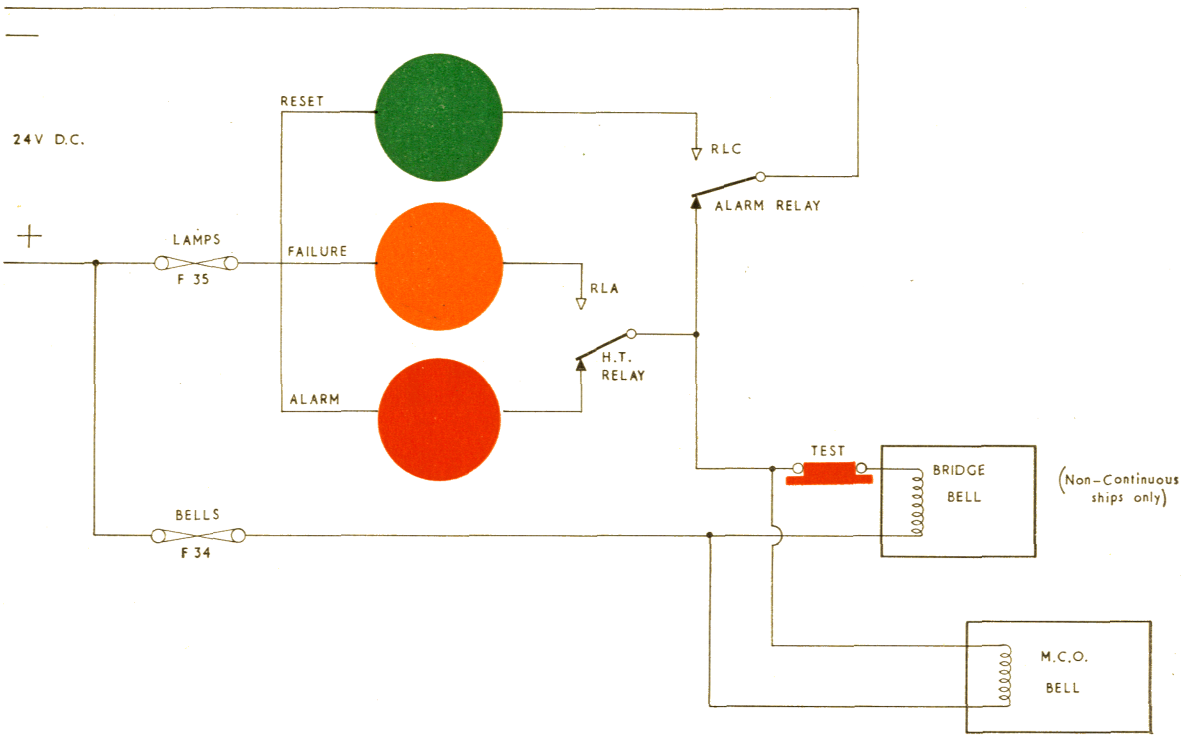


FIG. 2. SQA ALARM CIRCUIT IN THE ALARM CONDITION

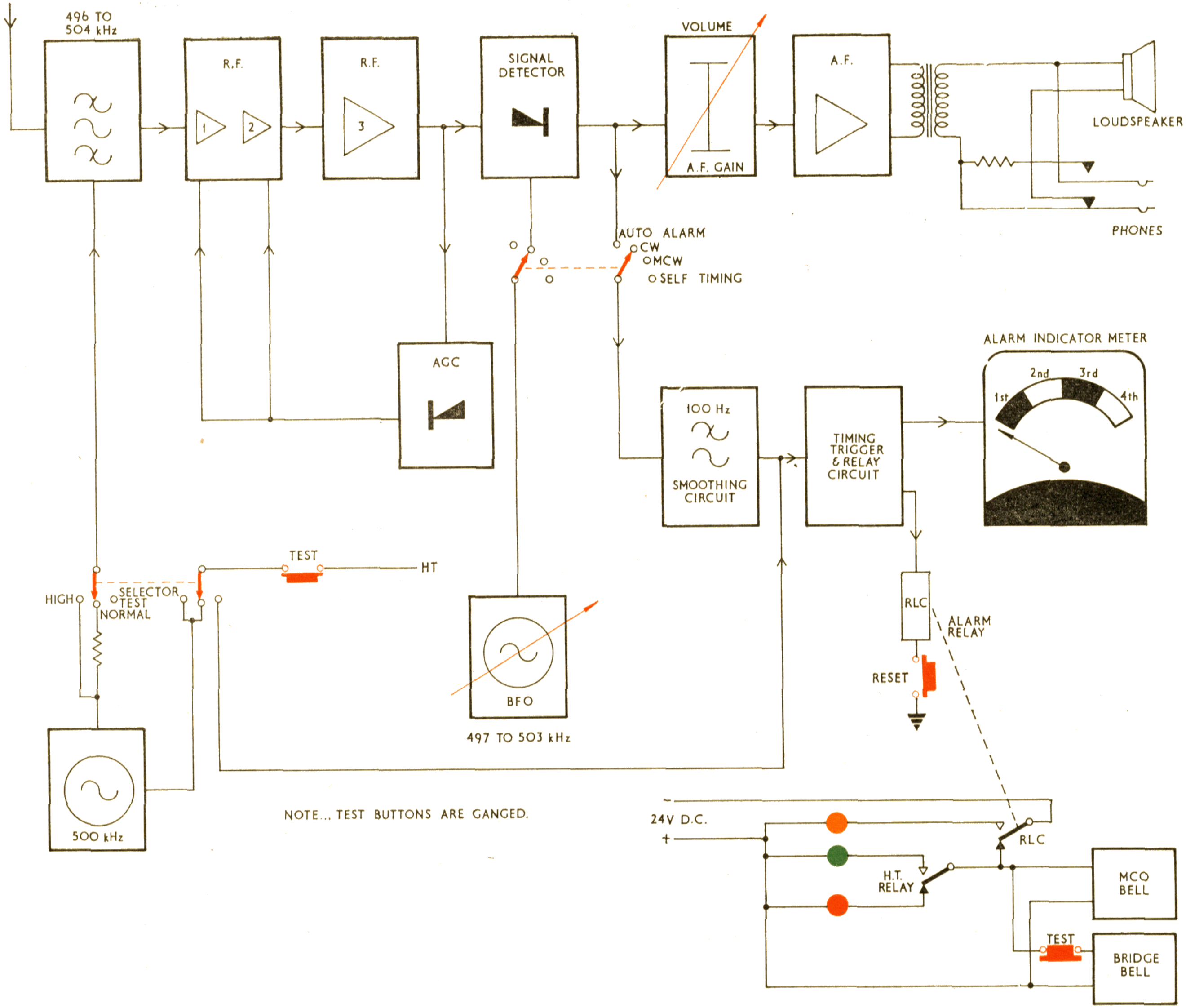


FIG. 3. BLOCK DIAGRAM SQA

4. Controls

a. VOLUME. Adjusts the output of the AF amplifier to the loudspeaker and phones.

b. TEST. When this button is pressed: (1) The 24V D.C. supply to the bridge alarm bell is disconnected. (2) H.T. is applied to the test oscillator or to the timing and trigger circuits depending on the position of the test switch.

c. TEST SWITCH

(1) Test Oscillator High. Connects the 500 kHz output to the test oscillator at 1mV to the grid of the 1st RF amplifier, oscillator HT being applied by the test button.

(2) Test Oscillator Normal. Connects the 500 kHz output of the test oscillator at 100uV to the grid of the 1st RF amplifier, oscillator HT being applied by the test button.

(3) Selector Test. Disconnects the HT from the test oscillator button for application to the timing, trigger and alarm circuits for testing alarm circuits only.

d. SYSTEM SWITCH

(1) Watchkeeping CW. Disconnects timing, trigger and alarm circuits. Connects output of BFO to the detector.

(2) Watchkeeping MCW. Disconnects timing, trigger and alarm circuits.

(3) Auto Alarm. Connects the timing, trigger and alarm circuits.

(4) Self Timing. Disconnects the alarm circuit. Selects a self timing auto alarm signal for checking the timing and trigger circuits. The timing is dependent upon the position of the meter switch.

e. METER SWITCHES. The timing of the self timing facility may be varied as follows:
3.45. – Selects the shortest acceptable mark time.
5.0. – Selects 3.45 second mark with the longest acceptable space time (1.55 seconds).
6.1. – Selects the longest acceptable mark time.
Positions A and B in conjunction with the associated 12 position meter switch select various circuits for voltage and current measurement.

f. B.F.O. Varies the BFO between 497 and 503 kHz.

g. RESET. Push button control to reset the alarm relay after receipt of an alarm signal, failure of HT or Mains supply, and during switching on procedure (para. 3*e*).

h. ON/OFF. Connects the mains supply to the receiver and the 24V D.C. to the alarm bells and lamps.

5. Testing Facilities A test oscillator, selected by the Test Switch, is incorporated to check the complete operation of the equipment from 1st RF onwards. The test signal will not however operate the alarm if the aerial is disconnected. In the "Test Oscillator Normal" position of the Test Switch, the test oscillator feeds a signal equal to the minimum level required to activate the alarm. The test oscillator is 'keyed' by the test button.

6. Operating Instructions

a.

1. Switch ON.
2. System Switch to AUTO ALARM.
3. Meter Switches to FEED METERING A position 1.
4. Wait approximately 1 minute until meter reads 400 to 500 to allow receiver to reach correct operating condition.
5. Press RESET button until meter reads 0.
6. Switch on external 24V D.C. supply to SQA. Green RESET lamp lights.

b. CHECK RECEIVER

1. System Switch to WATCHKEEPING CW.
2. Press TEST button.
3. Adjust BFO and VOLUME control to give required audio tone in loudspeaker/headset.

. TEST AUTO ALARM CIRCUITS

1. TEST OSCILLATOR to NORMAL or HIGH.
2. System Switch to AUTO ALARM.
3. Make four 4 second dashes with 1 second spacing on TEST button. On completion SQA Alarm Bell will ring and red ALARM lamp will light.
4. Press RESET button. Red ALARM light extinguished bell stops ringing and RESET LAMP lights.

4.11. MAGNETIC TAPE RECORDING OUTFIT REH5

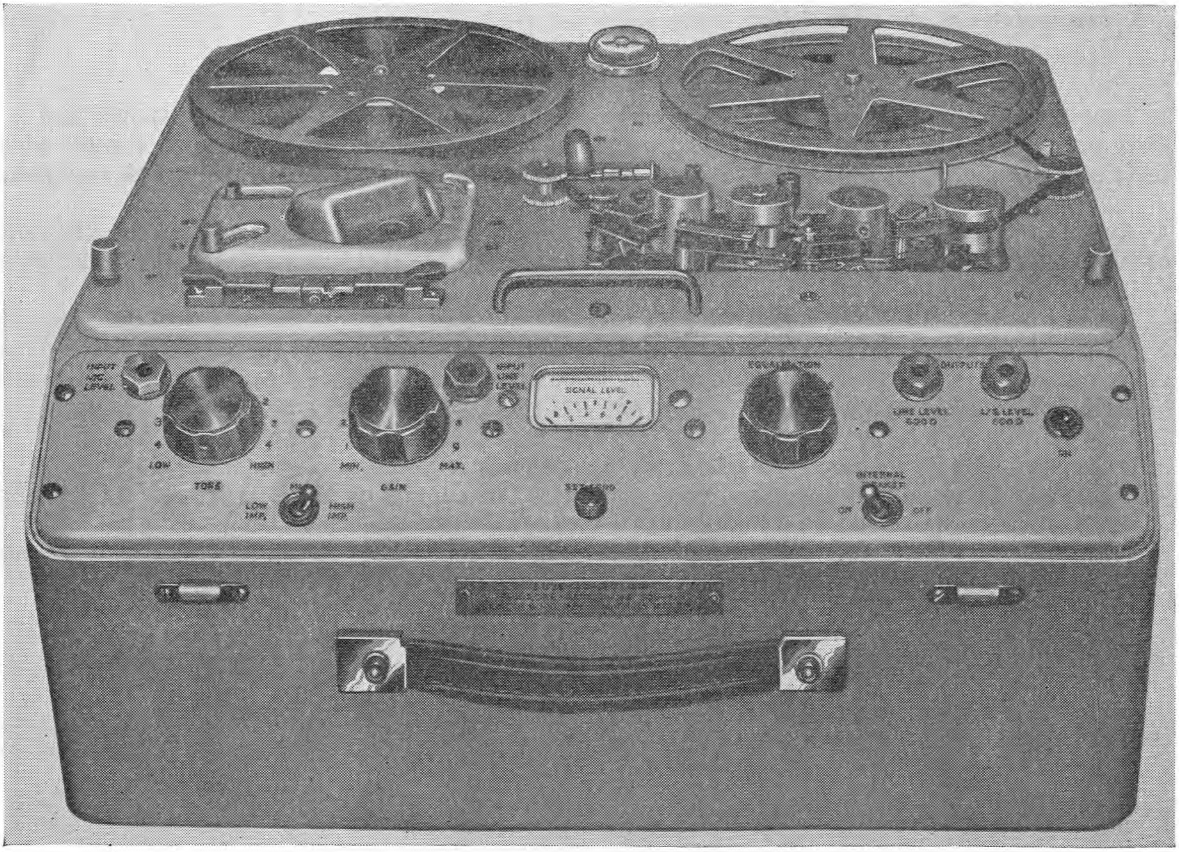


FIG. 1

DATE OF DESIGN	1964
HANDBOOK	BR 2395
ESTABLISHMENT LIST	E 1379
PLANNED MAINTENANCE SCHEDULE	R21/5C
POWER SUPPLIES	100 – 120V or 200 – 250V 50 Hz (For 60 Hz supplies, the appropriate capstan drive pulley must be fitted to maintain correct tape speed)

1. **General.** The REH 5 recorder is basically the same as REH 3, being a more modern layout with easier access to the amplifier controls. Design of the recording head provides a wider frequency response than that of REH 3, thus making this model more suitable for recording pulsed signals with less distortion. The following details will be those in which the REH 5 differs from the REH 3.

2. **Frequency response**

a. FAST SPEED 40 – 15000 Hz.

b. MEDIUM SPEED 40 – 10000 Hz.

c. SLOW SPEED 40 – 5000 Hz.

3. **Tape Speed Control.** This is sited in the centre of the tape deck, between the tape spools, and is a three position lever switch type. The speed control is interlocked with the equalisation control which must be set to the appropriate speed setting, otherwise the capstan motor supply will not be completed.

4. **Auto Tape Stop Switch.** This is a lever type switch worked by the tape pressure when in the RECORD or PLAYBACK modes of operation. The tape must be arranged so that it passes inside this lever switch, which is a white plastic lever sited on the right hand side of the tape deck.

5. **Inputs.** A 600 ohm input socket is provided along with a microphone input socket. High or low impedance microphones may be used, the appropriate impedance being selected by a selector switch mounted on the amplifier control panel.

6. **Recording Links.** At the rear panel of the machine two links allow two additional facilities:

a. BIAS AND ERASE LINK. Renders the Erase and Record function inoperative. This is useful for playing of valuable material and makes it impossible to erase or over record in error.

b. ERASE LINK. Removes the supply to the erase head, but supplies the record head bias. This provides a facility to record over previous material without erasing the original.

SECTION 5

CONTROL OUTFITS

5.1. KH SERIES GENERAL

1. **Purpose.** The KH series of Control Outfits is designed to provide a standard means of remote control of radio transmission and reception and, in certain cases, channel changing, in all types of ships. Its component units are standard, but the number and layout of units vary from ship to ship. The outfit for each type of ship has been allocated identity letters, although this does not mean that all ships with the same outfit will have exactly the same units.

2. **Outfits**

KHA Cruisers.

KHB Aircraft Carriers.

KHC Destroyers with a Second Wireless Office.

KHD Destroyers with an emergency position aft.

KHE Old type frigates and Ocean Minesweepers with only one office.

KHF Destroyers and frigates with separate transmitting and receiving rooms.

KHG Air direction frigates.

KHH Submarines, coastal and inshore minesweepers and other small craft with three or four transmitters.

KHJ Seaward defence boats and other small craft with only one or two transmitters.

3. **Outfit Differences**

a. KHA, KHB and KHG are normally the only outfits which incorporate aircraft control outfits KFF and KFG, and only KHB will incorporate KFJ.

b. KHA and KHB provide for parallel keying of transmitters.

c. KHC incorporates a switch unit in the 2nd Office instead of a C.C.X.

d. KHH and KHJ provide full flexibility for remote voice operation, but reduced flexibility for W/T operation. The units used in KHH are different from those in other outfits.

Remaining differences are in the number of lines required and consequently the number of units provided.

4. **Adapting Transmitters to the Control System**

Some transmitters, such as 618 and 692, are designed to operate into the KH control system. Other transmitters need special control units to adapt their control circuits to the system.

a. CONTROL UNIT DESIGN 8, Since this was designed for use with a variety of transmitters there are more controls on the unit than will be used in any one application. Those used for the control of transmitter 89Q are described here.

ON–OFF switch. On C.W. only controls the H.T. relay.

LOCAL REMOTE switch. The microphone socket, phone jacks, volume control and key jack are connected when this switch is placed to local, and the remote circuit is disconnected. When switched to remote they are disconnected.

b. CONTROL UNIT DESIGN 9. This is used with Type 86M.

A.C. SUPPLY ON–OFF. Supplies a.c. to the rectifier SE8. The rectifier should normally be left on and the supply controlled by this switch.

24 V (EMERGENCY ON–OFF). Control the 24 V Emergency Supply. LOCAL CONTROL ON–OFF. Controls power supplies to the Trans-receiver when LOCAL–REMOTE switch is to LOCAL.

LOCAL REMOTE switch. When switched to REMOTE the phone and microphone leads are connected to the remote control switch, and the ON–OFF and CHANNEL CHANGE functions are transferred to the CONTROLLER ELECTRIC. The local channel indication lamps remain in circuit, as does the local phone jack, but the local ON–OFF and CHANNEL CHANGE switches are disconnected.

LOCAL CHANNEL CHANGE switch. When using local control this permits the selection of any one of the four channels.

C.C.X. DIRECT switch. Not used.

ADJUST SIDE TONE. Control the side tone volume.

VOLUME CONTROL (LOCAL). Controls volume at the local phone jack.

MILLIAMETER SOCKET. This is across the 24 V supply.

CONTROLLER ELECTRIC LOCAL TEST. The CONTROLLER ELECTRIC may be tested at this socket regardless of the setting of the LOCAL–REMOTE switch.

Fuses. a. REMOTE FUSE. In the 13 V control circuit supply to the CONTROLLER ELECTRIC.

b. A.C. FUSES. In the a.c. OUT supply to the Transformer design 5 for remote lamp indication.

5. **Lamp Indication.** The Ready and Busy lamps described in this section are supplied with 24 V a.c., either from a Transformer Design 5 or from a winding of a transformer in the transmitter itself.

6. **The Control Circuit Exchange.** The main unit, common to all outfits except KHH and KHJ, is the C.C.X.

a. THE C.C.X. UPPER. This consists of rows of sockets each row containing four sockets wired in parallel. These sockets on the C.C.X. Upper are always connected to a transmitter or to a plug on a C.C.X. Lower in another compartment. Where a transmitter has a receiver associated with it (e.g. 692/CUJ, 619/CAT) the receiver output also is connected to these sockets.

In KHA and KHB there are two exceptions to the rule:

(1) Parallel keying. One row of sockets on the LRR C.C.X. Upper is connected via the P.K.U. to three plugs on the C.C.X. Lower.

(2) Extension Circuit. One row of sockets on the C.C.X. Upper in each main compartment is connected to a plug on the C.C.X. Lower. This extension circuit is used when more than four connections are required to the C.C.X. Upper socket.

b. C.C.X. LOWER. This consists of rows of plugs connected either to a row of sockets on a C.C.X. Upper in another compartment, or to an operating position either direct or via a Channel Selector Switch. The Operating position may be a bay in the same compartment as the C.C.X. or at a remote position.

When a plug on the C.C.X. Lower is inserted into a socket on a C.C.X. Upper the operator at the remote position has control of the selected transmitter.

7. **KH Facilities.** The plugs and sockets mentioned above are 11-pin connections.

1, 2 and 3. Keying Line. Switching Line and a common return. The Keying Line is connected to the morse key for controlling the keying relay of the transmitter. The switching line enables the transmitter to be switched on and off, normally by making and breaking the H.T. relay.

4 and 5. Phone Lines. The output of a receiver is connected to these lines as follows:

a. Transmitters with associated receivers (e.g. 633). In the line to the C.C.X. Upper socket.

b. Other transmitters (e.g. 603). Reception is not available until a C.C.X. lower plug for a receiver is plugged into the C.C.X. Upper Socket.

In each case reception is then available at the control panel of the transmitter.

Lines 6 and 7. Microphone Lines. These lines connect the remote mircophone to the transmitter.
Lines 8, 9 and 10. Lamp Ready. Lamp Busy and Lamp Common. A green light on the C.C.X. Upper and at remote operating positions fitted with lamps indicates that the transmitter is ready for use. (Lamp Ready.) On R.T. Control Units Design 6 and 7 an additional red lamp indicates when the transmitter is in use. (Lamp Busy). A common return is provided for these two lamp circuits.

Line 11. PS Line. This carries the d.c. loop for F.S.K. keying of transmitters.

8. **Types of Control Unit.** The type fitted at any position depends on the facilities required.

a. W/T and R/T Design 5. Fitted in operating positions in Wireless Compartments. Provides ON-OFF switch, key socket, microphone socket, two phone jacks, volume control and transmitter ready lamp.

b. W/T and R/T Design 4. Fitted in exposed positions. Facilities as Design 5. Weathertight.

c. Design 94 *Wireless*. Facilities as Design 4, but smaller. Weathertight.

d. Portable W/T and R/T Design 6. Facilities as above. Can be connected by a flexible cable to a socket on the upper deck, *e.g.* Emergency Conning Position.

e. Extension Unit Voice Design 3. Microphone socket, two phone jacks and volume control. Weathertight. Fitted in exposed positions. Design 2 is smaller, but with no phone.

f. Design 70 *Voice*. Facilities as above, but non-weathertight. Fitted in enclosed positions.

g. Control Unit Voice Design 6 (*KFF*). Provides for selection of any one of 6 channels, with Ready and Busy lamp for each, two microphone sockets, volume control.

h. Control Unit Voice Design 7 (*KFG*). Facilities as for Design 6, but with control of 12 channels.

Note. Where the control unit does not provide for switching on the transmitter this must be done locally.

9. *a.* **Receiver Outputs.** The 35 mW output of receiver outfits CAY and CAZ is fed via a Line Isolating Switch to the Design 5, C.C.X. Lower plug and to the R.I.C. Loudspeaker Exchange. When the Isolating Switch is broken the set may be operated locally without feeding into the KH system. An amplifier 2 W (A.P.32047) is fitted at the R.I.C. Bay for loudspeaker reception. The 2·5 W output of the receiver is not used.

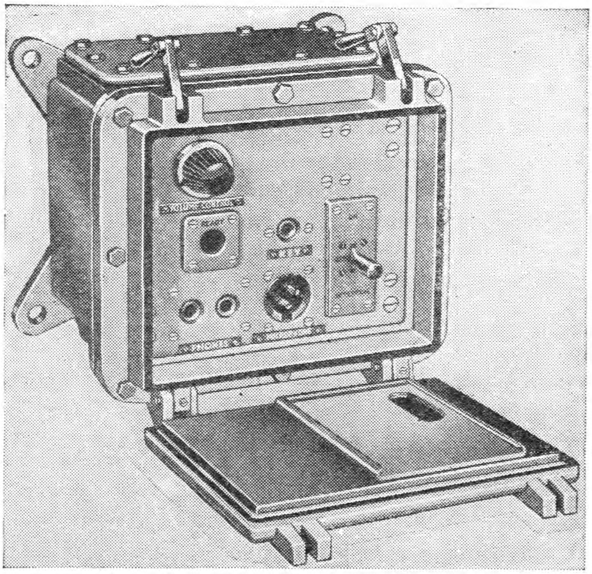
b. In ships fitted with only two receivers a double-pole double throw switch is fitted which feeds the output of either receiver to the control system or isolates both.

c. C.W. Broadcast Bays are fitted with a Board Receiver Output Exchange AP 65721 which enables the outputs of any number of receivers up to four to be fed either singly or combined into the control system. To isolate the Broadcast Bay output all four switches must be broken.

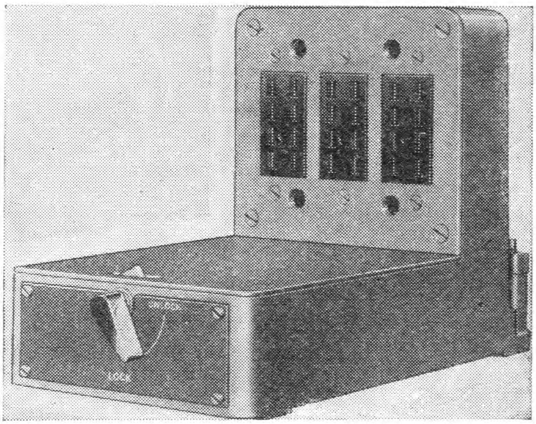
d. The output of each receiver in the RATT (2) Broadcast Bay is taken via the two switches, a PRIMARY and a SECONDARY. The Primary switch feeds the receiver output either to the F.S.K. Converter or to the Secondary Switch, from the Secondary Switch it may be fed to the Broadcast Bay Design 5 or to the Two Tone Bay Design 5.

10. **Amplifiers.** The amplifier most commonly used is the Amplifier 2 W A.P.32047. This has two inputs, one for a microphone and one for an a.f. line input. Beneath a hinged cover on the front panel are a supply switch, fuses and gain control. Also on the front panel are a pilot lamp and INPUT and OUTPUT test jacks. One of these amplifiers is provided for each loudspeaker.

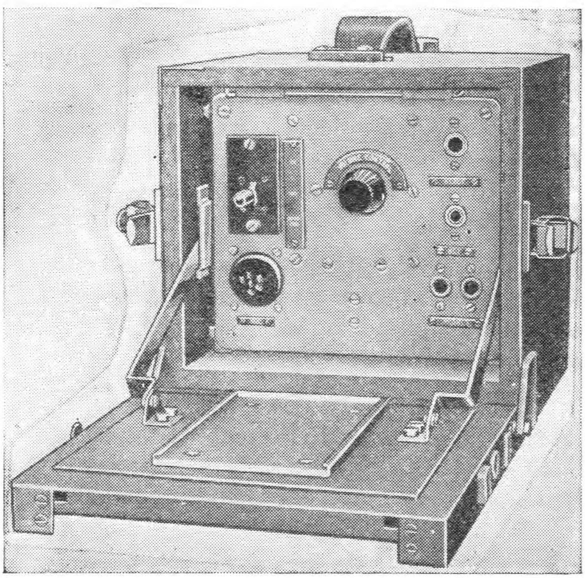
11. **Exchange Unit A.F. Design 1.** The exchange at the R.I.C. bay contains 20 jacks in two rows of 10, to which are connected the outputs of receiving bays. One of the jacks is wired to the amplifier input, and the amplifier output is wired direct to the R.I.C. loudspeaker. The R.I.C. may therefore monitor any bay by connecting a patchcord between appropriate jack and the amplifier input jack, or he may plug earphones into the exchange.



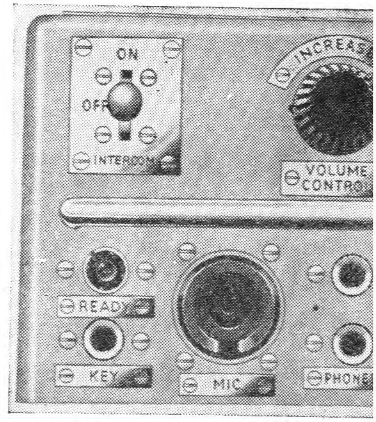
a. W/T AND R/T CONTROL UNIT, DES.4



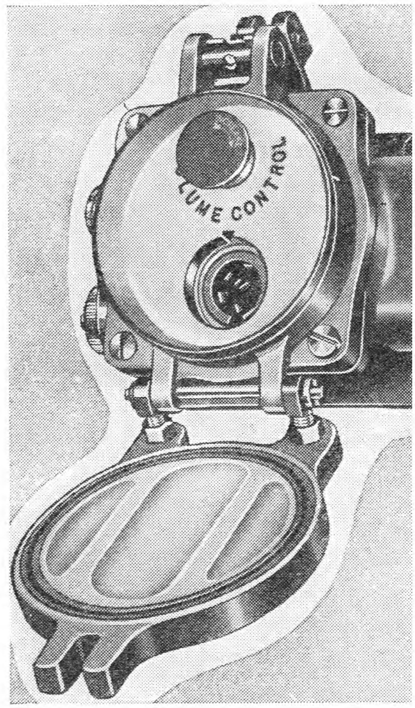
b. W/T AND R/T CONTROL UNIT, DES.5 – BASE



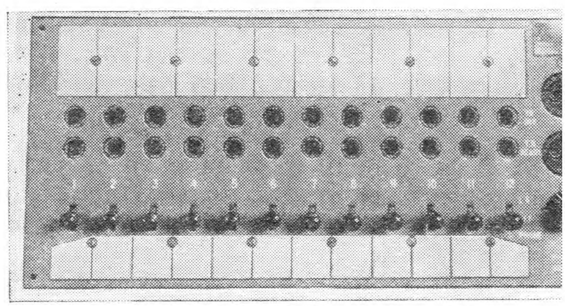
c. PORTABLE UNIT W/T AND R/T, DES.6



d. W/T AND R/T CONTROL UNIT
REMOVED FROM BASE

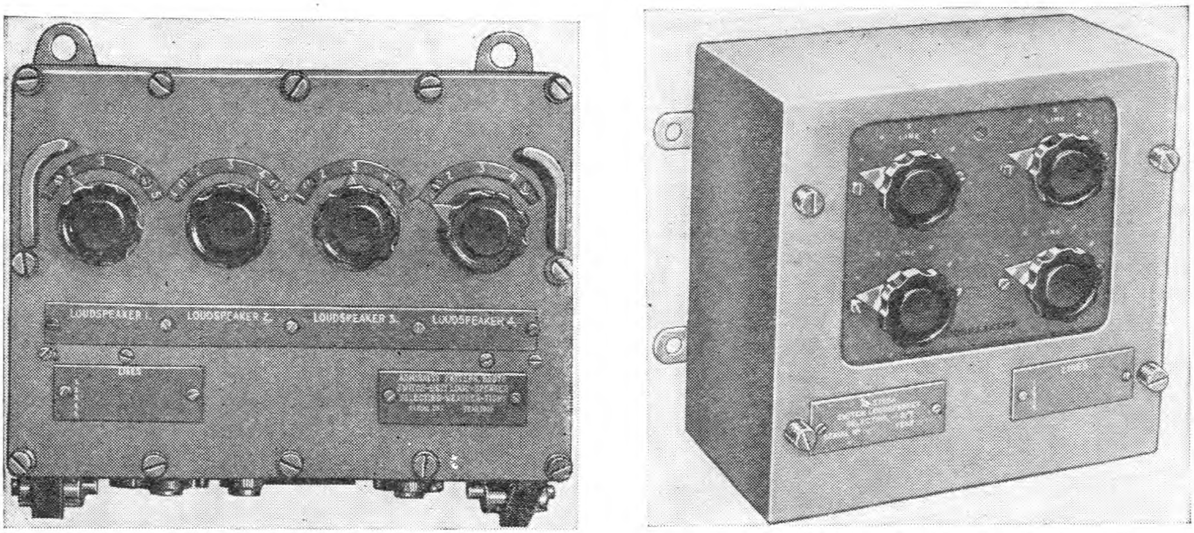


e. EXTENSION UNIT, R/T, DE
(Design 3 is similar, with built-in phc



f. R/T CONTROL UNIT, DES.7

FIG. 1



a. LOUD SPEAKER SELECTOR SWITCH UNIT (WATERTIGHT)

b. LOUD SPEAKER SELECTING UNIT (NON-WATERTIGHT)

FIG. 2

12. **Loudspeaker Selecting Switches.** Two types of loudspeaker selecting switches are provided, one for enclosed and one for exposed positions.

a. Switch Loudspeaker Selecting A.P.57115A. Non-watertight. Four switch control four loudspeakers, to each of which any one of six lines may be connected.

b. Switch Loudspeaker Selecting A.P.65872A. Watertight. Any of five lines may be connected via four switches to an associated loudspeaker.

13. **Ops Room Layout (KHA and KHB).** Some operating positions will have a Control Unit Design 70 Voice, either wired directly to the C.C.X. Lower or via a Channel Selector Switch. The Signal Desk position will be fitted with Control Unit Design 5. Direction Officers and other important users will have KFF and KFG units giving them control of 6 or 12 channels. The loudspeaker positions on the KFF and KFG switches are not connected, instead a separate loudspeaker exchange a.f. Design 1 is fitted.

14. **Ops Room Layout (KHC/D/F).** There is no Ops Room C.C.X. and all the operating positions are connected to the BWO C.C.X. Lower, either direct or via a Channel Selector Switch.

15. **Channel Selector Switch.** This unit has three horizontal rows of six switches. Each horizontal row is connected to a circuit which may comprise several operating positions. Each vertical row of switches is connected to a plug on the C.C.X. Lower, thus enabling six transmitting/receiving channels to be fed to the Channel Selector Switch. Each circuit therefore has a choice of any one of six channels. The phone lines from the C.C.X. Lower to the Channel Selector Switch are also taken to a loudspeaker exchange a.f. Design 1.

16. **Right-Hand Rule.** With the Channel Selector Switch and with Switch Unit Design 51 (see previous page) and KFF and KPG, if two switches in the same horizontal row are made only the right-hand switch will be operative.

17. **Switch Unit Design 51.** This unit, fitted with KHC only, is fitted in the Second Office instead of a C.C.X. It permits four transmitters to be connected to any of four control circuits.

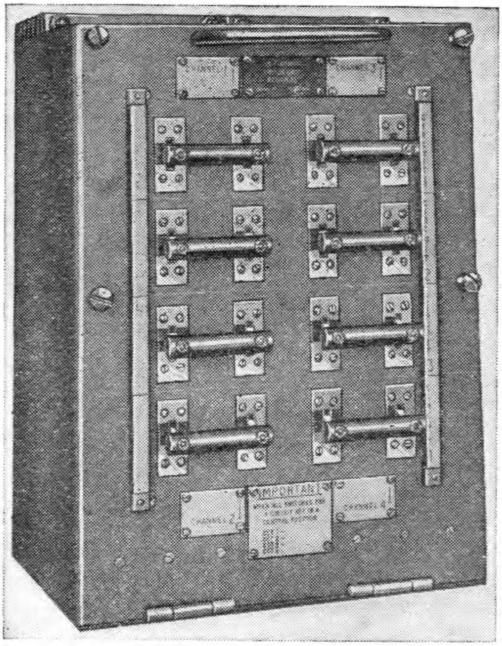


FIG. 3. SWITCH UNIT DESIGN 51

18. **Parallel Keying Unit.** This is provided with KHA an KHB only and is fitted in the L.R.R. to allow parall keying (morse only) for up to three transmitters. Recep tion cannot be passed through the P.K.U. The Read Lamp at the operating position will light when the fir transmitter is ready and is no indication that all transmi ters are on. When a Type 601 or 602 is being used wit Type 603 or 605 the source of supply for lamp circuit should be broken at the 601 or 602 transmitter to ensur that the lamp lights only when the delay contactor of 60 or 605 has operated.

19. **Side Tone and Loudspeaker Muting.** When the pres sel of a microphone plugged into any of the KH contro units is made, a resistor is switched into the phone line t reduce the level of the audio signal and the input to th loud-speaker amplifier is short circuited to mute the loud speaker.

5.2. SMALL SHIP SYSTEMS

KHH

1. **General.** Control Outfit KHH is used in coastal and inshore minesweepers, submarines and other small craft. It enables up to four control transmitter/receiver channels to be provided, but the keying circuit of one transmitter is extended by screened leads to one remote control position.

2. **Major Units**

a. SWITCH UNIT DESIGN 84. This is used as a C.C.X. On the front panel are four rows of four switches. Each horizontal row is wired to a control position, and each vertical row to a transmitter/receiver. A mechanical interlock bar prevents more than one switch being made in each horizontal row.

b. SWITCH UNIT DESIGN 85, LOUDSPEAKER SELECTING. This comprises four two-position switches, one for each receiver. Two loudspeakers are fed from the unit, one from the SWITCH UP position and one from the SWITCH DOWN position. A mechanical interlock bar prevents more than one receiver being connected to the same loudspeaker. Loudspeakers and Voice control units fitted in the same compartment are considered as a group and there is a Design 85 for each group.

c. SWITCH UNIT DESIGN 116 is a watertight version of the Design 85.

d. CONTROL UNIT DESIGN 103 VOICE. Provides ON–OFF switch, microphone socket, two phone jacks and volume control.

e. CONTROL UNIT DESIGN 104 VOICE is a watertight version of the Design 103.

3. **Use of Transmitters**

a. Types 618, 619 and 691 are used in the normal way. (*See* under appropriate transmitter in Section 2.)

b. If the Controller Electric is fitted with the 86M, operation is normal (see Section 2 for 86M, and Chapter 1, para. 4 *b.* of this section). If no Controller Electric is fitted the following differences from normal procedure should be noted:

(1) The channel required is selected at the Design 9 with the Local-Remote switch to LOCAL and the switch is then moved to REMOTE.

(2) The local channel indicating lamps will be extinguished when the set is switched to REMOTE.

(3) The set is switched on automatically by switching to REMOTE.

4. **Loudspeaker Muting.** To avoid audio feedback when Voice control units and loudspeakers are fitted in the same compartment, links are arranged on the Switch Unit Design 84, so that when the ON–OFF Switch on the Voice control unit is made, any loudspeaker connected to the same channel is disconnected. When the microphone pressel is made the sidetone in the MIC-TEL earpiece is reduced. The volume at other positions is unchanged.

KHJ

5. **General.** Control outfit KHJ is used in small craft such as Seaward Defence Boats where the requirement is for one set to be controlled at one or two remote positions. The control outfit may be duplicated if two sets are fitted.

6. **Major Units**

a. CONTROL UNIT Design 5. Fitted in enclosed positions. Provides ON–OFF switch, key jack, microphone socket, two phone jacks and volume control.

b. CONTROL UNIT Design 94. Similar to above, but weatherproof and is fitted in exposed positions. (Control Unit Design 4 which gives the same facilities may sometimes be fitted.)

7. **Use.** There is no C.C.X. The remote control units are wired in parallel direct to the transmitter/receiver so that when the Local Remote switch at the transmitter is placed to REMOTE the set may be controlled from either remote position. A loudspeaker may be fitted at each control position. *See* para. 4 above for notes on loudspeaker and sidetone muting. *See* para. 3 *b.* on the use of 86M without Controller Electric.

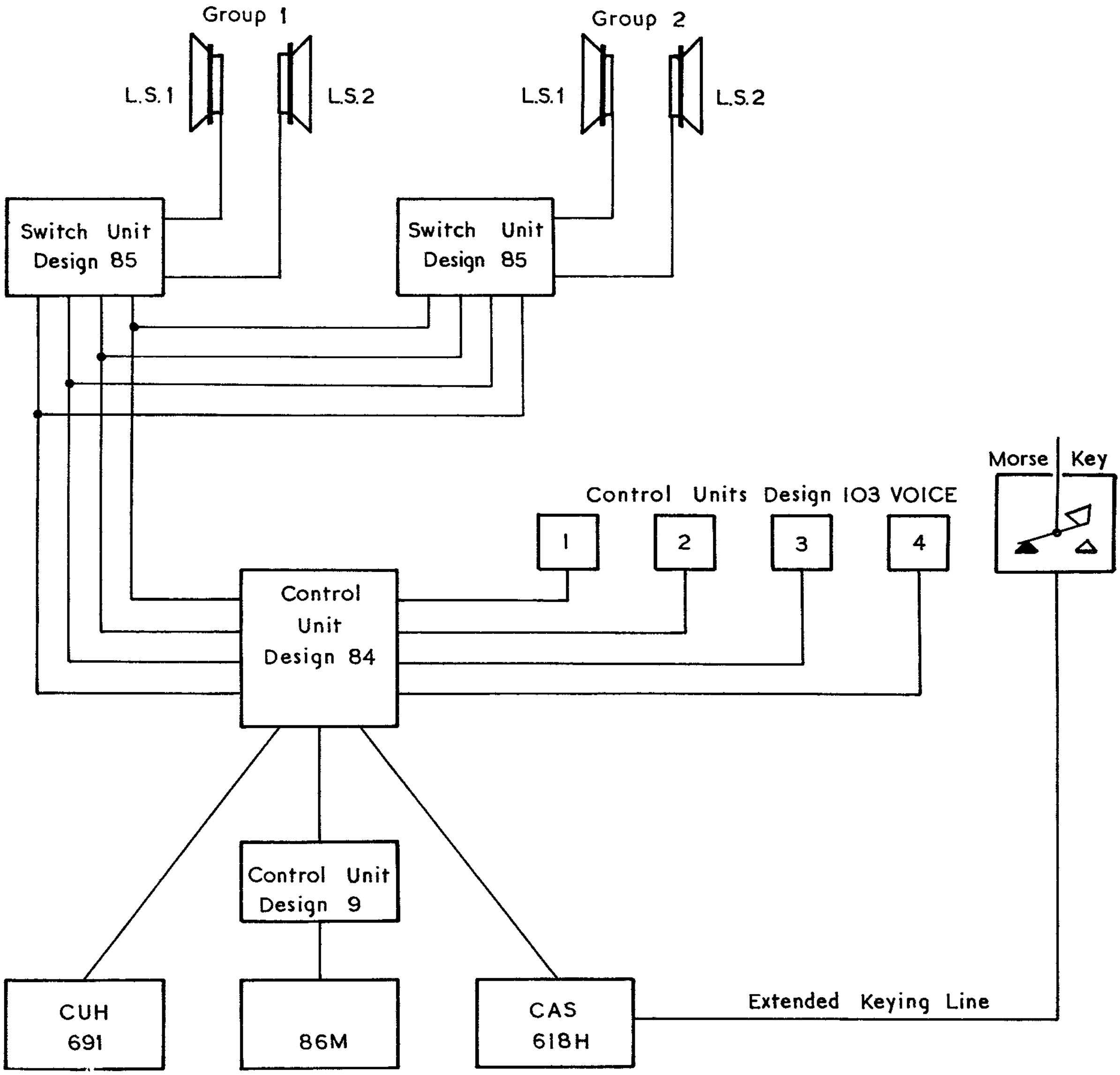


FIG. 1. TYPICAL LAYOUT OF CONTROL OUTFIT KHH

5.3. COMPOSITE COMMUNICATIONS SYSTEM (CCS)

GENERAL

1. The Composite Communications System was introduced into the Fleet in order that the user's communications facilities for both Internal and External circuits could be arranged in a convenient and compact manner. All the units involved are of standard size and provide particular facilities, *e.g.* a Basic Radio Tray for Radio circuits, etc. Normally they are fitted as part of a console or countersunk into a bay. Each user has a number of trays to provide particular facilities required.

2. The system allows a user to operate on either an internal telephone channel or an external radio circuit using one microphone and headset with split phones. It is only intended to give details of the radio application in the following paragraphs.

3. The C.C.S. is fitted in all new construction ships (like Leander) and some Carriers and provides a much needed improvement to the user's facilities. A similar arrangement is fitted in I.C.S. ships with Control Outfit KMM which is described in Section 11, the only real difference being that the units have been developed further.

4. There are three main parts of the C.C.S.:

a. Interphone facilities. These provide user with flexible internal communications between selected positions.

b. Intercom facilities. This is similar to the normal facility such as 'signal intercom' between the M.C.O., Ops Room, Bridge, etc.

c. Radio facilities. These provide each position with the facility to select a number of radio circuits as required. A number of user positions can share one circuit.

5. The distribution of radio facilities inside the operations room is different to the arrangements provided in KH control outfits in that a number of users can be in parallel on one circuit – one operator using the circuit at any one time.

The diagram shows how this is achieved. In short, a C.C.X. lower is wired to the Distribution Rack in the operations room or a.f. compartment and a number of user positions wired to the other side. When a particular user presses his pressel switch he connects his position to the selected radio circuit by a relay operation in the Distribution Rack.

6. **Composite Communication Units**

Each unit consists of one or more trays which serve different purposes as follows:

TYPE	NAME	TYPE	NAME
1	Basic Interphone Tray.	7	Remote Channel Selection Tray (R.C.S.)
2	Auxiliary Interphone Tray.	8	Loudspeaker.
3	Basic Talk-Back Tray.	9–13	Ships fitted with semi-automatic tote.
4	Auxiliary Talk-Back Tray.	14	Automatic exchange tray.
5	Basic Radio Channel Selection Tray	15	Radar selection tray 3 way.
6	Auxiliary Channel Selection Tray.	16	Radar selection tray 6 way.

There are two types of users for this equipment, the Basic Interphone User, who has a plug socket connected to a Basic Interphone Tray and who may or may not have a Radio facility, and the Basic Radio User, who has a plug socket connected to a Basic Radio Tray and who nearly always has an Interphone facility.

7. **Headsets and Microphones**

a. Microphones are of two sorts, Carbon Microphones which have a *Black Bar* painted on the face and go into sockets with a *Black tally*, and Electromagnetic Microphones (EM) which are marked with a *White Bar* and go into sockets with a *White tally*. Damage may result by plugging the wrong microphone into the wrong socket.

b. Headsets have split earpiece facility; a Basic Interphone User with a Radio facility has one earpiece permanently available to Radio. A Basic Radio User using his Interphone facility will have one earpiece remaining on Radio.

c. Carbon and EM Handsets are made for use in certain positions, the Carbon ones being wired in at Interphone positions. There is of course no split earphone facility.

8. **Basic Interphone Tray and Use of Interphone**

a. The Basic Interphone Tray has two lines operated by one key. It has call-up lamps for each line, a common buzzer ON/OFF switch; a Radio and a Priority switch which is only connected in certain Command positions.

b. To make a call put the Call-up Key towards the position required. The operator at the other end will see his Call-up Lamp glow and hear the Buzzer if switched on; all he has to do is move his key towards the glowing lamp, then the lamp goes out and the two operators can talk to each other. If one or the other of the operators has his Radio key made, he will have one of his earpieces remaining on Radio while the other earpiece and microphone will give him interphone communication. *Both operators must centralise their keys on completion of call.*

c. A Basic Radio User can use Interphone by depressing the Interphone key on his Basic Radio Tray, this connects one of his earpieces and microphone to the Basic Interphone Tray.

d. The Direction Officer's line has an arrangement of capacitors fitted at all positions to enable the D.O. to talk to all Basic Interphone Users without them making their key. Even if the called position is switched to Radio he can still hear the caller; he must make his D.O. key before he can reply.

e. The PRIORITY switch at the Direction Officer's position automatically connects one earpiece and the microphone at the called position to Interphone and conversation can immediately take place.

Until the call-up at the D.O.'s position is released the circuit remains made. This facility only works when the called position is a Basic Interphone User.

f. Since Basic Radio Users cannot be reached by the facilities described in paras 5 *d* and 5 *e* above, it is recommended, where there is a choice of sockets at a position, that the Basic Radio Interphone socket be used; thus 'D' will be able to contact the user by interphone.

9. **Full Remote Channel Selection**

This enables a specified remote user to select any one of the 10 channels (Design 90 fitted in 692/3) by use of the R.C.S. Unit. (Plugging as per diagram.)

Partial R.C.S. is also available at the Transmitter or Receiver, but care must be taken in using this facility. If a channel is selected by Partial R.C.S., when switching to Remote the R.F.S., R.C.S. must be set to the same channel.

10. **Partial Remote Channel Selection**

Remote User unable to select a channel. PRESS TO TUNE button at either the transmitter or the receiver will select channel (Design 90 fitted in 692), *e.g.* if receiver set to channel 5 by pressing PRESS TO TUNE button at the receiver, the transmitter will select channel 5. No special plugging required for Partial R.C.S. *see* diagram.

11. **Basic Radio Tray and R.C.S. Tray**

a. The basic radio tray presents a choice of three radio channels, only one channel may be selected at a time. If two channels are selected the right hand switch will take precedence.

A key, Ready light and Busy light, is available for each channel, a volume control which adjusts the line gain at the Radio tray, and an interphone switch.

b. Auxiliary Radio Trays with 5 channels each can be connected. The right-hand channel selected takes precedence, the Basic Radio Tray counting as if it were to the right of the auxiliary tray if not fitted at the same level. For this reason it is imperative to see that all the Channel Selection Keys are switched to the central position after using a position, as in a dimly lit compartment the next user may not notice that a key has inadvertently been left made.

c. Radio Trays have their various channels remoted to them on D.B. (Distribution Box) lines or Loop Lines, the only difference being the position served by the types of line. Some lines called Private lines serve only one position. Almost any frequency available in a ship may be remoted to any of these lines.

d. The Remote Channel Selection Tray (R.C.S.) has four lights at the top which show the state of the associated equipment, a ten-way selector switch in the middle, a Retune Button bottom left, and a test switch bottom right. The tray can be used on any line with suitable UHF equipment when plugged up through its own KH system.

e. To channel change using R.C.S. move the selector switch to the required channel (these are ship channels, not Air channels), press the RETUNE button for 1 to 2 seconds to allow the relays time to operate. After 5 to 20 seconds delay the three Green lights will burn and the new channel is ready for use.

If after pressing the RETUNE button the green transmitter ready for retune flashes four times it indicates that the Auto tune resonator has not set up. Two identical frequencies (Channels) have been selected using the same resonator on CAW.

The Test Switch is to test the equipment state lamps; when in the DOWN position all four lamps should burn at once. The Channel selector lamps should burn as the channels are selected. Moving the Channel selector switch without pressing the Retune button does not effect associated equipment.

12. Talkbacks

These have a tray which looks rather like an INTERPHONE TRAY at the Control Position with a PRESS TO SPEAK switch and a microphone on a lead. Outstations talk back into the Loudspeaker. The D.O.'s Talkback can be used as Command Intercom by raising the PRESS TO SPEAK switch.

13. Intercoms

These can be fitted with Moving Coil Microphones on leads or stalk type, and use the same type of Loudspeaker tray as talkbacks.

14. Automatic Exchange Tray

There is only one of these fitted at a selected position and it enables the user to use the Main Exchange telephone through his Interphone tray.

15. GENERAL HINTS TO USERS

a. Always wear your headset correctly, you will cause feed-back howl otherwise.

b. If a lapel clip is provided, use it. This takes the main wear off the cable joints.

c. Never put a carbon microphone (black bar) into an E.M. socket (white tally) or vice versa. Always look before you plug in.

d. Make sure your headset is fully home.

e. Do not touch the Amplifier Gain as this is set up and finely adjusted to give the best results on Radio and Interphone.

f. After using a Radio or INTERPHONE Position leave all keys on the OFF position, usually central.

g. If a Channel Ready or Busy Light does not work, check it on the same channel at another position; it may be that the bulb is broken and the transmitter and/or receiver is still in good order.

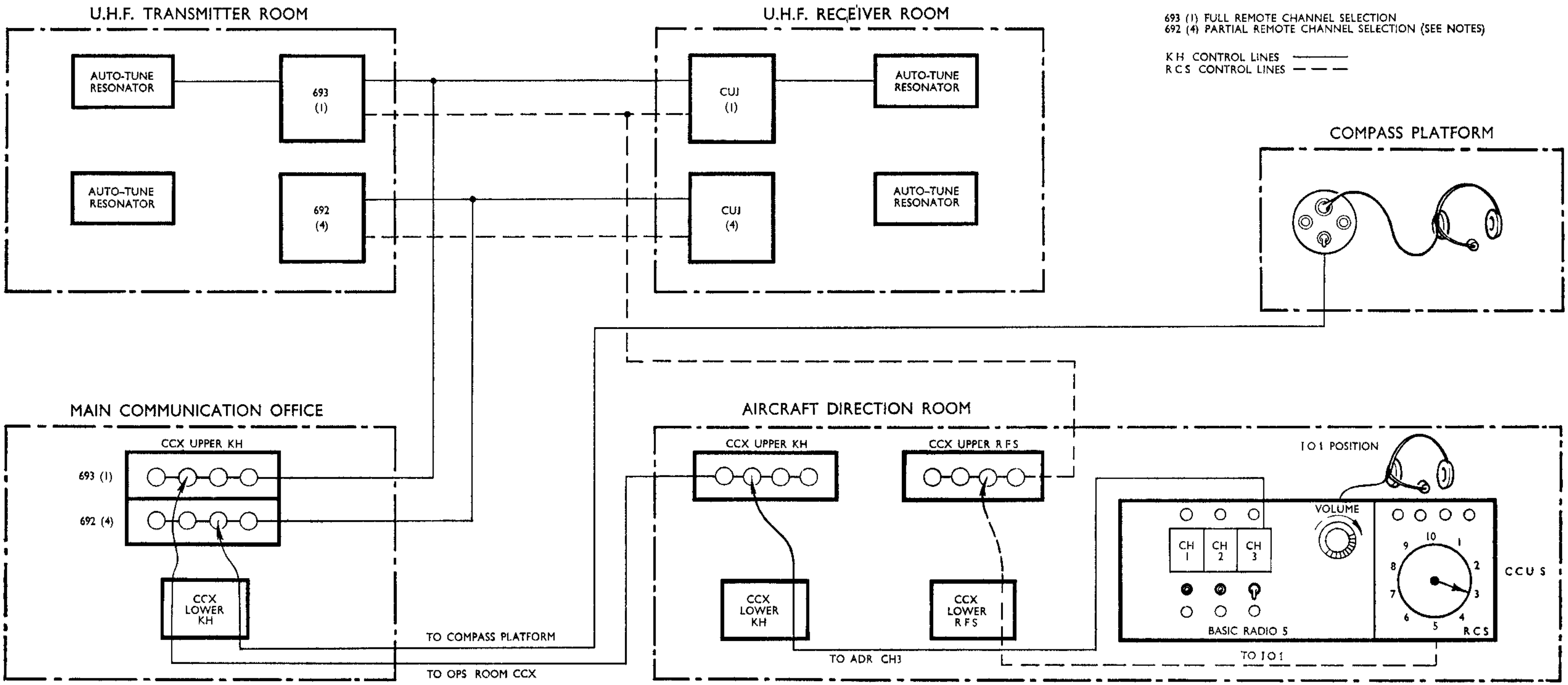


FIG. I. KH PLUGGING ARRANGEMENTS FOR FULL AND PARTIAL R.C.S.

5.4. COMPOSITE COMMUNICATION UNITS

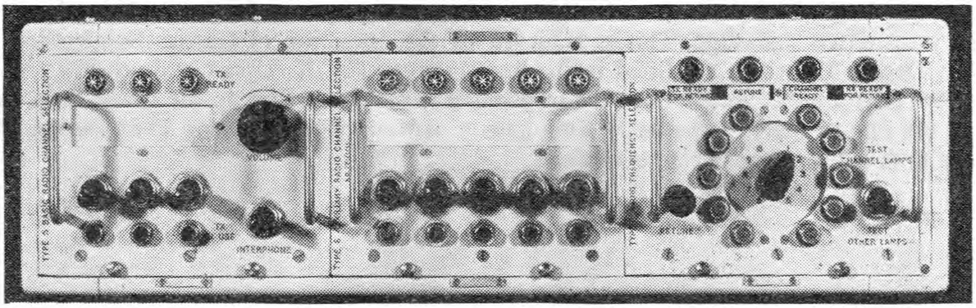


FIG. 1.

1. **General.** Composite Communication Units enable a common microphone and headset to be used for both internal telephone communications and external radio communications. This description is concerned with the radio control circuits, which are a simple extension of the KHB system, the C.C.U.s replacing outfits KFF and KFG (R/T Control Units Design 6 and 7). The units are connected to plugs on the C.C.X. Lower. The interphone circuits are not described in full.

2. **Major Units**

COMPOSITE COMMUNICATION TRAYS

a. TYPE 5 BASIC RADIO CHANNEL SELECTION. This unit carries three channel switches used to connect the MIC-TEL socket to a particular radio channel; READY and BUSY lamps associated with each channel; volume control; interphone switch. When the interphone switch is made the microphone tray and one earpiece are connected to the basic interphone, leaving one earpiece on radio. The pressel is then ineffective. Where a handset is used its single earpiece is switched to interphone and radio contact is lost.

b. TYPE 6 AUXILIARY RADIO CHANNEL SELECTION. This unit is fitted with five channel switches with READY and BUSY lamps. The RIGHT HAND RULE mentioned in Chapter 1, para. 16, applies to these units, the Basic tray counting as if it were to the right of the Auxiliary Tray where they are not fitted on the same level.

c. TYPE 7 RADIO FREQUENCY SELECTION. This unit is used in conjunction with auto-tuned resonators and Relay Units Design 90 to permit full remote channel selection of the ten present channels of Type 692/693/CUJ from a remote operating position.

d. SOCKET UNIT A.P.63940. A small unit for desk or bulk-head mounting, two MIC-TEL sockets, two phone jacks and volume control.

e. SOCKET UNIT DESIGN 2 A.P.64311. 1 MIC-TEL socket, table mounted.

3. **Distribution Boxes.** At some control positions the Radio Tray is wired direct to the C.C.X. lower. Some positions, however, are wired in groups, via distribution boxes to the C.C.X. In this case insertion of a plug marked, say, DISTRIBUTION BOX NO. 2 at the C.C.X. would give control of that particular channel to all control positions wired to that Distribution Box.

4. **Microphones.** Electro-magnetic microphones are used with C.C.U.s, but radio extension units fitted in the same compartment require the use of carbon microphones. It is mot important that the correct microphone is used in each application. Carbon microphones are *Red* with a *Black* band across the face and sockets at which they are to be used are marked with a *Black* label. Electromagnetic (EM)

microphones are marked with a *White* band and the positions at which they are to be used are marked with a *White* label.

5. **Teacher Outfit HRN.** This outfit permits the use of control positions for internal simulated exercises without the transmitters radiating. This is achieved by the operation of Carrier Suppression switches (Switch Unit Design 87) which are fitted in the lines between C.C.X. Upper and selected transmitters. They divert the microphone circuits from the transmitter microphone lines to the phone lines, and insert a resistor in the line to match impedance. Simulator operators have a Control Unit Design 118 which enables them to select any one of six channels.

5.5. AIRCRAFT CONTROL OUTFITS

KFJ

1. **General.** KFJ is fitted for C.C.A. in aircraft carriers. It enables four controllers, each on a separate channel, to converse with the pilot of an aircraft during his approach, with a stand-by transmitter/receiver immediately available in the event of failure on any channel. The Supervisor in the C.C.A.R. can listen or talk on any channel. Remote control is available at the Flying Control Position (F.C.P.) or at the Mirror Sight Position (M.S.P.).

2. **Major Units**

a. CONTROL UNIT DESIGN 138 (VOICE). Used by controllers. Provides four channel selection switches with channel indicator lamps, pressel switch, volume control, Normal-Standby switch, Standby transmitter in use lamp and ready lamp, two microphone sockets and a recorder jack.

b. C.C.U. TYPE 6.

c. CONTROL UNIT DESIGN 139. Used by C.C.A. Supervisor. Provides microphone socket, two phone jacks, and volume control.

d. CONTROL UNIT DESIGN 115. A weathertight unit used at the M.S.P. provides microphone socket, phone jack volume control, and a Port-Starboard change-over switch.

3. **Operation**

a. There are four controller's positions: DESCENT, OUTER, INNER and FINAL. Four 692/CUJs are employed using C.A.W. system EAH, and a standby 692/CUJ with an independent aerial. These equipments are connected to the KFJ C.C.X. In emergency a controller can be connected via the C.C.X. to the normal KHB system.

b. The stand-by transmitter is available to any controller should his own set fail. He switches from NORMAL to STANDBY and the standby set is automatically switched to the channel normally used by him.

c. An extension circuit from each controller's position is wired to the C.C.U. at the Supervisor's position and, via isolating switches, to the F.C.P. and M.S.P. These switches enable, for instance, the Final Controller's channel to be connected to Port circuit at the M.S.P. and the Standby set pretuned to the same channel connected to the Starboard circuit, so that the M.S.P. has an alternative set immediately available.

(*continued on page* 5–5–2)

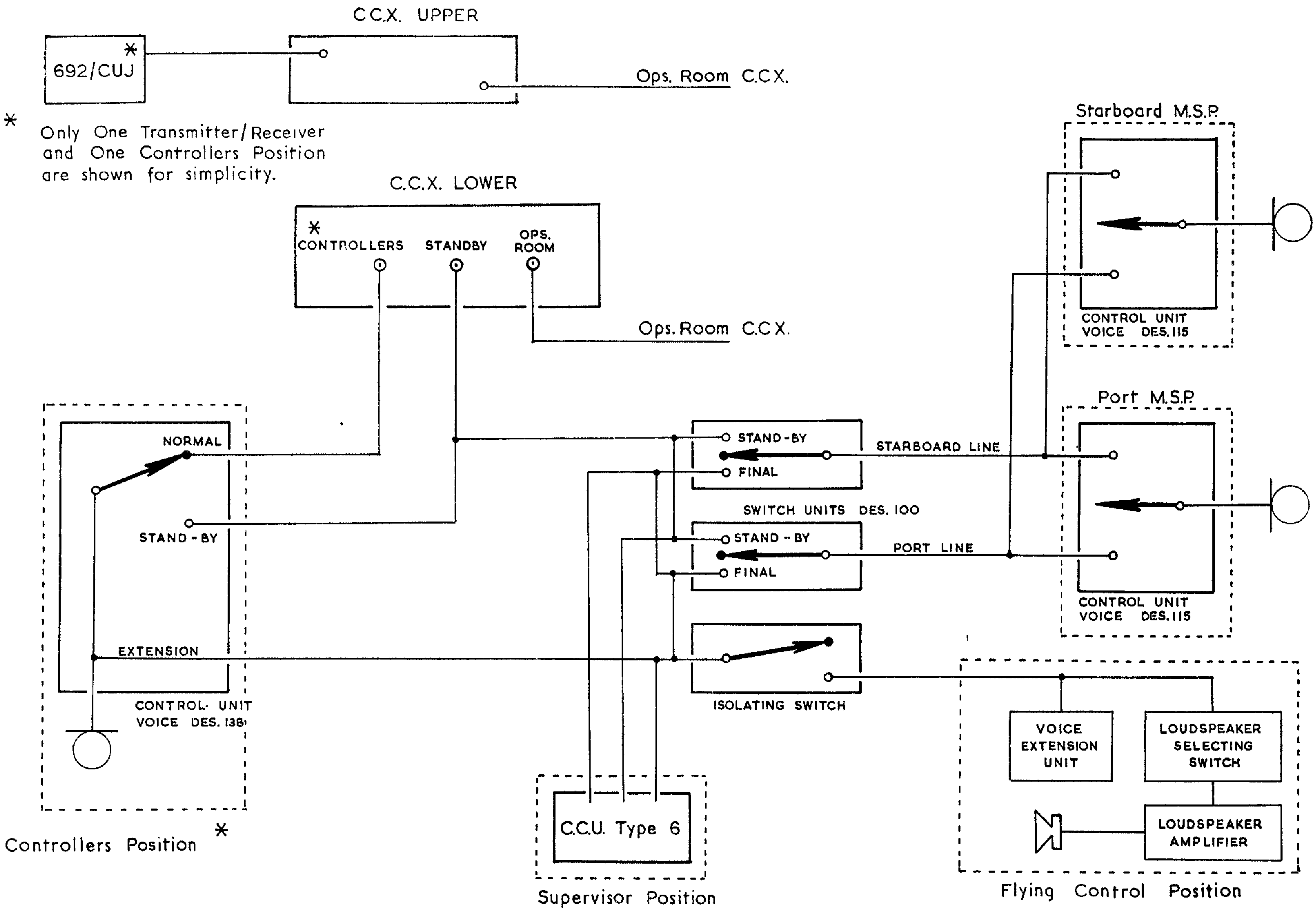


FIG. 1. KFJ CONTROL SYSTEM – BLOCK DIAGRAM

SECTION 6

AERIALS AND COMMON AERIAL WORKING

This section has been divided as follows in order to separate the different problems and their application.

6.1. HF AND MF AERIALS - THEORY

1. Maximum energy is transferred from the transmitter to the aerial when the aerial input impedance appears as a pure resistance matched to the transmitter impedance. The aerial input impedance appears as a pure resistance when the aerial is resonant. For a grounded monopole, *e.g.* a whip or wire aerial with the feed point between ground and the base of the aerial, resonance occurs when the physical length is somewhat less than $\frac{1}{4}\lambda$. The input impedance of such an aerial is approximately 35 ohms. When the physical length of the aerial is equivalent to other multiples of $\frac{1}{4}\lambda$ the input impedance of the aerial appears as a pure resistance, but the value will be approximately

$\frac{1}{2}\lambda$ . . . 600 ohms $\frac{3}{4}\lambda$ . . . 70 ohms λ . . . 700 ohms

2. At the lower frequencies of the HF band it becomes impractical to use an aerial $\frac{1}{4}\lambda$ in length. An aerial that is short compared with $\frac{1}{4}\lambda$ has a complicated impedance and is not such an efficient radiator as a $\frac{1}{4}\lambda$ aerial. For example, the input impedance at the base of a vertical monopole of height $\frac{1}{8}\lambda$ is of the order of 500 ohms reactive and 8 ohms resistive. The effective height of such an aerial can be made equal to that of a $\frac{1}{4}\lambda$ aerial by adding capacity at the top. This is known as top loading and is used in an L or T type wire aerial consisting of a vertical portion and a horizontal roof. In general, this is not a practical solution for shipboard aerials in the HF band. The reactive component is tuned out by adding inductance at the base of the aerial. If the aerial is greater than $\frac{1}{4}\lambda$ but less than $\frac{1}{2}\lambda$ the aerial is inductive and its reactance is tuned out by using a series capacitance.

3. The standard HF transmitting whip aerial (AWF) is some 35 ft long and has maximum efficiency at about 7 Mc/s. At 1·5 Mc/s it is approximately $\frac{1}{16}\lambda$ in length and at 30 Mc/s greater than λ. The range of inductance and capacitance to tune the aerial to resonance over such a wide range of equivalent wave length is considerable. In addition, the input resistance when the aerial is made resonant varies over approximately 1–700 ohms, and for maximum efficiency this must be matched to the impedance of the transmission line.

4. The aerial can be matched either to the feeder or to the transmitter. When the aerial is matched to the feeder the matching components are sited at the base of the aerial and the method is known as *Base Tuning*. This method has the slight disadvantage that tuning has to be carried out from a remote position and therefore involves the use of control circuits.

5. When matching is carried out at the transmitter the tuning components are normally contained within the transmitter cabinet. Tuning is carried out manually and no remote control is involved. With this type of tuning large V.S.W.R.s, often less than 0·01, exist on the feeder and increased losses are present. Also, under these conditions, the feeders have to be specially constructed to withstand the high voltage and current present. As is well known, with shipboard installations trunks are employed.

6. The energy leaving a linear radiator is in the form of electric and magnetic fields which are perpendicular to each other and mutually perpendicular to the direction of propagation. The polarisation of a radio wave is arbitrarily defined as the orientation of the electric field. This definition is convenient because the electric component is in the same plane as the linear radiator. Thus a whip erected vertically will emit vertically polarized waves.

7. For propagation near the surface it is essential to use vertically polarized waves because with horizontally polarized waves the electric field is parallel to the surface and is rapidly absorbed. resulting in very rapid attenuation.

8. From the above it will be seen that the standard transmitting whip aerial outfit AWF(M), although a very suitable aerial for installation in ships, suffers from the following defects:

a. The terminal input impedance varies considerably over the frequency band and the aerial tuning unit to cope with these variations is a fairly complicated unit.

b. The horizontal radiation pattern has a large minima due to the effect of nearby structures such as funnels and masts.

c. At some frequencies in the band the vertical radiation pattern is by no means optimum for the purpose required.

9. **Broadband Aerials.** For a vertical aerial fed at the base, the values of the resistive and reactive components of its input impedance depend on the ratio of the diameter to the length. A thick aerial shows much less variation in input impedance over the frequency band than a thin wire and the problems of matching and tuning out the reactance are eased. Such an aerial is known as a Broadband Aerial. In practice shipboard broad-band aerials can be designed, employing parts of the ship's superstructure to form the aerials. A frequency range of 3–1 can be obtained and with the help of fixed matching networks at the base of the aerial V.S.W.R.s of better than 0·33 can be improved to 0·85 at no great cost by the Common Aerial Working Filter Units.

10. Three aerials are required to cover the range 2–24 Mc/s. The aerials have to be tailor made for each type of ship, using the superstructure existing in the ship. Two types of aerial are principally employed, the Folded Monopole and the Sleeve Aerial. These are illustrated in Section 11 which describes the Integrated Communications System. By choosing suitable dimensions for the exciter wires any given structure can be made to work over a specified frequency range. For example, a mast of height 45 ft can be used in order to obtain the maximum possible bandwidth and to enable the aerial to work with a 50 ohm feeder. The Sleeve Aerial is fed at the base of the radiator. The frequency coverage that can be obtained for any given overall height is dependent on the ratio of the length of the sleeve and upon the respective diameters. The sleeve aerial can be built in many different forms, with the radiator offset from the centre of the sleeve and inclined at angles from the vertical. Another type of broad-band aerial is the Biconical Aerial, so called because it is made up of two cones. The aerial is essentially a fat monopole. It is sometimes used to cover the high frequency part of the band, 8–24 Mc/s, when a suitable ship's structure is not available to construct a folded monopole or sleeve aerial.

11. The use of parts of the ship's superstructure as aerials improves the horizontal pattern over that of a whip aerial. Restricting the frequency pattern band automatically avoids the poor vertical radiation patterns which are obtained when using a whip at the high frequencies in the band.

6.2. MF AND HF AERIALS

REFERENCES: B.608. *Installation Specification for Fitting W/T Transmitting and Receiving Wire Aerials.*
B.R. 1625. *Handbook for Whip Aerial Outfits.*

GENERAL

1. **Ship Aerials.** A ship's outfit of aerials is made up of:

a. *Wire Aerials,* for MF and HF transmission and reception.
b. *Whip Aerials* for MF and HF transmission and reception.
c. *Standard pattern aerials,* normally dipoles for VHF and UHF transmission and reception.
d. *Standard pattern aerials,* dipole or frame, for D.F. equipment.
e. *Emergency aerials* to replace temporarily any aerial in *a* to *c* above.

2. **Aerial Rig Drawing.** A.S.W.E. Specification B.608 gives general information and drawings for fitting Wire aerials. With new construction and modernized ships A.S.W.E. produce an Aerial Rig drawing for the ship or class showing the layout of all types of aerial to be fitted. The drawing takes into consideration length, height and distance apart of aerials, and distance from associated equipment.

3. **Length and Distance Apart of Aerials.** All aerials should be clear of funnels and stays and other rigging, and should not be run parallel to other aerials and rigging. Small ships which are unable to comply with the following rules must endeavour to mount their aerials as far apart as possible.

MF Transmitter Aerials. Normally wire and must be of maximum possible length.

HF Transmitter Aerials. Preferably whip. If wire, they must be at least 50 ft long and should be 70 ft long if possible.

MF and HF Receiver Aerials. Preferably whip. If wire, they must be at least 4 ft clear of any other aerial and should, where possible, be 100 ft clear of medium or high power transmitter aerials.

WIRE AERIALS

4. A.S.W.E. Specification B.608 gives details of the types of wire and pattern of insulators to be used for different aerials. Methods of hoisting and supporting wire aerials are also shown. This specification, together with the Aerial Rig drawing for the ship, should be followed whenever wire aerials are rigged.

5. **Protecting Loops.** These loops, often referred to as safety loops, should always be fitted in all horizontal (roof) or nearly horizontal aerials. They are designed to prevent the aerial falling in the event of a sudden shock or whip of the masts. The weak link ruptures first, but the aerial should still be held by the loop. Details of construction, types of wire to be used, etc., are given in A.S.W.E. Specification B.608.

6. **Wire Whipping.** The whippings used to secure aerial wire must be done carefully; otherwise they will cause noise interference, tear flags and look unsightly. In Fig. 2, Fig. A illustrates how interference and torn flags can be caused. Figs. B, C and D show in three stages the correct method of making a whipping for an aerial. The end of the wire is rove through the eye, or end of the insulator. The wire is then unstranded for about six inches for a yardarm receiving aerial, or about 12 inches for a main roof aerial, each strand being straightened and laid along the main part of the aerial as shown in Fig. B. Each strand in turn is then wound tightly round the whole (Figs. B and C). The whipping is finished off by squeezing the ends in tightly between the binding with a pair of sharp-nosed pliers (Fig. D). To prevent the ends protruding later the whipping should be tinned with solder.

WHIP AERIALS

7. **Comparison with Wire Aerials.** Whip aerials are constructed of lengths of cylindrical metal rod, fastened together so as to give good electrical connections. They are of robust construction and designed to withstand shock, gales up to 130 m.p.h. and icing. They can be sited independent of supporting masts, their characteristics are known and their relatively high diameter/length ratio gives a flattish frequency response, making them easier to match to their feeders than the normal wire aerial. The whip aerial is in most respects more efficient in a ship than a wire aerial. Whip aerials are normally permanent, but there are also non-permanent whip aerials for use as emergency, after action or transportable equipment aerials.

8. **Transmitter Whip Aerial Outfits**

AWF. 35 ft long. Can be fitted on a pedestal for mounting on the funnel or superstructure. Alternatively, the aerial can be fitted directly on to an 8-in trunk outfit. Widely fitted in frigates and above and intended for low and medium powered transmitters such as the 601 series.

AWC. Uses the same aerial as AWF, but designed for fitting in aircraft carriers. The aerial is mounted on a hinged pedestal, which allows it to be lowered to the horizontal by a hand operated mechanical device attached to the pedestal.

AWL. As for AWC but the aerial is lowered and raised hydraulically. Can be operated from a remote position, *e.g.* the Flying Control Position. Fitted in preference to AWC when the whip aerials are used as supports for wire aerials.

> *Note.* The suffix (M) after any of the above three aerials indicates that it is a 'lightweight' aerial, constructed of aluminium alloy rods instead of cylindrical steel tubing.

AWG. 36 ft long in nine 4 ft sections. A lighter steel whip for use with transportable HF transmitters (*e.g.* Type 612 ET) with a power output of up to 40 watts. Also used as an all-wave receiver aerial.

AWH. 24 ft. long. Consists of an AWG aerial without the top three sections. Used

a. As a permanent low power transmitter whip in small craft and ships.

b. As an emergency whip in large ships, when it fits directly on to a 4-in trunk outfit TK in place of the normal wire aerial.

c. Used with a modified base as the emergency receiving aerial for use with EAL.

AWJ. A telescopic aerial comprising five sections made of non-magnetic metal. Used as a non-permanent transmitter and receiver whip in submarines, with transmitter power output up to 400 W.

AWA. See 'Receiver Whip Aerial Outfits' (para. 9).

AWQ. An AWH aerial using a cable feeder instead of trunk outfit TK.

9. **Receiver Whip Aerial Outfits**

AWA. 30 ft long. To provide efficient reception over its frequency range of 100 kc/s to 25 Mc/s a matching unit containing 11 filters is fitted in the base. A remote switch unit in the Wireless Office operates a motor fitted in the base of the aerial which in turn works the filter selecting switch. The remote switch unit receives its a.c. supply from the normal a.c. supply outfit or, in emergency, an outfit DWB or DWE. An indicating lamp lights when the appropriate filter has been selected,

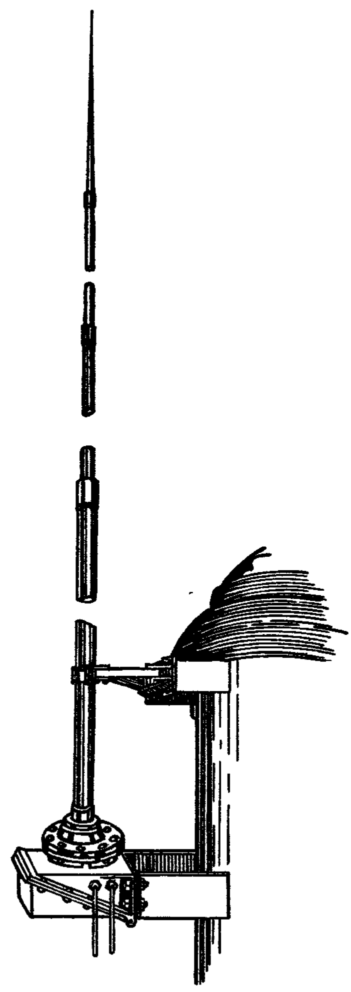


FIG. 1
AERIAL OUTFIT AWA

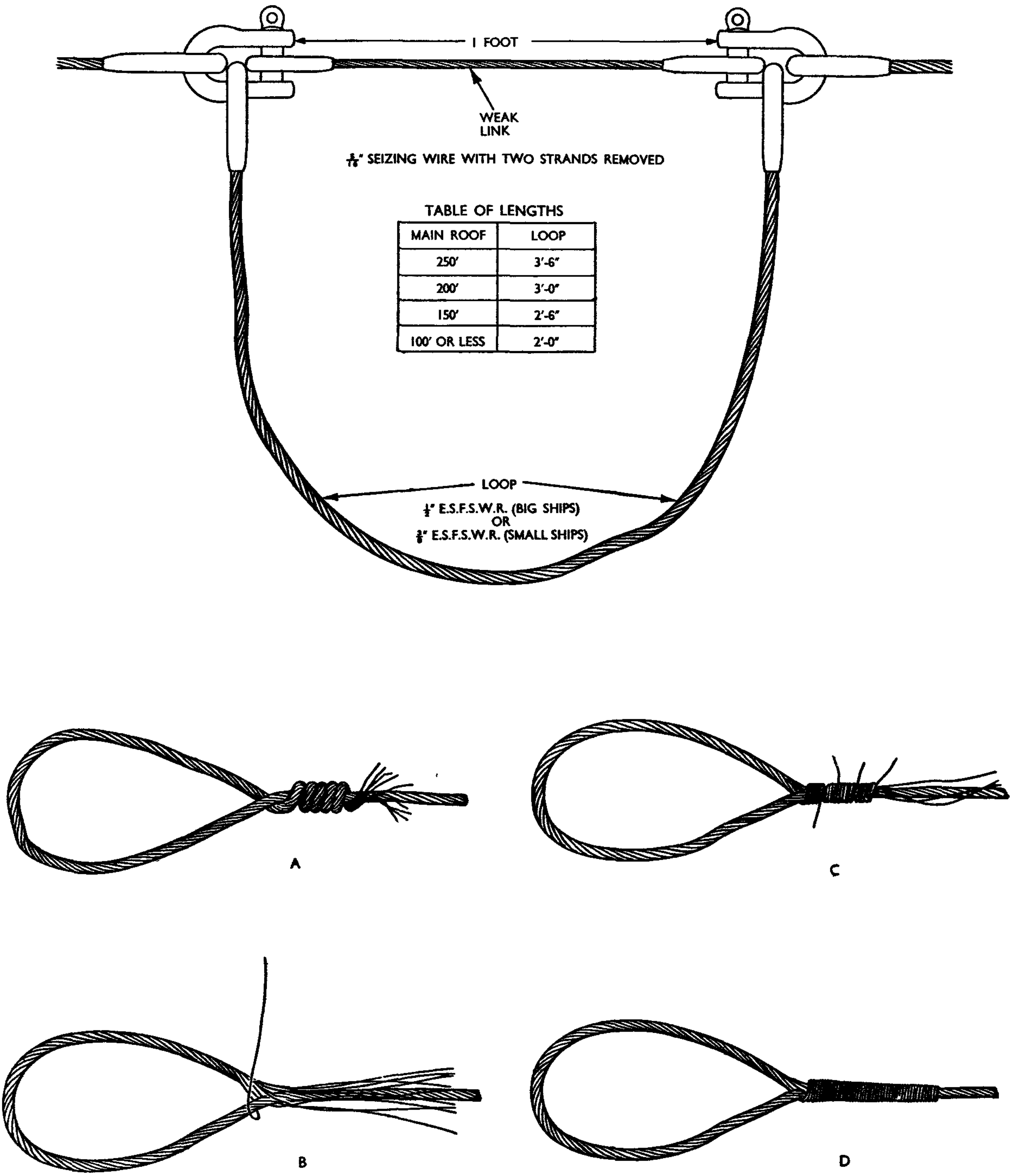


TABLE OF LENGTHS

MAIN ROOF	LOOP
250′	3′-6″
200′	3′-0″
150′	2′-6″
100′ OR LESS	2′-0″

FIG. 2

indicating that the aerial is ready for use. The filter selecting switch has a 'O' position in which the aerial is connected direct to the feeder, with no filter. In this position the aerial may be used as a low power transmitter whip. The suffix (M) indicates that it is a lightweight aerial, constructed of aluminium alloy rods instead of the usual cylindrical steel tubing.

AWG. See 'Transmitter Whip Aerial Outfits' (para. 8).

AWM. A 24 ft sectional whip aerial used with Navigational Aid Equipment in ships where no other suitable receiving aerial is available.

AWN. A 30 ft lightweight sectional whip aerial, fitted with Receiver Common Aerial Working Outfit EAL.

Note. Any transmitter aerial can be used as a receiver aerial provided it can be switched for this purpose, *e.g.* Type 601 series transmitters have a receiver position in the aerial c.o.s. which puts the aerial through to a receiver or to a receiver aerial exchange.

AERIAL FEEDERS AND MATCHING

10. **Transmitter Aerials.** A Trunk Outfit is used as the feeder between a transmitter and its aerial, the trunk being circular, 'D' shaped, or rectangular in shape. The conductor from the transmitter to the aerial is supported in the trunk by means of stand-off insulators, and the aerial is connected to a deck insulator at the top of the trunk. The size of the trunk depends on the power of the transmitter as follows:

Transmitter	*Size of Trunk*	*Outfit*
Low Power HF	4 in	TK
Low Power MF	8 in	TA, TL
Medium Power HF	8 in	TA, TL
Medium Power MF	18 in	TC

Although designed, trunk outfit TG has not been put into production. Consequently Type 605 MF is always associated with trunk outfit T.G.

11. **Receiver Aerials.** The correct matching of a receiver to a feeder line and aerial need not be so accurate as with a transmitter. Coaxial cable is therefore used as the feeder line instead of a trunk outfit. The aerial is secured to a deck insulator, the coaxial cable being led from the insulator to the receiver either direct or through an Aerial Exchange Outfit. When the coaxial feeder is very long, a deck insulator containing a matching transformer (Group OA) is fitted to avoid unacceptable mismatch. Similarly some aerial exchange boards are fitted with matching transformers, to allow for aerials normally fitted for B.W.O. reception (i.e. with short feeder lines) to be used, via the aerial exchange, for a receiver in the L.R.R.

12. **Deck Insulators for Receiving Aerials**
GROUP OA. Used for any aerial requiring matching transformers, *e.g.* LRR aerials. Two transformers A and B are fitted inside the cover plate and connected to the aerial by means of two 3-position links (see diagram). The positions are as follows:

Position A for 15 to 1500 kc/s (Transformer A)

Position B for 100 to 10,000 kc/s (Transformer B)

Position C for above 10,000 kc/s (no transformer).

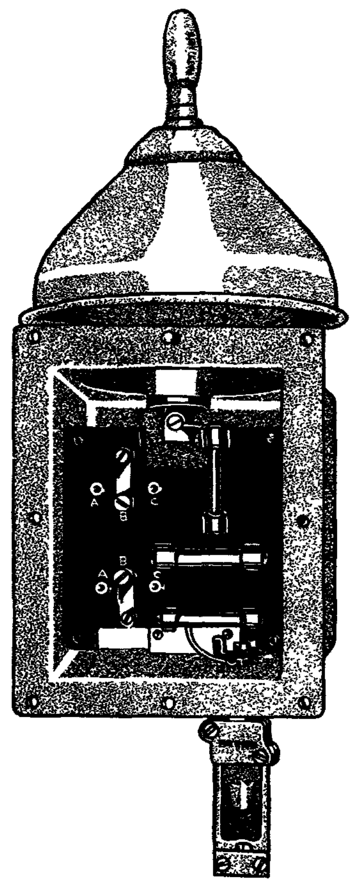


FIG. 3. GROUP OA

To maintain insulation a Group OA deck insulator is filled with grease and a grease nipple is fitted for topping up.

Group OB. Uses the same shield and frame as Group OA but allows for 'Straight through' connection only, having no matching trans- formers. Normally fitted in large ships for B.W.O. receiver aerials.

Group OC. A smaller version of Group OB fitted in frigates and below. When a matching transformer is used in a Deck Insulator the feeder is normally connected to the receiver by the low impedance or dipole input. When a matching transformer is not used the high impedance input is normally used.

13. **Receiver Aerial Exchange Outfits.** To allow for flexibility and because an individual aerial cannot be provided for each receiver in a ship Aerial Exchange Outfits are provided. These allow for any aerial to be connected to any receiver bay by means of plug and jack connections. The main outfits fitted are:

EE – for small ships
EF – for destroyers and frigates
EJ – for cruisers and aircraft carriers
EL – for leaders.

6.3. BASE TUNER OUTFITS AND AERIAL MATCHING UNITS

HF Matching Unit Outfit, ETC.

FREQUENCY RANGE. 1·5 to 24 Mc/s

AERIAL. AWF

DIMENSIONS. Height: 4 ft 3 in .
Width: 1 ft 10 in
Depth: 2 ft 0 in

WEIGHT. 246 lb

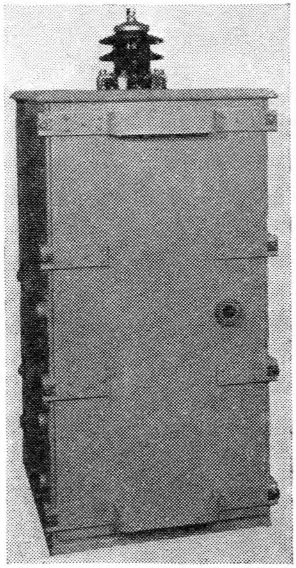


FIG. 1

MF Matching Unit Outfit ETB

FREQUENCY RANGE. 240 kc/s to 3 Mc/s

AERIAL. Wire

DIMENSIONS. Height: 4 ft 8 in
Width: 2 ft 0 in
Depth: 2 ft 0 in

WEIGHT. 300 lb approx.

DESCRIPTION AND OPERATION

1. Both Matching Units are housed in full weatherproof, welded aluminium cabinets suitable for open deck or bulkhead mounting. Access is provided by means of a removable front panel.

2. In the HF Matching Unit a wideband transformer is employed to transform from the 50 ohms feeder impedance up to approximately 800 ohms at the input of the matching circuit which consists of a variable capacitive leg and a series, continuously variable inductance. Series or parallel series capacitors are switched into the circuit by the band switch to allow for variation of aerial reactance.

3. The matching network of the MF base tuner comprises a variable capacitive leg and a series inductive leg formed by a variometer and loading inductance for the lower frequencies, or a variometer and series capacitor for the higher frequencies. The appropriate variometer and loading inductance or capacitor are selected by a bandswitch.

4. The capacitive and inductive elements of both matching units are tuned by means of remotely controlled split field, reversible d.c. motors. Switches on the Type 640 Control Unit control both the direction of rotation and the speed of these motors. Position indication meters on the Type 640 are fed from a d.c. supply via potentiometers geared to the capacitor, inductor and bandswitch shafts. Tuning of the matching unit is effected by selecting the appropriate position of the bandswitch and then adjusting the capacitor and inductor settings until the minimum reading is obtained in the V.S.W.R. meter.

5. The Type 640 r.f. output and controls are automatically switched to the appropriate matching unit when selecting the radiated frequency on the frequency synthesizer.

6. A fan circulates air within the matching unit to prevent overheating. To facilitate operation in low temperatures, a thermostatically controlled heater is incorporated in the fan duct.

BASE TUNER OUTFIT ETA

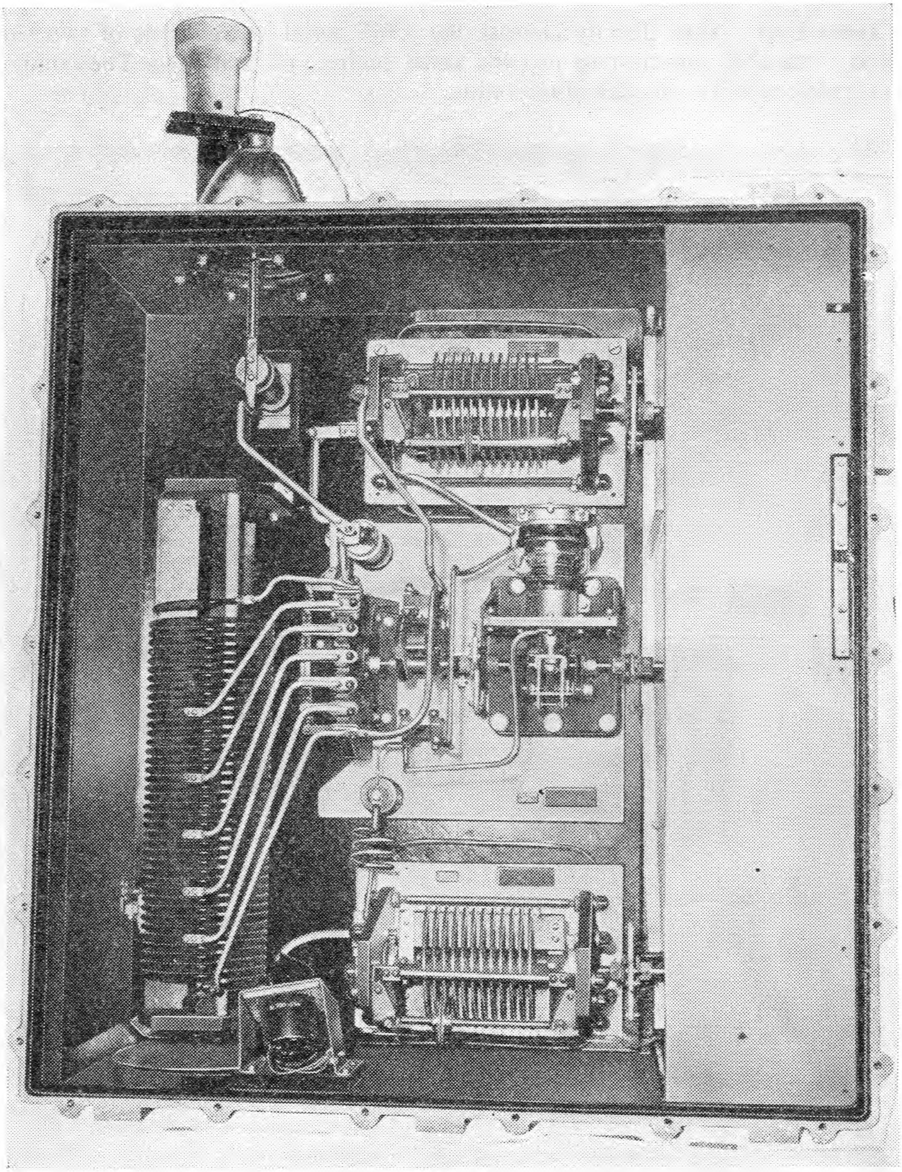


FIG. 2

FREQUENCY RANGE. 1·5 to 24 Mc/s

AERIAL. AWF

DIMENSIONS.

Height: 2 ft 11½ in

Width: 2 ft 11 in

Depth: 1 ft 3 in

WEIGHT. 300 lb

Handbooks.

B.R. 2363. *Aerial Tuning Outfits ETA series.*

B.R. 2216. *Cabinet HF 603/605 Matching.*

B.R. *I.C.S. Handbook on operation of C & M Desk.*

DESCRIPTION AND OPERATION

1. Associated with but not part of Outfit ETA is the Control and Power Supply Unit described below.

2. **The Base Tuner Unit** is sited directly beneath the AWF aerial and consists of two variable coils, a tapped coil and a variable capacitor to provide aerial tuning and matching. The components can be arranged to provide one of two modes of operation.

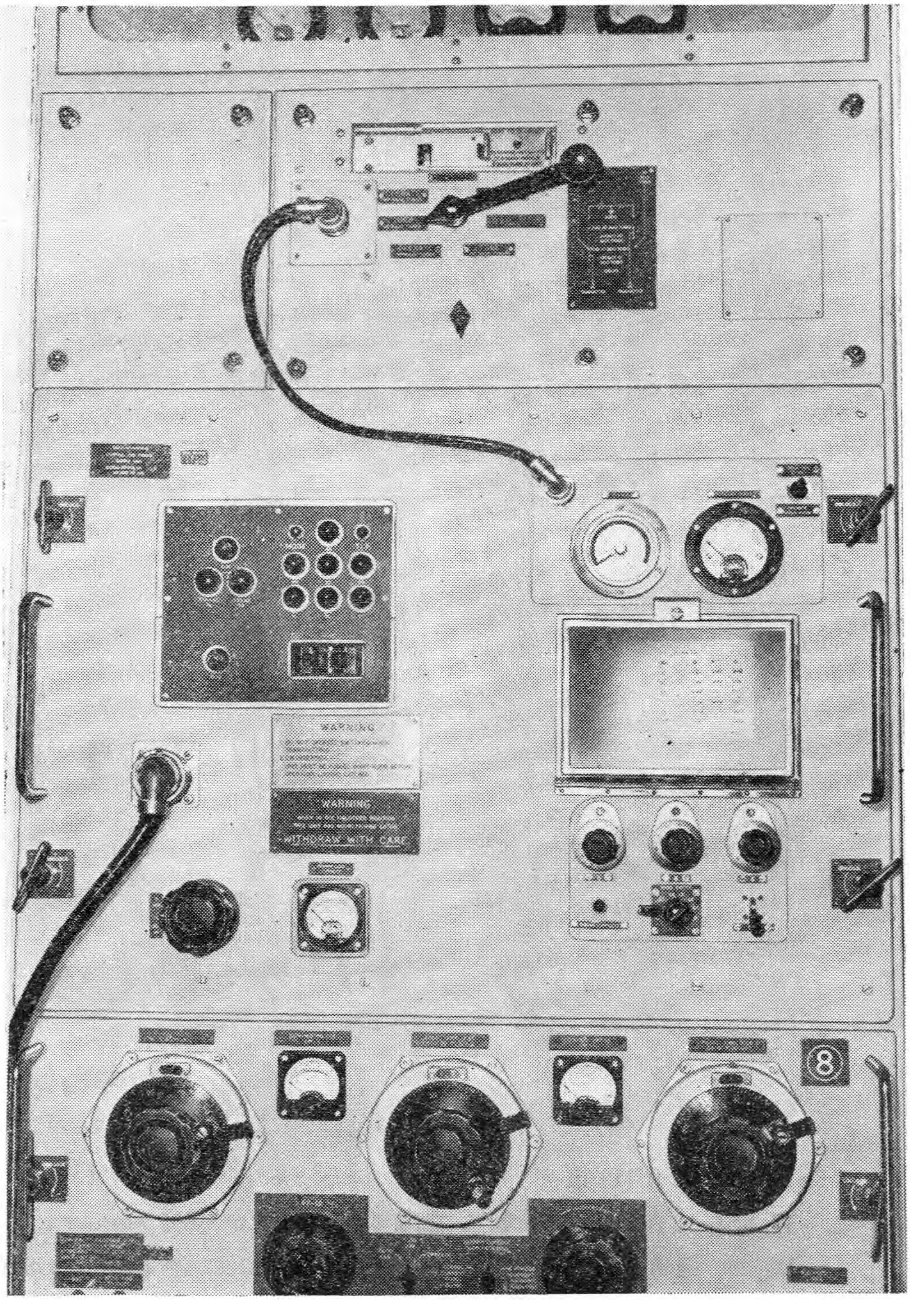


FIG. 3

a. L. Mode. A simple series inductance for tuning frequencies below approximately 5 Mc/s when the aerial is less than a quarter-wave length.

b. Pi Mode. Slight circuit changes and the introduction of the variable capacitor form a Pi-filter circuit for frequencies above about 5 Mc/s.

3. **The Control Unit and Power Supply Unit.** These units are sited in the HF cabinet of Type 603(5). In I.C.S. fitted ships, however, the Power Supply Unit is sited in the C.C.R. and the Control Unit is sited in the Control and Monitoring Desk. The Control Unit enables the Base Tuner to be remotely tuned from the transmitter.

4. **Switches**

a. Mode Switch. An eight-way position switch. Positions 1 to 7 alters the tappings on the Loading Coil.

b. Control A. Alters the tuning of the variable inductance coil.

c. Control B. Controls the tuning of the variable capacitor. It is inoperative when the L Mode is used.

d. Control C. Alters tuning of the Loading Coil.

e. Dummy Load Switch. Switches r.f. output either to DUMMY LOAD for tuning or Aerial Change Over SWITCH.

f. Tune ON/OFF Switch. Connects power supply to Base Tuner Drive Units and enables the Base Tuner to be tuned at the transmitter. When switched to ON the Tune Lamp Lights.

Lamps

a. Tuning Complete Lamp. This lamp is out until tuning is completed and is on when tuning completed.

b. Tuning in Progress Lamp. This lamp is on during tuning and goes off when tuning is completed.

Meters. V.S.W.R. and Forward Peak Power meters. The Base Tuner is correctly tuned when the needle of the V.S.W.R. meter is within the green portion of the meter scale.

Tuning. Instructions are contained in the Type 603(5) section. After first installation, calibration curves should be prepared and recorded on calibration charts.

6.4. HF/MF TRANSMITTER COMMON AERIAL WORKING OUTFITS

1. Common Aerial Working Outfit EAM is fitted in Tiger Class cruisers and Outfit EAW in I.C.S. fitted ships. Details of EAW are given in Section 11.

2. **Outfit EAM**

HANDBOOK: B.R. 1380.

3. Common aerial working for HF transmitters of the 601 series is at present designed for fitting in cruisers only.

4. Three aerials are provided.

Aerial 1 covers 2 to 5 Mc/s.	These bands may vary slightly in different ships.
Aerial 2 covers 4·5 to 17·5 Mc/s.	
Aerial 3 covers 17·5 to 24 Mc/s.	

These aerials are broadband aerials and are flatly tuned over the frequency band for which they are designed. Consequently Types 601 and 603 fitted for C.A.W. do not have Aerial Tuning Units, and are known as Type 601(2) and Type 603(2). The HF transmitters in Type 602 and 605 retain their Aerial Tuning Units. They can be used to tune into any conventional aerial but are also adapted for feeding into the C.A.W. system.

5. **Layout.** Types 601(2) and 603(2), together with all C.A.W. equipment, are fitted in the L.T.R. Types 602 and 605 are sited in the U.T.R. and their outputs can be fed to their conventional aerials through trunk outfits, or on HF to the L.T.R. for connecting into the C.A.W. system.

6. **Aerials**

AERIAL 1. 2 to 5 Mc/s. Uses mast excitation, with five vertical wires supported from the after end of the roof aerial halyards to a matching unit fitted on the deck or superstructure at the base of the mainmast.

AERIAL 2. 4·5 to 17·5 Mc/s. Uses funnel excitation, with six vertical wires from a support at the after side of the funnel to a matching unit on the deck or superstructure at the base of the funnel.

AERIAL 3. 17·5 to 24 Mc/s. Uses a broadband dipole fitted at the top of the mainmast on the after side.

The three aerials are each provided with matching units and are fed by coaxial feeder lines from the L.T.R. Two emergency whip aerials are provided, 1 for the U.T.R., 1 for L.T.R.

7. **Principles of HF Common Aerial Working.** (See diagram.) The output of each transmitter is connected to the aerial via a tuned filter, the filter passing only frequencies to which it is tuned. As the transmitter can be fed into one of three aerials, three tunable filters are provided for each transmitter. An Aerial Switching Unit enables each transmitter to be connected to any of the three aerials, or to a dummy load position used for tuning. A wattmeter is fitted to indicate the power passing from the transmitter through to the aerial or dummy load. The wattmeter has a red portion of the scale which reads power flowing in the opposite direction into the output stages of the transmitter, as would happen if two transmitters were tuned to the same or to nearly the same frequency and fed into the same aerial.

8. **Aerial Switching Unit.** This unit has three main functions, connecting the output of the transmitter 5AB or M.88 as follows:

(*continued on page* 6–4–4)

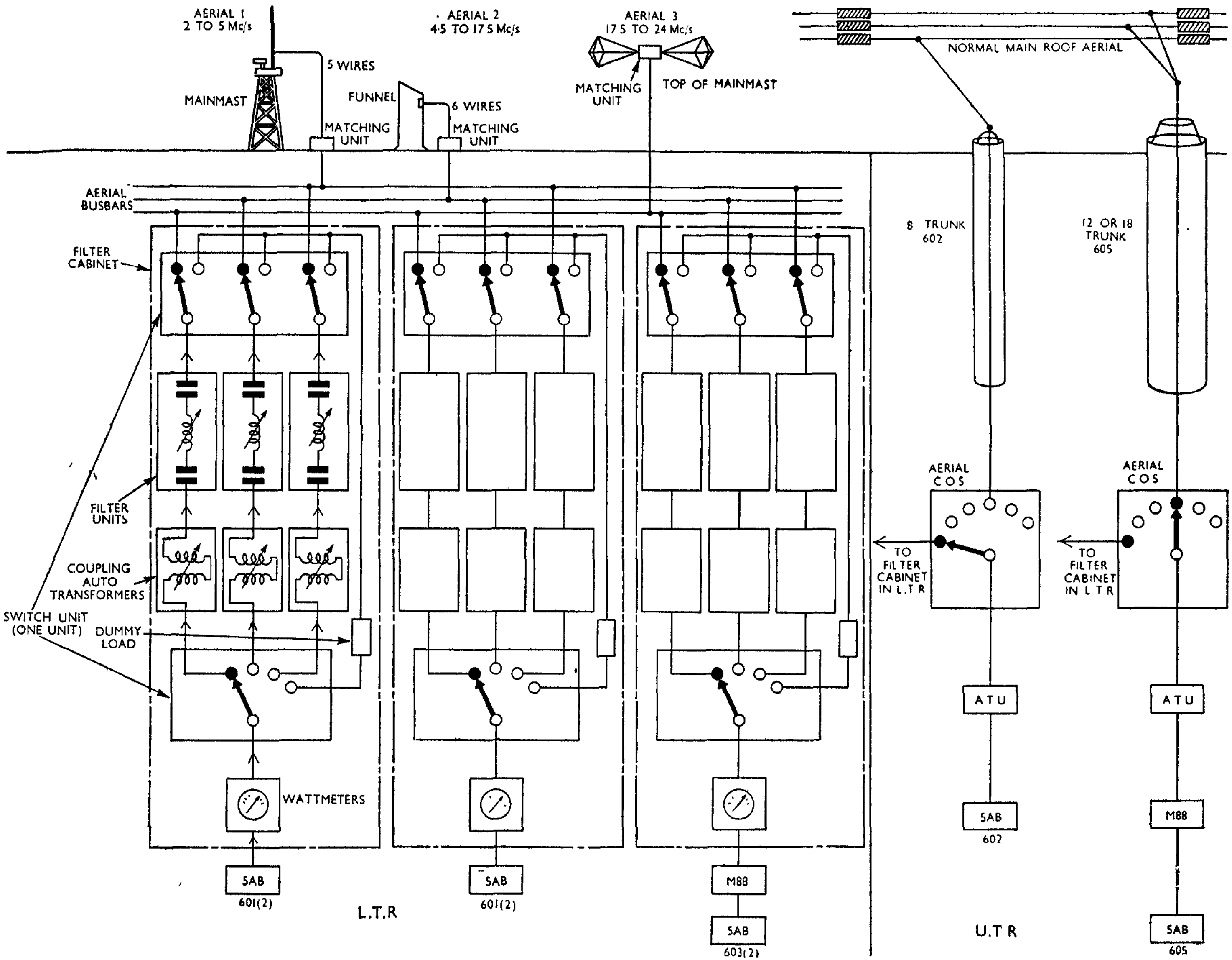
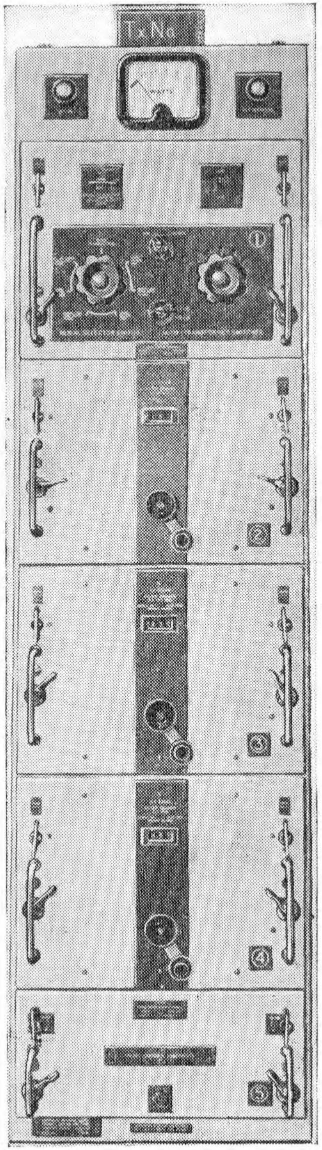
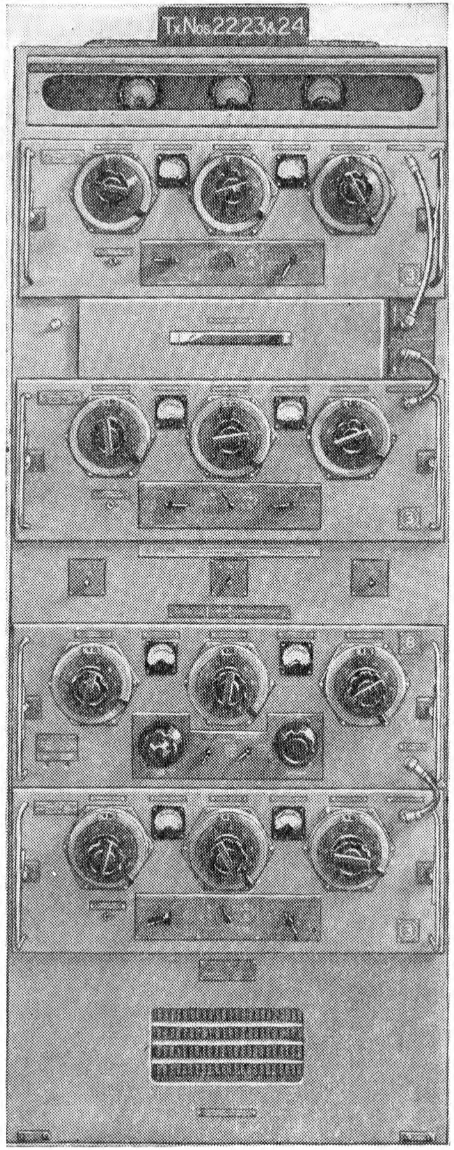


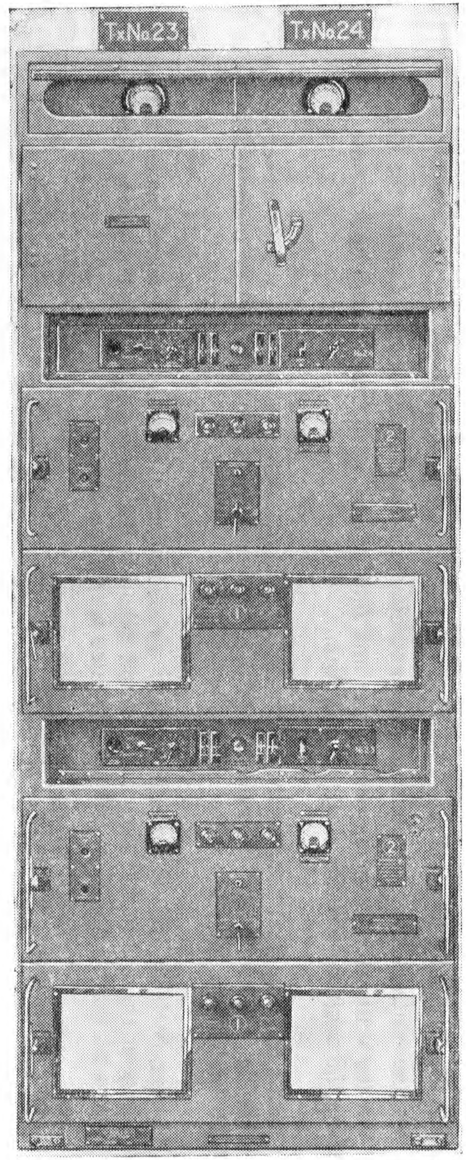
FIG. 1. HF TRANSMITTER COMMON AERIAL WORKING OUTFIT EAM



C.A.W. FILTER CABINET



TWO 601(2)S AND ONE 603(2)



POWER SUPPLIES FOR TWO 601(2)S

FIG. 2

(*continued from page* 6–4–1)

a. Via the wattmeter to the dummy load for tuning the transmitter.

b. Via the wattmeter, coupling transformer and filter into the dummy load for tuning the filter.

c. Via the wattmeter, coupling transformer and filter to the aerial busbars and appropriate aerial for setting the coupling transformers and operation.

9. **Channel Spacing.** To allow for the pass band of the filters, channel spacing of 2 kc/s every 100 must be used, *e.g.* if a transmitter is tuned to 4000 kc/s another transmitter must not be tuned within 80 kc/s of 4000, and for 18 Mc/s not within 360 kc/s.

10. **Cooling System.** The whole equipment is air cooled by a central system which sucks in through dust filters at the bottom of each cabinet and exhausts it outside the transmitter room. The blowers provided with transmitter Type 603 are not fitted with Type 603(2).

11. **Tuning Instructions.** See under Types 601 and 603 in Section 2.

6.5. HF/MF RECEIVER COMMON AERIAL WORKING OUTFIT EAL AND FILTER, BAND SUPPRESSION

1. Outfit EAL is the general Common Aerial Working outfit fitted in the fleet to provide reception for B40s, B41s and CJKs. The details of I.C.S. reception are given in Change No. 1 to B.R. 222.

2. Aerial distribution for conventional receivers in I.C.S. is achieved by Outfit EAO which is similar to EAL but with a reduced capability.

3. Outfit EAL has been modified by the addition of tuneable filters to suppress adjacent high power interference from a ship's own transmitters. Details are given at the end of this part.

LF/MF HF RECEIVER COMMON AERIAL WORKING (OUTFIT EAL)

HANDBOOK: B.R. 1615.

4. Common Aerial Outfit EAL is designed to provide Common aerial working for LF/MF and HF receivers in all types of ship fitted with six or more receivers. Reception is provided by two whip aerial outfits AWN and one wire aerial in all types of ship except carriers, where three outfits AWN and one wire aerial are provided. The AWNs act as HF main and LF/MF secondary aerials and the wire aerial is the primary LF/MF aerial.

5. **Receiver Arrangements.** Receiver outfits CAY ~~and~~ CAZ and CSK are used with outfit EAL. Outfit CAY consists of a receiver B40 model C or D, specially modified for use with common aerial working. Outfit CAZ consists of a receiver B41 model B or C, no special modification being required. Each receiver has a choice of two aerials, selected by means of an Aerial Selector Switch fitted at the base of the receiver. A third position of the switch provides for a test position (see under 'Test Lines', para. 9).

6. **Principles of Receiver Common Aerial Working.** An aerial is connected in series to each receiver in turn in such a way that each receiver only picks out signals on the line at frequencies to which it is tuned. All other signals are allowed to pass along the line to other receivers, eventually to be dissipated in a terminating resistance at the end of the line.

7. **Operation of Common Aerial Working**

LF/MF WIRE AERIALS. Normally fed to the B.W.O. to provide MF1 line. This goes to each B41 in the B.W.O. in turn and thence to a switch unit Design 75.

This switch has two functions:

a. To terminate the line to earth through a suitable resistance.

b. By means of a link to connect the outgoing line from the switch to Remote line to intermediate offices and L.R.R.

In the L.R.R. a second Design 75 switch enables the line to be terminated through a resistance or connected to each B41 in the L.R.R. in turn without the use of a link connection. In the latter case the line is terminated to earth via suitable resistance at the last B41.

HF WHIP AERIAL No. 1. No. 1 Whip is fed to the B.W.O. where it is connected to the Crossover filter containing a Low and High pass filter. Signals below 640 kc/s pass through the low pass filter to an output, which is normally connected to the MF 2 line, providing a second LF/MF aerial for each B41. The MF2 line may either be terminated in a switch unit Design 75 in the B.W.O. or fed through the switch unit to intermediate offices in the vicinity of the B.W.O. where it will be terminated at a pre-selected B41. Signals above 640 kc/s pass through the high pass filter to the second output which is normally connected to the HF1 line. This line goes to each B40 in the B.W.O. and thence to a switch unit Design 75, whose function is the same as the switch unit Design 75 described above.

HF WHIP AERIAL No. 2. No. 2 Whip is normally fed to the L.R.R. where it is connected in exactly the same way as the No. 1 Whip in B.W.O., i.e. it feeds the HF2 line which goes through each B40 and via two switch units, terminating at the last B40 in the B.W.O. It also feeds the MF2 line which goes through each B41 in the L.R.R. and via a switch unit, terminating in a preselected B41 in an office in the vicinity of the L.R.R.

8. **Emergency Whips.** Sockets are provided on the upper deck into which emergency whip aerials can be inserted. These sockets are connected by feeder cable to the emergency socket on the aerial exchange where link connections can be changed over in the event of damage to the normal aerials. These emergency whips then feed to HF and MF lines via the filter units in the normal way. These emergency whips are modified versions of AWH.

9. **Test Lines.** Provided in each main office, being the third position of the aerial selector switch on each receiver. This line is used for feeding a signal into any or all receivers for frequency measurement or for performance testing. When a receiver is not in use the Aerial Selector Switch should be left to the TEST position.

10. **Tie Lines.** Tie lines are provided (port and starboard) to allow for the connection of a B.W.O. Aerial direct to the L.R.R. and vice versa.

11. **Aerial Exchange Board.** The crossover filters, inputs to MF and HF lines, switch units design 75, and the input and output sockets of port and starboard tie lines all form the Aerial Exchange Board, mounted at the Rating-in-Charge position in the B.W.O. and L.R.R. They are normally left connected as shown in the layout diagram, but plug and jack connections are provided to give complete flexibility, and to restore communications to the maximum number of positions in the quickest possible time in the event of a breakdown or damage to equipment.

40 MHz

Filter Units Design 12, which are low pass filters with a cut off at about [redacted], are included in the aerial exchange board with flexible connections for insertion in each aerial input line. These filters are designed to cut out interference, mainly from metric radar sets such as Type 960.

12. **Use of Receivers.** The following operating procedures should be applied when using receivers connected into this C.A.W. system:

a. Receivers not in use should be left with the Aerial Selector Switch in the Test position.

b. Receivers should be calibrated with the Aerial Selector Switch in the Test position.

c. A.G.C. must be switched off when comparing the signal strength from each aerial line.

13. **Performance Testing** – Noise Factor Measurements.

It is possible for the operator to be unaware of deteriorating Noise Factor in a receiver, hence the necessity for carrying out tests at regular intervals. The test equipment for this purpose is installed 'in situ' at the position of the Rating in Charge in main offices, and from there provision is made to connect into the input and receive from the output of each receiver in the office. The input connections to the receivers are through the HF and MF Test Lines as applicable, while the outputs are routed via Switch Unit A.P.206620 to the 20 Way Exchange Unit A.F. Design 1 and 2 (which is part of the KH series Control Outfit).

The attenuator A.P.65248 enables the output level of the receiver under test to be adjusted at the Rating in Charge position. Switch Unit A.P.206620, when in the TEST position, dissociates the receiver under test from the KH Control system, thus avoiding dissipation of output power in the system.

Details of Performance Testing are contained in B.R. 1615, chapter 10.

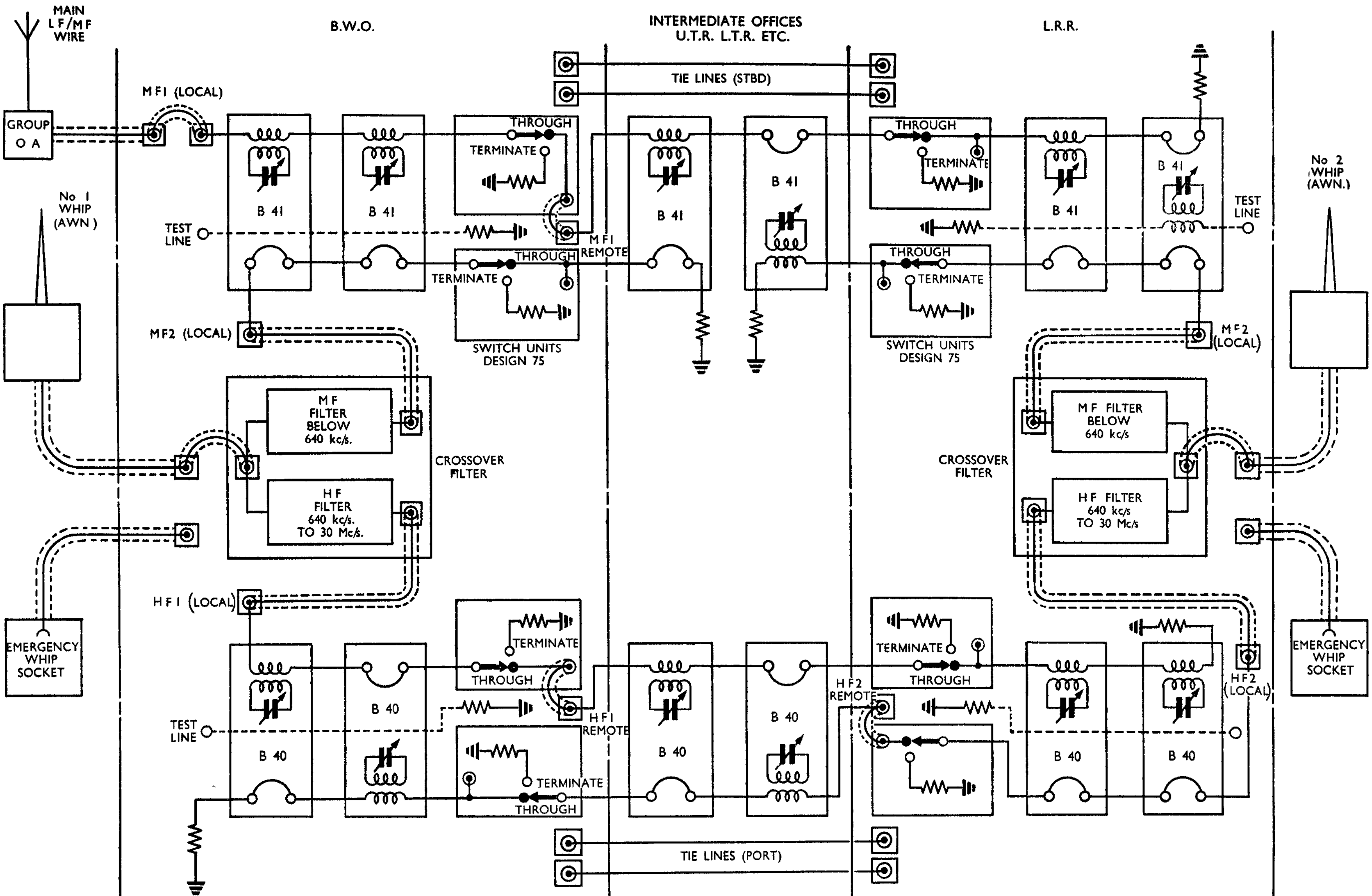


FIG. 1. RECEIVER COMMON AERIAL OUTFIT EAL

RECEIVER COMMON AERIAL OUTFIT EAL(3)—
USE OF FILTER BAND SUPPRESSION, LIMITED TUNING

1. The Unit consists of two identical filter sub-assemblies separated by a control panel. Each filter can be tuned over four bands centred on the 6, 8, 12 and 16 M/cs maritime mobile bands. The actual frequency coverage of the bands covered by this Unit is –

6 Mc/s	5·8–6·8 Mc/s
8 Mc/s	7·8–9·3 Mc/s
12 Mc/s	12·0–14 Mc/s
16 Mc/s	15·0–18·0 Mc/s

2. The purpose of the filter is to protect Ship's Receivers from their own transmissions by inserting at least 40 dB of attenuation at the required frequency during the period of transmission only. Thus, on VOICE, relays are operated by the press-to-speak key of the particular transmitter bringing the filter IN during periods of transmission but short circuiting it as soon as the pressel switch is lifted. On C.W. an additional slugged relay is used so that the filter remains IN as long as normal morse is made but is released if the key is lifted for more than about half a second. Normal LISTEN THROUGH facilities are therefore available. Similarly for F.S.T. working the additional slugged relay will remain in operation. For Two TONE working the VOICE relays are operated only.

3. CONTROLS

The controls are lettered A and B. A operates on the left hand filter and B on the right hand.

a. TX Select enables one of eleven transmitters to be chosen to control the filter. A list of numbered transmitters is posted near the EAL Aerial board.

b. System Switch marked OFF, R/T. C.W. selects the mode of operation. Because of wiring difficulties it is necessary to have separate positions for transmitters of the '601 series' from all other types.

Note. When using the 601 series transmitters both filter and transmitter must be set to the same mode, R/T. or C.W., or the LAMP BUSY light and the filter will stay on.

c. Test Switch. This must always be left in OFF position except when switching the filter locally for test purposes or for pre-tuning using a signal generator (see *Note* 1).

d. Band Switch. Selects the operating range of frequencies as shown above.

e. Tuning Controls. Marked CALL and WORK. These operate two separate tuning condensers only one of which is in circuit at a given time.

f. Balance. Controls a variable non-inductive potentiometer which balances the twin-T circuit to give maximum attenuation.

4. OPERATION

a. Set up Transmitter to the required frequency.

b. From list provided note Transmitter Number and select this on A or B TX SELECT.

c. Set corresponding (A or B) system switch to C.W. or R/T. as required. (For TWO TONES operation switch to R/T.; for F.S.T. operation switch to C.W.). On C.W. choose '600' for Transmitters Types 601 to 605 and OTHERS for any of the rest. The READY lamp should not light.

d. Select the required frequency range on corresponding BAND switch.

e. Tune Receiver (fitted with second detector current indicator) accurately to Transmitter Frequency i.e. dead space on TUNE). Switch to R/T. (or B.F.O. off) A.G.C. off. Adjust gain control to give near full-scale reading on indicator while transmitting.

f. Press Transmitter Key. The BUSY lamp should light. Tune CALL on filter for dip on indicator, increasing Receiver GAIN to maintain a suitable reading. Then tune BALANCE to further depress the dip. Repeat adjustments to CALL and BALANCE to obtain maximum attenuation or until the controls become so *touchy* that further adjustment is difficult.

g. Lift Transmitter Key. BUSY lamp should go out immediately on voice, but after appreciable (half second) delay on C.W. or F.S.T. The above covers normal single frequency operation, and if the Transmitter is adapted for CALL/WORK operation the CALL/WORK switch at the operating bay must be set to CALL. To enable the filter to perform in the CALL/WORK system the above procedure is carried out on the CALL frequency and must be followed by –

h. Switch Transmitter to a working frequency.

j. Tune Receiver to the working frequency. Reset to R/T. (i.e. B.F.O. off) A.G.C. off. Adjust GAIN control for suitable reading on indicator.

j. Press Transmitter Key. BUSY lamp should light. Tune WORK control on filter for dip. *Do not* adjust the CALL or BALANCE controls. Operation of the CALL/WORK switch at the bay then automatically switches the filter to the appropriate frequency.

> *Note* 1. If the Transmitter is not available for setting up the filters, say during radio silence, then the necessary tuning can be done by feeding the maximum signal from a signal generator on the requisite frequency into the appropriate EAL line by removing the aerial input into the first filter in the line and connecting the signal generator into the first filter, switching the appropriate TEST switch to CALL to tune the CALL circuit, and then to WORK to tune the working frequency circuit. Tune the Receiver to the appropriate frequency in turn. On completion, switch the TEST switch to OFF, remove the signal generator and reconnect the aerial to the first filter. Final *touching up* when actually transmitting should be achieved by use of the appropriate CALL or WORK control. On no account should the BALANCE control be used during this final adjustment.

> *Note* 2. It is necessary to tune filters to the same frequency in both EAL line 1 and line 2 otherwise the attenuation provided by a filter in one line can be by-passed by cross coupling from an unprotected line. When tuning a filter, all reception should be switched to the EAL line in which the filter is connected. The other EAL line should be either disconnected at the point of entry into the aerial exchange, or in ships with two or more offices the EAL line should be terminated by means of the switch on the aerial exchange. On completion of tuning the filter, connect the other EAL line to the aerial or switch the EAL line to the THROUGH position, switch all reception to the latter EAL line and then tune the filter in this line. On completion normal reception is possible in either EAL line.

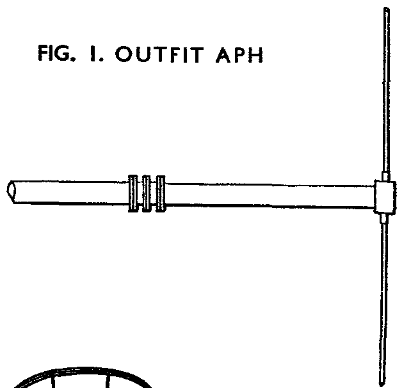
6.6. VHF AND UHF AERIALS

1. VHF and UHF aerials must be fitted as high as possible to obtain maximum range, as the range of VHF and UHF approximates to optical distance. Since it would not be practical to construct trunks or to have a tuning device at the base of the aerial, some form of self-tuned aerial is necessary. This is achieved by using dipole aerials cut to a particular frequency. In practice VHF and UHF aerials are usually cut to ½ wavelength for the middle or near middle frequency of the band covered by the transmitter or receiver. The aerial is made so that it presents an impedance of 70 ohms at the frequency for which it is cut. To match this a 70 ohm coaxial feeder is used, which allows perfect matching at the mid-frequency and a certain amount of acceptable mis-matching at the upper and lower limits of the band. The transmitter is matched to the feeder by means of normal aerial tuning. Broadband aerials are designed to be more efficient over a band of frequencies than the ordinary two rod dipole.

VHF AERIALS

2. The following aerials are used for the 100–156 Mc/s band, i.e. Transmitter Types 86M, and 87M, P, Q and Receiver Outfits CDV.

FIG. I. OUTFIT APH



AJA, APH AND ARU. These outfits all employ the same aerial unit which is a centre-fed ½-wave dipole. The types of feeder or mounting differ and are designed for fitting on yardarms or spurs as follows:

AJA – Small craft

AOH – Cruisers, destroyers and frigates

ARU – Aircraft carriers.

AJD. A ½-wave centre-fed broadband dipole designed for yardarm or spur mounting in aircraft carriers for use with Types 87P and Q and fitted in lieu of APH and ARU.

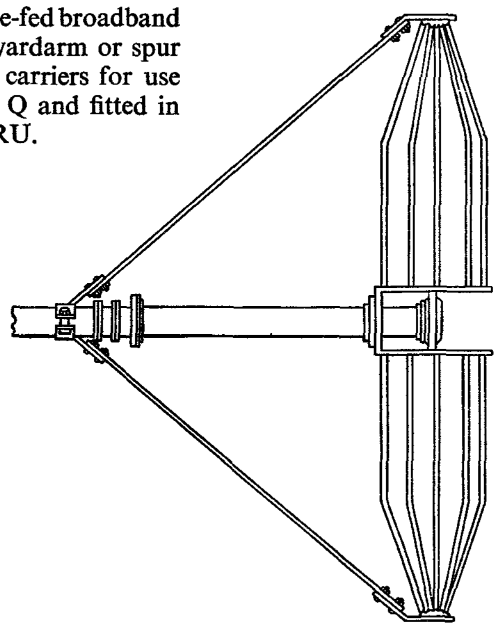


FIG. 2 OUTFIT AJD

ANC AND ANZ. A ½-wave centre-fed broadband dipole designed for mast-head mounting. The aerial for both outfits is the same. The mounting for ANZ fits on to the polemast in destroyers and frigates; the mounting for ANC fits on top of a radar aerial, normally in cruisers and aircraft carriers.

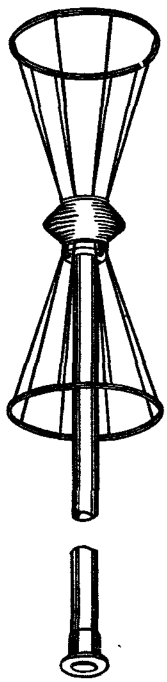
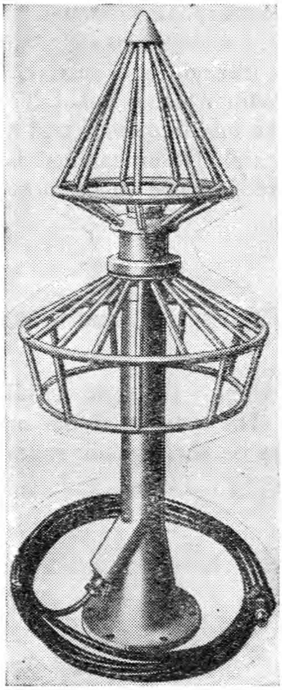


FIG. 3 OUTFIT ANZ

UHF AERIALS

3. The following aerials are used for the 225 to 400 Mc/s band, i.e. Transmitter Types 691, 692, 693 and 696 and receiver outfits CUH and CUJ.



AJC. A broadband dipole for yardarm or masthead fitting in all types of ship.

FIG. 4. AJC

AJE. Has the same characteristics as AJC but is made with much lighter metal and is only $\frac{1}{3}$ of the weight. Now being fitted in all types of ship instead of AJC.

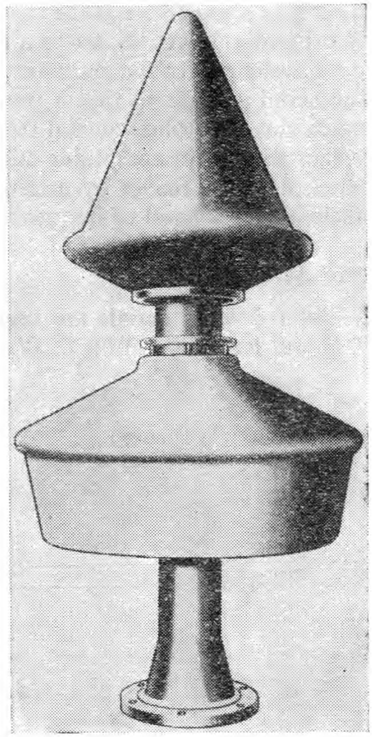


FIG. 5. AJE

6.7. UHF COMMON AERIAL WORKING OUTFITS

1. The reason for providing Common Aerial Working in the UHF band are slightly different to those used for HF, the main difference being the quantity of equipment fitted and, therefore, the number of aerials required. It would be impossible to allocate each transmitter or receiver in an aircraft carrier with individual aerials.

2. The solution is to arrange for a number of transmitters to share a common aerial and a similar arrangement for the receivers. This is achieved by fitting a type of filter into the aerial line between the transmitter/receiver and the aerial. These are called *Resonators.* There must be one resonator for each transmitter/receiver.

3. **Resonators.** These are simply UHF filters which are tuned to the frequency of the transmitter or receiver. They allow the wanted frequency to be radiated and prevent energy from another transmitter/receiver on the same aerial from being fed back. They normally consist of two cylindrical tubes, one inside the other, and are tuned, either manually or by a motor, by moving the inner cylinder up and down. The gap between the cylinders forms the capacitive component, and the line the inductive.

4. Resonators being selective in frequency are also used in a single transmitter or receiver as a filter.

5. Calibration curves are provided for approximate settings of the counter for 692/CUJ resonators and a table of settings for 691/CUH resonators.

6. C.A.W. with Type 691/CUH. Up to five transmitters Type 691 or receiver outfits CUH can use one aerial outfit AJC or AJE. Outfit EAK, consisting of three single resonators, is used for both transmitter and receiver common aerial working. The resonators are set up in accordance with a calibration chart and should not be tuned. When four or five transmitters or receivers are using the same aerial, two outfits EAK are required. Three connections must always be made to the junction box in each outfit. To allow for only two resonators being connected to a receiver or transmitter a dummy resonator is fitted in each outfit to which the third connection to the junction box is connected when only two resonators are in use

7. **Transmitters Types 692 and 693.** Up to six transmitters Types 692 or 693 or receiver outfits CUJ can use one aerial outfit AJE. Outfits are provided as follows:

Auto Tuned		*Hand Tuned*	
Outfit EAG	2 transmitters, receivers.	Outfit EAN	2 transmitters, receivers.
Outfit EAW	4 transmitters, receivers.	Outfit EAP	4 transmitters, receivers.
Outfit EAJ	6 transmitters, receivers.	Outfit EAQ	6 transmitters, receivers.

6.8. EMERGENCY AERIALS AND AERIAL MAINTENANCE

1. It is considered that in the setting of modern warfare the requirements for Emergency Aerials are simplified. When discussing these matters the provision made for emergency power supplies, equipment and effect of likely damage should be taken into account.

2. The requirements for aerials in an emergency are to provide an aerial for equipment that can still be used. Thus emergency aerials are those which can be rigged after damage has been sustained to provide aerials or feeders for equipment to enable communications to be carried out.

3. Communications personnel should be fully familiar with the layout of feeders and aerials in their ship and should be regularly exercised in fitting emergency aerials and feeders.

4. Sufficient stocks of aerial wire Pattern 611A are to be kept ready for immediate use as emergency receiving aerials with a quantity of insulators. The length of wire and number of insulators required will depend on class of ship. It is not recommended that the wire be cut to the sizes required until emergency aerials are actually required for use. Similar arrangements should be made for emergency HF transmitting aerials using large-size insulators. Ships fitted with Common Aerial Working systems are provided with replacement whip aerials, but should still make provision for providing emergency wire aerials in case the bases for the whip aerials are damaged. The aerial wire Pattern 611A can also be used to restore damaged sections of the feeder runs.

EMERGENCY UHF AERIALS

5. *a.* Construct a wooden cross with arms 24 in. in length. Take a length of feeder cable (coaxial), long enough to reach to the highest point at which the aerial is likely to be rigged. Bare the centre conductor to a length of 11 to 12 in and secure this with insulated staples to the wooden upright. Open out the braiding or screen of the cable and secure to the horizontal arms of the wooden cross. An Inglefield clip may be secured to the top of the cross for hoisting on a signal halyard. The junction should be sealed with rubber compound and the other end of the cable connected to a Pattern 5935–99–972–9195 plug for connecting to the transmitter.

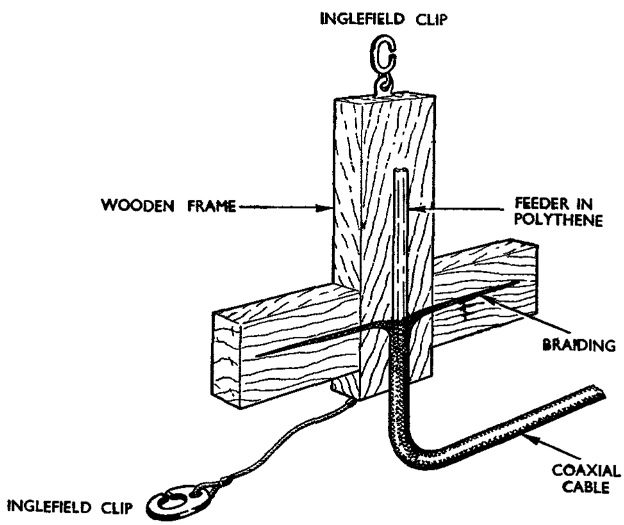


FIG. 1. EMERGENCY UHF AERIAL

b. Three spare dipole rods, or three brass or copper rods of length 11 to 12 in., may be secured to the same wooden cross as *a*, but the feeder cable is not bared. The vertical rod is connected to the centre conductor and the two horizontal rods to the braiding or screen of the cable.

c. Two dipole legs are made up of two 11 to 12 in. lengths of aerial wire. Receiving aerial insulators are fitted between the lengths and at each end. One dipole leg is connected to the centre conductor of the feeder and the other to the screen. The end insulators are joined to lengths of halyard wire or rope for securing the aerial in its emergency site. The aerial must be secured rigid and vertical, *e.g.* the top end could be secured to the yardarm and the bottom end to a suitably placed cleat.

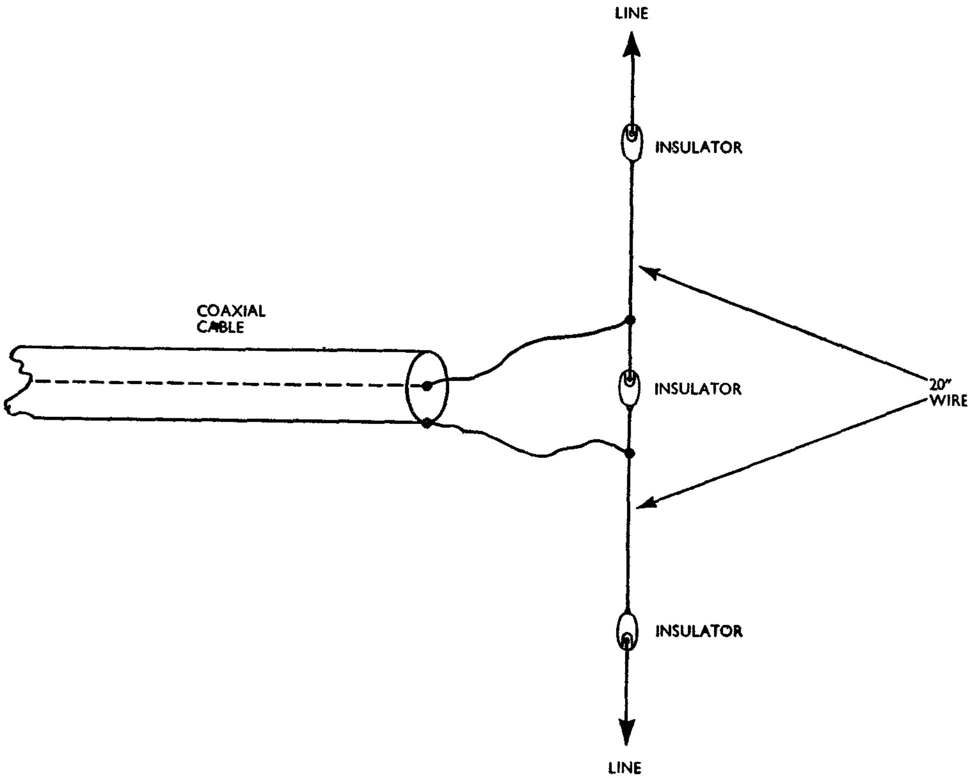


FIG. 2. EMERGENCY VHF AERIAL

AERIAL MAINTENANCE

6. **Division of Responsibility.** General responsibility for the maintenance of aerials is divided as follows:

Whip Aerials and Fixed Dipoles	Electrical Branch
Deck Insulators and Trunk Outfits	Electrical Branch
All forms of Wire Aerial	Communication Branch

The Communication Branch is also responsible for the making and hoisting of all wire aerials and for the making of all emergency and jury aerials which are made from wires or feeder cables.

7. **Maintenance of Whip Aerials and Fixed Dipoles.** Detailed instructions for the maintenance of Whip Aerials are given in B.R. 1625 and for dipole aerials in B.R. 1610 (1).

8. **Maintenance of Wire Aerials**

Replace aerials before wire becomes frayed.

Ensure good, clean and firm connections at the deck insulator.

Wash all glass insulators with soap and water at monthly intervals.

Keep all nut and bolt connections on insulators greased and free of rust.

Inspect all aerials once a month for broken strands, frayed whipping, etc., paying particular attention to the main roof aerial or any aerial over the funnels, where wire is likely to become damaged by funnel gases.

SECTION 7

PORTABLES, TRANSPORTABLES AND MOBILES

7.1. GENERAL

1. **Portables.** This term is used to describe equipment which can be carried about and operated by one or, in some cases, two men. Army sets are normally employed but are given naval numbers and sometimes adapted for special purposes.

2. **Transportables.** This term is used to describe equipment which can be taken ashore in a boat and/or transported by lorry and is designed for setting up a temporary station ashore. It is made up of units which can be manhandled.

3. **Mobiles.** This term is used to describe an outfit of equipment, collected together in vans or containers, including transmitters, receivers, telephone switchboards, M.S.O. facilities and the necessary power and maintenance units. The gear may be contained in radio vans, which are self-propelling vehicles, or in containers on wheels (known as MOCONS) which require transport to move them. A number of these vans or mocons form a Mobile, which is designed to perform a specific function such as a W/T and R/T communication station for a mobile Naval Air Base.

4. **Scale of Allowances.** The scale of allowances of portables and transportables to ships and craft is given in current DCIs (Conf).

7.2. TYPE 615 (88 SET)

FREQUENCY. 4 Spot frequencies of 40·2, 40·9, 41·4, and 42·15 Mc/s

RANGE. 1–2 miles over land
5–6 miles over water

WEIGHT (complete). 11 lb

MODULATION. F.M. Voice

POWER SUPPLY. Dry battery or vibral pack, 24 hrs. life

HANDBOOK. B.R. 1826 and 1827

ESTABLISHMENT LIST. E. 975

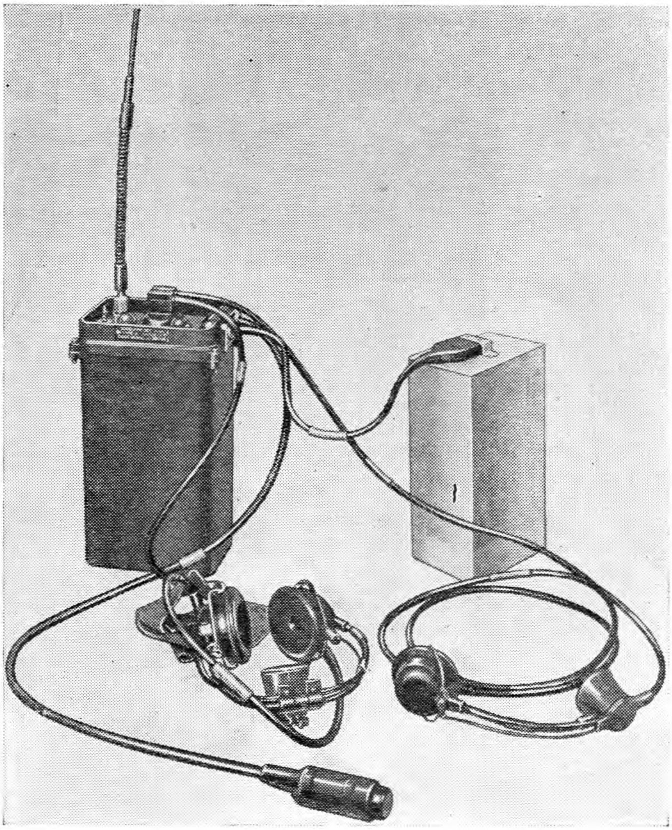


FIG. 1

1. **Description.** A light and portable one-man pack set used by landing parties for company nets, and for many other purposes. The transmitter-receiver is carried in one pouch and the battery in a second pouch. The necessary harness is also supplied with the set. A 4 ft rod aerial is used.

2. **615 A.F.V.** Has the same frequency and range as a normal 615 but has the addition of a power supply and LF amplifier unit and can be supplied by 12V d.c. as an alternative to its own battery, which is also fitted. Used in A.F.V's (armoured fighting vehicles) or in boats, where in either case it can be plugged into the vehicle's or boat's normal 12V supply. May still be found but is being removed from service.

3. **Flight Deck Control.** Three Type 615 in each Aircraft Carrier operating aircraft may be modified for use on the flight deck to provide improved control arrangements. Details of the gear required to effect this modification (i.e., improved headset) are given in current A.F.O's.

4. **W.S. 88B.** A Type B is sometimes found which has four spot frequencies between 38 and 40 Mc/s.

7.3. TYPE 620 (31 SET)

FREQUENCY. 40 channels between 40 and 48 Mc/s, 200 kc/s apart

RANGE. Three miles over land
12–15 miles over water

WEIGHT. (Not including batteries and ancillaries) 23 lb

MODULATION. F.M. Voice

POWER SUPPLY. Dry battery (life 25 hrs)

HANDBOOK. B.R. 1772

ESTABLISHMENT LIST. E. 1036

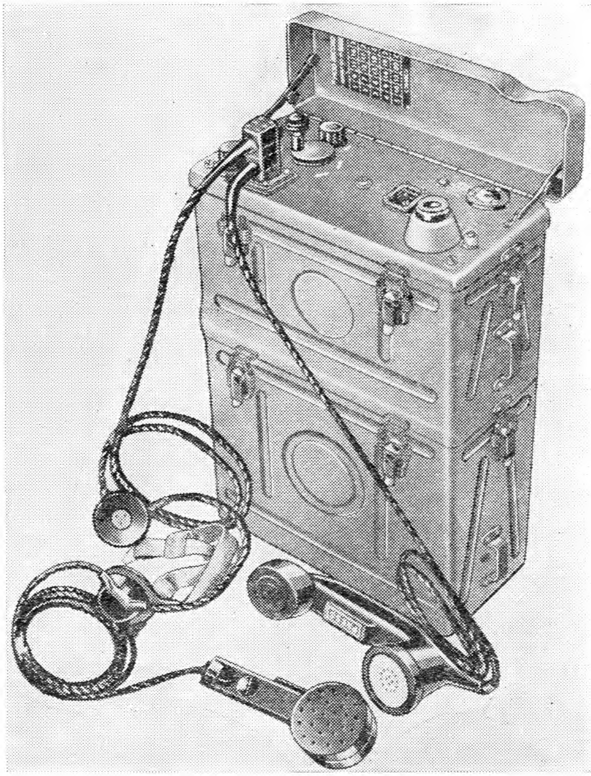


FIG. 1

1. **Description.** A one-man portable set supplied only to certain landing ships and craft and used for a battalion net and for general purposes. The transmitter-receiver is contained in the upper part of the weather-proof metal container and the battery in the lower part. Two types of whip aerial may be used, one in two sections (2 ft 9 in) or one in eight sections (10 ft 8 in).

7.4. TYPE 622 (62 SET)

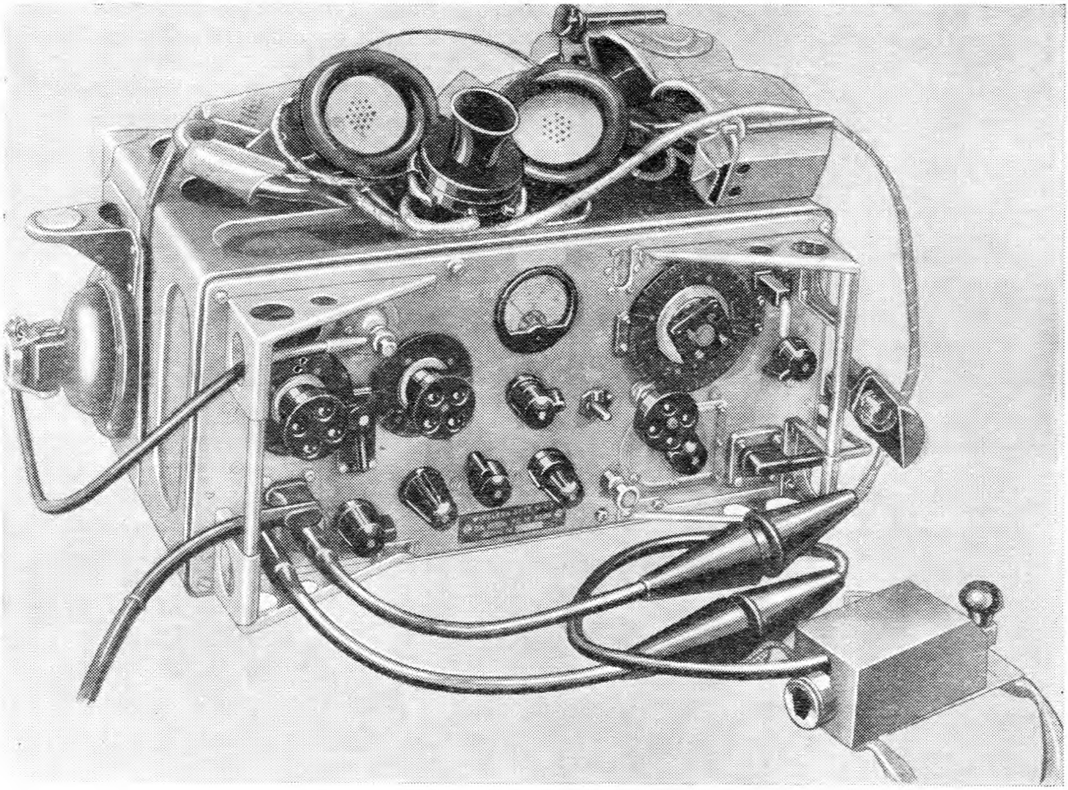


FIG. 1

FREQUENCY. 1·6 to 10 Mc/s, master oscillator or crystal control. Fitted to give two 'flick' frequencies for rapid frequency changing.

RANGE. 20 miles C.W.

14 miles Voice

WEIGHT (not including batteries and ancillaries). 29 lb

EMISSION. C.W. or A.M. Voice

POWER SUPPLY. 12 V accumulators

HANDBOOK. B.R. 1747

ESTABLISHMENT LIST. E. 1038

1. **Description.** A tropicalized transmitter-receiver used for a brigade net, Naval beach wave, bombardment spotting and other general purposes. The set is waterproof and will float. It can be carried by two men, one carrying the actual set and the other the accumulators. A power unit in the set, fed by the 12 V from the accumulators, provides H.T. at 300 V. Normally uses an 8–32 ft rod aerial but can also use a 100 ft sectional wire aerial. Remote control facilities are available, enabling the set to be operated up to ½ mile distant.

7.5. TYPE 625 (A40)

ARMY NO. W.S. A40.

FREQUENCY. Six spot frequencies between 47.0 and 54.4MHz (three of them common to Types A and B).

RANGE. 1 to 2 miles over open country between two sets with 4 ft rod aerials. 3 to 5 miles between sets fitted with 10 ft aerials.

DIMENSIONS. Height 11 in. Width 3.5 in. Depth 5.25 in.

WEIGHT. 10 lb.

MODULATION. F.M. Voice

POWER SUPPLY. Non-rechargeable dry battery providing the following voltages: +1.5, +45, +90 and −3.0.
Battery and transmitter-receiver share a common case.
Battery may be used on an extension lead in Arctic conditions to enable it to be warmed by the operator's body.

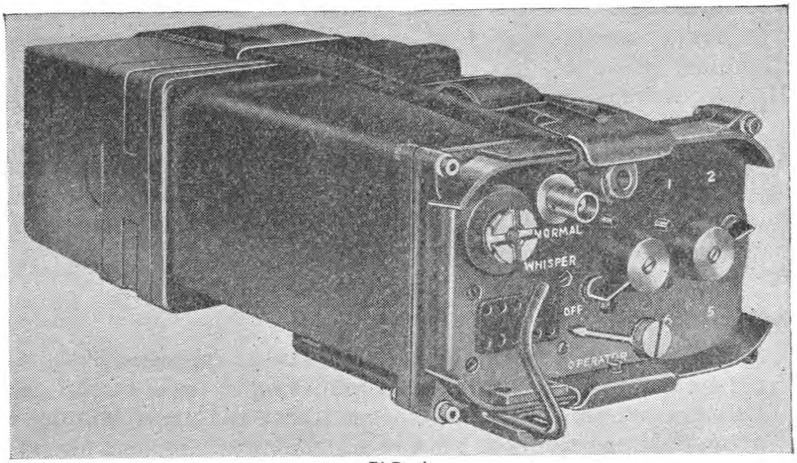


FIG. 1

ELECTRICAL PERFORMANCE. R.F. Output 300mW. Deviation 15kHz peak. Receiver 2 microwatt signal (20dB signal/noise) 15kHz deviation at 1kHz for 6mW output.

INTERCHANGEABILITY. Certain components are interchangeable with Canadian radio set CPRC–26.

HANDBOOK. BR 1193.

ESTABLISHMENT LIST. E.1193

1. **Description.** Replaces Type 615 as a short range, lightweight, VHF F.M. transmitter-receiver for voice communication. Fully sealed equipment case for use anywhere. Suitable for transport up to 25,000 feet and for dropping by parachute. Provided with straps for manpack use.
Two models, 625 Type A and 625 Type B provide alternative frequency allocations. Remote control is possible, using a handset extension cable at distances up to 60 feet.
Model A is for general Naval use. Model B is more particularly for Army and RM Commando use.
The two types are identified by the relevant Type letter stencilled on the front panel.

2. **Aerials**

a. 4 ft Vertical Rod

b. 4 ft wire

c. 4 ft Vertical Rod with earthed counterpoise wire

d. 10 ft half-wave antenna with matching unit and ground spike (remote up to 54 ft)

e. Portable homing loop.

3. **General.** Type 625 is a self-contained wireless station designed for short range use in either the manpack or ground station role. The very small R.F. power output of about 300mW gives short range communications of 1 to 2 miles over open country in the manpack role or between 3 to 5 miles in the ground station role. Good quality speech free from interference is obtainable.

4. **Station List.** The following items comprise a complete Type 625 wireless station:

Transmitter-receiver	Instruction plate
Expendable dry batteries	Two satchels
Headset Type SI No.1A	Earth spike
Headset Type SI No.4G	Connector 4 ft 6 in. coaxial
Extension Adaptor	Two 25 ft connectors coaxial
4 ft rod aerial	Audio extension lead
4 ft Earth counterpoise wire	Battery connector
Condition indicator	Adaptor unit
Harness, web and pad assembly	Connectors single

5. **Transmitter-Receiver.** The transmitter-receiver, is housed in a hermetically sealed case. All controls, aerial and control gear sockets are mounted on the front panel. Instructions for operating are printed on a metal plate, part of the equipment. The condition indicator provides a rough indication of transmitter power output and of the state of the battery.

6. **Power Supply**

a. The battery is housed in a water-proof case strapped to the base of the transmitter-receiver. Batteries are not rechargeable and will last about 18 hours under normal operating conditions.
Batteries will not supply power when frozen and the set will not work. They must, therefore, be kept above freezing point both when required for operation and also in store.

b. CHANGING THE BATTERY

(1) Slacken the strap securing the battery case.
(2) Discard the old battery.
(3) Place the new battery in the case, correctly aligned with the pins of the plug on the base of the transmitter-receiver.
(4) Tighten the securing strap so as to ensure a watertight joint between the cases.

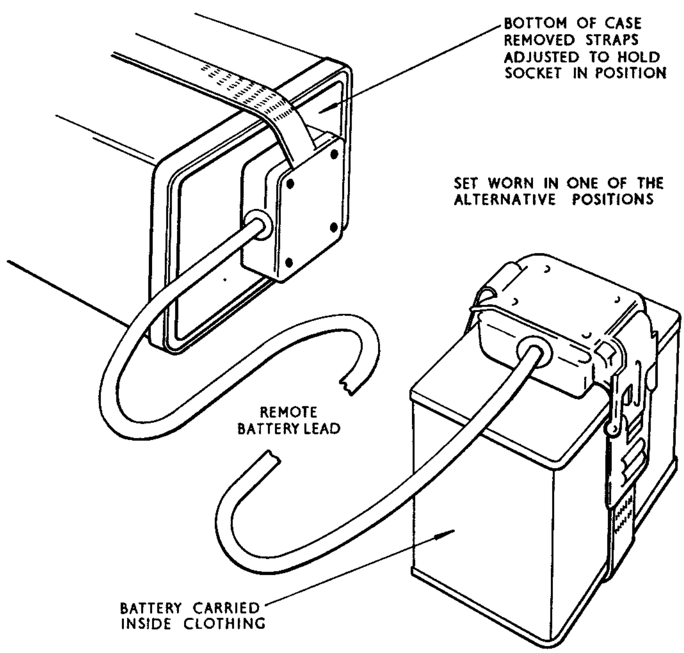


FIG. 2. EXTENSION BATTERY LEAD

c. Operation at or below Freezing Point

(1) Remove the battery case from the bottom of the set.

(2) Fit the 5-pin socket on the battery extension lead on to the plug at the base of the set and secure it to the set by means of the plug securing straps and map fasteners.

(3) Plug the 5-pin plug into the battery socket and secure it to the battery by means of the battery securing strap passing round the battery and engaging in the snap fastener socket on the battery plug.

(4) Stow the battery inside the operator's clothing to keep it warm.

7. Control Gear

a. The set is controlled from Type SI No.1A headsets or Type SI No.4G headsets. Both types include a pressel switch which, when operated, changes over from the Receive condition to the Send condition. When the operator speaks into the microphone, sidetone can be heard in the earphones. The first operator's control gear is plugged into the OPERATOR socket on the front panel.

b. Second Operator. A second hand or headset can be plugged into the 5-pin socket adjacent to the OPERATOR socket. If the person using this control gear wishes to send, both pressel switches must be pressed simultaneously and later released on the procedure word OVER. In emergency the pressel switch of the second control gear can be used alone but this causes severe battery drain.

c. Additional Operators. For three operators proceed as follows:

(1) Plug the 20 ft extension adaptor into the OPERATOR socket.

(2) Plug the first operator's control gear into the adaptor OPERATOR socket as marked on the protective shutter.

(3) Plug the second and third sets of control gear into the spare sockets on the set and adaptor.

(4) Observe the pressel switch procedure for more than one operator.

8. Carriage of the Set

a. The harness supplied as part of the equipment enables the set to be carried at the operator's belt with either the 4 ft or the 10 ft aerial in use. Alternatively it may be stowed in the small pack. In either position the controls are accessible to the operator.
Two satchels are provided for the stowage of spare batteries and auxilliary items.

b. Equipment Carrying Positions

(1) In the small pack – Illustration (a) in Fig. 3 shows the set in the small pack. The control panel faces the operator's left hand side and the ROD AERIAL socket is uppermost. The set should ride high on articles already in the pack so that the controls can be easily operated.

(2) In the lower position – Illustration (b) shows the set mounted at the operator's waist by means of a harness, web and pad assembly. The canvas pad is attached to the waist belt by three brass double hoods. The set is then strapped to the pad so that the control panel faces the operator's left hand side with the ROD AERIAL socket uppermost. The long strap is passed round the waist and fastened in front.

9. The Ground Station. In order to make the best use of available sites the 10 ft aerial and matching unit are mounted on an earth spike driven firmly into the ground. The set can be sited close to the aerial, using a 4 ft connector or the distance can be extended by means of one or two 25 ft aerial leads. It is also possible to use the 4 ft aerial instead of the 10 ft aerial, with reduced performance.

10. Operating Instructions

a. Use of the SYSTEM switch. This switch has three positions: OFF, WHISPER AND NORMAL. It should be used as follows:

(1) Set to OFF when the equipment is not in use.

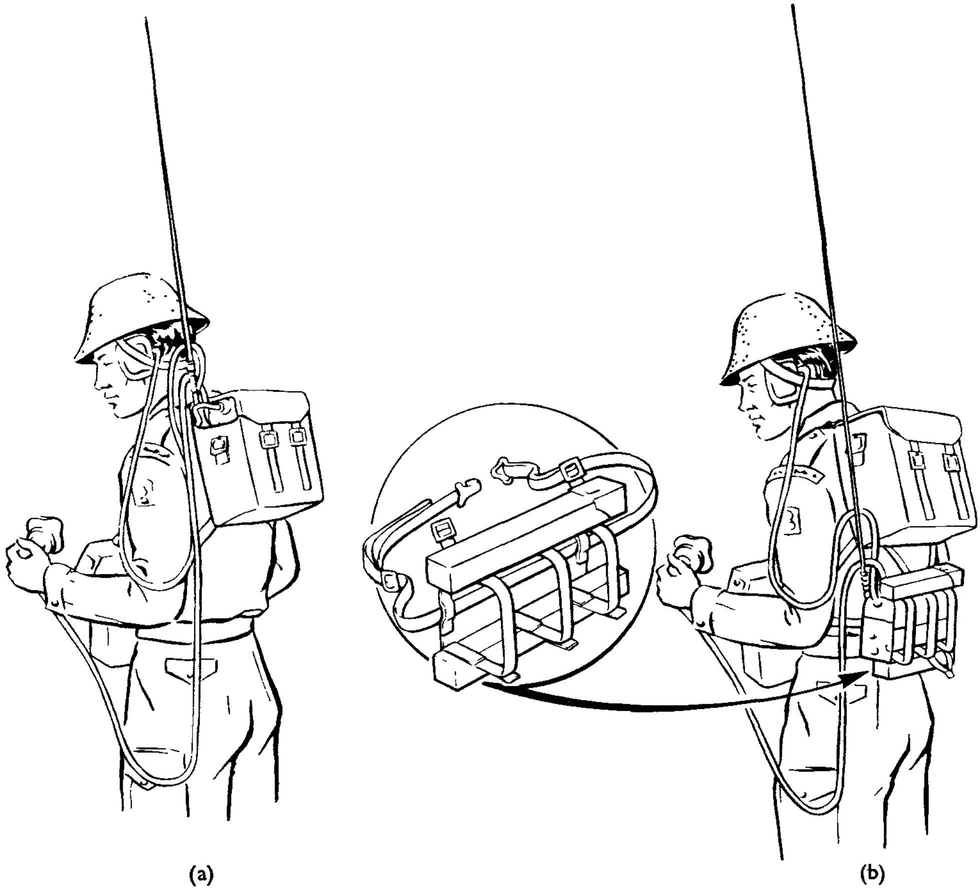


FIG. 3. ALTERNATIVE CARRYING POSITIONS

(2) Set to WHISPER when for tactical reasons the operator's normal voice would carry too far. The normal voice must never be used in this mode.

(3) Set to NORMAL when normal voice can be used.

b. SATISFACTORY OPERATION of the set under particular conditions requires optimum use of the available aerial, control gear and operating modes.

c. CHOICE OF AERIAL. The choice of aerial depends upon the range required, the nature of the site and the mobility of the station. The following information will assist in making the choice:

(1) The 4 ft vertical rod with flexible gooseneck gives an average range of 1 – 2 miles. This aerial should normally be used for highest mobility.

(2) The 10 ft vertical rod extends the range slightly. Performance is again improved when the earthed counterpoise wire is also connected.

(3) The counterpoise wire, if used by itself as a wire aerial, gives good concealment and reduces the range to about ½ mile. It is plugged into the ROD AERIAL socket and the wire extended vertically.

(4) The 10 ft rod erected as a matching unit and earth spike gives an average range of 3 – 5 miles. This aerial can be located up to 54 ft away from the set.

d. PREPARATION FOR OPERATION

(1) Check that a battery is in position.

(2) Plug a handset or headset into the bottom socket marked OPERATOR and secure it with the retaining arm.

(3) Set the SYSTEM switch to NORMAL and the CHANNEL switch to 1.

(4) Listen into the earphone. Noise should be heard if the battery is not too low. If noise cannot be heard change the battery or, if a battery tester is available, have the battery tested.

(5) Hold the prods of the condition indicator against the ROD AERIAL and REMOTE AERIAL sockets as shown in Fig. 4. The domed prod should be applied to the ROD AERIAL socket and the shorter of the remaining prods to the REMOTE AERIAL socket. (The third prod is used with Canadian set CPRC–26). Press the pressel switch. Turn the control knob on the condition indicator, watching the bulb until it burns with maximum brilliance. If the bulb burns brightly, transmitter and battery are normal. Blow into the microphone. If the side tone is operating correctly, the blowing noise will be clearly reproduced in the earphones. Release the pressel switch.

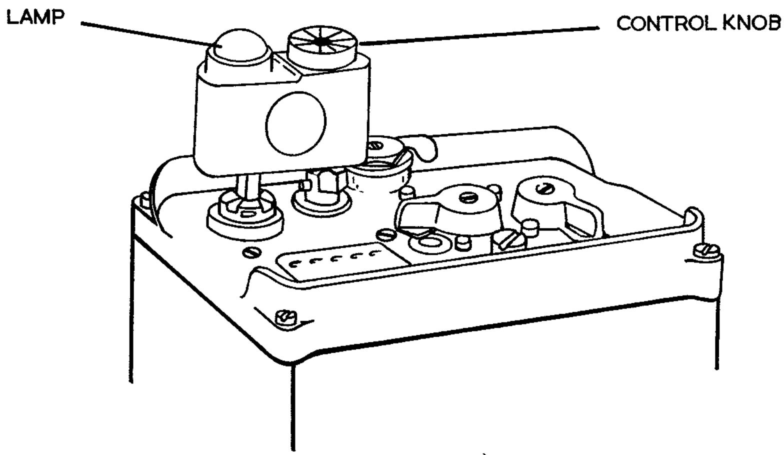


FIG. 4. USE OF CONDITION INDICATOR

(6) Repeat (4) and (5) for each channel in turn.

(7) Assemble the rod aerial required, plug it in by gripping the knurled base, pushing it into the ROD AERIAL socket and twisting to lock.

(8) If required, insert the earth counterpoise wire into the EARTH SOCKET and tuck the free end into the clothing (e.g. anklet, pocket).

(9) The set is now ready for operation.

e. OPERATING. If possible choose a good site, avoid thickly wooded areas, deep ravines, overhead power lines and large steel structures. Proceed as follows:

(1) Set the CHANNEL switch to the required channel.

(2) Set the SYSTEM switch to NORMAL or WHISPER according to the tactical situation.

(3) If reception is poor, improvement may be obtained by the operator placing his body between the set and the distant station, by tilting the aerial in various directions or by walking around until a good position is found.

(4) To SEND, operate the pressel switch and speak or whisper slowly and distinctly.

(5) When no longer required for operation the set must be switched off to avoid battery drain.

(6) The life of the battery is 18 hours under average conditions. Record the number of hours the battery has been in use and change it accordingly.

f. REMOTE CONTROL. To erect the remote 10 ft aerial:

(1) Push the earth spike firmly into the ground.

(2) Fit the matching unit to the earth spike and tighten the wing nut (see Fig. 5).

(3) Assemble the 10 ft rod aerial and screw it into the top of the matching unit. Tighten firmly by hand.

(4) Using the 4 ft 6 in coaxial connector, fit the small plug on one end of the cable into the REMOTE AERIAL socket on the set and the large socket on the other end to the plug on the aerial matching unit.

(5) To extend the coaxial lead by 25 ft or 50 ft, if required, connect one or both of the 25 ft coaxial connectors between the matching unit and the 4 ft 6 in connector.

(6) It is not necessary to use the counterpoise wire with this rig.

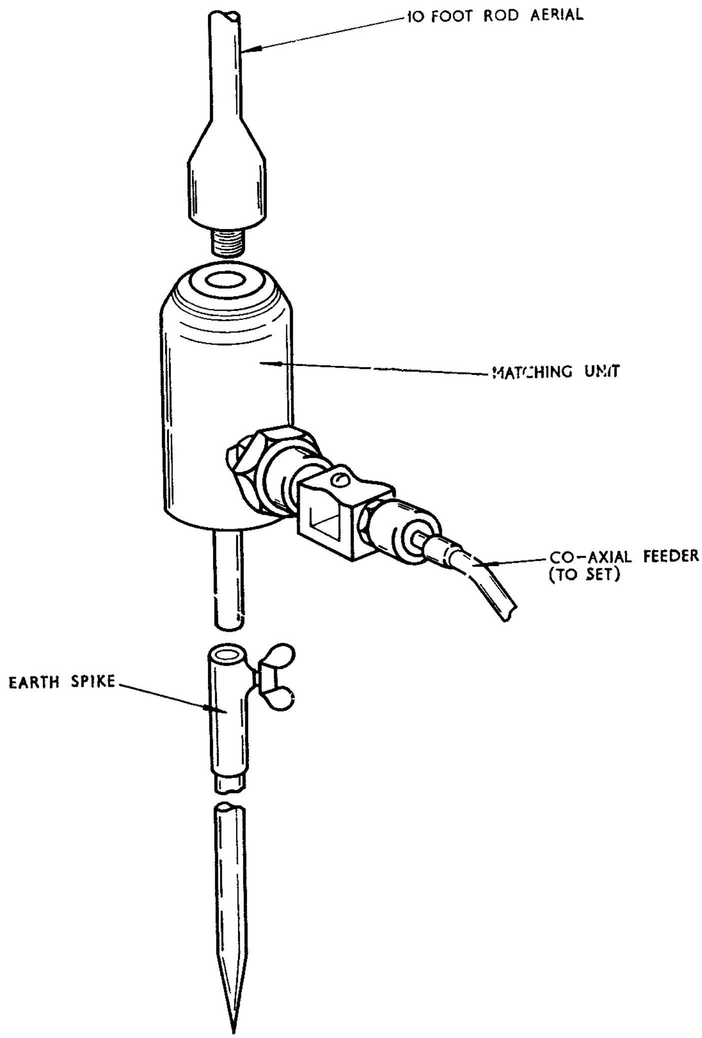


FIG. 5. REMOTE AERIAL

7.8. TYPE 634 (A 43 R)

FREQUENCY RANGE. 240–300 Mc/s (six spot frequencies)

CHANNEL SPACING. 100 kc/s

TYPE OF EMISSION. Voice (A3)

Beacon C.W. (AO)

Beacon M.C.W. (A2)

1. **Power Supplies and Associated Equipment**

a. Battery, 12 V Lead Acid type, designed for attachment to underside of Trans/Receiver Unit. Rechargeable.

b. Battery Adaptor, for attachment to underside of Trans/Receiver Unit when supplies are being obtained from source other than the normal battery (i.e. 12 V car supply).

c. Battery Charger is supplied for charging batteries from an input of 12 to 24 V.

d. Battery Life: 12 hours on Receive only.

6 hours on 10: 1 Receive/Transmit ratio.

2. **Range**

	WHIP AERIAL	DISCONE AERIAL
Ground-Ground	4 miles	10–15 miles
Ground-Air	25–45 miles	28–160 miles
	(up to 5000 ft)	(up to 30,000 ft).

Note. The above figures are obtained under average conditions, atmospheric conditions and ground structure will vary them.

Power Output 2 watts.

3. **Description.** A fully transistorized UHF Transmitter/Receiver designed for Ground-to-Ground and Ground-to-Air communications with Beacon facilities.

4. **Aerials**

a. WHIP AERIAL for man pack use, consists of flexible steel tape 15 in. long.

b. DISCONE AERIAL for static station use, consists of a flexible steel strip skeleton discone of 9 oz weight. This discone is mounted at the top of an 8-ft sectional mast and connected to Trans/Receiver by means of a 20-ft coaxial cable.

Notes. (i) Silica-gel desicattor fitted which, when removed, reveals Test Socket for measuring Power Unit Volts, Transmitter Output and Receiver A.G.C. (ii) Output indicator—fluorescent tube indicates r.f. output and depth of modulation on Voice. (iii) One Handset and one Microphone/Receiver headgear assembly provided, but only one may be used at one time. (iv) Six spot frequencies may be altered by changing of preset r.f. Tuning Units. (v) Receiver has two i.f.'s—I.F.1 = 19·05 Mc/s. I.F.2 = 930 kc/s. (vi) Weight of 634 for man pack use with only necessary equipment is approx. 24 lb.

169471—59

5. **Channel Marking.**

a. In order to avoid confusion in inter-service working it has been agreed for all three services to mark each channel of Type 634 (A 43 R) with the actual frequency to which it is crystalised.

b. All Type 634 sets are therefore to be so marked. The marking should be done in a waterproof material and should be secured to the control panel of the set so as to be clearly visible to the operator.

c. The standard crystalisation of Type 634 for general naval use is as follows:

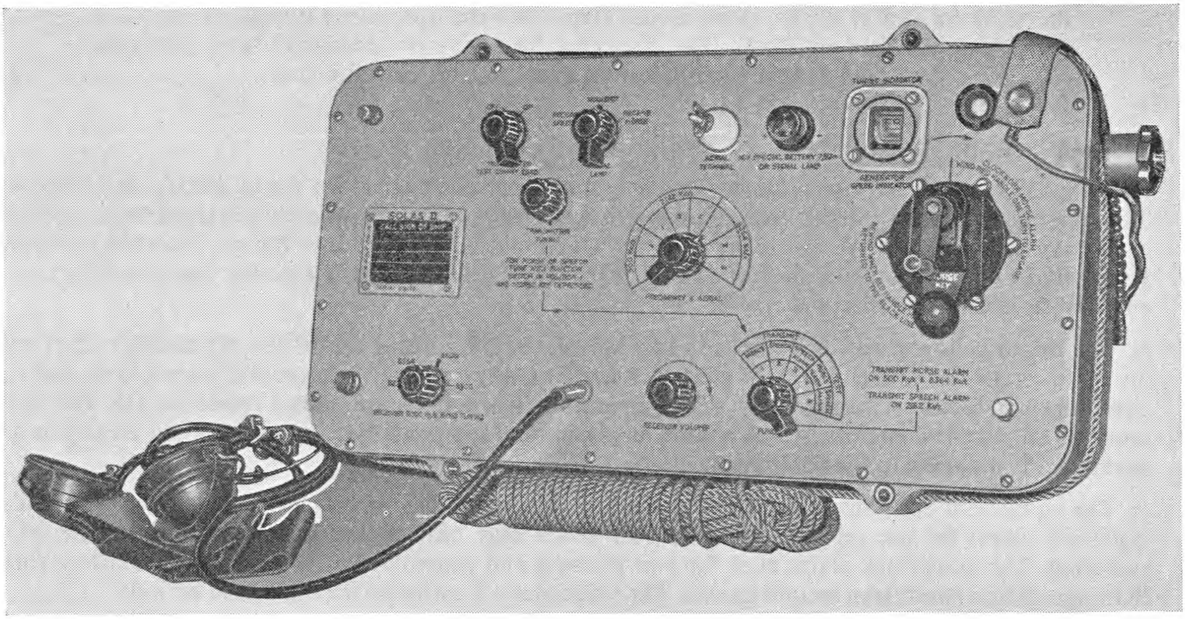
Channel No.	Frequency (MHz)	Channel No.	Frequency (MHz)
1	251.2	4	277.1
2	257.4	5	277.8
3	276.1	6	258.8

d. Variations to the standard crystalisation may be found in Commando and Assault ships, Landing craft and Minehunters.

e. It has also been agreed that Channel 6 will always provide a common channel and will therefore always be crystalised to 258.8 MHz in all services without exception so as to provide a common inter-unit and inter-service communication channel.

169471—60

7.9. TYPE 638



DATE OF DESIGN	1965
HANDBOOK	BR 2428
E LIST	
FREQUENCY RANGE	Transmitter: Crystal control on 500, 2182 & 8364 kHz Receiver: Crystal control on 500 & 2182 kHz and variable tuning from 8200 to 8800 kHz.
EMISSION	500 kHz – MCW & VOICE with Auto alarm 1.5 to 3.5 W. 2182 kHz – MCW & VOICE with speech alarm 1.5 to 3.5 W. 8364 kHz – MCW VOICE with Auto alarm 1.5 to 3.0 W.
KEYING	500 kHz and 8364 kHz; automatic distress signal, speech or hand key, 2182 kHz; two-tone alarm generator or speech.
POWER SUPPLIES	1. Hand operated, three phase induction generator which may be turned in either direction. The DC output is 15V at 0.8A at an average handle speed of 70 rpm. 2. Dry Battery, 16.5V (optional item not supplied with service units).
AERIALS	1. Preferred type is an 18 ft folding copper-plated fibre-glass whip. 2. 25 ft open wire. 3. 90 ft kite with reel (not normally supplied).
DIMENSIONS	$22\frac{1}{2} \times 11\frac{1}{2} \times 9$ inches when stowed.
WEIGHT	30 lb maximum.
OPERATING INSTRUCTIONS	A booklet and brief notes are contained within the lid of the equipment.

WARNING

It is an offence against the Merchant Shipping Radio rules to TEST the automatic morse alarm and/or the two-tone speech alarm with the transmitter tuned and radiating (even into the dummy load). The Function Switch is provided with two positions (4 and 5) that provide for an aural test of these functions.

1. General

a. Type 638 is a fully portable, buoyant watertight transceiver designed for use in liferafts and lifeboats. The equipment can be thrown overboard in an emergency and subsequently retrieved when survival craft have been manned. Wherever possible the set should be dropped into the sea from the minimum height and any drop of over 30 feet MUST BE AVOIDED. The 30 ft heaving line attached to the canister should not be disconnected or cut.

b. The bright yellow glass-fibre case is in two halves, the lid housing the 18 ft whip aerial, a 25 ft wire aerial, an earth line and sinker, two generator handles, a waterproof headset and microphone and the operating handbook. A further copy of the operating instructions are affixed inside the lid. The body contains all electrical circuits, sealed behind an aluminium top panel. The headset and the earth line are permanently attached to the equipment.

c. The equipment contains a clockwork automatic alarm for use on 500 kHz, and a two-tone audio oscillator alarm for use on 2182 kHz, both of which may only be tested with the transmitter NOT radiating. The clockwork alarm runs for two minutes and generates twelve four second dashes, three SOS signals and two fifteen second dashes. The voice alarm is switched for 30 second periods.

d. The unit is fully transistorised, and receives its power from the generator, the handles of which should be turned at 55–65 rpm. Speeds in excess of this will not damage the equipment but are wasteful and wearying to the operator and produce no increase in transmitter power, or lamp brilliance when this is used.

2. Receiver

a. The receiver operates as a superheterodyne on the 8 MHz and 2182 kHz positions, but as a straight (TRF) receiver on 500 kHz. When used as a superhet, the i.f. is also 500 kHz, so that the first three transistor stages are r.f. amplifiers on 500 kHz and become frequency changer – 1st i.f. amplifier – 2nd i.f. amplifier on the two superhet frequencies. 500 kHz and 2182 kHz are spot tuned, but the 8 MHz band is tunable from 8200 to 8800 kHz.

b. A beat frequency oscillator provides for c.w. reception on all three bands. It is fixed tuned to produce an audible beat of approximately 1000 Hertz.

c. An a.g.c. amplifier is associated with the demodulator stage. In addition to providing control of the 2nd r.f. or 1st i.f. stage, it exercises control over three overload protection diodes in the input circuit of the first transistor.

d. There are two audio stages, preceded by a low-pass filter.

3. Transmitter

a. The transmitter operates on three crystal-controlled spot frequencies: 500 kHz, 2182 kHz and 8364 kHz. The r.f. section comprises crystal oscillator, buffer amplifier and power amplifier. Transmission of automatic and hand morse is by A2 keyed tone of approximately 900 Hertz on a keyed carrier. An automatic morse alarm is obtained from a clockwork mechanism driving printed circuit keying discs.

b. The modulator section consists of a transistor driver/amplifier feeding a parallel-connected pair of modulator transistors. Speech on A3 telephony is derived from a carbon microphone. There is also a two-tone oscillator circuit which modulates the transmitter as a "speech alarm".

4. Power Supply

a. The hand generator is a three-phase, star wound induction motor which can be turned in either direction. The output is rectified by three pairs of silicon diodes arranged as a voltage doubler, which then feed three toroidal transformers and a Zener diode regulator circuit. A 3000 microfarad capacitor C1 smoothes the output.

b. The generator speed indicator lamp will not take appreciable current until the handle(s) are turned fast enough to reach to Zener voltage of the regulator diode. When this point is reached, the reduction in resistance of the diode will cause sufficient current to flow for the lamp to reach full brilliance.

c. Two diodes in the transmitter circuit protect the semiconductors against accidental reversal of the battery supply. A further Zener diode operates at 18 volts and protects the equipment if the generator speed is excessive by shunting the output of the generator.

7.10. MOBILES

1. **Definitions**

Naval Radio Van. A vehicle, fitted with wireless equipment, which is self-propelling and forms part of a Mobile Radio Station (Mobile).

Mocon. A container on wheels, fitted with wireless equipment, which also forms part of a Mobile

Radio Station but requires transport to move it from one place to another.

Mobile. A collection of Radio Vans or Mocons grouped together to perform a specific function.

> *Note.* The term 'Naval Radio Van' was used to describe both radio vans and Mocons before the term 'Mocon' was introduced. Existing radio vans were not renamed and some may therefore still be found which are not self-propelling.

2. **Distribution of Naval Radio Vans and Mocons.** These are distributed as follows:

a. Royal Naval Air Stations
b. F.O. Air (Home)'s Pool
c. Constituting certain Mobiles, held in reserve.
d. Miscellaneous services.

Application for their use must be made to F.O. Naval Air Command by R.N.A.S.s, and to the MOD (Navy) by other authorities.

7.11. TYPE 635 (A14)

Two versions of this equipment are available:
Type 635(1) – Army Type SR A14 – Low Power.
Type 635(2) – Army Type SR A14 – High Power.

DATE OF DESIGN	1961
HANDBOOK	
E LIST	
FREQUENCY RANGE	2 – 8 MHz.
FREQUENCY DETERMINATION	VFO or Crystal. K type crystals – high band. D type crystals – low band.
EMISSION	Voice (Amplitude or Phase modulation) and CW.
POWER OUTPUT	Low power – 1.5 – 3 watts. High power – 20 – 30 watts.
RANGE (with 8 ft rod aerial)	Low power 8 miles. High power 15 – 30 miles.
POWER SUPPLIES	Low power. a. 2 sealed Nickel Cadmium (NiCd) rechargeable batteries. b. 2 12V dry batteries in parallel. c. BCC 503 Battery Charger, enabling NiCd batteries to be used on float charge. High power, 4 sealed NiCd rechargeable batteries.
CHARGING UNITS	a. Hand generator BCC 13. b. Petrol electric portable charger BCC 20. c. Mains operated battery charger BCC 503. d. 12/24V operated battery charger BCC 501.
BATTERY LIFE	Using rechargeable batteries, and a send/receive ratio of 1:10. a. Low power. Ph. M, at least 16 hours. AM/CW, at least 14 hours b. High power. Ph. M, at least 8 hours. AM/CW, at least 8 hours.

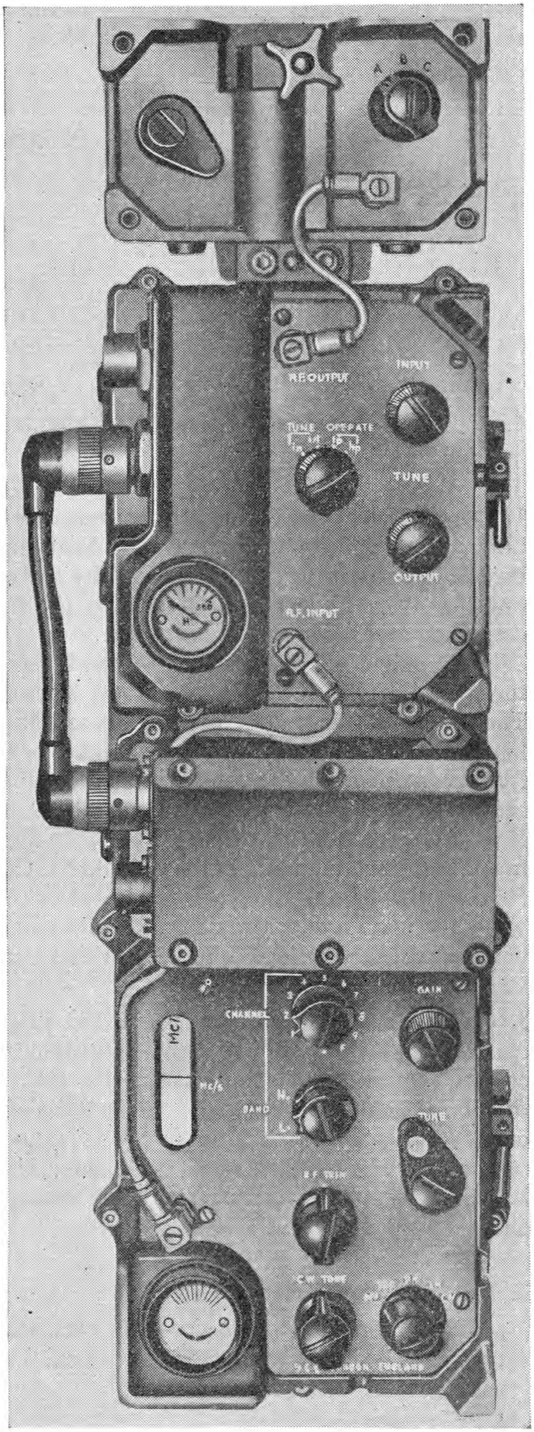


FIG. 1

Nickel Cadmium rechargeable batteries should have a life of not less than 50 charge/discharge cycles. In normal use, this figure should be two to three times as much.

WEIGHT (Basic units) Low power – 24 lb.
High power – 35 lb.

CHANNELISATION

	Low Band	High Band
Channel 1	2182 kHz	5270 kHz
2	2762 kHz	5393 kHz
3	2768 kHz	5410 kHz
4	3233 kHz	5435 kHz
5	3580 kHz	5960 kHz
6	3655 kHz	6755 kHz
7	3720 kHz	6806 kHz
8	Spare	Spare
9	Spare	Spare

Commando and Assault ships also supplied with crystals for channels 2226, 2261, 2386, 4735 and 6719 kHz.

1. **Description.** Type 635 is a fully transistorised packset contained within one unit and is supplied in both a high and low power version. Both are suitable for use as manpack, vehicle-mounting or semi-mobile operation. Power is provided by nickel cadmium (NiCd) batteries, or for the low power version only, by two 12V dry batteries, or by the BCC503 mains operated battery charger. The batteries are contained in a separate compartment.
When supplied as a high power set, the RF power amplifier is mounted above the transceiver. The aerial tuning unit (ATU) is detachable for use when the equipment is operated remotely from the aerial.
The set covers the frequency range from 2 to 8 MHz in two bands, the lower from 2 to 4 MHz and the higher from 4 to 8 MHz. Nine crystals may be fitted in each band. In addition to the nine channels, variable frequency operation is possible using a graduated frequency scale. When using VFO the scale should be calibrated to as near the output frequency as possible.
If no crystals are fitted, calibration may be achieved by fitting a 5 MHz ZDJ crystal in channel 9 L band, to enable a precise setting of the CW TONE CONTROL (BFO). This will produce a calibration note every 500 kHz throughout the frequency range of the set.
The equipment is supplied complete with carrier webbing and two signal satchels containing the rod and wire aerials, earthing spike, morse key and mic/tel head and hand sets.

2. **Calibration.** Before attempting to use VFO, the set must be calibrated. The dial calibration can be checked against any of the signal frequencies for which crystals are fitted. To check against any fitted crystal, that crystal is selected using the BAND and CHANNEL switches with the SYSTEM switch set to TRF. The dial is then tuned to the signal frequency associated with the chosen crystal (i.e. signal frequency=crystal frequency minus 500 kHz) and a beat note will be heard at or near the frequency marked on the dial. The tuning is set to peak meter deflection which occurs within the dead space. The dial setting is then noted, any difference then being used as a correction to the cursor line position when resetting the dial.

3. **Brief Circuit Description**

a. The equipment uses a common oscillator for both receiver and transmitter, which may be either crystal or variable frequency controlled. This oscillator frequency is always 500 kHz HIGHER than the signal frequency.

b. TRANSMITTER

(1) On transmit, the output of a second oscillator (500 kHz) is fed to a balanced mixer together with

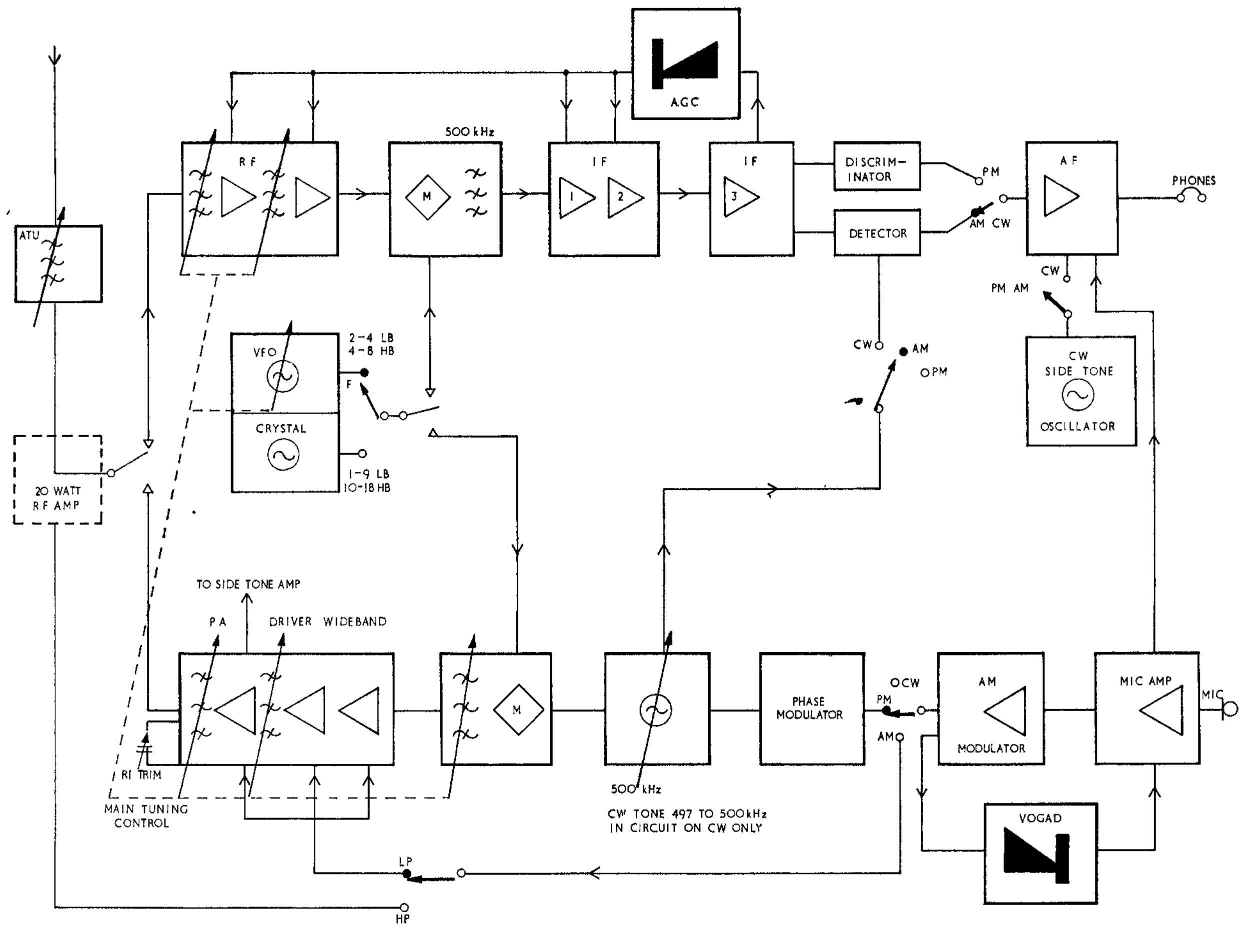


FIG. 2. TYPE 635 – BLOCK DIAGRAM

the output of the common oscillator. The 500 kHz is subtracted from the common oscillator frequency in the balanced mixer, the resultant output being the transmitted frequency. This is amplified in a wideband amplifier before being passed through a driver stage to the power amplifier (which is also wideband) from whence an output is fed either direct to the ATU in the low power version, or through a high power amplifier to the ATU in the high power version.

(2) MODULATION: For amplitude modulation, the microphone output is amplified in a modulation amplifier, which modulates the 12V supply to the wideband amplifier, power amplifier driver and power amplifier. To prevent over modulation, an automatic control circuit regulates the output to between 60 and 70 per cent. For high power operation, unmodulated r.f. drive is required and the modulation amplifier output is switched off. Part of the circuit is then used as a pre-amplifier for a separate amplitude modulator circuit located in the external r.f. amplifier. For phase modulation, the microphone output is amplified in the PM. amplifier and fed to a reactance circuit which controls the phase of the 500 kHz oscillator. In the voice mode of operation, a portion of the a.f. input from the microphone is fed to the a.f. amplifier of the receiver to provide aural indication of output.

(3) KEYING: CW keying is carried out by switching the 12V supply to the transmitter by means of a send/receive relay, and is restricted to a maximum of 25 wpm. When morse is being transmitted, a side tone oscillator is keyed and its output fed to the receiver a.f. amplifier.

(4) AUTOMATIC FREQUENCY CONTROL: The frequency of the 500 kHz oscillator is controlled during transmission by an automatic frequency control (AFC) loop. The oscillator output is coupled into the limiter discriminator which is tuned to the receiver i.f. of 500 kHz. Any deviation in frequency immediately causes a d.c. output to be fed back to the reactance circuit to correct the frequency.

(5) HIGH POWER: When the 20 watt r.f. amplifier is used, it is fitted on top of the basic transceiver unit, without precluding low power operation if required. For high power an output of between 1.5 and 2 watts is taken from the power amplifier to the input tuned circuit. During tuning this is amplified and fed to a dummy load. On completion of tuning, the output is fed through the selector switch to the aerial. This switch, besides selecting the tuning positions, can bypass the high power amplifier by switching the r.f. input directly to the aerial. This easy power reduction is a useful facility for conserving power supplies when satisfactory communication is possible without continuous high power operation.

(6) HIGH POWER MODULATION: For amplitude modulation, the output is taken from the pre-amplifier in the basic unit to a modulation amplifier in the r.f. amplifier.

c. RECEIVER

(1) The receiver uses two stages of r.f. and three stages of i.f. amplification. The output of the common local oscillator is 500 kHz above the signal frequency, the resultant i.f. of 500 kHz. The bandwidth provided is + or −3 kHz. Automatic gain control (AGC) is supplied from an AGC detector to the AGC amplifier, which feeds back to both r.f. and first and second i.f. stages. The i.f. output is passed to the detector, the resultant a.f. passing through the noise limiter to the a.f. amplifier for CW and AM voice, or to a discriminator then a.f. amplifier when using phase modulation.

(2) MORSE. For morse reception, the 500 kHz oscillator is switched on to act as a BFO and is manually variable by plus or minus 3 kHz.

4. **Controls**

a. SYSTEM SWITCH: marked OFF-TRF-PM-AM-CW.

TRF (Tune R.F.)	Used for aligning the transmitter and receiver tuned circuits to the selected crystal frequency.
PM	Used when tuning the aerial tuning unit to the indication on the meter, as well as when voice communication using phase modulation is required. Operation of this switch activates the discriminator in lieu of the detector in the receiver.

AM	Used when voice communication is required with amplitude modulation of the transmitter carrier. Also switches the a.m. detector into circuit instead of the discriminator in the receiver.
CW	Used for initially netting the set on free tuning to a control station, for C.W. operation on either crystal or free tuning. Provides a visual check of battery voltage through a reading on the set meter. Connects the 500 kHz oscillator as a BFO.
OFF	Switches off all supplies to the equipment.

b. CW Tone. This is the BFO control when using CW. For precise netting to a control station when using VFO, the pointer of the control should be set to the white spot.

c. RF Trim. Used for final tuning of the input circuit to the ATU, or in the high power mode, to the high power PA stage.

d. Band. Selects L (2 to 4 MHz) or H (4 to 8 MHz) as well as controlling a ledex switch in the high power PA unit for selection of the appropriate range aerial coils.

e. Channel Switch. Selects crystals 1 to 9 in the range selected by the band switch. Position F permits free tuning by means of the VFO.

f. Gain. Controls the receiver audio output level.

g. Tune. A slow-motion drive controlling the ganged oscillator tuned circuits for both the transmitter and receiver.

5. 20 Watt Amplifier

a. Selector Switch. Marked TUNE IN/OUT, OPERATE LP/HP.

TUNE IN	Switches the meter to the input circuit of the high power amplifier and switches the output to dummy load.
TUNE OUT	Switches the meter to the output of the high power amplifier. Dummy load still connected.
OPERATE LP	Switches the output of the low power transmitter directly to the ATU thereby bypassing the 20 watt amplifier which is out of circuit.
OPERATE HP	High power amplifier in circuit. Input from low power transmitter applied to the input of the PA stage, the output of which is fed to the ATU.

b. Input. Tunes the input circuit of the high power amplifier to the frequency being produced in the low power transmitter.

c. Output. Tunes the output circuit of the 20 watt amplifier.

6. Meters

a. Two meters are provided, one on the low power transmitter and the other on the 20 watt amplifier.

(1) Set Meter. With the system switch to CW, the green sector of the meter indicates the range of voltages suitable for efficient operation of the set. After use, the switch should IMMEDIATELY be moved to a different position to avoid unnecessarily draining the battery capacity. With the system switch to PM, this meter is also used for tuning the crystal oscillator circuit.

(2) 20 Watt Amplifier Meter. Used for tuning the high power amplifier when the selector switch is in either the TUNE IN or the TUNE OUT positions.

7. Calibration

a. If variable frequency operation is required, it is essential that the accuracy of the frequency markers on the tuning dial be checked. Two methods are available, the choice of which will be governed by whether the transmitter is fitted with crystals or whether the separate calibration crystal is available.

(1) With crystal fitted:

Set Band switch to required band.
Channel switch to selected channel, choosing frequency nearest to that required.
System switch to TRF.
Rotate TUNE control to the signal frequency associated with the selected crystal (signal frequency equals crystal frequency minus 500 kHz) and tune for a beat note at or near the selected dial frequency. When this is heard, tune for maximum meter deflection WITHIN the 'dead space'. Note the amount by which the dial differs from the signal frequency and apply this difference to the dial setting for the required frequency when tuning.

(2) No crystals fitted:

Fit a 5 MHz type ZDJ crystal into channel 9 L socket.
Set tune control anywhere between 3.5 and 4 MHz or between 7 and 8 MHz depending on band in which emission is desired.
Select band and channel switches for 9 L crystal.
Set system switch to CW.
Set CW tone control to 'dead space'. The BFO is now precisely set to 500 kHz and the harmonics of this frequency will be used to calibrate the VFO.
Set channel switch to F.
Set band switch to the band which contains the selected operating frequency.
Set tuning control to the nearest ·5 MHz to the selected operating frequency.
Search for a beat note and adjust tuning for the 'dead space'.
Note the amount by which the dial differs from the ·5 MHz position and apply this difference to the dial setting for the required frequency when tuning.

8. Tuning Instructions

SETTING UP

(1) Fit the selected aerial connecting the terminals as follows:

Rod: connect to ATU via flexible connector.
Dipole: connect to the co-axial r.f. output socket on the LP set or on the amplifier of the HP set.
Quarter wave end-fed: use the ATU-to-set co-axial lead or dipole feeder to connect between dipole centre connector and r.f. output socket on the LP set, or on the amplifier of the HP set.
27 ft end-fed: connect direct to ATU.

(2) Band switch to L for 2 to 4 MHz or H for 4 to 8 MHz.

(3) Channel switch to selected crystal or to F for VFO.

(4) ATU switch set as follows:

Position A – for rod and end-fed aerial when using low band and lower half of high band.
Position B – for rod aerial when using upper part of high band.
Position C – for end-fed wire aerial on upper half of high band.

LOW POWER (Crystal control)

(5) System switch to TRF. (This keys the oscillator circuit).

(6) Selector switch on HP amplifier to LP.

(7) Rotate tuning control to operating frequency indicated by dial setting, listen for beat note and adjust carefully for maximum meter deflection.

(VFO control)

(8) Adjust tuning control for dial setting of required frequency having first calibrated.

FINAL TUNING

(9) Set system switch to PM, press pressel switch.

(10) Adjust ATU tune control for maximum meter deflection.

(11) Adjust RF trim control (on set) for maximum meter deflection.

(12) Release pressel switch.

The set is now tuned. Select PM, AM or CW depending on emission mode desired.

HIGH POWER

(13) Carry out steps 1 to 12 above.

(14) Set HP amplifier selector switch to TUNE IN.

(15) With set system switch to PM, press pressel switch.

(16) Rotate tune input control on amplifier for maximum deflection in amplifier meter.

(17) Release pressel switch.

(18) Set selector switch to TUNE OUT and press pressel switch.

(19) Rotate tune output control for maximum deflection in amplifier meter, release pressel switch.

(20) Set selector switch to HP, press pressel switch, reset tune output control for maximum reading on amplifier meter.

(21) Release pressel switch.

The set is now tuned. Select PM, AM or CW depending on emission mode desired.

Note: The complete LP outfit must be tuned, including its aerial before any attempt is made to tune the HP amplifier.

SECTION 8

MISCELLANEOUS

8.1. OUTFIT FSA (3)

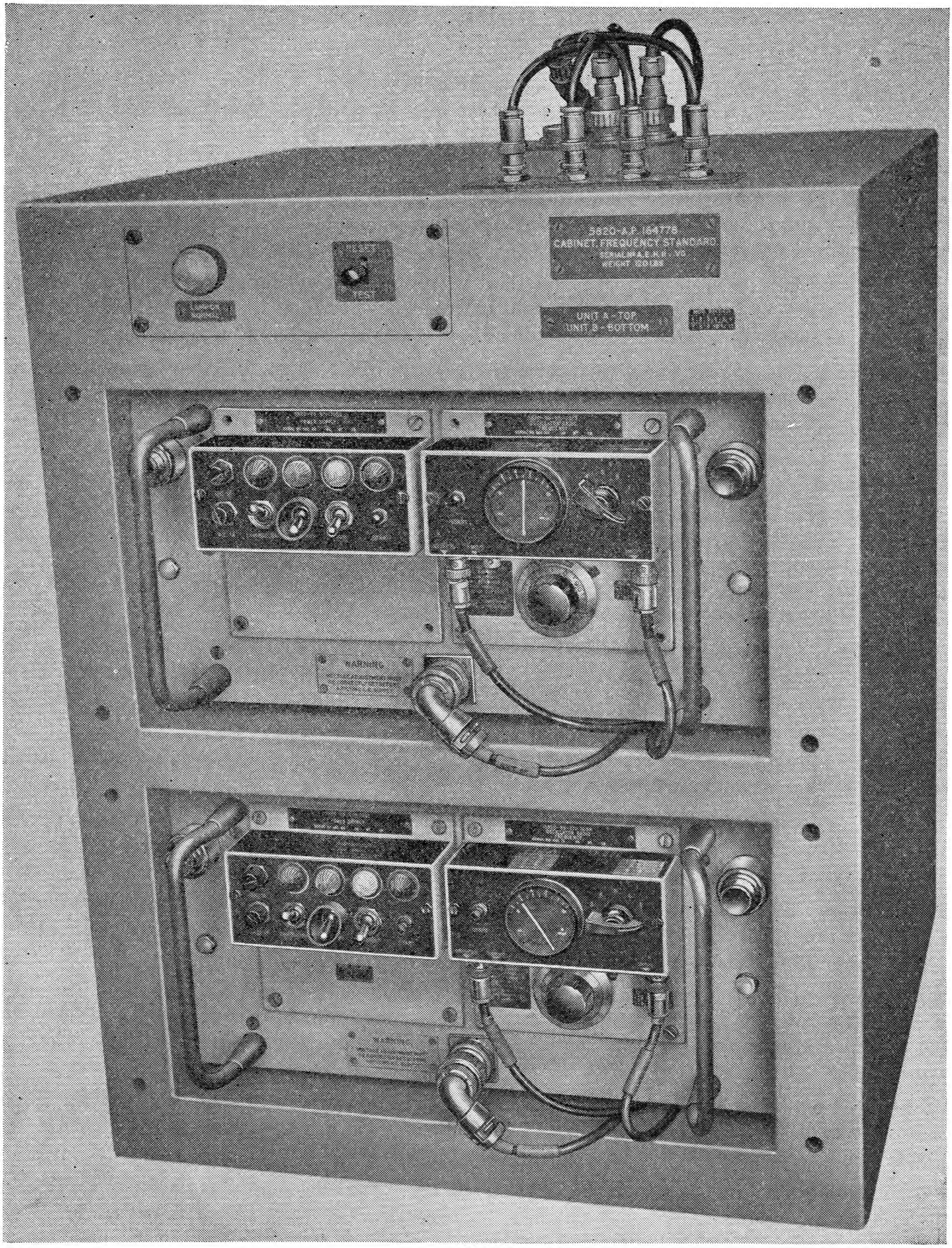


FIG. 1

Details overleaf

HANDBOOK	BR 2390 (1)
E LIST	E 1302
FREQUENCY	5 MHz, 1 MHz, 100 kHz
STABILITY	± 1 part in 10 per day
POWER SUPPLIES	115 or 230V a.c. NO BREAK Internal rechargeable batteries for emergency use (up to 4 hours)

General

1. Outfit FSA (3) is a frequency standard outfit designed to provide high stability output signals at 5 MHz, 1 MHz and 100 kHz. It is used as the frequency standard source in Standard 3B fitted ships and certain Fleet Auxiliary vessels.

2. The outfit has two separate frequency standard units each comprising an oscillator unit and power supply unit. These units are the same as the units in Frequency Standard Outfit FSA (1), details of which can be found in sub-section 11.2.

3. Outputs from FSA (3) are taken to sockets at the top of the cabinet. In the event of failure of one of the frequency standard units, changeover to the other standard is effected by changing output line plugs. There is no alarm system fitted to give indication of failure.

Brief Description

4. The frequency standard unit consists of a 5 MHz crystal and oscillator. To assist in maintaining the high degree of stability required, the components of the oscillator stage are temperature controlled within a double oven. The oscillator has two adjustment controls. A front panel fine frequency control gives an adjustment range of half a hertz whilst a preset trimmer gives coarse adjustment of 3 hertz. An A.G.C. circuit is included in the oscillator stage to improve stability.

5. The output of the oscillator stage is fed to a buffer amplifier, then to various divider circuits as shown in Fig. 2 to provide the required outputs. The 5 MHz output is available at a socket on the front panel of the frequency standard whilst the 1 MHz and 100 kHz output are taken to sockets at the top of the cabinet.

6. The first two divider stages have to be excited into operation and this is achieved by the divider starter circuit operated by a front panel push button.

7. **Metering.** A front panel meter and meter switch are provided to allow the functioning of various circuits to be checked. In meter switch positions 7, 8 and 9, the meter reads the output level at 5 MHz, 1 MHz and 100 kHz respectively.

8. **Power Supply Unit.** This unit is supplied with 115 or 230V a.c. from a 'no break' supply and converts this to the required d.c. voltage to operate the equipment. A battery outfit is incorporated as an alternative supply in the event of a mains failure.

9. The mains is applied to the power supply unit via a fuse and mains on/off switch to a full wave rectifier whose output is 16V d.c. The d.c. output is routed to the oscillator unit by way of a lamp and relay circuit, which also incorporates an alternative battery supply. The battery supply is automatically brought into circuit on failure of the mains.

10. When the mains switch is set to 'ON', the d.c. output of the rectifier lights the 'MAINS ON' lamp and energises Relay 'B' (Fig. 3). One contact of relay 'B' open circuits the amber 'MAINS FAIL' lamp. Contacts 2 and 3 select the d.c. output to the oscillator unit.

11. The rectifier d.c. output is also available to charge the batteries when the battery ON/OFF switch is set to 'ON'. A front panel switch allows a choice of two battery charging rates. In the 'HIGH' position, the full d.c. is applied across the battery and the 'HIGH CHARGE' lamp will light. In the 'LOW' position, the charging d.c. is reduced by R1 and the 'HIGH CHARGE' lamp is disconnected.

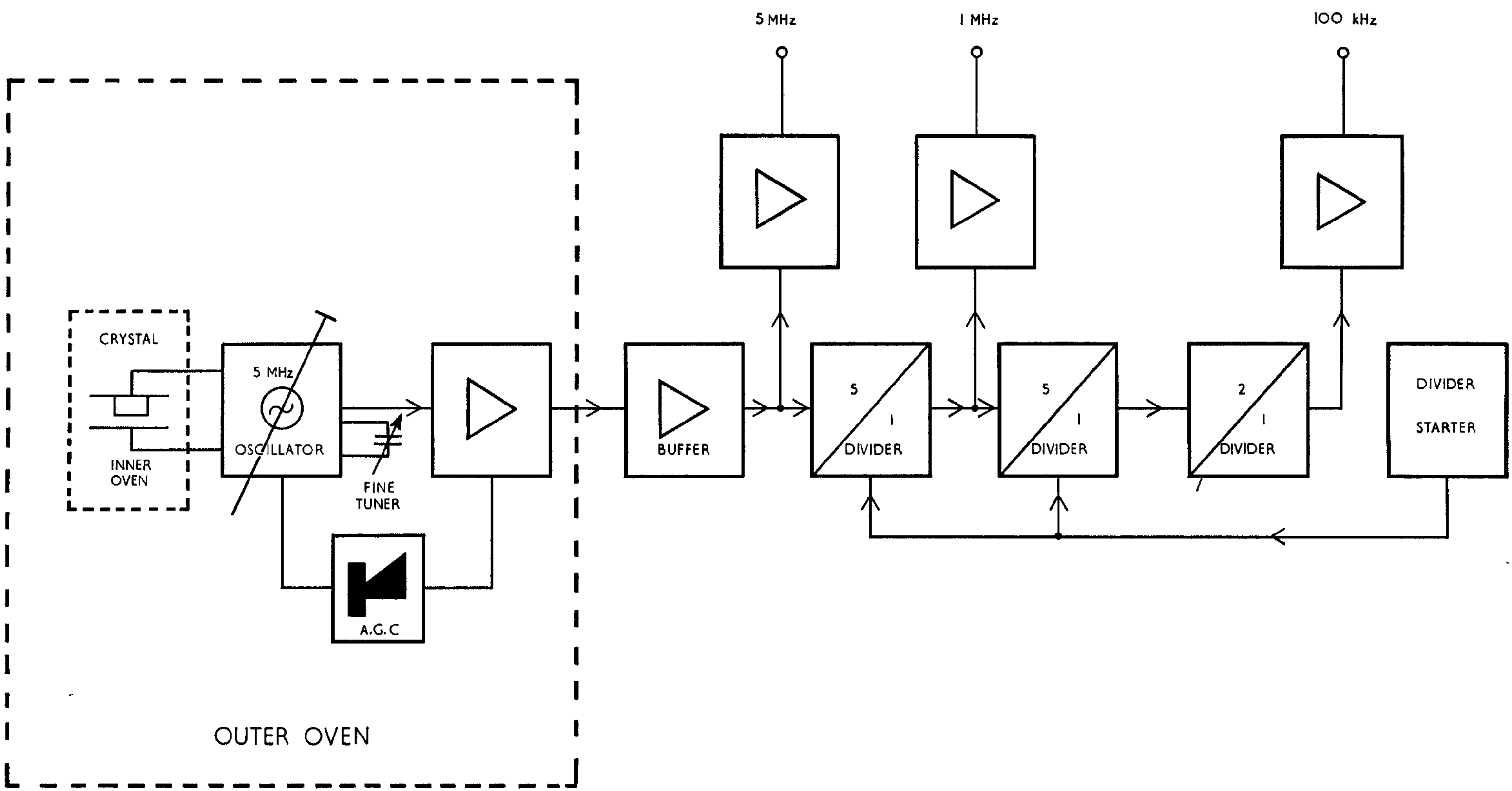


FIG. 2. FSA (3) – FREQUENCY STANDARD – BLOCK DIAGRAM

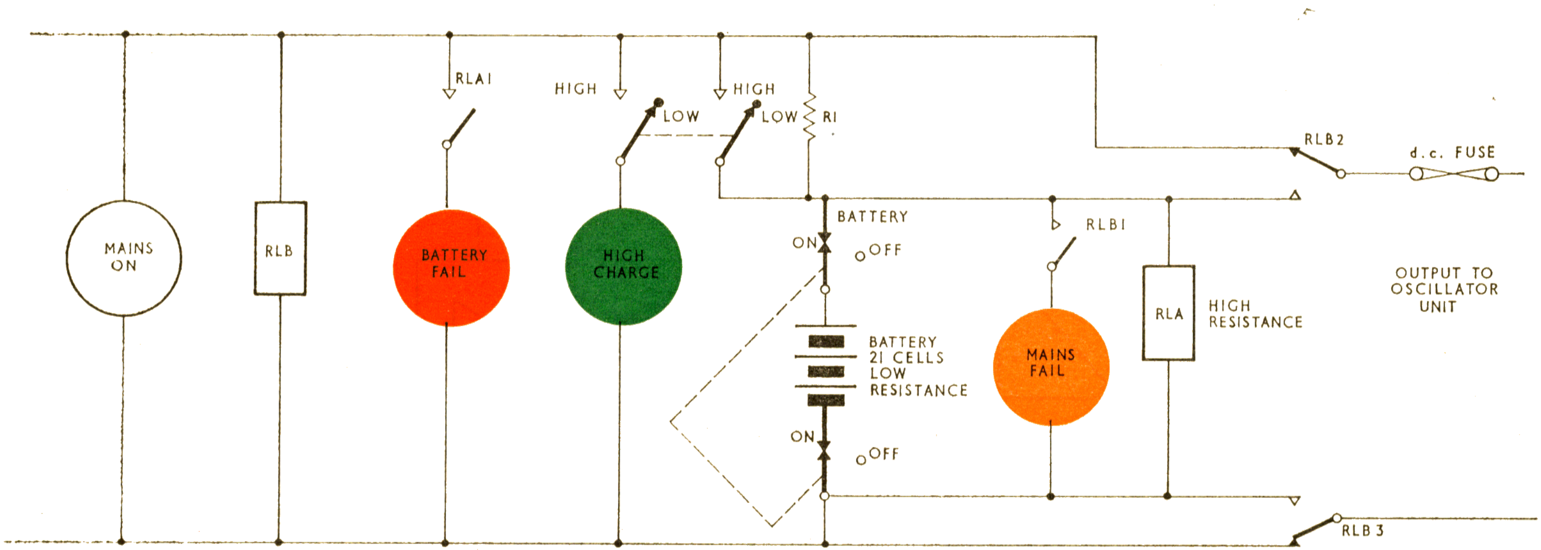


FIG. 3. FSA (3) – LAMP AND RELAY CIRCUITS

12. In the condition shown in Fig. 3, the battery and Relay A are connected across the rectifier d.c. Relay A is a high resistance relay and will draw little current in comparison with the low resistance of the battery. Relay A will not therefore be energised. If the battery is switched off or removed, relay A will be energised and contact 1 will connect the BATTERY FAIL lamp.

13. In the event of a mains failure, Relay B would be de-energised. RLB1 would close, lighting the 'MAINS FAIL' lamp. RLB2 and RLB3 would connect the battery supply to the output line.

14. **Controls**

a. Charge Rate Switch

Low. The normal position to trickle charge the battery.
High. Increases charge rate and provides lamp indication. Only to be used if it is known that battery voltage is low.

b. Battery ON/OFF Switch

Switches the battery in or out of circuit. Should normally be in the ON position. The OFF position is for servicing purposes.

c. Mains ON/OFF Switch

Switches the mains input to transformer and rectifier.

d. Start Buttons

(1) The start button on the power supply panel has its only application where it is required to operate the standard when no mains supply is available (as distinct from a main supply failure). It has no application in ship-fitted systems.

(2) The start button on the oscillator unit is used in the event of either mains or battery failure to restart the crystal oscillator and divider circuits.

e. Meter and Meter Switch—see para. 7.

169471—61-62

8.2 1 MHz MASTER OSCILLATOR UNIT OUTFIT FSB

HANDBOOK. B.R. 2345

ESTABLISHMENT LIST. E.1363

FREQUENCY STABILITY:

a. Short term stability at Constant temperature and supply voltage.
Better than ± 1 part in 10^8

b. Stability over ambient temperature range $-15°C$ to $+55°C$ and with ± 6 per cent
Mains supply variation
Better than ± 3 parts in 10^8

c. Ultimate long term ageing rate with provision for adjustment.
Better than 5 parts in 10^8 per month, positive.

FREQUENCY TRIMMING RANGE:

Fine ± 20 parts in 10^8 approximately.
Coarse 400 parts in 10^8 approximately.

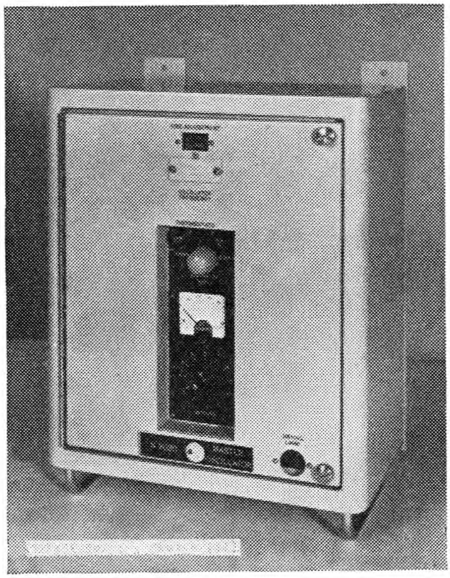


FIG. 1

Description

1. The Master Oscillator forms a compact self-contained unit intended for bulkhead mounting on shock mounts. Most of the components are mounted on the front panel which is hinged for easy access.

2. Although it is designed primarily to provide a high stability 1 MHz standard signal to drive up to six frequency synthesisers as incorporated in the Type 640, it is equally suitable for many other applications where a stable source of 1 MHz is required. In addition a 100 kHz output is provided to drive the receiver outfit CJK synthesisers.

3. The unit comprises a temperature stabilized 5 MHz quartz crystal oscillator, a 5:1 frequency divider and a buffer amplifier, together with a stabilized power supply unit. Two controls are provided for coarse and fine adjustment of frequency. A front panel meter, together with a metering switch, enables the various transistor feeds, the oscillator supply voltage and the r.f. output level to be checked.

4. Two main supply fuses, fuse blown indicator lamps and a 'supply on' indicator lamp are fitted, but no On/Off switch as it is intended that the unit should be left on continuously. A 15-watt lamp is fitted as an anti-condensation heater, but no switch or fuses are provided as it is intended that this heater should be connected to a separate externally switched supply.

8.3. SIGNAL GENERATOR CT 452A
(As used for Outfit EZ Filter Tuning)

HANDBOOK	BR 1771 (40)
FREQUENCY RANGE	10 kHz to 72 MHz
POWER SUPPLIES	115V or 230V AC

1. **Introduction.** In ships where there is no monitor cabinet, the CT 452A performs the function of the monitor TDA in that it supplies a drive for EZ filter tuning, and CJA No. 1 replaces the monitor CJA in providing an AF output. When the monitor switch of the EZ is switched to RX No. 16, the output of CJA No. 1 is fed to the EZ tuning meter.

2. **Brief Description.** The CT 452A consists of a free running RF oscillator covering the frequency range 10 kHz to 72 MHz in twelve ranges. As it will be used for EZ filter tuning only over the range 2 – 30 MHz, only ranges H to K inclusive are dealt with here.
The CT 452A has three outputs as follows:

a. Output is fed to the meter and to the RF output socket and thence to the EZ attenuator pad. This output is controlled by coarse and fine attenuators at the CT 452A.

b. Output fed direct to the DIRECT OUTPUT socket.

c. Output fed to a mixer where it is mixed with the output of the calibration crystal oscillators. The difference frequency is then amplified and fed to the phone jack. Frequencies at which the set may be calibrated are as described in para. 3*h*.

3. **Controls**

a. SET FREQUENCY RANGE. Selects one of 12 ranges A to L, frequency coverage and range letter automatically appearing in the window above the switch.

b. MAIN TUNING. This control adjusts a variable capacitor in the tuned circuit of the RF oscillator, allowing selection of any frequency within the range selected.

c. FINE TUNING ABOVE 80 kHz. Adjusts a variable inductor in the RF oscillator giving fine tuning of ± 5% of the frequency selected.

d. COARSE ATTENUATOR. This switch is not labelled. It selects the RF output required and is indicated in EMF in the window alongside the switch.

e. OUTPUT EMF. Attenuates the output in 1dB steps over the coarse range selected by the COARSE ATTENUATOR.

f. SET CARRIER. Accuracy of the output EMF dial depends upon the correct adjustment of the set carrier control. Adjustments to this control will be made in the CW position of the System Switch.

g. INTERRUPT CARRIER. A spring-loaded switch which, when depressed, breaks the HT to the RF oscillator and the DC amplifier.

h. SET CURSOR. Adjusts the cursor line of the Main Tuning control after calibration. Calibration can be carried out on frequencies as follows:
Range H – every 400 kHz
Range I–K – every 2 MHz.

i. SET MOD. Adjusts the depth of modulation so that the scale on the Mod % control is calibrated.

j. MOD %. Enables the % of modulation to be altered from 0% to 80%. (Controls (*i*) and (*j*) have no application in EZ tuning).

k. SUPPLY ON. Applies AC to the transformer through a 2 amp fuse. The secondary of the transformer has a separate winding for heaters and lamp indication.

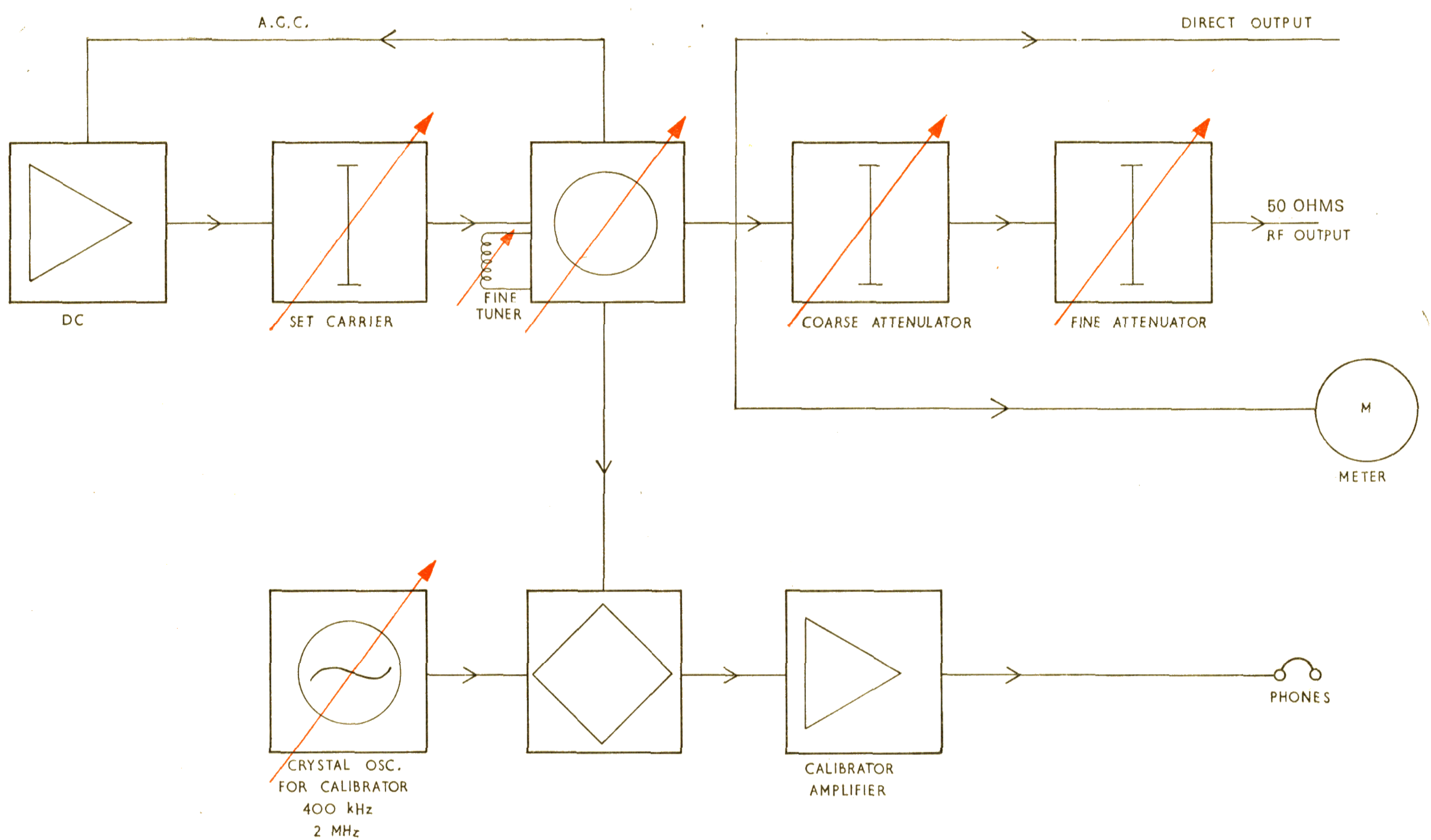


FIG. I. SIGNAL GENERATOR CT 452A – BLOCK DIAGRAM *l*. DIRECT OUTPUT. A two position switch, giving different values of direct output to the socket immediately below it. In the Normal position the output is a constant 2V for use into a high impedance load, while the High position supplies a 2.75V output for a low impedance load. When using the CT 452A for EZ tuning, this switch must be to Normal, as in the High position, the RF output is disconnected.

m. SYSTEM SWITCH. Not marked, but only two positions are used for EZ tuning. These are (a) Crystal Check (for calibration) and (b) CW.

4. **Operating Instructions**

1. Supply switch ON.
2. Set Mod Control to 0. (Fully anti-clockwise).
3. Set Mod. % to 0.
4. Select appropriate frequency range.
5. Fine Tuner to zero.
6. System Switch to Crystal Check.
7. Adjust Main Tuning control to calibration frequency nearest to output frequency required (para. 3*h*).
8. Plug in phones.
9. Adjust Tuning Control for zero beat in the phones and alter the Set Cursor control until cursor line is on calibration frequency.
10. Set System Switch to CW (first position after Crystal Check).
11. Adjust tuning control to required output frequency.
12. Alter Set Carrier Control until meter pointer reaches Set Carrier line.
13. Switch Coarse Attenuator to read ·64 to 2V in window (add 110dB).
14. Switch output EMF control to 2V (inner scale).
15. Set CJA No. 1 to Assigned Frequency, modulation switch to CW + or —, AE COS to position 4, AGC control to Manual.
16. Adjust CT 452A Main Tuning control for note in CJA AF output.
17. Tune EZ Band Suppression Filter as detailed in S. 1693 and page 11–8–9 of this book.

8.4. TELEGRAPH AUTOMATIC RELAY EQUIPMENT

1. **T.A.R.E.** (Telegraph Automatic Relay Equipment) was introduced in the Royal Navy to eliminate the traffic handling delays prevalent in the Manual Tape Relay Centre. The equipment at present in use was developed by the Standard Telephone Company under the commercial name STRAD. The T.A.R.E. is a fully electronic telegraph switching system employing a magnetic recording drum and designed to receive, store and relay intelligence by performing the following tasks described in succeeding paragraphs.

2. **On Incoming Lines**

a. Never to offer an engaged condition, i.e. to be in a position at all times to accept messages on any line.

b. To check each message as it arrives to ensure that no message has been missed or duplicated.

c, To store each message in its entirety.

d. To remember where a message is stored and over which Outgoing route it is to be transmitted.

e. To enter details of the message in an automatic log.

3. **On Outgoing Lines**

a. To ensure that an outgoing line is never idle if there is a message for it in store.

b. To ensure that over any particular line, messages awaiting transmission are selected in their order of precedence and time of receipt in the system.

c. To insert Transmission Identification.

Procedurally, the automatic equipment is concerned only with the following:

a. The Start of Message Indicator (SOM).

b. Security Warning Prosign.

c. Start of Routeing Indicator.

d. End of Routeing Indicator.

e. End of Message Indicator (EOM).

It follows then that to enable the system to function correctly, traffic must be offered in the standard prescribed format.

4. The system is capable of accepting traffic, in the Murray code, from line or radio circuits, for single or multiple routes, at speeds up to 75 bauds and to relay the traffic at the same or different speeds. Within the system all operations are performed at approximately 1000 times faster than the normal speeds of circuits connected to it.

5. The Automatic Log of traffic passing through the system is provided by local teleprinters (journals) connected to the T.A.R.E. The 'In' journals provide a number check by printing the transmission indication (T.I.), T.A.R.E. is expecting, followed by a copy of the incoming message up to and including line 3 of the message format. Should the transmission identification expected differ from the transmission identification of the actual incoming message, this is shown visually on the incoming journal and also both visually and audibly at the Supervisor's Console. The 'Out' journals give the transmission details of the relayed traffic by printing the new transmission identification inserted in the re-transmitted message followed by the transmission identification the message was received under, thereby giving a cross-check that a message has been relayed to all stations indicated in the basic routeing line (line 2). The T.A.R.E. is also engineered to print the time on these journals at given intervals (normally 5-minute intervals).

6. **Supervisor's Console.** The supervisor's console enables the Supervisor to exercise control over all circuits connected by providing –

a. 'Busy Keys' for each outgoing circuit.
b. Alarm Panel.
c. Waiting Display.
d. Overflow Control Panel.
e. Alternative Routeing Keys.
f. Supervisors 'In' and 'Out' position (reject position combined or separate as desired).

7. **Busy Keys.** When a particular 'Busy Key' is made, all traffic routed to that outgoing circuit will be retained in the central message store section of the drum until such times as the circuit is again made available by the restoring of the key to the release position or by re-routeing traffic (see alternative route keys). When a circuit is busied out for any reason (equipment failures, propagation, between schedules on a non-continuous circuit, etc.) traffic may continue to be transmitted into T.A.R.E. for that route.

8. **Alarm Panel.** This panel gives the Supervisor visual and audible warning of fault conditions on incoming or outgoing circuits, common logic circuits and 'In' and 'Out' journals. It also indicates T.I. disagreements, drum storage occupancy (this can be set to give warning at various percentage occupancy by the Supervisor), and notification that Flash traffic has entered the system.

9. **Overflow Controls.** Should the drum storage occupancy become excessive through a heavily loaded circuit being busied out, or any other reason, traffic for that route may be fed into overflow. Overflow is provided by means of a magnetic tape deck. The Supervisor's controls enables him to select any single route or combination thereof coupled with any precedence (with the exception of Z) or combination of precedences and divert that selected traffic into overflow. Messages of precedence Z cannot be diverted into overflow, and to prevent delays on the re-transmission of this class of traffic, an automatic break-in method has been engineered into the system.

10. **Waiting Register.** This is a lamp display showing the number of messages or those of selected precedence awaiting re-transmission for the route indicated. The routes may be scanned either sequentially or by selection. By means of a switch the overflow boxes may be examined in the same manner.

11. **Alternative Routeing Keys.** This panel provides keys for a predetermined number of routes facilitating one or two alternate routes. By manipulation of alternate route keys and busy keys both normal route and alternate route may be used together.

12. **Magnetic Drum.** To replace the human brain by an equivalent memory device the T.A.R.E. uses a magnetic drum. The portion of the drum circuit directly opposite and coming under the influence of a writing/reading head is known as a track. The standard drum provides 930 tracks, each capable of recording approximately 300 characters. Each track is divided into two, so that each half track of 150 characters serves either a single incoming or outgoing line. Each incoming line is permanently associated with one particular half track known as the incoming line storage half track. Similarly, each outgoing line has its respective outgoing line storage half track.

For the purpose of the explanation which follows, it is assumed that the message is short enough to be recorded in its entirety on this half track of 150 characters. When the recording is complete, the message is transferred to a central message store, thereby freeing the incoming line half track for the next message. Since there are many messages in the Central Message Store at any one time, it is necessary to have a Booking Register. When the message is transferred from the Incoming Track to the Central Message Store track, an entry is made in the Booking Register which states in effect that the message stored in Central Message Store track number N must be re-transmitted on outgoing lines 'A', 'B' and 'C'. The equipment, in effect monitors all outgoing lines, and as soon as one of them becomes free the equipment searches the Booking Register to see if there is a message waiting for that line. Having found one, that message is copied from the Central Message Store to the appropriate outgoing track and then to line. Details of this particular message are then deleted in the entry. When all address information for any one message has been erased that particular store track is released to record a new message.

THE PASSAGE OF A MESSAGE THROUGH T.A.R.E.

13. As the message is received it is passed to an incoming line circuit, which has associated with it an individual storage half track on the drum. As each character appears on the incoming line, the line circuit examines the line and stores the elements of the character in the register. The character register, which is a set of five triggers, is capable of storing five intelligence elements of the received character. The reason for this temporary intermediate storage is that the incoming signals are not related in time to the drum speed in any way and also it is essential to have the characters placed sequentially on the track. The required speed change is effected by transferring from line to the storage half track via the single character register. When the completed character is in the register it can be removed and passed to the incoming half track which is permanently allocated to the incoming line. However, before this can take place, the circuit must recognize a 'Start of Message Indicator'. Only after it has detected the arrival of the SOM in the correct order can recording on a half track begin. All preceding characters to the SOM are rejected by the register. The message continues, and during its reception the line circuit is looking for the 'End of Message' which it is designed to recognize.

Stage 1. *The complete message has now been received and is stored on an incoming line half track.*

Action is now taken to transfer the complete message from the incoming line half track into the Central Message Store. Before this can take place there is an intermediate stage, for the message must pass through a short term storage associated with the incoming link. The incoming lines are arranged in groups of six, each having its own line circuit and half track on the drum. A group is served by an incoming circuit. An incoming completed message cannot be allowed to remain on the incoming line half track, for this must always be ready to receive the next message which may follow directly upon the message just ended. The group circuit is able to detect that a complete message is present on one of the incoming half tracks which it serves. This can then be transferred to one half of the link storage track. Signals at the reading head of the incoming line half track are of small amplitude and must be amplified by a reading amplifier before transfer can take place. The input of this amplifier is fed by a transistor switch which selects the correct track and is switched on for the appropriate half track period. The output is now fed to the link circuit and the contents of the incoming line half track are written on to the carrier track situated in the incoming link circuit.

14. As soon as the carrier track fills up, the contents must be immediately transferred to the Central Message Store. This must take place without delay as the other incoming half tracks may be filling up and will require to use the link carrier track. The function of the incoming link is to connect any incoming group circuit which is requesting transfer to the common path which feeds traffic to the Central Message Store. It can also select a store section of the Central Message Store, detect whether this section has storage available and accept the store address within the section. The Central Message Store being divided into store sections, each of which affords access to a block of 72 half tracks on the magnetic drum. A store section can accept messages in half track lengths from the incoming link. It also informs the link of the store address used for each particular message.

Stage 2. *The message has now been transferred from the incoming line half track to a free half track in a store section of the Central Message Store, the incoming link storage (carrier track) is now free to accept any message which may have come in on another line.*

15. During the transfer the incoming link accepts the store address from the selected store section and extracts the identity of the incoming transmission from the message heading. This information is transmitted to the Booking Register and link informs the group circuit that the transfer is complete. The information in the Booking Register is assembled in three stages:

a. Record of store address and identity.

b. Check the incoming identity of incoming transmission with the locally generated designator and number and record this information.

c. Pass the message heading to the decoder circuit which detects from it the priority grading and the routes to which the message must be transmitted. These are also recorded.

Stage 3. All information relating to the transmission identification of the message, its store address, priority grading and the routes to which it must be sent, is now recorded as an entry in the booking register.

16. When the message and the booking information is complete the message must be sent to the appropriate outgoing lines provided that the line is not already engaged in sending a message. If this is the case the message will be stored until the line concerned is free.

17. All outgoing lines are fed by individual outgoing circuits and, as with the incoming circuits, each group of six is served by an outgoing group circuit. Another circuit, the Register of Outgoing Lines, makes a continuous examination of the outgoing lines and detects whether each one is engaged in sending out a message or is free to receive a transfer. The connection between store section and the selected outgoing group circuit is made through the Outgoing Link Circuit. This connection must be established before any transfer of information can take place.

18. Part of the equipment known as the Booking Search compares the entries in the Booking Register with the information in the register of outgoing lines. If it detects that there is a message waiting, the booking search circuit passes the information to the outgoing link of the store section and address in which the message is to be found. This information is passed to the appropriate store section, which selects the required store half track which is then available to the outgoing link and decoder.

19. In the decoder, the priority and routeing indicators of the message are extracted for comparison with the indicator of the route to be served, thus the decoder fulfils the requirements of routeing line segregation by signalling the identity of the route to the outgoing link, and when transfer takes place, only the routeing indicators appropriate to that transmission are included. Before any information flows to the outgoing group circuits the link permits the transfer of a code indicating to which group and line the message is to be sent. This information comes from the Register of Outgoing Lines. The Central Message Store, address and the routeing information are now passed to the Register of Outgoing Lines, which having found that the required line is free, causes the outgoing link to perform a transfer of the selected half track of information in the Central Message Store to the outgoing group circuits. The Register of Outgoing Lines records the fact that these lines are now busy and this information is passed on to the booking search circuit.

20. Having checked that the line now to be served is associated with the selected route, the Booking Search circuit causes the Booking Register to delete from its entry the 'mark' which signifies the existence of a message for that route, in the case of a multi-addressed message, as the message is sent out to each line the mark associated with that line is deleted from the booking entry. When there are no booking entries left that particular store track is released to record a new message.

21. The action of reading out a message from a store half track may be repeated many times without destroying the information recorded there. The information is only destroyed when another message is written over it and this can only be done when every destination mark has been deleted from the booking entry.

22. When an outgoing transfer takes place the information is offered to all the outgoing group circuits in the equipment. As stated before the information is preceded by a code word which is recognized after examination by the detector circuit in each group. The recognizing detector circuit accepts the transfer and it is then passed to the appropriate outgoing line track.

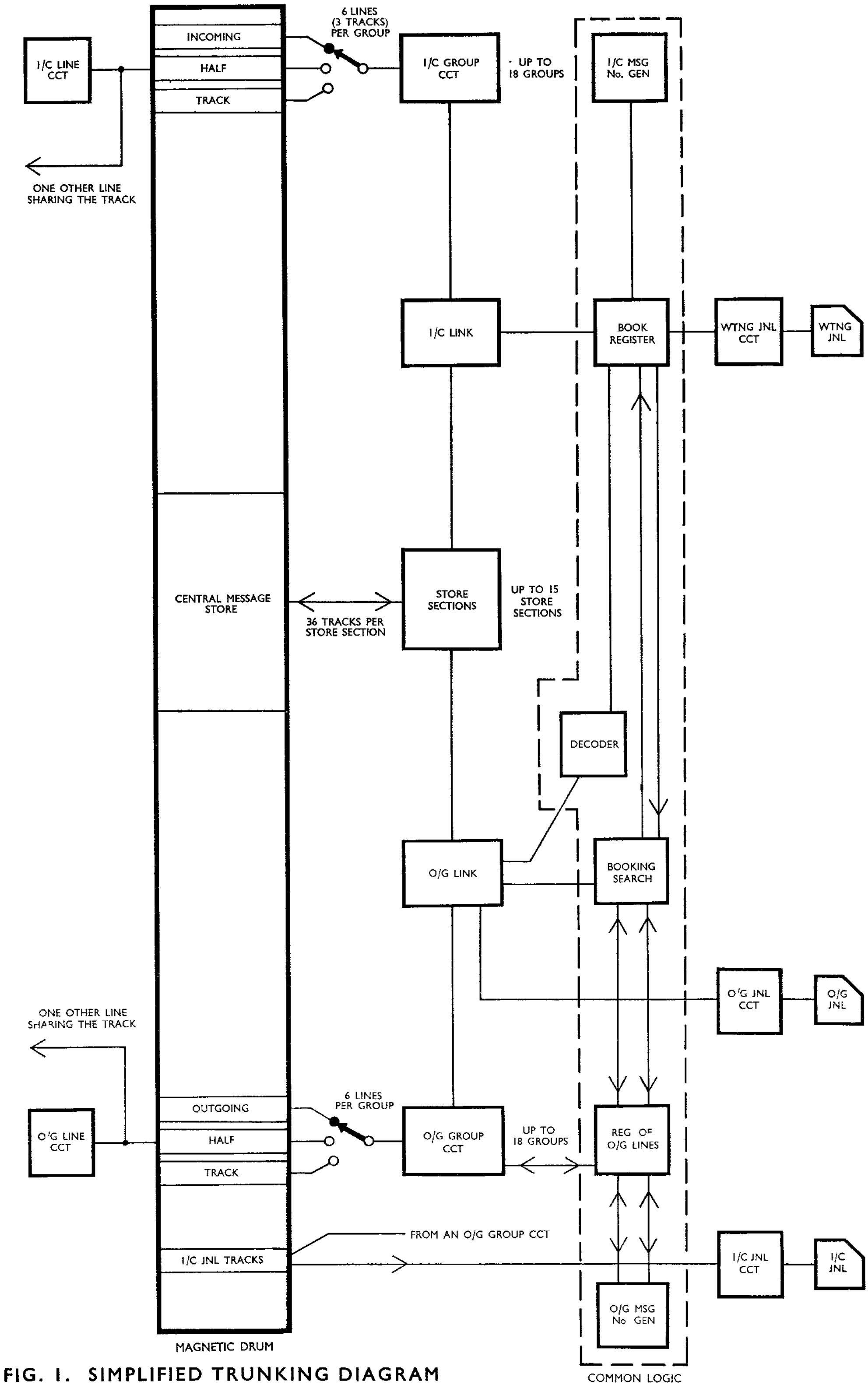


FIG. 1. SIMPLIFIED TRUNKING DIAGRAM

Stage 4. The message had been recorded on the outgoing line half track and the associated destination mark has now been deleted from the booking entry. If the recording in the store half track is no longer required, i.e. if all routes have been served, the half track is disengaged.

23. It is now necessary to extract information which has been written into the outgoing line half track, and transmit it to a telegraph circuit, at one of the standard speeds. The corresponding (reverse) process took place when the message first entered the system at the incoming line circuit.

24. The 'Start of Message' indicator which was lost when the message entered the system, regenerated and added together with a transmission identification and number to the modified heading when the message is re-transmitted. Thus the outgoing transmission conforms with the established procedure in all respects.

25. For messages of more than 150 characters in length a Store Index has been provided as part of each store section to keep a record of the addresses. It records the location of all the store half tracks on to which the message is written and also the order in which the half tracks are used. One of these circuits is provided for each store section and can deal with all the traffic entering that section at any time.

26. The first part of the message is in the store, and entries relating to it are in the Booking Register and the Store Index. Each subsequent half track load of the message is repeated except that no entry is made in the Booking Register. For this reason the end of routeing information must be detected before completion of the first half track (a maximum of 12 routeing indicators), otherwise the message will be rejected. The store address for each additional half track is added to the sequence in the Store Index. However, when the half track bearing the 'End of Message' indicator appears for transfer, this is noted by the Booking Register.

SECTION 9

FACTS AND FIGURES

9.1. RECORDS AND REPORTS

1. Records and reports on radio equipment are the responsibility of the Electrical department. Communication Officers and ratings, however, should know what is required.

RECORDS

2. **Set Office Performance Record Book.** One book is kept for each equipment in each office. Details of the following are noted on appropriate forms in the book:
Daily Performance
Weekly Performance
Quarterly Performance
Defects
Running hours.
The important points from this book are copied into the Radio Equipment Log.

Note: This book is being superceded by Planned Preventive Maintenance Schedules.

3. **Radio Equipment Log.** The following information is logged:
List of equipment fitted
Modifications and 'As and 'As'.
Defects
Monthly performance of each item of equipment fitted, compiled from the set office performance record book.

4. **Electrical Officer's Defect Book.** Portable fittings (i.e. main items of equipment, not stores) which are beyond the capabilities of ship's staff to repair are entered in this book for repair by dockyard when opportunity offers – e.g., a refit period.

REPORTS

5. **Report of Equipment Fitted (S.1116).** To be rendered to MOD (Navy), Captain Superintendent A.S.W.E., appropriate Commander-in-Chief and S.N.S.O., at the following times:
On first commissioning
On joining a new station (if Station Orders require it)
After a major refit involving Radio 'As' and 'As'
Annually on 31st May (in abeyance).

6. **Six-Monthly Radio Report.** An optional report, rendered to A.S.W.E., if there is anything of interest to state, e.g.:
Equipment failures
Equipment performance above or below normal
Maintenance difficulties
Criticisms of equipment or layouts and suggestions for improvements.

9.2. SEMI-CONDUCTORS

1. A semi-conductor, as its name suggests, is neither a good conductor nor a good insulator. Germanium is the main constituent of most semi-conductor devices. Pure Germanium has a resistance which is about 10 million times that of copper at normal temperatures. To understand the action of semi-conductor devices it is necessary to study the Germanium crystal structure.

2. Germanium is a tetravalent metal, which means it has four electrons in its outer or valency electron shell which are capable of bond formation. In its pure Germanium crystal these four electrons form bonds with electrons from four adjacent Germanium atoms producing a crystal lattice which is highly stable. The crystal lattice is three dimensional, but can be represented diagrammatically as follows.

The Germanium atom and the crystal is electrically neutral and this is represented by showing the nucleus with four positive charges, which balance the four electrons used in the bonds. As the valency electrons in the crystal are used in bonds and all the other electrons are bound firmly to the nucleus it might be expected that Germanium crystals would be good insulators. But in practice, at ordinary temperatures, there is sufficient energy in the crystal to break a small number of the bonds, which does not damage the overall structure, but allows electrons to flow through the crystal.

3. Once an electron has been removed from a bond or an atom it leaves a 'hole' in the crystal structure or an atom with a positive charge. The bond which is an electron short is referred to as a 'hole', and although the atoms of the crystal cannot move, the holes can move. If the hole is filled by an electron from the adjoining atom, that atom is then an electron short and the hole is associated with that atom.

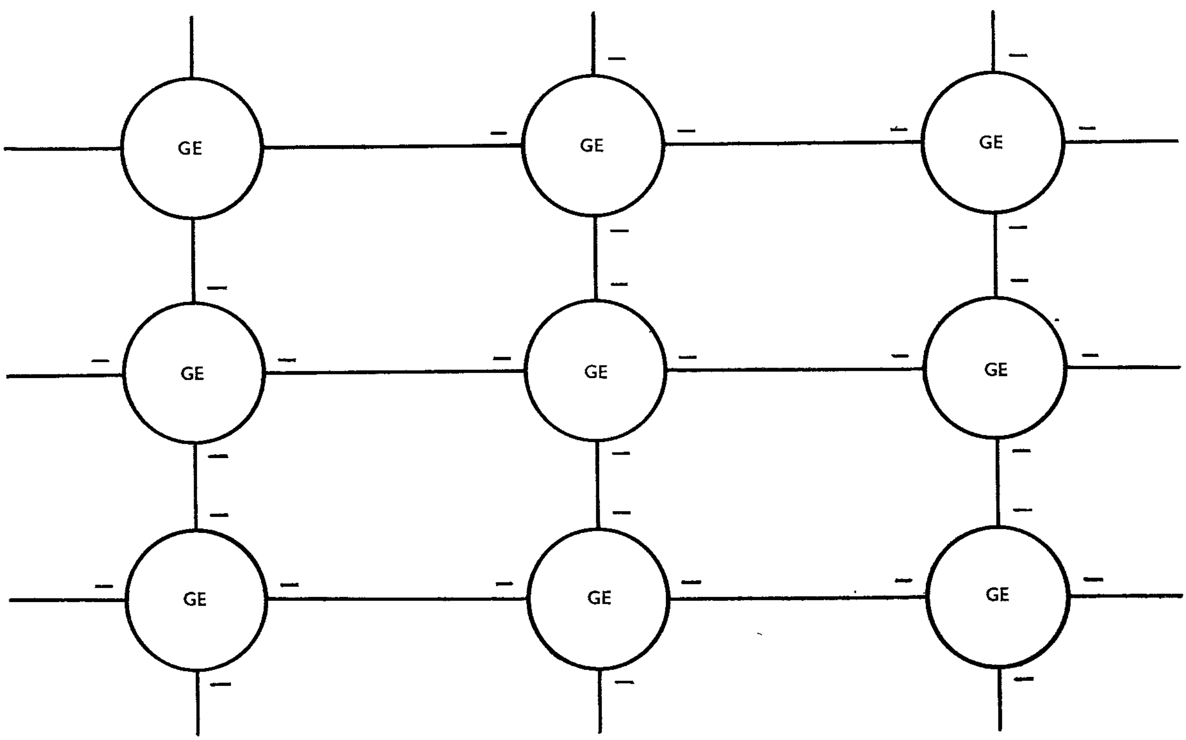


FIG. 1. DIAGRAMMATIC REPRESENTATION OF A GERMANIUM CRYSTAL. EACH LINE BETWEEN ATOMS REPRESENTS A BOND WHICH REQUIRES TWO ELECTRONS FROM EACH ATOM

In this way the hole appears to move through the crystal. This can be compared to a line of cars in a traffic jam. The cars are stationary, when one opposite a café pulls out of line leaving a 'hole'. The car behind then moves forward filling the hole, but at the same time the hole appears behind the second car. Hence the hole has apparently moved in the opposite direction to the car, and this process goes on down the line. Current is therefore carried through the semi-conductor in two ways:

a. By electrons moving in one direction.

b. By holes moving in opposite direction, which behave like free electrons except that they have a positive charge.

4. **Impure Germanium.** If impurities are introduced into Germanium in small quantities, and of atoms about the same size as the Germanium atom, they will not alter the crystal structure. However the impurities can be chosen so that they have either one more or one less electron in the valency shell than Germanium (i.e. either 5 electrons or 3 electrons instead of 4 electrons), so that the crystal structure has more or less electrons than are required for normal bond formation. Germanium containing an impurity with an extra electron is known as N-type Germanium, while if the impurity is an electron short it is known as P-type Germanium.

5. **N-type Germanium.** If a trace of arsenic, which is about the same weight as Germanium but has 5 electrons in its outer or valency shell, is introduced into the Germanium crystal, only four of its electrons are employed in forming bonds, leaving one spare electron which is easily moved. Hence the resistance of the crystal is greatly reduced.
The impurity which produces a surplus electron is called a donor impurity and the crystal structure now conducts because of a surplus of electrons.

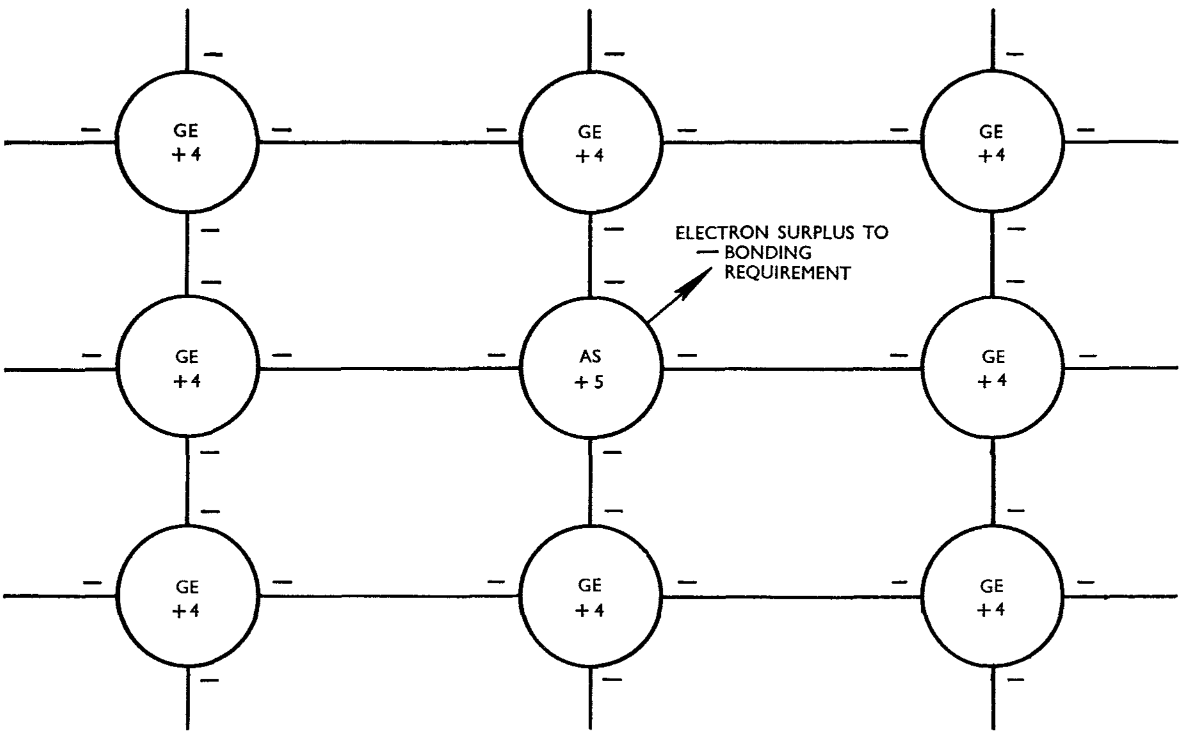


FIG. 2. N-TYPE GERMANIUM, SHOWING HOW AN ARSENIC ATOM FITS INTO THE STRUCTURE BUT HAS ONE SURPLUS ELECTRON

6. **P-type Germanium.** If a trace of indium, gallium or aluminium, all of which only have 3 electrons in their valency shell, are introduced in small traces into the Germanium, some of the bonds of the crystal lattice will be one electron short. The P-type Germanium will readily accept 'free' electrons to fill the vacancy. The crystal is made so that it contains holes created by the deficiency of electrons of the impurity, but these 'holes' can move as already described and are not necessarily associated with the atom of impurity.

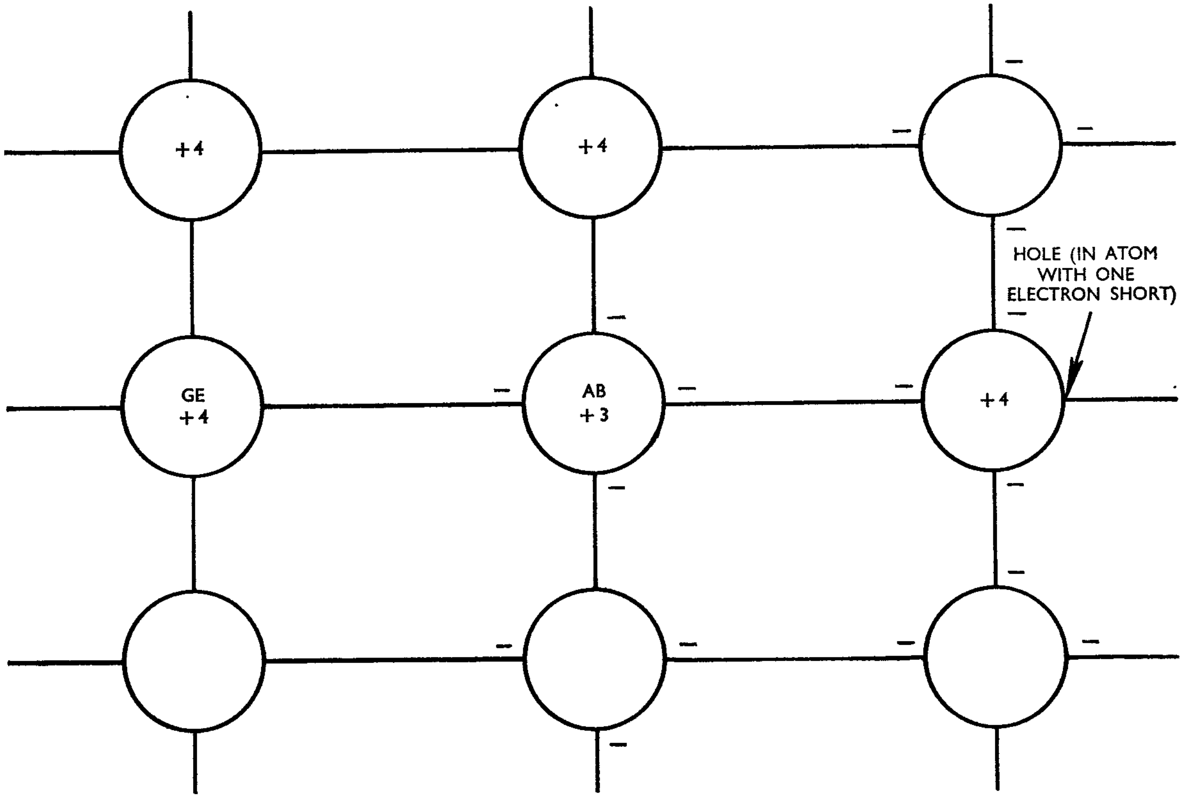


FIG. 3. P-TYPE GERMANIUM

(*continued on page* 9–2–4)

(*continued from page* 9–2–3)

7. **P–N Junction.** Now consider a junction between P-type and N-type Germanium crystal. In the region of the junction the surplus electrons of the N-type crystals will move across the boundary and fill the holes of the P-type crystals. Thus a junction potential will be established; as electrons leave the N-type Germanium, it becomes positive while the P-type Germanium becomes negative, hence in the vicinity of the boundary a 'potential barrier' is formed which tends to stop the flow of current. This barrier may be represented as a battery as shown in Fig. 4.

If a voltage is applied to the junction positive to N-type, the effect is to increase the potential barrier, the resistance to the flow of current in this direction is very large and 'reverse' current' is very small. However a voltage is applied to junction positive to P-type, which is called the 'forward direction'. The potential barrier is decreased and the resistance of the junction is decreased so that a current of several milliamps will flow. This is best shown by the characteristic of P–N junction.
If an alternating voltage is applied to the junction it acts as a rectifier, but it should be noted that a very small reverse current flows through the junction.

(*continued on page* 9–2–5)

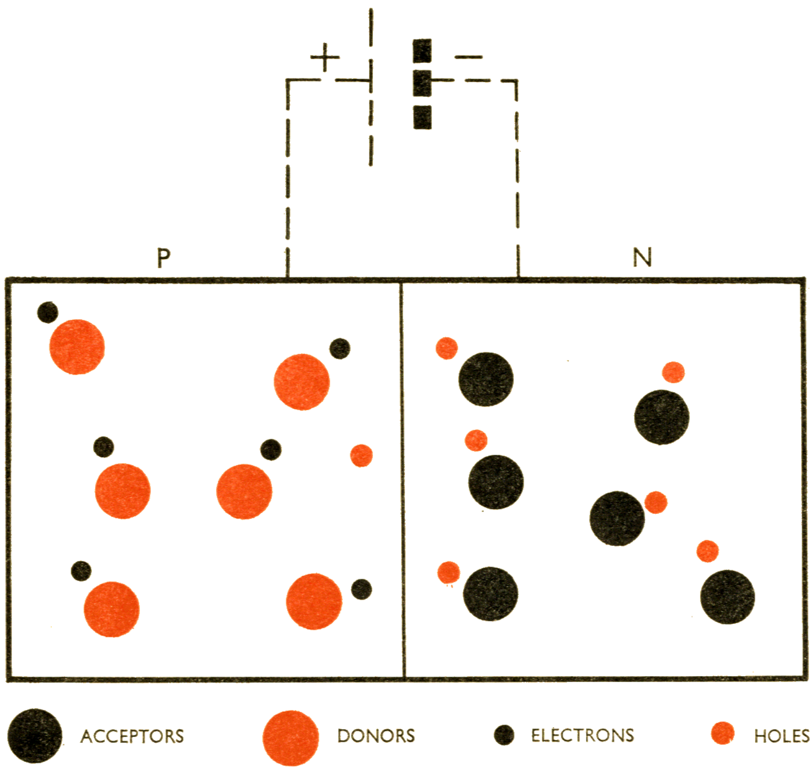


FIG. 4. P-N JUNCTION

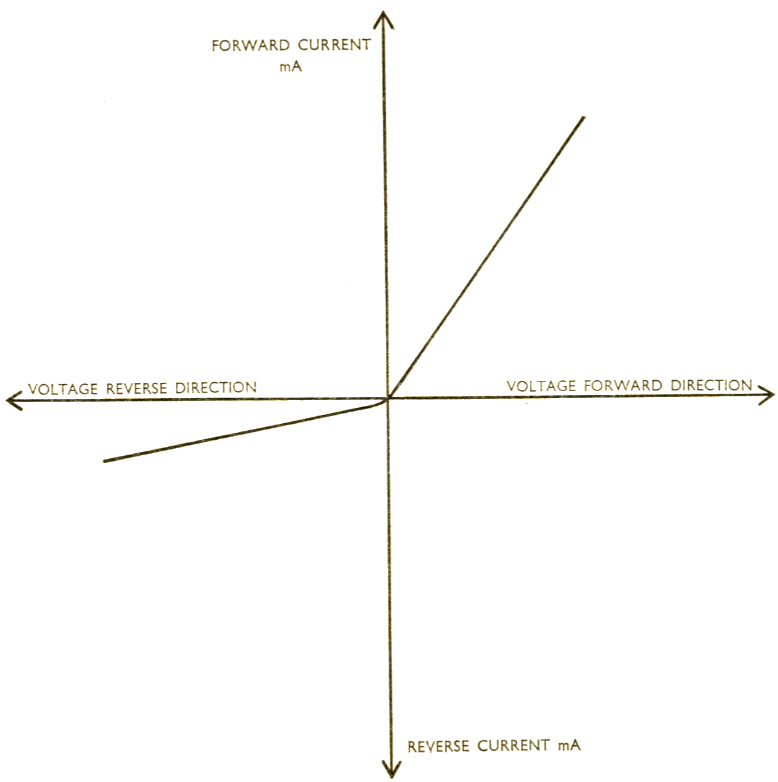


FIG. 5. CHARACTERISTIC OF A P-N JUNCTION

(*continued from page 9–2–4*)

8. **The Junction Transistor.** The junction transistor consists of three regions of P and N type Germanium arranged in a sandwich, i.e. P–N–P or N–P–N. There are three connections, one from each layer of the transistor. The three layers all form the 'Emitter', 'Base' and 'Collector'.
If the voltage applied as in Fig. 6 (a) only a small current will flow as the junction behaves as two P–N junctions back to back and the potential barrier of one of them will stop the current. In this case base-collector junction tends to stop the current. Now the next step is to give the base-emitter junction a forward bias as in (b). Under these conditions it would expect base-emitter current or base current Ib to flow and this does happen, but the base current is small compared with the current which flows through the two junctions which is called the collector current Ic. At first sight this seems impossible as current is flowing freely in the reverse direction through the collector base junction. When base current flows, electrons enter the P region or base, and these electrons are attracted to collector or upper N region which is positive. By making the base very thin so that electrons of the base current flow must come near the collector-base junction, it is possible to get about 95 per cent of the emitter current to the collector, hence the collector current is 20–100 times greater than the base current. So a small base current will cause collector current 20–100 times as large to flow.

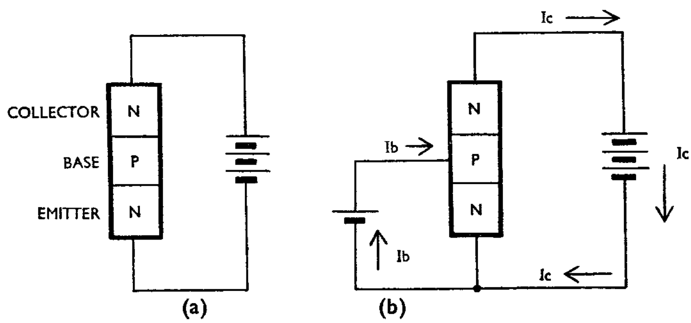


FIG. 6. N–P–N JUNCTION TRANSISTOR

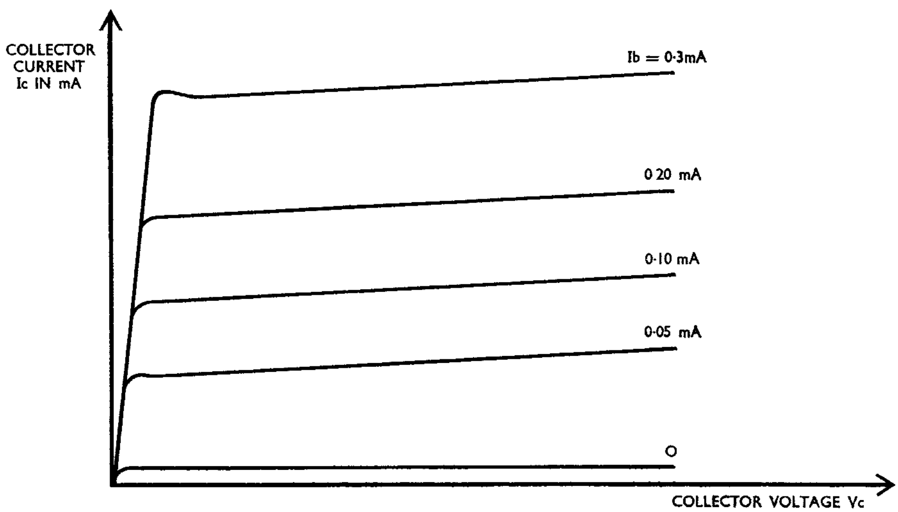


FIG. 7. COLLECTOR VOLTAGE Vc

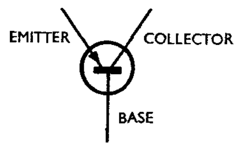


FIG. 8. CIRCUIT SYMBOL OF A TRANSISTOR

9. In the foregoing explanation a circuit with grounded or common emitter has been used. There are two other types of circuits which may be used. These are 'common base' and 'common collector'. The following diagram shows examples of these three types of circuits.

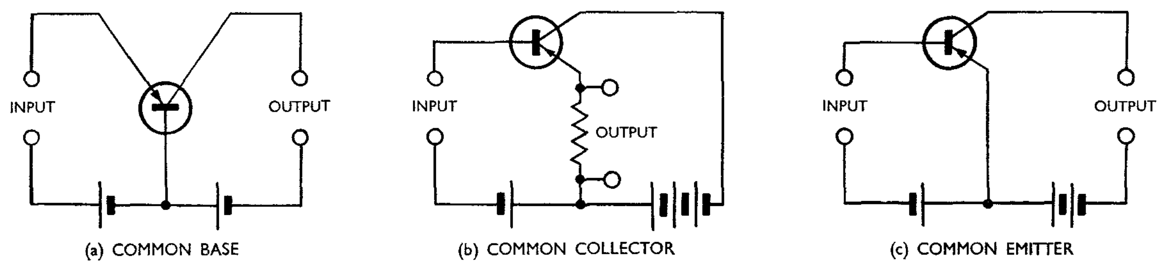


FIG. 9. P–N–P JUNCTION CONNECTIONS

9.3. DECIBELS

1. **The Decibel Notation.** This is a convenient method of measuring the power gain of amplifiers or the attenuation of transmission lines. The ratio of 'power out' to 'power in' is expressed as a logarithm which has the following advantage:

a. The gains of various stages may be found by addition (or subtraction if attenuation is involved).

b. The numbers used rarely exceed 200, which represents a gain of 10^{20}.

c. The human ear obeys a logarithmic law; that is the log of the power must be doubled to make the sound twice as great to the hearer.

2. **Definition**

$$\text{Gain in Bels} = \text{Log}^{10} \frac{\text{Power Out}}{\text{Power In}}$$

In practice the Bel is too large, so the sub-multiple unit the deci-bel (dB) is used.

$$\text{Gain} = 10 \text{ Log}^{10} \frac{\text{Power Out}}{\text{Power In}} \text{ dB}$$

Examples. A power gain of $10 = 10 \text{ Log}^{10}\ 10 \text{ dB} = 10 \text{ dB}$

A power gain of $20 = 10 \text{ Log}^{10}\ 20 \text{ dB} = 13 \text{ dB}$

A power gain of $100 = 10 \text{ Log}^{10}\ 100 \text{ dB} = 20 \text{ dB}$

Any gain must give a positive answer in decibels, but a loss will always give a negative answer in decibels. *For example:*

An attenuation to $\frac{1}{10} = 10 \text{ Log}^{10} \frac{1}{10} \text{ dB} = 10 \text{ dB}$ (as $\text{Log}^{10} \frac{1}{10} = \bar{1}\cdot 0000$ or -1).

Example. Each stage of a three-stage amplifier has a power gain of 20.

$$\begin{aligned} \text{Overall power gain} &= 20\times 20\times 20 \\ &= 8000 \\ \text{Gain of each} &= 10 \text{ Log}_{10}\ 20 \text{ dB} = 13 \text{ dB} \\ \text{Overall gain} &= 13+13+13 \text{ dB} \\ &= 39 \text{ dB} \end{aligned}$$

(*Note:* Gain $= 10 \text{ Log}_{10}\ 8000 \text{ dB} = 10\times 3\cdot 9 = 39$ dB)

3. **Voltage Gain.** By definition the decibel is a unit of power, but $P = \frac{V^2}{Z}$

$$\text{Hence Power out} = \frac{(\text{Voltage out})^2}{\text{Output Z}} \text{ and Power in} = \frac{(\text{Voltage in})^2}{\text{Input Z}}$$

$$\frac{\text{Power out}}{\text{Power in}} = \frac{(\text{Voltage out})}{(\text{Voltage in})} = \frac{\text{Output Z}}{\text{Input Z}}$$

If the input and output impedances are equal this becomes

$$\frac{\text{Power out}}{\text{Power in}} = \left(\frac{\text{Voltage out}}{\text{Voltage in}}\right)^2$$

$$\begin{aligned} \text{Gain} &= 10 \text{ Log} \left(\frac{\text{Voltage out}}{\text{Voltage in}}\right)^2 \text{ dB} \\ &= 20 \text{ Log } \frac{\text{Voltage out}}{\text{Voltage in}} \text{ dB.} \end{aligned}$$

DECIBEL TABLE

The decibel figures are in the centre column, figures to the left represent decibel loss, and those to the right decibel gain.

POWER RATIO	— DB ×	POWER RATIO
1·000	0	1·000
0·977	0·1	1·023
0·955	0·2	1·047
0·933	0·3	1·072
0·912	0·4	1·096
0·891	0·5	1·122
0·871	0·6	1·148
0·832	0·8	1·202
0·794	1·0	1·259
0·708	1·5	1·413
0·631	2·0	1·585
0·562	2·5	1·778
0·501	3·0	1·995
0·447	3·5	2·239
0·398	4·0	2·512
0·355	4·5	2·818
0·316	5·0	3·162
0·251	6·0	3·981
0·200	7·0	5·012
0·159	8·0	6·310
0·126	9·0	7·943
0·100	10	10·00
0·0794	11	12·6
0·0631	12	15·9
0·0501	13	20·0
0·0398	14	25·1
0·0316	15	31·6
0·0251	16	39·8
0·0519	18	63·1
0·0100	20	100·0
10^{-3}	30	10^{3}
10^{-4}	40	10^{4}
10^{-5}	50	10^{5}
10^{-6}	60	10^{6}
10^{-7}	70	10^{7}
10^{-8}	80	10^{8}
10^{-9}	90	10^{9}
10^{-10}	100	10^{10}
10^{-11}	110	10^{11}
10^{-12}	120	10^{12}

Example

Type 640 has a rated output of 500 watts PEP on Full Power. What output will be obtained on the High Power position of the Power reduction switch (A reduction of 5 dB)?

From the table 5 dB down = 0·316.

500×0·316 = Power on High Power position.

= 158 Watts PEP.

9.4. DOPPLER EFFECT IN RADIO TRANSMISSIONS

1. Relative motion between transmitting and receiving stations causes a change in the frequency of a signal; this is known as the Doppler effect. The speed of radio signals is 186,000 miles per second (i.e. $186{,}000 \times 60 \times 60$ miles per hour), and a greater (or smaller) number of cycles of the transmitted signal will be received per second if the receiver is closing (or opening) the transmitter, i.e. there will be a small change in the frequency of the signal. If the relative velocity between the transmitter and receiver is 670 miles per hour the frequency shift due to Doppler effect is $\pm$ 1 part in 10^6 (+ if closing, — if opening). The amount of Doppler Frequency Shift is given by the formula:

$$\mathrm{Fd} = \frac{\mathrm{V}}{\mathrm{C}} \times \mathrm{Fo}$$

Where Fd = Doppler Shift Frequency.
V = Relative Velocity between Transmitter and Receiver in m.p.h.
C = Velocity of Radio Waves in m.p.h.
Fo = Frequency of Transmission.

In each of the following examples the speed of the transmitting aircraft is 500 m.p.h. whilst the receiving station is stationary.

a. The aircraft transmits on 30 Mc/s:

$$\mathrm{Fd} = \frac{500 \times 30 \times 10^6}{186{,}000 \times 60 \times 60} = 22 \text{ c/s (approx.)}$$

b. The aircraft transmits on 20 Mc/s:

$$\mathrm{Fd} = \frac{500 \times 20 \times 10^6}{186{,}000 \times 60 \times 60} = 15 \text{ c/s (approx.)}$$

c. The aircraft transmits of 10 Mc/s:

$$\mathrm{Fd} = \frac{500 \times 10 \times 10^6}{186{,}000 \times 60 \times 60} = 7 \text{ c/s (approx.)}$$

2. If the receiving station in the above examples were also sited in an aircraft flying *towards* the first aircraft at the same speed, then the Doppler Shift Frequencies would be doubled.

3. Other factors, such as the motion of a ship which causes the aerials to sway, the speed of the ship, variations of the Ionosphere and, in the case of a portable, the walking of the operator, will also introduce a slight shift in frequency.

4. With Single Sideband transmissions the carrier frequency must be re-inserted with extreme accuracy. Errors of 50 c/s in the carrier frequency results in distortion of the signal, whilst errors of 160 c/s or more result in unintelligible signals. Consequently S.S.B. equipment must be designed for the error of carrier re-insertion to be less than 20 c/s, but even with this accuracy distortion may occur when working with high speed aircraft and the distortion will increase as the frequency of the carrier increases.

SECTION 10

AUTOMATIC TELEGRAPHY

10.1. SINGLE CHANNEL TELEPRINTER SYSTEMS

Introduction

1. One of the most significant results of introducing modern communication techniques into the Fleet has been the need for planners and users of communications to acquire a greatly increased knowledge of telecommunication systems.

2. This systems knowledge is based on a good understanding of basic definitions and agreed nomenclature, develops through the techniques of communicating and the way these are applied to the wide variety of equipment now fitted in the fleet and ultimately dictates the very format and content of fleet complans. The subject, though related to electronics, is very different to it; it is generally true with modern equipment that the user requires to know less than ever before about its circuitry; it is equally true, however, that for successful operation he now requires to understand precisely how a given equipment is designed to fit into the system of which it is part and to be able to relate the front panel controls to his basic system knowledge.

3. Hitherto the lack of adequate documentation has not made it easy to acquire a system knowledge; the problems inherent in the use of modern equipment have often emerged only after its introduction and in many cases an early solution has been hampered at the outset by the lack of an agreed nomenclature and common techniques. Nowhere has this been more evident than in the field of radio teletype communications. Though basically less simple than other conventional means of communicating, it must be stressed that on a system level, which is all that is required to plan, set up and operate RATT circuits, it is quite straightforward. Indeed, as a result of recent NATO and JOINT agreements it is far simpler now than it has been over the last two years.

4. The aim of this book is to acquaint the user with what experience has shown makes up a systems knowledge for RATT communications, incorporating, where appropriate, the content of recent agreements and the results of an important decision recently reached to standardize the basic philosophy of setting up equipment at RATT terminals afloat. The terminology used here is consistent with current tactical communications practice and agreements. It may be at variance in particular instances with the more precise terminology required and used in shore stations who are primarily concerned with multi-channel systems. These stations will continue to use between themselves the terminology laid down in BJTE1.

The Philosophy of Teleprinter Communications

5. Most telegraph communications are based on equipment that can be conditioned to one of two states, altered or keyed in a recognizable manner so as to communicate intelligence. In teleprinter communications the two states representing the intelligence are related to the teleprinter keying circuit and they indicate the condition of this circuit. The CCIR recommended terms ACTIVE (A) and INACTIVE (Z) are used to describe the two conditions. It should be noted that in teleprinter communications the terms Mark and Space do not have a self-evident meaning in relation to the condition of the equipment and should not normally be used.

6. The keying circuit of a teleprinter can be operated by either an on-off current, in which case it is known as "single current" working, or by the direction of flow of current in which case it is known as "double current" working. In either case, for the Type 12 teleprinter, the state of the current is related to a given condition in the following way:

	DOUBLE CURRENT (−80V+80V)	SINGLE CURRENT (ON/OFF)
ACTIVE (A) Condition	+80V	OFF
INACTIVE (Z) Condition	−80V	ON

7. Teleprinter communication is achieved by a digital system, the basic unit of which is a signal element. The length of this element decreases as transmission speed increases, so it follows that the number of signal elements transmitted in one second is the obvious measure of transmission speed. The unit used to describe the number of shortest signal elements per second (also referred to as bits per second) is the Baud. In teleprinter communications the signal element is used as a vehicle to convey the teleprinter conditions which, as already explained, may be either ACTIVE or INACTIVE. The conditions are grouped in fives according to the Murray Code (or International Telegraph Alphabet No. 2) to represent keyboard characters; each group of five is preceded by an element representing an ACTIVE condition, known as the start element, and is followed by a longer element – actually 1.42 times the normal length – representing an INACTIVE condition, known as the stop element. Together with these start and stop elements necessary to achieve synchronization between transmitting and receiving machines, the Murray Code becomes the 7½ unit Start Stop Code. Using a standard word length of five characters it can be shown that details of transmission speeds are as follows:

TRANSMISSION SPEED	WORDS PER MINUTE	SIGNAL ELEMENT LENGTH
50 bauds	66	20 msec
75 bauds	100	13⅓ msec

The Relationship of a Two-State System to Teleprinter Conditions

8. The allocation of the two possible conditions in a teleprinter keying circuit is arbitrary, the only requirement being that all equipment in circuit is so set as to ensure the same relationship in both transmitting and receiving machines. In line communications the terms adopted for reference by the ITU are "Position A" and "Position Z", the definitions of which are given in paragraph 40.

9. For ease of reference the following table relates ACTIVE and INACTIVE conditions to terms meaning the same thing:

ACTIVE (A) (POSITION "A")	Teleprinter Start Signal Teleprinter "Space" Morse "Mark"
INACTIVE (Z) (POSITION "Z")	Teleprinter Stop Signal Teleprinter "Mark" Morse "Space"

10. In purely line communications the teleprinter at any point in the circuit is represented by current, voltage or an on-off voice-frequency tone. The relationship of the state of the current, voltage or tone to the condition it represents is known as the POLARITY. The polarity may or may not be reversible in the line, but a clear understanding, for a given system, or if and where it is reversible is important to planners and essential to users.

11. The great majority of naval teleprinter circuits, however, are part line and part radio and it is because of the radio element, involving the use of transmitters and receivers of differing types and design characteristics, that it has, at the systems level, become fundamental to the success of communications that an agreed terminology be reached. This has now been achieved at JOINT level and the results, based on the guiding principle that terms used must be as self-evident and simple as possible, are shown below.

12. In very few JOINT or Intra-RN circuits can it be guaranteed that all units concerned will generate the RATT emission using the same technique. It is therefore both inappropriate and misleading that either the descriptive terms or the emission designators used at operational levels by the Services should refer to the technique of signal generation. Unfortunately this is what is now established or proposed for

international use. It has, therefore, been decided, for JOINT and Intra-RN working, that the descriptive terms and emission designators used in communication plans should refer specifically to the emission in the ether, which as will be seen later is compatible regardless of the technique by which it is generated. As it is not possible to achieve this within the framework of ITU definitions it is necessary to lay down a clear meaning for the terms now adopted in their place. These are explained below.

Frequency Shift Telegraphy (FST)

13. In this type of RATT the ACTIVE condition of the teleprinter is represented by one radiated frequency and the INACTIVE by a second, a predetermined number of cycles away from the first. At any one time, therefore, only one frequency of the pair is radiated. In practice there are three techniques which may be used to generate FST, of which ship-fitted naval equipment employs two. It must be stressed that reference to the technique employed should be avoided at operational levels, since each produces an FST emission designed to be compatible with the others. It is for this reason that JOINT agreement has recently been reached to use the emission designator F1 to describe all FST circuits. It is necessary, however, for planning and teaching purposes, to be able to identify the different techniques used and for this reason the two used by the Fleet have been named and are as follows:

a. CARRIER SHIFT TELEGRAPHY. The technique by which the two radiated frequencies are produced by keying a specially designed rf oscillator. Phase continuity is preserved during the change from one frequency to the other. Examples of such oscillators in use in the Fleet are the 5ABA used with the 601 series transmitters and the GK 185 A used with the 601 series or Type 89Q.

b. SUB-CARRIER SHIFT TELEGRAPHY. The technique by which a pair of keyed voice-frequency modulating tones is used. Each tone represents one condition. The tones are applied to a transmitter in the single-sideband (carrier suppressed) mode. In this technique phase continuity is not maintained during the change from one radiated frequency to the other.

Examples of transit terminals which employ this technique in the Fleet are the TDA/WBA with TTVF (Tactical) or Type 640 with Outfit GAA.

14. The third technique much used by the USN and the Army is a form of Sub-Carrier Shift Telegraphy in which the two separate modulating voice-frequency tones are derived from a single tone shifted as in the Carrier Shift technique to preserve phase continuity. It should be emphasized that all three techniques are applied in service equipments to produce compatible FST emissions.

A2 RATT

15. When neither a special two-state rf oscillator nor a single-sideband transmitter is available another less efficient type of RATT, hitherto called TWO-TONE RATT, has to be used. It has been necessary to change the name of this type of RATT because of its obvious connotation with the Sub-Carrier Shift technique of radiating FST. In A2 RATT a pair of keyed voice-frequency modulating tones, one of which represents each condition is applied to a transmitter in the DSB mode and results in a radiation comprising the carrier frequency with, equally above and below it, another radiated frequency which shifts in sympathy with the changes of voice-frequency signal from the tone keyer. Thus, in A2 RATT the transmitter is continuously radiating three frequencies, namely the carrier and the upper and lower sideband frequencies representing one or other teleprinter condition. This is the only type of RATT working possible in the Navy at UHF. Its use on HF is not covered by NATO agreement and should only be contemplated for Intra-RN working when FST is not possible. It is not used at all by either the Army or the Air Force.

16. It must be understood that in the context of single-channel operation the terms Carrier and Sub-Carrier Shift Telegraphy are not generally recognized outside the UK Services. Comparable terminology used to describe RATT emissions outside the UK has been tabulated for reference in para. 41, page 10–1–8. A quick look at this will show why it is essential to keep things as simple as possible.

17. **Frequency Shift.** In all types of RATT the shift between the frequencies radiated to represent the ACTIVE (A) or INACTIVE (Z) conditions of the teleprinter must be specified. CCIR recommendations

have been made as to the shift necessary in the various frequency bands; these are shown in para. 42, page 10–1–8 together with those at present applicable for use in the Navy and those agreed for JOINT and NATO working.

a. CAN/UK/US AUDIO BASEBAND. The agreed CAN/UK/US audio bands are shown in para. 43, page 10–1–9.

b. MODULATION TONE VALUES. R.N. equipment which uses the sub-carrier technique for Radio Teleprinter Communication achieves the various shifts by pairs of tones as shown in para. 44, page 10–1–9.

c. A.F. TONE EQUIPMENT. A list of ship equipment together with its A.F. Tone capability is shown in para. 45, page 10–1–10.

18. **Baud Speed.** Within NATO agreement has been reached to standardize the transmission speed for all RATT emissions at 75 bauds. On all UK joint tactical circuits 75 bauds is to be used except where it is known that RAF terminal equipment is involved, when the keying speed of 50 or 75 bauds is to be mutually agreed. ~~An amendment to JSP2 to reflect this will be issued in due course and meanwhile the baud speed is to be confirmed before circuits are established~~. A list of currently ship-fitted equipment and its baud speed capability is shown in para. 46, page 10–1–10.

19. **Baud Speed and Bandwidth Relationship.** As the baud speed increases so the bandwidth necessary to allow the receiving teleprinter to follow the changes in teleprinter conditions also increases. A diagramatic explanation of why Necessary Bandwidth increases with baud speed is shown in para. 47, page 10–1–11.

20. **Necessary Bandwidth and Bandwidth Designators.** The necessary Bandwidth and Bandwidth designators are shown in para. 48, page 10–1–12.

21. **System details of R.F. equipment.** The system details of ship-fitted R.F. equipment is shown in para. 49, page 10–1–12.

22. **Arrangement.** It has already been shown how, in line circuits, the relationship of current voltage or on-off tone to the teleprinter condition they represent is referred to as Polarity and that the Polarity may be reversible at various points. Since all RATT circuits are line in the transmit and receive terminals and it is impossible to guarantee that terminals in different units will be the same, the only sure means of ensuring successful communications for these circuits is to specify the relationship of the radiated frequencies to teleprinter conditions they represent. Since there is no simple international nomenclature for doing this, it has been agreed that the term Arrangement shall be used in Intra-RN and UK JOINT working with the meanings given below.

23. **For FST Circuits**

a. ARRANGEMENT 1. When the higher radiated frequency is used to represent the Active (A) condition of the telegraph apparatus and the lower radiated frequency is used to represent the Inactive (Z) condition.

b. ARRANGEMENT 2. When the higher radiated frequency is used to represent the Inactive (Z) condition of the telegraph apparatus and the lower radiated frequency is used to represent the Active (A) condition.

24. **For A2 RATT Circuits.** Due to the nature of an A2 RATT emission, it is meaningless to call such a circuit either Arrangement 1 or 2, using the FST definition of Arrangements, since it is both simultaneously. It is, however, important to state which frequency of each pair either side of the Carrier represents which teleprinter condition. This is best done by stating the "arrangement" of the voice-frequency modulating tones applied to the transmitter. The word arrangement is still used but, to avoid confusion with FST Arrangement, the term Modulating Arrangement has been adopted by the Navy with the following meanings:

a. MODULATING ARRANGEMENT 1. When the Higher audio modulating tone applied to the transmitter is used to represent the Active (A) condition of the telegraph apparatus and the Lower audio modulating tone applied to the transmitter is used to represent Inactive (Z) condition.

b. MODULATING ARRANGEMENT 2. When the Higher audio modulating tone applied to the transmitter is used to represent the Inactive (Z) condition of the telegraph apparatus and the Lower audio modulating tone applied to the transmitter is used to represent the Active (A) condition.

25. **FST Arrangement to be used.** The arrangement to be used on FST circuits is shown in para. 50, page 10–1–14.

26. **A2 RATT Modulation Arrangement to be used.** All circuits are to use Modulating Arrangement 2. (This is covered, when UHF working, by a Draft STANAG on Link 14 and STANAG 5028).

27. **Other Uses of "Arrangement".** The word "arrangement" is widely used to describe the relationship of two frequencies to the teleprinter conditions that they represent at any point in a communication system between aerial and voice-frequency tone generator and converter equipment. Such use is made of the word in para. 51 to trace the sequence of events within a CJK receiver and in para. 52 which shows simplified block diagrams of Outfit RWA. It should be clearly understood that in this context the word is used outside the definitions set out in para. 23 and 24.

28. **Promulgation of Arrangement.** The Arrangement applicable to each circuit must be known by all stations on it. In some instances, such as net and on-line working, it is absolutely vital if communications are to be achieved at all. The situation on naval circuits has now been greatly improved by the standardization on Arrangement 1 and it should no longer be necessary to quote in naval complans the Arrangement for each FST circuit. Although NATO has now agreed to adopt Arrangement 1 working, the exact timing of the change within the Services of each member country is not known and it would be prudent for authorities scheduling or conducting NATO exercises to pursue the matter at the planning stage and if necessary include a directive in the exercise communication orders. It should be noted that for the time being JOINT FST circuits remain Arrangement 2.

29. **Stating the Parameters of a RATT Circuit.** The parameters required for establishing a RATT circuit are as follows:

a. Emission Designator (F1 or A2 RATT).

b. The Frequency Shift.

c. The Arrangement for F1 or Modulation Arrangement for A2 RATT.

d. The Baud Speed.

e. The Assigned Frequency.

30. With the increasing use of RATT circuits in the Fleet it is becoming clear that there should be a simple method of stating these parameters at operational level. Consideration has been given to preceding the emission designator with both frequency shift and baud speed. This method has not been adopted, however, as the necessary bandwidths calculated by the recognized ITU formulae produce values which bear no obvious connection with a given shift and in some cases are very little different for different shifts and baud speeds. A more straightforward method is to decide on a standard sequence in which the parameters should be stated. This method has now been agreed for Intra-RN working and is explained in para. 53. ~~Adoption of this method for JOINT working is being pursued and will be promulgated in JSP 2 if agreed~~. Adoption of this method for JOINT working is also agreed and is promulgated in. JSP2

31. **Setting up RATT Terminal Equipment.** To set up either a transmit or a receive terminal correctly it is necessary for the user to understand clearly how and where either a line polarity or a tone "arrangement" reversal can be achieved in the system at his disposal; if he does not it will, almost certainly result in a loss

of intelligence. When the sub-carrier shift technique is used for transmission and in every receive terminal, this also requires an implicit understanding of the correct transmitter or receiver dial setting, a knowledge of voice-frequency tone generator and convertor equipment reversal facilities and the relationship of each to a particular radiated arrangement. In considering this problem it is better for the sake of clarity to deal separately with transmit and receive terminals.

32. **Transmit Terminals.** If, for example, a voice-frequency tone generator produces the lower of its two modulating tones to represent the Active condition of the teleprinter and the higher tone, the Inactive, any associated SSB transmitter will radiate Arrangement 1 on its lower sideband and Arrangement 2 on its upper. If, however, the "arrangement" of tones from the voice-frequency generator is reversed the same transmitter will radiate Arrangement 1 from its upper sideband and Arrangement 2 from its lower. In other words, the question, in the Sub-Carrier Shift technique of transmitting FST, of whether one uses the upper or the lower sideband of the transmitter and hence whether one offsets high or low from the assigned frequency to arrive at the correct dial setting (suppressed carrier) depends on the "arrangement" of tones set at the voice-frequency generating equipment. With this relationship understood the radiation of the correct Arrangement then depends only on the correct assessment of line polarity. In the Carrier Shift technique, line polarity is the only consideration since no voice-frequency tones are involved.

33. **Receive Terminals.** Regardless of the technique used in transmission, RATT receive terminals operate on the production of voice-frequency tones from the receiver which are converted by a voice-frequency converter into a line signal of current or on-off tone of a fixed or reversible line polarity. The input of these converters can be regarded as tones of a given "arrangement" and their output as of a given polarity. Hitherto, in the CV89A the polarity has been predetermined in design and has not been reversible, but the converter has been able to be set to either input "arrangement". With the arrival of the TTVF(B) the polarity is also reversible. As in the case of transmit terminals, there is a distinct relationship between the sideband of the receiver used (or the BFO "high" or "low" position in the case of some receivers) and the "arrangement" to which the voice-frequency converter equipment is set to respond. Indeed, the setting on the converter equipment is always the deciding factor in arriving at the frequency offset, whether external on the synthesiser, or internal on the BFO or sideband selector oscillator, to be applied to a receiver for a radiated signal of a given Arrangement. For example, if a converter of fixed output polarity is set to respond to an input "arrangement" whereby the lower tone represents the Active condition and the higher tone the Inactive, it will mean the use of the lower sideband of the associated receiver if the signal is radiated as Arrangement 1 and the upper if Arrangement 2. If either one of the input "arrangement" or the output polarity is altered without the other this configuration of receiver sidebands will be reversed.

34. **Standard Terminal Settings.** In the past, with transmit terminals using only carrier shift technique, the transmitter master oscillator or crystal frequency for a given Arrangement has been decided by a predetermined table or equation used in conjunction with a line polarity switch. In the case of receive terminals the converter and BFO settings have been operated by trial and error without any guiding principles. The introduction of the Sub-Carrier Shift technique for transmission together with tone generator equipment of reversible "arrangement" and the use of synthesised receivers with converters which have reversible settings for both "arrangements" and polarity have made it essential to derive a standard philosophy for setting up terminal equipment. This philosophy has now been decided and it is that wherever possible the upper sideband of the associated transmitter and the upper sideband of the associated receiver (or BFO/Sideband Selector "High" or "USB") together with "normal" line polarity should be used. The principal aim of this philosophy is to establish a standard direction of offset to apply to the transmitter/receiver from the assigned frequency to arrive at the dial setting. This direction for upper sideband working is always minus or BFO/Sideband Selector High (USB). When set in this manner a terminal, whether transmit or receive, is said to be set to USB (Standard) Settings.

35. Since the Fleet is still widely fitted with Outfits GAA and AN/SGC–1A whose output tone "arrangement" is not reversible, ships with this equipment will have to radiate and, in the case of 200 Hz shift FST,

receive through the lower sideband of transmitters/receivers for an Arrangement 1 signal and for these signals they will be unable to use USB (Standard) Settings. As the fitting of Outfit RWA becomes more general this will apply to fewer and fewer ships. In the meantime these ships will have to use LSB (Opposite) Settings for Arrangement 1 signals. LSB (Opposite) Settings may be used in exceptional circumstances as an alternative to USB (Standard) Settings, but for the sake of simplicity and ease of training should be avoided whenever possible.

36. Para. 54 gives the settings normally to be set on all transmit terminals and para. 55 the settings for all receive terminals. Although para. 55 lists all possible combinations of receiver and terminal equipment it should be realized that combinations of CJA, CJD or CJK with the TTVF(B) or TTVF(T) represent the very best terminals. The use, for example, of a B40/FAZ with a TTVF(B) or (T) should be avoided whenever a CJA or CJK is available to use in its place. Para. 56 gives the terminal settings for A2 RATT operation.

37. Para. 57 gives the details of RATT terminal equipment necessary for systems planning.

38. The instructions in 54 and 55 supersede those on the offsetting Disc, Form S.1707 which should no longer be used. It is being re-designed to show USB (Standard) Settings and will be issued without demand in due course.

39. A list of Teleprinters and Associated Automatic Transmitters is shown in para. 58, page 10–1–27.

40. **International Telecommunications Union – Definition**

a. The proposed ITU Definition of Positions "A" and "Z" is as follows:
Position "A": Position "Z".

b. Representation of the positions occupied by the moving parts (for example, relay armatures) in the circuit diagram.

(1) In a diagram representing a complete telegraph connection, operated by binary modulation, the positions which all the moving parts in this connection should simultaneously occupy, so that the electromagnet of the receiver shall be in a given position (A or Z), should be designated in the same way as this position.

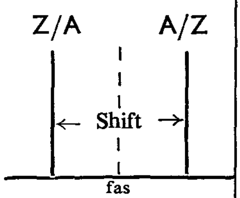
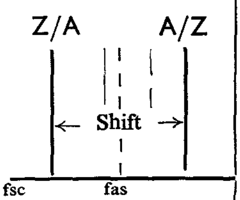
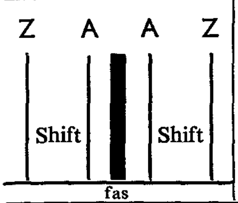
(2) Position A is that which corresponds to the start signal of a standardized start-stop apparatus; position Z is that which then corresponds to the stop signal.

(3) In the case of a point-to-point start-stop circuit, the moving parts should all be shown in position Z.

(4) In the case of a diagram of a switched connection, the moving parts should all be shown in the position corresponding to the free condition of the circuits.

Thus, for example, in the standardized international telex system, the position in question is A.

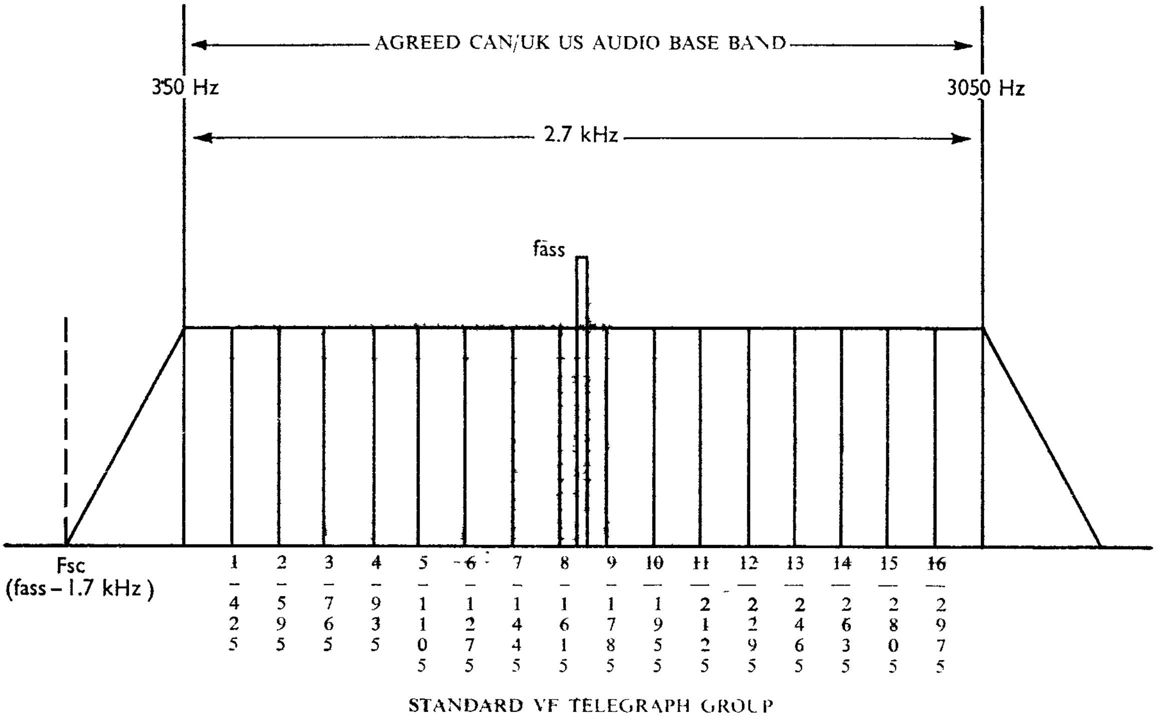
41. Table of Comparable Terminology

WHAT THE EMISSION LOOKS LIKE IN THE ETHER	UK JOINT DESCRIPTION	UK JOINT EMISSION DESIGNATOR	CCIR RECOMMENDED DESCRIPTION	ITU DESCRIPTION NOW	ITU EMISSION DESIGNATOR	USN TERMINOLOGY
	FST for operations (Carrier Shift Technique for Plan-ing and training)	F1	Frequency Shift Sig-nalling/ Keying (FSK)	FST or FSK	F1	FSK (F1)
	FST for operations (Sub-Carrier Shift Technique for plan-ning and training)	F1 (though it is recognised that the technique is A2J)	Frequency Exchange Signalling	None	A2J	TONE MOD RATT (A2J)
	A2 RATT	A2 RATT	None	None	A2	TONE MOD RATT (A2)

42. Frequency Shift Values

FREQUENCY BAND	CCIR RECOMMENDATION	INTRA-RN USAGE	NATO AGREEMENT	JOINT AGREEMENT
VLF (3–30 kHz)	50 Hz (±25 Hz)	50 Hz	50 Hz (for 50 Bauds)	NA
LF (30–300 kHz)	85 Hz (±42.5 Hz)	85 Hz	85 Hz	NA
MF (300–3000 kHz)	170 Hz (±85 Hz)	200 Hz Note: Intra-RN the MF Band is assumed to stop at 1.5 MHz	None	NA
HF (3–30 MHz)	340 Hz or 280 Hz (amongst others)	850 Hz or 200 Hz Note: Intra-RN the HF Band is assumed to start at 1.5 MHz	850 Hz	850 Hz

43. CAN/UK/US Audio Base band



44. Modulation Tone Values

SHIFT	TONE VALUES	
	Tx	*Rx Converter*
50 Hz	Not applicable (FSK)	Centred on 1000 Hz CV89A
85 Hz	Not applicable (FSK)	Centred on 1000 Hz TTVF(B)
200 Hz (Navy)	500 Hz / 700 Hz	500 Hz / 700 Hz
(Army)	1900 Hz / 2100 Hz	1900 Hz / 2100 Hz
850 Hz (Navy)	2125 Hz / 1275 Hz	2125 Hz / 1275 Hz
(Army)	1575 Hz / 2425 Hz	1575 Hz / 2425 Hz

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45. A.F. Tone Equipments

A.F. TONE EQUIPMENT	SHIFT CAPABILITY
TRANSMIT ONLY GAA	850 Hz only
TRANSMIT/RECEIVE TTVF(T)	850 Hz & 200 Hz (likely to be modified from 200 to 170 in due course)
RECEIVE ONLY CV89A	Continuous as follows: 0–200 Hz centred on 1 kHz 200–1000 Hz centred on 2.55 kHz
TTVF(B)	850 Hz 680 Hz 510 Hz 340 Hz 170 Hz 50–85 Hz centred on 1000 Hz

R.F. (FSK) KEYERS	SHIFT CAPABILITY
TRANSMIT ONLY GK185A 5ABA	 Continuous between 0–1000 Hz Continuous between 0–1000 Hz

46. Baud Speed of Ship-Fitted Terminal Equipment

a. TELEPRINTERS. Only teleprinters No 12 Mk III or Mk IV are to be used on 75-baud circuits. Mk IV machines have an intrinsic dual-speed (50 or 75 baud) capability, but Mk III machines require to have Modification No 1 incorporated to achieve dual-speed capability; this modification, which has been promulgated as Modification No 9 to RATT 1/2 in BR 1917 and as Modification No 3 to Terminal Equipment in BR 1917(S), permits the teleprinter speed to be switched between 50 and 75 bauds.

b. AUTO-TRANSMITTERS

(1) Broadcast control positions ashore require to be fitted with automatic numbering transmitter sets TAA6A or TAA6B. These have a dual-speed 50 or 75 baud capability and have been issued to the stations concerned for this purpose.

(2) Other control positions affected ashore and auto-transmitter positions in ships are fitted with auto-transmitters of the 6S6 family. Of these, the current production machines (Patt Nos 0555/972–4923 (115 volts) or 0555/972–490, 0555/972–4921, 0555/972–4922 (230 volts)) have an intrinsic dual-speed (50 or 75 baud) capability. Older versions (5815–99–980–7644 (115 volts)) or 5815–99–920–6223, 5815–99–920–6224 (230 volts) require to be modified to achieve dual-speed capability.

c. REPERFORATORS. A new Printing Reperforator Set PR76R will replace the currently fitted Reperforator Set 86R in positions requiring a 75-baud capability.

d. OTHER RATT TERMINAL EQUIPMENT (SHIPS)

(1) The following are all capable of 50 or 75 baud working without any physical change to the equipment.

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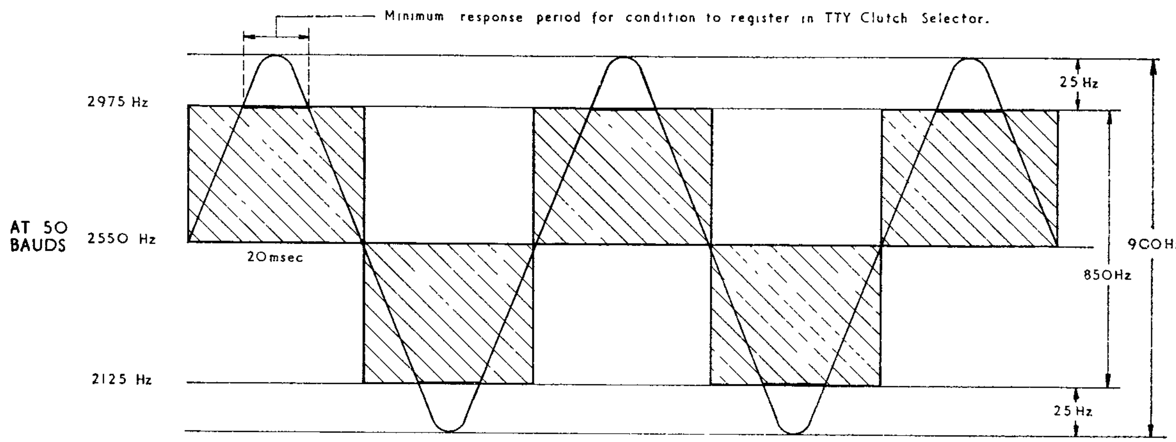
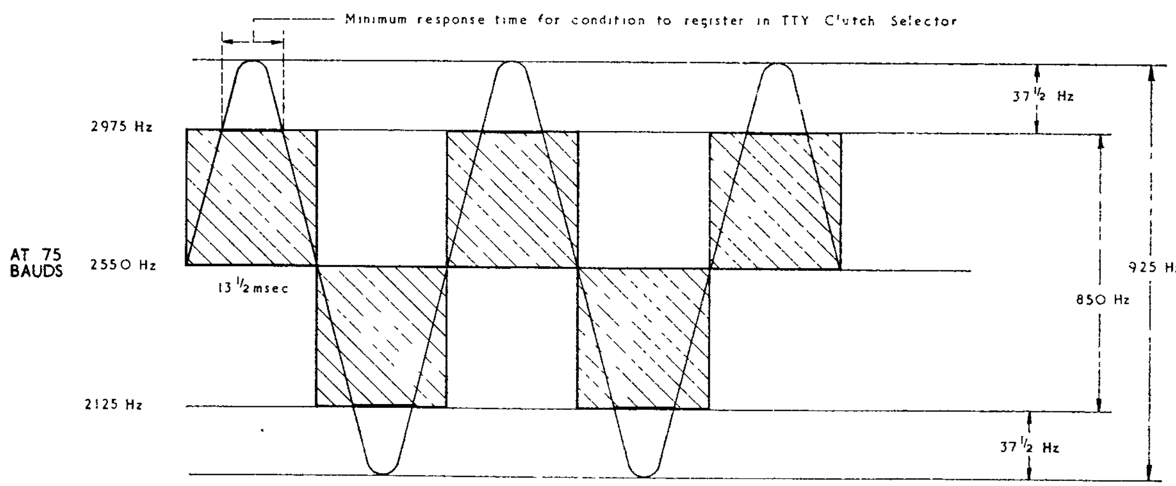
TT10	GAA	ANSGC–1A
TT11	GK185A	CV89A
TTVF(T)	GK198	TTVF(B)
SUR	GK199	

(2) Security Boxes 4 and 6 are capable of both but have to be set to the required speed.

47. Baud Speed and Bandwidth Relationship



To reproduce an exactly square wave form the receiver would need to receive all the harmonics of the signal therefore have an infinitely wide bandwidth. The TTY is designed to register changes of condition using only part of the 20 msec condition time period and so work off the fundamental together with the 2nd harmonic only.



At 75 bauds, as the duration of each condition has reduced from 20 msec to $13\frac{1}{3}$ msec, to achieve the required minimum response time the fundamental will extend further above and below the 2975 Hz and 2125 Hz. Thus the bandwidth necessary for the circuit must be increased.

48. Necessary Bandwidth and Bandwidth Designators

CIRCUIT CHARACTERISTIC	RELEVANT ITU FORMULA FOR NECESSARY BANDWIDTH	NECESSARY BANDWIDTH	FULL EMISSION DESIGNATOR
FST 850 Hz shift 50 bauds	$B_n = 2.1D + 1.9B$	987.5 Hz	0.99 F1
FST 850 Hz shift 75 bauds	as above	1035 Hz	1.04 F1
FST 200 Hz shift 50 bauds	$B_n = 2.6D + 0.55B$	287.5 Hz	0.29 F1
FST 200 Hz shift 75 bauds	as above	301.25 Hz	0.3 F1
A2 RATT 200 Hz shift 50 bauds at UHF	$B_n = BK + 2M$	1550 Hz	1.55 A2 RATT
A2 RATT 200 Hz shift 75 bauds at UHF	as above	1625 Hz	1.6 A2 RATT
A2 RATT 850 Hz shift 50 bauds at UHF	as above	6100 Hz	6.1 A2 RATT
A2 RATT 850 Hz shift 75 bauds at UHF	as above	6175 Hz	6.2 A2 RATT
A2 RATT 200 Hz shift 50 bauds at HF	as above	1650 Hz	1.65 A2 RATT
A2 RATT 200 Hz shift 75 bauds at HF	as above	1775 Hz	1.8 A2 RATT
A2 RATT 850 Hz shift 50 bauds at HF	as above	6200 Hz	Not applicable as A2 RATT 850 Hz shift should not be used at HF
A2 RATT 850 Hz shift 75 bauds at HF	as above	6325 Hz	

Note:

B_n = Necessary Bandwidth in Hertz.

D = Half the difference between the maximum and minimum values of the instantaneous frequency. Instantaneous frequency is the rate of change of phase (i.e. the shift).

B = Telegraph speed in Bauds.

K = An overall numerical factor which varies according to the emission and which depends upon the allowable signal distortion. It is 5 for fading circuits (HF) and 3 for non-fading circuits (UHF).

M = Maximum modulation frequency in Hertz.

49. The System Details of RF Equipment

TRANSMITTERS

a. 640

(1) "Channel A" for DSB CW or USB.
"Channel B" for LSB.

(2) System Switch: CW, ISB (SC), ISB (PC). (ISB positions are used for SSB as well as ISB).

(3) Synthesiser Increments down to 100 Hz.

(4) VF Baseband 300 – 3000 Hz.

b. TDA

(1) "USB Carrier Suppressed" or USB Carrier Controlled or USB Pre-set Carrier
"LSB Carrier Suppressed" or LSB Carrier Controlled or LSB Pre-set Carrier
"DSB" or Independent Sideband.

(2) Synthesiser Increments down to 100 Hz.

(3) Baseband 330 – 3300 Hz.

RECEIVERS

c. B40D

(1) Unstable.

(2) BFO: CW/FSK NARROW HIGH – Internal Offset of —1 kHz.
CW/FSK NARROW LOW – Internal Offset of +1 kHz.
FSK WIDE HIGH – Internal Offset of —2.55 kHz.
FSK WIDE LOW – Internal Offset of +2.55 kHz.

(3) Bandwidths: 1 kHz; 3 kHz; 8 kHz. Centred on point to which RX dial is tuned.

d. B40D with FAZ

(1) B40D instability counteracted by FAZ.

(2) FAZ BFO: "RATT N" – Internal offset of 1 kHz.
"RATT W" – Internal offset of 2.55 kHz.
VOICE – Internal offset of 1.5 kHz.

(3) FAZ USB/LSB – gives direction of internal offset as follows: USB—
LSB+

(4) B40D Bandwidths as in *c.* (3).

e. B41

(1) Unstable.

(2) BFO: FSK NARROW HIGH – Internal offset of —1 kHz.
FSK NARROW LOW – Internal offset of +1 kHz.

(3) Bandwidths: 200 Hz; 1 kHz; 3 kHz. Centred on point to which receiver dial is tuned.

f. B41 with FAZ

(1) B41 instability counteracted by FAZ.

(2) FAZ as in *d.* (2) and (3).

(3) B41 as in *e.* (2) and (3).

g. CJK

(1) Stable.

(2) Synthesiser with fine tuner gives continuously tunable dial setting.

(3) Bandwidths: 100 Hz; 300 Hz; 1.2 kHz; 3 kHz; 6.5 kHz and 13 kHz all centred on point to which RF stages are set (this is full dial setting.)

(4) Internal offset by Stable sideband selector of 1.5 kHz; direction controlled by switch to USB or LSB.

(5) Fitted with BFO which is not stable in comparison with other controls on the set, but is tunable to ±8 kHz.

(6) No system switch.

h. CJA

(1) Stable.

(2) Synthesiser tunable to 100 Hz increments.

(3) Modulation Switch controls BFO and bandwidth as follows:
Switched to CW + Internal offset of −1 kHz
Switched to CW − Internal offset of +1 kHz } Bandwidth 200 Hz centred on dial setting.
Switched to SSB–ISB – No Internal offset. Bandwidth either 350 Hz – 3050 Hz above or below dial setting or Both depending on Output Switch.

(4) Output Switch: USB, LSB, or DSB.

TRANSCEIVERS

i. Type 633

(1) The Carrier or suppressed carrier frequency is crystal derived and must be a whole number of kHz.

(2) Morse can only be made 1 kHz above the SSB Voice suppressed carrier.

(3) The set is able to work a DSB circuit by radiating a full carrier and the upper sideband.

j. COLLINS 618T

(1) Synthesiser increments limited to whole numbers of kHz.

(2) Morse can only be made 1 kHz above the Suppressed carrier.

(3) As *i.* (3).

50. **The Arrangement to be Used on FST Circuits** is established as follows:

RN Fixed Services and other services shore-to-shore	Arrangement 1
RN Maritime Rear Links shore-to-ship/ship-to-shore	Arrangement 2
RN Fleet Broadcasts (HF, LF and MF)	Arrangement 1
RN Task Force/Group Broadcasts (HF and MF)	Arrangement 2
RN Tactical FST Circuits	Arrangement 1
RN RATT Ship/Shore	Arrangement 2
UK JOINT Tactical FST Circuits	Arrangement 2 (See Note (i))
NATO FST Circuits and Broadcasts	Arrangement 1 (See Note (ii))
Draft STANAG on Link 14 for HF and LF working	Arrangement 1
Current British and European Commercial practice	Generally Arrangement 1 (See Note (iii))
Current US Commercial practice	Generally Arrangement 1
US Naval Multi-Channel FST Broadcast	Arrangement 2
CCIR Recommendation	Arrangement 1

Notes:

(i) The Army is unable to change to Arrangement 1 yet. Notice of the eventual change will be given in JSP2.

(ii) Relevant STANAGS are 4104 and 5028. OSE's with NATO forces should for the time being include a directive in the communication orders on the arrangement to be used. RCN Broadcasts are still Arrangement 2.

(iii) BRACKNELL MET is at present Arrangement 1.

51. An Example of an FST Signal Received on a CJK Receiver 850 Hz Shift Circuit Operating on an Assigned Frequency of 6414 kHz Arrangement 1.

ARRANGEMENT 1		ARRANGEMENT 2		ARRANGEMENT 2		ARRANGEMENT 1		ARRANGEMENT 2		ARRANGEMENT 1		ARRANGEMENT 1	
	RF Stages	VFO (1st LO)	1st IF	37.5 MHz Filter and OSC	2nd IF	Synthe-sizer Output (2nd LO)	3rd IF	1.7 MHz 1.7 MHz Oscillator Output (3rd LO)	4th IF	Sideband Selector Switch	Lower Sideband Filter	Carrier Reinser-tion	AF Out-put 1 or 2 USB
Frequency of Active Condition	6414.425 kHz		400085.575 kHz		2585.575 kHz		1601.425 kHz		99.375 kHz		20.125 kHz		2125 kHz
Frequency to which Receiver Circuits are tuned	6413.8 kHz	46.5 MHz (6 on MHz DIAL)	40087.050 kHz	37.5 MHz	2587.05 kHz	4187 kHz (415 on kHz DIAL)	1600.95 kHz	1700.8 kHz (.8 on FINE TUNING CON-TROL)	100 kHz (see signal centred .2 kHz below IF)	119.5 kHz (USB) (CLOCK-WISE)		18 kHz	
Frequency of Inactive Condition	6413.575 kHz		40086.425 kHz		2586.425 kHz		1600.575 kHz		100.225 kHz		19.275 kHz		1275 kHz

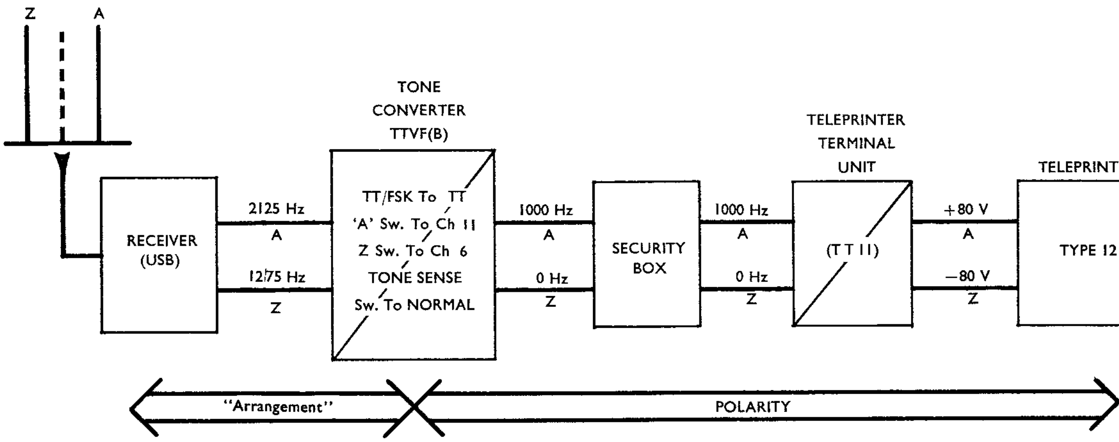
Notes

(i) A receiver dial setting OFFSET OF MINUS .2 kHz applied to the 2nd and 3rd local oscillators makes the signal at the 4th IF this amount below 100 kHz. The sideband selector switch is put to the "USB" position (clockwise) making the output of its associated oscillator 119.5 kHz. This in effect achieves an internal offset of −1.5 which, added to the −.2 applied directly to the synthesizer makes a total of −1.7 kHz.

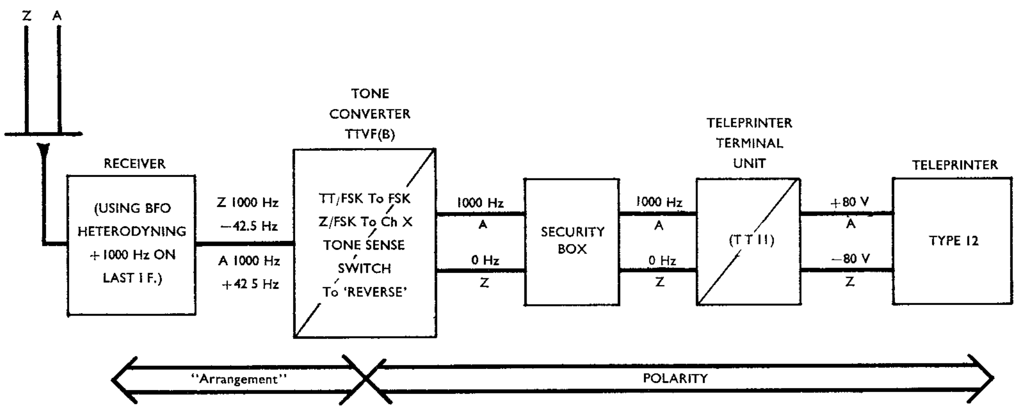
(ii) The terminal equipment, set to USB (Standard) settings, requires an audio input centred on 1.7 kHz which consists of the higher audio tone representing the ACTIVE condition of the teletypewriter and the lower audio tone the INACTIVE condition, as shown.

52. **Schematic Diagram of Typical Outfit RWA Terminals**

a. Broadcast Terminal shown with USB (Standard) Settings for an Arrangement 1 850 Hz Shift FST Signal.



b. Broadcast Terminal shown with USB (Standard) Settings for an Arrangement 1 85 Hz Shift FST Signal.

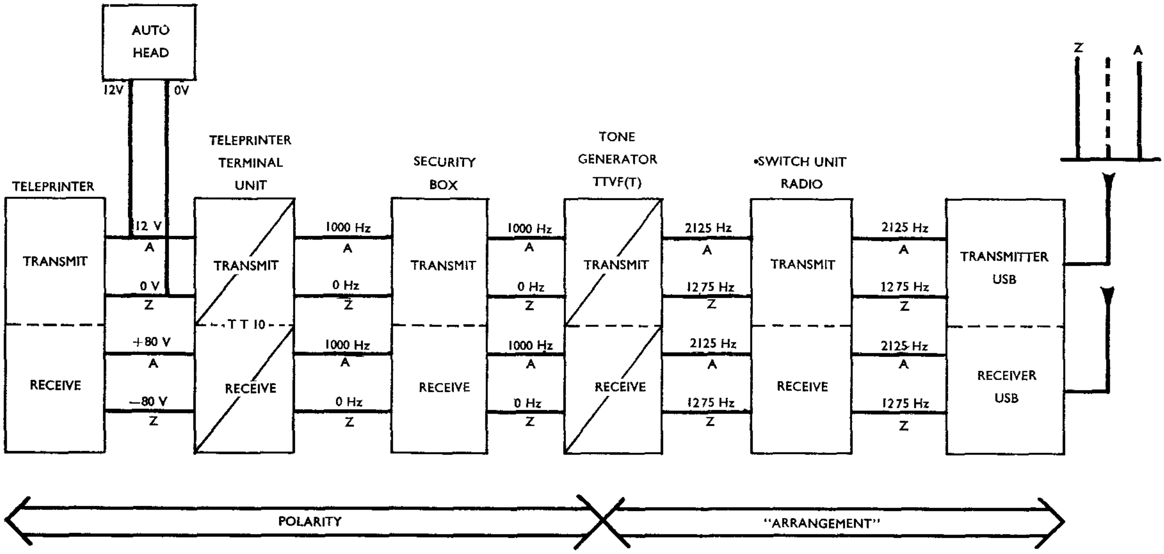


Notes:

(i) The Polarity shown is that which will exist when TTVFs (Broadcast) replace CV89As and the TTVF(B) Tone Sense Polarity, which is reversible, is set to "REVERSE".

(ii) Outfit RWA Broadcast terminals fitted with CV89As operate with a Polarity which is fixed, by temporary modifications to Security Boxes and TT11s, to make the 935 Hz or 1000 Hz represent the Inactive and 0 Hz represent the Active condition. These modifications will be removed as part of the installation instructions for the TTVF(B).

c. Transmit/Receive Terminal shown with USB (Standard) settings for an Arrangement 1 850 Hz shift FST signal.



Notes:

(i) The Tone Sense polarity in the Transmit/Receive Terminal operates as shown and cannot be reversed as it can be in the Broadcast reception terminal.

(ii) The TTVF(T) can be set to respond to either "arrangement" of input or output tones by swapping the tone oscillators and filters in the "A" and "Z" channels.

53. **Method of Stating the Parameters of RATT Circuits.** The parameters of RATT Circuits should be stated at operational level in the following sequence:

a. Emission Designator (FI or A2 RATT).

b. Frequency Shift.

c. Arrangement or Modulating Arrangement. But see para 26.

d. Baud Speed.

e. Assigned Frequency (assumed to be kHz for FST and MHz for A2 RATT unless otherwise stated).

EXAMPLES

CIRCUIT PARAMETERS	ABBREVIATED FORM	
1. FST, 850 Hz Shift, Arrangement 1, 75 Bauds on an assigned frequency of 3,600 kHz	FI/850/1/75	3,600
2. FST, 850 Hz Shift, Arrangement 2, 50 Bauds on an assigned frequency of 4210 kHz	FI/850/2/50	4,210
3. FST, 200 Hz Shift, Arrangement 1, 50 Bauds on an assigned frequency of 4964 kHz	FI/200/1/50	4,964
4. A2 RATT, 200 Hz Shift, Modulating Arrangement 2, 75 Bauds on an assigned frequency of 361.2 MHz	A2 RATT/200/2/75	361.2
5. A2 RATT, 850 Hz Shift, Modulating Arrangement 2, 50 Bauds on an assigned frequency of 267.3 MHz	A2 RATT/850/2/50	267.3

54. Setting up Transmit Terminals which Use the Sub-Carrier Shift Technique to Radiate FST (USB) (STANDARD) settings are shown except where they cannot be achieved.

VF TONE GENERATOR AND TRANSMITTER	ARRANGEMENT 1		ARRANGEMENT 2		REMARKS
	VF TONE GENERATOR	TRANSMITTER	VF TONE GENERATOR	TRANSMITTER	
TTVF(T) with TDA /WBA/B (850Hz shift)	1275Hz OSC and Filter to Z 2125Hz OSC and Filter to A Channel switch to CHAN 2	Synthesiser offset MINUS 1.7 kHz UPPER SIDE-BAND CARRIER SUPPRESSED	2125Hz OSC and Filter to Z 1275Hz OSC and Filter to A Channel switch to CHAN 2	Synthesiser offset MINUS 1.7 kHz UPPER SIDE-BAND CARRIER SUPPRESSED	
TTVF(T) with 640 (850Hz shift)	As above	Synthesizer offset MINUS 1.7 kHz Use CHANNEL "A" (USB)	As above	Synthesizer offset MINUS 1.7 kHz Use CHANNEL "A" (USB)	
GAA with 640 (850Hz shift)	Z OSC produces 2975Hz A OSC produces 2125Hz (cannot be reversed)	Synthesizer offset PLUS 2.5 kHz Use CHANNEL "B" (LSB)	Z OSC produces 2975Hz A OSC produces 2125Hz	Synthesizer offset MINUS 2.5 kHz Use CHANNEL "A"(USB)	Fixed "arrangement" of tones from GAA make LSB (opposite) settings inevitable to radiate arrangement 1.
TTVF(T) with TDA/WBA/B (200Hz shift)	500Hz OSC and Filter to Z 700Hz OSC and Filter to A Channel switch to CHAN 1	Synthesizer offset MINUS 0.6 kHz UPPER SIDE-BAND CARRIER SUPPRESSED	700Hz OSC and Filter to Z 500Hz OSC and Filter to A Channel switch to CHAN 1	Synthesizer offset MINUS 0.6 kHz UPPER SIDE-BAND CARRIER SUPPRESSED	
TTVF(T) with 640 (200Hz shift)	As above	Synthesizer offset MINUS 0.6 kHz Use CHANNEL "A" (USB)	As above	Synthesizer offset MINUS 0.6 kHz Use CHANNEL "A" (USB)	
AN SGC–1A with 640 (200Hz shift)	Z OSC produces 700Hz A OSC produces 500Hz (cannot be reversed)	Synthesizer offset PLUS 0.6 kHz Use CHANNEL "B" (LSB)	Z OSC produces 700Hz A OSC produces 500Hz	As above	Fixed "arrangement" of tones from the AN/SGC–1A makes LSB (opposite) settings inevitable to radiate arrangement 1.

55. Setting up Receive Terminals (USB) (STANDARD) Settings are shown except where they cannot be achieved.

RECEIVE TERMINAL EQUIPMENT	ARRANGEMENT 1		ARRANGEMENT 2		REMARKS
	RECEIVER	TERMINAL EQUIPMENT	RECEIVER	TERMINAL EQUIPMENT	
B40 with CV89A (850Hz shift)	Tuned to Assigned Frequency BFO to "FSK WIDE HIGH" BANDWIDTH to "3 kHz"	NORMAL/ REVERSE to "REVERSE" WIDE/ NARROW to "WIDE"	Tuned to Assigned Frequency BFO to "FSK WIDE HIGH" BANDWIDTH to "3 kHz"	NORMAL/ REVERSE to "NORMAL" WIDE/ NARROW to "WIDE"	
B40/FAZ with CV89A (850Hz shift)	Tuned to Assigned Frequency BFO to "TUNE" BANDWIDTH to "3 kHz" FAZ function to "RATT W" USB/LSB/ DIRECT to "USB"	As above	Tuned to Assigned Frequency BFO to "TUNE" BANDWIDTH to "3 kHz" FAZ function to "RATT W" USB/LSB/ DIRECT to "USB"	As above	B40 system switch to "R/T" may give better results.
B40/FAZ with TTVF(B) (850Hz shift)	As above	TT/FSK to "TT" Z/FSK to "11" A to "16" TONE/SENSE to "NORMAL" WIDE/ NARROW to "WIDE"	As above	TT/FSK to "TT" Z/FSK to "16" A to "11" TONE/SENSE to "NORMAL" WIDE/ NARROW to "WIDE"	As above
B40/FAZ with TTVF(T) (850 Hz shift)	As above	CHANNEL to "CHAN 2" 2125Hz OSC and Filters to "Z" 2975Hz OSC and Filters to "A"	As above	CHANNEL to "CHAN 2" 2975Hz OSC and Filters to "Z" 2125Hz OSC and Filters to "A"	Care must be taken to ensure that TTVF(T) contains filters shown in columns 3 and 5.
CJK with CV89A (850Hz shift)	SYNTHESIZER offset MINUS 1.05 kHz SB SELECTOR to "USB" (clockwise) BANDWIDTH to "3 kHz" BFO–DOWN (off) OUTPUT 1 or 2 to "USB"	NORMAL/ REVERSE to "REVERSE" WIDE/ NARROW to "WIDE"	SYNTHESIZER offset MINUS 1.05 kHz SB SELECTOR to "USB" (clockwise) BANDWIDTH to "3 kHz" BFO–DOWN (off) OUTPUT 1 or 2 to "USB"	NORMAL/ REVERSE to "NORMAL" WIDE/ NARROW to "WIDE"	
CJK with TTVF(B) (850Hz shift)	SYNTHESIZER offset MINUS .2 kHz SB SELECTOR to "USB" (clockwise) BANDWIDTH to "3 kHz" BFO–DOWN (off) OUTPUT 1 or 2 to "USB"	TT/FSK to "TT" Z/FSK to "6" A to "11" TONE SENSE to "NORMAL" WIDE/ NARROW to "NARROW"	SYNTHESIZER offset MINUS .2 kHz SB SELECTOR to "USB" (clockwise) BANDWIDTH to "3 kHz" BFO–DOWN (off) OUTPUT 1 or 2 to "USB"	TT/FSK to "TT" Z/FSK to "11" A to "6" TONE SENSE to "NORMAL" WIDE/ NARROW to "NARROW"	

55. continued

RECEIVE TERMINAL EQUIPMENT	ARRANGEMENT 1		ARRANGEMENT 2		REMARKS
	RECEIVER	TERMINAL EQUIPMENT	RECEIVER	TERMINAL EQUIPMENT	
CJK with TTVF(T) (850Hz shift)	As above	CHANNEL to "CHAN 2" 1275Hz OSC and Filter to "Z" 2125Hz OSC and Filters to "A"	As above	CHANNEL to "CHAN 2" 2125Hz OSC and Filter to "Z" 1275Hz OSC and Filters to "A"	
CJA with CV89A (850Hz shift)	SYNTHESIZER offset MINUS 2.5 kHz (or 2.55 kHz if the assigned frequency makes this possible) MODULATION to "SSB/ISB EXT" OUTPUT to "USB" SYN/FREE to "SYNTHE-SIZED" AUTO/MANUAL GAIN to "LONG TIME CONSTANT" INT/EXT AGC to "INT"	NORMAL/REVERSE to "REVERSE" WIDE/NARROW to "WIDE"	SYNTHESIZER offset MINUS 2.5 kHz (or 2.55 kHz if the assigned frequency makes this possible) MODULATION to "SSB/ISB EXT" OUTPUT to "USB" SYN/FREE to "SYNTHE-SIZED" AUTO/MANUAL GAIN to "LONG TIME CONSTANT" INT/EXT AGC to "INT"	NORMAL/REVERSE to "NORMAL" WIDE/NARROW to "WIDE"	
CJA with TTVF(B) (850Hz shift)	SYNTHESIZER offset MINUS 1.7 kHz MODULATION to "SSB/ISB EXT" OUTPUT to "USB" SYN/FREE to "SYNTHE-SIZED" AUTO/MANUAL GAIN to "LONG TIME CONSTANT" INT/EXT AGC to "INT"	TT/FSK to "TT" Z/FSK to "6" A to "11" TONE/SENSE to "NORMAL" WIDE/NARROW to "NARROW"	SYNTHESIZER offset MINUS 1.7 kHz MODULATION to "SSB/ISB EXT" OUTPUT to "USB" SYN/FREE to "SYNTHE-SIZED" AUTO/MANUAL GAIN to "LONG TIME CONSTANT" INT/EXT AGC to "INT"	TT/FSK to "TT" Z/FSK to "11" A to "6" TONE/SENSE to "NORMAL" WIDE/NARROW to "NARROW"	

55. continued

RECEIVE TERMINAL EQUIPMENT	ARRANGEMENT 1		ARRANGEMENT 2		REMARKS
	RECEIVER	TERMINAL EQUIPMENT	RECEIVER	TERMINAL EQUIPMENT	
CJA with TTVF(T) (850Hz shift)	As above	CHANNEL to "CHAN 2" 1275Hz OSC and Filters to "Z" 2125Hz OSC and Filters to "A"	As above	CHANNEL to "CHAN 2" 2125Hz OSC and Filters to "Z" 1275Hz OSC and Filters to "A"	
B40 with CV89A (200Hz shift)	Tuned to Assigned frequency BFO to "FSK NARROW HIGH" BANDWIDTH to "1 kHz"	NORMAL/ REVERSE to "REVERSE" WIDE/ NARROW to "NARROW"	Tuned to Assigned frequency BFO to "FSK NARROW HIGH" BANDWIDTH to "1 kHz"	NORMAL/ REVERSE to "NORMAL" WIDE/ NARROW to "NARROW"	It is presumed that the CV89A input link is to the parallel position.
B40/FAZ with CV89A (200Hz shift)	Tuned to Assigned frequency BFO to "TUNE" BANDWIDTH to "1 kHz" FAZ function to "RATT N" USB/LSB/ DIRECT to "USB"	As above	Tuned to Assigned frequency BFO to "TUNE" BANDWIDTH to "1 kHz" FAZ function to "RATT N" USB/LSB/ DIRECT to "USB"	As above	As above B40 BFO to "R/T" may give better results.
B41/FAZ with CV89A (200 shift)	As above	As above	As above	As above	B41 BFO to "R/T" may give better results
CJK with CV89A (200Hz shift)	SYNTHESIZER offset MINUS 1.0 kHz SB SELECTOR to "ISB" (central) BANDWIDTH to "3 kHz" BFO–DOWN (off) OUTPUT 1 or 2 to "USB"	As above	SYNTHESIZER offset MINUS 1.0 kHz SB SELECTOR to "ISB" (central) BANDWIDTH to "3 kHz" BFO–DOWN (off) OUTPUT 1 or 2 to "USB"	As above	It is presumed that the CV89A input link is to the parallel position

55. continued

RECEIVE TERMINAL EQUIPMENT	ARRANGEMENT 1		ARRANGEMENT 2		REMARKS
	RECEIVER	TERMINAL EQUIPMENT	RECEIVER	TERMINAL EQUIPMENT	
CJK with AN/SGC–1A (200Hz shift)	SYNTHESIZER offset PLUS 0.6 kHz SB SELECTOR to "ISB" BANDWIDTH to "3 kHz" BFO–DOWN (off) OUTPUT 1 or 2 to "LSB"	No controls for Arrangement or Polarity. Must be supplied with 700Hz tone representing INACTIVE and 500Hz tone representing ACTIVE	SYNTHESIZER offset MINUS 0.6 kHz SB SELECTOR to "ISB" BANDWIDTH to "3 kHz" BFO–DOWN (off) OUTPUT 1 or 2 to "USB"	No controls for Arrangement or Polarity. Must be supplied with 700Hz tone representing INACTIVE and 500Hz tone representing ACTIVE	The fixed "arrangement" of tones required by the AN/SGC–1A makes LSB (opposite) settings inevitable to receive Arrangement 1 signals
CJK with TTVF(T) (200Hz shift)	SYNTHESIZER offset MINUS 0.6 kHz SB SELECTOR to "ISB" (central) BANDWIDTH to "3 kHz" BFO–DOWN (off) OUTPUT 1 or 2 to "USB"	CHANNEL to "CHAN 1" 500Hz OSC and Filters to "Z" 700Hz OSC and Filters to "A"	As above	CHANNEL to "CHAN 1" 700Hz OSC and Filters to "Z" 500Hz OSC and Filters to "A"	
CJK with TTVF(B) (200Hz shift)	SYNTHESIZER offset MINUS 0.6 kHz SB SELECTOR to "ISB" (central) to "3 kHz" BFO–DOWN (off) OUTPUT 1 or 2 to "USB"	TT/FSK to "TT" Z/FSK to "Y" A to "X" TONE SENSE to "REVERSE" WIDE/NARROW to "NARROW"	SYNTHESIZER offset MINUS 0.6 kHz SB SELECTOR to "ISB" BANDWIDTH to "3 kHz" BFO–DOWN (off) OUTPUT 1 or 2 to "USB"	TT/FSK to "TT" Z/FSK to "Y" A to "X" TONE SENSE to "NORMAL" WIDE/NARROW to "NARROW"	
CJA with CV89A (200Hz shift)	SYNTHESIZER offset MINUS 1.0 kHz MODULATION to "SSB–ISB EXT" OUTPUT to "USB" SYN/FREE to "SYNTHESIZED" AUTO/MANUAL GAIN to "LONG TIME CONSTANT" INT/EXT AGC to "INT"	NORMAL/REVERSE to "REVERSE" WIDE/NARROW to "NARROW"	SYNTHESIZER offset MINUS 1.0 kHz MODULATION to "SSB–ISB EXT" OUTPUT to "USB" SYN/FREE to "SYNTHESIZED" AUTO/MANUAL GAIN to "LONG TIME CONSTANT" INT/EXT AGC to "INT"	NORMAL/REVERSE to "NORMAL" WIDE/NARROW to "NARROW"	It is assumed that the CV89A input link is to the parallel position.

55. continued

RECEIVE TERMINAL EQUIPMENT	ARRANGEMENT 1		ARRANGEMENT 2		REMARKS
	RECEIVER	TERMINAL EQUIPMENT	RECEIVER	TERMINAL EQUIPMENT	
CJA with AN/SGC–1A (200Hz shift)	SYNTHESIZER offset PLUS 0.6 kHz MODULATION to "SSB–ISB EXT" OUTPUT to "LSB" SYN/FREE to "SYNTHESIZED" AUTO/MANUAL GAIN "LONG TIME CONSTANT" INT/EXT AGC to "INT"	No controls for "Arrangements" or Polarity. Must be supplied with 700Hz tone representing INACTIVE and 500Hz tone representing ACTIVE	SYNTHESIZER offset MINUS 0.6 kHz MODULATION to "SSB–ISB EXT" OUTPUT to "USB" SYN/FREE to "SYNTHESIZED" AUTO/MANUAL GAIN "LONG TIME CONSTANT" INT/EXT AGC to "INT"	No controls for "Arrangement" or Polarity. Must be supplied with 700Hz tone representing INACTIVE and 500Hz tone representing ACTIVE	The fixed "arrangement" of tones required by the AN/SGC–1A makes LSB (opposite) settings inevitable for arrangement 1 signals.
CJA with TTVF(T) (200Hz shift)	SYNTHESIZER offset MINUS MODULATION to 0.6 kHz "SSB–ISB EXT" OUTPUT to "USB" SYN/FREE to "SYNTHESIZED" AUTO/MANUAL GAIN to "LONG TIME CONSTANT" INT/EXT AGC to "INT"	CHANNEL to "CHAN 1" 500Hz OSC and Filters to "Z" 700Hz OSC and Filters to "A"	As above	CHANNEL to "CHAN 1" 700Hz OSC and Filters to "Z" 500Hz OSC and Filters to "A"	
CJA with TTVF(B) (200Hz shift)	As above	TT/FSK to "TT" Z/FSK to "Y" A to "X" TONE SENSE to "REVERSE" WIDE/NARROW to "NARROW"	As above	TT/FSK to "TT" Z/FSK to "Y" A to "X" TONE SENSE to "NORMAL" WIDE/NARROW to "NARROW"	
B41/FAZ with CV89A (50Hz or 85Hz shift)	Tuned to Assigned frequency BFO to "TUNE" BANDWIDTH to "1 kHz" FAZ function to "RATT N" USB/LSB/DIRECT to "USB"	NORMAL/REVERSE to "REVERSE" WIDE/NARROW to "NARROW"	Tuned to Assigned frequency BFO to "TUNE" BANDWIDTH to "1 kHz" FAZ function to "RATT N" USB/LSB/DIRECT to "USB"	NORMAL/REVERSE to "NORMAL" WIDE/NARROW to "NARROW"	B41 BFO to "R/T" may give better results.

55. continued

Receive Terminal Equipment	Arrangement 1		Arrangement 2		Remarks
	Receiver	Terminal Equipment	Receiver	Terminal Equipment	
B41/FAZ with TTVF(B) (50Hz or 85Hz shift)	As above	TT/FSK to "FSK" Z/FSK to "X" TONE SENSE to "REVERSE" WIDE/ NARROW to "WIDE"	As above	TT/FSK to "FSK" Z/FSK to "X" TONE SENSE to "NORMAL" WIDE/ NARROW to "WIDE"	As above
CJD with CV89A (50Hz or 85Hz shift)	SYNTHESIZER set to Assigned Frequency BFO to "SSB 1" PRE NL to "120Hz" POST NL to "120Hz"	NORMAL/ REVERSE to "REVERSE" WIDE/ NARROW to "NARROW"	SYNTHESIZER set to Assigned Frequency BFO to "SSB 1" PRE NL to "120Hz" POST NL to "120Hz"	NORMAL/ REVERSE to "NORMAL" WIDE/ NARROW to "NARROW"	
CJD with TTVF(B) (50Hz or 85Hz shift)	As above	TT/FSK to "FSK" Z/FSK to "X" TONE/SENSE to "REVERSE" WIDE/ NARROW to "NARROW"	As above	TT/FSK to "FSK" Z/FSK to "X" TONE/SENSE to "NORMAL" WIDE/ NARROW to "NARROW"	

56. Equipment Required for A2 RATT Working

Transmission

Transmitter Required	VF Tone Equipment Required	Remarks
Any transmitter capable of transmitting DSB Voice unless precluded by Duty Cycle restrictions	AN/SGC-1A (200Hz shift only)	Can work only Modulating Arrangement 2
	GAA (850Hz shift only)	a. Can work only Modulating Arrangement 2 b. Can only be used in conjunction with a Type 640 (i.e. no use for UHF)
	TTVF(T) (200Hz or 850Hz shift)	a. Reversible b. 850Hz shift at UHF should only be used for Relay working by High Capacity ships

RECEPTION

RECEIVER REQUIRED	VF TONE EQUIPMENT REQUIRED	REMARKS
Any receiver, set as for reception of DSB Voice	AN/SGC–1A (200Hz shift)	
	TTVF(B) (200Hz or 850Hz shift)	Not normally considered, as they are receive equipment fitted in Broadcast Racks only
	TTVF(T) (200Hz or 850Hz shift)	
	CV89A (200Hz or 850Hz shift)	Not normally considered, as they are receive equipment fitted in Broadcast Racks only

57. **Details of Ship Fitted RATT Terminal Equipment**

a. CARRIER SHIFT KEYERS

(1) 5ABA

(a) 1.5–24 MHz

(b) No special crystals required

(c) Frequency shifts: continuous 0 – 1000 Hz

(d) Arrangement reversal by setting "SYSTEM" switch to the correct colour marking as follows:
Arrangement 1 to "FSK—"
Arrangement 2 to "FSK+"

(e) Loop current drive

(f) Fitted in 601 Series

(g) 50 or 75 bauds (max 100 bauds)

(2) GK 185A

(a) 1.7–9 MHz

(b) Crystals required derived from formula in RNCP 13

(c) Frequency shifts: continuous 0 – 1000 Hz

(d) Arrangement reversal by Keying Polarity switch to + or —

(e) Loop current drive

(f) Fitted with Type 89Q and some 601 series HF transmitters

(g) 50 or 75 bauds (max 200 bauds)

b. KEYER ADAPTORS

(1) GK 198

(a) This converts two-tone to loop current to key the 5ABA

(b) It makes the 5ABA compatible with Outfit RWA

(2) GK 199

(a) This converts two-tone to loop current to key the GK 185A

(b) It makes the GK 185A compatible with outfit RWA

c. VOICE-FREQUENCY TONE GENERATORS/CONVERTORS

(1) AN/SGC–1A

(a) UHF or HF for A2 RATT, HF for FST

(b) 200 Hz shift only

(c) Input/Output: Z=700 Hz, A=500 Hz. This is NOT reversible
(d) Part of RATT 2/2A Outfit. Loop current drive of fixed polarity Z=on, A=off
(e) Not compatible on-line
(f) 50 or 75 bauds

(2) TTVF(Tactical)
(a) MF or HF for FST, UHF or HF for A2 RATT
(b) 200 Hz or 850 Hz shift
(c) Input/Output "arrangement" reversible by internal movement of oscillators and filters
(d) Line polarity fixed at Z=OHz, A=1000 Hz
(e) Fitted in Outfit RWA Tactical bays
(f) Compatible on-line
(g) 50 or 75 bauds

d. VOICE–FREQUENCY TONE GENERATORS

(1) Outfit GAA
(a) Fitted with Type 640 transmitters in ships without Outfit RWA and only capable of working with their associated 640. Therefore ships with GAAs and no TTVFs(T) cannot radiate A2 RATT 850 Hz shift on UHF.
(b) Output "arrangement" Z=2975 Hz, A=2125 Hz. This is NOT reversible.
(c) Part of RATT 2/2A Outfit. Loop current drive of fixed polarity Z=on, A=off.
(d) Not compatible on-line
(e) 50 or 75 bauds

e. VOICE–FREQUENCY TONE CONVERTERS

(1) Outfit CV89A
(a) Frequency shifts:
OHz–200 Hz centred on 1000 Hz
200 Hz–1000 Hz centred on 2550 Hz
(b) Input "arrangement" reversal by NORMAL/REVERSE switch
(c) Loop current or tone on-off output to line of fixed polarity
Z=current on or 935 Hz tone. (Other tones are available).
A=current off or OHz
(d) Fitted with RATT 2/2A and RWA (until replaced by TTVF(B))
(e) Compatible on-line
(f) 50 or 75 bauds

(2) TTVF (Broadcast)
(a) Consist of two terminals type TT20 (i.e. the equivalent of two CVs 89A)
(b) 18 possible frequency tone inputs to either "A" or "Z" channels of each TT20 as follows:

1. 425 Hz	9. 1785 Hz	X 500 Hz "A" CHANNEL
2. 595 Hz	10. 1955 Hz	X 1000 Hz "Z" CHANNEL
3. 765 Hz	11. 2125 Hz	Y 700 Hz
4. 935 Hz	12. 2295 Hz	
5. 1105 Hz	13. 2465 Hz	
6. 1275 Hz	14. 2635 Hz	
7. 1445 Hz	15. 2805 Hz	
8. 1615 Hz	16. 2975 Hz	

(c) Frequency shifts from any pair of the above tones of which those now used are:
850 Hz from Channels 11 and 6 centred on 1700 Hz
200 Hz from Channels X and Y centred on 600 Hz
Also any shift between 50 Hz and 85 Hz centred on 1000 Hz or any channel frequency.

(d) Input "arrangement" reversal by swopping "A" and "Z" Channels

(e) Output line polarity reversible by NORMAL/REVERSE switch

(f) Fitted in Outfit RWA broadcast bays

(g) Compatible on-line

(h) 50 or 75 bauds

58. **Teleprinters and Associated Automatic Transmitters**

a. TELEPRINTERS (TG SERIES)

(1) The RN uses the Model 12 teleprinter (Creed 75), which is convertible, with a modification kit, between Single and Double current working.

(2) Each teleprinter is known by an Outfit designation which consists of 3 letters followed by a figure in brackets. The first two letters of the three are TG; the third letter signifies as follows:

A	115V	No reperforator attachment
B	115V	With reperforator
C	230V	No reperforator attachment
D	230V	With reperforator
E		Details not yet known except that the machine is fitted with a silent cover and may have automatic page winding facilities.

(3) The figure in brackets following the three letters gives a further indication of the type of basic machine as follows:

(1) The original Transmit/Receive machine which is now obsolete

(2) Transmit/Receive

(3) Transmit/Receive with "Who are U and Answer Back" facilities

(4) Receive only (No keyboard)

(4)

(a) Each model of the machine, which is identifiable by the letters/figure in sub-paragraphs (2) and (3) above, is further described by a Mark Number. This Mark Number, amongst other things, indicates the baud speed capability of the equipment.

Mark 1 – Not now used.

Mark 2 – 45.5 or 50 baud. No longer used but may still be found fitted in isolated cases.

Mark 3 – 50 baud: 75 baud after modification No. 1 which is promulgated in BR 1917 and BR 1917S (see (b) below).

Mark 4 – 50 or 75 baud.

(b) The main difference between Mark 3 and Mark 4 machines is an important modification to incorporate a much more reliable clutch selector mechanism. This modification was incorporated in Mark 4 machine during manufacture. A special modification has been issued, for ships staff action, to incorporate the new clutch selector mechanism in Mark 3 machines.

(5) In view of the complications involved in the nomenclature of Model 12 Teleprinters it is prudent to always quote the Naval Store Number when referring to a particular equipment.

(6) A list of the various outfits and their details is shown below.

(7) The Model 28 American Teleprinter, which was the first type of teleprinter to be fitted in ships, for use on RATT circuits, may still be found in some ships. It is capable of 50 or 75 baud working.

(8) Shipborne Teleprinters

OUTFIT	NSN OF TELEPRINTER	MARK	VOLTAGE	ADDITIONAL FEATURES	REMARKS
TGA(1)	5815–99–920–5003	Mk.2	115V		Obsolete
TGA(2)	5815–99–580–5118 5815–99–972–4926	Mk.3 Mk.4	115V 115V		
TGA(3)	5815–99–920–6002 5815–99–972–4934	Mk.3 Mk.4	115V 115V	+WRU & AB	TGA(2)+ WRU & AB
TGA(4)	5815–99–971–4359 5815–99–972–4930	Mk.3 Mk.4	115V 115V	Automatic Carriage Return/line feed	Receive only 50/75 bauds
TGB(1)	5815–99–920–5019	Mk.2	115V	+Reperf.	TGA(1)+Reperf (Obsolete)
TGB(2)	5815–99–580–5119 5815–99–972–4927	Mk.3 Mk.4	115V 115V	+Reperf.	TGA(2)+ Reperf.
TGB(3)	5815–99–920–6003 5815–99–920–4935	Mk.3 Mk.4	115V	+WRU & AB+ Reperf.	TGB(1)+ Reperf.
TGB(4)	5815–99–971–7361 5815–99–972–4931	Mk.3 Mk.4	115V 115V	Auto. carriage return/line feed +Reperf.	Receive only 50/75 bauds
TGC(1)	5815–99–920–5001	Mk.2	230V		Obsolete
TGC(2)	5815–99–580–5116 5815–99–972–4924	Mk.3 Mk.4	230V 230V		
TGC(3)	5815–99–920–6000 5815–99–972–4932	Mk.3 Mk.4	230V 230V	+WRU & AB	TGC(2)+ WRU & AB
TGC(4)	5815–99–971–7358 5815–99–972–4928	Mk.3 Mk.4	230V 230V	Auto. carriage return/line feed	Receive only 50/75 bauds
TGD(1)	5815–99–920–5002	Mk.2	230V	+Reperf.	TGC(1)+Reperf. (Obsolete)
TGD(2)	5815–99–580–5117 5815–99–972–4925	Mk.3 Mk.4	230V 230V	+Reperf.	TGC(2)+ Reperf.
TGD(3)	5815–99–920–6001 5815–99–920–4933	Mk.3 Mk.4	230V 230V	+Reperf.+WRU & AB	TGD(1)+ WRU & AB
TGD(4)	5815–99–971–7360 5815–99–972–4929	Mk.3 Mk.4	230V 230V	Auto. carriage return/line feed +Reperf.	Receive only 50/75 bauds
TGE(1)	5815–99–972–4924			Tx/Rx Silent cover, No page winder	
TGE(2)	5815–99–972–4924			Tx/Rx Silent cover, No page winder	
TGE(3)	5815–99–972–4928			Rx only Silent cover, page winder	
TGE(4)	5815–99–972–4928			Rx only Silent cover, No page winder	
TGE(5)	5815–99–972–4925			Rx only with reperf patt Number 5815–99–972–4929, page winder and silent cover	

b. AUTOMATIC TRANSMITTERS AND AUTOMATIC NUMBERING EQUIPMENT

(1) Automatic Transmitters (6S Series)

NSN OR A.P. No.	SUPPLY	BAUDS	MODEL	REPLACEMENT (see Note ii)
0555–27845	230V 50Hz	50	6S6	
5815–99–6218	115V 50Hz	45.52	6S6	
5815–99–920–6219	230V 50Hz	50	6S6	0555–A.P.972–4920
5815–99–920–6222	230V 50Hz 160V d.c.	45.52	6S6	
5815–99–920–6223	230V 50Hz 160V d.c.	50	6S6	0555–A.P.972–4921
5815–99–920–6624	230V 50Hz 160V d.c.	50	6S6	0555–A.P.972–4922
5815–99–920–7644	115V 50Hz	50	6S6M	0555–A.P.972–4923

Notes:

(i) Some models, originally issued as 45.52 baud models, have been modified by Conversion Kit 5815–A.P.105667 to operate at 50 bauds. When converted:

0555–27844 becomes 0555–27845
5815–99–920–6218 becomes 5815–99–580–7644
5815–99–920–6222 becomes 5815–99–920–6219

The following models are obsolete: A.P. 27598 6S2
A.P. 27599 6S4 100 to 110V
A.P. 27919 6S4 160V
A.P. 27920 6S4 220V

(ii) The replacement models 6S6 and 6S6M are dual speed machines, 50 or 75 bauds being selected by a switch.

(iii) A modification Kit has been issued for existing 50 baud machines, to give these equipments a 50 or 75 baud capability.

(2) Automatic Numbering Equipment (TAA6 Series). The TAA6A will work into fully automatic telegraph switching systems, access being gained by transmitting ZCZC, and release at the end of a message by sending NNNN, preceded by adequate feed-out. These functions, together with station identity and channel serial number, are inserted automatically. In the absence of traffic, and equipment may be adjusted to transmit identification signals every two minutes. A telegraphic test coder provides for the continuous transmission of a standard test message. Baud speeds of 45.5, 50, 75 or 100 bauds can be selected by the Range Switch.

10.2. RATT 2

1. **Introduction.** This part of Section 10 describes the Interim RATT Installation known as RATT 2. This was the general RATT fit for all ships until recently.

RATT 2 was put together to provide the following facilities:

a. Reception of an F.S.T. Broadcast.

b. Transmission and reception of a Simplex F.S.T. circuit, concurrent with *a* above.

c. Transmission and reception of a Two Tone Simplex circuit concurrent with *a.*

d. The facility to carry out a limited degree of Relaying.

The installation consists of attended receiver, converters, teleprinters, two-tone terminal unit, power supplies and a distribution panel in the form of a jack field. By plugging a teleprinter or auto-transmitter into the jack field in a particular manner, the Bay provides the facilities above.

2. **Film Strips.** Film strip S.A. 1114 *Introduction to RATT* covers the principles of Automatic Telegraphy and provides a good background to the study of the equipment. It is distributed to Frigate leaders and above, the exact distribution being given in D.C.I.s. It can also be obtained from Film libraries. Lecture notes accompany the film strip. They show a small picture of each frame and give an explanation.

3. **Types of RATT BAY**

a. Two-tone Bay. This consists solely of a teleprinter, terminal set, auto-transmitter and associated control units and is essentially the same as the two-tone bay in the RATT (1) installation.

b. Broadcast RATT Bay. This is mainly used as a reception bay, but it can be used as an F.S.T. simplex circuit if required. Although the Teleprinter Distribution Panel is fitted, the two-tone circuit is not wired and therefore the facilities to the user are limited.

c. Combined RATT Bay. This is a Broadcast Bay with a two-tone bay Terminal Unit wired into the T.D.P. and differing from the Standard Bay (see *d* below) in that only one teleprinter unit with KH control unit is available in a smaller bay size. This bay is only fitted where space is very limited as the facilities available to the user are on a reduced scale.

d. Standard RATT Bay. This is the basic unit of RATT installation and is fitted in frigates and above. This consists of a Broadcast Bay and a Two-tone Bay sited adjacent to one another and wired together in the T.D.P., giving the maximum number of facilities to the user. The Standard Bay, a two-tone simplex circuit and broadcast, or one of many combinations of facilities which are tabulated in the combined facilities section.

FREQUENCY SHIFT TELEGRAPHY – RECEPTION

4. Receivers in the Broadcast Bay. Three receivers are provided, as for a normal C.W. Broadcast Bay. A standard B41 is used but the B40s are Type D, which have been specially modified for the reception of F.S.K. signals and for working into their associated converters (see Receiver Section). The a.f. output of each receiver is fed into the 3-way primary receiver output change-over switch with positions as follows:

a. Normal. Output fed to a receiver output change-over switch (secondary), from which it can be fed to one of two Design 5 control units for Morse reception.

b. Off. The a.f. output of the receiver is broken.

c. RATT. Output fed to the F.S.T. convertor which converts the audio frequency output of the receiver into d.c. pulses to key the d.c. loop supply, which in turn operates the teletypewriter.

5. **Diversity Reception.** In RATT diversity reception, the output of two receivers is fed, one into Convertor A and one into Convertor B. The outputs of the convertors are automatically compared in the Comparator Unit and the output (which at any instant is providing the greater amplitude of singal) is selected to key the d.c. loop supply. This is no longer used.

6. **Loop Current Supply.** The d.c. loop supply circuits for the convertors and the comparator are fed through the Teletypewriter Distribution Panel. Two jack plug fittings are provided in each circuit, on the front of the T.D.P., so that either TTY or both can be worked from Convertor A, Convertor B, or the Comparator. Screwdriver controls are provided in each circuit, on the T.D.P., to enable the loop current to be adjusted to 60 mA.

7. **Power Supplies.**

Receivers. Fed from normal 230 V supplies.

Convertors, Comparator, Teletypewriters. American equipment, including American loop supply rectifiers, is fed with 115 V a.c., the normal 230 V a.c. supply being fed into a transformer through an a.c. supply switch. The convertors and comparator each contain their own rectifiers for providing the d.c. potentials required for each unit. British equipment is fed direct with 230 V a.c.

THE F.S.T. CONVERTOR

8. **Units.** The F.S.T. Convertor Cabinet contains the following plug-in units:

Power Supply Unit.	Discriminator Unit.	Oscillator/Keyer Unit.
Blower Unit.	Monitor Unit.	

9. **Input Filters.** The a.f. output from the receiver is fed into the convertor via the wide/narrow switch. This switch selects the input filters and the discriminator filters. The two input filters are:

NARROW. Bandpass between 775 and 1400 c/s. Used for the B41 and for the B40 when the system switch is to 'F.S.T. Narrow' (i.e. when the mean a.f. output is 1000 c/s).

WIDE. Bandpass between 1450 and 3650 c/s. Used for the B40 when the system swith is to 'F.S.T.' Wide (i.e. when the mean a.f. output is 2550 c/s).

10. **Discriminator Filters.** From the input filter the signals are fed to a Limiter Amplifier stage used to maintain a uniform input voltage to the discriminator. The discriminator filters, selected by the WIDE/NARROW switch, consist of two separate filter units as follows:

NARROW. For frequency shifts up to 200 c/s. The narrow filter unit consists of two filters, one with an approximate bandwidth of 900 to 1000 c/s and the other with an approximate bandwidth of 1000 to 1100 c/s.

WIDE. For frequency shifts of 200 to 1000 c/s. The wide filter unit consists of two filters, one with an approximate bandwidth of 2050 to 2450 c/s and the other with an approximate bandwidth of 2650 to 3050 c/s.

These discriminator filters are used to separate the Mark and Space signals and to direct each along a separate path via the Buffer Amplifier and Rectifier stages to the NORMAL/REVERSE switch.

11. **Normal/Reverse Switch.** Determines which of the two frequencies (mark or space) is to be used to key the teletype loop. The switch is used in conjunction with the F.S.K. High and Low positions of the system switch on the B40s. The system switch, which determines the frequency of the b.f.o., reverses the audio frequency output for the mark and space signals.

12. **Slow and Fast Speed Filters.** These filters are selected by means of the Slow/Fast switch. They work on the keying speed of the circuit and are designed to cover speeds up to 60 wpm for the slow filter and above

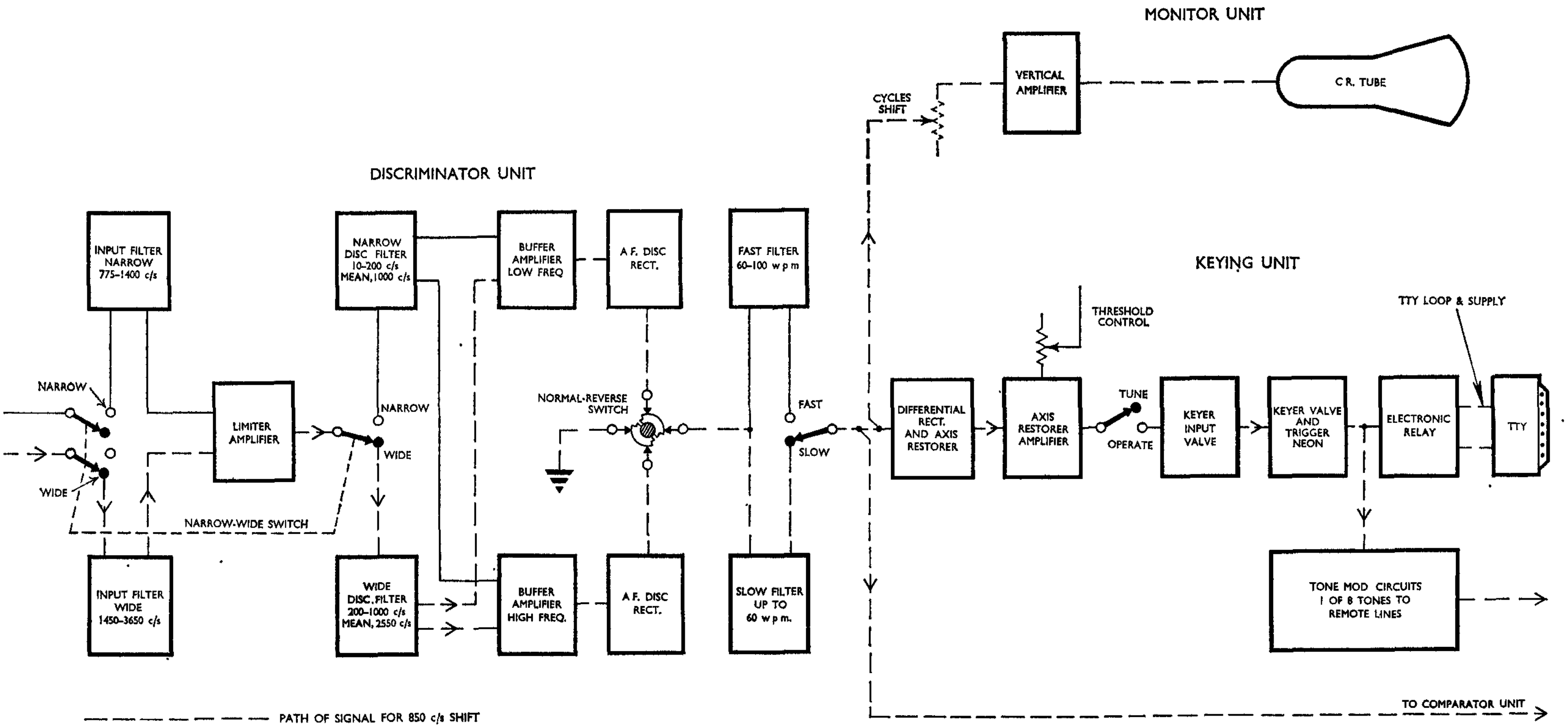


FIG. 1. CONVERTER UNIT

60 wpm for the fast filter. Their output goes to the Comparator, used with diversity reception, to the Axis Restorer Rectifier and Amplifier and to the Monitor Unit.

13. **Axis Restorer.** The axis restorer, rectifier and amplifier keeps the bias applied to the keyer valve at the optimum level, regardless of the waveform of the keying signal applied to it. The amplifier has a threshold control which varies the d.c. potential on the anode and is adjusted so that the noise produced by the receiver is not sufficient to operate the keyer valve. A signal is therefore required to operate the keyer valve and electronic relay.

14. **Tuning and Monitoring.** The output from the Axis Restorer can be broken by putting the Tune/Operate switch to the TUNE position, so that the teletypewriter is not operating whilst the receiver is being tuned. The output from the slow and fast speed filters is also taken to the Monitor Unit and fed through the Cycles Shift Control and Vertical Amplifier to the vertical plates of a Cathode Ray Tube, which is used as a visual tuning indicator when tuning in an F.S.K. signal. The pictures obtained on the C.R.T. are shown below.

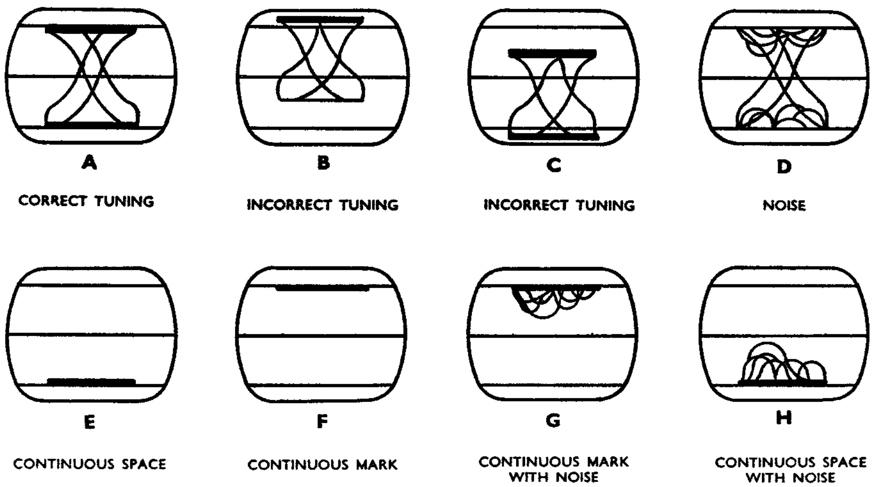


FIG. 2

15. **Keyer Unit.** This unit contains the keyer valve and the electronic relay which makes and breaks the teletype loop circuit. It also contains a Tone Oscillator which can be used to send the received signal to a remotely fitted teletypewriter. Two controls are provided, one to select the frequency of the tone and a second to control the volume, and a monitor jack is provided to monitor the tone output. The tone oscillator is not used in H.M. ships, except in RATT 2(a) installations.

16. Other Controls.

A.C. ON/OFF SWITCH. Completes 115 V a.c. supply to Power Pack. An indicator lamp glows to indicate power is on.

INTENSITY
FOCUS
HORIZONTAL POSITION
VERTICAL POSITION
} Control the trace on the cathode ray tube in the Monitor Unit.

17. **Operating Instructions**

a. Make all power switches and centralize RATT/Normal receiver output switches. Receivers should be switched on at least four hours before setting watch. (This period is required to allow the steady frequency

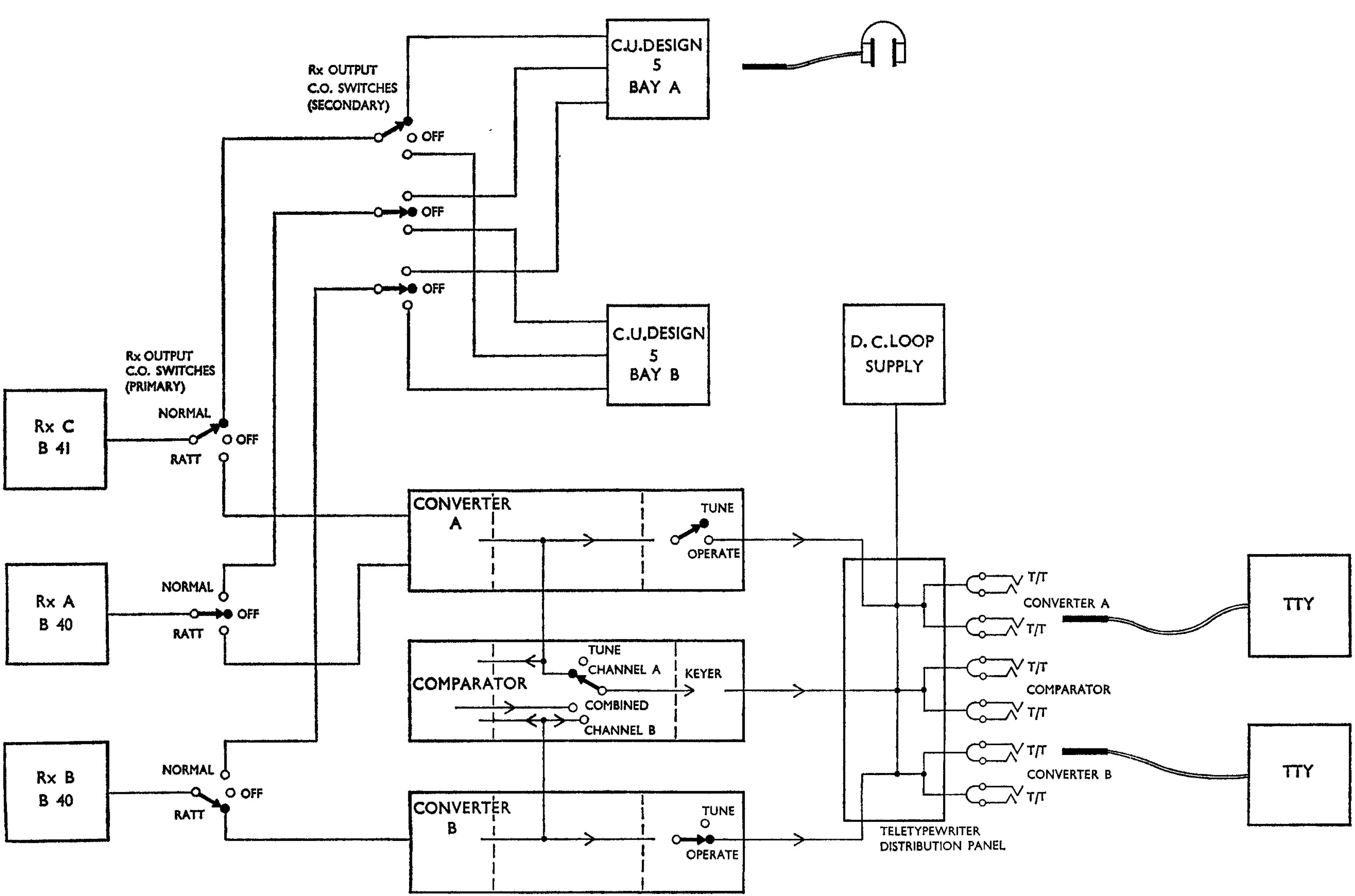


FIG. 3. F.S.K. RECEPTION

drift of the B40 D to stabilize. For shorter switch-on periods than four hours, small adjustments of the tuning of the receiver will frequently be required, especially at the higher frequencies. After about four hours the frequency drift should become negligible and little tuning of the receiver should be necessary.)

b. Set up the receivers.

(1) Set Osc. Trimmers on B40s to zero.

(2) Calibrate receivers by normal method near required frequency.

(3) Put System switches to F.S.T. Wide High (B40s) or C.W. High (B41).

(4) Put bandwidth switches to 3 kc/s (B40s) or 1 kc/s (B41).

(5) Switch on A.G.C.

(6) Set a.f. Gain Control fully clockwise.

(7) Tune receivers to a point of 'no signal' near required frequency.

C. Set up the Converters.

(1) Adjust oscilloscope controls for a well-defined trace, centred horizontally and vertically.

(2) Put Narrow/Wide switches to WIDE for B40 reception or NARROW for B41 reception.

(3) Put Normal/Reverse switches to appropriate position for receiving Arrangement 1 or Arrangement 2.

(4) Put Fast/Slow switches to Slow.

(5) Set Cycles Shift control to 850 c/s for B40 reception or 85 c/s for B41 reception.

(6) Set the Threshold Controls fully clockwise and set the Tune/Operate switch to Operate.

(7) Put RATT/Normal switches to RATT.

(8) Plug the required Teleprinter into the appropriate loop circuit on the front of the T.D.P. to provide loop current to the converter being used.

(9) Switch on the teleprinter.

(10) Turn the Threshold control on the converter anticlockwise until the teleprinter just stops chattering. The final setting of this control must not be less than 30.

(11) Put Operate/Tune switch on converter to TUNE.

(12) Tune receiver to required frequency until the distinctive F.S.T. signal is heard.

(13) Fine tune receiver until the trace on converter oscilloscope shows two lines equidistant from the centre, joined by a criss-cross pattern.

(14) During 13 it may be necessary to adjust the CYCLES SHIFT control so that the lines are positioned on the upper and lower window markings on the oscilloscope.

(15) Check tuning of the receiver by moving the bandwidth switch to its narrowest position. If oscilloscope picture alters, retune the receiver.

Note. With the System switch of B40 in the position F.S.T. Wide High, there will be two possible tuning points corresponding to i.f.s of 500 and 505·1 kc/s; similarly in the position F.S.T. Wide Low there will be two possible tuning points corresponding to i.f.s of 500 and 494·9 kc/s. With strong signals the monitor osilloscope display will be correct, and the teleprinter may print correctly, with the incorrect tuning positions corresponding to i.f.s of 505·1 and 494·9 kc/s. By making the i.f. amplifier more selective, the signal in the incorrect tuning position is attenuated and the oscilloscope display deteriorates. In B41 the effect is theoretically the same, in this case the incorrect tuning points corresponding to i.f.s of 802 and 798 kc/s.

(16) Put Tune/Operate switch on the converter to Operate. Check that the teleprinter is printing correctly.

18. **Adjacent Channel Interference.** With an F.S.T. signal where the mark frequency is the higher, as in naval broadcasts, the correctly tuned signal will print correctly if the following conditions are observed.

With the SYSTEM switch on the receiver to the HIGH position, the NORMAL/REVERSE switch on the converter must be to NORMAL. With the SYSTEM switch on the receiver to the LOW position, the normal/reverse switch on the converter must be to REVERSE.

The usual combination of switches is the HIGH-NORMAL arrangement, but it should be borne in mind that, should adjacent channel interference necessitate the LOW position of the system switch, then the REVERSE position on the converter must be used. Adjustment of receiver tuning may be necessary when the LOW/REVERSE combination is used.

FREQUENCY SHIFT TELEGRAPHY – TRANSMISSION

19. F.S.T. transmission requires a conventional transmitter, like an 89Q or 601 series, to be modified either to accept an input of two radio frequencies 850 cycles apart, from an F.S.T. drive unit like the GK 185, or to convert the loop current or tones from a teleprinter into a shifting radio frequency. This is achieved as follows:

a. The 89Q is driven by a drive unit, GK185, the output of which is fed to the crystal oscillator drawer in the transmitter. This unit is to be modified to accept tones as well as loop current.

b. The 5AB is driven in a similar way to the 89Q by a GK185, but in this case the r.f. is fed into the grid of the 1st Amplifier.

c. A 5AB/A is a redesigned transmitter where provision has been made in the frequency determination circuits for F.S.T. The loop current activates the shift circuits. This transmitter will be modified for accepting tones by the addition of a small conversion unit.

20. With the advent of tone keying in outfit RWA, modifications are necessary so that conventional transmitters can be used for either loop current or tone activation.

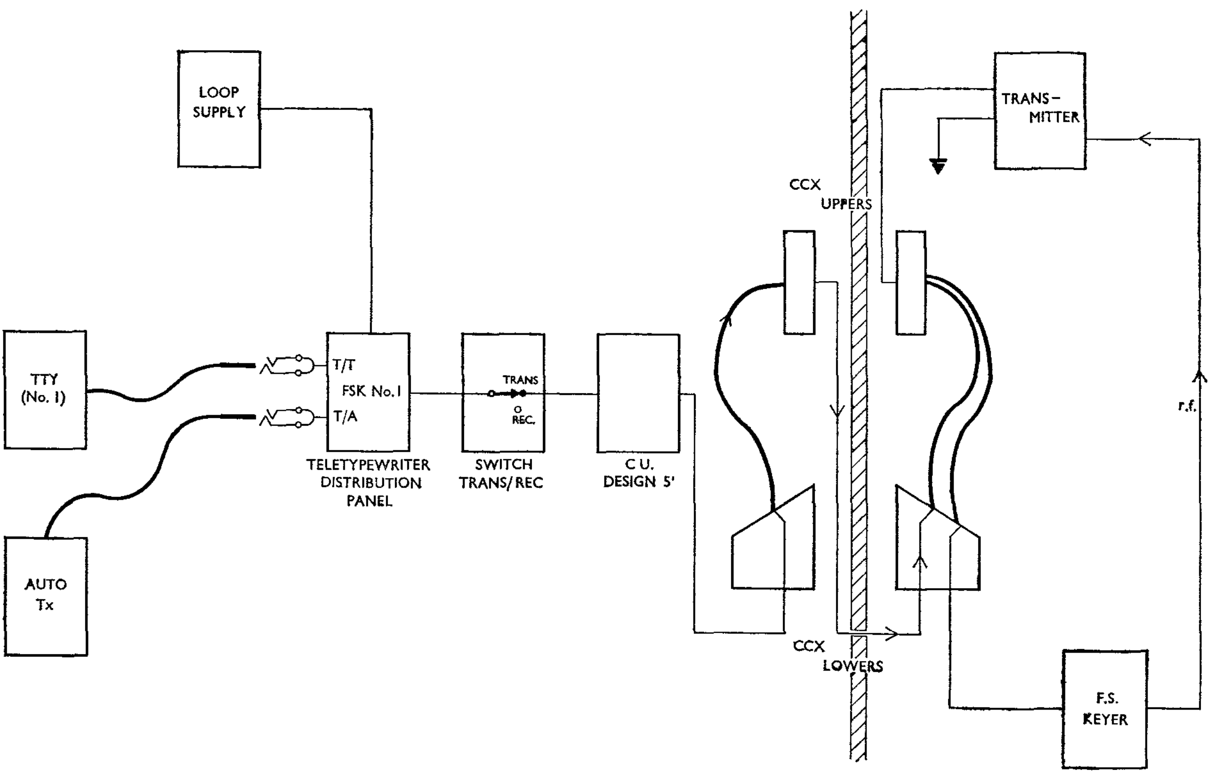


FIG. 4. TRANSMISSION

21. The problem in F.S.T. transmission is simply one of getting the loop current pulses or tones from the teleprinter to the transmitter or drive unit. This is done through the control outfit and Teleprinter Distribution Panel. The matter is only complicated by the fact that simplex working is a requirement and therefore there must be a SEND/RECEIVE switch in the loop current to decide whether the drive unit is keyed or the converter operates the teleprinter. The solution is to have a clear understanding of the control outfit and path of the loop current.

The diagram shows an example of F.S.T. transmission. Loop current is passed through the control system on the spare line PS.

22. In the transmit position of the T–R Switch Box, the switching line of the transmitter in use is earthed via the lines of the Design 5 control unit at the local bay, which must be plugged through to the transmitter, and the carrier thus brought on.

23. Each keyer is wired to a C.C.X. lower plug, marked F.S.T. Keyer No. 1, etc. To pick up the necessary control lines of the particular transmitter in use, the keyer C.C.X. lower plug is plugged into the particular transmitter's C.C.X. upper socket.

F.S.K. DRIVE UNIT REDIFON TYPE 185A

DATE OF DESIGN. 1958

HANDBOOK. B.R. 1166

ESTABLISHMENT LIST. E 1120

GENERAL

24. F.S.K. Drive GK185A can be used for converting to frequency shift operation any radio transmitter having a Variable Frequency oscillator operating within the frequency range 1·7 to 9 Mc/s.

In the Royal Navy Type 89Q and transmitter 5AB can be modified for operation with this unit.

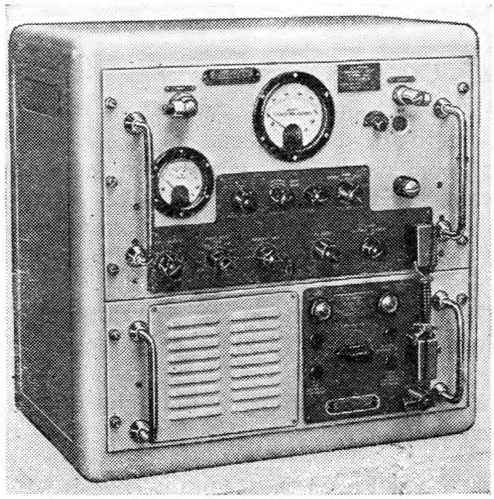


FIG. 5

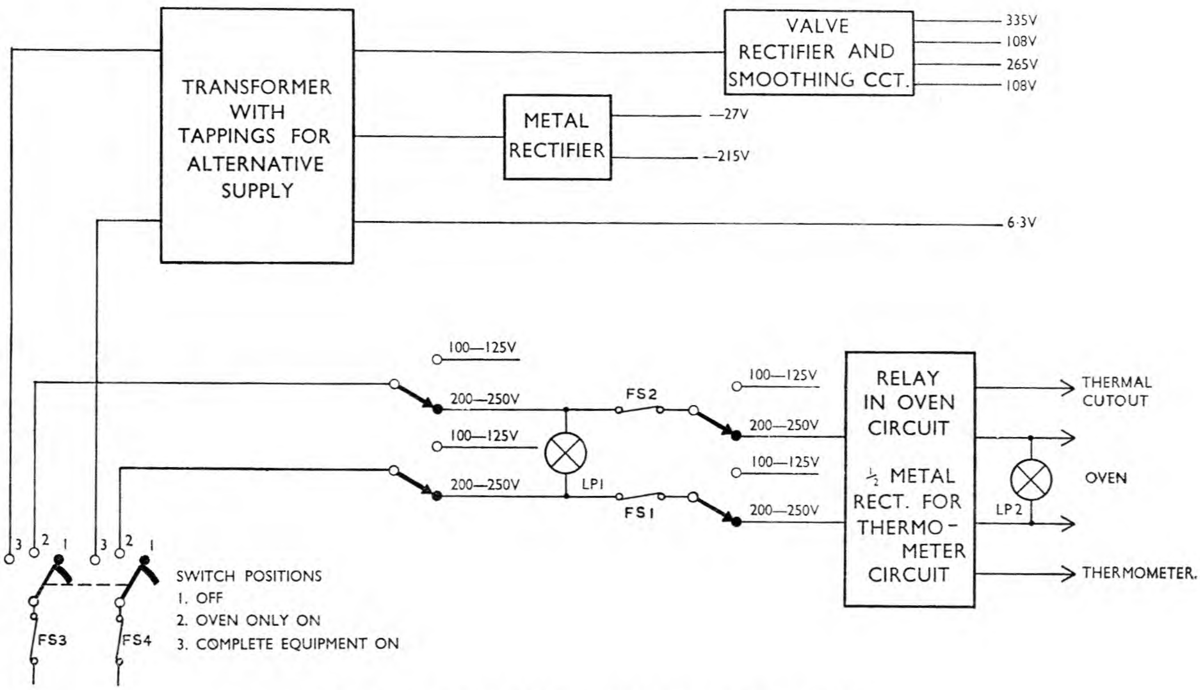


FIG. 6. UNIT GK185A – POWER UNIT PU96C

POWER SUPPLIES

Power Unit PU 96C

25. Can be supplied with 100 to 125 V a.c. or 200 to 250 V a.c. (With tappings in steps of 5 volts.) It provides the necessary H.T., auxiliary H.T.'s, Bias and Heater voltages, for the operation of the unit.

The thermostatically controlled oven circuits are energized directly from the mains supply.

LP1 indicates that the mains supply is completed to the oven control circuitry and LP2 lights when the oven heating elements are energized so that its periodic operation provides indication that the oven is 'cycling' satisfactorily.

R.F. Unit

26. The keying input is applied via the switching circuit to a trigger circuit which operates a shift keyer stage to alter the frequency of a basic 4·5 Mc/s oscillator by up to 1000 c/s as required. The output from the shift oscillator is mixed with the output from a 5 Mc/s vernier oscillator to produce a difference frequency of 500 to 501 kc/s. This signal is mixed with the output from a channel crystal oscillator. The carrier component of the resultant signal is removed and the upper sideband is selected and amplified. A frequency shift meter calibrated in cycles per second gives an exact indication of the amount of shift.

27. **Frequency shift.** In one direction only, representing a 'mark' signal (not equally about a centre frequency) from 0 to 1,000 c/s, continuously variable.

28. **Frequency Stability.** Within plus or minus 0·003 per cent of the nominal frequency after three hours' warm-up period.

29. **Keying Speed.** 200 bauds maximum.

30. **Crystal Frequencies**

Shift Oscillator 4·5 Mc/s.

Vernier Oscillator 5 Mc/s.

Channel Crystal Oscillator Output Frequency (i.e. keying unit output frequency or transmitter fundamental frequency) minus 500 kc/s. Attention is drawn to RN *Signal Orders*, page 124 (formulae for working out crystals with 89Q and 603).

Frequency Shift Meter Oscillator 497 kc/s.

31. **Switching Circuit.** During the positive 'mark' element of the input keying signal MR 5 passes current and the bobbin of the relay RL is energized causing its contacts to close and complete the HT to the screen grids of the mixer and balanced modulator valves. An allspace of approximately 200 milliseconds is required before the relay will de-energize and therefore the contacts remain closed during normal keying signals. With the test switch in either the mark or the space position, the screen grid supply to the mixer and the balanced modulator valves by-passes the relay and consequently the r.f. circuits will be in operation irrespective of any external keying input.

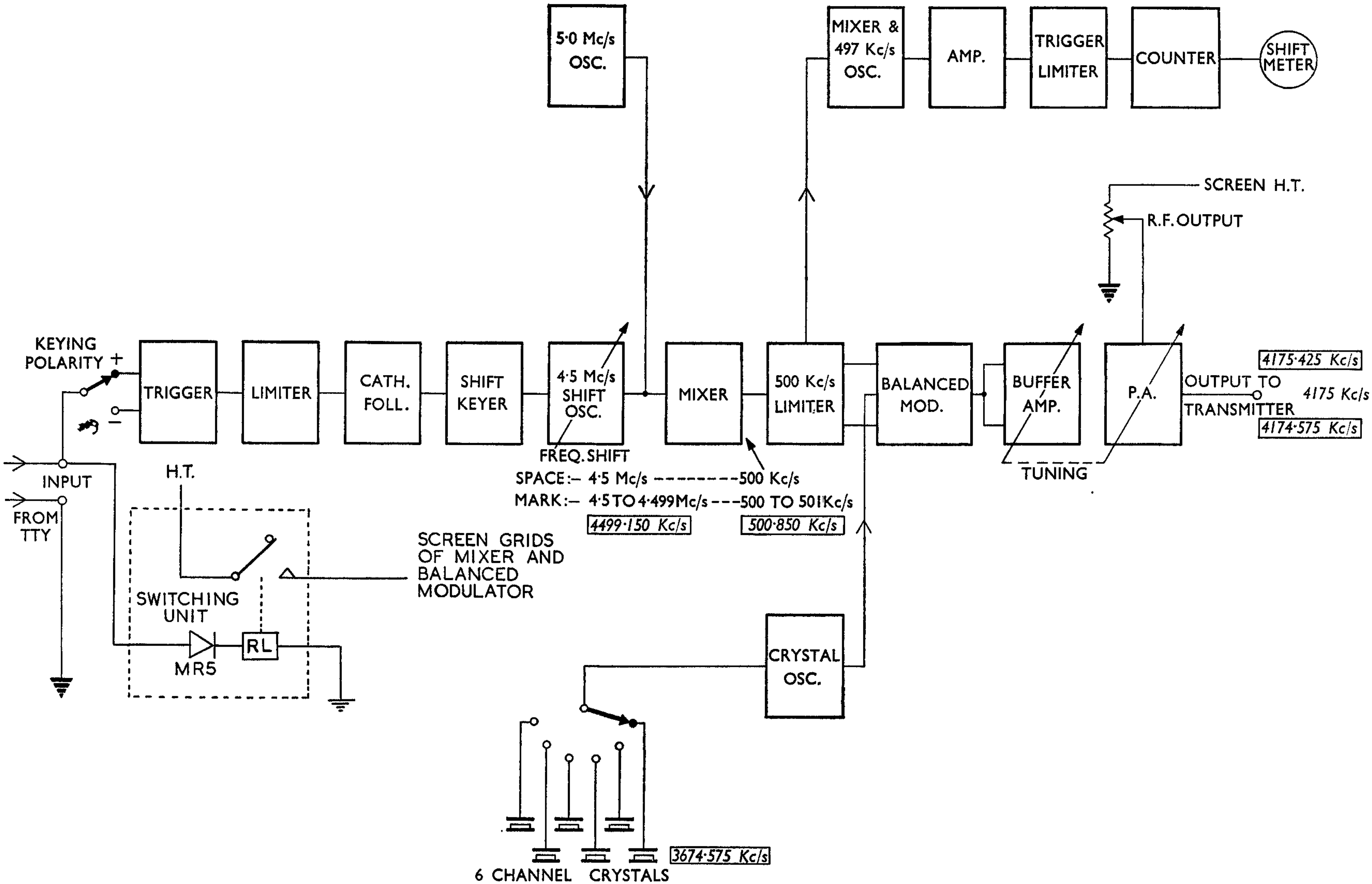
OPERATING INSTRUCTIONS

32. **General**

a. Switch on the mains supply to the equipment, set the Mains switch on the power unit to the OVEN ONLY ON position, when the mains lamp LP1 should light, and check that the oven heaters are energized as indicated by the oven lamp LP2. After a period of approximately 30 minutes the lamp should go on and off periodically to indicate that the oven is 'cycling.'

b. Switch the equipment on by turning the Mains switch on the power unit to the COMPLETE EQUIPMENT ON position and allow a warm up period of approximately two hours before carrying out any adjustments.

Note. It is advisable to leave the mains supply connected and the Mains switch on the power unit in the OVEN ONLY ON position when the equipment is not in use for periods up to two hours so that the oven will be maintained at the operating temperature.



FIGURES SHOWN THUS, $\boxed{4175{\cdot}425\ Kc/s}$ REPRESENT FREQUENCIES REQUIRED TO PRODUCE 4175 Kc/s WITH 850 ~ SHIFT

FIG. 7. FSK DRIVE UNIT GK185A

33. Tuning

Note. Up to six crystals appropriate to frequently used frequencies of operation may be initially fitted and it must first be ascertained that the crystal necessary for the required operating frequency is included.

a. Select the crystal appropriate to the intended frequency of transmission by means of the Crystal Selector.

b. Set the Range Switch to the appropriate frequency band.

c. Set the Test Switch to the Space position.

d. Set the Service Meter Switch to the V12 position.

e. Adjust the tuning control approximately to the intended frequency of transmission as indicated on the tuning scale.

f. Carefully re-adjust the tuning control for a peak reading on the service meter.

34. Setting of Frequency Shift

a. Turn the Meter Sensitivity control fully clockwise.

b. Adjust the Meter Zero control for a zero reading on the Shift Meter.

c. Set the Test Switch to the MARK position.

d. Adjust the Frequency Shift control to obtain the required shift as indicated on the Shift Meter.

e. Turn back the Meter Sensitivity control fully clockwise.

Note. (i) If the transmitter employs frequency multiplication, suitable allowance must be made when setting up the shift. For example, if the transmitter incorporates a frequency doubler then the Frequency Shift control must be adjusted so as to give a frequency shift, as registered on the Shift Meter, one half the final radiated shift. (ii) Accurate frequency shift adjustment or measurement can only be made when:

(*a*). A continuous 'mark' signal is injected, i.e. with the Test switch set to MARK.

(*b*). The Meter sensitivity control is set to maximum, i.e. fully clockwise.

(*c*). The Meter Zero control is correctly adjusted.

(iii) The Meter Sensitivity control should be tuned fully anticlockwise (after setting or checking the frequency shift) to avoid the possibility of damage being caused to the meter due to the inertia of the movement resulting in the needle hitting the end stops during keying.

35. Operation

a. Set the Test Switch to OPERATE.

b. Set the Service Meter switch to the VIA position.

c. Inject a continuous MARK signal from the teleprinter or other signalling apparatus into the Input plug.

d. Set the Keying Polarity selector to the position (+ or —) which gives the highest reading on the Service Meter.

e. The equipment is now ready to commence signalling.

Note. The Keyer will produce an output to the transmitter only: (i) When the test switch is to mark or space. (ii) When the test switch is to operate and a mark is injected from the TTy.

THE SINGLE CHANNEL TWO TONE KEYER – OUTFIT GAA

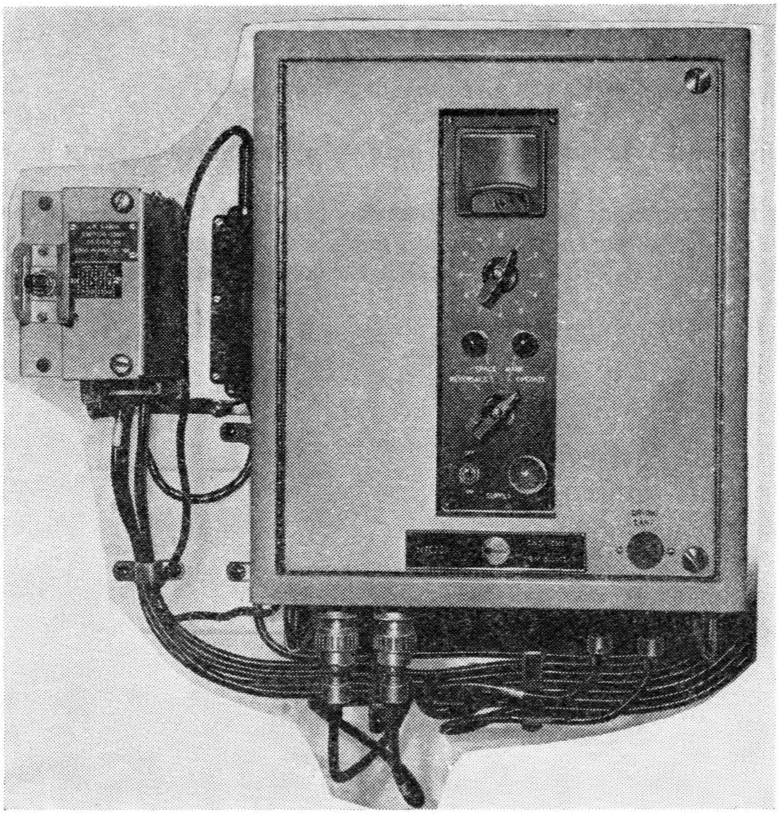


FIG. 8

36. Outfit GAA, which is associated with Transmitter Type 640, is used to convert the keyed d.c. from a teleprinter into a two-frequency audio signal for application to the audio input of the transmitter.

37. The circuit comprises of two oscillators, one tuned to the frequency of 2975 cycles and the other to 2125 cycles. The output of each oscillator is fed to a diode modulation circuit and via independent buffer amplifiers to a combining circuit and bandpass filters.

38. A stabilized power supply is incorporated and all circuits are transistorized. For test purposes the unit may be switched to a continuous Active or Idle condition.

39. **Controls**

System Switch Positions.

TEST.	For 100 baud test signal.
SPACE.	Constant 'Space' output.
MARK.	Constant 'Mark' output.
OPERATE.	Normal operating position.

Meter Switch. A 12 position switch for monitoring outputs and transistor feeds.

Supply Switch. Controls a.c. input and Supply Lamp.

Space – Mark Levels. Two screwdriver controls for adjusting output levels.

5. **Operation of GAA**

a. Switch On.

b. System Switch to Operate.

c. Meter Switch to position 1 – this will give a reading (normal) of 125.

40. The oscillator frequencies should be checked once every four months against digital counters.

41. Since the GAA tones modulate the 640, the tones are carried on the M lines on the control outfit. A switch is required to decide whether the transmitter is modulated by tones from the GAA or from a remote position. This is achieved by a RATT/NORMAL switch in the control lines from the GAA to the transmitter.

TWO-TONE MODULATION TELEGRAPHY

INTRODUCTION

42. Two-tone RATT uses a terminal set to provide two audio tones (700 c/s and 500 c/s) to represent Idle and Active conditions of the teleprinter. These tones can be fed to a transmitter or receiver and applied as amplitude modulation in exactly the same way as is voice. The performance of this system is identical to a voice circuit, i.e. UHF ranges out to 12 miles between frigates and HF ranges on a 40 watt transmitter out to 25 to 30 miles. It is not suitable for use with more powerful transmitters since F.S.T. would provide a much better solution.

43. The great advantage of this type of system is that it can be used on any equipment capable of voice operation.

44. This requirement is fulfilled in R.W.A. by the 'TTVF Tactical'.

GENERAL

45. Two-tone operation requires a terminal set, a teletypewriter, and, if necessary, an Auto-transmitter.

46. **Power Supplies.** The teletypewriter, terminal set and rectifier for providing d.c. loop supply are operated from 115 V a.c. supplies. These supplies come from the ship's 230 V a.c. supply via an a.c. supply switch and a transformer. The terminal set contains its own power pack for providing the various d.c. potentials it requires. The auto-transmitter is provided with a separate 230 V a.c. supply.

CONTROL CIRCUITS

47. Terminal Set AN/SGC – 1A is designed for transmission and reception. It contains a two-tone modulator, used to provide the tones to modulate a transmitter, and a receiver converter used to separate and rectify the tones fed from a receiver. The function of the equipment is determined by the control circuits, operated by the CONTROL switch on the front of the set, and the first impulses of the incoming or outgoing signal.

48. **Control Switch.** This allows for:

a. Transmission and Reception (Auto).

b. Transmission only (Trs).

c. Reception only (Rec. Stdby.)

When the control switch is set to Auto the equipment will be in one of three conditions, STANDBY, RECEIVE or TRANSMIT, as determined by the Control circuits.

49. **Auto.** The terminal set will be in the standby condition unless a signal is actually being received or transmitted.

Reception. The reception of a mark tone causes the control circuits to switch to RECEIVE and they are then held in this condition as long as a signal is being received, providing this signal is not a steady space tone. Whilst a signal is being received the operation of the teletype keyboard will not cause the equipment to be transferred to the transmit condition. When the received signal ceases the control circuits return to the stand-by position.

Transmission. The depression of any teletypewriter key when the equipment is in the stand-by condition causes the control circuits to shift to the TRANSMIT condition and the equipment is held in this state until approximately three seconds after the last key depression, when it automatically returns to the STAND-BY condition. This hold-on arrangement ensures that during pauses of less than three seconds in transmission an incoming signal cannot operate the teletypewriter.

50. **Rec. Stdby.** The terminal set is always either in the stand-by or receive condition and it is not possible to transmit. A received signal operates as for the *Reception* in 49 above.

51. **Trs.** The terminal set is always in the transmit condition and reception is not possible. Whilst not actually being keyed by the teletypewriter a permanent mark tone is radiated which will hold all receiving terminal sets on the net in the receive condition.

52. **Indicator Lights.** A red light on the front of the terminal set indicates that the set is receiving and a green light indicates that the set is transmitting. The amber light indicates that power supplies to the terminal set have been completed by the ON/OFF switch.

RECEIVING

53. **Receive Level Control and Band Pass Filter.** The two a.f. tones are fed from the receiver into the terminal set via the RECEIVE LEVEL control. This is virtually a volume control for controlling the level of the a.f. signal fed into the Band Pass Filter. This control is normally left in the 0 dB position and the input controlled by the volume control on the Receiver or the KH Control Unit Design 5. The filter allows only frequencies within the range 400 to 800 c/s to pass on to the Amplifier Limiter.

54. **Discriminator Filters.** The Amplifier Limiter is designed to provide a constant signal output to the discriminator filters. One of these filters has a mean centre frequency of 700 c/s and the other of 500 c/s. The filters are used to direct the high frequency tone (normally mark) along one path and the low frequency tone (normally space) along a second path, to their respective rectifiers.

55. **Rec. Bias Control.** The output of each rectifier is fed to a d.c. amplifier, the cathode of each amplifier being earthed through the Rec. Bias control. This control is adjusted so that the output of both d.c. amplifier valves is the same, even though the potential on the grid of each valve may be different, thus equalizing the length of the mark and space elements of the received signal.

56. **Receive Relay.** The output of the d.c. amplifiers is then used to operate the Receive Relay, which makes and breaks the d.c. loop supply, thus operating the teletypewriter.

TRANSMITTING

57. **Send Relay.** The operation of the teletypewriter keyboard makes and breaks the d.c. loop current and operates the Send Relay, which in turn operates the Two-tone Oscillator.

58. **Two Tone Oscillator.** This oscillator is designed to operate at 700 c/s for mark and 500 c/s for space. Frequency adjustment is allowed for both mark and space by means of variable resistors. With both resistors in the circuit, the low (space) frequency is transmitted. With the space frequency resistor shorted, the tone oscillator oscillates at the high (mark) frequency. The space frequency resistor is shorted out by the operation of the send relay and the metal rectifiers shown in the block diagram.

59. **Tone Amplifier and Band Pass Filter.** The output of the two-tone oscillator is fed through the Send Level Control to the Tone Amplifier and thence through a band pass filter to the microphone lines of the control system and finally to the modulator of the transmitter.

60. **Controls.** All controls are fitted on the front of the Terminal set except the mark and space frequency controls and the send level control. These are pre-set and are fitted inside the equipment. The following controls are fitted in addition to those already mentioned.

LOOP CURR. CONTROL. To adjust the current in the d.c. loop to 60 mA.

SEND BIAS CONTROL. Allows for distortion in the d.c. loop due to several teletypewriters being used on the same loop or due to the length of the loop wiring itself. It is adjusted to give the impulses in the loop a square wave form and constant unit length. No adjustment is normally required in H.M. Ships and the control should be left in the mid position.

CONDITION	RECEIVE CONTROL RELAY	TRANSMIT CONTROL RELAY
TRANSMIT	ENERGISED	ENERGISED
STANDBY	ENERGISED	DE-ENERGISED
RECEIVE	DE-ENERGISED	DE-ENERGISED

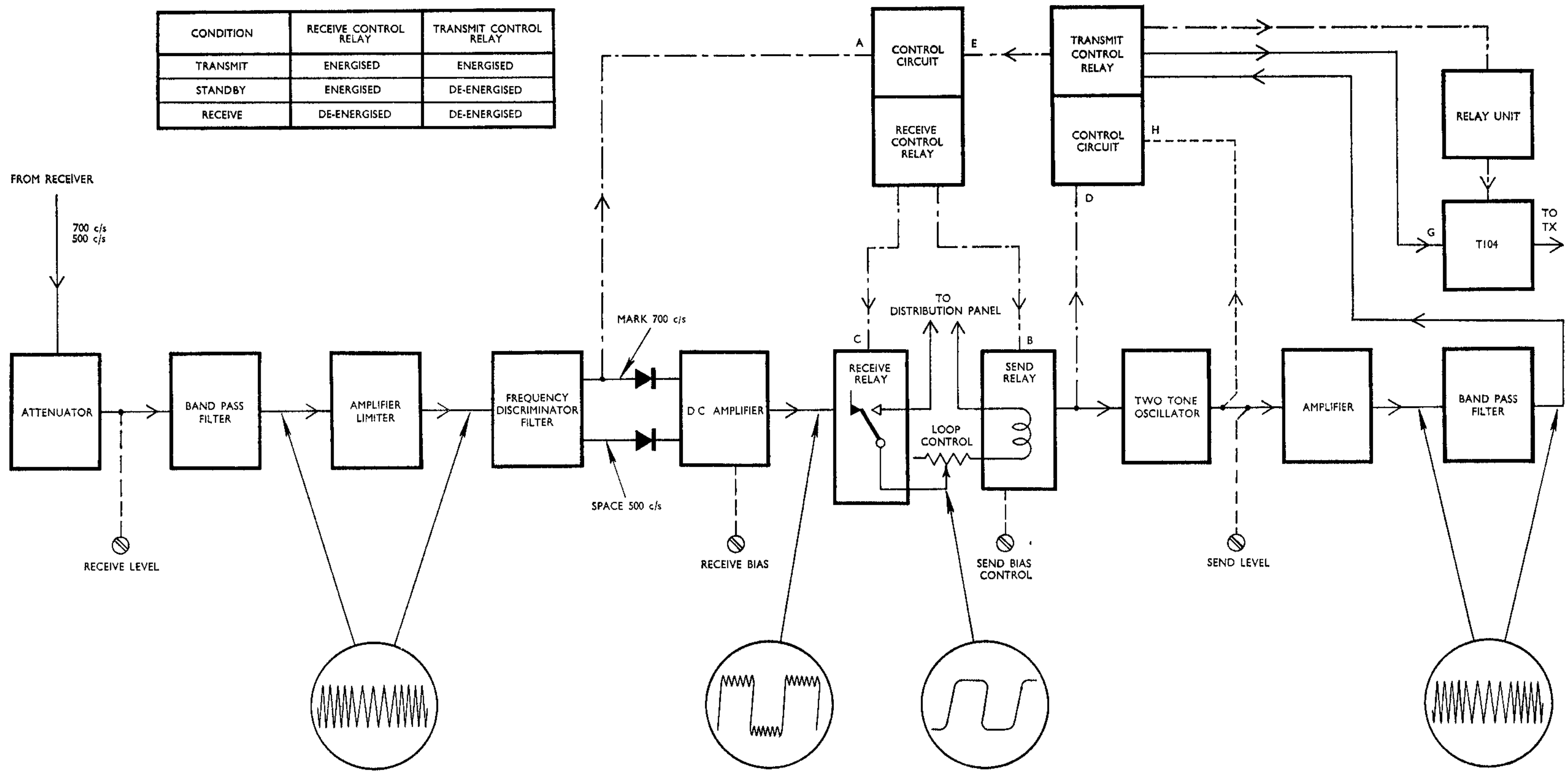


FIG. 9. TWO TONE TERMINAL SET

METER AND METER SWITCH. For taking the necessary readings when setting up the other controls.

A.C. ON/OFF SWITCH. Completes the 115 V a.c. supply to the power pack. An amber indicator light glows when power is made to the set.

OPERATING INSTRUCTIONS

For local operation the procedure is as follows:

61. Adjustment of Teletypewriter Loop Current

a. Ensure that the transmitting and receiving equipment to be used has been switched ON, set to the desired frequency, put to REMOTE, and that the terminal set is connected into the KH system at the required control unit.

b. Make the power supply switches.

c. Plug in the appropriate TTY signal line cord into the T.D.P. (Standard and Combined Bays) as required, or into the jack marked UHF TTY (Two-tone Bay and RATT (1) installations).

d. Switch on the TTY.

e. Switch on the terminal set.

f. Set the control switch on the terminal set to 'Trs.'

g. Set the meter switch on the terminal set to 'Loop Curr.' and adjust the control marked 'Loop Curr.' until the terminal set meter reads 60 mA on the upper scale.

62. Terminal Set Adjustments

a. Set the control switch to AUTO. Holding down the space bar and Rept. key on the teletypewriter turn the meter switch to Send Bias. The meter should read zero on the upper scale; if not, correct by means of the send bias control. Should there be little change in the meter deflection over the complete, send bias control travel, set the control at the mid-point. Set the meter switch to OFF before releasing teletypewritere keys.

b. Switch on the transmitter by placing the SET-ON switch on the KH control unit to the ON position.

c. Request a space bar transmission from a distant station.

d. On receipt of a space bar signal, turn the meter switch to Rec. Level and placing the Rec. Level control in the 0 dB position, turn the volume control on the KH control unit until the terminal set meter reads 0 dB on the lower scale.

e. Adjust the Rec. Bias control with the same incoming signal, by turning the meter switch to Rec. Bias and adjusting the Rec. Bias control until the meter reads zero on the upper scale. Return the meter switch to the OFF position.

f. To adjust Rec. Bias control with no incoming signal:

(1) Set Rec. Bias control fully anticlockwise.

(2) Set meter switch to Rec. Bias.

(3) Turn Rec. Bias control *slowly* clockwise until meter pointer moves to the right. Leave Rec. Bias control in the position where it just causes the meter pointer to move to the right.

(4) Return meter switch to OFF position.

The equipment is now set up correctly for local keyboard working; if transmission using an auto transmitter is required the following procedure should be adopted after *c*:

g. Plug the auto transmitter into the T.D.P.

h. Switch on the 230 V a.c. supply to the auto transmitter.

l. Insert the tape into the auto transmitter, switch on, and depress the tape control lever.

63. **Keyboard Operation**

The instructions given in the Handbook Navships 91713, Sect. 4, para. 10, cover the case of the teletypewriter working over land lines and are not applicable to the case of the teletypewriters working over a radio link. With the equipment in use:

a. The receiving terminal set will only condition to RECEIVE on the receipt of a mark (idle) signal.

b. The first character typed will not be received because of the time taken by the control circuits at both the transmitting and receiving terminals to operate.

c. The teletypewriter is fitted with a STOP/START power supply switch, which automatically operates if a pause occurs in transmission or reception of more than about 90 seconds. The actual period varies with individual machines, the maximum being in the region of 170 seconds.

d. In addition, the terminal set automatically reverts to the STAND-BY condition if there is a pause in transmission or reception of more than three seconds.

64. **Machine Functions.** Certain keys are used for specific machine functions, in addition to normal operation, before and during the transmission of messages. Detailed instructions for their use are contained in the relevant procedural publication. The keys are:

a. Break Key	Switches on own teletypewriter motor. Locks own keyboard.
b. Local Keyboard Unlock	Unlocks own keyboard.
c. Space Bar	Conditions own terminal set to TRANSMIT.
	Conditions distant terminal sets to RECEIVE.
	Switches on distant TTY motors.
	Clears tape if distant stations are reperforating.
d. Carriage Return	Aligns all TTYs.
e. Line Feed	Clears all paper rolls.

If a pause of more than three seconds (but less than 90) occurs during a transmission, distant stations terminal sets must be reconditioned to RECEIVE by making two letter or figure shifts as appropriate to the characters being transmitted.

65. **Terminal Set Conditions.**

The condition of the terminal set is indicated by the coloured lights on its front panel. The 'Red' indicates that a message is being received and the 'Green' light indicates that a message is being transmitted. When switched to the AUTO position the green light will remain alight for three seconds after the release of the key touched. If this light is extinguished during a transmission by a pause in keyboard operation, the procedure given above must be carried out. Extinction of both lights indicates that the terminal set is in STAND-BY condition and can go either to RECEIVE or TRANSMIT.

In the remote position, a meter serves the same purpose as the indicating lights on the terminal set. On receipt or transmission of a mark signal the meter will read 60 mA. During transmission or reception the meter will read between 0 and 60 mA depending on the characters transmitted or received. In the STAND-BY condition of the terminal set the meter will read about 40 mA.

COMBINED FACILITIES

GENERAL

66. The RATT (2) installation makes available the following facilities:

Key

A HF/LF Diversity Broadcast Reception
B HF/HF Diversity Broadcast Reception

Key

C HF Reception F.S.K.
D HF Reception Two-Tone
E Simplex Circuit F.S.T.
F Simplex Circuit Two-Tone (UHF) } Transmission or Reception using the same frequency
G Simplex Circuit Two-Tone (HF)
H Duplex Circuit F.S.T. – Transmission and reception using different frequencies
J HF Transmission F.S.T.
K HF Transmission Two-Tone } Transmitter Auto only, without a local teletypewriter
L Reception F.S.T. – Two-Tone Simultaneous Retransmit
*M Reception F.S.T. – F.S.T. Simultaneous Retransmit } Without local page copy
N Reception Two-Tone – F.S.T. Simultaneous Retransmit
O Normal Morse facility on HF Simplex Circuit

* Only available when Teletypewriter Distribution Panel F7/163002 is fitted.

67. **Combination Table.**

Listed below, under the headings of the different types of RATT bays, are the facilities which are available in these bays.

Associated with each facility are the additional facilities which can be provided simultaneously in the same bay with the equipment provided. For example in a Standard RATT bay facilities A, F and O can be achieved concurrently.

SINGLE FACILITY STANDARD BAY	DOUBLE FACILITY				TREBLE FACILITY			
A	AD	AF	AG	AJ	ADJ	AFJ	AFO	AGJ
	AK	AN	AO		AJK	AJO	AKO	
B	BF	BJ	BK	BN	BFJ	BJK		
C	CC	CD	CE	CF	CCJ	CCK	CCN	CDJ
	CG	CJ	CK	CL	CEJ	CFJ	CFO	CFM
	CM	CN	CO		CJJ	CJK	CJO	CJL
					CJM			
D	DA	DC	DE	DJ	DAJ	DCJ		
	DM	DO						
E	EC	ED	EE	EF	ECJ			
	EG	EJ	EK	EL				
	EM	EO						
F	FA	FB	FC	FE	FAJ	FAO	FBJ	FCJ
	FJ	FM	FO		FCM	FCO		
G	GA	GC	GE	GJ	GAJ			
	GM	GO						
H	HJ	HK	HL	HM				
	HO							
J	JA	JB	JC	JD	JAD	JAF	JAG	JAK
	JE	JF	JG	JH	JAO	JBF	JBK	JCD
	JJ	JK	JL	JM	JCE	JCF	JCK	JCO
	JO				JCL	JCM	JJA	JJB
					JJC			
K	KA	KB	KC	KE	KAJ	KAO	KBJ	KCJ
	KH	KJ	KM	KO				
L	LC	LE	LH	LJ	LCJ			
	LM	LO						
M	MC	MD	ME	MF	MCF	MCJ		
	MG	MH	MJ	MK				
	ML	MO						
N	NA	NB	NC					
O	OA	OC	OD	OE	OAF	OAJ	OAK	
	OF	OG	OH	OJ	OCF	OCJ		
	OK	OL	OM					

(*continued from page 10–2–20*)

BROADCAST BAY

A	AJ	AO	
B	BJ		
C	CJ	CM	CO
E			
J	JA	JB	JC
M	MC		
O	OA	OC	

TWO-TONE BAY

D
F
G
K

COMBINED BAY

A	AJ	AK	AO	
B	BJ	BK		
C	CJ	CK	CL	CM
D				
E				
F				
G				
J	JA	JB	JC	
K	KA	KB	KC	
L	LC			
M	MC			
O	OA			

Notes

(i) The RATT Broadcast Bay contains:

1 Teletypewriter, Model 12
1 Convertor/Comparator Group AN/URA-8B
2 B40 receivers
1 B41 receiver
1 Typewriter
1 Wireless Control Unit, Design 5
1 Teletypewriter Distribution Panel, F7/163000
1 Transmit/Receive Switch, F7/163001
1 Auto Transmitter.

(ii) The 'Two-Tone' Bay contains:

1 Teletypewriter, Model 12
1 Terminal Set AN/SGC – 1A
1 Transmit/Receive Switch, F7/163001
1 Auto Transmitter
1 Wireless Control Unit, Design 5.

(iii) The 'Standard' RATT Bay contains all the above items in one bay of 7 ft 6 in.

(iv) The 'Combined' RATT Bay contains:

1 Teletypewriter, Model 12
1 Convertor/Comparator Group AN/URA-8B
1 Terminal Set AN/SGC-1A
1 Transmit/Receive Switch, F7/163001

Notes

1 Auto Transmitter
1 Wireless Control Unit, Design 5
1 Teletypewriter Distribution Panel, F7/163000
1 Typewriter
2 B40 Receivers
1 B41 Receiver.

This arrangement is fitted where space does not allow for the full 'Standard' Bay.

68. **Use of the Table.** The table of facilities is used in the following manner:

a. Select from the Key given above, the code letters of the facilities which are required concurrently.

b. List, under the headings of the types of bay available in the particular ship, the different combinations of the desired facilities which are available simultaneously.

c. From this list determine whether the requirements can be achieved, and if so, how the bays must be arranged.

For example suppose that the following simultaneous facilities are required:

(1)	HF/LF Diversity Broadcast Reception	A
(2)	Simplex Circuit Two-Tone (UHF)	F
(3)	HF transmission F.S.T. (Transmitter Auto only)	J

The following list is derived from the table of facilities:

BAY	STANDARD			COMBINED			BROADCAST			'TWO-TONE'		
No. of facilities	1	2	3	1	2	3	1	2	3	1	2	3
	A	AF	AFJ	A	AJ		A	AJ	—	F	—	—
		AJ		F								
	F	FJ		J								
	J											

Hence this requirement can be achieved by a Standard Bay, or alternatively any combination of two of the other three types of bay.

69. **Compound Facilities.**

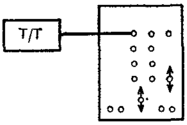
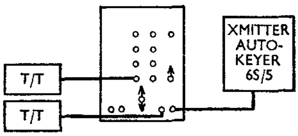
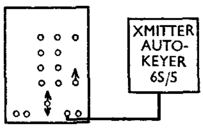
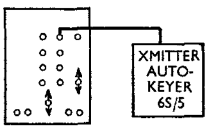
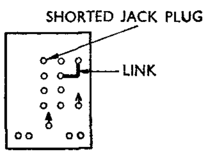
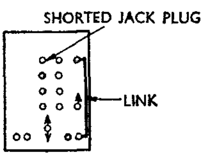
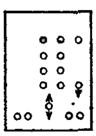
It should be noted that the table of facilities does not list all the simultaneous facilities which might be made available, but it does include all simultaneous facilities which can be made available with the equipment provided. The limitation in most cases is caused by either the number of teletypewriters or the number of transmitter remote control units which are available in the appropriate bays. Further, certain compound facilities have not been listed to avoid complicating the table. For example, it is possible to set up a simplex network using two-tone keying on UHF and at the same time to broadcast the whole of the network traffic over an HF transmission circuit using F.S.T. Such compound facilities are discussed in the *RATT* (2) *Handbook* which will be published as Part 2 of B.R. 2133.

TELETYPEWRITER DISTRIBUTION PANEL

70. This unit provides the necessary teletypewriter interconnection and voltages for F.S.T. transmission. Two similar units have been developed, namely:

F7/163000 Teletypewriter Distribution Panel

F7/163002 ,, ,, ,, Design 2.

KEY DIAGRAM	REF	FACILITY
	G	SIMPLEX CIRCUIT H F TWO TONE
	H	DUPLEX CIRCUIT F.S.K. (USING CONVERTER "B" AND F.S.K. No. 1)
	J	H.F. TRANSMISSION F.S.K. (AUTO ONLY USING F.S.K. No. 1)
	K	H.F. TRANSMISSION TWO TONE (AUTO ONLY)
	L	F.S.K./ TWO TONE SIMULTANEOUS RETRANSMIT (USING CONVERTER "A" AND F.S.K. No. 2)
	M	F.S.K./F.S.K. RETRANSMIT (SEE BEGINNING OF THIS PARA.)
	N	TWO/TONE/F.S.K. SIMULTANEOUS RETRANSMIT (USING F.S.K. No. 1)
	O	NORMAL MORSE

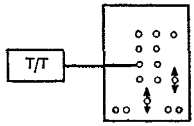
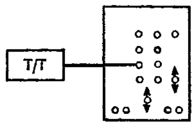
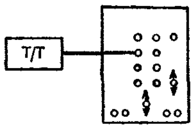
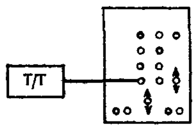
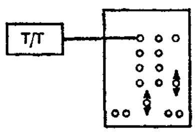
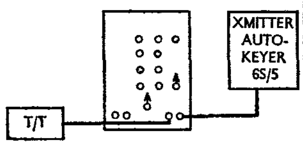
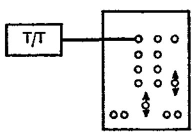
KEY DIAGRAM	REF	FACILITY
	A	HF/LF DIVERSITY BROADCAST RECEPTION
	B	HF/HF DIVERSITY BROADCAST RECEPTION
	C	HF/LF RECEPTION F.S.K. (CONVERTER 'A')
	C	HF RECEPTION F.S.K. (CONVERTER 'B')
	D	HF RECEPTION TWO TONE
	E	SIMPLEX CIRCUIT F.S.K. (USING CONVERTER 'B' AND F.S.K. No. 1)
	F	SIMPLEX CIRCUIT UHF TWO TONE

FIG. 10. DISTRIBUTION PANEL CONNECTIONS FOR RATT (2) FACILITIES

The latter gives the additional facility of F.S.T./F.S.T. simultaneous retransmission and is not at present generally fitted.

71. Basically this unit contains six independent main teletypewriter loop circuits, namely:

a. Two Tone (Terminal Set AN/SGC—1A)
b. Converter A
c. Comparator } AN/URA—8B
d. Converter B
e. F.S.T. No. 1
f. F.S.T. No. 2

Thus a teletypewriter can be plugged into any of the above circuits.

72. Loop current controls are provided in the converter and comparator circuits (*see* Reception). The two-tone loop circuit current control is in the terminal set. The loop current through the F.S.T. circuits is set at 60 mA by means of fixed resistors, unless F.S.T. 1 is modified.

Note. It can be seen from the figures that the jack-plug fittings in the T.D.P. are of two different types, certain ones being of the 'open' and certain of the 'closed' variety. Particular care must be taken therefore when cross-connecting facilities on the T.D.P. that the loop current is complete.

A shorting plug should be available for use when required (as for instance in example L in the Distributing Panel Connecting Diagram).

TRANSMIT - RECEIVE SWITCH BOX

73. This consists essentially of a double pole single throw switch key, and one is included in each of the F.S.T. loop circuits. In the TRANSMIT position it connects the F.S. Keyer into the loop circuit, via the KH system, and at the same time completes, with the control unit ON/OFF switch to ON, a path to earth for the transmitters switching line which brings on the transmitter carrier. In the RECEIVE position it switches the selected converter into the loop circuit so allowing the teletypewriter to print the received signal.

SIMULTANEOUS RETRANSMISSION

74. Before mentioning possible uses of these circuits it must be pointed out that any bias or end distortion existing on the received signal will automatically be retransmitted and therefore the signal received at the far end will successively degenerate depending upon how many relay stations the signal passes through. It is therefore recommended that if time is not a factor it is better practice to punch a tape (using a reperforator) and retransmit this tape with a Transmitter Auto. Below will be mentioned some of the possible uses of the retransmit circuits although possibly many others exist.

a. F.S.T./TWO-TONE Simultaneous Retransmit.

(1) Reception of a broadcast by a capital ship and simultaneous retransmission on UHF to her attendant ships.

(2) Automatic relay station (see *c* (1)).

b. F.S.K./F.S.T. Simultaneous Retransmit.

(1) With this facility a ship can become an automatic relay station between two capital forces or one capital force and shore station on an HF link over a reasonably long distance.

(2) Control of a distant ship's transmitter (Duplex circuit) to disguise the position of a capital force.

c. TWO-TONE/F.S.T. Retransmit.

(1) A ship with powerful transmitter can become an automatic relay station for a task force ashore using a UHF link (see *a* (2)).

(*continued on page* 10–2–28)

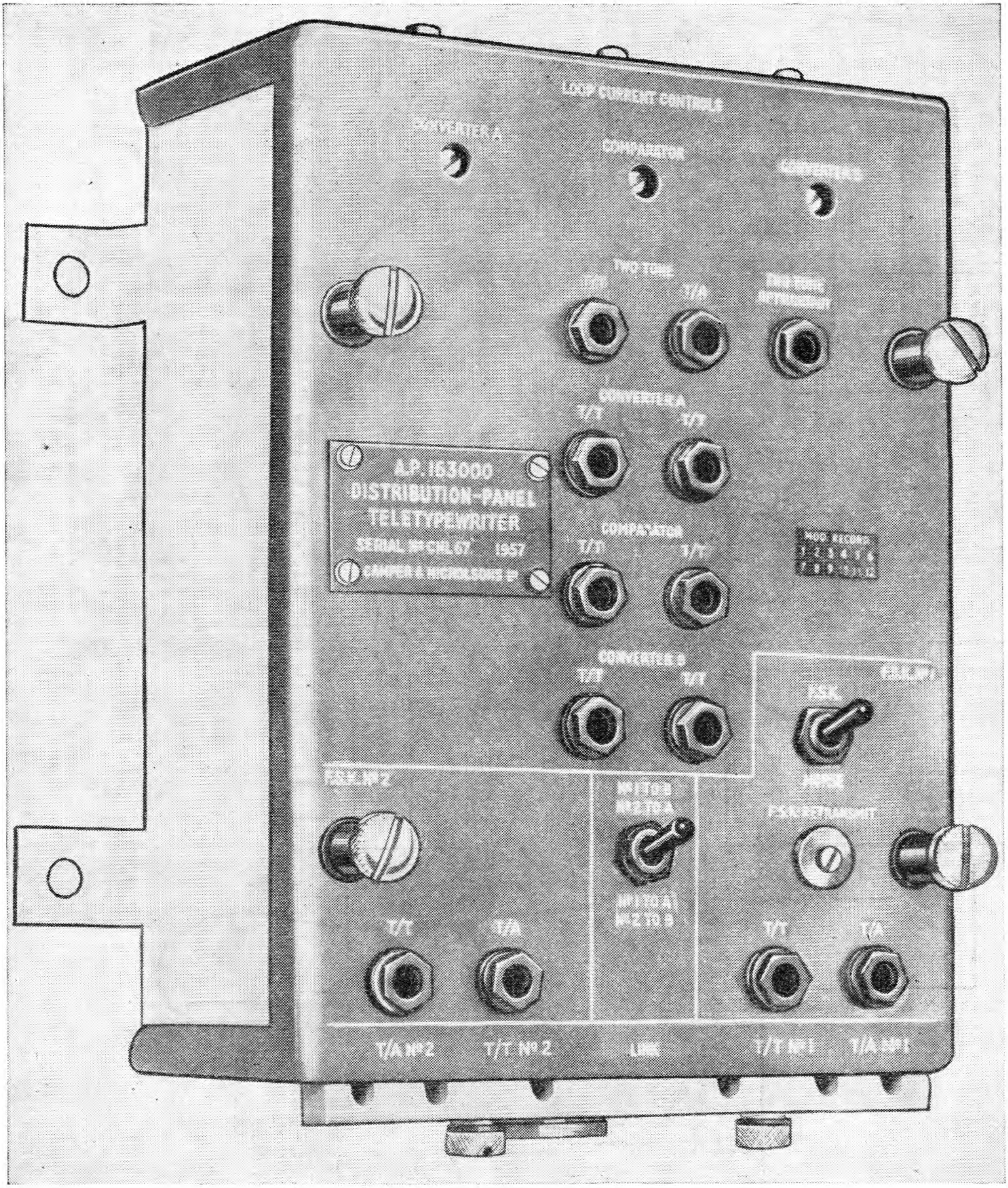


FIG. 11. TELETYPEWRITER – DISTRIBUTION PANEL

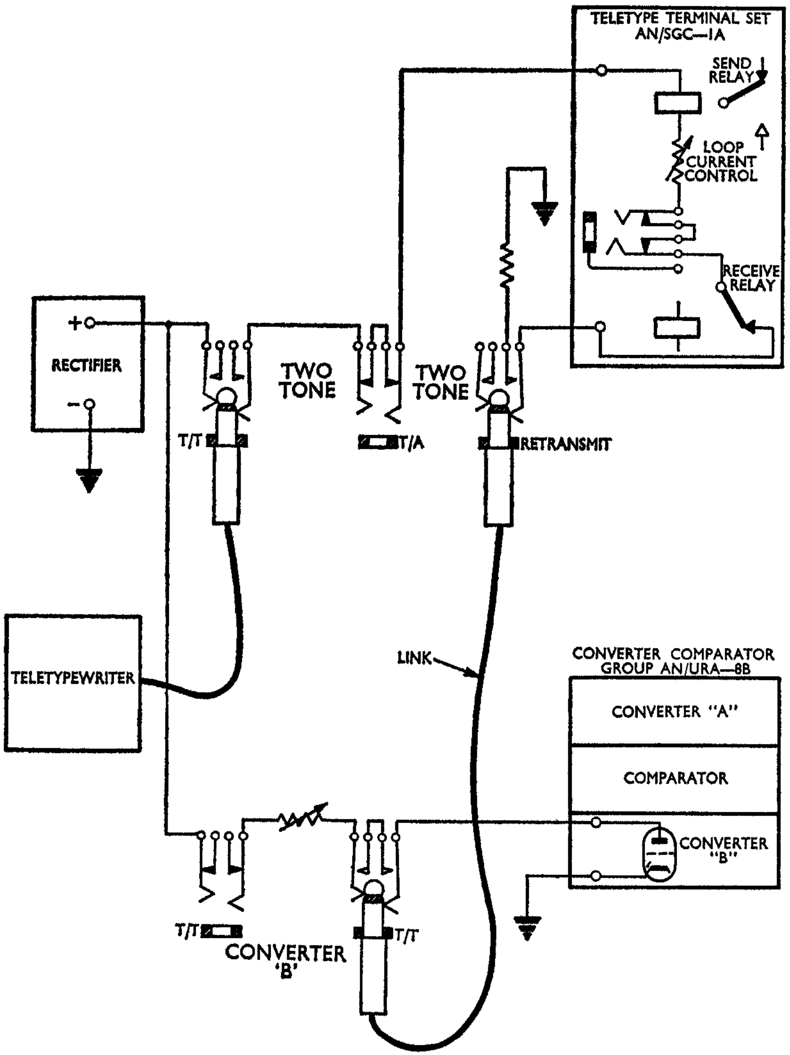
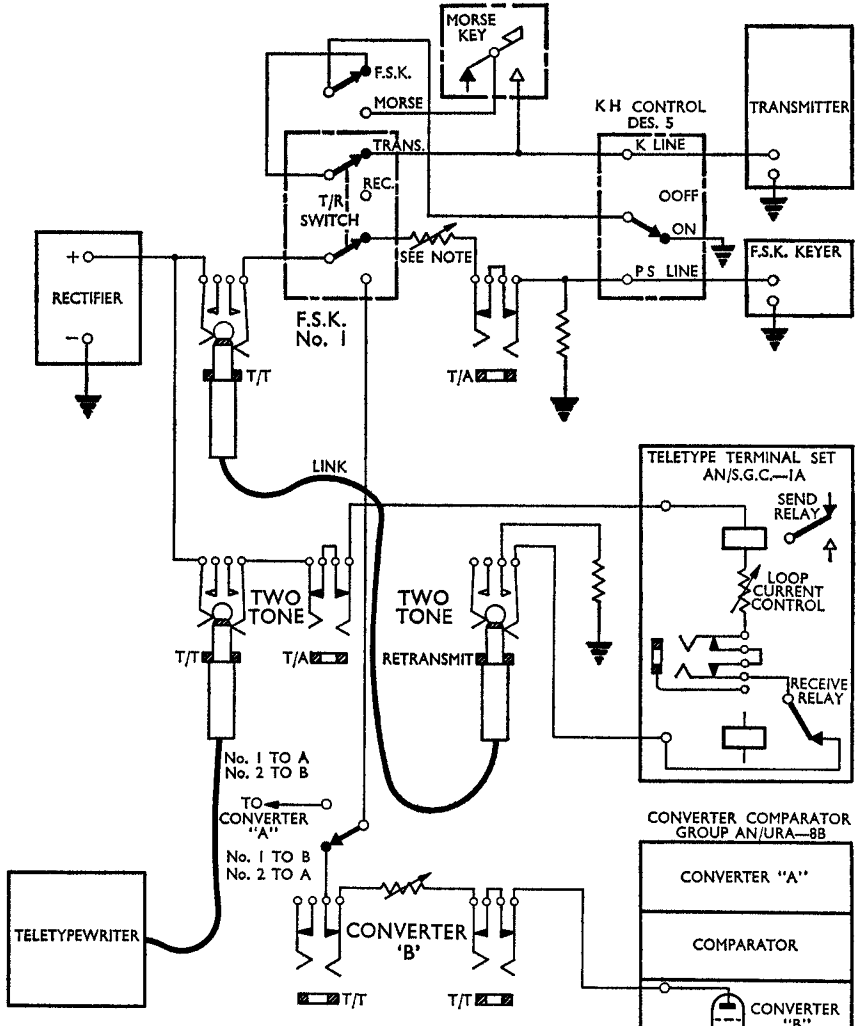


FIG. 12. SIMULTANEOUS F.S.T. TWO-TONE RETRANSMIT



NOTE:—THE FIXED RESISTOR AT PRESENT IN USE IS REPLACED WITH A 2·5K VARIABLE RESISTOR. LOOP CURRENT IS ADJUSTED WITH THIS RESISTOR TO 60 mA AS INDICATED IN THE TERMINAL SET METER.

FIG. 13. SIMULTANEOUS F.S.T. TWO-TONE TRANSMIT OR RETRANSMIT

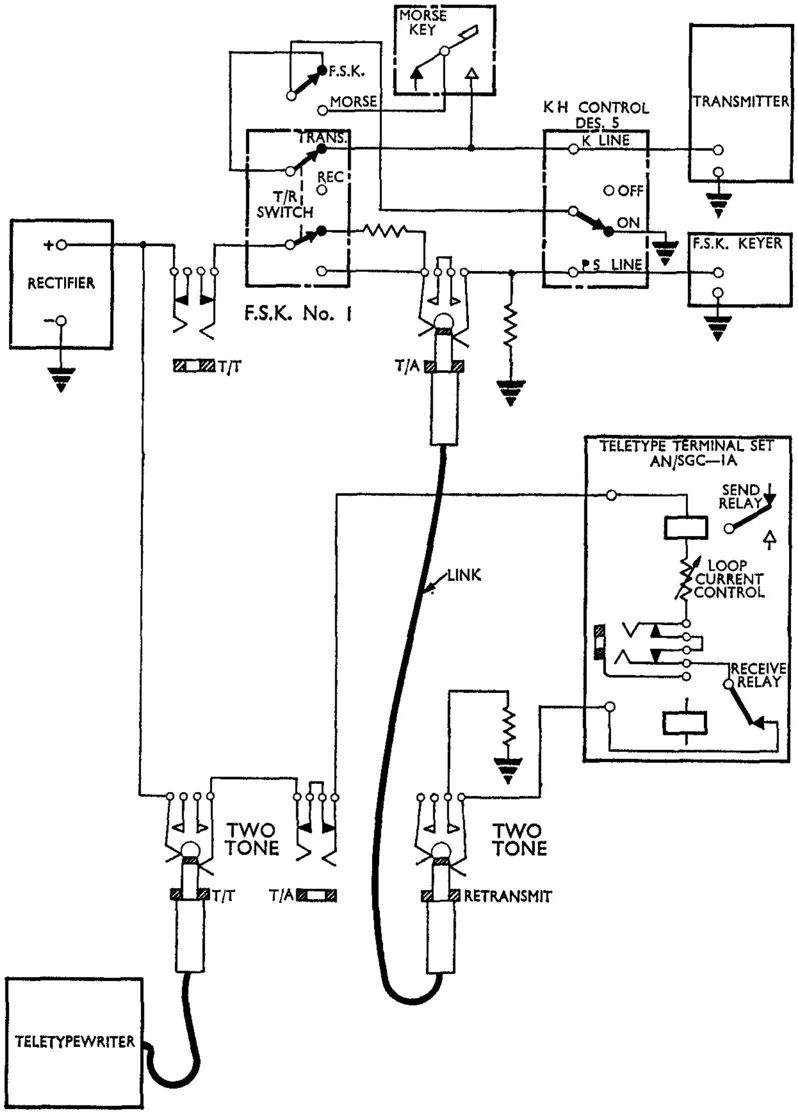


FIG. 14. SIMULTANEOUS TWO-TONE – F.S.T. TRANSMIT OR RETRANSMIT

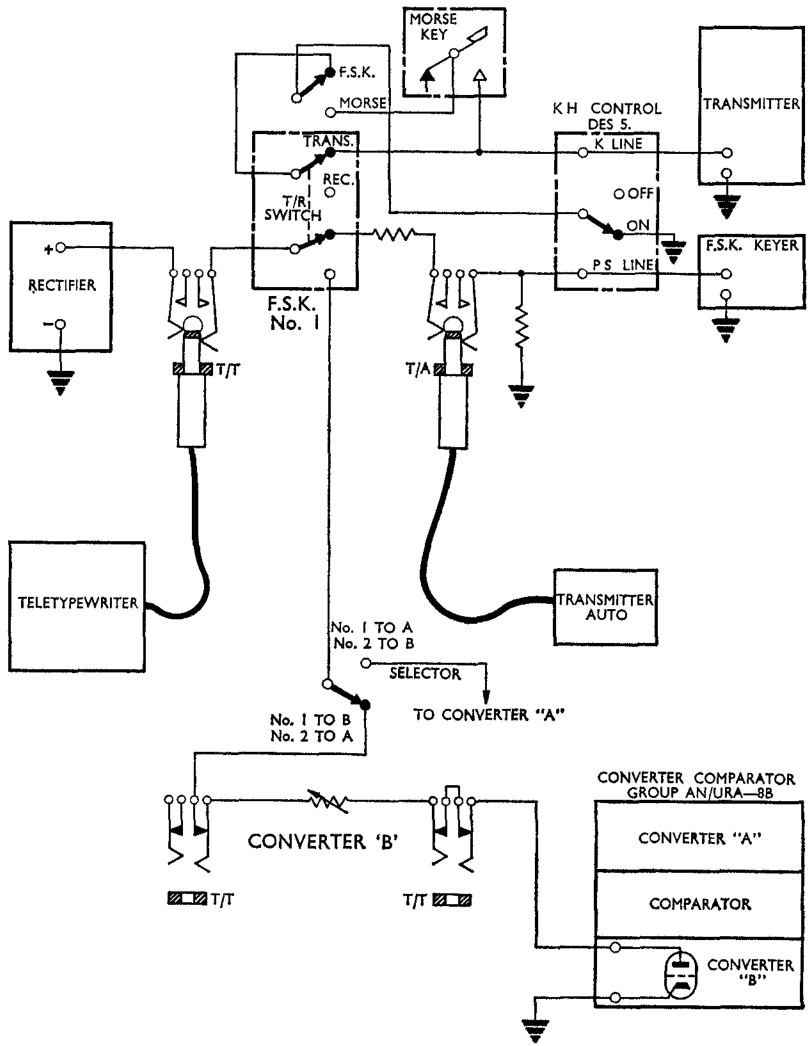


FIG. 15. H.F. F.S.T. SIMPLEX CIRCUIT

(*continued from page* 10–2–24)

(2) Control of an attendant ship's HF transmitters on a UHF link either to conceal its own position or to ensure better reception on a duplex circuit.

d. TWO-TONE/TWO-TONE Simultaneous Retransmit.

Acting as a relay link between two ships beyond their UHF range.

RATT (1) INSTALLATION

General

74. The main difference between this and RATT (2) is that there is no F.S.T. drive unit and therefore two-tone is the only form of RATT transmission available.

Broadcast Bay

75. The Broadcast Bay in the RATT (1) installation is almost exactly similar to the Broadcast Bay in RATT (2), with the difference that no T.D.P. is fitted.

Selector Switch Unit

76. An external selector switch is used to switch the d.c. loop supply into whichever unit is being used, i.e. Converter A or Converter B, when only one receiver is being used, or to the Comparator for diversity reception. A screwdriver control is provided on this unit to enable the loop current to be adjusted to 60 mA.

Two-Tone Bay.

77. This is similar to the Two-tone Bay in RATT (2). No T.D.P. is fitted, jack plugs being provided for the teletypewriter(s) in the loop circuit.

Auto-Transmission.

78. No auto-transmission facility is normally available.

(*continued on next page*)

(*continued from page* 10–2–28)

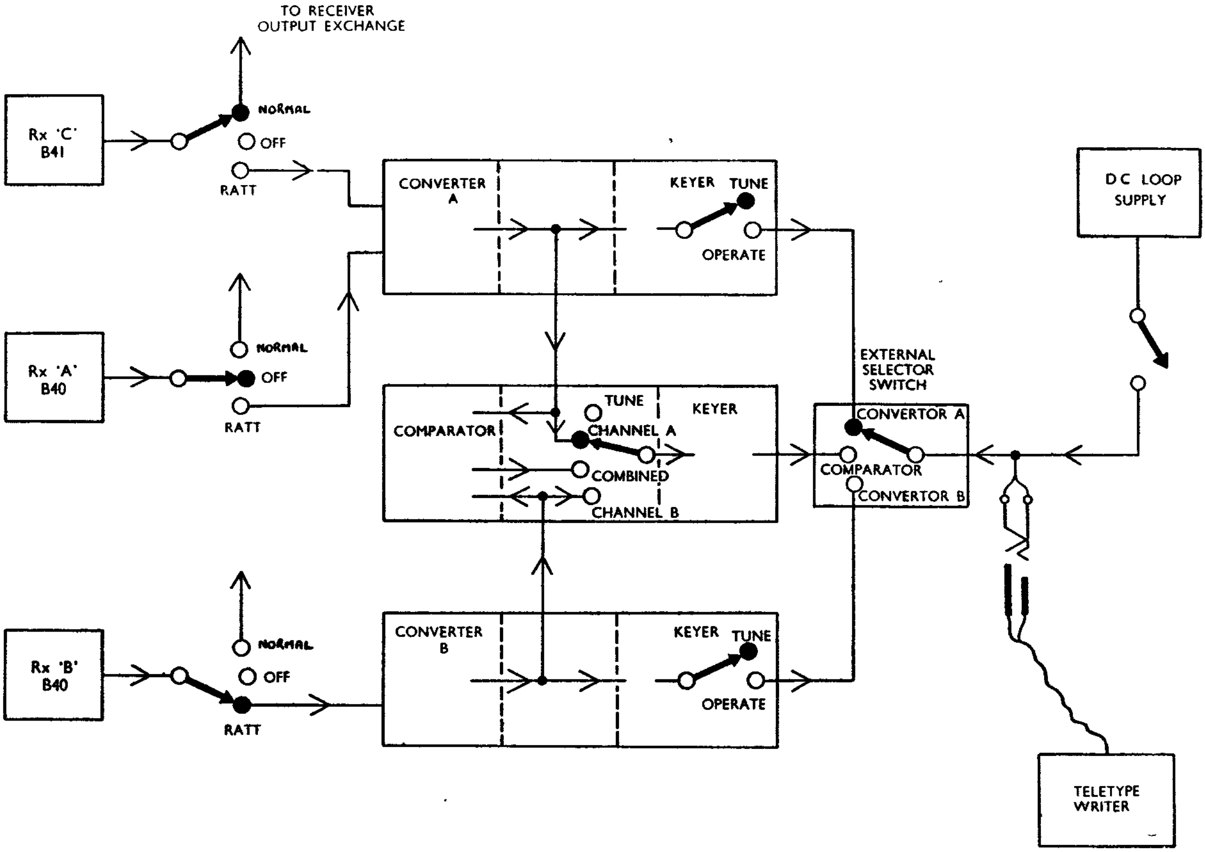


FIG. 16. RATT (1) BROADCAST BAY

(*continued on page* 10–2–30)

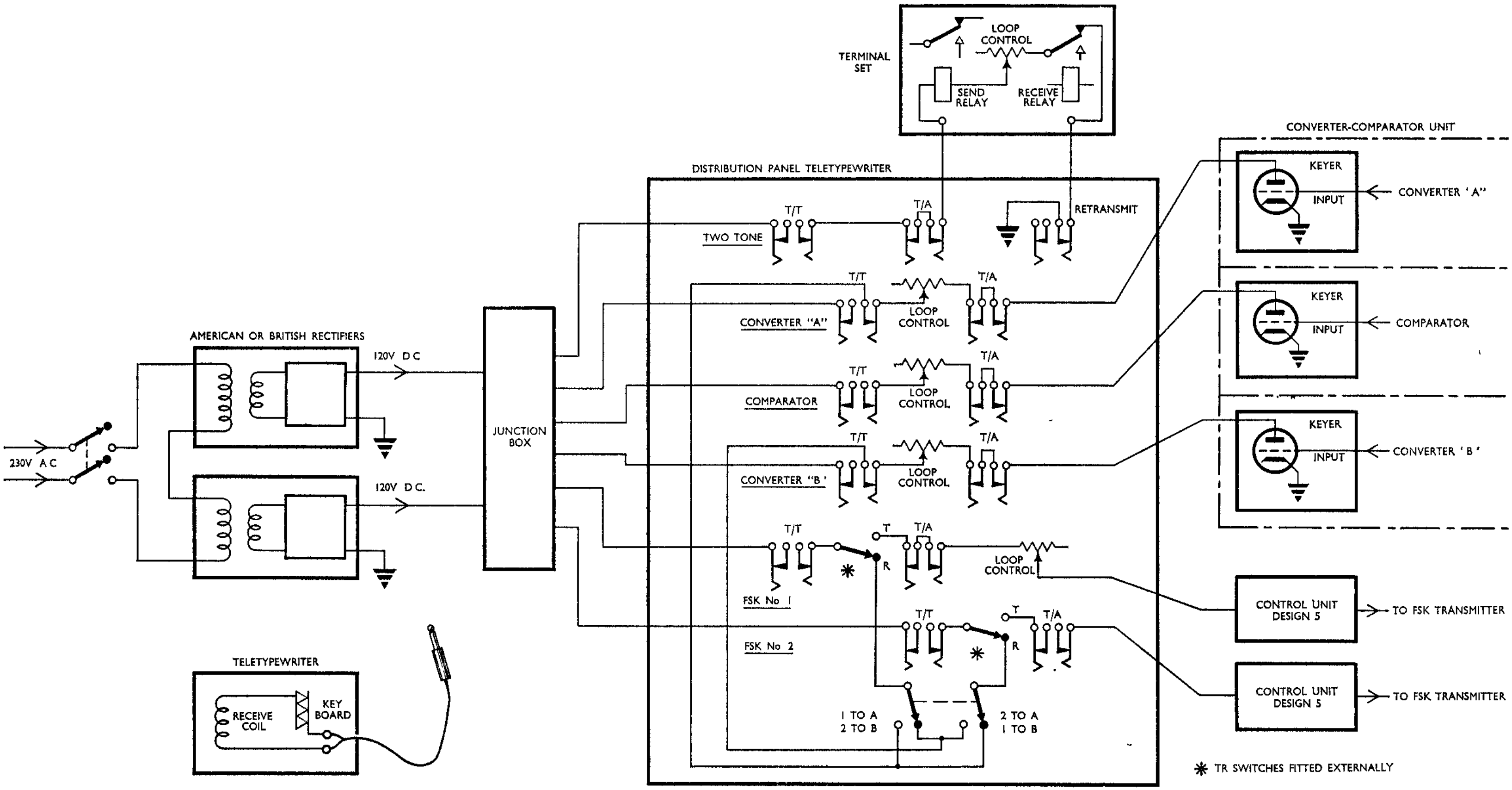


FIG. 17. RATT (2) d.c. LOOP CURRENTS

10.3 RATT OUTFIT RWA

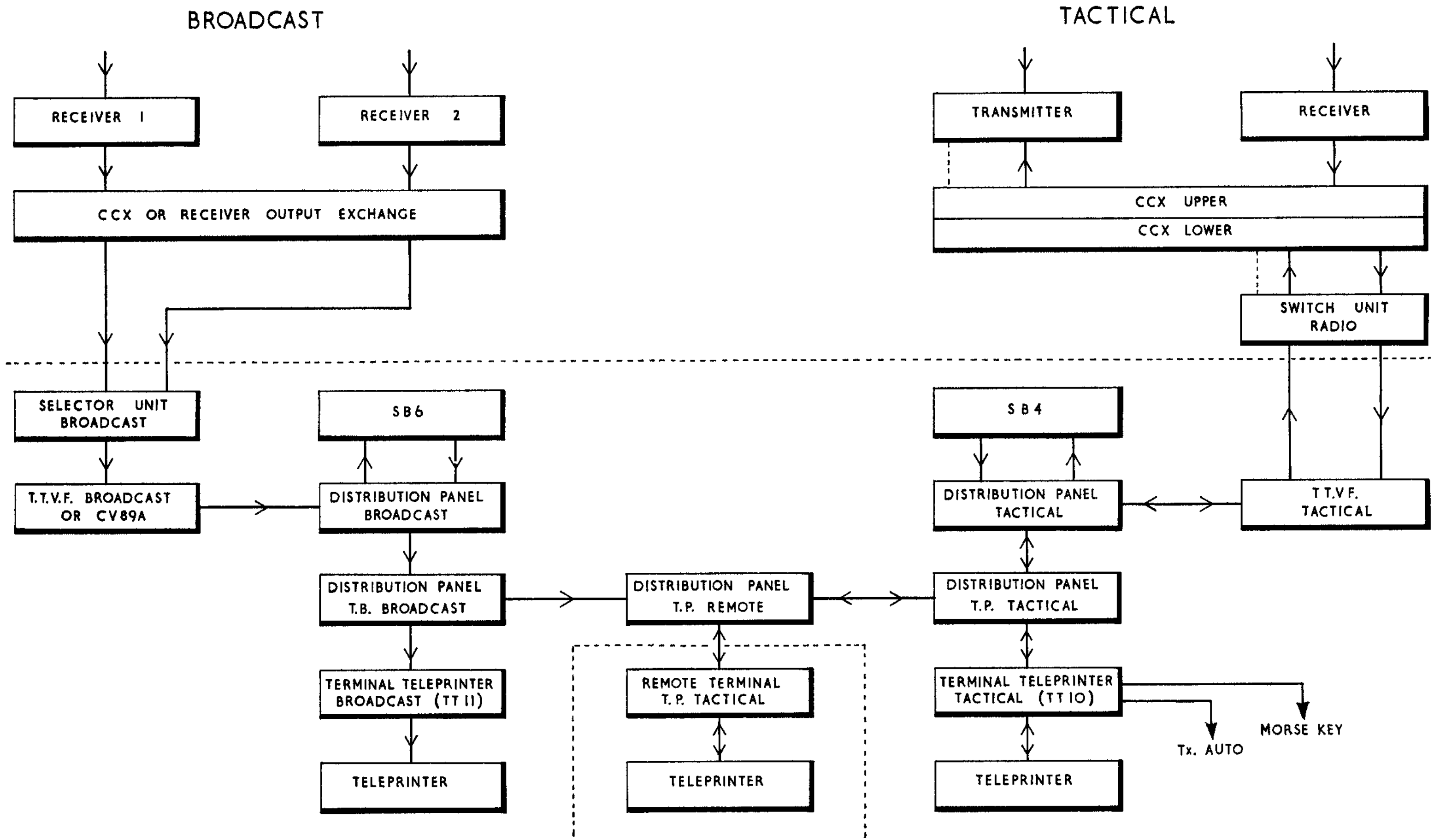


FIG. 1. RATT OUTFIT RWA – BLOCK DIAGRAM

RATT OUTFIT RWA

HANDBOOK BR 2384
E LIST BR 1402

1. Introduction

a. OUTFIT RWA is the first fully planned RATT system to be fitted in the Fleet. It is fitted in all ships which have Standard 3A and 3B radio equipment and may be found on an *ad hoc* basis in ships fitted to Standard 2.

b. OUTFIT RWA is designed to:

(1) Convert received audio tones into the requisite D.C. voltage to operate teleprinters and/or reperforators and present the received signal in typewritten page and/or paper tape form.

(2) Convert the D.C. output of teleprinter, auto transmitter or morse key into an audio form suitable for modulating a transmitter.

(3) Allow distribution of received signals to any RATT user position.

(4) Enable user RATT positions to key any radio circuit.

(5) Make up tapes for automatic transmission.

(6) Incorporate provision for the use of on-line systems if required. Note: Details of these are contained in separate publications and will not be discussed further.

(7) Obviate, or appreciably reduce the possibilities of re-radiation that were present with the high level keyed D.C. method used with earlier RATT systems.

2. General

a. BROADCAST SYSTEM. In this system, the received two-tone signal is selected by means of the Selector Unit Broadcast. This unit is connected to the receivers either through the control system or by direct line. The signal from the Selector Unit Broadcast is routed to the Terminal Telegraph Voice Frequency (Broadcast) where it is converted into a 1,000 Hz tone on-off signal. In some ships, Converter CV89A is used for this purpose but this is currently being replaced by TTVF(B). The tone on-off signal next passes to the Distribution Panel (Broadcast). At the DP(B), encrypted signals are routed through the Security Box, plain language signals being routed directly to the Distribution Panel Teleprinter (Broadcast). The DPTP(B) allows for plugging the signal to a teleprinter bay where a Terminal Teleprinter (Broadcast) (TT11) converts the tone on-off signal to high level D.C. pulses to produce a teleprinter page copy.

b. TACTICAL SYSTEM

TRANSMISSION. The outgoing signal originates as keyed D.C. pulses from the teleprinter or auto transmitter. These D.C. pulses are converted into 1,000 Hz tone on-off signals in the Terminal Teleprinter (Tactical) (TT10) which also contains indicating lamps operated by the associated equipment. The signal is then routed by way of the Distribution Panel Teleprinter (Tactical) (DPTP(T)) to the Distribution Panel (Tactical) DP(T)) where it can be plugged through the Security Box or direct to a chosen Terminal Telegraph Voice Frequency (Tactical). The TTVF(T) converts the signal to two tones and also controls the operation of the system in relation to the tactical network by sensing incoming and outgoing signals and giving indications on the lamps at the operating position TT10. The two-tone signal is passed to the Switch Unit Radio (SUR) which acts as a 'send relay' automatically switching the transmitter on when the signal passes through and off when the transmission ceases. Finally, the signal is routed to the audio input of a S.S.B. transmitter or to a Keyer Converter where it is converted to a pulsed D.C. voltage to key the older type of transmitter.

RECEPTION. The received two-tone signal is routed via the SUR to the TTVF(T) where it is converted to a 1,000 Hz on-off signal and control indications are provided for the operator. The signal is then routed to the DP(T) where it can be plugged through the Security Box or direct to the DPTP(T). At the DPTP(T) the signal can be plugged to a LOCAL or REMOTE operating position. The TT10 at the operating position converts the tone on-off signal into high level D.C. pulses to operate the teleprinter.

3. **Selector Unit Broadcast.** A standard 19 in. rack mounted unit normally fitted above the tone converters. It consists of six, or three, two-way switches for selecting the output of a particular receiver and passing it to either tone converter. The signal is normally plugged through to the Selector Unit Broadcast from a Receiver Output Exchange.

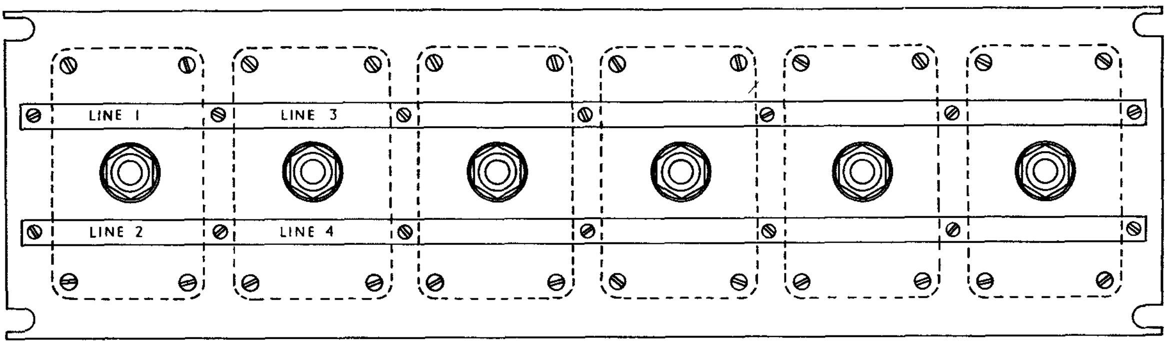


FIG. 2. 5985 – A.P. 163008 SELECTOR UNIT BROADCAST

4. **Distribution Panels**

a. GENERAL. In RATT Outfit RWA, five types of distribution panel are used to provide interconnection between major units. They may be broadly classified as Distribution Panels Tactical, Distribution Panels Broadcast and Distribution Panels Teleprinter according to their basic function. Distribution Panels Tactical and Broadcast are mounted in the standard 19 in. rack appropriate to their particular role whilst the Distribution Panels Teleprinter are grouped together and bulkhead mounted nearby. The sockets at the rear of the panels connect to the various equipments or to other distribution panels and to the corresponding plugs on the front of the panels. All terminations are Cannon plugs and sockets, referred to for ease of reference solely as sockets.

b. DISTRIBUTION PANEL BROADCAST. This panel is used to provide interconnection between the tone converters (either TTVF(B) or CV89A), Security Box 6's (when required) and the Distribution Panel Teleprinter Broadcast. Double-ended flexible connectors (A.P.181047) are used to connect the converter output to the selected security box input and to connect the security box output to the Distribution Panel Teleprinter Broadcast. When the security box is not required, the converter output is connected direct to the DPTP(B).

c. DISTRIBUTION PANEL TACTICAL. This panel is similar in appearance to the Distribution Panel Broadcast but the sockets, which now carry transmit as well as receive lines, are larger. It is used to provide interconnection between the tone converter (TTVF(T)), Security Box 4 (when required) and the Distribution Panel Teleprinter Tactical. Double-ended flexible connectors (A.P.181048 Long, 181150 Short) are used to connect the appropriate TTVF(T) to the DPTP(T) either direct or through the security box.

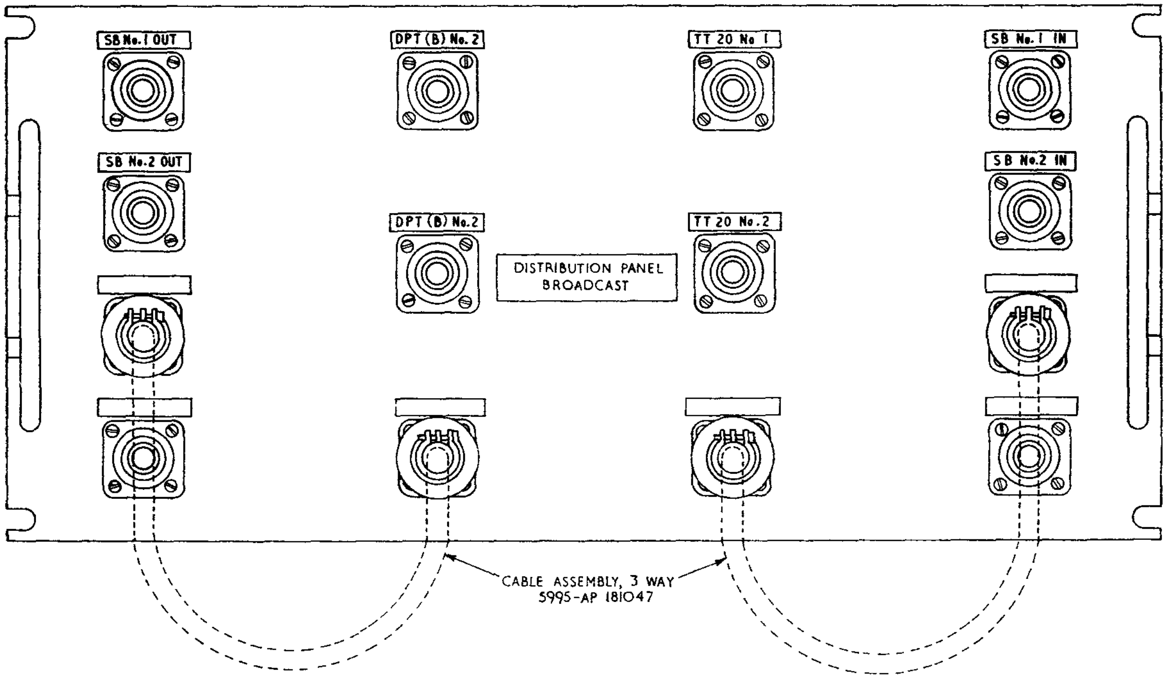


FIG. 3. 5815 – A.P. 163003 DISTRIBUTION PANEL BROADCAST

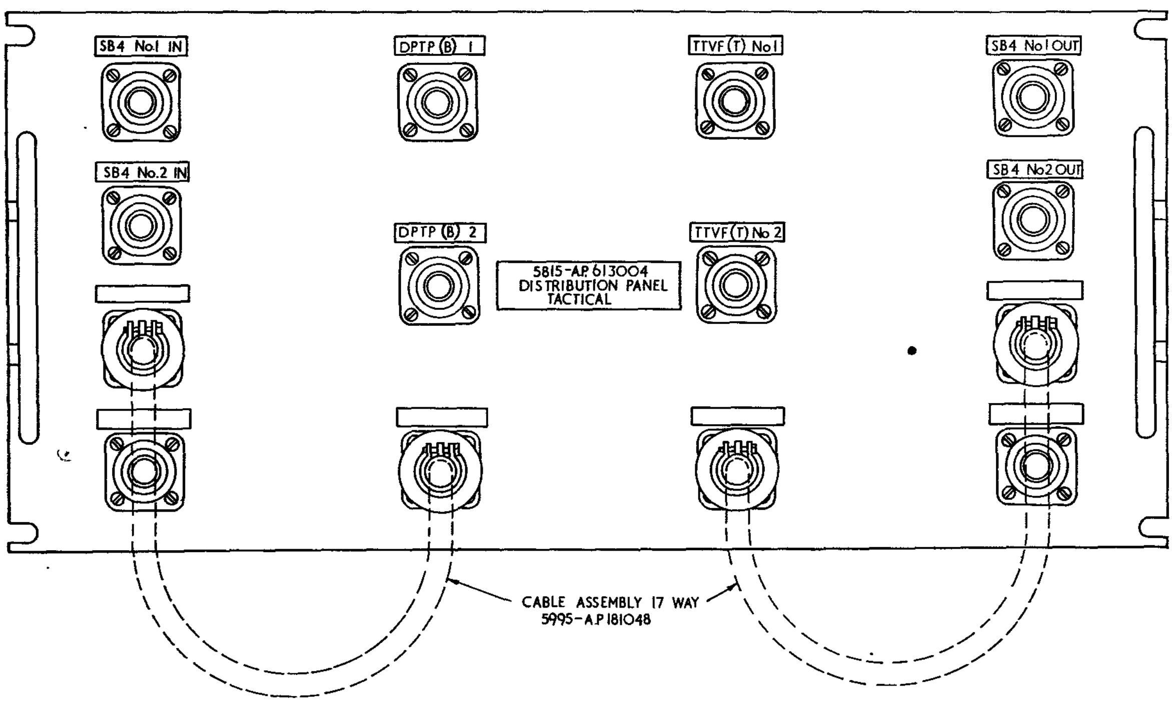


FIG. 4. 5815 – A.P. 163004 DISTRIBUTION PANEL TACTICAL

d. DISTRIBUTION PANEL TELEPRINTER BROADCAST. Used to connect an operating position to a selected broadcast channel (as selected at the Distribution Panel Broadcast). A.P.181047 double-ended flexible connectors are used. The sockets above and below the DPTP(B) marking are parallelled to provide a second output for monitoring purposes should this be required.

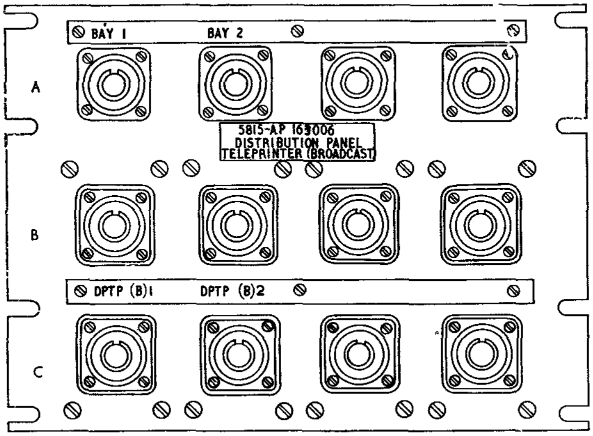


FIG. 5. A.P. 163006 DISTRIBUTION PANEL TELEPRINTER BROADCAST

e. DISTRIBUTION PANEL TELEPRINTER TACTICAL. Provides interconnection between the TTVF(T) and tactical teleprinter operating positions in the MCO. The A sockets are wired to the operating bays and the B sockets are either connected directly to those TTVFs(T) which can only be used for plain language working or to the Distribution Panel Tactical for those TTVFs(T) which can be used for on-line working if desired. Patching is accomplished by connectors A.P.181048. The C sockets are parallelled to the corresponding B sockets providing a monitoring facility for remote bays should this be required.

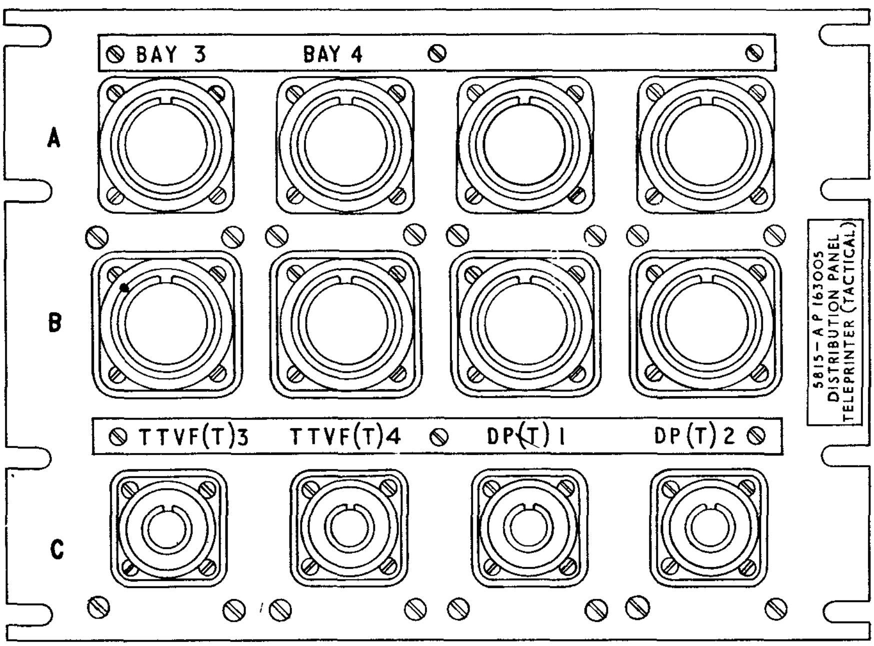


FIG. 6. 5815 – A.P. 163005 DISTRIBUTION PANEL TELEPRINTER TACTICAL

f. Distribution Panel Teleprinter Remote. This panel is for connecting remote (i.e. outside MCO) teleprinter positions to either control or monitor the signal on tactical line or a broadcast line if required. Any remote position can be connected into any desired tactical or broadcast circuit by patching between the indicated position socket and the required circuit socket from the Distribution Panel Teleprinter Tactical or Distribution Panel Teleprinter Broadcast. The A sockets are connected in parallel with one another so that by linking one of them to a C socket on the Distribution Panel Teleprinter Tactical or Broadcast, up to three remote bays can monitor one line concurrently.

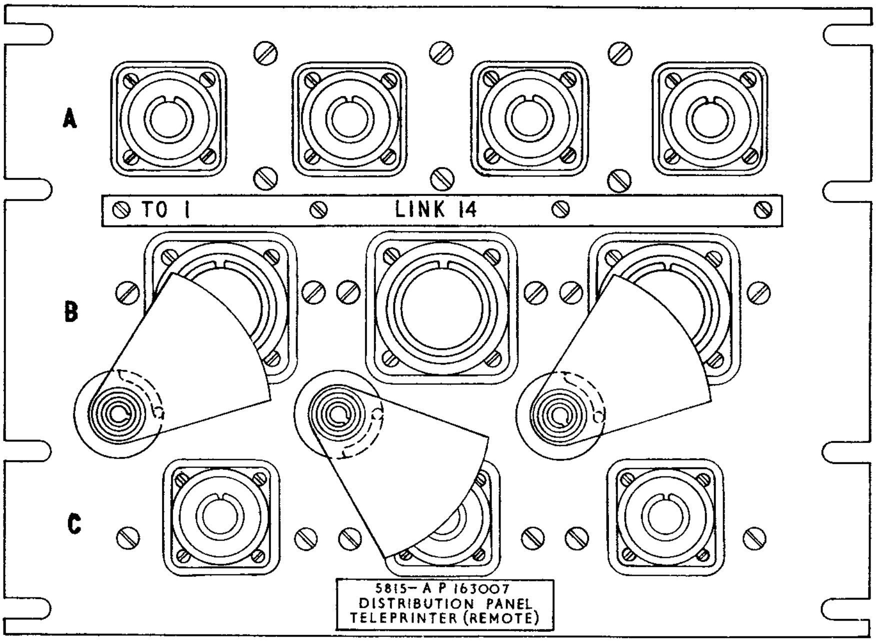


FIG. 7. 5815 – A.P. 163007 DISTRIBUTION PANEL TELEPRINTER REMOTE

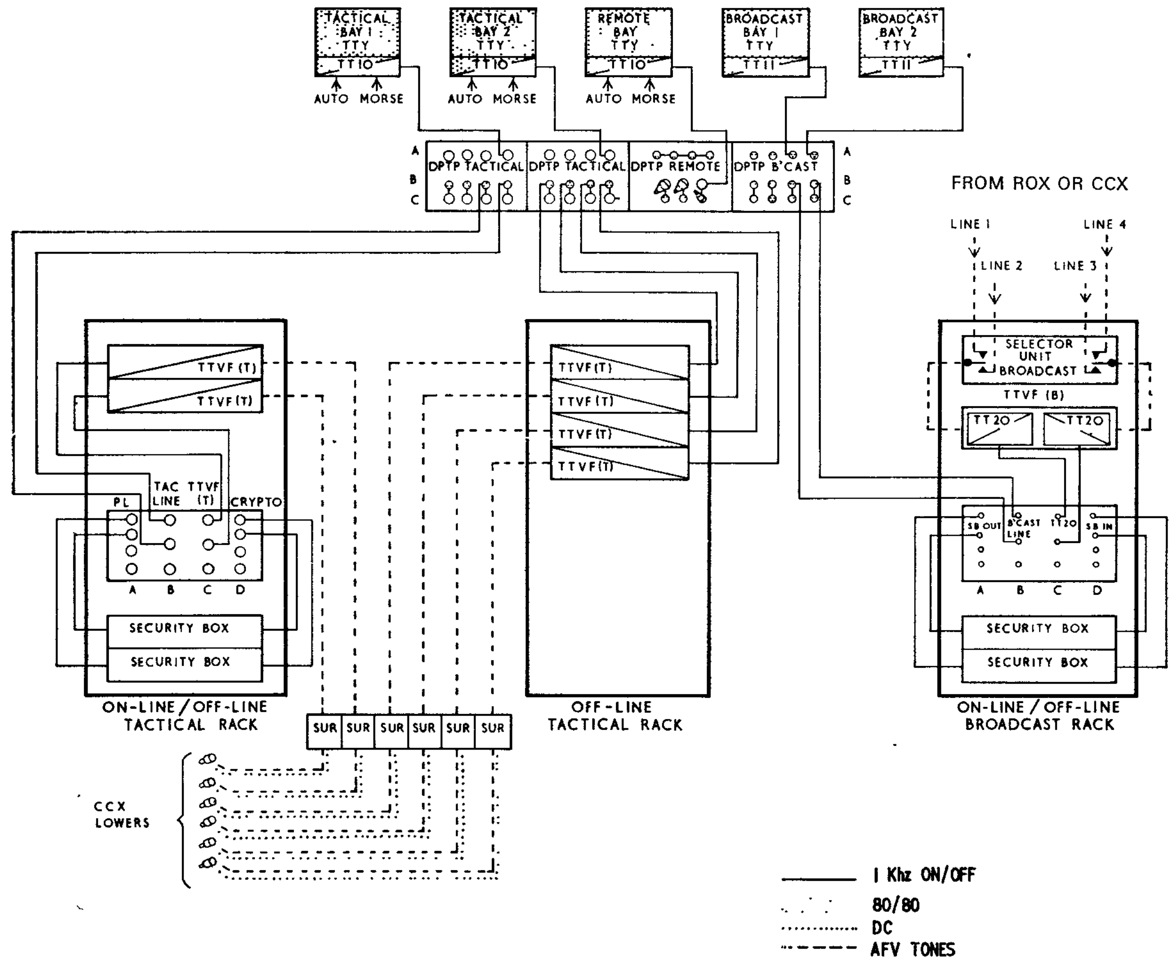


FIG. 8. OUTFIT RWA CONNECTIONS

TERMINAL TELEGRAPH VOICE FREQUENCY (BROADCAST)

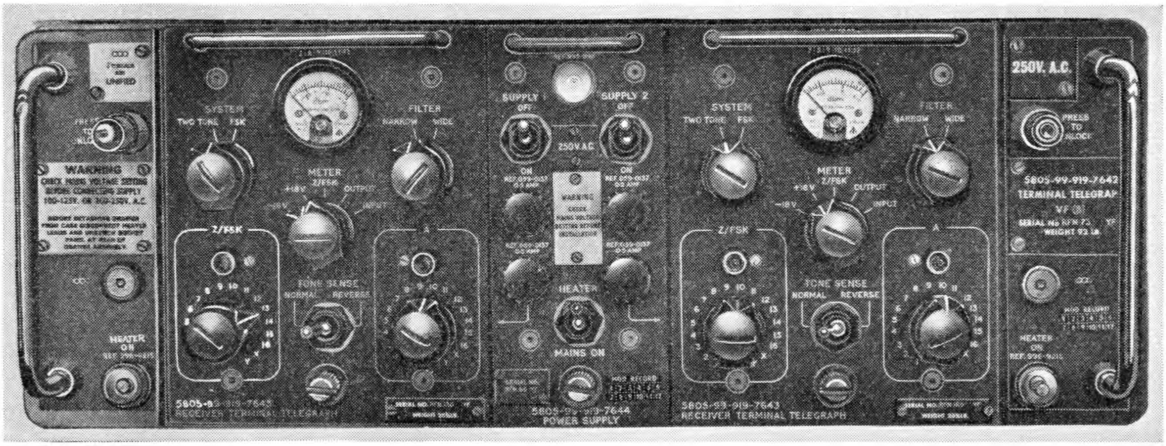


FIG. 9

HANDBOOK	BR 2444
ESTABLISHMENT LIST	E 1402, E 1472, E 1486
PURPOSE	TTVF(B) converts a received radio teletype signal comprising either a pair of consecutive tones or a frequency-shift-keyed tone to an on-off keyed 1000 Hz tone or a keyed low-level d.c. which after further processing may be used to activate a teleprinter selector.
MAINS SUPPLY	100–125V or 200–250V 50/60 Hz single phase. Consumption 20W.
SIGNALLING SPEED	50 or 75 bauds.
INPUTS	a. Two-tone operation (1) Two tones of 500 Hz and 700 Hz. (2) Any two tones from 255 Hz + 170 n, where n = 1 to 16. b. FSK operating. Two tones centred on 1000 Hz with a shift of between ± 25 Hz to ± 42.5 Hz.
CHANNEL SELECTION	By switching, of any one channel from a maximum of 18.
OUTPUTS	On-off keyed 1000 Hz tone or 6–0–6V d.c.
INTERMEDIATE FREQUENCY	3.65 kHz.
BANDWIDTH	a. Narrow ± 70 Hz b. Wide ± 250 Hz.

1. **Introduction.** The Terminal Telegraph Voice Frequency (Broadcast) comprises two receiver units type TT20 with a common twin-power-supply unit housed in a single cabinet suitable for rack mounting. Each receiver TT20 forms part of a single teleprinter channel accepting either a pair of consecutive tones or frequency shift keyed tones. These are converted to either an on-off keyed 1000 Hz tone or a keyed low-level d.c. of 6–0–6V d.c. Each TT20 contains an A and a Z channel, each of which can be set to respond to any input tone of 18 available channels. It permits low level a.f. signalling to be adopted between a receiver terminal and the teleprinter operating position, thereby obviating the transient interference that may be induced in neighbouring circuits by d.c. signalling. The equipment is designed for connection into 600-ohm lines and will accommodate keying speeds of up to 75 bauds. A test meter is provided in each receiver unit TT20 to check supply voltages from the common power supply unit as well as the signal input and output levels.
The TTVF(B) is fully transistorised.

2. **Terminology.** Throughout this summary of data, the terms ACTIVE and INACTIVE are referred to as conditions A and Z respectively to correspond with the markings on the equipment. Condition A is defined as that state of the input or output circuit in which the signal being transmitted or received corresponds to the START signal of an associated teleprinter.

3. **Mode of Operation**

a. The block diagrams in figures 10 and 11 show the various stages employed in the circuit. The receiver can be operated in the Two-Tone mode in which case both A and Z channels are used, or in the FSK mode when only the Z channel is used. Although several of the stages are common to both modes, it is convenient to consider them separately in this general explanation.

b. TWO-TONE OPERATION. The incoming two-tone signal from the receiver and Broadcast Selector Unit is fed via an input level control (a variable resistor (RV1) just inside the front of the opened drawer) to a 350 Hz – 3200 Hz bandpass filter and thence to two mixer stages, one each for the Z and A channels. In each channel mixer the incoming tones are combined with the outputs from two high-stability 18-frequency switched oscillators whose outputs are always 3650 Hz higher in frequency than the incoming tone desired to activate that channel. The unwanted frequencies occurring as the by-products of mixing action are suppressed in bandpass filters having values of ± 70 Hz in the narrow, or ± 250 Hz in the wide condition.

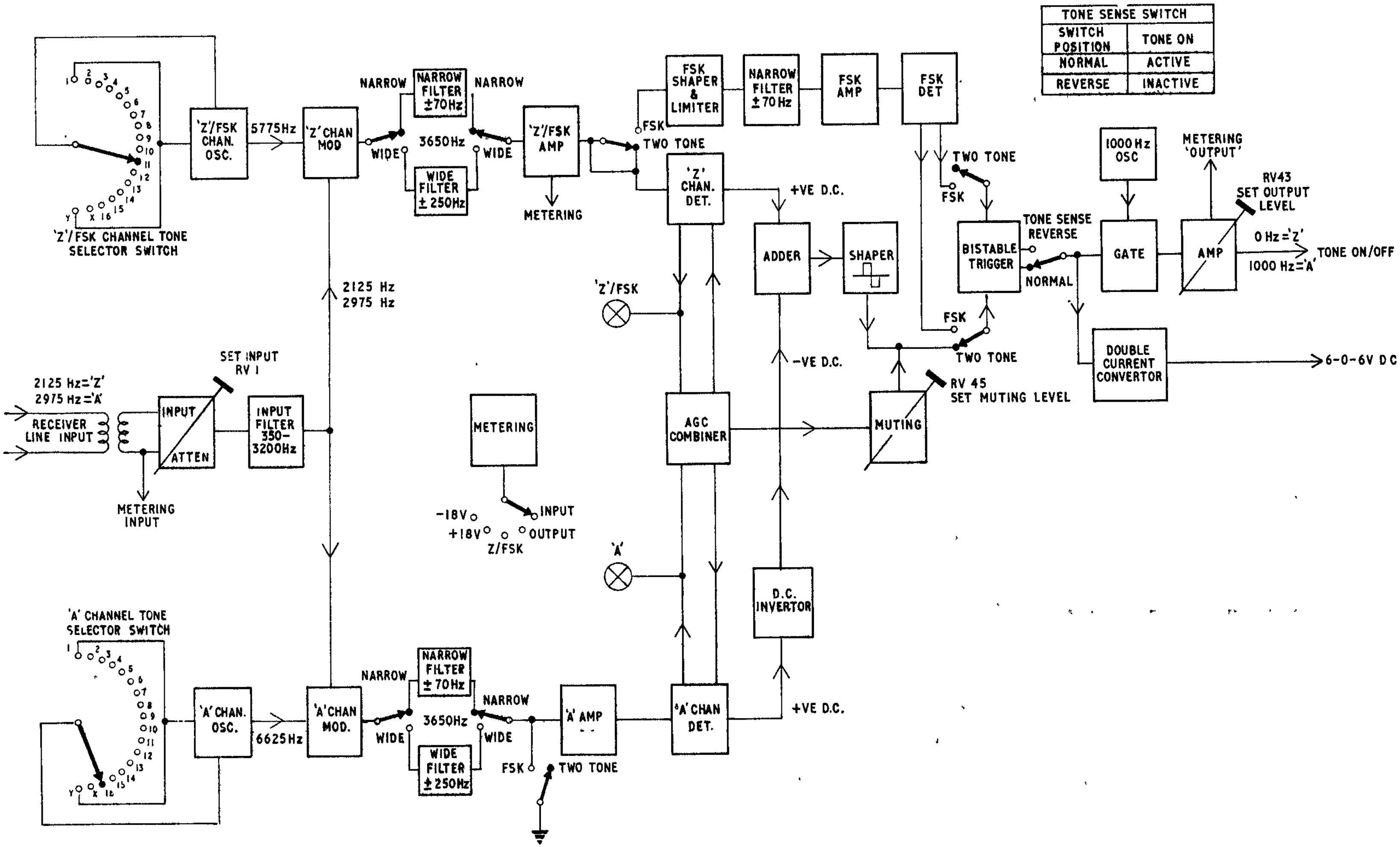
In each of the A and Z channels after filtering, a further stage of amplification occurs prior to the signal being fed to detectors to derive the voltages for automatic gain control and for control of transistor switches to energise the channel indicator lamps. The a.g.c. voltages are combined so that if there is a difference in signal levels between the two channels, the higher voltage will control the gain of both amplifiers. The d.c. signal from the A channel is then inverted in polarity and combined with the Z signal to an adder circuit. A feature of this adder circuit is its ability to eradicate the effects of broadband noise.

Because the noise level in each channel will be in phase, when the signal in channel A is inverted it will cancel out any corresponding noise in the Z channel.

The output from the adder circuit is then shaped to produce a square wave which is used to control a transistor switching circuit and the output from a continuously-running 1 kHz oscillator. The resultant on-off keyed 1 kHz tone is adjustable on installation or during maintenance schedules by RV43 which acts as an oscillator output control. A further stage of amplification raises the level of the 1 kHz tone before it is fed to an emitter-follower stage and passed to the Terminal Teleprinter Broadcast.

In the absence of a d.c. signal derived from an incoming tone in either the A or Z channel a muting circuit controlled by the a.g.c. voltage locks the trigger in a zero-output condition. The provision of a variable muting control (RV45) can be used to prevent the 1 kHz output from being triggered by noise in the absence of an incoming signal. This is particularly necessary when the TT20 is being used to receive a non-continuous signal like the Frequency Availability Broadcast. The muting control is located midway inside the opened drawer and should be adjusted with care in order to prevent too severe muting action which could prevent the reception of any desired weak signals.

c. FSK OPERATION. This mode of operation, though called FSK, is more self evident if thought of as two-tone operation – where the tones are separated by a shift restricted to between 50 Hz and 85 Hz – but with only the Z channel in use. The narrow shift signal, in the form of two tones centred on 1000 Hz, is fed from the receiver via the Broadcast Selector Unit. It enters the TT20 via the input level control (RV1) and input filter before being passed to the combined Z/FSK mixer in which it is heterodyned with a highly stable oscillator frequency of 4650 Hz to produce an intermediate frequency centred on 3650 Hz. From the mixer the signal, now centred on the i.f., passes through either the narrow (± 70 Hz) or wide (± 250 Hz) filter to the Z/FSK amplifier. At this point a diode circuit rectifies the signal so that unidirectional pulses representing the A and Z conditions are fed into the limiter which now acts as a trigger circuit. The signal is again amplified before being fed to the discriminator, the output of which is a squared wave. This operates the bi-stable trigger circuit thereby controlling the output of the continuously-running 1 kHz oscillator to produce the on-off keyed 1 kHz tone for the Terminal Teleprinter Broadcast (TT11).



TONE SENSE SWITCH	
SWITCH POSITION	TONE ON
NORMAL	ACTIVE
REVERSE	INACTIVE

FIG. 10. TERMINAL TELEGRAPH VOICE FREQUENCY (BROADCAST) – (TT20)
(shown with standard settings for receipt of FST 850 Hz arrangement 1 from USB of associated receiver)

169471—66

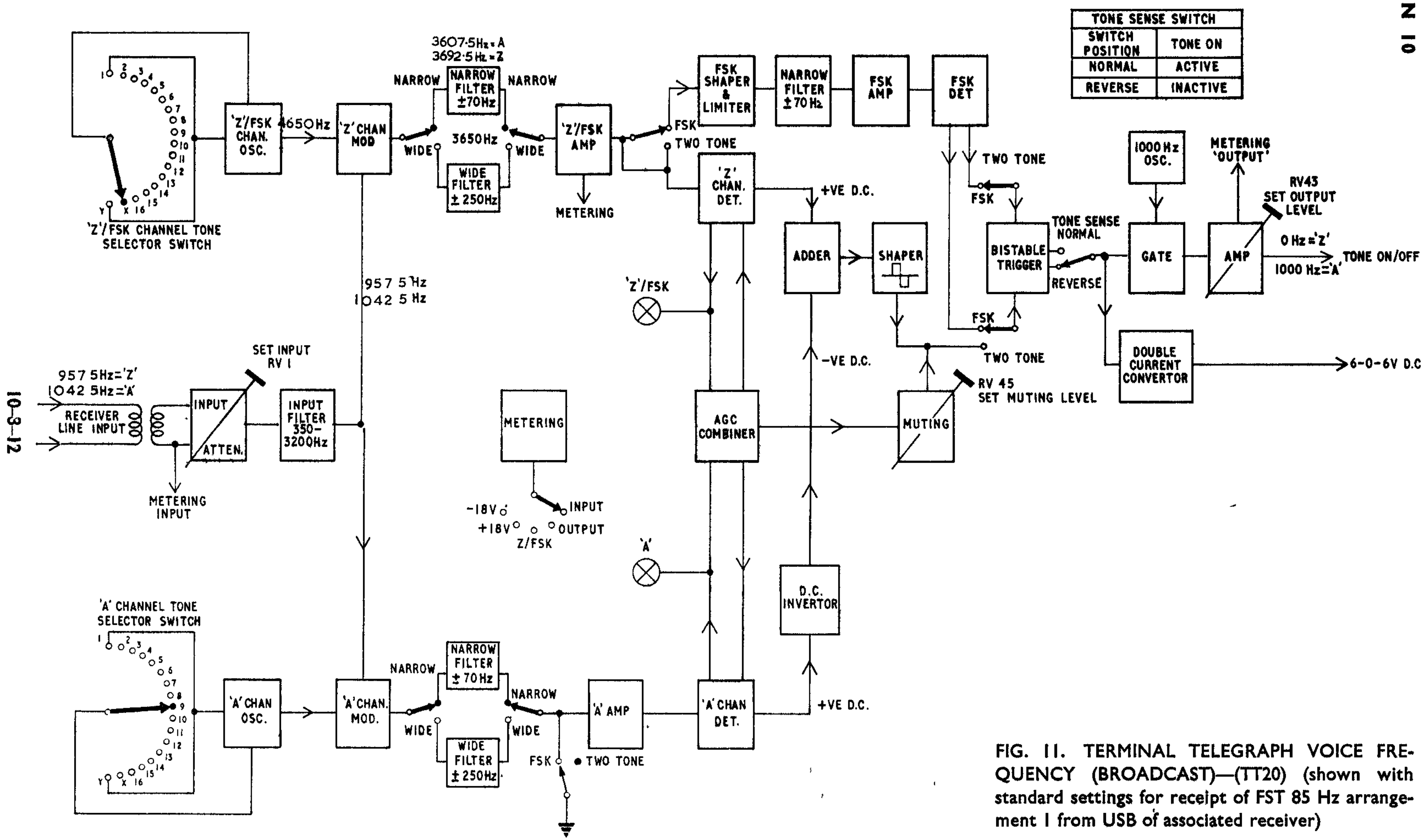


FIG. 11. TERMINAL TELEGRAPH VOICE FREQUENCY (BROADCAST)—(TT20) (shown with standard settings for receipt of FST 85 Hz arrangement 1 from USB of associated receiver)

d. TONE SENSE POLARITY SWITCH

(1) In the two-tone mode of reception, the NORMAL position of this switch permits a tone to be present in the output line as a result of a signal being present in the A channel. Any change of received arrangement should be compensated for by an alteration of the Z and A channel oscillator switches.

(2) When using the FSK mode of reception the tone is present in the output line as a result of a certain frequency deviation in the FSK discriminator circuit. The output of the discriminator (and hence the keying of the output tone) is dependent upon the input arrangement which in this mode cannot be reversed at the TT20. In order to maintain the relationship of tone on for ACTIVE, the TONE SENSE POLARITY switch must be put to REVERSE whenever an arrangement 1 signal is received.

e. POWER SUPPLY UNIT. The a.c. mains supply is fed via a transformer to two full wave rectifiers. Transistor controlled stabilisation is employed for the two outputs, consisting of +18 and —18 volts for each receiver unit.

4. Channel and Oscillator Frequencies

a.

TABLE 1

CHANNEL	INPUT TONE FREQUENCY (Hz)	OSCILLATOR FREQUENCY (Hz)	
1	425	4075	
2	595	4245	
3	765	4415	
4	935	4585	
5	1105	4755	
6	1275	4925	
7	1445	5095	
8	1615	5265	
9	1785	5435	
10	1955	5605	
11	2125	5775	
12	2295	5945	
13	2465	6115	
14	2635	6285	
15	2805	6455	
16	2975	6625	
X (Z/FSK only)	1000	4650	(See para. *b.* below)
X (A Channel only)	500	4150	(See para. *b.* below)
Y (Both channels)	700	4350	

b. Channel X of the Z/FSK oscillator has been modified to permit the reception of shifts between 50 Hz and 85 Hz about a centre frequency of 1000 Hz. Because the 'A' channel is inoperative during the reception 50 Hz – 85 Hz (FSK) signals, no modification of its oscillator was necessary. For this reason, any requirement to receive Arrangement 1 signals using a 200 Hz shift must be carried out with the oscillator selector switches as follows: Z/FSK to Y, 'A' to X, the polarity reversal necessary being carried out by means of the TONE SENSE POLARITY switch.

5. Operating Instructions

a. It is assumed that the setting-up procedure has been carried out. If not, the instructions in BR 2444 Chapter 4 must precede these.

b.

(1) Set the HEATER/MAINS-ON switch to MAINS ON. Check that the MAINS INDICATOR lamp is alight and that the HEATER ON lamps are out.

(2) Switch SUPPLY 1 to ON and set the METER SWITCH on the left-hand TT20 alternatively to +18 and −18, checking that a reading of 17 to 19V is obtained on the meter.

(3) If it is desired to use the right-hand TT20, switch SUPPLY 2 to ON and then repeat remainder of instructions in (2) above.

(4) Select the type of operation required – TWO-TONE or FSK – using the SYSTEM switch on the selected unit.

(5) Set the FILTER switch to NARROW. The WIDE position should only be used for two-tone operation when receiving an emission from a station with marked frequency instability.

(6) Set both Z/FSK and A channel selection switches to positions corresponding to the values of the received tones from Table 1 in para 4.

c. FOR FSK OPERATION. Repeat para. *b*. (1) to (3) above.

(4) Set TWO-TONE/FSK switch to FSK.

(5) Set Z/FSK channel selection switch to X. When this is done the lamp above the Z/FSK frequency selection switch will remain alight when the signal is being received.

(6) Set the TONE SENSE POLARITY switch as follows: Arrangement 1 – REVERSE
Arrangement 2 – NORMAL.

(7) If the right-hand TT20 is required, repeat 4 to 7 on right-hand unit.

6. **Keying Sense.** When the frequency-shift-converter CV89A (see page 10–2–2) is fitted in the RWA system, the tactical and broadcast keying senses are different. All remote bays are normally set to the tactical keying sense (tone on = 'A') and MUST therefore be connected to the Distribution Panel Teleprinter Tactical. When the TTVF(B) replaces the CV89A the keying senses will be identical, making it possible to connect directly from remote to either tactical or broadcast lines subject to the restriction that on-line signals must NOT be printed out in remote bays unless full radiation security precautions have been complied with.

TERMINAL TELEPRINTER BROADCAST (TT11)

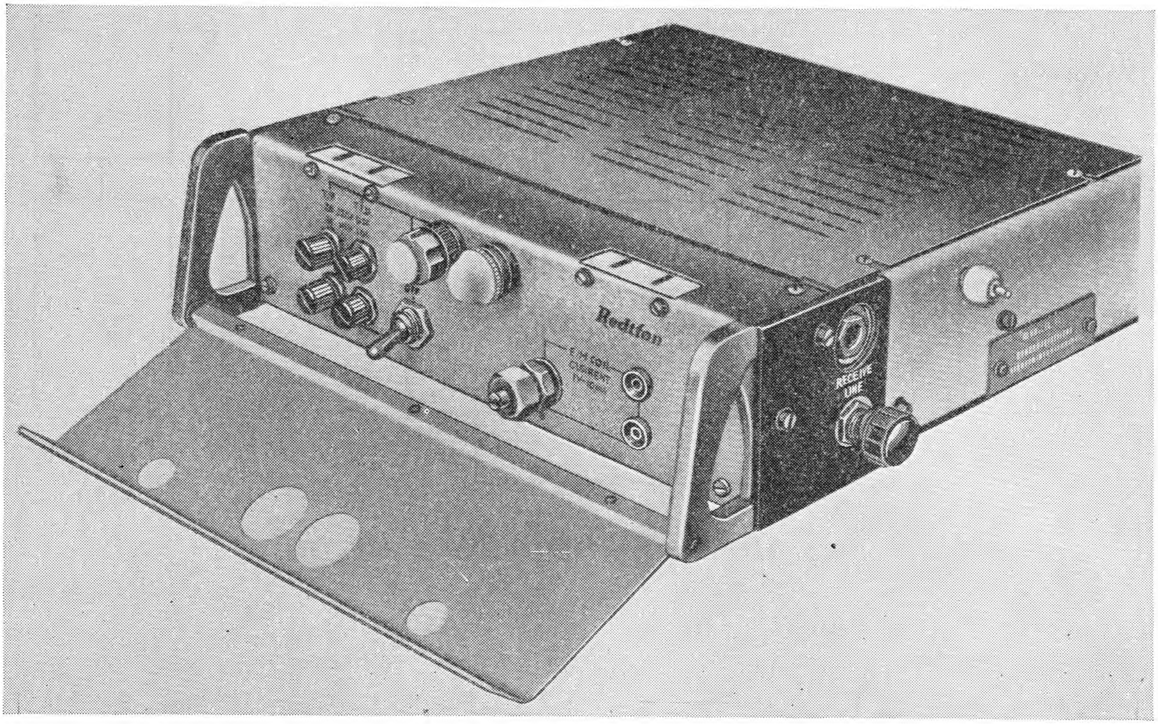


FIG. 1

1. **Introduction.** The TT (broadcast) or TT11 is a fully transistorised unit sited immediately beneath all teleprinters fitted in broadcast bays and converts the on-off keyed 1000 Hz tone from the tone converter into double current d.c. (+80 or −80) to operate the electromagnet of a teleprinter. The mains switch, indicator lights, fuses, monitoring points and output control are all mounted on the front panel. An input monitoring jack socket with an associated line gain control is mounted at the front of the right hand side. In outfit RWA the relationship of the 1000 Hz tone on-off to + and −80V is as follows: +80V=1000 Hz, −80V=tone off.

2. **Brief Circuit Description.** The incoming on-off keyed 1000 Hz tone is fed to an input transformer, input filter and attenuator to a receiver amplifier. The degree of attenuation is controlled by an a.g.c. voltage to reduce the effects of variations in amplitude, bias distortion and to lessen the possibility of the teleprinter operating on noise received between tone pulses. The tone-pulse/keying-pulse converter demodulates the amplified signal, producing two outputs. One consists of single current d.c. pulses for the driver circuit while the other is the a.g.c. voltage for the attenuator.
The driver circuit amplifies the d.c. keying pulses which then trigger the electromagnet coil-current switch. This is a bi-stable circuit, thereby producing the double current signal to operate the teleprinter. A second output from this stage is applied to the traffic indicator circuit, causing the traffic indicator lamp to light whenever a signal is received corresponding to the ACTIVE condition, remaining lit until a break in signalling of longer than half a second occurs.

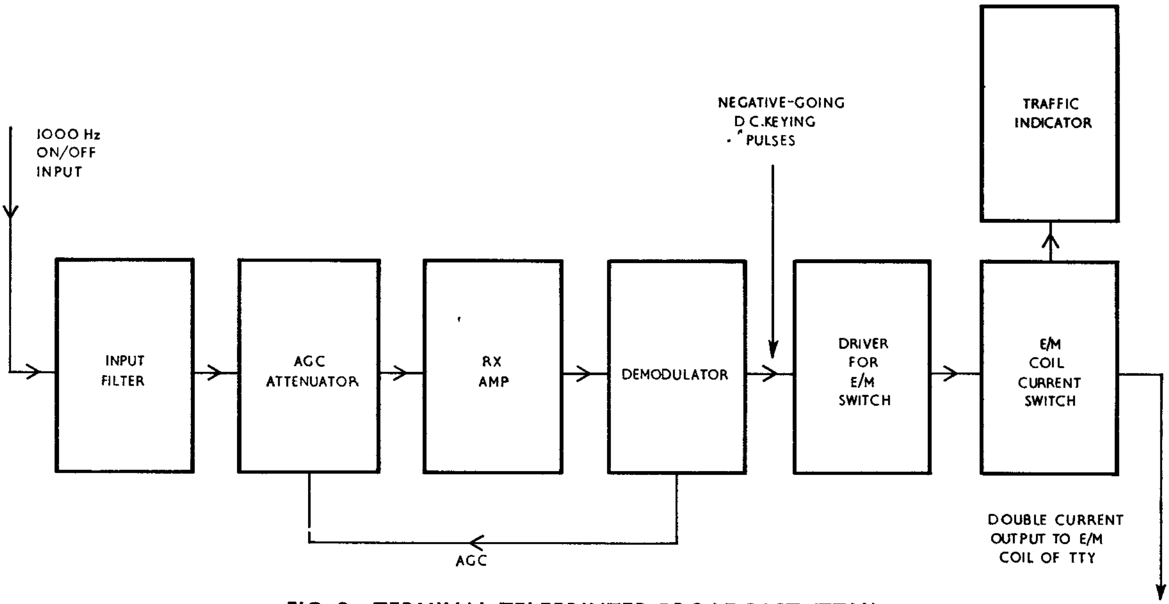


FIG. 2. TERMINAL TELEPRINTER BROADCAST (TT11)

3. **Operating Instructions**

1. Open HINGED FLAP.
2. Set MAINS SWITCH to ON, teleprinter motor will start.
3. Close HINGED FLAP.
4. Plug HIGH RESISTANCE phones into receive line monitor jack socket.
5. Turn LINE MONITOR gain control to provide convenient level in headphones.
6. Remove headphones from socket.

Note: For MORSE reception, mains switch should be set to OFF to keep teleprinter motor off.

TERMINAL TELEPRINTER TACTICAL (TT10)

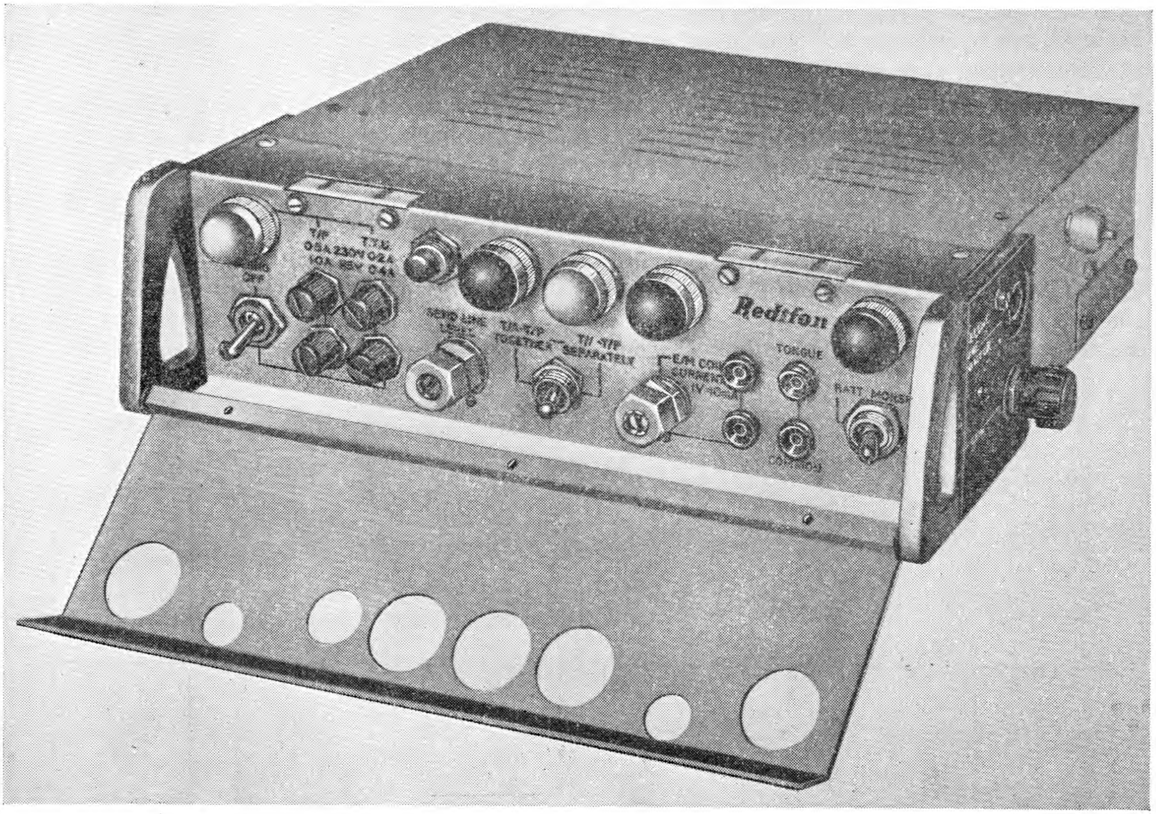


FIG. 1

.4.	HANDBOOK	BR ~~2412~~ 2384
	ESTABLISHMENT LIST	E ~~BR~~ 1402
	PURPOSE	To control the a.c. supply to or from the teleprinter motor; convert tone on-off to d.c. whilst on receive, or d.c. to tone on-off when on transmit.
	MAINS SUPPLY	100–125 or 200–250V 50/60 Hz single phase with a consumption of 22W.
	SIGNALLING SPEED	Up to 75 bauds.

1. **Introduction.** The TT10 is a small transistorised converter sited immediately beneath each teleprinter fitted for tactical operation. A hinged protecting flap covers the front panel and is held closed by magnetic catches. The equipment converts a received on-off keyed 1000 Hz tone into a double current d.c. suitable for operating the electromagnet of a teleprinter. It also converts d.c. signals initiated by the teleprinter into on-off keyed 1000 Hz tone signals for the input of the Terminal Telegraph Voice Frequency (Tactical). Adjustment of internal and external connections enables 'tone on' to be selected for either keying sense. In outfit RWA it is always set up so that a 1000 Hz tone corresponds to the +80V (receive) or +12V (transmit) of the teleprinter.

2. Brief Circuit Description

a. TRANSMITTING. The incoming keyed signal from the teleprinter is Single [redacted] current d.c. of 12V. The pulses are fed to a keying trigger and modulator circuit, where they control or gate the output of a 1000 Hz oscillator to produce the tone on-off waveform in conformity with the d.c. keying. The resultant tone is amplified by an output stage before being passed to the TTVF(T).

b. RECEIVING. The incoming on-off keyed 1000 Hz tone from the TTVF(T) is fed to a bandpass filter and an attenuator before being amplified. The degree of amplification is controlled by an a.g.c. voltage which affectively reduces distortion and the possibility of the teleprinter operating on received noise. After amplification the signal is fed to a tone pulse/keying converter which demodulates the signal to produce an output consisting of d.c. pulses and the a.g.c. voltage.

A driver circuit samples the d.c. pulses, amplifies them and passes them to the electromagnet coil-current switch. This is an on-off circuit delivering a double current telegraph signal to the teleprinter and to a traffic indicator lamp on the front panel, lighting it whenever an active pulse is being received and for a period of approximately half a second thereafter.

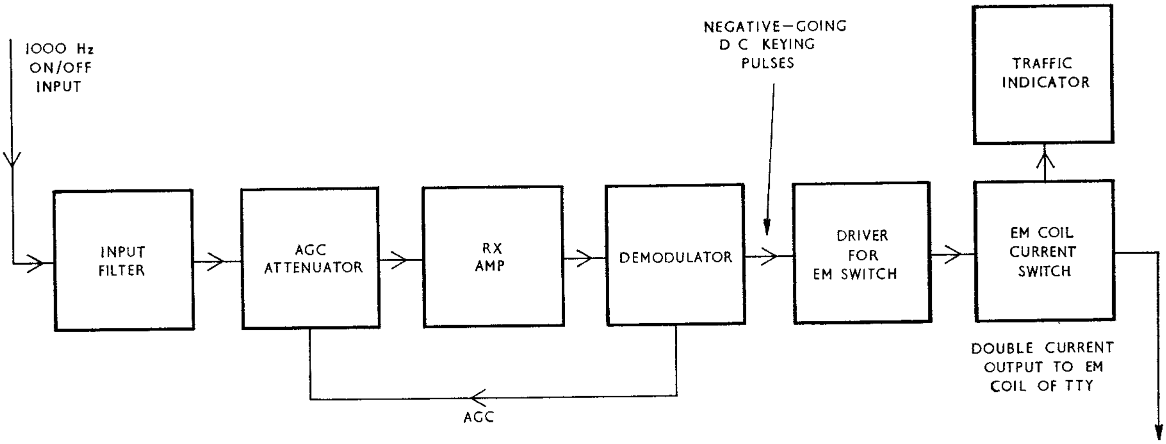


FIG. 2. TERMINAL TELEPRINTER TACTICAL (TT10) RECEIVE CONDITION

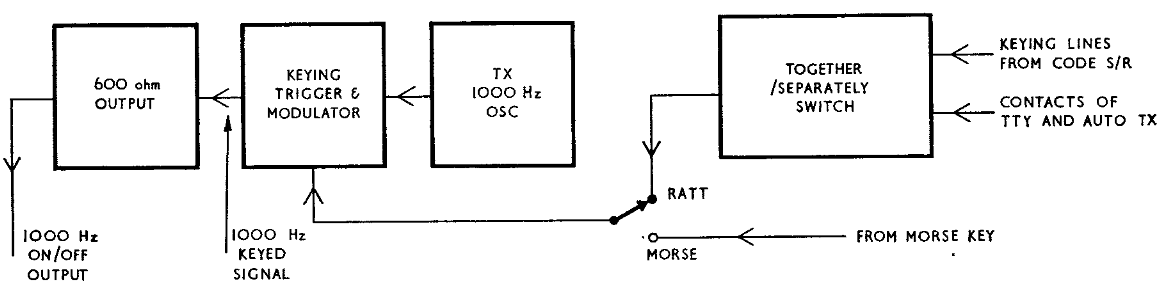


FIG. 3. TERMINAL TELEPRINTER TACTICAL (TT10) TRANSMIT CONDITION

3. **Together-Separately Switch.** This switch, located in the centre of the front panel sets the RATT circuit for either of the following conditions:

(1) Together: Keying input is accepted from either the teleprinter or the auto-tape transmitter. External connections must be coupled to both instruments but only one may be operated at a time.

(2) Separately: The keying input is accepted only from the teleprinter, or only from the auto-tape transmitter. External electrical connections must not be made to more than one instrument at a time whilst the switch is set for this condition.

4. **Operating Instructions.** Open HINGED FLAP by pulling upper edge forwards to gain access to front panel controls. Put MAINS SWITCH to ON. Mains lamp will light. A.C. supply is connected to teleprinter motor.

a. RATT OPERATION

(1) Set RATT MORSE switch to RATT. The traffic indicator lamp will light whenever an incoming signal is received and will remain lit until a break in signalling exceeding half a second occurs.

(2) If ONLY the teleprinter (T/P) or ONLY the auto-transmitter (T/A) is connected to the TT10, set the SEPARATELY-TOGETHER switch to SEPARATELY.
If BOTH teleprinter (T/P) and auto-transmitter (T/A) are connected to the unit, set the SEPARATELY-TOGETHER switch to TOGETHER.

(3) Close hinged flap. Operate teleprinter or auto-transmitter as required.
DO NOT ATTEMPT TO OPERATE THEM SIMULTANEOUSLY.

b. MORSE OPERATION

(1) Set RATT MORSE switch to MORSE.

(2) Close hinged flap over front panel.

(3) Plug HIGH IMPEDANCE headphones into the RECEIVE LINE MONITOR jack on the right hand side of the unit.

(4) Turn RECEIVE LINE GAIN control in a clockwise direction to give a convenient listening level in the headphones.

(5) Operate as desired using Morse Key and Headphones.

c. INHIBITING THE PAGE COPY

When a page copy is not required, e.g., when transmitting call or test tapes, the following procedure may be followed to prevent a page copy from being printed:

(1) Turn the receive line monitor gain control fully clockwise (max).

(2) Insert a short-circuiting jack plug (AP 650) into the receive line monitor jack socket.

5. **Switching Off**

1. Open HINGED FLAP, switch MAINS SWITCH to OFF and close hinged flap.
2. Switch auto-transmitter MAINS SWITCH to OFF.

169471—67–68 D

TERMINAL TELEGRAPH VOICE FREQUENCY (TACTICAL)

FIG. 1

HANDBOOK	B.R. 2412
ESTABLISHMENT LIST	
PURPOSE	The TTVF(T) is used in each tactical A.T. circuit to: (1) Convert the received two-tone signal into a single 1000 Hz tone on-off. (2) Convert the on-off keyed 1000 Hz tone initiated at a user position into two tones of a selected value for modulation of a transmitter. Of the TTVFs(T) fitted in a ship, only those connected to a Distribution Panel Tactical are capable of being connected into an associated Security Box.
MAINS SUPPLY	115 or 230V 50/60 Hz single phase a.c. with a nominal consumption of about 28W.
SIGNALLING SPEED	Up to 75 bauds.

1. Introduction

a. The equipment comprises four individual units, transmitter, receiver, common control unit and power supply, all within one cabinet which is rack mounted. An external changeover switch located on the front panel permits instantaneous selection of either Channel 1 (200 Hz shift using tones of 500 Hz/700 Hz) or Channel 2 (850 Hz shift using tones of 2125 Hz/1275 Hz). Both the transmitter and receiver units consist of A and Z channels into which may be fitted plug-in oscillators and filters for each of the tones mentioned earlier. These plug-in filters and oscillators are patternised items which can be replaced if it is ever desired to achieve FST or A2 RATT operation with shifts other than 200 Hz or 850 Hz, or to change the tone values by which the present shifts are achieved.

b. The transmitter converts on-off keyed 1000 Hz tone from a TT10 into a two-tone output suitable for modulating the associated transmitter.

c. The receiver unit accepts two-tone inputs from the associated receiver and converts them to an on-off keyed 1000 Hz tone for either a TT10 or TT11.

d. The output polarity of the TTVF(T) is fixed in design and works as follows:

(1) Transmission – When the tone input from the TT10 is 1000 Hz the A channel is activated. When the tone input from the TT10 is zero the Z channel is activated.

(2) Reception – When the A channel is activated by an input from an associated receiver the TTVF(T) keys a 1000 Hz output (tone on).
When the Z channel is activated by an input from an associated receiver the TTVF(T) keys a zero output (tone off).

e. A straight through connection is provided for morse operation.

f. All connections to the equipment are made via two plugs and a single socket at the rear of the cabinet.

2. Brief Circuit Description

a. TRANSMITTER. The on-off keyed 1000 Hz tone is fed via a line isolating transformer and input gate to a detector where the 1000 Hz tone is filtered away. The keyed signal modulation envelope is then passed through an assessor to a shaping circuit and d.c. restorer which convert the signal into two sets of rectangular waveforms of opposite phase. Two oscillators, one each for the A and Z tones, have their outputs gated or controlled by these waveforms. After passing through amplifiers and filters tuned to their associated oscillator frequencies, the oscillator outputs are mixed in a two-tone combiner. A further stage of amplification brings the tones to a level suitable for feeding a compound emitter-follower which matches the transmitter output to a line isolating transformer. A changeover key (KA) located just inside the drawer on the left-hand side is used for setting up the transmitter A and Z outputs, simultaneously diverting the transmitter output into a matched dummy load.

b. RECEIVER. The incoming two-tone signal is fed via a receiver input level control ~~line gain control (RV3)~~ just inside the unit, to an amplifier and two bandpass filters which separate the A and Z tones. This input amplifier is also controlled by an a.g.c. voltage which reduces the effects of variations in signal amplitude thereby minimising distortion. After filtering, each tone is again amplified before being fed to a demodulator and assessor. The balanced outputs from the assessor circuits are fed to a common channel where the resultant waveform is shaped and d.c. restored. An additional output from the demodulator is fed to a muting circuit in the control unit which opens the receiver unit output gate. The d.c. restored rectangular waveform gates the output of a 1000 Hz oscillator to provide the keyed 1000 Hz tone which is matched to the line output by an emitter-follower and isolating transformer.

c. CONTROL UNIT. The control unit provides the necessary control voltages to the transmitter unit input and output gates and to the receiver unit output gate to close either path for automatic operation. The unit can be manually controlled by the TX/RX/AUTO switch on the front panel. With the switch in the AUTO position, the equipment may be in any one of the following three conditions:

Condition 1 – Transmitting and receiving paths opened.

Condition 2 – Transmitting path closed and receiving path opened.

Condition 3 – Standby.

Necessary control voltages to effect the circuit changes are developed by sending the incoming signals in the transmitter unit or receiver unit input paths. These voltages then operate electronic 'gates' as follows.

Condition 1. Exists when signals on the transmitter unit input line are sensed before signals on the receiver unit input line. Control voltages open up the transmitter output gate, then bias the sequence gate to the transmit position. Signals arriving on the receiver line (such as sidetone) will, after this operation be able to pass straight through without causing the control unit to induce condition 2.

After transmission has ceased, a 3 second delay circuit operates which ensures that the transmitter path remains open for this period. If immediate reception is desired, the 3 second delay circuit can be over-ridden by pressing the '3 SECOND OVER-RIDE' switch at the remote position. When the 'cancel delay' circuit has been operated, it is impossible to re-commence transmission within the normal 3 second period.

Condition 2. Exists when signals on the receiver unit input line are sensed before signals on the transmitter unit input line. The control voltages close the transmitter input gate, thereby closing the transmitter unit input path.

Condition 3. Exists when signals are absent from either the transmitter unit or receiver unit input paths. The control voltages produced will close both the transmitter unit and receiver unit output gates but will open the transmitter unit input gate. This means that both transmitter unit and receiver unit input paths are opened ready to accept and sense signals to recreate either Condition 1 or Condition 2. The receiver output gate is closed to prevent unwanted signals operating the teleprinter and this is operated by a muting circuit which prevents random noise opening up the receiver unit output gate. A muting control (RV5) inside the unit, permits the degree of muting to be varied, should this prove necessary.

d. MANUAL OPERATION

TX Position. With the TX/RX/AUTO switch in this position, only condition 1 can exist.
RX Position. With the TX/RX/AUTO switch in this position, only condition 2 can exist.
In both the above positions, biasing voltages are applied to the input of the control unit and will operate the gates described as for conditions 1 or 2 regardless of the signal state on either the transmitter unit or receiver unit input paths.

e. SENSING POINTS. The transmitter unit is sensed for input signals at the 'A' detector. If present, they are fed via the 3 second delay circuit to a transmit/receive sequence gate. The receiver unit is sensed for input signals at both the 'A' and 'Z' detectors. If present they will also be fed to the transmit/receive gate which will close the transmitter unit input gate whenever the receiver unit is operating.

f. LAMP INDICATIONS. Amplifiers in the control unit provide outputs to operate local and remote 'transmit' and 'receive' indicator lamps. When switched to 'AUTO' the lamps will show whether the set is accepting transmit or receive signals or is in the standby condition.

3. Operating Instructions

1. Switch METERING switch to Position 2.
2. Switch TX/RX/AUTO switch to AUTO.
3. Switch RATT/MORSE switch to RATT.
4. Switch CHANNEL SWITCH to either CHANNEL 1 for 200 Hz shift or CHANNEL 2 for 850 Hz shift.
5. Switch EQUIPMENT switch to ON.
6. Unscrew the four knurled fastening screws retaining the drawer to the case and withdraw the chassis five or six inches to obtain access to the controls on the top front panel.
7. Set RX INPUT control fully anti-clockwise. Meter should read 28 μA. If not, adjust the radio receiver gain control until this figure is obtained.
8. Switch METERING switch to position 7.
9. Turn MUTING control (screwdriver slot) anti-clockwise until meter reads 70μA.
10. Adjust RX INPUT control to give a meter reading 10μA (5 divisions) lower than the reading obtained in 9 above.
11. Switch METERING switch to position 12.

12. Adjust MUTING control to give a meter reading of ZERO. (Occasional noise bursts may cause a reading of up to 10μA).

13. Switch METERING switch to position 6.

14. Switch ADJUST TX OUTPUT key to 'ACTIVE A' and adjust TX OUTPUT 'A' control to give a reading of 25μA on the meter.

15. Switch ADJUST TX OUTPUT key to 'Z INACTIVE' and adjust TX OUTPUT 'Z' control to give a reading of 25μA on the meter.
The equipment is now set up ready for automatic working.

16. Push cabinet home, fasten knurled retaining screws.

Note: 1. For Transmission only, switch TX/RX/AUTO switch to TX.

2. For Reception only, switch TX/RX/AUTO switch to RX.

4. **Standard Settings.** The principle feature of the TTVF(T) as far as the operator is concerned is his ability to arrange for the tone oscillators and filters to be placed in either the A or Z channels of the receive and transmit units. It is explained in Section 9.3 that the philosophy for setting up RATT terminals is always to use the Upper sideband of the associated receiver or transmitter. This means that if the FST circuit on which watch is to be set is Arrangement 1, the higher tone oscillators and filters (700 Hz and 2125 Hz) must be placed in the A channel in both transmit and receive units of the TTVF(T). When so set up, the TTVF(T) should be clearly marked on the front panel with 'ARRANGEMENT 1 USB STANDARD'. It cannot then be used in error on an Arrangement 2 FST circuit for an A2 RATT circuit.

If, on the other hand, the FST circuit on which watch is to be set is Arrangement 2, or if it is an A2 RATT circuit, the higher tone oscillators and filters must be set up in the Z channel of each receiver and transmitter unit of the TTVF(T). In this case the TTVF(T) must be clearly marked 'ARRANGEMENT 2 USB STANDARD/A2 RATT'. In a ship which has nine TTVFs(T) one would expect to find about 6 marked 'ARRANGEMENT 1 USB STANDARD' and 3 marked 'ARRANGEMENT 2 USB/A2 RATT'. The actual numbers set to each, would, of course, depend on circumstances and may well have to be varied during a commission. The full setting up drill in the handbook would have to follow an alteration of oscillators and filters.

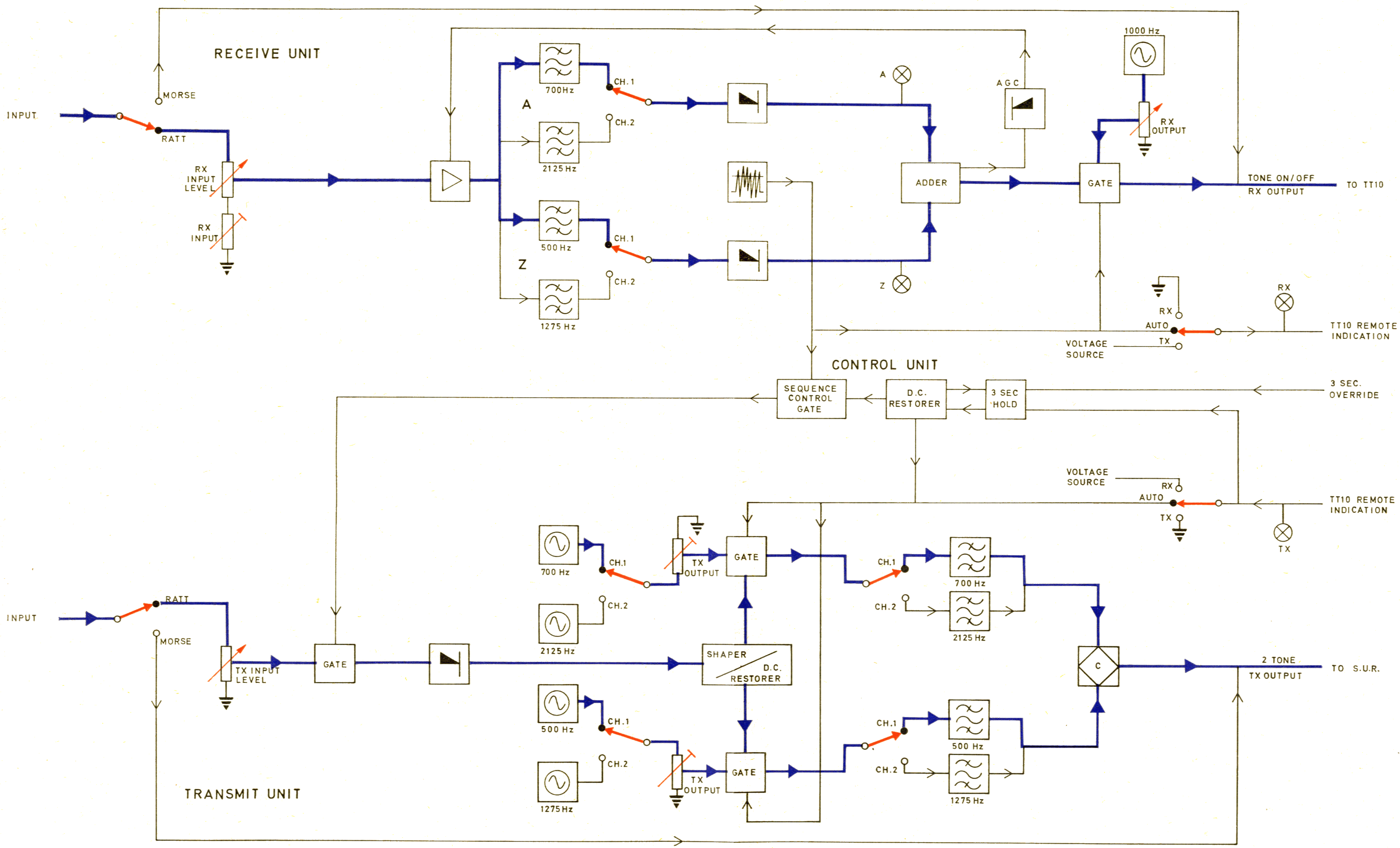


FIG. 2. TTVF(T)—BLOCK DIAGRAM

10–3–24A

SWITCH UNIT RADIO

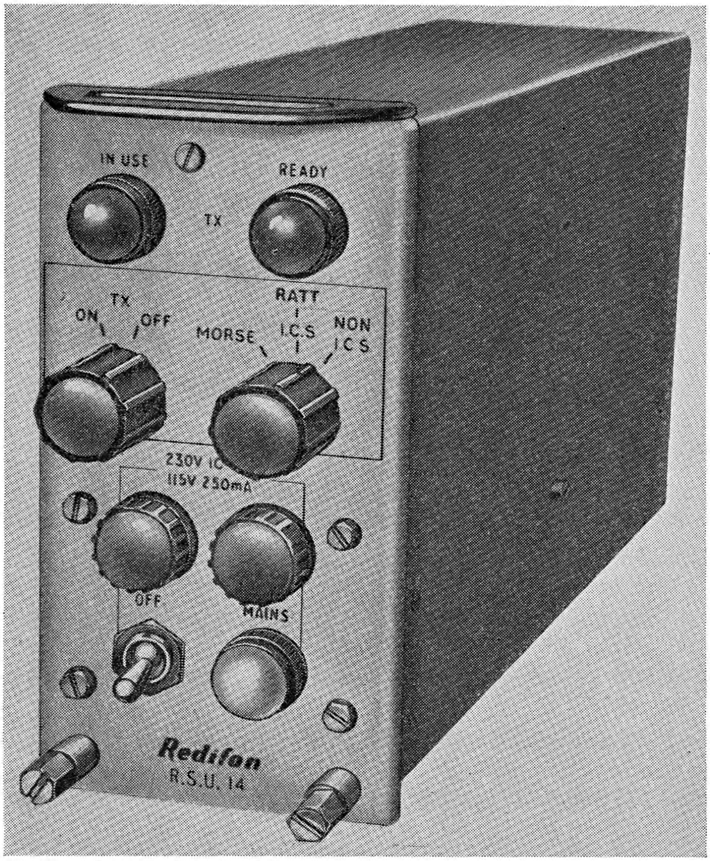


FIG. 1

1. **Introduction.** The Switch Unit Radio is used in RWA tactical RATT circuits requiring both receive and transmit facilities. It forms the junction between the terminal equipment and the communication circuit and is normally terminated at a Control Circuit Exchange lower plug.

The primary function of the SUR is to provide transmitter control. When a transmission is initiated by the teleprinter or auto transmitter, the two-tone output from the TTVF(T) is fed to the transmitter through the SUR. Having detected the outgoing two-tone signal by the START element which precedes the first Keyboard/Autohead character, the SUR produces d.c. pulses which are amplified sufficiently to operate relays connected to the transmitter control circuits thereby switching them to the transmit condition.

2. **Brief Circuit Description**

a. The incoming signal from the TTVF(T) is fed from the input plug (PL62) to a coupling transformer from whence it is passed to an isolating line buffer stage, followed by two stages of amplification. The output of the second amplifier stage is transformer coupled to a rectifier stage, resulting in the a.c. input pulse being converted to a negative d.c. pulse at the output of the associated filter. Automatic gain control voltage is also taken from this point and applied to the input circuits to control the signal about a reference level of approximately $2\frac{1}{2}$ volts d.c.

Any change in negative voltage between the d.c. pulse and this reference level is amplified by the d.c. difference amplifier, thereby causing the Schmitt trigger circuit to conduct. The input voltage to make this trigger change its state is known as the trigger level. The trigger is followed by a relay driver stage which conducts only when the input level exceeds the trigger level, causing the relay coils RLA and RLB to become energised.

The secondary winding of the input transformer provides a 600-ohm output to the output plug (PL41) pins D and E whenever the transmitter is switched to RATT and contact RLA1 is closed. A line from the input plug, pins A and B provides a signal path straight through the unit for reception whether or not the unit is energised.

b. Power Supply. The mains trànsformer is tapped for either 115 or 230V 50/60 Hz supplies by means of a link changeover. Two transformer input fuses are provided with lamp indication that 24 volts a.c. is available in the secondary of the transformer circuit.

3. **Operation**

a. The overall operation of the unit is as follows:

(1) Transmitter OFF. SUR switched to MORSE, RATT ICS or RATT NON-ICS. Output plug 41, pins D–E, C–F, C–G and C–H all open.

(2) Transmitter ON. SUR switched to MORSE. With a keyed on-off 1000 Hz tone input, a circuit is made from C–H on Plug 41. Pins C–G and D–E are open whilst pins C–F are closed.

(3) Transmitter ON. SUR switched to RATT ICS.
With a steady single tone or on-off two-tone input signal in the frequency range 300 Hz to 3100 Hz, circuits between pins D–E and C–G of plug PL41 close within a period of 10mS after the start of the signal. When the tone input has ended, the circuit associated with pins C–G opens at least 5mS before that associated with pins D–E. Pins C–H are open regardless of input condition whilst pins C–F are closed.

(4) Transmitter ON. SUR switched to RATT NON ICS.
With a steady single tone or on-off two-tone input signal in the frequency range 300 Hz to 3100 Hz, circuits between pins D–E and C–G close within 10mS after the commencement of the signal. The connection between pins D–E open circuits within 20mS after its finish.
The circuit between pins C–G opens at least 5mS before that between pins D–E whilst that between pins C–F is closed whether there is an input signal or not.

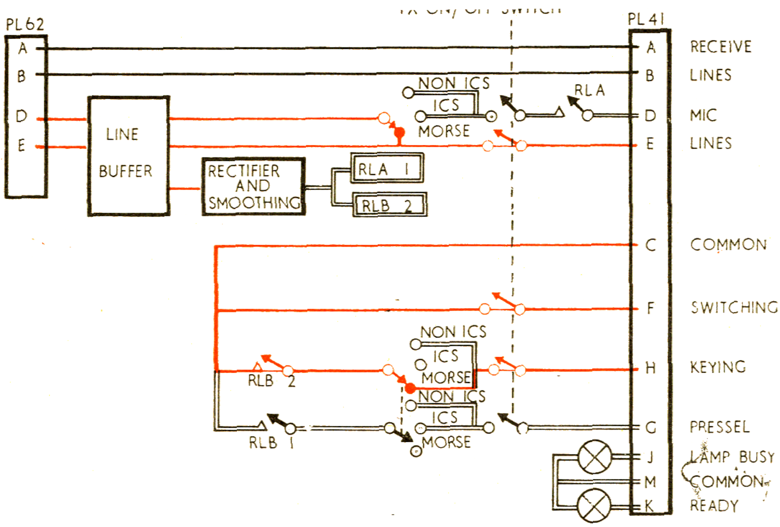


FIG. 2. SWITCH UNIT RADIO
SWITCHED TO MORSE

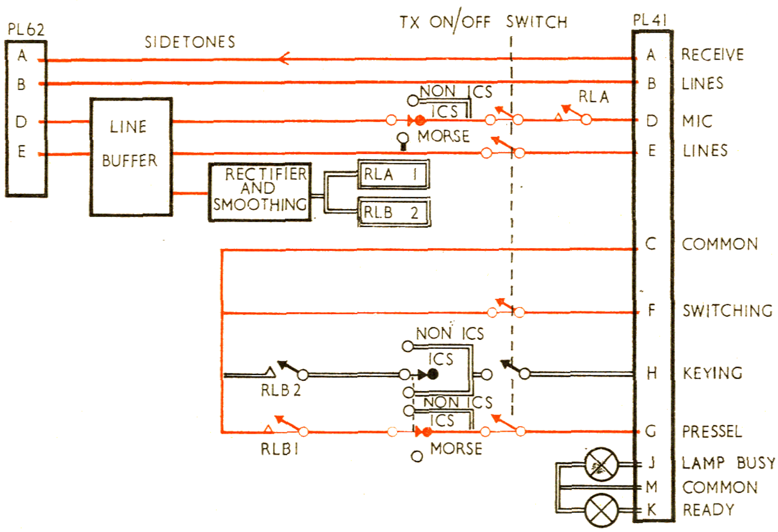


FIG. 3. SWITCH UNIT RADIO
SWITCHED TO ICS RATT
(Note) Type 640 Included

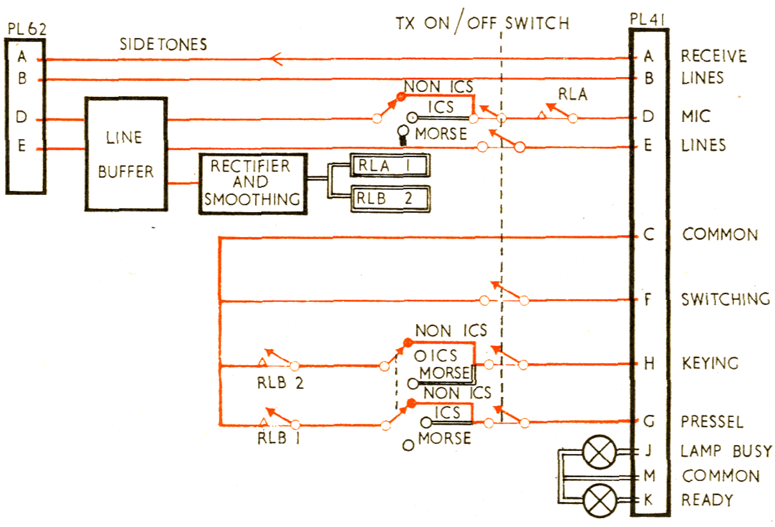


FIG. 4. SWITCH UNIT RADIO
SWITCHED TO NON ICS RATT
(Note) Old Equipment require Morse
Line made in addition to Pressel Line

SECTION 11

INTEGRATED COMMUNICATIONS SYSTEM

11.1. INTRODUCTION TO INTEGRATED COMMUNICATIONS SYSTEM

1. References

a. Handbooks.

B.R. 2362	WBA
B.R. 2363	ETA
B.R. 2368	Victorious System
B.R. 2385 (1)	TDA
B.R. 2386	Eagle System
B.R. 2387	Leander System
B.R. 2388	Valiant System
B.R. 2389	WBB
B.R. 2390	FSA (1) and (2)
B.R. 2391	Receiver Aerial System
B.R. 2407 (1)	CJD
B.R. 2414 (1)	CJA/CJC
B.R. 2420	Transmitter Aerial System
B.R. 2440	Spectrum Analyser
B.R. 2445	FSA (3)
B.R. 2471	Assault Ship system
B.R. 2529 (1)	KMM with Large Desk
B.R. 2529 (2)	KMM with Small Desk
B.R. 2529 (3)	Desk Units
B.R. 2529 (4)	Remote Units KMM
B.R. 2530	KMP
B.R 2526	ETB
B.R.2301	Series- Interphones

b. General.

Collins Handbook on S.S.B. and Multiplex.

2. **Requirements.** The need for an integrated system became clear in the middle 1950s. The reasons for having a new Communications System were obvious since at that time all our HF and MF equipment was outdated and unable to accept modern types of modulation. The control of HF/MF and UHF equipment was not integrated and the layout of ships with Transmitters divorced from the Main Office was inefficient. In addition each transmitter had its own aerial and the r.f. was fed from the transmitter to the aerial through a large trunk system.

a. The initial detailed requirement was for a complete Communications System covering the whole frequency range of MF to UHF. However this was considered to be too costly and so the existing UHF fitting programme was allowed to continue and the I.C.S. became related to HF and MF frequencies.

b. It was decided that the new I.C.S. should provide stable, accurate equipment using the most modern techniques so that any new form of modulation for the passing of information might be used. For example, s.s.b. Voice, i.s.b., Multi-channelling, Data Links, etc. The most important single factor being the stability, and frequency accuracy, necessary to improve Voice Communications in the HF Band using s.s.b. techniques.

c. At the time when design was started it was not considered advisable for the equipment to be completely transistorized and so much is built around miniaturized valve circuits with the result that it is rather large and requires forced ventilation.

3. **Facilities and Capabilities.** The system was built around the following points:

a. The use of s.s.b. techniques.

b. Broad-band transmitting aerials using suitable parts of the ship's superstructure as aerials.

c. A transmitter common aerial working (CAW) System so that several transmitters on different radio frequencies can use the same broad-band aerial simultaneously.

d. The use of some form of aerial selection for reception of HF transmission using the sky wave mode of propagation.

e. The provision in each ship of an accurate and stable frequency source from which the radio frequencies for the transmitters and receivers can be derived.

f. The provision of a central control and monitoring system.

It was clear that the change-over to the new equipment would take a number of years to complete. In the meantime ships fitted with the new equipment must be capable of working with ships fitted with conventional equipment. Under these circumstances it must be accepted that the performance of the new system might be limited and that some of the facilities built into it would not be used immediately.

4. **Frequency Range** ETB-240kHz-3MHz, ETA-1.5 MHz-3 MHz

MF – Transmission	– ~~240 kc/s–1·5 Mc/s~~	HF – Transmission	– 1·5 Mc/s–24 Mc/s
Reception	– 10 kc/s–200 kc/s	Reception	– 2 Mc/s–30 Mc/s

There is a gap in reception between 200 kc/s and 2 Mc/s. A temporary solution to this problem is the provision of s.s.b. Adaptor outfit FAZ for the B40/41 which will give the receivers an s.s.b. capability with increased stability.

5. **Power Output.** 1 kW on HF and 500 W on MF. This can be reduced if desired. Where Triple Drive equipment is fitted, the power output on equipment using this facility is reduced to 110 W per line.

6. **Types of Emissions**

a. Voice (d.s.b., i.s.b., s.s.b. with suppressed or partial carrier).

b. F.S.T. (using tones on s.s.b. s.c.).

c. CW and MCW.

d. Multi-channelling.

e. i.s.b.

f. Data Links.

g. Use of up to three drive units on one amplifier for low power circuits.

7. **Fitting Scales.** The detailed scales are given in current D.C.I.s. Regardless of the number of lines provided, the actual equipment necessary, or employed for any one line is identical. For example, a submarine's I.C.S. transmitter is the same as an aircraft carrier's. The advantages of equipment standardisation are obvious.

8. **Layouts.** The aerials in the I.C.S. are fed by coaxial feeders, since base tuned, or broad-band aerials are used, consequently the layout can be arranged so that all the offices are close to each other and low down in the ship.

a. In an I.C.S. ship there is a Main Communication Office (MCO) adjacent to the Operations Room, a Communication Control Room (CCR) next to the MCO which is subdivided to provide a Transmitter Annex for the Power Amplification equipment. UHF equipment is sited in a separate office.

b. The MCO contains terminal equipment for broadcast reception, ship-shore and attended reception.

c. The CCR contains all the low power equipment, e.g. Receiver Aerial exchange, Receivers, transmitter drive units, Control and Monitoring desk, frequency standard (in UHF Room in Leanders) and the main control outfit KMM distribution CCX.

d. The CCR Transmitter Annex is screened from the remainder of the compartment and contains all the Wide Band Amplifiers, TX Aerial Exchange and filter units.

e. The great advantage of I.C.S. is that all facilities can be controlled from one place, i.e. the Control and Monitoring Desk in the CCR. The Desk is normally manned on a 24–hour basis by Communications Ratings.

9. **Control Facilities.** The system for remoting equipment to a user is very similar to the conventional KH Control Outfits and is called Control Outfit KMM. The plugging arrangements are almost identical to KH, CCX Upper and Lowers.

Remote signal positions are provided with two types of facilities for control of a circuit.

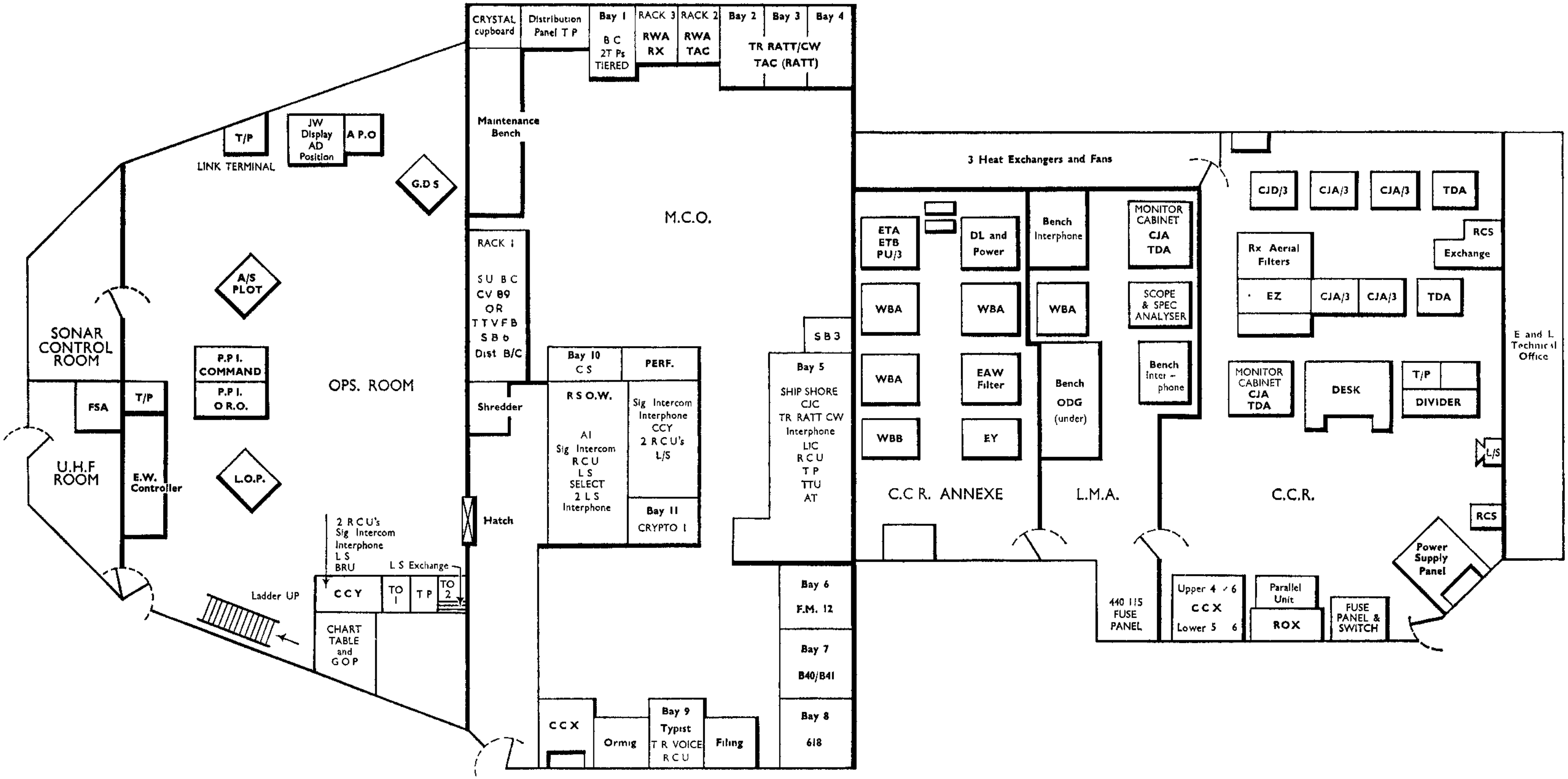


FIG. 1. I.C.S. COMMUNICATIONS OFFICES LAYOUT IN LEANDER CLASS

a. The Radio Control Unit, which replaces the Design 5 Control Unit, provides a signal operator with the usual facilities, e.g. keying, switching, lamp ready, etc., with an Intercom between RCU's and the Control Desk. This intercom is always available regardless of whether the particular position is connected to another by KMM. The Operator has a split earphone arrangement – one ear for the intercom and the other for the Radio Channel, when using the intercom facility.

b. A Standard Composite Communication Unit (CCU) is provided at all positions and gives the operator selection of a channel, loudspeaker or Interphone, etc. The CCUs are identical in principle to those already fitted around the Fleet, details of which are given in the *Control Outfit Handbook* BR1192 (1) Chapter 1 Section 3.

Remote positions for Information Circuits, e.g. ORO, are provided with a more sophisticated arrangement of CCU Trays giving the necessary facilities such as RCS, Interphone and circuit, selection, etc.

10. LIST OF EQUIPMENT IN AN I.C.S. INSTALLATION

Transmission

Outfit TDA. – HF and MF Drive Unit with frequency synthesizer in which frequency and type of emission are selected. Provides a 25 milliwatt output of r.f. which is then fed to a WBA/B. A Control Unit in the C & M Desk (TCU) can attenuate the output remotely.

Outfit WBA. – HF Wide Band Amplifier which increases the power of the output from the drive unit from 25 milliwatts to 1 kW or less, depending on the attenuation in the output from the TDA.

Outfit WBB. – Wide Band Amplifier modified to cover HF and MF frequencies (similar to WBA) with ~~output of 500 watts~~. output of up to 500 Watts on MF, 1000 Watts on HF.

Outfit EY (1) *or* (2). – TRANSMITTER AERIAL EXCHANGE. (1) is for large ships and (2) for small ships. It is sited in the TX Annex and is a 6 ft cabinet. Designed to allow for flexibility between WBAs and Aerials.

Outfit EAW (1–3). – Transmitter Common Aerial System similar to that in the 'TIGER' Cruisers. (1) for Carriers, (2) Assault ships and (3) for DLG and Leanders. EAW consists of various items of equipment:

a. Filter Units for feeding the output from WBAs to a broad band aerial structure such as the mast.

b. Bus bars for connecting the filters to the coaxial feeder to the aerial matching transformers at the base of the aerial feeder.

c. HF and MF Base Tuners for individual aerials. HF Base Tuner – Outfit ETA (1) used with an AWF Whip or Wire. MF Base Tuner – Outfit ETB used with a wire aerial. The Base Tuners are tuned from the C & M Desk.

d. A dummy load is provided for tuning, Broadband CAW only

Note. One HF line consists of a TDA and WBA which are permanently wired together.

11. Reception

The receiver aerials are normally conventional AWN whips. These are connected to an exchange by coaxial feeder. A degree of space diversity is achieved.

a. Outfit EZ. – Receiver Aerial Exchange which enables any receiving aerial to be connected to any receiver using CAW.

b. Receiver Output Exchange. – Gives flexibility in pairing an HF Receiver and an HF Transmitter.

c. Outfit CJA. – HF Receiver with synthesizer for unattended operation.

d. Outfit CJC. – HF general purpose receiver for attended operation in the MCO. (A CJA without the synthesizer).

e. Outfit CJD. – ~~MF~~ LF receiver for unattended use. CJD (1) is a single receiver and CJD (2) is a standard cabinet housing five receivers.

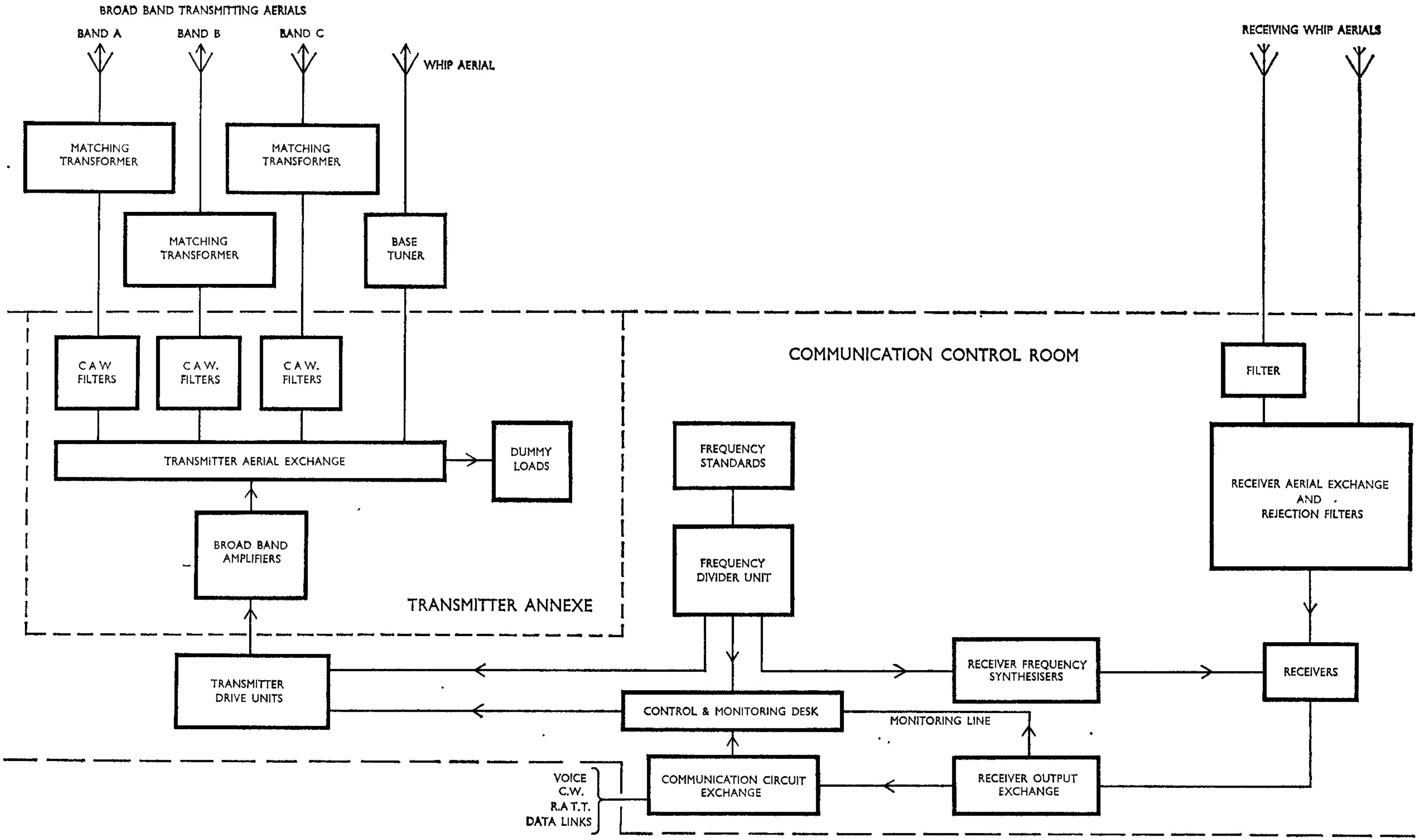


FIG. 2. BLOCK DIAGRAM OF AN I.C.S. INSTALLATION (A.F. AND R.F. CIRCUITS ONLY)

12. **Frequency Standard Outfit FSA.** The frequency standard provides a stable frequency output from which all circuits can be given the equivalent stability and accuracy. It is accurate to ±1 part in 10 to the ninth power. Facilities exist for the comparison between the three separate crystal outputs and for the checking of the accuracy of any one with a known accurate VLF transmission.

a. Outfit FSA has three variants:

Outfit FSA (1) – For Standard 3 ships with full I.C.S.

Outfit FSA (2) – For submarines fitted with I.C.S.

Outfit FSA (3) – For Standard 3 (mixed) ships (those with part I.C.S. and part COMIST equipment).

b. Outfit FSA. The outfit has two main components:

(1) Central Frequency Standard which is a cabinet containing three 1 Mc/s crystal oscillator units each providing a separate output of 100 kc/s, an Auto Control Panel for power supplies, a VLF check receiver and frequency comparison unit. Normally sited in the CCR but in the UHF room of Leanders.

(2) Frequency Divider Unit which is a cabinet sited next to the C & M Desk containing decade dividers whose outputs are fed to the C & M Desk and Synthesizers.

13. **Control and Monitoring Desk (C & M).** This is the focal point of the system. It provides for the remote control and tuning of the equipment in a central position and for monitoring any particular Radio Channel. Checks on the functioning of the system can be carried out while the system is in use. Each MF/HF transmission line is controlled through a Transmitter Control Unit in the Desk. Monitoring of any line is done at the Desk. Tuning of Filters, and Base Tuners, etc; intercommunication between other offices and signal user positions is provided. Main exchange telephone and I.C.S. clock are also fitted.

14. **Control Outfit KMM** – Contains many minor items but in general closely resembles the KH control system.

There are ~~three~~ five types of Control Outfit KMM:

a. Control Outfit KMM (1) – Fitted in Carriers..

b. Control Outfit KMM (2) – Fitted in Assault Ships ~~and DLGs~~.

c. Control Outfit KMM (3) – Fitted in Frigates.

d. Control outfit KMM(5) - Fi
S.

e. Control outfit KMM(6) - Fitt

Control Outfit KMM is very similar to the KH control system and the distribution circuits and CCXs are almost identical except that a 12–pin line is used. In addition parallel keying and automatic relay facilities are provided.

15. **RATT Outfit RWA.** The RATT outfit associated with I.C.S. is outfit RWA which succeeds RATT 2 and is described in Section 10.

16. **Limitations of the System**

a. Transmitters on a common aerial must be outside 10 per cent frequency separation.

b. A receiver must be outside five per cent from the nearest transmitter.

c. Two receivers must be outside two per cent separation.

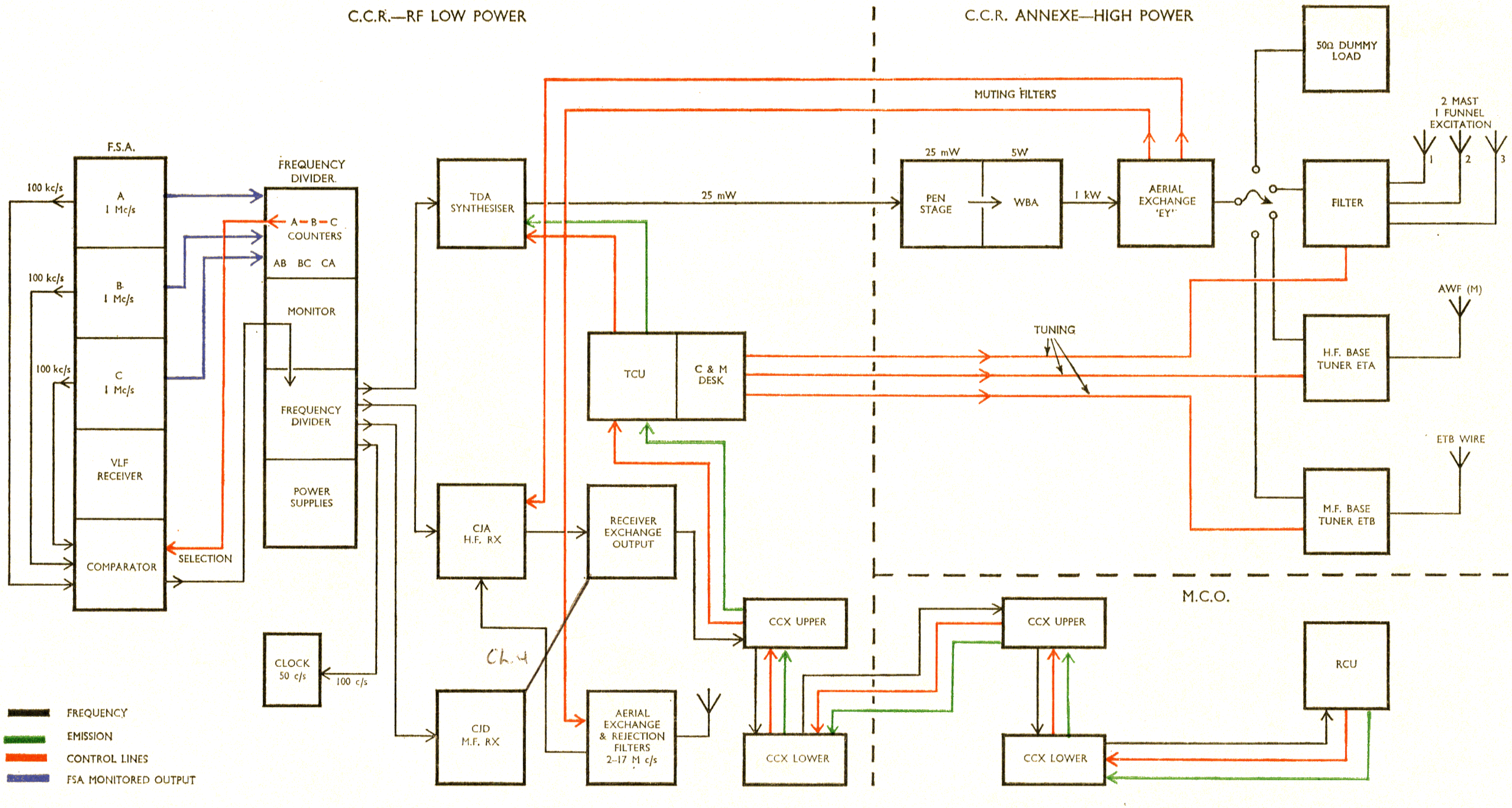


FIG. 3. I.C.S. LAYOUT

11.2. FREQUENCY STANDARD

FREQUENCY STANDARD OUTFIT FSA

1. **Function.** To provide a stable, accurate frequency standard for use in the I.C.S. as a basis for individual transmitter frequencies and receiver synthesizer frequencies.

2. **FSA.** (1). Three standard outfit with frequency monitoring and checking facilities fitted in frigates and above ship installations. Described in detail in this sub-section.

3. **FSA.** (2). Three standard outfit for use in submarines, is similar in functions to FSA(1) and differs only in output distribution from a special divider cabinet.

4. **FSA.** (3). Two standard outfit which provides a similar function for the part COMIST, part I.C.S. equipment of standard 3 (Mixed) ships.

5. **General Description FSA (1).** Three accurate and very stable frequency standards, one of which is selected to supply the system, the other two remaining available for manual selection or automatic selection in the event of the failure of the standard in use. No break power supplies are provided from a battery source with a six hour life. Battery float charge and recharge facilities ensure that the battery is always available. Frequency comparison between the standard in use and a selected submarine broadcast transmission provides a periodic check on the stability of the standard in use, whilst a continuous comparison between each of the three crystals provides a continuous cyclic presentation of relative stability. Distribution of the standard in use to individual equipments is effected at the Divider Cabinet, the main function of which is to produce the different values of frequency, all derived from the standard, which are required for various purposes.

The central frequency standard and the divider cabinet are the two main equipments involved, and need not necessarily be sited in the same compartment, but wherever fitted should be as free as possible from vibration and temperature fluctuations.

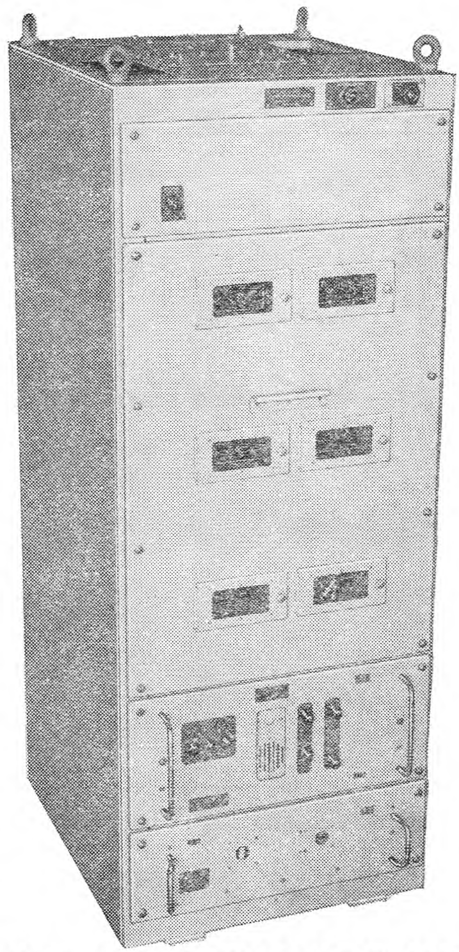


FIG. 1. THE FREQUENCY STANDARD

DETAILED DESCRIPTION

6. **Central Frequency Standard.** This contains the following sub units:

a. Three crystal units with associated ovens and maintaining circuits.

b. An auto control panel.

c. A frequency comparison unit.

d. A VLF monitor receiver.

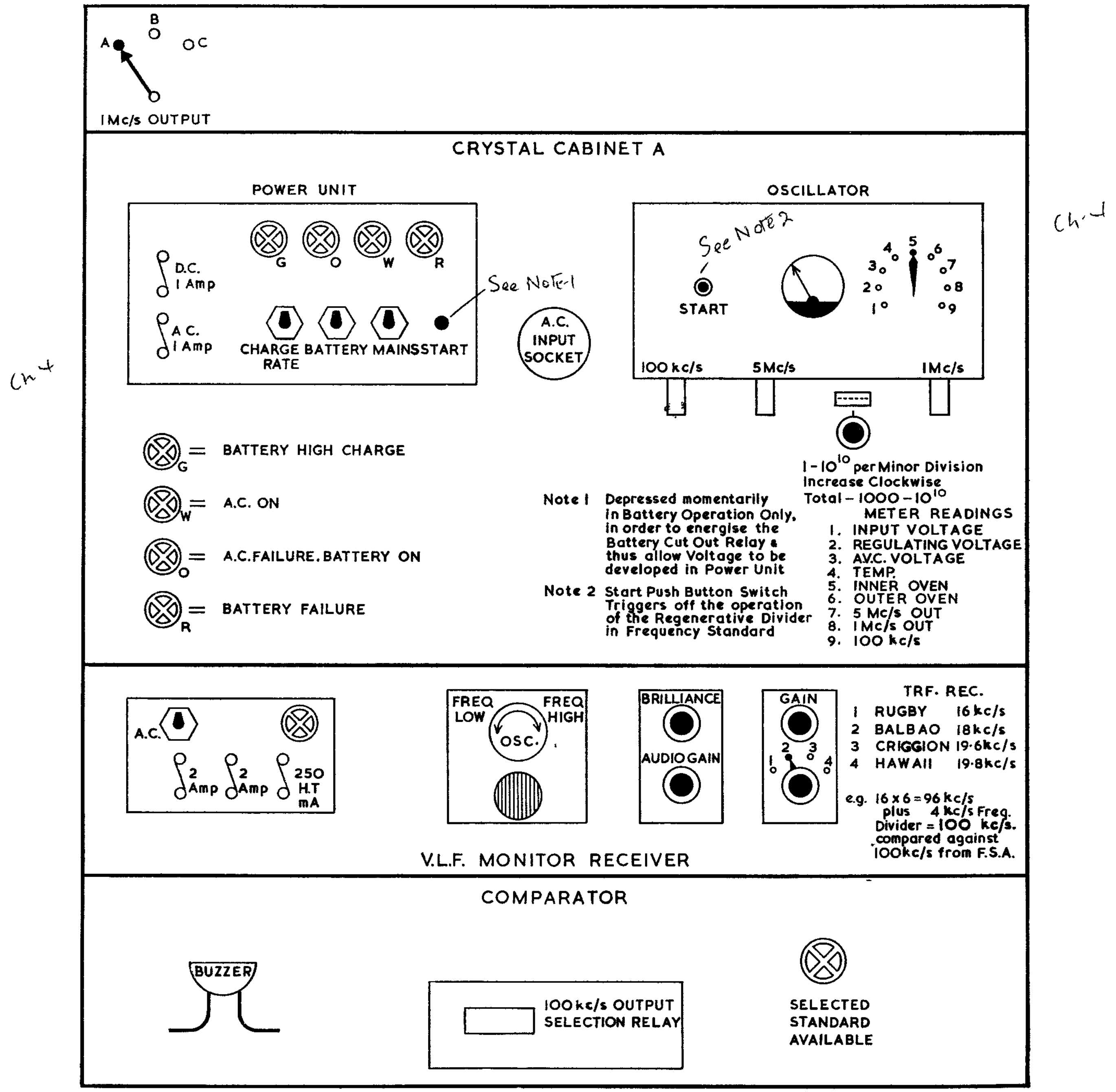


FIG. 2. CRYSTAL CABINET AND VLF MONITOR RECEIVER

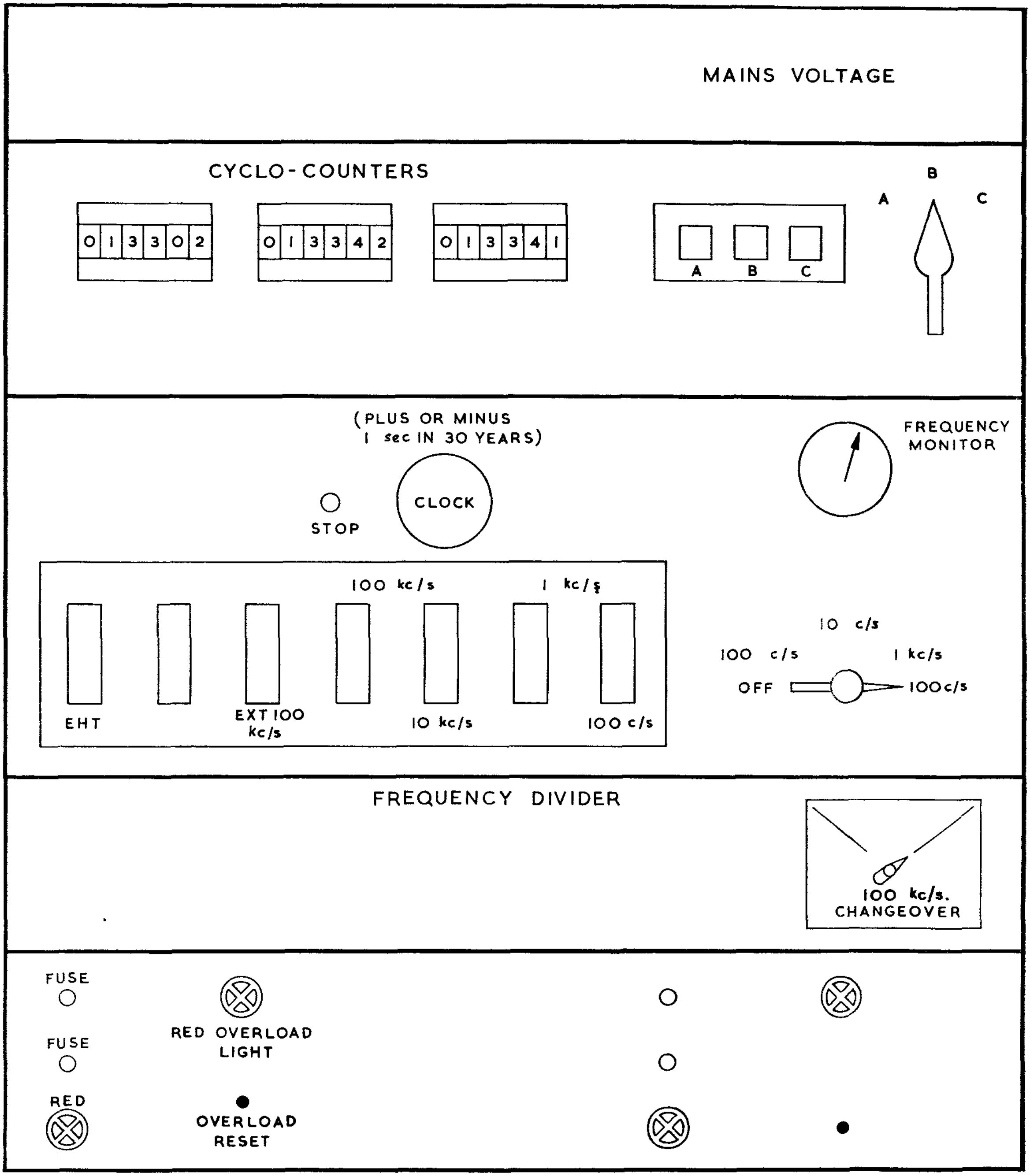


FIG. 3. DIVIDER CABINET

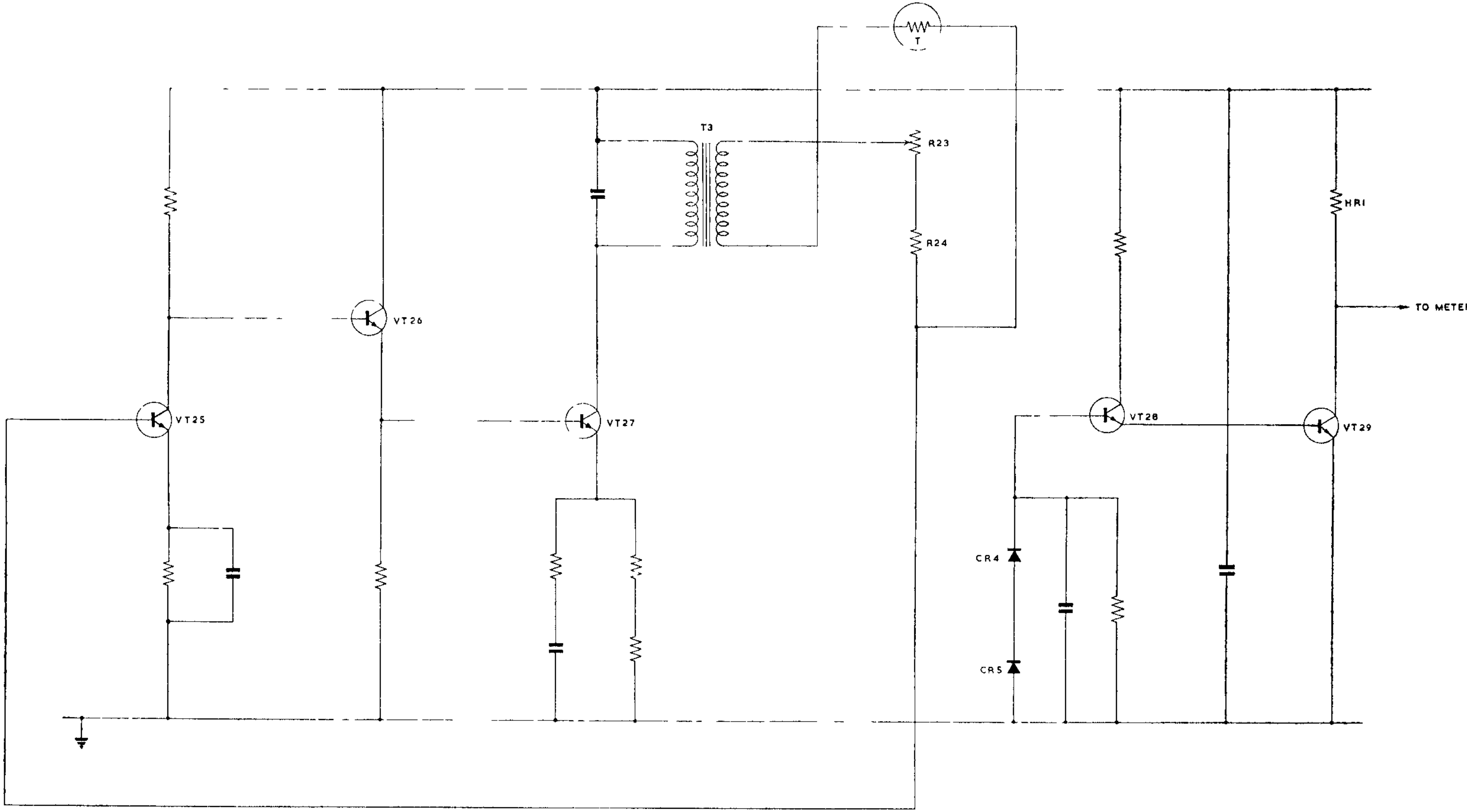


FIG. 4. INNER OVEN CONTROLLER

7. **Divider Cabinet.** This contains:

a. Mutal comparator cyclic counter.

b. Two divider units with automatic and manual change over.

c. Manual and automatic standard selection.

d. A 50 c/s clock.

e. Lamp and meter indication of outputs.

f. Power supply units.

8. **Crystal Units**

a. Three units, A, B and C, are fitted, but only one is used at a time, although all three are kept in operation to maintain accuracy and stability. Each crystal is manufactured of quartz and has an overall

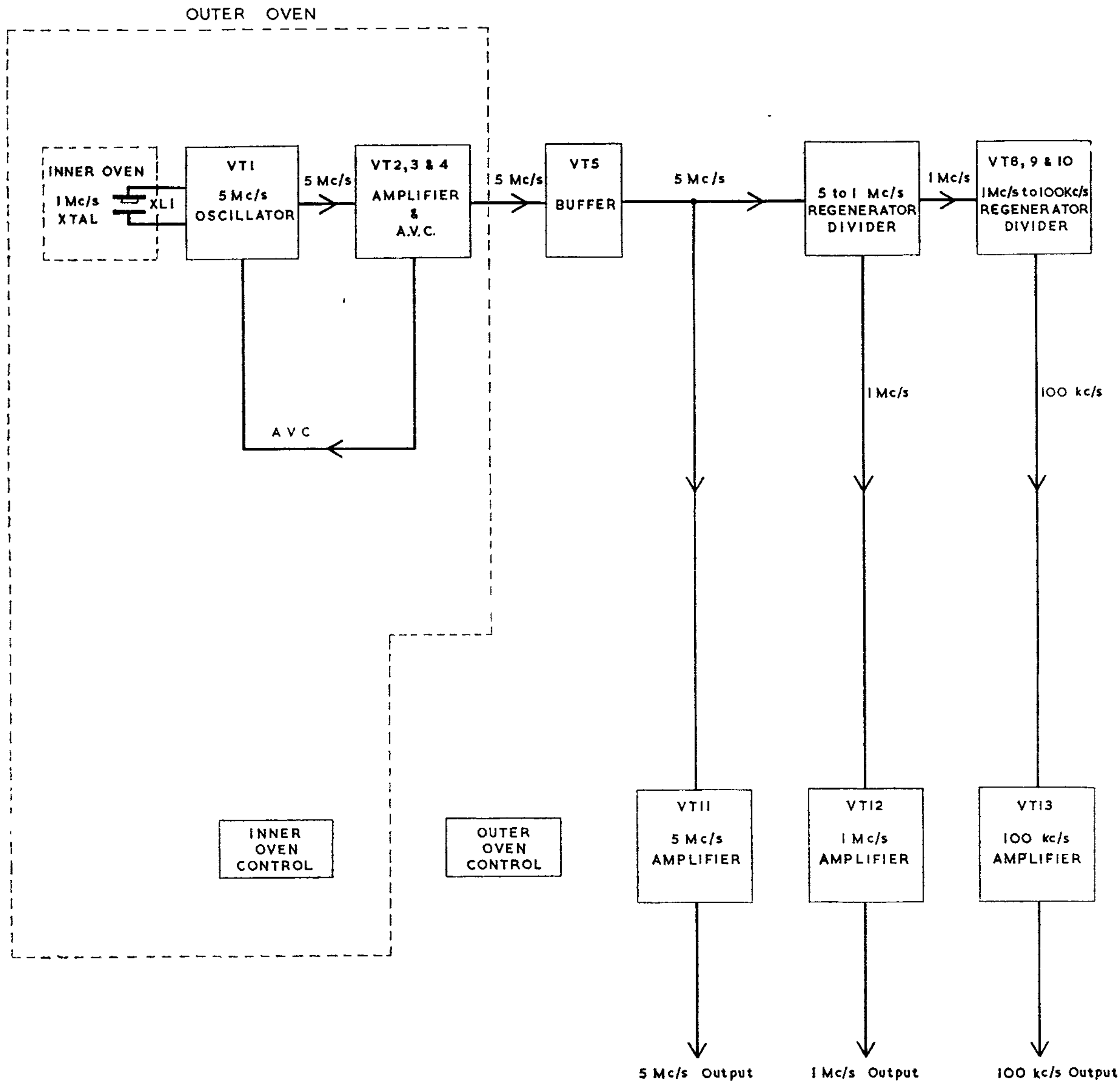


FIG. 5. FREQUENCY STANDARD TYPE MA 259

stability of 1 part in 10^9 and a short time accuracy of 1 part in 10^{10} per day. The crystal is contained in a temperature controlled oven at 75°C. It is designed to operate at 5 Mc/s which is the fifth overtone of its fundamental frequency.

b. The oven is operated at the so-called 'turning point' of the crystal unit. Operation here provides the minimum rate of change of frequency with temperature. ~~The temperature controller contains a 3-stage amplifier, Q5–Q7, which is tuned to a frequency of approximately 25 kc/s. Connected between the output and input of the amplifier is a bridge circuit which consists of the two halves of the secondary of~~

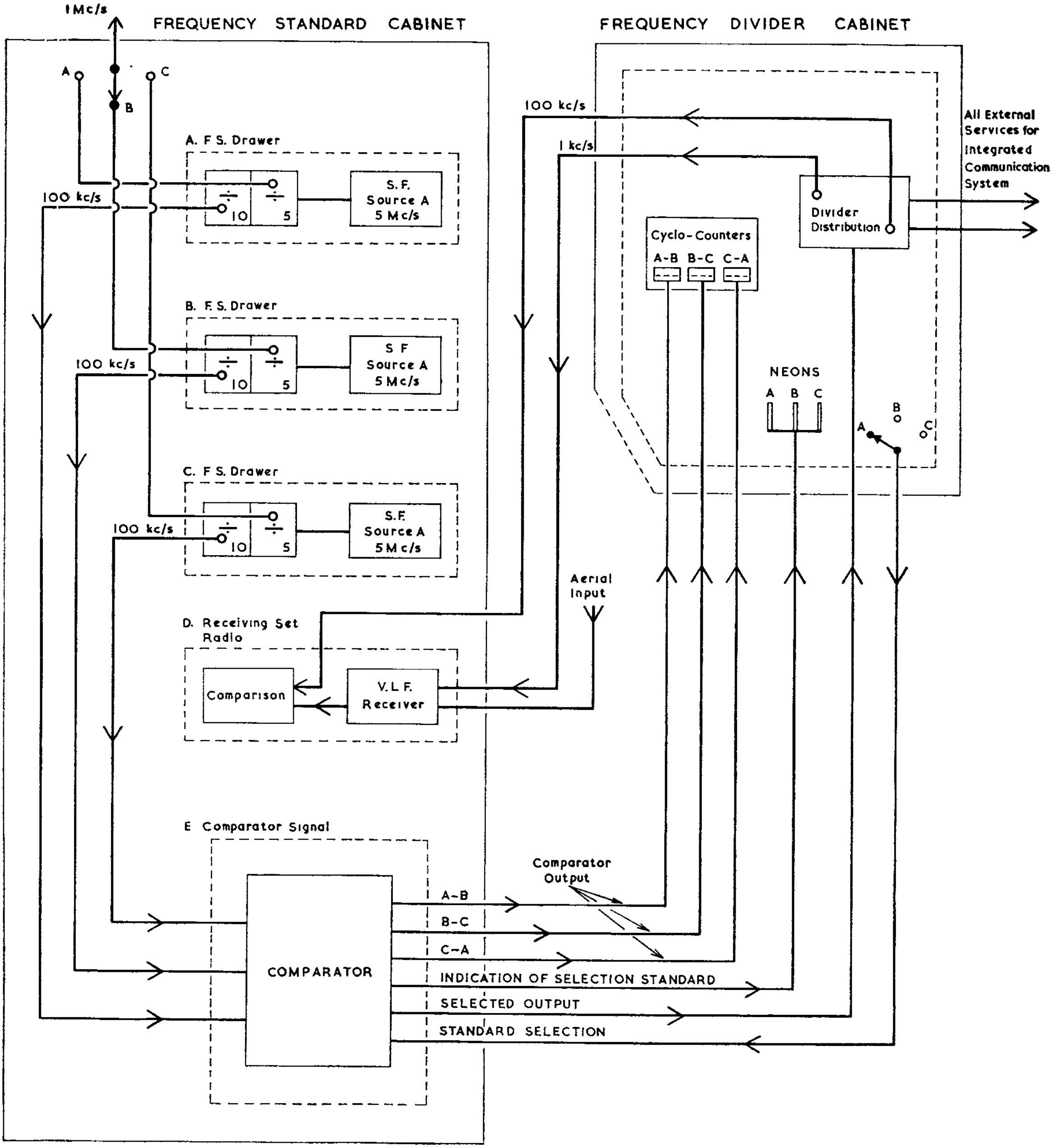


FIG. 6. F.S.A. AND DIVIDER

T3 ~~R23 and R24 in series and thermistor RT1. When the oven is below its operating temperature, the resistance of the thermistor is higher than its normal value, the bridge is in a state of unbalance, and positive feedback is permitted. The amplifier will then oscillate, driving rectifiers CR4 and CR5. The d.c. output current of these rectifiers is amplified by Q8 and Q9, and is used to heat the oven through resistor HR1, which is wound around the oven cylinder. As the oven heats, the thermistor resistance decreases, making the bridge approach a balance. This decreases the amount of positive feedback, the amplitude of the oscillation and the heater current. An equilibrium is finally reached at the point at which power supplied to the oven equals that which is needed to maintain the desired temperature. Any change in ambient temperature is largely offset by the action of the controller. As far as the inner oven is concerned~~, it ~~decreases the temperature variations within the outer oven by a factor of 600. Since the outer oven stability is better than 1°C, the inner oven temperature is constant to better than 1/600°C, which is adequate to produce the required frequency stability~~.

The inner oven contains the crystal unit and oscillator itself, the outer oven contains the inner oven as well as all of the other components of the oscillator and AVC systems. The outer oven controller is similar to the inner oven controller.

The AVC circuit is used to maintain oscillations at a constant level. The AVC amplifier output is amplified by the buffer stage and is further amplified by a 5 Mc/s amplifier – an output (not used) is available at 5 Mc/s on the unit front panel.

A regenerative divider carries out further division to 1 Mc/s (a one Mc/s output is available but is not used) and to 100 kc/s.

The unit has two external controls:

(1) a frequency dial (2) a start button.

The frequency dial has 1000 divisions which produces a frequency change of approx. 1×10^{10} per division. The crystal will age upward in frequency and when maximum amount of compensation is used on the dial, a coarse control can be adjusted to give a further maximum of 600×10^{9} or more. Even further adjustment can be achieved by increasing capacitance in the circuit. As the drift rate (ageing) will be regular, a regular amount of correction can be applied.

c. Start button – this activates the regenerative divider circuits.

d. Power Supply. The power supply unit delivers up to 500 mA at 27 V from a normal mains input. The power supply is arranged as 'no break'. If the mains input fails a battery unit will provide a power source for approximately 6 to 8 hours. The battery unit contains a cut-out which operates when the battery drops 6% below its normal value. Restoration of a.c. power automatically recharges the battery. The battery is normally charged at a 50 mA rate, but if the battery is thought to be more than 25% discharged, the battery can be given a high charging rate of approximately 150–200 mA. The battery is made up of maintenance-free sealed cells. If all power supplies are broken (mains and battery), on restoration a 48-hour period is required before the crystal will reach its stable operating point.

e. Controls and Lamps.

(1) MAINS ON/OFF SWITCH – applies mains to power unit.

(2) BATTERY HIGH CHARGE RATE SWITCH – applies high charge rate to battery.

(3) BATTERY ON/OFF SWITCH – (shrouded to prevent inadvertent operation) switches battery on or off (normally left on).

(4) START BUTTON – triggers circuit after mains have been restored (i.e. after battery operation).

(5) WHITE LAMP – a.c. on.

(6) AMBER LAMP – a.c. failure, battery on.

(7) RED LAMP – Battery failure.

(8) GREEN LAMP – Battery high charge rate.

9. Comparator Receiver

a. A frequency check can be made by comparing the 100 kc/s reference output of the standard in use with a signal from any one of four shore stations. The VLF receiver is pre-tuned to these stations, and selection of any station is by means of a four position switch. Frequency comparison is made in the comparator unit. Mutual comparison is also provided (each crystal is compared, one with the other). This mutual comparison is not a check of absolute frequency but gives an indication of relative frequency drift. The result of the mutual comparison is displayed on cyclic counters on the Divider Cabinet, the result of the frequency check being displayed on a CRT on the VLF receiver.

The receiver picks up transmission from one of four selected stations operating in the VLF band which are correct to within 1 part in 10^{10} over 24 hours. The frequency check is made at 100 kc/s but the transmitted frequencies are:

GBR Rugby 16 kc/s	GBZ Criggion 19·6 kc/s
NBA Balboa 18 kc/s	NPM Hawaii 19·8 kc/s

It is therefore necessary to synthesize the transmitted frequency up to 100 kc/s. This is done automatically by the operation of a four-position switch. The incoming signal is amplified and differentiated; the differentiated waveform includes harmonics of the input frequency and either the fifth or sixth harmonic is selected depending on the station being received. A 1 kc/s signal from the frequency divider, derived from the selected source of the frequency standard unit, is also fed to the receiver and the fundamental or a harmonic of this frequency (i.e. that frequency needed to make the harmonic of the transmitted frequency up to 100 kc/s) is used as the second input to the ring modulator; the resultant 100 kc/s is filtered to the radio comparator.

b. The 100 kc/s signal derived from the selected source of the frequency standard, feeds into a phase splitter which produces two 100 kc/s signals in quadrature. These signals are fed to the X and Y plates of the built in CRT. Under bright-up condition, with the grid modulation applied, a circular trace would appear on the screen. In fact, the cathode is maintained at a constant potential while the grid is held beyond cut off.

The 100 kc/s signal synthesized from the transmitted signal drives a blocking oscillator, the positive output pulses of which are applied to the grid of the CRT. The brilliance control is adjusted so that the peak of the pulses raises the grid potential above cut off and a portion of the circular trace is made visible on the screen.

c. If the transmitted frequency, when synthesized, and the frequency from the selected standard source are exactly the same, the portion of the trace made visible will continue to appear at the same position on the screen. If, on the other hand, there is a difference between the two frequencies, the spot will appear to rotate around the screen; the direction and speed of rotation indicating respectively whether the frequency of the standard source is higher or lower than the transmitted frequency, and the degree by which the frequencies differ.

d. The 100 kc/s synthesized signal also modulates the output of a 102 kc/s local oscillator to produce a 2 kc/s tone which feeds through an amplifier to a built-in loudspeaker so giving an aural indication when the standard frequency transmission is being received.

The results of this test, therefore, will indicate whether the periodic adjustments of the calibration control on the frequency source are keeping the source within the frequency stability specification, and so counteracting drift due to long term ageing.

Simple calculation can produce a stability figure; for example, as the check is being carried out at 100 kc/s and if one revolution of the spot takes 10 seconds, the frequency stability would be 1 part in 10^6. If the stability is to be 1 part in 10^9, one revolution must take 10,000 seconds ($2\frac{3}{4}$ hours approx.) a good estimation can be made by the timing of 45 degrees rotation only, the check then taking 21 minutes.

e. Doppler effect. In order to restrict errors caused by this it is important that:

(1) the check should take place with the ship stopped.

(2) a check should not be made when the ship is more than approximately 1000 miles from the transmitting station.

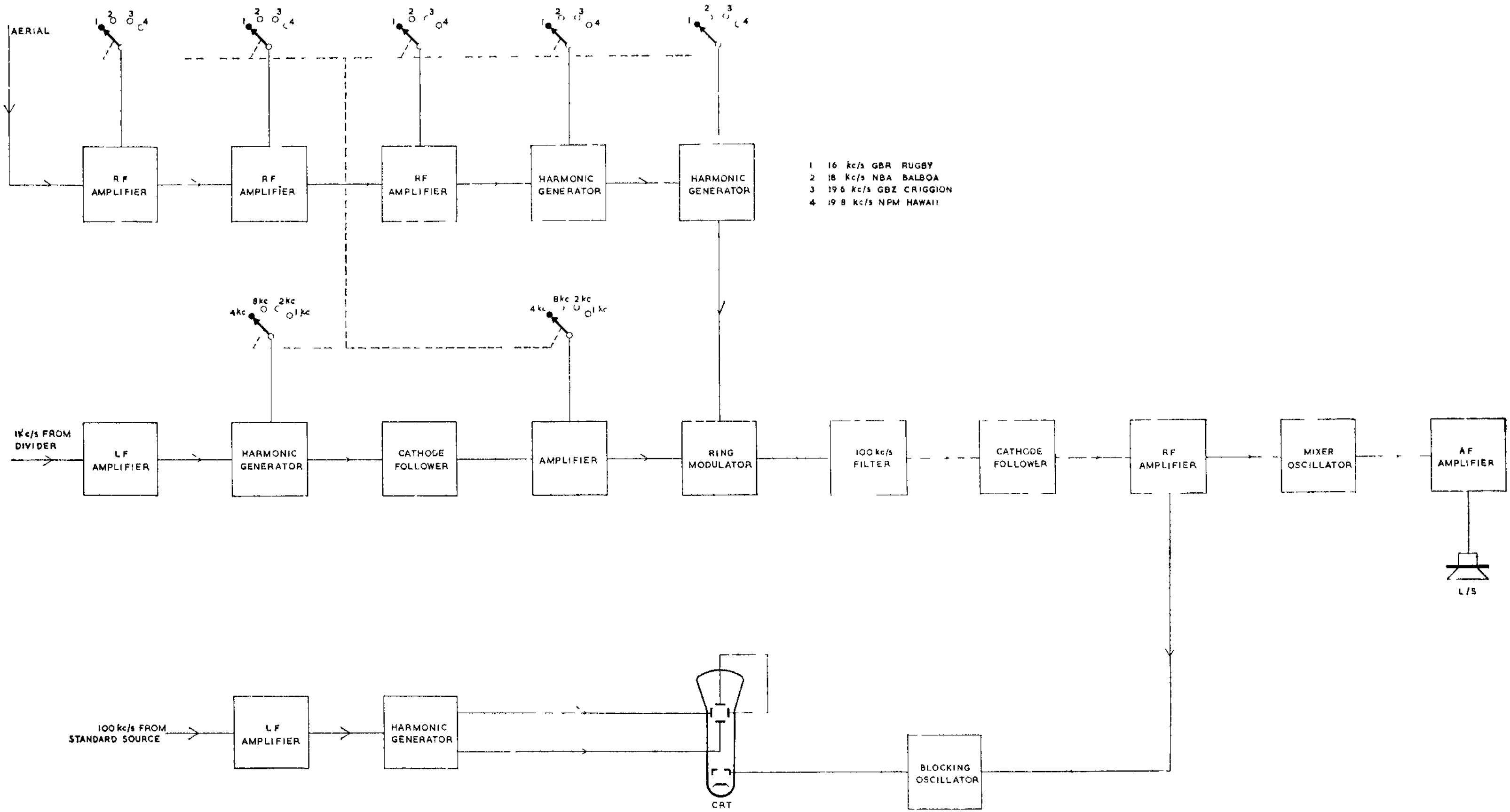


FIG. 7. VLF. RECEIVER AND COMPARATOR

10. **Divider.** The primary function is to provide a number of outputs of 100 kc/s, 10 kc/s, 1 kc/s and 100 c/s. These frequencies are a derived division from the 100 kc/s input of the frequency standard cabinet.

Additional functions are:

a. Manual selection of the preferred standard. Selection is achieved by switching one of three command voltages to the frequency standard. The automatic standard selection switching circuits operated by this command voltage are located in the frequency standard cabinet. If the selected standard should fail, automatic switching ensures that:

(1) The next standard in reverse alphabetical sequence is switched into circuit.

(2) An aural alarm sounds at the frequency standard cabinet. The alarm is cancelled by manually selecting the crystal which has been automatically selected. The crystal in use is indicated by a neon lamp.

b. A coarse check of frequency – accompanied by frequency counters. Crystal A is compared with B, B with C and C with A. Each comparison circuit is terminated by a cyclic counter which registers one count for each 360 degrees of phase rotation, thereby indicating the overall cyclic difference in frequency between pairs, i.e. if two pairs register a large count it is probable that one standard is drifting considerably.

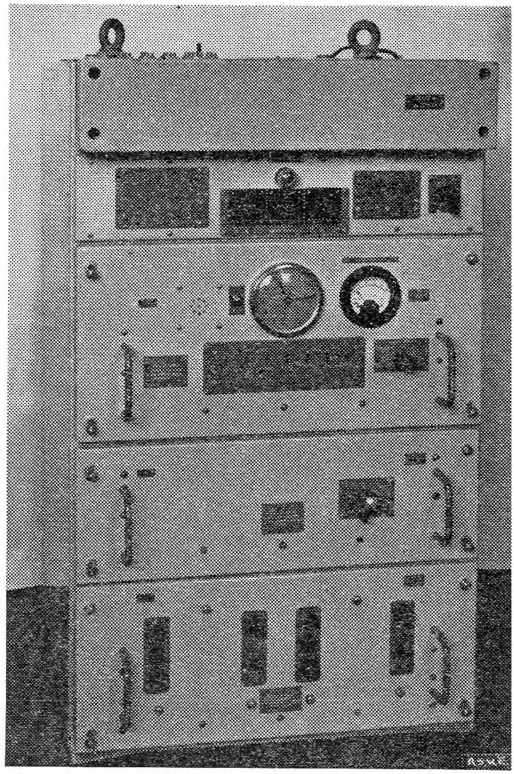


FIG. 8. THE FREQUENCY DIVIDER

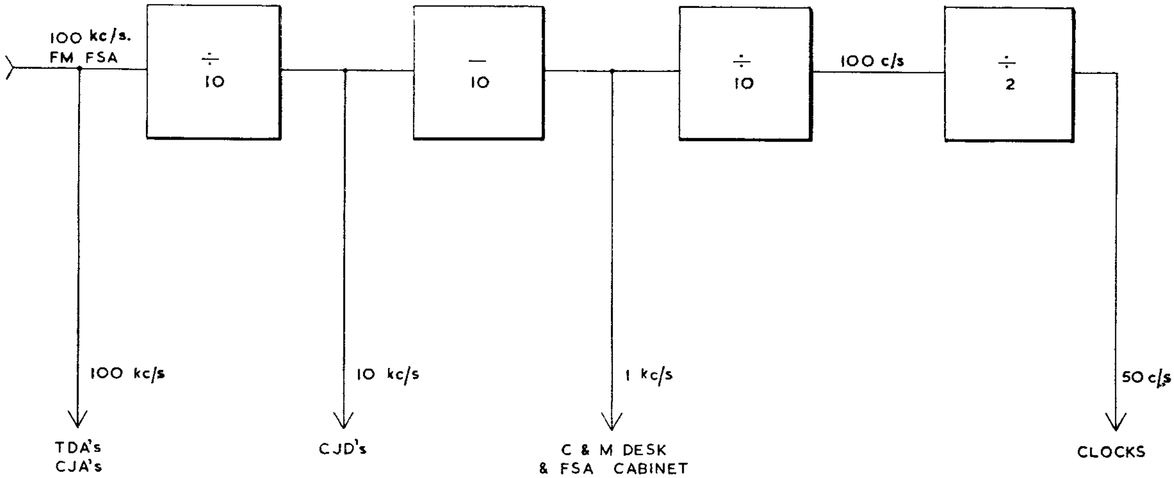
c. Monitoring of each frequency reference and aural indication of failure. The 100 kc/s, 10 kc/s, 1 kc/s and 100 c/s are each monitored by a monitor unit. A neon indicator is associated with each monitor circuit and an aural alarm is common to all. Whilst the amplitude of the output frequencies is above a determined level, the neon lamp associated with each reference frequency is alight. Should the output voltage of any one of the output units fall below 0·5 V, the earth to the relevant neon is transferred by the appropriate relay monitor unit actuated by the common alarm. Divider circuits are duplicated and may be operated by the divider change-over switch. Visual (meter) indication of correct output is also available.

d. An electric clock. The clock is powered by a 50 c/s supply derived from the 100 c/s frequency reference, giving it frequency standard accuracy and stability.

e. Complete divider unit failure. Certain equipments (CJAs and TDAs) may be operated by 100 kc/s fed direct from the frequency standard cabinet.

11. **Power Supply Units.** Two identical units are used for simultaneous operation so that if either develops a fault, the other is capable of supplying the operational load. Each unit is fitted with an overload indicating lamp and resetting switch.

12. **Auto Switching and Alarm Circuits.** These are housed in the mutual comparator drawer (frequency standard cabinet). An associated switch unit and neon lamp, which indicate that the demanded standard has been switched to supply the system, are housed in the divider cabinet. The required standard is demanded by operation of the standard selector switch and is thereon automatically switched to supply 100 kc/s to the divider cabinet. Evidence of successful switching is provided by the appropriate neon lamp on the divider



100 k/cs CAN BE SUPPLIED DIRECT TO CERTAIN CJA's/TDA's IN EVENT OF DIVIDER CABINET FAILURE

FIG. 9. I.C.S. STANDARD FREQUENCY DISTRIBUTION

cabinet. Should the selected standard fail, the next standard in reverse alphabetical sequence is automatically switched into use, and should this fail the remaining standard is switched in, i.e. if B is selected and fails, A is switched in, and if C fails B is switched in. In addition to neon indication of switching at the divider cabinet, a standard lamp is available, common to all three standards lights at the frequency standard cabinet. In the case of a standard failure, neon indicators go out and an aural alarm in the frequency standard cabinet is actuated.

11.3. HF/MF TRANSMISSION

1. *a.* **Transmitter Drive Unit Outfit TDA.** The function of a TDA is to provide HF and MF low level drive; front panel controls allow an operator to set up a channel. The TDA synthesizes the frequency and modulates it with the a.f. input from the transmitter control unit before feeding a low level drive of up to 25 milliwatts to the input of a WBA or WBB.

b. The TDA consists of three drawers, namely: Modulator, Synthesizer, and Power Supply, and the whole unit is mounted in a standard cabinet.

c. The TDA Synthesizer uses the Wadley Triple Mix technique and is locked to the frequency standard FSA, since the Frequency Divider provides the reference frequencies for the synthesizer.

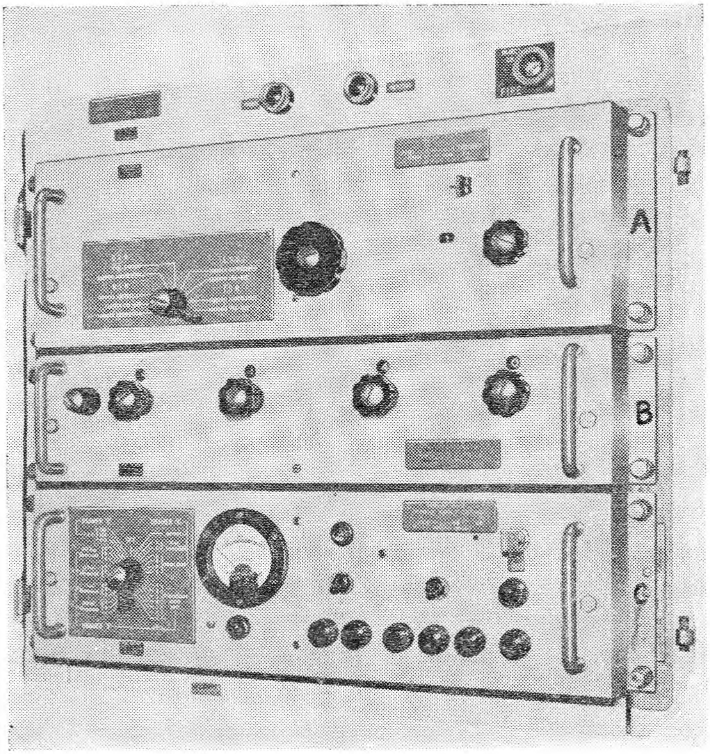


FIG. 1. THE TDA

d. For the frequency synthesizer five 'chains' are used, one each for the megacycles, the hundreds of kc/s, the tens of kc/s, the kc/s and the tenths of kc/s. The modulation is introduced at a fixed frequency of 300 kc/s in the hundreds of kc/s 'chain'.

e. The advantages of this system are:

(1) The accuracy and stability of the output frequency depends only on the input frequency (in the case of the I.C.S., the output of the C.F.S.).

(2) The inherent frequency stability requirements for the Auxiliary Oscillator are not severe.

(3) Fixed filters only are required.

(4) The frequency range of the variable oscillators can be much higher than the frequency to be derived and consequently the spurious frequencies which are generated are well outside the band of the derived frequency.

(5) The modulation can be eventually introduced into a 'chain'.

f. Each TDA has a modulator with inputs of:

(1) A.F. No. 1 connected from TCU for u.s.b. (all TX Channels).

(2) A.F. No. 2 connected from TCU for l.s.b. (some TX Channels).

(3) 50 kc/s.

(4) 250 kc/s.

g. The output of the modulator is determined by the a.f. input and the form of transmission selected by a nine position switch. The output from the modulator of 300 kc/s $\pm$ the audio frequency is inserted into the TDA frequency build-up. This process is similar to that used in the Type 640 Sideband Generator. The Drive Output attenuator on each TCU controls TDA relays and selects a combination of attenuators in the TDA so as to reduce the drive to the WBA or WBB in 1 db steps up to a maximum of 29 db.

2. **Frequency Range.** 240 kc/s to 24 Mc/s.

3. **Modulation.** Nine different types of modulation or modes of emission can be selected by a switch. The following facilities are provided:

a. Upper Sideband	–	Carrier suppressed.
b. Upper Sideband	–	Carrier preset.
c. Upper Sideband	–	Carrier controlled.
d. Double Sideband	–	Carrier suppressed.
e. Double Sideband	–	Full carrier (for tuning).
f. Lower Sideband	–	Carrier suppressed.
g. Lower Sideband	–	Carrier preset.
h. Independent Sideband	–	Carrier suppressed.
i. Independent Sideband	–	Carrier preset.

4. **Outputs.**

To Transmitter WBA	–	100 milliwatts into 75 ohms
To Receiver	–	1 milliwatt into 75 ohms

5. **Frequency Stability.** The output frequency required is selected on five controls with window indication of the number selected.

The accuracy of the output is that of the Frequency Standard since a Triple Mix Technique is used.

6. **Indicator Lamps.**

a. Anti-condensation heater on (Heaters).

b. a.c. on.

c. a.c. on to Drawer C.

d. 24 V d.c. to Drawer C.

7. **Controls**

a. 5 frequency selectors.

b. 9 position modulation switch.

c. Output tuning trimmer (C 125) (Drawer A).

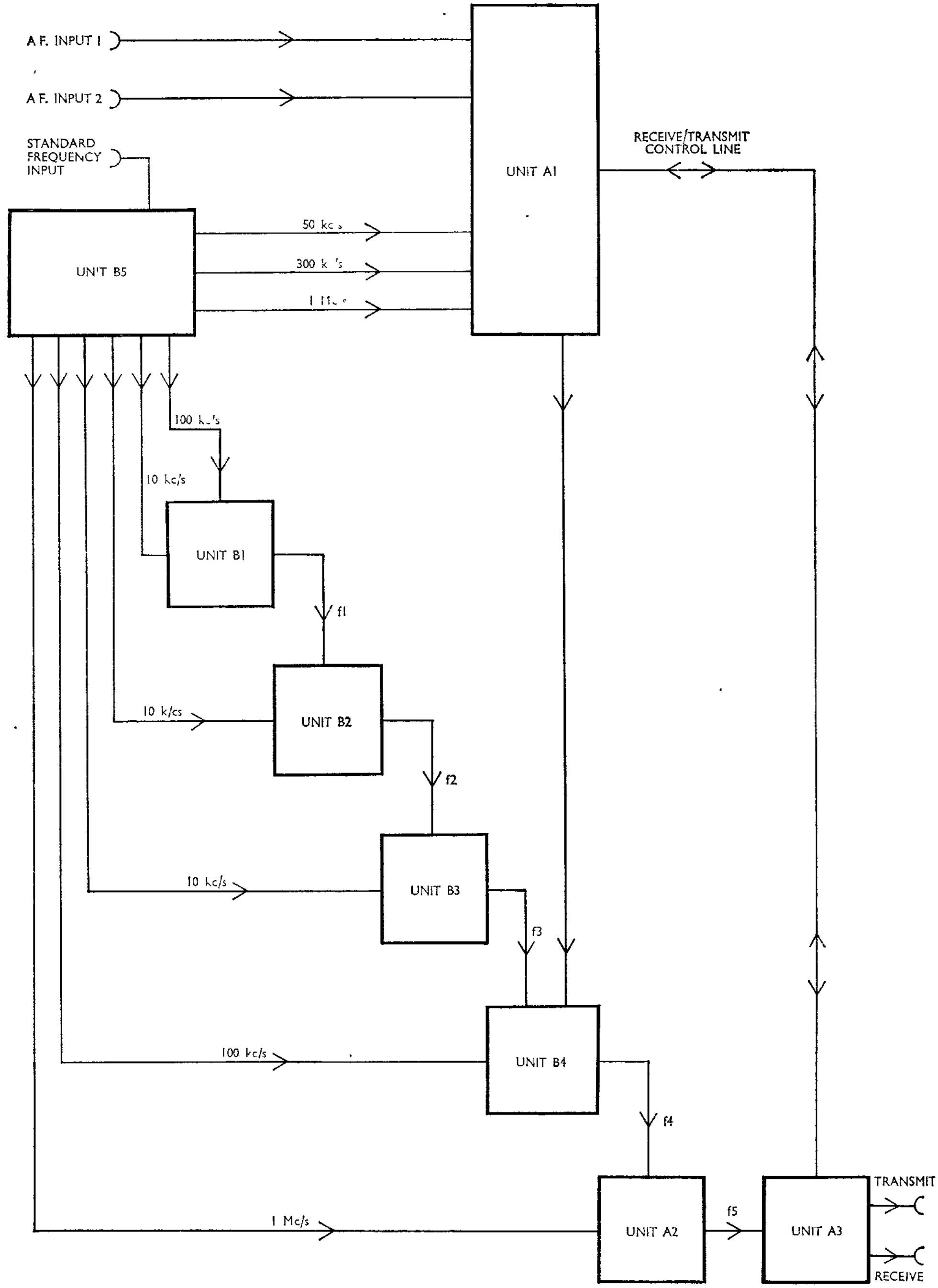
d. Output level R.V.2 (Drawer B).

e. 30 positions meter selector switch (Drawer C).

f. Mains on/off switch (Drawer C).

g. H.T. on/off (Drawer C).

h. Keying; control is exercised by the pressel switch of a microphone or key and energizes a TDA relay so as to allow the r.f. to the WBA or WBB.



f1 = ANYONE OF 10 FREQUENCIES AT 1 kc/s STEPS IN RANGE 91–100 kc/s
f2 = ANYONE OF 100 FREQUENCIES AT 100 c/s STEPS IN RANGE 90.1–100 kc/s
f3 = ANYONE OF 1000 FREQUENCIES AT 100 c/s STEPS IN RANGE 900.1–1000 kc/s.
f4 = ANYONE OF 10 000 FREQUENCIES AT 100 c/s STEPS IN RANGE 9.0001–10 Mc/s
f5 = ANYONE OF 237,600 FREQUENCIES AT 100 c/s STEPS IN RANGE 240 kc/s–24 Mc/s.

FIG. 2. I.C.S. – TRANSMITTER DRIVE OUTFIT TDA BLOCK DIAGRAM

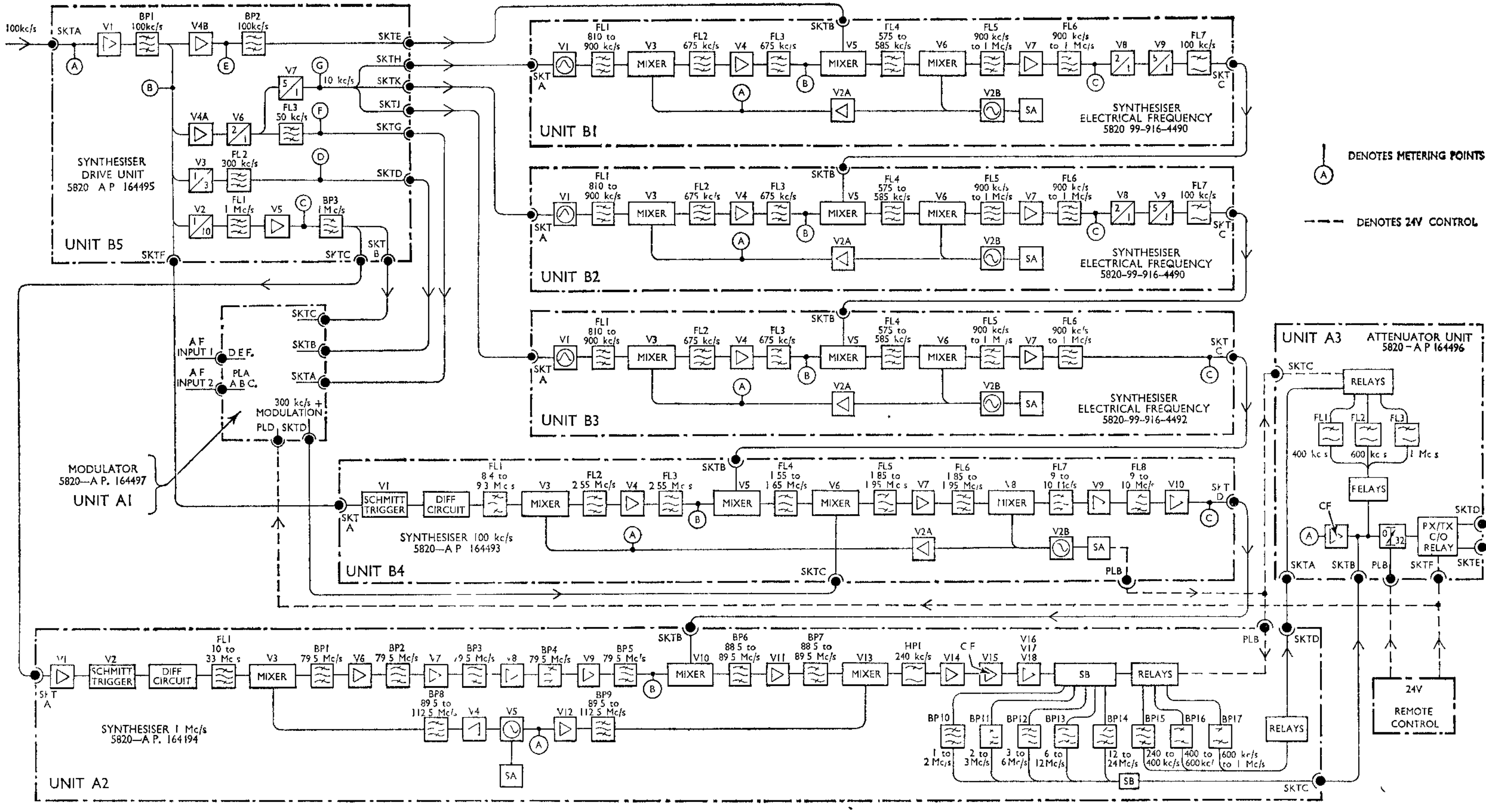


FIG. 3. TRANSMITTER DRIVE OUTFIT TDA FUNCTIONAL DIAGRAM

i. The TDAs are sited in the CCR in cabinets and in addition there is one beside the C & M Desk for the Cabinet Monitoring.

j. The low level r.f. is fed to its associated WBA or WBB.

8. Wide Band Amplifier Outfit WBA. (Detailed description in B.R. 2362.)

a. The WBA amplifies the output of a TDA, on any frequency, to a maximum power output of 1 kW. The WBA covers the HF Band (1.5– 24Mc/s) and the WBB extends the frequency range to cover the MF Band down to 240 kc/s. The WBA and WBB are very similar and to save space only the WBA will be described.

b. A WBA has the great advantage over a conventional tuned linear amplifier in that it will amplify all frequencies in the band 1·5 to 24 Mc/s without tuning of any kind. The equipment is simple and reliable. It requires an input of only 25 milliwatts to give a P.E.P. output of 1 kW. However, it is inefficient and draws a lot of power from the ship's supplies. Because the amplifier amplifies all frequencies in the band, a high order of linearity is demanded since there are no tuned circuits to filter out harmonic inter-modulation products.

c. The wide band properties are obtained by the use of artificial transmission lines in which the shunt capacitances are replaced by the valve capacitances.

d. The inductance separating individual valves, effectively isolates the valve inter-electrode capacitances, while the anode currents contributed by individual valves add up. Each valve is thus driven in succession, the time delay depending on the properties of the artificial line. This must be terminated at the far end by the characteristic impedance to avoid standing waves along the line and unequal driving voltages on individual valves. The anodes form a transmission line having identical delay characteristics, half the anode current of each valve will travel to the right and will add in phase in the output transformer. The other half will travel to the left and must be dissipated in the terminating resistor. At the low frequency end of the band the phase delay contributed by the line is negligible, and these currents will add in phase so that half the power developed by the amplifier dissipated in the resistor is reduced, neither the output power nor the efficiency increases. The anode voltage swing on some of the valves will be reduced and, therefore, extra power will be dissipated in these valves.

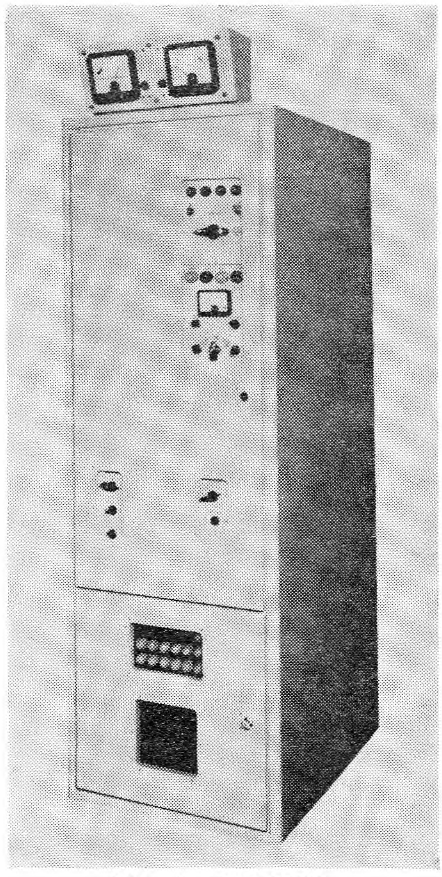


FIG. 4. THE WBA

9. Brief Description. The outfit contains nine units:

a. Cabinet.

b. Control amplifier for relays, metering circuits and transmitter state lamps.

c. Penultimate amplifier – 9 pairs of valves.

d. Final Amplifier – 8 pairs of valves.

e. r.f. Coupler stage – inserted in the power output stage and housing r.f. probes whose rectified output indicates v.s.w.r. and forward power at the WBA and also remotely at the C & M Desk.

f. Meter Unit – situated on top of the cabinet and has two meters for v.s.w.r. and power.

g. Power Supply – Heaters, lamps and H.T.2.

h. Power Supply – supply of mains to main H.T.

i. Main E.H.T. Transformer.

10. **Lamp Indications.**

Amber – Unready	White – In use
Green – Ready	Red – Overload

a. All power supplies have lamp indication of fuse failure.

b. Safety is achieved by having two yale locks in the r.f. and power compartment doors. The mains isolating switch cannot be operated unless the doors are locked shut and the keys inserted beside the switch.

c. Cooling is a major requirement as a considerable air flow is required and heat exchangers essential. An air switch is fitted in the WBA so that should flow drop to below 0·4 w.g. power is shut off.

11. The use of parts of the superstructure for transmitting aerials inevitably required the use of a common aerial working system, since there are not sufficient aerials available to provide one to each transmitter.

12. Since there is an opportunity to select which aerial is to be used for a particular transmission, an aerial exchange is required to provide flexibility.

13. **Aerial Exchange Outfit EY.** Outfit EY (1) is an exchange which handles 7 or more HF/MF lines and Outfit EY (2) is an exchange handling 6 or less lines.

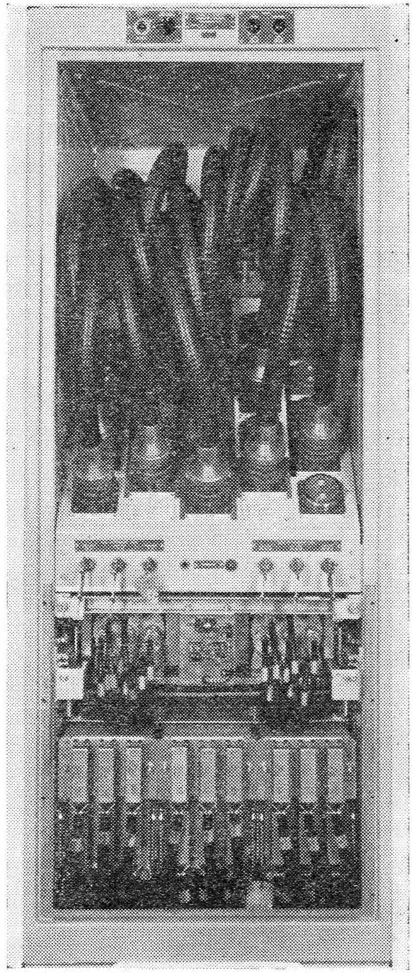


FIG. 5. AERIAL EXCHANGE TRANSMITTER

WBA/WB

14. The Outfit, whether one or two, provides a connection for any transmitter line (TDA and ~~WBA~~) to:

(1) CAW Filter for a broad band aerial. (2) Base tuned whip/ base tuned wire aerial (3) Dummy load for tuning.

15. The exchange is built in the form of a standard cabinet and is the same size in both EY (1) and (2). r.f. connections are made using coaxial feeders.

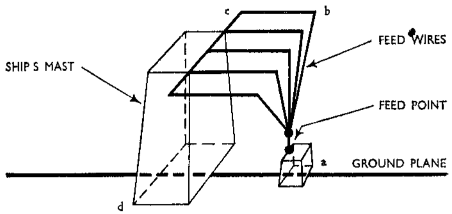
16. An HF line is permanently connected, i.e. one TDA is wired to one WBA, and there is no 'drive' exchange. However, this tied combination may be fed to any aerial bearing in mind the frequency in use. The transmitter exchange permits:

a. Aerial selection.

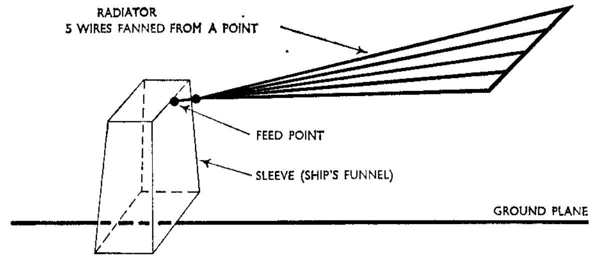
b. Interconnections for remote tuning of the filter drawers and base tuners.

c. Interconnections for remote display of v.s.w.r. and power output of a selected WBA or WBB.

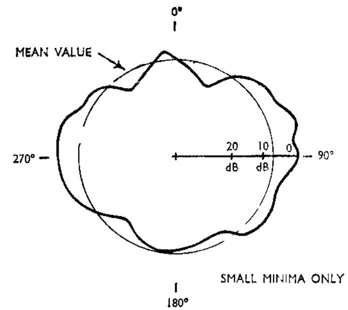
d. Switching of an r.f. from a WBA or WBB via a filter drawer to a dummy load for tuning or if power fails.



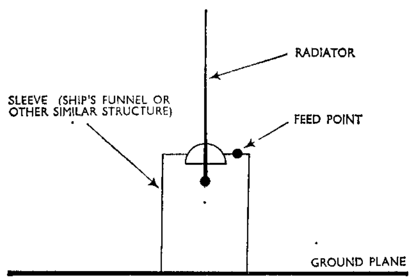
FOLDED MONOPOLE AERIAL



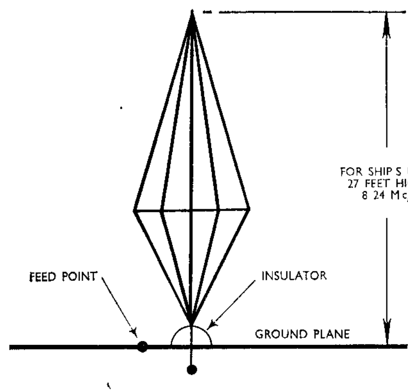
MODIFIED SLEEVE AERIAL



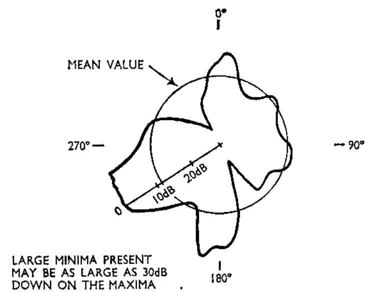
TYPICAL HORIZONTAL-PLANE RADIATION DIAGRAM
BROAD BAND AERIAL 8 Mc/s



SLEEVE AERIAL



BICONIAL AERIAL



TYPICAL HORIZONTAL PLANE RADIATION DIAGRAM
WHIP AERIAL 8 Mc/s

11–3–7

FIG. 6. I.C.S. AERIALS

17. Connection of r.f. cables inside the cabinet is by plug and socket and should be thought of as a semi-permanent arrangement. Should there be a fault in the exchange, all power, and therefore all HF/MF lines, would have to be shut down for maintenance.

18. Safe to transmit keys are located in the front panel of the Exchange. Communications with the C & M Desk are provided. The detailed way in which the filter cabinet and aerial exchange are used in tuning is too complex a diagram for this book, but the principle is as follows:

WBA No. 4 is connected via flexible connector No. 4 in the exchange cabinet to socket A in the cabinet desk, thereby connecting it to the wide band aerial via filter drawer A. With the filter drawer in the tune position, the r.f. is fed to the Dummy Load. When tuning is completed, the filter drawer is set remotely to 'operate' and a relay in the exchange energizes to pass the r.f. to an aerial rather than the dummy load. Should power fail, this relay automatically de-energizes, thereby diverting the r.f. to a dummy load.

19. **Common Aerial Working Outfit EAW.**

EAW (1) – Large ships.

EAW (2) – Assault ships and DLGs.

EAW (3) – Small ships.

20. *a.* The outfit may consist of a minimum of one or a maximum of four standard size cabinets, each containing 6 aerial filter drawers. Rear access to these cabinets is required. Filter drawers permit the aerial to be shared by a number of transmitters provided that none is on the same frequency as another and that 10 per cent frequency separation is adhered to. A slide rule is being developed (can easily be drawn locally) to give easy reference for frequency separation. A filter provides:

b. Pass band at the frequency associated with the WBA in use.

c. High impedance to other frequencies being transmitted in the aerial.

d. Introduction of an impedance transformation whereby the aerial and feeders are made to present a resistive load of approx. 50 ohms to the output impedance of 50 ohms of the associated WBA to achieve maximum transfer of power.

21. The r.f. output of each drawer is connected via an Aerial/Dummy Load change-over switch relay to a common aerial Bus Bar at the back of the drawers. The feed to the aerial is via a Port or Starboard run and through a matching transformer on the upper deck. The matching transformer has a broad band characteristic and matches the impedance of the feeder to that of the particular aerial.

22. The filter top panel houses the following:

a. a.c./d.c. Change-Over Switch.

b. Lamp indication of a d.c. supply selected.

c. Anti-condensation heater indication lamp.

23. The main units of the filter drawer are:

a. Internal matching transformer varied by remote control from the C & M Desk.

b. Tuneable LC Filter.

c. Aerial/Dummy Load C.O.S.

24. For the I.C.S. transmitter Common Aerial Working has been designed to use simultaneously up to a maximum of 8 one-kilowatt linear amplifiers on any of the three broad band aerials. For this, multicouplers or filter units are needed to prevent the energy from one transmitter being fed to the other transmitters. The design of such a filter must always be a compromise between selectivity and radiated power. A figure of 25 per cent has been arbitrarily set as the target for the loss in the worst case. At this level of loss the

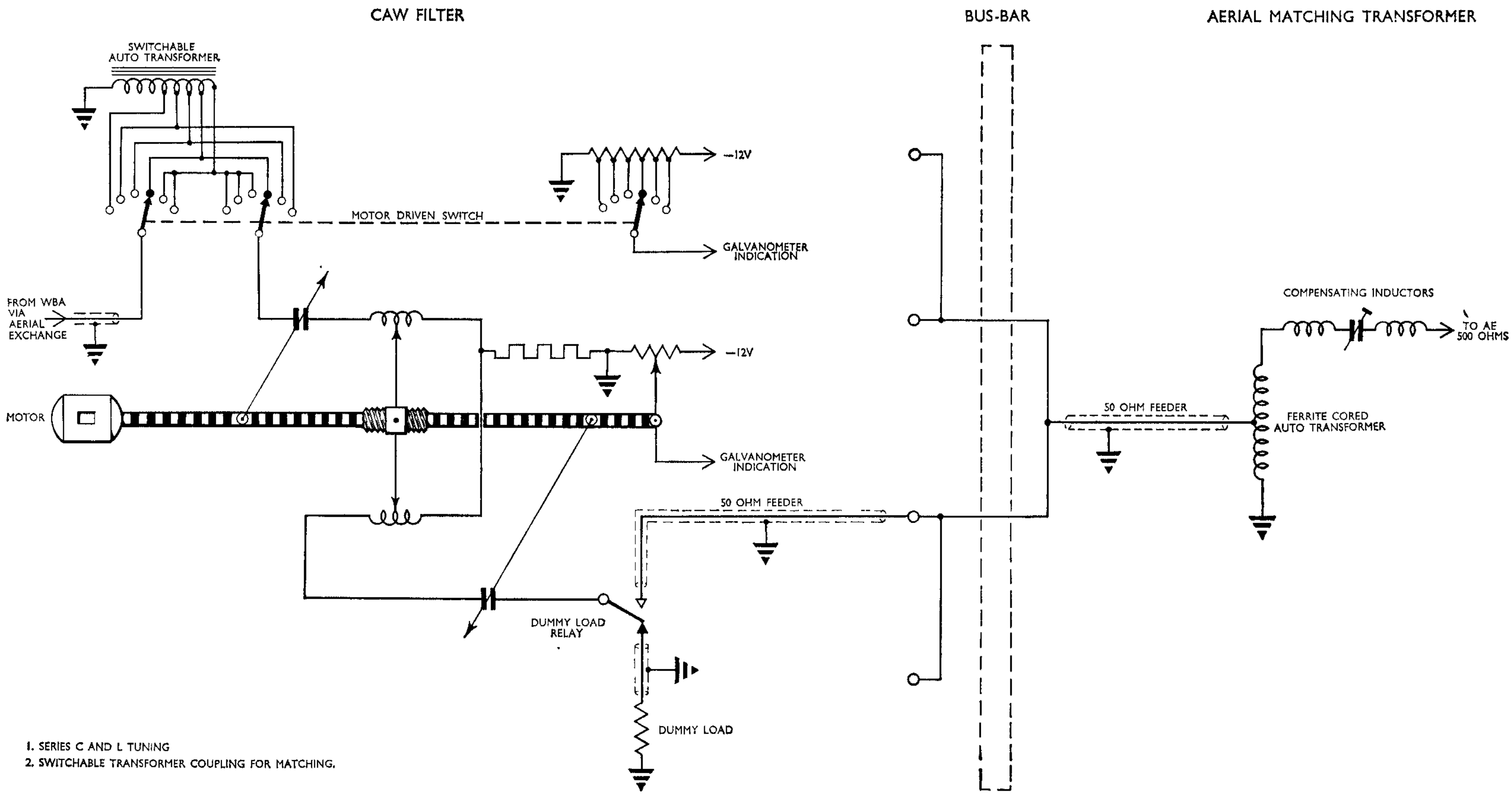


FIG. 7. AERIAL OUTFIT EAW (AS FITTED IN I.C.S. SHIPS)

filters will give a rejection of 20 db between two transmitters spaced 10 per cent apart in frequency. Using linear amplifiers this is sufficient to reduce the third order and higher intermodulation products to an acceptable level.

25. **Transmission**

a. The use of a transmitter common aerial system was essential with the fitting of a number of 1 kW transmitters in a small space. The use of a whip aerial for each transmitter would have produced considerable siting problems and the resultant radiation pattern and interference would have been unacceptable.

b. However, the limitation imposed by the CAW system, and in particular by the design of the filter units, is the need for ten per cent frequency separation between any two transmitters on the same aerial.

26. **Reception**

a. The design of the receiver input circuits and the increased power of own transmitters requires a frequency separation between a receiver and the nearest transmitter of five per cent. In certain areas this can be a problem when receiving the component of a broadcast and transmitting on a ship-shore frequency in the same band.

b. In addition there is a requirement for receivers on the same aerial to be separated by two per cent. This is seldom necessary and is not really a practical limitation. Separation is required to prevent reduction in signal strength due to inter-action between two receivers in the aerial line.

27. **Dummy Load Cabinet.** The cabinet houses:

a. Two dummy loads for dissipation of 1 kW each.

b. Cooling equipment (fan).

Each dummy load consists of twelve 600 ohms resistors in parallel which are mounted cylindrically. A sample of the r.f. absorbed is fed off to the Power Meter in the C & M Desk to indicate output from a particular WBA while tuning. This cabinet is somewhat smaller than a standard cabinet.

28. **Aerial Outfit AWF and ETA (1).** These are a conventional whip aerial and a base tuner respectively. The whip is mounted directly on top of the Tuner ETA (1). This HF Base Tuner is also fitted in ships with the 603(5) but is not the same as the base tuner fitted with type 640, although very similar.

11.4. RECEPTION

1. *a.* The reception system is similar to that already fitted in the Fleet at present. I.C.S. reception can be divided into two separate systems:

one for the I.C.S. receivers, and

one for the conventional receivers still fitted.

b. The system as a whole uses AWN whip aerials and the signals from these whips are fed through an exchange (outfit EZ) to either a chain of receivers or to a second distribution panel (outfit EAO), similar to EAL, for subsequent routing to B40 and B41s.

c. In general it is not practicable on a ship to find a sufficient number of sites to provide an aerial for each receiver, and a system of common aerial working is used. Cathode followers are generally used for such systems, but they are inherently non-linear devices and cannot be used in the presence of the large voltages arising from ship's own transmissions. The aerial is connected to up to a maximum of 14 receivers in series by a coaxial cable earthed at its far end through its characteristic impedance of 100 ohms.

d. Rejection filters can be inserted in the aerial feeder lines, before the receivers, to reduce the voltages due to ships' own transmissions. These are tuned to the frequency of the transmission and have an attenuation of the order of 40 db at the tuned frequencies and an insertion loss of not greater than 3 db at frequencies 5 per cent away from the tuned frequency.

e. The reception system is best described in diagrammatic form by Figs. 1, 2 and 3. The *Leander* layout has been used for simplicity; however, the same principles apply to any I.C.S. ship.

2. **Receiver Aerial Exchange Outfit EZ.**

a. The Receiver Aerial Exchange Outfit EZ provides eight primary lines (designated Aerial Lines 1 to 8), each having two aerial input connections; a primary output line to receivers and a return input of that line. The eight primary Aerial Lines are returned to the exchange for termination in 91 ohms or through connection to provide eight secondary aerial lines. Eighteen plug-in, tunable, Band Suppression Filters are provided; four having a frequency range of 2 to 5 Mc/s, nine of 5 to 10 Mc/s and five of 10 to 16·5 Mc/s. Each filter is plugged into an Aerial Line and can be relay connected into that line by the keying of a pre-selected transmitter(s) The transmitted signal is rejected by the tuned filter; thereby preventing the input of any receivers connected to aerial line being overloaded when the transmitter is actually radiating. Provision is made for connection of band suppression filters in only five of the eight primary lines, the remaining three lines being connected to aerials situated remote from transmit aerials and/or used mainly for the reception of LF or MF.

b. A FILTER TUNING UNIT which includes both meter and audio indication is for use when tuning the band suppression filters in conjunction with the Monitor Cabinet Receiver and TDA. The tuning unit also includes audio monitoring of the output of up to 30 operational receivers to facilitate tuning of the filters when they are actually in use. An A.P. 164531 Power Supply (as used in Outfit KMM and KMP) is incorporated in the exchange to provide 24V d.c. for filter relay operation.

c. In ships not fitted with a Monitor Cabinet (part of Outfit KMM) r.f. drive for tuning of the Band Suppression Filters is provided by a Signal Generator CT212 and the output of the Tuning Unit is connected to position 4 of receiver aerial selector switches.

3. **Common Aerial Outfits EAO Series.** Provision of aerial lines to miscellaneous services including Receiver Outfits CAY and CAZ and a sense aerial to MF–DF FM12 is accomplished via units of the older common Aerial Working Outfit EAL. These units are grouped together as required to distribute two lines from the EZ exchange and form an Outfit EAO(1), (2) or (3).

4. Figure 1 of the reception systems illustrate how EZ and EAO are linked into one system in the *Leander* layout.

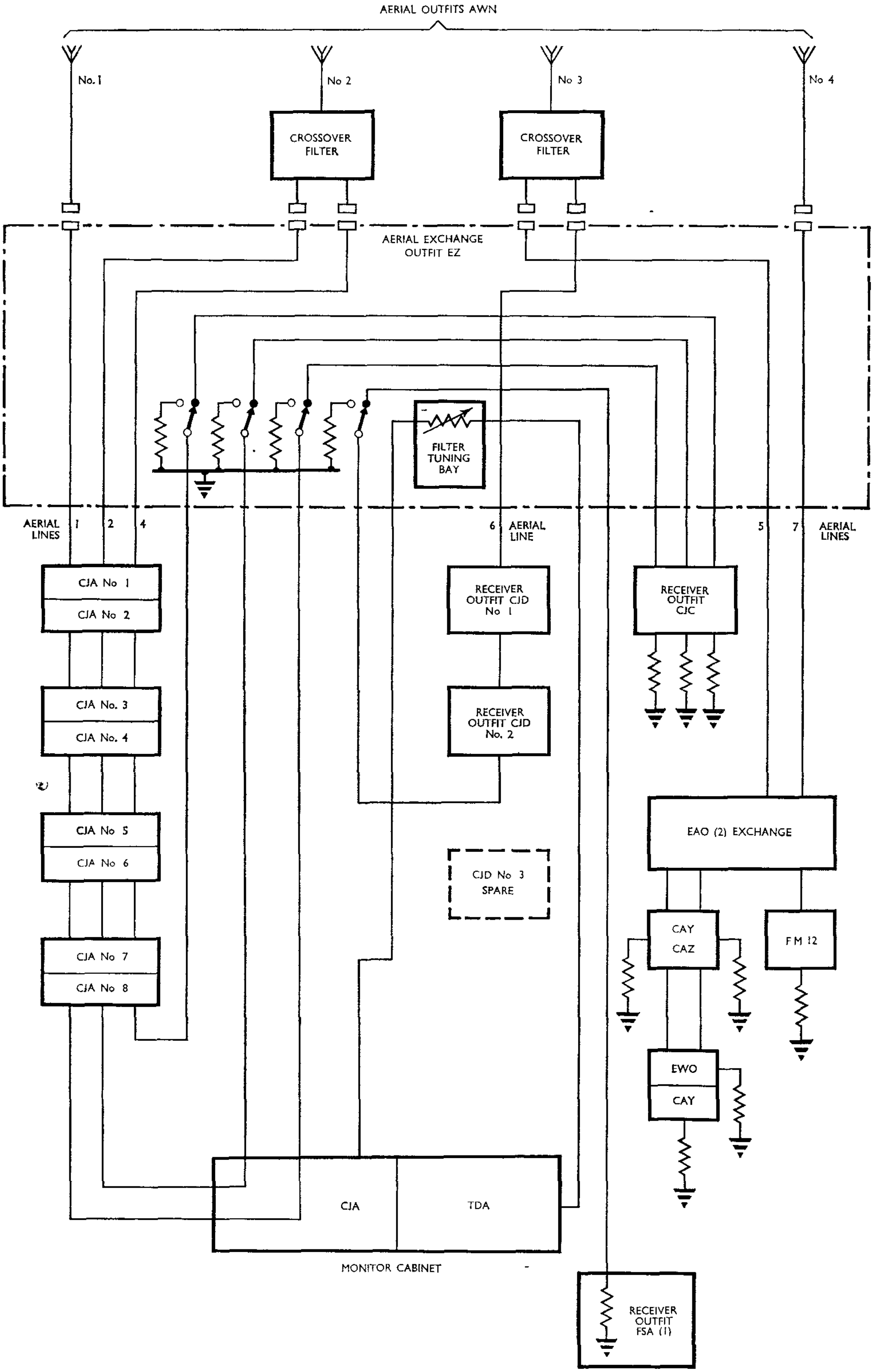


FIG. 1. I.C.S. LF – HF RECEIVER AERIAL DISTRIBUTION BLOCK DIAGRAM

RECEPTION

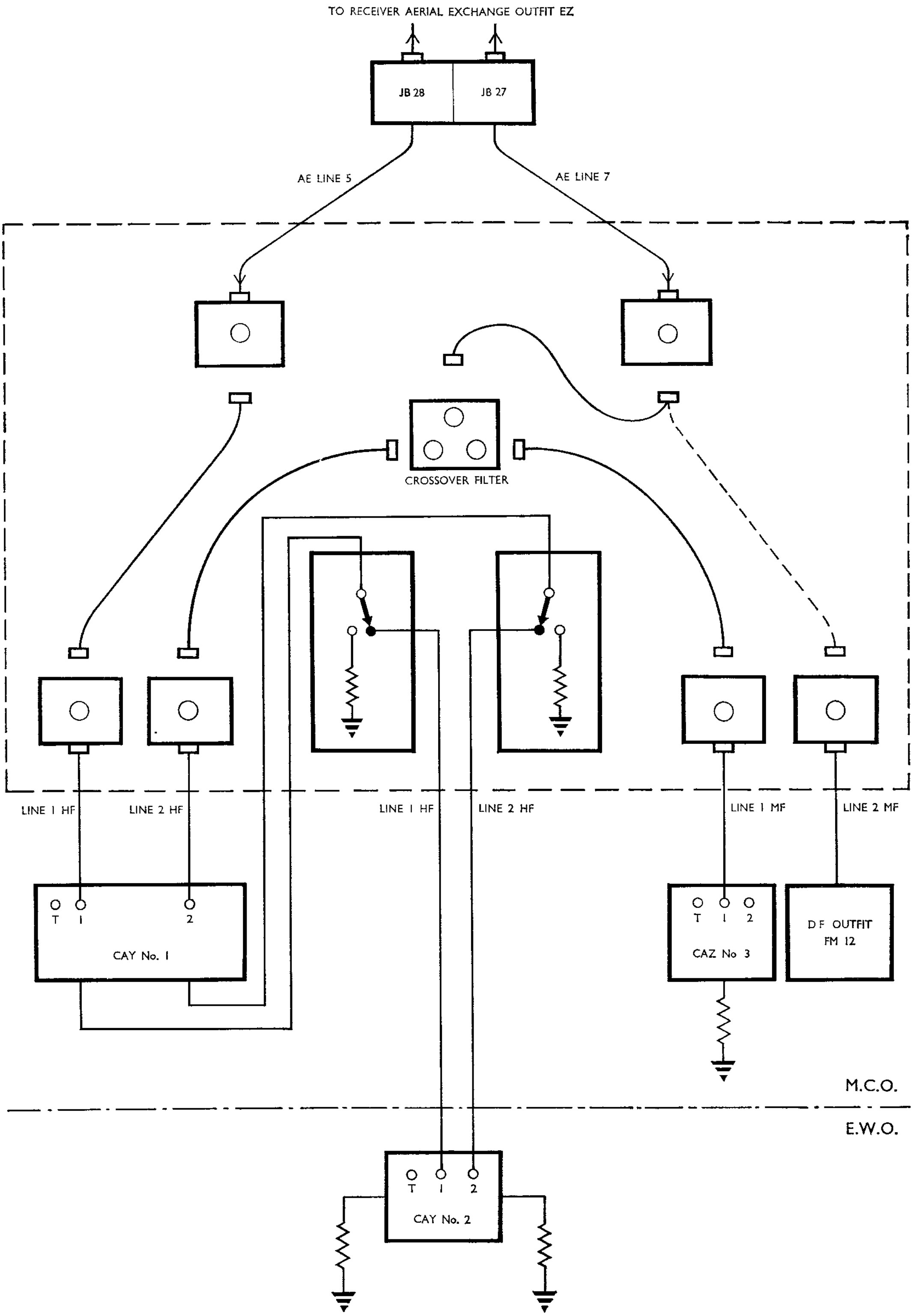


FIG. 2. AERIAL OUTFIT EAO (2) BLOCK DIAGRAM

5. **HF Receiver Outfit CJA.** Outfit CJA is the main HF I.C.S. receiver. The complete outfit is house in the standard cabinet and is made up of three drawers. Two receivers are fitted in each cabinet. Th receiver has a self-contained synthesizer in the lower of the three drawers and is designed for unattende operation. All CJAs are fitted in the CCR.

6. **Frequency Range.** 2–30 Mc/s in eight ranges divided as follows;

(1) 2–3 Mc/s	(4) 7–11 Mc/s	(7) 22–26 Mc/s
(2) 3–4.5 Mc/s	(5) 11–16·5 Mc/s	(8) 26–30 Mc/s
(3) 4·5–7 Mc/s	(6) 16·5–22 Mc/s	

7. **Power Supply.** 115/230 V 40/60 c/s a.c.

8. **Reception Modes.** d.s.b., s.s.b. or i.s.b., Voice FST CW and Data.

9. **Calibration.** Available at all multiples of 500 kc/s.

10. **Aerial System.** Common aerial working providing three aerial lines.

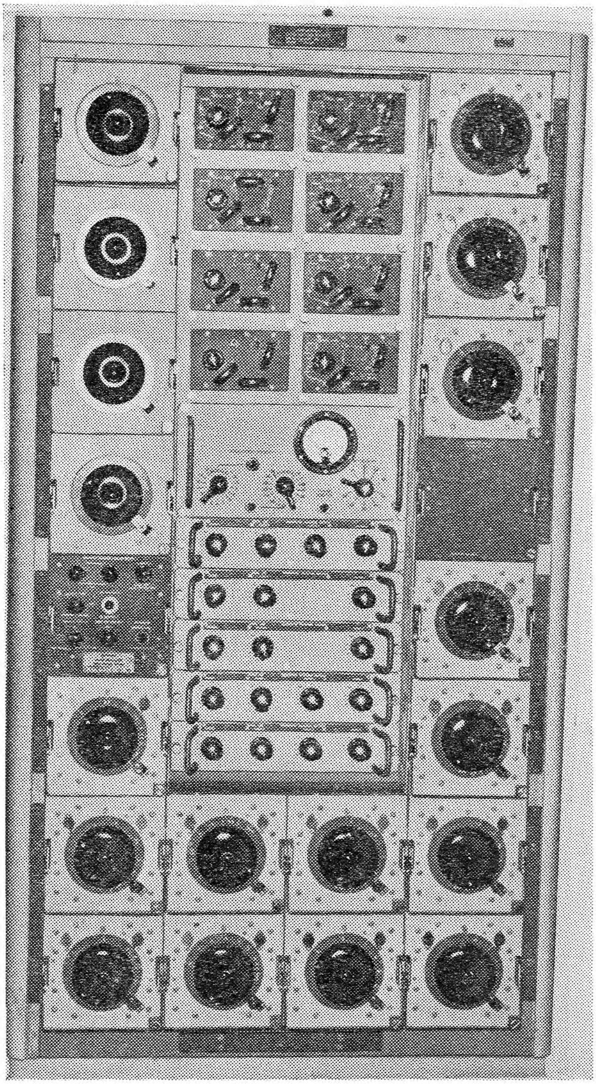


FIG. 3. RECEIVER AERIAL EXCHANGE OUTFIT EZ

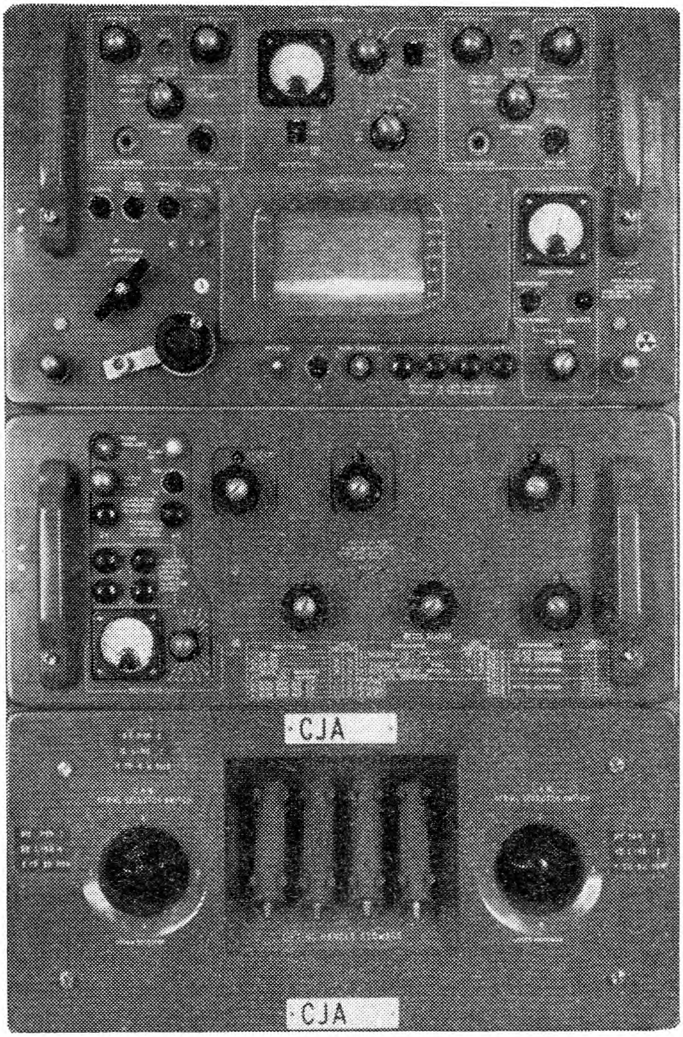


FIG. 4. RECEIVER OUTFIT CJA

A single receiver with synthesizer and aerial selection units is Receiver Outfit CJA (2) and two receivers with synthesizer and aerial selection units mounted in one rack is Receiver Outfit CJA (1).

11. The intermediate frequency is 1.6 Mc/s and the u.s.b. chain can be converted, by switching to receive d.s.b. amplitude modulated signals. For s.s.b. reception the carrier is reinserted at 1.6 Mc/s and is derived by multiplication of the 100 kc/s from the central frequency standard.

12. **Rack Mounting.** Two receivers with associated synthesizers and aerial selection facilities are stowed in a standard ICS cabinet.

13. **Handbook.** BR2414

14. **E. List.** E1300

15. **General Description.** This is a conventional superhet receiver providing for all reception modes in the simplest possible way; complicated circuit changes for the arrangement of all modes are made by the operation of two switches. Operators' controls are minimized but of necessity duplicated, to allow control of each sideband separately. This control is effected, along with appropriate bandpass arrangements, by employing separate i.f. strips for each of the two sidebands, one of which also serves as the single i.f. strip necessary for d.s.b. operation.

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16. **Frequency Stability.** This is provided by a reactance valve which alters the local oscillator frequency, as necessary, to correct frequency drift in response to error signals provided by an associated frequency synthesizer. Carrier reinsertion facilities, necessary to effect the demodulation process of an s.s.b. receiver, are provided by a harmonic of the standard at the i.f. frequency, the resultant difference frequency providing audio which, after amplification, is available at the Receiver Output Exchange (ROX) for distribution to the system. Forced air ventilation for cooling is provided by the I.C.S. ventilation system.

DETAILED DESCRIPTION (see Fig. 9 on page 11-4-15)

17. **Aerial Contact Box**

a. Its purpose is to connect the receiver into a common aerial line, or to remove the receiver from the line without interrupting the aerial input to other receivers on the same aerial line. Connection and removal of these takes place when:

b. Switching On or Off. A function of the ON/OFF switch is to energize Relay D which connects the aerial.

c. Changing Frequency Range. The operation of the range change switch controls a micro-switch which, whilst made, de-energizes relay D thus disconnecting the aerial.

d. Muting. The operation of an associated transmitter energizes relay E which simultaneously de-energizes relay D (disconnecting the aerial), connects the r.f. stage grids to earth and disconnects the audio output. Muting can be rendered inoperative by the CANCEL MUTING switch.

e. Overloading Receiver. Input signals in excess of a prearranged level will operate the overload relay, at which relay D is de-energized and an overload lamp lights on the front panel. An overload reset switch is provided to restore normal facilities when the offending strong signal has been removed. A variable resistor arranges the level of signal required to operate the overload relay, this level is normally 3-volts aerial e.m.f.

18. **R.F. Stages**

a. The input coupling to the r.f. stages is designed to reduce the amplitude of adjacent signals and of stronger signals further away in frequency which are likely to produce intermodulation distortion in the mixer stage.

b. 1st r.f. A double triode acting as a class A amplifier designed to provide the best compromise between gain and linearity. The two halves of the double triode are connected in cascade.

c. 2nd r.f. similar to b.

d. Mixer. The input signal is fed in push pull to the grids of a double triode, the local oscillator input connection being made at the grid circuit balancing centre tap. The resultant difference frequencies are accepted into the appropriate i.f. strip by the i.f. crystal filters.

e. Local Oscillator. A capacitance tuned transitron circuit designed to track at a frequency 1.6 Mc/s above the input signal. When used as a free running oscillator, an additional fine tuner control allows for variations of 100 c/s. In the synthesized mode, the local oscillator output is fed to the synthesizer where it is compared with a signal derived from the standard; and discrepancy noted in the oscillator signal will result in an error signal being applied to the grid of a reactance valve which will change the oscillator frequency so as to produce no error signal. The whole system comprises a phase locked loop which will effectively maintain a stable oscillator output.

f. Crystal Calibrator. Whilst the calibrate switch is held down into its functional position, harmonics of a 500 kc/s crystal are available at the cathode of the first r.f. stage. The harmonic selected by the r.f. stage circuits is employed for the alignment of the receiver tuning scale against a known accurate frequency. The crystal is housed in a thermostatically controlled oven.

19. **I.F. Crystal Filter Switching Unit**

a. This unit provides the requisite filters for d.s.b., c.w., u.s.b., l.s.b. and i.s.b. operation. The correct filter is selected by relay contacts which are controlled by the operation of the MODULATION switch.

b. S.S.B. or I.S.B. Two independent outputs from the mixer are brought to sockets on the crystal filter unit.

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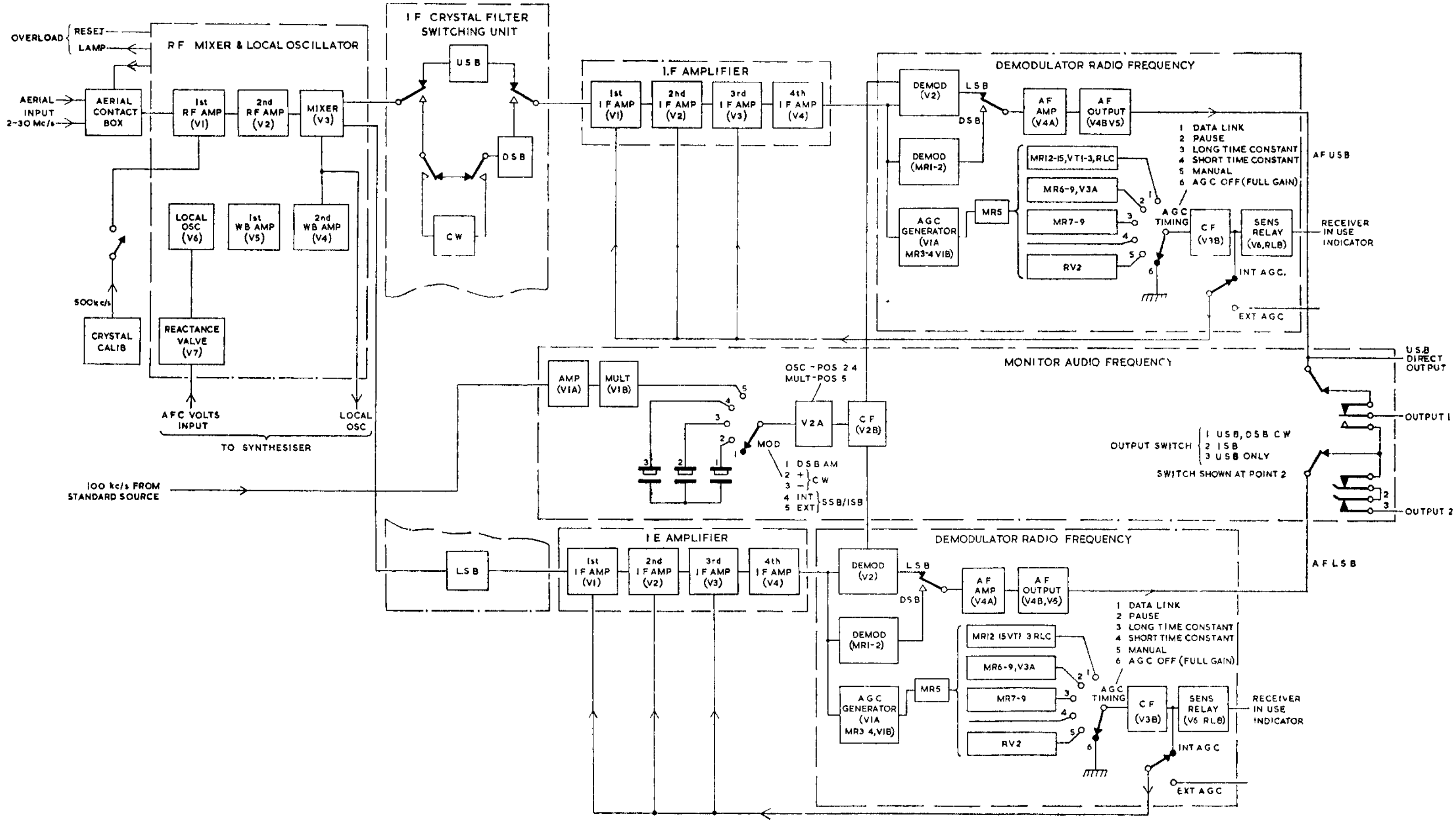


FIG. 5. BLOCK DIAGRAM OF CJA RECEIVER

One socket is wired permanently to the l.s.b. filter, thence to the l.s.b., i.f. amplifier. The other socket is wired to the u.s.b. filter through relay G for connection to the u.s.b., i.f. amplifier. This circuit provides for simultaneous or separate sideband use. The individual i.f. amplifiers will in the case of u.s.b. signals cater for frequencies which extend from —300 c/s to —3 kc/s on the i.f. frequency and in the case of l.s.b. signals, from +300 c/s to +3 kc/s on the i.f. frequency. The apparent reversal at this stage is because the local oscillator tracks high on the r.f. input, and a further correcting reversal will take place in the demodulation process.

c. L.S.B. The selection of this operates relay G, at which the d.s.b. filter replaces the u.s.b. filter in the path to the i.f. amplifier (the same i.f. strip as used for u.s.b.). The demodulator circuit is rearranged by the operation of the d.s.b. relay which is also operated by the MODULATION switch. Since the i.f. stage in this situation is handling the i.f. frequency+3 kc/s, the reversal apparent in s.s.b. does not apply.

d. CW. The operation of relay G connects the d.s.b. filter to the i.f. amplifier, and relay H connects the mixer output to the d.s.b. filter via a carrier filter which provides a narrow bandwidth of 100 c/s (about 1·6 Mc/s) sufficient to allow a wide margin of r.f. input or local oscillator drift.

20. **I.F. Amplifier.** This provides overall amplification of about 120 db at 1·6 Mc/s. There are four stages of amplification which supply between 0·5 V and 1·0 V RMS to the demodulator.

21. **Demodulator Radio Frequency**

a. Effects the process of demodulation, provides a variety of A.G.C. facilities and connects the amplified a.f. outputs to the Monitor Audio Frequency unit for distribution as required by the reception mode in use.

b. I.S.B. Demodulation. The outputs of the two i.f. amplifiers are connected to the grids of the respective demodulator valves where a mixing process takes place with the output of the carrier reinsertion oscillator which is connected to the demodulator suppressor grids. The carrier reinsertion oscillator will provide precisely 1·6 Mc/s derived from either the frequency standard or from an internal crystal. The resultant difference frequencies from each demodulator are the audio output of Upper and Lower sidebands.

c. S.S.B. Demodulation. The action of this circuit is identical to that described for i.s.b. except that it is restricted to the appropriate upper or lower sideband route.

d. D.S.B. Demodulation. Selection of d.s.b. at the MODULATION switch connects the i.f. amplifier output to a more conventional detector circuit employing two metal rectifiers in a voltage doubler method. Though this circuit forms part of both demodulator sections, only the one associated with upper sideband use is operative, and it follows that the d.s.b. output is available from the same terminals as the u.s.b. output.

e. C.W. Similarly only the u.s.b. route is employed and mixing takes place in the demodulator between the i.f. amplifier output and the carrier reinsertion oscillator which produces precisely 1601 kc/s or 1599 kc/s as decided by the MODULATION switch in the c.w.+ and c.w.— positions. The 1 kc/s difference frequency then follows the normal u.s.b. route to the receiver output.

f. A.G.C. Simultaneous with the demodulation process, the i.f. output in each of the sideband routes is connected to an A.G.C. generator which provides one stage of amplification followed by full wave rectification, the resulting negative d.c., whose mean value will fluctuate with i.f. signal amplitude, is used as the basis of a bias supply connected to the first three i.f. amplifier stages. Bias supplies obtained from an external source can be connected to the same i.f. stages via the EXTERNAL position of the A.G.C. switch.

g. A.G.C. Time Constants. A number of these are necessary to ensure that the individual receiver modes of operation are supplied with suitable 'Attack' times, i.e. the time between the receipt of a signal and the commencement of A.G.C. action, and 'Release' times, i.e. the time between the end of a received signal and the cessation of A.G.C. action. The various time constants are arranged by the operation of the A.G.C. switch as follows:

Data Link	Short attack and release times.
Pause	Short attack and extended release time to cover period between words or sentences when there is no signal in s.s.b. voice condition.
Long	Short attack and long release times to cover periods between c.w. pulses.

Short	Short attack and release times to allow quick recovery from A.G.C. action after signal ceases.
Manual	A.G.C. inoperative. Manual r.f. gain available.
A.G.C. Off	A.G.C. inoperative. Full gain available.

h. External Lamp Indication. Indicates the presence of a signal above a predetermined level, the level being decided by the setting of a variable resistor (set relay) in the A.G.C. output circuit which is indirectly used to operate relay B, which controls a lamp situated at the C.M. desk.

22. **Monitor Audio Frequency.**

a. This unit allows monitoring of various receiver supply voltages, valve currents and signal levels. It also allows the receiver to be adjusted to suit the correct supplementary characteristics by:—

b. Operation of relays which switch into circuit the correct i.f. filters and demodulator.

c. Choice of source of demodulation injection frequency.

d. Provision is made for switching a.f. outputs from the two demodulator units to the receiver output terminals.

e. Demodulator Injection
d.s.b. AM circuit inoperative – HT supply switched off.
Positions 2, 3 and 4 – V2 acts as a TATG crystal oscillator. Crystals are 1·601 Mc/s 1·599 Mc/s and 1·600 Mc/s. The first two are used for c.w. to give a 1 kc tone, the last is used for s.s.b.
In position 5, 1·6 Mc/s is derived from the external high stability 100 kc/s signal, the whole circuit acting as a ×16 multiplier in two stages.

f. A.F. Output Switching. The output from each demodulator is brought to the output switch i.s.b. Channel 1 output is connected to receiver output 1 and channel 2 output to receiver output 2.
u.s.b./d.s.b./c.w. – Channel 1 remains connected to output 1, channel 2 output is interrupted.
l.s.b. – Channel 2 output is connected to output 1 and channel 1 output is interrupted.

23. **Synthesizer.**

a. An external standard sine wave signal is applied to a harmonic generator which produces harmonics of 100 kc/s up to 32·6 Mc/s.

b. Following the generator is a high pass filter. This unit is provided with three switches (appearing on the upper half of the front panel) by means of which any frequency in the range 4·6 Mc/s to 32·6 Mc/s (2·6 Mc/s above the range of the receiver) may be selected in steps of 100 kc/s. The output of this filter is fed to the synthesizer mixer, and mixed with the amplified output of the receiver local oscillator at a frequency of 1·6 Mc/s above the receiver frequency. It is amplified and passed into the receiver mixer stage. This is combined with the selected frequency output from the band pass filter and the two produce an i.f. signal between 900 kc/s and 1 Mc. This signal is amplified in the later stages of the amplifier i.f. and the resulting output is fed to one input of a phase detector.

c. A second input of this detector receives a signal derived from the 100 kc/s standard source through the interpolating synthesizer. This latter has three switches (appearing in the lower half of the front panel) which can be operated to give frequency readings in decade steps of 10 kc/s, 1 kc and 100 c/s respectively, The frequency indicated by these three dials is complimentary to that referred to in the second paragraph above and represents the last three significant figures of the receiver signal frequency. These three switches and the three on the band pass filter can thus be set to give the receiver signal frequency to the nearest 100 c/s.

d. The frequency of oscillation of the interpolating synthesizer is normally 1000 kc/s when the signal frequency is a multiple of 100 kc/s, and the three dials associated with the interpolating synthesizer indicate zero. When the signal frequency is not a multiple of 100 kc/s, these three switches are operated to cover the relevant additional figures: the frequency of oscillation of the unit then becomes less than 1000 kc/s by the frequency indicated on the three dials. The output, which is fed into the phase detector, will be an interpolating signal of between 900·1 and 1000 kc/s in steps of 100 c/s.

The phase detector thus receives two signals, one the interpolating signal from the synthesizer which is stable, and the other from the amplifier i.f. which will vary if the frequency of the receiver local oscillator varies.

Any variation in the frequency of the local oscillator is detected by the phase detector resulting in a d.c. voltage, the polarity of which depends upon the frequency error between the input signals to the phase detector.

e. Automatic Frequency Control. This d.c. voltage is passed back to the reactance valve in the receiver as a bias voltage which varies the effective inductance of the valve, thereby adjusting the local oscillator frequency. The variation in the mean reactance of the valve is such that it corrects the variation in the local oscillator frequency, to reduce the frequency error between the two input signals to the phase detector to zero. The local oscillator can thus be controlled to oscillate anywhere in the required range 3·6 to 31·6 Mc/s (1·6 Mc/s higher than the receiver signal frequency) in 100 c/s steps to the same accuracy as the original 100 kc/s source.

f. Error meter. This indicates a frequency difference between the two input signals at the phase detector, caused by variation in the local oscillator frequency. This can be rectified by turning the receiver tuning dial in the correct direction; the direction of rotation of the dial is the same as the direction of movement of the meter pointer, i.e. a clockwise turn of the dial knob is necessary to move the pointer to zero in a clockwise direction and vice versa. The meter is wired to the second detector on the phase detector unit.

g. Locking indication. A lamp, designated UNLOCKED, is connected to relay contacts on the phase detector. This relay is un-energized, while the error between the two phase detector inputs is above a certain level and the lamp is then alight; when the error comes below this level, the receiver and synthesizer come into lock, the relay operates and the lamp connection is broken. The lamp remains out during the whole period in which the frequencies of the two units are locked.

24. **Power Supply**

Input of 115/240 V 40/60 c/s is required. All receiver and synthesizer power requirements are supplied by internal power supply units.

25. **Receiver Controls**

a. AERIAL SELECTOR SWITCH – choice of any one of three CAW lines or to special aerial line/test point.

b. MAINS AVAILABLE LAMP – mains supply present.

c. ON/OFF SWITCH – switching on and off of receiver.

d. MAINS ON LAMP – indicates receiver is switched on.

e. BAND SWITCH – selection of any one of eight frequency bands.

f. TUNING HANDWHEEL – frequency tuning.

g. SYNTHESIZED/FREE RUNNING SWITCH – Free running – the FINE TUNING control varies the local oscillator frequency over a small range on either side of the frequency, determined by the setting of the TUNING HANDWHEEL.

SYNTHESIZED – the local oscillator frequency constrained at the correct tuning frequency to correspond with the setting of the synthesizer controls.

h. FINE TUNING CONTROL – varies local oscillator frequency over small range.

i. UNLOCKED LAMP – will be lit permanently when switched to FREE RUNNING or when the local oscillator error is too great for the synthesizer to retain it in 'lock'.

j. ERROR METER – gives indication of direction and degree of error, between synthesizer and local oscillator provided error is not too great.

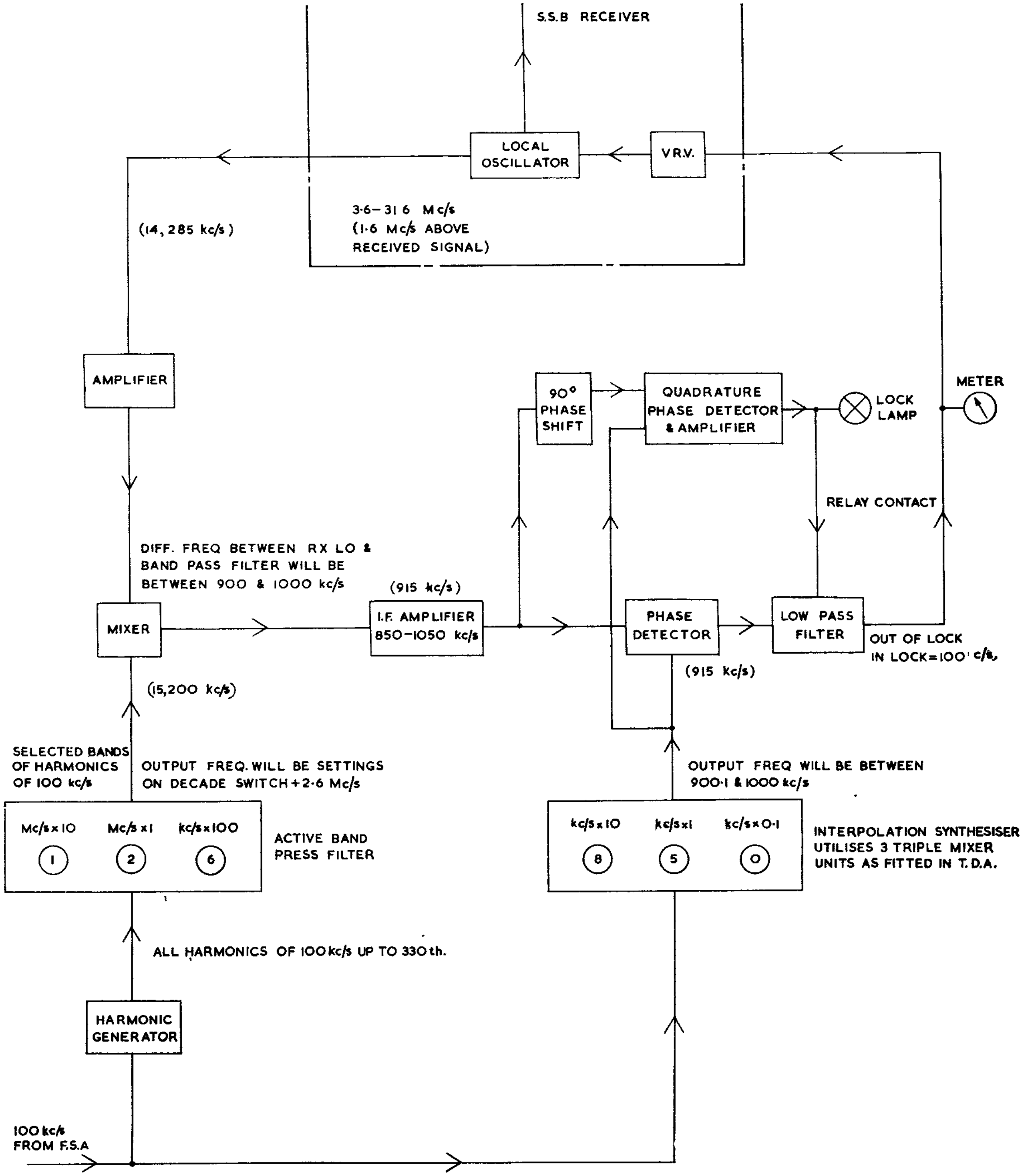


FIG. 6. CJA SYNTHESIZER

k. CALIBRATE SWITCH – biased control which switches on the 500 kc/s crystal oscillator for dial scale calibration checking.

l. CANCEL MUTING SWITCH – when depressed – prevents an external 24 V muting supply from muting the receiver.

m. OVERLOAD LAMP – indicates the receiver has been muted by an overloading input signal.

n. OVERLOAD RESET SWITCH – biased control which removes the muting.

o. MODULATION SWITCH

(1) DSB – selects an i.f. crystal filter giving a bandwidth of 6 kc/s and demodulator circuit is made.

(2) CW+,CW– – gives 100 c/s bandwidth with choice of position to clear adjacent unwanted signal.

(3) SSB/ISB/INT – gives 3 kc/s bandwidth, carrier reinsertion frequency of 1·6 Mc/s obtained from an internal crystal oscillator.

(4) SSB/ISB/EXT – 3 kc/s bandwidth, 1·6 mc/s derived from 16th harmonic of 100 kc/s input from F.S.A.

p. OUTPUT SWITCH (u.s.b./c.w./d.s.b.,i.s.b., l.s.b. ONLY) – selects required a.f. output.

q. INT/EXT A.G.C. SWITCH – normally set to INT. When set to EXT an external source of A.G.C. may be used.

r. (1) AUTO MANUAL GAIN SWITCH –gives correct A.G.C. time constant

(2) DATA LINK	Reception of Data
(3) PAUSE	Reception of s.s.b., suppressed carrier
(4) LONG TIME CONSTANT	Reception of CW
(5) SHORT TIME CONSTANT	Reception of d.s.b. AM
(6) MANUAL	A.G.C. varied by manual control
(7) A.G.C OFF	I.F. amplifier gives maximum gain

s. I.F. GAIN (MANUAL) CONTROL – varies A.G.C. level to i.f. stages.

t. A.F. MONITOR GAIN – varies gain to local headset.

u. A.F. MONITOR PHONE JACK – local headset.

v. SET RELAY – screwdriver control to adjust level at which a relay, sensitive to gain control voltage, will operate.

w. THREE POSITION KEY SWITCH – switching meter off, or monitoring u.s.b./d.s.b/c.w. or l.s.b.

x. 14 POSITION ROTARY SWITCH – selects line to be monitored in the meter.

26. **Synthesizer Controls**

a. MAINS AVAILABLE LAMP – mains supply present.

b. ON/OFF SWITCH – mains switching.

c. MAINS ON LAMP – indicates receiver switched on.

d. METER, with METER ZERO CONTROL and 19 POSITION ROTARY SWITCH for accurate zeroizing of meter and selection of line to be monitored.

e. SIX FREQUENCY SELECTION SWITCHES together with frequency indicating numbers (10,000, 1,000, 100, 10, 1 and 0·1 kc/s controls).

HF RECEIVER OUTFIT CJC

27. **Function.** As for the I.C.S. receiver. For use when unattended reception is not required. Currently only used as the receiver fitted in the MCO ship/shore bay where the operator requires direct receiver access

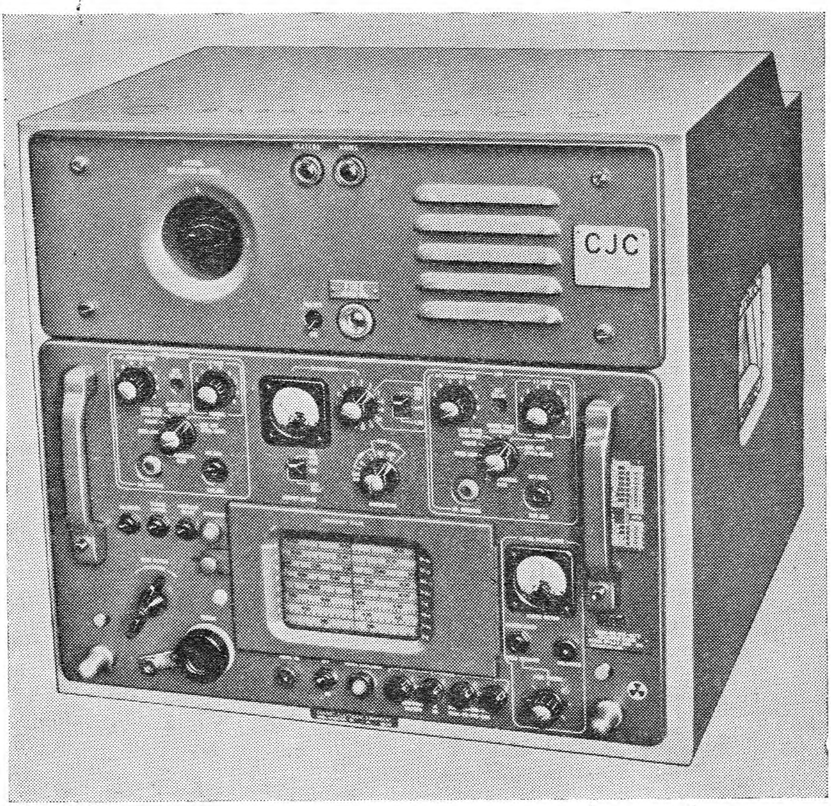


FIG. 7. OUTFIT CJC (See Fig. 9 on page 11-4-14A)

and control. The only physical difference is that the receiver is not provided with a synthesizer. General description and operating instructions are applicable to those of the CJA when used in the 'free running' mode.

(*Continued on page 11–4–15*)

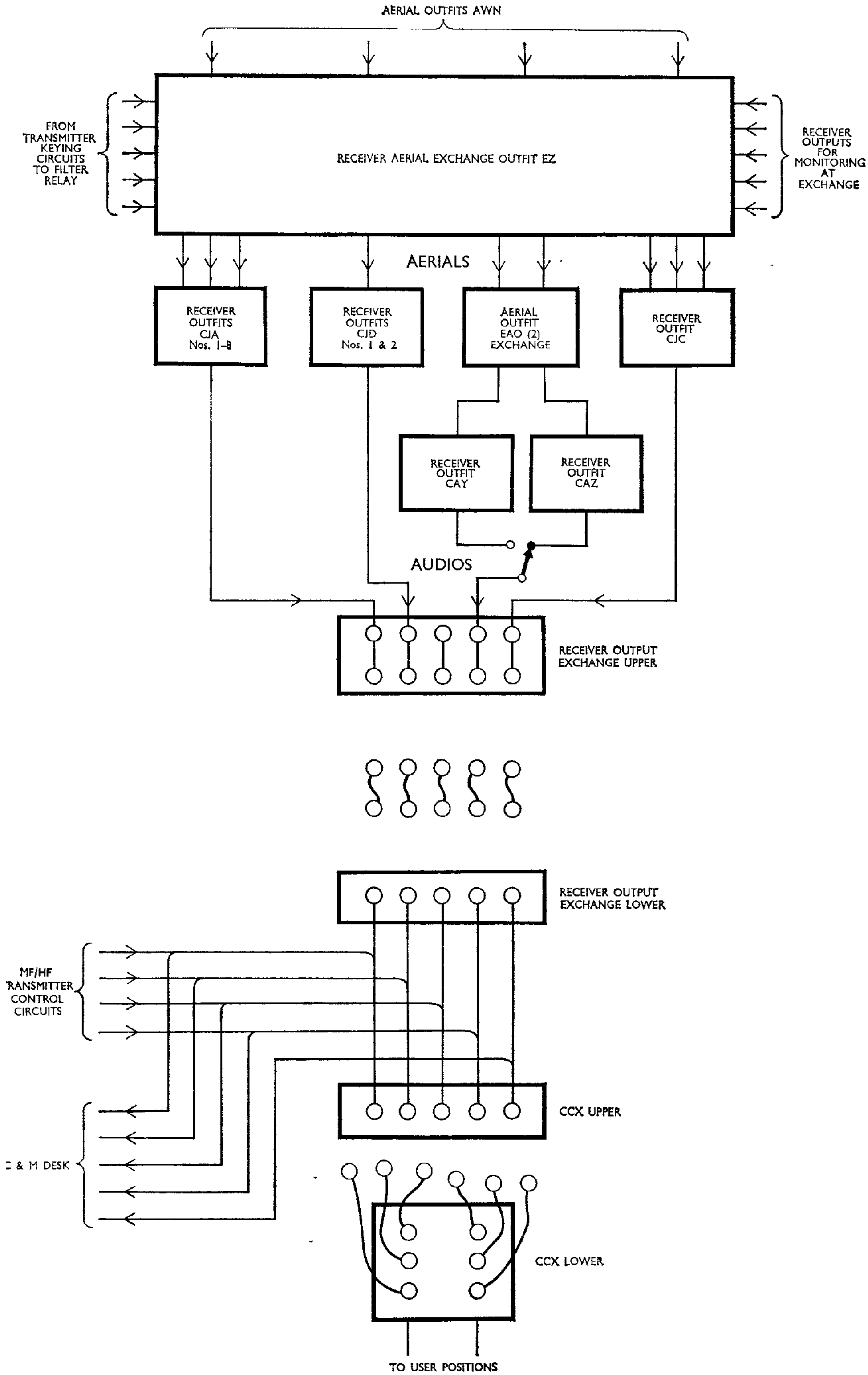
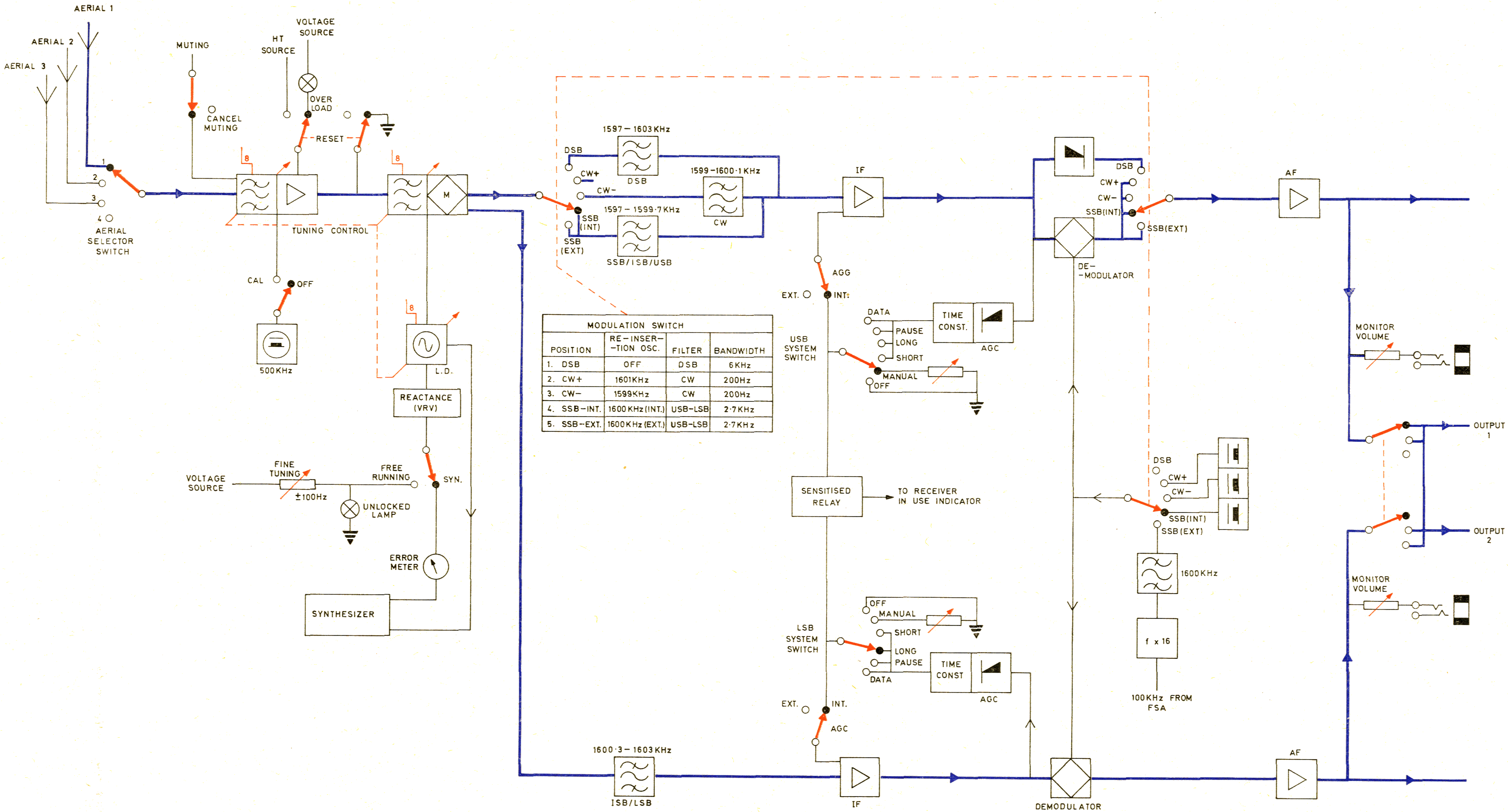


FIG. 8. I.C.S. – LF/HF RECEPTION BLOCK DIAGRAM



MODULATION SWITCH

POSITION	RE-INSER-TION OSC.	FILTER	BANDWIDTH
1. DSB	OFF	DSB	6KHz
2. CW+	1601KHz	CW	200Hz
3. CW−	1599KHz	CW	200Hz
4. SSB–INT.	1600KHz (INT.)	USB–LSB	2·7KHz
5. SSB–EXT.	1600KHz (EXT.)	USB–LSB	2·7KHz

FIG. 9. RECEIVER OUTFIT CJA/CJC

28. **L.F. Receiver Outfit CJD (see Fig. 11 on page 11–4–21)**

a. CJD (1) is a single mounted receiver and CJD (2) is mounted in a standard cabinet—each cabinet containing five receivers. The receivers in CJD (1) and (2) are electrically identical, but differ physically in that the power unit is mounted above the chassis in CJD (1) and behind it in CJD (2).

b. The receiver covers the frequency range 10 kc/s to 200 kc/s in five bands. It is intended for the reception of the following types of signal:

(1) Voice.

(2) c.w.

(3) Single and Multi-channel RATT.

(4) Facsimile.

c. The receiver is intended for use with a 115 V, 40 c/s to 60 c/s power supply. It is designed to operate in conjunction with a common aerial system, itself fed from either a high efficiency aerial or a low efficiency aerial (e.g. submarine aerial). Alternatively, the receiver can be operated from a separate and independent aerial. It includes the following conventional features:

(1) Variable selectivity (by changing the i.f. bandwidth).

(2) Reduction of interference by the use of a noise limiter.

(3) Control of local-oscillator frequency, when required, by locking the local oscillator to a frequency synthesizer.

(4) Automatic gain control to provide a reasonably constant level of audio-frequency output where the input signal is not of constant strength.

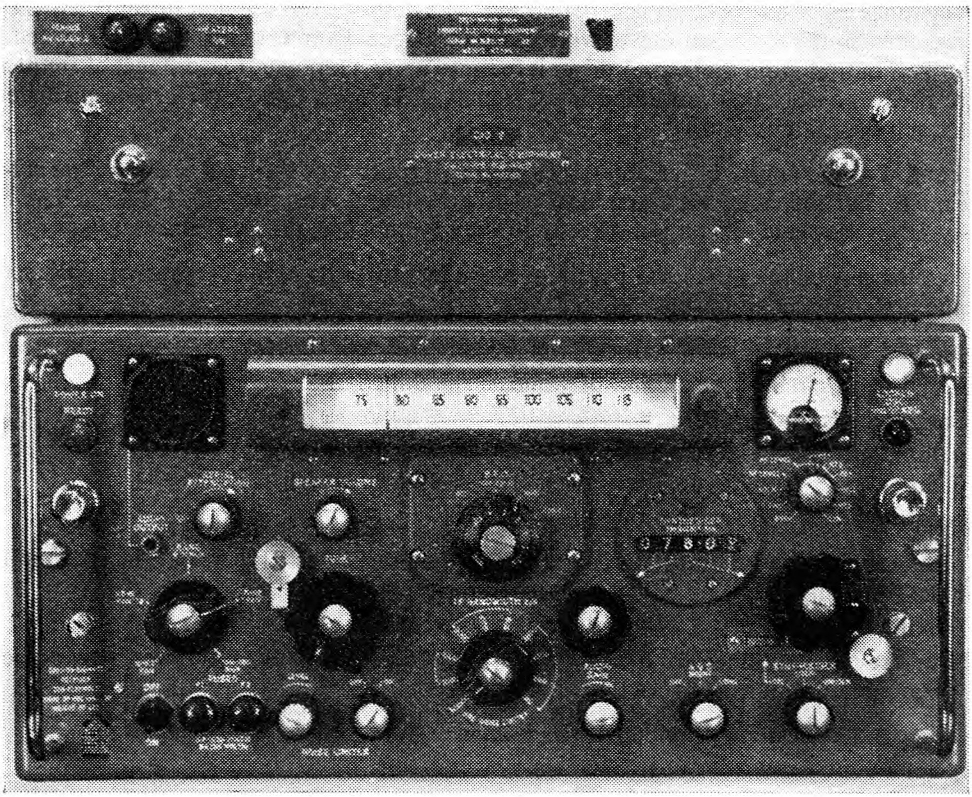


FIG. 10. RECEIVER OUTFIT CJD

(5) Beat-frequency oscillator to facilitate the reception of c.w. and RATT signals.

d. The audio-frequency output is fed to remote positions via a 600 ohms line. A loudspeaker for monitoring purposes is included in the receiver. Alternatively, monitoring can be affected with headphones plugged into the front panel. An i.f. output can be used to feed an external chart recorder or similar instrument.

29. **Brief Description**

a. R.F. CIRCUITS. The receiver covers a frequency range of 10 kc/s to 200 kc/s in five bands as follows:

BAND	FREQUENCY RANGE
1	10–23 kc/s
2	23–41 kc/s
3	41–71 kc/s
4	71–119 kc/s
5	119–200 kc/s

b. The input circuits of the receiver are designed to function either with a low-impedance common aerial system using high efficiency or low efficiency aerials or with an independent aerial. The input is fed via a variable attenuator to the two r.f. amplifying stages, of which the second only is used with a high efficiency aerial, a switch being provided for making the necessary circuit changes. Delayed A.G.C. is applied to the first r.f. amplifier.

c. On Band 1 the second r.f. amplifier is coupled to the first mixer, to which the oscillator, covering the frequency range 71·5–84·5 kc/s, is also connected. The output from the first mixer is fed via a 61·5 kc/s band-pass filter to the second mixer, to which a 40 kc/s signal from the synthesizer is also fed. The resulting 21·5 kc/s output from the second mixer is fed into an i.f. amplifier. (Two stages of frequency conversion are used to ensure that unwanted input signals at 21·5 kc/s, the receiver intermediate frequency, cannot reach the i.f. amplifier.)

d. On bands 2–5 the output of the 2nd r.f. stage and the output of the local oscillator are still coupled to the 1st mixer, but the circuits are arranged to give an output frequency of 21·5 kc/s. The band switch in these ranges connects this output directly to the i.f. amplifier, the 2nd mixer stage is not used.

e. The synthesizer enables the local oscillator to be locked to its correct frequency. Delayed A.G.C. is fed to the first and second mixers.

f. A pair of 3 gang variable capacitors, mechanically coupled, tunes:

(1) Aerial input circuit (one section of gang).

(2) Coupling circuits between:

(*a*) First and second r.f. amplifiers (two section of gang).

(*b*) Second r.f. amplifier and first mixer (two section of gang).

(3) Local oscillator (one section of gang).

g. I.F. AMPLIFIER. The intermediate frequency of the receiver is 21.5 kc/s. The i.f. amplifier circuits include the following:

(1) First i.f. Amplifier Stage. Delayed A.G.C. is fed to this stage.

(2) Four Pre-Noise-Limiter Band-Pass Filters, followed by an emitter follower. Any one of the filters can be connected in circuit by a selector switch.

The degrees of selectivity provided are as follows:

(*a*) 3000 c/s. (*c*) 300 c/s.
(*b*) 1000 c/s. (*d*) 120 c/s.

(3) Noise Limiter. A switch alters the bias on this stage when limiting is not required.

(4) Four post-noise-limiter filters, followed by an emitter follower. These filters are selected by the same switch as the pre-noise filters.

(5) Second i.f. Amplifier Stage. An output from this stage feeds the A.G.C. circuits via an A.G.C./i.f. amplifier which also provides a direct i.f. output.

(6) Third i.f. Amplifier Stage which feeds the detectors.

h. The pre-noise-limiter filters are used to stop low-level interference of all kinds, particularly adjacent-channel interference. The noise limiter tends to suppress sharp random interference spikes of high amplitude. The post-noise-limiter filters (information filters) limit the pass band to that appropriate to the type of signals being received. Accordingly, the pre-noise-limiter pass band selected can never be narrower than the post-noise-limiter pass band.

i. The ganged selector switch for the band-pass filters is a 10-way switch that enables the following combinations of filters to be chosen:

SWITCH POSITION	PRE-LIMITER FILTER (C/S)	POST-LIMITER FILTER (C/S)
1	3000	3000
2	3000	1000
3	1000	1000
4	3000	300
5	1000	300
6	300	300
7	3000	120
8	1000	120
9	300	120
10	120	120

j. A.G.C. CIRCUITS. The A.G.C. circuits are fed from the second i.f. amplifier via the A.G.C./i.f. amplifier and consist of a rectifier, a delay network, an amplifying stage and an emitter follower. Outputs are taken to the following circuits:

(1) First r.f. amplifier.
(2) First mixer.
(3) Second mixer.
(4) First i.f. amplifier.

k. DETECTOR AND BEAT-FREQUENCY OSCILLATOR. Two detector circuits are employed. When the beat-frequency oscillator is not in use, the third i.f. amplifier feeds a detector embodying a single crystal diode; when the beat-frequency oscillator is used, a ring modulator is switched into circuit instead of the single-diode detector.

The beat-frequency oscillator consists of:

(1) A crystal-controlled transistor oscillator with two crystals, either of which can be switched into circuit, to operate at frequencies 1000 c/s or 1500 c/s above the intermediate frequency.

(2) A variable-frequency oscillator covering the range $21 \cdot 5 \pm 3$ kc/s.

l. A.F. CIRCUITS. The audio amplifier consists of one pre-amplifier stage and, in common, two output stages one of which provides a 10 mW output into a 500 ohms line for feeding to positions remote from the receiver, and the other a 50 mW output for the monitoring loudspeaker or the headphones.

30. **Synthesizer and Associated Circuits**

a. The synthesizer operates in conjunction with capacitance diodes (i.e. diodes whose capacitance varies with the voltage applied to them) to lock the local oscillator to any required frequency within its operating range, provided the difference between the free and lock-on frequencies is small; the frequency-setting accuracy when the local oscillator is locked to the synthesizer is ± 6 c/s.

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b. The synthesizer includes a 10 kc/s crystal-controlled oscillator and a 11·5–21·4 kc/s variable-frequency oscillator both housed in a temperature-controlled oven. The 10 kc/s requirement is normally met by the internal oscillator, an output from the FSA being available as an alternative. At present, use of the ships frequency standard will have little effect on the frequency setting accuracy, but it is intended to introduce a new design of synthesizer, which will enable a frequency-setting accuracy of ± 2 c/s to be attained.

c. A selected harmonic of the output from the crystal-controlled oscillator and the output from the variable oscillator pass to a ring modulator to provide a signal of known and constant frequency separated from the required local oscillator frequency by 40 kc/s. This signal and the output from the local oscillators are applied to a mixer stage. The output from the mixer is passed to a phase detector, to which the fourth harmonic of the output from the crystal-controlled oscillator is also applied. The output from the phase detector is a varying unidirectional voltage which is applied to two silicon diodes connected in the local-oscillator tuned circuit to control their effective capacitance. This determines the local-oscillator frequency and sets it to its correct value.

d. An output from a second phase detector is taken out of the synthesizer to monitoring lamps, which indicate whether the local oscillator is locked to its correct frequency.

e. On band 1 only, a 40 kc/s output (fourth harmonic of the output from the crystal-controlled oscillator) is taken from the synthesizer to the second mixer.

f. The variable frequency oscillator is calibrated by comparing its output with harmonics of a 1 kc/s signal derived from the crystal controlled oscillator via a frequency divider. The 1 kc/s signal and the output from the variable-frequency oscillator are fed into a heterodyne detector, the output from which is fed to a meter.

g. POWER SUPPLY. The power-supply assembly includes a mains transformer, which feeds the following:

(1) A rectifier unit providing +250 V and + 150 V H.T. supplies.

(2) A rectifier circuit, from which a +20 V stabilized supply is derived for driving the transistor stages.

(3) A rectifier circuit providing a +24 V supply for energizing relays and lamps.

(4) A rectifier circuit providing a −30 V, −48 V and −60 V supplies for the oven control and other transistor circuits.

(5) Valve heaters.

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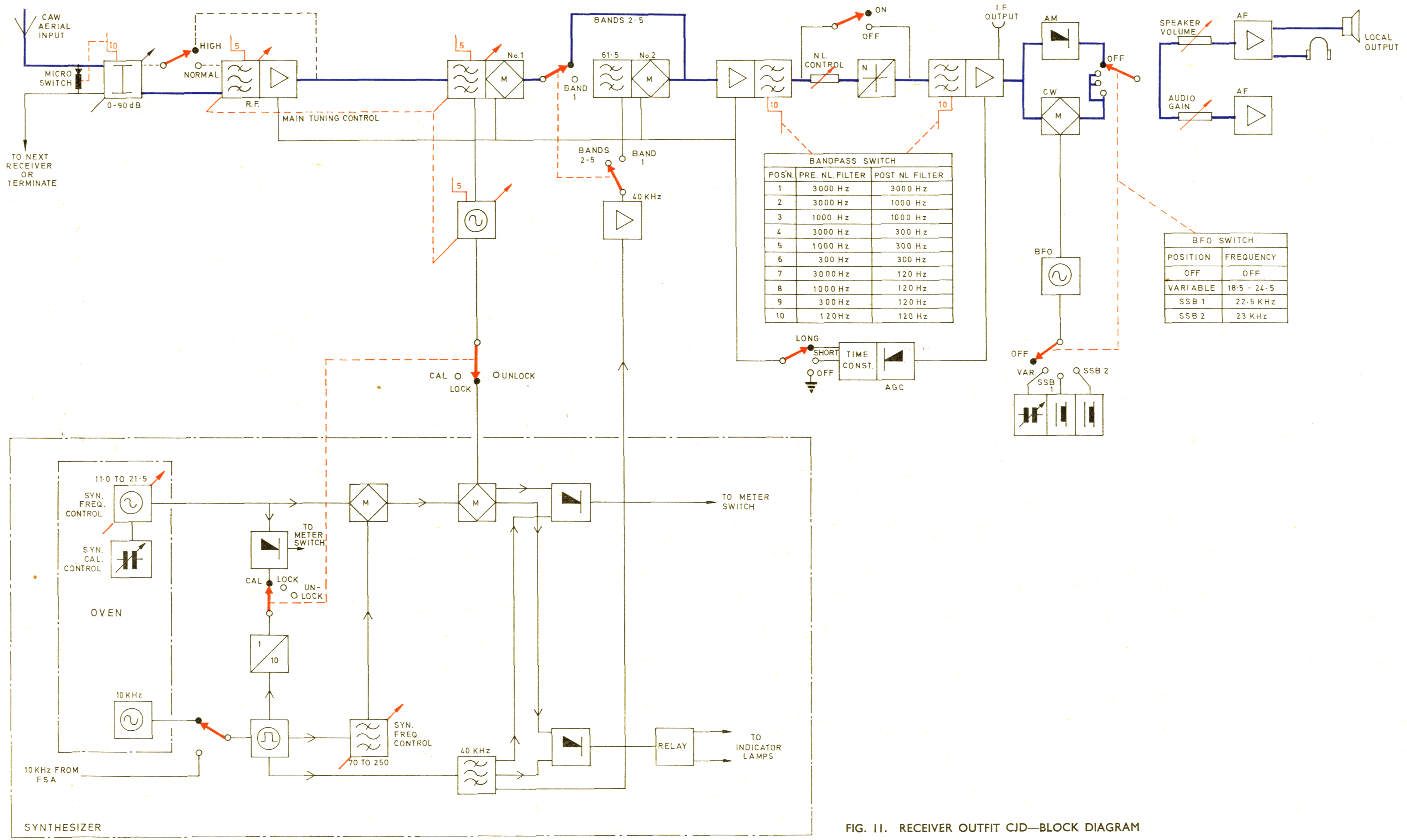

BANDPASS SWITCH

POS'N.	PRE. NL. FILTER	POST NL FILTER
1	3000 Hz	3000 Hz
2	3000 Hz	1000 Hz
3	1000 Hz	1000 Hz
4	3000 Hz	300 Hz
5	1000 Hz	300 Hz
6	300 Hz	300 Hz
7	3000 Hz	120 Hz
8	1000 Hz	120 Hz
9	300 Hz	120 Hz
10	120 Hz	120 Hz

BFO SWITCH

POSITION	FREQUENCY
OFF	OFF
VARIABLE	18·5 - 24·5
SSB 1	22·5 KHz
SSB 2	23 KHz

FIG. 11. RECEIVER OUTFIT CJD—BLOCK DIAGRAM

11.5. CONTROL AND MONITORING DESK

1. **The Control and Monitoring Position** (C & M)

a. The central control and monitoring position consists of a C & M desk, with a cabinet housing a monitor receiver (Outfit CJA) and r.f. drive (Outfit TDA), on the left and an AT terminal position, complete with teleprinter, on the right. The assembly is sited in the low power section of the CCR which is screened from the r.f. high power of the transmitter annexe.

b. The C & M desk operator will have plug and socket control of the adjacent CCX, ROX, RCS and receiver aerial exchanges in addition to the control and monitoring facilities afforded by the desk.

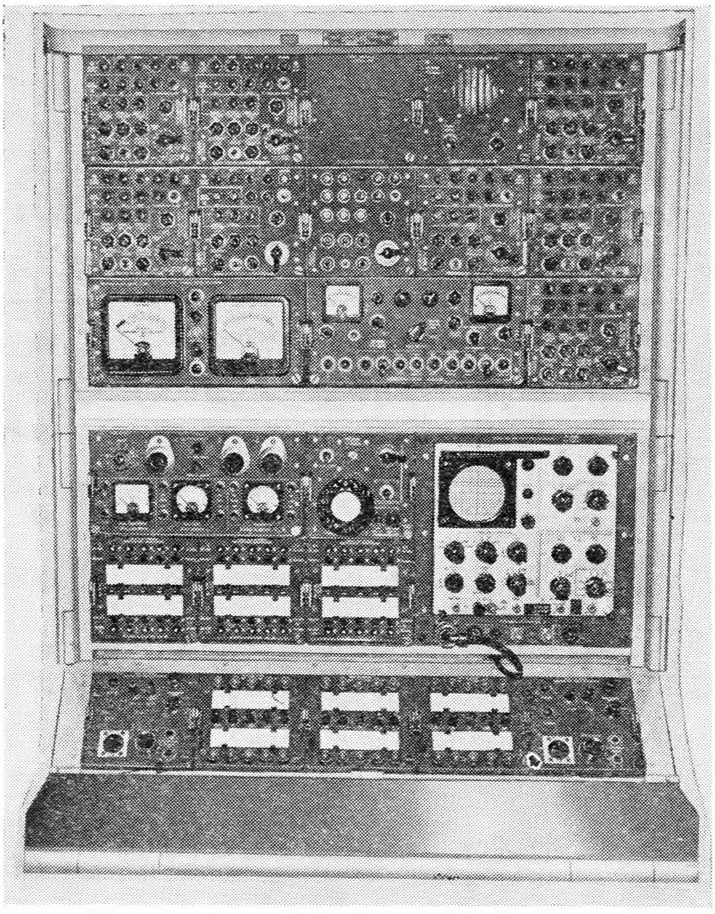

FIG. 1. THE C & M DESK

c. Two-way communication independent of the CCX plug and socket connection is provided to remote supervisors, user and maintainer positions including connection into the ship's interphone system and the provision at some positions of group intercom circuits (*e.g.* Signal intercom).

2. **The C & M Desk**

a. The desk is designed for use with up to six I.C.S. circuits sharing a maximum of nine transmitter

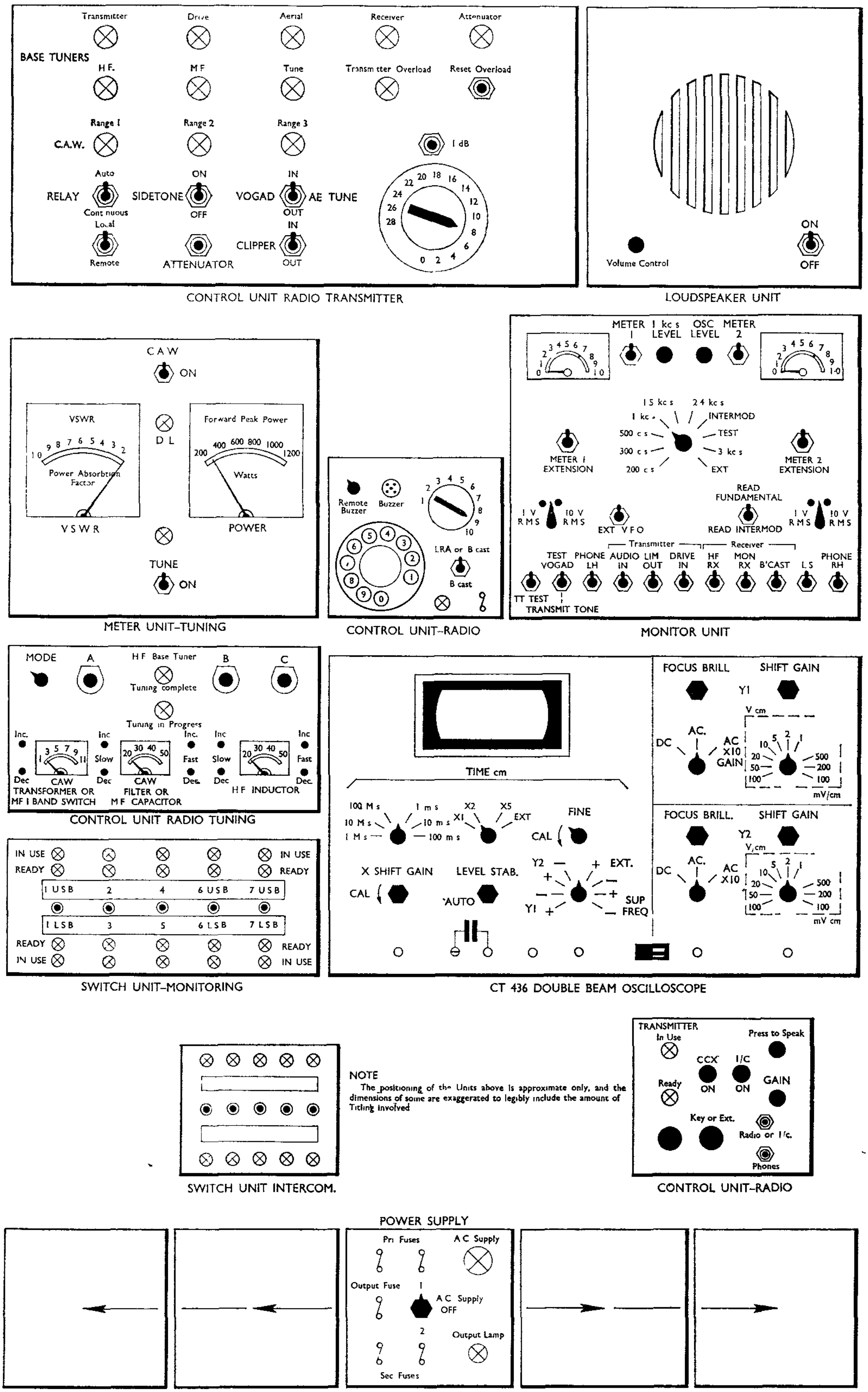

FIG. 2. I.C.S. – C & M DESK

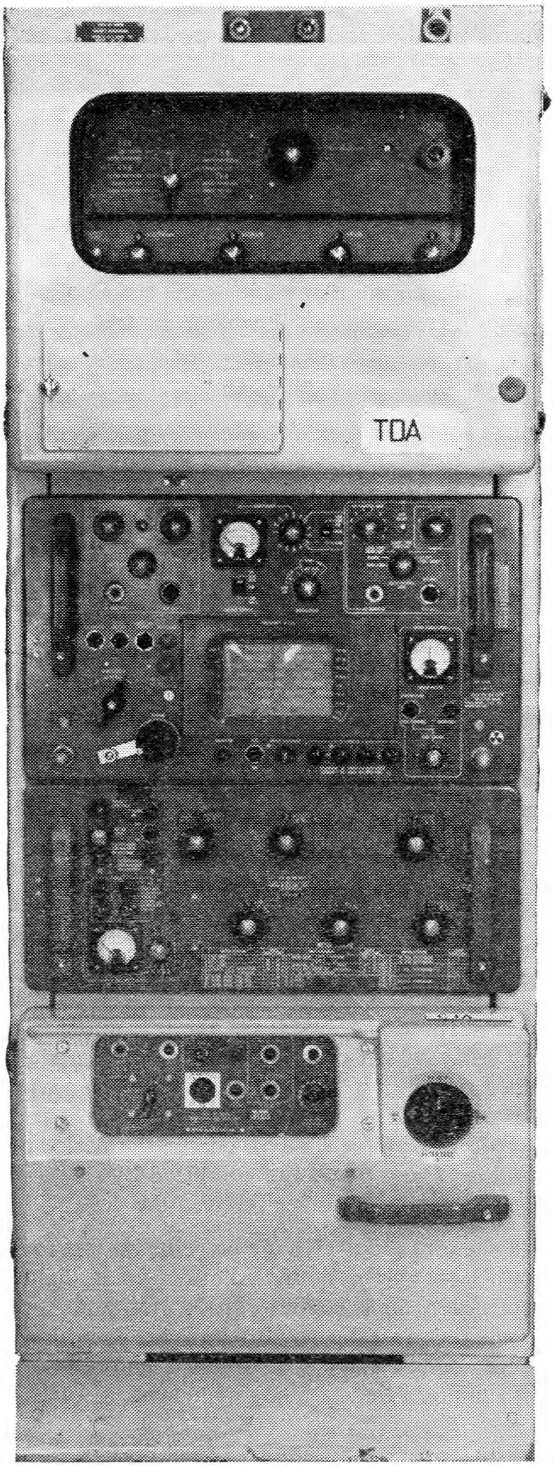

FIG. 3. MONITOR CABINET

control units (designated TCUs). The state panels are allocated one to each circuit, primarily for u.s.b. working and a second to circuits No. 1, 2 and 5 to meet possible l.s.b. circuit requirements (i.s.b.).

b. The desk includes:

(1) The ~~seven~~ nine transmitter control units;

(2) A monitor network;

(3) Ten power supply units;

(4) A monitor switch, with transmitter READY and BUSY lamp indication, for every external communication circuit.

c. Operation of a monitor switch connects its circuit to the single monitor network which comprises:

(1) An audio monitoring unit and associated oscilloscope CT436;

(2) A meter unit, relay connected to the WBA power and v.s.w.r. meters;

(3) A tuning unit for control of the transmitter CAW filter or aerial base tuner;

(4) Two desk operator control units (RCUs).

Connection to the monitor network does not interrupt a circuit or its users. In the event of operation of more than one monitor switch at a time the left hand switch is always the over-riding control.

d. The Monitor Unit READY and BUSY lamp indication is only given when a circuit is switched on to REMOTE. An MF–HF circuit is only required to be switched to the LOCAL condition, isolating it from remote users, for aerial circuit tuning and initial diagnosis.

3. **Control Unit Radio Transmitter 5820–A.P. 164520**

a. One of these units is included in each HF/MF transmitting circuit, and speech and keying signals from radio users pass via them to the transmitter drive amplifiers. The unit carries a transistorized Voice Operated Gain Adjusting Device (VOGAD) which adjusts its own gain so that its ouput level is constant for all inputs above a certain threshold level. This ensures that if the speech level from a user's microphone varies, the transmitter will still be modulated at a constant level. The output of the VOGAD is fed into a balanced limiter circuit in the unit, which clips any peaks of signal (above a present level) which may pass through the VOGAD, thus preventing overloading the transmitter due to such peaks. The reception lines associated with this particular transmitter receiver circuit are also fed to this unit for monitoring purposes and enable relaying to be carried out by switching these lines to the input of the VOGAD circuit for re-transmission.

b. A keying circuit is included in the unit to cater for the transmission of Morse. A loop, keyed by a Morse key, operates a keying relay which controls transmission of the ship's standard 1 kc/s tone. *A Sidetone Amplifier* is included in the unit and is used to feed the output of the limiter circuit to the R1, R2 lines. This enables other operators to hear what the user is transmitting. Relays in the unit connect points in the circuit to the Monitor Unit to enable the desk operator to carry out his duties of monitoring, testing and tuning. These relays are energized by operating the appropriate switch for the channel on one of the Switch units Monitoring fitted in the desk.

c. Fitted on the front panel of the unit are twelve indicator lamps, six toggle switches, two push button switches and one rotary switch. Four of the lamps coloured green, light when the following units are in a ready condition. The transmitter, the transmitter drive unit, and Aerial and the receiver. There are two yellow lamps to indicate whether an HF or MF base tuner is in use, and three more yellow lamps to indicate which of three ranges of CAW filters is in use. One red lamp shows a transmitter overload condition and another lights to indicate that retuning or a check of tuning is required.

d. The 15 position rotary switch is labelled DRIVE OUTPUT ATTEN and attenuates the output of the transmitter drive unit by remotely operating, in a binary combination relays fitted in that unit. The attenuation can be varied from 0 to 28 db in 2 db steps, and the switch must be set to the maximum attenuation position before operation of the push button marked ATTENR brings the circuit into operation.

A green lamp indicates the ATTENUATOR READY condition, i.e. that the attenuation switch is now effective.

e. The other six switches on the front panel have the following functions:

(1) The LOCAL/REMOTE switch is operated to the REMOTE position when the circuit is ready for operational use, and this switch operates relays in the unit which extend the transmitter control lines to the CCX and, thus, to the remote user.

(2) The SIDETONE switch enables the desk operator to disconnect the sidetone signal fed back to remote user via the reception lines.

(3) The three-position VOGAD switch operates relays to by-pass the VOGAD circuit when required and in its centre position marked AERIAL OFF prevents transmission to the aerial.

(4) The CLIPPER switch in its IN position increases the output of the VOGAD by 12 db and brings the limiter circuit into operation. This provides 12 db of clipping and increases the average audio power fed to the transmitter.

(5) The RELAYING switch connects the reception lines to the input of the VOGAD for retransmission. Continuous relaying, with the transmitter permanently operated, or automatic relaying with the transmitter operated only when the receiver is receiving a signal, can be selected by this switch.

(6) The switch marked 1 db is operated to introduce 1 db increments between the adjacent 2 db steps of the drive output attenuator switch.

f. The TX OVERLOAD RESET push button switch is operated to release the overload lockout relay in the transmitter r.f. amplifier if this should operate. This, of course, will only be effective if the overload fault has been cleared.

g. Three units are used for the lower sideband signals of three of the transmitters. The three lower sideband control units are wired so that independent monitoring of the lower and upper sideband signals can be carried out. Lamp indications are not given on this unit. Only the VOGAD, CLIPPER and SIDETONE switches are used. Other switches are ineffective and the facilities are controlled by the UPPER sideband unit.

4. **Switch Unit, Monitoring A.P. 164524.** This unit is designed to cater for up to 10 external communication circuits. Three units are fitted and provide switching of any one circuit to the monitor network, and READY and IN USE lamp indication of all circuits. Operation of a circuit switch energizes relays in the selected TCU (if an MF–HF circuit) or the appropriate relay in the CCX (if UHF, 689 or 618 circuit), to connect the selected circuit for control and monitoring; it does not interrupt the service. The operation of one of these switches also completes the C+line to the desk operator's control units, thereby extending control of the associated circuit to the desk operator.

5. **Monitor Unit A.P. 164523**

a. Provides monitoring of one, or simultaneously of two, of a number of preselected a.f. points in the circuit being monitored. Selected inputs are taken to the two meter amplifiers and to the upper and lower traces of the double beam oscilloscope CT436 to provide visual and more detailed monitoring. Inputs may also be switched, at PHONE 1 and 2, to the left hand and/or right hand operator's control unit headphone circuit or to the desk loudspeaker. Power supply for the meter amplifiers is completed at METER 1 and 2 and provision has been made for switching to extension meters (not fitted) if required.

b. TEST OSCILLATOR. Internal circuits include a test oscillator and connection for an external VFO, to provide test audio frequencies of a constant level for testing and tuning of the transmission channel, including the selected aerial circuit.

c. TWO-TONE. The TWO-TONE switch provides for modulation of the transmit channel being monitored by the output of a mixer circuit having two audio inputs of equal level. It is used when carrying out an intermodulation test. The switch completes:

(1) The 24 V d.c. supply to the two-tone mixer circuit and to the intermodulation filter and amplifier.

(2) The 1 kc/s input from Outfit FSA (1) Divider Cabinet and the output (switched to 2·4 kc/s) of the built-in test oscillator, to a two-tone mixer stage (the mixed output may be monitored at AUDIO IN).

(3) The MON RX monitor point (receive lines of the monitor cabinet receiver) to the input of an intermodulation filter and amplifier for monitoring, on Meter 1 and on the oscilloscope.

d. TEST VOGAD. Completes the output of the test oscillator to the VOGAD circuit. The transmitter pressel line is not completed, therefore the microphone lines will still be short circuited, by the delay circuit and by a pressel relay contact.

e. TRANSMIT TONE. Completes the output of the test oscillator to the VOGAD circuit, and unlike TEST VOGAD also completes the Transmitter pressel line. The second function is in parallel with the desk operator's foot switch.

f. PHONE 1 AND PHONE 2. Respectively, complete the left and right headphone circuit to the audio being displayed on Meter 1 or 2. In the centre position of the switches headphone circuits are connected to the receiver output (HF Rx monitor point).

g. AUDIO IN. Monitors the microphone lines (in an MF–HF circuit this is the input to the TCU VOGAD circuit).

h. LIMITER OUT. (MF–HF circuits only.) Monitors the microphone line at the VOGAD circuit output. (CLIPPER IN or CLIPPER OUT.) This monitoring is also the side tone amplifier input.

i. DRIVE IN. (MF–HF circuits only.) Monitors the microphone lines at the desk output to the TDA. confirming operation of the delay and pressel circuits in removing short circuiting and completion of the microphone lines.

j. HF RX. Monitors the receiver audio output and, if switched on at the TCU, the side tone amplifier output. (Operation of the circuit relaying switch completes the transmitter pressel line and transfers the receive line connections from the side tone amplifier input to the microphone line input, thereby transmitting the receiver output.) This monitor point is connected to the monitor cabinet from where it can be switched to the receiver aerial exchange, in lieu of the monitor receiver output, for use when tuning the rejection filters.

k. MON RX. Monitors the output of the monitor cabinet receiver CJA. The output of this receiver is connected to the intermodulating amplifier by the Two-tone switch independent of the MON RX switch.

l. BROADCAST RX. Monitors the output of the receiver selected at the control unit, radio (dialling unit).

m. LS AMPLIFIER. Connects the desk loudspeaker to the audio displayed on Meter 1 or 2 or, in the centre position of the switch, to a plug at the CCR CCX lower providing a loudspeaker watch or monitoring of any receive channel.

READ FUNDAMENTAL AND LEVEL controls are used in the INTERMODULATION CHECK.

6. Meter Unit, Tuning A.P. 164521

a. The meter unit provides switching and lamp indication of the tune and dummy load condition as well as meter indication of v.s.w.r. and power output of the monitored WBA.

b. TUNE ON. Operation of spring loaded TUNE switch to CW completes the tune relays which:

(1) Complete the 24 V d.c. supply to the CAW filter or aerial base tuner connected to the circuit at the

aerial exchange and, if a base tuner, its variables will, by rotary switch (ledex) control, take up positions set on the tuning unit dials. During this movement the TUNING IN PROGRESS lamp will light and on completion be replaced by the TUNING COMPLETE lamp.

(2) Complete the supply to the start relay in the dummy load cooling unit, thereby starting the fan.

(3) Light the TUNE lamp on the motor unit and on the T.C.U.

(4) Complete a hold on supply to retain the TUNE condition with the TUNE switch released.

c. DUMMY LOAD. Operation of the spring loaded DUMMY LOAD switch completes:

(1) The dummy load indicating lamp on the meter unit.

(2) The supply to one of the two co-axial switches in the transmitter aerial exchange which will in turn connect the associated dummy load to the monitored circuit.

(3) A guard relay which open circuits, the dummy load relay in the filter drawer, transferring the WBA output from the aerial line to the dummy load line.

7. **Radio Tuning Control Unit**

a. This unit provides facilities for tuning aerials. There are three types of aerial tuning required.

(1) MF Base Tuner.

(2) HF Base Tuner.

(3) CAW Filters.

The particular aerial required to be tuned is connected to this unit by the Monitoring Switch on the desk.

There are two systems of tuning.

b. HF BASE TUNER.

There are three variable controls, A, B and C, and a switch. These control the tuning motors in the base tuner and vary 'L' and 'C'. This tuning is the same as that used in a 603 (5) since the base tuners are identical (ETA (1)).

c. MF BASE TUNER (ETB) AND CAW FILTERS.

These are tuned in the same way as the 640 base tuner – by a series of buttons controlling units. There are three:

(1) *CAW transformer and MF Band Switch.* Controlled by two buttons marked INC and DEC, indication being in a meter marked from 1–11.

(2) *CAW Filter and MF 'C'.* Four buttons – two for slow INC and DEC and two for fast INC and DEC. Indication in a meter marked from 0–100.

(3) *CAW Filter and MF 'L'* As for (2) above.

8. **Control Unit Radio 5820–A.P. 164527 (Dialling Unit).** This unit enables the desk operator to select any one of up to 24 receiver outputs for monitoring. A toggle switch labelled LRA/BROADCAST selects either type of reception.

The telephone dial is used in conjunction with a switch unit to call up to 60 intercommunication users.

The REMOTE BUZZER ON OFF switch is used to disconnect the tone on all outlying units but NOT THE DESK.

9. **Loudspeaker Unit 5820–A.P. 164528.** This unit carries a transistorized audio amplifier capable of giving a maximum audio output of not less than 1 watt. Normal on/off and Volume controls.

10. **Switch Unit.** Intercommunication. 5820–A.P. 164526. Three such units are fitted, each comprising 5 three-way switches providing ten positions for allocation to remote radio users fitted with RCUs. One switch position is designated DIAL A and DIAL B, and provides facilities for dialling up to 60 additional Operations Room users by means of the dialling unit.

11. **Power Supply 5820–A.P. 164531.** This unit is a transistor stabilized power supply capable of providin a maximum current of 1 amp at 24 volts. One unit is used in association with each TCU.

12. **Oscilloscope 6625–99–919–7095.** This is a straightforward double beam oscilloscope for monitorin wave form as selected by the Monitor Unit.

13. **Control Unit Radio Operators 5820–A.P. 164525.** This is a similar unit to the CONTROL UNIT RADI REMOTE 5820–A.P. 164540 with the exception that it is designed to be fitted into the control and moni toring desk.

14. **Clock Electronic 6625–99–916–0020.** A 50 c/s clock, with a stop button for correction, running fron the ship 100 c/s supply. The ship's 100 kc/s supply is fed to the Divider Unit and the 100 cps output i then fed to a divider unit which drives the clock.

15. **Cabinet Monitoring Facilities.**

a. The Cabinet Monitoring comprises:

(1) A TDA, which may, in an emergency, be connected to an operational WBA/WBB.

(2) A CJA, which can be connected to an aerial line.

(3) A monitoring and test unit.

(4) A complete range of spare C & M desk units (excluding the oscilloscope) stowed at the rear o the control panel

b. The TDA can be used for:

(1) Setting up Filter Band Suppression Filters at the Tuning Bay of the EZ cabinet.

(2) Connection to the WBA in the LMA.

(3) Connection to a jack plug in the high power r.f. annexe.

c. The CJA provides monitoring of either:

(1) The monitor cabinet TDA output after it has passed through the filter in the EZ tuning bay (aeria COS to TUNE FILTER).

(2) Any HF frequency between 2 and 30 Mc/s from one of two aerial lines.

[FIG. 4. MONITORING AND TEST UNIT

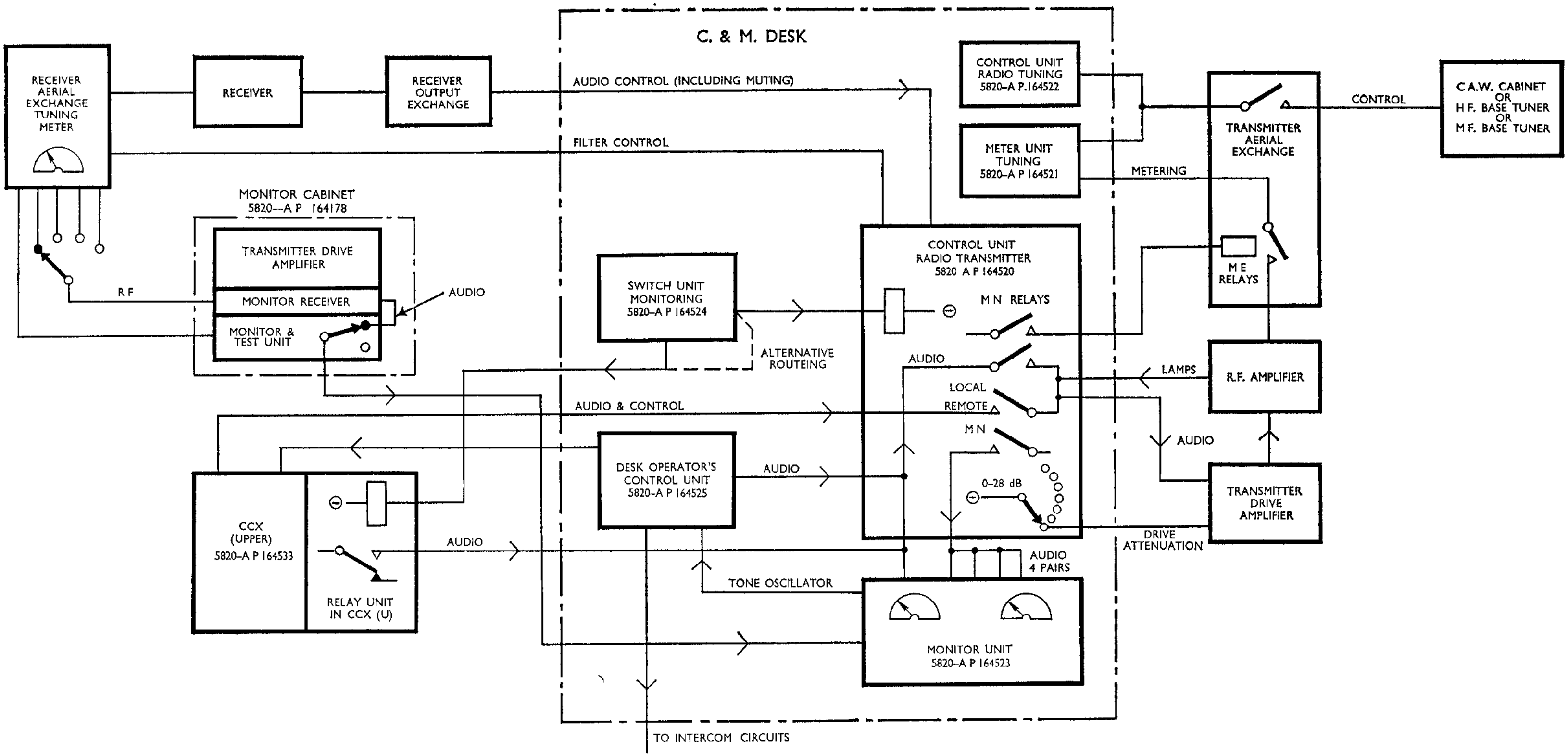

FIG. 5. I.C.S. TRANSMITTER CONTROL AND MONITORING

d. The Control Panel provides the following:

(1) Switching of the output of the monitor receiver, or the receiver being monitored at the C & M desk monitor unit, to the EZ Cabinet.

(2) Keying of the monitor cabinet TDA.

(3) Switching of the TDA output to either the LMA, the tuning bay of the EZ cabinet, or the jack plug in the high power r.f. annexe.

(4) Controlled attenuation of the TDA output.

11.6. CONTROL OUTFIT KMM

1. **Wireless Control and Monitoring Outfit KMM.** Outfit KMM(1) is for big ships, KMM(2) for assault ships [redacted] and KMM(3) for frigates. KMM(5) for submarines and KMM(6) for DLGs.

The principles for the system are the same throughout and, therefore, in order to keep things as simple as possible a LEANDER or KMM(3) outfit will be taken as an example for description. However, particular items of KMM 1–3 are described again after the KMM(3) descriptions to assist in clarifying any difficulties.

2. **General.** The object of the Central Control and Monitoring system is to co-ordinate the equipment in accordance with the overall communications plan and to maintain the circuits, when established, in a constant state of effectiveness. The system is flexible and simple to operate. The functions of the system can be considered under the following headings:

a. To set up the equipment to meet the communications plan in use;

b. To allocate circuits to remote users, and

c. To monitor the circuits while in use and apply simple tests to locate a fault.

3. In the I.C.S. there are no automatic tuning adjustments, and the general rule is that, apart from the initial setting up, the equipment which is in the same compartment as the central control and monitoring (C & M) desk is locally adjusted by hand and the equipment not in the same compartment is remotely adjusted from the desk. An exception to this rule is the attenuator in the output of the transmitter drive unit which, although in the same compartment as the desk, is remotely controlled at the desk to facilitate tuning.

4. The receiving and transmitting facilities provided are in the main required for use at positions remote from the equipment. The tactical operator in the enclosed bridge will require a tactical control circuit; the MCO operators at attended receivers may also require control of transmitters; operations room users will require individual and/or group control of a number of circuits.

5. Remote requirements are met by a series of plug and socket exchanges which, at the receiver output exchange (ROX), permit marrying of any MF–HF receive channel to a transmit channel to form a complete communication circuit. Circuit 'State Panels' in the control and monitoring desk then become the focal point of each circuit for connection to a control circuit exchange (CCX) where they are made available, with UHF, Type 689 and Type 618/CAS circuits for plug and socket connection to users and direct connection to the MCO CCX for further distribution.

6. **Receiver Output Exchange (ROX).**

a. The audio output and control circuits (ready lamp, muting A.G.C.) of receivers unattended and attended CJC and CAY or CAZ are permanently connected to the upper section, double sockets, of the 18-way ROX for distribution via double-ended flexible connectors to the 18 single sockets forming the lower section of the exchange.

b. The lower section sockets are labelled and permanently connected, in parallel with the C & M desk and both CCX uppers, to provide reception facilities as follows:

(1) 4 lines to the BSU in the MCO for RATT reception.

(2) 11 lines to the CCX uppers in the CCR and MCO.

c. The 4 lines in (1) above are also connected in the C & M desk, to the Radio Control Unit, Broadcast.

d. The 11 lines in (2) above are simultaneously connected to:

(1) The operations room loudspeaker exchange.

(2) The C & M desk, Switch Unit Monitoring.

7. **KMM Control Lines.**

a. The KMM control lines are used in the same way as in a KH system. However, there are 12 line instead of 11. The individual lines have the following functions:

M+	M2	C+	C2	PS	K	S	SU	LR	LB	R+	R2
1	2	3	4	5	6	7	8	9	10	11	12

Note. 1 is to the left of the keyway as you look at a CCX plug.

b. The functions of the lines are self-evident. M for Mircophone, R for Receive, K for Keying, LR fo Ready Lamp, LB for Busy Lamp, PS for Pressel, S for Control of morse keying, SU for L/S muting line C+ for 24 V positive to remote units and C2 for 24 V negative to remote units.

c. It is understood that in future I.C.S. layouts a system with 18 lines, using 17, will be fitted since 12 rather restrictive to development. Similarly a new design of plug is to be introduced.

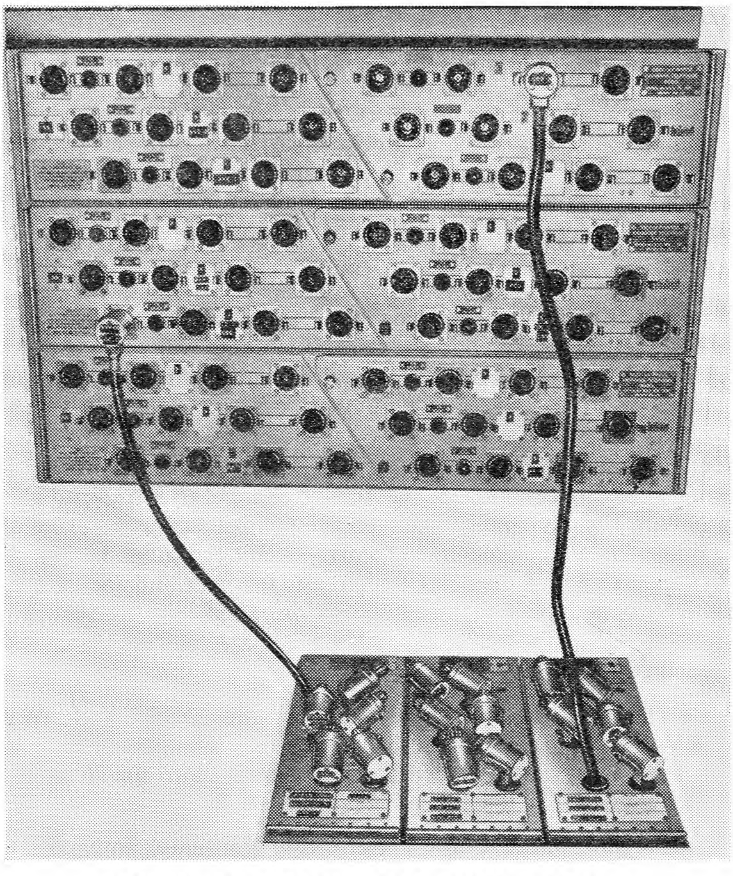

FIG. 1. EXCHANGE, TELEPHONE, RADIO

8. **Exchange Telephone Radio.** This is the correct title for a CCX and there are different patterns o radio telephone exchange units for CCX Uppers, Lowers, etc. Their function of providing flexibilit between user positions and radio channels is the same as in control outfit KH.

9. **Exchange Telephone Radio 5820–A.P. 164533 (Relay Unit 5820–A.P. 164175).** This unit is used as CCX Upper exchange unit in conjunction with Exchange CCX Lower (similar to the KH system).

10. **Exchange Telephone Radio 5820–A.P. 164534.** This unit is used as a CCX lower in conjunction with above (similar to KH).

Note. Both exchange units are being modified to 18 Pin Screw Plugs and Sockets.

11. **Exchange Telephone Radio 5820–A.P. 164535.** This is a 36–12 pole socket exchange providing access to 18 circuits, two sockets being available in parallel for each circuit. It is utilised as the ROX upper in the CRR.

12. **Exchange Telephone Radio 5820–A.P. 164536.** This is a 24–12 pole socket exchange providing access to 12 circuits, two sockets being available for each circuit.

13. **Exchange Telephone Radio 5820–A.P. 164537.** This is an 18–12 pole socket exchange providing access to 18 circuits. There are no parallel facilities. It is utilised as the ROX lower in the CRR.

14. **Exchange Telephone Radio 5820–A.P. 164538.** This is a 12–12 pole socket exchange providing access to 12 circuits. There are no parallel facilities. Two are used, one as the RCS exchange in the CRR and the other as an output exchange in the EWO.

15. **Exchange Telephone Radio A.P. 164539 (Relay Unit A.P. 164174).** This is a 48–6 pole socket exchange connected in pairs. Relay units are provided for muting loudpseakers. It is used as the loudspeaker exchange in the Operations room.

16. **Switch Unit, 5 Channel 12 Wire 5820–A.P. 164550.** This enables an operator to select any one of five transrec circuits. Each circuit has its own IN USE and READY lights; Precedence selection being from left to right.

17. **Switch Unit 5 Channel 4 Wire 5820–A.P. 164553.** This unit enables an operator to select any one of five circuits. It may also be used for selecting any one of four channels to feed a loudspeaker unit.

18. **Loudspeaker.** Each loudspeaker has a self-contained amplifier and therefore there is no requirement for a bank of 2 watt amplifiers as in the past. The loudspeakers are rather large, but this is due to the amplifier and muting relays which are built in and the Admiralty requirement for robustness.

The amplifier provides a 1·2 watt output and is muted by operating the PRESS TO SPEAK switch in the associated operator position, i.e. if the TO 1 in the operations room operates his transmitter, the TO loudspeaker will be muted automatically.

19. **Control Unit, Radio Relaying A.P. 164555.**

a. The control and monitoring desk state panels (TCU) include a relaying control which provides for relaying of the circuit receiver output by its own transmitter. A relaying facility is available to other circuits by the provision in the CCR of two bulkhead mounted relaying units each having an IN and OUT connection at CCX lower plugs. Connection at the exchange of two circuits to a relaying unit produces, with the unit switched to CONTINUOUS, relaying of signals received on the IN circuit by the OUT transmitter. With a relaying unit in this condition the OUT transmitter is continually on, radiating all the received signals including noise.

b. Switching of the relaying unit to the AUTO condition gives control of the unit, and in turn, of the OUT transmitter, to the IN receiver A.G.C., by operating the transmitter pressel control only on receipt of a signal. Receiver Outfits CJA, CJC and CJD include an A.G.C. controlled relay which is used to complete this circuit for MF–HF auto relaying. The remaining receiver outfits (*e.g.* UHF) have no such facility and relaying of signals from these receivers in the AUTO condition is restricted to CUJ No. 2 and 3 whose A.G.C. voltage is taken via an associated amplifier unit A.P. 164561, fitted in the UHF office, before connection to the CCX.

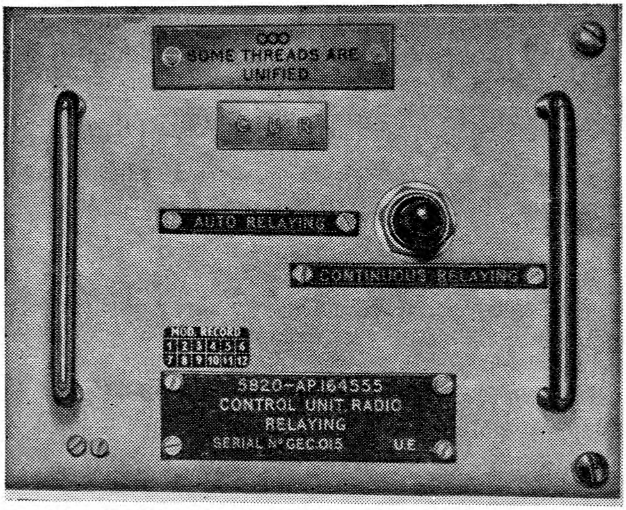

FIG. 2. CONTROL UNIT, RADIO, RELAYING

FIG. 3. AMPLIFIER UNIT d.c.

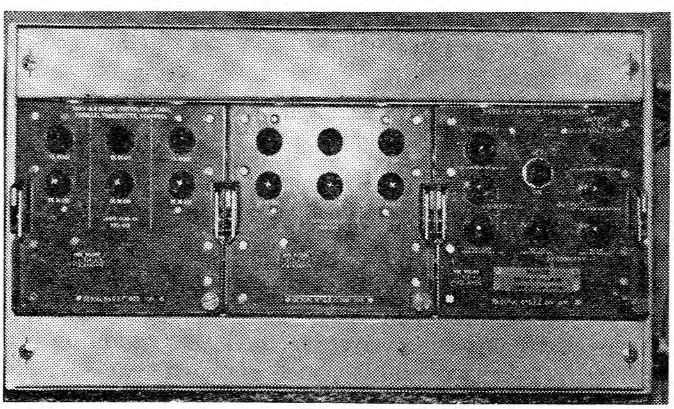

FIG. 4. CONTROL UNIT, RADIO, PARALLEL TRANSMITTER

20. **Amplifier Unit d.c. 5820–A.P. 164561.** This contains a sensitive transistorized d.c. amplifier and two relays, and on its front panel carries a level control, a push button, an indicator lamp and a jack socket. The unit is used in conjunction with UHF receivers and control unit radio relaying, for retransmission of a receiver output signal. Situated close to the receivers in the UHF receiving room.

21. **Control Unit, Parallel Transmitter.** Parallel control of up to five transmitters is available at the CCR and MCO CCX upper via a control unit-bulkhead mounted in the CCR.
A user position plugged to the CCR or MCO CCX Transmitter parallel socket will simultaneously key the transmitters selected by the control unit output which is connected to five CCR CCX plugs labelled channels No. 1 to 5. Channel No. 1 includes side tone monitoring of the transmitter selected by its plug to allow the operator to listen to his own transmission; it should always be connected irrespective of the number or transmitters (up to five) to be paralleled.

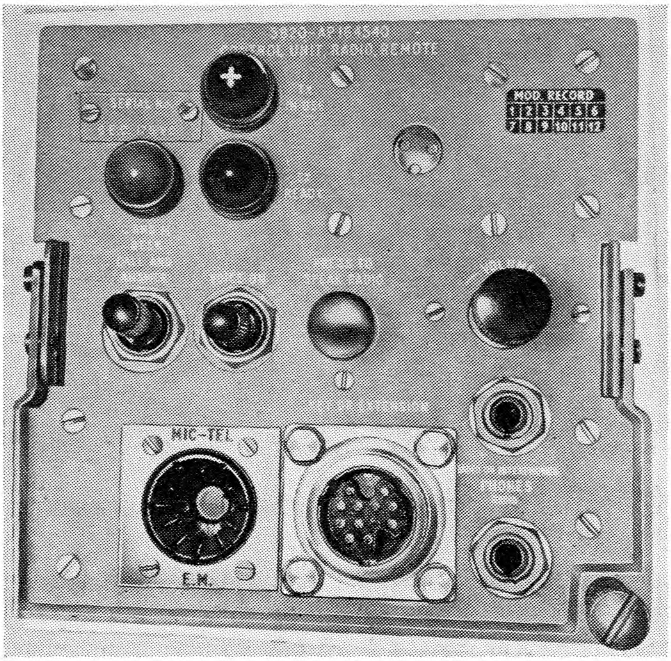

FIG. 5. CONTROL UNIT, RADIO, REMOTE

22. **Control Unit Radio (RCU)**

a. The RCU is very similar to the design 5 control unit fitted in remote signal positions at present with KH control systems.

b. The following facilities are provided for:

(1) Reception.
(2) Speech transmission with built-in speech amplifier.
(3) A combined headset into a mic-tel socket is normally used to provide (1) and (2).
(4) Key facilities.
(5) 'Press to speak' switch for control of the transmitter.
(6) Call and answer switch for connection to the C & M Desk intercom.
(7) 'Voice on' switch in case no pressel switch is fitted in the microphone circuit.
(8) Volume control.
(9) Two phone jacks.

c. Lamp indications are as follows:

(1) C & M Desk lamp indicates that the operator is being called from the C & M Desk.

(2) Transmitter ready lamp.

(3) Transmitter in use lamp.

(4) Buzzer note from a small earphone in the RCU for audio warning of a call on the intercom.

(5) The RCUs at MCO bays No. 1 and 5 are fitted for control desk inter-communication and interphone only, they have no radio facilities. The Morse keys at MCO bays No. 2–5 are AT channels and are connected to the teleprinter terminal units (TTUTac).

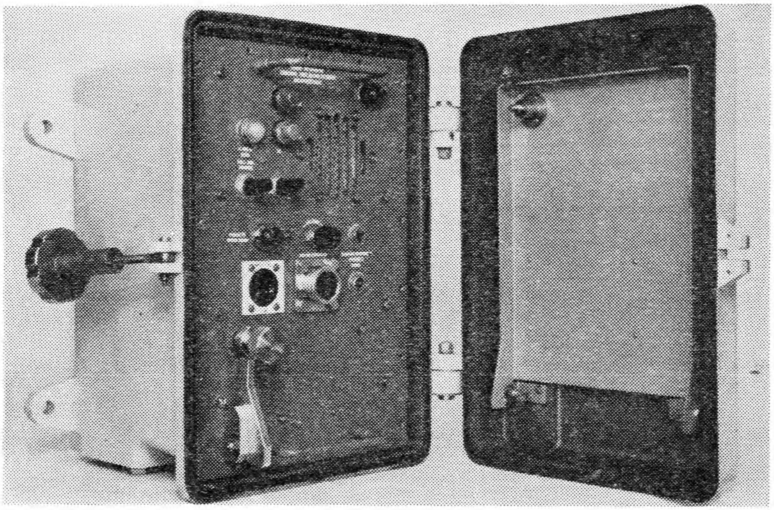

FIG. 6. CONTROL UNIT, RADIO, REMOTE, WEATHER TIGHT

23. **Control Unit Radio Remote Weathertight 5820– A.P. 164542.** A similar unit as above, bulkhead mounted and weathertight. A writing tray in the cover is provided.

24. **Control Unit Radio Remote Portable 5820–A.P. 164544.** A similar unit as both above with the exception of no interphone facilities. Used in connection with cable assembly A.P. 180094.

25. **Socket Unit Voice Extension 5820–A.P. 164551.** A small unit fitted at a radio operator's position (ops room). A mic-tel and Reception Socket is provided with pressel button and volume control. Communication to the C & M Desk and interphone is provided. It contains its own microphone amplifier for speech transmission.

26. **Extension Unit Voice 5820–A.P. 164513.** A small unit which carries a microphone amplifier for speech transmission and is plugged into Socket unit voice extension (above unit) utilizing its interphone lines. Relays prevent either interfering with each other.

27. **Control Unit Radio 4 Channel 5820–A.P. 164184.** This unit includes a microphone amplifier for speech transmission – normally fitted in the FLYCO position of an aircraft carrier. Facilities for selecting any one of four transmitters and CALL and ANSWER controls for communication with the C & M Desk. Interphone communication is also provided.

28. **Socket Unit Voice Extension A.P. 164182.** This unit is used in the FLYCO position as an extension to the above control unit radio 4 channel. It includes a microphone socket with a capsule type microphone amplifier, a volume control and pressel switch relays.

29. Composite Communication Units (CCUs)

a. The CCUs are used for the termination of a radio channel at a remote user, normally in the operations room. Those fitted in I.C.S. are very similar to those fitted with CDS (i.e. in the GMDs). However, in the I.C.S. version the units have been developed a little further and have minor advantages over the older design.

b. There are two types. One for use in an ADA console and the other for use in Trays at other user positions.

c. All microphone positions use EM microphones for Radio, interphone and intercom. The sensitivity is much reduced and the microphone should be held close to the mouth (like a boom microphone).

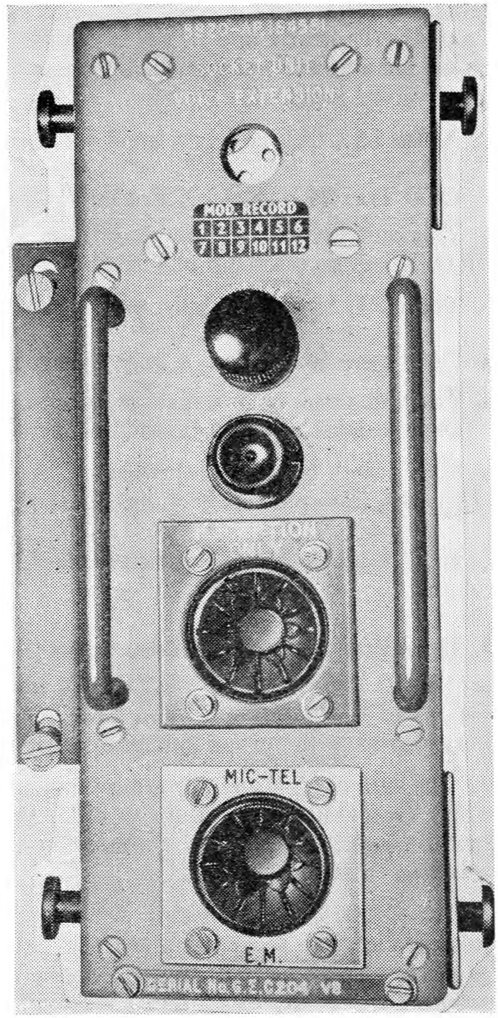

FIG. 7. SOCKET UNIT, VOICE EXTENSION

30. **Console Unit.** This unit fits into the structure of the console and has the following facilities:

a. Radio channel selection.

b. Ship's interphone.

c. Connection to the C & M Desk.

d. The unit contains a row of 10 three-way switches which select one of 20 radio channels. Transmitter ready and in use lamp indication is provided for each channel, only one of which can be used at any time. The channel selected is indicated by illumination of the channel label. The selection of a channel by operating a switch to the UP or DOWN position connects the mic-tel circuit to that particular channel. The microphone and headphones are plugged into a Socket Unit (voice extension).

e. The operator may connect himself into the interphone system by operation of a switch which connects the microphone and one ear-phone to interphone and leaves the other ear on the radio channel.

f. The C & M Desk can be called as in the RCU and vice versa.

BUTTON COLOUR CODE	LAMP CODE
a. Red – interphone	*a.* Red – for TX ready
b. White – Radio	*b.* Green – for TX in use
c. Blue – C & M intercom	*c.* Orange – for interphone

31. CCU Tray 25 – (5820 – A.P. 171006) Basic Radio Unit (BRU)

a. This unit is one of the many variations which will fit into a standard case and is usually fitted on a desk or above a display. Each position normally has a number of different CCUs of which this is one.

b. This unit has five three-position switches giving a selection of one of ten channels. Lamp indication of TRANSMITTER READY and IN USE is provided. There is intercommunication with the C & M Desk. Interphone facilities are not provided. (A separate CCU is needed for interphone.) A socket unit is required for a mic-tel input.

c. As for all CCUs the right hand rule for channel buttons applies.

32. **CCU Tray 26 – 5820 – A.P. 171007 (Auxiliary Radio Unit) (ARU)**

a. This unit extends the number of radio channels at the user position and is connected in series with a BRU. It has no intercom or interphone facilities or mic-tel socket.

b. The ARU has 6 switches providing an extra 12 channels with lamp indications as in the BRU.

33. **CCU Tray 39 – 5820 – A.P. 171009 Loudspeaker Switch Unit**

a. The unit provides loudspeaker selection. There are 7 three-position switches which select one of two loudspeakers on one of 7 radio channels.

b. Each switch has two positions one for each speaker and an OFF position. By selecting a switch one of the two loudspeakers is connected to one of 7 radio channels.

34. **CCU Tray 38 – 5820 – A.P. 198363 – Loudspeaker.** This tray contains a loudspeaker with a built-in amplifier.

35. **Operations Room Distribution Boxes (DB1, DB2)**

a. The 22 lines from the MCO CCX lower to the Operation Room Distribution boxes contain five groups of four communication circuits and one group of two circuits. The distribution of circuits is very similar to the group system installed in the GMDs.

b. The surface, A/S and Air groups are connected to DB1 for distribution and the Weapon (two circuits only), GOPO and EW groups to DB2. The circuits selected at the MCO CCX by the plugs of a group are all taken to each user position within that group, where a four circuit basic radio unit (BRU) allows selection of any one circuit.

c. The ORO, LOPO assistant, A/S plot and Helicopter Director positions have an extension of their selected circuit to socket units at tracker positions. One circuit of the A/S group and one of the Weapons group is also connected direct from the MCO to the GDP, and two circuits of the EW group carry Morse key facilities direct to the EWC position.

36. **Operation Room Loudspeaker Exchange A.P. 164539**

a. The 17 receive channels available at the MCO CCX upper are permanently connected to the operations room 24 way, double socket, loudspeaker exchange for distribution by flexible double-ended plug connectors to loudspeakers sited at the following user positions:

(1) Command Communications Supervisor

(2) EWC

(3) GOPO

(4) GDO Blind (TIU loudspeaker)

(5) APO (JW) ARROW

(6) A/S CO

(7) LOPO

b. A loudspeaker is muted, irrespective of the circuit to which it is connected at the exchange, by operation of the microphone pressel switch at the LS local user position. All receivers have an adjacent muting relay which, when switched in circuit and operated by the associated transmitter keying circuit, closes the receiver down.

c. The receiver lines (R1 and R2) of UHF office circuits, except 693/CUJ No. 1, are taken to the LS exchange before connection to the MCO CCX upper sockets. All other receive channels are connected to the LS exchange after connection to the CCX.

37. **EWO Exchange.** Up to four circuits, selected at the MCO CCX lower and labelled EWO line No. 1 to 4, are available at the 12 socket exchange in the EWO for distribution by double-ended plug connectors as required.

38. **Case Controls, Radio Transmitter 5820 – A.P. 164648 and Control Unit, Radio Transmitter 5820–99–916–4900.** This unit includes TX audio input and adaptor circuits for control of various transmitters and adaptor circuits for associated receivers. The various elements of the unit are joined by straps on the base of the unit which are made at installation to adapt the transmitter and receiver to the KMM control outfit. This unit contains:

a. LOCAL REMOTE switch.
b. Local mic-tel socket.
c. A KMM 12 pole keying socket.
d. A receiver output can be strapped straight through or passed via an amplifier or attenuator.
e. Lamp indication – READY and IN USE.
f. A variable resist for squelch control of 689.

39. **Distribution Unit, Audio Transmission 5820–A.P. 164507.** This unit provides output of 10 lines from a single input and enables an operator to transmit on up to 10 transmitters when used in conjunction with a Switch Unit, Transmitter Selector. It includes 10 transistor amplifiers driven via 2 input transformers from one audio pair. There are 10 output transformers, the output circuits being completed by 3 parallel relays operated under control of the pressel switch circuit.

40. **Switch Unit, Transmitter Selector 5820–A.P. 164554.** This unit enables the two operators to switch the speech outputs of the two distribution units to any up to ten in number, of the transmitters which may be allocated to them. The unit also allows both operators, if necessary, to be connected to the same channel simultaneously. TX ready and in use lights are provided.

41. **Mixer Unit Audio, Reception 5820–A.P. 164508.** The audio outputs of up to ten receivers allocated to the two operators are fed to each of these units and enable each operator to keep a listening watch on the channels selected at the Switch Unit Receiver selector.

42. **Switch Unit Receiver Selector 5820–A.P. 164506.** This unit enables the two operators to select any receiver output, up to ten in number, which may be allocated to them. The front panel is fitted with two rows of ten lever switches above which are 10 RX READY and 10 INCOMING SIGNAL lamps. The top row is associated with the left control unit and the bottom the right. Lines are used to mute any loudspeaker connected to the channel when the operators are transmitting.

43. **Intercommunication Unit 5820–A.P. 164171.** This unit provides intercommunication between the Desk, Control and monitoring and any one of up to 60 Radio Operators in the Operations Room. The unit is divided into two halves capable of working separately. This duplication is to preserve communication in the event of the failure of the one half.

44. **Control Unit Radio Operations 5820–A.P. 164505.** This unit is fitted in the operations room and provides an operator with facilities to keep a listening watch on several receivers simultaneously, up to 10 in number, and to transmit voice simultaneously on a number of transmitters up to ten in number.

C & M intercommunication links to the Desk are provided and also interphone facilities.

45. **Case Controls 5820 – A.P. 164549; Switch Unit Diversity 5820 – A.P. 164715; Power Supply 5820 – A.P. 164529.** The case is similar to A.P. 164548 but includes a Switch unit diversity A.P. 164715, a tumbler switch per channel for manual selection of either receiver and a rotary switch for switching u.s.b. audio or l.s.b. audio jacks to any pair of the receivers.

46. **Racks Electrical 5820 – A.P. 164201; 5820 – A.P. 164202; 5820 – A.P. 164203; 5820 – A.P. 164204.**

a. The four racks are interconnected to form a complete system which enables up to 48 users in the control rooms to connect to a number of the 36 available communication channels on the CCX lowers. The particular channels allocated to each user are set up on the racks according to a prearranged plan. The system is flexible and the plan can be rearranged as required.

b. On each of channels 1 to 30, seven lines are connected to horizontal strips of sockets on special selection boards. On the same boards vertical strips of sockets connect to seven lines from the user. To select a channel the user throws the relevant switch, operating the relays in the plug in relay unit.

47. **Relay Units for Relay Racks.** Relay units plugged into Relay Racks are of two kinds – left handed and right handed, not interchangeable, plugged into alternate columns. These are again sub-divided into units using SUL leads for ADR (lower level) and SUU leads for Operations Room (upper level).

48. **Racks Electrical 5820 – A.P. 164755.** This rack enables up to 24 users in the control rooms to connect to certain of the 28 available communication channels.

49. **Racks Electrical 5820 – A.P. 164756.** This rack enables up to 24 users in the control room to connect to certain of the 12 available communication channels.

50. **Relay Unit A.P. 164173.** This unit has relays, transformers and fuses performing the same function as those on the relay racks, for two users and two channels. They are plugged into a base carrying a 62 way unitor.

51. **Relay Unit A.P. 164176.** This unit has channel selection for 2 channels, 2 operators and a supervisor.

52. **Principal Units fitted in Control and Monitoring Outfit KMM**

a. Break-down of NATO Pattern Numbers:

Example: Loudspeaker – Pattern Number 5820–99–916–4901.

5820	NATO Supply classification Group (Admty F10 – 0625) Radio and Television Equipment Excluding Air.
99	Country of Origin (U.K.).
916–4901	Pattern Number of Equipment – i.e. Loudspeaker.

Note. The hyphen separating the last seven digit number is only for ease of reading. Also the country of origin is sometimes omitted. Admiralty class and group have also been reallocated to a four digit number, i.e. F10 is now 0625 (AF01946/61 refers).

b. Where NATO pattern numbers have not been allocated to the equipment the NATO supply classification group will be followed by the Admiralty pattern number, i.e. 5820 – A.P.16450.

11.7. OPERATION OF KMM

1. It is not the intention, at present, to give complete details of how an operator would use Outfit KMM. However, it is felt that it would be of value to describe how one or two units are operated. It is important to remember that some of these points may require revision in due course.

2. Remote Radio Control Unit

a. Reception. Plug the headset into the appropriate PHONES jack RADIO or RADIO or INTERPHONE and adjust the VOLUME control to suit. If a mic-tel set is used, it is plugged into the mic-tel 12 pole socket, the VOLUME control again being used to set the level of the receiver signal.

b. Voice Transmission. Plug the headset into the mic-tel socket and check that the TX READY lamp is lit. Operate the VOICE ON switch and press the PRESS TO SPEAK RADIO switch when about to speak and keep pressed while speaking. Sidetone will be heard in the headphones during transmission and the reception lines will be disconnected. A foot-operated PRESS TO SPEAK switch may be fitted in parallel with the unit switch at some positions. The TX IN USE lamp will be illuminated during transmission, and if this lamp is lit before operating the press to speak switch, it indicates that a parallel connected operator is using the transmitter.

c. Keying. Plug the lead from a Switch Unit, Morse Key A.P. 164548 or a Key, Morse Portable A.P. 164179 into the KEY OR EXTENSION socket. Operate the switch on the Morse Key Unit and use the Morse key, first checking that the TX READY lamp is lit.

> *Note.* For HF and MF transmitters, connection at the Control and Monitoring Desk can be made to energize the transmitter either when the ON switch of the Morse key unit is operated, or when only the Morse key itself is used.

d. Calling and Answering the C & M Desk. To call the desk operator, switch the C & M DESK TO CALL AND ANSWER key and wait for a reply. This will be in the left hand earpiece, the right hand one still being connected to the RADIO circuit. A call from the C & M Desk will light the C & M lamp and put a calling tone into the front panel earpiece. To answer, use the same procedure as for calling. Restore the key to the off position at the end of a call.

e. Calling and Answering on Interphone. If an Interphone tray is provided at the position and connected to the control unit, then, to call an interphone user, the reply will be heard in the left hand earpiece as for communication with the C & M Desk. A call from an interphone user will light the appropriate lamp on the Interphone Tray. To answer use the same procedure as for calling. Restore the key to the off position at the end of a call.

> *Note.* The ship's interphone takes precedence over the C & M I/C, and the PRESS TO SPEAK RADIO takes precedence over both the interphone and C & M I/C circuits for the microphone amplifier output (but not for the switched earpiece).

f. Reception. Plug the headset into the mic-tel socket and adjust the VOLUME control to suit. A second operator may plug his headset into the socket marked RECEPTION ONLY. The channel being received is selected by operating the appropriate switch on the associated Console Unit or BRU.

g. Voice Transmission. Plug the headset into the mic-tel socket and operate the appropriate channel selection switch on the console unit or BRU. When about to speak, press the PRESS TO SPEAK switch and keep pressed while speaking. A foot-operated PRESS TO SPEAK switch may be wired in parallel with the unit switch, in which case this can be used if preferred.

3. Receiver Output Exchange

a. Connect receiver output to (*a*) Transmitter, (*b*) Broadcast bay, or (*c*) CCX RECEIVER ONLY line, as required.

b. Operation:

(1) FOR S.S.B.–U.S.B./D.S.B./C.W. Place receiver output switch to c.w./u.s.b./d.s.b. and connect associated receiver socket on ROX upper to required facility on ROX lower.

(2) FOR S.S.B.–L.S.B. Place receiver output switch to l.s.b. and connect at ROX as above.

(3) FOR I.S.B. WORKING. Place receiver output switch to i.s.b. To remote the u.s.b. output, connect the receiver output socket on ROX upper to required facility on ROX lower.

To remote the l.s.b. output, connect the SECOND receiver output socket on ROX upper to a TX l.s.b. socket on ROX lower. If reception only is required, connection is made at KMM CCX upper from the selected TX l.s.b. socket to required RECEIVE LINE by means of a double-ended flexible connector.

c. To insert diversity switch No. 1 into circuit plug, outputs of Port and Starboard aerial connected receivers to diversity switch IN sockets 1a and 1b. Connect diversity switch OUT socket 1 to above or to *a, b* or *c* if required. They operate independently of one another. Operation is intended for the u.s.b. channel only. The l.s.b. channel is switched automatically to the same receiver as the u.s.b. channel but only under control of the u.s.b. signal.

4. **Two-wire Loudspeaker Exchanges using Jacks**

a. Connect bay jack to loudspeaker jack. The loudspeaker will be muted only when the bay to which it is patched is transmitting. 'Singing' is liable to occur if any other bay in the room transmits on the same channel. The supervisor can insert his control unit into the loudspeaker circuit by connecting the bay jack to the Supervisor's IN jack and the Supervisor's OUT jack to the loudspeaker. He also will then mute the loudspeaker when transmitting.

b. Loudspeakers connected to plugs on the CCX are for listening watch only. If transmission is required the loudspeaker should be unplugged at the CCX and connection should be made at the L/S exchange, otherwise 'singing' is liable to occur.

5. **Exchanges on Operations Room Relay Racks.** Plug the pair of users to the required 'channel' on the relay rack and plug the 'channel' to the TX–RX at the CCX. If there is a tendency to congestion of plugs on the channel sockets on the relay racks, replug the channels at the main CCX to open out the arrangement. If more than 6 pairs of users require connection to one channel, use a second row of sockets and plug this second channel to the same TX–RX at the CCX. Parallel the two channels at the 6 wire loudspeaker exchange if there is a loudspeaker connected to either. Different TX–RX circuits must not be paralleled at this exchange.

6. **MCO Control Circuit Exchange (CCX)**

a. The upper section sockets are in parallel with the CCR CCX sockets and therefore make available to the lower section plugs identical facilities. This duplication is desirable in that it makes all circuits and facilities available to the MCO, the hub of the ship's external communications, in addition to contributing to the requirement of central control and monitoring in the CCR. Care should be exercised when connecting into a circuit at a CCX, as no other office state is indicated other than transmitter ready lamp.

b. Connected to the MCO CCX lower which has 48 user plugs are:

(1) RCUs at MCO Bays No. 6–11.

(2) RCUs at the MCO supervisor and distribution supervisor positions.

(3) Switch unit, radio (SUR) No. 1–9 for the MCO and remote AT positions.

(4) Two lines to the enclosed bridge to positions TO 1 and TO 2, each having extensions to the Communication Yeoman, port and starboard positions. The TO 2 position is further extended to a weather-tight control unit and LS on the Flag Deck.

(5) Three lines to the operations room communication group, which consists of the command communication supervisor and tactical operator position No. 1 and 2.

(6) 22 lines to the operations room distribution boxes. Two of these lines are also connected direct to remote users at weathertight control units on the GDP, and two lines carry Morse key facilities direct to the EW controller's position.

(7) One line to each of the MCO supervisors, two loudspeaker switch units (LSU), which also receive inputs from the local RCU and from MCO Bays No. 7–11.

7. **Tuning Transmitter Aerial Circuits.** It is possible to tune three different types of aerial circuit from the desk, namely Common Aerial Working (or CAW) Filters, MF Base Tuners and HF Base Tuners. Aerials are selected and connected to transmitters by means of plug and socket connections in the Transmitter Aerial Exchange and the type of aerial connected to a particular transmitter is indicated by the lamps fitted on the appropriate TCU. The lamp circuits are strapped in the Tx Aerial Exchange to give the correct indication at the desk.

8. **Circuit Interlocks, Control and Associated Lamp Indications**

a. This explanation and Figure 1a/1b contain references to only those switches, relays and relay contacts, which are considered essential for the user to gain an understanding of relay action and lamp indications associated with switching during the tuning and setting-up of I.C.S. transmitter equipment. It is assumed that all power supplies are switched on, and it should be noted that 24-volt control voltages for relays are obtained from the following sources:

(1) TDA power drawer.

(2) TCU power unit.

(3) CAW outfit EAW power supply drawer.

b. With TDA door interlock open, 24V from TDA power drawer is completed to the associated TCU at the C & M desk and:

(1) Drive lamp remains lit.

(2) Energizes drive ready relay DRR (E10). Contact DRR2 (B11) closes and makes available 24V from TCU power unit to:

(3) Tune-attenuator relay GR (B14).

(4) Operate relay OPR (E12).

(5) Attenuator tune lamps in TCU.

c. 24V from TDA power drawer to the associated TCU drive door interlock relays DGS (H4) and EGS (G4) is broken by the TDA door interlock (H3). The relays are de-energized. Relay contact DGS2 (K2) breaks 24V from TDA power drawer (via pressel relay contacts) to TDA transmit relay RLK (J2) which is de-energized. Relay contact RLK1 (12) breaks the r.f. output line from the TDA attenuator network to the associated WBA. Relay contact EGS1 (B13) makes 24V from the TCU power supply unit to the tune/attenuator relay GR (B14) de-energizing winding. Relay contact GR1 (E11) removes 24V from the attenuator lamp and OPR (F12), and switches 24V to the tune lamp on the TCU. With OPR (F12) de-energized, the TDA output attenuator switching relays RLE, RLF, RLG, RLH and RLJ (not shown on diagram) are also de-energized with the result that full attenuation is applied to the TDA r.f. output.

d. **Summary.** With TDA door interlock open:

(1) The TCU drive lamp remains lit.

(2) The TCU tune lamp lights.

(3) The r.f. output of the TDA is at maximum attenuation and is disconnected from the associated WBA.

9. With TDA Door Interlock Closed

a. The TDA door interlock completes 24V from the TDA power drawer to relays DGS (H4) and EGS (G4) which are energized.

b. Relay contact DGS2 (K2) closes to complete 24V from the TDA power drawer (via pressel relay contacts) to RLK (J2) which is energized. Relay contact RLK1 (12) closes to complete the r.f. output line from the TDA attenuator network to the associated WBA. Irrespective of the position of the TCU attenuator switch, full attenuation is applied at the TDA because relay GR (B14) remains de-energized. Relay contact EGS1 (B13) returns to make available 24V to energizing winding of GR (B14), but this relay will not be energized until relay contact FPR1 (B14) is closed.

c. **Summary**, with TDA door interlock closed;

(1) The TCU drive lamp remains lit.

(2) The TCU tune lamp remains lit.

(3) Subject to the operation of the Pressel relays, which will be energized when the transmit tone switch is made, the r.f. output of the TDA is connected to the associated WBA.

(4) The TDA attenuation is at maximum.

10. Switching At The C & M Desk

a. With the TCU VOGAD switch (D11) to aerial off, 24V from the TCU power unit is broken to the dummy load relay DL (J12) in the associated EAW filter drawer and to the TCU aerial lamp.

b. With the TCU aerial lamp out and DL (J12) de-energized, relay contact DL1 (J14) connects the r.f. output from the filter drawer to the EAW dummy load via the aerial exchange EY.

c. Selection of the required transmitter at the switch unit, monitoring, completes by relay action (shown as a monitor switch (A1)) 24V from the EAW filter cabinet power supply drawer to:

(1) The meter unit tune switch (B2).

(2) The meter unit CAW D/L switch (C2).

(3) The transmitter on D/L relay TDL (D1) in the TCU.

d. With the tune switch on:

(1) The tune lamp (B2) on the meter unit lights.

(2) 24V is completed from the filter cabinet power supply drawer to the transmitter guard relay TGD (C4) which is energized.

e. With CAW D/L switch on:

(1) The D/L lamp (C2) on the meter unit lights.

(2) 24V is completed from the filter cabinet power supply drawer to the D/L ready relay DLR (C4) which is energized.

(3) Relay contact TGD1 (C13) de-energizes GR (B14) relay.

(4) Relay contact DLR1 (D2) closes and completes 24V return path from TDL (D1) which is energized.

(5) Relay contact DLR4 (E1) closes and completes 24V to D/L fan start.

(6) Relay contact TDL1 (C11) is now an additional break in the 24V line to relay DL (K12).

f. With the TCU attenuator switch (D12) to the 28db position, pressing the attenuator button (D10) completes 24V from the TDA power drawer to the attenuator switch relay FPR (C10) which is energized.

(1) Relay contact FPR1 (A14) closes and 24V energizes relay GB (B14), which remains energized when the attenuator button is released.

(2) Relay contact GR1 (E11) disconnects 24V from the TCU tune lamp and connects it via the TCU attenuator lamp to relay OPR (F12) which is energized.

(3) Relay contacts OPR2, OPR3 and OPR4 (D13) close, and complete 24V via the attenuator switch to relays RLE to RLJ (which are not shown on the diagram) and which select values in the TDA attenuator circuit.

(4) Relay contact OPR (B14) closes and completes the de-energizing path for relay GR (B14) in the event of the TDA door being opened.

Note. If the TDA door interlock is broken (door opened) and as a result GR (B14) is de-energized, the relay can only be re-energized by returning the TCU attenuator switch to 28db and pressing the attenuator button.

11. **On Completion of Tuning**

a. With the meter unit tune switch (B2) to off, the tune lamp goes out.

b. With the CAW D/L switch to off:

(1) The dummy load lamp goes out.

(2) DLR (C4) is de-energized.

(3) TDL (D1) is de-energized.

(4) Dummy load fan stops.

(5) TGD (C4) is energized.

(6) GR (B14) is de-energized.

(7) The TCU tune lamp lights, and attenuator lamp goes out.

(8) Relay contact TDL1 (C11) completes the path for 24V to the TCU VOGAD switch (D11).

c. With the TCU attenuator switch to 28db and attenuator button pressed, relay GR (B14) is energized so that the TCU tune lamp goes out and the attenuator lamp lights. The attenuator switch is now operative.

d. With the TCU VOGAD switch to IN or OUT, depending on the type of emission desired, 24V from the TCU power unit is completed through the TCU aerial lamp and via the aerial exchange EY connections and safe to transmit key (I10) to relay D/L (J12) which is energized.

e. The TCU aerial lamp lights and relay contact DL1 (J14) connects the r.f. output from the CAW filter to the broad band transmitting aerial.

f. Removal of the safe to transmit key breaks the 24V supply to D/L (J12) which is de-energized, ensuring that the r.f. output from the CAW filter is connected to the dummy load. This means that it is possible to tune any CAW HF line into dummy load even though the safe to transmit keys are removed.

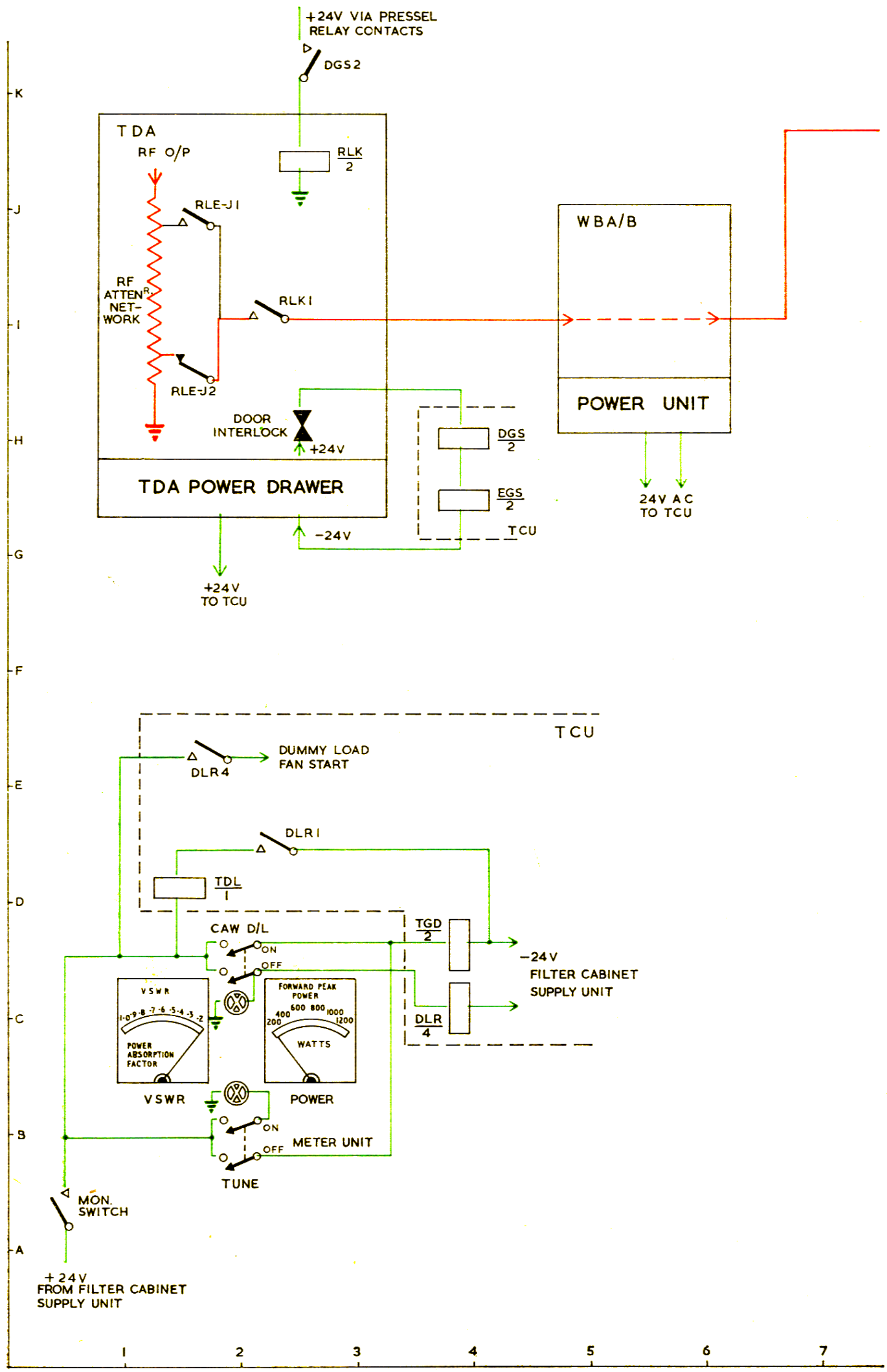

FIG. 1A. RELAY SEQUENCE

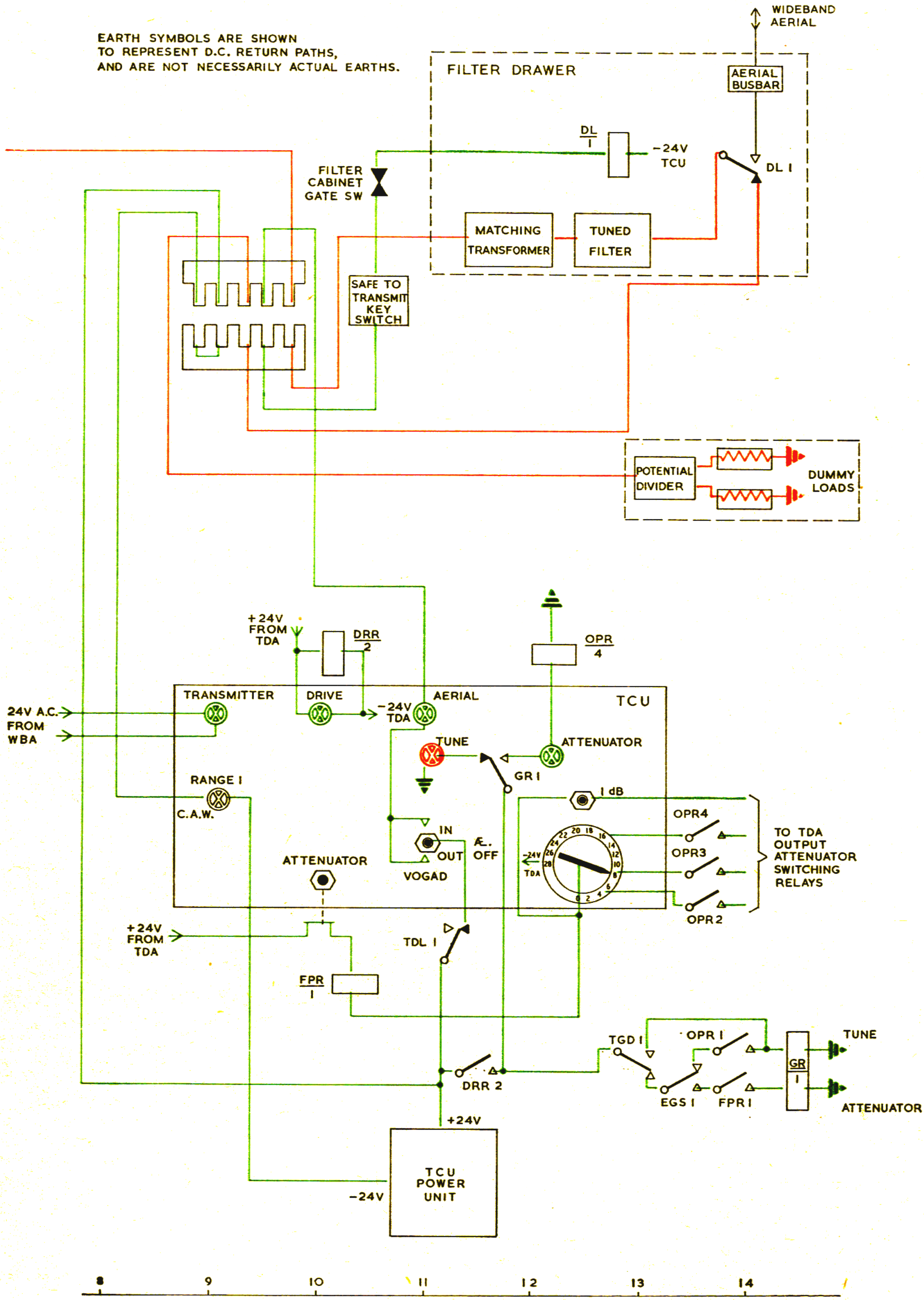

FIG. 1B. RELAY SEQUENCE

11.8. ICS TUNING GUIDE

1. Tuning a Transmit Line

Preliminary Drill – Two Hours Before System Is Required

DRILL	UNIT	ACTION
1	C & M Desk TCU	Set all LOCAL/REMOTE switches to LOCAL.
2	C & M Desk Switch Unit Monitoring	Centralise all Transmitter switches.
3	All Units	Switch ON associated services and equipment in accordance with the check-off list provided by the Ship, on the next page.

Note: The check-off list should cover such items as Air Treatment Units, Chilled Water, Fire Alarms, Smoke Detectors as well as MAINS and LOCAL power switches to ICS units.
The check-off list should state against each item the department responsible. It should be noted that Outfits WBA and WBB are covered separately in paras. 3 and 4, page 11–8–3.

2. **Check-off List for Starting System.** (To be completed by ship's staff).

DRILL	UNIT	ACTION

3. Outfit WBA

DRILL	UNIT	ACTION	CHECK
	WBA		
1		Set TEST/OPERATE switch to OPERATE	
2		Set SUPPLY MAINS switch to ON	UNREADY lamp ON
3		Set START switch to ON	After 70 seconds UNREADY lamp OUT READY lamp ON
4		Set START switch to OFF	READY lamp OUT UNREADY lamp ON
5		Set SUPPLY MAINS switch to OFF	UNREADY lamp OUT

4. Outfit WBB

DRILL	UNIT	ACTION	CHECK
	WBB		
1		Set TEST/STANDBY/OPERATE switch to OPERATE	
2		Set SUPPLY MAINS switch to ON	UNREADY lamp ON
3		Set START switch to ON	After 70 seconds UNREADY lamp OUT READY lamp ON
4		Set START switch to OFF	READY lamp OUT UNREADY lamp ON
5		Set SUPPLY MAINS switch to OFF	UNREADY lamp OUT

End of Preliminary Drill

5. Tuning Drill – As Required

DRILL	UNIT	ACTION	CHECK
1	C & M Desk		
1–1	TCU	Set associated LOCAL/REMOTE switch to LOCAL	
1–2	Switch Unit Monitoring	Centralise associated TRANSMITTER switch	
2	WBA/WBB		
2–1		Set TEST/OPERATE switch to OPERATE	
2–2		Set SUPPLY MAINS switch to ON	UNREADY lamp ON
2–3		Set START switch to ON	After 70 seconds UNREADY lamp OUT READY lamp ON
3	Transmitter Exchange EY		
3–1		Plug associated transmitter to appropriate aerial/filter	
3–2		Turn Safe to Transmit key for the aerial to be used to the SAFE TO TRANSMIT position	

DRILL	UNIT	ACTION	CHECK
4	C & M Desk		
4–1	TCU	Switch RELAYING to OFF	
4–2		Switch SIDETONE to ON	
4–3		Set VOGAD switch to AERIAL OFF for Broadband Aerial, VOGAD IN for Base Tuner	
4–4		Switch CLIPPER to OUT	
4–5		Switch Attenuation to 28dB	
4–6			TX lamp ON
4–7			DRIVE lamp ON
4–8		If Broadband Aerial	AE lamp OUT Appropriate RANGE lamp ON
		If Base Tuner	AE lamp ON HF or MF BASE TUNER lamp ON
4–9		If CJA/CJC connected to circuit	RX lamp ON
4–10		Set AUDIO IN switch to UP	TX O/L lamp OUT
4–11	Monitor UNIT	Set DRIVE IN switch down	
4–12		Set both METERS to 1V rms.	
4–13		Switch both METERS to ON	
4–14		Set both OSCILLATOR LEVEL controls fully anti-clockwise	
4–15		Set OSCILLATOR SELECTOR according to output emission as follows: A1 – 1 kHz A3/A3J – 1.5 kHz F1/200 – 500 Hz F1/850 – 1.5 kHz	
4–16	Switch Unit Monitoring	Select required Transmitter	
4–17	Meter Unit	Set TUNE switch to ON If Broadband Aerial used, set D/L switch to ON	Amber TUNE lamp ON Amber D/L lamp ON
4–18	Left Hand Operator's Control Unit	Set CCX ON switch to OFF position (UP)	
4–10	Monitor Unit	Select TRANSMIT TONE	
4–20		Adjust OSCILLATOR LEVEL control to give "Red Line" reading	Left Hand METER
5	TDA		
5–1		Set required dial setting frequency	
5–2		Select USB CARRIER CONTROLLED for all emissions	
5–3		Set OUTPUT TUNING to zero	

DRILL	UNIT	ACTION	CHECK
5–4		Set OUTPUT LEVEL to midway	
5–5		Set METER switch to OFF	
5–6		Adjust meter to read zero	
5–7		Set METER switch to OUTPUT	
5–8		Adjust TUNING CONTROL for first maximum reading	METER
5–9		Adjust OUTPUT LEVEL control to give reading of 15	METER
5–10		Select required emission	
5–11		Press GATE switch	METER reading 15 for all emissions except ISB. METER reading 8 for ISB.
5–12		Adjust OUTPUT LEVEL as necessary to attain above readings	
5–13		Close cabinet door	
6	C & M Desk		
6–1	TCU	Press ATTENUATOR button	ATTENUATOR lamp ON. TUNE lamp OUT

For Broadband Aerial Tuning of Normal Line proceed to 6 below.
For Broadband Aerial Tuning of Triple Drive Line proceed to 8, page 11–8–6.
For HF Base Tuned Whip Aerial proceed to 7, page 11–8–6.
For MF Base Tuned Wire Aerial proceed to 9, page 11–8–9.

6. **Broadband Aerial Normal Line**

DRILL	UNIT	ACTION	CHECK
1	C & M Desk		
1–1	Control Unit Radio Tuning	Set CAW TRANSFORMER to 6	
1–2		Set CAW FILTER to Setting from Calibration Chart	
1–3	TCU	Decrease ATTENUATION to give reading of 250W maximum	POWER METER
1–4	Control Unit Radio Tuning	Adjust CAW FILTER to give reading of 0.85 or better	VSWR METER
		Adjust ATTENUATION as necessary to ensure that 250W is not exceeded	POWER METER
1–5	Meter Unit	Switch OFF D/L	D/L lamp OUT TUNE lamp ON
1–6	TCU	Set 28dB ATTENUATION	ATTENUATOR lamp ON
1–7		Press ATTENUATOR button	TUNE lamp OUT
1–8		Set VOGAD to IN	

DRILL	UNIT	ACTION	CHECK
1–9		Decrease ATTENUATION to obtain reading of 250W maximum	POWER METER
1–10	Control Unit Radio Tuning	Select the CAW TRANSFORMER setting to give reading nearest to Unity	VSWR METER
1–11		Slightly readjust CAW FILTER control to further improve reading	VSWR METER
1–12	TCU	Decrease ATTENUATION to give a reading of: All emissions except ISB—700W maximum, ISB—250W maximum	POWER METER
1–13	Monitor Unit	Centralise All switches	
1–14	Switch Unit Monitoring	Switch TRANSMITTER to OFF	
1–15	TCU	Set LOCAL/REMOTE switch to REMOTE	READY lamp ON, on Switch Unit Monitoring

7. **HF Base Tuned Whip Aerial**

DRILL	UNIT	ACTION	CHECK
1	C & M Desk		
1–1	Control Unit Radio Tuning	Set MODE switch and A, B, C controls to settings from calibration chart	
1–2	TCU	Decrease ATTENUATION to give reading of 250W maximum	POWER METER
1–3	Control Unit Radio Tuning	Adjust BASE TUNER controls individually to give reading of 0.85 or better	VSWR METER
1–4	TCU	Decrease ATTENUATION to give a reading of: All emissions except ISB, above 2MHz—700W below 2MHz—500W ISB above 2MHz—250W below 2MHz—125W	POWER METER
1–5	Monitor Unit	Centralise ALL switches	
1–6	Switch Unit Monitoring	Switch TRANSMITTER to OFF	
1–7	TCU	Set LOCAL/REMOTE switch to REMOTE	READY lamp ON, on Switch Unit Monitoring

8. **Broadband Aerial—Triple Drive Line**

a. Frequency Separation.

When transmitters are connected to a Common Aerial, filters are used to provide mutual protection between transmitters and to minimise the degradation of the output of one transmitter, caused by another. The filters must be tuned to a setting for a frequency which observes the basic frequency separation rules. Where a system is switched for Triple Drive working, all three filters must be so tuned irrespective of the number of Triple Drive transmitters required for use.

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The basic FREQSEP rules are:

TRANSMIT LINES USING CAW	MINIMUM FREQUENCY SEPARATION
(1) Normal lines (Single Drive). (Maximum power output 1kW).	10% of the lower frequency.
(2) Triple Drive lines (Maximum power output 110W).	10% of the lower frequency.
(3) Triple Drive line with adjacent Single Drive line.	Not less than 12½% of the Single Drive frequency.
(4) Single Drive line at a Frequency between Triple Drive lines (Interlaced) this is permissible but normally done.	Triple Drive lines must be more than 22½% of the Single Drive frequency on each side.

b. FILTER TUNING.

The tuning adjustment of a filter connected to a Common Aerial system must be a fine adjustment, made with care, since the maladjustment of any one filter may have a detrimental effect on other transmissions from the same aerial.

Tuning a Triple Drive Line.

DRILL	UNIT	ACTION	CHECK
1	Transmitter Exchange EY		
1–1		Plug all three Triple Drive Transmitters to the appropriate three Triple Drive filters.	Remove each of 3 plugs in turn observing that in each case with one plug removed tuning for all three transmissions is inhibited.

Note: The transmitter plugs must be connected to the aerial sockets EXACTLY as specified for the system concerned.

The drills which follow are based on the assumption that S1690d, page 11–8–3, para. 5, (with drill 3–1 substituted by drill 1–1 above) has been complied with in respect of the first Triple Drive transmitter required, and that the system is switched to Triple Drive at the desk, Hybrid transformer and Filters.

DRILL	UNIT	ACTION	CHECK
2	C & M Desk		
2–1	Control Unit Radio Tuning	Set CAW TRANSFORMER to 6	
2–2		Set CAW FILTER to setting from calibration chart	
2–3	Monitor Unit	Switch off transmit tone	
2–4	Switch Unit Monitoring	Switch TRANSMITTER to OFF	
2–5		Select 2nd T.D. TRANSMITTER	
2–6	Meter Unit	Set tune switch to ON	Amber TUNE lamp ON
2–7	Control Unit Radio Tuning	Set CAW TRANSFORMER to 6	

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DRILL	UNIT	ACTION	CHECK
2–8		Set CAW FILTER to setting from calibration chart	Frequency chosen complies with Note 1
2–9	Switch Unit Monitoring	Switch 2nd T.D. TRANSMITTER to OFF	
2–10		Repeat drills 2–5 to 2–9 for 3rd T.D. TRANSMITTER	
3–1	Switch Unit Monitoring	Select TRANSMITTER to be used (for which S1690d drills have been carried out)	
3–2	Meter Unit	Set Tune switch to ON Set D/L switch to ON	Amber TUNE lamp ON Amber D/L lamp ON
3–3	Monitor Unit	Select transmit tone	
3–4	TCU	Press ATTENUATOR button	Attenuator lamp ON Tune lamp ON
3–5		Decrease ATTENUATION to give reading of 110W max	POWER METER
3–6	Control Unit Radio Tuning	Adjust CAW FILTER to give reading of 0.85 or better	VSWR METER
3–7	Meter Unit	Switch D/L to OFF	Amber D/L lamp OUT
3–8	TCU	Set 28dB ATTENUATION Press ATTENUATOR button	Attenuator lamp ON Tune lamp OUT
3–9		Set VOGAD to IN	Aerial lamp ON
3–10		Decrease ATTENUATION to give reading of 110W max.	POWER METER
3–11	Control Unit Radio Tuning	Select the CAW TRANSFORMER setting to give reading nearest to unity. Make slight and careful re-adjustment of CAW FILTER to further improve reading	VSWR METER
3–12	TCU	Adjust ATTENUATION to give reading of 110W max.	POWER METER
3–13	Monitor Unit	Centralise ALL switches	
3–14	Switch Unit Monitoring	Switch TRANSMITTER to OFF	
3–15	TCU	Set LOCAL/REMOTE switch to REMOTE	
4	As appropriate	If the 2nd and/or 3rd T.D. TRANSMITTER is required for use it will be necessary to carry out S1690d drill followed by drills 3–5 to 3–15 above for each transmitter. (S1690d drill is in page 11-8-3, para. 5).	

DRILL	UNIT	ACTION	CHECK
On completion of drill 4.			
5	As appropriate	Drive and monitor each T.D. TRANSMITTER in turn, very carefully adjusting CAW FILTER if necessary to correct any VSWR DEGREDATION Check that power does not exceed 110W	
6	As appropriate	Make transmissions from REMOTE positions and monitor to ensure that forward power does not exceed: 1 transmission 110W 2 transmissions 440W 3 transmissions 990W	POWER METER That 1kW capability of amplifier is not exceeded

9. MF Base Tuned Wire Aerial

DRILL	UNIT	ACTION	CHECK
1	C & M Desk		
1–1	Control Unit Radio Tuning	Set MF BAND switch, MF CAPACITOR and MF INDUCTOR to setting from Calibration Chart	
1–2	TCU	Decrease ATTENUATION to give reading of 100W maximum	POWER METER
1–3	Control Unit Radio Tuning	Adjust BASE TUNER controls individually to give reading of 0.85 or better (as the VSWR approaches Unity, keep power to 100W maximum by use of ATTENUATOR)	VSWR METER POWER METER
1–4	TCU	Decrease ATTENUATOR to give a reading of 500W (400W for FST emission) (WBA may be used on the ETB on frequencies between 1.5 and 3 MHz. If used, power must be kept to 500W maximum)	POWER METER
1–5	Monitor Unit	Centralise ALL switches	
1–6	Switch Unit Monitoring	Switch TRANSMITTER to OFF	
1–7	TCU	Set LOCAL/REMOTE switch to REMOTE	READY lamp ON, on Switch Unit Monitoring

10. When Necessary Plugging Has Been Completed

DRILL	UNIT	ACTION	CHECK
1	Remote Position		

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DRILL	UNIT	ACTION	CHECK
1–1		Key transmitter using the mode of emission for which the circuit has been set up	
2	C & M Desk		
2–1	Switch Unit Monitoring	Select required TRANSMITTER	Resulting from high selectivity of Tuner, VSWR may deteriorate in switching from MONITOR UNIT input to REMOTE input
2–2	TCU	Adjust ATTENUATION if necessary	POWER output is correct
2–3	Switch Unit Monitoring	Switch Transmitter to OFF	

11. **Tuning an HF Receiver Circuit**

a. CJA

(1) Select appropriate aerial line.

(2) Set SYNTHESIZER dials to dial setting frequency.

(3) Set SYNTHESIZED/FREE RUNNING switch to SYNTHESIZED.

(4) Switch Receiver to appropriate frequency band.

(5) Tune receiver to Dial Frequency—UNLOCKED lamp will go OUT (the UNLOCKED lamp will go out on frequencies other than the correct one—observe FREQUENCY SCALE for correct setting; this can only be relied upon if CALIBRATED after a Band change). Continue tuning carefully until reading of ZERO is obtained in the ERROR METER.

(6) Lock TUNING control.

(7) Set MODULATION switch as follows:
DSB Voice, MCW—set to DSB AM
CW —set to CW + or CW −
SSB Voice, FST —set to SSB/ISB EXT

(8) AGC SWITCHES—for USB/DSB/CW use left hand panel, for LSB use right-hand panel.

(9) Set INT/EXT switch to INT.

For reception of:	DATA	set to DATA LINK
	SSB Voice	set to PAUSE
	FST, MCW CW	set to LONG TIME CONSTANT
	DSB Voice	set to SHORT TIME CONSTANT

If full control of gain required set to MANUAL. (Not normally used).

(10) If MANUAL set, plug in earphones and set MANUAL GAIN control for a suitable level.

(11) OUTPUT switch—select required output.

b. CJC OR CJA FREE RUNNING

(1) Select appropriate aerial line.

(2) Set SYNTHESIZED/FREE RUNNING switch to FREE RUNNING.

(3) Set METER switch to USB position 8.

(4) Select CW+.

(5) Depress CALIBRATION Switch and tune receiver to harmonic of 500 kHz nearest to required

frequency. When correct calibration position is reached, a 1 kHz note (also indicated by a maximum METER reading) will be heard.

(6) Release CALIBRATION switch.

(7) Line up CURSOR.

(8) Tune receiver to required frequency, adjusting FINE TUNER control as required.

(9) Other tuning controls are set as for CJA, para. 11*a* (7) to (11), except that for CJC on SSB Voice or FST select SSB/ISB INT, not EXT.

c. NOTES ON HF RECEIVER CJA/CJC

(1) If muting of the receiver (Simplex working) is required, set CANCEL MUTING switch to the UP position.

(2) When the equipment is not in use or removed from cabinet, set AERIAL SELECTOR switch to position 4.

(3) If more than approximately 3V aerial e.m.f. is received, the equipment will overload, indicated by OVERLOAD lamp ON. Reset by depressing the OVERLOAD RESET switch.

12. **Tuning an LF Receiver Circuit**

a. CJD

(1) Set SYNTHESIZER switch to CAL.

(2) Set SYNTHESIZER frequency controls to 500 Hz reading nearest to required frequency, e.g., for 46.23 kHz, set 046.500 and for an even frequency, 73 kHz, set 073.500 or 072.500.

(3) Set METER switch to CAL.

(4) Adjust synthesizer CAL control. For slow meter swing see B.R. 2407(1), chap. 5, para. 11(4).

(5) Set METER switch to LOCK.

(6) Set SYNTHESIZER switch to LOCK.

(7) Set required frequency on SYNTHESIZER dial.

(8) Lock SYNTHESIZER TUNING control.

(9) Switch receiver to required FREQUENCY BAND.

(10) Tune receiver to required frequency. Red UNLOCKED lamp will go OUT, Green LOCKED lamp will light.

(11) Carefully adjust TUNING control to obtain a reading of 6 in the meter.

(12) Lock receiver tuning control.

(13) Set AGC switch as follows:
If no AGC required, set to OFF.
DSB Voice, set to SHORT.
SSB Voice, CW, FST, Set to LONG.

(14) Set BFO switch as follows:
OFF —DSB Voice
VARIABLE—CW (BFO tuneable by Variable control ± 3 kHz)
SSB1 —AF output centred on 1000 Hz
SSB2 —AF output centred on 1500 Hz

(15) Set AUDIO GAIN control to give suitable level.

(16) Set SPEAKER VOLUME as required.

(17) AERIAL ATTENUATION switch—may be used to attenuate very strong signals.

(18) NOISE LIMITER, normally OFF. Can be set ON and limiting level adjusted.

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(19) Set IF BANDWIDTH as required. Normal positions are:

POST-NOISE LIMITER—120 Hz for RATT and CW.
3,000 Hz for Voice.

PRE-NOISE LIMITER —120 Hz for RATT and CW.
3,000 Hz for Voice.

b. CJD FREE RUNNING RECEPTION

(1) Set AERIAL ATTENUATOR fully anti-clockwise.

(2) Set METER switch to RF LEVEL.

(3) Set SYNTHESIZER switch to UNLOCK.

(4) Set other controls as for CJD, para. 12*a* (13) to (19) omitting (17).

(5) Tune receiver to required frequency.

(6) Set AERIAL ATTENUATOR for reading of approx. 5 in meter.

13. Tuning a Band Suppression Filter

a. RECEIVER AERIAL EXCHANGE

(1) Insert the FILTER (correct range) to be tuned into the TUNING BAY.

(2) Set ATTENUATOR to 30dB.

b. MONITORING AND TEST UNIT

(1) Operate TDA TRANSMIT switch.

(2) Set ATTENUATION to 28dB.

(3) Set MONITOR receiver output to USB.

(4) Set MON RX OUTPUT switch to RX AE EX.

(5) Set DRIVE OUTPUT switch to RX AE EX.

(6) Set AERIAL SELECTOR switch to RX AE EX position 4.

c. MONITOR TDA

(1) Set SYNTHESIZER to assigned frequency.

(2) Set OUTPUT switch to DSB FULL CARRIER.

(3) Tune TDA in normal manner.

d. MONITOR CJA

(1) Tune receiver to transmitter frequency, reduce TDA ATTENUATION if necessary.

(2) Set SYNTHESIZED/FREE RUNNING switch to SYNTHESIZED.

(3) Set MODULATION switch to CW + or CW −.

(4) Set AGC switch to MANUAL.

(5) Set IF GAIN control to 7.

e. RECEIVER AERIAL EXCHANGE

(1) Plug earphones into TUNING MONITOR JACK and adjust ATTENUATION to give three quarters of full-scale reading on TUNING meter.

(2) Rotate FILTER TUNING control to give minimum level in TUNING meter and earphones (adjust ATTENUATION on the RECEIVER AERIAL EXCHANGE and/or TDA OUTPUT on the MONITOR AND TEST UNIT if necessary).

(3) Adjust FILTER TUNING control about minimum point to ensure setting is correct.

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(4) Lock FILTER TUNING control.

(5) Place FILTER in its operational position.

(6) Select the required transmitter on the TRANSMITTER SELECTION SWITCH section.