RESTRICTED

R.A.A.F. PUBLICATION No.
APRIL 1944

STANDARD NOTES
FOR
WIRELESS MAINTENANCE MECHANI
AND
WIRELESS ASSISTANTS

ISSUED FOR THE INFORMATION AND GUIDANCE OF ALL CONCERNED.

BY COMMAND OF THE AIR BO

SECRETARY.

AIRFORCE HEADQUARTERS,

FOR OFFICIAL USE ONLY

R.A.A.F. Publication 318,
April, 1944.

STANDARD NOTES FOR WIRELESS MAINTENANCE MECHANICS AND WIRELESS ASSISTANTS

CONTENTS

STANDARD NOTES FOR WIRELESS MAINTENANCE MECHANICS

AND WIRELESS ASSISTANTS

INTRODUCTION

These notes are issued for the assistance of airmen under training as Wireless Mechanics. They are not intended to form a complete text-book but are to be used in conjunction with lectures and demonstrations at Signals Schools.

The Notes are intended to cover in a general way the subjects with which the Wireless Mechanic should be familiar. They are not to be considered as official authority for detailed adjustments and repairs for which the appropriate Air Publication is to be consulted.

The Notes cannot be issued to each trainee as his personal property owing to the increasing need for economy in paper. They are to be returned at the end of each course, and at all times must be handled carefully. No alterations may be made without the authority of official amendment lists which will be issued from time to time.

Wireless mechanics after leaving their instructional courses will be able to refer to these notes if necessary, as a limited number of copies has been distributed to all stations.

R.A.A.F. Publication 318,
April, 1944.

STANDARD NOTES FOR WIRELESS MAINTENANCE MECHANICS AND WIRELESS ASSISTANTS

The amendments promulgated in the undermentioned amendment lists have been made in this publication.

Amendment List		Amended by	Date
Number	Date		

CHAPTER 1

REVISION OF BASIC ELECTRICITY

1. **General.**—*Electric current.*—An orderly movement of electrons from one part of a circuit to another.

Coulomb.—The unit of *quantity* of electricity (approximately equal to 6·3 million million million electrons).

Ampere.—*A rate of flow* of one coulomb per second (standard unit of current).

Conductor.—A substance with many free electrons, which readily permits the flow of electrons under " pressure " (i.e. when a voltage is applied).

Insulator.—A substance with few free electrons, which does not permit the flow of electrons.

E.M.F. (Electro Motive Force).—The " force " causing an electric current flow in a circuit, measured in *volts*. (1 volt causes a current of 1 ampere to flow through a resistance of 1 ohm.)

Potential difference (*P.D.*)—The difference in voltage between two points in a circuit.

Means of producing E.M.F.—(1) Chemical energy, as in batteries; (2) Heat, as in thermo-couples; (3) Mechanical, as in dynamos.

Resistance.—The opposition offered to the flow of current; measured in *ohms*.

Ohms law.—States that a constant relationship exists between the current in a conductor and the P.D. between its ends; e.g. P.D. doubled, current doubled; resistance doubled, current halved; or in symbols :—

$$I = \frac{E}{R}, \quad R = \frac{E}{I}, \quad E = I \times R.$$

2. **Practical.**—(*a*) *Circuits containing resistance.*—(i) *Parallel* (as for valve filaments). Total resistance always less than the lowest value of individual resistance.

Thus :— $$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \text{etc.}$$

(ii) *Series.*—Total resistance equal to the sum of all the individual resistances.

Thus :—$R_t = R_1 + R_2 + R_3 + \text{etc.}$

(iii) *Combination, series parallel.*—Work out parallel bank first. Obtain equivalent value resistance, and add to the others in series to find total.

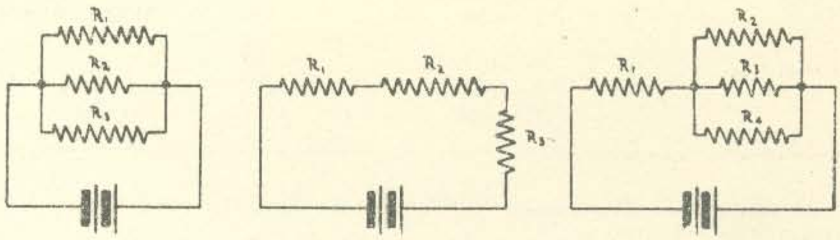


FIG. 1.—Resistance arrangements.

(*b*) *Power* is the rate of transfer of energy or rate of working.

Watt is the unit of power, and is equal to the product of amperes and volts. $W = I \times E$ (746 watts = 1 horse power).

Since $I = \frac{E}{R}$

$$W = \frac{E}{R} \times E \text{ or } \frac{E^2}{R} \text{ if value of current is not known.}$$

Since $E = I \times R$

$$W = I \times I \times R = I^2 R \text{ if value of voltage is not known.}$$

(*c*) *Effects of a current.*—(i) *Heat.*—All current-bearing conductors become heated—intentional effect in lamps and radiators, but unavoidable entirely in all circuits.

(ii) *Magnetic.*—A current-bearing conductor has a magnetic field surrounding it—used in electro-magnets and telephones.

(iii) *Chemical.*—In solutions conveying currents chemical changes occur, e.g. electro plating and secondary cells.

3. **Units.**—(*a*) In addition to the " standard " units, it is convenient to use larger or smaller units, to avoid large or small numbers. For example, small currents are measured in milliamperes (1/1000th of 1 ampere).

The full range of prefixes for such units is :—

Prefix.	Abbreviation.	Meaning.
Mega	M	1,000,000 times.
Kilo	k	1,000 times.
(Centi)..	(c)	1/100th (·01).
Milli	m	1/1,000th (·001).
Micro	μ	1/1,000,000th (·000001)
(Micro-micro) ..	($\mu\mu$)	(1/1,000,000,000,000th).

(*b*) The more common units, and their symbols, are given below :—

Class.	Name.	Symbol.	Size.
Current flow (I) ..	Ampere	A	1·0 amps.
	Milliampere ..	mA	·001 amps.
	Microampere ..	μA	·000001 amps.
E.M.F. or P.D. (E) ..	Volt	V	1·0.
	Kilovolt	kV	1,000 volts.
	Millivolt	mV	·001 volts.
	Microvolt ..	μV	·000001 volts.
Resistance (R)	Ohm	Ω	1·0.
	Megohm	MΩ	1,000,000 ohms.
	Microhm	$\mu\Omega$	·000001 ohms.
Power	Watt	W	1·0.
	Kilowatt ..	kW	1,000 watts.
	Milliwatt ..	mW	·001 watts.

4. **Meters and Measurements.**—These are classified according to the units which they measure :—

(*a*) *Voltmeter.*—An instrument designed to measure the potential difference between any two points in a circuit. Since the P.D. existing between any two points is proportional to the current flow, the voltmeter resistance must be high (say about 10,000 ohms) to avoid " by-passing " more than a very small fraction of the current.

(*b*) *Ammeter.*—An instrument designed to measure current, and, therefore, placed in series with the circuit. The ammeter resistance must be low so as not to reduce the circuit current.

(*c*) *Shunt resistance.*—May be placed in parallel with an ammeter, to extend the effective range.

5. **Types of Meters :—**

Type.	Advantage.	Disadvantage.	Service Remarks.
Moving coil ..	Even scale, accurate	Suitable for D.C. only.	Commonly used.
Moving iron ..	Cheap, robust ..	Uneven scale, high resistance.	Seldom used.
Thermo couple	Suitable for A.C., D.C. and R.F.	Easily damaged	Commonly used
Electrostatic ..	Low power consumption.	Not suitable as ammeter or for low voltage.	Used
Hot wire ..	Suitable for A.C., D.C. and R.F.	Requires frequent calibration.	Used.

Note.—Except where mentioned, all the foregoing are suitable in principle for use as ammeters or voltmeters.

(*a*) *Moving coil type.*—An instrument working on the " motor principle " and making use of the fact that the turning moment on a coil of wire in a magnetic field is proportional to the current flowing. Springs are arranged to oppose this turning moment, and a pointer is attached to the coil and made to travel over a calibrated scale.

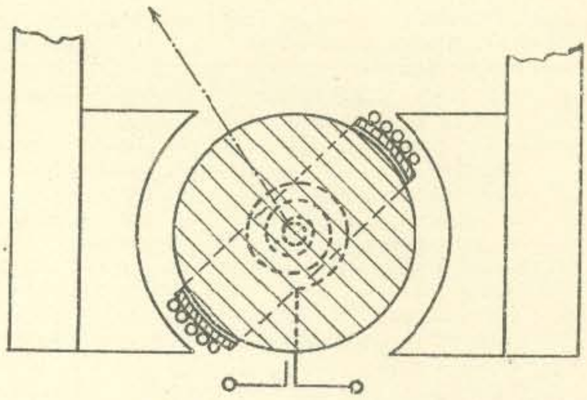


FIG. 2.—Moving coil ammeter.

Forces in moving coil instruments :—

(i) *Actuating force.*—The force driving the pointer over the scale, i.e. the interaction of the two fields.

(ii) *Controlling force.*—This returns the pointer to zero, and balances with actuating force to give correct readings. Usually phosphor-bronze springs.

(iii) *Damping force.*—This prevents pointer from oscillating, and brings pointer quickly to rest on final reading. Usually " eddy current " damping, employing aluminium " former ".

(*b*) *Thermo junction type.*—This instrument depends on the fact that if the junction of two wires of (certain) dissimilar metals is heated an E.M.F. is generated. The current flow in the circuit is used to heat the junction, and is measured by a sensitive moving coil instrument, calibrated to read units of current (amps. or milliamps.).

As the heating effect of a current is not in proportion to the amount o current, the calibration is non-uniform.

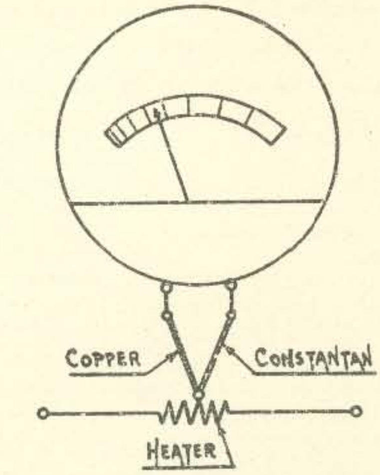


FIG. 3.—Thermo-junction ammeter.

Forces in thermo-junction instrument :—

(i) *Actuating force.*—Heater and thermo-junction.

(ii) *Controlling force.*—Springs, as in moving coil.

(iii) *Damping force.*—Eddy current type, as in moving coil.

(*c*) *Test meters.*—Measure current, voltage and resistance by the same instrument. They are known commercially as AVO meters (amps., volts, ohms), and are of three types :—

(i) *Type C* (D.C. only) ("AVO minor "). There are several sockets for use with the various ranges of readings expected—

(*a*) To read milliamps, insert the positive lead in +, and the negative lead in one of the other sockets marked 6, 30 and 120 m/A, as required.

(*b*) To read volts, positive lead in +, negative lead in one of the sockets marked 6, 120, 300 V, as required.

(*c*) To read ohms, insert positive lead in +, negative lead in socket marked " ohms ", connect them together and adjust slider to get full scale deflection. Then disconnect, and connect to the external circuit whose resistance will now be measured.

(ii) *Type E* (D.C. only).—This is similar to type C, with ranges as shown in fig. 5. The operation is similar, except that the positive lead is inserted in the desired socket, and there is a switch which doubles the range of the instrument when reading volts.

(iii) *Type D* (D.C. and A.C.).—This is the well-known " 40 range " Universal Avometer, and contains a rectifier which enables the milliammeter to read certain A.C. ranges as well as D.C.

(iv) N.B.—In using these test meters remember :—

(*a*) They are fragile and costly instruments.

(*b*) Always leave the meter switched to the highest voltage range when not actually testing.

(*c*) Type " E " must be put into case face downwards, to avoid pressing glass on to needle with fingers when withdrawing.

(*d*) "*Meggers.*"—Used for insulation testing, and the measurement of resistance above 10 kilohms. Consist of a hand-driven generator and a galvanometer, both with permanent magnet fields. The larger model (" tester insulation ") contains a slipping clutch, which prevents the generator from developing too great a voltage. The smaller (" Wee Megger ") has no clutch and the handle must be turned at 120–150 R.P.M.

The principle of the " Megger " is shown in fig. 6. The measuring system consists of two coils mounted at right angles to each other on a common shaft and called the current coil (C.C.) and pressure coil (P.C.) respectively.

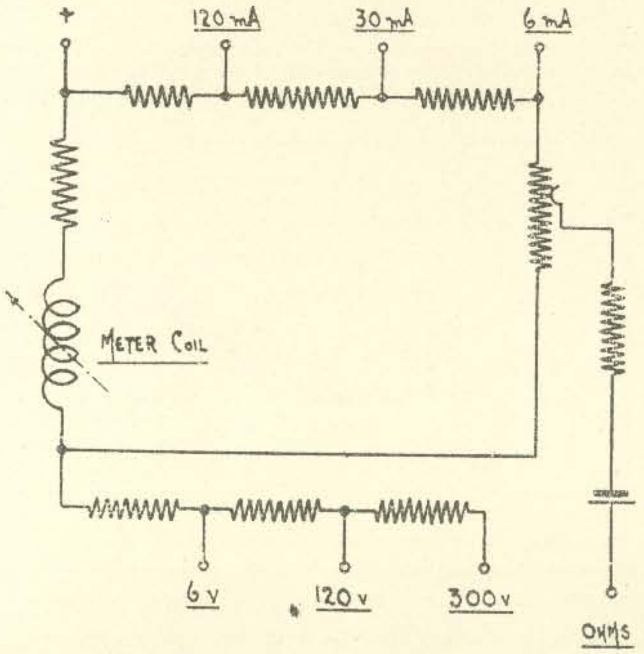


FIG. 4.—Test meter, type C.

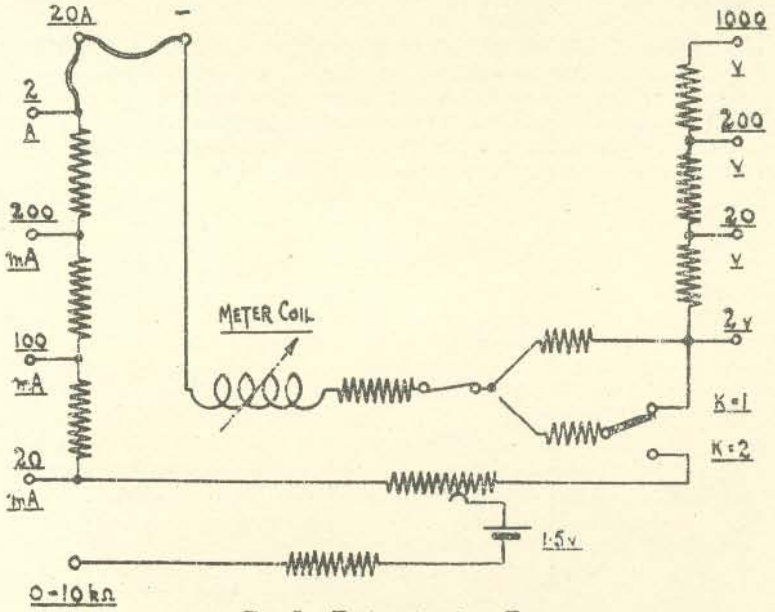


FIG. 5.—Test meter, type E.

They are pivoted so as to be free to move in the magnetic field of a permanent magnet, and wound so that when carrying current they tend to rotate in opposite directions.

The pointer thus comes to rest in a position determined by the relative values of the currents flowing in the two coils. When the current coil is on

" open circuit ", i.e. when the unknown resistance across A–B is infinite, current will flow only in the pressure coil, and the pointer will take up a definite position which is marked " infinity " on the scale ; when A–B are short circuited, i.e. when the unknown resistance is zero, the pointer will assume another position on the scale marked " zero ".

Intermediate values of resistance will cause the pointer to take up positions on the scale between these two limits, and these positions may be determined by using known resistances. The instrument is thus calibrated to read resistance directly.

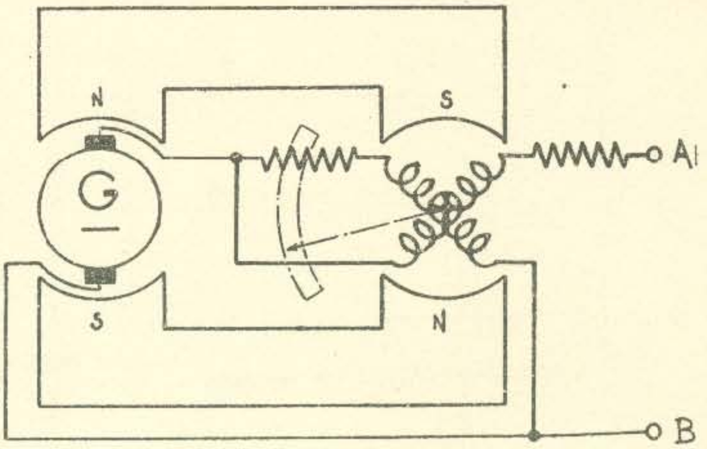


FIG. 6.—Megger.

(*e*) *Bridge megger*.—Used for the same purpose as the " meggers " in paragraph (*d*) and for measuring resistances from 0·01 ohms to 999,900 ohms.

This instrument employs the Wheatstone Bridge principle, as shown in fig. 7.

The unknown resistance forms one " arm " of the bridge, the fixed resistance in series with the current coil a second arm, and a known resistance with various tappings provides the other two arms as shown.

The bridge is balanced when no current flows in the current coil as shown the pointer in this case indicates " infinity " on the scale, so that the procedure is to adjust the tapping until this reading is obtained.

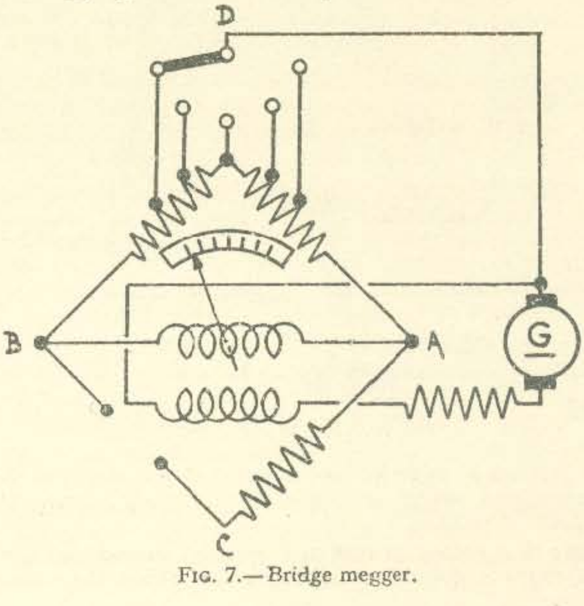


FIG. 7.—Bridge megger.

(*f*) *Bonding tester.*—The bonding between any two parts of an aircraft is tested by measuring resistance between them; this should be *less* than 0·025 ohms. For measuring this resistance a bonding tester is used, comprising

(i) an ohmmeter with a range of 0 to 0·1 ohms,
(ii) an alkaline accumulator to supply the testing voltage,
(iii) Special test leads.

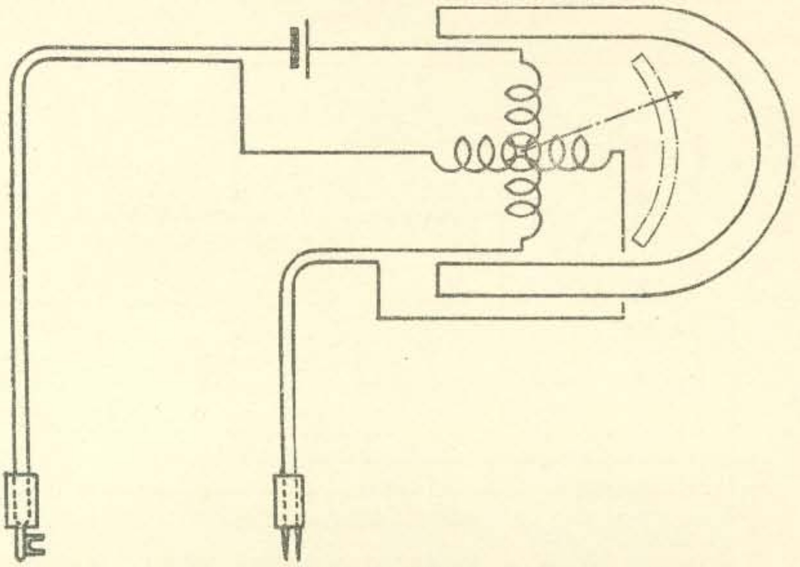


FIG. 8.—Bonding tester.

Fig. 8 shows the layout, and it will be noticed that the deflection is obtained in much the same manner as in the "megger".

6. **Primary Cells.**—The type of primary cell in common use in the Service is the Leclanche cell (E.M.F. 1·5 volts). It consists of carbon and zinc electrodes, sal-ammoniac electrolyte, and manganese dioxide depolariser.

Such a primary cell is really suitable for intermittent work only (when used for continuous work a very short life is the result). It differs from the secondary cell in that it cannot be recharged but must be replaced.

Types of Leclanche cell.—(i) *The "dry" cell* has its electrolyte (liquid) of sal-ammoniac absorbed by some kind of porous "paste" to prevent splashing. It is used in H.T. batteries for receivers, grid bias (G.B.) batteries and torch batteries.

(ii) *The "inert" cell* has an electrolyte of dry sal-ammoniac crystals, and in this state produces no E.M.F. It becomes "active" when water is added and the crystals are completely dissolved. The internal construction is such that there is little free liquid in the cell after solution is completed. The inert cell was introduced for use in the tropics, because a "dry" cell deteriorates in transit and storage at high temperatures.

(iii) There is a third type of Leclanche cell (the "A.D." type) in which the electrolyte is in solution form and all components are contained in a glass jar. The carbon electrode has a hollow centre and is porous; this enables the oxygen in the air to act as the depolarising agent.

This type of cell may only be used for stationary work, e.g. bells.

7. **Accumulators.**—*It must be realized that the correct charging and maintenance of W/T accumulators is of vital importance, and is one of the greatest responsibilities of the wireless mechanic. The lives of the aircraft crews depend on them.*

Practically all the information relevant to the charging and maintenance of accumulators is contained in *Forms 480 and 480A, R.A.F.*, which are exhibited in all charging rooms, and the provisions of these forms must be followed exactly. R.A.F. accumulators likely to be met by wireless mechanics are:—

(*a*) *Lead acid type.*—(E.M.F. about 2·2 volts per cell) :—

(i) *Ground use*—

Volts.	Capacity. Ampere-hours.	Case.	Remarks.
2	90	Glass	Planté plates.
2	120	Glass	
6	80	Moulded ..	M.T. and ground W/T use.
12	55	Moulded ..	M.T. and ground W/T use.
6	180	Moulded ..	Aero-engine starting.
6	230	Moulded ..	Aero-engine starting.
2	7	Celluloid ..	Wavemeter use.

(ii) *Air use* (all with non-spill vent, moulded case) :—

2 volts ..	.. 14 ampere hours.
2 volts ..	.. 20 ampere hours.
12 volts ..	.. 15 ampere hours.
12 volts ..	.. 25 ampere hours.
12 volts ..	.. 40 ampere hours.

N.B.—*Unspillable types.*—Two things are necessary to render an aircraft accumulator unspillable : (1) unspillable vent ; (2) correct level of acid in cell.

Item (2) is important, as an unspillable vent *will not prevent spilling if acid level is above that stated on makers' instructions.*

(*b*) *Nickel alkaline type* (E.M.F. about 1·25 volts per cell) :—

L.T. type, usually in metal containers.

H.T. type, " Milnes unit ".

Note.—Nickel alkaline cells *must* be kept apart from lead acid types. A separate charging room is essential.

Milnes unit.—For ground station receivers : 96 alkaline cells giving 120 volts output. Capacity : 0·6 to 0·9 amp. hours. Electrolyte : caustic potash, specific gravity 1·190. A special switching arrangement is fitted, with two positions.

(i) *Charge.*—24 banks of 4 cells each are switched to " parallel ", and can be charged from a 6-volt accumulator.

(ii) *Discharge.*—96 cells are switched to " series ".

(iii) *Boost charge.*—Occasionally an 8-volt accumulator should be used in conjunction with a 1-ohm resistance to give a freshening charge.

(*c*) *Ampere hour capacity.*—Any (lead acid) cell can be discharged at a steady rate from " fully charged " to " fully discharged " (i.e. 1·8 volts per cell—*not* 0 volts). The *capacity* of the cell is generally stated on the " 10-hour " rate, i.e. the current is adjusted so that 10 hours are required for discharge ; if the current is then 2 amps., the capacity is 2 × 10 = 20 amp. hours, and so on.

Notes.—(i) A 20 A.H. accumulator would not maintain a current of 10 amperes for 2 hours. Full advantage of a cell is taken only by discharging it at, or below, the manufacturers' rating.

(ii) R.A.F. standard rate of discharge is a discharge rate adopted by the service as the maximum safe discharge rate, and is that steady rate of discharge which will discharge a fully charged accumulator to 1·8 volts in ten hours, i.e. " 10-hour " rate.

(iii) It is in order to work at *less* than the ten-hour rate of discharge, but not advisable to exceed it.

(*d*) *Quarterly capacity test.*—A 20 A.H. accumulator on test may deliver 2 amperes for a period of 7 hours only, before the voltage reaches 1·8. Then amps. × hours = 14 A.H., i.e. 70 per cent. of its rating. All aircraft accumulators must be given a capacity test at least every 3 months to determine their actual capacity; this must be not less than 60 per cent. of their "rated" capacity. If only a little more than 60 per cent., a re-test is necessary before three further months elapse.

Accumulators with less than 60 per cent. capacity must be plainly marked with a *yellow band, and may not be used in aircraft.*

(*e*) *Serviceability.*—Aircraft accumulators must be carefully examined for :—

(i) Fully charged state.
(ii) Freedom from cracks.
(iii) Correct acid level.
(iv) Cleanness and terminals greased.
(v) Fitted with unspillable vents.
(vi) At least 60 per cent. of rated capacity.

(*f*) *Type "B" charging board.*—A complete three-circuit charging board with protective devices, designed to operate on a 36-volt D.C. supply. A.C. mains can be employed in conjunction with a step-down transformer and rectifier.

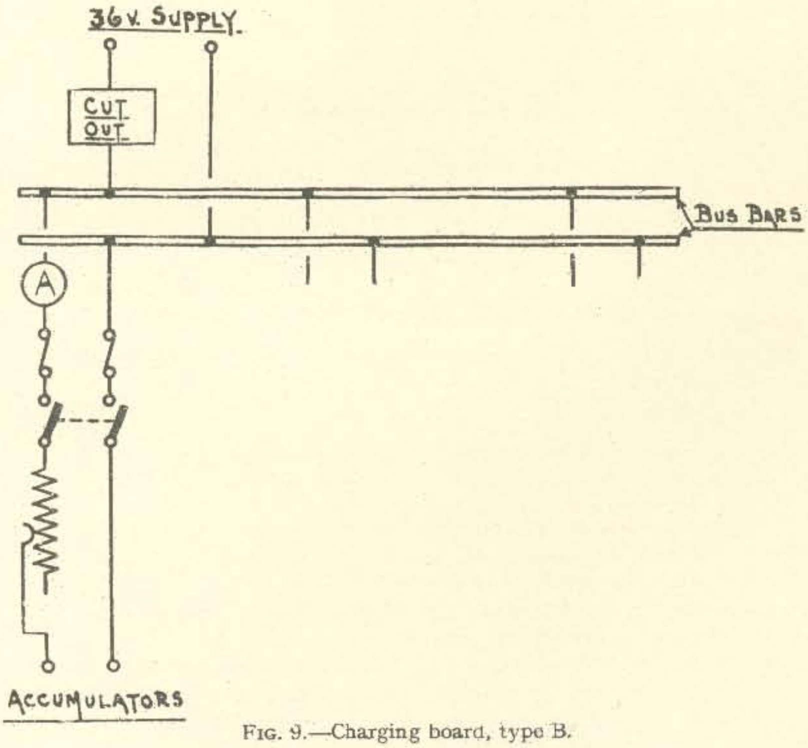


FIG. 9.—Charging board, type B.

Bus bars.—Heavy copper strips designed to carry large currents.
Ammeter.—To indicate the charging current.
Rheostat.—To enable adjustment of charging current.
Fuses.—To prevent an overload in the event of a short circuit. Rated at 50 per cent. overload (10-amp. maximum load, 15-amp. fusing).
Switches.—For the purpose of isolating any particular circuit.
Cut-out.—To prevent cells discharging in the event of a supply failure. This is really a reverse current switch ; the arrangement is as shown in circuit diagram.

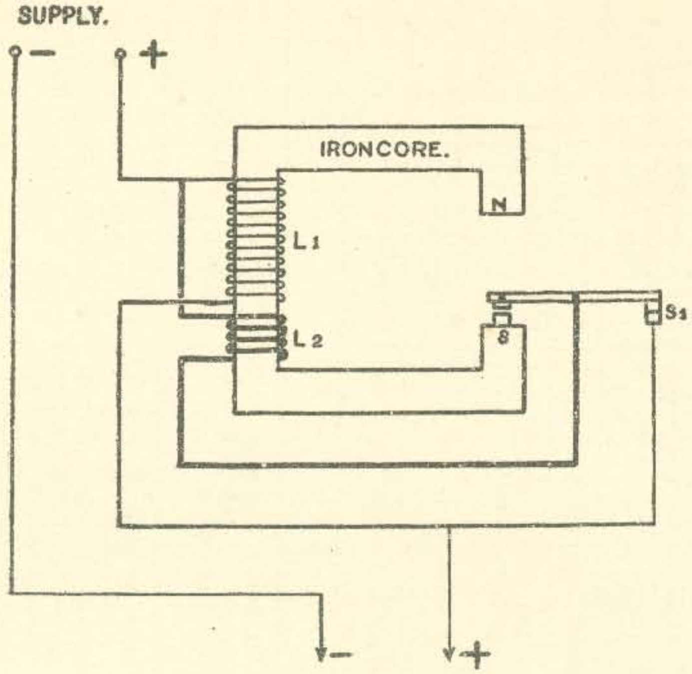


FIG. 10.—Cut out type B

CHAPTER 2

CABLES AND COLOUR CODES

1. **Cables.**—(i) *Core.*—The number of cores in a cable is indicated by the prefix to the class name :—

Uni means one.	Quinto means five.
Du means two.	Sexto means six.
Tri means three.	Septo means seven.
Quadra means four.	Nono means nine.

(ii) *Covering.*—The nature of the covering is usually indicated by the main part of the class name :—

(*a*) Flex	..	Coloured cotton braiding.
(*b*) Proof	..	Cotton braiding, waterproofed by varnish.
(*c*) Sheath	..	Tough rubber sheath.
(*d*) Core	..	Tough vulcanised rubber, coloured red.
(*e*) Cel	..	Cotton braiding, waterproofed by coloured cellulose.
(*f*) Met	..	Lapped with varnished cambric, and braided with metal wire.
(*g*) Com	..	Metal braided, compounded with rubber.
(*h*) Lead	..	Lead covered.

(iii) *Rating.*—The number following the cable name indicates the normal (maximum) current rating of each core in amperes, thus " uniflex 4 " will carry 4 amps., and " dusheath 19 " will carry 19 amps.

With the normal current flowing, the volts drop per yard is 0·1 volts for the smaller cables (4, 7, 19), and less than this for the larger.

2. **Typical Cables.**—(i) *High tension*

Cables.	Rating (amps.).	Insulation and Covering (Core).	Outer Insulation and Covering.	Uses and Remarks.
Uniplug	12	Pure and vulcanised india-rubber (" V.I.R.").	None	W/T., H.T., and sparking plug wiring.
Uniplugcotton	12	As for uniplug	Braided with red cotton ..	W/T, H.T.
Uniplugmet	12	As for uniplug	Lapped with cambric and braided with wire.	H.T. screened leads.
Unispark..	7	As for uniplug	None	W/T, H.T.; heavier insulation than uniplug.
Unilead (H.T.)	7, 19	Rubber	Taped and covered with lead sheath.	Ground W/T.

(ii) *Low tension*

Cables.	Rating (amps.).	Insulation and Covering (Core).	Outer Insulation and Covering.	Uses and Remarks.
Uniflex to Nonoflex ..	4, 7, 19, 37, 64 ..	Pure and V.I.R.; each core has coloured cotton lapping.	" Wormed " circular and braided with cotton-coloured yellow.	General A./C. wiring. Multi-core cables available in small ratings only, e g. nonoflex, 4 amp. only.
Uniflexred	4, 7	Pure and V.I.R.	Cotton braiding coloured red	W/T wiring.
Unicel to Septocel ..	4, 7, 19, 37, 64 ..	Pure and V.I.R., each core coloured throughout.	Covered with cambric tape, cotton braided and finished in black cellulose varnish.	As for " flex " cables.
Unisheath to Quinto-sheath.	4, 7, 19, 37, 64 ..	Pure and V.I.R., core has coloured cotton lapping.	Covered with tough rubber sheath (T.R.S.).	W/T and L.T.

2. Typical Cables.—(ii) *Low tension*—contd.

Cables.	Rating (amps.).	Insulation and Covering (Core).	Outer Insulation and Covering.	Uses and Remarks.
Unisheathcotton ..	4	As for unisheath	As for unisheath plus cotton braiding coloured red.	W/T.
Unisheathmet to Quinto-sheathmet.	4, 7, 19, 37, 64 ..	As for unisheath	As for unisheath, braided with metal wire.	A/C. wiring where screening is required e.g. D/F.
Uniproof to Nonoproof..	4, 7, 19, 37, 64 ..	Pure and V.I.R.; each core has coloured cotton lapping.	"Wormed" circular, and braided with waterproof material coloured yellow.	As for "flex" and "cel" cables; this type is obsolescent.

(iii) *Additional cables*

Quadracore to Nonocore	Cores have different ratings.	V.I.R.; each core has coloured rubber covering.	Cable lapped with cotton tape and covered with tough rubber sheathing coloured red.	Available in three sizes, W/T wiring, e.g. supply cable from M.G. to transmitter.
Unilead (L.T.)	4, 7, 19. 46, 64 ..	Rubber	Taped and covered with lead sheath.	Ground W/T, L.T. only.
Dumet to Septomet ..	4 7, 19. 37	V.I.R., each core coloured	Lapped with cambric tape, braided with wire.	W/T screened leads, also available with T.R.S. over wire braiding.
Quadragen	19 (3 cores), 4 (1 core)	Compound V.I.R., each core coloured.	Covered with tough rubber sheath.	E.D.G. wiring available in three sizes.

Quadragenmet	As for quadragen ..	As for quadragen	Lapped with cambric tape and braided with metal wire.	As for quadragen.
Unistart and Dustart ..	.. .. ..	V.I.R.	Lapped with varnished cambric, cotton braided and impregnated with oil paint.	For engine-starting on A/C.; available in various sizes.
Unistartal	.. .. ..	Aluminium core, two layers of compound vulcanising rubber.	Taped and braided with impregnated cotton.	For engine-starting on A/C.; available in three sizes.
Fiftypower	100	Pure and V.I.R.	Lapped with three layers of varnished cambric and closely braided with paint-impregnated cotton.	Accumulator supply leads for engine-starting.
Vircom (single core only)	3, 6, 12, 17, 33, 54, 75, 91, 113.	Pure and V.I.R.	Taped, braided and compounded, coloured red and black.	Ground power wiring.
Instruflex (double core only).	3	Cotton and rubber ..	Closely braided with cotton; two cores twisted together and coloured red and black.	Instrument wiring.
Twin T.R.S.	25	Copper and steel conductors, pure and V.I.R., cores coloured red and black.	Braided, compounded and cotton covered.	Ground use, 9 K.V.A., petrol-electro set.
Dulocapmet	2·5	V.I.R., "spider," surrounded by V.I.R. tube.	Cores laid parallel, taped with cambric, braided with metal wire, which is lapped with cambric and sheathed with rubber-wax compound.	D/F, screened.

3. **Colour Scheme—Miniature Radio Resistance.**—The colour of the *body* gives the first figure; the colour of the *tip* gives the second figure; the colour of the *spot* gives the number of noughts.

Colour.	Meaning if on Body or Tip.	Meaning as Spot.
Black	0	—
Brown.. ..	1	0
Red	2	00
Orange ..	3	000
Yellow ..	4	0,000
Green	5	00,000
Blue	6	000,000
Purple.. ..	7	0,000,000
Grey	8	00,000,000
White	9	000,000,000

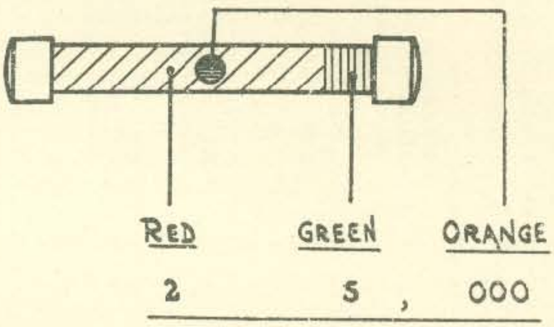


FIG. 11.—Colour code.

CHAPTER 3

ELECTRIC GENERATORS AND MOTORS

1. The requirements for a practical (direct current) *generator* are :—

(*a*) *Field.*—A means of producing lines of force—permanent or electro-magnet.

(*b*) *Armature.*—A rotating part on which a series of coils is wound.

(*c*) *Commutator.*—A band of small insulated copper segments fixed on the armature. These make connection with the coils, and receive the current generated there, for transfer to the brushes. The number of segments depends on the number of loops of wire. To ensure a nearly constant voltage ouput (i.e. little " ripple "), many loops are required.

(*d*) *Brushes.*—These connect the commutator to the external circuit. The brushes are of carbon, and fit in holders, a slight pressure being applied to ensure a good contact on the commutator.

2. The requirements of a practical *motor* are field, armature, commutator and brushes as in the generator. An E.M.F. is applied to the armature coils via the brushes and commutator, and the interaction of the armature field (due to the current produced by this E.M.F.) and the main field gives rise to rotation.

3. **Motor Generator** ("**M.G.**").—(*a*) When it is required to produce a high voltage from a low (D.C.) voltage source, use can be made of a combination of the electric motor and generator. The low voltage supply is made to turn an armature (exactly as in a motor) and on this same armature are wound many coils of wire for the high voltage output. The high voltage coils are brought out to the opposite end, to a second commutator. One field serves the two windings on the armature.

(*b*) *Type " E " 80-watt, M.G.*—(i) *Description.*—The output is intended for use with W/T apparatus, and particular care is taken in obtaining a smooth voltage output (minimum " ripple ") :—

Input—14 volts ; 12·5 amps. ; 175 watts.

Output—1,200 volts ; 72 mA ; 86 watts.

Speed—5,800 r.p.m. (efficiency 49 per cent.).

Field—the windings are connected across the L.T. supply (" shunt field ").

Brushes—L.T. end, a mixture of carbon and copper ; H.T. end, carbon and graphite mixture.

Smoothing—A 0·5μF condenser is connected across H.T. terminals to smooth out the " ripple " due to commutator action.

Interference suppression—condensers of 0·01μF are fitted between each brush and frame of generator, to suppress interference likely to be caused to W/T apparatus.

Tone wheel—this is part of the W/T equipment, but is fitted on the generator to make use of the rotation. Interchangeable tone wheels fit on the end of the armature spindle, five tone wheels being supplied with each motor generator.

Note.—See later for further explanation of the condenser sizes, and of the " tone wheel ".

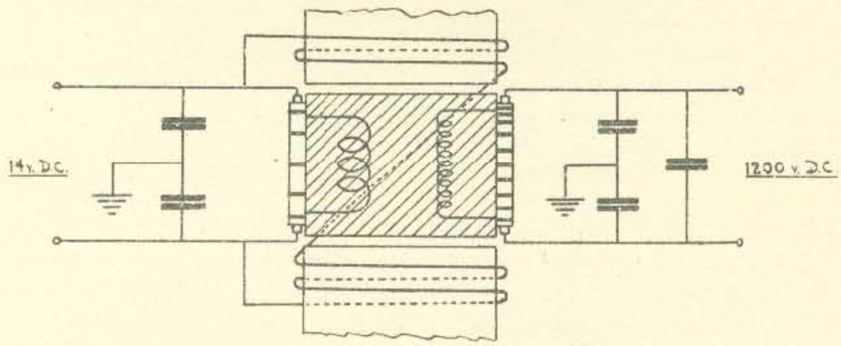


FIG. 12.—Motor generator, type E.

(ii) *Maintenance of M.G.*—The motor generator must be kept in a thoroughly serviceable condition, and the following parts are of importance :—

(*a*) *Lubrication.*—Apply five drops of anti-freeze oil at every 40-hour inspection. Oil valves are located on each end of frame.

(*b*) *Commutator.*—Must be cleaned frequently with a petrol-soaked rag.

(*c*) *Brushes.*—Should be a sliding fit in their holders. Brushes eventually wear short, when new ones are required. New brushes should be put in holder and a piece of fine glass paper wound on the commutator ; then by resting the brush on the glass paper and rotating the armature by hand, the brush takes the shape of the armature, ensuring better contact.

(iii) *Common faults* :—

(*a*) Leads may foul rotating armature ; keep well cleated to framework.

(*b*) Machine starts slowly, then races ; suspect disconnection to field.

(*c*) Reversed output ; check input for reversal (direction of rotation is no guide to this).

(*d*) Faulty insulation : see that bolts securing the insulation terminal block are not too long.

N.B.—Always check that armature is free to revolve.

(iv) The motor generator comes under normal inspection routine, and an example of tests to be carried out is as follows :—

(*a*) Test insulation of field to earth ..	at least 2 megohms.
(*b*) Test insulation of L.T. armature to earth	at least 2 megohms.
(*c*) Test insulation of H.T. armature to earth	at least 50 megohms.
(*d*) Test insulation between H.T. and L.T. armature	at least 50 megohms.
(*e*) Test resistance of field	to read 16·5 to 17·5 ohms
(*f*) Total resistance of L.T. armature ..	to read 0·03 to 0·01 ohms
(*g*) Test resistance of H.T. armature ..	to read 750 to 850 ohms.

(*h*) Test all condensers.

(*i*) Re-assemble and test for working, output voltage, etc.

(v) *Starters.*—The resistance of a motor armature winding is very low, and if the full voltage were applied, a high current would flow, thus damaging the armature, and possibly the supply battery. To obviate the high starting current a resistance is put in the circuit until the motor has gained speed ; it may then be taken out of circuit, since the " back E.M.F." generated by the motor then limits the current to a safe value.

Type "A" starter is used with type " E " M.G. to act as above, and to enable operation from a distance without loss of power.

Starter adjustments :—

(*a*) Double-pole switch spring to be adjusted to close on 8 volts.

(*b*) Single-pole switch spring to be adjusted to close on 8 volts.

(*c*) Clearance between armature and pole face 0·06 inch.

(*d*) Contact clearance, 0·025 to 0·030.

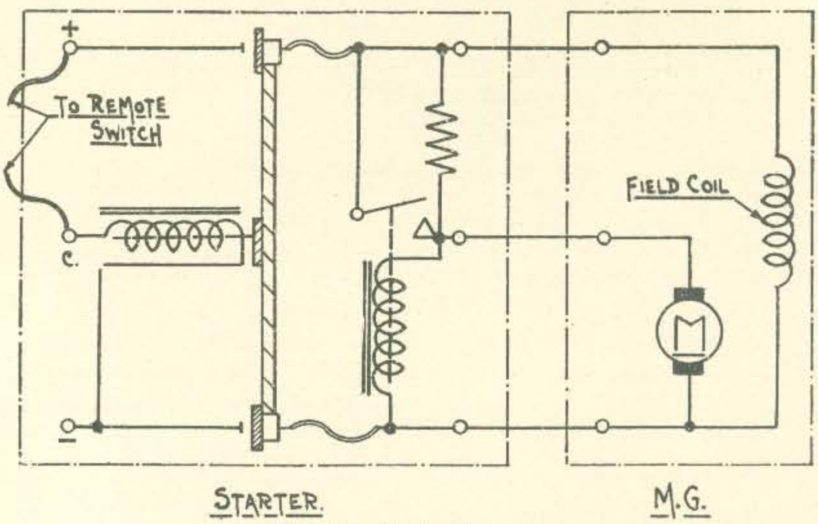


Fig. 13.—Starter, type A.

CHAPTER 4

ALTERNATING CURRENT THEORY

1. It is important to understand the properties of condensers and inductances with a view to studying their effects on alternating current circuits :—

(*a*) *Condenser* (symbol " C ") :—

(i) Two conducters, with an insulator (" dielectric ") between them, form a condenser and have the ability to store a " charge " when an E.M.F. is applied. The ratio of charge in coulombs to the voltage applied is known as the " *capacity* " i.e. $C = \frac{Q}{V}$ (where coulombs = Q). The unit of capacity is the Farad (F), but for practical values the micro Farad ($\mu F = \cdot 000001$ F) is used. A " capacity effect " is often present when it is not intended ; its effect is most noticeable in radio circuits.

(ii) The capacity of a condenser depends upon :—

(*a*) Area of conductors or plates.

(*b*) Thickness of dielectric.

(iii) With condensers connected in *parallel*, total capacity *increases*. $C_t = C_1 + C_2 + C_3 +$ etc., since area of plates is increased.

(iv) With condensers connected in *series*, total capacity *decreases*. $\frac{1}{C_t} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} +$ etc., since the thickness of the dielectric is increased.

(v) Common values of condensers are $0 \cdot 0001\ \mu F$ to $4\ \mu F$.

(*b*) *Inductance* (symbol " L").—When the current in a coil of wire is altered, its magnetic field alters, and by cutting the adjacent turns, induces an opposing E.M.F. (Lenz's law). This property is called " *inductance* ", and is measured in Henries (H). (When a current change of 1 amp./sec. induces 1 volt, the inductance is 1 Henry).

(*c*) *Transformer*.—When a change of current takes place in a coil of wire, the magnetic field changes. If another coil be placed within the field of the first, an E.M.F. will be induced in it. This is known as " mutual induction ".

If, as is usual, the second coil surrounds the first, the E.M.F. induced will depend on the rate of flux change (i.e. the " frequency ") and on the number of turns the second coil contains.

A combination of two coils intended to produce this effect is called a " *transformer* " and can be designed to " step up " or " step down " the applied (A.C.) voltage by choice of number of primary and secondary turns.

2. **Alternating Voltage** (symbol in diagram ~).—A voltage which undergoes regular recurring changes of values. It rises from zero to a positive maximum, falls through zero to a negative maximum and again rises to zero, then repeating the same sequence :—

(*a*) The " peak value " (i.e. the maximum voltage) is also known as the " *amplitude* ". (Thus the greater the amplitude, the greater the change of voltage during the complete cycle.)

(*b*) One complete series of values is one " cycle " and for convenience of quoting any part of a cycle it is likened to a revolution (360° or 2π radians).

Thus 1 cycle = 360 degrees = 2π " radians ".

f cycles = $360 \times f = 2\pi f$ radians.

The number of complete cycles per second is known as the " frequency " (f), a term also applied to any other similar regularly recurring motion (e.g. sound waves, etc.).

3. **Simple Circuits.**—There are three simple types of circuit to which alternating voltage is applied :—

(*a*) *Resistance only.*—A circuit containing pure resistance only obeys Ohm's law, that is, increased voltage means increased current, and decreased voltage, decreased current ; the resultant current in the circuit rising and falling in sympathy with the applied voltage. This condition is known as " *in phase* "

(*b*) *Inductance only.*—The effect of inductance only in a circuit is to prevent the current reaching its maximum value at the same time as the applied voltage reaches its maximum. This is because the induced (opposing) E.M.F. tends to prevent the current rising as the applied voltage rises, but as the applied voltage falls the collapse of the magnetic field tends to keep the current flowing in the same direction. It can be shown that, in fact, the current reaches a maximum when the applied voltage is zero, i.e. $\frac{1}{4}$ cycle later. This is expressed as a 90° " *lag* ".

(*c*) *Capacity only.*—In a circuit containing capacity only, the voltage has to charge the condenser. As the applied voltage rises the condenser becomes more and more charged, until when the applied voltage is maximum it is fully charged and no current flow takes place (i.e. the rate of change of charge is zero). But the rate of change of charge of a condenser is a current. In other words the current maximum occurs before the voltage maximum ; in fact, $\frac{1}{4}$ cycle before. This is generally expressed as 90° " *lead* "

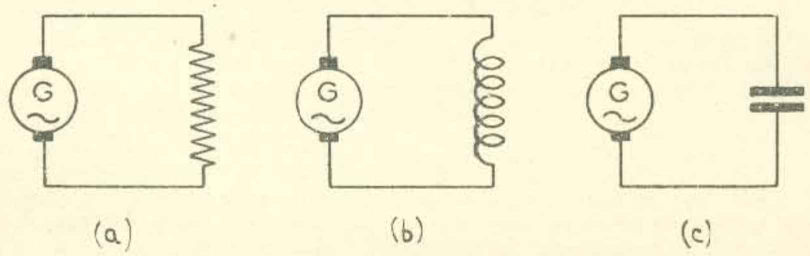


FIG. 14.—Simple A.C. circuits.

4. There are various oppositions to the flow of alternating current :—

(*a*) *Inductive reactance* is the opposition offered by an *inductance*, and is measured by *ohms*. It is proportional to the rate of change of current (Faraday's law). In symbols :—

Inductive reactance $= 2\pi f L$
where $2\pi f =$ rate of change of current
$L =$ inductance in Henries.

(*b*) *Capacitive reactance* is the opposition offered by a *condenser*, and is measured in *ohms*. The greater number of times the condenser is charged per second the greater will be the current. The reactance, therefore, decreases with increased frequency. In symbols :—

$$\text{Capacitive Reactance} = \frac{1}{2\pi f C}$$

where $2\pi f =$ rate of change of charge
$C =$ capacity in Farads.

(*c*) *Impedance* (symbol " Z ").—In a circuit where the opposition consists of resistance and reactance, the total opposition offered is referred to as " impedance "

For A.C. circuits Ohms law reads $I = \frac{E}{Z}$

5. **Resonance.**—(*a*) Since inductive reactance *increases* with frequency and capacitive reactance *decreases* with frequency, a certain frequency exists where the reactances are equal, and their oppositions cancel due to " phasing " (see

paragraph 3 (*b*) and (*c*)). When this state is reached the only opposition to the flow of current is resistance, and the circuit is said to be in " resonance " with the applied frequency.

In symbols, $2\pi f L = \frac{1}{2\pi f C}$ for resonance, and the resonant frequency (f) for any values of L and C is given by $f = \frac{1}{2\pi\sqrt{LC}}$

Resonance is made use of in tuning on radio receivers, adjustment of a condenser capacity being made to tune in a transmission of a particular frequency.

(*b*) *Series resonant circuit* is a resonant circuit with the condenser and inductance in series, and with the alternating voltage acting in series. The impedance of the circuit is minimum at the resonant frequency. The voltage across the inductance (the " derived " voltage) will be greater than the applied voltage, owing to the effect of " resonance ". The ratio of " voltage derived " to " voltage applied " is known as the " *circuit magnification* " and is greatest when least resistance is present in the circuit.

(*c*) *Parallel resonant circuit.*—A resonant circuit with the condenser and inductance in parallel, and with the alternating voltage applied across them. The impedance of the circuit is maximum at the resonant frequency. The current circulating inside the " parallel " circuit will be greater than the supply current in the external circuit. The ratio of " circulating current " to " supply current " is known as the " *circuit magnification* " and is greatest when least resistance is present in the circuit. The " magnification factor " is denoted by Q. $\left(Q = \frac{2\pi f L}{R}\right)$

(*d*) *Selectivity.*—The " circuit magnification " becomes less if the circuit is operated at other than the resonant frequency (" off resonance "). The ratio of magnification at resonance to magnification at some frequency " off resonance " is called the " selectivity ". A selective tuned circuit will, therefore, magnify greatly at the resonant frequency, and give little magnification to other frequencies.

Note.—A decrease of resistance or an increase of inductance, with the appropriate decrease of capacity (to maintain the same frequency, see paragraph 5 (*a*)) *increases* the selectivity and vice versa.

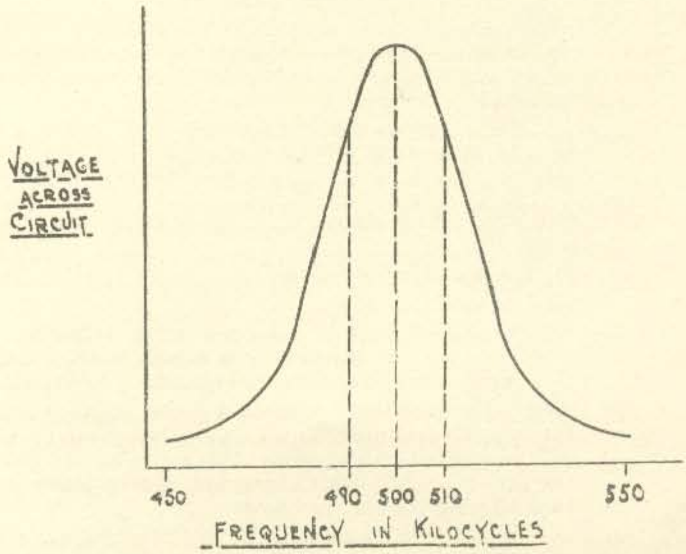


FIG. 15.—Selectivity.

CHAPTER 5

RADIO VALVES

1. The free electrons present in a conductor will tend to shoot off from it if it is :—

(i) Heated ;

(ii) subjected to " bombardment " by other free electrons ; or

(iii) subjected to high frequency light waves.

The first method is deliberately used in valves ; the second method appears as a secondary effect (often when not wanted) ; the third method applies to " photo-electric cells "

2. It is important to have an understanding of the following facts :—

(*a*) *Emission*.—When a conductor is heated a stream of electrons leaves its surface (see (i) above). This is known as emission.

(*b*) *Space charge*.—If the heated conductor is in a vacuum the electrons leaving the surface form a cloud round the heated body.

(*c*) *Electrostatic attraction*.—The electrons bear a negative charge and will, therefore, be attracted to anything with a positive charge (which means deficiency of electrons).

3. **Valves.**—The above facts are made use of in all valves ; a brief description of the simpler types is given below :—

(*a*) *Diode valve*.—The simplest form of valve, consisting of a " cathode " and " anode " in an exhausted glass bulb, usually with a four-pin base :—

(i) *Construction* :—

(1) *The filament* (*or cathode*) is the emitter of electrons ; it is a fine wire which is heated by the passage of a current.

(2) *The anode* is a conductor placed near to and surrounding the filament. It is connected to the positive pole of a battery and will, therefore, attract electrons emitted by the filament (see 2 (*c*)).

(ii) *Action*.—The electrons emitted by the filament are attracted to the anode, and then flow to the external circuit, and eventually back to the filament. This flow is the " anode current "

(iii) *Use*.—Since a diode only allows current to pass one way, it is used to provide a unidirectional current from an alternating potential and thus act as a " rectifier ".

(*b*) *Triode valve* contains three electrodes, and has a four-pin base :—

(i) *Construction* :—

(1) The filament. as above.

(2) The anode, as above.

(3) *The control grid* is an open mesh structure placed between the filament and anode, with a means of connection to an external circuit.

(ii) *Action*.—The electrons, emitted by the filament will pass through the grid mesh to the anode, but greater attraction will be exerted on the space charge around the filament if the grid is made positive, and less if it is made negative, thus altering the electron flow.

(iii) *Use*.—In such a valve a change in grid potential has a marked effect on the anode current, and thus a triode is particularly suitable for use in amplifiers and oscillators.

(c) *Tetrode valve* contains four electrodes, and has a four-pin base and a top cap :—

(i) *Construction* :—

(1) Filament.

(2) Anode.

(3) Control grid (all as above).

(4) *The screening grid* is an open mesh structure, placed between the anode and control grid, with a means of connection to an external circuit. The anode of this valve is taken to a terminal on top of the glass bulb.

(ii) *Action*.—Between anode and grid of a triode there is a "capacity" (C_{ag}), usually of a value between 2 $\mu\mu$F and 8 $\mu\mu$F.

At radio frequencies the C_{ag} will offer comparatively low reactance (see chapter 4, paragraph 4 (*b*)) and instability will result in amplifiers (due to the "feed back" between anode and grid circuits). In a tetrode, however, the addition of the screening grid will result in the C_{ag} being considerably reduced (thus increasing its reactance, see chapter 4, paragraph 4 (*b*)), the usual value being between ·001 $\mu\mu$F and ·02 $\mu\mu$F, thus preventing instability as encountered in a triode. The screening grid is connected to the filament through a condenser, to put it at earth potential to R.F. currents (the reason for this will be explained later), and it also necessarily has a D.C. potential, usually two-thirds that of the anode ; this potential, when varied, forms a convenient method of volume control.

(iii) *Use*.—This valve is very suitable for use as an amplifier at high frequencies, since it is desirable to keep the reactance of the C_{ag} in an amplifier as high as possible.

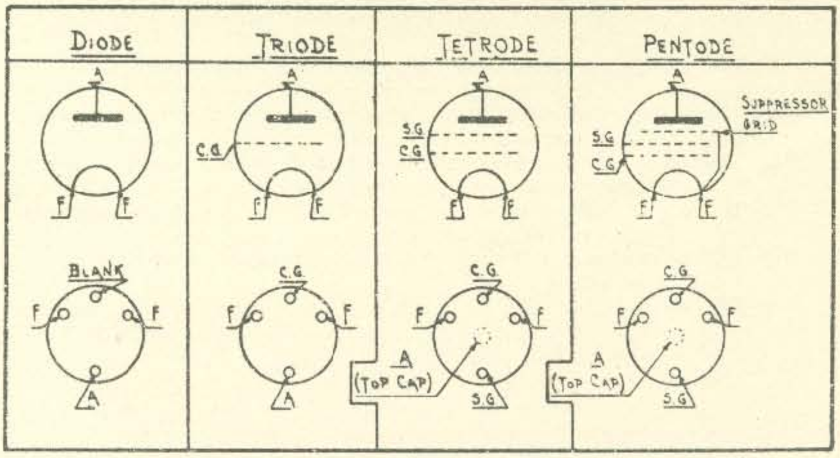


FIG. 16.—Radio valves : symbols and base arrangement.

d) *Pentode valve* contains five electrodes, and has a five-pin base, top cap.

(i) *Construction* :—

(1) Filament.

(2) Anode.

(3) Control grid.

(4) Screening grid (all as above).

(5) *The suppresser grid* is an open mesh structure, placed between anode and screening grid, with a means of connection to an external circuit.

(ii) *Action.*—Due to the acceleration given to the electrons by the anode and screening grid potentials, the electrons strike the anode with increased velocity and "secondary" emission takes place (see paragraph 1 (ii)). The "secondary" electrons in a tetrode would be attracted to the screening grid, resulting in an increase of screen current and a decrease in anode current. The suppresser grid in a pentode is at filament potential and prevents the "secondary" electrons from approaching the screening grid.

(iii) *Use.*—This valve is suitable for amplification at greater power, since it is not so prone to distortion if the anode potential should reach the same value as that of the screening grid.

4. (*a*) More complicated and specialized valves are in use, but all have anode, filament and grid. Additional grids, etc., are added for various purposes, and the filament may sometimes be indirectly heated.

(*b*) The useful feature of any valve is the anode current; this may be affected by :—

(i) *Filament temperature.*—This must be kept up to normal, or emission will be poor.

(ii) *Anode voltage.*—An increase of anode voltage gives an increase of anode current; this increase is constant for any particular valve. A small change of anode volts (V_a), divided by the small change produced in the anode current (I_a), is known as the "*A.C. resistance*" (R_a) of the valve, and is measured in ohms.

(iii) *Grid voltage.*—An increase of grid voltage will increase the anode current. A small change in I_a divided by the small change in grid volts (V_g) producing it is a constant for any particular valve, and is known as the *mutual conductance* (*or "slope"*) (Gm). Expressed in Ma/V.

(*c*) *Amplification factor.*—It will be seen that a change of either anode voltage or of grid voltage will affect the anode current. The ratio—

$$\frac{\text{Small change in anode voltage for given change in } I_a}{\text{Small change in grid voltage to produce same change in } I_a}$$ is a constant,

and known as "amplification" (μ). Expressed as "so many times".

5. Typical diagrams illustrating the above are given in figs. 17A to 17E :—

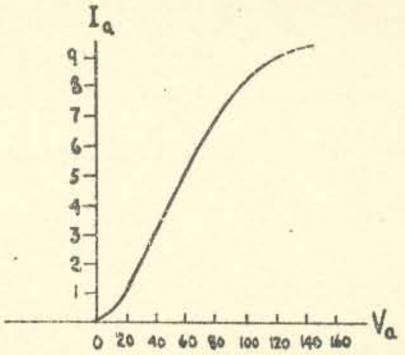
Fig. 17A shows the relationship between anode current and anode voltage for a diode.

Fig. 17B shows the relationship between anode current and grid voltage (for a constant anode voltage) for a triode.

Fig. 17C shows how a diode acts as a rectifier by "blocking" the negative half cycles.

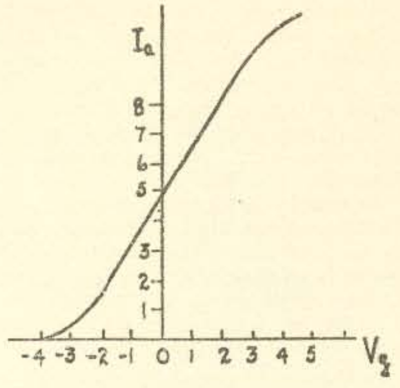
Fig. 17D shows the anode current in a triode resulting from an operating alternating voltage.

Fig. 17E shows the anode current variation in a triode resulting from an operating voltage being superimposed upon a steady negative bias (of 4 volts).



Volts V_a	mA I_a
20	1·0
40	3·0
60	5·0
80	6·5
100	8·0
120	9·0
140	9·2
160	9·2

FIG. 17A.—Diode characteristics.



Volts	Volts	mA
V_a	V_g	I_a
100	−4	0·0
100	−3	0·5
100	−2	1·5
100	−1	3·0
100	0	4·5
100	+1	6·0
100	+2	8·0

FIG. 17B.– Triode characteristics (a).

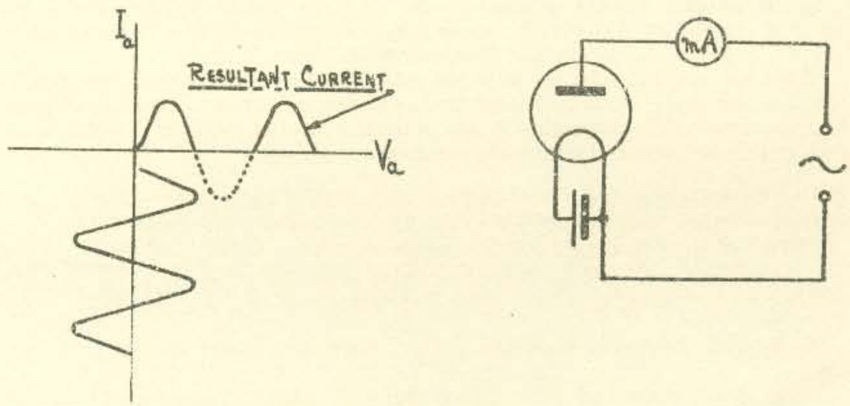


FIG. 17C.—Diode rectification.

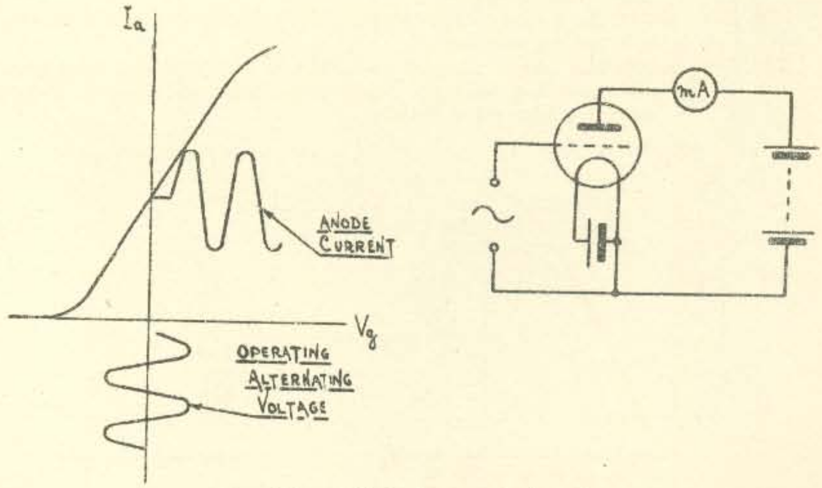


FIG. 17D —Triode characteristics (b).

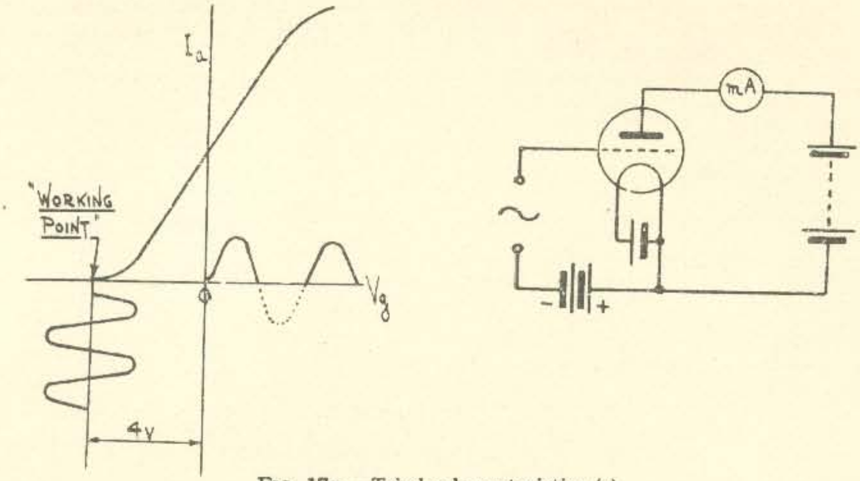


FIG. 17E.—Triode characteristics (c).

6. **Grid Bias.**—A steady potential difference (P.D.) may be applied between the grid and filament of a valve. The operating alternating voltage which is applied to the grid then varies about the steady grid voltage.

This steady P.D. is known as " grid bias " and in radio receivers is usually of a few volts only. The grid is nearly always made negative, both to reduce the anode current (" standing value ") and to prevent the grid itself from attracting electrons and causing grid current to flow.

7. **Grid Bias Methods.**—(*a*) *Battery bias.*—This provides a steady bias but is cumbersome, requires maintenance and is not automatic (see fig. 18). (Dotted and missing parts do not immediately affect the grid bias.)

(*b*) *Filament bias.*—The bias potential is provided by the P.D. across a resistance carrying the filament current of the valve ; e.g. if filament current is ·2 amps. and R = 1 ohm, then G.B. = IR = ·2 volts (see fig. 19).

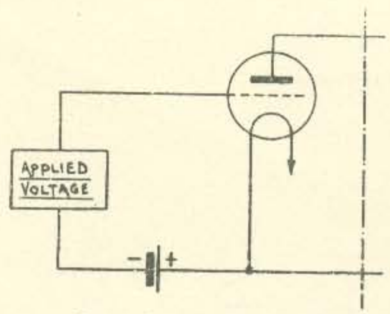


FIG. 18. Battery bias.

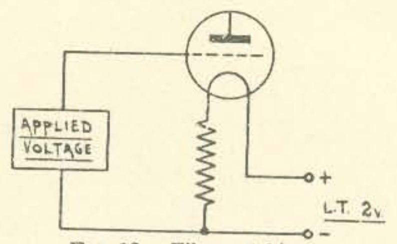


FIG. 19. Filament bias.

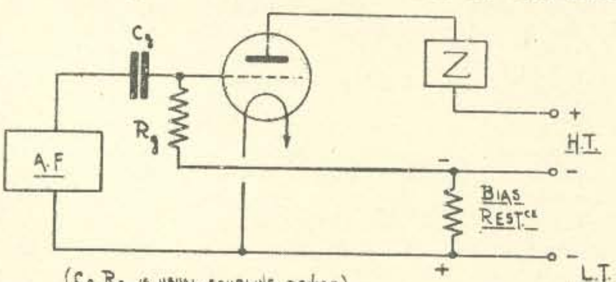


FIG. 20.—Automatic bias (receiver).

(*c*) ***Automatic bias*** (***receiver***).—The P.D. across bias resistance (caused by total anode current of set) is used as grid bias; e.g. if I_a = **10mA**, and bias resistance = 300 ohms, G.B. = 3 volts (see fig. 20).

(*d*) ***Automatic bias*** (***transmitter***).—Similar action as in receivers, difference being is that larger values of voltage, current and resistance are being considered (see fig. 21); e.g. if anode current is 60 mA, and maximum bias resistance 5,000 ohms, then the bias varies between 60 and 300 volts. R_1 is a safety resistance, ensuring that minimum bias is sufficient to prevent damage to the valve.

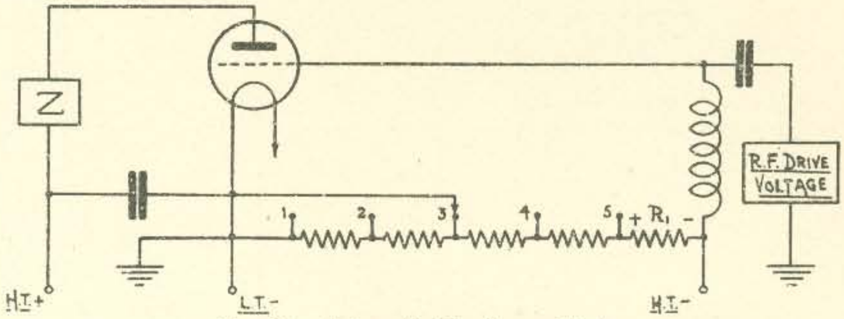


FIG. 21.—Automatic bias (transmitter).

(*e*) *Self bias.*—The potential is provided by the charge built up on a condenser by the operating voltage. The value of this voltage is kept at some value less than the peak operating voltage by means of a resistance placed across the condenser. It is self-adjusting. This type of bias is chiefly applied to oscillators.

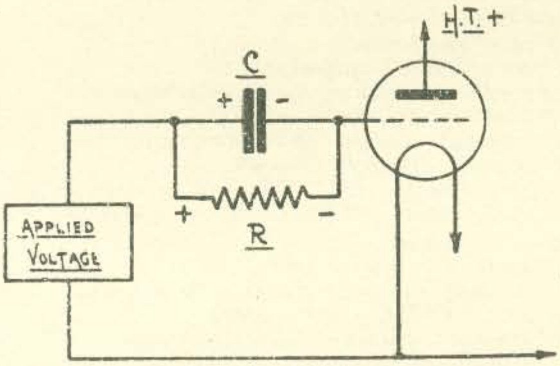


FIG. 22.—Self bias.

8. **Operating Conditions** of a valve are classed according to their faithfulness in reproducing an applied input, i.e. freedom from " distortion ".

(*a*) *Class A*.—A valve whose working point is so fixed that any variation of grid voltage will be faithfully reproduced in its anode circuit. For maximum use of the valve this working point must be the middle of the straight portion of its characteristic. This is known as *Class "A" amplification*, and is chiefly used in R.F. and A.F. amplifiers in receivers to avoid distortion. May be used in R.F. power amplifiers in transmitters, when maximum output is required with limited H.T. voltage regardless of efficiency. (Maximum possible efficiency is 50 per cent.)

(*b*) *Class B*.—A valve whose working point is so fixed that only positive half cycles of applied grid voltage cause anode current to flow. The bias is usually sufficient to make anode current zero. This is known as *Class "B" amplification*, and is used in some " push-pull " amplifiers in receivers, in oscillators, R.F. power amplifiers, and in " anode bend " wavemeters and detectors. (Maximum power efficiency approximately 75 per cent.)

(c) *Class C.*—A valve whose working point is so fixed that only positive peak values of applied grid voltage cause anode current to flow. The bias is usually twice the amount required to make the anode current zero. This is known as *Class "C" amplification*, and is used in oscillators, and R.F. power amplifiers, especially when "grid bias modulation" is used for R/T. (Efficiency may be as high as 85 per cent.)

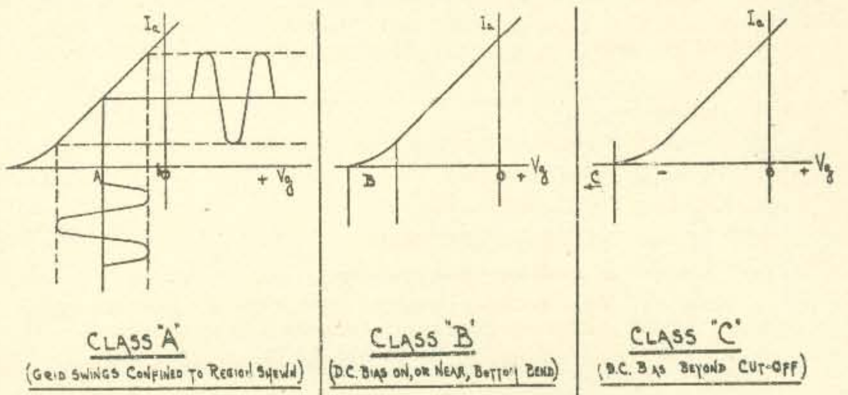


FIG. 23.—Classes of grid bias.

9. **Rectifiers** are used to convert A.C. to D.C. Use is made of a diode valve, or of the fact that certain combinations of metals (e.g. "copper oxide") allow current to flow one way only :—

(a) "*Half-wave*" *rectifier* :—
- (i) Uses only one ½ cycle of input.
- (ii) Transformer secondary volts = 3,000 peak.
- (iii) "No load" D.C. volts = 3,000.
- (iv) "Inverse" voltage = 6,000 maximum.
- (v) "Ripple" at supply frequency.

Note.—The "loaded" D.C. voltage depends on the valve of R,C, the internal resistance of the valve and the transformer, etc.

(b) "*Full-wave*" *rectifier* :—
- (i) Uses both ½ cycles of input.
- (ii) Transformer secondary volts = 6,000 peak.
- (iii) "No load" D.C. volts = 3,000.
- (iv) "Inverse" voltage = 6,000 maximum.
- (v) "Ripple" at *twice* supply frequency.

Note.—This type consists of two "half wave" rectifiers, supplied by a "centre tapped" transformer.

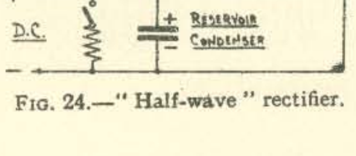


FIG. 24.—"Half-wave" rectifier.

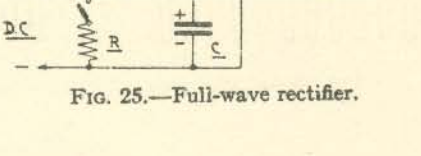


FIG. 25.—Full-wave rectifier.

(*c*) " *Full-wave " rectifier—" voltage doubler "* :—

(i) Uses both ½ cycles of input.

(ii) Transformer secondary volts = 1,500 peak.

(iii) " No load " D.C. volts = 3,000.

(iv) " Inverse " voltage = 3,000 maximum.

(v) "Ripple" at twice frequency.

Note.—This type is really two " half-wave " rectifiers, with output in series. A separate filament supply for each valve is essential.

(*d*) *Metal rectifier* :—

(i) Uses both ½ cycles of input (a true " full-wave " circuit).

(ii) Secondary volts = 30 peak.

(iii) " No load " D.C. volts = 30.

(iv) " Inverse " voltage = 30 maximum.

(v) " Ripple " at *twice* supply frequency.

Notes.—(i) Metal rectifier elements are suitable for low voltages only; higher voltages require several elements in series.

(ii) The circuit illustrated is a " bridge connected full wave " circuit.

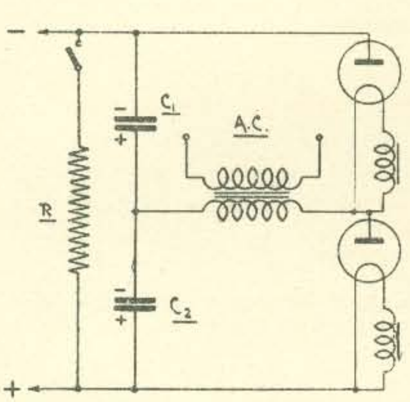


FIG. 26.—Voltage doubler.

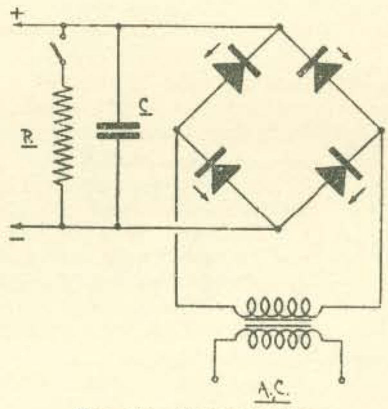


FIG. 27.—Metal rectifier.

CHAPTER 6

RECEIVER PRINCIPLES

1. **Reception of Signals.**—Incoming signals may be :—

(*a*) *Continuous wave* (C.W.) (fig. 28).—A uniform radio-frequency wave.

(*b*) *Interrupted continuous wave* (I.C.W.) (fig. 29).—A radio frequency wave interrupted at regular intervals of an audio-frequency; this interruption is carried out by means of a " tone wheel " (see Chapter 3, paragraph 3 (*b*) (i)).

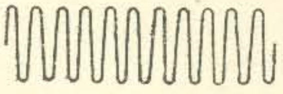


FIG. 28.—C.W.

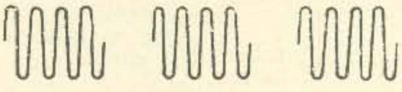


FIG. 29.—I.C.W.

(*c*) *Radio-telephony* (*R/T*) (fig. 30).—A continuous radio-frequency (R.F. wave whose amplitude is varied at an audio-frequency.

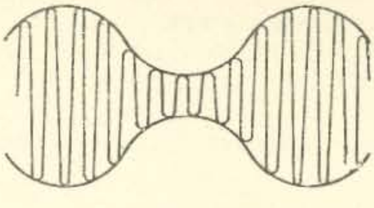


FIG. 30.—R/T.

2. **Elementary Receiver for R/T and I.C.W.**—A very simple receiving circuit may be seen in fig. 31. The aerial circuit, consisting of the aerial's own-inductance, capacity and resistance, is coupled by L_1 to L_2, and the whole is tuned by C_2. L_2 C_2 functions as a series tuned circuit, and possesses voltage magnification, so that a greater oscillatory voltage appears across C_2 than was originally picked up by the aerial. "Loose" coupling is employed between the aerial and L_2 C_2, to reduce the "damping" imposed upon the circuit by the aerial resistance; thus selectivity is increased

The circuit L_2 C_2 supplies an R.F. input voltage (fig. 32) to the half wave rectifier circuit V_1, C_3 (see fig. 24). A rectified audio-frequency (A.F.) current is thus produced in the telephones (fig. 33).

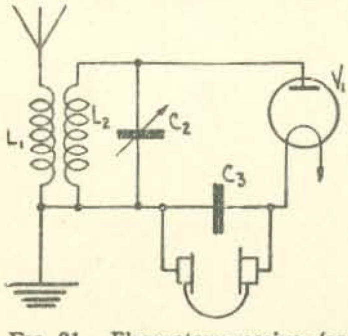


FIG. 31.—Elementary receiver for R/T or I.C.W.

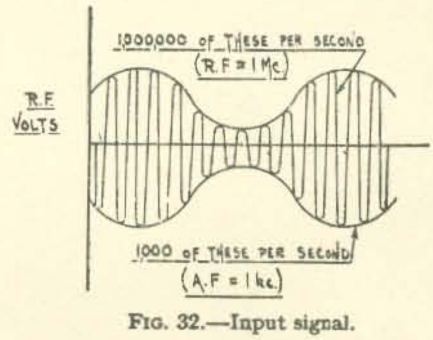


FIG. 32.—Input signal.

3. **Single Triode Receiver for R/T and I.C.W.** (fig. 34).—This functions in exactly the same manner as fig. 31, as regards its grid circuit (the resemblance can be noted in fig. 34A). But the A.F. voltages which appear across R_1 cause much larger A.F. currents to flow through the telephones than in the case of fig. 31, as the triode will also act as an amplifier.

4. **C.W. Reception.**—The circuit of fig. 31 is insufficient to receive C.W., because the amplitude of a C.W. signal does not vary at an audio-frequency. It is, therefore, necessary to introduce an A.F. component; this can be done by "heterodyning", which produces an A.F. component by the interaction between the C.W. signal and a second applied R.F. voltage whose frequency differs from the C.W. frequency by an audio frequency (generally about 1 kc/s). There are two types of heterodyne:—

(*a*) *Separate heterodyne*; (*b*) *Autodyne* (*or self heterodyne*).

When employing separate heterodyne a valve "oscillator" (see Chapter 7) can be used as in fig. 35. C_2 tunes the aerial circuit to 1,000 kc/s, the separate oscillator is tuned to, say, 1,001 kc/s, and L_2 is the coupling coil. Besides having voltages of 1,000 kc/s and 1,001 kc/s (among others) in the circuit, there will also be the resultant of the two, which is 1 kc/s. This is the audio-frequency which will operate the telephones.

The reception of C.W. may also be accomplished by allowing the grid circuit detector to generate its own oscillations (in a manner to be described later) by using a circuit similar to fig. 36. In this case the receiver itself must be mistuned to the incoming C.W. signal by, say, 1 kc/s, so that "self heterodyne" may take place. In fig. 36 the coil L_2 is coupled to L_1 so as to hand over R.F. energy from anode to grid circuit. This energy is used to overcome the damping losses in the grid circuit, so that it may remain in continuous oscillation and permit "autodyne" reception of C.W.

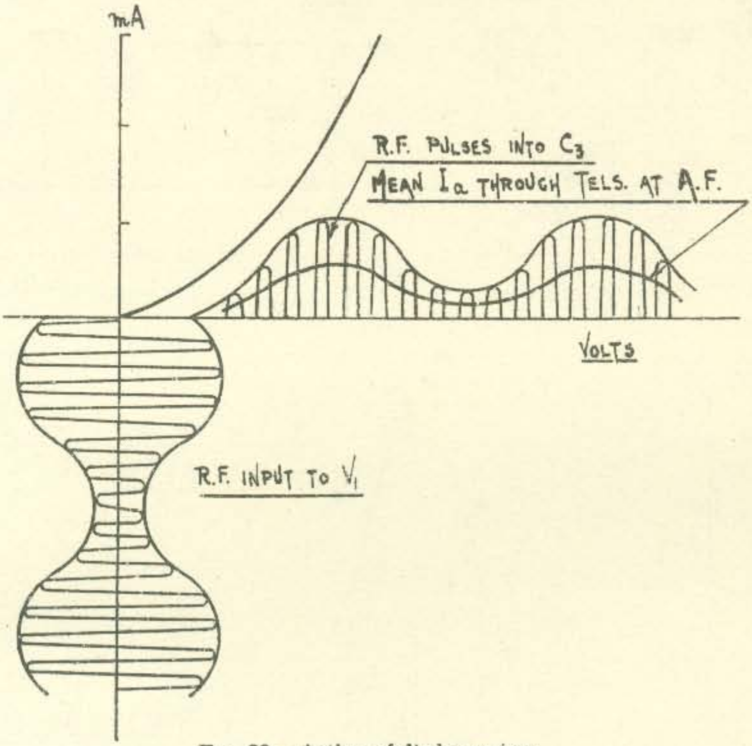


Fig. 33.—Action of diode receiver.

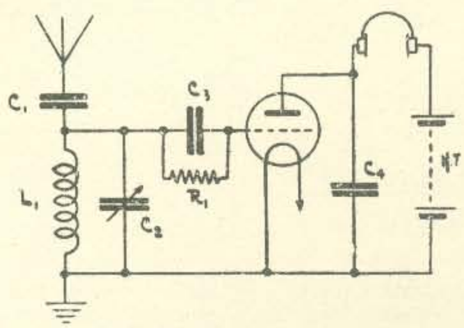


Fig. 34.—Single triode receiver.

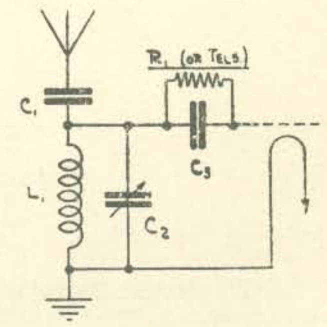


Fig.—34a.

5. **Reaction.**—In fig. 36, if L_2 is coupled to L_1 less tightly, so that circuit does not actually generate oscillations, R.F. energy will still be fed back into the grid circuit, and will make up for the damping losses there, but to a less extent. This will lead to increased circuit magnification in L_1, C_2, and will increase sensitivity and selectivity in the reception of R/T and I.C.W. signals (see fig. 37). This is called "regenerative R.F. amplification" or "regeneration". A "reaction control" is fitted so that any desired amount of "feed back" may be provided.

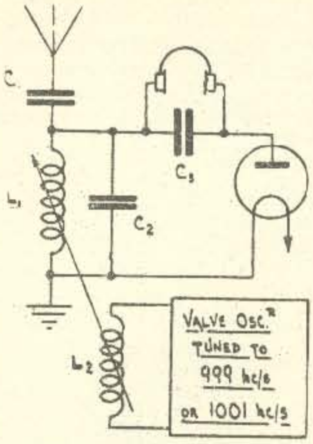


FIG. 35.—Separate heterodyne.

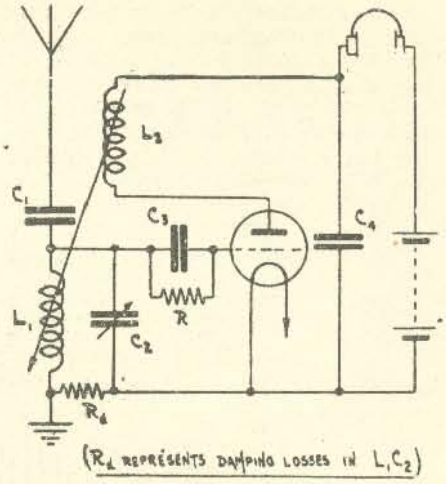


FIG. 36.—Autodyne.

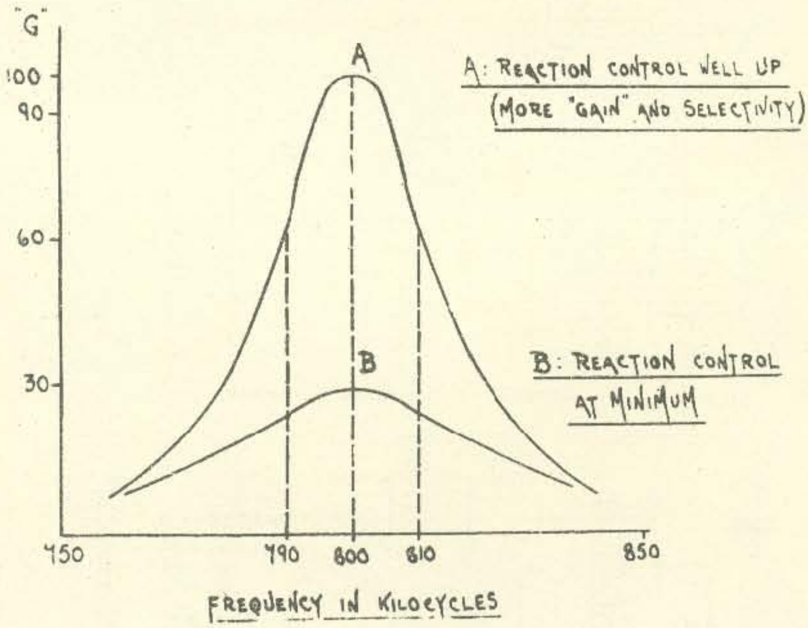


FIG. 37.—Effect of reaction.

6. **The Reaction Control** may take several forms. Fig. 36 is not a practical arrangement and may be modified so that the control of reaction is provided by a condenser (C_r) (fig. 38).

Better control still is provided if C_r and the coupling are fixed, and the H.T. voltage to the valve is varied as in fig. 39. This varies the " slope " (Gm) of the valve, and thus the amount of R.F. current actually flowing through L_3. Smooth, stable control is provided by this method, and the frequency does not shift when reaction is adjusted, as happens with capacity control.

Fig. 40 shows a method (capacity control) sometimes applied to R.F. amplifying valves. It is suitable for regeneration only, and not for the autodyne reception of C.W.

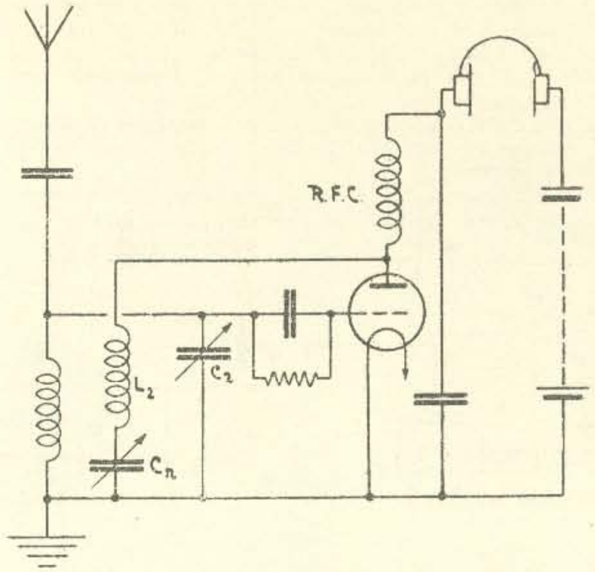


FIG. 38.—Magnetic reaction, capacity controlled.

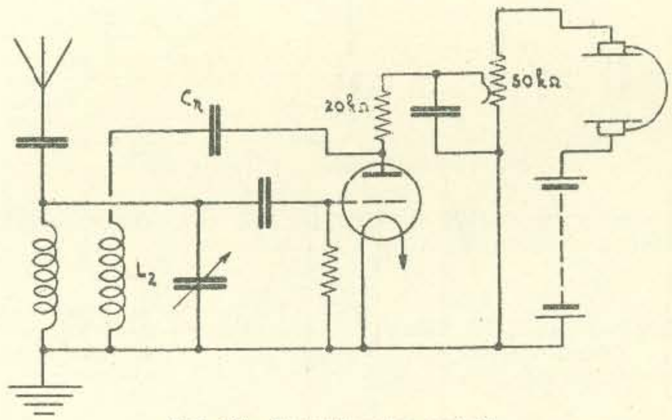


FIG. 39.—Potentiometer control.

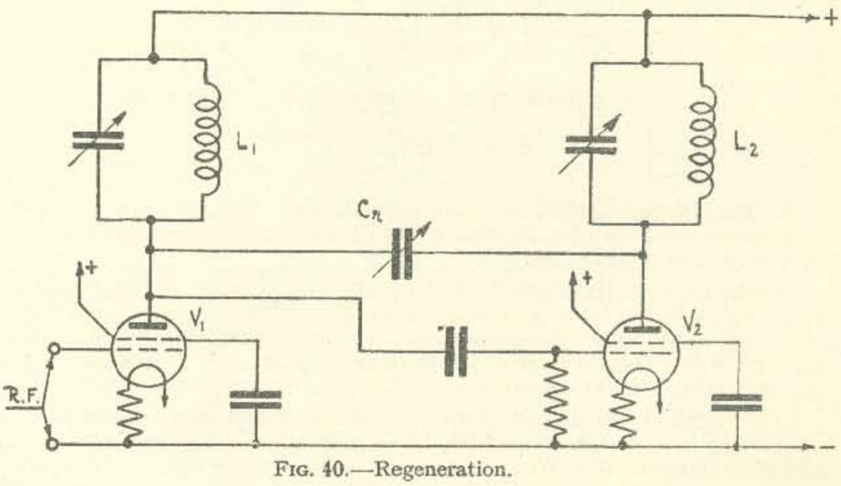


FIG. 40.—Regeneration.

7. **Audio Frequency Amplifiers** are used to magnify signals after rectification (" detection " as it is usually called). They are required to amplify equally well over a large range of frequencies. (In service practice for R/T, 400 to 3,000 c.p.s. will be sufficient range.) Resistance-capacity coupled amplifiers are generally used in the R.A.F. because :—

(*a*) The desired special sort of frequency response is easily produced.

(*b*) Resistances are very small in size, light and cheap, and have negligible self-capacity.

A resistance-capacity (" R.C.") coupled amplifier is shown in fig. 41. The amplification given by this arrangement would be :—

$$M = \frac{\mu R}{R + R_a} \text{ (where R = total anode load).}$$

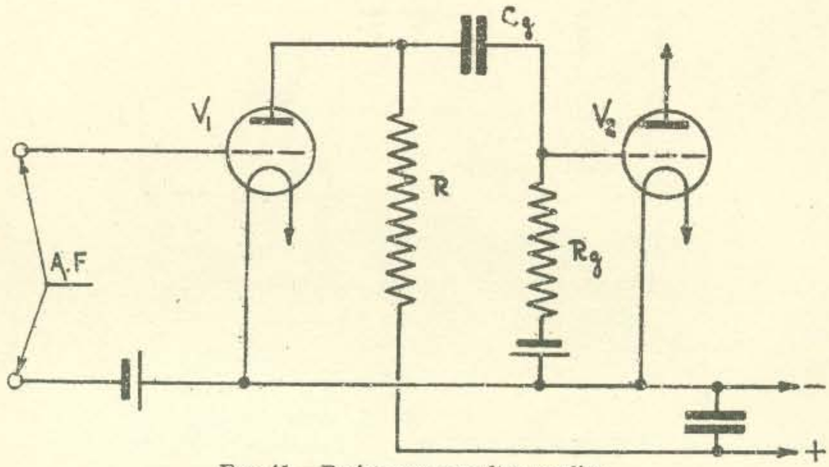


FIG. 41.—Resistance-capacity coupling.

The transformer-coupled amplifier (fig. 42) gives greater amplification, due to the " step-up " ratio of the transformer :—

$$M = \frac{\mu Z T}{Z + R_a}$$

and to the fact that H.T. voltage is not dropped in a large resistance, but frequency distortion is difficult to avoid, and a transformer is bulky and heavy compared with a resistance.

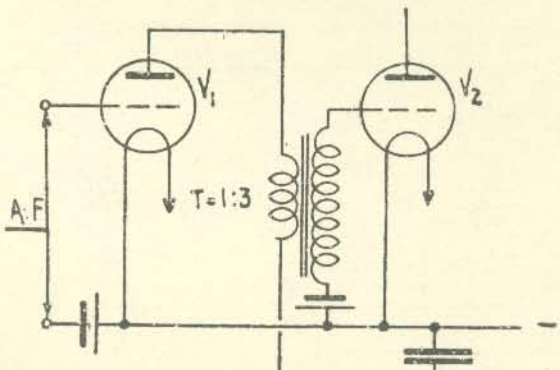


FIG. 42.—Transformer coupling.

8. **The Output Valve** is required to provide current for the operation of the telephones. It will have to have as low an R_a as is consistent with reasonable amplification. The anode load required for Maximum **power** output

would be equal to R_a. For maximum distortionless amplification, however, $R = 2\ R_a$ is found suitable. "Choke-capacity" output is generally used (fig. 43), since this provides a "filter" circuit isolating the telephones from the D.C., H.T. current, as well as giving anode load impedance to the valve.

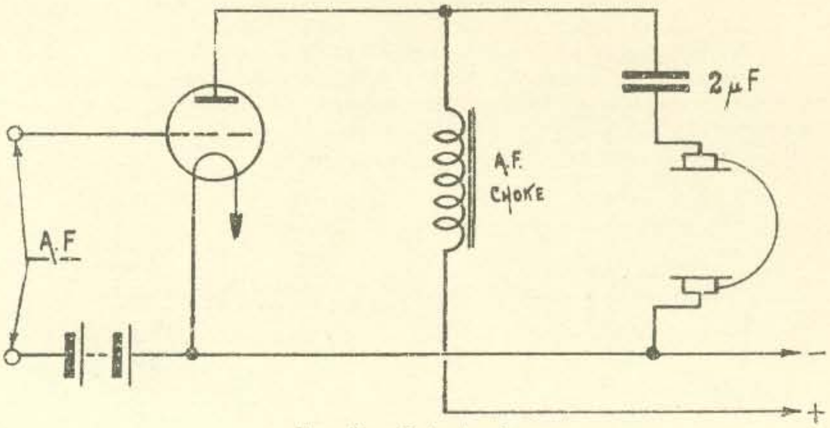


FIG. 43.—Output valve.

9. **R.F. Amplifiers** are used to provide the detector with sufficient R.F. input voltage, thus increasing the range of the receiver; and, more particularly, to provide a high degree of selectivity by introducing more tuned circuits.

"Tuned anode" coupling is almost invariably used in the R.A.F., the resistance of fig. 38 being replaced by the "dynamic resistance" $\left(\frac{L}{CR}\right)$ of a tuned circuit as in fig. 44. This gives high selectivity, and the stray capacities become part of the tuned circuit. Screened tetrode or pentode valves are invariably used in R.F. amplifiers for the reasons explained in Chapter 5.

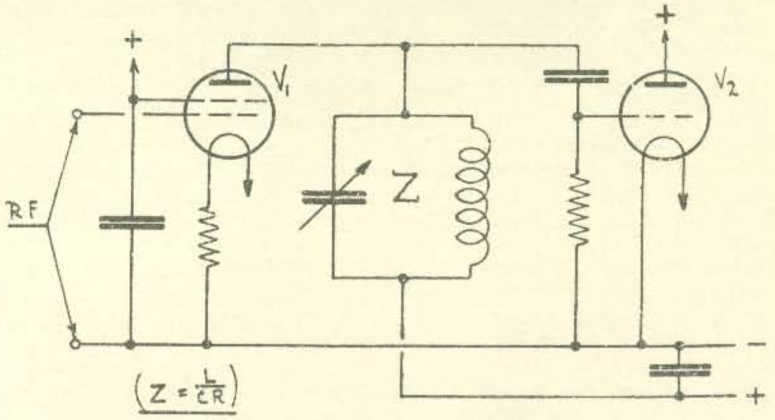


FIG. 44.—R.F. amplifier.

10. **Decoupling.**—In a receiver with several valves, if all the R.F. and A.F. circuits were allowed to flow through the H.T. battery or rectifier, "back-coupling" would result due to the voltages developed across the resistance of the H.T. battery by these currents. (The resistance of an H.T. battery when new is about 50 ohms, and up to 500 ohms when discarded. That of a mains rectifier may be 5,000 ohms.) This would cause instability and loss of amplification, and is avoided by completing each R.F. and A.F. anode circuit to cathode, via a low impedance condenser. The passage of alternating currents through the H.T. supply is further discouraged by inserting in each D.C., H.T. lead a resistance of suitable value (see fig. 46). Decoupling is most important in the case of detector valves.

11. **Grid Stoppers.**—It is essential to prevent R.F. voltages from appearing in the A.F. stages, and a "grid stopper" following the detector valve does this efficiently (see fig. 45 where R_s is the grid stopper). It works in conjunction with the grid-filament capacity (C_{gf}) of the valve. If R_s is 1 megohm and is in series with C_{gf} across the R.F. and A.F. supply, then :—

(i) At R.F., C_{gf} presents a reactance of (say) 3,000 ohms.
(ii) At A.F., C_{gf} presents a reactance of (say) 30 megohms.

Thus (i) at R.F., practically all the R.F. voltage will be dropped across R_s, and almost none across the input terminals of the valve ; (ii) at A.F. only one-thirtieth of the voltage will be lost in R_s.

Note that R_s must be on the grid-pin side of R_g.

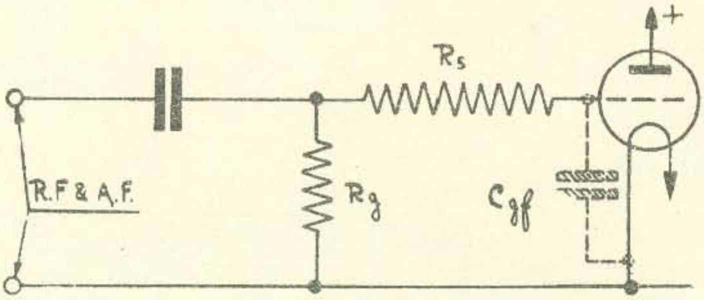


FIG. 45.—Grid stopper.

12. **Typical Straight Receiver** is shown in fig. 46. ypical valves and purpose of components are as follows :—

C.1.	Loose coupling condenser to reduce aerial damping.	50 $\mu\mu$ F.
C.2.	Aerial tuning condenser	300 $\mu\mu$ F.
C.3.	Anode tuning condenser	300 $\mu\mu$ F.
C.4.	Reaction condenser	200 $\mu\mu$ F.
C.5.	Screen earthing condenser, stabilising R.F. amp.	$0 \cdot 1$ μ F.
C.6.	Decoupling condenser for R.F. valve ..	$0 \cdot 1$ μ F.
C.7.	Coupling condenser V_1 to V_2 and detector grid condenser.	200 $\mu\mu$ F.
C.8.	R.F. by-pass for detector anode load ..	100 $\mu\mu$ F.
C.9.	Decoupling condenser for detector (R.F. and A.F.).	$0 \cdot 5$ μ F.
C.10.	Coupling condenser V_2 to V_3	$\cdot 001$ μ F.
C.11.	Decoupling condenser for V_3	$0 \cdot 5$ μ F.
C.12.	Coupling condenser V_3 to V_4	$\cdot 001$ μ F.
C.13.	A.F. output condenser	1 μ F.
C.14.	Decoupling (by-pass) condenser for bias resistance.	4 μ F.
C.15.	Decoupling (by-pass) condenser for H.T. battery resistance.	4 μ F.
R.1.	Cathode bias resistance	1 ohm.
R.2.	Screen feed and decoupling resistance..	100 kilohms.
R.3.	R.F. decoupling resistance	1,000 ohms.
R.4.	Detector grid leak	2 megohms.
R.5.	Detector A.F. anode load	100 kilohms.
R.6.	Reaction potentiometer	50 kilohms.
R.7.	A.F. amplifier grid leak	1 megohm.
R.8.	Grid stopper resistance	500 kilohms.
R.9.	A.F. anode load	100 kilohms.
R.10.	A.F. decoupling resistance	10 kilohms.
R.11.	Output valve grid leak	1 megohm.
R.12.	Automatic bias resistance	300 ohms.

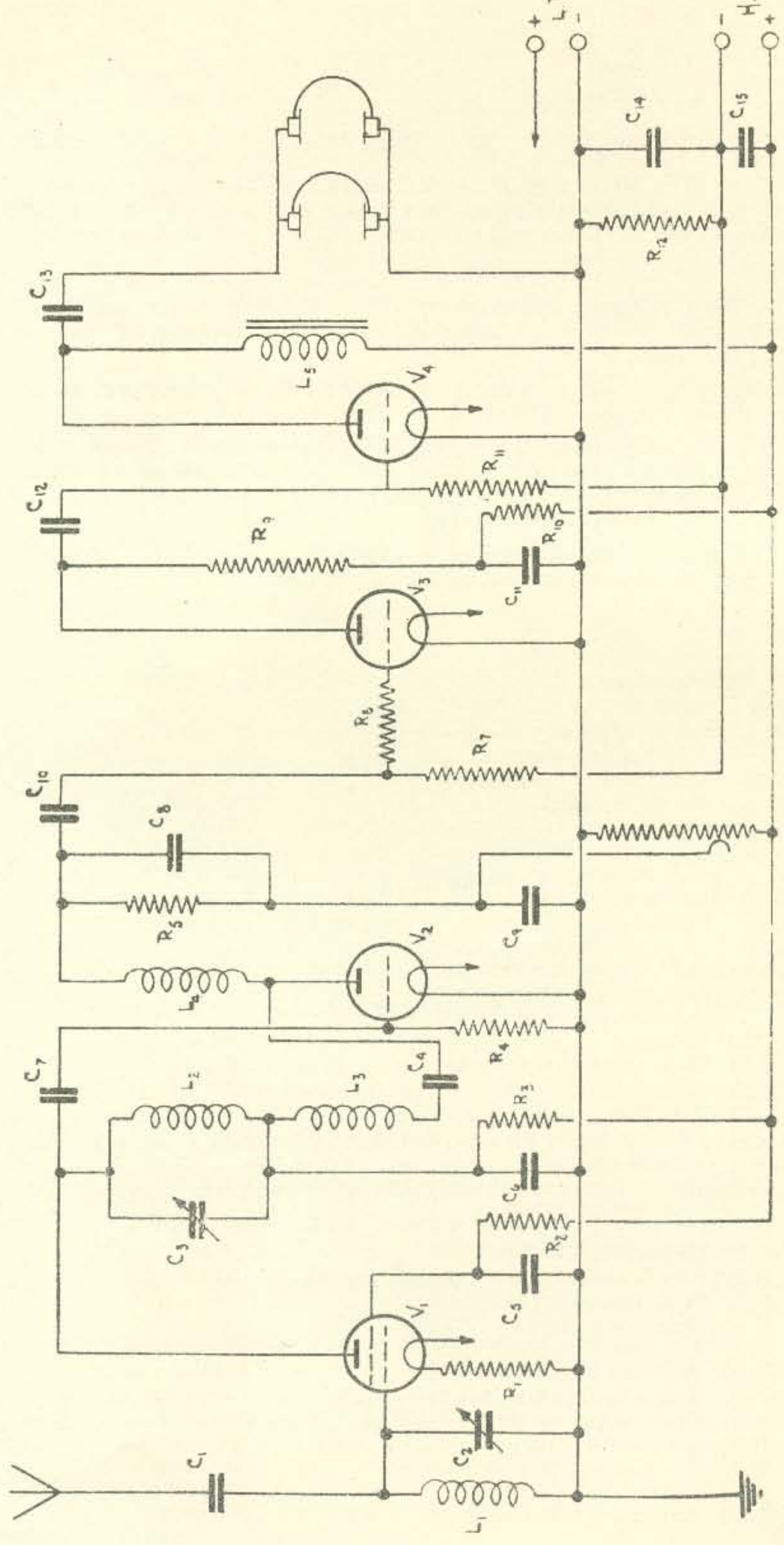


FIG. 46.—Typical straight receiver.

L.1.	Aerial coil	250 microhenries (M.F.).
L.2.	Anode coil	250 microhenries (M.F.).
L.3.	Reaction coil	50 microhenries.
L.4.	R.F. choke	10 millihenries.
L.5.	A.F. output choke	20 henries.
V.1.	(V.R.18), $\mu = 350$, $R_a = 300$ kilohms ..	R.F. amplifier (stable, selective).
V.2.	(V.R.27), $\mu = 12$, $R_a = 10$ kilohms ..	Grid circuit detector
V.3.	(V.R.21), $\mu = 12$, $R_a = 10$ kilohms ..	A.F. amplifier
V.4.	(V.R.22), $\mu = 15$, $R_a = 7$ kilohms ..	Power output valve.

13. **Valve Voltmeter Wavemeters.**—These instruments are used as frequency meters to check the actual frequency of a transmitter. Types in general use, W.69, W.1081, W.1117.

Their principle is clear from fig. 47, while details of circuits and frequency ranges are at figs. 48, 49 and 50.

In fig. 47, the circuit L.C. (which includes the valve grid filament capacity (C_{gf}) in series with the $0 \cdot 01\ \mu F$ condenser) is sharply tuned to act as a "series resonant" circuit and thus give maximum voltage magnification when in resonance with a transmitter.

The "anode bend" rectifier valve passes maximum anode current when maximum voltage applied to it by the circuit L.C.

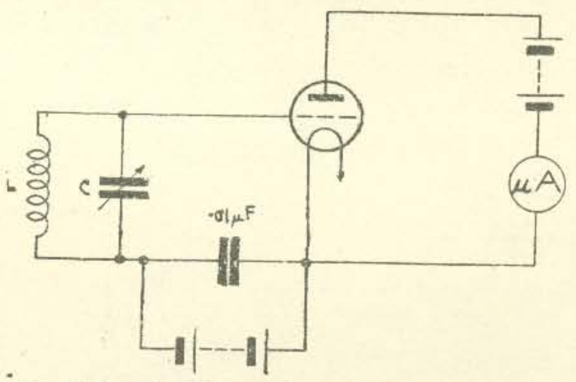


FIG. 47 (part).—Simple valve voltmeter wavemeter.

These instruments are very sensitive, and if more than a few millivolts be induced, the micro-ammeter may be damaged. They must, therefore, be operated at a suitable distance from the transmitter. A calibration chart is provided with each instrument and when using these remember :—

(*a*) Always check the serial number of the chart against that of the instrument before use.

(*b*) The correction curve usually shows the error in "degrees", not in "kilocycles".

(*c*) When reading the frequency of a transmitter, the "sense" of correction is reversed.

Special valves are used and issued in sets of three. When two of these become unserviceable, the instrument must be returned for recalibration with the other valve in order to complete the set once more.

The wavemeter may be mounted on a tripod for convenient use near an aircraft. W.1081 also has an extension lead for the micro-ammeter.

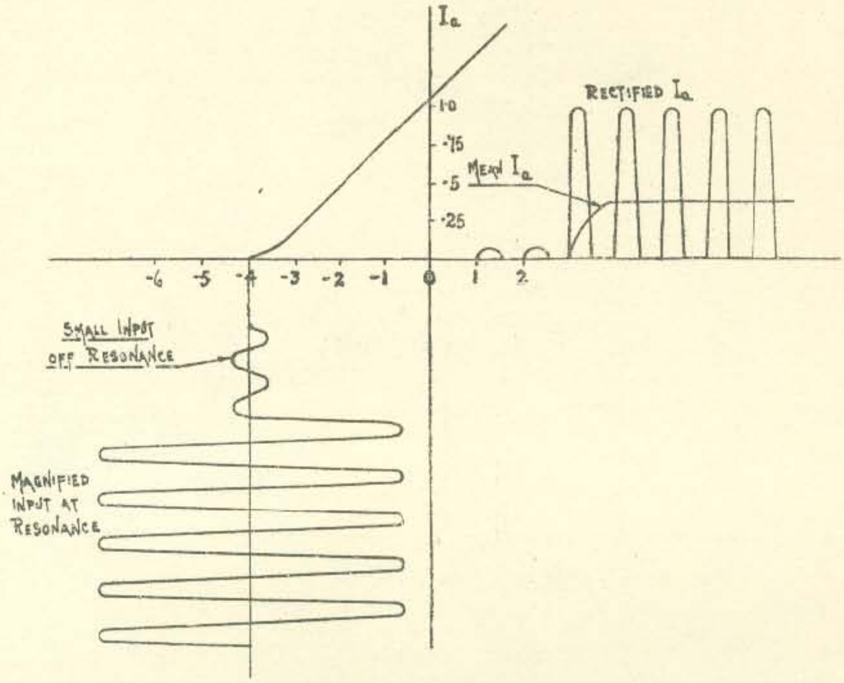


FIG. 47 (part).—Simple valve voltmeter wavemeter.

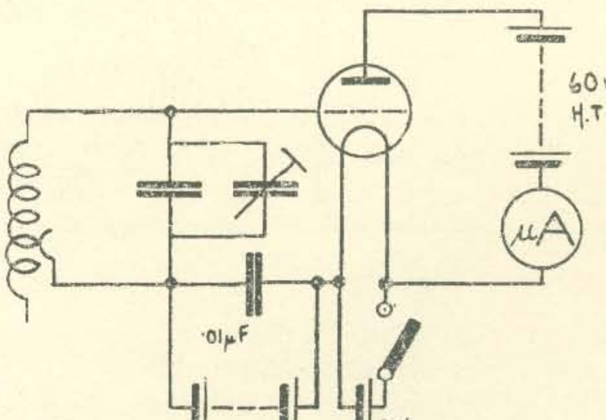


FIG. 48.—Wavemeter W.69 (4–7 mc/s).

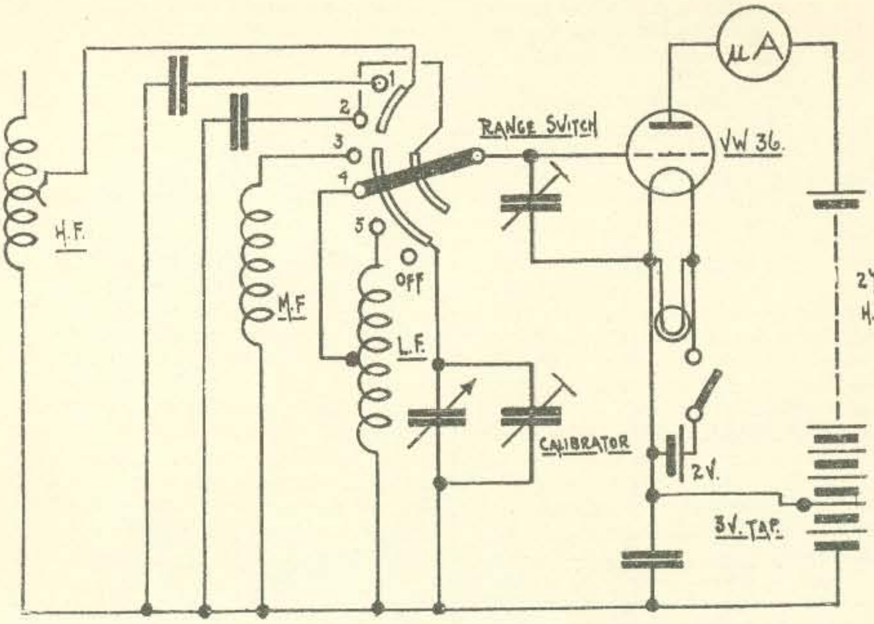


FIG. 49.—Wavemeter W.1081 (3–15 mc/s and 135–500 kc/s).

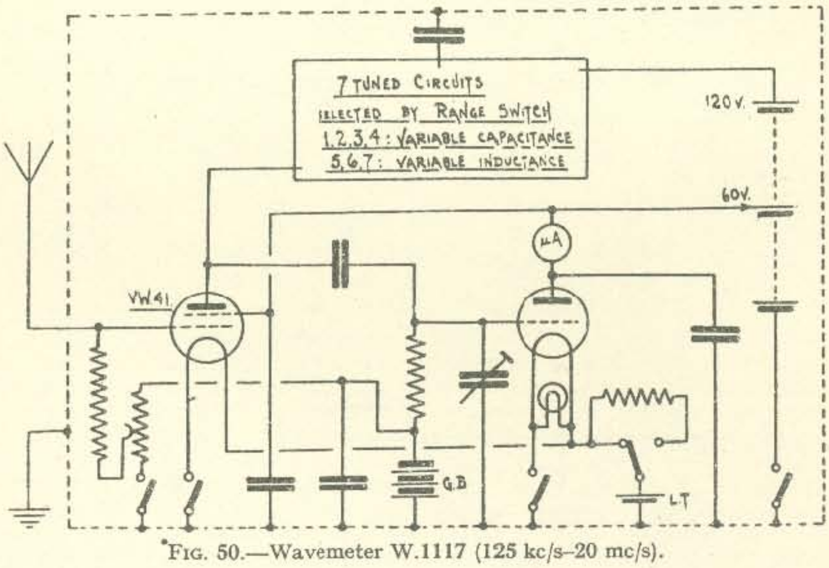


FIG. 50.—Wavemeter W.1117 (125 kc/s–20 mc/s).

CHAPTER 7

TRANSMITTER PRINCIPLES

1. **Oscillators.**—(*a*) W/T transmission makes use of R.F. alternating currents, which are easily produced by a valve across a simple (parallel tuned) circuit. Since a small voltage variation between grid and filament of an amplifier can be used to cause a variation in anode current, it is possible to make the valve supply its own R.F. input ; for coupling anode and grid circuits induces an R.F. voltage into the grid circuit. When this is done, oscillations

are generated and the valve acts as a " power converter " that changes the D.C. energy supplied from the H.T. battery to A.C. energy in the output circuit. Any amplifier arranged to supply its own input will act as an oscillator, providing :—

(i) That the R.F. input voltage is sufficiently great to release enough energy into the anode circuit, to compensate for the damping losses in the oscillatory-circuit (i.e. that the coupling between anode and grid circuit is " tight " enough).

(ii) That the input is supplied in the correct phase (i.e. the grid/filament voltage is the right way round).

(*b*) In fig. 51, L_1, C_1, is an oscillatory circuit forming the anode load of the self-excited R.F. amplifier valve, and L_2 is the grid coil coupled to L_1. In order to *commence* oscillations, C_1 must be charged. As soon as the H.T. circuit is switched on, the anode current rises, and the induced E.M.F. which it produces across L_1 will charge the condenser. The resultant oscillation will be feeble and would normally soon die away owing to the resistance of L_1, etc.; as L_2 is coupled to L_1, however, voltages will be induced in L_2, and these will be applied to grid and filament of the valve. The grid/filament voltage now fluctuates at the same frequency as the oscillation in L_1, C_1, and this voltage will cause the anode current to vary through L_1. This current will assist the oscillatory current in L_1, C_1, and oscillations will be maintained if the above conditions are fulfilled.

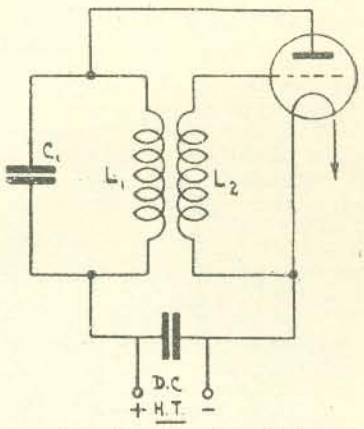


FIG. 51.—Simple oscillator.

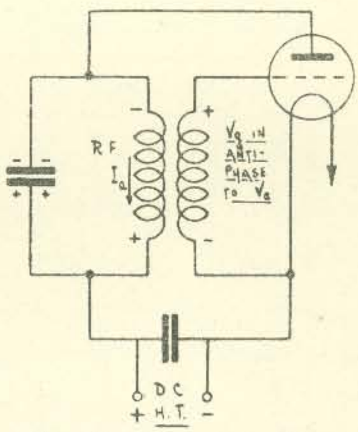


FIG. 52.—Phase relationship.

(*c*) In fig. 52 it is shown that the phase difference between anode and grid circuit voltages must be approximately 180° (i.e. they must be opposite as in any other amplifier). Suppose C_1 is discharging through L_1 so that the electrons are flowing in the direction shown, then this has the effect of making the top of L_1 negative with respect to the bottom, i.e. the anode is less positive with respect to the cathode. In order to maintain an electron flow in this direction an increase in anode current is required, and this is obtained by arranging that the induced voltage set up across L_2 swings the grid potential positive with respect to cathode at this instant. This means that anode and grid potential swings must be approximately 180° out of phase.

(*d*) *Improvements in efficiency.*—By operating the valve under Class B or C conditions, the losses due to a high steady anode current are minimised. In the case of oscillators, self-bias by grid leak and condenser (fig. 22) is almost invariably used. Note that fixed Class B or C bias is unsuitable, because the oscillator could never " start up ".

It can be shown that the maximum power is drawn from the valve when the anode load is equal to the R_a of the valve. The dynamic resistance of the tuned anode circuit may be many times the R_a of the valve, so considerable improvement in efficiency can be obtained by " tapping down " the anode coil, thus producing an " auto transformer " arrangement which affords a much better match between valve and anode circuit.

2. **Practical Circuits.**—The simple valve oscillator circuit of fig. 51 is similar to Meissner's valve oscillator, which also employed mutual inductance for coupling between anode and grid circuits, another variation is shown in fig. 36. The circuit of fig. 51 is insufficient for modern requirements, and a practical circuit is shown in fig. 53.

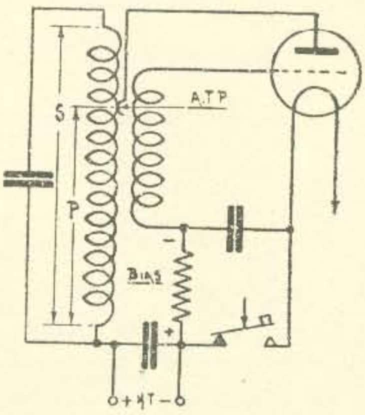


FIG. 53.—Practical oscillator for L.F.

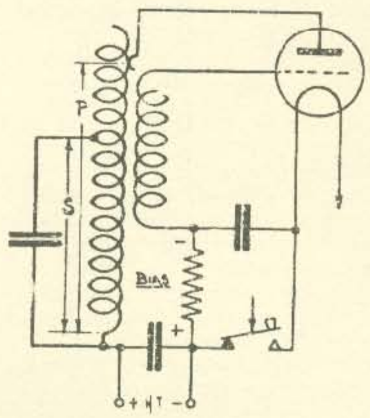


FIG. 53A.—Practical oscillator for H.F.

Other practical oscillator circuits are as follows :—

(*a*) *The Hartley oscillator* (fig. 54).—In this type of oscillator the grid excitation is obtained by tapping off a little of the R.F. voltage directly from the oscillatory circuit. Note that the grid and anode are connected to opposite ends of the coil for correct phasing, with the common filament tap somewhere between. This circuit is suitable for all frequencies up to V.H.F.

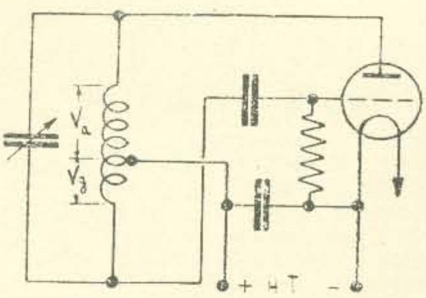


FIG. 54.—Hartley oscillator.

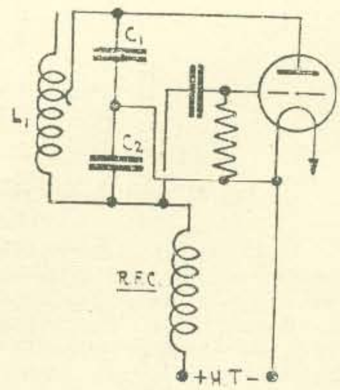


FIG. 55.—Colpitts oscillator.

(*b*) *The Colpitts oscillator* (fig. 55).—Here the grid excitation is also directly from the oscillatory circuit, but in a different manner. The voltage across the condenser C_2 is used, and the amount of feedback depends on the ratio $\frac{C_1}{C_2}$. Note the very necessary R.F. choke, which prevents C_2 from being effectively short circuited by the low impedance of the H.T. supply. This circuit is used mainly for L.F. work in the R.A.F.

(*c*) *The tuned anode—tuned grid* (*T.A.T.G.*) *circuit* (fig. 56).—Coupling in this type of oscillator is through the anode-grid capacity of the valve. The circuit is redrawn in fig. 56A to make this clear. Correct phasing is obtained when the grid circuit is tuned to about 80 per cent. of resonance with the anode circuit. The value of the anode grid capacity (about 20 $\mu\mu$ F. in the V.T.25) makes this circuit most suitable for use on frequencies of the order of 3–10 M/cs.

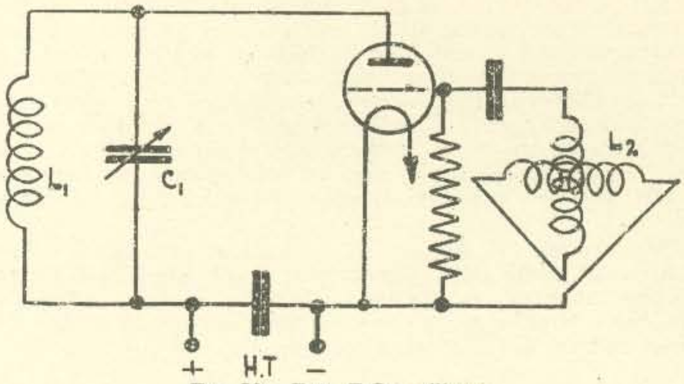


FIG. 56.—T.A.-T.G. oscillator.

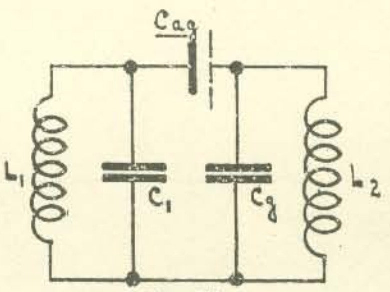


FIG. 56A.

3. **Supply or "Feed" Methods.**—All the circuits of figs. 51 to 56 are "series fed", i.e. the H.T. current passes through the oscillatory circuit, which is, therefore, at a high D.C. potential. If the "L.C." circuit is in parallel with the valve and the H.T. supply, as at fig. 57, the oscillator is said to be "parallel" or "shunt fed". A "blocking" condenser and R.F. choke are necessary in fig. 57, the condenser to prevent L_1 from short circuiting the D.C. supply, and the choke to prevent the low impedance of the D.C. supply short circuiting L_1 C_1. "Parallel feed" is not used to any extent in R.A.F. sets.

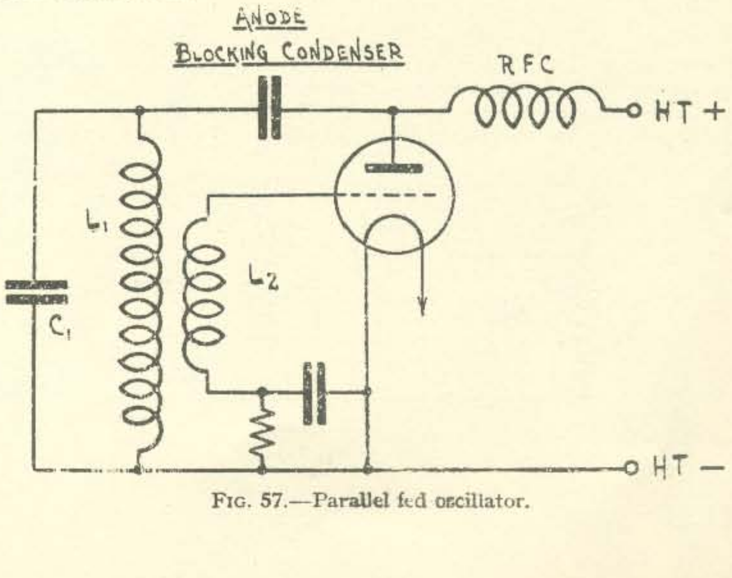


FIG. 57.—Parallel fed oscillator.

4. Crystal-controlled Oscillators.—(*a*) Pieces of quartz crystal exhibit a "piezo-electric" effect; i.e. if compressed, electric charges appear on opposite faces of the quartz plate; if placed in an electric field, the crystal is contracted or expanded. If the field is alternating, the crystal will *vibrate* at the frequency of alternation. If the electric field is alternating at the natural frequency of the quartz plate (which depends upon its thickness, and the method of cutting) the crystal behaves as a series acceptor circuit of tremendous circuit magnification, i.e. at the crystal frequency a large current is drawn from the supply, and large voltages appear at the crystal faces. At any other frequency the current drawn from the supply, and the voltage across the crystal faces, will be small. Since this effect may also be made practically independent of temperature, a crystal is extremely useful for controlling the frequency of an oscillator.

(*b*) Two methods are in common service use: (i) *Tuned anode-crystal grid* (T.A.-X.G.) (see fig. 58). The crystal is connected between grid and filament, and this circuit is very similar in action to the T.A.T.G. oscillator of fig. 56, the crystal replacing the variometer commonly used to tune the grid circuit, and the coupling being again via C_{ag}.

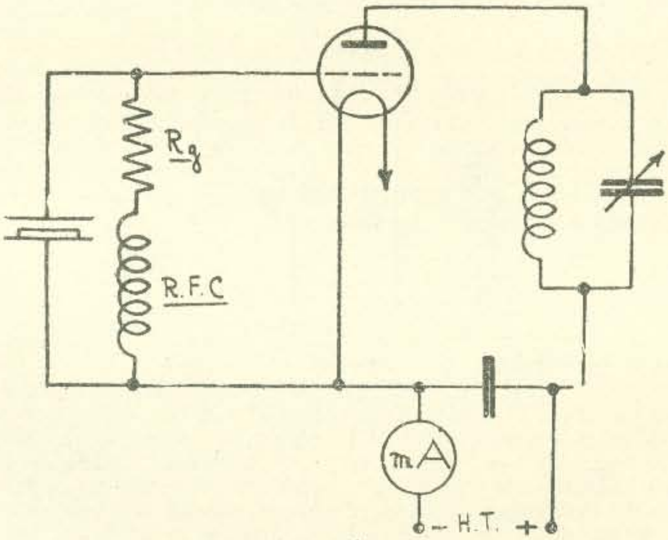


FIG. 58.—TA-XG oscillator.

(ii) "*Pierce*" *oscillator* (see fig. 59).—Here the crystal is connected between anode and grid. The oscillatory voltage across L_1 C_1 is applied to a capacity potentiometer, consisting of the crystal in series witn the C_{gf} of the valve. When the voltage is applied at the crystal frequency, the crystal impedance is very low, so that the voltage across C_{gf} is great. At any other

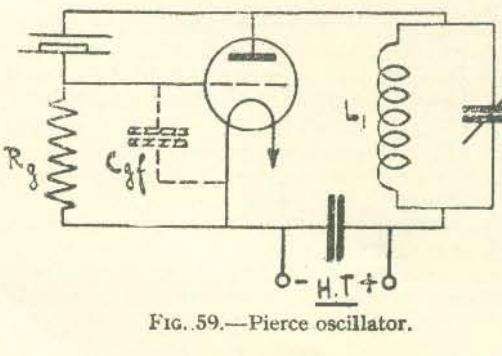


FIG. 59.—Pierce oscillator.

frequency very little voltage will appear across C_{gf}. This circuit is very suitable for low-power oscillations, and in this case the tuned circuit may be replaced by an R.F. choke, or even by a plain resistance of equivalent value (see fig. 60). This renders tuning of the crystal stage unnecessary, the frequency remaining absolutely dependent upon the crystal.

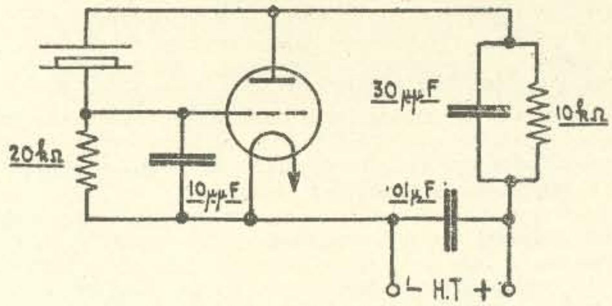


FIG 60.—" Untuned " H.T. pierce circuit.

(*c*) N.B.—When tuning a crystal oscillator, the anode current will fall gradually (denoting the commencement of oscillation) as the anode circuit is tuned. But if the capacity is increased slightly beyond the setting for minimum anode current, the crystal suddenly stops oscillating, and damage may occur to the valve or circuits. A crystal oscillator must therefore always be tuned to a position a few mA on the " slow " side of the " dip " in the meter (set to " X "—fig. 61). This apparent mis-tuning will not affect frequency, which is controlled by the crystal.

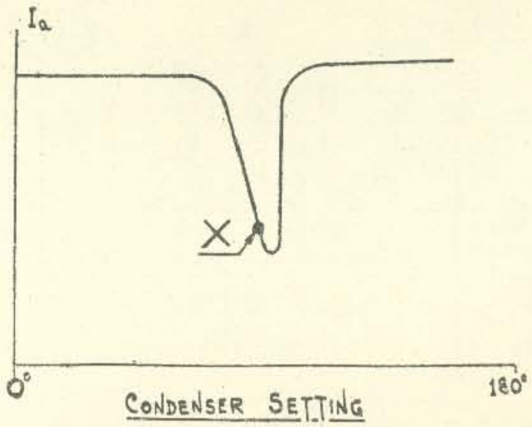


FIG. 61.—Correct setting of crystal oscillator.

5. **Frequency Stability.**—Any of the oscillators previously mentioned may be made into a simple C.W. transmitter by coupling an aerial system to the anode circuit. This arrangement is now obsolete, because it suffers from serious *frequency instability*. The need for frequency stability in transmitters arises because :—

(i) The vast number of channels of communication now in use necessitates very selective receivers, so that transmitter frequency must not " drift ", " wobble " or " spread ".

(ii) An unstable transmitter will interfere with other transmitters on near-by frequencies.

(iii) A transmitter must always " come up " on exactly the same frequency when certain adjustments are resorted to.

6. The Master Oscillator-Power Amplifier (M.O.-P.A.) Transmitter.—(*a*) The causes of frequency instability in a simple transmitter are (in order of importance) :—

(i) Swinging or vibrating aerial changes the L.C. value of the oscillatory circuit.

(ii) Changes of temperature cause change of valve and circuit constants.

(iii) An oscillator working on full power is heavily damped and unstable.

(iv) Variation of D.C. supplies (including variation by modulation if R/T is used).

(v) Mechanical vibration, effects of external fields, and " hand capacity ".

(*b*) The M.O.-P.A. system overcomes these disadvantages (taking them in order) thus :—

(i) Between the aerial and the oscillator is placed a *neutralised* triode R.F. power amplifier or a S.G. valve.

(ii) The master oscillator is run at a much reduced D.C. anode power, thus reducing temperature changes in operation to a negligible amount.

(iii) The reduced power and small load (the coupling between M.O. and P.A. is *loose*) promote frequency stability.

(iv) The L.T. supply may be from batteries. The H.T. is fed through a " swamp " resistance, which has the effect of reducing changes at the valve itself. The H.T. may also be stabilised.

(v) The M.O. is rigidly built and placed in a (ventilated) screening box.

A typical M.O.-P.A. transmitter is at fig. 62, which shows T.1083.

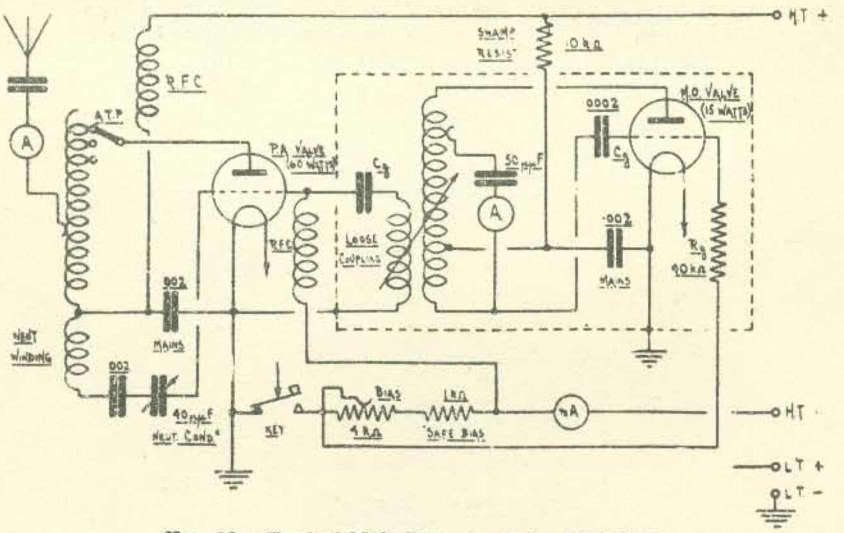


FIG. 62.—Typical M.O.-P.A. circuit for H.F.C.W.

(*c*) Frequency stability may be still further improved by using a crystal oscillator in place of the master oscillator (as in T.R.9D). The power amplifier is usually biased to Class B or C for high efficiency. Very high bias promotes harmonics in the P.A. output, and this idea can be used for frequency multiplication (as in T.R.1133). When high power is required, several R.F. stages may be used after the M.O. Several stages are also used when frequency multiplication is needed.

7. **Neutrodyne (Neutralising).**—At high R.F. the P.A. may act as a T.A.T.G. oscillator, the grid circuit being the M.O. anode circuit and the coupling device (fig. 63). The aerial is also coupled to the M.O. output circuit via the C_{ag} of the P.A. and the coupling device L_2 L_3. Hence this coupling must either be destroyed or " neutralised ".

It can be reduced very much by the use of a S.G. valve as P.A., but on H.F. neutralising may still be necessary.

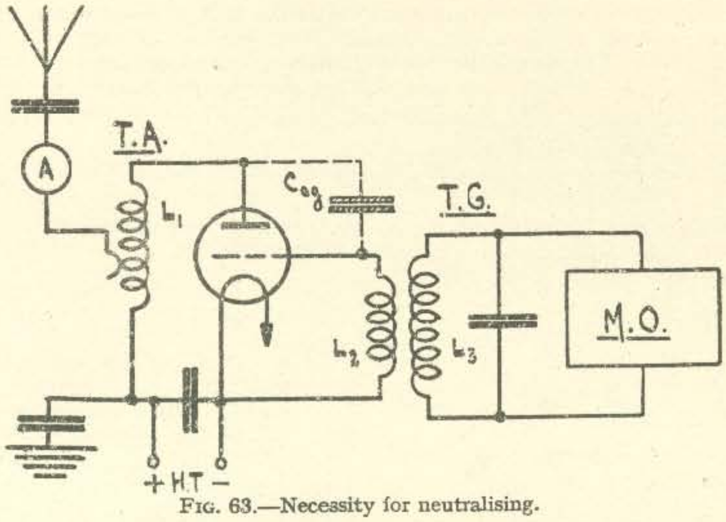


FIG. 63.—Necessity for neutralising.

Fig. 64 shows how the anode-grid capacity of a triode may be neutralised by giving to the grid circuit another input from the opposite end of the anode coil, which can be arranged to be equal magnitude and in exact antiphase to the input via C_{ag}.

In practice, the P.A. is put out of action by switching off H.T. or over-biasing, whilst the neutralising condenser (C_n, fig. 64) is varied until there is no energy in the P.A. tuned circuit

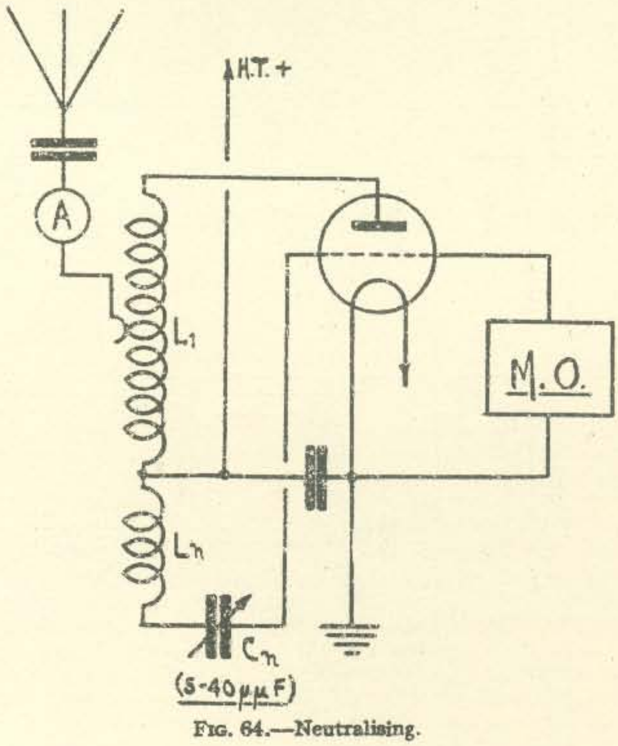


FIG. 64.—Neutralising.

8. **Modulation.**—In order to transmit R/T it is necessary to vary the amplitude of a C.W. " carrier " wave at an audio frequency. This will actually lead to the transmission of frequencies other than the nominal carrier frequency spreading over a band of equal width on either side of the carrier. A less selective receiver is, therefore, desirable, but the carrier frequency must remain stable. The amplitude modulation is produced in the R.A.F. by :—

(*a*) Variation of P.A. H.T. voltage at A.F. (T.R.9D).

(*b*) Variation of P.A. grid bias voltage at A.F., the P.A. being biased Class C (T.1083).

(*c*) Variation of screen grid voltage (T.R.1133) or suppressor grid voltage (T.1154).

Simple circuits illustrating methods (*a*) and (*b*) are at figs. 65 and 66. Note that less audio power is needed for grid modulation, and one valve may be saved by employing this method.

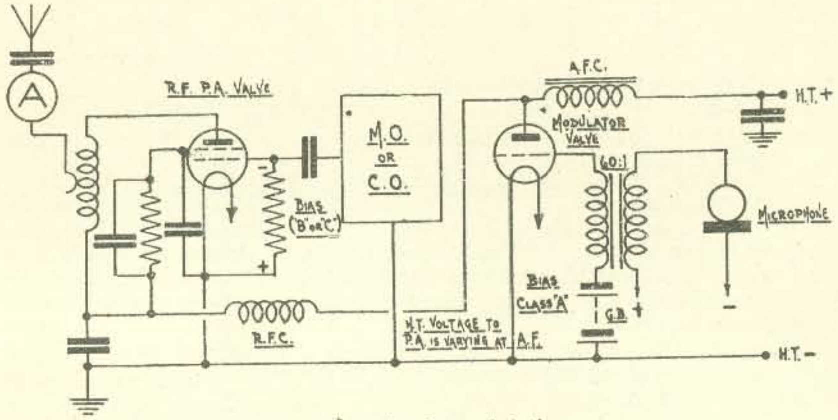


FIG. 65.—Anode modulation.

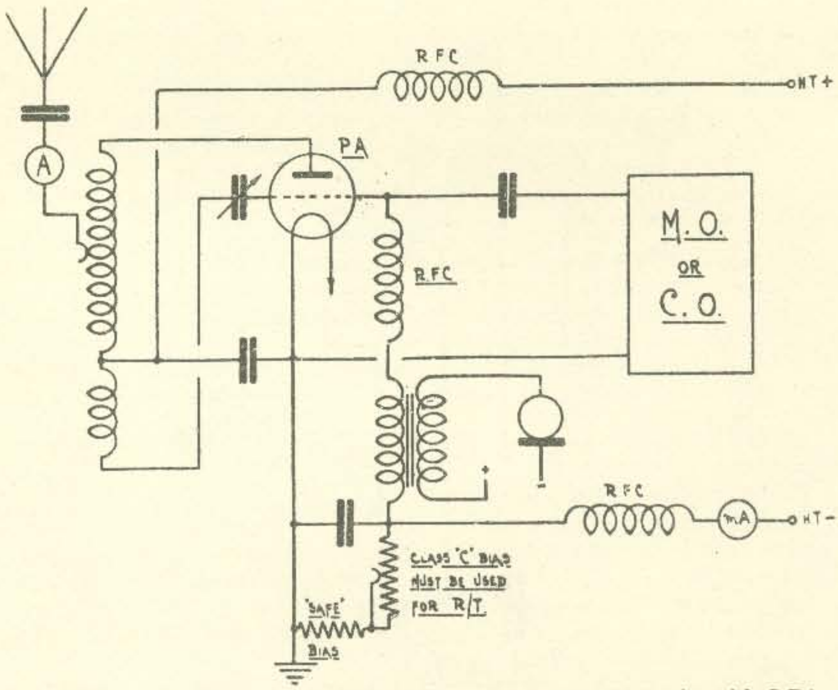


FIG. 66.—" Grid bias " modulation (R.F. voltages applied in series with G.B.).

CHAPTER 8

RECEIVER R.1082

1 **Requirements.**—General purpose aircraft receiver, capable of receiving C.W., I.C.W. and R/T signals over a wide frequency range. Normally accompanied in aircraft by transmitter T.1083.

2. **Frequency Range.**—111–15,000 kc/s, using fourteen sets of plug-in coils, ranges shown inside valve cover.

3. **Valves.**—Six; R.F. amplifier, V.R.18; Detector, V.R.27; A.F. amplifiers, 2 V.R.21; power output, V.R.22; limiter, V.U.33.

4. **Power Supplies.**—(i) *L.T.*, 2 volt, 20 A.H. accumulator; current 1·05 amps. without dial lights, 1·25 amps. with dial lights. (ii) *H.T.*, 120 volt dry battery; current, 12–15 mA.

5. **Aerial System.**—Normally that of the transmitter T.1083, but the trailing aerial may be used for reception on all ranges. Two coupling condensers give some degree of variable selectivity.

6. **Circuit** (see fig. 67).—Circuit changes are effected by plug-in coils in aerial and anode circuits (fig. 68). The " limiter " valve is a triode wired to operate as a diode, shunted across the input circuit and biased slightly negative. Because of this bias it will have no effect on normal signals, but when using " listening through " arrangement (fig. 69) (i.e. when T.1083 and R.1082 are coupled to the same aerial) it prevents damage to the R.F. valve or circuits from the very large input from the transmitter. When the transmitter key is pressed, large voltages start to build up across the R.1082 aerial coil. The limiter valve becomes conductive as soon as these voltages exceed its fixed bias, and it shunts the input circuit.

7. **Notes.**—(i) The range calibrations inside valve cover refer to condenser readings of approximately 30°–120° only, as there is a large degree of overlap.

(ii) Test supplies with switch " ON ", L.T. at dial light sockets, and H.T. at battery.

(iii) A numbered list of components is inside valve cover.

(iv) If the H.T. is shorted, the 300-ohm bias resistance may be burnt out.

(v) To test limiter valve, tune in a steady weak signal, remove valve; if signal strength increases, the valve is faulty and must be changed. The filament should also be tested for continuity. This test should be carried out every ten working hours.

8. **Maintenance.**—In any set the most important points are to keep the set clean and treat all components and accessories with great care.

The L.T. battery should be changed regularly and H.T. battery replaced when voltage falls below 100 volts on load.

If the receiver becomes faulty there are certain obvious points to look for. If noisy or intermittent, the trouble may be due to defective valves, bad contact in reaction or volume control, or a disconnection.

If the receiver is " dead " when switching " on " the fault may be traced by checking systematically.

Ensure phones are plugged in correctly.

Check power supplies and supply leads.

Test for both anode and filament currents.

Remove valves one by one and note if current decreases.

By means of a voltmeter test H.T. to valves.

The above are superficial tests and if unsuccessful then the fault must be in a minor internal component.

For successful fault finding, the operation must be carried out systematically.

VALUES

Condensers		Resistances	
Number	Capacity in $\mu\mu$ F unless otherwise stated	Number	Resistance
1	10	1	·5 M Ω
2	50	2	·5 M Ω
3	10	3	100 k Ω
4	200	4	50 k Ω
5	300	5	·25 Ω
6	·5 μ F	6	·75 Ω
7	200	7	5 k Ω
8	500	8	·5 M Ω
9	·5 μ F	9	1·5 Ω
10	300	10	·25 M Ω
11	200	11	100 k Ω
12	10	12	20 k Ω
13	100	13	50 k Ω
14	2 μ F	14	2 M Ω
15	1,000	15	1 M Ω
16	500	16	100 k Ω
17	1,000	17	·5 M Ω
18	1,000	18	200 k Ω
19	100	19	·5 M Ω
20	4 μ F	20	2 M Ω
21	2 μ F	21	150 Ω
22	2 μ F	22	150 Ω

Remarks

O.T.P. is Oscillator Test Point.
I/C is Terminal for Intercommunication.

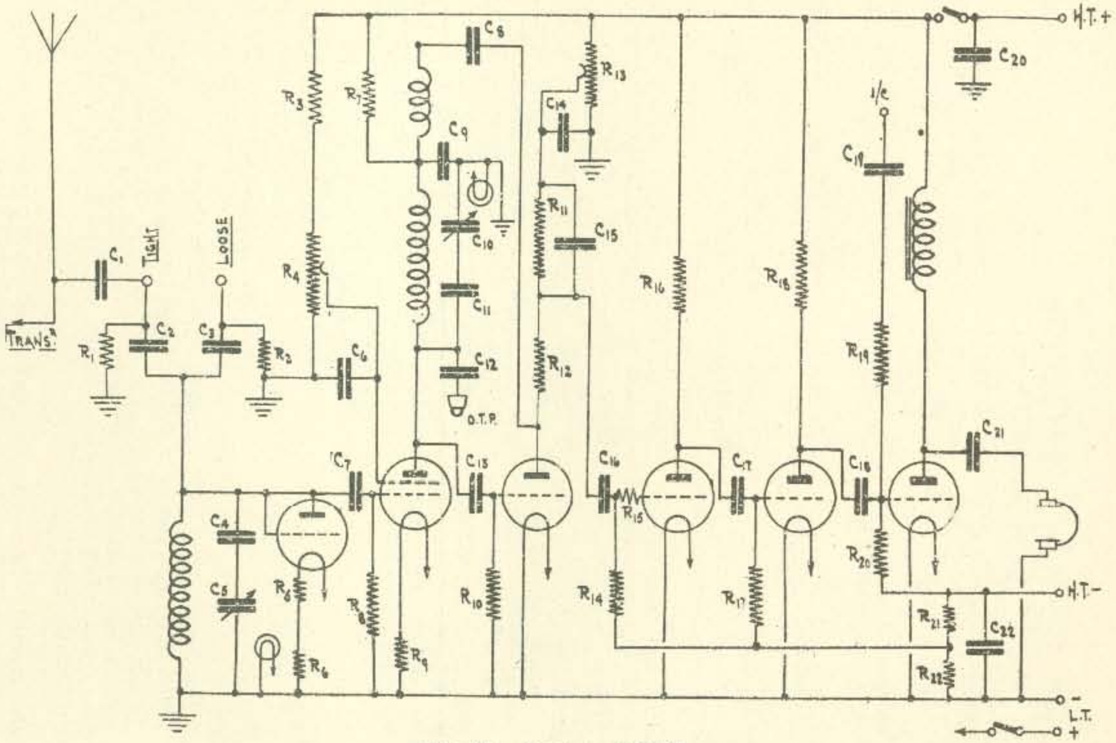


FIG. 67.—Receiver R.1082.

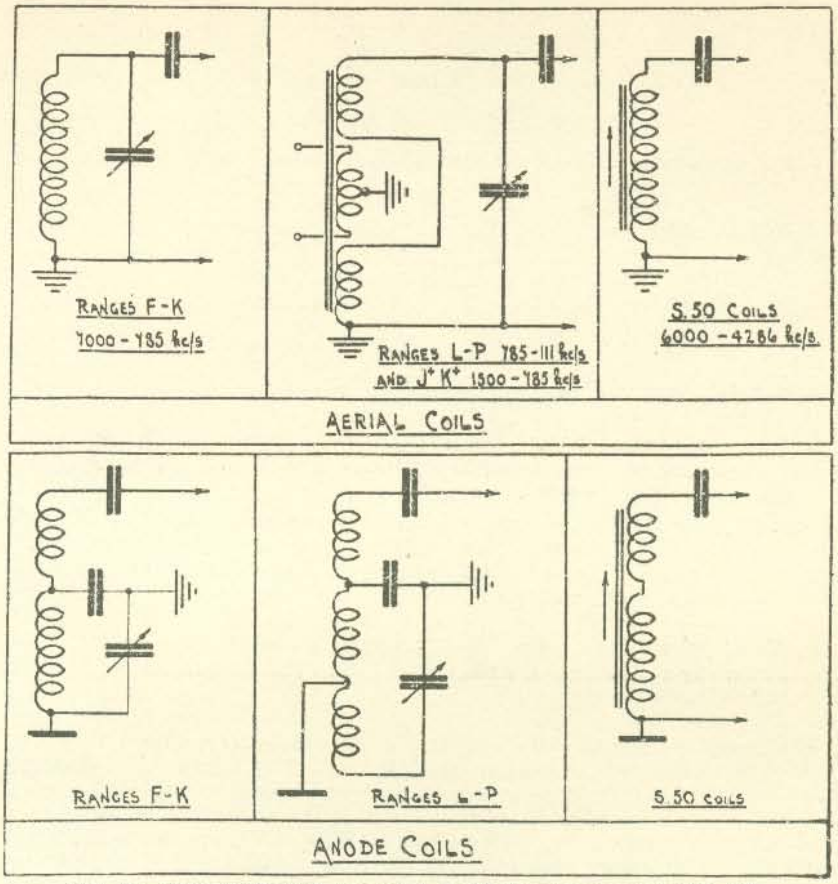


FIG. 68—Coils for R.1082 (ranges A–E (15–7 mc/s) shown in Fig. 67).

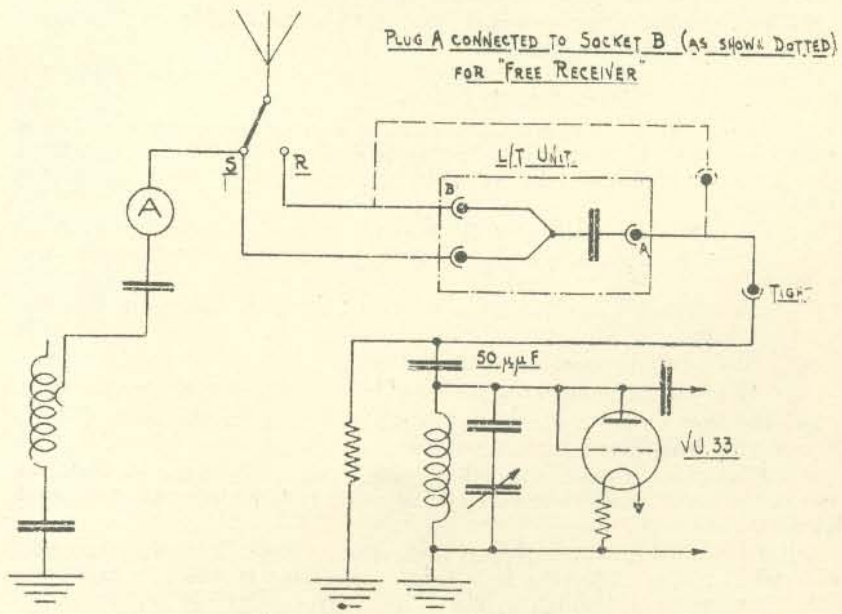


FIG. 69.—" Listening through " circuits (R.1082–T.1083).

CHAPTER 9

TRANSMITTER T.1083

1. **Requirements.**—General purpose aircraft transmitter (C.W., I.C.W. or R/T) for use with receiver R.1082.

2. **Frequency Range.**—136–500 kc/s and 3–15 mc/s covered by four ranges of coils :—

Range " A "	10–15 m/cs.
Range " B "	6–10 mc/s.
Range " C "	3–6 mc/s.
Range " D "	136–500 kc/s.

3. **Valves.**—Two V.T.25 (8 volt–60 watt D.E. triodes).

4. **Power Supplies.**—(i) *L.T.*, 8 volt 20 A.H. battery (or 12 volt 25 or 40 A.H. accumulator, with filament R.F. chokes used as dropping resistances), L.T., current 4·4 amps. (2·2 per valve).

(ii) *H.T.*, from 80 watt type " E " motor generator (supplied through R.F. choke unit), L.T. to M.G. from E.D.G. or 12 volts accumulator ; consumption 4–6 amps. " off load ", 12–13 amps. on 70 watt load. Output from M.G., 1,200 volts, 50–70 milliamps.

5. **Aerial Sytem.**—On range " D ", 250-ft. aircraft trailing aerial (7/28 S.W.G. stainless steel wire). On ranges "A", " B " and " C ", a fixed or very short trailing aerial is used.

6. **Circuit.**—(i) *Ranges " B " and " C "*.—The circuit is as shown in fig. 70, a T.A.–T.G. master oscillator being used. M.O. and P.A. are tuned by variable inductances, the M.O. grid being tuned by a variometer. Coupling between M.O. and P.A. is variably inductive ; to suit the frequency in use, a two position switch (marked A and B) on the coupling coil alters the turns in the circuit (use A for higher frequencies of the range), and the P.A. coil can be plugged in to one of two alternative positions, also marked A and B. This permits adjustment of neutralising and anode taps.

It is essential that the coupling coil switch be in the *same* (A or B) position as the position of the P.A. coil.

(ii) *Range "A "*.—The circuit is similar to the above, except that a Hartley oscillator is used in place of the T.A.–T.G.

(iii) *Range "D "*.—The circuit is similar to the above, except that a Colpitt's oscillator is used, the coupling between M.O. and P.A. is a fixed capacity (38 $\mu\mu$ F) instead of variable inductance, and the P.A. is not neutralised.

Notes.—(i) For transmitting R/T grid bias (Class C) modulation of the P.A. is employed. The bias switch makes the necessary circuit changes when switching from " C.W." to " R/T ".

(ii) In the " tune " position the switch puts the P.A. valve out of action by over-biasing.

(iii) " Sidetone " is provided in the T.1083.

(iv) " Intercommunication " is provided by using the R.1082 output stage.

(v) The neutralising meter is an external 0–0·5 thermo-ammeter (with a 300 mA lamp fuse) fitted in the earth lead.

(vi) A small fixed condenser shunted by a drain resistance may also be fitted in the earth lead to reduce aerial capacity in large aircraft when using high frequencies.

(vii) Another external component is the high voltage " listening-through " condenser (fig. 69). The plug and socket connection to the L.T. condenser permits either " listening-through " or " free receiver " operations. " Listening-through " (possible when transmitter and receiver use the same aerial and same frequency), is catered for by (*a*) L.T. condenser, (*b*) limiter valve in R.1082, (*c*) careful smoothing of H.T. supply, (*d*) keying M.O. as well as P.A. stage. It is also possible if transmitter and receiver are permanently connected to separate aerials. When using the former method, R.1082 *must be switched on before transmitting*, so that limiter valve is in operation. "Listening-through" is not possible when using R/T.

(viii) Manual remote control can be fitted to the S.R. switch.

7. **Tuning Procedure.**—N.B.1—an artificial aerial is used to set up T.1083 on the ground

N.B.2—there are four methods of tuning:—

(i) Setting up T.1083 to W.1081 or W.1117.

(ii) Using M.O. calibration figures only.

(iii) Tuning transmitter to receiver.

(iv) Using crystal monitor.

Range "A" 10–15 mc/s :—

(i) Switch on receiver R.1082.

(ii) Set artificial aerial to 25 $\mu\mu$ F.

(iii) Set grid bias and neutralising unit switches to "tune".

(iv) Set neutralising condenser to zero and "ABCD" switch to "A".

(v) Plug in P.A. coil, ensuring that correct anode and neutralising tap is used.

(vi) Set coupling coil switch to coincide with anode tap, plug in M.O. coil and set coupling control to a value consistent with frequency.

(vii) Set M.O. tuning to approximate position.

(viii) Switch on, check input, and tune P.A. coil for maximum reading in neutralising unit ammeter.

(ix) Adjust neutralising condenser until reading in neutralising ammeter is zero.

(x) Put G.B. switch to C.W.1 and the neutralising unit switch to "transmit", press key and re-tune P.A. for minimum input.

(xi) Measure frequency with wavemeter, and, if necessary, repeat operations iii to ix until frequency is correct.

(xii) Lock all tuning dials.

Range "B" and "C" (6–10 and 3–6 mc/s) :—

(i) Switch on receiver.

(ii) Set "artificial" aerial to 120 $\mu\mu$ F

(iii) Set G.B. and neutralising unit switches to "tune".

(iv) Set neutralising condenser to zero and "ABCD" switch to appropriate position.

(v) As in range A.

(vi) As in range A.

(vii) Adjust coupling control, and set grid tuning to approximate frequency setting.

(viii) Set M.O. tuning to approximate setting.

(ix) Switch on and tune grid variometer for maximum reading in the closed circuit ammeter.

(x) Tune P.A. for maximum reading in neutralising unit ammeter ; if this tends to exceed ·3 amps., reduce by adjusting neutralising condenser. Repeat operations (ix) to (xii) in range "A"

Range "D" 136–500 kc/s :—

(i) Switch on receiver.

(ii) Set artificial aerial to 250 $\mu\mu$ F.

Set G.B. switch and neutralising unit switch to "tune".

(iv) Set "ABCD" switch to "D".

(v) Plug in range " D " coils and set M.O. tuning to approximate setting.

(vi) Set P.A. coarse tuning to same figure as M.O. and fine tuning to zero.

(vii) Switch on and tune P.A. for maximum reading in neutralising ammeter.

(viii) Put G.B. switch to C.W.1 and neutralising unit switch to " transmit ", press key and readjust P.A. fine tuning for minimum input.

(ix) Check frequency and re-tune as necessary.

(x) Lock all tuning controls.

Note.—Very small aerial current is normal on range " D ".

8. **Maintenance.**—Faults in the transmitter are often found quickly by the intelligent use of the meters :—

(i) If P.A. appears to tune normally, but aerial current is low, P.A. may be tuned to a harmonic of M.O., coupling may be too tight (giving " double-hump " effect) or too loose. If coupling is altered, frequency must be re-adjusted.

(ii) If the M.O. is oscillating, but no aerial current is observed when tuning the P.A., make sure that :—

(1) the correct aerial is connected ;

(2) the aerial and earth series capacitances are correct ;

(3) The P.A. is not neutralised ; the neutralising condenser should be at zero.

(4) the fuse in the neutralising unit is not blown ;

(5) the coupling coil tap is correct ;

(6) the transmitter chassis is not earthed (via the front panel perhaps). If the transmitter chassis is earthed the neutralising unit and external earth condenser will be short circuited.

(iii) Faults in the grid bias switch might account for :—

(1) no anode current ;

(2) excessive anode current.

(3) key short circuited ;

(4) no carrier wave when switched to R/T.

(5) intermittent failure of amplifier.

(iv) If accumulator leads to M.G. are reversed, the polarity is changed ... H.T. end of M.G. and results in no input reading. Reversing leads from starter to motor-generator L.T. terminals causes machine to run in reverse direction, also a short circuit of the field takes place and machine races, which results in serious damage.

(v) Do not use studs 3, 4 or 5 (marked in red) of G.B. switch when R/T is in use, as depth of modulation will be greatly reduced.

VALUES

Condenser

Number	Capacity
1	70 $\mu\mu$ F
2	300 $\mu\mu$ F
3	300 $\mu\mu$ F
4	·01 μ F
5	·001 μ F
6	30 $\mu\mu$ F
7	·002 μ F
8	·01 μ F
9	·008 μ F
10	1 μ F
11	100 $\mu\mu$ F
12	{ 65 $\mu\mu$ F (A) 30 $\mu\mu$ F (B)
13	·002 μ F
14	100 $\mu\mu$ F

Resistances

Number	Resistance
1	500 Ω
2	1 $k\Omega$
3	20 $k\Omega$
4	4 $k\Omega$
5	10 $k\Omega$
6	40 $k\Omega$

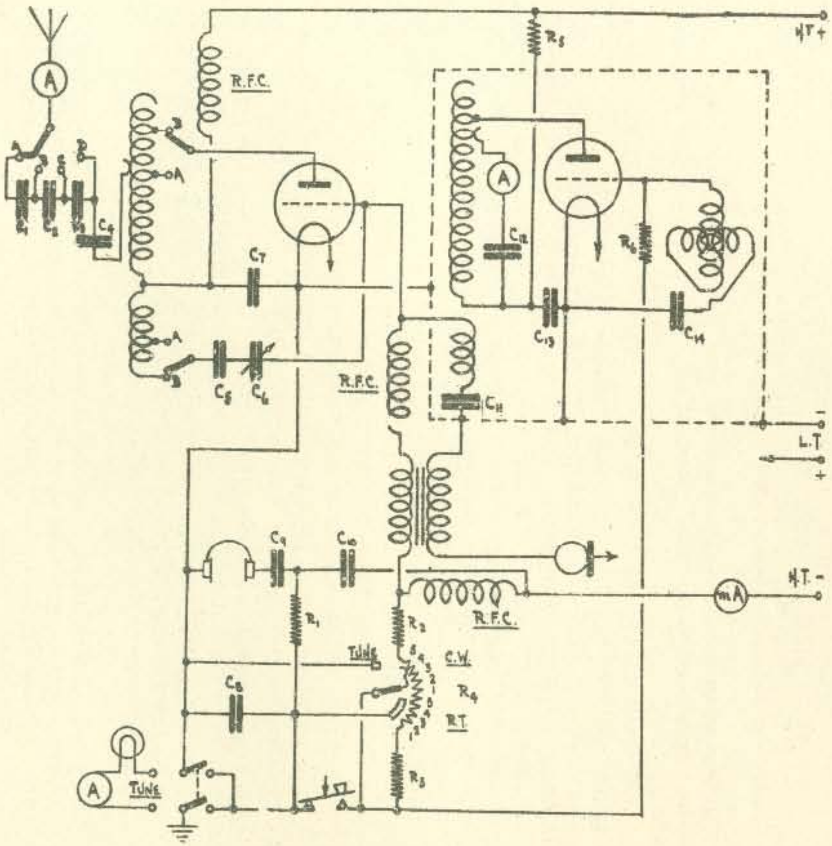


FIG. 70.—Transmitter T.1083.

CHAPTER 10

TRANSMITTER-RECEIVERS T.R.9D AND T.R.9F

1. **T.R.9D.**—(*a*) *Requirements.*—A lightweight, low power, crystal controlled R/T set for use as a "command" set in aircraft. Two crystals are incorporated in the transmitter; one controlling the "normal" frequency for R/T communication, the other controlling the "special" frequency for D/F purposes. The frequency is automatically switched from "normal" to "special" at regular intervals, unless the pilot prevents this by a separate switch

(*b*) *Frequency range.*—4·3 to 6·6 Mc/s.

(*c*) *Communication range.*—At least 35 miles air to ground and 5 miles air to air.

(*d*) *Valves.*—(i) Transmitter : three ; oscillator, triode, V.T.50 ; power amplifier, pentode, V.T.51 ; modulator, pentode, V.T.51.

(ii) Receiver : six ; R.F. amplifiers, 2, V.R.18 ; detector, V.R.27 ; A.F. amplifiers, 2, V.R.21 ; output, V.R.22.

(*e*) *Power supplies.*—(i) *L.T.*—2 volt, 20 A.H. accumulator. Current, 1·25 amps. on " normal " frequency, 1·6 amps. on " special " frequency.

(ii) *H.T.*—120 volt dry battery. Current approximately 28 mA on " transmit ", 18 mA on " receive ".

(iii) *Grid bias* (*transmitter*).—15-volt dry battery, tapped at 10·5 volts for modulator stage.

(iv) *Grid bias* (*receiver*)—4·5-volt dry battery.

Note.—H.T. and G.B. batteries are fitted internally in the set.

(*f*) *Aerial system.*—A small fixed aerial, usually from a stub mast to tail fin. In some aircraft the mast is retractable.

(*g*) *Transmitter circuit, general* (fig. 71).—(i) A crystal controlled oscillator drives an anode modulated, class C, R.F. power amplifier.

(ii) Oscillator and power amplifier use grid leak and condenser bias.

(iii) No neutralising is required for the P.A.

(iv) A " Pierce " circuit is employed, and so the oscillator requires no tuning.

(v) The P.A. is tuned for " normal " frequency by a continuously variable inductance, which is part of the aerial circuit for both transmitter and receiver. For the " special " frequency this aerial coil is tapped for coarse tuning, and a variable condenser provides the fine tuning.

(vi) The output from the microphone is amplified by a sub-modulator, consisting of the A.F. stages of the receiver, before application to the input of the modulator valve.

Note.—Either an electro-magnetic or a carbon granule microphone may be used, but before using the latter the 30 $\mu\mu$ F attenuating condenser must be brought into circuit by removing shorting link "A" (fig. 73).

(*h*) *"Special" frequency operation* (fig. 72).—(i) Two relays, energised from the L.T. accumulator via the " remote contactor ", control the switching from " normal " to " special " frequency whether the S/R switch is on " send " or " receive ".

When the contactor closes the relay circuit, the relays operate the spring loaded switches, and the frequency is changed to " special " ; when the contactor breaks the circuit, the frequency reverts to " normal ". The contactor is so arranged that " special " frequency is transmitted for 14 seconds in each minute.

(ii) The remote contactor is an electrically-driven " repeater " of the movements of the " master contactor ", which in effect is a spring-controlled clock. Movement of the clock " escapement " opens and closes contact points, thus allowing pulses of current to pass from the general service accumulator to the solenoid of the remote contactor. Each pulse causes the remote contactor " motor " to move one tooth ; the number of teeth is such that the motor makes one revolution per minute.

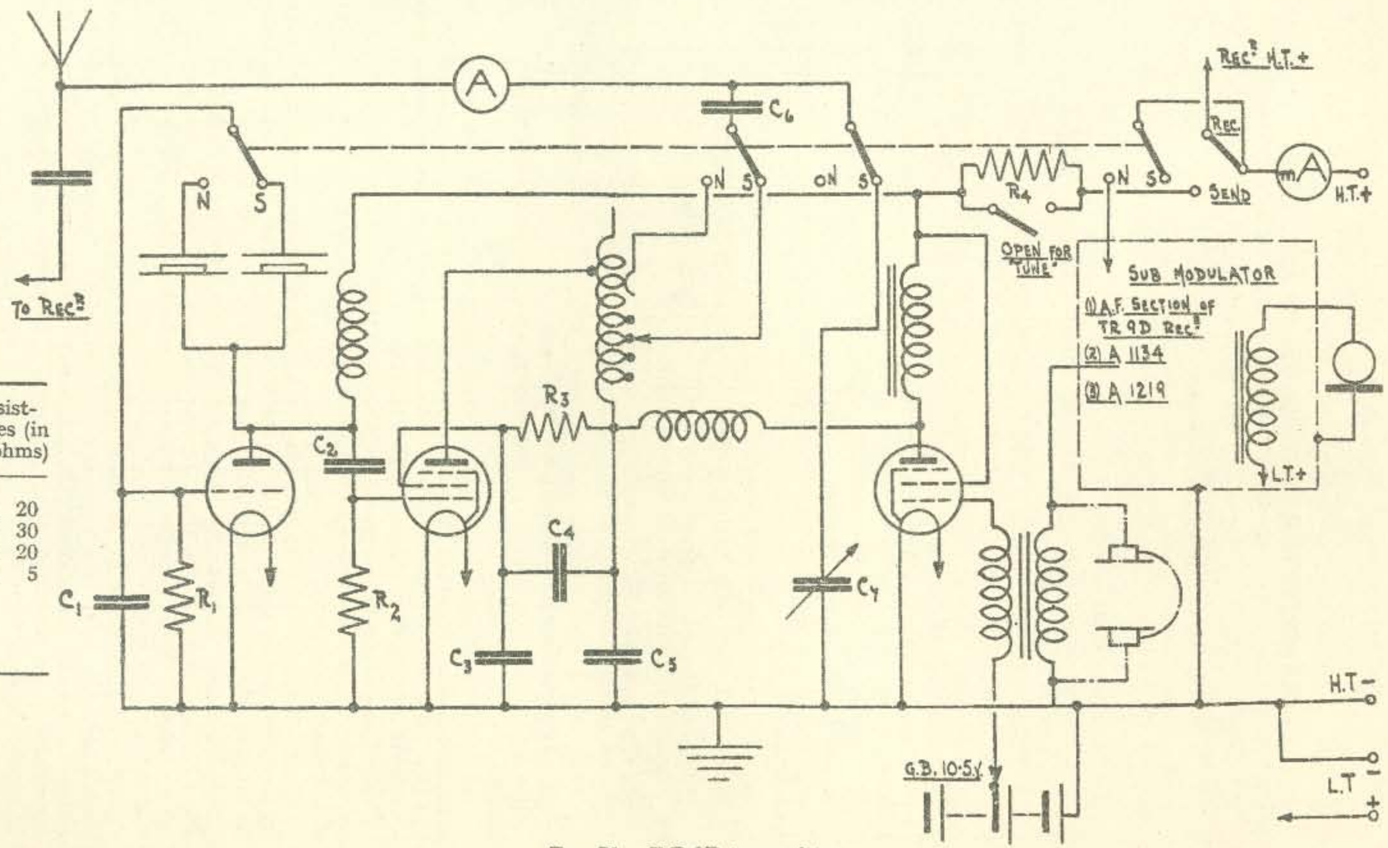


FIG. 71.—T.R.9D transmitter.

VALUES

	Condensers	Resistances (in kilohms)	
1	50 μμ F	1	20
2	10 μμ F	2	30
3	500 μμ F	3	20
4	·01 μ F	4	5
5	·001 μ F		
6	·002 μ F		
7	50 μμ F		

(iii) An index set to one of four positions allows four aircraft to use the same " special " frequency in any one minute, the transmissions following each other at one second intervals.

(iv) The pilot may suspend the transmission of the " special " frequency without stopping the remote contactor, thus preserving synchronisation.

(v) When switched to " special " the H.T. connection to sub-modulater is broken so that only a carrier wave is transmitted for D/F purposes.

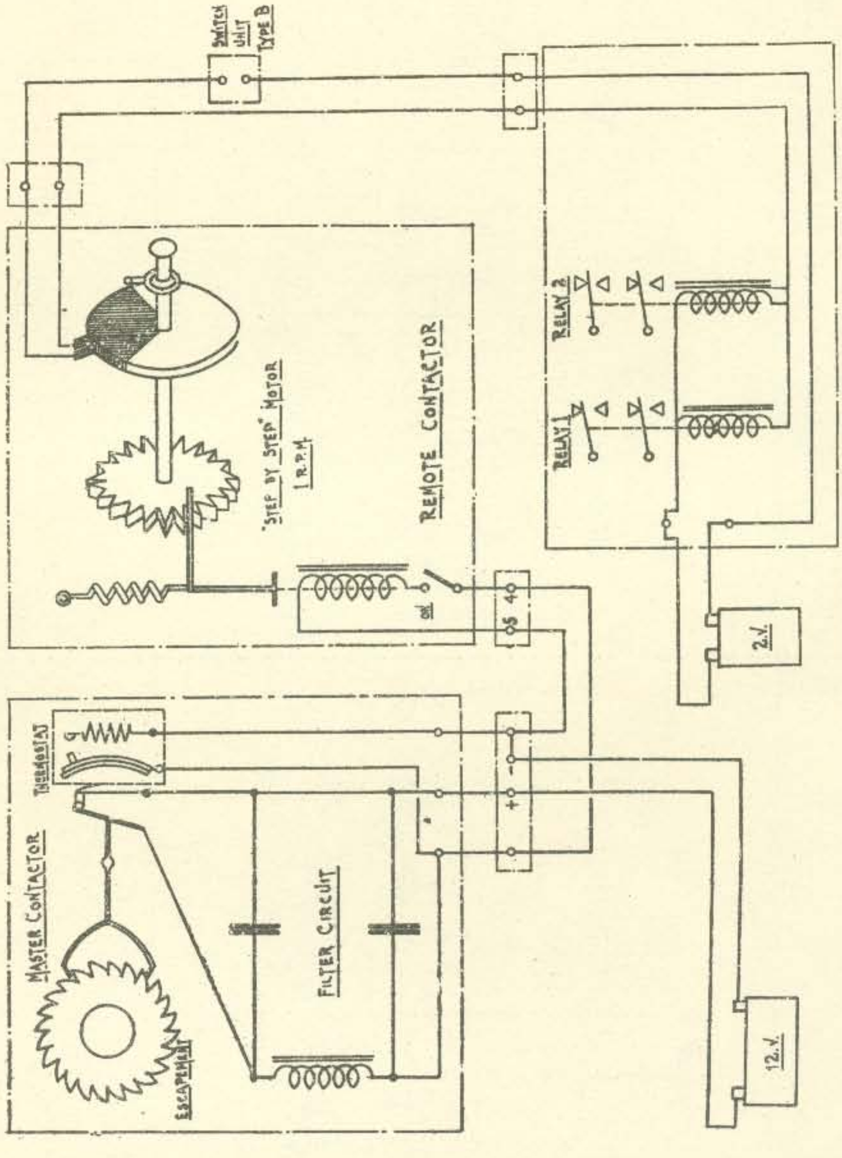


FIG. 72.—Contactor mechanism, T.R.9D.

(*j*) *Receiver circuit* (fig. 73).—(i) As the aerial circuit of the receiver is tuned when tuning the transmitter, the two main receiver tuning controls are the variable condensers in the two tuned anode circuits. Connected in parallel with these are two smaller condensers which are ganged together, and form the fine tuning control.

VALUES

Condensers		Resistances	
1	50 $\mu\mu$ F	1	50 $k\Omega$
2	·1 μ F	2	20 $k\Omega$
3	·5 μ F	3	10 $k\Omega$
4	·5 μ F	4	·5 MΩ
5	·5 μ F	5	1·5 Ω
6	230 $\mu\mu$ F	6	20 $k\Omega$
7	48 $\mu\mu$ F	7	1 MΩ
8	20 $\mu\mu$ F	8	1·5 Ω
9	·01 μ F	9	20 $k\Omega$
10	10 $\mu\mu$ F	10	2 $k\Omega$
11	300 $\mu\mu$ F	11	0·25 MΩ
12	·5 μ F	12	20 $k\Omega$
13	·5 μ F	13	0·5 MΩ
14	230 $\mu\mu$ F	14	1 MΩ
15	48 $\mu\mu$ F	15	2 MΩ
16	20 $\mu\mu$ F	16	20 $k\Omega$
17	·01 μ F	17	1 MΩ
18	100 $\mu\mu$ F	18	0·2 MΩ
19	·5 μ F	19	1 MΩ
20	·001 μ F	20	0·5 MΩ
21	·001 μ F		
22	·001 μ F		
23	·001 μ F		
24	·5 μ F		
25	·01 μ F		
26	200 $\mu\mu$ F		
27	30 $\mu\mu$ F		
28	2 μ F		

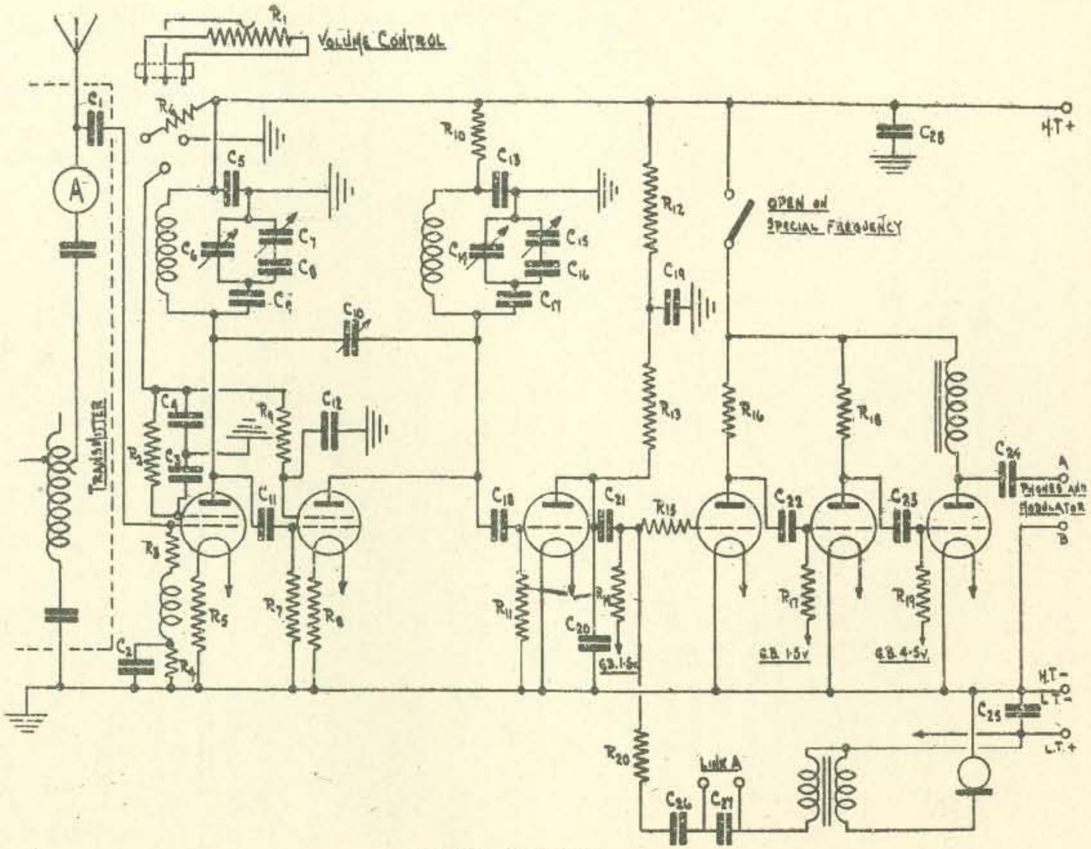


FIG. 73.—T.R.9D Receiver.

(ii) The volume control is external to the set, and is a potentiometer which adjusts the potential on the screen grids of both R.F. valves.

(iii) Regeneration is provided by a 10 $\mu\mu$ F condenser between the two tuned circuits.

(iv) Battery bias is used on the A.F. and output stages.

(*k*) *Tuning.*—(i) As the crystal oscillator does not require tuning, the setting up of the transmitter is very simple.

(ii) A limiting resistance in the H.T. positive lead reduces D.C. surges of current when tuning.

(iii) The receiver is usually tuned to an R/T tester, but a W.39A crystal controlled wavemeter may be used.

(iv) When tuning—

(*a*) always tune the transmitter first,

(*b*) have volume control at maximum, and

(*c*) have the regeneration control turned back one and a half turns from the point of oscillation.

(*l*) *General notes.*—(i) The transmitter-receiver is invariably mounted in a position inaccessible to the pilot; a special controller in the cockpit gives him remote control over the S/R switch, the fine tuning and volume control of the receiver. The S/R switch remote control is mechanical, as is the fine tuning control; the volume control is by an extension lead from a three-way socket on the receiver to a potentiometer in the controller.

(ii) Inter-communication is possible in two-seater aircraft, by a slight modification to the wiring of the S/R switch.

(*m*) *Maintenance.*—(i) The L.T. battery must be changed after every flight whose duration is nearly the endurance of the aircraft.

(ii) The H.T. battery must be tested daily. Insert a voltmeter between lower crystal socket and earth terminal, with switch at "send". Change battery if reading is 100 volts or less.

(iii) Before tuning a new transmitter for the first time, or when changing the V.T.50 valve, plug in crystals and oscillator valve only, and check that the anode current does not exceed 4·5 mA at "tune".

(iv) Good screening and insulation resistance of all microphone and telephone wiring is essential. Insulation resistance must be more than 10 meghoms and the telephone plugs are to be smeared lightly with mineral jelly.

2. **T.R.9F.**—(*a*) *General.*—(i) This set is similar to the T.R.9D in circuit layout and operation, and is used in addition to G.P. equipment in bomber aircraft. In the T.R.9F the "special" frequency may be used as a second channel for communication, because, due to the use of a separate sub-modulator (see below), switching from "normal" to "special" frequency has no effect on the microphone circuit. Thus R/T may be transmitted on both "normal" and "special" frequencies.

(ii) There is no remote or master contactor equipment, and the necessary changes from "normal" to "special" are completed by a manually-operated switch which completes the L.T. relay system.

(iii) A separate amplifier (A.1134) serves as the sub-modulator when using an electro-magnetic microphone; it also acts as an inter-communication amplifier.

(*b*) *A.1134.*—(i) *Power supplies.*—*L.T.*, 2-volt, 14 A.H. accumulator; *H.T.* 120-volt dry battery; *G.B.*, 6-volt dry battery—tapped at 3 volts and 6 volts.

(ii) *Circuit.*—The amplifier consists of a two-stage A.F. amplifier. The first stage is a V.R.21 voltage amplifier, transformer coupled to the output stage, which is a V.R.35 quiescent push-pull amplifier. This stage is also transformer coupled to the telephones. A separate on-off switch is fitted to the amplifier, and another multi-contact switch marked "A", "B" and "C" allows the amplifier to be used with G.P. equipment, if necessary. For use with T.R.9F the switch is locked at "B"

CHAPTER 11

THE SUPERHETERODYNE PRINCIPLE

1. **General.**—In Chapter 6, paragraph 4, it was shown that by introducing another radio frequency oscillation into the signal circuit of a detector, a quite different frequency can be produced in the output circuit. For example, with a signal of 1,000 kc/s, by introducing a local oscillation of 1,001 kc/s, an output at 1 kc/s (among other frequencies) is obtained.

If the frequency of the local oscillation is altered to (say) 1,100 kc/s, the resultant output will now be 100 kc/s.

This arrangement is, in fact, functioning as a " frequency changer ". The 100 kc/s signal would not operate the telephones in fig. 35, being above audibility (i.e. " supersonic ") ; coupling a straight receiver tuned to 100 kc/s to the anode circuit of the frequency changer produces a simple supersonic heterodyne (" superhet ") receiver (fig. 74), which will give the following advantages over a " straight " receiver.

(i) The supersonic (or " intermediate ") frequency (" S.F." or " I.F.") is fixed, and will normally be very low compared with the signal frequencies received, so that *stability* can be combined with *high amplification* (gain) and *great selectivity*.

(ii) The S.F. being fixed, it is necessary to tune the R.F. oscillator and signal circuits only, and these controls can be " ganged " so as to provide " one-knob " tuning. It is obviously necessary to have a " second detector " following the S.F. stages, because these are actually *radio* frequency amplifiers. If it is desired to receive C.W., another heterodyne oscillator is necessary, set to a frequency which differs from the S.F. by an audio frequency.

2. **" Second Channel " Interference.**—Whilst the " adjacent channel " selectivity of a superhet receiver is naturally high, steps must be taken to prevent interference due to stations on frequencies which differ from the desired signal by twice the S.F., e.g.:—

Desired signal at 1,000 kc/s.
R.F. oscillator set to 1,200 kc/s.
Supersonic frequency 200 kc/s.
" Second channel " 1,400 kc/s.

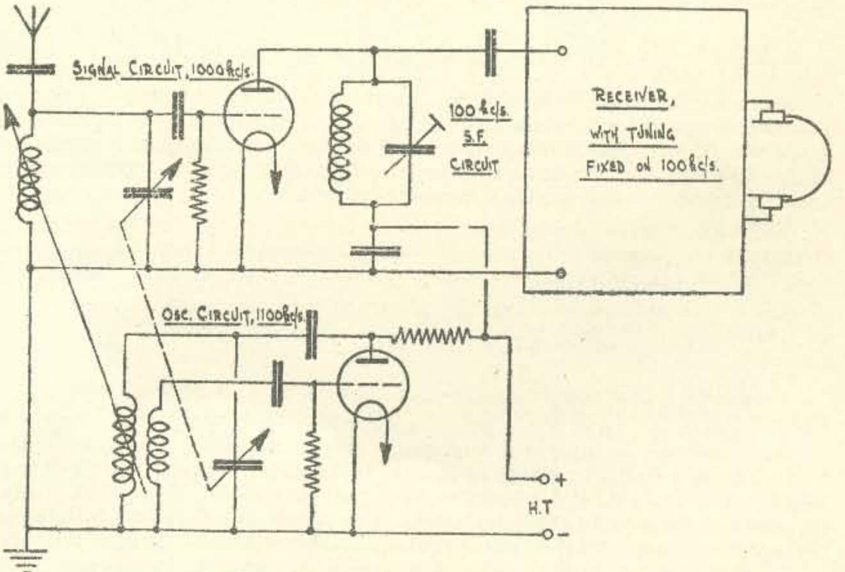


FIG. 74.—Simple " superhet " receiver.

It will be seen that stations on both 1,000 kc/s and 1,400 kc/s will produce signals in the S.F. stages, if the oscillator is set to 1,200 kc/s. Interference of this type can be avoided by using signal frequency amplifiers before the first detector. Such amplifiers also increase the overall " gain " and selectivity and improve the signal-to-noise ratio. A schematic diagram of a typical superhet receiver is at fig. 75.

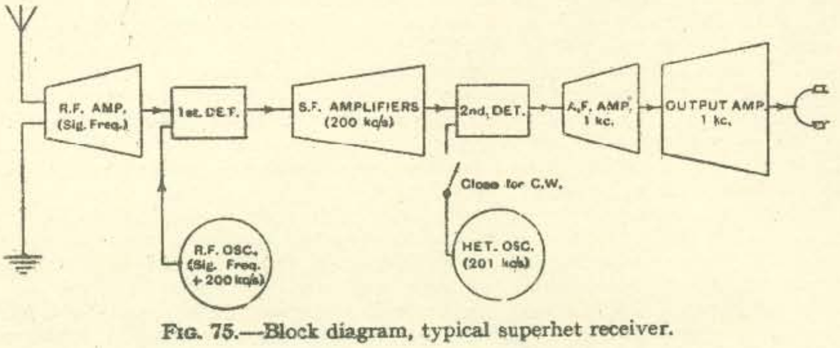


FIG. 75.—Block diagram, typical superhet receiver.

3. A frequency changer of the type in fig. 74 has the serious disadvantage that, as the signal and oscillator circuits are directly coupled, any alteration in one circuit will alter the other. This " pulling " of the circuit renders tuning of this arrangement very difficult, especially with C.W. signals. An " isolator " or " buffer " valve is therefore introduced between oscillator and signal circuits. This is a screen grid valve, so that coupling between its anode circuit (the signal circuit) and its grid circuit (the oscillator circuit) is effectively prevented.

This scheme is used in the receiver R.1084 (figs. 78 and 79). The same result can be achieved by using a multi-electrode frequency changer valve of the types shown in figs. 76 and 77. Here the oscillator and " first detector " valves are combined in one envelope, and the coupling is electronic. Besides saving two valves, this system has the advantage of much greater efficiency, a given input signal producing considerably more S.F. output.

Since a very high degree of selectivity can be provided in a superhet receiver, it is usual to provide some means of varying the selectivity, to allow " searching " for weak C.W. signals, and to permit undistorted reception of R/T. This can be done conveniently by switching a resistance across one or more of the S.F. coils or transformers. Extremely high selectivity may be obtained by :—

(i) A " note filter ", i.e. an A.F. tuned circuit of very high magnification factor (Q) included in the second detector anode circuit (R.1084), or

(ii) a " crystal filter ", with crystal resonant at the S.F., included in the coupling between S.F. amplifiers.

4. **Automatic Volume Control** (A.V.C.) is often available in superhet receivers and is useful for reducing fading, especially when receiving R/T. Numerous different circuits are possible, but the basic idea is to provide a D.C. voltage by means of a diode rectifier operated by the S.F. carrier. This voltage is applied to the S.F. amplifiers (usually variable-mu valves) in the form of grid bias, and sometimes to the R.F. stages and/or frequency changer as well. A small " delay " voltage prevents the A.V.C. diode from operating with small signal inputs. In this way, output remains nearly constant with wide ranges of aerial input.

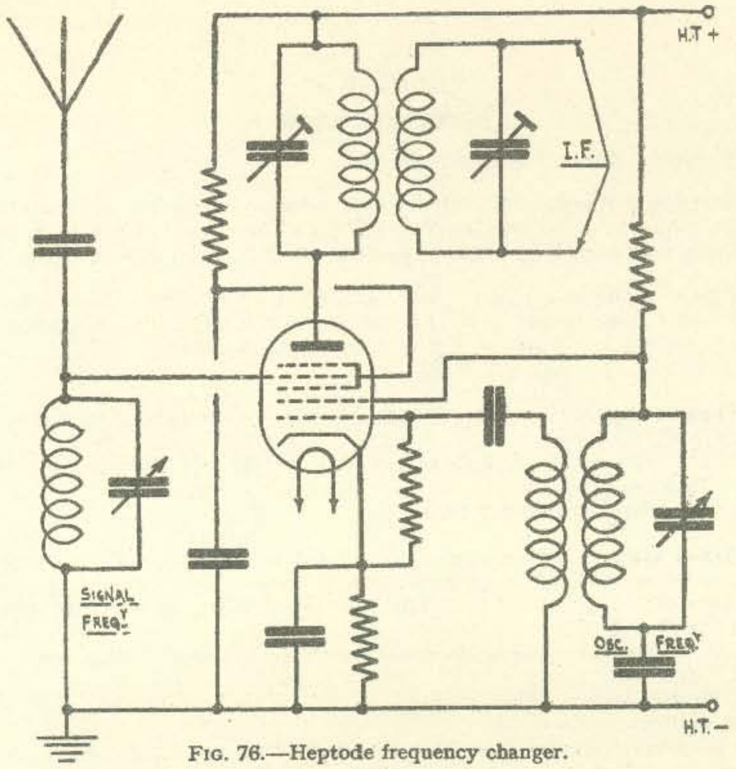


Fig. 76.—Heptode frequency changer.

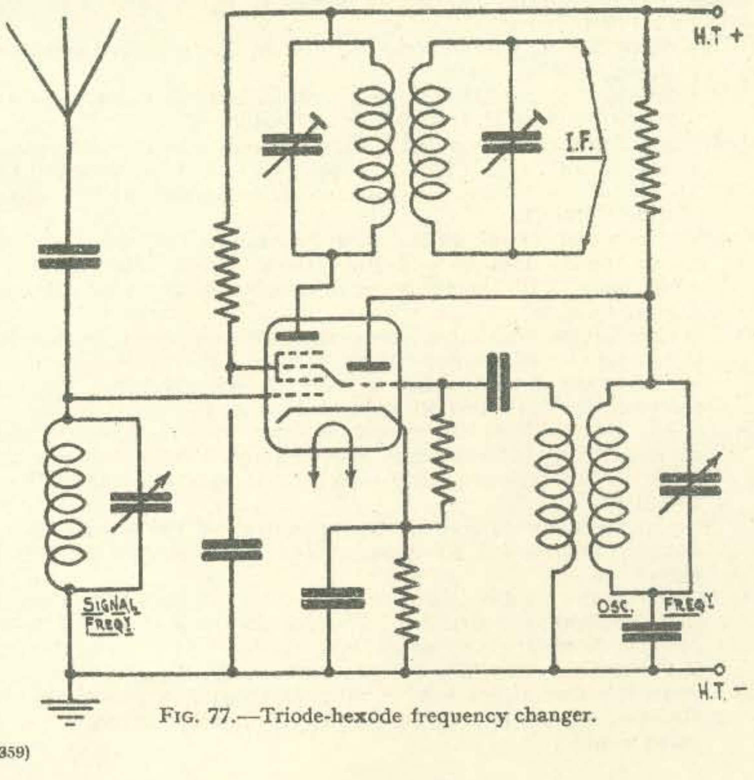


Fig. 77.—Triode-hexode frequency changer.

CHAPTER 12

RECEIVER R.1084

1. **Purpose.**—Ground station receiver.

2. **Frequency Range.**—120–20,000 kc/s, covered by eleven sets of plug-in coils and two sets of S.F. coils. The S.F. is 40 kc/s for 120–600 kc/s signal frequencies, and nominally 180 kc/s (actually 167 kc/s) for 600–20,000 kc/s.

3. **Valves.**—Thirteen in all; R.F. amplifiers, 2, V.R.28; first detector, V.R.27; R.F. oscillator, V.R.21; isolator, V.R.28; S.F. amplifiers, 4, V.R.28; second detector, V.R.27; heterodyne oscillator, V.R.21; A.F. amplifier, V.R.21; output, V.R.22.

4. **Power Supplies.**—(i) L.T.: 2 volt 90 A.H. accumulator; L.T. current approximately 2 amps.

(ii) H.T.: 120 volt from A.C. mains unit or 120 volt Milnes unit. H.T. current, 25–30 mA.

(iii) G.B., three 6-volt dry batteries.

5. **Aerial Systems (alternative).**—(i) Normal aerial (about 60-foot roof on 40-foot poles) connected to sockets "A.E.1" and "E"; except of ranges "J" (350–600 kc/s) and "L" (120–300 kc/s), when it is connected to "A.E.3" and "E".

(ii) Very small low-capacity aerial (such as a vertical rod) connected "A.E.2" and "E".

(iii) Dipole aerial feeder lines connected to sockets marked "dipole" (6–20 Mc/s only).

(iv) Resonant quarter wave aerial connected to one dipole socket, other dipole socket linked to "E" and earthed (6–20 Mc/s only).

6. **Circuit.**—A schematic diagram is shown in fig. 78 and a complete circuit diagram in fig. 79:—

(i) The three R.F. signal circuits are tuned by three ganged condensers with separate trimmers.

(ii) A separate R.F. oscillator is used with an isolator valve to prevent coupling between R.F. amplifier and oscillator.

(iii) The first detector and the four S.F. stages each have alternative tuned anode circuits, giving similar stage gain but different selectivity. This permits a wide variation in overall selectivity, without change in signal strength.

(iv) The anode load of the second detector may be resistance capacity, or an audio frequency tuned circuit (note filter) tuned to 1,000 c.p.s.; the latter is for use when extreme selectivity is desired on C.W.

(v) The second (C.W.) oscillator (often called "beat frequency oscillator") is referred to as the heterodyne oscillator in the R.1084, and is tunable over a small range around 40 and 180 kc/s. For C.W. reception it is switched on and set to 41 or 181 kc/s.

(vi) An A.F. stage follows the second detector, with resistance capacity coupling to a choke capacity output stage. The output circuit is suitable for a high resistance load such as standard high resistance telephones.

(vii) Three potentiometers give a volume control by varying the bias of the R.F. isolator and S.F. stages, all of which employ variable-mu valves.

(viii) The S.F. and second detector stages may be cut out and the receiver then becomes a "straight" set, the anode load of the second detector becoming the anode load of the first detector and the R.F. oscillator providing heterodyne for C.W. if required.

(ix) A potentiometer across L.T. positive and negative permits a small variation of the first detector bias, to suit characteristic of the valve in use.

(x) A 6-volt 40 mA lamp fuse is fitted in the H.T. negative lead. This must not be confused with the 2-volt pilot lamp.

(xi) Suitably shunted jacks and a milliammeter are provided for testing current consumption of various stages; they are also very useful for fault finding.

7. **Tuning Instructions.**—*Superhet operation, R/T or I.C.W.*—(i) Connect aerial to appropriate socket.

(ii) Plug in appropriate coils; set switch on first and last S.F. coils to "tune".

(iii) Ensure switches at each end of receiver are set to superhet "in".

(iv) Set R.F. and R.F. oscillator volume controls to maximum and S.F. to 6.

(v) By means of the calibration chart, set R.F. and R.F. oscillator main tuning controls, middle R.F trimmer, and R.F. oscillator fine tuning; first and third R.F. trimmers should be set to approximately the same as middle trimmer. Set heterodyne oscillator control to about 80 degrees.

(vi) Set note filter switch to "out".

(vii) Switch on eliminator and ensure that stabiliser is glowing, then make H.T., L.T. switch; switch on R.F. oscillator and leave heterodyne oscillator switched "off".

(viii) Search for any signal near desired frequency on R.F. oscillator main tuning control, and adjust R.F. main tuning and first and third trimmers for loudest signal.

(ix) Search for desired signal on R.F. oscillator main tuning and readjust R.F. main tuning and trimmers.

(x) Increase selectivity as desired by putting more S.F. switches to "tune".

(xi) Finally, adjust volume controls for required volume. Unless signal is very strong this should be done on S.F. control only.

Superhet operation, C.W.—(i) to (vi) As for R/T or I.C.W.

(vii) Switch on eliminator, ensuring that stabiliser is glowing, then make H.T., L.T. switch; switch on R.F. and heterodyne oscillators.

(viii) As for R/T or I.C.W.

(ix) To ensure that the heterodyne oscillator is mistuned from the S.F. stages by an audio frequency, switch off R.F. oscillator, set R.F. volume control to zero, and all S.F. switches to "tune", set S.F. volume control to a position where the S.F. stages are stable. Then tune heterodyne oscillator for "dead space" of background noise, and finally set the control 10 degrees below the dead space.

(x) Switch on R.F. oscillator, put switches on S.F. 2, 3 and 4 coils back to "stand by" and readjust volume controls.

(xi) As for (ix) R/T or I.C.W.

(xii) As for (x) R/T or I.C.W. (all switches at "tune" for C.W. or crystal controlled R/T).

(xiii) When receiving C.W. extreme selectivity may be obtained by switching "in" the note filter and adjusting heterodyne oscillator control slightly to give 1,000 cycle note.

(xiv) As (xi) for R/T and I.C.W.

"Straight" operation, R/T or I.C.W.—(i) Connect aerial to appropriate socket and ensure superhet switches are "out".

(ii) Plug in coils.

(iii) Set R.F. volume control to maximum.

(iv) Set R.F. main tuning and middle trimmer from R.F. calibration chart. First and third trimmers to approximately same setting as middle trimmer.

(v) Switch on H.T., L.T., leaving R.F. oscillator and heterodyne oscillator "off" and note filter "out".

(vi) Search for signal on R.F. main tuning and adjust first and third trimmers for loudest signal; finally adjust R.F. volume for required volume.

"Straight" operation, C.W.—As for R/T or I.C.W., but R.F. oscillator must be switched on, and R.F. oscillator main tuning adjusted for desired C.W. note. Note filter may be switched "in" for extreme selectivity.

8. **Maintenance.**—(i) Keep the set clean, physically and electrically.

(ii) Batteries must be in good condition :—

(*a*) L.T. leads to be short, uniflex 19, with soldered cable ends, and no black tape.

(*b*) H.T. Milnes units fully charged and lids kept closed. Where H.T. eliminator is used, check S.130 neon stabiliser frequently. This must strike when switched on with receiver load connected. H.T. voltage should not fall below 100 volts or rise above 130 volts.

(*c*) G.B. voltage to be tested frequently, voltage should be not less than 5 volts per battery. Inspect contact pins.

(iii) A good check on performance can be had by tuning normally on range "D" and operating R.F. trimmers for attenuation. This should be quite sharp. (R.F. efficiency is essential to increase signal-to-noise ratio.) Signal strength should not increase on switching from "tune" to "stand-by". If it does, this indicates either incorrect tuning or lack of alignment.

(iv) Stage-by-stage test : the anode current may be tested as follows :—

Stage.	Meter Position.	Remarks.	Current (mA).
Total mA ..	"Total mA" ..	All stages in operation	25–30 mA.
Output valve..	"Output mA"	Bias set to −3 volts ..	6 mA.
2nd detector ..	"2nd detector"	Filter "in", bias zero	4 mA.
		Filter "out", bias zero	2 mA.
1st detector ..	"1st detector"	.. ..	0·75 mA.
A.F. valve ..	"Total mA" ..	Remove A.F. valve ..	Fall of 1 mA.
Heterodyne oscillator.	"Total mA" ..	Switch "off" heterodyne oscillator.	Fall of 3 mA.
S.F. valves ..	"Total mA" ..	Swing S.F. V/C to give maximum anode current, switch off each S.F. in turn.	Fall of 1 mA.
Isolator valve	"Total mA" ..	Swing isolator V/C ..	Fall of 2 mA.
R.F. oscillator	"Total mA" ..	Isolator V/C zero, switch off Osc.	Fall of 3 mA.
R.F. amplifiers	"Total mA" ..	Swing R.F. volume control.	Fall of 3 mA.
To test R.F. amplifiers separately remove anode lead of one.			Fall of 1·5 mA.

(v) Noise and less of sensitivity can be traced and eliminated by carrying out above procedure. Volume controls sometimes become noisy, but this fault is self evident.

(vi) *To test for failure of R.F. oscillator* :—

(*a*) Switch to superhet "out".

(*b*) Plug milliammeter into "det. 2" position and switch in note filter.

(*c*) Set R.F. main tuning to zero with correct trimmer setting.

(*d*) Swing R.F. oscillator main tuning and a pronounced "dip" should be obtained as it comes into tune with the isolator anode circuit.

(vii) All valves should be changed after 1,000 hours' use.

(viii) Clean all valve pins and coil contacts frequently, using carbon tetrachloride.

(ix) *To align the S.F. stages* :—

(*a*) Remove aerial and earth plugs ; plug range "L" coil in R.F. oscillator.

(*b*) Set up heterodyne oscillator and switch it off, leaving all circuits at "tune".

(*c*) Plug milliammeter into "det. 2", with note filter in, and zero bias on detector.

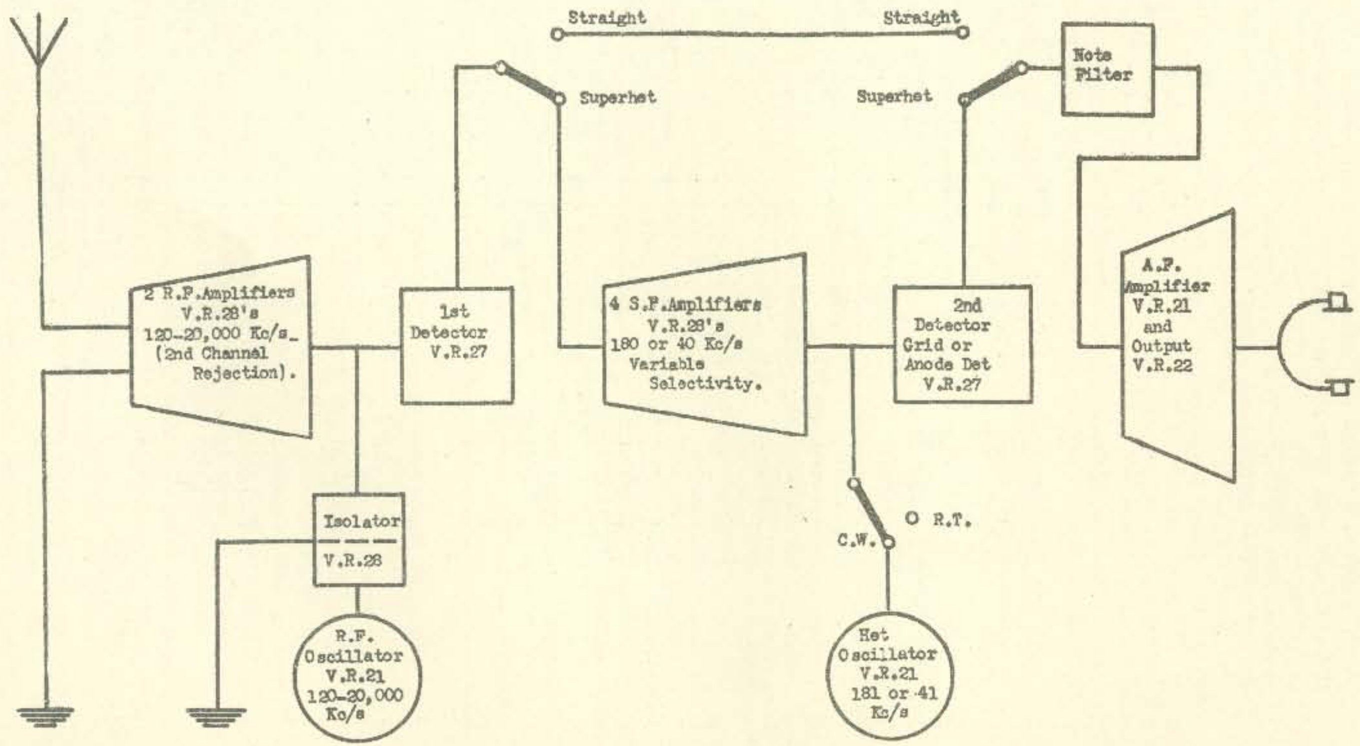


FIG. 78.—Block diagram R 1084.

(*d*) Tune for dip in milliammeter by means of R.F. oscillator main tuning. Adjust S.F. bias until maximum dip is 0·4 mA. This value is used as a "datum line" in aligning.

(*e*) Switch each S.F. coil to "stand by" in turn. Any coil which gives a reading on "stand by" of 0·4 mA or *less* needs re-aligning.

(*f*) To do this, switch back to "tune", break the seal and trim for greatest dip.

(*g*) Re-set meter reading to 0·4 mA by means of S.F. volume control and trim other circuits as necessary.

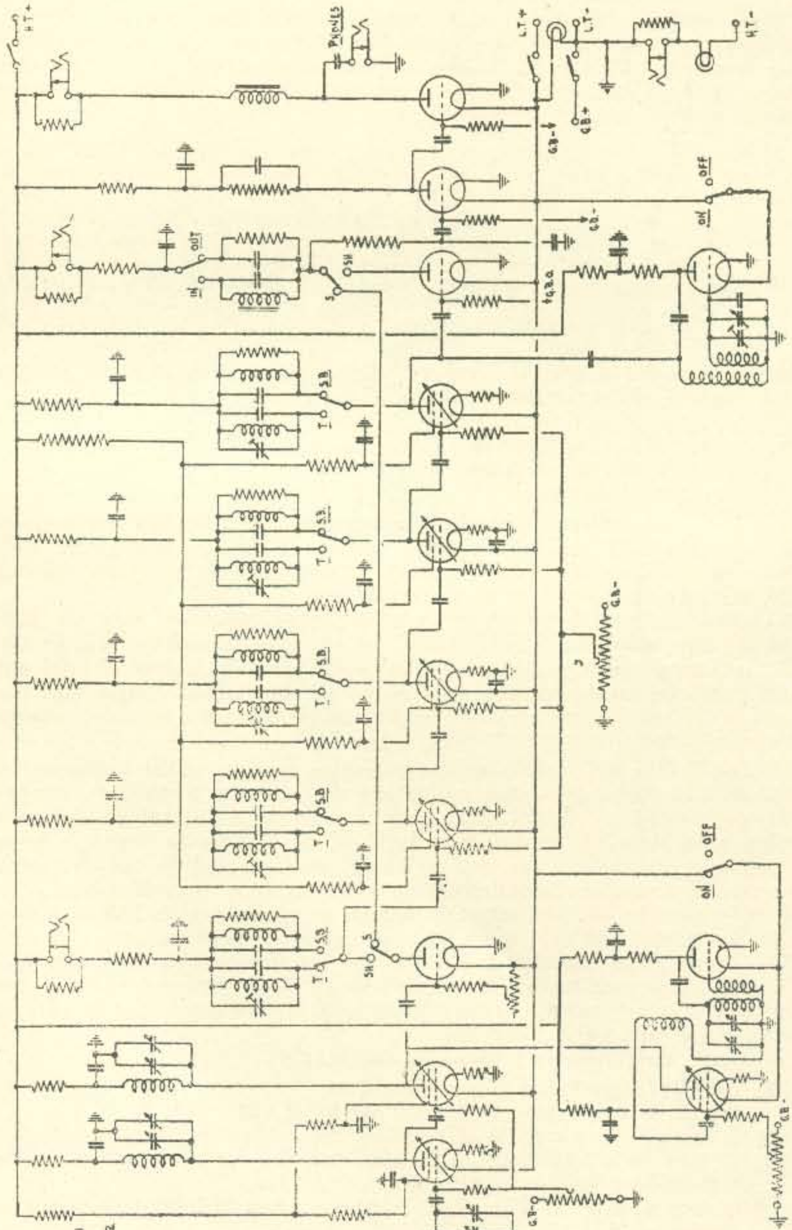


Fig. 79.—Receiver R.1084.

CHAPTER 13

V.H.F. AIRCRAFT EQUIPMENT

1. **General.**—V.H.F. aircraft equipment consists of :—

(i) T.R.1133 or T.R.1133B
(ii) Power unit, type 2
(iii) Controller, type 1.
(iv) Contactor system.
(v) Cable harness.

These items make up a V.H.F. R/T set for use in fighters, giving a two-way communication range of 100 miles, air to ground, and air to air, at 10,000 feet. Power is supplied by the 12- or 24-volt G.S. accumulator. Four frequency channels between 100 and 120 Mc/s are available by push-button control (channels A, B, C and D).

Channel "D" is normally reserved for "special frequency" D/F working, and controlled by a remote and master contactor system. When on "special" frequency, the transmission is M.C.W., although the same channel may be used for R/T if D/F is not required. The change-over from "receive" to "send" is voice-operated (although there is an over-riding hand control), and the volume control is fully automatic. The pilot, therefore, has no controls to adjust, and merely pushes a button should he require to change frequency.

2. **T.R.1133.**—The general lay-out of T.R.1133 is shown in the schematic diagram fig. 80. It is further divided into :—

(i) T.1136 transmitter.
(ii) R.1137 receiver.
(iii) A.1135 amplifier.
(iv) Main chassis.

(i) *The T.1136*, a crystal-controlled transmitter employing the valves shown in fig. 80. The C.O. has four crystals between 5,555 and 6,666 kc/s, each selected by the controller when required. There are two frequency trebling stages, bringing the frequency up to 50–60 Mc/s.

A screen-modulated frequency doubler valve produces R/T on 100–120 Mc/s ; this is amplified by a final power amplifier, consisting of a double-triode neutralised push-pull stage. The crystal circuit, trebler circuits and output grid and anode circuits are pre-set to the desired frequencies (see paragraph (7)), and these are selected by the push-button operated selector motor as required.

(ii) *The R.1137* is a superheterodyne receiver employing the valves shown in fig. 80. It has a push-pull oscillating detector for frequency changer, employing pentode V.R.56's with screens used as oscillator anodes, and carrying a 12 Mc/s I.F. transformer in their anode circuits proper. Aerial and oscillator circuits are tuned, frequency being selected by the controller. The oscillator frequency is stabilised by a special type of condenser.

Three stages of I.F. amplification follow, at 12 Mc/s, with 250 kc/s band width. Quietened and delayed A.V.C. is applied to these valves.

The double-diode detector and A.V.C valve is followed by an octode A.F. amplifier. This is used so that a compensating A.V.C. voltage may be applied to its grids in order that a perfectly level signal is obtained at ranges varying between a few yards and 100 miles.

Final A.F. amplification is given by the A.1135.

(iii) *The A.1135* performs five functions :—

(*a*) It acts as a two-stage A.F. amplifier for R.1137.
(*b*) It acts as a two-stage A.F. amplifier for modulating T.1136.
(*c*) It acts as a two-stage A.F. amplifier for intercommunication in multi-seat fighters. (Alternative is A.1219.)
(*d*) It acts as a 1,000 c.p.s. A.F. oscillator when M.C.W. is required on channel " D ".
(*e*) It contains the voice-operated-delayed-action-switching valve (V.O.D.A.S.), for operating the send/receive relays.

Another octode valve is used as the first A.F. amplifier, so that the **signal** voltages from R.1137 can be applied to a separate grid from the microphone input voltages, thus making V.O.D.A.S. possible.

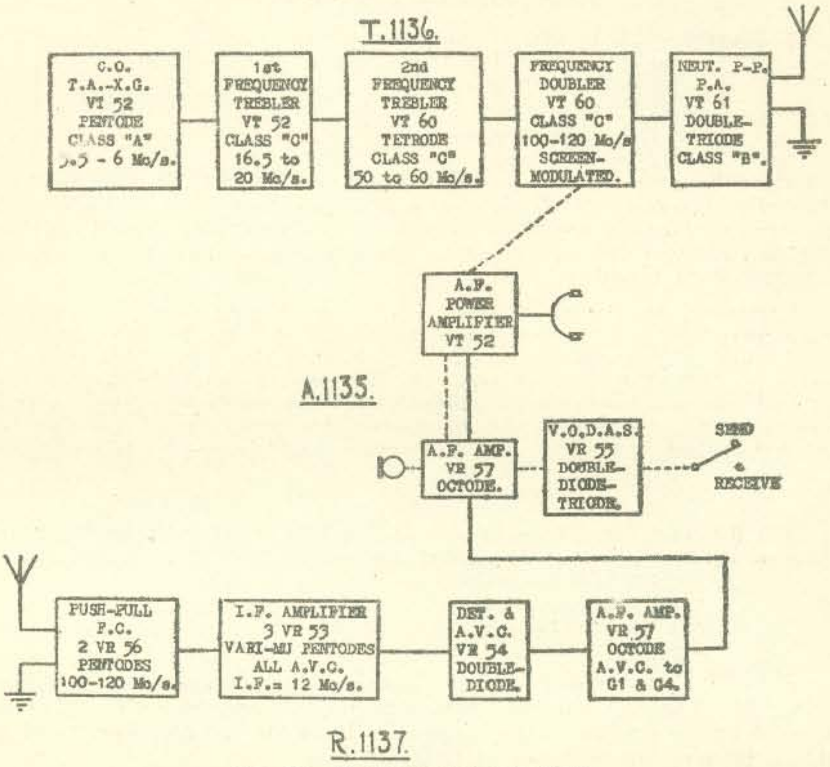


FIG. 80.—Block diagram, T.R.1133.

(iv) *The main chassis* contains potential dividing devices for H.T. : the H.T. stabilising valve V.S.68, the frequency-changing selector motor and five relays :—

(*a*) *"V" relay*—the V.O.D.A.S., operated by anode current of V.R.55.

(*b*) *" T " relay*—the " send/receive " switch.

(*c*) *" J " relay*—the relay causing channel " D " to be selected when required.

(*d*) *" L " relay*—bringing the 1,000 c.p.s. M.C.W. into use (" L" and " J " are in parallel).

(*e*) *"A" relay*—a small relay which prevents I.R. drop in the cable harness whilst selector motor is operating.

3. **The Power Unit** contains :—

(i) A rotary transformer giving the following outputs :—

(*a*) L.T.—6·3 volts, 5 amps., for cathode heaters.

(*b*) G.B.—150 volts, 10 mA, T.1136 and A.1135 grid bias.

(*c*) H.T.—300 volts, 240 mA—T.1136 and R.1137 H.T.

The input is 12 volts, 14–18 amps., or 24 volts, 10 amps., and the machine runs at 4,500 r.p.m. Smoothing and suppressor condensers are fitted to all brushes not already joined to earth.

(ii) Four relays :—

(*a*) *" R " relay*—the main starting relay for the whole equipment.

(*b*) *" G " and " K " relays*—similar to the two parts of a type "A" starter.

(*c*) *" Z " relay*—a bimetallic strip contact which breaks on overload, and works in conjunction with "R" relay.

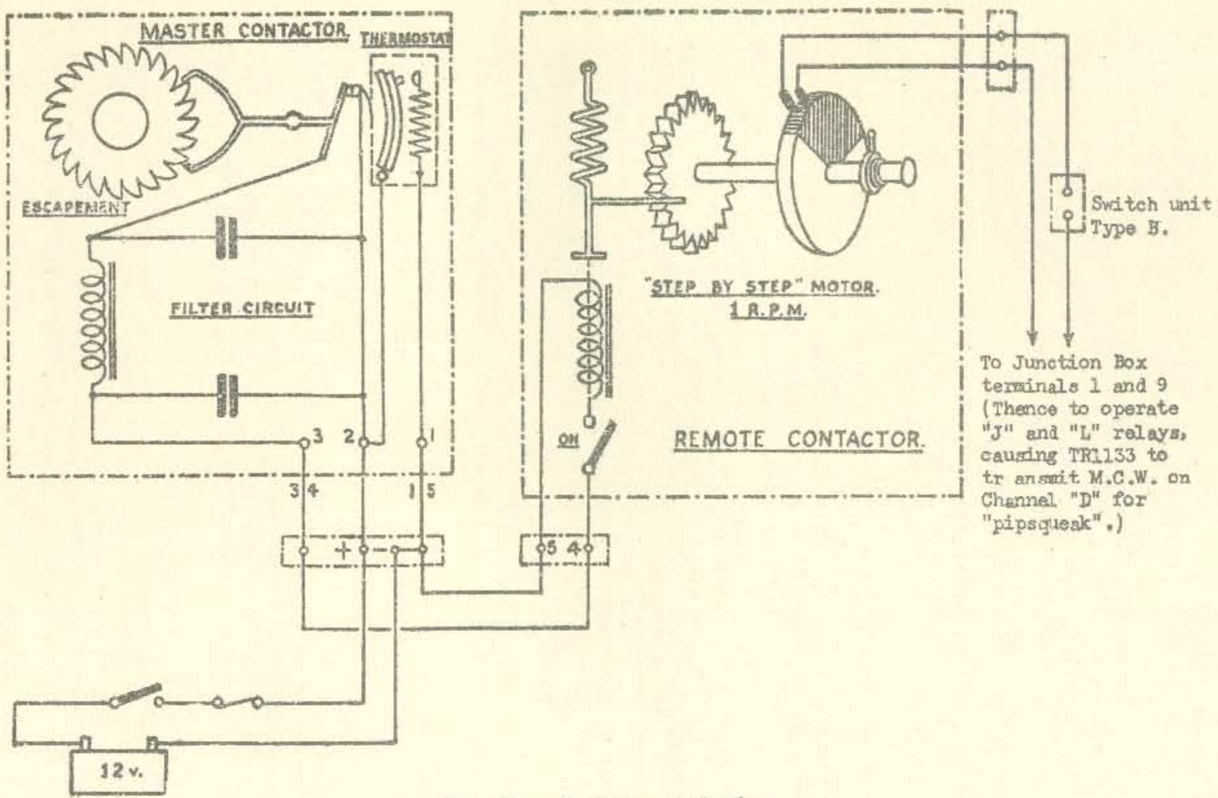


Fig. 80A.—Contactor mechanism.

4. **The Controller** consists of a four-button unit, with hand-operated switch for over-riding control of S/R switch. Pressing any button results in starting the equipment up and selecting the appropriate frequency ; a lamp also lights adjacent to the button pressed. A button already pressed is released on pressing another, and the equipment changes frequency. A fifth lamp lights only on " receive " and indicates whether the V.O.D.A.S. is working.

There is a fifth button, marked red, which switches the equipment off.

" 5. **The Contactor Mechanism.**—(i) For 14 seconds in each minute, the frequency is switched from any of the other communication channels to the ' special ', ' D/F ' or ' Pipsqueak ', frequency, channel D, by a master and remote contactor. The remote contactor completes the 12-volt circuit to the ' J ' and ' L' relays which operate spring-loaded switches and the frequency is changed to ' special '. When the contactor breaks the circuit the frequency reverts to ' normal '.

(ii) The remote contactor is an electrically-driven ' repeater of the movements of the ' master contactor ', which in effect is a spring-controlled clock. Movement of the clock ' escapement ' opens and closes contact points, thus allowing pulses of current to pass from the general service accumulator to the solenoid of the remote contactor. Each pulse causes the remote contactor ' motor ' to move one tooth ; the number of teeth is such that the motor makes one revolution per minute.

(iii) An index set to one of four positions allows four aircraft to use the same ' special ' frequency in any one minute, the transmissions following each other at one-second intervals.

(iv) The pilot may suspend transmission of the ' special ' frequency without stopping the remote contactor, thus preserving synchronisation."

6. **The Cable Harness** carries supplies to the power unit and completes all 12-volt circuits to and from the controller. All cables are metal-sheathed. The aerial system is fed from T.R.1133 by co-axial cable.

7. **Tuning Instructions T.R.1133B.**—(i) *General.*—(*a*) The set, with its power unit, should be connected up to a bench test-rig, or test set, type 10, and if possible the battery should be " boost " charged during use, to ensure that voltage is maintained at 12 volts.

(*b*) The transmitter should always be tuned first. This gives time for the receiver to warm up and prevents subsequent frequency drift of the oscillator.

(*c*) Connect the artificial aerial of test set, type 5A, to aerial socket of T.R.1133B, using short co-axial connector (type 166). Insert meter plugs in sockets having corresponding coloured dots (red for transmitter, green for receiver).

(*d*) Before commencing tuning, put meter switch on test set, type 5A, to " L.T. volts " and " H.T. volts " and check that these read 20 and 60 respectively. (This corresponds to actual values of 2 volts and 120 volts.)

(ii) *Tuning transmitter T.1136*—Instructions must be repeated for each " spot frequency ".

N.B.—All stages except C.O. are biased to cut-off or beyond. There is therefore no anode current to any given stage until an R.F. driving voltage is provided by the previous stage. The method of tuning is to switch the milliammeter into the *next succeeding stage* to that being tuned, and tune for maximum anode current.

(*a*) Remove cover over tuning condensers ; open door of crystal compartment and insert crystal into lettered socket ; press corresponding button on controller.

(*b*) Slacken locking screws on tuning cams which are held by their rocker arms. (*On no account slacken any other cams.*)

(*c*) Put meter switch on T.1136 to " anode 2 " and switch on test set type 5A to " trans. anode ". Switch to " transmit ".

(*d*) Tune crystal oscillator for maximum reading (i.e. for maximum anode current to first trebler stage). Note that needle rises slowly on one side of maximum and then falls quickly on the other side. Correct setting is about two scale divisions on *slow side.*

(*e*) Put meter switch to " anode 3 " and tune first trebler for maximum input to second trebler. Lock condenser cam.

(*f*) Put meter switch to " anode 4 " and tune second trebler for maximum input to doubler stage. Lock condenser cam.

(*g*) Put meter switch to " anode 5 " and tune doubler stage (amplifier grid circuit) for maximum input to P.A. Lock condenser cam.

(*h*) Put switch on test set, type 5A, to " trans. output " and tune P.A. anode circuit for maximum meter reading. Lock condenser cam.

(*j*) Without unlocking cams, slightly rock tuning of each stage in turn and ensure that each is tuned for maximum output. If necessary, unlock cam and adjust.

(*k*) Finally, tighten locking screws on all cams (no undue force should be used). Operate the selector mechanism and ensure that full output is again obtained when original button is pressed.

(iii) *After installation in aircraft.*—Place test set, type **11**, on tail of machine or other convenient position and switch on.

Switch T.1136 to " transmit " on correct frequency and tune test set for dip in meter reading.

Unlock cam of P.A. tuning condenser and adjust to increase dip if possible. (This will be the case if aircraft aerial differs in characteristics from artificial aerial.) Lock cam ; switch off test set.

(iv) *Neutralising.*—This is carried out on a middle frequency and will normally remain set unless the output valve is changed.

(v) *To check neutralising.*—(*a*) After item (*f*), paragraph (ii) above, put meter switch to G.5 position. This reads grid current of P.A. with H.T. off.

(*b*) Rock amplifier anode current condenser. If the meter dips by more than 0·01 mA, neutralising must be reset.

(vi) *To re-neutralise.*—(*a*) Insert screwdriver through holes in bottom of T.1136 and adjust neutralising condensers until the locking screws are 1 inch from the bottom of the slots. (These screws must first be unlocked, using key in clip.)

(*b*) Switch on transmitter, using a frequency in middle of range.

(*c*) With meter switch in " G.5 " position, tune P.A. anode condenser for maximum dip in grid current.

(*d*) Adjust one neutraliser for maximum grid current.

(*e*) Bring the other N.C. level with the first.

(*f*) Repeat (*c*), (*d*) and (*e*) until a dip of less than 0·01 mA is obtained, when the anode tuning condenser is moved through resonance.

(*g*) Return meter switch to any of the " anode " positions.

(vii) *Tuning receiver R.1137.*—(*a*) Put switch on test set, type 5A, to " check osc." Insert crystal of frequency one-eighteenth of final frequency and set tuning dial to final frequency. (This setting is *most* important, as many harmonics are present.)

(*b*) Switch on test set and set amplitude control for a reading of 40 to 60 in meter.

(*c*) Put switch to " Rec. A.V.C." T.R.1133B should already be switched on, after having tuned transmitter.

(*d*) Unlock condenser cams which are held by their rocker cams. (*On no account slacken any other cams.*) Set aerial condenser midway.

(*e*) Tune oscillator condenser for minimum input (see special note below). (Milliammeter is reading anode current of I.F. and A.F. stages. The A.V.C. bias causes a reduction in anode current when a signal is tuned in.)

(*f*) Slightly adjust tuning of test set to increase dip in meter reading. Adjust amplitude control for maximum A.F. signal.

(*g*) Tune aerial condenser for minimum input and lock cam.

(*h*) Return to oscillator condenser and re-tune for minimum input ; lock cam.

(*j*) Connect avometer between telephone terminals and adjust to read 0–150 volts A.C.

(*k*) Adjust volume control on R.1137 to give voltage as under :—
Single seater aircraft—17 to 20 volts.
Multi-seater aircraft with two positions manned—20 to 25 volts.
Multi-seater aircraft with three positions manned—23 to 30 volts.
(Telephone connection of A.1135 should be on tap 7.)

Special Note.—The oscillator is normally tuned to 12 Mc/s below the signal frequency and has, therefore, a frequency range of approximately 88 to 112 Mc/s. When tuning to the lower signal frequency (e.g. 100 Mc/s) it is possible to tune the oscillator to 12 Mc/s *above* the signal frequency, and this setting should be avoided to prevent undue interference.

8. **Maintenance of T.R.1133.**—(*a*) Keep clean, electrically and physically, but do not bend or displace any R.F. lead or component.

(*b*) Clean commutators regularly and set starting relay gaps " G " and " K " as for type A starter.

(*c*) Check emission of V.R.55 V.O.D.A.S. valve. Insert mA at pin 8 on A.1135. Normal Ia, 3·5 mA : V opens at 1·9 mA, closes at 2·7 mA.

Faults.—(i) Will not start up : " O " spring tension wrong, causing " O " to open before A, B, C or D " makes " on bottom contact.

(ii) Will not " hold on " (stops when button released) ; first contact on " R " relay O/C.

(iii) Starts and holds on, but selector motor will not run ; second contact on " R " relay O/C.

(iv) V.O.D.A.S. not working ; V.R.55 u/s ; or ·1μF condenser, anode to diodes, O/C.

(v) V.O.D.A.S. faulty ; high or low omission of V.R.55, or wrong tension on " V " relay.

(vi) No 1,000 c.p.s. modulation when terminals 1 and 9 S/C ; " L" relay O/C, or coupling or tuned circuit condensers, or resistances O/C. Also check that fixing screw of A.1135 bracing strut underneath is not shorting 1 μF condenser, putting doubler screen to earth.

(vii) *High* stabilised volts to receiver : faulty stabilovolt V.S.68, or 250 kilohms stabilising resistance O/C.

(viii) *Low* stabilised receiver volts : 3 kilohms resistance to V.S.68 anode O/C.

(ix) Excessive frequency drift on receiver (cannot hold signal) : bad matching of V.R.56's, bad alignment of I.F.s or I.F. transformer damping resistance O/C.

(x) Very low A.F. output from receiver ; faulty contact on " L" relay, leaving 2 megohms resistance in telephone circuit. Faulty V.7 in R.1137.

(xi) Unsteady transmitter output ; faulty connections to N.C.s ; bad seating of a valve or dry joints. See that strip connection to N.C. does not S/C to cathode pin of V.T.61.

(xii) No drive ; try new F.D. V.T.60. (Any V.T.60 will work as T.2, but only one in four as F.D.) If input voltage is low, try new V.T.52 in first trebler.

(xiii) Insufficient modulation ; poor V.T.52 in A.1135 ; low volume contro setting A.1135 ; poor F.D. valve in T.1136 ; wrong setting of series tuning condenser in F.D. stage. (Should be correctly set by makers.)

(xiv) Distortion with high input voltage ; bad V.T.52 in A.1135.

(xv) If test mA reads 0·2 mA in reverse direction, one contact of Yaxley switch is sticking on " 5 ", whilst the other goes to " 6 ".

(xvi) If test m/A reads 30mA in reverse direction, contacts on Yaxley switch are " out of step " between 1 and 2, 2 and 3, or 3 and 4.

(xvii) A typical set of test figures is given below :—

With input voltage	12·0 volts.
H.T.	300 volts.
Bias	107 volts.
C.O. screen	70 volts.
Doubler screen	185 volts.

(*a*) Test currents :—

Crystal.	Current (milliamps) in					Total current (mA).
	First trebler.	Second trebler.	Doubler.	P.A. anode.	P.A. grid.	
5,550	·20	·40	·39	·62	·24	168
6,810	·21	·40	·35	·60	·30	163
6,050	·21	·41	·37	·62	·32	166
6,170	·22	·43	·36	·58	·35	165
6,430	·23	·42	·35	·43	·24	148
6,590	·24	·43	·35	·43	·20	146
6,666	·24	·42	·35	·37	·17	140

All readings, except total, taken on standard 0–1 mA of 75 ohms resistance. Watts in aerials vary between 2·7 at 5·5 Mc/s and 1·3 at 6·6 Mc/s when modulated 100 per cent.

(*b*) *Working bias on valves* (test meter, type D) :—

T.1136. 1st trebler .. .. 107 volts.
T.1136. 2nd trebler .. .. 107 volts (at grid).
150 volts (at top of 60 kilohm resistance).
T.1136. Doubler .. .. .. 65 volts.
T.1136. P.A. .. .. .. 37·5 volts.
A.1135. First valve .. .. 2·2 volts.
A.1135. Output valve .. .. 15 volts.

(*c*) *H.T. voltages on main chassis* :—

Between Q.4 and E .. .. 300 volts.
Between Z.1 and E .. .. 210 volts.
Between K.12 and E .. .. 210 volts.
Between V.7 and E .. .. 210 volts (stabilised).
Between H.10 and E .. .. 210 volts
Between Y.6 and E .. .. 185 volts (unmodulated).
Between S.3 and E .. .. 70 volts (stabilised).

(*d*) Receiver H.T., feed (unstabilised) .. 210 volts 16·5 mA.
Receiver H.T., feed (stabilised) .. 210 volts 14·5 mA.

" 9. **Minor Faults found in Daily Tests in Aircraft.**—The following notes are intended to assist in localising a fault with the least dismantling of equipment, but are by no means complete fault-finding instructions. The more difficult type of fault, needing a ' bench ' test, is given above. It is assumed in all cases that battery voltages and 'Jones' plug connections will be checked :—

(i) *Common causes of failure*—

(*a*) Run down accumulators (especially in aircraft with poor charging arrangements).

(*b*) Dirty commutators (especially 12-volt motor).

(*c*) Damp in Mic-tel circuits, causing feed-back and howling. (Put vaseline on plug and transformer oil in socket, type 29).

(*d*) Aircraft voltage higher than that used for bench tuning, requiring change of tuning (to avoid, use boost charge on test bench).

(ii) *Likely faults* (in all cases check plug and socket connections)—

(*a*) Equipment not starting—20 amps. main fuse or 5 amps. fuses in power unit blown ; faulty controller (starting contacts opening before button makes on bottom contact) ; bad contacts on ' R ' relay.

(*b*) ' Off ' button does not stop M.G.—faulty controller. If M.G. still runs with controller removed, one of relays in power unit sticking.

(*c*) V.O. not working—microphone gain control turned back. Bad seating of V.R.55, grid connection loose or faulty valve. Check microphone circuits by listening for ' side-tone '.

(*d*) Low A.F. output from receiver—volume control turned back. If tuning meter on test set type 5A, shows normal dip, check A.F. valve V.R.57 and check amplifier by speaking into microphone and listening for ' side-tone (check that ' L relay is short circuiting the 2-megohm resistance in series with phones). If tuning meter shows low reading with set-off tune, check H.T. and L.T. voltages from M.G. No dip in tuning meter, check oscillator and I.F. valves.

(*e*) Low output from transmitter—check anode currents of each stage against standards with test set, type 5A. Low reading indicates that valve of stage being checked is faulty, or a fault in tuning circuits of previous stage. If all anode currents low, check H.T. supply. If meter with no drive, check G.B. generator, change valve. Check continuity and insulation between poles of co-axial feeder. Check aerial change-over switch.

(*f*) Selector mechanism faulty—motor sticks in one position. (If this is position D see that ' remote contactor ' circuit is broken). If no movement of motor armature, change controller. (Top contacts of one push-button not making, lamp opposite is lit.) Remove transmitter and press armature by hand. If motor turns and again stops in same position, check ' X ' relay and rotary switch. If motor does not turn, check ' locating ' contacts. If motor turns when disconnected from load, check vibrating contacts."

CHAPTER 14

TRANSMITTER T.1131

1. **General.**—A ground station transmitter of V.H.F. R/T or M.C.W. on 100 to 124 Mc/s, supplied by 230 volt 50 c.p.s. A.C. mains.

Consists of " C.O.–F.T.–F.T.–F.D." driver unit driving a neutralised push-pull output stage via a link coupling. The output stage is anode-modulated. A powerful modulation amplifier is incorporated with a 1,000 c.p.s. A.F. oscillator for the production of M.C.W. Separate power panels provide modulator and R.F. panels with L.T. and H.T. supplies.

A diode monitor coupled to aerial coil provides a check on outgoing signals. The special dipole aerial is fed via a 100-ohm co-axial cable, a matching unit being incorporated in the P.A. panel.

2. **Circuits.**—(i) *General.*—The set is built on a " rack-and-panel " system and consists of six panels. From bottom to top they are :—

(*a*) R.F. power unit.
(*b*) Modulator power unit.
(*c*) Control panel.
(*d*) Modulator unit.
(*e*) R.F. driver unit.
(*f*) R.F. power amplifier unit.

The general lay-out is at fig. 81.

(ii) *R.F. power unit.*—Supplies L.T. and H.T. for panels (i) (*e*) and (i) (*f*). The outputs are :—

(*a*) V.T.52 and V.T.79 heaters—6·3 volts 50 c.p.s.
(*b*) V.T.62 filaments—7·3 volts 50 c.p.s.
(*c*) H.T. all valves—1 000 volts D.C.

Two V.U.72's, H.C. mercury vapour diodes, are arranged in a full-wave rectifier to supply 1,000 volts H.T. A 1-amp. fuse is fitted in H.T. positive lead. A thermal delay switch in control panel ensures that H.T. cannot be applied to M.V. rectifiers until 60 seconds after cathodes have been switched on.

(iii) *Modulator power unit.*—Supplies L.T. and H.T to panel (i) (*d*). A separate panel is used to avoid any R.F. coupling between R.F. and modulator stages. The outputs are :—

(*a*) V.R.67 and V.T.75 heaters—6·3 volts 50 c.p.s.
(*b*) V.R.67 and V.T.75 anodes—300 volts D.C.
(*c*) V.T.76—separate 7·5 volts 50 c.p.s. each filament.
(*d*) V.T.76—1,000 volts D.C. anodes.

A 1-amp. fuse is fitted in both 300 volt and 1,000 volt H.T. positive leads. The H.T. supply to this rectifier is also delayed in control panel.

(iv) *Control panel.*—Contains switchgear and indicating lamps on front panel. A 24-volt metal rectifier supplies current for relays and microphone. After delay switch has operated, the relays are placed in series with the microphone. On picking up the distant microphones to speak, one relay makes the H.T. contactor circuit and the other makes a lamp circuit at the controller, indicating that the transmitter is " ready to speak ". The distant operator switches on the transmitter merely by picking up his telephone hand-set.

(v) *Modulator unit panel* consists of three parts :—

(*a*) The *screening box* contains microphone input circuits, volume control and a two-stage resistance-capacity A.F. amplifier.

(*b*) The *voltage amplifier* in screened box feeds a three-stage push-pull A.F. power amplifier, all transformer-coupled stages. The final amplifier has an input-limiting device, consisting of metal rectifiers joined across the grid circuits. Even so, the A.F. power output is 90 watts

(*c*) A small *A.F. oscillator* unit plugs into the panel at the rear and provides a 1,000 c.p.s. input to the A.F. power amplifier when M.C.W. transmission is required. It has its own volume control.

(vi) *The R.F. driver unit* panel contains a pentode V.T.52 crystal oscillator (5·5–7 Mc/s) followed by two frequency trebling stages, each employing a single "class C" tetrode V.T.79. This takes the frequency up to 50-63 Mc/s, and it is then doubled by a "class C" triode V.T.62 amplifier. All the driver stages have their anode circuits tuned by variable condensers. The anode current of each valve can be read by switching a milliammeter into its cathode lead.

(vii) *The R.F. power amplifier unit* panel contains a pair of V.T.62's in a neutralised "class C" push pull circuit. The 1,000 volts H.T. is fed via the modulation transformer and the stage thus anode modulated. Both grid and anode circuits tuned, and both grid and anode currents of each valve can be measured separately.

A separate tuned circuit is used for the aerial and this is tapped down to the 100-ohm co-axial feeder. Variable inductive coupling is used between P.A. anode and aerial circuit. A 2 $\mu\mu$ F condenser couples a diode monitor to the aerial circuit, enabling transmissions to be checked.

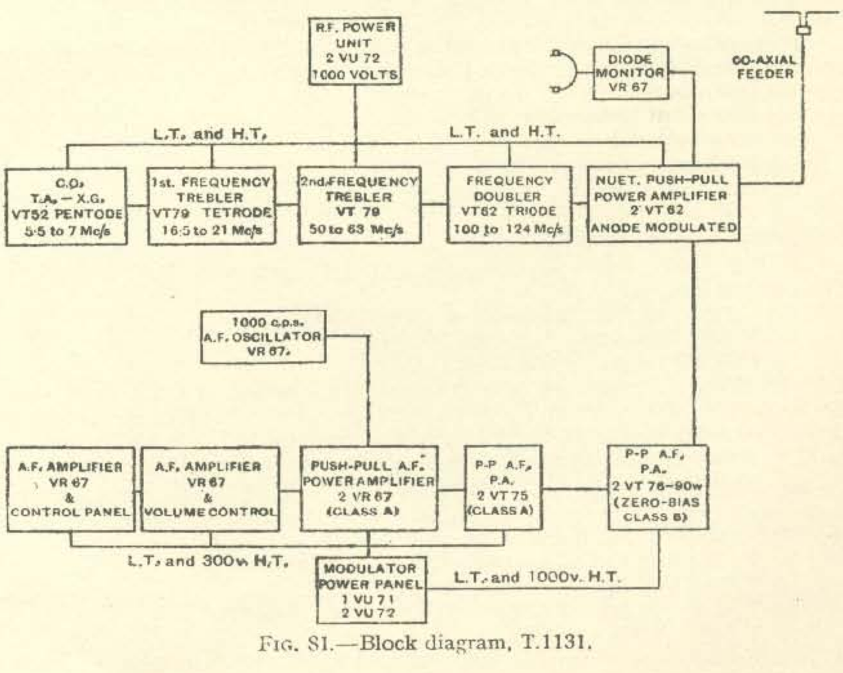


FIG. 81.—Block diagram, T.1131.

3. **Tuning Instructions.**—(i) *General.*—(*a*) Initial tuning must be done quickly, on half power. *Microphone must NOT be connected until tuning is finished.*

(*b*) A 60 seconds' thermal delay prevents application of H.T. voltage to the mercury vapour rectifiers before they have attained their correct operating temperature. If the M.V. diodes have been moved, filaments of valves should be run for at least 15 minutes before H.T. voltage is applied.

(*c*) Door switch breaks main A.C. supply when door is opened, and full thermal delay period must elapse before set can be operated.

(*d*) Neutralising adjustment should not be touched unless found to be faulty, as this will normally hold over a wide range of frequencies.

(ii) *Tuning.*—(*a*) Press master filament switch and see that green indicator lamps light.

(*b*) Check that power switch is at " half " and microphone plug out.

(*c*) Insert crystal in holder. Put meter switches to C.O., G.1 and C.1 respectively. Set aerial coupling and aerial tuning to zero and local-remote switch to " local ". Do not touch neutralising condenser.

(*d*) Press master H.T. switch and note that L.F. indicator lamp lights brightly with R.F. lamp at half brilliance.

(*e*) Tune crystal oscillator for dip in cathode current ; set to 2 mA on slow side of dip (12–14 mA):

(*f*) Put meter switch to T.1, T.2 and D positions, tuning for minimum cathode current in each case. Dial reading should be roughly the same.

(*g*) Tune P.A. grid circuit for maximum grid current.

(*h*) Tune P.A. anode circuit for minimum cathode current. (If neutralising is correct, this should also increase grid current.)

(*j*) Switch to full power and carefully re-tune from T.1 onwards. (Grid current should now be at least 15 mA.)

(*k*) Check neutralising carefully. If correct, the setting of the P.A. anode tuning which gives minimum cathode current should also give maximum grid current. If only slightly out, adjust by a *small* movement of neutralising control.

(*l*) Increase aerial coupling, keeping P.A. in tune. Bring aerial circuit into tune. If increase in coupling was correct, input will rise to a maximum of about 65 mA.

(*m*) Without further adjustment to tuning controls, increase coupling for *total* cathode current of 170 mA (85 and 85, 84 and 86, or etc.). Cathode current should balance to within 6 mA, grid current to within 2 mA.

(*n*) Check monitor current—should be 3 to 8 mA.

(*o*) Insert microphone plug (3 point) and check modulation. With normal speech, modulator cathode current should rise to 190 mA, and there should be a rise in input to P.A. stage. Quality may be checked by telephones in " monitor telephone " socket.

(*p*) Put local-remote switch to " remote ".

(iii) *Neutralising transmitter T.1131.*—If the neutralising adjustment is considerably out, proceed as follows :—

(*a*) Open door and remove " link for neutralising " at back of P.A. panel.

(*b*) Close door and after thermal delay period has elapsed, tune up to P.A. grid circuit on full power, as above.

(*c*) Rotate P.A. anode tuning condenser slowly to produce a dip in grid current.

(*d*) Adjust neutralising condensers to remove dip in grid current.

(*e*) Re-tune for maximum grid current and repeat (*c*) and (*d*) until P.A. tuning has no effect on grid current.

(*f*) Switch to half power, replace link, re-tune P.A. anode circuit for minimum cathode current, and complete tuning on full power.

N.B.—The neutralising should be checked and any slight adjustment made as described under " tuning ".

4. **Maintenance, T.1131.**—(i) Keep set perfectly clean inside, but take great care not to displace or distort any components or lead, particularly in the later R.F. stages. A slight movement of a coil, etc., may completely upset balance or seriously reduce the drive.

(ii) The following are the correct anode currents for each valve. No great departure from these limits is permissible :—

M.A.	C.O.	T.1.	T.2.	D.	G.1.	G.2.	C.1.	C.2.	Moni-tor.
Off-tune	44–47	48–51.	48–45	42–45	—	—	54–60	54–60	0·1
Tuned	30–32	46–48	48–55	60–65	8–12	8–12	85	85	3·0

In addition, the input to R.F. output valves, when unloaded by aerial should be 52 mA each.

(iii) If output R.F. amplifier will not balance (grid current of V.1 and V.2 not within 2 mA) :—

(*a*) Reneutralise carefully.

(*b*) Reverse link loads at doubler coil.

(*c*) Exchange V.T.62's.

(*d*) Bend link coil very slightly.

(*e*) Check values of 7,500 ohms bias resistances.

(iv) If insufficient drive from doubler (15 mA should be obtained in grid meter on first tuning grid circuit) :—

(*a*) Doubler valve may be exchanged.

(*b*) Slightly bend link coil.

(*c*) See that lead through screen from V.3 to doubler V.4 is not touching R.M.70 insulating bush. If this is so, drive will be lost in insulation resistance.

(*d*) Grid leak of doubler may be too high. It must be 60 kilohms$\pm$5 per cent. If, in older serial transmitters, 70 kilohms is fitted, exchange this with 60 kilohms screen feed resistance to oscillator (exchange R.4. to R.18 in official diagram).

(v) If mA takes to reading double on certain settings of switch (two shunts in series), the contacts of switch on which *normal* readings are obtained are S/C.

(vi) The modulator power stage should take about 44 mA undriven and rise to 190 mA when transmitter is modulated 100 per cent. In addition, the R.F.P.A. anode currents should rise slightly when modulated. If R.F. anode mA *kicks back* on speaking into microphone, however, one of the 4 μ F electrolytic decoupling condensers in cathodes of R.F. valves will be O/C.

(vii) The 250 ohms bias resistors to V T.75 valves are working at full rating and will get very hot. If one of these fails, chronic distortion will be noticed.

(viii) If diode monitor anode current is outside limits, change V.R.67 valve.

CHAPTER 15

RECEIVER R.1132 AND R.1132A

Purpose.—Sensitive V.H.F. R/T and D/F ground station receiver.

2. **Frequency Range.**—100–124 Mc/s.

3. **Valves.**—R.F., V.R.65 pentode ; F.C., V.R.65 ; oscillator, V.R.66 triode ; I.F. stages, 3 V.R.53 ; detector and A.V.C., V.R.54 ; B.F.O., V.R.53 ; A.F., V.R.57 ; output, V.R.67 ; stabiliser, V.S.70.

4. **Power Supplies.**—External power unit ; type 3 when A.C. mains are available ; type 4A for emergency supply, so that R.1132 may be run from a 6-volt 80 A.H. battery :—

(i) *Power unit, type 3,* is a straightforward valve rectifier employing a double-diode V.U.39. The input is 200 to 250 volts (six tappings) 50 c.p.s. A.C., and the output, 210 volts 55 mA D.C. for H.T., and 6·3 volts, 3·5 amps. A.C. for L.T.

(ii) *Power unit, type 4,* contains a D.C. motor-generator, requires an input of 6 volts, 7 amps., and gives an output of 220 volts, 30 mA for H.T., and 6 volts, 3·5 amps. for L.T.

5. **General.**—The receiver is normally remotely controlled and therefore must possess a high degree of frequency stability and completely automatic control. It is normally mounted in a rack, but may be used on a bench with either local or remote telephones. It is tuned by a single slow motion dial. A tuning meter is fitted and also an output attenuator. The B.F.O. and manual gain control are only used for the reception of D/F signals.

6. **Circuit.**—A schematic diagram is at fig. 82. The " R.F. unit " is contained in a screened box inside the receiver, and comprises pentode R.F. amplifier and frequency changing valves, the latter having a separate triode oscillator, the anode voltage of which is stabilised by a neon stabiliser. The " first detector " and oscillator have a common cathode resistance, so that frequency changing comes about by " cathode injection ". Coupling between the R.F. and F.C. valves is by tuned transformer ; there are thus four tuned R.F. circuits (aerial, R.F. anode, F.C. grid, and oscillator circuits). They are tuned by four ganged variable condensers with small trimmers for alignment. The oscillator circuit tunes from 88 to 112 Mc/s. The neon stabiliser is outside the R.F. screening box.

The I.F. is 12 Mc/s, and three vari-mu pentode valves are used as I.F. amplifiers. The I.F. transformers are brought into alignment by slight adjustments of their iron-dust cores. They have a band-width of about 150 kc/s.

A milliammeter is fitted in the cathode (R.1132) or anode (R.1132A) lead of the first I.F. valve, and this serves as a tuning indicator and signal strength meter. The second detector is a double diode valve which also provides delayed A.V.C. The A.V.C. voltages are applied to the R.F. amplifier, to the I.F. stages, and also to the two control grids of an octode A.F. amplifier (as in the R.1137). The whole of the A.V.C. system may be cut out by putting the gain control switch to " manual " ; the R.F. gain is then controlled manually by potentiometer. A pentode B.F.O. provides a local oscillation for the reception of the carrier wave only, when D.F. is required. This is switched on by means of the gain control system, which at the same time cuts out A.V.C. The B.F.O. is tuned by variable condenser between 11·9 and 12·1 Mc/s. Manually operated variable gain is also provided for the octode A.F. amplifier. This is followed by a triode output valve, with transformer output designed to work into a telephone line so that remote control may be used. An attenuator is fitted to this transformer to give outputs of 250, 60 or 15 milliwatts.

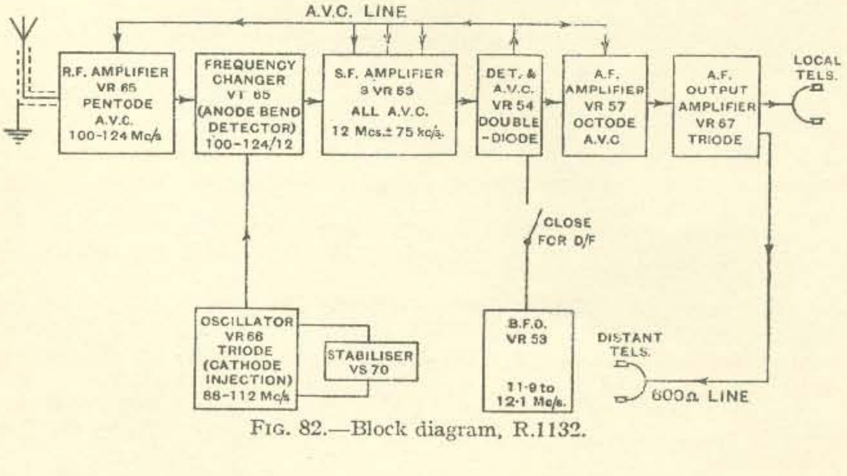


FIG. 82.—Block diagram, R.1132.

7. **Tuning Instructions.**—(i) See that power unit six-position input switch is in correct position and switch on. Voltmeter should become steady at 210 volts and mA read 50.

(ii) Insert telephones into jack marked "Monitor", and set attenuator to "6 db".

(iii) Set gain switch to "A.G.C.", and A.F. gain control knob about vertical.

(iv) Set tuning dial to desired frequency from calibration chart. If signal is present, tune to dip in meter.

(v) If no signal present, set crystal monitor to desired frequency with correct crystal and tune receiver to dip in meter.

(vi) Allow R.1132 to "warm up" for 30 minutes and then reset tuning carefully.

(vii) Set A.F. gain control to not more than three-quarters maximum, and attenuator to "0", "6" or "12" as required.

(viii) *Switch off crystal monitor.*

8. **Maintenance.**—(i) Do not bend or displace any R.F. lead or component particularly the R.F. coils.

(ii) Alignment of R.F. and I.F. stages is intricate, and must be done with signal generator and output meter. Re-alignment should not normally be necessary on changing an I.F. or B.F.O. valve; but changing R.F., F.C. and particularly oscillator valves, may necessitate complete re-alignment.

(iii) The R.F. ganged condenser may get out of line due to mechanical failure.

(iv) R.F. decoupling condensers, particularly the small tubular types, may fail.

(v) A shorted outgoing line causes a "dead" receiver, and may be tested by plugging monitor into the line jack.

CHAPTER 16

TRANSMITTER T.1154 AND T.1154A

1. **Purpose.**—General purpose aircraft transmitter for use with R.1155.

2. **Frequency Ranges.**—Range 1. (H.F.) .. 10–5·5 Mc/s (blue).
Range 2. (H.F.) .. 5·5–3·0 Mc/s (red).
Range 3. (M.F.) .. 500–200 kc/s (yellow).

Separate coloured tuning dials are used for above ranges. Variable condensers are used for tuning ranges 1 and 2, and for the M.O. only on range 3. The P.A. on range 3 is tuned by tapped inductance, with variable permeability fine tuning. Eight adjustable "click-stops" are fitted to each dial, so that twenty-four "spot" frequencies are quickly available. Fine tuning of the M.O. is also provided on ranges 1 and 2.

3. **Valves.**—M.O., V.T.105, triode; P.A., two V.T.104 pentodes (in parallel); tone oscillator and modulator, V.T.105.

4. **Power Supplies.**—L.T. and H.T. supplied from motor generators. One machine supplies L.T. and receiver H.T., and another the transmitter H.T. :—

(i) *L.T. machine*—
Input: 12 volts 23 amps., or 24 volts 10 amps.
Output: L.T.—7 volts 13 amps; H.T.—217 volts 110 mA.

(ii) *H.T. machine*—
Input: 12 volts 32 amps., or 24 volts 22 amps.
Output: 1,200 volts 200 mA.

5. **Aerial Systems.**—Aircraft fixed aerial on ranges 1 and 2. Aircraft trailing aerial on range 3 (except on D/F when fixed aerial is always used).

The aerial selector switch, type "J", selects the correct aerial, and also prevents transmission on "D/F" or "earth" positions. There are five positions :—

(i) *Normal.*—Both aerials connected ; correct one selected by transmitter range switch.

(ii) *D.F.*—Trailing aerial and H.T. starter relay disconnected. Receiver master switch on " balance ", " visual " or " ∞ "

(iii) *Earth*—Aerials earthed. H.T. starter relay disconnected.

(iv) *M.F. on fixed aerial.*—Fixed aerial loaded by 80 $\mu\mu$F to tune to 200–500 kc/s.

(v) *H.F. on trailing aerial.*—Trailing aerial connected on ranges 1 and 2.

6. **Circuit.**—A simplified circuit is at fig. 83. A Hartley M.O. is capacity-coupled to P.A., which has two pentodes in parallel. Neutralising is unnecessary. The P.A. is parallel-fed, and anode tap is varied automatically with P.A. tuning control. R/T and M.C.W. are obtained by suppressor-grid modulation of the P.A. A.F. voltage for modulation is obtained from the V.T.105 modulator valve, which acts as a 1,200 c.p.s. oscillator on M.C.W. It also oscillates on C.W., the audio note produced providing " side-tone ".

A master switch operates the necessary circuit changes and has the following positions :—

(i) *Off.*—Power units stationary. Transmitter and receiver " dead ".

(ii) *Stand-bi.*—L.T. machine running ; receiver on ; transmitter filaments heated.

(iii) *Tune.*—Transmitter H.T. on. Low-power C.W. transmission available with side-tone and listening-through. Power reduced by negative bias on suppressor grids and reduction of H.T.

(iv) *C.W.*—Full H.T., and positive bias on suppressor grids. Both M.O. and P.A. grid circuits are keyed.

(v) *M.C.W.*—Suppressor grids connected to bias resistance via output choke of 1,200 c.p.s. tone oscillator. Negative bias on suppressor grids gives 100 per cent. modulation without distortion. S/T and L/T still available.

(vi) *R/T.*—Circuit as for M.C.W., but tone oscillator valve used as modulation amplifier ; 70 per cent. to 80 per cent. modulation. Carbon microphone placed in grid circuit of modulator. E.M. microphone requires external amplifier, A.1134 or A.1219. Key must be pressed or key switch on pilot's cockpit closed. No S/T or L/T.

7. **Tuning Instruction.**—(*a*) *Setting up on H.F. ranges, using click-stops.*—(i) Select appropriate range by wave-change switch.

(ii) If type " J " aerial switch is fitted, put switch to " normal ". If aerial plug board is fitted, put H.F. on " fixed ".

(iii) Rotate M.O. tuning condenser until selected indicated click-stop pip is seen to engage in slotted bar.

(iv) Loosen grub-screw at the base of fluted channel by corresponding letter on M.O. tuning knob.

(v) M.O. should then revolve, leaving selected indicated pip still engaged.

(vi) Repeat for P.A., using the same letter.

(vii) Put master switch to " stand-bi " ; when the filaments have heated, move master switch to " tune ".

(viii) Note reading in input milliammeter when key is pressed.

(ix) Adjust M.O. approximately by rough calibration disc, which is read from white index line.

(x) Press key and tune M.O. to desired frequency, by crystal monitor if possible. (Plug in phones to monitor and tune for dead space.) If not possible use wavemeter, or back tuning from calibrated receiver dial.

(xi) Re-tighten grub-screw.

(xii) With indicated pip ***still engaged***, mark a line on celluloid disc, by the white index line, and write letter of click-stop.

(xiii) Put aerial tap switch to " 1 ".

(xiv) Tune the P.A. for minimum input mA.

(xv) Raise the aerial tap from " 1 ", and the input will be seen to rise.

(xvi) Retune the P.A. slightly and the input will be seen to dip, though not so much as before.

(xvii) Continue raising aerial tap switch reading and re-tuning each time until, at the bottom of a dip, the meter reads 65 milliamps (green line).

(xviii) On " tune " position a slight reading should be obtained in aerial external ammeter.

(xix) Put master switch to " C.W." and note reading in aerial ammeter. Ensure ammeter is not shorted by push button. Reading should rise in input to " 100 ".

(xx) Re-tighten grub-screw, and mark as M.O.

(xxi) Mark calibrated frequency by appropriate click-stop letter on calibration chart.

(xxii) Select either " C.W.", " M.C.W." or " R/T ", as required, remembering key has to be pressed on R/T.

(xxiii) Input meter should read 65 milliamps on " tune ", " M.C.W. and " R/T ".

N.B.—Aerial taps must not be adjusted with key pressed. If desired, aerial tap switch position may be marked on calibration dial, after the frequency.

(*b*) *Setting up on M.F. ranges, using click-stops.*—(i) As before.

(ii) If type " J " aerial switch is fitted put to " M.F." on " Fixed ". If aerial plug board is fitted, put " fixed aerial " on " M.F."

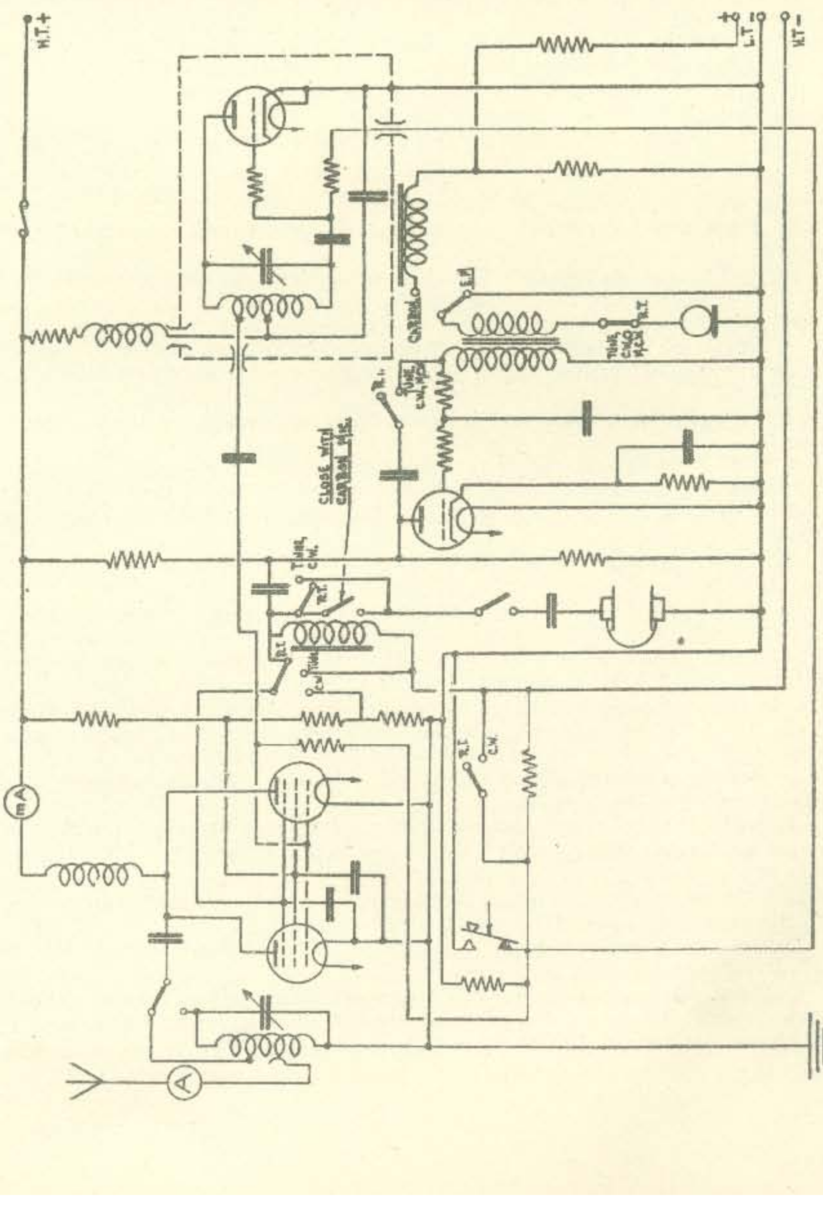


FIG. 83.—Simplified circuit T.1154.

(iii), (iv) and (v) as before.

(vi) Put P.A. aerial tap switch to 17 and anode tap switch to 18 (both pointing inwards).

(vii), (viii), (ix), (x), (xi) and (xii) as before.

(xiii) Press key and note input.

(xiv) Reduce aerial taps until minimum input is obtained, at the same time utilising fine tuning control to obtain exact minimum input.

(N.B.—Attempt to get minimum input with aerial tap switch reading as *high as possible*.)

(xv) Increase anode tap readings until the input rises to 65 milliamps, retrimming the P.A. for dip with the fine tuning control, and re-adjust aerial tap to obtain dip if necessary.

(xvi) Put master switch to " C.W.", and note reading in internal aerial ammeter.

(xvii) Mark selected frequency on calibration dial by appropriate click-stop letter.

(xviii) If desired, the aerial and anode tap switch readings may be noted here.

(xix) The fine tuning control position may be marked on ivorine disc at base of control.

Notes.—(i) Readjustment of P.A. tuning will be necessary when air-borne.

(ii) Aerial and anode taps must *not* be adjusted with key pressed.

(iii) The click-stops may be released at any time and a friction drive incorporated.

(iv) The vernier adjustment gives a clickstop variation of $\pm \cdot 1$ per cent.

(v) When tuning the P.A. always start with the tuning control fully anti-clockwise, and if two dips are obtained, tune to the greater of these "

(*c*) ***Back tuning*** (*transmitter to receiver*).—(i) Tune in appropriate signal on receiver.

(ii) If " magic eye " is closed, reduce volume control until eye *just opens*.

(iii) Select similar range on transmitter.

(iv) Put master switch to " tune " and press key.

(v) Rotate M.O. condenser until magic eye closes from transmitter signal.

(vi) For fine adjustment, *half open* magic eye by volume control and readjust.

(vii) To avoid harmonics, note rough calibration readings on transmitter.

8. **Fault Finding.**—(i) *Rotation of P.A. tuning does not alter feed.*—(*a*) Turn to another range and set tap switch to No. 1 tap. If no dip, check H.T. volts by turning to M.F., detuning P.A. and pressing key. Feed should exceed 200 mA.

(*b*) If no dip occurs on *any* range, inspect V.T.105 M.O. heater; if burnt out, replace.

(*c*) If H.T. and M.O. correct, suspect circuit of M.O. Apply Avo test. Take out H.T. plug, test from H.T. plus, plug C, to M.O. anode. Ranges 1 and 2, 50,000 ohms. Plugs C to E, range 3, 19,000 ohms. This verifies H.T. continuity. Check M.O. grid to E, 20,330 ohms. Check V.2, V.3 grids to plug D, pin 7, 20,350 ohms in " tune " position. Grids to E, 25,000 ohms.

(ii) *Aerial current low.*—(*a*) If anode current on " tune " also low, observe filaments of V.T. 104's. If of same brightness, valves probably correct. If not, change one with duller filament. If no spare available, use one valve only, but remove faulty valve.

(*b*) Aerial current may be low due to incorrect tuning. Check that harmonics are not being tuned. Check aerial for breakdown. See that all plugs are in position.

(iii) *No side tone.*—(*a*) Turn to " stand bi ". If signals audible on receiver and of normal strength, S/T valve faulty.

(*b*) If no signals on " receiver " or " tune ", fault in phone circuit. Verify H.T. by observation of " magic eye ".

(*c*) Make normal checks for H.T. on transmitter. If S/T valve correct, check circuits with Avo. Plug C to anode V.4, 75,000 ohms. Cathode to E, 800 ohms. Grid to E, 13,000 ohms.

(iv) *No feed current.*—(*a*) Inspect filaments of V.T.104's. If correct, examine fuse; if correct, check that H.T. is being supplied by Avo at valve anodes, 1,000–1,200 on ," tune ". If no H.T., check aerial switch receiver master switch combination. Check filaments at meter plug on receiver pins 4 and 5, 6–7·5 volts.

(*b*) If H.T. gives no reading, but machine runs in "tune" position, turn off machine and check continuity between P.A. anodes and plug C, 50 ohms. If correct, check resistance across H.T. plug C to E, 27,750 ohms.

(*c*) If H.T. circuits correct on T.1154, check from machine with care. Plug C to E, 1,200 volts.

(v) *Feed current very low.*—Screen grid probably disconnected. Check from plug C to screen V.T.104, 20,000 ohms. Screen to E, 14,000 ohms.

(vi) *Feed current excessive but P.A. tends to tune.*—P.A. grid circuit open. Check P.A. grid to E, 25,000 ohms. Plug D, pin 7, to grid, " tune ", 20,350 ohms. Suppressor grid circuits. " Tune ", suppressor grid to plug D, pin 7, less than 1 ohm, *C.W.*, 7,000 ohms; *R/T* 5,000 ohms.

(vii) *Valve tests.*—(*a*) *Suppressor grid circuits.*

Test plug (pin 7 to suppressor grid).	Switch position.	Resistance (ohms.).
D	" Tune "	0 (" short ")
D	C.W.	7,000
D	M.C.W.	5,000
D	R.T.	5,000
E	" Tune "	5,350
E	C.W.	2,000
E	M.C.W.	10,350
E	R.T.	10,350

(*b*) *Anode circuits*—Anode cap to plug C, 50 ohms.

(*c*) *Screen circuits.*—Screen to E, 14,000 ohms.; screen to plug C, 20,000 ohms.

(*d*) *Control grid.*—Plug D pin 7 to grid, "Tune ", 20,350 ohms; " C.W.", 20,000 ohms; " M.C.W.", 20,350 ohms; " R.T.", 20,350 ohms. E to grid, 25,000 ohms.

(*e*) *V.1 and V.4 circuits.*—V.I.—Plug C to anode (switch to R.1 and R.2), 50,000 ohms; plug C to anode (switch to R 3), 25,000 ohms; E to anode (switch to R.3), 19,000 ohms; cathode to E, " short "; grid to E, 20,350 ohms.

V.4.—Anode to plug C, 75,000 ohms; cathode to E, 800 ohms; grid to E, 13,000 ohms.

(viii) *Resistance of components.*—T.1. primary, 7 ohms approx.; L.1. test across C.2, less than 1 ohm. Secondary, 5,000 ohms; L.2. test across C.4, less than 1 ohm. L.F.C.3, 11 ohms; L.3 test across C.17, less than 1 ohm. L.F.C.2, 130 ohms; L.4 test across C.15, less than 1 ohm. H.F.C.2, 10 ohms; L.5. test across C.16, less than 1 ohm. H.F.C.1, 45 ohms; L.6 test between taps 1 and 17; switch at 17, 5·2 ohms. Keying relay coil A, 12 ohms; B.1, 5 ohms; C.2, 1 ohm. Microphone check. Pin and microphone to E link, switch to " E/M ", 7 ohms. Pin and microphone to pin 6, plug D, switch to " carbon ", M/S to R/T, 29 ohms.

9. **Points to Watch.**—(i) *Complete failure.*—Check main charging fuse and power unit fuse. See power unit plugs properly home and locked. Check accumulators (on ground); check starter socket.

(ii) *Complete failure in flight.*—Accumulator run down. Check charging switch and fuse. Check power unit fuses and plugs as above.

(iii) *No transmitter input.*—Check fuse of H.T. power unit and plugs of both units. Check H.T. fuse (tinfoil may be used in emergency). Check P.A. valves.

(iv) *Low input.*—Check charging switch and fuse. Increase power tap if possible and re-dip. Check P.A. valves (one probably unserviceable). On H.F. check pre-set anode tap.

(v) *Excessive input.*—Ensure resistance switch in and P.A. dipped correctly. M.O. or P.A. valves may be faulty.

(vi) *Input but no output on M.F.*—See range switch set correctly and using correct P.A. tuning. If dip is normal, current probably there but ammeter unserviceable. If no dip aerial disc, check plug board.

(vii) *Input but no output on H.F.*—If dip normal, ammeter may be out of circuit. A sharp dip and low input even on tap 9—no aerial. Check sockets on right-hand side of transmitter.

(viii) *Low output.*—If on tune and output insufficient, switch to "C.W." Ensure P.A. tuned to the correct dip, i.e. lowest feed. Run down accumulator: check charging switch and fuse. Aerial tap too low: normally, 5/6 H.F. and 28 M.F. Check P.A. valves.

(ix) *Excessive output.*—Ensure resistance switch "in" when flying. Dip may be past red mark on C.W.; reduce tap and re-dip.

CHAPTER 17

RECEIVER R.1155

1. **Purpose.**—General purpose aircraft receiver for use with T.1154. Provides receptions of C.W., M.C.W. and R/T, and also gives both visual and aural D.F. with sense determination.

2. **Frequency Ranges** :—

Range 1	.. ..	18·5—7·5 Mc/s (no D/F on this range).
,, 2	.. ..	7·5—3 Mc/s.
,, 3	.. ..	1,500—600 kc/s.
,, 4	.. ..	500—250 kc/s.
,, 5	.. ..	200—75 kc/s.

3. **Valves.**—V.R.100, R.F.; V.R.99, F.C.; two V.R.100, I.F.; V.R.101, A.V.C. and B.F.O.; V.R.101, detector and output; V.R.103, "magic eye". Also two V.R.99 aerial switching valves, and V.R.102 meter switching valve, for D/F. Ten valves in all.

4. **Power Supplies.**—Motor generator (see T.1154 notes).

5. **Aerial System.**—T.1154 aerials are used, via aerial selector switch, type J, and T.1154 keying relay. Normally, fixed aerial on ranges 1 and 2, trailing aerial on ranges 3, 4 and 5. Also rotating loop, type 3, in streamline casing for D/F, and loop with fixed aerial only for sense-finding.

6. **Circuit** (a schematic diagram is at fig. 84).—(i) *Communication circuits.*—(*a*) The R.F. amplifier is a vari-mu R.F. tetrode having a tuned grid circuit, and a tuned transformer coupling to F.C. A.V.C. or manual gain control is available.

(*b*) The F.C. is a triode-hexode, combining the functions of first detector and oscillator. The oscillator circuits are designed to give a high degree of stability, and their tuning condenser is ganged to those of the signal circuits, giving one-knob control on all frequencies.

(*c*) The I.F. is 560 kc/s, and the oscillator is set *high*. There is an I.F. wave trap in the signal grid circuit of the F.C. A.V.C. or manual gain control is available.

(*d*) The two I.F. amplifiers are tuned-transformer coupled, and aligned by adjustment of iron-dust cores. Capacity coupling between primary and secondary gives a band width of 5 kc/s. Both stages have A.V.C. or manual gain control.

(*e*) The heterodyne oscillator (or B.F.O.) is the triode section of a V.R.101, used in a Colpitts circuit tuned to 280 kc/s $\pm$ 3 kc/s. The second harmonic of this oscillator is applied, together with the I.F. C.W. signals, to the second detector. The diodes of the heterodyne oscillator V.R.101 valve are joined in parallel, and used to rectify the I.F. voltages for the purpose of applying delayed A.V.C. Full A.V.C. is applied to F.C. and first I.F., half is applied to the R.F. amplifier, and one-tenth only to the second I.F. (because it has to supply six diodes). A.V.C. is available with master switch to "A.V.C.", "visual" or "balance" Manual control is used on "omni" and "aural" position; but when using A.V.C. the manual gain control still varies the A.F. gain.

(*f*) The full A.V.C. voltage is always applied to the "magic eye" (V.R.103) tuning indicator, whether A.V.C. or manual gain control is in use. This device is arranged to give a varying shadow on a fluorescent target, and its principle can be explained with the aid of fig. 85. The valve consists of a conical anode T, which is so coated as to become luminous when bombarded by electrons. The cathode protrudes through a hole in the anode, and when H.T. is applied the anode "T" becomes luminous. The triode section of the valve beneath the target anode has another anode "A", attached to which is

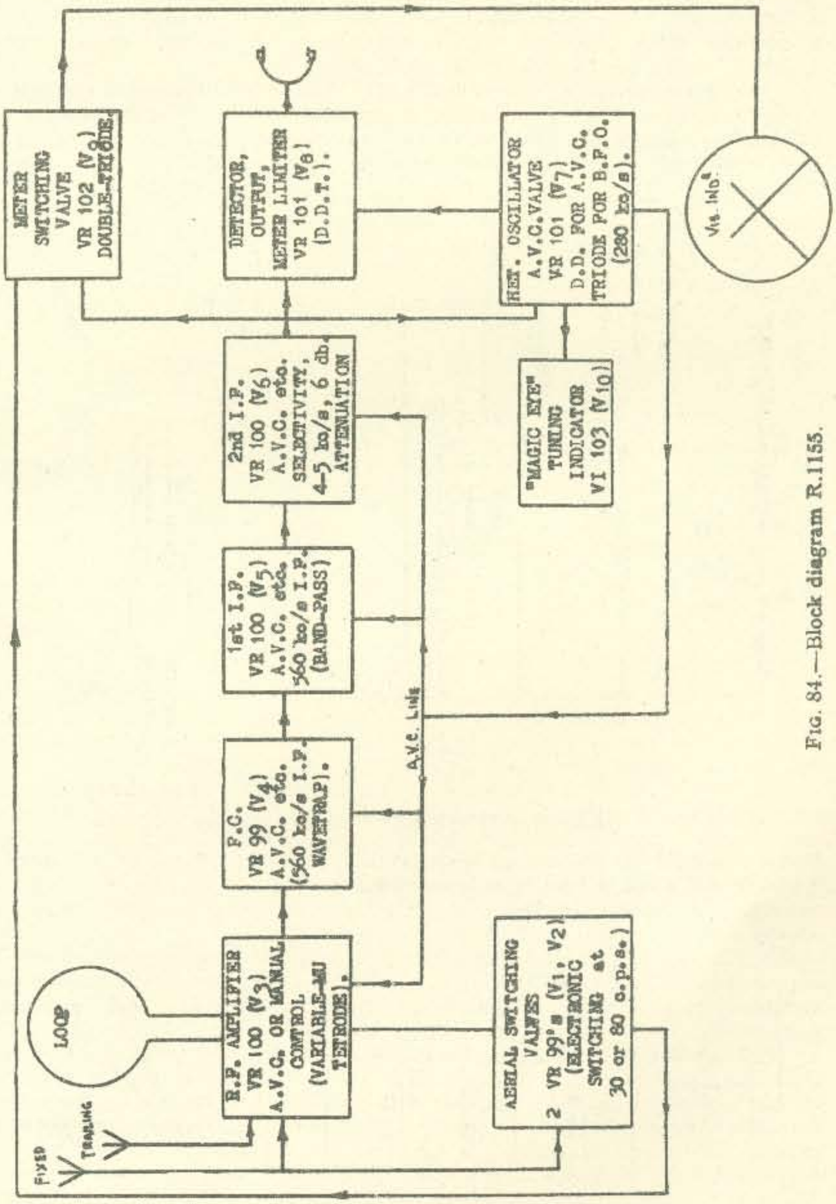


FIG. 84.—Block diagram R.1155.

a deflector wire " D ", which also protrudes into the upper portion of the valve.

The anode " T " is connected direct to H.T. plus, but "A" is connected via a 1 megohm resistance. There is thus a P.D. between " T " and the wire " D " so that electrons will be deflected away from " D " (which is negative with respect to " T "), producing a " shadow ". The A.V.C. bias is joined between grid and cathode, and when a signal is tuned in, the increased negative potential on the grid of the M.E. will cause a decrease in anode current, a decrease in P.D. between " T " and "A", and, therefore, a decrease in shadow (i.e. the " eye opens ").

(*g*) Another V.R.101 valve performs the functions of second detector (one diode) and output valve (triode section). A potentiometer controls the A.F. input to the triode, and is mounted on the same spindle as the volume control used to control the R.F. and I.F. valves when using " manual " gain control. A " high-pass " filter may be switched into the A.F. circuit to cut out all frequencies below 300 c.p.s. The second diode of this valve is the " meter limiting " valve used in connection with visual D/F.

(ii) *D/F circuits.*—(*a*) " Switched heart " D/F is used for visual indication. The principle is as follows :—Pick-up in the fixed aerial is the same irrespective of the direction or the position of the station being received, but with the loop it will vary according to the relative positions of the station and the

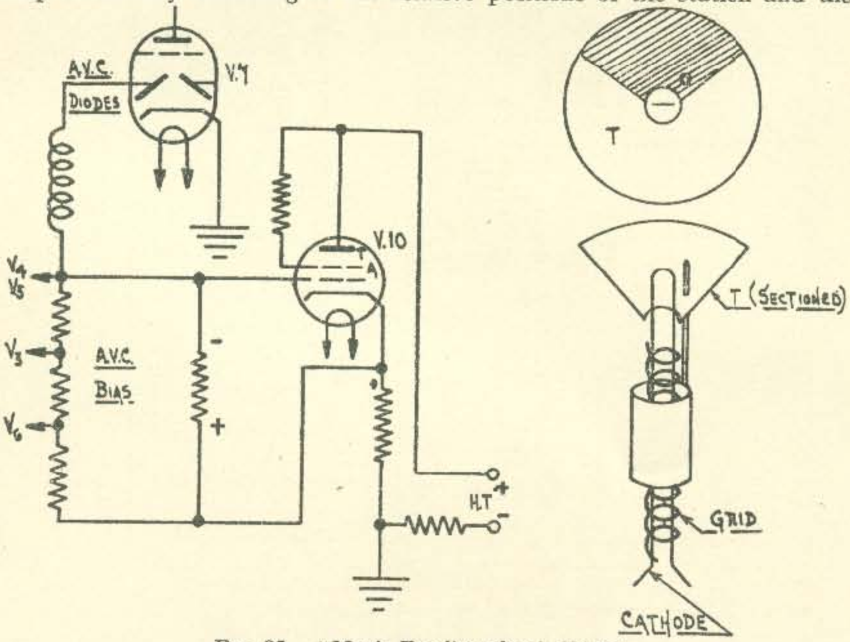


FIG. 85.—" Magic Eye " tuning indicator.

loop Consider fig. 86, and imagine the loop in two positions with respect to a station on which a bearing is being taken :—

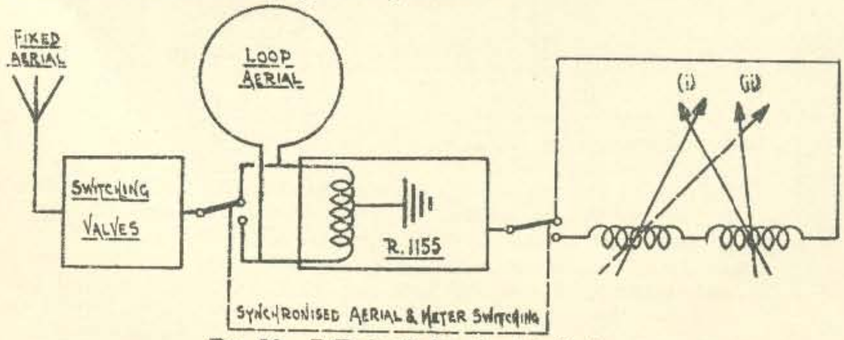


FIG. 86.—D/F circuit for visual indicator.

(1) Loop voltage zero, fixed aerial voltage 10. The vertical aerial is being switched, but the input voltage to the receiver will be the same (i.e. 10) in either position of the switch. The rectified output current fed to the meters will be the same in either position of the switch. The meters will, therefore, read the same, and the needles will intersect on the centre line.

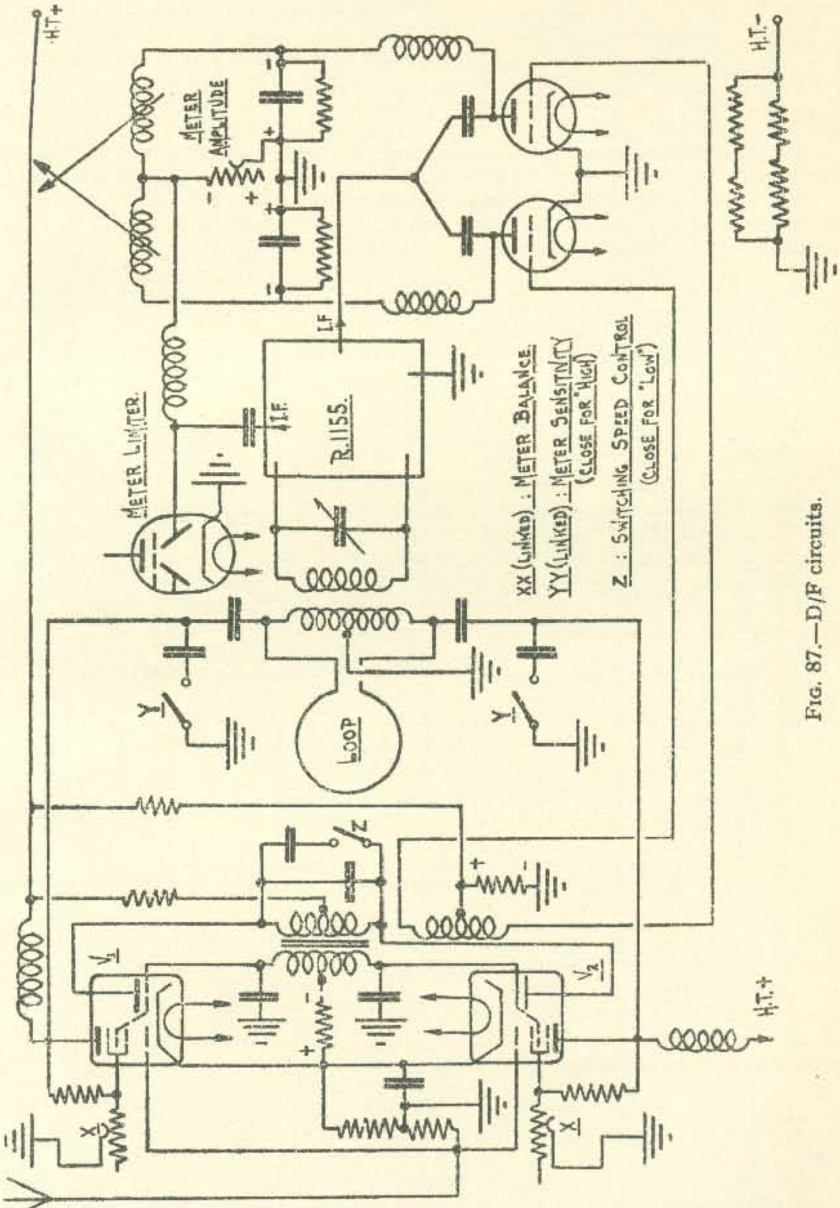


FIG. 87.—D/F circuits.

(2) Loop voltage 2, fixed aerial voltage 10 (loop somewhat offset, or aircraft off course). Input to receiver in one position of the switch will now be 12 (loop voltage assisting fixed aerial), and in the other position the total input will be 8 (vertical voltage reversed in sign). As the meter switch is being operated simultaneously with the aerial switch, the current through one meter will be larger than that through the other, so that one meter will read high and the other low, giving an "off-course" indication.

Mechanical switching at a sufficiently high speed to prevent the needles collapsing is impracticable, so that electronic switching is employed.

(*b*) Fig. 87 shows the D/F circuits of R.1155. Two V.R.99's are used to switch the fixed aerial at 30 or 70 c.p.s. (30 cycles for R/T and 70 for W/T). Voltages at these frequencies are also applied between grids and cathode of the double-triode meter switching valve. Each grid is at opposite potential, so that each valve conducts in turn and in step with the changing aerial input to the receiver. The " meter limiter " diode acts as a " second step " A.V.C. to prevent the needles of the meter flying off the scale with very strong signals.

(iii) *Meter balance control.*—When receiver master switch is at " balance " the loop is replaced by a " dummy loop " consisting of a suitably matched inductance and condenser, completely screened. The balance of the aerial switching valve circuits may then be corrected by adjusting their screen potentials until the needles intersect on the centre line.

(iv) *Meter deflection switch* by-passes a portion of the fixed aerial voltage to earth via two condensers when at " high ", increasing the sensitivity so that maximum deflection of the pointers takes place when the loop is off-set by 10°. With switch at " low ", maximum deflection occurs when loop is off-set by 25°. " High " deflection is used for bearings and " low " for " homing

(v) *Meter amplitude control* controls the polarising current through the meters and thus the *mean* height of the needles.

(vi) *Vertical aerial adjustments.*—The amount of input from the fixed aerial to the switching valves may be adjusted by a small pre-set condenser. This is a screwdriver adjustment on the right-hand side of the panel, made only when the R.1155 is first installed in the aircraft.

(vii) *Loop lead capacity adjustment.*—Another pre-set condenser, located in the loop load input socket, is adjusted when the R.1155 is installed. Tune in a signal on about 1,500 kc/s and adjust for maximum volume.

7. **Tuning Instructions.**—(i) *Normal.*—(*a*) Select appropriate range by wave-change switch.

(*b*) Put master switch to " stand bi ".

(*c*) Put tuning to approximate setting on calibrated dial.

(*d*) Tune in signal, using fine tuning if necessary.

(*e*) For C.W. reception " het. osc." must be " on ".

(*f*) The presence of a signal should also be indicated in the cathode-ray indicator.

(*g*) A.V.C. may be obtained by moving the master switch.

N.B.—On A.V.C. the manual volume control still *controls the strength of signal.*

(ii) " *Bearing* " (*using visual indicator*) —(*a*) The aerial selector switch should be turned to " D/F ". If aerial plug board is fitted :—H.F. on fixed, M.F. on trailing.

(*b*) Put transmitter master switch to " stand bi "

(*c*) Select appropriate range.

(*d*) Put receiver master switch to " omni ".

(*e*) Switch " het. osc." " on " for C.W. signals.

(*f*) Tune to selected station and adjust volume.

(*g*) Put switch speed to " high " for W/T bearings, and " low " for R/T bearings.

(*h*) Turn " meter deflection " switch to " high ".

(*i*) Turn master switch to " balance " and observe needles

(*j*) If needles do not cross on centre line, rotate meter balance potentiometer until they do.

(*k*) With meter amplitude adjust the needles to a convenient working height.

(*l*) Turn master switch to visual and the needles should operate.

(*m*) Rotate loop until needles cross on centre line, and note loop reading.

(*n*) To " sense ", *reduce* the loop reading, and if the needles move to the *right*, sense is correct.

(*o*) Return loop to original reading.

(iii) " *Homing* "(*using visual indicator*)—(*a*), (*b*), (*c*), (*d*), (*e*), (*f*) and (*g*) as before.

(*h*) Turn meter deflection switch to " low ".

(*i*), (*j*), (*k*) and (*l*) as before.

(*m*) Set loop reading to zero (across aircraft).

(*n*) Request pilot to alter course until needles on his indicator cross on centre line.

(*o*) To sense, (*a*) as before; (*b*) off-set course a few degrees to *starboard*. If station is ahead, needles will now intersect on the *left*.

Note.—(i) During homing, " balance " should constantly be re-checked.

(ii) When flying over the home station the needles will collapse for a few seconds.

(iv) *Aural D/F*.—(*a*) Tune in required station on " omni ".

(*b*) Turn master switch to " figure of eight " position.

(*c*) Rotate loop until *minimum signal* is obtained. (Use volume control if necessary to obtain zero signal.)

(*d*) *To sense, reduce* the loop reading, putting the " aural sense " switch to " R " If signal *rises*, sense is correct.

8. **Fault Finding.**—(i) *No signals*.—(*a*) Observe magic eye. If correct, tune to *known* loud signals, and note if deflection occurs with V.C. at " omni max ".

(*b*) If magic eye deflects, turn T.1154 to " tune " and press key. If side tone correct, V.8 is faulty.

(*c*) If side tone correct, either V.8, output transformer or telephone lead. Check output transformer by testing between power plug 6 and E ; 1,000 ohms. Meter plug 6 and power plug 5 ; 1,528 ohms. Check telephone lead. No S/T, circuit from transmitter faulty.

(ii) *No signals, magic eye dark*.—(*a*) Observe T.1154 filaments. If correct, H.T. to receiver is off.

(*b*) Inspect aerial switch and interlock socket, master switch combination. If correct, measure receiver H.T. volts, meter plug pin 6 and chassis ; 200 volts.

(*c*) Examine L.T. machine. Plugs may not be making contact. Check L_3 and L_4 (2·5 and 12 ohms). Examine commutators. If no filaments, check if L.T.M.G. is running. If running, fault in power cable. If not, examine starter circuits. Check plugs first and L.T. fuse.

(iii) *No C.W.*—(*a*) Check heterodyne switch " on ". Tune to known strong signal, and attempt to adjust B.F.O. by panel control.

(*b*) If no adjustment, tune to strong M.F. and turn to " visual ". If needles uncontrolled, suspect V.7 and change.

(*c*) If changing V.7 does not give C.W., suspect components. Check L.22 between fixed plates C.13 and R.18 ; 5 ohms.

(iv) *No signals, hiss or noise in phones*.—(*a*) Tune to 280 kc/s, turn on C.W. If whistle heard, suspect V.3 and change it.

(*b*) If no whistle on 280 kc/s, change V.4, V.5, V.6.

(*c*) If this produces whistle but still no signals, check aerials. If no signals when aerials are correct, suspect breakage of leads in V.3 and V.4 stages.

(v) *No signals on H.F. or part of H.F. ranges, but correct on M.F.*—(*a*) Check H.T. volts between meter plug contacts 4 (E) and 6, anode V.5 (200).

(*b*) If H.T. volts correct, change V.4. If H.T. low, check receiver for semi-short. Remove meter plug, check with Avo across pins 4 and 6 ; 1,000 ohms. Turn off power to do this.

(*c*) If H.T. volts correct and 11,000 ohms normal, check L.T. across pins 4 and 5 of meter plug. If these are low, check that res. unit is out of circuit ; if L.T. and H.T. are correct, suspect circuit fault on H.F. ranges, oscillator and input.

(vi) *Whistles and oscillation on all or some ranges, particularly range 4*.—(*a*) Due to instability of I.F. stages. Check that cap V.6 is on valve screen. Inspect screened leads for earthing on V.4 anode, V.5 and V.6 grids. Check screening on phone lead to power plug pin 6, in cable to transmitter.

(*b*) Turn to A.V.C. and check if whistles still occur ; if gain is down generally, V.5 or V.6 should be changed. Turn to H.F. and M.F., noting if whistles are worse on either range. If worse on M.F., instability of I.F. is certain.

(vii) *No volume control.*—(*a*) Due to shorting receiver, H.T. will probably be in transmitter plug A, contact 8.

(*b*) If H.T. not in transmitter, check cables at terminations. If cables correct, check receiver between contacts 8 power plug, and 4 meter plug, with frequency switch on ranges 3, 4 and 5 ; 1,200 ohms.

(*c*) If short to earth on receiver present, this may be due to C.1 disconnected ; re-check for 1,200 ohms. If open circuit, check R.4 and R.3 ; 120 and 1,200 ohms.

(viii) *Visual D.F. will not balance.*—(*a*) Turn to aural D.F. and find aural null. Turn down volume control, turn meter deflection to " low " and sense switch to L and R. If signals equal, V.9 faulty.

(*b*) If signals are unequal and balance control one-sided, i.e., turned to extreme left or right side, turn to aural again, and note to which side signals are louder. If possible, check sense roughly first by correct bearing of station. Obtain this, and turn to L and R again. If louder signals on L side, change V.2 ; if louder on R side, change V.1.

(ix) *Visual needles uncontrolled on loud signals.*—(*a*) Turn to C.W. and check that this is working ; if not, change V.7.

(*b*) If C.W. correct, limiting diode in V.8 may be faulty and V.8 should be changed.

(*c*) Examine receiver and note values of R.48 and R.50. If 6,800, change to 3,300. Also add 1,000 in series with V.8 diode and C.20. (*Record this.*)

(x) *Visual needles rise but do not move with loop movement.*—(*a*) Loop disconnected. Check plug and loop connections. Turn to " aural " and search for aural null.

(*b*) If very weak signals obtainable on aural, indicates complete disconnection of loop. If of fair strength, one side disconnected.

(*c*) Turn to L and R ; strength should be greater in L and R positions and of equal strength. If connections correct, inspect circuit.

(xi) *Needles only rise slightly on "balance" and "visual" and minimum broad.*—(*a*) Aerial plug disconnected. Check M.F. aerial to T.1154 and whole of fixed aerial system. Check cable from T.1154 to R.1155. T.1154 plug A pin 1, R.1155 power plug pin 1.

(*b*) Meter amplitude control may be at low setting. V.9 may be faulty. Examine heater.

(*c*) Meter may be disconnected.

9. Component Tests.

Components.	Test Points.	Resistance, ohms.
A.F. oscillator transformer (switching oscillator).	(P) V.1 oscillator anode to V.2 oscillator anode.	800.
	(S) V.1 oscillator G to V.2 oscillator G.	355.
	(Second sec.) R.65, C.29 to R.66, C.23, or across pins 7 and 8, meter plug.	331.
I.F. coils—		
L.19P	V.4 anode to R.34, C.32 ..	2.
L.19S	V.5 G to R.33, C.33	2.
L.20P	V.5 anode to R.30, C.29 ..	2.
L.20S	V.6 G to R.29, C.30	2.
L.21P	V.6 anode to R.58, C.27 ..	2.
L.21S	V.7 diode to R.20, C.11 ..	2.
B.F.O. coil L.22	Fixed plates C.13 to R.18 ..	5.
Anode chokes V.1 and V.2—		
L.24	V.1 anode to R.46, C.41 ..	550.
L.24	V.2 anode to R.46, C.41 ..	550.
Visual meter chokes—		
L.26	V.9 diode to C.3, R.25	130.
L.27	V.9 diode to C.5, R.24	130.

Components.	Test Points.	Resistance, ohms.
Limiter diode choke L.28 ..	V.6 limiter diode	130.
A.V.C. choke L.25.. ..	V.7 diodes to C.108, R.68 ..	130.
L.F. filter choke L.29 ..	S.5 switch to E	2,020.
Output transformer L.30 ..	(P) V.8 anode to pin 5 power plug.	1,528.
	(S) pin 6 power plug to E ..	1,063.
Aerial circuit—		
Range 1 input	V.3 grid to C.40 junction ..	Less than 1.
Range 2 input	V.3 grid to C.40 junction ..	Less than 1.
Range 3 input	V.3 grid to C.40 junction ..	Less than 2.
Range 4 input	V.3 grid to C.40 junction ..	Less than 5.
Range 5 input	V.3 grid to C.40 junction ..	Less than 57.
Loop input circuit.. ..	C.46 switch end, and C.47 switch end. Aerial circuits less than 1 ohm to earth.	—
V.4 input circuit	V.4 G to C.37, R.38 junction ..	Less than 1.
Range 2	Switch to R.2	Less than 1.
Range 3	Switch to R.3	Less than 3·5.
Range 4	Switch to R.4	Less than 11.
Range 5	Switch to R.5	Less than 78.
V.4 oscillator circuit ..	V.4 oscillator grid condenser C.35 (Z.F.12 contact) to joint R.35, C.34.	—
Range 1	Switch to R.1	Infinity.
Range 2	Switch to R.2	Infinity.
Range 3	Switch to R.3	1,600.
Range 4	Switch to R.4	1,650.
Range 5	Switch to R.5	0·5.
H.F. ranges 1 and 2 ..	Z.F.12 to Z.F.6 ranges 1 and 2	0·5.
	Ranges 3, 4 and 5	Infinity.
Oscillator anode coil ..	C.34, R.35 to C.75, C.74, C.73	—
	Range 3, C.34, R.35 to C.75 ..	2·5.
	Range 4, C.34, R.35 to C.74 ..	4·5.
	Range 5, C.34, R.35 to C.73 ..	8·5.
Oscillator anode coil taps ..	Z.R.6 to C.35 or Z.R.12 ..	—
	Range 1	Infinity.
	Range 2	Infinity.
	Range 3	1,600.
	Range 4	1,600.
	Range 5	1·5.
Output transformer ..	Withdraw meter plug measure between pin 6 and C.93.	1,528.

Components.	Test Points.	Reading.
	Voltage tests, etc.	
L.T. volts	Withdraw meter plug. Measure across plugs 4 and 5.	6–7·5 volts.
H.T. volts	Measure across plugs 4 and 6 ..	200 volts.
Standing bias, V.3, V.4, V.5, V.6	M.F. R.12 and chassis. Remote V/C to omni-max.	Negative, 3 volts.
	H.F., R.12 and chassis. Remote V/C to omni-max.	Negative, 1·5 volts.
D.C. resistance across H.T. positive and H.T. negative.	Withdraw meter plug, measure between pin 6 and chassis.	11,000 ohms.

Components.	Test Points.	Reading.
A.F. oscillator	Withdraw meter plug, measure between pins 7 and 8, using A.C. range of Avo.	" Slow " 28 V. " High " 35 V.
Colour code wiring ..	Red, H.T. positive .. .. Yellow, H.T. negative .. .. Blue, L.T. positive .. .. Black, earth .. .. .. Green, grids	Switches— W is aerial input. X is grid V.3. Y is anode V.3. Z is grid and oscillator V.4.

Notes.—(i) *Receiver—no signals, magic eye lit and working.*—Switch to " tune " and press key ; if no S/T, phones disconnected. Check at back of panel to which socket type 29 goes. Temporary connections may be made to the top pair of contacts, second socket from the left, T.1154. If S/T correct but no background with V/C at maximum, V.8 faulty.

(ii) *No signals, magic eye lit, but not working.* Aerial disconnected. Check plug board. See V/C is not too low. On M.F. (but not H.F.), V.4 faulty. Tune to 280 kc/s, if oscillator correct and whistle heard, V.3 faulty ; if not V.3 or V.4 it must be V.5 or V.6.

(iii) *R/T but no C.W.*—Ensure heterodyne switch " on ". If " on " V.7 faulty.

(iv) *Magic eye dark.*—No. H.T. Check plugs on receiver and power units, fuse L.T. unit. Ensure interlock socket not out. Magic eye may be faulty.

(v) *Weak signals.*—Switch may be to " D/F " ; change to " omni " or "A.V.C." Aerial disconnected, check plug. Low L.T., check charging switch and fuse. Valves : " eye " working, V.8 ; " eye " not working, V.3, V.5 or V.6.

(vi) *No visual facilities, low signals.*—Overloading limiter valve switch in filter, see interlock socket is not out. Check fixed aerial plugged into H.F. on board.

(vii) *As above, weak signals.*—Meter amplitude switch too low ; check tuning. Out of range.

(viii) *Meter working only one side.*—Change meter, V.1, V.2 or V.9 faulty. Switch to " ∞ ", tune to minimum, move to L and R ; if signals equal, V.1, V.2 correct, V.9 faulty.

(ix) *Instability, eye closed.*—Cover off I.F. valve. Screen off base of I.F. stage.

CHAPTER 18

BEAM APPROACH AIRCRAFT EQUIPMENT

1. **Purpose.**—To enable a pilot to approach an aerodrome on the correct track, and to maintain that track up to the moment of landing in conditions of bad (or nil) visibility. The equipment is remotely controlled by the pilot.

2. **Equipment** :—

(i) Main beacon receiver, R.1124A.

(ii) Main beacon receiver, vertical aerial system.

(iii) Marker beacon receiver, R.1125A.

(iv) Marker beacon receiver, horizontal dipole system and matching unit

(v) Pilot's control unit.

(vi) Visual indicator on pilot's dashboard.

(vii) Power unit.

(viii) Junction box, type 7, and breeze cable harness.

(ix) Junction box, type 9, or " mixer box ".

(x) Coaxial cable connectors—

(*a*) Type 57, main receiver to aerial.

(*b*) Type 86, marker receiver to aerial.

3. **Frequency Range.**—R.1124A ; six-spot frequencies in the band 30·5 to 40·5 Mc/s. R.1125A ; pre-set to 38 Mc/s.

4. **Valves.**—(Brimar valves are used throughout).—R.1124A ; R.F., V.R.106 vari-mu pentode ; F.C., V.R.107 pentagrid ; I.F., two V.R.106 ; second detector, V.R.108 pentode ; output, V.R.109 triode. R.1125A ; detector V.R.108 ; output, V.R.108. Power unit (neon stabiliser), V.S.110A or S.130.

5. **Power Supplies.**—Motor generator, permanent magnet type with smoothing equipment, starting relay, H.T. fuse, and a neon tube, for providing a stabilised H.T. voltage.

Input, 11 volts, 6·5 amps. Outputs, 13 volts, 1·8 amps L.T., 200 volts 50 mA H.T., stabilised line 120 volts ; speed, 5,000 r.p.m.

There is also a power unit for use in aircraft with 24-volt systems, providing the same outputs. In this case the input is about 22 volts, 3·5 amps.

Note.—Inputs should not be allowed to exceed :—

(i) 12-volt system, 7·5 amps.

(ii) 24-volt system, 3·75 amps.

6. **Aerial Systems.**—(i) R.1124A ; retractable vertical rod (normal length, 3 ft. 11 in.), connected to receiver by a 90-ohm coaxial cable. When specified by the makers a loading coil must be fitted.

(ii) R.1125A ; horizontal dipole, two ¼-in. tubes, each 39 in. long, enclosed in a bakelite housing. Fitted fore and aft on the fuselage, coupled by a coaxial cable and matched by a tapped tuned circuit (matching unit, type 8)

7. **Circuit** (the block schematic diagram (fig. 88) indicates the general principles of the equipment).—(i) R.1124A ; the aerial, R.F. anode, F.C. grid and oscillator circuits are each tuned by six pre-set condensers (24 condensers in all).

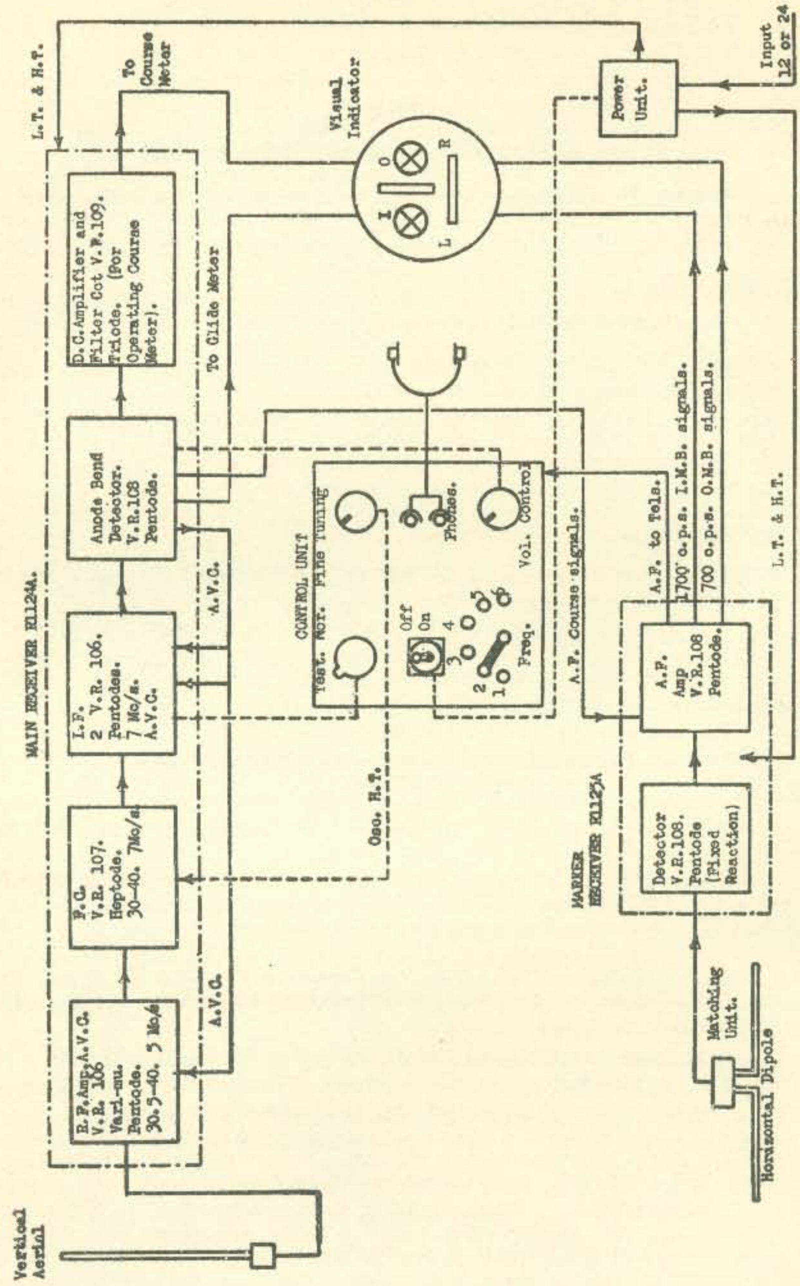


FIG. 88.—Block diagram beam approach aircraft equipment.

The oscillator anode H.T. is taken from the stabilised line and a variable series resistance provides the fine tuning control, giving a frequency variation of something between 40 and 60 kc/s.

The I.F. stages are tuned to 7 Mc/s band, width 60 kc/s, and a 10,000 ohm resistance is switched into the cathode circuit of the first I.F. valve, when the "test/normal" switch is at "test", giving a considerable decrease in gain. The "test" position is used for tuning purpose, limiting the input to the second detector to such an extent that the A.V.C. is inoperative. In the "normal" position the 10,000 ohm resistance is shorted. An A.V.C. system, which is especially designed to deal with the unusual type of signal, is incorporated, and A.V.C. is applied to the R.F. and both I.F. stages.

Note that the triode output valve does *not* deal with A.F. It is merely a D.C. amplifier whose job is to operate the " course " meter in the visual indicator. The 1,150 c.p.s. main beacon signals are amplified further and fed to the telephones by the output valve of the marker beacon receiver.

The volume control is a potentiometer arranged across the output transformer of the second detector, providing a variation of input to the common output valve in the marker receiver.

(ii) R.1125A ; a two-valve receiver employing two R.F. pentodes, a detector and output. The grid circuit detector is used in a Hartley circuit, the screen being fed from a fixed potentiometer between stabilised line and earth. This allows a small fixed reaction, giving good sensitivity.

The output pentode amplifies both main and marker beacon signals. There is no control of the volume of the marker beacon signals which come through very loudly.

The output transformer has three secondary windings across one of which the telephones are connected. The other two windings are each a part of two tuned circuits, one tuned to 700 c.p.s. and the other to 1,700 c.p.s., and across the respective capacities are connected the neon indicating lamps ; there is a potentiometer across each tuned circuit, providing a priming voltage for the neon lamps from the stabilised H.T. line.

8. **Pilot's Control Unit.**—(i) The " on/off " switch closes the supply circuit to the starter relay in the power unit.

(ii) The " test/normal " switch, used when tuning, stops A.V.C. action.

(iii) The frequency selector switch has six positions and permits selection of any of the frequencies to which the R.1124A is set up. The switch is remotely controlled by the pilot.

(iv) The fine tuning control varies the oscillator H.T.

(v) The volume control only varies the main beacon signals.

9. **Junction Box Type 9, or Mixer Box** (fig. 88A).—Only used in large aircraft where i/c is essential at all times. A three-position switch gives the following arrangements :—

(i) B.A. ; pilot on beam approach only (used when the pilot is actually making the approach).

(ii) Mix ; intercommunication and beam approach.

(iii) I/C ; intercommunication only.

10. **Visual Indicator.**—Provides visual indications as follows :—

(i) Course ; horizontal scale.

(ii) Glide path ; vertical scale (not used in R.A.F.).

(iii) Neon tubes ; two neon tubes marked I = inner and O = outer, which strike when the respective marker beacon signal is received.

(iv) The course meter is a centre zero moving coil micro-ammeter, which provides the " turn right ", " turn left " and " on course " indications. When flying in DOT sector (i.e. to LEFT of beam) the pointer kicks RIGHT. When flying in DASH sector (i.e. to RIGHT of beam) the pointer kicks LEFT ; hence, the meter is commonly known as the " kicker meter ". When flying ON the beam (i.e. in the equi-signal zone), the pointer remains in the centre position. The desired effect on this meter is achieved by shaping the pole pieces and the former, so that the pointer kicks quickly off centre, but returns slowly.

(v) The indicating neon lamps for the marker beacons are initially primed on the ground ; thus when the aircraft passes through the zone of signals from a marker beacon (say the outer), then a voltage is developed across the circuit tuned to 700 c.p.s., and this additional voltage is sufficient to strike the appropriate neon lamp.

Note.—In all cases the visual indications are supplementary to distinctive aural indications. In later receivers (R.1125B) neon lamps are not used.

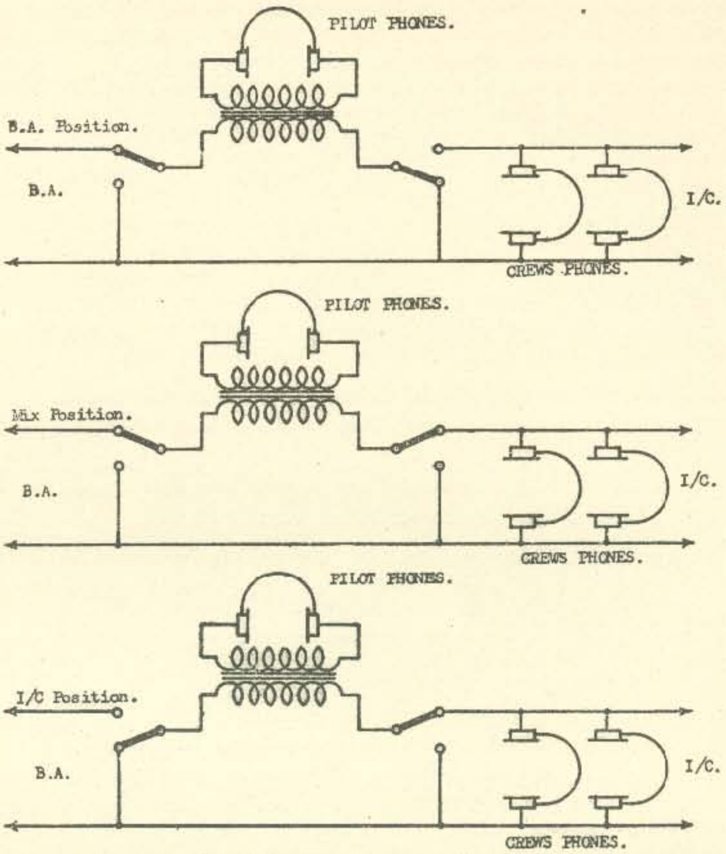


FIG. 88A.—Junction box, Type 9.

11. **Test Oscillator, Type 12** (fig. 88B).—Uses same principle as marker transmitter. Has C.O., R.F. mod., mixer-output and A.F. modulator stages, all triodes.

Issued with A.L. 1 to A.P. 1938

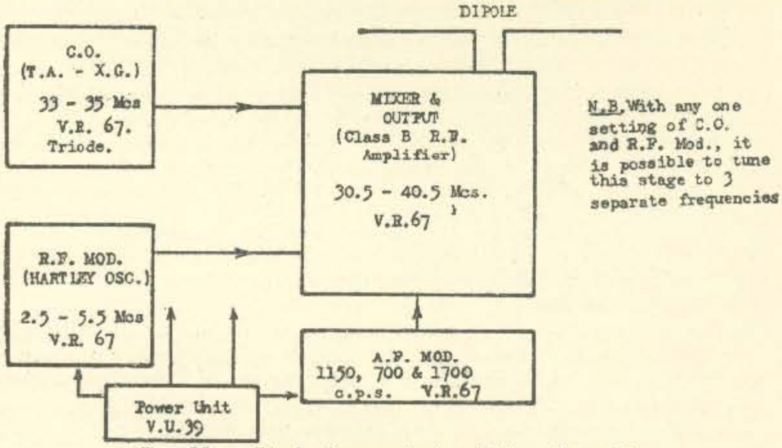


FIG. 88B.—Block diagram test oscillator, Type 12.

Gives crystal stability with M.O. flexibility of tuning, since it has C.O. and M.O. circuits working into a " mixer " valve, which has its circuit tuned to the desired sideband frequency.

The frequency range is 30·5 to 40·5 Mc/s, with two crystals. The crystals are ground to one-third of the desired frequency (i.e. about 11–13 Mc/s), and have a preponderance of third harmonic vibration.

The power supply is from 100–200 volts, 40–60 c.p.s., A.C. mains. A battery-driven (11-volt) motor alternator may be used if necessary.

A small dipole aerial plugs into sockets provided. The R.F. modulator tunes from 2·5–5·5 Mc/s, and can be set to within 5 kc/s. A.F. modulation is provided on 1,150, 700 and 1,700 c.p.s. Each stage may be disconnected, or a milliameter inserted, by means of removable two-pin links.

12. **Setting up Test Oscillator.**—(i) Main and A.F. modulator switches " off ". Insert dipole aerial.

(ii) Remove links of R.F. modulator and mixer stages.

(iii) Select the appropriate crystal from the calibration chart and plug into socket marked " crystal in use ".

(iv) Set crystal tuning condenser to appropriate mark and the reaction control to maximum.

(v) Insert mains plug and switch on. Pilot lamp should light. A 15 minutes warming-up period should be allowed.

(vi) Rotate crystal condenser until an upward kick is observed in grid current meter M.1.

(vii) Rotate the condenser through the tuning position and turn the reaction condenser to its minimum position. The steady off-tune deflection on M.1 should fall to zero, and the meter deflection rise sharply to a peak of 0·2 to 0·5 mA on passing through the tune position. Set crystal condenser to give maximum deflection. (Too much reaction will give rise to unwanted frequencies, and too little reaction will cause the oscillations to stop when the additional load of the modulators is applied.)

(viii) Check neutralising by rotating the output tuning condenser; no deflection should be observed in grid current meter M.1. (The dipole aerial should be removed for this test.)

(ix) If required to neutralise see that mixer link is out and set neutralising condenser to maximum, anti-clockwise position. Turn neutralising condenser until rotation of output condenser does not affect the reading of the grid current meter M.1.

(x) Insert mixer link and tune with output condenser for maximum in aerial meter, approximately 100–150 mA.

(xi) Set R.F. modulator to required frequency by means of calibration card, and switch to correct range.

(xii) Insert R.F. modulator link. Note setting of output condenser, then rotate it towards zero. A peak of approximately 50 mA should be observed corresponding to the lower sideband. Rotate the condenser towards the other end of the scale, and another peak of approximately 60 mA should be observed, corresponding to the upper sideband. Set condenser to sideband required.

(xiii) Switch on R.F. modulator and select the modulation frequency required by means of the tone switch.

(xiv) Check that the crystal is still oscillating.

13. **Setting up R.1125A.**—(i) Set up test oscillator to a frequency of 38 Mc/s, modulated at 1,700 c.p.s. and place it near to the marker dipole.

(ii) Set the neon priming controls fully clockwise. Adjust the tuning of the receiver and dipole until an output of 20 mW is obtained in a 20,000 ohms load. This corresponds to a reading of 20 volts on the 75 volts A.C. range of the universal avometer, and to 10 on the sensitive range (or 5 on the insensitive range) of the Taylor meter.

(iii) Advance the inner neon priming control until the neon just strikes and maintains a glow.

(iv) Switch test oscillator to 700 c.p.s. modulation ; the receiver will need to be slightly retuned to give 20 mW output.

(v) Advance the outer neon priming control until the neon just strikes and maintains a glow.

(vi) Switch test oscillator to 1,150 c.p.s.

(vii) First tune dipole, then receiver, return to dipole and finish on the receiver. If necessary, to obtain a suitable reading on the output meter, move the test oscillator farther away, or close in the aerials. When tuning the dipole, see that there are two tuning positions ; if only one, compress the coil to bring trimmer to centre of travel.

(viii) Check that the correct frequency has been tuned in by rotating output of the test oscillator and ensuring that the sideband required gives the maximum output in the receiver.

(ix) Check that the neons operate on 700 c.p.s. and 1,700 c.p.s. with the maximum obtainable signal. Ensure that only the correct neon strikes.

Note.—The equipment should be switched on and the marker receiver tuned before the main receiver. The lid should be in place.

14. **Setting up R.1124A.**—The main receiver should be given half-an-hour warming-up period before tuning :—

(i) Set the volume control to maximum, pilot's fine tuning to the centre position and normal/test switch to " normal "

(ii) Set trimmers approximately for each range by the reference marks (red, 40 Mc/s ; black, 30 Mc/s).

(iii) Set oscillator trimmer screws on the trimmer plate about midway (i.e. head of screw just below nick).

(iv) Set up tke test oscillator on the desired frequency for range 1 with 1,150 c.p.s. modulation, and place in best position for type of aircraft used. Usually this is just beyond the wing tip.

(v) Put range switch to range 1 and adjust oscillator trimmer until signal is heard. A non-metallic trimming tool should always be used and, as this will still alter the setting, the trimmer should be turned slightly anti-clockwise from the tuning point until the signal is about half its maximum value. The signal should return to maximum when the tool is removed.

(vi) Tune R.F. secondary, R.F. primary and aerial trimmers (in that order) for maximum signal. Check that correct frequency has been tuned in, by rotating output tuning of the test oscillator, and ensuring that the sideband required gives the maximum output in the receiver.

(vii) Set normal/test switch to " test " and complete the alignment with an output which must not exceed 0·5 mW in a 20,000 ohms load. This is indicated by a reading on the universal avometer of 10 volts on the 75 volts A.C. range and a reading on the sensitive range of the Taylor meter of 5. If the reading is greater than this the A.V.C. will be operative and will flatten the tuning response. To decrease the signal the test oscillator should be moved farther away or the aerials closed in. (Altering the main aerial will affect the frequency, and the volume control only affects the A.F. output, so that the A.V.C. will still be operative.)

(viii) With the three R.F. circuits aligned, the oscillator should be finally tuned by means of the vernier trimmer on the plate. Do not touch the R.F. secondary trimmer after the oscillator is finally set.

(ix) Check that the signal is at maximum when the pilot's fine tuning control is at zero. The needle should fall equally on either side. If it rises on the positive side the oscillator frequency should be increased, and if on the negative side, decreased. The oscillator frequency can be increased by turning the vernier screw on the trimmer, clockwise.

Note.—Universal avometer (test meter, type D). 20 mW = 20 volts on 75 volts A.C. range.

Taylor meter (output, meter type 4), 20 mW = full scale on sensitive range.

Microphone tester, type 1, 20 mW = 6 volts.
(Connect one of these meters across telephone terminals.)

15. **Maintenance.**—(i) Check battery volts (if glide meter rises to half scale immediately on switching on battery, polarity is reversed).

(ii) Ensure breeze harness is not chafing at any point. Breeze plugs correctly inserted and screwed right home. Clean pins when necessary with carbon tetrachloride.

(iii) Ensure aerial feeder cable joints properly made and locking rings firmly screwed up ; retractable aerial moves freely ; contact plate and brush of retractable aerial clean and making good contact.

(iv) Close attention must be paid to aircraft bonding ; dipole matching box bonded to airframe and free from dirt and moisture. As this is mounted in the belly of the aircraft, trouble frequently arises due to oil from the hydraulics, or water collecting about it.

(v) Check neon stabiliser by switching on and off and noting that neon re-strikes. Then by checking voltage between high potential end of marker receiver screen potentiometer, and earth. If this voltage is greater than 125 volts the neon should be changed.

(vi) Ensure frequency selector switch operating freely and correctly. Check freedom of Bowden remote control movement. Switch on ; rotate range switch. Loud clicks should be heard, and course meter should deflect slightly with each make and break.

(vii) With the equipment switched on but no signal, the glide meter should read no higher than the lowest dot on the scale. If it does so, replace the V.R.108. (It may still be used in marker receiver.)

(viii) With normal/test switch to "normal", the glide meter should not go off the scale at top ; if it does, suspect one of the V.R.106 valves.

(ix) Check course meter control. This should be set at the mid-point and meter should not overthrow. Check course meter connections by noting that with an increase of signal the meter kicks to R, and with a decrease to L.

(x) Power unit must always be mounted horizontally, since it has no end thrust bearings. Never remove armature. Clean commutators regularly. Trimmer condensers frequently develop faults and they should be frequently checked, ensuring that they are smooth in action and free from noise.

(xi) Check receiver free from noise under vibration conditions.

(xii) If heaters glow, but no signals, examine H.T. fuse and check polarity of 12-volt input.

(xiii) If glide meter reads three-quarter scale deflection or more with no signal, check A.V.C. line to earth for short circuit.

(xiv) Instability—check C.30, C.28, C.11, C.7, for open circuit.

Note.—Equipment with M.2 modifications completed is marked with a red band. Unmodified and modified pieces of equipment must not in any circumstances be used together.

CHAPTER 19

A.C. TYPE REMOTE CONTROLS

1. **General.**—Remote control permits the working of several channels simultaneously from a convenient centre. Minimum distance of transmitters governed by power used, frequency separation, and also considerations of space, strategy and siting of arrays. Scope of remote control is normally switching and keying, tuning adjustments being made manually. Filaments to be kept alight when transmission is probable or ten minutes before it is foreseen. This system is not usable over G.P.O. lines or over circuits including amplifiers or repeaters.

2. **Operation** (see fig. 89).—(i) *Switching on.*—Operating the switch at the receiving end, contact from battery negative is made momentarily to centre part of repeater coil at controlling end—equal currents established through lines A and B to centre of repeater coil at controlled end, via H.T. and L.T. switching relays to earth, thence to earthed positive of 12-volt supply. This direction of current switches both relays *off*. The next stud is connected to positive of battery, and thus a reversal of current occurs on passing over the stud, switching the relays *on*. In the actual "generator running" or "fils. on" position, the supply is broken, the switch resting upon an insulated stud. In this position the H.T. relay breaks contact due to its "space" spring bias, but the filament relay, which is neutrally biased, stays *on*. In the "transmit" position, a continuous "switching on" current holds both relays on. The momentary reverse current first mentioned (when switch passes negative battery stud) is to ensure that all relays open on switching off. This particularly applies to filament relay, which is biased neutral.

As line currents are equal and opposite in cores of repeater coils, no magnetising effect results and signals may be superimposed.

(ii) *R/T.*—Speech currents are applied via a transformer to primary of repeater coil, thence to lines (where they are superimposed on switching currents), to repeater coil at controlled end. The secondary of this coil is connected to the input of the modulation amplifier.

(iii) *W/T.*—At the "*controlled*" end, 14 volts 50 c.p.s. A.C., from L.T. transformer in type B rectifier, is applied to a metal rectifier in series with the primary of the controlled and repeater coil. When the key is up, the effective impedance of the rectifier supply circuit is high. Press key and the secondary is virtually short-circuited, primary impedance falls and the rectifier output rises sufficiently to operate the space-biased keying relay. In a typical installation primary impedance varies as follows :—

Key up	5,000 ohms (output, 1 volt)
Key down ..	150 ohms (output, 5 volts).

The keying relay is "slugged" by copper sleeves to prevent response to 100 c.p.s. ripple from rectifier.

Notes.—(i) Battery should be capable of supplying 50 mA for W/T and 600 mA for R/T.

(ii) For short lines (say, up to 1 mile), 24 volts, centre tapped will be adequate.

(iii) Relay adjustment—all relays are adjusted with ·004 in. between armature and pole-pieces (tongue to mark), and ·005 in. gap between tongue and space.

Bias.—L.T. relay " neutral ". H.T. relay " space ". Keying relay " space ", spring pressure just sufficient to give clean keying.

(iv) Lines must be tested with 500 volt Megger once a month. Lines having resistance of less than 1 megohm between them, or to earth, are u/s. Those whose resistance is less than 5 megohms, falling appreciably on three consecutive monthly tests, are defective.

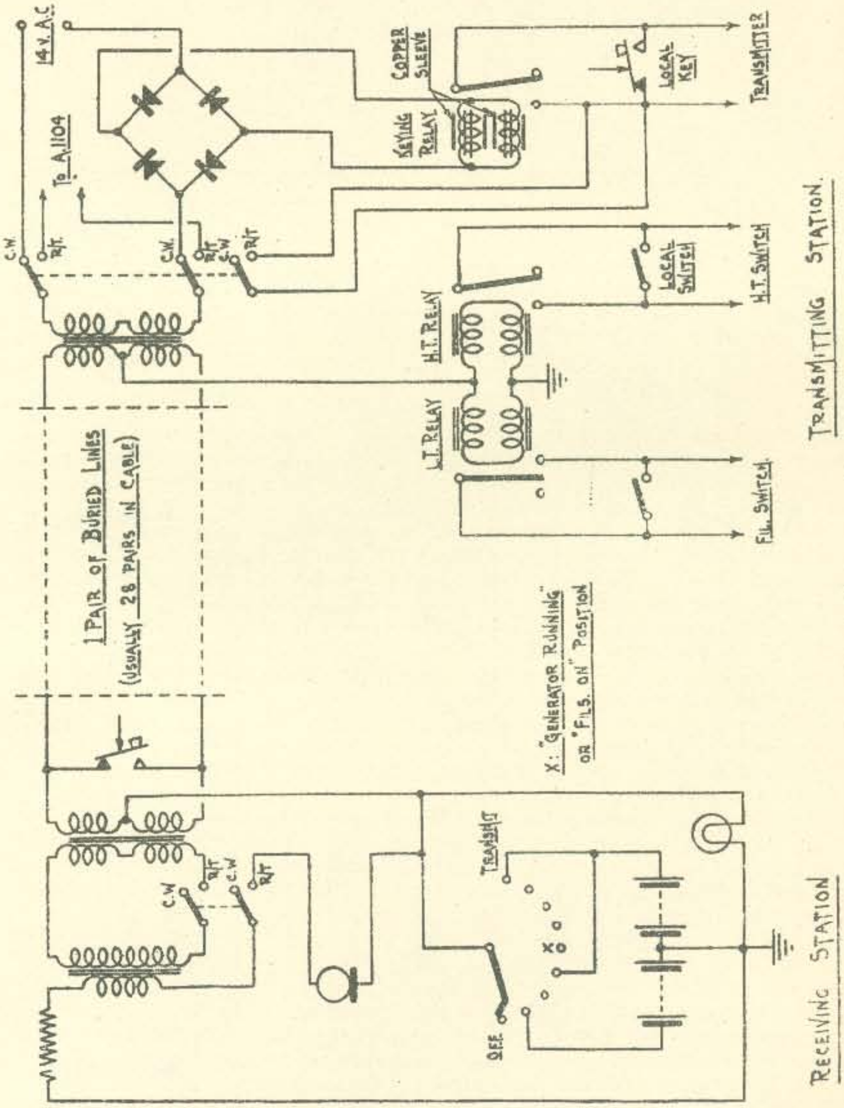


FIG. 89.—A.C. type remote controls.

3. **Types of Remote Control :**—

Type 2.—W/T only—open board type—obsolete.
Type 3.—C.W., M.C.W. and R.T—rack-and-panel type with A.1104.
Type 4.—W/T only—rack-and-panel-type without A.1104.
Type 5.—W/T only—open board type—replaces type 2.
Type 6.—Controller at *receiving end* for type 7.
Type 7.—As type 3, but incorporates remote change-over, W/T, R/T

CHAPTER 20

RECTIFIER PANELS

Rectifier Panels, Types A and B.—(i) *General.*—Used to supply power to ground station transmitters. Uses two hot mercury vapour diodes (V.U.29) in a voltage doubling circuit. Panels, types A and B, differ only in the type

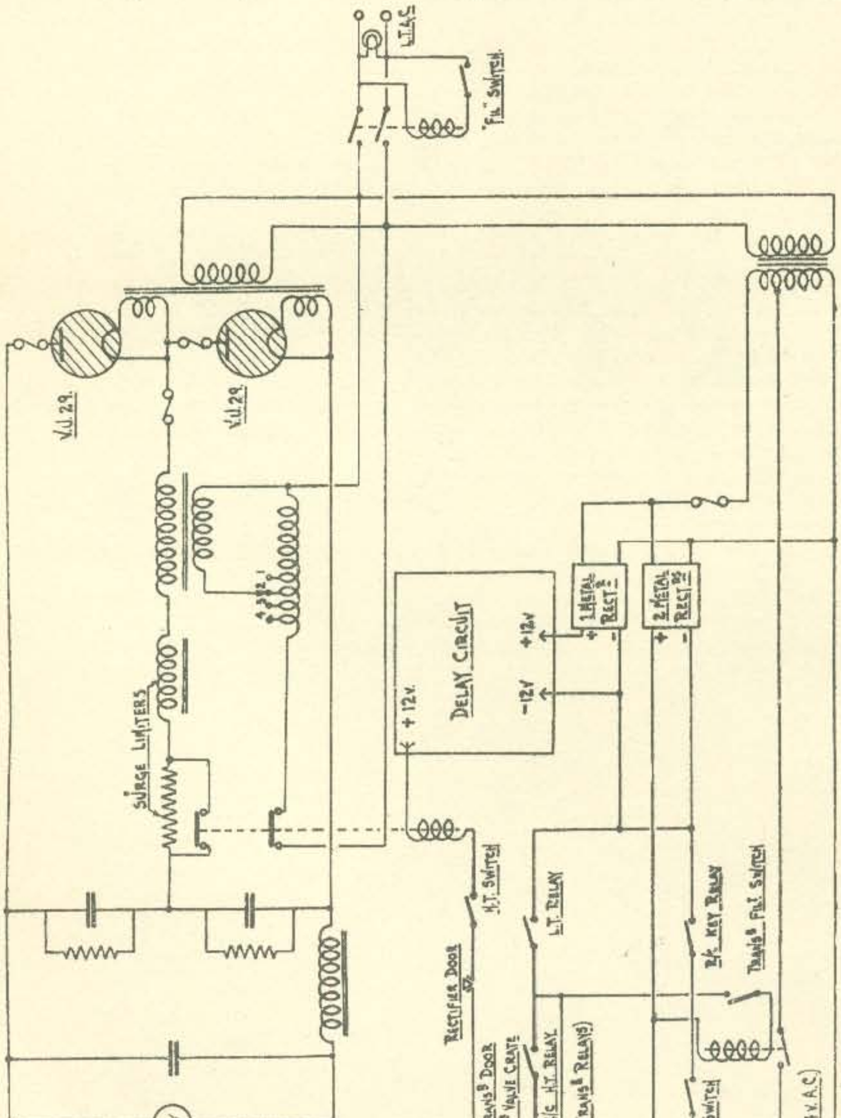


FIG. 90.—Rectifier panel, type B.

of switchgear fitted. The smoothing unit is part of the transmitter, so that the panel is not a complete rectifier. The supply is 230 volts 50 c.p.s. single-phase, A.C., and the maximum outputs are :—

H.T.	3,000 volts 500 mA, D.C.
L.T.	14 or 20 volts 20 amps, A.C.
Relay supplies ..	12 volts 1 amp and 12 volts 2 amps from three metal rectifiers.

(ii) *Circuit.*—Simplified diagram (fig. 90). The A.C. input is applied to the primaries of three transformers :—

(*a*) A step-down transformer with two secondaries supplying the filaments of the two rectifier valves.

(*b*) A step-down transformer supplying 20 volts for the transmitter filaments and metal rectifiers, with a 14-volt tap for the remote keying system, etc.

(*c*) An inductance potentiometer from which is obtained the required input voltage (choice of four taps—110, 150, 200 and 230 volts), for the primary of the step-up transformer supplying the plate voltage of the V.U.29's. Both primary and secondary circuits are controlled by a delay switch which prevents H.T. being applied until the rectifier filaments have been heated for approximately 40 seconds.

Output voltage is controlled by the tapping switch mentioned, which gives a range of 1,700 to 3,000 volts. Fuses are fitted and should be 3 amps for H.T. (in horn-type carriers) and 5 amps for metal rectifier input.

(iii) *Mercury vapour valves.*—(*a*) *Advantages.*—(1) The outstanding advantages of these valves is their low internal resistance (about 35 ohms in V.U.29 under working conditions). This gives very high efficiency and excellent regulation.

(2) These advantages are obtained with quite low cathode power since the filament is oxide-coated.

(*b*) *Disadvantages.*—(1) The valves must be operated under very rigid conditions as to cathode and anode voltages.

(2) The temperature of the valves must be correct whilst they are in use.

(3) The inverse break-down voltage is low.

(iv) *Precautions.*—These disadvantages render necessary the use of delay switching, surge limiters and H.T. fuses. A voltage doubling circuit is used in type B to reduce inverse voltage. There are also certain precautions which must be observed by the operator. These are :—

(*a*) Regulate A.C. mains, if possible, to 230 volts 50 c.p.s. $\pm$ 5 volts.

(*b*) Clean V.U.29 valve holders to avoid I.R. drop at contacts (cathode current is 9 amps).

(*c*) "Condition" a new valve by running filament for 30 minutes before switching on H.T.

(*d*) "Condition" a valve which has liquid mercury on filament (due to shifting set, etc.) for 15 minutes.

(*e*) Always keep spare valves ready "conditioned", stored in an upright position.

CHAPTER 21

RECEIVER A.R.7

Section A.

1. Mechanical Construction—Receiver

1. Mechanical Construction—Receiver.—The Receiver is constructed of No. 18 gauge sheet metal. The frame is a spot-welded fabrication heavily reinforced with angle pieces and gusset plates to ensure durability and complete rigidity.

On completion of fabrication the frame is given a heavy coat of copper plating of not less than one-thousandth of an inch. This plating is to provide a path for complete grounding throughout the chassis.

As a safeguard against corrosion the whole is then cadmium plated. Moisture will have no effect on this final coating. The electrical contacts on the Coil Acceptor Unit are constructed of phospor bronze, heavily silver plated. These contacts are self cleaning.

2. Power Supply Unit.—The frame of this Unit is fabricated and plated in the same manner as that of the receiver. Both Units are fitted with Dust Covers thoroughly ventilated and finished with Grey Crackle Lacquer.

Section B.

1. Design.—The basis of design of this Receiver is to provide stable operation at all frequencies between 138 K.C. and 25 M.C. with an R/F input of 1 microvolt absolute or better. The Receiver is designed to operate from standard 230V A.C. mains supply, or in an emergency from a 12V. Accumulator. The Power Unit Selection Switch provides instant selection of either of the above supplies on its front panel.

2. Electrical Characteristics.—The following measurements are an average as measured on test:—

(a) **Frequency Coverage**—138 K.C. to 25 M.C. in 5 bands with a gap of 45 K.C. on either side of the I/F channel, which is 455 K.C.

(b) **Sensitivity**—The absolute sensitivity is such that an input voltage of 1 microvolt modulated to a depth of 30% at 400CPS, applied through a standard dummy antenna to the receiver aerial terminals, gives 6 milliwatts in a 600 ohm non-inductive load with a signal-to-noise ratio of 1 : 1 in watts.

(c) **Selectivity**—by a variation of input voltage against constant output:—

6 K.C. off resonance	20 db down
10 K.C. „ „	40 db „
15 K.C. „ „	60 db „

With Crystal Filter in, a selectivity of 100 CPS may be achieved.

(d) **Automatic Volume Control**—The output remains constant to within $\pm$ 3db for variations of input voltage between 10 microvolts and 1 volt.

(e) **Stability**—Every precaution has been taken in the design to achieve stability of operation. Regulation of the power supply when working on the standard A.C. supply is such as to take care of variations of line fluctuations of $\pm$ 10%.

(f) **Power Output**—the Receiver delivers the following power output:—

To Headphone Circuit	100M/Watts
To 600 ohm output	100M/Watts
To Speaker of 1750 ohm impedance	1.8 Watts

This measurement is made with 100% modulation at 400 CPS.

(g) **Radio Frequency Amplifier**—two stages of R/F amplification are employed in this Receiver.

The signal to image ratio thus provided is as follows:—

Band.

A. $\geq$ 2000 to 1

B. $\geq$ 2000 to 1

C. $\geq$ 2000 to 1

D. $\geq$ 2000 to 1

E. At 22 MC. 500 to 1, at 12MC. 2000 to 1.

1. Controls.—The front panel on to which the Controls are terminated is clearly marked. In order that the Controls may be identified from this description reading from **left** to **right** read in three rows as follows:—

Top Row.—Signal Meter, Tone Control, Tuning, Noise Limiter.

Middle Row.—BFO. Note Control, AVC/BFO Switch, Meter Adjust, Variable Selectivity, Crystal IN/OUT Switch, Crystal Phasing Control.

Bottom Row.—Manual R/F. Gain Control, Coil Box Acceptor, Audio Gain.

Left Hand Bottom. Phone Jack 1.

Right Hand Bottom. Phone Jack 2.

Functions of Controls.

Signal Meter.—An indicator of carrier strength of the received signal.

Tone Control.—Arranged to reduce high frequency response to minimise static or other interference.

Tuning Control.—Controls 4 gang Condenser, effects band spread on all bands—equals pointer travel on a scale approximately 12 feet long.

Noise Limiter.—This control is arranged to limit the noise peaks so that in no case can they exceed the signal level particularly useful to adjust the signal—noise ratio when receiving C.W.

B.F.O. Note Control.—Arranged to shift the note of the beat frequency oscillator $\pm$ 2000CPS. either side of zero beat.

AVC/BFO Switch.—Used in AVC. position for reception of telephone signals—when turned to BFO. brings in BFO. and eliminates AVC. for reception of C.W. signals.

Meter Adjust.—Used to adjust signal meter to zero under no signal conditions.

Variable Selectivity Control.—This control is used only in conjunction with the crystal filter. With the filter inactive the control has no effect. When the control is on 0 the receiver is in the broad position, 10 provides maximum selectivity.

Crystal IN/OUT Switch.—With this switch on the IN position the crystal filter functions. Fine adjustments are then made on "Selectivity."

Phasing.—The Crystal Phasing Condenser should be in the Zero position for normal operation and should not be used unless an interfering signal appears. The method of operation for rejection of an interfering signal is to adjust the Phasing Condenser right or left of Zero until the interfering signal is eliminated or reduced. The tuning dial should be adjusted to exactly the desired signal frequency.

Manual R/F. Gain Control.—This controls the sensitivity of the Receiver irrespective of the A.V.C.

Coil Box Acceptor.—In the space provided the operator inserts the coil box unit required. Each unit is marked with its band letter:—

Band	Tuning Range
A.	138K.C. to 409K.C.
B.	495K.C. to 1430K.C.
C.	1420K.C. to 4.32M.C.
D.	4.25M.C. to 12.6M.C
E.	12.5M.C. to 25M.C.

The curve engraved on each coil box front is Frequency versus Dial degrees

Audio Gain—Stand By Control.—A combined Stand By Switch and Audio Gain control—when turned to "Stand By" H.T. is switched off but the valve heaters remain on. When the Pointer is advanced to "on" the Receiver is active and further advance of the pointer towards 10 increases audio gain.

Phone Jacks 1 and 2.—When telephones are plugged into Phones 1 the speaker is automatically silenced—Phones 2 is a jack provided for a second pair of operators telephones, but no audio power is available in Phones 2 unless a headset is plugged into phones 1.

CHAPTER 22

BENDIX AIRCRAFT TRANSMITTER T.A.12B AND ASSOCIATED EQUIPMENT

1. **Equipment.**—This consists of :—

(i) Transmitter T.A.12B
(ii) Receiver R.A.10DA
(iii) I/C amplifier 3611
(iv) Power unit M.P.28B
(v) Radio compass M.N.26C.

2. **Purpose.**—To provide long-distance C.W., M.C.W. and R/T communications on medium and high frequencies, being the American counterpart of the T.1154/R.1155 equipment.

3. **Transmitter** (block diagram fig. 92).—(i) *Frequency range.*—There are four ranges :—

(*a*) Range 1—300–600 kc/s
(*b*) Range 2—3,000–4,800 kc/s
(*c*) Range 3—4,000–6,400 kc/s
(*d*) Range 4—4,300–7,000 kc/s.

Note.—In the T.A.12C model, range 3 covers 4,800–7,680 kc/s, and range 4 covers 7,680–12,000 kc/s.

(ii) *Valves.*—(*a*) Transmitter, M.O., two pentodes, type 12 SK7 ; F.D. tetrode, type 807 (V.T.60) ; P.A., two tetrodes in parallel, types 807 ; (*b*) modulator, A.F. oscillator, double triode, type 6N7 ; A.F. amplifier, pentode, type 6F6 ; P.A., two tetrodes in push-pull, types 807.

(iii) *Power supplies.*—From aircraft motor generator :—

(*a*) Input, 25 volts (from accumulator or E.D.G.) 14·8 amps.
(*b*) 540 volts 0·45 amps.

A starting solenoid, fuses and filter circuits are incorporated in the power unit. The negative L.T. pole is earthed, and the negative H.T. pole is earthed via a 60-ohm tapped resistance to provide bias for the P.A.

(iv) *Aerial systems.*—The aircraft fixed or trailing aerial. In some aircraft an aerail plug board is used, as in T.1154/R.1155 equipment. In others an aerial switch gives the following positions :—

(*a*) Transmitter—fixed-trailing ; this enables the transmitter to be used on either aerial.
(*b*) Receiver—transmitter-alternate ; this switches the receiver to the transmitting aerial or aerial not in use, as desired.
(*c*) Fixed aerial—operate, earth ; this earths the fixed aerial when required (e.g. in conditions of severe static).
(*d*) Trailing aerial—operate, earth ; as for (*c*) but in this case for the trailing aerial.

(v) *Circuit* (fig. 93).—On each of the four ranges a separate oscillator valve and tuned circuit is used, which is inductively coupled to a F.D. stage (807 cathode biased), with the exception of range 1 when it becomes a buffer stage or intermediate power amplifier and works on the oscillator frequency.

On range 1 the M.O. is a typical Colpitts circuit, self-biased and tuned by means of a variometer.

On ranges 2, 3 and 4 a Hartley oscillator is used and is tuned by a variable condenser. The M.O. tuning is ganged to the F.D. tuning, making separate control unnecessary.

The P.A. stage consists of two 807 valves in parallel (rating 40 watts). Range 1 is tuned by a variometer in series with a tapped, separately mounted, loading coil, the whole being shunted by alternative fixed condensers. On ranges 2, 3 and 4 the circuits are similar, except that both coil and condensers are continuously variable and parallel fixed condensers may also be switched in. Series aerial condensers may be switched in if necessary, this type of output circuit making it possible to load efficiently a wide range of aerials. The P.A. stage is anode and screen modulated.

(vi) *Loading unit* (M.T.53B).—This consists of a tapped loading coil and vacuum relav. which short-circuits the coil except when transmitting on range 1, the operation being maintained by means of interlock contacts on range switch of transmitter.

(vii) *Range switching*.—The range switch is motor driven and is remotely controlled, but can be locally controlled by releasing a push-button on the front of the transmitter.

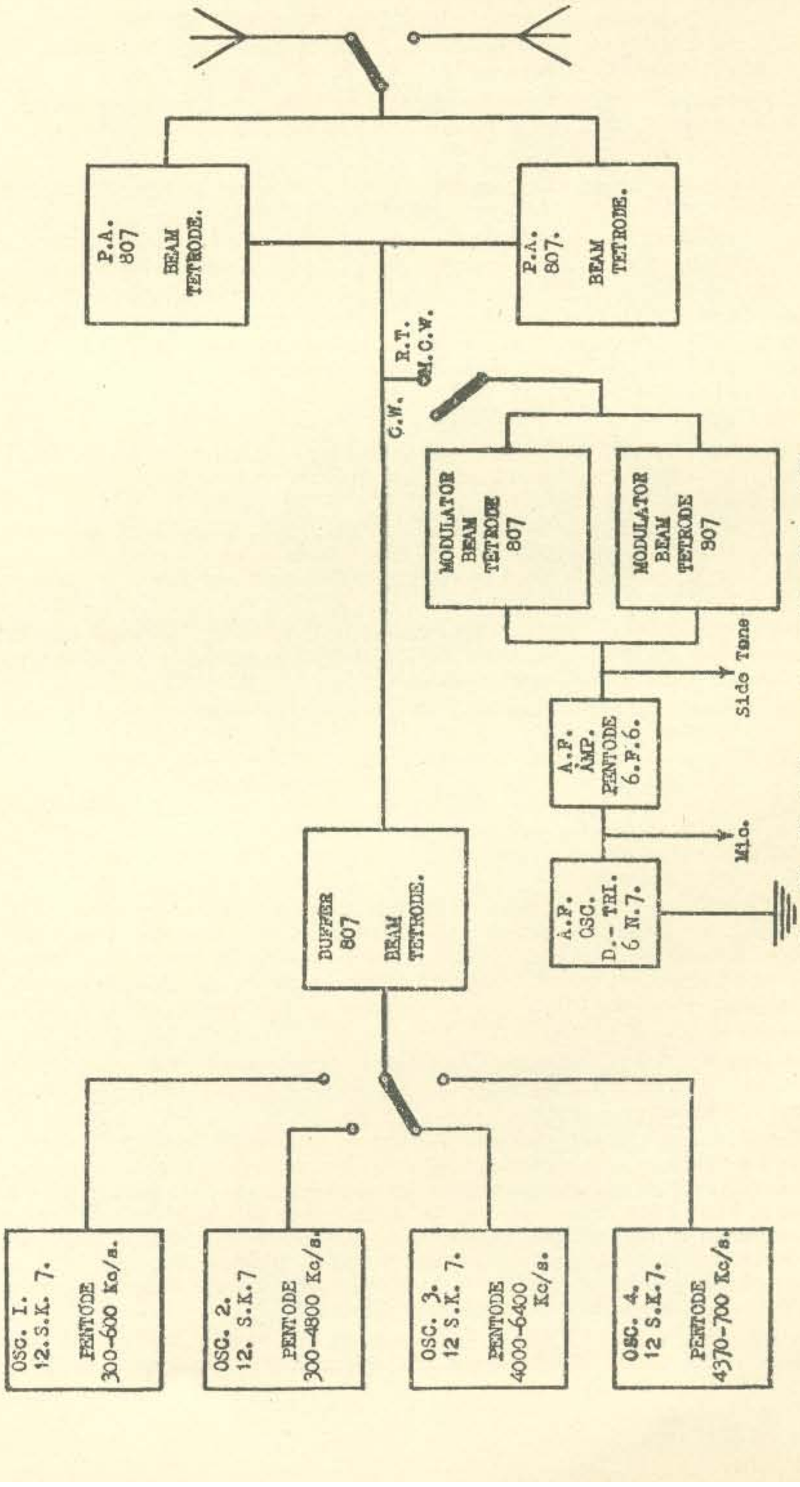


Fig. 92.—Block diagram transmitter, T.A.—12B.

VALUES

Resistances		Condensers	
1	250 K	1	150 $\mu\mu$ F
2	50 K	2	·003 μ F
3	100 K	3	·0005 μ F
4	50 K	4	·003 μ F
5	2 K	5	·0004 μ F
6	10 K	6	·0002 μ F
7	7	7	·0001 μ F
8	600	8	·01 μ F
9	12 K	9	·01 μ F
10	25 K	10	·01 μ F
11	5 K	11	·01 μ F
12	10 K	12	·005 μ F
13	50	13	·01 μ F
14	50	14	25 $\mu\mu$ F
15	50	15	·03 μ F
16	50	16	·001 μ F
17	2 M	17	·01 μ F
18	15 K	18	·002 μ F
19	100	19	·002 μ F
		20	·002 μ F
		21	·003 μ F
		22	·002 μ F
		23	·001 μ F
		24	365 $\mu\mu$ F
		25	·0003 μ F
		26	100 $\mu\mu$ F
		27	·01 μ F

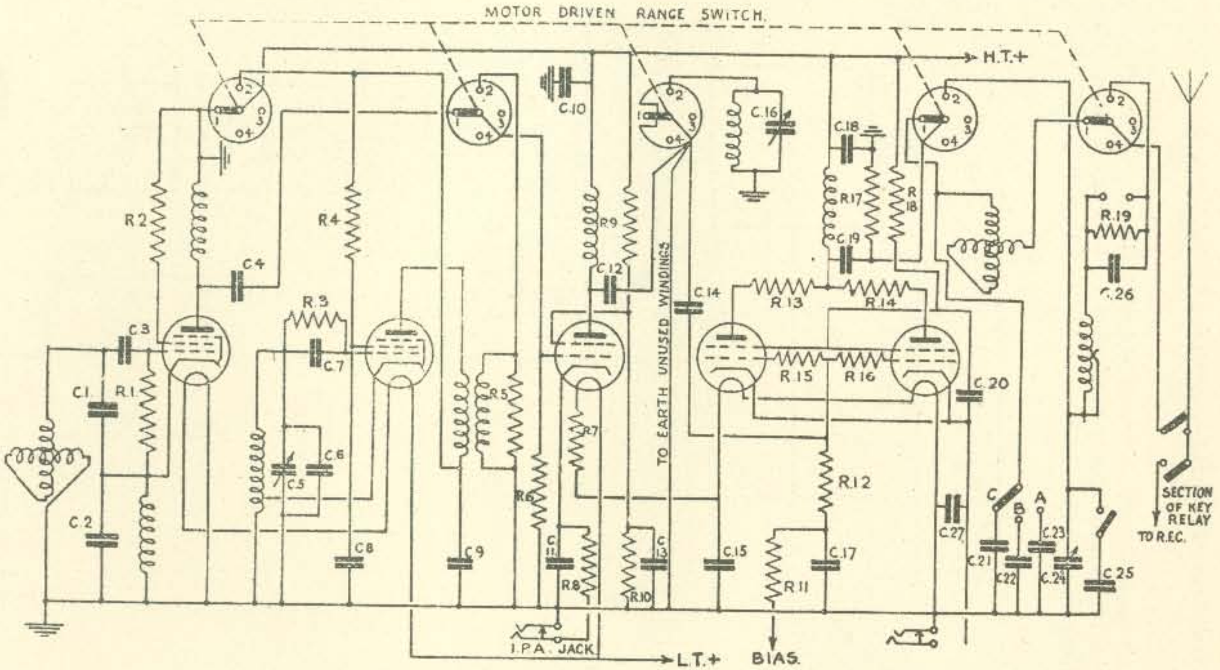


FIG. 93.—Circuit diagram transmitter, T.A. 12B.

(viii) *Keying relay.*—This keys the H.T. to the transmitter on C.W. and M.C.W. switches aerial from receiver to transmitter, and earths receiver aerial connection when transmitting ; a push-button acts as a local key when tuning.

(ix) *Transmitter remote control unit* 3616.—This is a master control unit for the transmitter and other control units :—

(*a*) Switch 1—" local/remote ", places transmitter under direct control or from control units.

(*b*) Switch 2—" radio only—I/C radio ", directs microphone to either transmitter or I/C amplifier.

In " radio only " position feeds microphone to modulator unit I/C amplifier is shorted out and the telephones are connected to the receiver.

In " I/C radio " position it joins microphone to I/C amplifier, a variable fraction of the output then feeding the modulation amplifier. In this position " side-tone " circuits are completed through a relay when S/R switch is pressed on C.W. or M.C.W. Telephones are now connected to I/C amplifier as well as receiver.

(*c*) Switch 3—" master radio " starts I/C amplifier and switches on filaments (filaments supply is main 24-volt supply).

(*d*) Switch 4—" S/R " starts up M/G on " send " position.

(*e*) Switch 5—" I/C amp." starts I/C only

(*f*) Switch 6—" range switch " controls range motor.

(*g*) Switch 7—" C.W./M.C.W /R/T." On R.T., H.T. is connected to valves. On C.W. and M.C.W. motor is started but H.T. is not connected until key is pressed.

(x) *Tuning instructions.*—(*a*) Range 1 :—

(1) Set M.O. tuning dial from calibration chart.

(2) Set P.A. tuning to O.

(3) Put loading switches to A–A (condensers in transmitter).

(4) Set connector in loading unit to extreme left-hand tap.

(5) Set range switch to 1 and press key push button on transmitter. P.A. current should rise to 250 mA approximately.

(6) Rotate P.A. tuning and if no dip obtained release key and move connector on loading unit one tap.

(7) Continue until greater dip is obtained, but if the dip is very low increase loading by moving condenser switches to B–B or C–C. Press key push button and re-tune P.A. for dip, which should be as near to 210 mA as possible, but must not exceed that figure.

(*b*) Ranges 2, 3 and 4 :—

(1) Set M.O. tuning from calibration chart.

(2) Rotate P.A. tuning control to extreme anti-clockwise position to bring in maximum inductance.

(3) Set series aerial condenser switches to " out " (switches situated next to loading switches on range 1).

(4) Set P.A. fixed tuning condensers to " out " (situated on rear of P.A. tuning units).

(5) Set output " channel loading " dial to 50.

(6) Set range switch to required position and press the key.

(7) Rotate " channel loading " dial for dip. If no dip occurs or if the dip is at zero, reduce the P.A. inductance. Tune again for dip, and repeat until maximum dip is obtained. A mutual setting should be found that gives a dip to 210 mA with aerial current at maximum. It may be found necessary to include P.A. tuning fixed condensers, or with a long aerial, series aerial condensers.

Note.—For local tuning the switching motor can be disconnected by removing the cap from the " local-remote " button which is next to the " key " button on the transmitter.

(*c*) Back tuning :—

(1) Tune the receiver to the station required.

(2) Adjust the receiver to the C.W. " dead space " of the signal.

(3) Reduce the volume of the receiver to half, or to individual requirement.

(4) Set switch, type 170, to " TUNE BACK "

(5) Adjust transmitter M.O. to the setting shown on chart for frequency required.

(6) Plug the test meter, type P, into the jack engraved " P.A.P." Switch on transmitter.

(7) When setting up the P.A. stage, the key is not to be depressed for more than 5 seconds, with 5-second intervals, owing to the possibility of excessive P.A. current when off tune. Tune the P.A. stage for minimum reading of the testmeter and adjust the loading up to the following :—

(*a*) TA.12B, all ranges 210 mA.

(*b*) TA.12C, ranges 1–3, 210 mA ; range 4, 175 mA.

(8) Slowly vary the adjustment of the M.O. until a C.W. note is heard in the receiver. Finally adjust for the " dead space " and lock.

(9) Check that the P.A. stage is in resonance.

(10) Disconnect the testmeter and stow the plug, type 1. This is necessary to prevent damage to the pivots when keying.

(11) Set switch, type 170, to " SIDE TONE "

(12) Note calibration for future reference.

4. **Modulator** (fig. 94).—The modulator amplifier is mounted with the

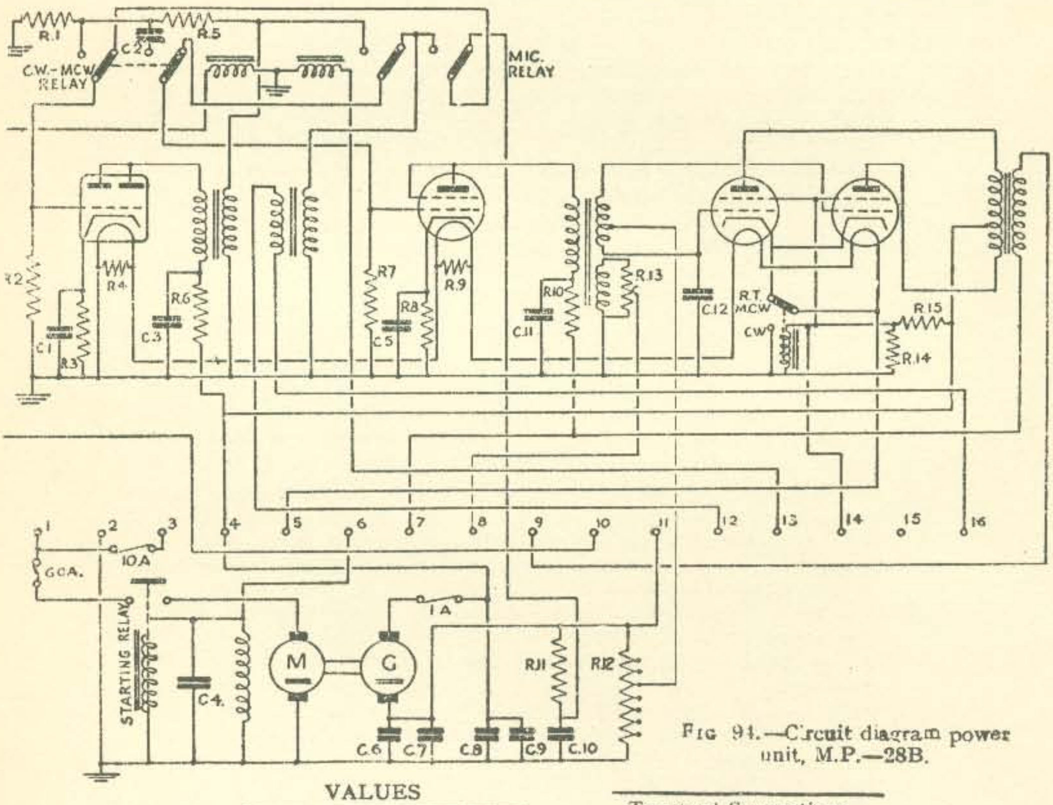


Fig. 94.—Circuit diagram power unit, M.P.—28B.

VALUES

Resistances		Condensers	
1	1 M	1	8 μ F
2	500 K	2	100 $\mu\mu$ F
3	1 K	3	·5 μ F
4	63	4	·5 μ F
5	25 K	5	8 μ F
6	35 K	6	·03 μ F
7	500 K	7	8 μ F
8	650	8	2 μ F
9	30	9	·03 μ F
10	7500	10	003 μ F
11	500 K	11	·5 μ F
12	60		
13	600		
14	15 K		
15	15 K		

Terminal Connections	
1	24 v.+
2	24 v.−
3	Filament Out
4	B + In
5	Filament In.
6	Dynamo Relay
7	B + Out
8	Side Tone
9	Audio
10	M.C.W.
11	Bias
12	Microphone
13	Emergency Mic.
14	Mod. Relay
15	Blank
16	Microphone

motor-generator unit. It consists of an output stage of two tetrodes (807) in push-pull, driven by a pentode amplifier (6F6). The latter stage may be preceded by an A.F. oscillator (6N7) when on " radio " or an I/C amplifier can be used as an external pre-amplifier when on " I/C radio ". Side-tone is taken off an extra winding of the output stage driver transformer and fed to the receiver output stage. A relay converts the 6N7 into an A.F. oscillator when R/T or M.C.W. is required. For C.W. working the cathode circuits of the output stage are broken, but side-tone is still fed to the receiver.

5. **Receiver** (block diagram fig. 95).—(i) *Frequency range* :—

(*a*) Range 1—150–400 kc/s.
(*b*) Range 2—400–1,100 kc/s.
(*c*) Range 3—2,000–5,000 kc/s.
(*d*) Range 4—5,000–10,000 kc/s.

The range required being selected by a range selector motor.

(ii) *Valves.*—R.F. amplifier, pentode 6SK7; F.C., triode-hexode, 6K8; I.F. amplifiers, 2, 6SK7; detector and A.V.C., double-diode-triode, 6R7; B.F.O., triode, 6C5; output, pentode, 6K6G; limiter, double diode, 6H6.

(iii) *Power supplies.*—(*a*) L.T., 6·3 volts, from aircraft battery through a series-parallel arrangement and/or dropping resistances.

(*b*) H.T. From a M.G. mounted inside the receiver. Input, 28 volts 3 amps. Output, 230 volts 100 mA.

(iv) *Aerial systems* (see para. 3, sub-para. (iv)).

(v) *Circuit* (fig. 96).—The receiver is a straightforward 7-valve superhet plus a limiter valve, with an I.F. of 1,630 kc/s.

Provision is made for either automatic or manual volume control, being selected by a switch on the remote control unit marked A.V.C.—M.V.C.—C.W. :—

(*a*) In the A.V.C. position the first three stages are controlled by a potentiometer across the output stage transformer secondary.

(*b*) In the M.V.C. and C.W. position (and also on range 1 on A.V.C.), the A.V.C. is reduced and the A.F. gain is fixed in the maximum position. The M.V.C. is a potentiometer tapping a variable portion of the H.T. supply, and applying positive bias to the cathodes of the R.F. and first I.F. valves.

Provision is made for a lock-in crystal controlled frequency on range 3 and on range 4. When specified on the order ranges 3 and 4 may be wired so that only the crystal controlled frequencies are available, thereby eliminating the necessity of tuning the R.F. circuits to approximately the crystal frequency. When the receiver is wired for general coverage of ranges 3 and 4 and the crystal is in use, lock-in occurs over a band width of at least 50 kc/s. The crystals are of a frequency 1,630 kc/s higher than the desired frequency. To provide side-tone, part of the audio voltages from the transmitter modulator unit are applied to the output stage via a side-tone relay. The diode limiter prevents overloading of the receiver under very high signal inputs. It is across the input circuit and conducts when the signal input exceeds 0·25 volts.

(vi) *Remote control unit.*—The receiver is designed for remote control only (units M.R.9B or M.R.9C). The unit has :—

(*a*) An " off/volume " switch which switches the receiver on and adjusts the signal input.

(*b*) " Tuning " control which is connected to the receiver by a flexible cable. The dial is calibrated directly in kc/s and Mc/s.

(*c*) " Range switch " which operates the range selector motor.

(*d*) "A.V.C—M.V.C.—C.W." switch. (*Note.*—A.V.C. available only on ranges 2, 3 and 4, but is not available when using C.W. on any range.)

(*e*) " Crystal on/crystal off " switch which connects the crystals into the receiver oscillator circuit.

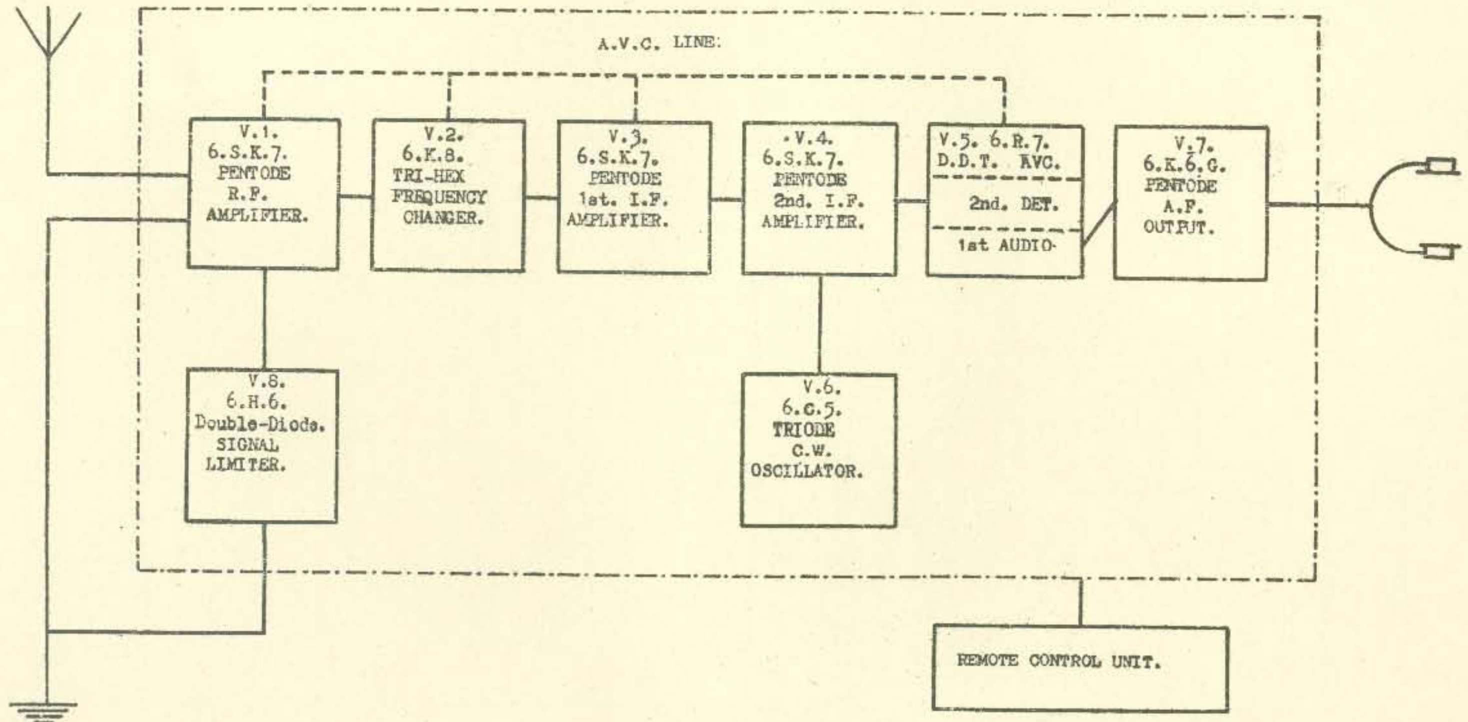


FIG. 95.—Block diagram receiver, R.A.—10DA

VALUES

Resistances		Condensers	
1	50 K	1	·001 μ F
2	250	2	·001 μ F
3	100 K	3	·1 μ F
4	5 M	4	·1 μ F
5	1 K	5	10 μμ F
6	300	6	·1 μ F
7	50 K	7	·1 μ F
8	20 K	8	·1 μ F
9	20 K	9	·1 μ F
10	15 K	10	·1 μ F
11	25 K	11	250 μ F
12	1 K	12	·1 μ F
13	300	13	·1 μ F
14	1 K	14	20 μμ F
15	50 K	15	20 μμ F
16	200 K	16	·02 μ F
17	100 K	17	300 μμ F
18	50 K	18	·1 μ F
19	1 K	19	·1 μ F
20	300	20	·1 μ F
21	100 K	21	·1 μ F
22	300	22	1 μμ F
23	1 K	23	·1 μ F
24	50 K	24	150 μμ F
25	500 K	25	150 μμ F
26	500 K	26	50 μμ F
27	500 K	27	·01 μ F
28	75 K	28	·1 μ F
29	500 K	29	300 μμ F
30	3 K	30	·01 μ F
31	25 K	31	1 μ F
32	1 M	32	1 μ F
33	1 M	33	5 μ F
34	500 K		
35	500		

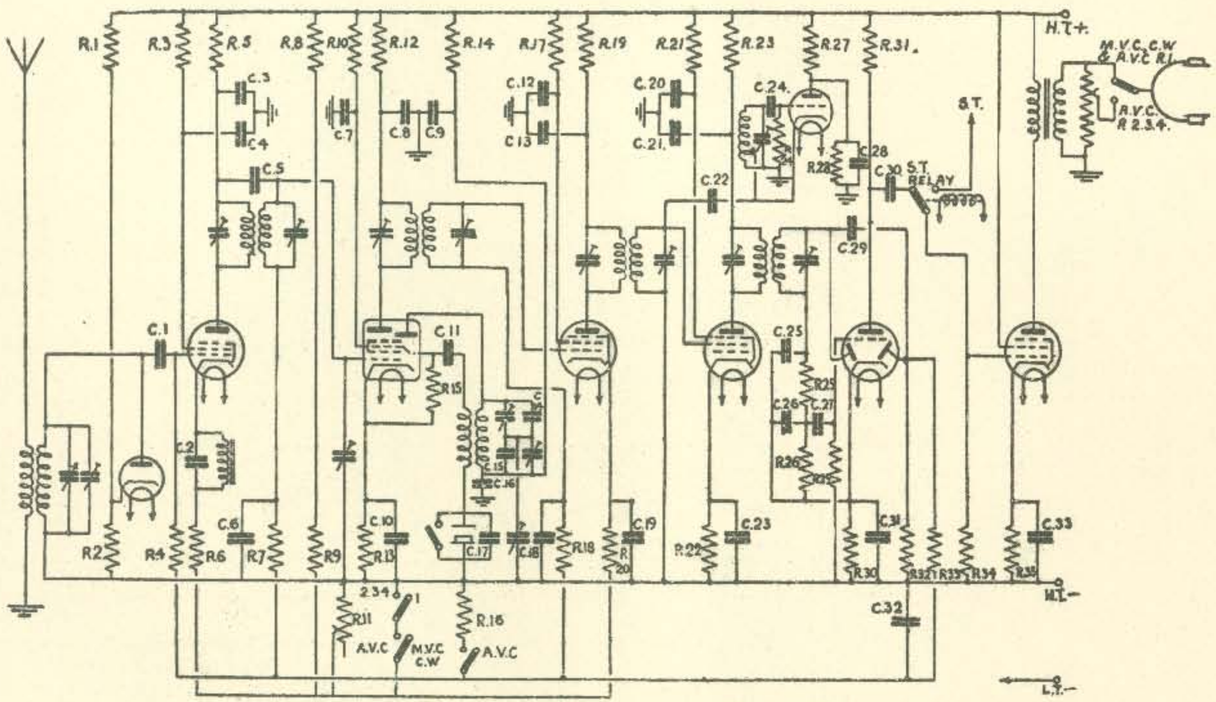


FIG. 96.—Circuit diagram receiver, RA—10DA

6. **Intercommunication Amplifier 3611** (fig. 97).—The amplifier is a two stage high gain unit employirg a pentode (6SK7), R.C. coupled to a beam tetrode (6V6). The power output is 3 watts at 1,000 cycles and may be worked into loads of 60 to 600 ohms. An internally mounted M.G. giving supplies of 230 volts at 60 mA for H.T. Both valves are cathode biased. The volume control is in the grid circuit of the first stage, and the " on/off " switch is situated in the transmitter remote control unit.

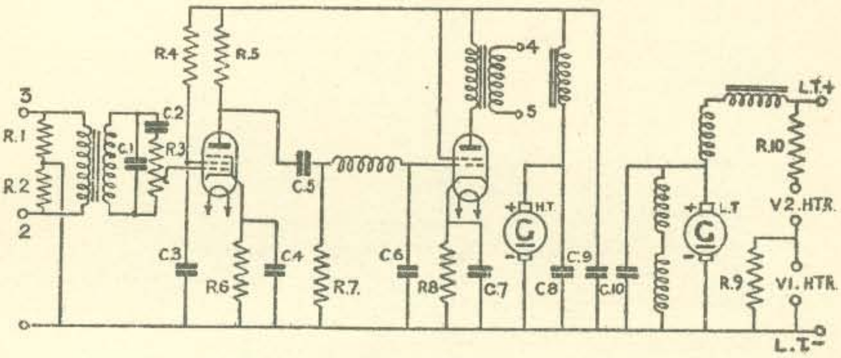


FIG. 97.—Circuit diagram I/C amplifier 3611.

VALUES

Resistances		Condensers	
1	500 Ω	1	100 μμ F
2	500 M	2	·0015 μμ F
3	250 M Ω	3	·03 μ F
4	1 M Ω	4	20 μ F
5	250 M Ω	5	·0025 μ F
6	1 M Ω	6	·0005 μ F
7	500 M Ω	7	20 μ F
8	350 Ω	8	10 μ F
9	40 Ω	9	10 μ F
10	30 Ω	10	·5 μ F

The input to the microphone transformer is shunted by two 500-ohm resistances, the junction point being earthed and so giving a balanced input. The amplifier is also used as a pre-amplifier for modulation on the " I/C radio " position. The telephones (which are permanently connected to the receiver) are also connected to the amplifier on the " I/C radio " position.

When on R.T. a relay in the remote control unit breaks the side-tone circuits, when on " I/C radio " to prevent the telephones receiving signals from both amplifier and modulator via receiver.

7. **Remote Control Unit 3612.**—The unit is designed as an accessory to the transmitter remote control unit. It incorporates a volume control, an emission switch and S.R. switch. It cannot be used until unit 3616 is set for remote transmitter control.

8. **Remote Control Unit 3613.**—The unit incorporates a volume control and S.R. switch and can only be used when unit 3616 is at " remote " It is for R/T transmissions only.

(6) Second detector and A.V.C. double diode pentode 6B8.

(7) A.F. output, pentode 6F6.

(8) Compass output 6K7.

For compass purposes this is preceded by a loop amplifier (6K7), A.F. oscillator (6N7) and a modulator (6N7).

(v) *Remote control unit M.N.*—28.—This has the following controls :—

(*a*) Tuning crank and dial.

(*b*) Range switch.

(*c*) Master switch :—

(1) " Off ".

(2) " Compass ".

(3) " Rec. Ant." (fixed aerial for communication).

(4) " Rec Loop " (loop aerial for au ai D/F and emergency).

(*d*) Audio gain.

(*e*) Compass sensitivity control (altering meter deflection).

(vi) *Operation.*—(*a*) *Visual* :—

(1) Master switch to " Rec. Ant ".

(2) Sele_t range and tune to desired frequency.

(3) C.W. switch on if required. Adjust audio volume.

(4) Switch to compass, put sensitivity control to maximum ; needle will deflect.

(5) Turn loop to bring needle back to centre line, read off bearing or reciprocal.

(*b*) *Homing.*—(1) and (4) as above.

(5) Set loop to zero.

(6) Pilot turns air raft to bring needle back to centre line.

(*c*) *Aural* :—

(1) Select range and tune to desired frequency.

(2) Switch to " Rec. loop ".

(3) Turn loop for aural minimum.

(4) Read off bearing or reciprocal.

VALUES

Resistances		Condensers	
1	50 K	1	·5 μ F
2	100	2	·5 μ F
3	50 K	3	·5 μ F
4	50 K	4	·05 μ F
5	300	5	100 μμ F
6	1 K	6	250 μμ F
7	2 K	7	250 μμ F
8	2 K	8	·05 μ F
9	100 K	9	·05 μ F
10	100 K	10	·1 μ F
11	100 K	11	·1 μ F
12	100 K	12	·05 μ F
13	500 K	13	·05 μ F
14	500 K	14	·5 μ F
15	50 K	15	·5 μ F
16	200 K	16	·05 μ F
17	300	17	·5 μ F

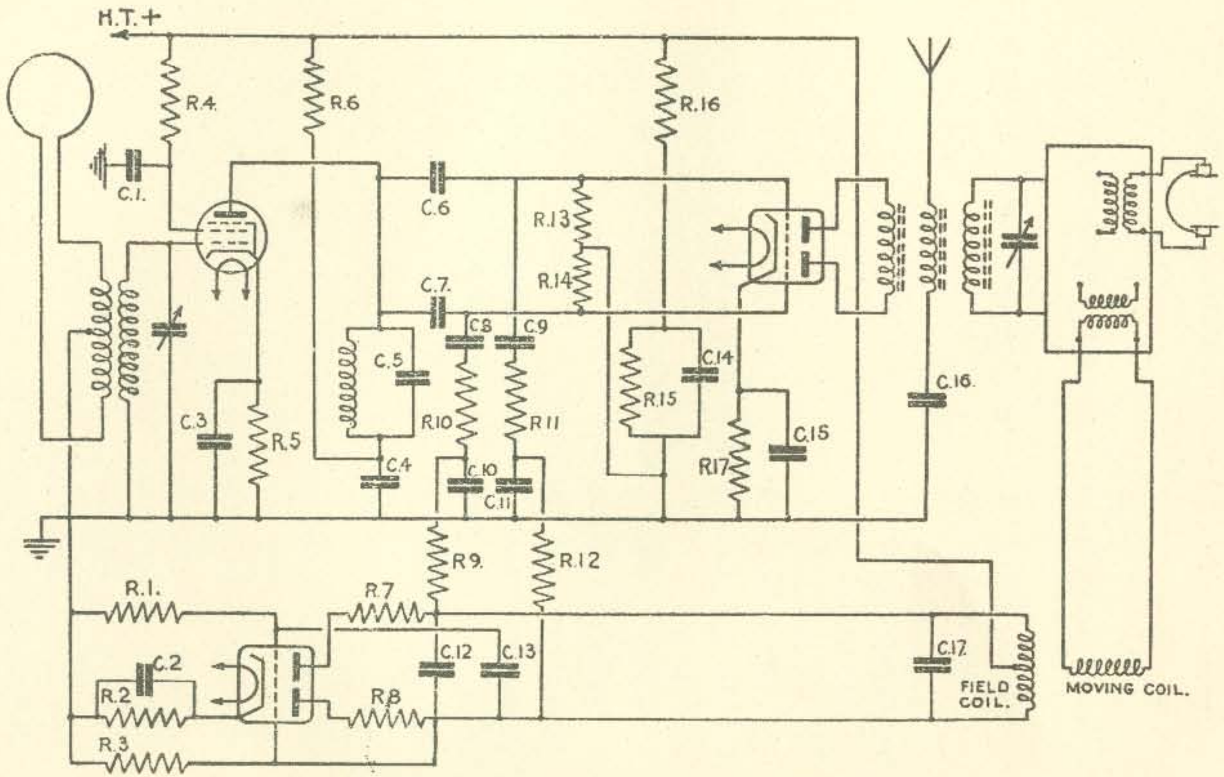


Fig. 98.—Circuit diagram radio compass, M.N.—26C.

CHAPTER 23

TRANSMITTER RECEIVER TR5043 (SCR 522)

Description

1. The transmitter assembly consists of Rack FT — 244 — A, Radio Transmitter BC — 625 — A and Receiver BC — 624 — A. When properly inter-connected to the other components of the SCR — 522 — A/TR 5043, this assembly provides transmission or reception of amplitude-modulated signals on any one of four crystal-controlled frequencies within the range 100 — 156 mc. Only R/T communication facilities are available, but continuous audio-tone modulation is also provided.

2. The a — f amplifier portion of the receiver is so designed that interphone communication between two or more persons is possible.

3. Remote control of the equipment is by means of the Radio Control Box BC — 602 — A. The five red pushbuttons are the means by which the frequency channels are selected and the power turned on or off. When the off button is pressed, the dynamotor is stopped. The five buttons are so interconnected that not more than one can be in the depressed position at any given time.

4. With the T — R — REM switch in the transmit position, the transmitter is placed in continuous operation; in the R position the receiver is placed in continuous operation, and in the REM position, transmit-receive control is transferrred to a press-to-talk (press-to-transmit) as explained in para. 5 below.

5. Press-to-talk operation may be obtained by means of a conveniently located switch (usually located on the throttle in U.S. installation). When this switch is depressed (closed) and the T — R — REM switch is in the REM position the equipment is switched from receive to transmit.

6. **Transmitter.**—The transmitter employs a crystal-controlled oscillator circuit resembling a Pierce circuit in which the tank circuit is provided by the crystal constants. The operating frequency range is 100 — 156 megacycles on any one of the four pre-set channels A.B.C. and D. Channels are selected by means of the Radio Control Box only. The top of the transmitter is equipped with four tuning controls, a receptacle for the D-C meter cord and a METER SWITCH. The following table shows, for each of the five usable positions of the transmitter METER SWITCH, the particular current being measured by, and the amount of current which will cause full scale deflection of the 0 — 1 ma D-C test milliammeter which is part of Test Set I — 139 — A or Signal Generator I — 96 — A. Position 6 of this switch is not used.

Transmitter Meter Switch Position	D — C METER Current	Full Scale Deflection
1	First Harm. AMP, Anode	50 ma.
2	Second Harm. AMP. Anode	100 ma.
3	Power-AMP. Anode	100 ma.
4	R — F Indicator Diode	1 ma.
5	Power-AMP Grid.	2 ma.

7. The antenna-coupling control is located on the right side of the transmitter panel, and the GAIN control is on the left. The crystal sockets are to the right of the METER SWITCH and are identified by the channel letters A.B.C. and D.

8. **Receiver.**—The receiver is a sensitive superheterodyne receiver employing a heterodyne oscillator whose frequency is controlled by any one of four quartz crystals. Thus, four crystal-controlled channel frequencies anywhere within the range 100 — 156 mc. are available for instantaneous selection at the remote control position (Radio Control Box) providing that these four receiver channels have been pretuned and the tuning controls locked. The audio amplifier portion of the receiver is used as an interphone communication and side-tone amplifier. A carrier-operated squelch circuit reduces extraneous receiver noises to a low level and prevents difficulties in niterphone communication due to ignition noises, etc. All tuning controls and installation adjustment controls are located on the receiver panel and are easily accessible when the receiver is mounted on Rack FT — 244 — A.

9. **Power Supply.**—A primary D-C source of between 22 and 32 volts is required to operate Dynamotor Unit PE — 94 — A.

The dynamotor unit is the source of the three regulated voltages required for operation of the transmitter-receiver assembly: 300 V D-C for the anodes and screens of the valves in the transmitter and receiver; 150 V D-C for grid bias in the transmitter and 13 V D-C for all valve heaters, control relays, the channel control motor, indicator lamps, etc. Cord shockmounts with ground straps attached are provided for mounting the dynamotor as a separate unit. Two sockets are provided: a 2-pin socket connecting with the dynamotor unit-to-battery cord and a 6-pin socket connecting with the dynamotor unit-to-rack cord.

Note.—Further details of this equipment can be obtained from the "Instruction Book for Operation and Maintenance of Radio Set SCR — 522 — A."

CHAPTER 24

BENDIX AIRCRAFT TRANSMITTER (TA-2J. 24)

1. **Uses.**—Long range aircraft transmitter for C.W., M.C.W., and R.T.

2. **Frequencies.**—Eight fixed frequencies in the bands 300–600 kc/s., 2·9–15 Mc/s.

3. **Power Output.**—(*a*) M.F. range: C.W., 30 watts; M.C.W. and R/T, 20 watts. (*b*) H.F. range: C.W., 100 watts; M.C.W. and R/T, 75 watts.

4. **Power Supplies.**—(*a*) L.T., 24–28 volts from aircraft generator and/or accumulators. (*b*) H.T.: 1,050 volts 300 mA. from motor generator.

5. **Current Consumption.**

Master switch on V.1, V.2, V.3, and white light ..	1 and 2 amps.
Remote control on all valves, fan, white and blue lights..	12 amps.
Crystal heaters (if fitted)	0·25 amps. each.
C.W. and M.C.W.	45 amps.
R/T	37 amps.

6. **Valves.**

V.1 ..	Type 807	Filament 6·3-volt	250-volt H.T.	Master oscillator.
V.2 ..	Type 807	Filament 6·3-volt	400-volt H.T.	Buffer.
V.3 ..	Type 803	Filament 10-volt	1000-volt H.T.	Power amplifier.
V.4 ..	Type 801A	Filament 7·5-volt	400-volt H.T.	Sub modulator.
V.5, V.6	Type 830B	Filament 10-volt	1000-volt H.T.	Modulators
V.7 ..	Type 646	Filament 6·3-volt		Aerial current indicator.

Different filament voltages are obtained from 24-volt supply by dropping resistances.

7. **Circuit.**—V 1 is a beam power tetrode crystal controlled master oscillator coupled to the grid of V.2, which is a buffer or intermediate power amplifier, also frequency doubler or trebler stage. This in turn is coupled to the power amplifier, V.3, a 125-watt pentode operating as a class " C " amplifier.

On M.C.W., V.3 is modulated by a mechanical buzzer housed in the remote control unit.

On R/T, the output from the carbon microphone is amplified by V.4 operating under class " A " conditions, which feeds V.5 and V.6 working as a class " B " push-pull modulating stage.

The output from this stage is used to modulate on both anode and screen of the P.A. valve.

Side-tone is provided on M.C.W., C.W., by feeding part of the buzzer output to the telephone circuit. On R/T part of the audio output is passed to the audio stages of the receiver. A filter is provided in the microphone circuit to cut-off below 400 cycles per second.

An optional remote aerial current meter may be fitted which takes its feed from V.7, which rectifies part of the main aerial current.

Tuning of the M.O. and buffer stages is carried out by the makers for each crystal fitted. The P.A. and coupling unit are set on the ground according to the aerials fitted in the machine.

The P.A. coils are mounted on a revolving turret 3 H.F. ranges being in the transmitter, the M.F. ranges in the coupling unit. These turrets are rotated by a small electric motor, controlled by the frequency selector switch on the remote control panel. Operation of this switch places the correct P.A. coil in circuit, and also correct M.O. and buffer coils, as well as switching correct crystal.

8. **Operating Instructions.**—(*a*) Close aircraft master switch (white lamp lights).

(*b*) Close " on " switch on remote control panel (blue lamp lights).

(*c*) Select frequency required (green lamp lights, while coils are being changed).

(*d*) Put selector switch to " phone ".

(*e*) Check aerials.

(*f*) Close microphone switch and talk.

(*g*) Release microphone switch for reception.

(*h*) To switch off temporarily, open switch on remote control panel.

(*i*) Finished with set, open aircraft master switch.

C.W. and M.C.W.—As above, only selecting required transmissions.

Note.—To receive, put selector switch to " phone ". In some installations an external aerial relay is fitted, operated by the key or microphone switch, in which case it is not necessary to put switch to " phone " for reception.

Precautions.—Never shift frequency with microphone or key pressed. Crystals are not interchangeable.

9. **Setting Up Instructions.**—300–600 *kc/s.*—(*a*) Put meter plug into jack marked " amp. 1 "

(*b*) Select channel to be used.

(*c*) Press key and note reading in m.A.

(*d*) Insert screwdriver and rotate appropriate fine tuning control for dip.

(*e*) If no dip occurs, release key and change appropriate coarse tap inside unit.

(*f*) Repeat until a good output is obtained with dip occurring at 150 mA. (Multiply meter reading by 100.)

2900–4500 *kc/s.*—(*a*) and (*b*) As above.

(*c*) Put both aerial and anode taps at centre of coil.

(*d*) Rotate coil with screwdriver for dip.

(*e*) If dip is below 150 m.A., move aerial tap (on left) back and turn coil clockwise for dip. (Multiply meter reading by 100.)

(*f*) Repeat until dip occurs at 150 m.A. This should coincide with maximum aerial current.

4500–15000 *kc/s.*—(*a*) and (*b*) As above.

(*c*) Disconnect aerial.

(*d*) Rotate coil for dip, at resonance m.A. should be about 50. A dip to 100 m.A. indicates that a harmonic has been tuned to. (Multiply meter reading by 100.)

(*e*) Replace aerial.

(*f*) Place aerial tap one turn from front end of coil, rotate coil for dip.

(*g*) Repeat, moving aerial tap forward and adjusting for dip, occurs at 150 m.A.

Precautions.—Do not press key for longer than 5 seconds at a time, until tuning operations have been completed.

Do not make adjustments to inside of transmitter or coupling unit with key pressed.

On the H.F. ranges, after P.A. coils have been set up, and the door closed, insert screwdriver through hole provided and make a small adjustment for dip.

CHAPTER 25

BENDIX AIRCRAFT RECEIVER (RA-1B. 24)

1. **Uses.**—With aircraft transmitter TA-2J. 24.

2. **Frequency Range.**—Range 1, 150 to 315 kc/s.; range 2, 315 to 680 kc/s.; range 3, 680 kc/s. to 1·5 Mc/s.; range 4, 1·5 Mc/s to 3·7 Mc/s.; range 5, 3·7 Mc/s. to 7·5 Mc/s.; range 6, 7·5 Mc/s. to 15 Mc/s.

3. **Power Supplies.**—(*a*) L.T. 6·3 volts obtained from aircraft generator and/or accumulators.

(*b*) H.T. 250 volts obtained from small motor generator working from aircraft 24-volt supply and taking 1·9 amps.

4. **Aerial Selector Switch.** Marked " D/F ", " Fixed ", and " Trailing ". When in " trail " position a small condenser is inserted in series with aerial.

Valves.	V.1, V.2, V.4, V.5 and V 8 Vari-mu R/F pentodes	6K7G
	V.3, Pentagrid mixer	6L7G
	V.6, Duo-diode triode	6R7G
	V.7, Output valve (beam tetrode)	6K6G

5. **Circuit.**—Eight valve superheterodyne receiver, capable of receiving C.W., M.C.W. and R/T.

V.1 and V.2 signal frequency amplifiers, followed by a pentagrid mixer, V.3. The intermediate frequency amplifiers V.4 and V.5 are followed by the second detector and A.V.C. valve, V.6, which also serves as a L.F. amplifier, the output valve V.7.

V.8 is the beat frequency oscillator, which is brought into use when C.W. is received.

Optional automatic or manual control is provided by the operation of a switch on the front panel. The manual volume control is also in use, to control the L.F. output, when on A.V.C.

Provision is made for either local or remote tuning control.

Testing points are brought out to the front of the panel for measuring H.T. and L.T. voltages.

CHAPTER 26

BENDIX INTERCOMMUNICATION SYSTEM

This comprises an amplifier, and control boxes at the various crew positions.

1. **Amplifier, Model 3611.**—Consists of a two-valve resistance-coupled high gain amplifier, output approximately 3 watts.

Valves.—6SJ7, A.F. pentode ; 6V6, power tetrode.

Power supply.—6·3-volt heaters from 24-volt supply through suitable resistances.

230 volts H.T. from self-contained motor generator.

General.—A volume control is provided in the front panel. All circuits are filtered and well screened. Microphone leads must not be earthed. Connections are taken via six-pin socket to the various station boxes and 24-volt supply. Electro-magnetic microphones are used.

2. **Operator's Station Box, Model 3618.**—This carries the " on-off " switch for the amplifier, a green indicating light, and a four-way selector switch marked " R.1 ", " R.2 ", " I/C " and " Call ". In the first two positions the operator's telephones are connected to the appropriate receiver, in the third position to the I/C amplifier, while in the " call " position, all outputs are paralleled to all phones, and the various red lights at the different stations flash.

It will be seen that if the main I/C amplifier volume control is adjusted to over-ride the receiver output, intercommunication may take place in the " call " position without turning off the receiver.

3. **Pilot's Station Box, Model 3619.**—Similar to above, but no controls for I/C amplifier and an additional position of the selector switch marked " Compass ". This is for a radio compass, if fitted.

4. **Crew's Station Box, Model 3617.**—As above, but provision made only for I/C and call.

CHAPTER 27

BENDIX RADIO COMPASS (Type MN-26C)

1. **Use.**—Use for homing, or taking bearings using the visual method.

2. **Frequency Ranges.**—Covered in three ranges: 150–325 kc/s.; 325–695 kc/s.; 695–1,500 kc/s.

3. **Power Supplies.**—(*a*) 6·3 volts from aircraft 24-volt supply; (*b*) 250 volts H.T. from self-contained motor generator running from 24-volt supply.

4. **Circuit.**—The receiver makes use of the valve-switched cardioid principle, using a single needle dynamometer type indicator.

The phase of the loop e.m.f.s is reversed at about a hundred cycles per second by means of the switching valves, which are double triodes. These switched loop e.m.f.s are combined with the fixed aerial e.m.f., and to the intermediate frequency stages of the receiver. The rectified output is then passed through the moving coil of the indicating valve.

The low frequency output from the L.F. switching valve is passed through the fixed windings of the indicating meter, so that the current through these windings reverses in phase with the receiver output.

Hence the indicating needle moves to the right or left of central position according to the position of the loop relative to the incoming signal.

A remote control is provided for the pilot's use only. The master switch on the panel has four positions: " off ", " compass " " receiver aerial " " receiver loop ".

Two volume controls are fitted, one for compass and one for audio. The beat frequency oscillator may also be switched " in "—in C.W. reception.

The loop and scale are also remotely controlled. An extra scale is provided on the loop scale, which may be adjusted to compensate for magnetic variation so that magnetic bearings may be read direct from the scale.

5. **Operation.**—(i) *Visual.*—(*a*) Switch master switch to " Rec. Ant ".

(*b*) Select correct frequency band.

(*c*) Select required frequency.

(*d*) C.W. switch on if required. Adjust audio volume.

(*e*) Switch to compass, put compass sensitivity control to max. position; needle will deflect.

(*f*) Turn loop to bring needle back to centre line, read off bearing or reciprocal.

6. **For Homing.**—(*a*) to (*e*) as above.

(*f*) Set loop to read zero.

(*g*) Pilot turns aircraft to bring needle back to centre line.

7. **Aural.**—(*a*) Select frequency band and frequency required.

(*b*) Switch to " Rec. loop ".

(*c*) Turn loop for aural minimum.

(*d*) Read off bearing or reciprocal.

8. **Equipment.** The equipment consists of—

(*a*) Receiver.

(*b*) Remote control unit.

(*c*) Loop control.

(*d*) Left, right indicators

(*e*) Self-contained M.G.

Note.—Both fixed and loop aerials are necessary.

9. **Purpose.**—The equipment provides:—

(*a*) Visual L.R. indications of direction of the transmitter with respect to the loop aerial, with simultaneous aural reception.

(*b*) Aural reception of R/T or C.W. with fixed or loop aerial.

(*c*) Aural D/F using the loop aerial.

10. **Theory of the radido compass.**—The radio compass equipment consists of a loop aerial, a loop input circuit and amplifier (6K7), a 90 degrees phase shifter, a balanced modulator (6N7) an A.F. oscillator (6N7), a non-directional (vertical) aerial, a sensitive receiver, a compass output circuit, a left-right indicator and a phone output circuit.

The voltage induced in the vertical aerial is in phase with the field of the E.M. wave. But the resultant of the voltage induced in the loop aerial is 90 degrees out of phase with the voltage induced in the vertical aerial, so the loop voltage is amplified and its phase shifted 90 degrees so that it is either in phase or in anti-phase with the vertical aerial voltage. This phase shift of approximately 90 degrees is achieved by tuning the anode circuit of the loop amplifier to a low frequency, so giving it a capacitive reactance in relation to the signal.

The voltage from the loop amplifier is then passed to the grids of the modulator valve, the two sections of which are alternatively cut off by bias supplied from an A.F. oscillator operating at 48 c/s. The push-pull anode circuit and the aperiodic vertical aerial circuit, are both coupled to the receiver input, and as the modulator anodes are in push-pull, the amplified loop voltages alternatively add to and subtract from the vertical aerial component. As the loop is rotated through a minimum, there is a reversal of this effect, whereas if the loop is at a minimum nothing is added to the vertical aerial voltage.

The combined signal fed to the receiver has the form of a modulated wave, where the depth of modulation depends upon the amount of loop input, and the phase depends upon the position of the loop relative to a minimum.

The signal is now amplified and detected and passed to two output stages. One supplies audio output for the phones via a transformer and audio gain control. The other feeds the moving coil of the indicator meter via an output transformer, the input of this stage being variable to provide a sensitivity control.

The field coil of the indicator meter, in conjunction with a condenser, actually forms the tuned circuit of the 48 c/s A.F. oscillator. With no signal from the loop, the field holds the moving coil needle in the central position. When, however, the loop voltage is not zero, there will be 48 c/s pulses of current through the moving coil, which will either lag or lead on the field of current, depending on the position of the loop.

In this case the needle will be deflected either to left or right, depending upon the position of the loop. The compass circuits are so arranged so that if the signal is coming from the left, the pointer turns left and *vice versa*.

11. **Compass receiver** (fig 98).—(*a*) *General.*—The receiver is a remotely controlled 12-valve superhet I.F., 112 kc/s.

(*b*) *Frequency range.*—(1) 150–325 kc/s; (2) 325–695 kc/s; (3) 695–1,500 kc/s.

(*c*) *Circuit* comprises :—

(1) Two R.F. amplifiers, pentodes 6K7.

(2) R.F. oscillator, triode 6J5.

(3) Mixer, heptode 6L7.

(4) I.F. amplifier 6K7.

(5) B.F.O. 6J5.

CHAPTER 28
GENERAL PURPOSE W/T EQUIPMENT TYPE A.T.5/A.R.8

SERVICE USE.

General Purpose Communication Equipment with separate M/F and H/F Channels, in which one M/F and one H/F can be pre-set and subsequently selected by the operation of one switch on the Transmitter and one on the Receiver.

The basic system is designed for control by an Operator having access to the front panels of all Units.

When required, the basic system can be expanded to provide for remote control one one pre-set frequency. The equipment is capable of C.W., M.C.W., and R/T. two-way communication and also aural D/F.

Consists of 5 Units—Receiver, Transmitter, Aerial Coupling Unit, Power Supply and Junction Box. All Units are inter-connected by means of Multi-pin plugs and sockets and Multi-core cables of standard length.

The entire equipment can be supplied for, and operated from, either 12 or 24 volt aircraft Battery. Employment of the correct power Unit for the supply available, automatically effects the necessary changes in all other units. Total weight approximately 170 lbs.

FREQUENCY RANGE.

A.T.5:—	M/F.	140 K.C.—500 K.C.
	H/F.	2 M.C.— 20 M.C.
A.R.8:—	M/F.	140 K.C.—740 K.C.
		765 K.C.— 2 M.C.
	H/F.	2 M.C.— 20 M.C.

POWER UNIT.

1. This unit supplies L/T and H/T to the A.T.5 and A.R.8 and power to the relays in the Aerial Coupling Unit.

2. The H/T is supplied from two motor Generators supplied from a separate E.D. Generator which maintains the 12 or 24 volt Aircraft Battery in a fully charged condition. For ground testing, the Aircraft starting battery cart must be used.

3. **Receiver Power Supply.** H/T is obtained from a 12 or 24 volt M.G. supplying 250 volt at 100 M.a. The Filaments are supplied from the Aircraft battery through the main Receiver Switch. The valves are wired in a series parallel circuit, which he Dial and Pilot Lamps, and a series of balancing resistors, ensuring that each valve or lamp receives its correct voltage, i.e., Valves, 6.3 Volts; Lamps, 3.2 Volts.

4. **Transmitter Power Supply.** H/T is obtained from a 12 or 24 volt M.G. supplying 550 Volts at 350 M.a. By means of a voltage dividing system, 300 Volts is made available for the oscillator, buffer, modulator and screen grids of the P.A. valves.

Filament power is supplied from the Aircraft battery through series parallel circuits and appropriate resistors. Total current drawn by the equipment with the key pressed is ·16 Amps. from a 24 Volt battery, and 35 Amps. from a 12 Volt battery.

5. Two switches, located on the front of the unit, operate as follows:—

Switching on the receiver switch supplies L/T to the receiver and starts the receiver generator, thus supplying H/T to the receiver also.

Closing the transmitter switch supplies L/T to the transmitter and places the transmitter generator on stand-by, which may then be switched on by the EMISSION switch on the Transmitter.

6. Normally, both switches on the power unit are kept "on" during flight even if it is unlikely that the Transmitter will be used. The circuit is so arranged that the Transmitter cannot be operated without the receiver switch being "ON."

7. Fuses are placed in the input of both the generators and are also located in the leads supplying Receiver H/T, Transmitter 550 Volts H/T, Transmitter 300 Volts H/T, and Transmitter Filament Circuits. Fuses in the receiver generator input, also act as fuses for the Receiver Filaments. All fuses are located on the front of the unit.

RECEIVER A.R.8.

1. Super-Hetrodvne Receiver capable of receiving C.W., M.C.W., and R/T with provision for Aural D/F.

2. **Valves:** Commercial Type Octal Socket valves are used as indicated below:—

Valves	Type	Function
V.6	6 X 5 G.T.	Diode Limiter
V.201, V.101	6 U 7 G.	R.F. Amplifier M/F & H/F.
V.202	6 A 8 G.	Converter on M/F.
V.102	6 A 8 G.	Mixer on H/F.
V.103	6 J 5 G.T.	H/F Oscillator.
V.1, V.3	6 U 7 G.	I/F Amplifier.
V.4	6 G 8 G.	2nd Detector, A.V.C. Audio Amp.
V.2	6 A 8 G.	Beat Frequency Oscillator.
V.5	6 J 7 G.	Power output and I/C Amplifier.

CIRCUIT DESCRIPTION—A.R.8.

1. Communication circuit employs dual R/F channel with common I/F and A/F channel. A diode limiter valve is connected between the aerial and earth and protects the R/F circuit by by-passing all input voltages over .7 volts R.M.S.

2. **M/F Circuit** consists of one stage of R/F amplification and converter, the M/F range being covered in three bands by coil switching operated by a band selector switch. Provision is made for D/F and Sense finding on all M/F bands.

3. **H/F Circuit** uses one stage of R/F amplification followed by a mixer and separate H/F Oscillator. The frequency range is also covered by a three band selector switch.

4. By means of an M/F—H/F switch either R/F channel can be coupled to the common I/F amplifier which consists of two stages tuned to a frequency of 755 K.c's. The output from the I/F channel is fed to a Double Diode Pentode valve, in which one diode is used for detection and the other for A.V.C. The rectified output from the diode is fed through a volume control to the pentode section for audio amplification. This is further amplified by the output valve and fed through an output transformer to the crew telephones.

5. By means of a microphone transformer connected to the control grid, the output valve serves as an I/C amplifier in the aircraft, capable of supplying five (5) pairs of telephones in parallel, when driven by a service type carbon microphone.

6. A beat frequency oscillator, capable of being tuned by the BEAT OSC. TUNING Control, 3.5 K.c's on either side of the I/F, is switched in for C.W. reception by the C.W.—R/T switch.

7. By connecting all the R/F and I/F cathodes together and completing the circuit through the keying relay, it is possible to make the R/F and I/F portion of the receiver "dead" during transmission periods. But the moment the key is lifted, the receiver cathodes are earthed again and the receiver immediately operates normally, thus providing listening through.

8. An "Inter-Tune" switch is provided on the Tone control which short circuits the receiver contacts in the keying relay allowing the receiver to function when the transmitter key is pressed. This enables the Zero beat system of Transmitter tuning to be employed.

RECEIVER CONTROLS.

(a) M/F. H/F RANGE SWITCH:—Selects the M/F or H/F channel as required.
(b) FREQUENCY BAND SELECTOR SWITCHES:—Switch coils to cover various frequency bands, also switch in special coils for D/F purposes.
(c) TUNING CONTROLS:—
    1. H/F. Single dial calibrated in M.c's for each range.
    2. M/F. Single calibrated dial (in K.c's) and M/F AERIAL TUNING CONTROL to obtain maximum efficiency from the wide range of aerials.
(d) C.W., M.C.W., D.F/RT SWITCH.
    1. **On the C.W.—M.C.W.—D/F Position:—**
        (i) The B.F.O., H/T is "ON."
        (ii) The A.VC. is not functioning.
        (iii) The A/F Volume Control is in-operative.
        (iv) The R/F Volume Control is operating.
    2. **On the R/T Position:—**
        (i) The B.F.O. H/T is "OFF."
        (ii) The A.V.C. is functioning.
        (iii) The A/F control is operating.
        (iv) The R/F volume control is short circuited.
(e) VOLUME CONTROL:—Two pentiometers mechanically coupled to control either the R/F gain in the pre-detector stages or the A/F gain after detection, depending upon the position of the CW/RT switch just described.
(f) BEAT OSC. TUNING:—Varies the beat note when receiving CW to suit operating conditions.
(g) TONE CONTROL & "INTERTUNE" SWITCH:—Tone control is used to cut down background noise. On rotating control to extreme anti-clockwise position, it operates a switch (the "intertune" switch) which short circuits the receiver keying contact in the keying relay and allows the receiver to operate with the key pressed and the transmitter functioning. This enables Zero Beat Tuning to be effected.
(h) TRAFFIC—D/F—SENSE SWITCH:—Switches the fixed aerial and loop to the appropriate circuits for taking D/F bearings and obtaining correct sense.
(i) BEARING/RECIPROCAL SWITCH:—Reverses the leads from the loop to enable sense to be determined.
(j) SENSE RESISTANCE:—Used to correct the phase of the fixed aerial and to effect the balance necessary for sense determination.
(k) AERIAL SOCKET:—Can be connected by means of a lead supplied for the purpose, to the RECEIVER Socket on the A.C.U. for NORMAL OPERATION, or if desired, directly to either aerial for FREE RECEIVER operation.

LOOP D/F.

The A.R.8 can be used in conjunction with an aircraft loop to obtain D/F bearings and sense on all M/F bands with the exception of the range 740-765 K.c's. This band of frequencies is not covered by the receiver owing to the use of a 755 K.c. I/F channel. The D/F controls are built into the front panel of the receiver and a separate set of coils is used and switched in, for "TRAFFIC" and "D/F AND SENSE." The A.R.8 gives satisfactory results with a wide range of aircraft loops and sense aerials. The D/F loop connection plugs into the D/F loop aerial socket, located in the lower left hand corner of the receiver front panel.

TO OBTAIN A BEARING.

1. Tune in and IF POSSIBLE identify station with both switches on TRAFFIC and the fixed aerial connected for "free receiver." Adjust M/F AERIAL TUNING for maximum signal.
2. Switch to C.W. and adjust until the best audio note is obtained.
3. Change both switches to D/F position, retune M/F AERIAL TUNING and turn loop until a good minimum is obtained. Note the loop reading in degrees on the bearing scale.
4. Switch to SENSE. Then turn the loop through 90 deg. to "SENSE" position, i.e., when the figures on the SENSE scale correspond in degrees to the indicated minimum on the BEARING SCALE.

5. Reverse the connections to the loop by operating the BEARING/RECIPROCAL switch; at the same time adjusting the SENSE RESISTANCE for the greatest difference on Signal strength on each position of the BEARING/RECIPROCAL switch. The minimum or weaker signal will indicate whether "bearing" or "reciprocal," that is, if the weaker signal is on the "BEARING" position, it indicates BEARING AND V.V.
6. Switch back to D/F, turn the loop to the indicated bearing. Disconnect fixed aerial and carefully check the exact reading of the minimum on the bearing scale. Apply quadrantal error correction. This gives a bearing relative to the true aircraft heading.

NOTE:—(a) Judicious adjustment of the volume control at all times is essential for satisfactory and accurate results.

(b) There is normally no error on 000, 090, 180 and 270 degrees, and advantage should be taken of this fact to obtain quadrantal error free bearings by heading the aircraft towards the station temporarily and reading the back compass bearing. N.B.—This gives a magnetic bearing.

SPECIAL NOTE:—Sense indication is reversed if the trailing aerial is used as a sense aerial. This is not to be used except in an emergency and must be checked, if possible, while the sense of the station is definitely known. Use approx. 30 turns of Trailing Aerial.

HOMING & LOCALIZING AIRCRAFT DIRECTLY OVER A BEACON TRANSMITTER

1. Obtain a bearing and check sense, as above, and instruct pilot to turn aircraft until heading towards beacon or broadcast station, as indicated by a true relative bearing of 000 degrees.

2. Pilot holds aircraft on course until D/R or Signal strength indicates that AIRCRAFT IS APPROACHING the station. N.B.—Adjust volume control at all times to maintain a suitable signal strength.

3. Request pilot to carefully hold course or switch in automatic pilot. Then switch to SENSE. Adjust SENSE RESISTANCE for greatest difference in volume in each position of the Bearing Reciprocal Switch.

4. Operate the BEARING RECIPROCAL SWITCH, maintaining suitable volume level until "Sense Reverses." This indicates that the station has just been passed over, pilot should be advised immediately. (NOTE:—During the above operation, i.e., para. 4, it is advisable to take fairly frequent checks on the heading of the aircraft to check for drift, if any. Each check can be done in approx. 10 seconds.)

5. After obtaining SENSE reversal and advising pilot, switch to D/F and take a quick back bearing, which should read approximately 180 degrees.

TRANSMITTER—A.T.5.

VALVES:—Commercial types are used as indicated:

H/F Oscillator	6V6G
H/F Buffer/Doubler Amplifier—M.F. Oscillator	807
Power Amplifiers	2-807
Modulator	6V6G

CIRCUIT DESCRIPTION A.T.5:—

The transmitter consists essentially of two separate sets of tuning circuits, M/F covering from 150-500 K.C.'s and H/F covering from 2-20 M.c's. The same valves are used on both ranges and the change of L C circuits, etc., from M/F to H/F is effected by a single switch. Thus one pre-set M/F and one pre-set H/F is available at all times.

On H/F the transmitter employs either a crystal controlled Pierce Oscillator or variable frequency Colpitts Master Oscillator. Provision is made for mounting six crystals, and a ten position switch enables any one of the six crystals or any one of four variable frequency circuits to be selected at will. There is no M.O. tuning adjustment for crystal controlled operation. The six crystals plug into sockets behind a hinged panel on the front of the unit. The M.O. operates between 2 and 5 M.C.'s only, the range being covered in four bands and tuned by an accurately calibrated dial. The output from the M.O.

drives a buffer-doubler amplifier stage (B.A.) which operates between 2 and 10 M.C.'c, the frequency range being covered in two bands 2 to 4.5 M.C's and 4.5 to 10 M.C's by coil switching. The B.A. drives the two paralleled power amplifier output valves, which operate between 2 and 20 M.C.'s, the range being covered in 5 switched bands. The output circuit is designed to supply the full available output power to a 100 ohm resistive load.

On M/F the H/F oscillator is inoperative and the B.A. VALVE becomes the M/F MASTER OSCILLATOR using a Colpitts circuit and covering the frequency range between 140 and 500 K.C.'s in four bands.

This is followed by the 2 P.A. valves which operate on the same frequency range as the oscillator and supply power to a 100 Ohm output. The P.A. frequency range is covered in three (3) bands.

The tuning dials of both M/F and H/F M.O.'s are directly calibrated in K.C.'s and M.C.'s. The H/F Tuning controls of the B.A. and P.A. are calibrated in frequency bands and it is important to ensure that the tuning point falls within the appropriate calibration area. All Tuning Controls are fitted with locking device to ensure permanency of adjustment.

A modulator valve Grid modulates the two P.A. valves for R.T. and M.C.W. This valve is also used as an audio oscillator to supply side tone when the transmitter is keyed on C.W. or M.C.W. and voice side tone on R/T. No neutralizing or coupling adjustments are necessary in this transmitter, but for R/T and M.C.W. on H/F, it is necessary to reduce the grid drive to the P.A. by de-tuning the B.A. until the P.A. grid current is reduced to approximately 2 M.A.'s. This is carried out after tuning has been completed and with the key held down on C.W.

No such adjustment can be made on M/F, and therefore the depth of modulation may vary for different M/F's, depending on the amount of drive supplied by the M/F oscillator.

TRANSMITTER CONTROLS.

M/F H/F RANGE SWITCH:—Selects the M/F or H/F Channel as required.

FREQUENCY RANGE SELECTOR SWITCHES:—These switches select the coils, etc., for the various frequency bands on M/F and H/F and in the H/F MASTER Oscillator the switch also selects the required crystal, if crystal controlled operation is desired.

TUNING CONTROLS.

(i) H/F (a) MASTER OSCILLATOR TUNER is carefully calibrated in M.C.'s and controls the output frequency when the variable frequency oscillator circuit is being used.

(b) The H/F B.A. and H/F P.A. Tuners are used to tune their respective output circuits to resonance with the grid drive frequency or its desired harmonic.

(ii) M/F (a) M/F MASTER OSCILLATOR TUNER is calibrated in K.C.'s and controls the radiated frequency on M/F.

(b) The M/F P.A. tuner operates in the same range as the M/F M.O. and resonates the output circuit to the frequency of the grid drive.

THE EMISSION SWITCH:—Controls the type of signal radiated. It has four (4) positions and functions as follows:—

(a) STAND-BY:—Filaments of all valves "ON," transmitter H/T supply generator "OFF." Aerial connected to receiver. Receiver operating.

(b) C.W. Transmitter H/T generator "ON." Transmitter operates when key pressed. Modulator valve connected to operate as an audio frequency side tone oscillator when the key is pressed.

(c) M.C.W. As for C.W., except that the modulator valve grid modulates the P.A. at 1000 C.P.S., also providing side tone when the key is pressed.

(d) R/T. Modulator valve operates as a microphone amplifier and grid modulates the P.A., also supplying voice side tone. Aerial connected to the transmitter. Transmitter is radiating. Microphones are switched to modulator input transformer.

METER SWITCH:—The following circuits are capable of being metered by means of a milli amp meter on the transmitter panel, and five position switch.

(a) The B.A. cathode current	0-250 M.A.
(b) P.A. cathode current	0-250 M.A.
(c) P.A. grid current	0-15 M.A.
(d) H/F Oscillator cathode current	0-15 M.A.
(e) Modulator cathode current	0-250 M.A.

100 OHM LINE SWITCH:—Connects the 100 ohm output from the tuned output circuits to the A.C.U.

KEYING RELAY:—Is located in the Aerial Coupling Unit and keys all valves in the transmitter and all R/F and I/F valves, with the exception of the H/F R/F oscillator in the receiver, through common cathode circuits and earth. Another set of contacts switches the aerial from transmitter to receiver.

ON PRESSING THE KEY:—

(a) Aerial is switched from receiver to transmitter.

(b) The earthed contact is switched from the receiver common cathode contact to the transmitter common cathode contact.

ON LIFTING THE KEY:—The reverse actions take place.

AERIAL COUPLING UNIT.

The A.C.U. is designed to couple the 100 ohm output from the transmitter to any aerial likely to be encountered in service aircraft. It consists of 2 separate circuits, one for M/F and the other for H/F. The output from the transmitter is switched from M/F to H/F by means of a relay operated by the M/F H/F switch on the transmitter. A common aerial current meter is also switched by the same relay.

The M/F portion of the unit consists of a coupling control labelled "M/F INPUT TUNING," which controls the amount of power fed to the aerial, and two "M/F AERIAL TUNING" controls, "COARSE" and "FINE," which inductively load and tune the aerial circuits to resonance with the transmitter output. For M/F operation the aerial in use is connected to the insulator labelled "TRAILING AERIAL." NOTE:—Minimum coupling is indicated by a scale reading of 100 on the "M/F INPUT TUNING."

The H/F portion consists of a "COARSE" and "FINE" coupling control labelled "H/F INPUT TUNING," and a "COARSE" and "FINE" H/F "AERIAL TUNING."

To cope with the wide range of aerials and frequencies encountered in H/F operation, another control is fitted which enables the aerial to be connected:—

(a) Direct to A.C.U.
(b) Through a fixed series capacity.
(c) In parallel with a fixed capacity to ground.

For H/F operation the aerial is connected to the insulator labelled "FIXED AERIAL."

Both the transmitter and the receiver are connected to the A.C.U. through leads and plugs supplied for the purpose, but as mentioned before, the receiver can be connected directly to either aerial to provide "free receiver."

A.T.5:—TUNING PROCEDURE ON M/F.

TUNING TRANSMITTER ON M/F.

1. Ensure that transmitter EMISSION switch is on STAND BY.
2. Turn 100 OHM LINE switch "OFF."
3. Plug aerial (either fixed or trailing, which ever is being used) into TRAILING AERIAL socket of A.C.U.
4. Turn both switches of power unit "ON."

This (a) provides L/T for transmitter and receiver, and
(b) starts the receiver generator and thus provides H/T for the receiver.
Wait one minute before attempting to operate transmitter.

5. Turn transmitter RANGE SWITCH to M/F.
6. Select the correct range on M/F M.O. and M/F P.A. band switches.
7. Set M/F M.O. tuner to the desired frequency calibration.
8. Set METER switch to P.A.
9. Turn EMISSION switch to C.W. This starts the Transmitter H/T Generator.
10. Press key and tune P.A. for minimum current.
11. Open key, turn line switch "ON" and proceed to tune A.C.U. as under.

IMPORTANT.

Never operate line switch or range switches with key down. This will cause arcing across the switch contacts and consequent damage.
Once the P.A. has been tuned to resonance, it must **NOT** be altered after the 100 ohm line has been switched "ON."

TUNING THE A.C.U. ON M/F.

1. Set the M/F INPUT TUNING to 100 (minimum coupling).
2. Set FINE AERIAL TUNING to 20.
3. Press the key, rotate the COARSE AERIAL TUNING from 12 to 1 until a dip is obtained in the P.A. current. Then adjust the FINE AERIAL TUNING for a minimum dip in the P.A. current. NOTE:—If no dip is observed during the above operation, it will be necessary to move the "COARSE AERIAL TUNING" one stud at a time, swinging the "FINE AERIAL TUNING" on each stud until a dip is obtained.
4. Increase coupling (M/F INPUT TUNING) slightly by decreasing scale reading to, e.g., 90. This will cause a considerable rise in P.A. current. Then retune the COARSE of FINE aerial tuning as necessary for minimum P.A. current. It will be noticed that the minimum dip registers a higher current than that previously obtained at the dip.
5. Continue this procedure, i.e., increasing the coupling and retuning the aerial until the In-tune current, as indicated by the dip, is approximately 150 M.a.
6. At this point, note the aerial current. Further increase the coupling and retune the aerial. Note carefully whether the aerial current is increased or decreased. If it increased, continue increasing coupling and retuning until a point is reached where the aerial current fails to show a further increase; then it indicates that the A.C.U. is tuned for maximum efficiency.
7. Lock all tuning controls on completion of adjustment.

TUNING PROCEDURE ON H/F.

TUNING TRANSMITTER ON H/F.

1. Ensure that the transmitter EMISSION switch is on STAND-BY.
2. Turn the 100 ohm line switch "OFF."
3. Plug the aerial into the FIXED AERIAL socket of A.C.U.
4. TURN both switches of power unit "ON." Wait one minute.
5. Turn transmitter RANGE switch to H/F.
6. Select the correct FREQUENCY ranges on the H/F M.O. RANGE switch and H/F B.A. & P.A. RANGE switches.
7. Set the H/F M.O. TUNFR carefully to the desired frequency calibration.
8. Set the METER to P.A. GRID.
9. Turn the EMISSION switch to C.W.
10. Press the key and tune B.A. TUNER for maximum P.A. grid current. (Check the B.A. TUNER dial reading to make sure that you have not tuned to harmonic.)
11. Open key, set METER switch to P.A., close key and adjust H/F P.A. tuner for minimum P.A. current. (Ensure tuning point fall within correct calibration area.)

12. Open the key, turn 100 OHM LINE switch "ON," and tune A.C.U. as under:—

TUNING THE A.C.U. ON H/F

1. Set the COARSE INPUT TUNING to 1, FINE INPUT TUNING to 0. (This is the position for minimum coupling.)
2. Set COARSE AERIAL TUNING to 11, FINE AERIAL TUNING to 15.
3. Set the H/F AERIAL LOADING CAPACITY switch to DIRECT.
4. Press the key, rotate COARSE AERIAL TUNING from 11 to 1 until a dip is obtained in the P.A. current.
5. If no dip is obtained, with the H/F LOADING CAPACITY switch on DIRECT, try SERIES, then PARALLEL. NOTE:—Using SERIES will shift the tuning point higher up the aerial tuning scale; parallel will move the tuning point down the scale.
6. When the dip is obtained, increase coupling slightly. This will cause a considerable rise in P.A. current. Then retune the FINE and/or COARSE AERIAL TUNING as necessary for minimum P.A. current.
7. Continue this procedure, that is, increasing the coupling and retuning the aerial until the "IN TUNE" current as indicated by the dip is approximately 150 M.A. NOTE:—If sufficient coupling has not been obtained when the FINE INPUT TUNING has reached 100, it should be returned to approximately 10, and the COARSE INPUT TUNING advanced one tapping.
8. At this point, note the aerial current. Further increase the coupling and retune the aerial, noting carefully whether the aerial current increases or decreases. If it increases continue to increase the coupling and retune the aerial until a point is reached where the aerial current fails to show a further increase. This maximum aerial current indicates that the A.C.U. is completely tuned. NOTE:— If no aerial current is observed, which is quite likely using some aerials on certain frequencies, the coupling should be increased until the "in tune" dip in P.A. current is approximately 10 M.A. lower than the "out of tune" P.A. current.
9. Lock all controls.

FREQUENCY DOUBLING.

(For Frequencies above 5 M.c's.)

1. Since the H.F. M.O. operates between 2 and 5 M.c's only, it becomes necessary to use the B.A. as a Doubling Amp on frequencies between 5 and 10 M.c's. If the output frequency is over 10 M.c's the P.A. is also used as a Doubling Amplifier.
2. The following examples demonstrate the frequencies to which each stage should be tuned to provide a desired output frequency.

Output Frequency Required	Oscillator Tuned to	B.A. Tuned to	P.A. Tuned to
M.C.	M.C.	M.C.	M.C.
2.75	2.75	2.75	2.75
3.1	3.1	3.1	3.1
5.2	2.6	5.2	5.2
8.25	4.125	8.25	8.25
10.8	2.7	5.4	10.8
19.0	4.75	9.5	19.0

NOTE:—The P.A. must NOT be used for doubling at frequencies below 10 M.C's.

When doubling it is VERY IMPORTANT to ensure that the tuning point falls within the correct calibrated areas on both B.A. and P.A. tuners.

3. When crystal control is used, it is merely necessary to tune the B.A. to resonance with the crystal frequency, or, if desired, its second harmonic. The B.A. output can then be amplified or doubled by the P.A. N.B.—There is no provision for crystal control on M/F.

TUNING TO A RECEIVED SIGNAL BY ZERO BEAT METHOD (M/F & H/F).

1. Zero beat the signal accurately to the receiver. Be SCRUPULOUSLY careful not to disturb the receiver adjustment once the Zero Beat has been obtained.
2. Rotate TONE CONTROL anti-clockwise until the INTERTUNE switch operates.
3. Select frequency ranges necessary to provide output on the frequency indicated by the receiver setting. Turn line switch off, etc., as indicated in previous tuning paragraphs.
4. Set the MASTER OSCILLATOR TUNER to the calibration necessary to operate the P.A. on the frequency to which the receiver is tuned,
   e.g. Receiver 3.3 M.c. — Osc. 3.3 M.c.
   Receiver 9.5 M.c. — Osc. 4.75 M.c.
   Receiver 12.4 M.c. — Osc. 3.1 M.c.
5. Turn EMISSION switch to C.W. and press key.
6. Slowly swing MASTER OSCILLATOR TUNER until signal from oscillator is hetrodyning receiver. Adjust oscillator carefully to zero beat. NOTE:—Judicious adjustment of the receiver volume control is essential for accurate results. After Zero beating check M.O. calibration.
7. Completely tune TRANSMITTER and A.C.U. as indicated previously.
8. On completion of tuning, always re-check radiated frequency for accuracy of Zero beat, and carefully readjust oscillator tuning if necessary.

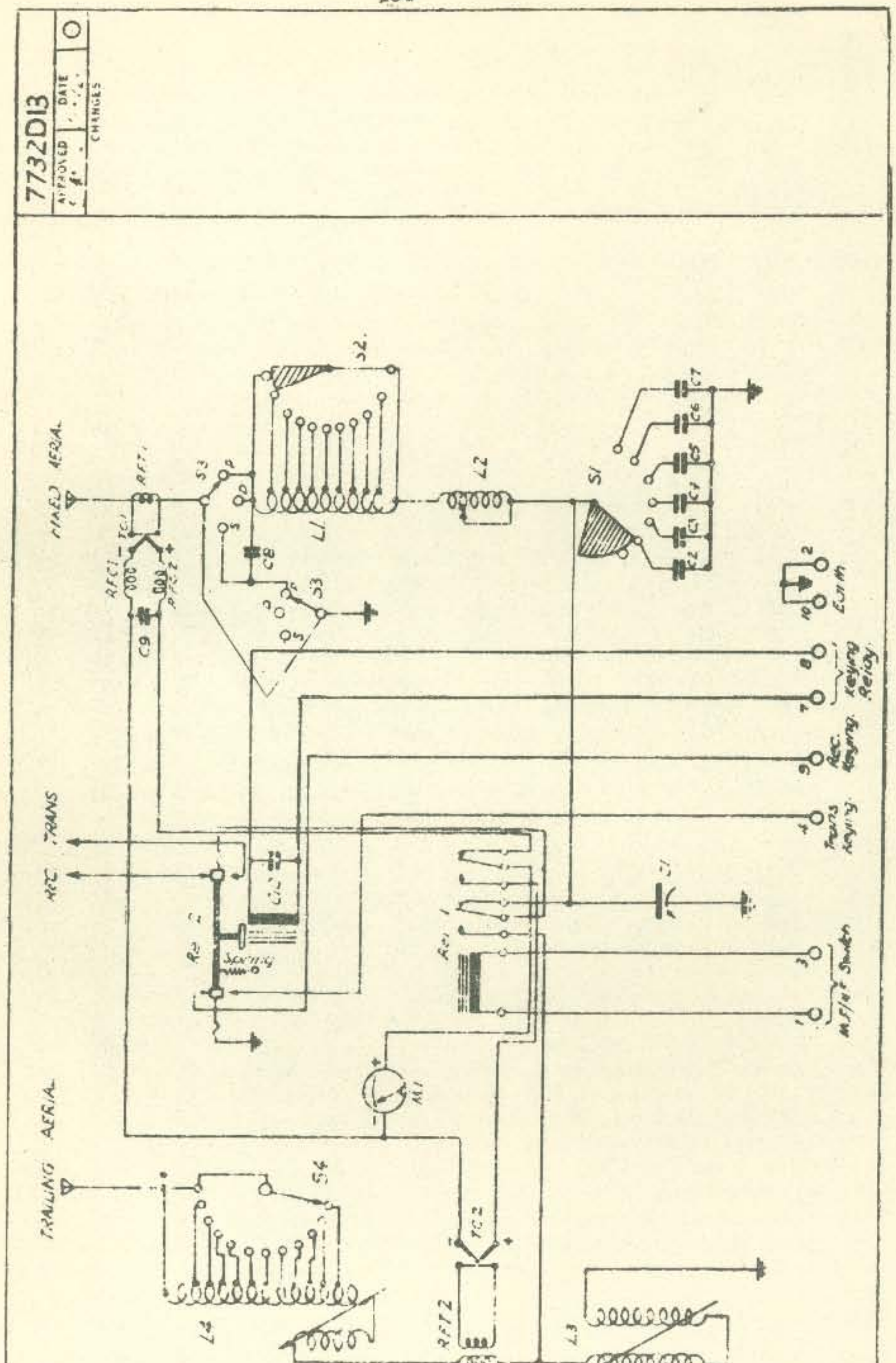
   NOTE:—Under NO circumstances alter the setting of the BEAT OSC. TUNING Control after Zero Beating as per Para. 1.

PRE-TAKE OFF DRILL A.T.5, A.R.8.

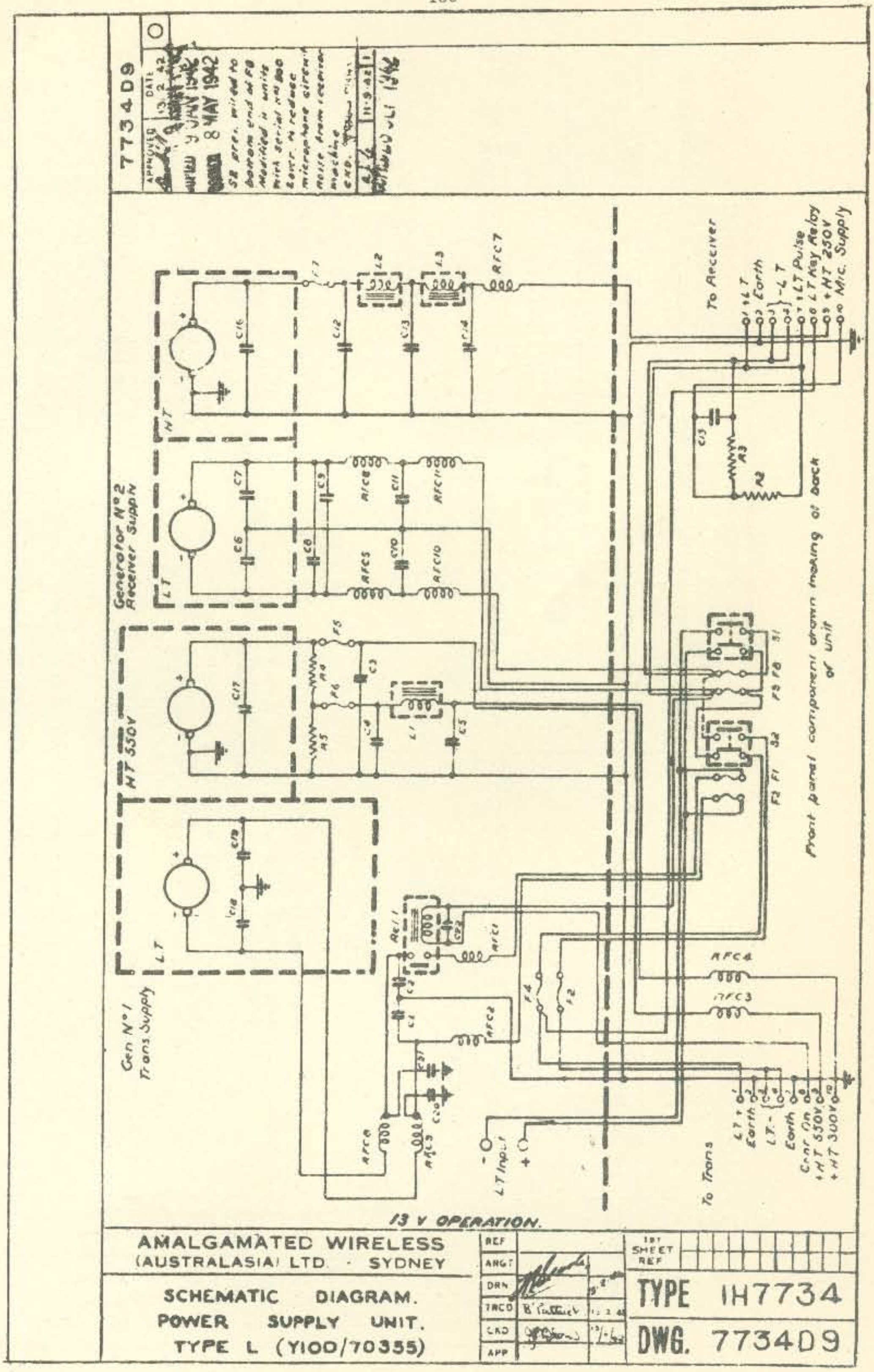
1. Turn aircraft master switch ON. Check Battery Voltage. If engine-driven Generator is not operating, Battery Cart must be used.
2. Ensure Transmitter Emission Switch is on STANDBY, Key open, and 100 OHM Line Switch Off.
3. Turn both switches of Power Unit ON. Allow one minute for cathodes to heat.
4. While waiting ensure Trailing Aerial is complete and locked. Loop working freely, etc.
5. Receiver should now be functioning. Connect aerial for "Free Receiver."
6. Check Receiver for correct operation on all bands; also check D/F loop for correct bearing and sense on a known station. Test out i/c at all points.
7. Test Transmitter on M/F and H/F, using fixed aerial and a frequency NOT liable to cause interference.
8. Check spare fuses.
9. Always return Emission Switch to STANDBY at conclusion of transmission.
10. Minor faults or wrong adjustments in the transmitter can normally be quickly rectified by an intelligent study of the meter readings.

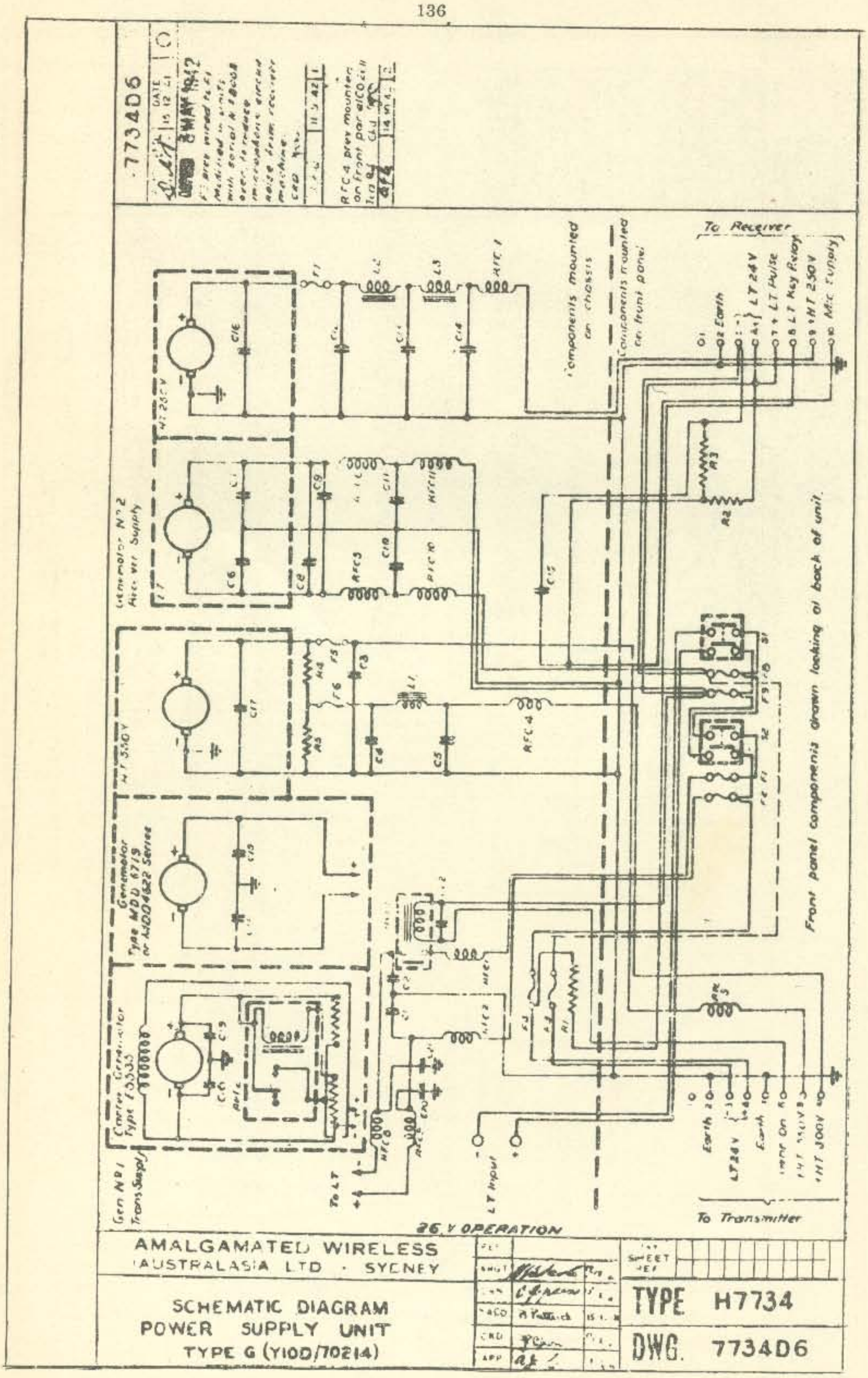
DURING FLIGHT.

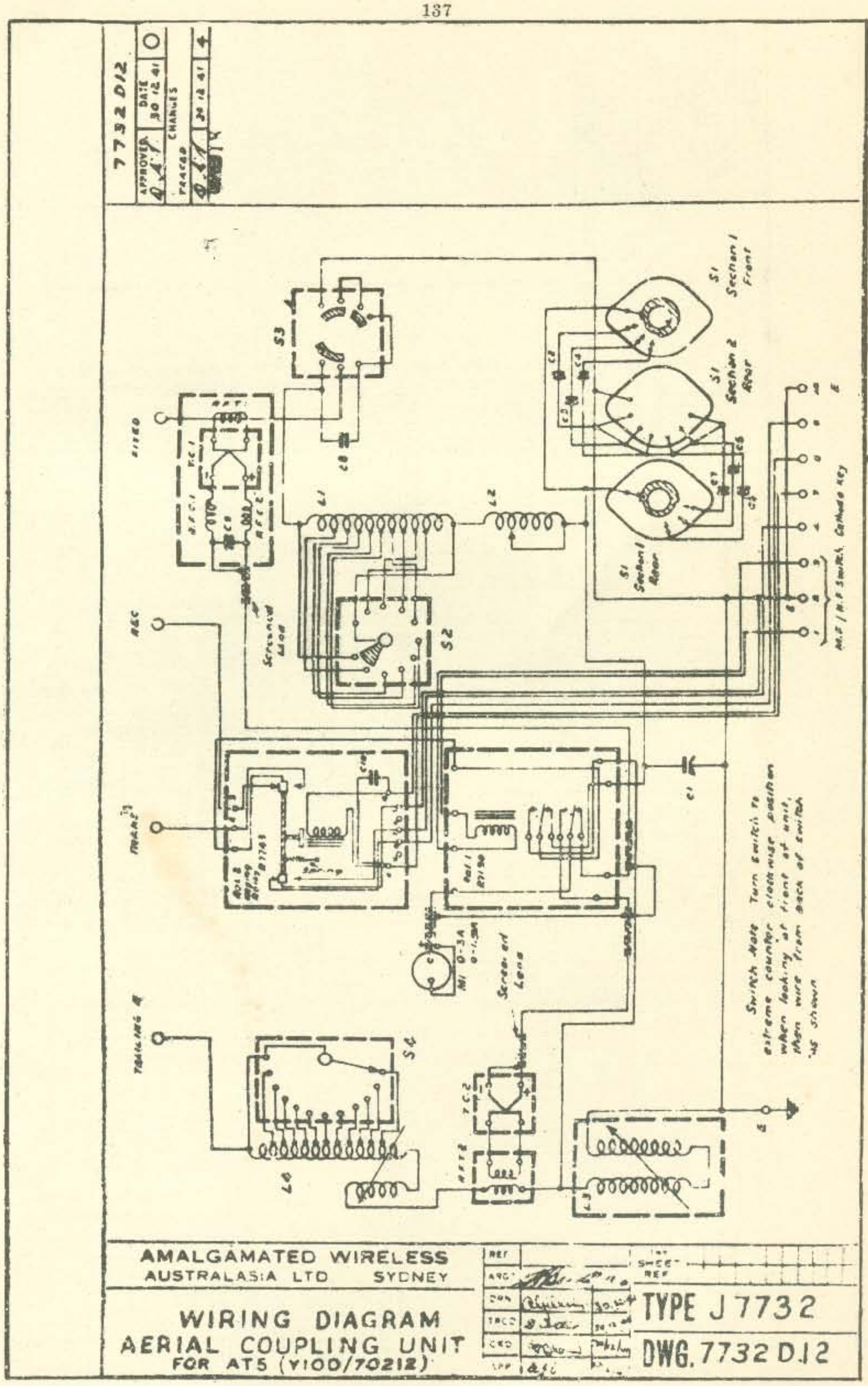
1. Check Battery Charging approximately every five minutes and LOG charging current.



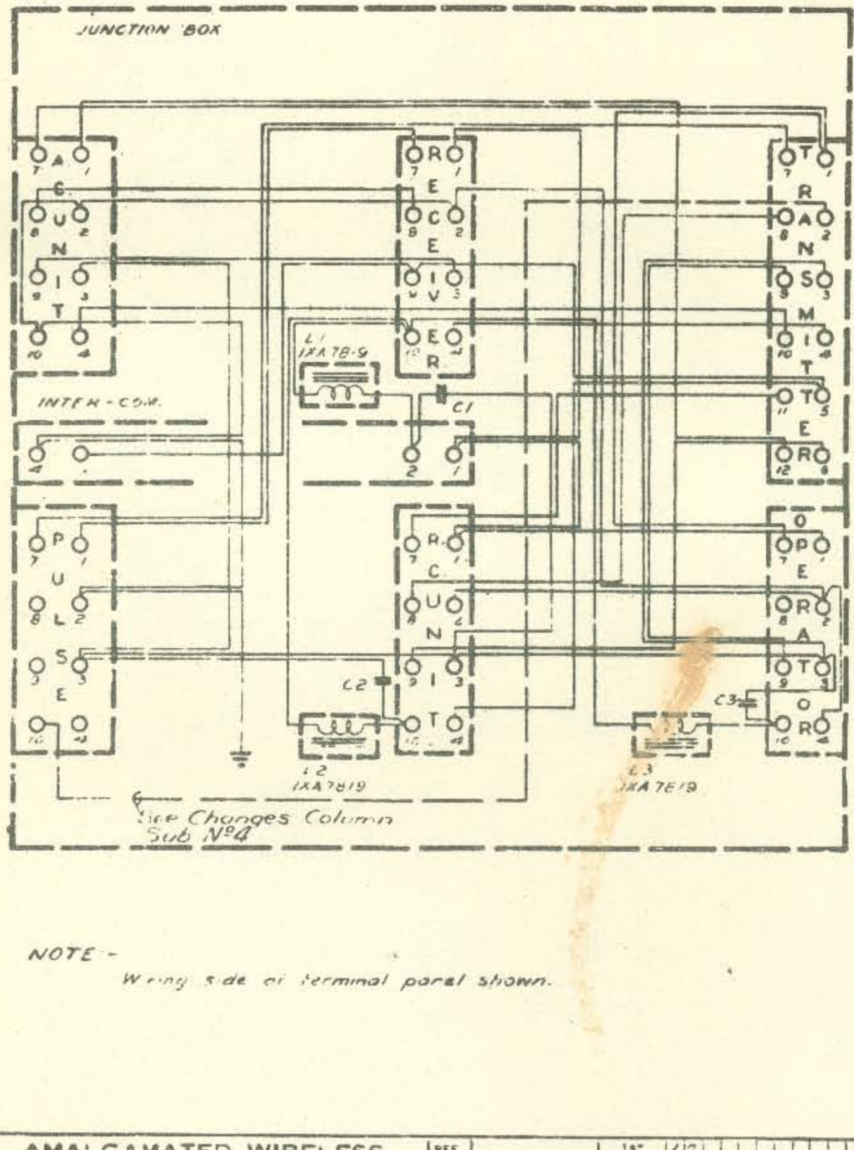
AMALGAMATED WIRELESS (AUSTRALASIA) LTD. SYDNEY	REF.		SHEET REF	
SCHEMATIC DIAGRAM AERIAL COUPLING UNIT FOR AT5 (Y1OD/70212)			**TYPE** J 7732	
			DWG. 7732D13	


773409
13 V OPERATION.
Gen No 1 Trans Supply
Generator No 2 Receiver Supply
HT 550V
LT
HT
To Receiver
To Trans
LT Input
Front panel component drawn looking at back of unit
AMALGAMATED WIRELESS
(AUSTRALASIA) LTD. - SYDNEY
SCHEMATIC DIAGRAM.
POWER SUPPLY UNIT.
TYPE L (Y100/70355)
TYPE 1H7734
DWG. 773409


7734D6
26 V OPERATION
To Receiver
To Transmitter
Components mounted on chassis
Front panel components drawn looking at back of unit.
AMALGAMATED WIRELESS
AUSTRALASIA LTD · SYDNEY
SCHEMATIC DIAGRAM
POWER SUPPLY UNIT
TYPE G (Y10D/70214)
TYPE H7734
DWG. 7734D6

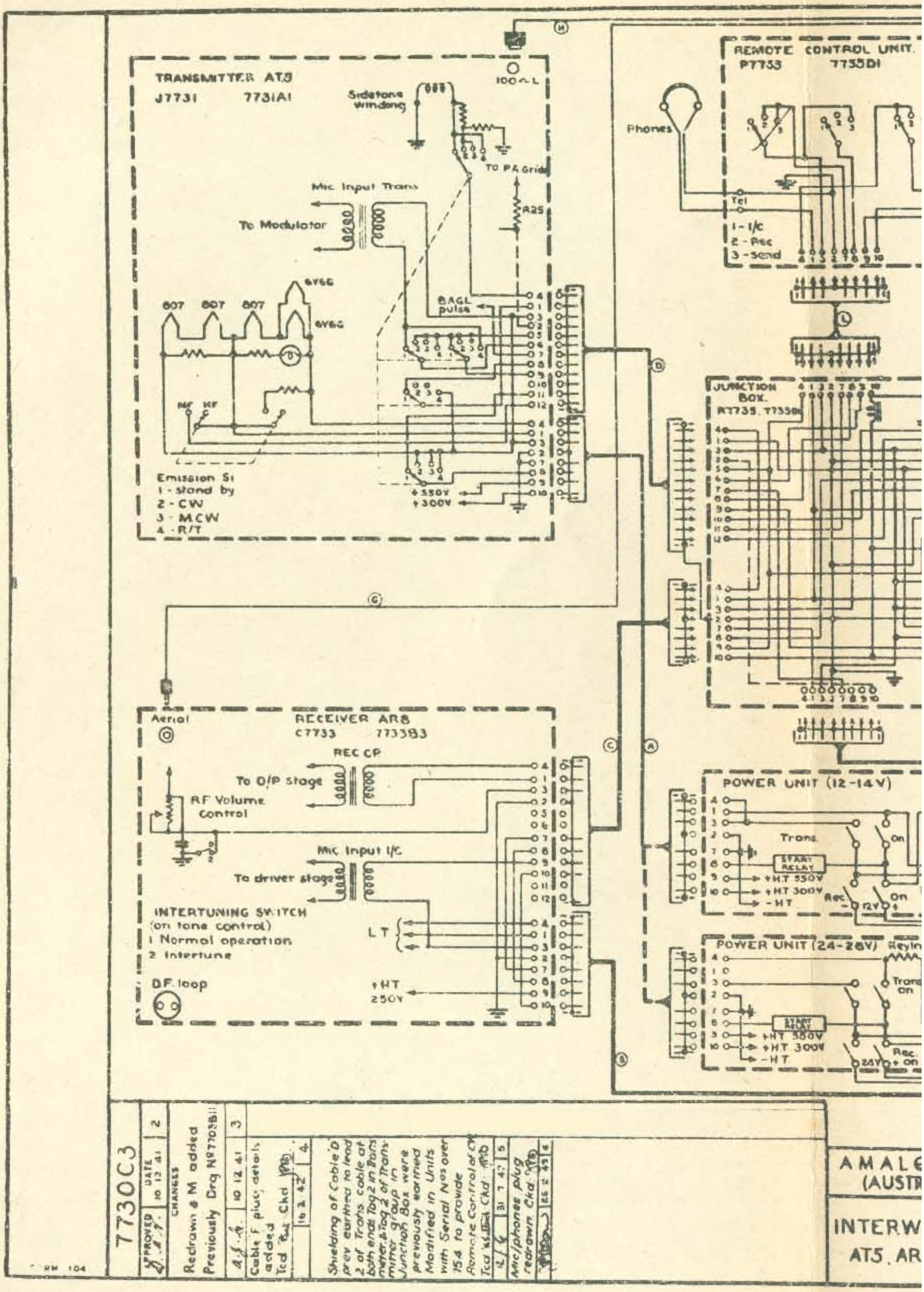

7732 D12
AMALGAMATED WIRELESS
AUSTRALASIA LTD SYDNEY
WIRING DIAGRAM
AERIAL COUPLING UNIT
FOR AT5 (Y100/70212)
TYPE J 7732
DWG. 7732 D12

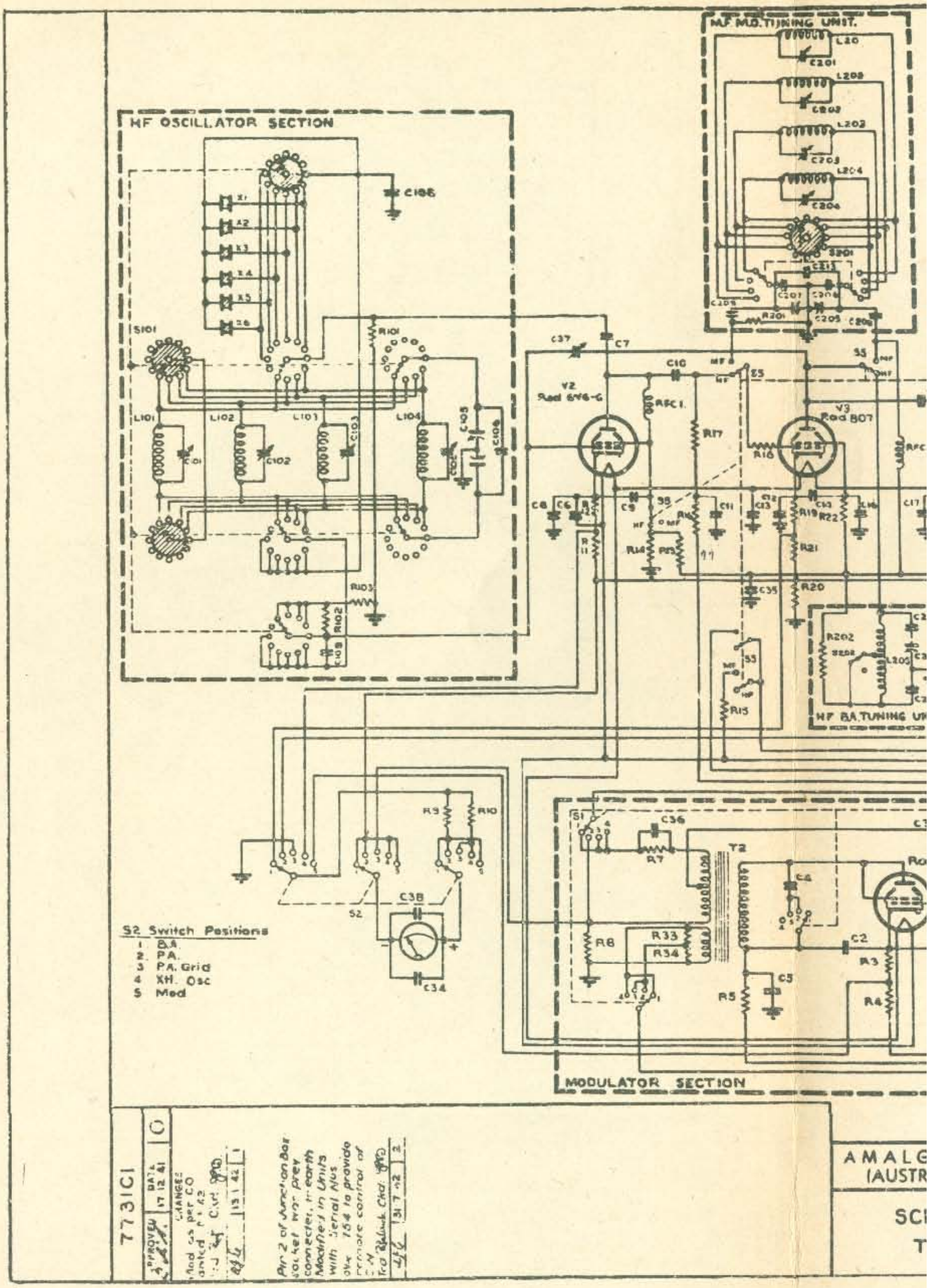
7735DI



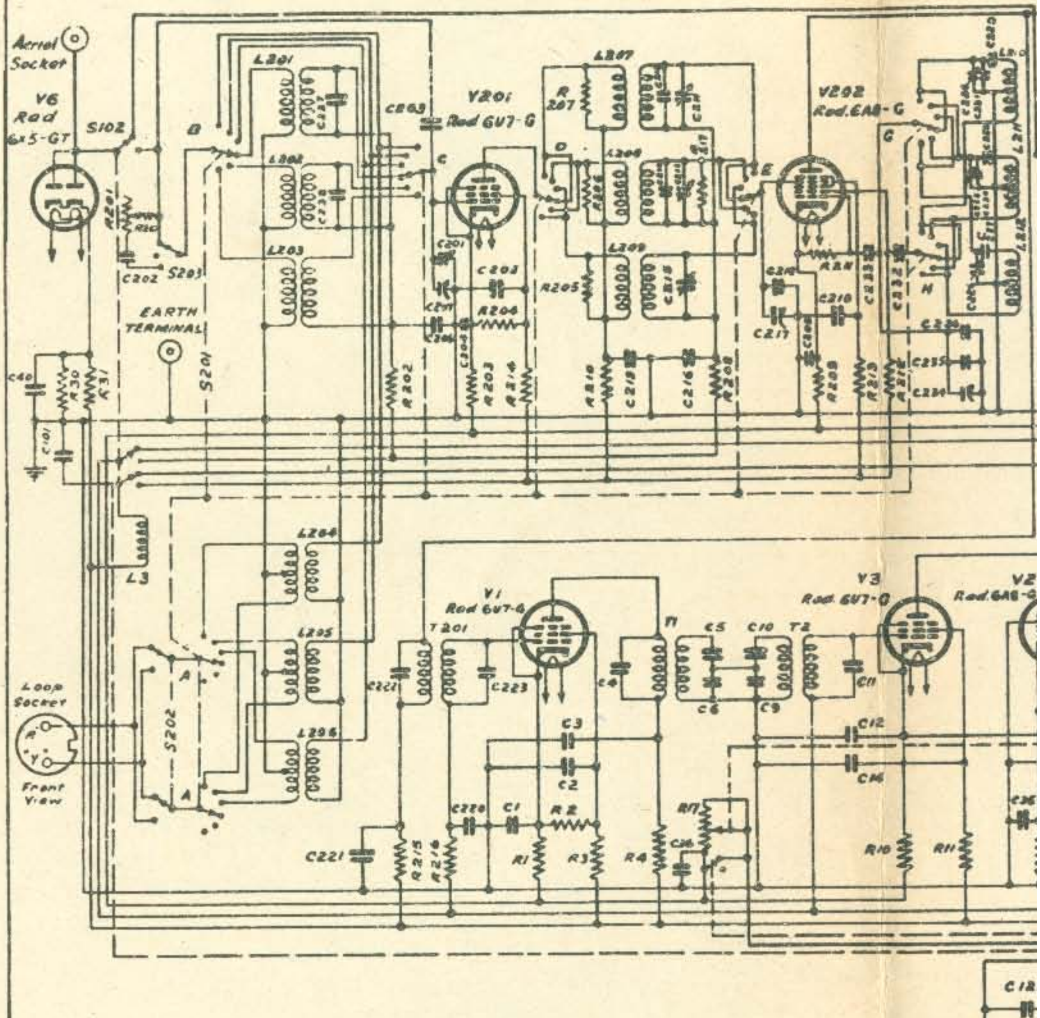
NOTE - Wiring side of terminal panel shown.

AMALGAMATED WIRELESS (AUSTRALASIA) LTD. - SYDNEY	REF / ANGT / DRN / TRCE / CKD / APP	SHEET REF
SCHEMATIC DIAGRAM		TYPE R7735
JUNCTION BOX FOR AT5/AR8 (Y10D/70215)		DWG. 7735DI


TRANSMITTER AT5
J7731 7731A1
Sidetone winding
TO PA Grid
Mic Input Trans
To Modulator
R25
6V6G
807 807 807
BAGL pulse
Emission S1
1 - stand by
2 - CW
3 - MCW
4 - R/T
+550V
+300V
100~L
REMOTE CONTROL UNIT.
P7733 7733D1
Phones
Tel
1 - I/C
2 - Rec
3 - Send
JUNCTION BOX.
R7735. 7735B
Aerial
RECEIVER AR8
C7733 7733B3
REC CP
To O/P stage
RF Volume Control
Mic Input I/C
To driver stage
INTERTUNING SWITCH
(on tone control)
1 Normal operation
2 Intertune
LT
D.F. loop
+HT 250V
POWER UNIT (12-14V)
Trans
On
START RELAY
+HT 550V
+HT 300V
-HT
Rec
12V
POWER UNIT (24-28V)
24V
7730C3
APPROVED
DATE
CHANGES
Redrawn & M added
Previously Drg No7705B
Cable F plug details added
AMALG
(AUSTR
INTERW
AT5, AR
FORM 104



HF OSCILLATOR SECTION
MF M.O. TUNING UNIT.
HF BA. TUNING UNIT
MODULATOR SECTION
V2 Rad 6V6-G
V3 Rad 807
S2 Switch Positions
1 B.A.
2 P.A.
3 P.A. Grid
4 XH. Osc
5 Mod
7731C1
APPROVED
DATE
17 12 41
CHANGES
Mod as per CO dated
13 1 42
Pin 2 of Junction Box socket was prev connected to earth. Modified in Units with Serial Nos 154 to provide remote control of
31 7 42
AMALG
(AUSTR
SC
T



All unused R.F. Coils are short circuited (not shown).
All R.F. Coils have iron slugs (not shown).

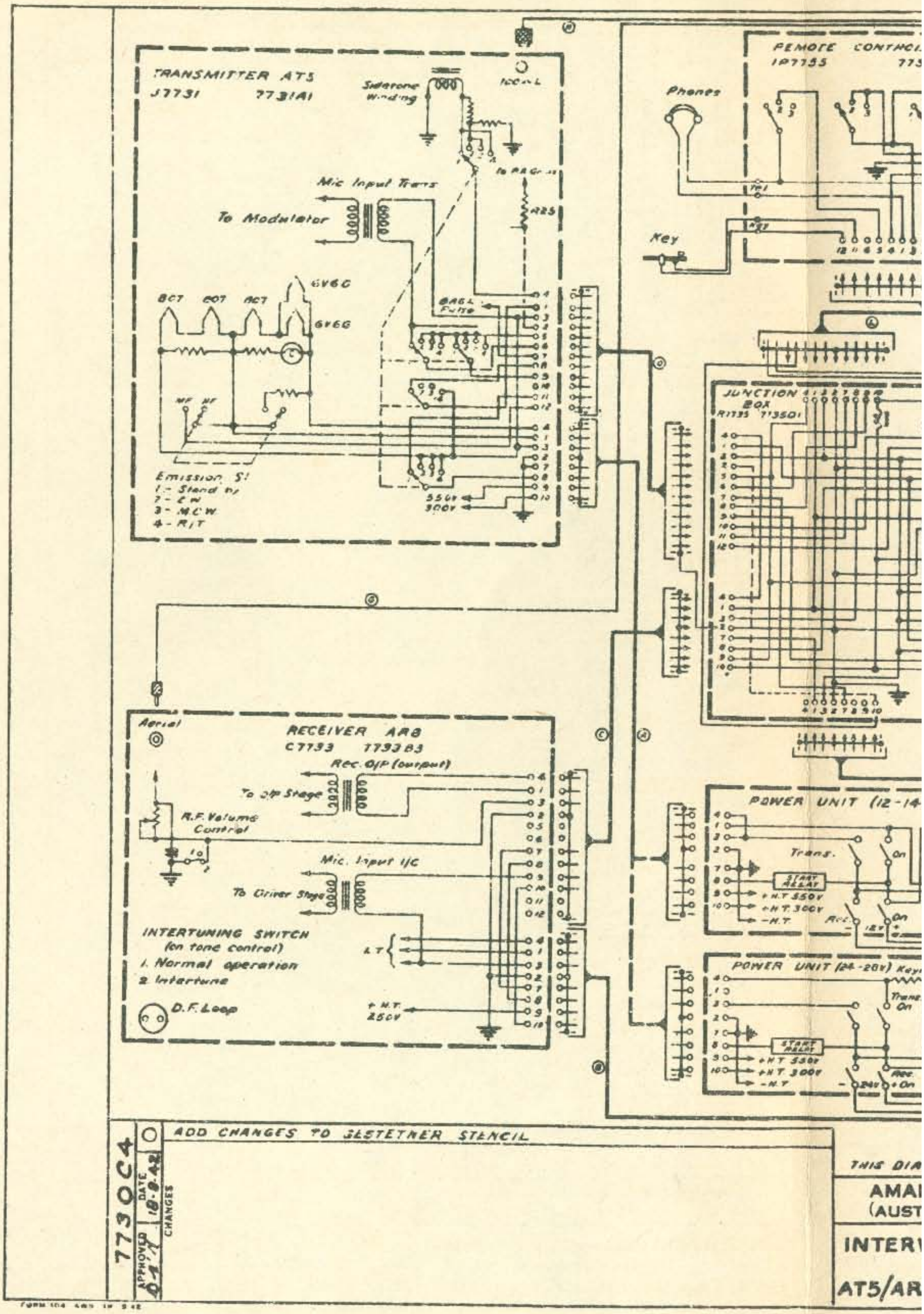
7733 C1

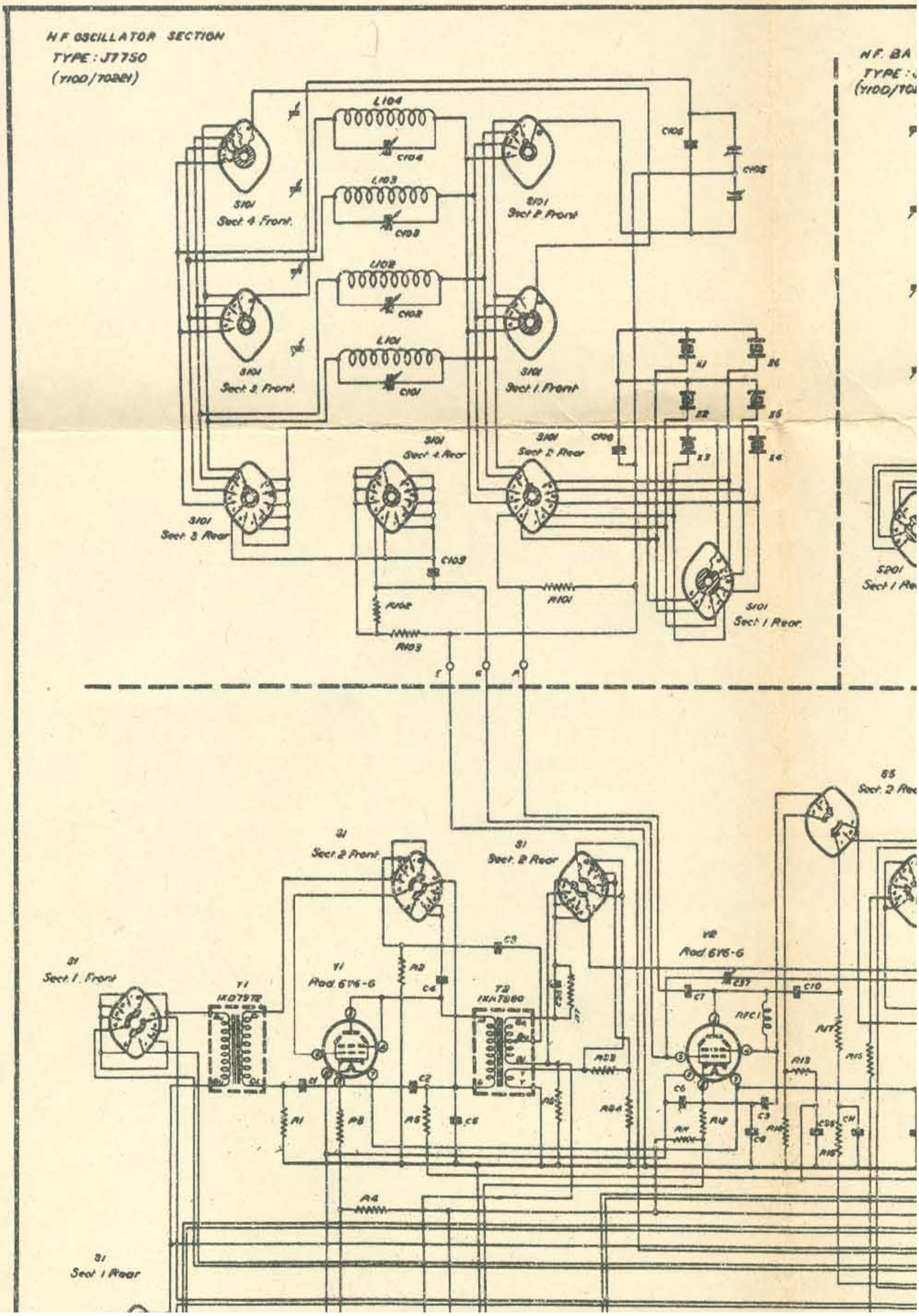
APPROVED	DATE	CHANGES	
A.A.T.	15-12-41		0
	1-1-43	R210 added to units with serial No's above 1161 C.O. 2490.	1

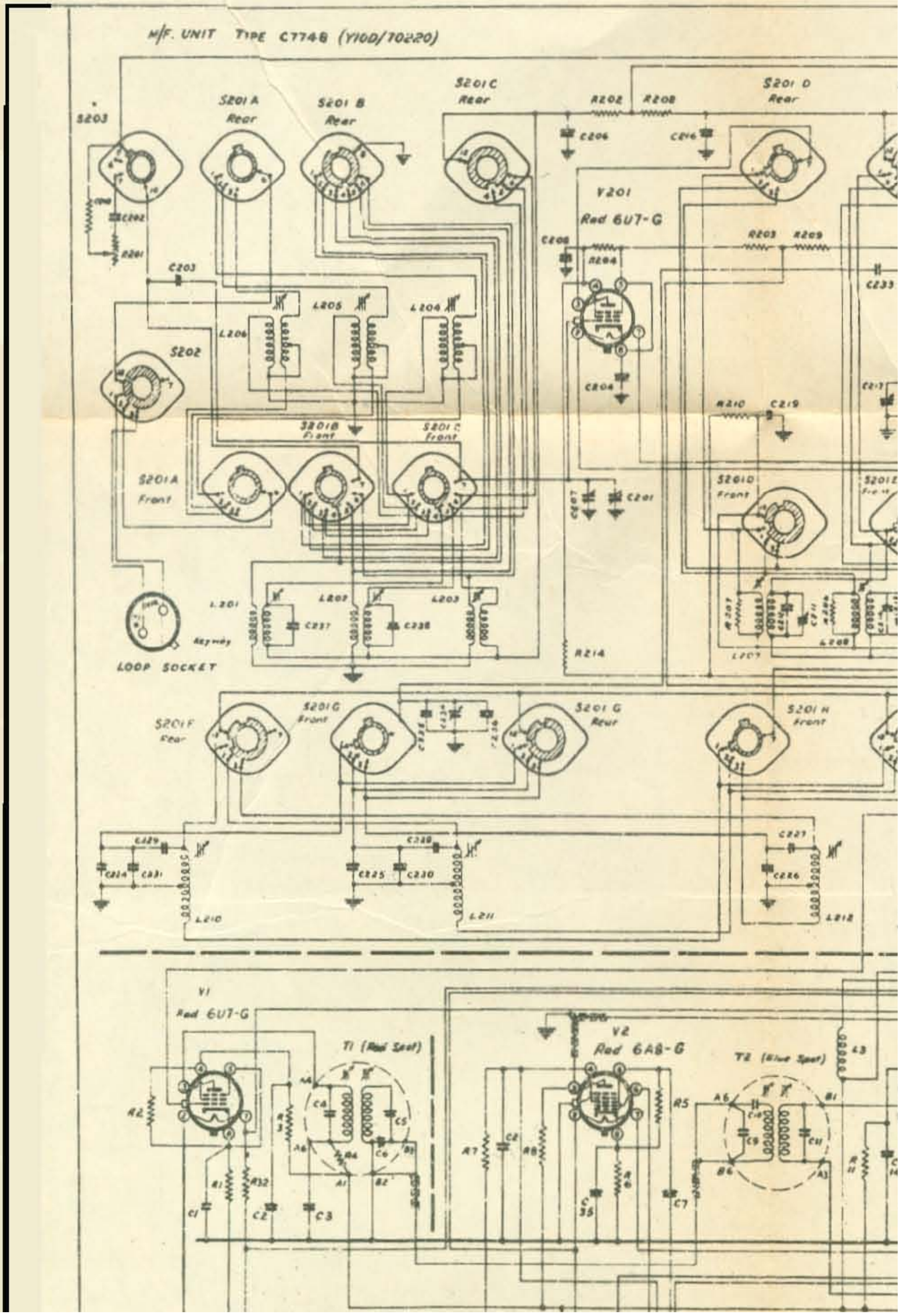
AMAL
(AUS

SCHE
R

FORM 104

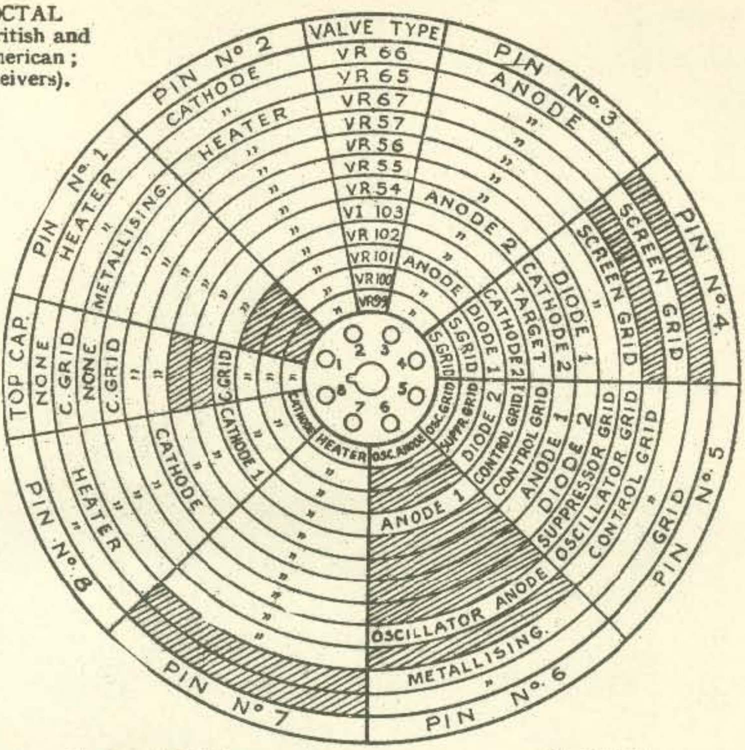

TRANSMITTER AT5
J7731 7731A1
Sidetone Winding
Mic Input Trans
To Modulator
6V6G
6V6G
807 807 807
Emission S1
1 - Stand by
2 - C.W.
3 - M.C.W.
4 - R/T
550v
300v
REMOTE CONTROL
Phones
Key
JUNCTION BOX
Aerial
RECEIVER AR8
C7733 7733B3
Rec. O/P (output)
To o/p Stage
R.F. Volume Control
Mic. Input I/C
To Driver Stage
INTERTUNING SWITCH
(on tone control)
1. Normal operation
2. Intertune
D.F. Loop
L.T.
+ H.T. 250v
POWER UNIT (12-14
Trans.
On
START RELAY
+ H.T. 550V
+ H.T. 300V
- H.T.
Rec.
POWER UNIT (24-28V)
START RELAY
+ H.T. 550V
+ H.T. 300V
- H.T.
Rec. On
ADD CHANGES TO GESTETNER STENCIL
7730C4
APPROVED
DATE 18-8-42
CHANGES
THIS DIA
AMAL
(AUST
INTER
AT5/AR


H F OSCILLATOR SECTION
TYPE : J7750
(Y100/70221)
H.F. BA
TYPE :
L104
L103
L102
L101
C104
C103
C102
C101
C105
C106
C108
C109
S101 Sect. 4 Front.
S101 Sect. 2 Front
S101 Sect. 3 Front.
S101 Sect. 1. Front
S101 Sect. 4 Rear
S101 Sect. 2 Rear
S101 Sect. 3 Rear
S101 Sect. 1 Rear.
R101
R102
R103
S201 Sect 1
S1 Sect. 2 Front
S1 Sect. 2 Rear
S1 Sect. 1. Front
S1 Sect 1 Rear
V1 Rad. 6V6-G
V2 Rad. 6V6-G
T1
T2
RFC1
S5 Sect. 2

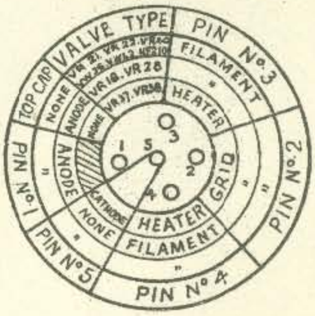

H/F. UNIT TYPE C774B (Y10D/70220)
S203
S201 A Rear
S201 B Rear
S201 C Rear
S201 D Rear
V201
Red 6U7-G
S202
S201 A Front
LOOP SOCKET
S201 F Rear
S201 G Front
S201 G Rear
S201 H Front
V1
Red 6U7-G
T1 (Red Spot)
V2
Red 6A8-G
T2 (Blue Spot)

APPENDIX 1

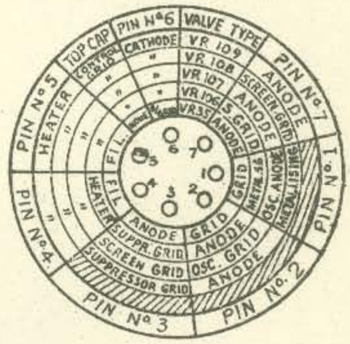
(1) OCTAL
(British and American; receivers).



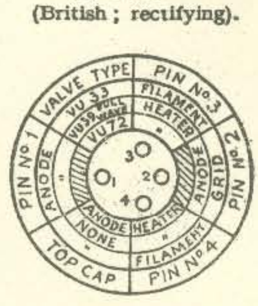
(2) 4 and 5-PIN
(British; rece.vers).



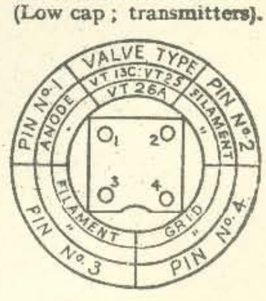
(3) 7-PIN
(British; receivers).



(4) 4-PIN
(British; rectifying).

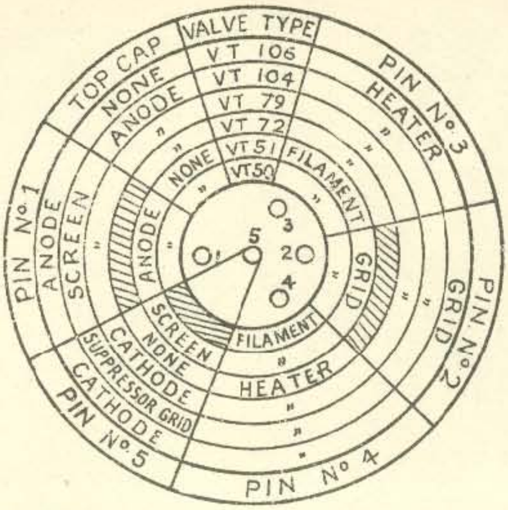


(5) LARGE PIN
(Low cap; transmitters).

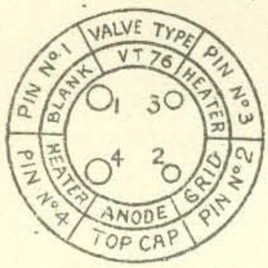


APPENDIX I.—*continued.*

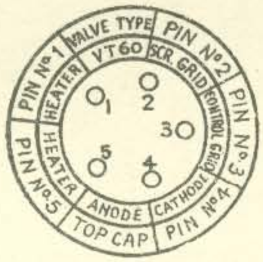
(6) 4 and 5-PIN (British ; transmitters).



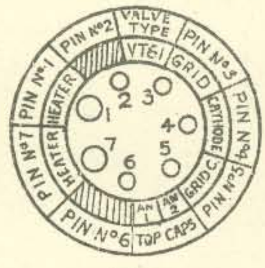
(7) 4-PIN (American ; transmitter).



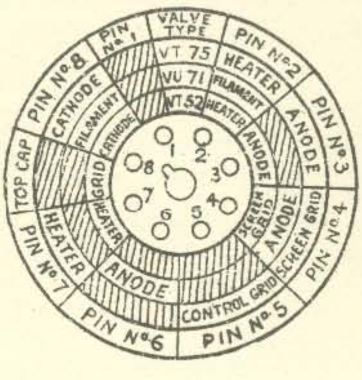
(8) 5-PIN (American ; transmitter).



(9) 7-PIN (American ; transmitter).



(10) OCTAL (American ; transmitter and rectifying).



TYPICAL R.A.F. RECEIVING VALVES.

Valve.	Filament.		Anode Volts.	A.C. Res. (Kilohms)	Amp. Factor.	Mutual Cond.	Base	Civil Equivalent.	Remarks.	Used in.
	Volts.	Amps.								
V.R.21	2·0	0·1	120	11·5	13·7	1·2	4-pin	210	General purpose triode	R.1082, R.1084, T.R.9,etc.
V.R.27	2·0	0·1	120	11·5	13·7	1·2	4-pin	210	V.R.21, selected as detector	R.1082, R.1084, T.R.9, etc.
V.R.22	1·8	0·2	150	6·7	16·0	2·2	4-pin	P.220	Output A.F. amplifier	R.1082, R.1084, T.R.9, etc.
V.R.18	2·0	0·15	120	300·0	330·0	1·1	4-pin, AnodeT.C.	S.G.215	Screen volts 60	R.1082, T.R.9's, T.R.1091, etc.
V.R.28	2·0	0·2	120	90/200	—	Var.	4-pin, AnodeT.C.	V.S.220	Vari-mu tetrode	R.1084.
V.R.35	2·0	0·4	150	—	—	—	7-pin	G.P.240	QP.P. double pentode	A.1134, A.1219.
H.F.210	2·0	0·1	60	15·8	24·0	1·5	4-pin	H.F.210	Special for wavemeters	W.1095, W.69, W.75, (sets 3).
V.W.36	2·0	0·2	30	6·7	16·0	2·2	4-pin	P-220	Special for wavemeters	W.1081, W.1117 (sets 3).
V.W.42	2·0	0·1	30	11·5	13·7	1·2	4-pin	210	Special for wavemeters	W.39A.
V.R.37	4·0	1·0	200	11·0	40·0	3·8	5-pin	AC/HL	Indirectly heated triode	A.1104, Crystal Monitor.
V.R.38	4·0	1·0	250	8·0	25·0	3·2	5-pin	M.H.L.4	Indirectly heated triode	A.1104, Crystal Monitor.
V.R.40	4·0	2·0	500	1·5	9·0	6·0	4-pin	Px.25	Directly heated triode	A.1104, Crystal Monitor.
V.R.53	6·3	0·2	210	—	—	Var.	Octal	E.F.5	I.D.H. vari-mu R.F. pentode	R.1137.
V.R.54	6·3	0·2	—	—	—	—	Octal	E.B.4	I.D.H. double-diode	R.1137.
V.R.55	6·3	0·2	210	—	—	—	Octal	E.B.C.3	I.D.H., D.D.T. (Vodas)	T.R.1133.
V.R.56	6·3	0·2	210	175·0	—	2·0	Octal	E.F.6	I.D.H., V.H.F. pentode	R.1133.
V.R.57	6·3	0·2	210	2000·0	—	—	Octal	E.K.2	I.D.H. octode	T.R.1133.
V.R.67	6·3	0.3	250	7·7	21·0	2·6	Octal	L.63	I.D.H. triode	T.1131.
V.R.99	6·3	0.34	220	—	—	—	Octal	X.66	Triode-hexode F.C. and switching	R.1155.
V.R.100	6·3	0.3	220	—	—	—	Octal	K.T.W.62	Vari-mu tetrode R.F. and I.F.	R.1155.
V.R.101	6·3	0.65	220	—	—	—	Octal	M.H.L.D.6	D.D.T., Det. A.V.C., B.F.O., and Limiter.	R.1155.
V.R 102	6·3	1.3	220	—	—	—	Octal	B.L.63	Double-triode-meter switch	R.1155.
V.R 103	6·3	0.3	220	—	—	—	Octal	Y.63	M.E.-Tuning indicator	R.1155.

APPENDIX I PAGE 2

Valve.	Filament.		Anode Volts.	A.C. Res. (Kilohms).	Amp. Factor.	Mutual Cond.	Base.	Civil Equivalent.	Remarks.	Used in.
	Volts.	Amps.								
V.R.106	13·0	0·2	200	600	—	1·65	7-pin Grid T.C.	9 D.2 ..	I.D.H. vari-mu R.F. screened pentode.	R.1124A.
V.R.107	13·0	0·15	200	360	—	—	7-pin Grid T.C.	15 D.2 ..	I.D.H. heptode	R.1124A.
V.R.108	13·0	0·2	200	—	—	1·25	7-pin Grid T.C.	8 D.2 ..	I.D.H. screened pentode	R.1124A, R.1125A.
V.R.109	13·0	0·2	200	10	40	4·0	7-pin Grid T.C.	4 D.1 ..	I.D.H. triode	R.1124A.

TYPICAL R.A.F. TRANSMITTING VALVES

Valve.	Filament.		Anode.		Mutual Cond.	A.C. Res. Kilohms.	Amp. Factor.	Base.	Civil Equivalent.	Remarks.	Used in
	Volts.	Amps.	Volts	Watts.							
V.T.4B	18·0	5·15	10,000	450·0	1·5	20·0	30	—	T.450	Bright emitter	T.77, T.70.
V.T.13C	5·6	1·4	1,500	30·0	1·0	35·0	35	4-pin low-cap (Lg.4A).	"R" (dev)	Bright emitter	T.1092, T.77.
V.T.20	1·8	0·2	200	3·0	2·2	3·7	8	4-pin	P.215	Dull emitter	T.R.9B, etc.
V.T.25	8·0	2·2	1,500	60·0	1·8	5·5	10	Lg.4A	D.E.T.1	Thoriated filament	T.1088, T.1090, T.1092.
V.T.26A	12·0	1·85	3,000	100·0	1·0	22·0	22	Lg.4A	—	Thoriated filament	T.77.
V.T.30	12·5	5·65	5,000	250·0	1·5	20·0	30	—	—	Special for H.F. (250 watts at 20 Mc/s.)	T.1087.
V.T.31	11·25	8·0	5,000	250·0	1·0	100·0	100	—	—	Tetrode	T.1087.
V.T.50	2·0	0·1	150	1·0	1·1	18·0	22	4-pin	H.L.2	Midget envelope	T.R.9D, T.R.9F, etc. Crystal Monitor Type 2.
V.T.51	2·0	0·2	150	3·0	2·5	—	—	5-pin	Pen 220	Pentode	T.R.9D, etc.
V.T.52	6·3	0·2	400	10·0	—	—	—	Octal	E.L.2	R.F. pentode	T.1131, T.R.1133.
V.T 60	6·3	0·9	600	21·0	—	—	—	5-pin ceramic (anode top cap)	R.C.A.807	I.D.H.V.H.F. tetrode	T.1136.
V.T.61	6·3	0·8	300	10·0	—	—	13	7-pin ditto	R.K.34	I.D.H. double triode	T.1136.
V.T.62	7·5	3·25	1,000	50·0	—	—	—	4-pin (2 dis) (A and G top cap)	T.Y.150 D.E.T.12	V.H.F. triode	T.1131.
V.T.75	6·3	1·27	300	22·5	6·3	—	—	Octal	K.T.66	Tetrode A.F. amplifier	T.1131.
V.T.76	7·5	2·5	1,000	40·0	—	—	62	4-pin Cer. A.t.c.	T.Z.40	Class B triode	T.1131.
V.T.79	6·3	1·27	600	25·0	—	—	—	5-pin Cer. A.t.c.	K.T.8	V.H.F. tetrode	T.1131.
V.T.81	7·5	3·0	1,250	40·0	—	—	—	5-pin Cer. A.t.c.	4052A	R.F. pentode	T.1087 (Crystal drive).
V.T.104	6·3	1·3	1,250	40·0	2·5/3·7	—	—	5-pin Cer. A.t.c.	P.T.15	D.H. pentode	T.1154.
V.T.105	6·3	0·7	250	5·0	2·9/4·7	—	—	5-pin Cer. A.t.c.	M.L.6	I.D.H. triode	T.1154.

RECTIFYING VALVES

Valve.	Filament.		Anode Volts.	(D.C. m/A.)	Base.	Civil Equivalent.	Remarks.	Used in.
	Volts.	Amps.						
V.U.29 ..	4·0	8/10	1500	600	Screw cap A.t.c.	—	M.V. diode, inverse 4 kV.	T.1087.
V.U.33 ..	2·0	0·4	30	75	4-pin	240B ..	Limiter valve	R.1082.
V.U.39 ..	4·0	2·5	500	120	4-pin	U.14 ..	Double-diode	A.1104 Crystal Monitor
V.U.71 ..	5·0	3·0	500	250	Octal	U.52 ..	Double-diode	T.1131.
V.U.72 ..	4·0	3·0	1500	250	4-pin Anode t.c.	G.U.5 ..	M.V. diode I.V. 4 kV.	T.1131.

APPENDIX II.—PETROL ELECTRIC SETS.

PETROL ENGINES

1. **General Principles.**—(i) If a gas be heated in a closed space its pressure will increase. In the petrol engine a combustible mixture of air and petrol vapour is burnt (thus producing heat) in the " combustion chamber " at the closed end of the " cylinder ". The pressure acts upon the " piston," which is free to slide in the cylinder, and is linked to a " crankshaft " by a " connecting rod," so that movement of the piston up and down the cylinder causes rotation of the crankshaft. A movement of the piston from one end of the cylinder to the other is called a " stroke ", and two strokes occur each revolution (one " up ", one " down ").

(ii) For continuous working it is necessary to arrange for a succession of impulses on the piston ; this involves the following operations :—

(*a*) Admitting a fresh charge of combustible mixture (through the " inlet valve ").

(*b*) Compressing this mixture into the combustion chamber (the more the mixture is compressed, the greater the pressure produced by combustion and the more powerful the engine).

(*c*) Igniting the compressed mixture at the proper moment, and allowing the pressure so produced to push the piston down.

(*d*) Expelling the burned gases (through the " exhaust valve ").

(iii) This " cycle of operations " is usually carried out on the " four stroke cycle ", as under. (A " two-stroke cycle " does exist, but is not used for engines in the Signals Branch of the R.A.F., and is far less common anywhere.)

(*a*) *Four stroke cycle* (theoretical)—

	Stroke.	Movement of		Valves.		Operation.
		Piston.	Crank.	Inlet.	Ex-haust.	
T.D.C.				Opens		
1	Suction	Down ↓	↻	Open	Shut	Change of mixture drawn into cylinder, to fill it.
B.D.C.				Shuts		
2	Compression	Up ↑	↻	Shut	Shut	Mixture compressed into combustion chamber.
T.D.C.						Spark ignites mixture.
3	Power or expansion	Down ↓	↻	Shut	Shut	Piston forced down by high pressure of burnt gases.
B.D.C.					Opens	
4	Exhaust	Up ↑	↻	Shut	Open	Burnt gases forced out.
T.D.C.				Opens	Shuts	

These four strokes (two revolutions of the crank) complete the " cycle ", which then repeats in the same order. As only one power stroke occurs in every two revolutions, a " flywheel " is needed to keep the engine running during the " idle " strokes ; an engine with a number of cylinders, arranged to " fire " one after the other, runs more smoothly than a single-cylinder engine.

(*b*) *Four stroke cycle* (practical)—

(1) *Valve timing.* In actual engines the valves are rarely opened and shut exactly at top or bottom dead centre.

The *exhaust* valve is opened *before* B.D.C. to allow the pressure to fall to atmospheric by the end of the stroke, thus preventing back pressure on the exhaust stroke. The exhaust valve is often closed a little *after* T.D.C., to allow the gases to continue to rush out. The *inlet* valve may be opened a little before or a little after T.D.C., depending on the engine design ; it is closed *after* B.D.C., to allow the mixture to continue to rush in.

(2) *Ignition Timing.* The spark is timed to occur *before* T.D.C., as the mixture takes a little time to get burning properly.

(3) The points at which valves open and shut, and the spark occurs, are stated by the *crank* position when the events occur (*i.e.* exhaust valve opens at 40° before B.D.C. means that it opens when the crank is in that position).

2. **Magnetos.**—(i) The spark which ignites the mixture occurs at the sparking plug, the high voltage required being produced by a magneto. Fig. 1 shows the electrical circuit of the " rotating armature " type magneto, and fig. 2 shows its magnetic circuit. The primary winding, consisting of roughly 200 turns of enamelled copper wire (about 26 g.), and the secondary winding, consisting of several thousand turns of very fine enamelled copper wire (about 40 g.), are both wound upon the laminated iron armature core (which is of the special section shown in fig. 2), with suitable insulation and binding. The armature core is fitted with end-plates carrying

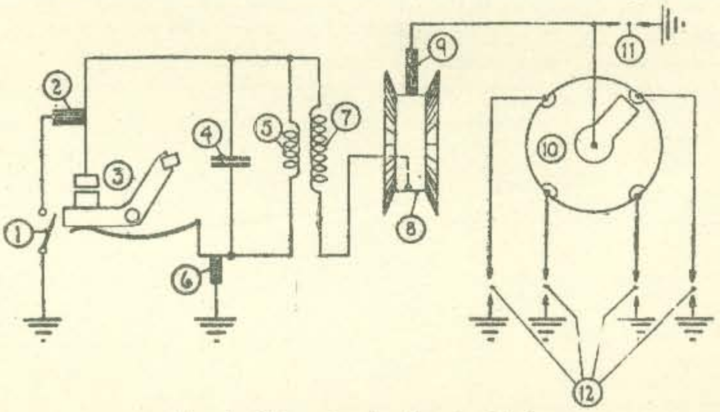


FIG. 1.—Magneto circuit—electrical.

1, Earthing switch ; 2, Carbon brush on cover ; 3, Contact breaker ; 4, Condenser ; 5, Primary winding : 6, Earthing brush ; 7, Secondary winding ; 8, Slipring ; 9, H.T. carbon brush ; 10, Distributor ; 11, Safety spark gap ; 12, Sparking plugs.

spindles which run in ball bearings mounted in the magneto body, so that the armature assembly can rotate with a small mechanical clearance between the magnet poles. The contact breaker is fitted to one end of the armature and rotates with it, being operated by a staionary cam ring fixed to the magneto body.

(ii) *Operation.*—(*a*) Rotation of the armature induces alternating voltages in the windings, which are zero when the armature core is in line with the pole shoes, and maximum at the " mid-pole " position. If the contact breaker is closed when the voltage is zero, a current will build up in the primary winding as it rotates, reaching maximum value slightly after the maximum voltage. This current will magnetise the iron core in such a direction as to drag round the flux of the permanent magnet in the direction of rotation, as represented in fig. 3 (*a*). If the current is now stopped by opening the contact-breaker, the distorting influence is removed from the main field, which now finds an easier path through the armature core in the opposite direction. Thus, at the instant the contacts open, the flux of the permanent magnet rapidly reverses its direction through the armature core, and the flux due to the primary current collapses ; these two effects together induce a voltage in the secondary windings which, applied across the sparking-plug points, is sufficient to cause a spark across the gap.

(*b*) The condenser ensures that primary current is stopped with the minimum possible sparking at the contacts when the contact-breaker opens ; the earthing switch puts the magneto out of action by short-circuiting the contact-breaker; the distributor is necessary on multi-cylinder engines to connect the secondary windings to each plug in turn; the safety spark-gap is adjusted to discharge if the voltage across the windings exceeds about 15,000 volts, thus safeguarding the insulation of the windings.

(*c*) In the rotating armature magneto the most delicate parts are rotated, and have to withstand the mechanical stresses imposed upon them by centrifugal force; this limits the speed at which it may be safely run to some 5,000 r.p.m., and as it produces only two spark each revolution, the number of sparks per minute is limited to about 10,000. Other types of magneto (usually found on large multi-cylinder engines only) are :—

(1) Rotating magnet: The necessary changes of flux are brought about by rotating a permanent magnet; the windings remain stationery.

(2) *Polar inductor.*—In these the flux changes are brought about by rotating soft iron inductors between the stationary magnet and stationary armature.

In both of these the rotating member is much more robust than the armature of the rotating armature type can be, and can safely withstand higher speeds.

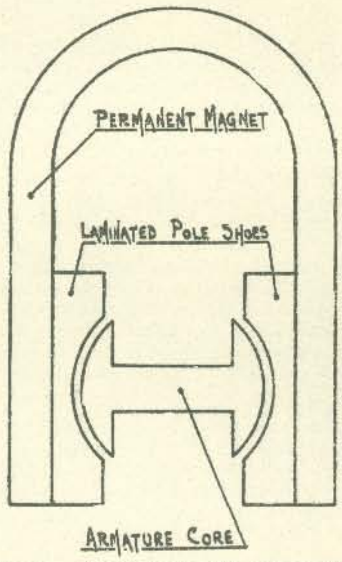


FIG. 2.—Magneto circuit—magnetic.

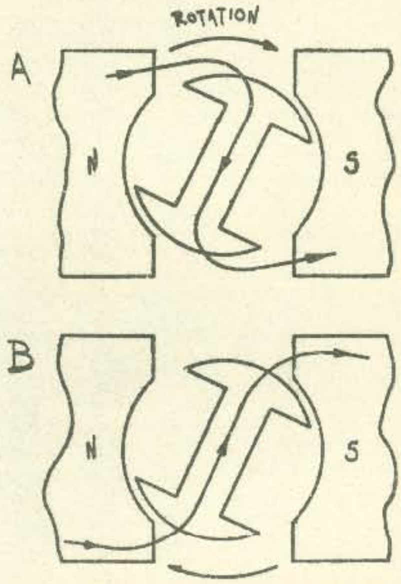


FIG. 3.—Magnetic circuit (A, contacts closed; B, contacts opened).

Also, by suitable arrangements of magnet poles or inductors, more sparks per revolution are obtainable, four being the usual number on aircraft magnetos. These types can supply multi-cylindered high-speed engines with the necessary sparks per minute without fear of mechanical breakdown.

(3) For four-stroke engines :—

(i) Magneto speed $= \frac{\text{Engine speed} \times \text{No. of cylinders.}}{2 \times \text{No. of sparks per rev. of magneto.}}$

(ii) Distributor speed $= \frac{1}{2} \times$ engine speed.

The distributor is usually incorporated in the magneto and driven by suitable gearing from rotating armature, magnet, or inductor shaft.

3. **Carburettors.**—(i) *General.*—The carburettor supplies the desired mixture for use in the engine by :—

(i) Mixing the petrol with the necessary amount of air.

(ii) Breaking the petrol up into a fine spray which is easily vaporised.

Fig. 4 shows a simple type of carburettor. The float, needle and needle seating control the level of petrol in the carburettor, allowing the petrol to flow in when the level is low, and shutting it off when the level reaches the top of the jet. When the engine is on its inlet stroke the pressure in the inlet pipe is lowered, sucking petrol through the jet and air through the choke tube at a rate depending on the sizes of these components and the pressure difference between the inlet pipe and the atmosphere. In addition to regulating the flow of air, the choke tube increases the speed of the air, at a point where it passes the jet, sufficiently to break up the petrol into a fine spray. The throttle regulates the amount of mixture passing to the engine, so controlling the speed and power of the engine.

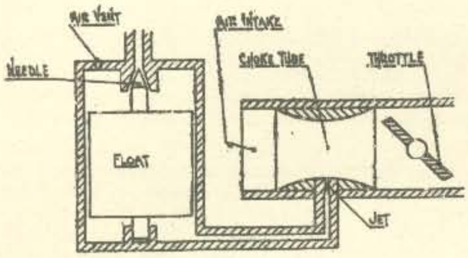


FIG. 4.—"Simple" carburettor.

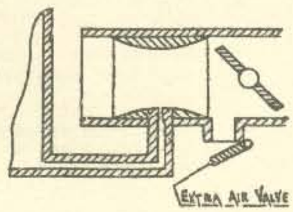


FIG. 5.—Extra air valve.

(ii) *Compensation.*—A carburettor of this simple type is only suitable for an engine running at a constant speed: at higher speeds the mixture is too "rich" (*i.e.* too much petrol): at lower speeds it is too "weak". (The reason for this is that the air density varies with its speed of flow, while the petrol density remains constant.) To counteract this, most carburettors have some means of "compensating" the mixture for varying speeds, and there are several methods in use:—

(*a*) *Extra air.*—The simplest method is to fit an "extra-air valve" to the simple carburettor (fig. 5). The choke-tube and jet are of the correct sizes to produce a suitable mixture at fairly low speeds, and the tendency for the mixture to become richer as speed rises is counteracted by opening the extra air valve sufficiently to admit enough additional air to prevent the mixture becoming richer. It is usual to couple the extra air valve to the throttle, since engine speed rises as the throttle is opened; as the speed is also governed by the load upon the engine, for which this carburettor makes no allowance, this type can only give good results where there are fairly small variations in load. The Stuart Turner carburettor works on this principle.

(*b*) "*Zenith*".—Fig. 6 shows an arrangement in which the jet does not open directly into the choke tube, but into a U-tube. One end of this U-tube (B) is open to atmospheric pressure, whilst the other end (C) is under the pressure prevailing in the choke tube, the float chamber (A) also being under atmospheric pressure. When the engine is not running the

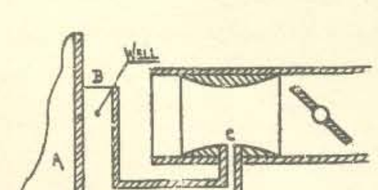


FIG. 6.—Principle of compensating jet.

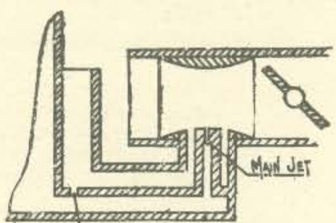


FIG. 7.—Zenith compensation.

pressure at A, B, and C are equal, and the level of petrol in each is also equal.

When the engine is running the pressure at C falls, resulting in a fall in level in B, which in turn causes petrol to flow through the jet at a rate proportional to the difference in level between A and B. Quite low engine speeds are sufficient to draw all the fuel out of B into the engine, all the petrol flowing through the jet now being drawn straight into the choke tube, together with a small amount of air drawn from B. As the difference in level between the petrol in A and B cannot be increased any further, the rate of flow through the jet cannot be increased as engine speed rises, so that rising engine speed results in an increased flow of air into the engine, but no increase in the flow of petrol: thus the mixture gets weaker as engine speed rises.

Such an arrangement is not used by itself: combined with a (second) jet it forms the "Zenith" carburettor.

Fig. 7 shows the compound jet arrangement used in the Zenith carburettor (Meadows engine). Petrol is drawn into the choke tube *via* two concentric tubes, the central one forming the main jet (which is of the type shown in fig. 4) and the outer one fed with petrol from the "compensating jet" (which is of the type shown in fig. 6). The jets and choke tube are of suitable sizes to form a suitable mixture at any speed: if speed rises, the mixture produced by the main jet gets richer whilst that produced by the compensating jet gets weaker, the combined mixture from the two jets together remaining practically constant throughout the speed range of the engine.

(c) "*Diffuser*".—Referring again to fig. 6, if the opening of B to atmospheric pressure is completely blanked off, fuel is drawn from the jet solely by the lower pressure at C, *i.e.* the carburettor behaves as in fig. 4 and the mixture gets too rich as engine speed rises, instead of too weak. There must, therefore, be some degree of opening of B to the atmosphere which will result in an unvarying mixture strength at all engine speeds: this principle is used in the Solex carburettor fitted to the 750 watt Norman-Lyon set, fig. 8 showing the arrangement of the jet. As the level in B falls, successive holes are uncovered which admit air: their size and position is such that the mixture is kept constant.

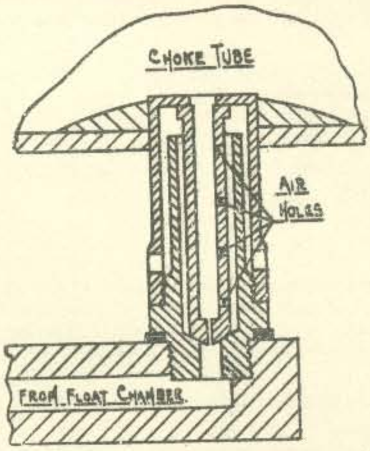


FIG. 8.—Diffuser compensation.

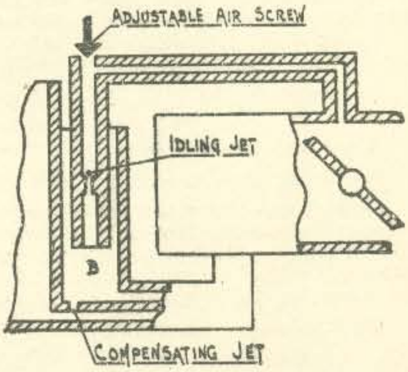


FIG. 9.—Slow running jet (Zenith).

(iii) *Slow running.*—In cases where an engine is required to "idle", or run slowly off load for short periods, a "slow-running jet" is needed. When the engine is idling the throttle must be very nearly closed, and the suction in the choke tube is too small to raise any fuel from the jet. Fig. 9 shows the principle of the slow-running jet used in the Zenith carburettor. A tube, containing a jet, dips into the well, which will contain petrol when the main and compensating jets are out of action. The upper end of this tube communicates with the inlet pipe at a point slightly on the engine side of the throttle, an adjustable air hole being arranged just above the jet. Petrol is drawn from the well through the jet, and air is drawn through the adjustable air hole, to form the mixture on which the engine runs; the strength of this mixture can be adjusted to suit the engine by means of the adjusting screw. When the throttle is opened the petrol in B is drawn away, preventing the slow-running jet from getting any petrol, and putting it out of action automatically when it is not needed.

(iv) *Mixture strength.*—If air and petrol are mixed in the proportion (by weight) of roughly 15 of air to 1 of petrol, all the carbon and hydrogen in the petrol combine with all the oxygen in the air. Mixtures which have a greater proportion of petrol than this are called "rich" mixtures, and those which have a lower proportion of petrol are called "weak" mixtures. Slightly rich mixtures (about 12 to 1) give maximum power and burn fastest, but the petrol consumption is greater. Slightly weak mixtures give the lowest petrol consumption, but with reduced power.

Excessively rich mixtures cause ;—

Very high petrol consumption.
Poor power output.
Sooted sparking plugs.
Black, sooty smoke from exhaust.

Excessively weak mixtures cause ;—

Very poor power output.
Overheating of the cylinder and head, and exhaust pipe.
" Spitting " in the carburettor.

4. **Brief Particulars of Engines.**—(i) *The Stuart Turner battery charging set.*—210 watts (30 volts, 7 amps.). A 1 H.P. horizontal opposed air cooled 2-cylinder engine.

Displacement volume	160 cc.
Valve clearance	Inlet ·004 in. to ·006 in. Exhaust ·006 in. to ·008 in.

Valve and ignition timing marked on flywheel cover.

Petrol tank capacity—1½ gallons. Gravity feed to carburettor, which is of extra air valve type. Petrol consumption, approximately 10 hours per gallon.

Oil tank capacity—1½ pints—level indicator inside tank.

Plunger pump feeds oil to governor gear, whence there is a return to the tank and to the crankcase *via* an adjustable sight feed.

Correct setting, 12 drops per minute.

Speed controlled by governor gear. Adjust to 1,700 r.p.m. by knurled nut on throttle spring.

(ii) *The Lyon-Norman battery charging set.*—750 watts (35 volts, 22 amp.). A 2¾ H.P. horizontally opposed air cooled 2-cylinder engine.

Displacement volume	295·56 cc.
Valve clearance	·003 in. for all valves *when cold.*
Ignition timing	3¼ in. before T.D.C. measured round fly-wheel.

Petrol tank capacity, 1½ gallons. Gravity feed to Solex carburettor.

Petrol consumption, approximately 2½ pints per hour.

Oil tank capacity, 1 pint. " Dry sump " lubrication. Pressure feed to big-end bearings; splash to remainder. Pressure and scavenge pumps both of gear type. Correct pressure 20 lb./square inch. Speed controlled by governor gear, having idling and normal running positions. Adjustment by knurled nut on control rod; set to speed given on generator rating plate.

(iii) *The Meadows generating set.*—A 12 H.P. 4-cylinder water-cooled engine.

Displacement volume	1,497 cc.
Valve clearances	·006 in. for all valves *when hot.*
Ignition timing	35° before T.D.C. *fully advanced.*

Petrol tank fitted below engine. (Capacity varies with different arrangement of sets.) Feed to Zenith carburettor by A.C. mechanical pump operated by eccentric on engine camshaft. Petrol consumption on full load, approximately 9 pints per hour.

Oil sump capacity, 1 gallon. Dipstick shows correct level. Pressure feed by gear pump to main bearings, big-end bearings, overhead rocker bearings, and rear camshaft bearings. Jet of oil squirts on to timing gears. Remaining bearings lubricated by splash.

Correct pressure .. .. .. 30 to 50 lbs./sq. in.

Speed controlled by governor gear. Adjust to 1,500 r.p.m. (output frequency 50 cycles/sec.) by knurled nut on governor spring. Capacity of cooling system, 3 gallons. Drain tap under radiator. Pump circulation.

At its normal speed of 1,500 r.p.m., this engine can develop 18.5 H.P.
On all above engines : Contact breaker gap, ·012 in.
Sparking plug gap, ·015 in. to ·019 in.

(iv) 9 *KVA Alternator set* (fig. 10).—For temporary lighting and A.C. power supply in the field. The power trailer normally contains two 9 KVA. sets with switchboards linked together so that either alternator can supply the load, or so that a heavy load may be shared between them. The alternators cannot, however, be run in parallel.

Alternators.—Rotating armature, 9 KVA. at P.F. 0·8, *i.e.* normally 230 volts 40 amps. Single-phase A.C. at 50 c.p.s. Stator 4-pole field.

Exciters.—Shunt-wound generator of approx. 0·5 kw., delivering 4·7 amps. at 97·5 volts. Belt-driven at engine speed.

Isenthal Regulator.—Driven by flexible coupling from exciter. Vibrating contacts vary exciter field resistance so as to maintain alternator voltage constant at 230 ± 5. The regulator solenoid is controlled by D.C., rectified from the alternator output. Control of regulation is given by the ballast resistance.

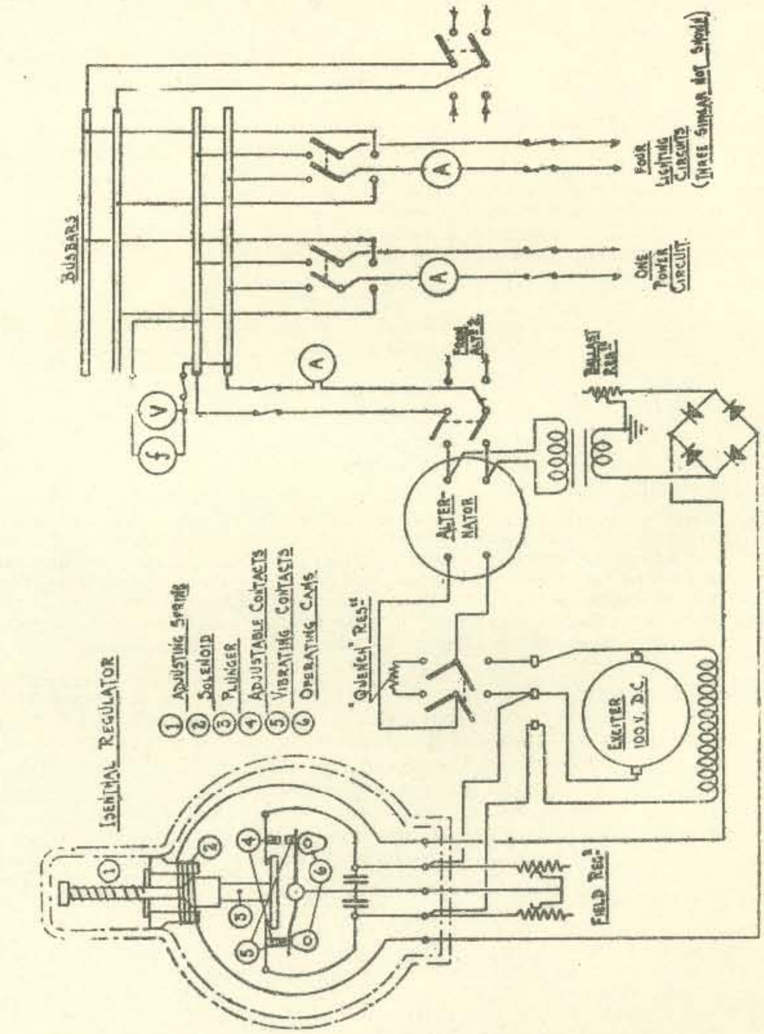


Fig. 10.—9 KVA alternator set.

Operation

1. Open main D.P. switch, *close* field switch.
2. Exciter field rheostat set in marked position—" 160 volts ".
3. Switch on regulator and magneto switch.
4. Start up engine. Adjust ballast resistance slightly to give 230 volts.

On first setting regulator—

1. Switch on, with field resistance all *in*.
2. Start up, and run up to 160 volts on no load.
3. Switch on regulator—voltage should rise to 230, and remain steady.
4. Adjust ballast resistance if necessary.

To reduce wear on contacts, regulator switch should be used in alternate positions for equal periods, say daily. Adjust solenoid assembly so that, with plunger in upward position, contacts are continuously open ; and with plunger *down* they make continuously.

(v) *Chore Horse battery charging set.*—350 watts (32 volts 11 amp.). $\frac{5}{8}$ H.P. Single cylinder side-valve engine. Air cooled.

Valve clearance	·012 in. (adjustable only by cylinder gasket thickness).
Valve timing	Marked on wheels.
Magneto timing	Marked . (Flywheel magneto) slightly adjustable.
Sparking plug	Champion J8 14 mm. Set to ·030 in.
Petrol tank capacity	Approx. 1 gallon. Filler is the *left hand* plug.
Oil sump capacity	$\frac{1}{2}$ pint. Filler on sump.

Splash lubrication.—Fill to overflow point ; check level every eight hours' running, change oil every 25 hours. The engine may be started by motoring the generator (which is directly coupled) with a 12-volt battery, or by means of a rope wrapped around the pulley. The "choke" should be pulled out whilst starting. The correct setting of the carburettor needle valve is $\frac{1}{2}$ to $\frac{3}{4}$ turns to the left from the fully closed position. The speed is 1,750to 1,850 r.p.m. controlled by governor The governor has an adjustable tension spring.

5. *Maintenance.* The objects of maintenance are :—

(i) To prevent breakdown in service.

(ii) To prolong the life of an engine.

It is convenient to divide the maintenance of an engine into groups, as under :—

(*a*) *The Mechanical parts.*—Check tightness of nuts, bolts, etc., especially those subject to vibration or heat. (Be careful not to over-tighten.) Check action and adjustment of all controls.

(*b*) *The ignition system.* (R.A. magneto.).—Clean slip-ring and H.T. collector. Check condition of carbon brush. Clean distributor cover inside and out, and clean insulation of rotor. Check contact breaker gap (·012 in.) and adjust if necessary. Check cleanliness of contacts, and see that they bed properly. Check H.T. leads for chafed or perished insulation, and replace if necessary ; check that leads are properly secured. Clean earthing switch and its wiring. Lubricate magneto, if provision is made, according to instruction plate. Do not over-lubricate magneto.

(*c*) *Carburettor and fuel system.*—Check air vent in tank. Check action of tap. Check petrol pipe for security of connections, leaks and internal cleanliness. Clean filters. Wash out float-chamber and jets. Do not interfere with adjustments unless absolutely necessary.

(*d*) *Lubrication system.* Before attempting to start any engine see that there is the correct quantity of oil in the tank or sump. Whilst engine is running, frequently check that system is operating correctly (pressure gauge or sight feed). Periodically drain out used oil from tank or sump and re-fill with fresh oil (every 100 hours on Meadows and Stuart Turner ; 50 hours on Lyon-Norman). Clean filters at same time as above. Check external pipes for security or leaks. Lubricate all external points (fan bearings, control rod joints, etc.).

(*e*) *Cooling system.*—(1) (a) Air cooling : Check fan drive if necessary, and check security of cowling if fitted. Keep engine clean. (b) Water cooling : Before attempting to start engine see that water level in radiator is *above* connection to header tank. Use rain water if possible. Check fan drive. Check connections for leaks. Check that overflow pipe is clear. Keep engine clean. In cold weather to avoid possibility of damage by frost, either add anti-freeze solution to the cooling water, or drain water from system before leaving the engine standing for any length of time.

No hard and fast rules can be laid down as to the running time after which the above attention may be needed, as this depends upon the initial condition of the engine and the working conditiions, and only experience can give any true guide. It is, however, suggested that engines be given the above attention about once a week to start with, the periods then modified if conditions warrant it.

Any minor fault noticed during running should be rectified at the earliest convenient moment.

In addition to the above it is important to keep the engine as clear as possible at all times.

4/42 (58364) (60359) Wt. 21819/L.1068 2,500 8/42 Hw. G.371

The Specialty Press Pty. Ltd., 174 Little Collins Street, Melbourne,