AIR PUBLICATION 1938.

Reprinted May, 1944.

Amendment Lists 1–5 incorporated.

STANDARD NOTES

FOR

WIRELESS MECHANICS

Promulgated for the information and guidance of all concerned,

By Command of the Air Council,

AIR MINISTRY

STANDARD NOTES

FOR

WIRELESS MECHANICS

CONTENTS

(72583)

STANDARD NOTES FOR WIRELESS MECHANICS

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 Radio 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.

Many circuit diagrams in this publication show crossing wires not making electrical contact, broken ; in future all diagrams will conform to the British Standard Specification No. 530 whereby *all* crossing wires are shown unbroken and those making contact are indicated with a dot.

AIR MINISTRY.

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 ot 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.

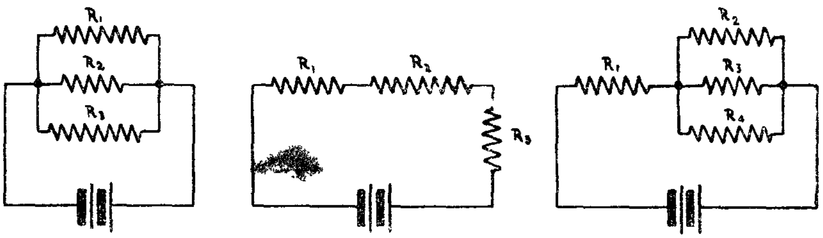

FIG. 1.—Resistance arrangements.

(*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.

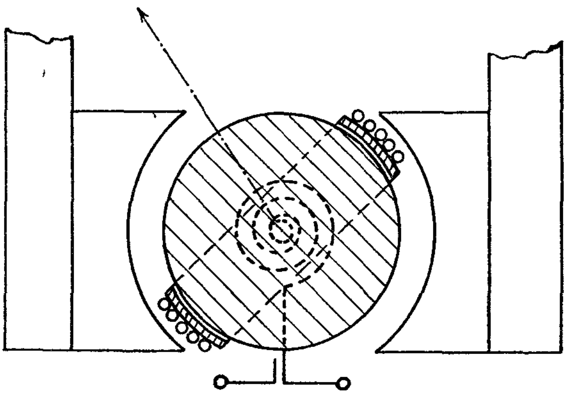

FIG. 2.—Moving coil ammeter.

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.

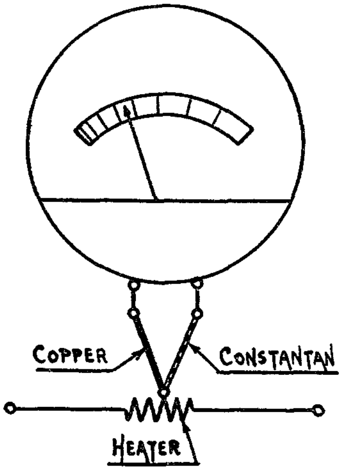

FIG. 3.—Thermo-junction ammeter.

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.

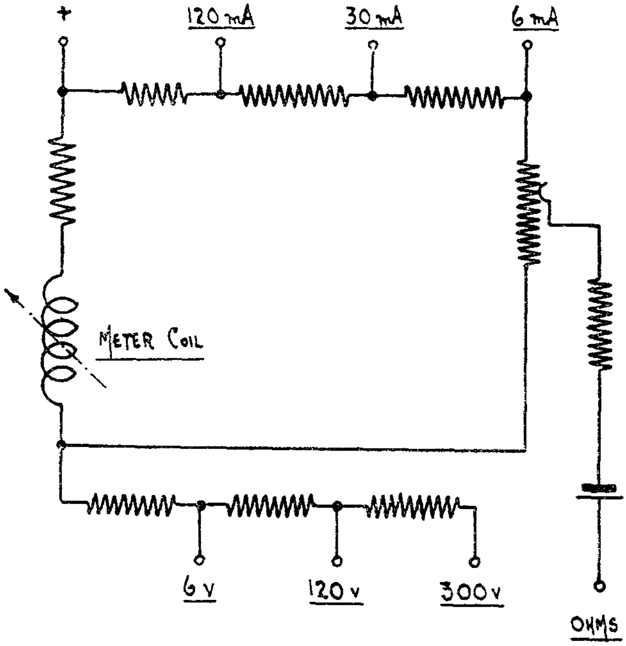

FIG. 4.—Test meter, type C.

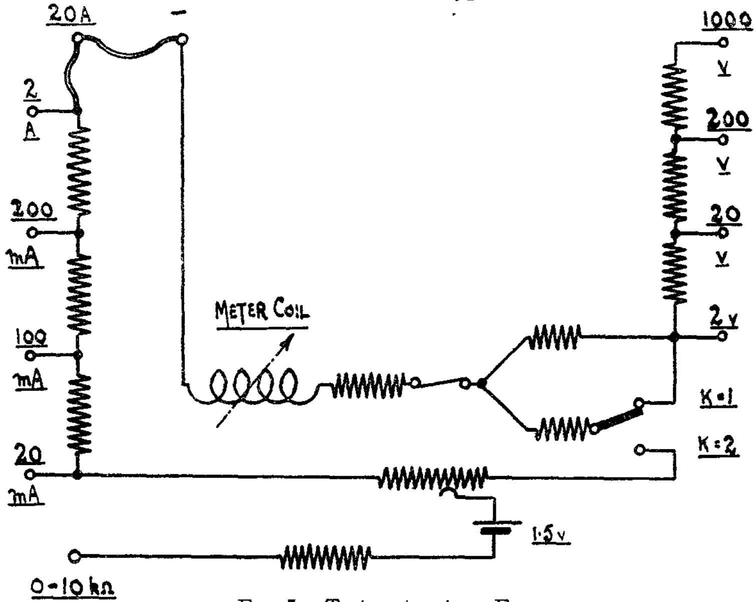

FIG. 5.—Test meter, type E

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.

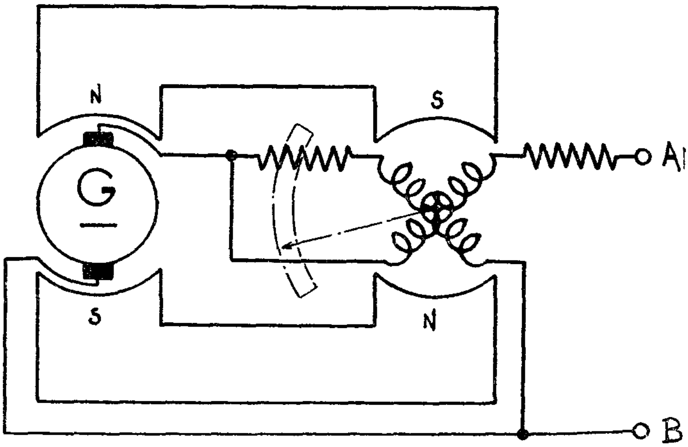

FIG. 6.—Megger.

(*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. When switched to the "Bridge" position, the instrument is transformed into a Wheatstone bridge. The internal arrangement of connections can be followed in fig. 7. The two ratio arms and the adjustable resistance form three arms of the bridge, which is completed by the resistance to be measured. The current coil of the ohmmeter serves as the galvanometer, and the galvanometer control force is provided by the pressure coil, which is independently energised from the generator terminals. When no current passes in the current coil, the force exerted by the pressure coil brings the moving system into the position in which the pointer reads "*infinity,*" so that the reading corresponds to a balanced condition of the bridge.

The procedure, therefore, is to adjust the variable resistance by the switches provided, and if necessary the ratio switch, until the pointer reads "*infinity.*"

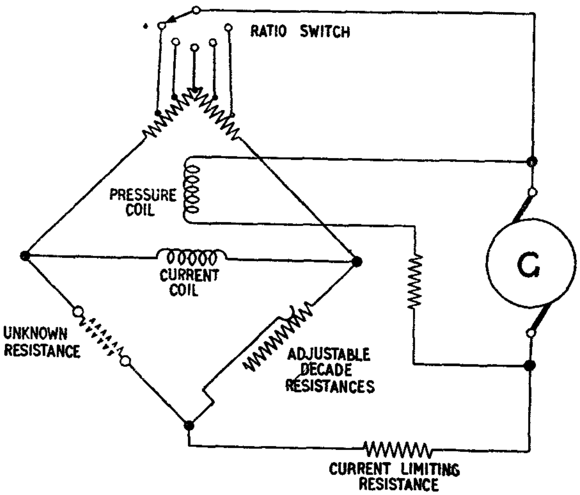

FIG. 7.—Bridge Megger.

Practically all the information relevant to the charging and servicing ccumulators is contained in *Forms 480 and 480A*, which are exhibited in harging rooms, and the provisions of these forms must be followed exactly. ..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*—

ts.	Capacity. Ampere-hours.	Case.	Remarks.
	90	Glass	Planté plates.
	120	Glass	
	80	Moulded ..	M.T. and ground W/T use.
	55	Moulded ..	M.T. and ground W/T use.
	180	Moulded ..	Aero-engine starting.
	230	Moulded ..	Aero-engine starting.
	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 $2 \times 10 = 20$ 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.

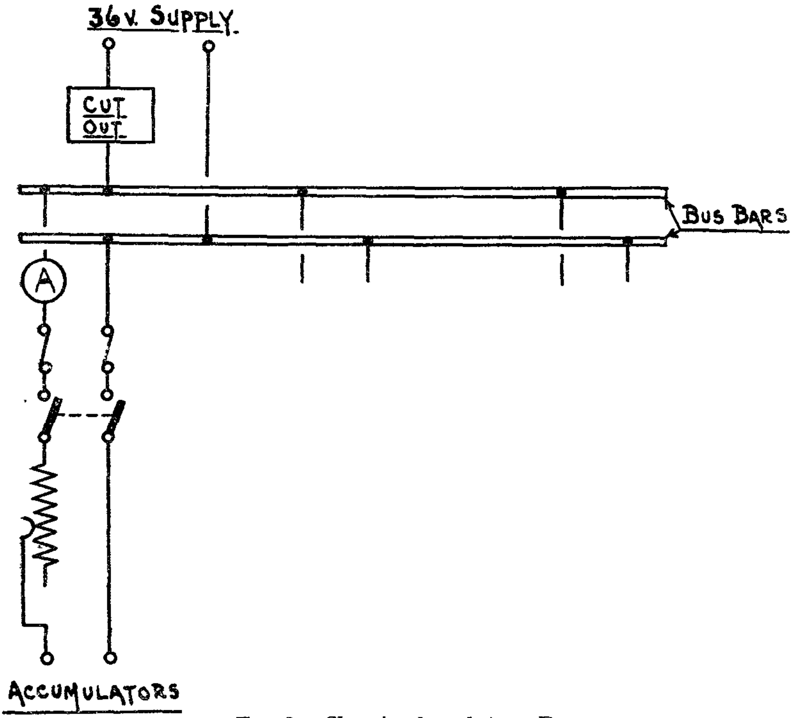

FIG. 9.—Charging board, type B.

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.

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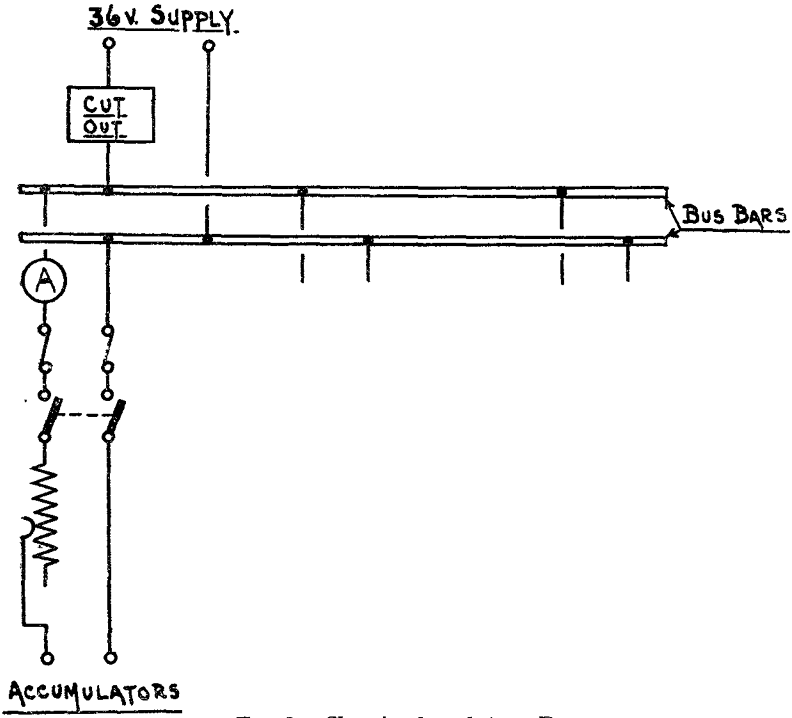

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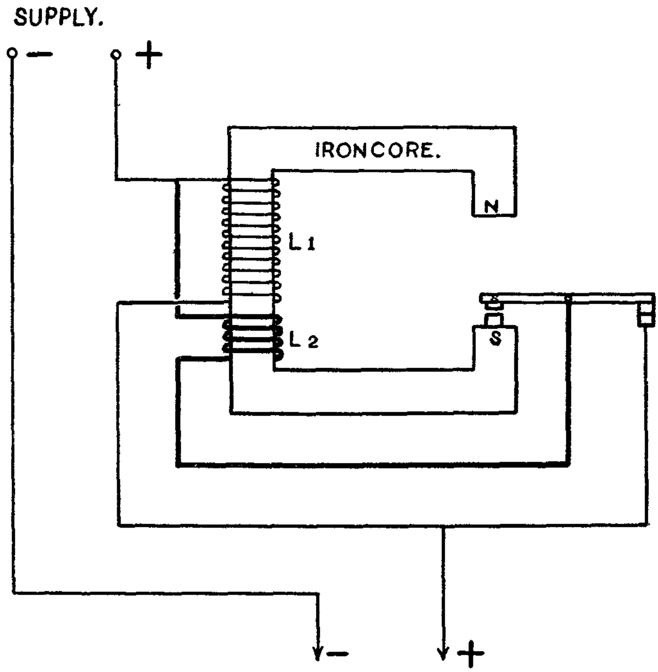


FIG 10.—Cut out type B.

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.

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*

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 Quintosheath.	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.

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.

Cables.	Rating (amps.).	Insulation and Covering (Core).	Outer Insulation and Covering.	Uses and Remarks.
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-electric 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

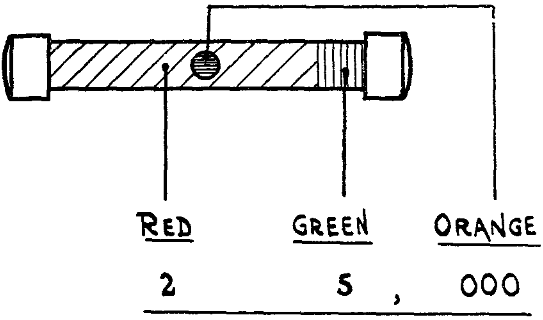


FIG. 11.—Colour code.

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 electromagnet.

(*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 output (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.

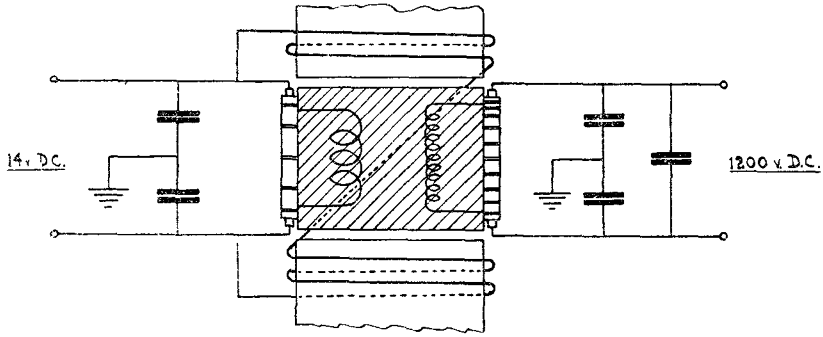


FIG. 12.—Motor generator, type E.

Interference suppression—condensers of $0 \cdot 01 \mu F$ 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.

(ii) *Servicing 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 inch.

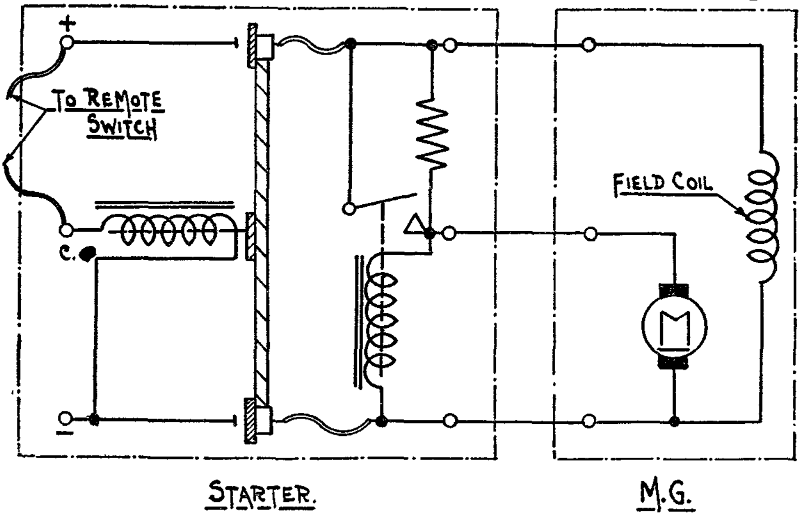


FIG. 13.—Starter, type A.

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 conductors, 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*".

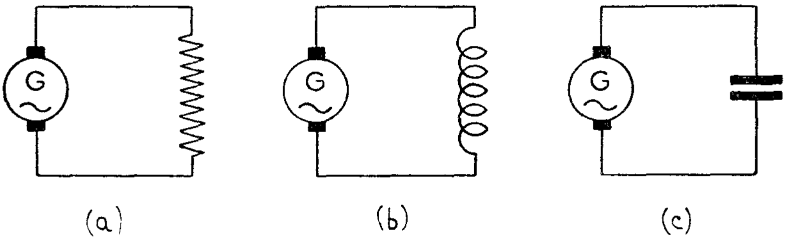


FIG. 14.—Simple A.C. circuits.

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 :—

$$\text{Inductive reactance} = 2\,\pi f L$$

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, $2\pi fL = \frac{1}{2\pi fC}$ 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. $\left(Q = \frac{2\pi fL}{R}\right)$

(*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.

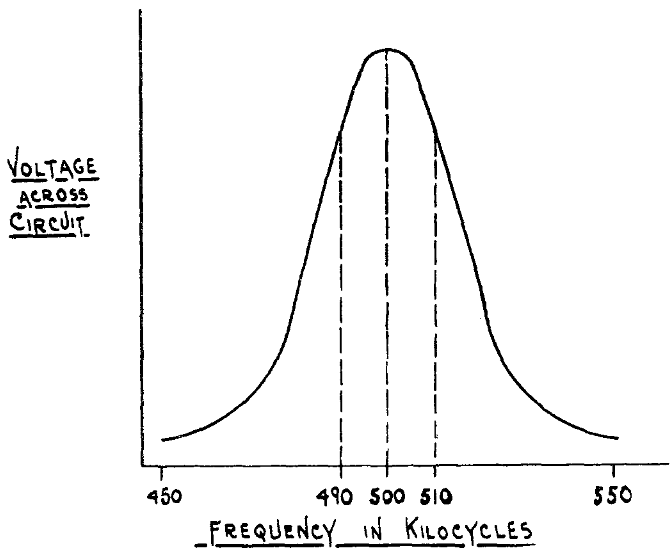


FIG. 15.—Selectivity.

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.

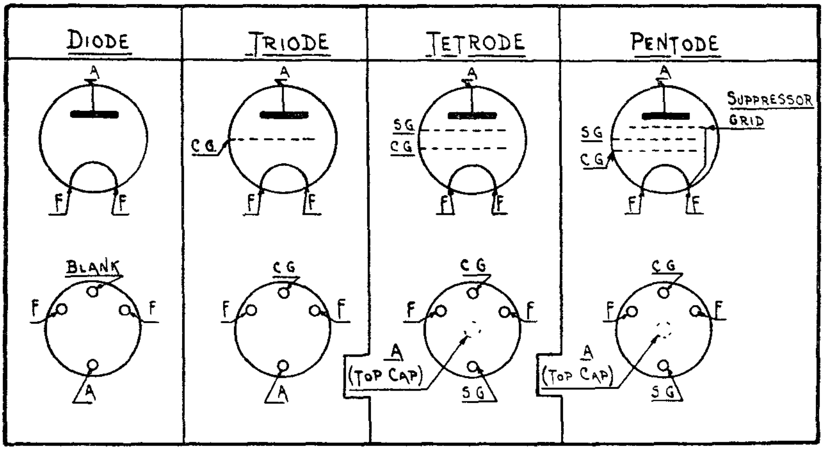


FIG. 16.—Radio valves : symbols and base arrangement.

(*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—

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

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

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

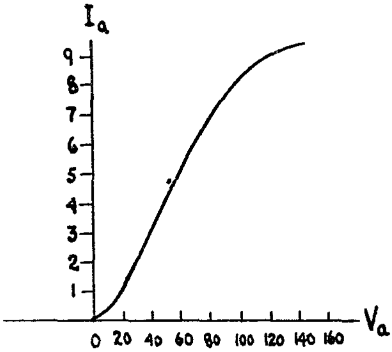
Fig. 17A shows the relationship between anode current and anode voltage for a diode.

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.

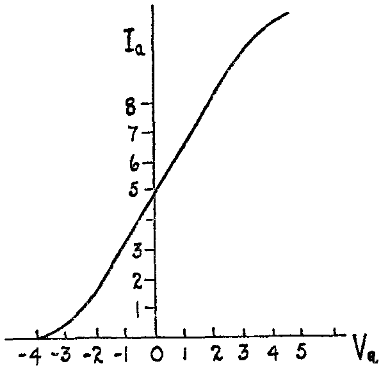
Fig. 17D shows the anode current in a triode resulting from an operating alternating voltage.

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	mA
V_a	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).

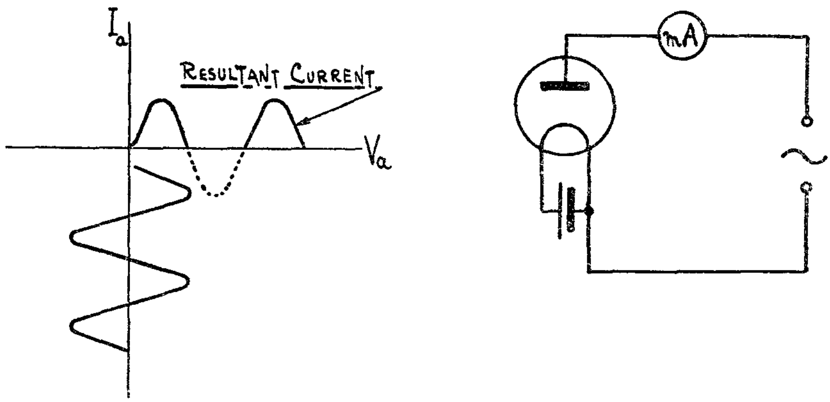


FIG. 17C.—Diode rectification.

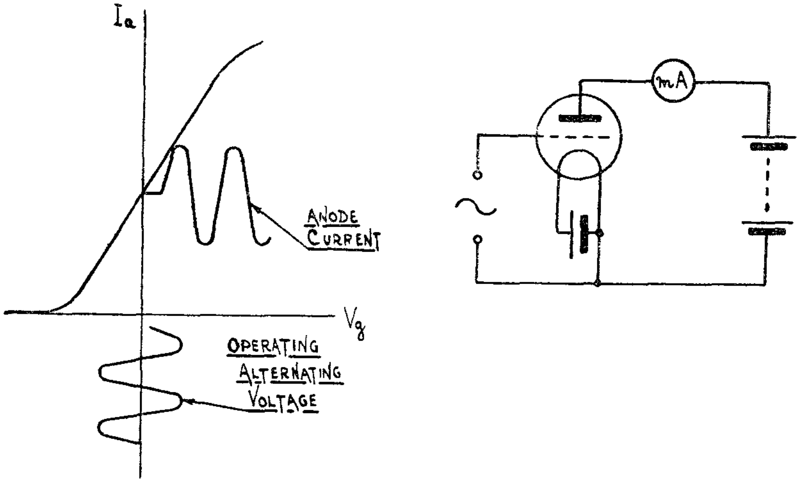


FIG. 17D.—Triode characteristics (b).

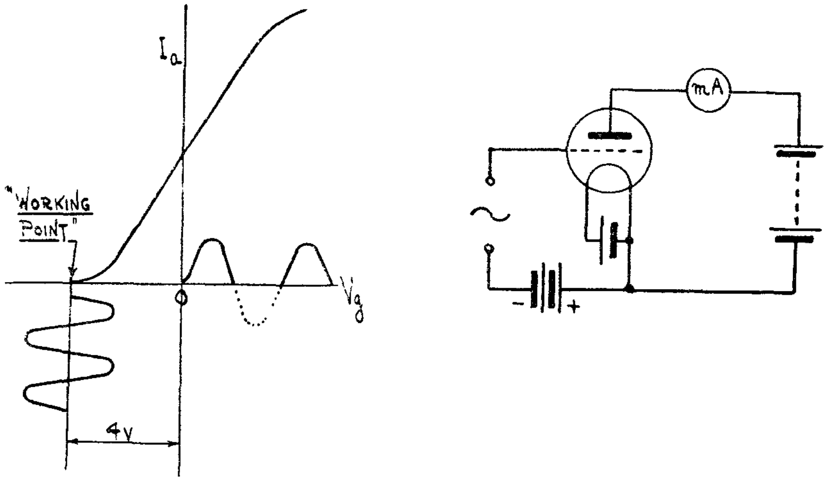


FIG. 17E.—Triode characteristics (c).

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).

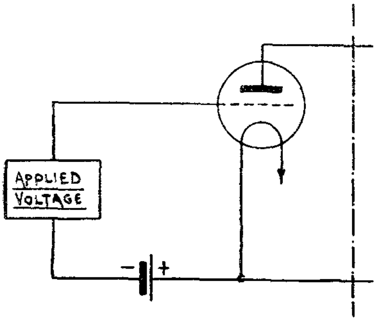


FIG. 18. Battery bias.

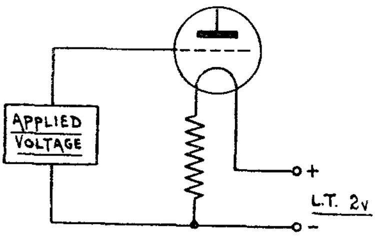


FIG. 19. Filament bias.

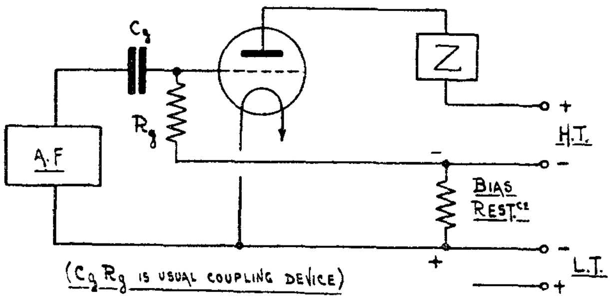


FIG. 20.—Automatic bias (receiver).

(*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.

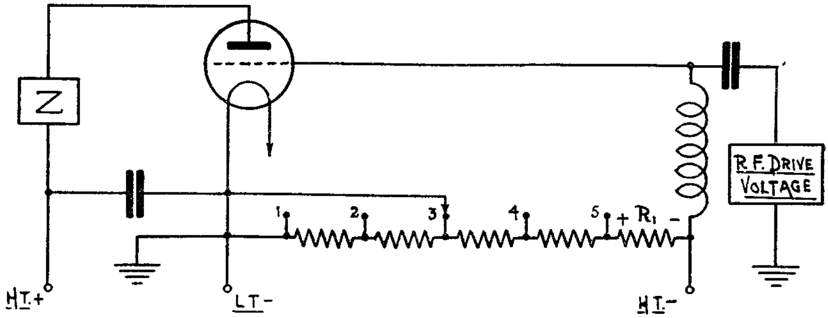


FIG. 21.—Automatic bias (transmitter).

(*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.

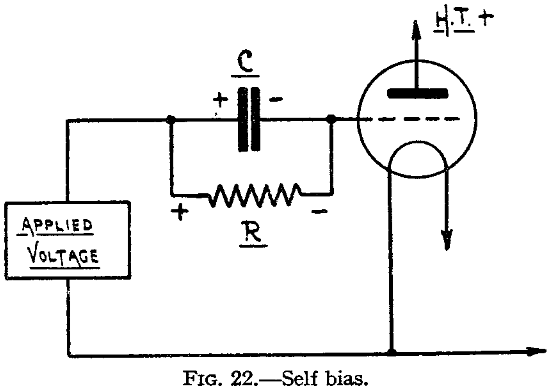


FIG. 22.—Self bias.

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.)

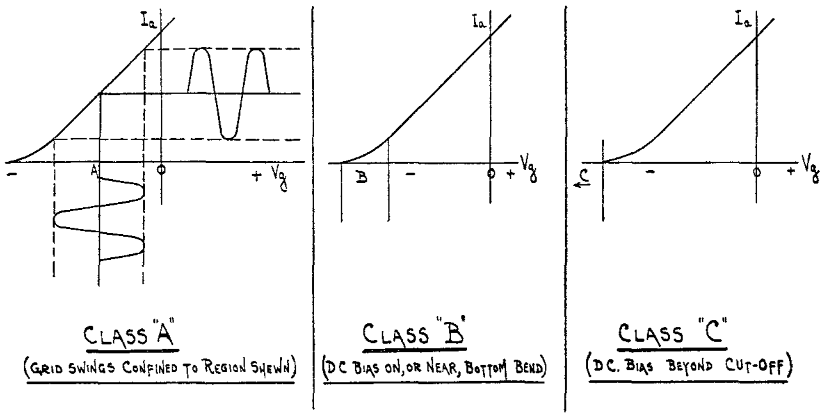


FIG. 23.—Classes of grid bias.

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 value 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.

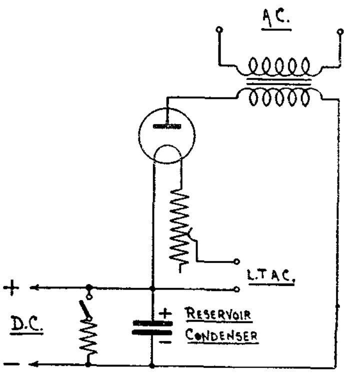


FIG. 24.—"Half-wave" rectifier.

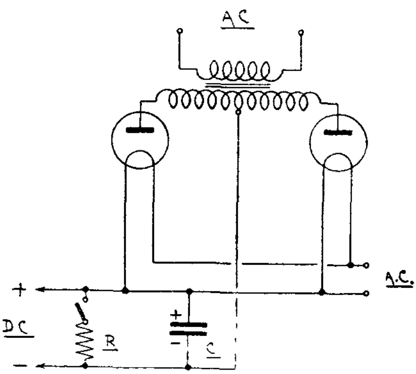


FIG. 25.—Full-wave rectifier.

(*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 supply 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.

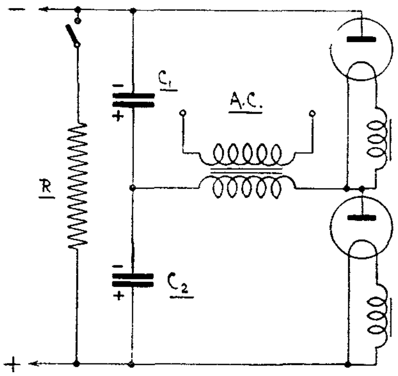


FIG. 26.—Voltage doubler.

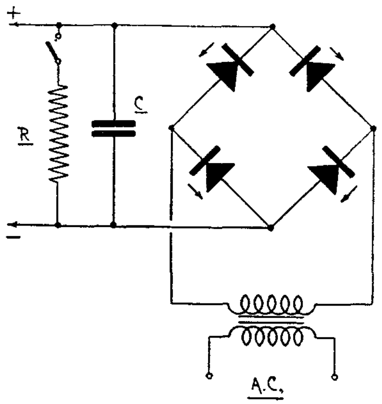


FIG. 27.—Metal rectifier.

10. **Indirectly Heated Valves**

Indirectly heated or mains type valves are being used to an increasing extent in the Service. The cathode consists of a metal tube with the emitting coating on its outer surface. Inside the cathode, and insulated from it, is the heater filament. This has the advantage that the L.T. supply can be either A.C. or D.C., on the other hand, the current consumption is greater than for battery type valves, e.g. 0·3 amps. at 6·3 volts.

These valves are mounted on either 7-pin or International Octal bases, and two typical triodes are shown in Fig. 27A ; the connections are shown as viewed from underneath the valve. The cathode has a separate pin. The pin number sequence is as shown, but it should be noted that the connections for a particular type of valve may differ with different makes.

I.D.H. valves cover the same range of operation as battery valves but differ in the method of applying grid bias. They have the advantage that grid bias of any value can be applied by means of a resistance between cathode and H.T. negative. The anode current flows via the resistance R (*see* Fig.27A (*c*))

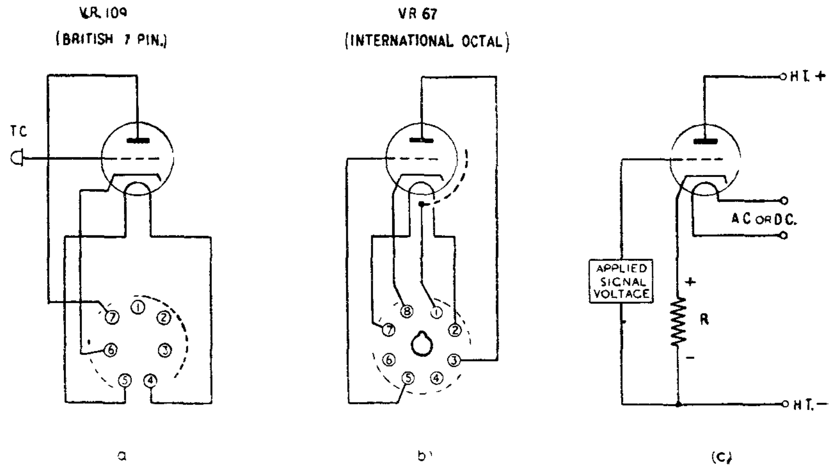


FIG.—27A—Indirectly Heated Valves.

across which a voltage is developed, thus making the cathode positive with respect to the grid. The value of the resistance is easily calculated from Ohms Law; e.g. if the valve takes 10 mA anode current at − 5 volts grid bias the value of R is given by :—

$$R = \frac{E}{I} = \frac{5}{0{\cdot}01} = 500 \text{ ohms.}$$

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*) *Modulated continuous wave* (*M.C.W.*) (Fig. 29).—A continuous radio-frequency wave whose amplitude is varied at a constant audio-frequency by a process known as " amplitude modulation."

(*c*) *Radio-telephony* (*R/T*) (Fig. 30).—A continuous radio-frequency wave whose amplitude is varied at a changing audio-frequency, as in speech and music.

Note.—M.C.W. and R/T can be obtained by " frequency modulation ". This is brought about by varying the frequency of the R/F wave at an audio rate, the amplitude remaining constant.

Fig. 28 - C.W.

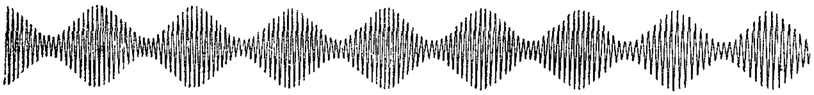


Fig 29 - M.C.W.

Fig 30 - R T

2. **Elementary Receiver for R/T and M.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).

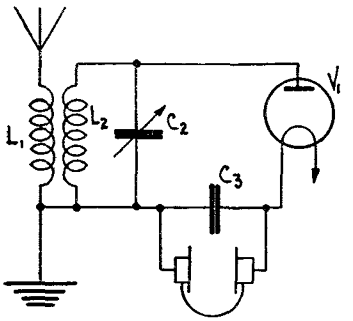


FIG. 31.—Elementary receiver for R/T or M.C.W.

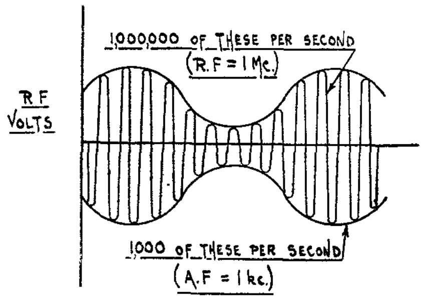


FIG. 32.—Input signal.

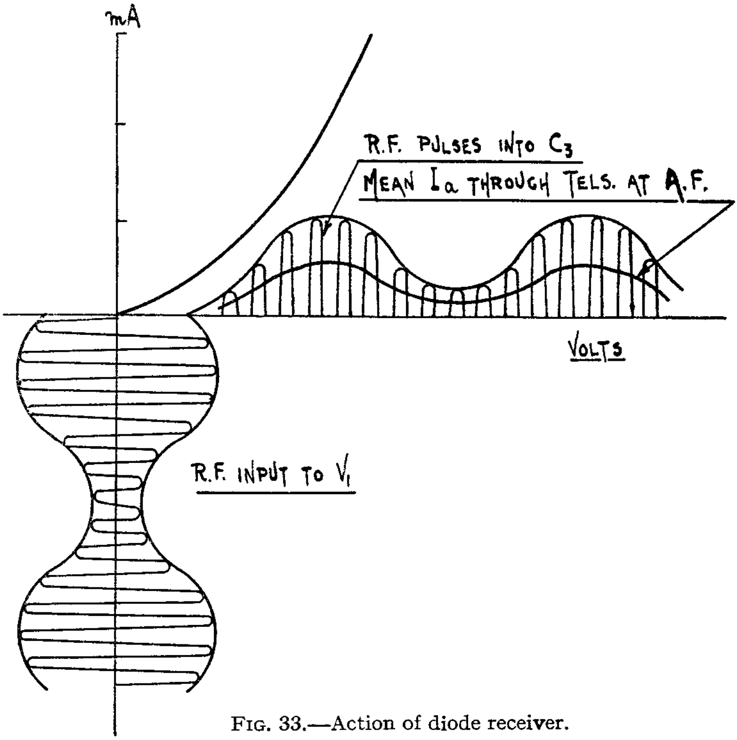


FIG. 33.—Action of diode receiver.

3. **Single Triode Receiver for R/T and M.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.

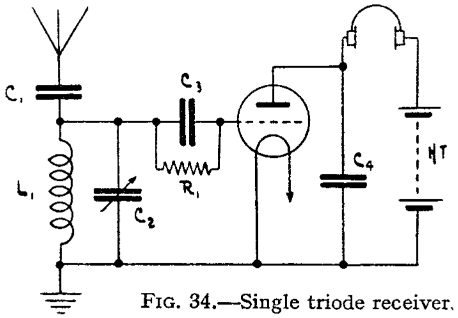


FIG. 34.—Single triode receiver.

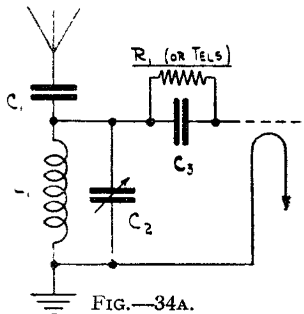


FIG.—34A.

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.

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

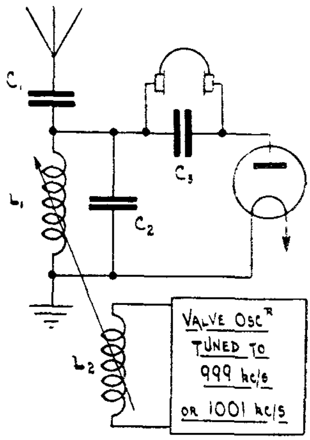


FIG. 35.—Separate heterodyne.

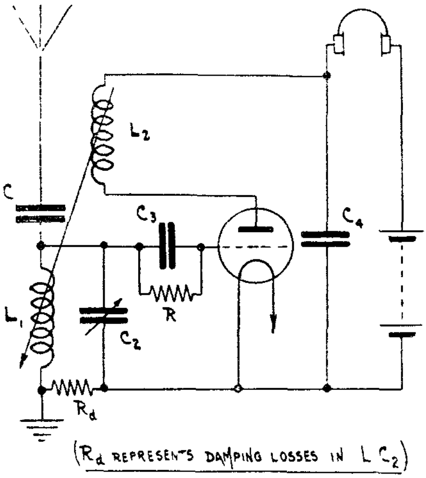


FIG. 36.—Autodyne.

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 M.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.

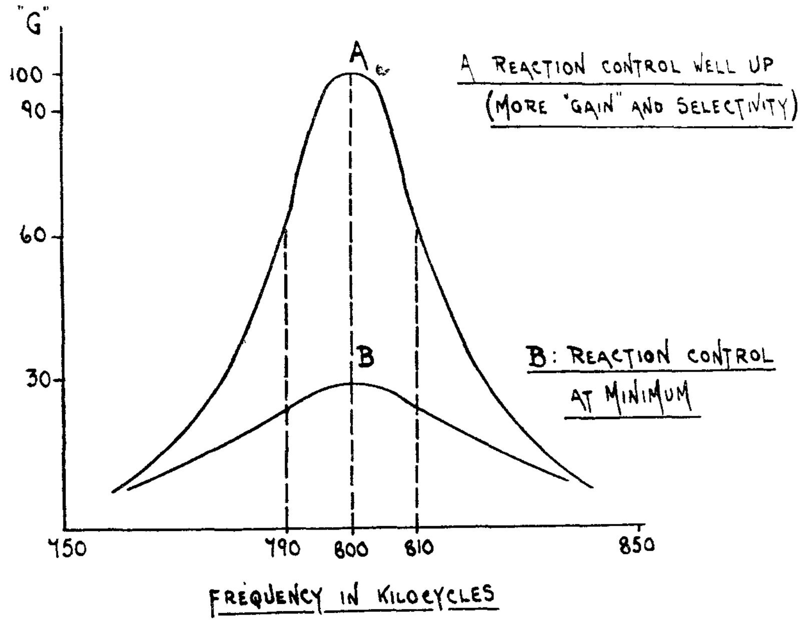


FIG. 37.—Effect of reaction.

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).

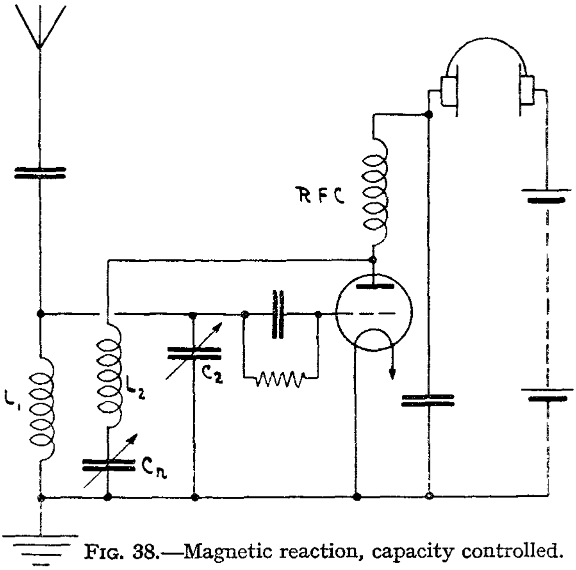


FIG. 38.—Magnetic reaction, capacity controlled.

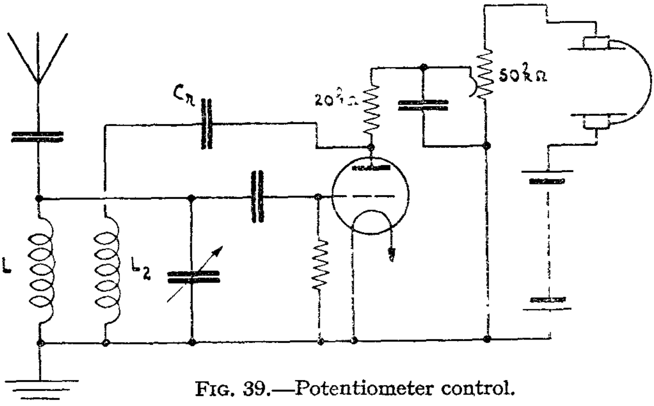


FIG. 39.—Potentiometer control.

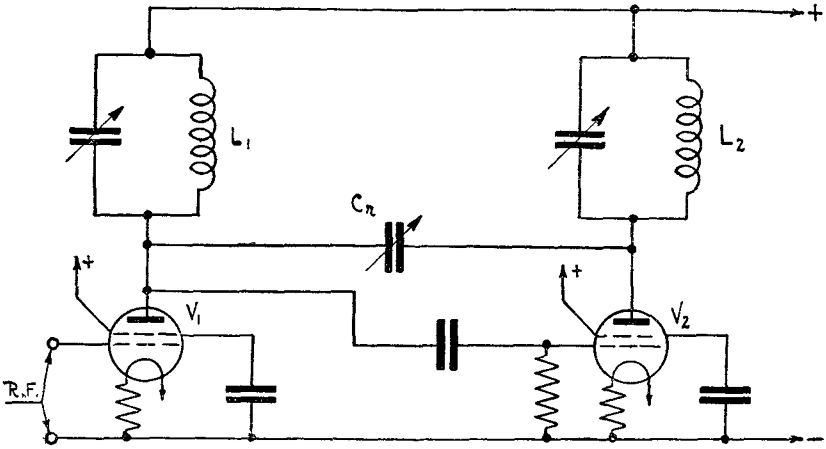


FIG. 40.—Regeneration.

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_2. 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.

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 :—

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

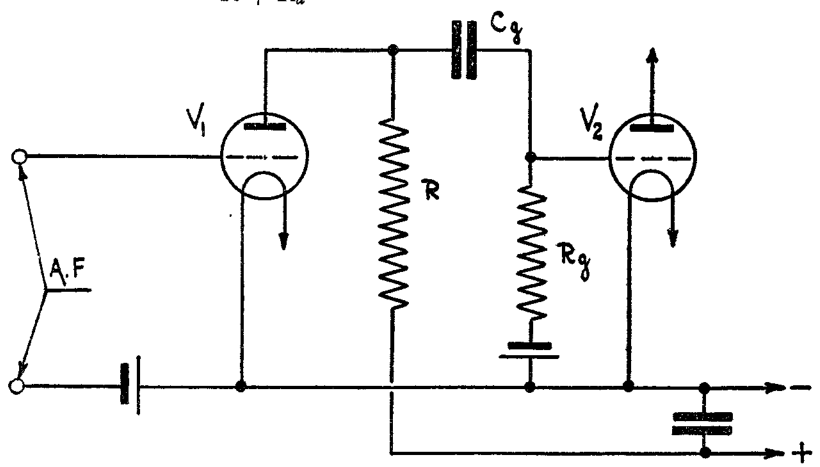


FIG. 41.—Resistance-capacity coupling.

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.

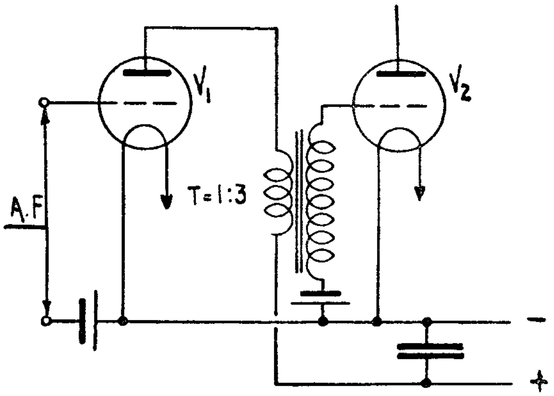


FIG. 42.—Transformer coupling.

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.

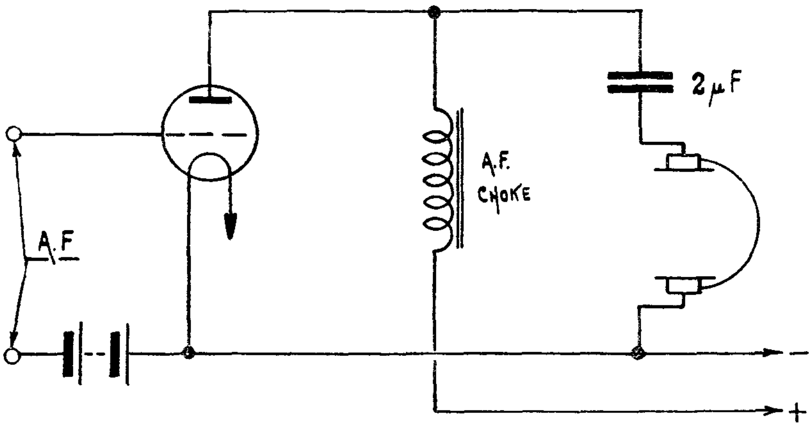


FIG. 43.—Output valve.

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.

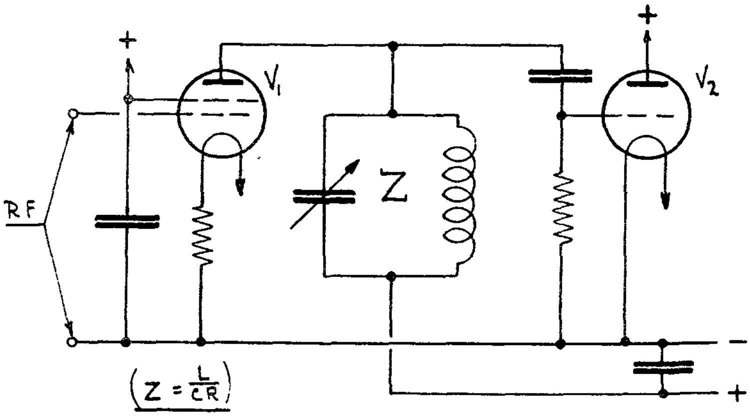


FIG. 44.—R.F. amplifier.

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.

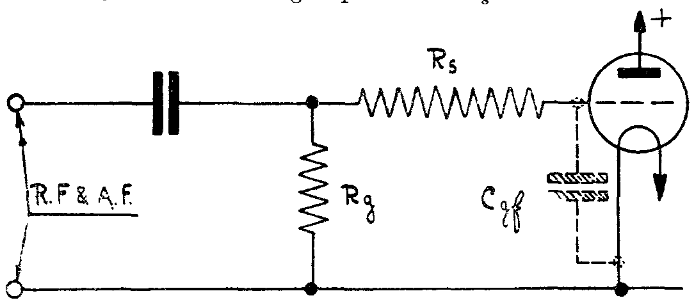
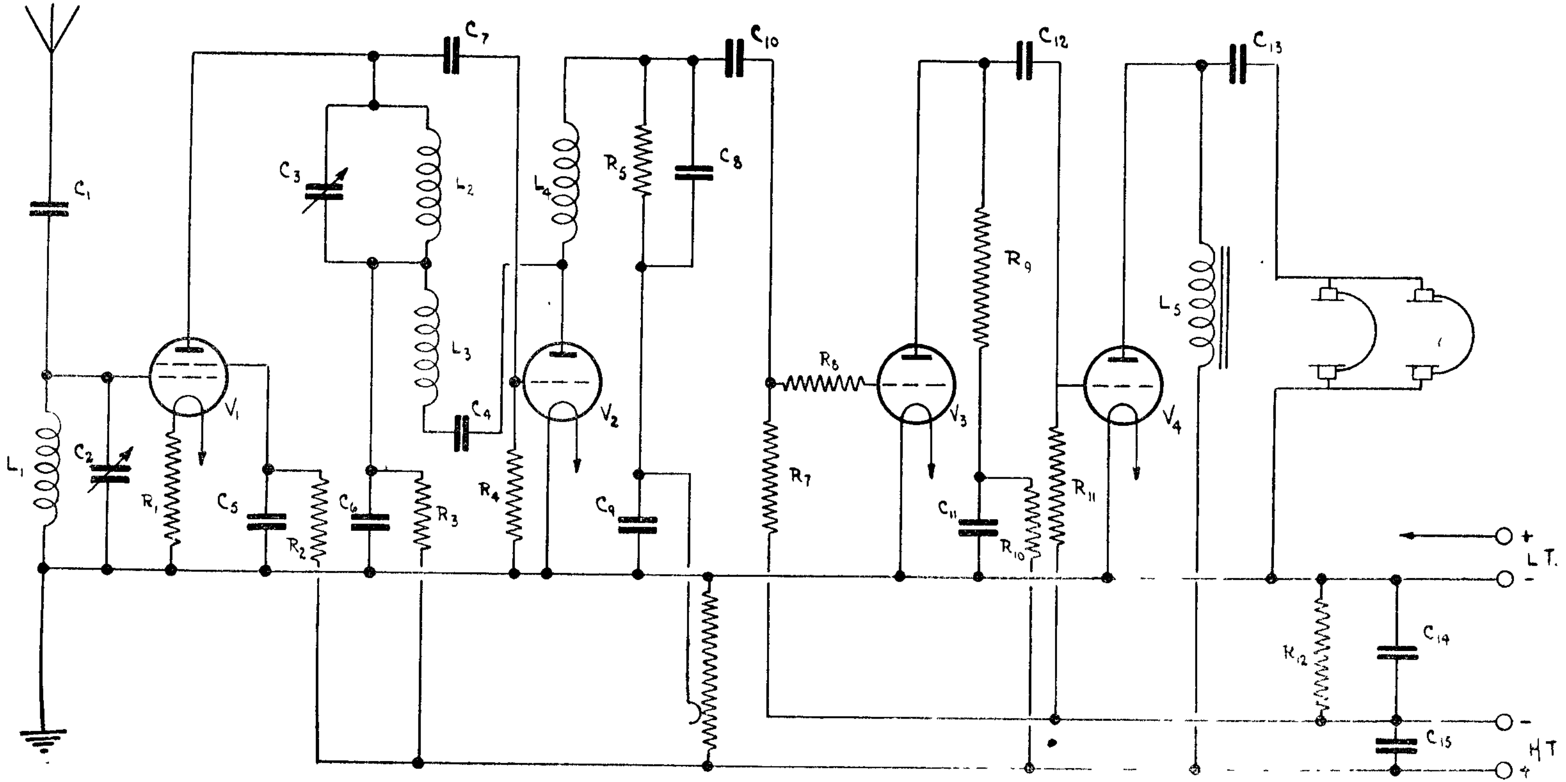


FIG. 45.—Grid stopper.

12. **Typical Straight Receiver** is shown in fig. 46. Typical values 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 .. .	$0 \cdot 5$ u 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.


C1
C2
C3
C4
C5
C6
C7
C8
C9
C10
C11
C12
C13
C14
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L1
L2
L3
L4
L5
R1
R2
R3
R4
R5
R6
R7
R9
R10
R11
R12
V1
V2
V3
V4
+
-
L.T.
H.T.

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.

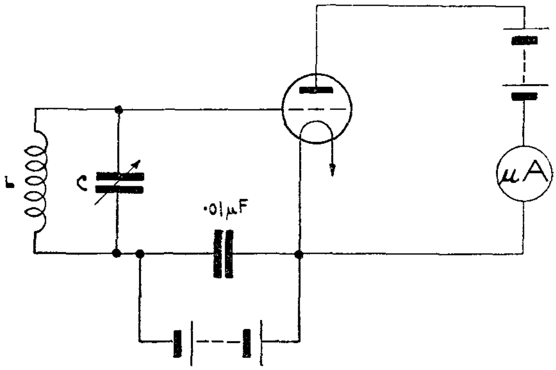


FIG. 47 (part).—Simple valve voltmeter wavemeter.

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.

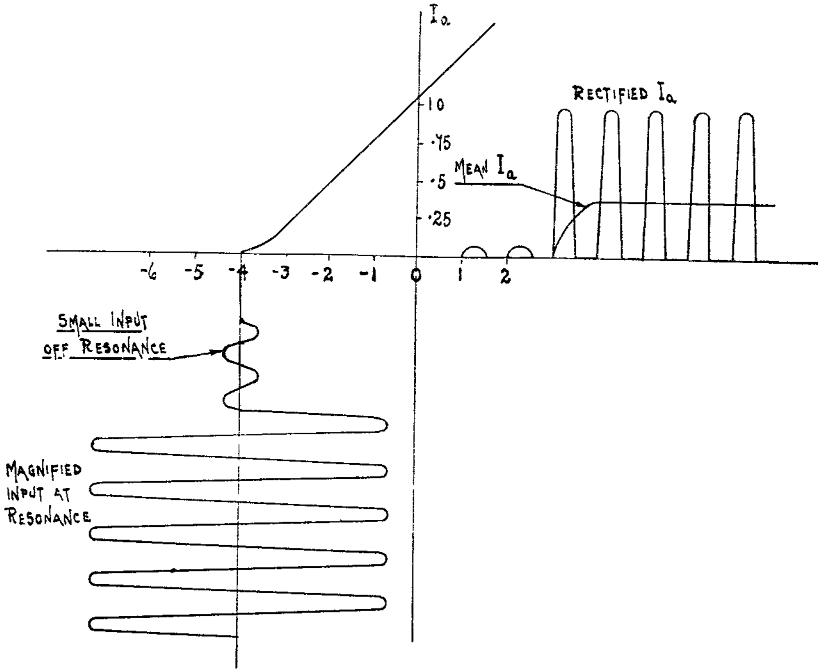


Fig. 47 (part).—Simple valve voltmeter wavemeter.

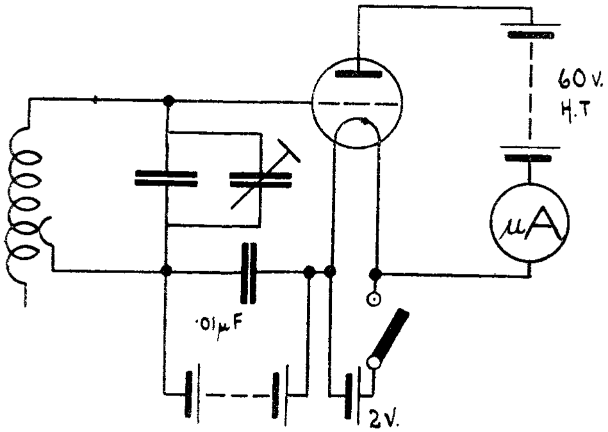


Fig. 48.—Wavemeter W.69 (4–7 mc/s).

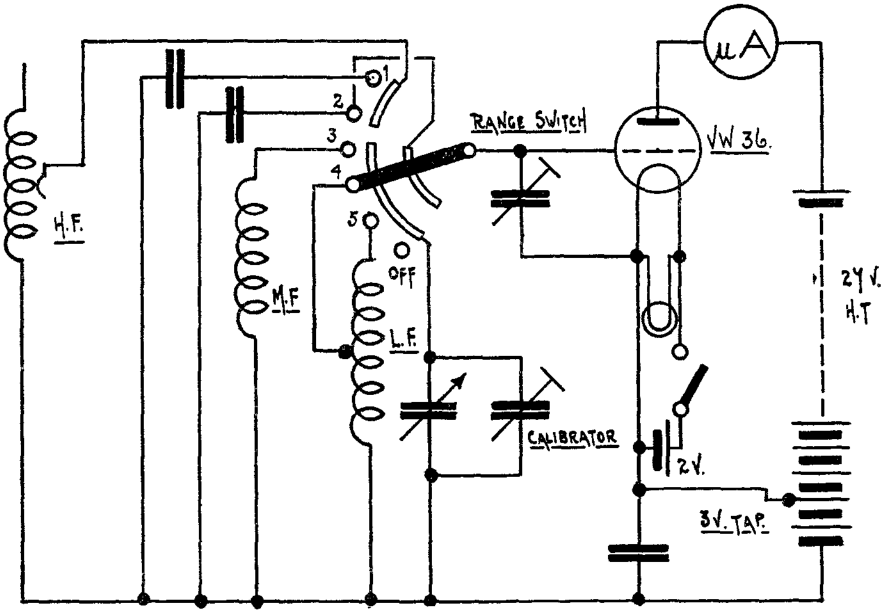


FIG. 49.—Wavemeter W.1081 (3–15 mc/s and 135–500 kc/s).

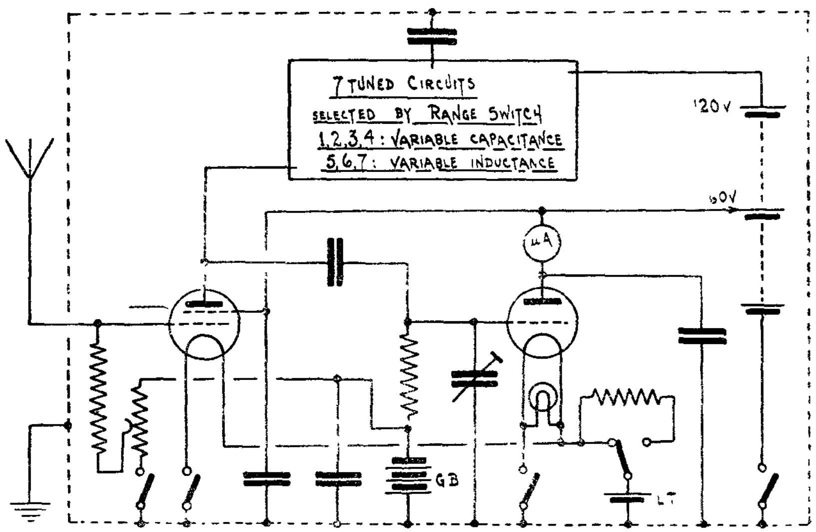


FIG. 50.—Wavemeter W.1117 (125 kc/s–20 mc/s).

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.

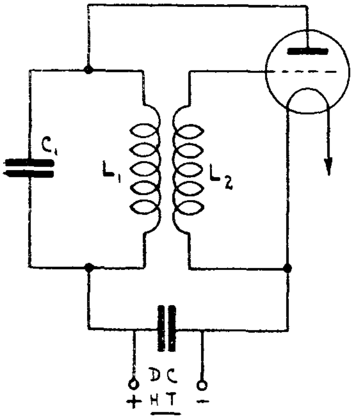


FIG. 51.—Simple oscillator.

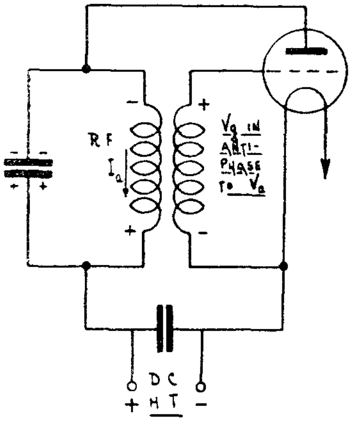


FIG. 52.—Phase relationship.

(*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.

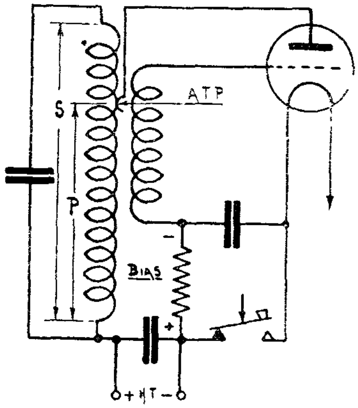


FIG. 53.—Practical oscillator for L.F.

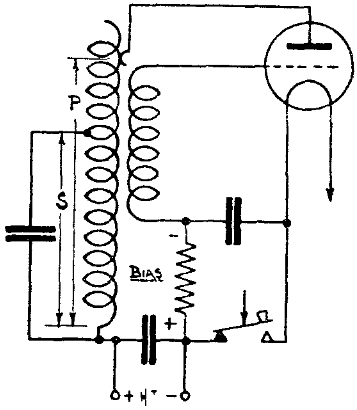


FIG. 53A.—Practical oscillator for H.F.

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.

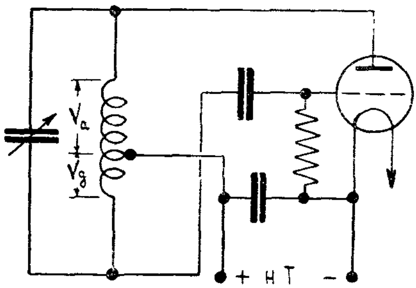


FIG. 54.—Hartley oscillator.

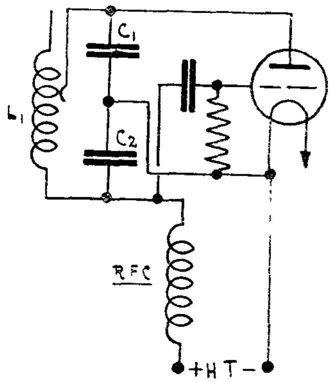


FIG. 55.—Colpitts oscillator.

(*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.

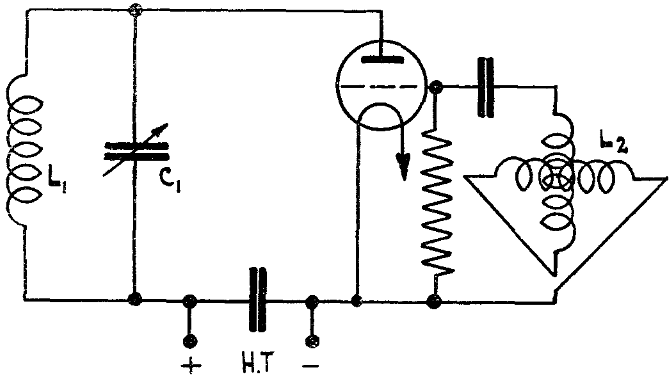


FIG. 56.—T.A.-T.G. oscillator.

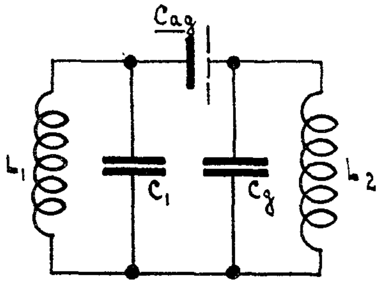


FIG. 56A.

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.

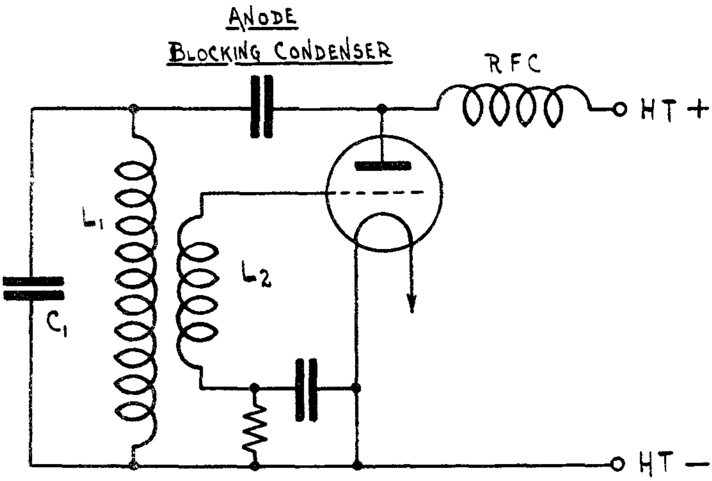


FIG. 57.—Parallel fed oscillator.

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}.

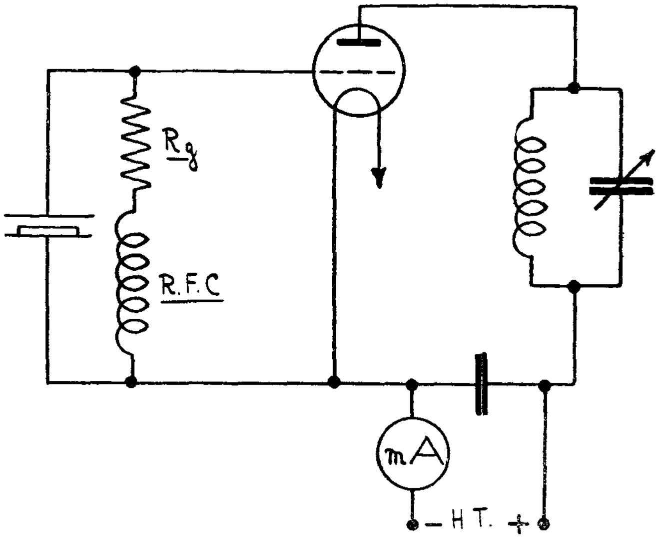


FIG. 58.—TA–XG oscillator.

(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 with 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

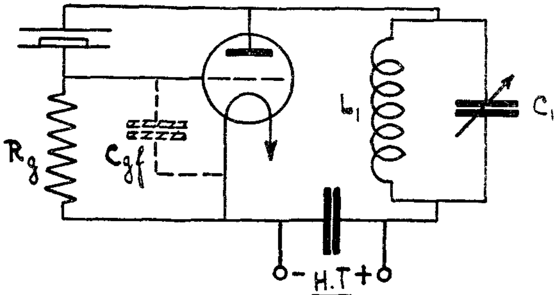


FIG. 59.—Pierce oscillator.

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.

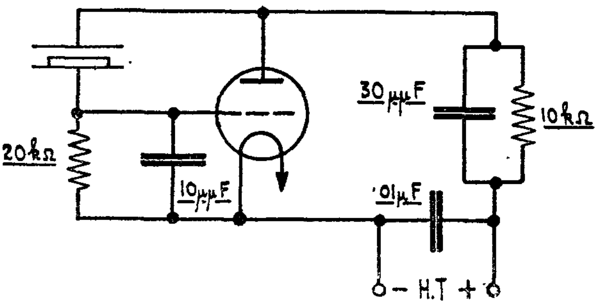


FIG. 60.—" Untuned " H.T. Pierce circuit.

(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.

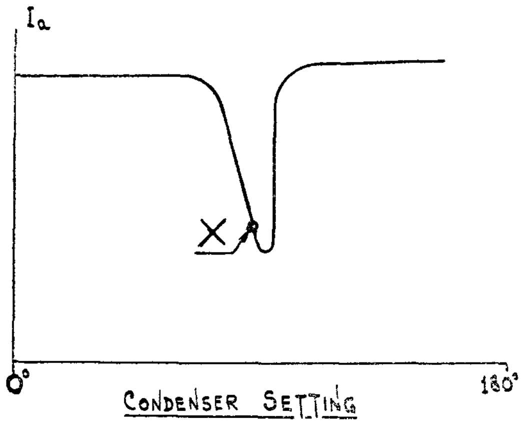


FIG. 61.—Correct setting of crystal oscillator.

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.

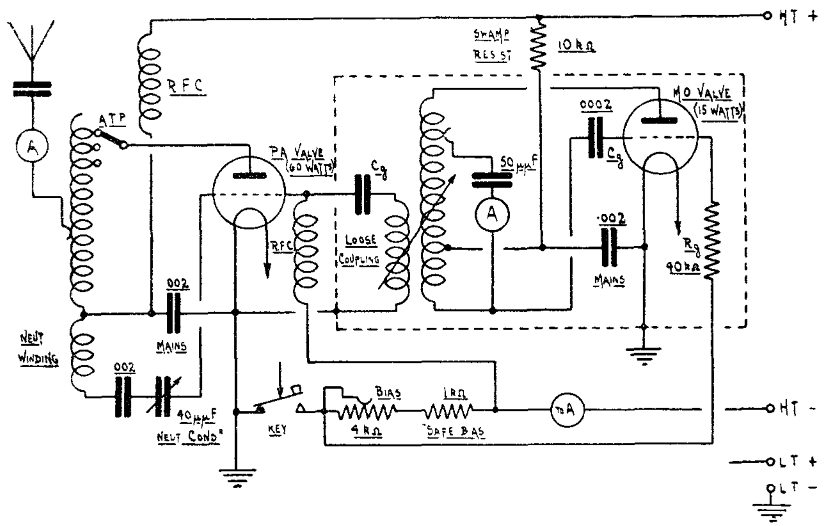


FIG. 62.—Typical M.O.-P.A. circuit for H.F.C.W.

(*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.

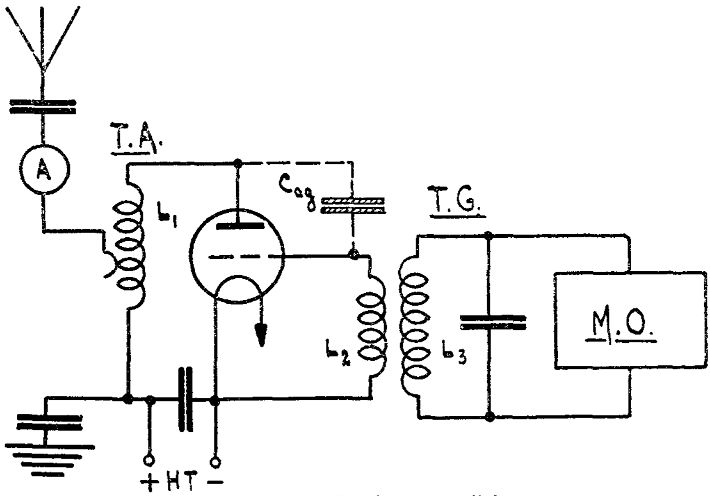


FIG. 63.—Necessity for neutralising.

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.

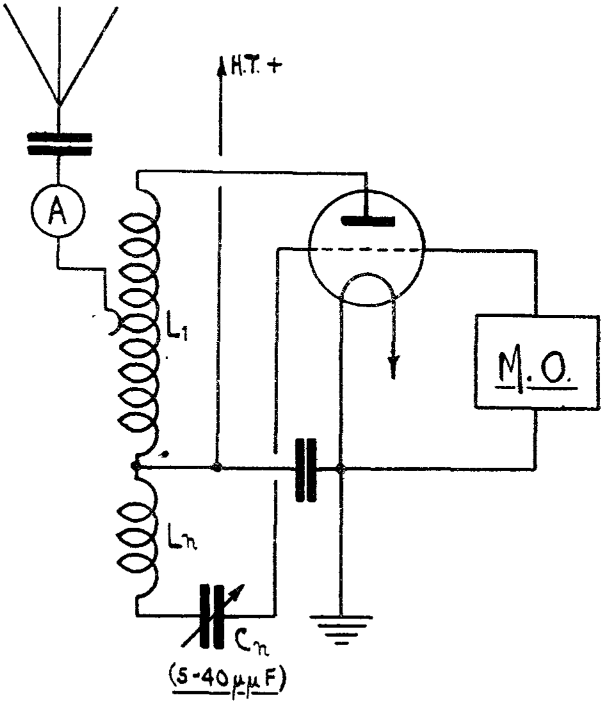


FIG. 64.—Neutralising.

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.

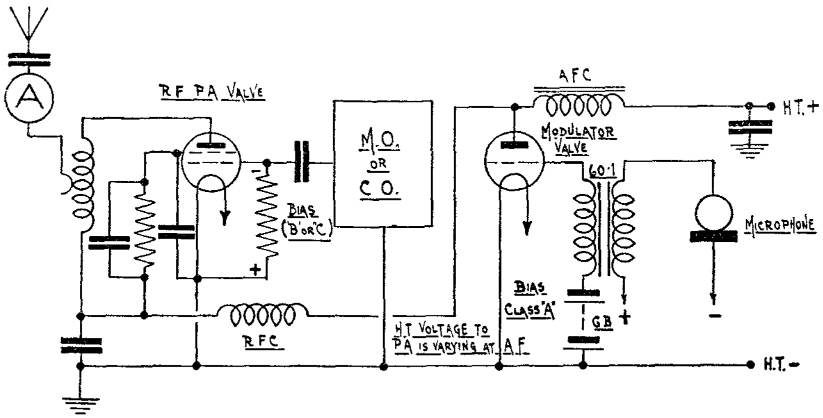


Fig. 65.—Anode modulation.

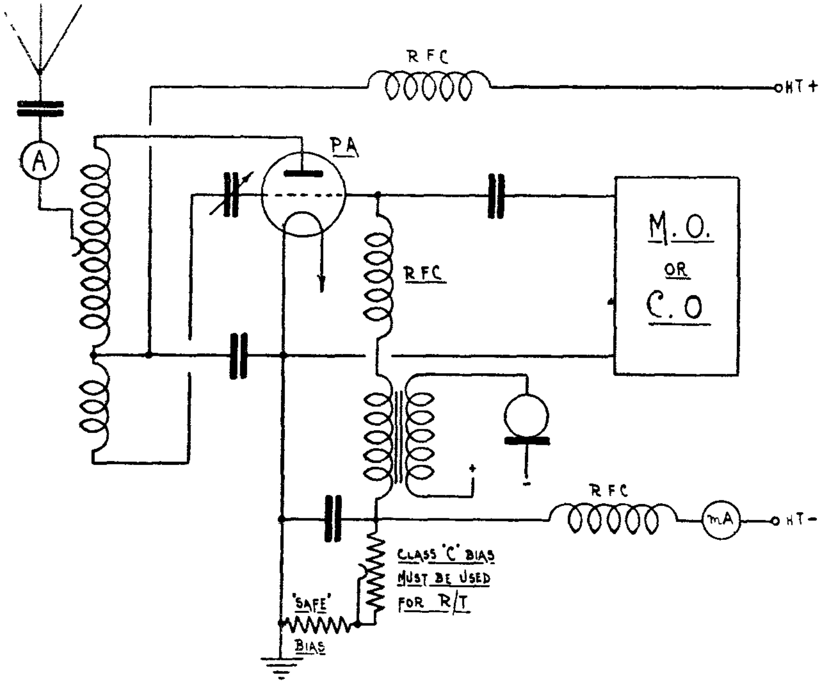


Fig. 66.—" Grid bias " modulation (R.F. voltages applied in series with G.B.).

CHAPTER 8

RECEIVER R.1082

1. **Requirements.**—General purpose aircraft receiver, capable of receiving C.W., M.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. **Servicing.**—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.

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.

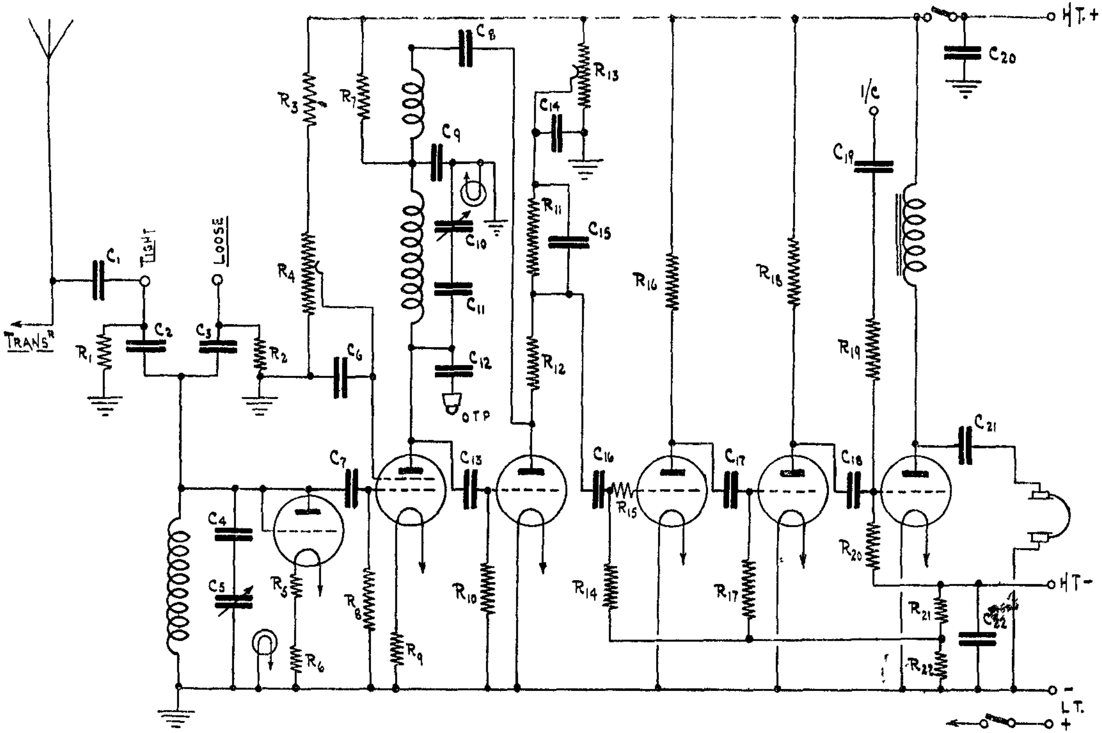


Fig. 67.—Receiver R.1082.

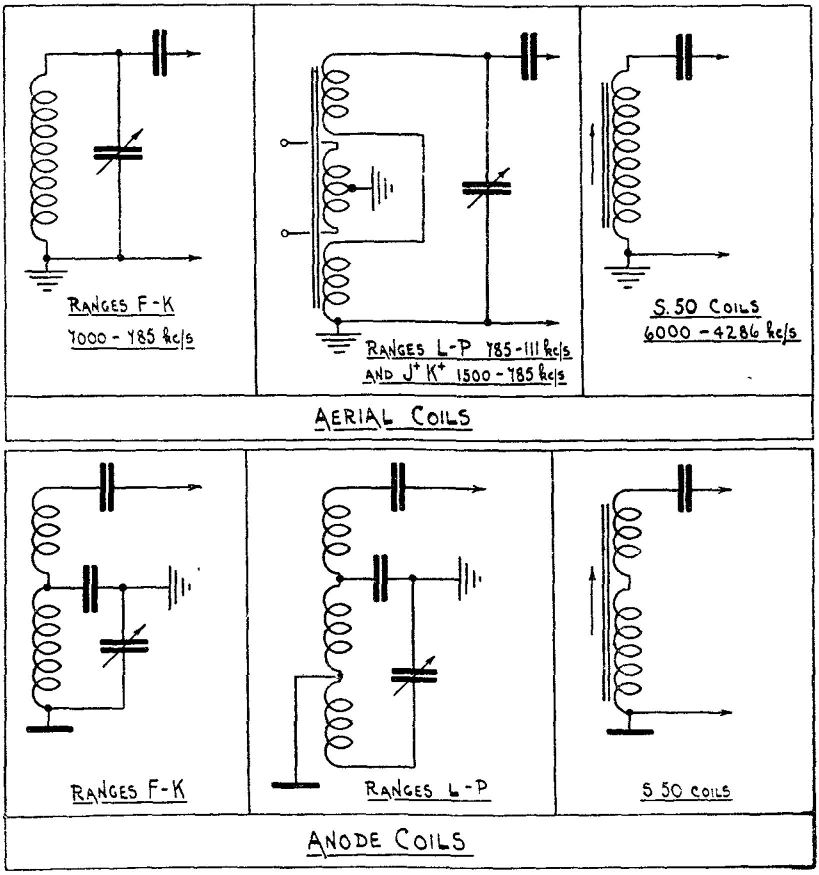


FIG. 68—Coils for R.1082 (ranges A–E (15–7 mc/s) shown in Fig. 67).

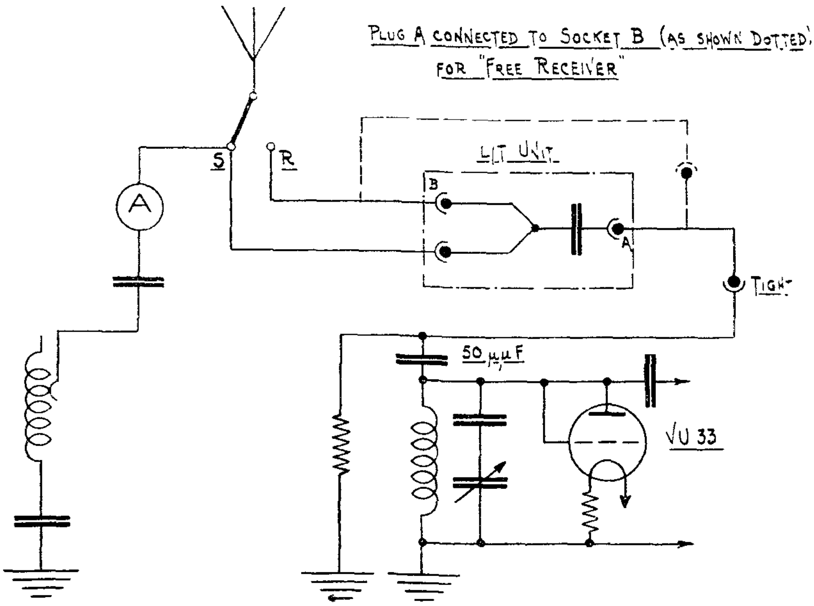


FIG. 69—" Listening through " circuits (R.1082–T.1083).

CHAPTER 9

TRANSMITTER T.1083

1. **Requirements.**—General purpose aircraft transmitter (C.W., M.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.
(iii) 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. **Servicing.**—Faults in the transmitter are often found quickly by 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 at 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.

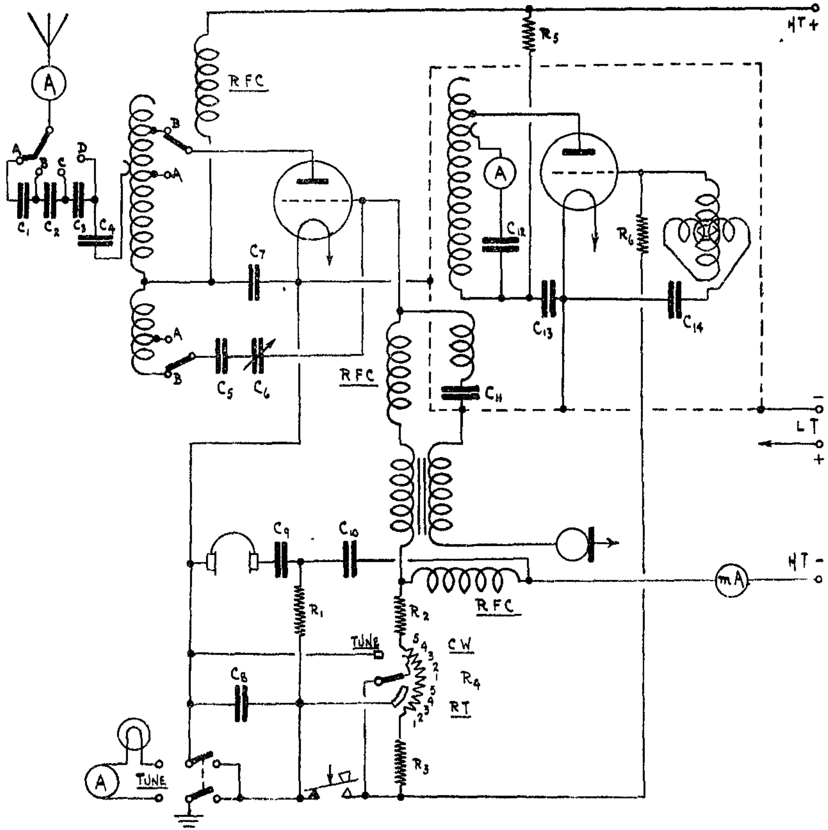
VALUES

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 $k\Omega$



CHAPTER 10

TRANSMITTER-RECEIVER T.R.9H

1. **Requirements.**—A lightweight, low power, crystal controlled R/T set for use in aircraft.

2. **Frequency Range.**—4·3 to 6·6 Mc/s.

3. **Communication Range.**—At least 35 miles air to ground and 5 miles air to air.

4. **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, two, V.R.18; detector, V.R.21; A.F. amplifiers, two, V.R.21; output, triode, V.R.22 or pentode, V.R.118.

5. **Power Supplies.**—(i) L.T., 2 volt, 20 A.H. accumulator. Current, 2 amps. on " transmit ", 1·15 amps. on " receive ".

(ii) H.T., 120-volt dry battery or power unit, type 173. This is a vibrator unit comprising a vibrator, transformer, metal rectifier, filter units and stabiliser (V.S.110). The unit takes 1 amp. (approx.) from the aircraft 24-volt supply. No adjustment is possible; change the stabiliser valve after 500 hours and the vibrator after 1,000 hours. Current, approx., 28 mA on " transmit " and 18 mA on " receive."

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

(*b*) Receiver; 4·5-volt dry battery.

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

6. **Aerial System.**—A small fixed aerial, type depending on aircraft. When necessary the aerial may be connected via a co-axial cable; this may necessitate a matching unit at the transmitter.

7. **Transmitter Circuit** (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 by a continuously variable inductance, which is part of the aerial circuit for both transmitter and receiver.

(vi) The output from the microphone is amplified by a sub-modulator, consisting of the external amplifier A.1134, before application to the input of the modulator valve.

8. **Receiver Circuit** (fig. 72).—(i) As the aerial circuit of the receiver is tuned when tuning the transmitter, the two main 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; this is not used in the air, and is normally locked.

(ii) The volume control is external to the set, and is a potentiometer which adjusts the potential on the screen grid of both R.F. valves; it is normally remotely controlled by the pilot.

(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.

9. **Control of T.R.9H.**—(i) *General.*—There are three methods of control :—

(*a*) For local control, the Yaxley pattern "send-receive" switch is used.

(*b*) By leaving Yaxley S/R switch at "receive", "push to talk" operation is available.

(*c*) By leaving Yaxley S/R switch at "off", complete electrical remote control is available at one point and "push to talk" operation at several others, providing the set has been switched on.

(ii) *Action of remote switching.*—When the remote "on-off" switch is closed, the winding of Relay 1 (fig. 71) is energised by the 2-volt L.T. battery and the following circuits completed :—

(*a*) L.T. + to receiver.

(*b*) L.T. + to C.O. valve in transmitter.

(*c*) L.T. + to winding of relay 2 via "P.T.T." switch.

(*d*) L.T. + to moving contact of relay 2.

(*e*) H.T. + to receiver via relay 2.

Thus at this stage the receiver is switched on, and the filament of C.O. valve heated. On pressing the "P.T.T." switch relay 2 is energised completing the following circuits.

(*f*) L.T. + to P.A. and modulator valves.

(*g*) H.T. + to transmitter, breaking H.T. + to receiver. There is a time delay of about ·75 seconds between switching to "transmit" and availability of the transmitter. This is the time taken for filaments of P.A. and modulator to heat.

VALUES

Condensers		Resistances in Kilohms	
1	50 $\mu\mu$ F	1	20
2	10 $\mu\mu$ F	2	30
3	500 $\mu\mu$ F	3	20
4	·01 μ F		
5	·001 μ F		
6	·002 μ F		

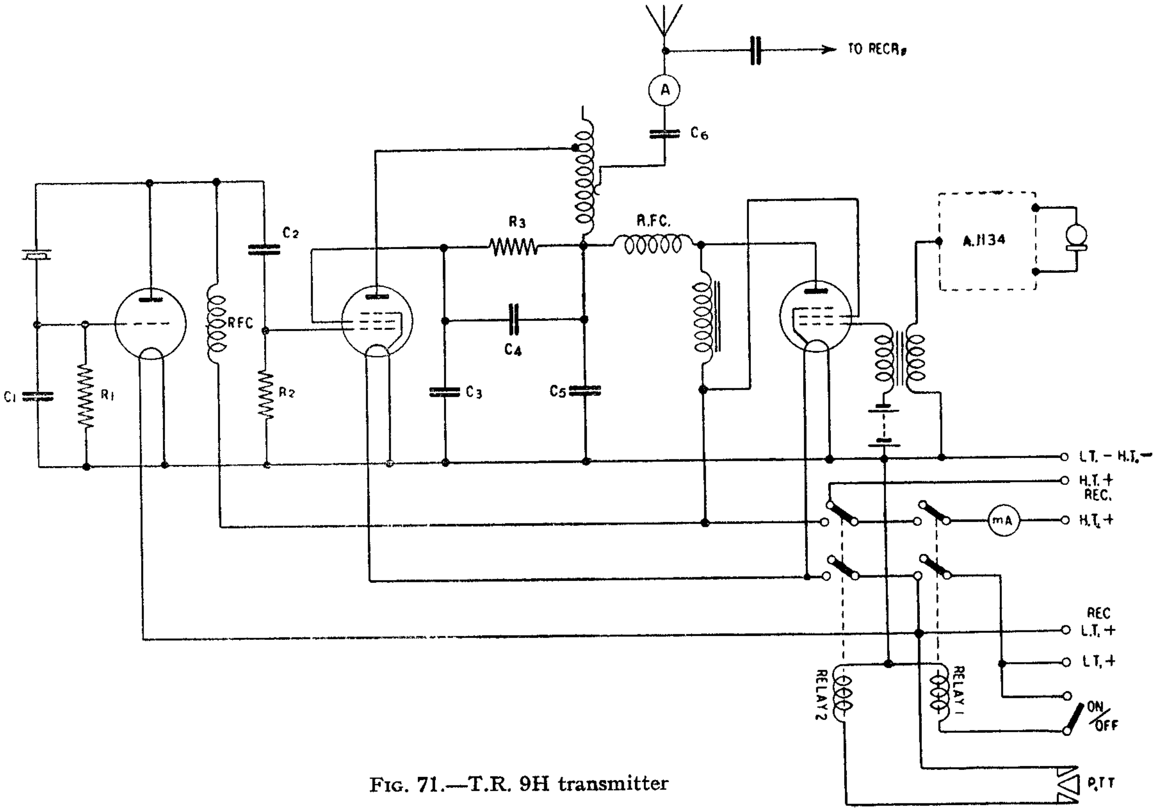
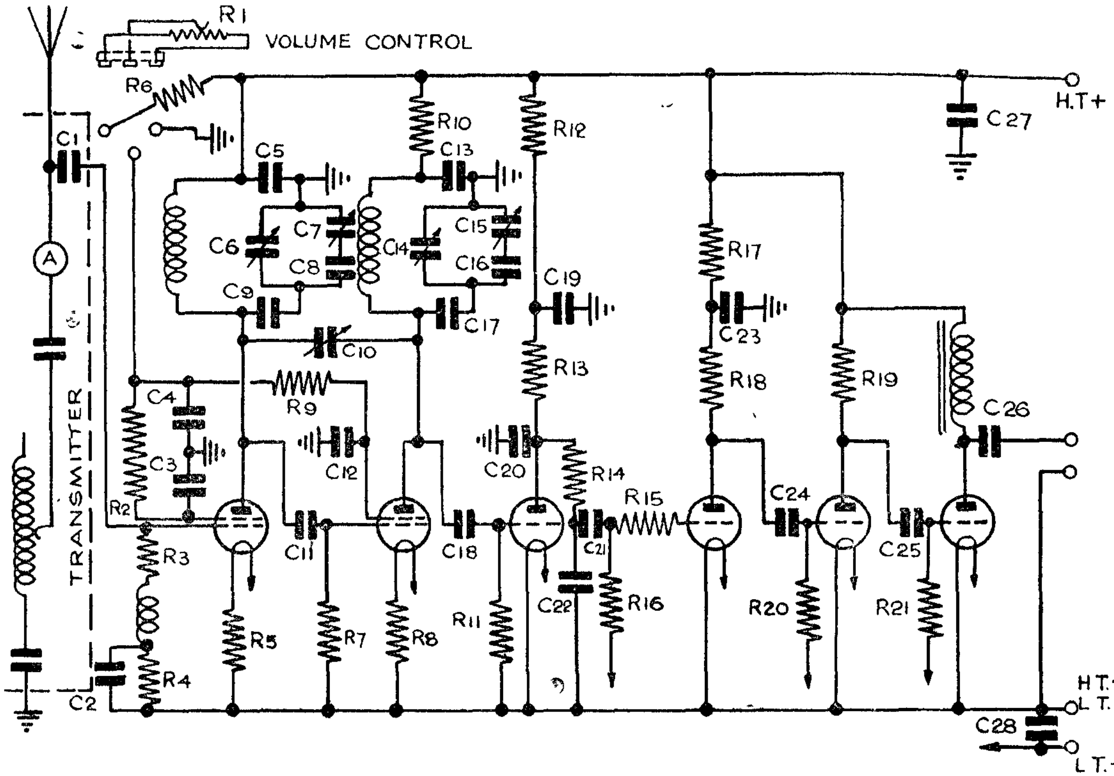


FIG. 71.—T.R. 9H transmitter

VALUES

Condensers		Resistances	
1	50 $\mu\mu$ F	1	50 K Ω
2	·1 μ F	2	20 K Ω
3	·5 μ F	3	10 K Ω
4	·5 μ F	4	·5 M Ω
5	·5 μ F	5	1·5 Ω
6	230 $\mu\mu$ F	6	20 K Ω
7	48 $\mu\mu$ F	7	1 M Ω
8	20 $\mu\mu$ F	8	1·5 Ω
9	·01 μ F	9	20 K Ω
10	10 $\mu\mu$ F	10	2 K Ω
11	300 $\mu\mu$ F	11	·25 M Ω
12	·5 μ F	12	20 K Ω
13	·5 μ F	13	·5 M Ω
14	230 $\mu\mu$ F	14	250 K Ω
15	48 $\mu\mu$ F	15	2 M Ω
16	20 $\mu\mu$ F	16	1 M Ω
17	·01 μ F	17	20 K Ω
18	100 $\mu\mu$ F	18	50 K Ω
19	·5 μ F	19	·2 M Ω
20	·001 μ F	20	1 M Ω
21	·001 μ F	21	1 M Ω
22	50 $\mu\mu$ F		
23	·5 μ F		
24	·001 μ F		
25	·001 μ F		
26	·5 μ F		
27	2 μ F		
28	·01 μ F		



10. **Tuning** (N.B.—The transmitter must be tuned first).—(i) *Transmitter* :—

(*a*) Set the normal aerial tuning inductance to O if frequency required is greater than 5 Mc/s, or to 16 if it is less.

(*b*) Switch on set, and switch on supply to power unit if fitted.

(*c*) Press " P.T.T." switch and tune A.T.I. until a dip is noticed in input milliamps ; set to greatest dip and switch off P.T.T. switch.

(ii) *Receiver.*—(*a*) Ensure that the transmitter is correctly tuned.

(*b*) Set volume control to maximum and leave it there during the whole process of tuning.

(*c*) Ensure that set is switched on, and power unit, if fitted, is " on ".

(*d*) Switch on and adjust R/T tester to frequency required.

(*e*) Adjust the two main tuning condensers carefully (keeping them in step) until the modulated signal is heard at full strength.

(*f*) When correctly tuned in, attenuate the signal input until the note is barely audible. This is done by moving the R/T tester, closing the lid, or both.

(*g*) Tune again very carefully, attenuating the signal to ensure absolute accuracy in tuning.

(*h*) Turn the regeneration control up until the receiver commences to oscillate, then turn it back one complete turn.

(*j*) Re-adjust main tuning condensers slightly for maximum signal.

(*k*) Lock receiver tuning.

Note.—Fine and accurate tuning of the T.R.9 receiver is a vital factor in the success of air operations.

11. **Amplifier A.1134** (fig. 73).—(i) *Power supplies.*—(*a*) L.T. 2-volt 14 A.H. accumulator.

(*b*) H.T. 120-volt dry battery.

(*c*) G.B. 6-volt dry battery—tapped at 3 volts and 6 volts.

(ii) *Circuit.*—The A.1134 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.

(iii) *General.*—(*a*) The amplifier is used for inter-communication purposes between members of the aircraft crew up to seven in number, in addition to acting as a sub-modulator for the transmitter portion of the T.R.9F.

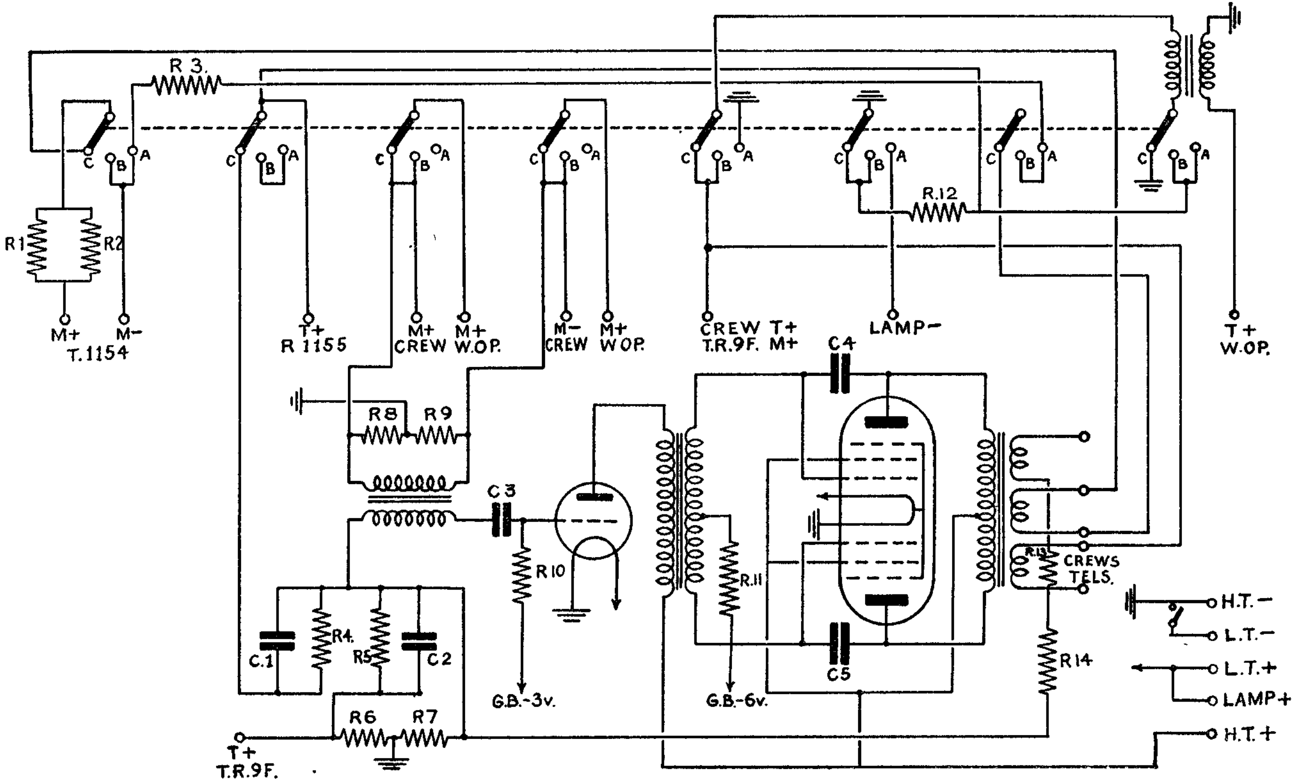
(*b*) The A.1134 may also be used as a microphone amplifier when it is desired to transmit R/T on the aircraft's normal long distance C.W. transmitter (T.1083 or T.1154).

(*c*) Switching of the amplifier is arranged so that whilst normal inter-communication is possible between other members of the crew, the W/T operator is left connected to his C.W. receiver, but he may be brought into the I/C circuit at will, or may use the amplifier to modulate his transmitter at will.

(*d*) In addition, the pilot has a switch which enables him to switch on the T.R.9H and communicate with his base.

VALUES

Resistances		Condensers	
1	75 Ω	1	100 μμ F
2	75 Ω	2	100 μμ F
3	50 Ω	3	500 μμ F
4	1 M Ω	4	50 μμ F
5	1 M Ω	5	50 μμ F
6	15 K Ω		
7	5 K Ω		
8	500 Ω		
9	500 Ω		
10	·5 M Ω		
11	150 K Ω		
12	15 K Ω		
13	50 K Ω		
14	2 K Ω		



(*e*) Fig. 73 shows the complete circuit diagram of the A.1134, and fig. 73A shows the operation of the "A B C" switch.

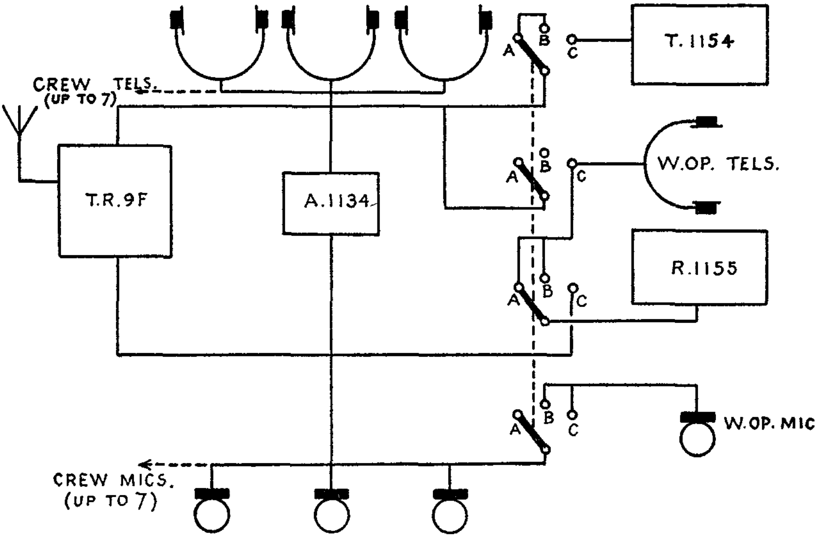


FIG. 73A.—Operation of A.B.C. switch.

(*f*) The connections to the various plugs and sockets are as follows :—

(i) 10-pin plug—

1. Lamp+
2. Lamp−
3. W/T operator T+
4. Crew T+ and T.R.9H M+
5. T.R.9H T+
6. C.W. receiver T+
7. T.R.9H M−, T−, and earth.
8. C.W. transmitter M−
9. C.W. transmitter M+
10. Earth

(ii) 4-pin plug—

1. Crew M+
2. W/T operator M+
3. Crew M−
4. W/T operator M−

(iii) 3-pin plug—

Red—T.R.9H receiver output.
Blue—earth.
Yellow—microphone input to T.R.9H transmitter.

12. **Panel, Type 192.**—This is a junction box fitted in the aircraft, accommodating the microphone and telephone leads from the T.R.9.H and the R.1155, and also the 10-pin and 4-pin plugs from the A.1134. From this panel, microphone and telephone leads go out to the W/T operator and the various crew positions. A switch on the panel provides an additional intercommunication facility, i.e. the use of the A.F. stages of the T.R.9.H receiver as an intercommunication amplifier. This is useful if the A.1134 becomes unserviceable or is damaged in action, although the output is only sufficient for two or three pairs of telephones.

13. **Low Impedance Intercommunication System.**—This consists of :—

(i) *A.1134A.*—This is an intercommunication amplifier, exactly similar to the A.1134, but having an output winding, connected to the crew telephones, which is such as to match the amplifier to an impedance of about 150 ohms, instead of the 20,000 ohms impedance of the A.1134.

(ii) *Microphone Assembly, Type 35.*—This consists of a pair of high impedance (type 16) telephones, an ordinary E.M. microphone, and a cord fitted with the usual plug and a small unit containing a transformer and switch. By means of the switch the transformer can be brought into circuit, or cut out. When the transformer is in circuit, the microphone assembly can be used with A.1134A (i.e. in a " low-impedance " aircraft). When transformer is out, the helmet is suitable for use with A.1134 (i.e. in a " high impedance " aircraft). When low impedance telephones (type 32) are fitted to this assembly, one lead is changed over, and the turns ratio of the transformer is thus reversed, permitting the use of low impedance telephones with either A.1134 or A.1134A. The assembly is thus universal, enabling air crews to operate in any aircraft with any telephones. Low impedance telephones may be recognised by a white square painted on the rear of the case of the earpiece.

(iii) *Junction Box, Type 9.*—This is a junction box containing a transformer, fitted in the telephone circuit of the R.1125 (S.B.A. receiver), and which matches the high impedance output of the R.1125A to the low impedance pilot's telephone.

(iv) *Matching Unit, Type 111.*—This is a transformer unit, included in the telephones circuit wiring of any other receiver (e.g. a navigator's R.1155, if fitted), whose impedance it is desired to reduce.

14. **Servicing of T.R.9H.**—(i) Change the L.T. battery after every flight.

(ii) Test the H.T. battery on load before every flight by inserting a voltmeter between lower crystal socket and earth terminal with switch at " send ". Battery must be changed when 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 5 mA.

(iv) Servicing of the intercommunication apparatus is extremely important and great attention is to be given to the following points :—

(*a*) Test the helmets of all members of the crew before each flight. Apart from testing the sensitivity with the tester provided, see that the insulation resistance between microphone and telephone leads, and to the earthed screen, is greater than 10 megohms and that the screening is serviceable and correctly connected to the microphone and telephone negative.

(*b*) Ensure that all telephone-microphone sockets are correctly anchored, clean and lightly smeared internally with petroleum jelly.

(*c*) The insulation resistance to all I/C wiring to be greater than 10 megohms (or as specified for a particular aircraft).

Note.—Ask the crew to refrain from swinging helmets and plugs idly about, whilst walking about the aerodrome, etc.

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.

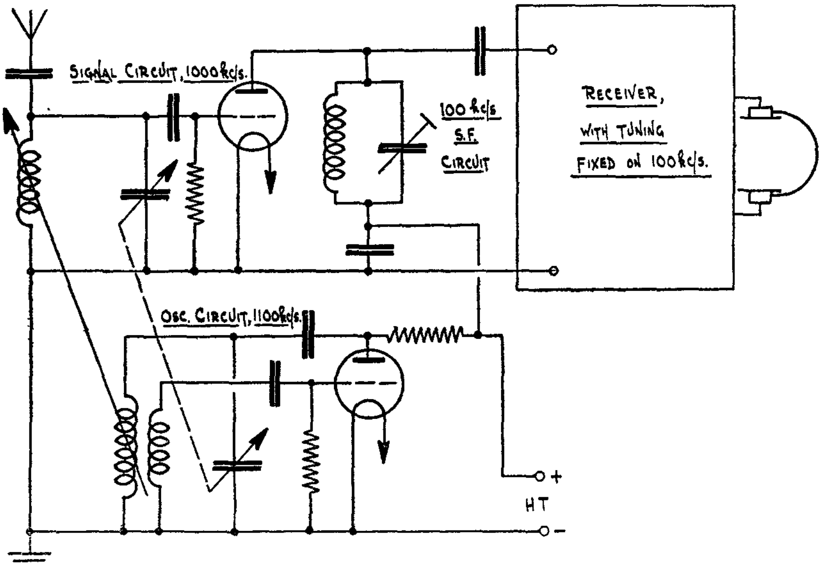


FIG. 74.—Simple " superhet " receiver.

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.

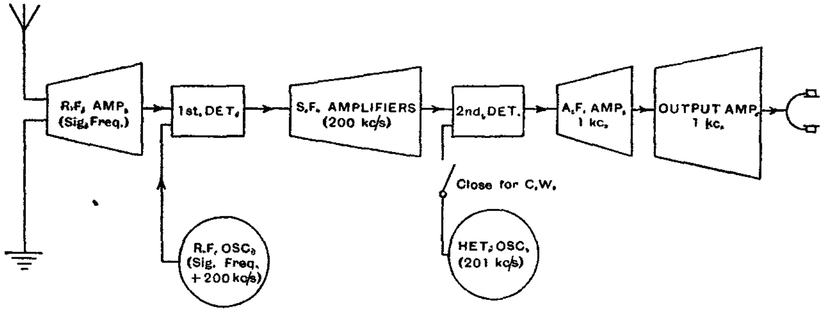


FIG. 75.—Block diagram, typical superhet receiver.

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.

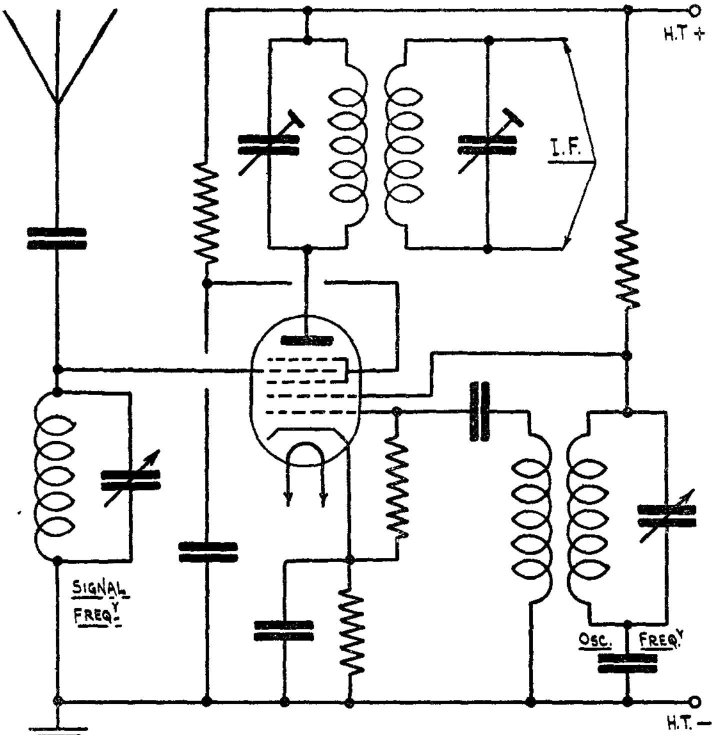


FIG. 76.—Heptode frequency changer.

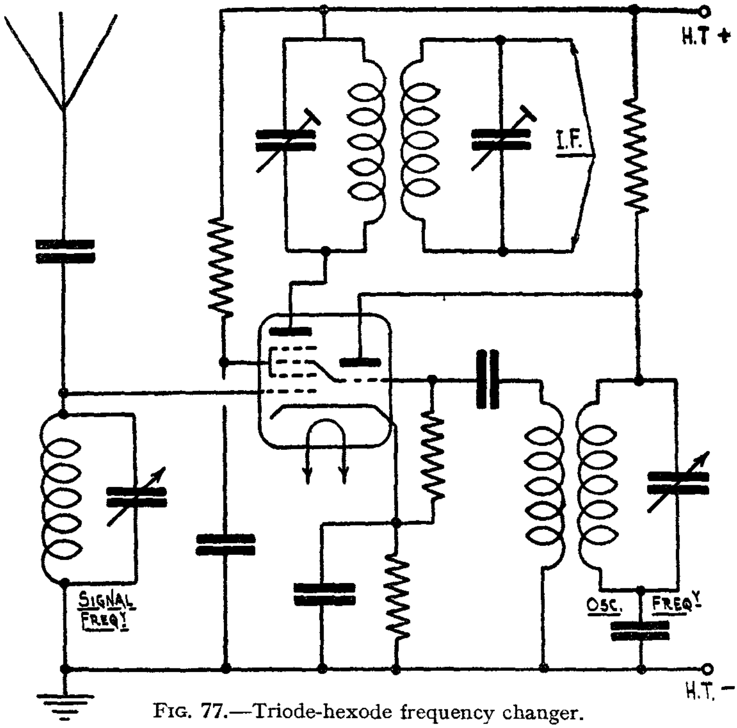


FIG. 77.—Triode-hexode frequency changer.

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 on 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 M.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 M.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 M.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 M.C.W.

(xii) As for (x) R/T or M.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 M.C.W.

"Straight" operation, R/T or M.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 M.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. **Servicing.**—(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 loss 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.

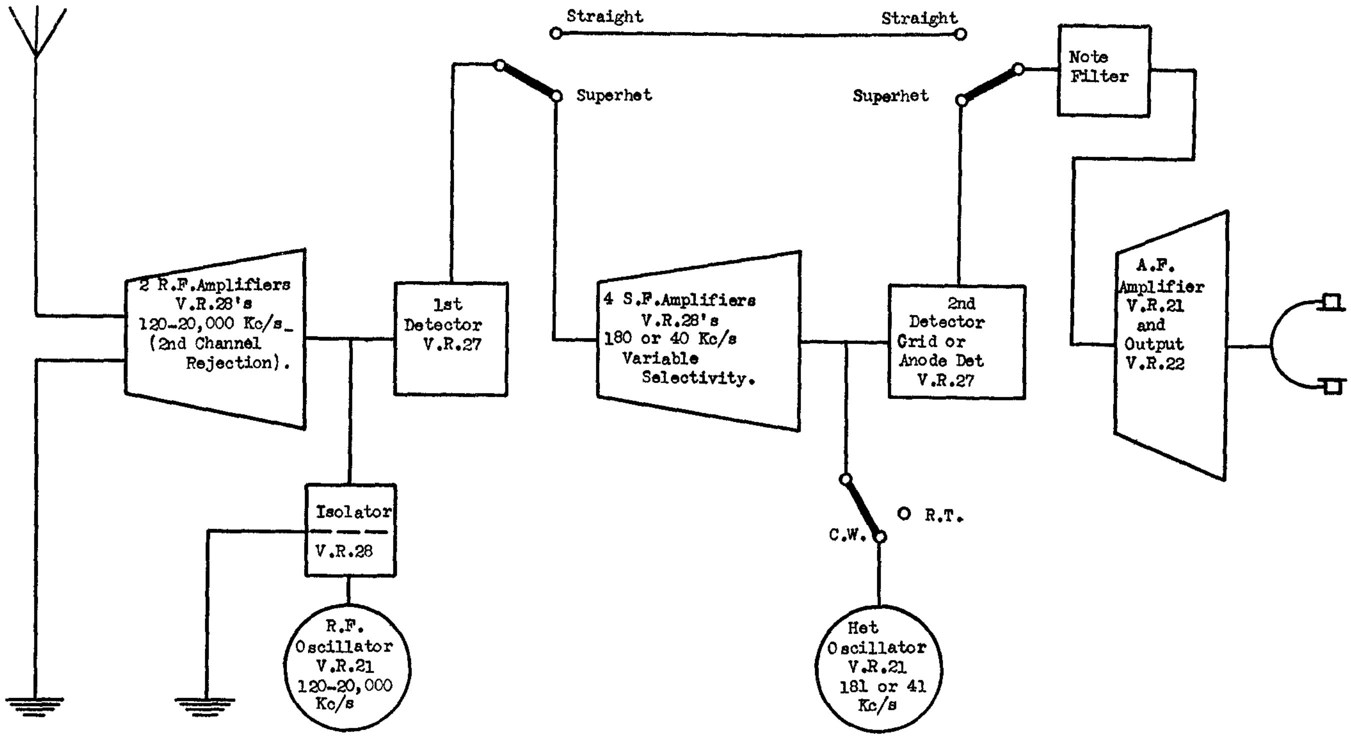
(viii) Clean all valve pins and coil contacts frequently, using carbon tetrachloride.

(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.



Straight
Straight
Superhet
Superhet
Note Filter
2 R.F.Amplifiers V.R.28's 120-20,000 Kc/s (2nd Channel Rejection).
1st Detector V.R.27
4 S.F.Amplifiers V.R.28's 180 or 40 Kc/s Variable Selectivity.
2nd Detector Grid or Anode Det V.R.27
A.F. Amplifier V.R.21 and Output V.R.22
Isolator
V.R.28
R.F. Oscillator V.R.21 120-20,000 Kc/s
R.T.
C.W.
Het Oscillator V.R.21 181 or 41 Kc/s

(*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.

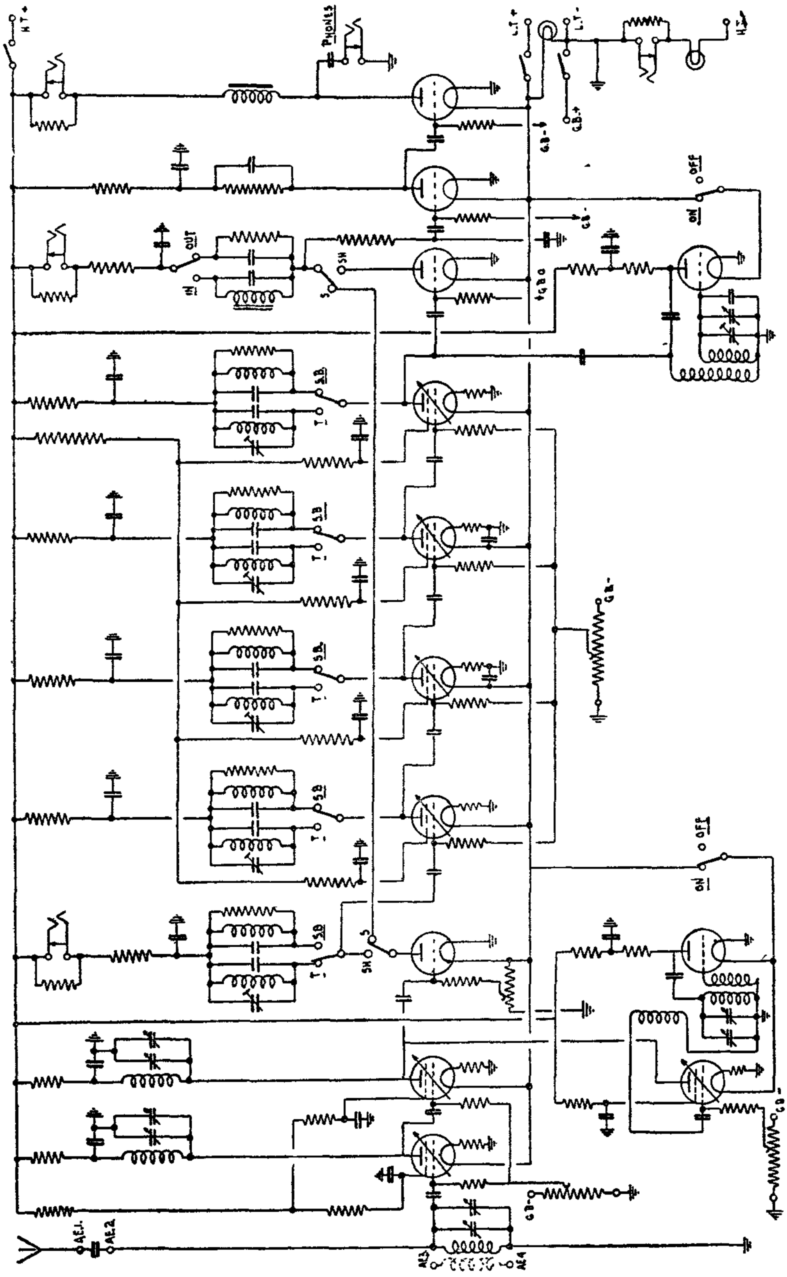


FIG. 79.—Receiver R.1084.

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) 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 used for obtaining a D/F " fix " by R/T if required. The volume control is fully automatic so that the Pilot 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. 80A. 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. 80A. 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. 80A. 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.

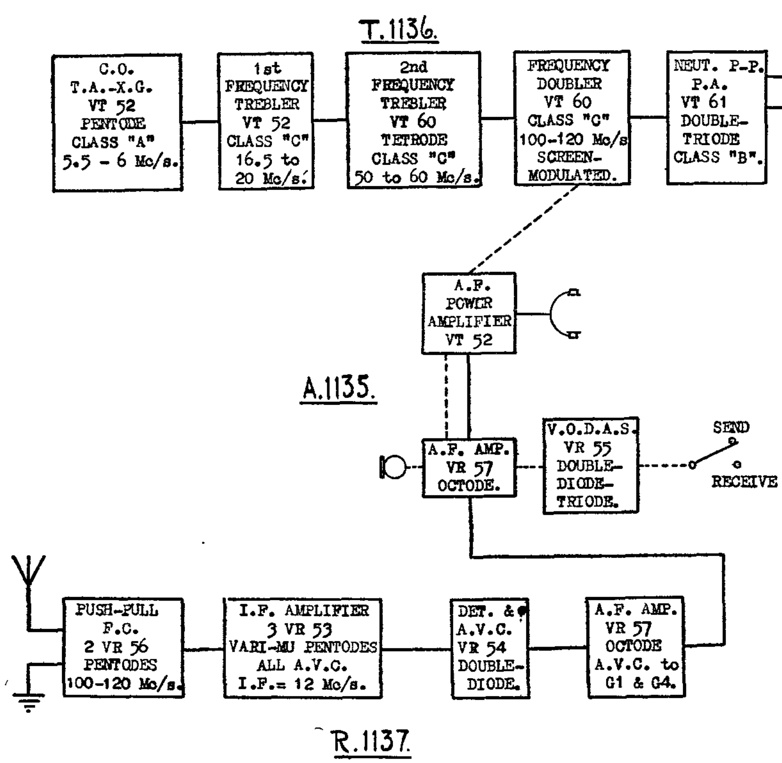


Fig. 80A.—Block diagram, T.R.1133.

(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.

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. *Deleted.*

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. **Servicing 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 emission 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 control 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 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."

10. **T.R.1133E, F, G, H**

T.R.1133E, F, G and H are identical with T.R.1133A, B, C and D respectively, except that receiver R.1137A in the latter equipment is replaced by receiver R.1225 and the outer case is modified to give access to the crystals used in this receiver. The R.1225 is a crystal controlled superheterodyne receiver designed to give a performance similar to that of the T.R.1143, as regards selectivity, frequency stability and sensitivity.

11. **Circuit Details**

A block schematic diagram is at Fig. 80B, showing valves employed and general lay-out of the circuit and equipment. A crystal controlled electron coupled oscillator with its anode circuit tuned to the third harmonic, is coupled to a frequency multiplier tuned to the eighteenth harmonic of the crystal. This is applied to a pentode mixer stage together with the output of the R.F. amplifier (which increases selectivity). A crystal of 540 kc/s below that of the transmitter crystal frequency will give an I.F. of $540 \times 18 = 9{\cdot}72$ Mc/s. I.F. amplification is provided by three pentode stages with overall band-width of 80 kc/s. The output from the third I.F. amplifier is applied to the double-diode detector and A.V.C. valve. Pre-set volume control varies the A.F. output applied to the A.1135A which provides all the A.F. amplification.

Note.—Delayed A.V.C. (10V.) is applied to the R.F. amplifier, mixer and first two I.F. stages.

12. **Tuning Instructions—R.1225**

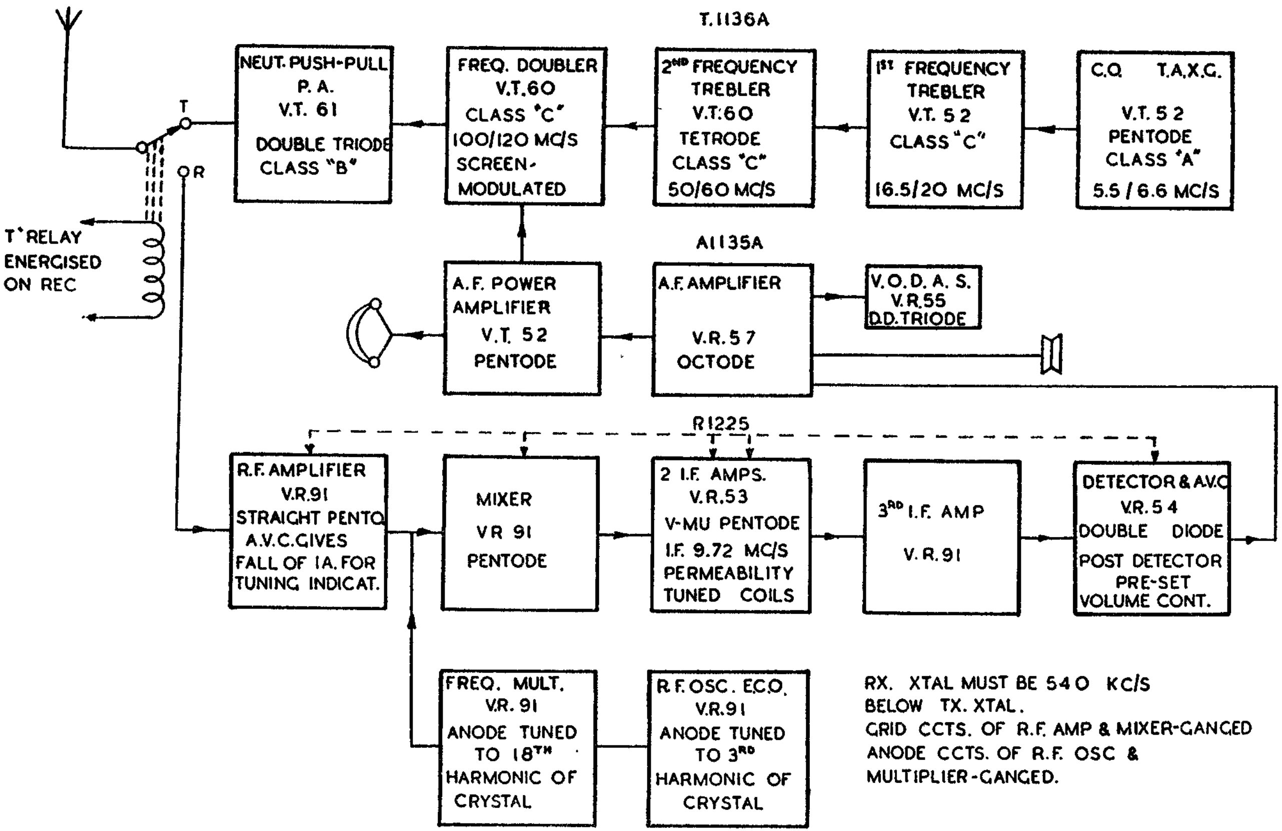
The tuning procedure for the R.1225 is identical with that described in para. 7, sub-para. (vii), with one exception, that the crystals must be inserted first. Receiver crystals must be 540 kc/s below those used for the transmitter.

Note.—The condensers should all be set to give the maximum dip on the test meter, type 5A.

13. **Servicing and Faults**

The information given in paras. 8 and 9 refers equally to this equipment, excepting those points relating specifically to R.1137A.

As regards R.1225, special care must be taken to ensure that the contacts of the crystal switches and pins of the V.R.91 valves are kept very clean, since even slight contact resistance will cause deterioration in results, or the receiver to cease functioning.


T.1136A
NEUT. PUSH-PULL P. A. V.T. 61 DOUBLE TRIODE CLASS "B"
FREQ. DOUBLER V.T.60 CLASS "C" 100/120 MC/S SCREEN-MODULATED
2ND FREQUENCY TREBLER V.T.60 TETRODE CLASS "C" 50/60 MC/S
1ST FREQUENCY TREBLER V.T. 52 CLASS "C" 16.5/20 MC/S
C.O. T.A.X.G. V.T. 52 PENTODE CLASS "A" 5.5 / 6.6 MC/S
T
R
T' RELAY ENERGISED ON REC
A1135A
A.F. POWER AMPLIFIER V.T. 52 PENTODE
A.F. AMPLIFIER V.R.57 OCTODE
V.O.D.A.S. V.R.55 D.D.TRIODE
R1225
R.F. AMPLIFIER V.R.91 STRAIGHT PENTO A.V.C.GIVES FALL OF IA. FOR TUNING INDICAT.
MIXER VR 91 PENTODE
2 I.F. AMPS. V.R.53 V-MU PENTODE I.F. 9.72 MC/S PERMEABILITY TUNED COILS
3RD I.F. AMP V.R.91
DETECTOR & AV.C V.R.54 DOUBLE DIODE POST DETECTOR PRE-SET VOLUME CONT.
FREQ. MULT. V.R. 91 ANODE TUNED TO 18TH HARMONIC OF CRYSTAL
R.F. OSC. E.C.O. V.R.91 ANODE TUNED TO 3RD HARMONIC OF CRYSTAL
RX. XTAL MUST BE 540 KC/S BELOW TX. XTAL.
GRID CCTS. OF R.F. AMP & MIXER-GANCED
ANODE CCTS. OF R.F. OSC & MULTIPLIER-GANGED.

TRANSMITTER-RECEIVERS T.R.1143 and T.R.1143A

14. Requirement

For use as a 4-channel V.H.F. R/T set in aircraft. M.C.W. may be radiated on channel D if required, for D/F purposes. It has been designed to replace the T.R.1133 series.

15. Frequency Range

100–124 Mc/s.

16. Communication Range

125 miles air to ground, and air to air, at 10,000 feet.

17. Valves

(i) *Transmitter.* (Seven) crystal oscillator and 1st trebler—V.R.53 (vari-mu R.F. pentode).

2nd trebler, doubler, and P.As.—V.T.501 or V.T.501A (beam tetrode).
Monitor—V.R.92 or V.R.78 (I.D.H. diode).

(ii) *Receiver unit.* (Eight) R.F. amplifier, mixer, and 3rd I.F.—V.R.91 (R.F. pentode).

1st and 2nd I.F. amplifiers—V.R.53.
Crystal oscillator—V.T.52 (pentode).
Frequency multiplier—V.R.91.
Detector, A.V.C., and muting valve—V.R.55 (double-diode triode).

(iii) *Amplifier unit.* (Six).

Driver (I/C amplifier)—V.R.56 (pentode).
Output (I/C amplifier)—V.R.55.
Driver (modulation amplifier)—V.R.56.
Modulators—V.T.52.
V.O.D.A.S. valve—V.R.55 (double-diode triode).

18. Power Supplies

These are derived from the 12- or 24-volt aircraft G.S. accumulators, this being used to operate a differentially-compounded motor generator. (12-volt input—power unit, type 15; 24-volt input—power unit, type 16.) The output is stabilised by means of a carbon-pile regulator.

Input :—
12 volt—25 amps. 24 volts—13 amps.

Outputs :—
L.T.—12·6 volts, 4·9 amps.
G.B.—150 volts, 10 mA.
H.T.—300 volts, 260 mA.

19. Aerial Systems

(i) *Aircraft.* Normally a quarter-wave vertical end-fed aerial. In some aircraft (e.g., a Mosquito) special aerials are used.

(ii) *Ground.* Portable stations. Vertical, with a reflector system at the base of the aerial.

(iii) *Mobile stations.* Vertical, mounted on the roof of a tender.

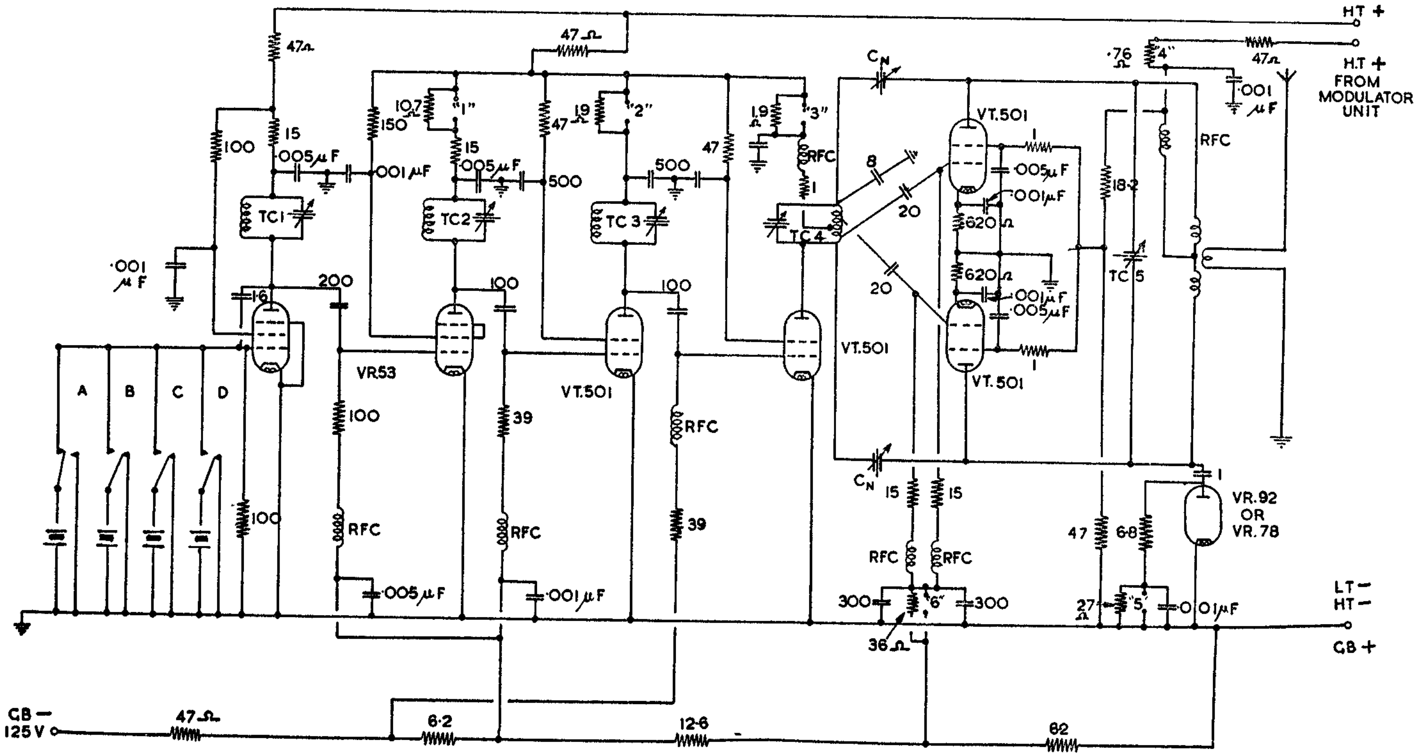
20. Associated Equipment

(i) The complete T.R.1143 or T.R.1143A installation consists of :—

(*a*) T.R.1143 or T.R.1143A.
(*b*) Power unit, type 15 or 16.
(*c*) Junction box, type 17A or 17B.
(*d*) Breeze cable harness.
(*e*) Controller, electric, type 3.

(ii) If V.H.F. beam approach is used, the following additional components are required :—

(*a*) Amplifier A.1271.
(*b*) Aerial system, type 62.



HT +
H.T + FROM MODULATOR UNIT
47Ω
47Ω
15
100
·005μF
·001μF
TC1
·001 μF
200
1·6
A
B
C
D
100
107Ω
"1"
150
15
·005μF
500
TC2
100
VR53
100
RFC
·005μF
19Ω
"2"
47Ω
500
TC 3
100
39
RFC
·001μF
VT.501
RFC
39
1·9Ω
"3"
47
RFC
1
TC 4
8
20
20
VT.501
C_N
VT.501
1
·005μF
·001μF
620Ω
620Ω
·001μF
·005μF
VT.501
1
·76Ω
"4"
·001 μF
RFC
18·2
TC 5
C_N
15
15
RFC
RFC
300
"6"
300
36Ω
47
6·8
1
VR.92 OR VR.78
27Ω
"5"
0·01μF
LT −
HT −
GB +
GB − 125 V
47Ω
6·2
12·6
82

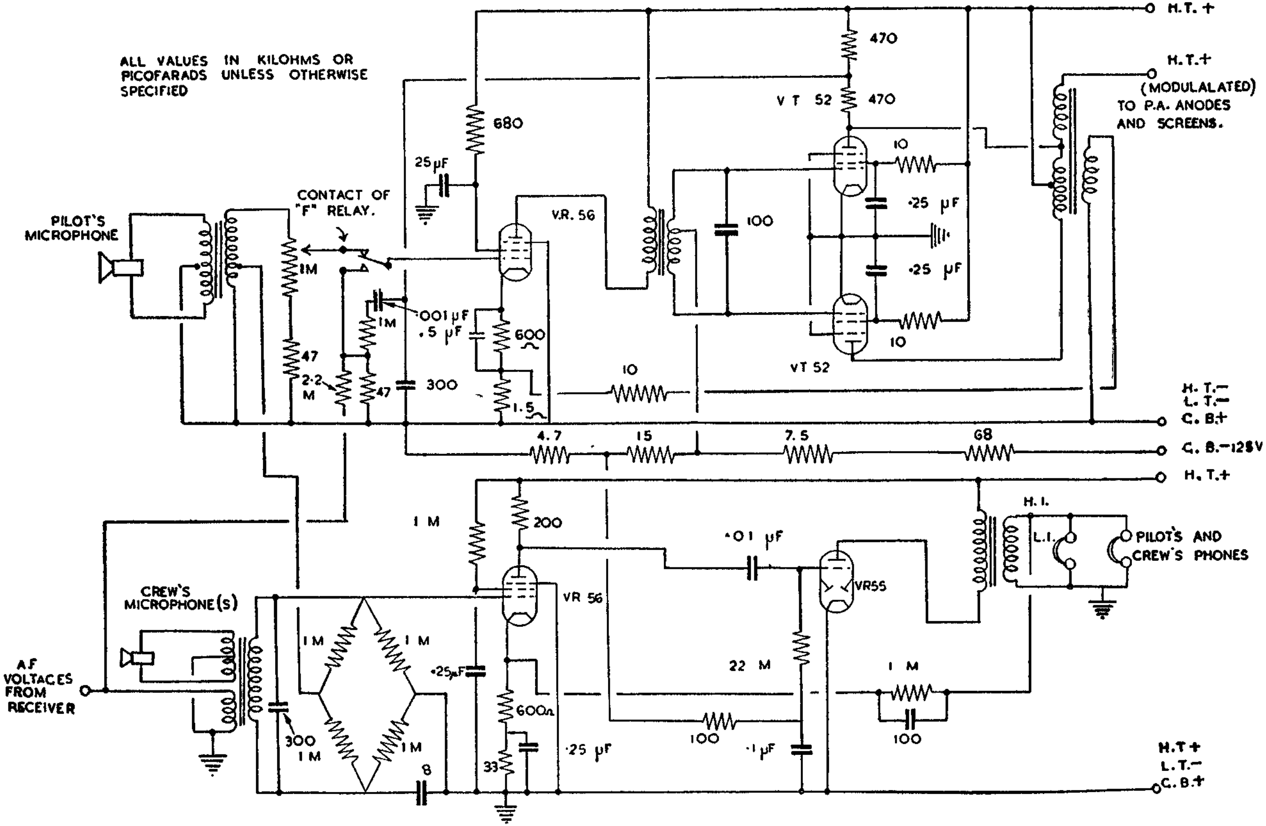
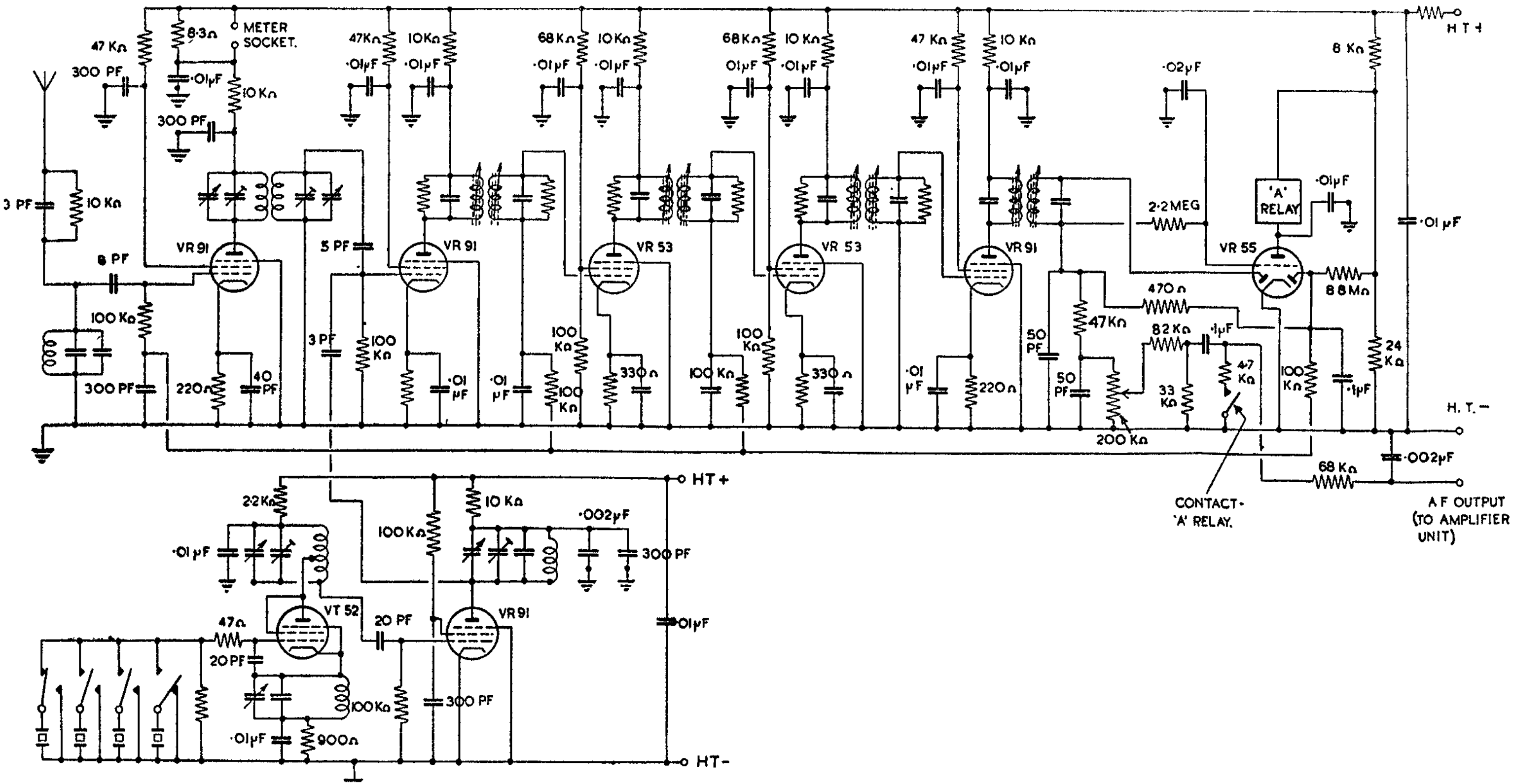


FIG. 80D.—AMPLIFIER UNIT, TYPE 18, SIMPLIFIED


METER SOCKET.
VR 91
VR 53
VR 55
VT 52
'A' RELAY
HT+
HT−
CONTACT- 'A' RELAY.
A F OUTPUT (TO AMPLIFIER UNIT)
200 KΩ
2·2 MEG
470 Ω
8·8 MΩ

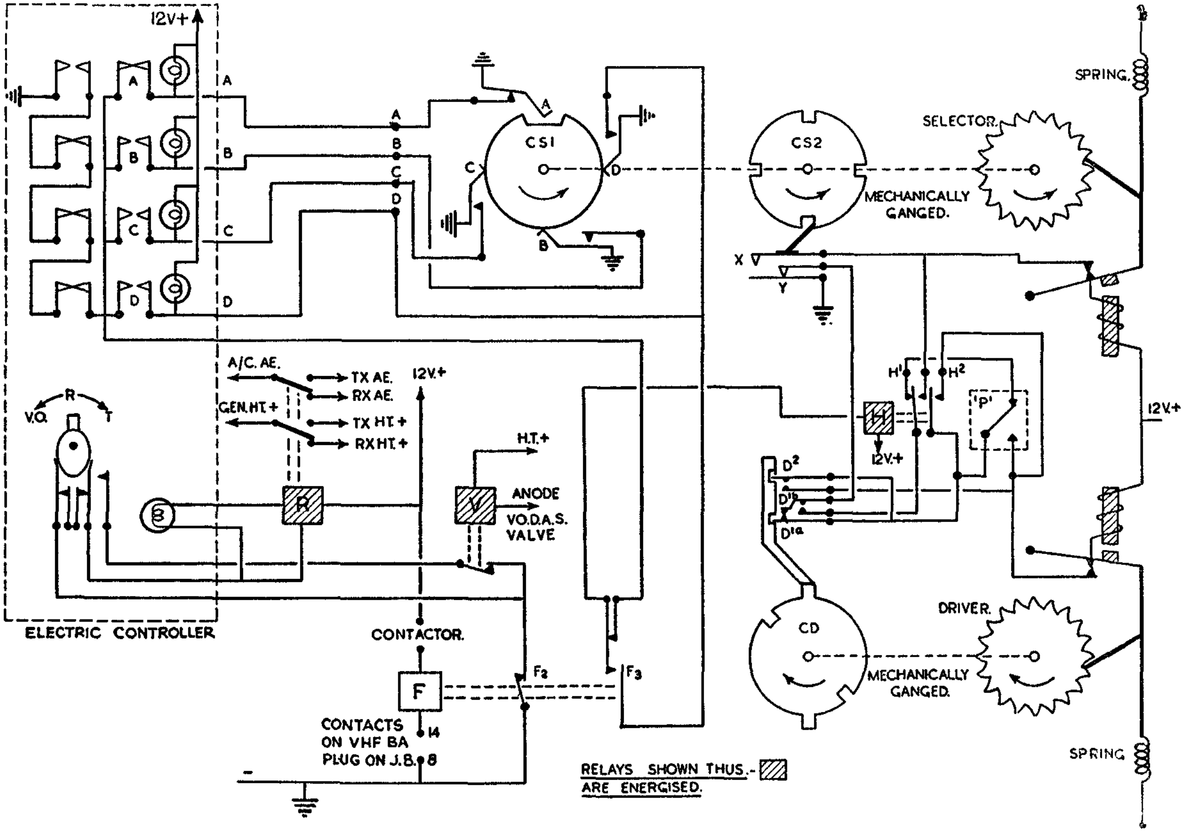


FIG. 80F.—TUNING MECHANISM AT REST ON CHANNEL A

21. Circuit Details

(i) *General.* The T.R.1143 and the T.R.1143A are similar in many respects to the T.R.1133 series, the chief differences being :—

(*a*) The transmitter is more powerful, having an output of 5 watts unmodulated on all frequencies.

(*b*) The receiver is more sensitive owing to its improved design and is more stable since the R.F. oscillator section is crystal controlled, the latter has enabled the I.F. band width to be reduced to about 90 kc/s, thus greatly increasing the number of channels available on the V.H.F. band.

(*c*) Servicing is simplified as unit construction is used throughout.

(ii) The chief differences between the T.R.1143 and the T.R.1143A are that the latter has " Press to speak " facilities instead of V.O.D.A.S. and consequently has a modified type of amplifier unit and slightly different relays.

22. The T.R.1143

The T.R.1143 may be divided into five sections as follows :—

(i) *Transmitter unit, type 17* (fig. 80C). The circuit is similar to that of the transmitter T.1136, different valves being used although the same stages are employed. The set is more suitable for V.H.F. working and incorporates its own diode output rectifier for tuning the P.A. stage. Anode and screen modulation of the P.A. stage is used, tuning being carried out by press button remote control.

(ii) *Amplifier unit, type 18* (fig. 80D). This may be conveniently divided into three main sections :—

(*a*) I/C amplifier. This is a two-stage amplifier using a high gain pentode (V.R.56) driving the triode section of the double-diode triode (V.R.55) which acts as the output valve. (The diode sections are not used.) It acts as the A.F. stage of the receiver unit, and as an I/C amplifier where this is necessary, also giving sidetone on channel D if D/F transmissions are radiated.

(*b*) Modulation amplifier. This is a high gain pentode (V.R.56) driving two power pentodes (V.T.52) in class " B " push-pull.

(*c*) The V.O.D.A.S. valve. This is not used at present.

(iii) *Receiver unit, type 19* (fig. 80E). This consists of an R.F. amplifier (V.R.91) followed by a pentode mixer (V.R.91) operating under anode bend conditions. The crystal oscillator (V.T.52) functions also as a frequency trebler. It drives a frequency multiplier (V.R.91) which has its anode circuit tuned to the 18th harmonic of the crystal. Its output is injected into the grid circuit of the mixer. Three I.F. amplifiers are used, the I.F.being 9·72 Mc/s. Signal rectification is provided by one diode section of a double diode triode (V.R.55). A.G.C. is obtained by means of the other diode, and controls the gain of the R.F. and first and second I.F. amplifiers. The rectified signal voltages are fed to the I/C amplifier section of the amplifier unit.

(iv) *Tuning motor unit* (fig. 80F). This uses two step-by-step motors, one for channel selection and the other for operating the tuning mechanism on the transmitter and receiver units. These are synchronised, so that no movement of the mechanism on transmitter or receiver takes place between channels, thus reducing strain and wear.

(v) *Main chassis.* This contains H.T. and G.B. smoothing equipment, the S/R relay, and the wiring interconnecting the units.

23. Relays (*see* fig. 80F).

(i) *" R " relay.* This is the S/R relay. It switches the aerial and the H.T. supply to either the receiver or transmitter, according to the position of the S/R switch, and is situated on the top tray.

(ii) " *N* " *relay*. This is the main starting relay, situated in the power unit (not shown on fig. 80F).

(iii) " *A* " *relay*. This is the " muting " relay. It reduces the noise level of the I/C amplifier when no signal is being received. It is situated on the receiver chassis.

(iv) " *V* " *relay*. This is the V.O.D.A.S. relay, and is situated in the relay box.

(v) " *H* " *relay*. This is the tuning mechanism relay, and is situated in the relay box.

(vi) " *F* " *relay*. This is the contactor relay. It selects channel D and causes the equipment to radiate an M.C.W. transmission when the contactor operates ; it is situated in the relay box.

24. Tuning Instructions—General

(i) Use test set, type 44, for bench tuning where available.

(ii) Ensure that the accumulator is fully charged, and is being boost-charged.

(iii) Ensure that the generator output voltages are correct. To adjust these, connect a voltmeter between L.T.+ on main chassis and the chassis itself ; with the equipment on full transmitting load, adjust the carbon pile regulator for a reading of 12·6 volts.

(iv) A test set, type 5A, should be used. This should be connected up by plugging the " L "-shaped meter plug (red spot) into the transmitter meter socket, and the straight plug (green spot) into the receiver meter socket. Connect a co-axial connector (type 705) from the aerial socket on T.R.1143 to the artificial aerial unit (type 14) on the test set 5A.

(v) Always tune the transmitter first.

25. Tuning Instructions—Transmitter Unit

(i) *Adjusting spot frequencies*

(*a*) Place operational frequency crystal in the crystal socket for the appropriate channel, on the transmitter unit.

(*b*) Put the control switch on the test set, type 5A, to " Trans Anode ".

(*c*) Put S/R switch to " send ".

(*d*) Select lowest operational frequency channel by depressing button.

(*e*) Release tuning motor by moving the " P " switch upwards, and unlock the locking nuts on all five transmitter tuning controls.

(*f*) Re-select channel by depressing " P " switch.

(*g*) Put meter switch on transmitter unit to position 1.

(*h*) Tune T.C.1 (crystal oscillator control) for maximum reading in the meter on the test set, type 5A.

(*j*) Tune T.C.2, T.C.3, T.C.4, T.C.5 with meter switch in position 2, 3, 4, 5, respectively, for approximately maximum reading in the meter.

(*k*) Repeat (*h*) and (*j*) above carefully, until maximum readings are obtained.

(*l*) Adjust T.C.1 on H.F. side of resonance, with the meter switch on position 6 until the meter reading falls to 40. Another more satisfactory method is to adjust T.C.1 on the H.F. side of resonance until the meter reading falls by 10 per cent. The latter method may not be used, however, if there is a tendency to frequency drift due to the equipment becoming overheated in the aircraft.

(*m*) Repeat the procedure in (*a*) to (*l*) above, for all the other three channels commencing with the one of lowest frequency.

(*n*) Release motor and rotate each transmitter tuning control to stop by gripping pointer.

(*p*) Tighten up all locking nuts.

27. Servicing

(i) *General.* Keep clean, electrically and physically, but do not bend or displace any R.F. lead or component.

(ii) *Power unit*

(*a*) Clean commutators regularly, and ensure that the brushes are well bedded in, and a good sliding fit in their holders.

(*b*) Lubricate bearings with two or three drops of anti-freeze lubricant on inspections.

(*c*) Clean and adjust starter relay contacts occasionally.

(*d*) Ensure that the carbon pile regulator is adjusted to give the correct generator outputs.

(iii) *Transmitter unit*

(*a*) Ensure that the P.A. stage is correctly neutralised, and reneutralise if the P.A. valves are changed.

(*b*) If a V.T.501 will not work in one position, try it in another stage. Alternatively, replace with a V.T.501A.

(*c*) If it is found that any stage has its H.T.+ circuit broken, suspect the appropriate 47 ohm resistor (wired across the Jones plug).

(*d*) Before attempting to remove the receiver or transmitter units from the top tray, the motor mechanism *must* be released from the transmitter or receiver unit tuning mechanism. This may be done by lifting the " P " switch, or by rotating the driving motor by hand.

(iv) *Receiver unit*

(*a*) It may be found that some crystals prove erratic in performance if used in the receiver unit. These should be replaced.

(*b*) Ensure that the pins of the V.R.91 used in the R.F. amplifier stage are kept very clean, since even very slight contact resistance will cause a deterioration in results, or even cause the receiver to cease functioning.

(v) *Amplifier unit*

(*a*) Ensure that the insulation resistance of the modulation transformer between windings, and from windings to earth, never falls below 5 megohms.

(*b*) V.T.52s. used in the modulator stage may deteriorate, and cause poor quality transmission.

(vi) *Tuning mechanism*

(*a*) Before removing the tuning motor, always remove the transmitter unit.

(*b*) If the transmitter or receiver units are removed from the top tray, care should be taken that they are replaced in the correct position relative to the arms of the tuning mechanism, otherwise a jam will result.

(*c*) If it is found that the tuning motor tends to become loose, spring washers should be fitted under its fixing bolts.

(*d*) It may be found that the " P " switch contacts tend to become unserviceable with use.

(vii) *Relays.* All relay contacts should be cleaned periodically with carbon tetrachloride, leaving the adjustments undisturbed. (This should be done using a thin piece of cardboard, dipped in carbon tetrachloride.)

28. T.R.5043

The T.R.5043, or S.C.R.522, is the American version of the T.R.1143A. It has a similar general circuit arrangement to the T.R.1143A, but the construction, component layout, and valve types used differ considerably. Its frequency range is 100–156 Mc/s, and it incorporates " press-to-talk " facilities.

27. Servicing

(i) *General.* Keep clean, electrically and physically, but do not bend or displace any R.F. lead or component.

(ii) *Power unit*

(*a*) Clean commutators regularly, and ensure that the brushes are well bedded in, and a good sliding fit in their holders.

(*b*) Lubricate bearings with two or three drops of anti-freeze lubricant on inspections.

(*c*) Clean and adjust starter relay contacts occasionally.

(*d*) Ensure that the carbon pile regulator is adjusted to give the correct generator outputs.

(iii) *Transmitter unit*

(*a*) Ensure that the P.A. stage is correctly neutralised, and reneutralise if the P.A. valves are changed.

(*b*) If a V.T.501 will not work in one position, try it in another stage. Alternatively, replace with a V.T.501A.

(*c*) If it is found that any stage has its H.T.+ circuit broken, suspect the appropriate 47 ohm resistor (wired across the Jones plug).

(*d*) Before attempting to remove the receiver or transmitter units from the top tray, the motor mechanism *must* be released from the transmitter or receiver unit tuning mechanism. This may be done by lifting the " P " switch, or by rotating the driving motor by hand.

(iv) *Receiver unit*

(*a*) It may be found that some crystals prove erratic in performance if used in the receiver unit. These should be replaced.

(*b*) Ensure that the pins of the V.R.91 used in the R.F. amplifier stage are kept very clean, since even very slight contact resistance will cause a deterioration in results, or even cause the receiver to cease functioning.

(v) *Amplifier unit*

(*a*) Ensure that the insulation resistance of the modulation transformer between windings, and from windings to earth, never falls below 5 megohms.

(*b*) V.T.52s. used in the modulator stage may deteriorate, and cause poor quality transmission.

(vi) *Tuning mechanism*

(*a*) Before removing the tuning motor, always remove the transmitter unit.

(*b*) If the transmitter or receiver units are removed from the top tray, care should be taken that they are replaced in the correct position relative to the arms of the tuning mechanism, otherwise a jam will result.

(*c*) If it is found that the tuning motor tends to become loose, spring washers should be fitted under its fixing bolts.

(*d*) It may be found that the " P " switch contacts tend to become unserviceable with use.

(vii) *Relays.* All relay contacts should be cleaned periodically with carbon tetrachloride, leaving the adjustments undisturbed. (This should be done using a thin piece of cardboard, dipped in carbon tetrachloride.)

28. T.R.5043

The T.R.5043, or S.C.R.522, is the American version of the T.R.1143A. It has a similar general circuit arrangement to the T.R.1143A, but the construction, component layout, and valve types used differ considerably. Its frequency range is 100–156 Mc/s, and it incorporates " press-to-talk " facilities.

An important point to note with this equipment is that if the American junction box is used, the appropriate American cable harness must be used also. A British junction box, with British cable harness, may also be used; but a British harness cannot be used with an American junction box, or *vice versa*.

The tuning differs considerably from that of the T.R.1143 and T.R.1143A, and special tuning instructions have been issued to units using this equipment.

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.72s, 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 switched 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.32'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.

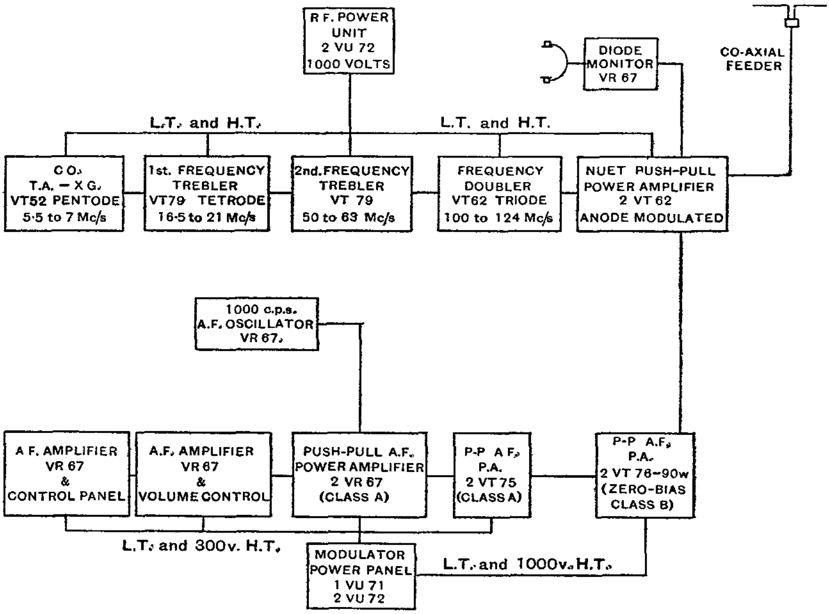


Fig. 81.—Block diagram, T.1131.

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 neutıalising 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 :—

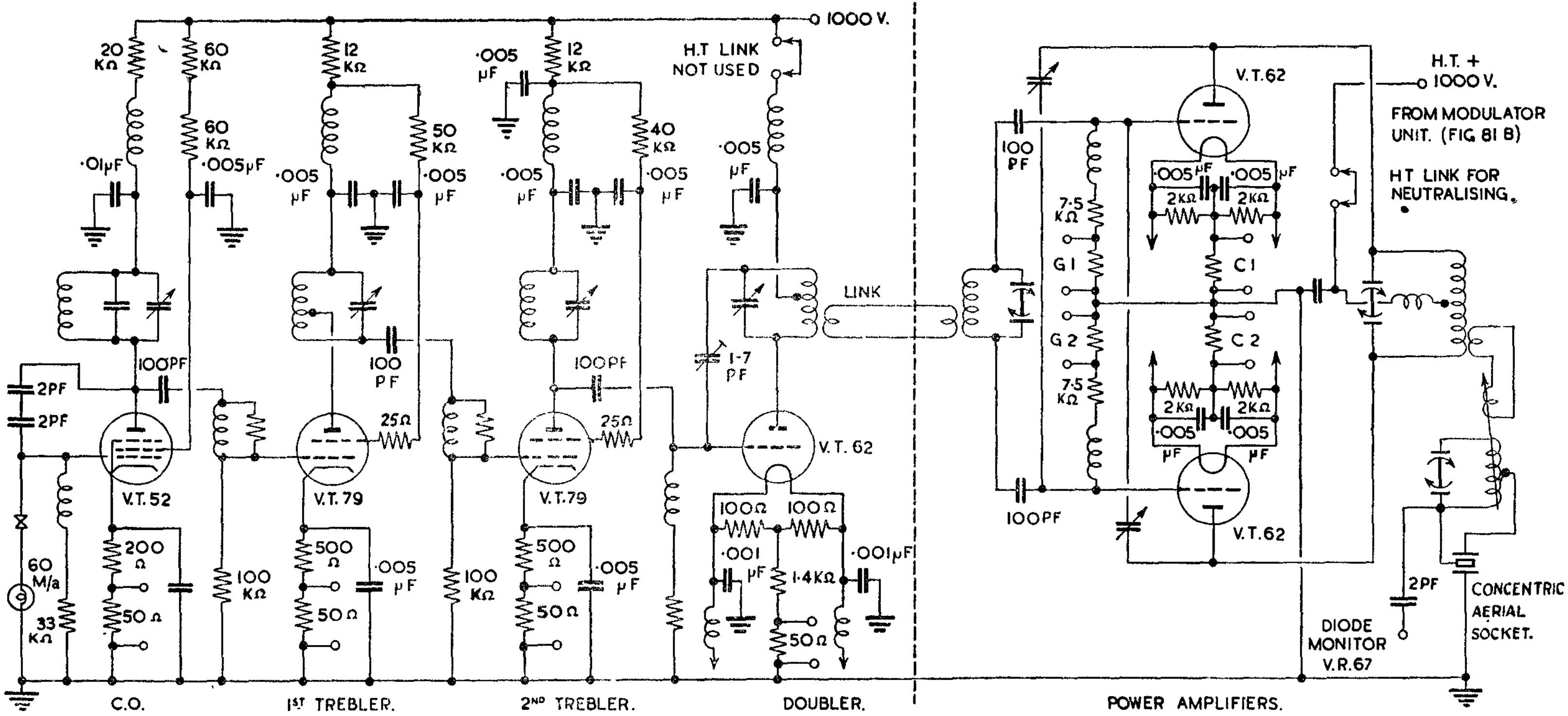
(*a*) Open door and remove " link for neutralising " at back of P.A. panel.
(*b*) Close door and after thermal delay period has elapsed, tune up to P.A. grid circuit on full power, as above.
(*c*) Rotate P.A. anode tuning condenser slowly to produce a dip in grid current.
(*d*) Adjust neutralising condensers 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. **Servicing, 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.	Monitor.
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



FUSE NOT FITTED

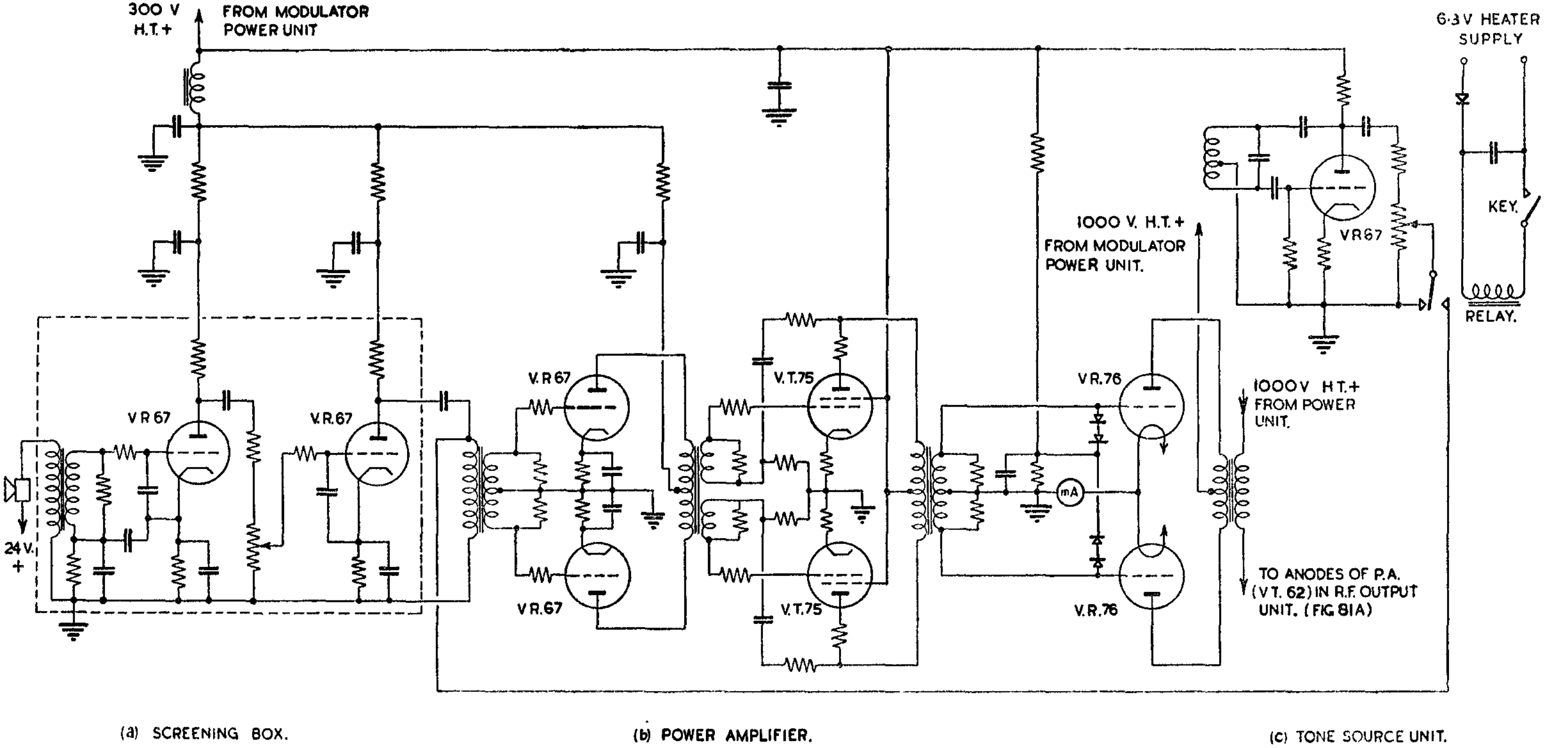


FIG. 81B—MODULATOR UNIT T.1131 (SIMPLIFIED)

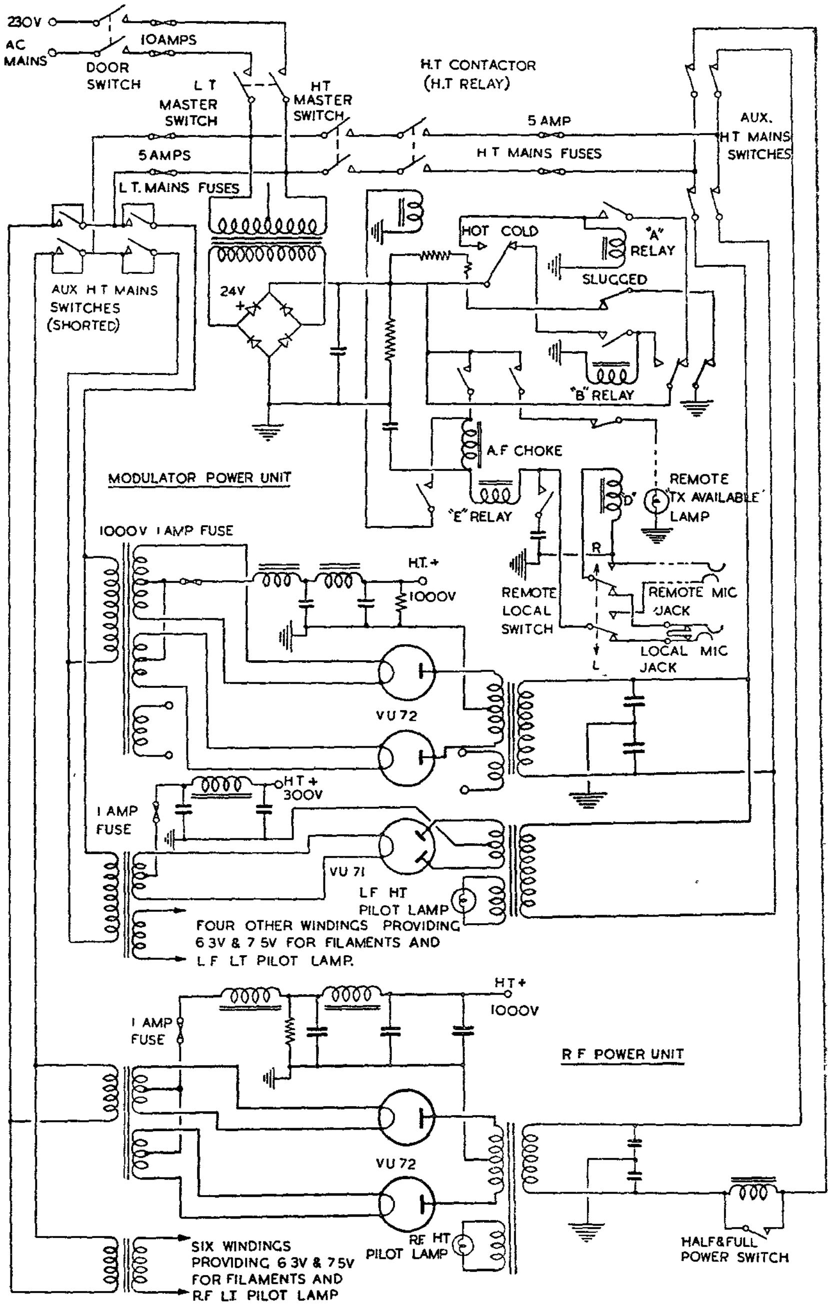


FIG. 81C.—CONTROL UNIT T.1131

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.

" (ix) *Minor daily faults*.—(*a*) Green indicator lamps not lit when ' master filament ' switch is pressed. If only one lit, probably other lamp is blown. Otherwise, check that main A.C. supply switch on wall is closed, door closed and L.T. fuses correct. Check with A.C. voltmeter.

(*b*) Red indicator lamps not lit when master H.T. switch is closed and key switch at ' local ' (remember 60 seconds delay—*see* para. 3 (i)). Check lamps, ' E ' relay, and H.T. contactor, also main H.T. fuses.

(*c*) Indicator lamps lit, but no readings in meters. Check H.T. fuses in power units, and rectifier valves and connections.

(*d*) Full H.T. with switch at ' half-power '. Check switch and connections to choke.

(*e*) No dip when tuning C.O. Check contact of crystal in holder or change crystal ; check fuse bulb for continuity and fit ; check cathode current against standard or try new valves in C.O. and T.1 stages."

CHAPTER 15

RECEIVER R.1132 AND R.1132A

1. **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.

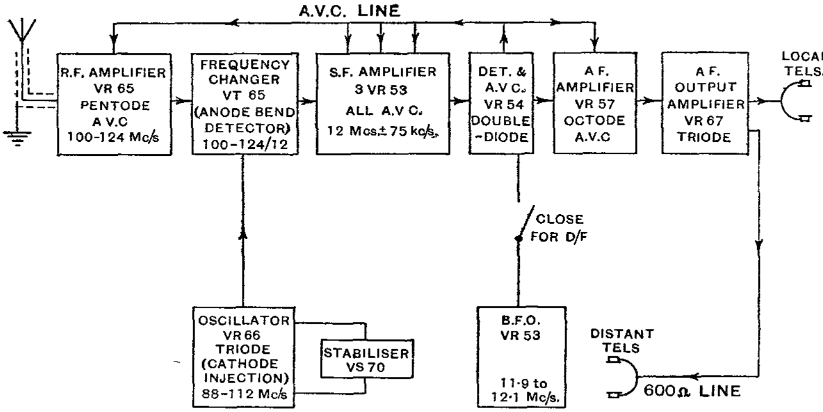


FIG. 82.—Block diagram, R.1132.

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. **Servicing.**—(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.

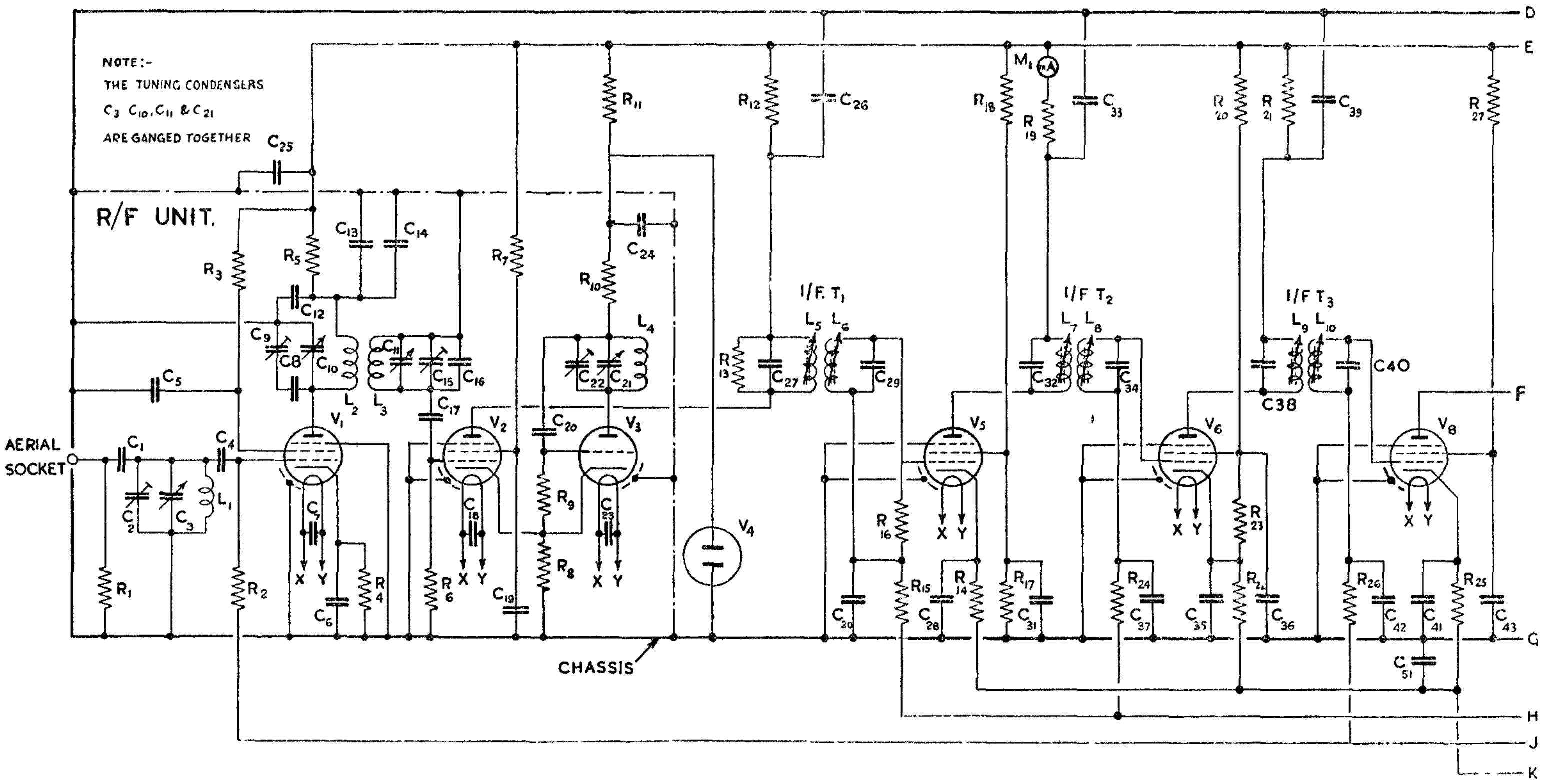


FIG. 82A (FIRST SHEET) THEORETICAL CIRCUIT DIAGRAM R.1132A

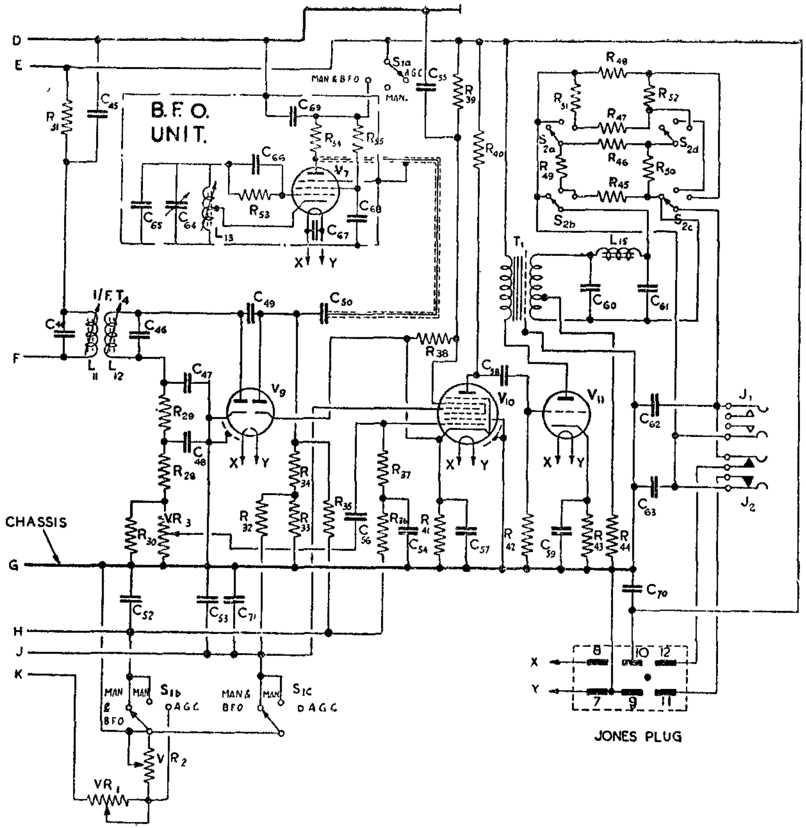


FIG. 82A (SECOND SHEET)
THEORETICAL CIRCUIT DIAGRAM R.1132A

C_{1}	5μμF	C_{34}	50μμF	C_{67}	·01μF	R_{28}	47,000Ω
C_{2}	2–8μμF	C_{35}	·01μF	C_{68}	·01μF	R_{29}	47,000Ω
C_{3}	3–18μμF	C_{36}	·01μF	C_{69}	·01μF	R_{30}	47,000Ω
C_{4}	10μμF	C_{37}	·01μF	C_{70}	·01μF	R_{31}	2,200Ω
C_{5}	·001μF	C_{38}	50μμF	C_{71}	·01μF	R_{32}	330,000Ω
C_{6}	30μμF	C_{39}	·01μF			R_{33}	100,000Ω
C_{7}	·001μF	C_{40}	50μμF	R_{1}	4,700Ω	R_{34}	220,000Ω
C_{8}	80μμF	C_{41}	·01μμF	R_{2}	100,000Ω	R_{35}	330,000Ω
C_{9}	2–8μμF	C_{42}	·01μF	R_{3}	4,700Ω	R_{36}	330,000Ω
C_{10}	3–18μμF	C_{43}	·01μF	R_{4}	160Ω	R_{37}	330,000Ω
C_{11}	3–18μμF	C_{44}	30μμF	R_{5}	2,200Ω	R_{38}	100,000Ω
C_{12}	300μμF	C_{45}	·01μF	R_{6}	100,000Ω	R_{39}	68,000Ω
C_{13}	·01μF	C_{46}	30μμF	R_{7}	100,000Ω	R_{40}	100,000Ω
C_{14}	·001μF	C_{47}	100μμF	R_{8}	620Ω	R_{41}	1,000Ω
C_{15}	2–8μμF	C_{48}	100μμF	R_{9}	47,000Ω	R_{42}	330,000Ω
C_{16}	5μμF	C_{49}	50μμF	R_{10}	18,000Ω	R_{43}	1,000Ω
C_{17}	10μμF	C_{50}	2μμF	R_{11}	10,000Ω	R_{44}	4,700Ω
C_{18}	·01μF	C_{51}	25μμF	R_{12}	2,200Ω	R_{45}	2,200Ω
C_{19}	·01μF	C_{52}	·05μF	R_{13}	47,000Ω	R_{46}	2,200Ω
C_{20}	80μμF	C_{53}	·05μF	R_{14}	330Ω	R_{47}	2,200Ω
C_{21}	3–20μμF	C_{54}	·1μF	R_{15}	330,000Ω	R_{48}	2,200Ω
C_{22}	2–8μμF	C_{55}	·1μF	R_{16}	47,000Ω	R_{49}	220Ω
C_{23}	·001μF	C_{56}	·002μF	R_{17}	220,000Ω	R_{50}	220Ω
C_{24}	·001μF	C_{57}	·5μF	R_{18}	100,000Ω	R_{51}	220Ω
C_{25}	·01μF	C_{58}	·002μF	R_{19}	2,200Ω	R_{52}	220Ω
C_{26}	·01μF	C_{59}	5μF	R_{20}	68,000Ω	R_{53}	47,000Ω
C_{27}	50μμF	C_{60}	·1μF	R_{21}	2,200Ω	R_{54}	22,000Ω
C_{28}	·01μF	C_{61}	·1μF	R_{22}	330Ω	R_{55}	100,000Ω
C_{29}	50μμF	C_{62}	·01μΩ	R_{23}	220,000Ω		
C_{30}	·01μF	C_{63}	·01μF	R_{24}	330,000Ω	V.R.1	100Ω
C_{31}	·01μF	C_{64}	1–5μμF	R_{25}	330Ω	V.R.2	2,000Ω
C_{32}	50μμF	C_{65}	80μμF	R_{26}	330,000Ω	V.R.3	60,000Ω
C_{33}	·01μF	C_{66}	·0003μF	R_{27}	68,000Ω		

CHAPTER 16

TRANSMITTER T.1154—SERIES

1. Purpose

General purpose aircraft transmitter for use with R.1155.

2. Frequency Ranges

(i) *T.1154A* (C/W. MCW. only), *T.1154 and* T.*1154B* (C/W. MCW. and R/T).

Range 1 (H.F.) 10 Mc/s to 5·5 Mc/s (Blue).
Range 2 (H.F.) 5·5 Mc/s to 3·0 Mc/s (Red).
Range 3 (M.F.) 500 kc/s to 200 kc/s (Yellow).

(ii) *T.1154C* (C/W. MCW. R/T.).

Range 1 (H.F.) 16·7 Mc/s to 8·7 Mc/s (Blue).
Range 2 (H.F.) 8·7 Mc/s to 4·5 Mc/s (Blue).
Range 3 (H.F.) 4·5 Mc/s to 2·35 Mc/s (Red).
Range 4 (M.F.) 500 kc/s to 200 kc/s (Yellow).

(iii) *T.1154D* (C/W. MCW. and R/T.), *T.1154E* (CW. MCW.).

Range 1 (H.F.) 8 Mc/s to 4·5 Mc/s (Blue).
Range 2 (H.F.) 4·5 Mc/s to 2·5 Mc/s (Red).
Range 3 (M.F.) 500 kc/s to 200 kc/s (Yellow).

Note.—Tuning is simplified by the use of different coloured tuning dials for each of the above ranges. Variable condensers are used for tuning the M.O. and P.A. stages of the H.F. ranges, and the M.O. stage only of the M.F. range. The P.A. on this range is tuned by tapped inductance, with variable permeability fine tuning. Eight adjustable " click stops " are fitted to the dials of all M.O. ranges and the P.A.–H.F. ranges. Vernier adjustment is available for fine tuning.

3. Valves

(Four) M.O. V.T.105, triode; P.A. two V.T.104 pentodes (in parallel); a second V.T.105 (housed in the M.O. compartment) for modulation and side tone oscillator.

4. Power Supplies

L.T. and H.T. supplied from motor generators. One machine supplies H.T. and L.T. for the R.1155 and L.T. for the transmitter, the other supplies transmitter H.T. only.

(i) *L.T. machine*

Input 12 volts 24 amps. or 24 volts 12 amps.
Output L.T.—7 volts 13 amps.; H.T.—220 volts 110 mA.

(ii) *H.T. machine*

Input 12 volts 32 amps. or 24 volts 16 amps.
Output 1,200 volts 200 mA.

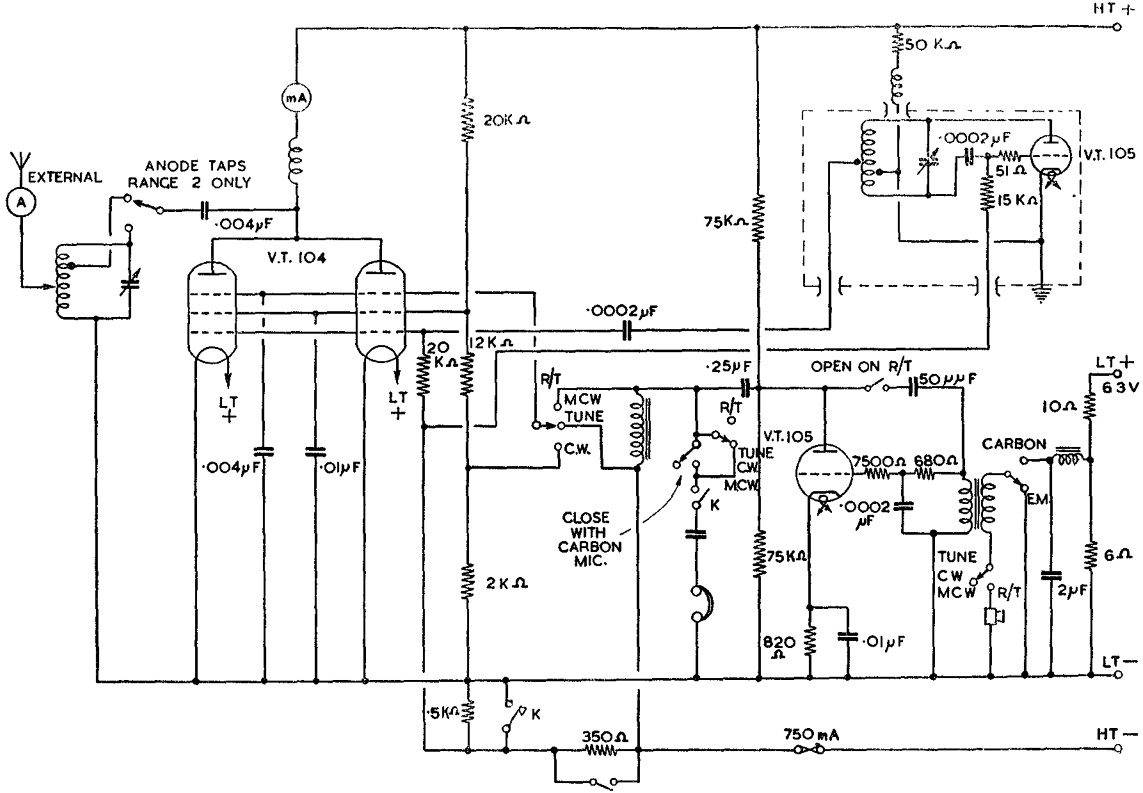
5. Aerial Systems

Normally employs aircraft fixed aerial on the H.F. ranges and aircraft trailing aerial on M.F. ranges.

6. Circuit

(Fig. 83) shows a simplified circuit.

A Hartley M.O. is capacity coupled to the P.A. which consists of two pentodes in parallel. Neutralising is unnecessary. The P.A. is parallel-fed. On the H.F. ranges the output circuit in each case consists of an inductance tuned by a variable condenser. The variable condenser has a commutator attached to its spindle, so arranged that the condenser can sweep from


HT +
50 KΩ
·0002μF
V.T. 105
51 Ω
15 KΩ
20K Ω
mA
EXTERNAL
A
ANODE TAPS
RANGE 2 ONLY
·004μF
V.T. 104
75KΩ
·0002μF
20
KΩ
12 KΩ
LT
+
LT
+
R/T
MCW
TUNE
C.W.
·25μF
R/T
OPEN ON R/T
50μμF
LT +
6·3V
10Ω
V.T.105
TUNE
CW
MCW
K
7500Ω
680Ω
CARBON
·0002
μF
EM.
·004μF
·01μF
CLOSE
WITH
CARBON
MIC.
2 KΩ
75KΩ
TUNE
CW
MCW
R/T
2μF
6Ω
820
Ω
·01μF
LT −
·5KΩ
K
350Ω
750 mA
HT −

minimum to maximum capacitance with the commutator brush contacts open, and then with the brush contacts closed. When the contacts are closed, a portion of the tuning inductance is short-circuited. This gives a much increased tuning range for a 360 degree movement of the dial. The aerial is matched to the anode circuit by a tapping switch. On the M.F. range the anode circuit is tuned by a variable inductance ; a series of taps providing coarse tuning, with a permeability tuning for fine control. The anode taps on this range are separately adjusted by another tapping switch, R/T. and M.C.W., etc. 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 the suppressor grids of the P.A. valves and slight reduction of H.T. Both the M.O. and P.A. grid circuits are keyed.

(iv) *C.W*. Full power transmission ; 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 side-tone modulator valve is used as modulation amplifier, 70 per cent. to 80 per cent. modulation. Carbon microphone connected in series with microphone transformer, the secondary of which is in the grid circuit of the modulator. E.M. microphone requires external amplifier A.1134 or A.1134A. The key must be pressed or key switch in pilot's cockpit closed. Reception only when the key or switch is open circuited.

7. Tuning Instructions

(i) *Setting up on H.F. ranges using click-stops*

(*a*) Put master switch to " Stand-bi ".

(*b*) If type J aerial switch fitted put switch to normal. If aerial plug board fitted put H.F. on " fixed ".

(*c*) Select appropriate range by frequency-change switch.

(*d*) Rotate M.O. tuning condenser until selected click stop pip is seen to engage in slotted bar.

(*e*) Loosen grub screw at base of fluted channel by corresponding letter on M.O. tuning knob.

(*f*) Repeat for P.A. using similar letter.

(*g*) Adjust M.O. approximately by calibrations on white scale.

(*h*) Set M.O. fine tuning lever to second mark from the bottom.

(*k*) Rotate P.A. tuning control fully anti-clockwise.

(*l*) Switch to " Tune ".

(*m*) Press key and adjust P.A. tuning control until a dip is observed in P.A. input mA. meter reading. Aerial tap switch on " 1 ".

Note.—If more than one dip occurs, use the largest.

(*n*) Increase aerial tap switch one division at a time, retuning condenser each time until bottom of dip coincides with, or is just below the green line (65 mA.).

(*o*) On tune a slight aerial current should be obtained in external aerial ammeter.

(*p*) Adjust M.O. to resonance with crystal monitor, wavemeter or R.1155.

(*q*) Adjust P.A. for bottom of dip in feed meter.

(*r*) Put master-switch to " CW." and note reading in aerial ammeter. Ensure ammeter is not shorted by push-button. Reading in feed meter should rise to 100.

(*s*) Re-tighten M.O. and P.A. grub screws and mark a line on white scale against tuning index. Write letter of click-stop against this line.

(*t*) Record frequency and aerial tap number against click-stop letter on ivorine panel in centre of Tx.

(*u*) Select " C.W.", " M.C.W." or " R/T " as required, remembering key has to be pressed on " R/T."

(*v*) P.A. feed mA. meter should read 65 on " TUNE ", " M.C.W. " and " R/T.", 100 on " C.W."

Note.—Aerial taps must not be adjusted with key pressed.

(ii) *Setting up on M.F. ranges, using click-stops.*

(*a*) Put master-switch to " Stand-bi ".

(*b*) If type " J " aerial switch is fitted, switch to " M.F. on fixed ". If aerial plug board is fitted put " fixed aerial " on M.F.

(*c*) (*d*) (*e*) As (*c*), (*d*) and (*e*) above.

(*f*) Put P.A. aerial tap switch to 17 and anode tap to 18 (both pointing inwards).

(*g*) Adjust M.O. by calibrations.

(*h*) Switch to " TUNE ".

(*k*) Press key and adjust aerial tap until minimum reading is obtained in feed meter, use fine tuning to obtain exact minimum.

Note.—Always attempt to get minimum P.A. feed with aerial tap as high as possible.

(*l*) Increase anode tap reading until P.A. feed rises to 65 (green line), using fine tuning if necessary to obtain exact resonance. If dip is lost when moving anode tap, reduce aerial tap by one position.

(*m*) Adjust M.O. to resonance with wavemeter or R.1155.

(*n*) Readjust P.A. fine tuning for bottom of dip.

(*o*) Tighten M.O. grub-screw and mark as before.

(*p*) P.A. fine tuning may also be marked.

(*q*) Mark frequency, aerial and anode taps against appropriate click-stop letter.

(*r*) Select " C.W.", " M.C.W." or " R/T " as required. Feed should be 100 on " C.W." Aerial current is indicated in internal ammeter.

Notes. 1. Readjustments of P.A. tuning will be necessary when air-borne.
2. Aerial or anode taps must not be adjusted with key pressed.
3. The click-stops may be released at any time and a friction drive incorporated.
4. The vernier adjustment gives a click-stop variation of $\pm 0\cdot1$ per cent.

8. **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.

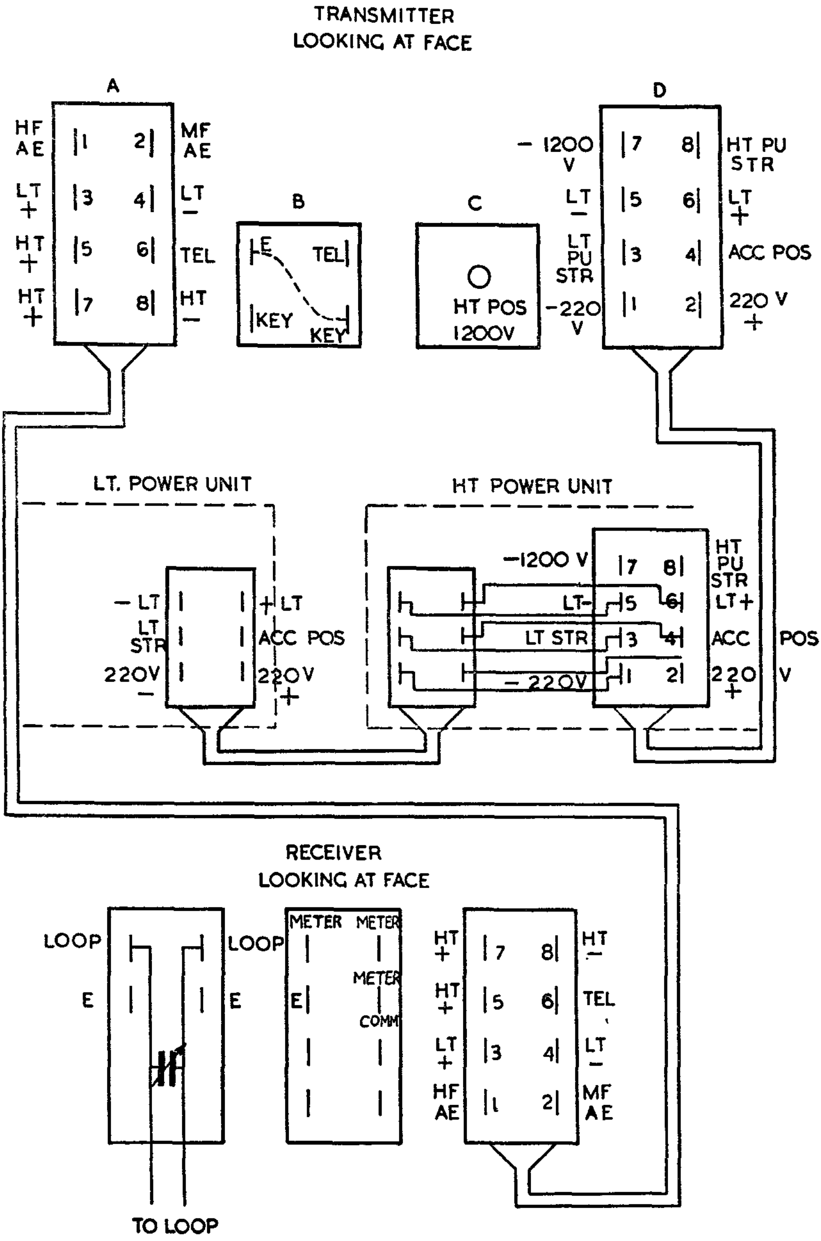


FIG. 84A.—PLUGS AND SOCKETS

9. Fault Finding—Complete Failure

(i) If there is a complete failure of the whole installation check :—
- (*a*) L.T. power unit fuse, aircraft G.S. supply voltage.
- (*b*) Plug and socket connections to power units and transmitter.
- (*c*) Resistance unit for fracture of element.

(ii) If above correct, check the following points in connection with th power unit.
- (*a*) Brushes not making contact.
- (*b*) Starter relay faulty, pitted or burnt contacts not " Making ".
- (*c*) Dry solder joints at chokes L.1, L.2 or L7.

10. **Fault Finding—Transmitter Failure**

(i) *No reading in P.A. input mA. meter with key pressed but side-tone is heard.* Check :—

(*a*) P.A. valve filaments, and anode cap connections.

(*b*) Test for 1,200 volts H.T. at anodes, if zero or low, check for disconnection between H.T. fuse and anodes. Check connections to P.A. input mA. meter and H.F.C.1.

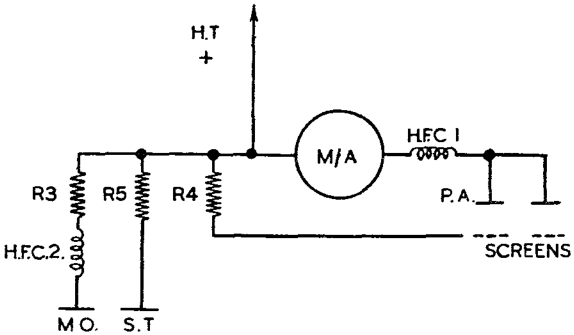


FIG. 84B.—H.T. FEED CIRCUIT

(ii) *No reading in P.A. input mA. meter and no S.T. with key pressed.* H.T. is " off " the transmitter.

(*a*) Check H.T. fuse. 750 mA. If fuse correct check that H.T. power unit is running when transmitter is switched to " tune," if correct check that 1,200 volts is on plug " C ", if not examine H.T. brushes and associated circuit.

(*b*) If the power unit is not running, check input fuse to unit-plugs and sockets and the interlocking plug or type " J " switch (H.T. unit " off " on D/F).

(*c*) H.T. short to earth caused by :—C.6 (·004 μF.) condensers (fig. 84C) breaking down, with cables disconnected test between power unit H.T.+ plug and frame. If the condensers are serviceable check the power cables. These should be tested for " shorts " due to dampness or dirt, and between core and screens for insulation.

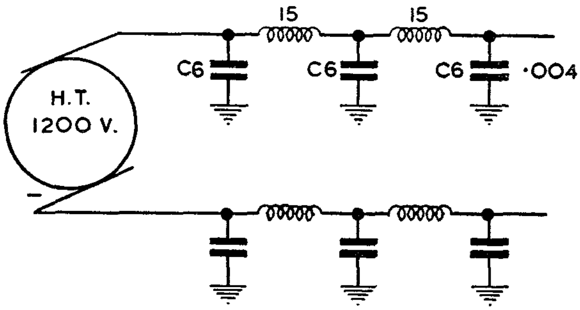


FIG. 84C—H.T.—P.U. SMOOTHING

(iii) *No dip, P.A. input reading above normal on " tune ".* If constant on all ranges check :—

(*a*) M.O. valve ; if correct.

(*b*) C.18 or C.19 ; if correct.

(*c*) R.3 for open circuit, or R.11 for faults.

(*d*) M.O. voltage and resistances in accordance with the following tables.

MASTER OSCILLATOR VALVE

Frequency Range.	Anode Volts (in volts).		Anode Current (in m/A)	
	Tune.	C.W.	Tune.	C.W.
200 kc/s, yellow ..	160	170	19·5	21·0
500 kc/s, yellow ..	212	233	17·7	18·6
3 Mc/s, red	210	215	18·5	19·0
5 Mc/s, red	225	235	18·0	18·5
6 Mc/s, blue	260	270	17·0	18·0
10 Mc/s, blue	240	250	18·0	18·0

CIRCUIT RESISTANCE TESTS

From	To	Range.	Resistance (ohms).
Anode V.1 ..	H.T. plug " C " ..	H.F.	50,000
Anode V.1 ..	H.T. plug " C " ..	M.F.	25,000
Anode V.1 ..	Earth	M.F.	19,000
Cathode V.1 ..	Earth	—	Less than ·2
Grid V.1	Earth	—	20·050

(iv) *No dip on one range only.* Check :—

(*a*) Switch contacts (range switches).

(*b*) M.O. circuit wiring at L.H. side of transmitter.

(*c*) Output circuit on that range (tuning condenser may be " shorting ").

(v) *No dip, P.A. input in mA. meter reading low.* Caused by :—

(*a*) Low H.T. voltage, check at plug " C " for 1,200 volts.

(*b*) C.13 broken down, check between screen of P.A. valves and earth 14,000 ohms.

(*c*) R.4 fully or partially open-circuited (with this fault the feed may rise after a few seconds, producing delayed keying effect).

(*d*) Faulty V.T.104 (one or both).

(*e*) If the M.O. and P.A. circuits are correct as far as the tests previously mentioned indicate, " No dip " can be due to C.14 being " open circuit ".

(*f*) For checks on the P.A. stage the following voltages and resistance measurements are given :—

POWER AMPLIFIER VALVES

Frequency Range.	Suppressor " G " Volts.		Anode Volts.		Screen Volts.	
	Tune.	C.W.	Tune.	C.W.	Tune.	C.W.
200 kc/s, yellow ..	−40	+20	1160	1200	200	215
500 kc/s, yellow ..	−40	+30	1160	1200	243	278
3 Mc/s, red ..	−45	+35	1155	1200	240	300
5 Mc/s, red ..	−45	+30	1155	1200	240	273
6 Mc/s, blue ..	−45	+32	1155	1200	255	290
10 Mc/s, blue ..	−45	+20	1155	1200	220	250

CIRCUIT RESISTANCE TESTS

From	To	Range.	Resistance (ohms).
Anode (either V.T.104)	H.T. plug C ..	H.F. or M.F. ..	50
Suppressor	Earth	Tune	5,350
Suppressor	Earth	C.W.	2,000
Suppressor	Earth	M.C.W.—R/T..	10,350
Suppressor	Pin 7, plug D ..	Tune	Less than ·03
Suppressor	Pin 7, plug D ..	C.W.	7,000
Suppressor	Pin 7, plug D ..	M.C.W.—R/T..	5,000
Grid	Earth	—	25,000
Grid	Pin 7, plug D ..	Tune	20,350
Grid	Pin 7, plug D ..	C.W.	20,000
Grid	Pin 7, plug D ..	M.C.W.—R/T..	20,350
Screen	Earth	—	14,000
Screen	H.T. plug C ..	—	20,000

(vi) *Tuning defects*

(*a*) Varying dip—may be caused by 200 $\mu\mu$F. coupling condenser between M.O. and P.A. being " open circuit ".

(*b*) Varying note—check 200 $\mu\mu$F. condenser (see (*a*)) for leakage from one side to fixing bolt (earth).

(*c*) Not tuning on parts of M.F. range—check aerial coil for shorted turns.

(*d*) NO fine tuning on M.F.—permeability tuning faulty, not turning when knob is rotated.

(vii) *Self-keying in C.W. position.* Check :—

(*a*) Condensers in H.T. power unit—test between H.T.— (pin 7 on 8-pin power plug on the power unit), and earth.

(*b*) Cable from H.T. power unit to transmitter by disconnecting at both ends " meggering " pin 7 to screening.

(*c*) C.29 (if fitted) for short-circuit. Test between pin 7 of plug D and earth—350 ohms, with switch at " tune ", relay to " transmitter ".

(viii) *No side-tone.* Check :—

(*a*) V.4 (modulator valve).

(*b*) Tel and S.T. contacts of relay.

(*c*) C.8 or C.9 open circuited.

(*d*) R.14–R.5–R.15 open circuited.

(*e*) L.F.C.2 faulty.

(*f*) Contacts on switch section " J " or " M " not making contact.

(*g*) Voltage at anode of V.4 (157 volts).

(ix) *No R/T, but side-tone heard in tune or C.W. positions.* Check :—

(*a*) Microphone circuit link, at the back of transmitter. (If A.1134 in use, set for E/M mic.)

(*b*) Check A.1134 working correctly.

(*c*) Check for " dry " joints on primary of mic transformer (put Avo across mic sockets on front of transmitter—should be 7 ohms).

1. Fault Finding, Aerial Faults

(i) *H.F. good dip—but will not load up.* Check :—

(*a*) Aerial external and internal connections.

(*b*) Plug board or type " J " switch.

(*c*) Aerial ammeter.

(*d*) Relay contacts and connections.

(ii) *H.F. dip—but high aerial current.* Check :—

Fixed aerial for short to earth (metal frame of aircraft)

(iii) *M.F. dip, low aerial current.* Check :—

(*a*) Trailing aerial for disconnection.

(*b*) Winch contact.

(*c*) Plug board or type " J " switch.

(*d*) Aerial cable and socket to transmitter.

(*e*) Relay contacts and connections.

(iv) *M.F.—no dip, or aerial current.* Aerial shorted to earth—check as above but for " short " to earth.

12. D.C. Resistance of Components

Description.	Test Point.	Resistance.
Microphone transformer T.1 ..	Primary	7 ohms.
Microphone transformer T.1 ..	Secondary	5,000 ohms.
Microphone choke I.F.C.3 ..	Across joint R.27, R.28 and R.26.	11 ohms.
M.O. anode, choke H.F.C.2 ..	R.3 to C.18	10 ohms.
P.A. anode, choke H.F.C.1 ..	Anode V.2 to S.2, anode section of moving arm.	45 ohms.
Modulator choke I.F.C.2 ..	C.8 to C.21	130 ohms.
M.O.coils L.1	Across C.2	Less than 1 ohm.
M.O. coils L.2	Across C.4	Less than 1 ohm.
M.O. coils L.3	Across C.17	Less than 1 ohm.
P.A. coils L.4	Across C.15	Less than 1 ohm.
P.A. coils L.5	Across C.16	Less than 1 ohm.
P.A. coils L.6	Across taps 1 and 17 (switch at 17).	5·2 ohms.

13. Emission Test V.T.104

Remove one valve from transmitter and set controls as follows :—Range switch to M.F., drive condenser to 500 kc/s, tap switches to 17 and 18, fine tuning fully anti-clockwise. Remove M.F. aerial socket from side.

Switch to " Tune ", press key and note reading on feed meter. The average indicated feed will be approximately 180/190 if the valve is in good condition and accumulator volts are normal. A very poor valve will read as low as 125 indicated mA, in which case the valve can be reckoned unserviceable.

Each valve should be tested in turn and it is recommended that the two P.A. valves in a transmitter should be matched to within 10 indicated mA. of each other.

Notes. 1. It is not sufficient to remove the anode cap of the valve not under test, it must be completely removed.

2. It should be remembered that the indicated feed on the meter is not an actual current reading in mA., the figures are a relative indication, suitable for a comparative test with top emission.

CHAPTER 17

RECEIVER R.1155

1. Purpose

General purpose aircraft receiver for use with T.1154. Provides reception 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).
Range 2 .. 7·5–3 Mc/s.
Range 3 .. 1,500–600 kc/s.
Range 4 .. 500–250 kc/s.
Range 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.I.103 "magic eye" also two V.R.99A 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. 85.

(i) *Communication circuits* :—

(*a*) The R.F. amplifier is a vari-mu R.F. tetrode having a tuned grid circuit, and 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 oscillator and mixer. 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*) Two I.F. amplifier stages employ band-pass coupling units. The coupling is effected by small fixed capacities, there being practically no inductive coupling. The inductances comprising the tuned circuits are adjusted to the I.F. of 560 kc/s by means of variable dust iron cores. The capacity coupling gives a band width of 4 to 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 Colpitt's circuit tuned to 280 kc/s with $\pm$ 3 kc/s adjustment. 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. A.V.C. is available with master switch to "A.V.C.", "visual" or "balance". Manual control of R.F. gain is used on "omni" and "aural" position; but when using A.V.C. the manual gain control varies the A.F. gain.

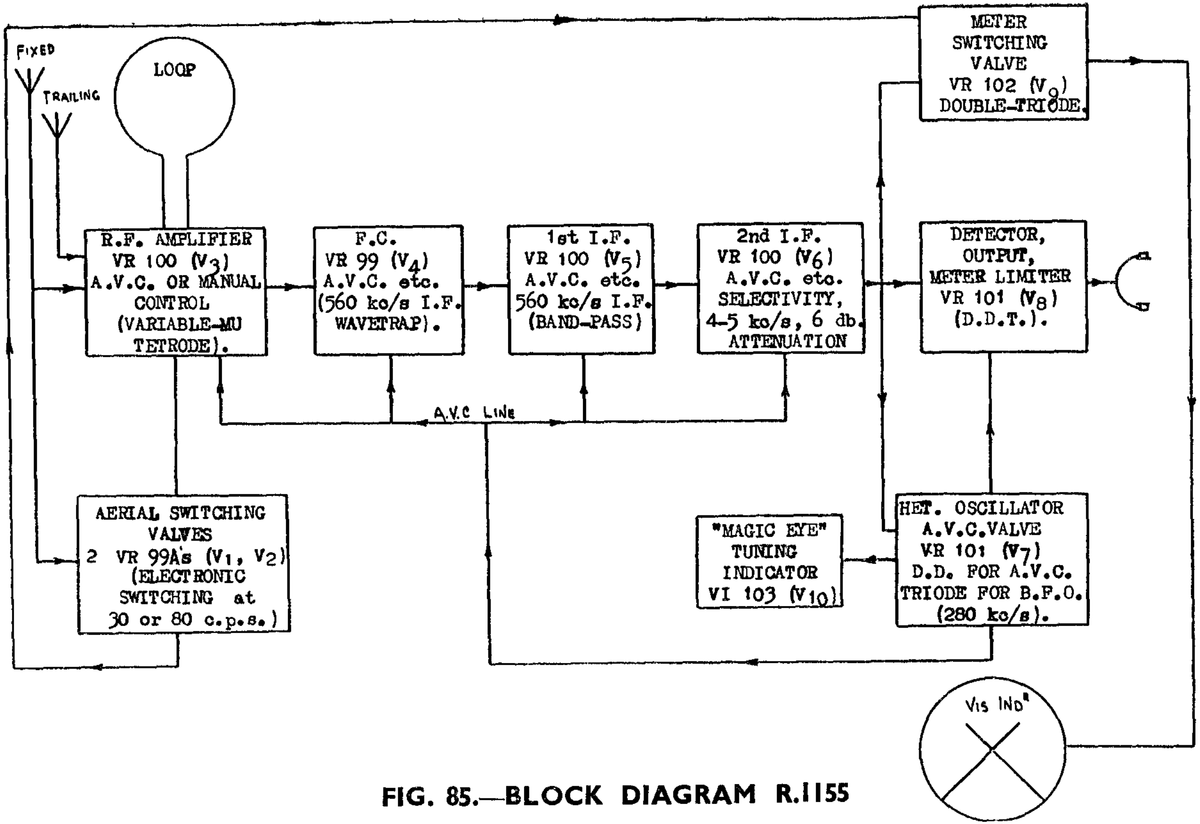


FIG. 85.—BLOCK DIAGRAM R.1155

(*f*) The full A.V.C. voltage is always applied to the " magic eye " V.I.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. 86. 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 a deflector wire " D ", which also protrudes into the upper portion of the valve.

The anode " T " is connected direct to H.T. +, 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 closes ".

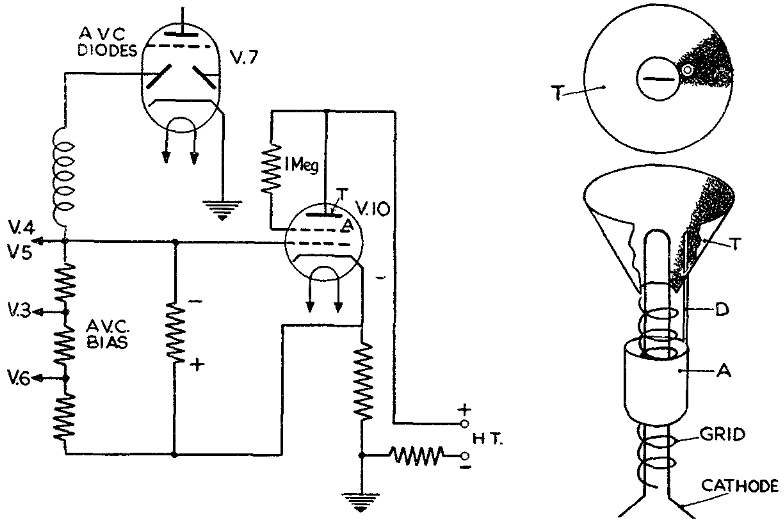


FIG. 86.—" MAGIC EYE " TUNING INDICATOR

(*g*) Another V.R.101 valve performs the functions of 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 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 loop. Consider fig. 87 and imagine the loop in two positions with respect to a station on which a bearing is being taken.

First position.—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.

Second position.—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.

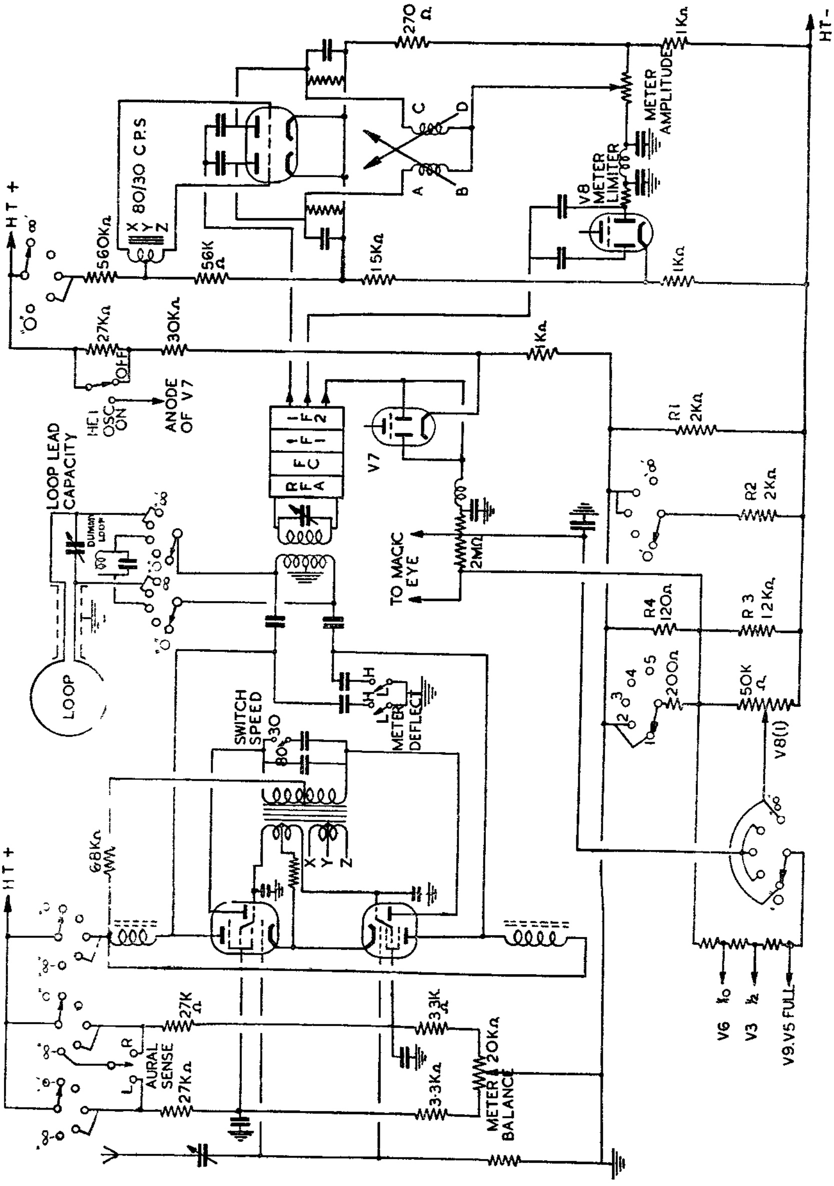


FIG. 87.—D.F. CIRCUIT FOR VISUAL INDICATOR

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.99As are used to switch the fixed aerial at 30 or 80 c.p.s. (30 cycles for R/T and

80 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.

(*c*) Meter balance control. When receiver 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.

(*d*) Meter deflection switch. This 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 ".

(*e*) Meter amplitude control. This controls the polarising current through the meters and thus the mean height of the needles.

(iii) *Adjustment of loop lead capacity*

(*a*) Find a weak signal on approximately 1,500 kc/s and then turn the master switch to " Figure of eight " position.

(*b*) Turn loop to position which gives maximum signals in telephones.

(*c*) Now adjust the trimmer condenser located in the loop plug which connects loop to receiver, to the position which gives maximum signals.

(iv) *Adjustment of " Vertical " aerial input.* The adjustable trimmer condenser C.56 used in this operation is situated behind the receiver control panel, but may be adjusted with an insulated screwdriver through a hole in panel on the extreme right of the receiver, just to the right of the master selector switch.

(*a*) Tune receiver to a suitable signal on range 4, and then turn master switch to " Figure of eight ".

(*b*) Rotate loop to position giving minimum signals in telephones, i.e. take the bearing.

(*c*) Set master switch to " Balance " and balance needles. Return master switch to " Figure of eight " and reduce loop scale reading by 30 degrees with meter deflection switch to " Low ".

(*d*) Hold aural sense switch to " Left " and " Right " determining which is the weak signal.

(*e*) Hold switch over to the weaker side and adjust C.56 through receiver panel for zero or minimum signal.

Note.—This is a most important adjustment, as it not only gives adequate sense determination on " aural ", but automatically gives the correct sensitivity deflection of the visual needles. It must be carried out each time a new receiver is fitted in an aircraft.

(v) *Checking " Sense "*

(*a*) Tune in suitable station on A.V.C.

(*b*) Switch to " Balance " and balance needles.

(*c*) Switch to " visual " and take bearing, i.e. rotate loop until needles intersect on the centre line. (There are two positions where this occurs, such positions being 180 degrees apart.)

(*d*) Find the position where a reduction of the loop scale reading causes the needles to swing right. This is the correct indicated bearing.

Note.—This bearing, if added to the bearing of the aircraft's head should equal approximately the known bearing of the station. If this is so, sense is correct. If the resultant bearing is 180 degrees different from the known bearing, then the sense is reversed.

If the aircraft's head is calculated by the aircraft's magnetic compass, then the resultant bearing is magnetic and must be compared with the known magnetic bearing of the station.

Always remember that the bearing read on the loop scale is only relative to the aircraft's head and the latter's bearing must be added to give the actual bearing of the station.

After checking sense on visual, it should be checked that aural and visual sense indications are similar. That is, when the loop scale reading is reduced and the visual needles swing to the right, if the master switch is put to "Figure of eight" and the aural sense switch held left and right the louder signal should be heard on the right.

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 "magic eye".
(*g*) A.V.C. may be obtained by moving the master switch.

Note.—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 in para. 7, sub-para. (ii).
(*h*) Turn meter deflection switch to "low".
(*i*), (*j*), (*k*) and (*l*) as in para. 7, sub-para. (ii).
(*m*) Set loop reading to zero.
(*n*) Request pilot to alter course until needles on his indicator cross on centre line.
(*o*) To "Sense", off-set course a few degrees to starboard. If the station is ahead the needles will now intersect on the left.

Note. 1. During "homing" balance should constantly be checked.
2. When flying over the home station the needles will collapse for a few seconds.

(iv) *Aural D.F.*

(*a*) Tune in the required station on "omni".
(*b*) Turn master switch to "figure of eight" position, meter deflection switch to "Low".
(*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 L and R. If the signal strength is greater on the right compared with the left, sense is correct.

8. **Fault Finding—No Signals**

(i) *Observe the " magic eye "*; if correct, tune to known loud signal: switch to " omni " V.C. max. and check 'phones and anode volts of V.8 (should be 188 volts).

(ii) *" Magic eye " glows green but filament is dim.* L.T. volts are low; check G.S. supply, P.U. brushes and the associated cables.

(iii) *" Magic eye " glows red.* H.T. is off the receiver. Check H.T. at points 7 and 8 of power socket on cable receiver end—should be approximately 240 volts. If zero, check power cables and brushes in the P.U. If still zero, check H.T. between point 2 plug D and point 7 socket A. Also check the cable between the two P.Us. and the L.T.P.U. for dry solder joints.

(iv) *" Magic eye " dim or out.* If other indications such as smell of burning or appearance of smoke; SWITCH OFF, suspect H.T.+ short to E. Check P.U. for breakdown of smoothing condensers. Megger between all cores and screens of power cables. Fault may also be in receiver; check between point 5 on receiver and E; should be 10,000 ohms. If less than this check C.93, C.25, C.41, C.29, C.32 and C.38 for breakdown and check that output transformer windings are not shorting.

(v) *" Magic eye " glows correctly.* Switch on " het ", tune to approximately 280 kc/s. If strong whistle is heard check V.3; the anode volts should be 172. With switch to " omni " vol max. screen volts 62. If correct check 'phone circuit.

(vi) *" Magic eye " does not respond.* Check V.4–V.5–V.6 and their associated circuits from the table.

Valve.	Anode.	Screen.	OSC-AN.	Remarks.
V.4	188 volts ..	58 volts ..	83 volts ..	Switch " omni "—maximum.
V.5	180 volts ..	64 volts ..	—	Switch " omni "—maximum.
V.6	180 volts ..	62 volts ..	—	Switch " omni "—maximum.

Note. 1. If the anode voltage of any particular valve is too high check the following :—
Resistance in the anode circuit.
Emission of the valve.
Grid bias may be too high owing to a faulty resistance.

2. Low voltage may be caused by :—
Short on the whole or part of the grid bias resistance; anode resistance too high.

9. **Fault Finding—Signals Weak or Distorted**

(i) *On all ranges.* Check power supplies and the G.S. accumulator. If correct, check the bias from junction of R.3, R.4 to E; should read on the H.F. range 2·5 volts negative and 3·5 on the M.F. range. If not normal, check R.3, R.1, R.4 individually; an excessive reading, i.e., 4 volts or more, can be caused by a breakdown of C.26, C.27 and C.28, which are together in a tubular can.

Note. A fairly common reason for weak signals has been found to be the grid connection from V.8 on L.F. filter switch broken.

(ii) *Correct on M.F. range, no signals on the H.F. ranges.* Check V.4 and check R.64, 200 ohms. If fault occurs on one range, check the switch contacts. If correct, check frequency changer circuit; disconnect the aerial and connect via a ·0001 μF condenser to the anode of V.3. If a signal is received the fault is in the first stage. If no signal is received the fault lies in the frequency changer stage. Check the D.C. resistance of the components from the table given at the end of this chapter.

(iii) *Weak signals when the filter switch is " On ".* Lead from C.10 to filter switch probably broken or disconnected.

(iv) *Weak signals with weak beat note on " Het ".* C.11 broken down, causing heavy potential to be put on detector diode.

(v) *" Magic eye " not responding*

(*a*) Not closing when signal is received; check C.103 for breakdown to earth.

(*b*) Not opening when off tune; check C.19 for breakdown.

(*c*) Out on " Het ". If the eye goes out when the heterodyne oscillator is switched on and there is no B.F.O.; check C.12 for breakdown.

(vi) *Volume control inoperative in " Omni " position.* This indicates H.T. negative is shorting to earth, thus shorting bias system. The fault can be :—

(*a*) In the receiver itself. With cables disconnected test between pin 8 (H.T.—) on receiver power plug and chassis (E). Should be :—

750/800 ohms on Omni-Max. or A.V.C.

450/500 ohms on Balance or Visual.

(*b*) In power cables. H.T.— line leaking to screening. Megger the H.T.— line to screening, in all cables concerned, i.e. receiver to transmitter, transmitter to H.T. power unit. Power unit (H.T.) to power unit L.T.

(*c*) In L.T. power unit. Smoothing condensers from H.T.— line to earth broken down. Check condensers.

0. Visual Faults

(i) *Visual meter will not balance.* Tune in a suitable signal and switch to " aural ". Adjust loop for minimum, and put aural sense switch to the right. If no signal change V.1. Put switch to left, and if no signal, change V.2. If O.K. both sides, change V.9. If changing these valves does not cure the fault, check the following :—

(*a*) Switch contacts may be dirty.

(*b*) May be earth on one side of meter or cables.

(*c*) One half of L.24 (550 ohm anode chokes) may be open circuited. Test straight across windings with ohm-meter. These chokes are frequently damaged through careless handling of the receiver.

(*d*) C.3 or C.5 (2·5 μF) condensers may be broken down.

(*e*) C.21 or C.22 (·005 μF) condensers may be faulty.

(*f*) C.23 or C.24 (·005 μF) condensers may be broken down.

(*g*) L.26 or L.27 (130 ohms) chokes may be open circuited.

(*h*) Balance potentiometer or associated fixed resistances may be faulty. Check voltages on screens of V.1 and V.2, measuring between screen and chassis; voltage should vary between 18 and 56 for full movement of balance control. It should be possible to find a midway position of this, that will produce equal voltages on the screens of the two valves.

(ii) *Needles uncontrollable.* If the controls are correctly set, check :— V.7 (A.V.C. valve) if correct, check :—V.8 (diode limiter).

(iii) *No balance with meter deflection switch " High ".* If correct on " Low " —check C.44–C.45. (Test as for H.T. short to E). Inspect bias resistances and replace as necessary.

(iv) *Needles rise on " omni " and A.V.C.* Check contact 9 on switch section A.R. Check following components in B.F.O. (visual portion) L.26, L.27, L.28—130 ohms each; C.3, C.5—2·5 μF each; C.4—1 μF; C.7, C.18, C.20, C.21, C.22—·005 μF each; R.24, R.25—22,000 ohms each.

(v) *Both needles " kicking down ".* Change V.9; if no effect check C.107 and C.7 for " breakdown " to E.

(vi) *Needles rise slightly in balance, come up on visual but do not swing L or R when loop is rotated.*

(*a*) When checking on an aircraft, test from pin 1 (H.F. ae. line) on the receiver power cable socket to the fixed aerial terminal in the fuselage of the aircraft, with transmitter switch at " standby ".

(*b*) If no continuity check plugboard or type " J " switch connections, also pigtail connection to centre contact of magnetic relay (fixed aerial contact) in the transmitter. Fault can also be in the cables themselves. Systematic testing for continuity will quickly show which part of the installation is faulty. Start from fixed aerial lead-in, work down through the plug board and aerial ammeter, through transmitter and relay and so through receiver power cable to point 1 mentioned above.

(*c*) Check also for leakage of the fixed aerial line down to earth (screening), which sometimes occurs with an old cable.

(*d*) If aerial is getting through to receiver, then fault must be in receiver and will be in the V.1, V.2 circuits. Check aerial continuity to one side of C.56, the ae. trimmer and from the other side to the grids of V.1 and V.2 (hexode portions).

Check voltages on V.1 and V.2. Switch at " Balance ".

Hexode	Anodes	..	188 volts.
	Screens	..	18 to 56 volts—variable.
Osc.	Anodes	..	136 volts (30 cycles).
			152 volts (80 cycles).

(*e*) If there is no voltage on the hexode anodes the fault will probably be a break in the lead between R.46 and the common junction of the two anode chokes L.24. The break may occur either in the lead itself or at the soldered connection to the chokes, both faults being fairly common.

(vii) *Needles " Balance " correctly but no swing to L or R when loop is rotated.* Check loop leads between points 15 and 16 with loop plug out—should be less than 1 ohm ; if correct, check between one side and E—should be infinity ; if correct, check that variable condenser in aerial loop lead plug is not shorting.

(viii) *Needles do not rise in Balance or Visual positions.* Check V.9 ; if correct, check common lead to meters.

(ix) *Both meters burnt out* (*no signals*). C.20 broken down causing + potential on limiter diode, drawing all emission from detector diode, and passing excessive current through visual meters.

B.F.O. Unit Faults

(i) *Heterodyne note off frequency and weak.* Adjust C.13 by the following method :—

(*a*) Tune to strong steady signal, preferably on the M/F band, ensuring station dead in tune by observation of the magic eye. Put down " het " switch and adjust C.13 for good note of approximately 1,000 cycles, without moving the main tuning knob.

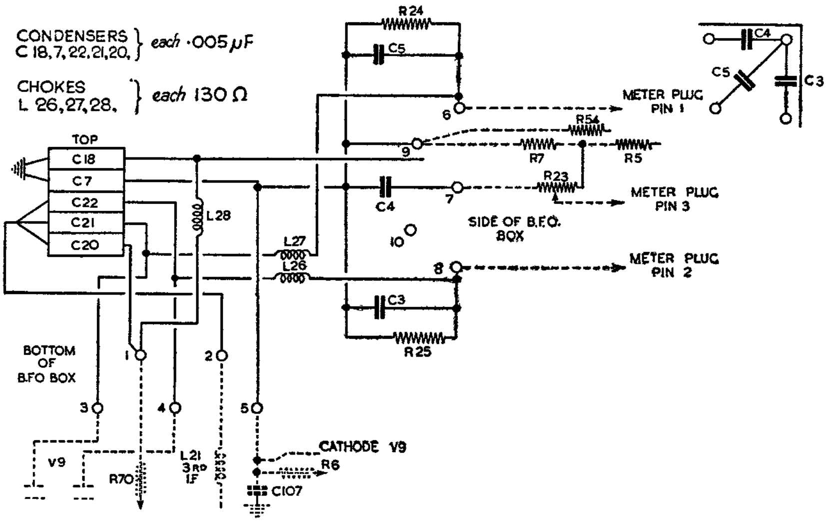
(*b*) If there is insufficient adjustment with this condenser to bring down oscillation to required pitch, the B.F.O. coil L.22 probably wants adjusting. The adjustment is a variable dust core, which is very small and needs careful handling. Proceed as follows :—

(*c*) Remove top metal cover of B.F.O. box and put variable condenser C.13 45 degrees in mesh by rotating it clockwise from position of minimum capacity. Check that the core of L.22 moves easily and freely. If it is stiff do not attempt to turn it by force as this will only result in the core breaking. The wax or other locking substance must be softened by the *careful* application of heat, until the core rotates easily. When the core has been freed, replace top of B.F.O. box. Tune to strong signal (M.F.) ensuring station dead on tune by observation of magic eye. Switch on " Het " and adjust core of L.22 through the hole in the top of box until a " zero beat " or " dead space " is obtained. From this position rotate C.13 further clockwise until a note of approximately 1,000 cycles is heard.

The B.F.O. is then correctly adjusted.

(ii) *Complete failure.* This may be due to the following :—

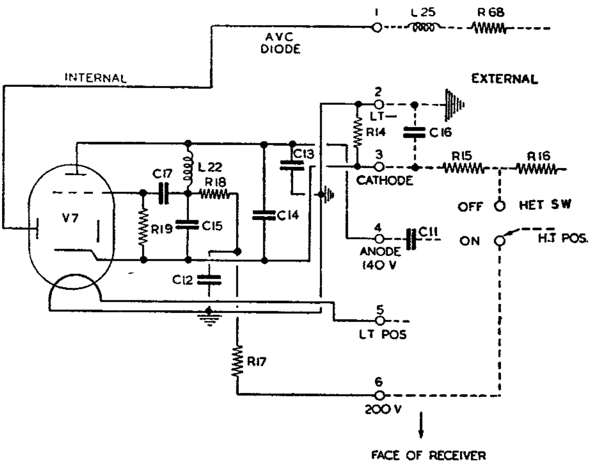
(*a*) L.22 coil broken at joint of C.17.
(*b*) C.14, 800 $\mu\mu$F condenser broken down.
(*c*) C.11, ·001 μF condenser broken down.
(*d*) R.17 or R.18 changing value.
(*e*) C.17, ·0001 μF condenser open circuit.



Between	Testing	Between	Testing
1 and 2	C20	4 and 2	C22
1 and 7	L28	1 and E	C18 via L28
1 and 5	C4	7 and 8	C18
3 and 2	C21	9 and 6	R24 (22,000) if less, C5 down
3 and 6	L27	9 and 8	R25 (22,000) if less, C3 down
4 and 8	L26	5 and E	C7

Disconnect external leads to avoid reading parallel paths.

FIG. 87A.—B.F.O. VISUAL SECTION



L22	4 or 5 ohms	
L14	1,000 ,,	
R15	30,000 ,,	
R16	27,000 ,,	
R17	1,500 ,,	
R18	10,000 ,,	
R19	56,000 ,,	
C11	·0001 μF	
C12	·1 μF	
C14	1,600 $\mu\mu$F	
C15	4,550 $\mu\mu$F	
C16	·5μF	
C17	·0001 μF	

Use terminals 1 to 6 as test points for checking internal components.

FIG. 87B.—B.F.O. UNIT

12. Valve Voltage and Current Measurements

Valve.	Electrode.	Volts on M.F.		Volts on H.F.		Current in mA. M.F.		Current in mA. H.F.	
		Vol. Con.		Vol. Con.		Vol. Con.		Vol. Con.	
		Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
V.3	Anode ..	172	198	174	200	5·2	0·8	6·6	0·9
V.3	Screen ..	62	80	57	78	—	—	—	—
V.4	Anode ..	188	204	184	202	1·0	0	1·0	0
V.4	Screen ..	58	82	54	81	—	—	—	—
V.4	Osc. anode	83	88	63	68	—	—	—	—
V.5	Anode ..	180	202	174	202	4·5	0·1	5·7	0·1
V.5	Screen ..	64	78	59	78	—	—	—	—
V.6	Anode ..	180	194	174	192	5·2	4·2	6·9	5·0
V.6	Screen ..	62	70	57	70	—	—	—	—
V.7	Anode ..	128	136	124	134	4·5	4·8	4·4	4·8
V.7	Cathode ..	7	7·5	6·8	7·5	—	—	—	—
V.8	Anode ..	188	198	182	198	9·4	9·6	9·3	9·6
V.8	Cathode ..	−28·5	−20·2	−34·0	−23·0	—	—	—	—
V.9	Anode ..	−15·0	—	—	—	—	—	—	—
V.9	Cathode ..	−24·0	—	—	—	—	—	—	—

13. 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
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

Components.	Test Points.	Resistance, ohms.
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.	Resistance, ohms.
	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
A.F. oscillator	Withdraw meter plug, measure between pins 7 and 8, using A.C. range of Avo	" Low " 28 V " High " 35 V
		Switches—
Colour code wiring ..	Red, H.T. positive	W is aerial input
	Yellow, H.T. negative	X is grid V.3
	Blue, L.T. positive	Y is anode V.3
	Black, earth	Z is grid and oscillator V.4
	Green, grids	

CHAPTER 18

BEAM APPROACH AIRCRAFT EQUIPMENT

1. **Purpose.**—To enable a pilot to approach an airfield 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).

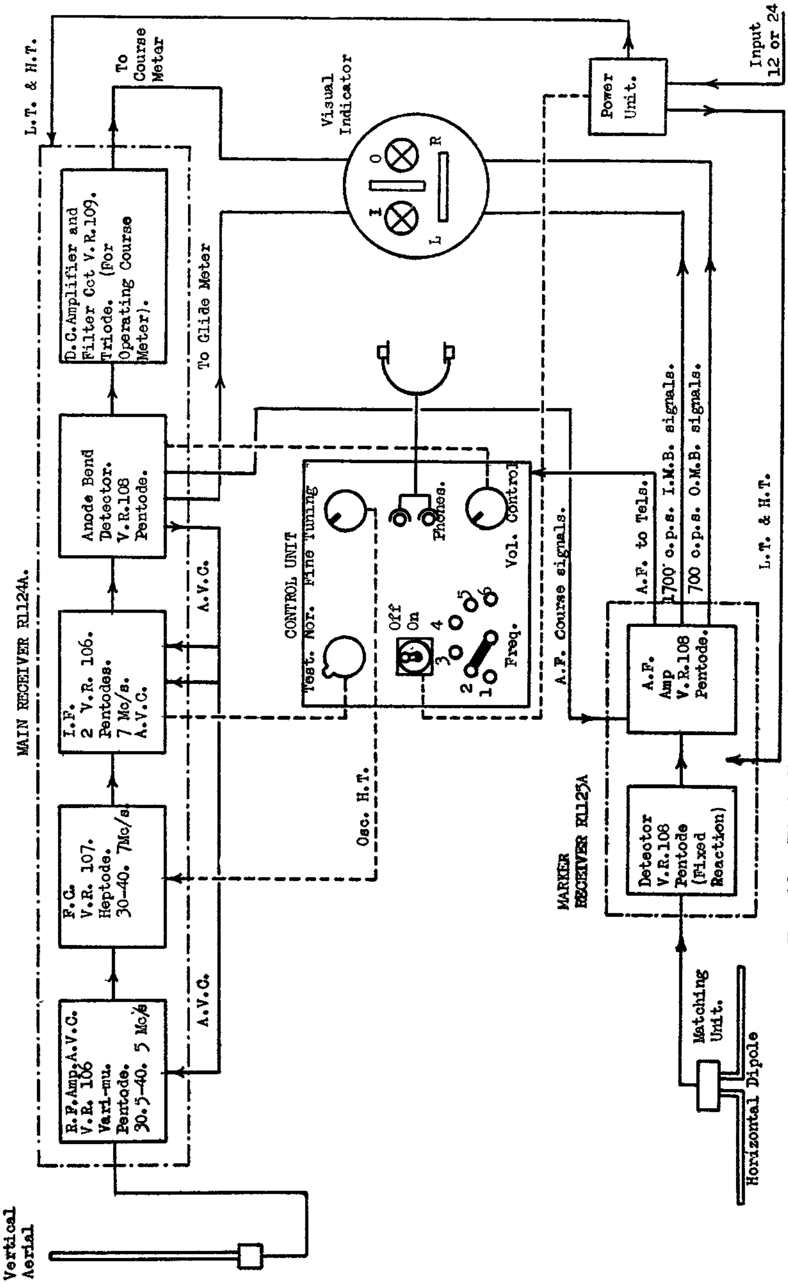


FIG. 88.—Block diagram beam approach aircraft equipment.

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.

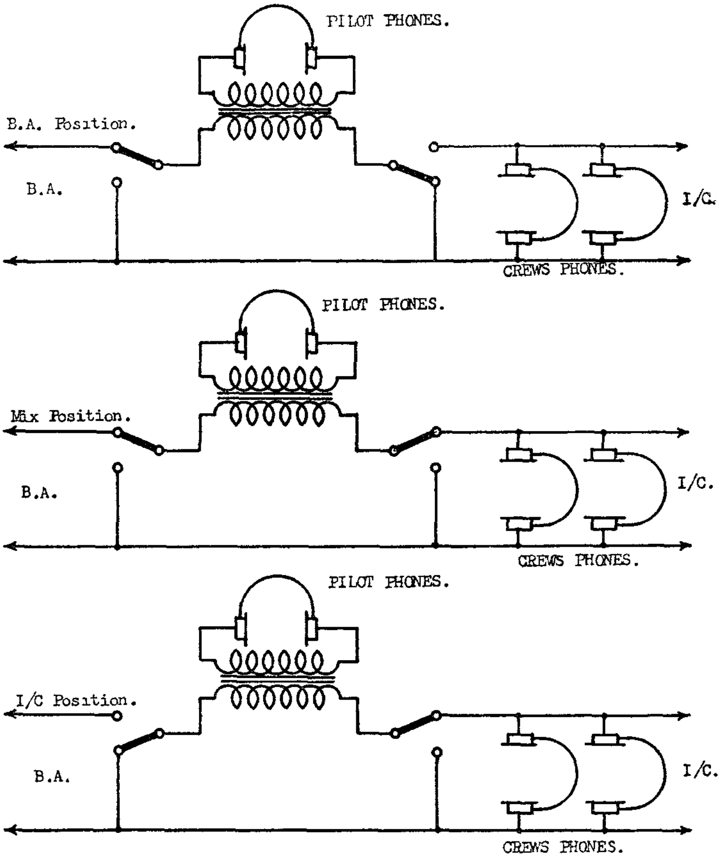


FIG. 88A.—Junction box, Type 9.

11. **Test Oscillator, Type 12** (fig. 88B).—Uses same principle as marker nsmitter. Has C.O., R.F. mod., mixer-output and A.F. modulator stages, triodes.

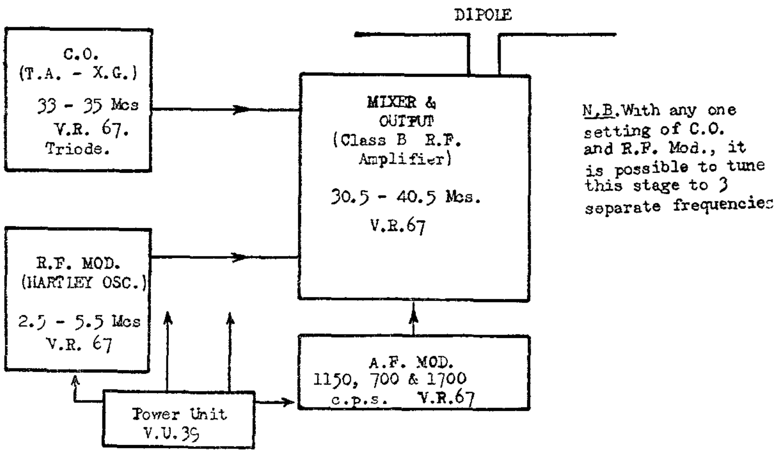


FIG. 88B.—Block diagram test oscillator, Type 12.

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 milliammeter 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 the 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. **Servicing.**—(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.

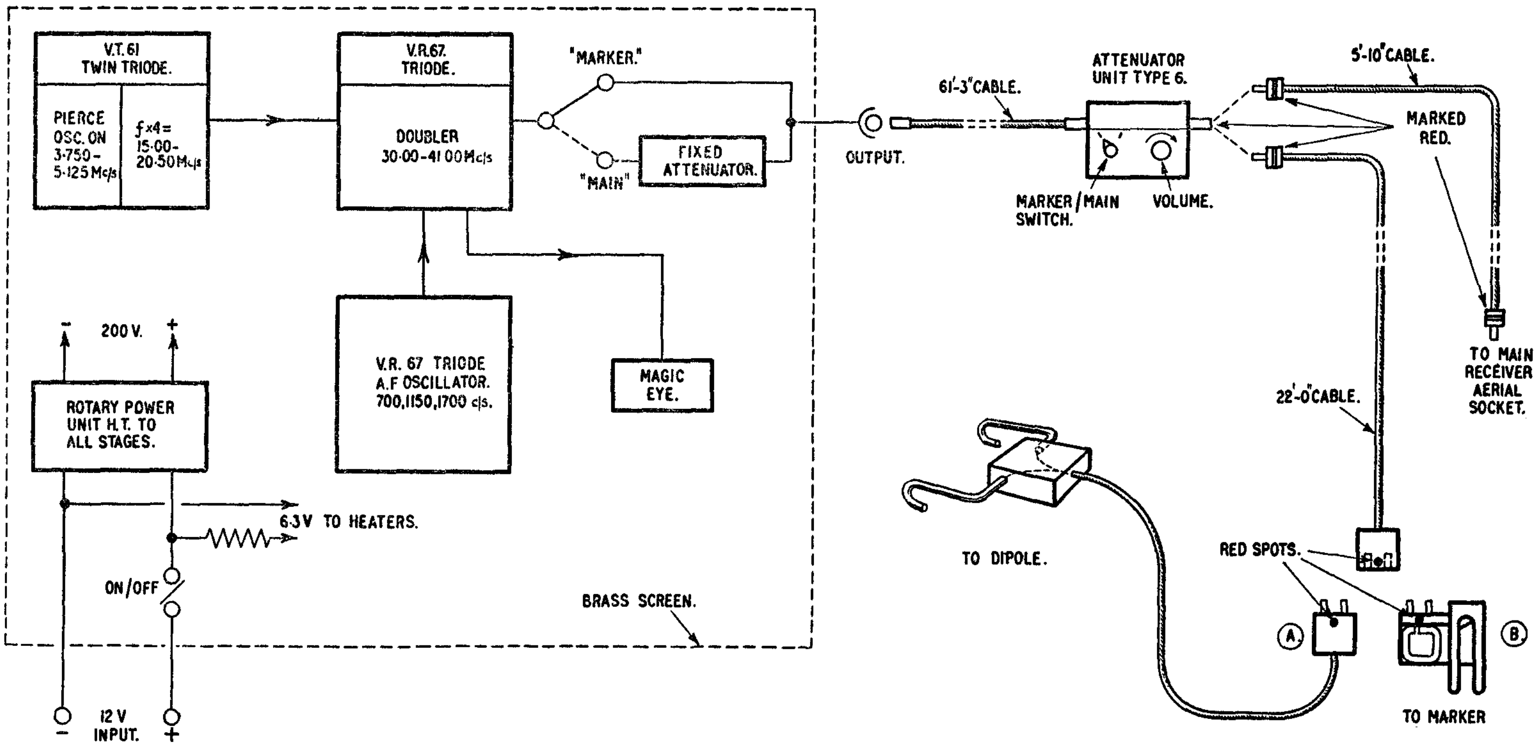
(xi) Check receiver free from noise under vibration conditions.

(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.



V.T. 61
TWIN TRIODE.
PIERCE
OSC. ON
3·750-
5·125 Mc/s
f×4=
15·00-
20·50 Mc/s
V.R.67.
TRIODE.
DOUBLER
30·00-41·00 Mc/s
"MARKER."
"MAIN"
FIXED
ATTENUATOR.
OUTPUT.
61'-3" CABLE.
ATTENUATOR
UNIT TYPE 6.
MARKER/MAIN
SWITCH.
VOLUME.
5'-10" CABLE.
MARKED
RED.
TO MAIN
RECEIVER
AERIAL
SOCKET.
22'-0" CABLE.
200 V.
-
+
ROTARY POWER
UNIT H.T. TO
ALL STAGES.
V.R. 67 TRIODE
A.F OSCILLATOR.
700,1150,1700 c/s.
MAGIC
EYE.
6·3V TO HEATERS.
ON/OFF
BRASS SCREEN.
12 V
INPUT.
TO DIPOLE.
RED SPOTS.
A
B
TO MARKER

16. **Test Oscillator Type 12A**

A schematic diagram of the Test Oscillator Type 12A with its connecting cables is shown in Fig. 88C. This equipment replaces the T.O. Type 12 for setting up and testing S.B.A. receivers R.1124 and R.1125 series. Eight crystals control eight spot frequencies within the range of 30·0 to 41·0 Mc/s ; actual crystal frequencies being 3·750 to 5·125 Mc/s.

A single tuning control tunes two frequency multiplying stages, final adjustments being made with the aid of a cathode ray tuning indicator (magic eye), operated by voltage due to grid current in the grid circuit of the doubler stage.

The output stage is anode modulated with A.F. at either 1,700, 1,150 or 700 c.p.s. selected by means of a switch. Output to the receivers is through special coaxial feeders and a portable attenuator unit. Alternative coupling units are provided for the marker dipole (*see* A and B, Fig. 88C). All these items are contained in a special transit case.

Power is obtained from a 12-volt accumulator which supplies 6·3 volts for valve heaters through a 3·2 ohm dropping resistance and also drives a small rotary transformer providing 200 volts H.T. for all stages. When T.O. Type 12A is in use the tuning procedure for the R.1124 and R.1125 receivers is the same as previously given in paras. 12 and 14 except that the position of the T.O. Type 12A with respect to the aircraft is unimportant, providing that the coaxial cable is not stretched or kinked. Reference to the position of the Test Oscillator in the above-mentioned paragraphs should therefore be ignored when using Type 12A.

The Test Oscillator must first be set up to 38 Mc/s and the correct cables and fittings used to set up the R.1125 Marker Receiver. When this is satisfactorily completed the Test Oscillator must be re-set to a frequency between 30·5 and 40·5 Mc/s and the R.1124 Main Receiver tuning carried out.

When the signal becomes audible on tuning the receivers, reduce the Test Oscillator output by use of the volume control on the Attenuator Unit ; not by varying the Test Oscillator position as when using Type 12.

17. **Setting up Test Oscillator Type 12A for R.1125.**

(i) Check that the 12-volt accumulator is serviceable and connect the leads from the Test Oscillator input socket to the accumulator, with correct polarity. (The positive accumulator clip is marked red.)

(ii) Switch on and allow a five-minute warming up period. Observe that the generator is running and that the tuning indicator glows green.

(iii) Connect the 61 ft. 3 in. cable between the Test Oscillator output socket and the left-hand socket of Attenuator Unit Type 6.

(iv) Connect the 22 ft. 0 in. cable between the right-hand (red) socket of the Attenuator Unit Type 6 and the loop coupling unit (A on diagram) ; ensuring that the latter is clipped on the left-hand side of the matching unit as high as possible to ensure sufficient coupling. The cover must be removed for this operation. If the matching unit is completely inaccessible use alternative lead (B) and hook the attachment on to the centre of the dipole casing.

(v) Set the switch on Attenuator Type 6, and Test Oscillator OUTPUT SWITCH to " MARKER ". Set the volume control on the Type 6 unit to " MAX MARKER ".

(vi) Move CRYSTAL SELECTOR switch to required crystal.

(vii) Set the calibrated dial to approximate output frequency and finally adjust carefully for minimum shadow (maximum green) angle on the tuning indicator.

(viii) Set the TONE SWITCH to the required frequency, usually 1150 c.p.s.

(ix) Tune the R.1125 Marker Receiver as detailed in paragraph 13.

Note. The two-pin plug and socket contacts on the coaxial leads are marked with red dots and must be connected so that the dots are adjacent.

18. To set up Oscillator, Type 12A for R.1124

(i) Remove the 22 ft. 0 in. cable and connect the 5 ft. 10 in. cable (with a red marked plug at each end) between the right-hand socket of the attenuator unit and the aerial socket of the main receiver in place of the normal aerial plug.

(ii) Set the attenuator switch and Test Oscillator OUTPUT SWITCH to " MAIN ". Set the volume control on the Type 6 unit to " MAX MAIN ".

(iii) Repeat operations (vi) (vii) and (viii) in paragraph 17.

(iv) Tune the R.1124 Main Receiver as detailed in paragraph 14. Particular attention is drawn to (ii) as accuracy is important for ease of tuning when using Type 12A.

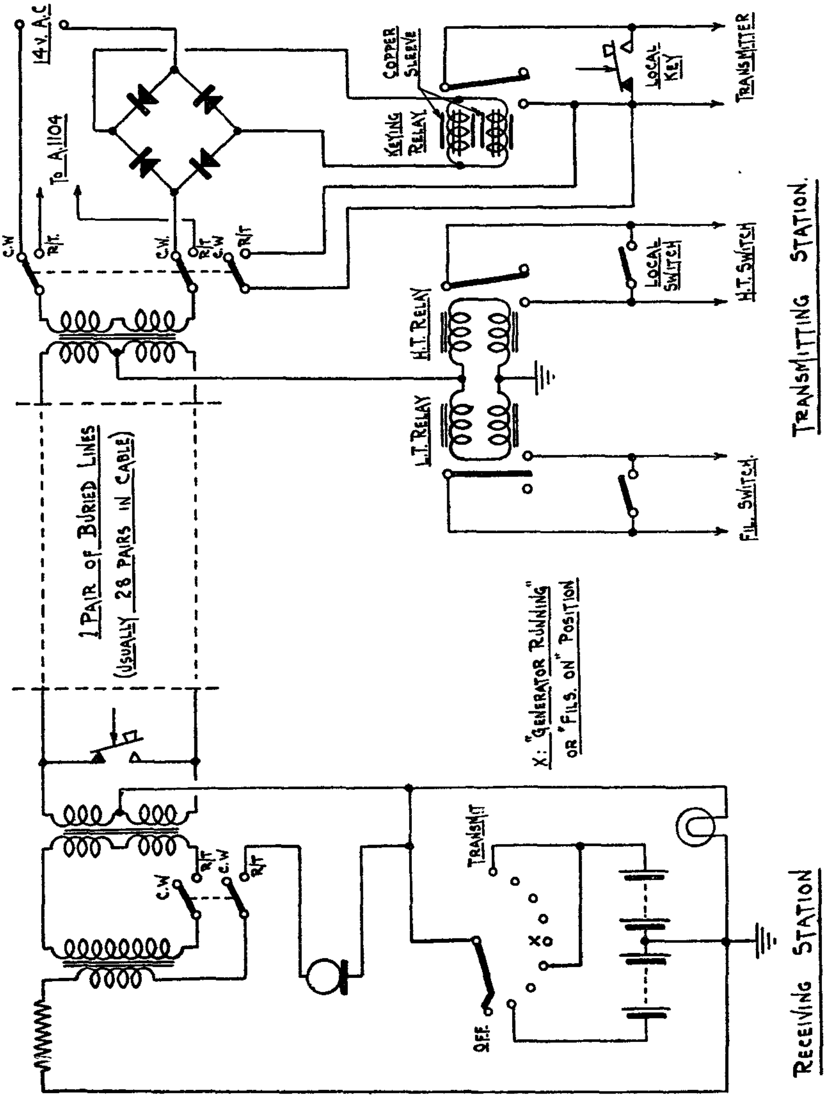
(v) Remove the Test Oscillator plug from the receiver aerial socket and replace the normal aerial. Place the plug of the Test Oscillator lead on top of the aerial plug to give a small coupling from the Test Oscillator and re-adjust the aerial trimmer on the receiver for maximum output.

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 end 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.

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

1. **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

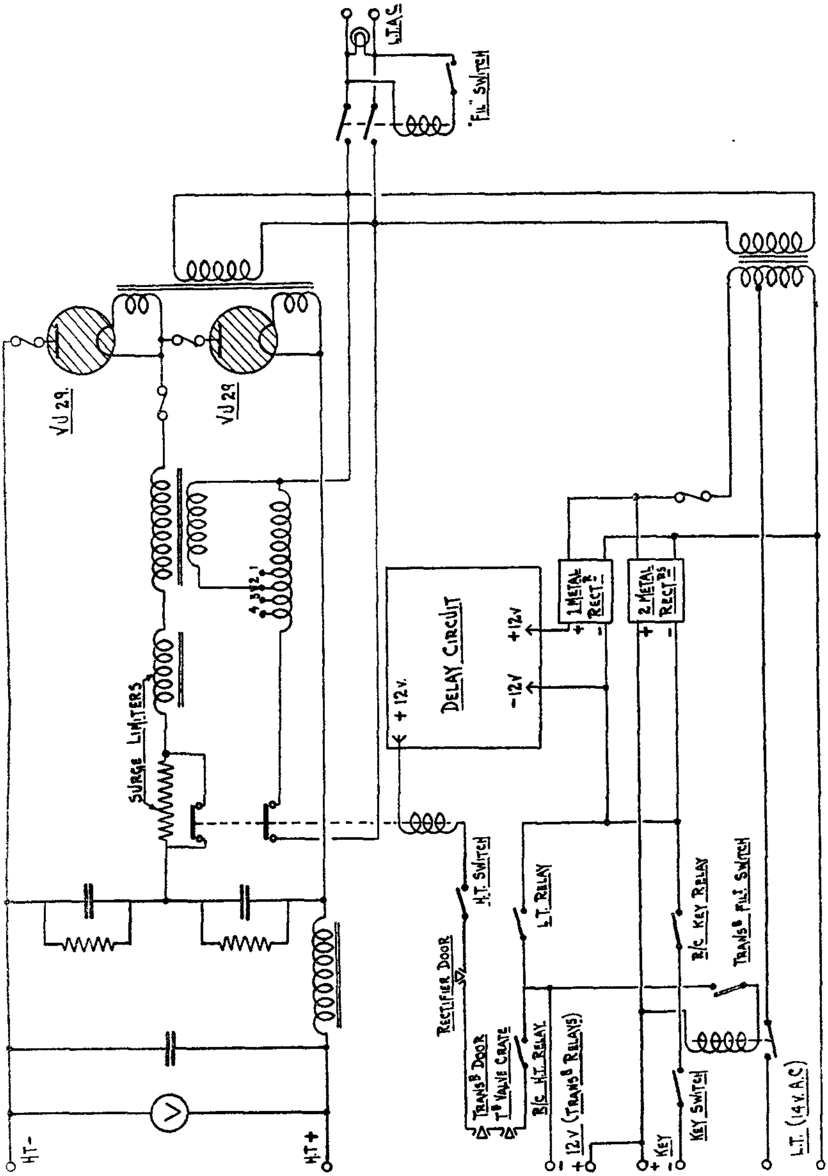


FIG. 90.—Rectifier panel, type B.

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

TRANSMITTER T.1087

1. **Purpose.**—Ground station transmitter of H.F., C.W., M.C.W. and R/T. Separate modulation amplifier (A.1104) for M.C.W. and R/T. Local or remote control.

2. **Frequency Range.**—20 to 1·5 Mc/s :—

Range A.	M.O. coil 1	20,000 to 16,666 kc/s.
Range B.	M.O. coil 2	18,750 to 15,789 kc/s.
Range C.	M.O. coil 2	15,789 to 11,110 kc/s.
Range D.	M.O. coil 2	11,110 to 7,500 kc/s.
Range E.	M.O. coil 2	7,500 to 3,000 kc/s.
Range F.	M.O. coil 3	3,000 to 1,500 kc/s.

3. **Valves.**—V.T.30, M.O. ; two V.T.31, P.A. ; V.T.25 bias valve ; two V.U.29 rectifiers.

4. **Power Supplies.**—(i) L.T., 14 volts, A.C. ; (ii) H.T., 1,700 to 3,000 volts, D.C. Relay supplies, 12 volts, D.C. ; obtained from built-in rectifier panel, types A or B.

5. **Aerial Systems.**—(i) *1·5 to 3·0 Mc/s.*—54-ft. vertical cage aerial (Res. = 70 to 100 ohms). Normal current, 1·0 to 1·5 amps. A 0–2·5 external thermo-ammeter should be fitted.

(ii) *3 to 7 Mc/s.*—Should be T-type cage with 14-ft. roof or 40-ft. single wire. In this aerial current should be about 5 amps. The 54-ft. aerial may be used up to 6 Mc/s with some loss of efficiency ; in this case the external ammeter will again be needed.

(iii) *7–20 Mc/s.*—One-quarter wave vertical aerial rising direct from aerial terminal 5, or a distant resonant system with feeders. If feeders are used, two external ammeters will be necessary. Direct aerials must be connected between terminals 5 and 3, and feeder lines between terminals 4 and 3.

6. **Circuit** (a simplified version in fig. 91).—Hartley M.O., tuned by variable condenser and three plug-in coils. M.O. capacity-coupled to a neutralised tetrode P.A. using two V.T.31's in push-pull. The P.A. is tuned by variable condenser and five tapped inductances, permanently fitted in the transmitter. The P.A. is capacity-coupled to the aerial matching transformer, which is tapped at every turn to work into aerial loads between 20 and 600 ohms.

The M.O. is self-biased. Variable bias (0–900 volts) is applied to the P.A. by means of a transformer and diode rectifier (the V.T.25 is used as a diode).

Keying is by magnetic relays which make and break H.T. negative and grid circuits. To prevent temperature variations, thermal and magnetic switching provides that when the key is lifted for more than 10 seconds, the M.O. recommences oscillation on a pre-determined " space " frequency, whilst the P.A., H.T., and aerial circuits are open. Safety switches cause H.T. and G.B. to be switched off when door is opened or P.A. valve crate removed. H.T. is off when rectifier door is opened.

CAUTION. Switch off the H.T. before making any changes which necessitate opening the doors of the transmitter. Do not rely entirely on the safety door switches. Although these switches isolate the power supply, the condensers of large capacity in various parts of the circuit take a few seconds to discharge. A period of 15 to 20 seconds should therefore be allowed to elapse after switching off and opening the doors, before any adjustments are made inside the transmitter. On C.W. or M.C.W. the condensers may be discharged by tapping the key, but even then allow the safety period to elapse. Always see that the main H.T. switch is off before unscrewing any of the side or back panels.

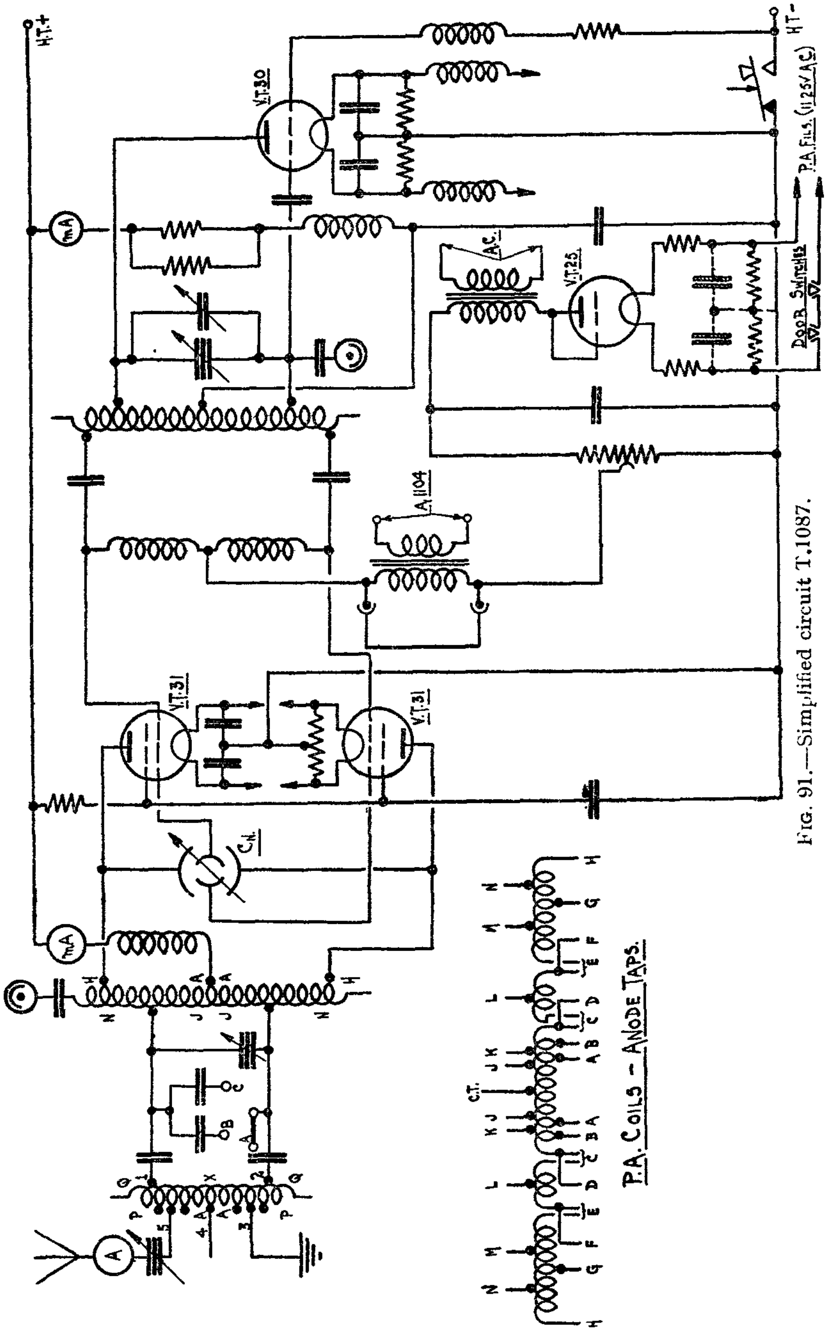


FIG. 91.—Simplified circuit T.1087.

7. **Tuning Instructions.**—(i) *C.W.*—(*a*) All switched off. Fit appropriate anode feed resistance and M.O. coil (2 × 20 kilohms on range F only, otherwise 2 × 10 kilohms).

(*b*) Switch on all filaments and adjust M.O. to 12·5 volts and P.A. to 11·25 volts.

(*c*) Set P.A. coil and aerial transformer taps according to tables.

(*d*) Set H.T. transformer switch to stud 1 and grid bias switch to stud 8.

(*e*) Set M.O. and P.A. tuning according to tables.

(*f*) Switch on H.T. and set remote control switch to R/T.

(*g*) Close key switch and set neutrodyne to zero.

(*h*) Reduce P.A. bias until P.A. mA reads 100. Tune P.A. for dip in mA, and reduce bias switch to " 8 ". The neon lamp should still glow.

(*j*) Adjust neutrodyne until neon lamp goes out. Then turn in both directions and note the settings at which it strikes. The mean of these is the correct neutrodyne setting and should be approximately 90°. Alternatively, couple W.1081 or W.1117 to aerial, adjust bias (and/or attenuator of W.1117) to give two-thirds full-scale reading, and neutralise carefully until wavemeter reads zero.

(*k*) Tune aerial condenser for maximum aerial amps (if using direct aerial).

(*l*) Check frequency with wavemeter.

(*m*) Re-adjust M.O. main and fine tuning, and repeat (*j*), (*k*), (*l*) and (*m*), until frequency is correct.

(*n*) Adjust grid bias to give maximum safe power. (H.T. watts input minus aerial watts = 500 or less.) This is normally stud O if P.A. is correctly loaded.

(*o*) Set remote control switch to " C.W."

(ii) *R/T.*—(*a*) Tune up as for C.W., leaving remote control switch to " R/T ".

(*b*) Note aerial current reading. Adjust P.A. grid bias so as to *reduce this reading by 50 per cent.* This is essential. If necessary, an external 0–2·5 ammeter should be used. Normal G.B. settings will be : stud 3 (H.T. stud 1), stud 4 (H.T. stud 2) or stud 5 (H.T. stud 3).

(*c*) Switch on A.1104 in " local microphone " position and plug in audio input to T.1087.

(*d*) Adjust volume control and attenuator in conjunction until a sustained note at the microphone causes current to *rise* by 20 per cent. At the same time, A.1104 mA should remain steady at 110.

(*e*) Switch to " 600-ohm line " or " direct grid ", as appropriate, and adjust speech level from distant point to give same result as local microphone. Check by listening to monitor.

(iii) *M.C.W.*—(*a*) and (*b*) as for R/T.

(*c*) Switch on A.1104 on " local oscillator " position and plug in.

(*d*) Adjust volume and attenuator to give 100 per cent. modulation.

(*e*) Switch R/control to " W/T ".

Note.—Crystal-controlled T.1087.—Many T.1087's have been modified to crystal control. The V.T.30 crate is replaced by a pentode V.T.81 crystal oscillator unit. The V.T.31's are joined in parallel instead of push-pull. Neutralising is dispensed with, as are " spacing " arrangements (by removing the thermal delay unit). The aerial matching transformer is not used, unless it is desired to use feeder lines.

(iv) *Tuning instructions, C.C. T.1087.*—(*a*) Fit one 20 kilohm anode feed resistance.

(*b*) Switch on filaments and adjust voltages.

(*c*) Set all taps and controls according to chart and aerial condensers to zero.

(*d*) Set H.T. to stud 1, G.B. to stud 8, switch on H.T. and key.

(*e*) Tune M.O. *slowly* for a sudden dip in mA ; set to greatest dip.

(*f*) Set H.T. to stud 2, and adjust bias switch to give 100 mA input to P.A.

(*g*) Tune P.A. for greatest dip and then gradually increase aerial condenser reading to give optimum coupling, altering P.A. tuning meanwhile to maintain resonance.

(*h*) For C.W. operation reduce bias to obtain maximum permissible input and trim C.O. carefully to minimum input. Then *reduce reading* on C.O. condenser until input to C.O. increases by 5 mA. This will ensure that C.O. " starts up " immediately on switching on or keying.

(*j*) For R/T adjust bias until aerial current falls to 50 per cent. of C.W. reading. Adjust audio input from A.1104 to give good modulation as before.

8. **Servicing and Fault-finding.**—(i) Keep the set clean.

(ii) Regulate A.C. mains to 230 volts 50 c.p.s.

(iii) Test V.U.29 filament voltage—to be between 4 and 5.

(iv) Keep two conditioned V.U.29's ready for use, stored in a vertical position.

(v) Clean and adjust all relay contacts frequently.

(vi) *Reservoir condenser S/C.*—Main (and possibly H.T.) fuses blow. Loud " crack " on switching on.

(vii) *Reservoir condenser leaky.*—Uneven blue glow, brighter in valve in series with faulty condenser.

(viii) *Punctured envelope, V.U.29.*—May be due to anode lead trailing on hot glass. Keep leads short and straight.

(ix) *L.T. and H.T.* will not switch on. A.C. mains off; 5-amp fuse in rectifier panel blown (ascertain cause before replacing).

(x) *Screen condenser S/C.*—Low aerial current and low P.A. input. No mA. on bias studs 8 to 5. Poor result studs 4 to 0.

(xi) *Bias valve U/S.*—R/T poor quality. High P.A. mA reading, decreasing only slightly when switching from stud 0 to 8.

(xii) *Bias valve S/C.*—Filament touching grid. Poor R/T; high P.A. mA on both studs 8 and 0, decreasing slightly towards studs 3 and 4.

(xiii) *Wobbly note.*—Incorrect neutralising ; incorrect filament temperature. Poor V.T.31.

9. **A.1104, General.**—The A.1104 is a modulation amplifier built up on a " rack and panel " system. It is designed to give suitable A.F. amplification to modulate ground station transmitters, producing 10 watts audio power with 0·5 volt input. Input impedance, 600 or 50,000 ohms; output impedance, 12,000 ohms (matched to T.1087 P.A. grid circuit).

(i) The *top panel* contains a two-stage audio amplifier employing an indirectly heated triode (V.R.38), transformer coupled to a directly heated class "A" push-pull triode output stage (V.R.40's). Both stages are automatically biased by cathode resistance. Power stage biased, decoupled and variable within limits.

(ii) The *second panel* is the power pack. The five secondaries of the power transformer supply :—

(*a*) Local microphone supply circuit (10 volts).

(*b*) Rectifier filament and delay circuit (4 volts).

(*c*) Rectifier H.T. (500–0–500 volts).

(*d*) First audio and oscillator heaters (4 volts).

(*e*) Output valve filaments (4 volts).

The rectifier is a full-wave type, employing a double diode V.U.39.

(iii) The *third panel* is referred to as the "local control panel" and contains :—

(*a*) Input switches—these give inputs from :—

(i) 600-ohm lines (normal R/Control).

(ii) G.P.O. or other lines, joined directly to the input volume control. Marked " 50,000 ohms direct grid "

(iii) A local oscillator.

(iv) A local microphone.

(*b*) A 1,000 c.p.s. valve oscillator (V.R.37), for use when M.C.W. telegraphy is required.

(*c*) A rectifier and smoothing circuit for the local microphone supply.

10. **Crystal Monitor, Type 1.**—(i) *General.*—Designed for setting up T.1087 to six frequencies and to monitor C.W., M.C.W. or R/T signals on these frequencies.

A " rack and panel " assembly is used and the same power panel as A.1104. A short copper rod should be fitted to the aerial terminal.

(ii) *The circuit* incorporates a detector stage (V.R.37 valve), tuned by six pre-set condensers. This is transformer-coupled to an A.F. amplifier (V.R.40), which is automatically biased by an adjustable cathode resistance.

A crystal-controlled heterodyne oscillator is coupled to the input circuit of the detector, and the tuning switch also selects a suitable crystal for the oscillator, when the detector circuit is changed. The oscillator uses a V.R.38 valve.

The on-off switch breaks H.T. to the oscillator when it is desired to monitor R/T or M.C.W., and the telephone jack automatically disconnects the loud speaker, and provides the correct output load when telephones are in use.

(iii) *Operation.*—(*a*) *To set up monitor* :—

(1) Plug correct crystal in No. 1 position and switch to " No. 1 ".

(2) Set up transmitter as closely as possible to crystal frequency with W.1081 or W.1117.

(3) Switch on monitor and heterodyne oscillator, plug in phones and adjust bias to 55 mA Ia.

(4) Turn up volume control until a signal is heard, insert screwdriver into " No. 1 " position and adjust condenser for loudest note.

(5) Repeat for frequencies 2, 3, 4, 5 and 6.

(*b*) *To set up transmitter* :—

(1) Tune T.1087 carefully to desired frequency.

(2) Switch on monitor and heterodyne oscillator. A note should be heard in loud speaker if T.1087 is within 10 kc/s.

(3) If note is good, adjust T.1087 M.O. fine tuning until exact " dead space " is found. If not—

(4) Adjust transmitter to give pure note (filament volts, etc.) and re-trim to exact dead space.

(5) Subsequent frequency drift of transmitter will cause a heterodyne note in loud speaker.

(6) To monitor M.C.W. or R/T switch off heterodyne oscillator.

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 aerial 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 relay, 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.

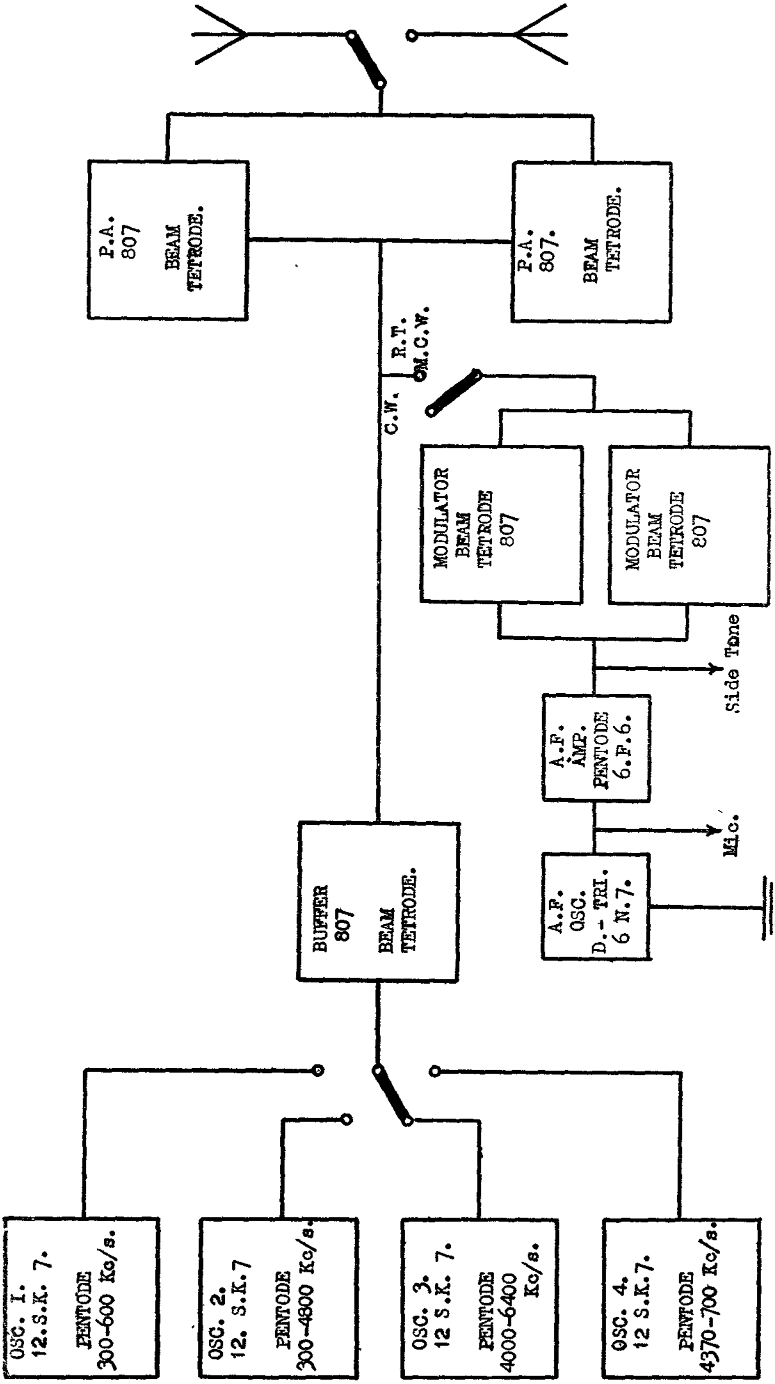


Fig. 92.—Block diagram transmitter, T.A.—12B.

	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

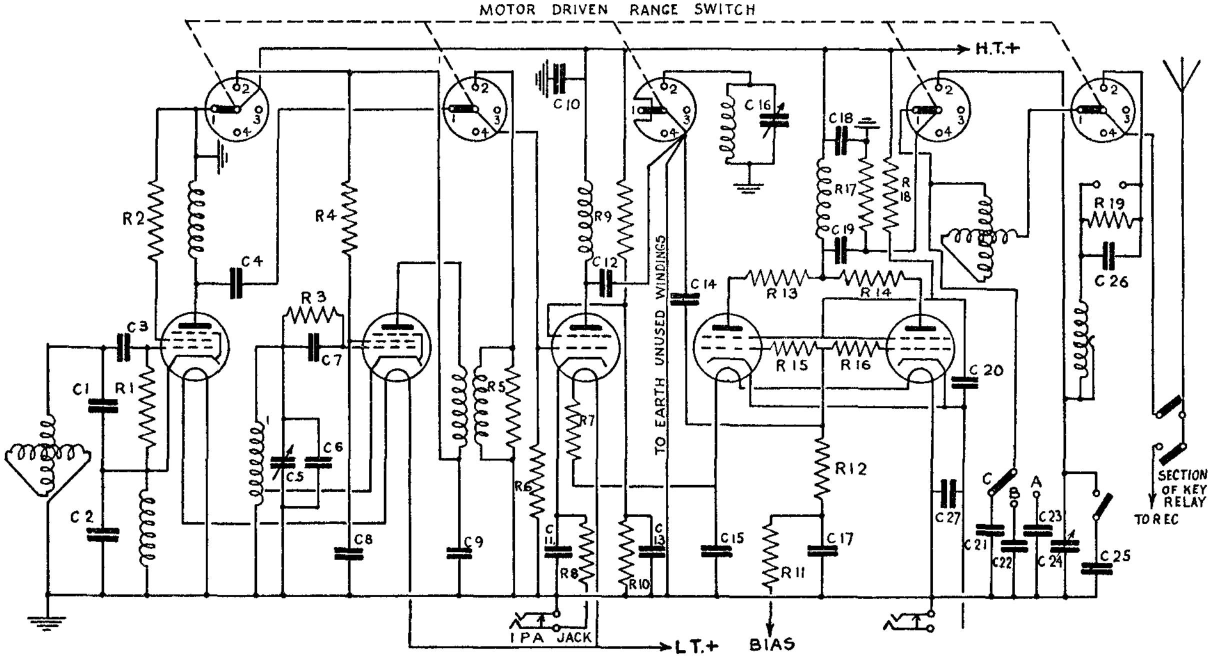


FIG. 93.—Circuit diagram transmitter, T.A. 12B.

(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

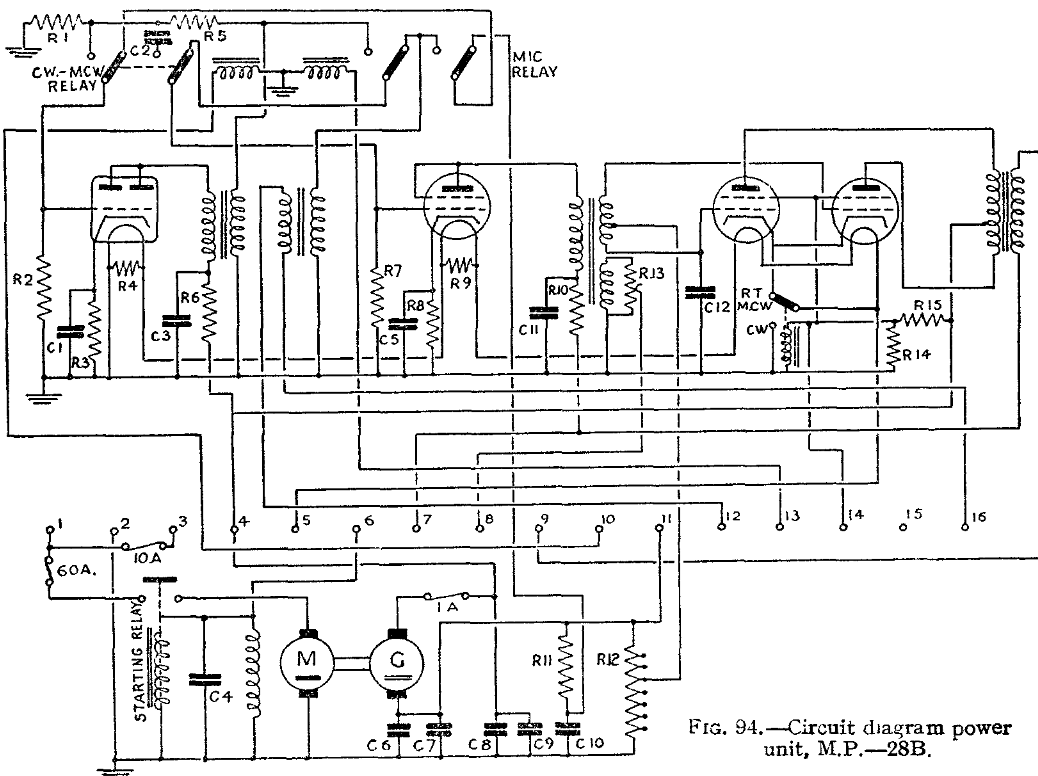


FIG. 94.—Circuit diagram power unit, M.P.—28B.

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 volt.

(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.

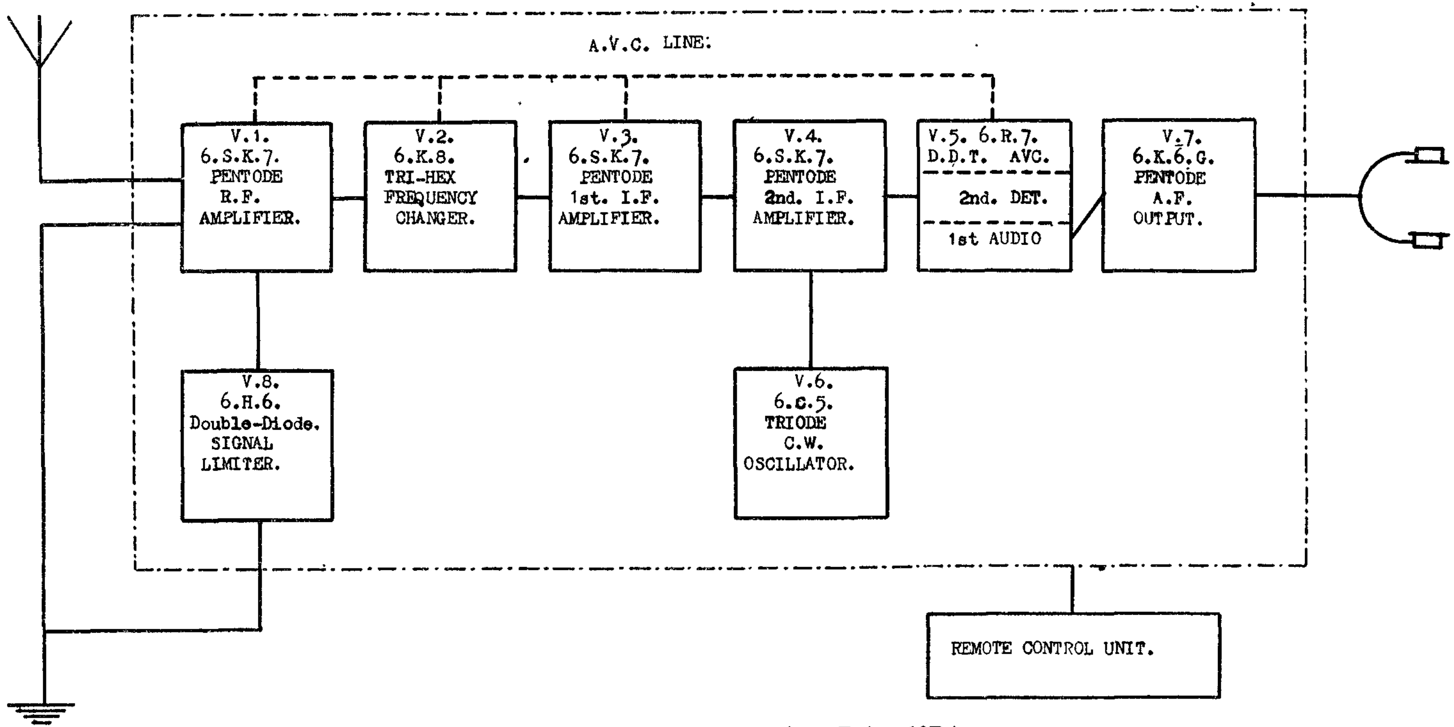


FIG. 95.—Block diagram receiver, R.A.—10DA

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		

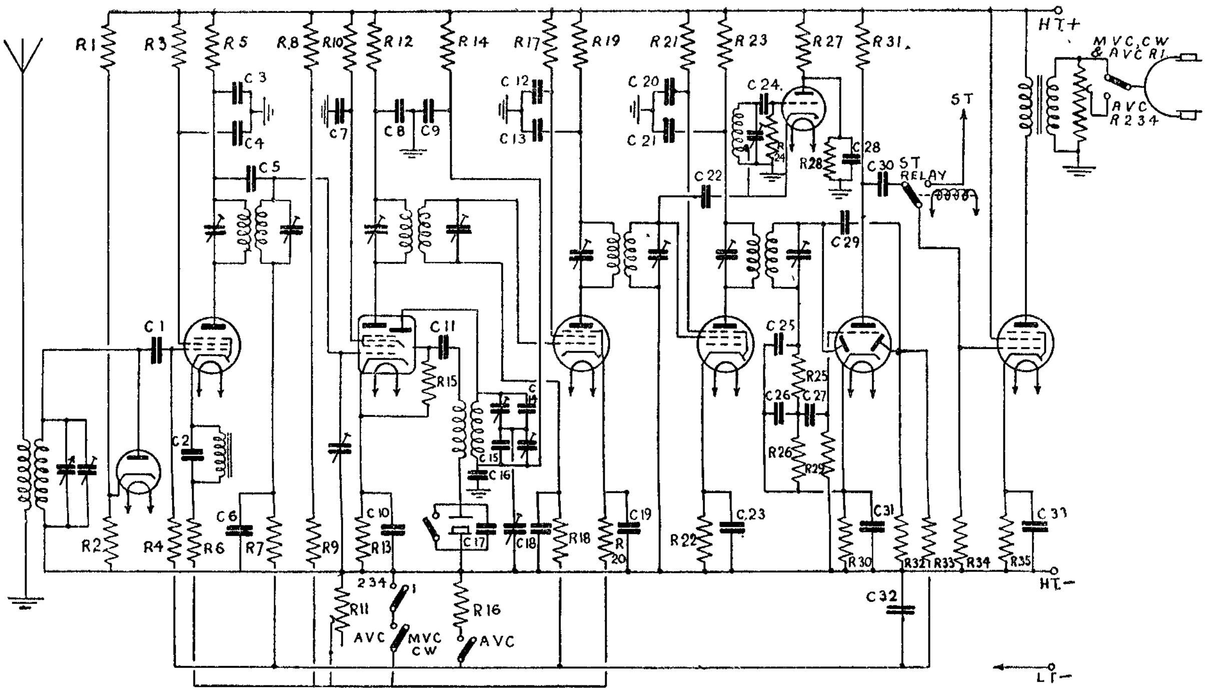


FIG. 96.—Circuit diagram receiver, RA—10DA

6. **Intercommunication Amplifier 3611** (fig. 97).—The amplifier is a two-stage high gain unit employing 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. gives 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.

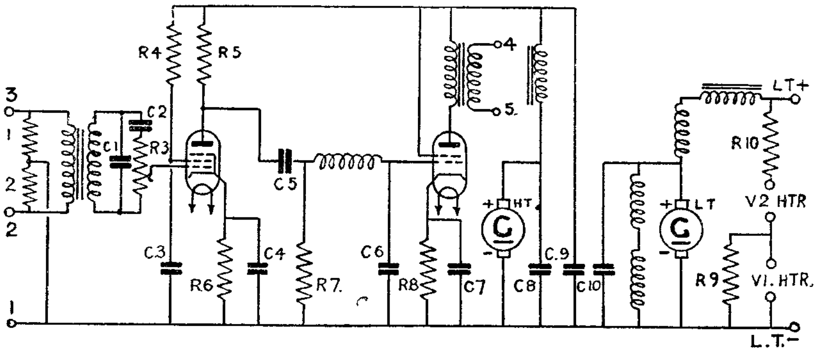


FIG. 97.—Circuit diagram I/C amplifier 3611.

VALUES

Resistances		Condensers	
1	500 Ω	1	100 $\mu\mu$ F
2	500 M	2	·0015 $\mu\mu$ 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.

9. **Radio Compass M.N.26.**—(i) *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.

(ii) *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.

(iii) *Theory of the radio 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.*

(iv) *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.

(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 aural 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) Select 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 aircraft to bring needle back to centre line.

(*c*) *Aural* :—

(1) Select range and tune to desired frequency.

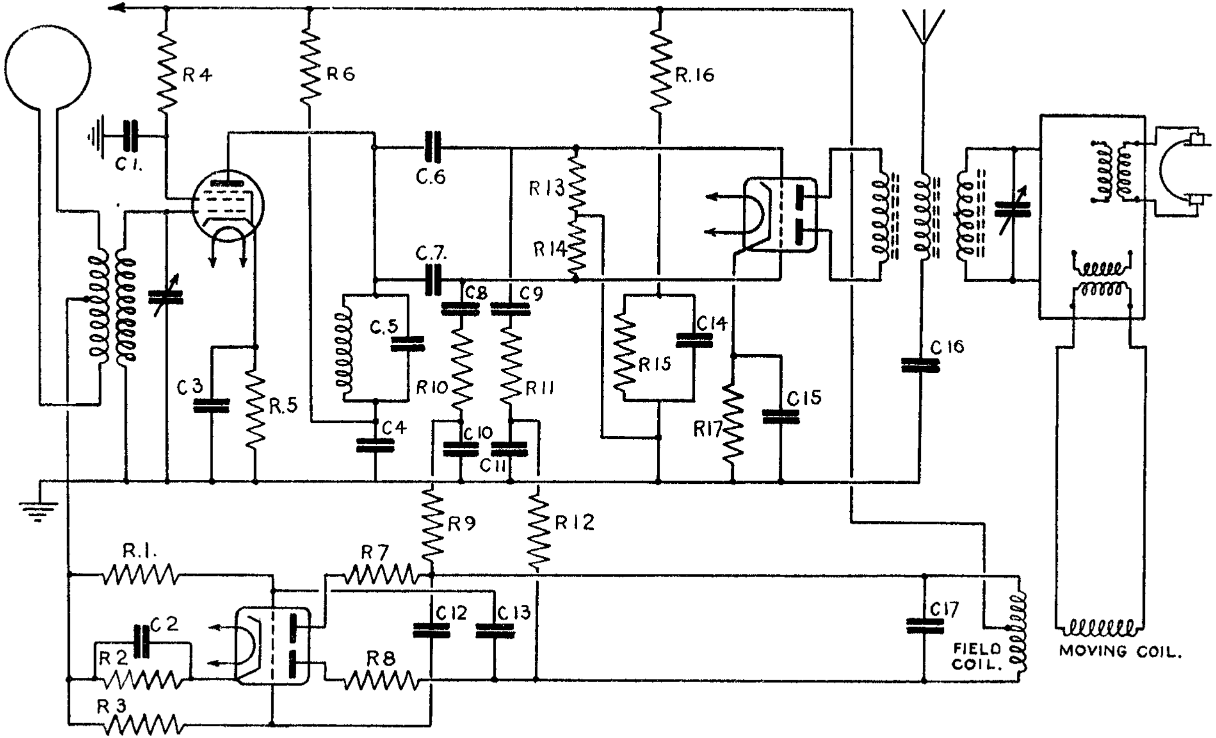
(2) Switch to " Rec. loop ".

(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



CHAPTER 23

BENDIX AIRCRAFT TRANSMITTER T.A.2J.24 AND ASSOCIATED EQUIPMENT

The associated equipment is similar to that used with the T.A.12B.

1. **Transmitter** (fig. 99).—(i) *Uses.*—Long-range aircraft transmitter for W., M.C.W. and R.T.

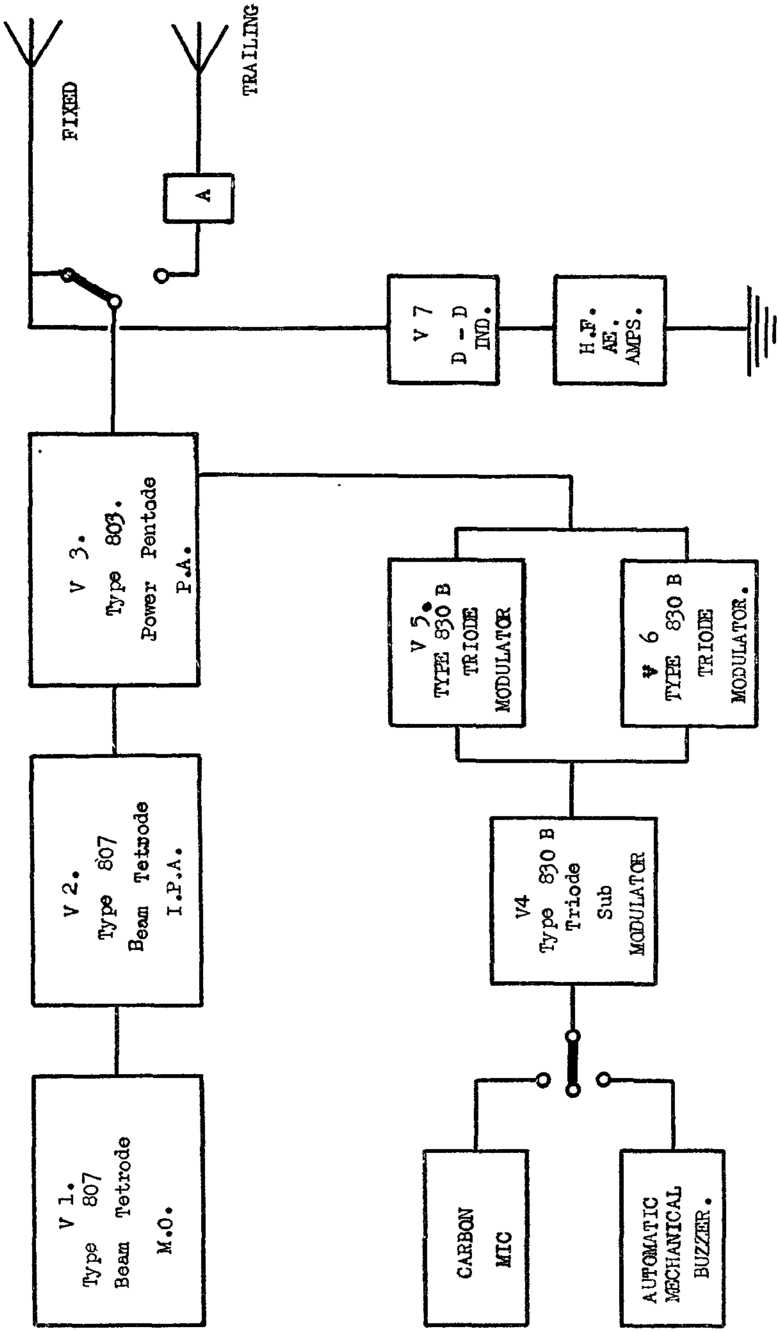


FIG. 99.—Block diagram transmitter, T A.—2J.

(ii) *Frequencies.*—Eight fixed frequencies in the bands 300–600 kc/s, 2·9–15 Mc/s.

(iii) *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.

(iv) *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.

(v) *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 amp. each.
C.W. and M.C.W.	45 amps.
R/T	37 amps.

(vi) *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 ; 1,000-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 ; 1,000-volt H.T. ; Modulators.
V.7 ..	Type 646 ; filament, 6·3-volt ; aerial current indicator.

Note.—Different filament voltages are obtained from 24-volt supply by dropping resistances.

(vii) *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. and 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, three 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.

(viii) *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.

(ix) *Setting-up instructions* :—

(*a*) 300–600 kc/s—

(1) Put meter plug into jack marked " amp. 1 ".

(2) Select channel to be used.

(3) Press key and note reading in mA.

(4) Insert screwdriver and rotate appropriate fine tuning control for dip.

(5) If no dip occurs, release key and change appropriate coarse tap inside unit.

(6) Repeat until a good output is obtained with dip occurring at 150mA (multiply meter reading by 100).

(*b*) 2,900–4,500 kc/s—(1) and (2) as above.

(3) Put both aerial and anode taps at centre of coil.

(4) Rotate coil with screwdriver for dip.

(5) If dip is below 150 mA, move aerial tap (on left) back, and turn coil clockwise for dip (multiply meter reading by 100).

(6) Repeat until dip occurs at 150 mA. This should coincide with maximum aerial current.

(*c*) 4,500–15,000 kc/s—(1) and (2) as above.

(3) Disconnect aerial.

(4) Rotate coil for dip ; at resonance this should be about 50mA. A dip to 100 mA indicates that a harmonic has been tuned to. (Multiply meter reading by 100).

(5) Replace aerial.

(6) Place aerial tap one turn from front end of coil, rotate coil for dip.

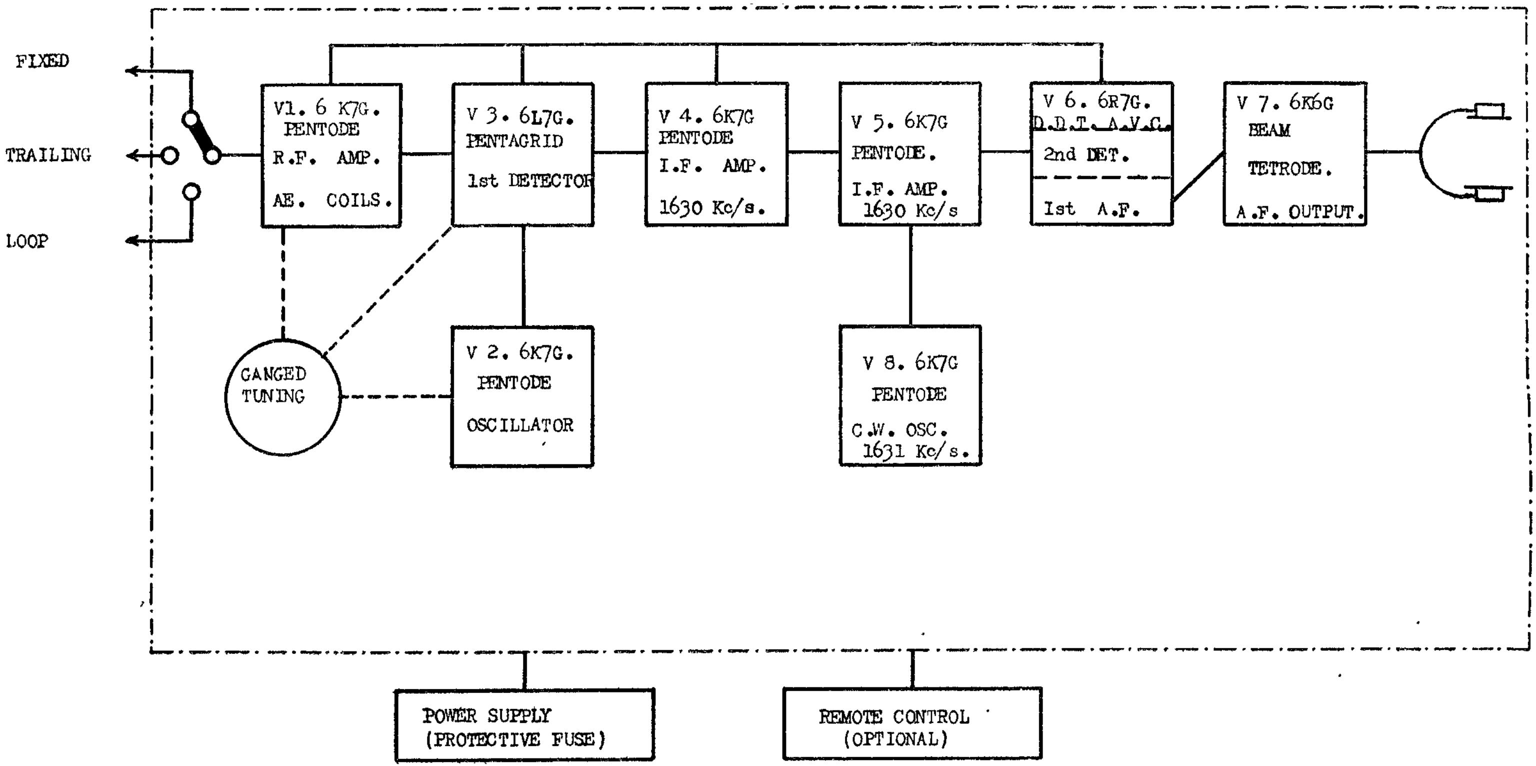
(7) Repeat, moving aerial tap forward and adjusting for dip, occurs at 150 mA.

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.

2. **Receiver R.A.1B** (fig. 100).—(1) *Uses*.—With aircraft transmitter, T.A.2J24.


FIXED
TRAILING
LOOP
V1. 6 K7G. PENTODE
R.F. AMP.
AE. COILS.
V 3. 6L7G. PENTAGRID
1st DETECTOR
V 4. 6K7G PENTODE
I.F. AMP.
1630 Kc/s.
V 5. 6K7G
PENTODE.
I.F. AMP.
1630 Kc/s
V 6. 6R7G.
D.D.T. A.V.C.
2nd DET.
Ist A.F.
V 7. 6K6G
BEAM
TETRODE.
A.F. OUTPUT.
GANGED TUNING
V 2. 6K7G.
PENTODE
OSCILLATOR
V 8. 6K7G
PENTODE
C.W. OSC.
1631 Kc/s.
POWER SUPPLY
(PROTECTIVE FUSE)
REMOTE CONTROL
(OPTIONAL)

(ii) *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.

(iii) *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.

(iv) *Aerial selector switch.*—Marked " D/F ", " Fixed " and " Trailing ". When in " trail " position a small condenser is inserted in series with aerial.

(v) *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, double diode triode	6R7G
V.7, output valve (beam tetrode)	6K6G

(vi) *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 pentigrid 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 an A.F. amplifier) and 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 A.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. voltage.

CHAPTER 24

RECEIVER R.1188 (R.C.A. A.R.77E)

1. **Purpose.**—Ground station communication receiver (American replacement for R.1084).

2. **Frequency Range.**—540 to 31,000 kc/s in six bands. I.F. is 455 kc/s.

3. **Valves.**—R.F. amplifier pentode, 6SK7; F.C. triode-hexode, 6K8; I.F. pentodes, 2, 6SK7; Det-limiter, double diode, 6H6; A.F. amplifier and A.V.C. double-diode-triode, 6SQ7; B.F.O. pentode, 6SJ7; Output, pentode, 6F6G; Rectifier, 5Z4; Stabiliser, V.R.150.

4. **Power Supplies.**—A.C. mains, 105 to 250 volts, 50/60 c.p.s. 70 watts.

5. **Aerials.**—A dipole is recommended. The R.A.F. model has a screened plug fitted for the accommodation of the co-axial feeder from a standard ground station aerial system. A vertical aerial of about 50-ft. length is also satisfactory.

6. **Circuit Details.**—Normal superhet circuit, with adjustable crystal filter between F.C. and first I.F. stages, giving a high degree of selectivity. A "noise limiter", also adjustable, is combined with the second detector. A tuning meter is fitted in the cathode circuit of the first I.F. stage. A.V.C. is fitted, but is switched out when receiving C.W. (the B.F.O. frequency is slightly adjustable) or when on "N.F.B.". In this position a degree of "negative feed back" is provided for quality reception of R/T.

7. **Tuning Procedure.**—(i) Switch on at volume control "V", turn to about three-quarters full volume and allow to warm up. Sensitivity control "S" to be fully "on".

(ii) Set T/R switch to "R", crystal and noise limiter to "OUT", and A.V.C. switch to "A.V.C." for R/T, or "B.F.O." for C.W.

(iii) Turn to range desired, and adjust aerial trimmer (centre knob) for loudest background noise.

(iv) The bandspread (right-hand main knob) only covers the 3, 5, 7, 14 and 20 Mc/s amateur bands. If reception is required outside these bands, this control should be set to the high frequency end of its scale. The main scale will then be found to be calibrated accurately in megacycles.

(v) The desired signal may now be tuned in on the main dial, slight adjustments being made on the arbitrary scale of the bandspread control if desired. Tune for maximum reading in the "S" meter.

(vi) In the case of R/T, the "S" control should be at maximum, and the volume adjusted by means of the volume control. For C.W., set the "V" control to three-quarter maximum, and use the "S" control for volume. The beat frequency can be adjusted at the control marked "H" if desired.

(vii) For high selectivity, switch in the required degree of crystal filtering. The filter must first be phased correctly. To do this, set the crystal filter to "4" and adjust the phasing control for minimum noise. (Use high gain and no signal.)

(viii) The noise limiter (N) may be brought in as required. To use this device, advance the "S" control to maximum, increase the "N" control and reduce the volume control until limiting takes place.

(ix) For quality reception of R/T, turn the A.V.C. control to "N.F.B." and increase volume as desired.

CHAPTER 25

TRANSMITTER T.1190

1. **Purpose**

The T.1190 is a modified form of the T.1087, and is used as a fixed or mobile crystal controlled ground station transmitter for C.W., or with the A.1104 for M.C.W. and R/T. It may be locally or remotely controlled, using remote control type 3 or 7.

2. **Frequency Range**

1·5 to 15 Mc/s.

3. **Valves**

(Seven) C.O. and Doubler, two pentodes V.T.96 or V.T.60A (tetrode) ; P.A. two tetrodes V.T.31 ; bias valve, double diode V.U.39 ; rectifiers, two M.V.Ds. V.U.29.

4. **Power Supplies**

Rectifier, type 11. (Similar to rectifier, type B—*see* chap. 20.) Input 230 volts 50 c.p.s. single-phase A.C. mains. Normal input 1½ kw. at 0·8 P.F. Obtained from A.C. mains, or mobile generating set.

Output—L.T. 14 volts 20 amps. A.C.
H.T. 1,700 to 3,000 volts, 500 mA.
D.C. (for relays) 12 volts, 2 amps.

5. **Aerial System**

See T.1087, Chap. 21, para. 5. Normally intended for ¼-wave vertical aerial, fed by low-impedance coaxial cable. Can be worked into a direct aerial system, or using aerial matching transformer, into 600-ohm. balanced feeder lines.

6. **Circuit**

Crystal-controlled pentode oscillator, followed by a pentode frequency doubler, driving a class B, P.A., consisting of two tetrodes in parallel. The C.O. and doubler valves, with associated components, are contained in adaptor, type 15 (fig. 106). The T.A.–X.G. oscillator is tuned by variable condenser and two plug-in coils. A coupling rod provides additional feedback from anode to grid between 1·5 and 4·5 Mc/s. The C.O. is capacity-coupled to doubler, the anode circuit of which is tuned by variable condenser and three plug-in coils to twice crystal frequency. P.A. is tuned by tapped inductance and variable condenser, and coupled to direct aerial by variable coupling condenser ; or to feeder lines via aerial matching transformer. (*See* figs. 104 and 105.)

C.O. and doubler are self-biased. Variable bias is applied to P.A. by means of full wave rectifier, V.U.39, working from 14 volts A.C.

Keying is by magnetic relay which makes and breaks H.T. negative and grid return to all valves. P.A. is grid-modulated. There is no neutralising, and no space frequency.

Small circuit alterations to adaptor, type 15, provide crystal fundamental working, using C.O. valve and anode circuit of doubler ; or M.O.P.A. operation, using doubler valve and anode circuit as Hartley oscillator.

CAUTION. Switch off the H.T. before making any changes which necessitate opening the doors of the transmitter. Do not rely entirely on the safety door switches. Although these switches isolate the power supply, the condensers of large capacity in various parts of the circuit take a few seconds to discharge. A period of 15 to 20 seconds should therefore be allowed to elapse after switching off and opening the doors, before any adjustments are made inside the transmitter. On C.W. or M.C.W. the condensers may be discharged by tapping the key, but even then allow the safety period to elapse. Always see that the main H.T. switch is off before unscrewing any of the side or back panels.

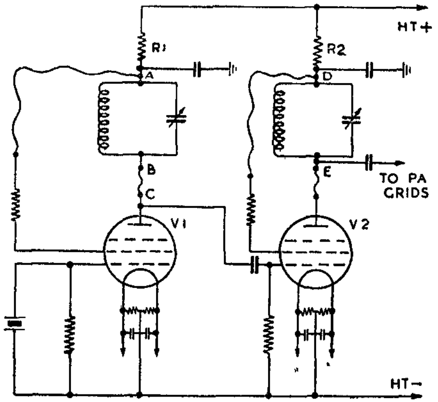


FIG. 101

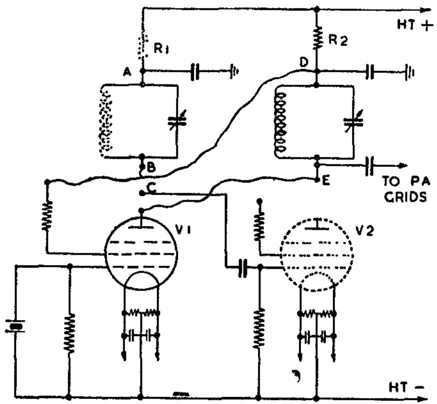


FIG. 102

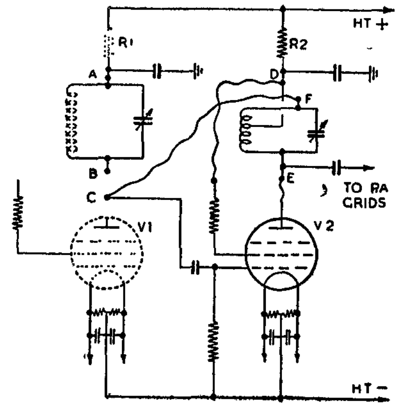
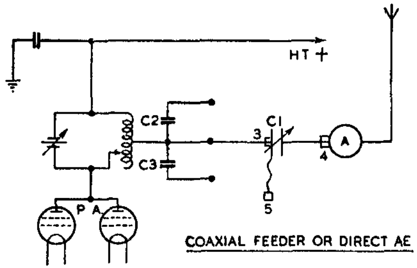
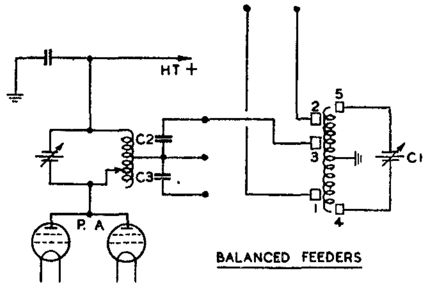


FIG. 103



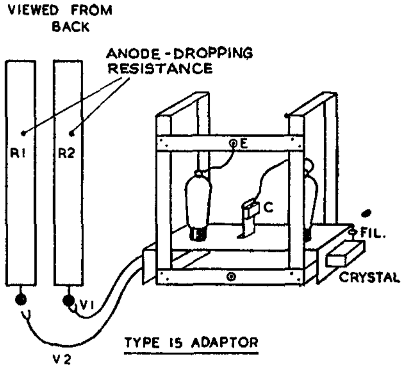
COAXIAL FEEDER OR DIRECT AE

ONLY PLUGS 3 & 4 USED 1 & 2 ARE LEFT LYING ON COMPARTMENT FLOOR. PLUG 5 MUST BE STOWED ON STOWAGE POINT ON TOP OF AERIAL VARIABLE CONDENSER



BALANCED FEEDERS

C2 & C3 ARE BLOCKING CONDENSERS C2 USED FOR FREQUENCIES BETWEEN 12–15 MC/S, AND C3 FOR 3 – 12 MC/S



TYPE 15 ADAPTOR

7. **Tuning Instructions—C.W.**

(i) *Normal doubler operation.* 3–15 Mcs. (*See* fig. 101.)

(*a*) Insert and connect adaptor.

(*b*) Insert crystal equal to half output frequency, and insert coupling rod if crystal frequency between 1·5 and 4·5 Mc/s.

(*c*) Plug in appropriate coils.
C.O.—" Q " coil 3–7 Mc/s. " P " coil 7–15 Mc/s.
Frequency doubler—" M " coil 3–6·5 Mc/s. " G " coil 6·5–13 Mc/s. " H " coil 13–15 Mc/s.

(*d*) Switch on all filaments and adjust C.O. to 12 volts. (6·3 volts, if V.T.60A used in place of V.T.96.) Adjust P.A. to 11·25 volts.

(*e*) Set P.A. coil taps according to tables; set frequency doubler P.A. condenser plugs and switch, according to frequency.

(*f*) Set output according to aerial (*see* figs. 104 and 105). If direct aerial used, set coupling condenser to zero.

(*g*) Set H.T. transformer switch to stud 1, and grid bias switch to 8.

(*h*) Switch on H.T., close key switch, and set remote control switch to " R/T."

(*i*) Tune C.O. for dip in mA meter, and set 5 mA on " slow " side.

(*j*) Reduce P.A. bias until P.A. mA meter reads 30 mA. Tune doubler for maximum.

(*k*) Tune P.A. for minimum.

(*l*) If using direct aerial, increase aerial coupling 5 to 10 degrees at a time, readjusting P.A. tuning for a dip in mA meter until, at bottom of dip, meter reads 100 mA.

(*m*) Adjust grid bias to give maximum safe power. (H.T. watts input minus aerial watts = 500 or less.) This is normally stud 0, if P.A. correctly loaded.

(*n*) Set remote control switch to " C.W."

(ii) *Crystal fundamental operation.* 1·5–3 Mc/s. (*See* fig. 102.) Assuming that transmitter is already set up for normal doubler operation :—

(*a*) Disconnect screen lead of doubler valve.

(*b*) Connect screen lead of C.O. valve to R.2. Remove R.1.

(*c*) Place anode connector of doubler on C.O. valve. Remove anode connector of C.O. and store in transit case.

(*d*) Switch off doubler filaments or remove valve.

(*e*) Remove C.O. coil and set tuning condenser at zero.

(*f*) Insert crystal equal to output frequency.

(*g*) Plug in appropriate coil in doubler stage—" R " 1·5—3 Mc/s., " M " 3–6·5 Mc/s, " G " 6·5–7·5 Mc/s.

(*h*) Switch on and tune as before, except that C.O. is now tuned by doubler condenser.

(iii) *M.O.P.A. operation.* 1·5–15 Mc/s. (*See* fig. 103.) Assuming that transmitter is already set up for normal doubler operation :—

(*a*) Remove C.O. valve, anode connector and C.O. coil.

(*b*) Disconnect screen lead of C.O. valve and remove R.1.

(*c*) Remove link between C and B on C.O. tuning condenser.

(*d*) Connect link between C and F on doubler tuning condenser.

(*e*) Insert coil in doubler stage. " S "—1·5 to 3 Mc/s, " N "—3 to 6·5 Mc/s, " K "—7 to 15 Mc/s.

(*f*) Switch on and set doubler condenser, which now tunes Hartley master oscillator, for correct frequency by wavemeter. Tune P.A., and load aerial, as for normal operation.

Note.—A reduced output will be obtained, and M.O.P.A. operation is only intended when a crystal is not available. Procedure for setting up T.1190 for R/T and M.C.W. is similar to that for T.1087, chap. 21, para. 7.

Servicing and Fault Finding

(i) General servicing as for T.1087, chap. 21, para. 8.

(ii) Grid bias rectifier valve filaments require 30 secs. to warm up, and if P.A. crate is removed, this time delay should be allowed before switching on H.T., or excessive P.A. current due to no bias will result.

(iii) If, when on normal doubler operation, decreasing bias does not give increase in output, doubler is probably tuned to fundamental and doubling is taking place in P.A. stage. Rotate doubler tuning towards zero until another tuning point is found.

CHAPTER 26

TONE TO LINE KEYING

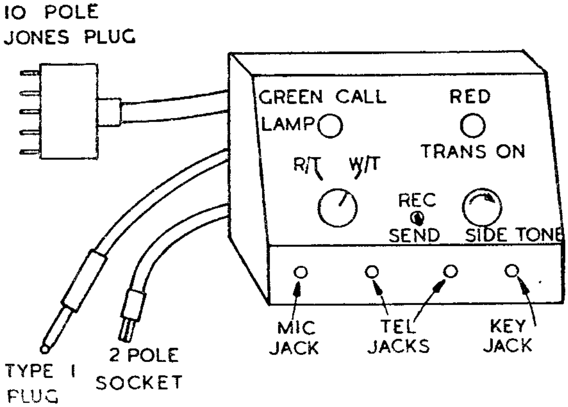


FIG. 107.—CONTROL UNIT, TYPE 88

1. General

At receiving station, a control unit, type 88, with a 24-volt supply replaces the switch, type 44, tumbler switches, repeater coil and microphone transformer used with "impedance keying" type of remote control. This control unit contains an A.F. oscillator, and a current alternating at 1,500 c.p.s. is applied to the buried lines when morse key is pressed. At the transmitting station, the remote control, type 3, is employed, with modifications so that the A.F. oscillator in the local control panel now acts as an A.F. pre-amplifier for the A.F. oscillations from control unit, which are further amplified by A.1104 before being rectified, and fed to keying relay.

Provision is made for remote control of transmitter H.T. supply, but not of filament supply, which must be switched on at transmitter all the time. The filament relay and switch are removed from remote control, type 3.

Whilst transmission is in progress, a side-tone control reduces the sensitivity of the receiver, to avoid possibility of local transmission overloading receiver.

A red lamp indicates that send/receive switch is at "send" and a green lamp may be used as a call light for controller working.

2. Operation (*see* fig. 108)

(i) *Switching on.* Putting send/receive switch on control unit, type 88, to "send", contact from battery positive is made to centre part of repeater coil in unit, and equal currents are established through lines A and B to centre of repeater coil at controlled end, via H.T. switching relay to earth; thence to earthed negative of 24-volt supply. A circuit is also made through red "trans. on" indicator lamp. A variable resistance is put in series with potentiometer, varying R.F. gain of receiver so that pick-up from local transmitter can be controlled to a suitable level for side-tone. In the "receive" position of the switch, battery positive to A and B lines and "trans. on" lamp is broken, and side-tone resistance is shorted out.

(ii) *R/T.* With R/T–W/T switch in R/T position and send/receive switch to "send", limited energising current for carbon microphone is obtained from 24-volt battery. Speech currents are applied via a transformer to primary of repeater coil, thence by lines to repeater coil at controlled end. With switch on local control panel at "600 ohm input", the secondary of this coil is connected via matching transformer to input of modulation amplifier A.1104.

(iii) *W/T.* With R/T–W/T switch in W/T position and send/receive switch to "send", filaments supply to tone oscillator valve V.T.20 is completed (110 ohm resistance limits filament voltage to 2 volts), and when key is pressed 24-volts positive is connected to anode. The

A.F. oscillations are fed via R/T-W/T switch to repeater coil at controlled end, where, with switch on local control panel in "pre-amplifier" (A.F. oscillator) position, they are amplified, rectified and fed to keying relay.

(iv) *M.C.W.* Local transmission of M.C.W. is not possible with this system. Remote transmission of M.C.W. can be achieved by placing the R/T-W/T switch on the control unit, type 88, to W/T, whilst that on the remote control, type 3, at the distant transmitter is at R/T. This entails the radiation of a continuous carrier by the transmitter, and is not used in practice.

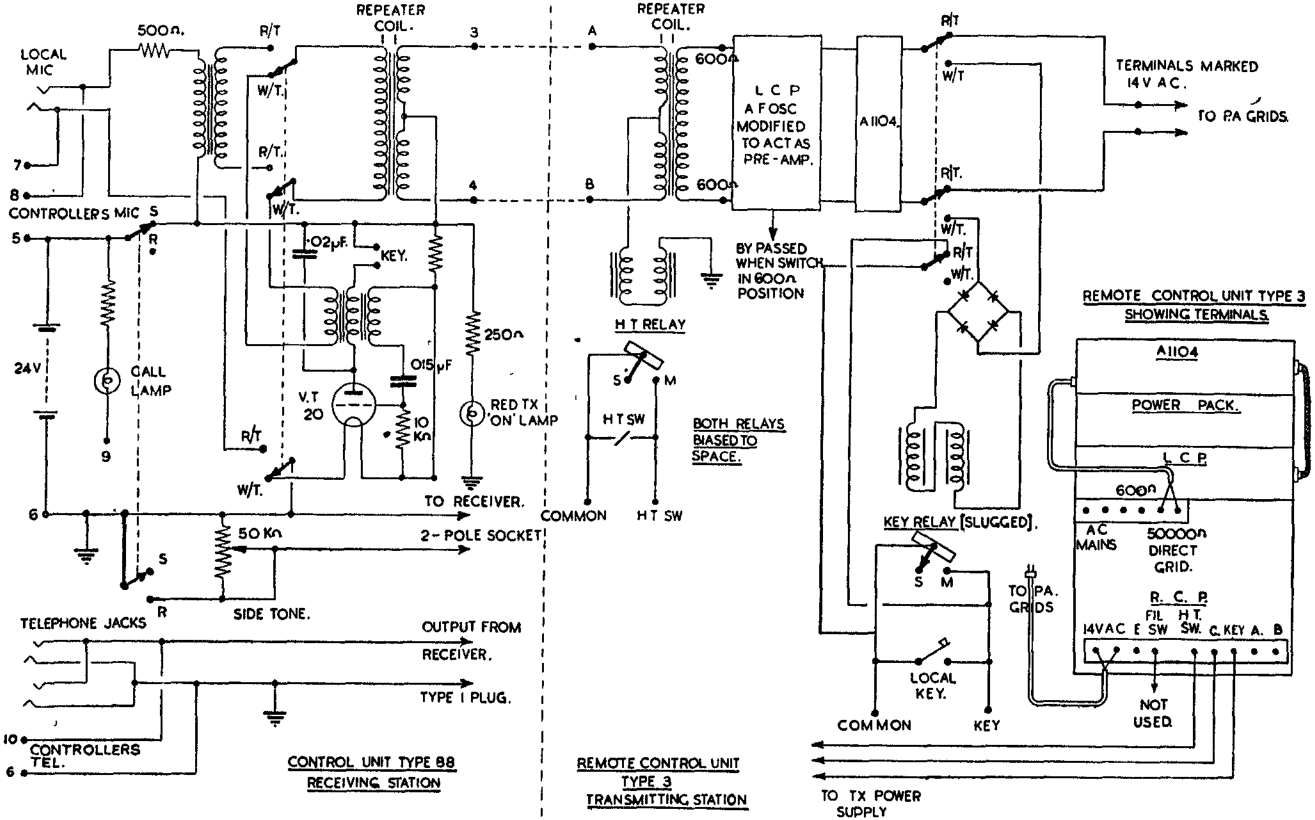


FIG. 108.—TONE TO LINE KEYING

CHAPTER 27

WAVEMETER W.1191

1. Purpose

The initial setting up, and subsequent frequency checking of ground or airborne transmitters and receivers. (Crystal check available giving 0·1 per cent. accuracy.)

2. Frequency Range

100 kc/s to 20 Mc/s.

3. Valves

Directly heated—not specially selected.

V.R. 82 triode-heptode; triode portion—T.R.F. "Hartley" oscillator heptode portion—mixer.

V.T.50 triode—leaky grid detector.

V.R.19 triode—untuned "Pierce" oscillator.

V.T.50 triode—audio frequency oscillator or amplifier.

The Pierce oscillator performs two functions :—

(i) Supplies a source of crystal controlled energy.

(ii) Operates as a crystal frequency check for the T.R.F. oscillator.

4. Spare Valves

Carried in transit case—V.R.82, two; V.T.50, one; V.R.19, one.

5. Crystal

A 1,000 kc/s crystal is incorporated, for crystal check purposes.

6. Power Supplies

H.T., 60-volt dry battery.

L.T., 2-volt—7 amp. hrs., accumulator. Carried at an angle of 45 degrees to prevent acid leakage during use.

7. Aerial System

Rod aerial supplied as part of the equipment.

8. Circuit Details

Block schematic (fig. 109) shows functioning of the stages for each method of operation.

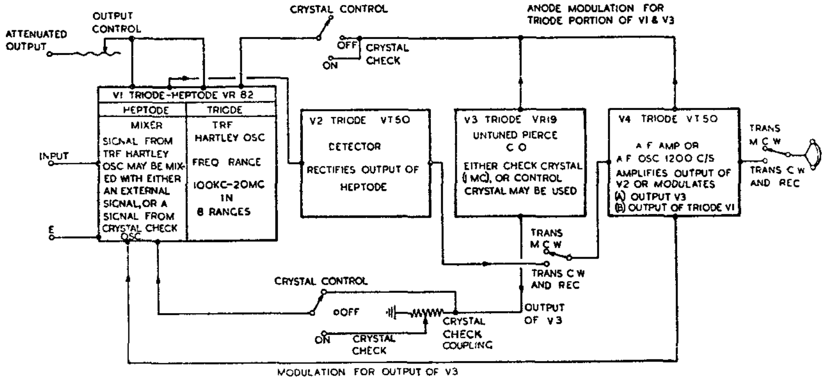


FIG. 109.—BLOCK SCHEMATIC WAVEMETER W1191

9. Setting Up

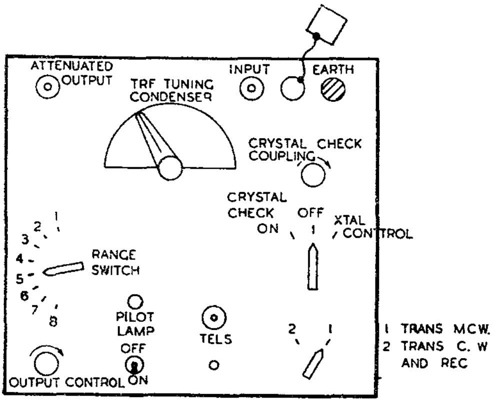
(i) *As heterodyne wavemeter to set up a transmitter, using the Hartley circuit as a local oscillator.* In this case the Hartley circuit must be tuned to the desired frequency with the aid of the crystal check oscillator and calibration chart, as follows :—

(*a*) Plug rod aerial into " input " position.
(*b*) Trans/rec. switch to " Trans. C.W. " and " Rec." position.
(*c*) Crystal switch to crystal check " On " position.
(*d*) From calibration chart, find approximate range and set range switch.
(*e*) Find nearest check point above the required frequency, and set oscillator tuning condenser approximately to check frequency marked on dial.
(*f*) Switch on wavemeter, plug in 'phones, tune for dead space. This is obtained because T.R.F. oscillator (fundamental frequency or a harmonic) is beating with the fundamental or a harmonic of the check crystal, both oscillators being " mixed " in the heptode portion of V.1, detected by V.2 and the resultant A.F. voltages amplified by V.3.

Note.—Set crystal check coupling so that beat note is only just heard.

(*g*) Look down column 1 of calibration chart from " Crystal check " frequency and see if required frequency is shown. If so, increase tuning condenser reading by number of divisions given in column 2. If not, number of divisions to be added must be calculated.

e.g., Suppose frequency required is 5,840 kc/s. From calibration chart, the nearest check frequency above is 6,000 kc/s, and since 5,840 kc/s lies between 5,900 and 5,800 kc/s the number of divisions to be added to the condenser setting must lie between 4·18 and 8·00, and will be less than 8·00 by the number of divisions corresponding to 40 kc/s.



SECTION OF A CALIBRATION CHART

W1191 SERIAL No 199 RANGE 6	
MC/SEC	INCREMENTAL DIAL DIVISIONS
6.0	CRYSTAL CHECK
5 9	4.18
5 8	8 00
5 7	11 51
5.6	14 87
5 5	18 05
5 4	21 10
5 3	24 06
5 2	26 94
5 1	29 73
5.0	CRYSTAL CHECK
4 9	2 70

FIG. 109A—FRONT PANEL W1191

For 5,800 kc/s condenser reading increased by 8·00 divisions.
,, 5,900 ,, ,, ,, ,, ,, 4·18 ,,
,, 100 ,, ,, ,, ,, ,, 3·82 ,,
,, 1 kc. ,, ,, ,, ,, ·0382 ,,
,, 40 kc/s ,, ,, ,, ,, ·0382 × 40 divisions
= 1·528 divisions.

So that for 5,840 kc/s, condenser reading must be increased by 8·00–1·528 = 6·472 divisions.

(*h*) Crystal switch to crystal check " Off " position.
(*j*) Tune transmitter for dead space in W.1191 telephones.

(ii) *As a heterodyne wavemeter to set up a transmitter, using crystal oscillator as local oscillator.*

(*a*) and (*b*) as in (i).
(*c*) Plug in crystal of required frequency in external socket.
(*d*) Crystal switch to " crystal control " position.
(*e*) Switch on W.1191 and transmitter. Tune transmitter for dead space.

(iii) *As a heterodyne wavemeter to measure the frequency of a transmitter.*

(*a*) and (*b*) as in (i).
(*c*) Crystal switch to crystal check " Off " position.
(*d*) Switch on wavemeter and plug in 'phones.
(*e*) Switch on transmitter.
(*f*) Tune triode oscillator for dead space, using main tuning control, and making final adjustment with vernier control.
(*g*) Note carefully position of range switch and reading of tuning condenser.
(*h*) Switch off transmitter.
(*j*) Crystal switch to crystal check " On " position.
(*k*) Set coupling to " Max ". Rotate tuning condenser anti-clockwise until a beat note is heard, and then reduce coupling until beat can just be heard. Set at dead space.
(*l*) Note carefully reading of tuning condenser and frequency of crystal check point from dial.
(*m*) Subtract (*l*) from (*g*) and calculate from chart provided, the frequency to be deducted from crystal check.

(iv) *As a signal generator, to set up a C.W. or R/T receiver, using T.R.F. oscillator.*

(*a*) Plug rod aerial into " attenuated output " position. Output control to " maximum ".
(*b*) to (*h*), as for (i).
(*j*) Trans/rec. switch to " Trans. C.W." position for C.W. receiver or " Trans. M.C.W." for R/T receiver.
(*k*) Plug 'phones in receiver and tune for dead space (C.W.), or maximum signal (R/T receiver). Make use of attenuator for final setting-up.

(v) *As a signal generator to set up a C.W. or R/T receiver, using crystal oscillator.*

(*a*) Plug rod aerial into " attenuated output " position. Output control to " maximum ".
(*b*) Plug in external crystal of desired frequency.
(*c*) Crystal switch to " crystal control " position.
(*d*) Trans/rec. switch to " Trans. C.W." position for C.W. receiver or " Trans. M.C.W." for R/T receiver.
(*e*) Plug 'phones in receiver and tune for dead space (C.W.), or maximum signal (R/T receiver). Make use of attenuator.

0. **Precautions in Use and Servicing**

(i) Ensure calibration chart has same serial number as wavemeter.

(ii) Wavemeter must be handled with great care, as it is a precision instrument.

(iii) H.T. battery must be tested frequently on load, and discarded when the voltage falls below 40.

(iv) L.T. accumulator must be inspected frequently, tested on load, and changed when voltage falls below 1·85 volts. Terminals to be kept greased and free from corrosion.

(v) When changing V.R.82, adjust preset condenser across main tuning condenser by means of insulated screwdriver, so that main crystal check beats agree with approximate markings on dial.

CHAPTER 28

TRANSMITTER-RECEIVER T.R.1196 and T.R.1196A

General Details

(i) *Purpose.* A light-weight self-contained crystal controlled R/T and M.C.W. transmitter-receiver for use in aircraft or on the ground. All crystals are incorporated and the set may be tuned to four spot frequencies; remote push button tuning is employed (controllers, electric, type 4, having buttons A, B, C, D and Off).

(ii) *Frequency range.* 4·3 to 6·7 Mc/s.

(iii) *Communication range.*
Air to ground 50 miles at 2,000 feet.
Air to ground 35 miles at 2,000 feet (channel D only).
Air to air 30 miles at 2,000 feet.

(iv) *Valves.*
(*a*) Transmitter—three; C.O., pentode V.R.91; P.A. tetrode V.T.501; modulator, pentode V.T.52.
(*b*) Receiver—six; R.F. amplifier, pentode V.R.53; frequency changer, octode V.R.57; I.F. amplifier, pentode V.R.53; A.F. amplifier, pentode V.R.56; A.G.C. amplifier, pentode V.R.56; det., A.G.C. and output, double-diode triode, V.R.55.

Power Supplies—Built-in Motor Generator

(i) Power unit, type 87, for T.R.1196—24 volts 2·5 amps. Supplied by the aircraft 24-volt supply.
Power unit, type 104, for T.R.1196A—12 volts 5 amps.

(ii) Output is the same in both cases.

(*a*) Transmitter.	H.T., 250 volts 60 mA.	L.T., 6·3 volts 1·3 amps.
(*b*) Receiver.	H.T., 275 volts 35 mA.	L.T., 6·3 volts 1·2 amps.

Aerial System

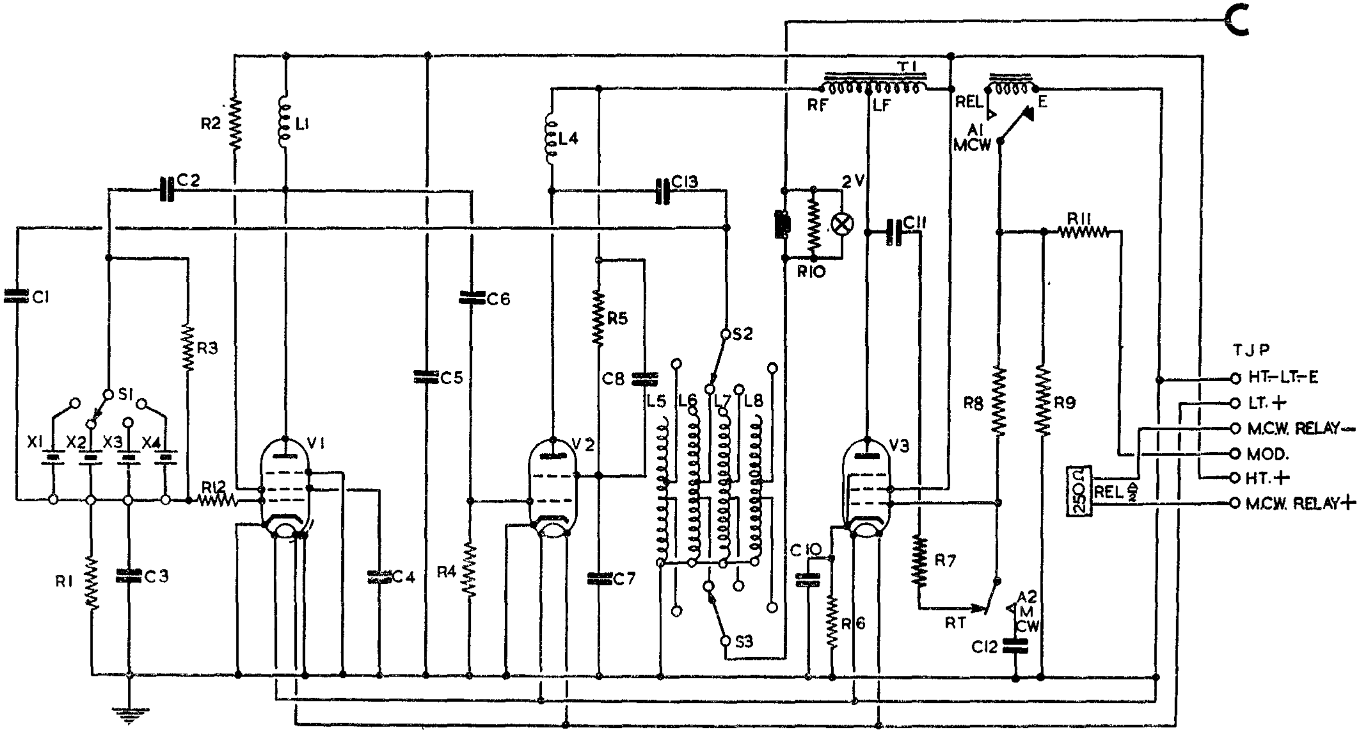
(i) *In the air.* Aircraft fixed aerial approximately 28 feet; capacity between 45 and 140 $\mu\mu$F.

(ii) *On the ground.* Vertical single wire length $= \dfrac{240 \text{ feet}}{\text{freq. in Mc/s.}}$
A 125 $\mu\mu$F condenser is connected in series with the aerial and a 500 $\mu\mu$F condenser between aerial and earth terminals.

Circuit Details

(i) *Transmitter unit, type 22* (*fig.* 110). Crystal controlled oscillator driving anode-screen modulated class " C " neutralised P.A. stage. Both valves use leaky grid and condenser bias. The modulator valve is preceded by a sub-modulator consisting of the A.F. stages of the receiver unit. This stage can also be transformed into a tone oscillator (800 to 1,500 c.p.s.) by the energising of the M.C.W. relay. The four aerial tuning inductances are selected by the push button operated selector motor.

(ii) *Receiver unit, type 25* (fig. 111). The transmitter aerial circuit is the aerial circuit of the receiver. The secondary of the R.F. transformer load is tuned by four variable condensers, selected, with the R.F, oscillator crystals, by the selector mechanism. The octode frequency changer includes the " Pierce " R.F. oscillator and has a 460 kc. I.F. transformer as its anode load. The frequency-changer output is coupled to the I.F. amplifier V.3, and A.G.C. amplifier V.4. The cathode circuits of V.2 and V.3 are used in conjunction with the " R.A." control (*see* below). V.3 is coupled to one of the diodes of D.D.T. (V.6) for detection, the load being the preset volume control. The A.F. voltages are coupled


C
T1
RF
LF
REL
E
A1
MCW
2V
R10
C11
R11
R2
L1
L4
C2
C13
C1
C6
R5
R3
S2
C5
C8
S1
L5
L6
L7
L8
X1
X2
X3
X4
V1
V2
V3
R8
R9
TJP
HT-LT-E
LT. +
M.C.W. RELAY –
MOD.
HT. +
M.C.W. RELAY +
250Ω
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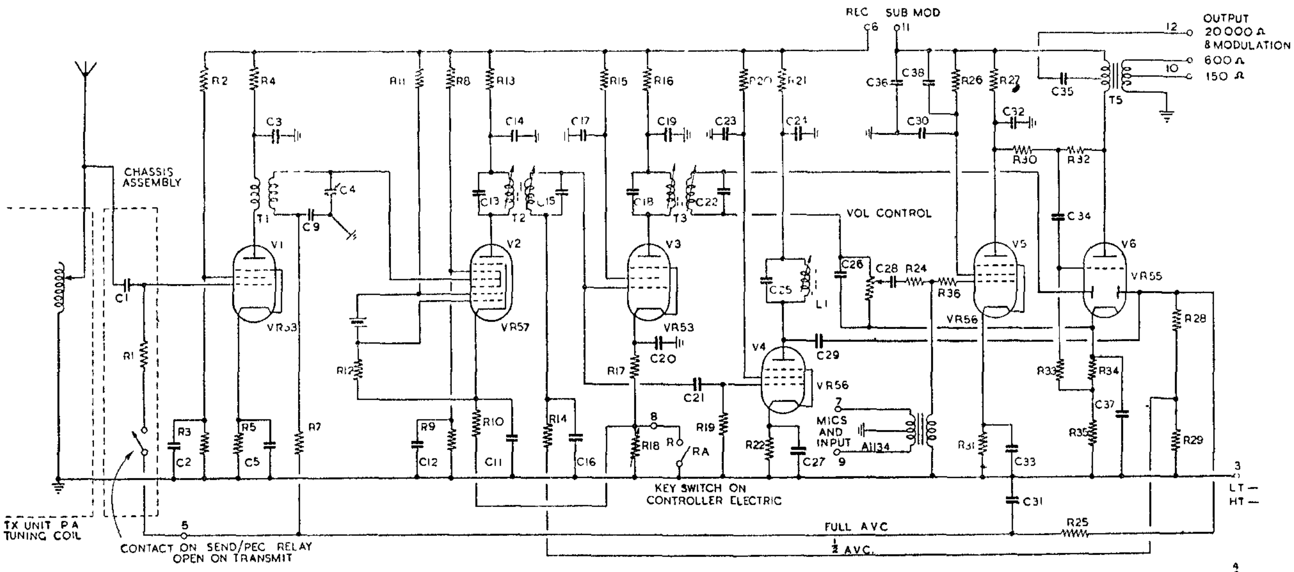
M
CW
C12
S3



CONDENSER VALUES

C1.	50 PF
C2, C3, C9, C11, C28 C34 C5	·01 μF
C4, C8	VAR
C12, C14, C16, C17 C19 C20, C23 C24, C27 C30 C31, C33 C36 C38	1 μF
C13, C15, C18, C22	150 PF
C21, C29.	100 PF
C25, C26	200 PF
C32.	500 PF*
C35	5 μF
C36	2 μF

RESISTANCE VALUES

R1, R7, R14, R25, R28 R29, R33	1 MΩ.
R2, R8, R9 R15, R23, R30	1 MΩ
R3, R20	2 MΩ
R4, R13 R16	2 KΩ
R5, R10	400 Ω
R19, R24 R32, R36	·5 MΩ
R31, R34 R35	600 Ω
R17	200 Ω
R18 R21	5 KΩ
R11, R12	50 KΩ
R22	500 Ω.
R28	25 MΩ
R27	60 KΩ

via the secondary of the microphone input transformer to the A.F. amplifier and the triode output portion of the D.D.T. (V.6). The tapped primary of the output transformer provides for high impedance telephones, the secondary winding provides for alternative outputs: the whole for 600-ohms working, and a tapping for 150-ohms 'phones. Amplified and delayed A.G.C. voltage is applied in full to the R.F. and frequency changer stages, half the A.G.C. voltage to the I.F. stage.

5. Control of T.R.1196

Uses controller, type 4, situated in the pilot's cockpit, and connected to the chassis assembly, type 7 (or type 8 for T.R.1196A). Pressing any button results in the energising of the B (starter) relay. The T/RA/R key switch controls the operation of the T/R relay, and the receiver attenuation switching.

(i) *T/R relay in chassis assembly.* When operative, switches H.T.+ from the receiver R.F. and I.F. stages to the transmitter.

(ii) *Receiver attenuation control.* On switching from "R" to "R.A." the receiver gain is attenuated; a preset variable resistance is brought in series with the cathode resistors of V.2 and V.3, reducing the gain of both stages, this reduces the background noise in the absence of a signal and makes for clearer I/C. In later versions the pre-set variable resistance is transferred to the receiver output circuit, and is connected in series with the output to A.1134 or A.1134A.

6. A.1134A

(i) When it is necessary to feed more than three pairs of 'phones, the A.1134A is used. The crews' microphones are connected to the amplifier and to the microphone input transformer, T.4, of the receiver unit. T.4 has two main uses:—

(*a*) To match the microphone voltages to the receiver sub-modulator stages (V.5, V.6), for modulation of the transmitter.

(*b*) To provide receiver output at microphone level, for amplification through the A.1134A.

(ii) If the A.1134A is u/s, or not in use, I/C is possible through the A.F. stage of the receiver, the telephones being placed across the output transformer of the receiver (normal/emergency switch of panel 192).

7. Tuning Instructions

(i) *Transmitter.* The transmitter must be tuned first.

(*a*) Insert crystals, set counter mechanism to 0–0, select the required channel and switch to "Transmit".

(*b*) "Press to tune" button held while the channel P.A. inductance is adjusted until indicator lamp attains maximum brilliance.

(*c*) Test for modulation by speaking into the microphone and noting the variation in brilliance.

Note.—Since channel D has been modified by the inclusion of an 1,800-ohm resistance in the output circuit, normal tuning may not be possible on this channel. Any one of the following alternative methods may be used:—

(*a*) Remove shunt from across indicator lamp and tune as before.

(*b*) Use an external aerial ammeter.

(*c*) Remove transmitter screening can, hold down M.C.W. relay (or press key if connected) and tune for the lowest note in the telephones.

(*d*) Substitute 150 mA tuning lamp for 300 mA lamp in normal use.

(ii) *Receiver.*

(*a*) Insert crystals (± 460 kc/s from transmitter crystals), crystals should be + 460 kc/s in aircraft, and — 460 kc/s in receiver used on the ground. Switch on A.1134A, with panel 192 switch to "Normal". (If no I/C amplifier used, panel 192 switch should be at "Emergency").

(*b*) Receiver volume control set at " Maximum " ; controller switch at " R ".

(*c*) Adjust appropriate condensers for maximum background noise.

(*d*) Ground test and get minimum setting of the volume control for adequate output.

(*e*) Set key to " R.A.", and under normal operating conditions adjust the R.A. control so that the background noise of the receiver is reduced. to allow efficient I/C and give adequate gain for " Listening out "

Servicing

(i) Feed to the transmitter may be tested by a fall in the generator note on switching to transmit.

(ii) Tests for H.T. :—

(*a*) Remove top cover of chassis assembly and place meter across T/R relay or watch the sparking of the relay when switching from " R " to " T ".

(*b*) Remove transmitter cover, when the P.A. anode and screen voltage can be tested between the end of choke L.4 and chassis.

(*c*) With the receiver, test between the crystal socket of the channel in use and chassis, for indication of H.T. on the R.F. Osc., portion of V.2.

(iii) Eliminate receiver trouble by testing the sub-modulator stages, i.e. V.5 and V.6 by microphone and 'phones of known reliability. If A.F. portion serviceable, fault must be in the R.F. or I.F. stages.

CHAPTER 29

W/T INSTALLATION IN AIRCRAFT

1. Installation of Equipment T.R.1143 or T.R.1133

V.H.F. R/T equipment is installed on most fighter aircraft in the space immediately to the rear of the pilots' cockpit. It consists of Transmitter-Receiver, Power Unit, Junction Box and Connectors, and an Electric Controller for remote control of the equipment. In bomber aircraft the T.R.1143 may be fitted in any convenient position.

(i) *The Transmitter Receiver* is mounted on a removable crate which is fitted with shock absorbers. This crate fits on to two slides which are bolted across the interior of the fuselage, and is secured in position by means of a collar and wing nut.

(ii) *The Power Unit* may be mounted either :—
(*a*) on the same crate as the Transmitter-Receiver, or
(*b*) inversely underneath the two slides (e.g. Spitfire).
A 20 amp. fuse is inserted in the positive input lead to the Power Unit and is located on the aircraft electrical panel (*see* Fig. 112).

(iii) *The Junction-Box* with its associated connectors is securely bolted to the airframe near to the Transmitter-Receiver. Neither the junction-box nor the connectors should be removed from the aircraft unless suspected of being faulty, or during a major overhaul. Great care should be taken, when disconnecting the connectors from the equipment, to see that the locking rings on the " W " sockets are not loosened, otherwise the interior cables will become disconnected.

(iv) *The Electric Controller* is mounted on a detachable mounting situated on the left-hand side of the pilots' cockpit and connected to the junction-box.

Inspections are carried out in accordance with Air Ministry Orders, Unit Servicing Orders, and the appropriate servicing schedule.

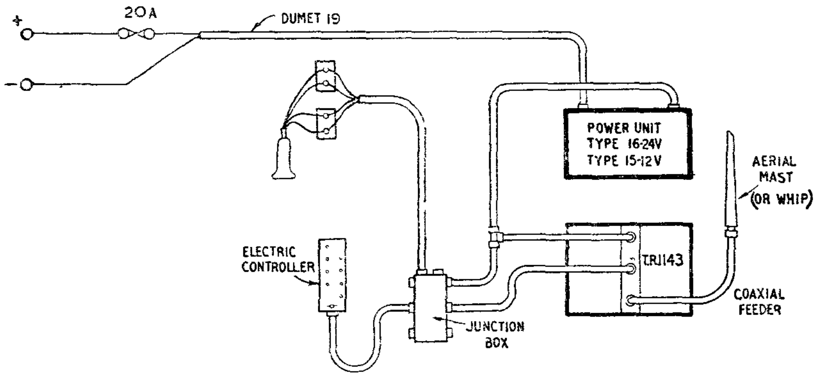


Fig. 112.—V.H.F. R/T INSTALLATION

2. Installation of S.B.A. Equipment

The Pilots' Control Unit, Mixer box, and Visual indicator, are installed in the Pilots' cockpit, but the rest of the equipment, consisting of Power Unit, Junction Box Type 7, Main Receiver, Marker Receiver, Aerials and connectors is installed in convenient positions, depending on the type of aircraft. It is important that the S.B.A. installation be completed as securely as possible, care being taken to ensure that cables do not rub against one another.

Bonding of receiver cases, covers and harness must be carefully carried out. The connectors must each be bonded to the airframe at least every eighteen inches. Connectors 1, 3 and 4 on Junction Box Type 7 could, by mistake, become reversed ; take great care that this does not happen.

The Mixer box is wired in the following manner :—

(i) The Breeze Connector (No. 10) is fitted in the usual way.

(ii) A lead (Dumet 2·5) is taken from a convenient Crew Telephone position to the mixer box and connected to the terminals marked " CREW I/C ".

(iii) A lead is taken from Pilots' phones to the mixer box, and connected to two terminals marked " PILOT ".

Note 1. Power Unit must be mounted in a normal level position and have a 10 amp. fuse in the input circuit.

2. Aerial connectors are to be kept as short as possible.

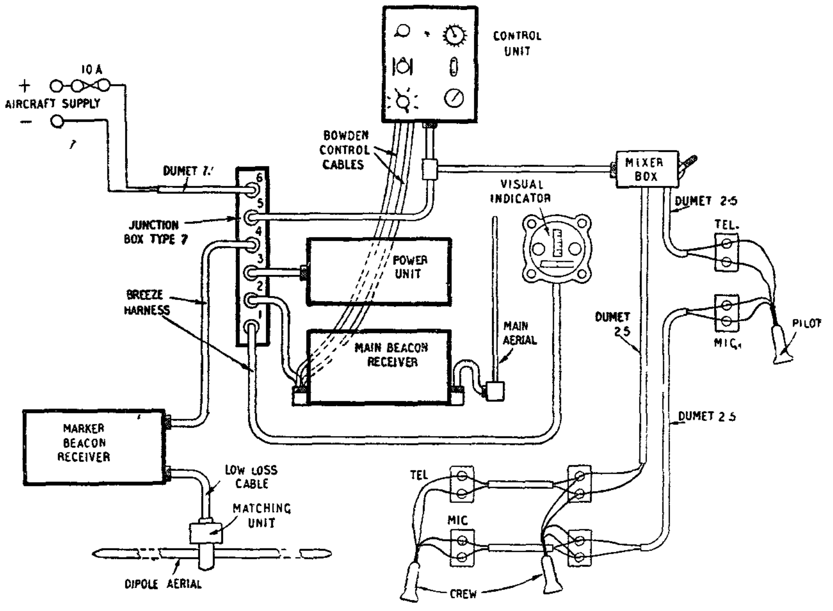


Fig. 113.—S.B.A. INSTALLATION

Examine the installation diagram carefully and make sure you know the positions of connectors on the Junction Box.

3. **Installation of Equipment T.1154/R.1155**

Positions of equipment vary with different types of aircraft. The following items, Transmitter T.1154, Receiver R.1155, Morse Key, one Visual Indicator, D/F loop and Switch Type J, are usually installed as near as possible to W/Ops position.

The input (29 volts) is taken through a 25 amp. fuse direct to the H.T. machine. The input to the L.T. machine is taken through a 25 amp. fuse and a Type 52 resistance. The resistance has tappings connected to a Londex Relay Type 220, the purpose of which is to short circuit this portion of the resistance when the E.D.G. is not operating (i.e. when 24 volts only are applied).

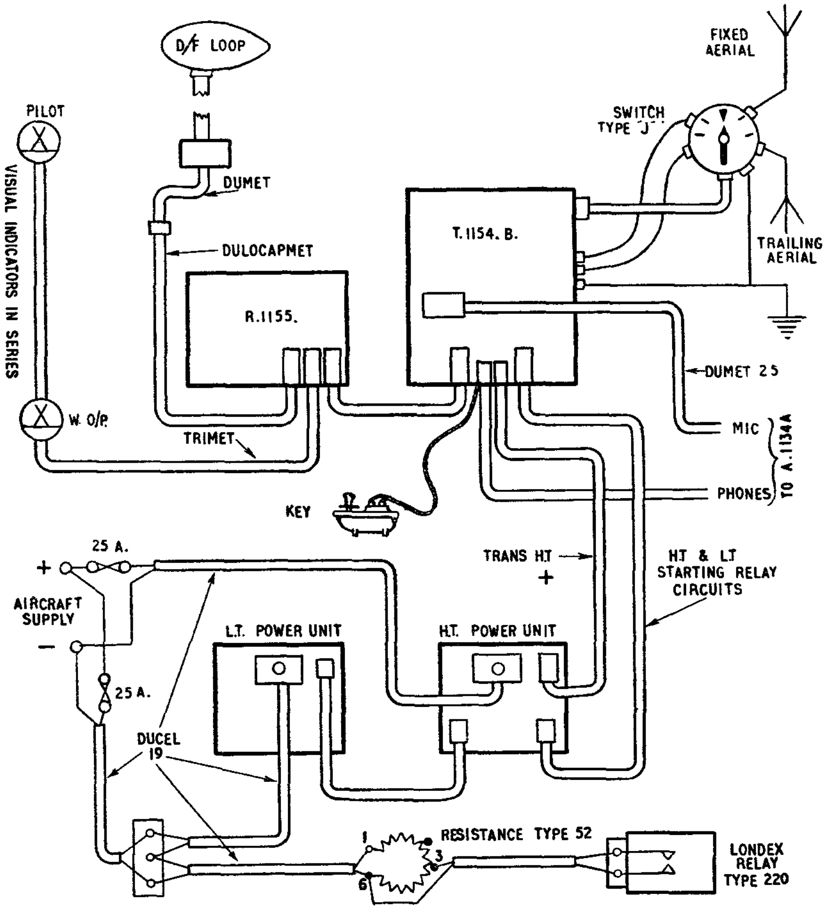


Fig. 114.—T1154/R1155 INSTALLATION

Examine the installation diagram carefully, noting especially types of cable used and supply to the power units.

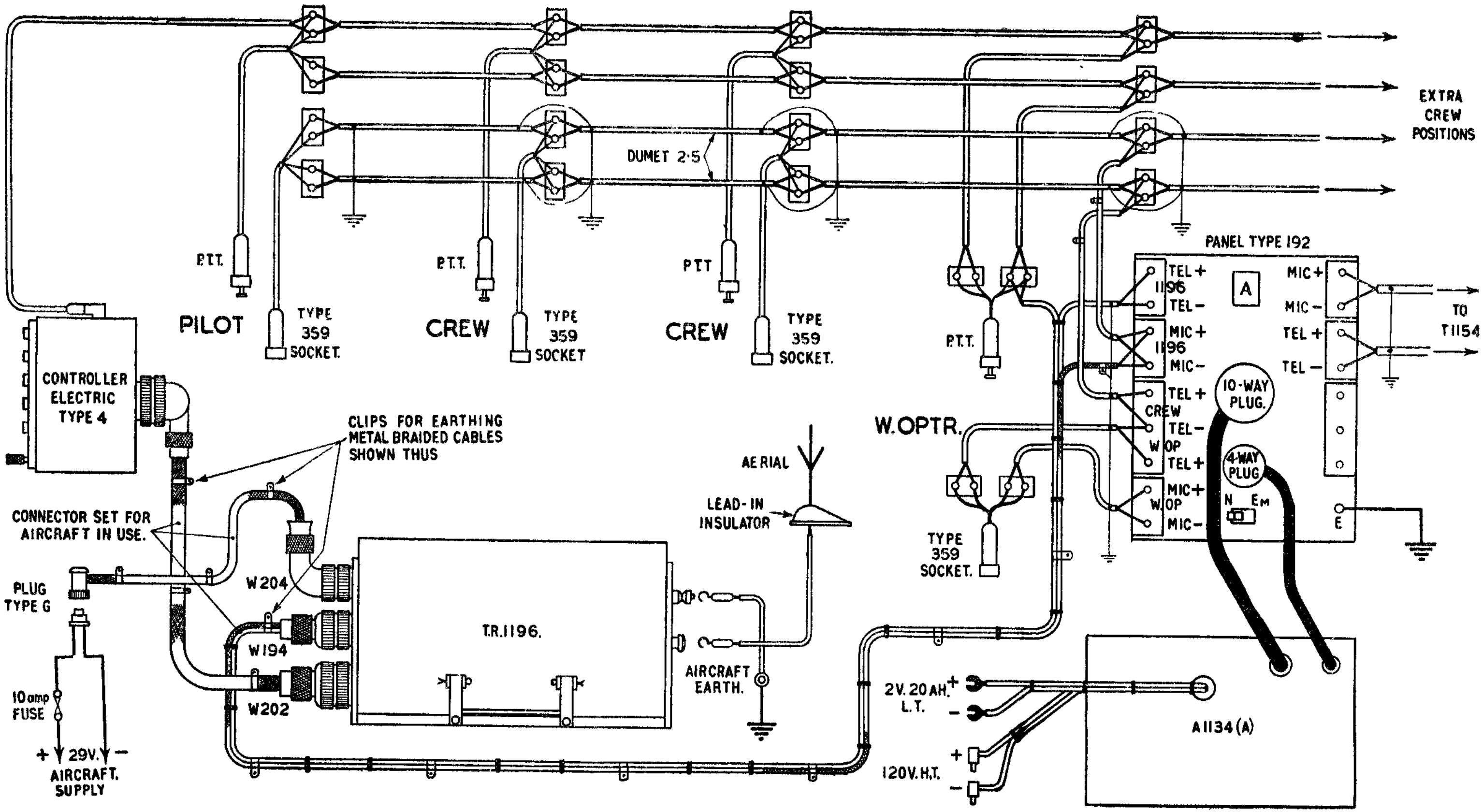
4. Installation of Equipment T.R.1196

Fig. 115 shows the typical lay-out of T.R.1196 and associated equipment when used with the A.1134 or A.1134A intercommunication amplifier. The T.R.1196 itself is mounted in a crate containing shock absorbing cushions, which may be fitted at any convenient place in the aircraft. The electric controller is fitted in the Pilots' cockpit, the amplifier A.1134 and panel Type 192 are fitted in the W/Ops position, and each member of the crew is provided with a microphone-telephone socket (Type 359) and a " push-to-talk " switch. Note carefully the run of main connections from T.R.1196 which terminate in " W " plugs at the set. Note also the lay-out of the " press-to-talk " wiring. It will be seen that two circuits are completed when one of the switches is pressed, these are :—

(i) The send/receive relay, and

(ii) Short circuit of the " R.A. " resistance.

The panel Type 192 is usually employed with this equipment, and the terminals on it are clearly marked. The only confusing point is the small terminal block marked " A " on Fig. 115 ; this is never short circuited when using the T.R.1196.



EXTRA CREW POSITIONS
DUMET 2·5
P.T.T.
PILOT
TYPE 359 SOCKET.
P.T.T.
CREW
TYPE 359 SOCKET
P.T.T.
CREW
TYPE 359 SOCKET.
PANEL TYPE 192
TEL + 1196 TEL −
MIC + 1196 MIC −
TEL + CREW TEL −
W OP TEL +
MIC + W OP MIC −
A
MIC +
MIC −
TEL +
TEL −
TO T1154
10-WAY PLUG.
4-WAY PLUG
N
E
P.T.T.
W.OPTR.
TYPE 359 SOCKET.
CONTROLLER ELECTRIC TYPE 4
CLIPS FOR EARTHING METAL BRAIDED CABLES SHOWN THUS
CONNECTOR SET FOR AIRCRAFT IN USE.
PLUG TYPE G
W204
W194
W202
T.R.1196.
AERIAL
LEAD-IN INSULATOR
AIRCRAFT EARTH.
10 amp FUSE
+ 29V. −
AIRCRAFT. SUPPLY
2V. 20 AH. L.T. + −
120V. H.T. + −
A1134 (A)

5. Installation of A.1134 and A.1134A Intercommunication System

Refer to Fig. 115. It will be seen that the A.1134 intercommunication system, although capable of functioning alone, is tied up from the installation point of view with the T.R.1196; and, to a lesser degree with the T.1154/R.1155 and S.B.A. installations.

The whole installation, except the power supply lead, is best made with screened cables, although the telephone circuits are sometimes wired with Ducel. Screened cables must be properly bonded or instability will result

The Type 359 sockets and their associated wiring are a prolific source of feedback and instability if the insulation becomes inpaired. The danger of instability is increased as more 359 sockets are placed in parallel ; i.e. the greater the number of crew positions, the greater the danger of instability. Every precaution must be taken against dampness ; the following are typical :—

(i) Inside connections of Type 359 sockets must be smeared with mineral jelly before being installed

(ii) Top of socket must be bound with insulating rubber tape and shellaced.

(iii) Opening of socket can be plugged when not in use.

Note. Dampness will be much more troublesome if sockets, terminal blocks and plugs are dirty. Keep them clean.

The A.1134A, having a low impedance output, is less prone to instability than the A.1134. For this reason it should always be used whenever possible, particularly in the larger aircraft ; the connections are precisely the same as for the A.1134.

6. Aircraft Aerials

(i) The following are general features to be considered :—

(*a*) Must be very strong. All attachments very secure and carried out without solder.

(*b*) Must stand up to weather conditions of all kinds.

(*c*) Must be well insulated from the airframe.

(*d*) Must be well away from guns and unlikely (if broken) to foul aircraft control surfaces.

(*e*) Must stand out at least 2 ft. 6 in. from the airframe as a general rule.

(*f*) Must not detract from speed of aircraft more than possible, therefore streamlined mast and fittings are used.

(*g*) Must not be left kinked or joined.

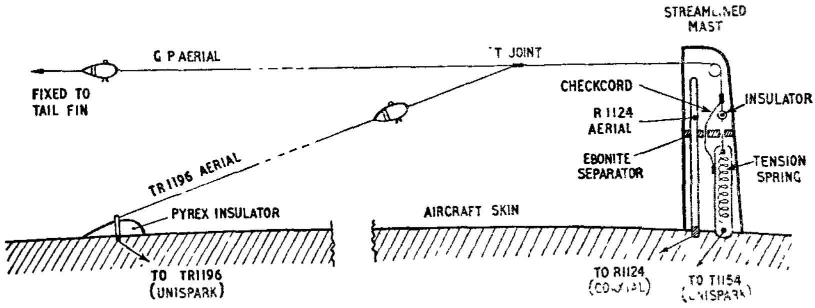


Fig. 116.—TYPICAL AIRCRAFT FIXED AERIAL INSTALLATION

(ii) *The V.H.F. Aerial System* used for R/T is the aerial mast itself, which is insulated from the airframe and acts as $\frac{1}{4}$ wave or $\frac{1}{2}$ wave aerial, depending on the size of the mast, which differs with different types of aircraft. In cases where a $\frac{1}{2}$ wave aerial system is employed (e.g. Hurricane) a matching unit must be used to match the aerials to the output circuit of the transmitter (approx. 40 ohms). In later types of aircraft a " Whip " aerial is used.

(iii) *G.P. aerials.*—The fixed aerial is made of R.7, 7-strand stainless steel wire of approximately 60 ft. length. Types of masts and methods of fixing and leading-in vary widely with different aircraft. One typical up-to-date system is shown in the diagram. Note the tensioning device and checkcord—an essential feature of fixed aerials.

The trailing aerial consists of 250 ft. R.7 wire wound on an ebonite drum and attached to the drum by a cord 49 in. long. The other end is weighted by a bead-weight attachment consisting of lead beads (plus end one of steel) threaded on a steel rope. The aerial is attached to the weight by means of a special splice.

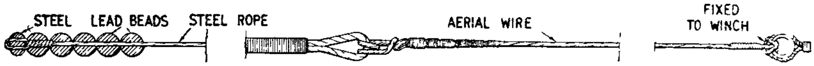


Fig. 117.—TRAILING AERIAL ASSEMBLY

(iv) *The T.1196 or T.R.9 aerial* is a short fixed aerial usually supported by the main aerial assembly, details of which are shown in the diagram The " T-joint " between T.1196 and G.P. main aerial must be bound and not soldered.

(v) *The S.B.A. aerials* are two in number. The Main Beacon receiver aerial may be a retractable vertical aerial mounted amidships, and led by a single coaxial cable to the receiver.

Note. This aerial, if retractable, must be kept well greased. A loading coil is fitted for matching purposes when the cable is of considerable length.

Instead of a Whip or retractable aerial, a fixed vertical aerial is sometimes used. This is mounted inside the front aerial mast which is then of a moulded material, as shown in the diagram. Here the loading coil is unnecessary as the coaxial cable is short.

The Marker Receiver aerial is a dipole formed of $\frac{1}{4}$-in. copper tube, and is usually mounted beneath the fuselage of the aircraft. In flying boats it is usually mounted beneath one of the mainplanes. The feeder to the R.1125A is of twin low loss cable (Dulocapmet). In fabric-covered aircraft it is necessary to mount an earthed reflector such as a metal plate behind the dipole. The installation of the dipole is completed by fixing the matching unit, which must be checked carefully during the first tuning operation.

(vi) *Special Equipment Aerials.*—The A.R.I. 5000 uses the tailplane of the aircraft as an end-fed dipole earthed at the centre. The aerial feeders are of R.7 wire attached to the tail unit by means of Ross-Courtney cable ends, properly insulated at the point of passage through the aircraft skin by rubber grommets.

Some aircraft use main planes for this aerial system. Wooden aircraft have copper strips mounted in the tail-plane, this time centre-fed in the more conventional manner.

The A.R.I. 5025 uses a Type 90 aerial. This is a light metal rod of streamlined cross-sectional shape, mounted on a small reflector plate, and pointing almost vertically downwards on most aircraft. It is connected to R.3090 by means of a single coaxial cable.

Note. All aerials must be inspected regularly for security, cleanliness and good insulation. Before testing the insulation of any aerial with a megger, make sure that the lead is removed from the set. Insulation should be approximately 100 megohms, although a lower reading is acceptable in wet weather. Wipe all damp and grease off insulators before testing.

7. Aircraft Electrical System

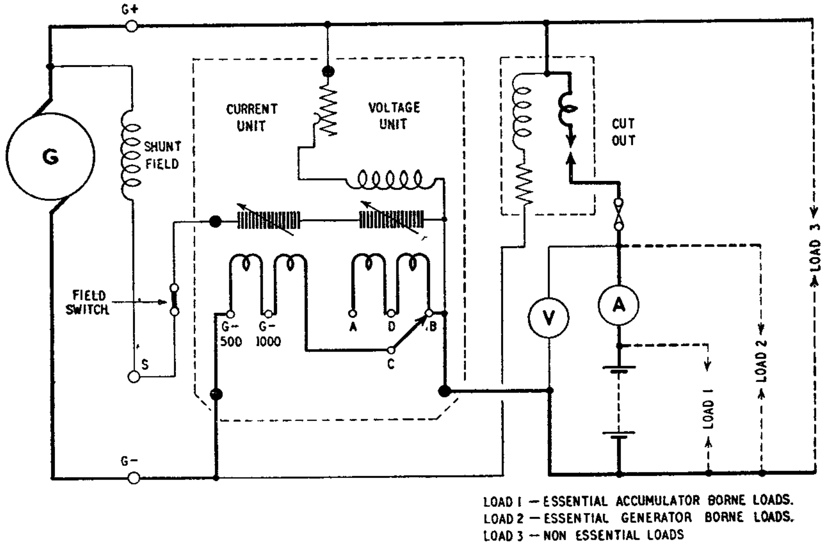


Fig. 118.—TYPICAL AIRCRAFT INSTALLATION

The electrical system on aircraft consists essentially of either a 12 volt or 24 volt accumulator (Type D) system which is connected to the various loads, electrical or radio, via a main fuse panel. On this is mounted a voltmeter indicating the voltage across the accumulator, and in some aircraft an ammeter reading the charge or discharge current through the accumulator is fitted. Fig. 118 shows a typical aircraft installation.

The accumulator is connected in parallel with a shunt wound engine-driven generator (E.D.G.), so that while the aircraft is airborne, the accumulator is merely " floating ", and the current taken by the various loads is supplied by the generator. It will be seen from the diagram that a cut-out is inserted in the positive lead between the generator and the accumulator, so that should the generator fail or stop for any reason, the accumulator will not discharge through the generator windings. A voltage regulator with a current limiter keeps the voltage output of the generator constant at 29 volts or 14·5 volts, and limits the current taken from the generator to 40 or 60 amps., depending on the type of generator used. In the regulator Types C and D, this is achieved by inserting two carbon piles, connected in series, in the field circuit, and varying the pressure applied to the carbon piles. This is done automatically by having two solenoids, one regulating the voltage and the other the current. Each solenoid and carbon pile is housed in a separate unit mounted one below the other.

The voltage regulator is designed to give the generator a level voltage characteristic up to full load if only one generator is employed. If, as on multi-engined aircraft, more than one generator is employed, an auxiliary current coil is brought into circuit by changing the link from CB to CD; this gives the generator a slightly falling voltage load characteristic, and ensures that an equal load is taken from all generators.

It should be noted that each generator in parallel requires its own voltage regulator complete, and cut-out.

The voltage regulator is adaptable for either a 500-watt or 1,000-watt generator, merely by altering the amount of turns in circuit on the current coils in each unit. Tappings are provided for this purpose.

Note. When testing W/T equipment on the ground, an external supply must always be used.

CHAPTER 30

SERVICING AND AIRFIELD PROCEDURE

1. Servicing

(i) *General.* " Servicing " means preserving the original condition of usefulness. For anything of a mechanical nature this involves :—

(*a*) Inspection at regular intervals to discover faults (if any).

(*b*) Lubrication at regular intervals to reduce wear and friction.

(*c*) Remedying of faults by repair, replacement, or modification.

(*d*) Cleaning and anti-corrosive treatment.

(*e*) Testing at regular intervals to ensure correct functioning.

(ii) The method of ensuring proper servicing is :—

(*a*) Specialised tradesmen are detailed to carry out their own groups of inspection, repair, and servicing.

(*b*) A scheme of servicing is prepared detailing the inspections to be carried out, and the types and methods of repairs allowable.

(*c*) A document—Form 700—defining the responsibility of each man is signed by him to certify that he has completed the job.

For an aircraft, this document forms the permanent record of its life history : for engines, propellers, and similar components, including W T equipment, this document is a permanent record of their life history only so long as they remain fitted to the airframe.

(iii) The complete aircraft is so complicated that the work necessary is subdivided into major groups each of which is done by specialised tradesmen : the tradesmen in each group may be of different degrees of skill and the responsibility of each man is defined.

(*a*) Wireless equipment is serviced by Wireless Operator Mechanics, Wireless Mechanics and Wireless Operator trades ;

(*b*) Electrical apparatus is serviced by Electricians I and Electricians II ; and similarly for airframes, engines, instruments and armament apparatus.

2. Organisation

(i) Flight tradesmen do Between Flight, Daily, and (usually) Minor Inspections. Group I tradesmen carry out Major Inspections, modifications, repairs and replacements required, and tests after repair.

(ii) The organisation for carrying out major inspections varies with the type of aircraft concerned, and with local conditions. The detailed organisation is usually similar to that shown on the " family tree " below as far as W/T tradesmen are concerned.

Engineer Officer
|
N.C.O. i/c Squadron Servicing Party
|
N.C.O. i/c W/T
|
Wireless Mechanics.

3. Servicing Orders

These are the official orders relating to servicing, and they state the work to be carried out, who is to do it, and the intervals between each inspection.

(i) *Unit Servicing Orders, Part I*, are issued by the station commander, and lay down the servicing organisation for the station, and define individual responsibility for inspection and servicing.

(ii) *Unit Servicing Orders, Part II*, contain a detailed list of items to be inspected, and the periods of inspection. As they are based on the Air Ministry " inspection schedule " as modified to suit local conditions, they are frequently referred to as the " aircraft inspection schedule."

(iii) *The Flight Order Book* is used to bring to the notice of tradesmen concerned such matters as :—
(*a*) Local orders relating to technical subjects, not otherwise recorded.
(*b*) Special orders.
(*c*) Weekly summaries of issues and amendments to publications. The book is initialled by the tradesmen to record that they have read and understood the order indicated.

(iv) *Flight desk*. A desk with a high back is kept (generally in the hangar) where all tradesmen have easy access to it. On it are carried all orders and notices relating to the servicing of the aircraft ; a watch is also fitted for the purpose of accurate time recording as required by Form 700.

4. Publications

The technical information and details required for thorough servicing are provided by the following publications and orders.

(i) " *Aircraft Servicing Regulations* " (Air Publication 1574) describes the servicing system, and acts as a guide book to servicing in general ; detailed instructions are found elsewhere (*see* para. 3).

(ii) *Aircraft Handbooks*.—Each type of aircraft has its own Air Publication sub-divided into three volumes.

Volume I—Aircraft Descriptive Handbook.

Volume II—

Part 1—Chief Orders and Modifications.

Part 2—Inspection Schedule (all trades).

W/T tradesmen are only concerned with the above volumes and parts.

(iii) *Other Publications*.—Other official publications contain special technical information, e.g. :—

A.P. 1095A, B, C, etc.—Electrical Equipment Manual.

A.P. 1186 and 1186A—W/T Equipment.

A.P. 1766 " G " and " Q "—Special Installation.

5. Form 700—Aircraft Servicing Form

This records the day-to-day history of the aircraft. Three types of Form 700 are in use, for single engine, two engine, and four engine aircraft respectively

Instructions for the use of the Form 700 are printed on the front and back covers : Page 1 contains a few useful particulars (fuel, oil, coolant to be used, etc.) and information regarding the next periodic inspections and when they are due. Subsequent pages vary slightly in the three types of Form 700 but all types contain the following :—

(i) *Daily Inspection Certificate*, to be signed by each tradesman on satisfactory completion of his daily inspection.

(ii) *Refuelling, Oil, Coolant, and Arming Certificates*, to be signed by each tradesman responsible for refuelling, rearming, etc.

(iii) *Pilot's Acceptance and Flying Log*, to be initialled by the pilot as certifying that he is satisfied that all is in order. The Flying Log records the flying time of the aircraft.

(iv) *Change of Serviceability and Repair Log* (separate log for airframe and for engine). This is used when an aircraft is placed unserviceable, the person placing the aircraft unserviceable filling in columns 1 to 4 and informing the Flight Commander and the Engineer Officer (or N.C.O.). Care must be taken to use the correct log, and not enter W/T defects in the engine log, but in the airframe log.

The N.C.O. i/c will detail a tradesman to carry out the work necessary and the tradesman so detailed completes columns 5 to 8. Instructions for completing column 5 are given on the back cover of Form 700, and depend on whether the work done is repair, modification, etc.

Pilots may also use the airframe log to record minor defects which do not render the aircraft unserviceable (e.g. aircraft flying slightly port wing low). To indicate that the aircraft is serviceable, the word " serviceable " is entered in column 5.

Notes. 1. All entries must be made in ink or indelible pencil.

2. Each form is to be used until it is full (or for any other period specified in Unit Servicing Orders, Part 1). It is then retained in a binder with the log card (*see* para. 10).

3. Every aircraft leaving its unit for a short period carries a separate Form 700 (A) known as the " Travelling Aircraft Servicing Form ". On this travelling copy are entered particulars of all necessary servicing carried out at the station(s) visited, and on return these entries are transferred to the current Form 700.

6. **Inspections**

(i) Each aircraft is normally inspected for certain items only as laid down. Inspections are carried out :—

(*a*) Between Flights.

(*b*) Daily.

(*c*) Periodically, at intervals depending on the type of aircraft. For well-tried types, " minor " inspections are carried out at 40, 80, 120, 160, 200, 240, 280 hours flying time, and a " major " inspection at 320 hours : for newer types, minor inspections may be at 30, 60, 90, 120, and 150 hours flying time, and a major inspection at 180 hours : or other times may be laid down (e.g. every 50 hours).

For new types an inspection every 10 hours may also be carried out, until considered unnecessary by the appropriate authority.

(ii) Details of each item to be inspected at each inspection are laid down in the Aircraft Inspection Schedule (Volume II, Part 2, of the aircraft handbook, as modified by Command Headquarters).

(*a*) Section 1 of this schedule deals with " Between Flights " and " Daily " Inspections, and Section 2 deals with " Minor " and " Major " inspections. Each section is divided into sub-sections for each trade concerned, distinguished by letters, e.g. " A " for Airframe, " B " for Engines, etc. Thus details of the Daily Inspection for Wireless Equipment are found in Section 1E, details of a Minor Inspection for Wireless Equipment in Section 2E, and similarly for other trades.

(*b*) Each sub-section lists the items to be inspected by the tradesman concerned, arranged by assembly groups indicated by code letters as follows :—

Ae	Aerials	Ge	General
Rt	R/T Equipment	Gp	General Purpose Installation
Ba	Beam Approach	Gt	Gun Turrets
Co	Cockpit	Ic	Intercommunication System
Fu	Fuselage		

Only certain of these will concern the Wireless Mechanic.

Notes. 1. One copy of the inspection schedule is kept for each aircraft: when not in use the schedule is kept with the current Form 700.

2. On all flights on which a travelling Form 700A is taken (*see* para. 5) section 1 of the schedule is also to be taken (except for flights over enemy territory).

3. Code letters are not used in the " between flights " list of inspection.

4. The aircraft is placed " unserviceable " for all inspections except " between flight " inspections: but no entry is made in the " Change of Serviceability log " on Form 700 for a daily inspection unless a defect is found.

7. " Between Flights " Inspection

These inspections, as officially laid down, are the minimum required: if the pilot passes any comment on the aircraft, if you notice anything unusual, or if the aircraft has been subjected to abnormal stress, you must do more than the minimum. An example of a " between flight " inspection is given below, as far as it concerns a Wireless Mechanic.

SECTION 1E

WIRELESS EQUIPMENT

INSPECTION BETWEEN FLIGHTS

Note. The details of this inspection are not to be entered on the aircraft servicing form (R.A.F. Form 700).

(1) Obtain a verbal report from the previous wireless operator that the whole of the wireless and ancillary equipment is functioning satisfactorily.

(2) Conduct a visual inspection of all instruments, checking them for security and correct fitment.

(3) Inspect all aerials for security.

(4) Conduct a brief functional test of the intercommunication system and the R/T and W/T sets consistent with current orders governing W/T and R/T silence.

(5) Report to the pilot before he takes off.

8. Daily Inspection

(i) Before carrying out a daily inspection, check the total flying time to ensure that a " periodical " inspection is not due. (The time at which the next inspection is due is given on page 1 of the Form 700.)

(ii) Each item to be inspected is listed in the Aircraft Inspection Schedule, group by group, and numbered. Each tradesman is provided with a copy of the inspection schedule relating to his inspections (Wireless Mechanics—Part 1E). The items listed in the schedule are considered to be essential for proper servicing: this does not mean that items not listed are automatically to be completely ignored.

(iii) Tradesmen sign the Form 700 (daily inspection certificate) as evidence that they have completed their daily inspection and are satisfied that all is in order.

(iv) After a " daily inspection " the aircraft is regarded as serviceable for a period of 24 hours, unless :—

(*a*) A defect is found during this period.

(*b*) A defect is found at any " between flights " inspection.

(*c*) The aircraft becomes due for a periodical inspection.

(*d*) The aircraft has been subjected to abnormal stresses (say, a heavy landing).

(*e*) Night flying is to be done, when the flight commander may order a second daily inspection.

(v) Should a defect be found inform the N.C.O.; if the defect cannot be immediately rectified, put the aircraft " Unserviceable " by filling in the relevant columns (1, 2, 3 and 4) in the " Change of Serviceability and Repair log " of the Form 700.

(vi) An example from the daily inspection orders for a certain aircraft is given.

INSPECTION DAILY.

Assembly Group AERIALS

Ae.1 Examine the fixed aerial for sag, wear and security of attachment.
Ref. A.P. 1186/G.12.

Ae.2 Examine the fixed aerial lead-in insulator for damage and ensure that it is clean and secure.
Ref. A.P. 1186/E.2 and G.12.

and so on—covering all assembly groups.

9. **Minor Inspection**

(i) (*a*) Inspections at intervals of 40, 80, 120 and 160 flying hours (or other intervals laid down) are known as minor inspections and are normally carried out by wireless mechanics.

(*b*) Each item to be inspected has a serial number; variations of the period of inspection are marked by stars (*) as follows :—

Unstarred items—to be done at each minor inspection.
* items —to be done at alternate minor inspections.
** items —to be done at each third minor inspection.
*** items —to be done at each fourth minor inspection.

Items shown in capitals with the code reference underlined are major inspection items.

(*c*) In an inspection cycle of 320 hours with minor inspections at 40-hour intervals, the schedule will operate as follows :—

1st minor inspection (40 hours)—Unstarred items.
2nd minor inspection (80 hours)—Unstarred and 1* items.
3rd minor inspection (120 hours)—Unstarred and 2* items
4th minor inspection (160 hours)—Unstarred, 1* and 3* items.
5th minor inspection (200 hours)—Unstarred items.
6th minor inspection (240 hours)—Unstarred, 1* and 2* items.
7th minor inspection (280 hours)—Unstarred items.

At 320 hours comes a major inspection (carried out by the "servicing" party); thereafter the above sequence repeats.

(ii) Details of the items to be inspected are listed in the "Inspection Record" form (Section 2 of the Inspection Schedule) which is filled in by the airman carrying out an inspection or part of an inspection.

Additional items noted in the "Supplementary Inspection Record" are to be inspected at the appropriate period.

An example is shown below :—

INSPECTION RECORD. SECTION 2E

		1st		2nd		3rd		4th	
		a	b	a	b	a	b	a	b
Ae.1	Run out the main trailing aerial to its full length and examine the wire for kinking, fraying and stretching.								
**Ae.2	Run out spare trailing aerial to its full length . . . etc.								
	COCKPIT								
Co 3	EXAMINE THE WIRELESS REMOTE CONTROL FLEXIBLE CABLE FOR WEAR AND LUBRICATE AS NECESSARY.								
Gp.4	Test all valves, using the valve tester.								

It will be seen that :—

Ae.1 is inspected at every inspection.

Ae.2 is a " two star " item, inspected at 120 and 240 hours.

Co.3 is a major inspection item, inspected at major inspection only.

Note. Column (a) is the "condition column" and column (b) the "rectification column."

(iii) The inspection is recorded, item by item, as follows :—

(*a*) If no rectification whatever is required, initial column (a). Use indelible pencil.

(*b*) If any rectification (no matter how small) is required, put an X in column (a). (*See* also Note 1 below.)

(*c*) Each item must be initialled (or marked with an X, if appropriate) immediately after it is inspected, and before going on to the next item.

(*d*) If the airman making an inspection is called away before finishing, he draws a line across column (a) immediately opposite the last item completely inspected, and adds his initials on this line (if the item is defective, the X is also inserted).

(*e*) Rectification of items marked X is carried out as appropriate—maybe immediately after that particular item has been inspected or after consultation with the N.C.O. (in the case of a more serious defect). The tradesman who carries out the rectification initials column (b) on completion of that particular rectification.

Notes. 1. As the Inspection Record Form should not only show that all items were inspected, but should also indicate which items required attention, it is important that an X be placed in column (a) if any adjustment whatever is carried out, even if it is the inspecting tradesman who carries out this adjustment.

2. Repairs and replacements only are recorded on Form 700.

3. The aircraft is placed " Unserviceable " on the Form 700 (" Change of Serviceability and Repair log ") for minor inspections.

4. An extension of the inspection periods may be made by a responsible officer who will record the fact in the " Change of Serviceability and Repair log " in the Form 700, in red ink, thus :—

" *Extension of — hours granted* "

(iv) The inspections are recorded in the " Periodic Inspection Certificate " attached to Section 2 of the Inspection Schedule.

Airframe Number. . . . . Section 2

Periodic Inspection Certificate

Certified that the periodic inspection mentioned below has been made in accordance with this schedule.

Periodic inspection	Due at hours	Made at hours	Name of Tradesmen (in block letters)	Initials	Date started	Date finished	Signature of N.C.O. in charge of inspection

Notes. 1. When the inspection is completed, the schedule must be handed to the N.C.O. He will arrange for all " crossed " items to be rectified (usually by the servicing party).

2. If in doubt about any point, consult your N.C.O.

10. **Major Inspection**

Major inspections necessitate the partial dismantling of the aircraft and usually take a much longer time to complete. For these reasons they are carried out in a hangar, wherever possible. A party of W/Mechs will be detailed to carry out the work, as far as W/T equipment is concerned. One N.C.O. normally supervises the whole of the inspection. All operations on the Inspection Schedule are carried out, and columns (a) and (b) initialled or crossed in the same way as for a minor inspection.

11. **Aircraft Inspection—New Procedure**

The inspection system as outlined in the preceding paragraphs has now been modified. This new system will eventually be used for all aircraft, but in the transitional stage both systems may be found. The main points in the new system are :—

(i) The Inspection Schedule is divided into three sections, as follows :—

Section 1—*Between Flights Inspection.* The code numbers referred to below are now used ; the only results recorded (on Form 700) are Rearming and Refuelling.

Section 2—*Daily Inspection.* This has been altered by starring certain items. These starred items are only inspected once every seven days if the aircraft has not flown in the interval.

Section 3—*Minor and Major Inspections.* There are now no *** items ; the cycle consists of eight inspections and the sequence is :—

1st Inspection—Unstarred items.
2nd Inspection—Unstarred and * item.
3rd Inspection—Unstarred items.
4th Inspection—Unstarred, * and ** items.
5th Inspection—As for 1st Inspection.
6th Inspection—As for 2nd Inspection.
7th Inspection—As for 3rd Inspection.
8th Inspection—Unstarred, *, ** and Major Inspection items.

(ii) Each section is divided horizontally into nine Trade Groups each with a code letter as follows :—

A—Airframe trades.
B—Engine trades.
C—Instrument trades.
D—Electrical trades.
E—Wireless trades.
F—Radar trades.
G—Armament trades.
H—Safety Equipment trades.
N—Photographic trades.

(iii) The items to be inspected—detailed in a vertical column—are now divided into fifty main headings in place of the eleven used previously. The larger of the main headings are subdivided : thus Communications Ancillary Equipment—main heading—is divided into five sub-headings. Each such sub-heading—and if there is no sub-heading the main heading itself—is given a Code Reference. For example, Aerials is a sub-head to Communications Ancillary Equipment and its Code Reference is Ae.

(iv) Only one copy of each Schedule is now held for any one type of aircraft at any one Unit. This is the Master Copy and is kept by the Engineer Officer for reference only. Tradesmen carrying out inspections will record the result on cards as detailed at (v).

(v) Cards are compiled by Commands from Schedules and on each card appears an identification reference : thus 2/E/35, where

2 indicates Daily Inspection—*see* (i).
E indicates (by) Wireless Tradesmen—*see* (ii).
35 indicates (in) Communications, Ancillary Equipment Group—*see* (iii).

Each card will only contain details of Inspections to be done by one tradesman, although more than one card may be required for all the work to be done by one tradesman during any one inspection. Each card, except that used for between flights, has the (a) and (b) columns and these are used for "Condition" and "Rectification" respectively exactly as under the old procedure.

When inspection is completed the result is transcribed in Form 700—the Minor and Major inspections being recorded on a newly incorporated page. The pencil markings on the cards are then erased and the same cards are again ready for use.

12. General Servicing

(i) *Bonding and Screening.* All metal parts, including the airframe structure, are bonded (i.e. connected electrically) thus maintaining all at the same potential. This is necessary :—

(*a*) To minimize risk of fire.

(*b*) To prevent noisy reception due to uneven distribution of static charges.

Bonding must be tested at Major Inspections with the Bonding Tester, the maximum resistance allowed between any two earthed (or bonded) points being ·025 ohms. Most W/T circuits are screened to prevent radiation and pick-up of interference, and to reduce the effect of stray capacitance and inductance, sometimes troublesome at high frequencies.

Note. Screened cables MUST be properly bonded at frequent intervals (approx. 18 in.), particularly at the ends, and across terminal blocks.

(ii) *Insulation test of I/C lines ;* proceed as follows :—

(*a*) Ensure that all headsets are out of circuit.

(*b*) Remove plugs from Panel Type 192.

(*c*) Remove G.P. MIC and TEL plugs.

(*d*) Put B.A. Mixer Box to MIX.

Megger between various combinations of the MIC and TEL positive and negative terminals at a convenient terminal block. Insulation must be above 10 megohms.

Note. I/C system causes more "W/T" failures than actual W/T equipment. Therefore, constant and careful servicing is necessary.

13. Handling Aircraft

When aircraft are to be moved, an N.C.O. or experienced airman will take charge of the handling party, each member of which must know exactly what to do. The aircraft may be towed by a tractor, or man-handled from one position to another.

On soft or uneven ground aircraft are to be towed forward to a towing "bridle" of wire cable, attached to lugs provided at the bottom of the main undercarriage oleo struts. (On small aircraft these lugs are sometimes at the top of the oleo struts, facing forward.) A steering arm attached to the tail wheel, or nose wheel for a tricycle undercarriage, is used to steer the aircraft.

On hard tracks, runways, hangar floors, etc., aircraft may be towed by a towing bar attached to the tail wheel or to the nose wheel for a tricycle undercarriage. Such towing bars are only to be used if an overload release is incorporated.

When towing an aircraft maintain as straight a course as possible, and avoid sudden changes of direction or high speeds. Do not push the tail plane from side to side to change the direction of the tail wheel.

Where no tractor is available the towing cable can be manned by a party of men. The handling procedure may vary with different aircraft, and the precise instructions are given in Volume I of the aircraft handbook. Small types of aircraft are usually man-handled, using a tail wheel steering arm, but they must be pushed on strong constructional members only.

(i) *Towing by bridle.* The aircraft is prepared for towing by turning the propellers to the most convenient position to suit the circumstances, and by attaching the towing bridle to the main undercarriage, and the steering arm to the tail wheel or nose wheel. One airman is required to control the steering arm : he should not pull or push, but should steer only, paying strict attention to orders. One airman is required in the cockpit to operate the brakes as required, to prevent the control surfaces from swinging, and to keep a lookout for the clearance of high components. Other airmen may be required to watch that the wing tips will not foul anything and to see that the towing cable does not foul.

(ii) *Towing by towing bar.* The towing bar has two hooks secured by spring-loaded locking pins at one end for attachment to the tail or nose wheel fork, and a spring-hook at the other end for attachment to the tractor. This hook may be so designed that an excessive pull causes it to disengage automatically : in any case, only towing bars fitted with some kind of overload release may be used. The towing bar must be inspected for freedom of movement of the locking plungers, as a faulty plunger may allow the bar to jump off and cause damage ; the overload release must also be inspected. The procedure for towing by towing bar is similar in general to that for towing by bridle, the aircraft being towed backwards if it has a tail wheel, or forward if it has a nose wheel.

14. **Taxying Procedure**

After running up the engines and finding everything satisfactory, the pilot signals " Chocks away " by waving his fully extended arm slowly from side to side, the arm coming as far down at each side as the cockpit allows. The airmen pull the chocks clear and stand clear or at the wing tips, as necessary.

Large aircraft fitted with two or more engines can be steered easily by the independent use of the port and starboard engines in addition to brakes : thus assistance during taxying is not required. With smaller types of aircraft assistance may be needed in taxying, particularly in a strong wind. This assistance is provided by airmen at the wing tips exerting a retarding effect against any attempt of the aircraft to " swing " out of the straight.

(i) During taxying the signals from the pilot are :—

(*a*) Stop. Arm raised to full extent above the head, hand open with palm to the front.

(*b*) Change direction. Arm moved from vertically above the head to as far down as the cockpit allows, on the side to which it is desired to turn.

(*c*) Stand clear. (Ready to take off.) Hand waved from side to side above the head.

(ii) Airman's taxying signals are :—

(*a*) Stop. Right arm raised to full extent above the head (if any obstruction is observed).

(*b*) All clear (answer to pilot's stand clear). A salute (whether head-dress is worn or not, and irrespective of rank of pilot). This is only given when the airman is satisfied that there is no aerodrome obstruction, or other machine about to land or take off.

Note. This signal is given by the airman at the port wing tip, who is to be considered the one in charge, where there are two airmen assisting taxying.

(iii) Signals by an airman to an aircraft approaching its " parking place " are :—

(*a*) Arms outstretched, to indicate the parking place. (Both arms may be waved from side to side above the head to attract the attention of the pilot.)

(*b*) Beckoning with both hands. Taxy straight ahead.

(*c*) Beckoning with one hand or the other, to signal to the pilot which way to turn.

(*d*) Both hands above the head, palms forward, to indicate " stop ".

(*e*) Forearms crossed in front of face, palms forward, to indicate " stop engine ".

The airman should face the oncoming aircraft and be sure he is in a position where the pilot can see his signals clearly.

(iv) At night, blue torches (one in each hand) are used to guide the aircraft as follows :—

(*a*) Torches waved in circular motion for " come straight on ".

(*b*) One torch waved in circular motion, the other steady, for " open throttle on side of waving torch, and turn towards steady torch " (multi-engined aircraft only).

(*e*) Torches held pointing straight down, for " stop aircraft : keep engine running ".

(*d*) Torches pointing down, waved criss-cross across body, for " you are in parking place ".

15. Precautions when working on aircraft

(i) Do not lean ladders or trestles against any part of the aircraft.

(ii) Do not forcibly lever off cowlings or cover plates with screwdrivers : this will damage the edges and distort the cowling. Adjustments must be made if removal is difficult.

(iii) Do not use a hammer to assist in locking or unlocking cowling fasteners. The supports will become distorted and fitting and removal become more difficult, even if breakage does not occur. Adjustments must be made if locking or unlocking is difficult.

16. Fire Precautions

Naked lights are not permitted in the vicinity of aeroplanes and hangars, and smoking is prohibited. Petrol lighters and matches, other than the " safety " type, must not be carried when flying in or working on aircraft. A fire tender is always in attendance ready for instant use, when flying is taking place. Flight personnel should make themselves acquainted with the use of all fire-fighting appliances.

The types of fire extinguishers for ground use are :—

(i) *Froth type*. This can be used on all fires other than electrical. It consists of a brown cylinder with a jet at the top. It is most effective when used on petrol and oil fires in which case the froth should be " laid " gently on to the burning oil from some distance away.

To operate. Turn the cylinder upside down and direct jet of froth on to the fire. (The contents can be thoroughly and more quickly mixed by placing a finger over the jet and shaking a few times.)

(ii) *Soda acid type*. This can be used on all fires other than petrol, oil, grease and electrical fires. It consists of a red cylinder with a plunger and jet at the top.

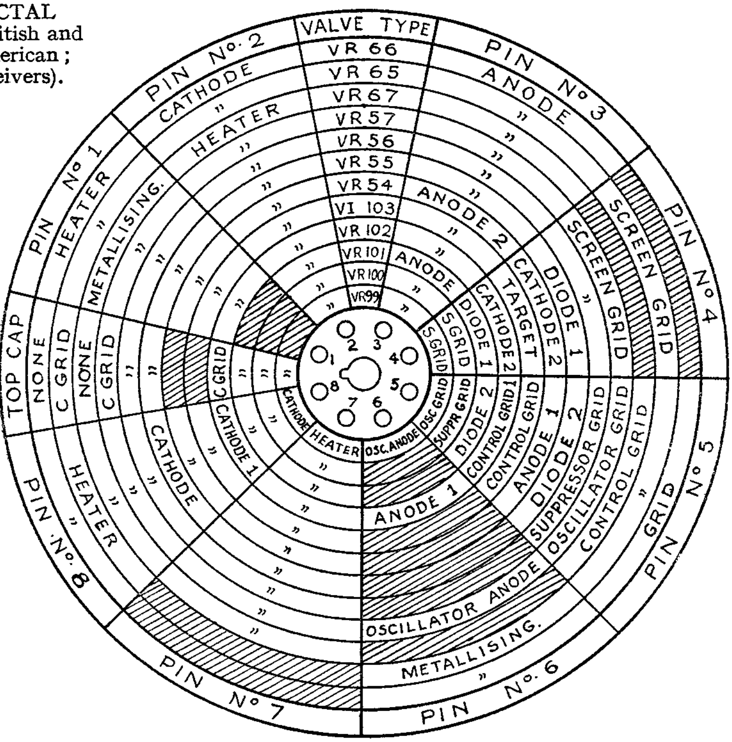
To operate. Strike the plunger and hold the extinguisher with the jet to the top. Direct jet on to the seat of the fire with as much force as possible.

(iii) *Tetrachloride type*. This can be used on electrical and small oil and petrol fires. It consists of a small brass cylinder fitted with an internal pump, with a handle at one end and a jet at the other.

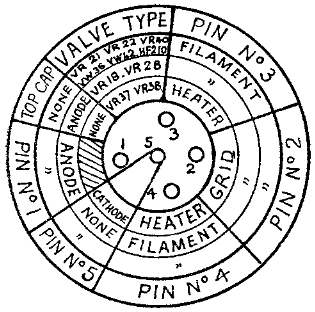
To operate. Unlock the handle by a half turn, operate it as a pump, and direct the jet on to the fire. Do not inhale the fumes, which are poisonous.

APPENDIX I.

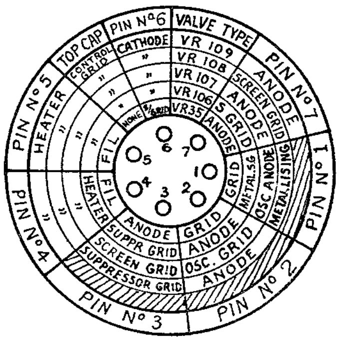
) OCTAL
(British and
American ;
receivers).



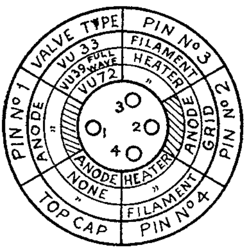
(2) 4 and 5-PIN
(British ; receivers).



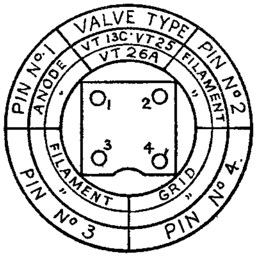
(3) 7-PIN
(British ; receivers).



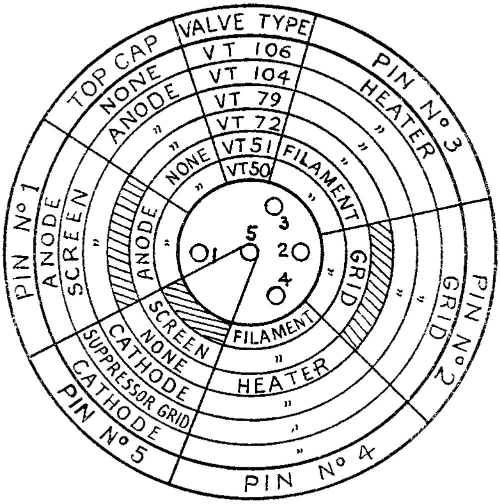
(4) 4-PIN
(British ; rectifying).



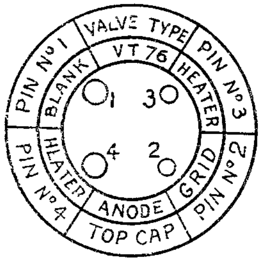
(5) LARGE PIN
(Low cap ; transmitters).



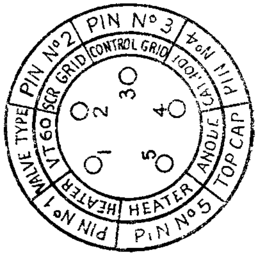
(6) 4 and 5-PIN
(British ;
transmitters).



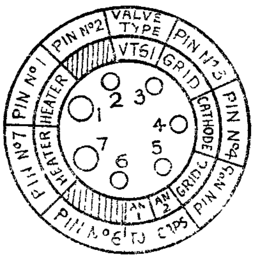
(7) 4-PIN
(American ; transmtter).



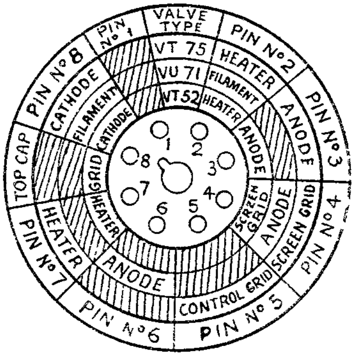
(8) 5-PIN
(American ; transmitter)



(9) 7-PIN
(American ; transmitter).



(10) OCTAL
American ; transmitter
and rectifying).



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	2·3	250	7·7	21·0	2·6	Octal	L.63 ..	I.D.H. triode	T.1131.
V.R.99 ..	6·3	2·34	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.

Valve.	Filament.		Anode Volts.	A.C. Res. (kilohms).	Amp. Factor.	Mutual Cond.	Base.	Civil Equivalent.	Remarks.	Used in
	Volts.	Amps.								
V.I.77 ..	6·3	0·2	250	—	—	—	Octal	E.H.31	High sensitivity, magic eye.	Crystal monitor, type 4.
V.R.65 ..	6·3	0·63	250	—	—	8·5	Mazda octal ..	S.P.41 (6·3 volts)	H.F. pentode (V.H.F.)	R.1132A
V.R.82 ..	2·0	0·2	150	8·5	16	1·8	7 pin, British ..	220 T.H.	Characteristics given for triode section only.	W.1191
V.R.91 ..	6·3	0·3	300	—	—	6·5	9 pin, glass ..	E.F.50	I.D.H. high slope pentode used, V.H.F.	T.R.1196,T.R.1143 etc.
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
V.R.118 ..	2·0	0·2	150	—	—	1·75	5 pin, British ..	K.T.2	Replaces V.R.22 ..	T.R.9H

Valve.	Filament.		Anode.		Mutual Cond.	A.C. Res. Kilohms.	Amp. Factor.	Base.	Civil Equivalent.	Remarks.	Used in
	Volts.	Amps.	Volts.	Watts.							
V.T.501 ..	6·3	0·8	400	7·5	3·4	—	—	Octal	E.1192	I.D.H. R.F. beam tetrode	T.R.1196, T.R.1143

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.1083, 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.

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.	Exhaust.	
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

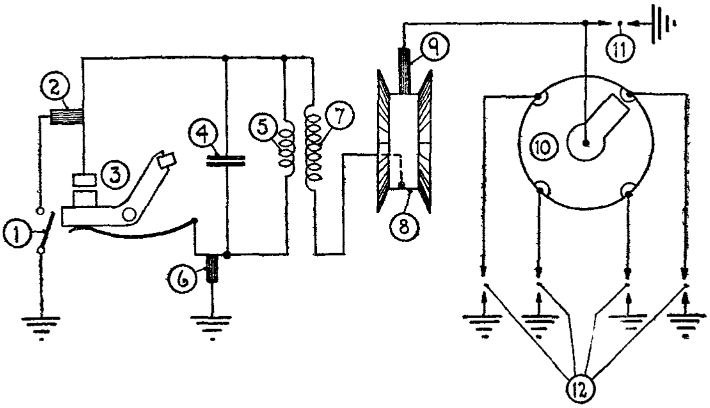


FIG. 1.—Magneto circuit—electrical.

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 stationary 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.

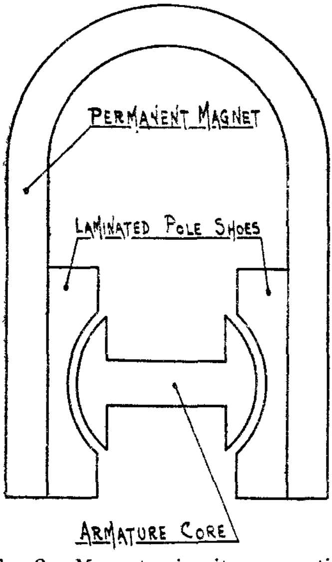


FIG. 2.—Magneto circuit—magnetic.

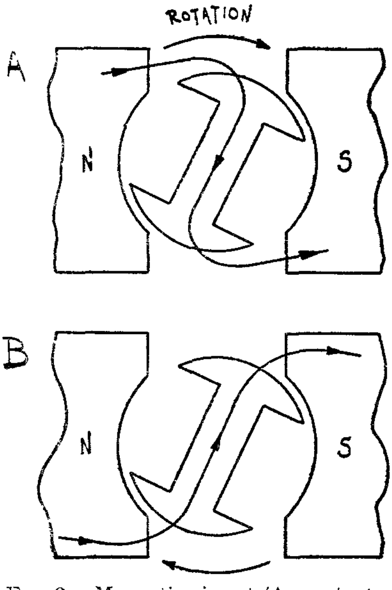


FIG. 3.—Magnetic circuit (A, contacts closed; B, contacts opened).

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 $= \dfrac{\text{Engine speed} \times \text{No. of cylinders.}}{2 \times \text{No. of sparks per rev. of magneto.}}$

(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 :—

(*a*) Mixing the petrol with the necessary amount of air.

(*b*) 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.

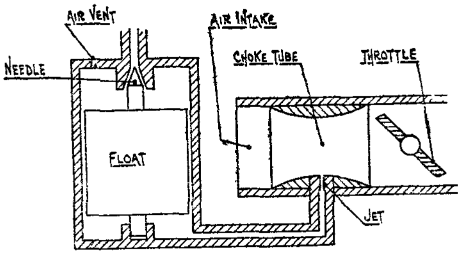


FIG. 4.—" Simple " carburettor.

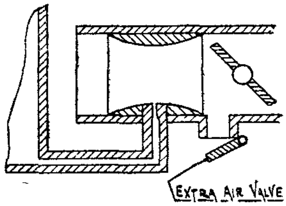


FIG. 5.—Extra air valve.

(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

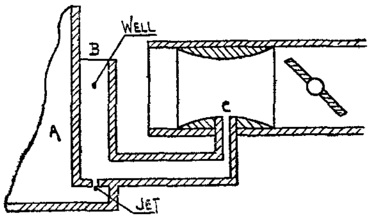


FIG. 6.—Principle of compensating jet.

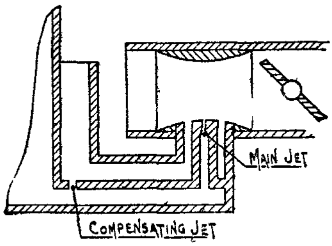


FIG. 7.—Zenith compensation.

pressures 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.

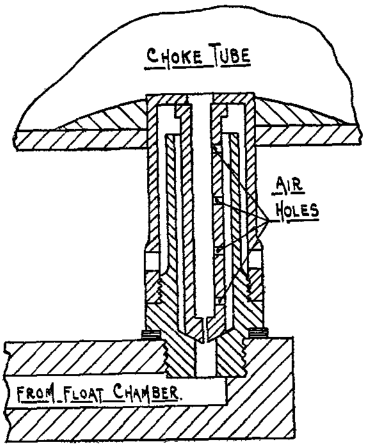


FIG. 8.—Diffuser compensation.

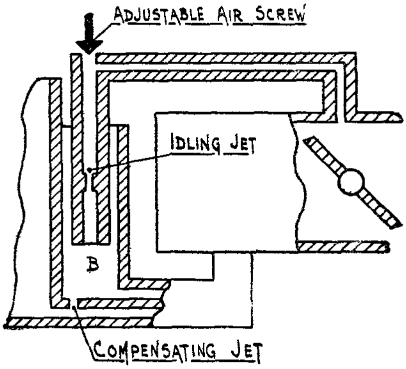


FIG. 9.—Slow running jet (Zenith).

(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	3½ in. before T.D.C. measured round flywheel.

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 $\pm$ 5. The regulator solenoid is controlled by D.C., rectified from the alternator output. Control of regulation is given by the ballast resistance.

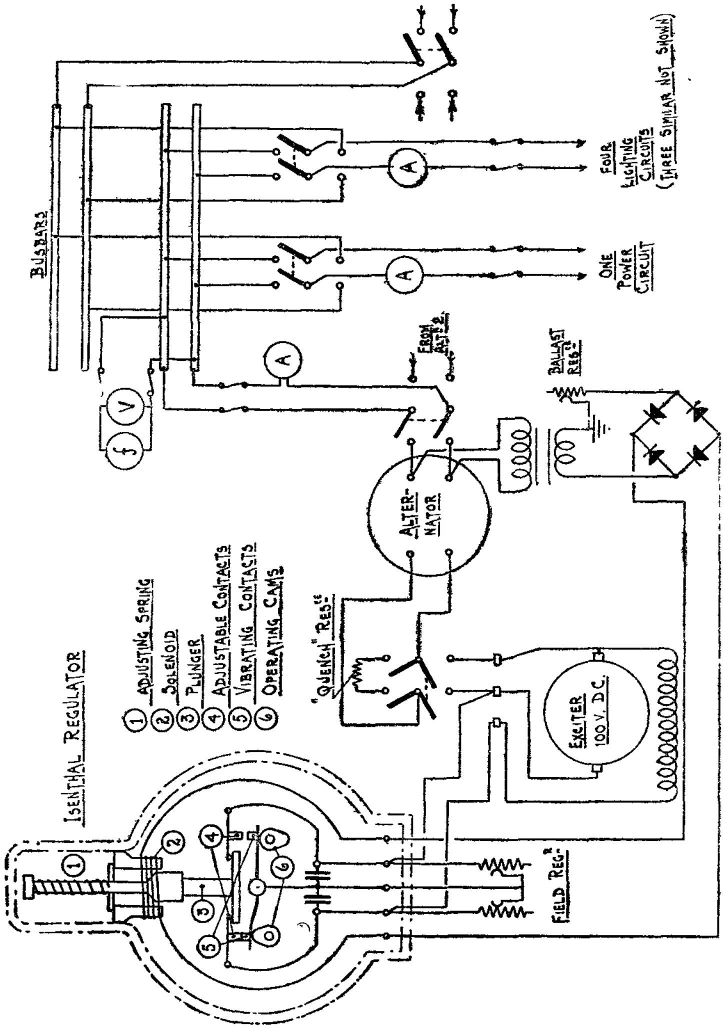


FIG. 10.—9 KVA alternator set.

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 1,750 to 1,850 r.p.m. controlled by governor. The governor has an adjustable tension spring.

5. *Servicing.* The objects of servicing are :—

(i) To prevent breakdown in service.

(ii) To prolong the life of an engine.

It is convenient to divide the servicing 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 conditions, 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 clean as possible at all times.

FIELD TELEPHONES, TYPE F, MK. I AND MK. II

1. Description

The field telephone is an important link in the R.A.F. communication system for single channel communication between points on airfields, or in conjunction with the "Field Telephone Exchange, 10-way", multi-communication between battle H.Q. and a number of emergency landing grounds, or defended areas. It may be used with two lines of D.3 or D.8 or in certain circumstances with one of these lines and an "Earth return" system. (With a good "earth" the range is increased.) The instrument consists of :—

(i) Bell.
(ii) Buzzer, Mk. I (microphone transformer, Mk. II).
(iii) Hand magneto generator.
(iv) Hand-set.
(v) Batteries and associated circuits complete with moulded case are housed in a transit case with webbing carrying strap and loop for earth rod.

2. Ranges

If well insulated wire with the minimum number of well insulated joints is used, the following ranges are obtainable :—

(i) Using two lines of D.8 wire, 12 to 15 miles.
(ii) Using two lines of D.3 wire, 9 to 10 miles.
} Not so great when cable is laid along the ground.

3. Facilities

(i) Call by buzzer.
(ii) Call by H.M.G.
(iii) Responds by bell to H.M.G. calling.
(iv) Responds by aural indication to buzzer calling.
(v) Speech communication.

4. Power Supplies

Two 1·5-volt dry batteries (Stores Ref. 5J/2000).

5. Details of Components

(i) *The hand magneto generator.* Consists of a laminated "H" type armature, having a single winding of D.S.C. copper wire (40 s.w.g.) of about 500 ohms. 185 r.p.m. by hand will produce 70 volts A.C. at 17 c.p.s. to operate the distant bell. A switch is provided, which is automatically operated by the handle, connecting the output from the generator directly across the lines (*see* fig. 3).

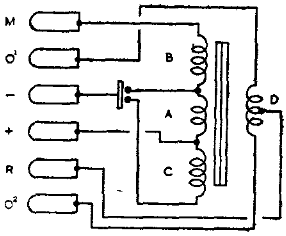


FIG. 1A.—BUZZER UNIT

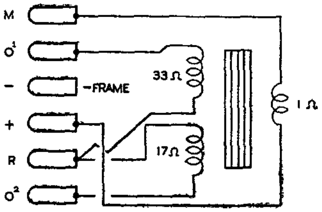


FIG. 1B.—TRANSFORMER UNIT

(ii) *Buzzer* (fig. 1A). Is only supplied with Mk. I instrument. Comprises a "step up" transformer, with interrupted primary, operating as an A.C. generator at a frequency of 350 c.p.s. giving 16·5 volts across 1,000 ohms. Performs the following functions :—

(*a*) Operates as a call buzzer.

(*b*) The secondary windings form two arms of an A.C. bridge to suppress side tone (fig. 4).

(*c*) The windings form a microphone transformer ratio 1 : 3·5.

Note.—In the Mk. II instrument the buzzer is replaced by a unit having properties (*b*) and (*c*) above (*see* fig. 1B).

(iii) *Polarised A.C. bell.* Comprises two coils of D.S.C. copper wire (40 s.w.g. 500 ohms each) in series, wound on soft iron cores, which are magnetised by a permanent magnet mounted between them. The coils (arranged to give opposite polarities) are energised by each alternation of the supply from the H.M.G. and the soft iron armature (A, fig. 2) is caused to rock at twice the supply frequency.

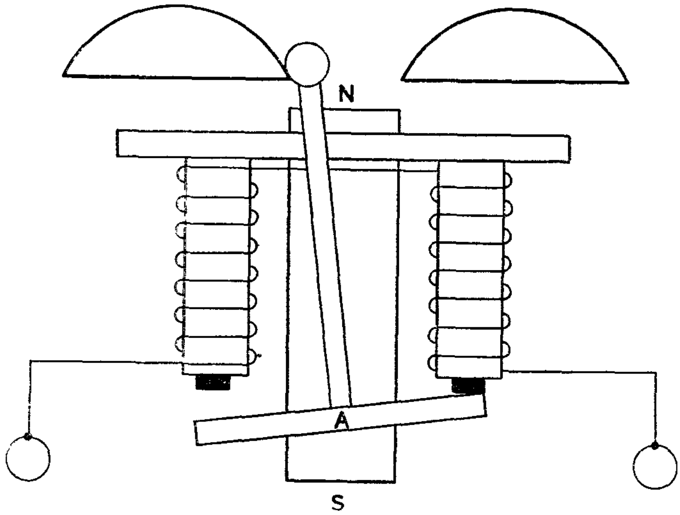


FIG. 2.—POLARISED BELL

6. Circuit Details (fig. 3)

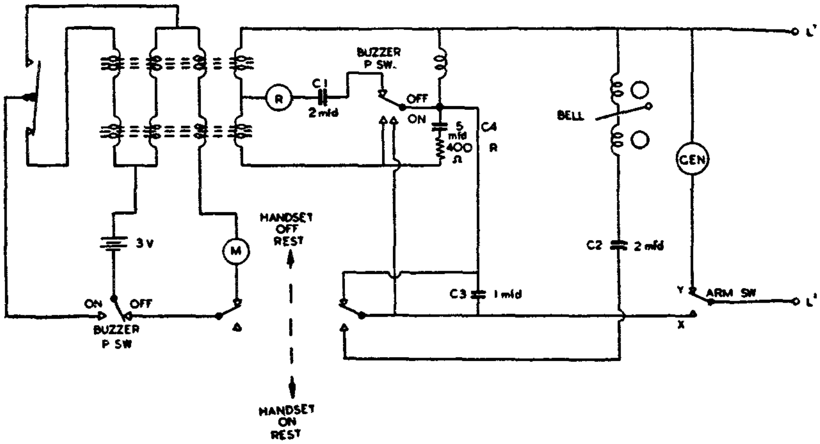


FIG. 3.—FIELD TELEPHONE TYPE F

(i) *Incoming calls*

(*a*) H.M.G. calls. It will be seen that the bell is connected in series with a 2μF condenser C.2, this being connected across the line when the handset is rested on the cradle, the cradle switch completing the circuit. C.2 prevents the lines being joined by a D.C. path through the bell, to permit central battery signalling (D.C. path only when handset is lifted). C.2 offers a negligible impedance to 17 c.p.s. ringing current, therefore this circuit impedance is low in comparison with rest of the network, C.3 offers a high impedance in the shunt circuit at this frequency. If handset is off the rest, H.M.G. calls cannot be received, but warning can still be received on buzzer.

(*b*) Buzzer calls. At buzzer frequency (350 c.p.s.) the impedance of the bell is high and that of C.3 is relatively low, therefore the shunting effect of the bell is low and the calling buzz is heard in the receiver.

(ii) *Outgoing calls.*

(*a*) H.M.G. calls. When the generator handle is turned the "arm" switch operates, breaking the X contacts, making the Y contacts, connecting the generator across the line, causing the distant bell to ring.

(*b*) Buzzer calls. The "press switch" disconnects the handset and energises the buzzer by completing the battery circuit through its primary windings. A second pair of contacts "shorts" the balance network, applying the maximum output across the lines.

(iii) *Speech communication.* The circuit is in the form of an A.C. bridge (fig. 4), the transformer windings forming one side, the other being made up by the bridging coil, the balancing network of a 400-ohm resistance and a ·5 μF condenser. A 2 μF condenser is inserted in series with the receiving unit R to prevent D.C. from passing through it. When the handset is removed from the cradle the contacts close and the microphone and battery circuit is completed. The buzzer is now used as a transformer.

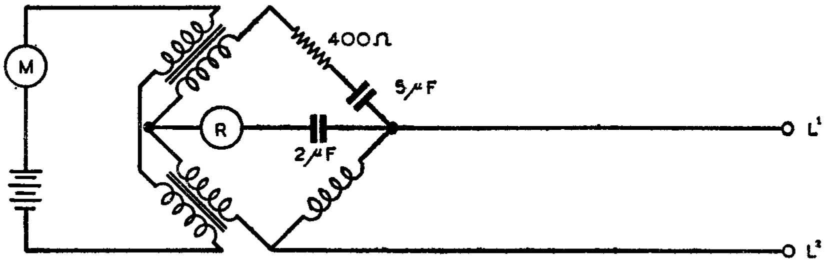


FIG. 4.—A.C. BRIDGE CIRCUIT

(iv) *Reason for side tone suppression.*

(*a*) In noisy surroundings "stray pick up" is reduced, this minimises the interference at the receiving station.

(*b*) A weak signal causes the operator to speak more clearly and distinctly.

7. General Servicing

(i) *Inspection.*

(*a*) Keep the instrument dry and clean.

(*b*) Good clean connections to the line terminals are essential.

(*c*) Discharged batteries must not be left in the instrument. Inspect regularly for corrosion.

(*d*) Check that buzzer (or transformer unit) connections are clean.

(*e*) Check that "Tel/Mike" plug and socket is clean and free from corrosion.

(*f*) Check that buzzer press button is "freed" when the handset is "lifted".

(*g*) Check that bell striker is free to move (*see* instructions, sub-para. (iv) (*a*)).

(*h*) Check that buzzer operates when the "press button" is pressed (*see* instructions, sub-para. (iv) (*c*)).

(ii) *Test for components.*

(*a*) Handset—disconnect line/s, lift handset and blow steadily across the " mike " ; a " breathing sound " should be heard in the receiver ; press " cradle switch " ; the sound should cease at once and a definite " click " should be heard. Alternatively, remove handset from socket and place two inner pins of the plug between L.1 and L.2. Press the buzzer and a loud buzz should be heard in the telephone.

(*b*) H.M.G. and bell—connect a short length of wire, from the Y contact to the bell side of C.2 ; the bell should ring, when generator is turned.

(iii) *Line test by H.M.G.* A quick line test may be carried out in the following manner. (With distant handset on cradle.)

(*a*) Lines shorted. Generator will be difficult to turn and makes a definite " gritty " noise.

(*b*) Lines open circuited. Generator turns very freely.

(*c*) Lines in good condition. Generator turns less freely than (*b*).

(iv) *Adjustments.*

(*a*) Bell. Before attempting to make any major adjustment to the bell mechanism, make sure the spaces between the gongs are correct. The gongs are mounted eccentrically on their centre pivots. If the ring is weak release the holding screw and rotate the gongs until a satisfactory ring is produced.

(*b*) Striker. To adjust the " throw " of the striker slacken off the grub screw which retains the bar magnet in the slotted bar. Move the bar magnet out to give greater throw to the armature, or in to reduce it, as required.

(*c*) The buzzer. Release the collar marked " Lock " (turn anti-clockwise) and screw out the contact screw slightly. Press the buzzer switch and, keeping it pressed, adjust the knob for loudest buzz, then lock the knob. Check this adjustment by operating the press button switch. The buzzer unit is sensitive in adjustment and should be adjusted carefully.

. Difference between Mk. I and Mk. II

(i) *Generators.* The Mk. II is neater and more compact, has a more powerful magnet, carbon and copper brush contacts to armature, and enclosed gear and pinion. Transformer unit replaces buzzer as explained previously.

(ii) *Cases.* The Mk. II has three captive locking bolts and is not hinged as in the Mk. I ; also it has two spring clips at the front to allow it to be completely or partially withdrawn from the transit case (operating position).

FIELD TELEPHONE EXCHANGE (CORDED) 10-WAY

1. Introduction

(i) *Requirements.* A portable telephone exchange for emergency or local use.

(ii) *Range.* Approximately 15 miles radius.

(iii) *Facilities* :—

(*a*) Communication over any of the 10 pairs of lines.

(*b*) Any two or all the lines may be connected together (bunching).

(*c*) Call any line by generator or buzzer.

(*d*) Visual and aural indication from any line calling.

2 General Description

Housed in metal container, divided into two compartments, one containing the switch board, consisting of two rows of 10 jacks—the top row marked " A " and lower one " B "—a four-pin socket marked " M.R.R.M." for operator's headset, a hand magneto generator for calling lines, and a battery pull-on switch. Second (rear) compartment contains line connections, 4·5 volt internal battery and stowage for night bell when not in use.

Each line is fitted with numbered indicator, and switching arrangement is made for calling by hand magneto generator (fitted on right-hand side of panel).

Cords with plugs at each end serve to connect the circuits. One cord is provided for each line circuit, and one cord for the operator ; one plug of this latter cord is inserted in the operator's jack and the plug becomes the operator's plug (" O " plug).

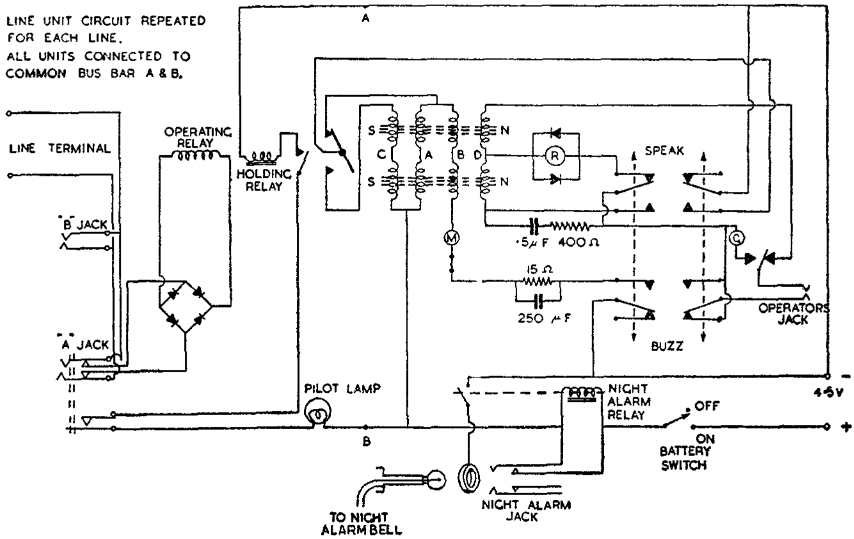


FIG. 5.—CORDED TELEPHONE EXCHANGE

3. Operation of Switch Board

(i) *General*

(*a*) Exchange bell rings, indicator lamp lights.

(*b*) Put operator's plug in " A " jack (light goes out). Switch to " Speak " ; inquire required extension.

(*c*) Place line cord plug in " B " jack.

(*d*) Call required extension (operator's plug in appropriate " A " jack) buzz or ring.

(*e*) Warn extension. " Hold on " (switch to speak).

(*f*) Connect other plug of cord connected to " B " jack of first extension in " A " jack of desired extension.

(*g*) Operator's plug to " A " jack of calling extension ; give " You're through ".

(*h*) Remove operator's plug.

(*i*) Both extensions ring off.

(*j*) Lamp lights on unit, with plug in " B ".

(*k*) Put operator's plug in " A " jack of this unit (to extinguish lamp) ; operator ensures conversation has finished and removes plug.

(ii) *Bunching lines.* Connecting all, or a number of lines, together :—

(*a*) Join " B " jack of line 1 to " A " jack of line 2.

(*b*) Join " B " jack of line 2 to " A " jack of line 3 (and so on).

4. Serviceability Tests

(i) *To test lamps :—*

(*a*) Select any cord.

(*b*) Connect the tip of one plug to the bottom right-hand holding screw of the line unit.

(*c*) Touch the tip of the plug at the other end of the cord, on each lamp holder in turn, lamp should light. (Spare lamps in rear of exchange.)

(ii) *To test relay circuits and generator or buzzer.*

(*a*) Insert " O " plug in any " B " jack.

(*b*) Turn generator handle or press buzzer switch ; appropriate lamp should light.

(iii) *Line circuit sensitivity.*

(*a*) Put switch to " speak ".

(*b*) Put " O " plug in " B " jack.

(*c*) Speak into " mike ".

Note.—Moderately loud speech should operate the relays, if not adjust as in para. 5.

(iv) *Night alarm.* Test as in (i) and (ii).

(v) *Installation test.*

(*a*) Remove the plug from " O " jack.

(*b*) Insert the free plug of each line unit for test into " O " jack.

(*c*) Rotate the generator handle slowly ; if the equipment is serviceable the indicating lamp should light, and the bell ring.

(*d*) Clear by inserting any free plug into the " A " jack of the line unit tested.

(*e*) When the test has been carried out insert the inner plug on the left-hand side of the board, into the " O " jack.

5. To Adjust Relays

(i) Connect test resistance marked " operate " in series with 4·5-volt battery across line terminals of faulty relay.

(ii) Adjust bias of armature by means of bias screw located on tip of pillar between relay coils until the armature pulls over.

(iii) Substitute test resistance marked " Not to operate ". If the armature still pulls over, readjust bias screw until it pulls back.

(iv) Repeat (i), (ii) and (iii) until the armature pulls over with the " Operate " resistance in, but does not pull over with the " Not to operate " resistance in. " Operate " current 1·2 mA. " Not to operate " current 0·9 mA.

FIELD TELEPHONE EXCHANGE (CORDLESS), 10-WAY

1. Introduction

(i) *Requirements and range* (*see* corded type).

(ii) *Facilities* :—

(*a*) Communication over any of the 10 pairs of lines.
(*b*) Any two or all the lines (bunching) may be connected together.
(*c*) Call any line by generator only.
(*d*) Visual and aural indication from any line calling.

2. General Description

The exchange is housed in wooden container, divided into two compartments (front and rear). The front panel contains the switchboard consisting of the indicating shutters, black and white keys, and a battery switch. Connection is made to the board, from the various extensions, by two rows of 10 brass screws situated at the top of the panel.

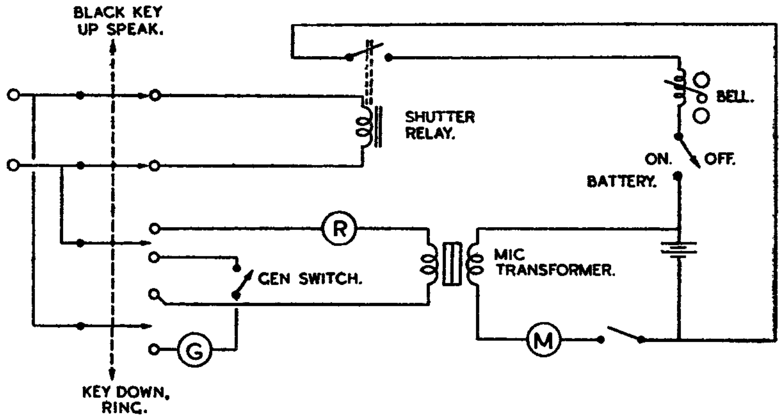


FIG. 6.—CORDLESS TELEPHONE EXCHANGE

3. Operation of Switchboard

When a call is received the shutter of the calling line drops and the bell rings. The operator should then :—

(i) Replace the shutter to disconnect the bell.
(ii) Raise calling line's black key to " speak ", ascertain required number.
(iii) Return caller's black key to centre position.
(iv) Depress the black key of the called line to " Ring " and turn the generator.
(v) Connect the two points by using the white keys (*see* para. 4) and return the second black key to centre.

Note.—It is of the utmost importance that a handset incorporating a " press " switch is used at all times by the operator, otherwise the batteries will be discharged through the microphone continuously, even when the battery " On "–" Off " switch is " Off ".

4. Connecting Two Lines

The white keys of the two lines must either both be raised or depressed : either row may be used but not both, e.g. No. 1 line may be connected to No. 2 by either :—

(i) Raising both white keys of the top row.
(ii) Depressing both keys of the top row.

(iii) Raising both keys of the bottom row.

(iv) Depressing both keys of the bottom row.

Supposing 1 and 2 are connected by (i), 3 and 4 must now be connected by (ii), (iii) or (iv), otherwise they will " cut in " on 1 and 2.

Four different pairs of lines may thus be connected at once without interference: this leaves one pair without any such facility; in an emergency they may be connected by raising the two black keys, but this will leave the operator " on the line ".

Each line must give its generator a turn when ringing off to warn the operator that the conversation is finished: his indication is the dropping of the two shutters.

5. Servicing

(i) The two 1·5-volt cells must be in good condition; test regularly, and discard when voltage is insufficient to operate microphone or bell.

(ii) *Tests* :—

(*a*) Generator and line circuit relays. Test by connecting two lines together and ringing on each alternately. Shutters should operate.

(*b*) Hand set. Test by blowing across microphone, and listening for breathing sound.

APPENDIX IV—BASIC FITTING

HAND TOOLS

1. Fitting

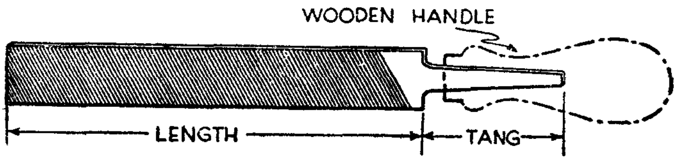
Fitting is the term applied to all those hand operations—as opposed to machine operations—which are necessary in order to shape the various parts of a mechanism to within the limits called for by the drawing. The subsequent operation of mating the various parts in order to build up the complete mechanism is called Erection or Assembly.

The principal hand tools employed by Wireless Mechanics, apart from the soldering iron, are files and hacksaws, with hammers and vices as ancillaries. In addition to these, other tools are employed, such as punches, drills, taps and dies; while others, such as pliers, screwdrivers and spanners are used in assembly operations. All the tools mentioned together with certain measuring instruments are illustrated and described below.

2. Files

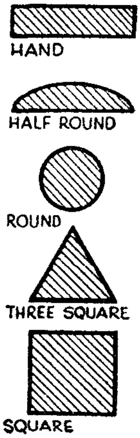
Files are cutting tools for removing metal from a surface and are made of high carbon steel, hardened, with a softened tang. There are many varieties in common use which are categorised by the length, section, cut and grade.

(i) *Length.* The length is measured from the shoulder to the tip of the blade; they are normally obtainable in sizes from 3 ins. to 14 ins.



FILE

(ii) *Section.* The section of the file to be used depends on the job for which it is required. The following sections are commonly used :—



(*a*) Hand. This is the most common section for general use.

(*b*) Half-round. A common section for rougher work and for filing large rounded holes.

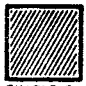
(*c*) Round. Used for internal filing in rounded holes.

(*d*) Three square. A triangular file for clearing out corners.

(*e*) Square. For internal work

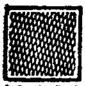
SECTIONS OF FILES

(iii) *Cut.* Different arrangements of teeth are used for filing different materials :—



SINGLE CUT

(*a*) Single cut. These are used on soft materials as the teeth are less likely to become clogged.



DOUBLE CUT

(*b*) Double cut. This is the most common cut used in general engineering.

DREADNOUGHT

(*c*) Dreadnought. This is used for very heavy cutting.

CUTS OF FILES

(iv) *Grade.* The spacing of the teeth may be fine or coarse depending on the finish required, and these grades are applicable to single or double cut files. In general, the longer the blade the coarser are the respective grades.

(*a*) Rough files are used for rough work only, to remove metal quickly.

(*b*) Bastard files are a common grade and are used for ordinary engineering work where the finish is not important.

(*c*) Second cut files are a common grade and give a good finish fairly quickly.

(*d*) Smooth files give a good finish but are slower cutting.

(*e*) Dead smooth files give a very fine finish and must be used for final finish only.

Note. " Hand " files in use in the Service have one edge left without teeth for working against a finished surface. This is called a " safe " edge.

In describing a file the grade, section and length must be stated, *e.g.*, Bastard, square, 8 in. or Smooth, hand safe edge, 6 in.

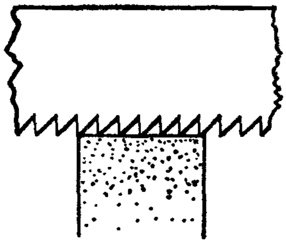
Double cut files will be provided unless otherwise ordered.

(v) *Hints on filing.* Never use a file without a handle and always ensure that the handle is tight on the tang. Remember, the file cuts on the forward stroke only, therefore relieve the pressure on the return stroke. Use the full length of the file for each stroke and do not rush it. Keep the teeth clean by using a scratch card. Chalk may be used for final finish to prevent scratches. Remember that the blade is very brittle and it may break if dropped or knocked. New files should, where possible, be used on brass or similar metals before being used on steel. Always use the correct size and grade of file, *e.g.*, do not use a small smooth file for rough work where a large amount of material is to be removed.

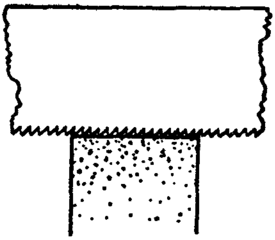
3. Hacksaws

These consist of a fixed or adjustable mild steel frame with a wooden or composition handle and a renewable blade of high carbon or alloy steel, hardened and tempered.

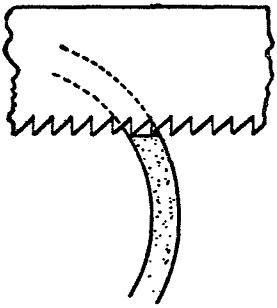
Fine toothed blades (22 to 32 teeth per inch) are used for cutting thin material, coarser toothed blades (14 to 18 teeth per inch) for thicker material.



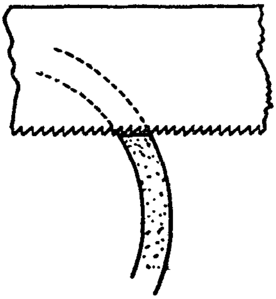
Thick material—Coarse teeth
Cuts well—Correct



Thick material—Fine teeth
Teeth clog—Incorrect

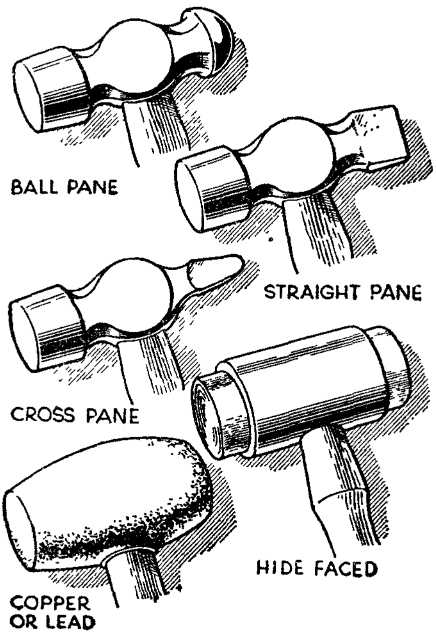


Thin material—Coarse teeth
Teeth straddle work and break—Incorrect



Thin material—Fine teeth
Several teeth in action
Cuts well—Correct

USE OF HACKSAWS



HAMMERS

4. Hammers

Hammers are classified by the type and weight of the head. The heads of (i), (ii) and (iii) are of high carbon steel, hardened and tempered on the faces ; the shafts are of straight grained ash. The principal types employed are as follows :—

(i) *Ball pane.* These are used for ordinary jobs, riveting, etc.

(ii) *Cross pane.* For general work and use in narrow spaces.

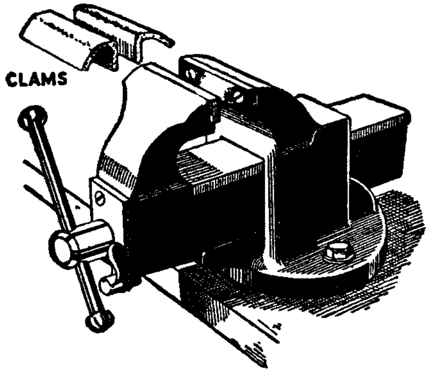
(iii) *Straight pane.* As for cross pane.

(iv) *Hide faced.* These are used where damage to the surface must be avoided.

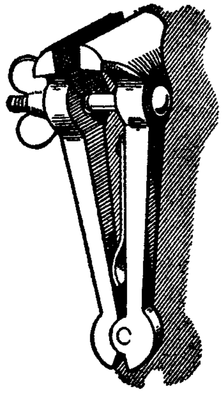
(v) *Copper and lead hammers.* As for hide-faced hammers.

5. Vices

Vices are used to hold firmly the material upon which work is to be carried out. Two types are commonly employed :—



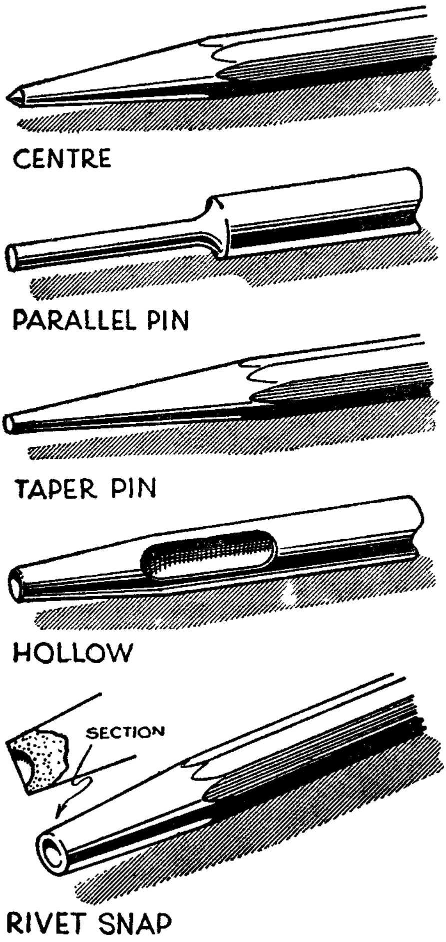
BENCH VICE



HAND VICE

(i) *Bench vices.* The body is made of malleable cast iron or cast steel with detachable steel jaws. The faces of the jaws are serrated and they are hardened and tempered. The screw is made of mild steel with a square or buttress thread. They are classified by weight and the length of the jaws (*e.g.*, 45 lbs. 4½ ins.). To protect finished surfaces from the steel jaws, " Clams " of copper, lead or aluminium are used.

(ii) *Hand vices.* The body is made of steel with jaws hardened and tempered. The screw is of mild steel.



PUNCHES AND SNAP

6. Punches and Snaps

These are made of high carbon steel hardened and tempered at the business end. Several types are in use as follows :—

(i) *Centre punches.* These are used for marking out by a series of light " pops " along a scribed line. They are also used to make a " pop " to locate the centre of the drill at the commencement of drilling. Stouter types of centre punches must be used for heavy work. A very sharp point must be maintained.

(ii) *Pin punches.* These are usually tapered but may be parallel. They are used to drift out split pins after the legs have been cut off, and pins, tight bolts, shackle pins and rivets, etc. They are obtainable in various diameters of small end.

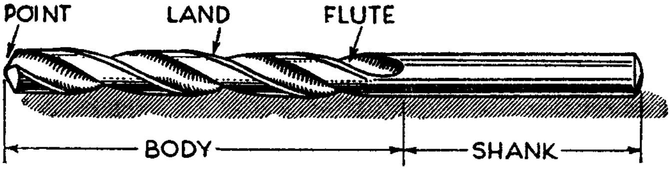
(iii) *Hollow punches.* These are used to punch definite sized holes in soft material such as leather, jointing material and sheet rubber. Punch on the end grain of a hard wood block to avoid damage to the cutting edge.

(iv) *Drifts.* These are stout flat-ended punches of steel, brass, copper or aluminium for localising hammer blows and preventing damage to the job. They are used for driving tight-fitting parts. Steel drifts only must be used for driving ball or roller races, as with softer drifts there is a possibility that small fragments of the drift may get into the race.

(v) *Rivet snaps.* These are specially shaped to form the heads on rivets. They are obtainable in various sizes and shapes to suit the size and type of rivets.

7. Drills

(i) *Types.* Various types of drill are used on different work, but the only drill the Wireless Mechanic is likely to use is the twist drill. This is the most efficient drill since the fluting presents the cutting edge to the job at the correct angle and clears the hole of swarf during the cutting operation.



TWIST DRILL

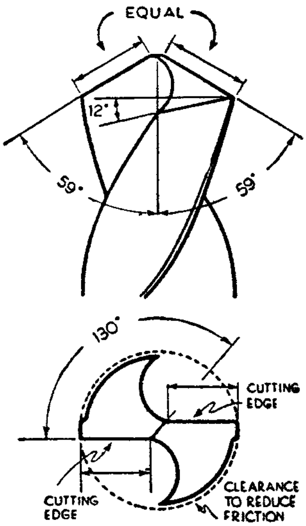
For efficient operation and accurate work it is essential that drills be accurately ground to give the correct cutting and clearance angles. This grinding must be carried out by qualified personnel.

(ii) *Drill sizes.* Twist drills are usually marked on the shank with their sizes.

(*a*) Fractional sizes. $\frac{1}{64}$ in. diameter to 1 in. diameter by steps of $\frac{1}{64}$ in. and 1 in. diameter and over by steps of $\frac{1}{32}$ in.

(*b*) "Numbered" sizes. No. 60 (·040 in. diam.) to No. 1 (·228 in. diam.)

(iii) *Grinding twist drills.* The cutting edges must be of equal length and equal angle (59 degrees) to ensure that each edge does its fair share. The clearance angles should be 12 degrees as shown, and the web angles will then be about 130 degrees. These last two angles are interdependent and if they are incorrect the drill will cut badly, if at all. The cutting edges do not extend to the centre of the drill, so the extreme point is non-cutting and must be forced into the job. When drilling holes it is good practice to drill a pilot hole first, larger than the non-cutting centre of the large drill, to assist the large drill to penetrate. On large drills the web may be thinned by local grinding to reduce the size of the non-cutting centre.



DETAILS OF TWIST DRILL ANGLES

(iv) *Use of drills.* When using drills the following points must be noted.

(*a*) When using a drilling machine ensure that the drill is running at the correct speed. This depends upon the size of the drill and the metal being drilled.

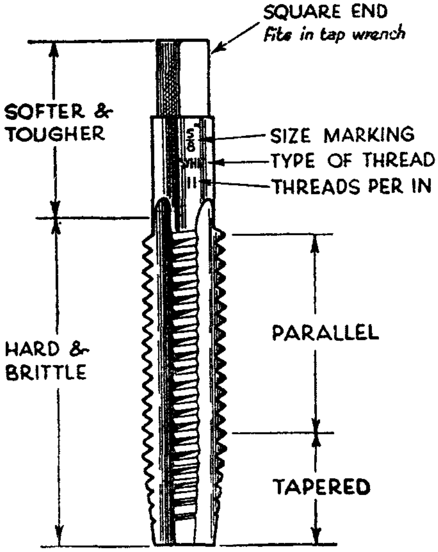
(*b*) When drilling large holes first drill a pilot hole of small diameter to act as a guide for the larger drill.

(*c*) Always use the lubricant given in the following table.

Material	**Lubricant**
Mild Steel	Oil, soda solution or soap and water.
High Carbon Steels and alloy steels.	Turps or paraffin.
Cast Iron	None (self-lubricating).
Brass	None.
Aluminium and Duralumin.	Paraffin.
Plastics	None.

8. Taps

These are used for cutting internal screwthreads. They consist of short screws of hardened and tempered steel, fluted to give cutting edges. The top is squared to facilitate turning with a wrench. They are made in sets of three—except for B.A. sizes in which the second tap is omitted—and are used in the following order.



SECOND TAP

(i) *Taper taps.* These are used for starting the thread and are usually tapered from the point to the sixth thread from the top. The diameter of the point is equal to the root diameter of the thread. They will produce a full thread in a through hole.

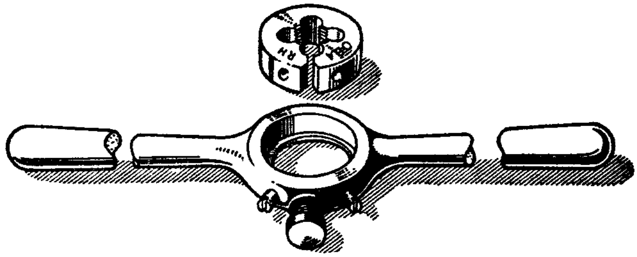
(ii) *Second taps.* These are used to deepen the thread cut by the taper tap in a blind hole. They are tapered in a similar manner to the taper tap, but only for the first six threads.

(iii) *Plug taps.* These are not tapered and their purpose is to finish the threads to the bottom of blind holes or deep through holes.

9. Dies

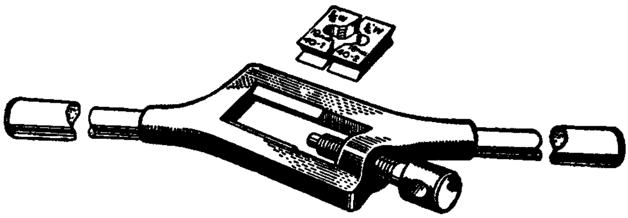
These are used for cutting external screwthreads. They are made of hardened and tempered steel and are held in a stock. Two types are used as under :—

(i) *Circular dies.* These usually cut a full thread in one operation, but springiness of the die allows very limited adjustment by the screws in the stock. The threads are tapered on one side of the die to afford a start. The correct assembly is with the shoulder of the socket in the stock to the top and the tapered threads of the die to the bottom. They are more commonly used on smaller types of threads.



CIRCULAR DIE AND STOCK

(ii) *Two piece adjustable dies.* These are usually used for larger threads and two or three cuts are needed to produce a full thread, the die being closed up after each cut. The threads are also tapered on one side as with circular dies. Ensure correct assembly; the numbers engraved on the two halves of the die must be on the same side.



ADJUSTABLE DIE AND STOCK

10. Screwcutting

(i) The procedure for cutting *internal threads* is as follows:—

(*a*) Drill the tapping size hole. The tapping size can be ascertained from tables, or by measuring the small end of the taper tap where the threads start. Alternatively select a drill which will just pass through a nut of the correct size.

(*b*) The tap must be entered vertically and tested with a square all round.

(*c*) Do not overstrain the tap and frequently turn it backwards to break the cuttings into chips.

(*d*) Lubricate where necessary. Lard oil for steel, paraffin for aluminium; brass is not lubricated.

(*e*) Clear the cuttings from the bottom of blind holes periodically.

(ii) *External threads* are cut as follows:—

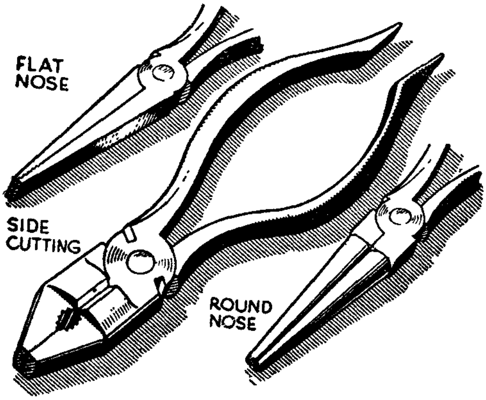
(*a*) The blank to be threaded must be cylindrical and not larger than the nominal diameter of the screw required.

(*b*) Special care must be taken to ensure that the die is started at right angles to the job.

(*c*) Do not overstrain the die; frequently turn it backwards to break the cuttings.

(*d*) Lubricate where necessary, lubricants as for tapping.

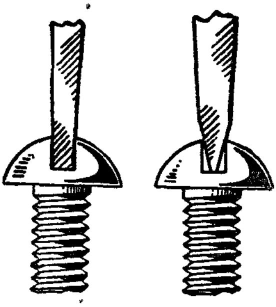
(*e*) As taps are not adjustable, cut the internal thread first and obtain a good fit by using the adjustment of the dies.



PLIERS

11. Pliers

These are made of high carbon steel with hardened and tempered jaws. They are obtainable in various shapes to suit special jobs such as flat nose for gripping small objects, and round nose for wire bending, etc. They are classified by the type and overall length.



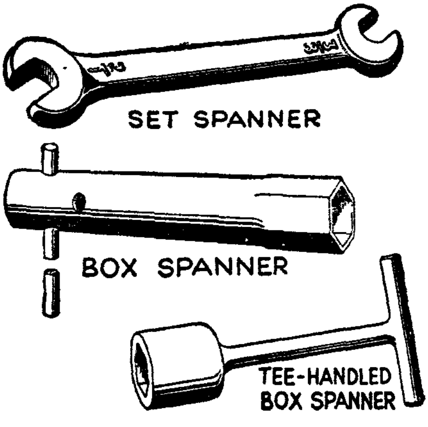
12. Screwdrivers

These consist of a hardened and tempered high carbon steel blade fitted with a wood or composition handle. They are classified by the length of the blade and may be fitted with a ratchet. The point of the blade is ground to fit the screw slot. It is essential that a screwdriver of the right size and the right shape be used, otherwise the slot will become distorted and burred and then the screw cannot be tightened or removed satisfactorily.

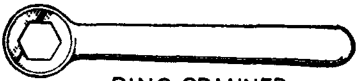
Screwdrivers must not be used as chisels.

13. Spanners

Spanners are made of hardened and tempered high carbon steel, alloy steel, or case hardened mild steel. They are usually made in Whitworth standard sizes and marked with the diameter of the bolt whose head they fit. A Whitworth standard spanner fits aB .S.F bolt one size larger. Wireless Mechanics are provided with a set of spanners in B.A. sizes. Several types are used.



(i) *Set spanners.* This is the most common type of spanner but it is not altogether satisfactory as it fits the nut or bolt on two faces only and the jaws tend to spring. Such spanners are often double ended to fit nuts of consecutive sizes. The head is usually at an angle to the handle for use in constricted spaces enabling a new grip to be made on the nut by turning the spanner over.



RING SPANNER

"C" SPANNER

(ii) *Box spanners and Tee-handled box spanners.* These fit the nut all round thus avoiding damage. They are especially used for nuts in inaccessible places.

(iii) *Ring spanners.* These resemble set spanners but fit the nut all round.

(iv) *" C " spanners.* These fit circular nuts.

(v) *Adjustable spanners.* These are very convenient because of the range of size available in the one tool. They should not be used if a suitable fixed spanner is available as the jaws have a tendency to spring and damage the nut.

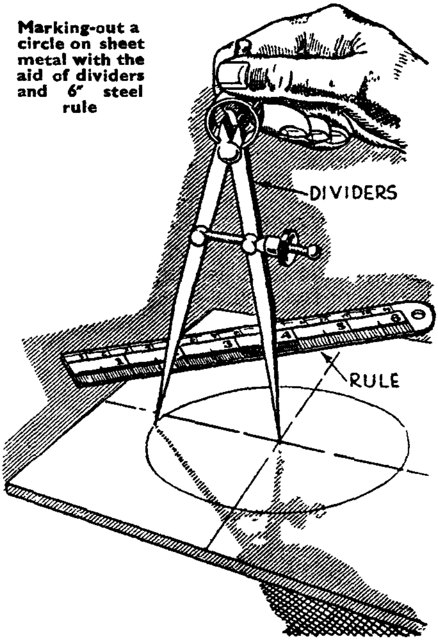
(vi) *Special spanners* of various shapes are issued and must always be used when working on the equipment for which they are issued. Punches must not be used instead of the proper spanner as they damage and strain the nut.

(vii) *Use of spanners.* Small bolts are weaker than large ones and small spanners have shorter handles or tommy bars to restrict the leverage that can be used in tightening. Despite this an ordinary person using a standard spanner can break a 2 B.A. or similar small bolt by a sudden jerk, or what is worse, leave it overstrained and useless without actual fracture. Experience alone can teach you the " feel " when a nut is tight. Tighten evenly without jerking and do not use a hammer or tube over the spanner to obtain greater leverage; such methods are *strictly forbidden* except where laid down in exceptional cases. An overstrained bolt may mean a wrecked aircraft and a loss of life.

MARKING AND MEASURING TOOLS

14. Rules

Rules are used for measuring and are made of high carbon steel hardened and tempered. They are graduated in the English and Metric Systems and are classified by their length. Protect them from rough usage and rusting.



RULE and DIVIDERS

15. Dividers

Dividers are used to set out distances and scribe arcs and circles. The legs are made of high carbon steel hardened and tempered, the spring of spring steel, and the adjusting arm of mild steel. They are classified by the length of the legs. Keep the points ground to a fine point, ensuring that the legs are of equal length. Grind on the outside only, with the legs together. Protect the points when not in use by a cork or other means.

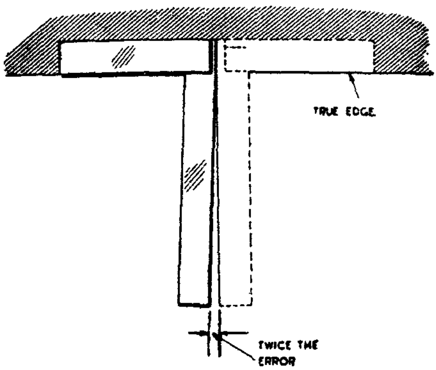
16. Scribers

Scribers are for marking lines on the surface of the job; they are made of high carbon steel hardened and tempered and are classified by the length. Keep the points keen and protect them when not in use.

17. Fitters' Squares

These are used for setting out lines at right angles to an edge or surface, and for checking right-angular work for truth. They are made of high carbon steel hardened and tempered, and are classified by the length of the blade. The blade and stock are accurately ground parallel, and set to exactly 90 degrees. They must not be roughly handled and when not in use must be kept in the box supplied.

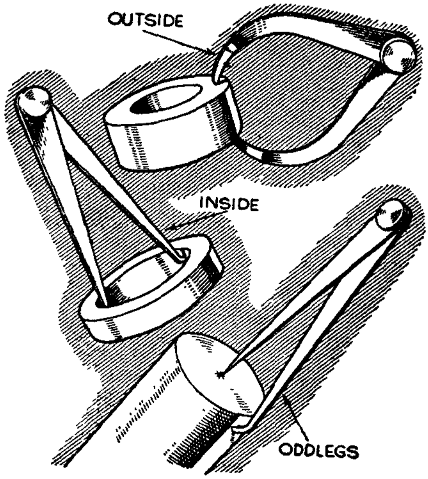
The square should be frequently tested for truth either with a master square or vee block. Alternatively, test as follows: Place the stock against the true edge of a flat surface and scribe a line along the outside of the blade. Turn the square over as shown in the sketch and check against the scribed line.



TESTING A SQUARE

18. Calipers

These are used for measuring distances between or over surfaces, or for comparing distances or sizes. Inside calipers for internal measurements, outside calipers for external measurements and odd-legs or jenny calipers for scribing lines from the edge of material. They are classified by the length. To set them, set almost to size by hand and get the exact size by tapping the leg (not the point) on a suitable rigid object.



Various Types and Uses of Calipers

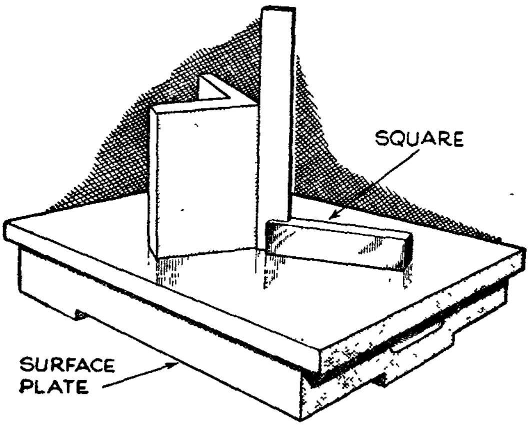
19. Marking-off Tables

These are used to support jobs for marking-out and form a base from which measurements are taken. They are made of close grained cast iron, are strongly ribbed on the under side for rigidity, and are supported on three legs to avoid distortion. The working surface is carefully machined flat, and when not in use it should be lightly oiled and covered with its wooden cover. No work other than marking-off and measurement must be performed on a marking-off table.

20. Surface Plates

Surface plates are used for testing flat surfaces for truth. The surface is covered with "marking" (thin colour film) on which the surface to be tested is lightly rubbed. The marking will be transferred to the job, thus indicating the high spots.

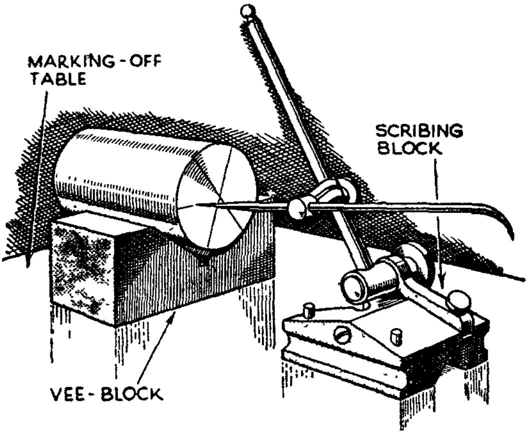
They are similar in construction to marking-off tables but are smaller and portable, are used on a bench and their surface is more accurately finished. Surface plates may be used in place of a marking-off table when the job is small and the table is not available.



Testing the accuracy of an Angle Plate with Fitter's Square

21. " V " Blocks

" V " Blocks are used to support round work on the marking-out table. They are made of cast iron or case-hardened mild steel in identical pairs, each pair being stamped with the same number. They are classified by the maximum diameter of the work which can be held. All surfaces are accurately machined with the " V " angle of 90 degrees.

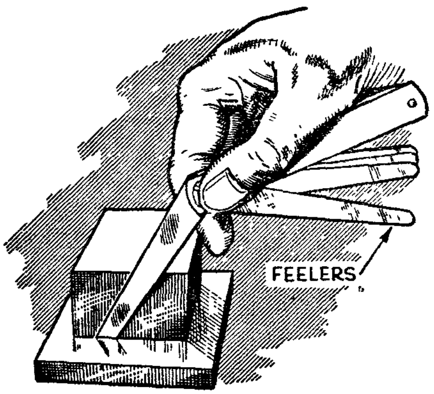


Scribing lines with a Scribing Block

22. Scribing Blocks

(i) *General.* Scribing Blocks are used to mark out lines parallel to a true surface ; they are generally used in conjunction with a marking-off table which forms the true surface. The base is made of cast iron or case hardened mild steel, the scriber of hardened and tempered high carbon steel, and the pillar and attachments of mild steel. They are classified by the height of the pillar. The pillar angle, scriber height and scriber angle can be adjusted, and there is a fine adjustment for the pillar. Dowels are provided in the base which can be pushed down to slide on the edge of the table.

(ii) *Method of use with rectangular work.* File one face true and square one edge to it. The job will then stand firmly on the marking-off table and lines can be scribed across its face by the scribing block to measurements from the true edge. In this way the finished size of the block can be marked together with the centres of any arcs that have to be scribed with the dividers, or holes that have to be drilled.



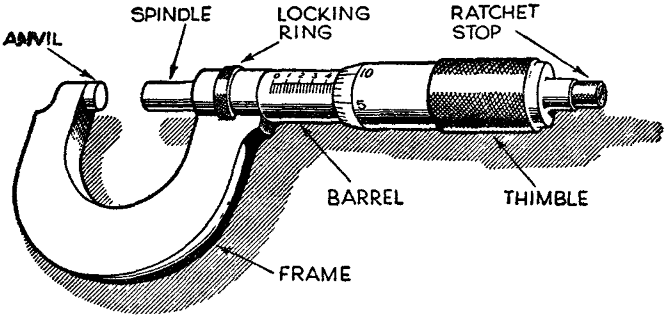
Gauging for error in a filing job
a test from the Fitter's Course

23. Feeler Gauges

" Feelers " are used to measure small clearances or gaps and consist of a series of blades of thin flexible steel, in graduated thicknesses, varying from $1\frac{1}{2}$ to 15 thousandths of an inch. They are classified by the length of the blades.

24. The Micrometer

If we know how far forward a screw moves for every complete turn given to it (*i.e.* its lead), together with the number of turns it makes, we can calculate the total distance it moves. This is the principle of the micrometer.



THE ENGLISH MICROMETER

(i) *English micrometer.* The lead of an English micrometer is $\frac{1}{40}$ in. and this is the length of each of the smaller divisions on the barrel. The larger (numbered) divisions on the barrel are each $4 \times \frac{1}{40} = \frac{1}{10}$ in.

The circumference of the thimble is divided into 25 equal divisions, and therefore

1 division on the thimble $= \frac{1}{25} \times \frac{1}{40} = \frac{1}{1000}$ in.

Hence we have :—

Thousandths of an inch given by the thimble.

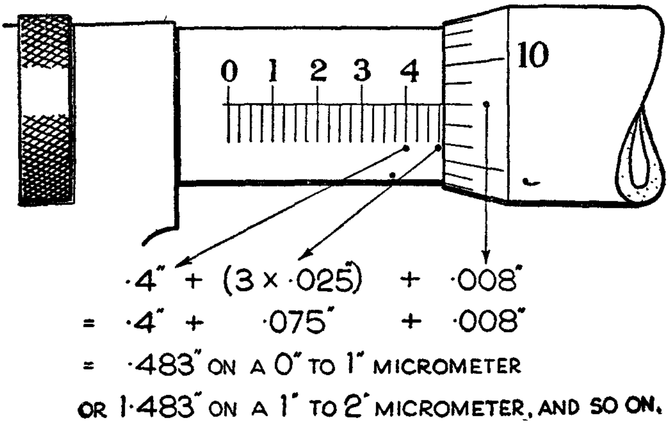
Fortieths of an inch given by the barrel.

Tenths of an inch given by the barrel.

For a micrometer as illustrated above, capable of reading from 0 in. to 1 in. the total measurement is the sum of the tenths, the fortieths and the thousandths.

Larger micrometers, however, are also used, but these, while having larger frames, still only permit a 1 in. movement of the spindle. It is clear, therefore, that in every case the zero reading of the micrometer must be added to the readings on the barrel and thimble. For example, in a 3 in. to 4 in. micrometer 3 in. must be added, and so on.

The following figure is an enlargement of part of the barrel and thimble shown above and (remembering that $\frac{1}{10} = \cdot 1$, $\frac{1}{40} = \cdot 025$ and $\frac{1}{1000} = \cdot 001$ the method of obtaining the reading ·483 in. is indicated.



HOW TO READ A MICROMETER

Notes. 1. If no division of the thimble exactly coincides with the line on the barrel, take the nearest division.

2. Some micrometers read to one ten-thousandth of an inch (·0001) by using an additional vernier marking on the barrel, so that in the case of non-agreement of the main divisions, the line on the vernier divisions agreeing shows the extra ten-thousandths.

(ii) *Use of micrometer.* (*a*) Keep the anvil and spindle end clean.

(*b*) Hold micrometer truly square with the job.

(*c*) Turn the thimble by the ratchet stud only—this ensures that the same grip is taken at each measurement.

(*d*) Lock the micrometer after it is set, before handing to another person.

(*e*) Always check a strange micrometer for correct zero setting. To do this, screw the spindle down on to the anvil till the ratchet slips (0 in. to 1 in. size only). The reading should be 0·000 in. If incorrect the micrometer must be re-set.

For larger micrometers, test pieces are provided, exactly 1 in., 2 in., 3 in., etc., which are "measured" between anvil and spindle. The micrometer scale should again read 0·000 in.

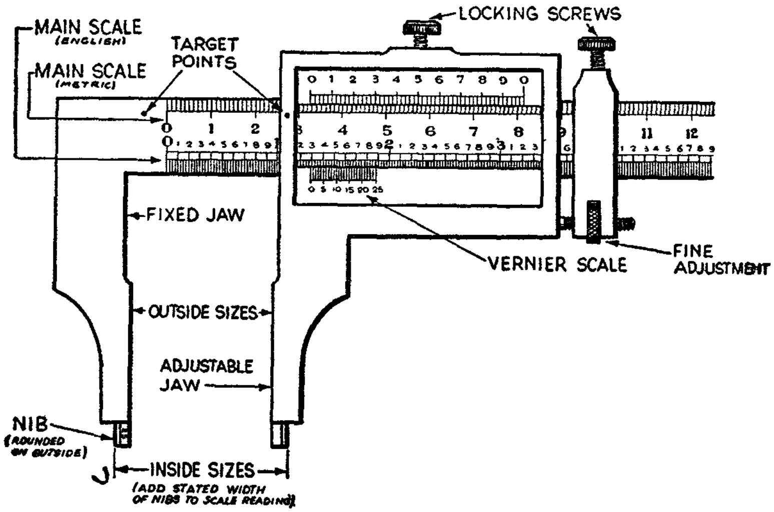
(*f*) The method of adjustment of the zero setting may be *either* by rotating the barrel on the frame by using a "C" spanner, *or* by adjusting the thimble on the spindle, *or* by adjusting the anvil in the frame.

(*g*) Play in the spindle threads is taken up by adjusting a nut at the thimble end of the barrel; this nut is normally covered by the thimble.

Note.—The adjustments given in (*f*) and (*g*) must be carried out by qualified personnel.

25. Vernier Calipers

These are a form of sliding calipers, with a vernier scale to read ·001 in. (or ·02 millimetres). They give inside as well as outside measurements, and have a much greater range than a micrometer: they frequently have small "target points" for setting dividers accurately. Both English and metric scales are usually incorporated in the same instrument. The back of the beam may be graduated in inches from the free end, for use as depth gauge.



VERNIER CALIPERS

(i) The main scale is graduated in inches and tenths, each tenth being numbered and subdivided into four parts (·025 in.). The "vernier" scale on the sliding jaw is formed by taking a length of twenty-four main scale subdivisions (24 × ·025 = ·6 in.) and dividing this into twenty-five equal parts (·6 ÷ 25 = ·024 in.). The difference in size between one main scale subdivision (·025 in.) and one vernier scale division (·024 in.) is clearly ·001 in. Hence the difference between (say) nine main scale subdivisions and nine vernier scale divisions is ·009 in., and so on. The vernier scale—each fifth division of which is numbered—reads in the same direction as the main scale. The main scale is read at the "0" of the vernier scale.

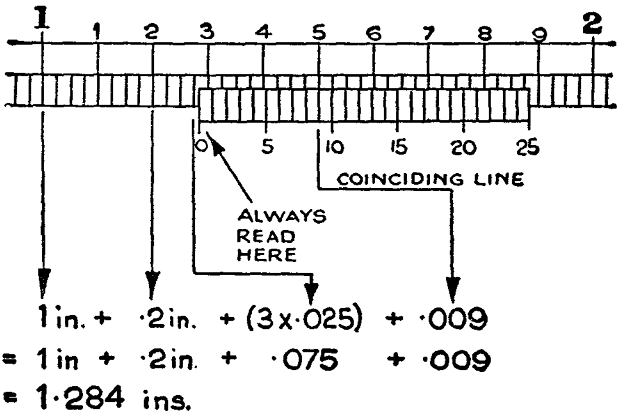
The measurement is indicated by :—

Main scale :—

- (*a*) the number of whole inches .. .. inches
- (*b*) the number of extra tenths .. .. tenths
- (*c*) the number of extra subdivisions .. .. .. fortieths.

Vernier scale :—

- (*d*) the value of the line on the vernier scale that coincides with any number on the main scale .. .. .. thousandths.



The vernier scale coincides at the ninth division : as shown above, the difference between nine vernier and nine main scale subdivisions is ·009 in. : so this is the distance by which the "reading point" (0 on the vernier scale) is to the right of the last main scale subdivision read.

Note. Other verniers exist, graduated on a 49/50 system (as in the metric vernier later described). These are read in a similar way, also to ·001 in.

(ii) *Metric vernier.* The main scale is graduated in millimetres, each tenth division being numbered 0, 1, 2, 3, etc. centimetres (10 millimetres = 1 centimetre).

The vernier scale is formed by taking a length of forty-nine main scale divisions (49 × 1 = 49 millimetres) and dividing it into fifty equal parts (49 ÷ 50 = ·98 millimetres). The difference between one main scale division (1·00) and one vernier scale division (·98) is clearly ·02 millimetres.

The vernier scale has each fifth division numbered 0, 1, 2, 3, etc. (5 × ·02 = ·1), indicating 0·1 of a millimetre of difference : subdivisions each indicate ·02 millimetres of difference, and the total difference read from the vernier scale at the point where the lines coincide is added to the main scale reading.

For example, the lines of vernier and main scales shown in the diagram coincide at one subdivision of the vernier scale past the vernier division numbered 6. This indicates ·62 millimetre difference on main scale, to be added to the main scale reading, giving a total reading of 32·62 mm.

Note. Other metric verniers exist, graduated on the 24/25 system ; they also read to ·02 millimetres.

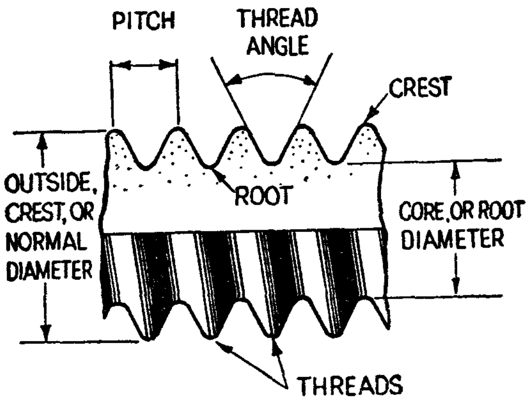
SCREW THREADS, NUTS AND BOLTS

26. General

A helical groove cut on the surface of a cylinder forms an external or male screw : its counterpart cut in a cylindrical hole gives an internal or female screw.

The groove may be either "right hand" or "left hand" : but unless special reasons exist "right hand" screws are used (*i.e.* clockwise rotation causes the male screw to move into the female).

Screws combine the advantages of the wedge and the lever, and form a convenient and readily detachable means of holding parts tightly together. They may be also used for transmitting power.



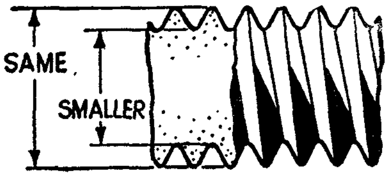
The groove may be of several forms, each with its own advantages : there are about half a dozen different standard screw systems.

(i) *Typical male single start thread.* The diagram illustrates the principal terms used :—

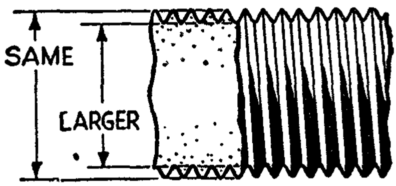
(*a*) Pitch is the distance from a point on one thread to the corresponding point on the next.

(*b*) Lead is the axial advance for one complete revolution of the moving member of a screwed pair. (Hence for single thread screw pitch equals lead).

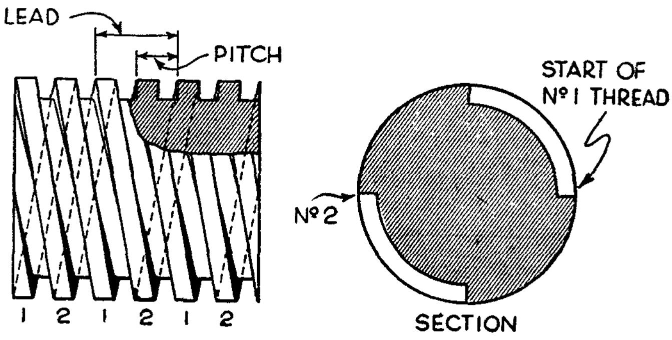
(*c*) The thread angle varies for different screw systems, *e.g.* 55 degrees for B.S.W., 47½ degrees for B.A.



(ii) *Coarse pitch.* Fewer threads per inch : slightly weaker bolt : more rapid action : stronger threads.



(iii) *Fine pitch.* More threads per inch : slightly stronger bolt : slower action : tighter grip : weaker threads : resists vibration better.



TWO START THREAD

(iv) *Multi-start threads.* These consist of a number of separate threads cut on the same cylinder. Their advantage is that they permit the rapid movement obtainable by the use of a coarser thread without the decrease in core diameter—and therefore strength—which would accompany it if a single thread of the same coarse pitch were used.

The definitions of Pitch and Lead as given above, apply.

(v) Male screw threads are usually cut into the surface of the bolt, and may thus be called "minus." Where it is important to avoid reducing the strength of the bolt, the end to be screwed is formed to a larger diameter, and the threads stand above the surface, forming a "plus" thread.

27. The more common Screw Systems

Name	Pitch	Sizes	Uses	Remarks
British Standard Whitworth (B.S.W.).	Coarse.	$\frac{1}{8}$ in. diam. upwards to 1 in., in steps of $\frac{1}{16}$ in. Over 1 in., in steps of $\frac{1}{8}$ in.	General heavy engineering.	The original standard screw: sizes of nuts, bolt heads and spanners are standardised on this system.
British Standard Fine (B.S.F.).	Fine.	$\frac{7}{32}$ in. diam. upwards. From $\frac{1}{4}$ in., in steps of $\frac{1}{16}$ in. to 1 in. diam.	Aero and motor work.	Similar to Whitworth, but finer pitch. Bolt heads and nuts one size smaller than the Whitworth standard.
British Association (B.A.).	Fine.	Numbered 0 to 10. (·236 in. to ·067 in.).	Small screws for aero, motor and electrical work.	Different type of thread. Engineers use sizes 0, 2, 4, 6 and 8. 2 B.A. is approximately $\frac{3}{16}$ in. diam.
British Standard Pipe (B.S.P.).	Fine.	Based on **inside** diam. of pipe, to use on **outside**. $\frac{1}{4}$ B.S.P. is about $\frac{1}{2}$-in. diam.	Pipe work.	Fine pitch ensures that enough uncut metal is left in the thin pipe wall.
Metric.	Fine.	Metric sizes.	Aero and motor work.	Found in machinery of Continental origin. Different type of thread from British systems.
National Coarse (American)	Coarse.	·073 in. diam. upwards.	General heavy engineering.	American equivalent of Whitworth, but with different type of thread.
National Fine (American).	Fine.	Numbered 0 to 12 (·060in. to ·216in.) omitting Nos. 7, 9, and 11. Then $\frac{1}{4}$ in. to $\frac{5}{8}$ in., in steps of $\frac{1}{16}$ in., and upwards to $1\frac{1}{2}$ in. in steps of $\frac{1}{8}$ in.	Aero and motor work.	American equivalent of B.S.F., but rather finer. Different type of thread.

All the above have triangular shaped threads: differences occur in thread angle, and shape of root and crest.

Caution. In view of the similarity of some of these systems, care must be taken not to put the wrong type of nut on a screw.

When dismantling apparatus, a good plan is to replace each nut on its bolt after the attached parts are clear. This also protects the external thread from damage.

28. Other Screw Threads

SQUARE

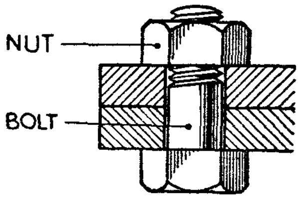
ACME

(i) *Square thread* and (ii) "*Acme*" *thread*: Used for transmitting power in both directions.

BUTTRESS

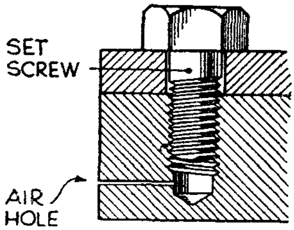
(iii) *Buttress thread.* Used for transmitting great pressure in one direction, as in vices.

29. Bolts, Nuts, Set-screws and Studs

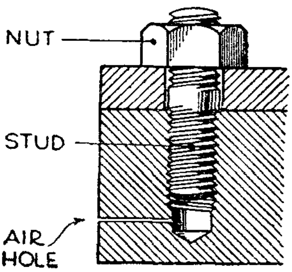


(i) *Bolts* are male screws with heads. Made of mild steel, alloy steel, brass, light alloy or other metals.

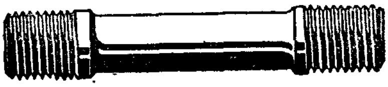
(ii) *Nuts* are shaped blocks similar to bolt heads, with a female screw to fit the bolt. The nut is nearly always the same shape and material as the head of the bolt it fits.



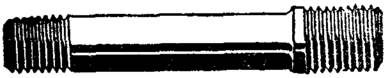
(iii) *Set screws* resemble bolts but are screwed into a thread cut in the job, instead of having a nut. Caution—set screws must be tight under the head: the screwed length must not reach the bottom of the hole, nor come to the end of the thread before the head is tight.



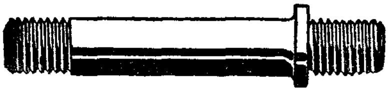
(iv) *Studs* are metal rods, screwed at each end. One end is screwed firmly into the job to the end of its thread (caution—see that the tapped hole is deep enough to allow this); an ordinary nut at the other end completes the fastening. In unfastening, the nut is removed: the stud must remain in position.



(v) *Waisted studs.* The unscrewed part of a stud may with advantage be reduced to the core diameter of its screwed ends. This saves weight, and makes the stud less likely to fracture from vibration and fatigue. Often found on aero engines.



(vi) *Stepped studs* have an enlarged thread at the end which screws into the job. Used for soft metal, the larger thread gives greater holding power. Also used to replace broken studs where tapped hole has been damaged, and has been re-tapped to a larger size.



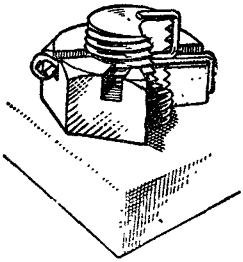
(vii) *Shouldered studs* have a collar above the thread which screws into the job. When screwed in so that the collar seats firmly, they are more rigid and secure than ordinary studs.

(viii) *Shapes of bolt heads and nuts.* Generally hexagonal (six sided), but may be square, round (with slots or holes to allow the use of a special spanner), or other shapes.

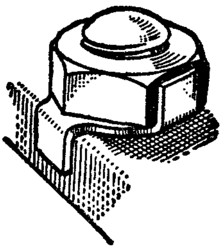
Whatever the shape, always use the correct spanner—not a pair of pliers or any other makeshift.

30. Locking Devices

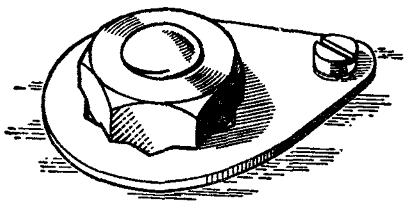
Under the influence of vibration and varying stresses, a nut is apt to unscrew. Various devices are used to prevent this. When fitting bolts, shackle pins or link pins they must, where possible, be fitted head uppermost to ensure that they will not drop out should the locking device fail.



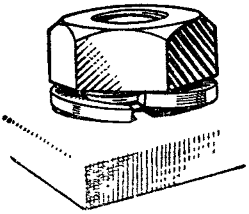
(i) *Split pins.* These are soft steel pins which pass through the slot in the nut and the hole in the bolt and are generally used with either slotted or castellated nuts. (See A.G.S. nuts for illustration). They must be a good fit in both slot and hole and the legs must be properly turned over. Each pin must be used *once only.*



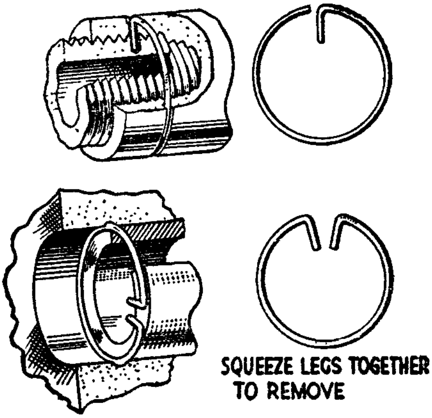
(ii) *Tab washers.* These are thin washers with two or more "tabs" or projections, one of which is bent over the edge of the job or fits in a hole in the job, the other being bent up against the face of the nut. Each washer must be used *once only.*



(iii) *Locking plates.* These are thin plates fitted round the nut after tightening, and retained against rotation by a small screw. The hole is usually twelve sided to allow for close adjustment. Sometimes they are made double ended to lock two nuts.. They may be used again if still a good fit on the nut.



(iv) *Spring washers.* They consist of a single coil of square section spring with sharp corners or a double coil of flat spring, placed under the nut and compressed flat on tightening. They may be used again if still springy and retaining their sharp corners.



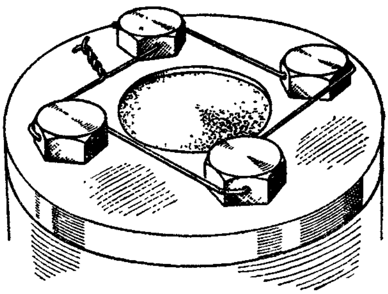
(v) *Circlips.* These may be used for circular screwed parts and act like a split pin but do not pass across a diameter. They are made of spring wire.

A circlip may also be used to prevent endwise movement by being sprung into a groove from which it partially projects. This second form is sometimes of rectangular section and may be used either internally or externally. Except for special circlips each circlip must be used *once only*.

(vi) *Simmonds nuts.* (For illustration see A.G.S. nuts, para. 33). A fibre washer fixed in the nut grips the thread of the bolt. They may be used again if the fibre is undamaged and gives a good grip.

(vii) *Locknuts.* These nuts are screwed down tightly on the ordinary nut or against the part into which a male thread is fitted. They are used on control rod ends, bracing wires, etc., where a rod is screwed into a fitting. They are not often used as a lock for ordinary nuts and bolts.

(viii) *Wire.* Soft wire is passed through a hole in the nut, with the ends twisted together after passing through a hole in or round another part. It is used for pipe union nuts, etc., or to lock a number of small bolts or screws, through the heads of which the wire passes. The lay of the wire must be such that it resists any tendency of the nut or bolt to unscrew. Wire must be used *once only*.



(ix) *Shellac varnish.* Small nuts and screws are locked in position by treating the nut and thread or screw head with varnish, which sets hard. Before unscrewing these nuts, apply heat by means of a soldering iron to melt the shellac.

Note.—All locking devices which are bent in use such as split pins, circlips, tab washers and locking wire, must be used *once only*. To ensure this, such parts on removal should be broken or bent to make them useless.

31. A.G.S. parts—General

" Aircraft General Standards " parts are small parts such as bolts, nuts, rivets, fork joints, taper pins, etc. common to many types of aircraft and engines. They are made in a range of sizes. The same part may be made of different materials, and a distinguishing system of identification markings is in use.

32. Bolts

All A.G.S. bolts have a right-hand thread, and are screwed only part of their length. The thread may be extended by careful use of a die, subject to final inspection by an Engineer Officer or Warrant Officer, or Signals Officer if used in Radio equipment or fittings.

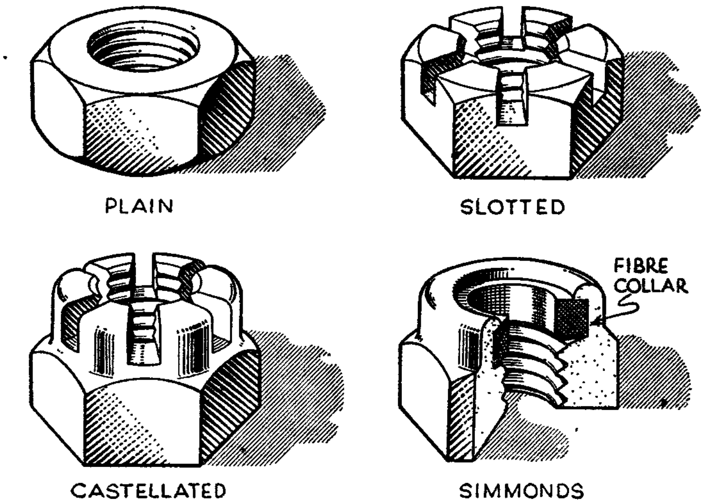
The material and size of A.G.S. bolts are shown by various markings. It should be remembered that many special engine or aircraft bolts will be encountered which will be marked, if at all, with a " part number " which gives no indication of size or material.

33. Nuts

(i) All A.G.S. nuts are marked as in the side view of the corresponding bolt, those over $\frac{3}{8}$ in. diameter having the diameter letter also.

(ii) Ordinary high tensile steel nuts are not to be used with high tensile steel bolts, as mild steel nuts are equally satisfactory : high tensile steel nuts of special design will be used in special places, as called for. If stainless steel bolts are used, the nuts must be of stainless steel.

(iii) Certain A.G.S. nuts have a left-hand thread : these are marked " L " if over $\frac{3}{8}$ in. diameter.



VARIOUS TYPES OF NUT

34. Rivets

(i) *General.* Rivets and bolts are both used to fasten various members together. Rivets are cheaper, lighter, and more rapidly fastened, but they are non-detachable, often require more elaborate equipment, and are not suitable for lengthwise loads (which tend to pull the heads off).

Rivets are supplied with one head already formed ; the head at the opposite end is formed by hand (or by machine), using special tools.

(ii) *Types.* Rivets are supplied in many different types to suit different conditions. Hollow rivets are used where there is a gap between the parts riveted together, or where there is more likelihood of the sheet metal tearing than of the rivet breaking ; solid rivets are used when these risks are approximately equal.

MATERIALS

35. General

All materials are divided into two groups, metallic and non-metallic. Two further classifications can be made ; materials which conduct electricity and materials which are non-conductors or insulators.

Engineering metals are divided into two classes. Those containing iron are called Ferrous metals and those containing no iron are called Non-Ferrous metals.

36. Ferrous Metals

Pure iron is not used in engineering ; it is always mixed with a proportion of carbon, which though small has a great effect on the properties of the metal. The most common ferrous metals are :—

Name of metal Per cent. of carbon Other constituents	Properties	Useful qualities	Uses
Cast iron (up to 4·7 per cent. and impurities).	Brittle, weak, fairly soft (very hard surface if "chilled").	Casts easily, wears to good surface. Resists crushing.	Machine frames, surface tables, piston rings.
Wrought iron (about 0·2 per cent. and fewer impurities).	Ductile, malleable, fairly strong, soft.	Easily magnetised, easily welded.	Cores of dynamos, lifting chains.
Steel. (1) Low carbon or " mild " (up to 0·25 per cent. and few impurities).	Ductile, less malleable, stronger, harder and more uniform than wrought iron.	Easily forged, welded, machined or stamped to shape.	Bolts, tubes, rivets, plates, all parts where great strength or hardness is not required.
Steel. (2) Medium carbon (0·25 per cent. to 0·7 per cent. and few impurities).	Rather stronger and harder, but less ductile and malleable than mild steel.	Not quite so easily worked as mild steel.	Shafts, rods, bolts, aircraft tubes. Rather stronger parts.
Steel. (3) High carbon (0·7 per cent. to 1·5 per cent. and few impurities).	Strong, less ductile. Hardness and toughness depend on heat treatment.	Can be made very hard without undue brittleness.	Cutting tools of all kinds.

Steel (nearly always with a low carbon content) may have varying proportions of another metal or metals added to it during manufacture. Such additions improve certain of its properties, making it more suitable for special purposes. Such steels are called alloy steels : the more common alloying elements are nickel, chromium, cobalt and tungsten.

37. Non-Ferrous Metals

(i) *Pure metals.* The most common non-ferrous metals are :—

Name	Colour	Properties	Uses
Aluminium	White	Soft, ductile, malleable. Work hardens. Fair corrosion resistance.	Aircraft sheets, tubes, rivets : engine parts : frequently alloyed.
Copper ..	Red ..	Ductile, malleable work hardens.	Small pipes : electric wires : frequently alloyed.
Tin.. ..	White	Malleable, not ductile, tough.	Anti-corrosion plating : alloys.
Nickel ..	Silvery	Hard, ductile	Anti-corrosion plating : alloys.
Zinc ..	Bluish	Soft, ductile	Anti-corrosion plating : alloys.

(ii) *Non-Ferrous alloys.* The most common non-ferrous alloys are :—

Name of Alloy	Constituents	Main Properties	Uses
Brass ..	Copper, zinc ..	Good wearing ..	Bearings.
Bronze ..	Copper, tin ..	Good wearing ..	Bearings.
Duralumin	Aluminium 95 per cent., copper, magnesium, manganese.	Light alloy. Nearly as strong as mild steel. " Age hardens".	Aircraft sheets, tubes, rivets, engine parts.
" Electron " (Magnesium alloy).	Magnesium, 90 per cent. aluminium, zinc, manganese, tin.	Very light : about ¾ strength of duralumin. Corrodes easily.	Engine and aero parts not highly stressed. Cover plates, etc.
Phosphor bronze.	Bronze and 1 per cent. phosphorous.	Stronger than bronze	Bearings.

38. Insulating Materials

The most common insulating materials used in electrical work are :—

Name of Material	Constituents	Main Properties	Uses
Asbestos ..	Mineral	Heat insulator, fireproof.	Resistance and heater formers.
Bakelite ..	Compressed synthetic resin and fillers such as wood flour, slate dust, mica, etc.	Can be moulded ..	Mouldings for electrical components.
Ceramic ..	Porcelain base or sintered aluminium oxide.	Very hard glazed surface. High heat and electrical resistance. Superior to porcelain.	Sparking plugs and condensers used in V.H.F. and U.H.F.
Chatterton's Compound.	Stockholm tar, resin and gutta-percha.	Low melting point..	Plastic insulator for sealing accumulators.

Name of Material	Constituents	Main Properties	Uses
Cotton ..	Vegetable fibre ..	Flexible. Fairly good insulator. Usually varnished or waxed to protect it from moisture. Spoiled by acids and oil.	Covering for wires.
Ebonite ..	Rubber and sulphur vulcanised.	Softens with rise in temperature. Slightly affected by moisture.	Instruments and switch gear where highest electrical properties required.
Enamel ..	Cellulose acetate ..	Is not suitable for flexible cables but provides maximum insulation for a minimum insulation thickness of material.	Covering for wires where it is necessary to obtain maximum number of turns in a given winding space
Mica ..	Mineral	Withstands high temperatures and voltages. Unaffected by moisture.	Condensers, commutators, formers for resistances.
Micanite ..	Sheets of mica cemented together under heat and pressure with insulating varnish.	Unaffected by moisture.	Where a high degree of flexibility is required.
Oil ..	Mineral	Moisture reduces dielectric strength. Must be free from acid and alkali.	A.C. transformers and switch gear.
Paper ..	Usually impregnated with paraffin wax or oil.	Absorbs moisture even when impregnated. Usually protected with lead covering when used on H.T. cables.	Dielectric for condensers and covering for H.T. cables.
Paxolin ..	Linen sheets or paper insulated with synthetic varnish under heat and pressure.	Light and durable..	Coil formers. Rotary switch cams.
Perspex ..	Synthetic resin ..	Translucent or transparent in appearance.	Used for U.H.F.
Presspahn ..	Pressed paper, heated and chemically treated.	Becomes brittle in time. Absorbs moisture slightly and warps.	Armature slot insulation. Field coils, etc., where a small amount of flexibility is required.
Porcelain ..	China Clay, quartz and feldspar.	High heat, electrical and weather resistance. Durable and hard.	Insulators for bare wires and sparking plugs.
Shellac ..	Resin	Inclined to chip. Softens with heat.	Insulating varnish.
Varnished cambric and systoflex.	Varnished cloth ..	Flexible	Insulating sleeving.

Name of Material	Constituents	Main Properties	Uses
Varnishes ..	Mixture of resin, oil and thinners.	Retain flexibility and electrical properties over long periods under varying temperatures. Usually baked to expel moisture.	Impregnating armature, field and transformer coils to seal and protect the winding from the effects of moisture. Tends to bond together the individual turns and give greater rigidity to the coil.
Vulcanised india rubber (V.I.R.).	Rubber vulcanised by heat treatment with sulphur.	Damaged by heat, petrol and oil. Fairly damp proof. Oxidises and perishes.	Covering for copper cables. A layer of pure rubber is usually put on the conductor first to prevent the sulphur attacking the copper.

39. Corrosion

Most metals and alloys, in the presence of air and/or water or when exposed to high temperatures, tend to form new compounds which entirely lack the good properties of the original material. This is known as corrosion.

(i) *Surface corrosion.* The corrosion products have a different appearance from the original material : reddish brown rust on steels, white or grey powder on aluminium and its alloys, greenish powder on copper.

Surface corrosion reduces the amount of material remaining and so weakens the structure. The surface finish is also roughened.

Remove corrosion products : if the thickness of metal has not been reduced below the limit of size, apply suitable protective coating (after restoring the surface finish, if necessary). If the corrosion has penetrated too deeply, the part must be scrapped.

(ii) *Corrosion due to galvanic action.* When in contact, dissimilar metals (such as steel and duralumin), or the same metal in different states (such as annealed and normalised duralumin) may corrode rapidly in the presence of moisture, due to electrolytic action.

The union of dissimilar metals should be avoided : where unavoidable, special protective compound must be spread over the surface before assembly.

(iii) *Protective treatment.* The idea is to exclude air and water. This is attempted by making the metal form its own protective coating (e.g. anodising), covering the surface with another metal less likely to corrode (i.e. plating) or by covering the surface with one of the following protective agents : —

(*a*) Stove enamel (i.e. enamel baked on by heat.)

(*b*) Paint, enamel or varnish applied by a brush.

(*c*) Oil, grease or lanoline.

Note.—Every care must be taken not to scratch a protective coating—which is very thin—by careless handling, use of scriber, etc.

SOLDERING AND PREPARATION OF CABLES

40. Soft Soldering

Soft soldering is a process for joining metal surfaces by the application of low melting point alloys called soft solders, usually composed of tin and lead. Grade " C " solder is used for most aircraft work and is issued in the form of sticks, but for electrical connections resin-cored solder must be used. The solder is usually applied by means of a heated soldering iron. A suitable flux must be used.

41. Soldering Irons

Soldering irons consist of a copper bit secured to a holder, fitted with a handle. The " iron " must be large enough to heat the job adequately. The following types are available :—

(i) *Common irons.* The bit is heated by a fire or blow-lamp. Various sizes are supplied.

(ii) *Electric irons.* Various sizes and voltages are available and the iron must not be connected to a voltage other than that stated. A switch is fitted in the lead for temperature control and must be switched off when the iron is not in use.

(iii) *Alumino-thermic irons.* This type of iron is used where no other heating source is available. The copper bit incorporates a circular cavity, in which is placed a " Mox " (Magnesium and Aluminium oxide) tablet. The tablet is ignited by a special match (fusee) and heats the bit. These irons must not be used near aircraft, M/T or other inflammable stores while the tablet is still burning.

42. Fluxes

Solder will only adhere to clean metals. Fluxes protect the cleaned surfaces from oxidation and so help the solder to flow. Some fluxes also have a cleaning effect on the surface. For electrical connections only resin or approved paste is to be used since these do not corrode copper. For other aircraft work only soldering paste or soldering solution is to be used except for stainless steel for which phosphoric acid is employed.

Note. Of the four fluxes at present in use in the Service, soldering fluid and phosphoric acid are corrosive and when these fluxes are used excess flux *must* be washed off with hot water.

43. Method of Soft Soldering

(i) Thoroughly clean the soldering iron and the job to be soldered.

(ii) Tin the iron by heating it and applying flux and solder.

(iii) Cover the surface to be joined with a thin film of solder using the appropriate solder and flux.

(iv) Place the surfaces together and reheat with the " iron " till the solder on both surfaces is fluid.

(v) Allow the job to cool and if a corrosive flux has been used, wash off all excess flux with hot water.

(vi) Test the joint by giving it a sharp tug.

Notes. (1) When nipples are soldered to cables ensure that the cable is well splayed in the countersink of the nipple.

(2) Use the minimum amount of solder—this makes the strongest joint.

(3) Keep the iron sufficiently tinned to facilitate the flow of the solder.

44. Dry Joints

This is the term applied to a badly-soldered joint, in which the solder has failed to adhere to the metal due to a non-conducting film forming between the solder and the metal. This film may be due to :—

(i) Dirty surfaces.

(ii) "Iron" too hot.

(iii) "Iron" not hot enough.

(iv) Dirty flux.

(v) Wrong type of flux.

45. Blowlamps

A blowlamp is a piece of apparatus by means of which paraffin is vaporised and burnt, so that the resultant flame can be used to apply heat to a soldering iron or to metals for brazing. Paraffin is placed in the container and is forced under pressure through a jet via a specially shaped tube known as the vaporizer. The pressure is obtained by a small hand pump incorporated in the lamp. The vaporizer is suitably heated to vaporize the paraffin, by burning methylated spirits in a priming well on the top of the container.

(i) *Operating procedure.* To fill the blow lamp remove the filler cap, close the air release valve and fill to ¾ with clean paraffin. Replace the cap and wipe off surplus paraffin. To light the blowlamp proceed as follows :—

(*a*) Open the air release valve and clean the jet.

(*b*) Fill the priming well with methylated spirits.

(*c*) Ignite the spirit and allow it to burn until the vaporising tube is hot.

(*d*) Close the air release valve and apply several strokes of the pressure pump.

(*e*) If the lamp is sufficiently hot, paraffin vapour will be forced through the jet and burn with a blue flame. Further pumping will increase the heat.

(*f*) If the lamp ejects liquid it is not hot enough. Open the air release valve and repeat operation of heating with methylated spirits.

(*g*) To extinguish the lamp open the air release valve.

(ii) *Precautions.* The following points must be observed when using lighted blowlamps :—

(*a*) "Pyrene" or "tetra-chloride" fire extinguishers must be available. Water must not be used.

(*b*) Lighted lamps must not be taken within 10 yards of aircraft, M/T or inflammable stores.

(*c*) Do not use lamps in excessive heat, i.e., near furnaces.

(*d*) Blowlamps must be placed on a piece of incombustible material, and never on wooden floors or benches.

(*e*) The flame must always be directed towards a metal sheet, asbestos or brick hearth.

46. Preparation of Cable Ends

(i) *General.* Where cables are connected to the terminals of a piece of apparatus, they should not be soldered if a satisfactory joint can be made without doing so. In the following instances it may be necessary to solder wire :—

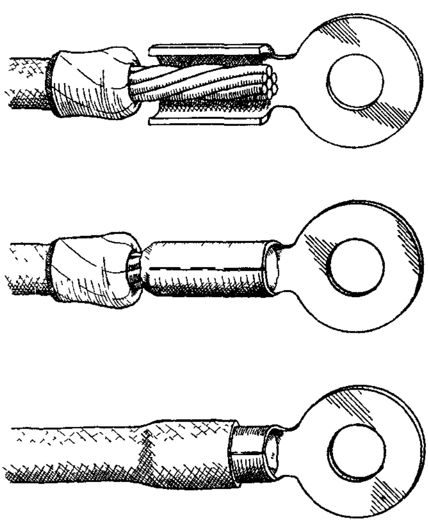
(*a*) Where space does not permit the use of a screw type terminal, in which case the cable conductors may be soldered directly into a hole on the contact point of the fitting. This method can only be used where infrequent disconnection is required.

(*b*) In engine starter and similar heavy multi-stranded cables, where the strands cannot be clamped under a screw head, a thimble with a soldering lug must be used.

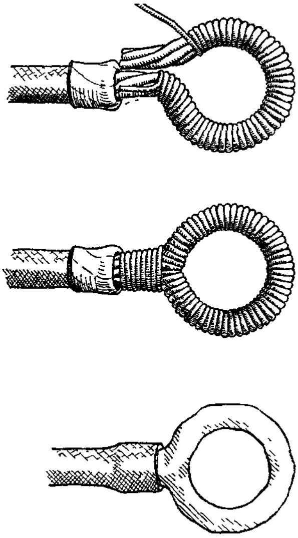
(*c*) Where apparatus is fitted with terminals of the pillar type with nuts, small metal eyelets which clamp the strands, or thimbles with soldering lugs may be used. Spring washers must be fitted.

(*d*) Where apparatus is fitted with terminals of the grub screw type, a thin copper sleeve is to be passed over the strands of the cable and spot soldered at the end.

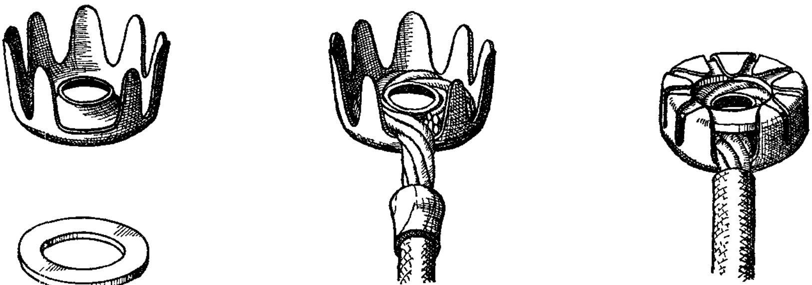
(*e*) In breeze, loom and strip connector wiring systems where plug and socket pins and connectors are soldered to cable ends.



EYE TYPE - *Channel end soldering*



WHIPPED TYPE



ROSS-COURTNEY

CABLE ENDS

(ii) *Precautions.* When preparing and soldering cable ends the correct measurements are given in the appropriate instruction sheet, but in general the following points must be observed.

(*a*) When stripping back the outer covering on multi-core cables care must be taken not to damage the rubber insulation on the inner cores.

(*b*) When removing the rubber insulation from the core, care must be taken not to cut or damage any of the wire strands.

(*c*) The rubber insulation of the core must be rolled back before soldering.

(*d*) When soldering leads to tags resin-cored solder must be used. Use of the wrong flux may lead to corrosion.

(*e*) The wires must be tinned after rolling back the insulation, and the solder end of the pin or tag must be cleaned and tinned at the same time.

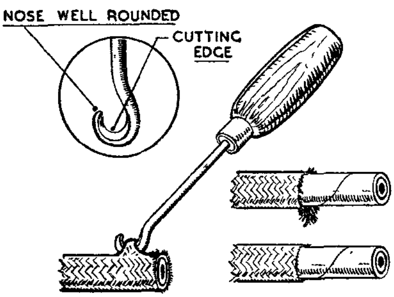
(*f*) When connecting the cable to the pin or tag the two parts are sweated together by holding the iron on the joint, but clear of the rubber. The connector should be held at an angle during this operation so that solder runs down into the connector and not up the stranded conductor.

(*g*) Care must be taken to prevent resin, solder or any foreign matter from damaging the contact faces of the connectors. Foreign matter should be removed from contact surfaces by a suitable spirit such as methylated spirits.

(*h*) After soldering, the rubber insulation must be rolled down to the connector. Rubber Hellerman sleeves should be fitted over the soldered joint.

(*i*) Great care must be exercised when soldering the flexible strands of a cable, as there is always the liability of strands breaking away at the point, where the core loses its flexibility by reason of the solder. In all such cases the flexible cable must be well supported at the point near the soldered position to avoid a bending movement, which may cause the strands to break. These points must be inspected regularly for breakage.

(iii) *Metal braided cable end connections.* The ends of metal braided cables are finished off by means of concentric inner and outer flanged sleeves, which grip the metal braid tightly between them. Prepare the cable by using a cable stripping tool as follows :—



CABLE-STRIPPING TOOL

(*a*) Insert the blunt end of the tool under the metal braid.

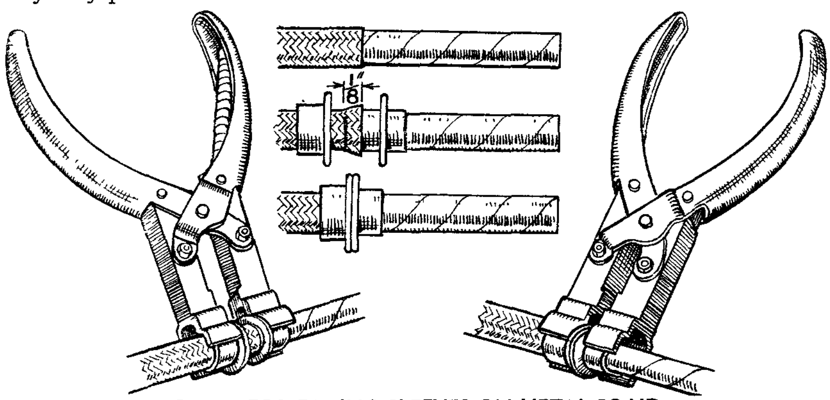
(*b*) Lever the strands onto the knife edge and sever by a sharp pull.

(*c*) Repeat until a slit is made in the braid, of the length stated in the appropriate instruction sheet of the particular terminal fitting.

(*d*) Lift the braid off the underlying cambric tape and trim the edge with a pair of scissors; unless removed loose strands may puncture the insulation.

(*c*) Fit the inner and outer sleeve, with the metal braid overlapping the inner sleeve by $\frac{1}{8}$ in. and force them together with sleeve fitting parallel motion pliers.

Note.—Sharp pointed tools must not be used for stripping metal braid as they may puncture the insulation and cause electrical breakdown.



PLIERS FOR FITTING SLEEVES ON METAL BRAID

47. Joining Damaged Aircraft Cables

Where it is impracticable to replace damaged cables, they may be repaired in an emergency by joining the cable. Where there is insufficient cable to allow twisting of the cores together, a short length of cable is to be inserted and two joints made. This method of joining applies to single core cables and is only suitable up to 37 amp. cable size. Joints in adjacent cables must not be opposite each other. To join the cables proceed as follows :—

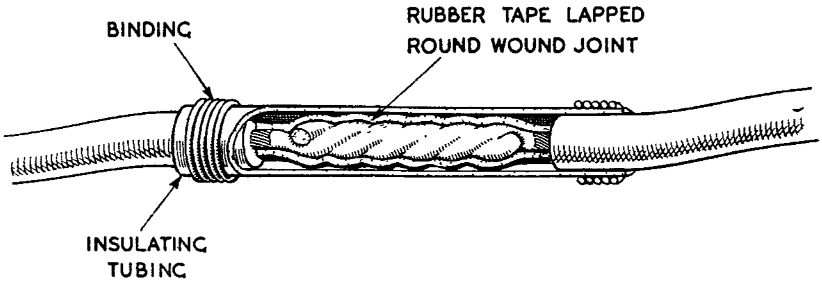
(i) Bare back the wires of the core at least 1 in.

(ii) Slide a length of systoflex insulating tubing over one cable.

(iii) Twist the core wires together and solder.

(iv) Lap the joint with two layers of rubber tape.

(v) Slide the systoflex over the joint so that it overlaps the cable insulation at each end, and bind it in position with black thread.



JOINT IN DAMAGED CABLE

(72583) Wt.28907/L.1652 1,500 10/45 Hw. G.371. (T.S. 12013)