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ELECTRICAL REMOTE CONTROL AND INDICATING SYSTEMS IN AIRBORNE RADIO EQUIPMENT

By D. R. GAMLEN, A.M.I.E.E.

Modern communication equipment for Civil Airlines presents new problems for the Servo engineer. The solutions adopted have been incorporated in apparatus which has undergone extensive tests and is now in production. Some of these results are described below but their choice will always be governed by factors, not always controllable by the engineer, which may prevent the adoption of the most elegant solution.

Introduction.

EXISTING practice and recent developments in the servo-control field have been fully described in the papers presented at the Convention on Automatic Regulators and Servo mechanisms arranged by the I.E.E. in May, 1947.

The papers are mainly concerned with the military applications on guns, torpedoes, searchlights, radar, etc., or aircraft applications such as automatic pilots, gyro-compasses, fuel and pressure gauges. Very little information, however, is given regarding airborne radio applications.

Applications.

It is necessary to consider the operational requirements and planning of a Radio Station for a Civil Transport fully to appreciate the need for Remote Control and indication.

The main equipment in the installation would probably comprise :—

(*a*) H.F. Receiver. Frequency Range 2.0 to 18.5 Mc/s.

(*b*) M.F. Receiver. Frequency Range 150 kc/s. to 2 Mc/s. (usually) combined with Radio Compass and operates Consol navigational system.

(*c*) H.F. High Power Transmitter. 2–18.5 Mc/s.

(*d*) M.F. High Power Transmitter. 320–520 Mc/s.
(*e*) Beam Approach Receiver.
(*f*) V.H.F. Communication Trans./Receiver.
(*g*) Cloud and Collision Warning Radar. } Carried on larger aircraft only.
(*h*) Rebecca Radar. }

This article is confined to consideration of items (*a*) to (*d*), but it will be immediately obvious that it is physically impossible to provide direct control of all the equipment which has to be manipulated by the crew. This limitation is common to all the equipment, each item having its own particular requirement for servo-control which is dealt with under the separate headings. Faced with the problem of remote controlling the equipment mentioned, the Servo engineer finds his choice of tool or system narrowed by certain limitations, namely :—

(*a*) Source of supply, usually 24 v. D.C. except where a 400-cycle supply is deliberately installed to supply the Servo system.
(*b*) Size and weight. The reduction of 1 lb. in the weight of equipment is worth £30 in payload over an estimated life of the aircraft of two years.
(*c*) Need for conversion to either local or remote control in service by customer (in certain cases).
(*d*) Cost.

M.F. Receiver.

Where the receiver is installed out of reach of the operator the following controls have to be manipulated by the radio operator, or in some cases by the pilot also, at another position.

CONTROL	METHOD	
	Radio Recr. End	Control End
Function Switch—On/off, etc.	Relays	Switches
Gain Controls	Extended Leads	Potentiometers
Frequency Range Switch	Controller Switch Drive Unit	Switch
Selectivity Switch	Ditto	Ditto
Tuning Condenser Drive	Aysynn	Aysynn
Frequency Indicator	Aysynn	Aysynn

This treatment enables the operator to control the receiver, at a distance, in just the same way as if it were in front of him. A changeover switch transfers control from one station to another, if dual control is required.

Fig. 1 shows a receiver with the controller switch drive units in place.

Fig. 2 illustrates the coupling of the Aysynn receiver and transmitter to the tuning condenser.

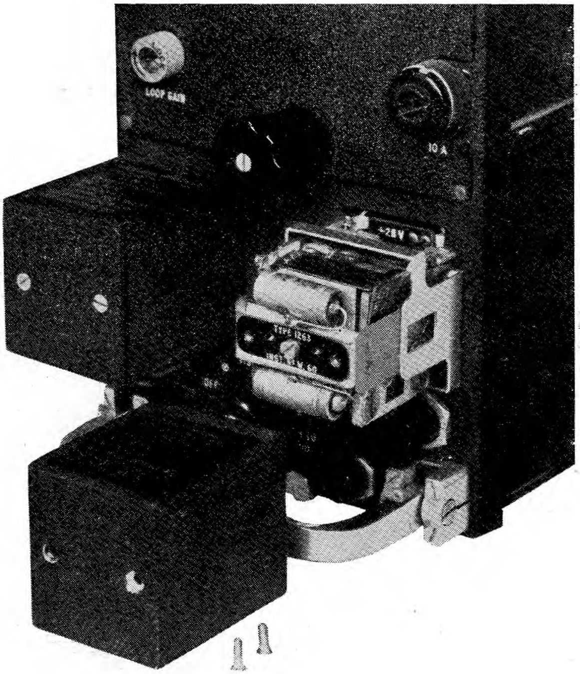


FIG. 1

AD. 7092 M.F. Receiver. Wave Range and Selectivity Controller Switch Drive Units in situ. They can be replaced by Control Knobs and click plates for local control installations.

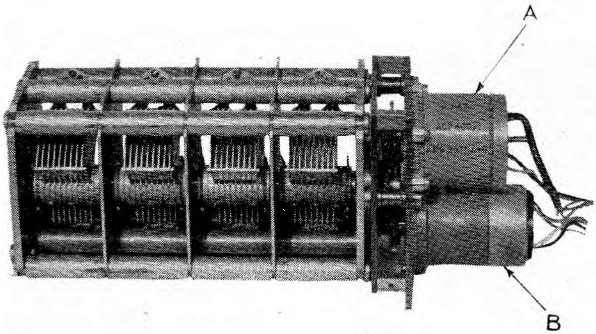


FIG. 2

Tuning Condenser and Slow Motion Drive Assy for Electrical Control. The gear box and Aysynns lie within the projected area of the condenser end plate.

A *Signal Generator 360° Rotor movement = 180° Condenser Movement.*

B *Aysynn Receiver 240° Rotor Movement = 1° Condenser Movement.*

High Power Transmitter.

Modern radio transmitters comprise several units, such as :—

Crystal-controlled Drive Unit.
Power Amplifier Unit.
Aerial Loading Unit.

These are not necessarily located together, but are disposed to suit the installation, and in each unit there is the requirement of circuit selection and/or tuning for maximum gain to bring the complete system into gang with the frequency required and to make it ready to transmit.

Operational requirements are also such that an operator must be able to change from one frequency to another without loss of time and with a minimum of effort.

These requirements taken together can only be satisfied by a system which is semi-automatic in operation and can be remote controlled. That is to say, to select a particular frequency it is desirable that the operator should only need to energise a circuit by a switch or push button, thereby operating the remote control system which immediately turns all the shafts to the position which coincides with the frequency desired.

One method of carrying this purpose into effect is to connect each adjustable shaft to a specially designed pre-selector unit comprising :—

(*a*) A motive force.
(*b*) A pre-selector.
(*c*) A gear box uniting (*a*) and (*b*).

The driving motor is preferably of a slow-running but inertialess type (to avoid over-running) such as a Type 1263 controller switch drive unit.

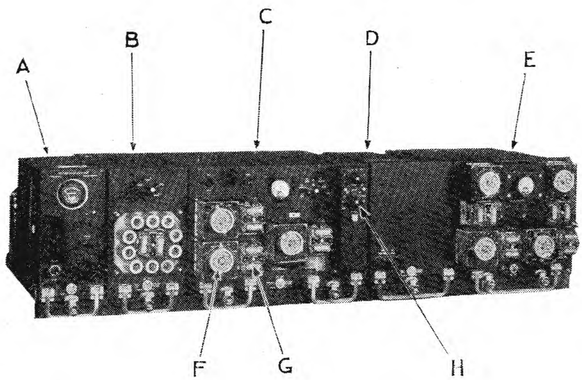


FIG. 3

AD. 107 H.F. Transmitter. There are seven Pre-selector units performing the duties of tap changing, variable condenser tuning, etc., plus five Controller Switch Drive Units for circuit selection.

A *Voltage Regulator Unit.*
B *Crystal Controlled Drive Unit.*
C *Power Amplifier Unit.*
D *Power Unit.*
E *Aerial Loading Unit.*
F *Pre-selector.*
G *Controller.*
H *Local controls.*

Fig. 3 shows a high power H.F. transmitter capable of pre-selection on ten crystal-controlled channels.

The Radio Compass.

The radio compass or automatic direction finder (Fig. 4) combines several Servo systems. Not only is the receiver remotely controlled but rotation of the loop is power operated, guided by the direction of radio signal arriving such that the axis of the loop always points towards the incoming signal.

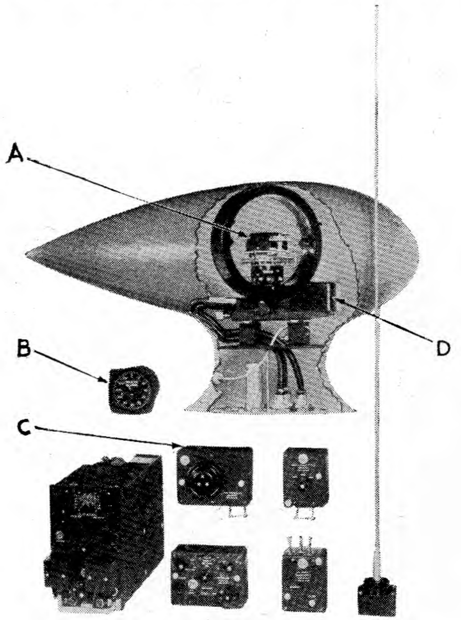


FIG. 4

AD. 7092 A.D.F. Installation. The equipment shown is for a plane with external aerials and single station control, with D.C. supply. For high speed aircraft where recessed aerials are required an iron cored loop can be used.

A *Desynn Transmitter connected to*
B *Bearing Indicator balanced against*
C *Controller.*
D *2-Phase Motor and gear box.*

This is achieved by a true Servo system comprising an A.C. power source from a 110-cycle vibrator and a 2-phase motor. One phase of the motor is continuously excited and the other is fed from a thermionic amplifier, the output of which is controlled by the amplitude of the incoming signal obtained from the loop. The motor therefore drives to null position where no signal is being received.

It is also necessary to be able to rotate the loop to take aural bearings. For this facility an artificial null is created by switching the input of the motor amplifier to a toroidal potentiometer which is balanced against a similar potentiometer on the loop shaft. The 2-phase motor then runs to reduce the error signal to zero. Displacement by the operator of his potentiometer control produces a corresponding response by the loop.

The position taken up by the loop relative to the aircraft is transmitted to receiving indicators on either the Desynn system in aircraft with a D.C. supply or Aysynn system when 400 cycles is available.

Where very accurate bearings are required for navigational purposes (as opposed to "homing") a Motaysynn Servo is employed. This method is more accurate since the needle is driven into alignment at the receiving end, no power being drawn from the transmitter.

A further advantage is that a differential generator can be interposed between the transmitter and receiver and the angular displacement of this can modify the bearing. The differential generator angular displacement can be made to coincide with the gyro-compass bearing and a conversion from Relative to True bearings thereby accomplished.

Description of Systems employed.

Reference has been made to various types of prime movers, servo and indicating systems in discussing the applications for remote control. It is proposed, in what follows, to give a short description of some of these systems.

Controller Switch Drive (Patented).

The specification of this unit is as follows :—

The rating is 24 volts 1 amp. R.M.S. $1\frac{1}{2}$ lb. ins. torque at 5 secs. per rev. (max. working load). Intermittent.

The overall size of the controller is $1\frac{9}{16}$ ins. by $1\frac{3}{4}$ ins. by 2 ins. projection, and the weight is 10 ozs.

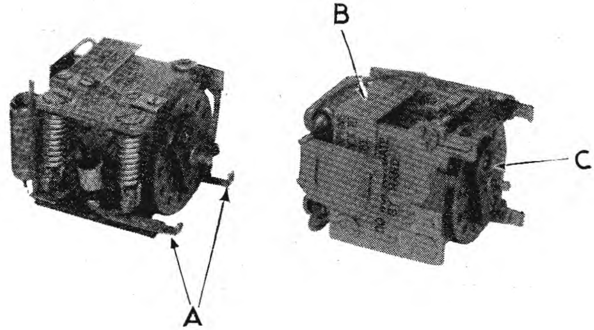


FIG. 5

Type 1263 Controller Switch Drive Unit. The unit is plugged into a special mounting bracket and contact board assembly. The shaft coupling into which the ratchet wheel engages forms one bearing.

A *Contact Plungers.*
B *Thermal cutout.*
C *Shaft coupling.*

A view of the motor is shown in Fig. 5. It consists of an electro-magnet with a vibrating armature coupled to a ratchet wheel, like the G.P.O. Uni-Selector in automatic telephony.

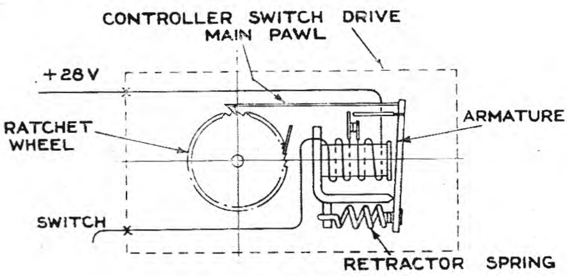


FIG. 6

When the coil is energised it attracts the armature, opening a pair of contacts in its own circuit. Due to the pressure exerted by the retractor springs, the armature returns, closing the circuit again. This cycle continues as long as the circuit is alive. See Fig. 6.

The forward and return stroke of the armature is converted into rotary motion by means of a pawl and ratchet wheel on one side of the magnet assembly.

The ratchet wheel has 120 teeth, and in addition to its primary driving function also actuates a pair of contacts (known as the " off-normal ") every 30° of rotation. (Every tenth tooth.)

This pair of contacts used in conjunction with an auxiliary wafer on the switch shaft is used to stop the motor at the selected position, as shown by a typical circuit. Fig. 7.

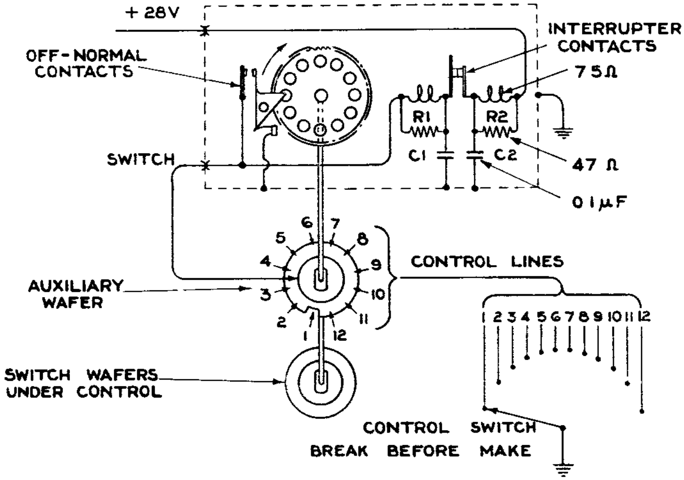


FIG. 7

It is evident that as many control lines are required as positions on the knob dial, and that the positions can be anywhere round the dial. (As long as they are multiples of 30° the standard unit can be used.)

The coupling on the ratchet wheel, which engages in the switch shaft, is normally fitted in line with the holes into which the " off-normal " cam falls. In this position the flats on the switch shaft are brought vertical, and the stopping positions (chosen by the " off-normal " cam) are in equal increments 30° away from the vertical.

To cater for particular cases where the switch wafers are not mounted with the contact positions 30° away from the vertical, the flats on the switch shaft can be advanced in relation to the ratchet wheel by fitting the coupling into a different pair of holes in the ratchet wheel. A choice of 2½°, 5°, 10° and 15° is given.

Referring to Fig. 7, assume the control knob is turned to line 4. The motor circuit is then completed to ground and the motor will begin to ratchet. As soon as three teeth are moved the circuit is made to ground through the " off-normal " contacts and the motor will run until this pair of contacts is open again with the rotor of the auxiliary wafer in position 4.

R.f. noise suppression has been achieved by connecting the interrupter contacts between the two halves of the coil and to ground through condensers as shown in Fig. 7. The voltage across each section of the coil is limited by a wirewound resistance. An even higher degree of suppression (Fig. 8) can be obtained by the addition of the 12 μF electrolytic condensers on the L.T. supply, fitted close to the motor. Under these conditions, in one particular application, only a faint ticking could be heard in the earphones indicating that the motor was running, when the Receiver was at full gain.

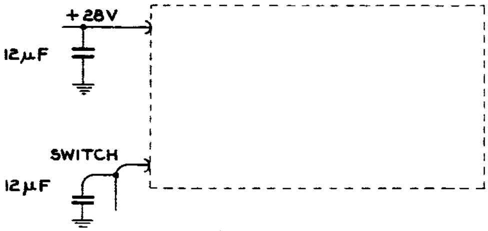


Fig. 8

A thermal overload cut-out is incorporated, designed to open the interrupter contacts when the motor reaches a temperature of 100° C. This temperature can be reached if for any reason the motor is left in circuit or is unable to find a "home" position. Once tripped, the overload must be reset by hand. This is done by removing the cover and lifting the thermal cut-out spring until the thermal cut-out (a bimetal strip) is released and springs back into its normal position.

The main interrupted contacts are duplicated and their action is delayed by a weighted arm giving time for the armature to recover for the next cycle. The contacts are made from 10% Iridium-Platignum.

This unit known as Type 1263 is suitable for use with wafer switches and other devices with 30° spacing of stopping positions.

Type 1263a is a replacement for Type 1263.

Type 1263b is suitable for use with devices incorporating their own stopping mechanism, i.e., in conjunction with a pre-selector.

Details of Motor Characteristics.

The coil is wound with 800 turns of No. 32 S.W.G. enamelled copper wire and the main retractor springs are set so that the armature closes with .9 to 1.1 amperes. Under these conditions on open circuit the pull exerted by the pawl on the ratchet wheel is 9½ lbs. falling to 9 lbs. relaxed, corresponding to a tractive effort by the magnet of 16 lbs. with a gap of .038 inches at the pole face.

Extended life tests at full load have been carried out; these show that at least six million "pecks" can be expected before replacement of worn parts. Provided the initial adjustment has allowed for some wear, re-adjustment in service is unlikely. Re-adjustment to accommodate wear on the main pawl may be necessary in some cases during the initial period of service.

Lubrication of the ratchet wheel bearing and periodic cleaning is also advisable.

Pre-Selector Unit (Patented).

This is a small ten-channel precision selector in which any channel may be set to any position in 360°.

Some of its important features are :—

(*a*) Variation between the initial manual set-up and any subsequent automatic reset, of not over 1° (includes backlash present in gearing).

(*b*) Ability to make the manual setting in either direction without affecting the accuracy.

(*c*) A cycling time of not more than 30 secs. Fig. 9 is a photograph of the complete unit, comprising a motive source, a pre-selector and a gear box uniting them.

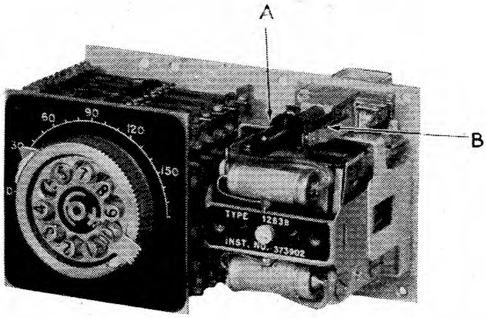


FIG. 9

Type 1326. Pre-selector mounted on Gear Box with type 1263B Controller Switch Drive Unit. Channel 5 plunger depressed.

A *Press knob to disengage controller.*
B *Muting contacts.*

Fig. 10 shows the controller and pre-selector detached from the gear box.

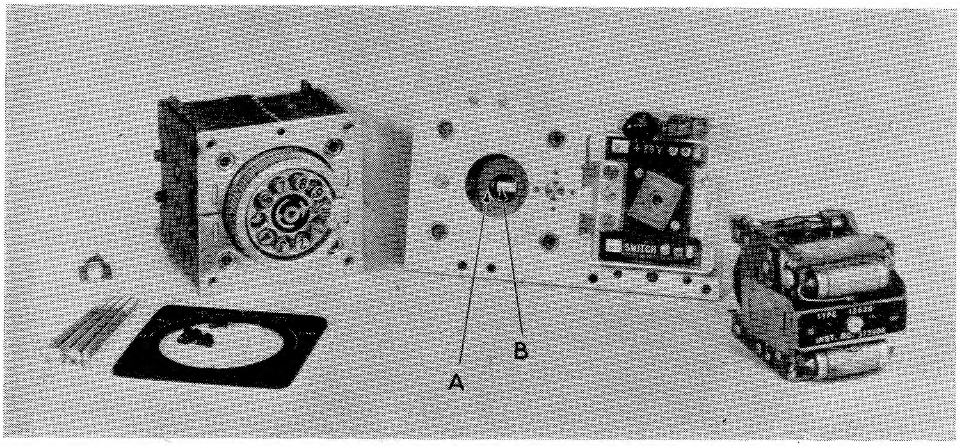


FIG. 10

Pre-selector and Controller dismantled. Note alignment pointer in gear to ensure correct reassembly.

A *Index.*
B *Alignment Pointer.*

Fig. 11 is a view of the pre-selector dismantled showing some of the component parts.

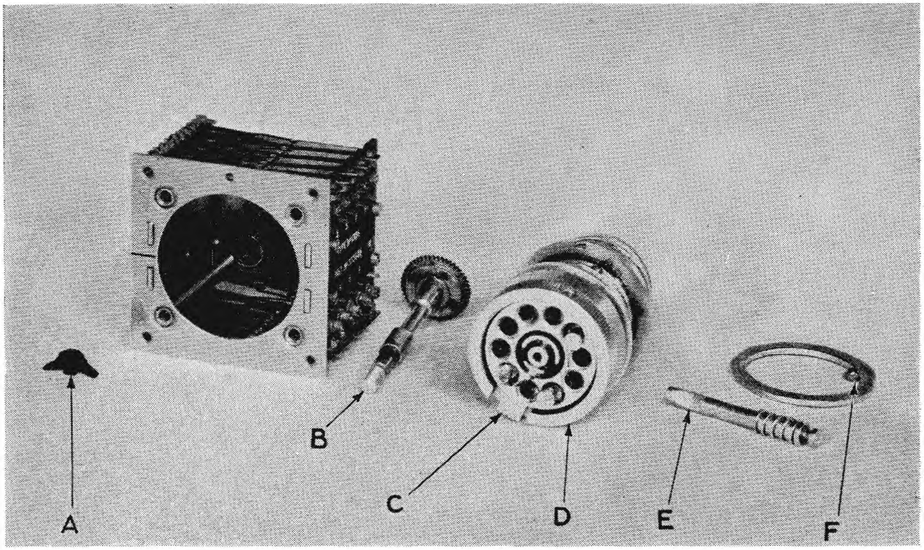


FIG. 11

Pre-selector dismantled. The notched rings are spaced by circling on the drums.

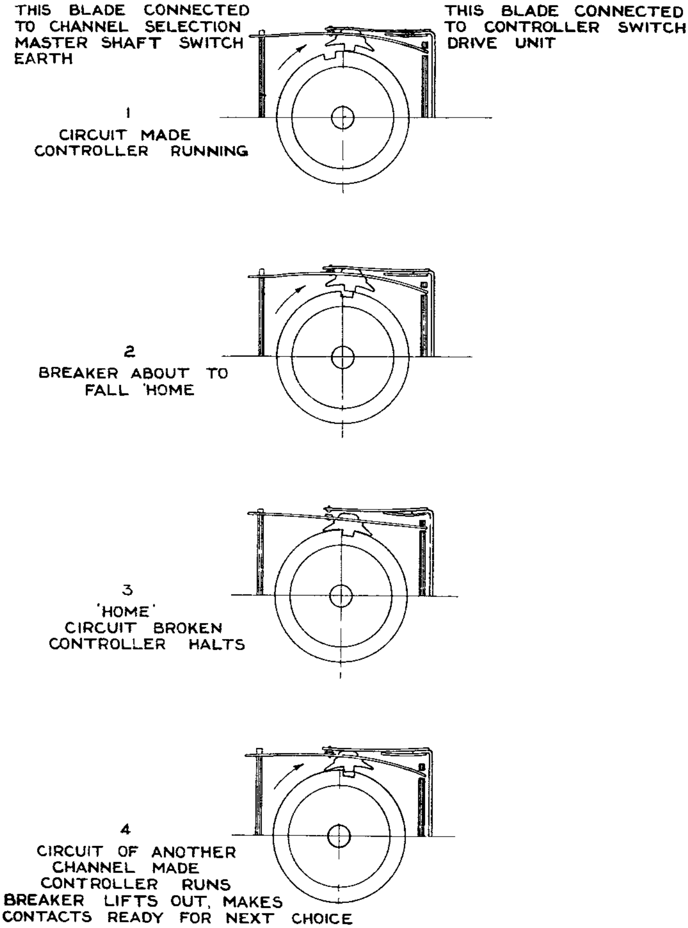
A *Contact breaker.*
B *Main shaft.*
C *Trigger disc to lock ring.*
D *Drum.*
E *Ramp.*
F *Ball and ring.*

The notched rings are gripped to the selector shaft except when unlocked for manual setting. Both rings and shaft are driven in synchronism with the output shaft connected to the switch turret or variable condenser, as the case may be. The contact arms are normally held together by the pressure of the contact breaker, except when it falls into the notch in the ring thus denying power to the controller and the shaft halts. Continued rotation caused by selecting another channel or manually turning the device will cause the contact breaker to lift itself out of the notch by the action of the arms on either side. (See diagrams of action of contact breaker Fig. 12.)

The notched ring is locked to the selector drum by the pressure of a spring conveyed via a plunger and ball. The ball is trapped between the ring and a ramp on the plunger. One extremity of the plunger is extended to be accessible at the front of the pre-selector and if this is pushed to overcome the spring tension the pressure locking the ring is removed and it is free to turn.

To free the ring, the plunger is pushed in and its head is caught behind a catch in the form of a disc.

If the contact breaker is in a notch in the loosened ring it will remain stationary when the selector drum is rotated to the desired position. To lock the ring, the disc is triggered releasing the plunger.



ACTION OF CONTACT BREAKER

FIG. 12

" Setting-up " procedure.

The system to be described allows "setting-up" the "in tune" position by two methods, either by hand control of the pre-selector drum, or power control with auxiliary contacts.

The method chosen will depend on the application.

Hand or manual control of the pre-selector drum is most suitable for condenser tuning control applications when clock-anti-clock movement is required to find an optimum position. In this case it is necessary to disengage the controller drive shaft by means of a clutch during the manual setting.

The latter method is adopted for turrets or switches where the angle between " Homes " is fixed, but not necessarily even sub-multiples of 360°. In effect an eleventh ring is fixed to the pre-selector drum with contact breaking positions that coincide with the contact making positions on the device it is desired to " Home." When setting-up by this method the onus of siting the pre-selector " Home " exactly central on the contact making position is taken from the operator, as it is automatically achieved by the controller which motors the selector and load into place (dictated by the eleventh ring) and is therefore uni-directional.

A circuit diagram is given on Fig. 13 to which reference should be made.

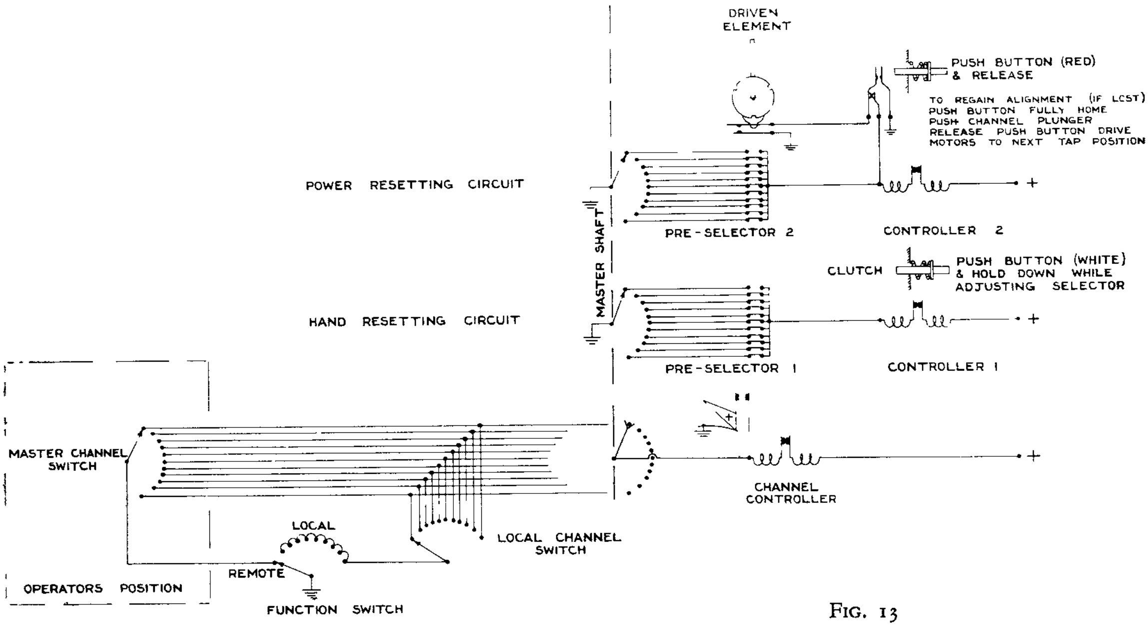


FIG. 13

TYPICAL PRE-SELECTOR CIRCUITS

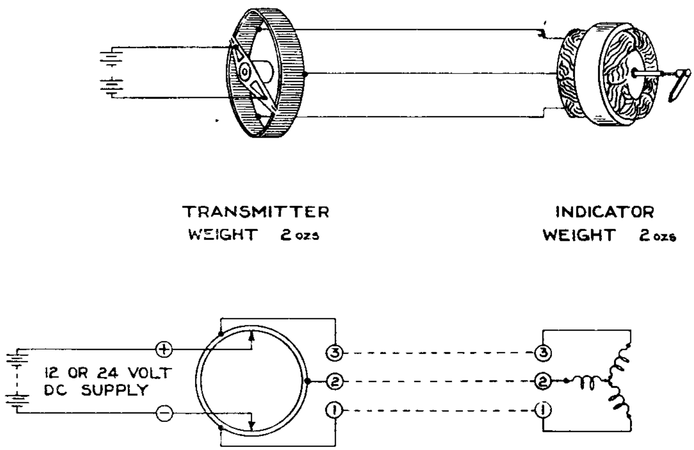
The sequence of operations to pre-set a selector can be briefly described as follows :—

The plunger is pushed in releasing the ring and the drum rotated (which in turn rotates the unit to which it is connected) until the desired tuning position is required. The ring is then locked by triggering the disc under which the plunger is trapped. It is necessary to declutch the controller by pressing the button provided, while turning the drum.

Where power control with auxiliary contacts is used, pressing the button will automatically advance the switch or turret on to the next tap position, the button being released before the pre-selector arrives at the tap position required.

Care should be taken :—

(*a*) To ensure that plungers belonging to another channel are not pushed in when setting-up. If this is done the controller will begin to run as soon as the pre-selector is rotated and try to return it " Home ".
(*b*) To trigger disc (to lock ring) after setting-up. If this is not done the manual setting-up will be lost as soon as the pre-selector is rotated by switching to another channel.
(*c*) Not to depress plungers or trigger disc while the pre-selector is rotating.



DESYNN SYSTEM BASIC ELEMENTS

FIG. 14

The Desynn System or D.C. Selsyn.

This will be described with reference to Fig. 14. The most usual form of transmitter comprises a uniform circular resistance with three equally spaced tappings. Over this can rotate a pair of contacts bearing on the resistance at diametrically opposite points, and it is through these contacts that the current is led into the system from a 24-volt battery. The indicator consists of a two-pole permanent magnet rotor pivoted to rotate within a soft iron stator. This carries a star-connected 3-phase distributed winding, and the connecting line between indicator and transmitter joins the ends of these windings to the tappings on the transmitter resistance. Thus the direction and distribution of the currents in the windings depend on the position of the contacts on the resistance, and the magnetic field thus produced within the stator rotates in almost perfect synchronism with the contacts through 360°. The direction of this field is shown by the position taken up by the rotor, and it should be clear that this depends solely on the relative value of the currents in the three sections of the windings, and not on their absolute strength. Consequently, the system should be independent of voltage changes, and this is found to be so in practice. The synchronism between transmitter and indicator is subject to certain cyclic errors. These are comparatively small, and can be dealt with by calibration.

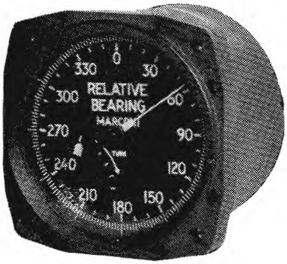


FIG. 15

Type 1272 Bearing and Range Indicator. $3\frac{1}{8}''$ dia. S.A.E. Case. The main blocks and pointer are fluorised. Weight 0.9 lb. The tune indicator is 500 μA full scale deflection.

The accuracy of the bearing indicator shown in Fig. 15 is within $\pm$ 2° error when compared with a perfect transmitter. The transmitter has an inherent cyclic error of approximately 1°. A 5-in. dia. bearing indicator with 1° graduations is available with an accuracy of not greater than $\pm$ 1° error. A more expensive movement is used in which special care has been taken in the design of pivots and magnetic circuit. The torque to weight ratio is lower than for the $3\frac{1}{8}$-in. dia. instrument.

Provision can be made to eliminate the errors in a system by cam correcting the transmitter.

More than one indicator can be paralleled on to one transmitter.

Rotation of the indicator can be reversed by interchanging leads 1 and 2. Indicators are set to the convention that, when connected to a transmitter with the positive contact of the latter on tapping No. 3, the pointer should be zero.

Electrical Characteristics.

The equivalent resistance between tappings of a transmitter is 430 ohms, while that of the receiver is 615 ohms. The input current is 65 mA and this produces an output torque of 5 gram cms. at 90° displacement of pointer relative to transmitter.

The Aysynn System or A.C. Selsyn.

The A.C. Selsyn system has been extensively applied to many branches of engineering. Under the trade name of " Autosyn " it is fitted as the standard system on certain civil and military aircraft in America. Other trade names are " Teletorque " and " Aysynn ".

There are two variations on the basic system employed in a radio compass or M.F. receiver :—

(*a*) Self-synchronous method (hence " Sel-syn ").
(*b*) Signal Generator and Follow-up Servo (" Motaysynn ").

Self-Synchronous Method—Aysynn.

The principle of operation of the system can be described with reference to Figs. 16 and 17. The transmitter and receiver are similar, each having a bi-polar or H type single-phase rotor and a stator with a distributed Y-connected winding similar to that of a 3-phase A.C. motor. These units can be regarded as transformers with a variable magnetic coupling. When the rotor or primaries are supplied with alternating current, voltages will be induced in the stator windings or secondaries. If the rotors of the transmitter and receiver are in similar relative positions the respective secondary voltages will balance one another. If the rotor of the transmitter be turned these voltages will become unbalanced and as a result current will flow in the stator windings, producing a torque which tends to align the rotors so that a condition of balance is restored—thus any displacement of the transmitter is followed by the receiver rotor. Where the system is used as an indicator (the receiver rotor carrying a pointer) each element will be accurate within $\pm 1°$ when compared with a perfect counterpart.

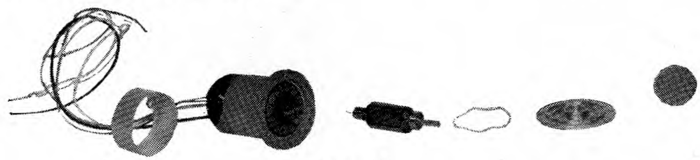


FIG. 16

Aysynn element. The small size and construction is shown by this illustration.

The self-synchronous elements can also be used to drive a mechanism at some remote point and they are employed to control the tuning condenser in the AD.7092A M.F. Receiver (Fig. 2). Since the torque available is 0.15 gm. cm./degree deflection and the torque to turn the condenser is 452 gramme cms. a ratio of 240/1 is necessary at the condenser end to make control " rigid " and without an apparent " dead space " where movement of the control takes place without a corresponding movement of condenser.

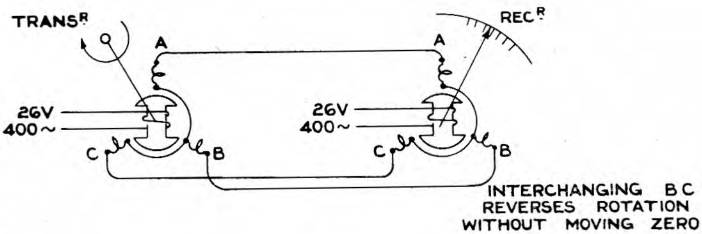


FIG. 17

Frequency indication can be achieved by using a self-synchronous pair of elements, the transmitter being geared to the condenser shaft in the ratio of: angle subtended by fixed scale to maximum angle turned through by condenser vanes. The receiver Aysynn has a pointer which moves over the fixed scale in synchronism with condenser rotor. This separate indication chain is essential to avoid ambiguity in position and the hazard always present with any form of setting-up procedure to eliminate the ambiguity.

Signal Generators and Follow-up Servo.

The Aysynn which is used as a signal transmitter or receiver consists of a single-phase distributed wound rotor and a Y-connected stator.

When used as a transmitter as shown in Fig. 18 the Aysynn will have its rotor mechanically driven for generating and transmitting electrical information corresponding to angular positions of the rotor and the receiver rotor will be mechanically driven until the voltage induced in the rotor from the stator becomes null.

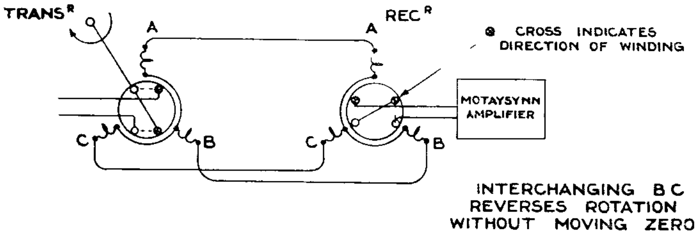


FIG. 18

The final angular position of the receiver rotor shaft will then correspond to the shaft position selected at the transmitter.

The voltages induced in the receiver rotor are generally applied to an electronic or similar amplifier used for the control of Servo units.

(The signal generator has a maximum error spread of 0.4° when tested against a perfect counterpart.)

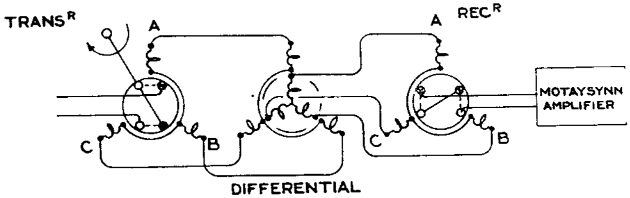


FIG. 19

Differential Aysynn.

The Aysynn which is used as a differential generator consists of a cylindrical 3-phase Y-connected rotor and a 3-phase Y-connected stator.

When used as shown in Fig. 19 in circuit between two signal Aysynns, one as a transmitter and the other as the receiver, the differential Aysynn can modify electrical angular information received from the transmitter and transmit electrical information corresponding to the algebraic sum or difference of the transmitter and differential rotor shaft angles.

Thus in the case of the A.D.F. loop bearing transmission system, if the transmitter element rotor angle corresponds to the D.F. bearing and the differential rotor angle corresponds to the gyro-compass bearing, the Motaysynn indicator will indicate the sum of these two angles, i.e., the " true bearing ".

The differential rotor is driven into correspondence with the gyro-compass bearing by a second Motaysynn receiver connected to a transmitter in the gyro-compass.

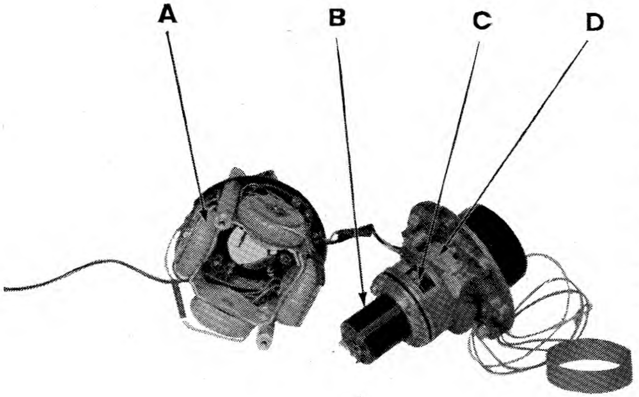


FIG. 20

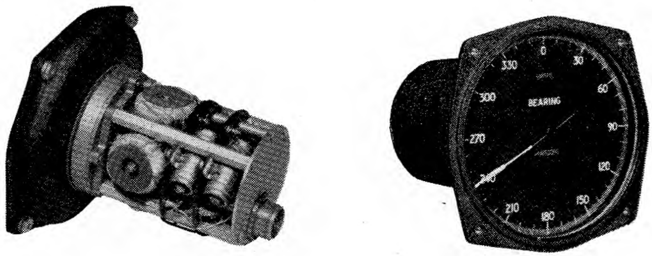
Motaysynn Receiver. A view of the Frequency Indicator with magnetic amplifier removed from the mechanism. The scale drum which encircles the Signal Generator is not shown.

A *Magnetic Amplifier.*
B *Drag Cup Motor.*
C *Gear Box.*
D *Signal Generator.*

The error spread in the differential is 0.8° max., which must be added to the error in the transmitter and receiver. This theoretical error ignores the fact that the individual errors are vectors and that it is unlikely they will be in phase together.

FIG. 21

Type 1336 *Bearing Indicator. Motaysynn 5″ dial. Accuracy* ± 0.4° *when compared with perfect counterpart. Case contains Magnetic Amplifier as shown in left-hand view. Intended for use at Navigator's station. Weight* 2.37 *lb.*



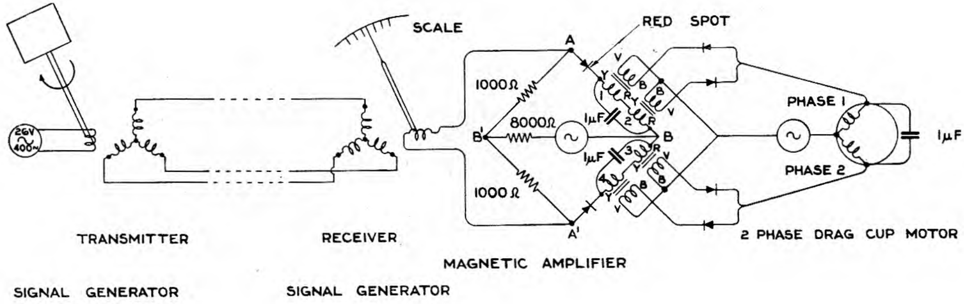
The Motaysynn Receiver.

A typical application for this system is to present relative and true bearings from the A.D.F. loop. (Figs. 20 & 21.) A circuit showing such a system is given in Fig. 22.

Under standstill or balance conditions there is zero P.D. between points A.A.′ and a small but equal D.C. current, 1.2 mA, circulating in both limbs of the bridge and in primaries of transformers. Under these conditions the impedance of both the secondary windings is sufficiently high to limit the current to approximately 25 mA in both phases of the 2-phase motor and consequently no rotation takes place.

If the transmitter is moved a voltage will appear at A.A.′ proportional to the angular displacement of the rotors; this will produce a D.C. current in one arm or the other of the bridge (depending on the polarity relative to supply voltage at B.B.′).

This D.C. current produces a flux which saturates the iron circuit of the transformer (in arm A.B. say) thereby lowering its secondary impedance. In response the secondary conducts an A.C. current via phase 1 of the 2-phase motor.



MOTAYSYNN CIRCUIT DIAGRAM

FIG. 22

In other words the transformer in phase 1 conducts while the transformer in phase 2 is a virtual open circuit. The motor begins to run since a quadrature voltage is produced on the second phase by the 1 μF condenser and restores balance in the bridge circuit.

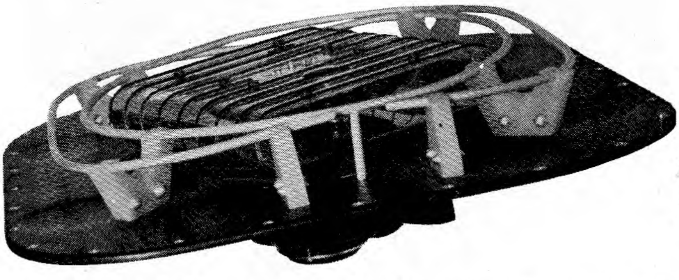


FIG. 23

Type 1324. *Loop. Iron cored. Side view. The Loop is surrounded by non-directional antenna and assembly is mounted in a recess in fuselage to preserve flush exterior. Weight* 8.75 *lb. complete.*

The speed of response of the Motaysynn is governed by the gear ratio between the 2-phase motor and Signal Aysynn shaft, the gain of the magnetic amplifier and the degree of velocity damping necessary. The response time of the frequency Indicator is 1 rev. in 24 secs. while the bearing indicator is 1 rev. in 7 secs.

When running both units take approximately 1 watt in addition to the quiescent consumption.

TABLE 1

Element Characteristics

	Input Current m A	D.C. Rotor Resistance ohms	D.C. Stator Resistance ohms	Weight ozs.
Self Synchronous Aysynn ...	150	14.3	8	5
Signal Aysynn	65	41	10.8	5
Differential Generator	—	11.3 (line to line)	10.8	5

Circuit Characteristics. 26 volts 400 cycles

Transmitter	Receiver	Input		Output		
		Current mA	Watts	Impedance	Sensitivity	Accuracy
Self Synchronous Aysynn	Aysynn	300	1.2	—	See below*	2° max.
Signal Aysynn	Signal Aysynn	100	1.3	260 ohms	.275 volts/degree	0.8° max.
Signal Aysynn—Differential-	Signal Aysynn	115	1.4	230 ohms	.15 volts/degree	1.6° max.

* Torque=0.15 gram. cm./degree deflection from null position at receiver shaft. 21 gram. cms. at 90° displacement at 30 volts.

General Particulars.

Table 1 gives a summary of the principal characteristics of the Aysynn elements and system.

Figs. 23, 24 and 25 illustrate a typical application for the systems described.

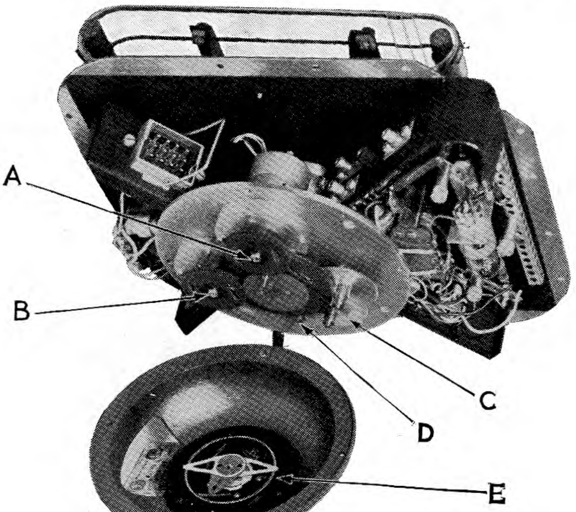


FIG. 24

Underside view of Loop mechanism (covers removed) showing transmitting elements. Weight 6 lb.

A *Aysynn Transmitter connected to Type* 1334 *Indicator* (*Fig.* 25).
B *Signal Generator connected to Type* 1336 *Indicator* (*Fig.* 21).
C 135/1 *Gear Train.*
D 2-*phase Motor.*
E *Desynn Transmitter balanced against loop controller.*

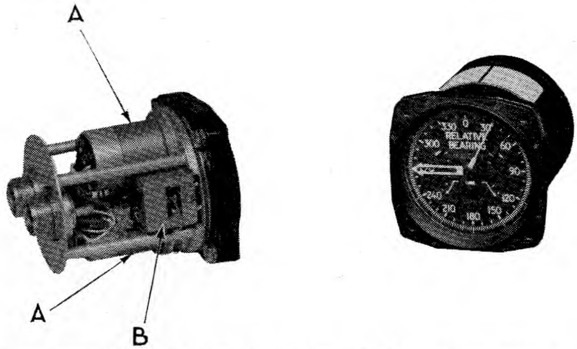


FIG. 25

Type 1334 *Dual Bearing and Range Indicator. The main blocks and pointers are fluorised. This instrument is cockpit mounted where the installation includes two Radio Compasses. Weight* 1.5 *lb.*

A *Aysynn Receivers.*
B *Tune Indicator movement*

Certain aircraft carry two radio compasses and bearings from both compasses are required to be displayed simultaneously in one instrument. This is achieved as shown by Fig. 25, the self synchronous elements being mounted side by side and coupled to the pointers by gearing.

Acknowledgments.

The author desires to acknowledge the help of colleagues in these developments, particularly Messrs. S. Smith & Sons, Ltd., Cricklewood, for permission to publish extracts of their publication, " Instruments for Flight Research " (London, 1943), and for their co-operation in the manufacture and supply of the " Desynn " and " Aysynn " components.

AIRCRAFT COMMUNICATIONS TRANSMITTER

TYPE AD. 107

By W. R. Bitcheno, A.M.Brit.I.R.E., A.R.Ae.S.

The increase of traffic over the air routes of the world and the use of aircraft capable of flying great distances non-stop, has created an inevitable demand from air line operators for a communication equipment of refined characteristics. High power, great flexibility with ease of operation and accurately stabilized transmission, are among the features demanded as essentials. To meet this need the Marconi Company has produced a high grade aircraft transmitter, the AD. 107, which is described in this article.

General Description.

THE complete High Frequency transmitter is made up of 4 units: Drive and modulator, Amplifier, Aerial and Power Units, weighing together some 85 lb. only and emitting a maximum power of 150 watts. The frequency coverage is 2 to 18·5 Mc/s and 10 crystal controlled spot frequencies are available, change of channel being accomplished in less than 30 seconds by the operation of a single switch. The Medium Frequency transmitter is similarly comprised of 4 units weighing 80 lb. and giving a maximum output, under the best conditions, of 120 watts. It covers 320 to 520 kc/s, the method of control and number of preselected channels being the same as the H.F. combination. Both H.F. and M.F. sections can be installed separately or together as desired.

The services offered are :—

C.W.	—	full power.
C.W.	—	¼ power.
M.C.W.	—	modulated 100% at 1,000 c/s.
R/T	—	modulated 95%.
Intertune	—	crystal oscillator only for back tuning of receiver.

The transmitter is operated directly by two main switches, channel selector and main system, located on the front panel of the amplifier unit, or remotely from a small remote control box.

Full listening through facilities are provided and keying at 25 words per minute is possible without noticeable distortion of morse characters.

Input voltages required are 28-volts D.C. for rotary transformer and general purposes and 19-volts D.C. regulated supply for valve heaters. This follows current aircraft practice. The total power consumption on C.W. (Key down) is 750 watts, this being reduced to 200 watts on Stand by.

An illustration of the AD. 107 transmitter is shown in Fig. 1 (a). The unit on the left, the station voltage regulator, provides the 19-volts regulated supply. Fig. 1 (b) shows an AD. 107 installation in a "Canadair" aircraft.

The equipment is fully tropicalized to British Civil Airworthiness requirements, and the H.F. section is capable of operation on full power up to an altitude of 50,000 feet using an aerial of not less than 200 $\mu\mu$F. capacity.

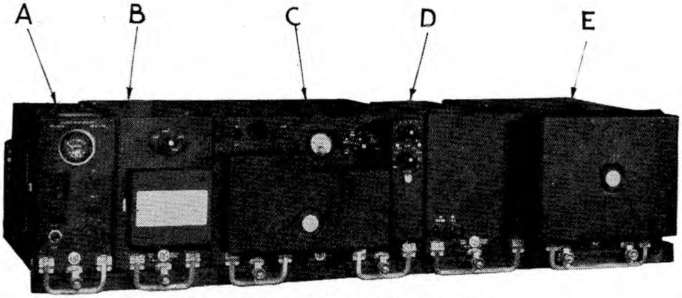


FIG. 1 (*a*) *AD.* 107 *Transmitter*

A *Station Voltage Regulator.*
B *Drive and Modulator unit.*
C *Amplifier unit*
D *Power unit.*
E *Ae Tuning unit.*

Construction.

All units plug into backplates attached to the standard aircraft racking system and are therefore easily removed and changed.

Each unit is built up from a series of completely wired sub-assemblies providing great accessibility for maintenance. This unit construction principle permits flexibility in installation and allows the aerial tuning unit to be mounted near the aerial lead-in insulator, thus reducing Radio Frequency loss inside the aircraft to a minimum.

All main chassis are manufactured from non-corrosive alloy (Birmabright) and miniature components are used throughout, including such items as relays, condensers, resistances and valves. To illustrate the achievement of miniaturization, it is worth recording that a relay changing over two sets of circuits and utilizing twin platinum contacts occupies a space of only $1\frac{3}{4}$ ins. $\times$ 1 in. $\times$ $\frac{5}{8}$ in. and weighs 1·2 oz. Considerable use of electrolytic condensers has been made, the excellence of modern manufacturing technique giving a high degree of reliability over the temperature range of $-30°$ C. to $+71°$ C.

A new technique in connecting the multiplicity of circuits has been used in which bakelite tagboards are superseded by a new system of glass insulated terminals. These terminals consist of small metal connector rods, glass sealed in the centre, with an insulation rating of 1,500 volts. They are made up on metal strips forming compact terminal blocks of any desired length and in other cases are fitted directly in chassis partitions, giving straight through connection without tagboards or grommets. For the connection of the very smallest components, minute ceramic bushes are used, tiny metal rods being inserted. These bushes are even smaller than the glass sealed terminals, but offer a high insulation resistance.

The extensive use of loom wiring has allowed the close packing of components and preserves a neat appearance while facilitating servicing. Terminals and socket pins are numbered and wires are colour coded. The colouring conforms to the standard figure coding used in resistance value identification, and enables the instantaneous recognition of an individual wire.

The application of such miniaturization techniques has accomplished a valuable saving of space and kept the weight of the equipment to a minimum. A complete H.F. transmitter weighing 85 lb. occupies a space of 32 ins. × $12\frac{1}{2}$ ins. × 8 ins. only, and with the high output power and facilities offered, this represents a considerable design achievement.

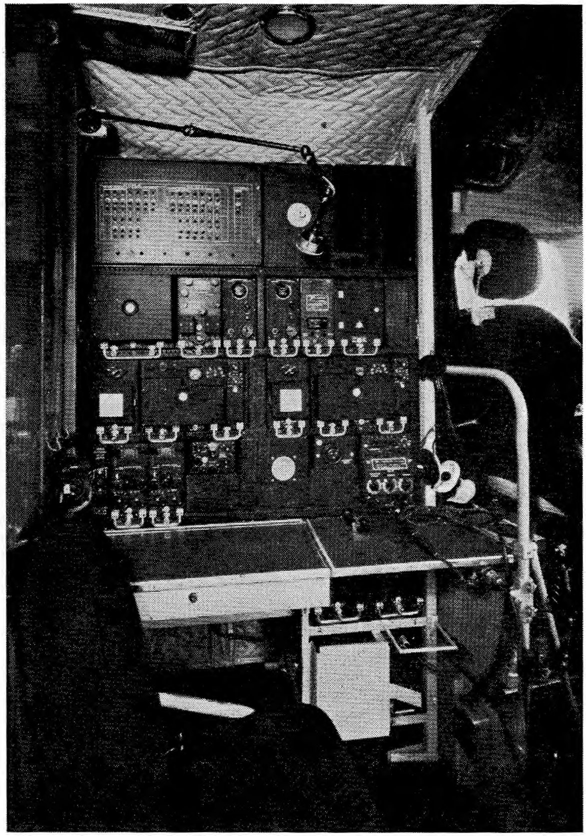


FIG. 1 (*b*) *AD.* 107 *Installation in a "Canadair" Aircraft.*

H.F. Transmitter. Drive and Output Circuits.

A stabilized drive to the power amplifier is provided by circuits contained in the Drive and Modulator Unit. A CV. 136 valve, connected as a triode, is used to form an aperiodic crystal controlled Pierce oscillator. This circuit will oscillate at any frequency between 2 and 9·5 Mc/s without special tuning. The cathode is earthed via the keying circuit and the drive circuit will commence to oscillate at the frequency of the crystal in use, as soon as the keying relay is over to "Transmit". The unit provides for the carriage of ten crystals which are mounted on the front panel in sunken holders. The crystal required is selected by a switch which is driven by a small control motor described later. On frequencies above 9·2 Mc/s the second harmonic of the crystal oscillator frequency is used and is selected by the first tuned circuit in the power amplifier. There is still a considerable weight of opinion among operators against crystal control and in favour of variably tuned master oscillator circuits. It is argued that provided back tuning facilities against a crystal checked receiver are available, any frequency within the range of the transmitter can be easily set up in flight, and the operation of the transmitter is not dependent upon the availability of the correct crystal at the right time. Last minute changes in flight plans and emergency working are therefore easily catered for. Although there is much to be said in support of this point of view, it must nevertheless be accepted that ordinary LC master oscillators suffer from frequency drift, some existing aircraft transmitters wandering as much as 4 kc/s at 6 Mc/s under certain conditions, representing a frequency drift of some 0·066%. The International Civil Aviation Organisation has ruled that aircraft transmitters must be stabilized to a frequency accuracy of 0·02% on the H.F. bands, and it is generally known that this stability cannot be attained with reasonable size and weight without the use of crystals. A very high degree of stability is achieved in the AD.107 by employing Marconi miniature evacuated crystals with a frequency tolerance of 0·01%. The suspension of the oscillating body in a vacuum lessens the possibility of frequency variation with changes of temperature and renders the crystal impervious to the effects of tropical conditions. Hermetically sealed crystals have a very high degree of activity due to elimination of air gaps and the reduction of air damping by evacuation. The crystal electrodes are brought out to a B7G base, and the unit is similar in size to the miniature valves used in the equipment. The transmission stability is specified as within I.C.A.O. requirements and in practice the frequency drift is considerably less than the figure of 0·02%, the stability closely approaching the accuracy of the crystal.

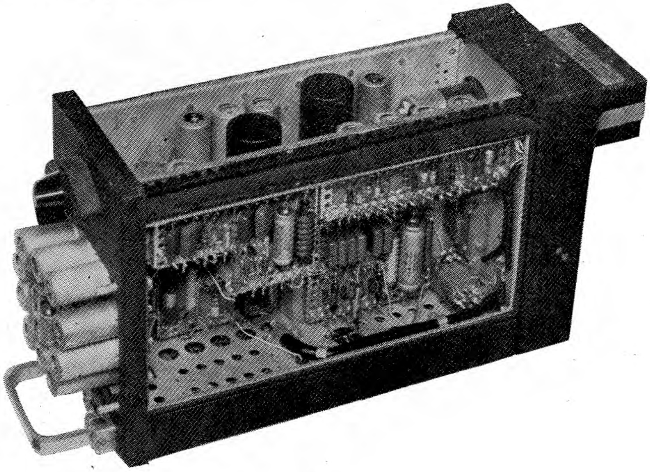


FIG. 2

Drive and Modulator unit with covers removed showing construction and accessibility.

The oscillator valve is RC coupled to an R.F. amplifying circuit, using a pentode valve (CV.173). The output from this stage is fed to the tuned grid circuit of the buffer stage via a fixed length coaxial cable, the latter stage being in the amplifier unit.

The buffer stage valve is a CV.2666 (Marconi C.144) double tetrode, the two sets of electrodes being connected in parallel, with anti-parasitic wire-wound resistances of 5·6 ohms on the control grids. The stage is tuned by a conventional LC circuit, the variable condenser being connected across one of five coils, depending on the frequency in use.

The output of the buffer stage is fed to the tuned grid circuit of the power amplifier. The latter consists of two CV.2666 double tetrodes with the two pairs of electrodes connected in parallel, anti-parasitic resistance being inserted on the four control grids. Although the envelope of the C.144 is only 3 inches long with a diameter of just over 2 inches, the two output valves in parallel handle a D.C. input power to the anodes of 250 watts. With heat dissipation and other losses, this produces aerial power under optimum conditions of 150 watts. The anodes are capacity coupled to a tank circuit comprising one of five inductances and a tuning condenser. The aerial is taken from a tapping on the inductance and thence connected to the aerial tuning unit (H.F.) which consists of two inductances in series, one with coarse tuning adjustments and the other with fine tuning variation. Various combinations of capacity are brought into circuit by a turret switch with seven positions.

Since an aircraft aerial of a given value has to cover a wide range of transmitting frequencies, radiation resistance will vary over the frequency band of the transmitter and aerial currents will alter in sympathy, although radiated power will remain sensibly constant. The value of a conventional hot wire ammeter reading quantitative aerial current is therefore doubtful, and instead, a radiation indication meter is provided in the aerial tuning unit and takes the form of a moving coil instrument calibrated in arbitrary divisions. A coupling coil induces current from the main tuning inductance and a rectifying and resistance network feeds the meter. The arrangement is non-linear, inasmuch as after approximately one-third of the scale reading, the sensitivity of the meter is effectively reduced and thereafter decreases

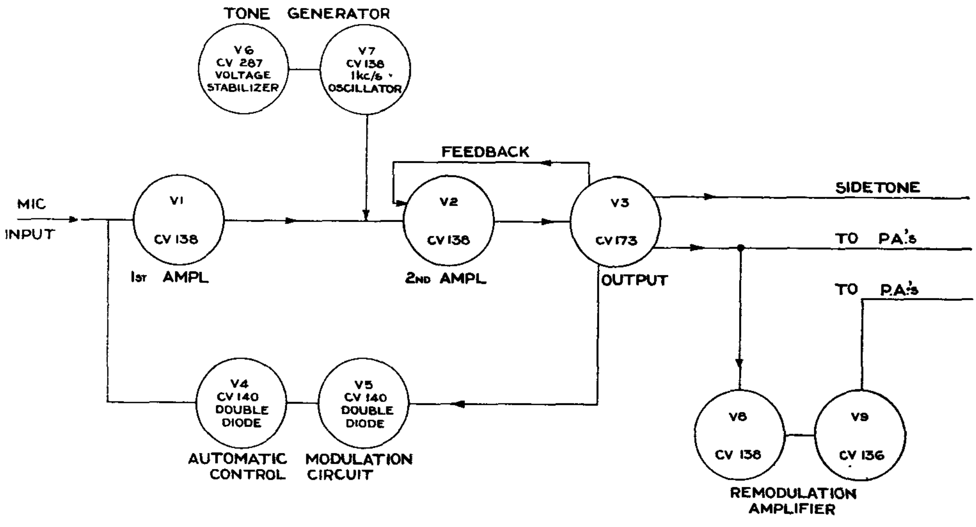


Fig. 3

as the aerial current increases. This ensures a substantial reading for small aerial currents while comfortably handling those of much greater magnitude. Transmissions on a variety of frequencies ranging from 2,912 kc/s to 11,319 kc/s with currents of 0·5 to 5 amps. give approximately similar readings on the radiation meter. The advantage of this arrangement is that the operator is in effect presented with an indication of radiated power and not an aerial current figure which means little to him.

Modulator Circuits.

In addition to housing the crystal oscillator, the Drive and Modulator Unit incorporates the necessary circuits to modulate the transmitter for M.C.W. and R/T working. The modulation system is shown in Fig. 3. V 1, V 2 and V 3 form the main amplifier, the output of which is transformer coupled to the cathodes of the P.A. valves, via a wafer on the system switch which connects only on the M.C.W. and R/T positions. For R/T working the microphone input is applied to the grid of V 1 via a step-up transformer. The primary is tapped to Earth to give a balanced input, while a 0·001 μF condenser is connected across the secondary to by-pass any parasitical RF and to reduce the response on the top frequencies. Negative feedback is introduced from the anode of V 3 to the cathode of V 2, which not only reduces distortion, but assists in stabilizing the gain, which may otherwise be altered by varying circuit voltages and valve changes. V 1 is not used for systems other than R/T and in all other positions of the system switch its cathode is isolated and the valve effectively biased to " cut-off ". The tone oscillator output is therefore applied to the grid of V 2, the level being adjusted by a potentiometer between the anode and Earth, isolated by the coupling condenser. Careful design of the tone generator minimizes frequency drift, a voltage regulator valve (V 6) being employed to stabilize the H.T. at 150 volts. This 1,000 c/s generator operates only in the C.W., M.C.W. and ¼ C.W. positions, in each one of which it provides sidetone for the operator to check his morse characteristics. On the M.C.W. position only it also modulates the output of the transmitter.

Two special circuits are employed in the design of the modulator, with the object of achieving the advantage of a high percentage depth of modulation without distortion of the transmitted speech.

The first is in the form of an Automatic Gain control which successfully controls the speech level by limiting amplification when the carrier is modulated to a depth of 95%. Two double diode valves (V 4 and V 5) are used, connected in the form of a balanced bridge circuit. The diodes of V 5 are connected in push-pull across a secondary winding on the output transformer of the modulation amplifier, providing equal and opposite D.C. outputs which are applied to the diodes of V4. The latter functions as a variable impedance across the input to V 1, this input therefore being automatically reduced as soon as the output from the amplifier exceeds the predetermined value required.

The second is called the re-moduation amplifier and is designed to eliminate distortion originating in the P.A. valves due to non-linearity at the ends of the valve slope. Modulation of the P.A.s is accomplished by applying the output from the modulation amplifier across the cathode bias resistance, the latter forming one arm of a bridge circuit (see Fig. 4).

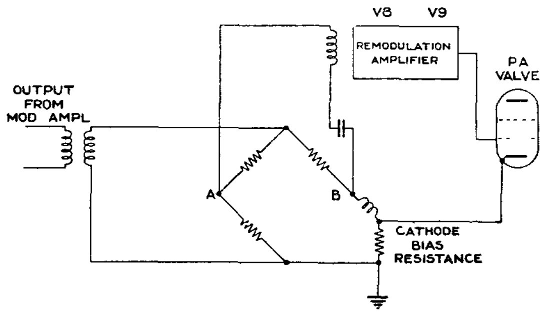


FIG. 4

It will be appreciated that while the volts across the cathode bias resistance follow the form of the applied modulating voltage, no volts will be developed across A and B. However, if due to valve slope non-linearity, the curve of developed volts does not follow closely the input modulation characteristic, a difference voltage will be developed across the bridge and applied to the grid of the P.A.s in opposite phase. This arrangement cancels out the effect of interference with the modulation characteristic by valve slope non-linearity and allows the depth of modulation to reach 95% with negligible distortion.

It will be noted that great care has been exercised in the design of the modulation system, meticulous attention being given to faithfully reproducing the primary modulating source. The practical result is transmitted speech of superb quality, this being remarked upon by receiving stations worked during flight tests. Apart from giving top class R/T communication in local control areas, the fidelity and depth of modulation assist greatly in voice communication at long distances. Transmissions with a poorer and lower depth of modulation become difficult to read when the received signal is weak.

Power Unit.

The power unit consists basically of a dual output rotary transformer with the necessary starter and filter circuits. It produces 650 volts and 275 volts from separate commutators with an input of 28 volts D.C., each H.T. output line and the L.T. input line being fitted with choke-capacity filters. Use is made of 8 μF electrolytic condensers in the 275-volts line and also in the L.T. filter. H.T. lines are fused with easily removable cartridge type fuses, 250 mA in the 275-volts line and 750 mA in the H.T. line.

Incorporated in this unit are relays which serve as L.T. switches for the transmitter units. This avoids heavy L.T. currents passing through the main transmitter switch. The 28-volts battery line and the 19-volts regulated supply are brought into the unit and up to two relays. A single parallel lead carrying 28 volts is taken up to the main switch on the amplifier unit. When the transmitter is switched to " Stand-by ", the two relays are energised and 28 volts and 19 volts are connected to the transmitter circuits proper. The rotary transformer is not running in this position. When the transmitter switch is turned to any live position other than " Stand by ", 19 volts is applied to a third relay which operates and connects the 28-volts line to the input brushes via a series field winding which restricts the initial current surge. The energising coil of a fourth relay is connected across the L.T. armature. While the inertia of the armature is being overcome, the volts at the brushes are low, due to the effect of the series inductance, but when the machine gains speed, armature current decreases and the volts rise, operating the relay. The contacts of the latter are across the series inductance, which is effectively short circuited.

To provide the D.C. power necessary to achieve 150 watts in the aerial, the rotary transformer must be capable of supplying 385 mA at 650 volts and 220 mA at 275 volts and the machine is therefore the heaviest single component in the equipment. The weight of the power unit is about 25% of the total weight of a complete transmitter, but the weight of 22 lb. is a great improvement on the 30 lb. of earlier power units delivering less output. The output power to weight ratio has been improved from 8 watts per lb. weight to 14 watts per lb. weight. The motor generator is secured on anti-vibration mountings and connects to the unit by a separate internal plug and socket, facilitating easy removal for routine maintenance.

Keying.

The telegraph key itself is connected between the earthy end of the energising coil of the Send/Receive relay mounted in the aerial tuning unit. This key line is first taken through contacts on the aerial change-over relay and muting relay, which are located in the amplifier unit. The aerial change-over relay is operated by a switch on the front panel of the amplifier and serves merely to change over the aerial and keying circuits to the selected aerial tuning unit if two are fitted. This condition obtains if two aerials are available. The action of pressing the key in either the C.W., M.C.W., R/T or ¼ C.W. positions completes the magnetizing circuit of the Send/Receive relay, which moves over to " Transmit ", this action removing the aerial from the receiver and connecting it to the transmitter output circuits. A separate contact on this relay effectively earths the cathodes of the P.A. valves, the oscillator and amplifier, thus short-circuiting the cut-off bias and allowing the transmitter circuits to operate. The contacts are adjusted so that the aerial is made before the bias is removed, obviating sparking at the aerial contacts. Two other relays, situated in the drive unit, are operated in step with the Send/Receive relay, the energising circuits being made from a parallel connection from the key line. One of these connects the sidetone transformer winding to the telephones on transmit and disconnects it on receive. The other controls the output from the modulator and connects to the cathodes of the P.A. valves.

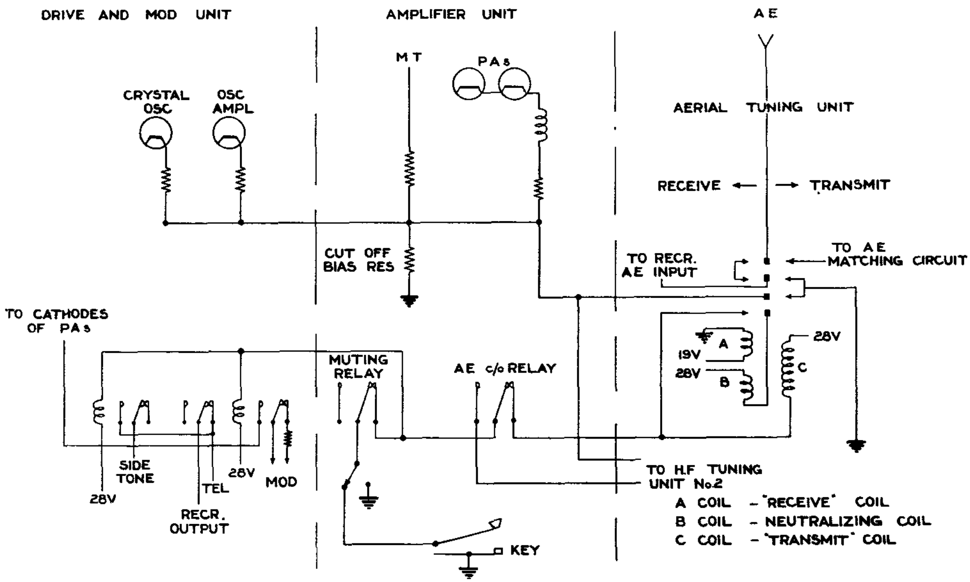


FIG. 5

The Send/Receive relay has no rest position but is operated by electro-magnets in both Send and Receive positions. The magnet on the Receive side incorporates a second coil wound in opposition to that which holds the relay on Receive. This second coil is in series with a pair of contacts on the relay which are made in the Receive position. When the key is pressed this auxiliary coil is energised. The magnetic field developed is in opposition to that holding the relay on Receive, and when it reaches a certain value, neutralizes the latter. The act of pressing the key also energises the winding on the second magnet (transmit side) and a field of attraction is built up. At the moment of neutralization of the Receive field, the natural spring of the contact blades imparts an initial movement, the " Transmit " field takes charge and pulls the relay sharply over. When it is over to " Transmit " the operating coil circuit is broken and the Receive field re-establishes itself, ready to exert its attractive force when the key is released. This 3-coil action results in the perfect response of the relay to key movements. The keying circuits are shown in Fig. 5.

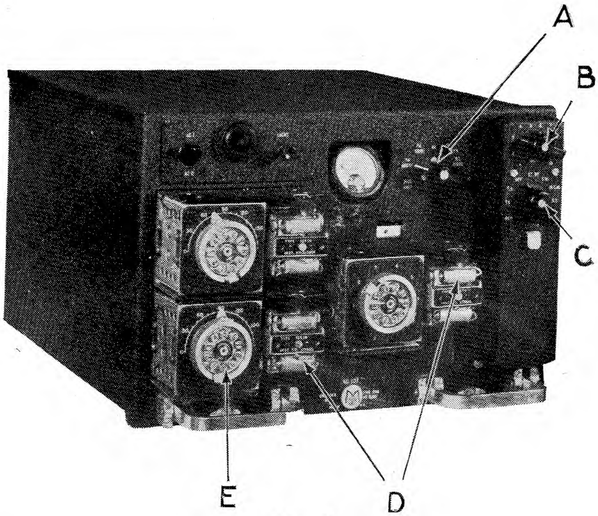


FIG. 6

Main amplifier unit with front cover removed showing control motors and mechanisms.

A *Meter switch.*
B *Channel selector switch.*
C *System switch.*
D *Controller switch drives.*
E *Selector mechanism.*

Tuning.

Most of the tuning adjustments of the transmitter are carried out on the " Tune low " position. In this condition the P.A. feed is reduced to about 120 mA by decreasing the screen voltage and this prevents damage to the output valves when the circuits are out of tune. In this position of the switch also the key circuit is bridged, making it unnecessary to handle the key when setting up the transmitter. The final loading of the aerial circuits is done with the switch on the " Tune high " position, the feed meter then reading P.A. anode current as for full power on C.W. The key circuit is again made in this position.

The $\frac{1}{4}$ C.W. position of the switch reduces the P.A. feed similarly to the " Tune low " condition, except that the transmitter is keyed normally. This facility is provided for short range working when the full power of the transmitter may be not only unnecessary but an embarrassment to the ground station operator.

A meter is fitted to the main panel which can be switched to any of the main valve feed circuits and the currents instantaneously checked. This meter is used for tuning indications when setting up the spot frequencies, it being switched to the relevant circuit as required.

The crystals in the transmitter can be employed to set up the receiver in use to a particular frequency, or alternatively, to check the scale calibration. When the system switch is turned to " Intertune ", the cathode of the crystal oscillator circuit only is earthed. This allows the drive to radiate while the rest of the transmitter remains inoperative. The receiver can then be set to the frequency of the crystal selected, using its own Beat Frequency Oscillator and tuning to zero beat.

Cooling.

In view of the small size and compact design of the amplifier unit, and the comparatively high power handled by the P.A. valves enclosed, some form of forced air cooling is a necessity. A motor blower unit is therefore incorporated, using a miniature fan motor and fitted with a Vokes air filter. Cleaned air is sucked in and blown through the amplifier unit, circulating round the P.A. valves and expelling itself through vents in the side. A similar motor blower is fitted to the drive and modulator unit, while the power unit is cooled by the inclusion of a fan on the end shaft of the rotary transformer.

Control Circuits.

The necessary switching of circuits in the several units to enable selection of the various transmission systems and spot frequency channels are carried out electrically by the wide use of a device called the controller switch drive. This is a ratchet type of electric motor, reduced to small proportions by careful design to fine tolerances. It operates from the 28-volts supply and has a torque of 1·5 lb. ins.

The controller switch drive consists basically of an electro-magnet, an armature arm to which is attached a pawl, and a ratchet wheel fixed to a spindle which is used to rotate other controls or switch wafers as desired (Fig. 7, A and B). When the coil is energised, it attracts the arm and the pawl is pushed forward into a ratchet tooth. At the same time the arm opens a pair of contacts which are in series with the operating coil, thus breaking the energising circuit. The magnet releases the attracted arm, which is pulled back by a retractor spring, the pawl rotating the

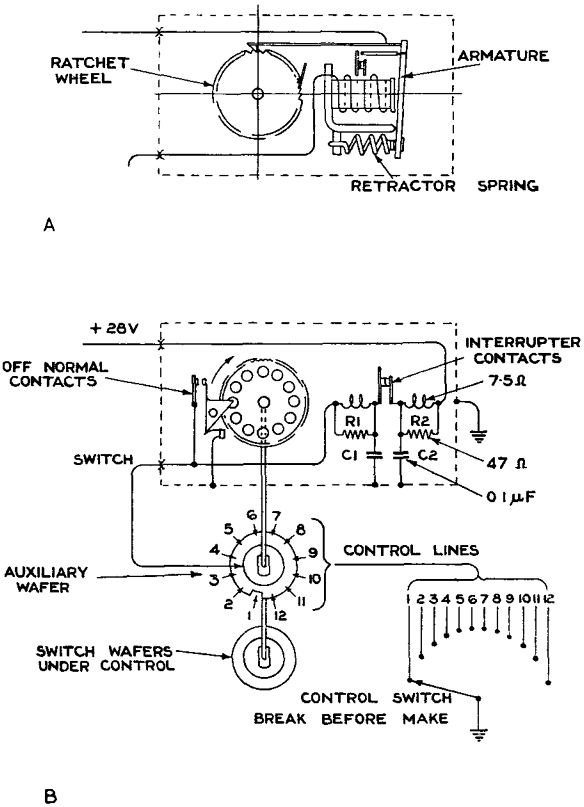


Fig. 7

ratchet wheel. When the arm regains its original position, the contacts are once again made and the arm attracted. This cycle of events continues until the energising circuit is broken elsewhere. This device is sometimes called a "pecking" motor, by reason of the action described. Another pair of contacts, called the "Off/Normal" contacts, are actuated by the ratchet wheel every 30 degrees of rotation. They are used in conjunction with an auxiliary switch wafer on the motor shaft, which has contacts also spaced 30 degrees apart. To this switch wafer are connected the control lines from the controller, which can be either a remote unit or a master switch on any convenient part of the main instrument panel. Referring to Fig. 7, B, it will be seen that if the control switch is turned to any position other than the one in which it is at rest, the energising circuit is completed and the ratchet wheel commences to move, driving not only the switch wafers under control, but also turning the auxiliary control wafer. When three teeth have been moved, the "Off/Normal" contacts close, thus making the completion of the energising circuit effective in two places. The motor will run until the auxiliary wafer reaches the position corresponding to the control line selected; the circuit is broken, but the motor will not stop until the "Off/Normal" contacts open at exactly the 30-degree angle. This accuracy is essential for the satisfactory operation of the switch wafers being driven.

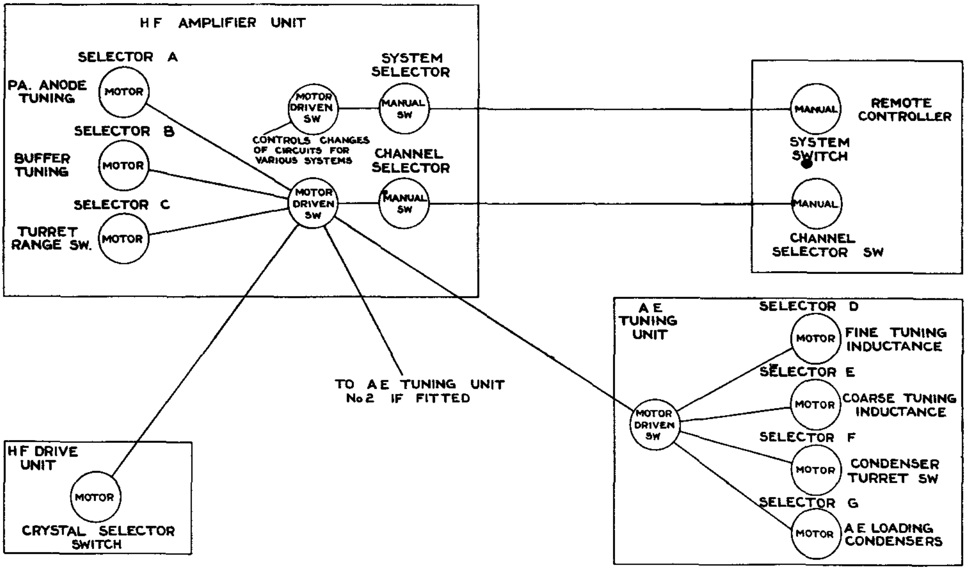


FIG. 8

If for any reason the motor is unable to find a "home" position and is left running, overheating may occur with consequent damage to it. A thermal overload cut-out is therefore incorporated which consists of a bi-metal strip arranged to open the interrupter contacts when the temperature of the motor reaches 100° C. This cut-out can be easily re-set.

Where circuits have to be controlled other than by switch wafers; *i.e.*, tuning condensers, variable inductances, etc., and where it is necessary to stop the shaft at any position in 360 degrees, a type of switch drive is used without the "Off/Normal" contacts described above. Instead a selector mechanism is used, which is in effect a rotary click stop device with ten sets of contacts. Each pair of contacts may be set to break at any position in the complete circle of rotation, simply by depressing a numbered plunger and adjusting the control to the required setting. Most existing remote control systems limit the user to the selection of a number of frequencies per frequency band. For instance, a transmitter with five frequency bands offering 10-spot frequency channels may only provide facilities for 2-spot frequencies in each band. This, to some extent, limits the operator in the practical application of his ten spots. One great advantage of the AD.107 control system, using a chain of controller switch drives and selector mechanisms is that 10-spot frequency channels can be set up anywhere in the full frequency range of the transmitter and the user is not restricted to a small number per section of the frequency band. Furthermore, there is no minimum separation of frequency channels, the selector mechanism being so designed that all ten spots can be set up within 1 kc/s of each other, if necessary.

Another attractive feature of the system is the simplicity of the remote controller. Since the operation of the main system switch and the channel selector switch on the transmitter merely set in motion the relevant drive motors and do not themselves switch any transmitter circuits proper, the remote controller is a simple unit, comprising parallel switches which earth the control line selected. It is consequently small (3 ins. × 6 ins. × 2 ins.) and can be mounted with ease in any position on the aircraft suitable to the operator.

When the remote control unit is used, the master switch on the transmitter is turned to " Remote " to bring the unit into circuit. Direct control of the transmitter is always possible by switching back from the " Remote " position, should the remote controller fail, or should certain operating conditions dictate the necessity for alternating between direct and remote control stations. Eleven controller switch drives are employed in the H.F. transmitter, each motor circuit incorporating a 2·5-amp. fuse. Any one of the motors can be replaced during flight, if necessary.

It is obvious that if the transmitter were operated while any of the motor drives were functioning, damage would result, and precautions have been taken by including a safety circuit called the " muting relay circuit ". The contacts of this relay are connected in series with the key circuit, while the earth return of the energising coil is taken via a selenium rectifier, to the negative side of all controller switch drives. If any one drive motor is functioning, its negative side is connected to earth, thus completing the energising circuit of the muting relay, which operates and opens the key circuit. The relay only returns to the rest position, when all drive motors are at rest and the negative end lifted from earth. Rectifiers are incorporated in the earth return lines to ensure that each motor is isolated from the others, otherwise the operation of one by completing its circuit to earth would actuate the others by means of the common line to the relay. A green indicator lamp on the front of the amplifier panel is connected via contacts on the muting relay and is illuminated only when the relay is at rest. The green light therefore indicates that all drive motors have stopped at their positions and all control circuits are accurately located at the predetermined settings. The failure of the green lamp to become illuminated indicates a fault in the control system and may be due to one drive motor failing to stop. By pressing a special button, the offending motor can be stopped and the selector re-set. A schematic diagram of the control system of the H.F. transmitter is shown in Fig. 8.

The tuning and setting-up procedure is straightforward. An aircraft can leave its base with ten channels pre-set, but additional crystals can be carried in the spares box and the transmitter re-set to other channels in flight, should special conditions require it.

M.F. Transmitter.

The M.F. transmitter, like the H.F., is comprised of four units, similarly named. The power unit is identical with that used in the H.F. combination, and the drive and amplifier units are fundamentally the same, although one or two minor differences exist. To obviate any possibility of late or non-oscillation of the M.F. crystals during periods of high-speed morse, the drive circuits, although using the same types and complement of valves as the H.F. drive unit, are arranged differently in a specially designed two-valve feedback oscillator.

The P.A. unit is similar to its H.F. counterpart, but has slight differences necessitated by the different frequency coverage. The aerial circuit is tuned by a variable inductance plus variometer and loaded by fixed capacities, brought into circuit by a switch. The main tuning inductance and variometer are situated in the aerial tuning unit. Two switches, each with its associated bank of condensers, are provided, to enable the transmitter to be tuned to either of two aerial tuning systems, if required. Approximately 75% of the components in the amplifier unit and 95% in the drive unit are common to the H.F. transmitter and therefore can be used as spares for either transmitter, this being advantageous from an economy aspect in relation to servicing stocks.

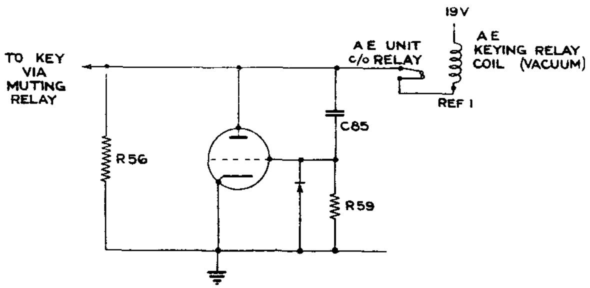
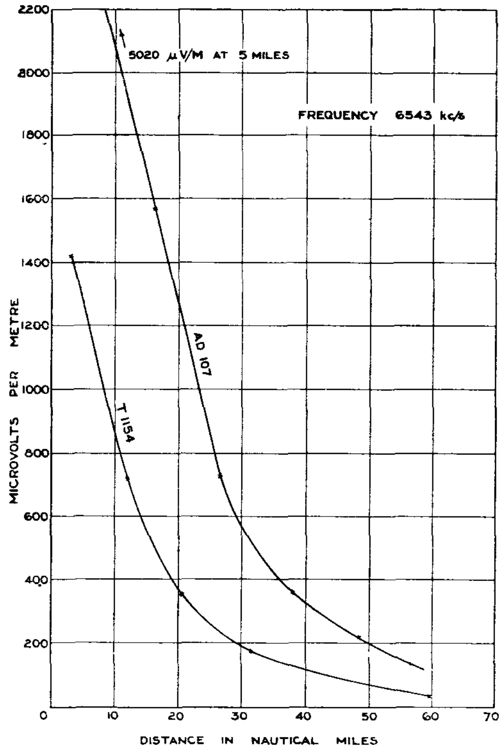
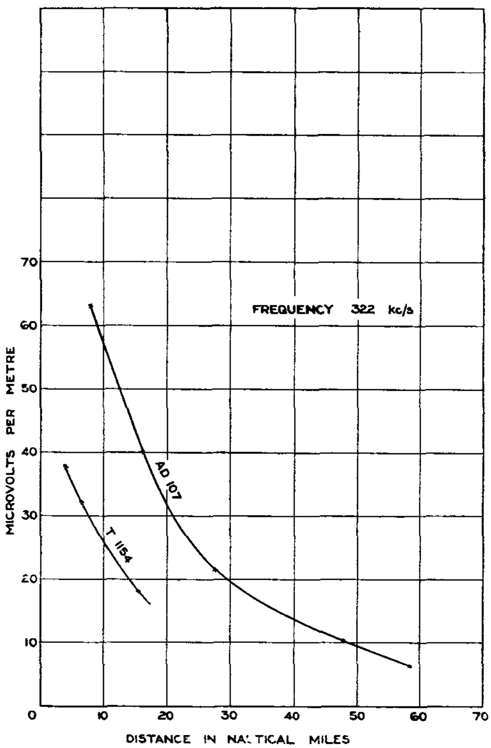


FIG. 9

The M.F. aerial tuning unit differs completely from the corresponding H.F. unit. Apart from the inductances already mentioned, it contains two aerial relays of special design. With very much higher voltages developed at the aerial on the longer waves, greater insulation is required, and this design problem becomes acute when the operation of the transmitter at high altitudes must be catered for, remembering that the aerial circuit must be keyed to provide listening through facilities. Use has been made of aerial relays contained in evacuated glass envelopes. The relay contacts are mounted in the vacuum, the magnetizing coil being located outside the envelope, which is sealed with a flexible diaphragm, through which the operating arm passes. An interesting feature of design is that the evacuated envelope assembly can be quickly detached from the relay mechanism and replaced without removing the whole relay. Two relays of the evacuated type are contained in the M.F. aerial tuning unit. One acts as the aerial keying relay, while the other, which can be called the aerial change-over relay, provides a facility for using the same aerial if both M.F. and H.F. transmitters are installed.

To minimise wear of the actuating mechanism of the vacuum relay a special delay circuit is incorporated. A CV. 136 valve connected as a triode, and a resistance R. 56 are connected in parallel with the key circuit. A 50 μF condenser (C. 85) is





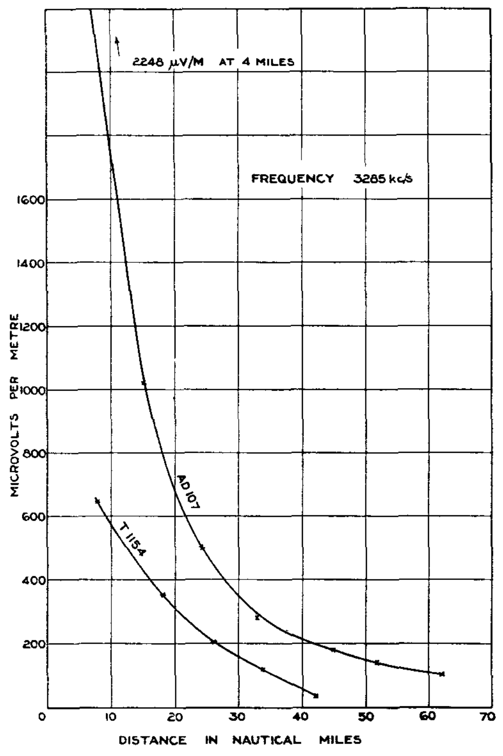


FIG. 10

Comparison of measured field strengths AD. 107 and T.1154.

connected between anode and grid of the CV.136. The earth return for the vacuum relay (ref. 1, Fig. 9) is taken to the key so that when the latter is made to E. the vacuum relay is energised. When the key circuit is broken, 19 volts D.C. is applied across the valve and resistance, and a current of about 35 mA flows. This is sufficient to retain the relay on " transmit ". The large condenser (C.85) previously uncharged, begins to charge through the grid resistance (R.59). After approximately half a second the grid potential falls sufficiently to cut off the valve. The current flowing through R.56 only is insufficient to hold the relay, which returns to the " receive " position. A variable resistance, physically situated in the M.F. tuning unit, is connected across R.56 and is adjusted for correct operation of the relay. A selenium rectifier connected across R.59 (the grid resistance) ensures the rapid discharge of C.85 when the key circuit is completed once more. The practical effect of the circuit is that the vacuum relay operates immediately the operator commences to key, but is not released to the receive position until the end of a series of code groups or words. The facility of " listening through " is retained, however, for although the operator does not receive between morse characters he has only to pause in his keying for half a second to receive.

Aerial power indication is given by a moving coil meter which obtains its operating energy from a transformer arrangement, the primary of which is in series with the main tuning inductance. Its indication is non-linear, as with the H.F. unit meter, greater sensitivity being obtained at the lower end of the scale.

Flight Tests.

Two series of air tests have been carried out, one in a Warwick aircraft and the other in a Viking operated by B.O.A.C. The Warwick installation was tested on local flights from Luton aerodrome and satisfactory long-distance communication was established with the Azores (CSY) and Malta (ZBJ2), the latter when the aircraft was on the ground. These flights were in the nature of preliminary tests and gave the Marconi engineers their first knowledge of the behaviour of the equipment under actual flight conditions.

The series of air tests performed in the Viking were more comprehensive and commenced with local flights in the United Kingdom, which included field strength tests with Pailton measuring station. At the same time, transmissions were made using a T. 1154 transmitter also installed in the aircraft. A comparison of the results at various frequencies is shown by the family of curves (Fig. 10). A study of the latter shows that measured field strengths of the AD.107 radiations were two to three times (H.F.) and twice (M.F.) those of the T.1154 at comparable distances.

A route flight was then undertaken, to Negombo in Ceylon, via Rome, Athens, Cairo, Basra, Sharjah and Karachi. No difficulty was experienced in communicating with ground stations in the various control areas through which the aircraft passed. Test calls were made to distant stations and contacts established at distances of 1,500 and 1,700 miles with ease. The long-distance test work was restricted as the transmitter was used as the route operational set. Primary importance was attached to the ability of the AD.107 to handle the normal radio traffic requirements of the flight and this it achieved without difficulty. Representative Radio Officers on board the aircraft expressed great satisfaction with the superiority of operation and rapid frequency changing facilities.

At Ceylon, local tests were made, and these proved the ability of the apparatus to run at very high temperatures since tests were conducted on the ground with the transmitter operating for long periods on full power. The hot tropical sun was beating on the aircraft at this time and the heat inside the fuselage was intense. In addition to the heat, heavy rain was experienced at night, resulting in a high degree of humidity, but no component failure was experienced under these extreme conditions.

Air tests were also carried out using Ceylon as a base, one flight being made at an altitude of 20,000 feet. Both M.F. and H.F. transmitters were used and functioned perfectly at this height, with no signs of aerial breakdown. Singapore was worked at 1,700 miles, and a D.F. bearing on H.F. was obtained from Karachi at a distance of 1,080 miles which was given as first class. The C.W. note was reported to be consistently good, all stations remarking upon its extreme clarity and readability. All contacts were made at the first call, this being a tribute to the note and frequency accuracy and stability. Ground stations also reported telephony transmissions to be of exceptional quality. Excellent communication distances are evident from the few contacts quoted, but the merit of the performance lies more in the fact that such contacts were established immediately and without difficulty.

Approval.

The AD.107 is approved for use in civil aircraft by the Ministry of Civil Aviation and the Air Registration Board and is also type approved by the Ministry of Supply to D.C.D. specification WT.1900.

PLANNING V.H.F. MOBILE SYSTEMS

By E. R. Burroughes

Short distance Mobile Radio Services have been largely revolutionised by the advances made in V.H.F. technique during and since the last War. As a result, Radio Communication can now be applied on Services which in the past were not of sufficient importance to justify the allocation of a frequency channel in an already overcrowded spectrum.

The objects of this article are to show the advantages that can be obtained from a correctly planned V.H.F. Communication System and also to provide information on the type of equipment available for Mobile Services.

Advantages of V.H.F.

THE principal advantages of V.H.F. for Mobile communication services are now becoming well known and may be summarised as set out below :—

1. Under normal conditions the range is mainly confined to line of sight so that with careful planning it is possible to repeat frequency allocations. In this way many more services can be provided with a clear channel and sharing of frequencies becomes largely unnecessary.
2. Frequencies used are not affected by atmospheric disturbances and are also less susceptible to interference by man-made noise. As an example, the ignition system of an internal combustion engine can be much more easily suppressed than on the lower frequencies.
3. A comparatively low-powered equipment can provide a reliable communication service, thus reducing to a minimum the power drain required in the mobile unit.
4. An efficient aerial system of small size and weight is easily obtained. This is particularly important in the case of the mobile equipment and also permits the use of comparatively cheap masts or towers in fixed stations.

Regulations and Frequency Allocations.

In Great Britain the regulations applying to the use of all Radio services are laid down by the Post Office, and V.H.F. equipment must receive their Type Approval before it is used in service. The regulations as originally laid down were confined only to specifying the type of emission, maximum power of the Transmitter and channel width which were permitted in the allocated frequency band. The Post Office have now issued specifications in which the performance of the Transmitter and Receiver is laid down in some considerable detail so that a customer is now protected with regard to the quality of the equipment purchased.

On a world-wide basis the V.H.F. frequency bands have been allocated by International Conference, although a certain amount of flexibility has been permitted to National Bodies as a result of the division of the World into three Regions. In

Region 1, which comprises the British Isles, the greater part of Europe and South Africa, the frequency bands permitted for Public and Private services have been defined in broad outline although local conditions have introduced certain modifications.

In the British Isles the frequency bands available for utility and private services lie between the limits 65-80 Mc/s. and 156-184 Mc/s. Certain parts of these bands are allocated to public services which are rigidly controlled by the Post Office and the remainder are allocated to private users. In the lower band frequency allocations are on a basis of 50 kc/s. channels and in the higher band the channel separation is increased to 100 kc/s. The greater proportion of the channels available between 65 and 80 Mc/s. have already been taken up and the majority of new services are, where practicable, allocated frequencies in the 156-184 Mc/s. band. For the average mobile service an allocation in the lower frequency band will provide a superior performance to that obtaining above 156 Mc/s. On the lower frequencies, the range obtained will exceed the true line of sight condition, whereas on the higher frequencies it is unwise to plan any service over an area where an optical path is not obtainable. The performance on the high frequency band also tends to be further degraded by more rapid flutter fading than is experienced in the low frequency band.

Operating Systems.

The three operating systems which may be used are :—

1. Common frequency Simplex.
2. Double frequency Simplex.
3. Duplex.

From the operating point of view (1) and (2) are identical, but, as indicated by the title, in the first case a single frequency is used for both the Fixed and Mobile equipment, whereas in the second instance one frequency is used for the Fixed to Mobile link and a second for the Mobile to Fixed channel. Where a common frequency is used two mobile units in a scheme can work together, but in the case of the double frequency operation they cannot communicate except through their Headquarters station. The only advantage of the two frequency system is that the risk of interference between mobile units working in services on adjacent channels is minimised.

On both Simplex systems, as the name indicates, either the Transmitter or Receiver is energised in turn. The changeover from the receive to the send condition is usually effected by means of a press to talk switch mounted in the microphone or handset. In the case of Duplex, both the Transmitter and Receiver are in operation at the same time and conversation is carried on as in the case of the normal telephone. Two frequencies must of course be used in this case.

It will be seen from the foregoing that single frequency simplex has the advantage of requiring only one channel but the disadvantage that interference between two services may be experienced. Two frequency Simplex avoids the interference problem but entails the use of two channels and also precludes direct communication between mobile units in the same service. Both require action on the part of the operator to change over from receive to send and also involves some small knowledge of operating procedure. Duplex involves the use of two frequency channels but reduces the skill required from the operator to a minimum.

When working Duplex, as both Transmitter and Receiver are energised at the same time, it is necessary, either to use two aerials or to use a common aerial with filters to eliminate interference from the local Transmitter.

The Siting of the Fixed Station.

The correct siting of the Aerial system of the Fixed Station is the most important factor in the satisfactory operation of a service. The aerial should, as far as possible, be installed in a position where it is not shadowed by nearby buildings or hills which are at a greater height. This point is particularly important in the case of services operating mainly in urban areas where screening from buildings may materially effect the performance of the service.

Where the site from which the service is required provides a reasonable aerial position the equipment itself should be installed as close as possible to the aerial in order to keep down the loss in the R.F. feeder. In general it is desirable that the length of feeder should not exceed approximately 100 feet. Where the required operating position does not fulfil this condition it is normal to arrange for the Transmitter and Receiver units to be mounted within the specified distance of 100 feet and for the equipment to be remotely controlled. This can be carried out in two ways, either by extension of the switching and audio circuits where the distance does not exceed 300 feet, or by full remote control which can, if necessary, be over one telephone pair up to distances of five or six miles. In both cases full control of the equipment is available at the operating position.

Modulation Systems.

Both Amplitude modulation and Frequency modulation are being extensively used in Mobile V.H.F. services and the merits and de-merits of the two methods are the subject of considerable controversy. In Great Britain the majority of equipment in use employs amplitude modulation, but in the United States frequency modulation is almost exclusively used. Both methods of modulation can be used to provide a first-class mobile service and under operational conditions there is little to choose between them.

The principal advantages claimed for frequency modulation are, firstly, that a better signal/noise ratio is obtained for a given field strength and, secondly, that the receiver inherently possesses better protection against impulsive and man-made noise. A further advantage frequently claimed is that the transmitter can produce a greater radio frequency power for a given power input owing to the modulation being at a low level. This is, however, largely offset by the greater number of multiplier stages needed owing to the necessity for the use of comparatively low frequency crystal in order to obtain a satisfactory deviation.

While the inherent design of a frequency modulated receiver does provide protection against amplitude variations, impulsive and man-made noise also possess frequency modulation characteristics and can, therefore, produce the same interference as in an amplitude modulated receiver. Many developments have been made during the past few years with noise limiters for use in amplitude modulated receivers and in a well designed equipment the protection against impulsive noise can reach a very high standard and be comparable with that of the frequency modulated type.

From an operational aspect the amplitude modulated system has the great advantage of being in general more stable in service and also easier in maintenance. In order to ensure optimum performance with a frequency modulated system it is generally necessary to use crystals with a very high degree of temperature stability, and the discriminator circuit in the receiver must also be very good in this respect. Unless these conditions are fulfilled, the frequency modulated system can produce bad distortion owing to the incoming signal being off centre in the discriminator circuit, whereas with the amplitude modulated equipment far more tolerance can be permitted provided that the carrier plus side bands sits within the pass band of the intermediate frequency circuits.

While there is much to be said for both systems, from the important viewpoint of obtaining reliable and trouble free service over a long period of time, particularly when maintenance is a difficult problem, the amplitude modulated system is generally to be preferred for mobile services.

System Planning.

If the greatest benefit is to be obtained from the installation of a V.H.F. service, careful planning of the system is essential. The various methods of operation and modulation systems have already been discussed in earlier sections and suitable equipment is described later.

Most Mobile services are now allocated two frequency channels for the outward and return circuits in order to avoid interference between systems operating on adjacent frequency allocations. The two frequencies are usually separated sufficiently to permit duplex to be used if desired.

In planning the system the choice of equipment is governed by the following considerations.

(1) The topography of the country in the service area.

(2) The desired method of modulation.

(3) The selected method of operation, i.e., simplex or duplex.

The carrier power of the transmitters and more particularly that of the Headquarters or fixed station is mainly dependent on the nature of the terrain over which service is required. If the major portion of the required service area is over urban or built-up districts it may be necessary to install a high power transmitter at the fixed station so that the field strength at the mobile receiver is sufficient to overcome interfering electrical disturbances. In cases where the required service area is mainly rural the powers of the fixed and mobile stations can be the same, as in general the prevailing electrical noise levels are low.

The selection of the method of modulation is very largely a matter of individual preference. This has already been covered in the preceeding section in which the advantages and disadvantages of the two methods have been discussed.

The majority of Mobile schemes use the simplex method of operation and where maximum efficiency is essential this is the best system. There is normally little difficulty in training semi-skilled personnel to use the press to talk switch which is mounted on the microphone and once educated in this technique communication can be carried out as rapidly as with a duplex arrangement. The major advantage of simplex work is that as only transmitter or receiver is energised at one time the drain on the battery supply is kept as low as possible. With duplex, both transmitter and receiver will be running together as long as communication is being carried out.

In some cases duplex working may be essential at the fixed or Headquarters station, particularly where control of the equipment is required at more than one position. In such cases use is frequently made of an internal office telephone system and in this case duplex must be used. Even though duplex is used for the fixed station the mobile units can still be operated on simplex basis and once again the operating personnel very quickly become accustomed to the necessary procedure. Where full duplex on all equipments is essential this arrangement can operate satisfactorily but will in general entail some degree of limitation of the service area. Unless very expensive and elaborate filters are included in the equipment it is very difficult to eliminate some small amount of feed back from the local transmitter into the mobile receiver with the aerial spacing that can be obtained on a vehicle. This tends to reduce the service area as the receiver is blocked to some extent by the feed back from the local transmitter thus degrading the sensitivity.

It will be seen from the foregoing that correct planning of a V.H.F. mobile system is highly desirable before equipment is installed and the extensive experience of the Marconi Company in this field is always available to potential users.

Equipment.

A comprehensive range of V.H.F. equipment to suit all types of mobile services has been produced by the Marconi Company. The range has been designed and produced after extensive development and field trials in order to determine the most suitable types for all services.

For fixed station service a 50-watt transmitter, type TGV. 472 and associated receivers type RP. 47 are available in both Amplitude and Frequency modulated versions. Normally a single crystal controlled frequency is provided within the required band, but for certain special requirements the equipment can be arranged for two channel operation with the proviso that the channels are not more than 500 kc/s. apart. This equipment is mounted on 19-inch panels for fitting to either a standard rack or cabinet. The preferred arrangement is in the latter form as it is then simpler to provide full safety precautions.

The mechanical arrangement is such that it is possible to fit two of these 50-watt transmitters together with their associated receivers in one 6-foot cabinet. Separate power supplies are provided for both transmitters and receivers so that the two channels thus provided can be in operation simultaneously or, if desired, may be used as a working channel with the second as a standby unit. This flexible arrangement is particularly suitable for ground to air service where a busy airport may require the provision of more than one channel. The arrangement of two 50-watt transmitters is shown in Fig. 1.

For general purposes the use of the 50-watt equipment would normally be confined to services operating mainly in urban areas. In conditions such as these the mobile receiver is frequently operating where the electrical noise level is of a high order and in these circumstances the provision of 50 watts at the fixed station ensures a satisfactory field strength.

This equipment can be arranged for both local control and remote control over Post Office lines. Where single channel equipment only is involved full control can be provided on a single pair, this including start/stop and send/receive. The equipment can be operated on either a Simplex or Duplex basis as required.

In rural districts, or where only a limited service area is to be covered, it is normally sufficient to provide transmitters of equal power for both the fixed and mobile units. The second equipment therefore available for fixed station use is a 10-watt transmitter type TGV.401 with the same receiver as that used for the 50-watt equipment. This transmitter is again available in amplitude or frequency modulated versions and is normally supplied for a single spot frequency in the specified band. For special services where more than one channel is required the transmitter and receiver can be supplied with switching up to six channels with a proviso that these channels are at 50 kc/s. spacing below 100 Mc/s. and at 100 kc/s. spacing above that figure. This arrangement permits considerable flexibility in planning where a complex scheme which cannot be adequately covered by a single channel is involved.

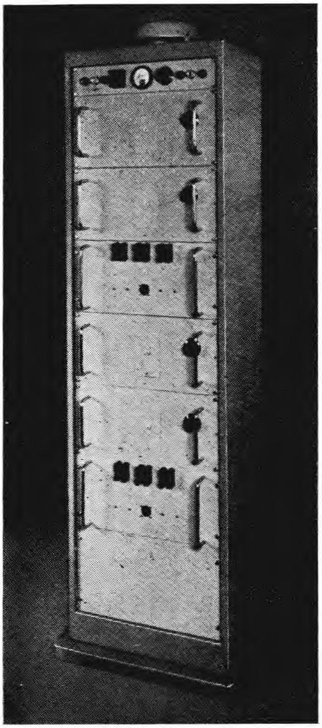


FIG. 1

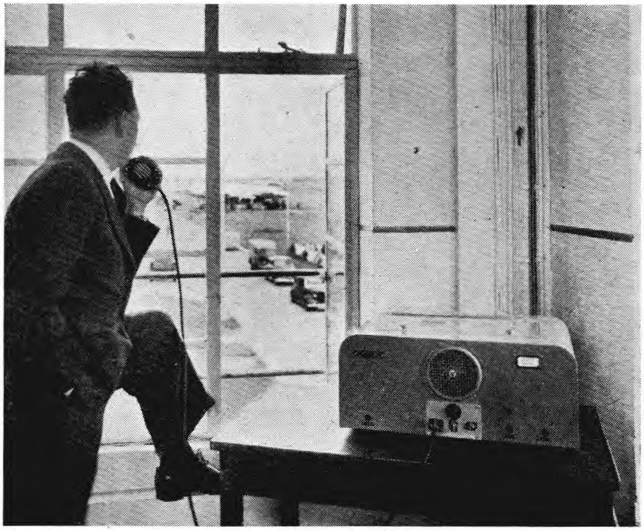


FIG. 2

The equipment is available with the transmitter and receiver mounted either in a single cabinet for desk mounting or on 19-inch panels with rack mounting. Fig. 2 shows a typical installation of a desk-mounted equipment on an airport. As in the case of the 50-watt equipment, the 10-watt set is available for either local or extended control and also full remote over Post Office lines. The extended local control is intended for use where the transmitter and receiver are installed in one room and the operating position is in a nearby office where the distance does not exceed 300 feet. Simplex or Duplex operation can be provided as desired.

The fixed station equipment is normally powered from A.C. mains. For special cases where it is vital that communication should be maintained in the event of failure of the power supply, the equipment can be arranged for rapid changeover to a stand-by battery.

The 10-watt equipment, type H.16 is also extensively used as the mobile unit, all circuits except the power supply being the same as used in the fixed station set. Mobile equipment is available for operation from 6, 12 or 24 volts, rotary converters being used to provide the high tension supply.

The Transmitter and Receiver are in two separate units as illustrated in Fig. 3, these being mounted in a frame which carries the interconnecting sockets and cables and also the shock absorber mountings. As will be seen from the illustration, the units are arranged with quick release catches so that replacement is simple and rapid. The transmitter receiver unit is normally

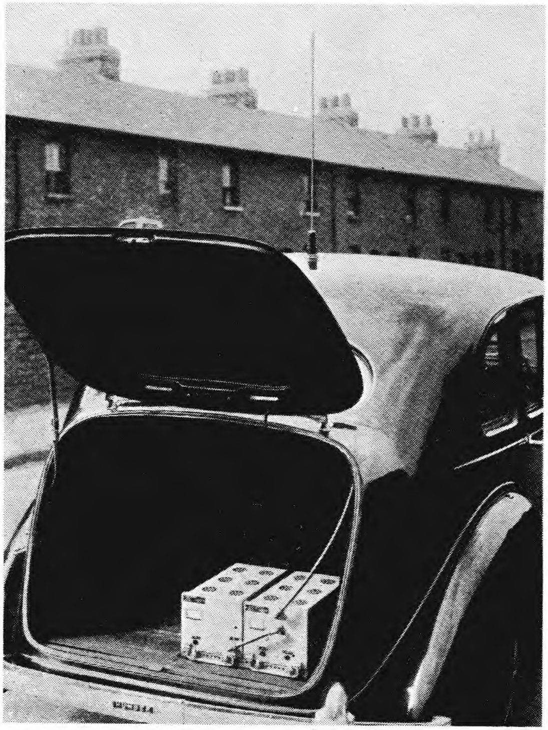


FIG. 3

mounted in the luggage compartment of a car and is controlled through a small control unit which includes the loudspeaker and is arranged for mounting below the dashboard. The microphone or micro-telephone handset is connected through this control unit and the send/receive operation is by means of a pressal switch.

In the amplitude modulated mobile units the modulator system can also be used in conjunction with a public address type of speaker, thus providing loudhailer facilities at only the extra cost of the speaker itself.

For mobile units where a limited service area is required, and for portable applications, the next equipment in the Marconi range is the type H.18 2-watt set. This equipment is completely self-contained with the exception of the battery and is shown in its fixed station form in Fig. 4. As will be seen from this illustration the unit is small enough to be mounted directly beneath the dashboard of a motor car so that external connections are confined to the battery lead, aerial feeder and handset cable.

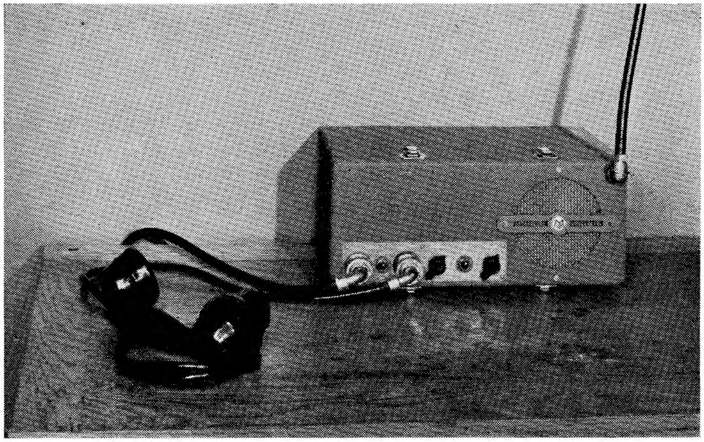


FIG. 4

This equipment is again available in amplitude and frequency modulated versions and can be supplied for single frequency operation or with the six switched channel facility already described on the 10-watt set. The power output of 2 watts from the transmitter is adequate for short distance mobile work and the receiver performance is comparable with that obtained from the H.16 counterpart. The high tension supply in the case of the H.18 is obtained via a synchronous vibrator unit and in order to render it suitable for all portable applications special arrangements have been made to render the equipment waterproof.

The final equipment in the series is the H.19 Walkie Talkie, which, as with the other units in the range, is available in both amplitude and frequency modulated versions and on the same frequency bands. With this set the switched channel facility can also be provided, but in this case a maximum of three is available. This equipment is not normally employed for mobile operation but is extensively used in connection with the H.16 and H.18 described earlier as part of an overall scheme. It is used, for instance, in Press services where a reporter transmits his story back to an H.16 installed in a car from whence it is relayed back to the newspaper office. The H.19 is completely self contained, a 2-volt accumulator being the primary source of power. The high tension supply is obtained via a synchronous vibrator and the equipment has been rendered waterproof for service under all conditions. The H.19 is shown in Fig. 5 with a harness designed to provide the wearer with the maximum comfort under arduous conditions.

Circuits and Performance.

The transmitters throughout the range have all been designed to make use of the latest technique in high frequency crystal manufacture thus reducing the number of multiplying stages and minimising the radiation of unwanted frequencies. In the two higher-powered equipments crystals operating under the third overtone conditions are used so that in some instances the initial frequency may be as high as 40 Mc/s. Owing to valve limitations this is not practicable in the low-powered equipments, and in these fundamental crystals at frequencies up to 20 Mc/s. are used. The crystals are all mounted in either miniature or sub-miniature glass envelopes and the grinding accuracy and temperature coefficient are such as to provide an overall frequency stability of better than ·01 per cent.

FIG. 5

All amplitude modulated transmitters employ high-power modulation of the final amplifier, the modulators being driven in the case of all equipments, with the exception of the 50-watt, directly from a differential microphone which provides first-class speech quality. In the frequency modulated editions a phase modulated crystal oscillator circuit is employed throughout the range. On amplitude modulation the carrier is modulated up to 90 to 95 per cent. and in the F.M. case the maximum deviation corresponding to 100 per cent. modulation is ± 15 kc/s.

The receivers throughout the range of equipment are of the double superheterodyne type, this arrangement being employed in order to obtain optimum gain together with a high degree of stability and second channel protection. In some instances a single crystal oscillator is used to feed both the first and second frequency changers and in these cases the first intermediate frequency varies in sympathy with the radio frequency. In other receivers a fixed frequency crystal controlled oscillator is used to feed the second frequency changer separately.

The receiver associated with the 10- and 50-watt equipments requires an input signal of between 2 and 5 microvolts for 20 db. signal/noise ratio, this corresponding approximately to a noise factor of between 4 and 8 dbs. The receivers with the smaller equipments have a somewhat inferior performance but are as good as the available valve types will permit. In the intermediate frequency amplifiers, two editions are available, one providing a wide pass band for multi carrier operation and the other a narrow band width for single channel use. The use of the narrow pass band intermediate frequency is particularly important where two services may be operating on adjacent channels in the same area as it provides a high degree of rejection at 50 kc/s. off tune. The band width in the case of the wide band I.F. is 50 kc/s. and in the case of the narrow band is 35 kc/s.

In amplitude modulated receivers series/shunt peak noise limiters are fitted in order to provide good protection against impulsive noise. In the frequency modulated edition the limiter is followed by a discriminator which employs a split capacity centre tap in place of the more conventional centre tapped inductance. In the larger receivers low pass filters are fitted in the audio circuits in order to restrict the response to noise outside the normal speech band.

In amplitude modulated receivers for fixed station use, and on frequency modulated receivers, a muting circuit is included, the circuit in the former operating on signal/noise ratio and in the latter on carrier level.

Aerials.

A number of different types of aerials have been developed for use with the equipments described above. For fixed station use a concentric ½ wave dipole is available where omni-directional radiation is required. A further development of this aerial is a series of stacked elements which provides a gain of 3-4 dbs. over the plain ½ wave dipole.

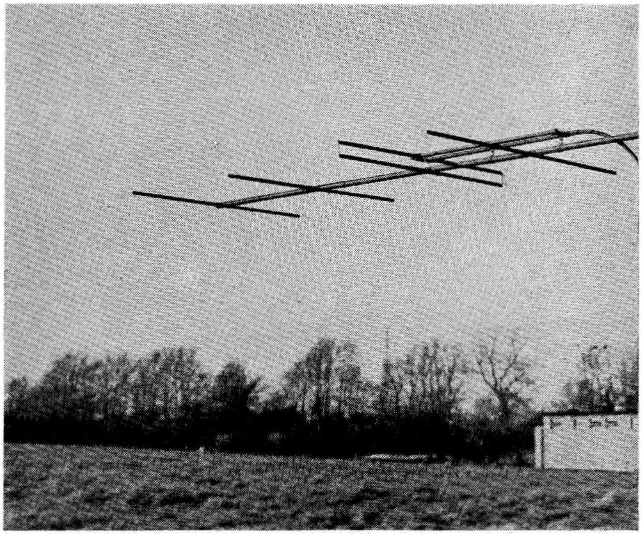


Fig. 6

For use in service areas where radiation is required mainly in one direction a number of editions of Yagi arrays have also been designed. A typical 4-element Yagi aerial is illustrated in Fig. 6. For most mobile purposes a ¼ wave flexible mounted rod aerial is used, this normally being fitted on the roof of a car. This aerial is shown in Fig. 3.

Test Equipment for Maintenance Purposes.

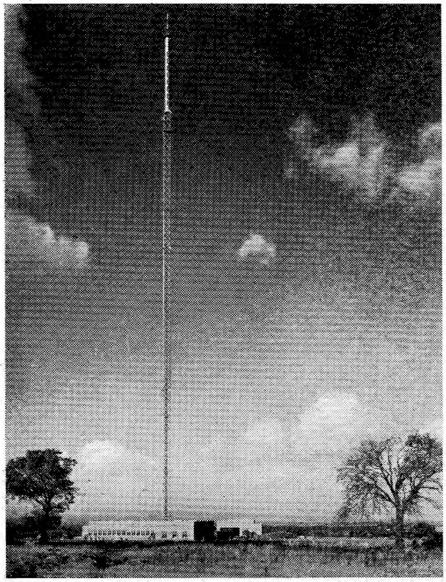
A number of items of test equipment are being produced by Marconi Instruments to provide for the maintenance of equipments such as that described above. The range includes a radio frequency power meter for use with all transmitters and two test sets by means of which both Amplitude and Frequency modulated receivers may be tested and re-aligned when the necessity arises.

These instruments are all self-contained and are therefore particularly suitable for testing in the field. Although they are small in size and light in weight a high degree of accuracy is provided.

MARCONI NEWS AND NOTES

SUTTON COLDFIELD

Marconi Contribution to the most Powerful Television Station in the World

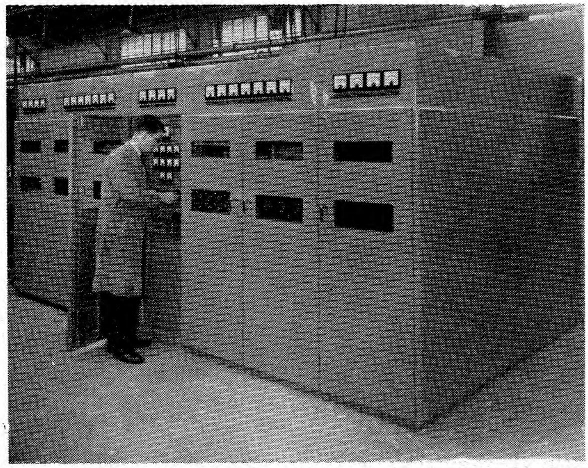


The Marconi eight-dipole sound and vision aerial array, at the top of the 750-ft. aerial mast at Sutton Coldfield. (B.B.C. Photo).

THE closest co-operation has been maintained between the B.B.C. and Marconi's Wireless Telegraph Company, Ltd., in the design and manufacture of equipment for the new Midland television station at Sutton Coldfield—the most powerful television station in the world—which opened on December 17th, 1949, and for which the following equipment has been supplied by the Marconi Company: The complete Sound Transmitter, the crystal RF drive for the Vision Transmitter, Sound and Vision feeders and Diplexer, and the eight-dipole aerial array.

An output of 12 kW (class B, Amplitude Modulated) is provided by the Marconi sound transmitter which is completely air-cooled.

The working frequency is 58·25 Mc/s. A Marconi crystal drive is followed by four stages of amplification and the output circuit is one BR.128 valve. A similar sound transmitter is to be installed at Holme Moss for the B.B.C's third television station for which the complete vision transmitter will also be supplied by the Marconi Company.



Marconi 12½ kW television sound transmitter for the new B.B.C. television station at Sutton Coldfield, under construction at the Marconi works.

A Marconi crystal drive, stable within ·005 per cent, is also used with the Sutton Coldfield vision transmitter, and works on a frequency of 61·75 Mc/s.

The mast and aerial system comprises a 610-ft. mast, 100-ft. of cylindrical slot aerial for V.H.F. transmission, and the 35-ft. television aerial array.

Two tiers, each of four folded vertical dipoles spaced at 90°, are used for radiating both sound and vision transmissions, and are fitted with electric heaters for de-icing.

Sound and vision, from their respective transmitters, are combined in a unit called a " Diplexer " and the combined transmission is fed to the eight dipoles.

Dehydrating units—situated in the transmitter buildings—provide a supply of dry air which circulates through the feeder system to avoid condensation in the feeders.

MARCONI TELEVISION TESTING EQUIPMENT

TELEVISION dealers, engineers and technicians have been preparing for the past few months for the advent of the British Midland television station. During the week commencing November 21st they were given an opportunity of seeing the very latest in radio and television test equipment in use when Marconi Instruments, Ltd., presented working demonstrations of their complete range of test equipment at their Midland showrooms at Leamington Spa.

The Test Equipment which was demonstrated included : H.F. Field Intensity Meter (TF.930) ; Transmitter Output Meter (TF.912) ; Universal Bridge (TF.868) ; 50 cycles Visual Detector (TF.536B) ; Circuit Magnification Meter (TF.329G) ; Video Oscillator (TF.885) ; Standard Signal Generator (TF.867) ; Signal Generator (TF.801A) ; R.F. Test Set (X Band) (TF.890) ; F.M. Receiver Tester (TF.913) ; Precision Heterodyne Wavemeter (TF.783/1) ; Valves Millivoltmeter (TF.899) ; Audio Tester (TF.894) ; Receiver Tester (TF.888).

In addition, Marconi's Wireless Telegraph Company, Ltd., demonstrated a complete portable television camera chain, and visitors to the demonstration were able to see themselves televised by means of the television equipment which proved so popular at the British Industries Fair and at Radiolympia when over 200,000 people saw themselves passing before the television camera and screen.

CIVIL AVIATION RADIO CENTRE AT GATWICK

AN important service has been introduced by Airwork, Ltd., at Gatwick Airport, which comprises a working display of aircraft wireless equipment, so that visitors to the Gatwick radio centre can inspect, at one central point, a full range of wireless communication and navigational aid equipment designed by leading British Manufacturers.

One of the principal exhibits of interest is the working installation of a Marconi Type AD. 7092 automatic direction finder. This equipment enables any wireless station within range to be tuned in (either aurally or by visual indicator) by an aircraft requiring bearings. The motor-driven loop is then automatically orientated and the correct bearing of the selected station is presented on a small meter. The AD. 7092 is fully remotely controlled. Other Marconi exhibits at this radio centre feature light-weight aircraft communications equipment and a beam approach receiver.

MARCONI POLICE EQUIPMENT

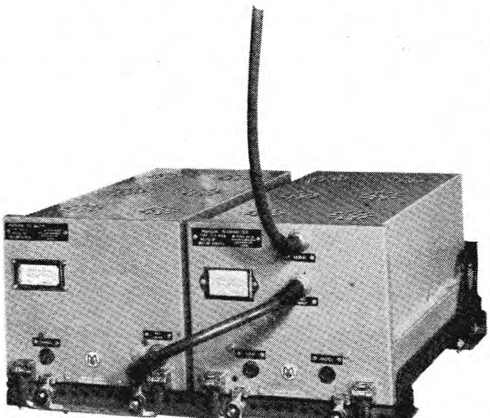
Demonstration of V.H.F. Telephone Control

ON Saturday, November 26th, a striking demonstration of the application of Marconi V.H.F. Equipments to the control of mobile units followed a lecture on the subject given by one of the Company's technical staff to some 200 members of the Reading Radio Society.

Among the Society's guests attending the demonstration were Chief Inspector Utterell, of the Berkshire County Constabulary, and Divisional Officer Evans, of the Berkshire Fire Brigade, with others of their staffs.

A Type H16A transmit/receive equipment was set up in the Lecture Hall while the mobile units comprised a saloon car fitted with a Type H16 set and two " Walkie-Talkies," Type H19.

The demonstration opened with a trial of communication between the " Walkie-Talkies." One of these was taken into the town and directed through the most highly screened areas by Chief Inspector Utterell using the other in the hall. Both sides of the conversation were made audible to the audience by means of the loudspeaker of the H16A set.



A mobile version of the 10-watt transmitter/receiver Marconi Type H16.

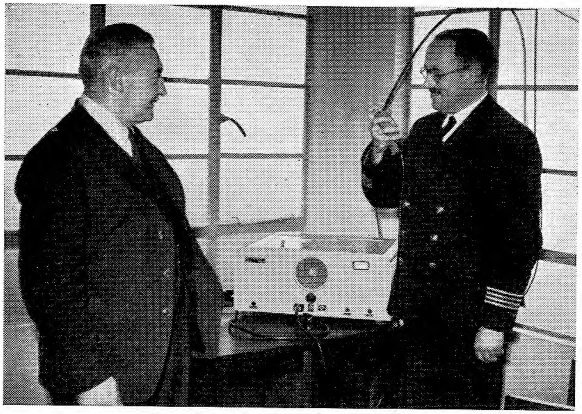
Following this the H16 car was sent into the outskirts of the town and a " Walkie-Talkie " was taken by another car in a different direction. When five miles from the hall the H16 was called up by the President of the Society operating the H16A set and was asked to contact the " Walkie-Talkie " in the other vehicle. This was done and contact established between the two " Walkie-Talkies " over a range of three-and-a-half miles of built-up terrain. Thereafter the H16 was directed through difficult areas around the city and in the Cotswolds, faultless communication being maintained throughout.

Police representatives in the car were able to report on a car " speeding " in the thirty-mile limit, and a section of street lights which were extinguished. A fortuitous meeting with a Mobile Police Car enabled the patrolman to report on the H16 channel direct to his Chief Inspector in the lecture room.

A striking feature of these faultless V.H.F. demonstrations was the fact that the sets were being operated by members of the Reading Radio Society and Police without previous acquaintance with the equipments.

Considerable interest was expressed not only by the representatives of the Berkshire Constabulary but by those of the Fire Brigade in the possibilities of V.H.F. in the operation of their fire sirens in the area and in the direct application of the " Walkie-Talkie " at the scene of a fire.

MOBILE RADIO AT LONDON AIRPORT

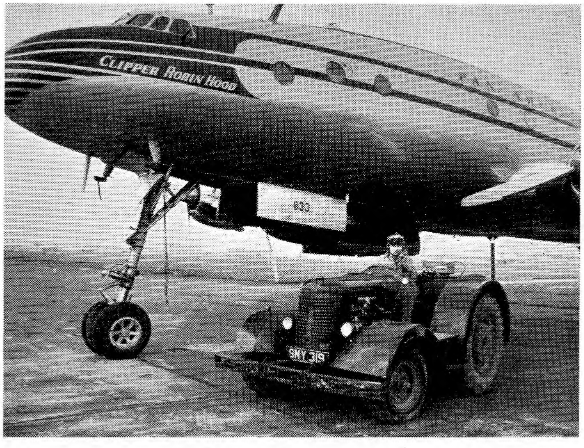


Mr. F. Neil Sutherland, General Manager of the Marconi Company and Mr. Huggins, Station Manager, B.O.A.C. London Airport, looking at a Marconi H16 V.H.F. headquarters set.

A LARGE gathering of representatives of all the major airlines saw a demonstration of Marconi Very High Frequency radio for the control of airport personnel and vehicles at London Airport on November 15th. The demonstration—organized by Marconi's Wireless Telegraph Company, Ltd., in co-operation with the Pan American World Airways and with the kind permission of Sir John D'Albiac, the Commandant of London Airport—showed how time and labour can be saved, and efficiency increased, when V.H.F. radio is used for passing instructions from Control Centre to ground crews ; as an aid to the towing and parking of aircraft ; and for receiving reports from members of the staff who are at remote points on the airport, with a minimum of delay.

A Marconi Type H16A 10-watt transmitter/receiver was installed at the airport and guests were able to hear the operational instructions and reports passed between Pan American Headquarters, an engineer on the runway who wore a Marconi Type H19 "Walkie-Talkie," and a tractor driver who had a Marconi Type H18 2-watt transmitter/receiver mounted on his tractor.

Pan American World Airways have adopted Marconi V.H.F. radio for use at London Airport and Marconi H18 equipment is now in regular service there.



A Pan American World Airlines System tractor fitted with Marconi H18 V.H.F. radio.

FIRST RADIO-EQUIPPED LONDON TAXICAB

ON the subject of V.H.F. communications it is of interest to note that the Commissioner of Police has recently approved the first London taxicab to be fitted with V.H.F. radio. The equipment is the Marconi Type H16 and the vehicle is one of a fleet owned by Confair Cars, Ltd., Plaistow, at whose headquarters a Type H16A has been installed. Many private hire cars have already been equipped by the Marconi Company with V.H.F., but this is the first London taxicab to be so fitted and the owners anticipate that the equipping of their new fleet of "Oxford" taxis in the North Woolwich Dock area will cut out at least 50 per cent. of waste mileage as a disengaged taxi can be directed quickly to fares in its immediate vicinity.

Use of two-way radio does not necessitate the driver taking his eyes off the road or holding a loose microphone. The microphone is fitted at the top of the windscreen where the driver can speak directly into it and the switch controlling it is on the dashboard some 6 inches from the steering wheel. The loudspeaker and control unit are also on the dashboard and the transmitting and receiving apparatus is beneath the driver's seat.

Marconi equipment on the first radio-equipped taxicab. The microphone is just above the driver's head and the Marconi type H16 V.H.F. transmitter/receiver is installed beneath the driver's seat.

The latest "Confair" taxis to be fitted with Marconi V.H.F. equipment have the microphone mounted on the steering wheel.

A second taxicab has since been fitted with Marconi V.H.F. equipment for Confair Cars, Ltd. In this taxi a slight change has been made in the installation. Instead of having the microphone installed at the top of the windscreen (as in the first taxi) it has been fixed on to the steering column and the driver has only to bend forward slightly to speak into it.

The loudspeaker and control unit and the transmitter/receiver are installed in the same positions as in the first taxi to be fitted.

Both installations are worked from the taxicab's normal 12 volt batteries.

NAVIGATION IN THE ANTARCTIC

Anglo-Scandinavian Expedition to Use Marconi Automatic Direction Finders

WHEN the Anglo-Scandinavian Antarctic expedition ship, the " Norsel ", reaches the belt of drifting ice off Queen Maud Land early in 1950, two aircraft will be used to reconnoitre these ice fields and guide the " Norsel " through them. The two aircraft will, in turn, be guided back to the ship, each time they fly out on reconnaissance, by Marconi Type A.D. 7092 automatic direction finders.

As the aircraft will be flying in regions near to the South Magnetic Pole their magnetic compasses will become unreliable. A trustworthy method of " homing " to the " Norsel " is therefore required and Marconi automatic direction finders have been chosen for this important work.

In addition to " homing " this Marconi equipment will enable approximate " fixes " to be made ; by computing flying speed and time, allowing for drift, and using the automatic direction finders in conjunction with the ship's transmitter for bearing, position will be calculated and plotted.

The expedition—which sailed for Cape Town in November—is probably the best equipped ever to enter Antarctic waters.

The Marconi equipments installed in the two aircraft provide a full range of navigational aid facilities together with other features. These are :

(a) Automatic visual indication of the relative bearing of any radio station to which the receiver may be tuned, together with simultaneous, uninterrupted, aural reception of modulated or unmodulated signals.

(b) Aural bearing determination by normal null signal method. This facility can be used with remote or direct manual control of the loop.

(c) Reception of normal communication signals—telephony, C.W., or M.C.W.—either on the loop or the non-directional whip aerial.

Radio range reception or voice reception can be used at the same time as any of the above facilities.

Both the receiver and the loop aerial can be fully remotely controlled. There is no sense ambiguity in the system and the visual bearing is presented on a panel-mounted instrument which incorporates a signal-strength indicator.

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BELGIUM AND BELGIAN COLONIES.
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BRITISH EAST AFRICA.
(Kenya, Uganda, Tanganyika, Zanzibar.) Kinleven Ltd., P.O. Box 35, Nairobi, Kenya.

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United Engineers Ltd., P.O. Box 41, Singapore.

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