RADAR FITTING AND MAINTENANCE NOTES

TYPE 242.

Notes on Type 242 Remotely Controlled Aerial.
(Type 242 with 272/3 and 276/7,293).

Difficulties have been experienced with these aerials. Observance of the following points will do much to prevent recurrence of trouble.

(1) Pedestal Motors Patt. W.6291/2. No load armature current should be less than ·15 amps.

(2) Pedestal Coupling. The red fibre coupling in the pedestal swells with moisture. A new coupling (Patt. 55472) 7/16" thick made of Synthetic Resin Linen Board will be supplied shortly.

(3) Follow up switch Patt. W7844 (242 with 276/7, 293 only).

(a) Stud and segments should project from the board by at least ·005".

(b) Outer contact finger should be flat, and should bridge the gap between two adjacent studs with 1/16" overlap on both sides.

(c) In 110v ships Resistance Patt. 50643 should be replaced by 240 ohms Patt. 51533.

(d) In 220v ships Resistance 50056 should be replaced by 1200 ohms Patt. 51460 or 50056 can be reconnected to board (by shorting first two studs) so that maximum resistance is 1200 ohms.

(4) Testing of assembled pedestal.

Coupling block should be free to move radially and axially (test through inspection cover on the pedestal). Armature current at full speed should be between .15 and ·25 amps.

(5) Failure of 24v. Supply when D.C. is on.

(a) For 272/3 applications. Circuit breakers Patt. 54311/2 to prevent burn out of the motor are being supplied.

(b) For 276/7, 293 application. A lamp Patt.6990/695 should be fitted in the office and wired across armature of pedestal motor. This will then indicate when aerial is rotating.

(6) Aerials of 242 and the associated radar set should always be lined up before switching to synchronous running.

TYPE 271 etc.

Additional Gear to be Fitted to Plan-Fitted Sets.

As bearing plotters, pattern W.5494 are no longer available it is proposed to fit Aerial/Gyro repeaters, pattern W.5212 instead. C.A.F.O. 311/44 refers.

It is also under consideration that when R.T.U.52 is fitted a range receiver pattern 10212 should always be fitted in the corresponding Radar Office as a local repeat. The 276/277/293 Specification will be amended to include this if approved.

TYPE 272.

Breakage of Leads.

Reports have been received from the Fleet of the frequent breakages of the office-to-lantern leads in Type 272 and of the difficulty of their replacement. It is not possible to prevent the breakages owing to the amount of flexing these leads undergo, and the type of cable which must be used for electrical reasons.

To facilitate the replacement of these leads a box, Patt. 55575, containing a plug and socket board, spare plugs and fitting instructions are being issued to all ships fitted with Type 272. The plug and socket board is to be inserted in the office-to-lantern leads inside the lantern. Spare leads are to be made up with the sockets provided, to allow quick replacement.

Performance.

It appears from reports received that many ships fitted with Type 272 are not getting the results of which the set is capable. The principal reasons are:-

(i) Some ships are fitted with the wrong cables for their office-to-lantern leads. These should be

Pulse lead	Patt. 13831
I.F. lead	13801
Local Oscillator lead	13821

Ships fitted with wrong type leads should replace them.

(ii) Sets are not being kept in tune. Special tuning instructions are being issued to C. in C's and Port Radar Officers. Radio Mechanics are to be instructed in this method of tuning. The instructions will also be issued as an amendment to the Type 271 Handbook, H374A.

Circular Perspex Lanterns Patt. 54679 are now in production and will be issued to ships fitted with Type 272 sets. The fitting of these lanterns will reduce the side echoes from which the set has previously suffered.

TYPE 276.

A number of ships have now been fitted with this set and, from the fitting reports received, a number of minor defects in the set have been noted and are being remedied.

Air Conditioning Unit, Patt. W8828. Owing to the difficulty of servicing this unit the design is being modified. Units bearing Serial Numbers 114 onwards will be of the new design. A C.A.F.O. is being issued giving servicing instructions for these units and spare heater elements Patt. 55204 will be issued to all ships fitted.

Output Unit S.E.2. The valve CV83 originally used in this unit as part of "valve circuit unit" design L has proved unsatisfactory and valve CV193 is now fitted as part of "valve circuit unit" design P which replaces "valve circuit unit" design L. Future policy will be to issue CV193's as separate items and a matching line complete with loop, Patt. W9915. In the meantime, CV193's, separate pick-up loops, Patt. W6752 and lead Patt. W5589 will be issued.

Transformer, Patt. W3977. A few of the earlier sets were fitted with this transformer, which has proved unsatisfactory in use. Sets should be examined and if this transformer is fitted, it should be replaced by Patt. 3977A.

Patt. W3976. This transformer is being superseded by Patt. W3976A.

TYPE 276 and 277.

The wave guide rotating joint in aerial outfits AUJ and AUK contain certain supports made of polythene, if R.F. power is applied to the guide before the guide has been dried there is a danger of these supports melting.

The following instructions should, therefore, be followed:-

If the waveguide drier has been switched off for any period longer than six hours then the drier must be run for at least two hours before H.T. is turned up on the transmitter. These instructions will be included in amendments to the Handbooks.

TYPES 282/3/4/5.
LineUnits and R.C. Switches.

Four cases have been reported recently of damaged contacts in line units Patt. 3894A and 3895A, and it is suspected that the damage was done during assembly, by the cam of the R.C. switch spindle distorting the blades of the contactor in the line unit.

It should always be ascertained that the contactor is clear of the hole in the base of the line unit before assembly with the R.C. switch.

Pig Trough and Fishbone Aerial Array.

Prevention is better than cure. If junction boxes are to remain watertight, they should be kept tightened up. Full details appear in the Handbooks (C.B.4221 series).

And the same applies to the spark gap in the Common Aerial Switch. For 100% efficiency the spark gap must be clean.

P.P.I. Safe Distances from Magnetic Compass.

When it is necessary to fit a P.P.I. in a weathertight box on the bridge position, the following are the minimum distances between the P.P.I. and magnetic compass.

Brass weathertight box - 6 feet.
Steel " " -10 "

Under no circumstances should P.P.I's be sited within these distances without special approval from the Admiralty.

TYPES 276/277/293.

Notes on the Pipe Wattmeter (A.P.W7283) used in setting up the above sets.

The pipe wattmeter consists of a piece of waveguide 14¾" long, with a resonance box and attenuator tube on one of the 3" sides. On one end of the attenuator tube is the wattmeter head, containing a vacuo junction which is connected to a galvanometer, Patt. W7559 mounted on the waveguide on the opposite side to the resonance box.

The resonance box, attenuator tube and vacuo junction may be moved along the waveguide by means of a rack and pinion. In this way, the galvanometer gives indications of the maxima and minima of the standing waves in the waveguide.

The resonance box is tuned by means of a plunger, adjusted by a micrometer screw on the top of the resonance box.

For use, the wattmeter is inserted in place of the 14¾" section of waveguide in the office.

Full scale deflection on the galvanometer must not be exceeded, as the vacuo junction is very easily burnt out.

Mean power in the waveguide is calculated from the product of the maximum and minimum readings of the galvanometer multiplied by a factor, depending on the position of the vacuo junction in the attenuator tube. Two multiplying factors are usually given, m = 0·1 and m = 0·003, and the scale attenuator readings which give these factors are recorded on the calibration label attached to the wattmeter head.

USE OF WATTMETER.

(1) Insert the wattmeter in the waveguide, with a shim at the transmitter and a gasket at the aerial end.

(2) Set the attenuator to a larger scale reading than that given for m = 0·1.

(3) Switch on the transmitter, set to long pulse.

(4) By means of the rack and pinion, move the resonance box along the waveguide until the galvanometer is roughly at a maximum reading.

(5) Tune the resonance box by means of the micrometer screw.

(6) Set the attenuator to the scale reading given for the m = 0·1 position, being very careful not to exceed the maximum galvanometer reading.

The mean power may now be calculated as follows.

$$\text{Power} = m \times S_{max} \times S_{min} \text{ watts.}$$

where m = multiplying factor.

S_{max} = maximum galvanometer reading.

S_{min} = minimum galvanometer reading.

The standing wave ratio is calculated as follows,

$$\text{S.W.R.} = \frac{S_{min}}{S_{max}}$$

and should be used with extreme care.

Each time adjustments are made to the transmitter, the resonance box must be retuned.

There may be present in the magnetron output, components at a much higher frequency which will give misleading readings on the wattmeter. This condition may be detected as follows:-

As the vacuo junction is moved up the attenuator tube, readings on the galvanometer should fall off nearly linearly. If the reading remains fairly constant, or rises and falls, harmonics are present. This must be remedied by attention to the transmitter.

If, as the resonance box is moved along the wave guide, the galvanometer reading changes more rapidly than when there is only a 10 cm. component, this can again be taken as an indication that harmonics are present. The interval between the maxima and minima of these rapid changes is usually 3·3 cms. on the centimetre scale.

Before final readings are taken on the wattmeter, the magnetron frequency spectrum should be examined by rotating the local oscillator tuning control and noting the behaviour of echoes on the A scan. Several tuning points will probably be found owing to bad frequency spectrum. The criterion is that the subsidiary tuning points should give an echo amplitude no larger than one tenth the size of the main frequency. It must be realised that readings taken on the wattmeter will be inaccurate if the frequency spectrum is bad.

VENTILATION OF RADAR OFFICES - AIR CONDITIONING.

The ventilation arrangements of certain Radar Offices have been under review with a view to improving working conditons by introducing air conditioning. So far this scheme has only been applied to A.D.R. and F.D.O's fitted with Skiatrons where arrangements have been made to supply clean air at not more than 75°F in temperature and 85° humidity to the office.

The extension of this policy to cover the whole of the A.I.C. (including the R.D.R.) is now being investigated.

D/F NAVIGATIONAL AIDS AND "Y"

M/F D/F.

In view of the present satisfactory state of M/F D/F in the Fleet generally, consequent on the general fitting of modern receiving equipment, i.e. FM7 and FM12, development work at the present moment is restricted to producing a design for a smaller edition of the receiver for FM11 for Submarines.

The reason for this is easy to understand in view of the small space available in a Submarine and the vast amount of gear which has to go into the W/T office. No great difficulty is anticipated in producing a D/F receiver of much smaller dimensions than the existing receiver unit FMA. It will cover the same frequency band, will be self-contained and will work off 230 volts 50 cycle mains.

No alterations will be made to the existing aerial and feeder cable arrangements.

H/F D/F.

There was a break in production of D/F outfits FH4 (cathode ray D/F) due to difficulties in obtaining certain materials. Supplies are now again becoming available and commencing in about April 1944, receiver units FHB will be supplied with an incorporated dial bearing indicator, enabling the operator to read off the gyro bearing direct, instead of having to work it out from a separate gyro repeater.

Supply is also expected to commence in May of additional quantities of the dial bearing indicator to enable retrospective fitting in all vessels fitted with D/F outfit FH4 to be carried out, and a C.A.F.O. on this subject will be published shortly.

In June 1944 deliveries should commence of a new receiver unit FHB for D/F outfit FH4 which will be a switched model dispensing with the present plug-in coil arrangements.

There will be 2 switches (one for each channel) which the operator will use to change frequency range, so the time taken to change frequency range will be considerably lessened. However, re-alignment of the receiver will still be necessary and Operator's Notes to cover the necessary instructions to operators will be issued in due course.

H/F D/F IN CRUISERS AND BATTLESHIPS.

There is considerable difficulty in obtaining a reasonable site in Battleships and Cruisers for any H/F D/F system, as the most suitable sites are already required for Radar or V.H/F aerials, etc.

It was therefore decided some time ago to investigate whether an H/F D/F system could be developed which would give reasonable results if sited much lower down, i.e. near the upper deck.

Development has now been completed of an outfit (D/F outfit RH2) working on the "spaced loop" principle, which does not necessitate the aerial being at a mast head, although the requirement to site the outfit as far away as possible from other masts and large upper deck fittings still remains.

This outfit is capable of giving useful bearings on the sky wave as well as on the ground wave and therefore would appear to be a better solution for Battleships and Cruisers than D/F outfits FH3 or FH4, which can only give reliable bearings on the ground wave, i.e. at fairly short ranges.

D/F outfit RH2 utilises a rotating aerial system with a hand wheel and receiver etc. in the office and a rotating shaft carrying the aerial system above the office.

The receiver used is a B36, which is a modified form of B21B and covers the same frequency range.

In Cruisers and Battleships, the policy is to fit this outfit aft on the quarterdeck, where good results have been obtained except for arcs about 20° on either bow. The disadvantages of such a site are quite evident from the point of view of washing down and possibility of damage and discomfort to the operator from gun blast.

In addition to the usual door to the office, there will be a hatch in the bottom of the office to enable entry or exit to be made when it is impossible to use the door.

Although it should be possible to obtain useful bearings with this outfit, results will depend to a certain extent on adequate signal strength of the transmission being observed, bearing in mind that the sensitivity of the outfit as a whole is governed by the size of the aerial system, which must clearly be restricted in size for fitting in ships.

V.H/F D/F.

(a) D/F outfit FV4 is being fitted in Fleet Aircraft Carriers and certain other vessels for homing of friendly aircraft. The set covers a frequency range of 100-150 mc/s and satisfactory results are being obtained.

A small Adcock aerial is mounted, in Aircraft Carriers, on one of the existing hinged masts with operating controls in suitable positions and with a tell-tale in the V.H/F D/F office indicating the position of the mast.

The receiver used in this outfit is the P48, which is a modified version of P38.

(b) D/F outfit FV3 continues to be fitted in Destroyers and certain other vessels and arrangements will now be made for a small transmitter covering the frequency band concerned to be issued to Captains D to enable practice to be obtained in obtaining bearings during dummy E-boat attacks etc.

(c) A limited number of outfits FV3 have been produced which cover a slightly modified frequency range, viz. 37-45 mc/s in order to enable bearings to be obtained of German aircraft using this frequency band. At present, these outfits have been allocated to a small number of Fighter Direction Ships and Tenders.

H/F D/F CALIBRATION.

An official A.S.E. report of calibration is rendered only on the first calibration after the ship is fitted with H/F D/F equipment. Each curve of correction contained in this report is divided into 1st, 2nd and 3rd class bearings so that an operator can tell at a glance the probable accuracy of any bearing obtained on a calibrated frequency. Bearings are graded for probable accuracy according to the slope of the correction curve and the amount of blurring present, into (a) 1st class with a probable accuracy of ± 3°, (b) 2nd class with a probable accuracy of ± 5° - 10° and (c) 3rd class with a probable accuracy of ± 20° - 30°.

By comparison between these 'classified' curves in this official report with those obtained at any check calibration, operators can receive a guide in classifying the probable accuracy of bearings obtained after a check calibration.

H/F D/F calibrations are sometimes carried out under adverse weather conditions which prevent a minimum distance of 6 - 8 cables being maintained between ship and calibrating vessel. When this happens, additional errors up to 30° may be introduced in certain sectors and on certain frequencies. This should be borne in mind when using the results of a calibration carried out under these conditions.

The standard against which D/F outfits are calibrated is of course the V/S bearings obtained during the calibration. Ships officers assist in obtaining these V/S bearings and the importance of these being taken and reported to the D/F office accurately is obvious.

During 1943, over 2,000 D/F calibrations of all types of D/F equipment (M/F, H/F and V.H/F) were carried out by A.S.E. officers at bases in the U.K.

I. F. F.

The importance of being able to distinguish between the echoes of friendly and hostile craft was appreciated in the early days of Radar. It was first achieved by fitting in British aircraft a TRANSPONDER (a super-regenerative receiver) which, when it was TRIGGERED by a Radar pulse within its frequency range, automatically transmitted an I.F.F. RESPONSE. This caused the echo to increase in height, thus distinguishing it from other echoes. The fact that radar sets operated on several different frequencies made it necessary for the transponder to sweep through these frequencies, responding to each type of radar set at regular intervals.

MK. III I.F.F. SYSTEM.

The introduction of an increasing number of radar sets working on widely separated frequencies made it impracticable to have a transponder to respond to all these sets. Hence the introduction of the Mk. III I.F.F. System, which makes use of a transponder sweeping through a small frequency band and requiring an INTERROGATOR - a low power radar set working in the Mk. III band - to be associated with each radar set requiring to identify echoes. The signals from the main radar set and its associated interrogator are normally transmitted simultaneously and therefore the echo and the I.F.F. response return at the same time. It is thus possible to display both radar the I.F.F. signals simultaneously on one display.

MK. III FREQUENCY SWEEP.

The Mk. III transponder has a frequency sweep of 30 mc/s so that interrogators can be spread throughout the Mk. III band to reduce the mutual interference and keep down the risk of transponders being over-interrogated.

The Mk. III transponder completes its frequency sweep in $2\frac{1}{2}$ seconds and therefore an interrogator will obtain a response from any given transponder once every $2\frac{1}{2}$ seconds. This response will last about $\frac{1}{3}$ second, as the bandwidth of the receiver is some 4 mc/s.

IDENTIFICATION OF ECHOES ON AN 'A' SCAN.

A second trace is provided on the 'A' Scans of WS, WA and WC sets, below the radar trace, on which signals from the associated interrogator are displayed. Thus, to identify an echo, the aerials of the radar set and its associated interrogator are trained on the bearing of the echo and the interrogator switched on. If the craft is fitted with a Mk. III transponder, and has remembered to switch it on, then the I.F.F. response will appear on the lower trace opposite the radar echo for about $\frac{1}{3}$ second once every $2\frac{1}{2}$ seconds, a clear indication of identity.

IDENTIFICATION OF ECHOES ON A P.P.I.

It would be most convenient if I.F.F. responses could be displayed direct on the P.P.I. The intermittent nature of the Mk. III response, however, imposes certain limitations on this scheme, as follows :-

(i) The beam width of the interrogator aerial (about 90°) is such that the intermittent responses will appear up to 45° ($\frac{1}{2}$ beam width) on either side of the associated echo (Figure 1).

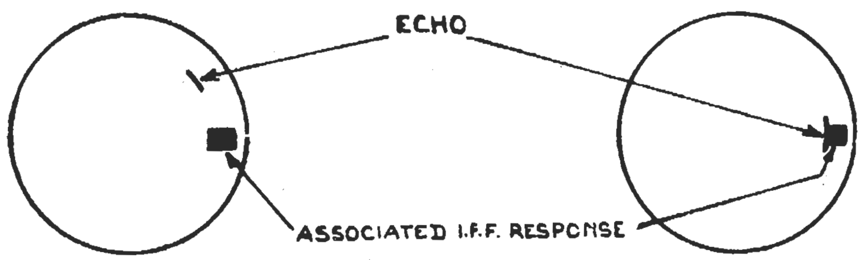

FIG. 1 FIG: 2

(ii) An I.F.F. response on the P.P.I. is of little value unless it coincides in azimuth as well as range, with its associated echo (Figure 2).

(iii) It follows that to guarantee a response every revolution of the aerial, in fact to obtain positive identification, the time taken to sweep out the arc of the associated echo must be at least $2\frac{1}{2}$ seconds.

(iv) Thus with Type 277, with an aerial beam width of about 6°, the speed of rotation of the aerial would be limited to a maximum of 6° in $2\frac{1}{2}$ seconds, that is, 1 revolution in $2\frac{1}{2}$ minutes. This is obviously impracticable.

It has therefore been necessary to arrange some form of 'A' scan display of I.F.F. for Plan Display sets. The simplest solution is to present the I.F.F. responses on a second trace on the 'A' scan of the set. To interrogate an echo on the P.P.I., the interrogator aerial is trained on the requisite bearing and the range of the response on the 'A' scan compared with the range of the echo on the P.P.I. If there are many echoes on the scan, it may also be necessary to stop the radar aerial on the same bearing, to obtain more definite range co-relation between echo and response.

This will be the standard method for plan display sets such as Type 277 in A/S destroyers, which normally do not expect to handle a high density of I.F.F. traffic.

I.F.F. DISPLAY PANEL L.43.

Panel L.43 has been developed to make possible range co-relation between radar echo and I.F.F. response without interrupting the Plan display. It will be available for fitting by Autumn, 1944, and will be provided for Type 277 in Cruisers and above and for all Type 276 and 293 used for Target Indication.

Panel L.43 has a long afterglow C.R.T. with an 'A' scan display, on which are presented two traces, the top one for the radar signal and the bottom one for the Interrogator signal (and range strobe if fitted). A "Sector Selector" is fitted which brings the top trace into operation only for the short period during which the radar aerials pass through the selected bearing. The bottom trace is available for the remainder of the time. Owing to the afterglow, the radar signals painted on the tube as the aerials pass through the selected bearing will remain until the aerials again pass through that bearing and the next 'paint' occurs. Thus the echoes on any selected bearing are continuously available on the top trace.

The handwheel which turns the Sector Selector also trains the interrogator aerial to the selected bearing. Thus, once the selected echo has been picked out on the top trace, the interrogator can be switched on and the associated response will then appear on the bottom trace, making range co-relation possible, as in normal 'A' scan presentation.

(To be continued).

A list of I.F.F. equipment is given in the appendices on pages 41, 42, 43.

APPENDIX I

I.F.F. MK. III.

TRANSPONDERS.

IN AIRCRAFT.

MK. III	Standard Mk. III transponder for all aircraft.
MK. III G	Mk. III transponder modified to include a 'G' band transponder giving, when asked for, a fixed frequency response to G.C.I. Stations. Suitable for plan display.
MK. III GR	Mk. III G modified to include Rooster facility in Mk. III band - homing aircraft to aircraft.

IN SHIPS.

253	Mk. III transponder fitted in ships. Fitting 30% complete 1st January, 1944.
(253M)	Mk. III, modified to give Beacon and keying facilities. Development suspended in favour of 253P.
253P	Mk. III, modified to give choice of :- 1. Normal Mk. III. 2. Chopped Beacon on fixed frequency in Mk. III band. 3. Alternate Normal Mk. III and coded responses on fixed frequency in Mk. III.
253MW.	Mk. III M, adapted and modified for fitting in Submarines.
950	"Secure Transponder". Under development.

APPENDIX II

RACONS (RESPONDER BEACONS).

FITTED IN SHIPS.

251	Obsolescent.
251M	Cruisers and above and certain Escort vessels requiring beacon facilities for aircraft.
257 (BABS)	Beam approach Beacon for Aircraft Carriers.
YJ	A Beacon fitted in certain Carriers for working with American aircraft with ASB and no Lucero. Interim measure only. Complementary to Type 251M.

FITTED ASHORE.

253 S	Type 253, adapted for fitting ashore. Modified by changing frequency sweep cam to reduce frequency sweep to 10 mc/s.
258	"Secure Beacon". Under development. To be fitted ashore for Navigational purposes.

OTHER BEACONS.

EUREKA	Small Portable Mk. III Beacon for C.C.O.
252P	Retained in Aircraft Carriers for use with aircraft with AI Mk. IV, where Lucero cannot be fitted. No further fittings.
256	Obsolescent. 252 (Mk. II system) fitted ashore for use by destroyers and Coastal Craft with 286, 291 and having no 242 fitted.
M.A.B.	251 M when fitted in Merchant Vessels.

APPENDIX III

MK. III INTERROGATORS.

To enable ships and aircraft to make use of Mk. III transponders and beacons, the following interrogators are required.

Fitted in ships.

RADAR SET	INTERROGATOR	REMARKS.
721/3/4/5, 286, 291	242	
276/7, 293.	242 M	Increased Transmitter Power and responder pre-amplifier.
294/5, 960, 990	242 Q	242 M, with new responder and trigger unit. Includes improved remote control facilities for L.43 and U.D.U. and A/J features. Will also be fitted with later 276/7 and 293 fittings.
274	-	No staff requirement for Interrogator with 274.
79/B, 281/B,	243	
279/B.	243 M	243 rack altered to fit on top of 279 Ranging Panel.
	Fitted in Aircraft.	
ASV Mk. II	-	ASV Mk. II is in the I.F.F. Mk. III band and therefore does not require separate interrogator.
'S' & 'X' band Airborne Radar.	Lucero	

G-BAND INTERROGATORS.

To enable ships required to direct fighters to be able to distinguish individual aircraft on the skiatron, 'G'. band interrogators are being fitted for use with Mk. III G as follows :-

RADAR SET	INTERROGATOR	REMARKS.
281B	941	A type 243 modified to work on G band.
294/5, 960 & 990.	940	One per ship carrying one or more of these sets.

NAVIGATIONAL AIDS

QH. This is the receiver of a Navigational aid system based on the following theory.

If an observer is placed in a certain position relative to two transmitters of pulse type and if these pulses are "locked", it is possible with suitable apparatus, to observe the difference in time taken by pulses radiated by the transmitters at the same instant, to reach the observer. If there is no time difference, then the observer must be somewhere on a line drawn at right angles to, and midway between, the transmitters.

When there are differences in time between the reception of the pulses, the observer must again be on a line, but this line will be not straight, but of hyperbolic form symmetrical to the two transmitters. A "family" of lines can be plotted about the two transmitters for various differences in time.

If a further pair of transmitters is set up, then two position lines can be obtained and the point of intersection is the "Fix". Special charts are prepared for the purpose and on these the Navigators will find "families" of position lines printed, marked up in microseconds.

In practice, three transmitters are used to form a "chain", one of these being a master to which the other two are locked on the same radio frequency and with the same pulse repetition frequency.

At the receiving end, the operator or navigator matches up the pulses of the two pairs on the cathode ray tube and reads off the time differences in microseconds, which he then transfers to the chart.

Accuracy. In favourable localities, (i.e. opposite the chain of transmitters), the accuracy of QH is approximately 1½ cables at 20 miles and about 3 cables at 150 miles, which is about the extreme range at sea level.

Apparatus. Responsibility for the transmitters rests with the Air Ministry, who are also responsible for the manufacture of the Receiving apparatus (except for small items supplied by the Admiralty).

QH2, has already been supplied in considerable numbers for fitting in ships and Landing Craft etc. and works off AC outfit DUN.

QH3, is now coming into supply and this is arranged for supply from 230 volts 50 cycle mains.

LORAN.

Loran, which is a short title for "Long Range Navigational Aid", is a system developed by the Americans subsequent to, and on the same lines as GEE. Its object is to enable ships and aircraft to obtain a position when in the North Atlantic or other localities where accurate position finding is essential. It works on considerably lower frequencies than the GEE system, in order to give the necessary range, but the broad principles remain the same. In other words, a chain consists of three transmitters of which the centre is the "master" all transmitting on the same frequency. However, the master consists of two transmitters, each transmitting on different repetition rates.

The accuracy obtainable is of the order of one mile at a range of 100 miles and the same proportion at longer ranges, i.e. 10 miles at 1,000 miles.

Observations on the ground wave can be made at ranges up to about 600-700 miles and on the sky wave up to about 1300 miles (but considerably greater ranges may be experienced). For sky wave observations, special corrections are necessary which have to take into account the height of the ionosphere, from which the transmissions are reflected to the ship. On the ground wave, of course, no such corrections are necessary.

It should be noted that supposing, say, a Coastal Command aircraft were endeavouring to rendezvous with an Escort vessel in mid-Atlantic, and, provided both were fitted with Loran receivers, they should be able to get accurate positions relative to each other and thus enable the rendezvous to be made, although the geographical positions might not be quite accurate.

Loran chains are in existence on the East coast of North America extending up to Greenland, and a chain is now commencing operation between Iceland, the Faroes and the Hebrides. It should thus be possible, and experience to date confirms this, for ships and aircraft to obtain reasonably accurate positions when in mid Atlantic in regions to the North of the Azores.

A chain has also been set up covering the area in the vicinity of the Aleutians.

Apparatus. Transmitters and receivers are supplied from the U.S.A. A start has been made in the fitting of H.M. Ships and later it should be possible to fit at least two ships in every escort group.