REPORT ON I.F.F.

The following report on the use of I.F.F. was submitted by the Commanding Officer of H.M.S. WHITEHALL.

"On 23rd August, 1944, while in the Barents Sea escorting Convoy JW59, a signal was received from the Admiral Commanding, 10th Cruiser Squadron, ordering WHITEHALL to a position ahead of the convoy where a T.B.R. aircraft might be "ditching" with engine trouble. On receipt of a further signal, Type 242 WS was switched on to look for the distress signal from the aircraft. At 0110 a very wide response appeared on the scan between the bearings of 060 and 150, range 33,000 yards. A centre bearing of 105 was passed to the bridge and course was altered towards. At 0113, while the centre bearing of the I.F.F. distress signal was still 105 - 25,000 yards, an aircraft echo appeared on the scan of Type 271Q bearing 090 - 25,000 yards. After sighting this aircraft, it was called by Aldis lamp and comfirmed that it was the aircraft with engine trouble. The pilot believed that he could make VINDEX safely. Excessive vibration caused by a speed of 24 knots made operating difficult and this might account for part of the error between true bearing and the centre bearing of the I.F.F. response."

(Editor's Note: The maximum accuracy normally obtainable with Type 242 WS under these conditions is between 5° and 10°, so that an error of 15° is not excessive. Although it would clearly be desirable to have an interrogator aerial giving greater bearing accuracy and bearing discrimination, it is observed that the accuracy obtained in this case was fully sufficient to enable a rendezvous with the aircraft to be effected.)

At 0030 on 30th August, 1944, the striking group with Convoy RA 59A consisting of KEPPEL (S.O.), PEACOCK, WHITEHALL and MERMAID was ordered to investigate an aircraft A.S.V. contact. The aircraft was showing an I.F.F. response Code No.5. Using the method described in W.A.G.O. 349, a centre bearing of 015 - 14,500 yards was obtained and this was used by WHITEHALL as the estimated diving position of the submarine.

During the passage of JW.59 and RA.59A, aircraft echoes obtained by Type 271Q up to a range of 13 miles were identified by their I.F.F. code settings, set in accordance with the operation orders for the convoy.

EXTRACTS FROM A REPORT OF AN ACTION WITH GERMAN DESTROYERS.

"I.F.F. recognition is vitally important, which means that high priority must be given to the maintenance of Type 253."

"Usually, but not always, I.F.F. was a valuable aid in appreciating the situation when own forces were separated."

"The remarks as to the use of I.F.F. are fully concurred in, it being particularly stressed that further efforts should be made to render this device a more reliable method of identification."

"Radar contact was made with own forces bearing 360° at six miles (five echoes showing I.F.F.)."

"Type 242 was switched on at various times throughout the action and was a great help in establishing the identity of ships in company."

WHAT'S THE USE OF I.F.F.

Reprinted below is part of an article taken from "Combat Information Center" dated 15th September, 1944, - an American Navy official magazine dealing with Radar matters. The article has been written after a complete survey, by a group of American officers and scientists, of the functioning of the I.F.F. Mk. 3 system in the Pacific war theatres and deals very fully with the subject. There is no doubt that all its conclusions are well founded and apply equally to our own forces.

It is a common impression that I.F.F. is a toy, a temporary gadget which need not be taken seriously. This is quite wrong; as the author of the article points out, the higher the proportion of our forces to the enemy, the greater becomes the need for reducing to a minimum the number of unidentified radar echoes. The INDOMITABLE was torpedoed by one of the very few Italian aircraft to put in an appearance during the invasion of Sicily and no action was taken to repel this attack because there were so many friendly aircraft about.

Another reason for this false impression is that, up to now, visual recognition has always been a final safeguard because it has always been necessary to see a target before destroying it. Radar blind fire from ships and radar blind bombing from aircraft, both now on our threshold, must change all this: if ships can shoot accurately at echoes long before they come in sight, they will not want to wait until the unknown reaches a position to release its bombs or torpedoes. Conversely, if our aircraft are going to bomb all unidentified echoes at sea and our ships outnumber the enemy by five to one, presumably they will bag five times as many of ours as of the other side.

The faults do not always lie with the airman; reports recently received by the Admiralty shew that a number of recent attacks on H.M. Ships by R.A.F. and F.A.A. aircraft are at least partially due to the Type 253 in the ships being inoperative from various causes. These attacks cost this country one Liberator, one modern M.T.B., a damaged destroyer and over twenty seamen and airmen killed. Navigational barriers, such as free and restricted bombing areas aided by Q.H. and shore radar control, were imposed to prevent these incidents but they failed. I.F.F. could have done so, but it was not used.

"ARE YOU SABOTAGING THE I.F.F. SYSTEM ?"

"If you have anything to do with I.F.F., directly or indirectly - as an area commander, as a commanding officer of a ship, squadron, or base; as a pilot, as a flight operations officer, as a radar maintenance man - chances are that you are guilty of contributing to I.F.F. failures !

Recognition by radar - I.F.F. - has run the gauntlet since its inception. It has been scoffed at as impractical, reported unnecessary, and eulogized for saving countless lives and many planes. And this for the same equipment, the same area - same time!

It is quite obvious that any recognition system, I.F.F. or any other, becomes indispensable in warfare if it gives timely warning of whether friend or foe is approaching. I.F.F. was designed to do just that, can do it, but has not done it. Why? "

A special working committee studied the situation in the war theaters to answer that question. Their answer, pathetically simple : "Turn it on!"

They found that we have a good weapon but we aren't giving it a chance to work properly. To summarize their findings :

> IFF is ineffective in nearly all theaters because the operation is poor.
>
> The equipment is reliable - the necessary corrective measures are simple.
>
> The primary obstacle to improvement is lack of interest on the part of many responsible officers.

In many theaters investigated, IFF was identifying only 50% of planes. In others, it has been better, but not good enough. It has been proved that simple remedial measures taken in the field will lift performance to 98% everywhere.

Think of the problem facing the intercept officer, who is confronted daily with 20 or 30 unidentified flights approaching a vital target. What shall he do? He has no choice but to alert the base or ship and send fighters to intercept the bogies. When bogey after bogey turns out to be friendly, the pilots making the interceptions begin to feel silly and suffer a loss in morale; the AA batteries may well become a bit slack after a series of such anti-climaxes; and all base or ship personnel who were needlessly alerted become disgruntled. We cannot afford this drain on morale and material. Strange as it seems, the problem becomes worse as our air superiority increases, because the number of friendly "bogies" increases proportionately.

How to Eliminate Failures.

What, you may inquire, are the simple remedial measures? They are :-

1. The commands must let it be understood that the matter is important; that they really intend to have the IFF system properly used.

2. There must be improved indoctrination, training and briefing of pilots to make up for past omissions. It was found in one area that 2/3 of the friendly bogies were due to pilots forgetting to turn on their IFF! Pilots should be given a chance to see radar stations in operation, see the IFF replies from planes, see how they are used, and be shown the excellent IFF training films.

3. Additional simple operating procedures can be introduced. A sign reading IFF ON? in large letters held by a mechanic at the end of the runway, to be acknowledged by a thumbs up gesture, is used in aircraft carriers, and has been found to be a great help.

4. An IFF interrogator can be installed at an air-field to check which planes are taking off and landing with IFF inoperative.

5. Routine maintenance procedures must be improved. It is important that field test equipment be actually used and not left on the shelf.

6. The operation and maintenance of ground stations must be improved by proper use of test equipment and by checking performance on fixed echoes. The present tendency is to put all the blame for poor operation on the airborne equipment; part of the failures are due to ground equipment.

Improved I.F.F. performance will not result unless you demand that improvement. You should have an I.F.F. officer who is charged with seeing that these measures are carried out.

These recommendations are not based on armchair brain-trusting. A team of officers and civilians went to the South Pacific and Southwest Pacific areas to make a special study. They set up at Emirau, where it was possible to check every plane arriving and leaving the island and find the reason for inoperative I.F.F. When they came, it was found that 25% of planes had inoperative I.F.F., and that of 100 bogies, 66 were attributable to pilots' errors, 30 to airborne equipment having obvious flaws (broken antennas, etc.) and only 4 to defects of ground equipment. Briefing of the pilots, and use of the "IFF ON?" sign caused cases of inoperative I.F.F. to drop to 10%. Then simple maintenance procedures were instituted, and inoperative I.F.F. dropped to 3%. It can be done, because it has been done.

Perhaps you are thinking that there is not much enemy activity in your area and that the whole thing is more trouble than it is worth. Do the troops or ships in your area keep their ordnance clean and have any target practice? Are you going to come up against carrier or land-based Japanese aircraft later? Are you going to be co-operating with your sister service later on? This is a very serious business in the Navy. A bombed airfield may be badly mussed up and repaired but a badly bombed carrier is out for a long time and may stay permanently mussed up on the bottom. The Navy has to shoot first and investigate later why the friendly plane showed a bogie - if there is anything left to investigate. This has happened. How much of the responsibility for its happening again do you wish to take?

I.F.F., by itself, of course, won't win the war - but if we use it properly, it may help us to win sooner and at lower cost. Let's get going and make the most of what we have. "Instructions for Improving I.F.F. Performance" shows how it can be done.

Instructions for Improving I.F.F. Performance.

I. Appointment of I.F.F. Officers.

(a) A full time I.F.F. officer should be attached to the headquarters of each area commander to co-ordinate all I.F.F. activities within the areas, and to prepare general directives on I.F.F. matters for signature by the area commander. He should be personally responsible for the effective operation of the I.F.F. in the area.

(b) A full time I.F.F. officer should be appointed for each Navy task force and region covered by an Information Center, to co-ordinate all I.F.F. activities, including operation and maintenance within that task force or region. While attached to Fighter Command, or other unit charged with air defence, he should have authority to cut channels and take corrective measures involving I.F.F. in all naval military commands within the area under his control.

II. I.F.F. Program.

Various means of improving I.F.F. performance are discussed in this section of the article. Since they apply mainly to aircraft they are summarised below :-

(a) Ensure that the pilot knows when and how to switch on.

(b) Ensure that the transponder in the aircraft is working by:-

(i) Test of equipment in aircraft not more than 48 hours before take off.

(ii) Test of equipment on the bench after every 60 - 100 hours of operation.

(c) Reports of bogies (other than those known to be enemy planes) should be made by Ground Stations daily or weekly so that defective equipment may be located and the general efficiency of the system checked.

(d) Interrogators should be installed at key points so that they may be used to check the operation of airborne equipment.

(e) Information obtained under (c) and (d) should enable the Regional I.F.F. Officer to discover any defect in the system and remedy it.

Maintenance and Testing of I.F.F. Sets.

Many of the points in this I.F.F. programme may well be applied to ship installations. A few notes are given below:-

Testing Type 253. A complete overall test of the set and aerial can be carried out in less than five minutes with Test Set 74A which is very simple to operate. The test set is available in all ship's carrying a Radar Officer, and in such ships the transponder should be tested every day. In smaller ships arrangements should be made for the set to be tested by the base staff whenever opportunity occurs. As soon as the supply permits, Test Set 74A will be provided to all frigates and above. The most common defects in Type 253 are:-

(a) Failure of power supply. Batteries should be checked daily. Rectifiers are now being provided for new fittings and will shortly be available for retrospective replacement of batteries.

(b) Failure of spring. A number of spares have been distributed to bases. Pattern article boxes of springs will be available shortly.

Testing Type 242/3. Performance Meters are now being made available for testing interrogators (A.F.O. 6060/44). One Performance Meter will be fitted with each interrogator and will enable the operator to tell at a glance whether his set is operating efficiently or not. (This facility is not yet available to Type 243 owing to the difficulty of finding a site for the test aerial. It is however provided with Type 243Q and will be provided with Type 941).

Operational Tests. Several bases have installed interrogators and transponders at suitable points so that ships can test their I.F.F. when entering or leaving port. The ship tests Type 242/3 by interrogating the shore Type 253 and the shore station tests the ship's Type 253 by interrogating them. Similar tests can of course be carried out between ships in company at sea.

WHY BOTHER WITH I.F.F.? "SOCIAL SECURITY" WILL

TAKE CARE OF YOUR WIDOW!

INTERROGATION FOR TYPE 281

Various notes have been published in previous numbers of the Bulletin dealing with interrogation and reference has been made to Types 243Q and 941. Further details are given in this article of the interrogation organisation in ships fitted with Type 281, as Types 941 and 243Q are now being fitted.

Functions.

Types 243Q and 941 together provide the interrogation facilities required for long range warning and fighter direction using Type 281 Radar. (See fig.).

Type 243Q operating in the normal I.F.F. frequency band (called the A band) is used to determine which of the aircraft located by the radar are friendly. It may therefore need to interrogate all aircraft located. The operating position for Type 243Q will normally be the radar display room. Here responses from I.F.F. Mk. III are combined with "sector selected" radar and displayed on panel L43 of Indicator Outfit JH(2). These responses are also displayed on the radar warning tube in Type 281 office for emergency operating conditions. The responses are not suitable for plan display.

Type 941 operating in the G band of frequencies is used for the special function of identifying and locating friendly fighters under the ship's control. The fighters may carry I.F.F. Mk. III G, I.F.F. Mk. III GR, AN/APX1 or AN/APX2. These transponders may be switched by the pilot, <u>on request</u>, to give chopped responses on the frequency at which Type 941 operates, for a short automatically timed period. The responses are displayed on the Type 281 skiatron and certain P.P.I's. Except for the short period (about 20 seconds) after a fighter has been requested to show "G", Type 941 will not normally receive any responses. During this period, the transponder gives responses on the G band for about 2/15th seconds followed by responses in the A band for 1/15th second. At all other times the transponder gives normal responses to Type 243Q.

The Equipment.

The equipment is mounted in a rack which contains Type 243Q transmitter and responsor, Type 941 transmitter, responser, mixer unit and suppression and control unit. This rack takes up little more deck space than the original Type 243 rack, which it replaces, but is somewhat taller. The Type 243 suppression and control unit, aerial control unit, and the performance meters for both interrogators are mounted adjacent to the radar panels. In ships in which Type 243 is converted to Type 243Q when Type 941 is fitted, certain units of Type 243 are retained and moved from the old rack, which is scrapped, to the new one.

Aerials and Display Type 941.

Type 941 aerial is mounted on the top of Type 281 aerial, and rotates with it. This aerial replaced Type 243 aerial (Outfit ASC).

Type 941 signals are available on one or two skiatrons in the A.D.R., on the P.P.I. in the office and on one other plan display. At these displays, the Type 281 signals may be shown either alone or mixed with the Type 941 responses, according to the position of a switch. Thus, the Fighter Direction Officer, when doubtful which of the arcs on the skiatron represents the fighter he is controlling, requests the pilot to press his "G" button, and at the same time switches Type 941 display on to the skiatron. Then an arc of "spokes" appears, centred about the radar signal representing the fighter.

Three independent outputs are provided from Type 941, one for each of the two skiatrons and one for the remaining two displays in parallel. The selection of one type of display (mixer or unmixed) on one output does not affect the availability of either type from any other output.

Type 243Q Aerial.

Type 243Q aerial (AQF) is mounted on an independent pedestal, the aerial unit and pedestal being identical with that used for Type 243M. Its rotation is normally controlled by the sector selector unit associated with Panel L43 in Outfit JH(2) (in the R.D.R.), but in the emergency operating position it can be controlled from a control unit in Type 281 receiving office. A switch in this unit puts the control of the aerial either to this control unit or to Outfit JH(2).

Type 243Q Display.

When the handwheel on the Sector Selector is rotated so that the bearing pointer indicates a given direction, radar echoes on that bearing are sector selected and the interrogator aerial is rotated to the same bearing. Thus, when the radar aerial is rotating continuously, radar echoes from the selected sector are displayed for a short period once per revolution on the upper trace; for the remainder of the time, I.F.F. signals are displayed on the lower trace. In this way, the regularly recurrent I.F.F. signals may be correlated in range with the afterglow of the radar signals, which are repainted once per revolution.

The interrogation procedure would be roughly as follows :-
An operator on a plan display observes an echo of whose identity he is doubtful; he informs the JH(2) operator of its bearing and range; the JH(2) operator turns his sector selector to that bearing and watches on the given range until he locates the designated echo; he then presses his interrogator switch and waits to see if I.F.F. responses appear, correlated in range with the echo.

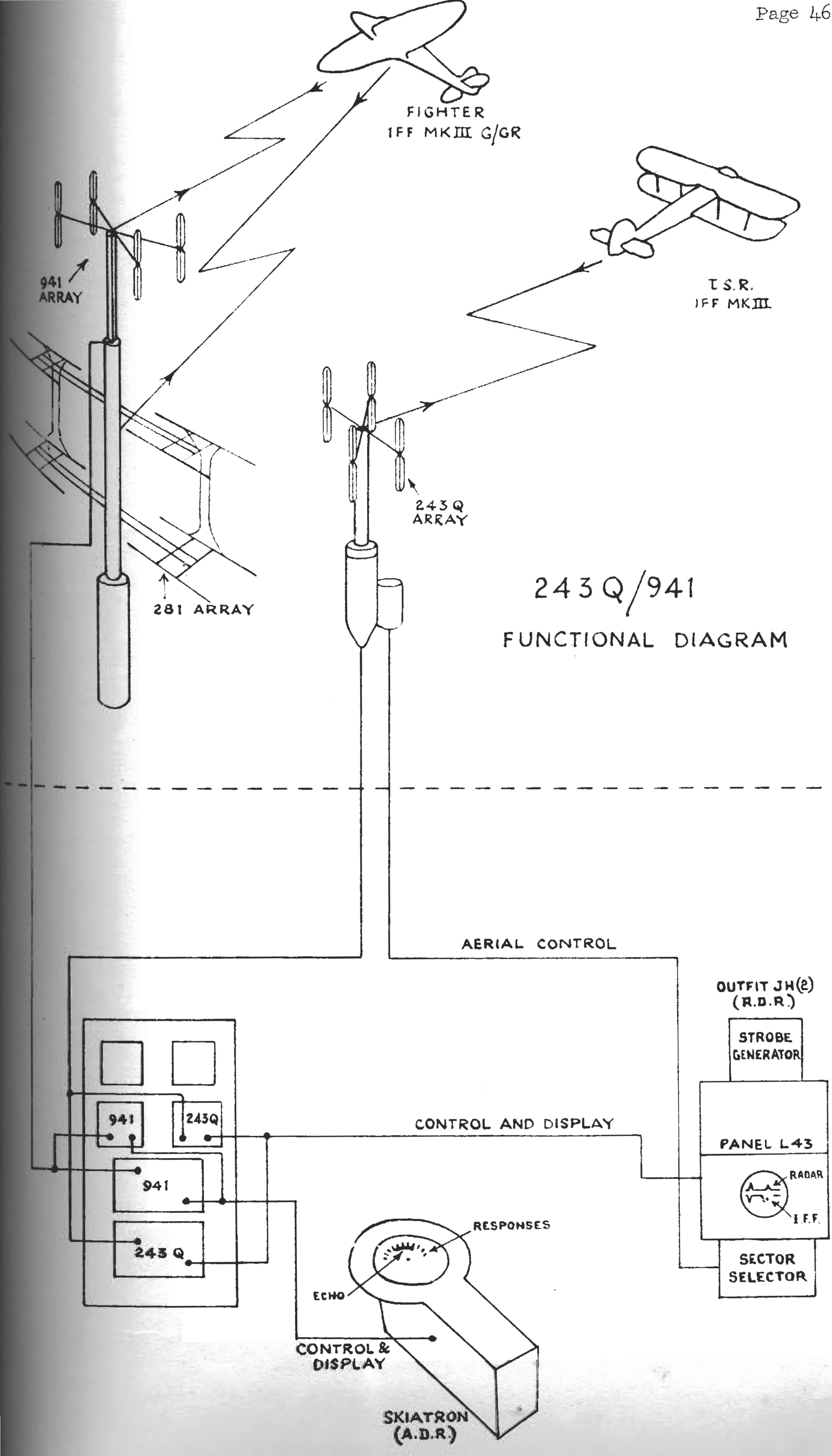
Should there be a number of echoes at approximately the same range and bearing, the operator may expand the trace to obtain a clearer picture. This he does by moving a strobe to the range required and turning a switch. A trace covering the 15,000 yards beyond the strobe then appears on the tube. This should enable the operator to distinguish between the echoes.

Additional Interrogator Displays.

Other sector selected interrogation displays provided (but not connected with Type 281) are :-

(a) Outfit JH(2) with Types 277 and 242M in cruisers and above. This outfit, which is almost identical with JH(2) for Type 281, will be fitted in the RDR if this exists or in the enlarged Type 277 office in ships not provided with an RDR. It will provide interrogation facilities for surface craft and low flying aircraft.

(b) Outfit JH(1) with Type 276 or Types 293 and 242M. This outfit provides interrogation facilities in the T.I.R. It is similar in principle to JH(2) but the sector selector is incorporated in the T.I.U.


FIGHTER
IFF MK III G/GR
T.S.R.
IFF MK III
941
ARRAY
243 Q
ARRAY
281 ARRAY
243 Q/941
FUNCTIONAL DIAGRAM
AERIAL CONTROL
OUTFIT JH(2)
(R.D.R.)
STROBE
GENERATOR
941
243Q
CONTROL AND DISPLAY
PANEL L43
RADAR
I.F.F.
941
243 Q
RESPONSES
ECHO
SECTOR
SELECTOR
CONTROL &
DISPLAY
SKIATRON
(A.D.R.)

SECTOR SELECTION

(RANGING OUTFITS RTB AND RTE).

Sector Selector units are used in conjunction with panels L.37 in Ranging Outfits RTB and RTE and instructions for setting them up are given respectively in C.B. 4112(8) (Handbook on Radar for Gunnery Purposes - Visual/Radar Target Indication) and in RH649 (Handbook for RTB/E). The Sector selectors for RTB are component parts of the T.I.U. Mark IIA or IIB and those for RTE are part of the ranging outfit itself. (Sector selector Patt. W9083).

The instructions given in both these handbooks suggest that the sector selector is to be lined up to straddle the target bearing symmetrically while the aerials are at rest. C.B. 4112(8) suggests 4 degrees on either side of the target bearing, and RH 649, $1\frac{3}{4}$ to $2\frac{3}{4}$ degrees on either side.

When the aerial is rotating, there is a lag in the "make and break" of the contact and relay systems. At 10 R.P.M. the calculated relay lags are $\frac{1}{2}$ degree for "make" and 1 degree for "break". Trials with Type 293 at Eastney were carried out with the centre of the selected arc offset by $1\frac{1}{2}$ degrees, which effectively counteracted the total lag of the system.

The correction for lag in any individual outfit can be determined by observing a fixed echo as follows :-

(a) Line up all the equipment in the usual way with the aerials stationary.

(b) Switch on the aerials and observe the true bearing (B) of a fixed echo on the P.P.I.

(c) Set the sector selector to this bearing and turn slowly anti-clockwise until the echo on panel L.37 disappears. Measure this bearing (C).

(d) Confirm that bearing (B) has not changed.

(e) Turn the sector selector clockwise until the echo on L.37 again disappears. Measure this bearing (E).

(f) Confirm that bearing (B) has not changed.

The average make and break lag for the system is $\frac{1}{2}$(2B-C-E).

To supply this correction to ranging outfit RTB, stop the aerials on the bearing of true North and adjust the aerial chaser motor on the T.I.U. until the aerial dial reads $\frac{1}{2}$(2B-C-E) true bearing. This correction should be applied to outfit RTE when lining up the sector selector.

Warning.

Corrections due to "make and break" lag will depend on aerial speed and should be measured and applied for the speed normally in use. Care should be taken when applying these corrections to RTE fed from Type 277 as the aerial speeds for this set are variable.

If the maximum sector width of 8 degrees is used, this correction will be unnecessary, but it is suggested that this figure is too high and that a narrower sector will be found preferable.

High flying aircraft, targets with a high rate of change of bearing, and rolling conditions will however necessitate a greater sector width than otherwise necessary and experience will be required before the most satisfactory sector width is found. With larger aerials than at present fitted echoes will have a "ghostly" appearance if the full sector width is used.

Reports from sea of the most satisfactory sector width under varying conditions and of the amount of "offset" of the centre of the arc used will be welcomed by A.S.E.

READING RANGES ON THE L.37 (RANGING OUTFITS RTB AND RTE)

Complaints have been received that the paper range scales used with these panels are difficult to read in the usual dim and dismal light normally found in Radar offices and T.I. Rooms. Two suggestions are put forward to improve this:-

(1) Use really black ink for marking the paper scale.

(2) Turn up the brilliancy control of the strobe trace behind the paper scale. The scale is sufficiently translucent for this to illuminate its markings enough for easy reading.

The surface of the paper will reflect some of this light back into the C.R.T. and cause a certain amount of halation on the C.R.T. screen along the edge of the paper scale. As long as this does not exceed 2 or 3 mm. it is not serious and can safely be ignored.

TESTING CONDENSERS

A SIMPLE METHOD OF TESTING CONDENSERS FOR CAPACITY USING AN AVOMETER

Condensers are usually the most difficult components to check under Service conditions. A rough check of capacity between the values •25 mfd and •001 mfd may be obtained with the aid of an avometer and 50 cycle or 500 cycle A.C. Power Supply. Set avometer on "A.C. 120 volt" range with the "Q" potentiometer operating. Connect avometer leads to mains and rotate "Q" potentiometer until avometer reads "zero" on resistance scale. If the condenser is now placed in series with the avometer and power supply, the avometer will read the reactance of the condenser. Multiply the scale reading by 1000 because the avometer is set to read 0-1 megohm. If the condenser is open circuited or short circuited, the meter will read infinity or zero. If the component has capacity there will be an intermediate reading between zero and infinity, the actual numerical value being :

$$\text{Meter Reading} \times 1000 \times \Omega = \frac{I}{C} \quad \text{(in farads).}$$

Ω = 300 or 3000 according to frequency of power supply. Normally one would not bother to calculate because the only information required is whether the component possesses capacity or not. The method is only practical for condensers with reactance between say 1000 ohms and 500,000 ohms at frequency of power supply.

(Editor's Note: We are indebted to Mr. E.J.L. Dell - a fitting-out officer at Rosyth - for the above)

VERTICAL COVERAGE DIAGRAMS

A method has been suggested which slightly simplifies the calculation given in C.B.4224(44) for WA sets. In the case of a single aerial and with the usual notation the complete diagram is given by :

$$H = \frac{D^2}{2R} + n\left(\frac{\lambda D}{2h}\right) \pm \frac{\lambda D}{2\pi h} \sin^{-1} D\sqrt{\frac{X}{2C}}$$

or $H = h_1 + nh_2 \pm h_3$

where $h_1 = \frac{D^2}{2R}$, the increment due to the curvature of the earth.

$h_2 = \frac{\lambda D}{2h}$, the increment in height which separates corresponding sections of adjacent lobes.

$h_3 = \frac{\lambda D}{2\pi h} \sin^{-1} D\sqrt{\frac{X}{2C}}$, the increment in height resulting from the interference pattern.

A sketch of a method which is slightly simpler than Method B on page 16 C.B.4224(44) is then as follows :

(a) Initial Curves. Plot on the height - distance chart :

(i) The curve $H = h_1$. This is independent of radar sets or particular fittings.

(ii) The minima lines $H = h_1 + nh_2$ for n = 1, 2, 3.

This can best be done by determining values of h_1 and h_2 corresponding to the values of distance D: 20, 40, 60, 80, 100 and 120 miles. The curve (i) may then be plotted simply; the lines (ii) may be obtained by laying off multiples of h_2 along the height ordinate from curve (i) by the use of a compass.

(b) Calculate the constant C.

This is done as in para. 31 of the C.B., by plotting a smooth first detection curve obtained from calibration runs; then by selecting points on the curve and obtaining a value of C for each point from the relations :

$$C = \frac{XD^2}{2 \sin^2 \frac{\pi h}{\lambda} \left(\frac{2H}{D} - \frac{D}{R}\right)}, \quad X = 2$$

Finally by averaging the values of C so obtained.

Where a ship is under construction or refit and no calibrations have been made, it is satisfactory to assume a value of C and proceed with the calculation. The effect will be that the first detection curve when ultimately determined, will not coincide with the contour X = 2 but with some other value, e.g. X = 1·7 or X = 1·5

(c) Obtain maximum ranges for selected contours.

As in para. 32 of the C.B.

(d) Plot the contour X = 2.

To do this it is necessary to determine h_3 corresponding to a series of values of D. Then by laying off these values with a compass along the height ordinate above curves (a) (i) and both above and below the minima lines (a) (ii), sufficient points on the contour are obtained for it to be plotted.

(e) The higher numbered contours are then derived as in para.35 of the C.B.