RADAR TYPE 262

It was in the first half of 1942 that initial discussions were held on the staff requirements for a radar set which would provide certain close range directors and gunmountings with the necessary present-position data to enable them to engage unseen targets. This requirement was the corollary to the A.S.V. type of radar then being fitted in aircraft whose continued development, it was foreseen, would, in course of time, enable attacks to be made by aircraft at night or in conditions of poor visibility with a fair degree of concentration and accuracy.

The development of a suitable radar set which was at first associated with the Bofors Mk. IV was complicated by a subsidiary requirement which stated that future designs of close range gunmountings were to be "self-contained" - i.e. that the power supplies, radar and control arrangements should be positioned on the mounting itself.

It was obvious from the start therefore that the radar set would have to be designed to be sufficiently flexible to allow of its being built into several different mountings and directors. The solution adopted was to build the set into a number of standard "boxes" or "units" to which the necessary circuit connections were made by "self-mating" plugs and sockets. The basic Type 262 set, in fact comprises seven and a half of these units being plugged into suitably wired frameworks inside weathertight "cubicles" positioned on the mounting or director structure. A photograph of a typical unit is shown in Figure 1.

As work proceeded it became apparent that the Bofors Mk. IV mounting would have neither the strength nor rigidity required for fitting Type 262; work was accordingly confined in the first place to mating the set to the S.T.A.A.G. Mk. II mounting which was then under development. The director programme suffered a similar set-back in the early stages with the abandonment of the Close Range Predictor project with which Type 262 had been associated. No other director design was immediately available for development and it was therefore decided to adopt a new one based on the S.T.A.A.G. system and using the same control equipment. This programme has fulfilled its promise and it is already apparent that the C.R.B.F.D. will be more than a stop-gap director designed to take advantage of Type 262's blind fire facilities, as was the original intention.

The Type 262 radar sets which will be first seen at sea, therefore, will be associated with, and inseparable from, the S.T.A.A.G. Mk. II (Stabilised Tachymetric Anti-Aircraft Gun) (Fig. 2) and the C.R.B.F.D. (Close Range Blind Fire Director) (Fig. 3).

Two further projects are under development - the B.U.S.T.E.R. gunmounting and C.R.S.1/M.R.S.1 director - but as they will not be seen at sea for at least 18 months no further mention of them will be made in this article.

The choice of a suitable wavelength for the radar set was dictated by considerations of the weight and size of the equipment which would be tolerated and also the high accuracies required for close range fire control. Technical advances made the use of X-Band valves possible and as this wavelength was suitable it was adopted for the Type 262 series.

While there are no radical departures from established radar technique as far as transmission and reception are concerned there are, however, several innovations one of which is worthy of special mention.

The errors in measured radar-range and thus range-rate, which are inevitable when an operator controls the output by following the echo with a strobe, are obviated by the incorporation of automatic echo-following in the range-measuring circuits.

The most interesting feature, however, which Type 262 will bring to sea, is its capacity to follow a target automatically in elevation and azimuth.

The use of the automatic circuits is not the only way of following an unseen target and, indeed, auto-following was not originally specified in the staff requirements for Type 262; the incorporation of this feature is, moreover, attended by some considerable increase in complication and weight of the equipment and it is therefore important that the fleet should be aware of the reasons why auto-following was introduced in the first place and also its limitations.

It is already clear that visual aiming will be substantially more accurate than auto-aiming when engaging seen targets so that the use of auto-following can be considered solely in relation to the blind fire requirement. Its use is, in fact, connected with Type 262's solution to the problem of searching for and subsequently holding an unseen target, a solution which by its completeness distinguishes Type 262 from any other equipments of a similar nature under development in other countries. A paragraph on this aspect will therefore be of interest in itself and will also show why auto-following was incorporated.

The radiated power of modern gunnery radar sets, owing to the requirement for blind fire, is in all cases concentrated into a narrow beam which can be likened to that of a searchlight; this is particularly the case with Type 262 whose beam when scanning only covers a field of about 5°, and which therefore needs continuous and accurate information as to a selected target's range, bearing and angle of sight.

The present target indicating system, Type 293 and T.I.U. II, does not provide range and bearing to the required accuracy needed and does not give target elevation at all. Type 262 therefore has a form of local search which is carried out centred round the indicated range and bearing supplied from the T.I.U. II. This "search condition" is initiated by the Control Officer of the mounting or director but is otherwise entirely automatic in operation. The volume searched corresponds to a segment in space 1500 yards deep (± 750 yards from indicated range) and covering an arc of 30° in the sight plane (± 15° from indicated bearing) from elevations of -5° to +80° in steps of 3°, the starting and stopping elevations of the elevation search being controlled by the Control Officer.

The local search in elevation is carried out mechanically by continuously elevating the guns and aerial, the time taken for a full search being approximately seventeen seconds. The bearing search is also carried out mechanically by training the aerial independently of the rest of the mounting and relative to the sight line. The range search is carried out electronically within the radar set.

The search continues until a target comes within the orbit of the volume being searched.

FIG. 1
"RECTIFIER UNIT"
(REAR VIEW)

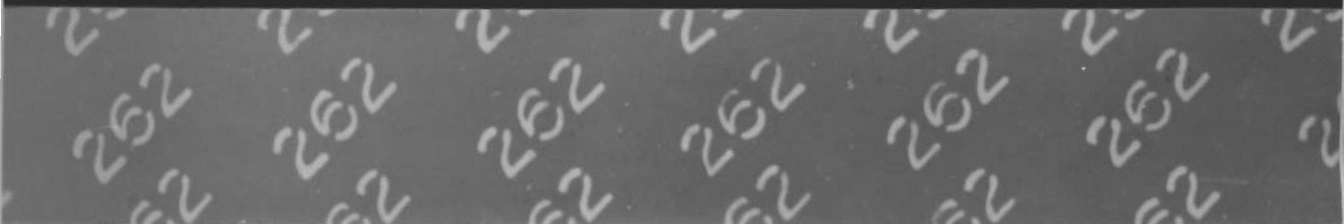
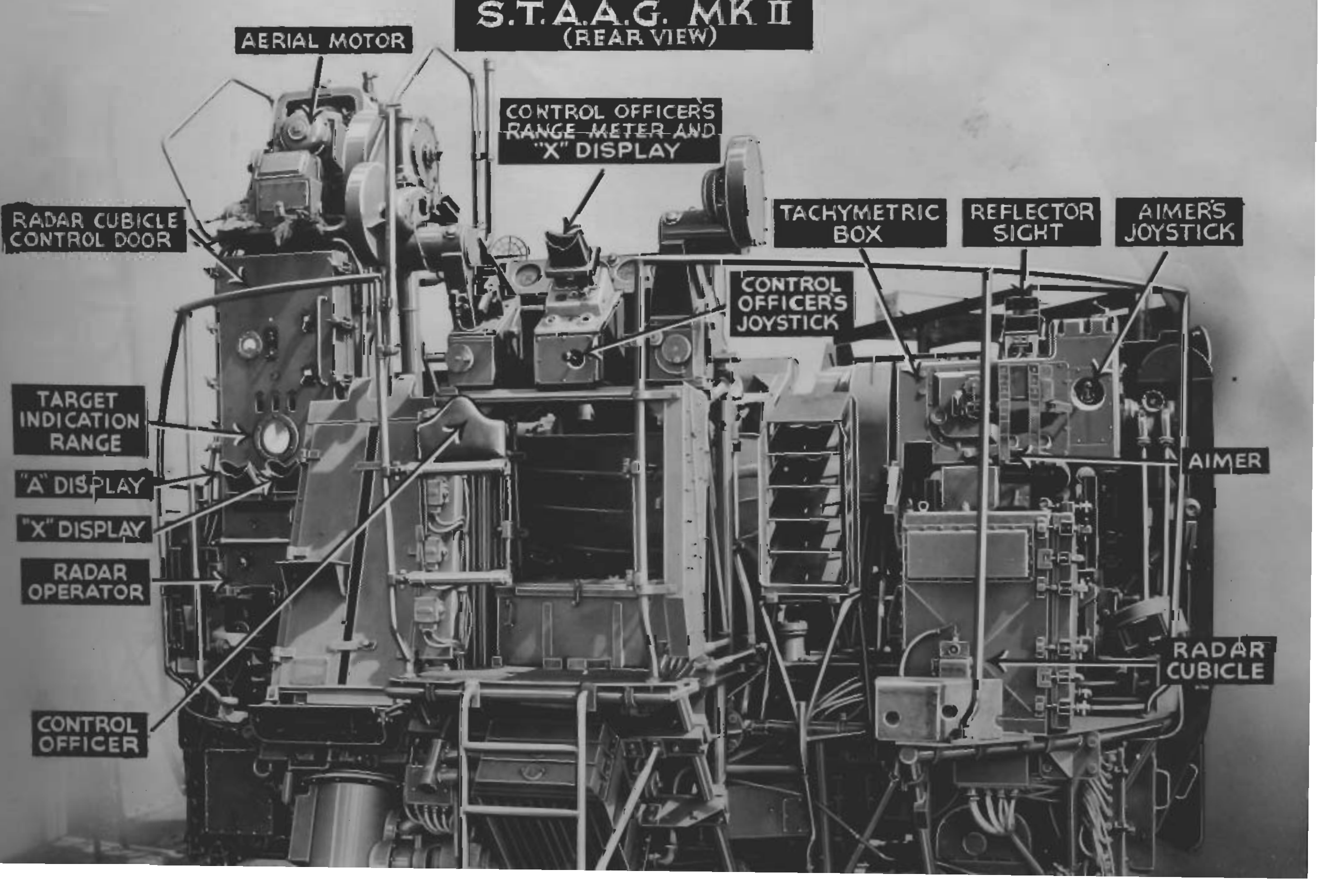


FIG. 2
S.T.A.A.G. MK II
(REAR VIEW)



When this happens, the range strobe "locks" on to echo and by so doing brings the search to an immediate stop leaving the aerial pointing at the target; the aerial may then be as much as 15° off the sight line of the mounting.

A further train of relays then operate and the aerial and mounting/director are made to move so that in the "lock complete" position both the mounting/director and aerial are aligned and pointing at the target. With targets moving at high angular rates, however, this situation only obtains for a very short time and the target will speedily move out of the radar beam and be lost unless the correct rates are set. With radar manual aiming, in which an operator tries to keep a spot central on a cathode ray tube, it is certain that on many occasions the target will be lost at this stage; by cutting out the human link in the chain, however, and using auto-following this difficulty is obviated. This is the main reason why auto-following was adopted in the Type 262 series.

A subsidiary reason for its adoption was that difficulties were anticipated when tracking by radar manual owing to excessive "jitter" of the displacement of "spot" on the "spot indicator". The practicability of radar manual aiming at all has yet, in fact, to be proved by trials.

Both of the forms of radar aiming referred to in the foregoing paragraph function from misalignment signals received from the aerial system. Conical scanning is used as in Type 275 but in the Type 262 case it is the reflector which moves and not the waveguide aperture. The reflector is fitted $1\frac{1}{4}^{\circ}$ skew from the shaft and rotated at 1800 r.p.m. to achieve the necessary conical beam.

The stringent operating conditions imposed on the radar equipment - particularly on the S.T.A.A.G. - have been accentuated by the weight and space restrictions which have also been necessary; it has not, for instance, been possible to fit the cubicles with any form of lagging. The air conditioning system has therefore had to be designed to cope with considerable ranges of temperature and humidity and has had to be made an "open" system with all the attendant drawbacks. Elimination of salt from the main air supply has been one of the greatest difficulties, but results of trials which are still continuing, have been encouraging.

Very considerable efforts have also been made to make the cubicles thoroughly weathertight but water will get in unless all the door fixing bolts are screwed down; much unnecessary servicing and repair work will be avoided if this point of drill is observed.

Scrutiny of the photographs of the S.T.A.A.G. and C.R.B.F.D. show that the question of maintaining the radar equipment presents a very real problem - a problem unique in naval radar but not dissimilar from that confronting the R.A.F. with the maintenance of airborne equipments.

There would be little advantage in enlarging on the details of the problem, most of which are obvious, but it has always been clear in the minds of those responsible for providing a solution that it would be quite useless sending a radar set of the nature of Type 262 to the fleet unless arrangements were made to make its maintenance a practicable matter at sea. No pains have, in fact, been spared, to bring this required practicability into effect and it may somewhat reassure those who view Type 262's approach with misgiving to learn that the work put into the testing and servicing equipment, rivals that which has been put into the original set.

Broadly, the solution to the maintenance problem has been based on a policy of "unit replacement" (i.e. as a faulty unit is located on the director/gunmounting it is removed and immediately replaced by another one). The advantages of this principle are obvious: the armament is made serviceable again in a very short time and upper deck maintenance and testing work are reduced to a minimum. Work on faulty units and most of the routine maintenance on them is done in "Test Racks" sited in the Auxiliary Radio Maintenance Rooms. (See Fig. 4). The racks have been designed to be completely comprehensive and by means of dummy loads, special control panels, etc. simulate the working conditions on the director/gunmounting. The various items of test equipment, having in all cases been specially designed for Type 262, are relatively simple to work.

It has also been possible to incorporate various features such as inspection lamps, tool drawers, stowages for spares, etc., all of which will make for added efficiency in the radio mechanics work.

Outfits of test racks are provided one for every four or less Type 262 equipped directors and/or gunmountings; this proportion being in line with the scale of Auxiliary R.M.R's allowed to be fitted as outlined in C.A.F.O. 24/45 and subsequent amendments, C.L. 3090 and the last A.S.E. Bulletin.

The proportion of spare sets of "units" allowed is on a more generous scale, sets of units borne in excess of test racks being stowed in stowage lockers supplied specially for the purpose. It is not possible to carry out any maintenance work on units housed in these lockers which are intended to provide stowages of ready access to directors/mountings of a group most remote from the associated Auxiliary R.M.R.

The proportions of test racks and spare sets of units referred to above, details of which are given in C.A.F.O. 24/45, have been based on theoretical considerations of the percentage of directors/mountings in a ship which may be expected to be out of action owing to defection of one of the units at any one time and under certain sets of conditions. Only sea experience will show whether these allowances are satisfactory and it is anticipated that in many ships difficulties in siting A.R.M.R's will necessitate amendments to the number of test racks and/or spare sets of units carried. Ships should not hesitate to draw attention to any such amendments, which appear to be required.

It is only right to point out that the requirement for A.R.M.R's when Type 262 was fitted was not fully recognised when the S.T.A.A.G. and C.R.B.F.D. were originally conceived, although the need became apparent very soon afterwards. The statement that their provision is essential if Type 262 is to be fitted was only made with reluctance as it not only cuts across the "self-contained" policy for the gunmountings but also gives rise to further congestion in ships which the release of the Type 282 offices was designed to alleviate. The proportion of test racks have therefore been kept to a minimum for efficient maintenance and the racks themselves together with associated power supplies have been so designed as to make the work of ship fitting as easy as possible; it is,

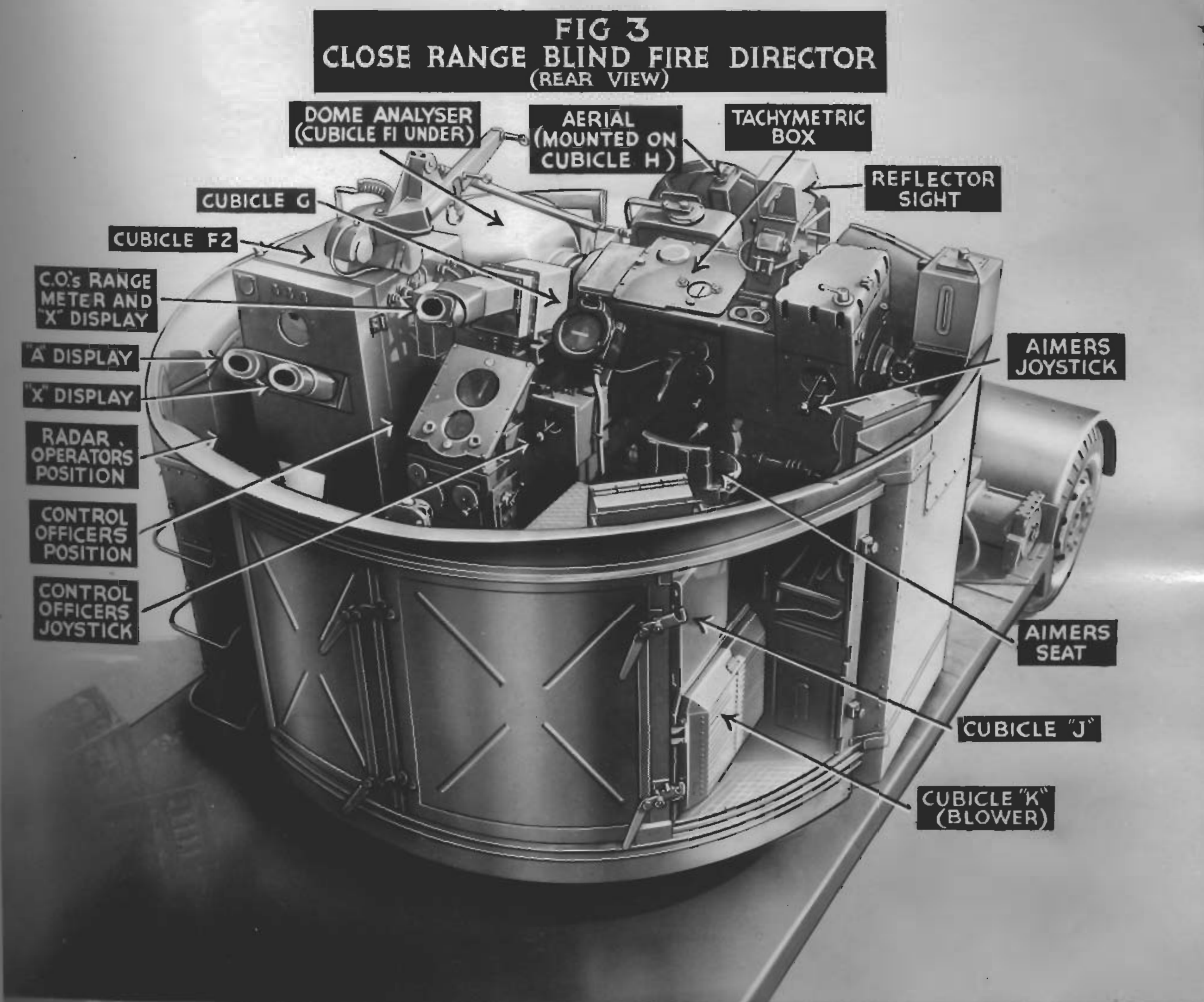


FIG 3
CLOSE RANGE BLIND FIRE DIRECTOR
(REAR VIEW)

FIG. 4
TEST RACKS IN AUXILIARY R.M.R.

in fact, broadly speaking, limited to the running of two multi-core cables and the provision of ventilation trunking for exhausting hot air from the racks.

Details of performance of the equipments are not yet available but trials carried out on the prototype S.T.A.A.G. show that Type 262 will provide accurate range in visual fire and will enable unseen targets to be fired at out to the maximum effective range of the gun with an accuracy reduced but comparable to that obtained in visual fire. It has also been reported that the radar equipment has proved very reliable over the limited period of the trials which have already been carried out. This is particularly encouraging in view of the strenuous operating conditions.

The purpose of this article has been to introduce the Type 262 radar which, it is believed, in conjunction with the S.T.A.A.G. and C.R.B.F.D. will give the fleet the most outstandingly efficient blind fire equipments yet seen at sea. It is important, however, that what has been written should not give rise to any misconceptions as to availability or to ease of maintenance. The equipments carry out a complicated function and they are therefore complicated to produce; it is already clear in fact, that fitting in both cases will be limited to new construction for at least a year and that in relatively small numbers. Maintaining the sets will, in the first place, undoubtedly require a considerably higher standard of technical ability than has been required with the Type 282's, and even with the arrangements which are being made for pre-commissioning training, a high degree of perserverence and interest will be needed to keep the Type 262's up to scratch until they are better known in the fleet.

Given such initial perserverence and interest by ships' maintenance staffs, however, it is confidently predicted that Type 262 will herald a new era in close range gunnery which in the words of an Admiralty Staff Division very closely connected with the project, "will be comparable with the advent of the breech loader in the age of the muzzle-loading gun".

REPORTS FROM ABROAD

One article of faith of the Briton abroad is the belief that Britons at home are incapable of corporate activity. Another article in the same creed is that those placed in authority are averse to signing documents whose contents include more than a small fraction of technical matter.

The welcome flood of personal letters received by officers of D.R.E. and S.S.E. proves the effectiveness of the creed.

At home, however, a system prevails whose origins go back, pehaps, to Samuel Pepys. This system (whose wisdom it is not sought here to question) provides for the strongest action being taken when Authority is in evidence. Thus it comes about that whilst the welcome flood of letters provide much food for Gossip, and can sway Opinion to a large degree the longed-for Action may seem somewhat shy.

The Moral is this :- Write as you have always done, for great is the value of these letters. But when action is wanted move also in those waters called "OFFICIAL CHANNELS".

AERIAL ROTATION SPEEDS - TYPE 293M

The following extracts from a report by H.M.S. ORWELL indicate the increase in the number of paints per minute obtained, of targets at limiting ranges, at high speeds of aerial rotation over the number obtained at low speeds. The echoes were described in the report as "faint".

TARGET	RANGE IN YDS.	HIGH SPEED 15 R.P.M.	LOW SPEED 7½ R.P.M.
STACK SKERRY	24,300	4	2
	32,000	4	4
	32,000	2	4
	33,100	4	3
	24,000	4	5
CORVETTE	20,000	8	5
FAEROES	23,000	14	6
	6,000	4	4
SWORDFISH A/C	37,500	0	5
	24,800	12	8
TRAWLER	11,900	15	5
CONVOY	35,000	14	6
MERCHANT SHIP	13,400	14	6
CORVETTE	13,000	14	6
CORVETTE	17,000	14	6
CORVETTE	22,000	12	6
	19,000	14	6
CORVETTE	18,000	13	6
BEAR ISLAND	83,000	0	1

TARGET	RANGE IN YDS.	HIGH SPEED	LOW SPEED
SAILING VESSEL	20,000	6	5
DESTROYER (Held to 28,000 on "A" Scan)	23,500	14	4
2 CRUISERS AND 3 A/C CARRIERS (Held to 33,000 on "A" Scan)	26,000	15	6
FAEROES (Held to 120,000 on "A" Scan)	110,000	1	5
4 FRIGATES (Held to 25,000 on "A" Scan).	20,000	2	6

ANALYSIS OF WAVEGUIDE CONDITIONS

TYPE 293

It is impossible to overemphasise the importance of a satisfactory waveguide run for all radar sets using waveguide and, in particular, for Type 293/M. The following extracts from a report by A.S.E. sea trials party are therefore published as an indication of troubles that may occur, and as an example of a logical method of isolating them.

A visit was paid to H.M.S. PETARD in order to find the cause of sparking which occurred in the waveguide and prevented the transmitter from being run at full power.

Reports on work already carried out showed that all the usual tests for locating a fault of this nature had been completed without success.

It was therefore possible that the results of these tests had not been analysed correctly. One report seemed to confirm this by the statement that sparking occurred when the test flare was used to terminate the waveguide in the office. No conclusions had been drawn from this result on the grounds that reflecting surfaces were in close proximity to the mouth of the flare.

It was decided to repeat this test as it was necessary to prove the office section of the waveguide was not faulty before starting to dismantle suspected parts of the waveguide up the mast.

TESTS CARRIED OUT AND MEASUREMENTS TAKEN.

Test 1. To check magnetrons. The section of waveguide in the office was dismantled. The output unit SE2 was removed and replaced by a pipe-wattmeter standing on end. There was no room to terminate the wattmeter with a test flare, so the end of the wattmeter was left open facing up to the deck-head some 18 inches above.

Measurements taken :-

H.T. = 14 kV. C magnetron.
Maximum power obtained over a piston range of 8·5 to 9·5 cms.
Power fell off for piston settings above 9·5 and below 8·5 cms.
For maximum power S.W.R. = 50:83 = 0·6
Mean R/F power = 415 watts.

Similar results were obtained with another 'C' and a 'B' magnetron.

Magnetron current and voltage pulses were normal.
H.T. was raised to 17 kV. without trace of sparking in waveguide.
At this H.T. the safety gap on the pulse transformer flashed over.

Conclusions.

The standing wave ratio of 0·6 showed that conditions were suitable for a test, in spite of proximity of wattmeter waveguide opening to deck head and lack of proper termination.

All magnetrons were up to standard power.

Wattmeter and piston section of waveguide were free from faults.

Test 2. To test output unit SE2.

The apparatus was set up as in Test 1 but with the wattmeter removed and replaced by the output unit SE2 upper half.

H.T. was raised to 17 kV. without trace of sparking in the waveguide.

Magnetron current and voltage pulses were normal.

Conclusions.

It is reasonable to assume that S.W.R. and power were the same as in Test 1, in which case, the output unit SE2 could be considered free from faults.

Test 3. To test right angle bend Pattern W8406.

The apparatus was set up as in Test 2 with the addition of the right angle bend W8406 above the output unit SE2 with $\frac{1}{8}$ inch air gap. The wattmeter was connected to the bend in the normal manner and terminated by the test flare.

It was necessary to pull the flare end of the system across some four inches so that the flare could face out through the office doorway instead of facing directly on to the metal bulkhead. This resulted in misalignment of the airgap over the SE2.

Measurements taken.

H.T. = 10 kV. C magnetron.
Maximum power obtained over a piston range 8 to 9 cms.
For maximum power S.W.R. = 48:60 = 0•8.
Mean R/F power = 288 watts.

Sparking occurred inside the right angle bend when the H.T. was raised above 10 kV. Occasionally it was possible to raise H.T. to 12 kV. but sparking occurred after a few minutes and then persisted until H.T. was reduced to 8 kV.

Magnetron voltage and current pulses were normal. The current pulse displayed a fuzz on its flat top when sparking occurred in the waveguide.

The other 'C' and 'B' magnetrons, tested in Test 1, were tried, the results being exactly as described.

Conclusions.

The standing wave ratio of 0•8 showed that conditions were suitable for a test with flare facing through doorway. Misalignment of the air gap above the SE2 did not reduce R/F power to any extent. In any case sufficient R/F power was getting through to produce sparking. The mean power of 288 watts is a reasonable figure for an H.T. of 10 kV.

Reflection due to misalignment of the air gap would affect the magnetron, but not the right angle bend since the bend came after the air gap.

Since the right angle bend was the only section of waveguide not so far tested, the sparking must presumably have been due to this bend. The fact that sparking occurred with a mean power of 288 watts and S.W.R. = 0•8 showed that the bend had a serious fault.

The pattern W8406 right angle bend was closely examined but no obvious fault could be found. It is possible that the dimensions were not correct, as these are very critical. This could not be checked as no data was available.

No spare W8406 bends were available for testing at the time. The possibility of fitting two 45° natural minor bends was considered and, subject to passing a test, had several advantages, being available and reducing the total number of bends in the office.

Test on 45° natural minor bends.

Two natural bends were fitted in place of the W8406 right angle bend above the output unit SE2. The special flanges on the right angle bend were removed and fitted to the corresponding positions on the natural bend. The wattmeter was connected and terminated by the test flare.

Measurements taken.

H.T. = 14 kV. Class C magnetron.

Mean R/F power of over 300 watts was obtained with all piston settings between 6 cm. and 10 cm. with a maximum of 575 watts at 9·5 cm. The standing wave ratio varied between ·84 and ·9.

H.T. could be raised to 17 kV. giving 590 watts R/F power without sparking in the waveguide.

The 'B' magnetron was tried and gave exactly similar readings.

Conclusions.

The two 45° natural minor bends seemed to be satisfactory and to be able to handle considerably more than normal power without sparking. Furthermore, there did not seem to be any reason to suppose that losses were higher than when using a right angle bend.

A final test was carried out after the bends had been permanently installed and two S bends removed from the waveguide run and the transmitter, as finally set up, gave a mean R/F power of 436 watts with a standing wave ratio of ·66 for the whole waveguide and aerial.

SCHELDE RADAR NAVIGATION SCHEME

As the war in Europe moved into Germany, the use of Antwerp as a supply port became increasingly important to the Allies. There are many problems in opening up captured ports after years of enemy occupation and, in this particular case, the difficulties are even greater. There is a fifty mile approach channel up the Schelde from Flushing to Antwerp. Before the war this was a difficult channel, in many places only 200 yards wide with strong tides and changing mudbanks.

While the Schelde was being swept and buoyed in the latter part of 1944 it was evident that, with the approach of winter would come the added delay of fog. Fog could, and would, hold up shipping, but it was essential that, even in the worst visibility, facilities should be provided to enable at least one or two vital ships to navigate the Schelde when required. It was impossible to say just what ship or ships would be needed to fill the army's needs, so that the fitting of vital ships with Radar and other Navigational aids was out of the question. Some means had to be devised by which we could select one or more ships from amongst those arriving at Flushing, and lead them safely up the Estuary to Antwerp.

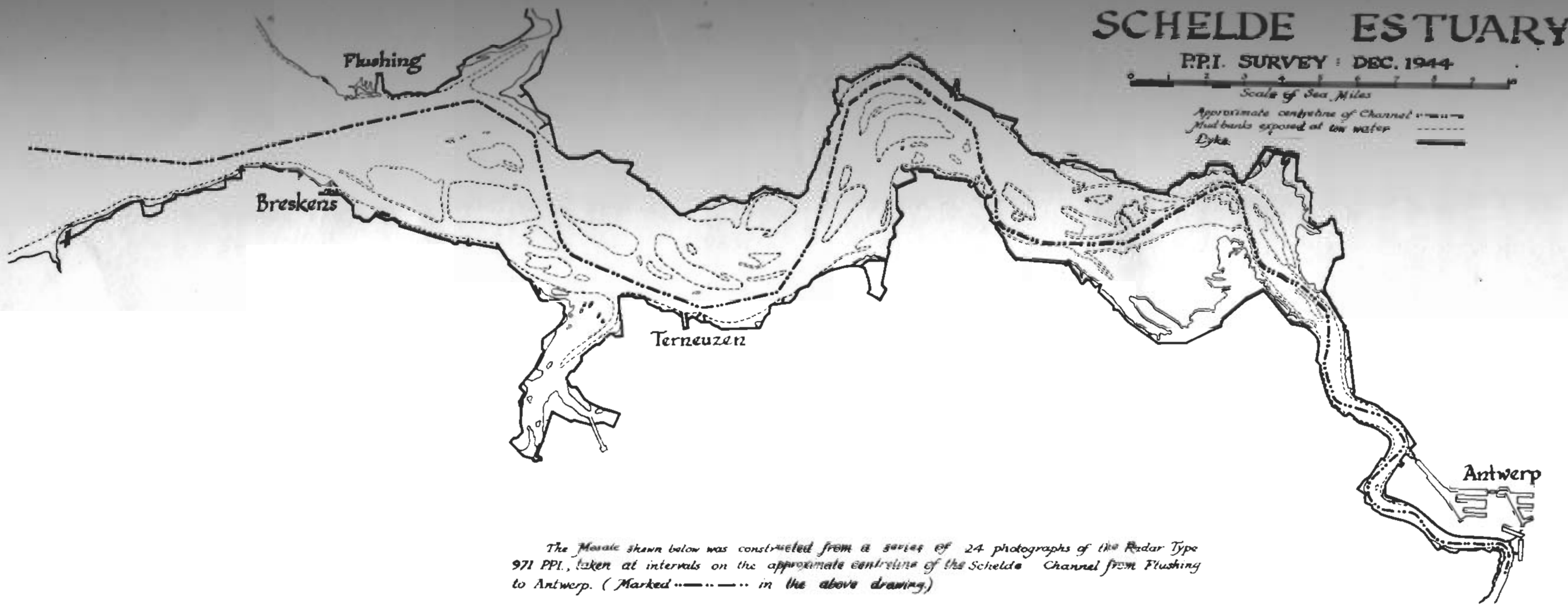
It was finally decided to fit six L.C.I.(L)'s with Type 971, and Outfit QM and R/T, to establish QM stations and Radar beacon sites ashore. The plan was to use each L.C.I.(L) as a pilot craft, giving it all possible facilities for navigating the channel and for leading a merchant ship. The merchant ships could follow closely behind the L.C.I.(L). Each would carry a pilot familiar with the channel. The pilot in the L.C.I.(L) would know exactly where he, and the merchant ship, and other shipping etc., was at all times and would be able to guide and advise the merchant ship with continuous pilot-to-pilot R/T communication.

Type 971 was chosen as the best Radar set to be used because it was the only set likely to be available in the time which would give all the advantages of X-band working. Type 970, its predecessor, had been used with success in L.C.I.(L) and other landing craft for navigating confined waters. With a 5 inch P.P.I. presentation; a range accuracy of $\pm$ 50 yards; 0 - $3\frac{1}{2}$ mile, 0 - 7 mile and 0 - 25 mile range scales; good bearing and range discrimination; and, most important of all points, a minimum range of below 50 yards; and added to this by modification a beamwidth of $2\frac{1}{2}^{\circ}$ together with almost negligible side lobes and improved X-band definition, the pilot in the L.C.I.(L) should have a plain picture of events.

Outfit QM, is a navigational aid which uses the synchronised signals from three shore transmitters to determine its position relative to these transmitters to an accuracy of 10 yards (approx.).

The Type 951 beacons to be used had been produced for use with Type 970, but would require conversion to X-band and a permanent power supply to replace its accumulator.

It was in early November 1944 that work commenced on the project, with the hope that the scheme would be in operation in January 1945. Six L.C.I.(L) were made available, and taken in hand, two each at Chatham, Portsmouth, and Devonport. Meanwhile, work was started at A.S.E. to convert six 970's to 971, by hand. This involved six new aerial outfits complete with prefabricated waveguide, together with extensive modification to the transmitter-receivers and receivers of the units supplied by Air Ministry for the conversion. Work was also commenced on modification of Type 951 for X-band working. It was



The Mosaic shown below was constructed from a series of 24 photographs of the Radar Type 971 P.P.I., taken at intervals on the approximate centreline of the Schelde Channel from Flushing to Antwerp. (Marked ·· ▬ ·· ▬ ·· in the above drawing.)

necessary to locate these beacons ashore on the banks of the Schelde and a preliminary visit to sites revealed that they would be located in bleak country, probably on dykes, and well away from any accommodation or supplies. It was therefore decided to fit the beacons in Naval Radio Vans, supplying each van with duplicate beacons and battery charging plants. Accommodation and living facilities were also provided in the vans for the operator required at each site. Work was put in hand immediately on three of these beacon vans with a programme for a further three if the first ones proved successful. The ship-fitting side of the R/T communications and Outfit QM was fortunately simple, but three portable stations had to be set up ashore for the QM chain, and to get this chain working in the time required a terrific amount of work.

Meantime, while all preparations were taking place, M.L.151 was fitted with an experimental model of Type 971 and sailed to the Schelde to carry out a Radar survey, gather information, and train crews in the equipment in readiness for the arrival of the L.C.I.(L). The conditions on the Schelde in December 1944 were far from pleasant. Antwerp and its approaches were subjected to more than their share of enemy attention from sea and air, and the survey M.L. was on one occasion badly shaken by a near miss from a V2. Trouble was also experienced from ice in the river.

The Schelde is bounded by low dykes for almost its full length. The surrounding countryside is below sea level, so that the Radar picture in the river is somewhat unique. For the purpose of navigation a series of 30 Radar P.P.I. predictions were prepared for Type 971 at intervals from Antwerp to Flushing, to show the expected Radar picture, the intended track for the vessel, together with the outer limits of the channel. These predictions are projected on to the P.P.I. by a Reflectoscope and enable the operator to compare the position of the spot representing own ship's position with the intended track. By such comparison he can report to the navigator who can thus keep the craft on the intended track. A series of photographs of the P.P.I. were also taken along the length of the river. These have been mounted as a mosaic and are published with this article. Comparison between this mosaic and the associated drawing will reveal how closely the Type 971 Radar picture agrees with the actual plan of the shoreline.

By the time this survey was complete three 952 beacon vans had been completed and shipped with their crews, and a Radar maintenance vehicle for the entire scheme, to Ostend. From here the vans were taken overland to their sites, one to the eastward of Breskens, one near Terneuzen and the other at Kalloot. Unfortunately, it was not just a matter of siting the vans and switching on. The lowlands of Belgium and Holland had been used as a battlefield for a time and in many places were flooded. On occasions the army had to be called on for help and horses were also used to move the vehicles. (It was never understood how Belgian horses understood commands in Naval English).

The QM chain was landed at Antwerp. There was considerable difficulty in getting the chain into operation. Trouble was finally found to be chiefly due to presence of barrage balloons. Stations were set up at Antwerp, Bruges and Ghent.

With the arrival of the first 3 L.C.I.(L)'s at Antwerp on January 24th an intensive training programme was commenced, and the technique adopted was soon sufficiently perfected for the craft to navigate in conditions of almost nil visibility. To quote, as an example, an incident during the working up, will give some idea of the standard achieved :

"The M.L. left Antwerp and ran on Radar information. During the 15 miles from Antwerp to Bat, visibility was about 500 yards and only one other ship of those sighted was under way; for some time this ship was proceeding down river ahead of the M.L. but when last seen near Bat she was outside the channel and apparently going full astern to avoid a mudbank! From Bat onwards visibility rapidly deteriorated and, during the whole of the next 20 miles to Margaretapolder, was never better than 25 yards. This run included the most difficult part of the river (that between Bat and Hansweerd) but was accomplished without incident. Near Walsoorden the presence of anchored ships necessitated passing closer in shore than usual and was the cause of an item of amusement. A barge was seen some 20 yards off (the only object sighted in this 20 mile run!) and its occupants were shouting in Dutch and gesticulating wildly, first in the direction of the M.L. and then in the direction of Walsoorden Spit, invisible in the fog. This excitement was not without reason as the M.L. was then running straight for the spit at 8 knots and the occupants of the barge could not know that the spit was clearly visible on the M.L.'s Radar! The M.L. rounded the end of the spit at a distance of less than 50 yards without it being sighted by the lookouts. Later, in the more open stretch of river off Hoedekenskerke the O.O.W. felt sufficient confidence in the Radar to clear the engines by increasing to full speed of approximately 12 knots and maintaining it for the next 4 miles! Speed was again reduced while passing through the narrow channel north of Margaretapolder; here the channel runs between a wreck and a light-buoy about 200 yards apart and, on this occasion, neither wreck or buoy were seen by the O.O.W. During the last few miles of the run, visibility steadily improved and was some 200 to 300 yards on entering Terneuzen harbour".

The final confidence felt in Radar is evidenced by the increase to full speed during the run in nil visibility and by the following extract from the Commanding Officer's own report : "Had Radar failed <u>at any point</u> from the time of leaving Antwerp the only action compatible with safe handling of the Ship would have been to anchor immediately. There was no possibility of proceeding without Radar."

By early February the standard of training reached was such that the scheme was ready for operation. By this time, it had been hoped that additional staff would have been available for the scheme. To operate the six L.C.I.(L)'s a total of six Sub-Lieutenants and three Radar operators were supplied additional to complement. There was a large amount of work to be done connecting charts, etc., and it was also felt that the entire scheme should be co-ordinated by some qualified Navigating Officer. However, additional staff was not forthcoming.

Fortunately the war situation changed rapidly, and it was decided at this stage to hold up the scheme. This was done in mid February, but not before a large amount of valuable and definite information had been gained on Radar Navigation in confined waters. The ability of suitably fitted craft to operate on Radar information alone in conditions of nil visibility was adequately proven.