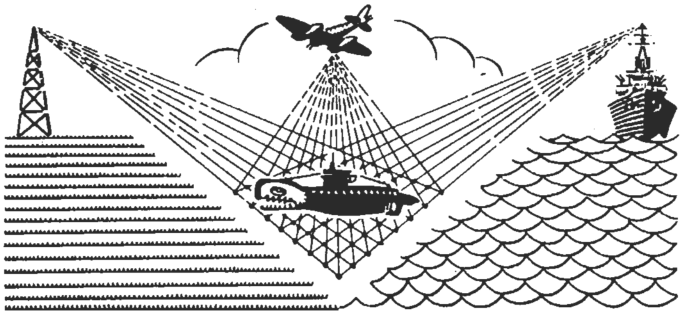
RADIO versus THE U-BOATS



An Account of the Part Played by Radio in the Battle of the Atlantic

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The story of the Battle of the Atlantic, of which the official account has just been published, would be incomplete without an account of the vital part played by radio, both in ships and aircraft, for it was largely fought behind the scenes between Allied and Axis technicians. Each was constantly striving to be one jump ahead of the other in producing equipment which more effectively met operational requirements whilst avoiding detection and thereby the production of counter-measures by the enemy.

High-frequency direction-finding, which played such an important part, had been developed as early as 1930, but the results achieved were poor compared with those of M/F and unless the D/F aerial was fitted at the truck of the highest mast the results were generally of negligible value. A fair proportion of capital ships, cruisers and destroyers were fitted with an early form of high-frequency D/F before the war, but in 1939 the equipment was rapidly being removed in order to free the masthead positions for the aerials of the newly developed radar warning sets.

In 1940, however, it was appreciated that high-frequency W/T transmissions from U-boats in the Atlantic were an indispensable part of their operations, particularly for developing pack tactics. Whilst these transmissions could be located by the naval shore D/F stations and the approximate position of a U-boat thereby fixed, the information was not of sufficient accuracy to enable convoy escorts to take offensive action against the submarine. The urgent need for H/F direction-finding in the escorting vessels thus became apparent and at the beginning of 1941 two destroyers were fitted for trial with a newly developed set, covering 1 to 20 Mc/s. It incorporated for the first time sense-finding facilities.

The aerial for this set was fitted on the foremast at the expense of a radar warning set. The Fleet was very reluctant to accept this sacrifice. Consequently effort was concentrated on finding ways of reducing the errors to which these sets were subject when their aerials were fitted in inferior sites. It was found that useful results were obtainable in destroyers with the aerial sited aft on a short pole mast, provided its distance from the foremast or funnel or any other vertical structure was sufficiently great.

Three destroyers were fitted in this way in the latter half of 1941 and a programme for fitting many more vessels employed on convoy escort duties was initiated.

Initially the principal value of high-frequency D/F in ships was to supplement fixes obtained by shore stations by giving greater accuracy and thereby enabling convoys to take more effective action. It was not long, however, before its more important offensive capabilities were shown.

Unfortunately, with the direction-finders then in use it was very difficult for even skilled operators to distinguish between ground-wave interceptions from U-boats probably endangering the convoy, and sky-waves from U-boats which might be hundreds of miles away. The technique for doing so was gradually developed, and, as the number of D/F-equipped ships with each convoy increased, it became possible to supplement the operator's estimations of range by plotting simultaneous cross-bearings from several ships.

In 1941-42 a new H/F direction-finder was developed employing cathode-ray tube presentation of intercepted signals. This enabled operators to distinguish with greater certainty between skywave and ground-wave and thereby to determine whether a U-boat was within about 50 miles. It also enabled accurate bearings to be taken of the comparatively short transmissions which U-boats were then radiating in an effort to avoid being located. A more accurate estimation of range became practicable as a result of an examination of the W/T equipment of a U-boat (re-named H.M.S. *Graph*) captured in 1941 and extensive trials with it to ascertain the normal field strength obtained at different ranges. The new set proved much superior to its predecessor. It was first fitted in a sloop at the end of 1941 and soon afterwards became the Navy's standard high-frequency D/F set.

Throughout the war our convoys and their escorts kept wireless silence as far as possible, though conditions sometimes arose when the use of R/T by escorts was essential if they were to co-operate with each other and with aircraft in searching for U-boats closing the convoy and driving off those which attacked. For this a frequency of the order of 2,500 kc/s was normally used and the risk of interception and D/F by the Germans had to be accepted. In fact the German shore D/F stations seldom, if ever, did intercept such transmissions, and few U-boats were fitted with equipment by which they might have intercepted our escorts' transmissions and homed on to our convoys.

Towards the end of the war an attachment called " Presskohle " enabling a standard U-boat receiver to be used for taking bearings in the band from 1,500 to 3,000 kc/s was produced. Later the idea was conceived of a set using crossed D/F loops fixed to the top of the Schnorkel tube, a combined breathing tube and exhaust for the diesel motors enabling the U-boat to operate practically continuously submerged—a necessity owing to the increased use of radar by ships and aircraft. This was not ready for sea trial when the war ended and the " Presskohle " had been fitted in only a small number of U-boats.

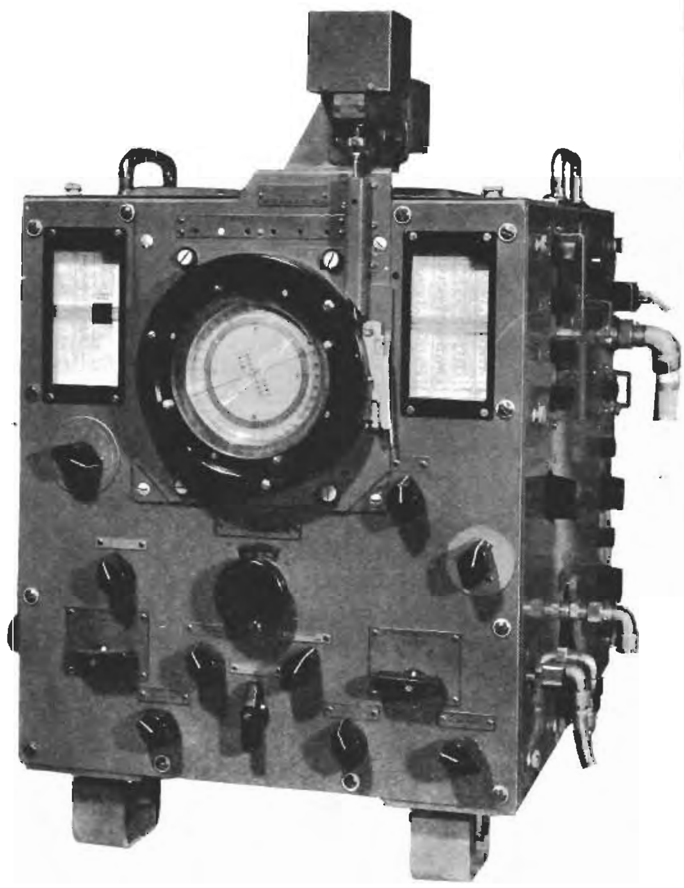
At the beginning of the war the Navy gave priority to the development of long-range radar equipment to give warning of the approach of enemy aircraft. No equipment had been developed for the detection of surface craft, including submarines on the surface. R.A.F. Coastal Command had, however, developed A.S.V. radar operating in the 1½-metre band, which came into operational use as a means of detecting surfaced U-boats from the air early in 1941.

Meanwhile, an officer of the Fleet Air Arm, working on the adaptation of this R.A.F. equipment for Naval Air Arm work, was testing a set in a Walrus aircraft on a slipway at Lee-on-Solent when he noticed that it could detect shipping in the Solent at a useful range. Proposals followed to adapt this set, of which large numbers were already in production, for use in destroyers and other types of warship employed escorting convoys. A fixed aerial resembling a cross between a giant box-kite and a wire mattress was produced and fitted at the masthead. With this equipment the display took the form of horizontal echo deflections on either side of a vertical trace. When equal echo deflections appeared on either side of the trace, the target was dead ahead. The equipment was, therefore, limited to the extent that it was only possible to detect objects within an arc of approximately 40 degrees on each bow and to obtain an accurate bearing it was necessary to alter the course of the ship. Such limitations, which were of no importance in aircraft, were so serious for ships that the fixed aerial was soon replaced by a rotating one. Subsequently, in 1942, a more powerful transmitter of naval design, incorporating a rotating aerial, replaced the adapted aircraft type and the equipment then fulfilled the dual functions of detecting both surface vessels and aircraft.

Meanwhile the Germans had appreciated that their U-boats were being located and attacked too often for this to be due to visual sightings alone. They were alive to the possibilities of metre-wave radar and early in 1942 they captured a complete A.S.V. set. They accordingly concluded that this was causing the trouble and tests in the summer of 1942 confirmed that the transmissions were easily detectable by a simple receiver and aerial. Doenitz ordered the speediest equipping of all boats with a make-shift equipment. The result was the " Metox," a tunable search receiver. Technically it had many shortcomings, though it was undoubtedly capable of fulfilling the functions for which it was designed.

In particular, A.S.V.-fitted aircraft could be detected at ranges which enabled U-boats to dive before they approached. Of its principal technical defect—radiation—more will be said later.

All this time the research effort of the Allies had

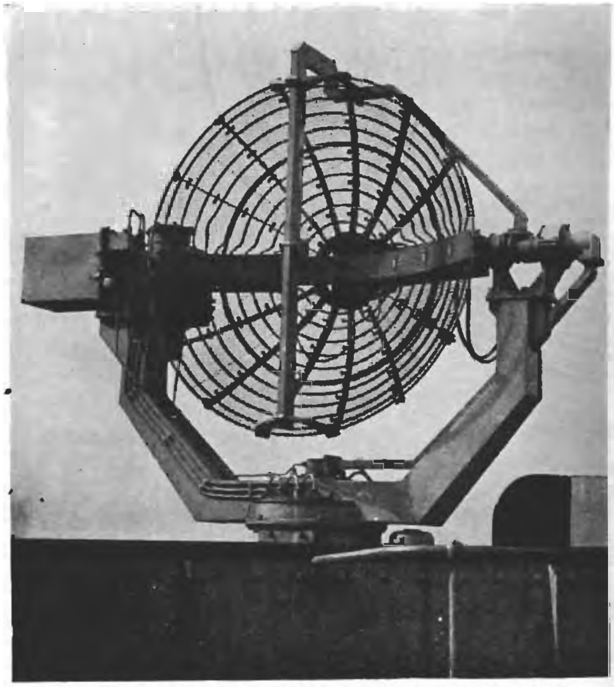


H.F. Direction Finder employing Cathode Ray Tube Presentation of Intercepted Signals been concentrated on the development of higher-powered radar operating on shorter wavelengths. Both were made possible by the development of the strapped magnetron for the transmitter and of a new type of velocity-modulated valve to provide the local oscillator frequency required for a receiver operating on such a high frequency. The production of new surface-detection radar ships and A.S.V. for aircraft followed. Tremendous efforts were made both by the manufacturers to produce the sets and by the shipyards and R.A.F. technicians to fit the maximum number of ships and planes with this new equipment, since it gave markedly superior results over the previous longer-wave type. To cite but one example, the range at which a surfaced U-boat could be detected by ships was increased from about one and a half miles to four miles. As a result the extent to which the German Metox receiver provided immunity from detection by the Allies was almost at once nullified. U-boat sinkings, which had temporarily dropped, were once again on the up-grade.

By the early part of 1943 the Germans were again very worried. In seeking a reason for the renewed Allied success in detecting U-boats, they discounted the possibility of it being due to radar operating on shorter wavelengths since, without the strapped magnetron, they themselves had been unable to produce radar operating on such frequencies. The first possible explanation which occurred to them was that we were employing supersonic modulation on our metre-band A.S.V. which resulted in a signal inaudible in the headphones of the Metox. They accordingly fitted a visual tuning indicator of the "magic eye" type. Fortunately, some naval aircraft operating at this time were employing supersonic modulation and this was sufficient to suggest to the Germans, temporarily at least, that they had solved the problem. But after a further couple of months of steadily mounting U-boat losses it became painfully apparent to them that the "magic eye" was, in fact, no solution and a search for an alternative began. They then explored two further blind alleys. Reports from operational U-boats of observations which were in fact erroneous suggested that the Allies had either developed infra-red detection apparatus or alternatively an anti-interception technique for A.S.V. which involved it being only switched on for such short periods as to render it undetectable.

Hardly had the Germans started to pursue these two ideas when they dropped them in favour of a real will-o'-the-wisp. They decided that all their troubles were due to the fact that we were detecting the already mentioned strong radiations from the Metox receivers. They were at once withdrawn from service and a new search receiver, the Wanz G1, developed at high speed, was fitted in lieu. The radiation from this was relatively small but under pressure of continued sinkings of U-boats a mental stampede began, the new set was withdrawn from service almost as soon as it had been fitted and in August, 1943, they went to the extent of producing a replacement, the Borkum, which remarkably enough employed a crystal detector. They accepted its inefficiency in favour of its complete inability to radiate.

It is of interest to record that it was at about this



Stabilised Aerial Type AUK with Parabolic Reflector employed with 10 cm. Radar. The Waveguide will be noticed.

time (early 1944) that the German U-boat Command took the step of sending to sea a U-boat fully equipped to investigate every type of Allied radio and carrying one of their best technicians with operational experience. Unfortunately (for the Germans) this U-boat was sunk after thirteen days at sea. Another vessel was at once similarly equipped but had an even shorter career.

It was not to be expected that the Allies' use of 10-centimetre radar would indefinitely remain secret. They first became aware of it in the latter half of 1943 by the capture of the R.A.F. blind-bombing aid H2S. But though they appreciated that we might be using such frequencies against U-boats their efforts to produce a search receiver covering this waveband for fitting in U-boats were at first singularly unsuccessful. They turned to the production of radar decoys of which the most notable were a radar decoy balloon and a radar decoy spar buoy. Both of these could be discharged from submarines and gave to our radar sets an effective echo. It was hoped that our ships would pursue the decoys, thereby giving time for a U-boat to submerge and escape. Though these devices at first achieved some success it was not long before the ships' radar operators and plotting teams learnt to appreciate when a target was drifting with the wind or sea.

All this time Allied technicians had been far from inactive. Many improvements for the 10-centimetre radar sets had been developed, notably stabilised aerials, which enabled the narrow beam radiated from the very directional aerial to remain horizontal despite the motion of a ship, and P.P.I. methods of presentation. Of even greater importance, however, was the production of equipment operating in the 3-centimetre band. This was of particular importance in the case of aircraft owing to the reduction in size of both the equipment and the aerial. As a result, by the time the Germans were having any success at all with the 10-cm. surface receiver ("Naxos ZM," which was only fitted in Coastal Forces craft), the Allies were already replacing equipment operating on that frequency with 3-cm. apparatus. The Germans tumbled to our use of this frequency with the unavoidable capture of a new version of H2S and turned to the development of a search receiver for use against it. They failed, however, to produce the Naxos ZX (3 cm.) or Naxos ZD (3 and 10 cm.) before the end of the war. The Naxos ZM used a high-speed spinning aerial rotating at 1,300 revolutions a minute.

The results were presented on a cathode-ray tube. By an ingenious device a spot of light was made to rotate round the edge of the tube in synchronism with the rotation of the aerial and the spot was then suppressed except when a signal was being received. All signals received appeared as bright spots round the periphery of the tube, which was calibrated in degrees whence bearings could be read off.

Aerial for H/F Direction Finder (Fixed Crossed Loop) mounted at top of Foremast on Destroyer

In connection with search receivers the only item remaining to be mentioned is the German development of an aerial for fitting at the head of the Schnorkel tube in order to enable such sets to be operated while the U-boat was to all other intents submerged. The requirement for this arose as soon as they appreciated that, to the all-seeing eye of 3-centimetre radar, not even the small target presented by the head of the tube was wholly immune from detection by radar. Only the "Rundipole" aerial, operating in the metre-band, was produced, whilst the "Athos" aerial working in the 3-cm. band was under development.

There remains to mention briefly the extent to which the Germans fitted radar in their submarines. In this they were materially hampered by their inability to produce, for a long time, equipment operating in the centimetre band. The early German naval radar was heavy, bulky and subject to frequent breakdown. Although fitted in a number of U-boats it was abandoned in the autumn of 1943 in favour of a modified version of the Luftwaffe A.S.V. set. Until the end of the war this remained standard U-boat equipment, using a small extensible "mattress" aerial which was housed in the side of the conning tower and rotatable from below.

This equipment was intended for the detection of our patrolling aircraft, but its use was always limited because the U-boat captains, influenced by the extent to which they believed we were making use of the radiations from their search receivers, were extremely loath to transmit with it. Towards the end of the war the Germans by making a "Chinese copy" of a captured British magnetron, succeeded in getting centrimetric radar going. But it is noteworthy that, whereas we had produced a radar set for our submarines effective for both the detection of aircraft and surface vessels, the Germans had been forced to design two, one for each purpose.

In conclusion, it may truthfully be said that radio played an essential part in the great majority of sinkings of Axis submarines during the war. Our decisive victory in the radio war was, in fact, acknowledged by Grand Admiral Doenitz even before the end of hostilities.