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COASTAL COMMAND REVIEW

December, 1942

No. 8

HEADQUARTERS,
COASTAL COMMAND
ROYAL AIR FORCE

PLATE 1

Gibraltar : North Front Aerodrome at the beginning of the North Africa Campaign. All through one week aircraft were landing and taking off at Gibraltar at the rate of over one every eight minutes.

COASTAL COMMAND REVIEW

No. 8—December, 1942

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EDITORIAL

COASTAL COMMAND

December, 1942

The outstanding event of the month was the successful dispersal of an unusually large and determined U-Boat pack in the Atlantic, south of Iceland, which resulted in the passage between U.S.A. and U.K. of Convoys HX.217 and SC.111 with the loss of only two ships. This is analysed in some detail in the present issue, although the full story is not yet available and a further report may follow. Other convoy escort work remained normal.

The weather conditions during the month were much less favourable for flying than during November. Widespread southerly gales were experienced in the Eastern Atlantic, and towards the end of the month strong-to-gale north-westerly winds were encountered over the North Sea.

In spite of these adverse weather conditions, an average of 48·6 anti-submarine patrols were carried out daily, the total for the month being 1,506. That these figures are considerably lower than for the previous month is due in part to the fact that during November an increased number of patrols were carried out in the Bay of Biscay area in preparation for the passage of the convoys to North Africa. The U-Boat campaign is still being vigorously pursued, as is shown by the number of sightings and attacks which, in spite of the falling off in the Bay of Biscay area, remains at the high figure of 105 with 53 attacks (44 by depth-charge). While official assessment is incomplete, it seems probable that some kills were made.

Meteorological sorties were maintained at approximately the same number as has obtained since June, a most creditable result in view of the deteriorated weather conditions already noted.

Air Sea Rescue sorties remained normal in relation to the total volume of operations. During the month 84 lives were saved, maintaining the ratio of one successful rescue in every three attempted.

The number of P.R. sorties, 192, was the lowest of the year. This was only to be expected, as December is the worst month for photographic light and, in addition, weather conditions were unfavourable.

The process of maintaining and backing up the forces in North Africa continued to impose a heavy load on Gibraltar, although this lightened in comparison with the peak activity of November, when, for a week, aircraft landed or took off at North Front at the rate of over one every 8 minutes.

The total operational flying time for November of all units belonging to or operating with Coastal Command reached the figure of 25,394 hours, being nearly 25 per cent. greater than any previous maximum. It was therefore improbable that the figure for December would approach this peak, and in fact it totalled 19,565 hours. Non-operational flying by the Command alone totalled 26,308 hours in November, 23,149 in December.

That only a few squadrons accept seriously their responsibilities for continuing the training of aircrews is unfortunate, and it is evident that this responsibility is still not sufficiently recognised. It cannot be over-emphasised that the training given up to the time of joining an operational squadron, good though it is, does not and never can claim to turn out an aircrew with nothing to learn. It must therefore be the constant pre-occupation of Squadron and Flight Commanders, and of Captains of aircraft to see that planned and systematic training continues on every possible occasion.

A REVIEW OF THE YEAR

Growth of the Coastal Command Offensive

The year 1942 saw the United Nations pass from a period of building up strength, which necessitated in some measure a defensive attitude, to a period of offensive activity on an ever-increasing scale. This is not to say that the United Nations have reached the peak of their war effort, but only that the twin efforts of production and training have allowed us to wrest the initiative from the enemy.

In Coastal Command this has been instanced by the growth of our anti-U-Boat and anti-shipping offensive, without any corresponding diminution of other activities (as is shown by the accompanying graph, Chart 1). The monthly total of 1,414 sorties in January had by June risen to 3,254, and by November had again mounted to the imposing number of 4,012, notwithstanding the seasonal decline in favourable flying weather. The rise was accompanied by a greater average length of sortie, for while in January it was only about 4·25 hours, in June it was 4·4, and in November, 6·15 hours.

It is also of interest to see how the percentage of sorties on different tasks has changed.

Sorties.	A/S Patrol.	Anti-Shipping.	Convoy Escort.	P.R.	Met.	A.S.R.
January ..	25·6	24·8	14·4	15·2	16·6	3·4
June	34·8	17·0	14·6	11·8	13·4	8·4
November ..	46·0	17·0	11·2	6·0	11·9	8·0
December ..	46·0	15·2	11·8	5·9	14·0	7·1

In broad terms, at the beginning of the year nearly half our total effort was not directly offensive. By the end of the year we were carrying out nearly twice as many offensive as non-offensive sorties, notwithstanding the fact that the number of the latter had increased.

As regards U-Boat warfare, anti-submarine patrols jumped from 363 in January to 1,849 in November. The percentage of U-Boats attacked to U-Boats sighted rose from 55 per cent. to a maximum of 71 per cent., but later fell back to about 60 per cent. This is an indication that the enemy's fear of aircraft has spurred him to greater efforts to obtain a measure of success in evading attack, but only at the cost of a reduction in his offensive efficiency.

One of the reasons for the reduction in the numbers of attacks is, of course, that aircraft, having expended their armament upon one U-Boat, sight other U-Boats. One factor which will tend to redress the balance in this respect is a greater number of large aircraft whose bomb-load permits of more than one attack. Some technical developments have increased our chances of success, and others which may be expected within a reasonable time should still further enhance the efficiency of the Command in its anti-submarine war.

Anti-submarine patrols imposed a severe handicap on the enemy in the Bay area by forcing his submarines to remain submerged for the greater part of their passage from base to operating ground and back. It has been estimated that this results in the loss of three or four day's operating time.

In short, the immense effort expended by the enemy in his U-Boat campaign has been definitely checked as far as Coastal Command's area is concerned, and though the United Nations have suffered grave losses on a world-wide basis, his success does not seem proportionate to his effort. To enable us to convert his partial success into definite failure demands a constant evolution of new tactics and unremitting concentration by aircrews to attain, as nearly as may be humanly possible, 100 per cent. efficiency in an arduous and normally unspectacular task.

Attacks on enemy shipping remained fairly constant, but the peak month was May, when 88 attacks resulted in eight vessels sunk and 42 damaged. These successful low-level bombing attacks forced the enemy to make a considerable increase in the escorts and defensive armament provided for his convoys. This in turn brought the abandonment of low-level and the adoption of medium-height attack, before a really efficient bomb-sight had been provided and before the training and formation of replacement torpedo-squadrons could be completed. In July, 62 attacks on enemy shipping were made, but only one vessel was sunk and seven damaged, and subsequent months did not bring increased success. This was due to two factors, the adoption of medium-height bombing and the transfer of a number of specialised squadrons to other theatres of war. But the cost to the enemy of maintaining his sea communications undoubtedly went up and may have produced indirect results.

Coastal Command have been unable to prevent some enemy success in running the blockade, but measures now being taken should put a stop to this serious leakage, or at least materially reduce its volume. The enemy's success was to some extent offset by the loss, in various parts of the world, of five ships carrying cargoes of great value to the Axis; these losses were due partly to air action, partly to surface craft in co-operation with aircraft, and partly to surface action alone. Some progress was made in torpedo attacks against surface vessels, and it is hoped that the upward trend of this form of offensive will be maintained and even increased.

Owing to the limited suitability of Coastal Command aircraft to lay mines, the bulk of this work has been carried out by Bomber Command. None the less, some measure of success has rewarded our efforts in this field, in which a notable contribution has been made by squadrons of the Fleet Air Arm which have operated under the Command during part of their time ashore.

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Photographic reconnaissance showed a marked increase during the summer, when light conditions are more favourable for photography. This was followed in the autumn by a return to about the same level of activity as at the beginning of the year, in accordance with the normal seasonal variations.

Meteorological sorties are now more than twice as numerous as in the early part of the year, and their ranges have increased considerably. The irregularity has unfortunately occurred owing to lack of suitable aircraft to meet the increased requirements.

Exactly 1,000 personnel (excluding enemy airmen) were saved in home waters by Air-Sea Rescue, with an additional 236 overseas. While the Command cannot claim all the credit for this work, it certainly played a major part. The sorties showed a steady increase taking the year as a whole ; in the peak month, November, 322 were made and 106 lives saved. Air-Sea Rescue work depends to some extent on the volume of air activity of all operational commands, and there is not the slightest doubt of its importance in the war effort.

In the general expansion of the R.A.F., Coastal Command has opened up a number of new stations and has also transferred some for other work. In the course of the year 15 new squadrons were formed, others are being formed, and ten left the Command.

The outstanding contribution to the war by this Command was undoubtedly its part in the successful arrival of our forces in North-West Africa. The air aspect of this operation is described in the present issue ; from the facts one can hardly avoid the conclusion that the work of our aircraft was nothing less than indispensable.

The role of our aircraft in assisting the passage of convoys to North Russia also deserves a high place in order of merit. While not always wholly successful, the distances involved and the bad weather encountered would have made this virtually impossible—the degree to which it was achieved reflects the highest credit on those concerned in such arduous work, which has been described in previous issues.

Two gallant failures may also be remembered. In February took place the big Channel battle for the *Scharnhorst* and the *Gneisenau*. On the 12th of the month these big ships, with the *Prinz Eugen* and a powerful escort of destroyers and fighter planes, left Brest uuder a smoke screen. The visibility was bad, and the defensive barrage was so great that our aircraft attacked under difficult conditions. The cost to this command was five aircraft : three hits with torpedoes were claimed. The attack on the *Prinz Eugen* was continued when, in the middle of May, the cruiser was attacked by a force consisting of 27 Beauforts, six Blenheims, eight Beaufighters and 13 Hudsons.

In co-operation with the Royal Navy, aircraft of Coastal Command brought off in November one of the greatest air-sea rescues of the war. When the ex-Danish ship *Buchanan* was torpedoed in the North Atlantic, 73 passengers and crew took to four open boats, which were finally located after prolonged search by aircraft. All the personnel were saved. The last boat to be rescued had been at sea for 13 days. During the course of this operation the aircraft engaged flew over 55,000 miles.

Out of the very large number of attacks on U-Boats, many of which have been described in the Review, it would be invidious to select one as the best of the year, but mention may be made of a record performance by two Liberator aircraft of this Command in December, which prevented serious loss to an important convoy from America. Within nine hours these two planes sighted 13 U-Boats and 11 were attacked. At least one of them was sunk, three others were definitely damaged and the remainder crash-dived and were unable to launch their torpedoes at the convoy. The patrol of one of these Liberators lasted for 17 hours, during which eight sightings and seven attacks were made. This is described in the present issue.

Looking back on the year, it can be said that a considerable degree of progress has been achieved, the most important single factor being the development of the offensive. While some squadrons stand out in general efficiency and some remarkable feats have been performed by individual aircrews, there is still room for professional improvement in general, particularly in reducing the number of avoidable accidents and weapon failures, and in raising the standard of navigation and of operational procedure.

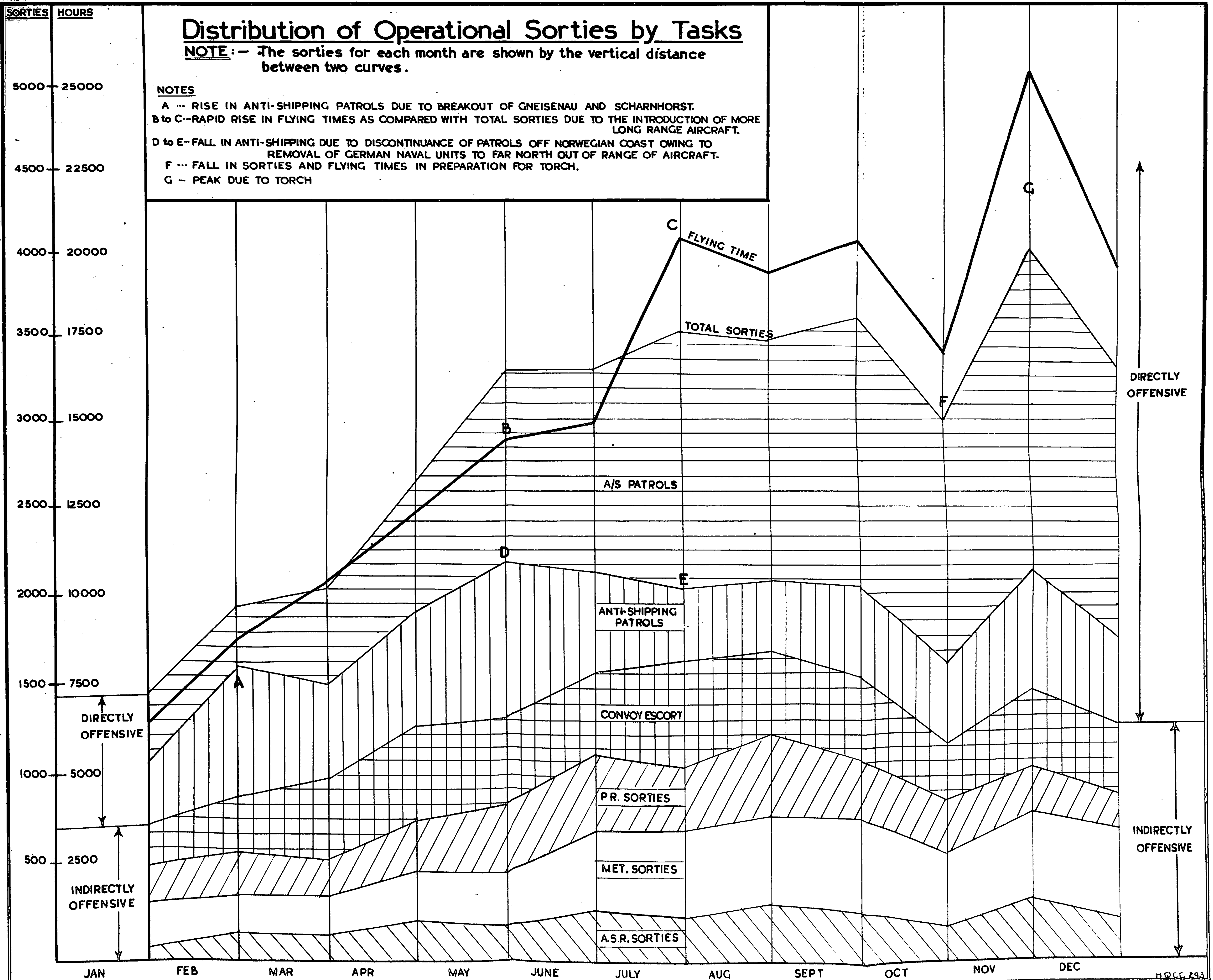

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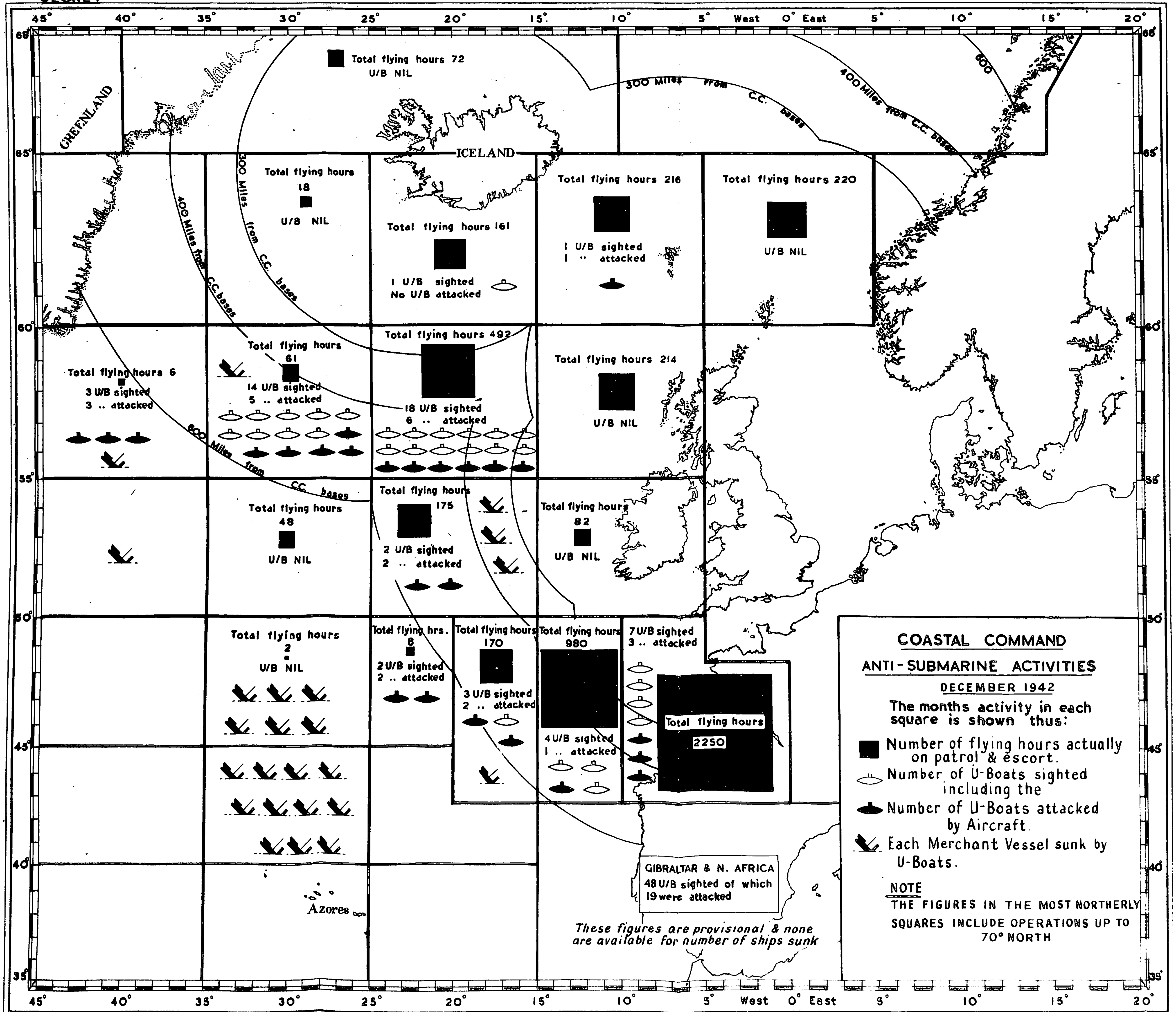
CHART 2.



I.—ANTI-SUBMARINE SECTION

Anti-Submarine Operations in December

(*See Chart 2*)

In December, 105 U-Boats were sighted and 44 attacked by depth-charge; in addition nine U-Boats were attacked with gunfire only.

The heavy air offensive of November in the Western Mediterranean seems to have driven away most of the U-Boats in that area; consequently as few as 43 sightings and 19 attacks were made in December by Coastal Command aircraft based on Gibraltar. No less than 24 of these sightings, however, followed by 19 attacks, were made by the Searchlight Wellingtons of 179 Squadron, as a result of about 125 sorties. Coastal Command aircraft based on the United Kingdom and Iceland made 55 sightings followed by 25 attacks; five of these sightings were followed up by hunts of one sortie each, the average length of sortie in the hunt area being four hours, but no second sightings were obtained.

In the Bay of Biscay air escort was again given to most of the North Africa convoys, but no sightings were obtained. The usual patrols in the Bay gave 13 sightings and six attacks, and two additional attacks further to the north were made by aircraft of No. 1 Squadron U.S.A.A.F. Only one U-Boat was sighted (and attacked) by anti-submarine aircraft in the Scotland–Iceland channel.

In the Western Approaches about 24 ships were sunk—all but five more than 600 miles from the nearest Coastal Command base. The U-Boats have carried on with their policy of attacking as far as possible outside the range of our aircraft. Packs have sometimes followed convoys into the area of air cover, but received sufficient aircraft attacks to force them off.

This is illustrated by the history of Convoy HX. 217, which is discussed fully on page 10, and to a lesser extent by other convoys. On the 14th, HX. 218 was escorted by a Liberator of 120 Squadron, which attacked two U-Boats, and the next day two more Liberators obtained a sighting apiece, followed by attacks; afterwards no more U-Boats were sighted and no more ships sunk. On the 17th, two U-Boats were sighted by a Liberator escort to ON. 153, then at about 800 miles from base; but both dived too soon for attack. Some days later the next ON convoy from Great Britain was also picked up by U-Boats. A sweep by another Liberator on the 26th, resulted in two sightings and attacks. But the convoy was moving out of range for air cover, and in the following days several ships were sunk.

Shipping Protection

The following table shows the amount of shipping passing through the Coastal Command area, and what proportion was given air protection :—

Type of Shipping.	*Number of Sailings.*	*Number Protected.*
Naval Forces and Convoys.	62	51
Independents ..	72	9

This protection was given by 292 sorties, divided as follows :—

Type of Shipping.	*Escorts.* *Met.*	*Escorts.* *Failed to Meet.*	*Sweeps round Convoy Tracks.*
Naval Forces and Convoys.	111	50	120
Independents ..	8	2	—

Analysis of Operations

This table analyses U-Boat sightings in terms of the different types of duty engaged in by aircraft, excluding those based on Gibraltar, and the average duration of the sorties in the area of operations. Hunts, offensive sweeps and anti-submarine patrols are classed together as "offensive operations" :—

	All Anti-Submarine Escorts.	Offensive Operations. Around Convoy Tracks.	Offensive Operations. Bay of Biscay.	Offensive Operations. Elsewhere.	Chance.	Coastal Command Total on Anti-submarine Work
U-Boats sighted	29	7	13	6	2	57
U-Boats attacked	10	5	6	4	—	25
Sorties	171	120	576	194	—	1,061
Average number of sorties per sighting.	6	17	44	31	—	19
Hours actually on patrol ..	420	659	2,260	768	—	4,107
Average duration of sorties, actually on patrol.	2½ hrs.	5½ hrs.	4 hrs.	4 hrs.	—	4 hrs.

Sightings and Attacks by Squadrons, December

Aircraft based on the United Kingdom or Iceland :—

Squadron.	*Aircraft.*	*Station.*	*Sightings.*	*Attacks.*
120	Liberators	Iceland and Ballykelly.	23	11
172	Searchlight Wellingtons	Chivenor	2	2
201	Sunderlands	Lough Erne	2	0
206	Fortresses	Benbecula	5	3
224	Liberators	Beaulieu	1	1
269	Hudsons	Iceland	3	1
405	Halifaxes	Beaulieu	2	0
502	Whitleys	St. Eval	3	1
612	Whitleys	Wick	1	1
10 O.T.U.	Whitleys	St. Eval	5	2
1 U.S.A.A.F.	Liberators	St. Eval	2	2
84 USN	Catalinas	Iceland	6	1
Transit aircraft	—	—	2	0
		TOTAL ..	57	25

Aircraft operating from Gibraltar (no information is available yet about aircraft from other Mediterranean bases) :—

		Sightings.	*Attacks.*
179	Searchlight Wellingtons	24	16
202	Sunderlands and Catalinas.	3	0
210	Catalinas	5	1
233	Hudsons	10	2
1404	Met. flight	1	0
	Transit aircraft	5	0
	TOTAL ..	48	19

Recent Attacks on Submarines

There have again been long delays in receiving full reports of attacks, so many of which have been carried out from bases outside the British Isles. But in any case the material available was so large that a number of attacks of great promise could not be described. One episode deserves special attention: **F/224,** flying at 6,000 ft., sighted a U-Boat at 8-miles range on a cloudless day, yet succeeded in attacking before it had completely submerged.

Again there is evidence that baiting tactics are not properly understood. One pilot waited half an hour on the scene of attack, and then made a series of 20-mile trips, returning between each. As he had one and a half hours P.L.E. in hand, he would have done better to have stayed away till the end of it, for an attacked U-Boat will stay deep for at least half an hour before even coming up to 30 ft. to look around through the periscope.

A U-Boat Crippled

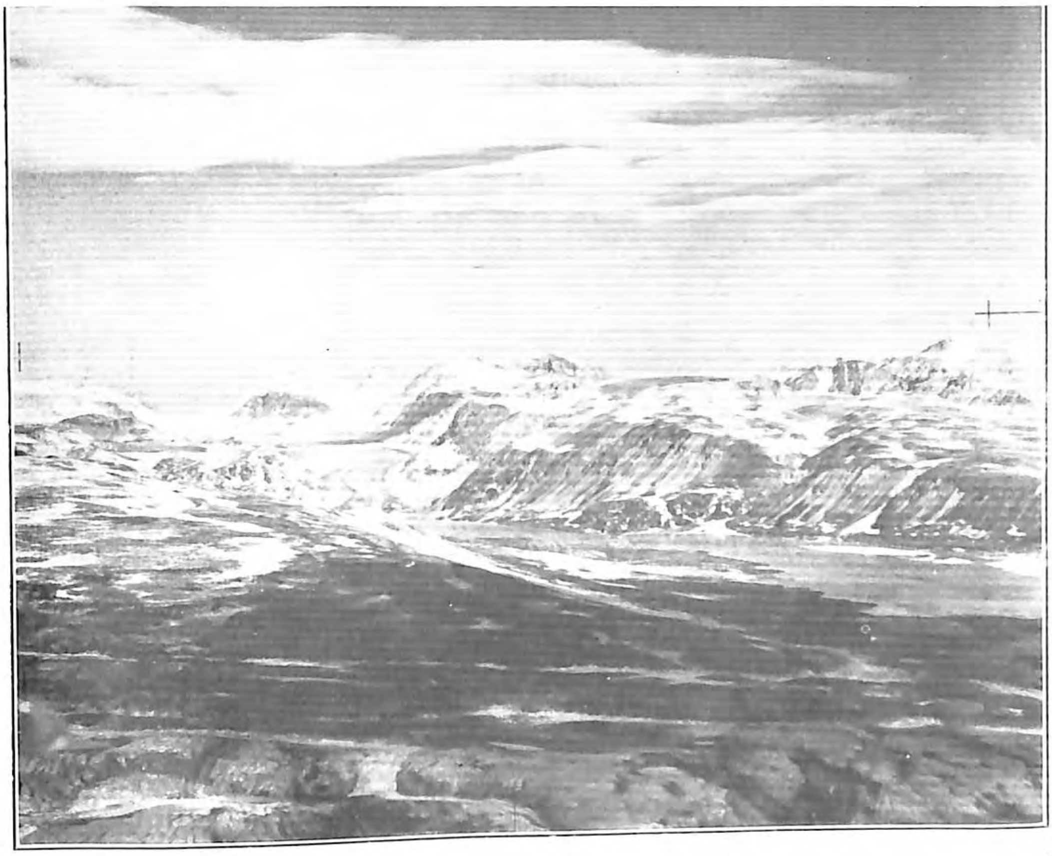
At 1403 hours on 11th November, **Hudson S/500** was flying off Algeria, when a 517-ton U-Boat was sighted 6 miles away on an easterly course. The pilot immediately turned to port, and dived to sea level about 1½ miles from the U-Boat, which had already begun to submerge. The attack was delivered from the U-Boat's port side at an angle of 80° to the track; four torpex depth-charges were released from 70 ft. about seven seconds after the U-Boat had disappeared. The stick straddled the U-Boat's line of advance, with its centre about 75 ft. ahead of the leading edge of the swirl. By the time the aircraft had circled, the U-Boat had resurfaced, having apparently blown all tanks to do so, as she was surrounded by large air bubbles and all forward way had ceased. As soon as the U-Boat surfaced, six or more of her crew manned the machine-gun on the conning-tower and opened fire on the aircraft, but were silenced by return fire from the Hudson. The aircraft then attacked again from astern of the U-Boat, using the front guns, after which the U-Boat's gun crew were seen prostrate on the bridge deck. The Hudson then circled and climbed to 1,500 ft., during which time further members of the crew came on deck. A bomb attack was then delivered from the U-Boat's port beam at an angle of 30° to the track, one 100-lb. A/S bomb being released from 1,500 ft., while the U-Boat's bows were awash. The bomb overshot by 30 yards. Two further front-gun attacks were made, and the U-Boat turned 180° to starboard, taking five minutes to do so. For the next half hour the U-Boat proceeded on a westerly course equally slowly, the aircraft opening fire whenever any movement was seen in the conning-tower. Having reached P.L.E., the aircraft had to set course for base, leaving the U-Boat with forward part awash and stern at full buoyancy. Without doubt serious damage had been caused, in addition to casualties to the crew, and the U-Boat may well have failed to return to port. (38° 00′ N., 04° 05′ E.)

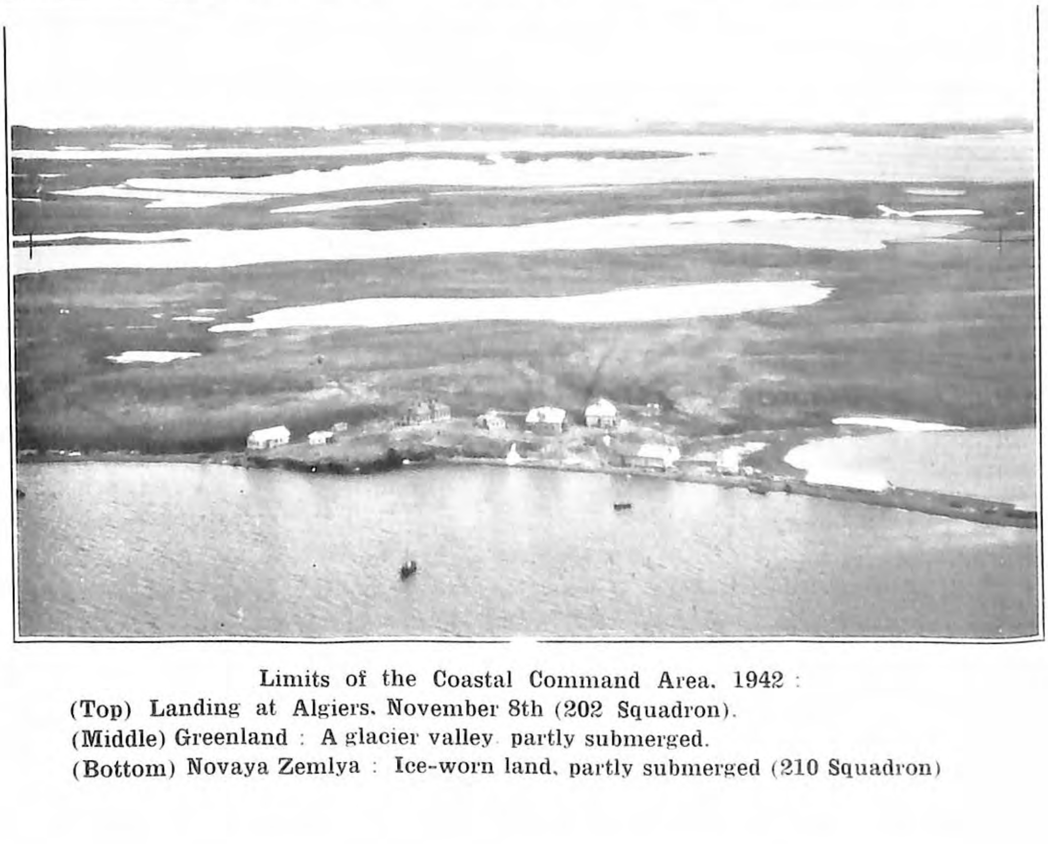
The Deck Broken Up

Hudson D/608 was on anti-submarine patrol in the Mediterranean off Cartagena on 13th November, when first the wake and then the conning-tower of a half-submerged U-Boat were sighted 12–15 miles away on the starboard beam. The conning-tower was painted Mediterranean blue. The aircraft took the shortest line of approach, and at 1205 hours attacked from the U-Boat's starboard side at right angles to the track, releasing from 30 ft., three torpex depth-charges only 18 seconds after the U-Boat had disappeared. The stick exploded 60–70 yards ahead of the swirl, with its centre on the U-Boat's track. This might have been just not lethal, but near enough to cause damage. Only depth-charge residue was observed before D/608 left on baiting procedure, but P/608, which was also in the vicinity, sighted some debris on the scene, two or three minutes after D had attacked. The debris consisted of small black objects two or three feet long, and might have been bits of the wooden slats from the upper deck. (37° 25′ N., 00° 12′ W.)

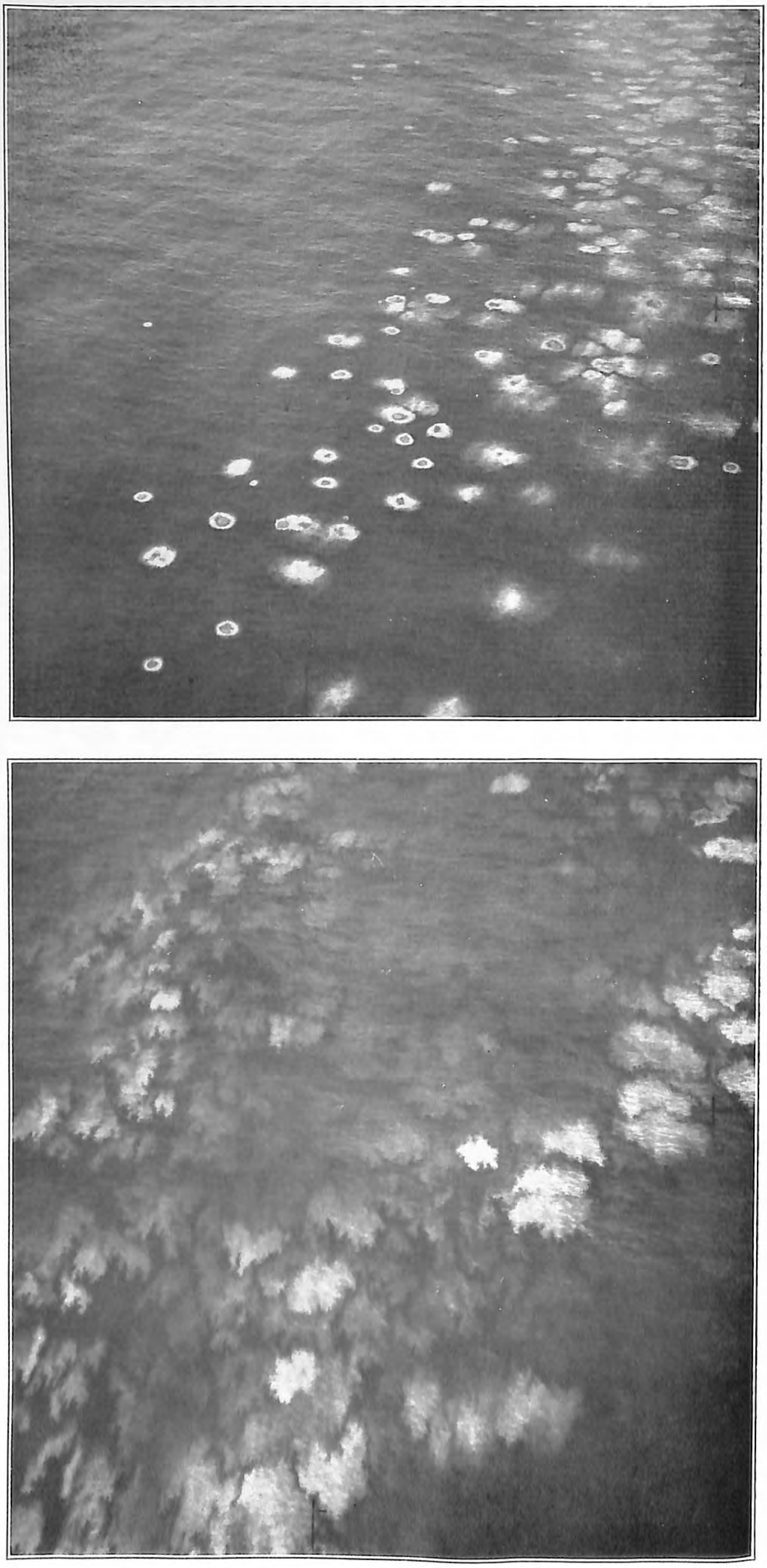
Attack by Two Hudsons

Flying in the Mediterranean on 14th November, **Hudson D/608** sighted at 0942 hours a wake 25 miles away, which at 18 miles was identified as a U-Boat's. The aircraft attacked from the U-Boat's starboard bow at 30° to the track, releasing from 30–50 ft., four Mark XI torpex depth-charges, while the U-Boat was still fully surfaced. Three depth-charges certainly exploded,





Limits of the Coastal Command Area, 1942 :
(Top) Landing at Algiers, November 8th (202 Squadron).
(Middle) Greenland : A glacier valley partly submerged.
(Bottom) Novaya Zemlya : Ice-worn land, partly submerged (210 Squadron)



Oil bubbles rising and (a minute later) spreading at the head of a streak left by an attacked U-Boat (1407 Flight).

water being thrown up on either side of the hull; the fourth struck the U-Boat abaft the conning-tower on the port side and is believed to have exploded. The U-Boat apparently submerged on a level keel immediately after the attack. As soon as it had done so, a large patch of oil, 250 yards across, appeared on the surface. Five to eight minutes later, the U-Boat re-surfaced 200 yards ahead of the swirl, and was immediately attacked with machine-gun fire, hits being estimated. At this juncture **L/608** appeared on the scene, having sighted the depth-charge explosion 15 miles away, and proceeded to deliver another attack from the port bow, with four Mark XI torpex depth-charges, while the U-Boat was still surfaced. The stick straddled the U-Boat from port to starboard, two depth-charges falling on each side, with the nearest 15 ft. to starboard. The U-Boat appeared to lift in the water, and then settled by the stern; it cruised slowly in tight left-hand circles, down by the stern and with the bows high above the water. There were oil streaks in the water. L/608 then made a diving attack with the front guns, scoring hits from stem to stern and on the conning-tower. The Hudson sustained hits on the starboard wing from cannon-shell; also it was momentarily threatened by a Ju.88 that dived out of a cloud but was driven off by gunfire before it could open fire. It is questionable whether the U-Boat's injuries would have allowed it to make port, even had it not been attacked later by other Hudsons of 500 Squadron, based on North Africa, from which no reports are available. It was very probably the one that was later beached near Oran. (36° 25′ N., 00° 08′ W.)

The Stern Blown Upwards

Hudson S/608 was on an anti-submarine sweep west of Gibraltar on the morning of 14th November, when a submarine travelling at 2 knots was sighted on the surface 5 miles away. It was believed to be Italian. At 1105 hours, the aircraft attacked up the track, releasing from 100 ft., four Mark XI torpex depth-charges while the submarine was still fully surfaced. The stick fell along the track, No. 4 falling underneath the stern. When the aircraft pulled away, the rear gunner saw the stern rise out of the water at an angle of apparently 60° as the fourth depth-charge exploded. The submarine then disappeared. Immediately after the explosions, gushes of oil came to the surface, followed by one large stream of air, indicating that serious damage had been inflicted on the submarine. The aircraft remained in the vicinity for 35 minutes, by which time a patch of rather thin oil was covering an area of about one mile by half a mile. (36° 03′ N., 11° 13′ W.)

Presumably a Kill

Hudson B/233, flying in visibility of 20 miles in the Mediterranean, on 14th November, sighted a wake 12 miles away, and when five miles distant, a U-Boat was seen on the surface travelling at 12 knots. At 1615 hours the aircraft attacked from the U-Boat's starboard bow at an angle of 20° to the track, releasing from 40 ft. three Mark XI torpex depth-charges (a fourth hung up), while the conning-tower was still above water and the decks could be seen just below the surface. The explosions straddled the hull, No. 1 directly forward of the conning-tower to starboard, No. 2 abaft the conning-tower slightly to port, and No. 3 also to port near the stern. The U-Boat's hull was lifted by the explosions, and 30 ft. of the stern rose clear of the water at an angle which looked like 45°, after which the U-Boat slid under water, disappearing in about five seconds and leaving no swirl. Immediately afterwards an oil-patch appeared; it was brownish and 100 yards across, and had many small light brown objects floating in it. This evidence points to serious damage if not destruction of the U-Boat. (36° 20′ N., 01° 01′ W.)

Explosion of a U-Boat

At 1003 hours on 15th November **Hudson S/500** was flying an anti-submarine sweep off Algiers, when a U-Boat of the 517-ton type was sighted ten miles off, proceeding at ten knots. The aircraft dived to sea level; the U-Boat began to submerge when it was four miles away. The Hudson delivered its attack from the port side of the U-Boat, releasing from 70 ft. four Mark XI torpex depth-charges while the top of the conning-tower was still visible. The stick straddled the U-Boat; two seconds after the release a violent explosion took place, and according to the rear gunner two more large explosions occurred simultaneously in the U-Boat, removing the main gun and most of the conning-tower. Nos. 1, 3 and 4 depth-charges then exploded, No. 1 to port and the others to starboard of the U-Boat. When the spray of the explosions subsided, the U-Boat's bows were on the surface in the middle of an area of air bubbles; it stayed so for half a minute and then disappeared. Owing to the damage sustained by the aircraft in the first large explosion, nothing further could be observed, but it seems clear that No. 2 depth-charge exploded on impact with the U-Boat and may have caused an internal explosion—possibly the spare air torpedoes in the casing had warheads on with pistols fitted. At any rate the U-Boat appears to have been effectively destroyed. The first large explosion blew the aircraft 300 ft. up, removed the rudders and elevators, jammed the ailerons and bent six feet of each wing-tip at right angles. The port engine cut after 20 minutes, the crew baled out at 1,500 ft. and landed in the water of Algiers Bay. Two were lost. (37° 20′ N., 03° 05′ E.)

Miles of Oil

Hudson Y/500 was flying in the Mediterranean in visibility of 25–30 miles on 15th November, when a wake, later identified as a U-Boat's, was sighted at 20 miles range at 1015 hours. The aircraft attacked from the port quarter, at 30–40° to the track, releasing from 50–60 ft. four Mark XI torpex depth-charges, while the U-Boat was crash-diving. It had its bows under water, conning-tower above water and stern projecting at an angle of 45°; the tanks were seen blowing. The depth-charges exploded with the centre of the stick on the U-Boat's bow. Five or six minutes after the attack, air bubbles of 10–15 ft. diameter surfaced continuously for four minutes, oil appeared round them, and more oil rose over an area 200–300 yards across, just ahead of the explosion and spread till three-quarters of an hour later it extended 4–5 miles. This after evidence indicates the destruction of the U-Boat. (37° 36′ N., 01° 58′ E.)

Countering a Dive to Port

Hudson S/233 was flying on an anti-submarine sweep in the Atlantic west of Gibraltar on 15th November, when at 1318 hours a U-Boat was sighted ten miles off. It was of the German "U 27" class, and travelling at 12 knots. The pilot turned off to gain cloud cover, and stalked the U-Boat for 12 minutes until he had worked round astern of it. Then he attacked on the starboard quarter at an angle of 20° to the track, releasing four torpex depth-charges from 50 ft., five seconds after the U-Boat disappeared. It dived under port wheel—it could still be seen under water at the time of release. The stick dropped along the swirl, No. 1 depth-charge falling in the leading edge. The range was correct, but it is not possible to say whether in the short time the U-Boat had turned sufficiently to port to make the stick lethal for line. Two minutes after the attack, an oil-patch, measuring 125–150 yards by 70–80 yards, appeared with bubbles, indicating that one or more of the depth-charges were close enough to damage the fuel tanks, but that does not necessarily mean that any were close enough to fracture the pressure-hull. (36° 40′ N., 10° 43′ W.)

Failure and Success by Night

On the night of 24/25th November, **Whitley E/502** was on a combined anti-submarine and anti-shipping patrol over the Bay of Biscay, when at one minute past midnight a Special Equipment contact was obtained slightly to port at four miles ahead. The aircraft homed, immediately sighted a wake, and when practically over it identified a fully surfaced U-Boat in position 47° 27′ N., 04° 00′ W., proceeding eastwards at twelve knots. The aircraft circled to port and again homed; when the U-Boat again came into view it was in a position where it could not be attacked. The aircraft circled again, but failed to pick up any further contacts, and resumed its patrol. After several more contacts, which investigation traced to tunnymen, a further contact was obtained at 0250 hours at a range of four miles on the port bow. The aircraft homed, and a wake was seen two miles away; then a U-Boat was found, travelling eastwards at twelve knots. This U-Boat was possibly a 740-ton German type. The aircraft attacked it with four G.P. bombs, which overshot by about 100 yards. As the aircraft passed over, the U-Boat opened fire with cannon, to which the rear gunner replied. The Whitley then circled to port, flew on a track parallel to that of the U-Boat until it was well ahead, and then turned 180° to port to carry out a second attack, in which it released a further four 250-lb. G.P. bombs. As the U-Boat began to dive, the first bomb hit it just abaft the cannon, which was still firing at the aircraft; the other three exploded along its starboard side. The rear gunner saw a distinctly yellow flash on the deck just abaft the conning-tower, with three other white flashes along the starboard side of the U-Boat—the flashes of the explosions of the previous stick were all white. The aircraft experienced a much bigger bump from the explosions of this second stick, a fact which could not be explained by the difference in height of only 100 ft. in the two attacks. When the aircraft went down and switched on its landing lights, an oil patch was seen about 150 yards by 40 yards with a white foam patch about 50 ft. across in its centre, and a second patch of oil just ahead of the first was about 40 yards across. A 250-lb. G.P. bomb is quite capable of fracturing a U-Boat's pressure-hull, and the evidence of oil and foam seems to confirm the claim of a direct hit and to hold out every possibility of the U-Boat having been destroyed. (47° 40′ N., 04° 42′ W.)

Attacks on an Escorted U-Boat

At 1115 hours on 27th November, **Halifax J/405** was flying on an anti-submarine patrol off the Basque coast, when a U-Boat was sighted in the wake of an escort vessel, with a second escort vessel of "T.B." class bearing 330° from it. The U-Boat was of the 517-ton type, similar to "U.45," and was travelling at ten knots. The aircraft altered course, and the escort vessels fell back on the U-Boat's quarter and opened intense flak. The aircraft attacked down sun from the U-Boat's starboard side at right angles to the track, releasing six torpex depth-charges from 200 ft., while the U-Boat was fully surfaced. Just before their release the U-Boat turned away from the aircraft, and the stick fell towards its stern; no result was observed, as the escort vessels were putting up an intense barrage of flak. The U-Boat now turned 180° to port, and the aircraft turned and made a second attack from the port side, releasing from 50 ft. three torpex depth-charges, while the U-Boat was still fully surfaced. This stick fell across the conning-tower with No. 1, a few feet short, and No. 2 on or below the conning-tower; No. 3 was not observed. The U-Boat was lost to sight in swirl and explosions while the aircraft was avoiding the flak from the escort vessels, which were now very close. The Halifax's trailing aerial was shot away, but none of the crew was injured. When the aircraft came out of cloud it could not find either the U-Boat or the escorts. Probably this U-Boat was the one attacked six hours afterwards by T/59 in Hendaye Bay, where it had no doubt gone for refuge as a result of the injuries inflicted by J/405's second attack. (43° 35′ N., 02° 55′ W.)

Liberator T/59, flew an anti-shipping patrol off the north coast of Spain, on 27th November, sighting many Spanish trawlers and merchant vessels, mostly inside territorial waters. At 1732 hours, three merchant vessels were sighted heading out of Hendaye Bay, all of them like shortened tankers with a funnel aft and a high bridge structure of a type similar to the German U-Boat tender *Memel.* On sighting the aircraft the ships turned back towards the coast. Immediately afterwards the Liberator sighted a German 500-ton type U-Boat on the surface, one and a half miles away, proceeding at four knots, probably the same one that was attacked by J/405 six hours previously. Almost simultaneously a destroyer was sighted half a mile astern of the U-Boat. As the Liberator passed over the merchant vessels, they opened fire; so did the destroyer when it came within range. The aircraft passed to the east of these ships, circled, and climbed to 1,500 ft., then passed over the destroyer, dropping six 250-lb. G.P. bombs, and immediately afterwards released six more at the U-Boat, which was still fully surfaced. After attacking the U-Boat the aircraft at once took cloud cover. As the aircraft left the scene after breaking cloud, the destroyer was still firing at it, but the U-Boat could not be seen in the gathering dusk. Violent evasive action prevented any accurate observation of the results during this very determined attack, and poor visibility and continuous flak prevented the aircraft returning to try and see what had happened. (43° 23′ N., 01° 47′ W.)

A Flare Attack

Whitley C/502 was flying at 4,000 ft. on anti-submarine patrol in the Bay of Biscay on 1st December, when at 0533 hours a Special Equipment contact was received, dead ahead at a range of eight miles. The pilot began to lose height to 1,500 ft., but the contact disappeared into the sea return at two miles. As the aircraft tracked over, however, the second pilot, who was in the front turret, saw the dim shape of a vessel half a mile ahead. The aircraft continued on the same course for six miles, and then circled on to reciprocal, losing height down to 1,000 ft. Special Equipment contact was regained at four miles' range, and as the aircraft approached at 0543 hours the second pilot again sighted a vessel, with a V-shaped bow wave and wake, on the Whitley's port bow. The pilot continued flying on the same course for four or five miles, and then turned to port, intending to carry out a direct visual attack, but the visibility was so poor that he finally decided to carry out a flare attack instead. Special Equipment contact was again obtained three or four miles' ahead, and the pilot set course so as to keep the U-Boat three or four points on his starboard bow, and began to climb. The Special Equipment contact disappeared into the sea return at one mile; 30–40 seconds later, a 4·5-in. recce flare (35 fuse) was dropped about a quarter of a mile on the port quarter of the U-Boat's estimated position. The aircraft turned to starboard, and as the flare ignited, the U-Boat was sighted on the surface proceeding in a north-easterly direction at eight knots. When the aircraft was a quarter of a mile on the U-Boat's starboard bow, a dark object, believed to be the conning-tower, was seen in the middle of a swirl. At 0548 hours the Whitley attacked from the starboard bow at an angle of 30° to the track, releasing six torpex depth-charges from 150 ft., 1–5 seconds after the U-Boat disappeared. The rear gunner estimated that the explosions were in approximately the same position relative to the flare as the U-Boat which he had observed about half a minute before; immediately afterwards the flare hit the water, and the crew could see no more. Such are the inherent limitations of flares that the results of this exceedingly careful and well-executed approach and attack under difficult conditions were almost as favourable as can ever be expected. (46° 50′ N., 06° 50′ W.)

Seven U-Boats attacked, one Sunk

On 8th December, **Liberator B/120** was flying over the Atlantic, south-east of Greenland, on offensive cover to convoy HX.217, when at 0928 hours a U-Boat was sighted a mile and a half on the port bow and eleven miles from the convoy. The aircraft continued on the same course of 231° for one minute, as it was impossible to make an immediate attack, and then turned 180° and approached the U-Boat up-track. A mile away from the U-Boat, the Liberator dived from 1,500 ft. and delivered an attack from 50 ft. with six Mark XI torpex depth-charges, while 40 ft. of the U-Boat's stern was still visible, projecting from the water at an angle of apparently 30°. The stick completely straddled the U-Boat from stern to bow; the actual line of attack was almost up-track, being 10° on the U-Boat's starboard quarter and dead up-wind. After the explosion of the first depth-charge, the stern was still visible in the same attitude, but during the remaining explosions it disappeared from view, and during either the third or the fourth explosion a metal object, at least six feet long, was blown about 40 ft. up into the air, and fell back into the sea with a large splash ahead of the explosions. As soon as the main explosion spray had subsided, an eruption about six feet high was seen on the forward edge of the explosion mark. One minute later the leading two-thirds of the mark was covered with dark brown oil, the remaining third being of a turquoise blue—presumably the result of finely divided air bubbles in clear water. Two marine markers were dropped on the position of the attack. A quarter of an hour later the aircraft rejoined the convoy, and informed them of the attack and the large oil patch. When the Liberator returned half an hour afterwards, a corvette had been despatched from the convoy and was approaching the scene of the attack. By this time the oil patch had elongated in streaks down-wind to about 800 yards in length and 130 yards in width. From the air it was clear that many small pieces of yellow wood, 6–18 ins. long, were floating in the streaks, with a large number of sea-gulls wheeling round them. The aircraft directed the corvette to the oil patch by means of Very lights, and shortly afterwards the corvette reported seeing parts of dead bodies and wreckage off the after-deck floating in the water, adding "You have certainly got him." There is thus no doubt that the U-Boat was sunk, but it is worth noting that the photographs of the oil patch taken by the aircraft disclose nothing unusual—after several attacks photographs have shown very similar patches of oil. Although the aircraft's visual evidence of wreckage would have been put forward as a claim for serious damage, destruction could not have been claimed without the corvette's positive evidence. (57° 25′ N., 35° 19′ W.)

At noon that same day B/120 sighted two U-Boats on the surface two miles on the port bow, 20 miles from the convoy. The aircraft turned and dived to attack the more distant U-Boat, as the other had almost submerged. The attack was delivered from the starboard bow at 70° to the track, and the remaining two Mark XI torpex depth-charges were released ·16 seconds after the U-Boat disappeared. The U-Boat left a long streak of oil behind the swirl. The stick straddled the line of advance about 200 ft. ahead of the apex of the swirl, which should mean that it exploded just by the conning-tower but about 20 ft. over the top of the pressure-hull. When the spray was subsiding, an upheaval of water was seen about 50 ft. ahead of the explosion mark; it was about 30 ft. high, and consisted of solid white water with no spray. No other after effects were seen. The upheaval seems to have been considerably more violent than any which could be caused by the U-Boat blowing its main ballast, and might indicate either an internal explosion in the U-Boat or a delayed explosion of one of the depth-charges, which would have put it within lethal range of the pressure-hull. It is, however, difficult at present to assess the damage, if any, caused to the U-Boat. (57° 37′ N., 34° 43′ W.)

During the remainder of its sweep the aircraft made five further sightings of U-Boats (making eight in all), which were all attacked by cannon fire.

A Searchlight Kill

At 0405 hours on 25th December, Searchlight **Wellington C/172,** flying over the Bay of Biscay, received a Special Equipment contact on the beam aerial to port at a range of 6½ miles. The aircraft homed, and four minutes later switched on the searchlight, illuminating a U-Boat three-quarters of a mile away on the surface. The aircraft made a diving attack from the U-Boat's port beam, releasing from 50 ft. four torpex depth-charges, while the U-Boat was fully surfaced. The rear-gunner saw the stick explode on either side of the conning-tower and completely envelop the U-Boat amidships. The U-Boat's bows were lifted out of the water, and he then saw a purplish-blue flash in the middle of the spray, which was also seen from the astrodome. As the aircraft passed over, the rear-gunner fired about 50 rounds at the U-Boat. Two or three minutes later the crew observed a boiling mass of white foam, about ten yards across; three minutes later still there were two such patches, joined together and boiling more violently than before. The continuation for at least six minutes of the "boiling foam" indicates that the U-Boat was destroyed. (45° 55′ N., 06° 00′ W.)

Air Protection to Recent Convoys

The previous article published in No. 7 of the *Coastal Command Review* analysed five convoy actions from the air point of view in a certain period of time. It so happened that once these convoys came under cover of Coastal aircraft, sinkings ceased and the rest of the passage was relatively uneventful. This is no unusual occurrence for, as the records show, the combination of surface escort and aircraft more often than not achieves this result. But there must be occasions, even if they are comparatively rare, on which the spell fails to act and losses follow. The case of the HX.212 illustrates one of these.

HX.212 (Chart 3)

The HX.212 was dogged by bad weather from the time the mouth of the Gulf of St. Lawrence was cleared. On the 21st October and again on the 22nd an escort was provided, but from then on until the limits of the Eastern Air Command's patrols were crossed early on the 26th, sorties had to be recalled or cancelled. There was reason to believe that, despite the weather conditions, U-Boats in the area were aware of the presence of the convoy: and indeed, on 21st October a Hudson from Canada sighted and attacked a U-Boat several hundred miles ahead of the convoy.

On the 26th October the convoy was in the area 52° to 54° N. and 37° to 40° W. The sea was rough with a heavy swell. Iceland had to close down, and it was impossible to provide air cover throughout the day during which the build-up of U-Boats became increasingly apparent. Conditions were much the same on the 27th. At 2108 hours that night, two ships were sunk, to be followed by another at 0345 hours on the 28th, while a fourth was torpedoed at some time during the night but left afloat.

Flying was possible on the 28th and one Liberator (120 Squadron) carried out a close escort on the convoy from 0909 hours to 1755 hours. At 1510 hours, 1530 hours, and 1736 hours, U-Boats were sighted and the second of these was attacked. Touch was maintained with the S.N.O. escort, as a result of which, to quote the account given in the *Admiralty Statistical Review* for October, "the escort kept down three U-Boats which had been pointed out by the Liberator." During the course of the 28th, the convoy had made an alteration in course to avoid an area suspected to contain U-Boats. Possibly because of this, and also because of the bad weather conditions which were reported by aircraft as one mile at 0900 hours increasing to a variable maximum at noon of 10 miles, three Fortresses (206 Squadron) and one Liberator (120 Squadron) despatched on October 29th, failed to meet the convoy. It is probable that the bad weather, combined with the fact that the convoy is believed to have been some 30–40 miles behind its assumed position due to evasive action, was responsible for this. One aircraft after searching for three to four hours, contacted an SC. Convoy which thus came in for air cover not rightly its due. Meanwhile, further U-Boat attacks had materialised; two ships were sunk, one damaged and later sunk by our own action, and one damaged. At least two and possibly three of these sinkings occurred in daylight.

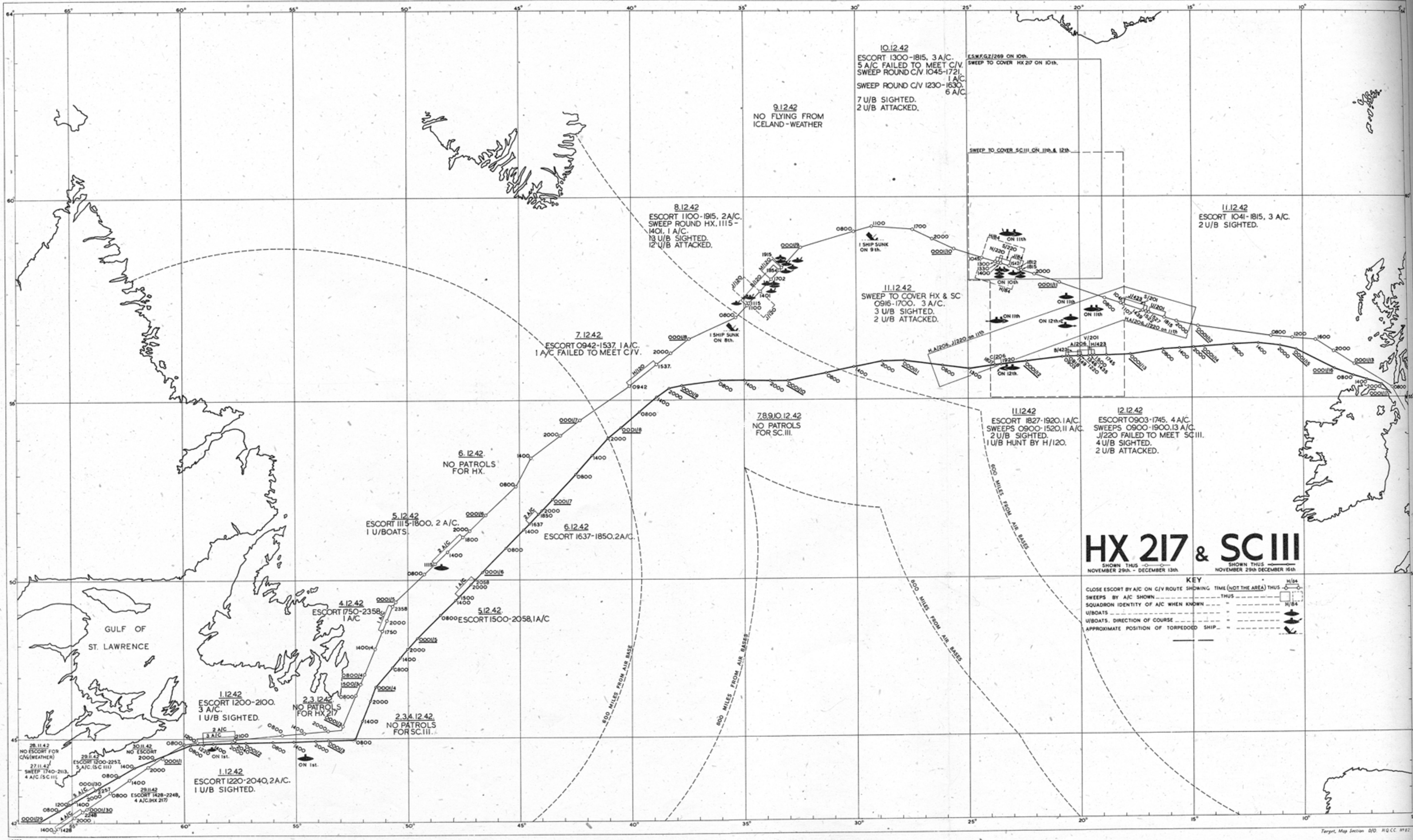
On the 30th, one Liberator (120 Squadron) and one Sunderland (201 Squadron) gave close escort from 1137 hours to 1915 hours without incident, the convoy arriving in harbour on 1st November.

There were at least five U-Boats present at the critical period. The escort was particularly active but they were hampered by having to attend to both damaged ships and stragglers. In this case the odds proved too heavy, and the inability to break up the concentration effectively on the 28th and to provide air cover on the 29th, undoubtedly led to at least two sinkings on the latter day. It should be said that these remarks do not imply that the Captains and aircrews concerned were in any way to blame for this: circumstances, not individual action, were responsible.

The lessons to be drawn from this action mostly concern higher policy but perhaps the following comments may be made :—

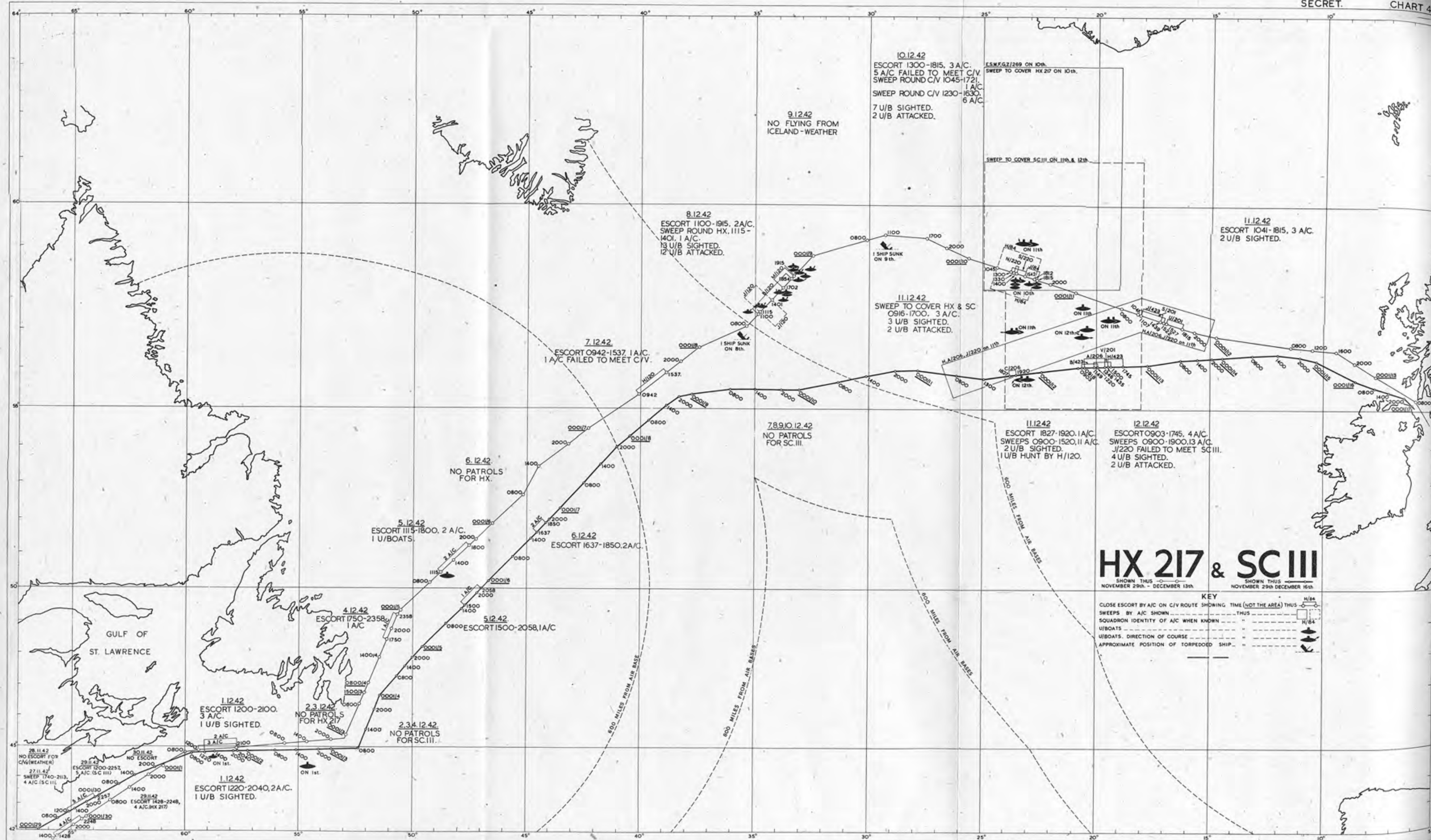
(*a*) It is of greatest importance to contact a convoy in the early stages of the U-Boat build-up. The impracticability of doing so on the 27th, and the bad weather conditions on the 28th, which probably restricted the number of sightings, allowed the U-Boats to become well established round the convoy. As a result of the convoy being not met on the 29th, further attacks materialised.

SECRET. CHART 4.



6070.

SECRET. CHART 4.



6070.

Target, Map Section

(*b*) The most exact knowledge of the convoy position is essential, particularly when conditions are bad. Evasion, which is often most necessary, and certainly cannot be restricted, may in some cases be a contributory cause to not meeting.

(*c*) The importance of homing procedure.

(*d*) The dependence upon bases remaining open. Unfortunately at the critical time there was no alternative base. It may be noted that ability to operate from two or more separated bases increases very materially the chances of being able to operate in the Atlantic.

The history of the HX.212 may not be without blemish but, as is often the case, it is particularly instructive. That of the next convoy to be considered is likely to become a classic, for it shows to the full the power of escorts and aircraft to break up the heaviest U-Boat concentration.

HX.217 and SC.111

At the time of writing these notes, full information is not available and in particular, details of the action of surface craft are lacking. It is known, however, that they were most active in the defence of the convoy and that they had a number of engagements. It is hoped that at a later date it may be possible to publish a full account giving in detail the parts played by air and surface craft since there is every reason to believe that it will provide most valuable reading and many lessons which will repay study.

The two convoys travelled on routes sufficiently close to each other to become involved with what was probably the same pack of U-Boats and so their stories become interlocked at the critical period. For the sake of clarity it is proposed to deal with them separately.

HX.217 (Chart 4)

The HX.217 cleared the mouth of the St. Lawrence River between the 1st and 3rd December. During the afternoon of the 1st, three escorts were provided by Eastern Air Command and one U-Boat was sighted at a short distance from the convoy. No attack was made but an escort vessel was directed to the position. An escort on SC.111, then in the neighbourhood, sighted a U-Boat near that convoy and well ahead of the HX.217. It was clear from this and other indications that the sailing of these convoys was known to the U-Boats almost from the beginning of their passage.

On the afternoon of the 4th and again between 1115 and 1800 hours on the 5th, sorties were flown from Canada and almost immediately after meeting the convoy on the latter date the aircraft sighted and put down a U-Boat. No further air cover was given, and soon after 0200 hours on the 7th the 600-miles radius from the Canadian coast was crossed. So far the convoy had come through without loss but there was ample evidence of trouble in store.

On 7th December, two Liberators (120 Squadron) were despatched from Iceland. One was forced to return owing to engine trouble and did not meet the convoy. The second maintained a close escort from 0942 to 1537 hours. It is noteworthy that the convoy was met in approximately 55° 30′ N., 40° W., more than 800 miles from base. Full information on the prevailing weather conditions has not yet been received but it is known that they were at least indifferent, which makes meeting at this range a remarkable navigational achievement.

The 7th passed without incident. In the early hours of the 8th one ship was torpedoed and sunk in position 56° 55′ N., 35° 15′ W. During the day, one Liberator (120 Squadron) provided escort while two Liberators of the same squadron carried out a sweep for thirty miles round and ahead of the convoy between 1150 and 1401 hours and 1702 and 1915 hours respectively.

The experiences of two of the Liberators (B, the same aircraft which had had engine trouble the day before, and M) are probably the most remarkable in the annals of convoy protection.

B/120 joined the convoy at 1100 hours and escorted it until 1854 hours and during this period sighted no less than eight U-Boats and by one means or another made seven attacks. It will perhaps be more convenient to tabulate these attacks as follows (*see also* p. 9) :—

Sighting No.	*Time.*	*Action Taken.*	*Remarks.*
1	1127	6 depth-charges	Position : 57° 25′ N., 35° 19′ W. Stick straddled conning-tower. Eruption of water, oil in quantity, pieces of yellow wood. Seagulls over the oil patch. Corvette investigated the scene and reported debris, including human remains. U-Boat sunk.
2 3	1245	2 depth-charges	Assessment not complete. Eruption of water 13 ft. high seen 3 secs. after explosions. Attack analyses well.
4	1426	60 rds. cannon fire	
5	1449	60 rds. cannon fire	
6	1524	60 rds. cannon fire	
7	1619	60 rds. cannon fire	
8	1643	60 rds. cannon fire 100 rds. m/g fire	

Meanwhile M/120 met the convoy at 1702 hours and swept in the convoy area for a little more than two hours. During this time five sightings were made; the first and third U-Boats were attacked with nine and one depth-charges respectively, and the fourth and fifth with machine-gun fire.

At the time of writing, full information upon, and assessment of, the attacks of these two aircraft are not available. It is probable that there were between 8 and 12 U-Boats round the convoy and the fact that 13 sightings and 11 attacks were made, one of which was lethal, undoubtedly broke up what was intended to be an overwhelming concentration; and it must be remembered that through this and succeeding days and nights the surface escorts were equally active participants in the battle.

On the 9th, the weather, at no time good, so far deteriorated that no flying was possible. At 0815 hours one ship was sunk in 58° 59′ N., 29° 14′ W. That only one ship was lost serves to show how effective the actions of the day before had been and to emphasize what might have happened on this day, when no air cover was possible, if it had not been available on the previous day.

Flying became possible on the 10th and support was given from both Iceland and the United Kingdom.

(*a*) One Catalina (210 Squadron) was despatched from Sullom Voe owing to the convoy being on the edge of the range of land-based aircraft. The convoy was not located. The overall flying time was from 0028 hours to 1940 hours.

(*b*) Six Hudsons (269 Squadron) swept an area covering the convoy between 58° and 63° N. and 19° and 25° W. One U-Boat was sighted and attacked.

(*c*) Four Catalinas (84 U.S. Squadron) carried out sweeps to a radius of 30 miles round the convoy. The first was on the convoy from 1210 hours to 1721 hours, having probably reached the area two hours earlier. Six U-Boats were sighted. Five were put down but not attacked. The sixth, attacked at 1603 hours with one U.S.N. depth bomb, was at least very badly damaged and probably sunk. Debris and two bodies were seen. The second Catalina escorted the convoy from 1542 to 1815 hours. The third Catalina swept in the area from 1659 to 1812 hours without incident or sighting the convoy. The fourth also failed to meet.

(*d*) Three Fortresses (220 Squadron) were despatched for close escort and two met the convoy, escorting from 1300 to 1542 hours and 1330 to 1400 hours respectively. The convoy was then at extreme range for these aircraft and this accounts for the short time on escort.

(*e*) One Fortress (206 Squadron) also failed to meet and was forced to return early owing to technical trouble.

At this point the destinies of the HX.217 and SC.111 become intermixed. It is proposed, therefore, to break off tracing the course of the first convoy and to introduce briefly the story of the SC.111.

SC.111 (Chart 4)

The SC.111 passed the mouth of the St. Lawrence on an easterly course between 1st and 3rd December, and crossed the 600-mile radius from Canadian bases just before midnight on the 7th. Air cover was given on the 1st, when two U-Boats were sighted, one close to the convoy and one some considerable distance ahead; and again on the 6th and 7th. On the 6th a sighting was made, well on the port side of the convoy. No specific air cover was given to this convoy until 11th December, although it will be recollected that a considerable amount of flying was taking place on the 8th and 10th in connection with the HX.217, upon which the U-Boats were concentrating. It can be seen from Chart 4 that the two convoys were converging and that the position of the HX.217 was slightly in advance of the SC.111 and near the intersection of the lines of their routes. The U-Boats were mostly concentrated between the two convoys, and thus air cover to either operated in favour of both.

HX.217 and SC.111, 11th December

The action taken was as follows:—

(*a*) Two Fortresses (206 Squadron) and one Fortress (220 Squadron) carried out a sweep covering both convoys between 0916 and 1700 hours.

One Fortress (206 Squadron) sighted three U-Boats and attacked two.

(*b*) Two Sunderlands of 201 Squadron and one of 423 Squadron, escorted HX.217 from 1041 to 1522 and 1527 to 1815 hours, and 1107 to 1439 hours, respectively.

These flights were characterised by exceptionally good liaison with S.N.O. Escort, who despatched them on hunting missions with the result that two sightings but no attack was made.

(*c*) One Sunderland (423 Squadron) was sent to hunt U-Boats known to be in the area, one of which was sighted as mentioned above.

(*d*) Six Hudsons (269 Squadron) from Iceland swept the area to the north of the SC.111 from 1025 hours to 1134 hours, and two sighted U-Boats some 180 miles from the convoy. Up to the present, no information is available as to the action taken.

(*e*) One Fortress (206 Squadron) escorted the SC.111 from 1827 to 1920 hours.

(*f*) Five Catalinas (84 U.S. Squadron), carried out a sweep between 0900 and 1520 hours, north of the convoy, without result.

(*g*) One Liberator (120 Squadron) hunted the U-Boat mentioned in (*d*) between 1638–1830 hours without result.

By 12th December, the HX.217 was well within the 400-mile line beyond which this very persistent U-Boat pack did not dare to venture further.

The SC.111 had to run the gauntlet for one more day, during which the following action took place :—

(*a*) Two Sunderlands (423 Squadron) escorted from 0903–1230 hours and 1435 to 1735 hours respectively, one Fortress (206 Squadron) from 0918 hours to 1346 hours and one Sunderland (201 Squadron) from 1149–1500 hours.

(*b*) The Fortress (206 Squadron) of the above was despatched by S.N.O. to patrol at a distance 30–50 miles from the convoy and made two sightings and one attack.

(*c*) One Fortress (220 Squadron) failed to meet convoy owing to deteriorating weather conditions, and was diverted to carry out a square search and returned early owing to weather.

(*d*) Six Hudsons (269 Squadron) carried out sweeps north of the convoy from 1101 to 1422 hours without result.

(*e*) Five Catalinas (84 U.S. Squadron) carried out sweeps, similarly without result, from 0800 to 1458 hours.

(*f*) Two Liberators (120 Squadron) carried out sweeps from 1047 to 1900 hours and one sighted two U-Boats in company. One was attacked.

By early on the 13th, the 400-mile line was reached and the U-Boats finally left the convoy. The SC.111 arrived in port safely on the 17th.

The balance-sheet of these two convoys is interesting. Information as to the achievements of the surface escort is not available so that all the credits are not known.

On the debit side—

Of 70 merchant vessels involved, two were lost.

On the credit side, in the Coastal Command area only :—

27 U-Boats were sighted from the air.

16 U-Boats were attacked, 10 by depth-charges and six by cannon or machine-gun fire.

2 U-Boats were almost certainly destroyed.

The main lesson to be drawn from these events which resulted in the arrival of these convoys almost untouched, is the extreme importance of getting air cover out to the convoy as early as possible—and by cover is meant not only escort but sufficient aircraft to sweep offensively the area round the convoy up to at least 50 miles on either beam, ahead and astern. This places a premium on the highest standard of navigation and homing, which alone will put the aircraft over the U-Boats at 800 miles from base in poor weather conditions.

Secondly, an appreciation of the U-Boats' tactics is of great value. This was shown in particular by the action of B/120 on 8th December, which sighted eight U-Boats, attacked seven and sank at least one. Coupled with this is the importance of close and intelligent co-operation with the S.N.O. Escort, this in several instances reached a high level of efficiency.

A study of the HX.217 and SC.111 shows air and sea cover of convoys at their best—which at the same time should be the normal: in consequence, U-Boats were destroyed and the convoys brought to port in the face of the most determined opposition yet encountered.

Coastal Command and the North African Campaign

The problem of air cover for the convoys carrying the North African expeditionary force came up on 20th October for decision in full detail. A naval force and seven convoys were involved; one had just sailed. The Admiralty believed that enemy submarines could be expected to converge in the path of the convoys in large numbers, perhaps 50 within the first ten days of the enemy's knowledge of the impending operation and a further 75 in the ensuing ten days. To meet this situation, it was decided to make every endeavour to provide each convoy with an escort of at least one aircraft throughout the hours of daylight. At the same time the anti-submarine activities in the Bay of Biscay were to be maintained at the highest possible pressure, while Iceland also continued normal anti-submarine activities and in addition maintained patrols in Denmark Strait and in the passage between Iceland and the Faeroes, to counter a possible break-out of the enemy's heavy warships from Norwegian ports.

By 23rd October plans for the disposition of aircraft had been made, calling for co-ordination of effort between Nos. 15 and 19 Groups. The resources of Coastal Command were not enough to provide sufficient long-range aircraft for all this convoy escort, while still maintaining the anti-submarine activities and other work of the Command. Loans had, therefore, to be requested. Bomber Command detached one and a half squadrons of Halifaxes, to be located at Beaulieu, and VIII U.S.A.A.F. Bomber Command provided Liberators for anti-submarine patrols; in the first place it was agreed that one squadron should undertake four sorties a day in the Outer Bay area. It was decided that these aircraft should not be employed on convoy escort except in emergency. Moreover, their employment was seriously restricted by the fact that they were not night-trained. The Liberators were modified overnight to carry British depth-charges, though arrangements were also made to transport American depth-bombs to Holmesley South for their use. Later a second U.S.A.A.F. squadron of eight Liberators was moved to Holmesley South to provide additional anti-submarine aircraft in the Outer Bay area.

Although Holmesley South was not completed when it had to be brought into commission, the aerodrome situation became acute. This was due not only to the increased long-range commitments and the need to reach as far as possible out into the Atlantic to provide the maximum escort to convoys, but also to the concentration in south-west England of aircraft scheduled to fly out to the operational area. Non-essential aircraft were removed from the south-western aerodromes to make room, but even so St. Eval had to handle a peak load of 72 aircraft, Chivenor 88 and Davidstow Moor (also still far from complete) up to 50.

It was realised that a heavy transport commitment would arise between England and Gibraltar, and 461 Squadron (Sunderlands) was, therefore, taken out of the line and employed solely on transportation duties, carrying staff officers, maintenance personnel and equipment, including a Tannoy set to assist in the despatch of aircraft at Gibraltar.

Instructions were issued for additional meteorological flights for a distance of 550 sea miles into the Atlantic from St. Eval and Gibraltar. For this purpose, two long-range Hudsons were despatched to Gibraltar and two Fortresses of 220 Squadron to St. Eval.

The first convoy sailed on 19th October, followed by others on the 22nd and 23rd. The weather was generally bad, and only a small proportion of the total flying time was spent on convoy escort, but the anti-submarine effort in the Bay was maintained at the highest pressure. On several days anti-submarine flying alone accounted for over 250 hours' flying, while over 100 hours a day was being flown by aircraft engaged on convoy escorts. Moreover, arrangements were made for the Halifaxes to provide a heavy anti-submarine striking force for use at short notice in the event of any particular convoy becoming seriously threatened. The threat to the convoys, however, remained extremely small; no submarines had been sighted in their vicinity, nor apparently had enemy aircraft or submarines sighted or reported the convoys, though one, homeward-bound Sierra Leone, suffered heavily on four consecutive nights while off Africa. It seems as though the large-scale air effort in the Outer Bay area, before and after the sailing of the convoys, had decided the U-Boats on passage to travel submerged, so that the convoys were not seen before they reached Gibraltar.

Meanwhile, all Torpedo-Bomber Squadrons were prepared and disposed in the North, and one was ready to go to Iceland, if required by C.-in-C., Home Fleet, for use in the event of a break-out by German capital ships.

Throughout this period 500 and 608 Hudson Squadrons were being prepared for service overseas. Another Hudson Squadron, 233, returned the majority of its aircraft to England, where they were replaced by new and overhauled aircraft, to ensure its full strength by the time the convoys were due to approach the Straits of Gibraltar. By the beginning of November, a detachment of 12 Catalinas of 210 Squadron had also arrived at Gibraltar. To provide additional anti-submarine cover for American convoys approaching the Casablanca area, 73 (U.S.) Squadron, consisting of 12 PBY amphibians, went to Ballykelly, on call to move to the Casablanca area as soon as it had been occupied by the U.S. forces.

Thus, by 8th November, the following Squadrons and Flights were operating from the congested air base of Gibraltar (Frontispiece), where, during one week, aircraft took off or landed at the rate of over one every eight minutes: Hudsons from 233, 500 and 608 Squadrons, Catalinas from 202 and 210 Squadrons, Mosquitoes of 540 (P.R.) Squadron, Spitfires of No. 4 P.R., and a Met. Flight of two Hudsons. In addition, eight P.R. Spitfires had arrived in Malta; their job was to photograph Taranto, Naples, Cape Lena, Palermo and Bizerta every third day. Photography of the operational area of Algiers–Oran–Casablanca was to be covered from Gibraltar, Dakar every third day from West Africa, and the French Fleet in Toulon from England.

By 6th November it became clear that enemy submarines were concentrating off North-West Africa, apparently in the belief that we were contemplating an attack on Dakar. They were encouraged in this belief by the American occupation of Liberia and by persistent references in the Allied Press to the significance of Dakar.

The landings in North Africa began on 8th November. On the 9th Gibraltar reported that the intensive anti-submarine patrol in the past two days, when fifteen sightings resulting in nine attacks on U-Boats were made, had contributed materially to the safe arrival of all forces at the assault positions; only one ship, an American transport, had been damaged by a torpedo. Air opposition was greatest in the Casablanca area, where on the day of the assault four Hudsons were lost, but as it was then expected that it would be rapidly overcome, it was decided not to send out a detachment of Beaufighters which had been prepared.

The U-Boat warfare continued to grow in intensity, the expenditure of depth-charges by aircraft rising to over 400 a week. Aircraft from the British Isles made 29 sightings, resulting in 16 attacks in the period from 23rd October to 30th November, while aircraft from Gibraltar and North Africa sighted 113 and attacked 60 U-Boats in the same period. Our aircraft were operating from Oran by 10th November, and by the 14th some of our G.R. aircraft were operating from the Algiers area.

The aerodromes in North Africa were generally found to be good. Tafaroui near Oran in particular was noted for its good runways, which were laid down in the shape of an L on its side, the short runway pointing south; the rest of the ground was very flat, and when dry quite suitable for taxying heavy aircraft.

Servicing the aircraft was found rather difficult for the first four days, but although the ground crews were very short-handed and had inadequate equipment, they coped very well until it came to doing any major repairs. Great difficulty was experienced in refuelling with the American type of four-gallon petrol tins, until someone produced the spinners off some abandoned French aircraft and with the aid of a short length of pipe which he soldered to the bottom made a very serviceable petrol-filler. By dint of this and working in shifts, they managed to reduce refuelling time to a minimum.

Sand did not give any trouble, though that may be exceptional, and perhaps in the summer sand would cause a lot of bother.

608 Squadron at Blida outside Algiers were rather better off for maintenance, as it was an established aerodrome and the French had not sabotaged any of their equipment. They were still living on the aerodrome, and were, in fact, quite helpful from all reports. As soon as clean bedding had been organised, the sleeping conditions at Blida were quite reasonable, but at Tafaroui the R.A.F. had great trouble getting any serviceable beds; in fact, 90 per cent. of the personnel slept on some camouflage matting spread out on the floors of the hangars. Later on the officers and N.C.O.s found some spare sleeping quarters and improvised beds of various sorts.

Food was a bit of a problem in both places, but the American rations were very good when everything is considered, and a case of beer sent to Tafaroui from the A.O.C., Gibraltar, was very welcome, as there seems to be no beer in North Africa.

Flying conditions were generally good, with visibility usually unlimited except during the heavy but infrequent storms, which usually passed quickly. On most days just then conditions were ideal for carrying out surprise attacks on U-Boats. Aircraft patrolling at heights between 5,000 and 8,000 ft., were, with a few exceptions, flying either through or over broken cloud, with excellent visibility down sun. Under such conditions many sightings were followed by attacks of great effectiveness. The majority of the sightings and attacks were made by Hudsons, but all aircraft, both at Gibraltar and in North Africa, were flying at maximum effort.

Aircraft of the Fleet Air Arm also contributed handsomely to the general air effort, particularly in the earlier stages before any aerodromes in N.W. Africa had been occupied.

Throughout the period a high standard of co-operation between air and surface craft was maintained, and this combined operation clearly demonstrated the essential nature of inter-Service and inter-Allied collaboration, and the success which follows its achievement.

Coastal Command against the U-Boat, 1939—1942

At the outbreak of war Coastal Command was woefully short of aircraft, and those that were available were mostly of types unsuitable for anti-submarine work. The backbone of the Command was the Anson, a most remarkable aircraft whose performance surprised not only the Command and the designers, but even more the crews who flew it. But however well it performed, there was no getting away from the fact that its range was quite inadequate and its bomb load pitiably small.

Not only was this a fact, but in addition no one had any real knowledge of the art of anti-submarine warfare. The standard height of patrol was 1,000 ft. or less. When a U-Boat was sighted pilots attempted to attack with one bomb at a time, and practically every available aircraft was employed on close escort to convoys. At that time the U-Boat knew little or nothing about our methods either, and was particularly and surprisingly ignorant about the possibilities and limitations of even naval anti-submarine methods. Thus he worked close to our coasts, and although our aircraft were being operated in a way which we now know to be wrong, we were able to get in a few attacks, and were thus able to start to learn the error of our ways.

It soon became apparent that the standard weapon we were using, the 100 lb. A/S bomb, was useless, and even the larger bombs were not really suitable. Experiments were carried out with the normal naval depth-charge and, though this imposed serious limitations on the height and speed of attack, and provided only for settings too deep for efficient use by aircraft, it was put into service as a stop-gap. From this weapon the T.N.T.-filled 250-lb. depth-charge was designed for air use, and this has remained in service with various modifications till the present date. Owing to the limitations on the height from which the naval depth-charge could be released, the tactics of very low level attack became inevitable. This proved an important step towards success, as from this low level, and with practice, bombing errors were considerably reduced.

Towards the end of 1940 the U-Boats moved slightly further from our coasts, and longer range aircraft were needed to meet this new threat. 502 Squadron was re-equipped with Whitleys and started operating towards the end of October of that year, but these aircraft were still used to escort convoys. By this time it was becoming clear that the purely defensive policy of escorting every convoy for which we had aircraft available could never produce the desired results. As in all other forms of warfare, it was essential to take the offensive. Now the pack tactics adopted by the U-Boats, while increasing their success against surface craft, added to their danger from aircraft, giving us opportunities for heavy counter-attack. But at that time convoy escorts were considered the be-all and end-all of anti-submarine warfare, and old ideas die hard. However, on 9th May, 1941, after prolonged consideration of the pros and cons, permission was obtained to assume the offensive and give escort only to threatened convoys. This was a red-letter day as far as the Command was concerned. But before turning to the offensive phase it would be worth while to consider the results obtained in the early stages.

Records of U-Boats sighted were kept only from July, 1940, though, of course, records of attacks are available throughout the war. From July, 1940, to April, 1941, 105 U-Boats were sighted and from September, 1939, to April, 1941, the number of attacks was 182. This is an average of 10·5 sightings and 9·1 attacks per month. The results of these attacks can be obtained from the *Monthly Anti-Submarine Report*. In the period 11 U-Boats were sunk or seriously damaged by aircraft alone or in co-operation with H.M. ships. Slight damage has not been included in the above figures. This means that Coastal Command aircraft were wholly or partially responsible for about 8 per cent. of all U-Boats sunk or seriously damaged from all causes.

As soon as permission was granted to seek out and destroy the enemy, the whole policy of A/S warfare in the Command was changed. All available aircraft were employed on A/S patrols in the passage areas north of Scotland and in the Bay of Biscay. In addition, sweeps were organised along the convoy lanes, and it was only convoys known to be threatened which received escort. The results were immediate and striking. The largest number of sightings in any one month before May, 1941, so far back as records go, was 19, and, as we have seen, the average is 10·5. In May, 20 U-Boats were sighted, in June, 31, in July, 19, in August, 39, in September, 47, and so on. The results of this intensified offensive were also obvious from the positions of attacks on ships and convoys. The life of the U-Boat became that of the hunted pariah. The enemy was forced further and further to sea, until a time came when for months on end only very occasional sinkings occurred within 450 and eventually within 600 miles of our bases. Convoys outside the range of our aircraft were attacked and many ships sunk, but in case after case, as soon as the convoy came within range and air cover was provided, the sinkings stopped and the pack was broken up. The facts are indisputable, and no one will be more willing to testify to them than the S.N.O.s of escort groups.

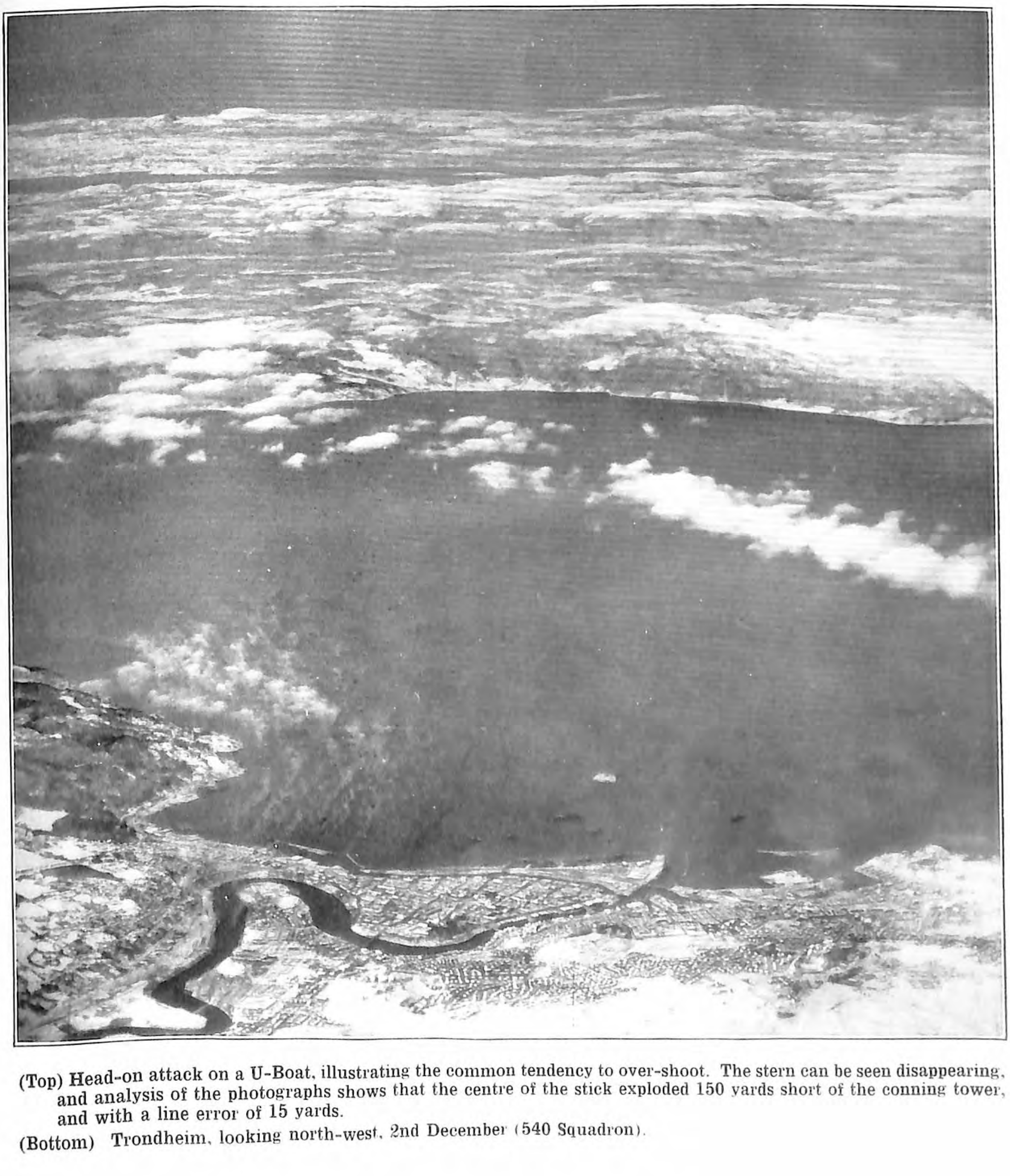
The life of the U-Boat on passage was also made unbearable and by the end of 1941 every sort of evasive policy was employed by them in an endeavour to avoid our patrols. In the Bay they remained submerged by day and only surfaced at night; they went further south in the Bay and tried snooping along the Spanish coast. But the offensive went on and the threat remained. Any U-Boat which was foolish enough to show its head above water by day stood a good chance of being pounced upon and attacked. So effective were the air patrols in the passage area that the U-Boats were forced to accept an extra three or four days more on passage to avoid day attack. The morale of the crews reached a low ebb. Every moment on the surface was filled with tense anxiety. They had been forced so far out from our shores that convoys were harder to locate and so sinkings fell off. In fact, the counter-blockade was not paying a dividend. And the remarkable fact about this achievement of Coastal Command was that it was obtained by the use of a weapon which was only partially effective. It was simply the moral effect of constant harrying.

In December, 1941, America entered the war, and in a very short time the U-Boat found a happy hunting ground on that coast. Convoys could not immediately be organised, and anti-submarine patrols were naturally not fully efficient. Once having found this soft spot, the Germans exploited it to the full. Shipping in the Coastal Command area was left alone, but the losses on the American coast reached an almost critical figure. All we could do was to increase our efforts in the passage areas. We did what we could, but the enemy was prepared to waste time in the Bay and our sightings fell off. The morale of the U-Boat crews soared and sinkings went on almost unchecked. Throughout this period, adequate air patrol was maintained in the whole of Coastal Command's area to ensure that the fear of Coastal Command's anti-submarine patrols was not diminished by the U-Boats' successes elsewhere.

Another milestone in the campaign was reached in May, 1942, which saw the introduction of two new weapons, the Searchlight Wellington and the Torpex-filled depth charge. The effect of the former was instantaneous and spectacular. The U-Boat Captain had considered himself safe by night, but now he was more "on the spot" than ever. By day he had been able to back his look-outs against those in the aircraft. Now the first indication of the approach of danger was the blinding beam of the searchlight, too late for anything to be done. One can imagine the consternation in German U-Boat circles. The important consequence, from our standpoint, was that U-Boats again appeared on the surface by day, and probably resorted to submerging at night to avoid the new danger. In consequence of this night danger, day sightings in the Bay remained at a steady level, for a given amount of flying, throughout the summer of 1942, though the greatly increased effort put up by the Command enabled the number of attacks per month in the Bay to rise to an average of 24 per month—a number nearly three times as high as that which at the end of 1941 had forced the U-Boats to remain submerged almost all day. Sightings, which had fallen to as low as an average of 12 a month in the winter, rose to 88 in August, 1942, and 120 in September, mainly because of this continued success of the Bay offensive and of the success of patrols between Scotland and Iceland against new U-Boats coming round from Germany. And with the larger number of sightings came a higher percentage of casualties, since the destructive power of the Torpex depth-charge is about 50 per cent. (originally 30 per cent.) greater than the T.N.T.-filled weapons. This was increased even more by the fitting of nose spoilers and break-off tails, which represented the final step in the achievement of a satisfactory shallow setting of about 25 ft., and made the weapon lethal to a U-Boat on the surface and down to a depth of 44 ft. (Even the intermediate step towards a shallow setting in the autumn of 1941, exploding at about 35 ft. depth, seems to have inspired a German opinion, quoted from neutral sources, in the *Daily Telegraph*, that the British had taken to using a new bomb of devastating effect!) Once more the morale of the U-Boat crews waned. But now we have again reached the stage where night evasive measures are defeating the air offensive, though no doubt the good work will soon again be pressed home as hard as ever.

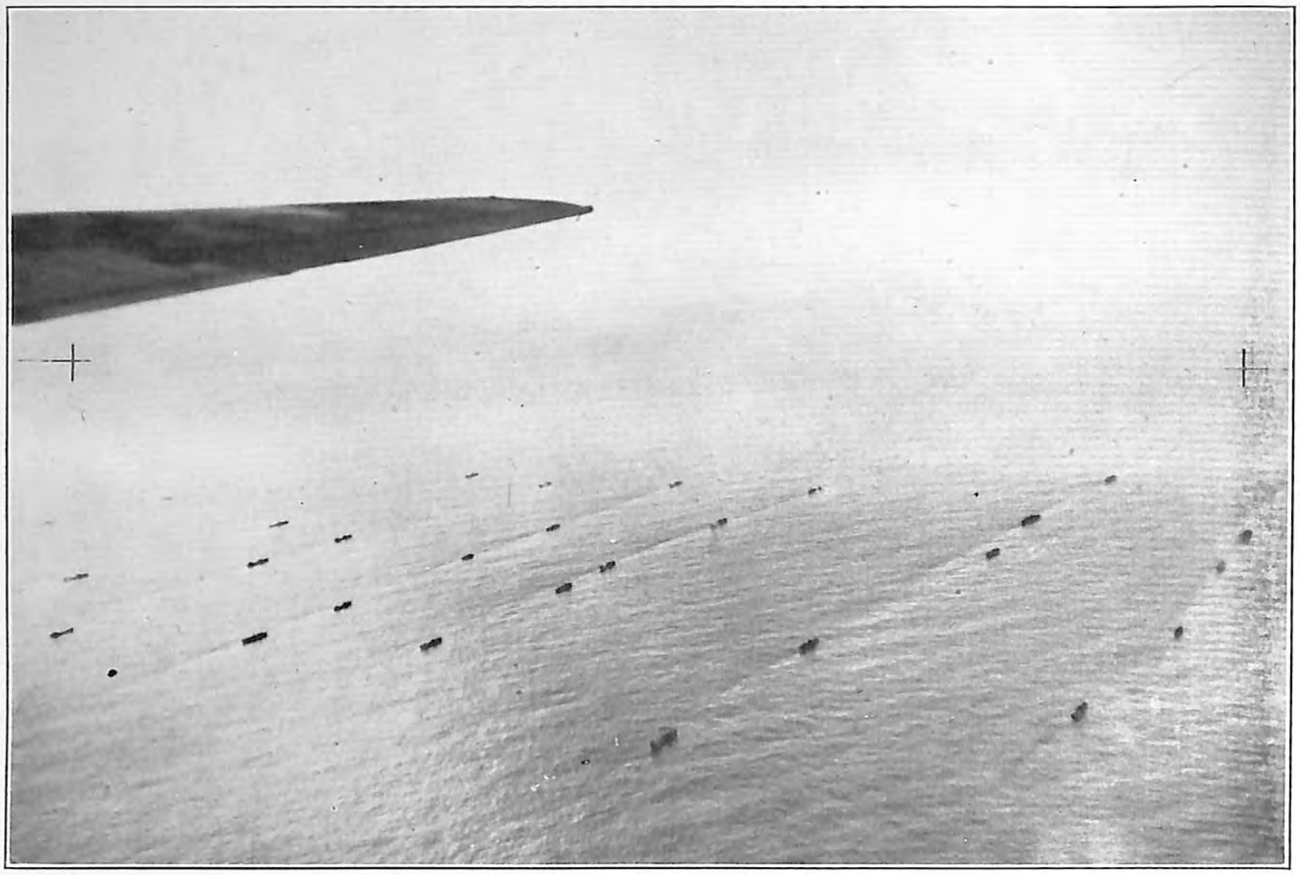
Next the results for the offensive period from May, 1941, to November, 1942, should be considered. In that period were 885 sightings and 529 attacks. Thus the average number of sightings went up from 10·5 to 46·6 per month, and the attacks from 9·1 to 27·8 per month. The case for the offensive policy is thus clearly proved. And how about the effect of these attacks? More success was to be expected, due to improved tactics and better weapons. From May, 1941, to about the end of October, 1942, the figure for U-Boats sunk or seriously damaged, solely or partially, by Coastal Command aircraft is 99, again ignoring those slightly damaged or about which insufficient evidence is available. Thus, the percentage of U-Boats so dealt with by Coastal Command rose from 8 per cent. to well over 30 per cent. of the whole. Coastal Command then, in spite of the fact that they are very seldom in a position to substantiate their claims in the same way as surface craft, are officially credited with about one-third of the total number of U-Boats destroyed or seriously damaged since the offensive tactics were brought into force. It is not improbable that an even higher figure should be credited. During the last three months the number of those sunk and damaged by Coastal Command aircraft has been greater than that by all other causes. Thus, from a small force defensively employed and achieving negligible results, Coastal Command has become a most important unit in the anti-submarine campaign. It may well prove to be the deciding factor.

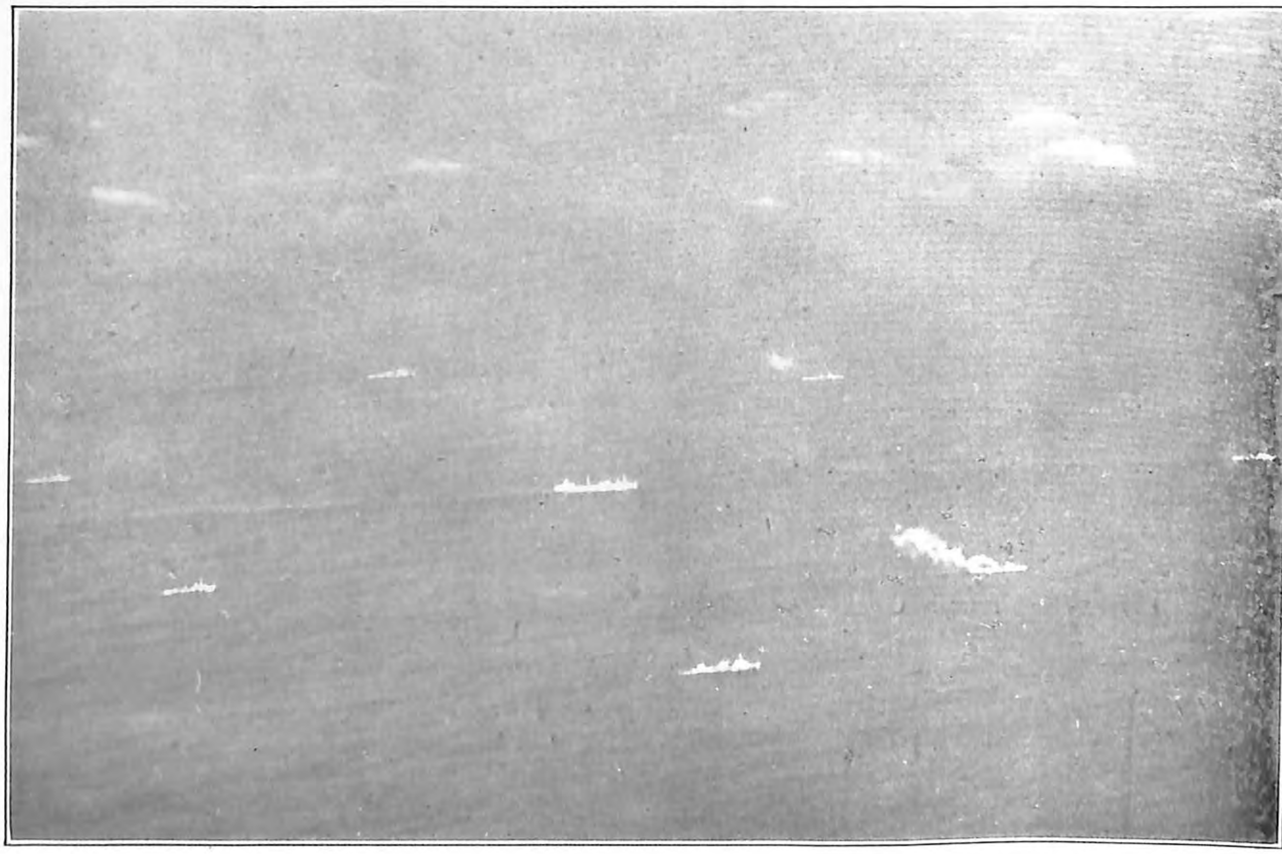
No summary would be complete without a reference to Coastal Command's part in the recent operations in North Africa. So far the attacks by such aircraft have not been fully analysed or assessed, but approximate figures show that during November in that theatre of war alone, U-Boats were sighted on 112 occasions and 66 attacks followed. At a conservative estimate, it is thought that some 8 U-Boats were sunk or seriously damaged and 25 more damaged. Air patrols were



(Top) Head-on attack on a U-Boat, illustrating the common tendency to over-shoot. The stern can be seen disappearing, and analysis of the photographs shows that the centre of the stick exploded 150 yards short of the conning tower, and with a line error of 15 yards.

(Bottom) Trondheim, looking north-west, 2nd December (540 Squadron).





(Top) British convoy in mid-Atlantic (120 Squadron).

(Bottom) Enemy tanker and escorts off north coast of Spain, 9th December (405 Squadron).

The 10,711-ton German tanker *Antarktis* on her way from Ferrol to Nantes. She had previously been laid up in the Spanish port of Vigo for a considerable time, and her return to an enemy controlled port may foreshadow her use as a blockade runner. It will be noticed that she is being escorted by no less than two small destroyers of the *Elbing* class (equivalent to our *Hunt* class) and five torpedo boats, a weight of escort that we should consider sufficient for an ocean convoy.

Shortly after this photograph was taken, our aircraft, X 405, was attacked by two Ju 88's which were also in the escort, and, after a short combat, succeeded in shooting one down into the sea.

instituted days in advance of the arrival of the convoys, and it can be fairly stated that the safe passage of these convoys was almost entirely due to the efforts of the Command in seeking out, harrying, and destroying the U-Boats which had collected to destroy our ships.

Looking back over the achievements of the past three years, Coastal Command has much to be proud of. From a depressingly small foundation it has become a vital part in the war against the U-Boat. It is feared and hated by the German U-Boat Command and probably has more effect on the morale of the U-Boat crews than any other factor. But the war is by no means over. And however much Coastal Command squadrons have done in the past, even more is expected of them in the future. The U-Boat fleet is very large and is growing day by day. To counter the menace, more and more must be sunk, and aircraft alone can be made available in sufficient numbers to do this. Command Headquarters will strive to obtain the best weapons and equipment, and tactics will be altered to meet new moves by the enemy. But in the end it all rests with the aircrews. Nothing can be achieved without constant training and enthusiasm, and so to them we would say: "Well done; you have done a magnificent job. Now try really hard and do better!"

Bombing Errors

At the present time it is no exaggeration to say that the aiming problem is fundamental to the whole anti-submarine offensive. The process of seeking out and attacking U-Boats, although a long and arduous task for the individual, has been so successful for the Command as a whole that on the average every single U-Boat in operation is attacked once per cruise. The existing weapons for destroying U-Boats, although not perfect, are by no means to be despised, as the number of recent kills will have proved. The weak link lies at the moment in putting the weapons close enough to the U-Boat to ensure its damage, if not destruction. Better weapons employing more powerful explosions may increase the number of kills considerably, but it will be appreciated that new weapons incorporating advanced designs require much time and labour for development and mass production, and because of the shortage of man-power and machinery it is reasonable to expect a greater delay in producing these weapons at the present time than in pre-war years. If we consider the various ways of increasing the destruction of U-Boats, including the development of new weapons, there is no doubt that the most speedy measure would be to improve bombing accuracy. If the average bombing error could be halved it should be possible, in the opinion of experts who have spent many hours in the laborious task of analysing the various factors, to treble the number of kills. Although the conduct of a successful U-Boat offensive is the concern of scientists and tacticians, as well as air crews, the chance of immediate improvement depends upon the aircrews alone. Ultimately the measure of success will be determined by a greater number of U-Boats destroyed and ships saved, but such are the variations of chance, when only small numbers are involved, that neither of these effects will become reliable measures for some considerable time; meanwhile a decrease in average bombing error is the surest quick sign of improvement in the offensive.

Relation between Errors and Kills

Before examining the various causes of error and the possibilities of overcoming them, it is of interest to estimate what success may be expected with any given average error. The average error of any single crew will vary from day to day but, taking the Command as a whole, irregular variations will not be very evident. Figure 1 below shows the percentage of attacks within lethal range (in plan) to be expected with different average range errors when attacking a U-Boat at 30° to track with six Mark XI depth-charges spaced at 36 ft. Line error has been taken as half the range error, a figure which is found to be roughly true in practice, though the proportion may vary somewhat with the direction of attack. The conditions of attack which have been taken in Figure 1 are intended to be illustrative and not necessarily the best. (*See overleaf.*)

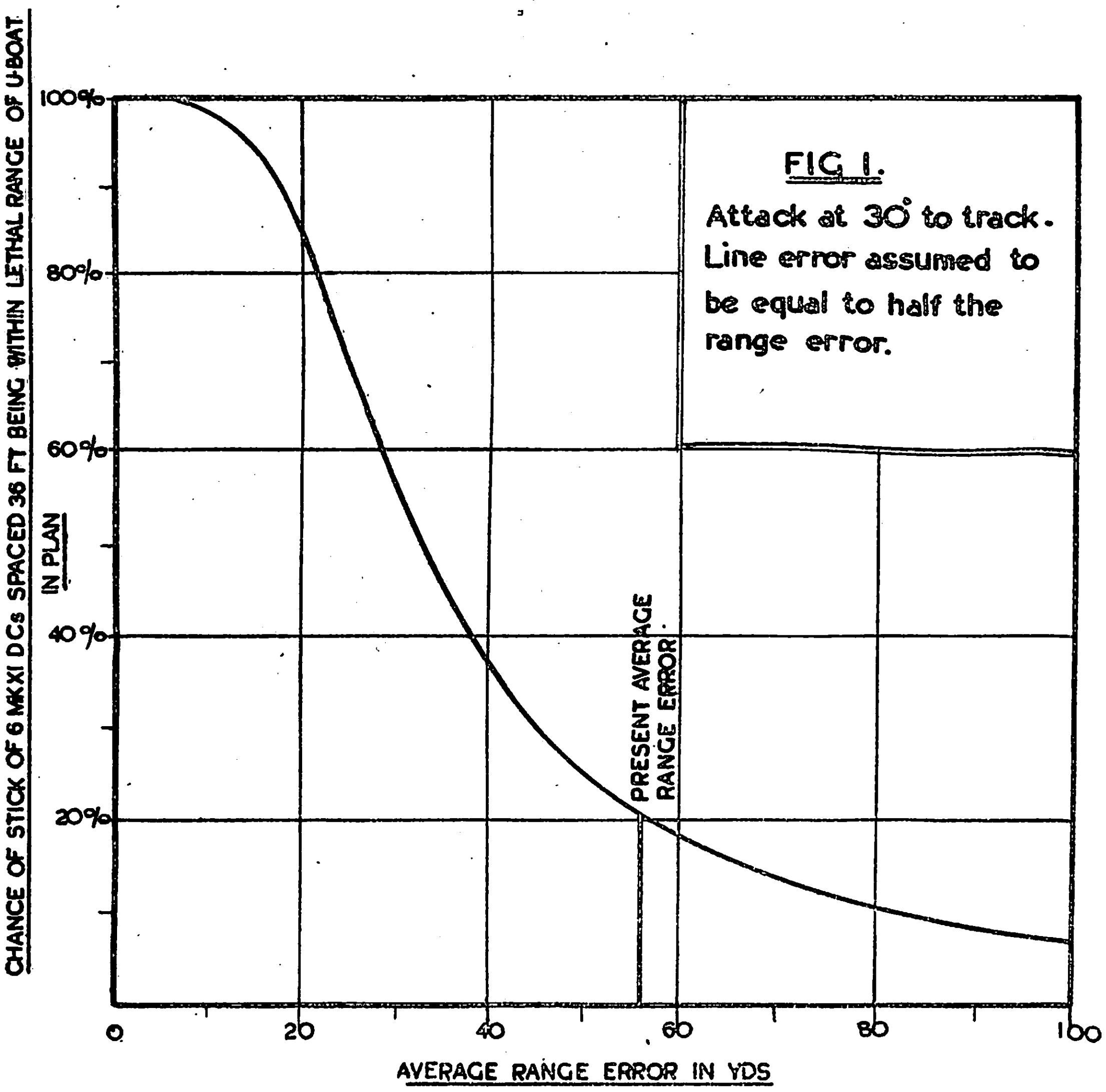
This diagram does not give the number of kills to be expected, because a stick may be within lethal range in plan, but not result in a kill owing to a variety of causes, *e.g.* hang ups, incorrect depth setting, break up of the weapon, ricochet, etc. The depth setting of the Mark XI depth-charge (25 ft.) has been carefully chosen to give the best chance of a kill for class A attacks (upon U-Boats either visible or submerged for less than 15 seconds) and the armament failures do not occur very frequently, so that the actual chance of a kill for these U-Boats will not be much less than the chance given in the diagram and will in any case be proportional to it. The actual average error of operational attacks at the present time is not known with any certainty, but a number of attacks over the last four months in which the photographs have been analysed have given an average *range* error of 56 yards. This average is for attacks made by both experienced and inexperienced pilots, but selected at random, so it can be accepted as being fairly representative of the Command as a whole. Referring to Figure 1 above, it will be seen that if this average error both in *line* and *range* could be halved, there would be about three times as many kills.

Estimation Error

In attacks on U-Boats there are two main types of error. First there is the pilot's error in estimating the correct point of aim, and subsequently his error in dropping his depth-charges on that point. Taking the estimation first, what are the possibilities of reducing the error in this? There are two processes involved—a mental calculation of how many yards ahead of the swirl or the surfaced U-Boat to aim, and the judgment of this distance on the surface of the sea. There should be no error in the first process, because the answer should be ready made for the standard tactics of attack, *e.g.* in the case of a U-Boat doing 10 knots on the surface, the allowance for a *beam* attack is simply the distance travelled by the U-Boat during the time that the depth-charges sink to their functioning depth. This distance amounts to approximately 15 yards (allowing 2·5 seconds for the depth-charges to reach 25 ft.). No allowance is necessary for U-Boat movement in a beam attack during the time of fall in air of the depth-charges, because if the attack is carried out correctly the aircraft will track over the point of aim and the depth-charges will drop on the same point, since they fall vertically beneath the aircraft. In an attack along the track of a U-Boat, however, allowance must be made for forward movement of the U-Boat during the time of fall in air of the depth-charges. Taking a typical attack along track with release from 100 ft., the additional distance to be allowed for a U-Boat moving at 10 knots will be 15 yards, so that a total allowance of approximately 30 yards must be made for advance of the U-Boat. In the case of a submerged U-Boat a further allowance for advance between submergence and release, at the rate of 10 ft. per second, must be added to the respective allowances mentioned above for the beam and up-track attacks.

Quite apart from these allowances for travel of the U-Boat, there is a further allowance to be made in order that the *centre* of the stick may explode at the required position. Not only must the first depth-charge be dropped half the stick-length short, but also an allowance must be made for the underwater travel of the weapon—amounting to 12 yards for the Mark XI depth-charge. Therefore, with a stick of six depth-charges spaced at 36 ft. (making a total stick length of 60 yards), the first of the stick must be dropped 42 yards short. To sum up, the allowances required in attacking a visible or partly visible U-Boat may be expressed as follows for the standard conditions :—

Beam.	First depth-charge to fall 42 yards short in range and 15 yards ahead of conning tower in line.
Up-track attack.	First depth-charge to fall 12 yards short of conning tower (42 − 30).
Down track.	First depth-charge to fall 72 yards short of conning tower (42 + 30).



The second process in estimation of allowance involves judgment of these distances on the surface of the sea, and is the main source of estimation error. Experience has shown that almost every individual, however experienced, underestimates true distance on the surface of the sea. During the analysis of some recent bombing trials in which the results were both estimated by eye and subsequently measured from vertical photographs, it was found that the true errors were underestimated by about 50 per cent. when small and by as much as 300 or 400 per cent. when large. Conversely, in estimating the correct allowance from a U-Boat or a swirl, the tendency is always to make the allowance too large. In the analysis of photographs of operational attacks already referred to, it was found that in attacks on visible or partly visible U-Boats, where the allowance for the forward travel of the U-Boat should have been 15 or 30 yards only, there was actually an average error ahead of as much as 60 yards. Fig. 2 shows a plot of these attacks all referred to one U-Boat. This again, as in the bombing trials, indicates an error of estimation of approximately 300 or 400 per cent.

Practical Simplification

At first sight it may appear that what has been said above represents all the difficulties to be overcome in attacking a U-Boat. Let it be recognised at once that it is one thing to discuss the problem from an office chair, and an entirely different matter to carry out an actual attack from an aircraft, very probably towards the end of a sortie. As in most things, some practical application will help in solving the problem.

Fig. 2 shows that in the operational attacks on visible or partly visible U-Boats which have been analysed there was actually a systematic error 60 yards ahead of the U-Boat. The importance of reducing this systematic error is obvious—in fact, if the mean point of explosion of the sticks plotted in Fig. 2 had been on the conning tower instead of 60 yards ahead, then more than half as many kills again would have resulted. The cause of this systematic error is not certain, but it seems likely from what has already been said that a very large part, if not all, of it is due to the difficulty of estimating the allowance for forward travel of the U-Boat. If this is so then the practical solution to this difficulty is to ignore all allowances for forward travel in the case of visible or partly visible U-Boats and to aim at the conning tower as though it were a stationary target. The error which will arise from this is, as we have seen, about 30 yards for an attack along track and only 15 yards in a beam attack. In either case the error introduced is less than the true bombing error and is taken up by the length of the pressure hull (53 yards for the 517-ton class U-Boat), and in the case of an attack along track by the length of the stick. Hence by adopting this practical simplification, what appears to be one of the main sources of error can be effectively eliminated.

True Bombing Error

The second type of error is the true bombing error, which arises in dropping the first depth-charge on the point of aim selected. It must be admitted that there is no doubt that a really experienced pilot can do this by eye with surprising accuracy. Such pilots, however, have had

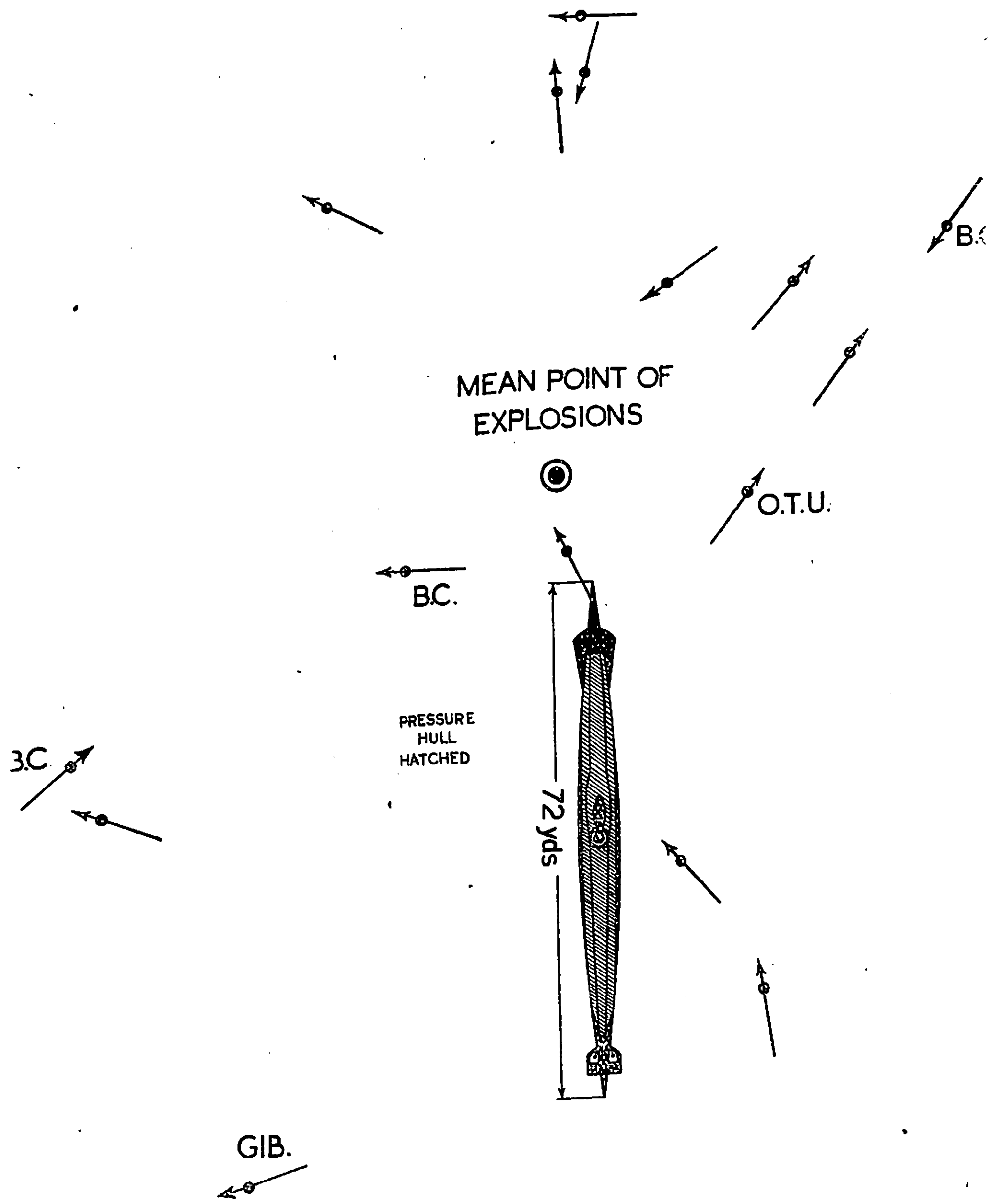


Fig. 2. Plot of the attacks on U-Boats which have been analysed from photographs during the last few months, showing a marked tendency to overestimate forward allowance. Each arrow indicates the direction of a depth-charge stick, while the blob on the arrow gives the position of the centre of the stick relative to the U-Boat at the instant of explosion. Attacks by Bomber Command and O.T.U. aircraft are distinguished by lettering.

many hours of operational flying and have probably dropped numerous practice bombs during training. We must not consider the expert but rather those who have not had much experience or training, and it has been decided that the quickest and best method for raising the average standard is to employ low-level bombsights. The advantage of using a bombsight is not only that it improves the general standard of bombing and raises the average to a fairly high level, but also that it enables allowances for stick length and underwater travel of weapons to be made correctly, thereby eliminating some of the estimation error. Further steps are being taken to introduce a method of making the other allowances by mechanical means, which should be of assistance even to the most experienced pilots. By these means it is hoped that the average operational bombing error of the whole Command may be reduced to about 30 yards in range and 15 yards in line—which, as already stated, should result in an increase of three times in the number of kills. Pending the introduction of mechanical aids, there is no doubt that the general standard of accuracy can be considerably improved by intensive practice and a greater appreciation of the main sources of error. This should be the chief concern of every crew on anti-submarine operations. Success in bombing a U-Boat is so difficult to attain that, in spite of all precautions, the best of pilots can never guarantee to bring off a kill, though by ignoring the precautions the outcome *can* be guaranteed; it will be to miss the target.

Tricks of Anti-Submarine Training in Squadrons

Practice Bomb Attacks on Imaginary Submarine

When an anti-submarine aircraft has left the patrol area and is heading homewards, the captain often instructs a gunner to drop a smoke-float some time during the next quarter of an hour. As he does so, the gunner announces that a submarine has been sighted, prefixing his report with the word "exercise." The crew then goes through the entire procedure of an attack, with the modifications required by its fictitious character. The sighting report, for instance, is written but not transmitted. Instead of real bombs or depth-charges a single bomb is released, which is regarded as the first of a stick. The pilot drops it by means of a bell-push or something of the sort on the end of a cable attached to a makeshift carrier. A wooden box will do as carrier, but all sorts of Heath-Robinson devices are invented by different pilots.

At any moment the captain will announce that the submarine has submerged. Then the stop-watches are set clicking, and the crew check up to see if the right allowance has been made. The results are photographed, and eventually analysed by the Squadron Commander. In these dummy attacks so many deviations from the normal procedure are thought out that when it comes to dealing with a real submarine everything seems very smooth, quick and straight-forward; in fact crews say it is a positive rest cure.

Rocks off shore are never used for these practice attacks because the local population is apt to jump to false conclusions.

Mock Air Combats

When anti-submarine aircraft approach the English coast they often find Spitfires on convoy patrol or duty, or doing flying training. It has become a regular practice among these local fighters to accept an invitation to mock combat—after mutual recognition, of course. Of course, all gunners are cautioned that the fighter is friendly before it begins its fierce attack. The navigator stands in the astrodome, and keeps up a running commentary on the intercom. The second pilot has the job of preparing the air attack signal, which is torn up when the exercise is over.

Gunnery practice on Sea-gulls

Sea-gulls and gannets are found to be extremely useful targets for gunnery practice. Their constant changes of course make them difficult to hit; their airspeed, though low, is enough to necessitate deflection; and yet they are passed so quickly that rapid thinking and snap shooting are essential. The gunner who brings one down is rewarded by five shillings when his claim is confirmed by another gunner; it is rare for anyone to earn it even twice. The drill is that a first sighting report comes from the fire control position, "One sea-gull, one hundred yards, port bow, shoot him down."

Navigational Training for Rear-Gunners

The construction of a Sunderland makes it impossible to take an accurate drift reading from the front on a smoke or flame float. By the courtesy of Messrs. Frazer-Nash an excellent drift sight has been manufactured for a four-gun turret: it is relatively simple to graduate the rear gunner's inner turret ring and the four guns which serve instead of drift wires. In flying boats with this equipment, the rear gunner is given some instruction in navigation so that he appreciates the importance of obtaining accurate drifts at frequent intervals, a process which has the incidental advantage of giving him an interest to relieve the tedium of his isolation. A definite note of superiority can be detected in his voice as he reports to the navigator "a drift of 4½° to starboard." His activities are specially valuable at night when they save the navigator a series of hurried walks to the rear turret to observe flame floats. But warning must of course be given whenever he is going to neglect his look-out duties for this reason.

Ditching Practice

When a flying boat is nearly home the Captain sometimes gives the order "Abandon aircraft" five minutes before he touches down, and as soon as it comes to a stop the crew carry out the complete drill including taking to the dinghies, so that they have all left the ship, properly equipped, before the marine craft reach it.

II—ANTI-SHIPPING SECTION

Air Attack on Merchant Vessels

Though the main effort of the Command is directed against U-Boats, it carries out other important operations, not the least of which is the disruption of the enemy's sea communications. The shipping traffic along the Dutch and Norwegian coasts carries essential goods and could hardly be replaced by overland transport. Similarly, the traffic between French and Spanish ports is considerable and of importance and so is blockade-running to the Biscay ports and the ocean. The enemy's shipping sails so close to his own bases that our submarines and destroyers are practically unable to tackle it, with the exception of an occasional blockade-runner, so that air attack presents the most effective means of dealing with the problem.

The resources which the Command has had at its disposal for this task have been very limited. Nevertheless in the last eighteen months or so nearly a thousand attacks have been made on enemy merchant ships, mainly along the Dutch and Norwegian coasts. This limited offensive has resulted in sinking about 50 ships and damaging considerably more, the ships concerned having an average tonnage of about 3,000. While the exact numbers of ships available to the enemy for this coastal traffic is not known, the above results probably mean that a high proportion of them have at least been damaged, at one time or another. The importance attached by the enemy to this traffic, and the seriousness of the danger from the air, are proved by the considerable surface escort which he provides. An intensification of the air attack might well lead to decisive results, and it is important to see first what can be done to improve the quality of this offensive.

In what follows (an abstract of ORS/CC/ Report 212), we shall consider only one aspect of these operations: the attack itself. That is the final stage of an anti-shipping operation, the initial stage generally being the detection of the target by a reconnaissance aircraft, and the intermediate stage being the finding of the target by the striking force.

In considering the actual attack it is convenient to distinguish the following factors:—

(i) The accuracy of the bombing (or torpedoing).

(ii) The effectiveness of the bombs (or torpedoes).

(iii) The danger to which the aircraft is exposed in carrying out the attack.

The first and third are evidently interrelated and depend very much on the tactics used. The second, which may be defined as the chance that a bomb (or torpedo) which hits a ship will sink it, is less dependent on the conditions and will be considered first.

How can these chances be ascertained? There are two possible sources of information—trials and actual operations. This also applies to the corresponding problem of the effectiveness of bombs or depth-charges against submarines. However, in the case of submarines there is a more definite criterion of effectiveness than for ships, namely the rupture of the pressure hull; and so at least for underwater explosions, the effectiveness of a bomb or depth-charge may be expressed in terms of lethal range alone, *i.e.*, the maximum distance from the pressure hull at which the latter will be broken by the explosion. The thickness and quality of the pressure hull of U-Boats is fairly well known and this one quantity—the lethal range—may therefore be determined from trials without undue extravagance. The situation is much less simple in the case of ships. They vary far more in construction, and their cargo, another variable quantity, may play an essential part. The part of the ship hit and the position of the explosion are also essential factors. Furthermore, the hull of the ship can be ruptured without the ship necessarily sinking, since the consequent flooding may be countered by pumping. As a result of all these complications, only very limited information about the effectiveness of bombs against ships is obtainable from trials. We thus have to appeal to operational data, with the object of arriving at a *statistical* figure to represent the average chance that a bomb will sink a merchant ship.

One remarkable result of such an analysis is that a big ship is almost as vulnerable as a small ship, as the figures in the following table show. This table actually refers to the sinking of British ships by enemy aircraft, and is based on information collected by the Admiralty Naval Air Division (*N.A.D.* Report, 1133/41).

Average tonnage of ship.	*No. of bombs hitting.*	*No. of ships sunk.*	*Chances of sinking per bomb hitting the ship.*
			Per Cent.
400	16	6	37
1,200	67	24	36
4,200	67	19	28
8,000	35	9	26

It will be seen that, as far as these figures go, the chance of sinking is not much more for a 400-ton ship than an 8,000-ton ship. Considering that a small ship offers a much smaller target than a big one, it follows that the small one is the more difficult to sink. Since the amount of ship-borne flak is not as a rule proportional to the tonnage, the vulnerability of aircraft remains much the same, and the large ship, therefore, provides the better target.

The bombs used in enemy attacks correspond in type to the British M.C. bomb, the filling ratio being about 50 per cent. and the casing fairly robust. The actual size of the German bombs used in the different attacks is not known with any certainty, but a likely average weight is about 500 lbs. Hence, if a merchant ship is hit by a 500-lb. bomb of this type, the chance of it being sunk is about 30 per cent.

An analysis of our own attacks against enemy shipping with A/S bombs leads to much the same kind of figure. G.P. and S.A.P. bombs are, however, much less effective, so far as the records go. This is understandable, in that blast is very effective in sinking a merchant ship, and the blast effect from an S.A.P. or G.P. bomb (owing to their small filling ratio) is many times less than the blast from an A/S bomb. The use of the A/S bomb is limited by its liability to break up on hitting the ship, which may be quite pronounced from height of 4,000 ft. or so. Thus the M.C. bomb, which has nearly the same filling ratio as the A/S bomb but a stronger casing, is the best available against ships.

Summing up, the chances that a merchant ship will be sunk when hit by a 500-lb. bomb of the M.C. type is roughly about 30 per cent., with a somewhat lower figure for the same weight of A/S bombs. (If the weight of bombs hitting is less or greater than 500 lbs., the chances may, within limits, be scaled in proportion.) Taking an aircraft with a bomb load of, say, 2,000 lbs., M.C. or A/S, if *on the average* 20 per cent. of the bombs hit, the *average* chances of sinking per attack will be about 25 per cent.; if 1 per cent. hit, they will be only 1 per cent. or so.

What percentage of bombs dropped in past attacks have hit? It is difficult for the pilot or his crew in any given attack to tell how many bombs hit the target on those occasions when it is hit at all. In the analysis that has been made, the average number hitting (in cases when at least one bomb hits) is accordingly deduced from the stick spacing and the effective size of the target.

The conclusion arrived at is that in the low-level attacks carried out last summer by 16 Group off the Dutch coast, about 20 per cent. of the bombs dropped hit the target. This represents very good aiming, equivalent to a successful tracking over the target in line, and a range error of only about 50 yards. In low-level practice bombing (mostly A/S practices) the range error has been 30 to 40 yards; therefore, considering the flak opposition in ship attacks, the results represent a high standard of accuracy and morale. The casualties were, however, high, and consequently low-level attack was abandoned, though in terms of aircraft lost per ship sunk, the operations were the most profitable that have been carried out against merchant shipping.

From July onwards, attacks have in general been made from a medium height of about 4,000 ft. This change resulted in a very satisfactory drop in the casualty rate, but unfortunately there was also a large—in fact larger—drop in the accuracy. As far as can be judged from the reports only 1 per cent. or so of the bombs dropped in these attacks hit the target. This corresponds to an average radial error of nearly 200 yards. Whenever possible the C.S.B.S., Mark I was used in these attacks, and under suitable conditions and with adequate training that sight is of course capable of giving very much greater accuracy. It does, however require considerable computation and manipulation in the air, and also a long straight run up to the target, which is difficult to maintain in the face of flak (even though the actual danger may not be large). The Mark XIV sight, which is described in another article in this number, presents itself as the surest big step forward towards better aiming in operations, requiring as it does less work in the air and also a much shorter run on the target prior to release. It has not yet been produced in quantity, but it is hoped that it will soon be available for those aircraft in the Command whose main job it is to attack ships. The prospect of this sight must, however, cause no relaxation in the current effort and training, and in particular the accurate determination of wind should be given the utmost attention in practices and in operations. For though the Mark XIV will automatically sort out the range and drift components of the wind in the actual attack, the operator must beforehand feed in an accurate wind into the sight. Thus without a good wind determination the Mark XIV will be wasted, and its introduction will be a case of "casting pearls . . . ."

By a good wind determination we mean an average vector error not greater than six knots or so. An indication of the present standard of wind determination could be got if, in the case of a number of aircraft taking part in a strike, the consistency of the winds obtained by the different aircraft was subsequently studied. A possibility in operations might also be for the aircraft concerned to pool their winds and then adopt an average—provided the attendant risk of communication was not too great.

Assuming accuracy within about six knots in the wind, and a ship speed of about six to ten knots (in which case the fourth vector can be allowed for by aiming at the bows), it is estimated that, using the Mark XIV from about 4,000 ft., the percentage of bombs hitting the target would be approximately 10 per cent. That is roughly ten times greater than at present, a result almost as good as in low level attack.

This article is becoming too long to devote much space to torpedo attacks. It might be noted that, even though conditions varied, much the same results were obtained against merchant ships by Coastal Command aircraft, R.A.F. Middle East aircraft and also Naval Middle East aircraft. Actually about 9 per cent. of all these torpedo attacks lead to assessed sinkings, this 9 per cent. being roughly the product of a 25 per cent. chance of hitting the target, and a 35 per cent. effectiveness on the part of the torpedoes. Coastal Command's torpedo attacks were carried out against considerable enemy opposition, and the rate of casualties was almost as high as in the low level bombing attacks, as indeed would be expected.

The following table summarises, for comparison, the results of torpedo attacks by all British aircraft, and of the two classes of Coastal Command

Type of attack.	*No. of attacks.*	*Ships assessed. sunk.*	*Ships sunk per attack. Per cent.*	*Ships sunk per attack per 1,000 lb. load. Per cent.*
Torpedo :—				
Load, 1,800 lb.	439	35	8	5
S.A.P./G.P. bombs :—				
Average load, 950 lb., low level (C.C., 1941–early 1942).	209	13	6	7
A/S bomb :—				
Average load, 1,000 lb., low level (C.C., Summer, 1942).	78	13	17	17
M.C. bomb :—				
Average load, 2,500 lb., medium level with Mark XIV sight.	(100)	(15)	(15)	(6)

bombing attacks from a low level, together with the results expected with the Mark XIV sight from about 4,000 ft. using M.C. bombs.

Reduced to the same load, the torpedo attacks are seen to be less effective than the bombing attacks, especially 16 Group's low level attacks with A/S bombs last summer. In view of the high casualty rate in the torpedo attacks and the low level bombing attacks, bombing from medium level with good bomb-sighting emerges as in general the most profitable single way of attacking merchant ships. No hard and fast rule can, however, be laid down, and the combination of different forms of attacks carried out simultaneously may, for instance, prove very successful. There is, however, one golden rule, and that is that conscientious and constant training is absolutely essential for success, whatever be the weapons or the sighting equipment.

Minelaying

Probably the most arduous, least spectacular, and apparently worst rewarded of the operations carried out by the Royal Air Force is that of minelaying, which, while calling for a very high degree of concentration and navigation, is at the end not even granted the welcome sight of a bomb burst. Furthermore, while results of bombing operations can be quickly assessed through photographic reconnaissance, information about minelaying operations usually only trickles through after a considerable lapse of time, if at all.

Although this form of offensive may be slow in producing positive results, there are certain directions in which it is quickly productive, since minelaying must be met with minesweeping; and it is the amount of negative effort involved in the counter measures which the enemy is called upon to employ, that rates it high in methods of offence.

After being the pioneer of minelaying by aircraft, Coastal Command has, through other commitments, withdrawn considerably from this type of operation, but in recent months minelaying operations on a small scale have been resumed. In the intervening period, increasing mining operations by Bomber Command—which have now reached a scale undreamt of a year or so ago—resulted in the enemy minesweeping fleet being stretched to its utmost, so that every additional area that can now be mined, and every additional mine that has to be swept, tends to overload his already overworked system, causing increasingly frequent and lengthened delays to his shipping.

A testimony to the efficacy of minelaying is the institution of the Sperrbrecher, which, it will be remembered, is a specially strengthened merchant vessel to precede a convoy and clear mines in its path. In recent months casualties among Sperrbrechers have been considerable and recent reconnaissance suggests that, for every one of these vessels which has been sunk or withdrawn from service through damage, the enemy has had to substitute from four to six minesweepers.

In consequence, at the present moment it is probably no exaggeration to say that the enemy is hard up to find sufficient vessels to counter our mining operations. Whereas at one time the laying of mines may only have caused a hold-up of hours, it is now probable that through lack of sufficient equipment such hold-ups may be lengthened into days.

In one direction the mine has a very decided advantage over the bomb. Our own experience has shown that even after a blitz of several days duration, it is almost impossible to close a large port by bombing: minelaying outside a port on several consecutive nights can effect such a closure, and more economically, both as regards the use of aircraft and missiles. An example recently came to hand of how a port, constantly used by the enemy, but until then not mined, was closed for ten days following a surprise mining operation, and the upset to the enemy's programme of sailings and deliveries can well be imagined.

The mining at present being carried out by this command is mainly in the Channel area, where the amount of commercial traffic is not, at the moment, large—in fact the enemy only passes his shipping up and down the Channel when it is particularly important for him to transfer a unit from one area of operations to another. This he usually does by moving a vessel by a series of short stages from port to port. Consequently, mining of these ports may not only cause casualties to the unit he intends to move, but may also confine it in harbour long after its intended departure time, with a resultant disorganisation of his plans.

While, therefore, it is usually difficult to produce a balance sheet showing in round figures the results of a specific mining operation, there is an immediate result, namely the measure of the enemy's embarrassment, that makes minelaying one of the most worthwhile of operations.

III—FLYING SECTION

Forced Landings in Sunderlands

In case any other pilot should find himself in similar difficulties, an experienced flying-boat pilot has written these notes as a sequel to the article in No. 6 (p. 23), "Ocean Landing and Take-off." That is the story of a Sunderland, which through engine failure force-landed in the open Atlantic in a 45-knot wind, and succeeded in taking off again, though the pilot was comparatively inexperienced.

In such circumstances you should put the good engine into fine pitch, and if time permits switch the I.F.F. to the distress setting (when such a setting is provided). Remember too, that a Sunderland cannot fly on two engines with bombs out and you should jettison them before landing. When the decision has been taken to land, the flaps should be turned to "out." There are two schools of thought as to the best method of effecting the actual landing. If you drop the boat into the water, it sustains a serious blow, but if you aim at gliding on to the surface, there is a risk of getting bounced off a wave and then flopping down out of control. Before taking off in a heavy sea, jettison as much fuel as possible, leaving just enough for the return flight.

In the case of this particular Sunderland, there was no necessity at all for a forced landing. It has been established that the failure of its two port engines was due merely to the petrol tanks on that side running dry, which could not have happened had a proper check been kept on the contents. The only reason for carrying a flight engineer in the larger aircraft is to ensure that such matters receive the necessary attention: if this member of the crew does not do his job, he would be better left on the ground. At the same time, it is also the responsibility of the Captain of the aircraft to draw up a proper list of watch duties, and to see that they are carried out. So the forced landing could have been avoided if all fuel cocks on the port side had been turned on immediately after the failure. Naturally disciplinary action resulted, but to authority that is a poor substitute for the loss of effort while this aircraft is under repair; and if luck had not been on their side, as well as good piloting, the whole crew might have had an even more unpleasant experience.

Meteorological Flying

"You poor beggars," said a pilot of Bomber Command, when he heard that his friend had been posted to the Met. Flight, "you've got to fly every day in all weather. We at least have our weather picked for us." And it is the Met. Flights which make it possible to pick the weather. Met. Flights also enable Bomber Command to select targets with a reasonable expectation of finding them, and this may save many useless and dangerous sorties. Further, the icing layer in the atmosphere is comparatively narrow—a few thousand feet—and continually shifts its level, which is usually somewhere around 10,000 ft. Knowledge of its top and base heights, gained on Met. Flights, is of enormous value in Bomber operations.

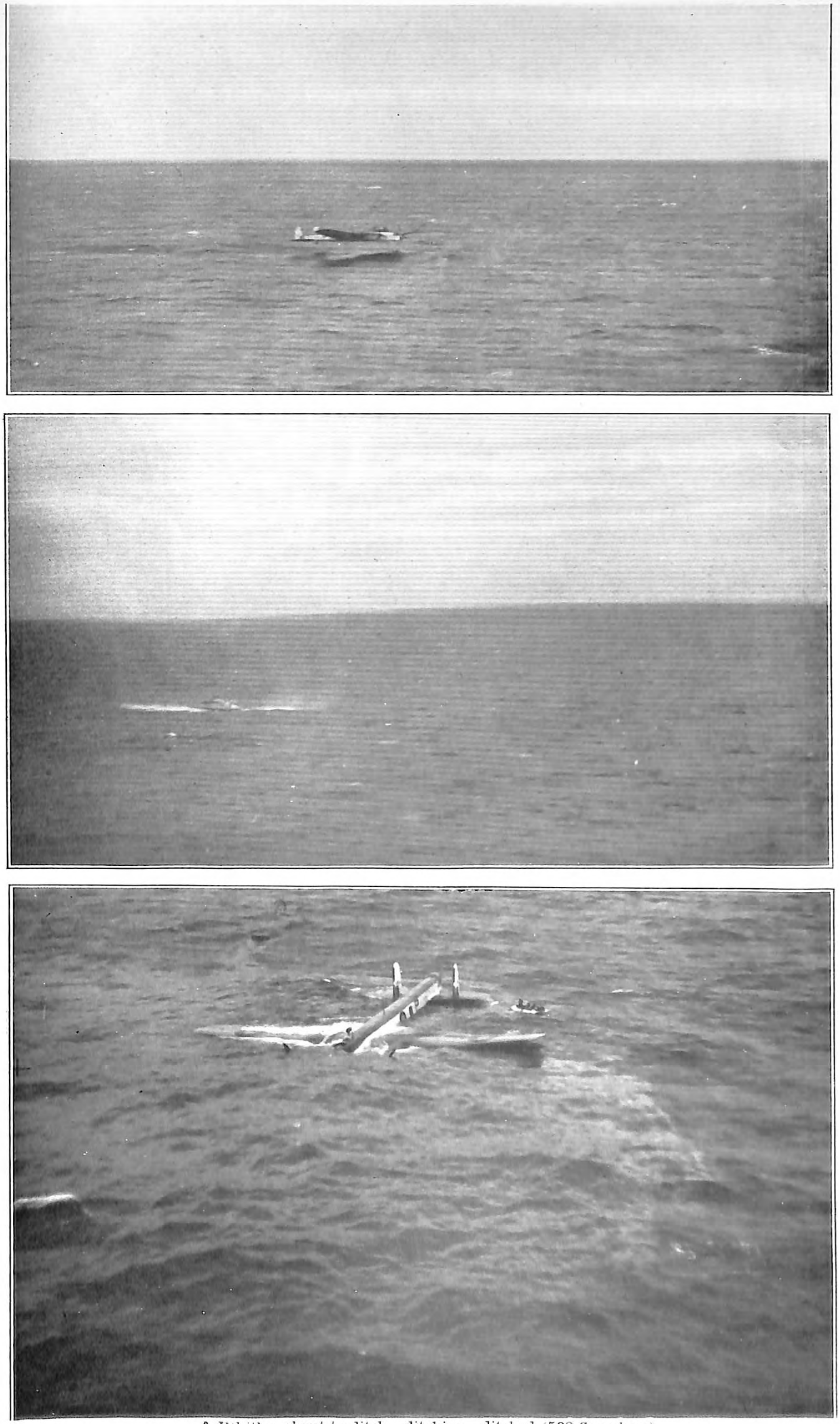
Met. Flights were discussed by a weather expert in the first issue of the Review (p. 23); this article is written from the flying point of view, based, as it happens, mainly on the experience of 1402 Flight (Aldergrove). Since it began Met. work in 1937, 1402 has made at least one of its programme flights every day except one. Individual trips have been cancelled, but on only one day has there been no flying at all. This happened on a bright but very windy day after deep snow, when a runway that had been cleared by 40 Pioneers, working all through the morning, was piled up again before the pilot finished his lunch.

As explained in the previous article, there are two main types of flying, vertical ascents and reconnaissance sorties.

Vertical Ascents

The vertical ascents can be divided into two classes, those up to 24,000 ft., which are flown by Gladiators, and those up to 40,000 ft., for which Spitfires are used. At Aldergrove the Gladiators go up three times a day—at dawn, midday and dusk—to a height of 23,000–24,000 ft., the whole flight taking just about an hour. The Spitfires' sorties into the stratosphere have been running for about a year at Aldergrove. They start at dawn, together with the first of the Gladiators, and go up in theory to a height of 40,000 ft. within a radius of 10 miles of the aerodrome; in practice they sometimes go no higher than 38,000 ft. The deciding factor is the temperature and height of the tropopause, which varies by some thousands of feet around 33,000. What this really means is that the aeroplane ceases to climb at the level which makes a 1,000-h.p. engine on the ground produce about 160 h.p. On the way up the pilot levels out for two minutes at 5,000, 10,000 and 15,000 ft.; at every 2,000 ft. between 20,000 and 30,000 ft., and above that at every 1,000 ft.; this allows the thermometer to settle, and he can then take the readings.

The Spitfire carries a Cambridge Electrical Thermometer, the element of which is fitted to the under-surface of the main plane, but the indicator on the pilot's instrument panel. The lowest temperatures recorded by present members of 1402 Flight have been −64° C. by the thermometer readings, corresponding to roughly −62° actual. In terms of Fahrenheit this means 112° of frost. The Spitfires, however, have no de-icer, their speed being enough to keep them safe for the brief period of the flight, which, it must be remembered, is made over their own aerodrome. The anti-icing equipment of the Gladiators consists of a porous rubber shoe through which glycol is pumped out. This shoe runs along the leading edges of the wings, allowing the glycol to streak back over the wings and ailerons. Unfortunately, the shoe has the effect of reducing



A Whitley about to ditch   ditching   ditched (502 Squadron).

Air-Sea Rescue :

(Top) The dinghy can just be distinguished, towards the left near the upper edge, 8th December (279 Squadron)

(Middle) The Polish destroyer *Sla ak* making its fourth rescue in two days of a Whitley crew, in their own dinghy and a Lindholme, 2nd November (279 Squadron).

(Bottom) A High Speed Launch turning home with dinghy, 8th December (280 Squadron).

the top speed of the aircraft by some 40 m.p.h. and its ceiling by about 5,000 ft., but this limitation has to be accepted.

All pilots should be tested physiologically before they begin Met. work to make sure they are not liable to a severe form of "bends," a very painful affliction caused by nitrogen bubbles in the blood. Mild bends may be incurred if a pilot passes too much of his time at great heights, but the onset of an attack can be prevented by exercising just before flying while breathing pure oxygen. This reduces the nitrogen content of the blood below normal, and by the time it has again reached threatening proportions the pilot should have descended from the danger-level. Actually no one should feel any tendency to bends or stiffness, because pilots generally leave the Met. Flight after 600 hours' flying—equivalent to some 600 trips in a Gladiator, or perhaps 400 in a Spitfire.

It is advisable to eat before high flying, otherwise one feels very empty; and the food should not be of windy content. The Spitfire pilot turns on his oxygen as he leaves the ground, and increases the supply during the climb till he is breathing 100 per cent. oxygen. In spite of the intense cold, heated clothing is not necessary, because the time spent at a great height is too short to chill the body. The standard leather suit is quite sufficient, with one or two pairs of silk gloves. The toes feel cold at 20,000–30,000 ft., but no higher. Occasionally the fingers feel numbed when over 30,000 ft., and a too rapid descent may give them "hot-ache" by a sudden rush-circulation of the blood. There has also been a recent case of frostbite in the hand, due to touching the throttle through a hole in the glove when nearing the Spitfire's ceiling. Even at the comparatively moderate altitudes reached by Gladiators, the cold can do surprising things. One pilot, who had walked through snow to his Gladiator, found when he landed that his boots had frozen to the rudder-bars so firmly that he had to leave them and pull his feet out.

As the Spitfire climbs towards its peak the colour of the sky deepens, but only occasionally is it definitely purplish and never strikingly purple. The very strong, fierce light seldom allows the pilot to notice this effect of rarefied atmosphere.

The pilots get used to flying in bad weather, and it soon ceases to worry them, though their aircraft carry little equipment to bring them back to base. For wireless communication the Gladiators have T.R.9, and they can home by cathode ray D/F. The Spitfires have VH/F, like fighters. The general practice at Aldergrove is to land there regardless of visibility. When conditions are such as anybody else would consider totally unfit for flying, even the long-range aircraft seldom trouble to go to other aerodromes to land, but drop in from 150 or 200 ft. Sea fog is rare, and though the runways may be impenetrably wrapped in mist, they lie close to the great expanse of Lough Neagh, 200 ft. below, and it so happens that the cloud-base rarely descends to the lake surface. To break cloud, you home on the station, then steer 210° and lose height over the lake. When you are accustomed to low flying, it then seems a simple matter to turn and come up blind to the aerodrome, and finally drop your wheels on it.

Only two aircraft have been seriously damaged landing at Aldergrove in bad weather. In the early days a Spitfire astonished its pilot, who was used to a Gladiator with fixed wheels, by making a belly landing, because he had forgotten to lower the undercarriage. The second casualty was a Gladiator. The pilot took off in fog, intending to land at Limavady, but that too became invisible, so he was told to bale out. He refused, saw a hilltop showing vaguely through the fog, and got down very nicely, but at the end of his run he hit the scattered stones of an old wall, which broke off a wheel. The aircraft stood upright on its nose for a few seconds, and then toppled forwards on its back; the pilot was unhurt.

To land at Bircham Newton in very poor visibility, the Met. pilots make an abbreviated ZZ approach, which leaves much to individual discretion. The aim of this ZZ is to cross the D.F. Station and get "engines over" at about 50–100 ft. at 90 m.p.h., then to throttle back and land, if necessary, "on the altimeter". After getting "engines over" the pilot glides in on the same course to the aerodrome boundary 100 yards ahead. When he reaches this, two men with Verey pistols fire off green lights on each side of him to mark his crossing the boundary. A flare path of glim lamps is laid further on, diagonally across his approach, to show him where the centre of the aerodrome is.

Routine Reconnaissance Sorties

The regular reconnaissance flights are flown out from Iceland, Northern Ireland, Cornwall, Norfolk and the North of Scotland, timed in each case to reach their extreme point at dawn. The aircraft fly along a line of constant pressure, the 950 millibars level, which means in practice anything between 500 and 2,000 ft. At intervals of 50 miles the pilot takes readings of humidity, temperature, type and height of cloud, and sea conditions. If there is icing or bad bumping along the 950 millibars line, the aircraft is flown at a more pleasant height for the greater part of the time, and only brought to 950 millibars for five minutes every 50 miles, to allow the instruments to settle. Readings are then taken and the pilot thankfully brings the aircraft back to comparative comfort.

At Aldergrove these sorties were originally carried out by Blenheims, but they are now done by Hudsons with a crew of four. The take-offs are timed so that the earlier one reaches its extreme point at dawn and the second starts at the same time as the mid-day Gladiator. The Blenheims used to go 350 miles, from Aldergrove to Rockall, and turn there. The Hudsons fly 500 miles out, on a track which passes west of Rockall. At the furthest point they climb to 18,000 ft.

The instruments originally carried by these aircraft consisted of an accurate aneroid barometer and a psychrometer. To read the temperature, the pilot looks out at the psychrometer, which is fixed to the outer strut of the wing, where there is a light just strong enough to enable him to make the reading. The psychrometer has two columns, a wet bulb and a dry bulb. The idea of carrying it in this position is that the atmosphere there is not much disturbed by airflow. The psychrometers originally supplied were designed to be fixed to the vertical struts between the wings of biplanes. The difficulty of fitting them on to a monoplane was overcome by the ingenuity of a corporal, who fixed a strut on to the side of the Blenheims, a device since adopted for Blenheims and Hudsons in all Met. Flights. This device, by the way, was instrumental in saving an observer of 1404 Flight from injury or death, in a Blenheim that was returning on one engine from a trip over the Bay. The propeller of the dud engine could not be feathered, and finally the crankshaft sheared through, so that the propeller came adrift and shot violently towards the aircraft's nose. It looked as though it would crash through the starboard observation panel and hit the observer, but was deflected by the psychrometer and fell into the sea.

On one of these Blenheim sorties the aircraft was coming down from 18,000 ft. over Rockall when 3 in. of ice formed on the guns and the tailplane was smothered in it. Then both motors cut, at about 8,000 ft. The A.S.I. had frozen and the aircraft was in thick cloud. When the machine had dropped to 2,000 ft. one motor picked up, and the other did so at 1,000 ft. That is merely one of the bad cases of icing in Met. Flight history.

On Flying Control

This is not a comprehensive catalogue and survey of all those navigational aids available to aircraft generally associated with the name of Flying Control. Such information is readily available to those who have the time and the inclination to find and digest it. This article is chiefly concerned with certain aspects of Flying Control which, owing to the increasing provision of new equipment, have been overlain or forgotten, though they can still be of considerable assistance to aircraft when special navigational equipment has failed.

A good many aircrews are probably not aware of the extensive organisation which exists for their benefit. Apart from Flying Control on Stations there exists at each Group Headquarters in this Command a continuous Flying Control watch. This watch besides performing the executive duties of the Air/Sea Rescue Service, keeps a co-ordinating and benign supervision over the movements of all aircraft. The Group Flying Control Officer gets the whole of the information available from every possible source, and does the best he can with it for the benefit of aircraft. He receives the D/F bearings taken by all the Stations, H/F D/F working on the Group frequency, and also the bearings taken by the M/F D/F Sections; these include bearings and fixes not only on aircraft of his own Group, but on all others using the frequency of that M/F D/F section. In addition he receives an enormous amount of help from Flying Control Liaison and other Officers at Fighter Command Groups, together with reports from the Royal Observer Corps, Coastguards and coast watches. By combining all the information thus available he can find out where a lost aircraft is, and once he has done that and established communication with it, he can really help it. Although he is miles away from the receiving stations, he gives assistance with the maximum speed to any aircraft.

This may seem to be an ambitious claim for Group Flying Control, but it *is* true, as examples will prove.

Firstly let us consider an example of the use of H/F D/F bearings exclusively. About 1½ hours before dusk on a September evening, a message was received from Hudson T: "Compass U/S, undercart U/S," followed by a position well out over the North Sea. The aircraft's transmission was rather poor, but rough bearings were obtained, and the aircraft was instructed to "Steer west until in sight of land. Jettison bombs. Transmit for D/F fix. Await further instructions. Notify your remaining endurance. Do not land until ordered." The aircraft acknowledged this message and replied that it had four hours' endurance. Although the bearings taken were not very accurate, they *did* give a check on the aircraft's course, and alterations of this course could have been given if necessary; actually the aircraft proceeded straight towards its base. Shortly afterwards it was instructed: "Jettison your bombs now, your petrol when within sight of land." A D/F position was then obtained, showing the aircraft to be nearing the coast, and the message sent: "Have you jettisoned petrol and bombs? Do both now. Circle base. Land, not on runway. Cut switches on touching down." A quarter of an hour later the aircraft replied: "Instructions carried out." By this time it was almost dark. The flare path had to be relaid off the runway so the aircraft was instructed: "Stand by until flare path changed. Wait for green." Shortly after this the aircraft was overhead and the laying of the flare path off the runway had been completed. The pilot made a good belly landing on the grass, without any of the crew being injured.

In this case the H/F D/F bearings gave a series of approximate positions over the sea, enabling the Group Flying Control Officer to keep a rough check on the aircraft's progress. A fix by means of H/F D/F, however, is not nearly as accurate as one obtained by M/F bearings, or by R.D.F. or Royal Observer Corps plots, but the two latter methods are not available unless an aircraft is within R.D.F. range over the sea, or is over land.

Here is an example of the combined use of H/F D/F bearings and Royal Observer Corps plots. Early on a winter morning an S.O.S. was received from Wellington G (Bomber Command) on the Group Reconnaissance frequency. Only two bearings were available. They cut at a narrow angle and indicated the aircraft to be somewhere over Yorkshire. It was instructed to transmit again for a fix. The result was approximately the same position. The appropriate Fighter Group had no trace of any aircraft flying there, so a third transmission was requested. The position now indicated was more towards the Solway Firth. On enquiry, Prestwick Fighter Sector reported that they were trying to attract a lost bomber aircraft by searchlights and pyrotechnics, and their Royal Observer Corps plots agreed with the H/F D/F fix. Just prior to this the aircraft had given its endurance as 45 minutes. As soon as its position was established, the aircraft was instructed to land at Prestwick, and given a QDM and distance. These were acknowledged at once.

From that point control was effected purely from Royal Observer Corps plots. Three minutes later the aircraft was given another QDM and a distance of 15 miles, together with a warning as to the position and height of balloons in the neighbourhood. Seven minutes' later, another QDM and a distance of 5 miles was passed. At the same time, the aircraft was told to look out for a searchlight on the aerodrome; it had been switched on while the flare path was being laid. (This was before Drem lighting became general). Three minutes later, the aircraft sent: "Found it, reeling in aerial," and landed 5 minutes later with 15 minutes' petrol to spare.

When using R.D.F. and Royal Observer Corps plots you have to be able to identify with absolute certainty which plot refers to the aircraft in question. Fighter Groups can only say that an aircraft is in a certain position; they are not sure which aircraft, but they think it is So and So. To identify the plot it is necessary to work by D/F bearings and to consider the positions of all aircraft flying in that particular locality, by no means an easy matter. One night, a Coastal aircraft, returning from a strike on the Norwegian coast, was homing to its base when the transmitter burned out. The pilot with great acumen switched his I.F.F. to radiate the distress signal, hoping that somebody would give him a QDM. Unfortunately it was not possible to identify the plot before the aircraft had crossed the coast. After that the IFF was not picked up (since R.D.F. stations generally cope only with seaward traffic) and he had the bad luck to run into a lot of enemy activity, which not only prevented his plot from being picked out from the numerous hostiles, but precluded him from obtaining searchlight homing aid. This was almost a case for those famous last words: "The wireless packed up, so we had to fall back on navigation." Unfortunately they had more or less packed up on navigation before the W/T burned out, so were only vaguely aware of their very rough position. They were lucky to get clear of the Hun and make a good crash landing in a highly unfavourable spot.

If, however, there is no enemy activity, a great deal of help can be given even without two-way communication. Just by circling for a little while, an aircraft attracts the attention of Flying Control at a Fighter Group, and everything possible is then done to assist. For instance, no W/T contact could be established with Hudson O, which was returning by night from operations. A Fighter plot showed an aircraft to be circling Belfast Lough and this was thought to be Hudson O. Naval lights were put on near Belfast; West Freugh and Silloth were asked to switch on their flare paths. Seven minutes later the aircraft was reported to have gone in the direction of Ayr at 1,000 ft. Ayr were asked to put their lights on and the Searchlight Homing procedure for Ayr was instituted. At the same time a message was broadcast to Hudson O: "Follow searchlights Ayr," in the hope that his receiver might be working. But the aircraft climbed to 5,000 ft. and went eastwards over Glasgow. Then it climbed to 8,000 ft. over Loch Lomond and turned south-east. Balloons were close-hauled, Royal Observer Corps plots were passed to the aircraft together with courses to steer, and some of the messages were acknowledged, showing that at last his transmitter was working in addition to his receiver. The aircraft flew south towards Ayr and at the appropriate time was instructed to lose height to 3,000 ft. After five minutes it was circling Prestwick and reported that it was in searchlights; it landed five minutes later at Ayr.

Space in the issue prevents any discussion of other methods by which Flying Control can assist aircraft, for example, the use of M/F D/F sections in relation to Air/Sea Rescue operations. This glimpse into the operation of Flying Control is given, not to advertise the organisation, but to indicate to aircrews something of what is being regularly done. Few of them fully appreciate the extensive resources that are now available or the degree to which modern scientific discoveries have been harnessed to ensure that they are brought safely home.

Leaves from a Navigator's Log Book—I

Everybody likes an easy life and it would be a mistake to suppose that we navigators are not human in this failing. Taking things easily is certainly at the root of most of the failures that we are wont to suffer. As somebody once very wisely said, *á propos* the sublime art: "A navigator has to think he is wrong all the time if he is to be right." In other words, it is no good waiting for things to happen; we must meet them half way.

How many of us haven't felt a surge of pleasure when, after hours of sweeping over the Bay or the Western Approaches, or perhaps after a do-or-die dash to the Dutch coast and back, we arrive plumb on our expected landfall within measurable minutes of our E.T.A.? Our Captain has even "shot a line" for us over beer in the Mess afterwards, and we have honestly believed it was partly, if not all, our own doing. The other day we even heard of a crew making capital out of an arrival at their intended landfall, though they were an hour and a half late on E.T.A.! You laugh at that; but for every such "beam" there are a thousand lesser "motes" which tend to clog the wheels of war. Have you ever considered how many factors go towards making each flight a navigational failure or a success? Next time you are tempted to be at all smug about your performance as a navigator, remember that things don't always go wrong. Every dog has his day.

There are those of us whose painful duty it is to examine and sometimes criticise navigators' logs. With our hand on the pulse of the Command's navigation, we can soon tell when all is not well. Recently we have gone a step further by applying a stethoscope to the whole proceedings in the shape of a detailed form analysis, so as to diagnose ailments in the body navigational with greater certainty. It is a pity the diagnosis cannot be made in the air, for it is so difficult at times to believe the evidence of one's own eyes. A recent case we came across might have happened to almost anyone. Indeed, it is only by being always intelligently alert that we avoid putting up similar "blacks" every time we fly.

A navigator having been out for half an hour or so, and finding a whole series of drifts quite different from the one he calculated, had the natural inclination to check up on the wind. So far so good, particularly as he went to the little extra trouble of using the three-course method (how well this repays and yet how little is it used by self-styled "good" navigators). True enough, there had been a considerable backing of the wind and it was slightly less strong than the "met." wind he had used. Yet—and here is the rub—when he reached the E.T.A. indicated in his Flight Plan, he calmly "called it a day" and set course for his next track. He had done nothing more effective about recovering his intended turning point, before or after finding the wind, than altering course to allow for his latest drift, and so he merely crawled down a track parallel to the one required, but some distance from it. It so happened that the results of this were very serious—that is another story which need not concern us here. Suffice it to say that confirmed "track crawlers" would do well to reflect on their technique and on its obvious weaknesses. We know we are in the minority in condemning this practice, and we realise we are suggesting a radical change for most navigators, and an unpopular one at that. But we have our reasons for wanting to see a much more frequent use of the Air Plot.

Navigation is an art, not a precise science, and the idea is to make it as exact as possible. Have you ever stopped to think how accurate "track crawling" really is? To start with, when you find a drift and steer a course to allow for it, how accurate and reliable is your drift? Again, how many navigators check back on the drift as soon as they have altered course? It is very often different, especially in a head wind. The normal slipshod way is to wait for some period of anything up to an hour, and then to take another drift. This may be, and probably is, different from the last one observed. When was the exact moment of change? The navigator doesn't know—the best he can do is to alter course at once to allow for the new conditions. The aircraft has of course been affected by the new drift since the moment the change took place. Depending on the direction of the change of drift, the aircraft will be to one side or other of the required track. Since the navigator can't say when the change took place, he can't tell how much to one side or the other he is. In the circumstances it is easy to see why he fools himself into believing he is still on track. Of course, the wind changes almost continuously in speed and/or direction as the aircraft flies from place to place, and it can do so without any visible effect on the drift on any one course. So it is clearly impossible to say just where the "track crawling" aircraft is at any time by D.R.

The great advantage of the Air Plot is that the pilot is not pestered with frequent course alterations of 1°, but can settle down to a steady course. This in itself means an improvement in your navigation by reducing the pilot's errors of steering and speed-keeping, besides allowing him to keep a better look-out. Having found a good three-course wind, you can use this for calculating the course for the required track. Then, with your weather eye on the drift at regular and frequent intervals—not less often than every 20 minutes—make a note of all drifts, even if no change is observed. (You never know when you may want to refer back to your log for corroboration). Whenever drift has changed by three degrees, or after every 100 miles—whichever is sooner—find another three-course wind, noting the time you take to find it. Every time you obtain a reliable wind, namely at least every 100 miles, work out a D.R. position from your air plot, using a mean wind vector derived by simply combining this wind with the last one you found. Your position will not be absolutely exact because of the gradual change of wind over the whole period, but it will be as near as you can expect to be in practice. Having plotted this D.R. position, start a new air plot from it, using the wind you have just found for the new course to make good your track, or the new track required to rejoin your intended track.

We are aware that all this will mean more work for most of Coastal Command navigators, but we are determined to secure a higher order of accuracy than we now have. We are not impressed by low figures of Calculation Error shown on the returns of navigational analyses when, more often than not, they are accompanied by winds found by estimation and by the now very discredited drift and wind-lane method, to mention only two of the sadly common popular pitfalls. We hope shortly to have D.R. compasses in increasing numbers in all our long-range aircraft, and it would be a waste of war effort if this instrument was not backed up by accurate navigational technique. Then there is the Air Position Indicator, which will automatically keep the air plot in latitude and longitude with greater than human accuracy. The introduction of this device is almost in sight, but it will be asking for trouble to rely upon it exclusively. Experience will dictate what precautions will be necessary, but it is certain that a manual air plot will have to be kept as well, and accepted in preference to the mechanical position if this differs widely from the former. The net gain will be one of accuracy, but we don't anticipate an alleviation of the navigator's task. What we are anxious to see at present is a marked increase in the number of navigators keeping an air plot and a tremendous increase in the use of the three-course method for finding the wind. If this is achieved before we can provide you with improved and novel instruments, you will have shown yourselves capable of benefiting from them when they do arrive.

Introducing BABS

Why is it that so many people go all sloppy at the sight of day-old chicks, young lambs, puppies, kittens, or even babies? Some say that Nature gives this particular form of appeal to young creatures incapable of defending themselves against the attacks of their enemies. If this is so, it is a pity that the same form of protection cannot be offered to that attractive young creature BABS, who has recently made her appearance in a hard and sometimes hostile world. She is perhaps unfortunate in having an elder brother, STAN (or, to give him his full name, Standard Beam Approach) who has been the centre of attraction among pilots for the last few years, and who is, maybe, jealous of her early successes, fearing that she may oust him from his important position in the flying world. He therefore goes around muttering in the ears of pilots, particularly the old diehards, "You don't want anything to do with this new-fangled upstart device, do you? Why not stick to the old friend you know so well? Why have two different techniques which are bound to lead to confusion? . . ." and a lot more stuff like that. Maybe we are doing STAN an injustice. Quite possibly he really loves his baby sister, so like him in many ways, and those base rumours are spread abroad by that most crafty of gremlins, the Instrument Flying Confidence-Shaker. It seems, however, that, now the existence of BABS is becoming widely known, the time has come when the merits and demerits of BABS and STAN should be examined side by side, so that all concerned with their use, may judge for themselves which they prefer, and understand the reasons which prompted Coastal Command to champion BABS almost as soon as she was hatched.

The fundamental principle of each system is exactly the same. Two intermittent, distinctive, but complementary signals are transmitted into two zones which are arranged so that they overlap slightly. This overlap provides a sharply-defined beam or "equi-signal zone" in which both signals can be received at equal strength so that they interlock to give a continuous steady signal. The pilot tries to bring his aircraft into the steady beam and to fly along it right onto the runway.

From this point on, the differences between BABS and STAN become more apparent. First there is the method of receiving and interpreting the signals. BABS does this by means of the S.E. receiver which is already installed for other purposes in most Coastal Command aircraft. STAN requires a special receiver. Admittedly, if the aircraft has no S.E. in the ordinary way, and Beam Approach facilities are required, then STAN is the better bet, because it is smaller, lighter, and needs less power to work it than the Special Equipment which would be required for BABS.

There has not as yet been any suggestion that S.E. should be installed purely to enable BABS to be used. The policy is that, where S.E. is already installed in the aircraft, it shall be used for BABS as well as for its primary operational function, because this obviates the necessity of installing further equipment simply and solely to provide the aircraft with Beam Approach facilities. Over half the aircraft in Coastal Command already have S.E. fitted and the numbers are increasing steadily, which means an ever-increasing demand for BABS. Bomber Command Beam Approach is a different story, and the present or future policy there is outside the scope of this discussion.

The next difference to be considered lies in the two methods of presentation or interpretation of the signals to the pilot. STAN feeds his indications directly to the pilot through head-phones, and/or to a pilot's visual indicator, and the interpretation of them is the pilot's job. BABS, on the other hand presents a picture on a screen to the S.E. Operator, who has to interpret it to the pilot, again through his head-phones, over the intercom. This is where one of the major controversies starts. STAN's supporters say the BABS interpretation is bad because—

(i) it introduces an extra link, and therefore an extra delay, between the reception of the signal and the pilot's reaction to it, and

(ii) most pilots would naturally prefer to rely upon their own judgment in interpreting the signal rather than upon that of their operator.

To these sound arguments, BABS fans produce the equally sound replies that—

(i) the delay is not significant because, if things become so rushed during a beam approach that every second counts, the approach is a bad one, and the pilot should go round again.

(ii) the pilot's attention is fully occupied in watching his instruments, flying the aircraft, and keeping a look-out for his first glimpse of the ground.

The effort of listening to morse signals in his head-phones and/or watching his visual indicator and interpreting the signals for himself, will divide his attention which needs to be concentrated on flying the aircraft. The longer the trip and the more tired the pilot, the greater will be the effort required. It is therefore important that pilots should be relieved of as much of the work as possible. The separate operator interpreting the signals for the pilot not only provides this relief, but also is able to concentrate *all* his attention on to interpreting the signals where the pilot could only give it part of his attention. Hence the operator's interpretations are likely to be more accurate and more reliable than those of the pilot. The importance of this "fatigue effect" cannot be over-estimated. It would be foolish to pretend that a pilot who made a reasonable beam approach on a practice flight after one or two hours flying would be equally capable of repeating the performance to the same standard after an operational flight of 10 or 20 hours. And in Coastal Command to-day, flights of 10 and even 20 hours are probably more numerous than those of one or two hours.

Another aspect, which also links up with the fatigue effect, is the Range versus Marker Beacon argument. STAN gives the pilot no definite indication of his position along the beam until he reaches the outer marker beacon, and after he has passed that he has to listen intently for the first sign of the inner marker beacon. To a pilot who is feeling his way down the beam, tired out after a long operational flight, probably surrounded by darkness and filthy weather and harassed by every kind of gremlin, the long wait for the outer marker beacon seems like Eternity; between the outer and inner markers, the gap is either nothing at all, or else another 100 years, according to how much he has to try and do in the time. An exaggerated description, perhaps, but the effect on the pilot of this additional nervous tension must not be lightly dismissed.

What has BABS to offer in this respect ? With pardonable pride, she states that she can give continuous range indications from 10 miles out right down to the end of the runway. The pilot knows where he is throughout the approach and can take his time about doing such things as reducing height, and coping with flaps, wheels, and anything else which requires his attention. Sceptics may say, " That's all very fine, but how do we know that the range-scale is accurate ? We have known occasions when it was a mile out. It may be quite nice in the distant stages of the approach, but we would like something to tell us with absolute certainty when we pass over the air field boundary." The answers are simple. First, there is no earthly reason why the range-scale should not be absolutely accurate and reliable provided that the equipment is properly maintained and calibrated. Anyone who experiences any trouble should corner his squadron R.D.F. officer and make him pep up his maintenance standards. Second, the idea of a boundary marker beacon for use with BABS is already receiving serious consideration and experiments are being conducted by the B.A. Development Unit to decide what form this should take if it is thought necessary.

There are many other technical points of difference, over which the rival exponents of STAN and BABS are prepared to argue for hours, which need not be mentioned here. Enough has been said to introduce BABS to many readers who previously were hardly aware of her existence. It must not be forgotten that BABS is barely a year old, and there may still be snags ahead to be overcome.

However, the system has been thoroughly examined by the self-same experts who fostered STAN and has been found worthy of introduction into the Service. So, when it comes your way, give it a fair trial and try and help to overcome any difficulties which may crop up instead of damning it out of hand before you know all about it. Don't listen to the anti-BABS gremlins and STAN fanatics who will try and convince you that BABS is useless and STAN is marvellous. There is much to be said for each. Make it your business to find out all you can about both and judge for yourself.

Meet the Fishermen

As a result of a scheme of liaison with the local fishing fleet personnel, a party of the skippers and mates paid a visit the other day to our flying-boat station. Over a glass of beer we heard a few of their experiences.

Mr. C. told how for three days running he heard an aircraft pass close to his trawler precisely at 1330 hours, while he and his crew were taking their midday meal. On each occasion they ran on deck to prepare for action, and on each occasion the aircraft proved to be a Sunderland. On the fourth day at exactly the same hour an aircraft was heard, and, assuming it to be the Sunderland, the crew carried on with their meal, only to be bombed. The visitor this time proved to be a Hun !

Several instances of low flying by our own aircraft over the fishing fleet were given : in one case a British bomber " shot up " the fleet, then only forty miles south of the Irish coast, finally opening up with machine-guns, aimed off target of course.

We realised that although the fisher folk are glad to see us, the very real danger exists that if they assume that every aircraft which flies low over them is friendly, they run the risk of being attacked by an enemy aircraft when they are not prepared for it. Skipper R. said he could, and would, take no chances. He intends to machine-gun *any* aircraft which " shoots up " his trawler.

Next we heard of cases of aircraft flying alongside a ship several times. The skipper, assuming that his help was required in the direction pointed out by the aircraft (perhaps to pick someone up from the sea), in each case cut his gear adrift and steamed in the direction indicated, but in no case had anything been sighted. Now, when fishing gear is abandoned, it means a loss to the owners and a loss to the crew, for they are paid not for work done but for fish caught. It may even mean that the fishermen receive no pay at all for 14 days spent at sea—in dangerous conditions, to say the least. Leading fishing vessels up the garden may be fun for our P/O Prunes, but it is not fun for the skippers and their crews.

We for our part have promised to keep away from our own trawlers as far as possible. If we want to go in, we are first going to circle at a distance of at least a mile, so that our silhouette can be recognised with certainty before the approach is made.

Both fishermen and aircrews have thus gained some knowledge of the other fellow's difficulties. A visit of aircrew personnel to the fishing fleet brought some more concrete results, not only in the form of a handsome gift of fresh fish and kippers for the Mess ! For we were taken on board various types of boats, and shown the different methods of fishing, so that we could see for ourselves how each method called for craft having special characteristics. In this practical way our aircrews have learned to recognise the various types of fishing vessels, and with an understanding of the methods used by each and of where the fish are found, they should be able to decide *while on patrol* whether any boat they see is honest or otherwise.

IV—SPECIALIST AND GENERAL ARTICLES

Bombsighting and the Mark XIV Sight

The Mark XIV Bombsight is now being introduced into the Service, and this account is intended to indicate its place in relation to other types of sight. It does not go into the construction and mechanical working of the instrument, which are described in official publications S.D. 211, P.Arm. P.19 and (most fully) in A.P. 1730A, now in the press.

When a bomb is released from an aeroplane, its forward speed and direction are initially those of the aircraft. If we neglect the effect of air resistance, it is clear that the bomb will strike a point lying beneath the track of the aeroplane, and at a distance beyond the release point equal to the ground distance flown by the aeroplane during the time of the bomb's fall. The air resistance has two effects : it lengthens the time of fall; and causes the bomb to trail behind the aircraft. Since the bomb and aeroplane are both carried by the wind, the trail takes place along the reversed heading of the aeroplane and not down the actual track, so that the bomb falls a little to one side of the track by an amount called the cross-trail. In the case of a typical bomb of good aerodynamic properties, the trail is fairly small and the bomb falls very nearly in the direction of the aircraft track at the instant of release. It is important to notice that even if the track is curved and the aeroplane banked at the instant of release, the bomb falls in a vertical plane which is tangential to the track at release.

The functions of a bombsight are, firstly to enable the aeroplane to be flown so as to track towards the target at the instant of release (subject to a small correction for cross-trail), and secondly to indicate the instant of bomb release. These functions are called line control and range control. Bombsights hitherto developed may be divided into two classes " vector " and " tachymetric." In vector sights the airspeed and course, windspeed and direction, are set into the sighting mechanism, which calculates the drift and groundspeed by mechanical solution of the vector triangle. Height and bomb ballistics are set into the sight. The sight is then able to calculate the sighting angle from the vertical, at the correct instant of release. The result presented to the bomb-aimer is a drift line indicating the aircraft track over the ground, and a release mark which trails over the target at the instant of release. The course-setting bombsight is the prototype of this class, and in its Service form it gives a very accurate solution of the bombing problem.

The accuracy of all vector sights is necessarily limited by the accuracy with which the wind is known. A wind vector error of 1 knot gives a bombing error of 13 ft. from 1,000 ft., 30 ft. from 5,000 ft., 42 ft. from 10,000 ft. Similar errors are introduced by the motion of a ship target unless the ship's speed is known and introduced into the vector mechanism of the sight.

In fully tachymetric sights, the control of line and range is effected by observations of the target and is in principle independent of previous knowledge of airspeed or wind. In sights of this type, exemplified by the stabilised automatic bombsight and the Sperry sight, the bomb-aimer keeps an optical graticule on the target by repeated adjustment of a tracking mechanism, which eventually follows the target by itself. Line control is effected by arranging that when the sight is turned through a certain azimuth angle relative to a gyroscope datum, the aeroplane is turned through an angle several times as great. The sight is kept on the target by repeated adjustment of sight and course, and it can be proved that this makes the aeroplane's track become less and less curved and finally lead straight over the target. By following the target with the graticule in range, the groundspeed is measured and the release-point mechanically calculated. When the optical system reaches the correct angle, the bomb is released automatically. The advantage of the tachymetric sight lies in its independence of previous knowledge of wind. Further, the motion of the aircraft is measured relative to the target, and the motion of the latter is automatically taken into account. On the other hand, once the run has been started, the tachymetric sight leads to a mathematically determined curve of approach ending normally in a considerable straight run, and an attack of this kind delivered from a moderate height is extremely vulnerable to anti-aircraft fire.

The Mark XIV Bombsight (Plates 8 and 9).

The Mark XIV Bombsight has been developed to allow bombing of moderate accuracy with a very considerable degree of tactical freedom. It is a vector bombsight, in which the height and airspeed are fed in continuously and automatically. The course may be fed in from a D.R. compass.

When the wind setting has been made, the sight calculates automatically the drift and bombing angle. A gyroscopic level in the sight automatically corrects the angle for the effects of climbing and diving flight. All these variables are dealt with in a computor box as indicated in Fig. 3, and the bombing angle and drift are fed out through mechanical flexible drives to the

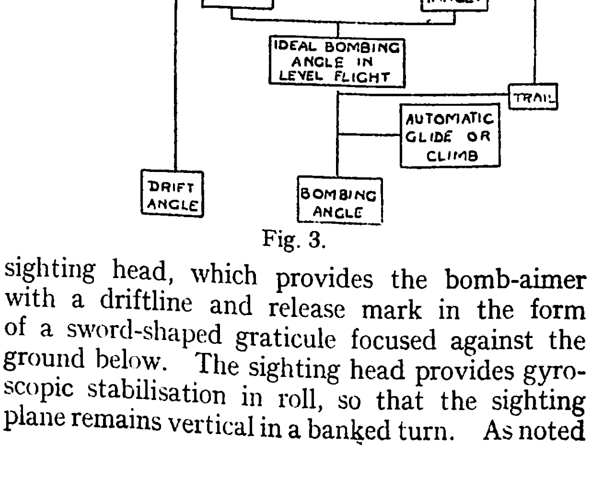


Fig. 3.

sighting head, which provides the bomb-aimer with a driftline and release mark in the form of a sword-shaped graticule focused against the ground below. The sighting head provides gyroscopic stabilisation in roll, so that the sighting plane remains vertical in a banked turn. As noted above, a bomb released in a turn falls in a vertical plane tangential to the track, and this is correctly indicated by the roll-stabilised graticule of the sight.

The bombsight provides a great simplification of the bomb-aimer's duties. When the wind, the bomb characteristic, and the servo altimeter zero have been set, all changes in height, airspeed, course, and attitude are kept continuously up to date, and whenever the sight is switched on, the graticule shows where a bomb would fall if released at that instant. It is only necessary for the bomb-aimer to steer the graticule-cross on to the target and then release the bomb. Actual bombing with the sight shows that bombing in a turn is quite practicable—for example, practice bombs were dropped from 10,000 ft. with fairly violent turns nearly up to bomb release, and the aeroplane turning at rate 1–1½ actually at the release-point. The errors (about 120 yards mean error) were not significantly greater than in straight flight. The successful use of this method requires some practice in co-operation between pilot and bomb-aimer, since the corrections require changes in the rate of turn rather than right or left turns. Like any other vector sight, the Mark XIV sight assumes that the aeroplane is moving through the air in the direction of its fore and aft axis, and very appreciable errors result from side-slip at release. It is therefore important to make correctly banked turns and not flat turns. Since the sight is roll-stabilised, the bomb-aimer has no difficulty in directing the graticule on to the target in a banked turn.

The accuracy of the sight is, of course, limited by the accuracy with which wind settings can be made, and the wind vector error is normally the limiting factor in bombing precision. It is therefore important to set the best wind information available; this will usually be obtained from navigation though there is a possibility that special methods for finding local winds may be available in some cases. The wind ideally required is, of course, the local wind at the height of release.

No special provision is made for a "fourth vector" allowance when bombing moving targets. Since with a roll-stabilised sight there is no need for a long run up, by using the drift wires it is hoped that a simple aim-ahead allowance may be practicable for attacks on moving ships from moderate altitudes. It is clear from the vector error figures given above, that this method would present no difficulty in attacking merchant ships where a bomb aimed at the bows from below 5,000 ft. would in most cases strike somewhere along the ship's length.

Some special limitations of the sight in its present form arise from the necessary compromise between features desirable in use and reasonable simplicity of construction—the latter being an important factor in relation to supply and maintenance. The lower limit of height is 1,000 ft., primarily because the bombing errors due to inaccuracy of height-setting increase rapidly with decreasing height. Neither the mechanical perfection of the servo altimeter nor the ordinary barometric setting of its zero would be adequate at low altitude. The sight does not allow the use of bombs with terminal velocity lower than 1,000 ft. per second, since the restriction allows cross-trail to be neglected and leads to great mechanical simplification. Bombs of low T.V. are in any case subject to secondary wind effects which makes them unsuitable for accurate aiming from any but low altitude. It is, however, possible that the present limitation of height may be overcome in a later model.

The rate at which the bombing-angle setting mechanism operates is rather slow; while the sight operates satisfactorily in level flight (straight or curved), and in a steady glide or shallow dive, it will not cope with sudden changes of attitude, as when entering a dive or pulling out. Bombs released under these conditions may show considerable range errors.

The calibration of the sight depends on the type of aeroplane, so that each aircraft type requires its own type of computor box; exceptionally two or more aircraft may share one type of computor.

The primary aim of the sight is to increase the chances of operational success (as distinct from instrumental or practice accuracy) by carrying out a part of the bomb-aimer's former duties automatically and better than he could. It must be remembered that this advantage is purchased by the use of a fairly complicated mechanism. In effect, part of the aircrew's responsibilities are transferred to the maintenance staff, and it should be understood that a regular maintenance routine is a necessary condition of success with any instrument of this scope.

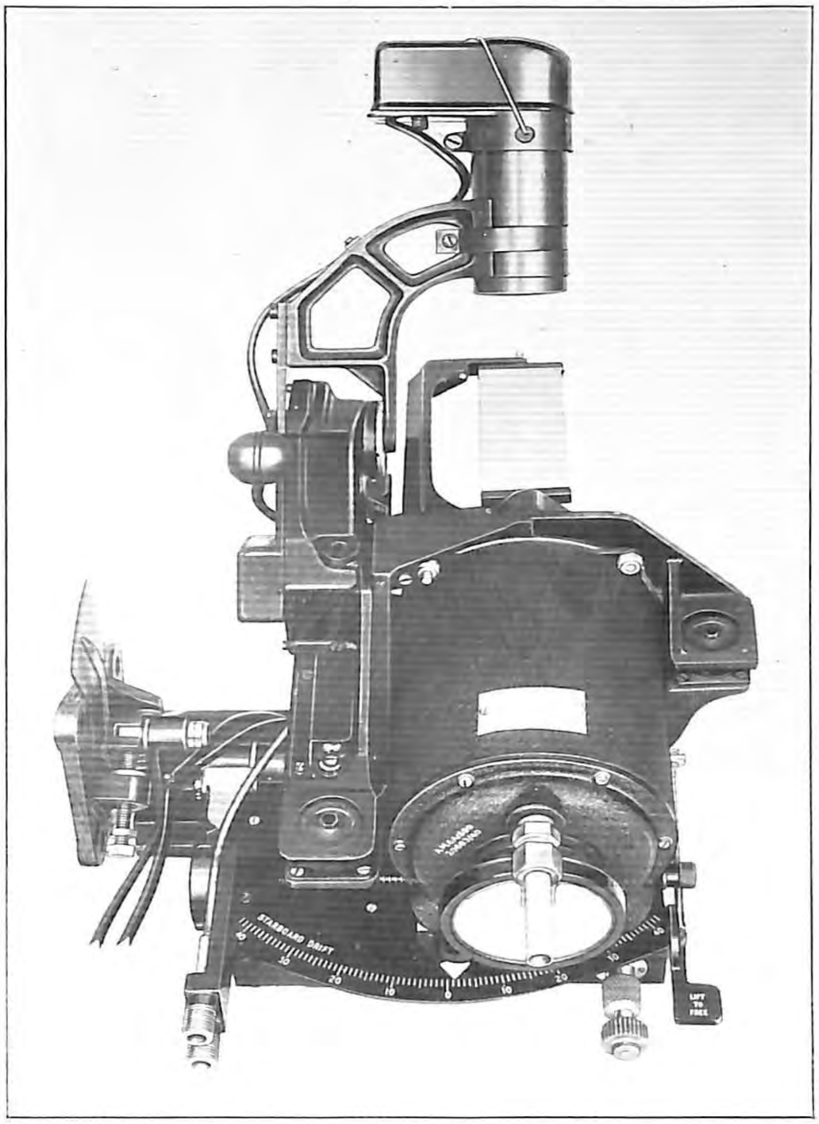
I Think They're Battleships

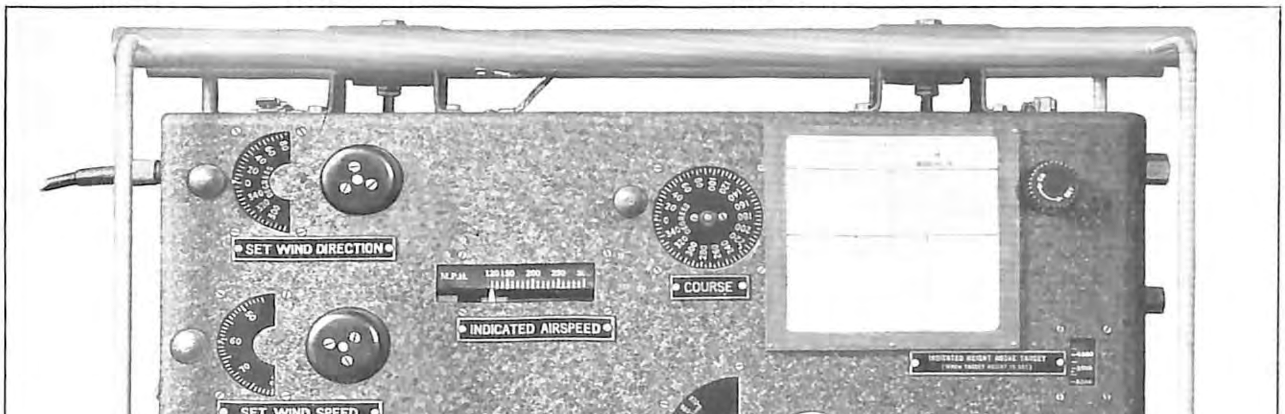
First Sighting Report, that first vital signal, tells all concerned of contact with the enemy; that small combination of letters and figures sets the wheels of attack or defence into motion. Visualise, then, the importance of the painstaking care which must be taken by the originator of this report in order to pass a true assessment of the enemy force and bring about a victorious result by our engaging forces. To make this point clear, let us discuss an ordinary everyday reconnaissance flight in which these circumstances may be applicable at any time. It may simplify things to divide the events into Compilation, Transmission and Action.

Compilation

This first phase may be sub-divided into recognition and application of information to the Code Book (A.P. 1927). When the average pilot, like myself, is briefed and sets out on a reconnaissance trip, on my Form Green is a note to the effect that an enemy force, strength unknown, is believed to be in the area I shall be searching. This, then, is not the average routine patrol: I am out to do something definite. The time now comes when the expanse of sea in front of me changes scene, and far ahead I see two ships on the horizon; with the use of glasses I can distinguish smaller escort vessels around them.

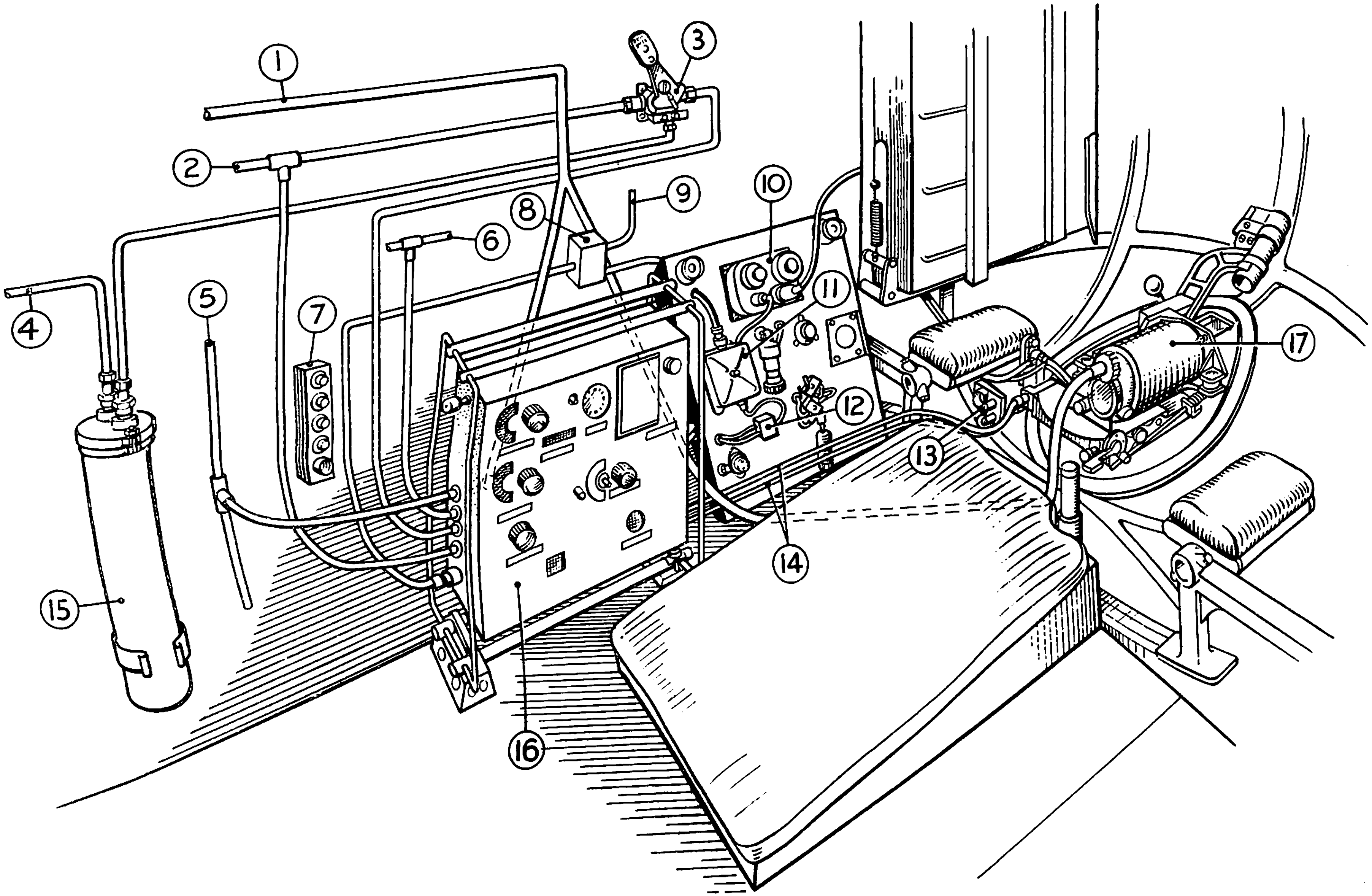
Now for my first sighting report. I must manœuvre myself into a position where I can give a true assessment of the force ahead. The only information required in order to make out my first sighting report is composition and type of enemy, the bearing from me, the distance from me, its approximate course, and my position. The accuracy of this information is of paramount





Mark XIV Bombsight

1. Suction pipe.
2. Compressed air supply.
3. Bombsight cock.
4. Exhaust.
5. Static.
6. Pitot.
7. Stowage for pipes to computor unit.
8. Distribution box.
9. Connection to D.R. compass installation.
10. Switchbox.
11. Radio interference suppressor.
12. Fuse box.
13. Stowage for connections to sighting head.
14. Flexible drives.
15. Air drier.
16. Computor unit.
17. Sighting head.



Mark XIV Bombsight in a Halifax.

importance; no vestige of doubt should enter into this factor. The size of the engaging force will depend entirely on my information. If I underestimate, the result may well be a loss of the action and the loss of lives of my countrymen and valuable aircraft and ships. On the other hand, if I overestimate, the result of the action might certainly be favourable, but the movement of unnecessary forces from other theatres of war might bring about disaster in another direction.

Having collected this information, and being satisfied with its accuracy, I turn to the composition of my signal. There are four things to remember.

(1) The first sighting report must not be encoded.
(2) There is a laid-down sequence in the code book in the S/E code section (A.P. 1927) for the composition of such a signal and this must be adhered to.
(3) The appropriate " O " (emergency) must be used, and
(4) The signal must be sent by " G " method, *i.e.*, the receiver of the signal must repeat it back to the transmitter.

Assume, then, I have collected the following information :—

2 Battleships.
6 Escort Destroyers.
Bearing from me 180° True.
Distance 10 miles.
Approximate True Course 270°.
My position ABCD 1234.

I start off the signal with the address, including the number of this message, the priority and the "G," *i.e.*, NR2—O—G = (assuming that this is the second message I have sent to base).

I now have to apply my information to the S/E code to make up the text. The sequence laid down in A.P. 1927 is as follows :—

= Composition and type bearing from me—distance from me—approximate true course—my position = TOO.

The T.O.O. must be the time of sighting, and not the time when I hand the message to the wireless operator for transmission.

Therefore my full signal will read as follows :—

NR2—O—G = 2BB6DD180—10—270—ABCD 1234 = 0830.

This, my first sighting report, is sent exactly as written except that in practice the wireless operator sends the " O—G " before the NR number in order that the degree of priority may be immediately gauged by the recipient.

I can now be assured that the wheels are moving to effect an interception, but my work is by no means finished, for I must continue to shadow and also prepare an amplifying report giving more details of the force. I have to remember that this must contain a reference to the first sighting report, or the recipients may not know what it links up with : I must therefore start off with "My. . . . " quoting T.O.O. of the first report. My amplifying report may be compiled in either S/E or Naval Code. The Naval Code is more satisfactory because more detail may be given by the use of Groups, *e.g.*

425 : position, course and speed of enemy battle fleet (or type indicated) are—

432 : enemy previously reported (or ships indicated) is accompanied by—

426 : position of enemy (type) is—

I therefore compile the following information for my first amplifying report, with a view to using Group 425 of the Naval Code :—

Enemy type—2 Battleships
6 Destroyers.
Enemy position—ABCD 2345.
Enemy course—275° True.
Enemy speed—15 knots.

My first amplifying report is now sent off as follows :—

NR3—O—P = My 0830—425—2BB 6DD—ABCD 2345—275—15 = 0900.

Base has now a full picture of the situation and sufficient information to dispatch an engaging force. Nevertheless, I must continue to shadow, keeping careful watch, and looking out for alterations of course and of disposition. By careful observation I identify the major war vessels and note alterations of course and speed. By use of the Naval Pendant Code the names of the ships may be relayed from the table in the Code Book. Again, using Group 425, I prepare my second amplifying report with the following information:—

Enemy type—1 Capital Ship *Tirpitz*.
1 Capital Ship *Lützow*.
6 Destroyers.
Enemy position—ABCD 5910.
Enemy Course—265° True.
Speed—20 Knots.

I can now compile my second amplifying report :—

NR4 —O—P = My 0900—425—$\overline{\text{1 PT 1}}$ GA $\overline{\text{1 PT 1}}$ GD 6DD—ABCD 5910—265—20 = 0920.

From now onwards I shadow, only transmitting further similar amplifying reports to indicate alterations of course or changes in disposition, if and when they occur.

Transmission

So much then for compilation. Now we arrive at phase 2, *i.e.*, Transmission. No error should occur at all in this phase. The Wireless Operator must remember to transmit by the " G " method, and ensure the message is repeated back to him accurately to give him proof of correct receipt. Most important of all, he should keep a careful watch on his wave-length in order to pick up any queries from Base in connection with his signals. Failure to do this may result in Base being unable to check back a corrupt signal, with the risk that the intercepting force may fail to make contact, and the enemy may be able to slip away without an engagement.

Action

The Controller at Base now comes into the picture. He has already instructed me by signal to shadow to the limit of my endurance, which he naturally knows, and so will send another aircraft to relieve me in good time : so I remain shadowing until my relieving aircraft arrives, when I can set course for base. On my homeward journey I ponder on the events of the day, and feel pleased that I have been instrumental in bringing the enemy to action under the most favourable tactical conditions.

But suppose my counterpart had been on the patrol, the pilot who does not know his code book, what would have happened then? There is an instance on record of an aircraft on patrol, which sighted an enemy convoy of eight vessels, including escorts steering due east in the Bay of Biscay. The text of his first sighting report was "465—ABCD 1234" = which means "I am over a Submarine in position ABCD 1234." It seems fantastic that such a message could be sent; apart from the Group from the code book being incorrect, there is no trace whatever to indicate what the pilot really saw. The actual composition of the convoy was not found out until the aircraft returned to its base, by which time we had lost the chance of engaging the convoy with a sufficient force and meeting small opposition.

This is hardly a typical example of a bad sighting report because, although it was intended to be a sighting report, there was no trace of the correct composition procedure in the signal at all. More typical examples have been in the cases of stating the enemy position instead of the aircraft position, or stating times of origin as the time of sending instead of the time of sighting, each of these mistakes giving Base an erroneous impression of the situation.

It is obvious, therefore, that perfect recognition without knowing how to compile the information into the correct signal is just as useless as complete knowledge of the code book (A.P. 1927) without the knowledge required to recognise the quarry. One slip, and the whole picture of the situation changes: our engaging force may carry out searches and sweeping-line-ahead patrols in the middle of the ocean, while the enemy steams quietly into port; or it may be thoroughly knocked about, because due to an erroneous report we only sent out a small force to engage two "cruisers" which turned out to be battleships; or else an unnecessarily large force is sent to engage two "battleships" which turned out to be cruisers, while somewhere else a real battleship attacks the depleted escort of one of our convoys.

Last Thoughts on Planned Flying and Planned Maintenance

This article has been called "Last Thoughts," not because the final mental effort upon it has been expended nor because an end has been reached of argument and discussion about it. On the contrary, there will almost certainly be After Thoughts and Further Thoughts which someone may have the energy to commit to paper. All that the title signifies is that the trilogy is complete and that anything that may appear in future will come from another pen.

A French savant has remarked, in more philosophical language, that thoughts which cannot be simply expressed are better consigned to the dustbin. It is, of course, much easier to make an epigram than a simple exposé of a complicated proposition, especially if it is not the writer's own pet theory. Still, the effort is worth while, for in these days we tend to rate our intelligence highly and to build up a barrier of protective conservatism against new ideas, the drift of which we do not grasp.

It is not impossible to state briefly the cardinal points of this subject. They are :—

(i) Assessment of the effort required in terms of numbers of sorties per Unit and their periodical recurrence: The Flying Plan drawn by Air Staff.

(ii) Determination of the effort in terms of labour which the establishment, facilities, etc., can give: The Maintenance Plan drawn by the Engineer Staff.

(iii) The adjustment of (i) and (i), either by modifying the Flying Plan, or by increasing the Maintenance facilities and staff until the economic limit has been reached.

It is not for the writer to make any categorical statement as to whether Planned Flying and Planned Maintenance are applicable to other Commands or in other circumstances. Since the whole object is the saving of man-power, the promotion of greater efficiency, and (above all) the delivery of a more effective effort against the enemy, it would seem that at least it warrants investigation and careful consideration.

Economical use of aircraft is a matter which should always be in the forefront of the minds of those who plan and operate, even if it is not dignified by a more highfalutin name than common sense. Serviceability will rise to a peak but falls from it with much greater rapidity: a maximum effort may be essential at times, but it is necessarily followed by natural consequences in the shape of a period of unserviceability and, therefore, can only be regarded as wasteful unless the justification is great. It so happened that unfavourable weather conditions gave a certain squadron a long respite from flying, with the result that serviceability reached an unprecedented level. One Monday morning the sun rose in an unclouded sky and the air was vibrant with the running of engines. Nearly the whole pack were out to hunt the U-Boat and a heavy bag was confidently hoped for. But it proved to be exceptionally light, for a simple reason which emerged on reflection that the U-Boats, too, had taken advantage of the weather to make their inward and outward journeys on the surface, secure from aircraft attack. And so the flow of them was interrupted, and when in several days' time it had become normal again, the squadron found that its effort had been largely used up in beating the air. Had a portion alone of the available resources been used, not only would the ratio of serviceability have been maintained, but also aircraft would have been available when the need for them really existed.

To conclude this series of articles some account will now be given of an experiment made in planned flying and maintenance, and of the results attained.

The Squadron chosen was equipped with Whitleys, and was employed on routine anti-submarine patrols in the Bay of Biscay. It had, for that time, a fine record of flying performance behind it, but by the early summer of 1942 it had virtually flown itself out, through no fault of the Squadron Commander or squadron personnel. The continued use of every available serviceable aircraft, augmented by engine trouble, and frequent moves, reduced it to a chronic state of unserviceability. Drains made on the maintenance personnel became acute and aggravated the situation.

Accordingly, steps were taken to plan, as from the beginning of August, 1942 the flying and maintenance of this squadron, with the results given in the table below:—

1942.	July.	August.	September.	October.*	November.†
Sorties	52	73	102	119	145
Casualties	3	2	3	3	2
Operational flying hours ..	440	545	884	1,045	1,265 (662 day; 603 night)
Training flying hours	56	143	191	204	242
Total flying hours	496	688	1,075	1,249	1,507

* *Limitations in October.*—At least nine days were unfit for flying at the station, and on five days operations were curtailed due to bad weather or other causes.

† *Advantages in November.*—The weather was exceptionally good for the station.

The gain in flying effort is immediately apparent and calls for little comment, except to say that owing to the exceptional weather conditions in November the figure of 1,507 hours cannot be taken as a standard; in addition, no major inspections had yet arisen. Probably 1,250 hours will be the normal expectation from a Whitley squadron so planned. Attention should be drawn to the gradual build-up of results as the plan got into action and the absence of any drops after the peaks in September and October were reached. Marked fluctuations are an inevitable feature of unplanned flying and overflying, but should not occur where a properly organised plan is in force.

Now to the working out of the plan. The first step was to decide what effort could be demanded from the squadron of 20 aircraft. Naturally, Air Staff wanted the maximum effort, but after consulting with the maintenance staff they agreed to accept four sorties per day, which was all that engineers could guarantee with the squadron in its weak state. It was conceded that if there should be spells of bad weather which would enable a certain accumulation of serviceable aircraft to be made, the maintenance staff would offer further sorties. There are two points to notice about this. Firstly, it was up to the maintenance staff to offer additional sorties and not for the Air Staff to take them. Secondly, such a course is desirable, although it may seem to contradict statements made in "First Thoughts," published in *Review* No. 6. If there should be long spells of non-flying weather, maintenance may get so far ahead that a danger will exist of the maintenance organisation coming to a standstill owing to a lack of work to do. When this happens, judicious offers of extra sorties will permit the working flow to continue and future work to be evenly spread. Air Staff are unlikely to turn down such offers and thus there is no difficulty in ensuring a smooth running organisation of inspection and repair.

As the squadron grew stronger, the number of sorties was gradually increased up to six or even seven, following bad weather, or in case of grave operational necessity.

Once Air Staff had decided the number of sorties they were prepared to accept the maintenance plan which was formulated. The Engineer Officer was given permission to anticipate inspections by more than the standard 10 per cent. limit. This allowed inspections to be staggered. A proportion of the maintenance personnel was screened and steps were taken to stabilise them at 85 per cent. of establishment of fitter trades and 95 per cent. of unskilled trades for a period of at least three to four months.

The early days of the experiment were by no means all plain sailing. To begin with it took time to build up the squadron strength to establishment and it was not until approximately September that the full complement was reached. If this were not enough, a decision was made to exchange the aircraft for a modified version, which resulted in the squadron being overloaded with aircraft. By the middle of August they rose to a peak of 30 aircraft and only dropped to their usual establishment of 20 and their normal maintenance load in the second week of November.

Finally, the Squadron Engineer Officer responsible for conducting the experiment, left on promotion in August, and the Commanding Officer in September.

And yet despite all these difficulties and the deteriorating weather of the autumn, the squadron went from strength to strength as the figures for the results plainly show.

Those who are charmed by figures may care to consider this breakdown.

A.—Flying Hours

		Hours
(i)	Average flying hours September to November inclusive	1285
(ii)	Highest number of hours *in any one month prior to* August, 1942 ..	935
(iii)	Highest monthly average *over any three months prior to* August, 1942	696
(iv)	Highest number of hours by *any Coastal Command* Whitley squadron prior to August, 1942	1041
(v)	Highest monthly average taken as in (iii) for *any Coastal Command* Whitley squadron	865
		Per cent.
(vi)	Increase in monthly output over the best Whitley squadron previously	45
	Increase in monthly output over the same squadron's best record	61

(vii) Increase in three-monthly average output over the previous best Whitley squadron 49
Increase in three-monthly average output over the same squadron's best record 85

B.—Strength of Maintenance and Servicing Personnel

(i) From 20th September the maintenance and servicing personnel were screened with an overall strength of nearly 100 per cent. of the establishment, with the understanding that the strength of the fitter trades should not fall below 85 per cent. of establishment nor that of other trades below 95 per cent.

(ii) The actual average strength over a sample period—4th–20th November—was 216 (excluding sergeants and higher ranks), or 94 per cent. of the establishment figure. The actual strength in the fitter trades (corporals and airmen) was 98, or 99 per cent. of establishment. The actual strength in the other trades was 118, or 90 per cent. of establishment.

(iii) The average number away on leave during the sample period, 4th–20th November, was 46·5, or 21·5 per cent. of the total strength.

(iv) The average number of corporals and airmen actually engaged on maintaining and servicing aircraft was 139, *i.e.*, 64 per cent. of the actual strength or 60 per cent. of the establishment strength.

(v) *Thus, the increase in flying hours was not achieved by excessive application of man-power.*

C.—Aircraft Strength

(i) The average number of aircraft on the strength for each of the months August—November was 26, 24, 20 and 20 respectively.

(ii) The average number of flying hours per aircraft per month is thus 26, 45, 63 and 75 for the four months respectively.

D.—Aircrew Strength

(i) The number of air crews on the strength was 23 from 1st August to 31st October: and 28 in November.

(ii) Thus the average number of flying hours per air crew per month was 30, 47, 55 and 66 for the four months respectively.

E.—Weather

(i) Using the Meteorological Office standards of fitness of weather for flying, and counting "indifferent" days as half, the numbers of days fit for flying at the station in the four months August–November were 24, 24, 22 and 29 respectively.

(ii) Thus the average number of flying hours per fit-for-flying day was 29,45, 57 and 52 respectively for the four months.

F.—Serviceability

(i) The serviceability (as given by the "Mayfly" signal) averaged 52 per cent., 67 per cent. and 56 per cent. for September, October and November, respectively.

The true operational serviceability (*i.e.*, covering the whole 24 hours as distinct from the "Mayfly" which is a spot reading at a given time) for the period 11th October to 13th November, was 36 per cent. of the total aircraft time when aircraft were on operations or fit for operations. Added to this the true non-operational serviceability for the same period was 6 per cent.

This is the record of one squadron—an ordinary squadron in something of a bad way, requiring skilful attention. It recovered its health thanks to the remedies applied by the Operational Research Section and to the co-operation of the patient itself. For in order that the best is got out of such circumstances it is very necessary for Groups, Squadron Commanders, technical officers, aircrews and airmen to work together in an organised manner and to apply with intelligence the principles employed. It is with this end in view that these articles have been written in the hope that they may give, however disjointedly and inaptly, some notion of what the planning of flying and maintenance is driving at.

The reader may be tempted to jump to the conclusion that this remarkable increase in flying hours was due entirely to bringing up the squadron strength to its approximate establishment and to screening the personnel. He may feel that any squadron given these advantages would produce similar figures. But this line of thought is fallacious. If this were done and unlimited flying were allowed, the resulting graph would not be a steady rise maintaining a high constant level, but a series of peaks and low points with a total effort considerably below that obtained by planning. Planned flying and planned maintenance are complementary, and results are the product of both. Without planned maintenance and reasonable stability it is impossible to make an offer to Air Staff with any guarantee of its being carried out: without planned flying it is impossible to build up a smooth running organisation which will, in fact, produce the offer made. It is planning which makes more flying available, not only for operations but for squadron training as well.

One comment has arisen from these articles which can only be answered in part in the space available. It is generally agreed that the application of planning to a routine squadron is perfectly feasible: indeed, that has already been demonstrated beyond doubt. But, the argument goes on, the Strike Squadron is quite another case. It is called upon to operate at irregular periods, which may be determined by factors outside our control, such as weather or the initiative of the enemy. Taking the most difficult target of all, the passage of major enemy units (such as the *Tirpitz* along the Norwegian coast or the *Scharnhorst* and *Gneisenau* up the Channel), it is open to the enemy to make the move when conditions are favourable to him, and above all he is in the position to exploit surprise. In this, as well as anti-shipping strikes and bomber operations, it will be necessary to put on a very great and often a maximum effort.

Now it is not impossible to plan for this and, at the same time, to offer the maximum number of sorties on the day of opportunities and nothing less. But the ramifications of such essential action go back far through the planning system and a price necessarily has to be paid, as would be expected, in accordance with the ordinary laws governing output and input of energy in any circumstances. It is the task of maintenance planning to reduce this to a minimum.

In a routine Squadron, true operational serviceability of the order of 35 per cent. will be normally required to provide the maximum effort over a period of weeks and more. In the Strike Squadron an availability of 70 per cent. and above will be needed for short periods, which may or may not be capable of definition ; it depends on the type of work. We may, for instance, decide that for tactical reasons the most profitable time to attack shipping is during the moon period, and if so this gives us a natural division of time into operating the non-operating periods. In bomber operations we shall want to take advantage of spells of fine weather whenever they may occur. This is to a large extent not a matter which can be controlled, although by an analysis of weather statistics probably some measure of anticipation can be achieved. In the case of isolated incidents such as the breakouts and movements of enemy units, reliable advanced prediction is likely to occur only very occasionally.

The Strike Squadron, however, differs from the Patrol Squadron in one important particular, namely, that the total effort in such squadrons over a prolonged period is roughly half that of a Patrol Squadron. The wear and tear due to consistent flying is lower, the replacement rate is probably higher and the Squadron does not have to deal with aircraft which have flown hundreds of hours and which have reached the stage of needing constant servicing in minor details to keep up serviceability. After the effort has been made, there will be a relatively long period for recuperation before the next opportunity occurs. For these reasons a Strike Squadron should be able to run upon a much lower establishment of ground staff amounting to probably about 50 per cent. of the Patrol Squadron.

Clearly, if the opportunity extends over several days, as it will in bomber operations, unserviceability will whittle down the force available until it may drop so low as 20 per cent. and there will be a corresponding build-up of aircraft awaiting attention. If this condition is reached before the opportunity subsides, then a small portion of it must be wasted unless special precautions have been taken. On the other hand—and the point is important—since more and more the trend of short supply is likely to be towards shortage of manpower and not of aircraft, the fact that the Squadron is established on approximately 50 per cent. ground staff, enables us to have two Squadrons where we had one before. And, therefore, although we may have lost perhaps 20 per cent. of effort where one Squadron is concerned, the minimum nett gain over two Squadrons will be at least 60 per cent. and probably more. In the case of offensive strike operations, in which we determine the employment of our aircraft, this proportion provides a definite overall gain and no objection arises. Where defensive strike operations are concerned, a certain inflexibility is introduced because it may be necessary to move a Squadron at short notice, and, in that event, as mentioned in the first article in *Review* No. 6, a full staff equivalent to that of a Patrol Squadron will be necessary. But this contingency need not arise in the circumstances which we are considering.

Provision can be made to reduce the fall of serviceability in order to take further advantage of an opportunity which extends over a period, but this brings in a number of factors of higher policy. As an indication, one fairly obvious way would be the creation of pools of aircraft fully serviceable and ready for drafting to squadrons, made up of the surplus and above the strike effort allocated to meet the current situation. The maintenance of intensive effort also calls for an adequate supply of trained air crew. This is sufficient to show that the problem is not incapable of resolution and that it is one which itself calls for planning and considerable thought upon all its repercussions.

Finally, perhaps a note should be added on the working of the 50 per cent. establishment. Since economy of manpower is of paramount importance, a certain pooling of resources is envisaged. It has been said that a single Strike Squadron will need an equivalent establishment to a Patrol Squadron, but that where two or more are located on one Station, the individual establishments can be virtually halved. This, of course, presupposes that according to the dictates of the situation the men of one squadron can be used to work in aid of the other. For this reason great advantage accrues from keeping squadrons of similar types together on the same station. This is a revolutionary principle and may not be one that will be welcomed at first sight. But it is a case of needs must when the devil drives, and since pooling offers so much greater output of effort, prejudice and conservatism should not be allowed to stand in the way of open consideration of its possibilities. It is a fundamental conception of Planned Flying and Planned Maintenance that all available manpower is taken up fully employed and never allowed to be idle or run to waste. The reduction of the establishment must be made on a basis of adjustment and not by mere division for the following reasons :—

The technical personnel of a Squadron fall into three categories—

(i) Fitter Trades responsible for maintenance and repair, major inspections, engine changes, modifications.

(ii) Fitter Trades and Flight Mechanics responsible for minor inspections and small repairs.

(iii) Flight Mechanics and supervising personnel responsible for daily inspections and adjustments.

Since the daily work during the active periods will be intensified, an increase in (iii), will be necessary. These comprise for the most part the less skilled trades and on the whole have specialised experience in simple work rather than the high technical qualifications, which are needed by (i) and (ii). It is in (i) and (ii) that the shortage of satisfactory staff is greatest and the main economies can be made.

Little has been said about the application of the principles of Planned Flying and Maintenance to Training and at the O.T.U.s and Schools, because they are already organised on this basis. Training is perhaps more readily adaptable to planning because the aim is defined and remains constant for a certain length of time. Further, it is more in accordance with what has already been done in the past and therefore is accepted as a modification of what is already in force and not as something new.

These articles do not pretend to cover the whole field of the subject. They, no doubt, leave many questions unanswered. They do not set out to be a complete guide to what is a most important and complex subject. They may serve, however, to provide an introduction to it in relatively simple language and to stimulate thought not only among the Technical Staffs but also amongst the Air Staffs and operating Staffs at Command, Groups, Stations and Squadrons. Planned Flying and Planned Maintenance has, it seems, come to stay in this Command: and it is being applied in one form or another to a number of Squadrons in it. It is not a rigid scheme but is fundamentally flexible and because of this its principles can be used with benefit throughout, even if the gain that accrues may vary in differing circumstances. It should be approached as something that will help: as a system which will enable more effort to be put out at the same cost and, therefore, an increased total effort: and not as some new-fangled whim, difficult to comprehend and of doubtful advantage.

Returns, Records and Research

A talk " off the record " with almost any body of people, ground crew or air crew, in almost any squadron, will at some time or another get round to the question of the immense number of forms that have to be filled in, and the mere suggestion of another record brings forth a storm of protest. This article is not written in justification of the mountains of paper work, and the writer is convinced that much of the existing paper work can be reduced if not eliminated. The danger of the present attitude is that many important returns are carelessly filled in, if not actually faked, and hence are valueless, if not dangerous, since incorrect conclusions may be drawn. This article will attempt to give some idea of how returns can be used and how they may affect current practice.

To take one of the simplest cases: the quantities of the various types of bombs and ammunition that are needed in the future must be known so that orders can be placed, and to do this consumption rates must be known. A guess made at the beginning of the war was the basis of initial provisioning, but as the war proceeds we get actual figures of what has been consumed and hence we can provision more accurately. The data given in Form 765 are tabulated, and tables for future provisioning are then derived. This is simple enough.

A more difficult problem is the provisioning of man-power. From the squadron standpoint there is an establishment, and if " bodies " are drafted in to fill that establishment everyone is happy and contented. The bodies are theirs and provided there are no grouses from elsewhere the matter then ends. But at some time trouble commences; firstly there are warnings for posting abroad, then actual postings, but newcomers to make good the deficiencies fail to arrive. This has a confusing effect and people begin to wonder about what is going to happen, but the result is not usually as bad as they feared. If the total effort of the squadron does not decline as drastically as the Engineer Officer feared, and then stabilises, this means that the establishment is somewhat in excess of actual requirements.

Let us consider how an establishment is arrived at. Establishments have a long history that goes back to a period when man-power was more plentiful and experience of requirements very limited. The establishments were at the best merely shrewd guesses, which tended to err on the side of generosity. It was considered better to be quite certain that there were sufficient people for the job. Now that there is a shortage of man-power, everyone is being called upon to effect reductions in establishment. How can such reductions be effected? Merely to chop establishments would, in many instances, lead to complete chaos and inefficiency.

The only solution is to get a good return of what people are doing. Let us take aircraft maintenance as an example. We can find out what jobs have been done and how long they take, trade by trade, over a certain period, and by an analysis we can get the necessary data for adjusting establishments. As this means a great deal of work for the people on the squadrons, the people responsible for drafting the returns must consider the *pro forma* of the returns very carefully; it must be designed to give the maximum of information for the minimum of paper work. Once this has been done, the people responsible for filling in the detail have the responsibility of seeing that the return is completed accurately.

So far we have been dealing with records whose analysis is simple. It is then merely a question of rather elaborate arithmetic. In this type of record we are merely entering numbers, and someone at a central bureau totals the records from various places. This kind of return has very little concern for the aircrew. They are, however, very much concerned with the finicky detail of the questions which the Intelligence Officer insists on putting to them when they return, tired and irritable after a long and arduous flight. His insistance on eliciting this information for incorporation in a Form Orange is annoying and it may be difficult to understand the necessity for it. But these records go up to Command Headquarters where the events are tabulated, and it may be some consolation to know that they are very carefully examined and that without them it would be impossible to arrive at important and far-reaching conclusions.

Let us consider, for instance, attacks on shipping. In order to decide the best method of attack, such details as the height from which the attack was made, the distance of sighting, the nature of cloud cover, the use of bombsight, and so on, are all of importance. By combing the records of each and every attack we can build up a picture of what are the most important considerations for a *successful* attack. The details of each attack are sorted out and we then get a record of *how many* attacks have been made in any particular way. In this way we get a composite picture incorporating the experience of all squadrons. Such a picture may differ very widely from that built up by the individual squadron from its own more limited experience, or even from the picture built up by a single group. Not only this, the enemy reactions change, and we can sort out *trends*. To meet the trend of enemy opposition we must develop a trend of our own, so the question becomes more complicated and a limit is set to the information we can get from the Form Orange, however much we try to retabulate and regroup the frequency of the events in records. Another difficulty that arises is the difference in emphasis as between different Intelligence Officers in their interrogations for the Form Orange. The need develops for a standardised return, which is more elaborate and hence unsuitable for sending by signal. So duplication arises. We shall return to this question of duplication later, but in the meantime we give an example of the value of a detailed operational return.

Perhaps the most striking example is the Form "U-Bat." At first sight this contains a large number of entries whose bearing on the war seems rather remote, but consider for example the section about the time interval between the U-Boat diving and the aircraft's attack. There are always four or more men on the look-out on the deck of every U-Boat, so that the fact that an attack has been delivered at all means that the aircraft's look-out has beaten them to it. One "U-Bat" tells nothing about the general chances of pulling off the surprise, but a study of a number of them tells a lot. If the "U-Bats" show that the time interval is shortening, then our tactics are improving. On the other hand if the time interval increased then we should conclude that the U-Boat crews were improving the quality of the look-out; fortunately that has not been happening. But beyond the facts about the look-out competition, we can derive information of importance for armament policy. A U-Boat that can still be seen is obviously the best target, as its plan position and depth are known. But if the U-Boats beat us in the look-out competition, so that they were only rarely caught on the surface, then we have to design weapons and sights for those that had submerged some time in spite of the greater uncertainty in position. In fact a study of large numbers of returns has shown that about 60 per cent. of U-Boats are submerged for less than 15 seconds at the time of attack. This fact, coupled with the much greater accuracy of estimating the position of shallow U-Boats, led to the introduction of the shallow setting depth-charge in 1941. The section "Distance and bearing of U-Boat from convoy" has yielded valuable information about where U-Boats are most likely to be found by air escort. The photographs and descriptions of the attack give information about bombing error, and help in deciding whether bomb-sights are necessary. This does not by any means exhaust the scope of the information provided by the "U-Bat."

Frequently the trends and countertrends are fairly obvious, but in many instances they are by no means clear. We then have to discriminate between different theories or hypotheses. This is not easy and sometimes the methods used appear very highbrow and remote from reality. But this is not really the case. They are derived from the everyday experience of insurance companies and gamblers, for that is how the modern science of statistics arose. In some instances, discrimination does not involve any calculations beyond dividing by the total number of occurrences. It is surprising how often this is overlooked. On numerous occasions comparisons are made on the basis of the number of successes alone, and the unsuccessful have been ignored. The proportion of successes is important, and it merely means dividing the number of successes by the total of all attempts. But even when this is done the issue is not settled. We all know that in tossing a coin we will occasionally get a run of heads or a run of tails, and the methods of discrimination must take account of that kind of occurrence.

If we have a very large number of trials, the occasional "run of luck" is lost in the grand total, but where the number of trials is limited we must resort to other devices. If we get a discrepancy between the actual numbers and our expectations, the difference may either have a real cause or else be due to chance. From the theory of probability, the theory of the toss of the coin or of drawing a particular kind of ball from a large urn, we can state the odds against a particular difference being due to chance. Having found such odds, however, the matter is by no means ended. What odds must we get in order to justify a decision that the discrepancy has a real cause? Some people may feel, inclined to let odds of 5 to 1 decide the issue, the ultra cautious may decide on odds of 1,000 to 1. In British scientific circles a convention has been established that if the odds against a difference being due to chance are 20 to 1, then a difference may be regarded as established; in Continental circles the arbitrary standard chosen is 100 to 1. Generally speaking we should be wise to accept the 20 to 1 standard, but in war we must adopt an elasticity depending on circumstances. For example, if a modification is simple and cannot possibly do any harm, we should agree that odds of 5 to 1 against the difference being due to chance are sufficient, while if at the other extreme the modification was elaborate or there was a possibility of danger, then we should work on odds of about 500 to 1.

At first sight this looks as if we really don't know that we are evading the issue and that in fact the answer is a lemon. This is not so, because it is by these methods that the stock-breeder works and has worked with such remarkable success. It gives us a firm working basis to be revised and adjusted, till finally we shall arrive at a really sound practicable conclusion, immediately acceptable by all.

By now we can see clearly why returns are wanted, but we have not dealt with the question of the duplication of returns. This is an extremely complex problem, and no doubt something could and should be done about it. The trouble is that the same basic return is needed by a number of departments within the Command, and by Command H.Q. and Air Ministry. Let us take the "Mayfly" for example. It is a return originally designed by Air Ministry, and at Command it goes to the Equipment Branch. At first Air Staff at Command used the Mayfly, but it subsequently turned out to be inadequate for their purposes. With the best will in the world, the Equipment Branch at Command could not agree to the cancellation of the Mayfly because it was a return placed in their charge at Command by Air Ministry. At Air Ministry it would be difficult to alter, unless for all Commands simultaneously, quite apart from the internal reorganisation that would be needed at Air Ministry. So the two returns remain. It is always easier to lay on a new return than to get an old one cancelled. However, a revision and consolidation of returns is under consideration.

Don't Lose the Use of Your Legs

The Cult of the Body Beautiful has never seriously appealed to the English-speaking peoples. Its very solemnity is ridiculous, smacking as it does of the too self-conscious and regimented nudism of Nordic Youth Movements. Deliberate physical self-training, however right it may be, remains in Anglo-Saxon eyes repulsive. We prefer to sugar our pills with a coating of golf or rugger or tennis, and we prefer the spasmodic to the routine. Such incidental exercise is usually sufficient to ensure high-precision operations in the Stock Exchange, the Law Courts and the Pulpit; it is not always sufficient to ensure high-precision operations in the Inner Leads, the Heligoland Bight and the Bay of Biscay.

In the Air Force we do our fighting sitting down; some of us even do it lying down—and a very comfortable way to fight it is; no trouble at all. Unfortunately therein lies a very great danger. Our fighting makes too little demand on our bodies for us ever to be able to check in battle just how fit our bodies are. Ostensibly it is enough if we are "pretty fit"—fit enough, that is, to fly our aircraft, to drop our bombs and depth charges, to release our torpedoes, to fire our guns; and if when we land again at base, we feel tired, well, we are justified in feeling tired. But that is not enough. What matters is with what precision we flew our aircraft, with what precision we dropped our bombs and depth charges, with what precision we released our torpedoes, with what precision we fired our guns. It is difficult even for us to gauge that degree of precision, and almost impossible for those others on the ground to assess even with the aid of diagrams, photographs and reports. Yet it is upon that degree of precision that success and failure depend.

War may be an imprecise science, but battles are fought with highly precise scientific instruments. The success or failure of a bullet is measured in inches, of a bomb, depth charge or torpedo in feet, of an aircraft taking evasive action in yards. A high degree of precision is essential, therefore, if our flying is to be anything more than happy-go-lucky skylarking. But that is all it will too often be if we are content merely to be "pretty fit." Training in the flying of modern, high-precision aircraft and in the operation of modern, high-precision sights and instruments is largely useless unless it is matched by a parallel training of our eyes and brains and bodies to be themselves high-precision executives. We must not only attain but maintain the highest possible pitch of visual, mental and muscular alertness; the time-lags between eye and brain, and brain and hand must be reduced to the minimum—and kept there. Otherwise though we may be fit to fly, we are certainly not fit to fight.

This is no plea for puritanism. The ancient Greeks had a word for it—*meden agan*, or "nothing to excess." They loved and they ate and they drank and they just lazed around in the sun to their hearts' content; but they were deliberately content with *enough*. And so it was that the gayest people of all time were also fine athletes, fine shots, fine artists and magnificent fighting men. But of us it is too often brutally true to say that our progress from the I.T.W. through the E.F.T.S., through the F.T.S. and through the O.T.U. to our Operational Squadron has been, in terms of physical fitness, a Rake's Progress. Let each one of us search his conscience and ask "Am I soft or am I hard?"

They were a wise people, those Greeks of the fifth century B.C. They identified the bowels as the seat of the emotions, and Harley Street endorses that belief. How bored or depressed or nervous or un-self-confident one feels is usually dictated by one's liver. We all know very well to what Shakespeare was referring when he wrote: "And all that is within him does condemn itself for being there." Spiritual contentment, physical courage, pride in the perfect mastery of one's craft are the personal rewards of physical fitness; they are more than that—they are one's duty as a patriot. Without them all one's stripes and all one's gongs hide nothing more frightening than a scarecrow.

Over and above the twin motives of operational efficiency and operational contentment, a third and more compelling motive exists for deliberately training one-self to a high pitch of mental and physical fitness—the motive of self-preservation. If and when the day comes when one has to escape, whether it be from death by the elements or from capture by the enemy, one's chances of escape will be in direct ratio to one's physical and mental well-being.

Baling out sounds simple enough—until you have to do it; then it may involve every ounce of strength you have got to bust through a jammed hatch, all the presence of mind you have got to perform the simple operation of pulling your rip cord, all your sense of judgment to "spill" yourself away from the spike on the Church steeple, all your muscular elasticity to alight without hurting yourself. Always remember that escape depends in the first instance upon being able to get as far away from the "scene of the crime" as fast as possible. If you have never learnt to fall and fall hard without hurting yourself, you will probably not be able to run very far or very fast when, for the first time, you "hit the deck." And never forget that the sea is just as hard as the earth if you hit it hard enough.

In Coastal Command ditching is the more likely occurrence. Enough can never be said or written about the importance of ditching drill—but all the drill in the world is not going to help you if your circulation is not what it was when you took your first "Medical." In August of this year a German fighter pilot was shot down over the North Sea, baled out successfully, "landed" and settled himself in his single-seater dinghy. He was badly wounded and entirely without food or water. He was not picked up for six days and six nights. Yet he suffered no ill effects of any kind. The doctors, cynical men, were surprised. Oh, yes, he drank a certain amount. Smoke? Well, yes, moderate. Take much exercise? But on that subject he was more communicative. There practically wasn't a game which he didn't play and play regularly—and whenever he got ten days' leave from "Ops." he went off ski-ing wherever he could find some snow and used to do regular twelve hour trips in the mountains every day.

Tougher still was the Canadian pilot who alone of his crew survived for 14 days and 14 nights in his dinghy, retained sufficient co-ordination between hand and eye to capture a seagull with his bare hands and (minus only a few toes) remained fit enough to broadcast his experiences the night after his rescue. Yet another survivor—again the only one of his crew—survived because he alone was able to swim 500 yards to a dinghy. In civil life he had been a professional Life Saver on one of the Australian beaches.

These examples, just three among hundreds, prove one thing. One does not survive by accident. One survives because one is not merely fit to fly but also fit to swim, fit to climb into a dinghy and to go on climbing into it every time it overturns, fit to endure lying in soaking clothes in icy water, fit to suffer the griping misery of sea-sickness on an empty stomach, fit to watch night follow day and day follow night without food, without water, without company, perhaps without hope. To do that, one must be very, very fit indeed.

The two best aids to escape on land are one's legs. Read any book on the subject of escaping in the last war whether from Germany or across the desert from a Turkish prison camp, and you will find that every man bent on making his get-away systematically hardened himself, systematically built up his health and muscular strength by every means at his disposal. When you come to the last page, you will find that fit though these men were when they set out, few of them had the strength in the end to do much more than stumble blindly across the frontier, and collapse. And they were the fittest. The majority never got so far. They could not do without food; they could not do without water; they could not endure the cold or the heat; their feet blistered past bearing; they could not suffer to lie hidden for hours at a time in the cramped postures which their hiding places in ditches and pigsties and railway trucks imposed. They had every aid to escape except one—the constitution. If you wish to come home again to tell the tale—and it is your duty to come home again—then you must realise "what it takes," and you must make sure that you have "what it takes." That is something that we have all got to do for ourselves. Nobody can do it for us.

If you want to know honestly why your torpedo missed, why your depth charges overshot, why you got your aircraft shot full of holes when you were taking what you so blithely imagined to be evasive action—run once round the perimeter track, swim just 100 yards in the nearest lake in your clothes, run in full flying kit flat out from the Mess to the Range and there fire five rounds rapid. The answer will be painfully obvious. The Chinese are alleged to pay their doctor only while they are well. Squadron Commanders might well adopt that philosophy and employ the doctors to devise ways and means of hardening their crews, getting sluggish circulations galloping, building up their muscular strength, toning up their reluctant livers, fining down their reactions. It is no question of physic—"throw physic to the dogs." It is a question of "nothing to excess," of sound and regular sleep, of regular and hard exercise, of healthy but not greedy appetites, of more fresh air and less Mess froust; in fact, *for a fighting man, of the commonsense of survival.*

The tempo of war is gathering speed. As we pass on ever widening fronts to the attack, we shall be called on to endure, to go on enduring and then at last when we think we are all in, to endure more. It will not long suffice that we should be fit to fly. We must prepare ourselves now to be fit to win.

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