THE GORDON SHEPHARD MEMORIAL PRIZE ESSAY, 1919

AERIAL CO-OPERATION WITH THE NAVY

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Motto:–
'He who will know what shall be in the future must study what has been in the past'.
– *Old Proverb.*

CONTENTS.

INTRODUCTION.

The object of a nation at war is to stop the enemy's national life, and the strategic plan which either belligerent follows to achieve this end may be divided into three classes, viz, naval strategy, military strategy, and independent air strategy.

When aircraft are employed for reconnaissance over the sea and in co-operation with the Navy the objectives must be the same as those which are the aims of the naval strategy, hence the use of

aircraft against any other objectives comes under the heading of independent air strategy, or possibly military strategy, and is outside the scope of this paper.

Now the object of naval strategy is the control of maritime communications, and the destruction of the enemy's battle-fleet is the principal means to this end. The subject may be conveniently considered under the three following headings:

(a) The Battle Fleet.

(b) Commerce protection and prevention of the enemy's commerce.

(c) Support of military expeditions overseas.

In Chapters I, II, and III the use of aircraft in the late War in co-operation with the Navy under the above three headings will be examined and some criticisms offered. In Chapter IV the limiting factors of various types of aircraft will be considered in conjunction with the probable requirements of future naval warfare. From this a forecast will be made of 'the possible future of the various types of aircraft in a war against a first-class naval power'.

Whenever 'The War' is mentioned the late world conflict is meant. And the phrase 'the future', unless specially stated, refers to the next ten years, for the author considers that the progress of aeronautics may be so rapid as to render impracticable conjectures beyond that period. No attempt has been made to discuss the work of aeroplanes and kite balloons in any detail, as they are not included in the 'Definition of Subject' given in AMWO 915 of 14th August, 1919.

CHAPTER I.

CO-OPERATION WITH THE FLEET IN THE NORTH SEA

Evolution of the Aeroplane Carrier. On the outbreak of war very little was known of working aircraft from ships, therefore the solution of the problem of how to provide aircraft for the Fleet at sea was at once energetically sought.

Two classes of seaplane carrier were tried: a large ship with considerable stowage space for machines and considerable radius of action, and smaller ships with correspondingly less radius and stowage. In the former class was the old Cunarder, the 'Campania', for use with the Grand Fleet; and in the latter class were the 'Engadine', 'Riviera' and 'Empress', all three cross-Channel packets.

By December the three last-named ships had joined the Harwich Force, and on Christmas Day, 1914, a successful air raid on Cuxhaven and Wilhelmshaven was made by the seaplanes from them. This popularized such operations. The three existing carriers were fitted with improved accommodation for seaplanes, and others of a similar class were taken up.

When the refitted ships rejoined the Harwich Force, however, attempts to make similar raids led to repeated failures and disappointments. It was found that the North Sea in average weather was too rough to permit of seaplanes being hoisted out and in. Also surprise was practically impossible because the flotilla on passage to the German coast was almost invariably observed by Zeppelins, which the low performance seaplanes were quite incapable of bringing down. The seaplane carriers, too, had only a speed of about 19 knots, consequently it was very risky to keep them near the enemy's coast once they had been observed. Therefore, the policy of raiding the enemy's naval bases continuously was abandoned, and no more than sporadic attacks were afterwards attempted.

HMS 'Campania' joined the Grand Fleet in the summer of 1915. Experience with her, confirming that gained with the Harwich Force, was that the use of aeroplanes from ships at sea was impracticable, that an aircraft carrier must have a speed at least equal to that of the ships with which she works, and that there was a need for both the large and the small class of carrier. Further, this experience enabled the Commander-in-Chief to lay down his aerial requirements for the Fleet at sea as follows:

(i) To prevent reconnaissance by Zeppelins.

(ii) To reconnoitre the enemy's fleet.

(iii) To spot for gunfire after the battle was joined.

Accordingly the pre-war experiments in flying seaplanes with wheels, or aeroplanes, off the deck of a ship steaming at high speed into the wind were pressed on, and the results were good. In the meantime the possibility of an aeroplane alighting on the deck of a ship under way became recognized, which obviated the necessity of stopping to hoist-in after a flight, with the consequent risk from submarines. The construction of HMS 'Argus', with a special alighting deck, began in 1916. In the autumn of 1917 successful trials of landing an aeroplane on HMS 'Furious' were carried out, also the practicability of flying an aeroplane off a turret had been proved; and from this date onwards aeroplanes were carried on ships in lieu of seaplanes.

Grand Fleet's Aircraft. At the time of the Armistice a comprehensive programme for Grand Fleet aircraft was nearly completed. There were two large aeroplane carriers ('Furious' and 'Argus') and one small one ('Vindictive') whilst two more large ones were under construction. 'Argus' had torpedo machines, the other carriers reconnaissance machines.

In each light cruiser, except when prevented by questions of stability, a single-seater fighter was carried, whose primary role was the attack of Zeppelins.

Each battleship, or battle-cruiser, carried two seaplanes. These were either single-seater fighters or two-seaters, so distributed that each squadron of ships had its own planes for spotting or reconnaissance, and fighters to protect them.

This use of aeroplanes for overseas flying was necessary, because no seaplane existed which had the necessary performance to permit of flying off platforms, or of landing on a deck, or to bring down a Zeppelin. Nevertheless, there were certain unavoidable drawbacks. Even with air-bags and hydrovanes on the chassis, the strain on the pilots and observers and the wastage of machines was greater than if seaplanes could be used. Also, to keep the personnel in practice, there must be aerodromes, lighters for landing and embarking machines, etc, at each Fleet base. In the War these drawbacks were not prohibitive, because as the oversea flying was only occasional the strain on the personnel was never very great, neither was the wastage excessive, as the aerodromes and shore organization could be easily provided. In peace, however, or in a war where the Fleet was more at sea, the same methods might not work. This matter will be dealt with further in Chapter IV.

Kite balloons were carried in a proportion of the cruisers, TBDs and battleships, being used respectively for reconnaissance, anti-submarine work, and control of gunfire. Considering that a great division of opinion existed as to the value or otherwise of the balloons, and that shortage of either men or material, or both, was always a difficulty throughout the War, the author considers that once the aeroplane programme was accepted the kite balloons should have been given up,

except in a few destroyers for anti-submarine work. Airships of sufficient performance to meet the Fleet's requirements were not available during the War.

German Aircraft in the North Sea. Having reviewed the development of aircraft with the Grand Fleet, it is appropriate to consider the enemy's naval aerial resources, before passing on to a more detailed examination of their employment. Unlike ourselves, the Germans started the War with an efficient service of large rigid airships, whose primary role was the patrol of the south-east corner of the North Sea. They were based on Tondern, Altona and Cuxhaven, and it is no exaggeration to say that in the region of their patrols they held the supremacy of the air. Hence, the German Fleet when at sea in good weather always enjoyed aerial co-operation, the movements of any ships were nearly always screened by airships, whose great radius of action, speed range, and long endurance rendered them capable of this work.

The airship patrols were supplemented by seaplanes from Sylt, Heligoland, a station near Cuxhaven, and Borkum. Flying-boats were not used, but the German float-seaplanes were much superior to our own. They had no aircraft carriers, neither were aircraft carried aboard warships. Presumably the enemy relied on his large airships to fulfil the requirements of the Fleet at sea.

Narrative of Events in the North Sea, with some observations and criticisms. A brief review will now be made of the work of the Grand Fleet and Harwich Force, in order that the work of aircraft co-operating with them may be examined. Generally speaking, the guiding policy for our Fleet was to keep the majority of ships in harbour, and to carry out continual sweeps of varying strength with the remainder. Early in the War, as already mentioned, there were no aircraft to co-operate in these sweeps, which extended far beyond the range of our aircraft working from shore bases. The direct result was that the enemy's Zeppelins, being entirely unopposed, were in a position to warn their outlying small craft; if the sweeping force was small it rang the risk of interception by a superior force suitably guided by information from the air; if the sweeping force was strong this fact was reported, and the enemy was not to be enticed out. In any case the sweeps were far less effective and much more risky than if aircraft had been available.

The only offensive operations made by the enemy's ships were three similar sweeps, during which towns on our east coast were bombarded. On only one of these occasions were we able to intercept the raiders by our surface ships and submarines. Had there existed on our side a more extensive system of air patrols, airships at long range, and seaplanes and aeroplanes closer inshore it seems that our Fleet would certainly have had a much better chance.

It was in January, 1915, that our battle cruisers intercepted the enemy's, who were probably embarking on one of these sweeps. The running fight of the Dogger Bank took place, in which two enemy battle cruisers were sunk and one seriously damaged before they could escape behind their minefields. This gives an excellent example of an opportunity for torpedo-carrying aircraft, had they been available. One hit on each ship with even a 14-inch torpedo would probably have so reduced the squadron's speed that all would have been overtaken and sunk.

In May, 1916, the Battle of Jutland took place. As is well known, before a superiority could be brought to bear, the German Fleet turned away under cover of a smoke screen and a failing light, and escaped a decisive defeat. On neither side were aircraft available in any numbers, yet the action is of interest by reason of the work which the few aircraft did, and more especially by reason of the proof it provides of the imperative necessity for air work in a fleet action.

The seaplanes in HMS 'Engadine' were the only aircraft available for the British. One of these sent by wireless an accurate report of part of the German Fleet before the action commenced –

information which light cruisers could only have obtained after considerable fighting. The author believes, but does not know definitely, that during the battle the German airships patrolled to the southward of the High Sea Fleet, watching its line of retreat. On the morning following the battle they did valuable work in reporting our Fleet's position.

Two points are made strikingly evident by the official despatches and Lord Jellicoe's book, 'The Grand Fleet'. The first point is the uncertainty in the C-in-C's mind as to the position of the enemy, after receiving a few reports from the battle cruisers; in other words, insufficient reconnaissance. The second point is that until about twenty minutes after the enemy had turned away, the C-in-C was unaware that they had done so, and to this their escape seems largely due. Again, insufficient reconnaissance. Any aircraft flying above the mist and the smoke might well have reported the turn immediately it was made.

After the Battle of Jutland the enemy abandoned any idea of an active policy for his High Sea Fleet, and concentrated on the submarine campaign. Accordingly, we greatly extended the Heligoland Bight minefields, and in connection with the mining, long reconnaissance flights from Killingholme, Yarmouth, and Felixstowe were made as often as possible by flying-boats. The chief object of these flights was to ascertain if and where the Germans were sweeping. At the end of the War the F2As were capable of patrols measuring 400 miles on the chart, but this only took the reconnaissance about half-way across the Bight, and the need for longer range aircraft became increasingly evident. This was emphasized during the last few weeks when a final sortie by the High Sea Fleet was confidently expected.

An interesting point in connection with these long reconnaissances was the difficulty of accurate navigation over the sea, and the need for developments in this direction. Obviously the more accurate the position of mine-sweepers reported, the more valuable the report.

Whenever the flying-boats were near Borkum, considerable fighting occurred with the German seaplanes. This led to development in flying the boats in strong formation, and of defensive armament and control of fire in the boats, which eventually enabled them to hold their own.

But to send a strong formation for each reconnaissance was most uneconomical, thus showing the need of a moderately manoeuvrable seaplane of high performance, which, though not intended for offensive fighting, could look after itself if attacked (A). These machines would have undertaken the work near Borkum, and the flying-boats would have undertaken the longer range work, the latter of necessity avoiding areas where opposition was likely to be very heavy. Such a machine, the 'Fairey', with a Rolls-Royce engine, was produced just before the Armistice. There was much controversy on this subject, one school of opinion declaring that aeroplanes could do the work. It is, however, significant that those actually employed on continuous long-distance overseas flights (frequently over minefields) were emphatic that seaplanes or flying-boats, providing, as they do, more chance of safety in case of engine failure, are essential. Where the flights were less frequent and the strain consequently less, as in the Grand Fleet, the use of aeroplanes was satisfactory.

Whilst the large flying-boats, sometimes extending their radius by the use of lighters, confined their activities to the southern part of the 'prohibited area', a number of reconnaissances over the northern part, and a raid against Tondern, were made by aeroplanes from the 'Furious'. The aeroplanes in light cruisers also, from time to time, had chances of attacking Zeppelins. In these operations it became evident that although the large airship falls an easy prey to an aeroplane that brings it to action, yet the action is often most difficult to bring about, because the airship can generally make a reconnaissance without coming very close, and if pursued can often escape in clouds of fog. Critics of the airship are much too prone to make capital out of the number of

German airships destroyed over the North Sea (actually only six!), whilst forgetting the countless occasions on which they did valuable work without molestation.

The reconnaissances made latterly by machines from the 'Furious' had an excellent effect on the morale of the Fleet's flying personnel, and in the Tondern raid gave a fine return in material damage done, but unfortunately the extent to which the minefields had now increased, put most objectives out of range. It is interesting to examine the good results which would probably have followed if more aeroplane carriers had been sanctioned along with the 'Argus' in 1916, whereas actually it was nearly a year later that 'Furious', 'Vindictive', etc, were sanctioned, and at a time when there was very little more data than in 1916 regarding the capabilities of aeroplanes flying off and on to ships, and when the pressure on the shipyards had increased. Had more carriers been available earlier, before the great expansion of the minefields in 1917, continuous air raids on a small scale could have been made. Their object would have been to keep the enemy occupied, to collect information, and to keep up an offensive. If the development of the torpedo aeroplane, whose possibilities were proved at the Dardanelles in 1915, had received the attention it deserved, these machines would have played an important part in such raids, which might have been developed into the landing of raiding parties on the Frisian Islands, etc. Actually, however, the enemy enjoyed complete immunity from attack on his seaboard, he was thus able to decrease his defensive measures to a minimum, and concentrate on the offensive submarine campaign. Perhaps also the earlier provision of more fast carriers would have enabled the enemy's air patrol to have been neutralized. Efforts were made in this direction with the 'Vindex' and 'Manxman' in the Harwich Force, but their low speed and inferior carrying capacity prevented success.

The author considers that our inability to raid the German seaboard with ships and aircraft, and the fact that until the end of the War we lacked efficient aircraft with the Fleet, handicapped us and helped the enemy (whose airships provided the aerial co-operation which we lacked) to an extent not fully realized at the time. Had our Fleet not been so handicapped the War might have been considerably shortened.

CHAPTER II.

COMMERCE PROTECTION AND THE PREVENTION OF THE ENEMY'S COMMERCE

The Blockade. To the stoppage of the seaboard commerce of the Central Powers, their collapse and our ultimate victory were largely due. Their stoppage was accomplished by means of the blockade, based on the right of search, which necessitated the examination of all ships entering or leaving the North Sea by the Dover Straits or round the North of Scotland.

A minefield across the Straits of Dover compelled merchantmen to enter the Downs, where examination took place, and rendered this part of the blockade comparatively simple. But the Northern Patrol was a much more difficult proposition, involving as it did the watching of a line of some six hundred miles, from Scotland to Iceland, and thence to Greenland, where the weather was of the worst and submarines were a constant menace to the patrolling ships. In June, 1918, the laying of a mine barrage from Scotland to the Norwegian coast was commenced. Primarily this was an anti-submarine measure, but it would also have helped the Northern Patrol, by forcing merchantmen to use certain swept passages.

In conjunction with the plan for this barrage a considerable aircraft programme was contemplated, which comprised the expansion of the existing seaplane stations in the Orkneys and Shetlands, the use of airships, and the allocation of aircraft carriers and kite balloons to the patrol. Actually the programme was never undertaken, for it was realized that the long nights, the bad weather, and the

great distances required to be flown rendered the work beyond the capabilities of contemporary aircraft. Had the conditions been easier there can be no doubt but that the effect of aircraft would have been great. For instance, they would have provided a most economical method of locating merchant ships and directing them to rendezvous where the searching craft would be. Again, they would have provided valuable protection for the patrol ships against submarines. In short, the great possibilities of the more efficient aircraft of the future in connection with a maritime blockade were clearly shown.

The activities of the German cruisers, such as the 'Emden', and their raiders such as the 'Wolf', merely emphasize the difficulty from which surface ships suffer in searching and patrolling, by reason of their limited speed and vision, as compared to aircraft. This amplifies the remarks made above concerning the use of aircraft in a maritime blockade. It is interesting to note that the 'Wolf' used a seaplane, which is believed to have materially helped her.

Anti-Submarine Warfare – General Description. The German submarine campaign, and our anti-submarine war, can conveniently be considered in five phases. In October, 1914, the first submarine attack on an allied merchant ship was made; later the enemy announced that all shipping in a prescribed zone round the United Kingdom was liable to attack, and in January, 1915, the first merchant ship was sunk without warning. Meanwhile, our policy had been one of attacking submarines wherever they were reported, in so far as the very limited means available would allow. By December, 1916, however, the situation had become so serious that a special organization was established in the Admiralty to deal with it, and with its establishment the first phase ended.

The main feature of the second phase was that increased efforts were made to harass each submarine from the moment of leaving base until her return. During this phase Germany declared her policy of unrestricted submarine warfare, which virtually brought the United States into the War.

The third phase commenced with the inauguration of the convoy system in the spring of 1917, previously to which the trade had been directed by 'routeing' or by 'suspended sailings'. It was the convoy system which, above all other methods, did most to prevent the success of the German submarine campaign, and it was in connection with the convoy system, above all other anti-submarine operations, that aircraft proved of the greatest value.

In the summer of 1917 the policy of intensively mining the Heligoland Bight began to take effect, and the fourth phase may be said to have begun. Its characteristic was the great extension of mining in the North Sea and Dover Straits. The final phase was inaugurated by the enemy abandoning his attack on merchant ships, recalling his submarines, mine-laying off our Northern Fleet bases, and apparently making all preparations for a large naval engagement.

The five phases referred to apply mainly to the waters round the United Kingdom. In the Mediterranean we followed the same methods, so far as resources allowed. The work of aircraft during these phases will now be examined.

First Phase: October, 1914, to December, 1916. During this period air stations grew up near every naval base at home and in the Mediterranean. Also a Wing was sent to Flanders during the first weeks of the War, which later became based on Dunkirk. It is doubtful if aircraft contributed much towards anti-submarine measures as were taken during this period, but experience was gained which helped greatly towards the aircraft being usefully employed when the inception of the anti-submarine division of the Admiralty led to the more vigorous measures of the later phases.

By the end of 1916 the force at Dunkirk had grown to a strength of about four Wings, composed of fighters, bombers, reconnaissance and photographic machines, and seaplanes. These were used continuously over Zeebrügge and Ostend, and it was proved conclusively that seaplanes are so handicapped by the weight and head resistance of their floats, that they cannot be used where the opposition from anti-aircraft guns and hostile aircraft is very strong.

Second Phase: December, 1916, to March, 1917. Immediately on the inception of the Anti-Submarine Division there followed a great increase in all anti-submarine measures, and co-ordination of the methods of their employment.

At Dunkirk the RNAS was continually augmented, until at the time of transfer to the RAF it consisted of a Brigade. Up to the closing months of the War constant reconnaissance and bombing of the Flanders naval bases was done. This reconnaissance, which provided accurate data of the extent to which submarines used the Flanders ports, was of great value.

As regards the bombing in April, 1918, 17.5 tons of bombs were dropped, while in August this had been increased to 98.8 tons. From the evidence available it seems that the material damage done was slight, probably one submarine was destroyed in Zeebrügge Docks, and in July, 1918, the lock gates at that place were probably burst. On the other hand, the enemy was forced to construct the most elaborate protection for the submarines, the constant alarms of raids must have retarded the refitting of the boats, and the effect on the crews necessitated their being sent into Germany for their leave. In addition to this, the enemy's very elaborate anti-aircraft organization must have absorbed great numbers of men and many aeroplanes, searchlights, etc, on purely defensive work.

The distinguished air officer who is best qualified to judge has estimated the relative value of the moral damage to the material damage done by the Independent Bombing Force as twenty to one. It is probable that the effects of the Dunkirk bombers and the bombing of Cattaro were similar. Certain it is, however, that aircraft provided the only means of attacking submarines in their bases.

All this bombing was done by aeroplanes, and therefore falls outside the strict scope of this paper. Mention has been made of it, however, because it shows where the legitimate work of seaplanes ends and that of aeroplanes begins.

Third Phase: March, 1917, to Midsummer, 1917. The feature of this phase was the substitution of the 'convoy' system for the previous system of 'routeing'. In the latter, merchant ships had been instructed, as far as possible, to keep clear of dangerous areas. Also trade was ordered to pass through one of the four 'cones of dispersion', of which the apexes were Falmouth, Innistrahull, and Kirkwall. It was thought that the submarines would operate in these areas where the trade converged, and that it would be possible to patrol them adequately with every means available, including aircraft. However, this proved to be bad policy, for the increasing range of the submarines so magnified the cones that the patrolling craft were insufficient. This led to the introduction of convoys, by which system merchantmen were collected at certain ports, and then escorted to their destination. It will readily be seen that the new system presented great advantages over the old, especially for aircraft. Patrolling a large 'cone of dispersion' for a periscope was indeed searching for a needle in a haystack, but convoying ensured that the flying was done where the submarine was most likely to be, and most likely to take risks.

To co-operate in the convoy system, air-stations were built up first of all in the Channel and on the East Coast, and later were extended to the Mediterranean, Irish Channel and French Coast. The USA took over the convoy work in Ireland, and the Canadians made stations in Newfoundland and at the mouth of the Gulf of St Lawrence.

The general organization was as follows: An Air Group was formed for each operational area. The headquarters of the Group was in immediate touch with the SNO and the local Base Intelligence Office, and also in telephonic and wireless connection with the air stations or sub-stations of the Group. This provided the rapid means of communication which experience had shown as essential. As regards the equipment of such a Group, this came to comprise airships, flying-boats, seaplanes, aeroplanes, and kite balloons. The functions of each of these in convoy work will now be examined.

Airships for Convoy Work. The SS Airship, virtually a BE aeroplane stripped of its wings and suspended under a small envelope, was the first type to be used. Early in 1918 it was superseded by SSZ, which had greater speed, duration, bomb-carrying capacity, and facilities for observation.

The SSZ was in turn being superseded by the twin SS. This type, whilst giving an all-round increase in efficiency, had the great advantage of twin engines, and consequent greater safety in the case of engine failure or adverse winds. Further, to meet the demand for increased performance, larger non-rigids of the coastal and North Sea classes were produced but never in great numbers.

Except for the R29, which helped in sinking the U115, no rigids were completed in time to play much part in the anti-submarine war, but had the War gone on they would probably have done important work in escorting convoys far into the Atlantic, for which purpose large airship sheds were in course of erection in Ireland. As the submarines were gradually driven to work farther and farther from the coast, the problem of how to provide an escort when the convoy was out of range of the smaller types of surface craft and aircraft began to arise. The difficulties of flying aeroplanes from and back to a ship are so great that at present there is little chance of each convoy carrying its own aerial escort (except kite balloons), and for the future it seems that convoy work at a great distance from the coast will be the rigid airship's role.

The airship's greatest difficulty was that of providing adequate sheds. Finally, mooring out sites were selected for the smaller non-rigids, and this proved most satisfactory, the ships riding out gales of over 60 mph without damage.

Much criticism was levelled at the policy of employing airships. The great expenditure on the sheds was one argument, but this was largely met by mooring out. Another argument was based on the airships' inability to fly in strong winds, and although this was true in fact it was counteracted by the facility with which they flew by night or in foggy weather.

When escorting a convoy and a submarine is sighted, the airship on account of its low speed usually fails to get over the submarine with bombs before the enemy dives. Hence it is clear that the principal value of the airship is that it locates the submarine and frightens it into diving, whereupon the submarine's speed is so reduced that probably it cannot get into position to attack.

The great variation of speed facilities for observation, signalling, and accurate bombing make airships excellent for convoy work, though on account of their vulnerability this must be confined to areas which hostile aircraft do not frequent.

Very careful statistics were kept at the Admiralty of man power, etc, used up by the various anti-submarine arms in relation to the results achieved. By these the employment of airships was fully justified. In the author's opinion the only criticism that can justly be levelled is against the pre-war policy which so neglected airships.

Large Flying-Boats for Convoy Work. The large flying-boats very early proved their value, for they had the essential qualities lacking in smaller seaplanes, viz, excellent view, good bomb-carrying capacity, big radius of action, and reliable engines.

Compared to airships the boats could fly in much stronger winds provided they had calm water for the take off. With the convoy station-keeping was more difficult, but the high speed gave a better chance of bombing a submarine before it dived. They were also capable of escort work where hostile aircraft were met; for instance, the Dutch traffic from Felixstowe.

As regards disadvantages, the F2A suffered from extreme heaviness on controls, which was, however, largely rectified in later types. The chief disadvantage was the great requirements in sheds and slipways; but as in the case of airships this was met by the expedient of mooring out. Although this was satisfactory in moderate weather, the machines were always exposed to the risk of a gale when they would almost certainly 'fly' at their moorings and stave in the hulls. To render the large flying-boats really reliable when they are away from main bases where extensive slipways and sheds exist, some means of enabling them to ride-out gales in a sheltered anchorage must be found. Possibly an adjustable trailing edge by which the planes could be set to give no lift would meet the case. The author considers that this question of mooring is of great importance, and demands immediate attention (D). Some improvement was effected by keeping machines moored on lighters, but this did not entirely meet the case in really heavy weather.

Seaplanes, Aeroplanes, and Kite Balloons for Convoy Work. Several types of seaplanes, the Short, the Wright, the Sopwith Baby, etc, were used and all suffered from the bad view ahead, inevitable in a single-engined tractor, and insufficient bomb capacity. These disabilities, together with the fact that the seaplanes were often prevented from rising by a choppy sea, and also the necessity for reducing the number of types in production, led to the gradual elimination of the seaplane, whose inshore work was taken over by aeroplanes.

In turn these aeroplanes suffered from the same disadvantages as the seaplanes, except in the case of the Blackburn 'Kangaroos', and in addition flying over the water, even with air-bags, imposed an extra strain on the personnel, and caused extra casualties.

This leads one to the logical conclusion that the type of heavier-than-air machine required for inshore anti-submarine work, say, up to about 30 miles to seaward, is a medium-sized amphibian with floats and detachable wheels, carrying at least one 500 lb bomb and either a pusher or twin tractor (C). Normally the machine would work from an aerodrome, but, if necessary, the wheels could be dropped, and she could alight on the sea and be capable of taxying or rising again.

Kite balloons were extensively used with convoys, for they provided the only possible aerial escort when out of flying range of the shore stations. As in the Grand Fleet there was much difference of opinion over their value, and finally the majority held the opinion that they did more harm in giving away the position of the convoy than they did good as look-outs or as 'scarecrows'.

Fourth Phase: Midsummer, 1917, to Autumn, 1918. The feature of this phase was the great extension of mining and barrage work in the North Sea, the Dover Patrol, and the Straits of Otranto – the work of aircraft in this connection in the North Sea has already been described.

At Dunkirk seaplanes were originally employed for this. Their value lay in their ability to observe any change in the positions of buoys or surface nets, to act as 'scarecrows' and force the submarines to dive into minefields, and to help hunting flotillas. Later the use of seaplanes had to be abandoned

because they were no match for the German fighter aeroplanes, and the overseas anti-submarine work was taken over by a squadron of DH4s with Rolls-Royce engines.

At the Otranto barrage most of the flying consisted of hunting in co-operation with the surface craft. Kite-balloons unquestionably proved their value, for, used at the extremities of the barrage area, they forced the submarine to dive before entering the area. Generally speaking, experience on this barrage led to the same conclusions as at home.

Seaplanes were found preferable on account of the reduced risk from engine trouble, but a certain number of aeroplanes were essential for weather when seaplanes could not get off, and to provide machines to get away quickly in response to urgent calls. That aircraft are a necessary part of a mobile barrage is proved. However, it was also proved that a mobile barrage is an extravagant method of using aerial and other resources, for after the Armistice it was found that the Otranto barrage had accounted for only one submarine.

Last Phase: Autumn, 1918 – General Considerations. Of this period little need be said. The enemy abandoned the attack on merchant ships, and concentrated on submarine mine-laying off our Scottish Fleet bases. To meet this all available aircraft were moved to the East Coast of Scotland and England, and employed with hunting flotillas and on patrols.

Throughout all the anti-submarine operations there was a constant demand for increased size of bombs, more accurate bombing, and better fusing. The fusing question was the most difficult, and remained unsolved at the time of the Armistice. What was required was a variable fuse, which the observer could adjust to whatever depth he required.

Intercommunication between aircraft and ships was another vitally important question. Visual signalling by Aldis lamps was proved the best, wireless only being used for long ranges. Especially abroad, however, many patrol craft carried only indifferent signallers, and in these cases dropped messages in watertight containers proved a good expedient.

Frequently aircraft failed in their attacks because a submarine heard their approach without seeing them and dived. Experiments were made to try and find a means of silencing both engine and propeller, but they met with little success, and it is hoped that the research will be continued on this most important question.

The destruction of a submarine by aircraft alone proved most difficult. Officially aircraft are credited with only twelve submarines, though the instances when they helped surface craft in successful hunts are numerous.

Undoubtedly the most effective role of aircraft in anti-submarine warfare was convoy work. This was proved by statistics in 1918, when of 7,000 convoys escorted by aircraft only six were attacked.

CHAPTER III.

SUPPORT OF MILITARY EXPEDITIONS OVERSEAS

Dunkirk, Dardanelles, etc. A considerable proportion of the anti-submarine work already described was in support of our numerous military expeditionary forces. However, in addition to this, certain other air work falls within the scope of this chapter, of which some of the flying on the Dover Patrol and that at the Dardanelles form the most important part.

The principal duty of aircraft, in this connection, on the Dover Patrol was to keep so close a watch on Zeebrügge, Ostend, and the eastern approaches to the Straits as to prevent the enemy's naval craft bringing off a raid in force against the cross-Channel communications of the Army in France. During the passage of the Expeditionary Force a seaplane patrol was maintained from Westgate to Ostend, and a mixed force of aeroplanes and seaplanes was sent to Belgium.

After the German occupation, however, the aircraft for the Dover Patrol were based on Dunkirk and Dover. It has already been stated that the great opposition necessitated the anti-submarine patrols and bombing being done by a squadron of DH4s with RR engines. Exactly the same conclusion was reached in the work of spotting for monitors, and reconnoitring (chiefly by photography) the enemy bases.

At the Dardanelles conditions were different. Enemy opposition was much less, calm water was nearly always available for the get-off, and hence throughout the operations seaplanes played an important part.

When the operations began in February, 1915, the only aircraft available on either side were seaplanes on HMS 'Ark Royal', which were employed chiefly in locating the forts and entrenchments on the Peninsula. Later, both sides were reinforced by aeroplanes, and in May HMS 'Ben-my-Chree', a small seaplane-carrier of high speed, arrived.

From this time onwards the presence of submarines necessitated 'Ark Royal' (a ship of only eight knots) remaining in harbour. Her machines were chiefly employed in spotting for the monitors and blister ships against positions on the Peninsula. This work they did most satisfactorily, their performance being quite sufficient against the limited numbers of enemy aircraft and anti-aircraft guns. Spotting for ships was gradually developed, and together with the experience gained at Dunkirk led to the following definite conclusions:

(1) The best intercommunication between plane and firing ship is by WT (but the wireless telephone gives a great promise for the future).

(2) The clock system gives the best results.

(3) With these aids a ship at anchor can fire sufficiently accurately to take on counter-battery work.

(4) It is, however, risky to take on targets very close to our own troops ashore.

Value of the Fast Seaplane-Carrier. The work of 'Ben-my-Chree' exemplified the great value of a fast seaplane-carrier, used as a self-contained highly-mobile unit. Wherever aircraft were suddenly required, this ship was sent. In July, 1919, her machines were spotting for the monitor 'Roberts' against the Asia batteries. During the second landing in August they assisted in a dummy landing, as a diversion, near Smyrna; and later, in the same month, effectively used torpedo seaplanes in the Marmora and Dardanelles. When Bulgaria entered the war, 'Ben-my-Chree's' machines reconnoitred most of the Bulgarian coast, and were used from the Island of Milo in demonstrations against Greece. Finally, when aerial reconnaissance of the approach to Egypt through Syria and Palestine (which were out of range of aeroplanes in Egypt) were urgently required in January, 1916, this ship was detached to the Egypt and East Indies stations. In each of these various operations it was found possible for seaplanes, judiciously employed, to compete with such moderate opposition as was found at first. The opposition invariably grew too strong later, but by this time the less mobile aeroplane units had had time to select their aerodromes, etc, and get to work. The simplicity

of working seaplanes from a carrier, granted always the *sine qua non* of sheltered water, is very marked in comparison with the use of aeroplanes from an aeroplane-carrier, which must be both under way and head to wind.

Similar work was done by seaplanes in the operations on the coast of German East Africa, and also in the Red Sea, when in the spring of 1916 the Allied diplomatists were beginning to cast their flies over Mecca, and during the evacuation of North Russia in 1919. All of which proves not only the great value of the fast seaplane-carrier under certain circumstances, but also the value of the type of 'fighter reconnaissance' seaplane already mentioned (see A, above).

Future 'Combined Operations' by Navy, Army and Air Force. Now an opposed landing on the enemy's territory (which may be termed a 'combined operation') or the defence of our own possessions against such expeditions, has been a very frequent employment for the fighting forces of the Empire throughout history, and would seem to be a probable task for them in the future. Moreover, it seems that the effect of aircraft on such operations will be great. Therefore, the subject may now be considered briefly in the light of war experience and of probable developments.

Let us examine the effect of aircraft on such an expedition in its various stages. The first point is that the selection of the base or advanced base will be largely governed by the range and characteristics of the defender's aircraft. Even if his aircraft were not very strong the base could hardly be as close to the actual point of landing as were Imbros and Mudros, or all secrecy would be lost.

If, however, the defender's air force was strong, and included large airships, to ensure secrecy during the preparations and embarkation of troops the base would need to be about 1,000 miles from the point of landing.

The next point is the air work during the voyage from the base to the landing. This will comprise aerial escorts against hostile aircraft, surface craft, and submarines. The relative distance between the base or advanced base and point of landing must largely decide what types of aircraft are used for these duties, and whether they work from aircraft carriers or shore bases.

The effect of the defender's air patrols might be considerable. For instance, if it was intended for the expedition to approach the coast after dark, and land by night, a machine patrolling to seaward in the previous afternoon might discover the whole expedition, and to retain any chance of surprise the attacker's air force must shoot down that machine, not merely drive it off. Probably, too, the defenders would have coastal aeroplane patrols in the evening, which would prevent the expedition approaching to very near the coast before dark, and might be a considerable handicap at a season when nights were short.

The provision of the necessary flying for covering the landing, and immediately after, presents considerable difficulties for various reasons. First, because the number of aircraft carriers would probably be limited, and there might be difficulties against keeping them under way or even anchored head to wind. Again, landing grounds ashore might be bad or even non-existent. These considerations might necessitate the use of seaplanes, providing another example of the value of seaplanes and their carrying-ship under certain circumstances. Further difficulties are imposed by the great variety of work required, such as spotting for naval or military guns, fighting, contact work, and naval or military reconnaissance.

The great vulnerability of the beaches to low-flying aircraft, and of the large numbers of anchored transports to attack by torpedo aeroplanes, must not be overlooked.

Generally speaking, the introduction of aircraft into 'combined operations' appears to favour the defender more than the attacker, as the latter's machines will probably have to work from ships, or extemporized bases, and whilst suffering from the inevitable disadvantages which such conditions impose, will have to carry out complicated, varied and difficult flying.

CHAPTER IV.

THE POSSIBLE FUTURE OF THE VARIOUS TYPES OF AIRCRAFT

A forecast of the future of the various types of aircraft can only be attempted after duly weighing the various governing factors of the problem. There appear to be three factors: First, the limitations of the various types; second, the probable requirements in another war against a first-class naval power; and finally, the teachings of the late War, many of which have already been dealt with in previous chapters. On the above lines the problem will now be considered.

Limitations of Machines Heavier-than-Air and Lighter-than-Air. The way in which machines are likely to develop in the future appears to be determined by certain mechanical facts. If heavier-than-air be considered first, the farthest that an aeroplane or seaplane can fly in still air, taking a reasonable load of bombs, guns, etc, is, to-day, about 400 miles. Now this is not improved by increasing the size of the aeroplane, because in practice the bigger the aeroplane the greater is the structural weight compared to the useful load carried; and also because the spreading of weights over the structure, which seems necessary with increase of size, causes heavy stresses when alighting. Hence, in the future aeroplanes and seaplanes appear to be limited to flights of about 400 to 600 miles, and the average speed at which they fly is at present about 110 mph. (Attention is drawn to the fact that, as explained in the Introduction, 'the future', unless specially stated, refers to the next ten years).

Improvements in the motor, in constructional methods, in propellers, will doubtless cause greater efficiency, but as these are likely to be gradual improvements and not fundamental changes, the limit suggested above seems reasonable.

With the airships the conditions are different. If the ship is increased in all its dimensions in the same proportion, the volume increases as the cube, and the surface as the square, therefore to drive it at the same speed requires relatively less power. This advantage is not all lost through the fact that the stresses on each circular sector increase with the diameter. Generally speaking, then, the bigger the airship the more efficient it is, and the limits which are met first are the size of the shed, or the difficulty of mooring out a really large ship. Notwithstanding these limits, the present-day airship is capable of carrying a reasonable fighting load a distance of about 1,500 miles in still air at a speed of about 60 mph. In the future, then, the use of the airship is for flights beyond the limits of heavier-than-air machines, accomplished at a more moderate speed and with a bigger load.

The extreme vulnerability of the airship to attack by a high performance aeroplane is another limit. At present it precludes the use of airships from localities where enemy fighters are strong, and the writer considers that probably this will remain the case in the future. The question of defensively arming the big airships demands very careful investigation, also the question of airships fighting each other.

Probable Requirements in a Future War Against a First-Class Naval Power. Having defined the fundamental limits of the two main classes of aircraft it is appropriate next to consider whether the requirements of a future war against a first-class naval Power are likely to differ from the late War.

A little reflection leads to the conclusion that we are most unlikely to find ourselves placed in so favourable a strategic position as in the late War, with the British Isles situated across the arteries of the sea communications of our enemy.

Again, in the late War the main bases of the opposing Fleets were separated only by some 500 or 600 miles. Is this likely to occur again? On the contrary, it is far more probable that this distance will be greatly extended, and the key of the naval situation instead of being the control of the North Sea may be the control of a great ocean. Or it is possible that the enemy's fleet may be so distant that before naval operations on a large scale can begin, our Fleet will have to move to bases situated nearer the enemy, whilst our trade and possessions within striking distance of the enemy's fleet are protected as much as possible in the meantime by local resources.

Another consideration is that the increasing use of aircraft in naval warfare will have the effect of forcing fleets to move at night or under water if they are to be unobserved, in the same manner as troop movements are nowadays made in darkness, or with great attention paid to concealment and camouflage.

What, then, are the inferences to be drawn from the difference between the probable requirements of the future and those of the late War? Obviously we cannot be content with ranges and performances which would have suited the North Sea. There must be no slackening of effort to produce aircraft with greater radius of action, greater speed, and greater all-round efficiency. Night flying and anti-submarine work must continue to be developed. Also the possibility of the Admiralty calling upon the Independent Air Force to endeavour to secure aerial supremacy over a specified part of the ocean during any big fleet movement should be recognized. The possibility referred to above of distant possessions and maritime trade being protected by local resources pending the arrival of our Fleet (which would probably take several months) opens up great possibilities for aircraft. Aircraft would be invaluable as part of these local resources – their use in defence against invasion has been emphasized in Chapter III.

The rapidity with which aeroplanes can get to Australia forms a striking contrast to the time it would take our Fleet to reach the Pacific should its presence there be necessary. When once the Empire's air routes are developed, a powerful air force from some central position such as Egypt, could be sent to any threatened possession long before the Fleet could arrive.

If imagination is allowed to take us somewhat beyond the ten years by which the writer defines 'the future' for the purpose of this paper, it is not difficult to visualize the Air Force undertaking some of the present functions of the Fleet, transporting expeditions to enemy countries by air, arriving rapidly to reinforce beleaguered garrisons, or fighting a campaign against merchant shipping with large numbers of torpedo-carrying aircraft. Indeed, the imagination leads us into a veritable Abdullah's Cave of strategical possibilities. We are led, perhaps, out of the scope of this paper – co-operation with the Navy – into the sphere of independent air strategy. But in an age when the rapidity of communications and transportation continues to increase, a contemporary speeding up of warfare is inevitable, and such possibilities for the more distant future must be recognized. By recognizing them we can ensure that aerial development in the immediate future, and the development of imperial strategy, progress along lines which will eventually enable air power to be a safeguard to the Empire.

To return, however, to the question under consideration. Another point which should be borne in mind before trying to predict the future uses of aircraft, is that in the late War machines designed for work with the Army were produced in much greater numbers than those for the Navy. Therefore, it was often good policy to adapt a primarily military machine to naval use, because only

by reducing the number of types could sufficient production be maintained. But in the next War the opposite might be the case, and therefore in peace time the provision of makeshift machines for naval purposes should be avoided.

Subject to the various considerations enumerated in this Chapter, some prediction of the future of the various types of aircraft for sea reconnaissance and co-operation with the Navy will now be attempted, and aircraft from ships at sea will be dealt with first.

Aircraft in Fighting Ships. In a modern Fleet the writer considers there should be special aircraft-carriers and also aircraft in certain fighting ships.

Each light cruiser should carry a machine, either a single-seater fighter or a two-seater reconnaissance machine, so allotted that there was one of each type in each pair of light cruisers. The role of the fighters would, of course, be keeping down all enemy machines. The reconnaissance machine was not part of our Grand Fleet programme during the War, but as so much of a light cruiser's work is reconnaissance there can be little question that they would be most valuable, and it should be possible in the future to produce a suitable two-seater for this work. Wireless telephony will probably prove a most useful means of communicating with reconnaissance machines, and also with spotters.

As regards the battleships and battle cruisers. Each, it is thought, should carry at least one two-seater for spotting and at least one fighter. This would ensure that each squadron of ships had its own quota of spotting planes and fighters to protect them. Also it would avoid the complications and the anxiety to the flag officer commanding the squadron which there would be, if machines from a special aircraft carrier accompanying the squadron carried out these duties. In future it may be possible to produce a three-seater for spotting; if so, it would be a great advantage to have a gunner in addition to the pilot and observer. The author considers that spotting, and reporting enemy movements in a naval action is too difficult for the pilot alone to do, and this necessitates the passenger (if only one is carried) being primarily an observer.

Aircraft in Carriers. Now as regards the aircraft carriers. It is impossible to lay down any definite proportion of these to the other classes of ships, since this must depend on the composition of the adversary's fleet and the nature of the battle it is expected to fight. But it is possible to predict the types of machines to be used from the carriers. These ships should work directly under the Commander-in-Chief (except, perhaps, one or two under the flag officer commanding the most advanced light cruisers or battle cruisers), and should be stationed within visual signalling distance of him, if possible. They should carry fighters to enable aerial supremacy to be obtained at any given time and over any particular area should the Commander-in-Chief wish it; also torpedo machines, bombers and reconnaissance machines, all working directly under the C-in-C. It is quite clear that this will necessitate there being a considerable number of aircraft carriers in a modern fleet, and that the number of carriers should be greater in proportion to the surface craft than was the case in the Grand Fleet in the late War.

Another use for the fighters will be low-flying attacks on ships, particularly destroyers whose personnel is so exposed. A determined low-flying attack on a flotilla by a squadron of fighters might easily prevent a destroyer attack being pressed home.

The carriers generally should be large ships, but a certain number of small ones (probably without landing-on decks) will be necessary for operations with light forces, like the Harwich Force in the War. Apart from the value of carriers in a fleet action, they will be useful for minor offensive operations against objectives which are beyond the reach of aircraft from shore bases.

Then there is the question of whether the machines carried in fighting ships and in carriers should be aeroplanes, or seaplanes with wheels for flying-off and capable of being dropped. The author considers that if seaplanes can be produced to fulfil the necessary flying-off conditions from the fighting ships, and in addition the necessary alighting conditions in the carriers, and also have the required performance in the air, they should be used. Obviously the fighters must be aeroplanes, but in the future the spotting machines and perhaps those for reconnaissance might be seaplanes. With the seaplanes the strain on the personnel and the wastage would be much reduced. Also, wherever the Fleet went in peace time the machines could make daily practice flights, weather permitting, irrespective of whether there was an aerodrome near by or not, and of whether the Fleet was at sea or in harbour. There will also be special uses for seaplanes from seaplane-carriers, in combined operations and minor operations, as explained in Chapter III.

Aircraft from Shore Bases. From shore bases the future of the airship is to work beyond the range of heavier-than-air machines, or in localities where hostile fighters are weak or neutralized. Fleet reconnaissance, patrols, anti-submarine work, bombing and reconnaissance of enemy ports, and perhaps mine-laying will all be part of the airship's duties under these conditions.

The same duties will be carried out at shorter ranges by heavier-than-air machines. Here, again, the question of seaplane or aeroplane arises, and the answer, the writer considers, is the same, viz, where the performance which is required permits, use a large flying-boat if a big machine is wanted, or a seaplane (fitted with wheels and flown off an aerodrome if sheltered water is not available) if a smaller machine is wanted. The writer considers that small flying-boats have no future, as experience has proved that they are easily swamped.

But if the employment necessitates a very high performance an aeroplane must be used; for instance, the amphibian suggested (see C, above) would be suitable for anti-submarine work if there was little opposition, although for similar work or reconnaissance on a strongly-defended hostile coast, everything else should be sacrificed to performance, and an aeroplane used.

In addition to the duties enumerated, heavier-than-air machines would be most valuable for attacks against an attempted landing, as already explained. In such operations, and for attacks on ships in harbour the torpedo machine has a great future. These machines should be developed on two lines, the small handy machines (particularly suitable for work from ships) to attack at close range, and large machines for attack at longer ranges, requiring less manoeuvrability. For the latter work the flying-boat is believed to have already been found suitable. With the advent of the improved mooring-out capabilities suggested (see D, above), it is easy to visualize a squadron of torpedo-carrying flying-boats working like a destroyer flotilla of today.

In all aspects of overseas flying the difficulty and importance of accurate navigation is very great. Too much attention cannot be given to this question. At present directional wireless seems the most promising method.

Conclusion. Finally, it is only necessary to add that whereas in the late War aircraft gradually became valuable in nearly every branch of naval warfare, study leads to the conclusion that in the next war against a first-class naval Power the use of aircraft will be very greatly extended. Consequently, to a naval Power which now develops aerial co-operation with the fleet, largely and on sound lines, aircraft are a vast accession of strength. But to a nation which fails to do this they are a most serious danger.