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THE SUBMARINE AND FUTURE NAVAL WARFARE.

By LIEUT. W. S. KING-HALL, R.N.

On Wednesday, April 7th, 1920, at 3 p.m.

ADMIRAL SIR F. C. D. STURDEE, Bt., K.C.B., K.C.M.G., C.V.O.,
in the Chair.

THE CHAIRMAN: I have much pleasure in introducing Lieutenant King-Hall, who has kindly come here to give us his views on the submarine and future naval warfare. He hardly requires an introduction. During the war, between the times of fighting the enemy, he considered the problems of naval warfare and competed in the Gold Medal Essay competition and obtained the Gold Medal of this year. I ask him, as a Gold Medallist of the Institution, to read his paper.

LECTURE.

WHEN the Council of this Institution honoured me with an invitation to deliver a lecture, I submitted a draft of what I proposed saying to the necessary authorities at the Admiralty. I was given permission to lecture on the understanding that I made it clear that the views I expressed were entirely my own and were in no way official.

In dealing with futurities it is necessary to be on guard against making extravagant prophecies of a more or less imaginative nature. Prophecies such as: "The day will come when we shall be crossing the Atlantic in aerial liners," are of no assistance either to intending transatlantic passengers, or to the directors of transport companies.

What prophets ought to do is to stick to practical facts, name the day, explain how results are to be achieved and on what lines developments should proceed.

Consequently I wish to emphasize at the outset that I have endeavoured to examine the subject matter of this lecture from a strictly practical and definite point of view—which is as follows: The subject has been treated from the point of view of the British Empire, and my ideas are those on the effect which submarine ships will have on our methods of conducting naval war within a period limited by the date 1930.

In all forms of warfare there are certain simple truths which have been known from the earliest times. One of these is that an advantage may be gained by surprising the enemy, both tactically, and

strategically. An obvious method of obtaining surprise is to approach the enemy without his being aware of your movements. There are of course other methods such as approaching him openly but concealing your hostile intentions from him, but the first method of surprise is the one that concerns us to-day.

It must have been realized thousands of years ago in land warfare, that use could be made of rocks and trees for the purpose of surprise, but for centuries the flatness of the oceans entirely prevented tactical surprise in sea warfare. The only way in sea-fighting of approaching the enemy in an unobserved manner during the daylight hours is to get under water, since this manœuvre gives concealment from one of the enemy's defensive weapons—his eyes, though he may yet detect you by using his ears.

About 300 years ago the first attempt was made to navigate under water in a ship, but progress in submerged craft was slow up to the end of the first decade of the XXth Century. I do not propose to say any more as to the early development of submerged craft as this subject is usually dealt with at length in the opening chapters of books on submarines.

Bearing in mind that the root idea of making a warship move under water is to obtain surprise, I propose to devote five minutes to classification of the different types of warships in use to-day; this accomplished, the way will be clear for a discussion as to the effect of submersion upon the powers of different classes of ships.

Experience has shown that certain operations have to be carried out in naval war, but since it is impossible to build sufficient suitable ships for every imaginable duty, certain *types* of craft have been evolved, each being specially suited for some of the most important operations which are likely to arise.

These types are: The battleship type, the cruiser type, and the auxiliary type.

First, as regards the battleship type, so often condemned as obsolete on paper, invariably triumphant in practice up to the present moment.

I suggest that much of this apparent inconsistency between theory and practice is due to the use of terms which have not been clearly defined.

The "battleship" should be defined somewhat in this manner:

"She is that craft, aerial, surface or submerged, which combines in one unit the best tactical powers for battle purposes."

From this definition, it seems to me that the battleship can never "die" as long as naval war "lives."

The matter open to argument narrows down to the question as to what is the best combination of tactical powers to put into the battleship to enable her to carry out her duty of destroying enemy battlecraft.

In addition to the ship for battle purposes, experience has shown that it is necessary to have other ships in the Navy. This need is partly due to the size and cost of battleships, and partly owing to the fact that, as a battleship is designed in the first instance for battle duty,

she is not entirely suited for other naval operations, such as inshore work, reconnaissance, etc.

An important type of warship additional to the battleship is the cruiser class.

Any craft may have to do "cruiser duties," if the craft built specially for the purpose are not sufficiently numerous.

Finally, I consider that all other kinds of ships except submarines, can be conveniently classed as auxiliaries. In this class, I group "Specialist" ships whose design is primarily connected with a special object, as for example—minelayers, C.M.B.'s (which were originally only intended to be very rapid torpedo carriers), bombarding ships, aircraft carriers, etc.

I exclude submarines from belonging to any particular group of naval instruments because such inclusion is, to my mind, entirely wrong.

It was once correct to speak of "submarines" as being an individual class of ship; in 1908 it was correct so to do because at about that time the submarine was a very special limited kind of craft not far removed from a slow moving mine. Probably when the Navy was changing from sail to steam one might, with some reason, have classed ships as battleships, cruisers and steamships.¹ At the present day, and especially in the future, to describe a craft as a submarine tells one nothing more than that she can go under water, she may be a mine-layer, a torpedo carrier, or even a survey ship, of which class I believe there is at present one example in commission.

I might as well attempt to describe the "Queen Elizabeth" by saying that she is a steamship. Submersion must be considered as part of a ship's fighting powers, like speed, armour, or armament. The ground has now been cleared and the main problem stands clear from the undergrowth. Three groups of ships are needed for the various operations of naval war. To what extent will it pay us in the immediate future to apply the capability of getting under water to each group?

Before considering the effect of submersion on the individual groups of warships certain general aspects of the question affecting all submersible ships require mention. The first general point is that any submerged warship can make use of her peculiar powers in two ways—tactically and strategically.

By the expression "tactical submersion," is meant that the submarine proceeds under water as part of the operation of actually attacking the enemy; by strategical submersion is meant that the submarine goes under water in order to proceed in a secret manner to the place where she hopes to attack the enemy. If an instrument was invented to-morrow which accurately located submarines at a distance of ten miles, then until the submarine develop an antidote there would not be much point in any craft getting under water for tactical purposes. I am not at liberty to disclose the details of the development of underwater detection, but if we take the figure ten as representing either

¹ The official publication giving details of warships is still designated "Steamships of England."

perfect immunity or perfect detection, I consider that from the tactical point of view

in 1914—the Submerged ship was	..	9
the Surface ship was	..	1
1919—the Submerged ship	..	7
the Surface ship		3
and that 1925 to 1930—the Submerged ship will be		6
the Surface ship		7

The last figures are of course purely my own estimate; but whether right or wrong, I feel fairly certain that as the art of concealment had a good many years' start on that of detection, so the means of detecting submarine craft have still a certain distance to go before equilibrium is reached, when, of course, the submarine may be obliged to start trying other methods of concealment beyond that of merely disappearing from *sight*. In fact the German practice of running their motors at a synchronous speed was a halting step in this direction.

My conclusion in this matter is that within the next few years we shall see a development of submarine detecting apparatus which will give large and important ships a certain measure of protection against tactical attack by submarine.

Looked at from the submersible ship's point of view, her powers of tactical surprise are likely to be less than they are to-day. Her powers of strategical surprise remaining the same except in these special cases where to reach the open seas she has to pass through narrow channels whose coasts are in the hands of her enemies.

The second general point which concerns all submersible craft is that of the weapons available for submerged attack on shipping.

The only way at present to attack from a submerged position is by mine or torpedo. Both these weapons have occupied the attention of designers for a number of years, whilst methods of underwater defence have only been closely investigated since about 1915. The development of special internal construction, blisters, paravanes and other defensive devices, have considerably lowered the offensive value of mines and torpedoes. It may well be that we are on the eve of a fresh effort by mines and torpedoes in their struggle against ships' hulls, but I do not see any great development impending at the moment in this direction; rather am I inclined to expect under-water protection to continue to develop fairly rapidly for the next few years.

If the submerged ship makes no use of mines and torpedoes, the only alternative known to me is gas.

It is my personal opinion that the use of gas may eventually revolutionize warfare much as gunpowder did when it was first introduced, but this question is outside the scope of the paper.

As far as we are concerned to-day I merely wish to throw out the suggestion that by 1930 experiments may have been made with the object of discharging gas from submarines under water.

The gas might be discharged on to an enemy coastline. I believe there was a proposal to do this from coastal motor-boats on to the

Belgian coast during the last war, but out of deference to Belgian susceptibilities the idea was abandoned. If it ever became necessary to use gas in this manner a submarine would have many advantages as a gas discharger especially if the gas could be made invisible.

I have not at present mentioned the gun as a weapon because a submarine using gunfire can not make tactical use of submersion, she can only use it strategically, i.e., she carries the gun underwater to the selected place on the surface from which it is to fire at the enemy.

The third general matter affecting all submarine ships may be described as "submarine construction."

Some of the requirements of submarine construction are likely to be permanent, others may not be so. Amongst the former are such essentials as a specially strong hull, possessing few openings, easily made watertight. Amongst the latter are the two power units which have to be fitted to all submersible ships built to-day. The use of storage batteries makes the electrical unit remarkably heavy and inefficient.

For instance, in an L class boat the motors for submarine propulsion weigh about 40 tons, the batteries about 130 tons, to which may be added about 15 tons of material incidental to their efficient installation in the submarine.

It would remove a great handicap from submersible ships if they could be built with one power unit. It does not seem fantastic to imagine such a state of things, as the energy for under-water work could be carried in an explosive form, i.e., containing its own oxygen.¹ But this entails exhaust, and this in turn means that unless methods are devised for combining the exhaust gases with sea water the submarine's powers of concealment are lessened.

In peace time when naval estimates are lean, developments in material do not move very quickly and a tremendous amount of experiment would be necessary before a single power unit submarine could be built, and my personal opinion is that submarines will still have two power units in 1930.

Two further technical features common to submerged ships call for mention.

Firstly, the fact that submarines demand stream line shapes all over their hulls: this imposes certain disadvantages upon them as compared to surface ships.

Secondly, the difficulties of manœuvring ships under water when they get very big and especially when they get long.

To dive a very large submarine, unless a static dive is intended, necessitates a considerable depth of water, and once down, when cruising at periscope depth, if the boat takes up a very slight angle, her bow or her stern will break surface, and give her position away.

These facts must be kept in mind when considering the application of submersion to large ships.

¹ An example is the "Cage" submarine—an American boat—24 hours, 23½ on bottom.

I have now finished my general remarks on submerged ships, and the desirability of making the different types of future warships submersible will now be considered.

First as regards the battleship. In this connection I had intended to examine at some length the relative values of the latest form of surface battleship, such as the "Hood," and a possible submersible ship, which might be designed in the immediate future for battle purposes.

This comparison has become unnecessary, for during the last few weeks two pronouncements have been made on this subject. These statements have an authority far exceeding any that might be attached to my own remarks, and they coincide exactly with my own beliefs. The first pronouncement was made by the First Lord of the Admiralty in an explanatory statement presented with this year's Naval Estimates. He said:—

"There has been some criticism of the maintenance in commission of the present types of vessels, especially in regard to the capital ship. A contrary policy has been openly advocated, this policy being based, it is presumed, on the idea that the battleship is dead and that submersible and air vessels are the type of the future. The naval staff has examined this question with extreme care, and as a result we profoundly dissent from these views.

"In our opinion the capital ship remains the unit on which sea power is built up.

"So far from the late war having shown that the capital ship is doomed, it has, on the contrary, proved the necessity for that type. On the German side the whole of the submarine campaign against merchant vessels was built up on the power of the High Sea Fleet. On the British side the enemy submarines in no way interfered with the movements of capital ships in carrying out operations; destroyer screens, new methods of attack, and altered tactical movements defeated the submarine History has shown that the introduction of a type to destroy the capital ship has been quickly followed by the evolution of counter-measures which sustain its power. It is even possible that the present battleship will change to one of a semi-submersible type, or even of a flying type, but such types are visions of the far future, *not practical propositions of the moment*. By gradual evolution and development the types forecasted may arrive, but the immediate abandonment of the capital ship in favour of a visionary scheme of aircraft and submarines, would leave the British nation destitute of sea power and without the means of progressive training."

The second authority was Sir Tennyson D'Eyncourt, who, at the conclusion of his recent paper on H.M.S. "Hood," which he read on March 24th at the Annual Meeting of the Naval Architects, said:—

"But with our present knowledge it would be quite impossible to design a submersible ship which on the same displacement and cost had anything like the fighting qualities on the surface which are possessed by the "Hood." Every ship is a compromise, and if in addition to the ordinary qualities of a battleship, she is required to submerge, or

even partially submerge, a very considerable percentage of weight has to be added to give her this additional capability of submergence. She becomes still more of a compromise, and the added weight must detract from the fighting qualities of the ship when on the surface, so that whatever is done, other things being equal, the submersible ship must be inferior to a surface ship in an ordinary action. There are many difficulties of details in the design of a submersible battleship which would take too long to go into fully now, and, although there is no doubt that submarines are capable of great development, a little thought will make it clear to anybody that if naval warfare is to continue, the surface ship of the line must still hold the field as the principal fighting unit of any great navy. This view is apparently shared by other countries who are developing their navies, and both Japan and the United States are building large capital surface ships."

The next type of fighting ship to be considered is the cruiser.

A cruiser is best defined as any craft which does cruiser duties, and, broadly speaking, these duties may be divided into two sections. Firstly, the duties of cruisers with the battle fleet. Secondly, their duties when working quite apart from the main forces. In the first-mentioned case a very important portion of a cruiser's duty when working with the fleet is reconnaissance. There are various forms of reconnaissance.

We will take first the observation of an enemy's port.

There is no need to labour the advantages to be gained by giving submersion to the cruisers doing this work; the recent war proved conclusively that the submarine cruiser is the best ship for this duty. There are three reasons why this is so.

1. Because the submerged ship can cruise slowly off the enemy's base, and therefore has endurance.
2. Because she can remain close to the enemy's strong forces without tactical support.
3. Because she has a good chance of seeing the enemy without being seen herself. If she achieves this her information is much more valuable to the C.-in-C. The following future developments seem probable:—

Hydrophone Observation.—This will cut both ways.

Our boats observing off the enemy's bases may be able to lay hydrophones right up in his channels, and then listen on the bottom many miles to seaward. It is possible that the hydrophones will be placed in position by coastal motor boats if the waters close to the enemy base are so heavily mined that the submarines cannot get in.

If our boats rely on ordinary visual observation, their greatest difficulty will probably be to get their information away by wireless without the enemy locating them by directional wireless. It may be necessary to establish a chain of boats within close range of each other, so that the information can be passed along at weak strength. If this becomes necessary it would be an interesting parallel to the chain of frigates between the inshore squadrons and the main fleets in the blockades of the Napoleonic Wars.

As regards the defence of our own bases, it will probably be desirable to establish a fairly elaborate system of underwater detecting apparatus within a zone of, say, thirty miles of the base. This system would be worked in connection with aircraft and fast surface craft patrols from a central station on shore.

Doubtless, use will be made of minefields, especially bottom mines, but in my opinion the value of moored mines as a fixed defence against observing submarines may be largely offset by the application to submarines of some form of mine protection, especially as a submarine cruiser on patrol will not want to move very fast.

Net defences, booms and gates will remain with us, and a fleet will always have to lie behind such defences or the observing submarines would soon start using the torpedoes which they will normally carry for the purpose of attacking the fleet on its return to harbour. For if their first duty is to observe, they will probably be ordered not to disturb the fleet on its way out.

These were in fact the orders to our own observation submarines during the last war.

I should like to draw attention at this juncture to the desirability of British fleets being able to carry their own submarine proof defences on their backs. Our fleets may have to fight in any ocean and use many bases, and we ought to have arrangements whereby any squadron can, at short notice and with its own resources, make a base temporarily submarine proof.

As regards other reconnaissance work, such as locating an enemy fleet which has got to sea, or scouting ahead of our own fleet, it is not apparent to me that the advantages gained by using submersible ships for these purposes outweigh the inevitable disadvantages. In the case where it is necessary to sweep out a large area of sea, high speed and visibility are required. Submersible craft have no advantage in this respect over surface craft and are at a disadvantage to aircraft, though submarines may be used in conjunction with the latter, as will be shortly explained. It is also my opinion that the scouting work ahead of a fleet can be more suitably done by surface craft and aircraft. There is another duty of the cruiser with the fleet and that is a tactical one.

This is the delivery of early torpedo attack on the enemy's fleet.

It is for this purpose that the K boats were built.

I have mentioned in this paper my belief that when attacking heavily screened modern battleships the submerged ship from the tactical point of view, both as regards her powers of disappearance and her under-water weapon, the torpedo, is likely to remain stationary in development if not retrograde.

Consequently the future of the K boat when used as a weapon for torpedo attack seems doubtful. Personally, I would substitute for them a large type of submarine cruiser with oil engines and very quick diving powers which would be more useful for what may be the main fleet duty of submarine cruisers in the future. This duty is that of shadowing a hostile fleet.

The long range of present-day guns, the development of aircraft, and other factors seem to make it extremely difficult, if not impossible, for surface cruisers to shadow a fleet.

Yet occasions may arise, particularly in our own case, when it will be essential to keep touch with an enemy fleet at sea whilst our main forces hasten up to destroy it.

It is in such a situation that I foresee a possible co-operation between aircraft and submarine cruisers.

Imagine a situation in which it was desired, to obtain news of, and bring to action, an enemy fleet if they entered a large area. This might be done by stationing a few submarines at widely separated points in the area, and using in co-operation with them large flying boats or lighter than air ships.

The aircraft would be able to examine large sections of the area, but once they had sighted the enemy they might not be able to maintain touch with him in face of the fighting planes carried in the fleet; our aircraft would report the position of the enemy to the submarine cruisers and the latter would then endeavour to shadow the enemy and report continuously to our main forces.

Submarine cruisers employed on this duty would probably be much harassed by aircraft carried in the fleet, but on the other hand they would have certain advantages.

It would be difficult for the Commander in Chief of the Fleet to ascertain how many shadowing craft were keeping touch with him.

Submarines shadowing a fleet would always exercise a considerable moral effect; the fleet would always fear that the submarines were steaming round its flanks during the night, to lie submerged in the track of the fleet at dawn.

Having briefly outlined the future possibilities of cruiser submarines for fleet work, I propose to examine the influence of submersible ships in connexion with cruiser work away from the fleet. Such work embraces all the cruiser operations which have for their purpose the protection of our sea traffic and the interruption of the enemy's. As our Empire depends for its existence upon a certain minimum flow of traffic across the seas of the world, this matter is of the first importance. In considering the problem contained in the question, "How will our exercise and control of sea communication be affected by submersible craft" it is advisable to be on our guard against jumping to conclusions derived from the result of the last war.

Though we won the war, it was proved that even when we were very favourably situated from a geographical point of view enemy cruisers got to sea in large numbers and destroyed much shipping; most of these enemy cruisers got to sea because they were able to get under water when necessary.

In a future war, if our enemy has an ocean coast line we shall be even less able to prevent his submarine cruisers from getting to sea, than we were during the last war.

In the last war our trade, generally speaking, moved under two conditions. It was either in or outside what was called the submarine zone.

This submarine zone was limited to within a few hundred miles of the coastal waters of Europe.

When the trade was outside the zone it only ran the risk of attack by a few surface raiders, when inside the zone it was protected by special local anti-submarine craft.

Now as the war proceeded the zone enlarged and consequently the strain on the anti-submarine defence was more intense, destroyer escorts had to proceed so far out into the Atlantic to meet convoys that they almost ran out of fuel. Fortunately for us the enemy collapsed, but we must not blink the fact that in the future the so-called submarine zone will be world-wide. This does not mean that every ocean will be full of submarines; no Power would have enough, and it would not be a paying proposition to scatter them over the seas; but what it does mean is that all focal areas where trade must congregate will be infested by submarines, and that all trade will be liable to world-wide attack by the submarine cruisers on their way to and from the focal areas.

There is also this additional fact, that though on an average most of the U boats were small craft, weakly armed, and in many cases afraid of drifters, the later U boats of the U 139 variety were armed with two 6-inch guns. Incidentally this craft in 1918, under the command of Arnauld de la Perrière, attacked a convoy by gun fire, sank two ships, outranged and very nearly sank the armed escort H.M.S. "Perth," as well. The future submersible commerce destroyer will always remain a small ship because numbers of them will be required, and numbers are incompatible with size, but she may easily carry four 6-inch guns, and her radius of action will be not less than 6,000 miles, and more probably 12,000.

Such a craft could be built to-morrow.

These vessels will not make use of their submarine qualities for tactical attack on trade; they will use it for strategical purposes—and they will use it in two ways.

In the first instance we must be prepared to find a concerted attack on our trade taking place in widely separated areas; this attack may coincide with the outbreak of war. Up to the outbreak of war there may be no sign of the enemy outside his home ports, but during strained relations the enemy submarine cruisers may be secretly moving to their war areas.

In the second place the enemy cruisers will make use of their powers of disappearance in the area where they are operating, so as to confuse us as to the number of enemy cruisers in the locality. The careers of the "Emden" and the "Karlsruhe" emphasized the difficulties of locating surface craft, and these difficulties will be still greater when the problem consists in trying to find submersible cruisers.

What is the best way to protect our sea traffic against this menace?

A certain number of operations will take place off the bases from which the enemy cruisers leave and to which sooner or later they must return—though it may be a good deal later than sooner, since the endurance of a submarine of size is very great, and if the use of oil fuel becomes more general in merchant ships the commerce raider may often

be able to refuel from captured ships at sea, an easier operation than that of transshipping a captured cargo of coal.

The value of operations against raiders off their home ports will depend greatly on geographical conditions, and even when circumstances are favourable to us a certain proportion of enemy cruisers will assuredly get to sea.

To counter the operation of these ships our sea traffic must either go under water or move in convoy. The Mercantile Marine being a business proposition will not go under water as long as submarine ships require special hulls, and special machinery. The convoy system, with an escort suited to the new conditions, i.e., world-wide extension of the old submarine zone will have to be our principal measure of defence. In addition to the purely defensive measure of convoy we shall also have to hunt down the cruisers in the area where they are operating.

Future convoy work will be so important and the immediate control of our merchant shipping so insistent if war breaks out, that it is very desirable that close touch be maintained in peace between the R.N. and the Mercantile Marine. It would be good if every master of a steamer of any size were an officer in the R.N.R. who could be given a few days' instruction from time to time on convoy work and similar subjects. We cannot expect to practise convoy in peace time, but there is no reason why we should not be always ready to put it instantly into practice. This act would be the best counter to the possibility of surprise attacks on our trade taking place coincident with the outbreak of war.

I have already suggested that, generally speaking, the future submersible ships will not find their submerging powers of great tactical use to them, having regard to the likely developments of torpedo defences and detecting apparatus; and this will apply especially to the large submersible cruisers. They will not be very handy under water, and as a rule they will not attack submerged. They will do most of their work on the surface, using long-range gun fire.

The most successful of all U boat commanders, Arnauld de la Perrière, held that this was the best way of attacking trade.

If these views are correct, the convoy must be protected from this method of attack.

I wish I could think of some brilliant means of defence other than the very obvious one of giving the convoy an escort capable of fighting the submarine with her guns, but I must confess I can not do so.

It seems to me that if we want to give our future convoys adequate protection against submarine cruisers we have got to build a class of ship capable of doing the work.

My idea of such a ship is a vessel of about 20 knots maximum speed, with oil engines giving her big endurance and no smoke, of 3,000-4,000 tons displacement, carrying four 6-inch guns, or if potential enemy submarines mount heavier armament, then the convoy escort class must follow suit. She would be fitted with the best detecting apparatus and be supplied with the latest anti-torpedo protection, such as blisters, etc.

She would also carry a copious supply of depth charges and a battery of throwers.

Finally, it is of the first importance that she carry at least one aircraft, provided arrangements can be made for the aircraft to return to the convoy ship—perhaps the Helicopter will permit of this.

If some of the big ships in the convoy can carry aircraft so much the better. It should be considered whether an arrangement can be made with shipowners to construct their ships so that in war they can be fitted with a temporary landing platform; for in the future it may be very desirable to arm merchantmen not only with guns but with aircraft.

The duty of the aircraft with a convoy will be to scout ahead during the day time and sweep astern at dusk, the latter operation in order to see if the convoy is being followed by an enemy desirous of making a night attack.

In any case the important point will be to sight the enemy on the surface as far away from the convoy as possible.

If circumstances permit the convoy will then be diverted whilst other forces are called upon to attack the enemy.

If the convoy must pass near the enemy, the convoy escort ship should tackle the submarine and hunt her until the convoy is safe, the latter making such use of smoke screens, etc., as is possible. I have not lost sight of the fact that to construct a class of convoy escort ship takes what we are all short of—money.

It may be urged why not arm selected ships in the convoy, and arm them sufficiently strongly to beat off the submarine attack. My objection to this proposal is that the defence of convoys is so important a matter to us, that the escort ship must be designed primarily to fulfil that duty.

Officers who served in destroyers during the last war will remember what happened when the destroyers had to be turned into ships suitable for other duties. There was a danger that in endeavouring to make a destroyer fulfil three duties, a ship was produced that would do none.

By all means let the possibility of using the convoy escort class for trade purposes in peace and war be borne in mind and considered, but let such consideration be secondary to the decisions as to the necessities for defeating the ocean-going submarine.

In addition to the more or less passive defence obtained by convoys, active operations will be required with the object of hunting down the enemy cruisers.

In the past a recognized method of attacking enemy surface cruisers which have preyed on sea traffic has been to establish offensive patrols in focal areas.

This principle will still hold good, but the method of applying it will be different. It will be useless to order a surface light cruiser to patrol, say off the Cape of Good Hope, if enemy submarine cruisers are attacking trade in that area.

I suggest that the best way of attacking such enemies will be by a combination of aircraft and our own submarine ships.

If the area is near one of our own bases the use of heavier than air craft seems indicated, if the area is far from a base large airships might be employed.

The principle of operation might be as follows :

The aircraft being able to examine large areas in a short time would scout for our own submarines. As soon as the aircraft sights the enemy, in all probability making him dive, the aircraft calls up our nearest submarine. Sooner or later the enemy must come to the surface to charge his batteries, and he is almost certain to do so at night.

There seems a possibility that under favourable conditions this operation might be made hazardous for the enemy if the airship could periodically illuminate several square miles of sea.

Next day the enemy will be sighted again by the airship if he surfaces, and he will then also run the risk of being torpedoed by our own submarines, which by this time should be close at hand. The other alternatives then open to the enemy are to dive, or else vacate the area. In any case as long as the submarine cruiser is on the surface she will probably be seen and reported by the aircraft, and once a cruiser operating against trade has been reported it is time for her to move elsewhere.

The use of our own submarines in an area for the purpose of destroying the enemy submarine cruisers has the following advantages :

1. Submarines having large endurance, our boats could cruise for prolonged periods in the area.

2. If we endeavoured to use surface craft such as the American chasers, we must fit them with guns, approximately equal to those carried by the submarine cruiser. This would make the chaser rather large and she would then run a risk of being torpedoed.

3. The greatest moral effect would be produced on the enemy if we used submarines.

The U boat commanders disliked our offensive submarine patrols more than any other anti-submarine measure. There is something peculiarly unsettling in the feeling that a submarine is stalking one. When on the surface no relaxation of vigilance is permissible and even when submerged a hydrophone duel may be in progress.

An enemy cruiser submarine knowing that she had been seen by the aircraft might suspect that other forces bent on her destruction were at hand. As long as the horizon was clear there would be no danger from surface craft, but her fear of submerged attack would be continuous.

To get the best results from our submarines it would be desirable to design a special type of boat for this work.

Her qualities should include :

1. Very high endurance.
2. Good methods of communication with aircraft.
3. Crew accommodation suitable for the tropics.
4. Either a torpedo armament, or a big gun to be used on torpedo lines, i.e., the boat to surface at short range and fire one shot with a flat trajectory.
5. A bow meant for ramming.
6. Good manœuvring powers on the surface.
7. Depth charges and throwers.

If some such scheme of combined operations between aircraft and submarines is the best way of dealing with enemy submarine cruisers in focal areas a number of our small possessions overseas may become exceedingly important as bases from which our combined patrols will work. Ascension and St. Helena, for example, may have their cliffs crowned with airship hangars. This concludes my general survey as to the value of applying submersion to cruisers, both for fleet work and for duties away from the fleet.

There remains one group of war vessel to be examined—those ships which I classed as auxiliaries. By such ships are meant:

1. Minelayers.
2. Special torpedo-carrying craft.
3. Monitors.

Within the limits of this short paper it is only possible to deal very briefly with each of the foregoing types.

First as regards Minelayers.

A submersible minelayer has the strategical advantage common to all submersible ships of being able to evade action with our main forces during passage from her home ports to the scene of her operations.

Her tactical advantage, if she is kept small, is that she can lay her mines close into harbour entrances. A good example of this took place in the last war when E 45 laid her mines from the surface in the gate entrance off Heligoland in 1918.

It was a dark but clear night and the captain of E 45 told me afterwards that whilst they were laying their mines they had listened to some German sailors singing songs on the forecastle of a guard ship about three hundred yards away. The disadvantage of the submarine minelayer is that she carries such a small cargo. In a future war, if we are able to prevent surface enemy minelayers from getting out of their bases we must expect to have small minefields laid by submersible ships in the entrance to our chief ports such as Sydney, Melbourne, Cape Town, Calcutta, Bombay, etc.

The only difference in this aspect of war against our trade between past and future is that in the future we must expect these small minefields to appear all over the world. Submersible minelayers will always be of some value to our enemies, who will generally be carrying out extensive operations against our sea trade—that trade which is our strength and our weakness. From our point of view the value of submarine minelayers will depend a great deal on the geographical situation of our enemy, possibility and value of minelaying off his bases, etc. The next auxiliary is:

Special torpedo-carrying craft.

Concerning the use of these for fleet action purposes, I have stated my reasons for doubting whether within the next ten years the type of submarine destroyer of which the K boat is an example is going to be of much use.

But I suggest that if geographical circumstances are favourable to their employment, our enemies may use small handy torpedo-carrying submarines for attacks on our sea traffic. This attack might be useful

to our enemies in an area which was too strongly patrolled to admit of the big cruiser submarine carrying on a gun attack.

From our point of view the main use I see for the torpedo-carrying submarine is for patrols against enemy submarine craft.

The next type is *submarine monitors*.

These seem more likely to be useful to our enemies than to ourselves. I have suggested that the protection of our sea traffic in a future war will entail the use of a considerable number of isolated bases used by our submarines and aircraft. If these bases are not adequately defended by guns they might be bombarded by submarine monitors which have evaded our main forces.

There should be plenty of guns left over from the last war to defend every base we shall require to use. And all over the Empire, for at least ten years, the ex-artillery man will be found.

It is difficult to imagine a submersible monitor carrying out an accurate bombardment unless she remains on the surface, that is to say, that strategically there is a gain by applying submersion to a monitor, tactically there is a loss.

These auxiliaries, minelayers, torpedo carriers and monitors seem to me the only three to which submersion may be applied in the immediate future.

I think that at present submarine transports, or submarine aircraft carriers, except in so far as a commerce-destroying submarine might have a small seaplane, are rather fantastic.

I might perhaps have mentioned submarine supply ships, but the use of such craft would be automatic on the part of a Power whose over-sea submarines found it too dangerous to work from home ports.

The summarized conclusions of the arguments in this paper are as follows:—

1. As regards the general principle of making use of submersion in naval war. It is thought that from the point of view of actually attacking ships from under water the advantages of the submerged ship are not within ten years likely to be as great as those enjoyed by U boats between 1914-16; and if methods of detection and under-water defence make normal advances the tactical advantages of the submerged ship over the armed surface ship may in the near future be a good deal less than they were in 1919.

Strategically, the advantages of submersion are great, and as constructional difficulties are overcome and we are able to apply submersion to additional classes of ships without sacrificing other essential qualities, the strategic influence of submersible ships in naval war will increase in a corresponding manner.

The actual developments to be expected during the next ten years are thought to be as follows:—

1. *The battle fighting ship.*

It will not pay us to try and give this class of ship submarine qualities.

2. *The Cruiser.*

Cruisers intended for observation work off enemy ports must be of submarine type.

Cruisers watching areas in which it may be necessary to shadow enemy fleets must be of submarine type. *Cruisers* employed on screening and scouting duties with a fleet will be of aerial and surface type, working in co-operation.

Cruisers employed on *guerre-de-course* will be of submersible type and they will destroy shipping by gun fire. These craft are particularly suited to our enemies and appear to me to be the greatest future naval danger of the Empire.

Cruisers employed against these raiders must be of aerial and submarine type, working in conjunction.

If a potential enemy is known to be building these commerce-destroying submarine *cruisers* it is suggested that we should lay down a special class of ship for convoy escort in time of war.

The Auxiliaries.

The submersible minelayer will not have a general value to us, but might be useful if we went to war with certain Powers whose geographical situation was such that inshore minelaying would be profitable. To our enemies the submersible minelayer will be useful for mining in the entrances to our commercial ports as part of the campaign against our sea traffic. The same remarks with the substitution of the word "bombardment" for minelaying apply to the case of the *submersible monitor*.

The torpedo-carrying submersible.

For fleet action purposes she is only likely to be of marked use for covering the retreat of a defeated fleet. It is suggested that the K boat class will die out for the time being if the view is correct, as expressed in this paper, that the tactical advantage of submersion is on a temporary decline.

DISCUSSION.

ADMIRAL MANN: I rise only to start the discussion. As an old retired Admiral I am not qualified to criticise so technical a subject. It records the view of a young officer who has gained his experience during the great war, and we all congratulate him on writing such an excellent paper. It shows that initiative is now encouraged in a way we old fellows never dreamed of. We were not allowed to think in the days when I was a lieutenant. We had to obey orders, follow the routine and carry on. This is a serious matter, and I hope now other young officers will come forward. I am sorry the lecturer's father was not able to be present to hear his son read his paper; he may well be proud of the way he has collected his ideas and put them into form. But I see his uncle here, who I am sure is well pleased with his nephew. This Institution gains by having him as a member. He has already won the Gold Medal, which proves him to be a thinking man, and now has again placed before us matter for serious consideration.

CAPTAIN P. WORTHINGTON, R.A.F.: The author lays considerable stress on the co-operation of aircraft and submarines, and one great essential, as it seems to me, for such co-operation is that the aircraft must have very considerable endurance. In one case in point he suggested the use of large airships with anti-submarine *cruisers*, but it is quite impossible for any aircraft as at present known to endure weather which a submarine can stand. There is only one

craft at the present moment which will do it, and that is the kite balloon. Some very interesting experiments were carried out at the end of the war in fitting a winch on a "K" class submarine. I should think that therein lies the development of the future co-operation between aircraft and submarines, in the shape of small non-rigid airships, which can be towed by the submarine or which can operate under their own power. They would then have all the endurance of the kite balloon and could manœuvre independently of the submarine. It is a difficult problem to be solved aerodynamically, but a certain amount of progress has been made already. For convoy work a convoy ship should be certainly fitted with a kite balloon, as it will give continuous observation against the enemy. In the war it was demonstrated on the "Cambrian" that it was possible for balloons to endure for 2,500 miles continuously in face of a wind of up to 80 knots.

COMMANDER BELLAIRS, M.P.: I should like to congratulate the author on the exceedingly able paper he has read to us, a paper which I am sure will be very much discussed in the future. One reason why we have had very little discussion here is that the paper only just came into our hands to-day, and another reason is that the Active List officers of the Navy are very shy of coming here. I wish we had one or two Sea Lords of the Admiralty here, because we could tell them things. I believe the Admiralty are very favourably disposed to discussion now, but the Navy recollects the fact that for about twelve years discussion has been damped down, and therefore the Active List officer does not come here, and now we have to get him here. After all, we who have retired from the Navy become obsolete in two years in our material knowledge; we have lost touch with it. With regard to the paper, I am very glad that the author confines his forecast to a period of about ten years. At the beginning of the war I made a collection of the forecasts of Mr. H. G. Wells—unfortunately I lost them, but at the time when Liège was being besieged Mr. Wells said the Germans had lost the war. It shows that a man who can make forecasts of the distant future is not a practical judge of the immediate future. In confining his forecast to ten years the author takes a period which is a very good one. Everything points to ships becoming obsolete within a period of about eight years, and I believe the Japanese programme is based on that assumption. There is only one possible fault which could be found with the paper, and that is that the author rather lays out a big plan which will cost a good deal of money. He himself refers to the fact that we are in for lean times, and, as a politician, I must point out that his assumption is perfectly true; we are likely for several years to come to be in for very lean times in regard to the Navy. The idea that it is necessary to carry out very elaborate experiments was borne out by very elaborate experiments extending over several years before oil fuel was introduced into the Navy. Undoubtedly lean times lie before us, and the Navy will have to adopt old material as best it can, and to that problem it would be very wise for the Navy to address itself—especially for convoy work—rather than designing brand new ships for that purpose. The author speaks of utilizing the old guns all over the Empire, and says that plenty of artillerymen will be found to man them. That is true, but it will cost a great deal of money to adopt old guns and mount them on shore. I think we shall have to run more risks in that direction at any rate, because you can divert a very large sum of money towards shore defences and not reach finality. That is one caveat I should like to enter against the proposal to put up big shore defences all over the Empire because of the submarine menace. I congratulate the author on his paper, I think it will provide subject for discussion for some time to come, and I hope many young naval officers will follow the example of the author and give us papers at this Institution.

LIEUTENANT KING-HALL: I have listened with a great deal of embarrassment to the quite undeserved praise handed out to me. The first practical point that was brought up was the question of kite balloons and submarines. I did not quite gather whether the suggestion was that a kite balloon should go with a submarine. There would appear to be a difficulty as to what would happen when the submarine dived. However, I followed the argument as to the small airship. I am aware that experiments are in progress, but I have no knowledge whatever as to what has been arrived at from those results. As regards the amount of weather airships can stand, I have no special technical knowledge, merely having read about it. The only bad weather I know of is the bad weather experienced by our airship when she went to America a few months ago and met a wind of 70 miles an hour at one period. The question of small balloons which could be detached from the submarine and proceed on their own power seems to be one well worthy of investigation. I consider the chief disadvantage of the suggestion that the escort ship should have kite balloons instead of aircraft is that whenever the submarine sees a kite balloon, which is a more or less easily recognized body, it would know it was attached to something, and ultimately the kite balloon might give away the position of the convoy. That was an objection raised in the war by convoy people. There was a good deal of discussion, and the objection to kite balloons was that, while they might enable the convoy to see the submarine, they certainly enabled the submarine to see the convoy. The advantage of having aircraft operating independently from the escort ship is that she can scout the sea out of sight of the convoy altogether, and either report by flying back, if wireless silence is necessary, or report by wireless and inform the convoy of the presence of a submarine in a definite area, and possibly enable the convoy to steer clear of that area. Unless the aircraft makes the mistake of rejoining the convoy on a direct course, it should be possible for it to rejoin the convoy without giving the submarine any indication as to where the convoy is. With regard to the point raised by Commander Bellairs, I know it is very unpopular and probably very unwise to suggest any new construction at the present moment. I was rather looking at it from the point of view that these would be my suggestions if I were asked what I thought would be required, and I should then wait to see how much money the political gentlemen would give me. I understand there is more or less agreement amongst all parties that a certain sum of money will be spent annually on the Navy as part of the insurance premium of the British Empire. I considered carefully the question as to whether it was really necessary to build a special convoy escort class, whether one could not do something with the merchant ships we already have. I think we had a fairly good example during the war of the sort of thing that happens when you have to make shift. I do not know whether any destroyer officers are present, but if any are, who towards the end of the war were in destroyers which were primarily built to attack the enemy's fleet, but had been turned into submarine-hunting ships and convoy ships loaded up with all sorts of patent apparatus, I am sure they had some bitter things to say upon the subject. Suppose we took the South African trade and make arrangements for the Union Castle liners to be armed with a certain number of guns when war breaks out, can we be absolutely certain that when war breaks out those ships will not be seized to send an expeditionary force to some part of the Empire? If we have escort ships specially built they will be naval ships and earmarked for convoy work. In peace time it should not be impossible to make use of them on cross-Channel ferries, and in war time they could carry cargo, but the first consideration should be the defence of the convoy.

THE CHAIRMAN: I believe I shall voice the sense of the meeting in proposing a vote of thanks to the author, and in doing so I will make a few remarks on the paper. First of all I congratulate the author on having collected the facts and put in a very clear form the situation of submarines in the future, and not only putting it in a clear form but doing so in a very practical manner, recognizing their advantages and disadvantages. I should like to congratulate him on having written his paper before the First Lord's statement was issued. It is very creditable. The matter had been under the consideration of the War Staff of the Admiralty, and a lieutenant writes a paper beforehand which practically coincides with the War Staff views; it is a great compliment to him. I think the table he gives on page 4 of his paper is very interesting and it is a very true one, showing that the submarine is going back in one sense but is still a menace in another. I think the conclusions he has formed are very sound, and I quite agree with Commander Bellairs about the ten years' life of ships, because it is no use looking too far ahead. I am pleased the author does not recommend battleships being submerged. I think that is quite impracticable and very undesirable, because a ship that comes to the surface for a short time will not make any correct aim. I hear a good deal of talk about the "Hood," as one heard a good deal of talk about the first "Dreadnought." A battleship is not a unit of a battle fleet, the unit of a battle fleet being four ships. If one submarine came up to attack four "Hoods" I think she would soon meet her fate. As the size of the submarine gets larger it becomes a big torpedo target, and that limits the size of a submarine. It is most important that the three forces, surface craft, the submarine craft, and the aircraft, should work together in absolute sympathy and co-operation. No doubt aircraft will be of great assistance. They have been of great assistance in the war, and will be of greater assistance in the future for reconnaissance purposes and I have no doubt that aircraft will be of great assistance for reconnaissance purposes in connection with convoys. I rather lean towards the author's views about kite balloons. We had them in the Grand Fleet, and I think they were a mistake, because they marked the Fleet. If you mark a convoy it is a disadvantage. Sometimes they got blown away and sometimes we could not haul them down. Still, it was a development. But if an aeroplane can go off a battleship deck and come back it is far better, as an aeroplane can scout over a larger area and does not mark the convoy. I think the paper is a very hopeful sign for the British Navy. It shows that the submarine is not the menace that some people want to think it is. Of course it will always be a menace. I believe why this menace has affected this country more than any other is that we have always used a wrong term in talking about "the command of the sea." We have never had command of the sea. It would have been truer to have used the term "control of the sea." Whenever one goes to war it will be found that the British Navy or any other navy has never commanded the sea so long as the hostile nation can build a ship: that is, until every enemy ship is destroyed one cannot have command, but you can have control, and that is all one can expect in a maritime war. I should like to address a remark to Commander Bellairs, as he represents the House of Commons and the Estimates. We are living in lean times, and rightly so, in order to establish our finances, but remember you can establish your finances and yet lose your stability, and it is no use losing your stability by not having an adequate Navy, because without an adequate Navy one soldier cannot be sent across the sea, and therefore England might be found with, say, an Army of 5,000,000 men that cannot be sent across the sea, starving. I am sure all will agree with that. I do think it is a good thing to get a true perspective and see how much is the least you should spend to ensure the stability of this great State and Empire.

With regard to the use of old material, we have tried old material in the war and the war tried the old material severely. If one is outranged by the gun one cannot do much. A submarine will carry the latest gun, which will outrange the old material altogether. I thoroughly agree with Commander Bellairs on the question of shore defences. Our trouble in this war was that the Navy was sufficient to protect the country from invasion, but the Navy, even with the Allies, was not sufficient to protect the trade of the country from damage. Therefore that is the first requirement, and accordingly sufficient guns must be allotted to floating defences before shore defences. With those few remarks I ask you to pass a hearty vote of thanks to the author. I hope his paper will be thoroughly read and will be digested by everybody, Parliament included.

The motion was carried unanimously.

ADMIRAL MANN: I have been asked by the Secretary to propose a hearty vote of thanks to Admiral Sturdee for presiding here to-day, which I am sure you will accord to the victor of the Falkland Islands action.

The motion was carried with acclamation.