THE SURFACE FLEETS OF WORLD WAR I

PART II—THE WAR ITSELF

BY

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This article is the second of two based on a paper presented by the author at the Colloque International Marine et Technique at Paris in November 1988. Part I, covering the shipbuilding programme, armament and armour of the participating navies in the period leading up to World War I, was published in the last issue of the Journal.

ABSTRACT

The achievements of naval architects, marine engineers and weapon designers during World War I are described and discussed. The lessons learned during the war are considered, together with the changes made to the surface fleets. The revolutionary changes planned at the end of the war are mentioned briefly.

PROOF IN WAR

In this second part of the article the events of the Great War are examined to see how well the ships designed in peace fulfilled the requirements envisaged. Consideration is also given to the versatility of the ships in meeting unforeseen circumstances. These studies are not easy since the big battle, fought to a finish, did not occur. It was not a false assumption; such a battle could have come about in 1915 (Scarborough raid) or in 1916 (Jutland) and possibly on other occasions.

Sustained Speed

Machinery proved generally reliable; normally about two capital ships (10%) and a similar proportion of cruisers of the Grand Fleet were not available because of essential maintenance. Up to 25% of destroyers might be in refit[1]. In 1914 one serious problem arose, usually known as 'condenseritis'—impingement attack on the brass sea water tubes (either 30% copper, 69% zinc, 1% tin, or later 40/60). Such attack is critically dependent on water velocity which was higher in turbine ships but it had not occurred at the slower speed and lower usage of peacetime. This was a problem in all navies until the thirties when it was cured by the addition of 1% aluminium. The German Navy seems to have suffered more than the British. Both *Kaiserin* and *Grosser Kurfürst* lost the use of one engine at Jutland due to condenser problems and *von der Tann* had her speed reduced to 18 knots by dirty coal[29]. In 1914 there were a few problems with boiler trouble in British cruisers.

The endurance of British destroyers was a continuing problem. The original Admiralty M Class vessel had a nominal radius of action of 2530 miles at 15 knots, but under wartime conditions they were limited to 3 days operation. The R Class had about 10% more fuel but gained 28% at 25 knots and 12% at 18 knots due to the greater efficiency (both thermodynamic and hydrodynamic) of their geared turbine plant[20]. Further increase in endurance would have been possible only if resources permitted a considerable increase in ship size.

Gunnery

Gunnery achievements and success rates by both sides at Jutland are shown in TABLE I. Such crude statistics are hard to interpret; range, visibility, etc., varied rapidly favouring first one and then the other. In good conditions *Iron Duke* had 7 hits on *König* from 43 rounds at 12600 yards. *Lützow*, overall, achieved 19 hits from 380 rounds. Overall, one may suggest that the 1st and 2nd Battle-cruiser squadrons were out of practice and suffering from unfavourable light; with similar lighting the 5th Battle Squadron did much better whilst the main force of the Grand Fleet did well. The old ships of the 3rd Battle-cruiser squadron, fresh from practice, and at short range, obtained very good results.

Both navies could fire heavy salvoes at roughly 30 second intervals (*Marlborough* 14 salvoes in 6 minutes with a time of flight of 15 seconds).

TABLE I—*Gunfire hits at Jutland (based on Campbell*[29]*)*

	Shells Fired	*Hits*	*%*
BRITISH			
1 & 2 Battle-Cruiser Squadron	1469	21	1·43
3 Battle-Cruiser Squadron	373	16	4·29
5 Battle Squadron	1099	29	2·64
2,4, & 1 Battle Squadron	1593	57	3·70
GERMAN			
1 Scouting Group	1670	65	3·89
Battleship	1900	45	2·37

Resistance to damage

Shell Fire

Ships of both navies proved very resistant to shell fire (FIG. 1), *provided* that the magazines did not explode, a topic considered a little later. TABLE II below, based on Cambell[29], lists some of the more heavily damaged capital ships at Jutland, with the number of hits sustained and the time taken to repair them.

The damage to *Lion* at Dogger Bank was both disturbing and technically interesting. She was hit on the 9 inch belt, below the static waterline, by four heavy shells on the port side and one on the starboard. The frame behind the armour fractured, causing flooding and loss of feed water. The cause was lack of support at the junction between plates, sharp edges to the

TABLE II—*Resistance to shell fire at Jutland (31 May, 1916)*

Ship	*Hits by Heavy Shell*	*Notes*	*Date Repaired*
GERMAN			
Lützow	24	sunk	—
Derflinger	21	in action	15 Oct
Seydlitz	22	sinking condition	16 Sept
König	16	in action	21 July
BRITISH			
Lion	13	in action	20 July (Q turret 23 Sept)
Tiger	15	in action	1 July
Warspite	15	in action	20 July

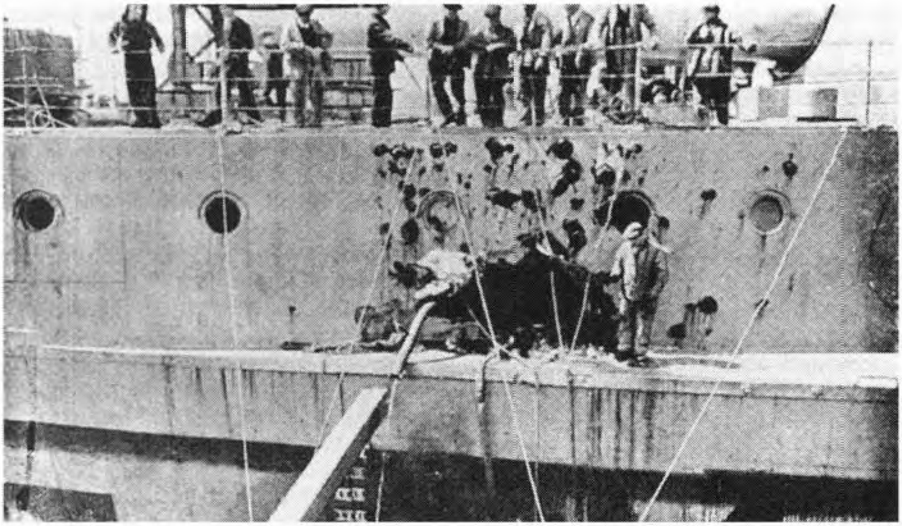

FIG. 1—A HIT ON H.M.S. 'WARSPITE'

plates and a discontinuity at the lower deck. It is also important to note that this action was fought at high speed in shallow water which would cause the height of the waves round the ship to be greatly increased, exposing the lower part of the belt amidships, normally partially protected by water[30]. Later British battleships were tested in model form in shallow water to explore this effect.

Penetration of Armour

At Jutland there were no hits by German shells on armour thicker than 9 inches. An 11 inch shell hit the *Tiger*'s 9 inch belt and failed to penetrate, probably due to the great range. There were 17 hits by British shells on armour of 10 inches or greater. Of these, seven shells broke up or burst without penetrating; four more made a hole but the effect of the explosion was outside. Only one shell functioned properly. Even against thinner (6 to 9 inch) armour, the great majority of shells broke up or burst either outside or in penetrating. The reasons were overhardened shells which broke up and a sensitive filling (Lyddite) which detonated due to the concussion on impact. The powder filled common (cpc) shell was at least as good.

Magazine Explosions

Before the war it was recognized that nitro-cellulose could decompose and spontaneously explode and it was also appreciated that enemy weapons could explode magazines or shell rooms. It was believed that the accidental risk was the greater and that it could be reduced by limiting the service life of charges, keeping them cool, avoiding impurities in manufacture, and providing venting arrangements. Despite these precautions there were several accidental explosions before the war, and during the war the R.N. lost the *Natal, Vanguard* and *Glatton* (and possibly *Bulwark*), whilst the German Navy lost *Karlsrühe* (possibly due to a fuel explosion).

It was not appreciated how rapidly pressure could rise in a bulk stowage if one or more charges ignited, providing conditions for detonation. The method of ammunition supply seemed safe but had a fatal weakness. The magazine doors opened into the handing room where the charges were placed in the lower hoists which were in a trunk which rotated with the turret. These hoists brought shells and charges to the working chamber, where they were transferred to the gun loading trays. Two charges could lie in the working chamber and two more in the handing room so that in action there could be 8 charges between magazines and guns. Flash doors were fitted to the trunk and the cages of the hoists but they were not strong enough to resist the pressure from a burning charge. In practice, too many doors were left open—or even removed—to improve the rate of fire, and too many charges were out of their protective cases. During the battle of the Falklands the *Kent* was almost lost because of flash from a cordite fire. The lesson was clear but not appreciated; lessons are seldom learnt from victories. One may wonder if the division between DNO, responsible for turrets and DNC for the ship meant that neither looked at the interface.

German ammunition supply arrangements differed considerably between ships and even between turrets in the same ship[29], but there were few flash precautions. When the after barbette of *Seydlitz* was hit by a 13·5 inch shell at the Dogger Bank, red hot armour fragments ignited 11 inch charges in the working chamber and the flash spread up and down igniting a total of 62 complete charges. However, they burnt rather than exploding and the ship was not lost. As a result, the German navy limited the number of charges out of their cases but very little was done to improve flash resistance of the supply route.

The German charges themselves were much more resistant to flash than the British. The latter had the charges in two parts, each in a silk bag with a gunpowder igniter at each end. The Germans had an igniter at one end only of the main charge enclosed in a brass cartridge case. The fore charge, in a silk bag, had no igniter. More important, the German charge contained RPC 12, the first solventless propellant which was stabilized and far less likely to detonate than the old material. The British MD was much more sensitive and made worse by poor quality control[29, 31, 32, 33].

The three British battle cruisers were lost due to magazine explosions and it is not possible to say how the explosion was initiated. Of the British ships which survived, seven turrets or barbettes were hit and, whilst all hits holed or displaced the armour, only in two cases did the shell penetrate and in one of these it did not burst.

There were 11 similar hits on German turrets and barbettes, of which two penetrated and burst (*Derflinger*), causing serious propellant fires. Two other hits caused fires but the magazine did not blow up. Campbell notes that, had the Germans used British cordite, *Derflinger* and probably *Seydlitz* and *von der Tann* would have been lost.

Flash precautions in the supply of charges to the secondary armament were even worse e.g. in *Barham* and *Defence*.

Remedial Actions and Trials

Within days of the Fleet returning to port after Jutland, sketches were issued by Whale Island of temporary measures to prevent the spread of flash. By the spring of 1917 a great deal had been done by the use of fearnought and leather screens, better working practices and the construction of handing room for the supply of cordite to secondary batteries. The 'obsolete' leather 'Clarkson' case was reintroduced to carry cordite to secondary armament. It was decided that a trial was needed to test the measures and a series of tests was carried out using the fore turret of the old battleship *Vengeance*. This turret was quite similar in design to the latest versions and was given all the post-Jutland modifications. The first series, in August 1917, showed that the improvements had been very successful, resisting the flash from two full charges in the handing room. Later that month, tests with 15 inch full charges showed that the doors were weak and could distort allowing flash to pass. A further trial, using *Prince of Wales*, in July 1919 showed that this problem, too, had been overcome (FIG. 2). Concurrent trials at Whale Island had concentrated on the design of a flash-tight scuttle which would allow ammunition to be supplied rapidly without opening doors. Whale Island tests showed the danger of bare charges being ignited by the burning of a neighbouring charge, particularly if the igniter was exposed. It was also found molten lead dropping from the insulation of electric cables could could ignite charges and such cables were removed from magazines.

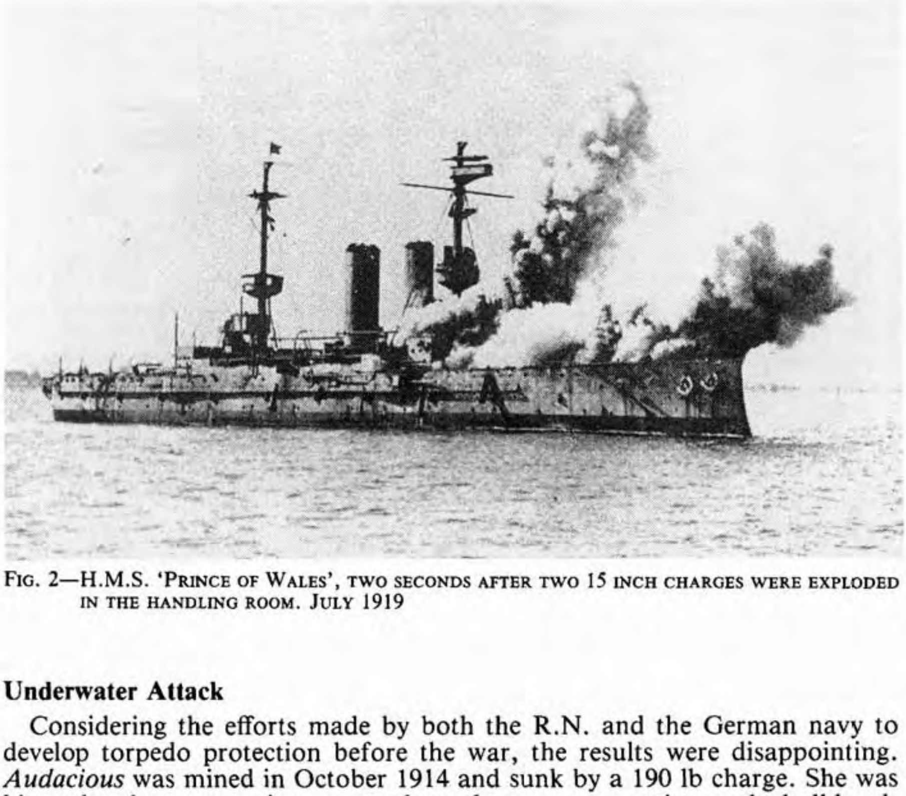

FIG. 2—H.M.S. 'PRINCE OF WALES', TWO SECONDS AFTER TWO 15 INCH CHARGES WERE EXPLODED IN THE HANDLING ROOM. JULY 1919

Underwater Attack

Considering the efforts made by both the R.N. and the German navy to develop torpedo protection before the war, the results were disappointing. *Audacious* was mined in October 1914 and sunk by a 190 lb charge. She was hit under the port engine room where there was no anti-torpedo bulkhead, 5 to 10 ft forward of its after bulkhead, and listed 10–15° at once. The immediate flooding to the port engine room should not have endangered the ship but flooding spread to the centre engine room and to most spaces aft. Doors and hatches were not properly closed, there were small holes in 'watertight' bulkheads, particularly at glands and broken soil pipes and from damage to the bulkhead-shell boundary. The fittings to enable the main circulating pumps to be used as bilge suctions did not fit. When the quarter deck went under, the accomodation ladder carried away and broke the watertight tops of ventilators[30]. *Inflexible* was mined in the Dardanelles in March 1915 and was left in a dangerous state by a 190 lb charge.

At Jutland *Marlborough* was hit by a torpedo at a point 25 ft below the waterline just forward of the forward boiler room, leaving a hole 28 ft long and distorting structure over a length of 70 ft. It is likely that the torpedo was from *Wiesbaden* and was a G7** with a warhead of 400 lb of Hexanite.

There was a protective bulkhead but it failed to prevent flooding of the forward boiler room and the diesel generator room. However, the ship was able to remain in action at 17 knots for some six hours. There were difficulties on the return journey due to blocked pumps but, by and large, this incident was a success[30]. *Lützow's* damage was caused by shells but she sank from uncontrolled flooding. The vast underwater torpedo flat flooded through a leaky emergency hatch; this lead to a bow trim which brought other shell holes below the waterline and flooding spread through voice pipes and ventilation trunks, many of which did not have bulkhead valves. Her problems were compounded by the destruction of power cables above the armour deck[29].

Seydlitz had somewhat similar problems, exacerbated by a torpedo hit. Leakage through voice pipes and ventilation and even pump drains caused flooding to spread. It seems certain that she would have sunk had she had to cross the North Sea to return to base.

Wartime Changes

Director firing was completed for the main armament of all capital ships and then extended to the secondary armament. Cruisers were fitted in 1917–18. The Henderson gyro equipment was fitted in 1917 to ensure that guns only fired when the ship was at zero angle of roll. Improved Dreyer tables, for longer range, were fitted. A few ships received anti-torpedo bulges, whilst all had anti-aircraft guns, searchlights, paravanes and longer base rangefinders. Most conspicuous of these changes was the fitting of platforms for the launching of aircraft (discussed later).

After Jutland, some attempt was made to improve deck protection mainly by fitting one inch thick plates on top of the middle deck and extra gratings in the uptakes. New and much more effective shells reached the fleet by 1918 which would penetrate, even at oblique impact, and explode inside.

Battleships

There were no new battleship designs built during the war. The 1915 design were variants on the *Queen Elizabeth*, with higher speed, thinner armour and, in some variants, 18 inch (458 mm) guns. The last two ships of the REVENGE Class were redesigned as battlecruisers, carrying thin armour to the extreme, with a 6 inch belt, high speed and 6 to 15 inch (380 mm) guns. The *Repulse* was a success only in respect of time for design and build[21]:

Design started	19 December 1914
Build started	12 January 1915
Trials	15 August 1916

Further developments were planned with either eight 13·5 inch or eight 15 inch guns. It would seem that these studies merged with the fast battleship to give the *Hood* design. A feature of all these designs was the sloping armour belt devised by Attwood to reduce the chance of penetration. Two very large 'light cruisers' with four 15 inch guns were completed and a similar ship with two 18 inch guns was converted into an aircraft carrier.

Cruisers

Though it can be argued that the pre-war light cruiser such as *Arethusa* was already a very good design, there was much scope for improvement. Most important was the shift to an all 6 inch (150 mm) armament in both existing and new ships, with numbers increasing from four to seven mounts. The 100 lb shell was so much more effective than the 31 lb 4 inch. Director firing was also introduced[22].

Other than in the E class, speed in calm water remained at just under 30 knots. Seakeeping was improved by the trawler bow in the later C and D Class ships giving additional freeboard and a knuckle, a feature further developed in the E Class[34].

The light cruiser had too little endurance for oceanic trade protection and a bigger class, CAVENDISH, was introduced. This class had a relatively high freeboard and a bigger 7·5 inch (188 mm) gun firing a 200 lb shell. Hand loading of such a big shell was an undesirable feature.

The resistance of smaller ships to shell fire was outstanding. Campbell[29] estimates that *Wiesbaden* was hit by 15 heavy shells, six 9·2 or 7·5 inch and a number of 6 inch and 4 inch plus a torpedo hit aft. However she was immobilized by the very first hit which put both engine rooms out of action and started a fire. *Southampton* was hit by one 11 inch, two 5·9 inch and about eighteen 4·1 inch which caused heavy casualties to gun crews but left her fit to fight. *Chester* was hit by about seventeen 5·9 inch which caused a slight loss of speed and two guns out of action. Again, casualties amongst gun crews were heavy. *Dublin, Dartmouth* and *Penelope* all survived torpedo hits. *Falmouth* hit by four torpedoes nearly reached port, whilst *Nottingham* with three hits, flooded from the bow to the middle boiler room but remained afloat for several hours.

Destroyers

The pre-war M class was judged to be a very satisfactory design and 103 were built, together with 131 variants of the R and S Classes. Flotilla leaders, a little bigger and better armed, also proved their value and were built in moderate numbers.

The R Class destroyers proved considerably faster than the early leaders and the DNC destroyer section under Hannaford designed the V leader with four 4 inch guns superimposed fore and aft. Freeboard was increased and the bridge placed further aft, making their seakeeping very good by the standards of the day. As a result of fears that the Germans were building large numbers of big destroyers, it was decided to build more Vs as destroyers, followed by the Ws which, in modified form, introduced the 4·7 inch Mk. 4s with a 50 lb shell. Even bigger leaders followed.

Two destroyers were given a 6 inch gun on the forcastle which was unsuccessful and soon removed. The accelerations on these small ships were too great to handle a 100 lb shell and to elevate and train the gun effectivley[34].

TABLE III—*Destroyer seakeeping characteristics*

Class	*L* ft	*f/L*	$1\cdot 1/\sqrt{L}$	*Bridge abaft Bow/L*
V and W, RN	309	0·063	0·062	0·27
B98, German	321·5	0·065	0·061	0·26
DECATUR, U.S.N.	314	0·049	0·062	0·24
MASTIFF, R.N.	270	0·062	0·067	0·23

f: freeboard
L: length

Seakeeping of destroyers was largely a function of length, freeboard and the distance from bridge to bow. It is suggested[34] that freeboard ratio (f/L) should be given by $1\cdot 1/\sqrt{L}$ (imperial units). TABLE III shows a comparison of wartime designs. Despite these figures, B98 was seen as wet compared with the Vs and Ws by a British officer after the war. This was probably due to the low bridge and short forecastle of the German ship[35].

Considering the large numbers of destroyers in service—and very hazardous service too—losses were not heavy[30] (see TABLE IV). FIGS. 3 and 4 show how some damage was overcome.

TABLE IV—*R.N. destroyer losses in World War I*

Sunk in action by gunfire or torpedo	25
Mined	21
Lost in collision	13
Wrecked	8
Total	67

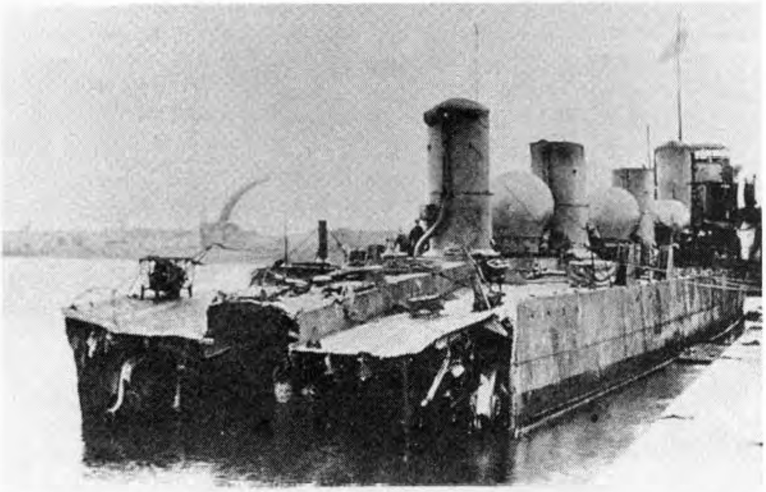

FIG. 3—THE BOWS OF 'ZULU' (SEEN HERE) WERE JOINED TO THE STERN OF 'NUBIAN' TO FORM H.M.S. 'ZUBIAN', WHICH LATER SANK A U-BOAT

AIR POWER IN THE SEA WAR

Aircraft Carriers

On the outbreak of war *Hermes* was recommissioned but soon lost. Three cross-channel steamers were converted similarly with two canvas hangars for seaplanes. It was these simple ships which launched the first air strike from the sea against Heligoland in December 1914. The old liner *Campania* was taken over and given a slightly more elaborate conversion to work with the Grand Fleet, carrying 10 seaplanes. She was on the slow side, at 18 knots, but showed the value of aircraft to the fleet[27].

Ark Royal had been commissioned and went to the Dardanelles together with the converted Isle of Man steamer *Ben-My-Chree* which launched the first successful torpedo bomb attack. In March 1917 it was decided to remove the forward 18 inch turret from the cruiser *Furious* and fit a ramp and hangar for six seaplanes and four fighters. During her trials, in August 1917, Squadron-Leader Dunning made the first landing on a moving ship but was killed a few days later attempting another landing. It was then decided to remove the after turret and fit a landing deck 300ft long with a further hangar beneath. This deck was not a success as the air flow was too disturbed by the mast and funnel and, of 12 landings, there were 9 crashes. However *Furious* did launch a strike against Tondern, which destroyed two airships.

The pace of development was further hastened by a plan devised in December 1916 by Commodore Sueter and forwarded in 1917 by Admiral Beatty. This plan was to attack the German fleet at anchor with 121 torpedo bombers launched from eight aircraft carriers. It was over ambitious for its day but the Admiralty response was to build four new carriers, two big and two small. Shipyard capacity was already over-committed and all but one of the new programmes had to be in the form of conversions.

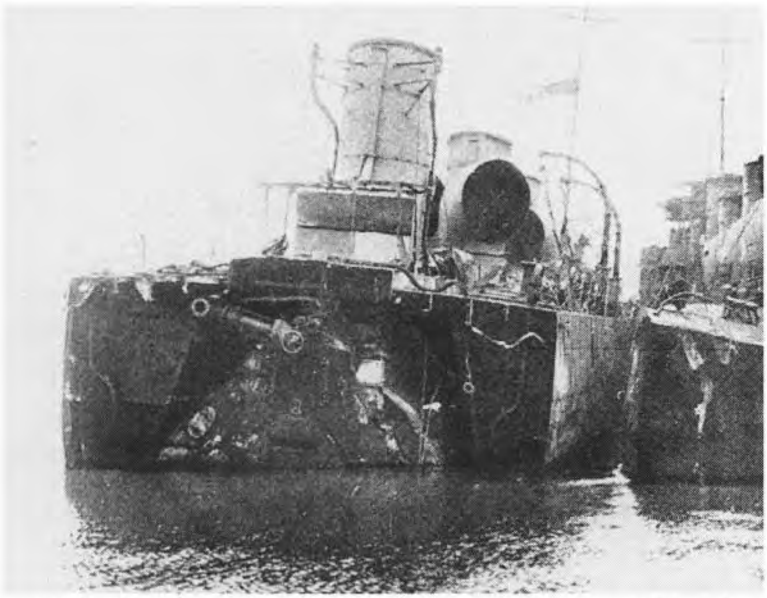

FIG. 4—THE STERN HALF OF 'NUBIAN', BEFORE INCORPORATION IN 'ZUBIAN'

The starting point was a very clever design of Beardmore's (possibly inspired by Sueter) in 1912 for a carrier with an island superstructure each side amidships, joined by a bridge. The liner *Conte Rosso*, building at Beardmore's, was requisitioned in 1916 and was first intended to be a seaplane carrier but it was soon decided to complete her on the line of the 1912 design. Wind tunnel tests showed that air flow over this configuration was impossible and she was redesigned with a flush flight deck. She had all the features of a modern aircraft carrier with a spacious hanger, having doors at the aft end so that seaplanes could be lifted in and out. Great attention was paid to fire precautions following the loss of the seaplane carrier *Ben-My-Chree* in the Mediterranean[27]. The petrol stowage for 4000 two-gallon cans was separately ventilated and isolated from the rest of the ship by void spaces, and the lifts to the flight deck were interrupted by a flash barrier. Smoke from the boilers was carried to the stern by ducts below the flight deck. She completed in 1918 as H.M.S. *Argus* (FIG. 5), the only full aircraft carrier of World War I. Evolution was rapid and very soon after completion she was used for landing trials with a dummy (wood and canvas) island superstructure on the starboard side. Pilots liked the scheme and most subsequent carriers followed this style.

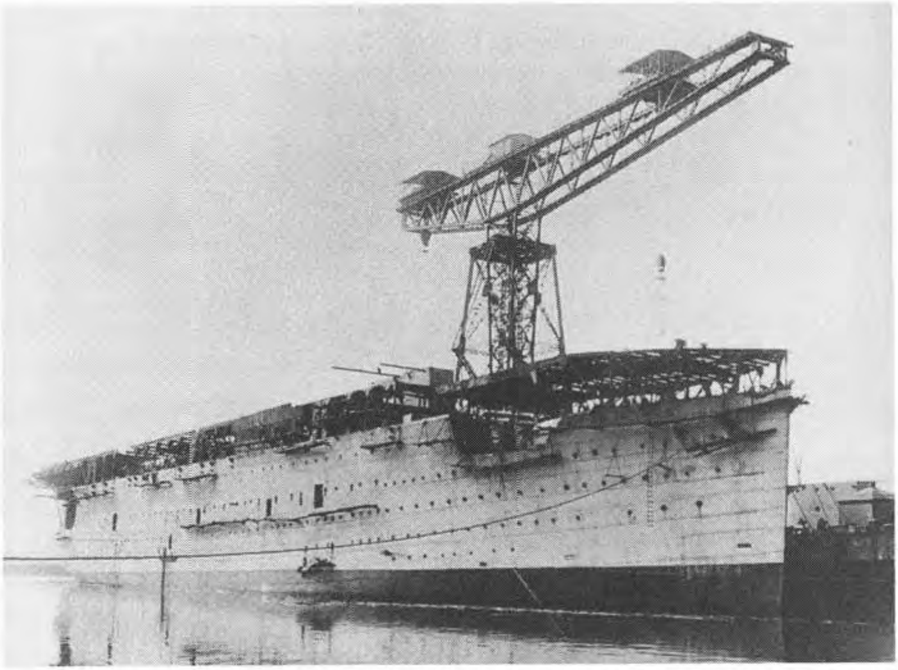

FIG. 5—H.M.S. 'ARGUS' BUILDING AT BEARDMORE'S. THE STARBOARD ISLAND IS IN POSITION; THE PORT ISLAND IS ON THE QUAY. AN EARLY EXAMPLE OF PREFABRICATION

The only new ship from the 1917 programme was *Hermes*. Originally she too followed the 1912 plan but was successively altered, completing after the war with an island superstructure. The Chilean battleship *Almirante Latorre*, building in the U.K., was requisitioned and converted into the carrier *Eagle* with similar design changes to *Hermes*.

The Royal Navy was the only navy to build and operate aircraft carriers in World War 1. This simple fact must go far to contradict the widely held view that all admirals were reactionary. Particular credit must go to the naval pioneers, Sueter and Williamson, and to the naval constructors who designed these strange ships — J. H. Narbeth, C. J. W. Hopkins and W. A. D. Forbes.

Naval Aircraft in other Ships and Ashore

These were not the only achievements of the Royal Naval Air Service (R.N.A.S.). By the end of the war it was operating a very large force of land-based aircraft against submarines in Home Waters[36]—75 airships (mainly non-rigid), 190 land planes, 216 seaplanes and 85 large flying boats. The flying boats were amongst the largest aircraft in the world but were already being outperformed by smaller land planes (e.g. Kangaroo) which were half the weight and carried double the load.

In June 1917 experiments on the launching of aircraft took place on H.M.S. *Yarmouth*, using wheeled aeroplanes. A short platform on the forecastle was used initially but later revolving platforms were installed in some cruisers so that there was no need to head into wind. By the Autumn of 1917 *Repulse* had a flying-off platform on B turret (see also FIG. 6) and in March 1918 bigger platforms were tried which could launch a two-seater. These planes could fly ashore or land in the sea. The engine could usually be recovered[30, 37]

FIG. 6—H.M.S. 'IRON DUKE' LATE IN THE WAR, WITH AIRCRAFT, DIRECTORS, ETC.

By the end of the war the Grand Fleet ships carried 103 aircraft—battleships 66, battle-cruisers 17 and cruisers 20.

An even more ingenious scheme was to tow fast lighters carrying aircraft behind destroyers[30]. Initially, the lighters were intended to carry 'Large America' flying boats but some were modified to carry Camel fighters. One such, piloted by Tulley, was able to destroy a Zepplin. Other lighters were built as maintenance docks for flying boats.

Balloons

Yet another way of getting air power to sea was the use of kite balloons, initially for spotting fall of shot and later for submarine hunting. Five merchant ships were converted as kite balloon ships with hydrogen plant, etc. In addition a large number of other warships were fitted to operate kite balloons—18 battleships, 3 battle-cruisers, 7 cruisers, 65 sloops, 38 destroyers, 28 P boats and 12 other vessels, plus 11 U.S.N. ships. The Royal Navy was committed to air power as strike force, and for reconnaissance, fighting, spotting and, most of all, submarine hunting. On 1 April 1918, when the R.N.A.S. was incorporated into the new R.A.F., it owned 103 airships, 2000 aeroplanes, 650 seaplanes, 150 flying boats and 120 balloons. With 100 establishments and 55 000 men, the R.N.A.S. was far larger than any other naval air arm and bigger than almost all air forces.

SHIPBUILDING DURING THE WAR

Major Vessels

Even by 1916 45% of the British gross national product was devoted to defence and this rose to 51% later[4]. This was sufficient to pay for very large building programmes. The designs of major vessels was discussed in Part I and the numbers built are listed in TABLE V. German production, though less in surface vessels, was still impressive.

Many other categories of warship can only be described in outline (TABLE VI). The numbers of vessels concerned were very large indeed.

Battleships were built in the Royal Dockyards (Portsmouth and Devonport) and eight commercial shipyards. Two more Dockyards and four more commercial yards could build cruisers and there were 17 shipbuilders who had the skills required for destroyers. It is interesting that the great expansion in building of regular warships was handled by the established yards. The vast programme of sloops and minesweepers went to 35 yards, mainly small companies not involved in major warships, and few of which would survive the great slump between the wars. All these ships were designed by 125 members of the Royal Corps of Naval Constructors (+ 76 temporary officers) who also supervised their building[21].

TABLE V—*Major warships completed during the war*

	Number	
	British	*German*
Battleships and Battle-cruisers	18	7
Cruisers	39	15
Monitors & Coast Defence Ships	40	—
Destroyers	283	80
Submarines	146	333
Aircraft Carriers	8	—
Sloops, P & PC boats	187	—
	721	435

TABLE VI—*Minor and auxiliary British vessels completed during the war*

Patrol gun boats, whalers, trawlers, drifters	412
Minesweepers	99
River Gun Boats	28
Repair and Depot Ships	10
CMB	83
X lighters	225
Others	160
	1017

Sloops, Minesweepers, etc.

Immediately after the outbreak of war, it was realized that large numbers of small vessels would be needed for minesweeping and miscellaneous services. J. H. Narbeth produced a simple, single-screw design based on merchant ship practice—the ACACIA Class. The first two completed trials 17 weeks after order; altogether 72 generally similar vessels were built. Later, the emphasis turned more to anti-submarine warfare and a further 30 vessels were built with differing merchant ship profiles as a simple disguise. These were all seen as excellent vessels and many remained in service long after the war. Finally, a class known as the '24 Class' was built, intended as improved FLOWERS but generally found inferior, in part at least due to poor seakeeping (heavy rolling). The general design style was developed in the post-war fleet.

The P boats were a more adventurous design by A. W. Watson. They were small destroyers with a very low freeboard, it being intended that seas should wash over the upper deck, reducing motions, leaving a narrow superstructure, like a submarine fin, projecting clear of the sea. 44 were built, together with a further 20 partially disguised as merchant ships. The latter group, PC boats, had a higher freeboard and were seen as much better sea boats. Neither type was further developed; nor did they remain in service after the war except for experimental work. There were also 85 (reduced to 70) KIL Class patrol gunboats ordered in mid 1917 but not completed for war.

Many paddle steamers were taken up from trade and found to be very useful minesweepers. As a result, 32 specially designed paddle minesweepers were built and were generally successful, at least in calm seas. The HUNT Class (20 ships + 32 'improved') of twin screw minesweepers (FIG. 7) were outstanding ships, many serving in World War II.

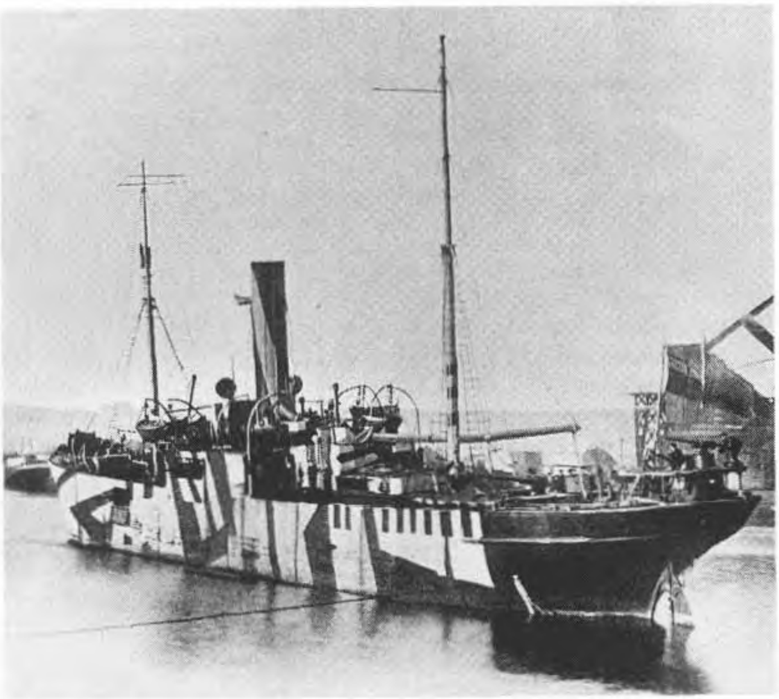

FIG. 7—'HUNT' CLASS MINESWEEPER, H.M.S. 'ACTON', CLEARED FOR ACTION

Coastal Warfare Vessels

Monitors

Operations off the Belgian coast in 1914 showed the need for special types of ship for coastal operations, a need reinforced by the Dardanelles campaign and the abortive plans for a Baltic landing. Three small monitors[38] building for Brazil were purchased in August 1914 and two Norwegian vessels were bought later.

A purchase of four twin 14 inch gun turrets from America led to the design, by Lillicrap, of the first purpose-built coastal bombardment vessels of the ABERCROMBIE Class. They were amongst the first ships fitted with 'bulge' anti-torpedo protection which, together with a very bluff form and undue haste in ordering the ship before tank tests of the model were complete, led to a speed of only 6 knots instead of the 10 hoped for. It is interesting to note that in the action when she was sank, *Lord Raglan* experienced an explosion in the gunhouse. The flash did not go below the floor of the gun well and the elaborate American flash precautions worked well. They were followed by eight similar vessels using 12 inch turrets out of the old pre-DREADNOUGHTS and by two pairs of ships with a twin 15 inch turret.

Fourteen smaller ships designed for a single 9·2 inch gun (234 mm) and five with a pair of 6 inch were also built. Bombardments by these ships achieved few physical results but had some effect on morale. The bigger ships can also be seen as 'capital ships' in controlling the narrow seas.

Gunboats

Twelve large gunboats (two 6 inch) were built for Danube operations and 12 smaller ships (one 4 inch) for the Tigris. To confuse, all were referred to as 'China gunboats' and they were based on pre-war designs for Chinese river gunboats.

Coastal Motor Boats

Fast motor boats, armed with torpedoes, were seen as important for coastal work[39]. Details of the three classes built are given in TABLE VII. The 40ft boats were suitable for carrying in cruiser davits; the 70 ft boats were designed for laying the new magnetic mines; whilst the bulk of the production—and the action—lay with the 55 ft boats. Successes were few, the most notable being a hit on one of four German destroyers at anchor. The end of the fast attack craft, in daylight at least, came on 11 August 1918. Six boats were caught by eight German seaplanes off Terschelling. At the cost of one seaplane, three boats were sunk, one beached and two interned.

TABLE VII—*World War I Coastal Motor Boats*

Length ft	*Displacement* tons	*Typical Speed** knots	*Armament*	*No. Built*
40	5	35	one 18″ torpedo	27
55	11	40	two 18″ torpedo	81
70	24	26–36	7 mines	5

*Varied considerably with engine fit.

Landing Craft

Perhaps the most successful, if least glamorous, were the 255 'X lighters', landing craft, used in the Dardanelles and elsewhere to carry all sorts of loads. Many lasted until after World War II.

Anti-Torpedo Bulges

D'Eyncourt suggested that a bulge or blister be added outside the hull to explode torpedoes at such a distance that blast and splinters could be absorbed with little or no damage to the main hull.

Several old cruisers were fitted with bulges and at least two successfully withstood torpedoes. The bigger monitors were also fitted and some withstood very large explosions. Only a few battleships were bulged during the war though most were fitted soon after. In this case the loss of speed was about 1 to 1½ knots. Certainly, against contemporary torpedoes, the bulge gave near certain protection at little penalty (FIGS. 8 and 9).

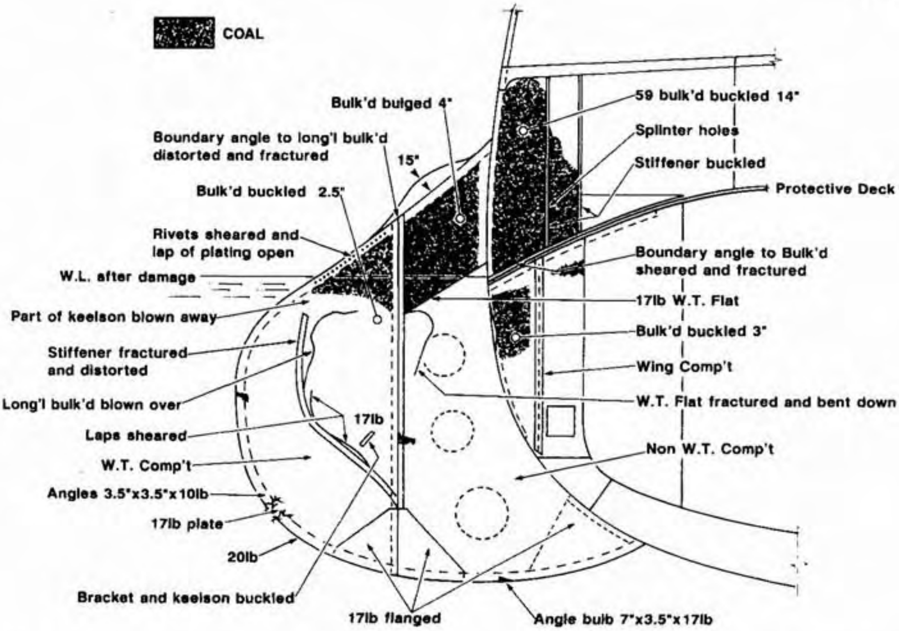

Fig. 8—Bulge on H.M.S. 'Edgar' after action damage. There were no leaks in the ship herself. The dark tone denotes coal

REVOLUTION MANQUÉ

When the war ended in 1918 the technological revolution was gaining speed and by 1919 war at sea would have been very different. Real aircraft carriers, able to use torpedo bombers to strike the German fleet in harbour would have been in service. Work was already starting on a radio-controlled 'cruise missile', known as the RAE 1921 target, which would have carried a 200 lb warhead. This was later developed into the Larynx with a 250 lb warhead and a range of 300 miles, launched from a destroyer during trials in 1927[40].

Anti-submarine warfare would have changed with the introduction of ASDIC (active sonar) but the use of passive hydrophones was also being extended[41]. In particluar, a great deal of attention was being given to 'silent propulsion'. Two trawlers were completed with internal pump jet propulsion, quiet but very inefficient[42, 43]. In 1917 trials were carried out using air bubbles to screen both machinery and propeller noise. The trial was not successful, due to the lack of a suitable air compressor. Both these developments were abandoned since it was thought that silent propulsion was not needed by ships with ASDIC. An acoustic mine was in prototype and the magnetic mine used successfully in service.

The multiple pompom was already conceived and would have been a most effective weapon in the twenties and thirties. Control of the big guns was improving as were their shells and, eventually, their propellant. Oxygen-enriched torpedoes were in development. By 1919, Portsmouth Dockyard had set out, and proved, rules for electric arc welding and the all-welded ship was seen as desirable—and not far off. Collaboration with the U.S.N. on welding was very active, Goodall taking a prominent part.

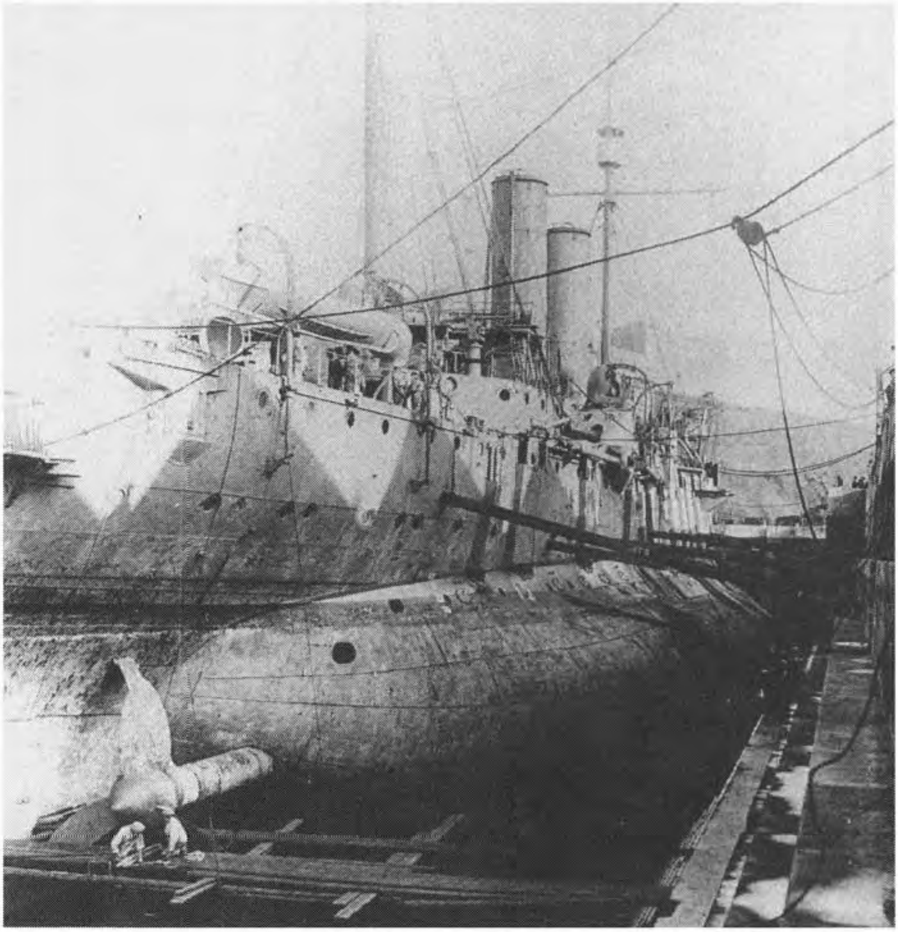

FIG. 9—H.M.S. 'EDGAR' STARBOARD BULGE

Battleships and battle-cruisers were still seen as separate types, the latter being bigger to get speed with only slight sacrifice in guns and armour[44]. Side armour was sloped, inside a modified bulge, and deck armour was greatly increased in thickness (up to 8 inches). The arrangement adopted was similar to that of *Nevada*.

Battle-Cruisers

At the end of World War I most major naval powers had battle-cruisers under construction or planned. Their ability to reinforce distant stations (Falklands), escape from superior forces (*Goeben*) and to act as a fast wing of the battle fleet (Dogger Bank, Jutland, etc.) justified continuation of the species. The original concept of *Invincible*, lightly armoured to keep size and cost to the same order as the battleship and the more extreme variants (*Repulse, Glorious*) were rejected by all except the U.S.A. (*Lexington*).

The losses of three British and one German ship of this type at Jutland as well as the near fatal mine damage to *Inflexible* and armour failure of *Lion* at Dogger Bank were seen as detail problems, serious but easily corrected.

The damage received by *Tiger* and *Lion* and by German ships at Jutland showed that the battle-cruisers could receive many heavy hits and still remain in action, even if somewhat degraded.

The later battle-cruisers were bigger than battleships, very fast (32 knots), and well armoured with at least eight guns, sometimes of smaller calibre than contemporary battleships. Such ships included G3 (R.N.), *Ersatz York* (Germany) and *Amagi* (Japan), but none were completed. To some extent, *Dunkirque* and *Scharnhörst* can be seen as evolving from this concept.

Only in the late thirties did improvements in machinery lead to the evolution of the true, fast battleship. The laws of hydrodynamics and economics prevented an even faster 'battle-cruiser'.

CONCLUSIONS

Though the anticipated 'big battle' to a finish did not occur it does not seem to have been an unreasonable basis for planning. From this followed the concentration of effort on the battle fleet and mainly on the battleship, inevitably leading to a shortage of small vessels.

The capital ship performed well, in general. The percentage of hits scored may seem disappointing but in the light of the visibility and ranges at Jutland it is not unreasonable. Ships stood up well to damage, *provided* that their magazines did not blow up. Hindsight suggests that armour decks should have been considerably thicker (say 3 inches) in order to keep out large splinters even at fighting ranges of 10 000 yards.

Cruisers and destroyers of both main navies were successful but British ships had a distinct edge in seakeeping, and generally had more advanced machinery. The British destroyers, with an emphasis on guns rather than torpedoes, actually proved a better torpedo launching vehicle than the German, and were better sea boats.

The production capability of British industry enabled the shortage of small craft to be made good quickly even against the outstanding German production of U-boats.

Technical development was rapid and still gathering speed when the armistice put an end to many of the better schemes.

Acknowledgements

Much of the material on guns and armour is derived from both published and unpublished material from John Campbell, to whom I am most grateful. I am also grateful for many interesting ideas from Jon Sumida.

References

1–28. The first 28 references relate primarily to part I of this article, though they are occasionally cited here also. They are to be found in the June 1989 issue of the *Journal of Naval Engineering*, vol. 31, no. 3, pp. 669–670.

29. Campbell, N.J.M.: *Jutland—an analysis of the fighting*; London, Conway Maritime Press, 1986. This book has been amplified in correspondence with the author.
30. Records of Naval Construction during the war 1914–1918, DNC Department, London, 1918. (copy held in the Naval Library, London).
31. Campbell, N.J.M., Cordite; *Warship* (6), April 1978.
32. Dale, G. F.: Stability of nitro-cellulose based powder; *Warship International* (4) 1980.
33. Bowditch, M. R.: *Cordite-Poole*; Holton Heath, Ministry of Defence, 1983.
34. Brown, D. K.: *Sustained speed at sea in the RN*; Newcastle, North East Coast Institution, Centenary Publication NEC 100, 1984.
35. Preston, A: *V&W class destroyers 1917–1945*; London, Macdonald, 1971.
36. Price, A.: *Aircraft versus submarines*; London, Jane's, 1980.
37. Nailer, R.: Flying off platforms; *Warships Supplement* (86), (87), (88), World Ship Society, Kendal, 1986–7.

38. Buxton, I.: *Big gun monitors*; Tynemouth, World Ship Society—Trident Books, 1978.
39. *A short history of the Thornycroft coastal motor boats*; London, published by the Company, 1918.
40. Layman, R. D.: Catapults; *Warship International* (3) 1970.
41. Hackmann, W.: *Seek and strike: sonar and the Royal Navy 1914–1952*; London, H.M.S.O., 1984.
42. Brown, D. K.: Jet propulsion in the RN; *Marine Propulsion*, March 1980, pp. 48–49.
43. Brown, D. K.: Silent propulsion 1917–1919; *Journal of Naval Engineering*, vol. 30, no. 2, June 1987, pp. 423–425.
44. Campbell, N. J. M.: Washington's cherry trees; *Warship* (1), (2), (3) and (4), 1977.

Other Souces

I have also used the annual statements in the Navy Estimates and *Germany—war vessels*, an Admiralty report (CB 1087) held in the Naval Library. My thanks are due to J. D. Brown for this material.