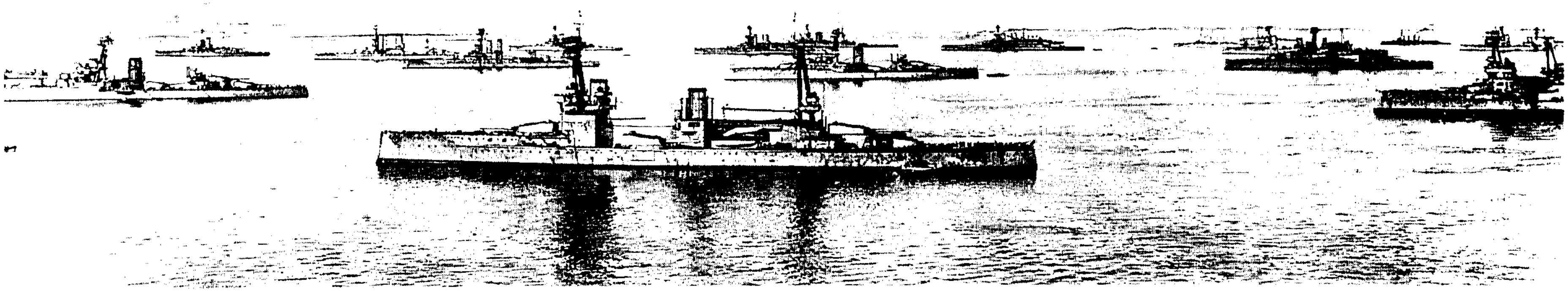

Fig. 1—The Grand Fleet at Scapa Flow, 1917

Royal Sovereign, Canada, Royal Oak, Erin, Iron Duke, Glorious, Birkenhead, Marlborough, Town class cruisers, Active, Australia, New Zealand, Orion, Monarch, Thunderer, Neptune, St. Vincent

# THE SURFACE FLEETS OF WORLD WAR I

## PART I—PREPARATION FOR WAR

BY

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*This article is based on a paper presented by the author at the Colloque International Marine et Technique at Paris in November 1988.*

ABSTRACT

The article describes and reviews the achievements of naval architects, marine engineers and weapon designers, before and during World War I. The resources available are listed and the preparations made before the war are discussed. The lessons learned during the war and the changes made to the surface fleets will be considered in Part II, to be published in the December 1989 issue of the *Journal*, and brief mention will be made of the revolutionary developments planned at the end of the war. It is clear that most problems were identified and solutions found.

### Introduction

The success of naval staffs and ship designers in developing the fleets which fought the 1914–1918 war can be judged from two viewpoints. Firstly, it may be asked if they used existing knowledge wisely in support of their perceived naval objectives and, secondly, if with hindsight either the aims or the means used could have been better.

To discuss the question 'What is a "good" design?' is not easy; the bigger question of what is a good fleet is even more difficult. These questions and their answers are seen very differently by different professions and at different times. The naval architect is correct, but limited, in the view that an economic and satisfactory response to a stated staff requirement is 'good'. The historian is liable to view the success of a design with hindsight, placing too much emphasis on the last years of its career, when the ship is obsolete, worn out and used for tasks very different from those for which it was designed.

The good design must show to advantage in operational effectiveness and minimum through-life cost of ownership based on appropriate technology in all disciplines. It should also be versatile in its capability when built and adaptable to new tasks during its life. To some extent, the same qualities must be displayed by a good fleet—effectiveness, economy and flexibility. In judging success, national objectives and the resources available must be considered.

In discussing the fleets of World War I, emphasis is placed on the navies of Britain and Germany which bore the brunt of the fighting at sea, but where appropriate, developments in other major navies such as France and the United States are outlined.

## AIMS

The Royal Navy had the traditional objectives of a sea command navy. Jellicoe[1] outlines such tasks succinctly:

- to secure the use of the seas for British ships and keeping them from the enemy;

- to bring economic pressure on the enemy country;
- to prevent invasion of the homeland.

To some extent, the potential to carry out these tasks was seen as a deterrent to war.

The aims of the French navy were similar but largely confined to the Mediterranean.

Germany's maritime objectives were less clear. Initially, Tirpitz intended to build a fleet of such a size that, though still inferior to the Royal Navy, it would pose such a threat, concentrated in the North Sea, that Britain's imperial ambitions would be constrained. There was a second duty; to keep the Baltic a German lake. It would seem possible that this second aim was overstated at times to reassure politicians both at home and abroad[2].

The potential threat of a large German navy combined with political rivalries led to studies on the effect of this threat and of evolving technology on British planning and strategy. In 1908–9 there was a re-appraisal of the traditional 'Two power Standard' under which the R.N. would have a 10% superiority over the two next largest fleets combined. The second naval power was now that of the U.S.A. and war with that country was unthinkable. A more realistic standard was seen as a Royal Navy about 60% bigger than the German Navy and this was finally agreed by Parliament in March 1912[3].

British planning slowly recognized the changing threat. In 1903 plans were approved to build a new dockyard at Rosyth but funding was limited and it was only usable to a very limited extent in the early years of the war. The threat of torpedo attack, particularly from the submarine was gradually recognized and the old close blockade dropped in favour of a more distant blockade, sealing the exits from the North Sea.

It seemed inevitable that conflict in the North Sea would, sooner or later, lead to one or more major battles. The German aim would be to defeat an isolated portion of the R.N., perhaps even attaining superiority over what remained. Both tradition and more recent history—e.g. the wars between Japan and China and then Russia, and the Spanish American war—appeared to confirm the inevitability of a big battle. Since battles were dominated by the battleship, a building race developed in such ships and the next section will show how the battle line absorbed a major part of the available resources.

## Geography

In wars of earlier centuries, British command of the sea ensured rapid and easy transport of armies to any point on the coasts of Europe (or even further afield) since sea transport was much faster than movement over the dreadful roads. The development of railway systems during the nineteenth century changed this situation, giving the Central Powers the advantage in rapid military movements on the European mainland.

The United Kingdom still possessed real geographical advantages. Sealing the exits from the North Sea not only stopped German trade but protected British merchant ships from attack. This policy left the east coast of England vulnerable to bombardment and even to the threat of invasion. Attempts to protect the coast brought the Grand Fleet into waters where it was at risk to attrition from torpedoes and mines. Rosyth was not in effective use until 1916 and the other dockyards were badly sited to support operations in the North Sea. Overseas, the Royal Navy had the advantage of a secure chain of bases and fuelling stations linked by both cable and wireless. German overseas stations were quickly eliminated by operations under the umbrella of the Royal Navy.

## RESOURCES

Sea power must always be based on economic power. During the nineteenth century the United Kingdom became the leading European industrial power and just maintained that position until the outbreak of war[4]. Germany was, however, catching up fast; between 1898 and 1914 her industrial production rose by 85% compared with only 40% for the United Kingdom leaving the two powers level. In the vital aspect of steel production, Germany already produced more than twice as much as Britain (17 million tons). The United Kingdom retained a big advantage in shipbuilding industries.

During the critical period 1908–10 British defence budgets were crucially affected by the policy of successive governments (Fig. 2). In 1908 tax revenue fell as a result of an economic slump whilst the following year, it was no longer possible to make savings in naval expenditure by further reductions in stores holdings[3]. The 1909 budget introduced major improvements in social security benefits but despite this, naval spending increased, due to a sympathetic approach by the prime minister and a clever taxation policy as well as the reaction to a growing threat.

In the early years of the century, the U.K. was spending more on the services than was Germany but this position reversed later. However, a much larger proportion of the German budget was spent on the army and the R.N. was consistently able to outbuild the German navy. Fig. 3 shows the sums devoted by the two navies to new construction. Such figures give only a rough guide since the detailed content differs.


Fig. 2—Total defence budgets, 1906–1914

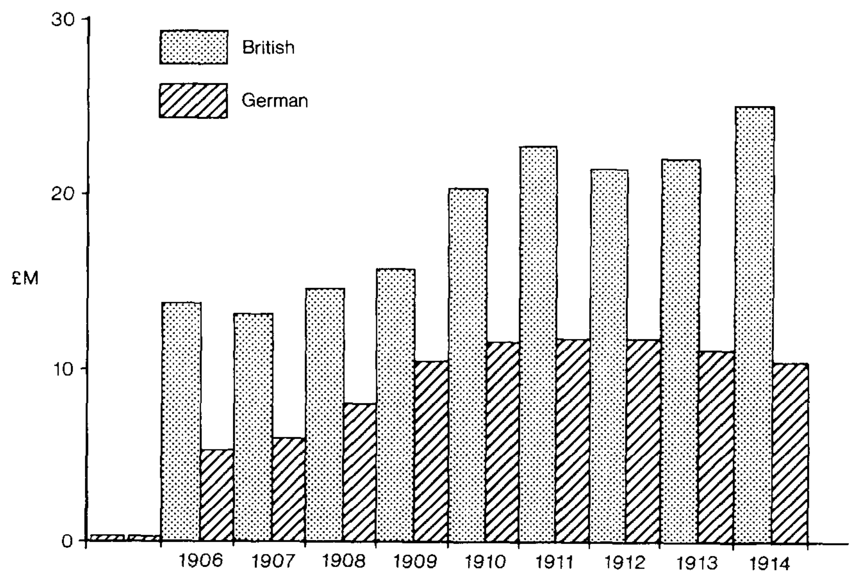
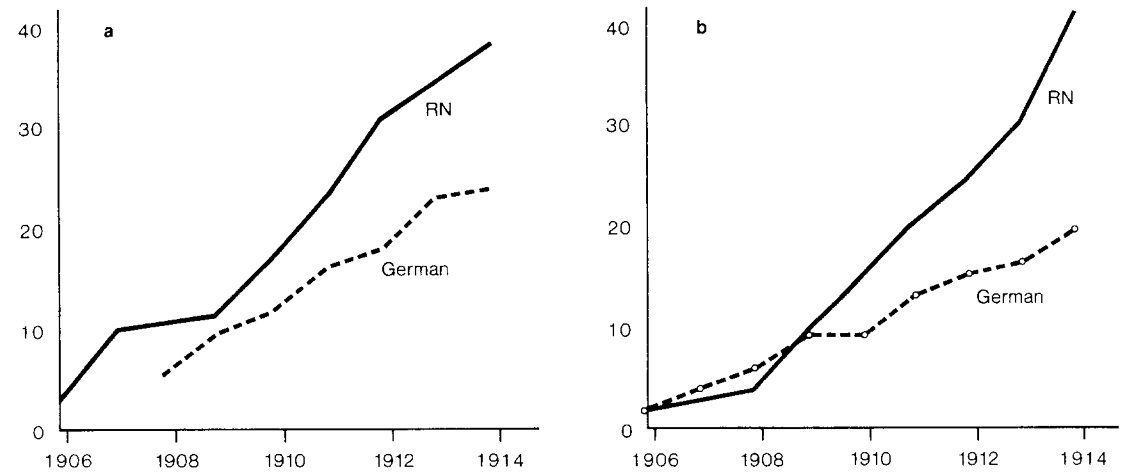



Fig. 3—New construction estimates for Royal Navy and German Navy, 1806–1914 (based on information in Appendices I and II)



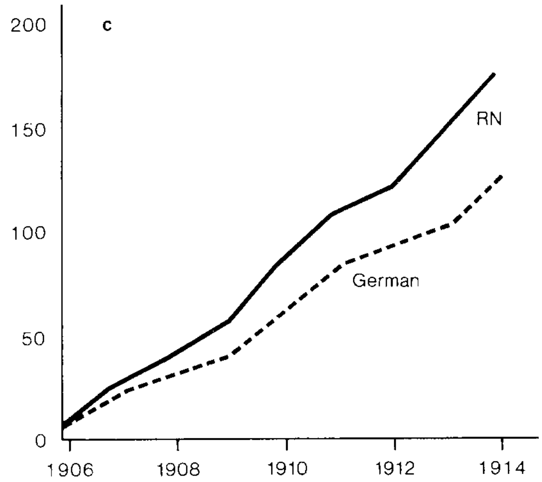




FIG. 4—CUMULATIVE SHIP TOTALS
a. CAPITAL SHIPS
b. CRUISERS
c. DESTROYERS

The number of fighting ships in the major categories launched in each year from 1906 to the end of 1914 is given in Appendix III and is illustrated in FIG. 4.

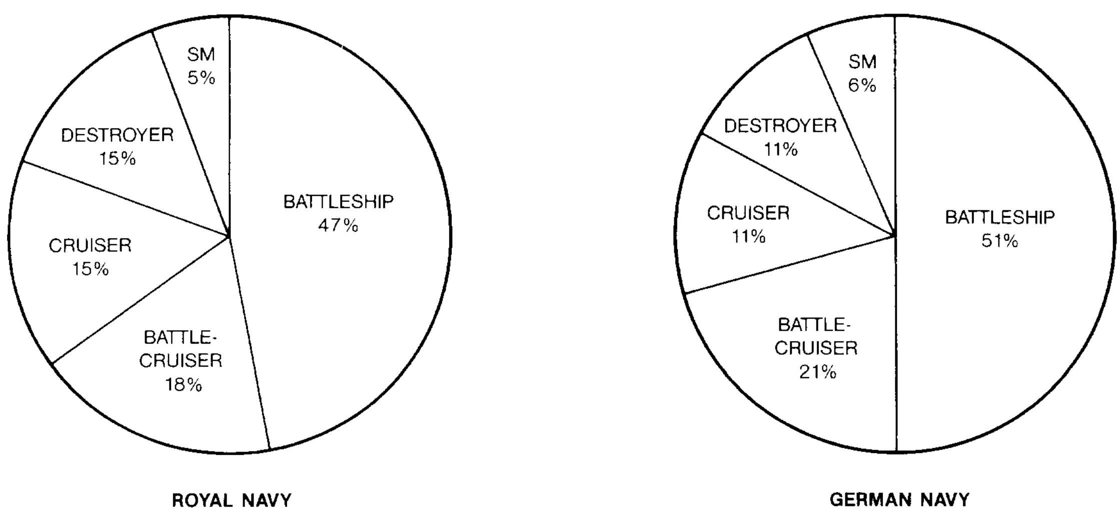



FIG. 5—PROPORTIONS OF NAVAL SPEND BY CATEGORY, 1906–1914

In FIG. 5 the approximate breakdown, between categories, of the new construction budget is shown for the U.K. and Germany. The proportions differed slightly, with Britain spending 65% on capital ships against the German 72% share, with corresponding differences in smaller craft. Neither country was spending very much on submarines though in both the building rate and the individual size was increasing rapidly.

It would seem that Germany built all the capital ships which it could afford (see Appendix IV). Resources were limited not only financially but also by the rate of production of big guns at Krupps. Britain's response in capital ships (close to the ratio of 1·6:1), absorbed so much of her resources that little was left for trade protection, minesweeping, etc. If more had been spent on such tasks, there would have been fewer battleships.

## PREPARATIONS FOR WAR

To win the expected great battle it was necessary to find and catch the enemy, to hit and go on hitting and to hit hard whilst withstanding the impact of the enemy's fire. In the years leading up to war all these aspects of battle were radically affected by a series of technical revolutions. Elaborate trials of new equipments by all navies ensured that they were generally well developed and that their operational consequences were understood.

### Communications

Finding the enemy was greatly aided by the invention of radio. From the Crimean War onwards, cable telegraph had greatly aided the transmission of information about the position of both hostile and friendly fleets and of orders to meet the situation. Cable messages affected only strategic moves: radio (wireless) further improved strategic control but affected tactics even more.

Wireless had been tried in warships before the 20th century started and was first used operationally at sea during the South African war in 1900. The Russo-Japanese war saw much more extensive use. Thanks to the combination of Marconi and Captain Jackson the R.N. kept in the van of progress and by 1905 all ships above destroyer size had been fitted with wireless. Only a year later there were replaced with more effective sets and in 1907 modern destroyers were also so fitted[5,6].

The U.S.N. had equipment as good, or better, than the R.N., but the R.N. had more effective discipline in communicating. Most navies had tried jamming but without a great deal of success. Long range, shore-based stations provided links independent of cables. The Germans put a great deal of effort into such a network but all their stations were quickly captured or destroyed when war broke out.

### Catching

To catch a fleeing enemy it is necessary to be able to steam faster than the enemy for a considerable period of time. The R.N. under the Engineer-in-Chief (Durston), had seized on Parsons's steam turbine with enthusiasm. Tested and proved, first in destroyers, then in cruisers, the turbine entered the battle line in *Dreadnought*. Indeed the combination of power with light weight given by the turbine was the main factor which permitted her powerful armament to be mounted in a ship still of moderate size. *Dreadnought* was the culmination of evolutionary trends in gunnery, machinery and hull design as well as the prototype for all the capital ships of the coming war. The developed turbine was much more reliable than the reciprocating engine, plagued with vibration and lubrication problems, and could sustain high speed for much longer periods.

Other navies were behind the R.N. in introducing turbines to the battle fleet and fell further behind in the quest for sustained speed when the R.N. went to oil fuel in the QUEEN ELIZABETH Class. There were then few problems with boilers choking on clinker and ash and refuelling was quick and did not tire the crew as did coaling.

In machinery, the R.N. only fell behind in its choice of boilers having made a conservative choice in favour of large tube designs, the Schultz-Thornycroft design used by the Germans being as reliable, but smaller and lighter. Tactically, the R.N. seems to have given too little thought to the successful pursuit of an inferior force of the enemy.

**Hitting**

There was a series of revolutions in gunnery which greatly increased the effective range at which battles were fought. Even so, 'long range' was usually interpreted as about 10000 yards until just before the war. The effects of rapidly changing range and bearing were explored but solutions were not in service in 1914.

*Target Practice*

At the end of the 19th century, British target practice took place against a stationary target, at a range of about 1500 yards, and even so, only 30–40% hits were achieved. Using simple training aids to rapid loading and gun laying (continuous aim), Percy Scott achieved 80% hits in 1899. The main value was psychological, competition between ships was keen and reported in the press, whilst captains saw that good gunnery was an essential step to promotion. By 1899–1900 the Mediterranean Fleet under Hopkins and Fisher was carrying out experimental firings at 6000 yards. Similar progress was made in the U.S.N. under Fiske.

*Battle Practice*

The unreal conditions of target practice were changed in 1905 with range increased to 5000–6000 yards, though still against stationary targets. In 1908 the range increased to 8000 yards and heavy guns were scoring some 0·8 hits per gun per minute against targets moving on a parallel course. Many problems were already apparent. As the range increased, the shell ceased to travel horizontally and the gun elevation had to be matched precisely to the range, itself difficult to measure and varying even during the time of flight of the shell. The R.N. introduced Barr & Stroud rangefinders in 1900 with a 4ft 6in (1·5 metre) base length, using the coincidence principle. By the outbreak of war, the R.N. and most other navies were using similar rangefinders with a base length of 9ft (3m) (15ft in the very latest ships). The German navy used stereoscopic rangefinders with a base line of 10ft which required unusually good eyesight to operate, but seem to have been good at getting an accurate first estimate of range[7], perhaps because more frequent readings could be taken leading to a subjective estimate of rate of change.

*Fire Control*

The first aid to estimating changes of range and bearing was the Dumaresq, introduced into the R.N. in 1902. Given the ship's own speed and course and the enemy bearing, together with estimates of enemy course and speed, it would generate estimated rate of change of range and bearing. By firing salvoes and spotting the fall of shot, errors in estimating range and its rate of change could be corrected. Such observations were an important part of gunnery control and the fact that *Dreadnought*'s mast and spotting top were placed abaft the funnel for ease in boat handling (and hence obscured by smoke) on the advice of the Director of Ordnance (Jellicoe) shows how little

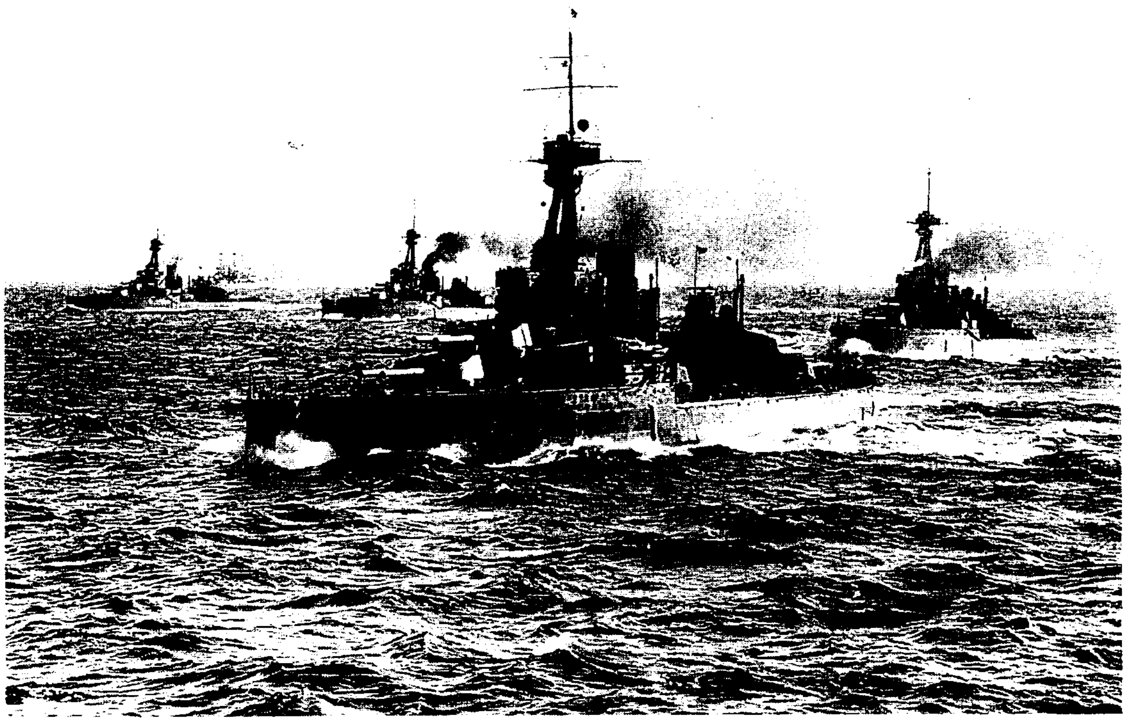


FIG. 6—AN 'ORION' CLASS BATTLESHIP AT SEA, SHOWING THE SPOTTING TOP LIABLE TO BE OBSCURED BY FUNNEL SMOKE

really long range firing was considered in the design of that ship. That the error was repeated in the ORION (FIG. 6) and LION Classes, designed in 1909, shows how long it took for the consequences of the gunnery revolution to be appreciated in the Ordance Department.

A more elaborate fire control system, by Pollen, was tried first in *Jupiter* in 1905 and much improved in later years. His aim was to determine rate with precision. Pollen's instruments were ultimately rejected in 1913 in favour of a simpler system derived by Lieutenant Dreyer, R.N. a decision which is still a matter of controversy[3] though a few Pollen systems (Argo) were used in the Grand Fleet. After the war, Pollen was awarded the sum of £30 000 in recognition of the use of features of his work incorporated into the Dreyer table. However, even the Dreyer system of gunnery control was well ahead of anything available in other navies and could give the R.N. an advantage in a prolonged exchange of fire.

*Tsushima*

The battle of Tsushima, in September 1905, generated considerable confusion due to misreading of the lessons. It was argued that the 'long range' phase (about 7000 metres), in which the Russians did best, was ineffective and that the battle was won at close range. The lesson which should have been read—and was in the R.N. and Japanese navies—was the need to hit at long range. It was even argued, wrongly, that closely grouped salvoes might all miss and that a scattering of shells had more chance. Not everyone realized the awesome effect of heavy shells compared with the almost trivial blows of the 'hail of fire' from smaller weapons. *Dreadnought* was given her uniform armament of 12 inch guns in recognition of their power to inflict concentrated damage at medium range and not, as is often stated, to improve gunnery control.

*Director Firing*

The use of even simple fire control instruments at long ranges suggested the need for control by a single sight, high above the smoke of the guns, and for the calibration of guns to give tightly bunched salvoes. Key trials were in 1907 when Scott fitted an extemporized director to the cruiser *Good Hope* and in 1912 when an improved version was fitted to the battleship *Thunderer* for comparative firing trials at 8500 yards in a moderate sea with the *Orion*, the champion gunnery ship. The results were dramatic, *Thunderer* got off 30 rounds in 3½ minutes of which 25 would have hit an enemy battleship (0·66 hits/gun/minute) whilst *Orion* in the same time could only get off 27 rounds for an estimated 5 hits (0·11 hits/gun/min). Progress in fitting directors was fairly rapid, with 8 ships fitted by August 1914, 24 (+14 monitors) by the end of 1915, and all but 2 capital ships by May 1916.

FIG. 7—H.M.S. 'EMPRESS OF INDIA' AS THE TARGET OF GUNNERY TRIALS, NOVEMBER 1913

*The Eve of War*

By 1913, the Royal Navy could score a devastating rate of hitting against targets on a fairly steady course at 10 000 metres or below as demonstrated by the destruction of the old battleship *Empress of India* in November (FIGS. 7,8 and 9) Perceptive officers were already seeing the need to hit at longer ranges and whilst manoeuvring at high speed. In the spring of 1913, Beatty carried out a battle-cruiser practice at 23 knots and 16 000 metres range. The 9ft rangefinders gave only a marginal performance at that range and hits were few. On the other hand the R.N. had achieved a significant advantage in long range firing. They had concentrated on big guns, firing a heavy shell at moderate velocity, and these projectiles proved to be more accurate at longer range than the smaller, high velocity shells of German guns. It would also seem that the British weapons were very much cheaper and quicker to build than the over-sophisticated German guns.

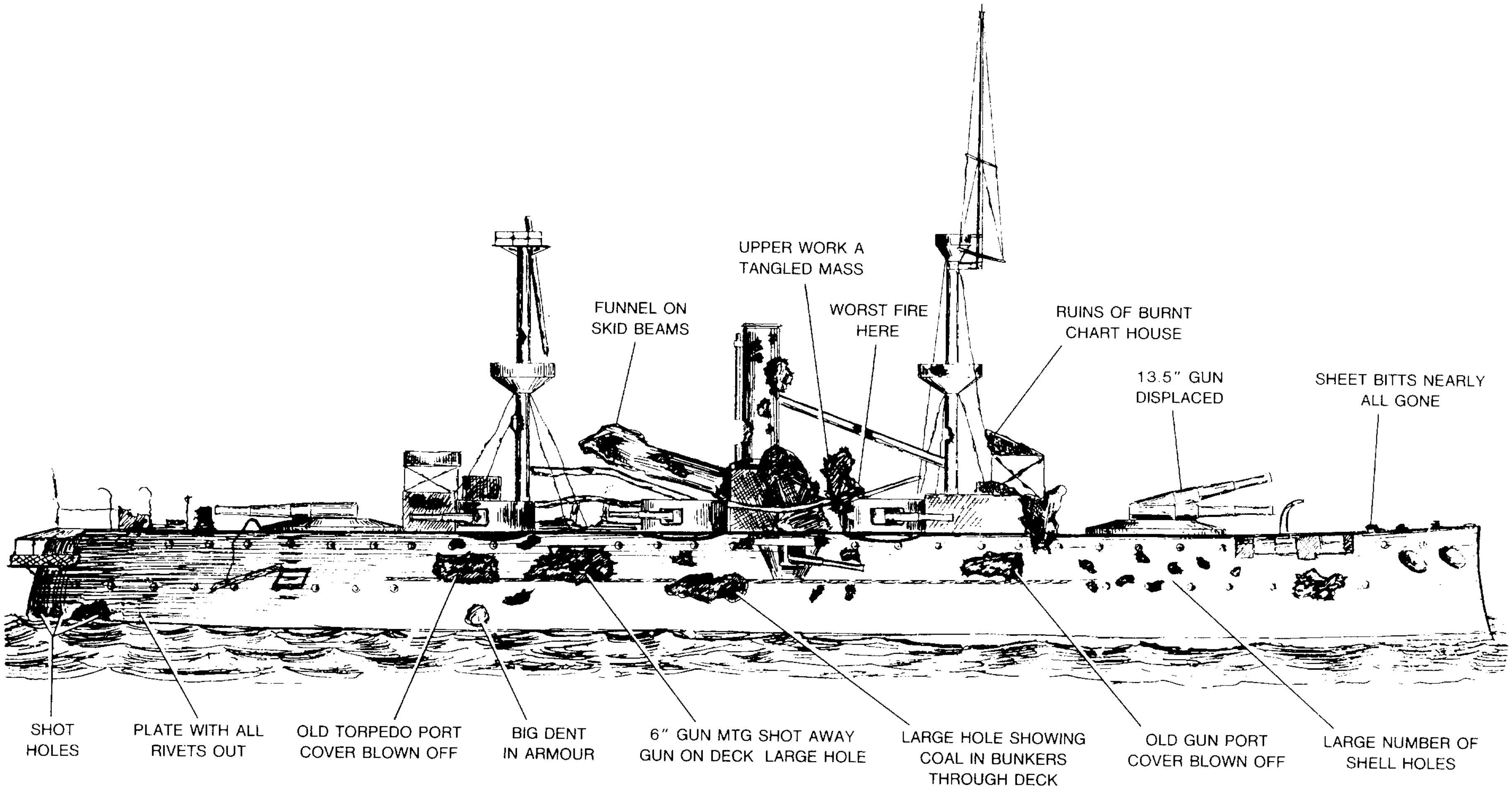



FIG. 8—H.M.S. 'EMPRESS OF INDIA': DAMAGE TO STARBOARD SIDE AFTER GUNNERY TRIALS

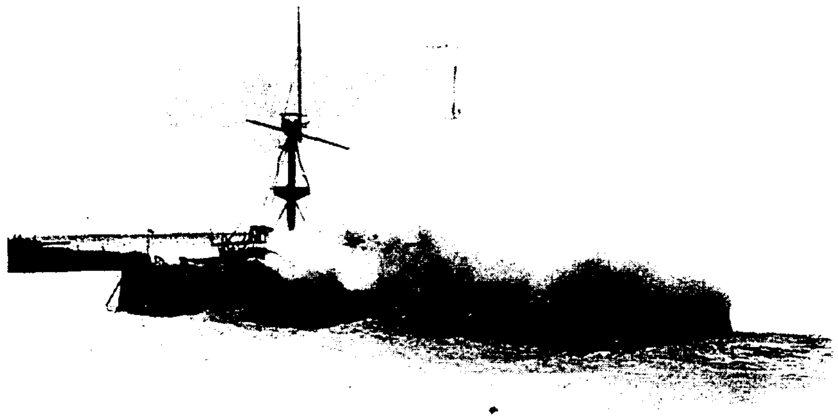


FIG. 9—'EMPRESS OF INDIA' TRIALS, NOVEMBER 1913

## Armour

Developments in armour steel were tried at shore ranges but the arrangement of armour and the effect of big shells could only be tested on ships. Most navies carried out such trials, the target ships sometimes being modified considerably. Between 1900 and the outbreak of war, the R.N. carried out at least a dozen such trials[8,9].

An early, 1900, trial was that against the *Belleisle* which was intended to study the risk of fire from wooden decks and fittings, to observe the effect of large shells and to develop damage control procedures. The effect of 12 inch, high explosive (HE, Lyddite) shells against unarmoured structures was dramatic and this trial was seen to demonstrate the need for areas of fairly thin armour to explode such shells outside the ship[10]. The battle of Tsushima was seen to reinforce this lesson.

A more important trial was that carried out against *Edinburgh* in 1909–10 (FIG. 10). The propellant charges were adjusted to give a striking velocity and angle of descent appropriate to a 6000 yard range (still seen as the battle range) and the ship was heeled 10° to simulate the effect of roll or damage. Quite extensive modifications were made to the ship, including the installation of sections of Krupp Cemented (KC) armour.

These trials demonstrated once again the effect of large HE shells but also showed that the powder-filled common shell could cause very extensive, though less spectacular, damage, because the large splinters would destroy bulkheads and equipment. It was also noted[10] that armour-piercing (APC) shells were likely to detonate prematurely in penetrating thick armour. Protective decks were much less effective than expected in protecting spaces below against large splinters or spalling from shells exploding above. This again was interpreted as showing the value of light side armour to activate the fuse early; a lesson which was specially important for light cruisers.

The firing in 1913 against *Empress of India* tested the ability of several ships to concentrate effective fire against a single target. It was found very difficult to identify the fall of shot from one's own ship but little was done to improve matters. Other trials were carried out against turret roofs (showing the need for a ductile rather than a hard steel), casemates, and several against old destroyers which showed the value of 4 inch HE shells. Tests were carried out of the danger due to shells bursting in magazines or shell rooms and of flash passing down hoist. However, these last trials did not include the effect of a large mass of cordite being ignited; a tragic omission. With this one exception, pre-war trials had explored all the effects which would be seen in war.

The French trials against *Jena* in 1909 seem to have led to the conclusion that heavy, armour-piercing shells (3% melinite charge) were much more effective than high explosive projectiles. They, too, showed the value of the intermediate, or semi-armour-piercing shell with a 7% or 8% charge ratio[11].

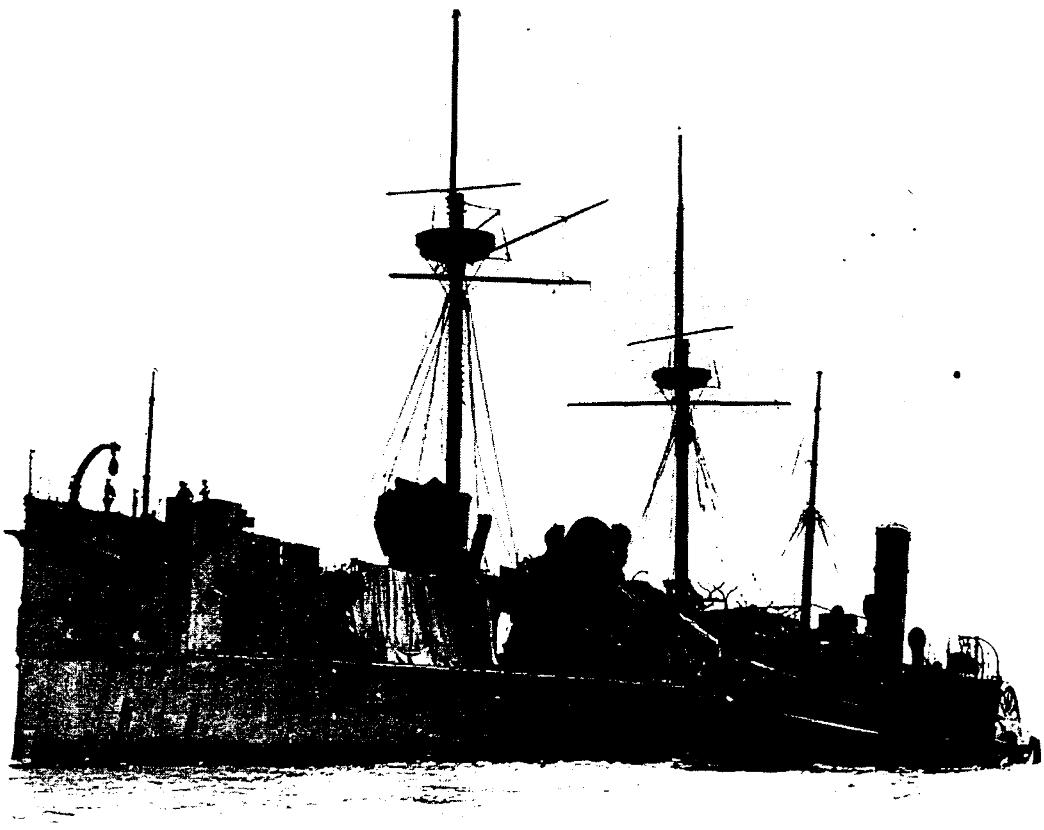


FIG. 10—H.M.S. 'EDINBURGH' STRIPPED FOR TRIALS OF ARMOUR AGAINST SHELL FIRE, 1909
J. M. Maber collection

## Torpedo Protection

The *Belleisle* trials in 1903 included the firing of 230 lb of wet gun cotton against a torpedo protection system, 12ft deep, with 5 longitudinal bulkheads. Damage was extensive and the system failed[12]. A more successful scheme, with a thick inner bulkhead, was built into the old merchant ship *Ridsdale* and this formed the basis of the protection for *Dreadnought*. Due to weight limitations, she was protected only in way of the magazines. In following classes the protection was extended but reduced again in *Hercules* and *Colossus* to make room for wing turrets. Only in the *Queen Elizabeth* was a full protection provided. Trials on such a system were successfully carried out on the old *Hood* in 1914. (The hull of *Hood* may still be seen blocking a gap in Portland breakwater).

## THE SHIPS

### Battleships

There were marked differences in emphasis between battleships of the great powers. As a generalization, British ships featured larger guns, with lower muzzle velocity, than did German ships. They had somewhat thinner side armour (there was little difference in the thickness of decks, universally thin), with stronger hull structure and heavier machinery. German ships had a heavier secondary armament and closer subdivision, often compromised by large submerged torpedo flats. U.S. and French practice differed again.

It is less easy to quantify such differences. The design of battleships was dominated by weight and the naval architect was always conscious of every extra ton going into each of the weight groups building up the total displacement—hull, machinery, armament, armour, equipment, fuel, etc. Overall comparisons of such weight groups can be most misleading, as the way in which weights were broken down varied considerably from one country to another and even from one design team to another.

The most difficult point is whether protective plating was included in 'hull' or 'armour'. British practice for battleships (but not for cruisers) was to include non-cemented protection in the hull weight if it was less than a certain thickness. The actual thicknesses seems to have varied from one class to another, sometimes $1\frac{1}{2}$ inches, sometimes 3 inches (37–75 mm). Turret armour sometimes appears under armament. In consequence, it is not surprising that Friedman[13,14] quotes two weight breakdowns for *Pennsylvania*, with, in one case, an armour weight of 8400 tons and in the other of 11 900 tons. French breakdowns would put barbette and battery armour as well as turret shields under armament.

TABLE I presents some recorded battleship weights but, for the reasons given above, it must be seen as indicating very broad trends only.

TABLE I—*Comparison of group weights for battleships*

| *Navy* | *Class* | *Load Displacement** tons | *Weight Group* (tons) | | | |
|---|---|---|---|---|---|---|
| | | | *Hull* | *Armour* | *Machinery* | *Armament* |
| U.S. | PENNSYLVANIA | 31 400 | 9 869 | 11 943 | 2 399 | 2 968 |
| U.K. | QUEEN ELIZABETH | 27 500 | 8 900 | 8 600 | 3 950 | 4 550 |
| U.K. | ROYAL SOVEREIGN | 25 740 | 8 600 | 8 250 | 2 550 | 4 570 |
| France | NORMANDIE | 22 590 | 7 119 | 7 619 | 2 395 | 4 853 |
| Germany | BAYERN | 25 900 | 8 411 | 11 335 | 3 086 | 4 102 |

*Load displacement is the 'normal' displacement in service

#### *Armament*

British and German ships carried their heavy guns in twin turrets (FIG. 11). They had considered designs with more guns per turret but decided that the twin mount gave a better rate of fire, was more accurate, and there was less risk of losing a large part of the armament from a single hit. The U.S.N. used triple mounts and the French a quadruple mount in order to get more guns on a ship of given size[15].

The R.N. was reluctant to use super-firing turrets because of an insistence on open siting hoods on the roof which made the blast in the lower turret intolerable when the guns above fired. This led to wasteful arrangement of turrets, reducing the number of guns which could fire on the beam.

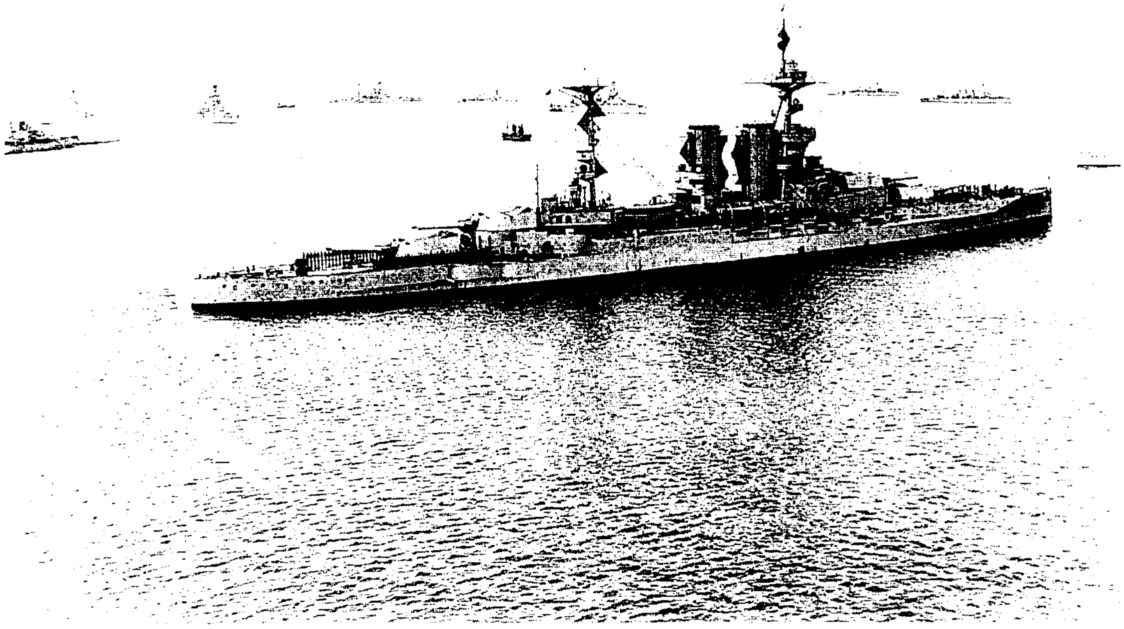


FIG. 11—H.M.S. 'BARHAM' ('QUEEN ELIZABETH' CLASS) WITH FOUR TWIN 15 INCH TURRETS

*Secondary Armament*

Before *Dreadnought* a heavy armament of 6 inch (150 mm) quick firers was seen as necessary to demolish unarmoured positions of the enemy ship. Tsushima showed the fallacy and *Dreadnought* had an all big gun armament, a decision which proved valuable as ranges increased in following years. She was given an anti torpedo boat armament of 12 pounder (75 mm) guns which was soon proved to be inadequate. Following ships had 4 inch (100 mm) guns firing a 31 lb shell which should have been able to score sufficient hits on a destroyer to disable it before it reached effective torpedo range (about 3000 metres).

By 1910, the effective range of torpedoes had increased to about 10 000 metres and it was seen as necessary to move to the heavier 6 inch gun. Emulation of the German ships, which had always mounted a six inch battery, may also have played a part in this decision. It should have been realized that the chance of hitting a small, fast target at 10 000 metres from a handworked and locally controlled gun close to the waterline was remote. The true protection of the battle line against torpedo attacks from destroyers lay in its own destroyers and their accompanying light cruisers. The weight, space, and vulnerability associated with a heavy secondary battery was wasted.

*Torpedo Armament*

Most battleships carried torpedo tubes below the waterline with elaborate arrangements to protect the torpedo when it left the ship whilst steaming at high speed. There were usually a considerable number of reload weapons which meant that the torpedo compartments were large and had large hatches. As gun ranges increased the chance of a hit from a battleship-launched torpedo became remote and yet navies persisted in this useless and potentially dangerous equipment. The Germans devoted more space and weight to it than other navies and were to suffer in consequence.

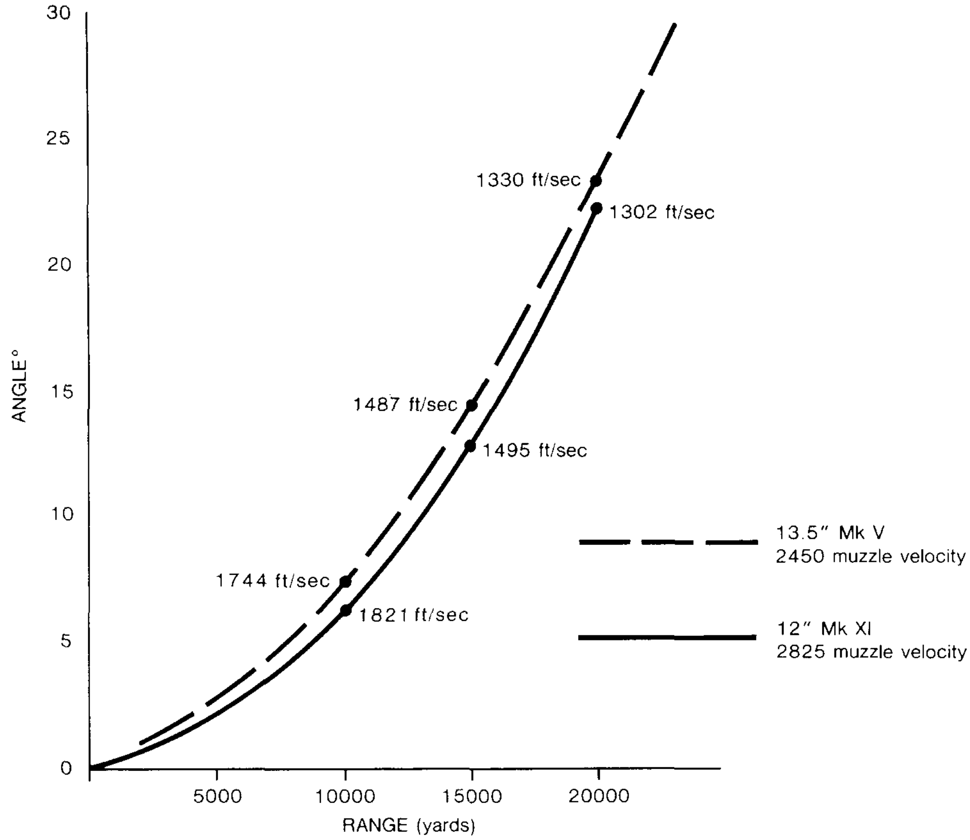



FIG. 12—ANGLE OF DESCENT V. RANGE, WITH SOME VELOCITIES

*Armour Style*

Armour was clearly intended to keep out shells at fighting range (FIG. 12) but there were different types of shell, of different penetrating power and with the ability to cause damage inversely proportional to their penetration. The traditional British style (FIG. 13a), copied by most nations, aimed at keeping big armour-piercing shells out of the vitals, at 8000–10 000 metres, by a thick armour belt some 13 inches (32·5 cm) thick from the front of A barbette to the rear of Y barbette. This thick armour was usually intended to extend to the deck above the waterline (2 metres) and some distance below the waterline usually tapering to about 20 cms at the bottom.

Above this thick belt would be a much thinner belt (6 inch, 15 cm) which served two purposes. Initially, it was intended to keep out shells from the secondary, quick-firing guns of the enemy. Latterly, it was seen as essential to detonate and limit the effects of main armament, HE shells which had caused so much damage in the *Belleisle* and *Edinburgh* trials (and at Tsushima). This thin belt would also initiate the fuses of AP shells travelling close to the horizontal. They would burst above the protective deck (1 to 2 inches (2·5 to 5 cm) thick, roughly at the level of the waterline) which was intended to keep out splinters. Thin armour extended along the side, at the waterline, fore and aft of the main belt, for much the same reasons as the thin upper belt.

There were interesting variations on this theme. In the ROYAL SOVEREIGN Class (1913 programme) d'Eyncourt decided to reduce the metacentric height by adopting a smaller beam with the object of obtaining lower roll accelerations and hence improving gunnery. (It would seem, with hindsight, that the difference in roll made little difference to the accuracy of gun fire). In order to ensure enough protected freeboard after damage from two torpedoes it was decided to raise the protective decks to the level of the top of the armour belt (Fig. 13b). This increased the protected volume of the ship and was probably a better scheme while range remained at 8000–10 000 yards but it increased the risk of penetration by an AP shell falling more steeply at longer ranges.

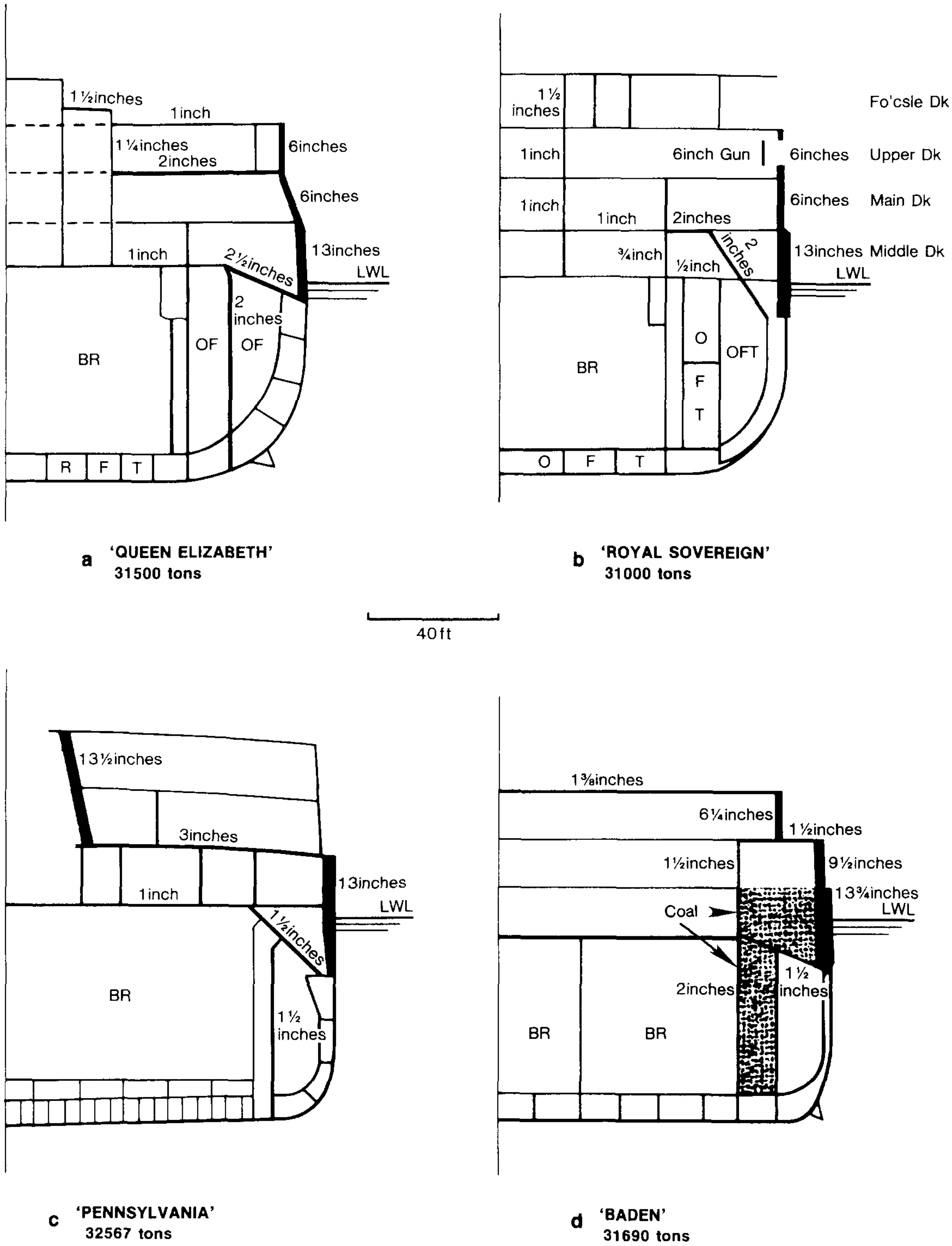



Fig. 13—Armour styles

BR: boiler room
LWL: load water line
OF/OFT: oil fuel tank
RFT: reserve feed water tank

The U.S. Navy decided that it was essential to keep out AP shells and in the NEVADA Class they maximized the extent of thick side armour with a 3 inch (7·5 cm) deck level with the top of the belt, and this was repeated in the very similar PENNSYLVANIA Class (FIG. 13c). It gave no armour outside the citadel except for barbettes, uptakes and a few other vital points—no thin armour belt, no end protection. This style of protection became essential in the twenties under the weight limits of the Washington Treaty and hence the U.S.N. has been praised as pioneers of effective armour style. However, it is not at all clear that this was the right style for World War I battles, particularly in the North Sea when visibility would usually limit effective firing to about 10 000 metres. Only if all vital services were below armour could a battleship remain in action (*Bismarck* in World War II was put out of action very quickly due to loss of gunnery control circuits run above the protective deck).

Because shells arrived close to the horizontal at 10 000 yards, fairly light protection to the turret roofs was seen as adequate. Against plunging shells such protection was far from sufficient.

*Hull Style*

It is fortunate that S. V. Goodall, a most distinguished designer of battleships and later DNC from 1936 to 1944, made some comparisons between British and U.S. practice whilst Assistant Naval Attaché, Washington, and later between British and German practice[16]. In a series of letters and articles he discusses U.S. design in great detail, seeing much to commend and a little to criticise.

He gave the weight comparisons shown in TABLE II.

Goodall was critical of lack of support to armour in the U.S. ships, particularly to the barbettes. The subdivision was very good but seriously degraded by the number of openings, including glass windows, in the bulkheads. The light U.S. cage masts were inadequate for modern fire control gear. The machinery spaces were very generously sized.

TABLE II—*Comparison between U.S.N. and R.N. practice in hull design*

| *U.S.N. lighter* | *R.N. lighter* |
|---|---|
| Transverse framing | Inner bottom |
| Bulkheads | Protective deck |
| Strength deck | Stanchions |
| Framing and Plating behind armour | Paint and cement |
| Ventilation | Boat hoisting gear |
| Masts | Doors and Hatches |
| Electrical wiring | |

The *Baden* (FIG. 13d and 14) was seen by d'Eyncourt[17] and Goodall[18] as very lightly built with stresses some 20-25% higher being accepted than in British practice. To some extent this was due to elaborate—and expensive—design features. One exception was the main anti-torpedo bulkhead, more continuous and thicker than in R.N. ships. Subdivision was generally good but suffered from the very large number of penetrations for pipes and ventilation. A very elaborate pumping and draining system was fitted to aid damage control but the many bulkhead valves involved were, themselves, a source of weakness.

Since *Majestic*, British designers had made determined and successful efforts to reduce the weight of the hull[19] and its fittings[20]. *Dreadnought*, a much bigger ship, had almost the same hull weight as *Majestic* and carried

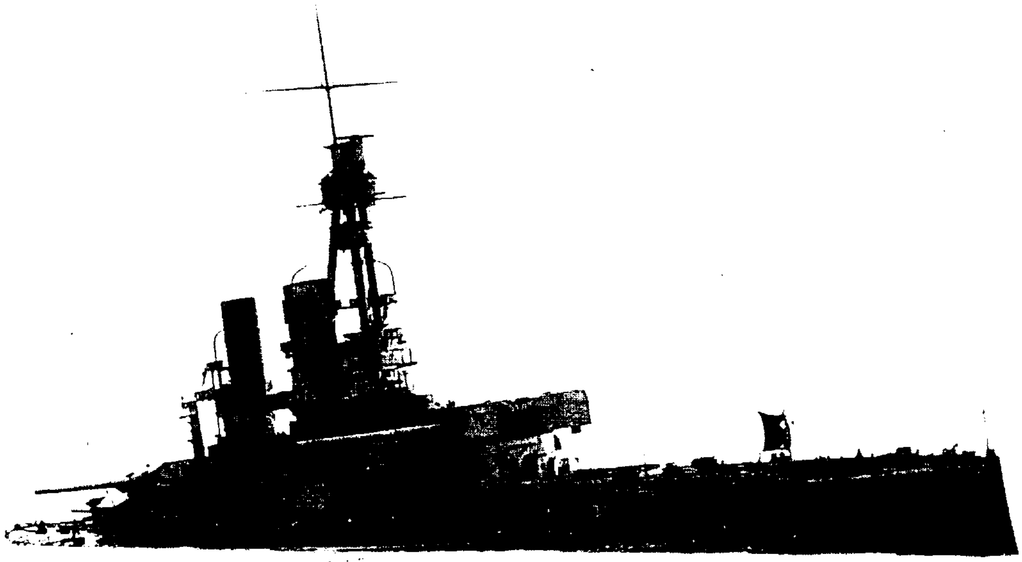


FIG. 14—THE FORMER GERMAN BATTLESHIP 'BADEN', USED FOR TARGET TRIALS OFF PORTSMOUTH, 1920-1921

J. M. Maber collection

less equipment, as shown in TABLE III. The loss of H.M.S. *Victoria* by collision showed the need for watertight bulkheads to be unpierced by doors, valves, etc., and by *Dreadnought* this had generally been achieved[19].

TABLE III—*Hull weight as a proportion of displacement*

| | *Displacement* | *Hull Weight* | *Equipment* |
|---|---|---|---|
| *Majestic* | 14 900 | 5 650 | 670 |
| *Dreadnought* | 17 900 | 6 100 | 650 |

Goodall's description of *Baden's* machinery is amusing. It . . . 'would be described by a naval architect as "compactly arranged" and by a marine engineer as "very congested" . . .'[18]. Certainly, the early introduction of the small tube boiler (Thornycroft-Schulz) made possible very considerable weight savings only achieved by the R.N. in *Glorious* and later ships.

To the British historian it is convenient that all the modern, pre-war ships were designed under Sir Phillip Watts whilst Sir Eustace Tennyson d'Eyncourt was responsible for wartime construction. Sir William White's vast and revolutionary fleet was ageing and generally relegated to secondary duties. Both R.C.N.C. and family traditions see Watts as a true gentleman, intelligent but rather lazy. This accords well with consideration of his designs which were well conceived and fit for purpose but had detail flaws. One may note that faults in cordite, in shells, in turret protection and in fire control occurred whilst Jellicoe was Director of Naval Ordnance or Controller.

Detail but serious faults were not confined to R.N. ships (see the comments on U.S. and German practice above) and were not unexpected after such a long period with few major wars. It was a strange era, a transition from the leisurely ways of the 19th century to today's bustle. British constructors complained of being overworked due to the increasing number of ships and the increased complexity of each unit yet their working hours were still very short by the standards of today[21].

## Cruisers

In the early years of the century, British cruiser policy was in disarray, partly due to Fisher's contention that there was no need for anything between the battle-cruiser and the big destroyer such as *Swift*. The armoured cruiser, costing as much as a battleship, was built as late as 1905 and had little speed advantage over later battleships.

The smaller protected cruisers were intended for colonial and trade protection and had little fighting value. A group of eight 'Scouts', commenced in 1903 largely inspired by Admiral Fitzgerald, were the germ of what was required but they were too small to maintain speed in a seaway and their armament of 75 mm guns was far too light to be effective. This concept was developed until, in 1909, the BRISTOL Class was laid down. With a length of 453 ft (138 m), and reasonable freeboard at the bow they were acceptable sea boats[22], and the armament of two 6 inch (150 mm) and ten 4 inch (100 mm) was adequate. Protection was confined to a 2 inch deck. Successive classes of increasing size developed this theme with armament increasing to 9-6 inch in the BIRMINGHAM Class. The latter classes had a belt of 2 inch protection over 1 inch hull plating with a thinner deck based on the EDINBURGH trials. This category of ship had become big and expensive and the speed of 25 knots was inadequate to work with destroyers.

In 1911, a committee was appointed to consider the requirements of a cruiser to work with destroyers. There was support, led by Fisher, for a 37 knot super-*Swift*, but the majority favoured an improved 'Scout' at about £285 000, still much cheaper than the later TOWNS at £350 000. The ARETHUSA Class which resulted had a sea speed of about 28½ knots (a little disappointing), two 6 inch and six 4 inch guns, and a 3 inch armour belt which was an integral part of the shell plating[23]. At 3750 tons they were a little small and the ships of the 1913 and 1914 programme were bigger, still with a mixed armament of 6 inch and 4 inch guns.

All these ships were turbine engined and the last two pre-war ships introduced the geared turbine with great improvement to fuel consumption and some benefit on top speed. *Calliope* is said to have burned 420 tons per day and *Champion* 470 compared with 530 tons/day for the direct drive ships[22]. From 1912 onwards, cruisers used oil fuel exclusively and, whilst earlier ships mainly burned coal, they could use oil.

German cruiser development was more consistent from the *Königsberg* of the 1903 programme—3390 tons, triple expansion engines, 23 knots, coal, 30 mm deck protection and ten 105 mm guns. Turbines were introduced in one of the class and became universal from then on. Thin belt armour was introduced in the 1908 programme by which time mixed fuel (coal and oil) was adopted. All ships in service at the outbreak of war carried an all 105 mm armament (12 guns in the later ships), though the 1912 programme (completed 1915) and later had eight 150 mm. Speed had increased to about 28 knots by the outbreak of war. Amazingly, neither France nor the U.S.A. built cruisers at all in the years prior to 1914. Japan, too, built very few cruisers until the CHIKUMA Class, launched in 1911, which were comparable with British ships.

## Destroyers

The 1905 destroyers (TRIBAL Class) were another of Fisher's dreams which failed. The BEAGLES of 1908, were a successful design which was developed into the M class of 1913, built in very large numbers during the war. These ships had a speed of 34 knots, three 4 inch (100 mm guns), four 21 inch (533 mm) torpedo tubes, oil fuel and good sea keeping for their size. Geared turbines were under trial in two boats of the 1912 programme and, once their success was demonstrated, many derivatives of the M class, but with geared turbines, were built[24].

German destroyers were generally smaller with a weak gun armament of 88 mm guns (22 lb shell) but with six torpedo tubes (500 mm, roughly the same warhead size as contemporary British 533 mm torpedoes). They were much later in going to all oil fuel and never adopted the geared turbine. French concepts were similar to the British but tended to be smaller.

American destroyers differed considerably in layout and style from European practice[25]. They tended to be bigger, with a heavy armament of guns and torpedo tubes. Considerable emphasis was placed on seakeeping though the benefits which they should have obtained from their longer hulls were largely lost due to flimsy upperworks.

**Aircraft Carriers**

During the 19th century most navies had experimented with the use of kites and balloons from ships but the air age began for navies on 14 November 1910 when Ely took off from the stationary U.S. cruiser *Birmingham*. In 1911 he succeeded in making a landing on the *Pennsylvania* (also stationary). That year the French started the conversion of *Foudre* to a seaplane carrier with the first hangar to go to sea[26].

The R.N. carried out a series of trials in 1912 including the first take off from a moving ship (*Hibernia*). At the Naval Review of 1912 the R.N. flew past all four of its aircraft, and one dropped a 300 lb (136 kg) weight representing a torpedo or bomb. By May 1913 *Hermes* was given a simple conversion to a seaplane carrier and showed the potential value of the aircraft during manoeuvres.

During 1914, the first purpose-built aircraft carrier, *Ark Royal*, was under construction[27]. She was a seaplane carrier and, though based on a collier already under construction, the changes were so radical as to justify calling her a new design. Her designer, Narbeth[28], introduced most of the features of a modern aircraft carrier with a well thought out hangar, workshops, an engine test bay and protected petrol stowage. Only her speed was inadequate. The Royal Naval Air Service was set up on 1 July 1914 by which time it had 52 seaplanes, 39 aeroplanes and seven airships—and the first torpedo drop had been carried out.

The action of the Establishment to change is never as rapid as the enthusiast would wish but the fact that the R.N. had by far the most numerous forces of submarines and of aircraft, together with advanced systems of fire control and wireless suggest that the pre-war Admiralty was far from reactionary. Many new ideas do not come to fruition and this, combined with the need for wise use of limited public funds justifies a measure of caution.

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## APPENDIX I—RN ESTIMATES VOTE 8—SHIPBUILDING

| *Date* | *£ (million)* | | | |
|---|---|---|---|---|
| | *Dockyard* | *Materials* | *Contract* | *Total* |
| 1906 | 2·4 | 2·8 | 8·6 | 13·8 |
| 1907 | 2·5 | 3·6 | 7·6 | 13·1 |
| 1908 | 2·9 | 4·2 | 7·7 | 14·8 |
| 1909 | 3·1 | 4·4 | 8·3 | 15·8 |
| 1910 | 3·4 | 4·6 | 12·4 | 20·4 |
| 1911 | 3·5 | 5·0 | 14·4 | 22·9 |
| 1912 | 3·5 | 5·1 | 13·1 | 21·7 |
| 1913 | 4·1 | 5·9 | 12·2 | 22·2 |
| 1914 | 4·0 | 7·1 | 14·3 | 25·4 |

*Dockyard*: salaries and wages with a few other minor items
*Materials*: timber, metal, coal, rope, canvas, electrical freight, rent, gas, etc.
*Contract*: the breakdown for a typical year (1903–4) was:

| | £K |
|---|---|
| Propelling machinery | 3 439 |
| Auxiliary machinery | 168 |
| Hulls | 3 671 |
| Purchase | 12 |
| Repairs | 722 |
| Inspection | 70 |
| Guns | 1 354 |
| Machinery | 188 |
| Reserve Merchant Cruisers | 79 |
| Total | 9 571 |

## APPENDIX II—GERMAN NEW CONSTRUCTION AND ARMAMENTS

| *Date* | *Amount Voted* £ (million) | *Ships* | | | |
|---|---|---|---|---|---|
| | | *Battleships* | *Large Cruisers* | *Small Cruisers* | *Destroyers* |
| 1906–7 | 5·2 | 2 | 1 | 2 | 12 |
| 1907–8 | 5·9 | 2 | 1 | 2 | 12 |
| 1908–9 | 7·8 | 3 | 1 | 2 | 12 |
| 1909–10 | 10·2 | 3 | 1 | 2 | 12 |
| 1910–11 | 11·4 | 3 | 1 | 2 | 12 |
| 1911–12 | 11·7 | 3 | 1 | 2 | 12 |
| 1912–13 | 11·5 | 1 | 1 | 2 | 12 |
| 1913–14 | 11·0 | 2 | 2 | 2 | 12 |
| 1914–15 | 10·3 | 1 | 1 | 2 | 12 |

*Note*: It should not be assumed that these figures can be directly compared with those given for the R.N. since the breakdown of the above figures is not known.

## APPENDIX III—BUILDING PROGRAMMES, LAUNCHED 1906-1914

| *Great Britain* | *1906* | *1907* | *1908* | *1909* | *1910* | *1911* | *1912* | *1913* | *1914* |
|---|---|---|---|---|---|---|---|---|---|
| Battleships | 2 | 4 | 1 | 1 | 3 | 5 | 4 | 3 | 3 |
| Battle-Cruisers | — | 3 | — | 1 | 1 | 3 | | 1 | — |
| Cruisers | 2 | 1 | 1 | 6 | 5 | 5 | 4 | 5 | 11 |
| Destroyers | 9 | 19 | 14 | 15 | 28 | 24 | 11 | 27 | 25 |
| Submarines | 6 | 8 | 9 | 12 | 6 | 5 | 6 | 6 | 10 |
| *Germany* | | | | | | | | | |
| Battleships | — | — | 4 | 3 | 1 | 3 | 1 | 3 | 1 |
| Battle-Cruisers | — | — | (1)† | 1 | 1 | 1 | 1 | 2 | — |
| Cruisers | 2 | 2 | 2 | 3 | — | 4 | 2 | 1 | 3 |
| Destroyers | 8 | 15 | 8 | 11 | 21 | 18 | 11 | 8 | 22 |
| Submarines | 1 | — | 1 | 2 | 7 | | | | |
| *France* | | | | | | | | | |
| Battleships* | | | | | | 2 | 2 | 3 | (3)‡ |
| Cruisers NIL | | | | | | | | | |
| Destroyers | | | 4 | 5 | 12 | 6 | 7 | 4 | 1 |
| Submarines | 2 | 7 | 9 | 7 | 11 | 7 | 10 | 4 | 4 |

*Excludes Danton Class, pre-Dreadnoughts †*Blücher*, 8.2″ guns ‡not completed

## APPENDIX IV—COMPARATIVE COST OF BRITISH AND GERMAN BATTLESHIPS

| | *Cost* £ (thousand) | | | | | | |
|---|---|---|---|---|---|---|---|
| | *Hull* | *Armour* | *Gun Mounts and Steam Boats* | *Machinery* | *Incidentals* | *Guns* | *Total* |
| *Colossus* | 466 | 415 | 401 | 231 | 46 | 132 | 1692 |
| *Ostfriesland* | | | | | | 621* | 2304 |

*includes mounts

*Ostfriesland* armament is given as:

| | £(K) |
|---|---|
| Guns, mounts (and possibly spares) | 621 |
| Accessories, optical equipment | 17 |
| Fire control | 12 |
| Ammunition (1st outfit and reserve) | 259 |
| Miscellaneous | 20 |
| Total | 929 |