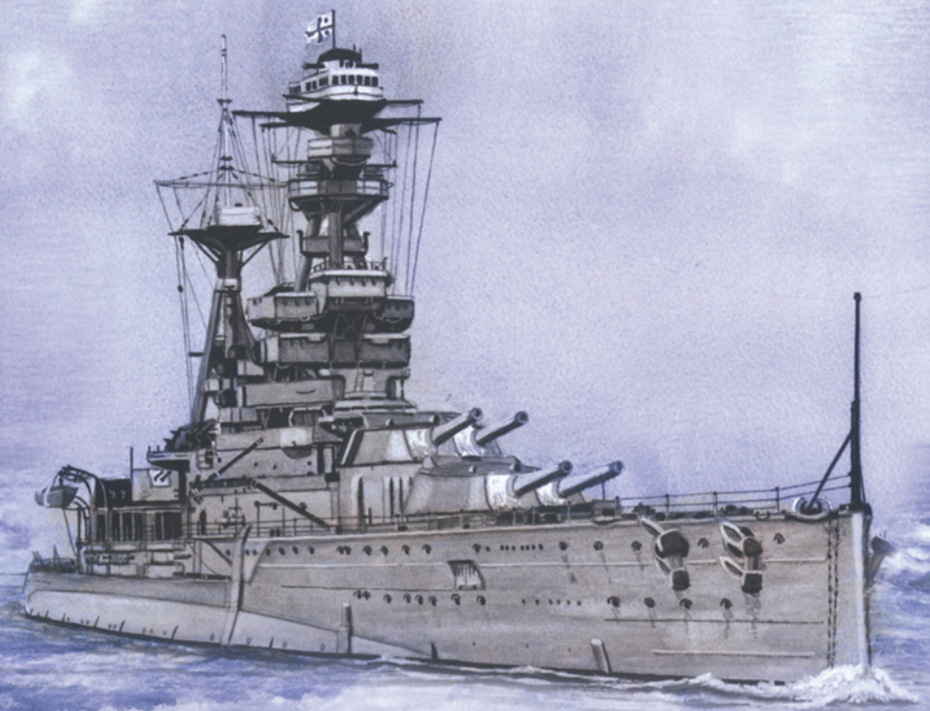
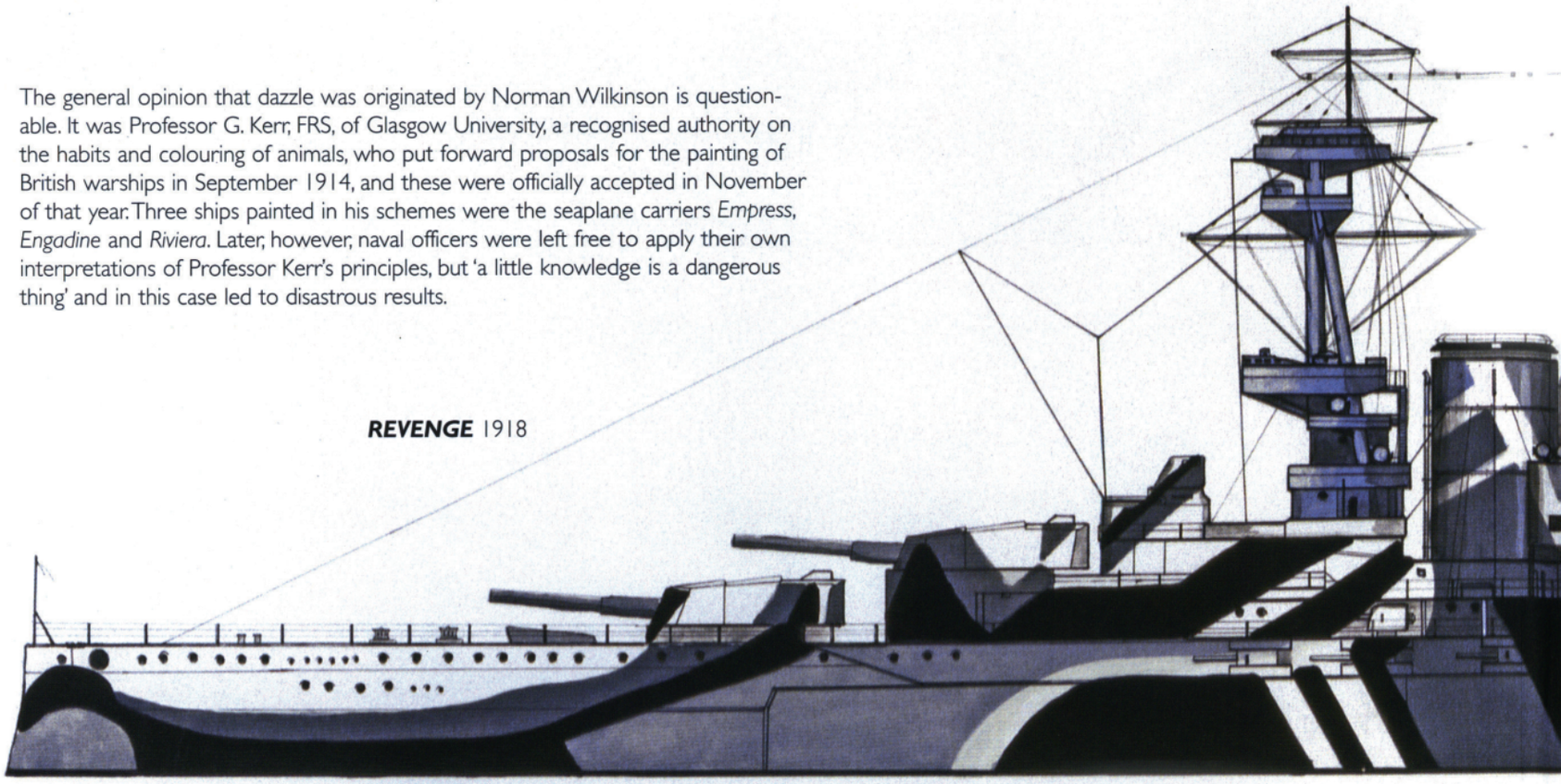
BRITISH BATTLESHIPS 1919–1945

NEW REVISED EDITION

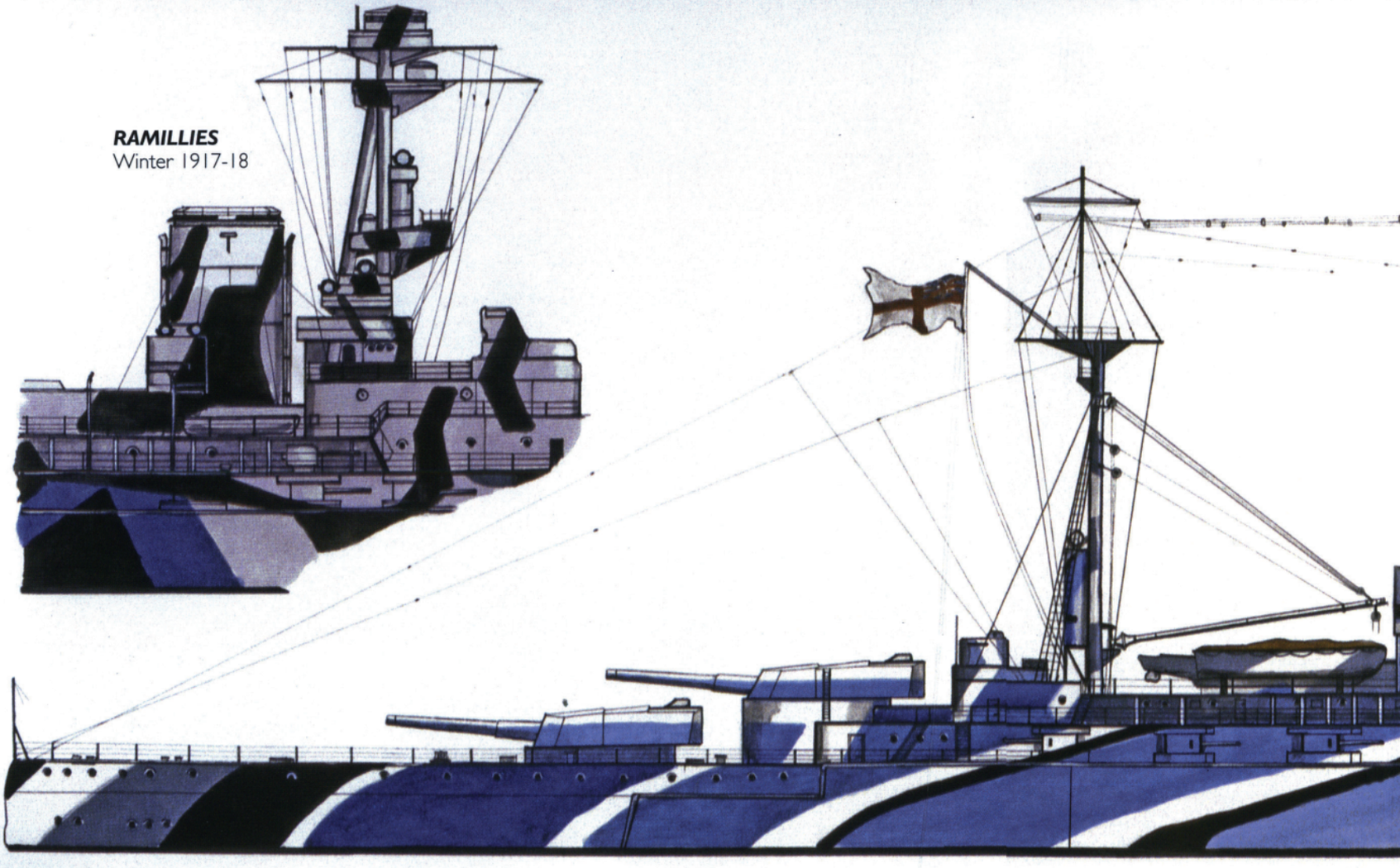


R A BURT

The general opinion that dazzle was originated by Norman Wilkinson is questionable. It was Professor G. Kerr, FRS, of Glasgow University, a recognised authority on the habits and colouring of animals, who put forward proposals for the painting of British warships in September 1914, and these were officially accepted in November of that year. Three ships painted in his schemes were the seaplane carriers *Empress*, *Engadine* and *Riviera*. Later, however, naval officers were left free to apply their own interpretations of Professor Kerr's principles, but 'a little knowledge is a dangerous thing' and in this case led to disastrous results.



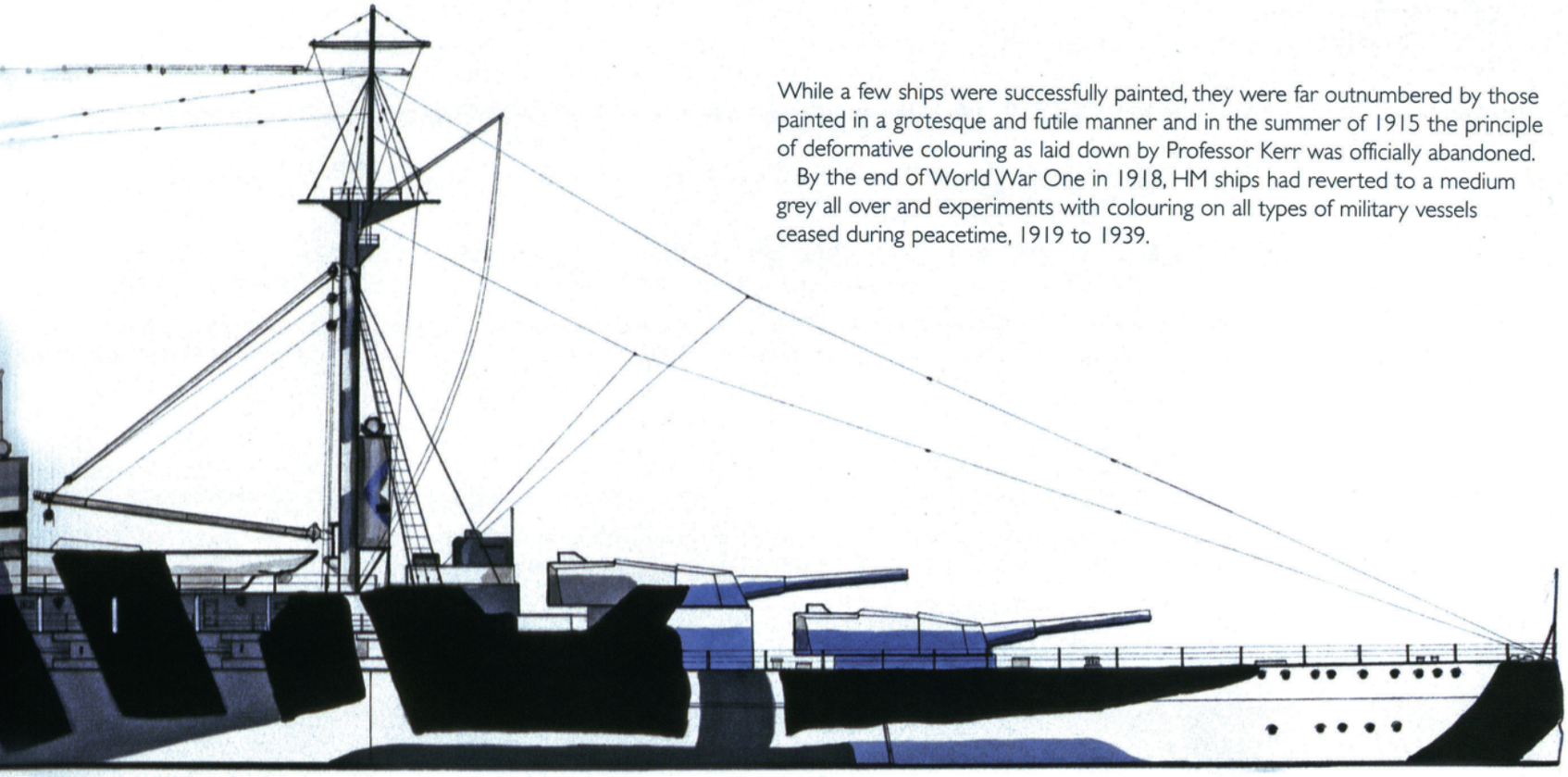
REVENGE 1918

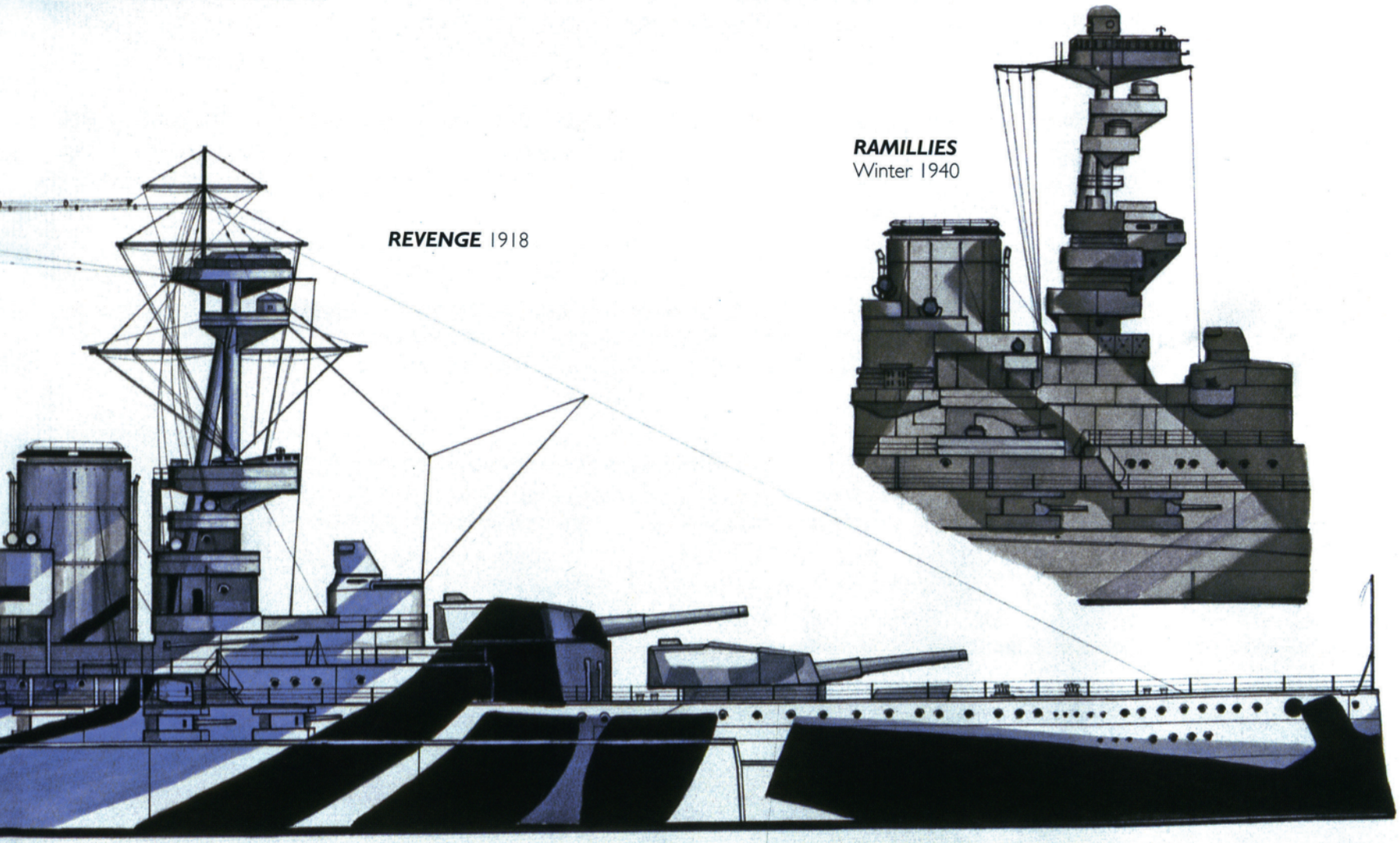


RAMILLIES
Winter 1917-18

While a few ships were successfully painted, they were far outnumbered by those painted in a grotesque and futile manner and in the summer of 1915 the principle of deformative colouring as laid down by Professor Kerr was officially abandoned.

By the end of World War One in 1918, HM ships had reverted to a medium grey all over and experiments with colouring on all types of military vessels ceased during peacetime, 1919 to 1939.





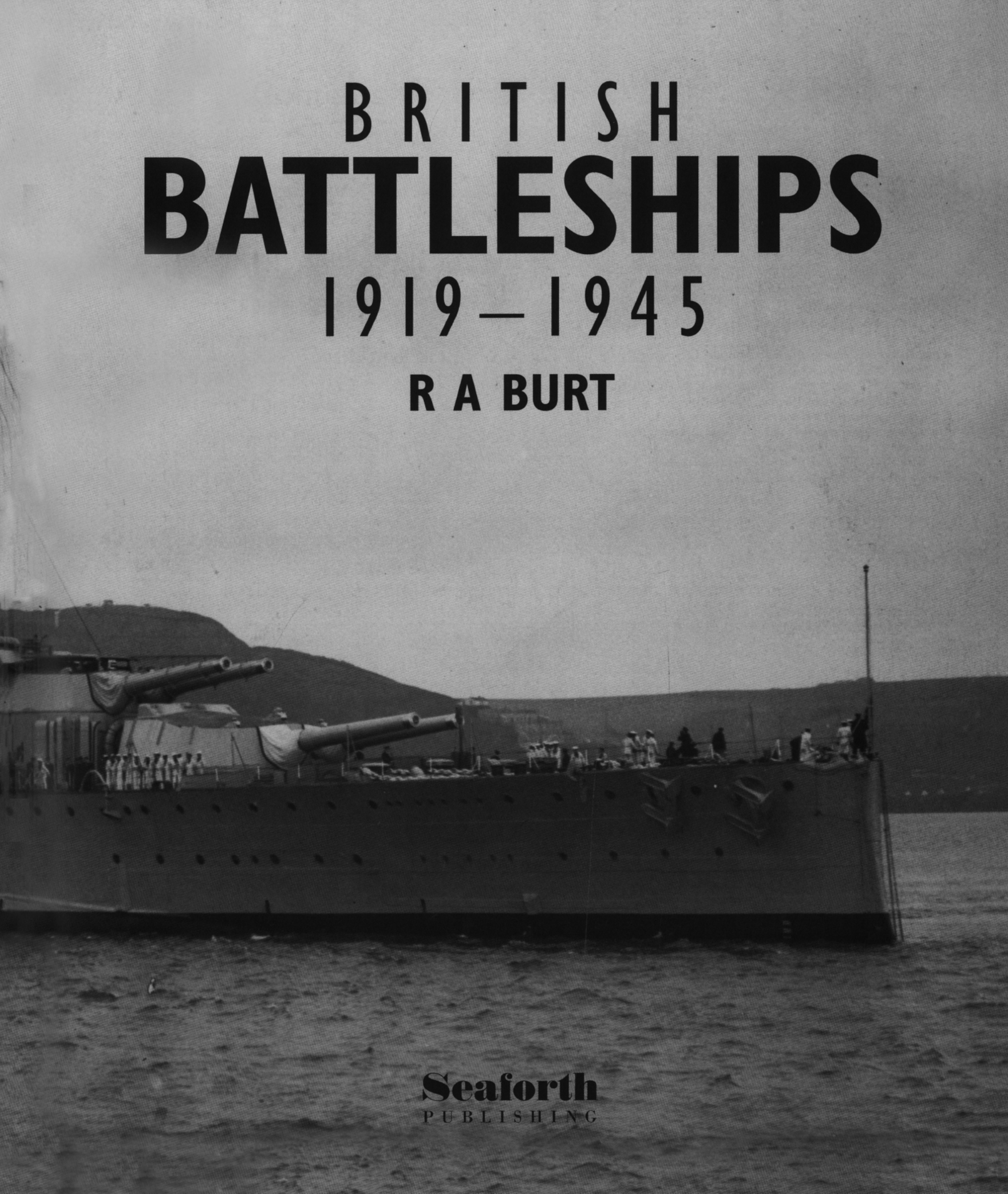
REVENGE 1918

RAMILLIES
Winter 1940

BRITISH
BATTLESHIPS
1919–1945

BRITISH BATTLESHIPS 1919–1945

R A BURT



Seaforth
PUBLISHING

Title page: *Ramillies* fresh out of refit, Devonport, April 1927.

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In particular I should like to extend sincere thanks to John Roberts for all his help; to J. Hitchon, A. S. Norris and R. Wilson for help with material; and appreciation is also due to T. W. Ferrers-Walker for material and for great encouragement throughout the preparation of the book.

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R A Burt

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Contents

Preface

The period from 1919 to 1939, although a time of peace between the major powers, probably produced more wartime ideas than the hostilities themselves. The naval treaties that brought a halt to capital ship construction (from 1921) meant that the time and money available was spent either on the reconstruction of existing warships, or on basically new designs to be built as soon as new programmes could begin. It was a time when 'Jack' could join up and see the world without fear of having to fight for his country (although always ready to do so).

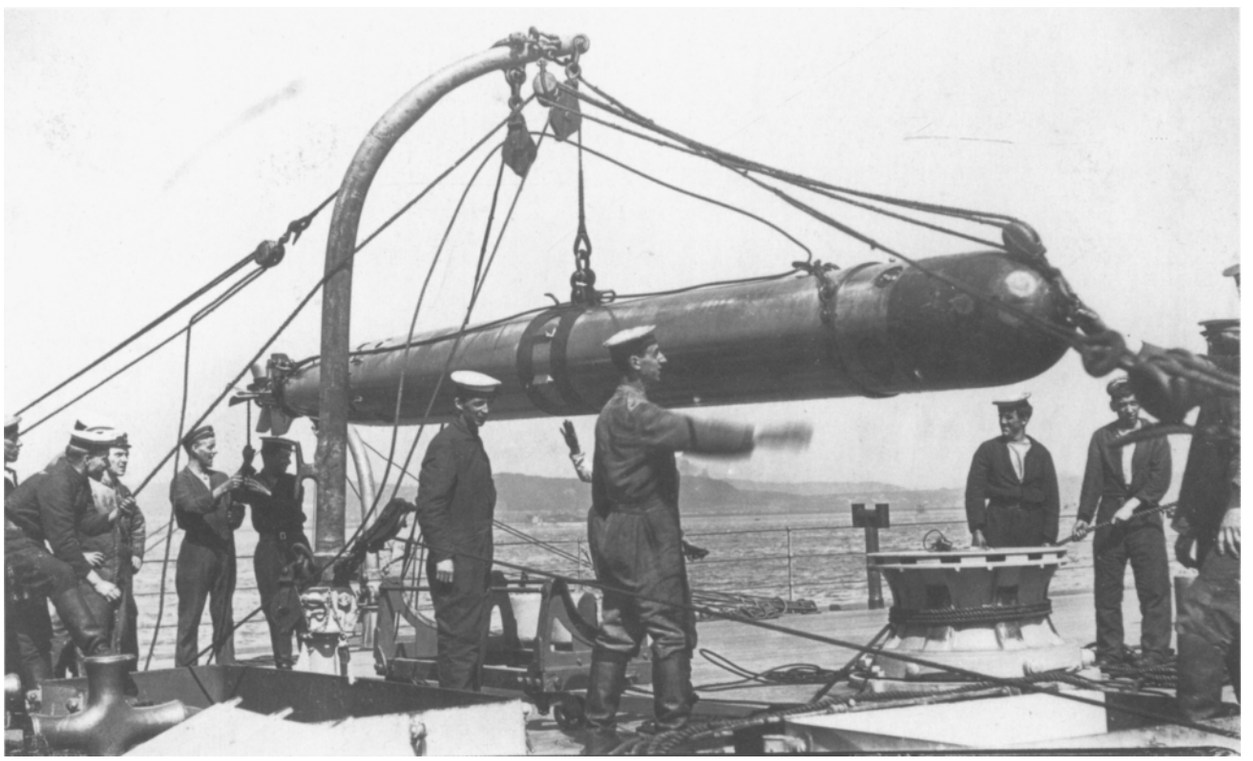
Commissions came and went, bringing a much needed showing of the flag, and no memories are fonder than when an old 'salt' recalls his happy days aboard one of His Majesty's battleships. During those years it seemed that the Royal Navy was still the major force on the oceans, even though her ships had reduced in number to parity with the US Navy. The Union 'Jack' still counted for something and the Royal Navy was still the Senior Service in more ways than one. Indeed, it had the most battle experienced ships and crews, and had carried out some of the most meticulous tests against old battleships ever witnessed.

Although there was much change so far as reconstruction was concerned, on the whole the administration and policies of the Royal Navy were little altered and Fleet practice and exercises were carried out in a fashion similar to those current during the First World War. The Admiralty saw no reason to change its thinking in this regard; it considered the battleship to be supreme despite the many critics who believed that the day of the big ship had passed. The aircraft carrier, still not fully developed, came into its own during the inter-war years, but at that time the main strength was still envisaged as lying in straight battle divisions that would engage an enemy line when required to do so.

True, future action would differ from the Great War, given the greatly reduced numbers in the type, but even though Japan and the USA were looking towards the aircraft carrier and submarine, all major powers still struck up a massive construction programme of battleships during the years leading up to the Second World War. British battleship designs often take a knock, and lately it has become trendy to highlight their faults, but this is probably because it is comparatively easy to analyse a service that has such a long history of battle experience. Most British battleships were a compromise – no battleship ever constructed was perfect, but they contended with attacking aircraft, torpedoes, mines, submersibles, contemporary battleships and finally all weathers in all sea conditions throughout the world.

It is a simple matter to compare ship against ship statistics on paper, but it means very little in practical terms; actions speak louder than words and when one examines the record of the British battleship from 1919 to 1945, the Royal Navy's designers, the crews serving them and the vessels themselves, it becomes clear that they had little reason to pay heed to derogatory opinions. They did all that was asked of them – and sometimes paid a heavy price. As war approached in 1939 the Admiralty was all too aware that the Royal Navy was ill equipped and unready, but naval treaties, politics and financial restrictions had all taken their toll of the service since 1919. War was hard for the Navy the second time around, and by 1941 capital ships had been seriously depleted. There were few new ships and many of the older ones were in great need of modernization and long-awaited refits. The battle was pursued, however, and by 1942 the tide had turned, but the battleship had taken second place to the aircraft carrier as the most important unit in the fleet. Policy and battle tactics in the Atlantic and Pacific had altered drastically and it no longer seemed imperative to have a massive battlefleet as had been the case in 1939. The all-important weapons were carriers and fast light AA cruisers to look after them. The new enemy would now come from the air, not from over the horizon.

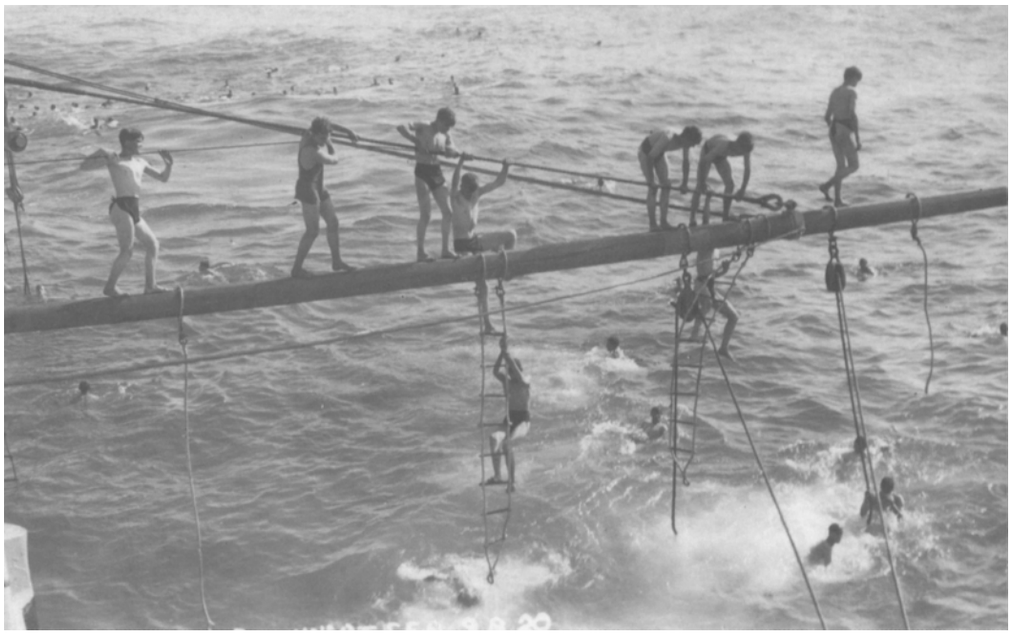
And what of the ships themselves, the mighty battleships –



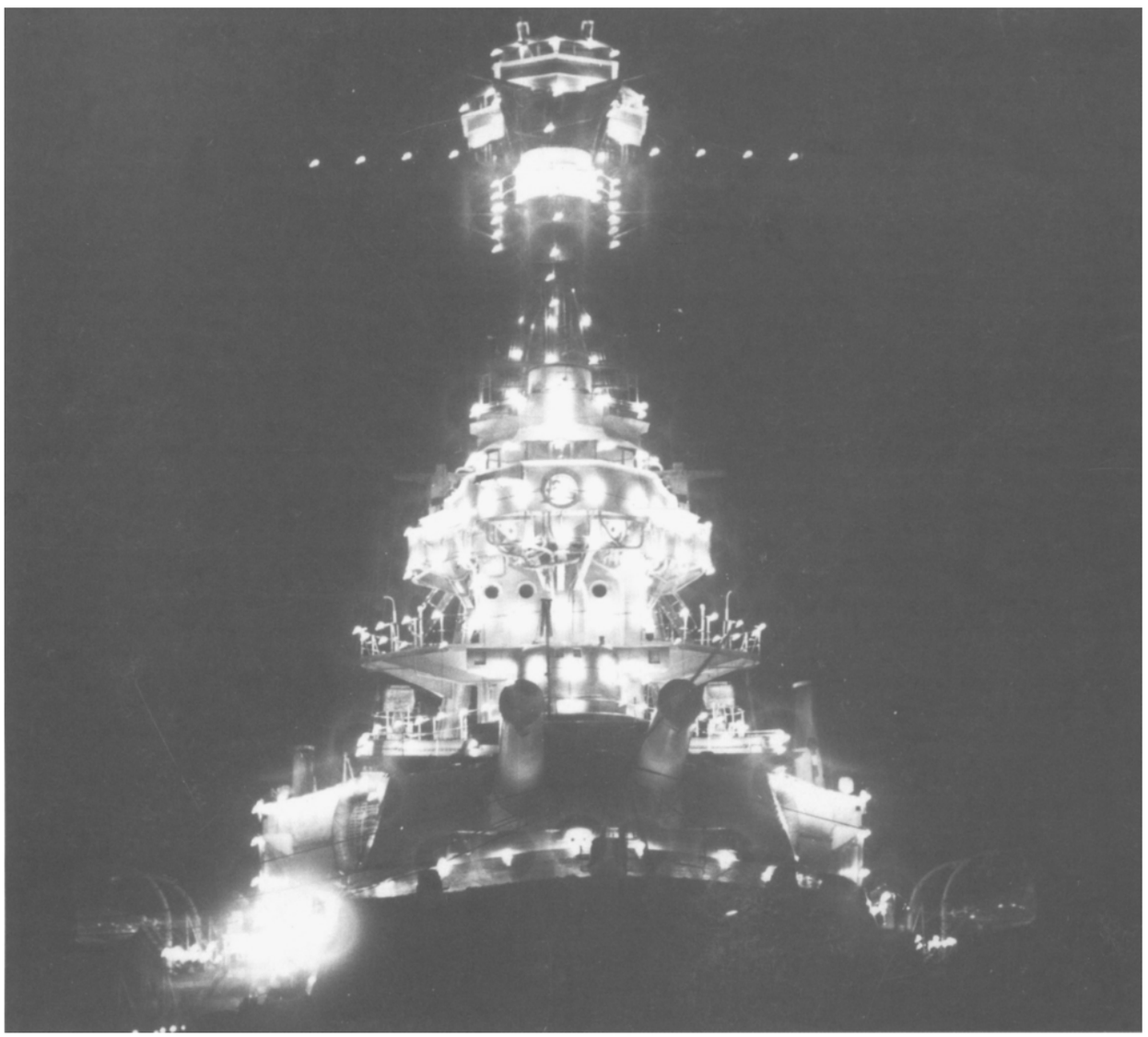
Life was never dull for long when serving on board a capital ship – one day nothing much, but the next might well bring a double shift. During the lull in capital ship construction (1919 to 1939) the crews carried on regardless with what ships they had. The following views show a lifestyle that was familiar to the British matelot.

Right: Hoisting a torpedo on *Ramillies*. Careful procedure was needed when handling torpedoes because a slip could mean broken bodies as well as damage to the weapon itself – worth more than £2,000 each.

those floating leviathans of the world's oceans, that had inspired the serviceman, the journalist and the general public for generations. The sight of a 'friendly' battleship imparted a sense of visual pleasure and powerful reassurance. Crowds would flock to the sea front at Portsmouth and Devonport to see one return from a commission. On many a visit to a foreign port hundreds would gather to see the British Fleet entering their harbour. They would glide in, gondola like, over a sun-blessed sea through schools of dolphins, while overhead convoys of seagulls kept close vigil for titbits. On board, a cacophony of noise as the off-duty watch prepared to come up on deck. Many were sun-worshippers, particularly those that had just left the inclement weather of Pompey or Guz. Hatches and scuttles were opened and the awnings would go up as soon as the anchor had been dropped. The King's ships had entered harbour in all their glory – usually with main armament at salute elevation – freshly painted in the light grey (almost bleached white in the bright sunshine) Mediterranean colours. 'Anchors aweigh!' sounded and the Fleet came to rest – 'Jack' was in for some well-earned leave ashore and he would hope, a good stretch before having to return to a home port. Romantic it may sound, an idyllic picture it may seem, but this was the scene that had not changed for hundreds of years; this was the life to which 'Jack' was accustomed (even though times in general were extremely hard



Above: 'In for a dip' – nothing would be more welcome after coaling or heavy work on the anchor party than a refreshing swim, especially when at a tropical port. Some of the lads are shown here working their way along a boom on *Royal Sovereign*, 9 August 1920.



Left: 'All lit up at night'. A familiar and spectacular sight in foreign ports and one that is remembered with great fondness. The superstructure and forward 15in turrets of *Ramillies* are illuminated while anchored at Alexandria, 1930.

Right: 'Stand easy'. After work there was a period when crews could either relax, play cards or write letters, etc. Here some of the crew are seen lazing on the forecastle of *Marlborough*.

Below: 'Crossing the line'. Every time a ship crossed the Equator there were ceremonies and games on board. Any new rating or officer certainly went through it. The photograph shows some of the crew on *Repulse* receiving a ducking *c.*1926. Note the ever-present Neptune on the extreme left.

during the 1920s and 1930s), and these were the battleships with which he was so familiar.

In January 1948, when Lord Hall announced the scrapping of certain ships, he said: 'The First Sea Lord and I feel like padres taking a funeral service for a number of old friends. The ships the Admiralty is scrapping are old friends in every sense of the word to every officer and man in the Navy.' Without doubt, this was also the feeling of the general public. The period itself is probably the most popular with naval historians, enthusiasts and collectors alike, and when casting bait to ascertain what kind of book they would next like to see, the answer came back loud and clear – another battleship book, but with fresh information if possible, new drawings and different photographs. The first two requirements have not proved easy to furnish and the latter were even more difficult. There have been a few books on the subject over the past twenty years and a real 'dig' was needed to secure the required items. Masses of official documents have been consulted, but unfortunately many have been either destroyed or have gone missing over the years so a certain degree of continuity in the material is lacking. Private papers have been included and the drawings are from official Admiralty sources as well as unofficial ones from the author's archives. The photographs have been carefully selected so as to avoid the oft-repeated shots; those seen here will, in most cases, not have been published for 40 years.

Although the sailors and the man in the street were fiercely proud of the fleet, they probably never took much account of the technical changes that were taking place, perhaps because the general way of life itself was undergoing profound change. This book contains, I hope, a blend of ingredients to interest not only the technical man, but also the enthusiast, naval photograph collector, model maker and the general public, and is a tribute to all the crews that served in the Royal Navy's capital ships from 1919 until the end of the war in 1945.

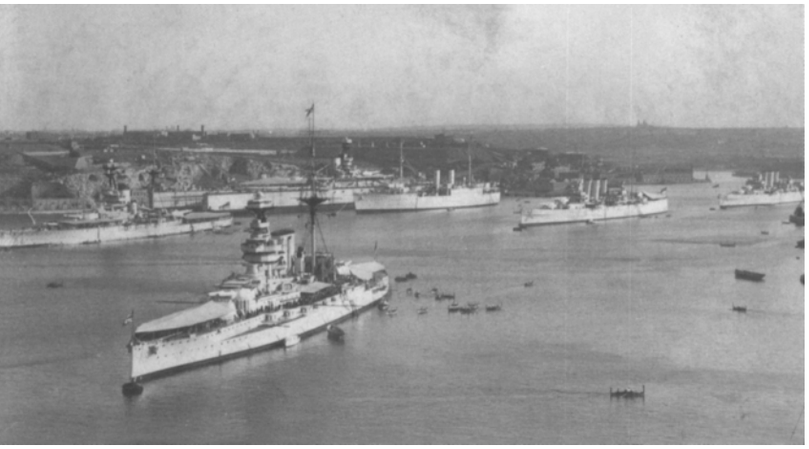
R. A. Burt, Rayleigh

Above, left: 'The concert party'. A spot of light relief to cheer up the crews and restore morale. Often the acting members would 'send up' the officers, which always received good applause. *Royal Oak.*

Above: Christmas Day at sea. The festive season was not the best time to be away from home. Nevertheless Jack made the most of it and there was much 'splicing of the Mainbrace' and plenty to eat.

Left: 'Football team'. Each capital ship had its own team, and there was fierce competition between the squadrons. Often there were periodicals for service use only to show who was winning what in football, rowing or boxing. *Repulse*, BCS, 1931.

Below, left: A visit to a foreign port and welcome shore leave. HM ships *Queen Elizabeth*, *Resolution*, *Revenge* (in dry dock), *Resource* and a *London* class cruiser are seen in the favourite port of Malta *c.* 1935.



Above: One of Jack's favourite pastimes was to get his head down for 'forty winks'. Newcomers to hammocks said that they took a lot of getting used to but once mastered they were more comfortable than conventional beds.

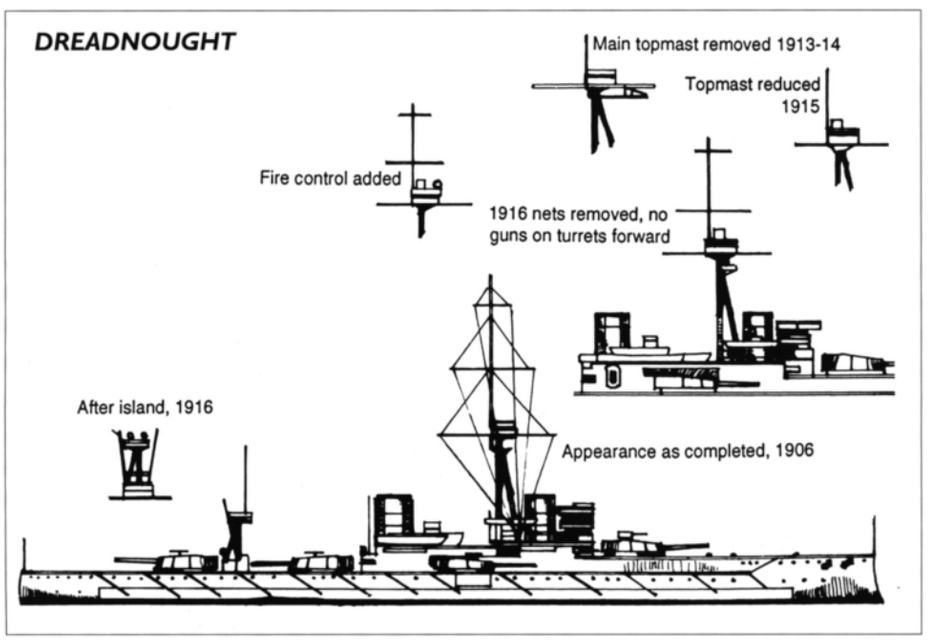
Evolution of the Dreadnought

The beginning of the 20th century saw the metamorphosis in British battleship design that signalled a departure from the practice of the previous ten years during which the basic design had adhered to a uniform layout (*Majestic*, 1893) with little or no improvement (see R. A. Burt, *British Battleships 1889–1904*). By 1902 there was a growing appreciation of the advantages of long range and it was being realized as a result of practical experience that action could be commenced at ranges up to 10,000 yards rather than the 3–4,000 yards that had been the norm up to this time. It also became obvious that fire control would have to improve greatly if the all-important accurate spotting of the fall of shot were to be achieved. Moreover there was a need to give British battleships a heavier armament (only 4 x 12in for the last ten years) so that an enemy ship could be overwhelmed by a huge weight of broadside before he could bring his own guns to bear.

In 1904–5 intelligence reports from the Russo-Japanese War confirmed many of these theories and suggested that it would only be a matter of time before one of the leading maritime powers seriously considered building an all big gunned ship to suit long-range fighting requirements. After hearing a general intimation from abroad that Russia and Japan were thinking along these lines for any future construction, and that the United States had indeed gone farther by actually laying down such a vessel, the Admiralty needed no further stimulus.

When Admiral Sir John Fisher was appointed First Sea Lord in October 1904, the first thing he did was to gather a staff who were of the same mind as himself – that Britain should be the first to build the first new type of ship. His position and drive ensured that a prototype was laid down in October 1905. Named HMS *Dreadnought* at Fisher's instigation, the vessel was built in an unprecedentedly short time (1 year and 1 day) and became the first all big gunned turbine-driven battleship to go to sea.

Fred Jane, the eminent naval historian, once asked 'What is a Dreadnought?' and for some strange reason the question agitated many people. In the columns of *The Scientific American* during 1909, a Major Boerum Wetmore of Allenhurst, New Jersey put forward the vessel *Roanoke* as the first true Dreadnought type and stated that with her two 15in and one 11in guns she should rightfully take this position in history. What he forgot to mention, however, was the fact that *Roanoke* was a converted frigate which had been razéed, plated with iron, armed with large guns and was, on the whole, very experimental. She also proved to be quite unsatisfactory. She was precluded from service in Confederate waters and although serving with the North Atlantic Squadron for a year proved to be a terrible seaboat, the weight of her giant turrets making her roll dangerously and the thrust of her spindles always threatening to force her out of keel when the turrets were keyed up for action.



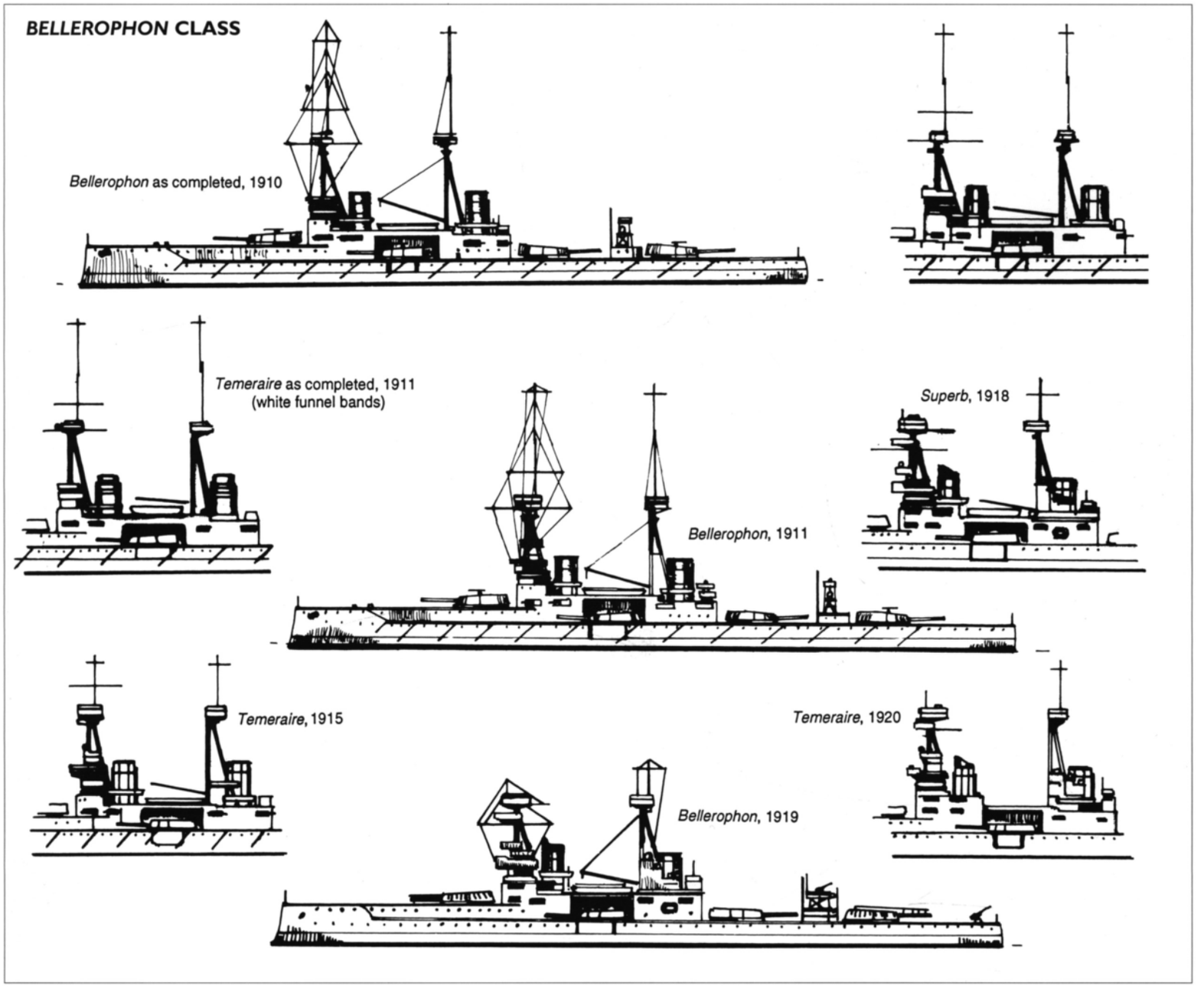
A Mr Percival Hislam replied to the Major's letter, defending the claims of early British vessels and putting forward the *Royal Sovereign* of 1864 as a contender. 'This ship was the first true Dreadnought type,' he said. As was *Roanoke*, *Royal Sovereign* was a converted wooden hulled ship which had been iron plated and armed with five 10.5in guns mounted along the centre line, and could rightfully claim to be the first British turret ship.

The undaunted Major returned the charge with *Onandanga*, another monitor authorized by Congress in 1861. He stated that, '... she was of high freeboard and, armed with two 15in guns, must take preference to the *Royal Sovereign*'. This small war of words swelled the columns in the Press for some time, and it seems as if the conclusion was that the definition of a Dreadnought was 'a seagoing all big gunned ship' in which case the United States can rightfully lay claim to having had the first vessels of this type. In 1859 in his book *The Navies of the World*, Hans Busk, MA wrote 'At all events the authorities in the United States have not yet abandoned the principle of building gigantic vessels, in order to carry a few heavy guns.' The context referred to criticisms that had been voiced about the American idea, and predicted that it would be short lived. These ships were officially rated as 40-gun frigates, but actually carried only twelve, all mounted so as to ensure that seven could fire on either broadside. They were 345ft long and displaced 5,013 tons. The largest British warship of the day was *Marlborough*, a three-decker, 131-gunned screw ship displacing 4,000 tons. Clearly, those American ships embodied the principles of the true Dreadnought concept.

Although these facts should not be forgotten, the naval historian of today when asked the question 'What is a Dreadnought?' would almost certainly refer to the British *Dreadnought* herself, built in 1906, and others that followed her being loosely dubbed dreadnoughts or super dreadnoughts. This in no way reflects on any of the vessels previously mentioned, but there is a difference between modifying and experimenting with an existing vessel, and the design and construction of a true sea-going all big gunned ship. It would, however, be incorrect to claim that HMS *Dreadnought* of 1906 was the first to be designed as such, or indeed even the first to be laid down. Nevertheless, when one compares her innovatory features with existing or even proposed designs of 1906, a clear margin of superiority is apparent and at the time of her completion there was no comparable ship afloat; regardless of debate then and now, she can rightfully claim her position in naval history as the first true all big gunned dreadnought type.

When F.T. Jane gave his first opinion of HMS *Dreadnought* in 1906 after he had seen her in Portsmouth Harbour, it was obvious that he was more than a little impressed. His reactions published in *The Naval and Military Record* say it all:

> As regards those details which most strike the eye, perhaps the chief one is the bigness of everything. The mast, which is the most conspicuous object, has a peculiar massiveness about it. It



is a tripod affair but each tripod-leg is like the trunk of some enormous forest tree. Similarly the funnels. They are not particularly high, and end-on they are narrow to reduce wind resistance, but seen from the broadside they have the characteristic immenseness of the Dreadnought. Aft, the eye is caught by a couple of square box-like erections. They are apparently some kind of ventilator. Each is about the size of the tower of a village church. Everything is big; everything is on the grand scale.

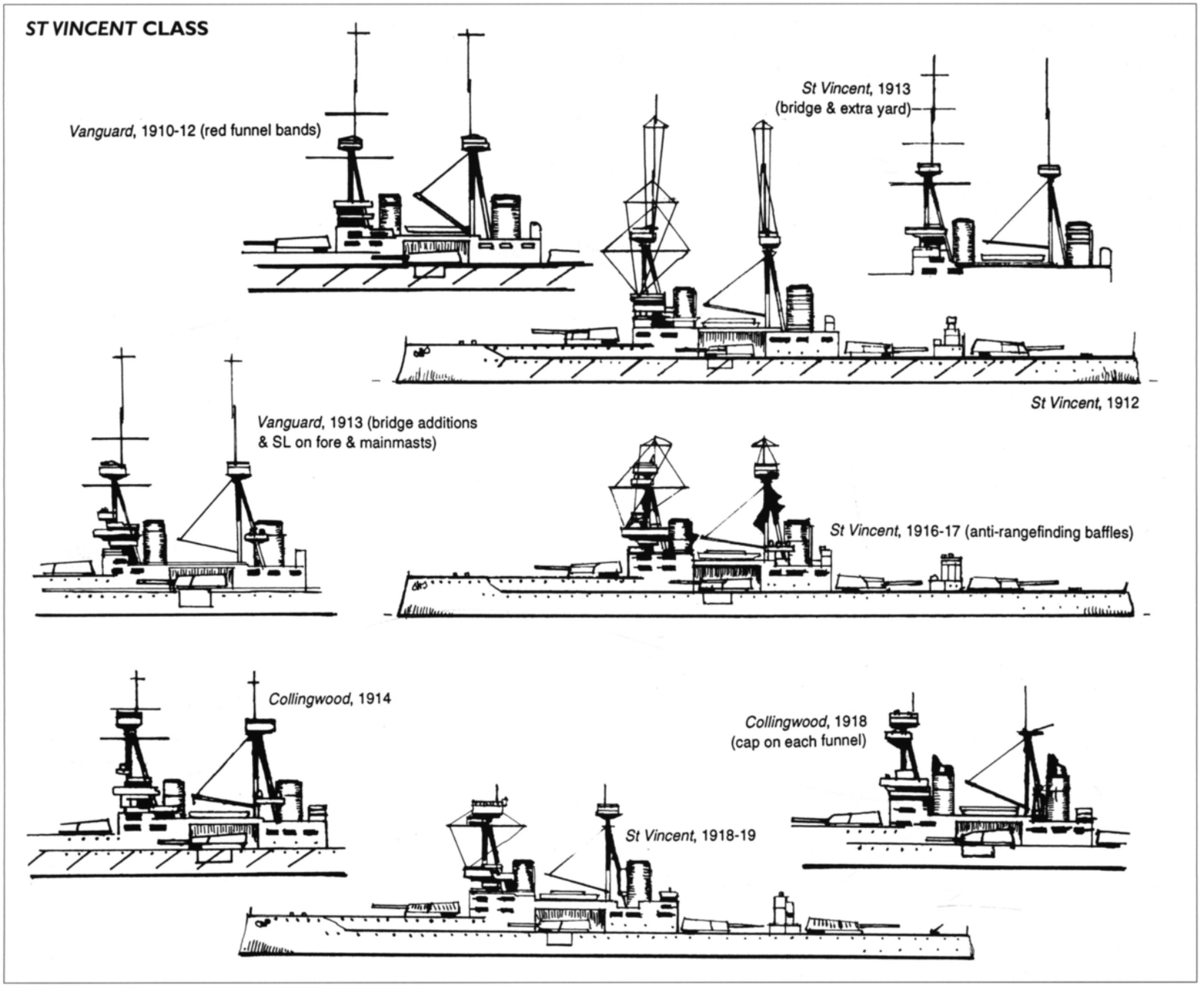
She is not in any way one's conception of a ship. Regarded as a ship I suppose she is ugly, because she is unconventional. But her ugliness is that of one of Brangwyn's best pictures alongside the oleographic effort of the conventional R.A. There is no Alma-Tadema about her. But she looks what she is – the embodiment of power, of solidity, of all that we delight to call English and which some neurotics call Philistine. One's first and last conception of her is that.

It is well documented that *Dreadnought* started one of the greatest arms races ever known, but for all that it was Great Britain that had managed to lead the field in construction technology by the time the Great War had started in 1914. Suffice to say that never before had a single type of ship caused such controversial mayhem and practical upset – and certainly never since.

From *Dreadnought* onwards the vessels remained a source of debate, but remain they would for the next forty years as the supreme capital ship in the navies of the world. Toppled somewhat by the ever-increasing submarine warfare and finally the arrival of the accurate airborne torpedo-bomber launched from aircraft carriers, the battleship was slowly relegated to subsidiary duties. Her demise was forecast as long ago as 1920 but she still served on with distinction throughout the Second World War and in fact was still at sea as late as 1991 in the US Navy, proving that there has been little to compare with her power even by modern standards; the battleship has no equal and at times there is still a demand for heavy gunfire – not a bad record for a type of vessel primarily designed more than 100 years ago.

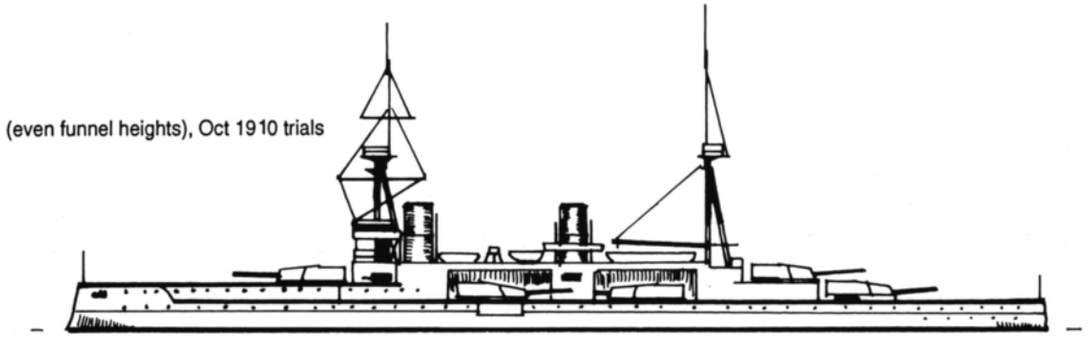
Some of the British battleships that followed *Dreadnought* were as different from her as she had been from the *Majestic* of 1893,

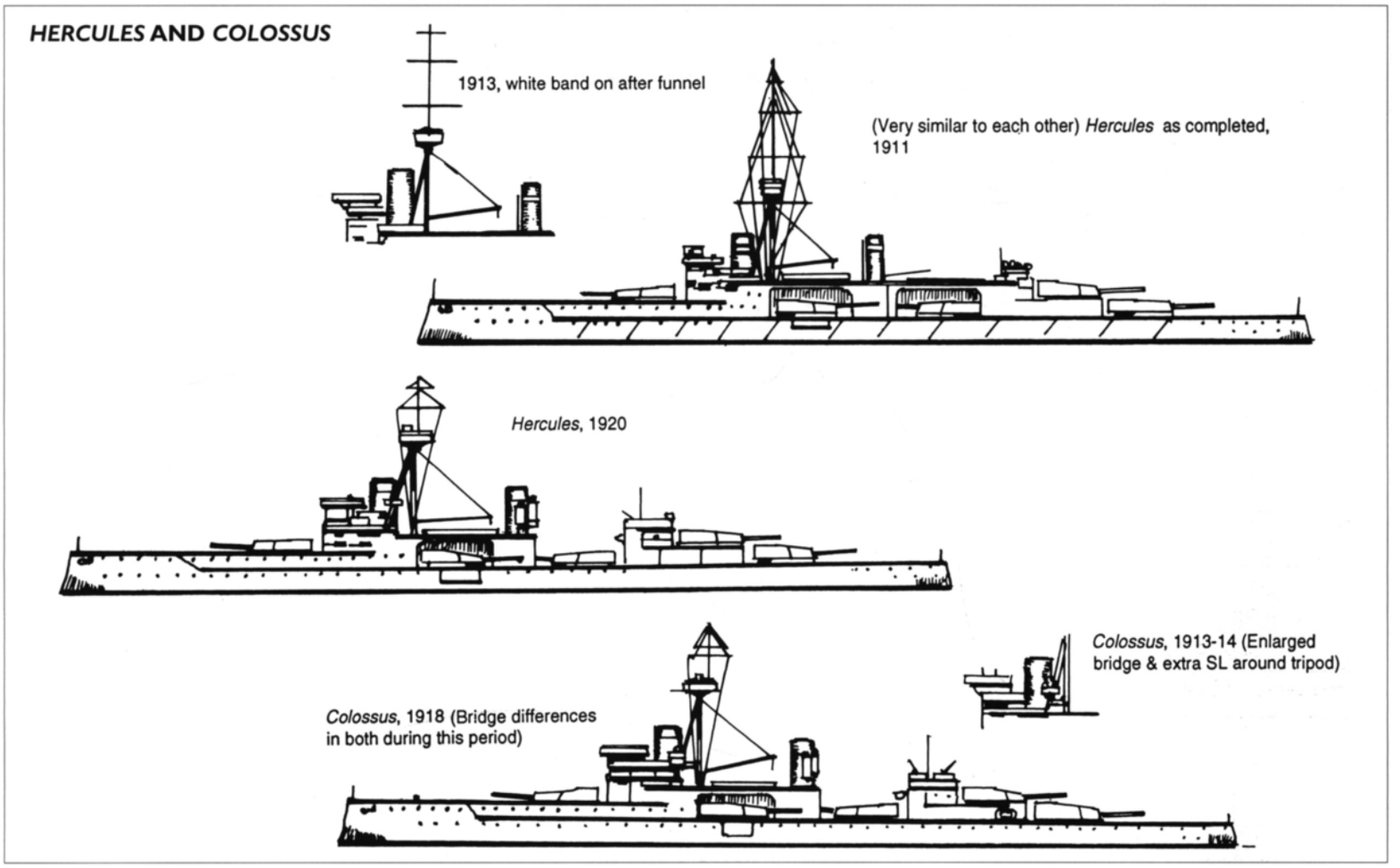
ST VINCENT CLASS

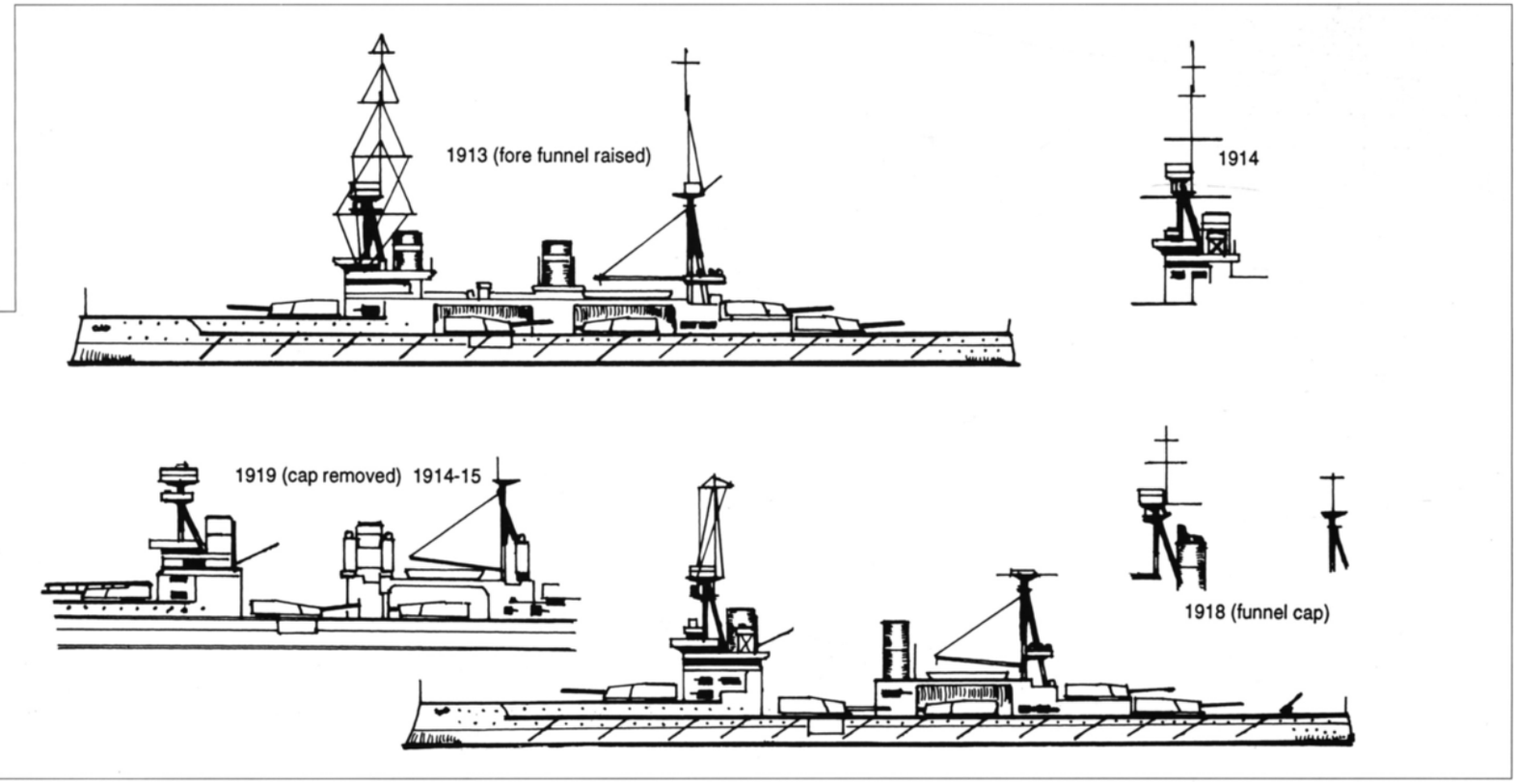


NEPTUNE

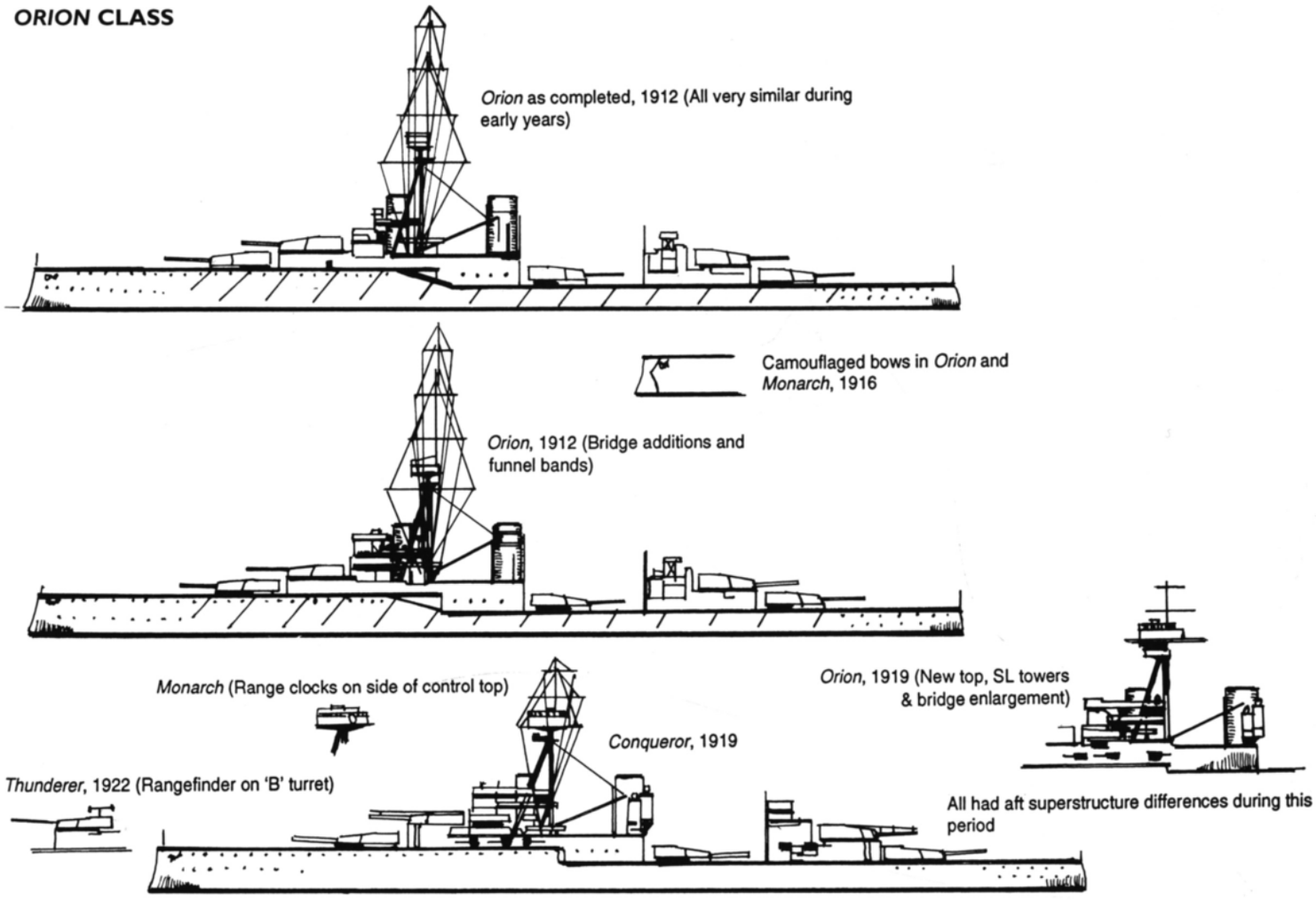
As completed



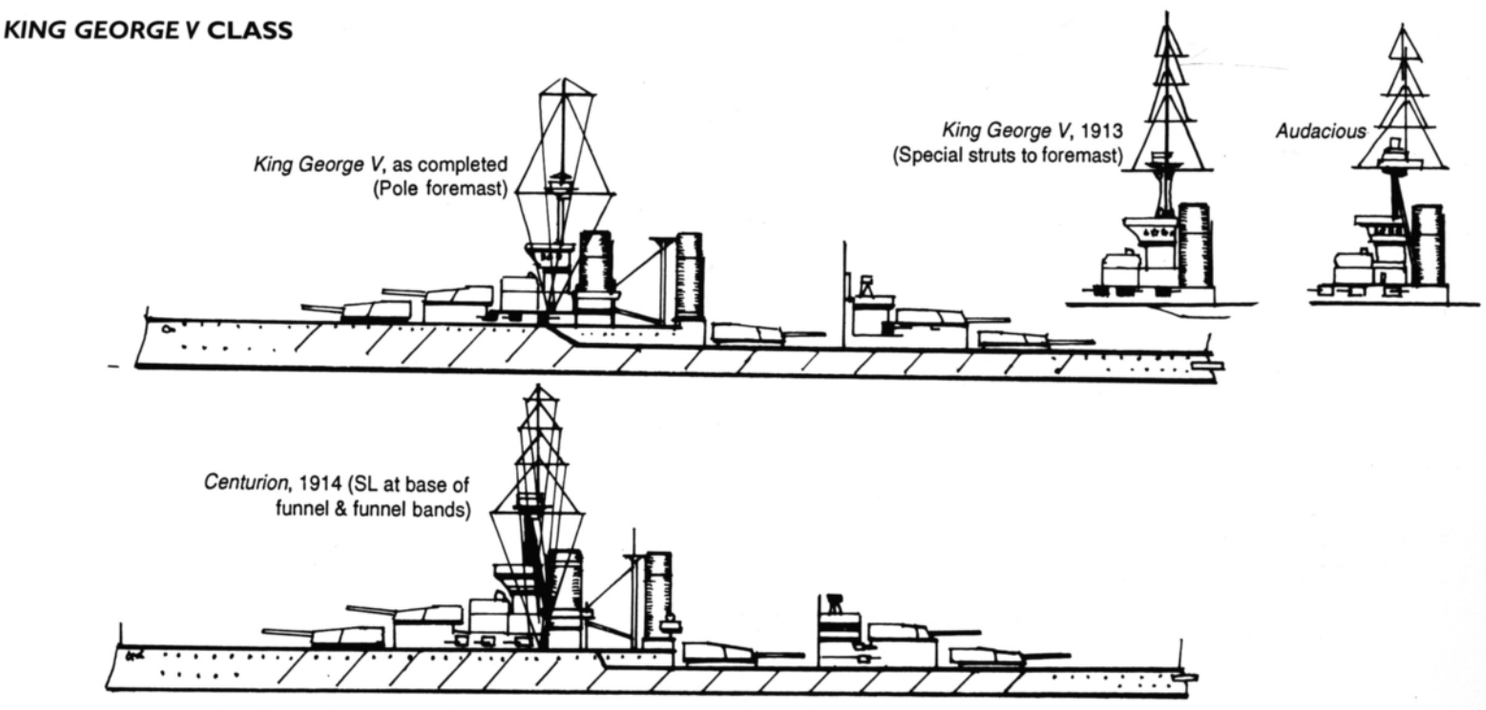

HERCULES AND COLOSSUS
1913, white band on after funnel
(Very similar to each other) Hercules as completed, 1911
Hercules, 1920
Colossus, 1913-14 (Enlarged bridge & extra SL around tripod)
Colossus, 1918 (Bridge differences in both during this period)

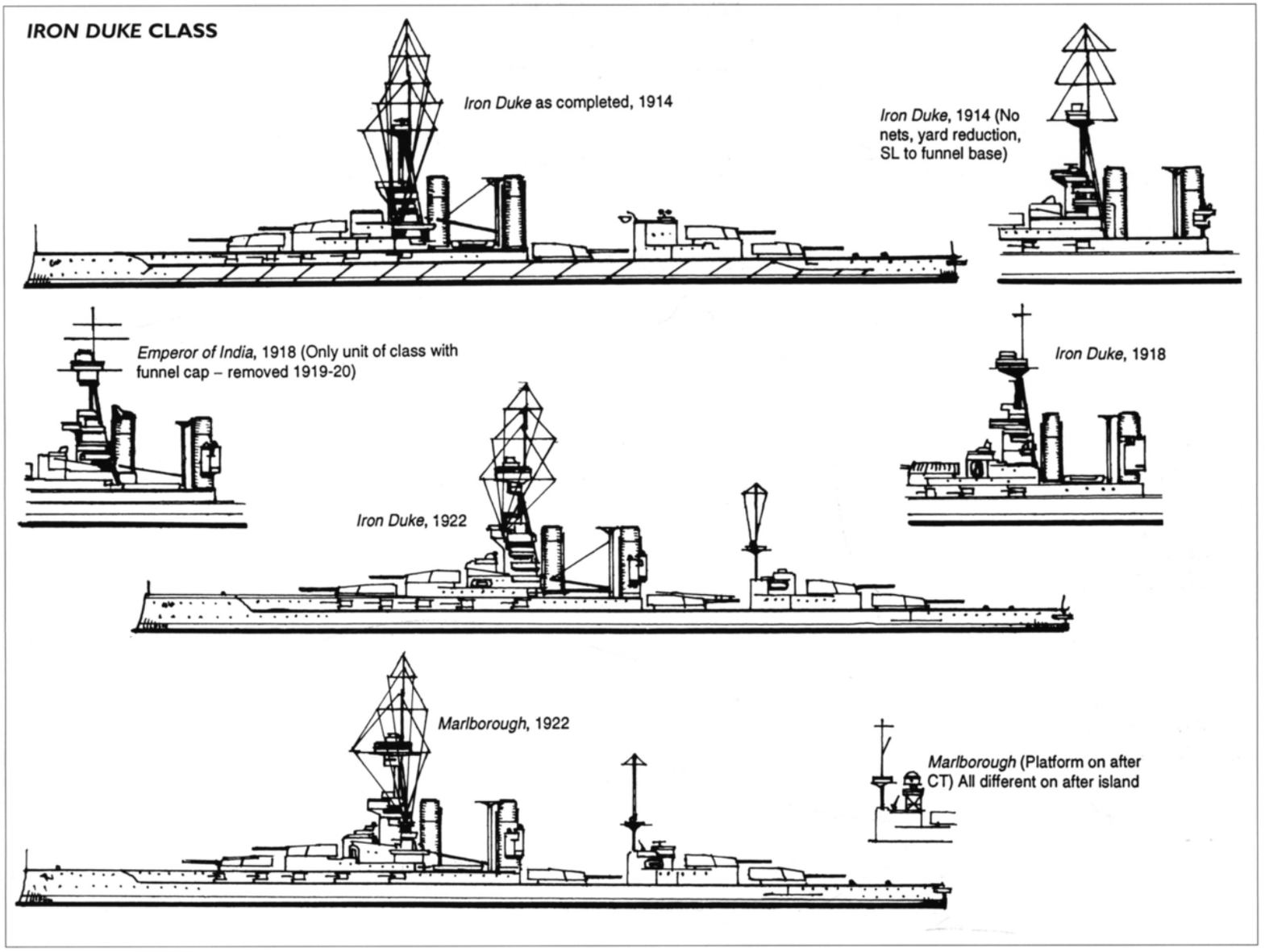

1913 (fore funnel raised)
1914
1919 (cap removed) 1914-15
1918 (funnel cap)

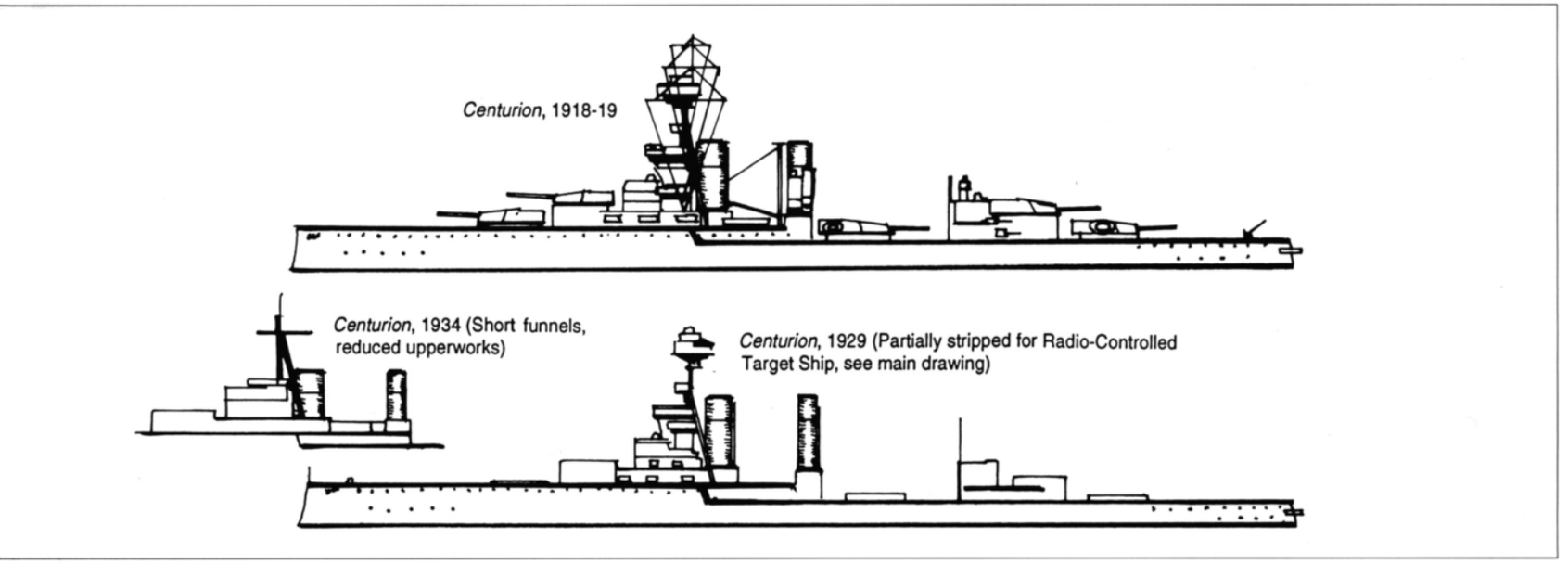
ORION CLASS

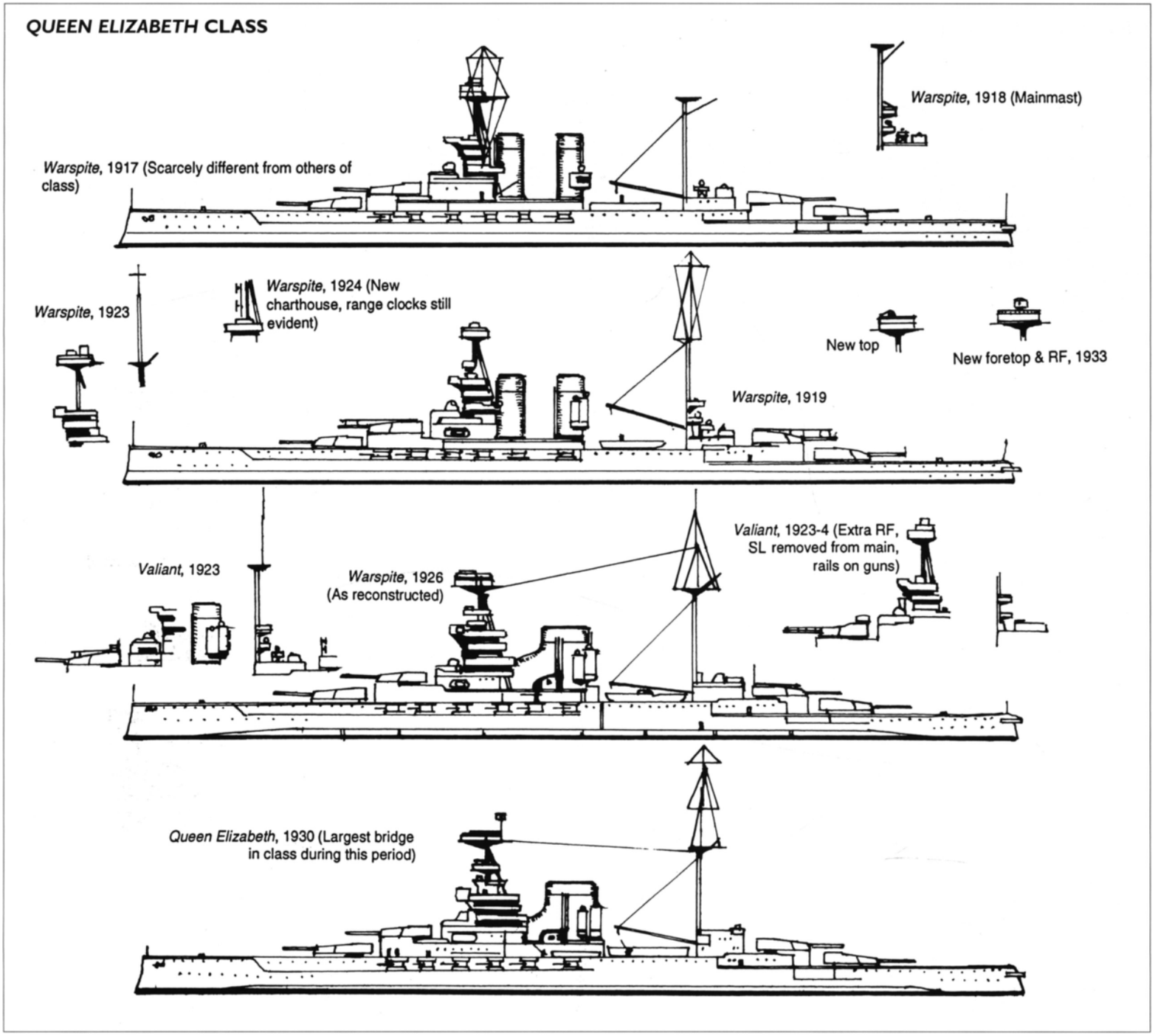


KING GEORGE V CLASS




IRON DUKE CLASS
Iron Duke as completed, 1914
Iron Duke, 1914 (No nets, yard reduction, SL to funnel base)
Emperor of India, 1918 (Only unit of class with funnel cap – removed 1919-20)
Iron Duke, 1918
Iron Duke, 1922
Marlborough, 1922
Marlborough (Platform on after CT) All different on after island


Centurion, 1918-19
Centurion, 1934 (Short funnels, reduced upperworks)
Centurion, 1929 (Partially stripped for Radio-Controlled Target Ship, see main drawing)

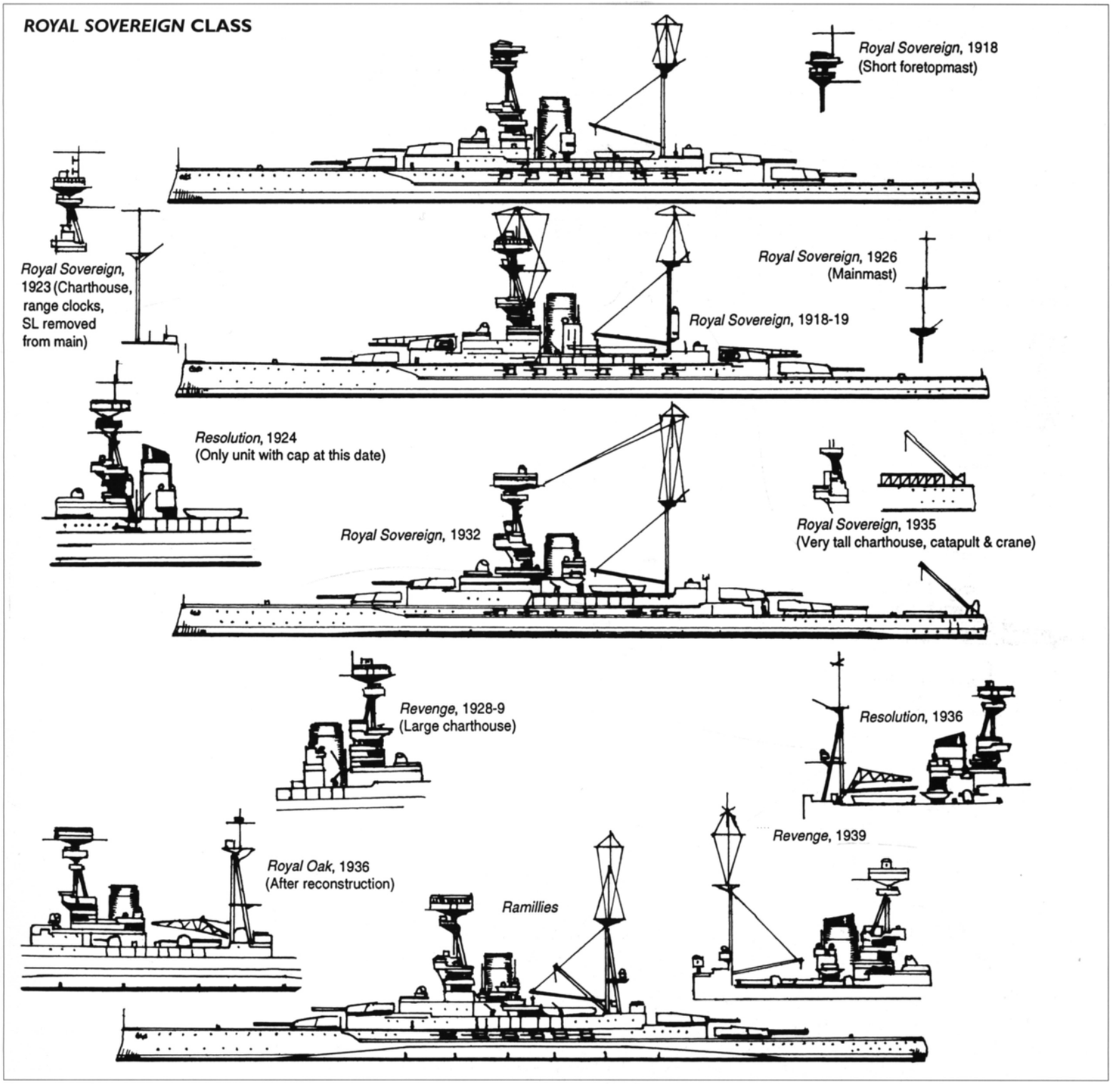


but they all had one thing in common in that they were all designed to carry the heaviest possible armament on a load displacement. In fact, gun sizes increased dramatically from 12in diameter to a massive 15in in just a short period of time when it was realized that modern layouts could only muster ten big guns in different arrangements without cramping the basic design. After *Dreadnought* in 1906 came the following classes: *Bellerophon*, *St Vincent*, *Neptune*, *Colossus*, *Orion*, *King George V*, *Iron Duke*, *Queen Elizabeth* and *Royal Sovereign*.

Three war purchases supplemented the Royal Navy's inventory during the war, *Agincourt*, *Erin* and *Canada*, and the world's first battlecruiser was laid down in 1906 (*Invincible* class) followed by the *Indefatigable*, *Lion*, *Queen Mary*, *Tiger*, *Renown*, *Courageous* and *Furious* classes.

During the Great War many improvements were made internally and externally of necessity because of action damage, and by 1918 the British capital ship was the most capable of its type in the world. The early Dreadnoughts saw limited appearance changes which usually amounted to little more than bridge and searchlight development, but the vessels that escaped the great scrapping programme of 1921 underwent drastic measures to keep pace with modern-day requirements. With no new ships (except *Nelson* and *Rodney*) entering service from 1920, it became difficult to keep some of the vessels fit for front-line duties and some of the designs suffered as a result. Nevertheless, it was a task that all navies had to undertake.

It is difficult to give a comprehensive account of internal alterations made from 1920 to 1945 because many of the refit docu-



ments have been lost or destroyed, but at least photographic evidence, where existing, shows us the external alterations that were made, and it is hoped that the small-scale drawings in this chapter will give an insight to the procedure of development from *Dreadnought* in 1906 through to *Royal Sovereign* of 1913 (the last battleships to be built during the Great War). Some of the basic changes to look for are:

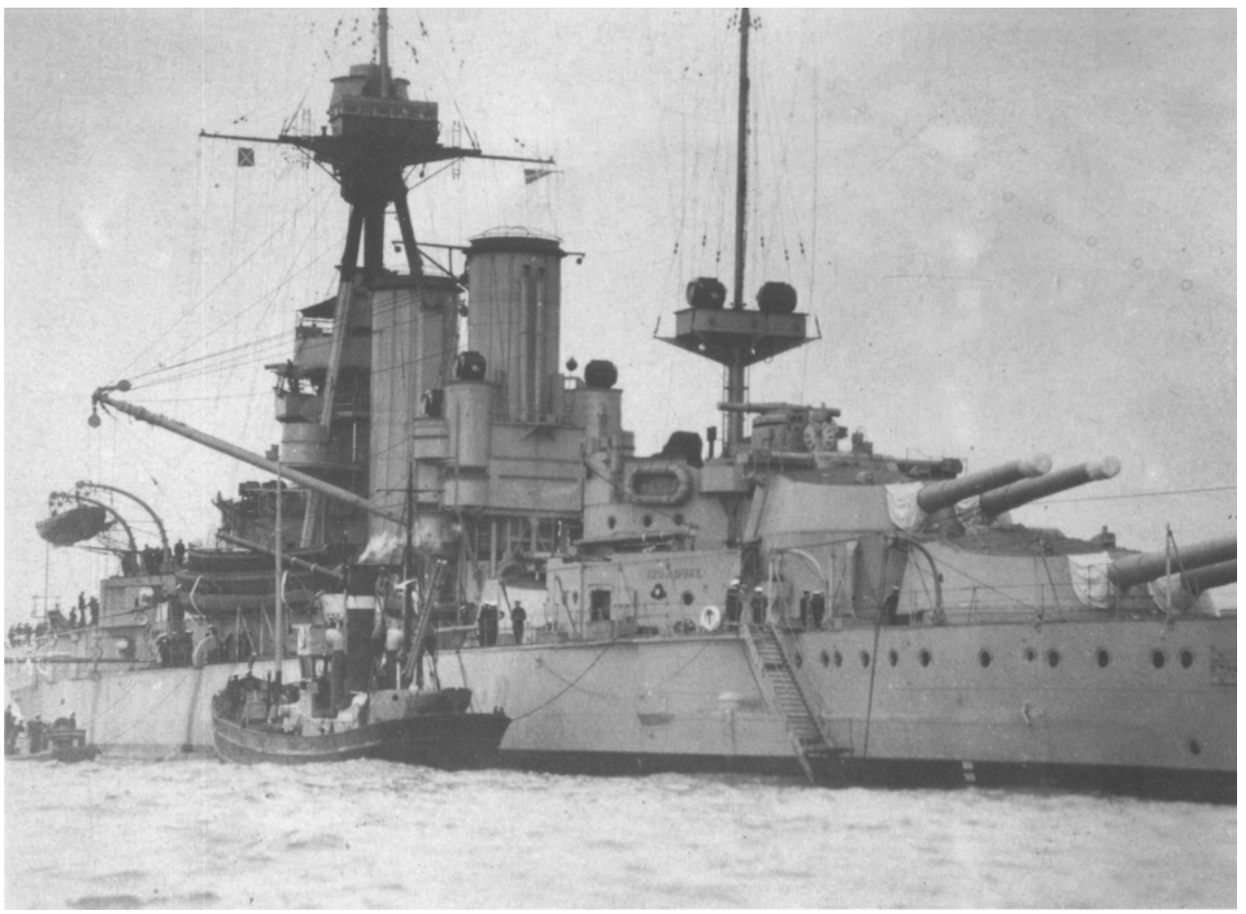
Extended bridgework.
Anti-torpedo net removal.
Drastic searchlight redistribution.
AA guns added.
Searchlight towers around funnels.
Removal of all flying decks.
Secondary armament closed in and given some protection.
Fire control installed.
New heavy foretops.
Reduction of topmasts.
Clinker screens to funnels.
Aircraft flying-off platforms on top of main turrets.

Post-War Reorganization and Naval Treaties

Although the Great War had hit Britain's economy hard, it was realized that no reduction in her navy could be planned immediately hostilities ceased because of a great deal of uncertainty about the future. Burdened with a massive fleet it certainly did not need in peacetime, the Royal Navy was anxious to reduce it, but both America and Japan were busy planning massive construction programmes. Faced with these problems and the fact that the Treasury was not exactly forthcoming with the appropriate funds, the Admiralty had to decide whether it would be beneficial to build new ships or reconstruct some of the many warships in service that were fast becoming obsolete. Either measure represented severe financial outlay, but, given its international commitments, the Admiralty was practically forced into an uneasy situation of a battle fleet reconstruction. The war ended in November 1918, but it was an uneasy peace so far as the Royal Navy was concerned. What was to be done with the massive German fleet that had just arrived in Scapa Flow – not to mention the crews aboard the ships? Writing for the Admiralty Reconstruction Committee Sir William May stated:

> The work of the A.R.C. cannot be satisfactorily proceeded with unless a definition of policy on which to work is decided upon. The majority of questions to be considered hinge exactly on the peace terms and consequently the strength at which the Navy is to be maintained. What peace terms may be is impossible to say definitely, but they might be on the terms of the following:
>
> 1. A patched-up peace, i.e., one which would be little more than an armistice and in which the nations would continue to develop preparations for possible future hostilities.
> 2. Peace terms which, though apparently lasting, would not bind entirely, any or all of the opposing nations to a definite demobilization of their armed forces, or which would entail only a partial reduction in the preparations for war.
>
> It is not therefore possible at the present time to base a reconstruction policy on the future terms of peace but it may be assumed that economic considerations will govern this policy. Whatever the peace negotiations may determine, there can be little doubt that all the belligerent nations will, from the financial point of view, do their best to reduce expenditure and cut down their armaments to avoid involving themselves in further expenditure on war requirements.
>
> Great Britain with other nations will have to reduce expenditure on the navy to the lowest possible point compatible with retaining it in such a state of efficiency and superiority as will enable it to meet the German Navy in case of further war.

On 21 June 1919 the German Navy ceased to be a problem when it scuttled its huge fleet while at anchor in Scapa Flow, but this was not entirely to the satisfaction of the Admiralty because the German ships could have been put to good use in the Royal Navy by using materials, or by scrapping them and using the funds towards fresh construction. But the High Seas Fleet had gone.



Right: Port quarter view of *Iron Duke* in Weymouth Bay, 1929.

During the second post-war year (1920), however, a situation came about to prompt consideration of new construction at an unprecedented level so far as battleship size was concerned. It seemed that the war had done little to end the struggle for naval supremacy, but merely substituted Japan for Germany. Moreover, America was preparing to rebuild its battlefleet completely to meet any challenge world-wide. On the drawing-board were: America: six battleships (*Indiana* class, 43,000 tons); six battlecruisers (*Constellation* class, 43,000 tons); Japan: two battleships (*Kaga* and *Tosa*, 40,000 tons); two battlecruisers (*Amagi* and *Akagi*, 43,000 tons); two battleships completing with 16in guns (*Nagato* and *Mutsu*, 33,000 tons). It was impossible for Great Britain to ignore such a threat and preparations were made to meet the new ships.

Early in 1921 orders were given to scrap dozens of the 1914–18 veterans to make way for new construction. The original *Dreadnought* plus all battleships and battlecruisers built from 1907 to 1910 were sold – the largest scrapping programme up to that date.

At a stroke the Royal Navy had reduced its power of sea supremacy to an all-time low. Gone was the 'Two Power Standard' of the late 1900s and the struggle was on to maintain a suitable level to meet different requirements. By the end of 1921 the DNC and staff had produced designs for what were probably the finest and most powerful warship to date. The 1921 battleships and battlecruisers matched (in most cases completely outmatched) anything in foreign navies and moves were made to lay down four of them simultaneously (see *Nelson* class and G3 designs).

When the figures for these ships were released, both America and Japan were less than pleased because it meant that they would have to build even larger ships than envisaged. The only solution was to call a meeting to consider a disarmament policy that would considerably reduce what was perceived as a future war programme, with Great Britain, America, Japan, France and Italy all invited. The delegates met in Washington on 12 November 1921 to discuss a suitable treaty and without going into the very difficult negotiations that took place and the fact that Great Britain conceded much more than any other nation, it will suffice to show the actual results. The treaty made provision for the scrapping of a very large amount of tonnage: America to retain eighteen capital ships with an aggregate of 500,650 tons; Great Britain to retain twenty-two with an aggregate of 580,450 tons (America to retain a smaller number of capital ships because the American ships were, in general, later and larger than those of Britain). Japan retained ten capital ships aggregating 301,320 tons. The maximum for any replacement tonnage was fixed at 525,000 tons for America and Great Britain and 315,000 tons for Japan. France retained ten ships for a total tonnage of 221,170 tons and Italy ten aggregating 182,800 tons. Each nation was permitted to lay down new tonnage in 1927, 1929 and 1931.

Each nation was allowed a replacement allotment of 175,000 tons. It was agreed that none of the powers should build a replacement capital ship displacing more than 35,000 tons and armed with greater than 16in guns, and the age limit for capital ships was fixed at twenty years. It was also agreed that no power should build more ships than the minimum required. After a heated debate, and as a concession to Great Britain, the Royal Navy was permitted to construct two ships of 35,000 tons armed with 16in guns (*Nelson* and *Rodney*) because the American ships under construction (*Colorado*, *Maryland*, *West Virginia*) and the Japanese pair (*Nagato* and *Mutsu*) were armed with 16in guns. The agreement was signed on 6 February 1922.

There were many in Great Britain who saw the Washington Naval Treaty as the end of the Royal Navy as the supreme power in the world's oceans, and in a strict sense this was true. The DNC, Sir Eustace Tennyson D'Eyncourt, wrote:

Dear Mr Lloyd George,

I wish to place before you my views on the subject of the present Conference at Washington, more particularly regarding the proposal for a Naval Holiday. There appears to be a tendency to set on one side the opinion of naval and technical men on the subject.

This is very dangerous, and as Chief Technical Adviser to the Admiralty, I feel it my duty to give you my definite opinion.

A ten-year naval holiday would result in a complete debacle in the matter of efficient naval material. It would take us many years to recover the ground lost and we should absolutely cease to retain the lead we have held for so long in the matter of thorough efficiency of our ships.

I need not weary you with all the details and arguments on the subject, but it is in my very carefully weighed opinion that our present ships would be altogether obsolete in a few years. Some of them are nearly so now, and we should be unable to produce the best ships to replace them after a long period of inactivity such as proposed. We have had practically four years' 'Holiday' already.

You will never produce A1 material if you stop constructing; without an A1 Navy we are finished.

The French are logical in asking the great powers if they can give assurance and guarantees against aggression from Germany. If not the French say they must have the army they consider necessary. We should be equally logical in saying 'can you give us a guarantee at securing our communications our food, etc., in case of war? If not, we must have the Navy we consider necessary.'

Insistence upon a thoroughly efficient if not large navy should be our equivalent cry to the American Monroe doctrine, and it is far more vital to us. A ten-year Naval Holiday would render this impossible.

There are those who wish deliberately to wreck our capacity for producing efficient war material. That cannot be permitted, as we should be at the mercy of other European powers – perhaps Germany and Russia or a latin combination in the future.

These 'peace at any price' people may argue that we can restore the Navy at any future time; that is a delusion. When once it has been allowed to go down, it will take years to restore; this applies to both material and personnel. It is therefore absolutely necessary to continue building at a reduced rate, but not to stop. The Navy is the sole life-assurance of the nation.

The careful householder may effect economies in many directions, but he never allows his insurance premiums to lapse.

Possibly the old saying *Si vis pacem para bellum* requires qualification, but the converse *si vis bellum para pacem* is certainly true.

During the years following the Washington Treaty there were constant talks aimed at further reducing any show of naval strength:

League Preparatory Commission, 1925

At the end of 1925 the Council of the League of Nations brought into being a Preparatory Commission to take over the work which had been going on since 1921. It stated that the maintenance of peace required further reduction of national armaments to the lowest point of consistency. Although a good idea in principle, it was found that it did not do away with the 'germ' of renewed naval competition. It became a simple case that the great maritime powers could not agree on a suitable limit to tonnage and just how many warships of different types should be scrapped and what should remain.

Geneva Conference, 1927

On 20 June 1927 Britain, America and Japan met again for renewed talks on the further reduction of the armed forces of each nation. Italy and France did not attend in their full capacity but sent observers instead. The failure of the meeting lay in the inability to agree on cruiser strength because of each nation's different requirements. The British suggestion that cruisers be divided into two classes: 10,000 tons and 8in guns, and smaller cruisers with 6in guns did not go down well with the Americans.

Pact of Paris, 1928

A pact by which 56 nations agreed to renounce war as an instrument of policy was signed on 27 August 1928.

Anglo-American conversations, 1929

Talks between Ramsay MacDonald (Prime Minister) and President Hoover took place during June 1929 when the President stated: 'We must find a yardstick with which to make reasonable comparisons' of naval units. During most of the talks since 1921 it had become increasingly difficult to get all the parties to agree on anything. Each country still insisted on doing what was best for its own navy. There was much talk of constructing smaller battleships than were really needed and scrapping larger battleships that were not yet obsolete. Britain saw America as being particularly awkward and America felt the same of Britain. Japan, on the other hand, was seen to be becoming more distant from all parties concerned.

Naval Treaty, 1930

Talks finally evolved into action during the 1930 discussions when Britain, America, Japan, France and Italy all primarily agreed to limit warship construction.

1. The five powers agreed not to build any new battleships before 1936, but France and Italy could use up their unused tonnage allotted to them from 1927 and 1929.
2. America would scrap the battleships *Utah* and *Arkansas*. Britain would scrap the battleships *Iron Duke*, *Benbow*, *Marlborough*, *Emperor of India* and the battlecruiser *Tiger* (*Iron Duke* and *Arkansas* to be retained as training ships). Japan would scrap the battlecruiser *Hiei* (she was, in fact, retained as a training ship).

Further scrapping would take place over the next few years after the conference. Aircraft carriers were limited in size to 10,000 tons (new construction) and an even tighter limitation was proposed on cruiser construction.

From that date the naval side of British affairs was left to decay and many of the skilled workers, draughtsmen and shipbuilders left the service. Battleships themselves were thought to be completely obsolete and there were renewed calls to scrap the lot, but the situation in Germany, where the military element was on the move once more, led to disquiet throughout Europe and among the Pacific powers.

There was to be no more new construction until January 1937 by which time Germany was becoming a real threat and Japan had long gone her own way and was most secretive about her intentions. When the long capital ship holiday ended it had been agreed to limit new construction to 35,000 tons and 16in guns. This agreement was not at first favoured by the British who had instigated a move towards a smaller battleship which would have only 12in guns (see design notes) and displace about 25,000 tons. America, however, would not agree to this and a compromise was reached. No limit to the number of new ships was fixed, but it would be governed by financial restrictions imposed by individual nations.

Freed from the treaties that had so hampered it during the twenties, and thirties, the Royal Navy began a panic construction programme in January 1937, but was never ever again on a par numerically with America whose large resources easily outmatched all the other maritime powers. Thus Great Britain's battleships entered the Second World War ill equipped, under powered and at a stage of mid construction.

Introduction

Design

Although there were basic ideas regarding design that had been formulated in the light of war experience, it became necessary to re-evaluate the entire issue when preparing new ships, given the financial restrictions imposed after the war. Before and during the war types of ships were developed for certain basic roles, but it was found that they needed many additions and alterations if they were to be efficient in multiple roles. Many new types were built for special purposes (*Renoun* class, etc.), but as British capital ships had to be all things and carry weapons of all types, it was seen as unnecessary to load a ship down with all sorts of fittings it really did not need. It was argued that if a ship had a main role the designer would have a clearer idea of what was required. The question arose as to whether the differing qualities and functions of the battleship and the battlecruiser could be combined in one ship as a compromise. It seemed that there was no reason why such a type should not be more efficient than the two specialist types – the heavily armoured slow ship and the lightly armoured fast ship. The devastating outcome at Jutland, where lightly armoured ships came into contact with the enemy fleet before the slower, heavily armoured ships, made the prospect of a fast, heavily armoured ship an appealing one.

After the war there was no shortage of personal opinions and the DNC's Department was often bombarded with sketch designs from serving officers as well as from the private sector. One such sketch design came from Rear-Admiral Sir Richard Phillimore, KCMG, CB, MVO (President of the Post-War Questions Committee, 10 October 1919):

> Is there any intention of radically altering the system on which our ships have hitherto been armoured and placing the bulk of the armour in a horizontal deck covering the ships' vitals instead of on the side of the ship? If not, please state what reasons are considered to make this impossible as the main idea in capital ship construction or to make the placing of armour at 20 degrees to the normal preferable to placing it at 70 degrees. What conclusions were drawn by the DNC Department from the trials recently carried out on HMS *Swiftsure* and a target representing armoured protection of *Hood* abreast certain magazines? 10 x 16in; 16 x 5.5in; 4 x TT; 6,000 miles radius; speed 25 knots maximum; armour 6in horizontal; splinterproof control structures; no conning tower.

In the Admiralty corridors there was much talk of submersibles carrying large guns, super ships showing ridiculous features and, as always, the school of thought that was inclined to 'scrap the lot!'. After many months of post-war debate it was concluded with great clarity that if the big gun was still to be the primary weapon (which it was) the ship should be designed accordingly. 1. Make battleships as strong as possible. 2. Do away with torpedo tubes in large ships (they were dangerous in case of direct hit). 3. Give priority to special-purpose ships – cruisers, destroyers, etc. The argument against having two different weapons of offence requiring different tactics and making life difficult for the operators was a sound one that was heeded during those post-war years. Torpedo attacks were better made from specialist vessels: torpedo-boat destroyers, submarines or torpedo-cruisers. Any weight saved by deleting this weapon from capital ships could be better used in protection qualities.

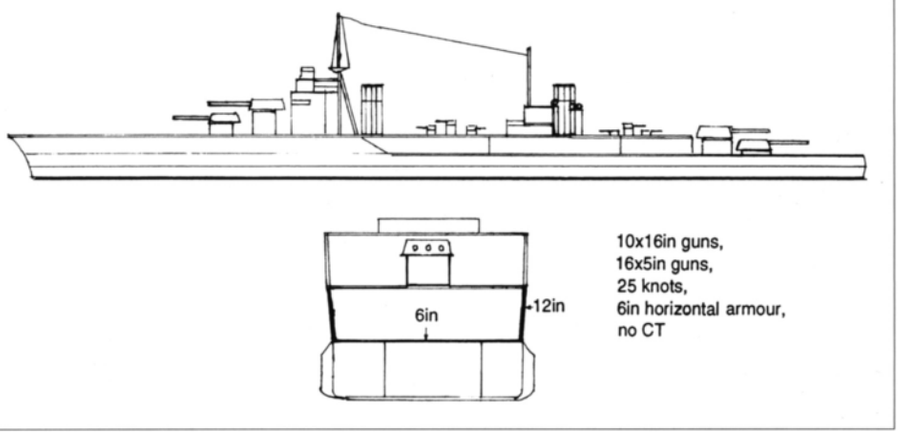
The influence of the Washington Treaty on design in the Royal Navy was profound, but Britain accepted the proposals, admitting that with regret she was no longer able to maintain the 'two power standard' she had enjoyed before the war. Since 1919 the Admiralty had been engaged in the wholesale scrapping of older vessels, but many were good ships that need not have been scrapped. The Washington Treaty only made matters worse; a letter in the German *Gazette* said it all: 'The Washington Conference may prove to be a milestone in the next war.'

The outstanding feature of the Washington Treaty was that naval strength was still classed in terms of capital ships, in complete disregard of the strong opposition that maintained that the day of the battleship was past. The ever-forceful Sir Percy Scott wrote in March 1922: 'Naval strength is no longer measured by the number of battleships a country has but by the number of aeroplane carriers and aeroplanes.' Clearly, however, it had been proved that although the submarines and aircraft were an essential part of the modern fleet, they were certainly by no means a substitute and future designs were prepared accordingly. Although no official sketches of a hybrid battleship/carrier were prepared, many unofficial sketches were put forward and make interesting reading.

Official sketches drawn up during 1920/21 before the Washington Treaty took effect, show ships of massive proportions. The first few were merely developments of *Hood*, but later culminated in a completely new type (G3) with 18in guns. There was obviously a need for a fast battleship and a slower, heavier armoured battleship, and these early sketches reflected just that. The battlecruiser type had in fact evolved into a fast battleship and the battleship into a huge, well-armed, heavily armoured and capable warship. Most of the sketches sported 18in guns at the largest and 16in at the smallest. To reach final layouts by November 1921 (N3–G3) proved quite complex and the designs had moved through more than eighteen stages (full development of type is described in Raven and Roberts' *Battleships of World War Two*). They came to nothing, however, and naval treaties were expedited to stop the very expensive, over the top, programme which no country could sustain financially. Some of the designs prepared for the G3 group and others that followed are shown in the *Nelson* class chapter, but there were also masses of designs produced in an endeavour to get round the Washington Treaty limitations and they seem to have been produced merely speculatively and to go on record for future use.

When one considers the policy and strength of the Royal Navy during the Washington Treaty discussions, one concludes that there was little realization at that time that the proposals as finally

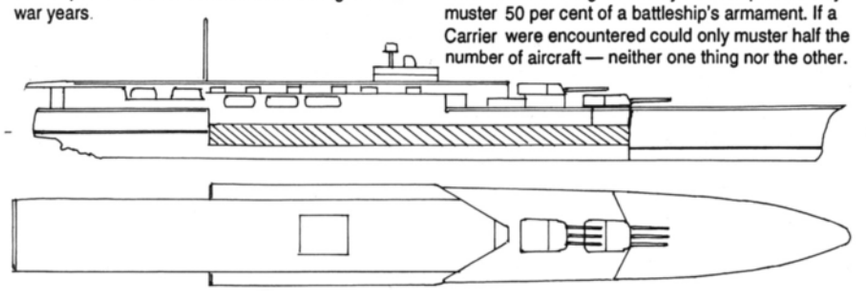
DESIGN FOR HMS *HOOD*
Submitted by the President of Post-War Questions Committee, 1919



BATTLESHIP-CARRIER PROJECT

One of the many variants of a typical Battleship-Carrier put forward for consideration during the inter-war years.

Reason for dismissal:
When encountering an enemy battleship could only muster 50 per cent of a battleship's armament. If a Carrier were encountered could only muster half the number of aircraft — neither one thing nor the other.



agreed would seriously restrict the decisions of those who were responsible for the design and construction of major fighting units. In fact the limitations, although feasible on paper, were just not practicable. As *Nelson* and *Rodney* completed (1927) and with a construction gloom for many years during and after their construction, it was only natural that new designs should be proposed. Those that were, however, were a compromise still based on severe weight and size restrictions and the sketches show this most clearly. Unofficially the battleship/carrier (see sketch) idea was being debated and in theory and practice it was actually feasible, but unfortunately it was never seriously considered.

After debate, staff requirements in 1928 for new battleships showed an improved *Nelson* type, but a return to four twin turrets mounted fore and aft as was usual standard Admiralty practice before *Nelson*. Twelve 6in guns remained as secondary armament but were more widely spaced than in *Nelson* (40 feet centre of turrets as opposed to *Nelson*'s 30 feet). The tertiary battery was eight 4.7in guns, and general fire control was a repeat of *Nelson*. To save weight the aft DCT was omitted and control was to be from 'X' turret. In the past the principal objections to the directing turret were: 1. The directing gun had to cease fire, since the loading operation interfered too much with the director layer. 2. A human link was introduced into the elevation and training transmission which introduced lag and errors into the system. Both these objections were largely discounted by modern methods of sighting turret guns and high-speed direct electrical transmission. The system was admittedly not so good as an independent director position, but was good enough for a rarely used alternative and certainly saved the use of personnel and officers.

Protection was similar to that of *Nelson*'s, but the serious threat posed by diving APC shells *vis-à-vis*, for example, *Nelson*'s shallow belt was now realized. *Nelson*'s arrangement of side armour had its advantages, but it was considered that placing the belt inboard from the waterline could result in projectiles glancing down to explode inside the ship and possibly passing under the armoured belt (see drawings). *Nelson*'s belt was severely criticized officially in 1927 and this fault was at last given serious consideration. The weakness, however, was never officially acknowledged. A meeting was held on 20 November 1928 to discuss Design 545-A+B and most items on the agenda were primarily agreed.

During those doldrum years it was necessary for Britain to watch foreign trends closely and strongly resist any commitment to single types (such as *Deutschland* and *Dunkerque*) being laid down. Certainly no group of ships was planned until it was certain that the design could match any foreign adversary. Displacement and gun calibre were fixed; the two remaining factors being speed and armour. In this respect it was considered sound policy to give any new ships normal battleship speeds and good protective qualities rather than strain the design for a high speed which, it was thought, usually fell off with age. One particular point in all the designs forwarded was that the main armament strongly favoured the standard twin mountings as in the *Queen Elizabeth* and *Royal Sovereign* groups.

A meeting was called by the First Sea Lord on 10 January 1934 to discuss the question of size of future battleships in the light of the approaching 1935 Naval Conference. The following factors governed the situation: 1. A proposal made at Geneva by Britain to reduce the size of future battleships to 25,000 tons with 12in guns, or alternatively ships of 22,000 tons with 11in guns. 2. The proposal by Japan for a ship of 25,000 tons with 14in guns. 3. The American wish to preserve the present size of ship and gun, namely 35,000 tons and 16in guns. 4. The recent construction by the French of a battlecruiser of 26,000 tons and 13.5in guns (*Dunkerque*). 5. The expressed wish of the Germans to build a larger battleship than *Deutschland*.

With severe financial restrictions in force and an unwillingness to build a fleet of gigantic battleships when the treaties allowed new construction again, it was thought that the US Navy might be willing to agree, under gentle pressure that is, to a reduced size of capital ship – about 28,000 tons with 12in guns. They were to be built to stand up against 16in gun fire, attack from 2,000lb bombs and 750lb torpedoes. The Controller was asked to investigate designs of a ship carrying eight, nine or ten 12in guns with a speed of 23 knots. Sketch designs were prepared (see table) accordingly and after some debate suitable arrangements were agreed. Unfortunately, however, no other maritime power showed the slightest interest in conforming to such moderate dimensions.

The sketches for these ships were well laid out and some of the features deserve to be highlighted:

1. Armour and protection. The belt armour was placed on the outside of the hull and not, as in *Nelson* and *Rodney*, slightly inboard. Experiments had shown that the vents provided in the upper portion of the bulges of *Nelson* and *Rodney* could be omitted without disadvantages. The outside position of the armour belt necessitated a different form of bulge from that in *Nelson*, but experiments showed that it was as effective as that in the latter ships.
2. A lower and thinner belt was proposed to be placed below the main belt to meet the impact and explosion of long-range projectiles falling short as in number four round against the target *Emperor of India* and afford protection to the magazines against such plunging shellfire hitting below the main belt.
3. Main armament. Very similar to that in the *Queen Elizabeth* and *Royal Sovereign* classes but better location arrangements were made.
4. Secondary armament. In most cases this was protected in turrets but some provision was made for armouring the turrets and barbettes.

The small battleship proposals having been dispensed with, the Admiralty returned to the main characteristics of the standard battleship which had been thoroughly worked out by November 1933. (For main dimensions see *King George V* class, 1937.) Designs on paper, although of great importance for theory and the historical record, do not in fact mean a great deal. It is comparatively simple to outline requirements in a sketch design, but to put these into practice, which means financial support and the solving of conflicting design requirements, is another matter. As can be seen from these notes designs took many directions and in fact the 1933 capital ship designs were very different from those planned during the 1920s when the Admiralty was looking ahead to the time when Great Britain could renew her battlefleet. The governing factor in designs although not straightforward are in fact easy to understand: 1. Financial considerations have priority. 2. Information about development abroad. 3. Fleet and staff

TABLES FOR VARIOUS BATTLESHIP DESIGNS, 1928 TO 1934

	'12A'	'12B'	'12C'	'12D'	'12E'	'12F'	'12G', '12H' and '12J'
Length (ft/in)	610	610	620	620	610	610	all similar to
Beam (ft/in)	96	100	100	102	100	104	'12A' except in
Draught (ft/in)	27	26	26ft 8in	26ft 2in	25ft 5in	25	displacement and
Displacement (tons)	25,040	25,430	26,700	26,800	24,690	24,930	'12J' had 3 triple
SHP	37,000	40,000	53,200	55,000	39,000	48,000	12in turrets.
Fuel (tons)	2,700	2,700	3,000	3,000	2,700	2,700	
Complement	1,264	1,266	1,286	1,286	1,166	1,264	
Main armament	4 twin 12in	4 x 12in	4 x 12in	4 x 12in	4 x 12in	2 triple, 1 twin 12in	
rpg	80	80	80	80	80		
Secondary	6 twin 6in	6 x 6in	6 x 6in	6 x 6in	6 x 6in	As '12A'	
High-angle	4 twin 4.7in	4 x 4.7in	4 x 4.7in	4 x 4.7in	4 x 4.7in		
TT	none	none	none	none	none		
Catapult and seaplane	1 of each	1 of each	1 of each	1 of each	1 of each		
Speed (knots)	23	23	25	25	23		
Armour:		As '12A'	As '12A'	As '12A'	As '12A'	As '12A'	
Main belt	10–3in						
Bulkheads	8–3in						
Turrets	12–8½–5¾in						
Barbettes	11–9in						
Conning tower	10–7–4½in						
Decks:							
Over magazines	6in						
Machinery	4in						
Steering gear	4in						
Conning tower	10–7–4½in						
DCT	2in						
Torpedo bulkhead	1½in						
Weights (tons):							
Hull	10,510	10,600	11,100	11,090	10,475	10,670	
Armour/protection	7,230	7,400	7,530	7,600	7,240	7,090	
Armament	4,190	4,190	4,190	4,190	3,810	4,020	
Machinery	2,050	2,180	2,800	2,840	2,150	2,090	
General equipment	1,060	1,060	1,080	1,080	1,015	1,060	

requirements. 4. Balanced design (well armed, protected and good speed). 5. Unrestricted displacement.

Without a free hand on all these requirements no maritime power in the world could have built the ships that it needed at that time, and the result was that those ships that were built shortly before the Second World War were untried and, if the truth be told, generally left much to be desired.

Armour

With the cessation of hostilities in November 1918 some of the longest and most important debates concerning standards in capital ship design began. Looking back at certain disasters during the war it was considered at some length (since 1916) that views regarding protection were over-influenced by the losses of the battlecruisers at Jutland. Apart from those tragic losses the war in general had highlighted the fact that modern battleships' (both British and German) armour had withstood gunfire very well. In fact even ships with pre-war standards of protection, which on paper did not have complete immunity from existing attack, still stood up very well to severe punishment and in most cases had made it back to port under their own steam.

It was considered that this capacity to take heavy punishment was the criterion of a good design, and all protection beyond the requirement of being able to withstand heavy hits was thought to amount to wasted weight. What the required protection ratio should be, however, varied a great deal from ship to ship. So far as armoured plating was concerned the Royal Navy entered the war believing that, at the fighting ranges favoured in 1914, 9in side armour and 4½in turret roof plating was immune against 12in guns which the German battleships possessed in great numbers. In 1920, however, the Post-War Questions Committee dismissed these thicknesses, and although some favour was given to medium-range armour it was questionable whether the present-day thicknesses (13in in *Queen Elizabeth* and *Royal Sovereign*) would be impervious to the ever-increasing power of the latest APC shells being developed.

Because it had stood up so well to British shelling, the perception of German armour as being superior had been exaggerated, the truth being that the old British APC shells were incapable of penetrating the magazines and other vital areas of German heavy ships in a fit state for bursting, so not too much importance should be attached to the fact that the ships were able to return to harbour after having been hit. Defects in pre-1917 APC shells of 12in and greater calibres were: 1. They broke up on oblique impact having only been proved at normal; 2. The burster was too sensitive to be carried through a thick armour plate; 3. Some failed at proof. The German ships never faced the APC shells that were developed after Jutland.

Luckily for British ships it was found that the German shells were not always up to much either; for example in 1915 an 11in shell hit the battlecruiser *Lion* at Dogger Bank and, although having pierced the armour plate, the shell was found lying on the crown of one of the turret magazines, the fuses having failed to detonate.

The latest ship at the end of the war was the mighty *Hood* but her protection had fuelled controversy from the outset, and it was proposed that a series of tests be held with a view to improving her if possible, and any other capital ship that followed. The Royal Navy was well aware of deficiencies in horizontal armour and as

early as 1921 made the following statement: 'We can lay down the important axiom that it must be made impossible for the enemy to destroy your ship by one fortunate hit, i.e., it must be impossible for him to ignite your store of explosives. Nothing else is of such vital importance as this. Hits which damage some of the engines and boiler rooms or turrets are of secondary importance. Accepting this principle it can probably be asserted that it is impossible to armour all the important parts of a ship completely against the gun you carry and which it must be presumed the enemy will also carry, but if your design and material are superior to the enemy's you will take correspondingly less risk.'

The form of protection to date (1920) was based on the principle that armour fulfilled its requirements if it remained unholed after attack by shells, and to this end the plates were so designed that their resistance to being holed was measurable. The measurement of imperviousness to particular shells was called the 'limit of resistance' of the plate against the shell. The power of attack up to 1917 made it possible to armour capital ships sufficiently well to render them capable of resisting shell attack (in most cases) at the ranges then envisaged. The introduction of the new APC shell greatly modified the values of shell and armour and the subject of relative strength came under great scrutiny. It was found that if new construction was to be immune against heavy APC shells of 15in calibre and greater, maximum armour thickness would have to be applied. These findings, however, did not quite coincide with a quote from the DNC; 'If such protection as will give, on paper, complete immunity against 18in attack be adopted, there are bound to be methods of defeating the ship and it is not difficult to picture a huge, superbly armoured vessel with its superstructure and control positions obliterated and its machinery personnel gassed, drifting at the mercy of the submarines or aircraft attending the enemy fleet. Such however is likely to be the fate of a ship in which offensive powers have been sacrificed to defence against a vessel in which superiority in offence has been the first consideration.'

After tests had shown just how good the APC shells were, the entire design of the Navy's new ships was open to question, and the Construction Department was constantly engaged in design development. The new shells would govern new standards of protection because it was obvious that other maritime powers would soon (if they had not done so already) reach adequate levels of shell ability. Trials showed that a large proportion of any target was represented by the deck, and making a ship invulnerable to shell hits in this area was exceedingly difficult within the limitations of capital ship design. Various modifications were tried, but the general conclusion was that unless some new radical form of armour were developed it was impossible to improve arrangements in heavy ships other than by increasing armour thicknesses far beyond the present level (1920 = 3in average) which would involve unacceptable weight addition.

It is impossible to deal with a single design feature, such as protection, in isolation. The designer has to consider the ship as a whole, all features depending upon one another. At that time (1920–21) speed was considered a most important factor in relation to other features of a ship, as it affected the other elements of the layout, with the exception of the armament. If machinery

Below: *Valiant* 1919, anchored in Scapa Flow overlooking the German battleship *Baden* which would later be used for firing tests to help evaluate armour protection.

TABLE FOR VARIOUS BATTLESHIP DESIGNS, 1928 TO 1934

	'14A'	'10A'	'16A'	'14B'	'11A'	'10G'	'12K'	'12L'
Length (ft/in)	660	620	692	620	600	600	630	620
Beam (ft/in)	104	96	106	104	98	98	102	102
Draught (ft/in)	27ft 6in	25	30	27	26	25	27	27
Displacement (tons)	30,700	21,670	35,000	29,070	23,300	22,000	28,150	27,750
SHP	60,500	54,000	45,000	43,500	48,000	48,000	80,000	80,000
Fuel (tons)	3,500	2,700	3,000	3,000	2,700	3,000	3,000	3,000
Complement	1,320	1,050	1,342	1,300	1,030	1,030	1,030	1,030
Main armament	4 twin 14in	4 twin 10in	4 twin 16in	4 twin 14in	4 twin 11in	4 twin 10in	4 twin 12in	3 triple 12in
rpg	100	80	80	100	80	80		
Secondary	6 x 6in	4 x 6in	6 x 6in	6 x 6in	4 x 6in	4 x 6in	12 x 4.7in	12 twin 4.7in
High-angle	4 x 4.7in	4 x 4.7in	4 x 4.7in	4 x 4.7in	4 x 4.7in	4 x 4.7in		
TT	none	none	none	none	none	none	none	none
Catapult and seaplane	2 of each	1 of each	2 of each	2 of each	1 of each	1 of each	1 of each	1 of each
Speed (knots)	25	25	23	23	24	24	27	27
Armour:								
Main belt	11–3½in	8–2½in	13–4in	11–3½in	9–3in	8–2½in	10–5in	otherwise as
Bulkheads	10–7in	8–4in	11–7in	10–7in	9–5in	8–4in	10–7in	'12K'
Turrets	14–9–7in	11–8–5¼in	15–6in	14–6in	12–5¾in	11–5¾in	12–5¾in	
Barbettes	12–11–10in	9–8–7in	13–10in	12–10in	10–8in	9–7in	10–7in	
Conning tower	11–8–4in	9–6–4in	12–6in	11–4¼in	10–4½in	9–4in	10–4½in	
Decks:								
Over magazines	6¼in	5½in	6¼in	6¼in	5¾in	5½in	6in	
Machinery	4¼in	3½in	4¼in	4¼in	3¾in	3½in	4in	
Steering gear	4in	3½in	4in	4in	3¾in	3½in	4in	
DCT	2in	2in	2in	2in	2in	2in	2in	
Torpedo bulkhead	1½in	1½in	1½in	1½in	1½in	1½in	1½in	
Weights (tons):								
Hull	12,000	9,460	13,400	11,250	10,000	9,800	11,500	11,320
Armour/protection	8,970	5,500	11,150	8,700	6,250	5,700	8,470	8,100
Armament	5,680	3,010	6,900	5,680	3,550	3,350	4,250	4,400
Machinery	2,950	2,800	2,450	2,350	2,500	2,500	2,880	2,880
General equipment	1,100	900	1,100	1,090	1,000	950	1,050	1,050

were reduced the length of the machinery space, the length of the armoured citadel, the amount of fuel, the amount of deck protection were also reduced, leading to, finally, a smaller hull with fewer fittings and less equipment. This was immediately apparent when the design of a battleship of say 22 or 23 knots was compared to that of a battlecruiser of say 30 knots and it was at once found impossible to give the same thickness of protection to the faster ship as to the slower. In HMS *Hood* it was found possible to provide the protection and even increase it over that of the *Royal Sovereign* class battleships while maintaining the same armament and giving the speed of 31 knots, plus a very heavy weight of underwater protection. This result, however, was only achieved by making a very big ship of great length and going to the extreme dimensions that the largest docks could accommodate, and it was here that British constructors came up against a difficult problem since the existing docks precluded ships of even a slightly larger size. Until larger docks were built (which they were not) the Admiralty would have to content itself with vessels of no greater dimensions than those of *Hood*.

It had long been known that the deck protection of the latest giant battlecruiser *Hood* left a lot to be desired, and as she neared completion the Post-War Questions Committee called for a series of trials relating to her deck strength. It was decided to use the new APC shell, which was capable of carrying through and bursting about 40 feet beyond the first plate struck, to determine any critical weaknesses, the main question being, was she adequate against the Navy's 15in APC shell? During the autumn of 1919 plates arranged to simulate *Hood*'s armour were tested. Test 1. Shell perforated and burst 40 feet behind 7in armour in the magazine. Test 2. With magazine roof thickened from 1in to 2in. Shell perfo-

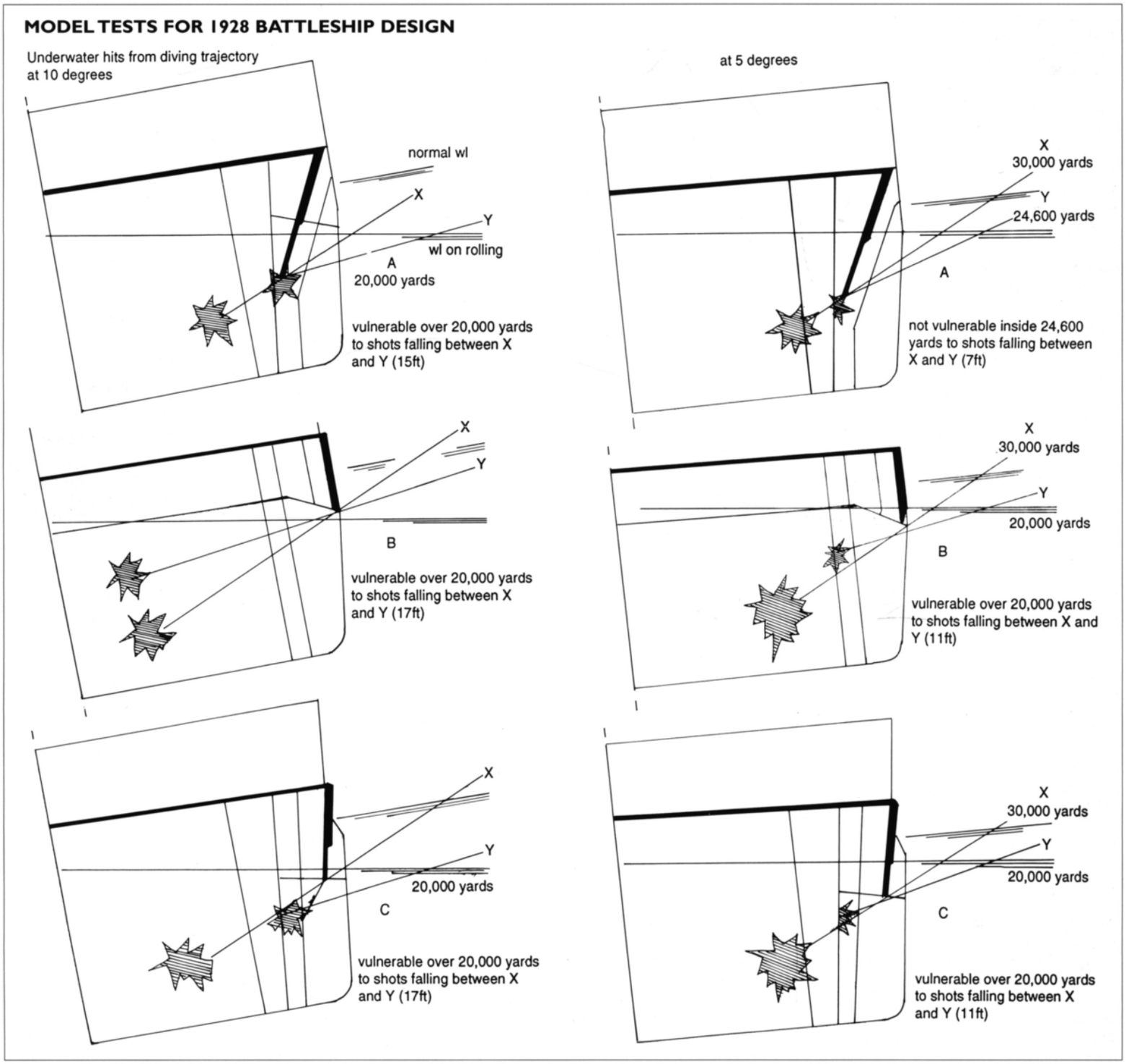
TABLE FOR VARIOUS BATTLESHIP DESIGNS, 1928 TO 1934

	'12N'	'12O'	'12P'	'12Q' Same
Length (ft/in)	614	614	634	as '12N' except
Beam (ft/in)	102	102	103ft 6in	12 x 12in guns in triple turrets
Draught (ft/in)	29	29	28ft 6in	
Displacement (tons)	28,500	28,130	28,500	
SHP	45,000	45,000	45,000	
Fuel (tons)	3,500	3,500	3,500	
Complement	1,378	1,400	1,425	
Main armament	8 x 12in	9 x 12in	10 x 12in	
rpg	80			
Secondary:	12 x 6in		otherwise	
High-angle	12 x 4.7in	all same	same as	
TT	10 above water	as '12N'	'12N'	
Catapult and seaplane	1 on turret			
Speed (knots)	23			
Armour:				
Main belt	9–6in			
Bulkheads	10–4in			
Turrets	11–5½in			
Barbettes	11½in			
Decks:				
Over magazines	5½in			
Machinery	3½in			
Steering gear	3½in			
Torpedo bulkhead:	2in			

rated and burst 34 feet in rear of 7in armour. Roof plate blown to pieces. Test 3. (See page 27). Target: 2in HT plate, 3in HT plate and 2in HC plate (magazine roof). Projectile 15in APC (weighted). Angle of descent 32 degrees striking at 1,350 feet per second. Corresponding range 25,000 yards. A weighted shell was used and the 3in HT plating representing the main deck was wrecked, but the shell did not penetrate and glanced off. Thus the modification to the main deck (as seen in the drawing) gave fairly good protection to magazines from shells hitting the side armour.

At the conclusion of the trials it was seen that the weight available to protect *Hood*'s magazines was inadequate against plunging fire unless the ship were re-built with a new deck of thick homogeneous plate. Later, however, it was proposed that more trials be carried out on the *Hood* deck target, with the main deck being reinforced by 4¾in roof plate quality armour. No approval for this was sanctioned, however, and although the matter was not dropped, it was seen to be impossible to modify a ship that had been designed to 1916 standards.

Further tests were carried out against armour in the captured German battleship *Baden* in 1921 and HMS *Superb* in 1922 (see *Nelson* chapter), and these yielded an amazing amount of data for future use. It was concluded in 1921–2 that a main belt of 14in



and decks of 7½–8in were necessary to keep out 16in and 18in APC shells at modern battle ranges and it was these thicknesses that were envisaged for the G3 design. By 1937, however, it had been decided that thicknesses would have to be greatly increased if they were to keep out modern bombs and shells, and the protection of the later *King George V* class (1936) was designed accordingly but within the limits of a maximum displacement of 35,000 tons.

Some comfort was offered in a note by DNC Tennyson D'Eyncourt: 'Looked at broadly it is considered that the action of the shell will not be quite so serious as the trials hitherto made would seem to indicate. The conditions of actual warfare do not in general test so severely the armour and protection of ships as do the trials specially made on the material. This is partly due to the angle incidence of the shell being frequently less than that taken, and partly to the fact that in addition to the vertical or deck armour which is erected for special trials, there is always the structure of the ship which adds very considerably to the protection afforded in practice and the chance of the shells hitting some of the very substantial structure of our capital ships is a very great one, and therefore the thickness of the protection given on paper is considerably augmented by the structure which is met with in the passage of the projectile.'

In general this applied to ships that served during the Second World War. It was to prove that shellfire was not the most important threat but aerial and underwater attack proved the most fatal of all. The new *Prince of Wales*'s 6in armoured deck was not pierced nor was her 14in or 15in belt, but she was most effectively sunk beyond the armour limitations. (For further tests against armour plates see Operation 'Bronte' in *Nelson* class chapter.)

Chemical Warfare

Gas and chemical warfare had shown their deadly possibilities for the first time during the Great War. The mustard and respiratory gases, that could burn, blind or choke men to death, were obviously seen to pose a major threat in any future conflict. Although never used at sea during the Great War, it had become possible to attack ships at sea with gas dropped from an aircraft, and the problem of anti-gas defence was much debated during the inter-war years.

The Admiralty set up a Chemical Warfare Committee which held its first meeting on 7 July 1920. One of the first battleships to undergo gas-attack tests was *Ramillies* (*Royal Sovereign* class) during the winter of 1920 but results showed that with her open bridge work and conning arrangements it was practically impossible to keep out poisonous fumes, and it would be an absolute nightmare if personnel faced such attack. More tests were carried out during the next few years – the most notable being in the aircraft carrier *Courageous* in 1922, but again, because of her numerous openings it was quickly realized that it would be extremely difficult to render many compartments gas tight. In August 1923 their Lordships received an article entitled 'Protection of Capital Ships against Poison Gas' which highlighted tests and trials in which the US Navy had been engaged. The article had three headings:

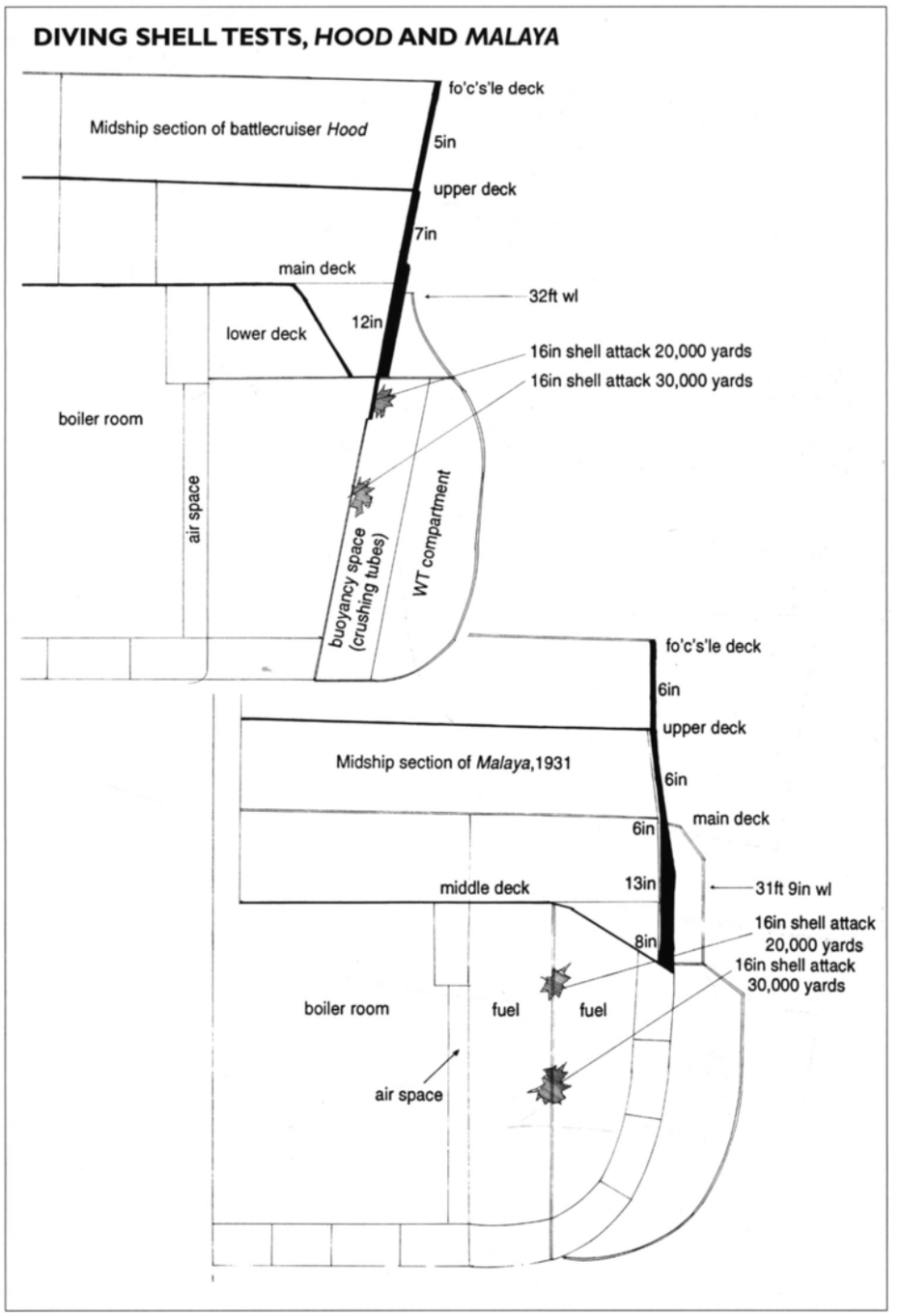
1. Methods of producing a gas cloud
2. Individual protection
3. Collective protection

Methods of producing a gas cloud:

1. A time-fused smoke float.
2. Liquid gas sprayed on the surface of the water from aircraft out of gun range.

Individual protection:

The writer advocated the use of four different types of masks for the personnel:



1. Manual labour mask – container carried on the head so as not to impede the arms or body
2. Diaphragm mask – for use of telephone operators etc
3. Optical mask – for use of range-takers, gun-layers, etc
4. A combination of b and c – for fire control officers

The British Admiralty favoured the use of a single mask for all ranks and ratings and provided that this universal type proved efficient (a new version was being developed at that time) the question of special masks for special duties would not arise. It was suggested that an optical mask be built in to range-finders and telescopes, one advantage being that the user would be better accustomed to action conditions than would obtain from intermittent use of a personal mask. Serious consideration would be given to this proposal should difficulties arise with the new

version of the individual mask. Protective clothing against mustard gas was considered and it was suggested that special overalls be issued in wartime for action only.

Collective protection:

The writer dealt with this subject exhaustively, various suggestions being made as to how to prevent gas entering a ship. The opinion was that the whole ship below the upper deck should be made gas tight including turrets, ammunition passages, secondary batteries, etc., and even engine and boiler rooms. Briefly, compartments were termed either semi-closed or fully-closed. For the first, the idea was to make the compartment as gas tight as possible with regard to fighting efficiency and to prevent gas from entering by keeping the spaces under air pressure. To keep the air pressure up and at the same time filter the air, use of the 'seco spray' machine was suggested. With regard to the fully-closed compartments, the idea seems to have been for an agent for absorbing CO_2 and to replenish the oxygen from tanks or cylinders in the compartment. There was emphasis on the need for collective protection everywhere to avoid the loss of efficiency resulting from the wearing of respirators by personnel. At the same time it was advocated that permanent gas masks be fitted as part of range-finders, gun-laying telescopes, etc., which should be used at all times, thus accepting a reduction in efficiency of the users of these instruments.

The Admiralty took the view that the writer had lost sight of the fact that a ship may be hit during an action and that in almost any compartment that was not well protected collective protection would disappear. It was also thought that the writer in his efforts to bring the gas menace to the notice of the US Navy had rather overstated the case. Such conditions as he postulated might be possible in the future, but not at the present time and the first requirement was to examine the means whereby gas could be got into a ship and only then determine practical methods of dealing with it.

In the Director of Naval Ordnance's opinion, the correct line to take was:

1. Stake everything on a good gas mask, and regard this for the time being as the primary and most effective defence.
2. Carry out further research on methods of getting gas into a ship in order to ascertain just how great a danger the new threat might pose during a war.
3. Investigate systematically the means of making some of the more important stations gas tight.

It was thought that any proposals to make the engine and boiler rooms gas tight were somewhat fantastic.

The spraying of gas from aircraft was considered worthy of investigation, not only from the point of view of possible use in a naval action, but also as means of defending beaches from hostile landings.

With regard to the proposals to provide anti-gas apparatus of different types to suit specific duties, Admiralty experience to date suggested that it was possible, but it was highly improbable that any definitive apparatus could be devised. It was realized that the chances of a ship's personnel being gassed were probably greater in harbour than during any fleet action. It was therefore essential that each man be provided with personal anti-gas equipment in the first place; special types for specific duties could be considered

Below: On the forecastle of *Barham*, showing some of the crew undergoing chemical warfare practice and the use of gas masks, c.1925.

when experience had been gained in the use of the new type of respirator being developed.

The emphasis on the need of protective clothing against mustard gas and the proposals to introduce an overall of protective material for use in action was sound in principle and indicated the lines on which issue should be made as soon as suitable material could be developed. It was understood that this was engaging the serious attention of the Chemical Warfare Committee.

US proposals followed generally the lines along which the Admiralty was proceeding. The air purifier, the air filter and the use of compressed air for overcoming small leaks were all at this time under consideration for use in HM ships. The loss of efficiency resulting from closing-in might be as great as, or greater than that resulting from the wearing of gas masks, especially at times of low visibility, a condition that would frequently prevail during a gas attack. For items such as turrets, secondary batteries etc., it was considered that in view of the great practical difficulties in making such spaces even reasonably gas tight, the policy to rely on in respect of these spaces was that of individual protection. It was clear that the main questions regarding collective protection that confronted the US Navy were the same as those with which the Admiralty was faced. In conclusion the Board considered that progress in protecting the personnel of ships against gas should be made along the following lines:

To stake everything at this time on a good gas mask and to regard this as the primary and most effective defence. The Board suggested that the sooner the fleet was completely equipped and had gained sufficient experience in the use of the personal gas mask, the better. Orders were given to carry out research and experiments to ascertain how to get gas into a ship, and to investigate the means of making the more important stations gas tight. The investigations which were then in progress were considered to be on sound and practical lines, but would probably require modification or amplification in the light of experience gained.

Strict procedural training was carried out during the 1920s, the outcome seems to have been that individual safety was favoured, rather than trying to make large areas gas tight. *Nelson* and *Rodney* (and *King George V* class 1937) were fitted with limited gas filter arrangements in their large superstructures, which would at least ensure that most of the bridge personnel would be protected from serious harm, but that seems to have been as far as it went in the days of battleships.

The Arrival of Aircraft

During the Great War *The Times* newspaper was always noted for its lively reviews on military matters and this of course continued into peace time. In December 1920, however, a series of letters regarding capital ships and the extent of their usefulness sparked off a debate in which practically everyone who was anyone in naval circles joined. The controversy quickly spread to official circles and became the great discussion of the period.

A first article had appeared on 29 November 1920 under the title 'The Navy – A Question for the Nation' and although it is too long to recapitulate here, suffice to say that it pointed out that, as a consequence of the enormous construction programme being undertaken by the USA and Japan, the British Battle Fleet would soon be relegated to third place rather than her usual prime position. It asked 'are battleships really the capital ships for the future or are submersibles and aircraft really the new weapons to conquer all?'

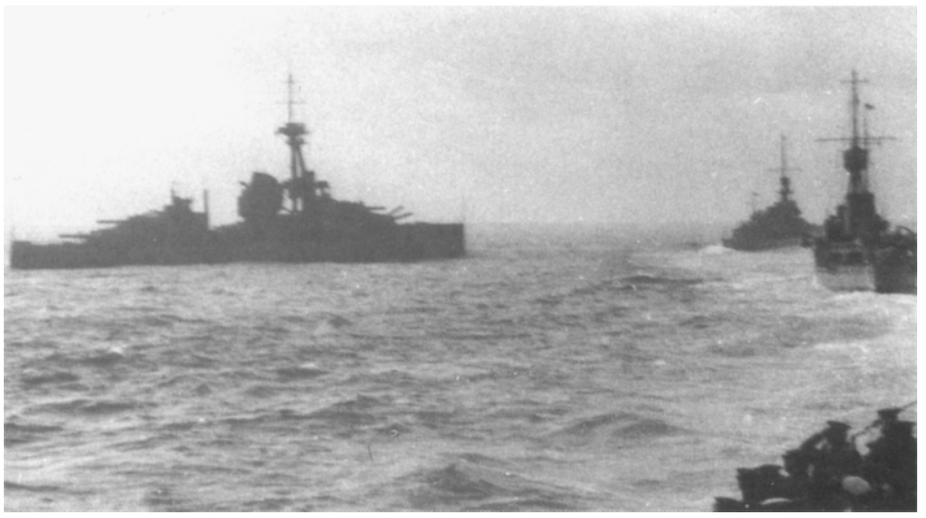
At the end of the war even Sir John (Jackie) Fisher himself stated: 'The greatest possible speed with the biggest practicable gun was, up to the time of aircraft, the acme of sea fighting. Now there is only one word – submersibles.' One of the most prominent naval officers of the day, the gunnery expert Sir Percy Scott, was quick to reply to the letter to add weight to the doom of the battleship and in fact had, as far back as 1914, been saying that submarines had entirely revolutionized naval warfare. Many famous names were seen on letters which flooded into the columns of *The Times*. Admiral Sir Cyprian Bridge, Sir Herbert King Hall, Lord Sydenham, Admiral W. H. Henderson and Admiral R. H. Bacon to name a few. The most formidable antagonist to the battleship was of course Sir Percy Scott who then came up with an article 'What Use is a Battleship?' (13 December 1920), and to this there were literally dozens of answers, of which he took no notice whatsoever. Sir Percy's article read:

> Sir – Will you help me in my ignorance? I cannot get an answer to my question 'What is the use of a battleship?' She must be of some use or the United States and Japan would not be building battleships. A lot of naval officers have written to me but they only tell me what she is not useful for, they will not answer my question. Is her use a secret that only a few know and will not disclose? Will it be disclosed by the Committee of Imperial Defence who are going to tell what the weapons of the new navy are to be? Admiral Hall, a young and vigorous officer, who had wide experience during the war, will not enlighten my ignorance; he is only telling the public what the battleship is not useful for. What is the good of that? Before we spend 109 millions on battleships and another 100 millions in making safe harbours for them, we ought to know what use they are. Now, Sir, do try and enlighten my ignorance. Ask Lord Sydenham or someone else who knows all about naval affairs.

As can be imagined the political cacophony that followed was unprecedented, but one of the best replies came from someone who signed himself simply as 'naval officer': (15 December) 'Sir, – In reply to Sir Percy Scott, on the lines of the well-known nursery rhyme I would say the capital ship is: The ship that sinks the enemy's capital ship, that protects the cruisers that sink the cruisers which protect destroyers, that sink the submarines that attack the merchant ships that bring the food that feeds the people who build the ships that transport the army that defends the house that Jack built – the British Empire.'

The columns of *The Times* were ablaze for more than ten weeks, but after that the editor decided to end the debate as it seemed to be going nowhere. In fact it had got out of hand. There was certainly no easy answer to be had by the written word – practical tests, trials and lengthy experiments were needed to give any degree of truth to the question of how much use was the present-day battleship in the light of four years' wartime experience.

Ships had been set aside after the war, there being no shortage of surplus vessels. The Admiralty at first put forward a few of the



Below: *Monarch* after shell tests and in a mutilated condition. Her funnel has collapsed, the bridgework is wrecked and the forecastle deck has a large hole in it.

pre-dreadnoughts to see how they would stand up against modern technology (*Swiftsure* and *Agamemnon*), but ultimately experience was needed in the dreadnought type and as a result *Monarch* (*Orion* class) was used from 1923 to 1925; *Centurion* (*King George V* class) became Remote Control Target Ship (1927–37) and *Emperor of India* and *Marlborough* (*Iron Duke* class) were used extensively as test ships against shells and explosives of all types.

Probably the most experimental battleship during the 1920s was *Monarch*. She was used extensively for tests to see how armour strength in British battleships would stand up against light, medium and heavy shells (see *British Battleships of World War One*). She was also used in gas and chemical attacks, and later for special tests to see how machinery in the Royal Navy's capital ships would take a knock to its vitals.

On 1 August 1923 she was anchored in eleven fathoms of water and a charge of 2,081 pounds of TNT was hung from a boom fitted 40 feet below the waterline and 7 feet 6 inches from the side superstructure. Her machinery had been prepared in accordance with Admiralty instructions and steam was raised in numbers A1, A2, A3, A5, B1, B2, B4 and B5 boilers. Auxiliary steam pipes were at working pressure throughout the ship. Oil fuel tanks in use were in 'A' Boiler Room (keel to second longitudinal port) and 'B' Boiler Room (second to fourth longitudinal port). Because of bad weather the test was postponed until 4 August when the charge was ignited at 09.06. After the explosion the vessel was boarded and the following notes were compiled:

At the moment of explosion boiler pressure was evidenced by the lifting of safety valves immediately prior to the charge being fired. After the explosion, as far as could be seen from outside the ship, the machinery was continuing to run satisfactorily, the pilot light on the aft superstructure showed that the dynamo engine was functioning and the funnel discharge appeared normal. As soon as personnel were allowed on board and prior to permission being given for the Engine Room staff to open up compartments and go below, listening at the various ventilating trunks, seemed to show that normal running of the auxiliary engines was continuing. Soon after they returned on board they observed that the funnel discharge from 'A' Boiler Room was diminishing and, suspecting loss of suction of the oil fuel pump because the ship was listing about 11 degrees, shut off the oil fuel pump and oil filter discharges of 'A' Boiler Room. The boilers in 'B', as far as could be ascertained, continued to function satisfactorily. At about 09.40 the hydraulic pumping engine ceased to work and a thick vapour from burning oil fuel was rising from the port after fan intake to 'B' Boiler Room, the dynamo engine had stopped and steam was issuing to a considerable extent from the centre Engine Room ventilating trunk into the after superstructure. Because of the risk of fire in 'B' Boiler Room the oil fuel was shut off at 10.00. At 10.10 the centre Engine Room was entered but the steam vapour was too dense to locate the cause. As the air cleared it was seen that the starboard main condenser inboard door was split and sea water was spurting freely through the fissure. All sea connections were shut as quickly as possible, but it was found that the bilge had already flooded to a depth of just over three feet. All sea valves were still working freely.

The steam pressure in 'A' Boiler Room had remained at 10psi, fans were still running, main feed pumps still moving and all water gauge glasses intact; a few boilers were short of water but A1 boiler was leaking badly at the starboard and blowdown valve. All floor plates were displaced, but ladders and gratings were still in place and slight leaks had occurred here and there. The oil fuel had caught fire in the drip pans of A5 boiler, but this burnt out shortly after the entry of the examination party. 'B' Boiler Room pressure was the same as that in 'A' and the only damage here was confined to a few leaks on the main steam expansion gland; a small oil fire was in progress in the front of B5 boiler but this was easily extinguished. 'C' Boiler Room appeared to have suffered more from shock than either 'A' or 'B', nearly all the glass fronts of the gauges being shattered, floor plates dislodged and much dust shaken down. The boilers themselves, however, did not appear to have suffered. Most of the auxiliary machinery in the area remained intact except for a few fractures to some of the sea water pumps, but on the whole there was no discernible damage.

All engines in use during the test were tried by hand and still moved freely and appeared undamaged.

The damage as a whole was minimal, the only failure being a reduction in water pressure. It was considered that all auxiliary machinery in those compartments not destroyed or flooded at the moment of explosion, could still have been kept in use had immediate access been allowed. With regard to the main propelling machinery, the leakage from the starboard main condenser cover would possibly have been diminished by pads and shores to such an extent as to allow the use of the starboard engines with main circulator bilge suctions in operation. Had the turbines been in running condition it was considered the lift would have been much diminished so that if the blading had fouled the resulting damage would have been slight and the turbines would have remained usable. It was submitted that if any further trials of a similar nature were carried out it would be an advantage to fit gauges and equipment on the upper deck so that it would be easy to see what was going on down below.

This trial was just one of the hundreds carefully carried out by the Royal Navy to try to ascertain how capital ships would fare when damaged. While these and many other extremely valuable tests were taking place during the period of the 'What use is a Battleship?' debate (although published in 1920 it certainly never lost its appeal for the general press), tests were being carried out in the USA on an old German war prize, the battleship

Below: After *Centurion*, *Monarch* was the battleship most used for experimental purposes. Her test results furnished much needed information towards capital ship construction. Shown here shortly before being shelled, she is listing to starboard to expose her armour strake. Note the white bands around the hull (range taking aids). 1925.

Ostfriesland, by the USAAF (United States Army Air Force). The debate over the ship became a fiasco after the pilot 'Billy' Mitchell (Brigadier General William Mitchell) claimed after he had bombed the ship that the day of the battleship was truly past. The saga was long, but briefly what happened was this:

Mitchell had set his sights on what he saw as magniloquent Admirals and Sea Lords on both sides of the Atlantic, and after attacking all of them verbally in articles appearing in journals, periodicals and newspapers, went on to test his theories in a practical manner. After knocking the old coastal defence battleship *Indiana* to bits, he made moves to get *Ostfriesland* allocated as a sitting target to be destroyed by aircraft. Trials started on 20 July 1921 when the ship was attacked with 230lb bombs, but of 33 bombs dropped only eight hits were scored on the main deck and did little damage. Later, 600lb and 1,000lb bombs were used but none seemed to affect the water integrity of the old battleship. Next day, however, six more 1,000lb bombs were dropped, but only two made contact. One caused no damage whatsoever, but the other was a near miss on the port side which caused the hull to cave in from the 'water hammer' effect – it opened her up to the sea and she began to sink. Disappearing beneath the waves in about forty minutes, it looked like a victory for the arrogant Mitchell and the anti-battleship brigade. In fact the test had proved little so far as the British Admiralty was concerned – a matter of an old, unmanned, sitting target sunk as a result of constant bombing. Would not a crew aboard have saved her by isolating the area of damage? Would she not have been a more difficult target if under way and yet more difficult if firing at the attacking aircraft? The Admiralty, although taking note of the 'interesting' trial, concerned itself with more methodical tests which would furnish them with sound information regarding the real strength of modern battleships. Even the committee set up in the USA had registered its verdict: 'It cannot be said that the battleship has become superfluous because of the possibility of bombing attacks by aircraft. The battleship represents the highest and ultimate fighting strength of the fleet.'

In 1923 more debates took place in the House of Lords regarding the capabilities of capital ships to defend themselves against attacking aircraft, and it was asked whether the wings of sea power had been clipped? It was pointed out as usual that new naval weapons had been developed (namely submarines and aircraft) which greatly weakened the offence in modern sea power. Forces could not, as before, be carried across the seas. A weak power without a navy could, in theory, challenge the strongest sea power simply by having a strong minefield, an adequate aircraft and a handful of submarines.

Even the great Admiral Von Scheer, who commanded the German High Seas Fleet, a staunch believer in battleships, was forced to concede that by the time the Great War ended the submarine had proved its worth and could, in theory, hold off a fleet of capital ships. It was a known fact that had there been a fleet of submersibles present in the Dardanelles in 1915 it would have been almost impossible for any surface ship to approach the beaches for bombardment, as was so often accomplished during that campaign. What more could be said to prophesy and haste the demise and ultimate doom of the world's battleships?

It is obvious that there was more than a degree of truth in the arguments of the anti-battleship lobby, but during the decade from 1920 to 1930 there was more to the affair than just questions of what use were battleships, or what if they were faced with a fleet of submarines, or indeed could they defend themselves against a squadron of high-level bombing aircraft? The entire subject of defence had to be addressed, and the Admiralty was only too aware that some of the questions were almost impossible to answer. The main question of course was what would replace battleships if they were all deleted from the world's battlefleets? Submarines and aircraft carriers at that time were not yet developed to their full potential – there was still much to be done in that area. Moreover there was still a need of a strong, fast, heavily armed type of warship which was and would always be needed to protect smaller ships – especially merchant vessels which could not be looked after by submarines or indeed aircraft at that time. Although the Second World War proved to be the final frontier for the big battleship, the type never lost favour with many of the world's navies and it continued to serve until well after the conflict.

Today (2011) battleships as a species are extinct but it does seem that even with all the modern technology – missiles, aircraft and submarines – the 'big gun' still has a place in any war. There was much speculation when during the 1991 Gulf War a Silkworm missile was heading for the battleship *Missouri*, and an uninformed press release declared: 'She would have been completely wrecked. Her fate would have been sealed.' Alarming statements and riveting reading, but in fact these statements were made by people who obviously did not know the facts. Of course it would be foolish to say that the ship would not have suffered superficial damage, but it is very doubtful that she would have been sunk. Like all battleships, she was designed to take (and deliver) a tremendous pounding – and that is why the battleships survived the barrage of opinion during the inter-war years and why they have not been completely erased from the US Navy. The *Wisconsin* was decommissioned in 1991 and in 1996 was moved to the Norfolk Navy Yard. In 2006, along with the *Iowa*, she was struck off the Naval Vessel Register and they were to become museum ships.

However, the US Congress was deeply unhappy about the loss of heavy naval gunfire support, and passed a Defence Act that requires the battleships to be kept and maintained in a state of readiness should they be needed again, and further measures have been implemented to ensure that *Wisconsin* at least could be quickly returned to active duty in an emergency. It is possible then that the history of the battleship is not completely over.

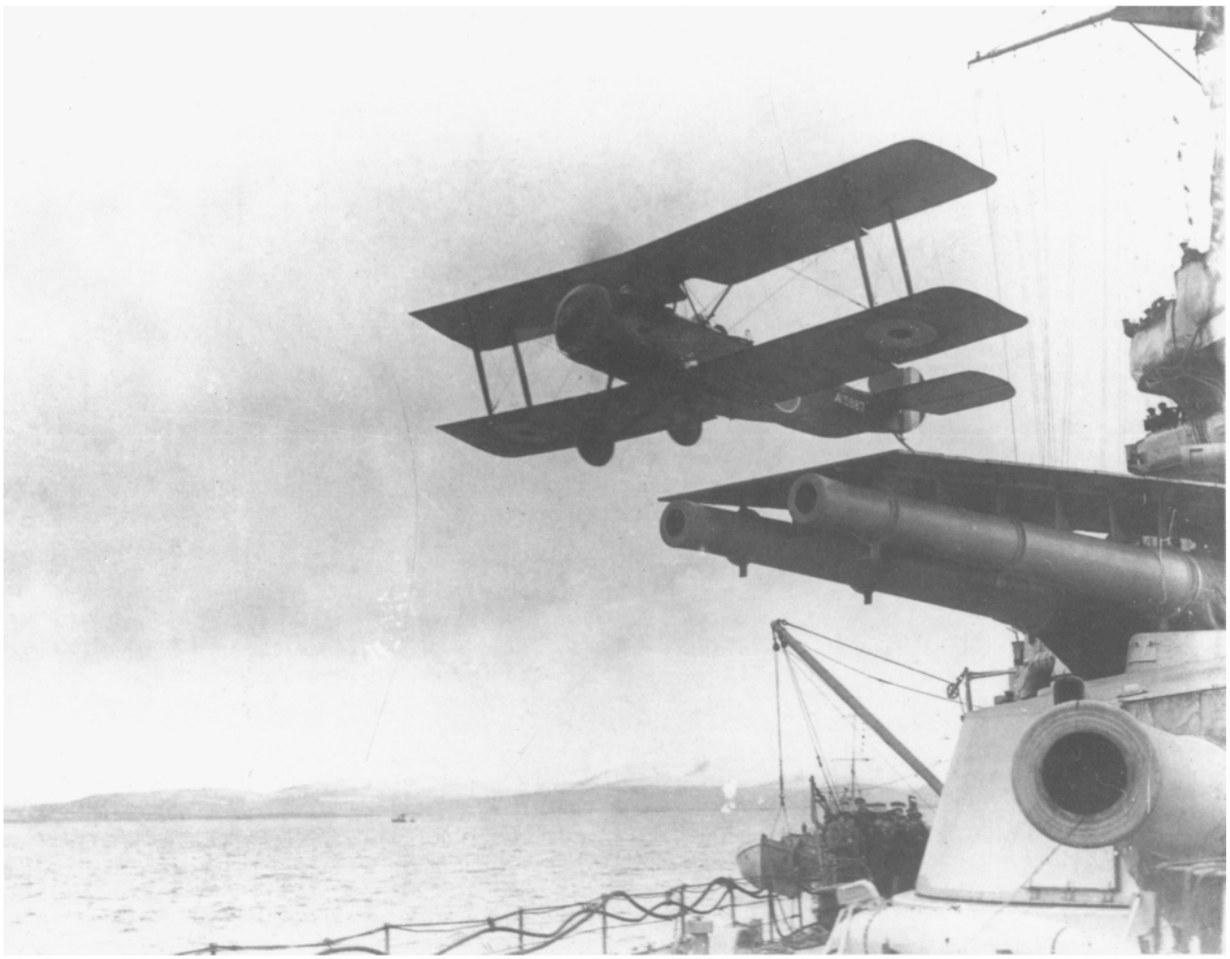
Aircraft in Battleships

After countless trials from 1920 to 1930, there was general agreement by the early 1930s that aircraft had a definite role within the fleet at sea, and many of the older battleships were given hangars and catapults during their modernization. There was a strong lobby of official opinion, however, that held that such aircraft should be confined to aircraft carriers. The late 1920s witnessed many debates on the subject and the Commander-in-Chief, Directors of War, Staff Colleges and Tactical School, Director of Naval Ordnance and the Air Ministry featured prominently in the discussions. In about 1933–4 the general opinion was that fighters were the best defence against attacking aircraft – a view which often changed from month to month. What was fully agreed was that the expansion of the Fleet Air Arm was of paramount importance and the use of aircraft in conjunction with battleships and cruisers for trade protection was worthy of serious investigation. The following points outlining the needs to be considered were placed before the Board.

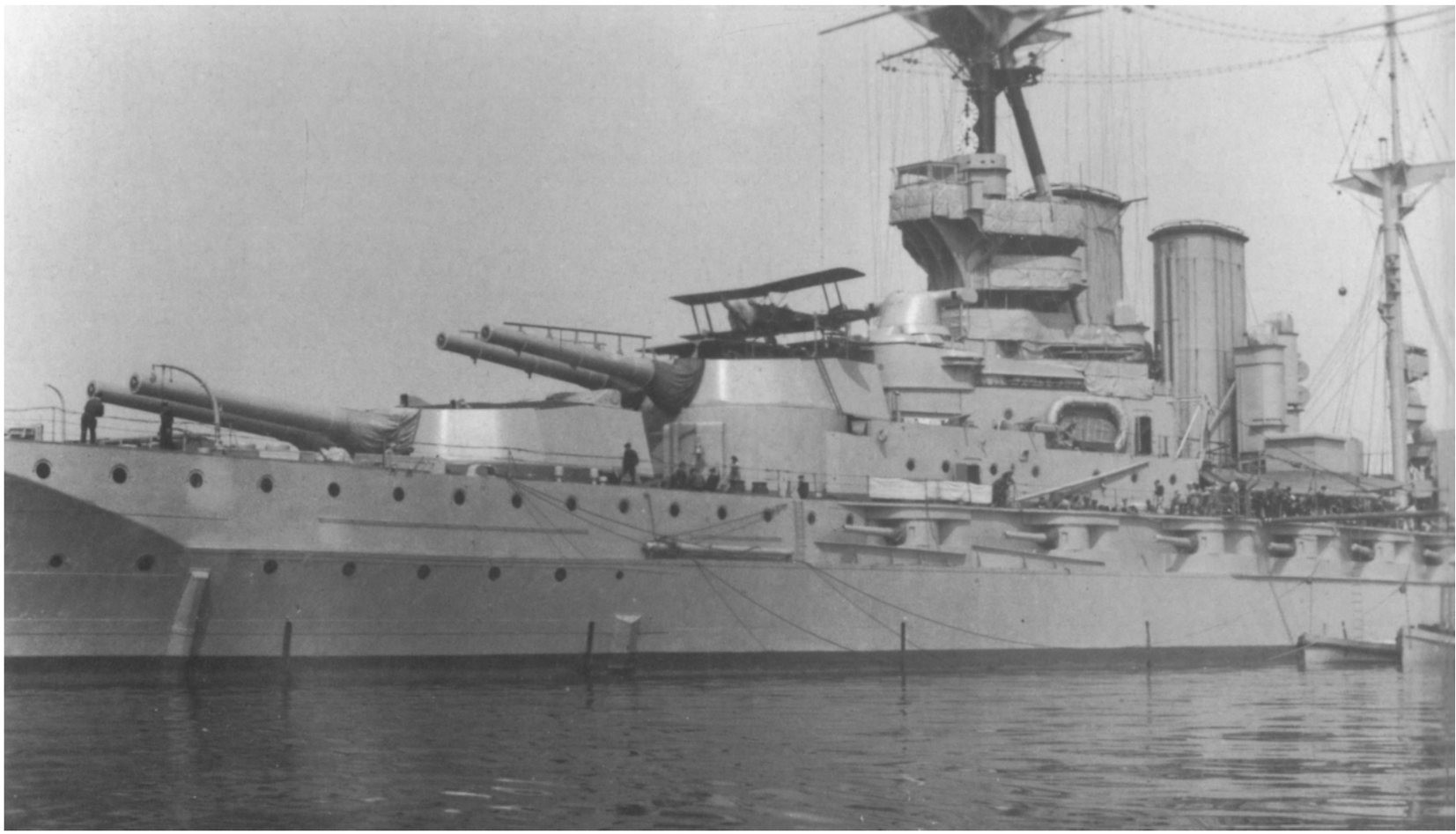
1. Operational, including the types of operation for which aircraft are essential, the frequency of such operations, and the scale of requirements of aircraft in relation to the strength of the forces engaged.
2. Technical, including the effects on the ship's design of carrying aircraft in capital ships and cruisers, and the limitations inherent upon the operation of aircraft from such ships imposed either by weather or by the ship herself.
3. Financial, to determine the most economical method of carrying the aircraft required for the operation envisaged.

Operational. It was obvious that aircraft were required in practically every operation likely to be undertaken by the fleet as a

Right: Aircraft on battleships – before the fitting of catapults, the only method of flying-off aircraft was by means of a ramp fitted over the main guns. The aircraft engine was pitched to high speed and then flown off. This photograph shows a Sopwith Pup flying off from *Warspite* c.1919.



Below: *Valiant* port amidships showing her aircraft and flying-off equipment on 'B' turret c.1920.



whole or by detached forces. Moreover aircraft were viewed as essential for the effective control of sea communications.

Technical. The technical aspect of carrying aircraft on catapults was dominated by two main factors:

1. The technical limitations of the aircraft itself with especial reference to its ability to land and be recovered at sea.
2. The limitations imposed upon the ship herself by reason of the inclusion of the catapult and the space and weight taken up thereby. It had also to be borne in mind that catapult-launched aircraft depended to a great extent on calm sea and weather for recovery, which precluded their deployment on a high percentage of days in the year.

The limitations imposed upon the ship by carrying aircraft on a catapult were discussed in 1936. The main technical effects were:

1. The catapult and hangars occupied approximately one-sixth of the upper deck space between the forward and after gun mountings in any class of ship. The remaining space was therefore congested and limitations were imposed upon the arrangement of the secondary or HA armament which was already difficult to site satisfactorily clear of blast.
2. The weight of the equipment was considerable (approximately 160 tons in the 1936 battleship). It was thought that with qualitative limitation of total displacement, to use this weight in ships with the fleet on 'one shot' aircraft was uneconomical and would detract from other important characteristics such as protection or offensive power.
3. The modern type of fixed catapult, necessitating operating machinery between decks, affected accommodation.
4. The aircraft on the catapult could not be arranged satisfactorily to be clear of blast from the high-angle or secondary armament (it was assumed that the aircraft would be flown off before the armament was fired). It was considered extremely likely that the anti-aircraft guns would be fired before the aircraft was required to be flown off, in which case it could not be guaranteed that the aircraft on the catapult would still be serviceable after an air attack.

Financial. It was difficult to assess the relative annual cost of catapult-borne and carrier-borne aircraft, but it was thought that the former were more expensive. The initial cost of a catapult was approximately £17,000.

The arguments for and against catapult-borne aircraft were:

For

1. They provided an increase in the required number of fighters and/or fighter spotters carried in the fleet since as much as possible of the existing carrier space was required for reconnaissance and strike aircraft.
2. The battleship or cruiser flagship carrying a fighter spotter could be self-contained as regards air spotting (with its attendant increase in hitting power and the ability to carry out indirect fire).
3. It was held by some officers that improved results were obtained by the closer co-operation made possible between ships and aircraft's personnel.
4. The offensive power of ships for subsidiary operations would be increased.
5. There were more baskets for the eggs.

Against

1. Aircraft on catapults were 'one shot' aircraft and must be refuelled or re-ammunitioned aboard a carrier on expiry of their endurance or ammunition. Carrier-borne aircraft were capable of continuous operation. Catapult aircraft could not be recovered in weather that would not preclude flying from carriers.
2. Inclusion of fixed catapults rendered the arrangement of the upper deck and secondary and HA armament (for long or close-range defence) unsatisfactory. The efficiency of the AA armament was therefore impaired.
3. Aircraft on catapults were liable to blast from AA guns and arrangements were very difficult to circumvent this.
4. The weight of catapults was considerable and would need to be met by limited displacement from other services.
5. Air spotting entailed a large organization for reliefs etc., and these could only be arranged from carriers.
6. Training of observers was better carried out and more easily co-ordinated from carriers.

In 1933 the Commander-in-Chief of the Home Fleet made a strong plea for more aircraft in the fleet, especially of fighter and reconnaissance types, and requested a statement of policy. The following are extracts from remarks prompted by his letter:

1. 'In general stowage for fighters is not provided in capital ships owing to space restriction and difficulty of launching, a spotting aircraft being the primary consideration. It is therefore considered that the provision of additional carrier tonnage is the proper policy for increasing the number of fleet fighters.' (DNAD)
2. 'As a general rule battleships do not work singly or in pairs but in squadrons or fleets and the right place for aircraft is in aircraft carriers attached to the squadron or fleet controller.
3. 'My conclusion is that it is unwise to neglect any opportunity of providing for the transport of a limited number of aircraft in capital ships provided their main characteristics are not thereby impaired.' (ACNS)
4. 'I agree with the general view that we must have as many aircraft available as is practicable, especially in view of the vulnerability of carriers, and the small number of ships we have.' (DCNS)
5. 'It is essential that we make every reasonable use of such aircraft carrying power as we can in vessels other than carriers to strengthen our air defences.' (CNS)

A staff meeting was held on 26 May 1936 to further discuss the policy of carrying aircraft in capital ships and cruisers even though the new programme of British battleships laid down in 1936 was showing hangars and aircraft within the design (*King George V* class). The subject was still under discussion at some length. It was agreed that the aircraft were better off in carrier types, but the fleet did not possess enough of the type. Moreover, it could be argued that aircraft in battleships and cruisers would be capable of reconnaissance on a scale not possible by other ships of the fleet (i.e., destroyers and scouts etc.). The conclusive results of the meeting saw the staff recommending the following:

1. That battleships and cruisers with the fleet should not carry aircraft on catapults but that all fleet aircraft should be carried in carriers.
2. That the carrier building programme be accelerated to provide an adequate number of efficiently borne aircraft with the fleet and for trade protection duties.
3. That the carrier building programme required immediate review in the light of the above and that after arrears had been made up it should be correlated to the programme of other categories.
4. The development of the autogiro type of aircraft should be treated as urgent and money devoted to the necessary experiments for this purpose.

The general summary implied that when sufficient numbers of armoured carriers had been built, other light carriers should be built which would enable the battleships and cruisers to have their aircraft equipment removed. This policy had two great advantages: 1. More efficient use of aircraft with the fleet. 2. More efficient use of weight and space in ships for offensive and defensive weapons.

It was considered, however, that until this time arrived the policy of carrying catapults in other ships would continue. The Controller, R. G. H. Henderson, on hearing of this general consensus was not happy with it:

> I find myself in entire disagreement with the general policy outlined in this paper. Although I have no wish to be unjust to the appreciation prepared by the naval staff, I do think that the disadvantages of carrying aircraft in ships have been very much stressed, while the advantages therefrom have been treated in the opposite way.
>
> Firstly, I do not think it should be argued too strongly that the existence of aircraft in battleships and cruisers is due to limitations hitherto imposed by treaty, although no doubt the treaty rules hastened the development of sea-borne aircraft. Further, though there may now be no limitation by treaty as to the number of carriers, we have it in another form, namely cost, if the number of aircraft for fleet use is maintained at a high level. It must be remembered that, with the design of armoured deck carrier, the maximum number of aircraft to be carried is 36, and, assuming we have ten of these carriers then broadly speaking, the Fleet Air Arm would consist of only 360 aircraft, and these might well be distributed all over the world for commerce protection, diversions and other operations which must necessarily be away from the main theatre of the war. I should think that in a war the aircraft carriers will be kept busy and that even subsidiary movements and periodical sweeps will necessitate operations by such ships; when they get back to their base they will want to rest and yet the Commander-in-Chief in his base will probably require daily reconnaissance flights, which I suggest should be done by the ship-borne aircraft.

Only experience during the following conflict (1939–45) was to settle the debate when it was seen that the battleship had moved aside as the capital ship to give pride of place to the aircraft carrier with its aircraft and their deadly bombs and torpedoes. Aircraft equipment in battleships was of some value for reconnaissance at the beginning of the war, but the weight and space involved and the personnel – who could more practically be used elsewhere – showed the ineffective value of this type of fitting in anything but the proper vessel. From 1942 all aircraft equipment and catapults were removed from battleships and the space was taken up by stores, boat stowage and anti-aircraft batteries.

Camouflage

Although this book is intended to cover the period 1919 to 1939 and not merely war history, it has proved impossible to stop short of the 1939–45 conflict (as can be seen in the main chapters). Camouflage is a wartime subject and one of the most popular and interesting items by far for serious warship enthusiasts and modellers alike, and to that end it is therefore worthy of some discussion. Camouflage was first used in warships during the Great War although in 1915 it was applied in a somewhat haphazard fashion so that no two ships were alike. There were no hard and fast rules as to how a ship should be painted, or indeed, as to the type of colours that should be used. Some official interest was shown during 1916–17 and observation units were set up after certain vessels had been given different paint applications. In the beginning only a few colours were used – usually variations of grey and black, but later blues and greens could be seen. Camouflage in big ships virtually disappeared at the end of 1917 and did not appear again until Lieutenant-Commander Norman Wilkinson, RNVR developed his dazzle painting methods and the Admiralty set up a proper Camouflage School at Burlington House in London where many tests using models were carried out under controlled conditions.

The result of this, so far as capital ships were concerned, was that only a few ships were given the treatment: *Revenge*, *Ramillies* and the aircraft-carrying cruiser *Furious* all received fully fledged schemes. *Ramillies* was very different from *Revenge* as was *Furious*, as can be seen from the paint schemes. The battlecruiser *Repulse* was painted up in a two-tone grey at the end of the war as an experiment, and the effect was not unlike that applied to that ship in 1941 only in lighter shades.

At the end of the war camouflage took a back seat, but was picked up again during the early 1930s and a thorough investigation was made into the matter of how to apply suitable war paint to different types of ship. The subject proved extremely complex and exhausting and although the schemes applied were in most cases rather spectacular in the battleships, the achievement of satisfactory schemes and patterns was not accomplished easily. At the outbreak of the Second World War a few big ships were given 'one off' examples of camouflage which tended to emulate the earlier dazzle types but with fewer colours (*Ramillies* seven colours, *Revenge* five – 1918) (see endpapers). Although there are a few photographs of these ships taken during 1939–40, little information was collated about the patterns or colours because in some cases the schemes were only evident for a few months (certainly in the case of *Revenge*, *Ramillies* and *Royal Sovereign*) and therefore were never recorded officially, which leaves some doubt as to the actual colours used.

When examining the official accounts of the use of camouflage it is essential to be sure of the real meaning of the word. When discussing camouflage the actual terms of description used are: 'invisible', 'visible', 'conspicuous' and 'inconspicuous'.

Invisible in plain terms means something that cannot be seen with the naked eye because of its nature and position. Visible objects are capable of being seen – usually without aid; but some complication arises here because one can have good visibility, moderate visibility and poor visibility. When dealing with camouflage this description is best avoided in referring to how visible a ship is. Conspicuous means easy to see, obvious or striking to the eye. Inconspicuous means not readily seen, not bold or prominent in appearance.

These two last descriptions are best when describing camouflage because it is easier to explain how something becomes less conspicuous than to describe how the painting of a ship in strong disruptive colours makes the ship seem invisible or of doubtful visibility. A ship can be very inconspicuous if painted in one colour, but only in certain conditions – in either bright or dull conditions she will be most conspicuous. On the other hand in many conditions a colourful pattern tends to scramble the outline, and the characteristics that identify a ship are affected to some extent. The tremendous difference in illumination between sunlight and overcast conditions can affect the appearance of a camouflaged ship in many ways, as can a moonlit or moonless night. Moreover, light differs greatly from ocean to ocean; the extreme haze to be encountered in some tropical waters calls for yet more alteration to colour tones.

Although early camouflage (1939–40) underwent many forms in battleships, it was clearly understood that the function of a pattern in sea camouflage was to reduce the range of visibility of the ship from aerial observation and from surface observation including the submarine periscope. At certain long ranges, however, the patterns ceased to be apparent and the ship became a uniform tone. The Admiralty endeavoured to achieve an overall

tone to blend in with existing conditions where possible – hence the many colours for home waters and greys and blues in many foreign waters. Additionally, it was decided that an enemy observer or lookout would have no data against which to check a moving target, and his difficulties could be compounded if the ship were badly angled from his point of view. So anything that might blur his image would be more than beneficial in rendering a ship less conspicuous. Once a ship had been spotted, however, a good, coloured pattern could achieve two important results:

1. Cause confusion of identity.
2. Cause confusion of inclination.

So pattern had these useful features: 1. Reduction of visibility caused by at least one tone harmonizing with its background and reducing the apparent size of the object and the psychological effect of the shapes left possibly visible. 2. The obliteration of the violently arrestive shapes of the 'natural' pattern of the ship resulting from the hard core of unavoidable shadows.

From June 1940 the big ships sported many weird and wonderful patterns in various colours, but the most used tones were light and dark grey (507b and 507c – see drawings and photographs).

Queen Elizabeth
At the end of her reconstruction she left the docks sporting an early Admiralty disruptive type scheme of five different shades. This was worn until her refit after being damaged in Alexandria in December 1942.

Barham
Dark Home Fleet grey until the summer of 1940 when she was painted up in an unofficial two-tone scheme (black and white). Repainted all grey for a short period then repainted in black and white again under the direction of Peter Scott. Lost in this condition. (See photographs.)

Malaya
Dark Home Fleet grey until the summer of 1940, then painted in two-tone unofficial pattern (grey 507a and 507c). Repainted medium grey after leaving the Mediterranean in the spring of 1941.

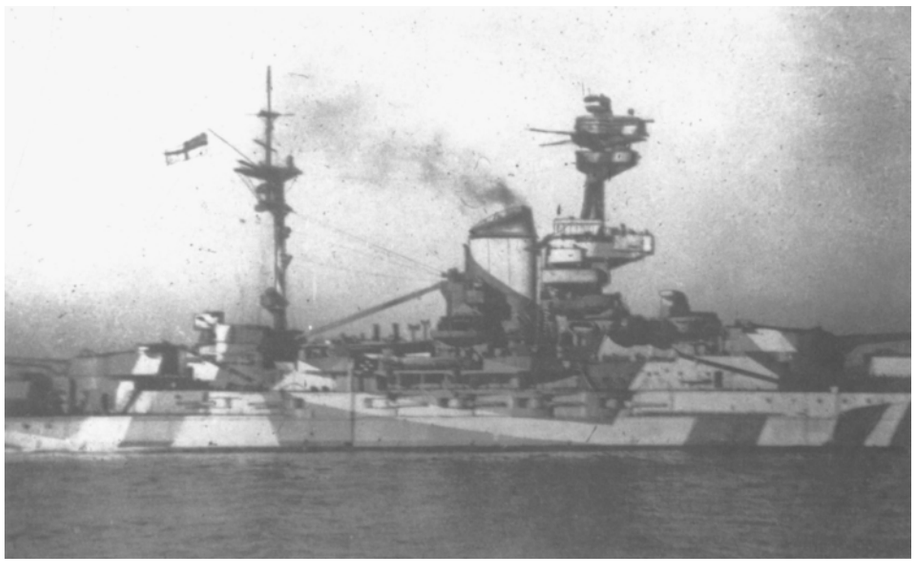
Warspite
Dark Home Fleet grey until the winter of 1941, then painted in two-tone grey (as *Malaya*) but with different scheme (unofficial).

Valiant
Dark Home Fleet grey until early 1941 when painted up in two-tone grey (507b and 507c or possibly B5). Worn until Christmas 1942.

Royal Sovereign
Entered the war in medium grey tone. Summer 1940 painted in unofficial five-colour 'dazzle' type scheme. Altered during this period to another 'dazzle' scheme but with fewer colours. Repainted in two-tone grey by November 1940.

Royal Oak
Medium grey until sunk (1939).

Revenge
Dark Home Fleet grey at beginning of war until repainted in unofficial four-colour 'dazzle' type scheme by October 1940. Repainted in early 1941 in another 'dazzle' scheme with fewer colours.



Ramillies
Entered war in medium grey until repainted in 'dazzle' in November 1940 (two shades of grey and white). Repainted all grey in early 1941.

Resolution
Dark Home Fleet grey from the beginning of the war until the winter of 1940 when she was repainted in an early experimental two-tone grey with false bow wave.

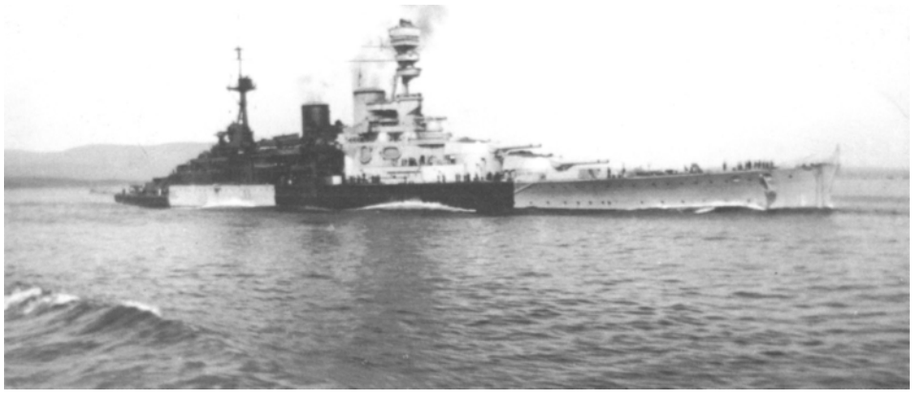
Nelson
Dark Home Fleet grey from the beginning of the war until mid-1940 when she appeared in a darker shade. Lighter grey during the summer of 1941.

Rodney
Dark Home Fleet grey from the beginning of the war until late 1940 when she appeared a shade lighter (colour unknown – probably grey) – wore an experimental scheme for a short period in the spring of 1940 (see photograph)

Renown
Medium grey at beginning of war. Darker grey during Force H period. Repainted in early Admiralty Disruptive type in the winter of 1941.

Top: A full broadside view of *Revenge* in 1940, showing a one-off unofficial camouflage. It consisted of about four shades, the layout being very similar to those used in First World War dazzle, but it was basically an experiment and not carried for long.

Above: A superb close-up view of *Revenge* showing clearly her 1940 camouflage shades. No radar is yet fitted. *Revenge* and *Resolution* were the only units of the class with funnel caps at this date.



Top: *Repulse* in the Contrast paintwork, 1941. Note the strange layout.

Above: A rare view of *Rodney* showing her one-off unofficial camouflage scheme (brown, green and grey) in the Spring of 1940. The scheme does not appear to have been carried for long.

Repulse
Medium grey from beginning of the war until early 1941 when she was repainted in black and white 'contrast' scheme. Lost in this condition (see drawings).

Glorious
From the beginning of the war in medium grey. Repainted in a two-tone grey. Lost in this condition.

Courageous
Dark Home Fleet grey. Lost in this condition.

Furious
Dark Home Fleet grey throughout the early years of the war. Admiralty Disruptive 1942.

King George V
From the beginning of the war in two-tone grey (possibly 507 variation) until the spring of 1941 when she returned to overall medium grey.

Prince of Wales
Medium grey until August 1941 when repainted in early Admiralty Disruptive type. Sunk in this condition.

Duke of York
Two-tone Admiralty disruptive type (experimental) until the winter of 1941 when repainted dark grey.

During late 1940 there was some confusion regarding camouflage methods and the Admiralty ordered that all schemes be painted out with a view to further investigations. In December 1940, however, the commanding officer of *Repulse* (Captain W. Tennant) sent a report on the subject of camouflage to the Vice-Admiral commanding the Battlecruiser Squadron, pointing out these salient features:

1. HTM288 orders that capital ships are not to be camouflaged. I suggest that if controlled and carefully worked out by those who have studied camouflage and not left to the whim of individual captains and executive officers there are certain occasions when considerable benefit may be obtained from it.
2. Capital ships are too big to attempt concealment by camouflage except possibly under certain conditions of light and when against the land; which conditions are unlikely to apply in a Fleet action.
3. On the other hand, it is considered possible that by means of efficient camouflage it is possible to make a ship a much more difficult target on which to obtain an accurate inclination.
4. The gunnery officer of this ship reports to me that recently when carrying out an inclination exercise on the ex-USA destroyers it was exceedingly difficult to obtain their inclination due to their contrasts in painting.
5. I suggest that in the case of battlecruisers much could be done merely by contrast of two shades of grey.
6. Commander E. B. Clark, RN (retired) of this ship, who has studied the subject, has independently produced the attached drawings of this ship giving some idea of what might be done with two shades of grey.
7. I would suggest that if it is decided to give reconsideration to contrast painting of capital ships, his ideas, in greater detail, might be of service.

In answer to this it was concluded that although a variety of designs had been tried and rejected since the beginning of the war, it would be an advantage to camouflage the battlecruisers, but before proceeding with the proposal it would be necessary for the subject to be officially studied in detail with due regard to previous evidence. The following observations on dazzle painting were offered:

1. It called attention to the presence of a ship.
2. It made a ship more visible from the air. This occurred when HMS *Naiad* (camouflaged) was seen by Skuas whereas HMS *Hood* and destroyers (not camouflaged) in company at the time were not seen.
3. At short and medium ranges it caused temporary confusion regarding the type and class of ship until she was examined through glasses.
4. Could only be said to huff the inclinator under certain conditions of light and range favourable to the particular scheme of camouflage in use.
5. Contravened the wartime policy of darkening all surfaces so as to avoid giving aircraft an aiming mark.
6. Consideration given to visibility at night.

It had been established over the past twelve months (1939–40) that dazzle painting was of value only against a land background and that the present suggestion was not for dazzle but for 'contrast painting' which it was hoped would render inclination difficult by contrasting large masses of light and dark. The principles put forward were:

1. Only very large masses of contrast were of any value.
2. 'Cut in' lines do not tell and should be avoided. The entire constructional features of the ship needed to be contrasted.

3. A bow and stern painted comparatively light did, in fact, confuse the inclinator and the hull line needed to be broken if possible.

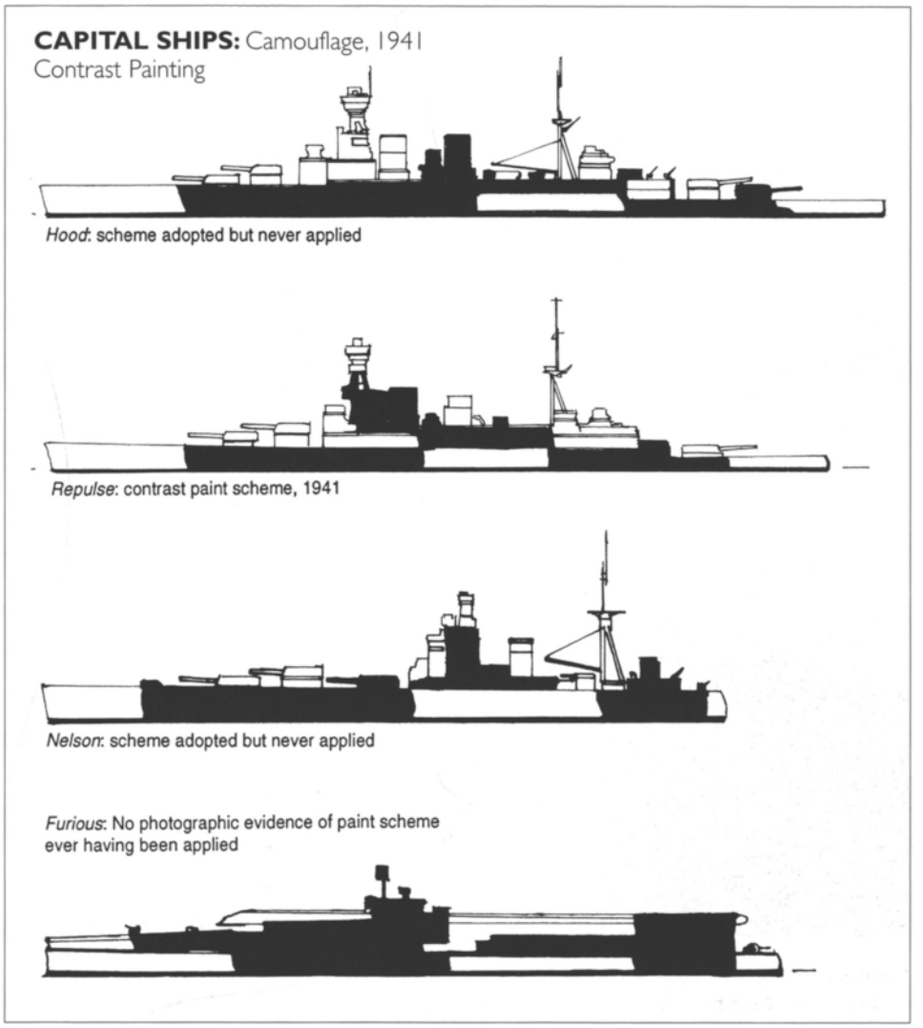
To test these theories, two models, of *Repulse* and *Furious*, were painted as stipulated. It was found difficult to approximate to sea-going conditions but the experiment established that inclination was more difficult on them than on the same models painted dark grey, particularly in certain conditions of light. A land background rendered them almost unrecognizable.

Repulse was painted up in a very dark and a very light grey – almost white; both colours were similar to 507b and 507c but were extreme. After tests – although when sailing with destroyers it was said that *Repulse* was difficult to spot at night during certain conditions – this type of contrast paintwork had disappeared by late 1941 (see drawings).

During 1941 the Admiralty introduced the Disruptive type of camouflage on a suggestion from the Experimental Camouflage School, but not content with limited success further observation trials were carried out at Scapa Flow in 1941. The object of the trials was:

1. To observe any effects that might be at variance with Admiralty camouflage policy.
2. To observe whether full-scale trials confirmed model-scale trials.
3. To determine the advisability of employing camouflage designs similar in principle to Western Approaches designs for general-purpose ships, particularly cruisers, capital ships and aircraft carriers.
4. To determine the effect of pattern on concealment.
5. To obtain telephotometric readings for summer conditions in the area observed so that correlations between natural and artificial conditions as produced in the experimental tank could be checked and, if necessary, developed.
6. To give designers further experience of the effects of camouflage as seen under full-scale conditions.

Many different types of vessel were used but the following obser-



Left: *Royal Sovereign* in March 1941, just off Bermuda, showing a modified camouflage scheme. The colours are simply light and dark grey.

Right: *Ramillies*, November 1940, showing her three-tone grey, dazzle-type (unofficial) paintwork.

Below: *Royal Sovereign* at Gibraltar, November 1940, showing a two-tone grey paintwork scheme.

Bottom: *Malaya* in an unofficial two-tone grey camouflage scheme whilst operating in the Mediterranean during October 1940. *Ramillies* is the battleship behind.

vations were made on *King George V*, *Duke of York* and *Anson* from the shore: *King George V* at a 3-mile range had a slightly better concealment value than *Anson*. The Commander-in-Chief, Home Fleet, had earlier requested that the colour MS1 should be substituted by 507A which gave a difference of 9 per cent reflection factor and it seemed to work. It needed to be seen, however, how far the stronger contrasting pattern of *Anson* would produce the same effect at, say, three or four times this range. In sunlight and diffused sunlight both ships, by reason of their broken-up silhouettes and certainly in diffused sunlight because of their lighter mean tones, were markedly less conspicuous than *Duke of York*. Only in one particular intensity of sunlight was *Duke of York* observed to be definitely less conspicuous than the other two ships.

In general the trials were very satisfactory and produced some data which was considered to be of considerable value. It was felt that the results proved beneficial to designers who were enabled on several instances to see their designs working satisfactorily, and in cases where designs were not so satisfactory the reason why was usually pretty obvious and the lessons learnt would bear fruit. Observers felt encouraged by the general improvement in camouflage designs. Although there was still much to be learned and

faults to be remedied the general trend suggested a definite advance. It was felt that this was due in no small measure to the fact that designers had been able to view their models under conditions that generally represented natural conditions very closely. Although it was felt that some slight improvement was probably possible and even desirable in the tank, the close resemblance to natural conditions would only serve to give designers confidence in the tank's general performance. The high degree of co-operation afforded to the trials by the Commander-in-Chief, Home Fleet, was most satisfactory, indicating as it did, the keen interest the administrative authorities were showing in the question of sea camouflage and its complex problems. Moreover, it was considered that camouflage observation trials were now established as a recognized element of the weekly programme of fleet exercises and it was felt that there would be little difficulty in cooperating further trials.

Further research work was carried out at the Paint Research Station in Teddington during 1942 and finally brought about a standardization of Admiralty camouflage colours. This work was concerned with a series of nine shades of grey chosen as standards for Admiralty use. It had the following main purposes:

1. To establish as a standard of reference the colour and brightness values of the nine standard colours supplied.
2. To establish the tolerance in brightness value allowable in the practical production of these colours.
3. To prepare a number of sets of standard colours for future use.

The grey shades were divided into a bluish grey series: B15, B30, B45 and B55. The greenish grey series were: G5, G10, G20, G30 and G55 – the number of colours indicating the approximate brightness value (these numbers replaced the original designations MS1, 2 and 3, etc.). In setting up this range of colour standards special attention was paid to the correct choice of brightness levels. From late 1942 the battleships carried the following types of camouflage:

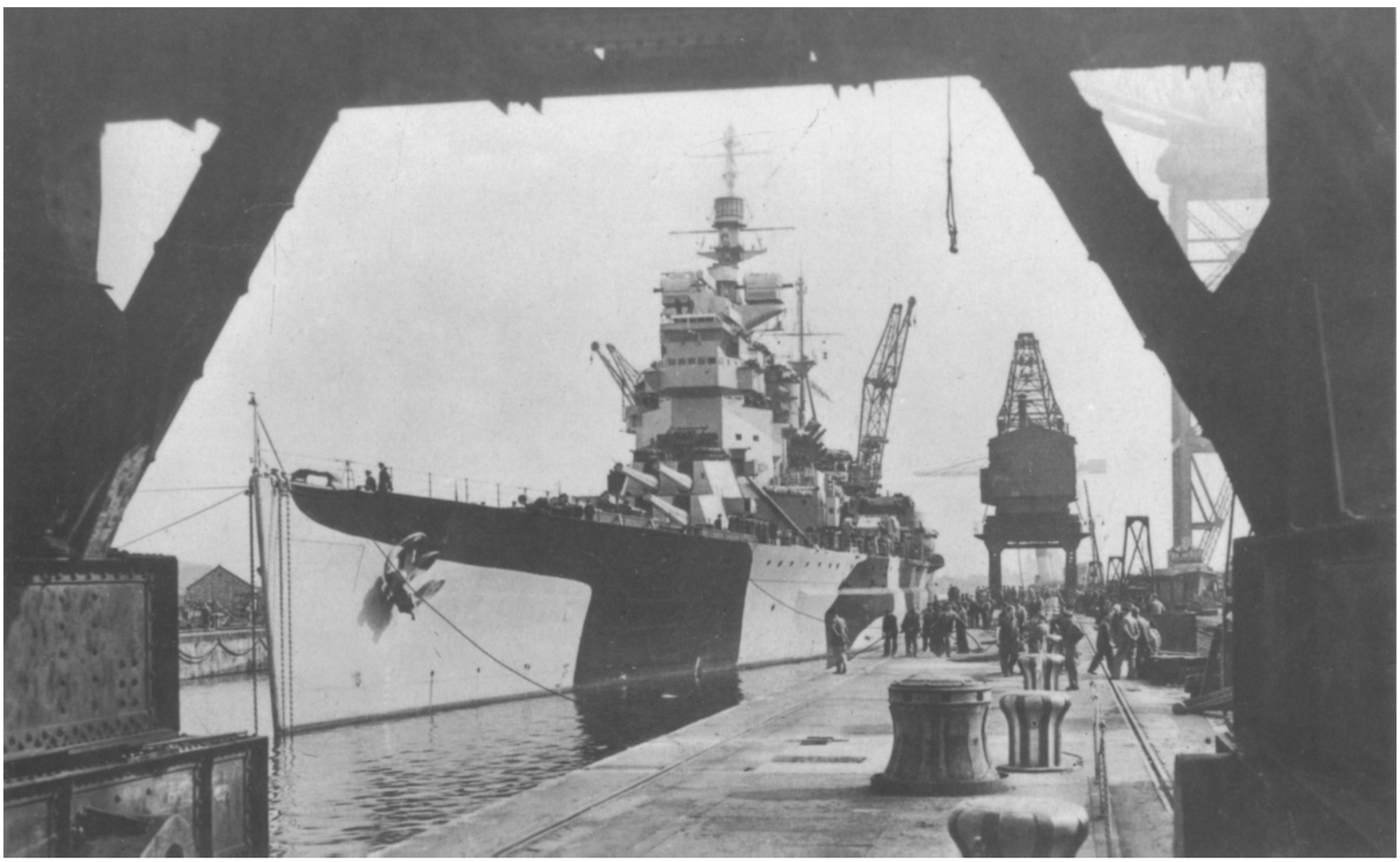
Queen Elizabeth
Repainted in Admiralty Intermediate disruptive scheme on re-entering service after Alexandria damage. Slight variations to this scheme by May 1943. Repainted Admiralty Standard type during 1944 (blue panel on hull; light grey on upper works). (Dark grey upperworks by 1945).

Malaya
Admiralty Disruptive type (see painting) until late 1944. All grey by spring of 1945.

Warspite
Same scheme as in 1941 except variation in shades. Scrapped in this scheme.

Valiant
Unofficial Disruptive scheme painted up in late 1942/early 1943. Repainted Admiralty Disruptive type in May 1943. Repainted Admiralty Standard type in 1945. All grey by end of 1945.

Royal Sovereign
Still two-tone grey. Repainted Admiralty Intermediate type in September 1943. Left for Russia in this condition. Repainted two-tone grey (dark hull, light upper works) 1944 until scrapping (1949).



Left: *Howe* in the builder's yard showing her original camouflage as completed in November 1942. The colours were slightly altered at the bow at a later date (see *Howe* page 401).

Revenge
Repainted early 1942 with unofficial two-tone grey which she kept until 1943 when she was repainted dark grey.

Ramillies
No photographic evidence during 1942, but repainted in Admiralty Intermediate type during the summer of 1943. Repainted Admiralty Standard type 1944 (dark grey panel amidships). All grey again by mid-1945.

Resolution
Early Admiralty Disruptive type during 1942–3. Repainted all grey in 1944.

Nelson
Two variations of Admiralty Disruptive type from 1942–4 (green type). Repainted Admiralty Standard type (blue panel). All grey again in about March 1946.

Rodney
Early Admiralty Disruptive type from 1942 until scrapping.

Renown
Repainted in early Admiralty Disruptive type in late 1941. Variation of scheme in 1942 until 1944. Admiralty Standard type (blue panel) 1945. All grey again shortly after war.

Furious
Repainted in Admiralty Disruptive type in 1942 until 1943–4 then all grey again.

King George V
Medium grey until mid-1942 when repainted Admiralty Intermediate type. Repainted in 1944 with Admiralty Standard type. Repainted in Pacific colours (dark blue hull, light uppers) 1945.

Duke of York
Medium to dark grey in 1942, then repainted with dark grey hull and light upper works (1943). Repainted Admiralty Standard type 1944. Repainted Pacific colours (dark blue hull, light upper works) 1945.

Anson
Entered service with Admiralty Intermediate type 1942. Repainted Admiralty Standard type late 1944.

Howe
Entered service with Admiralty Intermediate type 1942. Repainted in Admiralty Standard type 1944. Repainted in Pacific colours during spring of 1945.

By 1943 in ships as large as battlecruisers and aircraft carriers it had become obvious that only strongly contrasted designs had been really effective because complete concealment of the ships was out of the question. The experiments continued throughout the war and in 1945 most big ships were still wearing camouflage of some sort, but although the final conclusion was on the whole unfavourable to camouflage, it was noted that some of the schemes had shown some limited success.

Radar

Radio direction-finding (or Finders) was not a product of war, but rather a development of W/T transmissions, although the Second World War certainly pushed the idea forward to a remarkable degree. In about 1933 the policy was to pick up approaching aircraft before they could be heard or seen and a naval RDF experimental works was set up later in the 1930s. The work was directed towards two main themes: 1. Long-range warning of aircraft using a wavelength of a few metres. This was achieved using a wavelength of about four metres and ranges up to 40 miles were obtained using moderate power. Then during 1937/8 the wavelength was changed to about seven metres which led to the Type 79X. During 1939 the wavelength was again reduced to three to four metres, leading to Type 281. This set could also detect surface craft at ranges of the order of 10 to 20 miles. At that time aircraft could be detected at about 70 to 100 miles at a ceiling of 10,000 to 15,000 feet. 2. Detection of surface ships using a 50cm wavelength. At first the only valves available were of the ACORD type but later valve development, notably the GEC series, led to the introduction of the Type 282 series for gunnery, ship and low-level aircraft detection.

After the war started there began a period of valve development which eventually enabled higher power to be obtained on a wavelength of 10cm. Hence by 1942 there were sets available for long-range warning of aircraft and shorter range for surface ships (Types 279 and 281); short-range warning and gunnery (Type 282, etc.); short-range on surface ships and a few miles on aircraft (Type 271 series).

On the W/T side rapid advances in interception and DF enabled a technique to be developed whereby wavelength of a few metres could be intercepted at very long ranges and their direction found. The development was not regarded as vital, partly because attention was focused on longer HF wavelengths for the Atlantic battle. Research indicated the line to be pursued if wavelengths of a few metres were to become vital from the interception and DF aspects.

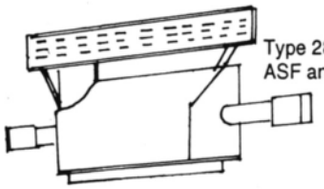
The first of many sets produced from 1938 were experimental, but by 1942 the Royal Navy's ships had possibly the best RDF equipment in the world. Each type had its own function and had been designed accordingly. Battleships and aircraft carriers had a variety of aerials and strange-shaped objects to house the equipment within. Space precludes mention of the huge number of radar types and their function that was developed, but the most important ones (certainly for battleships) are given below.

The first naval sets were developed for air warning. The numbers in sets were not in sequence (e.g., 281, 285) but in most cases sets developed for the same purpose had similar numbers. Numbers started at relatively high figures, probably because of the many early sets being numbered in sequence with normal W/T sets. At first the early heavy aerials could only be fitted at the masthead (to obtain adequate height), and both mastheads had to be used – one for sending and one for receiving.

In November 1940 orders were issued for operational fitting of an improved type of AW radar. Most of the earlier research had been directed towards continual improvement of means of detecting hostile aircraft (particularly at low level). The new air warning set was designated Type 281. It was an SWG (ship warning and gunnery) set and could give ranges of surface targets accurate enough for gunnery. Wavelength was three metres and frequency 85 to 94 MHz. An intermediate set – Type 280 – did not come into general use. This outfit had a wavelength of 3.66 metres and a frequency of 82 MHz. The object was continually to shorten the wavelength with increasing frequency. Ranges were as follows: Type 280 – six miles against battleship target, five miles against a cruiser target, three miles against a destroyer target, five miles against aircraft at 100 feet, sixteen miles against aircraft at 1,000 feet, 65 miles against aircraft at 16,000 feet. Type 281 – twelve miles against a battleship target, eight miles against a cruiser target, five miles against a destroyer target, two miles against a surfaced submarine, seven to nine miles against aircraft at 100 feet, 38–50 miles against aircraft at 3,000 feet, 88–115 miles against aircraft at 16,000ft. Accuracy: Type 280 – plus 50 yards between ranges 2,000–14,000 yards; Type 281 – plus 100 yards between

VARIOUS TYPES OF EARLY RADAR AERIAL

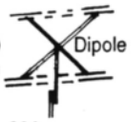
By 1940 sets had been developed from RAF equipment for air warning and AA gun control, and attention now centred on long-range gun control.



Type 284 aerials designated ASF and ATH

Type 286MY (introduced Apr 1941)
A rather odd arrangement of dipoles to give some indication of dead-ahead targets. The ship had to be swung for the set to be used. Max. range was only 3 miles.

Type 286P (introduced July 1941)
also Type 286PQ (introduced Dec 1941)
Dipole aerials inside cover for protection (introduced Jan 1941)



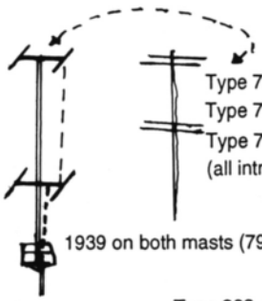
The old bedstead aerial for Type 286 proved hopeless and was replaced as soon as possible by the above compact arrangement which was a clever way of combining two miniature masthead arrangements on one mast. Range was limited but performance proved reliable.

This was the range of pure Radar aerials available to the Royal Navy during the period when Britain stood alone and when Radar was seen as essential for sea and aerial warfare. In 1939 only aircraft could be detected and then only rather approximately. By 1941, however, any target could be detected to an accuracy of about 50 yards.

Type 273 (below)
Type 272
Aerial types AUE, AUG and AUH
These were sets using H/F which was achieved by the cavity magnetron.

They were intended for very precise detection at low level:
273 for large ships
272 for smaller ships
(introduced Dec 1941).
The particularly delicate sets were housed in lanterns of various patterns to protect them from the elements.

Type 273 upper part glazed with Perspex to enable equipment to be examined from outside. Frequently fitted on mast but this was not essential.

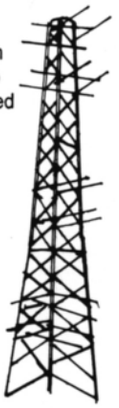


Type 79B
Type 79Y
Type 79Z
(all introduced 1939)

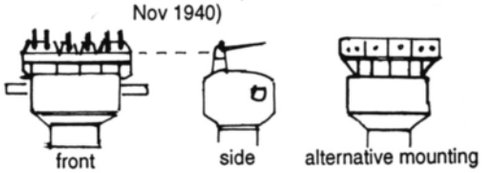
1939 on both masts (79M on one only)

Type 279 (both masts)
Type 279M (one mast only, first model introduced Jan 1940, virtually same as Type 79)

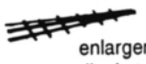
In 1938 Britain had five defensive Radar sites with 200ft towers like this. Two of them had beeen installed since 1935.



Type 285 aerials designated ASQ & ATJ (introduced Nov 1940)



Type 282 aerials designated ASE & ATG (introduced Nov 1940)

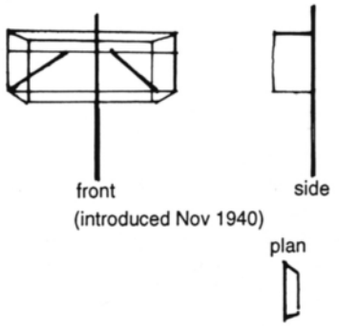


enlargement of Yagi dipole transmitter

Directors are turned until strength returned is equal on all reflectors

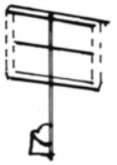
3 twin Yagi dipole transmitters with 4 reflectors 6 beams out and return

Type 286 aerials designated ATQ & ATR



(introduced Nov 1940)

Type 281 aerials designated ASJ & AQB (introduced Dec 1940)



2 masts

Note: German warships were fitted with *Fernmessergerät* from 1936, but the aerials were cumbersome frames (8m long), dismantled in port for security. They had considerable range but poor definition.