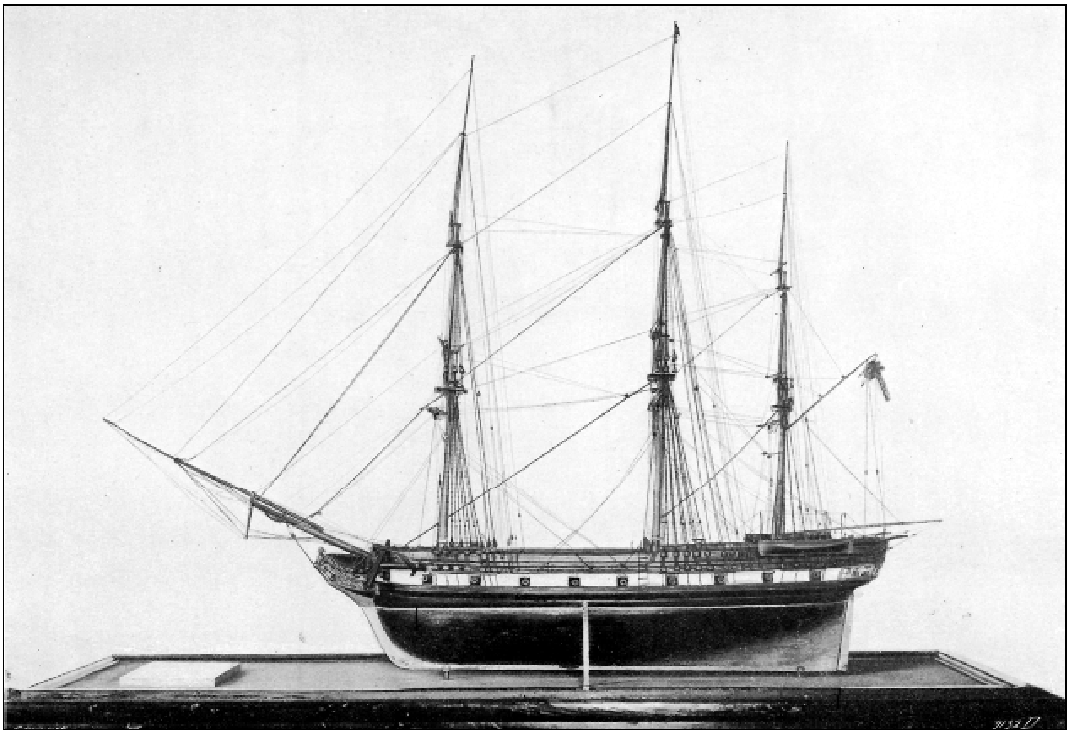
Inverclyde council

Two Centuries of Shipbuilding by the Scotts at Greenock – Published 1906

A Century's Work for the Navy.

The work for the Navy by the Scotts began with the building, in 1803, of a sloop-of-war named The Prince of Wales; a photograph from the model of this vessel is reproduced below.



Model of H.M.S. Prince of Wales 1803

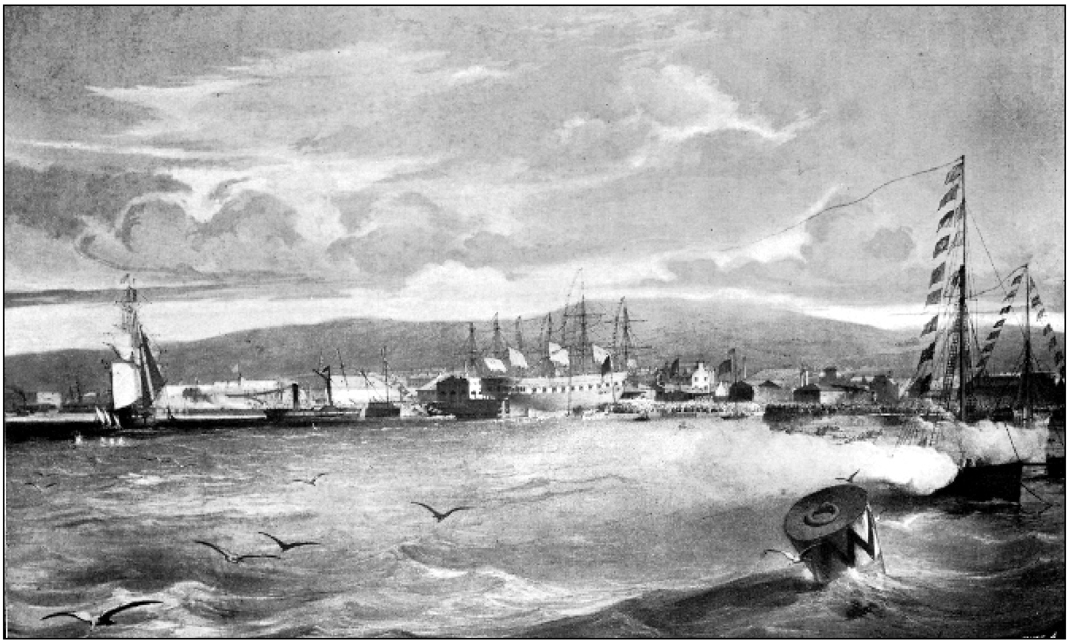
Since the construction of this ship the firm have carried out several important Admiralty contracts, including the first machinery manufactured in Scotland for a dockyard-built ship, the first steam frigate built in the North, and several later ships, with their engines; the most recent order being for the machinery of the armoured cruiser Defence, of 14,600 tons displacement, and 27,000 indicated horse-power, to give a speed of 23 knots.

The progress demonstrated by a contrast between the small sloop-of-war and this latest powerfully - armed and well-protected high-speed cruiser, is a record of research and invention, not only on the part of the naval architect, but also of the chemist, the metallurgist, and the engineer; the triumph is greater than that reviewed in the case of the Merchant Marine. Great speed has been achieved, notwithstanding that the problems to be solved in its attainment have been intensified by the limitations in the size of the ship in order to minimise the target presented to the enemy's fire, and by the necessity of providing for heavy armour, armament, and ammunition in the displacement weight.

When a comparison is made of the Navy ships at the beginning of the nineteenth century with those of a hundred years earlier, it is found that little progress had been made, either in design or in gun-power. The largest vessel in 1700 was of 1809 tons burden, with a hundred' guns. A century later, the size had increased only to 2600 tons, with a hundred and twenty guns. But even this was an exceptionally large vessel. The British ships were, as a rule, smaller, and perhaps slower, than the French ships; but then—as now and always—skill in strategy, courage in combat, and devotion to duty were the most powerful factors in action. No fault in these respects could be found with the work of our Navy in the various engagements which terminated in the epoch-marking victory in Trafalgar Bay.

The peace following the Napoleonic wars was not conducive to advancement, as there was little incentive to pursue the sciences which contributed to the development of destructive weapons. Steam as a motive power and iron as a constructive material were not so readily adopted in the Navy ship as in the Merchant Marine. Progress in the utilisation of iron was not continuous. The first application of steam was belated, and its popularity was not unalloyed.

The Admiralty ordered their first ship of iron in 1839—a small, non-fighting boat for the Dover station— and there followed other vessels for the exploration of the River Niger. But the first iron fighting ship was not built until 1843. In 1848-9 the Scotts constructed the iron steam frigate Greenock, the largest iron warship of her day, and the first steam frigate built on the Clyde. The over-all length of this vessel was 213 ft., the beam 37 ft. 4 in., and the depth of hold 23 ft. She was of 1413 tons burden, and carried ten 32-pounder smoothbore muzzle-loading guns. The illustration on Plate XV. is a reproduction from an old engraving of the launch of the vessel.

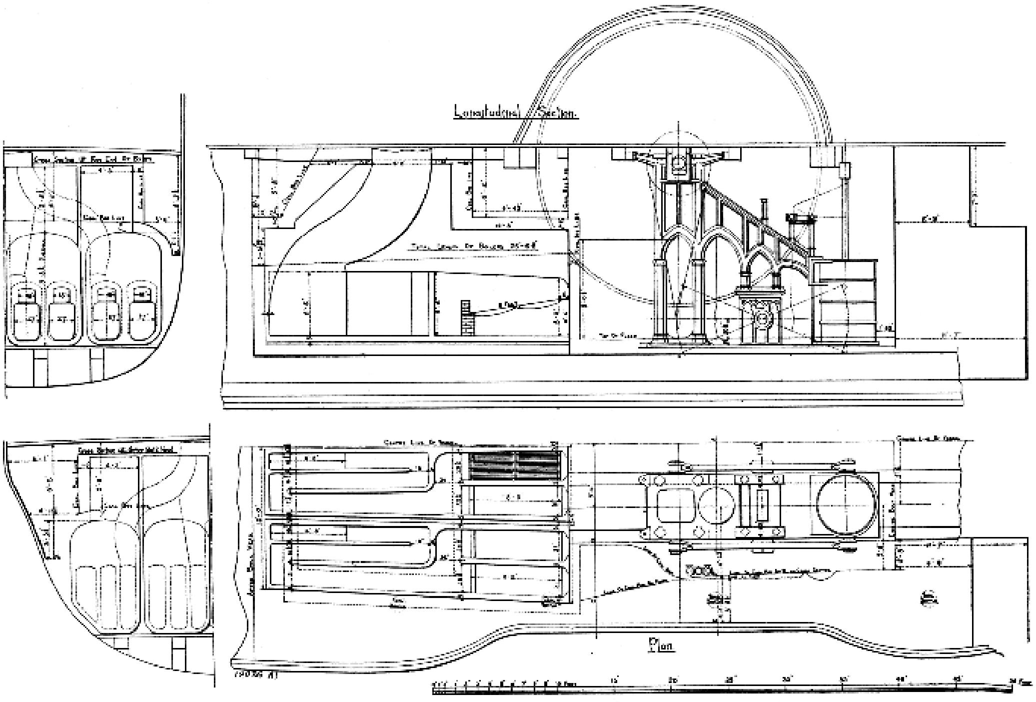


Launch of the first Clyde built steam Frigate *GREENOCK* in 1849

It is a noteworthy feature that the figure-head was a bust of John Scott, the second of that name. This compliment by the naval authorities of the time was well merited, as he did much not only for the advance of naval architecture, but also for the development of Greenock.

As a writer of the day put it, this vessel was the experimentum crucis of the principle of constructing fighting ships of iron. By 1850 there were six large iron vessels, ranging downwards from the 1980 tons of the eighteen-gun ship Simoon, with eleven smaller vessels; but they were all condemned, because it was found by experiment that the 32-pounder gun at short range could perforate the side of the iron ship, and that the projectile carried its “cloud of langrage” with great velocity into the interior of the ship, so that men could not stand against it. Tests were also made with sixteen wrought-iron plates superposed, to give a total thickness of 6 in., but these also were perforated by the 32-pounder projectiles at 400 yards range; so that the adoption of iron on the main structure of the ship was practically delayed until armour-plates were first rolled in 1859.

The obstacle to the adoption of steam was the unsuitability of paddle-wheel machinery for fighting ships. The wheel was exposed to gun-fire, and the whole of the machinery could not be located below the water line. Moreover, the side wheel limited the number of guns which could be utilised for broadside fire. The first steam craft ordered by the Admiralty was a small vessel of 210 tons and 80 nominal horse-power, built in London in 1820. Several other non-fighting steamships followed. By 1837, the largest steam vessel in the fleet was a sloop of 1111 tons and 320 horse-power. In 1839 five steam vessels were built, and two of them—the Hecate and Hecla— were engined by the Scotts. These wooden steamers were the first naval vessels sent to Scotland to have their machinery fitted on board. They were of 817 tons and 250 horse-power. The paddle-wheels had a diameter of 25 ft. £ in., and there were seventeen floats. The main engines, illustrated on page 29, represent the type adopted, not only in the Naval, but in the Merchant service of this time. The steam pressure was then about 3 Ib. per square inch.



Machinery of H.M.S. HECLA and HECATE 1839

Above we illustrate the general arrangement of the machinery in the Hecate and Hecla. There were four boilers of the rectangular type, each with two wet-bottomed furnaces at one end and large return flues at the other end. The uptakes passed up inside the boilers through the steam space, uniting in one funnel.

Smith's screw-propeller was tried experimentally in 1837, and Ericsson's about the same time. The comparative trials of the Archimedes fitted with Smith's screw against existing paddle-steamers did much to prove the efficiency of the new system. The screw-ship excelled the performance of paddle-steamers on the service, and the screw-propeller was adopted by the Admiralty in 1845; twin-screws followed twenty-five years later.

The Greenock, built in 1848, was the first war vessel by the Scotts fitted with the screw-propeller. We have already referred to her construction in iron, and to her launch. She had a displacement of 1835 tons, and her engines were of 719 indicated horse-power. The speed realised on the trial was 9.6 knots. The Greenock's machinery, which is illustrated on the next page, is especially interesting, as it represents one of the earliest attempts to drive the screw-propeller by gearing. Two horizontal cylinders were fitted, each 71 in. in diameter, with a stroke of piston of 4 ft. The gearing consisted of four sets of massive spur-wheels and pinions, in the ratio of 2.35 to 1, so that 42 revolutions per minute of the engines give 98.7 revolutions to the propeller-shaft. The propeller was 14 ft. in diameter, and was so fitted that it could be detached and raised to the deck. There were four rectangular brass-tube boilers, each with four wet-bottomed furnaces, and all the internal uptakes united in one funnel, which was telescopic, so that when it was lowered and the propeller raised out of the water, the vessel had the appearance, as well as the facility, of a sailing frigate.

As will be seen from the drawings, both the engines and boilers were arranged very low in the hull, to be safe from the enemy's fire. The engine and boiler compartment occupied 72 ft. of the length of the ship—about one-third of the total length—and the seating for the machinery was specially constructed, with a very close pitch of frames which were only 1 ft. apart. For comparison with the drawings of the machinery in the Greenock, we give on page 49 a similar drawing of the machinery of the Canopus, of 12,956 tons displacement, seven times that of the Greenock. To double the speed, the power of machinery had to be multiplied twenty times, and yet the space occupied is only about trebled.

In 1850 the largest of the steam vessels in the Navy had a displacement of 3090 tons, but the most noted was the Dauntless, of 2350 tons displacement, with engines of 1347 indicated horse-power to give a speed of 10 knots. It is true that there were three smaller vessels of greater speed, one of 196 tons steaming 11.9 knots; but this was the highest rate reached in the Navy service. By this time some of the fast mail steamers made 13J knots. These latter were suited for war service, but we have already dealt with them.

Following the adoption of the screw-propeller in warships came the abandonment of gearing for the engines. For many years various forms of horizontal engine were used; first with return-connecting rods, and subsequently with direct-acting rods. Steam pressures steadily increased, largely owing to stronger materials being available. It was, however, not until the 'seventies that the cylindrical boiler, the compound engine, and the surface condenser admitted of an increase to 60 Ib. per square inch—several years after these improvements had been introduced in the Merchant Marine.

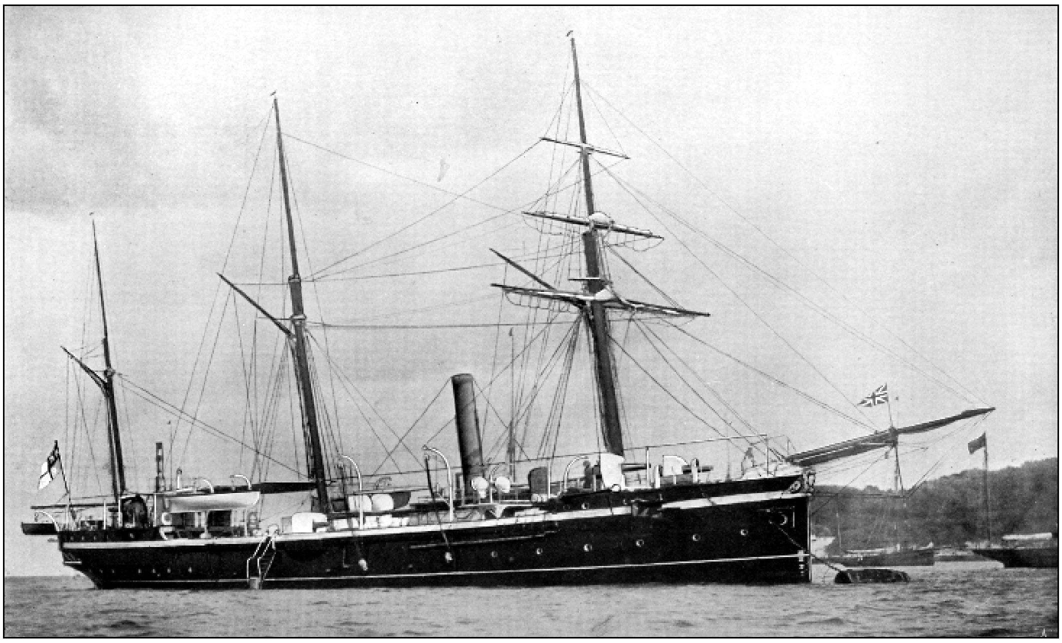
The Scotts had worked steadily at the solution of the problem from their trials with the Thetis in 1858. In 1860 the late John Scott, C.B., laid before the Admiralty a system of water-tube boilers and compound engines, but objection was raised to the system. The French Naval authorities, with whom the Scotts then had close business connection, took up the scheme, largely because of the favour with which it was viewed by M. Dupuy de Lôme, the head of the Department. The first ship fitted was a corvette of 650 tons displacement; the boilers worked at a pressure of 140 Ib., while the initial pressure at the compound three-cylinder engines was 120 Ib. These were the first engines of the compound type in the French Navy.

The Scotts were at the time building engines for four corvettes under construction at the Woolwich and Deptford yards for the British Navy; and the Admiralty agreed to have fitted in one of them water-tube boilers and engines similar to those built for the French boats. The boilers may be said to have belonged to the same general type as the Thornycroft and Normand water-tube steam generators. It was subsequently found impossible, however, to ensure that the top of the boilers should be at least 1 ft. under the load-line—a condition then enforced in steam vessels for the Navy—and the adoption of the water-tube boiler was deferred, the ordinary machinery of the period being fitted to work at 25-lb. pressure instead of 120-lb.

This was unfortunate, as it removed the incentive to continued research needed to make the water-tube boiler a really satisfactory steam generator. The Scotts, however, continued to work for the successful application of high pressures, and it was this that brought them into contact with the late Mr. Samson Fox, with whom they were closely identified for many years in connection with the development of the corrugated flue and the cylindrical steam boiler.

Opinion being adverse to the water-tube boiler, notwithstanding its acceptance by many foreign Navies, there was a strong agitation fostered by engineers to induce the societies for the registry of shipping, and also the Board of Trade, to increase the ratio of the working to the test, pressure in boilers. The British Admiralty allowed the boiler to be worked up to within 90 Ib. of the test pressure, whereas in the Merchant Service the working pressure was limited to one-half of the test pressure. In 1888 the Scotts, being convinced that the Admiralty system afforded quite a satisfactory factor of safety, undertook the experiment of submitting a warship boiler, then being built by them to Admiralty specification, to the highest possible pressure, even up to bursting-point. The boiler ultimately leaked to such an extent, after the pressure had been maintained for a long period at 620 Ib. per square inch, that it was not considered necessary to proceed further. The stresses at this stage worked out to 48,130 Ib. per square inch; and the result proved that there was some justification for a reduction in the minimum scantlings of the shells of marine boilers to, at least, the scale adopted by the Admiralty.

These suggestive experiments were carried out in connection with the boilers constructed in 1888-9 for two war vessels built by the Scotts. These vessels were the Sparrow and the Thrush. At the same time, the Scotts engined two other vessels of the same type, constructed at the Royal Dockyards.



H.M.S. THRUSH 1889

A view is given above of the Thrush, which was commanded by H.R.H. the Prince of Wales on the North American and West Indian stations in 1891. She was a vessel of composite build, of 805 tons displacement, with machinery of 1200 horse-power, to give a speed of 13 knots; but, as is shown by the illustration, she was fitted as a three-masted schooner, and utilised her sails when the wind was favourable. In this respect, she marks the transition stage between the days of the sailing craft and the modern ship, depending entirely on steam for propulsion. Indication is afforded of the progress towards this transformation by Table III. on the opposite page, which shows the improvement in economy in the machinery of warships at various stages in their development.

TABLE III. PROGRESSIVE TYPES OF WARSHIP MACHINERY, AND THEIR ECONOMY, 1840 TO 1905.

	1840 to 1865	1855 to 1875	1875 to 1890	1890 to 1895	1895 to 1900	1900 to 1906
Type of boiler	Rectangular box	Rectangular box	Single-ended cylindrical	Single-ended cylindrical	Belleville water-tube	Water-tube
Steam pressure per square inch	3 lb. to 4 lb.	25 lb.	90 lb.	155 lb.	300 lb.	300 lb.
Coal consumption per indicated horse-power per hour	7 lb.	4 lb. to 5 lb.	2.5 lb.	2 lb.	1.8 lb.	1.8 lb.
Type of engine	Geared screw	Simple horizontal surface condensing	Three-cylinder compound	Three-cylinder triple-expansion	Three-cylinder triple-expansion	Four-cylinder triple-expansion
Piston speed in feet per minute	220	500 to 600	750	840	918	1000
Weight of machinery per indicated horse-power	10 cwt.	3 cwt. to 5 cwt.	3 cwt.	2.75 cwt.	2 cwt.	1.6 cwt.
Speed of ship	8 to 9 knots	14 knots	16 knots	18 knots	18.25 knots	23 knots

The figures in the Table are average results rather than highest attainments during the periods. For 1890-95 we have taken the Barfleur, the engines of which were constructed by the Scotts in 1894; whilst the particulars for 1895-1900 refer to the Canopus, engined by them in 1900. In 1902 they also supplied the machinery for the battleship Prince of Wales, and commenced the construction of the armoured cruiser Argyll. But before referring in detail to these latter ships, we may briefly review the advances in applied mechanics, metallurgy and chemistry, which have contributed largely to the perfection of these modern fighting ships in respect of offensive and defensive qualities.

The gun most in favour at the close of the eighteenth, and at the opening of the nineteenth, centuries was the cast-iron, smooth-bored, muzzle-loader: first the 32-pounder and later the 68-pounder. Carronades were used for "smashing" rather than for penetrating the skin or structure of ships. Although the 68-pounders were improved by a lining of wrought iron being inserted in the bore, whereby the energy at 1000-yards range was increased from 290 to 600 foot-tons, little progress was made until after the Crimean War, when chemists undertook the investigation of the action of explosives and metallurgists sought to produce stronger metals.

The general idea as regards the powder used as a propellant was that the ignition was instantaneous, and that the more violent the explosion the greater would be the velocity of the projectile. Under such conditions short weapons naturally found favour; and indeed, with a light, spherical, ill-fitting projectile, there was very little advantage to be gained by lengthening the bore. But with the introduction of rifled cannon, much heavier and better-fitting shot became possible, and a rapid-burning powder gave rise to dangerous pressures in the gun. It was then realised that it was not an explosion that was wanted, but continuous pressure acting on the base of a shot for a relatively considerable period. This needed a slow-burning explosive, and led to the manufacture of powder as pebbles or prisms; the enlargement in the late 'seventies of the chamber of the gun, and the provision of air spaces for the expansion of the powder, greatly added to the velocity with which the shot left the gun, and therefore augmented its carrying power.

Gun-makers had meanwhile improved the strength of the weapon by a recognition of the fact that wrought iron was twice as strong in the direction of the fibre as across it; and thus in the 'sixties they began to coil the central tube, surrounding it by hoops, welded or shrunk on. The full advantages of fibre were thus secured for resisting circumferential strain. The bore was rifled to give the shot that rotatory motion which prevents irregularity in flight and conduces to accuracy of fire at long range. The smooth-bore gun was effective up to only 1000 yards range, as compared with the 6000 yards and 7000 yards for the modern weapon. Breech loading was first introduced into the Navy in the 'sixties, but discarded because the details for closing the breech end proved unsatisfactory. Finally, it was reintroduced in 1878, a satisfactory mechanism having been devised.

These various improvements gradually increased the power of the gun. The length and weight had enormously grown, as is shown by the particulars of successive large naval guns, shown in Table IV.; but the increase in energy up till the 'eighties was not commensurate with the augmentation of the weights of the projectile and charge.

TABLE IV. PARTICULARS OF THE SUCCESSIVE LARGE NAVAL GUNS, 1800 TO 1905

	Type.	Weight. tons cwt.	Length (ins.)	Calibre (ins.)	Weight of Projectile (lb.)	Weight of Charge (lb.)	Muzzle Energy ft.-tns.	Penetration of Wrought Iron at 101 Yards Range (ins.)
1800	Cast-iron smooth-bore	2 12	114	6.4	32	10	400	
1842	Ditto	4 15		8.12	68	16	700	
1865	Woolwich wrought-iron	4 10		7	115	22	1400	7
1870	Built-up muzzle-loader	38 0	200	12.60	810	200	13,900	17
1880	Ditto	80 0	321	16	1700	450	27,960	22fc
1887	Built-up breechloader	110 10	524	16.25	1800	960	54,390	32
1895	Wire-wound breech-loader	46 0	445.5	12	850		33,940	34.6
1900	Ditto	51 0	496.5	12	850	210	36,290	35.4
1906	Ditto	58 0	540	12	850		49,560	42

The advance from the 38-ton gun of 1870 to the 110.5-ton gun in 1887 involved the multiplying by five of the charge of powder, which quadrupled the energy of the gun, but the carrying power of the shot was still deficient.

The velocity had increased in twenty years from 1600 to 2000 ft. per second, slower-burning powder having been introduced.

Attention was further directed to the improvement of explosives; and ultimately, instead of gunpowder having a potential energy of 480 foot-tons per pound, modified gun-cotton was introduced, with an energy of 716 foot-tons per pound, and still later there were evolved explosive com-pounds of which the potential energy per unit of weight was fourfold greater than in the case of gunpowder, namely, 1139 foot-tons per pound. Finally, the explosive has taken the form of cordite, which ensures slow burning, great expansion, and, consequently, augmented propelling power behind the projectile, without material addition to the maximum strain upon the weapon. But in any case the constructional strength of the modern gun is enormously superior to the earlier built-up weapons, as around the inner tubes there is coiled something like 120 miles of wire, which itself has a breaking-strain of between 90 and 110 tons per square inch, and is put on under a tension of from 54 tons per square inch on the inner wires to 32 tons per square inch on the outer wires,1 so that the ultimate resistance to strain consequent upon the firing of the gun is enormously increased. Velocities of 2600 ft. per second are thus realised, and even more is quite feasible, so that penetration of wrought iron at 1000 yards range has now been increased to 42 in.

If we compare the 12-in. gun to-day with the weapon of the same calibre of twenty years ago, when there was no widened chamber for the explosive, when prismatic powder of low expansive power was used, it is found, as shown in the Table opposite, that the penetration at 1000 yards has been doubled, and the possible effective range multiplied fivefold. There has also been an enormous gain in quicker fire by improved breech mechanism and efficient hydraulic and electric mountings, whereby the gun and all its loading, elevating, and training machinery is rotated.

The metallurgist has also been successfully occupied, and it is probable that the armour plate of to-day is still invulnerable. The earlier wrought-iron plates were increased from 4j in. in thickness on the Warrior of 1861, to the 24 in. on the Inflexible of 1881; the area protected being almost proportionately reduced. The artillerist with improved projectiles ultimately defeated this heavy cleading on the ships; but compound armour, first made in 1879, enabled the maximum thickness on the broadside to be reduced to 18 in., permitting a greater area to be covered for the same weight. At first the 80-ton gun failed in its attack, but heavier weapons, with improved projectiles, prevailed. The next step was the introduction of all-steel armour in 1890. Two years later there was introduced the super-carburising and subsequent chilling of the face of plates made of an alloy of nickel steel. In 1897 the process of hardening was still further developed, and now the 9-in. plate on the modern battleship is equal in resistance to a 26-in. wrought-iron plate of the 'sixties, or a 20-in. compound-plate of the 'eighties, or a 13-in. plate of the early-hardened type. For the present, therefore, the armour seems to have secured the victory, as at 5000 yards range 9-in. armour can scarcely be defeated by even the 12-in. gun.

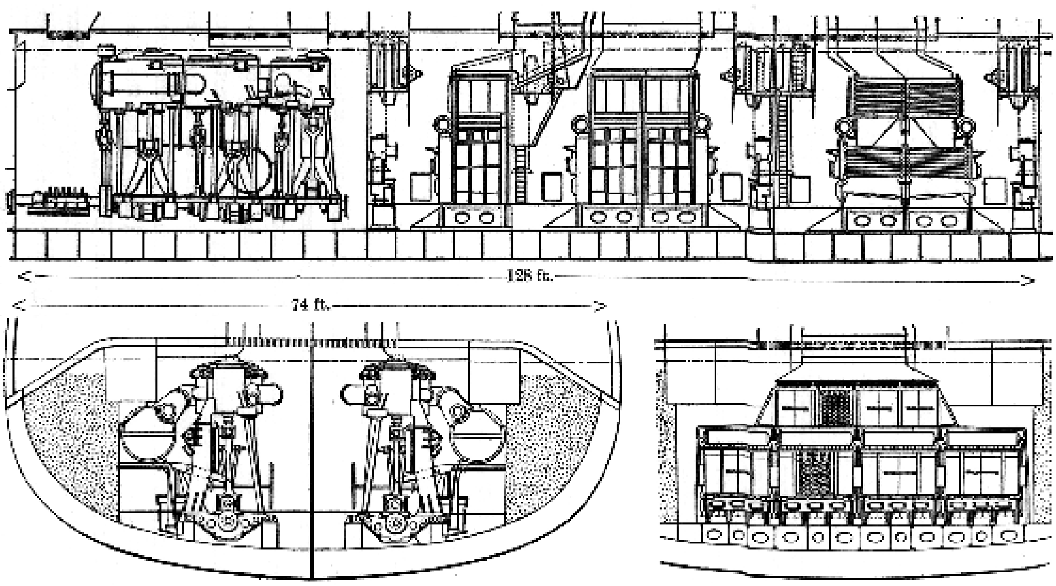
With the increased resistance of armour and the consequent reduction in its thickness, the naval designer can spread his protecting plates over a much wider area, so that the whole broadside of ships like the Prince of Wales, or the cruisers Argyll and Defence, is clad with armour of satisfactory resisting power. At the same time the gun-power and speed of ships have been greatly increased without making the displacement inordinately high. On the opposite page a Table gives the main features of representative ships at different epochs, which will show this at a glance.

The growth in the size of battleships has been steady, with the exception of the class represented by the Barfleur and Canopus, both of which were engined by the Scotts. These vessels are embodiments of a desire to check the advance in the size and cost of the battleship. The deficiency in the number and calibre of their guns was partly compensated by the introduction, for the first time in battleships, of quick-firing weapons of large calibre. The Barfleur had four 12 in. breechloaders and ten 4.7 in. quick-firers; while the Canopus had four 10 in. breechloaders and ten 6 in. quick-firers. But opinion has again strongly grown in favour of having in each British ship the best that can be achieved; and thus the Prince of Wales has a displacement greater than any previous ship, while in the King Edward and the Lord Nelson classes there has been a further growth in every element of power. The probabilities, too, are that we have not yet by any means seen the end of this advance.

TABLE V. SIZE AND FIGHTING QUALITIES OF BRITISH BATTLESHIPS OF DIFFERENT PERIODS.

Name	Date of Completion.	Displacement (tons)	Side Armour (ins.)	Speed (knots)	Total Weight of Shot in One Round. (lb.)	Collective Energy at Muzzle of One Round (foot-tons)
Warrior	1861	9,210	4.5-in. wrought iron	14.5	3800	61,476
Hercules	1868	8,680	9-in. to 6-in. wrought iron	14	5400	70,200
Alexandra	1877	9,490	12-in. to 6-in. wrought iron	15	5426	71,400
Inflexible	1881	11,880	24-in. to 16-in. wrought iron	13	6936	123,120
Benbow	1888	10,600	18-in. compound	16.75	4600	135,560
Royal Sovereign	1892	14,150	18-in. and 5-in. compound	17.5	5800	159,610
SarJUwr	1894	10,500	12-in. compound	18.5	2450	67,670
Canopus	1900	12,950	6-in. hardened steel	18.25	4600	178,720
Prince of Wales	1902	15,000	9-in. super-hardened steel	18.25	4600	194,400
King Edward VII.	1904	16,350	9-in. super-hardened steel	18.50	5920	270,040
Lord Nelson	1905	16,500	10-in. super-hardened steel	18.50	7960	413,900

As to the machinery made by the Scotts for these battleships, the Barfleur had three-cylinder, triple-expansion twin-screw engines, to run at 108 revolutions, and to develop 13,000 indicated horse-power. On her trials the power was 13,163 indicated horse-power. There are eight single-ended, return-tube, cylindrical boilers, working at 155 Ib. pressure. Other details are given in Table III.



Machinery of H.M.S. CANOPUS 1900

The engines of the Canopus are illustrated above by a drawing taken from a Paper read at the Institution of Civil Engineers, by Sir John Durston and Admiral H. J. Oram. This was the first type of British battleship fitted with water-tube boilers. She was followed soon after by the Prince of Wales.

The Argyll, which was built and engined by the Scotts, and the Defence, which is being built in one of the Royal Dockyards, and is having its machinery constructed by the Scotts, signalise progress in cruiser design. The hardening of armour, increasing its resistance, permits of a reduction in weight for a given measure of protection, so that it has been possible to effectively defend the modern cruiser, while at the same time giving an enormously increased gun-power and a speed far in excess of that possible ten years ago. The Argyll is a vessel of 10,850 tons displacement, being 450 ft. long, 68 ft. 6 in. beam, and having a draught of 25 ft.; while the Defence is a vessel of 14,600 tons displacement, having a length of 490 ft., a beam of 74 ft. 6 in., and a draught of 26 ft. In both ships the greater part of the broadside, from 5 ft. below the water-line to the upper deck, is armoured, and a very large proportion of the area thus clad has 6-in. hardened plates.

In the late 'nineties it was assumed that quick-firing artillery was best suited to the work of a cruiser, and thus the 6-in. gun was exclusively adopted. But since then Naval strategists have developed their ideas as to the function of armoured cruisers, and now anticipate their use in the line of battle; so that not only has the defensive quality be-en improved, but the offensive power has been materially increased. In the Defence, and the other ships of the class, the 6-in. gun has been entirely discarded in favour of an installation of 9.2-in. and 7.5-in. weapons. Owing to the perfection of the hydraulic and electric mountings, little has been forfeited in respect of rapidity of fire, while much has been gained in the striking energy at a given range of each projectile. Thus, while the 6-in. gun five years ago had an energy equal to penetrating 6 in. of wrought iron at 3000 yards' range, the 7.5-in. weapon now may perforate 6J in., and the 9.2-in. gun 9 in. of the hardest armour at corresponding range. The total weight of projectiles fired from the present-day cruiser in a minute is double, and the muzzle energy quadruple, the results attained by the cruisers designed at the close of the nineteenth century.

The modern cruisers steam at 23 knots, the power of the machinery in the Argyll being 21,000 indicated horsepower, and in the Defence 27,000 indicated horse-power. The machinery of the Argyll, which is typical, consists of four sets of triple-expansion engines, arranged in separate watertight compartments. The diameters of the cylinders are: high-pressure, 41.5 in; intermediate-pressure, 65.5 in.; and the two low-pressure, each 73.5 in., all having a stroke of 42 in. At full power, developed with 138 revolutions, the piston speed is 966 ft. per minute. The cylinders are fitted with liners, and are steam-jacketed; forged steel is used for the liners of the high- and intermediate-pressure cylinders, and cast-iron for those of the low-pressure cylinders. The cylinder covers and pistons are of cast steel, the latter being of conical form. The high- and intermediate-pressure cylinders have piston valves, and the low-pressure cylinders flat valves. The cylinders are supported at the front by eight forged-steel columns, and at the rear by four cast-iron columns formed with guide-faces, and one forged steel column. The crankshaft is in four pieces, the high- and intermediate-pressure parts being interchangeable with each other, and the two low-pressure parts with one another. The shafts are hollow, and three - bladed propellers of manganese bronze are fitted to each. The condensers are entirely separate, and independent air pumps are fitted.

The Argyll had a combination of six cylindrical and sixteen water-tube boilers, but in the later ships, including the Defence, the boilers are entirely of the water-tube type. The working pressure of the boiler is 275 lb., reduced at the engines to 250 lb. The trials of the Argyll were carried through most satisfactorily, and the vessel, under the new Admiralty conditions, was completed for commission by the builders. The fact that this armoured cruiser was so completed at the builder's yard is of itself evidence of the capacity and efficiency of the plant.