SHERLOCK, WILLIAM (1641–1707), dean of St Paul's, was born at Southwark in 1641, and was educated at Eton and Cambridge (Peterhouse). In 1669 he became rector of St George, Botolph Lane, London, and in 1681 he was appointed a prebendary of St Paul's. In 1684 he published *The Case of Resistance of the Supreme Powers stated and resolved according to the Doctrine of the Holy Scriptures*, an ably written treatise, in which he drew the distinction between active and passive obedience which was at that time generally accepted by the high church clergy; in the same year he was made master of the Temple. In 1686 he was reproved for preaching against popery and his pension stopped. After the Revolution he was suspended for refusing the oaths to William and Mary, but before his final deprivation he yielded, justifying his change of attitude in *The Case of the Allegiance due to Sovereign Powers stated and resolved according to Scripture and Reason and the Principles of the Church of England* (1691). During the period of his suspension he wrote a *Practical Discourse concerning Death*, which became very popular and has passed through many editions. In 1690 and 1693 he published volumes on the doctrine of the Trinity which involved him in a warm controversy with South and others. He became dean of St Paul's in 1691, and died at Hampstead in 1707.

SHERMAN, a city of the United States, in Grayson county, Texas, 73 miles north of Dallas, is a substantially built and flourishing place, with a court-house and a college. Its population, only 1439 in 1870, was 6093 in 1880 and has since increased to about 8000. The surrounding country is a cotton and grain district.

SHERWIN, JOHN KEYSE (1751–1790), engraver and history-painter, was born in 1751 at East Dean in Sussex. His father was a wood-cutter employed in shaping bolts for shipbuilders, and the son followed the same occupation till his seventeenth year, when, having shown an aptitude for art by copying some miniatures with exceptional accuracy, he was befriended by Mr William Mitford, upon whose estate the elder Sherwin worked, and was sent to study in London, first under John Astley, and then for three years under Bartolozzi—for whom he is believed to have executed a large portion of the plate of Clytie, after Annibal Caracci, published as the work of his master. He was entered as a student of the Royal Academy, and gained a silver medal, and in 1772 a gold medal for his painting of Coriolanus Taking Leave of his Family. From 1774 till 1780 he was an exhibitor of chalk drawings and of engravings in the Royal Academy. Establishing himself in St James's Street as a painter, designer, and engraver, he speedily attained popularity, and began to mix in fashionable society. His drawing of the Finding of Moses, a work of but slight artistic merit, which introduced portraits of the princess royal of England and other leading ladies of the aristocracy, hit the public taste, and, as reproduced by his burin, sold largely. In 1785 he succeeded Woollett as engraver to the king, and he also held the appointment of engraver to the prince of Wales. His professional income rose to about £12,000 a year; but he was constantly in pecuniary difficulties, for he was shiftless, indolent, and without method, open-handed and even prodigal in his benefactions,—and prodigal, too, in less reputable directions, for he became a reckless gambler, and habits of intemperance grew upon him. He died in extreme penury on the 24th of September 1790,—according to Steevens, the editor of Shakespeare, at "The Hog in the Pound," an obscure alehouse in Swallow Street, or. as stated by his pupil J. T. Smith, in the house of Robert Wilkinson, a printseller in Cornhill.

It is as an engraver that Sherwin is most esteemed; and it may be noted that he was ambidexterous, working indifferently with either hand upon his plates. His drawing is correct, his line excellent, and his textures are varied and intelligent in expression. Such of his plates as the Holy Family after Nicholas Poussin, Christ Bearing the Cross after Murillo, the portrait of the Marquis of Buckingham after Gainsborough, and that of Pitt occupy a high place among the productions of the English school of line-engravers. He also worked after Pine, Dance, and Kauffman.

SHETLAND ISLANDS. See ORKNEY AND SHETLAND.

SHIELD. See ARMS AND ARMOUR, and HERALDRY.

SHIELD, WILLIAM (1748–1829), composer of English operas, was born at Swalwell, near Newcastle, in 1748. His father began to teach him singing before he had completed his sixth year, but died three years later, leaving him in charge of guardians who made no provision whatever for continuing his musical education, for which he was thenceforward dependent entirely upon his own aptitude for learning, aided by a few lessons in thoroughbass which he received from Charles Avison. Notwithstanding the difficulties inseparable from this imperfect training, he obtained admission into the opera band in 1772, at first as a second violin, and afterwards as principal viola; and this engagement he retained for eighteen years. In the meantime he turned his serious attention to composition, and in 1778 produced his first comic opera, *The Flitch of Bacon*, at the Little Theatre in the Haymarket, with so great success, that he was immediately engaged as composer to Covent Garden theatre, for which he continued to produce English operas and other dramatic pieces, in quick succession, until 1797, when he resigned his office, and devoted himself to compositions of a different class, producing a great number of very beautiful glees, some instrumental chamber music, and other miscellaneous compositions. He died in London January 25, 1829, and was buried in the south cloister at Westminster Abbey.

Shield's most successful dramatic compositions were *Rosina*, *The Mysteries of the Castle*, *The Lock and Key*, and *The Castle of Andalusia*. As a composer of songs he was in no degree inferior to his great contemporary Charles Dibdin. Indeed *The Arethusa*, *The Heaving of the Lead*, and *The Post Captain* are as little likely to be forgotten as Dibdin's *Tom Bowling* or *Saturday Night at Sea*. His vein of melody was inexhaustible, thoroughly English in character, and always conceived in the purest and most delicate taste; and hence it is that many of his airs are still sung at concerts, though the operas for which they were written have long been banished from the stage. His *Introduction to Harmony* (1794 and 1800) contains a great deal of valuable information; and he also published a useful treatise, *The Rudiments of Thoroughbase*.

SHIELDS, NORTH. See TYNEMOUTH, within which borough the port is included.

SHIELDS, SOUTH, a seaport, market-town, and municipal and parliamentary borough of Durham, is situated on the south bank of the Tyne, at its mouth, immediately opposite North Shields and Tynemouth, and on the North-Eastern Railway, 18 miles north-east of Durham and 9 east of Newcastle-on-Tyne. It is connected with North Shields and Tynemouth by steam ferries. The town possesses a spacious market-place, and some of the newer streets are wide and handsome, but the old street running along the shore is narrow and mean. Formerly salt was largely manufactured, but the principal industries now are the manufacture of glass and chemicals, and shipbuilding and ship refitting and repairing, for which there are docks capable of receiving the largest vessels. The North-Eastern Railway Company possesses extensive docks, and the port has a large trade in coal; but, owing to the fact that in the shipping returns of the United Kingdom it is included under the general title "Tyne Ports," it is impossible to give an accurate statement regarding the number and tonnage of vessels. The number of fishing vessels connected with the port in 1884 was 15, of 204 tons and employing 98 men. At the mouth of the Tyne there is a pier about a mile in length. A townsman of South Shields, William Wouldhave, was the inventor of the lifeboat, and the first lifeboat was built there by Henry Greathead, and first used in a storm in 1789. The principal public buildings are the church of St Hilda, with a picturesque old tower; the town-hall in the market-place; the exchange; the custom-house; the mercantile marine offices; the public library and museum, which includes a large hall for public meetings and a school of science and art in connexion with South Kensington; the high school, the grammar school, the marine school, the master-mariners' asylum, the Ingham infirmary; and the union workhouse. There is a pleasant marine park near the pier. On elevated ground near the harbour are the remains of a Roman station, where numerous coins, portions of an altar, and several sculptured memorial stones have been dug up. The site of the old station was afterwards occupied by a fort of considerable strength, which was captured by the Scots under Colonel Stewart 20th March 1644. The town was founded by the convent of Durham about the middle of the 13th century, but on account of the complaints of the burgesses of Newcastle an order was made in the 43d year of Henry III., stipulating that no ships should be laden or unladen at Shields, and that no "shoars" or quays should be built there. This early check seems to have been long injurious to its prosperity, for until the present century it was little more than a fishing station. It received a charter of incorporation in 1850, and is divided into three wards, governed by a mayor, eight aldermen, and twenty-four councillors. In 1832 it received the privilege of returning a member to parliament. The corporation act as the urban sanitary authority, and the town has a specially good water supply from reservoirs at Cleadon. The population of the municipal and parliamentary borough (area 1839 acres) was 45,336 in 1871, and in 1881 it was 56,875.

SHI'ITES. See SUNNITES AND SHI'ITES.

SHIKÁRPUR, a British district in the province of Sind, Bombay presidency, India, with an area of 10,000 square miles, lying between 27° and 29° N. lat. and between 67° and 70° E. long. It is bounded on the N. by Khelat, Upper Sind Frontier district, and the river Indus; on the E. by the native states of Bahawalpur and Jaisalmir; on the S. by Khairpur state; and on the W. by the Khirthar Mountains. Shikárpur is a vast alluvial plain, broken only at Sukkur and Rohri by limestone hills. The Khirthar range attains an elevation of 7000 feet, and forms a natural boundary between the district and Baluchistan. Extensive patches of salt land, known as *kalar*, are frequently met with, especially in the upper portion of Shikárpur, and towards the Jacobabad frontier barren tracts of clay land and ridges of sand-hills, covered with caper and thorn jungle, form a poor but distinctive feature in the landscape. The desert portion of Rohri subdivision, known as the Registhán, is very extensive. The forests (207 square miles) are situated on the banks of the Indus, mostly in the Rohri and Shikárpur subdivisions. The Indus Valley State Railway runs through the district, and the Kandahar railway also goes through a part of it.

In 1881 the population numbered 852,986 (males 461,033, females 391,953), of whom 93,341 were Hindus, 684,275 Mohammedans, and 736 Christians. The chief towns are Shikárpur, Sukkur (population 27,389), Larkhana (13,188), and Rohri (10,224). The cultivated land in 1882–83 amounted to 764,488 acres, of which 108,636 were twice cropped. Cereals—chiefly rice, joár (millet), and wheat—form the principal crops; but a considerable area is also under pulses and oil-seeds. The chief manufactures are carpets and coarse cotton cloths. The total revenue raised in 1882–83 amounted to £234,792, of which the land contributed £189,869. Passing from the dominion of the caliphs, Shikárpur was overrun by Mahmud of Ghazni in 1025, and a little later was governed by the Sumras, the Sammas, and the Arghuns in succession. The Kalhora dynasty came into prominence in the 18th century, and was followed by the Tálpur mirs, who annexed a part of the Durani territory and incorporated it in the district. In 1843 Shikárpur passed to the British, and in 1852 the greater part of the Rohri subdivision was resumed from the mir of Khairpur, who had acquired it by fraud.

SHIKÁRPUR, the chief town of the above district, is situated 18 miles west of the Indus, in a tract of low-lying country annually flooded by the canals from that river. It is a great entrepôt for transit trade between the Bolan Pass and Karachi. The population in 1881 numbered 42,496 (males 22,889, females 19,607).

SHILOH, a town of Ephraim, where the sanctuary of the ark was, under the priesthood of the house of Eli. According to 1 Sam. iii. 3, 15, this sanctuary was not a tabernacle but a temple, with doors. But the priestly narrator of Josh. xviii. 1 has it that the tabernacle was set up there by Joshua after the conquest. In Judges xxi. 19 *sq.* the yearly feast at Shiloh appears as of merely local character. Shiloh seems to have been destroyed by the Philistines after the disastrous battle of Ebenezer; *cf.* Jeremiah vii. 12 *sq.* The position described in Judges, *loc. cit.* (*cf. Onomastica*, ed. Lagarde, p. 152), gives certainty to the identification with the modern Seilûn lying some 2 miles east-south-east of Lubbán (Lebonah), on the road from Bethel to Shechem. Here there is a ruined village, with a flat double-topped hill behind it, offering a strong position, which suggests that the place was a stronghold as well as a sanctuary. A smiling and fertile landscape surrounds the hill. The name Seilûn corresponds to Σιλοῦν in Josephus. LXX. has Σηλώ, Σηλώμ. The forms given in the Hebrew Bible (שִׁילֹה, שִׁילוֹ) have dropped the final consonant, which reappears in the adjective שִׁילוֹנִי. On Shiloh in Gen. xlix. 10 see JUDAH.

SHIMOGA, or SHEEMOGA, a district in the north-west of the native state of Mysore, Southern India. It forms a part of the Nagar division, and is situated between 13° 30′ and 14° 38′ N. lat. and between 74° 44′ and 76° 5′ E. long. It has an area of 3797 square miles, and is bounded on the N. and W. by the Bombay districts of Dhárwár and N. Kánara, and E. and S. by the districts of Chitaldroog and Kadur. Its river system is twofold; in the east the Tungra, Bhadra, and Varada unite to form the Tungabhadra, which ultimately falls into the Kistna and so into the Bay of Bengal, while in the west a few minor streams flow to the Shirávati, which near the north-western frontier bursts through the Western Gháts by the celebrated Falls of Gersoppa, said to be the grandest cataract in India. Flowing over a rocky bed 250 yards wide, the river here throws itself in four distinct falls down a tremendous chasm 960 feet deep.

The western half of the district is very mountainous and covered with magnificent forest, and is known as the Malnád or hill country, some of the peaks being 4000 feet above sea-level. The general elevation of Shimoga is about 2000 feet; and towards the east it opens out into the Maidán or plain country, which forms part of the general plateau of Mysore. The Malnád region is very picturesque, its scenery abounding with every charm of tropical forests and mountain wilds; on the other hand the features of the Maidán country are for the most part comparatively tame. The mineral products of the district include iron-ore and laterite. On the summits of the Gháts stones possessing magnetic qualities are occasionally found. The soil is loose and sandy in the valleys of the Malnád, and in the north-east the black cotton soil prevails. Bison are common in the *taluk* of Sagar, where also wild elephants are occasionally seen; while tigers, leopards, bears, wild hogs, *sámbhar* and *chitál* deer, and jungle sheep are numerous in the wooded tracts of the west. Shimoga presents much variety of climate. The south-west monsoon is felt in full force for about 25 miles from the Gháts, bringing an annual rainfall of more than 150 inches, but the rainfall gradually diminishes to 31 inches at Shimoga station and to 25 inches or less at Chennagiri. There is no railroad in the district, but it contains 225 miles of roads.

The population in 1881 was 499,728 (males 259,296, females 240,432); Hindus numbered 470,678, Mohammedans 27,574, and Christians 1476. The only place with more than 10,000 inhabitants is Shimoga town, the capital and headquarters, which is situated on the Tunga river, with a population of 12,040. Rice is the staple food-crop of the district; the next in importance is sugar-cane; areca-nuts are also extensively grown; and miscellaneous crops include oil-seeds, vegetables, fruits, pepper, and cardamoms. Of the total area of 3797 square miles only 699 are returned as cultivated and 702 as cultivable. The chief manufactures are coarse cotton cloths, rough country blankets or *kamblis*, iron implements, brass and copper wares, pottery, and jaggery. The district is also noted for its beautiful sandal-wood carving.

During the Mohammedan usurpation of Mysore from 1761 to 1799, unceasing warfare kept the whole country in constant turmoil. After the restoration of the Hindu dynasty Shimoga district repeatedly became the scene of disturbances caused by the maladministration of the Deshasta Bráhmans, who had seized upon every office and made themselves thoroughly obnoxious. These disturbances culminated in the insurrection of 1830, which led to the direct assumption of the entire state by the British.

SHINTO. See JAPAN, vol. xiii. p. 581.

SHIP. The generic name (A. S. *scip*, Ger. *Schiff*, Gr. σκάφος, from the root *skap*, *cf.* "scoop") for the invention by which man has contrived to convey himself and his goods upon water points in its derivation to the fundamental conception by which, when realized, a means of flotation was obtained superior to the raft, which we may consider the earliest and most elementary form of vessel. The trunk of a tree hollowed out, whether by fire or by such primitive tools as are fashioned and used with singular patience and dexterity by savage races, represents the first effort to obtain flotation depending on something other than the mere buoyancy of the material. The poets, with characteristic insight, have fastened upon these points. Homer's hero Ulysses is instructed to make a raft with a raised platform upon it, and selects trees "withered of old, exceeding dry, that might float lightly for him" (*Od.*, v. 240). Virgil, glorifying the dawn and early progress of the arts, tells us, "Rivers then first the hollowed alders felt" (*Georg.*, i. 136, ii. 451). Alder is a heavy wood and not fit for rafts. But to make for the first time a dug-out canoe of alder, and so to secure its flotation, would be a triumph of primitive art, and thus the poet's expression represents a great step in the history of the invention of the ship.

Primitive efforts in this direction may be classified in the following order: (1) rafts—floating logs, or bundles of brushwood or reeds or rushes tied together; (2) dug-outs—hollowed trees; (3) canoes of bark, or of skin stretched on framework or inflated skins (balsas); (4) canoes or boats of pieces of wood stitched or fastened together with sinews or thongs or fibres of vegetable growth; (5) vessels of planks, stitched or bolted together with inserted ribs and decks or half decks; (6) vessels of which the framework is first set up, and the planking of the hull nailed on to them subsequently. All these in their primitive forms have survived, in various parts of the world, with different modifications marking progress in civilization. Climatic influences and racial peculiarities have imparted to them their specific characteristics, and, combined with the available choice of materials, have determined the particular type in use in each locality. Thus on the north-west coast of Australia is found the single log of buoyant wood, not hollowed out but pointed at the ends. Rafts of reeds are also found on the Australian coast. In New Guinea catamarans of three or more logs lashed together with rattan are the commonest vessel, and similar forms appear on the Madras coast and throughout the Asiatic islands. On the coast of Peru rafts made of a very buoyant wood are in use, some of them as much as 70 feet long and 20 feet broad; these are navigated with a sail, and, by an ingenious system of centre boards, let down either fore or aft between the lines of the timbers, can be made to tack. The sea-going raft is often fitted with a platform so as to protect the goods and persons carried from the wash of the sea. Upright timbers fixed upon the logs forming the raft support a kind of deck, which in turn is itself fenced in and covered over.[1] Thus the idea of a deck, and that of side planking to raise the freight above the level of the water and to save it from getting wet, are among the earliest typical expedients which have found their development in the progress of the art of shipbuilding.

Whether the observation of shells floating on the water, or of split reeds, or, as some have fancied, the nautilus, first suggested the idea of hollowing out the trunk of a tree, the practice ascends to a very remote antiquity in the history of man. Dug-out canoes of a single tree have been found associated with objects of the Stone Age among the ancient Swiss lake dwellings; nor are specimens of the same class wanting from the bogs of Ireland and the estuaries of England and Scotland, some obtained from the depth of 25 feet below the surface of the soil. The hollowed trunk itself may have suggested the use of the bark as a means of flotation. But, whatever may have been the origin of the bark canoe, its construction is a step onwards in the art of shipbuilding. For the lightness and pliability of the material necessitated the invention of some internal framework, so as to keep the sides apart, and to give the stiffness required both for purposes of propulsion and the carrying of its freight. Similarly, in countries where suitable timber was not to be found, the use of skins or other water-tight material, such as felt or canvas, covered with pitch, giving flotation, demanded also a framework to keep them distended and to bear the weight they had to carry. In the framework we have the rudimentary ship, with longitudinal bottom timbers, and ribs, and cross-pieces, imparting the requisite stiffness to the covering material. Bark canoes are found in Australia, but the American continent is their true home. In northern regions skin or woven material made water-tight supplies the place of bark.

The next step in the construction of vessels was the building up of canoes or boats by fastening pieces of wood together in a suitable form. Some of these canoes, and probably the earliest in type, are tied or stitched together with thongs or cords. The Madras surf boats are perhaps the most familiar example of this type, which, however, is found in the Straits of Magellan and in Central Africa (on the Victoria Nyanza), in the Malay Archipelago and in many islands of the Pacific. Some of these canoes show a great advance in the art of construction, being built up of pieces fitted together with ridges on their inner sides, through which the fastenings are passed.[2] These canoes have the advantage of elasticity, which gives them ease in a seaway, and a comparative immunity where ordinary boats would not hold together. In these cases the body of the canoe is constructed first and built to the shape intended, the ribs being inserted afterwards, and attached to the sides, and having for their main function the uniting of the deck and cross-pieces with the body of the canoe. Vessels thus stitched together, and with an inserted framework, have from a very early time been constructed in the Eastern seas far exceeding in size anything that would be called a canoe, and in some cases attaining to 200 tons burthen.

From the stitched form the next step onwards is to fasten the materials out of which the hull is built up by pegs or treenails; and of this system early types appear among the Polynesian islands and in the Nile boats described by Herodotus (ii. 96), the prototype of the modern "nuggur." The raft of Ulysses described by

[1] The raft of Ulysses described in Homer (*Od.*, v.) must have been of this class.

[2] See Capt. Cook's account of the Friendly Islands, La Perouse on Easter Island, and Williams on the Fiji Islands.

Homer presents the same detail of construction. It is remarkable that some of the early types of boats belonging to the North Sea present an intermediate method, in which the planks are fastened together with pins or trenails, but are attached to the ribs by cords passing through holes in the ribs and corresponding holes bored through ledges cut on the inner side of each plank.

We thus arrive, in tracing primitive efforts in the art of ship construction, at a stage from which the transition to the practice of setting up the framework of ribs fastened to a timber keel laid lengthwise, and subsequently attaching the planking of the hull, was comparatively simple. The keel of the modern vessel may be said to have its prototype in the single log which was the parent of the dug-out. The side planking of the vessel, which has an earlier parentage than the ribs, may be traced to the attempt to fence in the platforms upon the sea-going rafts, and to the planks fastened on to the sides of dug-out canoes so as to give them a raised gunwale.[1] The ribs of the modern vessel are the development of the framework originally inserted after the completion of the hull of the canoe or built-up boat, but with the difference that they are now prior in the order of fabrication. In a word, the skeleton of the hull is now first built up, and the skin, &c., adjusted to it; whereas in the earlier types of wooden vessels the outside hull was first constructed, and the ribs, &c., added afterwards. It is noticeable that the invention of the outrigger and weather platform, the use of which is at the present time distributed from the Andaman Islands eastward throughout the whole of the South Pacific, has never made its way into the Western seas. It is strange that Egyptian enterprise, which seems at a very early period to have penetrated eastward down the Red Sea and round the coasts of Arabia towards India, should not have brought it to the Nile, and that the Phœnicians, who, if the legend of their migration from the shores of the Persian Gulf to the coast of Canaan be accepted, would in all probability, in their maritime expeditions, have had opportunities of seeing it, did not introduce it to the Mediterranean. That they did not do so, if they saw it at all, would tend to prove that even in that remote antiquity both nations possessed the art of constructing vessels of a type superior to the outrigger canoes, both in speed and in carrying power.

The earliest representations that we have as yet of Egyptian vessels carry us back, according to the best authorities, to a period little short of 3000 years before Christ. Some of these are of considerable size, as is shown by the number of rowers, and by the cargo consisting in many cases of cattle. The earliest of all presents us with the peculiar mast of two pieces, stepped apart but joined at the top. In some the masts are shown lowered and laid along a high spar-deck. The larger vessels show on one side as many as twenty-one or twenty-two and in one case twenty-six oars, besides four or five steering. They show considerable camber, the two ends rising in a curved line which in some instances ends in a point, and in others is curved back and over at the stern and terminates in an ornamentation, very frequently of the familiar lotus pattern. At the bow the stem is sometimes seen to rise perpendicularly, forming a kind of forecastle, sometimes to curve backward and then forward again like a neck, which is often finished into a figure-head representing some bird or beast or Egyptian god. On the war galleys there is frequently shown a projecting bow with a metal head attached, but well above the water. This, though no doubt used as a ram, is not identical with the beak *à fleur d'eau*, which we shall meet with in Phœnician and Greek galleys. It is more on a level with the proembolion of the latter.

The impression as regards the build created by the drawings of the larger galleys is that of a long and somewhat wall-sided vessel with the stem and stern highly raised. The tendencies of the vessel to "hog," or rise amidships, owing to the great weight fore and aft unsupported by the water, is corrected by a strong truss passing from stem to stern over crutches. The double mast of the earlier period seems in time to have given place to the single mast furnished with bars or rollers at the upper part, for the purpose apparently of raising or lowering the yard according to the amount of sail required. The sail in some of the galleys is shown with a bottom as well as a top yard. In the war galleys during action it is shown rolled up like a curtain with loops to the upper yard. The steering was effected by paddles, sometimes four or five in number, but generally one or two fastened either at the end of the stern or at the side, and above attached to an upright post in such a way as to allow the paddle to be worked by a tiller.

There are many remarkable details to be observed in the Egyptian vessels figured in Duemichen's *Fleet of an Egyptian Queen*, and in Lepsius's *Denkmäler*. The Egyptian ship, as represented from time to time in the period between 3000 and 1000 B.C., presents to us a ship proper as distinct from a large canoe or boat. It is the earliest ship of which we have cognizance. But there is a noticeable fact in connexion with Egypt which we gather from the tomb paintings to which we owe our knowledge of the Egyptian ship. It is evident from these records that there were at that same early period, inhabiting the littoral of the Mediterranean, nations who were possessed of sea-going vessels which visited the coasts of Egypt for plunder as well as for commerce, and that sea-fights were even then not uncommon. Occasionally the combination of these peoples for the purpose of attack assumed serious proportions, and we find the Pharaohs recording naval victories over combined Dardanians, Teucrians, and Mysians, and, if we accept the explanations of Egyptologists, over Pelasgians, Daunians, Oscans, and Sicilians. The Greeks, as they became familiar with the sea, followed in the same track. The legend of Helen in Egypt, as well as the numerous references in the *Odyssey*, point not only to the attraction that Egypt had for the maritime peoples, but also to long-established habits of navigation and the possession of an art of shipbuilding equal to the construction of sea-going craft capable of carrying a large number of men and a considerable cargo besides.

But the development of the ship and of the art of navigation clearly belongs to the Phœnicians. It is tantalizing to find that the earliest and almost the only evidence that we have of this development is to be gathered from Assyrian representations. The Assyrians were an inland people, and the navigation with which they were familiar was that of the two great rivers, Tigris and Euphrates. After the conquest of Phœnicia they had knowledge of Phœnician naval enterprise, and accordingly we find the war galley of the Phœnicians represented on the walls of the palaces unearthed by Layard and his followers in Assyrian discovery. But the date does not carry us to an earlier period than 900–800 B.C. The vessel represented is a bireme war galley which is "aphract," that is to say, has the upper tier of rowers unprotected and exposed to view. The apertures for the lower oars are of the same character as those which appear in Egyptian ships of a much earlier date, but without oars. The artist has shown the characteristic details, though somewhat conventionally. The fish-like snout of

[1] Compare the planks upon the Egyptian war galleys, added so as to protect the rowers from the missiles of the enemy.

the beak, the line of the parodus or outside gangway, the wickerwork cancelli,[1] the shields ranged in order along the side of the bulwark, and the heads of a typical crew on deck (the πρωρεύς looking out in front in the forecastle, an ἐπιβάτης, two chiefs by the mast, and, aft, the κελευστής and κυβερνητής). The supporting timbers of the deck are just indicated. The mast and yard and fore and back stays, with the double steering paddle, complete the picture.

But, although there can be little doubt that the Phœnicians, after the Egyptians, led the way in the development of the shipwright's art, yet the information that we can gather concerning them is so meagre that we must go to other sources for the description of the ancient ship. The Phœnicians at an early date constructed merchant vessels capable of carrying large cargoes, and of traversing the length and breadth of the Mediterranean, perhaps even of trading to the far Cassiterides and of circumnavigating Africa. They in all probability (if not the Egyptians) invented the bireme and trireme, solving the problem by which increased oar-power and consequently speed could be obtained without any great increase in the length of the vessel.

It is, however, to the Greeks that we must turn for any detailed account of these inventions. The Homeric vessels were aphract and not even decked throughout their entire length. They carried crews averaging from fifty to a hundred and twenty men, who, we are expressly told by Thucydides, all took part in the labour of rowing, except perhaps the chiefs. The galleys do not appear to have been armed as yet with the beak, though later poets attribute this feature to the Homeric vessel. But they had great poles used in fighting, and the term employed to describe these (ναύμαχα) implies a knowledge of naval warfare. The general characteristics are indicated by the epithets in use throughout the *Iliad* and the *Odyssey*. The Homeric ship is sharp (θοή) and swift (ὠκεῖα); it is hollow (κοιλή, γλαφυρή, μεγακήτης), black, vermilion-cheeked (μιλτοπάρηος), dark-prowed (κυανόπρῳρος), curved (κορωνίς, ἀμφιέλισσα), well-timbered (ἐύσσελμος), with many thwarts (πολύζυγος, ἑκατόζυγος). The stems and sterns are high, upraised, and resemble the horns of oxen (ὀρθοκραίραι). They present a type parallel in the history of the shipping of the Mediterranean with that of the vikings' vessels of the North Sea.

On the vases, the earliest of which may date between 700 and 600 B.C., we find the bireme with the bows finished off into a beak shaped as the head of some sea monster, and an elevated forecastle with a bulwark evidently as a means of defence. The craft portrayed in some instances are evidently pirate vessels, and exhibit a striking contrast to the trader, the broad ship of burden (φορτίς εὐρεία), which they are overhauling. The trireme, which was developed from the bireme and became the Greek ship of war (the long ship, ναῦς μακρά, *navis longa*, *par excellence*), dates, so far as Greek use is concerned, from about 700 B.C. according to Thucydides, having been first built at Corinth by Aminocles. The earliest sea-fight that the same author knew of he places at a somewhat later date,—664 B.C., more than ten centuries later than some of those portrayed in the Egyptian tomb paintings.

The trireme was the war ship of Athens during her prime, and, though succeeded and in a measure superseded by the larger rates,—quadrireme, quinquereme, and so on, up to vessels of sixteen banks of oars (*inhabilis prope magnitudinis*),—yet, as containing in itself the principle of which the larger rates merely exhibited an expansion, a difference in degree and not in kind, has, ever since the revival of letters, cocnentrated upon itself the attention of the learned who were interested in such matters. The literature connected with the question of ancient ships, if collected, would fill a small library, and the greater part of it turns upon the construction of the trireme and the disposition of the rowers therein.

During the present century much light has been thrown upon the disputed points by the discovery (1834) at the Piræus of some records of the Athenian dockyard superintendents, which have been published and admirably elucidated by Boeckh. Further researches carried out by his pupil Dr Graser, who united a practical knowledge of ships and shipbuilding with all the scholarship and industry and acumen necessary for such a task, have cleared up most of the difficulties which beset the problem, and enable us to describe with tolerable certainty the details of construction and the disposition of the rowers in the ancient ship of war.

One point it is necessary to insist on at the outset, because upon it depends the right understanding of the problem to be solved. The ancients did not employ more than one man to an oar. The method employed in mediæval galleys is entirely alien to the ancient system. M. Jal, Admiral Fincati, Admiral Jurien de la Gravière, and a host of other authorities have all been led to erroneous views by neglect of the ancient texts which overwhelmingly establish this as an axiom of the ancient marine—"one oar one man."

The distinction between "aphract" and "cataphract" vessels must not be overlooked in a description of the ancient vessels. The words, meaning "unfenced" and "fenced," refer to the bulwarks which covered the upper tier of rowers from attack. In the aphract vessels these side plankings were absent and the upper tier of rowers was exposed to view from the side. Both classes of vessels had upper and lower decks, but the aphract class carried their decks on a lower level than the cataphract. The system of side planking with a view to the protection of the rowers dates from a very early period, as may be seen in some of the Egyptian representations, but among the Greeks it does not seem to have been adopted till long after the Homeric period. The Thasians are credited with the introduction of the improvement.

In describing the trireme it will be convenient to deal first with the disposition of the rowers and subsequently with the construction of the vessel itself. The object of arranging the oars in banks was to economize horizontal space and to obtain an increase in the number of oars without having to lengthen the vessel. We know from Vitruvius that the "interscalmium," or space horizontally measured from oar to oar, was 2 cubits. This is exactly borne out by the proportions of an Attic aphract trireme, as shown on a fragment of a bas-relief found in the Acropolis. The rowers in all classes of banked vessels sat in the same vertical plane, the seats ascending in a line obliquely towards the stern of the vessel. Thus in a trireme the thranite, or oarsman of the highest bank, was nearest the stern of the set of three to which he belonged. Next behind him and somewhat below him sat his zygite, or oarsman of the second bank; and next below and behind the zygite sat the thalamite, or oarsman of the lowest bank. The vertical distance between these seats was 2 feet, the horizontal distance about 1 foot. The horizontal distance, it is well to repeat, between each seat in the same bank was 3 feet (the seat itself about 9 inches broad). Each man had a resting place for his feet, somewhat wide apart, fixed to the bench of the man on the row next below and in front of him. In rowing, the upper hand, as is shown in most of the representations which remain, was held with the palm turned inwards towards the body. This is accounted for by the angle at which the oar was worked. The lowest rank used the shortest oars, and the difference of the length of the oars on board was caused by the curvature of the ship's side. Thus, looked at from within, the rowers amidship seemed to be using the longest oars, but outside the vessel, as we are expressly told, all the oar-blades of the same bank took the water in the same longitudinal line. The lowest or thalamite oar-ports were 3 feet, the zygite $4\frac{1}{4}$ feet, the thranite $5\frac{1}{2}$ feet above the water. Each oar-port was protected by an *ascoma* or leather bag, which fitted over the oar, closing the aperture against the wash of the sea without impeding the action of the oar. The oar was tied by a thong, against which it was probably rowed, which itself was attached to a thowl (σκαλμός). The port-hole was probably oval in shape (the Egyptian and Assyrian pictures show an oblong). We know that it was large enough for a man's head to be thrust through it.

The benches on which the rowers sat ran from the vessel's side to timbers which, inclined at an angle of about 64° towards the ship's stern, reached from the lower to the upper deck. These timbers were, according to Graser, called the diaphragmata. In the trireme each diaphragma supported three, in the quinquereme five, in the octireme eight, and in the famous tesseraconteres forty seats of rowers, who all belonged to the same "complexus," though each to a different bank. In effect, when once the principle of construction had been established in the trireme, the increase to larger rates was effected, so far as the motive power was concerned, by lengthening the diaphragmata upwards, while the increase in the length of the vessel gave a greater number of rowers to each bank. The upper tiers of oarsmen exceeded in number those below, as the contraction of the sides of the vessel left less available space towards the bows.

[1] See Rawlinson, *Ancient Monarchies*, vol. ii. p. 176.

Of the length of the oars in the trireme we have an indication in the fact that the length of supernumerary oars (περίνεῳ) rowed from the gangway above the thranites, and therefore probably slightly exceeding the thranitic oars in length, is given in the Attic tables as 14 feet 3 inches. The thranites were probably about 14 feet. The zygite, in proportion to the measurement, must have been $10\frac{1}{2}$, the thalamite $7\frac{1}{2}$ feet long. Comparing modern oars with these, we find that the longest oars used in the British navy are 18 feet. The university race is rowed with oars 12 feet 9 inches. The proportion of the loom inboard was about one third, but the oars of the rowers amidship must have been somewhat longer inboard. The size of the loom inboard preserved the necessary equilibrium. The long oars of the larger rates were weighted inboard with lead. Thus the topmost oars of the tesseraconteres, of which the length was 53 feet, were exactly balanced at the rowlock.

Let us now consider the construction of the vessel itself. In the cataphract class the lower deck was 1 foot above the water-line. Below this deck was the hold, which contained a certain amount of ballast, and through an aperture in this deck the buckets for baling were worked, entailing a labour which was constant and severe on board an ancient ship at sea. The keel (τρόπις) appears to have had considerable camber. Under it was a strong false keel (χέλυσμα), very necessary for vessels that were constantly drawn up on the shore. Above the keel was the kelson (δρύοχον), under which the ribs were fastened. These were so arranged as to give the necessary intervals for the oar-ports above. Above the kelson lay the upper false keel, into which the mast was stepped. The stem (στεῖρα) rose from the keel at an angle of about 70° to the water. Within was an apron (φάλκις), which was a strong piece of timber curved and fitting to the end of the keel and beginning of the stern-post and firmly bolted into both, thus giving solidity to the bows, which had to bear the beak and sustain the shock of ramming. The stem was carried upwards and curved generally backwards towards the forecastle and rising above it, and then curving forwards again terminated in an ornament which was called the acrostolion. The stern-post was carried up at a similar angle to the bow, and, rising high over the poop, was curved round into an ornament which was called "aplustre" (ἄφλαστον). But, inasmuch as the steering was effected by means of two rudders (πηδάλια), one on either side, there was no need to carry out the stern into a rudder post as with modern ships, and the stern was left therefore much more free, an advantage in respect of the manœuvring of the ancient Greek man-of-war, the weapon being the beak or rostrum, and the power of turning quickly being of the highest importance.

Behind the "aplustre," and curving backwards, was the "cheniscus" (χηνισκός), or goose-head, symbolizing the floating powers of the vessel. After the ribs had been set up and covered in on both sides with planking, the sides of the vessel were further strengthened by waling-pieces carried from stern to stem and meeting in front of the stern-post. These were further strengthened with additional balks of timber, the lower waling-pieces meeting about the water-level and prolonged into a sharp three-toothed spur, of which the middle tooth was the longest. This was covered with hard metal (generally bronze) and formed the beak. The whole structure of the beak projected about 10 feet beyond the stern-post. Above it, but projecting much less beyond the stern-post, was the "proembolion" (προεμβόλιον), or second beak, in which the prolongation of the upper set of waling-pieces met. This was generally fashioned into the figure of a ram's head, also covered with metal; and sometimes again between this and the beak the second line of waling-pieces met in another metal boss called the προεμβολίς. These bosses, when a vessel was rammed, completed the work of destruction begun by the sharp beak at the water-level, giving a racking blow which caused it to heel over and so eased it off the beak, and releasing the latter before the weight of the sinking vessel could come upon it. At the point where the prolongation of the second and third waling-pieces began to converge inwards towards the stem on either side of the vessel stout catheads (ἐπωτίδες) projected, which were of use, not only as supports for the anchors, but also as a means of inflicting damage on the upper part of an enemy's vessel, while protecting the side gangways of its own and the banks of oars that worked under them. The catheads were strengthened by strong balks of timber, which were firmly bolted to them under either extremity and both within and without, and ran to the ship's side. Above the curvature of the upper waling-pieces into the προεμβόλιον were the cheeks of the vessel, generally painted red, and in the upper part of these the eyes (ὀφθαλμοί), answering to our hawse holes, through which ran the cables for the anchors. On either side the trireme, at about the level of the thranitic benches, projected a gangway (πάροδος) supported by brackets (βίαχα) springing from the upper waling-piece, and resting against the ribs of the vessel. This projection was of about 18 to 24 inches, which gave a space, increased to about 3 feet by the inward curve of the prolongation of the ribs to form supports for the deck, for a passage on either side of the vessel. This gangway was planked in along its outer side so as to afford protection to the seamen and marines, who could pass along its whole length without impeding the rowers. Here, in action, the sailors were posted as light-armed troops, and when needed could use the long supernumerary oars (περίνεῳ) mentioned above. The ribs, prolonged upwards upon an inward curve, supported on their upper ends the cross beams (στρωτῆρες) which tied the two sides of the vessel together and carried the deck. In the cataphract class these took the place of the thwarts (ζύγα) which in the earlier vessels, at a lower level, yoked together the sides of the vessel, and formed also benches for the rowers to sit on, from which the latter had their name (ζυγῖται), having been the uppermost tier of oarsmen in the bireme; while those who sat behind and below them in the hold of the vessel were called θαλαμῖται or θαλάμακες (from θάλαμος). In the trireme the additional upper tier was named from the elevated bench (θρᾶνος) on which they were placed (θρανῖται). On the deck were stationed the marines (ἐπιβάται), fighting men in heavy armour, few in number in the Attic trireme in its palmy days, but many in the Roman quinquereme, when the ramming tactics were antiquated, and wherever, as in the great battles in the harbour at Syracuse, land tactics took the place of the maritime skill which gave victory to the ram in the open sea. The space occupied by the rowers was termed ἔγκωπον. Beyond this, fore and aft, were the παρεξειρέσιαι, or parts outside the rowers. These occupied 11 feet of the bows and 14 feet in the stern. In the fore part was the forecastle, with its raised deck, on which was stationed the πρωρεύς with his men. In the stern the decks (ἴκρια) rose in two or three gradations, upon which was a kind of deck-house for the captain and a seat for the steerer (κυβερνήτης), who steered by means of ropes attached to the tillers fixed in the upper part of the paddles, which, in later times at least, ran over wheels (τροχιλίαι), giving him the power of changing his vessel's course with great rapidity. Behind the deck-house rose the flagstaff, on which was hoisted the pennant, and from which probably signals were given in the case of an admiral's ship. On either side of the deck ran a balustrade (*cancelli*), which was covered for protection during action with felt (*cilicium*, παραρρύματα τριχινά) or canvas (π. λευκά). Above was stretched a strong awning of hide (κατάβλημα), as a protection against grappling irons and missiles of all kinds. In Roman vessels towers were carried up fore and aft from which darts could be showered on the enemy's deck; the heavy corvus or boarding bridge swung suspended by a chain near the bows; and the ponderous δέλφις hung at the ends of the yards ready to fall on a vessel that came near enough alongside. But these were later inventions and for larger ships. The Attic trireme was built light for speed and for ramming purposes. Her dimensions, so far as we can gather them from the scattered notices of antiquity, were probably approximately as follows:—length of rowing space (ἔγκωπον) 93 feet; bows 11 feet; stern 14 feet; total 118 feet; add 10 feet for the beak. The breadth at the water-line is calculated at 14 feet, and above at the broadest part 18 feet, exclusive of the gangways; the space between the diaphragmata mentioned above was 7 feet. The deck was 11 feet above the water-line and the draught about 8 to 9 feet. All the Attic triremes appear to have been built upon the same model, and their gear was interchangeable. The Athenians had a peculiar system of girding the ships with long cables (ὑποζώματα), each trireme having two or more, which, passing through eyeholes in front of the stern-post, ran all round the vessel lengthwise immediately under the waling-pieces. They were fastened at the stern and tightened up with levers. These cables, by shrinking as soon as they were wet, tightened the whole fabric of the vessel, and in action, in all probability, relieved the hull from part of the shock of ramming, the strain of which would be sustained by the waling-pieces convergent in the beaks. These rope-girdles are not to be confused with the process of undergirding or frapping, such as is narrated of the vessel in which St Paul was being carried to Italy. The trireme appears to have had three masts. The mainmast carried square sails, probably two in number. The foremast and the mizen carried lateen sails. In action the Greeks did not use sails, and everything that could be lowered was stowed below. The mainmasts and larger sails were often left ashore if a conflict was expected.

The crew of the Attic trireme consisted of from 200 to 225 men in all. Of these 174 were rowers,—54 on the lower bank (thalamites), 58 on the middle bank (zygites), and 62 on the upper bank (thranites),—the upper oars being more numerous because of the contraction of the space available for the lower tiers near the bow and stern. Besides the rowers were about 10 marines (ἐπιβάται) and 20 seamen. The officers were the trierarch and next to him the helmsman (κυβερνήτης), who was the navigating officer of the trireme. Each tier of rowers had its captain (στοιχαρχός). There were also the captain of the forecastle (πρωρεύς), the "keleustes" who gave the time to the rowers, and the ship's piper (τριηραυλής). The rowers descended into the seven-foot space between the diaphragmata and took their places in regular order, beginning with the thalamites. The economy of space was such that, as Cicero remarks, there was not room for one man more.

The improvement made in the build of their vessels by the Corinthian and Syracusan shipwrights, by which the bows were so much strengthened that they were able to meet the Athenian attack stem on (προσβολή), caused a change of tactics, and gave an impetus to the building of larger vessels—quadriremes and quinqueremes—in which increased oar-power was available for the propulsion of the heavier weights.

In principle these vessels were only expansions of the trireme, so far as the disposition of the rowers was concerned, but the speed could not have increased in proportion to the weight, and hence arose the variety of contrivances which superseded the ramming tactics of the days of Phormio. In the century that succeeded the close of the Peloponnesian War the fashion of building big vessels became prevalent. We hear of various numbers of banks of oars up to sixteen (ἑκκαιδεκήρης)—the big vessel of Demetrius Poliorcetes. The famous tesseraconteres or forty-banked vessel of Ptolemy Philopator was in reality nothing more than a costly and ingenious toy, and never of any practical use. The fact, however, of its construction shows the extent to which the shipwright's art had been developed among the ancients.

The Romans, who developed their naval power during the First Punic War, were deficient in naval construction till they learnt the art from their enemies the Carthaginians. They copied a quinquereme which had drifted on to the coast, and, with crews taught to row on frames set up on dry land, manned a fleet which we are told was built in sixty days from the time the trees were cut down. After the Punic War, in which the use of boarding tactics gave the Romans command of the sea, the larger rates—quinqueremes, hexiremes, octiremes—continued in use until at Actium the fate of the big vessels was sealed by the victory of the light Liburnian galleys. The larger classes, though still employed as guardships for some time, fell into disuse, and the art of building them and the knowledge of their interior arrangements were lost.

Table of Measurements, &c., after Graser.

	Triremé.	Quinquereme.	Tesseraconteres.
Length, exclusive of beak	(?) 149 ft.[1]	168 ft	420 ft.
Beam, greatest	18 "	26 "	76 "
Passage between διαφράγματα	7 "	11 "	49 "
Draught	$8\frac{1}{2}$ "	$11\frac{1}{2}$ "	20 "
Tons measurement	(?) 232	534	11,320 (?)
Number of rowers	174	310	4,054
Crew, total complement	225	375	7,500

Mediæval Ships.—It is not at present possible to trace in its successive stages the transition from the ancient ship of war to the mediæval galley. The sailing vessels of the time of the early Roman empire, such as that in which St Paul suffered shipwreck or the great merchantman described by Lucian, were the direct precursors, not only of the mediæval merchant vessels, but also of the large sailing vessels which, after the invention of gunpowder, and the consequent necessity of carrying marine artillery, superseded the long low galleys propelled by oars. The battle of Actium gave the death-blow to the ancient type of vessel with its many banks of oars. The light Liburnian galleys which, though fully decked, were aphract, and, according to Lucan's testimony (bk. iii.),

> Ordine contentæ gemino crevisse Liburnæ,

had only two banks of oars, were biremes. This apparently became the type of Roman war galleys; and, though the old name trireme survived, its meaning became simply "man of war," and did not any longer imply three banks of oars. Light vessels were in vogue, and galleys with single banks of oars are common in the representations on coins and in such frescos as survive, but trireme and quinquereme, &c., have vanished.

A cloud of obscurity rests on these, the dark ages of naval history. We know nothing of the character and composition of the fleet in which Ricimer defeated the Vandals in the 5th century of our era. Nor have we any details of the fleets of the Byzantine empire until the end of the 9th century, when a light is thrown upon the subject by the *Tactica* of the emperor Leo. This emperor, in giving his directions as to the constitution of his fleet, prescribes that dromones (δρομῶνες)—that is, triremes—are to be got ready in the dockyards with a view to a naval engagement. The vessels are not to be too light or too heavy. They are to be armed with siphons for the projection of Greek fire. They are to have two banks of oars, with twenty-five rowers a-piece, on each side. Some of the vessels are to be large enough to carry two hundred men; others are to be smaller, like those called galleys or one-banked vessels, swift and light (ἐλάττους δρομικωτάτους οἱόνει γαλαίας ἤ μονήρεις λεγομένους ταχινοὺς καὶ ἐλαφρούς). Here we have the name galleys distinctively attached to vessels with one bank of oars. This passage should have saved much of the labour that has been thrown away in attempting to prove that the distribution of rowers in the mediæval galleys was upon the same principle as that observed in the ancient biremes or triremes.

The light thrown by the philosophic Byzantine on the naval construction and equipment of his time is but a passing flash. After the 9th century there is darkness again until the 11th and 12th centuries, when the features of the mediæval galley first begin to be visible. And here perhaps it is not out of place to say that it is necessary to distinguish between those imaginary representations of the antique in which painters, such as Tintoret, give fanciful arrangement to the oars of their galleys, so as to meet their ideas of bireme or trireme, from those that are historically faithful and figure, perhaps in an ungainly and inartistic manner, the galleys of Venice and Genoa as they appeared in the Middle Ages. It would exceed the space at our disposal here to enter into details which can be gathered from Jal's *Archéologie Navale* and the *Glossaire Nautique* of the same author, or the later works of Admiral Jurien de la Gravière and Admiral Fincati. It must suffice to indicate here a few of the main characteristics in which the mediæval galley differs from the ancient, and exhibits the last development of man-power as applied to motion in vessels larger than the boats of the present day.

These characteristics may be sketched briefly. Upon the mediæval galley, which was essentially a one-banked galley (μονόκροτον), the use of the longer oar or sweep took the place of the small paddling oars of the ancient vessel. The increased length of the oar requiring for its efficiency greater power than one man could employ led to the use of more than one man to an oar. The necessity therefore arose of placing the weight (or point at which the oar, used as a lever, worked against the thowl, and so pressed against the water, which is the fulcrum) at a greater distance from the force or man who moved the lever. This was gained by the invention of the apostis.

[1] Taking the interscalmium at 4 feet; but this does not agree with Vitruvius, who gives 2 cubits.

Upon the hull of the mediæval galley was laid a framework which stood out on either side from it, giving on either side a strong external timber, running parallel to the axis of the vessel, in which the thowls were fixed against which the oars were rowed. It will be readily understood how this arrangement gave a greater length inboard for the oar as compared with that of the ancient vessels, where the thowl stood in the aperture of the vessel's side or port-hole. On the inner side, rising inwards towards the centre line of the decks and inclining upwards, were the banks or benches for the rowers, arranged *à la scaloccio*, who could each grasp the handle of the oar, moving forward as they depressed it for the feather, and backward for the stroke as they raised their hands for the immersion of the blade. The stroke no doubt was slower than that of the ancient galleys, but much more powerful. For the rest we must refer to the works above mentioned, where the reader will find minute descriptions of the build and the equipment of mediæval vessels, such as those which fought at Lepanto or carried the proud ensign of the Genoese republic.

Literature.—1. For Ancient Ships:—Duemichen, *Fleet of an Egyptian Queen*; Chabas, *Études sur l'Antiquité Historique*; Rawlinson, *Ancient Monarchies*; Scheffer, *De Militia Navali Veterum*; Boeckh, *Urkunden über das Seewesen des Attischen Staates*; B. Graser, *De Re Navali Veterum*; Id., *Das Model eines Athenischen Fünfreihenschiffes (Pentere) aus der Zeit Alexanders des Grossen im Königlichen Museum zu Berlin*; Id., *Die Gemmen des Königlichen Museums zu Berlin mit Darstellungen antiker Schiffe*; Id., *Die ältesten Schiffsdarstellungen auf antiken Münzen*; A. Cartauld, *La Trière Athénienne*; Breusing, *Die Nautik der Alten*; Smith, *Voyage and Shipwreck of St Paul*. 2. For Mediæval Shipping:—A. Jal, *Archéologie Navale* and *Glossaire Nautique*; Jurien de la Gravière, *Derniers Jours de la Marine à Rames*, Paris, 1885; Fincati, *Le Triremi*. (E. WA.)

SHIPBUILDING

The art of ship-building.

WITHIN the memory of the present generation shipbuilding, like many other arts, has lost dignity by the extended use of machinery and by the subdivision of labour. Forty years ago it was still a "mystery" and a "craft." The well-instructed shipbuilder had a store of experience on which he based his successful practice. He gained such advantages in the form and trim and rig of his vessels by small improvements, suggested by his own observation or by the traditions of his teachers, that men endeavoured to imitate him, neither he nor they knowing the natural laws on which success depended. He had also a good eye for form, and knew how to put his materials together so as to avoid all irregularity of shape on the outer surfaces, and how to form the outlines and bounding curves of the ship so that the eye might be compelled to rest lovingly upon them. He was skilled also in the qualities of timber. He knew what was likely to be free from "rends" and "shakes" and "cups" which would cause leakage, and which would be liable to split when the bolts and treenails were driven through it. He knew what timber would bear the heat of tropical suns without undue shrinking, and how to improve its qualities by seasoning. He could foretell where and under what circumstances premature decay might be expected, and he could choose the material and adjust the surroundings so as to prevent it. He knew what wood was best able to endure rubbing and tearing on hard ground, and how it ought to be formed so that the ship might have a chance of getting off securely when she accidentally took the ground or got on shore. Such men were to be found on all the sea-coasts of Europe and on the shores of the Atlantic in America.

A great change came over the art when steam was introduced. The old proportions and forms so well suited for the speeds of the ships and for the forces impressed upon them were ill adapted for propulsion by the paddle, and still less so for propulsion by the screw. Experience had to be slowly gained afresh, for the lamp of science burned dimly. It needed to be fed by results, by long records of successes and failures, before it was able to direct advancing feet. The further change from wood to iron and then to steel almost displaced the shipwright. Ships for commercial purposes may be said to be built now, so far as their external hulls are concerned, by draftsmen and boilermakers. The centres of the shipbuilding industry have changed. The ports where oaks (Italian, English, and Dantzic), pines from America and the north of Europe, teak from Moulmein, and elm from Canada were most accessible,—these marked the suitable places for shipbuilding. The Thames was alive with the industry from Northfleet to the Pool. It still lingers, but it is slowly dying out. Travellers along the Mediterranean shores from Nice to Genoa mark the completeness of the change which a few years have made. The Tyne and the Clyde and the Mersey have become the principal centres of the trade. It has been drawn there because the iron and the coal are near.

The science of naval construction.

But, while the art of shipbuilding has lost dignity, the science of naval construction has increased in importance. English art is of an eminently practical character. It is shy of experiment, as being costly in itself and likely to lead to delays and changes of system and of plant. It loves large orders and rapid production. It practises great subdivision of the details in order to cheapen production, and it stereotypes modes of work. There is no lack of boldness and enterprise; but the patient continuous inquiry and the slow but sure building up of theory upon research,—this is the exception. Naval construction in England has had the good fortune during the last quarter of a century to have not only a thriving industry but a home for research. Twenty-five years ago, when the high-pressure condensing engine was in its infancy, when shipbuilding steel was not, and armour-plated ships had not yet displaced the wooden line-of-battle ship, this home was founded. The Institution of Naval Architects may be fairly called the home for research in naval construction. It owes its establishment mainly to four well-known men—John Scott Russell, Dr Joseph Woolley, Lord Hampton, for many years its honoured president, and Sir Edward Reed, its first secretary. It has published every year a volume of *Transactions* recording the experience of all the shipbuilders and marine engineers in England. These *Transactions* contain also valuable contributions from French, Italian, German, and other eminent constructors and engineers.

Shortly after the foundation of the Institution one of its members, Mr William Froude, set up an experimental establishment at Torquay, under the auspices and with the assistance of the Admiralty. The object was to submit to experiment various proportions and forms of ships in model in order to compare the relative resistances in the same model at various speeds, and in different forms and proportions at equal speeds. There was some reason to doubt the possibility of inferring from a model on a scale of $\frac{3}{4}$ of an inch to a foot what would happen in a ship of corresponding form and proportions. In order to establish satisfactorily the relations between the real and the model ship a series of experiments was desirable upon a real ship in which the resistances could be measured by a dynamometer at various speeds and compared with those indicated by the model. Up to the date of this trial the "scale of comparison" which had been employed by Mr Froude was based upon *prima facie* theoretical truth, and it had some experimental justification. It may be stated as follows, as given by Mr Froude in the volume for 1874 of the *Transactions* of the Institution of Naval Architects:—

If a ship be D times the "dimension," as it is termed, of the model, and if at the speeds $V_1, V_2, V_3 \ldots$ *the measured resistances of the model are* $R_1, R_2, R_3 \ldots$, *then for speeds* $D^{\frac{1}{2}}V_1, D^{\frac{1}{2}}V_2, D^{\frac{1}{2}}V_3 \ldots$ *of the ship, the resistances will be* D^3R_1, D^3R_2