Upon the hull of the mediaeval 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 mediaeval 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, *Etudes 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.)

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.

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 ship building 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 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 Fronde 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 *. . . the measured resistances of*

*the model are R*1, *R*2, *R*3 *. . . ., then for speeds D*1/2*V*1, *D*1/2*V2*

*D*1/2*V*3, *. . . of the ship, the resistances will be D*3*R*1*, D*3*R*2