can be lessened materially by frequent cleaning and repainting, provided, of course, that docks are available. The fourth objection, the effect of iron on the compass, was very serious. After experimenting with the “ Rainbow ” at Deptford and the “ Ironsides ” at Liverpool, Sir G. B. Airy in 1839 read a paper on the subject before the Royal Society, and the rules which he gave for the correction of the error caused by the iron at once became the guide for future practice. Besides the above, a further objection was raised which applied only to warships, namely, the nature of the damage which would be done to an iron ship by the enemy’s shot: this also was found to be less serious, when proper appliances were supplied, than the damage done in the same circumstances to a wooden ship. Thus during the Chinese War in 1842 the “ Nemesis,” an iron vessel, was able to repair her damage from shot in twenty-four hours at the scene of the fight, while some wooden ships had to go to Bombay, the nearest port at which repairs could be carried out.

Steel, as a material for shipbuilding, was introduced under modern conditions of manufacture during the years 1870-1875.

It is a homogeneous metal, stronger than iron, and of a more uniform and more trustworthy character. Its quality is to a considerable extent independent of the skill of those employed in its manufacture, whereas iron is produced by a laborious and unhealthy process, and is largely dependent for its quality on the skill of the workmen. Among the advantages which experience has proved iron and steel to possess over wood for the purposes of ship construction are: (1) the structure of the ship has less weight; (2) it has greater durability; (3) the requisite general and local strengths

are much more easily obtained.

The importance of the first of these advantages can scarcely be overstated. The primary object of a particular ship is to carry cargo or passengers, or both, from place to place, at a given speed (in the case of a warship, the armament, ammunition, armour, &c., constitute the weight to be carried); and since at the maximum draught at which the vessel can properly and safely proceed on her passage the total weight of vessel, cargo, &c., complete, must be a definite quantity, namely, the weight of the water displaced by the ship, it follows that the less the weight required for the structure of the ship, the greater is that available for the cargo, &c.

As to durability, in wooden ships the chief source of deterioration is dry-rot, in iron or steel ships the wasting of the surfaces, especially of such portions of the outer surfaces of the bottom plating as are frequently left bare of paint and exposed to the sea, and of the inner surfaces of the bottom in machinery spaces, &c. If dry-rot can be prevented, the life of the wooden ship will be lengthened; so also will the life of the iron or steel ship if the surfaces can be kept covered with paint, to prevent the corrosive action of air and water. With both wood and iron or steel ships, if the parts which have become deterior­ated can be removed and replaced, this is usually worth doing when the deterioration is only local. At the end of the 18th century the preservation of wood was not so well understood as it is at the present day, and teak, one of the most durable of woods, was, in Great Britain at least, little known. The ships for the Royal Navy as then constructed were only expected to be available for service some fifteen or twenty years. The ships built for the East India Company made, on an average, four voyages, which occupied eight years. This at one time was considered the vessel’s life, so far as the Company’s service was concerned; but subsequently, if on examination at the expiration of that time they appeared worth repairing, this was done, and they were allowed to make two more voyages. It was unusual for one of these ships to make more than six voyages; after this they were sold or broken up.

In certain cases, however, ships lasted a considerable length of time; a number of vessels built in the 17th century continued in the service of the Royal Navy until the middle of the 18th century, though with a reduced number of guns, and specimens of the old wooden battleships which served in the fleet in the earlier part of the last century are still to be found in the naval and other ports as training vessels, hospital ships, &c. The best-known example is Nelson’s “Victory” (fig. 1,Plate XIII.). Laid down in 1759, she had been afloat 40 years before she took part in the battle of Trafalgar, and to-day flies the flag of the commander-in-chief at Portsmouth. Of small wooden merchant vessels there are instances of the attainment of very remarkable ages. Lloyd’s Register for 1909-1910 shows one sailing vessel, the “Olivia ” of 94 tons, as having been built as early as in 1819, two vessels built in the ’twenties, and twelve built between 1830 and 1840. The collier brig “ Brotherly Love,” of South Shields, was over one hundred years old when she was broken up; and the schooner “ Polly” built in 1805, was still sailing in 1902; as also was the brig “ Hvalfisken,” built at Calmar in Sweden in 1801. The

dimensions of the last vessel are: length, 88 ft. 8 in.; breadth, 21 ft. 2 in.; depth of hold, 14 ft. 7 in.; and her gross tonnage, 211. The oldest vessel afloat in 1910 was said to be the Danish sloop "Constance" *—a* small wooden sailing vessel built in 1723 and still employed in the coasting trade of Denmark. This vessel is 52 ft. 6 in. long, 14 ft. 8 in. beam, 6 ft. 8 in. depth in hold and of 35 tons gross.

In the cases of these very old wooden vessels it should be remembered that many portions of the original structures have been replaced by continual repairs. We have less experience concerning the life of iron and steel ships when taken care of, and in most instances ships have been condemned and broken up only because they were obsolete; but after twenty or even forty years’ service, those parts which by accident or intention had remained properly covered and protected were found very little the worse for wear. Thus the inner surface of the outside plating of such vessels, coated with cement, have been found to be in as good condition as when the ships were first built. The hulls of many of the early iron vessels still afloat are known to be in excellent condition. The "Himalaya,” an iron vessel of 3453 tons and 700 h.p., 6 guns, length 340 ft. 5 in., breadth 46 ft. 2 in., depth 24 ft., built by Mare of Blackwall in 1853 for the P. & O. Steam Packet Co., and purchased by the Admiralty, was actively employed, chiefly as a troop-ship, until 1896, when she was converted into a coal depot, it being found that her plating and framing were almost as good as new. Known as “ C. 60,” she seemed likely in 1910 to survive for many years in her new service. The “ Warrior ”— the first British iron battleship, built in 1861, was converted into a floating workshop forty years later at Portsmouth, where in 1910 &he was known as “ Vernon III.” The hull and framing of the vessel were then practically as sound as when first put together. Experi- ence up to 1910 with vessels built of mild steel indicates that this is more liable to surface corrosion than iron, especially where exposed to the action of bilge water and coal ashes in boiler rooms. Some owners on this account require the plating for the tank tops under the boilers to be of iron in vessels otherwise built of mild steel, al- though the iron is inferior in strength and costs more than the mild steel.

That general and local strength are more easily obtained in an iron or steel ship than in a wooden one follows partly from the fact that the weight required for the structure is less in the former than in the latter, and also from the fact that iron and steel are more suitable materials for the purpose. They can be obtained in almost any desired shape, the parts can be readily united to one another with comparatively little loss of strength, and great local strength can be provided in very little space.

For some purposes, and in some markets, wood is still in favour. In scientific expeditions to the Polar regions, it is of the highest import­ance to avoid any disturbance of the compass, and this can be ensured by constructing the vessel of wood, with metal fastenings. The “ Fram,', built in 1892 for Nansen’s Arctic expedition, was of wood, her outside planking, in three thicknesses, amounting in the aggregate to from 24 in. up to 28 in.; she was 117 ft. long, rigged as a three- masted schooner, and provided with auxiliary machinery working a screw propeller. The “ America,” fitted out for the Ziegler expedition to the North Pole, was an old Dundee whaler (the “Esquimaux”), and was reported to be still a “ stout ” ship with timbers as sound as on the day they were put in thirty-six years before. She is 157 ft. long, 29½ ft. beam, 19¼ ft. deep, net tonnage 466 ; her engines have a nominal horse-power of 100, and she has a lifting screw. In 1901 the “ Discovery,” a wooden vessel, 172 ft. in length, was built at Dundee for Antarctic exploration, under Captain Robert Scott, R.N.,@@1 and a wooden vessel for similar service was constructed in Germany, and in 1910 the “ Terra Nova ” (Plate 1., fig. 2), a wooden Dundee whaler, 187 ft. long, barque-rigged and fitted with auxiliary steam power, which had already seen service in the Far South, carried to the Antarctic regions an expedition also led by Captain Scott. Some wooden sailing vessels are still built in the United States and employed in the coasting and other trades. One of these, the “ Wyoming,” the largest wooden sailing vessel ever built, was launched in December 1909 at Bath. She was a six-masted, schooner 350 ft. long, 50 ft. wide and 30 ft. deep. Wood is also in favour for most of the large and palatial river steamers of the Western states of America.

Some progress had been made in the introduction of steam propulsion before the end of the 18th century, but the advance became more rapid in the 19th. In the early steam vessels paddle-wheels only were used for propulsion.

In 1801-1802 the “ Charlotte Dundas,” one of the earliest steam vessels, was constructed by Symington in Scotland. She proved her capability for towing purposes on the Forth and Clyde canal. Fulton now made his experiments in France, and after visiting Scotland and witnessing the success of the “Charlotte Dundas,” constructed the “Clermont” on the Hudson river in America in 1807. The engines for this vessel were obtained from Boulton & Watt,

@@@1 A very complete account of this vessel was given by her designer, Mr W. E. Smith, C.B., in the *Transactions of the Institution of Naval Architects* (1905).