3. To provide for a return journey without a cargo, in addition to the double bottom and peak tanks, large water ballast tanks are provided abreast of and above the cargo spaces, and arranged so that when ballasted down the metacentric height of the vessel is not excessive. Much of the ballast is carried in side or wing tanks extending to the upper or main deck, or in triangular tanks beneath the main deck, ballast discharge valves or pipes being arranged so that the tanks may be emptied by gravity when practicable.

4. The holds have been cleared of obstructions—such as pnlars, hold beams and web frames—so that the stowage space for the cargo is unbroken, the necessary strength being given by a heavier system of framing of the ship and by the construction of the wing or side tank bulkheads.

5. To facilitate rapid handling of cargo, hatches have been increased in size and number, and special appliances fitted for rapidly loading and unloading the vessel—particularly, large numbers of derricks or cranes, with convenient steam or electric winches.

Several well-known types of cargo vessels have thus been pro­duced, such as the “ Mancunia ” built by Messrs W. Gray & Co. at West Hartlepool in 1898, with *side-ballast tanks* on McGlashan’s patent; *cantilever-framed* vessels by Messrs Raylton Dixon & Co. on Harrowby and Dixon’s patents; *trunk-deck* vessels by Messrs Rayner & Co., and *turret-deck* vessels by Messrs Doxford & Co. of Sunderland. Fig. 10 (Plate 11.) is a photo of a turret-deck steamer. Her dimensions are: length 439 ft. 8 in., beam 51 ft. 7 in., gross tonnage 5995 and net tonnage 3794 tons. Many such vessels have been built; they have the reputation of being good dead-weight carriers, and the shelf on each side of the central trunking can very conveniently be used for carrying timber and for other purposes. The “ Echunga,” built by Sir Raylton Dixon & Co. in 1907, is an example of a modern cantilever-framed flush-decked vessel,—she is 404 ft. long over all, 56 ft. beam, 23 ∙6 ft. moulded depth. On a draught of 23 ft. 9 in. her displacement is about 12,000 tons and dead-weight capacity over 8000 tons, while as regards space she has a stowage capacity of more than 400,000 cub. ft. These results are obtained on the low net register tonnage of 2245 tons, the gross tonnage being 4590 tons. The vessel has continuous upper and main decks, and the underside of the wing tanks carried by the cantilever frames is at such a slope that coal will naturally stow close up on being dumped into the hold. The triangular wing tanks take 1350 tons of water ballast and the double bottoms and the fore- and after-peaks take 1850 tons.

The “ Herman Frasch,” a modern American cargo vessel of 3804 tons, gross, built in 1909 by the Fore River Shipbuilding Co., Quincy, Massachusetts, for the sulphur trade, is a single-decked vessel, with triangular side ballast tanks and fitted with a short forecastle which carries the windlass gear, a bridge-house well forward to accommodate captain and navigating officers, a poop for firemen and crew, and cabins above the poop for the engineer officers. Her dimensions are: length 345 ft., breadth 48 ft. 3 in., depth of hold 27·1 ft. At a draught of 23 ft. 6 in. her displacement is 8770 tons, of which 6125 tons may be dead-weight carried. Her engines are of 2100 I.H.P., are fitted right aft, and give her a speed of 10∙5 knots.

An interesting cargo vessel of a different type is the “ Vollrath Tham,” recently completed by Messrs Hawthorn, Leslie & Co. for the Swedish ore trade. She is 387 ft. long, 56 ft. 6 in. beam, depth 30 ∙9 ft., tonnage 5826 tons, gross, and dead-weight capacity 8000 tons. Instead of the usual open hold arrangement she has been divided into a series of hoppers and automatic discharging holds, and fitted with

10 electric discharging cranes. Trunks are provided in each hold, through which buckets or skips of two tons capacity can be lowered into position beneath discharging doors under the cargo hold. (Fig.

11 shows the general arrangement of this vessel.)

*Great Lake Freighters.—*The greatest development of cargo handling the world has yet seen is, however, to be found in North America, where the Great Lake freighters have been built to meet the rapidly growing trade in iron ore, coal and grain. Some of these vessels are 600 ft. or upwards in length, 60 ft. beam, and 32 ft. moulded depth, and on a draught of 20 ft. can carry 12,500 tons of coal or ore or 450,000 bushels of grain. The hatches of these vessels are 12 ft. apart, and are so wide that the holds are self-stowing. The holds are quite unobstructed fore and aft, and built with flat bottoms and vertical sides, so that practically the whole of the ore can be removed by clam shell grabs. For loading, the vessels are brought alongside huge stacks of ore stored on long lofty piers called ore docks; these docks are provided with shoots from which the cargo is run into the ships by gravity, thus loading large vessels in two hours. When unload- ing at the Cleveland end of the voyage the cranes and transporters fitted ashore can hoist out the cargo of 12,500 tons in ten hours, using grabs of 5 to 15 tons capacity. The propelling machinery is placed right aft and develops from 1800 to 2200 H.P., giving a speed of from 10 to 12 knots. They are well equipped with auxiliary machinery including steam steering gear, steam winches and hoists, pumps and electric light. The wheel-house and bridge are fitted at the after end of a short forecastle ; the officers are accommodated forward and the crew aft, both being provided with excellent quarters (see fig. 15, Plate IL, and fig. 16).

*Colliers.—*In a number of cases vessels are built to carry special

cargoes; coal carrying vessels, *colliers,* are well-known examples of this class. One of the first colliers to be fitted with steam-engines was the sailing vessel “ Q.E.D.,” built at Wallsend in 1844, and fitted by Messrs R. & W. Hawthorn with auxiliary machinery of 20 N.H.P driving a screw propeller. She was constructed of iron, had an overall length of 150 ft. with a breadth of 27½ ft. In certain respects she was a remarkable vessel, for she was fitted with a double bottom, the space between the bottoms being divided into tanks and arranged for water ballast, a system which has since been re-invented and is now common in colliers and in most cargo ships. The advantage of the arrangement in colliers is especially great, as they usually carry a full cargo one way and return empty; in their light condition sufficient water ballast can be at once added to make them sea­worthy, and this at the end of the voyage can bé pumped out at a small cost. It was not until about 1852 that steam alone began to be relied on for propelling colliers; in that year the iron screw collier, “ John Bowes, was built by Messrs Palmer of Jarrow ; she was 152 ft. long, 26 ft. 4 in. beam, had a dead-weight capacity of about 540 tons, was fitted with temporary tanks for water ballast; had machinery of 70 N.H.P. placed right aft; and she took her cargo to London in 48 hours. The saving in time and cost, as compared with the transport of coals to London by the sailing colliers then in vogue, was very great, and this led to the building of many other such vessels.

In 1880 the ordinary steam collier carried 600 or 700 tons of cargo ; a steady increase in size has been in progress, and the popular collier of to-day carries about 3000 tons, while for long voyages vessels of from 8000 to 10,000 tons capacity are used. While improvements have been made in hull and machinery, so also have improvements been made to enable the colliers’ cargoes to be handled more rapidly. Appliances have been adopted for emptying truckloads of coal into the vessels when loading, and many arrangements have been devised for discharging rapidly, but derricks and winches supplemented in some cases by Temperley transporters are still generally relied on. An interesting vessel in which special appliances have been fitted to reduce the amount of hand labour in discharging is the “ Pallion,” built by Messrs Doxford & Sons in 1909. She is of the following dimensions: length 269 ft., breadth 44½ ft., depth 22 ft.; tonnage 2474 tons gross, 1307 tons net, and can carry 3100 tons on a draught of 17 ft. 10 in. She is a single screw ship fitted with three cylinder compound engines of 217 N.H.P. and 1200 I.H.P. fitted aft. Systems of conveyor-belts are fitted so that the cargo can be delivered direct into trucks ashore or into barges or other vessels alongside by steam power, and under trial conditions at Sunderland the rate of discharge was found to be 1000 tons per hour.

*Oil Tank Steamers.—*These form another class of vessels built for a particular cargo, and their construction and the character of the material carried are such that they cannot ordinarily be used for other

purposes. In 1863 two sailing tank vessels were built on the Tyne. In 1872 Messrs Palmer built the “ Vaderland,” which appears to have been the first oil tank steamer. The oil carrying steamer “ Zoroaster ” was built in 1877 in Sweden and in 1910 was still on service. She was built of steel of length 184 ft., breadth 27 ft., draught 9 ft., and had a loading capacity of 250 tons. The oil tanks in the “ Zoroaster ” were separate from the hull, but after successful trials other vessels were built for Messrs Nobel Bros. in which the skin plating itself formed the tank. In 1886 Messrs Armstrong, Whitworth & Co. built the “ Baku,” and since that date large numbers of steamers have been built for this trade, the majority of them having been built by the Armstrong firm. Many of these steamers are of large dimensions while some are comparatively small. On the Caspian Sea, for instance, numerous small steamers are employed conveying oil from the Baku district to other ports, and to towns along the Volga; and in other places small steamers are used for the local distribution of oil brought across the ocean and stored in large depots. Such a small steamer is the “ Chira,” built by Smith’s Dock Company in 1909; in size and appearance this vessel resembles a steam trawler, she is 95 ft. long, 19 ft. 3 in. beam, depth moulded 7 ft. 9 in., 108 tons gross, 46 tons net tonnage. The fish hold is in this vessel replaced by a tank for carrying oil in bulk and a hold for case oil. Vessels of 6000 to 12,000 tons carrying capacity are now preferred by the large companies for transporting oil over very great distances on account of their relatively great economy. Fig. 12 shows the general arrangements of a typical modern oil tank steamer. As an example of a large oil vessel, the “ Pinna,” engaged in carrying petroleum from Russian ports to the East, may also be mentioned. She is 420 ft. long, 52 ft. broad, and 32 ft. deep, and can carry 9000 tons of oil in her fully-laden condition. The machinery is placed well aft, and the cargo space is divided up into twelve large tanks, extending to the height of the main deck, by seven transverse bulkheads and a longitudinal middle-line bulkhead. The spaces between the transverse bulkheads are called Nos. 1, 2, 3, 4. 5 and 6 holds respectively, and each hold has a port and a star- board tank. Each tank is provided with an expansion trunk, in order that the free surface of the oil may always be small, however much the bulk of the latter may expand or contract with changes of temperature.

*Motor Tank Vessels.—*Several oil tank vessels have been fitted with internal combustion engines instead of steam propelling machinery. In 1903 the “ Vandale" and “ Sarmat,” capable of carrying 75o tons of refined petroleum each, were built for Messrs Nobel Bros., and