goods wagons. Ballast tanks are provided, and powerful centrifugal pumps fitted, so that the trim of the vessel can be adjusted as necessary while embarking and disembarking the trains; she is built specially strong so that she can be driven through ice during the winter months.

In 1883 the “ Solano,” a large train ferry 406 ft. long, was built by Messrs Harlan & Hollingsworth of Wilmington, Delaware, to run between Bernicia and Porto Casta in connexion with the Central Pacific railway. In 1899 the American railways employed nearly 200 ferries, with an aggregate capacity of over 2000 large wagons, and by 1909 the numbers and capacity had increased to about three times those amounts, on Lake Michigan alone nine such ferries being at work.

Two other interesting examples of train ferries were built on the Tyne by Sir W. G. Armstrong, Whitworth & Co., Ltd., in 1895 and 1896, the former for service on the river Volga, and the latter for service on Lake Baikal in Siberia. The Volga has a rise and fall of no less than 45 ft. between spring and midsummer, and the ice upon it in winter is usually 2 ft., and sometimes 3 ft., thick; thus the problem presented considerable difficulties, which were increased by the fact that the locks of the Marinsky canal system, through which all vessels bound for the Volga must pass, are of such dimensions that it was impossible for vessels of sufficient size to be got through in one piece. It was decided to use two vessels to do the work, the first to act only as an ice-breaker, and the other to act only as a train-carrier. The ice-breaker was built in two pieces, the parting being at the longitudinal middle-line plane of the vessel. This was satisfactorily carried out by means of a double longitudinal middle- line bulkhead extending the whole length of the vessel. On arrival at the canal she was divided into halves, and was joined up again after passing through the last of the locks. Her dimensions were: length 147 ft., breadth 37 ft. 6 in. and depth 16 ft. 6 in., and she was fitted with compound engines and twin screws. The ferry steamer itself (fig. 38, Plate IX.) was 252 ft. long, of 55 ft. 6 in. beam, and of 14 ft. 6 in. depth. Four lines of rails were laid upon her deck, sufficient space being provided for 24

trucks or carriages, which are shown in

position in the figure. The difficulty

presented by the great difference in the

river level was got over by an arrangement of hydraulic hoists, placed at the

bow, by which two trucks could be lifted

at once to a height of 25 ft., and by having lines of rails at the landing-stages at

two levels. The vessel was fitted with

twin screws and compound engines,

which gave her a speed of 9 knots. It

was found necessary to divide her into

four parts for the passage through the

canal locks; the divisions were made

at the longitudinal middle-line plane and

athwartships at her middle. Each

quarter, when apart, formed a water­

tight hull, and reunion was effected while

the parts were afloat.

The *Lake Baikal Ferry* was built for carrying trains across the lake in connexion with the Siberian railway. For more than half the year the lake is frozen over to a considerable thickness, and in this case the vessel must of necessity be herself a powerful ice­breaker as well as a ferry steamer. Her dimensions are: length 290 ft., beam 57 ft., draught under ordinary conditions 18 ft. 6 in., and displacement 4200 tons. The hull is closely subdivided for additional safety in case of perforation. She has three sets of triple- expansion engines, working three independent screw propellers, two placed aft, as in ordinary twin-screw ships, and one placed at the forward extremity for the purpose of disturbing the water under the ice, thus assisting the heavy cast-steel stem and armoured bow to break up the solid field-ice which the vessel has to encounter. The complete structure was first erected on the Tyne, then taken to pieces and shipped to St Petersburg; from thence its numerous parts were carried to what was at that time the terminus of the Siberian railway, whence they were taken to their destination on sledges, and there the ship was re-erected and launched. The boilers constituted the heaviest individual pieces thus trans- ported, as the weight of each could not be reduced below 20 tons.

An interesting example of a modern river train ferry is the “ Fabius,” built by Messrs G. Rennie & Co., Greenwich, in 1909, for service in southern Nigeria, where the river is 2 m. across. She is a double-ended paddle-wheel vessel; length 160 ft., beam 33 ft. 6 in., depth 10 ft., draught 5 ft. 6 in., speed 7 knots. She can carry six railway carriages and freight and passengers up to a total of 200 tons.

*Ice-Breakers.—*Steamboats for breaking a passage through frozen waters date from an early period; one is spoken of as early as 1851. The “Ermack” (fig. 39, Plate IX.), built in 1898, is one of the largest and most effective vessels of this type. Her dimensions are: length 320 ft., breadth 71 ft., depth to the upper deck 42 ft. 6.in., and displacement 8000 tons; her engines develop 8000 l.H.P., giving her a speed of 15 knots.

Her general outline is shown in fig. 40, from which it will be seen that her bow slopes upwards from below, so as to enable her to run up on to the ice and bring her weight to bear in breaking it. The “ Ermack ” made her maiden voyage in the winter of 1898-1899, when she steamed through the Baltic to Kronstadt, crushing the ice with comparative ease.

5wmyfng *Vessels.—*Special vessels are employed by various governments, and occasionally by institutions or individuals, to survey the oceans and ocean beds, and pursue scientific inquiries of a general nature regarding the sea. The British Admiralty employs the “ Egeria,” “ Fan tome ” and “ Mutine,” sloops of about 1000 tons displacement, modified and fitted up for the purpose, as well as two yachts purchased and suitably modified, and two vessels built especially for the purpose. The yachts are the “ Waterwitch,” 150 ft. long, 640 tons displacement and 10 knots speed, purchased in 1893; and the composite built vessel “ Sealark,” 180 ft. long. 1034 tons displacement and 11 knots speed, purchased in 1903; both are employed in Eastern waters. The vessels built for the purpose are the “ Triton,” 145 ft long, 415 tons displacement, 10 knots speed, built in 1882; and the “Research,” 155 ft. long, 545 tons displacement, 10½ knots speed, built in 1888; both these vessels are propelled by paddle wheels, and both are of composite build. The “ Dart,” a steel yacht 130 ft. long, 500 tons displacement, 7½ knots speed, purchased by the Admiralty in 1882, was in 1910 employed by the New South Wales government. The Canadian government has provided vessels such as the “ Cartier,” a twin- screw steel vessel, built in 1909, 164 ft. long, 29 ft. beam, 648 tons gross and 11½ knots speed, for survey work on the coast of British Columbia. The lndian government had the steel single-screw vessel “ Investigator ” built by Messrs Vickers, Sons & Maxim for survey of Indian waters; she is 204 ft. long, 33 ft. beam, 15 ft. 3 in. moulded depth, has a displacement of 1170 tons and a speed of 13⅜ knots.

The United States government built a surveying vessel, the “ Pathfinder,” in 1899. She is a steel single-screw vessel rigged as a brigantine, length over all 193 ft., on water-line 165 ft., beam 33 ft.

6 in., depth moulded 19 ft. 8 in., displacement 875 tons at 10 ft. draught, I.H.P. 1170 and speed 13½ knots. She has bunkers for 230 tons of coal, and is fitted up with very complete auxiliary machinery arrangements, electric lighting and ventilation, steam heating, and accommodation for a large staff. The outfit for hydrography and research is perhaps the most complete ever provided. The Carnegie Institution of Washington has fitted out the special non-magnetic vessel “ Carnegie,” 128 ft. long, 35 ft. beam, 12 ft. 7 in. draught, 568 tons displacement.

*Lightships.*—In many places round the coast the safe navigation of ships is assisted by vessels called lightships, moored in positions where lighthouses cannot well be built. Around the southern portion of Great Britain these vessels are maintained by the Trinity Corporation (see Lighthouse).

*Fishing Vessels.—*It is not many years since a few old paddle tugs were fitted up with fishing appliances. They proved very profitable, and the experiment led to the building and fitting out of steam vessels specially designed for such employment. Screw steam trawlers (see Trawl) or other fishing-boats are among the vessels most frequently met with round the British coasts. In 1910 some 3000 such steam vessels of an average net tonnage of 50 tons were on the British register, as well as 23,000 sailing boats of an aggregate net register tonnage exceeding 200,000 tons. Fig. 41 (Plate X.) is the steam herring drifter “ Three,” and gives a general idea **of** the type, but there is considerable variety in the methods of fishing, and the fittings of the vessels vary accordingly.

*Coastguard and Fishery Cruisers.—*The lightships give warning of danger, and can also send signals ashore for the benefit of vessels in distress, but cannot themselves render help. The principal organiza­tions for giving assistance to vessels in distress and for saving life around the British coasts are:—

1. The coastguard service maintained by the Admiralty.

2. The signal services, stations and agents maintained by Lloyd’s.

3. The lifeboat services maintained by the Royal National Life- boat Institution.