

(Paper No. 2987.)

"Railway Steam-Ferries in Denmark."

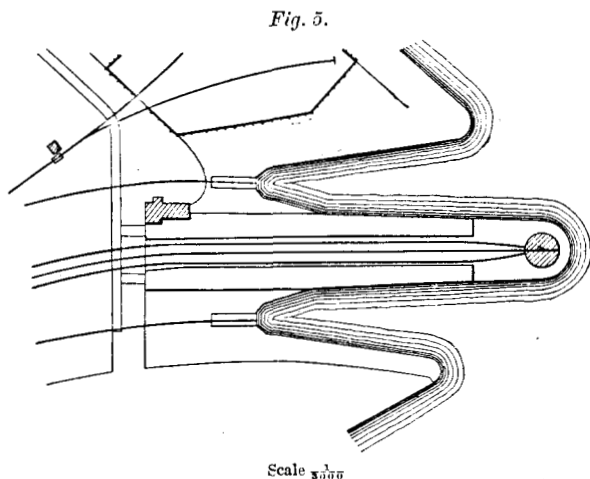
By JOHANNES ANDREAS PRIOR.

THE kingdom of Denmark comprises a large number of islands scattered between the Jutland Peninsula and Germany on the west, and the Scandinavian Peninsula on the east. The Sound lies between the largest of the islands, Zealand, and the Swedish province Skåne. Between Zealand and Jutland is situated the next largest island, Fünen, which is separated from the former by the Great Belt, and from the latter by the Little Belt. Connection of the railways in Denmark has accordingly necessitated crossings of these waterways, which, on account of their international character and other difficulties, allowed only partial use of bridges, whilst submarine tunnels had to be abandoned as too expensive. Steam-ferries, capable of carrying railway wagons, had therefore to be resorted to. The first was constructed in 1872 to connect Jutland with Fünen over the Little Belt. The connection over the Great Belt, between Fünen and Zealand, was established in 1883, and over the north part of the Sound, between Elsinore on the Danish side and Helsingborg in Sweden, in 1891. In 1895, communication was also established between Copenhagen and Malmö, thus allowing railway wagons of the normal gauge, 4 feet 8½ inches, to pass, without unloading, from the remotest stations in Norway and Sweden to the continent of Europe.

The distance across the Little Belt is only about 1½ nautical mile, and here, as well as across the north part of the Sound, where the distance is about 2¾ nautical miles, ferry-steamers of a small type, Figs. 1, Plate 6, could be employed. These vessels, crossing in about 12 minutes or 20 minutes, can deal with a large traffic by continuous day and night service. The distance across the Great Belt is about 14 nautical miles, and across the south part of the Sound about 16 nautical miles; on account of the longer time required in crossing, and the more exposed nature of the sea, ferry-steamers of a larger type, Figs. 2 and 3, had to be used.

Beside the railway connections on the international routes referred to, other railways of the country are similarly connected by steam-ferries. The Danish State Railways have now seven connections of this kind, beside one by ordinary mail steamers from Korsør in Zealand to Kiel; and a fleet of twelve paddle-wheel and three screw ferry-steamers, and four paddle-wheel and seven screw steamships, aggregating a total registered tonnage of 12,932 tons, and 20,650 I.H.P. Several of the vessels are specially built for the winter traffic to encounter difficulties from ice.

Transshipment of railway wagons can only be effected when suitable means of connecting the lines of rails on shore with those on board the vessels are provided. In this respect Denmark



PLAN OF DOCKS FOR TRANSHIPMENT.

possesses the advantage that, in its position at the mouth of the Baltic, the tidal rise and fall of the North Sea is little felt. The difference of levels is for the most part dependent on the prevailing winds; those from the north-west cause a rise, whereas winds from south to east cause a fall, giving a range of levels seldom more than 2 feet above or below the normal. The docks, where the transshipment is effected, are shown in Figs. 4, Plate 6, and *Fig. 5*. Wooden piles are driven into the ground in lines corresponding to the outer shape of the ferry-steamers, which, when lying in the dock, can thus be kept in an exact line with the rails on shore. Elasticity is given to these piles, to meet the shock of the ferry-steamers when entering the dock, by inserting buffer-springs

between the upper ends of the piles and the quay-walls. At the inner end of the docks two groups of piles are fixed to take the thrust endways, and prevent the ferry-steamer approaching too near a strong iron girder-bridge, Figs. 6, 7, and 8, Plate 6, 59 feet 10 inches in length, hinged at the shore end, Figs. 7. Upon the end of the vessel is fixed a suitable bracket to take the movable end of the bridge when lowered. Upon this bridge rails are laid, corresponding with those on shore and on board the vessels. To ensure an exact position of the bridge relatively to the ferry, a pin, Figs. 8, is fixed upon its end, in a vertical position, to drop into a hole in the bracket on the ferry-steamer, thus keeping both together, but at the same time allowing them to accommodate themselves to each other according to the angle of inclination of the bridge or the heel of the vessel. This is effected by suspending the pin from hinges on the head of the bridge, which is again hinged to the girders, the cross connections of which are also hinged. When the bridge is lowered upon the brackets, the lines of rails on board and ashore are continuous and the transshipment of wagons can take place. When the weight is thus transferred to the ferry-steamer its end next the land will be pressed down and its other end lifted until all the wagons are on board. To accommodate this movement, the movable end of the bridge end is suspended by chains connected to counterweights, which leave the bridge so much heavier that it always follows the movement of the ferry-steamer, whereas the winch gear, which is applied for lifting the bridge out of connection, is left free to revolve until the wagons are transhipped, when the bridge is lifted to its highest position free of the ferry-steamer, and the winch gear is locked by pawls. The winch is driven by electricity at both the Danish sides of the Sound; elsewhere the movement is effected by hand, as shown in Figs. 9 and 10.

Two methods of suspending and lifting the bridge are used. At the Danish side of the Sound, two separate winches, Figs. 9, are applied, one at each side of the bridge, with the counterweights working in wells below the surface; the other, Figs. 10, allows the counterweights to work above the surface, and they are therefore placed inside tower-like erections, connected at the top, and forming a kind of portal. This arrangement allows only one winch to be used, and has the further advantage that the counterweights check each other. The features of the arrangements are otherwise identical at all the docks, which only vary according to the size of ferry-steamer.

The ferry-steamers are constructed symmetrically at both ends,

and are supplied with rudders forward and aft, so that the transshipment is independent of the direction in which the ferry has entered the dock. This is of importance at the short crossings, where a turning at each passage would detain the ferry too long. To effect a quick and ready handling of the ferries steam steering-gear is used. Upon the decks are placed steam-winches for ordinary hauling, and for moving the wagons in case the locomotives cannot do so; otherwise the movements of the wagons are effected by the locomotive, the bridges and ferry-steamers being constructed strong enough to carry these heavy loads.

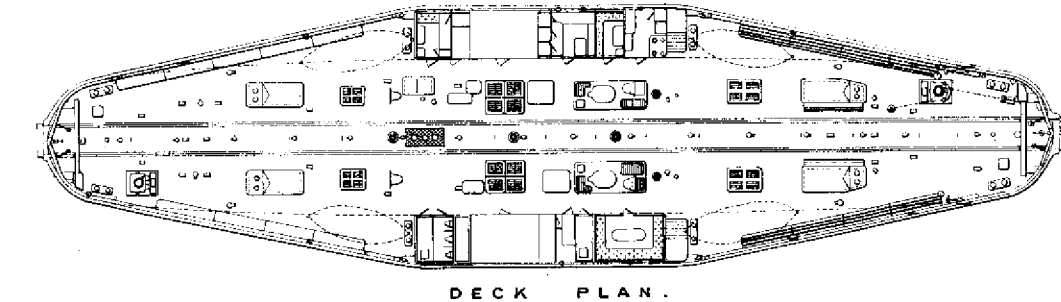
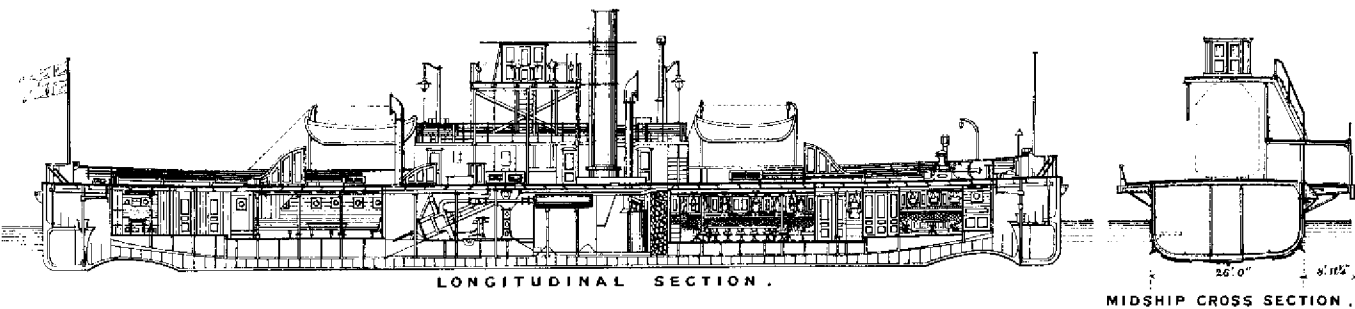
On the Little Belt and over the north part of the Sound, ferry-steamers of a small type, Figs. 1, having only a single line of rails, on which six ordinary goods wagons can be taken at a time, each loaded with 10 tons, are employed. The vessel taken as an example is the "Thyra," built in 1893, by Messrs. Burmeister and Wain of Copenhagen, for service on the Elsinore-Helsingborg route.

On the Great Belt and on the Copenhagen-Malmö route larger ferry-steamers, having double lines of rails, are used. The most recent vessel, the "Kjöbenhavn," Figs. 2, built in 1895 by the same firm, can take eighteen goods wagons, loaded with 10 tons each. As the double line of rails are laid out with curves to meet each other at the ends, very long wagons can only be embarked when fitted with bogie frames. The continental saloon carriage belonging to H.R.H. Prince of Wales, has often been thus brought across the Great Belt upon the older double-line ferries; and the largest saloon carriage of this kind which has been taken across, had a length of 60 feet and a breadth of 9 feet 7 inches, with a wheel-base of 52 feet 10 inches. The reason for laying out the rails with curves, was to avoid broad square-shaped ends to the vessels, which would be objectionable in a heavy sea, and to retain as far as possible the shape of a ship. The ferry-steamers behave exceedingly well in rough weather, and easily carry heavy deck loads; they keep time and are easily handled, regardless of the weather. Large bilge-keels contribute to the steadiness of the vessels, which are propelled by feathering paddle-wheels, which also add to the steadiness, but are not suitable for working in heavy ice. The limited depth of water, however, in the harbours, necessitated the use of paddle-wheels, and to meet the occasional occurrence of heavy ice several spare steamers are required, specially constructed as ice-breakers, but necessitating unloading of the wagons.¹ These spare vessels also include two single-

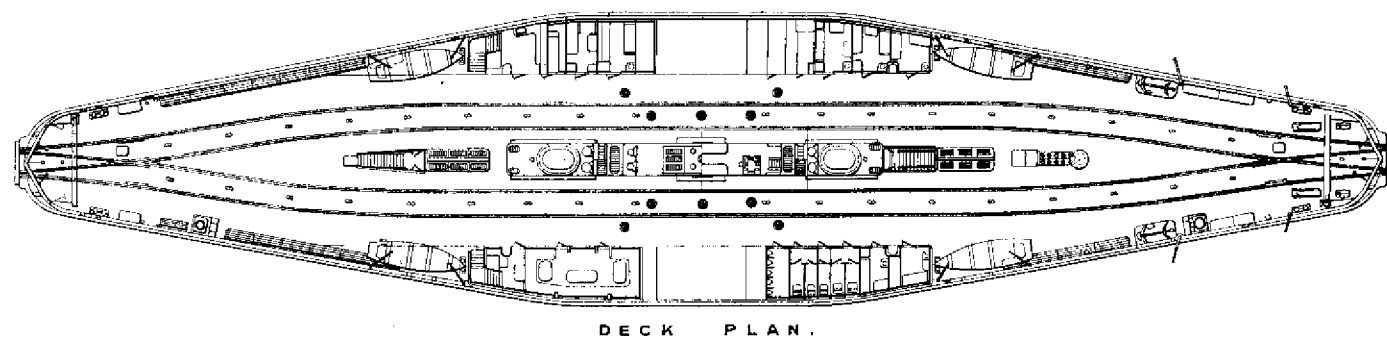
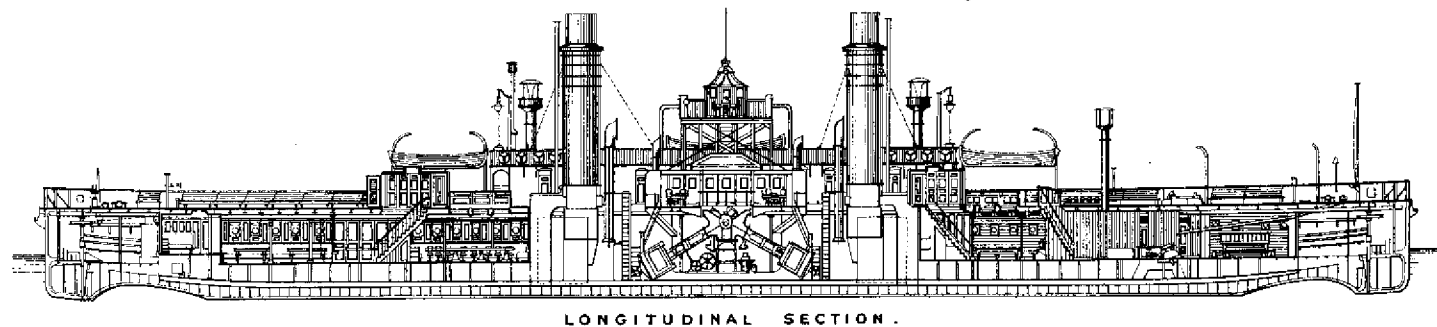
¹ Minutes of Proceedings Inst. C.E., vol. xcvii. p. 300.

lined twin-screw ferry-steamers for transhipment of wagons over the Little Belt, when the ice is too strong, and also one double-lined single-screw ferry-steamer for the Great Belt; these screw boats have done very good service. The vessels are not used for through passenger-train service, as passengers in general prefer to leave the carriages while crossing, but mail- and luggage-vans are always taken across, as are also single through passenger carriages on the short crossings. The decks are built flush, with as few encumbrances as possible; and funnels, companions and skylights are arranged according to the position of the rails. At both ends of the deck are placed booms, corresponding in height with the buffers on the wagons, and easily lifted when necessary for taking wagons off or on. They serve to check the movement of the wagons, which, however, must be tied longitudinally during the passage by chains fixed to eye-bolts in the deck, and by booms across the rails and under the wheels. The wagons are besides tied transversely by screw tighteners applied to the tops of the rails. A bridge is erected amidships, high enough to allow the largest wagons to pass below, and on it is placed the steering-house, with a separate connection so that each rudder can be worked independently. To support the rails and the considerable weight that may traverse or rest upon them, the deck beams, upon which they are fixed, are supported by longitudinal girders resting upon pillars from the floor. The flat-bottomed rails are firmly riveted in troughs of iron, which are partly filled with cement. The deck is of wood adjoining this trough, and the rails project about $1\frac{1}{2}$ inch above it. In all the ferry-steamers are arranged large and airy saloons for first- and second-class passengers at one end below deck, and at the other end similar saloons for third-class passengers. The vessels are lighted throughout by electricity, and are heated by steam. Ventilation is effected from the funnels, which are double, the space between the inner and outer portions being in connection with the rooms, and exhausting the foul air. Several Boyle exhaust and down-cast ventilators are also installed. On the decks are placed four pillars, from which are suspended arc-lamps for lighting the deck while embarking passengers or wagons. The vessels are built of steel to the highest class in the "Bureau Veritas," and the engines are compound, working diagonally, with surface condensation. A special centrifugal pump, with its own steam-engine, supplies the cooling water. The starting and reversing is simply and quickly effected by steam-power.

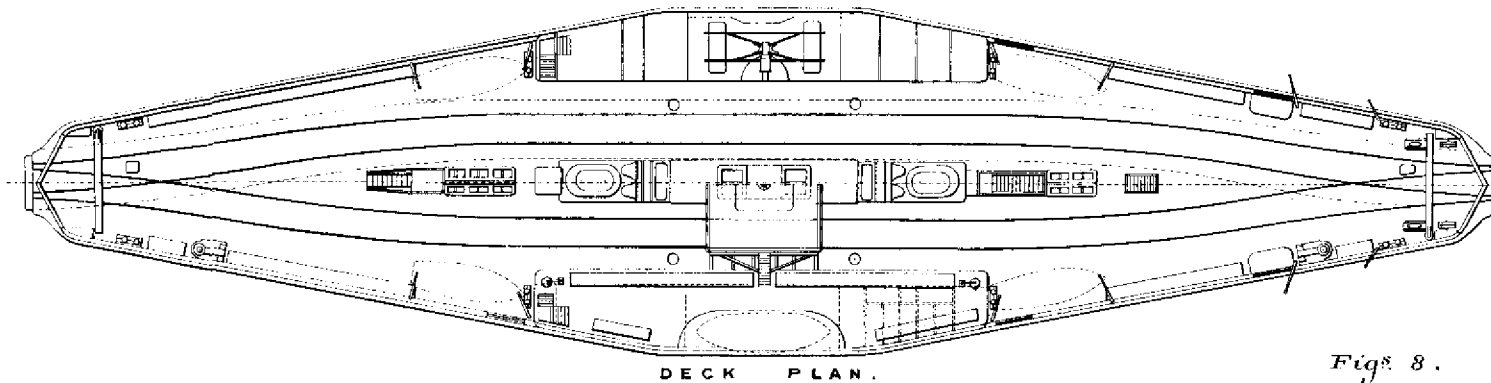
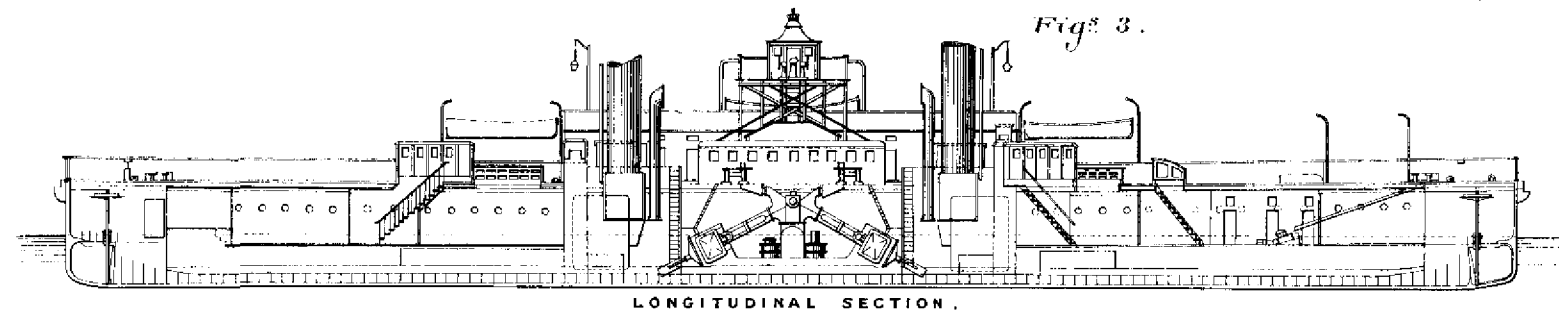
Fig^s 1.



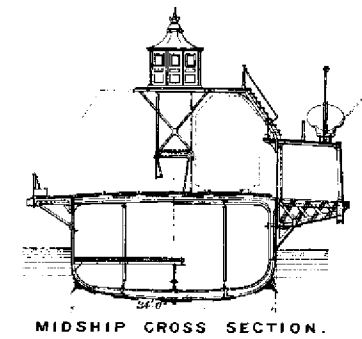
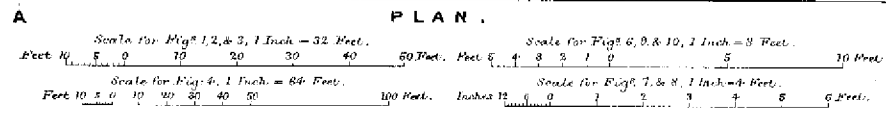
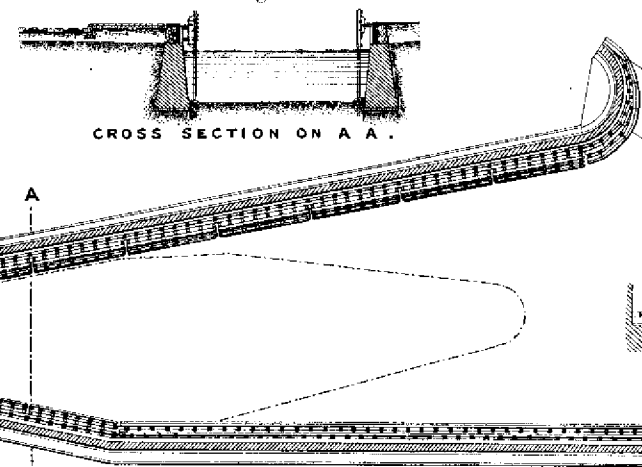
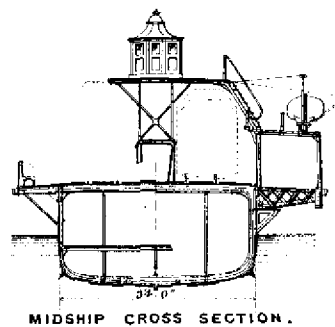
Fig^s 2.



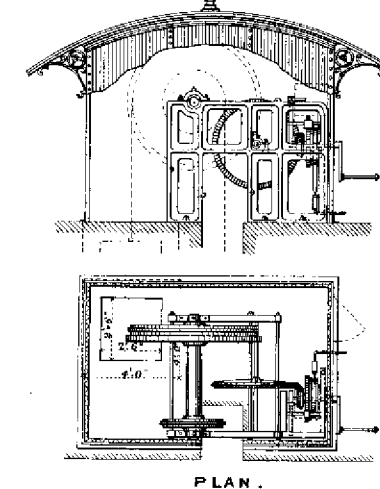
Fig^s 3.



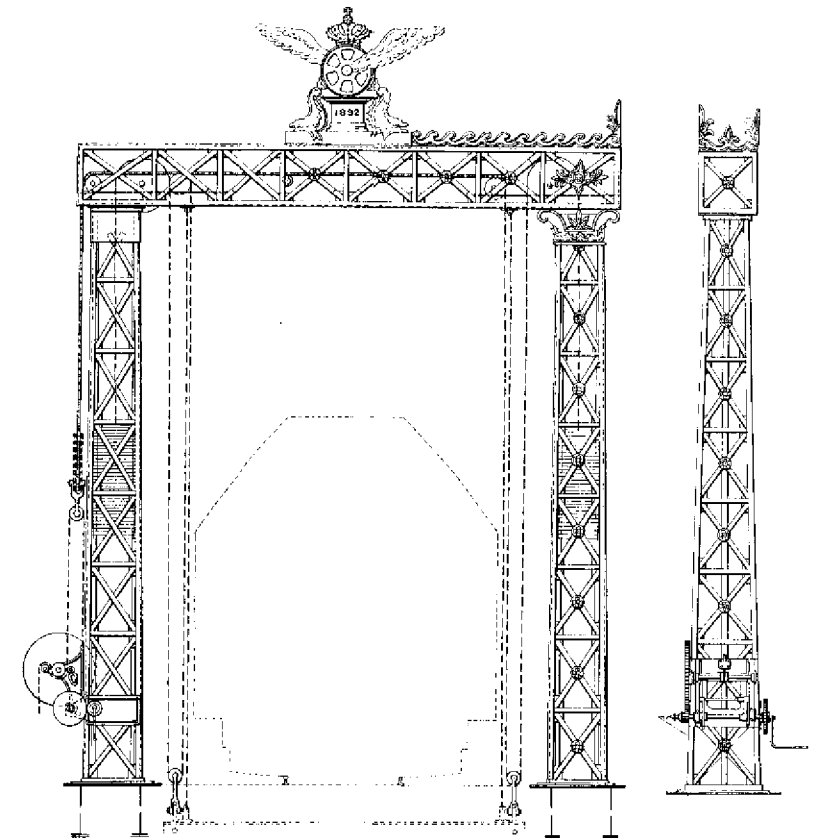
Fig^s 4.



Fig^s 9.



Fig^s 10.



Fig^s 6.

