Discussion.

Mr. Carson. Mr. Carson said the subject of the Paper had been suggested by the unhappy accident to the "Princess Alice," and it had been approached rather from a public than from a technical point of view. The question was, whether such craft were safe or unsafe? and it had been thought desirable that a Paper should be prepared with a view of eliciting an expression of opinion on that subject.

Mr. Mackie. Mr. S. J. Mackie asked permission to say a few words, having taken for more than twelve years a great deal of interest in the construction of vessels with regard to their safety. When it was considered that river vessels were specially designed for carrying living freights, and ought therefore above all others to be protected, it would be seen that it was a matter of the utmost importance that they should be efficiently constructed. If any engineer or naval architect would conscientiously study the design of such a vessel as the "Princess Alice," or the "Albert Edward," or vessels of that type, carrying five hundred passengers and upwards, he would see that they were utterly unfitted for the service they were intended to perform. The engine space and the boiler space occupied the whole of the centre—a space which, above all others, should be devoted to the buoyancy of the vessel; and there was a length of from 60 to 70 feet open from one end to the other, and defended against the ingress of water by plates which were as worthless as brown paper, being only $\frac{5}{16}$ inch in thickness. Considering the dead weight in the centre and the buoyancy of the two ends, separated by bulkheads, if the central portion were pierced, nothing could save the vessel from being rent in twain, and the engines would not be able to run the vessel even the shortest distance ashore. The principle which he had for many years endeavoured to carry out, at a considerable expenditure of time and money, had been that of constructing vessels upon a system which would involve little, if any, greater weight of iron than that hitherto adopted. He would utilise the saloon, or central part of the vessel, by carrying the saloon walls down to the bottom; in other words, using longitudinal girders, or bulkheads, one on each side, leaving the central space perfectly free for the service of the ship. In case of a collision the general buoyancy of the ship would not be affected. By putting the boilers abaft and forward, and the engines in the centre, dividing them by bulkheads, the vessel would be rendered secure. The iron could be disposed in a better manner than by adhering to the old form of ship-building, and the total weight of the ship

Mr. Mackie.

would not be more than by the system hitherto adopted. The chief practical objection to the system was, that it cost about 5 per cent. more than in the case of an ordinary vessel. The method had been approved by builders of the highest eminence. The officers of the Board of Trade had also unofficially examined it, and he desired to say that he was quite satisfied with the treatment he had received from those gentlemen. Unfortunately they had no one to support them in regard to matters of safety; there were many adverse interests, and, unless a public movement were initiated by this or some other Institution, he did not think the officers were powerful enough to do that service to the country which he believed it was their desire to render. The Author had credited Messrs. Henderson with the design of a vessel with longitudinal girders. Mr. Mackie had designed a passenger steamer for the Thames, in 1870, under this system.[1] It would be seen that the longitudinal girder system was thoroughly carried out according to the principle he had then patented.

Mr. Winter.

Mr. T. B. WINTER said that, some years ago, the Government of India, desiring to improve the navigation of the shallow and rapid rivers in that country, appointed a commission, of which he had the honour to be a member, to visit the different European rivers with a view of gathering information on the navigation and the class of vessels used. In the course of their investigation they visited the Danube, the Rhone, and other rivers of importance, including the Clyde. The navigation of the Danube was, in many respects, similar to that of the Clyde. The risks were mainly end-on risks; the amount of traffic was not considerable, and, generally speaking, the vessels used were similar to those adopted on the Clyde. The draught of water was about 4 feet, and the speed was from 11 to 16 knots an hour, according to the class of service. There were, however, some parts of the Danube, mainly the "Irongates," where a specific class of vessels was required. The "Irongates" was a name given to rapids running, according to the season of the year, from 7 to 10 miles an hour. The depth varied at different seasons, but during summer it was little more than 2½ feet. The vessels which, at the time of their visit, were employed upon the service, were plying for a few miles above and below the rapids. Their draught was only 1 foot 3 inches; their length 150 feet; their breadth 20 feet; the engines were 40 HP., driving two distinct pairs of paddle-wheels, each pair being actuated by a distinct pair of engines. The result

[1] *Vide* "The Illustrated London News," December 7, 1872.

Mr. Winter. was certainly very good. The boats went through the extremely rapid currents with great regularity; accidents were extremely rare, and the service was admirably performed. He believed, however, that the river was now so far improved that those vessels were not needed. These boats with four paddle-wheels answered their purpose so admirably that the Company, who owned them at the time to which he alluded, had in consequence put upon the river two other vessels of much larger dimensions, also with four paddle-wheels, for the navigation of the deeper portions of the river; but he believed they were not found to answer for the ordinary navigation: they were costly, and the same amount of fuel did not produce the same result as to carrying capacity or speed. There was another peculiar class of vessel on the Danube, which was used for towing. The draught of water was about 4 feet, and the vessels were propelled, as in the case of American vessels, by over-head beam engines, driving paddle-wheels about 40 feet in diameter. They were about 220 feet long, 40 feet beam, and 80 feet wide over the paddle-boxes. Their peculiarity was, that they had no "run" in the ordinary sense, they were the same breadth abaft as amidships, the after body being shelved up to the load line much like a Thames barge. The bow was of ordinary form but very bluff, the bottom perfectly flat. The vessels were most efficient, and he knew one of them which towed sixteen barges, each loaded with 250 tons, at a speed of 3 miles an hour against a 2-mile current. The effective power of the vessel seemed to be enormous, and the work was done most economically. These were the principal vessels of interest on the Danube.

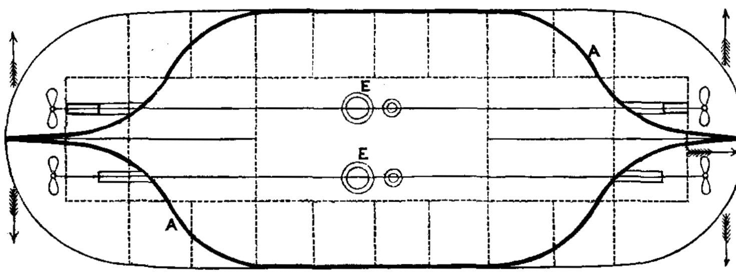
On the Rhone, a much more rapid river, flowing from 5 to 6 miles an hour, there were some extraordinary vessels. They were built first about 130 or 150 feet in length and 18 or 20 feet beam; but as trade increased, it was suggested that they might be cut and lengthened, which had been done over and over again. The longest vessel which he saw at work was 475 feet long by 19½ feet beam, drawing 4 feet of water; she carried an enormous amount of goods, but was extremely unsightly. The competition of the railway had driven those vessels off the river, and he did not think many of them were now running.

As the result of their investigation the Commissioners were led to advise, for the use of Indian rivers, a different class of vessel from that which had been previously adopted. They found, from experience on the Danube and on the Rhone, that great dimensions did not, in a material degree, interfere with the success of the navigation.

Indeed, lengths and breadths seemed to be of little importance, Mr. Winter. one vessel being nearly as handy as another. The Indian rivers differed from those of Europe, inasmuch as although some were as rapid, the effective depth was much less. The bottom was almost always sand, which, from the rapidity of the current, was constantly being shifted, and sand-banks were sometimes thrown up in a night where there had been a deep channel the day before; consequently, vessels were frequently running aground and getting into every sort of trouble. The vessels so often ran on to the sand-banks that it was necessary to adopt some means of preventing their cutting too deep into them. The Commissioners suggested that future vessels should be made of a spoon shape at both ends, so that in case of their running on to a bank either ahead or astern they would shelve themselves up on to it, and so be more easily got afloat again. One of those vessels, built from his drawings and under his instructions, was put together on the Mersey and tried there. It was a paddle boat 239 feet in length by 38 feet beam, and 2 feet working draught, with about 400 effective HP. The vessel was built by Messrs. Laird, and the result of the trial was very successful. When put in competition with a tugboat of the Mersey, although of so light a draught, there was no doubt that her towing capacity was greater than that of the tug. She, with several similar vessels, had since done good service in India. The Commissioners also recommended, as an experiment, the construction of a very large vessel, 375 feet long by 46 feet beam, and 74 feet wide over the paddle boxes; draught, 2 feet, and to go at a speed of 10 miles an hour. This vessel was put together, and tested on the Thames with considerable success; but notwithstanding the stipulation that she should never be exposed to a sea swell she was rebuilt in India, in such a position as to necessitate a sea passage before reaching her station; the consequence was that she broke her back, and the experiment was lost. If the vessel had been worked on the river, he believed she would have done good service. She could carry a regiment with ordinary baggage on 2 feet draught. The Government, however, now subsidised railways, and did not need a flotilla. Indeed, considering the difficulties of Indian river navigation, and the great cost of the boats required for the purpose, he was not surprised to find river navigation was being largely superseded by other means of transit.

Mr. JAMES TAYLOR (Birkenhead) desired to bring before the Insti- Mr. Taylor. tution a novel construction of ferry-boat used at Woodside. For sixteen years he had been connected with the Ferry Committee, Mr. Taylor. and had taken great interest in the working of the boats both for passenger and goods traffic. For the last two years he had been chairman of the committee of the late Birkenhead Improvement Commissioners, and he had made it a particular point to endeavour to arrive at a mode of construction for a ferry steamer that would be safe and handily used on the waters of the Mersey. The model exhibited represented the "Oxton," a boat 130 feet long by 45 feet beam; draught, from 7 feet 8 inches, with a free board of about 6 feet 9 inches; constructed to carry carts, carriages, horses, cattle, and goods across the river, between Liverpool and Birkenhead on the Woodside Ferry.

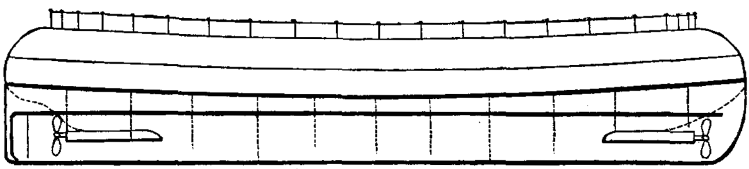
FIG. 1.



Plan.

In Fig. 1 A A represented the skin of the vessel, where the propeller shafts passed through from the engine E E inside to the screws outside. When going straight ahead the screws being made right and left-handed required the engines to be driven in opposite directions; but when required to spring from her berth, the engines went in opposite directions, whilst the screws operated upon the water also in opposite ways, and turned the vessel round as on a pivot. The dimensions were extraordinary as contrasted with those of the vessels previously described. She was built with two pairs of engines; one pair on one side driving one propeller forward and one aft, and the same on the other side. That was for the purpose of taking the place of the paddles with fixed floats as in the vessels of the Claughton type, having a pair of engines to each paddle-wheel. The vessel had been working since July, 1879, with great success. On the trial trip, the gentleman who had the handling of her, apart from the contractors, dropped a buoy, when she was in a state of rest, at each bow, the vessel being double-ended. Putting the vessel in motion he turned her round in her own length in about four minutes. He then took a run back and came up to the first buoy at full speed, reversed the engines, and she pulled up within a distance of about her own Mr. Taylor. length. To be able to pull up a vessel of this class in so short a distance was a matter of great importance on the river Mersey, which was often crowded with vessels, and where they were exposed to dense fogs. The engines were compound cylinders, 19 inches and 34 inches in diameter, with a stroke of 24 inches. The two pairs indicated at the trial about 570 HP. At first she did not attain the speed contracted for, but that was on account of the propellers being four-bladed, too broad, and having too coarse a pitch. They were then replaced by others having three blades, and the speed was now equal to that of any of their other paddle steamers. The builders, Messrs. Simons & Co., of Renfrew, had informed him

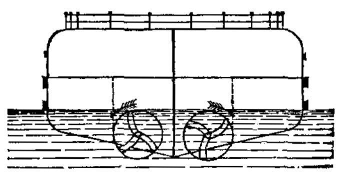
Fig. 2.



Side elevation.

Fig. 3.

Promenade deck.



that they could undertake, on that bottom, 130 feet by 45 feet beam, as in Figs. 2 and 3, to construct a vessel with saloon and other accommodation capable of carring fifteen hundred passengers. With regard to the consumption of coal, the Claughton class took about $10\frac{1}{2}$ cwt. per hour, but the vessel he had described only consumed $4\frac{1}{2}$ cwt.; so that if she could carry as many passengers, the saving of fuel would be very considerable. He also exhibited another model showing the construction of a passenger boat, furnished to him by the contractors, Messrs. W. Simons & Co., in which there was an arrangement of water-tight compartments immediately within the hull, as in dotted lines in Fig. 1. He believed that the desired end of safety would thereby to a considerable extent be attained. The question of having four propellers was no doubt open to discussion. He was not

Mr. Taylor. very familiar with naval work, but, as an engineer, he thought that the two forward propellers entering the water freely took a better grip and would do most duty. Some persons had said that it might be objectionable to send the water against the bow of the boat with forward propellers, but the lines were such that the water coming from the propellers was sent underneath. The after propellers might perhaps be constructed of a rather coarser pitch than the forward propellers, and in that way he believed a better speed could be attained. He might mention that in the "Oxton" there was one bulkhead running fore and aft over the keel. Such had been the success of the boat, that the Birkenhead Corporation had resolved to build another of the same type, and he believed that instead of there being one fore and aft bulkhead, there might be two, as in Fig. 1. That would tend in a great measure to make her unsinkable, and leave the machinery, and a cabin fore and aft, to be used for passengers, out of danger. For ferry or river purposes, or for the channel service, he thought this structure much safer than a paddle-boat, even if the latter had overhanging sponsons, for there must necessarily be a gap on each side for the paddle wheels. He could hardly claim to be the first to place two pulling screws at the bow, but he believed that the bow screws working in unison with after screws was a novelty. Since the "Oxton" came from the Clyde, Mr. John Horn, late of Waterford, informed him that, about the year 1842, he applied two bow screws to a steam-tug canal boat of dimensions suitable to the locks on the Union Canal, Scotland. The boat was driven by a high-pressure engine having the screw shafts geared into an internal and external wheel. He was prevailed upon to change the position of the screws from the bow to the stern, but upon this being done the tug did not answer so well. The Union Canal soon after was purchased by the Edinburgh and Glasgow railway company, upon which Mr. Horn changed his employment, and heard no more of this screw steamer. From this Mr. Taylor gathered that bow screws, with the faces of the blades to the water, would do more duty in pulling and towing through water than screws propelling at the stern. But the screws of the "Oxton" were differently situated, they being back to back, and when the engines were reversed, the forward screws, which formerly had the round backs of the blades, and were working in conjunction with the after propellers, became powerful brakes and suddenly checked the forward progress of the vessel in consequence of the blades having their faces towards the water. In this respect, therefore, the "Oxton," if fitted with a saloon and upper deck, might be termed a passenger river locomotive. He found from a report of the officials at the ferry made to the new committee, that, "when under way her motion through the water is steady, no horses having been thrown down, even during the gale which visited the river on the 13th of November, 1879. Neither is she affected by ordinary weather as soon as the passenger paddle boats are." And he might add, as an additional advantage with the four screws, that they need not be heavy or of large diameter, and the shafts being only 3 feet 7 inches below the water line could almost be reached for renewal, if need be, without docking the vessel. Also, in considering the passenger requirements, the bow screws if lost or damaged were not a very serious drawback as compared with safety of human life. Mr. Taylor.

Mr. J. P. Symes said there was no doubt a great advantage in applying bulkheads to large steamers, but in the case of the small boats running above London bridge, it would be very difficult to arrange them, to give any accommodation whatever; and at present their accommodation below deck was of a very inferior character, and the ventilation and light extremely defective. He agreed with the Author that in rivers like the Thames and the Mersey, where there was much traffic, the greatest safety would be obtained by having full control over the steering and engine power. He exhibited models of two small steamers corresponding in dimensions to the above-bridge and the below-bridge boats on the Thames. They were light-draught boats, intended for passenger traffic. The dimensions of the smaller boat were: length, 80 feet; beam, 11 feet; depth, $5\frac{1}{2}$ feet. She was a paddle-wheel boat, drawing 1 foot 8 inches, was constructed for running on the coast of Spain over shallow sands, and had compound surface-condensing paddle-wheel engines. The effective diameter of the paddle-wheels was $7\frac{1}{4}$ feet, and the speed was 11 miles an hour. She was rather smaller than the above-bridge London boats, whose dimensions were: length, 90 feet; beam, $13\frac{1}{2}$ feet; depth, $6\frac{1}{2}$ feet, and was not constructed with more than ordinary regard to safety. The ship was divided by four athwartship bulkheads into five water-tight compartments, the centre compartment containing the machinery. The boat had lofty cabins, the windows and lights being above the deck, and above the cabins were promenade decks. It was fitted with awnings fore and aft on account of the hot climate of Spain. The safety of the boat depended upon the control of the engine and steering power. With regard to strength, the vessel had Mr. Symes.

Mr. Symes. been loaded down with coals to about 3 feet draught of water, and crossed the Bay of Biscay, and a boat that would do that was strong enough for ordinary passenger traffic in smooth water. The other boat was of a much lighter construction, corresponding somewhat in dimensions to the boats running below London bridge. Her length was 140 feet, beam 18 feet, depth $6\frac{1}{2}$ feet, speed 12 miles an hour. She had been built for the African trade, and contained cabins on deck for only a few passengers. She was required for cargo and mixed traffic on the River Quanza, on the West Coast of Africa. She was built to carry machinery, coal, and 20 tons of cargo on a draught of 2 feet. On the trial trip she attained a speed of a little over 12 miles an hour with 27 tons of cargo, and a draught of 23 inches. The vessel was remarkably light so far as scantling was concerned, as there was not a plate in the hull exceeding $\frac{3}{16}$ inch thick. The vessels previously built had not answered the purpose, and in order to ensure success the contractors were ordered to build a ship at home, test it, and take the risk of running it out. The desired result had been attained, and the vessel could now run 30 miles higher up the river in the dry season, which was a matter of great importance. Formerly the cargoes had been brought by natives in their canoes. The boat had now run for two years, and had given great satisfaction.

Mr. Perkins. Mr. Loftus Perkins stated that he had long travelled up and down the river in a steamer of his own, and he had brought a cylinder for the inspection of the members, that they might see how it had worn. It was a high-pressure cylinder, working at 500 lbs. per square inch. He could not agree with the statement that the Thames steamers were managed badly. He had been in America and elsewhere, and he considered that the steering and the general management of the London boats were as good as any that he had ever seen. The steersman performed a double duty—steering and carrying a fender to defend the stern. He had never known an accident happen to the river boats. Naturally their consumption of fuel was very large, but they often stopped, and during a great part of the day they did not run. With regard to Mr. Taylor's statement as to the consumption of fuel in the case of the steamer he had described, he thought there must be some mistake, as it amounted to less than 1 lb. per HP.

Mr. Taylor. Mr. Taylor said the boat was not incessantly working under steam, but while stopping to load and unload was making steam.

Mr. Rogerson. Mr. John Rogerson observed that, in the earlier part of the present century, open wherries propelled by rowers were employed Mr. Rogerson. for the conveyance of passengers by water between Newcastle and the towns of North and South Shields, at the mouth of the Tyne. These boats could only go with the tide, and make one trip each way during the day. The times of starting were always varying, and the boats occupied several hours on the journey of about 10 miles, not unfrequently grounding on the numerous shoals which then existed in the river. These were succeeded by a sort of floating omnibus, a rude imitation of the "Venetian gondola," called comfortables, having a raised covered cabin at the after part of the vessel; and they in turn were superseded, in the year 1814, by the "Perseverance," a small wooden paddle steamer. At various times attempts were made to organise a regular traffic; but as the boats were owned by proprietors acting independently, and were used indiscriminately for towing purposes as well as for passengers, the service was intermittent, tedious, and irritating to those who had occasion to have recourse to it. At that time there were only the two terminal landings, passengers for intermediate points being obliged to embark or disembark by small boats. Uncertainty and delay were the prevailing characteristics of the traffic, which altogether failed to keep pace with the industrial progress of the district. Recognising these inconveniences, and believing that a large traffic could be developed on the river, Mr. Rogerson gave his attention to the building of suitable steamers and to the establishment of a regular passenger line. The traffic on the Tyne might be divided under several heads. Above the bridges connecting Newcastle and Gateshead there was little movement of vessels, and only sculler boats and keels, sometimes towed by steamers, presented difficulties to be guarded against. Below the bridges ships came in large numbers to discharge at the quays of Newcastle and Gateshead. Tiers of vessels were moored to buoys at various places. There were frequent sculler-boat ferries. There was a constant movement of large sea-going steamers, and of tug steamers towing vessels or keels, or seeking employment; in a word, a ceaseless traffic coming up, going down, and crossing the river. This continued until within 2 miles from the mouth of the river. There were large docks on each side of the river. At high tide the water-way was crowded with vessels under tow; besides which there were tiers of vessels between North and South Shields. The breadth of the river varied from 100 to 300 yards; but in consequence of these tiers the river way was so narrowed that when meeting vessels under tow the passenger steamers had sometimes to make their way

Mr. Rogerson. inside the tiers. Then in summer the sands and neighbourhood of Tynemouth were a great resort to pleasure seekers. The steamers, therefore, had to be constructed so as to be able to run, at the proper season, to Tynemouth Haven. This portion of the traffic required that the steamers should have to some extent sea-going qualities; since, notwithstanding the large piers north and south of the harbour, broken water was frequently experienced. Wrecks had occurred during storms inside the piers, and on one occasion the passenger-steamer pier at Tynemouth Haven was cut in two by a wrecked vessel. Besides those characteristics of the traffic, some of the steamers made pleasure trips out to sea in summer.

He at first judged that fine lines would be best suited for speed, and that good accommodation and higher speed would attract an increase of passengers. He therefore built, in 1859, the "Louise Crawshay," of the following dimensions:—111 feet long, 6½ feet deep, and 14 feet beam. This vessel carried three hundred and fifty passengers, and had a pair of common condensing diagonal engines, of 30 nominal HP., cylinders 22 inches in diameter, and a stroke of 2 feet 4 inches, the draught of water being 4 feet. The boat plied regularly between Newcastle and North Shields. He next built the "Harry Clasper," to carry five hundred and eighty-five passengers—a still more commodious steamer, 115½ feet long, 16½ feet beam, 7½ feet deep, having a pair of engines of 40 nominal HP., cylinders 24 inches in diameter, a stroke of 2½ feet, and 7½ feet depth of hold; the draught of water was 3½ feet. The public responded to the facilities and accommodation, especially in visiting Tynemouth; and, having studied the saloon steamers on the Mississippi and Hudson rivers, on returning from America in 1860 he built the "Charlotte Annie Williamson," a saloon steamer, 114½ feet long, 16½ feet beam, 7 feet deep, and of 50 tons net and 82 tons gross register. The sponsons were carried out to the paddle-boxes, and extended fore and aft, the beams overhanging outside of the hull being supported by stays. The vessel accommodated three hundred and eighty passengers, and had a saloon deck 90 feet long, under which were fore and aft cabins; the engine-house was amidships, and there was a passage-way outside the saloons on the main deck. The engines were a pair of common condensing diagonal ones; the cylinders were 24 inches in diameter; the length of stroke 2 feet 6 inches; the HP. 40 nominal; the boiler, vertical tubular, was subjected to a pressure of 27 lbs. per square inch. Of two other vessels built at this time, the "Garibaldi," which had the saloon arrangements similar to the last, carried

Mr. Rogerson.

two hundred and seventy passengers, and was 89½ feet long, 16 feet beam, 6¼ feet deep, and of 36 tons net and 55 tons gross register; the engines were common condensing oscillating, of 20 nominal HP.; the cylinders 18 inches in diameter; the length of stroke 26 inches, and the boiler a vertical tubular one. The "Wansbeck" was a double-stemmed boat, with a rudder at both ends; the shell plating was continued out to the sponsons; the saloons were partially sunk below the main deck. This vessel, which was built in 1861, and carried two hundred and eighty passengers, had recently been almost rebuilt, and was now the only saloon passenger steamer on the Tyne. The "Wansbeck" was 97½ feet long, 16¼ feet beam, 5½ feet deep, of 38 tons net, and 56 tons gross register, and was steered from a wheel-house amidships on the saloon deck. The engines were oscillating, of 30 nominal HP.; the cylinder was 22 inches in diameter, and the length of stroke 30 inches.

In the meantime he erected landing stages at short distances apart on both sides of the river; but it was found that the class of steamer above mentioned, although adapted for the direct passage between Newcastle and North Shields or Tynemouth, was unwieldy for general purposes, not being easily handled. He might mention that, as the North and South Shields Ferry Company had a monopoly for conveying passengers between North and South Shields, he applied, in conjunction with some friends, for an Act of Parliament; and the passenger line started by him was incorporated as the Tyne General Ferry Company in 1862.

Subsequently a somewhat different type of steamer was adopted, and in 1865 the "John Edwin" was built. This vessel was 100 feet long, 13 feet 10 inches beam, 6½ feet deep, 99 tons builders' measurement, 36 tons register, and had a draught of 3¾ feet, representing a displacement of 61 tons. The vessel was certified for two hundred and seventy-five passengers; the speed was 10 miles per hour; the engines were a pair of common condensing oscillating, the cylinders 20 inches in diameter, and the length of stroke 2 feet, indicating 122 HP.; the boiler was longitudinal, multitubular, fitted with a copper back tube plate and brass tubes; the pressure was 30 lbs. on the square inch; the paddle-wheels were 10 feet in diameter with feathering floats. Three transverse bulkheads divided the hull into four watertight compartments, strong sponsons protected the engine-room from external injury, and a wooden fender 9 inches broad was carried round the hull immediately below the deck line for the protection of the ends of the vessel. The cabins were below the

Mr. Rogerson. deck, and were lighted and ventilated by skylights. The boat was steered from a bridge forward of the funnel by the captain, who was protected from the weather by a wheel-house, the upper part of which was fitted with carriage windows on all sides. The engines were worked from the deck, and had link motion reversing gear. The engineman was immediately behind the captain, from whom he received orders direct.

The passenger service of the Tyne was now carried on by four direct ferries, viz., the North and South Shields Direct Ferry, the North and South Shields Market Place Ferry, the Whitehill Point Ferry, and the Howdon and Jarrow Ferry; three of these carried passengers only, the fourth conveyed besides, carts and general street traffic. A line of steamers also plied eastward from Newcastle to Tynemouth, a distance of 10 miles, and westward to Elswick, a distance of 2 miles. The number of passengers was six millions per annum. This great traffic was conducted over a crowded waterway, the river being navigable by large vessels at all times of tide. The clearances outwards of four of the principal ports of Great Britain in 1876 were: the Tyne, 16,581 vessels; the Thames, 15,883; Liverpool, 13,496, and Glasgow, 5,453 vessels; the Tyne standing highest in the number of vessels.

It would thus be seen that the conditions under which the Tyne passenger traffic was carried on, were such as to require a class of steamers easily and quickly handled. In the run of 12 miles there were now no less than twenty-three stations, many of them difficult of access on account of the tiers of vessels on either side which had to be approached at nearly right angles with the line of the river. Unlike the Thames and the Clyde, the Tyne passenger traffic was conducted during many hours of darkness, thus materially increasing the risk of collisions. The principal direct ferry ran night and day, and the up- and down-river steamers began plying at 5 A.M., in winter as well as in summer, for the accommodation of workmen proceeding to their employment, and continued running every half hour from each end till 7 P.M. in winter, and 9 P.M. in summer.

The Tyne traffic was totally different from that on the Clyde, therefore no comparison could be made between the classes of steamers employed. The only resemblance to the service on the Mersey occurred in the case of the principal ferry-boat plying between North and South Shields, which resembled the Birkenhead ferry-boat on a small scale. The "Tyne," one of the direct ferry-boats referred to, carrying six hundred and eleven passengers, was a single-stemmed flush-decked boat $99\frac{1}{4}$ feet long, $26\frac{1}{4}$ feet

Mr. Rogerson.

beam, 43 feet broad over the sponsons, and $8\frac{1}{4}$ feet deep from keel to gunwale. The hull was protected by a strong sponson projecting the width of the paddle-boxes, and carried fore and aft. The boat was steered from a wheel-house amidships, immediately over the engine-room, elevated on a large hurricane deck which served the double purpose of a promenade and a shelter in wet weather. The propelling power was by a pair of disconnecting side-lever engines of 80 nominal HP., with two cylinders 26 inches in diameter, and of 3 feet 9 inches stroke, and two flue boilers with a working pressure of 20 lbs. per square inch. The vessel drew 4 feet 9 inches of water, and had transverse watertight bulkheads; but not the longitudinal ones described by Mr. Carson as an important factor of safety in the Mersey boat. The principal cabins were below the main deck.

The Thames service from London bridge to Chelsea, and down the river to Woolwich, represented more nearly than any other that of the Tyne. Suppose the Thames to possess the best design of steamers obtainable, a similar class of vessel might be expected on the Tyne; but the Tyne boats, though of similar dimensions to the above-bridge boats on the Thames, differed from the latter in several important respects, the excessive displacement, and greater draught of water being specially noticeable. The reason was that during four or five months of the year the boats ran to Tynemouth to a point outside the bar, though within the limits of the piers; also, when specially surveyed for the purpose, they were employed on trips along the coast, being thus subjected to strains from rough water; they were heavier than the Thames boats, and drew more water. The draught might be lessened by making the boats longer, but the length could not be materially increased on account of the difficulty in approaching some of the landing stages. This class of steamer had conformed most nearly to the peculiar conditions of the service.

With a view to obtaining economy in the consumption of fuel, at the instance of the Chairman of the Company, the "Perkins" patent engine and boiler had been fitted in one of the boats. The safety-valves were loaded to 450 lbs. per square inch, and the boiler tested to 2,000 lbs. on the square inch. The engines had three cylinders, one high pressure 10 inches, one medium 14 inches, and one low pressure 28 inches, in diameter. The length of stroke was 18 inches, and the indicated HP. 150. The fuel was gas-coke, and the consumption under trial on a day's work of twelve hours was 25 cwt., or $1\frac{1}{2}$ lb. per indicated HP. per hour. The vessel had run with passengers ninety-one days, making in all 5,582 miles, in

Mr. Rogerson. addition to a great number of trial trips. After this period, during six months of which a Board-of-Trade certificate for passengers had been held, the boiler tubes were drilled for the surveyors, and proved perfectly clear and free from scale. The consumption of second-class steam coals in other boats doing the same work as the "Loftus Perkins" was 45 cwt. per day, costing 13*s.* 3*d.*, as against 7*s.* for the "Perkins," being a saving in favour of the latter of $37\frac{1}{2}$ per cent. in the consumption and 47 per cent. in the cost of fuel.

Another general question was whether, by reason of its intrinsic merits and moderate cost of production, mild steel was not likely to supersede the use of iron for engineering and shipbuilding purposes.

He had a steel boiler at the Stanners Closes Steel Works, near Wolsingham, which had been working continuously for more than ten years; it had cost little for repairs, and every plate in it remained nearly as sound as when first put in. It was of the usual Cornish type, 6 feet 6 inches in diameter, by 33 feet long, fitted with two furnaces each 2 feet 9 inches in diameter, and 33 feet long; the plates were of Attwood's steel, $\frac{1}{4}$ inch thick throughout, except the end plates, which were $\frac{1}{2}$ inch thick; the whole was double riveted with steel rivets, and all the holes had been drilled. This boiler, which was loaded to a steam pressure of 50 lbs. per square inch, supplied steam to two steam hammers, one a 2-ton and one a 10-cwt. hammer; it likewise supplied motive power to a machine for washing blacklead. The consumption of fuel for twelve hours was 33 cwt. This boiler had been built by Mr. Daniel Adamson, of Manchester, who informed him that he had constructed fourteen hundred steel boilers, all now in use and working at a pressure of from 60 to 160 lbs. per square inch.

A boiler made of Attwood's steel had been fitted to the "Wansbeck" in April last. The boiler in this boat was of the cylindrical form, with eighty-six horizontal tubes, $3\frac{1}{2}$ inches in diameter by 6 feet long; it was 9 feet in diameter by 8 feet 3 inches long, and was fitted with two furnaces, each 2 feet 9 inches in diameter and 6 feet long; the plates, as well as the tubes, stays, &c., were made of Attwood's steel, $\frac{5}{16}$ inch thick; the tube plates were $\frac{5}{8}$ inch thick, the shell and furnaces were double riveted with steel rivets, and all the holes were drilled. The boiler was loaded to a pressure of 30 lbs. per square inch, and supplied steam to two 22-inch cylinders, the length of stroke being 2 feet 6 inches. The consumption of coal was 67 cwt. per twelve hours.

In September 1877 he witnessed a series of experiments by Mr.

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D. Adamson, at Dukinfield, with the object of testing the endurance of iron and steel when subjected to violent percussive forces, such as were produced by the explosion of gun-cotton or gunpowder; twenty-seven pieces of plates were tried, each piece of a different quality, and selected from the principal manufacturing districts. The iron was the finest boiler-plate, and the steel had been manufactured both by the Bessemer and Siemens-Martin processes. Each piece of metal was placed on a cast-iron anvil block, having a segment of a sphere hollowed out on the top; about 8 inches above the plate was fixed the gun-cotton which was exploded. The result of these experiments afforded conclusive evidence in favour of mild steel so far as regarded its power of resistance to a sudden and violent shock[1].

In order to have some idea of the comparative corrosion of iron and steel, experiments were made at the laboratory of the Weardale Iron and Coal Company, Limited, at Tudhoe Iron Works, on specimens of iron and steel plates of the following chemical composition:—

—	Mild Steel.	Medium Hard Steel.	Tudhoe Best Best Iron.	Tudhoe Crown Iron.	Common Iron.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Iron	99·354	98·400	99·000	98·900	98·800
Carbon	·115	·330	Trace	Trace	Trace
Manganese	·504	1·008	·216	Trace	Trace
Silicon	·055	·065	·111	·107	·177
Sulphur	·028	·022	Trace	Trace	·008
Phosphorus	·037	·075	·165	·217	·532
Copper	Trace	Trace	Nil	Nil	Nil

These specimens were originally 2 inches square by $\frac{3}{8}$ inch thick, and had been immersed in a bath of water containing 1 per cent. of sulphuric acid, and the loss in weight recorded every twenty-four hours. The "mild steel" in seventeen days only lost 4·8 per cent. of its weight, while the iron samples in the same time lost from 34·7 to 79 per cent.

Guided by these and other results, there was now in course of construction for the Tyne Ferry traffic, a steamer of Weardale steel, which would be 6 feet longer, 14 inches wider, and 4 inches deeper than the "Tyne" previously described. It would give the

[1] *Vide* "The Journal of the Iron and Steel Institute," 1878, p. 383.

Mr. Rogerson. same displacement, but would carry fifty additional passengers on 9 inches less draught of water. The plates were $\frac{3}{16}$ and $\frac{1}{4}$ inch in thickness; the total weight of steel being 30 tons. The steel was tested according to Lloyd's rules, and every plate, angle, &c., had an ultimate tensile strain of between 27 and 31 tons per square inch of section, and an elongation of not less than 20 per cent. in a length of 8 inches. The chemical composition of the steel was:—Iron, 99·375; carbon, ·110; manganese, ·400; silicon, ·028; sulphur, ·037; phosphorus, ·050; and copper, trace; total, 100·000. The boiler would also be built of Weardale steel of the same chemical composition as that used for the boat, and in accordance with the Board of Trade requirements, which, in the case of boilers were "that a strip cut from every plate shall stand an ultimate tensile strain of between 26 to 28 tons per square inch of section, and shall show an elongation of not less than 20 per cent. in a length of 10 inches."

The advantages to be obtained by the use of steel for marine purposes would be decrease in weight, increase of strength, greater ductility, and probably extra durability. Such, briefly, were the results of experiments that had come under his supervision and direction in regard to steel up to the present moment; such the action already taken in regard to it—that was in a boiler already in use, and a passenger steamer now building—and such the expectations which he anticipated would be realised at an early period.

Mr. Bramwell. Mr. F. J. Bramwell said the Paper had been avowedly written in consequence of the accident to the "Princess Alice." No doubt that accident had excited the attention of the public to a very large extent, and also, happily, it had excited the attention of gentlemen such as the Author of the Paper and that of others competent to advise what should be done for the future. The Author had stated that he had considered the various circumstances which should be taken into account in dealing with such a subject, and Mr. Bramwell was glad he had intended to bear in mind that it was not desirable to propose such remedies as were prohibitory in consequence of their adding too much to the cost of the work. Nevertheless, he did not think that the Author had sufficiently taken those matters into consideration in regard to the up-river Thames steamers. He gathered from the Paper that the Author considered that in order to have safety there must be a cellular system of construction. In the case of an up-river steamer 16 feet beam, it was proposed to have a continuous longitudinal bulkhead. That certainly seemed to him (Mr. Bramwell) very much out of keeping with anything like use or comfort of Mr. Bramwell. the lower part of a steamer of that size. It might be said, "Look at the steamers upon the Mersey and upon the Clyde, and it will be found that the passengers are disposed of in saloons on deck." But bearing in mind the nature of the navigation of the upper Thames, it would be seen that the steamers were limited in their beam by the width of the bridges, so that it was impossible to have those wide sponsons which were put forward as a means of increasing the deck room and of protecting the sides from the effect of a blow; they were also limited in height by the bridges, so limited that, even with lowering funnels and paddle-boxes kept low, it was not uncommon (as he himself had experienced at Hammersmith Bridge) for the boats to be detained a considerable time, unable to get through until the tide fell. Thus these steamers were precluded from width, from height, and, owing to shoals, from draught of water: they therefore must neither be wide, nor lofty, nor heavy. Under those circumstances it seemed to him that there was not much room for improvement in the manner suggested by the Author by the cellular construction, or by a longitudinal bulkhead dividing a 16-feet-beam boat into two equal parts. With regard to the navigation below bridge, Mr. Mackie, who had paid so much attention to the subject, and who, in common with all those who desired to save life, deserved their warmest approval, said that a boat might be made of two continuous longitudinal bulkheads from end to end; then there would be the external skin and the two bulkheads, and by suitable transverse divisions there would be an almost unsinkable structure, without adding much to the weight. Was he right in that supposition? He had complained of the plates of the "Princess Alice" as being of little more value than brown paper (a phrase that had been much used), those plates being only $\frac{5}{16}$ inch. What did he propose to do? Was he going to make the external skin of the boat thinner? He supposed not. If he intended to have the internal bulkheads from end to end, what were they to be? Were they to be $\frac{5}{16}$ inch, or something thinner? If they were to be something thinner, they might answer so long as the outer skin was uninjured and they were in the dry, but directly the outer skin was injured, if the bulkheads were not strong enough to stand against the pressure of water—when they became as they would then become the external parts of the vessel, they would give way, and the vessel would sink. It appeared to him, therefore, that it was not possible to retain the same weight of vessel and to adopt the plan proposed by Mr. Mackie. With respect to

Mr. Bramwell. the "Princess Alice," he did not think there was any proper complaint to be made against the thinness of the plates of the vessel, or that there was anything in the suggestion that the vessel would have been practically safer if the plates had been thicker. He said so for this reason: when two vessels came into collision, if they were of equal strength and struck each other equally, perhaps both would go down; but if one were strengthened, it might stop up and the other go down. If a brass vessel and an earthenware pot were going down stream, it would be a bad case for the earthenware pot. But you could not so strengthen vessels that both would stand; one of them would go down if they came into collision. If a proof of that were wanted he might refer to the lamentable accidents that had taken place in the English and in the German navy, where vessels built with plates of enormous thickness and with numerous watertight compartments had come into collision and had gone down. If the question of expense were wholly unimportant, still it was idle to suppose that you could so strengthen a river passenger steamer that, when she came into collision with even an ordinary merchant vessel with a heavy scantling, she would not go down. He knew that the view he was taking was not a popular one. He remembered the applause that was given to those who had proposed to save life at any cost, and he was aware that he was laying himself open to the charge of being indifferent to life. That, however, would not be a deserved charge; true he was of opinion that it was possible to buy life too dear, and in considering the cost of the purchase the number of lives to be saved must be taken into account. Now what had been the result of the navigation on the Thames? He was old enough to remember it for fifty years. The percentage of loss of life by accident had been extremely small, and if to lessen that very small percentage plans were proposed which would result in costliness of structure and working, the result would be practically to prohibit cheap fares and cheap trips down the river, and thus in the end more harm than good would be done. He knew that when any one came forward in all earnestness and sincerity and said that life had been lost, and proposed that certain things should be done with a view to avoid that calamity, it was a taking thing, and everybody was inclined to agree with him. The Board of Trade—that most mischievous institution in respect to its excessive interference with marine engineering—was called upon to give its help, and the result was harm and not good. If the Board of Trade managed the pressure upon the railways, he believed there was not a single railway that would not have to lower the pressure on its locomotives from 140 lbs. to 80 lbs. the square inch in order to pass muster. Complaints had been made that the Thames ships were without signalling apparatus, and that the barbarous custom of calling was resorted to. That, however, was only half a fact. The signalling was not done by calling, but by hand signalling—the captain moved his hands to the call-boy. He would ask whether any of the travelling members of the Institution knew of any place in the whole world where vessels were navigated with the ease and ability exhibited on the Thames? The vessels went along with a three-mile tide in their favour, and yet they were brought up alongside the pier in a manner quite different from that adopted abroad, where it was the custom to turn the boat round and go in with her head against the stream. With one hand the captain directed the steersman, and with the other communicated with the call-boy. The plan might be inartistic, but it worked well; and he knew no place where, although the appliances might be much better, the practice was so good. Mr. Bramwell.

Mr. J. I. Thornycroft desired to offer a few remarks on the Paper, but he would make them with much deference, as many naval architects were far better able to deal with the subject, having devoted their time to the construction of the very vessels under consideration. Mr. Bramwell had shown that to strengthen the vessels in the way proposed might be very expensive, and the Paper contained some evidence to show what that expense would be, for the number of passengers was generally given, also the displacement and the speed of the vessels. Taking Mr. Samuda's boat, the weight of the passengers was about 48 per cent. of the displacement. That was large in proportion to the others. The speed was not high—10 or 12 miles an hour. On the Mersey the attempt to make the boats proof against collision had been successful. He did not say that they were safe from a violent collision with a large ship, but he thought there was a great chance under ordinary circumstances of their swimming in the event of collision, although they would no doubt be injured. It had been proposed to put longitudinal bulkheads in narrow boats built for speed, but it did not appear to have occurred to those who made the proposition that the effect on the stability of the vessel might be so destructive as really to make the proposed remedy a disadvantage. In the Mersey boats the weight of the passengers carried was only 17 per cent. as against 48 per cent. in the London boats. In order to divide a boat into watertight compartments, a very great amount of material had to be expended, and a larger expendi- Mr. Thornycroft.

Mr. Thornycroft. ture of power was required to get the same speed. It was curious that in the boats supposed to be stronger, and that could go further down the river Mersey, the percentage of the weight of the passengers was 21 instead of 17. Why the stronger boat should be the lighter he could not understand. On the Clyde there were beautiful examples of vessels built for high speed. The speed attained was said to be 22 miles per hour, and the percentage of the weight of passengers was 21. If it was required to build a boat divided into compartments with the same expenditure of material per passenger, the speed would only be 10 knots instead of 22 miles; and if the boats of the Thames were so hampered as to have their speed reduced to 10 knots, he thought that for long trips they would be practically useless. With regard to the effect of high-speed engines, there was a model on the table of one of the Mersey ferry boats—a screw boat—and the gentleman who had exhibited it had stated that the vessel was considerably lighter for the number of passengers carried. She had four screws and two shafts running the whole length of the vessel. That appeared to him one shaft more than was necessary. He thought that if one screw was retained on one side at one end, and the other screw at the other side at the other end, both screws retained being of a slightly larger diameter, the friction of the shaft would be reduced, and the efficiency of the boat probably be increased, the steering qualities remaining nearly the same. What an engine could do really depended on how many reciprocations it could make in a unit of time. A paddle vessel with very large paddle wheels could only make a very few. As to the wear and tear, it might be somewhat excessive or greater in rapid-working engines, but he thought the saving in first cost would more than balance the wear and tear. He thought that the screw might be adapted in a modified form to shallow draught, and to a great extent take the place of paddle wheels as now used. He hoped it might be found possible to work out the system so as to give satisfactory results. His firm had built a vessel having a very limited draught, 30 inches, and she was able to tow on the Nile very successfully. She might have been much larger had she not been required to be used as a towing vessel. He thought there were means at hand by which the draught of water of vessels of similar power could be much further reduced, and a vessel having equal power could be built at about 18 inches draught.

Mr. Bramwell. Mr. Bramwell asked what would be the maximum thickness of the plates in a vessel of that draught.

Mr. Thornycroft. Mr. Thornycroft replied that the thickness would be about $\frac{1}{8}$ inch.

Mr. J. R. RAVENHILL said it was stated in the Paper that under the conditions of the navigation of the Thames above bridge, "great strength of hull would defeat its object. Great handiness is necessary, and when a choice must be made between strength to resist the force of collisions and handiness to avoid them, in the latter quality lies the greater probability of safety." It might be taken that the Author, in speaking of the greater probability of safety, alluded to handiness only; but in his opening remarks he certainly spoke of the strength of the hull, and if he had stated that the same remark would apply to the Thames between London bridge and Gravesend, the Paper would have been very much to the point. Mr. Bramwell had, in his usual lucid way, referred to the above-bridge navigation. He could not remember so long back as Mr. Bramwell; but he had stood many times on the piers above bridge, and on the boats themselves, sometimes in company with foreigners, who had invariably admired the way in which those boats had been handled. The best proof of the efficiency of the boats was the fact that, dating back, as the service did, more than forty years, there had been no serious accident or collision. He wished that Mr. Bramwell had said something about the below-bridge traffic; but he had a few figures on that subject which might prove interesting. At certain times of the tide the river eastward of London bridge could only be compared to one great tidal dock. If there were sluice gates across the bridge, and some ordinary dock gates down the river, the tidal dock would be complete. The traffic had grown to an enormous extent; that on the Tyne, to which reference had been made, was nothing in comparison with it. The number of sea-going vessels arriving in London—sail and steam, foreign and coasting, amounted, in 1874, to 43,848, with a gross tonnage of 8,337,977 tons. In 1878 the number of vessels had increased to 47,728, with a gross tonnage of 9,415,873 tons. In addition to that enormous tonnage, which the waterway of the Thames had to provide for, there were all the river craft, the river steamers and barges plying within the port, which were not included in the Custom House returns. The barges alone amounted to about 1,000 a day, passing from the docks below bridge into the Thames; and the total number of barges at that time registered amounted to 7,000. Taking those vast figures into consideration, had the accidents been numerous or serious? In the years ending the 30th of June 1875–76–77, 131 vessels, including 95 barges, had been sunk by collision between London bridge and Yantlett creek. Of those, many succeeded in reaching the shore before sinking, and nearly all were raised. The number of lives

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Mr. Ravenhill. lost was 15. Above Gravesend, between June 1877 and June 1878, 419 casualties were reported to the Board of Trade, of which 373 were collisions, and in which 836 vessels were concerned. The total number of lives lost was 6. Thus the number of lives lost amounted to 21, and he believed they were all connected with the crews, there being no passengers in the usual acceptation of the word. He did not wish to make any allusion to the unfortunate accident with regard to which he had had the honour to serve on the Committee of Inquiry; but he should like to draw attention to one important point in connection with it. The navigation of the Thames was carried on under totally different circumstances from those existing in the Clyde, the Mersey, the Tyne, or any other river in the world. There was an old guild dating from the 14th or the 15th century, called the Watermen's Company, who possessed the greatest possible powers that could be held by any body of men in connection with the navigation of the Thames. He was a Conservative, and had no wish to see an old company, that doubtless had done much good, swept away; but he maintained that the company should move with the times. It was something past comprehension that a vessel carrying between 800 and 900 human beings was compelled to be navigated by a man earning 50*s.* a week, and that the owners of the vessel were debarred from going into the open market and buying the best skill and seamanship that the world could supply. The Paper, according to the reading of many, implied: Mersey, perfection; Clyde, good; Thames, very bad. Mr. Ravenhill had the authority of the senior member of one of the firms alluded to as having built a vessel for the Thames, to say that everything was brought to him—that he was asked to build a vessel for old machinery—that he had simply carried out the plans furnished to him, and had nothing to do with the design. He believed the second vessel alluded to was also given to the builders under similar circumstances, but he could not say so with the same authority. With regard to the Gravesend boats, he remembered the time when they were the pride, not only of the Thames, but of Europe. When he was an apprentice it had fallen to his lot, on more than one occasion, to have to take a vessel, well known on the Gravesend station, and measure her against a new comer in a good slogging race all the way from Gravesend to Blackwall. That was in early days, before Mr. Bramwell was troubled with his nightmare of the Board of Trade. Engineers and shipbuilders could then do as they liked, and they did as they liked. The Thames held its own, and he believed there were firms on the Thames now, who, if things were left entirely to them, could hold their own as

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in days gone by. No vessel could be built to stand a huge screw collier coming right into her amidships; but the difficulty that owners or companies had to deal with was that railways had run off the vessels he had alluded to, and there was now no such thing as Gravesend passenger traffic by water. There was during the summer a Gravesend excursion traffic, but the owners had been so hard put to it to earn a dividend that they had been compelled to introduce a refreshment bar on board the vessels. If they were required to have bulkheads for the vessels in the way suggested, they might as well be told that the traffic should cease altogether. An excursionist would only give a few pence for his ticket, and the receipts therefore were very small in comparison with the large sums earned by the Birkenhead Ferry. So long as the traffic existed between London bridge and Gravesend, the passenger steamer must be a compromise. There had lately appeared on the Thames a class of vessel for which the public had mainly to thank Mr. Thornycroft. Some few years had passed since he had astonished them by the results of his screw launches. When Mr. Bramwell read a Paper "On Quick Steam Launches,"[1] at the Institution of Naval Architects, many of them shook their heads and said they "should like to see it done." Out of the launches had grown the torpedo vessels of the present day. There were now two firms in London producing torpedo boats that had attained a speed hitherto unknown in the history of steam navigation. From the result of those vessels he believed much might be gained with reference to light draught passenger ships of the future. They had led the way to higher pressures. The plan which had proved successful on board those vessels was about to be tried on a large scale by the Admiralty for the engines of a vessel, building at Chatham, called the "Polyphemus;" and, should it be a success, he believed in a short time there would be a vast difference in machinery connected with river navigation. Experiments were also being made with a much lighter form of boiler even than those working on board torpedo vessels. If that also succeeded (and he had seen a boiler at work that had run 1,500 or 1,600 miles, and appeared to be working efficiently) there could be no doubt that additional strength could be given to passenger steamers with good effect, and without increasing the cost of the hull and machinery. If an artificial blast were adopted, two bulkheads could be introduced, one forward and one aft, between the engines and the stokeholes, which would strengthen the ship and help her in the event of a

[1] *Vide* Transactions Inst. Naval Architects, vol. xiii., p. 269.

Mr. Ravenhill. collision by reducing the present enormous engine space. The present great stoke-hole hatchways, where there were a number of half beams would also be got rid of. It was all very well to say that they were as strong as if the beams went right across, but he should prefer them to go across, and that might be done. In those respects passenger ships might be improved, and in such improvements, he believed, the Thames would lead the way in the future as it had done in the past.

Mr. Beloe. Mr. CHARLES H. BELOE said there was no Waterman's Guild on the Mersey, and men could be obtained from the open market. The wages paid were: the master, 50*s.* a week, the mate, 35*s.*, and the crew, 30*s.*, and there was no difficulty in obtaining good men at those prices. With regard to the "fancy" fares mentioned by the last speaker, the fare was only a penny, and he did not think that could be well reduced. The largeness of the receipts was of course due to the enormous traffic between Liverpool and Birkenhead. By the courtesy of the Wallasey Local Board he was enabled to exhibit a model of the last passenger steamer built for the Mersey. The following were the conditions enforced by the Board in regard to the design. The number of water-tight compartments was not to be less than seven. The paddle shaft was to be in the centre of the vessels, so that they might have an equal rate of speed going either end first. The engines to be arranged so that the cylinders should be one on each side of the shaft. The engines, boilers, and paddle shaft to be under the deck. The draught of water not to exceed 5 feet with the usual amount of coal, and with 900 passengers on board. The guaranteed speed to be not less than 13 statute miles per hour in smooth water. The passenger boats to have a certificate for at least 900 passengers. The saloon not to be less than 80 feet long, 12 feet wide, and 7 feet high. The length of the vessels not to exceed 150 feet. That limit as to length was imposed by the Dock Board, who would not allow a steamer of greater length to occupy a berth at the Liverpool landing stage. Another condition was that the deck should not be more than 5 feet 6 inches above water amidships, in order to suit the level of the landing stage at New Brighton. To comply with those conditions it was necessary to employ two boilers to balance the weights, and having to keep them under the deck entailed the use of low-crowned boilers, with the risk of priming, which made it a matter of some difficulty to attain the desired speed. Fifteen or sixteen firms tendered, and the tender accepted was that of Messrs. T. B. Seath & Co., of Rutherglen, Glasgow, who had supplied two passenger steamers from the designs of Mr. Alexander Richardson, Naval Architect, Liverpool. The dimensions were: length, 150 feet; beam moulded, 25 feet; depth, moulded, 10 feet 6 inches. Driven by a pair of diagonal oscillating surface-condensing engines made by Messrs. David Rowan & Co., of Glasgow, having cylinders 36 inches in diameter, with a stroke of 5 feet. Boiler pressure, 40 lbs. The saloon was 93 feet long, 13 feet wide and 7 feet high. The stipulated number of watertight compartments had been exceeded, the boats being divided into twelve, without any openings in them; and the coal bunkers could be closed by watertight doors, making sixteen watertight compartments in all. The largest compartment was the engine-room, but before this could be penetrated in a collision the heavy sponson or paddle-box would have to be cut through. He was sorry that Mr. Carson had not given more information on the subject of cargo boats. The "Oxton," with four screws, was intended entirely for cargo purposes, being the last cargo boat built for the Mersey and at work. Another boat had since been built for the Wallasey Local Board, from Mr. Alexander Richardson's designs, but it had not been set to work on account of the landing stage at Seacombe not being completed. The Seacombe boat had to comply with the following conditions: to carry a deck load of 100 tons; to load and discharge "end on;" to have rails on deck to receive railway wagons; draught of water not to exceed 5 feet when light; height of deck above water at bow and stern not to exceed 6 feet when light; speed not less than 9 miles an hour. The boat was divided into seven watertight compartments. As to the condition to load "end on," it was somewhat strange that the corporation of Birkenhead did not adopt that principle in the "Oxton," where there were side gangways, as shown in the model, two on each side. No doubt where the "end on" principle could be adopted for goods traffic it was much superior to the side loading, because vehicles could drive straight on to the steamer and straight out again at the other end without having to turn round, which was a difficult operation with a heavy load on a slippery deck. The Seacombe luggage boat was designed to load "end on," to accommodate her to the new stage at Seacombe, which was being built from Mr. Carson's designs. It was formed with a recess at one end. Provision had been made in the Liverpool stage for a similar embayment, but a double one, the stage being of course much larger. Owing to the great velocity of the tide in the Mersey it was impossible for vessels to lie "end on" to the stage at right angles to the river; hence the necessity of an

Mr. Beloe.

Mr. Beloe. embayment deep enough to receive the whole length of the vessel. The embayment on the Liverpool side had never been used, and it was doubtful whether boats would be able to enter it, owing to the strength of the current. The Seacombe stage was left open at one end, and it remained to be seen how it would work. The other requirement, that rails should be laid on the deck, was somewhat peculiar, for although the Seacombe stage was connected with the railway system, the Liverpool stage had no such connection, so that if the wagons were brought across in the Seacombe boat they must stop there. Perhaps in no part of the world had the ferry-boat system been adopted so largely as in the United States, and there the "end on" system of loading had been carried out in every case where it was practicable. In the ferry-boats crossing the Hudson and East River at New York the landing places were provided with rows of piles driven into the river on each side forming a sort of blunt V. The boats were semicircular at each end, and as they entered in between the rows of piles they were guided up to the exact spot required; then platforms were lowered down to them from the shore, and vehicles could readily pass on board. The boats were of somewhat peculiar construction. They were driven exclusively by what was known as the walking beam-engine with a beam overhead, and a single cylinder was employed in most cases. The engine was very narrow, occupying but little space, but owing to the extreme light draught it could not be contained below the deck. There was room on each side of the engines for a row of vehicles; and on the sponsons, which projected like those in the Claughton, there was a narrow cabin built on each side, the passengers entering at one end and going out at the other. The whole boat was roofed over except a small space at each end. The captain steered from a pilot-house erected on the roof near the bow, changing his station to another pilot-house at the other end when proceeding in the opposite direction. No deck hands were employed, the attachments at the shore being made by men at the landing. The gates at the ends of the boats were generally made on the lazy-tongs principle, folding up very easily and occupying but very little space. He wished the Author had said more about the engines employed in working ferry steamers. A peculiarity of American engines was that nearly all were driven by double-beat valves, worked off a cam shaft instead of by the slide-valve used in most English marine engines. He thought that the double-beat valves possessed a great many advantages, especially for steamers that had to be stopped and reversed very quickly. Any one who had seen the men working the large engines of the "Bristol" and "Providence" (two of the largest river steamers in America) would be struck by the ease with which they were handled. There was a single cylinder 110 inches in diameter and with 14 feet length of stroke, and it was easily worked by two men, when going in and out of the harbour. In the hull were the dining-rooms and bars and the boilers; on the main deck were ladies' cabins, offices, and cargo space and engine room; on the upper deck were two main saloons with state rooms all round them, and above that another range of state rooms opening on to a balcony running round the two saloons. Their height out of water was very great, and for a short portion of their journey they were exposed to the roll of the Atlantic. They had always done their work satisfactorily, and without incurring any danger. He was, however, once caught off Sandy Hook in an American river-boat that ventured there, and he was bound to say that her behaviour was the reverse of pleasant, and the passengers were all very glad when they got into smooth water. The boat was going on a pleasure excursion and was caught by the wind broadside on and nearly capsized. Of course it was never intended that the boat should go so far out to sea. He had recently read a description of an enormous ferry-boat just launched at San Francisco, called the "Solano," which had a greater width of beam than any other vessel afloat. Her measurements were as follows:—"Length, 424 feet; height of sides in centre, 18 feet 5 inches; height at ends, 15 feet 10 inches; width over guards, 116 feet. The 'Solano' will have two vertical beam engines of 60 inches diameter and 11 feet stroke, built by Harlan and Hollingsworth, Philadelphia. The wheels are 30 feet in diameter, with buckets having a face of 17 feet. Eight steel boilers, each 28 feet in length, will be provided, and will be made in pairs, with a smoke stack to each pair. Four Pratt trusses give a longitudinal stiffness, and connect the deck and bottom of the boat in true bridge style. She is a double-ender, and has four rudders at each end, worked by a hydraulic steering apparatus operated by an independent steam pump. By this improved method of steering, she can be handled by one man where ordinarily three would be required. The engines work independently, each moving one wheel, which will revolve independently of the other. The boilers are on the deck. Four tracks will be placed upon her decks, which will accommodate forty-eight freight cars or twenty-four passenger coaches. Her slips will be provided with aprons 100 feet in length, which will admit of cars being taken aboard without uncoupling from

Mr. Beloe.

Mr. Beloe. the engine." He ought to state that these details were taken from a San Francisco newspaper, and that he could not be responsible for their accuracy. He wished particularly to draw attention to the use of trusses in most of the American river steamers to strengthen the long shallow hulls. He could not help thinking that in such boats as those on the Clyde and the lower reaches of the Thames, such a method of construction would greatly strengthen the vessels without materially increasing their weight. He was one of those who thought that if the "Princess Alice" had been so strengthened she would not have broken in two as she did when the water found its way into the engine-room. A vessel built as she was, having a depth $\frac{1}{26}$ of her length, was not capable of bearing the weight of water in the central compartment. It was of no use to divide a vessel into compartments, if, when the compartment was penetrated and filled with water, the weight of the water broke the vessel in two. He believed if the trusses to which he referred were generally adopted the vessel would be safe enough to enable her to be beached before sinking, especially in narrow waters like those of the Thames. With regard to the remarks of Mr. Bramwell and others that it was impossible to divide vessels into water-tight compartments without increasing their weight to an enormous extent, he thought that the model exhibited was a complete answer to them, showing that the thing could be done. There was another element of safety in the "Claughton" which the Author had not described—the rubber or fender—running nearly her whole length just above the water line. It was applied to those vessels in consequence of one of them having been nearly sunk on the Mersey, by a barge or flat, which being very low in the water was not stopped by the overhanging sponsons, but went underneath and fractured the vessel's side. The accident created a great scare at the time, and each of the Birkenhead boats was put in dock and fitted with a rubber forthwith. He did not think the experiment of ramming had been tried since the rubber had been put on, but he had no doubt the result was beneficial. The boat—a model of which he had exhibited—was intended for working in the lower reaches of the Mersey down to the mouth of the river, where it would be exposed to much heavier seas than anything the "Claughton" had to encounter. From the distance she had to go, and the speed she had to attain, it would not be advisable to construct her upon the same plan as the "Claughton," with an overhanging deck carried to such an extent, but he believed, for the traffic for which it was intended, the "Claughton" was one of the finest boats in the world. Mr. Beloe.

Mr. J. F. FLANNERY said it was astonishing that the important subject of ferry-boats had not been publicly discussed before. It was fortunate that it had been introduced by one who had had experience for many years as the managing engineer of one of the largest ferry traffics in England, that of the Wallasey ferries. He felt great diffidence in attacking one or two of the Author's suggestions. Starting with the assumption that the up-river Thames traffic was much more dangerous than the below-bridge traffic, Mr. Carson complained of the want of subdivision in the small boats above bridge, and also of their cabin accommodation. Any one who had read the report of the Thames Traffic Committee, or the evidence given before that committee, or any one who had heard the statistics just given by Mr. Ravenhill, could not avoid coming to the conclusion that the danger of collision above London Bridge was almost *nil*, in comparison with the danger below London Bridge. With regard to the suggested improvement in the cabin accommodation, there was at least one objection to it. If the weight of the passengers were raised, would the vessels, with their limited beam—limited as Mr. Bramwell had described—have sufficient stability? On the Mersey, the weather to which the passenger was exposed was sometimes very rough. In the upper reaches of the Thames there was a sort of omnibus traffic: the passengers went on board for a five or ten minutes' transit, and never, unless driven below, left the deck; so that, even in winter, the whole load was upon the deck. If the load were raised, would the boat have sufficient stability? Probably not; but without going into calculations it was difficult to say. Looking at all the circumstances, the boats appeared to have had a just balance preserved in their design, and the result of their working had proved that they were thoroughly adapted to the traffic. With reference to the boats on the Mersey, he might mention that the "Heatherbell" was designed by Mr. Carson ten years ago, and she had been exceedingly successful. It was (as Mr. Thornycroft had pointed out) a little remarkable that she carried so large a proportion of passengers in comparison with her displacement, as contrasted with the "Claughton." She carried nine hundred passengers, with a displacement of 280 tons, so that for each ton of displacement she had 3·21 passengers. The "Claughton" had only 2·53 passengers for each ton of displacement, and the "Lord of the Isles" 3·26. The "Heatherbell," which was considerably longer than the "Claughton"—eight beams instead of five—had performed her Mr. Flannery.

Mr. Flannery. work for ten years at that rate, and her great success showed very strongly the authority with which the Author was able to speak. With regard to the question of the absolute safety of river steamers with a horizontal deck—the power of withstanding almost any collision—it would be remembered that the "City of London" not long ago had a violent collision with a German ship. He had had the opportunity of surveying that vessel closely, and the damage done to the bow of the colliding vessel, by reason of the horizontal deck of the "City of London," was something that could hardly be believed without being seen, especially when taken in comparison with the small amount of damage done to the iron deck of the "City of London." Bearing that in mind, he did not consider that it would be possible to construct ships that would be absolutely safe; but vessels would be made having much greater safety than they now possessed. It had been said that it was no use to have an immense number of water-tight subdivisions unless they were properly disposed. If, for instance, a vessel were put out of trim, so that the water could get down the hatchway, no subdivision could be of any avail. A vessel should be properly designed with regard to trim, and also with regard to longitudinal strength. The London Steamboat Co. were, not long ago, overwhelmed with proposals and designs for absolutely safe vessels; he believed something had been evolved which might come very close to absolute safety. At any rate, he was sure the Thames would hold its own against any other rivers with regard to passenger steamers. He had no doubt that the London Steamboat Company, under its present energetic management, would, in a short time, produce vessels well worthy of discussion at some future meeting of the Institution.

Mr. Donaldson. Mr. JOHN DONALDSON said he was of opinion that half a loaf was better than no bread, and he agreed with Mr. Flannery that if absolute immunity from danger could not be secured, an attempt ought to be made as far as possible in that direction. He thought that the problem of securing immunity from danger in cases of collision admitted of three general solutions. The first, and by far the best, was undoubtedly to avoid collision; but as that was a matter which interested captains and those concerned in navigation more than constructors, he did not propose to say much about it. The second consisted in arranging the materials of the structure so that the work of the collision might be taken up in destroying that which would not be essential to the safety of the vessel. Placing a sponson round the vessel, as proposed by the Author, was an example of that kind, and in river vessels which could carry a large amount of material in that way in proportion to their tonnage Mr. Donaldson. he thought it would answer, but not in the case of large steamers. But if the vessel to be struck could not be armed, something might be done by disarming the striking vessel. Some time ago at Portsmouth he witnessed a collision between a collier brig and H.M. steamer "Sprightly." The "Sprightly" was lying at anchor; the brig was drifting up the harbour broadside on, impelled by the wind and tide, at a speed of 3 or 4 knots per hour. On touching, the bulwark of the brig was carried away, and the bow of the "Sprightly" rose up over the angle formed by the deck of the brig, and her side, until the whole work of the collision was taken up, when she slid gently down again, and the brig was hauled out. That was all that happened; but had the "Sprightly" been fitted with a vertical stem, the brig would have been sunk. In this case the work was taken up in destroying the bulwark of the brig and in raising the forward end of the "Sprightly." He remembered another collision which took place in the Red Sea. The old P. and O. steamer "Valetta," then in the Egyptian service, was going down the Sea with troops for one of the seaports, and came into collision with another vessel, which struck her on the fore starboard sponson. She was cut down to within a foot of the water's edge; but so little was she hurt in any vital portion that she steamed back to Suez, was put into dock, and repaired, without any loss of life occurring. Here the work in the collision was taken up in destroying the sponsons, the deck, and part of the side of the "Valetta," and in destroying the bow of the colliding vessel. Another case had recently occurred, and was reported in the "Times." The "Herreschoff," torpedo boat, was out on a trial run with one of the second-class boats built by his firm. After the trial run, by some misapprehension, the boat was run into the steam-tug "Manly." She penetrated the "Manly's" side, and as she had an overhung bow, the penetration occurred above the waterline, and no great harm was done. He thought if merchant vessels were built with overhung bows, as in the case of the "Sprightly" (which was the fashion some years ago) a great deal of life and property might be saved. Unfortunately, he was unable to give an exact estimate of the value of the immunity from danger which might be expected from overhung bows. He had applied to the Board of Trade for permission to examine the wreck registers to see if he could ascertain the amount of life and property lost in collision through vessels with straight stems, as compared with those with overhung stems; but as the surveyors had not been instructed to report upon that matter, there were

Mr. Donaldson. no data upon which to form an opinion. He then wrote to the Board asking them to instruct their surveyors to send the required information in future reports. The reply was to the effect that the Board did not think it necessary to obtain statistics for the purpose of substantiating a fact which they believed to be generally admitted, agreed with him as to the value of overhung bows in cases of collision, and that therefore there was no necessity for obtaining the information sought. He wrote again, thanking the Board for the expression of their opinion, but pointing out that what he wanted was data for forming an estimate as to how much overhung bows reduced loss in cases of collision as compared with vertical bows. The reply, however, was still more unsatisfactory—the Board did not think they could justify on grounds of public utility the expense which would be incurred in the collection and publication of statistics of the nature specified. The third general solution consisted in constructing the hull of the vessel in such a way that, should she be damaged in a vital part, either the whole hull or the parts of the hull into which she might be divided would still float, and he thought that was best carried out, as in the case of the vessels in the Royal Navy, by a cellular construction; but from what he had heard as to the paying properties of river steamers, he was afraid that that could not be carried out. Something, however, might be done by way of compromise. The torpedo boats built by his firm were divided into six watertight compartments by five bulkheads, and between those were placed half bulkheads, rising from the keel to 6 or 8 inches above the level of the water, so that in the event of the hull being penetrated, and the water rising between any two of those half bulkheads, it might be possible for a man to go in and plug the hole up, and clear out the water by means of the pumps in the engine-room. Something of that kind might perhaps be adopted in the case of river steamers. It would be awkward, and would interfere with the comfort of the passengers below, no doubt, but he did not think there was much comfort at present in the cabin of a Thames river steamer. The difficulty of getting backwards and forwards might be overcome by having steps rising over those bulkheads, or by having a gangway along the centre with steps leading down to the floor, so as to reach the seats on the sides. Of course something in the way of a skylight would have to be constructed overhead. Possibly some of these suggestions might receive consideration in the construction of future steamers, but he thought decidedly that the idea of having overhung bows upon all merchant steamers was a good one:—All the naval men to whom he had spoken considered that it was, and he hoped shipowners and shipbuilders would agree with them, and that the idea might be adopted. Mr. Donaldson.

Mr. H. Hayter wished to draw attention to a model of a light-draught iron steamer, of the most recent type, in use on the rivers of Eastern Bengal. As consulting engineers to the Eastern Bengal Railway Company, his firm had recently been called upon to order two steamers for the river navigation in connection with that railway, and he now exhibited a model and drawings of those steamers, and a photograph of the engines. Not being themselves experts in marine engineering, they had solicited the aid of Mr. Josiah McGregor, M. Inst. C.E., who held the important post of chief marine engineer to the Government of Bengal, and who had designed the steamers in question. They would, it was expected, attain a speed of 12 miles an hour, and were designed to carry goods as well as passengers. The length over all was 156 feet 6 inches; length between perpendiculars, 151 feet; breadth moulded, 22 feet; depth moulded, or from the underside of the floors to the underside of the deck amidships, 7 feet 10 inches; tonnage, builders' old measurement, 367 tons; draught, about 3 feet 6 inches. The engines were compound paddle engines on the diagonal principle; diameter of the high-pressure cylinder, 26½ inches; of the low-pressure cylinder, 46 inches; length of stroke, 3 feet. The steam was supplied to the smaller cylinder at a pressure of 80 lbs. His object was simply to draw attention to steamers of the most recent type introduced on the navigations of Eastern Bengal, embracing the rivers, Brahmapootra, the Ganges, and their extensive navigable tributaries—constituting one of the largest systems of inland navigation in the world, extending over hundreds if not thousands of miles. The steamers were now let under contract to Messrs. Hawks, Crawshay and Company, of Gateshead, at the cost of £5,100 each, delivered in London. This price excluded most of the woodwork, which would be supplied in India. Mr. Hayter.

Mr. J. N. Shoolbred desired to make some remarks in connection with the ferry traffic on the River Mersey, apart from the consideration of the form and construction of the steamers, and which referred more to the locality itself. It was stated in the Paper, that the circumstances of the Mersey traffic differed much from that on the Thames and on the Clyde, and that, while on the latter two rivers it was essentially up and down, and for considerable distances, on the first-named it was "cross traffic, and for short distances." On the Mersey it was concentrated at a single point on the Lancashire shore, whence the ferry-tracks diverged in a Mr. Shoolbred.

Mr. Shoolbred. fan-shape. The Woodside ferry, carrying nearly eleven million passengers per annum, passed almost directly across the stream; the remainder inclined diagonally to it at different angles according to the length of their passage. The main up and down navigation of the river was therefore nearly at right angles to the ferry traffic. In addition, vessels, accompanied by their tugs, were constantly veering round either to enter or to leave the docks, on one or other side of the river. Then again, besides these sources of danger which were in motion, vessels were frequently at anchor in mid-channel, as the holding-ground was good in the neighbourhood of the great landing-stage. The area within which these impediments to navigation mainly existed was not more than 1 mile square. The dangers within this comparatively small space should, therefore, be diminished as much as possible, as the ferry service, particularly the most crowded one, the Woodside, had to be continued through the greater part of the night. The Author of the Paper had drawn attention to precautions which might be, and also which were, taken in the construction of the ferry-boats, and in their regulation and guidance; but there was one means as regarded the locality which would still further reduce the dangers. That was the illumination of the entire area at night by the electric light. Experiments for military purposes in France, at Chatham, and recently at Fort Monckton, had shown that it was possible to illuminate, by means of parabolic reflectors, a large breadth of surface horizontally. A series of such stations on both banks of the Mersey, and placed at a sufficient elevation to keep the direct beams of the electric lights out of the observer's line of sight, especially near the shore, would readily effect the object of illuminating the entire area. The band of light from each shore being fully able, on ordinary nights, to reach at least half across the river; while lights of lesser intensity might be used to illuminate the landing-stages. Indeed the entire Mersey, in its course from the Rock lighthouse to the Dingle Point, might be thus made clear; and on the shore the several landing-stages, the entrances to the different docks and points of approach, might each have special and minor illuminations. No signal electric lights should in this crowded locality, in Mr. Shoolbred's opinion, be placed on the ferry-boats or other vessels; as this would rather tend to increase the confusion, owing to the difficulty of judging the distance of these bright lights in motion. This remark must not, however, be taken as prejudging the case of the use of the electric light at sea for the mast-head and for the side-lights of vessels. There the conditions were widely different, and must be considered by themselves. The objections now raised as to "too brilliant a light," and as to "intensity of surrounding darkness," &c., would probably disappear with time as the eye of the mariner got more accustomed to it. Proper precaution should also be taken to prevent bright lights of this kind being mistaken for those from lighthouses. This might easily be done, by causing each of the latter class of lights to have some distinguishing feature; according to the method being gradually introduced by the Trinity House, or according to that suggested by Sir William Thomson. Another objection which had been raised to the electric light was its not piercing a fog, and its so-called deficiency in this respect in comparison with other lights. Not many months ago Professor Tyndall, in the discussion on Mr. Douglass's Paper, "On Lighthouse Illumination by the Electric Light,"[1] had shown that the penetrating qualities of the electric light were proportionately quite as great, if not more so, as those of any other light; and he had referred to the labours of Professor Draper to confirm his view. The proportion of nights, even on the Mersey, when fogs prevailed, was, however, so small that they need not be considered in dealing with the question. Some experiments were carried out a few months ago by the British Electric Light Company near the great landing-stage to show the projecting power of the electric light on to the River Mersey; and Mr. Lyster, M. Inst. C.E., the engineer of the Mersey Docks and Harbour Board, contemplated, it was understood, lighting some of the dock entrances with electric light. But it was a general illumination of the entire river, as suggested in the previous remarks, which was needed. An illumination of this kind was equally applicable to all narrow and crowded waterways; such as the Thames, where it would be desirable for some distance both above and below London bridge. Mr. Shoolbred.

Mr. J. Fernie said there was a capital service of omnibus steamers upon the Seine; they plied between the fortifications, thus going right through the centre of Paris. There were fourteen stations, and the distance traversed was about 7 miles. The steamers were between forty and fifty in number, and they were built with raised cabins at each end, and there were only a few steps to descend to get into the cabins. By means of the break thus formed by the cabin's deck, passengers were sheltered very much from the bleak winds. The boats were exceedingly comfortable, pleasant, and clean; they were propelled by screws, and had upright high-pressure cylindrical boilers. The captain Mr. Fernie.

[1] *Vide* Minutes of Proceedings Inst. C.E., vol. lviii., p. 158.

Mr. Fernie. steered and communicated with the man at the engine by an india-rubber tube, so that he had full command of the vessel. The boats carried from one hundred to one hundred and fifty passengers. The great object seemed to be to make the boats ply as continuously as possible, and they ran in the summer every few minutes. The great defect in the Thames boats was that they were too large—nearly as large again as the Paris boats. Paris was splendidly supplied with omnibuses, yet the comfort and convenience and a pleasant sail on the river attracted a vast number of passengers. The navigation of the river was rather difficult. Near the centre of the town the river was encumbered with floating laundries, baths, and obstructions of various kinds; the river itself was narrow; some of the bridges were old, and had wide buttresses, so that when two steamers met there was often very little margin. The river was also rather swift, and altogether he considered that the navigation was more difficult than that of the Thames above bridge. The Thames was wide, the arches of the bridges were also wide, and the captain could see a long way before him; whereas on some parts of the Seine it was impossible to see for any great distance. Judging by the comparison of a paddle-wheel ocean steamer and a screw steamer, he imagined that the Paris boats worked at a third of the cost of the Thames boats. The crew of the Paris boats consisted only of a captain, an engineer, a ticket man, and a boy. Reference had been made to the competition of the omnibuses in London interfering with the river traffic; but in Paris the omnibus competition was still greater, for the omnibus system there was one of the best in the world. Instead of starting from a public-house, and stopping at public-houses, the omnibuses took their departure from great central points, stopping at comfortable offices where the passengers could take tickets for the next omnibus, and sit down while they were waiting. It was melancholy to see in London this public-house system adopted wherever people were likely to stay a few minutes; and he was ashamed, as an Englishman, to hear it stated that the boats could not be supported without the introduction of a bar. The uniform fare charged on these boats for all distances used to be $1\frac{1}{2}d.$, now $1d.$; a similar distance by omnibus or tram would cost $4\frac{1}{2}d.$ to $6d.$ The boats were well filled. Ladies and gentlemen, summer and winter, were found on the decks and in the cabins, and the boats managed to pay without a bar. The finest river steamers in Europe were those upon the Rhine—he referred, especially, to those above bridge. The highest compliment which the Germans could pay them was to call them

American steamers. They were not, however, made in America, nor on the Clyde, but on the Thames, and they did great credit to the Thames shipbuilders. Perhaps they did not come up to the American steamers in their great variety of comfort and convenience; but for ordinary day passenger-steamers, they were all that could be desired. He did not agree with the doctrine that had been propounded, that although life was very valuable, it was possible to buy it at too dear a cost—that doctrine he considered was a very dangerous one to advance in the Institution of Civil Engineers, and while it was wrong in principle, it was also untrue in practice. It was said twenty-five years ago that the safest place for a man to be in was a railway train, and yet, since that time, there had been many inventions and improvements for the saving of life; steel tires fastened on and made part of the wheel, the lock system in regard to points and crossings, the block system, and the like. Similar improvements had been made in the construction of steamboats. He had recently visited the "Orient," and had been delighted with the wonderful applications of science exhibited in her construction. The only thing that seemed to him to have made no progress was the penny steamer on the Thames. Even the system of communication, which had been described as so perfect, was as far behind the age as the steamer itself. With regard to the American steamboats, the reason why they had naturally adopted the "end on" principle was that they had such facilities in consequence of the tides rising so little. While there was a tide of 32 feet in the Mersey, in New York the rise and fall was only some 6 or 7 feet; so that there was none of that great pressure from the current of the tide, turning the steamer away from the pier to which she was moored. He had, in 1876, travelled in a steamer similar to that which had been described as now being made at San Francisco, but not so large. He had come from Boston to Harlem river, New York, by a train which was there run on to a huge ferry-boat; the train had six Pullman cars, three of which were put on one line of rails and three on another, in ten or fifteen minutes. As soon as the cars were fixed the announcement was made that dinner was ready, and the passengers dined in a large sumptuous dining-room carried over the tops of the carriages. As they sailed along they had a fine view of the city of New York; down the North River and across the Hudson to Jersey city, where the cars were put on the line for Philadelphia. He did not attach much value to the arguments on the ground of expense. It was true that the "Grösser Kurfürst" and other great iron-clads had gone down when they had Mr. Fernie.

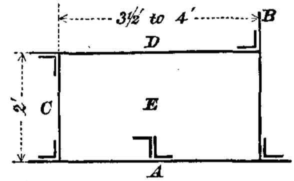
Mr. Fernie.

touched one another; but they were made for the very purpose of striking and sinking one another. No one would think of making penny steamers with prows to enable them to run one another down. Within the last few weeks an instance had occurred of a ship dashing at full speed into an iceberg, and then striking it a second time; yet the vessel did not sink, and the passengers were safely landed at Halifax. Those who had crossed the Atlantic and remembered the intense fogs that sometimes lasted for two or three days and nights, so that it was impossible to see the length of the ship ahead, and remembered the immense advance that had been made in marine engineering, could not but look forward to the time when the Thames steamers would be made so strong and safe that they might run against Blackfriars bridge without going down.

Mr. De Rusett.

Mr. E. W. De Rusett was glad that the discussion had turned upon the question of safety. The Author had begun with bulkheads, gone on with sponsons, and finished with handiness; but he thought it would have been better if he had begun with handiness in order to avoid collision. In the different drawings exhibited he did not see any special provision made for handiness. With this object he would direct special attention to the remarkable boats turned out by Messrs. Thornycroft, in which the keel rose at each end. In the case of a vessel 395 feet long, which had been lengthened 80 feet under his superintendence, he had raised the keel at the ends only $16\frac{1}{2}$ inches, and she steered equally well with her old rudder, notwithstanding her additional length. What was chiefly wanted was an easy steering craft. Mention had been made of hydraulic steering-gear; but he hoped it would not be used on the Thames without some thought, because he had recently heard of such gear getting frozen and the pipes bursting. With regard to sponsons as a means of safety, he thought if they were put on at all they should not form part of the vessel's hull, because then they might be knocked away without injuring the main structure. The Americans were in the habit of projecting the deck far over the side, with struts underneath for support where it overlapped. In reference to safety by watertight bulkheads, the centre line longitudinal bulkhead system would require a vessel to be divided into very small parts, otherwise she would get seriously out of trim if the water found its way into her. This difficulty might be overcome by the two fore and aft bulkheads advocated by Mr. Mackie. The decks would be well supported, a clear space left without pillars in the middle of the ship for cargo, and the wings would be available for coals, stores, &c. With athwart-ship bulkheads alone it was easy to arrange a steamer so that if one compartment was stove in she would not sink; but it was well so to arrange matters that if the vessel were struck on a bulkhead two spaces might not be knocked into one, and probably cause the loss of the vessel. He exhibited a diagram (Fig. 4), in which the line A represented the ship's side, B the ordinary transverse bulkhead, and C a bracket frame, say 2 feet deep. The plate D was to be riveted to the ship's side at about the floor heads, to the bulkhead B and bracket frame C, so as to make an internal and separate watertight space, E. A somewhat similar design was made in 1860, for a different purpose, by Mr. J. Carr. Mr. De Rusett suggested that form, so that if a vessel was struck, either in the forward or the after part of a bulkhead so constructed, the water would either get into the intermediate space E, or to the after or forward compartment, and hence it would be difficult to ram the two compartments into one. This addition would also add to the strength of the vessel and bulkhead without displacing much cargo. Mr. De Rusett.

Fig. 4.



Mr. J. B. Redman said, the Gravesend steamboat traffic of past years was a remarkable example of the diversion of river traffic by the railway. Going back to 1821, twenty-seven thousand persons were landed at Gravesend in the course of that year. In 1845 the number had increased to one million and three quarters. The town itself was duplicated, also the steamboat companies and the piers. A score of large steamers were employed in the traffic, but when the railways were completed, the companies, after contending for some time against them, were dissolved, and the boats sold. The two piers went into Chancery, and the Town pier was now a ferry pier, the Terrace pier affording a look-out house for pilots, and it was occasionally used by royal and other distinguished persons for landing and embarking; but even that was now circumscribed by the opening of a new route by Queenborough. Mr. Ravenhill had spoken in no exaggerated terms of the merits of the Gravesend steamers, of which eight or nine belonged to each of the two companies, and two to the railway company. They were unequalled in point of speed, beauty of form, and deck and saloon accommodation, but they were the antitypes of the "Princess Alice" class of steamer. The saloon accommodation was all below water. They were not only good river boats, but were also good sea boats, as their ultimate fate would show. He had taken the Mr. Redman.

Mr. Redman. trouble to inquire into that subject, and one of the builders, Mr. Sidney Young, had written to him: "Our old firm only built one of the Star line, the 'Mercury,' and she was launched nearly forty-six years ago." Mr. Young further stated that he did not know what had become of her. Messrs. Arnold and Co., solicitors, of Gravesend and Lincoln's Inn Fields (Mr. Arnold being son of the manager of the Star Company), stated: "We sold one or two of the Star boats to Mr. Churchward, for light mail service over the Channel; the others went to Scotland, to the Clyde, and elsewhere." Mr. Hilder, solicitor, of Gravesend, who was in partnership with the clerk of the Star Company, stated that no one knew what had become of the boats. Mr. Quaife, manager of the Town pier, under the Court of Chancery, had sent the best account of the fate of the old steamboats. From this it appeared, of the Diamond Company, engined by Seward and Co. and the Penns, and of the Star Company, mainly engined by Miller, Ravenhill, and Co., that the following was their ultimate fate, viz.:—

DIAMOND COMPANY.

Diamond.—Sold. Broken up.
Ruby, Sapphire.—Sold to General Steam Navigation Company.
Emerald (new).—Sold. Converted to a schooner.
Ditto (old).—Sold to Licensed Victuallers' Company, and ran to Boulogne.

STAR COMPANY.

Medway.—Broken up.
Comet.—Sold. Ran from Hartlepool to Sunderland.
Mercury, Star.—Sold to General Steam Navigation Company.
Jupiter.—Sold. Ran from Dover to Calais.
Venus.—Sold. Ran to Guernsey and Jersey.
Satellite.—Sold. Went to Liverpool.

Having an intimate knowledge of the traffic on the Thames, he was prepared to endorse all that had fallen from various speakers as to the admirable manner in which the above-bridge boats were navigated. The style in which the boats were brought alongside the piers was unequalled; but in all other respects the service had deteriorated. With all its drawbacks it was a popular mode of transit with the masses, but (now that it had fallen into the hands of a very few persons) from the utter absence of discipline and cleanliness it was tabooed to a large class of the community, although it might be made as popular to them as the masses. It had been urged that large saloon steamers were not adapted to the above-bridge traffic, and there was some reason in the objection, as might be seen from the difficulty experienced in bringing up one of the larger boats plying to Greenwich and Woolwich alongside a pier in a heavy gale of wind and in certain states of the tide; but

Mr. Redman.

when it was considered that the boats themselves had been nearly stationary, and that the river above bridge during the last forty years had been developed 30 per cent. in regard to total carrying capacity, the objection did not appear to be tenable. Of that statement there was a standing, or rather a floating proof, in the existence of a new fleet of steamers that made the entire voyage from the Tyne to the head of the metropolitan river-traffic above Vauxhall bridge, discharging their coals there to save lighterage. Those steamers were 1,000 tons burthen, and drew 8 feet of water; they were flat-bottomed, and the spars and funnels folded down upon the deck. That was a sufficient proof that large steamers might, if required, be introduced into the upper reaches of the Thames. It had been urged by those interested in the above-bridge steamboat companies, that screw steamers were not adapted to navigate the upper parts of the river, on account of the difficulty of bringing them alongside the piers as compared with paddle steamers. The model described by Mr. Taylor with four screws appeared, to a certain extent, to remove that objection. One of the most serious drawbacks to the navigation in the upper river was that no improvement had been made in the mode of embarking and landing, which was the same as it was thirty or forty years ago. If paddle-boxes were done away with there would be many opportunities of improving the mode of landing. At present, the sponsons of the river boats were so small, and at so acute an angle, that it was often difficult in a gale of wind, or with the tide in a certain direction, to get the rolling stage on to the sponson. The rolling stages themselves were the same primitive things that they were forty years ago, running upon wheels something like the end of a cotton-reel; and an enormous amount of time was wasted in getting people on board. At Gravesend he had had some stages constructed of light wrought iron, with open battens, and mounted with large wheels; they were of very great assistance, being more easily moved and affording a wider gangway. Stages of that kind might be introduced for the upper river, which would allow persons to pass two abreast. With screw steamers it would be possible to have, now that the landing dummies were all of one regular height, bulwarks which would drop in sectional lengths (the deck of the vessel being always kept above the dummy), so that people might pass over in a mass instead of being throttled through the narrow gangways. He thought every one would admit that the community at large was much indebted to the Author for having in his interesting Paper ventilated a very important subject.

Admiral Selwyn.

Admiral SELWYN said that as an old seaman he had paid attention to the changes which were gradually taking place in the form of river steamers. He had for years believed that no speed could be got out of a vessel that did not resemble a plank set on edge, and that the more nearly she resembled a plank set on edge the faster she would be. That was not doubted for a moment by those who studied Beaufoy's experiments; but Beaufoy never recommended that a deck cargo should be put upon such a plank. If it was desired to construct a vessel, which should offer as little resistance as possible in its motion through the water, and should yet be capable of carrying in safety on deck a large number of passengers without any of the accidents that constantly occur from the heeling over of a narrow vessel due to the rush of passengers to one side, those difficulties would be obviated by cutting away the fore-foot, cutting away the heel, and widening the beam. That led to the question of the proper shape to be adopted. Looking at the bottoms of some of the newest vessels, it would be found that they were of the spoon shape,—the shape which the Americans had long since adopted, having necessarily to carry a heavy deck cargo with saloons and passengers. That it added to those conveniences the power of turning, which was essential to rapid manœuvring, was only an additional proof of the fitness of the structure for the purposes for which it was designed. Was there any good reason, in regard to the expenditure of fuel or in any other way, for believing that those vessels would be more expensive to run? because the whole question was how to pay dividends, how to run the greatest number of passengers at the smallest expense and with the greatest safety. Those objects were to be obtained above bridge as well as below bridge, mainly, by first attending to the form of the structure. In the form of a sphere elongated into the shape of a spoon would be found the greatest safety, the greatest carrying power, and the greatest power of division into compartments without injuring the general qualities of the ship. Great speed could be attained, and the athwart-ship compartments, under those conditions, would give large spaces between them. It was very easy to expose the fallacy of the longitudinal bulkhead, because the instant the water got into one side of a ship longitudinally divided she lost her trim, and as soon as the trim was lost sufficiently, the hatchways, which opened into both sides, secured her sinking. In the case of one compartment in one of the modern long ships being filled, particularly if it were the centre compartment containing the engines, one speaker had stated that it was a question of the weight of the water

Admiral Selwyn.

that got in; but he had forgotten that it was the unsupported weight of the engines and everything else inside. The flotative power of the two ends then only contributed to break up the structure. That was the true way of looking at the subject. Having a good form and dividing it judiciously, the next question was how thin ship-builders might, with perfect safety, make the skin. Sailors would rather have two skins of $\frac{1}{8}$ inch, divided by 6 inches space (if it were necessary to divide them only by 6 inches), than one skin of $\frac{1}{4}$ inch. A little accident might occur to break through the outer skin, but it was generally certain that the inner skin would not be broken through. He did not know a more magnificent instance of the added security of large ocean steamers by a double skin than that which occurred on one of the voyages of the Great Eastern, when she was struck by an ice-floe for 160 feet of her length, and when, owing to her cellular construction and her skin of 18 inches, she was saved, and continued her voyage. Of course a space of 18 inches for river boats was not always wanted, nor was it always requisite to be able to get inside, but sufficient facilities were desirable for separating the outside from the inside skin of the ship. Under certain conditions, Prof. Barff had taught all who chose to learn how entirely iron or steel could be prevented from decay from salt water. It had been said that such things had been tried and failed. How tried, and by whom? Who had made that which Prof. Barff only professed to make after long experience, and how had it been tried? There was no conclusive evidence whatever on the subject. All that was known was that whenever perfect peroxidation of iron or steel had been obtained, no inferior oxidation could take place. Some would ask how the rivets could be dealt with? There were plenty of protective fluids which would entirely meet the question of riveting; but it was not generally at the rivets that the great danger was encountered. There was ordinarily a double thickness there, and it was not there that damage was apprehended. Violence might sometimes tear through the rivets; but the great evil to be feared in steamers built of metal was the sudden attacking of one or two plates between wind and water, generally by galvanic action. He presumed that the Institution of Civil Engineers was devoted to progress and improvement; but many of the speakers had virtually said, "So long as somebody else improves, and I am at liberty to take his improvements, well and good; but if you ask me to improve, all I can say is that I have done the best I can for myself, and nobody can do anything so well." That was not the

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spirit in which great institutions—lying under the shade of Westminster Abbey—should look upon the subject. The nation would continue to commit great sums to the charge of those Institutions so long only as it was satisfied that reasonable progress was being made. Engineers ought to be the last to say that there was any finality whatever. They had provided (and he had contributed to some of them) great improvements in economising fuel, in the use of steam power and in other ways, so that they were enabled to conduct traffic at the required speed; and he believed that all the luxurious requirements of the day could be given at a low price, if only progress were allowed to have its legitimate development. But so long as for any reason those things, instead of being inquired into closely, were kept in the background and looked upon as inimical, further progress would not be made. Improvements were going forward rapidly in America, and Englishmen would be beaten if they did not also go ahead. Reference had been made to a steamer built at San Francisco, 400 feet in length and nearly 200 feet in width, and he wished to draw attention to the enormous carrying power obtained by the spherical shape carried out on those dimensions. He had himself devised a man-of-war, 400 feet long, 200 feet wide, and 18 feet draught, with a capacity of 16,000 tons under water, so that she could carry twenty 80-ton guns comfortably with all their stores and have another capacity of 16,000 tons above, although she was only 8 feet out of water. In those forms lay the power which was sought. The gain might not be so remarkable where the dimensions were cut down to those possible on a river; yet they might afford a measure of the advantages. The engine power of the American steamers was about 8 indicated HP. per square foot of mid-section for a speed of 20 miles per hour on a draught of 6 feet. They might appear to be very poor models above water, overburdened with cabins and with everything that would make a wind resistance; but they attained a very great speed per indicated HP. employed, which, after all, was the true test. In spherical-shaped ships it would be well to remember, as had been pointed out, that one should not expect with a certain frictional surface to get a much better effect (although there were beautiful under-water lines) than was due to the same number of square feet of frictional surface in any other shaped ship; but there would be the advantage of the tonnage. About 0·308 HP. per square foot of frictional surface sufficed to drive a well-shaped ship at 16 knots per hour. Mr. John Elder, who had tried the experiment, found that there was no difference between the resistance to progress of a fine-lined, deep-keeled, narrow model, and that of a spherical model of equal tonnage. He desired to draw attention to experiments[1] that had been recently tried by Mr. Gwynne showing that the hydraulic propeller gave 2 tons of push for every 100 indicated HP. That was exactly the same as with the paddle and the screw; but the hydraulic propeller enabled one to deal with river-boats in a way that was impossible with either paddle or screw; it did away with all idea of sponsons or anything of the kind; it facilitated the approach to piers and the passage on board the ship; it enabled the vessel if grounded in shoal water to clear away the shoal and get off in a few minutes; and it had the additional advantage in case of serious damage, such as would compel instant beaching in any other case, of enabling the water to be pumped out. He strongly pleaded for the further consideration by the Institution of the problem involved in propulsion by reaction. Another experiment on the reactive force of a jet was made by Mr. Thornycroft, and he was partially the means of getting it tried. Sir Isaac Newton was the first to state that the reactive effect of any jet issuing from the bottom of a column of pressure was double that due to the column of pressure. The late Mr. Gravatt, M. Inst. C.E., had devoted considerable time to proving the same thing by figures; but the idea was discredited, and it was looked upon as utterly impossible. Within the last few months the matter had been considered by the Admiralty, and Mr. Thornycroft, when he heard the objection, said, with his usual practical common sense, "What is easier than to try?" He had accordingly rigged up a copper tube in his yard, and weighed the reactive effect against a set of weights in a scale; and he found that the statement was absolutely true that the reactive effect was double that due to the column of pressure. This was a motive power which would act at all times, not subject as with the paddle to rolling one wheel out of the water while the other was deeply immersed in it, and not subject to be pitched out of the water like a screw—a power which would take the above-bridge steam- Admiral Selwyn.

[1] At Ferrara, Italy, each of eight centrifugal pumps, by Messrs. J. and H. Gwynne, discharges 57,000 gallons per minute, total 456,000 gallons, 7 feet 3 inches high, or 656,640,000 gallons per day. The river Thames discharges 362,000,000 gallons per day. The best information on the hydraulic propeller will be found in various Papers in the Journals of the Institution of Naval Architects, and the United Service Institution, the last Paper being one on the most powerful ironclad, in the discussion on which Admiral Sir George Elliot gives the results of the last trials of the "Waterwitch."—J. H. S.

Admiral Selwyn. boats into the open ocean without feeling the motion and preventing the effect of the engines being the same as before. He thought that the subject was deserving the closest attention of the Institution.

Mr. Hollingum. Mr. GEORGE HOLLINGUM was pleased at the turn the discussion had taken in regard to the longitudinal system of bulkhead. He agreed with Admiral Selwyn that double skins presented great advantages. He believed that if the "Princess Alice" had been constructed as Mr. Mackie had proposed she would not have gone down, because there would not only have been the second skin in tension on the side struck, but two skins on the opposite side in compression assisting, thus affording time for putting the vessel ashore.

Mr. John. Mr. WILLIAM JOHN thought one point had not been made sufficiently clear in the discussion with reference to the division of light-draught steamers into watertight compartments. It had been said that it was very difficult to divide them because it was required to save weight; but, as a matter of fact, some of the very best divided and safest vessels afloat were vessels of very light draught; indeed, he would go so far as to say that the lighter the draught the easier it was to divide a vessel into watertight compartments, and to make her safe against sinking by the bilging of one compartment. In the case of a vessel of 2-feet draught divided into eight compartments by transverse bulkheads, if one of the compartments were bilged, practically the vessel would be sunk only one-eighth of her draught, or 3 inches; so that if there were a bulkhead or a partial bulkhead coming up a foot or so above the water, the vessel would be absolutely safe against being sunk by that compartment being bilged. Of course, getting nearer the ends of a vessel the trim would be altered by a compartment being filled, and it would be necessary to carry the bulkheads, or partial bulkheads, higher up, or to divide the vessel into shorter compartments; but it was easy to prevent a very light-draught vessel sinking by either one or two compartments being bilged. Mr. Donaldson had pointed out that it was not necessary, in order to render the vessel safe, to carry up the bulkheads to the deck and absolutely shut off the compartments one from the other, but that by deep floors or partial bulkheads all the required safety could be obtained; he also pointed out the difficulty created by taking the bulkheads through passenger cabins. Mr. John ventured to say that passenger cabins of vessels intended for still-water traffic should be entirely above water, and might be there without the slightest difficulty. One objection raised to this was the want of stability; but in a vessel intended for smooth water a greater beam could be given, and indeed plenty of stability could be obtained from a comparatively small increase of beam without any material increase to the resistance of the vessel. Another objection mentioned by Mr. Bramwell was that with an increased beam it would be more difficult to go through the arches of bridges; but if paddle-wheels were done away with it would be possible to have considerably more beam and greater stability, and yet to go with more ease through the arches of bridges than the present boats could do. As a naval architect, he thought that the Clyde boats stood far higher in point of constructive skill, and as illustrating successful naval architecture, than either the Thames or the Liverpool boats. The Liverpool boats displayed considerable skill and (unlike the Thames boats) a common-sense adaptation to the work to be performed, which was chiefly ferry work. He could not help thinking that the original designer of the Thames penny boat must have had in his mind the model of a large ocean-going yacht, and simply adopted it on a reduced scale. If it were required to produce a vessel that had a minimum of deck room, of cabin accommodation and comfort for passengers, and the maximum difficulty of going through the contracted arches of bridges, no better example could be found than the Thames river boat. Mr. John.

Mr. W. H. Cutler remarked that he had had considerable experience, principally as a passenger, of steamers on the Elbe, the Meuse, the Rhine, the Moselle, the Thames, the Seine, the Tyne, and the Mersey, and he should also mention some beautiful little passenger steamers on the Alster basin at Hamburg, from which he imagined the passenger steamers now plying on the Seine at Paris must have been copied. The Citizen and Woolwich boats on the Thames were the most uncomfortable and dirtiest passenger steamers he had found anywhere, except, perhaps, the steamers which crossed the mouth of the Seine from Havre, and ran up the River Orne to Caen. The London boats had only two good points about them—one, that they were splendidly handled, and the other that they afforded every possible facility for jumping overboard if anything went wrong. They were not fast, and they hardly afforded any protection from the weather unless the passenger chose to be stifled in a miserable cabin. They were wasteful in fuel, and no improvement seemed to have taken place in their machinery during the last thirty years. As long as eighteen years ago he remembered some twin passenger boats, the "Unions," on the Seine at Rouen, similar in construction to the "Castalia." Mr. Cutler.

Mr. Cutler. Sixteen years ago a small steamer called the "Fury" ran between Rouen and Havre having the same kind of engines, and evidently made from the same patterns as the engines on board the Citizen boats on the Thames, but the engines had been modified, and a boiler suitable for a working pressure of 120 lbs. on the square inch had been substituted for the original low-pressure boiler. One of the cylinders of the engines had been converted into a steam-jacket for a high-pressure cylinder, which had been placed inside it, and which it therefore enveloped. The steam from the high-pressure boiler was conducted to the high-pressure cylinder, and when it had done its work there, it escaped into an exhaust-pipe, which was passed through the steam dome of the boiler for the purpose of superheating, and then was conducted to the low-pressure cylinder, and from thence to the condenser. This modification resulted in a considerable economy of fuel. He thought a good deal could be learnt from careful observation of the great many different specimens of steamers on the Seine, where compound engines were much in favour, and also spoon-shaped boats, not only with a spoon-shaped bottom, but also with a regular spoon-shaped bow. There were also a great number of luggage-boats called "Porteurs," with paddle-wheels hung over the stern; and also an extensive system of "Remorqueurs," or towing-boats, which hauled on a chain laid down in the centre of the river, by means of drums, which were worked by a steam-engine; the drums wound up the chain and relaid it as the Remorqueur passed on, dragging after it several barges of 1,000 tons burden each, and working, he believed, at a good profit.

Mr. Forbes. Mr. J. S. Forbes said he had been unable to follow many of the arguments brought forward by previous speakers. He happened to be one of those who had to find their way amongst much conflicting scientific evidence to a practical result. He had recently come to the knowledge that the Thames above bridge might be made a remarkable collecting ground for passenger traffic, and upon the strength of that conviction, and with the assistance of Mr. Barry, a railway terminating at a pier on the Thames at Fulham was being constructed. He was, however, at his wits' end to know how they were to provide a satisfactory means of collecting and delivering the traffic in connection with that pier. He had therefore come to listen to the discussion, to endeavour to pick up what he could upon the subject. He confessed to have been a little puzzled with the various opinions that had been expressed, and he did not know that he had heard anything quite *ad rem*, except that there were certain steamers on the Seine and elsewhere which seemed to contain the germs Mr. Forbes. of what he wanted, which was a steamer somewhat differing from the Thames penny boats. He willingly admitted that, as far as mere handling was concerned, the Thames boat was a marvel of discipline and skill, but he did not think that it combined all the elements of comfort, cleanliness, shelter and convenience required. He was not particular as to the mode of construction, but he wanted a boat to comply with the conditions which he should prescribe as being necessary for the public service. She should draw but little water; be very handy, comfortable, capacious, cheaply worked, and as safe as was compatible with his duty to the public, or with Mr. Bramwell's notions as to what was practical and what was theoretical. He wished to make a suggestion to the Institution. Between, say Battersea bridge and Richmond, a particular thing was wanted which did not exist. Could the Institution direct the minds of rising engineers to invent something which would comply with the prescribed conditions? and would it be out of place in him as representing those who had a deep interest in the question, to suggest that a small premium should be offered to induce them to devote their energies to the subject? The river should be treated as a mere collecting ground in connection with the railway, and the problem should be, how to bring people from certain parts on the river to a railway station, in order that they might find their way into the interior of London in the cheapest, most economical, and most comfortable manner. In order to bring the matter to a focus, he would be happy to offer a premium of 100 or even 200 guineas for the best report or proposal on the subject, to be submitted to the Council for their approval.

Mr. JOHN ANDREWS, N.A., of Messrs. Westwood and Baillie, Mr. Andrews. observed that the Author of the Paper contended "that from collision alone need danger be apprehended, and its results anticipated in their design," and suggested as a precaution against this danger "division by bulkheads." Now a vessel, when intact, had a certain amount of shoulder or freeboard; that was, her power only to stand upright on the surface of the water, and if, in the event of collision, or other cause, any of the holds became filled with water, so much of this shoulder or freeboard might be lost as to render the vessel unstable and liable to capsize. What was meant by the shoulder or freeboard, was the angle contained between the line of flotation of the vessel, when in a quiescent state, and the line drawn to any angle of inclination. The weight of the hull acted downward through its centre of gravity, and always tended to overturn

Mr. Andrews. the vessel. The shoulder was the power that counteracted the effect of this downward weight, and tended to restore the vessel to her upright position; and that, the power of the overturning weight, was the momentum due to the weight through its centre of gravity; and the power of the shoulder was the moment due to the volume of the shoulder by the distance of its centre out from the middle line of the vessel. If the moment of the shoulder was greater than the momentum of the weight, the shoulder would have a surplus of righting power. But if the power of the shoulder were destroyed, the righting moment would be altogether lost; the weight would be forcing the vessel down; there would be no buoyancy to counteract this downward pressure, and the vessel would roll over. Thus, not only was a vessel in danger of sinking through collision by loss of her buoyancy, but also, even when the buoyancy was maintained, by loss of the power of the shoulder to restore her to the upright position. The latter effect usually happened before the former, because it took so little to destroy the shoulder and bring about instability, even where considerable precautions might be taken to prevent the vessel sinking. Attention might therefore be more particularly directed to the question of maintaining a reserve of shoulder, whilst at the same time considering the question of the maintenance of buoyancy. Now in River Steamers there was absolutely no prevention of this tendency to capsize in the event of their being in collision, and their holds becoming filled with water. Although watertight transverse bulkheads might be fitted to them, these would not prevent capsizing if the portion between any two of them became filled with water. In a vessel of 250 feet length and 25 feet beam, if $\frac{2}{5}$ the length were filled with water, the shoulder would be so much destroyed that the remaining portion would not be sufficient to maintain the vessel upright. Such a vessel when intact would have a buoyancy, if tolerably fine, of 470 tons; and a surplus righting moment of shoulder of 270 foot-tons; and if $\frac{1}{5}$ the length were destroyed, the vessel would sink deeper into the water in proportion to the $\frac{1}{5}$ of the length lost. This would be equal to a loss in the righting moment of 145 foot-tons. Thus by the $\frac{1}{5}$ deeper immersion 145 foot-tons would be lost to the righting moment of shoulder, leaving a surplus of 125 foot-tons; and if $\frac{2}{5}$ were destroyed, the surplus righting moment would be reduced to *nil;* the returning power would be gone, and the vessel would roll over.

Longitudinal bulkheads had been proposed, and had been worked along the sides of vessels to provide against the effects of collision;

Mr. Andrews.

but these bulkheads took up so much of the shoulder that in the event of collision, and the side divisions becoming filled with water, so much of the shoulder might be lost as to be fatal to the vessel; and although the transverse bulkheads might be tolerably close, still the space between them might be so large that injury to one compartment might cause the vessel's overturning. Now, to obviate the effects of collision; and to prevent this tendency to capsize, and to secure a positive reserve of shoulder and of buoyancy, these River Steamers might be constructed with air-chamber belts along the sides; which air-chamber belts might be divided into any number of smaller compartments by diaphragms, and not interfere in any way with the internal arrangements of the hull of the vessel. The air-chambers would be made of a capacity and buoyancy that would entirely float the vessel in the event of any of the compartments of the air-chamber belts becoming damaged, and all the hold or internal portion of the vessel becoming filled with water, and would give safety and protection to the vessel from overturning or sinking. In River Steamers some arrangement of reserve of buoyancy, and reserve of shoulder or stability, seemed to be required to prevent capsizing and sinking in the event of their being in collision, and their original buoyancy and shoulder becoming destroyed.

Commander Curtis.

Commander JAMES D. CURTIS observed that a previous speaker had suggested the cutting away of the fore foot. Mr. Scott Russell had said, "Cut away the dead wood aft in the heel." A vessel pivoted on her fore foot, and consequently it would be found that the statement of the previous speaker was wrong in principle. With regard to sponsons he would suggest that there should be a heavy rubbing or collision streak all round the ship to prevent such a collision as that of the "Princess Alice" proving so fatal. If, for instance, there was a heavy baulk of timber round the vessel she would have a much better chance in the case of collision. The London boats reminded him of the old ferry-boat to which he was accustomed when a boy, very few modern improvements having been adopted in them; they had not kept pace with the street and suburban traffic improvements. One of the late improvements adopted since the "Princess Alice" went down was the putting of tin boxes under the seats to be thrown overboard when they were wanted. He thought that something still further was wanted—something fastened to the boxes through which a person might put his arm and hang on. It would be also desirable to have a slight rod connecting two of them, because he believed that two so connected would keep eight or ten people breast high

Commander Curtis.

in the water. What boats they had, the oars in them were not secured by laniards; in event of their being swamped, in all probability the oars would drift away. A suggestion had also been made by a Mr. Reed, coastguard officer, with a view of showing the direction in which a vessel was coming round a point, or steering, the helm moving the red or green shade over the masthead light. He had seen the Rockferry boats at Liverpool with a screw and a rudder at each end. They were managed very well, and were easily got alongside. The captains of the London boats, however, objected to screw steamers, because they said they could not get them alongside the piers. He had no doubt that engineers could put speed into vessels with a large beam. The true form of a vessel, in his opinion, was that of a section of an egg, the transverse sections being in all cases semicircular. The stability of river boats should be greatly due to their being of considerable beam. For above-bridge boats he would suggest a spheroidal shape of which the length was 4 times the beam, and for below-bridge boats a length $5\frac{1}{2}$ times the beam, with a rubbing streak $3\frac{1}{2}$ feet amidships from the waterway plank, tapering off at the ends, with planking intervening. There should be awning decks for two-thirds the distance, and saloons with seats facing amidships, 2 feet or so intervening between the seats (a lane 2 feet wide). Screw propellers should work in tubes, one at either end, which would lessen the vibration, with a ball and socket jointed nozzle, to divert the water from the screws, in lieu of rudders, thereby facilitating the steerage. The vessel could then be made to move broadside on to the piers if required. The vessels below bridge should have an awning deck aft only. There should be no dead wood, or very little, as he imagined its use was principally for sailing vessels, keeping a steady course and holding a good wind. False elastic spring stems, or buffers, would be useful to lessen concussion. The present boats might be trustworthy end on, but he doubted it in a beam sea. The rubbing or collision streak should be arranged to prevent boats being swamped when the vessel rolled; possibly air-tight wings and braces and stays might be affixed to it. The scuttles should be higher, and pointing skywards. The Thames captains had no superiors in river navigation; they were civil, cool and collected, and handled their boats, such as they were, as well as it was possible for mortal to do so. But that was no reason why the boats should not be improved upon. They should be shorter, more buoyant and stronger, and pivot on their centre, and be able to move broadside on. A vessel should have appli-

Commander Curtis.

ances for floating all hands in case of emergency. The living telegraph, or call-boy, was a useful individual; he had his eye at all times on the captain, and he repeated the commands given by hand; ultimately he became a helmsman. Telegraphs by wire and chains and rods were apt to stretch and get out of gear, and the indicator did not then indicate correctly. The Ship Electric Telegraph Company appeared to meet all the requirements for sending messages. Paddle-steamers should have paddle-box life-boats ready for hoisting out at all times, and the crew should be exercised at times; paddle-boats pulled as well as any cutters of men-of-war, and they were prolonged semi-spheroids.

Mr. Carson.

Mr. W. Carson, in reply upon the discussion, said he regretted it had been supposed that a comparison unfavourable to the Thames had been attempted in the Paper. The peculiar circumstances of the Thames, and the land competition, were specially noticed. It was rather the object to enable those who had to do with river traffic to compare their practice with that of their neighbours; and to strengthen their hands as regarded the public by a favourable expression of opinion. He had suggested some modifications in the Thames vessels, but it was admitted that it would not be possible to construct such craft so that absolute safety in collision could be obtained. Mr. Bramwell and Mr. Ravenhill had argued that to attempt any more than had already been done was not necessary, looking at the small percentage of accidents; and was not reasonable, looking at the traffic earnings. The latter gentleman had, however, thrown some light on the first point. No opinion was ventured in the Paper upon the staff of the London River Company, but what did he say? He objected to the way in which the company's hands were tied up in choosing their men, owing to the restrictions of the Watermen's Company. Was it possible that he thought good luck had something to do with this immunity from accident, or why was he not content to leave "well enough" alone? Then, as to whether vessels more expensive in first cost would or would not pay, that was a duty to face if additional safety could be purchased in that way. But Mr. Ravenhill went further. He said old engines were put into a new hull to particulars supplied by the owners, for which the builders were not responsible; and the result had been embodied in the Paper and described as the type of a Thames river steamer. He implied a want of progress because builders were not consulted. These remarks were most valuable, and his concluding suggestions, if the river company were spirited enough

Mr. Carson. to carry them out, no doubt pointed to a thoroughly satisfactory class of vessel, which would enable the Thames to take the lead in the future as in the past. Heavy pressures, such as were indicated by Messrs. Perkins and Thornycroft, lighter machinery and probably screw propulsion, with the same displacement, would leave a sufficient margin, even in the smaller vessels, for that extra weight which a better bulkhead division would entail. Mr. Rogerson's experiments with the "Loftus Perkins" tended to the same conclusion. As to the form this extra weight was to take to secure the best results, longitudinal bulkheads had been found fault with on grounds which were stated and met in the Paper. Mr. Bramwell said they would unduly interfere with the use of the below-deck spaces; and other speakers suggested a loss of stability from weights being carried higher, and from unequal immersion. There was little doubt but that the draughtsman might safely be left to dispose of these objections: with a break for the cabins at each end the first would disappear; and a proper subdivision would satisfactorily meet the latter. Then as to the position of the steersman, it went without saying that the bridge, in the presence of the master, with an all-round look out, was the proper position; and the steersman's duties ought to be confined to his own work without the distraction even of the stern fender. Excellent, it had been said, was the call-boy arrangement, but the telegraph was at least as reliable; and it was also a labour-saving instrument; its use on that ground, if on no other, ought to be encouraged. Let the master have a telegraph, put the steersman in the very best position, and, by way of suggestion, the call-boy might be left to deal with the fender; so that without additional cost there would certainly be a not less satisfactory distribution of the navigating force. It had been mentioned as a matter for regret that the engines had not received more attention. No doubt that was a most important matter, though not immediately within the scope of the Paper; and the same of the material of which such craft should be built. Steel had been mentioned, but it was tolerably evident that it was not likely just yet to be used for the hulls of river craft. There was no margin for saving in a plate $\frac{1}{4}$ or $\frac{5}{16}$ inch thick (which, notwithstanding the comparison with brown paper, was generally sufficient); and a reliable countersink could not be obtained with a lesser thickness. He thought that the difference in cost between similar steel and iron plates would be expended with greater advantage in a superior bulkhead division. Some remarks had been made on cargo traffic, and the arrangements at Liverpool for end-on loading. Those arrangements were perfectly suited to the traffic, and no difficulty whatever had arisen, even with the ordinary vessels, in working into and out of the embayment. The new piers and stages at Seacombe, which were on the point of completion from his designs, were intended to form the complement of the Liverpool facilities; and, together, would afford complete accommodation for cart and horse traffic across the Mersey. It was to be regretted that the boat, described by Mr. Beloe, which was to carry this traffic, had been built without special reference to the requirements, so that the immediate result would not probably be entirely satisfactory. The discrepancy between the displacement and carrying capacity of the "Claughton" and "Heatherbell" arose in this way: the "Claughton," a cross-river boat, had two pairs of engines, with sponsons of the full width all round; the "Heatherbell," a down-river vessel, had a single pair of engines and only partial sponsons. Mr. Donaldson had suggested half bulkheads. The Author had fitted these athwartships in several Mersey boats, with a great saving of weight. This was the principle of the longitudinal bulkheads suggested in the Paper. He did not think trusses for longitudinal strength necessary for ordinary lengths with a good bulkhead division. It had been said that if the machinery compartment filled, such vessels would break their backs. Here was a case in point; a sister ship to the "Water-lily," with a depth of one-twentieth of length, struck a wreck and filled amidships: the vessel had eight hundred passengers on board; the fires were put out, but she managed to steam $\frac{1}{2}$ mile to a landing-place, where the passengers were disembarked, ignorant, until they had done so, that they had been in danger. The vessel remained afloat for six or seven hours until docked for repairs, and she sustained no injury beyond the local one. There could be no doubt that thorough bulkhead division saved many lives on that occasion. The discipline of the crew was also worthy of notice; although aware of what had happened, and not knowing what the result might be, no sign escaped any of them; panic might have undone all that the most perfect division of the ship could do to save them and the passengers. And in his experience this was a fair sample of the crews of Mersey river steamers. The use of water power for steering had been objected to on account of the risk of freezing. There was no risk on board a river steamer in this country, because the pipes could be perfectly sheltered. In exposed positions water pressure might be safely used when mixed in the proportion of 4 to 1 with crude brown glycerine. He had used this mixture, through uncovered pipes of over 300 feet Mr. Carson.

Mr. Carson. long, on an exposed pier on the Mersey, for six or seven years without freezing.[1] In more rigorous climates a small addition of methyl alcohol might be required to overcome the excessive pipe friction which would arise if a greater proportion of glycerine became necessary; but this did not apply to the British climate.

Correspondence.

Mr. Chanute. Mr. O. CHANUTE, Chief Engineer of the Erie Railway Company, furnished the following notes concerning the principal points in which the American differed from the European practice. The first general impressions produced upon an American by a European steam ferry, more particularly those of London and of Paris, were the small size of the boats, which were very long in proportion to their width, and that the cabins were below the deck. This of course resulted from the necessities of the traffic, and especially from the fact that in Europe the passenger business was separated from the cart traffic, while they were almost invariably accommodated upon the same ferry-boats in the United States. This concentration of both classes of traffic upon the same vessel was thought in America to result in several advantages. The boats could be made materially larger than they would be were the traffic divided, and were hence more economical in operation, as they required nearly the same crew, whether the vessel were large or small. The average loads sustained a larger proportion to the carrying capacity, as each class of traffic preponderated at a different hour of the day, the passenger transit chiefly taking place in the morning and evening, and the cart traffic being greatest in the middle of the day. The large size of the boats, moreover, admitted of the cabins being placed above the decks; they could thus be thoroughly lighted and ventilated, and in many cases were handsomely furnished. It should be explained, however, that the American ferries very seldom did an "omnibus business" in the line of the streams. Almost all the traffic went across, and the boats rarely plied between more than two landing points. A more important difference in the American practice consisted in the method in which the boats crossed the stream. In the eastern sections of the country, and on tidal rivers, they landed "end on" at right angles to the shores, and plied like shuttles between them. They thus crossed direct, they lost no time in turning, and were loaded and unloaded with great rapidity; the

[1] *Vide* Minutes of Proceedings, Inst. C.E., vol. xlix., p. 39, and vol. lii., p. 242.