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.

carts and passengers simply going on at one end, and off at the other. For this purpose the boats were made double ended, with a rudder at each end, and two pilot houses. One, or more frequently, two carriageways, about 10 feet wide, extended longitudinally from end to end of the deck, the cabins being placed outside of these, but sometimes overhead. To obtain space for these the deck projected beyond the hull from 10 to 15 feet on each side, the outside being flush with the outside of the wheels. The "slips" into which the boats ran were a little longer and wider than the boats, and were built of a double or triple row of piles driven deep into the mud. The piles sprung when struck by the boats. The shore approaches were provided with an adjustable floating bridge, the inner end being hinged, and the outer end supported by a pontoon; and to this bridge the boat was made fast by chains and large wooden bolts, which, in connection with the enclosing "slip," maintained her firmly at the landing. The hulls were mostly 120 to 200 feet long, and in the proportion of $\frac{1}{5}$ to $\frac{1}{7}$ of their length in beam (generally $\frac{1}{6}$), and drew from 6 to 8 feet of water. They steered well, and were quite manageable, but it was desirable that they should oftener be provided with watertight compartments. The engines were usually of the beam condensing type, placed amidships, and mostly below the deck; they were housed in, and the only portions exposed to view were the overhead walking beams and their attachments. The shaft was provided with a crank at its centre; it passed below the deck, and was attached to the side wheels, the steering being done altogether with the rudder. The cabins were placed over the projecting guards fore and aft of the wheels; they were well furnished, heated by the waste steam, and lighted with gas stored in a flexible india-rubber holder. These boats were certainly more comfortable than those of European ferries; they were generally provided with two lifeboats, and a large number of cork life-preservers stored under the seats. Although collisions occasionally occurred, they very seldom resulted in loss of life, the projecting guards affording an efficient protection to the hull, which was almost invariably built of wood. The range of the tides, in which these ferries operated, was about 5 or 6 feet. In some sections where the range was greater the approaches had been made upon a series of floating bridges, hinged end to end upon floats, which successively grounded upon a series of submerged piers, so as to preserve the same inclination of roadway on and off the boat at various stages of the tide. The boats crossed tide-ways in which the current ran from 4 to Mr. Chanute.

Mr. Chanute. 5 miles per hour, and entered their slips without difficulty. In consequence, however, of their doing this "end on," it was probable that in a more rapid current than 5 miles per hour advantage would have to be taken of some indentation of the shore, or artificial protections built at the ends of the slips to preserve the boats from swinging upon entering or leaving them.

On the Mississippi, Missouri, and other western rivers, a different type of boat and approaches was used. The summer floods rising to a height of sometimes 30 and 40 feet above low water, the boats landed broadside against floating stages, connected by gangways to the shore, and moved in or out as occasion required. The boats were single ended, and landed with the bow up stream. The favourite mode of construction consisted of two hulls joined in a single bow, with the single wheel placed nearly amidships. This was driven by a horizontal high-pressure engine, forward of the wheel, and the boilers were placed on the main deck near the bow, and fired from the outside of their enclosing shelter. The boilers, engine, and wheel thus occupied most of the central portion of the boats on the main deck, and the cabins were placed overhead and surmounted by the pilot house. Guards projected beyond the hull on all sides, and upon these, all around the machinery, boilers, and wheels, a carriageway extended, upon which carriages and animals were driven, coming on from one side and going off on the other. A light railing surrounded the outer guard of the boat, gates being left at suitable intervals, and a light apron extending between the boat and the landing-stage. Oddly and crudely as these boats seemed to be arranged, they yet subserved an excellent purpose, were easily steered and handled, and accommodated a large business. They were from 75 to 150 feet in length, with a draught of 2 to 5 feet, and an extreme width of 30 to 40 feet, this of course including the projecting guards, and the space between the hulls. The lightness of all the work above decks conveyed an impression that the boats were very frail; but in point of fact the hulls, which were built of wood, were strong, and would bear a good deal of pounding on sand bars, and against snags and floating drift. During the civil war a number of ferry boats were transformed into gun-boats, and did excellent service in running past hostile batteries.

The peculiarities of the American systems, like those of the European ferries, had been dictated by the surrounding circumstances as well as by the character of the traffic to be accommodated. The conditions were so different in Europe from those which obtained upon western rivers in America, that no hint of improvement was likely to be derived from western ferry-boats. The eastern feature, however, of landing end on, and of crossing the stream without turning, was believed to be more economical and convenient than that of landing broadside on, and there were doubtless several ferries in Europe where it might be introduced to advantage. It had been adopted as early as 1811, being designed by Robert Fulton for the first steam ferry-boat ever built, and had answered so good a purpose that no other plan was now used in the eastern tidal rivers of the United States. Mr. Chanute.

Mr. C. W. Copeland, of New York, desired to direct attention to the following articles bearing on the subject of passenger steamers:—"Iron hulls for western river steamboats;"[1] "Internal navigation;"[2] "Light-draught, fast, stern wheel steam yacht."[3] He also forwarded, for the library, a copy of the specifications and plans for a light-draught steamer for the Mississippi river.[4] This was the first complete specification and plans of this class of steamer which had been published. The speed in still water would probably be about 12 miles an hour. Mr. Copeland.

Mr. E. A. Cowper observed that the Paper gave a good deal of information, particularly in reference to the Mersey ferry-boats; but it would have been of greater value had the information been more complete, for instance, if the pressure of steam had been given in all cases; but perhaps the Author would be good enough to supply this in his reply. The Paper, no doubt, was not a history of the boats on the several rivers, as nothing was said about old boats now out of use; but it so happened that the Mersey boats had greatly improved from the time when they had single engines and a fly-wheel close to the inside of the boat, whilst the Thames boats had greatly deteriorated in consequence of the competition by railway; in fact, all the fine fast boats to Gravesend, Margate, and Ramsgate had been taken off. These were more fit to be compared with the large boats on the Clyde and Mersey, and were very fast. The circumstances of the three rivers were so different, that they necessarily caused the adoption of very dissimilar classes of boats. Many facts would have to be Mr. Cowper.

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[1] "Transactions of the American Society of Civil Engineers," 1874, Paper No. lxv., p. 271.

[2] *Ibid.*, vol. vii., p. 393.—"American Engineering." The Paris Exposition of 1878.

[3] "Scientific American," Supplement, 1879, Nos. 172, 179.

[4] U.S. lighthouse establishment. Specifications for building the side-wheel steamer "Joseph Henry," 1879.

Mr. Cowper. noticed, particularly in reference to the Thames, if a sound judgment was to be formed as to the suitable character of the boats used above bridge; thus the height of the bridges above high water spring tides, the depth of the river at many places at low water, the width of the bridges and set of the stream through them, the character of the freight, and particularly the nature of the traffic on the river, which might interfere with the boats. The conditions of the traffic on the Mersey were peculiar, and very different to the Thames above bridge. There was often a heavy sea on, which in a gale was most violent, and there were ships of the largest class moving about, and anchoring just where they pleased, so that with a 6-knot tide there was no safety in stopping, as the boat might drift across the sharp stem of a large ship which might have just anchored in a fog, or the boat might be run down by a steamer five or six times the tonnage of the ferry-boat; indeed, during a storm, the ferry-boats were often much bruised. They certainly seemed now to be well protected with good timbers all round, and to be of a very handy shape for manœuvring, and being large enough for division by bulkheads, full advantage appeared to have been taken of them to render the boats unsinkable, and with a large amount of power on board there existed good means of avoiding danger when it could be seen. There was nothing to curtail their dimensions, but the necessity of keeping them of a handy size, and they necessarily were made large enough to take the cart traffic, and strong enough to bring up alongside the piers in a heavy sea. Now the traffic on the Thames above bridge was quite different, and he did not altogether agree with several parts of the Paper. The Author said, "assailants are to be looked for from all quarters above bridge." But was this the case? There were the large old-fashioned barges floating up and down, and now and then half-a-dozen of them in a line behind a steam-tug moving through the water; then there were a few small row boats, steam launches, and other river boats, but nothing of large tonnage moving about quickly, or crossing the path of the boats, which were not ferry-boats, but which carried passengers up and down the river, over a distance of about 12 miles; so that unless a boat were injured by running into a bridge, a barge, or a pier, no particular damage could occur, and should she spring a leak by running on to an anchor, she was only a few yards from the shore, on which she could generally be beached without danger. The competition by railway had undoubtedly stood in the way of higher fares being obtained, and had of late years prevented much capital being invested in better boats and more powerful engines and boilers; but in order to meet the demands of the public these boats had to be run at very frequent intervals, and therefore carried a moderate number of passengers; and, consequently, it would be worse than useless to make them large, with spacious saloons; and moreover the bridges would not admit of it, and the river would not float boats of much greater draught of water, though there was more depth of water above bridge now than there used to be. Possibly some advantage might be gained in displacement by making the boats with more of a "spoon bow" and stern, and with very decidedly "flashing out" sides at the water-line, and particularly at the full-load water-line fore and aft of the paddle-wheels. This would render them safer with a heavy deck-load, the deck being carried out somewhat so as to increase the accommodation. Then if the boats were also made of steel, they might be made lighter, as they were amply strong enough now, and carry better boilers at a higher pressure, and much more powerful engines, so as to be thoroughly handy and faster. He could not agree with the Author in wishing to cut up the small cabin by a number of bulkheads, particularly by a longitudinal bulkhead, as this would have to be carried up a considerable height to be effective when the boat should heel over from one side filling with water, thus cutting the small cabin up into two wretched narrow passages. The extra weight of more bulkheads would also be highly objectionable; he trusted no such paternal control as that of a hard and fast rule for such a construction would ever be allowed on the Thames. He would add that he agreed with the Author, that to some extent the tendency was that, "the fares fix the paying engine power, and the speeds will be higher or lower according to the weight to be driven;" and that it was a point of great importance that the boats should be "well under engine control," as the increase of the engine power he held to be the key to improving the river boats above bridge. He agreed also with the Author when he said: "No doubt their designers were somewhat hampered by the small dimensions of the boats, and the limited head-room under bridge; and for these reasons, and also on account of its wind draught, the type of vessel with the saloon on deck is unsuitable." But the following remarks from the first page appeared to be very much to the point: "On the Thames above bridge, where short distances are traversed, small vessels of moderate speed and light draught, possessing great steerage power, and well under engine control, are used, and appear to be well adapted to deal with the traffic of a restricted and crowded smooth-water area. Under such conditions

Mr. Cowper.

Mr. Cowper. 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 in order to avoid them, in the latter quality lies the greater probability of safety."

Mr. Deas. Mr. J. DEAS remarked that the most recently-constructed steamer for the cart-and-horse traffic over the Clyde at Glasgow was of the following general description: Extreme length, 60 feet; extreme breadth, 35 feet; depth at sides amidships, 3 feet 10 inches; depth at sides at end, 1 foot 5 inches. There were hinged platforms at each end for the vehicular traffic, for which there were two roadways on deck; these platforms projected 15 feet from each end of the steamer. There was also a hinged gangway for foot passengers at each end. The steamer was worked by two chains, each $\frac{3}{4}$ inch in diameter, stretching across the river, and up a slip on each side, having gradients of 1 in 14. The engines two in number, were high pressure non-condensing, of the diagonal inverted type; the cylinders were 11 inches in diameter, and the length of stroke 18 inches. The two boilers were upright, 8 feet high, and 3 feet 6 inches in diameter. This steamer carried eight carts and horses, or four lorries and two carts and one hundred and sixty-five passengers, or five hundred and fifty passengers alone.

Mr. Evans. Mr. W. W. EVANS, of New York, observed that it had always been a matter of astonishment and delight to him to watch the skill with which the pilots of the Hudson river steamers, 380 feet long, drove their craft, at 20 miles an hour without break, through the Highlands, on a dark night when nothing was to be seen but a very faint outline of the tops of the mountains on each side, with a crooked channel ahead; and frequently encountering fleets of twenty to forty canal boats towed by a single powerful steamer, termed a "tow," six or seven of the grain or timber boats being on each side, and strings of them behind. There were turns so sharp in the windings of the Hudson river in this locality, that a stranger standing on the bows of a boat in daytime, within less than a mile of a bend, could not tell if the river turned to the right or to the left. The night-boats running on this river were masterpieces of work and engineering. What struck a stranger most was that they appeared to be without any officers. As a general thing, no one ever heard an order given. There were officers, but they could not be told from the passengers, as they were in citizens' dress. The boats were seldom stopped or slowed down from New York to Albany; but, when necessary, this was done by the pilot by the ringing of bells or of sounding gongs placed in the engine-room, the pulls being within reach of the pilot's hand. The valves of the engines were poppet valves counterbalanced, sometimes called compensation valves. The engine-room was on the main deck, where passengers promenaded, and always had the doors open; it was generally without any one in it. The engineer, also in citizen's dress, was usually outside among the passengers; but near enough to reach the levers inside the room in a moment, should the gong be sounded, and to stop the vessel before running much more than its own length. He had been familiar with the river many years, and had more than once gone up and down it with the late Dr. Lardner, in 1841, who expressed his delight at the perfection of the service. Mr. Evans.

He had an idea, that with double-engines, and anything but "poppet-valves" in the engine, this happy handling of the boat could not be effected. All these boats had single engines, he never saw a boat with double-engines on the river, and it had always been a mystery to him why the English would persist in having two engines when one was sufficient; the two cost more, they occupied more room than one, they required more care, attention, and cleaning, they often worked to a certain extent one against the other, the risk of accident was in a measure proportioned to the number of pieces and parts in all, there was more waste and condensation of steam in two cylinders than there was in one. About twenty-seven years ago he brought this matter of river boats, and the use of one engine instead of two, to the attention of the late Mr. Robert Napier, M. Inst. C.E., who said that the people who ordered them would not have any other. He then attacked him on the matter of short beam, long narrow deep vessels, instead of wide sharp bows and flat bottoms. Mr. Napier answered, "The Americans are right, but the English will not have such vessels as you talk of. We know that every vessel that floats, no matter what her model, displaces her own weight exactly; we know that every vessel afloat displaces her own weight in water every time she runs her own length; we know that every vessel cuts a canal, from the start to the stop, in the water equal in area and shape to her greatest submerged midship section; and we know that it requires more force to displace a cubic foot of water 20 feet below the surface than it does at the surface, or any other depth less than 20 feet." Mr. Napier admitted all these points, as he put them to him in an inquiring way; he was induced to do so, as he had just before made some voyages in four long narrow deep vessels

Mr. Evans. just sent out by him to the Pacific. From what he said Mr. Napier had evidently been trammeled in the models of those ships and of many more ships, by the owners, just as most of the English locomotive builders had always been trammeled by the engineers of the railways in England, who made drawings of every bolt and bar, lever and link, of every engine they ordered. It was astonishing to go among these steam-boat builders, and engine builders of America, and see how few of them were men of scientific education, and yet they worked out practically some of the most difficult problems to complete success in applied mechanics. Wiesbach could beat them in the constructive geometry and the algebra of the thing; but not a man could beat them in the practical application of an idea when once they comprehended it. This was mechanical instinct, just that happy faculty which George Stephenson possessed. More than thirty years ago Mr. J. Scott Russell, M. Inst. C.E., read a Paper before the British Association for the Advancement of Science on the "wave-lines" of ships, in which he demonstrated mathematically the propriety and value of such lines, and then said, "The Americans have been building ships on these lines for twenty years or more, but I doubt if there is a man among them that can demonstrate in figures the reason why they so build." He was right, at that time most probably there was not a single scientifically educated ship-builder in the United States, but times were changing fast.

He submitted data in reference to several American steamers. Of these, the "Drew" had been running as a night boat on the Hudson river, from New York to Albany, for about ten years. The "Rhode Island" ran as a night boat on Long Island Sound from New York to Fall river. This boat met the ocean wave after passing the eastern end of Long Island, and had been built to resist the greatest storms. The steam ferry-boat "Pacific," of the Union Ferry Company, ran from New York to Brooklyn, across the East river. The steam ferry-boat "Plainfield," belonging to the New Jersey Central Railway Company, ran between New York and Jersey City across the North or Hudson river. The "J. M. White" ran on the Mississippi river from New Orleans to Grenville, 547 miles. He also presented some data in reference to the "Gitana," a steam yacht on the Lake of Geneva, belonging to the Baroness Rothschild. Finally he gave a list of ferries, and the number of ferry-boats running out of New York to New Jersey across the North river, and to Long Island across the East river.

Mr. Evans.

"Drew."

Length of vessel	380 feet.
Breadth ,,	48 ,,
,, ,, over wheel-boxes	75 ,,
Depth from main deck to keel	$10\frac{2}{3}$,,
Height from main deck to top of chimney	34 ,,
Diameter of paddle-wheels	40 ,
Length of face of floats	$11\frac{1}{2}$,,
Diameter of cylinder	$6\frac{3}{4}$,,
Length of stroke	15 ,,
Pressure of steam generally used	45 lbs.
Greatest number of revolutions of wheels per minute	18
General speed per hour	18 miles.
Fuel burnt per hour	$1\frac{1}{2}$ ton.
Kind of fuel—anthracite coal.	
Number of passengers that can be berthed	1,000
Number of state rooms	200
Freight that can be carried all on deck	800 tons.
Draft of water, light	4 feet.
,, ,, loaded	6 ,,
Number of persons employed	75
Cost complete	450,000 dollars.
Kind of engine—beam.	

"Rhode Island."

Length of vessel over all	340 feet.
Breadth of vessel	47 ,,
,, ,, over wheel-boxes	80 ,,
Depth of vessel from main deck to keel	$15\frac{1}{2}$,,
Height from main deck to top of dome	29 ,,
Height from hurricane deck to top of chimney	32 ,,
Diameter of wheels	39 ,,
Length of face of floats	$11\frac{1}{2}$,,
Diameter of cylinder	$7\frac{1}{2}$,,
Length of stroke	14 ,,
Pressure of steam generally used	25 lbs.
Highest pressure of steam ever used	27 ,,
Greatest number of revolutions of wheels per minute	$19\frac{1}{2}$
Greatest speed per hour	20 miles.
Average speed per hour	18 to 20 ,,
Fuel burnt per hour	$2\frac{1}{2}$ to 3 tons.
Kind of fuel—anthracite coal.	
Number of passengers that can be berthed	400
Number of state rooms	160
Greatest number of passengers carried	800
Freight that can be carried	500 tons.
Draft of water, light	9 feet.
,, ,, loaded	10 feet.
Number of persons employed	90
Number of cubic feet of gas burnt in a trip of 120 miles	1,800 to 2,000 feet.
Tonnage, Custom House measurement	2,740 tons.
Kind of engine—beam.	

Mr. Evans.

"PACIFIC."

Length of boat	185 feet.
Breadth ,,	30 ,,
,, ,, over paddle-boxes	52 ,,
Depth ,, main deck to keelson	12 ,,
Height of chimney ,, to top	50 ,,
Diameter of paddle-wheels	22 ,,
Length of face of floats	7 ,,
Diameter of cylinders	3½ ,,
Length of stroke	10 ,,
Pressure of steam generally used	30 lbs.
Number of revolutions of wheels per minute	26
Kind of fuel burnt—anthracite coal.	
Kind of engine—beam.	
Fuel burnt in a day	7 tons.
Greatest number of passengers carried	1,000
Draft of water loaded	6 to 7 feet.
Number of men employed	5
Cost complete, about	80,000 dollars.
Age	20 years.

"PLAINFIELD."

Length of boat	225 feet.
Breadth ,,	30 ,,
,, ,, over paddle-boxes	60 ,,
Depth ,, main deck to keelson	12 ,,
Height of chimney ,, top	48 ,,
Diameter of paddle-wheels	22 ,,
Length of face of floats	9 ,,
Diameter of cylinder	4⅓ ,,
Length of stroke	12 ,,
Kind of engine—beam.	
Pressure of steam generally used	25 to 30 lbs.
Number of revolutions of wheels per minute	30
Speed per hour	12 knots.
Kind of fuel burnt—anthracite coal.	
Fuel burnt in a day	7 to 8 tons.
Greatest number of passengers carried	3,000
Draft of water, loaded	6 feet.
Number of men employed	5
Cost complete about	125,000 dollars.

"J. M. WHITE."

Length of vessel	321 feet.
Breadth ,, the hull	50 ,,
,, ,, over all at rear guards	100 ,,
Depth from main deck to keel at centre	11½ ,,
,, ,, ,, ,, at stem and stern	17½ ,,
Diameter of paddle-wheels	44 ,,
Length of face of floats	19 ,,
Depth ,, ,,	3 ,,
Height of chimneys (two in number)	86 ,,
Diameter ,,	6¼ ,,

"J. M. White"—*continued*.

Mr. Evans.

Number of main engines	2
Diameter of engine cylinders	$3\frac{7}{12}$ feet.
Length of stroke	11 „
Pressure of steam generally used per square inch	150 lbs.
Pressure per square inch allowed by Government	173 „
Pressure at which boilers are tested „	259 „
Kind of boilers—cylindrical: ten in number, of steel, 34 feet long, $3\frac{1}{2}$ feet in diameter, each with two 16-inch flues.	
Greatest number of revolutions of wheels per minute	18
General speed per hour against current	$12\frac{1}{2}$ miles.
Current in river per hour	3 to $3\frac{1}{2}$ „
Kind of fuel—wood.	
Number of state-rooms	126
„ „ passengers that can be berthed in state-rooms	250
Freight that can be carried	2,000 tons.
Bales of cotton „	10,000
Draft of water, light	$6\frac{1}{2}$ feet.
„ „ loaded, about	9 „
Horse-power (indicated) of both engines	4,000
Main cabin or saloon, 233 feet long, 13 feet high, and 19 feet wide, exclusive of state-rooms.	
Journals of main shaft 21 inches in diameter; shaft and cranks of wrought iron.	
Each engine works one wheel independently.	
Engines of the horizontal-lever poppet class, with a connecting rod, 44 feet long.	
These engines, like all engines on the Mississippi river, are non-condensing. The vessel was built in 1877, and	
Cost complete	200,000 dollars.

Ferries and Number of Boats.

Staten Island to North River.

Staten Island ferries (3 ferries)	6 boats.
North River, Barclay Street ferry	7 „
New Jersey Central railway, Liberty Street	6 „
Pennsylvania railway, Courtlandt Street to Desbrosses Street	7 „
Morris and Essex railway, Hoboken to 10th Street	4 „
New York and Erie railway, Chamber Street to 23rd Street	8 „

East River.

Union Ferry Company	Hamilton Street, South „, Wall „, Fulton „, Catherine „	17 „
Williamsburg and Brooklyn Ferry Company	South 7th Street, Grand „, Houston „	11 „
Greenpoint Ferry		2 „
Hunterspoint „		6 „
Astoria „		2 „
Total ferry-boats		76

Messrs. Fletcher, Harrison & Co.

Messrs. FLETCHER, HARRISON & Co., of the North River Iron Works, New York, supplied the following particulars of steamers constructed by them :—

——	"Mary Powell."[1]	"Chauncey Vibbard."	"Daniel Drew."	"Sylvan Dell."	"Sylvan Glen."
Boat.					
Length on water line, in feet	286	281	265	178	153
" over all "	295	294	277	185	160
Breadth of beam "	34	34	33	26	26
" over guards "	63	60	56	48	46
Depth of hold, top of floor-timbers to under side of deck, in feet	$9\frac{1}{2}$	$9\frac{8}{12}$	$9\frac{1}{2}$	$8\frac{9}{12}$	$8\frac{1}{2}$
Draft of water, from bottom of plank, in feet	$5\frac{8}{12}$	$5\frac{8}{12}$	$5\frac{8}{12}$	$4\frac{3}{4}$	$4\frac{1}{2}$
Engine.					
Diameter of cylinder, in inches	72	$62\frac{1}{4}$	68	51	40
Stroke of piston, in feet	12	12	10	8	8
Diameter of wheels, outside of buckets, in feet	$31\frac{8}{12}$	30	29	$25\frac{10}{12}$	$23\frac{1}{2}$
Face of wheels, length of buckets, in feet	$10\frac{1}{2}$	$9\frac{1}{2}$	9	8	7
Dip of buckets, in inches	42	39	39	31	27
Average pressure of steam, in lbs.	28	32	32	30	40
Cut off, part of stroke, steam follows full pressure	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$
Revolutions, at average	23	24	24	27	$26\frac{1}{2}$
Speed of boat, at average, in miles per hour	20	$19\frac{1}{2}$	$19\frac{1}{2}$	19	$17\frac{1}{4}$
Maximum pressure of steam, in lbs.	40	45	45	43	50
Maximum cut off, part of stroke, steam follows full pressure	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{5}{8}$
Maximum revolutions	25	27	27	30	$29\frac{1}{2}$
" speed of boat, in miles per hour	22	22	22	$20\frac{1}{2}$	$18\frac{1}{2}$
Route.					
From New York to, and return	Rondout.	Albany.	Albany.	Harlem.	Harlem.
Miles one way	95	150	150	9	9
Landings one way	7	8	8	4	4
Average time, one way, including landings	5h. 25m.	9 hrs.	9 hrs.	39 min.	43 min.
Average time for all landings.	40 min.	40 min.	40 min.	12 "	12 "

The steamer "Mary Powell" was perhaps the best example of a fast river steamer in this part of the country, because the route

[1] *Vide* Journal of the Franklin Institute, 3rd Series, vol. lxxviii. p. 18.

traversed was all in deep water, and with few landings for the length of route. The business was also comparatively steady. The vessel carried passengers only (averaging about eight hundred) with their baggage. The boat had for nineteen years done work at the average stated in Table, with and against tide; during exceptional runs, even greater speed than the maximum stated in the Table had been obtained. The Albany day boats, "Chauncey Vibbard" and "Daniel Drew," ran through the same water as the "Mary Powell," and at times, in this deep water, make equally good runs; but 30 miles of their route below Albany was in shallow water, which, in some stages of the tide, and in some places, was not much more than enough to float the boat. The Harlem boats run on the East and Harlem rivers, making one landing at Astoria on the Long Island side. Their route was in swift flowing water, full of eddies, and carried them through part of the notorious "Hell Gate." The speed given in the Table could, however, be easily made by them in good water. These five boats were fair examples of the best river boats. They were all built on the American plan of saloons and passenger accommodation on and above the main deck. Only the dining-room, kitchens, and berths for the crew, were placed below the main deck. They all had also the American style of overhead beam engines with jet condensers. Messrs. Fletcher, Harrison & Co.

Sir Charles Hartley stated that in November 1873 he inspected the "City of Richmond" steamer at St. Louis, and obtained from her captain the following particulars:— Sir Charles Hartley.

Extreme length of deck	340 feet.
„ width „	85 „
Load line, draught	11 „
Light „ „	4 „
Burthen	2,500 tons.
Freight carried	2,000 „
Cylinders, two, diameter	5 feet.
Length of stroke	10 „
Six boilers, pressure per square inch . . .	25 to 35 lbs.
Paddle-wheels, diameter	44 feet.
Floats „	14 „
Height from water-line to top of funnels . .	92 „
„ „ „ pilot-house .	60 „

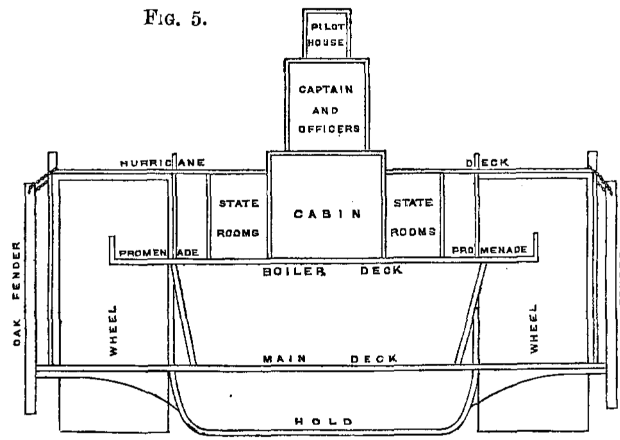
This steamer was then advertised as being the only low-pressure steamer on the Mississippi river. She frequently accomplished the voyage of 1,165 miles from New Orleans against a 2 to 3-knot current in six days. She was built in 1867 for $232,000, and was sold three years afterwards to her present proprietors for $100,000.

The following additional information regarding U.S. river

Sir Charles Hartley.

steamers had been obligingly obtained for Sir Charles Hartley by Mr. Max E. Schmidt, of Memphis, Tenn., Member of the American Society of Civil Engineers, and chief assistant-engineer to Captain Eads, M. Inst. C.E., at the South Pass jetties during the whole period of their construction. The "Edward Richardson" was a side-wheel steamer, with wooden hull, of 2,048 tons burthen, extreme length, 313 feet; beam, $48\frac{1}{2}$ feet; depth of hold, 10 feet; draught when light, 5 feet; draught when loaded, 12 feet; diameter of cylinders, 38 inches; length of stroke, 10 feet; boilers, nine in number, high pressure, 173 lbs. per square inch; diameter of paddle-wheels, 39 feet; length of paddles, $17\frac{1}{2}$ feet; height from water to top of chimneys, 120 feet; to top of pilot-house, 75 feet;

FIG. 5.



Scale 30 feet = 1 inch.

SECTION OF THE "ED. RICHARDSON," MISSISSIPPI STEAMBOAT.

she was able to run at the rate of 15 miles an hour against a current of 3 miles an hour, when light; the steering was effected by hand, the wheel being about one-third of the distance from the stern of the boat; communication was effected between the pilot-house and engine-room by a speaking-trumpet and bells; the engines acted independently on each paddle-wheel, and thereby perfectly controlled the steerage; there were no bulkheads or watertight compartments; life-boats and life-preservers were carried sufficient for the passengers; the deck platform projected 21 feet on each side of the hull; the cabin on the boiler-deck was 240 feet long, 18 feet wide, and 16 feet high; there were fifty state-rooms, accommodation for two hundred and twenty-five first and second-class passengers, and when well filled with passengers,

Sir Charles Hartley.

8,000 bales of cotton in a non-compressed state could be carried with safety.

In presenting this matter Mr. Schmidt stated that the steamers which navigated the Mississippi were chiefly transporters of freight, cotton being the main article. The passenger traffic, although by no means inferior in comfort, was only of secondary importance, and seldom paid large revenues to the owners. Certainly, two hundred and twenty-five passengers was a small number for so large a steamer as the "Ed. Richardson." But taking into consideration that the cotton was often piled up on both sides of the boat in four parallel rows of bales 40 feet high, the top reaching above the hurricane-deck, and thus completely hiding the exterior of the cabin, the importance of closely limiting the number of passengers became apparent. These steamers were often loaded down until the water flowed over the guards, but in such an event it was not attempted to run the boat up-stream. All freight went down the river, to the now open mouth, for trans-shipment to Europe. It should be stated that through the presence of cotton, and the imminent danger from fire, great precautions were enforced by law to prevent disaster. Hydrants and a full supply of hose were within immediate reach on all the decks. There was: 1, a main deck, on which the boilers, the engines, and the freight rested; 2, a boiler-deck, about 16 feet above the main deck, on which the cabin rested; and, 3, a hurricane-deck, about 17 feet higher, on which were officers' quarters, captain's state-room, and a pilot-house still higher. On the platforms or overhangs the cotton was piled. No better protection against the effects from collisions could be desired than this bulwark of cotton on each side, 21 feet in thickness.

Regarding the style of architecture employed in the construction of the Mississippi steamers, there was very little variety in shape, model and general appearance. The dimensions varied frequently, and alterations tending to the safety and comfort of the passengers, and to an economical disposition of freight, had been introduced with the progress of invention. The saloon or cabin was almost exclusively built upon the boiler-deck. The luxurious manner in which the cabin was finished on the larger steamers, and the perfection aimed at in all appointments tending to comfort were well known. Fig. 5 was a section of the "Ed. Richardson," which showed the position of the different parts of the steamer, and served in general to explain how the space on the larger Mississippi steamers was disposed. Ample room for promenade was obtained on the boiler-deck, each state-room having two doors,

Sir Charles Hartley.

one leading into the cabin, and the other out on that part of the deck reserved for promenade. Perfect ventilation might thus be given to each state-room. Most of the promenade was covered by the hurricane-deck, or by tarpaulin to shelter promenaders from the heat of the sun or from rain. In order to protect the steamer from the wear and tear incident to landings, oak fenders, which on the "Edward Richardson" were 35 feet long, were suspended from the hurricane-deck to the water's edge. These fenders were placed at distances of 10 feet from centre to centre, and had given good results.

Mr. Schmidt had also supplied a pamphlet[1] descriptive of the U.S. mail steamer "J. M. White," in which was the following Table of the dimensions and power of the fastest steamers on the Mississippi river:—

Boats.	Built.	Hull.			Boilers.			Cylinders.		Paddle-wheels.	
Names.	Year.	Length.	Beam.	Hold.	No.	Length.	Diameter.	Diameter.	Stroke.	Diameter.	Floats.
		Feet.	Feet.	Feet.		Feet.	Inches.	Inches.	Feet.	Feet.	Feet.
Sultana . .	1843	250	35	8	7	32	42	30	10	30	14
J. M. White	1844	250	31	8⅓	7	32	42	30	10	32	15
Peytona. .	1846	260	35	8	6	32	42	30½	10	33	16
Aleck. Scott	1848	285	34	7⅔	5	32	42	30½	10	..	..
Eclipse . .	1852	363	36	9	8	32½	42	36	11	41	15
A. L. Shotwell	1852	310	36	8	6	32	42	30	10	37	15
Princess .	1855	280	38	9⅓	6	34	42	34	9	40	..
R. E. Lee .	1866	300	44	10	8	32	42	40	10	38	16½
Frank Pargoud . .	1868	250	41	9⅓	7	28	38	32½	9	36½	15½
Natchez. .	1869	301½	42½	9½	8	34	40	34	10	42	16
R. E. Lee .	1876	315	48½	10½	9	32	42	40	10	39	17
John W. Cannon . .	1878	250	43	9½	7	34	42	34	9	37½	16
J. M. White	1878	321	50	11½	10	34	42	43	11	44	19

Mr. Kirk.

Mr. A. C. KIRK remarked that in constructing successfully river steamers, whether the object was to build steamers which should carry passengers at the highest possible speed, or cargo on the least possible draught of water, the problem resolved itself into reducing the weight of hull, propelling machinery, and fuel

[1] *Vide* "Description of the Steamer 'J. M. White,' Construction, Machinery, Outfit, &c." By Chas. H. Clarke, 8vo., Louisville, Kentucky, 1878.

to the utmost. In putting the matter thus he assumed that the lines and proportions of the hull had been made as good as circumstances would allow. In considering the three elements of weight, which he had put above in order of their importance, it would be convenient to invert this order and commence with the last. Mr. Kirk.

1. *Fuel.*—The quantity of fuel to be carried would depend of course on the quantity consumed per hour, and the frequency with which the coal bunkers could be replenished. The quantity to be consumed per hour would depend on the machinery, and would fall more fully under the next head. The frequency with which the bunkers could be replenished depended on local considerations. This to a great extent regulated the value to be attached to a low consumption of fuel, the longer the run before the bunkers were replenished, the greater the value of arrangements for economy of fuel.

2. *Machinery.*—In all except the very shortest runs, there was, unquestionably, a gain of speed to be got by using compound engines; the smaller quantity of coal to be carried being a decided saving; for the compound engine could be made with surface condenser complete almost as light as any ordinary engine, and if working in fresh water quite as light, the surface condenser being then dispensed with. For short runs and frequent coaling the only question to be considered in determining whether a common or compound engine be adopted was, first cost in favour of the common engine, and daily economy of fuel in favour of the compound. The most serious part of the weight was the boiler, and much of the success of the Clyde steamers was due to the use of the haystack water-tube boiler, which not only occupied little space, but was light in itself and carried little water. The "Marquis of Bute," a Clyde steamer, of 190 feet length, 18 feet breadth, with engines of 690 indicated HP., weighing, with the boilers and water, 74 tons, was fitted with a single-cylinder injection condenser engine, feathering wheels, and haystack boiler, the whole weight of machinery being 2·15 cwt. per indicated HP. as tried on the measured mile at Wemyss Bay. As additional examples he might mention "The Lancelot," of 190 feet length by 18 feet width, having two oscillating cylinders and one haystack boiler. The machinery and water weighed 60½ tons. The engines were of 690 indicated HP.; the whole weight of machinery being 1·76 cwt. per indicated HP. "The Guinivere," 200 feet long by 19 feet wide, having two oscillating cylinders and two haystack boilers. The machinery and water weighed 85·5 tons. The indicated HP. was 742, or 2·3 cwt. per indicated HP. "The Elaine"

Mr. Kirk. was 175 feet by 17 feet width. She had two oscillating cylinders and one haystack boiler. The machinery and water weighed 45 tons. The HP. was 420, 2·14 cwt. per indicated HP. There seemed little reason why for short-trip high-speed steamers forced blast should not be adopted, as had been done in torpedo boats.

3. *Hull.*—Little more in merely reducing scantlings could be attempted. Up to the present time but little change had taken place in the structural arrangement of river steamers, and years of experience and trial had pretty well settled the extent to which reduction of scantlings could be carried. In fact, the considerations of local strength imposed (except in the case of the largest) scantlings quite sufficient for general strength, and it was only in the largest of our river steamers that there was much room for improvement. In these, something might be done by applying the lattice principle, and the same strength got by increased depth as was obtained by shallow floors, &c., and beams of solid plate webs. But, unquestionably, the greatest improvement by which weight could be reduced had been the introduction of steel. By the use of this material not only could the required general strength be got with less thickness, but from the vastly greater margin for punishment and distortion before fracture occurs, a smaller margin of local strength would afford safety equal to that got with ordinary iron. At present, however, the real value of steel was but half got; ship-building authorities having ordained that ship steel should be as nearly as possible an imitation of wrought iron; as near to wrought iron in fact as the steel makers by taking the utmost pains could produce. The Liverpool underwriters had of late very wisely (though with even an excess of caution) been breaking through this prejudice. They had raised the limit of maximum strength from 30 tons, which had been adopted by the Admiralty and Lloyd's, to 32 tons, and he was happy to say they contemplated raising it to 35 tons, and there was no reason why it should not be higher. Up to 35 tons punching along with countersinking was quite safe; but why should the use of the punch limit the strength of the steel? With a proportionate reduction in thickness for increased strength it would pay every one concerned to drill, if that were found necessary. Steel must no longer be treated as if it were iron, and be made practically only iron. By a more intelligent treatment the higher qualities of the material should be utilised.

Mr. Lawrie. Mr. J. G. Lawrie remarked that two classes of steamers had chiefly been considered in the discussion, "ferry passenger steamers," and "ordinary river passenger steamers." In all steamers, whether river or sea-going, in which the speed desired was moderate, or not extreme, much greater scope existed for the development of strength than when the speed desired was extreme. By a small diminution of a moderate speed, greater strength might be obtained, or by increased length and breadth, and the accommodation afforded by the steamer would be unimpaired. But when the speed desired was extreme, or the utmost attainable, the elements of the problem were entirely altered. Take, for example, river passenger steamers, which were the steamers chiefly considered in the Paper itself, apart from the discussion, and practically, the problem to be solved was to produce a steamer which should combine in the greatest degree the requisite strength, with the requisite accommodation under and above deck, and the highest attainable speed. Under deck there was an after cabin, a fore cabin, a restaurant cabin, steward's accommodation, and other fittings. On the deck there was the deck saloon, with the promenade deck over it. The number of passengers for which the steamer was licensed was measured by the unencumbered deck surface. To reduce the deck surface was substantially to diminish the size of the steamer, and practically to make her of less length and breadth. To cripple, and therefore to lessen the under-deck accommodation by longitudinal or transverse bulkheads, or to transfer the under-deck accommodation to the deck, which would be the result of carrying out some of the suggestions proposed in the discussion, would be to reduce the gross amount of accommodation afforded by the steamer, and would therefore be to reduce the size of the steamer. If, in addition to this reduction of accommodation, fittings were introduced which would increase the weight of the steamer, the attainable speed would inevitably be diminished, and the efficiency of the steamer would be impaired. In the existing competition to produce the utmost attainable accommodation and speed, there existed the strongest inducement to use the best material, and the most effective machinery; and the inducement was equally strong to avoid the addition of weight, which involved a loss of speed or the reduction of accommodation. If Parliament ever rendered either course imperative, Parliament would simultaneously exact a diminished traffic, and consequently an increase of fares. For such a measure a stronger case of necessity must be made out than was at present possible. Accidents arising from the collision of steamers did, no doubt, happen occasionally, though very seldom, and they would continue to occur from time to time even though the strength were Mr. Lawrie.

Mr. Lawrie. increased. The true direction in which to look for safety was in the command of the steamer by steering, and in the facility of going ahead or astern. No suggestions made in the discussion pointed to improved and increased accommodation, or to increased speed beyond the results obtained in the modern Clyde river steamers, and he believed a careful consideration of the question would satisfy an experienced engineer that no such suggestions were possible. *A priori*, a broad gauge would seem to obtain for a train greater stability and greater safety than a narrow gauge, and probably it did do so; but experience had taught that in the accompanying evils the advantage was lost, and that the narrow gauge was the best for the purpose. Similarly an increase of bulkheads and increased strength in a river passenger steamer were apparent advantages, but experience proved that they were better omitted.

Mr. Mackie. Mr. S. J. Mackie said it was familiar to every engineer, that in no other way could any given weight of iron be disposed to such advantage as on the tubular bridge or "box-girder" form. By applying this principle to the designing of ships, the strongest construction of hull was obtained with the utmost amount of security; and, as in the application of all right principles, every subsequent requirement entered into harmony with the main outlines. A central tubular chamber could be thus produced perfectly watertight and totally independent of the external hull or outward form of the ship. By this means the effect of any collision on the broadside would be limited to that particular small section or exterior cell alone which was breached by the blow; for what would have been a single large compartment of the vessel under the existing ordinary division by transverse bulkheads, would, by the introduction of two longitudinal girders, be subdivided into three portions, of which the middle one would always remain intact if either or both of the external spaces were destroyed. The division of the hull by two longitudinal girders would suffice to give ample security; but the safety of the vessel would be still farther advanced if the saloon above deck constituted a portion also of the interior tubular chamber, by making its walls to form the upper parts of the longitudinal girders, and thus increasing their depth. In the earlier designs of vessels upon this plan, a novel mode of hydraulic propulsion was introduced, to allow of which the beam of the vessel was increased by a second set of longitudinal girders, with an interspace for the flood of water by which the propulsion of the ship was effected. At the same early period, however, the idea was also developed of making or converting ordinary vessels into safety ships, by the introduction of two longitudinal girders, whereby a central tubular chamber was practically formed, by which the security of both vessel and cargo was ensured. He exhibited a model, an illustration of a sea-going vessel of this safety class, designed by Mr. George Hollingum, a naval architect, in consultation with himself, for the service of the South-Eastern railway, between Folkestone and Boulogne. The dimensions of this vessel were the largest that Company's harbour at Folkestone in its present state would admit, viz., length, 250 feet; breadth of hull, 30 feet; extreme breadth from outside to outside of paddle-boxes, 50 feet; load draught with five hundred passengers and 80 tons of cargo and coals, 8 feet; engine power, 2,500 HP. indicated; and estimated speed 18·37 knots per hour. The saloon formed an integral part of the ship, contributing enormously to its strength and rigidity. On the other hand, the saloons of ordinary vessels were mere deck-houses, adding further burthens to long beams and slender scantlings, already suffering under severe stresses from ever present and ever varying contortional strains. The iron walls of the saloon were continued down to the double bottom formed by the base of the central box-girder chamber; an iron deck constituted the floor of the saloon, and nearly all the space below this was devoted to the engine power and to the service of the ship. The top of the saloon afforded a promenade, which, from its height above the sea, would be available in almost any weather, and in summer would give accommodation to a considerable addition to the five hundred passengers which were regarded as the ordinary freight. The motive power was disposed in three distinct sections of the middle division, of which the engines themselves occupied the central one, the boilers being respectively placed in the forward and after ones. By this arrangement the whole of the middle body of the saloon was preserved for the best accommodation of first-class passengers. It was naturally the part of least motion in the entire vessel—a consideration of the very highest value for the comfort of the passengers. By this disposition of the motive power, other and very important advantages were attained. Thus, in the case of collision, if even the inner girder of the central tubular chamber should be pierced, which was not likely, and one of the boiler compartments were thus to be filled with water, the other boiler compartment would remain intact, and the engines would be supplied with steam to the extent at least of half-boiler power. As to the engines themselves, protected as their compartment was, not only by the double iron wall of inner longitudinal

Mr. Mackie.

Mr. Mackie. girder and outer skin, but further defended by the projecting paddle-boxes and sponsons, it was not easy to believe they could receive, in even the most extreme degree of violence in collision, any disabling damage; and if they were, as according to his own views they should be, independently fitted to each paddle-wheel, their complete derangement would be next to impossible. Under the existing arrangements of ordinary ships, where the boilers and engines were in the closest proximity, considerable inconvenience from heat would be experienced in that part of the saloon disposed over them; but in the present plan the heat from the boilers was minimised by the distance at which one half the furnaces were placed from the other half of the furnaces, whilst very little heat indeed was given off from the cylinders of the engines themselves; so that, in the present instance, any slight increase of temperature from these causes was kept so low as to be of no practical consequence. The steam was conveyed in covered pipes in the cellular spaces between the outer skin and the inner longitudinal girder on each side of the engine-room, and consequently no inconvenience arose from this source. The construction of the saloon, moreover, allowed of perfect ventilation, and was such as under ordinary circumstances would provide against any discomforts from overheated atmosphere. In the case of grounding, the double bottom of the safety vessel would form an effective protection; and in such circumstances as running on a rock at full speed, and remaining on the fall of the tide, with such long overhangs that the weight of the cargo would inevitably break an ordinary vessel in twain, the longitudinal girders of the central box-girder chamber would be equal to the strains, and everything would remain as secure in the ship as the goods or passengers in a train passing through the Menai or the Conway bridge. The final subject for notice in the description of the model vessel was her speed, for engines of such power could not be worked at such extraordinary rates of revolutions in any ordinary light-draught vessel without ceaseless and serious depreciations of the hull, through the irresistible vibrations propagated through its ill-constructed fabric, whilst the engines themselves were liable constantly to injury from heated bearings and other evils of contortional strains. The rigidity of the box-girder central chamber, the shortness of all bearings in consequence of its construction, and the supports which the longitudinal girders gave to the paddle-shafting and to the framings of the cylinders, were such, that vibration would be prevented by the smoothness with which the vessels would run under such advantageous conditions, to say

Mr. Mackie.

nothing of the disposition of the materials of the safety-hull for encountering such vibrations if they could arise. It might here be incidentally remarked that such a speed as over 18 knots per hour was not conceived by previous designers for steamers of such limited dimensions, and adapted for that particular service. It was as unnecessary as it would be out of place to dwell at greater length upon sea-going vessels, and the example brought forward was only introduced because it was clear that, with obvious modifications, it would be as much the type of a true river-steamer as in its actual form it was an effective type of ship for channel passage. Whatever in its fundamental principles was important in regard to strength and security, was not less but more important in vessels adapted for river services, where the freights carried were almost always and entirely passengers, and in regard to which security to life ought to be alike the primary foundation of the principles of construction, and the ground of official certificate for plying with passengers. To begin in such onerous services with utterly insecure hulls, and to trust to life-buoys and floating-seats in a first as well as last emergency was radically wrong. The fundamental object in the design of such steamers ought to be the preservation at all times of sufficient buoyancy in the hull itself to secure its flotation under even extreme conditions. This was most certainly to be relied upon by having the reserved buoyancy spaces devoted to that purpose specially, and not to be used for anything else whatever. One could not say this could only be done by the double-skin system of construction, of which the model was an example; but one might say that under no other than similar circumstances would the reserved spaces be likely to be kept in a condition of reliability in sudden emergencies. The inter-cellular system between the longitudinal girders and the outer skin was one which caused the least inconvenience in the arrangement of the internal capacity of the hull; and two light-class steamers for river and canal traffic which were designed in 1870–1, were examples of how much could be made and done upon the central tubular-chamber system for the real accommodation of travellers. Both these vessels, the one intended for the Thames stations and the other for one of the Austrian canals, were adapted to the system of hydraulic propulsion, at that time proposed, and which it was still considered would be the best suited for river or canal purposes. It would be clear, however, that if the hydraulic propulsion were put aside for the ordinary paddle or screw, that vessels could be produced far more efficient and incomparably safer than either of those employed at the

Mr. Mackie. present time on the Thames or the Clyde. For river work, where there was putting alongside of quays or piers every few minutes, and where excessive speed was not an object, and ordinary speeds of 10 or 12 miles an hour the utmost working speed attained, the hydraulic propulsion would give the advantage of an unobstructed ship side, and this condition had also been availed for giving greater facilities of ingress or egress for passengers by means of landings specially formed by the turn-over of the bulwarks. Another advantage of the hydraulic system was its capacity for the rapid handling of the vessel. By it all degrees of turning-power were available, up to actually pivoting the ship by turning one current ahead, and the other current astern. The saloon need not be entirely above deck, but might be partially seated in the hull proper, so as to leave a portion only of its elevation exposed above the deck-line. The subdivisions of the boilers and engine would have a very high value in such river vessels as were of sufficient dimensions to permit its adoption; and there were very few, if any, in which protection by longitudinal girders could not be adopted. The subdivision of the motive power ought to be insisted on authoritatively in all the larger passenger vessels, particularly those employed for excursions, such as the saloon boats of the Thames or Clyde, where from five hundred to one thousand or more passengers were carried on holiday excursions. No door openings were permitted in the sides of the saloon; the passengers should all enter the saloon from above, or at least from a break of some height above the deck proper. By this means a space of deck was left all round for the proper working of the ship by the crew; and the raised portion of the saloon always thus remained as a combing to keep out the water from the central tubular chamber, even if the deck proper were actually submerged, or a part of it immersed. He might be pardoned for asking the mental comparison of a vessel so constructed with the common sight of one of the Thames saloon-boats in the summer, with scores of hands out of the ports waving handkerchiefs, or dipping them in the waves of the currents from the paddles, the whole vessel swaying from side to side with the motion of its living freight, any sudden rush of which, in any impulse, might bring in the flood through those fatal windows, at best only a foot or two above the level of the steamer's draught. In river-boats, the imperforate character of the ship's side, and of the longitudinal girders, were the most important elements of safety, and any opening in either ought never to be permitted. In conclusion, he would only add that the imperforate condition of the longitudinal girders in sea-going vessels was not only of value in protecting the ship from the dangers of leakage and sinking, but the triple division of the hulls of cargo vessels had the further advantage of preventing those shiftings of cargo in stormy weather which so often led to the abandonment, or not unfrequently the total loss, of the ship. Mr. Mackie.

Captain Bedford Pim, R.N., M.P., stated that he knew the Thames, the Mersey, the Clyde, and the nature of the passenger steamers plying upon those rivers. He knew something also of the river steamers of Europe, Asia, Africa, and America, and he had no hesitation in saying that the English people had the worst service of river passenger traffic in the world. That on the Mersey was the best in Great Britain, because it was an imitation of the American system. It would be amusing, if it were not humiliating, to hear the comments of Americans on the Thames passenger steamers, of which they expressed their disgust in no measured terms; in fact, there was only one redeeming feature about the service, and that was the great skill with which the vessels were handled by the Watermen and Lightermen of the river, who fortunately for the public must be employed to navigate the steamers; every exertion ought to be made to encourage so useful and trustworthy a body of men. It was not too much to say that if one of her own crew had been at the wheel of the "Princess Alice" instead of a stranger, the collision between that vessel and the "Bywell Castle" might have been avoided. Several points in the Paper cropped up which should be explained; for instance, speaking of the vessels on the Thames above bridge the Author said that under the circumstances of dealing with the traffic of a restricted and crowded smooth water area, "great strength of hull would defeat its object." The Author would perhaps be surprised to hear that the above-bridge boats were stronger than those below. First, because they were not out of all proportion too long for their beam, and secondly, because strength was specially secured by the simple expedient of placing a timber stringer fore and aft on each side of the vessel below the deck, so that another craft running into her would have to cut through this stringer, which he thought was (for he feared the new boats were not built in this way) 12 inches wide by 6 inches thick, before knocking a hole through the skin. The Author also pointed out that "high speeds and large carrying power lead to the employment of long vessels." But Captain Bedford Pim considered the employment of long vessels a great mistake, not to say a blunder. Captain Pim.

Captain Pim. Compare the "Princess Alice," for example, with a Hudson river boat. The former was 220 feet long by 20 feet wide, and 7 feet deep; in other words, eleven times her beam for length, and thirty times her depth for length, the extreme breadth between the paddle-boxes being 37 feet. It was hard to speak of such a vessel with patience. She was a mere gas-pipe cut off to measure and sharpened at both ends. The exact shape might be made clear to any reader of a penny newspaper; if he would cut a column of that paper and add one sixth to it, he would find it eleven times the breadth to the length, the proportions of the "Princess Alice," and of other river boats also. It must be apparent to everybody that a slight blow struck near amidships was quite sufficient to destroy such a craft. The force of the blow of the "Bywell Castle" had been described as a mere kiss; but, nevertheless, the "Princess Alice" actually parted in halves immediately, and so completely that the foremost half turned round and headed down stream before it sank. In fact, directly a ship was lengthened, the risks increased, and the vessel became more unseaworthy. It was astonishing that long vessels of the "Princess Alice" type were allowed to run on the Thames below bridge, where the traffic was not, as the Author stated, "end on," as was proved by the collisions taking place in nine cases out of ten before or even abaft the beam. He believed that if the Board of Trade did their duty, and strictly enforced the law laid down in the Merchant Shipping Act of 1854, which enacted that two surveyors, a shipwright surveyor as well as an engineer surveyor, must certify to the fitness of the steamer for service, there would be a decided falling off in shipping disasters. The last return (1877–8), for instance, showed wrecks, casualties, and collisions in or near the coasts of the United Kingdom, amounting to three thousand six hundred and forty-one, or nearly ten a day, with, of course, the usual proportion of lives lost. In fact, the state of the Mercantile Marine and the passenger steamers of our rivers was disgraceful. When he reflected on the difference between our river passenger steamers and those of the United States, he was surprised that the English public were content with such wretched accommodation. He knew of no American river boat more than six times its beam for length at the outside; generally it was five, and even that was below the overhang. It could, therefore, readily be understood how much more handy American vessels were than vessels of the "Princess Alice" type, of eleven times their beam, to say nothing of their great additional safety and buoyancy. But the most important feature, so far as safety was concerned, lay in the overhang, or strong deck, extending several feet beyond the hull, and which, in the event of a collision, acted as a fender. The characteristics of the river passenger steamers in American waters were great speed, handiness, comfort, stability, buoyancy, and seaworthiness, and great strength and durability, in all of which attributes English vessels were lamentably deficient. To give an idea of the speed and comfort of these vessels, he might mention one or two instances. He made a passage in the old "Constitution," from Newport, Rhode Island, in winter, up Long Island Sound to New York, the first part of the voyage exposed to the full roll of the Atlantic waves. There were nearly one thousand passengers on board; the ship drew 9 feet of water, and travelled easily at the rate of 17 miles an hour. There were sleeping berths for all, from a splendid cabin lit by gas, and with hot and cold water laid on, to the common bunks for emigrants. The main saloon was covered with Brussels carpet; and easy chairs, not secured to the deck, thus showing the smooth motion of the ship, invited in every direction the passengers to be seated. In these chairs many passengers slept to save the cost of a cabin. He afterwards went up the Hudson in a similar vessel, but at an average speed of nearly 18 miles an hour the best part of the way from New York to Albany. With regard to strength he had a most unpleasant opportunity of testing that point. Coming up from Grey Town, Nicaragua, in the "Santiago de Cuba," the steamer ran on shore northward of Cape Hatteras, with a nasty sea on, and unfortunately several of the passengers were lost in trying to land through the surf. The ship, however, held together, and when the weather moderated she was got off with but little damage to the wooden hull. He thought he had said enough to show the immense superiority of the American river boats over English boats. He hoped the Institution of Civil Engineers would be the means of directing attention to the fact, that long narrow vessels were not adapted for either sea or river traffic, for they could not answer the helm as quickly as necessary, they had little inherent stability, comparatively poor accommodation, and were certainly not faster than the beamy American boats, while, beyond question, they were more risky. He might mention that the hull of long vessels actually cost more than the hull of short ones, and this could be proved by the following method: A and B were vessels of the same tonnage, the cubic contents being 972 each; A had a length of 270 feet, beam 30 feet, depth 30 feet, and all round measurement of 540 feet. B had a length of 180 feet, beam 45 feet, depth 30 feet, and all round measurement of 360 feet. Now it would be seen that the Captain Pim.

Captain Pim. long narrow ship, with the same depth of hold as the broad one had, was nevertheless 180 feet more in circumference, and therefore cost so much more for materials and workmanship, to say nothing of increased friction. Moreover, the strain, the wear and tear, and the consequent additional outlay for repairs, putting on one side the extreme uneasiness of these long vessels, was surely sufficient to condemn them. He was at a loss to understand why such a form was still adhered to, particularly when, as was now proved, the natural shape of ships was in every respect so far preferable. In conclusion, he wished to point out that no matter how great the skill of the naval architect, how conscientious the workmanship of the builder, or how scientifically strengthened the vessel might be, all was of no avail without men to navigate it, brave, ever watchful, well trained, such as were happily found in the Watermen and Lightermen of the River Thames.

Mr. Robinson. Mr. W. C. Robinson remarked that the through passenger traffic on the River Rhine from Mannheim to Rotterdam was in the hands of two companies, the Cologne-Dusseldorf Steam Co., and the Netherlands Steam Co. The boats of the latter company ran a mixed goods and passenger traffic; whereas the former company had in its hands the bulk of the great summer passenger traffic on that part of the river which offered most interest in its scenery between Bonn and Mainz. There was nothing particularly worthy of notice in the ordinary steamers of either company; they were almost without exception constructed on an old-fashioned, but practical paddle-steamer model, imported from the Thames in the year 1839, and which had not been materially departed from since. They had generally three bulkheads, but no great attention was paid to watertight compartments, the river being nowhere very deep, and the risk of sinking therefore hardly worthy of consideration. The engines were, as a rule, low pressure, not compounded; the price of coal being moderate, as the river skirted the great Westphalian coal basin, the passenger steamship companies had not yet adopted the newer system, whereas the tugs and cargo steamers had nearly universally done so. The last steamer from England was imported in 1845, since which time both companies had constructed their boats in Holland, the Cologne-Dusseldorf Co. at the wharf of Mr. L. Smit, at the Kinderdijk, a well-known and successful builder of iron steamers; and the Netherlands Co. at their own wharf at Fyenoord, near Rotterdam. In the year 1869–70 the Cologne-Dusseldorf Co. constructed four saloon passenger boats on the most approved model, under the inspection of their technical manager, Mr. Dietze, through whose kindness he was able to supply a diagram (Plate 8) of these steamers. They had proved very successful. They could carry one thousand passengers each, and had more than once transported a whole infantry battalion (one thousand men) with all effects, &c.; they could comfortably accommodate six hundred passengers, with luggage, and could dine one hundred and seventy-five persons in their excellently arranged deck saloon, whose large and high windows permitted an uninterrupted view of the scenery on both sides. These boats had also three compartments, and had no special safety arrangements in case of collision; but the risk was a minimum one. They ran from Mainz to Cologne. The following were the particulars of construction, speed, &c.: Length, 260 feet; breadth, 24 feet; draught, $3\frac{4}{5}$ feet; displacement, 355 tons; HP., 140 nominal, and 900 indicated; revolutions, 43 per minute; the engines were low pressure, by Ravenhill, Salkeld & Co.; the cylinders 46 inches in diameter, and the length of stroke 4 feet; the coal consumption was 3,248 lbs. per hour, or 3·6 lbs. per indicated HP.; the maximum steam pressure was 30 lbs. per square inch, and the vessel attained a speed of $13\frac{1}{2}$ knots per hour. Mr. Robinson.

There were numerous small local passenger steamers on the upper and middle Rhine, generally, however, of an antiquated model and of inferior construction, cheapness being in all these cases too much a desideratum in Germany. Nor did the Dutch passenger steamers, plying from Rotterdam to the interior of Holland, offer much to remark upon. They were, as a rule, much better constructed than the German boats of the same class; cattle and goods traffic were combined with passenger accommodation of a very modest description. The paddle steamers plying between Rotterdam, Dordrecht, Gorinchem, Bois-le-Duc, Middleburg, Brielle, &c., were generally old boats of a type of hull used thirty years ago in England. Lately, however, a few steamers of improved model had been introduced on the more frequented passenger routes. For canal navigation small screw steamers were employed in great number. The bulk of the ferry steamers on the Rhine were small, old, and of obsolete construction. The Rhenish Railway Co. had constructed at Griethausen, near Cleve, and at Bonn, steam ferry-pontoons which took a whole train across the stream at once, by an engine hauling on a wire rope stretched across the bed of the river.

Mr. DAVID ROWAN observed that one danger to river steamers which had not been referred to, but which might be peculiar to the Mr. Rowan.

Mr. Rowan. Clyde, was that in that river there were many timber ponds, especially about Port Glasgow. These were not well protected, and in stormy weather the logs not unfrequently got adrift. The Clyde Trustees exercised considerable vigilance in looking after and picking these up. He had known upwards of one hundred of them collected at one time, floating about and lying on the banks within the jurisdiction of the Trust. When these logs were hard wood floating all but submerged they were not easily seen, and if any of the river steamers when at full speed were to strike one in the right place and the log in the proper direction, no doubt it would break the plate and cause disaster.

Mr. Sharrock. Mr. S. Sharrock offered the following remarks on the ground of actual long experience in the designing and constructing of many light and shallow draught vessels for Indian and other foreign rivers. In his opinion the chief and most essential structural conditions to be secured in these vessels were the following:—

1st. Such vessels being necessarily very light, a far higher quality of iron should be insisted upon in their construction than was usual for sea-going vessels.

2nd. More numerous and really watertight bulkheads than was customary in river steamers were essential, both transversely and longitudinally. Whilst these bulkheads, so far as the plating was concerned, must be light, yet they should have sufficient lateral stiffness, by ribs or frames, as to be able to resist any possible maximum head of water without collapsing or bulging in.

3rd. Owing to their frequent small depth in proportion to length, special attention was needed to secure strength at the deck level, in order to permanently resist the stresses occasioned by an unequal or severe local loading by machinery, passengers, water in compartments, or grounding in shallow rivers or on the banks, and much more strength than was customary was needed at the waterway plates or deck stringers to resist either tension or compression.

4th. The riveting of these light vessels should be of a special character, viz., the longitudinal seams of skin plating should be double riveted, and the butt ends of plates should be treble riveted.

With regard to the principle upon which the number of watertight compartments should be determined, he was fully of opinion that they should be of such number as would enable the vessel to carry her load safely with any one of her compartments completely broken into by collision. No doubt the owners of such craft must be required to provide able and experienced commanders, careful, and with the fertility of resource derived from long experience. Yet he was convinced the above structural conditions were quite as essential, and quite as necessary to avoid loss of life. Mr. Sharrock.

Mr. J. Evelyn Williams agreed with the Author as to the points of importance to be studied in designing river passenger steamers. He would, however, like to add another point, viz., that in all cases where the cabin was situated below deck, ample and easy means of exit should be provided in case of emergency. In some river passenger steamers the cabin was a long triangular cavern below deck at the extreme end of the vessel, and from which the deck was only gained by a fixed step-ladder or straight narrow stairs. In the event of collision the loss of life for want of proper and easy means of exit from these cabins might be serious. Mr. Williams.

The hulls of all river passenger steamers should be subdivided into a series of compartments by perfectly watertight bulkheads, the distance between any two adjacent bulkheads should be so regulated that the vessel would float safely were any one of the compartments to be filled with water, or be placed in free communication with the sea. In cross-river traffic the main deck of the vessel should be carried out on each side so as to form a continuous fender or sponson to protect the hull proper in the event of collision. In designing vessels for such traffic, buoyancy and staunchness should be more important elements of consideration than high speed and luxurious saloons.

In cross-river traffic, such as that on the Mersey, exterior means should also be adopted for further protecting human life, and to minimise the risks of collision on rapid tidal streams; for example, the principal ferry track across stream should be defined laterally by means of a floating beacon anchored in mid-stream on each margin of the track. These beacons should exhibit an electric light at night, and sound a powerful horn or bell during fogs. Within the limits of the ferry track so defined, steamers going up or down stream should proceed with extra caution and slackened speed, and be strictly prohibited from anchoring there. Thus a clear and defined ferry track would be secured, and the risks attending cross-river traffic would be considerably diminished. Further, in the case of all river passenger traffic, clear and definite steering signals should be understood, so that in the event of vessels approaching each other, the steam whistle sounded, say twice, should mean "I port," or "I starboard," as the case

Mr. Williams. might be; the intended course of the approaching vessels would thus be definitely known, and the uncertainty and confusion which so often resulted in collision and loss of life would be avoided.

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9 and 16 December, 1879.

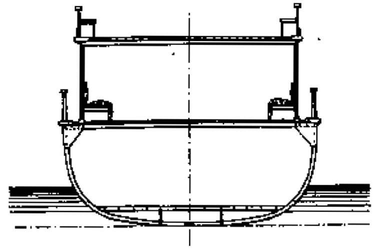
WILLIAM HENRY BARLOW, F.R.S., Vice-President, in the Chair.

The discussion upon Mr. Carson's Paper, on "Passenger River Steamers," occupied both evenings.

PASSENGER RIVER STEAMERS.

ON THE RHINE.

PLATE 8.



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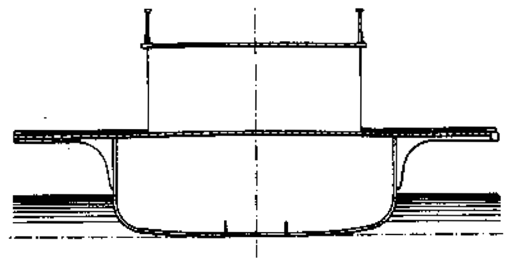

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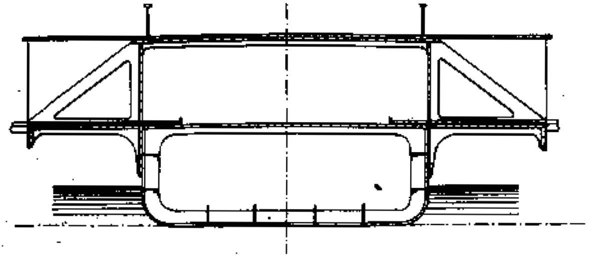

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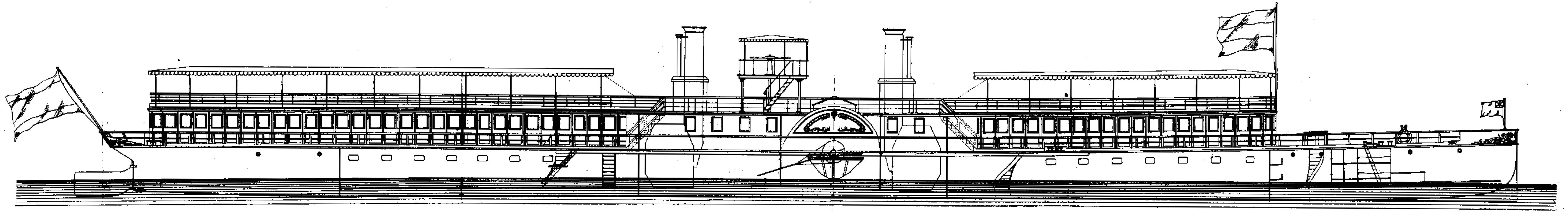
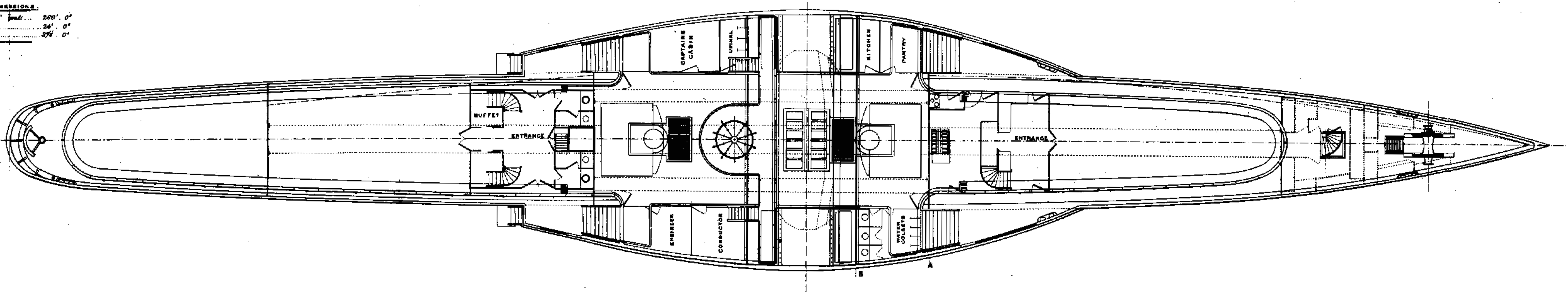


DIMENSIONS.

Length of boat	260′. 0″
Breadth	24′. 0″
Draught	3⅞′. 0″



Scale 1/16 Inch = 1 Foot.

Feet 10 5 0 10 20 30 40 50 Feet

W. C. ROBINSON DELT

THOS KELL LITH 40, KING ST COVENT GARDEN.