REPORT

OF

THE COMMISSION APPOINTED BY THE HON. EAST INDIA COMPANY

TO VISIT THE RIVERS

DANUBE AND RHONE,

WITH

THE VIEW OF OBTAINING A CONCLUSIVE OPINION UPON THE

DESCRIPTION OF BOAT ADAPTED FOR THE

RIVERS IN INDIA.

(Amended Issue.)

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features in some others, respecting which we have been less fortunate in gaining information, and to which we are free to admit the possibility that our conclusions may, to a certain extent, be found inapplicable, still the general characteristics of all would appear to be very similar.

During the whole time thus occupied, we have engaged ourselves in carefully embodying the information collected, and, for the more ready means of clearly defining the different subjects, have divided them in sections, thus:

SECTION 1—Is devoted to the navigation and leading peculiarities of the rivers Rhine, Danube, Rhone, Saone, and Seine, together with some remarks on a peculiar means of transport employed on the Clyde; and further, it contains some notes regarding the river navigation of the United States.

SECTION 2—Treats on the general features of Indian rivers, and the mode of navigation hitherto adopted, the principal remarks applying to the Indus and its tributaries; but further noting the Euphrates, the Ganges and its tributaries, and the Godavery.

SECTION 3—Embodies the opinions and results at which we have arrived regarding the best means for the future and more extended navigation of these rivers.

And lastly, in an Appendix, will be found the principal reasons on which our conclusions regarding the machinery are based, and a statement of the opinions of various shipbuilders and engineers, which, for easy means of comparison, we have given in a tabular form.

We finally here wish prominently to thank all those gentlemen with whom we have been in communication for the readiness with which they have placed their valuable time and information at our service; and we would also beg most cordially to acknowledge the courtesy and liberality with which the Directors and officers of the Imperial and Royal Danube Steam Navigation Company, as well as of the various Companies on the Rhone and Saone, have attended to our inquiries, and given us the results of their extended experience.

We have the honour to be,

SIR,

Your most obedient humble Servants,

J. H. G. CRAWFORD,
Major, Engineers.

W. BALFOUR,
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SECTION I.

On the Steam Navigation and General Features of the Rivers Danube, Rhone, &c. &c.

In order to visit the rivers Danube and Rhone, we have necessarily travelled over a considerable extent of country, and in so doing, wherever practicable, have made use of water conveyance, thinking we should be more fully carrying out the wishes of the Honourable Court by taking every chance of gaining information relative to river navigation, which might fall within our reach.

Our route was therefore direct to Cologne, whence we ascended the Rhine to Mayence.

The general features of this river are so well known, that we need here do no more than remark that, as a rule, it runs at a speed of about 3½ miles per hour, increased at such parts as the rapids of Bingen and St. Goar to 4 or 5 miles. The only real difficulties on the main part of the river have been much reduced by blasting, and are no longer serious. With the exception of a few deep places, it is generally very shallow, and at some parts the water, during summer, is not more than 3 ft. 6 in. deep. The bottom is usually of sand or mud.

The following are examples of the dimensions of boats used in its navigation. There is nothing peculiar in their form of model, and the cabins are below deck:—

	Ft.	In.
Length	150	0
Beam	20	0
Draught, including load	3	0

Engines, nominal, 100 horse-power.
Speed, about 9 miles per hour.

Another boat.

	Ft.	In.
Length	185	0
Beam	18	6
Draught, with ordinary load	3	9

Engines, nominal, 110 horse-power.
Speed, 11 miles per hour.

And another.

	Ft.	In.
Length	225	0
Beam	18	0
Draught, with ordinary load	3	3

Engines, 120 horse-power.
Speed, 11½ miles per hour.

The comparatively low speed must be attributed to the constant shallowness of the river.

All the engines which we saw were on the ordinary condensing principle; but we understand that one or two of the tug-boats are fitted with non-condensing engines.

From Mayence we took rail to Frankfort, the river Maine being so low as to prevent the passage of the steam-boats, which, however, are very small, with engines of about 40 horse-power, and a draught of about 16 inches. From Frankfort we proceeded to Ulm in Wurtemburg, near the Bavarian frontier, where we had been informed the steam navigation of the Danube commenced; but in this we were disappointed; the attempt had been made, but not proving a successful speculation, was soon discontinued, and the railway is now open to Donauwörth, about 40 miles lower down, the highest point to which steamers ascend.

THE DANUBE.

The Danube.

The Danube rises at Donaueschingen, in Suabia, about 100 miles above Ulm, and 1,700 from the sea, 1,560 of which are navigated by steam. At Ulm it is comparatively a small river, here about 1,500 feet above the sea, and the length of its course being 1,600 miles, gives an average fall of nearly 1 foot per mile. In so large a river there is, as might be anticipated, a great variety in the nature and character of the stream itself, its banks, and the neighbouring country. Its general course is remarkably tortuous, and below Vienna it is almost entirely bounded by its natural banks; in its higher parts, however, extensive operations have been effected for controlling and thus deepening the channel. Its breadth and depth vary very much, not only in different parts, but also according to the season of the year: it is frequently divided into many channels and intersected by archipelagos of islands, which spread it on a chart to a vast width; as for instance, just below Presburg, where, measuring over all, it is stated to be 15 miles wide; in many places again, where the land is very flat, a few feet rise of the river puts miles of country under water, giving it, in winter, quite the appearance of a lake. The navigation is continued throughout the year, with the exception of about two months, when it is stopped by the ice.

The first steamer was placed on the Danube in 1830—more than 150 are now engaged in navigating its waters, together with 500 iron barges for carrying merchandise, irrespective of the wooden boats of the country.

Approximate details, showing the breadth and depth of the main channel in low seasons, are given under the heads describing the various sections into which the river is divided for the purposes of navigation, which are as follows:—

1st. Between Donauwörth and Linz.
2nd. „ Linz and Vienna.
3rd. „ Vienna and Pesth.
4th. „ Pesth and Galatz.
5th. „ Galatz and the Black Sea, *viâ* the Soulina mouth.
6th. The special local service at the rapids of the "Iron Gates."

Our visit was from the middle of August to the early part of September, at which time there is generally least water; but owing to the continued dry weather, the river has been unusually low during the past summer, and a further subsequent fall stopped the navigation of the "Iron Gates."

Taking the above heads in succession, we will describe the navigation.

1st.—Between Donauwörth and Linz.

The distance is 270 miles; the breadth at the former place is 300 feet, and increases until it becomes 828 feet at the latter. 1st Section.

The depth is very variable, but ordinarily there is an average of 4 ft. 6 in. in summer, and 7 ft. 6 in. in winter; sand-banks, however, are of frequent occurrence, which materially diminish the available depth. The steamers in which we travelled were drawing less than 2 feet of water, and had difficulty in passing at several points.

The speed of the current is over 5 miles per hour, and the average fall of the river is $2\frac{1}{2}$ feet per mile.

There are no peculiar obstacles to the navigation of this portion of the river, excepting a badly-planned bridge at Ratisbon, which so obstructs the stream as to render it expedient to employ separate boats above and below.

The boats on this section, belonging to a Bavarian company, vary from 130 to 150 feet long, and from 12 ft. 6 in. to 15 feet beam, with a draught of from 1 ft. 6 in. to 2 feet, with working weights on board.

The engines are all high pressure non-condensers, bolted to their boilers, and working much in the same manner as a locomotive at 100 lbs. pressure, and are about 120 horse-power. Their speed is about 8 miles per hour.

The passenger-boats have cabin accommodation of a simple kind below deck, and carry no goods beyond ordinary luggage. The goods traffic is carried on in barges, towed by steamers kept for that purpose.

There is nothing extraordinary in the construction of these boats; they are of an inferior class, make but little speed compared to their power, and carry very little without putting them too deep in the water for their work.

2nd.—Between Linz and Vienna.

Linz is the highest station on the river served by the steamers of the "Imperial and Royal Danube Steam Navigation Company," although their barges loaded with goods destined for places still higher, go as far as Donauwörth. 2nd Section.

The Company possesses 118 steamers, and more than 500 barges: all of these are built of iron, and the engines are on the ordinary condensing principle, working with steam of about 15 lbs. pressure.

The goods traffic is carried on by three classes of boats.

1st. In barges towed by steam tugs.
2nd. In cargo-steamers propelled by paddle-wheels.
3rd. In ditto propelled by screws.

The distance between Linz and Vienna is 119 miles.

The breadth increases from 828 feet to 1,737 feet at Nussdorf, the station on the main stream for Vienna.

The depth varies from 5 feet at the former to 7 feet at the latter place, but again is interrupted by shallow bars or sand-banks, which occasion the greatest efficient draught of the steamers to be reduced to 3 ft. 6 in.

The speed of the current is about 4½ miles average, and the fall of the bed is 2 feet per mile.

The rapids called Greiner Schwall, Wirbel, and Strudel, occur in this portion of the river; the stream at these places runs from 5 to 7 miles per hour, the river-bed at the Strudel falling 1 in 200. These have been among the greatest difficulties in the navigation of the Danube, but by blasting, sufficient water has now been gained to allow the ordinary steamers to pass without danger.

The boats here employed are far superior to those described in the preceding section, but have nothing peculiar in their construction; the cabins are better arranged, but are below deck; and indeed they very much resemble the general class of larger boats employed in such numbers on the Thames and Clyde.

The dimensions of the most successful passenger-boats are:—

	Ft.	In.
Length	184	0
Beam	23	0
Depth	9	0
Ordinary working draught	3	3

Engines, nominal, 120 horse-power.
Ditto, effective, 300 horse-power.
Speed, from 10 to 11 miles per hour.

The tug-steamers here in use are:—

	Ft.	In.
Length	195	0
Beam	23	0
Depth	8	0
Ordinary working draught	3	0

Engines, nominal, 100 horse-power.
Ditto, effective, 300 horse-power.

The paddle-wheel goods-boats are:—

	Ft.	In.
Length	171	0
Beam	20	3
Depth	8	0
Light draught	2	10

Engines, nominal, 80 horse-power.
Ditto, effective, 230 horse-power.

The iron barges chiefly used are:—

	Ft.	In.
Length	180	0
Beam	21	0
Depth	8	6
Draught, light	2	0
Ditto, with 300 tons	5	0

They are loaded according to the depth of the river.

The screw cargo-boats do not run above Vienna.

Small passenger-boats of the following dimensions run from Nussdorf through the canal to Vienna, about 5 miles:—

	Ft.	In.
Length	120	0
Beam	12	0
Depth	6	10
Ordinary working draught	1	3

Engines, 24 horse-power.

They are simply adapted to the local service, and are not employed on the main river.

3rd.—Between Vienna and Pesth.

The distance is 172 miles. 3rd Section.

The breadth begins at 1,737 feet, and at its widest single stream is about 2,500 feet; at Pesth it is reduced to 1,500 feet.

The depth is from 7 to 10 feet, but the frequent shallow places do not admit of more than 5 feet draught, and the boats are most successful when only drawing about 3 ft. 6 in.

The ordinary speed of the current is about 3½ miles per hour.

The fall of the bed is about 6 inches per mile.

There are no serious difficulties to navigation on this portion of the river.

The passenger-boats are very similar to those employed between Vienna and Linz, and require no further description.

The dimensions of the best boats are:—

	Ft.	In.
Length	200	0
Beam	19	0
Depth	9	6
Ordinary working draught	3	3

Engines, nominal, 150 horse-power.
Ditto, effective, 360 horse-power.
Speed, 11 to 12 miles per hour.

Tug-Boats.

	Ft.	In.
Length	195	0
Beam	23	0
Depth	8	0
Ordinary working draught, about	3	2

Engines, nominal, 100 horse-power.
Ditto, effective, 250 horse-power.

The larger tug-boats and screw cargo-boats described under the next head as running below Pesth, are also employed on this station when required.

4th.—Between Pesth and Galatz.

At Pesth the Company have established their principal workshops, &c. for building and repairing their boats and machinery. Upwards of 3,000 men are thus employed at busy seasons, and the arrangements are most complete in every respect. 4th Section.

Between Pesth and Galatz are the celebrated rapids of the "Iron Gates," near Orsova, where, during summer, the depth of water varies from 1 foot to 2 ft. 6 in., and consequently special arrangements for the transhipment of passengers and goods are here required, as described under the 6th section of this river. During the winter months there is sufficient water to allow the same boats to run through to Galatz.

Below the "Iron Gates" are several shallow places, and one near Sistova, consisting of a sunken rock, is dangerous to pilots unaccustomed to the river; but there is a channel which will almost always allow the passage of boats drawing 4 feet of water.

The distance from Pesth to Galatz is 875 miles.

The breadth of the river increases considerably soon after leaving Pesth. A few miles below that place it is 2,500 feet wide; below Belgrade it is 4,000 feet wide; at the defile of Kasan, near Orsova, it is only 480 feet; at the "Iron Gates," about 4,200 feet; and below this, from 5,000 to 8,000 feet.

The depth of the river is as variable as its breadth. Its ordinary depth is about 12 feet, but the shallow places and shifting sand-banks are so numerous as to make this merely a nominal measure. In the steamers by which we travelled, drawing nearly 4 feet, we twice had difficulty in finding sufficient water, and several times were obliged to run almost directly across the stream in following the channel. The deepest place is at the defile of Kasan, where the depth is 170 feet, and the shallowest at the "Iron Gates," only some 25 miles lower down.

The average speed of the current throughout the whole distance does not exceed 2 miles per hour. The fall of the bed is between 4 and 5 inches per mile.

The boats employed on this section are very different, and far superior to those trading higher up; indeed Donauwörth, Linz, Vienna, and Pesth being approached by railway, almost all travellers prefer this mode of conveyance; the boats, therefore, do not require the class of accommodation which is fairly looked for where the river is the sole means of locomotion.

The passenger-boats are of two classes:—

1st. The "express boats," calling only at principal stations.
2nd. The "omnibus boats," which call everywhere.

The following description of the former applies equally to the latter, with the exception of the extended sponsons and forward deck-house, which are not there supplied.

The express passenger-boats are rather larger than those used on the upper portions of the river, but their draught is not materially increased. New boats are now being built of still greater size.

In their model every care has been taken to obtain the due amount of carrying capacity, with the least resistance to speed; but beyond being very fine samples of river-boats, there is nothing remarkable in their form below water. The saloons are in deck-houses abaft the engines; similar erections forward and on the sponsons being divided into private cabins for passengers and the chief officers. The main sleeping accommodation is below deck. The paddle-wheel sponsons are continued all fore and aft, and form a very spacious deck. An additional promenade-deck is made on the top of the saloons. The whole boat during the day in summer is covered with awnings; and very good arrangements are made for ventilation, which, however, do not appear to be so fully appreciated as would be the case in a tropical climate.

A hot-water apparatus is fitted up in the engine-room, with pipes leading to the saloons and cabins, for use during the severe weather in winter. A spare movable capstan is carried, to render assistance in heaving the boats afloat, should they run aground; but by all accounts these casualties are of comparatively rare occurrence; indeed, as the boats run usually at night, and always when it is moonlight, the difficulties cannot be either so great or so numerous as is commonly supposed.

The dimensions of these boats are:—

	Ft.	In.
Length	200	0
Beam	26	0
Depth	9	0
Ordinary working draught	3	9

Engines, nominal, 140 horse-power.
Ditto, effective, 330 horse-power.
Speed, 14 miles per hour.

And the omnibus boats:—

	Ft.	In.
Length	215	0
Beam	26	3
Depth	9	0
Ordinary working draught	3	6

Engines, nominal, 150 horse-power.
Ditto, effective, 340 horse-power.
Speed, 14 miles per hour.

Some of the tug-boats are of an extraordinary class and power. Their dimensions are:—

	Ft.	In.
Length	210	0
Beam	30	0
Depth	9	0
Draught	4	0

Engine, effective, 300 horse-power.
The engine is a single cylinder, on the American system, with a huge overhead "beam;" ordinary pressure of steam, about 30 lbs., expanded and condensed.

Another boat:—

	Ft.	In.
Length	220	0
Beam	40	0
Breadth over paddle-boxes	80	0
Depth	9	0
Draught	4	0

Engine, effective, 400 horse-power; on same principle as above noted.

This boat, and another exactly similar, is built of the same breadth abaft as amidships, both below water and on deck; the bottom being sloped up to the water-level for the last 30 or 40 feet, and a trunk formed for the rudder. These tugs are able to tow 16 barges, loaded with an average of 250 tons each, at a speed of 3 miles per hour against a 2-mile current.

There are other tug-boats of a more ordinary form, and engines of a kind we are more accustomed to see in this country, of the following dimensions:—

	Ft.	In.
Length	186	8
Beam	22	9
Draught	3	6

Engines, nominal, 120 horse-power.
Ditto, effective, 320 horse-power.

The screw cargo-boats are of the following dimensions:—

	Ft.	In.
Length	176	0
Beam	25	0
Depth	9	0

Draught, light, 3 ft. 8 in. aft, 0 forward.
Ditto, with 300 tons cargo, average 5 feet.
Engines, nominal, 25 horse-power.
Ditto, effective, 45 horse-power.
Speed, from 5 to 6 miles per hour.

Several of these boats are now in use, and more are building: they are very efficient at the 5-feet draught, but are not of much service when drawing less than that amount. We understand the Company is satisfied if they make one mile per hour against the average current.

5th.—Between Galatz and the Sea, by the Soulina Mouth.

5th Section. This distance is about 120 miles, the breadth is generally about 800 feet; and when the river is low, it would have much the appearance of a canal but for its tortuous windings. In high seasons it is more like an extensive lake.

The depth varies from about 8 feet to 18 feet; and on the bar at the mouth there is but little more than 8 feet. The boat in which we travelled, drawing 7 ft. 6 in., had difficulty in passing at one place, and just touched the ground in crossing the bar out to sea. The bar is very dangerous in bad weather, as is proved by the number of wrecks in its vicinity, forty-two being in sight on the occasion of our visit. The speed of the current is very small, not more than 1 mile per hour.

The boats employed are the same which proceed over sea to Constantinople and Odessa; they are in consequence more strongly built than any higher up.

The best boat is of the following dimensions:—

	Ft.	In.
Length	195	0
Beam	24	0
Depth	12	0
Ordinary working draught	5	3
Ditto, when fully loaded	6	0

Engines, about 200 horse-power.

Others draw more water, but the above is found most efficient.

6th.—The Service of the "Iron Gates."

6th Section. Between Drenkova and Skela Gladova, a distance of about 60 miles, there are several of the greatest difficulties on the Danube. First amongst these, in going down, is the rocky bottom and shallow water known as Islas, followed shortly by a very similar place called Tachtalia. Boats drawing 2 feet of water can, however, always pass these obstacles in ordinarily dry seasons. About 35 miles lower down are the raqids of the "Iron Gates," and beyond them for some miles the bottom is very rocky, and the channel shallow. The worst part of the rapids is little more than 1 mile in length, and in this distance the total fall of the river is 16 feet. During low seasons the aspect of this, the great difficulty of the Danube, is indeed formidable, from the speed of the stream and the amount of broken water. Its successful navigation requires on the part of the steersman an amount of skill and coolness only to be gained by constant practice and unremitting attention.

The breadth of the river is about 4,200 feet, but the navigable channel is only about 200 feet wide; its depth as we passed was under 2 feet. Occasionally it is not more than 1 foot; in which case passengers and goods have to be taken round by land. During winter the depth is about 6 feet.

We were informed the speed of the river at this place is above 10 miles per hour in high seasons, and from 6 to 7 miles at the lowest. We estimated it to be more than the latter, but it would be presumptuous to hazard a decided opinion in water so much disturbed.

At Drenkova or Orsova, according to the depth of water at Islas and Tachtalia, the transhipment of passengers and goods is effected in descending during summer for the passage of the rapids. In ascending the river, the station is either Skela Gladova or Schimian.

The steam-boats employed in this service are of a peculiar class, being fitted with two distinct pairs of engines and four paddle-wheels. They do not carry any baggage; even that belonging to passengers is often towed behind in a small barge.

Their dimensions are:—

	Ft.	In.
Length	150	0
Beam	20	0
Depth	3	0
Ordinary working draught	1	3

Engines, 2 pair, of 20 horse-power each.
Or collectively, 40 horse-power, nominal.
Ditto, 100 horse-power, effective.

The depth, it will be remarked, is very small; but strength is obtained by the introduction of fore and aft bulkheads, which are placed about 14 feet apart, rise 3 ft. 6 in. above the deck, and form the engine-room amidships and small cabins fore and aft.

This arrangement was, we believe, adopted under the impression that it possessed advantages for the peculiar requirements of the case, which were these:—

To have very large power for ascending so rapid a stream, on a draught of water not exceeding 1 foot when light.

The same plan has been adopted in two new boats lately built at Pesth, but not engaged on any station at the time of our visit.

Their dimensions are:—

	Ft.	In.
Length	200	0
Beam	26	0
Draught	2	9

Engines, collectively, 140 horse-power, nominal.

We have been informed that their length is about to be increased by 40 feet.

The result of this experiment we understood to be unsatisfactory; at the same time it is fair to remark that the engines were not in perfect order, and this might occasion a part of the reported loss in the speed, which, with one pair of wheels, has been obtained from the same power.

All these boats are fitted with direct-action condensing engines inclined to the shaft; their stroke short, and wheels of small diameter. The crank-shaft and most of the moving parts are of steel, for the sake of lightness; and, indeed, while due attention is paid to strength, every means has been adopted to reduce the total weight.

We have seen abstracts from the report recently submitted to the French Government by a commission appointed to inquire into the navigation of the Danube. In most important points we agree in their views; but our estimate of the difficulties is not so serious as theirs would appear to be.

THE RHONE.

The Rhone.

The Rhone takes its rise in the Glacier of Furca, on the mountain of Gletcherberg, in Switzerland, from which, following the valleys of the Alps, it runs through the Lake of Geneva, in a S.W. direction, to Lyons, where it takes a bend almost directly south, and, passing through Vienne, Valence, Avignon, Arles, and other well-known towns, falls into the Mediterranean by several mouths, the most navigable of which is about 25 miles west of Marseilles. At Lyons it is joined by its principal tributary, the Saone, which takes its rise in Mount Fosges, in the department of Upper Saone, in France, and passes through Chalons, Macon, and Trévoux.

The Upper Rhone, *i.e.* the part above Lyons, is chiefly dependent on the melting snows of the high land in Switzerland, and is consequently highest during early summer.

The Saone, on the contrary, draining a comparatively low-lying country, is fullest during the rains of winter, and its junction, therefore, tends to equalize the amount of water in the Lower Rhone.

The length of the Upper Rhone is about 230 miles, of which only 80 (between Lyons and Seysell) are navigated by steamers: from Lyons to the sea is 206 miles; making a total navigable length of 286 miles.

The breadth of the river at Lyons varies from 900 feet to 1,500 feet, and in its downward course it is constantly altering, according to the character of its banks and the surrounding country. At Tain, it is about 800 feet, whilst at Pont Saint-Esprit, where it is crossed by one of the longest stone bridges in Europe, it is nearly 3,000 feet. These breadths are subject to considerable variations at different seasons of the year.

The average height of the river allows boats to run drawing 5 feet water below Lyons, and 2 feet above that place. In summer, the available depth of the lower river is seldom less than 3 feet, but on the Upper Rhone barely 2 feet; in very dry seasons, however, boats drawing 2 feet are unable to run below Lyons.

For many years, the Rhone was thought to present insuperable difficulties to steam-navigation; but extensive works were successfully carried out for improving the channel; and the necessities of a large trade demanding transit, at length called forth an energetic attempt, which, proving successful, has led to the adoption of steamers of an extraordinary class, and of proportions probably without a precedent in the world. Their peculiarity consists in great length compared to their beam; in some cases this proportion being as high as 24 to 1, and ordinarily 19 to 1: and it must be noted, that these dimensions have not been arrived at through any dogmatic rule; but as the trade and demand for carrying capacity has increased, the boats have been cut and lengthened from time to time, without producing the difficulties which at first view would be expected from such a course. This gradual increase in length, however, has probably reached its limit, for the investment, proving lucrative, called forth so much competition as to over-supply the demand; and the railway being now opened from Lyons to Marseilles, almost all the passenger-traffic is diverted in that direction, and little is now carried on the river but the most bulky and least valuable goods; showing that the theory of railways being unable to compete with water-carriage does not hold true in every instance.

The difficulties in the navigation are as follows:—

1st. Great uncertainty in the depth of water; sometimes the river being so high as to prevent boats passing the numerous bridges, and again so low as only to allow of an extrêmely limited draught.

2nd. The great speed of the current, which, on an average, below Lyons runs over 5½ miles per hour.

3rd. The formidable cross-currents and eddies occasioned by the tortuousness and narrowness of the channel, as well as by the numerous islands and sandbanks.

There is no part of the Indus which presents greater difficulties than the Rhone at the junction of the Isère, where three currents of great power unite at a point where the river makes a sudden bend, and is much contracted by an island. The steam-boats, however, pass even this spot without apparent difficulty; but it is to be remarked that their success is owing in great measure to the perfect skill with which they are handled. This was demonstrated in a most marked degree on the first occasion of our travelling by one of these boats, which was in coming from Turin, *viâ* Lake Bourget and the Rhone, to Lyons. The outlet of this lake into the main river is by a narrow stream or passage, known as the Canal de Sevières: the direct distance from end to end of this natural canal is 2 miles, while by its course it measures 3¾ miles; its breadth is almost uniformly 66 feet, and in many cases the bends are so abrupt, that each end of the steam-boat (242 feet long by 34 ft. 6 in. wide, over the paddle-boxes), was within 10 feet of the bank on the same side. It is necessary at many such points to check the boat by a rope from the banks, but the engines are not stopped, and we made the passage in 34½ minutes, or at the speed of 6½ miles per hour. This was so extraordinary a performance in such a boat, that we paid a second visit to the spot as a check to our first netes, and further, made a rough survey of the canal.

We had hoped to find a boat descending the Upper Rhone from Seysell (Culoz) to Lyons, but were disappointed, and ultimately the discontinuance of the navigation for the season obliged us to forego seeing this part of the river.

The navigation of the Rhone is not carried on by any one or two large companies as on the Danube, but (notwithstanding a comparatively recent combination) by a number of smaller bodies, which renders it more difficult to discover the minor details worthy of notice.

The boats are of two classes:—

1st. Passenger-boats.
2nd. Goods-boats.

The peculiarities of the stream have prevented the success of tug-boats towing barges astern, and the narrowness of the river above Arles prevents their being lashed alongside, as below that point.

All the boats are built of iron, and are of very light construction: their bottoms are perfectly flat for nearly the whole length; the keel is straight, the bow and stern being tapered off in the usual manner. They are steered by a rudder of very great size, worked direct by a tiller, which is curved upwards to an elevated stage, on which the steersman is placed, that he may see clearly the course before him. We understand some of the boats are fitted with a small engine for working the tiller, but think this must have been discontinued, as we did not see anything of the kind. The whole deck of the goods-boats, and the part over the engines and boilers in the passenger-boats, is of iron.

They all have capstans for service in case of running aground, and some of the goods-boats have small engines connected for working them. They are all fitted with condensing engines, working with steam of from 40 to 50 lbs. pressure, generally expanded through about $\frac{6}{10}$ths of the stroke. The cylinders are usually horizontal, a pair of engines being supplied to the passenger-boats, and in most cases a single engine to the goods-boats.

The boilers are tubular, the tubes being in continuation of the furnaces, without any return; a steam-jet in the funnel is universal, and is constantly in use; a cowl is also placed on the top of the funnel, turning always away from the wind, and thus still further encouraging the draught.

The fuel used is coal. The effective horse-power is taken by a brake, and consequently differs so much from the indicator power, generally referred to, that it is not easy to compare the result of thus condensing with steam of considerable pressure, with that more generally employed in this country; but we were unable to discover any marked degree of saving; indeed the economy, theoretically due to the high degree of expansion, is probably more than counterbalanced, practically, by the great loss of heat by radiation from the cylinders, which are worked without steam-jacket or covering of any kind.

There is nothing elegant in the appearance of any of the boats, but they are eminently efficient.

The following dimensions of one of the most successful passenger-boats may be taken as a sample of the rest,—the cabins are entirely below deck:—

	Ft.	In.
Length	267	0
Beam	13	9
Draught, light	2	3
Ditto, with ordinary load	3	4

Engines, 80 horse-power; 2 horizontal cylinders, diameter 36 inches; stroke, 3 feet; steam pressure, 45 lbs.; 35 revolutions per minute.

Speed of boat, 13 miles per hour.

Goods-boats.

	Ft.	In.
Length	426	0
Beam	21	3
Draught, light	1	8
Ditto, with 500 tons cargo	5	0

Engine, single horizontal cylinder, diameter 55 inches; stroke, 8 feet; steam, 45 lbs., cut off at $\frac{4}{10}$ths the stroke; 24 revolutions per minute; say 170 horse-power; 350 horse-power by brake.

Speed, $7\frac{1}{2}$ miles per hour.

Another Goods-boat :—

	Ft.	In.
Length	426	0
Beam	23	0
Depth	7	6
Draught, light	2	0
Ditto, with 600 tons of cargo	5	3

Engines, 400 horse-power by brake; a pair of horizontal cylinders, diameter 36 inches; stroke, 8 feet; steam pressure, 45 lbs.; cut off, $\frac{4}{10}$ths the stroke.
Speed, $7\frac{1}{4}$ miles per hour, fitted with steam capstans amidships.

Another Goods-boat :—

	Ft.	In.
Length	475	0
Beam	19	6
Draught, light—about	2	0
Ditto, with 600 tons	5	0

Engines, about 180 horse-power; 400 horse-power by brake.

Passenger-boat on the Upper Rhone :—

	Ft.	In.
Length	220	0
Beam	14	0
Draught, loaded with passengers only ...	2	4

Engines, 60 horse-power.

Passenger-boats on Lake Bourget, passing through the Canal de Sevières :—

	Ft.	In.
Length	242	0
Beam	15	6
Draught, with passengers	2	2

Engines, 60 horse-power.
Speed, 11 miles per hour.

It will be observed that the boats of extreme length are those employed on goods traffic.

THE SAONE.

The river Saone is much less difficult of navigation than the Rhone, chiefly owing to the current running at a less speed. Very extensive works have been executed for banking in the river, and thus causing it to deepen itself. The navigation during a part of the summer was generally stopped until this was done, but there is now sufficient water during the whole of the year to allow boats drawing 2 ft. 6 in. to ascend to Chalons, distant 85 miles from Lyons. The breadth of the river varies from 600 to 1,000 feet, and the average speed of the current during summer is about $1\frac{3}{4}$ mile per hour, increased occasionally to as much as $2\frac{1}{2}$ miles. The Saon

The passenger-boats employed on this river are of the same type as those on the Rhone, but not quite so large. As a good sample—

	Ft.	In.
Length	220	0
Beam	13	6
Draught, light—about	1	6
Ditto, with ordinary load	2	4

Engines, side lever, 50 horse-power, nominal; diameter of cylinders, 24 inches; stroke, 3 ft. 6 in.; 33 revolutions per minute.
Speed, 9 miles per hour.

The goods traffic on the Saone is carried in barges towed by suitable steam tugs. Indeed, the load-draught of the goods steamers on the Rhone would render them useless on the Saone.

Some of these tug-boats have not sufficient power to draw their load through bridges or round quick bends in the river, and are consequently worked in a peculiar manner. When arriving at any such difficulty, the load of barges is cast off and moored in the stream. The tug runs ahead, paying out cable, which is fast to the foremost barge. On getting to a suitable distance, she lets go an anchor, and by means of a steam capstan hauls in the cable, and slowly draws the barges through the difficulty. The anchor referred to is made on a long stock, which is fixed to the ship's bow by a moveable joint; thus only allowing the fluke end to descend into the river bottom, by which much time is saved in weighing.

This plan of towing is also in use on some of the Russian rivers, and is found to answer, but is very slow.

Teams of horses are kept at some of the difficult parts of the river to assist the passage of tugs which have no such addition to their capabilities.

THE SEINE.

The Seine. The Seine, at the time we were passing through France, was so low as to stop the passage of the boats running to Rouen, and thus prevented our seeing much of the river.

The boats employed for this trade are of about the following dimensions:—

	Ft.	In.
Length	237	0
Beam	14	0
Draught (light)	2	2

Engines, a pair of horizontal cylinders, diameter 30 inches; stroke, 4 feet; 35 revolutions per minute.
Speed of the boat, 11¼ miles per hour.

The boats running between Paris and St. Cloud measure approximately:—

	Ft.	In.
Length	160	0
Beam	12	0
Draught (light)	0	11

Engines, a pair of cylinders, 27 inches diameter; stroke, 1 ft. 9 in.; steam pressure, 15 lbs.; say 40 horse-power, nominal.

The cargo-boats appear to be wholly devoted to freight. Some of them are propelled by two screws, some by one screw, some by paddles on the ordinary plan, and others by one wheel placed quite at the stern of the boat. Their effective speed is about 6 miles per hour.

Through a considerable length of the Seine a chain is laid in the stream, and a certain class of goods-boats are fitted to haul upon this by steam power, and thus draw themselves and barges with cargo against the stream. The current, however, of the Seine is very slow during summer: we timed it at about 1 mile per hour. The average through the year is about 2 miles.

Another class of boats employed on this river are constructed in sections, which can be separated one from another, one portion carrying the engines, &c. for the whole. These were not running when we were at Paris, and we understood they had not been found to answer, and were laid up as useless.

THE CLYDE.

A very successful instance of river trains of barges is in constant use on the Clyde, being employed by the Commissioners of the river as a means of transporting the material raised by the dredging-machines. The Clyde

The punts employed for this purpose are square flats of the following dimensions:—

	Ft.	In.
Length	32	0
Beam	14	0
Draught (light)	1	3
Ditto, with 15 tons load	2	6.

Two rows, generally of 12 each, of these punts are lashed close together, with one of double the breadth at their fore end, shaped somewhat like the bows of a boat, to save resistance in passing through the water. Another smaller barge is attached at the stern, with a rudder 3 feet deep by 4 ft. 9 in. long. The front or bow-punt is attached to the tug which proceeds with the train (being in all 560 feet long), at an effective speed of $4\frac{1}{2}$ to 5 miles per hour. The power of steering by the rudder named is very great, and it appears fully to answer its purpose: how far this would be the case in a rapid river full of cross-currents, with numerous shoals and an occasional chopping sea, can only be proved by trial. This much may be said, however, that on the Clyde it is not considered feasible to run the train where exposed to the last-named risk.

The tug used for this train on the Clyde is:—

	Ft.	In.
Length	105	0
Beam	20	0
Depth	10	0
Draught	6	6

Engines, 60 horse-power; 2 side lever cylinders, 30 inches diameter; 5 feet stroke; 20 revolutions per minute; steam pressure, 7 lbs.

This means of conveyance is very economical on the Clyde, the river being so slow as to prevent the necessity for great power to overcome the current; but it must be remembered that to run at the requisite speed of 9 miles per hour on the Indus, at least five times the power will be required.

The ordinary river steamboats employed in this country are so well known, that it is not necessary here to mention them; but we cannot do justice to the subject before us without a few notes on the American river-boats.

AMERICAN RIVERS.

The boats on these rivers appear to be of two distinct types.

First.—Those employed on the Hudson and other rivers of the Atlantic States; and

Second.—Those on the Mississippi and other western rivers.

Not having seen these boats, we quote the following from Dr. Lardner's publications on the subject, and from the last edition of Tredgold on the Steam-engine. The form of boat adopted for ordinary purposes, so far as we can ascertain, is quite flat on the bottom for the greater part of the length, but the fore and aft lines made excessively fine. They have a straight keel and a long over-reaching stem for landing passengers, &c.; there is nothing otherwise unusual in their model *below water*. On some stations, however, where very small draught of water is required, we understand boats are employed with rounded water-lines, very much as shown in the accompanying drawing. These boats are generally of comparatively small dimensions.

From Dr. Lardner.

"In the steam-vessels used on these rivers no other strength or stability
" is required than is sufficient to enable them to float and bear a progressive
" motion through the water."

he Hudson.

"The current of the Hudson is said to average nearly 3 miles per hour."

"To obtain an adequate notion of the form and structure of one of the
" first-class steamboats on the Hudson, let it be supposed that a boat is con-
" structed similar in form to a Thames wherry, but above 300 feet long, and
" 25 or 30 feet wide. Upon this let a platform of carpentry be laid, project-
" ing several feet upon either side of the boat, and at stem and stern. The
" appearance to the eye will then be that of an immense raft, from 250 to
" 350 feet long, and some 30 or 40 feet wide. Upon this flooring let us ima-
" gine an oblong rectangular wooden erection, two stories high, to be raised.
" In the lower part of the boat, and under the flooring just mentioned, a long
" narrow room is constructed, having a series of berths at either side three
" or four tiers high. In the centre of this flooring is usually, but not always,
" inclosed an oblong rectangular space, within which the steam machinery is
" placed; and this inclosed space is continued upwards through the structure
" raised on the platform, and is intersected at a certain height above the plat-
" form by the shaft or axle of the paddle-wheels.

"These wheels are propelled generally by a single engine, but occasion-
" ally, as in European states, by two. The paddle-wheels are usually of
" great diameter, varying from 30 to 40 feet, according to the magnitude of
" the boat. In the wooden building raised upon the platform already men-
" tioned, is contained a magnificent saloon, devoted to ladies and to those
" gentlemen who accompany them. Over this, in the upper story, is con-
" structed a row of small bedrooms, each handsomely furnished, which those

" passengers can have who desire seclusion, by paying a small additional fare. " The lower apartment is commonly used as a dining or breakfast room.

" In some boats the wheels are propelled by two engines, which are " placed on the platform which overhangs the boat at either side, each wheel " being propelled by an independent engine; the wheels in this case acting " independently of each other, and without a common shaft or axle. This " leaves the entire space in the boat from stem to stern free from machinery.

" In the following table are exhibited the dimensions and other particu- " lars of some of the steamers plying on the Hudson:—

NAME OF VESSEL.	Dimensions of Vessel.			Engine.			Paddle-wheel
	Length.	Beam.	Depth of Hold.	Diameter of Cylinder	Length of Stroke.	Number of Strokes.	Diameter.
	Ft.	Ft. In.	Ft. In.	In.	Ft.		Ft. In.
Isaac Newton	333	40 4	10 0	81	12	18½	39 0
Empire State	304	39 0	13 6	76	12	21½	38 0
Hendrik Hudson	320	35 0	9 6	72	11	22	33 0
New World	376	35 0	10 0	76	15	18	44 6
Alida	286	28 0	9 6	56	12	24½	32 0

" Considerable changes have been made in the proportion and dimen- " sions of the vessels navigating this river, all these changes having a tendency " to augment their magnitude and power, to diminish their draught of water, " and to increase the play of the expansive principle. Increased length and " beam have been resorted to with great success. Vessels of the largest " class now draw only as much water as the smallest drew a few years ago: " 4 ft. 6 in. is now regarded as the maximum.

" The increase of the dimensions of these vessels and their machinery " has been attended with a greatly augmented economy of fuel."

" The results of their performance show that the resistance per square " foot of immersed midship section is not perceptibly increased by the in- " creased length of the vessel and the consequently augmented surface and " friction."

" The engines in all cases are constructed on the condensing principle, " and although steam of 40 or 50 lbs. above the pressure of the atmosphere " is frequently used, it is worked expansively, and a good vacuum is always " sustained behind the piston by means of the condenser."

" The effective or indicator power of the *New World* is equivalent, " according to the ordinary mode of expressing steam-power, to 2,640 horse- " power."

" The new and largest class of steamers are capable of running from twenty " to twenty-two miles an hour, and make on an average eighteen miles an " hour. These extraordinary speeds are obtained usually by rendering the " boilers capable of carrying steam from 40 to 50 pounds pressure above the " atmosphere, and by urging the fires with fanners worked by an independent " engine, by which the furnaces can be forced to any desired extent; but this " extreme increase of speed is obtained at a disproportionately increased con- " sumption of fuel.

" A separate engine is generally provided for driving the blowers: some " of those blowers are 10 feet in diameter."

" It must be observed that, in relation to the navigation of these Eastern " rivers, the occurrence of explosions is almost unheard of."

The Mississippi.

" The steam-navigation of the MISSISSIPPI is conducted in a manner en- " tirely different from that of the Hudson and the Eastern rivers. Every one " must be familiar with the lamentable accidents which happen from time to " time, and the loss of life from explosions which continually takes place in " those regions.

" A frequent cause of explosion in these boilers is the quantity of mud " held in suspension in the water of the Mississippi."

" In a Mississippi steamboat, the cabins, &c., are erected on a flooring " six or eight feet above the deck of the vessel. Upon this deck, and in the " space under the cabins, are placed the engines, which are of the coarsest " structure. They are invariably worked with high-pressure steam without " condensation; and in order to obtain the effect which in the boats on the " Hudson is due to the vacuum, the steam is worked at an extraordinary " pressure, the ordinary working pressure being 150 lbs., not unfrequently " raised to even 200 lbs. Many of the vessels are 300 feet and upwards in " length, and are capable of carrying 1,000 tons freight, and 300 or 400 deck " passengers, besides cabin passengers."

FROM THE LAST EDITION OF TREDGOLD ON THE STEAM-ENGINE.

" The great hazard attending the navigation of these rivers [Mississippi, " &c.], from snags, sawyers, and shifting sand-bars, to say nothing of col- " lisions, blowing-up, and burning, is so great, that it is absolutely necessary " to a profitable investment that steamboats intended for traffic upon their " waters should be built and fitted up with the utmost regard to economy of " first cost; hence the use of non-condensing engines and small scantling of " timber, as compared with other steamers."

SECTION II.

On the Rivers in India.

THE following brief description of some of the principal rivers of India is partly derived from personal experience, and partly from reports of various officers who from time to time have noted their characteristics; and it is here given to show, in a general condensed form, the chief points on which we found our deductions regarding the class of vessel for their future navigation.

As a rule, the Indian rivers may fitly be described as wide, shallow, turbulent streams, traversing a vast extent of more or less level country, the bottom usually of sand or mud, which, as a mass, is constantly on the move towards the sea, the channel consequently always shifting its position, and the depth very uncertain. The navigable channel, although deep enough, is often difficult to discern in a wide expanse of waters or amongst sand-banks intersected in every direction by blind channels, among which the open one is undistinguishable. The current will often present swirls or eddies running contrary to the stream, which frequently shoots from an abrupt turning, at such an angle to the course as to deprive the rudder of its command, and throw a boat violently across the stream, or even completely turn her round. These are but a few of the manifold difficulties which a knowledge of Eastern rivers suggests as of most common occurrence.

For the navigation of such rivers, a powerful light-floating, easily-managed boat will escape difficulties, and overcome obstacles, which would entail serious embarrassments or delays to the same boat when too deeply immersed, and consequently comparatively slow and difficult of management, and would certainly, in many cases, be found insuperable by the existing vessels. Such a boat, combined with a carrying capacity which will make her valuable either for Government or commercial purposes, is the great desideratum for Indian rivers.

Owing to the peculiarities of the service, nearly all the boats hitherto employed have drawn more water than originally contemplated by their constructors; and indeed, on the dimensions to which they have been limited, it would be a very difficult, if not an impossible problem, to build a boat which would fulfil all the stipulated conditions. In fact, the only way in which this can be done, is by adopting greatly increased dimensions; and most Indian rivers are so wide, and their bends, although comparatively speaking sudden, are nevertheless of so great an actual radius, that there can be no practical reason against the employment of boats, if necessary, even as long as those before described on the Rhone, which is quite as bad a river for navigation as the Indus, or Ganges.

In Section III. (see also Plan) we give the particulars of the class of boats which in our judgment will be found most successful under all circumstances; at the same time, the amount of trade which may be developed on many Indian rivers is, without doubt, far beyond ordinary calculations or past experience; and therefore we would not wish to discourage any plan for their navigation, unless manifestly presenting features which must of necessity end only in failure, and consequently tend to prevent the investment of British capital in such undertakings.

THE INDUS.

The Indus. The facilities for navigation on the Indus are necessarily subject to considerable variations. During inundation, from April to October, the rapidity of the current and the constant changes in the channel constitute obstacles which it requires considerable experience to meet successfully, while in the low season, the shallowness of the water and the intricacy of the channels are frequent causes of delay. These shallows are to be found on every portion of the river, but they occur most frequently in the first 400 miles, as high as Sukkur, and consist of loose sand-banks easily acted on by the current, incessantly undergoing changes, both as regards their place in the bed of the river, and the position of the navigable channel through them. It would be certainly difficult, if not impossible, to maintain a continuous deep channel by artificial means, and these banks must consequently be considered as the principal obstacle to the navigation of the river.

The whole length of the river, from its source to the sea, is nearly 1,900 miles; of which about one-half, namely from 30 miles below Attock to the sea, 942 miles, is known to be navigable by steam-boats: as the crow flies, the distance from Attock is 648 miles.

For the purposes of this description, it may be divided into four sections; namely,—

1st. From its source to Attock.
2nd. From Attock to Mittun Kote, generally known as the Upper Indus.
3rd. From Mittun Kote to Tatta.
4th. From Tatta through the delta to the sea.

1st Section. 1st. From its source to Attock, a distance of about 873 miles, very little is known of its characteristics, beyond the fact of its being interrupted by serious rapids and waterfalls. In August, when at its highest point, it is said to be 100 yards wide 60 miles above Attock. Immediately above the town, the Kabool river falls in. It is said to be navigable for 40 miles from the confluence, while the Indus is known to be unnavigable from a rapid which occurs at that point.

2nd Section. 2nd. From Attock to Mittun Kote the distance is 450 miles, the first 30 of which present many difficulties, and have not yet been navigated by steamers. Attock is 1,000 feet above the level of the sea, and the total average fall is nearly 1 foot per mile (the same as the Danube). It is here 540 feet wide, and 60 feet deep at the bridge of boats; 20 miles lower down it is in July ¾ths of a mile wide.

In descending for 100 miles to the neighbourhood of Kalabagh, the river is, generally speaking, a narrow and deep stream, rushing down a valley from 100 to 400 yards wide, between high precipitous banks, through successive ranges of mountains. In this part it rises 50 feet during inundations. The fall of this portion of the bed is 20 inches per mile.

Emerging from this hilly region, the stream expands on approaching the level country near Kalabagh; from thence to Mittun Kote, a distance of 340 miles, it becomes during inundations like an extensive lake, and to Deerah Ismael Khan, a distance of 100 miles, in July and August, one bank is often not seen from the other. The rise during inundations between Kalabagh and Mittun Kote is 8½ feet, and the fall of the bed is 8 inches per mile. The speed of the current in low seasons, below Kalabagh, is from 3 to 3½ miles per hour, and during inundations is as much as 6 miles, increased at the part known as the Rapids of Kalabagh, to 8 miles per hour during inundations; at this place it also runs 6 miles per hour in low seasons. On entering the plain at Kalabagh, the river loses its previous clearness, and becomes loaded with mud. The depth also materially diminishes, and the shifting sand-banks still further obstruct the channel; but it is nevertheless navigable thus far through the year, by boats drawing 2 feet water. The voyages on this section have been only of an experimental nature, and have done little more than show the possibility of its navigation by suitable steamers.

3rd. From Mittun Kote to Tatta the distance is 500 miles. About two or three miles below the former place, the collected waters of the Punjab fall into the Indus through the channel known as the Panjnud. In augmented volume the river then flows to the south, past the towns of Sukkur, Sehwan, and Hyderabad. 3rd Section.

With exception of a range of rocks which cross the river at Sukkur, the general features are much as described between Kalabagh and Mittun Kote, but the river necessarily much extended in volume; the available depth, however, is not increased; for although the ordinary depths vary from 10 to 20 feet, and probably a channel of 3 feet always exists in some part or other of the breadth of the river, the sand-banks are so constantly shifting their position, that not more than 2 feet draught can be depended on without the risk of constant annoyances and delays.

The great speed of the current at Sukkur (9 miles during inundation) is the only real obstacle to the navigation of this section; but the water here is deep, the channel, clearly defined by precipitous rocks, is 400 yards wide; and for a boat with sufficient power, no fear need be entertained for the certainty of the passage.

The breadth of the river at the junction of the Punjab rivers, near Mittun Kote, is occasionally more than 30 miles during inundations; at other places the flood has often extended to a breadth of 20 miles, but its ordinary breadths vary from 1,500 feet to 5,000 feet. The fall of the river-bed is about 6 inches per mile.

The speed of the current varies at different places and seasons, from nearly 9 miles at the greatest, in inundations, to about 2 at the least, in dry seasons. The former is only an exceptional speed, such as at Sukkur or any special bend of the river. The general average velocity is about 7 miles per hour in inundations, and 3 miles per hour in dry seasons; giving an average through the year of about 5 miles per hour; it is greatest in the deepest portions of the channel, being in 14 feet about double that found at 6 feet depths.

4th. From Tatta to the sea, through the delta by the main channel, the distance is about 60 miles; and thence, *i. e.* from the Beacon to Kurrachee, either by sea or by the old sea-channels of the river, is about 100 miles. 4th Section.

Near Tatta, the river throws off a great branch—the Buggaur, through which, during inundations, the navigation can be carried to the vicinity of Kurrachee.

The influence of the tide is felt about 35 miles up the river; but the current is, nevertheless, always running down on the surface of the flood to within 15 miles of the sea; and the water is more or less fresh for 3 miles beyond the Beacon, where the rise of tide is 6 to 7 feet.

The depth in the navigable channel varies from 12 to 30 feet at the deepest time, but is subject, like places higher up, to the uncertainties of shifting sand-banks, which do not allow free navigation above the tidal influence to vessels drawing more than 2 feet of water.

The fall of the bed is about 6 inches per mile.

THE RIVERS OF THE PUNJAUB.

The Panjnud.

The Panjnud (or Five Rivers), which falls into the Indus near Mittun Kote, is formed by the junction of the Chenab and Sutlej, the first having previously received the tributaries Jhelum and Ravee, and the second the waters of the Beas.

The length of the Panjnud from Mittun Kote to Buckree, the junction of the Chenab and Sutlej, is about 60 miles; in the low season its width is from 300 to 400 yards, and the depth of the navigable channel varies from 4 to 12 feet; it is in general less obstructed by shoals than the Indus; in the dry season of 1846 there was not a sand-bank across any part of it, and vessels drawing 3 feet commonly pass up it without interruption in the low season.

The Chenab.

The Chenab, from Buckree, where it joins the Panjnud, as far as Mooltan, a distance of 80 miles, and on to the junction of the Jhelum, is very similar to the Panjnud, with a depth of from 4 to 10 feet, but sand-banks are more frequent. Beyond that point it becomes, in some places, narrow and tortuous; but with vessels not drawing more than 1 ft. 6 in. its navigation is considered feasible to Ramnuggur, a further distance of about 250 miles. The average speed of the current is 5 miles during inundation, and 2 to 3 miles in the low season.

The Jhelum.

The Jhelum much resembles that part of the Chenab before the two unite. Steamers drawing 1 ft. 6 in. can ascend at all seasons to Ahmedabad, and, during the season of inundation, probably to Pind Dadur Khan, nearly 150 miles farther.

The Sutlej.

The Sutlej is very slow during the low season, so much so that the more rapid Chenab, flowing across and into its mouth, creates a backwater which so silts it up that the Sutlej can only make its way through by a number of small channels, about 100 yards wide, and 2 to 3 feet deep. When this obstacle is passed, the stream is ordinarily confined to one channel, and has frequently been ascended by vessels quite unsuited, both in draught and power, to the prevailing depths, the result leaves little question that boats suitably constructed for the river; and not drawing more than 1 ft. 6 in., will navigate it with success to Ferozepore, a distance of about 320 miles, or even as far as the confluence of the Beas, about 40 miles beyond. Higher than this the navigation is probably not feasible during the low seasons, although in the inundation (May to September) it has been found possible for a steamer of the description above mentioned as unsuitable, to ascend to Roopur, which is close to the foot of the Himalayas. In the upper sections the characteristics are mainly those of a mountain-stream. From Ferozepore to the confluence with the Chenab, the banks are uniformly of mud, never exceeding 8 feet in height, and no hill or rock of any kind is found.

PRESENT NAVIGATION OF THE INDUS.

Present Navigation of the Indus.

The river Indus and its tributaries have been navigated over a period of twenty years by the steam-boats of the Honourable Company.

The vessels of the flotilla are habitually employed in conveying troops and public stores, and on general government duties, between Kurrachee and Mooltan. They also carry on, once a month, a continuous voyage over the whole of that distance, conveying private passengers and goods on freight. The voyage is made from Kurrachee, along the sea-coast (or through the tidal channels which intersect the delta) to the river-mouth; from thence the vessels ascend the main stream, passing successively the towns of Tatta, Hyderabad, Sehwan, and Sukkur, to Mittun Kote; here they leave the

Indus, and, passing through the Panjnud into the Chenab, continue the voyage to Mooltan. The regular navigation has not been extended beyond these points; but the exploration of the rivers of the Punjab, and of the Upper Indus, has been a less constant, though still important part of the employment of the boats whenever they could be spared for such purposes.

With four new boats, which are now being put together at Kurrachee, the Indus flotilla will consist of 12 steamers. These may be divided into two classes:—

1st. Those placed on the river prior to 1843.
2nd. Those especially constructed for its service since that date.

Two of the best boats under the first head, the "Planet" and "Satellite," are of the following dimensions:—

	Ft.	In.
Length	128	0
Beam	24	0
Draught, with working weights on board ...	2	10
Ordinary working draught, about	4	0

Engines, nominal, 65 horse-power.

These are still serviceable, strong boats, but are deficient in power and accommodation, and, moreover, draw far too much water. There are other boats under the same date (constructed for the Euphrates) of still smaller dimensions; but all partake, in a greater or less degree, of the same faults.

The form of all is that ordinarily given to river steamers, namely, with sharp water-lines and a straight keel; and although some had the keel rounded up forward for a considerable distance, or, in other words, had the "fore-foot" removed, they have been found very unsuitable in the turbulent, rapid waters of the river; when they take the ground, they are very difficult of removal, and being obliged, from the draught, to contend with the stronger currents, their progress against the stream is anything but satisfactory.

The boats of the second class (eight in number) are of an entirely different form. The ordinary model proving so unsuccessful, Mr. Laird, of Liverpool, was induced to design a boat very much on the principle of the native craft; and the first of the kind sent out (the "Napier") is a good representative of the class. The peculiarity in the form is, that the whole is composed of rounded surfaces, and the keel rises from near the centre of the boat towards each end, no "dead wood" whatever being given. This is the form referred to and recommended under the name of "Spoon-ended," in Section III.

It is interesting to observe that a similar model was proposed by Mr. C. Cowles, first assistant master-attendant of the port of Calcutta, in the year 1829, for a tug-boat of the following dimensions:—

	Ft.	In.
Length	130	0
Beam	30	4
Draught, loaded	2	0

Engines, nominal, 50 horse-power.

The design was published in 1830, by Mr. G. A. Prinsep, in his work "On the Steam Navigation of British India." The boat, however, was never built; and the credit of practically introducing the model on Indian rivers is due to Mr. Laird.

The result of his experiment was most successful, and all the more recent boats have been of the same form; some have, however, been constructed of too full a model, and have not done so well.

The dimensions of the "Napier" are:—

	Ft.	In.
Length	160	0
Beam	24	0
Depth	5	0
Draught, with working weights on board, say 65 tons	2	7
Ditto, with ordinary load	3	6

Engines, nominal, 90 horse-power.

The new boats are:—

	Ft.	In.
Length	166	0
Beam	28	0
Depth	7	7½
Draught, with working weights on board ...	3	2

Engines, nominal, 110 horse-power.

The actual weights in this case are (besides every necessary article of equipment) coal, 25 tons; and two months' provision for a crew of 50 men. The "Frere" is here referred to.

The "Falkland," a boat of the same form, but of a size more likely to give satisfaction, was lost at sea, between Bombay and the Indus. Her dimensions were:—

	Ft.	In.
Length	220	0
Beam	33	0
Depth	6	3
Draught	2	9

Engines, nominal, 160 horse-power.
Speed, 11 miles per hour.

Notwithstanding the vast improvement in the form of these boats, their draught is still far too great, obliging them, among other disadvantages, to keep in the deeper parts of the stream, and stem a stronger current.

The boats of the existing flotilla are indiscriminately used on all parts of the Indus and its tributaries. This is manifestly undesirable, for the different sections and affluents of the river vary so much that the best boat for one part might be wholly unsuited to another,—a subject which has received our detailed attention, under Section III. of this Report.

THE TIGRIS AND EUPHRATES.

The Tigris and Euphrates.

Amongst Indian rivers we include for the purposes of this Report the Tigris and Euphrates, these streams having been navigated for a series of years by the steam-vessels which now form part of the Indus flotilla.

The capabilities of these rivers for navigation, as thus tested, are described in the following abstract of an *official* Report by Lieutenant (now Commander) J. Jones, I.N., dated May 26th, 1853, to her Majesty's Minister at Constantinople:—

The Euphrates.

"The Euphrates has entirely lost its character as a navigable river for "many years past, owing to the embankments which formerly controlled the "spring floods in the lower part, between Sukesh-Sheukh and Korneh, having "been swept away about ten years back. Indeed, its capabilities for navi-

" gation at any time have never been great, though I am aware the general " opinion, founded upon the reports of the Euphrates expedition in 1836, are " in favour of it as a feasible route to India. It must be borne in mind, " however, that Colonel Chesney's vessels navigated the stream during the " period of its highest rise; and in a year, too, when the flood attained some " feet beyond its ordinary level; consequently no obstacles were met with in " the *descent of the stream* to lead to the inference that any existed. The " contrary is, however, the case; for many obstructions, both artificial and " otherwise, are found in its course, that develope themselves only in the " *ascent of the stream.* There are impediments to navigation, even in the " season of its greatest height, and these, during eight months of the year, " close its channel entirely to steam-vessels of the most moderate draught of " water.

" The character of the tribes located on its banks offers also a serious bar " to its usefulness for commercial purposes, for I am convinced, that unless " some great political change in the country interposes to coerce them, none " but well-appointed steam-vessels of war could effect the passage.

" Independent of the obstructions caused by shallows, ancient mill-dams, " and rocky ridges, which traverse its bed from Hit northward as far as the " latitude of Aleppo, the rapids coursing over these during the freshes from " April to June could only be surmounted by the steam-boat I commanded " in 1841, with the aid of 200 men attached to tow-ropes acting in concert " with the steam power; and I question much if the superior vessels now " built could overcome them without similar assistance: at all events, the " delays that would ensue from the manœuvring requisite to effect the object, " would neutralize the advantages derivable from the agency of steam.

" A knowledge of its character in autumn and winter may be gleaned " from the fact of the descent in these seasons occupying the *Nitocris* from " October to April; her draught was 3 feet 6 inches; not more than would " be requisite, perhaps, for a vessel carrying both cargo and passengers in " addition to her fuel. In some places, indeed, it was necessary to remove " every article but the engine, to insure a draught of 2 feet 6 inches, before " these ridges could be crossed, and then only after several days' hard labour, " with anchors and chain-cables laid out to force her forward in the direction " of the current of the river.

" Such were the impediments met with in 1841 and 1842; now they are " still more serious, for the river has left its bed, and is entirely lost in the " marshes and vast swamps on either side. It must remain sealed to shipping " until, in the course of time, it opens for itself a new channel.

The Tigris.

" The Tigris, however, is eminently navigable from the sea to Baghdad, " at all seasons of the year, by very ordinary steam-vessels, drawing 3 feet " water. In the autumn, when in its lowest state, a little difficulty only is " experienced, but this is easily overcome by common activity and attention " to the proper channels. There are, indeed, no impediments to its naviga- " tion by steam-vessels upwards, for a distance of 500 miles, and the tribes, " though at times refractory, are in general less violent and exacting than " those on the Euphrates. From Baghdad northwards, well-formed, fast " steam-boats could reach the Upper Zab, and with perseverance might " attain as far as Moosul, from February to June; at other times this portion " of the Tigris is impracticable, from the low state of the water."

We think it right to place in contrast with the above, the opinions expressed by Captain Campbell, I.N., whose experience of these rivers has been very extended:—

He says,—" The physical difficulties of these rivers were indeed "formidable to steam-navigation in its infancy; but I may ask, Where is "there now difficulty in obtaining boats to run a speed of 12 or 13 knots per "hour, and drawing not more than 2 feet water? Such boats are to be seen "every day on the Thames; and with them the Euphrates can be navigated "from end to end. Skill and experience, and a little outlay, will remove "many difficulties which our ignorance of the localities makes us regard as "very formidable; and the fact that the volume of water always finds "a passage without anything like the perils of the 'Iron Gates,' will show "that there is no really serious or insurmountable obstacle to be overcome."

THE GANGES.

The Ganges.

The whole course of the Ganges, from its rise in Thibet to the Bay of Bengal, is stated to be about 2,300 miles.

It can only be considered navigable as far as Allahabad, a distance by the short route of 957 miles from Calcutta; but steamers have on occasion reached Cawnpore, 177 miles higher up.

The Ganges having left the mountain district at Hurdwar, and entered the plain, takes a southern course for about 130 miles, and then runs in a S.E. direction, receiving several tributaries by the way. The distance from Hurdwar to Allahabad is estimated at about 470 miles, the average fall in the river-bed being about 1 ft. 10 in. per mile. Throughout this distance Captain South describes the Ganges as a stream of shoals and rapids.

At Allahabad it receives the waters of the Jumna, and the junction of the two rivers occasions a considerable difficulty to the navigation; for the rivers constantly rising and falling on different levels, alternately disturb each other, and the large quantities of earth and sand brought down by the current, particularly of the Ganges, are deposited near the eddies and slack water; thus forming a shallow and continually shifting bar. The difficulties arising from the existence of this bar are chiefly felt at the season of low water; but there are in this locality other impediments. A few miles below the city, the stream, notwithstanding its increased volume, so shoals in the dry season that the depth is not more than 2 feet. In consequence of these obstructions, the commercial companies owning steamboats on the river ordinarily make Mirzapore, 86 miles below Allahabad and 701 from Calcutta, the terminus of their operations.

From Allahabad the Ganges pursues its course in a S.E. direction, and receives new affluents. At Benares we find the river 1,400 feet wide in the dry season, and 3,000 feet in the rainy season. It is difficult, however, to give an idea of the ordinary breadth of the stream, on account of its great variations, which are from 1,000 to 6,000 feet in low seasons, and from 1 mile to 3 miles in times of flood, when also occasionally it spreads to a breadth of some 30 miles over the flat country.

The average depth, when high, varies from 35 to 58 feet, and when low, from 3½ to 10 feet.

The average speed of the current varies from about 2½ miles per hour in dry seasons, to 4 miles per hour in inundations; but at various places it runs at 6, 7, and sometimes 8 miles per hour in times of flood.

The Ganges, in the last 200 miles of its course, breaks into different branches, all of which find their way into the Bay of Bengal, forming an extensive delta; two of these branches, the Bhaugruttee and the Jellinghee, uniting their waters, form the river known as the Hooghly: when these streams are full, and, consequently, navigable with ease downwards, the force of the current makes it a difficult passage upwards. But for three or four months in the year, owing to the shallowness of the above branches, all the steamers and much of the native boat-traffic have to proceed along the Ganges as far as the Goraee channel, and thence through the intricate channels of the Soonderbunds, up the Hooghly to Calcutta,—an extra distance of about 360 miles.

The waters of the Ganges begin to rise about the end of May, usually reach their highest point in September, and then gradually subside.

From this description, it will appear that the Ganges and the Indus are very similar rivers in their general characteristics. From the draught of some of the steamers employed in its navigation, the Ganges might be supposed to have a greater available depth in high seasons, but, from all accounts, the detention and delays to which these boats are subjected, at all times of the year, through getting aground or having to expend unnecessary time and power in passing up through the deepest and, consequently, most rapid channels, induce the opinion that greater success will be attained by the future adoption of a class of boats of much less draught of water. As high as Mirzapore, boats might constantly run with a draught of 2 feet, but above that place, 1 ft. 6 in. would appear to be the greatest available draught for insuring punctuality during dry seasons.

The Ganges has many tributaries, but few of them can be considered as navigable rivers. The most important are the Jumna, the Goomtee, and the Gogra. The Jumna, as has been stated, unites with the Ganges a little below the fort of Allahabad. Its navigation appears to be by no means free from difficulties. The bed is shallow and the current strong; the banks high and precipitous, with ridges of rock advancing in many places into the stream. These circumstances render the navigation both slow and dangerous. But a boat not drawing more than 1 ft. 6 in. would avoid many of the obstacles. The Jumna.

The Goomtee joins the Ganges about 20 miles below Benares, and during the rains is perhaps navigable for vessels of very light draught as far as Lucknow, a distance of about 250 miles; but it will probably never be navigable for large steamers. The Goomtee.

The Gogra rises in the Himalayas, and flows in a south-east direction, until it unites with the Ganges a few miles above Patna. It is stated to be navigable for a distance of about 200 miles. The breadth of the channel is generally considerable, but at three places it is said to be reduced to about 70 feet for 50 to 60 yards. The average depth as high as Fyzabad, 160 miles, is 8 or 9 feet, frequently 20 feet, and nowhere less than 4 feet. Above Fyzabad is a shoal on which there is only 2½ feet of water; but it is said this could easily be cleared; and when done, there is no obstruction to navigation up to Byram Ghât, about 30 miles higher up. The only real difficulties are ridges of hard sand called *masina*, which are dangerous to the native boats, but could easily be avoided by steamers. The river is stated to be easily navigable as high as Fyzabad for all vessels not drawing more than 3½ feet of water, at all seasons of the year. The Gogra.

THE GODAVERY.

The Godavery.

This river takes its rise about 90 miles north-east of Bombay, and follows a course generally from west to east as far as Chinoor, at which place it is joined by the Wurdah, and from whence it flows in a south-east direction to Rajahmundry, where, dividing into several streams, it falls into the Bay of Bengal, about 250 miles north of Madras.

The navigation of this river is of much importance, as it forms the highway of transit to and from the great cotton-fields of India; but unfortunately, from the accounts, it appears to present greater difficulties than many others; and although, without doubt, capable of navigation during flood seasons, even in its natural condition, requires artificial assistance before it can be so readily used as the Ganges or Indus. In common with other rivers taking their rise in the table-land of the Deccan, which are solely dependent on the monsoon for the supply of water, it is, with the exception of a portion near the mouth, inferior in its navigable capabilities in the dry season.

The principal obstacles appear to be ridges of rocks which run across the river, and the rapidity of the current, which is equal at certain parts to the worst portions of the Ganges or Indus; and third, at the rocky places mentioned whirls are formed, which are more or less dangerous in flood seasons. As a set-off, however, to these difficulties, the general course of the stream is said to be very straight, and to have few bends requiring much skill in the management of a steamer.

We understand that boats drawing 1 ft. 6 in. can run as high as Chinoor, about 180 miles above Rajahmundry, and thence into the centre of the cotton district to Chadnah, on its affluent the Wurdah, a further distance of 100 miles.

SECTION III.

Suggestions regarding the Best Class of Boats for navigating the Rivers in India.

THE subject of the navigation of the shallow rivers of India is one of very considerable extent, inasmuch as boats which might be well adapted to some would be unsuitable on others, or even on different parts of the same river. But there are certain broad characteristics in them all, which will enable the boats to be made considerably to resemble each other in respect to general form, being simply adapted in dimensions and power to the nature of the river they are intended to navigate. In short, the boats must be suited to the varying conditions of the rivers, and not to any arbitrary standard.

It has been suggested that the goods and passenger traffic may be combined; and this subject having been prominently brought before us, we have given it our best attention, and have carefully inquired on the Danube and Rhone regarding the advantages of such an arrangement. We find that on both these rivers it has been tried and given up; the annoyance and delays of the goods traffic discourage passengers from travelling, and the officers, naturally anxious to please their passengers, are too much hurried to devote due attention to the goods department.

Taking our conclusions from the experience of the powerful companies on these rivers, we recommend that the two departments shall be entirely distinct.

The following classes of boats will be required:—

1st. Boats for the tidal channels and deltas.
2nd. Boats for the larger and lower rivers above the influence of the tide.
3rd. Boats for the upper and smaller rivers.

Each of those classes will be further subdivided into boats for passenger traffic, and tug-boats and barges for goods traffic; the latter being in each case the class most suited to government or general service.

The three following heads are the chief points requiring attention:—

1st. The draught of water;
2nd. The effective speed;
3rd. The form of model.

On the first of these heads, it is found that on the deltas and tidal portions of the rivers (specially referring to the Indus) the extreme load-draught must not exceed 4 feet. Draught.

On those portions of the larger rivers above the influence of tide which are to be navigated throughout the year, the extreme load-draught must not exceed 2 feet, owing to the sand-bars and other obstructions which are constantly occurring and ever shifting their positions.

On the upper and less practicable rivers, including streams which are not navigable during the whole of the year, the extreme load-draught should not exceed 1 ft. 6 in.

Speed.

2nd. In reference to speed—

We consider the passenger-boats should have sufficient power to propel them at 8 miles per hour against the average stream of the river for which they are intended, excepting on some of the smaller rivers, where probably not more than 6 miles could be attained if other conditions are fulfilled.

The tug-boats, with two barges in tow, each carrying 150 tons, should be capable of making at least 4 miles per hour against the current.

Form.

3rd. The boats for navigating the deltas within the tidal influence will be best if built of the form below water ordinarily adopted for such purposes; but the gunwale should be kept low, and the accommodation for either passengers or crew must be in houses above the deck, as described for boats on the main river.

Their best dimensions will be,—

	Ft.	In.
Length on water-line	180	0
Beam	22	0
Depth	7	0
Draught, loaded	4	0

Engines, effective, 350 horse-power.
Ditto, nominal, 100 horse-power.

And boats of these dimensions may also serve as local tugs to Kurrachee Harbour.

Above the deltas the form of model should be that most easily managed in a rapid current while steaming, and most readily got afloat when grounded; and it must further be such as to admit of a high velocity combined with suitable capacity on a very light draught of water.

The form which experience has proved to include the greatest number of these requirements is that with spoon-shaped ends, or, more properly speaking, with rounded water-lines and a keel rising towards each end from nearly the middle of the boat. It is intended in its motion to displace the water by *vertical* pressure, rather than by the *lateral* action from the bows caused by boats of the ordinary model.

The advantages of this form are, first, that, every part presenting a rounded surface, cross-currents of the river have less power in forcing the boat from her course, and consequently she steers more steadily; secondly, that when accidentally the boat takes the ground, she touches on one part only, and the rising ends being freely exposed to the current, keep her in motion, as if on a pivot, which tends to get her off the shoal, and prevents the accumulation of river-deposit on her side. This model has been extensively tried on the Indus, and found far superior to all others.

The same principle has been adopted in some of the light-draught boats in America, and has been very favourably reported on as working on one of the Australian rivers.

In cross-section it is important that the bottom shall not at any part be perfectly flat. A slight "rise of floor" has the double advantage of draining all the bilge-water to one line, where it can be readily disposed of; and further, of being a much better form for speed.

The natural motion of a boat when on a shoal is necessarily only a collateral aid, and cannot solely be depended on for getting her afloat. We suggest, therefore, that the boats shall be provided with a powerful capstan at each end, by which they may be hauled to an anchor laid out on the occasion. On the Rhone, a species of capstan worked by steam power has been adopted and found very efficient, and to save much labour. From the peculiar deck hamper on the passenger-boats for Indian rivers, it would be difficult to work the capstans at their ends in this manner; but we strongly recommend that on each side the engine-room some such apparatus shall be fitted, so as to have a direct lead fore and aft; and in the tug-boats possibly the ordinary hand-capstans may be dispensed with. Capstan.

We must here observe, that one vessel on the Indus has been fitted with such an apparatus, worked by the main engines of the boat. We have failed in ascertaining how this has answered, but think that, while right in principle, it was not well carried out, inasmuch as it was necessarily only available so long as the ship's engines could be kept in motion; and as in most cases these have to be stopped before the vessel is free, the capstan would from that moment be rendered useless. As arranged on the Rhone, it is driven by a small supplemental engine; and we think this an essential to success.

The steering-gear will require especial attention; and the peculiar form of the boats will necessitate a rudder of extra size, which must be so made as to rise vertically, should it at any time come in collision with a bank or snag. The wheel for steering should be placed as far forward in the vessel as possible, and must be larger than the proportion generally allowed, a tiller being attached to the rudder for instant use at difficult places. Steering-gear.

It is also desirable that an additional rudder be placed at the bows. We are aware that this has been already tried, and although found of great service in steering, ultimately discarded. We think, however, it may be so arranged as to be secure from the casualties which before hindered its success.

When travelling on the Danube, it occurred to us that an improvement might be made on the ordinary rudder, by employing two blades, set at a suitable angle, one on each side of the keel, and capable of vertical motion, one rising when the other is lowered. On returning to England, we find this idea has recently been patented: if it answers thoroughly, as anticipated by the patentee, it will be a great boon in dispensing with the unwieldy rudder now necessary abaft; and we should therefore advise it being thoroughly tried, before any more steamers are sent out.

Mooring-chocks, timber-heads, hause-pipes, and ground tackle must all be of more than ordinary strength as compared with the class of the vessel. The introduction of substantial well-fixed double leading-sheaves will also be a great help in the difficulties the boats will frequently encounter. Fittings.

Iron is the best material of which the boats can be built: it would be very difficult to gain the requisite strength and lightness in wood. Even in iron, it is by no means easy so to adjust the various parts as to give sufficient strength, without overloading the boat and causing her to draw too much water; indeed, this can only be secured by using material of such slight scantling that the best iron which can be obtained, irrespective of price, can solely be depended on. A material technically called "Homogeneous Iron," being in fact, a species of steel, has lately been introduced and used with considerable advantage in the construction of boilers: its strength far exceeds that of iron, and we think that for some portions of the boats it may be well Material.

to adopt it. The remainder of the outside plating should be of Lowmoor iron, or some brand of equal quality.

Framing.

In the passenger-boats all cabins should be above the gunwale-line. Head-room below deck being therefore unnecessary, the vessel's interior may be devoted to such a class of framing as is best adapted for giving strength, and at the same time the gunwale kept conveniently low—say from 3 to 4 feet above water-line.

The class of framing recommended (in addition to the ordinary frames or ribs) is a series of longitudinal and athwart-ships bulkheads or girders, combined with an overhead trussing corresponding with the "hog-frame" of American steamers.

Passenger Accommodation.

The passenger accommodation is a point which, while minor to those of general form and strength, is nevertheless of very great importance.

For comfort and convenience on this head, it is necessary—

1st. That the whole shall be arranged in houses above the ordinary deck of the vessel, the tops of which will form a promenade.

2nd. That every means shall be adopted to give ventilation; and with this view, the whole panelling of deck-houses, doors, &c., should, wherever practicable, be constructed of Venetian openwork; and we would suggest that an artificial draught be produced in the cabins by the introduction of a fan-blast having many openings, which could be closed at pleasure. The fan could be worked by the same supplemental engine as is intended to work the capstans, and possibly the air-pumps: this will give great comfort to the passengers at a small cost.

3rd. That the cabins shall be spacious, and the saloon beds only be sofa berths divided by curtains, a far greater area being absolutely indispensable for each passenger in a tropical climate than is ordinarily supplied in other parts of the world. The sleeping-berths, couches, and seats, should be light frames covered with cane-work, or some such material, thin cushions of chintz being used instead of the woollen stuffs often employed. In decorating the cabins and other woodwork, we would recommend the utmost plainness; mouldings, scrolls, and carved work of every kind, simply harbour vermin, and are of no use.

4th. That the whole boat shall be covered by awnings of a very efficient description; and as the gusts of wind on Eastern rivers are very severe, the stanchions, and other means of fixing the same, must be of far greater strength than usually supplied in this country.

5th. That ample bathing and washing accommodation, also numerous water-closets, be provided.

6th. That European and native travellers shall, as far as possible, be kept to distinct departments.

To particularize our recommendations, we will assume them as applied to the boats required by the Scinde Railway Company to trade between Hyderadad and Mooltan.

As a general summary of the requirements for those boats we find:—

Scinde Railway Company's Boats.

1st. They must have accommodation for 200 passengers with their baggage and provisions, all in addition to the crew necessary for working the ship. Of these passengers, we assume that 100 at least will be the lower class of natives, needing only deck accommodation, who, together with natives requiring cabins, we propose keeping to one end of the vessel, the other end being devoted solely to Europeans. Divisions should be made for ladies, and spare cabins provided for private parties or passengers out of health.

Whether the forward or after deck is treated as first class, is a detail for future decision; the forward deck will be most airy, but subject to greater annoyances from the working of the vessel.

2nd. That, being unable to run during the night, they must not lose time during daylight in taking in fuel, and consequently should carry at least eighteen hours' consumption (of wood).

3rd. That with everything on board and ready for a journey, they must not draw more than 2 feet water.

4th. That under these conditions they should be capable of ordinarily attaining an effective speed of 8 miles per hour against the average current, which, being assumed at 5, will give 13 miles as the speed of the boat in still water.

These points, we think, will be found fairly well combined in the annexed plan of a boat for this service, which is an example of what appears to us the best *class* of passenger-boat for navigating the larger and lower rivers of India above the influence of the tide. The *dimensions* requiring to be modified to suit the amount of trade in each particular case,—

We must premise that there is no precedent on any river of a boat which would fulfil all the foregone requirements; and therefore, while we have most perfect confidence in the success of steamers built according to the conclusions at which we have arrived, we nevertheless must remark, that, the conditions being novel, the boats for fulfilling them will assume proportions which in this country may at first view be thought extraordinary, but for the reception of which the previous remarks on the Rhone, Hudson, and Mississippi will perhaps pave the way.

Our recommendation, therefore, is that these boats shall be— Dimensions.

	Ft.	In.
Length on 2-feet water-line	350	0
Beam	46	0
Depth to main-deck beam (moulded)	5	6
Ditto to top of fore and aft girders, amidships	14	0
Draught, loaded	2	0

Engines, effective, 800 horse-power.
Ditto, nominal, say 200 horse-power.

The speed of this boat on a trial trip or special emergency may equal 15 miles per hour; but not more than 13 miles can be depended on as an average performance.

Such a boat would be capable of transporting a whole regiment and its equipage at one time, if required; and, so loaded, would not draw more than 2 ft. 6 in. water.

We are aware that these dimensions are considerably in excess of those previously contemplated; and a consequence in this increase will be additional cost.

With a view to true economy, we think the requirements for accommodation are not too high; and even in the dimensions given, 1st-class passengers are more crowded than we could have wished: probably it may be some time, however, before the boats will daily get their complement. To obviate the additional outlay of capital, it has been suggested that barges might be fitted with passenger accommodation, and be towed with the cargo-barges by the regular tug-steamers.

We have already mentioned that this mixing of different trades has failed on other rivers; but, irrespective of this, it would not effect the anticipated saving; for as the speed of the tugs could not be efficiently increased, the time occupied on a trip would be at least double, and consequently the number of tugs and barges required for the daily service must be proportionably greater; so that the saving would be very small, and moreover the working expenses would be considerably higher, as each day's tug and barge would require nearly the same crew, and take *ten* days on the road, as the large passenger-boat recommended, which is estimated to take only *five* days. It would, therefore, appear wiser at once to build the best boats for the purpose, and allow for a service at first only every other day, and a tug with goods-barges, say every fourth day; for any passenger would prefer waiting one additional day at either terminus to being five days longer on the road, and the commercial result would be far more satisfactory.

Tug Steamers for the larger and lower Rivers.

Tug-steamers and General-service Boats. We consider it desirable to avoid, as far as possible, the multiplication of distinct classes of boats, and therefore would so construct the tugs as to be equally suited for general or government service.

For them we recommend the same form of boat as for the passenger trade; the deck cabins being smaller, and principally arranged for the convenience of the crew. They must necessarily be governed in their draught of water by the same limit of 2 feet.

With a view to avoid multiplying wooding-stations, we should advise the boats being constructed to carry fuel for double the time recommended for the passenger-boats, say 36 hours, as they will not run more than half the distance per day.

On this 2-feet draught, they must further be capable of carrying two guns and the requisite amount of ammunition, in addition to the extra crew for working the same, say, in all, equal to 25 tons dead weight. When on ordinary trade, these weights will not be carried, and they will therefore have capacity for an equal amount of cargo.

Their speed with two barges in tow, each carrying 150 tons, must equal 4 miles per hour against the average stream. On the Indus between Hyderabad and Mooltan, this is equivalent to 9 miles per hour in still water.

We must here observe that on the Indus, as on the Rhone, it has been found almost impracticable to tow barges astern; they are therefore lashed alongside, a plan which limits the number to be taken at one time, but requires less power in tracking than that ordinarily adopted, unless barges and tug are made in one continuous line, as proposed in Mr. Bourne's steam-barge train. This arrangement is in principle very like the previously described trains of mud-barges employed on the Clyde, and on any river of similar characteristics; that is to say, with an equal and clearly-defined channel, free from sand-banks and cross-currents, it will probably prove an eminently economical means of goods transport; but we fear will be very slow. Success, however, under such circumstances, is no criterion of comparison with the navigation of Indian rivers, the features of which above the tidal influence are so widely different. We think the effects of the chopping sea to be met with on the Indus, and the difficulty of so connecting the barges as to be sufficiently rigid for their work, are more to be feared than the extraordinary length. Without, therefore, pronouncing any opinion on Mr. Bourne's adaptations, from which successful results are anticipated, we feel bound to observe, that very great difficulties may be expected in the practical use of these trains on the streams in question.

Tug-dimensions.

The dimensions of the tug-boats for the Scinde Railway Company and general Government service-boats on the Indus, and on other large rivers above the influence of the tide, should be,—

	Ft.	In.
Length on 2-feet water-line	220	0
Beam	38	0
Depth	5	0
Draught, loaded	2	0

Engines, effective, 400 horse-power.
Ditto, nominal, say 110 horse-power.

Cargo Barges.

Cargo-barges.

These should also be of the spoon-ended form, but the sides carried higher than in the steamers, to give room for the cargo below deck. They must be fitted with large hatches for easy access to the holds, each hatch being supplied with a derrick or crane, to give despatch in loading and discharging.

They should be capable of carrying about 100 tons of cargo on 1 ft. 6 in. draught, and 150 tons on 2-feet draught; and it will be found convenient that their length should be about five-sixths of that of the tugs; say,—

	Ft.	In.
Length	190	0
Beam	32	0
Depth	8	0
Draught, with 150 tons dead weight	2	0
Ditto, 100 ditto	1	6

Upper River Boats.

Boats for upper and smaller Rivers.

For the passenger and general-service boats, on those upper and smaller rivers on which it is necessary to limit the draught to 1 ft. 6 in., we recommend boats of the same form of model, and passenger-accommodation on the same plan as on larger rivers, but for fewer numbers. It is difficult in a general report to recommend specific dimensions, when no actual station is prescribed; but we think the following should not be exceeded; say,—

	Ft.	In.
Length on the 1 ft. 6 in. water-line	190	0
Beam	36	0
Depth	4	6
Draught, loaded	1	6

Engines, effective, 200 horse-power.
Ditto, nominal, 60 horse-power.

The speed must not be assumed at over 10 miles per hour on a trial trip, or say an ordinary performance of 9 miles per hour. Such a boat could have cabin accommodation for about 20 passengers and say 50 natives on deck; and until the trade is considerable, could also work as a tug-boat.

MACHINERY.

Machinery.

Our deductions from the review of different classes of engine-power, which will be found in the Appendix, are that, all points considered, condensing engines working at a moderate pressure, say of 16 to 18 lbs., are best suited to the navigation of Indian rivers; and we may further remark, that a large proportion of the builders and engineers with whom we have consulted agree with us so far as the adoption of condensation is concerned.

Our chief objection to an increase on the pressure named is the additional weight it involves in the boilers, and the doubt of safely maintaining the same pressure after a few years' service.

Several officers in command of the existing Indus flotilla have advised that future condensing engines shall be fitted with a branch exhaust-pipe through the side of the vessel, to admit of the engines being worked when the vessel is aground, by the pressure of the steam alone. In this we quite agree, and would suggest that the result may be best and most simply obtained if the air-pumps are worked by an auxiliary engine.

We deem it beyond our province to recommend any definite form of engine, and therefore, although fore-and-aft oscillating cylinders are shown in the accompanying drawing, we only wish to convey that direct-action engines should be employed, the particular description being left for future decision. The following general heads must, however, be attended to, whatever form is adopted.

Arrangement of Engines & Boilers.

1st. The engines and boilers should be spread, if possible, over a length of the boat sufficient to float that part of the ship's weight, together with its load of machinery, water, fuel, &c., or at any rate over as great a length as can conveniently be spared.

Weight.

2nd. Total lightness of the engines is of much importance; but in aiming at this, it must be remembered that efficiency and durability are the chief essentials.

Framing.

3rd. The framing of the engines should, wherever practicable, be of wrought iron, not only for lightness, but partially to avoid risk of accidents from the twisting of such light boats; further, the engine-bearers should be very carefully arranged, to give the requisite support and stiffness without undue weight.

Air-pumps and Condensers.

4th. The air-pumps and condensers must be much larger than those ordinarily employed in this country. The average temperature of the water of the Indus is 84°, and the calculations should be made on this basis. There should be two injection sea-cocks on each side of the vessel, one placed in the best position for ordinary service, and the other near the surface, for use when the water is very muddy; and both should be considerably *before* the paddle-wheels. If the air-pumps are worked by an auxiliary engine, the ventilating-fan, the steam capstans, and ship's pumps, can be driven by the same means.

Paddle-wheels.

5th. The boats should be propelled by paddle-wheels, and not by screws.

It has been suggested that two pairs of wheels might be adopted with advantage, and again, that one pair should be used, but each wheel be worked by separate power; for reasons given in the Appendix, however, we conclude in recommending that the boats be propelled by one pair of engines working one pair of wheels.

These wheels must be considerably stronger than the ordinary proportions given for deep water, and power should be given for throwing either wheel out of gear on an emergency.

It has been said that the old-fashioned wheels with straight arms are best suited to a service where collision with the banks is of frequent occurrence; on inquiry, however, we find it is the outer arms only which get injured on these occasions; and as such a construction necessitates a bearing on the spring-beam which often gives rise to trouble, and has in consequence been quite discarded on the Danube and Rhone, we suggest the use of a modification in the form which has been adopted with success on these rivers. The outer and centre sets of arms in this are straight, but those next the ship's sides are bent, to give space for the paddleshaft-bearing. This wheel is simple, efficient, and not more liable to injury than one with straight arms only.

We do not think feathering-wheels would be at all suitable, and in so small a depth of water their performance would be little superior to those recommended.

Boilers.

6th. The boilers should be tubular, and will require very large furnaces in those boats intended to burn wood fuel. The value of this fuel being $2\frac{1}{2}$ to 1 of coal, the fire-bar area must be increased in the same ratio.

They must have very large spaces in every direction, and more than the ordinary proportions of cubic contents, on account of the dirty water. The great weight is against this; but it will be better to carry a few tons more water than get the boilers choked, and possibly burned, by the accumulated deposit of sand.

It has been suggested that the furnaces being necessarily so large, the heating surface might be obtained by the old flue, instead of the multitubular arrangement. This would possess the advantages of greater durability and ease of repair, but we fear will be found to occupy too much room, and to be too heavy.

In construction of the boilers we think the before-mentioned "homogeneous iron" may be employed with advantage.

Engines made template.

7th. With a view to prevent the unnecessary multiplication of spare parts of the engines, and also for certainty in re-making anything which may have worn out or become broken by casualty, we recommend that all the engines of each class shall be fitted to *templates*, in order that they may be precisely similar; the *templates*, of course, being preserved for future reference.

Ease of shipme

8th. In designing both engines and boilers, particular attention must be paid to ease of shipment. The castings should, therefore, not be made larger than necessary, and the boilers must be in small portions.

We wish it should be clearly understood, that in our opinion none of these river-boats can be safely trusted to inferior officers: the best men who can be obtained should be employed. By degrees a private company might train a class of officers who will not be so highly paid; but at first the extra salary of the best men will bear but a small proportion to the risk of trusting to inexperienced persons.

We further wish to state, that none of the boats intended to trade above the deltas will in any way be suited to encounter the risks of deep-sea navigation, and should be retained exclusively for river service.

It would be advisable that the first of the larger boats should be completely put together in this country, and well tried before sent out to India,

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We further wish to state, that none of the boats intended to trade above the deltas will in any way be suited to encounter the risks of deep-sea navigation, and should be retained exclusively for river service.

It would be advisable that the first of the larger boats should be completely put together in this country, and well tried before sent out to India, in order that any improvements which might thus be suggested may be adopted in those which follow.

A general summary of our opinions on the best dimensions and form of the various classes of boats for navigating the Indus and its tributaries is given in the following table; all the boats being fitted with paddle-wheel direct-action condensing engines:—

SERVICE.	Length.	Beam.	Depth.	Load-Draught.	Engines.		Form.
	Feet.	Feet.	Ft. In.	Ft. In.	Effective h.-p.	Nominal h.-p.	
Tug & General-service Boats within the tidal influence	180	22	7 0	4 0	350	100	Straight keel, with ordinary water-lines.
Passenger Boats on the main river (Hyderabad to Mooltan)	350	46	5 6	2 0	800	200	Spoon-ended, *i. e.* rising keel & rounded water-lines.
Tug & General-service Boats on those rivers which admit of 2 feet draught	220	38	5 0	2 0	400	110	Ditto.
Passenger and General-service Boats for rivers on which 2 feet would be an inadmissible draught; dimensions not to exceed	190	36	4 6	1 6	200	60	Ditto.
Cargo-barges	190	32	8 0	with 100 tons, 1 6; with 150 tons, 2 0	...	...	Ditto.

APPENDIX.

On the Machinery for Indian River Steamers.

Non-condensing engines have so frequently been referred to as best adapted for Indian river steam-boats, that we feel obliged briefly to review their stated merits.

The advantages claimed for them are:—

1st. That they are lighter than those with condensing apparatus, and that, being more compact, they occupy less space.
2nd. That they are of a much simpler construction.
3rd. That, having no air-pumps or condenser, the risk of injury to those parts by sand or mud choking them is avoided.
4th. That they are cheaper in first cost.

Noting these claims in succession—

1st. Non-condensing engines are stated to be lighter and more compact.

This will be the case if, as in the locomotive, the parts of the boilers are greatly crowded, and the blast from the exhaust steam is employed so to urge the fires as to make a small boiler do the work of a large one; but the heat of the furnace is thus necessarily much increased, and consequently, the tubes and other parts exposed to it last a proportionably shorter time, and an undue amount of heat is wasted up the chimney.

The quantity of water carried in a locomotive boiler is very small, and the evaporation extremely rapid: perfectly clean water is always employed, and a small mixture of mud causes most serious inconvenience from priming or boiling over; any such arrangement for saving weight would therefore give rise to serious difficulty from the dirty water, which will always be used in the steam-boat boilers. Constant watchfulness would be required on the part of the engineer, as a few minutes' carelessness might cause great danger, should a sudden loss of water not be instantly observed, and the fires drawn out. Again, the high working pressure, say of 80 lbs., may be perfectly safe when the boilers are new; but where repairs are infrequent, expensive, and difficult to effect, a properly cautious man, after a time, will hesitate in pressing his boilers so high, and, consequently, the ship will fall off in her speed, and dissatisfy all connected with her.

Also the speed with which a locomotive piston works is an essential to the elements of lightness and compactness; for if allowed to run slower, the same amount of power could only be obtained by increasing the size of the cylinders, and consequently augmenting their weight; but this speed is very detrimental to the durability of the engine.

All these peculiar features are necessities of the service to which a locomotive is adapted; but it would appear unwise to adopt the admitted disadvantages of a given arrangement where the requirements are so very dissimilar.

If, however, instead of the locomotive form, a suitably large area is given to the furnaces, wide spaces between the tubes, and a large quantity of water allowed, or, in other words, if an ordinary marine boiler of good proportions is supplied (whether round or square), and of sufficient strength to work at the increased pressure—say of 80 lbs.—the pistons arranged to work at a fairly moderate speed, and the engines kept separate from the boilers, the total weight will be *greater* than that of an ordinary condensing engine of the same indicator, or effective power, working at a pressure of 16 to 18 lbs. and having the same form of boiler. The cause of this is, that although the *engines* themselves are lighter, the *boilers* are very much heavier, for the steam blown into the air and causing a considerable back (or counter) pressure on the pistons in the one case, is made to add some 10 lbs. of effective pressure in the other; or, assuming steam of 80 lbs. pressure, a non-condensing engine is blowing away one-eighth or 12 per cent. of its power; this proportion varying *inversely* according to the pressure employed; so that, with 50 lbs. pressure, 20 per cent. would thus be lost. In order to obtain the same efficiency, therefore, with a natural (or an equal amount of) draught in each case, the boiler to work at 80 lbs. must be one-eighth larger; and not only so, but, to stand the increased working pressure, it must be stronger, the stays must be closer together if a square boiler, and the plates increased in thickness if a round form is adopted. And further, the consumption of fuel will be increased one-eighth, and the amount to be carried will therefore be greater in the same proportion.

The following is an instance in demonstration of the statement that non-condensing engines are not lighter than others, if the *actual power exerted* is compared in either case. The high-pressure engines of her Majesty's screw gun-boats complete with water in boilers, &c., weighed 42 tons, and indicated 240 horse-power. The condensing engines of her Majesty's despatch-boat *Elfin*, with feathering paddle-wheels, under the same circumstances, weighed 27 tons; and also indicated 240 horse-power. This is probably an extreme case, but, after making every allowance, shows a decided balance against non-condensing engines.

As to the benefit of compactness:—

The great difficulty of construction in these boats of light draught is to give them sufficient strength to carry their machinery; therefore the obvious aim should be to spread this weight over as great a length of the boat as convenient.

2nd. The next advantage claimed for non-condensing engines is that they are less complicated; but this consists only in the abolition of the air-pump, which is simply an additional pump of larger dimensions, but otherwise the same as those employed for the feed and bilge; the injection-pipe and cock answering to the suction-pipe, and the condenser to an enlarged bottom chamber. Four such pumps of smaller proportions would be employed, whether for non-condensing or condensing engines; thus the only complication of the latter is, that five, or at most six pumps, are worked in place of four; and for this saving a great and constant increase would be made to the working expenses of the engines.

3rd. That, having no air-pumps or condenser, the risk of injury to those parts by sand or mud choking them is avoided.

This is an argument which cannot be contradicted; but the question is, at what cost the advantage is gained.

Besides the additional amount of fuel burned for the *same effective power*, the risks consequent on the tendency to priming with high-pressure steam, as before mentioned, are not confined to the boilers, but also extend to the engines, for these may be seriously injured by water getting into the cylinders; and it must be observed that on the Nile (Mahmoudeh Canal), the Rhine, and Weser, which are far more muddy than the Indus, and the Rhone, which is as bad, no difficulty is ever found with properly proportioned air-pumps, but occasionally the boilers become so choked with mud, that, notwithstanding continual blowing out, the boats have had to be stopped on their journey until they can be cleaned out, again filled, and steam got up. Moreover, the only occasion on which injury from this cause could arise to the pumps, is when the boat is aground, or nearly so; and it would be easy to arrange the engines, so that at these exceptional times they should work without condensation.

4th. Non-condensing engines are said to be cheaper in first cost,—and so they are if the locomotive type is adopted; but if arrangements and proportions are given which will adapt them to the service in question, it will be found that for a *given effective power* the saving will be more nominal than real; and in any case this saving is obtained at a large and constant additional cost in the amount of fuel burned.

As a recapitulation of these remarks, we find that, in reply to the first claim for superiority, non-condensing engines are not materially more compact when arranged in the only way suitable; and, moreover, that if they were, it would be no gain in this case, where it is best to spread the engines very much, to save overstraining the boat. That the nominal saving of weight is only true regarding the *engines*; for, if properly adapted to the service, the *boilers* will be so much heavier that the *total* weight would be increased.

2nd. That the claimed simplicity comes to the fact of one, or at most two, pumps being dispensed with.

3rd. That by dispensing with the air-pumps, &c., a great addition is made to the fuel burned, and the consequent amount to be carried and paid for; that the mud on other rivers has been found to cause more trouble to the boilers than the engines; and the extra amount of priming with the high-pressure steam more than counterbalances the risk of injury to the pumps.

4th. The small economy in first cost is so dearly bought as not to be worth consideration.

Probably the best class of engines, if weight and durability were not of so much importance, would be that adopted on the Hudson and its tributaries, in America, and on the Rhone and Saone, where steam of from 30 to 50 lbs. pressure is employed, considerably expanded and afterwards condensed; but this necessitates a very heavy engine, for the boiler has to be strong to bear the increased pressure, and is of course subject to the before-named inconveniences, and the cylinders, pistons, and other parts of the engines, although only exposed to the force of high pressure through a part of the stroke, must be proportioned in dimensions to this, the greater strain, and thus materially increased in weight. Moreover, the economy of great expansion is doubtful, unless the cylinders are incased in steam jackets, which renders them still heavier.

The principle of surface condensation would be specially applicable to such a case as this, if any means could be devised to insure its success, and would overcome all difficulty from mud in the boilers, from the fact of their being constantly supplied with perfectly clean water. Unfortunately, as yet, the various attempts in this direction have so frequently been unsuccessful, that notwithstanding a better result which has lately attended a modification of the apparatus, we hesitate in recommending its being tried in boats so far from means of heavy repairs or alterations; and moreover, the weight would be considerable.

Our deductions from this review of the merits of various classes of engine power (as given in the body of the Report) are, that, all points considered, condensing engines, working at a moderate pressure of say 16 to 18 lbs., are best suited to the navigation of Indian rivers; and as a confirmation of our views, we must remark that on the Ganges, which is a more muddy river than the Indus, condensing engines are constantly used, and non-condensing engines have been tried, but proved unsuccessful.

With regard to the suggestion that one boat should be fitted for the Indus with non-condensing engines, as a trial, we can only say that success in this country would be no guarantee for a like result on Indian rivers, on which, if anything fails, the expense and time lost in setting it right are enormous; and the practical and theoretical views of the question have so decided a bearing towards the condensing arrangement, that we cannot advise the outlay necessary for the trial of non-condensing engines.

Method of Propulsion.

The boats should be propelled by paddles in preference to screws.

The following adaptations of the paddle-wheel have come under our notice:—

1st. Two distinct pairs of wheels might be employed, each driven by separate engines.

The advantages said to be derived from this arrangement are:—

That the necessary power for propelling the boat being transmitted at two points, instead of one, much less strength and consequent weight will be required in the boat, the weight of machinery will be more equally distributed; and, further, a greater hold is taken of the water.

We think, however, that the additional weight occasioned by such an arrangement, if applied in so strengthening the boat as to stand the whole strain at one part, would produce a better result; for, looking to past experience, we cannot think the same efficiency is obtained from the four wheels as from two; the after pair, however long the boat, being necessarily working to a great extent in the disturbed water-trail of the forward pair, and thus expending much of their power without aiding in the propulsion of the boat: moreover, the distribution of weight will practically be the same with the engines in centre and boilers fore and aft, as with the boilers in the middle and engines fore and aft. But, irrespective of these reasons, we consider the great increase in the number of parts requiring the attention of the engineers would be a serious objection, and add considerably to the working expense; and as sufficient power can be transmitted through one pair of wheels, we do not recommend the adoption of this plan.

2nd. The boats being of extraordinary length, it has been suggested that each wheel should be worked by a separate pair of engines, so that one wheel might be stopped while the other is running, to give ready means of turning.

This would be an advantage, but has the objection above mentioned of multiplication of parts; and boats of still greater length being readily managed on the Rhone without any such assistance, we do not see sufficient reason to advise this being adopted.

We therefore conclude in recommending the boats being propelled by one pair of engines working one pair of wheels.

J. H. G. CRAWFORD,
Major, Engineers.

W. BALFOUR,
Commander, I.N.

T. B. WINTER,
Marine Engineer.

TABLE OF THE DIMENSIONS AND OTHER PARTICULARS

Supplied by various Builders and Engineers for fulfilling the following requirements for Passenger Steam-boats on a wide, shallow, rapid River.

ESSENTIAL REQUIREMENTS.

To have spacious Cabin Accommodation for 100 Passengers, and room for 100 more on Deck.
The weight of these, with their baggage and provisions, being assumed as 55 tons dead weight.
Weight of Crew, Ship's Stores, and Sundries, 27 tons dead weight.
Also to carry Wood Fuel for 18 hours' steaming; the requisite quantity of which, as compared with Coal, is $2\frac{1}{2}$ to 1.
With all this on board, in addition to every item of necessary outfit, the extreme Load-draught must not exceed 2 feet.
And the speed of the Boat must equal 15 miles per hour.

NAMES.	LENGTH.	BEAM.	DEPTH.	ENGINES.			ABSTRACT OF FURTHER REMARKS.
	Ft. In.	Ft. In.	Ft. In.	Effective h. p.	Nominal h. p.		
MESSRS. J. & A. BLYTH	.. ..	.. ..	.. ..	.. ..	.. ..	Dimensions .... Strengthen .... Engines	Advise considerable increase on the length of boats hitherto employed, the limit being decided by an accurate knowledge of the river. By fore and aft bulkheads, or girders, rising above main deck, as noted in boats at the "Iron Gates" (Danube) Think that condensing engines have the balance of advantage; would prefer four paddle-wheels.
MESSRS. FORRESTER & CO...	330 0	30 0	4 0 to 6 0	450	150	Form .... Strengthen .... Engines .... Tug-boats .... Boats	Straight keel, and ordinary lines. By overhead trussing, and making girders of sides of cabins, which are entirely in houses on deck. Condensing, with steam of 25 to 30 lbs. pressure. To be—Length, 290 ft.; Beam, 27 ft.; Engines, nominal, 150 h. p.; 450 h. p. effective. For smaller rivers—Length, 170 ft.; Beam, 24 ft. 6 in.; Depth, 4 ft. 6 in.; Engines, nominal, 60 h.p.; 200 h. p. effective.
MESSRS. J. HENDERSON & SON	255 0	26 0	7 3	250	.. ..	Form .... Steer .... Cabin .... Engines	"Spoon-ended," *i. e.* rising keel, with rounded water-lines. By patent "blades," mentioned in body of Report. Advise use of "homogeneous iron." Accommodation below deck. High-pressure non-condensing, with upright tubular boilers and exhaust-blast.
MESSRS. HUMPHREYS, TENNANT, & DYKES	.. ..	.. ..	.. ..	.. ..	.. ..	Engines	Condensing, and working at 15 lbs. steam pressure. Horizontal cylinders and radial paddle-wheels. Flue boilers in preference to tubular, on account of large furnaces being required; also as being less liable to injury, and easier repaired. Think air-pumps may be worked by a separate engine with advantage. And consider such engines would be of the minimum weight for their power.
MR. JOHN LAIRD	350 0	50 0	5 0	800	200	Form .... Cabin .... Strengthens .... Engines	"Spoon-ended," *i. e.* rising keel and rounded water-lines. Built first boat of this description for the Indus. Accommodation entirely in deck-houses. The hull by raising sides fore and aft of paddle-boxes for some distance. Recommends use of "homogeneous iron." Prefers high-pressure non-condensing, but suggests one boat being so fitted, and one with condensing engines, as an experiment. For alternative main river passenger-boats gives the following dimensions of boats which might suit, but would carry very little :—

(1)	Length, 300 ft.	Beam, 43 ft.	Depth, 5 ft.	Draught, 2 ft.	Engines, 170 h. p.—	700 h. p. effective.
(2)	,, 250	,, 36	,, 5	,, 2	,, 140	560 ,,
For sea channel-boats	,, 160	,, 25	,, 7	,, 3	,, 80	320 ,,
For Upper Indus do.	,, 210	,, 35	,, 5	,, 2	,, 90	360 ,,
For smaller rivers ...	,, 168	,, 28	,, 4	,, 1 6 in.	,, 30	120 ,,
For Tug-boats......	,, 210	,, 35	,, 5	,, 2	,, 160	640 ,,
For Barges	,, 150	,, 30	,, 6	,, 2 with 100 tons cargo.		

MESSRS. MAUDSLAY, SONS, & FIELD	.. ..	.. ..	.. ..	.. ..	.. ..	Engines	Condensing, with steam at 20 to 25 lbs. pressure, and capable of working without condensation on emergencies. Engines to be of the steeple description; radial paddle-wheels. Think there might be advantage in using two pairs of wheels, if they can be kept far enough apart to avoid the evils in their ordinary use. Suggest the use of "homogeneous iron" in the boilers.
MESSRS. C. J. MARE & CO.	350 0	35 0	9 6	1400	.. ..	Form Strengthen Cabin	Straight keel, and ordinary lines. By diagonal trussing, forming sides of cabins. Accommodation partly below deck and partly in deck-houses.
MESSRS. R. NAPIER & SONS	380 0	30 0	9 0 amidships.	700	250	Form Strengthen Cabin Engines	Ordinary water-lines, but keel rising forward. Depth of hull greater amidships than at ends. By using sides of deck-houses as girders, their top being of corrugated iron. Accommodation entirely above deck. Suggest use of "homogeneous iron." High-pressure, non-condensing. Radial wheels.
MESSRS. PALMER (Bros.) & CO.	350 0	40 0	3 6	.. ..	.. ..	Form Strengthen Engines	Straight keel, and ordinary water-lines. By fore and aft bulkheads. A combination of condensing and non-condensing, as most economical. Each paddle-wheel to be worked by a separate pair of engines. Paddle-wheels to have feathering floats. Round boilers. Think this the lightest arrangement possible.
MESSRS. GEO. RENNIE & SONS	260 0 to 280 0	26 6 to 27 0	Quite low.	.. ..	180	Cabin Engines	Accommodation in deck-houses. Non-condensing, with apparatus to free the water of sand.
MESSRS. RICHARDSON & DUCK	350 0	34 0	6 0	.. ..	160 to 170	Form Strengthen Engines	Ordinary water-lines, but keel rising forward. By fore and aft bulkheads and overhead trussing. Have built boats somewhat similar for Russian rivers. Condensing; oscillating.
MR. J. SCOTT RUSSELL	300 0	36 0	12 0		360	Form Strengthens Engines	Straight keel, and ordinary water-lines. Would prefer greater length, but doubts the strength of a longer boat. By fore and aft kelsons and bulkheads, combined with depth of boat. Taking into account safety, durability, economy, and weight, recommends condensing engines, working at 30 lbs. pressure. Has built non-condensing engines for the Ganges, and not practically found them work well.
MESSRS. R. STEPHENSON & CO.	350 0	30 0	5 0	....	280	Form Strengthen Cabin Engines	Spoon-shaped bow, and careful attention to steering capabilities. By raising sides of hull for some distance amidships. Accommodation entirely above deck, in a double-storied deck-house. Condensing, and working with 30 lbs. steam-pressure. Radial paddle-wheels and round boilers.
THE THAMES IRON WORKS COMPANY	372 0	31 0	4 10	.. ..	160	Form Strengthen Cabin Engines Tug-boats Barge	Ordinary water-lines, but keel rising forward. By fore and aft bulkheads. Accommodation entirely on deck. Condensing. Length, 230 ft.; Beam, 28 ft.; Depth, 4 ft. 10 in.; Draught, 2 ft.; Engines, 100 h. p.; capable of towing two of the following barges at 10 miles per hour. Length, 270 ft.; Beam, 28 ft.; Depth, 4 ft. 10 in.; Draught, 2 ft. with 200 tons cargo.
MESSRS. WESTWOOD, BAILLIE, & CAMPBELL	350 0	32 6	.. ..	675	.. ..	Form Strengthen Cabin Engines	Ordinary water-lines. By using sides of deck-houses as girders. Accommodation entirely above deck. High-speed non-condensing. Geared on to the paddle-shaft.

LONDON:
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