The Leviathan Steam-Ship

Captain Fishbourne R.N.

To cite this article: Captain Fishbourne R.N. (1858) The Leviathan Steam-Ship, Royal United Services Institution. Journal, 2:6, 117-132, DOI: [10.1080/03071845809415901](https://doi.org/10.1080/03071845809415901)

To link to this article: <http://dx.doi.org/10.1080/03071845809415901>

Published online: 11 Sep 2009.

Submit your article to this journal [↗](#)

Article views: 5

View related articles [↗](#)

THE
Journal
 OF THE
United Service Institution.

VOL. II.

1858.

No. VI.

LECTURES.

Wednesday, 17th March, 1858.

Colonel the Hon. JAMES LINDSAY in the Chair.

THE LEVIATHAN STEAM-SHIP.

By CAPTAIN FISHBOURNE, R.N.

ON a subject that has been so much discussed and so interesting as the *Leviathan*, I must not be expected in the space of an hour to describe every point of economy and usefulness involved in her construction, or do more than gather into a focus the scattered rays of light that have been given to the public, and place some of the more important in a new point of view.

The first point which attracts our attention is her enormous magnitude, which so far surpasses anything that has as yet been built, that men in all ages would have doubted the feasibility of constructing a really efficient ship of such a size; and now she is built there seems to be an impression abroad, either that she cannot be sufficiently strong to resist the action of the sea, and that therefore she will break in two, or that she will be subject to an inordinate

amount of motion, or that as a mercantile speculation she will be a failure—this last I fully believe is the only point which has the smallest chance of becoming a fact.

Some idea of her dimensions may be gathered from a comparison of them with those of the largest ships:

	Length. Breadth.		Length. Breadth.
Duko of Wellington .	240 ... 60	Himalaya	370 ... 43
British Queen . . .	275 ... 61	Persia	390 ... 45
Great Britain . . .	322 ... 51	Leviathan	680 ... 83!

Her cubic contents are about five times those of the largest 180 gun ship, and for those who may be unable to realise such dimensions, I may add that her length is nearly double the height of St. Paul's, or if she were laid across Russell-square, her length is so great that it would not admit of her dropping between the houses, while her breadth is equal to that of Pall Mall.

The dimensions of this ship have also not inappropriately been compared with those of the Ark, and whatever may have been its form, its proportions are very interesting as being demonstrably superior to those that have been until very recently deemed best, dimensions which are especially suitable for large vessels.

2ndly. We may consider how far weakness and accidents are provided against by the mode of construction adopted.

The pressures which ships are subject to may be reduced to the three principal; one inwards, one the effect of rolling motions, each provided against for the most part by the ribs, and a third arising from pitching motions and from an unavoidable or improper distribution of the weight of hull and lading. This has been sought to be provided against by the keel, and a system of diagonal trussing: beautiful as this scheme is, it only partially serves its purpose, and therefore ships gradually work and deteriorate, the ends of sailing ships droop, and the middle of steam vessels, owing to the fact that their engines and coals are placed there, and their weights are greater than the sum of the pressures of the water on that part.

These effects it is fairly presumed will be entirely prevented by the application of the tubular principle to this ship, associated as it is with a material that admits of a more perfect connection of part to part than is possible to obtain in wood, by which is effected a

more immediate transmission of and distribution of the pressures throughout the whole fabric.

One of the objections taken to the size of this ship is one that has been taken to all ships of unusual length, namely, that her back would be broken owing to her being suspended by her extremities on two seas. The President and Pacific are cited in proof. The note recovered from the latter ship disproves that view as respects her; and the President was known to be weak of her kind, and further, her form contained an element of weakness that ought on all accounts to be avoided, and which, she being weak, may have led to the catastrophe.

The apprehension implied in the above-stated idea is utterly groundless and contrary to the facts, for, just in proportion as a ship is long, *ceteris paribus*, will she be less likely to be suspended between two seas; for, were it possible for ships to be so suspended, short seas, or seas a short distance apart, being much more frequent than the long seas, or seas a considerable distance apart, short ships must be more frequently suspended than long ships.

Dr. Scoresby, a man who combined accurate observation with profound thinking, states that the waves rarely exceed 28 feet in height; a fact previously observed by another accurate observer, Admiral Fitzroy, who gave 24 feet as their maximum height; the former gives their maximum length as 600 feet, adding that in a moderate gale they are only 300 feet, and in a fresh sea only 120 feet.

The figure 1 is a profile of the Leviathan, with the profile of two such seas, the crests of which are 600 feet apart, which is the most unfavourable position in which she could be placed.

2, 3, and 4 represent cross-sections of that ship at the parts under which they are placed. Figures 5, 6, and 7 are profiles of the Duke of Wellington in a similar length of sea, and 8, 9, and 10, are cross-sections of that ship.

Now on a reference to the figure it will be observed that at the utmost the support taken away from the centre of the Leviathan could only extend 14 feet deep in the centre, and, as she will draw about 30 feet, or about that quantity will be immersed, she would still have the support which would be afforded by 16 feet of her centre

being immersed; but the fact is, that the wave would not fall so low in the centre, or, in other words, she would not be lifted so great a quantity, arising from the fineness of her extremities as compared with the fullness of her centre, which will be evident from a comparison of figures 2 and 4 with figure 3: in fact, there would scarcely be any rise or fall of the Leviathan in such a sea, whereas on reference to figures 5 and 7, the first being the Duke on a sea, and the second being the Duke in a hollow between the waves, it will be seen that she would be subject to a perpendicular rise and fall of about 12 feet, and, as this rise and fall would be effected one end before the other, the greater fullness of her extremities would tend to strain her much more than those of the Leviathan would her, for it will be observed that figures 8 and 10 are larger in proportion to 9 than 2 and 4 are to 3.

The President had a full bow, yet not so full as that of "the Duke," a form of bow which I have long thought had many grave faults and no redeeming quality.

A shorter sea than that portrayed would be more favourable to the Leviathan, and less so to the Duke; and a sea of that length is much less rare, as it occurs when there is less wind.

But in addition to her form and size, she has a further very considerable advantage in the mode in which she is constructed.

We know the enormous strength of tubular formations from the experience of the Britannia tubes, that are supported only by their extremities. It may be said that all ships are an approximation to this principle; but it will be observed, that in forming these double cylinders each plate or substitute for plank is lapped over the other, and riveted to it in a manner that is little short of making them one, for the point of junction is stronger than the plate. This you will observe is a manifest advantage over the mode of construction by wood, in which the planks are merely laid side by side and bolted to the timbers. In wood ships the latter alone have to bear the cross-strain from seas and from rolling, the planking affording none; and though the riveting of the *plates* of both cylinders affords a strength not obtainable from *planks*, yet this vessel is not without ribs, for she has iron plates which connect the two cylinders, and, as the latter are two feet ten inches

apart, the strength afforded by such a depth or thickness of rib is enormous.

But long ships manifest weakness more in the rising or drooping of the extremities than in any other direction.

No doubt in wood ships the planking affords some strength, yet nothing in comparison of the plates of an iron ship, and this because they are so intimately connected to each other that they cannot yield.

When iron was introduced, the mode of construction in use in building wood ships was applied to iron; plates taking the place of planks, and angle iron ribs the place of timbers, but Scott Russell introduced horizontal iron stringers or bands of iron which were connected with those ribs, and extended the whole length of the ship, giving an immense increase of strength in the direction most required; and in building the Leviathan he merely connected these stringers or bands by placing bands of the width of the open spaces between them, and so completed the cylinder which constitutes the inner ship, or ship within a ship, and thus added still further to strength.

No doubt the Leviathan has not a keel, but she has that which is not possessed by other ships, and which affords her vastly more strength, and that is, three perpendicular diaphragms or bulkheads running the whole length of the ship, and reaching up to her lower deck, dividing her practically into three ships, and these are again strengthened and stiffened by thirteen transverse diaphragms or bulkheads, so completely separating the ship, that if she were broken transversely into parts, the parts thus divided would float in their separated condition, and while these bulkheads add to the general strength, and thereby, indirectly, to the greater safety, they add directly to the safety by being water-tight, and so separating the ship into as many distinct parts, so that if a hole were knocked in any one of these the water would fill only one compartment; even two of them might be so damaged without material danger to the ship, and were a fire to occur on board in any one of these divisions, it might be flooded without the risks incurred in the Sarah Sands troop-ship. None of these advantages have ever been obtained in

any vessels of wood, except Chinese junks, which have water-tight compartments, and are often saved from foundering by this provision.

In a paper of this sort it would not be proper to overlook disadvantages, and it must be admitted that it often happens in a wooden ship on her coming in contact with a hard substance her bottom yields, and though a hole should be made temporarily, yet the wood, owing to its elasticity, recovers, and the hole closes ; on the contrary, an iron ship has no such elasticity, therefore the hole remains.

This is provided against, and even a greater degree of safety than that possessed by a wooden ship is obtained by the cellular construction of the *Leviathan* ; for if the blow above alluded to were more violent, a permanent hole would be made in both iron and wood, but the consequences in each case would be different ; a hole in all wooden ships involves this, that the ship may fill and go down. In iron ships, on the contrary, that have water-tight bulkheads, each division affords an additional chance, and in the cellular system, such as that employed in the *Leviathan*, a hole may extend only to the outer skin, which would be very unimportant, and though through both skins, even then the water would be admitted but to one of thirteen compartments: each compartment has its own pumps quite distinct, and a limited number of the numerous cells between the skins are connected by pipes and then with pumps in the event of any leakage.

The propriety of employing this ship in any of the various purposes for which she is suitable is questioned, as if navigation belonged to the class of chances, and it is asked who would trust so many men or so much cargo in one venture—a question asked with every increase in the size of ship: since the days of Columbus, or before.

Many will recollect the fact given by Basil Hall in his *Fragments of Voyages* of that great discoverer having rounded the Horn and approached Rio from a distance of 1,800 miles without having seen land: when nearing his port he determined his position by lunar distances, and steered for it, but having run his distance he had to in

a fog, head towards his port, and when the fog lifted he made the Cocovardo right a-head, not far off; since which chronometers have been introduced. And we have hundreds of cases such as that.

But, though navigating ships were a mere adventure, I ask are not the chances of danger reduced to the smallest amount by the indefinite number of cells, and by the multiplicity of bulkheads, transverse and longitudinal?

The furnaces are 14 in number; and, though many of them are necessarily in separate compartments, access from one stoke-hole to another is provided by water-tight passages capable of being shut off by water-tight doors. The coals are stowed above the furnaces in such a manner that they drop down in front of the fire-places without needing the aid of coal trimmers, which effects an immense saving in the number and expense of the crew.

This ship is also furnished both with a screw-propeller and paddle-wheels, the latter so fitted that one may turn a-head and the other a-stern when necessary, by which the vessel may be turned short round, and her engine-power is divided so as to adapt it to these different modes of propulsion.

This arrangement has many advantages, and I am not aware that it is attended with any disadvantage. The amount of power applied to the screw will perhaps be as much as could be economically applied in that way, and the whole power being divided affords facilities for repairs of engines, cleaning boilers, &c.; and when there is wind one or other of the modes of propulsion may be temporarily dispensed with. The paddles are only half the ordinary width usual in wheels of their diameter: but these will exercise a very beneficial use in steadying the ship, and I am quite satisfied that the employment of paddles in this vessel will tend to demonstrate their value, and prove that mode of propulsion to have been underrated.

Great dimensions were necessary fully to develop the effect of steam-power, and to reduce its expense to a minimum, and so to enable steam-vessels to compete with sailing-vessels of the most approved form and size.

It may well be conceived that the difficulty of propelling a vessel through the water would approximately be in proportion to the size

of the hole she has to make in the water, and that it would be proportioned to the area of the greatest cross-section; and therefore that double the amount of steam-power would be required to give equal velocity to a vessel having this area double the size of that in another. That is to say, if engines of 50-horse power are sufficient to drive a vessel 100 feet long by 12 feet wide and 6 deep ten miles an hour, 100-horse power would drive a vessel of 200 feet by 18 wide and 8 deep at least at the same rate. But, though the length, cross-section, and horse-power are only doubled, the cubic content is increased fourfold, which after deducting the amount of displacement necessary to provide for the increased weight of hull, there will be a large amount of additional space available for the stowage of an increased quantity of coals and cargo. Plate II., shewing areas of cross-sections and corresponding displacements, will place this point in a clear light. Consequently great size is an important element in economy.

But there are special reasons for supposing that vessels of the form of the Leviathan would admit of greater speed than that obtainable from vessels of the ordinary form; these may now be discussed.

Fig. e.

Fig. f.

When a vessel is floating it is obvious that she makes a cavity in the water in which she floats, the form of which corresponds to hers.

Let the figures *e* and *f* represent, generally, horizontal sections of

two such vessels. Let e represent that of the wave form, and f a mean of all the varied forms contradistinguished from that, and generally characterised as having "a cod's head and mackerel's tail."

Suppose vessels of which these are sections to be of equal breadth, and to have an equal area of cross-section, such as fig. g : obviously

Fig. g .

then the hole or space necessary to admit of either passing through would also be equal; but it by no means follows from this that an equal amount of power would be required to drive them at an equal speed.

Let lines ab and cd , figs. e and f , be drawn across 20 feet from the fore end of each section, and let it be assumed that a power has been applied to drive each forward 20 feet in a horizontal direction in the same space of time.

In this case it is clear that before they could be moved forward that quantity, the water which occupied the spaces eab and fdc must be moved to either side, and the quantity that would require to be thus moved in each would be proportional nearly to the lines ab and cd respectively. A cursory glance will suffice to perceive that the quantity before fig. f is vastly more than that before fig. e , and that, therefore, more power will be required to drive a vessel of the form of the former figure at an equal rate with a vessel of the form of fig. e .

It is quite evident that motion will be communicated to the water before e more slowly and more uniformly than to that before f , but it is established that the more slowly motion is communicated the less is the power required to produce it, consequently on this account less power will be required to move a vessel of the form of e .

We shall obtain a clearer view of this by dividing each bow, and considering the effect on each section.

Suppose r and t to represent half-sections of e and f enlarged, and each thus divided into eight.

Fig. r . Fig. t .

It is clear that as 1 to 18, fig. t , is thirteen times as much as from 1 to 1 in fig. r , a particle of water coming in contact with the stem of t , and passing to 13, will require to travel thirteen times as fast as a particle passing over the first section of fig. r , since the vessels are supposed to be moved ahead at the same rate. But resistance varies as the square of the velocity, consequently the resistances on these two divisions will be as the square of 13 to the square of 1.

The difficulty of generating a velocity sufficient to carry the water away from before fig. f is such, that it becomes heaped up in her path, and only finds its way outwards by the rapidity of its fall from a great height, which carries it unnecessarily far, and wastes power. The expense of steam-power is such that no merchant could afford to give the form of fig. t to the bow of any vessel from which he desired to obtain much speed, and it may be confidently affirmed that no fast steam-vessel has such; in other words, no such vessel has "a cod's-head bow."

I have divided the above bows into eight parts. The curves, and

therefore the lengths of the ordinates or lines dividing fig. *t* into these divisions, are arbitrary, that is, according to the fancy of the architect, who, because he follows the rule of thumb, is called a practical builder, though neglecting that eminently practical part of all such questions, viz., the *£. s. d.*

Not so in the case of fig. *r*, or the wave-form, where the ordinates to the curves are the spaces passed through in the fall of a body acted on by gravity, viz., 1, 4, 9, 16, in each quarter of a second. This is the ratio that obtains in the rise and fall of an ordinary wave, and in the case of a bow of this form, as it drives the water out from before the vessel it forms a vertical wave or rise at the middle of the bow, as may be observed in smooth water when she is going fast.

The increments of velocity imparted at each division of the wave bow are 1, 3, 5, 7—7, 5, 3, 1, the sum of the squares of which are 167; while the increments of velocity imparted by the cod's-head bow are 13. 6. 4. 3. 2. 5. 1. 5. 1. and the sum of the squares of these = 238, that is the resistance on both sides of each bow would be as 334 to 476.

This may be taken for a low velocity, and just in proportion as the velocity is greater will the difficulty of driving the cod's-head be greater; in fact, no vessel of ordinary length could carry steam-power and fuel to drive such a form at a high velocity,—a fact that we have been very slow to learn in the navy.

The above argument is on the supposition that the sea is smooth; which state is the exception, therefore the case should be considered when the sea is rough.

Let the same forms be supposed to be propelled against a head-sea, then on occasion of the first wave meeting them additional buoyancy will be added to each in proportion to the cubic contents of their bows. Assume that they have moved the first division a-head, then, as that section in fig. *r* is only $\frac{1}{13}$ -th that of fig. *t*, only $\frac{1}{13}$ -th the amount of buoyancy added to fig. *t*. will be added to fig. *r*; nor does the evil end there, for the bow having passed the wave it enters the hollow, when the amount of buoyancy taken from fig. *t* will be thirteen times the amount of that taken from fig. *r*, which aggravates all the evils of resistance, and shows that it would be physically impossible even to continue a vessel of the form of fig. *t* moving at

the same rate as one of the form of fig. *r*, were it possible to drive her at an equal rate.

Then the after body is no less different; this also is the result of design. It has not been sufficiently considered that a vessel may be so fine as to cause a partial vacuum behind her.

When a vessel is at rest in the water she is retained in that state in consequence of equal and opposite pressures, thus she does not move a-stern in consequence of the pressure on the bow because there is an equal and opposite pressure on the stern; but if an extraneous pressure be applied to push her a-head, then in proportion to the rapidity with which she moves will the pressure on her after parts be lessened, and in proportion as these points are well or ill formed will less or more power be required to give and sustain the velocity imparted.

The water under these circumstances finds its way in behind her only because of the force of gravity, and obviously there is an early limit to the horizontal velocity which that force can generate, especially at and near the surface of the water, as in that case the water has but a small height to fall through.

We know that a dense body will fall the first quarter of a second 1 foot, in the first half-second 4 feet, the first three-quarters 9 feet, and in the first second 16 feet.

We may assume this to be true of a column of water, and we may assume that a column falling 4 feet will project horizontally a stream of particles that will describe a distance of 4 feet in the first half of a second, and a column falling 9 feet a stream that will describe 5 feet in three-quarters of a second. Suppose *r s t u* to represent half the cross-section of a vessel, and a line parallel to the centre line *r u* to be drawn from the extreme outer part of the ship's side; suppose then ordinates of the above lengths laid off from points in this parallel line at the respective depths 1, 4, 9, 16, towards the middle line of the ship; if now a line be drawn through the points where these lines terminate, it would give the curve of least fullness that was consistent with any pressure on the after body from water coming in at that rate, that is to say, if the vessel is moving say at 6 knots an hour, the section thus described should not be nearer to the midship section *r s t u* than 10 feet, and if

moving 12 knots not nearer than 20 feet. Let $op u$ be the curve described, it is clear from the above reasoning that oxy or any

curve on that side of p would entail a partial vacuum, and involve therefore a useless absorption of power.

But the above argument proceeds on the supposition that there are columns of 4 and 9 feet respectively uninterruptedly falling, and producing the above described horizontal currents, but the presumption is that a large number of interfering currents would prevent the velocity described; and in fact it may fairly be presumed that there would not be any such current running towards the ship's side from the upper part of the column of water, since in proportion as the water was deeper it would be subject to a greater pressure, and in that proportion would those particles acquire an inward velocity both greater and earlier, consequently the upper particles instead of passing in horizontally would fall perpendicularly to fill up the place left by the lower particles; it is therefore absurd to have fine, and still more so hollow lines abaft near the surface, since the water could not, unless the vessel were going very slow, find its way into them, consequently the curve o, q, q' , would be a more correct shape for the vertical sections. But the

horizontal curves yet remain to be described. This may be done in a few words, as from what has already been written it must be evident that at and near the load waterline or surface, the motion of the water towards the ship cannot be rapid, and that to curve these waterlines rapidly inwards would involve a loss of space in the ship, and would uselessly absorb power to drive her, as a partial vacuum would be caused by this form.

Where, then, it may be asked, is the water pressure on the after body to be obtained? From either side, below where the water will be readily pushed in by the high column of water above it, and the form of body should be formed so as to admit the rise of the water from amidships, and below by a curve in the direction of the vessel's length, similar to that already described, viz., 1, 4, 9, 16.

The question may be asked, But what is the practical result obtained from the wave-form, or any approach to it? This is easily answered; ten years ago there was a class of coasting steamers of about 800 tons nominal burden, having engines of 400 horse-power (nominal); it was considered very good if they attained a speed of ten knots. We now find steamers of 2,500 tons nominal burden effecting a greater speed with engines of 400 horse-power. From the Leviathan we may expect from fifteen to eighteen knots.

In an article in the Journal of the Society of Arts, the question of size is discussed, and its value generally admitted. This article enters more into the economical bearing than consists with the intention of this paper to do, but in doing so I think the superiority of large ships for long voyage is somewhat undervalued. Thus it is contended that on a passage to Calcutta, the large ship steaming the whole way without touching, and the small ship coaling at three places, the former would have only the advantage of a few days' shorter passage, the number depending on the speed of the larger.

But this view proceeds upon the supposition that six days is sufficient for calling and coaling three times, a period inadequate even under favourable, and very inadequate under adverse and not uncommon circumstances, at the Cape of Good Hope.

In the arguments in question there are several points overlooked—one or two I may mention.

1. The increased distance and risks, and cost of insurance, owing to calling at three places on the way out.

2. The fact that while the small ships would have to steam against the S.E. trade in going to the Cape, the large ships would go down a parallel almost under fore and aft sails, which, while they would steady and increase the speed of the ship, would reduce the wear of the ship and consumption of coals, and would also greatly increase the comfort and health of troops or other passengers.

The views alluded to, though favourable to large ships, are founded upon facts drawn from inferior types of forms, consequently the advantages of size when associated with a good form for realizing great results are much undervalued.

Added to which, the mercantile view is of too limited a kind, for in a nation like that of Great Britain there are always circumstances occurring that render such ships of incalculable value.

One of our colonies is an empire, and two are fast growing into like grandeur and importance. We have seen how much of life, of honour, not to say of money, might have been saved had we been able to have landed 10,000 men in India in five or six weeks instead of from 75 to 120 days. Troops were not sent in steam-vessels because there was not sufficient coals at the stations to supply them; such a ship would have carried her own coals.

The knowledge that we possessed the means of sending an army thus quickly would add no ordinary amount of power and prestige, and would bind India in security of 10,000 men to keep the peace.

The day is not distant when the demands for increased intercourse between these growing empires can be satisfied only by such ships as the Leviathan, and thus much may be said in justification of the course adopted by the high-spirited Company who have built this ship, that in every instance in proportion as facilities for intercourse and traffic have been given, has traffic and intercourse increased in

amount. They have dared to be in advance of their age, have risked the penalty of failure, and are therefore entitled to the unqualified praise of their countrymen. She may prove to be a mercantile failure, nevertheless we may point to her as a triumph of Anglo-Saxon enterprize.

As a model of form and of mechanical skill she is unequalled, and reflects the highest credit on Mr. Scott Russell, who I fully believe has done more for the improvement of naval architecture than any man living. The country owes him also a deep debt of gratitude for the handsome and disinterested way in which he has given the public the benefit of his knowledge.