

MODERN SHIP DESIGN.*

FROM DRAFTING BOARD TO TRIAL TRIP.

BY LESLIE DENNY.

THE general principles involved in the design of a vessel are the same whatever type is required, and it must be assumed that a large amount of data derived from vessels previously built are available for preliminary estimates. So full are these data possessed that it is possible to scheme out a vessel in the course of an hour, which is so nearly correct that when passed to the drawing office for more careful analysis only minor alterations have to be made. The principal items tabulated are the dimensions of the vessel, of her machinery, her tonnage, and its distribution in detail, her displacement and weights in detail, particulars as to her stability, capacity, rig, class, details as to passengers, number of staterooms, water ballast capacity, fresh water capacity, the length of engine room and boiler room, dimensions of cylinders, stroke, kind of engine, number of boilers, their length, diameter, description, and working pressure, number of furnaces, diameter of same, heating surface, grate surface, diameter and pitch of propellers, or paddle wheels, then follow particulars of the trial trip, giving draft, displacement, power, speed, revolutions, slip, ratio of heating surface to grate surface. Then follow details as to form, then coefficients worked out from these, which are used in estimating.

The following are a few of the terms used:

The dimensions usually taken are molded dimensions. The length is the length on the water line between the front of the stem and the back of the stern-post.

The molded breadth is the greatest breadth amidships over the frame and inside the skin plating.

The molded depth is the depth from the top of the keel to the top of midship frame at side.

Tonnage is somewhat of a mystery to those unconnected with shipbuilding and shipowning, but broadly the gross tonnage is the entire internal capacity of the vessel, taken in cubic feet divided by 100, while the net tonnage is this figure less deductions for machinery space, crew space, also light and air for machinery, etc. In a typical cargo boat whose dimensions were 410 feet by 50 feet 6 inches by 32 feet the gross tonnage was 5,149, while the net tonnage was 3,323 tons, the difference of 1,826 was made up by allowance for space occupied by propelling power 1,673, for crew space 153.

In our calculations for displacement, etc., we use the molded draft, which is the draft as shown on the draft marks forward and aft minus the thickness or depth of the keel. We do this because vessels are fitted with different kinds of keels, some as much as 12 inches deep, whereas other owners prefer to turn the keel on its flat, and while it may be 12 inches broad it will only be 2½ inches to 3 inches deep. Now the displacement of a vessel can best be described as follows: Suppose a vessel floating freely in salt water and that suddenly by some means she was frozen solidly in, and that then she was lifted out of the ice; there would remain in the ice an exact mold of her shape. If, then, this mold was filled with salt water through a meter, the number of cubic feet of water divided by 35 would give the tons displacement of the vessel, which is the weight of the vessel, and any cargo, etc., she may have on board at that time. Shipbuilders now use the Amsler planimeter for ascertaining this displacement from the drawings. Now the data previously mentioned are analyzed and tabulated not only directly, but also in the form of coefficients; thus the cubic feet of displacement is compared with that of a block, or parallelepipedon, having for dimensions the length, breadth, and draft molded, and a coefficient which is commonly called the block coefficient is obtained. For example, to take the vessel just referred to, her dimensions were 410 feet by 50.5 feet, and on trial her molded draft was 24.62 feet, and her displacement 11,870 tons. If this be multiplied by 35 the cubic feet displaced comes to 415,000. Now multiply the length by the breadth by the draft—that is, 410 feet by 50.5 feet by 24.62 feet, and we get the figure 510,000. If 415,000 be divided by 510,000, we get the figure 0.815, which is called the block coefficient.

Other coefficients are used, such as midship area coefficient, which is the area of the midship section divided by the area obtained by multiplying the breadth by the draft. There is also the prismatic coefficient, which is the volume of the displacement in cubic feet divided by the volume obtained by multiplying the area of the midship section by the length.

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Now in regard to weights. For the purpose of estimating, the weights are divided into three rough items, namely:

First, net steel, which is the net weight of the steel hull structure of the vessel, namely, all the frames, reverse frames, floors, beams, shell plating, deck plating, casings, and the rivets to attach them.

Second, wood and outfit, which comprises the wood used in the decks, ceiling of the hold, woodwork in cabins, masts, spars, as also all the other fittings of the deck, such as windlasses, winches, hawse pipes, boats, davits, rigging, awnings, sails, etc., indeed everything except the net steel weight and the machinery.

Third, the machinery weight, comprising the engines, boilers, tunnel shafting, propellers, condensers, and the water in the boilers and condensers.

These three items make up what is called the net weight of the vessel, and then a fourth item is the dead weight, which covers coal, fresh water, and provisions for the passengers and crew, the weight of the crew and passengers, and in addition any paying dead weight which the owner may desire to carry. The latter in the case of cargo vessels is the largest item, while in the case of passenger vessels the paying dead weight is naturally very small. The handiest method for the steel and wood weight in similar ships is to take as a basis a figure called the "cubic number," which is simply the length, breadth, and depth of the vessel multiplied together and divided by 100. If the net steel weight and the wood weight be divided by this figure a fraction coefficient is obtained. This varies with different types of boats, but quite a common value for an ordinary boat is 0.38 for the steel and 0.14 for the wood. For the machinery the common method is to have tabulated the number of indicated horse-power produced per ton of total machinery weight. This again varies, being high in the case of fast passenger steamers and low in slow cargo steamers. Five is not an uncommon figure for a cargo vessel, about ten for cross-Channel steamers, and a much higher figure still for such vessels as torpedo boats.

For practically all the vessels finished complete in this country we have carried out what is called a measured mile trial. By taking the mean of the speeds (not the mean of the times) and the mean of the powers, the power required to drive the vessel at any particular speed on the measured mile is obtained.

By means of these trials a curve of speed and power was constructed, which could be produced at each end for a reasonable distance. At the same time the revolutions were observed, and they were found to be at 9.1 knots 47 revolutions, at 10.8 knots 58 revolutions, 12 knots 64 revolutions. The reason for the progressive trial is that while the speed for this vessel was specified to be from 11½ to 12 knots, other owners might ask for a similar vessel to steam only 10½ on similar dimensions, the engine and boilers could then be reduced, because the power at 10½ would be only 1,440, as ascertained from the curve. One would thus be in a position to say at once what the power was, and could design the engines and boilers so as to produce the most economical result. But one might be asked for a vessel which was not of identical dimensions, and then modifications would be necessary to ascertain the power for this purpose. A very convenient way is to use what is called the "Admiralty Constant," obtained as follows: The displacement is taken and the two-thirds power ascertained, this is then multiplied by the speed in knots cubed, and the whole is divided by the indicated horse-power. This coefficient is called the "Admiralty Constant," which, through far from constant, is exceedingly useful in ascertaining the power when used with discretion.

Other useful tabulated figures are the power obtained per square foot of grate and per square foot of heating surface, as by this means it is easy to see at a glance what any particular type of boiler can be expected to produce in the way of power.

Take now a concrete example to illustrate the procedure in designing a vessel. Sometimes all the particulars received from the ship owner are that he wants a vessel to steam, say, 12 knots, to carry 5,000 tons of dead weight on 24 feet, to have, say, 50 first-class and 50 second-class passengers, to be classed to one of the Classification Societies' rules, and to have a Board of Trade certificate. In other cases the owner, having had previous experience, specifies gen-

eral dimensions, the speed, the number of passengers, and dead weight. It may be of interest to state that I have known cases in which we have been asked to carry a certain amount of dead weight in a vessel of a special type, where even if the block coefficient had been unity she could not possibly have done it.

The following example shows details of calculations for a cargo and passenger vessel which was actually built. Owners' requirements about 360 feet long, to carry 6,000 tons total dead weight at a draft of about 24 feet, and to steam 10½ to 11 knots at sea.

From previous experience ratio of beam to length should be about 1 to 8, and depth about 0.65 of beam. Then try dimensions—

$$\frac{360 \times 45 \times 29, \text{ cub. number} = 360 \text{ ft.} \times 45 \text{ ft.} \times 29 \text{ ft.}}{100} = 4,698.$$

A somewhat similar ship already built, but about 20 feet shorter, had net steel coefficient = 0.35, and wood weight coefficient = 0.11, here due to slightly more erections, etc., required, say, net steel, $0.36 \times 4,698 = 1,690$. For wood, more accommodation and decks required, say, 13, then wood = $0.13 \times 4,698 = 610$. Machinery weight for type-ship, whose speed at sea had been 10½, was 338; here larger ship and rather better speed required, say, 375 for first approximation. Then weights—

Net steel	1,690
Wood and outfit.....	610
Machinery	375
Dead weight	6,000
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	8,675

Say, 8,700 tons, with a margin of 25 tons.

8,700 tons at 24 feet gives a block coefficient as follows:

$$\frac{8,700 \times 35}{360 \times 45 \times 24} = 0.784.$$

Type-ship had dimensions 345 × 44 feet 6 inches × 22 feet draft on trial displacement = 7,490, block coefficient, 0.783, so that she was not very far different; her power at 10¾ knots was 1,500, therefore Admiralty constant

$$\frac{\Delta^{\frac{2}{3}} \times V^3}{C} = \frac{385 \times 1,242}{1,500} = 317.$$

Dealing with other typical ships in the same way, it was found that none of the others gave such a high constant, showing that the above vessel was abnormally efficient, which indeed was the case, and it was therefore decided not to exceed 300 as the constant for the new ship.

Then

$$\text{I. H. P.} = \frac{\Delta^{\frac{2}{3}} \times V^3}{C} = \frac{423 \times 1,242}{300} = 1,750 \text{ I. H. P.}$$

This gives power required on trial for the ship, but owners wished speed at sea, and hence, say, 20 per cent must be added to this.

$$\frac{1,750 \times 120}{100} = 2,100 \text{ I. H. P. at sea.}$$

Now type-ship was capable of doing 1,800 at sea, and her weight of machinery was 338.

$$\text{I. H. P. per ton of machinery was } \frac{1,800}{338} = 5.3.$$

$$\text{Hence weight} = \frac{2,100}{5.3} = 395.$$

Therefore apparently the first estimate for machinery weight was too small. The final figures were as follows:

	Ship estimate.	As built.
Dimensions,	360 ft. × 45 ft. × 29 ft.	360 ft. × 45 ft. × 29 ft.
Draft	24 ft.	23.78
Displacement	8,700	8,615
Net steel	1,690	1,662
Wood and outfit.....	610	569
Machinery	375	384
Dead weight	6,000	6,000
Margin	25
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	8,700	8,615

Showing the estimate to have been on the safe side.

This shows how the first rough estimate for a ship

is got out, and afterward, of course, the design is fully worked out in the drawing office. This procedure is practically the same for all ordinary vessels, but for special vessels, such as those your president is more immediately interested in, while the first rough calculation, so far as weights are concerned, is made in a similar fashion, when dealing with speed and power, especially where a departure has occurred from anything previously done, another factor is introduced and that is the data got from an experimental tank, where such is available. While you may not be familiar with the details of such a tank, you know generally it is a long canal, in my firm's case, 300 feet long by 22 feet broad by 10 feet deep, over which there is a pair of rails on which runs a carriage and attached to this carriage is an accurate model of the ship immersed in the water to her correct designed draft.

The truck is driven along by means of electric power at suitable speeds, and by somewhat elaborate calculations the resistance of the model is obtained. This resistance is then translated into resistance for the full-sized ship, and by this means a curve is obtained of what is called the effective horse-power, or the horse-power which would be necessary to tow the ship. But the difficulty of deciding the power which must be placed in the ship to drive herself at this speed only begins at this point, because it is found that this power is very considerably greater than the effective horse-power, indeed sometimes as much as double, or even more—that is to say, the efficiency of the propulsive apparatus is, say, 50 per cent. In other words, suppose the effective horse-power of such a ship for 20 knots to be 4,000, then the indicated horse-power which would require to be placed on board, if the

efficiency were 50 per cent, would be 8,000. The skill of the builder is shown in fixing this percentage and designing propellers or paddle wheels to produce it. Theory alone, unless backed up by ample practical experience, is of very little value in fixing the efficiency.

You will thus see that the procedure for an exceptionally fast vessel is somewhat different, and that the tank is the final court of appeal in such cases. After we have decided upon the power thought necessary, we, as a rule, make careful experiments with propellers, because quite small differences in propellers often make large differences in the results, and even after we have done all we can, we are only perfectly happy in the case of exceptionally fast vessels when the first double run on the measured mile confirms our calculations.

FLIGHT OF THE "ZEPPELIN I."

RECENT PERFORMANCES OF THE FAMOUS GERMAN AIRSHIP.

AS MAY be known to our readers, the German government has put its new airship in the hands of the aeronautic battalion for further tests. Unfavorable weather delayed the filling of the balloon until March 6th. The first ascension was to take place on March 8th, but the motors were not in order, and could not be made to operate satisfactorily until the evening of that day.

Consequently, the first ascension of the airship took place on the morning of March 9th, lasting from 9:15 A.M. till 10 A.M., and serving as a drill for the members of the staff. The second ascension took place at 11 A.M., lasting until 12:30 P.M.

At the third ascension, the airship rose from the ground without assistance, and covered a distance of 150 to 200 kilowatts (93 to 124 miles), the voyage lasting for about 2½ hours, the estimated speed being about 1.3 meters per second (28½ miles an hour) even with a contrary wind.

By a fortunate coincidence, a meteorological station is situated on Lake Constance. Thus atmospheric conditions are tested by means of kites before each ascension, and unpleasant surprises are obviated.

Accordingly, on March 10th, an ascension was undertaken at 11:15 A.M., after the determination of the conditions of the atmosphere. The younger Count Zeppelin was in the car, but the elder Count Zeppelin did not ascend, though he had consented to accompany Major Sperling, Capt. Jena, and the younger count the previous day on the first military ascension. The descent was made very smoothly about 1 P.M.

In the afternoon, when the brisk wind which rose about noon had died down, the balloon was drawn out of the shed about 4:30 P.M., and remained out about three-quarters of an hour.

As the fine weather continued, another ascent was undertaken at 9:30 A.M. on March 11th.

On this trip special observations were made from above of the land in the neighborhood of the new balloon shed of the Zeppelin Airship Construction Company, with the object in view of attempting within a few days a descent upon *terra firma*. At 3 o'clock in the afternoon the airship again rose, coming down about 5:20 P.M. upon the surface of the water.

The flight on the 12th of March was the highest thus far attained with any airship of rigid construction, the balloon rising very rapidly to a height of some 900 meters, and afterward ascending still higher.

The greatest height reached was estimated from 1,500 to 1,800 meters (4,921 to 5,905 feet).

This flight had for its special object the testing of the horizontal rudders. Count Zeppelin himself took part in this test, the other participants being all military—the four officers and the mechanics of the Berlin Aeronautic Battalion.

On the 15th of March an event occurred which may prove to be of much significance in the further development of airships of rigid construction. The "Zeppelin I." rose shortly after 8 A.M., crossed over the city, and then descended on the place previously determined by the Airship Construction Company.

The descent was accomplished by making use of the horizontal rudders till the balloon was 25 to 30 meters (82 to 98 feet) above ground, when it was drawn down to earth by ropes in the hands of the men of the Aeronautic Division.

The photographs show these maneuvers very clearly, and also display the extreme ease and comfort with which communication is established between the car and the ground.

Part of the steering gear sustained a trifling injury by being dragged past a tree.

This first successfully planned and accomplished landing of an airship of the rigid type on *terra firma* took place in the presence of the Inspector of Troops,

Lieutenant-General von Lyncker, and Major Gross, Commander of Aeronautic Battalions.

Encouraged by this success, a similar landing was undertaken on March 18th, and likewise accomplished smoothly and successfully.

In both cases the airship returned to the shed.

As soon as the "Zeppelin I." demonstrated that a descent upon solid earth could be made without difficulty, an extended voyage was planned, and on April 1st a journey to Munich was attempted.

The airship started from Friedrichshafen at 4:05 A.M., while it was still dark and cloudy. The start was made against a strong northeast wind. The huge air craft rose to a height of about 1,000 feet and was headed for Munich, 111 miles away. The principal intervening cities were brilliantly lighted, so as to show aerial navigators the course to be followed. Munich was reached shortly before 9 o'clock, and the airship's approach was signaled by the ringing of church bells and the firing of cannon. After reaching the exposition grounds the airship descended to within about 300 feet of the earth. A great crowd assembled, and the Prince Regent saluted Count Zeppelin as he stood in the car of his airship. The wind had increased in intensity, and the Count was afraid to attempt a landing. The airship again soared aloft, and soon it was being driven before the wind. It was impossible to hold the huge air vessel against the gale, which soon attained a velocity of nearly 40 miles an hour. Consequently, since it had a speed of but 26 miles an hour, it drifted at the rate of 14 miles an hour, and in five hours' time reached Dingolfing, 70 miles from Munich. Here the Count attempted to land, and he was successful in accomplishing this dangerous maneuver. The airship was moored over night without damage, and at 11:15 the next morning it reascended in a moderate wind, and returned to Munich in 2¼ hours. Another successful landing was made on the parade grounds on the outskirts of the city, and Count Zeppelin was decorated with a gold medal by the Prince Regent of Bavaria. At 3:30 P.M. the airship again reascended and started for Friedrichshafen, which place was reached at 8 P.M. at a speed of about 24.6 miles an hour.

On April 5th the airship started at 9:18 A.M. on a 24-hour endurance trip; but owing to unfavorable weather conditions, this was abandoned, and the airship returned to its shed at 7:25 P.M. During the nine hours that it had been in the air, it descended twice to the surface of Lake Constance to take in water ballast. The airship traveled to Biverach, and then returned to the lake, where it spent most of the time in executing various maneuvers. A strong easterly wind rose early in the evening, and as it was impossible to make much headway against this wind, the airship was returned to its floating shed. The following day a short flight was made across the lake to Constance, and the airship landed successfully on the parade ground near the city. On April 7th the airship made a 12-hour flight, going first to Wanger in Wurtemberg, and then returning to Friedrichshafen by another route. The trip was entirely successful.

These flights are the first that have been made by the officers of the German army. In some of them as many as twenty-six men were carried upon the airship. This vessel is the remodeled "Zeppelin III." which has been renamed "Zeppelin I." since it is the first Zeppelin airship to be taken over by the German government. Another new airship—the "Zeppelin II."—is almost completed. It is the purpose of the German government to have one such airship at each important fort on the outskirts of Germany. The management of the Frankfort Aeronautical Exposition, which is to be held from June to October, have also contracted for one of these airships for exhibition purposes.

The demonstration which was given during the trip

to Munich on April 1st shows that the rigid type of airship is entirely practical, even under the most severe weather conditions. The fact that it was able to land on the ground without sustaining any serious damage shows that such a vessel can be used for transporting people, and landing them safely in case of accident. We look for the building of large numbers of these vessels for passenger transportation in the near future.

PASSENGER CAR WINDOW GLASS. A SUGGESTION FOR INVENTORS.

ONE feature of a railway car upon which all passengers are qualified to pass judgment is the window design. This part of a car structure is worth a careful study when new equipments are being planned. The shape of the windows has a great deal to do with the impression a car creates upon those who see only the exterior, as well as those who ride within the car. Next in importance to the proper contour for a car window and the choosing of the sash fixtures so that accidents may be minimized, is the choice of the glass. The cost of window glass is made up not only of the installation cost, but of the charges for maintenance occasioned by breakage. On the score of appearance, also, glass should present a smooth, flat surface, devoid of bubbles and irregularity. In general, the window sash of high-class cars are glazed with coach glass, polished plate, or so-called "cylinder" glass. The experience of the Kansas City Railway and Light Company has tended greatly to favor the latter named grade of glass, and is mentioned as illustrating the good results to be derived from careful observation of replacement materials and their costs. The records of this company for one year show that there were in operation cars with 10,000 sash containing cylinder glass 5/32 inch and 3/16 inch thick, and 9,000 sash with AA coach glass. All these cars were in city service. During the year the cost of replacements of the 10,000 cylinder glass windows was only about 55 per cent of the cost of replacing the AA glass. It is stated that the original cost of the cylinder glass is about three times that of the coach glass, but that a considerable economy is shown when the cost of glass and labor for renewals is considered. It is the careful observation of such maintenance details as these that serves to place a repair shop on a basis for maintaining equipments in the best condition at a low expenditure.—Electric Railway Journal.

In the eighteenth century the patient direct observations of William Herschel were crowned with the discovery of Uranus, and in the nineteenth century the solar system was extended by the calculations of Le Verrier to include Neptune. According to the American astronomer, W. H. Pickering, it is not impossible that in the twentieth century photography, by means of which the existence of the tenth satellite of Saturn, which cannot be seen with the most powerful telescope, has been demonstrated, may extend the frontier of the solar system still farther by revealing the existence of a planet more distant than Neptune. The most probable position of this planet at the commencement of the year 1909 has been calculated by Pickering, who has announced the following approximate co-ordinates: Right ascension, 7 hours 47 minutes; declination 21 degrees north. At the observatory of Arequipa, in Peru, photographs of this region of the sky have already been made, with the Bruce telescope of 24 inches aperture. Pickering expresses the wish that all astronomers possessing suitable instruments will join in the search and proposes a systematic exploration of this part of the zodiac.