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President: Sir David Gill, K.C.B.

The Stability of Ships

By Mr. EDWIN TATE

(Inventor of the Patent Stability-Indicator),

READ ON

Monday, April 4, 1910.

Chairman: Mr. J. T. MILTON (Chairman of Council).

Having been convinced for many years that the matter of the Stability of Merchant Ships has not received sufficient attention, I would be glad if by this paper I could assist in causing the matter to be more carefully gone into and better understood by seafaring men. It is the duty of everyone having to do with the designing and loading of ships to minimize as much as possible the risk to life and property involved. I am of the opinion that a considerable percentage of the vessels that have mysteriously disappeared have capsized; and I have in memory a large Atlantic liner being missing and lost with all on board ; after the event a bottle was washed ashore on the west coast saying that the ship was turning over.

In endeavouring to gauge the stability of a ship we make use of two measures. For the first 10 or 15 degrees of heel the distance between the centre of gravity and the transverse metacentre is used. This is called the Initial Stability or G.M. After 10 or 15 degrees of heel the Statical Stability should be taken into consideration. The lever of statical stability is the horizontal distance between the centre of gravity and the new centre of buoyancy, and is designated the G.Z. Initial stability, or stability at the commencement of heel, is great or small in proportion to the distance between the vertical height of the centre of gravity and the transverse metacentre. This metacentre is called transverse to distinguish it from the longitudinal metacentre, which has only to do with the longitudinal alteration of trim. The transverse metacentre is an imaginary point through which a ship rolls or heels over, and can be taken as a point of suspension below which the centre of gravity swings. The centre of gravity of course is the mean centre of weight of the ship and everything she has on board. As long as the centre of gravity is below the transverse metacentre the ship has some initial stability, but if it is above she is in an unsafe condition, having what is termed a minus G.M. and would not stand upright. It should be remembered that the metacentre height or G.M. is the height of the transverse metacentre above the centre of gravity, no matter where the centre of gravity is situated.

A wide water-line with a fine bottom gives a high transverse metacentre ; and this with a low centre of gravity will ensure getting a stiff ship, for several degrees of heel at any rate. A large G.M. is not always desirable, as a very stiff ship is liable to be a heavy roller, for by having the centre of gravity low down a pendulum motion is set up. And yet I do not think that a small G.M. will ensure having a comfortable ship unless the weights on board are arranged in a gradual or regular manner from the keel upwards. A ship with heavy weights on her floor and others near the uppermost deck might have a small G.M., but these weights would act as pendulums and cause great rolling.

The metacentre should never be less than nine inches above the centre of gravity, but its height should be arranged to suit each particular class of vessel. A ship with a large free board should have a large G.M. to minimize the danger caused by a large area of side being exposed to squalls or heavy seas ; for calculation see page 96. A shallow vessel with low freeboard should also have a large G.M., because after her deck at the lee side becomes submerged she quickly loses her stability. The G.M. is generally taken as remaining unchanged for the first 10 or 15 degrees of heel. After that the water-line generally becomes wider and the metacentre rises. This is what makes a top-heavy ship rest on one side, because a ship with a minus G.M. will heel over until the centre of gravity and new metacentre coincide.

The height of the metacentre is calculated from the offsets of the water-line. The method of calculating is given on a subsequent page. The G.M. can be obtained by an inclining experiment which is shown following the calculations for the metacentre. The method of arriving at the G.M. by calculation is next shown. It is an easy calculation by moments, but one wants to be very careful, as the draught, centre of gravity, and metacentre are always changing.

The beam in relation to depth is an important factor in the stability of a ship. A rough guide in designing a ship with all weights normal would be to have the greatest midship depth of a small vessel ·5 of the beam and gradually increased up to ·7 in a very large vessel. Vessels with very high top sides, such as American river and coasting steamers, which have two or three decks above the water, are very misleading to amateur students of stability. These vessels have a very great beam and extremely light upper works, or they could not stand upright. The G.M. is a splendid guide to a ship's stability, even though nothing is known about her righting power when considerably heeled over. It is not wise to cut down the G.M. to the fine point for the sake of a comfortable movement. There should always be some reserve stability in case of a breakdown in a heavy seaway, when a ship would get into the trough of the sea and easily be capsized ; and besides, you cannot always foresee what a tender ship would do if an accident should cause a large inrush of water on board.

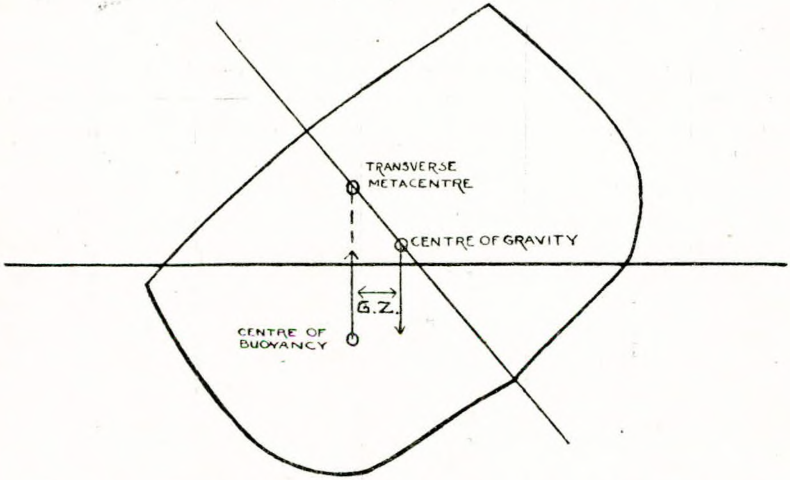
Statical Stability.—After 10 or 15 degrees the statical stability can be reckoned as the gauge of a ship's stability. As the ship heels over the centre of buoyancy travels to the lee side, and by its pressure being upwards it tends to right the ship. But after a certain inclination the centre of gravity gets as far to the lee side as the centre of buoyancy, at which point the ship has no power to right herself. This point is called the vanishing point, the stability vanishing here. The horizontal distance between the centre of buoyancy and the centre of gravity, when the centre of buoyancy is at the lee side of the centre of gravity, is the righting lever, and this distance in feet multiplied by the displacement in tons is the righting moment or the moment of statical stability in foot tons. (See sketch which follows.) Statical stability is found by a long calculation, and errors are very liable to creep into it, but there are several methods of finding it by models. Barnaby's approximate method, which is described further on, is very good, and very simple to carry out. In reckoning the position of the vanishing point it should be remembered that if there is any loose cargo on board it would begin to run to leeward after a certain inclination and thus decrease the range of stability.

Dynamical stability is another expression of a ship's stability which I shall not deal with here, except by saying that it is the measure of the work done in putting a ship over to any angle of heel, and is the difference between the vertical distance from the centre of buoyancy to the centre of gravity in an upright position and at the angle of heel. The centre of buoyancy is depressed and the centre of gravity is raised as the ship heels over.

Barnaby's Approximate Method of Finding a Ship's Statical Stability.—Divide the length of the ship into any convenient number of equal parts. A large number of divisions is better than a small number. Cut out cross sections in thick paper representing the underwater part at each of these divisions, at say 15 deg. of heel. Gum these sections together, with the centre line of ship and water-line coinciding in each case. If this paper model is suspended at two or three different points, plumb lines from each will cross at a point which is the centre of gravity of the paper model, and is in the same position as the centre of buoyancy of the ship at 15° of heel. As the ship heels over the waterline will probably either rise or fall, so that the sections should be made with a good margin above the water-line to allow of making this correction. A set of sections should be made at the upright position and gummed together; the weight of this will represent the displacement of the ship, and the paper model of 15°

heel should be reduced by cutting off parallel strips at the water-line until the weight is the same as that of the upright position. The horizontal distance between vertical lines drawn through the new centre of buoyancy and the centre of gravity is the length of the righting lever or GZ. If this process is repeated for say every 15° of heel a curve of righting levers can be drawn from the models.

SECTION SHOWING RIGHTING LEVER OR GZ.



PRESSURE OF WIND ON THE TOPSIDES OF A SHELTER DECK STEAMER, 460 FEET × 58 FEET × 34 FEET, LOADED.—Mean draught, 27 feet; displacement, 16,200 tons; G.M., 2 feet; righting lever 2 feet at 45° heel which is the angle of the heel where the stability is greatest in this case. Exposed topsides 10,660 sq. feet × ·75 on account of ship's form = 8,000 sq. feet.

Wind pressure allowed for on bridges, etc. = 56 lb. per square foot. Distance of centre of topsides above centre of lateral resistance = 25 feet. 8,000 square feet × 56 lb. = 200 tons. 200 tons × 25 feet = 5,000 foot tons wind pressure. This will heel the vessel over 9°.

Disp. × G.M. × tan 9° = 5,120 foot tons.

PRESSURE OF A CURLING WAVE 30 FEET HIGH OF THE SAME VESSEL.—Greatest pressure of a 30 feet wave = 1 ton per square foot. 8,000 square feet × 25 (lever) × 1 = 200,000 foot tons, total pressure of wave. Greatest righting moment of ship = 16,200 (disp.) × 2 (lever) = 32,400 foot tons or $\frac{1}{6}$ the power of the wave on the ship's side.

It is very unlikely that a wave would strike the whole side at once.

Method of calculating Height of Transverse Metacentre.

Water-line 6 *feet above keel. Ordinates* 13·5 *feet apart.*

	Ordinates = $\frac{1}{2}$ width of water line	Cubes of ordinates.	Simpson's multipliers.	Functions of ordinates.
0	·0	0	1	0
1	2·25	11	4	44
2	8·0	512	2	1,024
3	13·1	2,248	4	8,922
4	16·0	4,096	2	8,192
5	17·6	5,452	4	21,808
6	17·85	5,687	2	11,374
7	18·1	5,930	4	23,720
8	18·2	6,029	2	12,058
9	18·2	6,029	4	24,116
10	18·2	6,029	2	12,058
11	18·2	6,029	4	24,116
12	18·2	6,029	2	12,058
13	18·2	6,029	4	24,116
14	18·0	5,832	2	11,664
15	17·7	5,545	4	22,180
16	17·1	5,000	2	10,000
17	15·5	3,724	4	14,896
18	11·5	1,511	2	3,022
19	5·5	166	4	664
20	·0	0	1	0

			246,032
Displacement	1,082 tons	$\frac{1}{3}$ interval . .	× 4·5
	× 35		
do. in cub. ft.	37,870		1,107,144
		2 sides . .	2
			3)2,214,288
			37,870)738,096(19·49

Transverse metacentre	19·49	feet above Centre of Buoyancy.
Centre of Buoyancy	3·41	,, ,, top of keel.
Transverse metacentre	22·9	,, ,, ,, ,,

If the height of the centre of buoyancy is not known it can be closely approximated by multiplying the mean draught above top of keel by ·53 in full ships, to ·58 in fine ones.

Method of Calculating the Height of Centre of Gravity of a Loaded Ship, and showing the Amount of G.M.

	Tons.		Height of centre above base in feet.		Moment ft. tons.
Displacement of ship light	4,600	×	22·0	=	101,200
Cargo in lower holds ..	5,000	×	14·7	=	73,500
,, 'tween decks ..	2,000	×	28·5	=	57,000
Coal in bridge bunkers ..	800	×	37·5	=	30,000
Cargo in poop	200	×	39·0	=	7,800
Total displacement at 25 ft. draught	12,600				269,500

269,500 ÷ 12,600 = 21·4 ft. = height of centre of gravity loaded.
Height of transverse metacentre @ 23 ft. draught = 22·5 ft.
,, centre of gravity loaded ,, ,, = 21·4 ,,

G.M. = 1·1 ft.

Any number of weights put on board can be treated in the same way, and the mean centre of gravity obtained.

Working by moments in above manner is very much resorted to in shipbuilding calculations.

The centre of gravity of a ship light can be closely calculated by taking each part of the ship separately and multiplying its weight by its height, adding up the moments and dividing the total by the total weight.

The fore and aft centre of gravity can be found in the same way, only measuring from a point at either end of the ship in a horizontal direction instead of vertical.

To Ascertain the G.M. by Inclining Experiment.

Use about 3 tons of inclining weights for every 1,000 tons displacement; but as the G.M. at the commencement of heel is required, the ship should not be heeled more than two or three degrees.

1. Having fixed a plumb line at centre of ship with bob free to swing, put half of the inclining weights at each side of deck, the ship being upright.

2. Place all the inclining weights at one side and measure the distance the pendulum has moved.

3. Carry all the weights to the opposite side of deck and again measure the movement of the pendulum.

Then A = Inclining weights in tons.
B = Distance in feet weights are moved across deck.
C = Length of pendulum in feet.
D = Displacement of ship in tons.
E = Distance pendulum moves in feet.

$$\frac{A \times B \times C}{D \times E} = \text{G.M. in feet.}$$

A correction has to be made on account of heeling weights being placed on deck.

Loose water on board destroys the exactness of the experiment, but this can be allowed for by treating the water as an inclining weight, reckoning for the distance it moves, the same as is done for the other inclining weights.

Explanation of the Inclining Experiment.—When a weight is moved in a thwartship direction across a ship the centre of gravity of ship is moved a distance that can be calculated by moments, as previously described. The ship heels through a certain angle when the weight is moved. Now the point where a vertical line from this new centre of gravity cuts the centre line of ship, or a vertical line above the original centre of gravity, is the transverse metacentre. The G.M. bears the same proportion to the distance the centre of gravity moves as the length of pendulum does to the distance the plumb-bob moves. If the distance the centre of gravity moves is multiplied by the cotangent, or divided by the tangent of the angle of heel, it will give the G.M. Both this and the calculation of moments are included in the formula previously stated.

Correction for Heeling Weights.—If these weights have raised the centre of gravity of the ship, which can be calculated by moments, add the amount to the G.M., and if the transverse metacentre is lower at the increased draught caused by the weights being placed on board, also add the amount to the G.M. and vice versa.

That the foregoing calculations for height of centre of gravity and metacentres and the metacentres system of gauging a ship's stability are quite reliable, has been proved by long experience. The writer has often had occasion to estimate the effect of alterations and ballasting, and in every case the heeling experiment has shown the effect to be the same as estimated.

CHAIRMAN: I take it, from the applause you have given, that you desire to thank Mr. Tate for the paper he has been good enough to read to us this evening. The subject is now open for discussion.

Mr. J. CLARK: This is a subject that I take a good deal of interest in, and I am sorry Mr. Tate did not add a word or two on yachts. Referring to statical stability, Mr. Tate says: "After a certain inclination the centre of gravity gets as far to the lee side as the centre of buoyancy." I was always under the impression that the centre of gravity never shifted; that it was a point that could not be altered unless some structural alteration were made in the vessel itself. Mr. Tate has confined his remarks to the stability of ships, but I am sure he could have told us a great deal more regarding the form of vessels and its effect upon the shifting of the centre of buoyancy when heeled. Mr. Tate referred to the method of obtaining the meta-centric height, etc., and the difficulty of finding such details in text-books. I am not familiar with many, but Dixon Kemp's book on Yacht Architecture gives it in full detail. I have had much pleasure in listening to Mr. Tate's paper.

Mr. G. F. ROBSON: I feel some diffidence in speaking this evening, as I am not a member of the Institute, but as Mr. Tate and I were fellow-apprentices together, I should like to support him if I could. One thing I would like to ask him is if he would show us with his cardboard model how the stability alters as a ship is being heeled over, and I should like to see the alteration of draught that would take place at different angles of heel.

Mr. TATE: The meta-centre generally rises when a vessel commences to heel over. The centre of buoyancy goes towards the submerged side of the ship, and the lever of statical stability increases until a certain angle of heel is reached, then it decreases until it reaches the vanishing point where a vessel has no power to right herself. In some vessels the middle line at the water plane rises whilst in others it sinks as the vessel is being heeled over; this is governed by the form of the vessel. The draught of a flat-bottomed ship increases rapidly as she lists, by her bilge going below the original level of the ship's bottom.

Captain LAWSON: It is evident when ships are loaded on the mud in the Royal Albert Docks an end is put to any experiment during such loading, and it is advisable to have some kind of guide to let us know the G.M. when finished. Mr. Tate has made an apparatus for calculating that quickly, and I think deserves very great credit for the work. It is so simple that any novice could work it, and ascertain at any time during the operation what margin of safety there is to go on. I do not know of any other means except by making long calculations to obtain this information. It is a common thing at the Docks in loading ships to go by former experiences, and at times by the rule-of-thumb method, viz., keep the weight well down and make sure of it, leaving till later on to find out whether this has been overdone or otherwise.

Mr. A. ROBERTSON: I have listened to the paper with great interest, as I have given considerable attention to the subject in past years, and certainly think it is one that engineers do not go into sufficiently, as it is of vital importance to engineers generally. I should like Mr. Tate to have explained in this paper—possibly he will explain it before the meeting this evening—the effect that a half-empty tank has on the meta-centric height of the vessel. No doubt the effect on the meta-centric height is entirely due to the free surface of water in the tank. If the tank is quite full up the only effect is the shifting of the centre of gravity, but if the tank is only partly full you do not only get that effect, but you get the alteration in the G.M., which is governed by the free surface of the water in the tank. Members may have the idea that this experiment is easily carried out, but I would disabuse them of that. This experiment is one which has to be carried out with a great degree of exactness, and is a difficult one owing to the fact that one has to contend with all sorts of conditions in trying to heel a ship over with weights. I certainly agree with Mr. Tate that allowance has to be made for free bodies of water, yet it seems to me that, to get exact information, it would be better to have no free water, but to have the boilers absolutely empty, and all tanks either empty or hard pressed up. Then in making the experiments care must be taken that all moorings are free and also that they are conducted on a day when there is little or no wind, and no tugs or vessels are passing to disturb the water. Even the wind has an effect on these experiments, as the distances measured are so small that one has to be extremely accurate in arriving at final information. Mr. Tate has not referred to the question of the G.M. of warships. This is a very important item, and it materially differs from that of a merchant ship. In the case of a warship, the gun-platform is a deciding factor, and if it has a high G.M. the ship rolls heavily. I think Mr. Tate will bear me out that the G.M. is generally lower on a warship than on a merchant vessel. As regard general shipping, the G.M. of a vessel varies considerably, as Mr. Tate mentioned, according to her loading. Some of those concerned in loading vessels, I believe, do not study the fundamental rules as to the stability of the ship, or they do not give sufficient care to the way in which they load the ships. They put all the heavy cargo at the bottom of the ship instead of distributing it. I remember that particularly in the case of one ship I was in. On the first voyage all the rails were put at the bottom, and she rolled most uncomfortably. On the next occasion we had the same quantity of rails, but they were distributed between the bottom of the ship and the 'tween decks, with the result that the ship was steady all the way out.

Mr. W. E. Farenden : There is one point I would like to question Mr. Tate upon; and that is with regard to the wind pressure. He gives a figure of 56 lb. per square inch, but does not give the velocity of the wind or speed of the ship. No doubt he can tell us how he arrived at this figure. It is an important point, as in ships of 17 to 18 knots the wind pressure must be considerable. With regard to this apparatus, Mr. Tate has been explaining, I take it, that it is only used in still water ; that in case of a cargo shifting at sea this apparatus would be of no use at all.

Mr. A. H. Mather : The remarks I intended making were pretty much to the same effect as those of Mr. Robertson. I felt rather diffident in putting forward this view, but his remarks, added to the remarks of Captain Lawson, confirmed me in the opinion that in a great many instances the loading of ships is not conducted on any definite or scientific plan. I was sorry to hear Captain Lawson say that the loading was still done by rule-of-thumb methods. I recollect a case similar to that mentioned by Mr. Robertson, of a tramp steamer loaded with rails. They were packed with spaces between the rails in the lower part of the holds until a certain height was reached. Higher up they were packed closer, until at the top they were stowed in a solid mass. Of course, the weight at the top prevented the lower tiers from shifting, and also raised the centre of gravity. I do not know whether this graduation was done on any definite plan or whether it was simply a matter of experience of the men loading the ship ; there was, at any rate, no information available on board to tell how far they could with safety raise the centre of gravity in this manner, and it seems to me that Captain Lawson's remarks were in that event applicable. As it happened, however, in this case the ship was all right, and was very comfortable at sea.

Mr. J. R. Ruthven : I have listened with great interest to Mr. Tate's paper. The subject of stability is of great importance. Some years ago Mr. Rowe read a valuable paper before the Institute on this subject, and I then suggested, and strongly urge now, that there should be proper officers at all ports whose duty it would be to test the stability before the vessel went to sea. Every time a ship goes to sea she is, so to say, a different ship ; her centre of gravity is altered perhaps several inches, and her stability consequently altered to some extent.

Mr. W. B. Anderson : Though a visitor, I hope I may be allowed to say a few words, being deeply interested in the subject as one of the largest loaders of cargo in London and dealing with about half a million tons per annum. I feel quite certain that there are not many ships which capsize ; I do not think anyone here can point to more than two or three in the course of his own lifetime. In the case of ships which are said to have capsized, they are much more likely to have foundered, because we are always more inclined to give too much stability than too little, and, as Captain Lawson said, although we work by "rule of thumb," and have to, yet, knowing our liability to error, we go rather too much the other way. The difficulty of making very accurate calculations when loading a steamer will be understood when it is remembered that as much as 5,000 to 6,000 tons may be loaded in three or four days. It would be necessary to make calculations of the cargo in the lower holds and also of the deck cargo, which, perhaps, arrives unexpectedly, and to get a stevedore to calculate that down to the last ton is a difficult matter. The varied nature of the cargo and the different weights of the materials are other matters to be considered, and therefore we see that there is good weight in the bottom and do the best we can with the rest of the material to be put in. Take the case of a ship which perhaps loads first at Antwerp, where she takes in, perhaps, 1,000 tons of iron; then she goes on to Middlesbrough to take in 3,000 tons of rails, and enough room has to be left for that to be loaded. That is put in as well as possible in the lower holds, and then she comes on to London to take in 5,000 tons general cargo; and to distribute the rails, as has been suggested, would mean unloading them and separating them out, which would be quite impracticable. To go into the matter is a very long question. It is also a serious one, and an apparatus such as Mr. Tate has brought out, which would assist the captains of ships, and the owners, who are the people most concerned, to find the stability of the ship, would be of great advantage. One cannot make calculations on the spot, and with new ships the task would be still more difficult, as one has to go by some other ship one has had experience of. It is not an exact science, and when the builders themselves do not know the stability one can hardly expect the stevedores to be able to tell it.

Mr. RUTHVEN: The builders know the stability with a homogeneous cargo.

Mr. J. CRUICKSHANK: I can support what Mr. Anderson has said. Having supervised the loading of many ships myself, I can fully appreciate the difficulty.

Mr. J. S. GANDER: I should like to ask Mr. Tate whether this inclining experiment would act as well in an oil tank ship where the tanks are longitudinal, and the effect on passenger liners of carrying coal on the shade decks.

Mr. TATE: The first question was about the stability of yachts. The same system of stability applies to all classes of ships, although this paper was written more with reference to merchant vessels. With regard to the centre of gravity moving, it does not alter its position in the ship unless the cargo begins to move, but it moves relatively to the centre of buoyancy. In reply to Mr. A. Robertson, regarding loose water in tanks, when a vessel is heeled to any angle loose water going to the lee side moves the centre of gravity of the ship to the lee side of the middle line, a distance that can be calculated by moments. This distance is the amount by which the GZ is reduced. With regard to the question about a warship, the warship has a wide water-line and the meta-centre will therefore be high, and if a low GM. is required it would be necessary to keep the centre of gravity up.

In reply to Mr. W. E. Farenden, the calculation of the wind pressure I have given is only a rough one to give an idea as to how to commence to carry out the system. The instance given is an extreme one, being a hurricane of 90 knots per hour right abeam, but it is necessary to be prepared for the worst. In this calculation of the wind pressure no allowance is made for momentum ; if a sudden squall came it would have double the effect I have shown. If a ship is inclined until the centre of gravity is on the lee side of the centre of buoyancy the ship is bound to go over. As to the stability indicator, which I invented at the suggestion and by the help of Captain Lawson, it gives very accurate results, showing the meta-centric height under any conditions of loading. But as it is only a representation of the ship it is not affected by the sea, or cargo shifting.

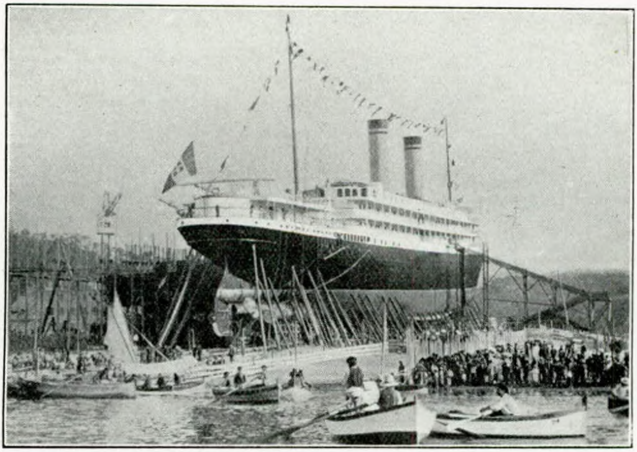
In reply to Mr. J. Anderson, with regard to ships capsizing, I remember one instance which occurred in the North Sea. A ship, laden with timber, was seen floating off the coast of Northumberland bottom upwards. I saw this vessel myself. Another, a steamer, capsized after being loaded with coal. She had just left harbour and set her small sails when she began to lie over to the wind and turned right over ; the sole survivor's account leaves this beyond dispute. These are proofs that ships do capsize.

In reply to Mr. Gander, with regard to the stability calculation for oil ships, it would be just the same as for ordinary ships, but the oil moving about in the expansion chamber would make a little difference to the G.M. It would be necessary to calculate the weight which would be moved from one side of the chamber to the other and allow for its effect.

Votes of thanks were accorded to Mr. Tate and to the Chairman, and the meeting closed.

*Stability of Vessels

"THE paper recently read before the members of the Institute of Marine Engineers on 'The Stability of Ships' revives the memory of several unhappy events which may be fittingly illustrated as typical cases of those incidentally referred to in the paper, or bearing upon the subject matter. The *Baron Aberdare*, a sailing ship of 1,700 tons, broke away from her moorings in the Victoria Dock, London, under the pressure



The *Principessa Iolanda.*

of a gale of wind and capsized, in January, 1884. This was a case where the wind pressure upset the vessel, unprepared for a gale at the mooring berth and lacking the weight adjustment which would have given her stability in sea trim. The passages made by the *Cutty Sark* and others of the old sailing clippers is sufficiently fresh in our memories to show that although some of them were very wet ships and uncomfortable at times, heeling over under a press of canvas, they held on well to their work. There have been cases where the initial stability on launching has been based on too narrow a margin to allow for eventualities; the overturning of the

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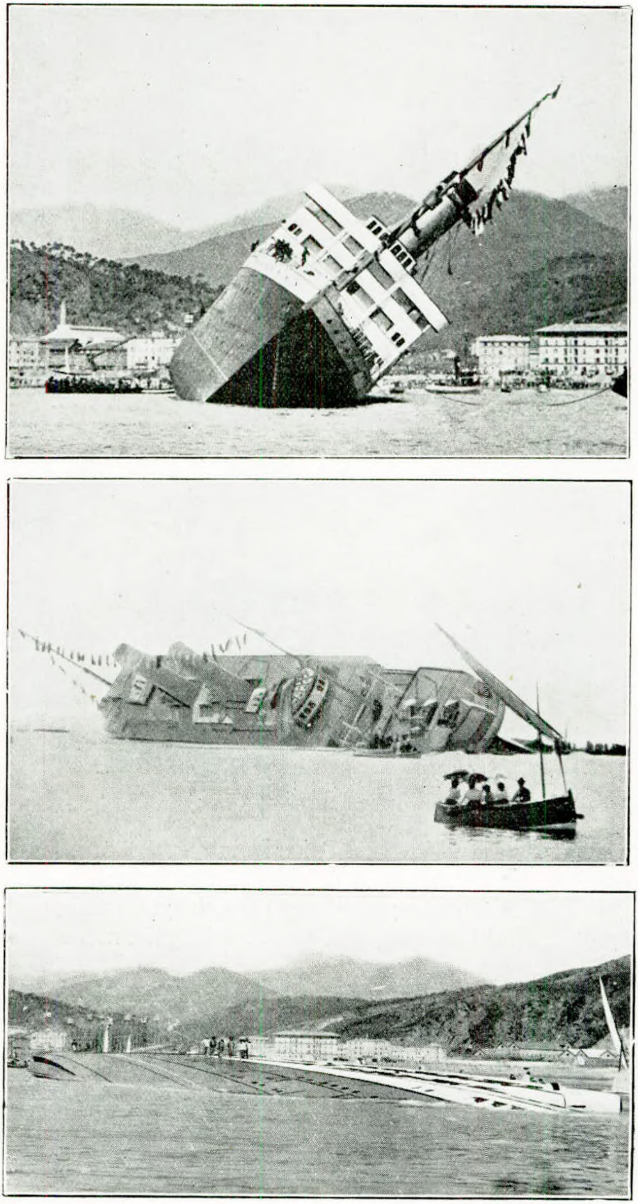
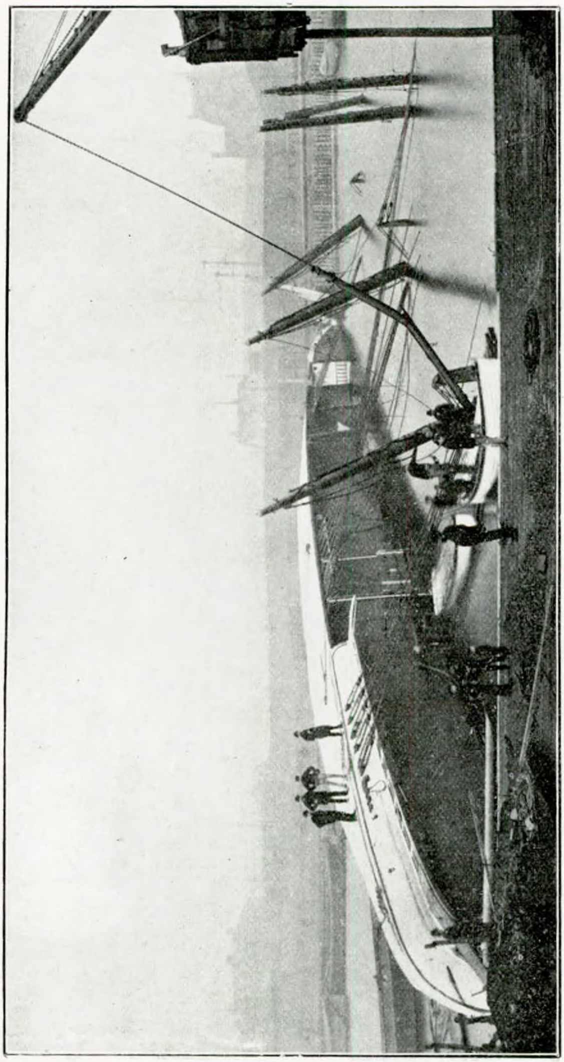
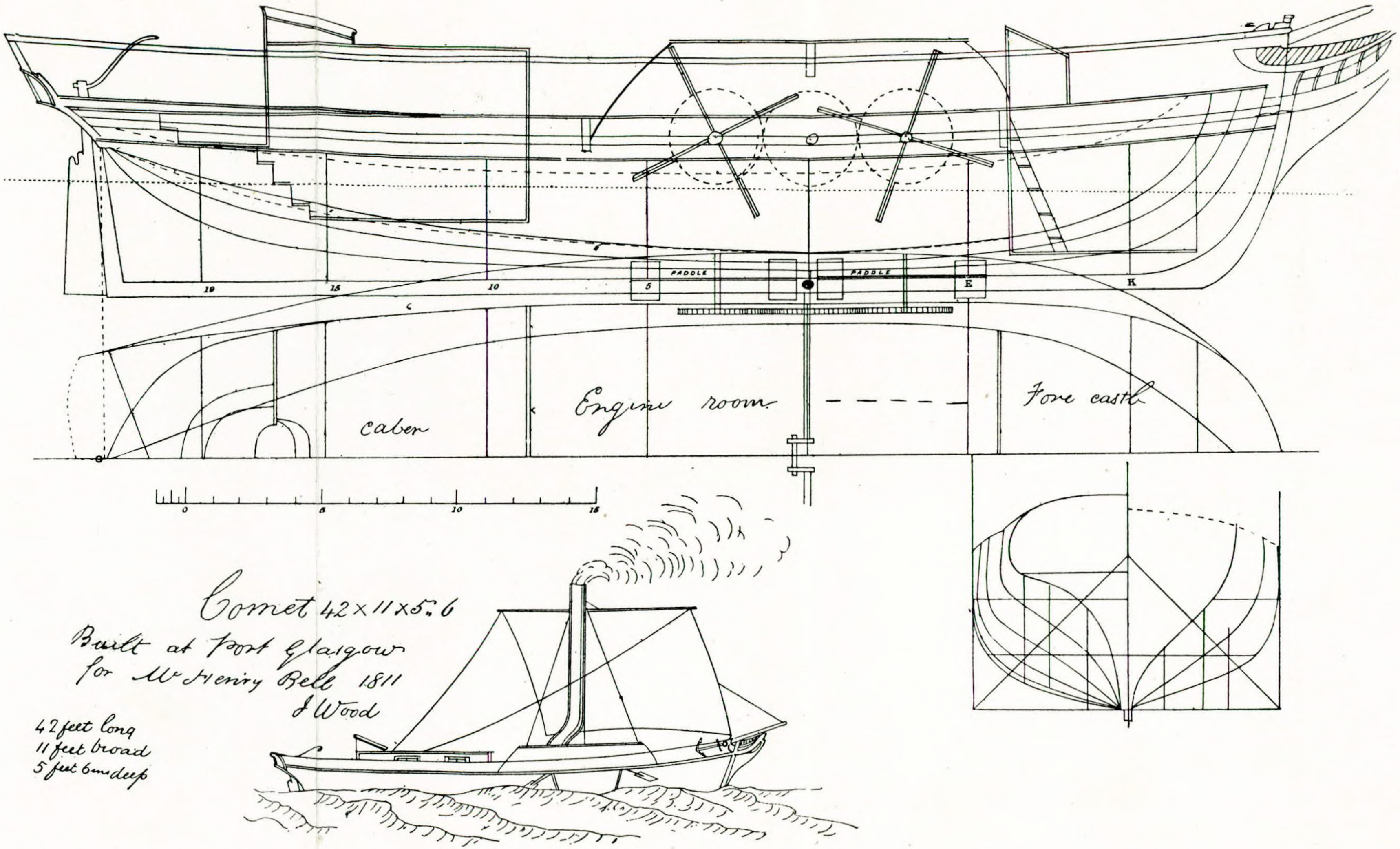


Three further views of *Principessa Iolanda.*



The *Baron Aberdare*, capsized in January, 1884.

The *Maria Rickmers.*



ORIGINAL DESIGN OF THE "COMET," SHOWING THE LINES OF THE SHIP.

Daphne on the Clyde, and of the *Principessa Iolanda*, are instances of capsizing in the process of launching. The *Maria Rickmers* was a fine-looking ship, fitted with auxiliary engines and propeller, steaming about eight knots when circumstances required in the regions of calms; unhappily she was lost while on a part of her voyage under ballast trim, having failed to reach her destination from an unknown cause, the possibility being that too small a margin had been allowed to steady her while proceeding to a loading port. These are typical cases, showing the need of some ready method of testing the stability of a vessel in confirmation of the usual data evolved by the builders. The cases are fortunately rare where an apparent want of care and forethought, lack of knowledge, or it may be a mistaken sense of duty has led to disaster, by the balance of forces being upset under unlooked-for conditions—the beam tilted beyond recovery. The percentage of accidents and losses is very small where there is a suspicion of instability being at least a contributory cause, but there are sufficient to justify the inventor elaborating a simple means to verify the question of where stability can be relied upon in the loading of a ship. The overturning of the *Austral* in Sydney Harbour is hardly a case in point, but even here the importance of the subject was not realized, and the fact of an appliance for testing being on board might have called attention to the danger in time."

In connection with this subject, the illustration inserted in this number will doubtless be of interest. It is a copy of the tracing showing the original design and lines of the *Comet*.

J. A.