

THURSDAY, JULY 12, 1877

THE "INFLEXIBLE"

THE question which has been raised respecting the stability of the *Inflexible*, important as it is with reference to that ship, leads to very much wider and more general considerations. It is already known that the same principle, or want of principle, which has brought doubt upon the one ship appears also in the *Ajax* and the *Agamemnon*, and is to be reproduced in the only ship of much size or importance which the Government purpose commencing during the present year. But even in this succession of large and costly ships we see probably but the beginning of a system which, having thus received countenance and sanction in the highest quarters in this country, may not improbably become extended over the navies of the world. We propose, therefore, to explain to our readers the nature of the question itself and the manner in which it has arisen.

And as an essential preliminary we will first explain what is meant by the terms "stability" and "curve of stability." For the purpose of this elementary explanation it will be sufficient to take the case of a ship floating in still water. In Fig. 1, which represents the transverse section of a ship taken through the centre of gravity, M represents the metacentre, G the centre of gravity, and B the centre of buoyancy, W L being the water-line when the ship is in an upright position. Supposing the ship to be inclined through an angle of θ degrees from that position by an external force, and $W_1 L_1$ to become the new water-line; she will now tend to return to the upright position with a righting force equal to her total weight or displacement, acting with the leverage of GZ, and therefore equal to $W \times GZ$. This is obviously the case, because while the ship is held in the inclined position her weight will be acting downwards through G in the direction of GH, which is perpendicular to the water's surface, $W_1 L_1$, and her buoyancy, which may be supposed to act collectively through its centre of buoyancy, B_1 , will be pushing upwards through the line $B_1 M$, and therefore the righting effect will be that of the two forces (weight and buoyancy, which are alike) acting at the opposite ends of the lever, GZ, as previously stated. It is equally certain that in all ordinary forms of ship GZ will be changed in length as the ship's angle of inclination is changed, and if we calculate its lengths for a series of angles, and set up the lengths so obtained as ordinates along a base line on which abscissæ are measured off to represent the angles of inclination, we can draw a curve line through the points so obtained, and thus form what is called a "curve of stability." The first instance on record of this being done for an actual ship or design is that given in a paper "On the Stability of Monitors under Canvas," read in 1868 at the Institution of Naval Architects, and published in their *Transactions*, and in several other places. After stating the amount of stability which certain rigged monitors would have under given conditions, and showing that the maximum stability, and even the vanishing stability was reached in them at moderate angles of inclina-

tion, Mr. Reed said: "It must be obvious that the danger to be apprehended by these monitors when under canvas is very great; and when we think that they are liable at any moment to be overtaken by sudden gusts of wind, and that if they are heeled over beyond 8 deg. or 10 deg., the further they go the less resistance they offer to being capsized, their unfitness to carry sail must be quite evident."

The curve of stability was next constructed in the case of the *Captain*, immediately before her loss, and from a report by Mr. Barnes, one of the present Admiralty constructors, we take the following:—"We assume that the side plating on the poop and forecastle has been so damaged that the ship may be considered a rigged monitor with a free-board of about 6 ft. At that draught (25 ft. and $\frac{1}{2}$ an inch) with an inclination of 14 deg., the gunwale on the immersed side is level with the water, but the stability of the ship notwithstanding goes on increasing until an inclination of 21 deg. is reached. As Mr. Reed has pointed out in his paper (quoted above) on rigged monitors, with a pressure of canvas which would incline the ship to say 8 deg., the inclination of the ship to the surface of the wave may reach about 34 deg. (in this case) before the ship would upset. As this angle is large we do not consider that even with the sides of the poop and forecastle destroyed, the *Captain* would be unsafe."

The above cases are both those of rigged ships, which the *Inflexible* can scarcely be considered, although it must be acknowledged that, as designed, she carried a considerable spread of canvas on two masts, and the present proposals—which we understand have been made—to diminish the spread of sail at all times, and to do away with it altogether in war time, are no doubt consequences of recent discoveries respecting the stability, or want of stability, of the ship with the unarmoured ends badly injured. After what has passed, however, we must accept the *Inflexible* as a mastless ship in time of war, and therefore a ship which can do with less stability than rigged ships require. In order to illustrate the nature and character of these curves we copy, in Fig. 2, a figure from Mr. Thearle's valuable work on "Theoretical Naval Architecture,"¹ in which he has grouped half-a-dozen curves which may be regarded as types of various kinds of curves of statical stability which occur in practice, viz. :—

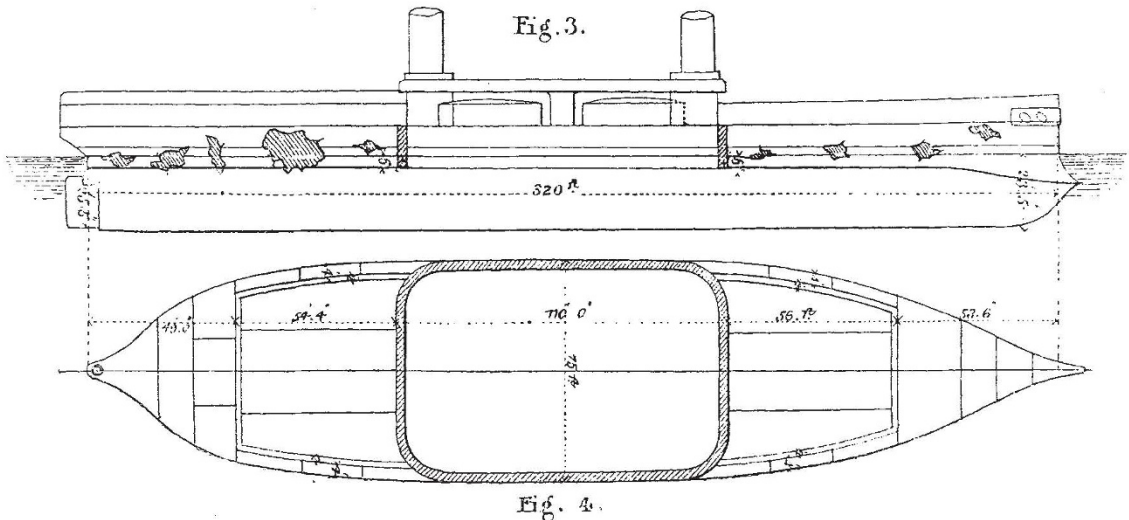
- A. A lofty-sided troop-ship, carrying sail.
- B. Do. Do.
- C. A broadside iron-clad frigate, Do.
- D. A turret-ship with high freeboard, Do.
- E. A low freeboard iron-clad gun-vessel, not carrying sail.
- F. A breastwork monitor, Do.

To facilitate comparison, we have added to Fig. 2 dotted lines showing the stability of the *Captain* as ascertained at the Admiralty just before her loss. The curve marked *a* shows the stability when the ship is fully stored and provisioned, and with the proper complement of coals on board with the poop and forecastle water-tight and assisting stability. The curve *b* refers to the ship under the same conditions, except that the poop and forecastle are supposed to be so damaged as not to assist stability. It will be observed that although Mr. Barnes considered

¹ Published by Collins, Sons, and Co., in the "Advanced Science Series."

assert in this respect, it is clear that in the case of the *Captain*, they thought this amount of injury possible, and it is equally clear from the quotations given by Mr. Goschen in Parliament, that they thought the same of the *Inflexible*, when they proposed that she should be built, and thought this, notwithstanding the introduction of certain cork-filled chambers and other sub-divisions upon which they now seem disposed to rely for the ship's safety. We may add that even during the present controversy, Mr. Barnaby has published figures which assume the total annihilation of the ends, and if they can be totally annihilated it is clear they may be so far injured as to lose all buoyancy and stability. We may confidently assume, therefore, that the ends can be so far wounded and damaged as to cease to help the ship's stability, and therefore to leave her wholly dependent upon the citadel for the power of keeping from capsizing. In Fig. 3 we have shown several large injuries, such as we may assume modern shells are fully capable of inflicting, merely to help the reader to get clear ideas on the subject.

The question now at issue really is, therefore, what amount of stability has the ship (by virtue of the citadel) with the ends thus injured? The *Times* and Mr. Reed say that careful calculations which have been made show that she has none, or next to none. Hitherto the Admiralty have refrained from saying how much they claim for her. They say that the *Times* and Mr. Reed are entirely wrong in their calculations, and that the ship really has abundant stability for all purposes of safety, and they appeal to a model which is at the Admiralty to prove this. Let us say at once no model can possibly prove anything of the kind; the model must be weighted and arranged entirely to represent the results of calculations, and it is these results which should be clearly, and fully, and authoritatively stated. The Government have laid certain papers on the table of the House of Commons, but they are not yet published, and until they are in our hands it is impossible to pursue the subject further. We shall hereafter give due consideration to them. All that we can now say is that with the *Captain* case fresh in our memory, in which the Admiralty office dangerously



overrated the safety of the ship in this very respect, and, remembering as we do that for a ship to be safe at sea, she should have a very large margin of stability over and above that which mere statical and smooth water conditions point to, we shall not ourselves be satisfied with less than the Committee on Designs laid down, viz., "that the angle of vanishing stability should not be fixed at less than 50 deg." Nor shall we be content with this if this range is obtained only in conjunction with a small amount of stability from point to point. Mr. Reed has pointed out, in his letters to the *Times*, the great danger of considering range only, and has attacked the dictum of the Committee on this ground. Dr. Woolley, one of its scientific members, has replied, admitting the accuracy of Mr. Reed's view, but explaining that the truth he enunciates is so elementary and obvious that the Committee thought it unnecessary to mention it, and would indeed have considered it "impertinent" (in the proper sense of the word) to state it. It is difficult to take this view of the matter, however, when we remember that the highest scientific officer of the Admiralty, in a matter affecting the

safety of four of H.M. ships of the largest and newest type, has seized this dictum of the Committee as a sufficient and satisfactory guarantee of their security. We fear we must conclude that the Committee either neglected a very serious element in the calculations, or else greatly overrated the skill and discernment with which their words would be interpreted.

THE DEVELOPMENT OF THE OVUM¹

Bütschli on the Earliest Developmental Processes of the Ovum, and on the Conjugation of Infusoria.

Studien über die ersten Entwicklungsvorgänge der Eizelle, die Zelltheilung und die Conjugation der Infusorien. Von O. Bütschli. (Frankfurt, 1876.)

II.

COMING now to the large and important question of the *Conjugation of Infusoria*, its nature and bearing upon the life-history of the forms, we are bound to state at once our conviction of the inefficiency of the observa-

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