water-line AN, draw AD perpendicular to EG, and meet­ing it, when produced, in D ; and, having calculated the values of AB and GE, put AB = *a*, DE or DG + GE = *d,* and the angle of inclination between the water-lines AN and KL — ∆ ; then BO = (*d*/cos.∆ + *a*)1/tan.∆ ; which must be set off upon the perpendicular PBO, above or below AN, according as *d/cos.*∆ is greater or less than *a*.”

There are several other methods by which the centre of gravity of a ship may be found experimentally. One was proposed by Don Juan d’Ulloa, a Spanish writer on naval science, and a navigator and mathematician of very great eminence, whose works are among the best extant on the subject of the theory of ships. They have been translated into French ; and the description and investigation of the experiment for finding the centre of gravity of a ship has been translated into English by Mr Read, in the Essays and Gleanings on Naval Architecture, a periodical work con­ducted for a short time with great ability by Messrs Laire, Read, and Chatfield, all members of the late School of Naval Architecture. Another method was proposed by a student at the same establishment, since dead, named Barton. This method was published in the fifth number of Papers on Naval Architecture.

We have hitherto, throughout our investigations, assumed that the vertical pressure upward of the water to support a ship acting in the direction of its resultant, must exert a force tending to resist the force of the wind by which we have supposed the ship to be inclined. We shall now pro­ceed to show that this is not necessarily the case, but that the tendency of this force may not be to act in the manner we have hitherto assumed it as acting ; and that its effect is dependent upon the position of the centre of gravity of the ship, the point around which she is supposcd to revolve in inclining. There are three cases which may occur. The first is, that the vessel, when acted upon by the force of the wind, may assume a permanent inclination. This perma­nent inclination would ensue if the resultant of the upward pressure of the water were, after the inclination, still to pass through the centre of gravity of the ship. The second case is that in which the vessel would recover the upright posi­tion immediately on the removal of the inclining force. This would ensue whenever the resultant of the upward pressure of the water, after the inclination, would pass on the immersed or lee side of the centre of gravity of the ship. The third case is that in which the effect of the ver­tical upward pressure of the water would be to increase the inclination of the ship. This would ensue whenever the direction of the resultant of the upward pressure would pass on the emerged or weather side of the centre of gravity of the ship. These three states of equilibrium, which arise from these considerations, are called the state of insensible equilibrium, of equilibrium of stability, and of equilibrium of instability.

*On tlu∙ Metacentre.*

It is evident, from the foregoing considerations, that there is some limit to the height of the centre of gravity of a ship, and below which it must necessarily be placed, in or­der that the upright position may be recovered ; that is, that the ship, when inclined by the force of the wind, may be in an equilibrium of stability. The situation of this point was first investigated by Bouguer, who called it the *metacentre,* which name has been generally adopted by sub­sequent writers on naval architecture. Its height is deter­mined in the following manner : The vessel is supposed to be inclined through an infinitely small angle of inclination, that the intersection of the new load water-section with that previous to the inclination may not be supposed to deviate from the middle line of either, so that the infinitely small solids of immersion and emersion may be considered to be equal to each other. Then the point in which the new line of direction of the vertical upward pressure of the water will cut the line of direction of the same vertical pressure be­fore the inclination, is the point beneath which the centre of gravity must necessarily be situated to insure the vessel’s floating on the water in the equilibrium of stability.

In order to determine the height of the metacentre above the centre of gravity of the displacement, let the half breadth at the water-line AB of the midship section ADB (fig. 4) = *y.* Let E be the centre of gravity of the dis­placement before the inclination, F the centre of gravity of the displacement after the inclination, and let *ab* be the new water-line ; then through E and F draw EG and FG respectively perpendicular to the water-lines AB and *ab.* They will meet each other in some point G. G, the point of their intersection, is the metacentre, and EG is the height of the metacentre above the centre of gravity of the dis­placement.

The triangles AC*a*, BC*b* are equal, by the conditions of the construction ; and if *x* be the length of the pris­matic solids of immersion and emersion, AC*a* · *dx* and BC*b* ∙ *dx* are equal, and may be supposed to be concen­trated in their respective centres of gravity M and N, MN being by construction 4/3*y.* Then the moment of the trans­fer of the solid of emersion to the position of the solid of immersion = BC*b* ∙ *dx∙*4/3*y.* Let A*a* = *Bb=b*. But the triangle BC*b* = therefore the moment of immersion *= 2/3*y2bdx,*,* therefore ∫*2/3*y2bdx = D ∙ EF ; but

*b:y::EF:EG therefore b = EF/EG*y.

By substituting and multiplying both sides by EG/EF

∫*2/3*y2bdx = D ∙ EG, ∫2/3*y^3dx/D=*EG

The height of the metacentre is the measure of stability used by the French naval architects, and indeed gene­rally by all since the first investigation of its principles by Bouguer in his *Traité du Navire.* The error in its prac­tical application is, that the investigation involves the erro­neous supposition, that the transverse sections of the im­mersion and emersion are right-angled triangles, and that the horizontal distance between their centres of gravity is two thirds the breadth of the load water-line. These as-