force of the water resolves itself ; and their effect is neces­sarily in proportion to their distance from the centre of gra­vity. If they are equally distant, they will destroy each other, and the ship will remain at rest with respect to the line of its course ; if the resultant of the resistance of the water passes before the resultant of the wind, the ship will turn to the wind ; but if the resultant of the wind passes before that of the water, the effect will be the contrary, and the ship will fall off from the wind. In either case it will be necessary to equalize the forces, by the action of the water on the rudder, on its lee side, to bring the resultant of the water more aft, and on its weather side to destroy a part of the effect of the wind. This is the principle of the action of the wind on the sails, and of that of the water on the hull, with respect to the course of the ship through the water ; and it is on these considerations only that the va­rious alterations can be regulated, which it may from time to time be necessary to make in the trim either of the sails or of the ship ; and hence the accurate determination of the positions and directions of these two forces is a point of great importance in naval architecture. The position of the centre of effort of the wind on the sails may be found under certain reservations ; and that being known, enough is determined to lead to correct conclusions on the other circumstances attendant on the subject.

In order to find the distance of the centre of effort of the wind on the sails before the centre of gravity of the ship, the moment of each sail is calculated by multiplying its area by the horizontal distance of its centre of gravity from that of the ship; the sum of the negative moments, or those abaft the centre of gravity of the ship, is then subtracted from the sum of the positive moments, or those before the centre of gravity of the ship ; the remainder is then divided by the total area of the sails, and the result gives the required distance of the centre of effort of the wind on the sails before the centre of gravity of the ship. The situation of this point with respect to the length of the vessel must determine in a considerable degree the positions of the masts ; for experience has proved, that it is among the most essentially requisite good qualities of a ship, that she shall carry a weather helm.

It does not at first appear evident why the rudder should have more effect on the ship when it meets the water on one side of the middle line, than it has when put to an equal angle on the other side ; the reason has, however, been partially explained by several writers on naval archi­tecture, from the consideration of the direction of the mo­tion of a ship through the water. Among these Don Juan has been the most explicit. The reasoning he pursues is as follows : That as a great portion of the force of the wind, in all oblique courses, tends to drive the ship bodily to lee­ward, and as this effect cannot by any means be wholly destroyed, the true course of the ship is not in the direction of its own middle line, but in that of a line passing from the lee bow to the weather quarter, parallel to the ship’s wake ; and he supposes that the fluid meets the rudder in the di­rection of this line of lee-way, both on the lee and weather side of the ship ; and that therefore, when the helm is a- weather, the angle of incidence of the fluid on the rudder is equal to the sum of the angle of lee-way, and the an­gle made by the direction of the rudder with the middle line of the ship ; while, when the helm is a-lee, the angle of incidence is only equal to the difference between these two angles, and that therefore, when they are equal to each other, this difference vanishes, and all action of the water on the rudder ceases ; and this, under Don Juan’s suppositions, would occur when the rudder was in the direction of the line of lee-way. And hence, as the most advantageous ge­neral position for the rudder is that in which, by offering no obstacle to the passage of the water, it offers no resist­ance to the velocity of the ship, and yet may by the least variation from this inactive position be brought to act effec­tively, it follows, either that Don Juan’s reasoning is in­correct, or that the most advantageous general position for the helm should be a-lee. But experience proves, that with the helm a-lee, the rudder would not have the effect on the ship which has been described ; therefore, although Don Juan’s reasoning shows the main principle of the greater effect of the rudder when it is to leeward of the middle line of the ship, than when it is inclined at an equal angle to windward of the middle line of the ship, it is insufficient to account for the fact, that the general position of the helm should be a-weather ; indeed his reasoning, on the contrary, proves that it should be a-lee ; which error arises from the incorrectness of the assumption which he makes, that the fluid meets the rudder on the weather side of the ship, in the direction of the line of lee-way. Now when a ship is on a wind, her course, we have said, is along a line passing from the lee bow to the weather quarter, which line is also that of the direction in which the ship impinges upon the particles of water. Each particle of water, after its impact with the lee bow, will be reflected from it in a direction which, accord­ing to the law of the collision of bodies, will form an angle with the bow, and consequently with a tangent to the bow at the point of impact, and would therefore, if produced to cut the middle line of the ship, form a greater angle with that line than would be formed by this tangent to the bow at the point of impact, produced to cut the same line.

This will be the case with the whole of the particles of water which come in contact with the lee bow, and along all that part of the lee side of the ship, a tangent to which, if produced, would meet the line of the ship’s course at any finite distance before her bows ; so that as a ship progresses along the line of her course, since these motions may all be supposed to become constant, her lee side will pass through water having an absolute motion with respect to the motion of the ship, the direction of which forms an acute angle with the middle line of the ship produced aft.

We will now consider the effect of the accumulation of the water at the bows of the ship, either to diminish or to increase this angle. Since there must be a constant ten­dency in the particles of water which compose this accu­mulation to recover their level, there must also be a con­stant run of particles from the apex of this accumulation to its base ; the ultimate direction of the sum of all these mo­tions would therefore evidently form an acute angle with the middle line of the ship produced forward ; and conse­quently, by the composition of forces, the action of the par­ticles of water to recover their level would increase the angle which the direction of the motion of the water makes with the middle line of the ship produced aft.

By extending the same reasoning to the motion of the water on the weather side of the ship, a very little consi­deration will show that the principal effect the passage of the ship through the water would have on the particles of water on that side, would be to cause them to rush aft in a direction inclined towards the middle line of the ship, in order to fill the vacuum created under the weather quarter by the passage of the vessel along the line of lee-way.

We may therefore assume that the particles of water have a motion at the stem of the vessel, the direction of which forms an acute angle with the middle line of the ship produced aft, which angle will evidently be dependent on the fulness or the fineness of the after-part of the body, and on the angle which the line of the ship’s course, or that of the lee-way, makes with the middle line of the ship, consequently the inactive position of the rudder will be when it forms this angle with the middle line of the ship, that is, when the rudder is to leeward, and consequently the helm a-weather. And this position should be the theoretic limit of the degree of weather helm a ship should carry, as in any other position there must be a force acting on the rudder, which must increase the resistance the ship expe­