of lee-way will vary from that which would occur by the ship’s almost drifting in the direction of the sine of the angle of incidence of the direction of the wind on the sail, to that which would exist if her course almost coincided with the line of her keel, or to a quantity which, in practice, would evidently be scarcely observable.

There is some difficulty in accounting for this difference between the results of theory and the facts observed from experience. It depends in a great measure on the imper­fection of our knowledge respecting the laws of the motion of bodies in fluids, so that we are unable to estimate the cir­cumstances of the resistance of the water on the bows and on the sides of the ship. The results of the theory of re­sistances, when applied to oblique impulses, vary very con­siderably from the actual resistances as observed by expe­riment, more especially as the angles of incidence become more acute. This discrepancy affects the lateral resistance, or the resistance on the broad-side, more than the direct, or that experienced by the bows of the vessel, and therefore has a corresponding influence in causing the actual lee-way of a ship to differ from the theoretic result. But this, again, is one of those difficulties arising from the imperfect state of the theory of resistances, which may be classed among those which were referred to in the early part of these ob­servations, as requiring “ only to be fully known and under­stood, to be, if not absolutely theoretically solved, at least, from the collection of facts, from experiment, and from ana­logy, so far overcome, as to leave nothing to be desired.” The course of these remarks will tend to show the possi­bility of this. Professor Robison, in the excellent article on Seamanship, speaking of the results deduced by Bouguer, says, “ that the person who should direct the operations on ship-board in conformity to the maxims deducible from M. Bouguer’s propositions, would be baffled in most of his at­tempts, and be in danger of losing his ship. The whole proceeds on the supposed truth of that theory which states the impulse of a fluid to be in the proportion of the square of the sine of the angle of incidence, and that its action on any small portion, such as a square foot of the sails or hull, is the same as if that portion were detached from the rest, and were exposed singly and alone to the wind and water in the same angle....But let it be observed, that the theory is defective in one point only ; and although this is a most important point, and the errors in it destroy the conclusions on the general propositions, the reasonings remain in full force, and the *modus operandi* such as is stated in the theory.”

There is another cause existing to occasion the devia­tion which is observable in the practical results of the lee­way of a ship from the conclusions of theory, which arises from the theory’s not embracing the whole of the circum­stances attendant on a vessel’s motion through the water. By recurring to the explanation which has been given of these circumstances in a previous portion of this article, some further elucidation may be afforded to the unsatisfac­tory result of the theory. When motion is communicated to a vessel from a state of rest, or from a lesser degree of motion, the effort of the wind on the sails is greater than that of the water on the hull, whether to propel the vessel in the direction HE of the keel, or, laterally, in the direc­tion GH, and the velocity of the vessel in each of these directions is accelerated by the excess of the force of the wind over the resistance of the water, until, ultimately, by the diminution in the relative velocity of the wand, and the increase of the relative velocity of the water, an equilibrium ensues between the propelling and the resisting forces, and the vessel continues to move in the direction of the last acting force, and with the last acquired velocity. Now the resistances of the water in the direction EH and HG may be assumed to increase as the squares of the velocities, and from the nature of the form of a vessel, and from the com­parative direct and lateral resisting areas, the resistance

arising from form or area is much smaller in a direct than in a lateral direction, and therefore the equilibrium between the forces which act laterally may ensue before that be­tween the forces which act directly ; in which case the la­teral motion of the vessel will become uniform before the direct motion, and consequently the ultimate course or di­rection of the vessel, when all the forces have arrived at a state of equilibrium, will approximate to that of the last acting force, that is, will more nearly coincide with the di­rection of the keel, and the angle of lee-way will be dimi­nished. As this reasoning depends on the intensity of the force of the wind, the effect will vary as the cause ; and the greater the force of the wind, and consequently the velo­city of the ship, the greater must be the dimination of the angle of lee-way, that is, the angle of lee-way will, so far as it is affected by these considerations, vary inversely as the sine of the angle of incidence of the wind on the sail.

Romme, in his *Traité du Navire,* differs from the opinions advanced by Bouguer ; and though his reasoning on this subject is far from clear, his opinions arc valuable, as he founds the conclusions at which he arrives, that the lee-way varies inversely as the square of the velocity, and that it increases with the obliquity of the sails to the keel, princi­pally on observations and experiments on the actual per­formances of vessels ; and these are the only means by which, as yet, we can hope to arrive at the solution of this problem. However, much further observation is necessary to afford sufficient data on which to found an approxima­tion to the lee-way which a vessel makes. The general facts which influence it appear to be the greater or lesser angle of incidence of the wind on the sail, as the velocity of the ship is dependent on this ; the angle of the inclina­tion of the sails with the keel ; the form of the vessel as it affects the ratio of the direct and lateral resistances ; the form of the vessel as it affects the velocity ; the stability as it affects the lateral resistances ; the quantity of sail set ; and the state of the sea.

The distance which a ship falls to leeward of her course in any given time may generally be very easily ascertain­ed ; and it would not be a task of any great difficulty to form tables, from actual observation, for ships, under all the various circumstances which have been shown to affect the deviation of their course from the line of direction of the keel. In the open sea the quantity of lee-way made in any certain time may be easily ascertained by measuring the angle which the ship’s wake makes with the line of the keel ; then, if the distance run during the time for which the lee-way is to be observed be ascertained, as that distance is measured along the line of lee-way, the distance run in any period of time will be to the distance which the ship has fallen to leeward of her course during that time, as radius to the sine of the angle of lee-way. When a ship is in sight of land, the angle which the direction of the keel makes with the line of lee-way may be more correctly observed by means of a fixed object on the shore, whenever the state of the wind and sea may render an estimation of the lee-way desirable, that is, whenever the wind is sufficiently steady ; as, of course, it is supposed that the angle formed by the direction of the wind with the line of the keel will remain constant during the whole time for which the distance fallen to leeward is to be ascertained. If, when the ship is either approaching or leaving the shore, her head be constantly kept to the same point of the compass, the ship’s course will be along the line of lee-way ; and as all things are supposed to remain constant during the time of the observation, this line will form a constant angle with the line of the keel, and therefore the point on the shore, which will have the same bearing from the ship as the line of lee-way, will re­main at that bearing during the whole time in which the ship either approaches to or recedes from the shore. Con­sequently, if, when a ship either approaches to or recedes