from a shore, an object on the shore be observed which has a constant bearing from the ship, it must be in the di­rection of the line of lee-way, and therefore the angle which it makes with the direction of the keel will be the correct angle of lee-way ; and then, as before, if the distance run in any time be taken as the radius, the distance which the ship has fallen to leeward of her course in that time will be equal to the sine of the angle of lee-way to a radius equal to the distance run by the vessel in the time assumed.

The actual quantity gained to windward in any given time may also be easily ascertained. The motion of the vessel through the water may be considered in four directions, and the velocity with which it advances in either of these directions determined.

The actual velocity of the ship, or the velocity along the line of lee-way, which may be called the oblique velocity, may be resolved into two ; the direct velocity, or that esti­mated in the direction of the keel, and the lateral velocity, or that which is in a direction at right angles to the line of the keel ; and contemporaneous with these is the velocity with which the ship gains to windward. Let AB (fig. 10) be the direction of the line of the keel of the vessel, and EF the di­rection of the yard, cut­ting that direction of the keel obliquely. Then, whatever may be the direction of the wind GH, the course of the vessel will be along some line HK, forming an angle KHB with the direction of the keel ; then suppose HK on the line of lee­way to represent the velocity of the ship in that direction, from K draw KL perpendicular to HB, and cutting HB in L ; then the velocity HK is equal to the two velocities HL and LK ; ι and HL and LK will represent respectively the direct and lateral velocities of the vessel, in proportion to the oblique velocity HK ; and if from the points H and K, HM be drawn perpendicular and KM parallel to the direc­tion of the wind GH, MK will represent the velocity with which the ship has gained to windward in the time in which she has described the space HK. For the origin of the wind being supposed to be at an infinite distance from the vessel, as HM is drawn perpendicular to GH, the direc­tion of the wind, it may he supposed equidistant in every point from the origin of the wind; and as the angle GHK is less than the angle GHM, the line HK is within the line HM ; and therefore the point K is nearer the origin of the wind than the point H, by a quantity equal to the perpen­dicular distance KM, of the point K, from the line HM ; or the ship has gained the distance MK to windward in running from H to K. It is evident that if HM coincided with HK, the ship would neither have gained to windward nor fallen to leeward ; and that if HM fell within HK, the ship would have fallen to leeward. When the distance HK run by the vessel along the line of lee-way, and the angle of lee-way KHL, are known, the value of KM may be easily determined; for since the angles GHF, FHL, and LHK, are all known, and the line MH is drawn perpendicular to HG, their complement, the angle MHK, is known ; there­fore, as HMK is a right angle, HK is to KM as radius is to the sine of the angle KHM ; or KM is the sine of the angle KHM, to a radius equal to the distance run by the vessel in the space of time in which the required distance to wind­ward, KM, was to be gained. The only difficulties in the practical solution of this proposition are, to determine the direction HM, or the perpendicular to HG, the direction of the wind, and the value of the angle GHF ; for when the vessel is in motion, unless the directions of the wind

and of the course of the vessel coincide, that is, unless the vessel is before the wind, the direction of the wind as shown by the vane on board will not be its true direction ; for, from the velocity of the vessel through the air, the vane is subject to a force acting upon it in a direction opposed to that of the course of the vessel, the effect of which may be considered the same as if the vane was at rest, and was acted upon by a current of air having a velocity equal to that of the vessel, but acting in an opposite direction ; con­sequently the vane is acted upon by two forces, the one in the real direction of the wind, acting with a velocity equal to the velocity of the wind in that direction, and the other acting in a direction opposed to that of the course of the vessel, with a velocity equal to that of the vessel in its course ; and therefore the direction of the vane will be the diagonal of the parallelogram of which the sides represent these two forces in quantity and direction. It is therefore evident that, all things else remaining the same, the greater the velocity of the vessel, the more will the direction of the wind, as shown by the vane, or the apparent wind, de­viate from the actual direction of the wind, or the true wind ; and as this deviation arises from the action of a force in a direction opposed to the motion of the vessel, or acting along the line of the course from the fore-part of the vessel towards the after-part, the apparent direction of the wind will in all cases head the vessel more than the true direc­tion of the wind, and consequently the vessel will always appear to lie nearer the wind than she actually does.

The true direction of the wind may be found if the ve­locity and direction of the vessel be known, and also the velocity and direction of the apparent wind, as the corre­sponding velocity and direction of the true wind will form the third side of a triangle, of which the three sides will be to each other as the three velocities ; and as two of these are known, and include a known angle, that formed by the direction of the apparent wind with the course of the ves­sel, the third side, or the direction and velocity of the true wind, may be easily found. But as there is a difficulty in ascertaining the velocity of the apparent wind, the most easy way of determining the direction of the true wind will be by observing the arc through which the ship’s head passes from close-hauled on one tack to close-hauled on the opposite tack. The bisection of this arc will, all things else remaining the same, give the direction of the true wind, as the course of the vessel, in relation to the direction of the wind, will be the same on either tack. Or the directions of the apparent wind may be observed both before and after tacking, and the true wind will be the middle point between the two directions, as the cause of the deviation of the di­rection of the vane from that of the true wind, or the velo­city of the vessel, will be equal on each tack ; and when the direction of the true wind is known, all the other parts of the triangle may be found, as the direction and velocity of the ship are known, and also the angle made by the ap­parent wind with that direction.

Should the velocity of the vessel be greater on one tack than on the other, it will be necessary, in order to determine the direction of the true wind, to divide the arc described by the vane when the ship is tacked into two segments, which shall be to each other in the inverse ratio of the ve­locities of the vessel on the tacks adjacent to these segments.

Writers on naval architecture and seamanship appear to have fixed the limit of the angle which is formed by the direction of the wind with the line of the keel, when a ship is close-hauled, at six points. This exceeds the angle which the writer of this article has repeatedly observed, by the means which have been described, as being formed by the direction of the wind with the line of the keel, on board the Acorn, one of the corvettes of the experimental squadron of the year 1827. The following table will show the re­sults of some of the observations then made.