it is diminlſhed ſolely by the sail withdrawing itſelf *in that direction* from the wind; and as *g* E may be considered as the real impulſive motion of the wind, GE must be conſidered as the relative and effective impulſive motion. The impulſe would have been the ſame had the ſhip been at rest, and had the wind met it perpen­dicularly with the velocity GE.

We muſt now show the connection between this im­pulſe and the motion of the ſhip. The sail, and con­sequently the ſhip, is preſſed by the wind in the direc­tion CI perpendicular to the ſail or yard with the force which we have just now determined. This (in the ſtate of uniform motion) must be equal and oppoſite to the action of the water. Draw IL at right angles to the keel. The impulſe in the direction CI (which we may meaſure by CI) is equivalent to the impulſes CL and LI. By the firſt the ſhip is impelled right forward, and by the second ſhe is driven ſidewiſe. Therefore we must have a leeway, and a lateral as well as a direct reſiſtance. We ſuppoſe the form of the ſhip to be known, and therefore the proportion is known, or diſcoverable, between the direct and lateral reſiſtances correſponding to every angle *x* of leeway. Let A be the ſurface whoſe perpendicular reſiſtance is equal to the di­rect reſiſtance of the ſhip correſponding to the leeway x, that is, whoſe reſiſtance is equal to the reſiſtance real­ly felt by the ſhip’s bows in the direction of the keel when ſhe is sailing with this leeway; and let B in like manner be the ſurface whoſe perpendicular reſiſtance is equal to the actual reſiſtance to the ſhip’s motion in the direction LI, perpendicular to the keel. (N. *B.* This is not equivalent to A' and B' adapted to the rectangular box, but to A' · coſ.2 x and B' · sin.2 x.) We have therefore A : B = CL : LI, and LI = CL∙B/A. Also, becauſe CI= √CL2+LI2, we have A : √A1 + B2 = CL : CI, and CI = CLV^ + B\ The resistance in the direction LC is properly meaſured by *mAv2,* as has been already obſerved. Therefore the reſiſtance in the direction IC muſt be expreſſed by *m* √*A2* + B2 ∙ *v2;* or (making C the surface which is equal to √Α2 +B2 and which will therefore have the ſame perpendicular reſiſtance to the water having the ve­locity v) it may be expreſſed by *m*C*ν2.*

Therefore, becauſe there is an equilibrium between the impulſe and reſiſtance, we have mCv2 = nS (V∙ ſin. *a — v* ∙ sin. *b* + x)2 and m/n C *v2, or qCν2=* S (V∙ sin. *a—v ∙* sin. b + x)2, and √*q*√*Cν =* √*S* (V ∙ ſin. *a—v* · ſin. b+x).

y S·V∙sin. *a*

Therefore v = ——^y— =

√q√C+√S·sin. *b+x*

V·sin. a Sin. *a*

√C Z^i~^, = V √C ⅜∕y Ç/g- + ſin. b+ *x* √5,^>^g+fin.

Obſerve that the quantity wſhich is the coefficient of V in this equation is a common number; for ſin. *a* is a number, being a decimal fraction of the radius 1. Sin. *b + x* is alſo a number, for the ſame reaſon. And since *m* and n were numbers of pounds, m/n Or *q* is a common number. And becauſe **C** and S are ſurfaces, or quantities of one kind, C/S is alſo a common num­ber.

This is the simpleſt expreſſion that we can think of for the velocity acquired by the ſhip, though it muſt be acknowledged to be too complex to be of very prompt uſe. Its complication ariſes from the neceſſity of introducing the leeway x*.* This affects the whole of the denominator; for the ſurface C depends on it, becauſe C is = √A2 + B2 and A and B are analogous to A'coſ.2 *x* and B'sin.2 *x.*

But we can deduce ſome important conſequences from this theorem.

While the ſurface S of the ſail actually filled by the wind remains the same, and the angle DCB, which in future we ſhall call the Trim of the sails, alſo remains the same, both the leeway *x* and the ſubſtituted ſurface C remains the ſame. The denominator is therefore con­stant; and the velocity of the ſhip is proportional to √S ∙ V ∙ ſin. a; that is, directly as the velocity of the wind, directly as the abſolute inclination of the wind to the yard, and directly as the ſquare root of the ſur­face of the sails.

We alſo learn from the conſtruction of the figure that FG parallel to the yard cuts CE in a given ratio. For CF is in a conſtant ratio to Eg, as has been juſt now demonſtrated. And the angle DCF is conſtant. There­fore CF ∙ sin. *b,* or FH or Gg, is proportional to E*g,*and OC to EC, or EC is cut in one proportion, what­ever may be the angle ECD, ſo long as the angle DCF is conſtant.

We alſo ſee that it is very poſſible for the velocity of the ſhip on an oblique courſe to exceed that of the wind. This will be the caſe when the number

ſin. *a exceeds* unity, or when ſin. a / √*q*C/S + sin. b + x

∕ C~

exceeds unity, or when sin. a. is greater than √q C/S — + sin. b + x. Now this may eaſily be by ſufficiently enlarging S and diminiſhing b + x. It is indeed frequently ſeen in fine sailers with all their sails ſet and not hauled too near the wind.

We remarked above that the angle of leeway *x* affects the whole denominator of the fraction which expreſſes the velocity. Let it be obſerved that the angle ICL is the complement of LCD, or of b*.* Therefore CL: LI, or A : B = 1 : tan. ICL, = 1: cot. *b,* and B = A ∙ cotan. *b.* Now A is equivalent to A' · Coſi2 *x,* and thus *b* becomes a function of x*.* C is evidently ſo, being = √A2+B2∙ Therefore before the value of this frac­tion can be obtained, we muſt be able to compute, by our knowledge of the form of the ſhip, the value of A for every angle x of leeway. This can be done only by reſolving her bows into a great number of elementary planes, and computing the impulſes on each and adding them into one ſum. The computation is of immenſe labour, as may be ſeen by one example given by Bouguer. When the leeway is but small, not exceeding ten degrees, the ſubſtitution of the rectangular priſm of one determined form is abundantly exact for all leeways contained within this limit; and we ſhall ſoon ſee rea-