really moves in the line CE, would always be found in the tube *Ce.* While CE is the real direction of the wind, Ce will be the position of the vane at the mast head, which will therefore mark the apparent direction of the wind, or its motion relative to the moving ship.

We may conceive this in another way. Suppose a can­non-shot fired in the direction CE at the passing ship, and that it passes through the mast at C with the velocity of the wind. It will not pass through the off-side of the ship at P, in the line CE; for while the shot moves from C to P, the point P has gone forward, and the point *p* is now in the place where P was when the shot passed through the mast. The shot will therefore pass through the ship’s side in the point *p,* and a person on board seeing it pass through C and *p* will say that its motion was in the line *Cp.*

Thus it happens, that when a ship is in motion the ap­parent direction of the wind is always ahead of its real di­rection. The line *wC* is always found within the angle WCB. It is easy to see from the construction, that the dif­ference between the real and apparent directions of the wind is so much the more remarkable as the velocity of the ship is greater. For the angle WCw or ECe depends on the magnitude of Ee or CF, in proportion to CE. Persons not much accustomed to attend to these matters are apt to think all attention to this difference to be nothing but affec­tation of nicety. They have no notion that the velocity of a ship can have any sensible proportion to that of the wind. “ Swift as the wind,” is a proverbial expression ; yet the ve­locity of a ship always bears a very sensible proportion to that of the wind, and even very frequently exceeds it. We may form a pretty exact notion of the velocity of the wind by observing the shadows of the summer clouds flying along the face of a country, and it may be very well measured by this method. The motion of such clouds cannot be very different from that of the air below ; and when the pressure of the wind on a flat surface, while blowing with a velocity measured in this way, is compared with its pressure when its velocity is measured by more unexceptionable methods, they are found to agree with all desirable accuracy. Now observations of this kind frequently repeated, show that what we call a pleasant brisk gale blows at the rate of about ten miles an hour, or about fifteen feet in a second, and exerts a pressure of half a pound on a square foot. Mr. Smeaton has frequently observed the sails of a windmill, driven by such a wind, moving faster, nay much faster, towards their extremities, so that the sail, instead of being pressed to the frames on the arms, w as taken aback, and fluttering on thcm. Nay, we know that a good ship, with all her sails set, and the wind on the beam, will in such a situation sail above ten knots an hour in smooth water. There is an observation made by every experienced seaman, which shows this dif­ference between the real and apparent directions of the wind very distinctly. When a ship that is sailing briskly with the wind on the beam tacks about, and then sails equally well on the other tack, the wind always appears to have shifted and come more ahead. This is familiar to all sea­men. The seaman judges of the direction of the wind by the position of the ship’s vanes. Suppose the ship sailing due west on the starboard tack, with the wind apparently N.N.W., the vane pointing S.S.E. If the ship put about, and stands due east on the larboard tack, the vane will be found no longer to point S.S∙E., but perhaps S.S.W., the wind appearing N.N.E., and the ship must be nearly close- hauled in order to make an east course. The wind appears to have shifted four points. If the ship tacks again, the wind returns to its old quarter. We have often observed a greater difference than this. The celebrated astronomer Dr. Brad­ley, taking the amusement of sailing in a pinnace on the river Thames, observed this, and was surprised at it, ima­gining that the change of the wind was owing to the ap­proaching to or retiring from the shore. The boatmen told him that it always happened at sea, and explained it to him

in the best manner they were able. The explanation struck him, and set him a musing on an astronomical phenomenon which he had been puzzled by for some years, and which he called the aberration of the fixed stars. Every star changes its place a small matter for half a year, and returns to it at the completion of the year. He compared the stream of light from the star to the wind, and the telescope of the astronomer to the ship’s vane, while the earth was like the ship, moving in opposite directions when in the oppo­site point of its orbit. The telescope must always be pointed ahead of the real direction of the star, in the same manner as the vane is always in a direction ahead of the wind; and thus he ascertained the progressive motion of light, and dis­covered the proportion of its velocity to the velocity of the earth in its orbit, by observing the deviation which was necessarily given to the telescope. Observing that the light shifted its direction about 40", he concluded its velo­city to be about 11,000 times greater than that of the earth ; just as the intelligent seaman would conclude from this ap­parent shifting of the wind, that the velocity of the wind is about triple that of the ship. This is indeed the best me­thod for discovering the velocity of the wind. Let the di­rection of the vane at the mast-head be very accurately noticed on both tacks, and let the velocity of the ship be also accurately measured. The angle between the direc­tions of the ship’s head on these different tacks being halved, will give the real direction of the wind, which must be com­pared with the position of the vane in order to determine the angle contained between the real and apparent direc­tions of the wind or the angle ECe; or half of the observed shifting of the wind will show the inclination of its true and apparent directions. This being found, the proportion of EC to FC (fig. 6), is easily measured.

We have been very particular on this point, because since the mutual actions of bodies depend on their relative mo­tions only, we should make prodigious mistakes if we esti­mated the action of the wind by its real direction and veloci­ty, when they differ so much from the relative or apparent.

We now resume the investigation of the velocity of the ship (hg. 4), having its sails at right angles to the keel, and the wind blowing in the direction and with the velocity CE, while the ship proceeds in the direction of the keel with the velocity CF. Produce Ee, which is parallel to BC, till it meet the yard in *g,* and draw FG perpendicular to *Εg.* Let *a* represent the angle WCD, contained between the sail and the real direction of the wand, and let *b* be the angle of trim DCB. CE, the velocity of the wind, was expressed by V, and CF, the velocity of the ship, by *v*.

The absolute impulse on the sail is (by the usual theory) proportional to the square of the relative velocity, and to the square of the sine of the angle of incidence ; that is, to FE2× sin.2wCD. Now the angle GFE=wCD, and EG is equal to FE× sin. GFE; and EG is equal to *Εg—gG.* But *Eg=EC* × sin. ECg, =V × sin.a; and gG=CF, =*v*. Therefore EG= V × sin. a—*v,* and the impulse is propor­tional to (V X sin. a—w)2. If S represent the surface of the sail, the impulse, in pounds, will be nS(V *×sin.a—v)2*.

Let A be the surface which, when it meets the water per­pendicularly with the velocity *ν,* will sustain the same pres­sure or resistance which the bows of the ship actually meet with. This impulse, in pounds, will be *m*Av2. Therefore, because we are considering the ship’s motion as in a state of uniformity, the two pressures balance each other; and there­fore *m* Av2=nS(V ×sin.a—v)2andm/nAu5=S(V × sin.a-v)2;

therefore √ A χ β= √S× V×sin. *α*—cs∕ S, and *v =*

x/s X V X sin, *a* V × sin. *a* V X sin. α

*√m . .τ. ∕t"Λ,* , ∕~A ,

-Λ+√b <^-+1 √7s+,∙