from CM of any point of the arch C*mM*, and therefore the ship will recede farther from the coast PQ in any given time, by holding the course Cm than by any other course.

This course is easily determined; for the arch CmM =360°—(arch CO+parch OM), and the arch CO is the measure of twice the angle CFO, or twice the angle DCB, or twice *b+x,* and the arch OM measures twice the an­gle ECM.

Thus, suppose the sharpest possible trim of the sails to be 35°, and the observed angle ECM to be 70°; then CO + OM is 70° +140° or 210°. This being taken from 360°, leaves 150°, of which the half Mm is 75°, and the angle MCm is 37° 30'. This added to ECM makes ECm 170° 30,, leaving WCm=72° 30,, and the ship must hold a course making an angle of 72° 30’with the real direction of the wind, and WCD will be 37° 30,.

This supposes no leeway. But if we know that under all the sail which the ship can carry with safety and advantage she makes 5 degrees of leeway, the angle DCm of the sail and course, or *b*+*x*, is 40°. Then CO + OM=22O°, which being taken from 360°, leaves 140°, of which the half is 70°, =M*m*, and the angle MCm=r35°, and ECm=1O5°, and WCm=75°, and the ship must lie with her head 70° from the wind, making 5 degrees of leeway, and the angle WCD is 35°.

The general rule for the position of the ship is, *that the line on shipboard which bisects the angle* b+x *may also bisect the angle* WCM, or make the angle between the course and the line, from which we wish to withdraw, equal to the angle between the sail and the real direction of the wind.

It is plain that this problem includes that of plying to windward. We have only to suppose ECM to be 90° ; then, taking our example in the same ship, with the same trim and the same leeway, we have *b* + x=40°. This taken from 90° leaves 50°, and WCn=90—25 =65, and the ship’s head must lie 60° from the wind, and the yard must be 25° from it.

It must be observed here, that it is not always eligible to select the course which will remove the ship fastest from the given line CM ; it may be more prudent to remove from it more securely though more slowly. In such cases the procedure is very simple, viz., to shape the course as near the wind as is possible.

The reader will also easily see that the propriety of these practices is confined to those courses only where the prac­ticable trim of the sails is not sufficiently sharp. Whenever the course lies so far from the wind that it is possible to make the tangent of the apparent angle of the wind and sail double the tangent of the sail and course, it should be done.

These are the chief practical consequences which can be deduced from the theory. But we should consider how far this adjustment of the sails and course can be performed. And here occur difficulties so great as to make it almost impracticable. We have always supposed the position of the surface of the sail to be distinctly observable and mea­surable ; but this can be hardly affirmed even with respect to a sail stretched on a yard. Here we supposed the sur­face of the sail to have the same inclination to the keel that the yard has. This is by no means the case ; the sail as­sumes a concave form, of which it is almost impossible to assign the direction of the mean impulse. We believe that this is always considerably to leeward of a perpendicular to the yard, lying between CI and CE, (fig. 6). This is of some advantage, being equivalent to a sharper trim. We cannot affirm this, however, with any confidence, because it renders the impulse on the weather-leech of the sail so exceedingly feeble as hardly to have any effect. In sailing close to the wind, the ship is kept so near that the weather- leech of the sail is almost ready to receive the wind edge­wise, and to flutter or shiver. The most effective or draw­

ing sails with a side-wind, especially when plying to wind­ward, are the staysails. We believe that it is impossible to say, with anything approaching to precision, what is the position of the general surlace of a staysail, or to calculate the intensity and direction of the general impulse ; and we affirm with confidence that no man can pronounce on these points with any exactness. If we can guess within a third or a fourth part of the truth, it is all we can pretend to ; and after all, it is but a guess. Add to this, the sails com­ing in the way of each other, and either becalming them or sending the wind upon them in a direction widely differ­ent from that of its free motion. All these points we think beyond our power of calculation, and therefore that it is in vain to give the scaman mathematical rules, or even tables of adjustment ready calculated ; since he can neither pro­duce that medium position of his sails that is required, nor tell what is the position which he employs.

This is one of the principal reasons why so little advan­tage has been derived from the very ingenious and promis­ing disquisitions of Bouguer and other mathematicians, and has made us omit the actual solution of the chief problems, contenting ourselves with pointing out the process to such readers as have a relish for these analytical operations.

But there is another principal reason for the small pro­gress which has been made in the theory of seamanship. This is the error of the theory itself, which supposes the impulsions of a fluid to be in the duplicate ratio of the sine of incidence. The most careful comparison which has been made between the results of this theory and matter of fact, is to be seen in the experiments made by the members of the Royal Academy of Sciences at Paris, mentioned in the article Resistance of Fluids. We subjoin another ab­stract of them in the following table; where column 1st gives the angle of incidence ; column2d gives the impulsions really observed ; column 3d the impulses, had they followed the du­plicate ratio of the sines ; and column 4th the impulses, if they were in the simple ratio of the sines.

|  |  |  |  |
| --- | --- | --- | --- |
| Angle of incid. | Impulsion  observed. | Impulse as sine.2 | Impulse as sine. |
| 90 | 1000 | 1000 | 1000 |
| 84 | 989 | 989 | 995 |
| 78 | 958 | 957 | 978 |
| 72 | 908 | 905 | 9511 |
| 66 | 845 | 835 | 914 |
| 60 | 771 | 750 | 866 |
| 54 | 693 | 655 | 809 |
| 48 | 615 | 552 | 743 |
| 42 | 543 | 448 | 669 |
| 36 | 480 | 346 | 587 |
| 30 | 440 | 250 | 500 |
| 24 | 424 | 165 | 407 |
| 18 | 414 | 96 | 309 |
| 12 | 406 | 43 | 208 |
| 6 | 400 | 11 | 105 |

Here we see an enormous difference in the great obliqui­ties. When the angle of incidence is only six degrees, the observed impulse is forty times greater than the theoreti­cal impulse ; at 12° it is ten times greater ; at 18° it is more than four times greater ; and at 24° it is almost three times greater

No wonder then that the deductions from this theory are so useless and so unlike what we familiarly observe. We took notice of this when we were considering the leeway of a rectangular box, and thus saw a reason for admitting an incomparably smaller leeway than what would result from the laborious computations necessary by the theory. This error in theory has as great an influence on the impulsions of air when acting obliquely on a sail ; and the experiments