to contain much ; and as their plan is logical, it seems to occupy the whole subject, and therefore to have done al­most all that can be done. But, alas ! they have only open­ed the subject, and the study is yet in its infancy. The whole science of the art must proceed on the knowledge of the impulsions of the wind and water. These are the forces which act on the machine ; and its motions, which are the ultimatum of our research, whether as an end to be obtain­ed or as a thing to be prevented, must depend on these forces. Now it is with respect to this fundamental point that we are as yet almost totally in the dark. And in the performances of M. Bouguer, as also in those of the other authors we have named, the theory of these forces, by which their quantity and the direction of their action are ascer­tained, is altogether erroneous; and its results deviate so enormously from what is observed in the motions of a ship, that the persons who should direct the operations on ship­board, in conformity to the maxims deducible from M. Bou- guer's propositions, would be baffled in most of his attempts, and be in danger of losing the 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, single and alone, to the wind or water in the same angle. But we have shewn, in the article Resistance of Fluids, both from theory and experience, that both of these principles are erroneous, and this to a very great de­gree, in cases which occur most frequently in practice, that is, in the small angles of inclination. When the wind falls nearly perpendicular on the sails, theory is not very erro­neous ; but in these cases, the circumstances of the ship’s situation are generally such that the practice is easy, occur­ring almost without thought; and in this case too, even con­siderable deviations from the very best practice are of no great moment. The interesting cases, where the intended movement requires or depends upon very oblique actions of the wind on the sails, and its practicability or impractica­bility depends on a very small variation of this obliquity ; a mistake of the force, either as to intensity or direction, pro­duces a mighty effect on the resulting motion. This is the case in sailing to windward, the most important of all the general problems of seamanship. The trim of the sails, and the course of the ship, so as to gain most on the wind, are very nice things ; that is, they are confined within very nar­row limits, and a small mistake produces a very consider­able effect. The same thing obtains in many of the nice problems of tacking, box-hauling, wearing after lying-to in a storm, &c.

The error in the second assertion of the theory is still great­er, and the action on one part of the sail or hull is so greatly modified by its action on another adjoining part, that a stay-sail is often seen hanging like a loose rag, although there is nothing between it and the wind ; and this merely because a great sail in its neighbourhood sends off a lateral stream of wind, which completely hinders the wind from getting at it. Till the theory of the action of fluids be established, therefore, we cannot tell what are the forces which are acting on every point of the sail and hull ; therefore we cannot tell either the mean intensity or direc­tion of the whole force which acts on any particular sail, nor the intensity and mean direction of the resistance to the hull ; circumstances absolutely necessary for enabling us to say what will be their energy in producing a rotation round any particular axis. In like manner, we cannot, by such a computation, find the spontaneous axis of conversion, (see Rotation), or the velocity of such conversion. In short, we cannot pronounce with tolerable confidence *a pri­ori* what will be the motions in any case, or what disposi­tions of the sails will produce the movement we wish to

per orm. The experienced seaman learns by habit the general effects of every disposition of the sails ; and though his knowledge is far from being accurate, it seldom leads him into any very blundering operation. Perhaps he sel­dom makes the best adjustment possible, but seldomer still does he deviate very far from it ; and in the most gene­ral and important problems, such as working to windward, the result of much experience and many corrections has settled a trim of the sails, which is certainly not far from the truth, but, it must be acknowledged, deviates widely and uniformly from the theories of the mathematician’s closet. The honest tar, therefore, must be indulged in his joke on the useless labours of the mathematician, who can neither hand, reef, nor steer.

After this account of the theoretical performances in the art of seamanship, and what we have said in another place on the small hopes we entertain of seeing a perfect theory of the impulse of fluids, it will not be expected that we en­ter very minutely on the subject in this place ; nor is it our intention. 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 of the chief propositions, the reasonings remain in full force, and the *modus operandi* is precisely such as is stated in the theory. The *principles* of the art are therefore to be found in these treatises ; but false inferences have been drawn, by computing from erroneous quantities. The rules and the practice of the computation, however, are still beyond controversy. Nay, since the process of investigation is le­gitimate, we may make use of it in order to discover the very circumstance in which we are at present mistaken ; for by converting the proposition, instead of finding the motions by means of the supposed forces, combined with the known mechanism, we may discover the forces by means of this mechanism and the observed motions.

We shall therefore in this place give a very general view' of the movements of a ship under sail, showing how they are produced and modified by the action of the wind on her sails, the water on her rudder and on her bows. We shall not attempt a precise determination of any of these move­ments ; but we shall say enough to enable the curious lands­man to understand how this mighty machine is managed amidst the fury of the winds and waves ; and, what is more to our wish, we hope to enable the uninstructed but think­ing seaman, to generalise that knowledge which he pos­sesses ; to class his ideas, and give them a sort of rational system ; and even to improve his practice, by making him sensible of the immediate operation of every thing he does, and in what manner it contributes to produce the move­ment which he has in view.

A ship may be considered at present as a mass of inert matter in free space, at liberty to move in every direction, according to the forces which impel or resist her ; and when she is in actual motion, in the direction of her course, we may still consider her as at rest in absolute space,'but exposed to the impulse of a current of water moving equally fast in the opposite direction ; for in both cases the pres­sure of the water on her bows is the same ; and we know that it is possible, and frequently happens in currents, that the impulse of the wind on her sails, and that of the water on her bows, balance each other so precisely, that she not only does not stir from the place, but also remains steadily in the same position, with her head directed to the same point of the compass. This state of things is easily con­ceived by any person accustomed to consider mechanical subjects, and every seaman of experience has observed it. It is of importance to consider it in this point of view, be­cause it gives us the most familiar notion of the manner in which these forces of the wind and water are set in oppo­sition, and made to balance or not to balance each other by the intervention of the ship, in the same manner as the