necessary that the impelling forces, estimated in their mean direction, be equal and opposite to the resisting forces esti­mated in their mean direction ; but also that these two di­rections may pass through one point, otherwise she will be affected as a log of wood is when pushed in opposite direc­tions by two forces, which are equal indeed, but are applied to different parts of the log. A ship must be considered as a lever, acted on in different parts by forces in different di­rections, and the whole balancing each other round that point or axis where the equivalent of all the resisting for­ces passes. This may be considered as a point supported by this resisting force and as a sort of fulcrum : therefore, in order that the ship may maintain her position, the ener­gies or *momenta* of all the impelling forces round this point must balance each other.

When a ship sails right afore the wind, with her yards square, it is evident that the impulses on each side of the keel are equal, as also their mechanical *momenta* round any axis passing perpendicularly through the keel. So are the actions of the water on her bows. But when she sails on an oblique course, with her yards braced on either side, she sustains a pressure in the direction CI (fig. 5,) perpendicu­lar to the sail. This, by giving her a lateral pressure LI, as well as a pressure CL ahead, causes her to make leeway, and to move in a line *Cb* inclined to CB. By this means the balance of action on the two bows is destroyed ; the general impulse on the lee-bow is increased ; and that on the weather-bow is diminished. The combined impulse is therefore no longer in the direction BC, but (in the state of uniform motion) in the direction IC.

Suppose that in an instant the whole sails are annihilated and the impelling pressure CI, which precisely balanced the resisting pressure on her bows, removed. The ship tends, by her inertia, to proceed in the direction C *b.* This ten­dency produces a continuation of the resistance in the op­posite direction IC, which is not directly opposed to the tendency of the ship in the direction C A; therefore the ship’s head would immediately come up to the wind. The experienced seaman will recollect something like this when the sails are suddenly lowered when coming to anchor. It does not happen solely from the obliquity of the action on the bows : It would happen to the parallelopiped of fig. 2, which was sustaining a lateral impulsion B∙sin.2x, and a direct impulsion A∙cos.2x. These are continued for a mo­ment after the annihilation of the sail : but being no longer opposed by a force in the direction C D, but by a force in the direction *Cb,* the force B∙sin.2x must prevail, and the body is not only retarded in its motion, but its head turns towards the wind. But this effect of the leeway is greatly increased by the curved form of the ship’s bows. This oc­casions the centre of effort of all the impulsions of the water on the leeside of the ship to be very far forward, and this so much the more remarkably as she is sharper afore. It is in general not much abaft the foremast. Now the centre of the ship’s tendency to continue her motion is the same with her centre of gravity, and this is generally but a little before the mainmast. She is therefore in the same condi­tion nearly as if she were pushed at the mainmast, in a di­rection parallel to *Cb,* and at the foremast by a force par­allel to IC. The evident consequence of this is a tenden­cy to come up to the wind. This is independent of all si­tuation of the sails, provided only that they have been trimmed obliquely.

This tendency of the ship’s head to windward is called griping in the seaman’s language, and is greatest in ships which are sharp forward, as we have said already. This circumstance is easily understood. Whatever is the direc­tion of the ship’s motion, the absolute impulse on that part of the bow immediately contiguous to B is perpendicular to that very part of the surface. The more acute, therefore, that the angle of the bow is, the more will the impulse on

that part be perpendicular to the keel, and the greater will be its energy to turn the head to windward.

Thus we are enabled to understand or to see the proprie­ty of the disposition of the sails of a ship. We see her crowded with sails forward, and even many sails extended far before her bow, such as the spritsail, the bowsprit top­sail, the fore-topmast staysail, the jib, and flying jib. The sails abaft are comparatively smaller. The sails on the mizenmast are much smaller than those on the foremast. All the staysails hoisted on the mainmast may be consider­ed as headsails, because their centres of effort are consider­ably before the centre of gravity of the ship : and notwith­standing this disposition, it generally requires a small action of the rudder to counteract the windward tendency of the lee-bow. This is considered as a good quality when mode­rate ; because it enables the seaman to throw the sails aback, and stop the ship’s way in a moment, if she be in danger from any thing a-head ; and the ship which does not carry a little of a weather helm, is always a dull sailer.

In order to judge somewhat more accurately of the ac­tion of the water and sails, suppose the ship AB (fig. 9,) to have its sails on the mizen­

mast D, the mainmast E, and

the foremast F, braced up or

trimmed alike, and the three

lines D », Ee, *Ff,* perpendicu­lar to the sails, are in the pro­

portion of the impulses on the

sails. The ship is driven

a-head and to leeward, and

moves in the path *αCb.* This

path is so inclined to the line of the keel, that the medium direction of the resistance of the water is parallel to the di­rection of the impulse. A line CI may be drawn parallel to the lines D *i*, E *e*, F *f* and equal to their sum : and it may be drawn from such a point C, that the actions on all the parts of the hull between C and B may balance the *mo­menta* of all the actions on the hull between C and A. This point may justly be called the *centre of effort,* or the *centre of resistance.* We cannot determine this point for want of a proper theory of the resistance of fluids. Nay, although experiments like those of the Parisian Academy should give us the most perfect knowledge of the intensity of the ob­lique impulses on a square foot, we should hardly be bene- fitted by them : for the action of the water on a square foot of the hull at *p,* for instance, is so modified by the in­tervention of the stream of water which has struck the hull about B, and glided along the bow B *o p,* that the pressure on *ρ* is totally different from what it would have been were it a square foot or surface detached from the rest, and pre­sented in the same position to the water moving in the di­rection *b*C. For it is found, that the resistances given to planes joined so as to form a wedge, or to curved surfaces, are widely different from the accumulated resistances, cal­culated for their separate parts, agreeablv to the experi­ments of the academy on single surfaces. We therefore do not attempt to ascertain the point C by theory ; but it may be accurately determined by the experiments which we have so strongly recommended; and we offer this as an ad­ditional inducement for prosecuting them.

Draw through C a line perpendicular to CI, that is, par­allel to the sails; and let the lines of impulse of the three sails cut in the points », *h,* and *m.* This line *im* may be considered as a lever, moveable round C, and acted on at the points *i*, *k,* and *m,* by three forces. The rotatory mo­mentum of the sails on the mizenmast is D *i* × *i* C ; that of the sails on the mainmast is E *e* × *k* C ; and the momen­tum of the sails on the foremast is *F f × m* C. The two first tend to press forward the arm C », and then to turn the ship’s head towards the wind. The action of the sails on the fore­mast tends to pull the arm C *m* forward, and produce a