mutual eliding of the fibres which we mentioned a little ago ; nay, this lateral compression may change the law of longitudinal cohesion (as will readily appear to the reader who is acquainted with Boscovich’s doctrines), and increase the strength of the very surface of fracture, in the same way (however inexplicable) as it does in metals when they are hammered or drawn into wire.

The reader must judge how far these remarks are worthy of his attention. The engineer will carefully keep in mind the important fact, that a beam of quadruple length, instead of having one fourth of the strength, has only about one sixth ; and the philosopher should endeavour to discover the cause of this diminution, that he may give the artist a more accurate rule of computation.

Our ignorance of the law by which the cohesion of the particles changes by a change of distance, hinders us from discovering the precise relation between the curvature and the momentum of cohesion; and all we can do is to multi­ply experiments, upon which we may establish some *em­pirical* rules for calculating the strength of solids. Those from which we must reason at present are too few and too anomalous to be the foundation of such an empirical for­mula. We may however observe, that Μ. Buffon’s expe­riments gave us considerable assistance in this particular ; for if to each of the numbers of the column for the five-inch beams, corrected by adding half the weight of the beam, we add the constant number 1245, we shall have a set of num­bers which are very nearly reciprocals of the lengths. Let 1245 be called *c*, and let the weight which is known by ex­periment to be necessary for breaking the five-inch beam of the length *a* be called P. We shall have *— c∙=,p.*

Thus the weight necessary for breaking the seven-feet bar is 11,560. This added to 1245, and the sum multiplied by 7, gives P-f-c×α=89,635. LetZbelS; then^^’^^—1245 =3725 = *p,* which differs not more than 1/40th from what experiment gives us. This rule holds equally well in all the other lengths except the 10 and 24 feet beams, which are very anomalous. Such a formula is abundantly exact for practice, and will answer through a much greater variety of length, though it cannot be admitted as a true one ; be­cause, in a certain very great length, the strength will be nothing. For other sizes the constant number must change in the proportion of *d3,* or perhaps of *p.*

The next comparison which we have to make with the theory is the relation between the strength and the square of the depth of the section. This is made by comparing with each other the numbers in any horizontal line of the table. In making this comparison we find the numbers of the five-inch bars uniformly greater than the rest. We imagine that there is something peculiar to these bars ; they are in general heavier than in the proportion of their section, but not so much so as to account for all their su­periority. We imagine that this set of experiments, intend­ed as a standard for the rest, has been made at one time, and that the season has had a considerable influence. The fact however is, that if this column be kept out, or uni­formly diminished about one sixteenth in their strength, the different sizes will deviate very little from the ratio of the square of the depth, as determined by theory. There is however a small deficiency in the bigger beams.

We have been thus anxious in the examination of these experiments, because they are the only ones which have been related in sufficient detail, and made on a proper scale for giving us data from which we can deduce confi­dential maxims for practice. They are so troublesome and expensive that we have little hopes of seeing their number greatly increased; yet surely our navy board would do an unspeakable service to the public by appropriating a fund for such experiments under the management of some man of science.

There remains another comparison which is of chief im­portance, namely, the proportion between the *absolute co­hesion* and the *relative strength.* It may be guessed, from the very nature of the thing, that this must be very uncer­tain. Experiments on the absolute strength must be con­fined to very small pieces, by reason of the very great forces which are required for tearing them asunder. The values therefore deduced from them must be subject to great in­equalities. Unfortunately we possess no detail of any ex­periments ; all that we have to depend on are two passages of Muschenbroeck’s *Essais de Physique;* in one of which he says, that a piece of sound oak 27/100ths of an inch square is torn asunder by 1150 pounds ; and in the other, that an oak plank twelve inches broad and one thick will just sus­pend 189,163 pounds. These give for the cohesion of an inch square 15,755 and 15,763 pounds. Bouguer, in his *Traité du Navire,* says that it is very well known that a rod of sound oak one fourth of an inch square will be torn asunder by 1000 pounds. This gives 16,000 for the cohe­sion of a square inch. We shall take this as a round num­ber, easily used in our computations. Let us compare this with Μ. Buffon’s trials of beams four inches square.

The absolute cohesion of this section is 16,000×16= 256,000. Did every fibre exert its whole force in the in­stant of fracture, the momentum of cohesion would be the same as if it had all acted at the centre of gravity of the section at two inches from the axis of fracture, and is there­fore 512,000. The four-inch beam, seven feet long, was broken by 5312 pounds hung on its middle. The half of this, or 2656 pounds, would have broken it, if suspended at its extremity, projecting 31/2 feet, or 42 inches, from a wall. The momentum of this strain is therefore 2656×42 = 111,552. Now this is in equilibrio with the actual mo­mentum of cohesion, which is therefore 111,552 instead of 512,000. The strength is therefore diminished in the proportion of 512,000 to 111,552, or very nearly of 4∙59 to 1.

As we are quite uncertain as to the place of the centre of effort, it is needless to consider the full cohesion as act­ing at the centre of gravity, and producing the momentum 512,000 ; and we may convert the whole into a simple mul­tiplier *in* of the length, and say, *as* in *times the length is to the depth, so is the absolute cohesion of the section to the re­lative strength.* Therefore let the absolute cohesion of a square inch be called *f,* the breadth *b,* the depth *d,* and the length *I* (all in inches), the relative strength, or the exter- *fbd3*

nal force, *p,* which balances it, is ’ -, or, in round num-

**y\* 18\***

bers,∙^^- ; for m=2×4∙59.

y\*

This great diminution of strength cannot be wholly ac­counted for by the inequality of the cohesive forces exert­ed in the instant of fracture ; for in this case we know that the centre of effort is at one third of the height in a rect­angular section (because the forces really exerted are as the extensions of the fibres). The relative strength would

*fbtP*

and *p* would have been 8127 instead of 2656.

We must ascribe this diminution (which is three times greater than that produced by the inequality of the cohe­sive forces) to the compression of the under part of the beam ; and we must endeavour to explain in what manner this compression produces an effect which seems so little explicable by such means.

As we have repeatedly observed, it is a matter of nearly universal experience that the forces *actually* exerted by the