AB, and that one part ABCD is pushed laterally in the direction AB, there can be no doubt that it will yield only there, and that the resistance will be proportional to the surface.

In like manner, we can conceive a thin cylindrical tube, of which KAH (fig. 23) is the section, as cohering more weakly in that sec­tion than anywhere else. Suppose it to be grasped in both hands, and the two parts twisted round the axis in opposite directions, as we would twist the joints of a flute ; it is plain that it will first fail in this section, which is the circum­ference of a circle, and the particles of the two parts which are contiguous to this circumference will be drawn from each other laterally. The total resistance will be as the number of equally resisting particles, that is, as the cir­cumference (for the tube being supposed very thin, there can be no sensible difference between the dilatation of the external and internal particles). We can now sup­pose another tube within this, and a third within the se­cond, and so on till we reach the centre. If the particles of each ring exerted the same force (by suffering the same dilatation in the direction of the circumference), the resistance of each ring of the section would be as its cir­cumference and its breadth (supposed indefinitely small), and the whole resistance would be as the surface ; and this would represent the resistance of a solid cylinder. But when a cylinder is twisted in this manner by an external force applied to its circumference, the external parts will suffer a greater circular extension than the internal ; and it appears that this extension (like the extension of a beam strained transversely) will be proportional to the distance of the particles from the axis. We cannot say that this is demonstrable, but we can assign no proportion that is more probable. This being the case, the forces simultaneously exerted by each particle will be as its distance from the axis. Therefore the whole force exerted by each ring will be as the square of its radius, and the accumulated force actually exerted will be as the cube of the radius ; that is, the accumulated force exerted by the whole cylinder, whose radius is CA, is to the accumulated force exerted *at the same time* by the part whose radius is CE, as CA3 to CE3.

The whole cohesion now exerted is just two thirds of what it would be if all the particles were exerting the same attractive forces which are just now exerted by the particles in the external circumference. This is plain to any person in the least familiar with the fluxionary calculus. But such as are not may easily see it in this way.

Let the rectangle AC*ca* be set upright on the surface of the circle along the line CA, and revolve round the axis Cc. It will generate a cylinder whose height is C*c* or Aβ, and having the circle KAH for its base. If the diagonal C*a* be supposed also to revolve, it is plain that the triangle *cCa* will generate a cone of the same height, and having for its base the circle described by the revolution of ca, and the point C for its apex. The cylindrical surface generated by *Aa* will express the whole cohesion exerted by the circum­ference AHK, and the cylindrical surface generated by *Ee* will represent the cohesion exerted by the circumference ELM, and the solid generated by the triangle *CAa* will re­present the cohesion exerted by the whole circle AHK, and the cylinder generated by the rectangle *ACca* will represent the cohesion exerted by the same surface if each particle had suffered the extension *Aa.*

Now it is plain, in the first place, that the solid generated by the triangle eEC is to that generated by aAC as EC3 to

call this product *f* Multiply *f* by 651, and divide by the length in feet. From the quotient take 10 times *f*. The re­mainder is the number of pounds which will break the beam.

We are not sufficiently sensible of our principles to be confident that the correction 10 *f* should be in the propor­tion of the section, although we think it most probable. It is quite empirical, founded on Buffon’s experiments. Therefore the safe way of using this rule is to suppose the beam square, by increasing or diminishing its breadth till equal to the depth. Then find the strength by this rule, and di­minish or increase it for the change which has been made in its breadth. Thus, there can be no doubt that the strength of the beam given as an example is double of that of a beam of the same depth and half the breadth.

The reader cannot but observe that all this calculation relates to the very greatest weight which a beam will bear for a very few minutes. Μ. Buffon uniformly found that two thirds of this weight sensibly impaired its strength, and frequently broke at the end of two or three months. One half of this weight brought the beam to a certain bend, which did not increase after the first minute or two, and may be borne by the beam for any length of time. But the beam contracted a bend, of which it did not recover any considerable portion. One third seemed to have no permanent effect on the beam ; but it recovered its rectili­neal shape completely, even after having been loaded seve­ral months, provided that the timber was seasoned when first loaded ; that is to say, one third of the weight which would quickly break a seasoned beam, or one fourth of what would break one just felled, may lie on it for ever with­out giving the beam a set.

We have no detail of experiments on the strength of other kinds of timber: only Μ. Buffon says, that fir has about 6/10ths of the strength of oak ; Mr Parent makes it 10/12ths ; Emerson, 2/3ds, &c.

We have been thus minute in our examination of the mechanism of this transverse strain, because it is the great­est to which the parts of our machines are exposed. We wish to impress on the minds of artists the necessity of avoiding this as much as possible. They are improving in this respect, as may be seen by comparing the centres on which stone arches of great span are now turned with those of former times. They were formerly a load of mere joists resting on a multitude of posts, which obstructed the navi­gation, and were frequently losing their shape by some of the posts sinking into the ground. Now they are more generally trusses, where the beams abut on each other, and are relieved from transverse strains. But many performances of eminent artists are still very injudiciously exposed to cross strains. We may instance one which is considered as a fine work, viz. the bridge at Walton on Thames. Here every beam of the great arch is a joist, and it hangs together by framing. The finest piece of carpentry that we have seen is the centre employed in turning the arches of the bridge at Orleans, described by Perronet. In the whole there is not one cross strain. The beam, too, of Hornblower’s steam-engine is very scientifically constructed.

IV. The last species of strain which we are to examine is that produced by twisting. This takes place in all axles which connect the working parts of machines.

Although we cannot pretend to have a very distinct conception of that modification of the cohesion of a body by which it resists this kind of strain, we can have no doubt that, when all the particles act alike, the resistance must be proportional to the number. Therefore if we suppose the two parts ABCD, ABFE (fig. 22), of the body EFCD to be of insuperable strength, but cohering more weakly in the common surface