

are achievements which have, in the ages in which they occurred, been received with great admiration and applause; but in those cases the principle of the structure had been tried and verified for ages upon a smaller scale. Here not only was the space thus spanned wider than any ever spanned before, but the principle of such a beam with a cellular structure of its parts, was invented for this very purpose, experimentally verified with care, and applied with the most exact calculation of its results.

Roofs—Arches—Vaults.

The calculations of the mechanical conditions of structures consisting of several beams, as for instance, the frames of roofs, depends upon elementary principles of mechanics; and was a subject of investigation at an early period of the science. Such frames may be regarded as assemblages of levers. The parts of which they consist are rigid beams which sustain and convey force, and *Ties* which resist such force by their tension. The former parts must be made rigid in the way just spoken of with regard to iron beams; but ties may be rods merely. The wide structures of many of the roofs of railway stations, compared with the massive wooden roofs of ancient buildings, may show us how boldly and how successfully this distinction has been carried out in modern times. The investigation of the conditions and strength of structures consisting of wooden beams has been cultivated by Mathematicians and Engineers, and is often entitled *Carpentry* in our Mechanical Treatises. In our own time, Dr. Robison and Dr. Thomas Young have been two of the most eminent mathematicians who have written upon this subject.

The properties of the simple machines have been known, as we have narrated, from the time of the Ancient Greeks. But it is plain that such machines are prevented from producing their full effect by various causes. Among the rest, the rubbing of one part of the machine upon another produces an obstacle to the effectiveness of a machine: for instance, the rubbing of the axle of a wheel in the hole in which it rests, the rubbing of a screw against the sides of its hollow screw; the rubbing of a wedge against the sides of its notch; the rubbing of a cord against its pulley. In all these cases, the effect of the machine to produce motion is diminished by the friction. And this *Friction* may be measured and its effects calculated; and thus we have a new branch of mechanics, which has been much cultivated.