relative motion. It is to be borne in mind that all the parts do not necessarily move, and as a matter of fact there are very few machines in which one part, which we shall refer to briefly as the frame, is not stationary, but all parts must move *relatively* to one another. If we stand on the frame of an engine the motion of the connecting rod is quite evident if it is slow enough, and if on the other hand we stood on the connecting rod of a very slow moving engine the frame would appear to us to move, that is, the frame has a motion relative to the connecting rod, and vice versa.

Now as to the nature of the motion, and it is this that especially distinguishes the machine. When a body moves in space its direction, sense and velocity depend entirely upon the forces acting on it for the time being, the path of a cannon-ball depends upon the force of the wind, the attraction of gravity, etc., and it is impossible to make two cannon balls travel over the same path, because the forces acting continually vary; a thrown ball may go in an approximately straight line until struck by the batter when its course suddenly changes, so also with a ship, etc., *i.e.*, in general, the path of a body in space varies with the external forces acting upon it. In the case of the machine, however, the matter is entirely different, for the path of each part is predetermined by the designer, and he arranges the whole machine so that each part shall act in conjunction with the others to produce in each a perfectly defined path.

Thus, in the steam engine, the piston moves in a straight line back and forth without turning at all, the crank pin describes a true circle, each point on it remaining in a definite plane, normal to the axis of the crank shaft, during the rotation, and again the motion of the connecting rod, although not so simple, is yet perfectly well known. The same is true in a lathe, the carriage for instance slides along the frame, the spindle has no longitudinal motion, but only rotation, and the gears are not free to slide along their axles. These motions are fixed by the designer and the parts are arranged so as to *constrain* them absolutely, irrespective of the external forces acting; if one presses on the side of the crosshead its motion is unchanged, and if he produces sufficient pressure to change the motion he breaks the machine and makes it useless. The carriage of the lathe can only move along the frame whether the tool which it carries is idle or subjected to considerable force due to the cutting of metal, should the carriage be pushed aside so that it does not slide on the frame, the lathe would be stopped and no work done with it till it was again