CHAPTER XI.

CHAINS INVOLVING SCREW MOTION.

90. Formation of Screw Surfaces.—It has already been stated (§ 8) that lower pairs of elements can be constructed in which the surfaces in contact are screws of uniform pitch. Fig. 186 serves to illustrate the formation of

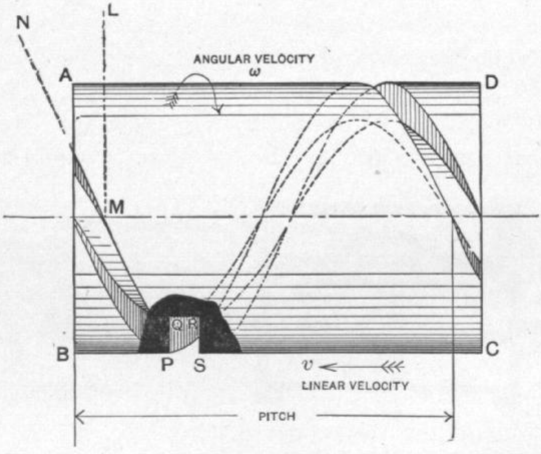

FIG. 186.

such surfaces. Imagine that a cylinder *ABCD* is caused to rotate with uniform angular velocity, as indicated by the arrow, and let a cutting tool whose point is ground into the shape *PQRS* be moved with uniform linear velocity v in a direction parallel to the axis of the cylinder, so as to cut out a continuous groove in the material of the cylinder. If now the tool is so set that the lines *PQ* and *SR* when pro-

duced pass through the axis of the cylinder, the surfaces forming the side of the groove will be screw or helical surfaces of uniform pitch. It will evidently be possible to form in a somewhat similar manner a hollow cylinder having the material of its inner surface removed in such a way as to leave a projecting thread of such a form as will exactly fit into the groove $PQRS$. The inner surface of this nut will be the exact counterpart of the outer surface of the screw, and when working together their relative motion must be a copy of the original relative motion of the cutting tool and the cylinder. In other words, the only possible relative motion of such a screw and its nut will be a motion of rotation, combined in a constant ratio with a motion of translation along the axis of rotation. By the term *pitch* we mean the distance (measured along the axis of rotation) through which the nut moves relatively to the screw during one complete relative rotation. Thus if ω be the angular velocity of the cylinder in radians per second, the time of one complete rotation will be $\frac{2\pi}{\omega}$ seconds. During this time the cutting tool will have moved a distance $\frac{2\pi v}{\omega}$; this expression therefore gives the numerical value of the pitch. If we imagine that a piece of paper wrapped round the cylinder has the outline of the screw-thread marked upon it, and is then unwrapped, the line representing the edge of the screw-thread will be found to be straight, and it will make with the line representing the edge AB of the cylinder an angle such as LMN. A little consideration will show that the tangent of this pitch-angle will be

$$\frac{\text{pitch of thread}}{\text{circumference of cylinder}}.$$

It is quite easy to arrange a mechanism which will cut a screw-thread of *variable pitch*. This is, in fact, often done in rifling guns. In this case, if the angular velocity of the screw is uniform, the linear velocity of the tool must be

variable, and the pitch-angle changes as we go along the thread. A hollow surface the exact counterpart of the screw would then only fit exactly in one position, and no relative motion of such a pair of surfaces would be possible. It is for this reason that a screw pair composed of rigid elements must consist of screw surfaces of *uniform pitch*. The section of the thread, as governed by the form of the cutting tool producing it, may be of any convenient form, and a number of standard threads are described in text-books on machine design. The reader should note that screws are often made with two, three, or a larger number of threads by cutting the required number of independent grooves on the cylinder. These threads may further be either right- or left-handed. The thread in Fig. 186 is right-handed; Fig. 187 shows a left-handed screw having

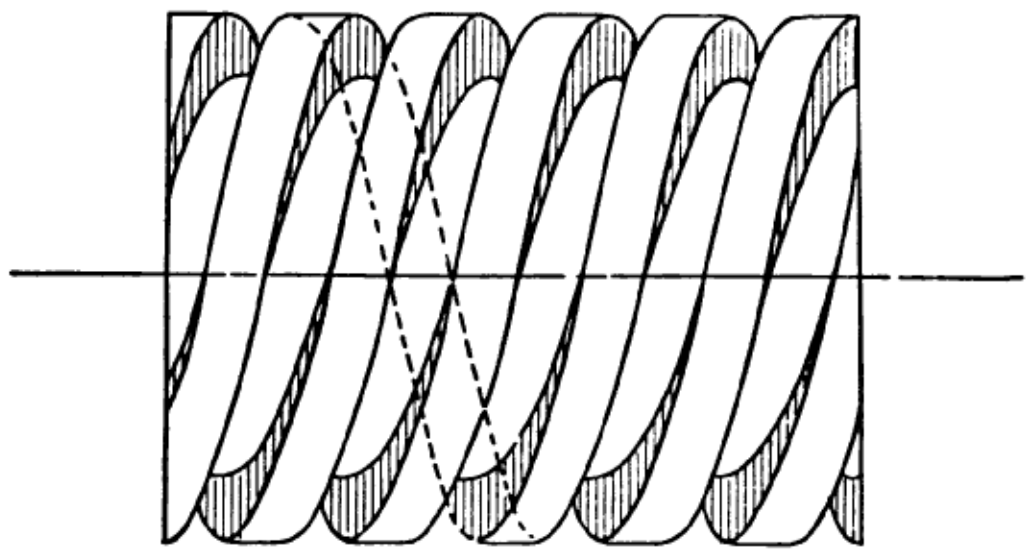

FIG. 187.

three threads. We shall see later that these multiple-threaded screws are of importance in screw mechanisms involving higher pairing, and we now consider certain cases in which lower pairing of screw surfaces is used in chains containing rigid links only.

91. Screw Mechanisms Involving Lower Pairing of Rigid Links.—The relative motion of screw links is in general non-plane. On examination it will be found that in a screw and its nut, while there is at any instant rotation about the axis of the screw, there is also a simultaneous linear movement along that line. In more complex cases of the screw