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PART V.—TRANSMISSION AND CONVERSION OF ENERGY BY FLUIDS.

231. *Introductory Remarks.*—We now return to the subject of Machines with the object of studying those machines in which fluids are employed as links in a kinematic chain for the purpose of transmitting energy, or as a means by which energy is supplied, stored, or converted.

A fluid is a body in which change of form is produced by the action of any distorting stress, however small, if sufficient time is allowed. In a perfect fluid a sensible change would be produced by a stress of sensible magnitude in an indefinitely short time, but in all actual fluids a time is required which is inversely as the stress—that is, the stress is proportional to the rate of change. This property of fluids is called Viscosity, and is measured by a co-efficient, as will be seen hereafter. The viscosity of a fluid varies greatly in different fluids, and, in the same fluid, is dependent on the temperature. At high temperatures it is much less than at low temperatures. The viscosity of water is exceedingly small.

Fluids are either liquid or gaseous. In liquids the changes of volume are in general small, and no diminution of pressure on the bounding surface will cause their volume to increase beyond a certain limit. Gases, on the other hand, expand indefinitely as the external pressure diminishes.

Liquids are employed in machines either as a simple link in a kinematic chain transmitting energy from some source independent of the liquid, or as a medium by means of which the force of gravity exerts energy. Such machines are called Hydraulic Machines, the fluid employed being in most cases water. On the other hand, gases in general serve as the means by which that form of energy which we call Heat is converted into mechanical energy, capable of being utilized for any required purpose. They may, however, also be employed for the storage and transmission of energy.

The motions of fluids may be studied in two different ways. In the first the Principles of Work and Momentum are applied to the whole mass of fluid under consideration, or to portions which, though small, are yet of visible magnitude; but no attempt is made to conceive, much less to determine, the movements of the smallest particles of which the fluid may be imagined to be made up. This method may be described as the experimental theory, and, as applied to water, forms that part of the subject which is called "Hydraulics." It is based directly on experiment, and requires continual recourse to experiment, just as is the case in questions relating to the friction of solids. Nevertheless, being continually verified by the large-scale experiments of the hydraulic engineer, its results, as far as they go, are as certain as those of any purely experimental subject. On the other hand, an analytical theory has been constructed, by means of which the motions of fluids are determined directly from the laws of motion, without reference to experience. This theory is usually called Hydrodynamics in treatises on mechanics. In the cases in which it is applicable it completely determines the motion of all particles of the fluid, and not merely that of the fluid as a whole.

The first two chapters of this division of our work will be devoted to Hydraulics and Hydraulic Machines, and the third to a brief discussion of the various applications of Elastic Fluids. The transmission and storage of mechanical energy by elastic fluids is often considered as part of hydraulics, because the method of treatment is in many respects similar. In this treatise it will be called "Pneumatics." The relations between heat and mechanical energy form a distinct science called "Thermodynamics," the principles of which will only be referred to when absolutely necessary.

NOTE.—On the value of C in the formula on p. 462 for the discharge of a pipe the reader is referred to the Appendix.