A TEXT-BOOK ON HYDRAULICS: INCLUDING AN OUTLINE OF THE THEORY OF TURBINES

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ON

HYDRAULICS

INCLUDING AN OUTLINE OF THE

THEORY OF TURBINES

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HYDRAULICS

CHAPTER I.

PRELIMINARY DEFINITIONS AND PRINCIPLES.

1. Definition of Subject.—The mechanics of fluid bodies is called *Hydromechanics*. It embraces *Hydrostatics*, dealing with the principles of fluid equilibrium, and *Hydrokinetics*, dealing with the laws of fluid motion.

Hydraulics, the subject of this book, may be defined briefly as practical Hydromechanics. It deals especially with the flow of water in streams of various kinds, but may be taken to include all the principles and applications of Hydromechanics that bear directly upon problems of practical utility. Many of the laws of Hydraulics are largely empirical, but certain fundamental dynamical principles, especially the law of energy, serve to unify the subject and to put it upon a scientific basis.

The bodies dealt with in Hydromechanics may be either liquids or gases. Hydraulics deals mainly, but not exclusively, with liquids, and especially with water.

2. Distinction between Solid and Fluid Bodies.—A solid body can permanently resist change of shape; a fluid body cannot.

A fluid is either liquid or gaseous. A gas tends to expand indefinitely, so as to fill any continuous closed volume in any portion of which it may be placed. A liquid changes its volume only slightly under changes of pressure; a given portion may be wholly freed from external pressure without expanding beyond a certain volume.

The distinction between solids and fluids may be made more definite by a consideration of internal stresses.

3. Internal Stresses in a Body.—The two equal and opposite forces exerted by two portions of matter upon each other constitute a stress. The forces making up a stress are thus the "action and reaction" of Newton's third law of motion.

If the two portions of matter are parts of the same body, the stress is *internal* with reference to that body. Internal stresses, acting between adjacent portions of a body, are called into action whenever external forces tend to change the shape or size of the body.

If a plane surface be conceived to divide a body into two contiguous parts, the forces which these parts exert upon each other will for convenience be regarded as resolved into components normal and tangential to the plane. The stress composed of these forces is thus resolved into

(*a*) A normal stress, which resists whatever tendency there may be for the two parts of the body to approach or recede from each other in the direction of the normal to the plane of separation, and

(*b*) A tangential stress, which resists any tendency to sliding, or relative motion parallel to the plane.

4. Mathematical Definitions of Solid and Fluid.—A fluid body is one in which tangential stress cannot act, except while the shape of the body is changing.

If, by reason of external forces, any two adjacent portions of a fluid tend to slide over each other, tangential stresses come into action to resist such sliding. The sliding is not prevented, however, but continues until a condition of equilibrium is attained; in this condition the tangential stress on every plane vanishes.

A solid body is one in which tangential stresses can act permanently to resist change of shape.

A "perfect" fluid may be defined as one which offers no resistance to change of shape. In other words, no tangential stress acts in a perfect fluid even while the particles are sliding over one another. No known fluid is perfect in this sense.

The laws of equilibrium are the same for an actual fluid as for a perfect fluid, since it is only when the parts of a body of fluid move relatively to one another that tangential stresses act. In other words, the statics of actual fluids is the same as the statics of perfect fluids.

5. Pressure; Intensity of Pressure.—The normal stress between two adjacent parts of a body may be either tensile or compressive.

Tensile stress (or tension) resists a tendency of the two portions of the body to separate.

Compressive stress (or pressure) resists a tendency of the two portions of the body to approach each other.

In Hydromechanics we are concerned mainly with pressure, since a fluid body can sustain only a slight tensile stress. We shall have to consider not only *internal* pressure, but also pressure acting between a body of water and other bodies in contact with it.

Intensity of pressure means pressure per unit area. If, on any surface subject to pressure, the pressures upon any two elementary areas, however small, are proportional to the areas, the intensity of pressure is uniform over the surface. In this case its value is at every point equal to the total pressure divided by the total area. Algebraically, let

P = total pressure on area F;

p = intensity of pressure at any point of the area;

then
$$p=\frac{P}{F}.$$

If the intensity of pressure has not the same value at all points of the area, we may regard P/F as its average value for the area F. The true value of p at any given point may be expressed approximately as its average value over a small area containing the point. If ΔF is the area of this element