STRENGTH OF MATERIALS

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FOR THE USE OF STUDENTS

WITH MANY DIAGRAMS AND ILLUSTRATIONS

THE BENNETT COLLEGE
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SHEFFIELD

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Chapter I

STRESSES AND STRAINS

1.—WHENEVER a force or a number of forces act on a rigid body the general effect is to put the body in what is called a *state of stress*. By this is meant that there is a tendency for one part of the body to move relatively to another as a result of the force or forces acting on the body. For example, a colliery winding rope is said to be in a state of stress because the force acting along the rope, due to the weight of the cage, tends to separate the lower portion of the rope from the upper.

As another example we may take the case of an engine crank shaft. Here again, the shaft is in a state of stress because the thrust along the connecting rod, acting at the crank pin, turns the shaft and tends to separate one section of the shaft from another by twisting the one relatively to the other.

Stresses are of different kinds. When the forces act in one straight line in opposite directions, away from each other, as represented by Fig. 1, the stress is known as a *tensile stress*. Thus the colliery winding rope above referred to is subjected to a tensile stress due to the forces acting on it, viz. the weight of the cage and the force or reaction resisting this weight; these forces act in the same straight line but in opposite directions, away from each other. The student is of course aware that wherever there is an action there is an equal and opposite reaction. This is Newton's Third Law of Motion.

Fig. 1

Fig. 2

If the forces act in one straight line but in opposite directions, towards each other, as represented by Fig. 2, the stress produced is known as a *compressive stress*.

A vertical column supporting a roof, for example, is subjected to a stress of this nature, the load resting on the column acting downwards, and the reaction due to the load acting in the same straight line but in the opposite direction, i.e. upwards.

The piston rod of a steam engine is in tension one stroke and in compression the other.

Another kind of stress is that known as *shear stress*. This kind of stress is produced when the forces applied act parallel to each other in opposite directions, as indicated in Fig. 3. The general effect of forces acting on a body in this manner is to cause one portion of the body to slide relatively to another. Metal plates cut in a shearing machine are exposed to shear stress, one portion of plate being separated from another in consequence of two forces acting in opposite directions parallel to each other, one on each blade of the machine.

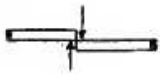

Fig. 3

An ordinary line shaft on which are secured driving pulleys is exposed to shear stress, but as the force applied tends to twist the shaft, the stress is more often spoken of as a twisting or *torsional* stress.

One other kind of stress sometimes referred to is that termed a *bending* stress. Thus a beam supporting a load in the manner indicated by Fig. 4 is subjected to bending. As a matter of fact, however, although the beam is subjected to bending, the resulting stresses resolve themselves into tensile, compressive, and shear stresses, all three actually existing, as will be shown later, in the beam.

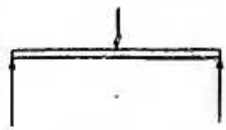

Fig. 4

It must be understood that the stresses we shall be called upon to consider are the result of forces acting external to the body; such stresses are usually known as *external stresses*. It sometimes happens that stresses exist in a body although the body is not exposed to any external forces. Such stresses are termed *initial* or *internal* stresses, and are usually the result of defects in manufacture, such as uneven cooling of metal castings. These initial stresses cannot as a rule be estimated.

2.—Whenever a body is put in a state of stress it undergoes a change of form or shape. This change of form is termed *strain*. A body which was absolutely rigid would of course remain unstrained, no matter how intense was the stress, but no such bodies actually exist. If a body be of a soft and yielding nature, such as indiarubber, the amount of strain for a given stress may be considerable, but if the body be very hard, such as tool steel, it will be strained very little even when exposed to great stress.