Previous to 1896 Johnson's figures for the strength of timber were based upon the assumption that it contained 15% moisture, but since then they are given for wood containing 12% moisture; as representing the condition of well-seasoned wood. In a dry-heated building the moisture content often falls as low as 8% or 10%.

Testing Laboratories.—In Europe many tests have been made by Bauschinger, Laslett, Tetmayer, Julius, Barlow, Tredgold, Warren, H. D. Smith and C. Graham Smith; whilst in the United States of North America the strength of several commercial species has been investigated by Johnson, Sharpels, Lanza, Tiemann, Thurston, Trautwine, Unwin and others. Unfortunately, however, the methods of testing and the varying percentages of moisture present in the specimens used have varied so much that it is impossible to reduce the results obtained by a number of these investigators to a satisfactory basis for comparison.

This whole subject of the strength of wood is of such importance to engineers and builders that in recent years the United States Forest Service has established wood-testing laboratories at Washington, D.C.; New Haven, Conn.; Madison, Wis.; Seattle, Wash., and a number of other places where the leading commercial species of the region are being investigated according to a uniform plan. From time to time, the results obtained are published in bulletins and circulars which may be obtained from the Superintendent of Documents, Washington, D.C., for a merely nominal charge.

Elasticity.—Elasticity refers to the ability of a horizontal beam of given dimensions to recover from a given amount of deflection, or "sag," when the force which has produced the deflection is removed, and is therefore closely related to stiffness. Obviously, pressure applied transversely to a beam of wood has a tendency to break the fibres across, and in modern testing machines is applied gradually to a system of levers by means of small weights or hydraulic pressure, and the force exerted upon the specimen is indicated by a delicately adjusted steel-yard. To avoid shearing along the grain the length of the beam should be ten to twenty times its depth, and to minimize the amount of crushing across the grain-bearing plates of the same width as the beam are used. The distance to which the middle point of the beam is forced down is termed its "deflection," and may be indicated by means of the letter d; the readings being taken to hundredths of an inch for large beams and to thousandths of an inch for smaller ones. For solid rectangular beams repeated tests have shown that the "modulus" or measure of elasticity varies directly as the pressure applied at their centre and the cube of the distance between the points of support, and inversely as their breadth and the cube of their depth. This explains the common practice of setting flooring joists on edge, which enormously stiffens the whole structure. For example, if the joists consist of 2 x 10-inch material, then setting them on edge and placing diagonal braces between them to keep them in position gives a floor $\frac{2}{10}$ of $\left(\frac{10}{2}\right)^3 = 25$ times as stiff as if they were laid flatwise. In practical engineering the load acts continuously and it has been found that the deflection for wooden beams should not exceed $\frac{1}{480}$ of their length; which would amount to only half an inch for a 20-foot beam.

Stress Diagrams.—When the deflections, in inches, are plotted on the horizontal axis of a sheet of cross-section paper and the number of pounds pressure required to produce these deflections are plotted on the vertical axis, it is found that the series of points obtained gives us a curve which is practically a straight line up to a point known as the "elastic limit"; beyond which it still continues to rise but soon curves away from the straight line to another point known as the "maximum load." After this it descends gradually because of the failure of the piece being tested, as is well shown in the accompanying diagram (Fig. 1) for a piece of fairly straight-grained red spruce having a span of 14 feet between the roller bearings and measuring 6 inches in width and 8 inches in height. From the diagram it will be noticed that the

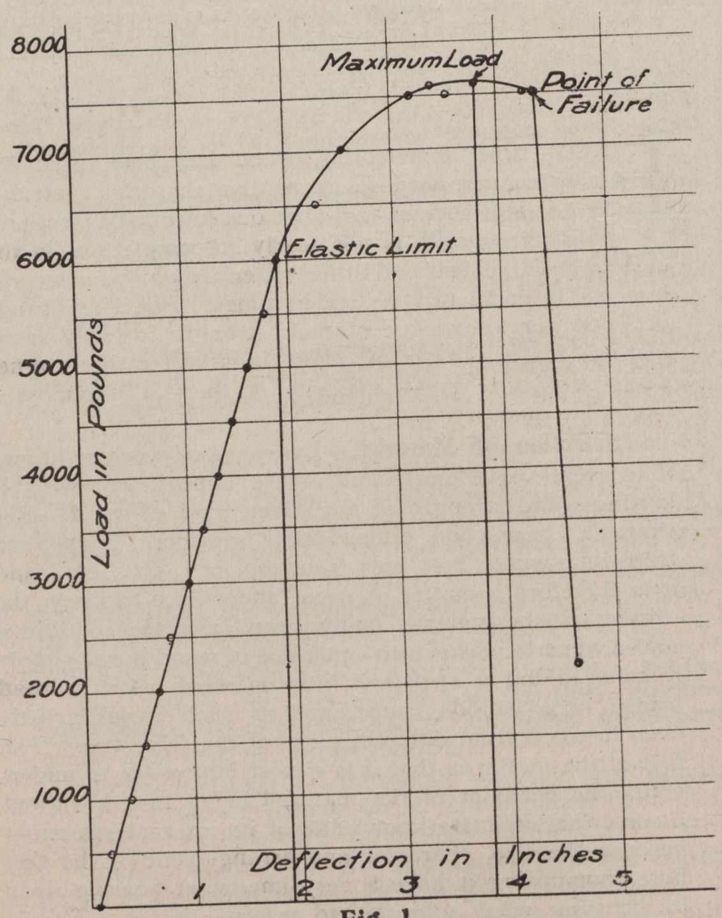

Fig. 1.

elastic limit was reached under a strain of 6,000 pounds and the maximum load at 7,580 pounds. Disks cut from the beam near the point of failure and dried in a steam-heated copper kiln showed moisture content of 25%, 33% and 42; according to the distance they were taken from the surface.

Modulus of Elasticity.—From the reading obtained at the elastic limit, the deflection observed at that pressure and the dimensions of the piece tested we may calculate what is known as the "modulus of elasticity" by means of the formula

$$E = \frac{w\,l^3}{4\,d\,b\,h^3}$$

where w represents the pressure in pounds midway between supports, d the deflection or "sag" in inches, l the number of inches between the horizontal supports, and b and h the breadth and height of the beam, in inches. Any