NOTES ON MACHINE DESIGN

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BY

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Contents.

Preface to Second Edition.

In presenting this book no claim is made of originality of subject matter, as nearly every thing in it can be found elsewhere. The object in preparing the book was to gather together in small compass the more simple formulas for the strength and stiffness of machine parts, with an explanation of the principles involved, and with such tables and general information as the designer of machinery might find useful.

The book pre-supposes an acquaintance with mathematics and the laws of the strength of materials.

In short, the aim has been to put the mathematical principles of machine design in a compact form at a moderate price for the use of the student and the young engineer.

In revising the text for a second edition some additions have been made to the physical constants in tables I and II as the result of recent experiments. Experimental data obtained by the author in the laboratories of the school have also been added, notably those in regard to iron and steel pulleys, belts, fly wheels, gear teeth, ball bearings, and the friction of steam packings.

The author wishes to acknowledge the great assistance given him by Mr. J. Verne Stanford in the preparation of drawings for the cuts in this edition.

Chapter 1.

UNITS AND TABLES.

1. Units. In this book the following units will be used unless otherwise stated.

Dimensions in inches.
Forces in pounds.
Stresses in pounds per square inch.
Velocities in feet per second.
Work and energy in foot pounds.
Moments in pounds inches.
Speeds of rotation in revolutions per minute.

The word *stress* will be used to denote the resistance of material to distortion per unit of sectional area. The word *strain* will be used to denote the distortion of a piece per unit of length. The word *set* will be used to denote total permament distortion of a piece.

In making calculations the use of the slide-rule and of four-place logarithms is recommended; accuracy is expected only to three significant figures.

2. Materials. The principal materials used in machine construction are given in the following tables with the physical characteristics of each.

By *wrought iron* is meant commercially pure iron which has been made from molten pig-iron by the puddling process and then squeezed and rolled, thus developing the fiber. This iron has been largely supplanted by soft steel.

In making *steel*, on the other hand, the molten iron has had the silicon and carbon removed by a hot blast, either passing through the liquid as in the Bessemer converter, or over its surface as in the open-hearth furnace. A suitable quantity of carbon and manganese has then been added and the metal poured into ingot molds. If the steel is then reheated and passed through

a series of rolls, structural steel and rods or rails result.

Steel castings are poured directly from the open hearth furnace and allowed to cool without any drawing or rolling. They are coarser and more crystalline than the rolled steel.

Open hearth steel is generally used for boiler plates and of these, two grades are commonly known as marine steel and flange steel.

Bessemer steel is largely used in the manufacture of rails for steam and electric roads.

Crucible steel usually contains from one to one and a half per cent of carbon, is relatively high priced and only used for cutting tools. It is made by melting steel in an air tight crucible with the proper additions of carbon and manganese.

Cast iron is made directly from the pig by remelting and casting, is granular in texture and contains from two to five per cent. of carbon. A portion of the carbon is chemically combined with the iron while the remainder exists in the form of graphite. The harder and whiter the iron the more carbon is found chemically combined. Silicon is an important element in cast iron and influences the rate of cooling. The more slowly iron cools after melting the more graphite forms and the softer the iron.

Malleable iron is cast iron annealed and partially decarbonized by being heated in an annealing oven in contact with some oxidising material such as hæmatite ore. This process makes the iron tougher and less brittle

All castings including those made from alloys are somewhat unreliable on account of hidden flaws and of the strains developed by shrinkage while cooling.

The constants for strength and elasticity are only fair average values, and should be determined for any special material by direct experiment when it is practicable. Many of the constants are not given in the table on account of the lack of reliable data for their determination.