Harbord

THE METALLURGY OF STEEL

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VOLUME I.—METALLURGY.

BY

F. W. HARBORD.

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Fifth Edition, Enlarged and Revised.

With 54 Folding Plates, comprising 115 Figures, over 500 Illustrations in the Text, and nearly 80 Photo-micrographs of Steel Sections.

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PREFACE TO FIFTH EDITION.

SINCE the last edition appeared there has been no special development in the Manufacture of Iron and Steel which has had far reaching results on the industry, but there has been steady progress in details of practice. As far as possible these advances have been dealt with, and amongst them may be mentioned the Production of what is a very near approach to Chemically Pure Iron in the Basic Open-Hearth Furnace from Phosphoric Pig-Iron, and several methods for producing Sound Ingots and for decreasing Segregation.

The Chapter on Armour Plate Manufacture has been largely rewritten, and also the Chapter on the Theory of Hardening of Steel. In this last chapter Professor Carpenter has very kindly contributed a short summary of the various Stress Theories which have been advanced, with his own views on this subject. Constitutional Diagrams have been added for Special Steels.

In the second volume on the Mechanical Treatment of Steel, by Mr. J. W. Hall, little alteration has been necessary, as in the last edition a great deal was rewritten, and new chapters added dealing with all the more recent developments.

We have to thank Mr. C. O. Bannister, A.R.S.M., for reading the proofs of the first volume, for preparing the Index, and for seeing it to press.

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THE METALLURGY OF STEEL.

SECTION I.

INTRODUCTION.

DURING the last sixty years the introduction of the Bessemer and Open Hearth processes have not only revolutionised the steel manufacture of the world, but have compelled us to revise our definition of steel. Before 1856, the year in which Bessemer first published the particulars of his great discovery, there were practically only two varieties of steel in the market—viz., crucible or cast steel, and shear steel—although small quantities of puddled steel and steel made direct from the ore were produced.

Crucible or cast steel was made by melting blister steel bars containing different percentages of Carbon, according to the grade required, with small percentages of steel scrap in crucibles, and casting the fluid metal into small iron moulds, the ingots thus obtained being afterwards forged down to the required size and shape. The percentage of Carbon in such steels usually varied from ·25 to 1·75, although sometimes it was higher. Shear steel was made by piling and welding together plated, cemented, or blister bars into what was known as a "faggot," and afterwards forging and rolling this faggot down into thin strips, suitable for the manufacture of cutlery.

The distinguishing features of these classes of steels were, that by rapid cooling from a red heat by quenching in water, they became extremely hard and more or less brittle, and that by re-heating to different temperatures, or "tempering," this hardness could be modified, the brittleness removed, and great elasticity, combined with varying degrees of hardness conferred upon the steel. The maximum degree of hardness which each steel was capable of taking depended upon the Carbon content, the higher the percentage of Carbon, the greater the hardening power of the steel; and the use of crucible and shear steel was practically confined to the manufacture of cutlery, tools, etc., and some special parts of machines which required a material which could be hardened after it had been forged or machined into shape. For structural purposes wrought iron and cast iron were the materials almost, if not quite, exclusively employed, the former possessing properties which enabled it to be wrought or forged into any required shape, and the latter being moulded into different forms by pouring it, while in a molten condition, into moulds of the required shape. The chief distinction between wrought iron and steel was that the former was not hardened by rapid cooling in water from a red heat, and contained always less than 0·20 per cent. of Carbon, and generally less than 0·10. Cast iron, on the other hand, contained from 2·5 to 4·0 per cent. of Carbon, and was distinguished from both steel and wrought iron by being brittle at a red heat, and incapable of being wrought or forged, and by having a comparatively low melting point of from 1,075° to 1,276° C., against 1,500° C., or higher, for wrought