

specified rules, to rectify it if needful, and to take the responsibility in case of rejection. Professor Sauveur, when engineer to the Illinois Steel Company, devised a regular system of micrographic analysis.<sup>1</sup>

For industrial applications the complete method which has been described in this paper will not, as a rule, be necessary. Like the general rules of chemical analysis, this method allows, according to circumstances, simplifications suggested by experience. It is a method of investigation which may be laborious in the case of original research, but which will, eventually, be much simplified.

<sup>1</sup> *Trans. Amer. Soc. of Min. Eng.*, t. xxii, p. 546.

## APPENDIX I.

## PURE ELECTRO-DEPOSITED FERRITE.

IN a recent research by Stead on Pure Electro-Deposited Iron manufactured by the Langbein-Pfannhauser - Werke, Leipzig - Sellaerhausen, some remarkable observations were made.

The analyses according to "Röhl" and "Pattinson & Stead" were as follows:—

	Röhl.	Pattinson & Stead.
	Per cent.	Per cent.
Iron by difference . . . .	99·991	99·967
Carbon . . . . .	Nil	0·008
Manganese . . . . .	Nil	0·009
Silicon . . . . .	0·003	0·014
Sulphur . . . . .	0·006	Trace
Phosphorus . . . . .	Trace	0·002
	100·000	100·000

The strips of iron when received were exceedingly ductile, and could be cold rolled to eight times their length without breaking up. The iron had evidently been annealed after it had left the electrolytic tank. The crystalline structure was identical with that of the purest commercial ferrite, but the size of the



crystals varied in different strips. Heating the fine-grained material to between  $700^{\circ}$  and  $800^{\circ}$  C. in an annealing box for forty-eight hours did not cause any development in the size of the crystals.

Heating for varying periods of time in hydrogen at temperatures varying between  $600^{\circ}$  and  $910^{\circ}$  did not affect the crystalline structure. Heating to  $920^{\circ}$  and above that temperature, and withdrawing from the muffle, developed enormous crystals.

On cooling the strips in such a way as to cause the heat to pass from the centre towards the edges, crystalline development followed the cooling, and long columnar crystals were obtained starting from the centre and terminating near the edges.

On reheating the pieces with the long columnar crystals to above  $920^{\circ}$ , the columnar structure disappeared and was replaced by large crystals of an entirely different order, which were on the average equiaxed.

Dr Carpenter, whose attention was drawn to this extraordinary behaviour of electrolytic iron, and to whom specimens were sent, made the interesting discovery — afterwards confirmed by Stead — that the rapid growth of the crystals occurred in cooling through the critical point  $Ar_3$ .

Cold rolling the coarsely crystalline iron shattered the crystals, and when the cold worked material was annealed at between  $700^{\circ}$  C. and  $800^{\circ}$  C. a fine crystalline structure was obtained.

The iron after heating to  $950^{\circ}$  in air was invariably enveloped with an exceedingly thin coating of iron of very fine structure, and in order to ascertain the nature of the metal below, it was necessary either to grind the coating away or to dissolve it in acid. On

reheating to  $920^{\circ}$  C. and above the coarse structural material, denuded of its fine-grained envelopes, the envelopes of fine-grained material again invariably appeared.

According to careful determination by Dr Carpenter of the University of Manchester, the critical arrest

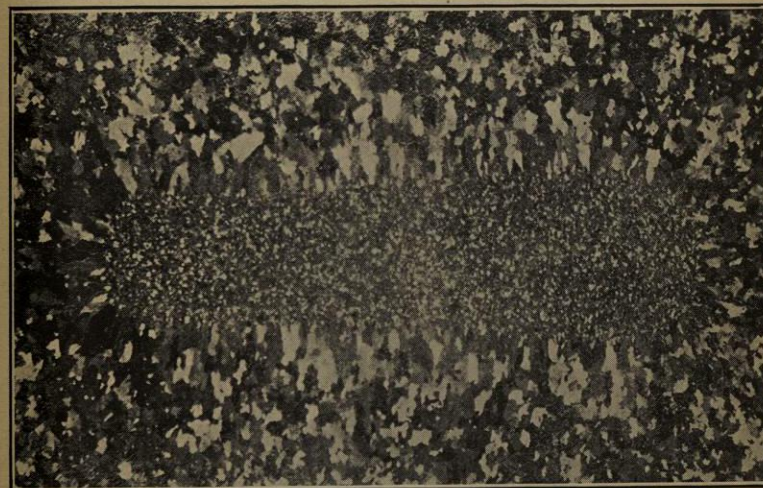


Fig. 191.—Pure iron cooled through the critical point  $Ar_3$  and etched.

point  $Ar_3$  occurred at about  $900^{\circ}$  C., while the crystallising point was at  $915^{\circ}$ , a result closely confirming that of Stead.

The photographic reproduction, fig. 191, magnified two diameters, represents an etched strip of iron which had been heated on the bottom of a muffle furnace at a temperature of about  $950^{\circ}$  for one minute. On the centre of the strip a piece of steel was placed so as to prevent the iron immediately beneath it reaching the critical point during the



period of heating. The strip was then removed and cooled in air. The cooling through the critical point  $Ar_3$  took a radial direction from the central position to the outside, and columnar crystals resulted. The centre part is fine-grained, because the temperature had not reached the crystallising point. These results are apparently quite contrary to those obtained on heating practically pure iron produced by fusion methods.<sup>1</sup>

<sup>1</sup> Since writing the above, a joint paper by one of the authors and Dr H. C. H. Carpenter on "The Crystallisation of Pure Iron" has been presented to the Iron and Steel Institute, Sept. 1913, to which the reader is referred.

## APPENDIX II.

THE NOMENCLATURE OF THE MICROSCOPIC SUBSTANCES AND STRUCTURES OF STEEL AND CAST-IRON.

At the Sixth Congress of the International Testing Association, held during the first week of September 1912, the following report on the Nomenclature of the Microscopic Substances and Structures of Steel and Cast-iron was presented, and formally adopted by the Association. The committee originally appointed to deal with the subject was as follows:—

Professor H. M. Howe, New York, *Chairman*.

Professor Albert Sauveur, Boston, *Secretary*.

Members: F. Osmond, Paris; Dr H. C. H. Carpenter, Manchester; Professor W. Campbell, New York; Professor C. Benedicks, Stockholm; Professor F. Wüst, Aachen; Professor A. Stansfield, Montreal; Dr J. E. Stead, Middlesbrough; Professor L. Guillet, Paris; Professor E. Heyn, Berlin; and Dr W. Rosenhain, Teddington.

The complete text of the report, omitting the introduction, is given below:—

At the end of the several descriptions the reader is referred officially to the illustrations in Osmond and Stead's "Microscopic Analysis of Metals." The references were to the 1904 edition, but have here been