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METALLURGICAL EXAMINATION OF MALLEABLE IRON SAMPLES WHICH RESPONDED POORLY TO ANNEALING

by

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SUMMARY OF RESULTS

The poor annealability of the samples examined has been attributed to the presence of 0.09% antimony in the metal. A pearlite rim was also present but is thought to be secondary in importance to the antimony. Annealing trials showed that extremely slow cooling rates would be necessitated in order to correctly anneal castings made from this metal.

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(1 table, 6 illus.)

INTRODUCTION

Several malleable iron test bar samples were received on February 25, 1958, from the International Harvester Company of Canada Ltd., Hamilton, Ontario, with a request that an examination be carried out to determine the reason for the poor response to annealing that was encountered in the particular heat in question. The covering letter, dated February 20, 1958, from Mr. J.F. Morris, Works Metallurgist, stated that the mechanical properties of the test bars, after going through the normal annealing cycle, were 63,000 psi ultimate tensile strength and 4% elongation.

CHEMICAL AND SPECTROGRAPHIC ANALYSES

The analysis of one of the test bars was obtained, using both chemical and spectrographic techniques. The results are listed below:

Element	-	Percent
Carbon	-	2.34 (C)
Manganese	-	0.30 (C)
Silicon	-	1.06 (C)
Sulphur	-	0.056 (C)
Phosphorus	-	0.14 (C)
Chromium	-	0.05 (S)
Vanadium	-	0.01 (S)
Tin	-	0.01 (S)
Copper	-	0.10 (S)
Nickel	-	0.10 (S)
Magnesium	-	0.008 (S)
Aluminum	-	0.01 (S)
Titanium	-	0.03 (S)
Antimony	-	0.3 (S); 0.09 (C)
Lead	-	>0.01 (S); 0.008 (C)

(C) - chemical (S) - spectrographic

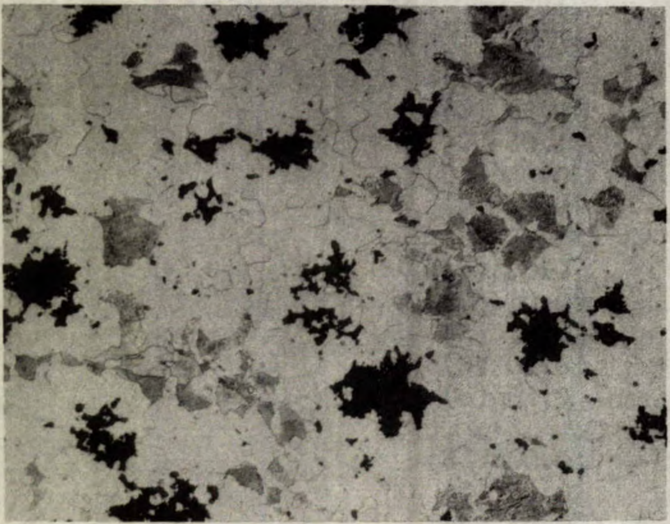
ANNEALING TRIALS

Preliminary microscopic examination showed that no primary carbides were present, indicating that the first stage annealing had been successful. Therefore, annealing trials were concentrated on second stage annealing only.

Samples were cooled at different rates, varying from 15°F per hour to 5°F per hour, from a temperature of 1400°F to 1275°F. Isothermal annealing at 1320°F was also carried out for as long as 89 hours. Longer soaking times or slower cooling rates were not employed as these would not be economical in commercial operation.

MICROSCOPIC EXAMINATION

Microscopic examination of the samples received did not reveal any primary carbides, but a considerable amount of pearlite was present. A pearlitic rim was also observed. Figures 1 and 2 verify these remarks.

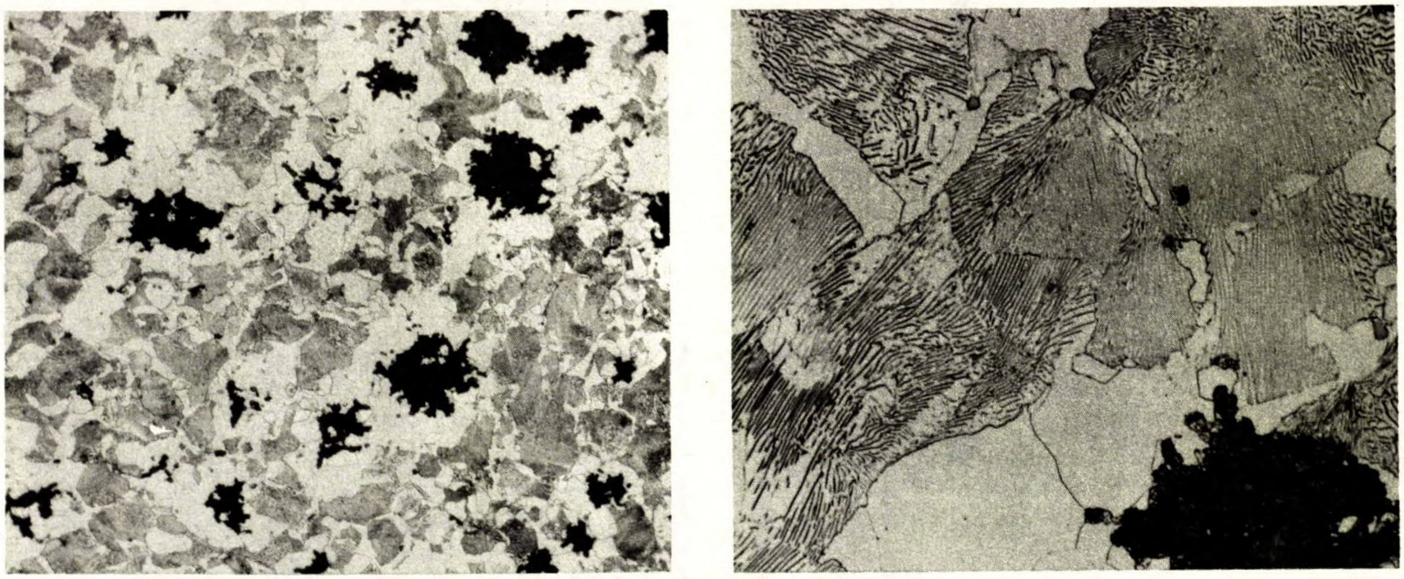


Mag. X100

Mag. X500

(Both etched in 2% nital)

Fig. 1. - Photomicrographs taken near the centre of the samples "as received", showing absence of primary carbides and the amount of pearlite still present after going through the normal annealing cycle.



Mag. X100 Mag. X500

(Both etched in 2% nital)

Fig. 2. - Photomicrographs taken from the same sample as Figure 1, but near the edge, showing the larger amount of pearlite present in this region.

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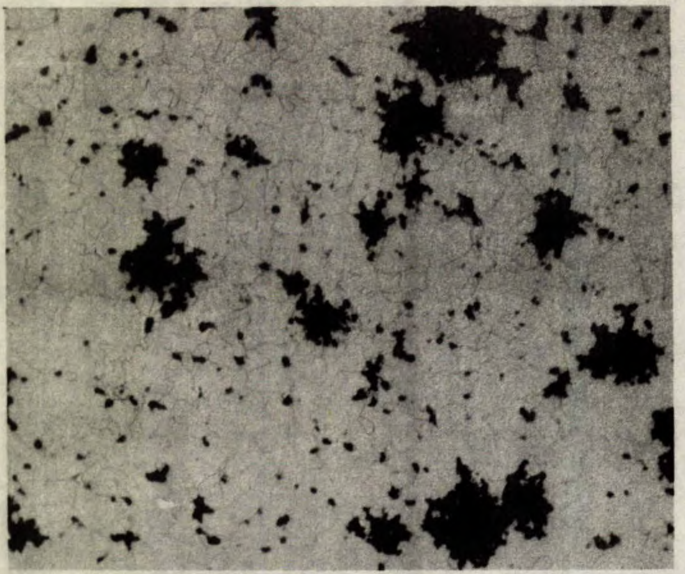
The photomicrographs shown in Figures 3 and 4 illustrate the effectiveness of isothermally annealing the sample for 89 hours at 1320°F, while Figures 5 and 6 show the results of cooling the sample from 1400°F to 1275°F at 5°F per hour (25 hour treatment).



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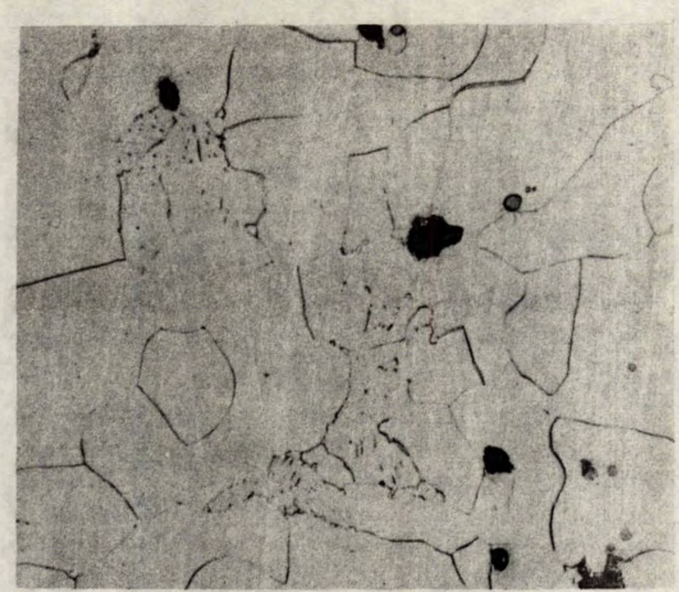
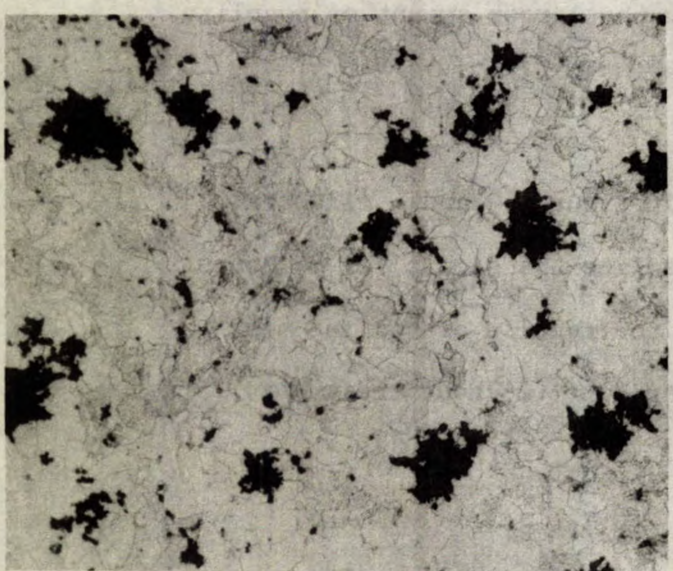


Mag. X500

(Both etched in 2% nital)

Fig. 3. - Centre of specimen isothermally annealed for 89 hr at 1320°F. Pearlite is almost completely decomposed.



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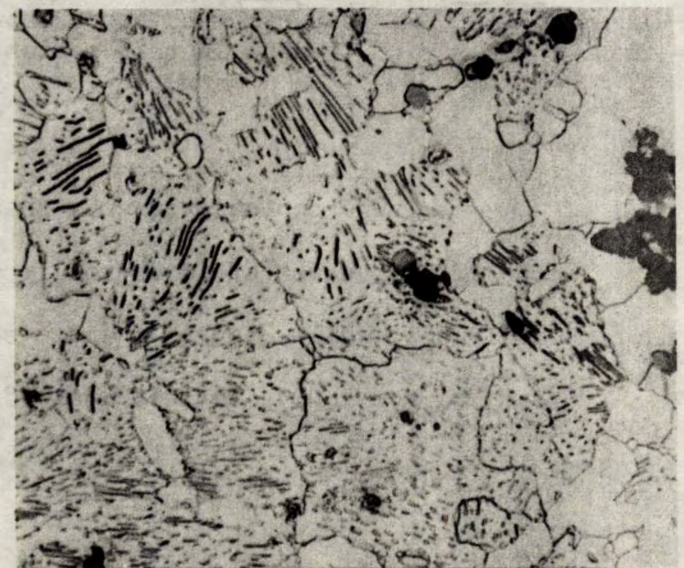
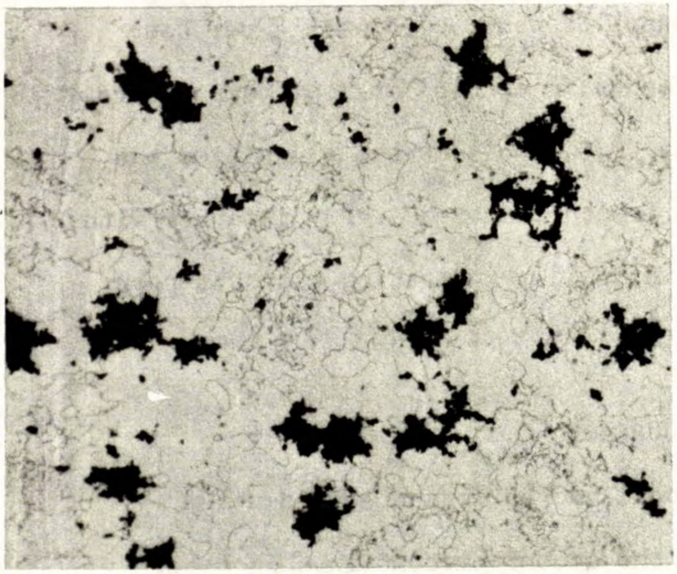
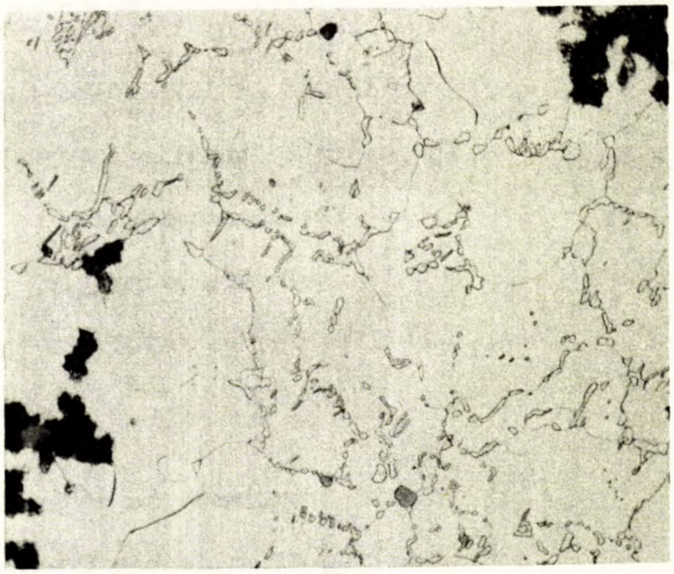


Mag. X500

(Both etched in 2% nital)

Fig. 4. - Edge of specimen isothermally annealed for 89 hr at 1320°F. The pearlite has only started to decompose in this region.

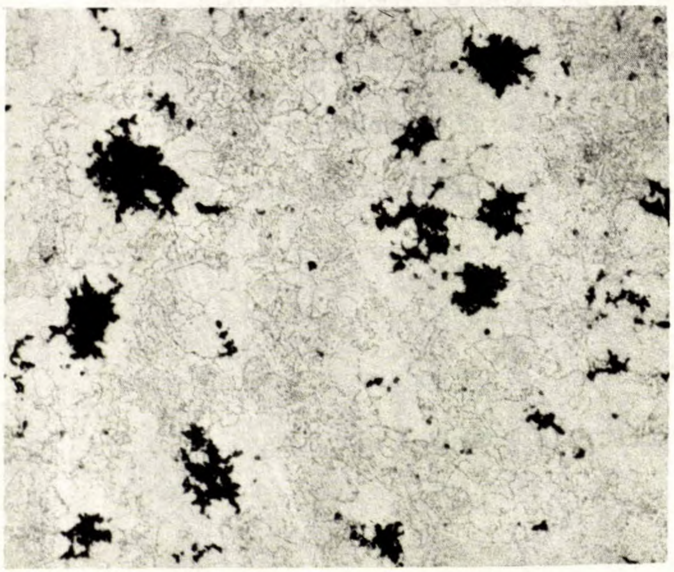


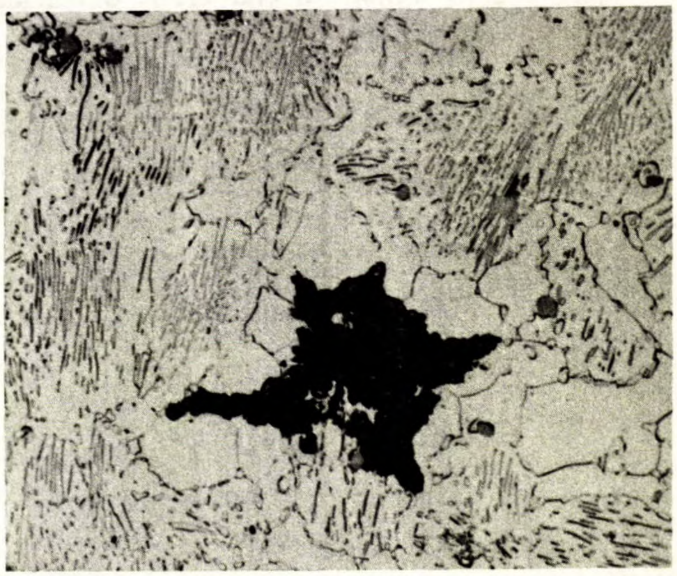


Mag. X100 Mag. X500

(Both etched in 2% nital)

Fig. 5. - Centre of sample cooled from 1400°F to 1275°F at 5°F per hour. Decomposition of the pearlite is nearing completion.





Mag. X100 Mag. X500

(Both etched in 2% nital)

Fig. 6. - Edge of sample cooled from 1400°F to 1275°F at 5°F per hour. Decomposition of the pearlite is just starting in this region.

MECHANICAL TESTS

One of the test bars supplied was cooled at 5°F per hour from 1400°F to 1275°F and then tested in tension at room temperature. The ultimate tensile strength was 59,500 psi and the elongation was 5.5%. Visual examination of the fracture showed a grey interior with a bright rim approximately 1/16 in. thick, indicating that the poor ductility is due mainly to the rim.

DISCUSSION

Antimony is generally believed to retard second stage annealing of malleable iron, and the amount present in this heat, 0.09%, is certainly much higher than is ordinarily found in malleable iron. The presence of this element is believed to be the primary cause of the poor annealability of the iron.

The presence of a pearlitic rim is sometimes attributed to hydrogen in the iron, often caused by burning too moist a coke. However, since no protective atmosphere was used in the annealing trials carried out at the Mines Branch, the resultant decarburization, and possibly desiliconization, would leave the pearlite near the surface more stable, thermally, than before. The importance of this pearlitic rim in the samples tested is thus exaggerated. The presence of the rim must be dealt with but is felt to be of secondary importance in the problem, and the poor annealability is attributed primarily to the presence of 0.09% antimony.

CONCLUSIONS

1. The poor annealability is thought to be caused mainly by the presence of 0.09% antimony.

2. A pearlitic rim was present in the sample, likely due

initially to the presence of hydrogen but probably exaggerated in the annealing trials because of surface oxidation.

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