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REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1986.

Growth of Cast Iron Exposed to High Temperatures.

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(Copy No. 6.)

Bureau of Mines
Division of Metallic
Minerals

Physical Metallurgy
Research Laboratories

CANADA

DEPARTMENT
OF
MINES AND RESOURCES

Mines and Geology Branch

OTTAWA January 8, 1946.

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Origin of Request and Purpose of Investigation:

In a letter dated December 11, 1945, from Mr. H. J. Smith, purchasing agent of the Renfrew Machinery Company Limited, Renfrew, Ontario, it was requested that three pieces of cast iron be examined.

The specimens were described as "three pieces which make up the back lining of the fire box next to the oven. These are Parts Nos. 862B, 863B, and 864B." Trouble had been encountered due to expansion when these parts were used in a stove.

Description of Specimens:

The stove parts submitted were approximately 6 in. by 7 in. and ½ in. thick. It was assumed that they were from the same heat of metal. Specimens and drillings were obtained for chemical analysis and microstructure examination. In addition, growth test specimens were prepared and ground to 2-inch length and ½-inch square section.

Chemical Analysis:

		Per Cent
Carbon	-	3.42
Manganese	-	0.61
Silicon	-	2.41
Sulphur	-	0.08
Phosphorus	-	0.55

Microstructure:

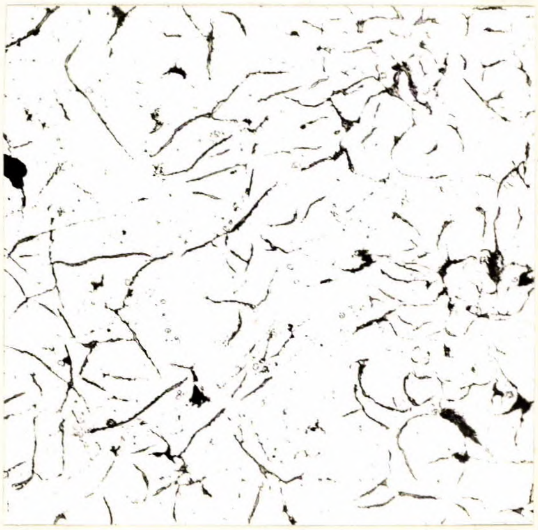
Figure 1.

X500, nital etch.

SHOWING STRUCTURE OF IRON AT CENTRE OF CASTING.

This is a completely pearlitic iron.

Figure 2.



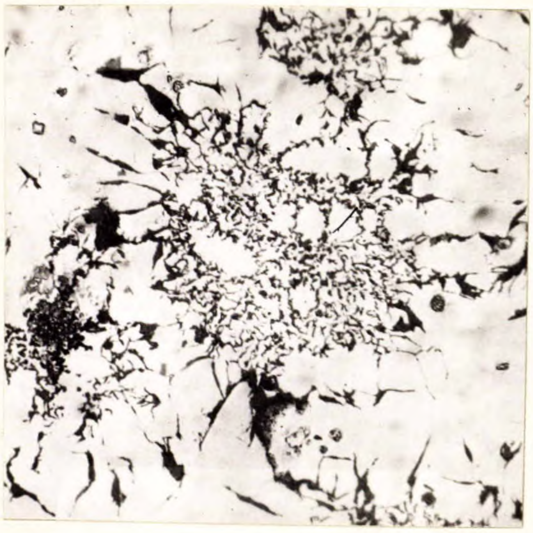
X100, unetched.

SHOWING GRAPHITE FLAKES AT CENTRE OF CASTING.

(Continued on next page)

(Microstructure, cont'd) -

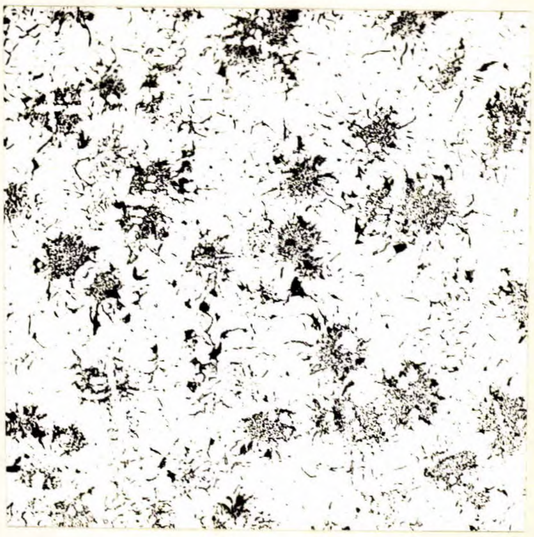
Figure 3.



X500, unetched.

SHOWING "EUTECTIC" GRAPHITE AT EDGE OF CASTING.

Figure 4.



X100, unetched.

SHOWING "EUTECTIC" GRAPHITE AT EDGE OF CASTING.

The graphite flake pattern varies with section size. Growth of iron at high temperatures is a result of two phenomena. First, all the carbon in the iron migrates to the graphite flakes. This causes an increase in length amounting to approximately 2 per cent. The remainder of the growth occurs due to the graphite burning out and iron oxide taking its place. Finally, the iron is full of oxide and is pushed apart, since the oxide occupies more space than the graphite did in the original structure. "Eutectic" graphite promotes more rapid growth than does "flake" graphite.

Prevention of growth is accomplished by chromium and other carbide-stabilizing alloys. Chromium prevents the migration of carbon to the graphite flake. It also makes the graphite flakes smaller. This is an advantage, as the smaller the graphite flake the harder it is for oxygen to penetrate through the structure of the metal. Of further importance is the ability of chromium to prevent or retard the formation of iron oxide.

Growth Tests:

Specimens were measured for length and heated for 100 hours in an oxidizing atmosphere. After they had cooled to room temperature they were measured again. The test results are recorded in Table I.

TABLE I. - 100-Hour Growth Test.

Temperature, °F.	Increase in length, per cent
800	0.0
1000	0.65
1200	0.80
1400	1.20
1600	7.05
1800	Specimen disintegrated.

The welding section of the Laboratories prepared some specimens coated with aluminium metal about 0.020 in. thick. The metal was applied with a Metco spray gun.

The plating section of the Laboratories prepared some nickel-plated specimens. (Nickel about 0.0060 in. thick).

Growth test results on these specially treated specimens are shown in Table II, in comparison with results on an untreated specimen.

TABLE II. - 100-Hour Growth Test.

Treatment	Temperature, °F.	Increase in length, per cent
Aluminium metal sprayed -	1600	2.5
Nickel-plated -	1600	5.4
Untreated -	1600	7.4

Discussion:

The properties of the iron examined show no appreciable deviations from normal quality grey iron as used

(Discussion, cont'd) -

in machinery or stoves.

Expansion of this iron when used in a stove is not due to any defect in the iron, but rather to the fact that it is heated to a temperature in excess of 800° Fahrenheit in service. Ordinary grey iron will "grow", or expand permanently, at temperatures exceeding 800° F.

If expansion of the stove parts is to be avoided, three courses of action are available;

1. Change design of stove.
2. Coat the castings with a heat-resistant surface.
3. Use a heat-resistant iron.

1. Expansion could be avoided by changing the design so that the parts that are now giving trouble, would not be heated above 800° F. This may not be practical, however.

2. Protective coatings, such as nickel plate and sprayed aluminium metal, are effective in preventing growth. Results on a trial set of treated specimens are shown in Table II. These indicate that aluminium metal spray treatment may be a commercial possibility.

3. A considerable number of heat-resistant irons have been developed. These irons owe their heat resistance to additions of nickel and chromium. It is possible that a small amount (1 per cent) of chromium would be sufficient to impart the necessary increase in heat resistance.

Recommendations:

1. By attaching a thermocouple to the casting when installed in a stove, some idea may be obtained of the temperature conditions in service. Corrective measures will depend upon the heat conditions encountered.

2. The addition of from 0.50 to 1.0 per cent

(Recommendations, cont'd) -

chromium to the ladle, in the form of foundry ferrochrome or of Chrome-X, is an immediate practical solution.

3. The Bureau of Mines is ready to give further assistance by making up special heats of grey iron and preparing special surface treatments in order to develop better heat-resisting metals.

4. It is suggested that a set of castings be submitted to these Laboratories for coating. Aluminium metal spray will be applied to the castings, and they will be returned for a practical test in a stove.

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