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O T T A W A October 30, 1945.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1953.

Metallurgical Examination of Enameled Cast Iron Stove Plate Containing Pinhole Defects.

(Copy No. 10.)

Bureau of Mines
Division of Metallic
Minerals

Physical Metallurgy
Research Laboratories

CANADA
DEPARTMENT
OF
MINES AND RESOURCES
Mines and Geology Branch

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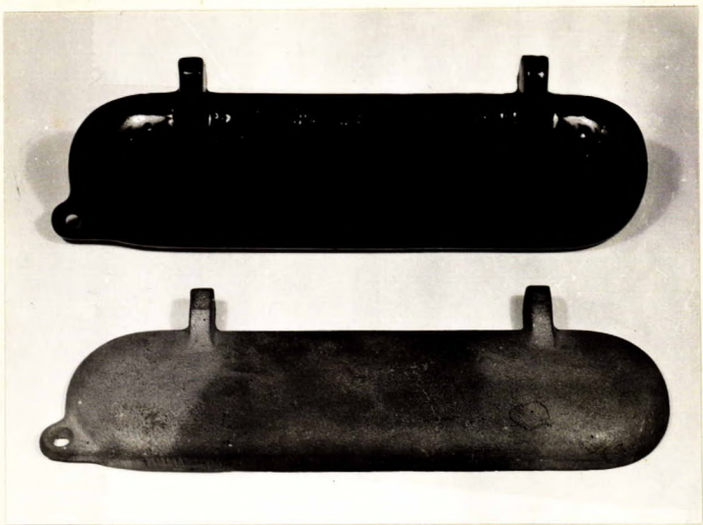
Origin of Material and Object of Investigation:

On September 11, 1945, two samples of cast iron stove plate (see Figure 1), one in the "as cast" condition and the other cast and enameled, both containing pinhole defects, were submitted by Mr. J. K. Hossack, of Ferro-Enamels (Canada) Limited, Ottawa, Ontario, for metallurgical examination. The castings were being made by Findlay's Limited, Carleton Place, Ontario.

In response to a request made by these Laboratories, a sample of the sand employed in the casting of these parts was also submitted.

(Origin of Material and Object of Investigation, cont'd) -

Figure 1.



CAST IRON STOVE PLATE CONTAINING
PINHOLE DEFECTS.

(Approximately 1/3 actual size).

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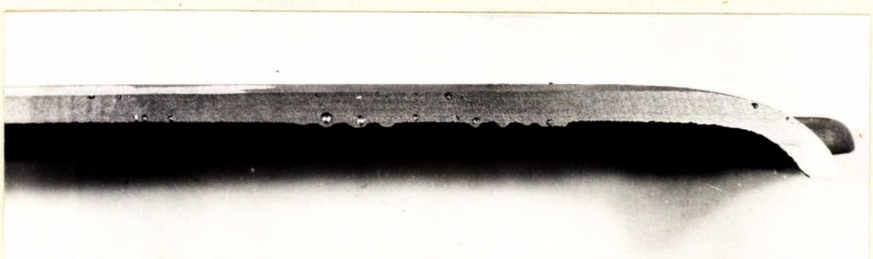
PROCEDURE:

1. Macroscopic Examination.

A section was cut longitudinally from the "as cast" sample (see Figure 2). Visual examination revealed that the holes were located at or near the surfaces of the casting.

Figure 2.



LONGITUDINAL SECTION OF "AS CAST" SAMPLE,
REVEALING LOCATION OF HOLES AT OR
NEAR SURFACE OF CASTING.

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(Procedure cont'd) -

2. Chemical Analysis:

The results of a chemical analysis made on a sample cut from one of the parts submitted is given in the following table:

TABLE I.

		Per Cent
Total carbon	-	3.26
Graphitic carbon	-	2.48
Combined carbon	-	0.78
Manganese	-	0.60
Silicon	-	2.54
Sulphur	-	0.062
Phosphorus	-	0.536
Nickel, Chromium, Molybdenum	-	Nil.

3. Properties of Moulding Sand.

Typical test values (see Figures 3, 4 and 5) obtained on the moulding sand submitted by Findlay's Limited were:

Moisture	- 7 per cent
Green bond	- 5.7 lb./sq.in.
Green deformation	- 0.009 inch
Permeability	- 10
Dry bond	- 50 lb./sq.in.
Flowability	- 75

Screen analysis shows 4 to 7 per cent on each of the screens from 70 mesh to 270 mesh. **There is too much fine silt in this sand. The removal of the excess fines from this sand is considered advisable.**

DISCUSSION:

1. Figure 2 shows that the metal bulges outward from the surface where blowholes occur. This would lead to the conclusion that gas was generated in the metal as it cooled. This gas caused holes in the casting and was the direct cause of the enameling defect.

2. Iron absorbs gas when hot and gives off gas when cooling. The source of the gas producing the blowholes

(Discussion, cont'd) -

observed in Figure 2 may be:

(a) Wet sand or green ladles generate steam which is broken up into hydrogen and oxygen. The hydrogen is absorbed by the hot metal. As the metal cools the gas is given off again.

(b) Excessively rusty material in the charge will cause hydrogen to be dissolved in the hot metal. As the metal cools, this hydrogen is liberated.

(c) Oxidizing conditions at the melting zone of the cupola will cause iron oxide in the metal. Iron oxide is reduced by carbon as follows:

$$4C + Fe_3O_4 \longrightarrow 3Fe + 4CO.$$

The CO (carbon monoxide) gas is liberated as the metal cools.

Recommendations:

If the defect observed in Figure 2 is to be prevented, precautions must be taken to avoid the three conditions mentioned above. Therefore, the following is recommended:

1. The pouring ladles should be thoroughly dried.
2. The moulding sand permeability should be increased and the moisture content watched carefully.
3. Excessively rusty scrap should be used only sparingly in the cupola charge. Thin rusty sheet metal is undesirable.
4. The cupola blast should be regulated so as to avoid extremely oxidizing conditions. The colour of the fumes from the cupola will indicate whether oxidizing conditions exist.

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AF:HHF:LB.

(Figures 3, 4 and 5, charts, follow, comprising Pages 5 to 7.)

Figure 3.

MOULDING SAND

FINDLAY'S LIMITED OCT. 11, 1945

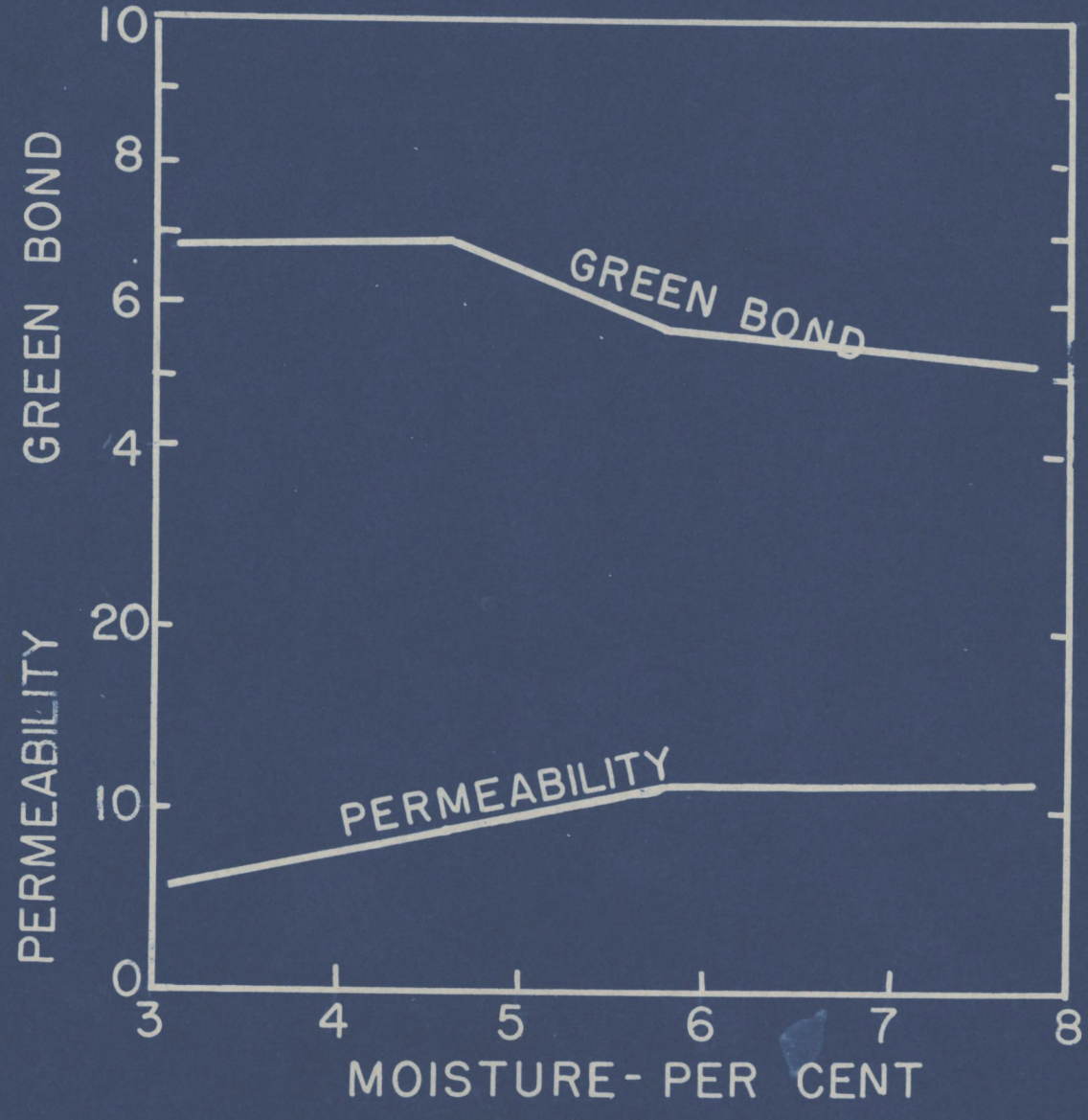


Figure 4.

MOULDING SAND
FINDLAY'S LTD

OCT. 11, 1945.

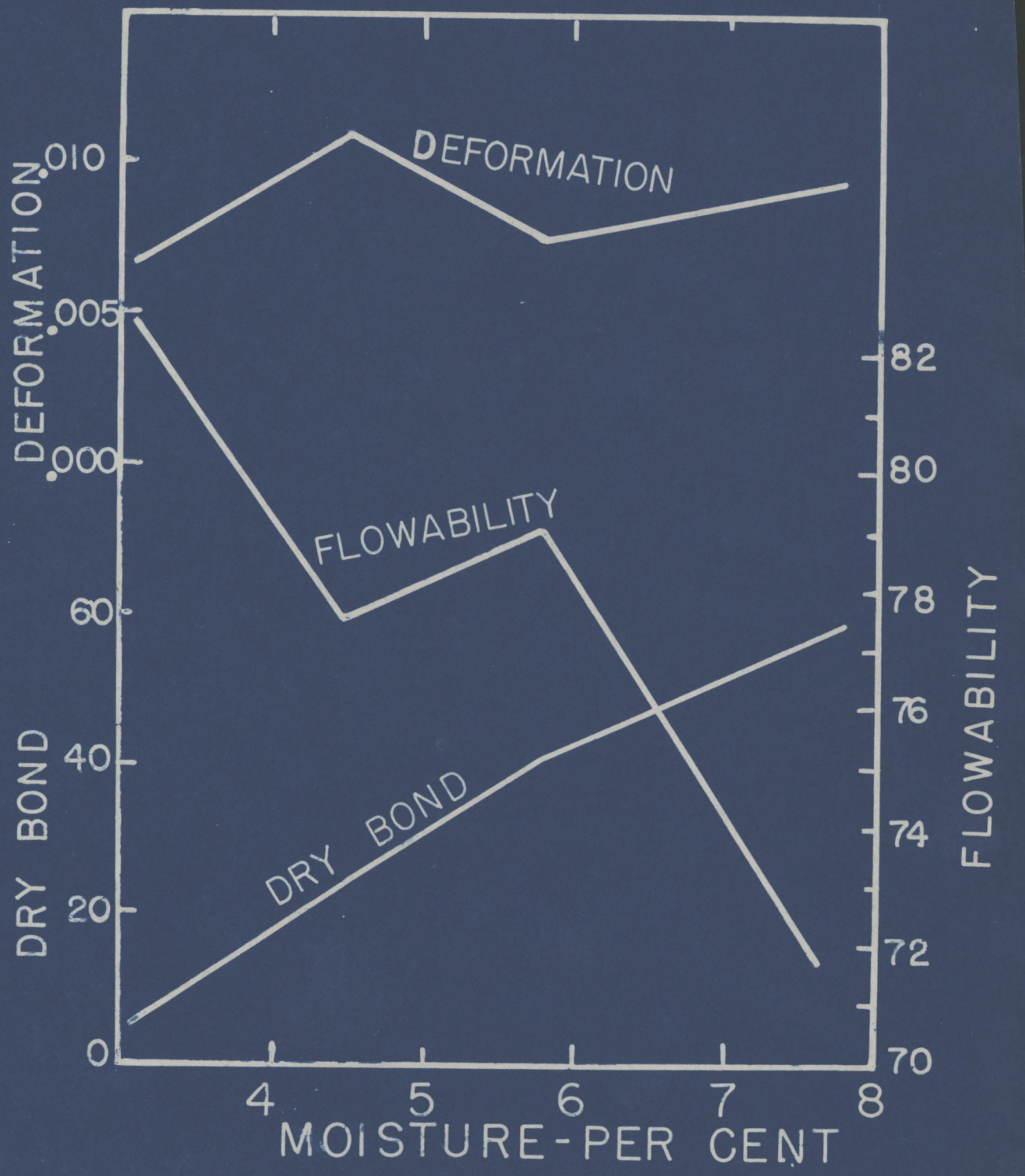


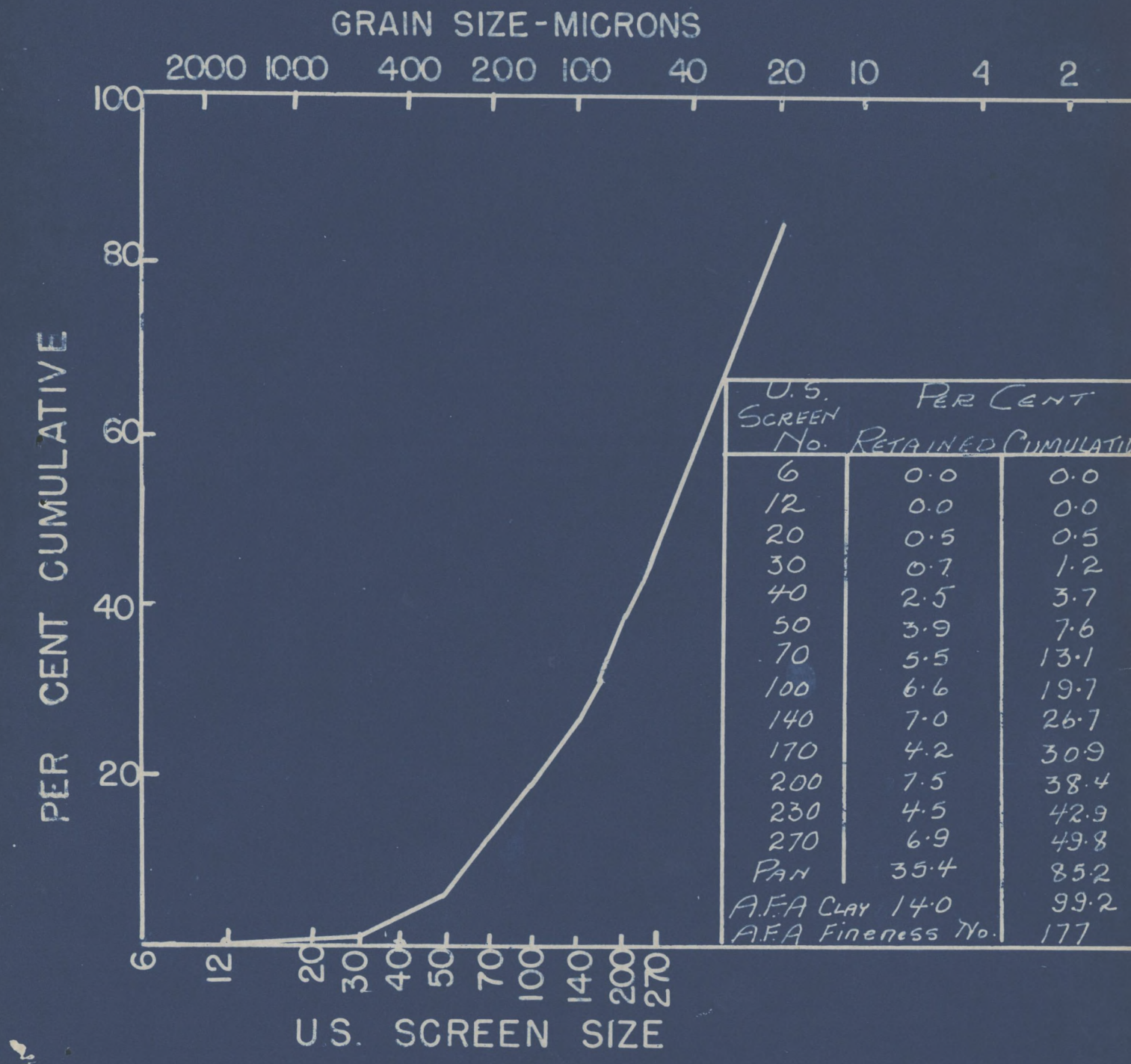
Figure 5.

MOULDING SAND

FINDLAY'S LIMITED

OCT. 18, 1945.

GRAIN SIZE TEST



U.S. Screen No.	Per Cent Retained	Per Cent Cumulati
6	0.0	0.0
12	0.0	0.0
20	0.5	0.5
30	0.7	1.2
40	2.5	3.7
50	3.9	7.6
70	5.5	13.1
100	6.6	19.7
140	7.0	26.7
170	4.2	30.9
200	7.5	38.4
230	4.5	42.9
270	6.9	49.8
Pan	35.4	85.2
A.F.A Clay	14.0	99.2
A.F.A Fineness No.		177