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DEPARTMENT OF MINES AND RESOURCES

BUREAU OF MINES

CANADA

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Ottawa, December 19, 1946.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 2156.

Metallurgical Examination of Two Cast Iron Connecting Rods.

(Copy No. 5.)

Bureau of Mines
Division of Metallic
Minerals

Physical Metallurgy
Research Laboratories

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REPORT

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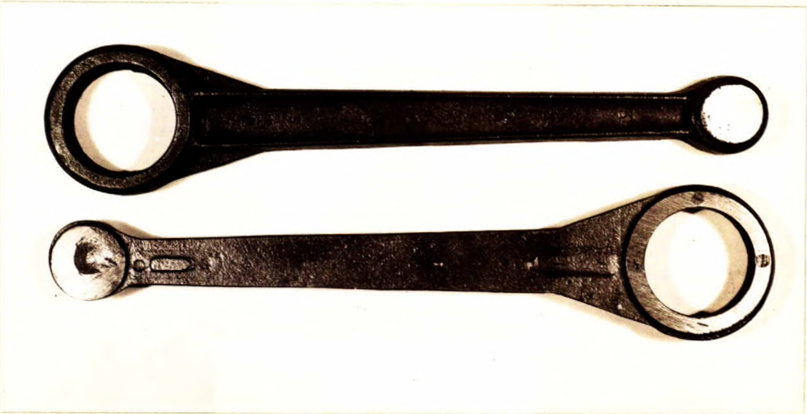
Source of Material and Object of Investigation:

On December 10, 1946, Mr. D. J. Campbell, of J. H. Connor & Son Limited, Ottawa, Ontario, submitted two cast iron connecting rods for examination. One of the castings, which was produced in the Connor foundry, was stated to have good machining properties, while the other casting, made in the foundry of Alloy Foundry Inc., Merrickville, Ontario, was harder and machined with difficulty. A full metallurgical examination was requested in order to determine, if possible, the reason for the difference in the machining properties of these castings.

Macroscopic Examination:

Figure 1 is a photograph showing the two castings as received for examination. The two castings appeared to have been made from sound metal and were free from surface defects.

Figure 1.



CAST IRON CONNECTING RODS.

(Approximately 1/4 actual size.)

Chemical Analysis:

The castings had the following chemical composition:

	Connor Casting	Alloy Foundry Casting
	- Per	Cent -
Total carbon -	3.34	3.08
Graphitic carbon -	2.64	2.26
Combined carbon -	0.70	0.82
Manganese -	0.67	0.42
Silicon -	2.53	2.29
Phosphorus -	0.338	0.506
Sulphur -	0.108	0.122
Chromium -	Nil.	Nil.
Nickel -	"	"
Molybdenum -	"	"

Note: All determinations carried out in duplicate.

Mechanical Properties:

A tensile test bar was machined from each of the castings. These bars had the following mechanical properties:

	Connor Bar	Alloy Foundry, Bar
Ultimate stress, p.s.i.	29,300	34,100
Brinell (3,000-kg. load)	187	241
Size of test bar, inches	0.49 x 0.346	0.495 x 0.351

Heat Treatment:

The following experimental heat treatment tests were carried out on additional Alloy Foundry castings in order to improve their machinability.

Experimental Annealing Data.

Connecting Rod No.	Furnace Used	Temp., ° F.	Time, Minutes	Brinell Hardness Before	Brinell Hardness After	Remarks
1	Small Vapocarb	1410	60	241	201	All samples cooled in the furnace.
2	Large Vapocarb	1500	60	235	146	
3	" "	1500	"	235	149	
4	" "	1350	"	255	229	
5	" "	1350	"	241	179	
6	" "	1350	"	241	159	
7	" "	1350	"	241	207	
8	" "	1350	"	229	167	
9	" "	1350	"	229	170	
10	" "	1350	"	229	163	
11	" "	1350	"	229	156	

Microscopic Examination:

Specimens cut from the "as received" and "heat treated" castings were polished and examined under the microscope in the unetched condition and also after etching in 2 per cent nital. The two "as received" irons were characterized by a fine graphitic structure (see Figures 2 and 3). The nital-etched structure of the Connor iron and the Alloy Foundry iron are shown in Figures 4 and 5 respectively.

(Figures 2, 3 and 4 follow, on Page 4.)

(Microscopic Examination, cont'd) -

Figure 2.

X100, unetched.

"AS RECEIVED"
CONNOR CASTING.

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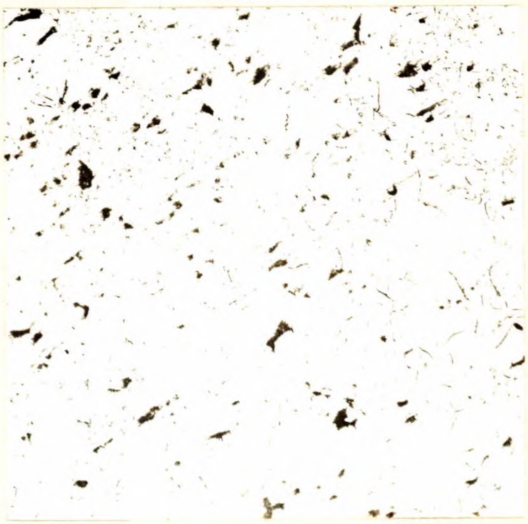
Figure 3.



X100, unetched.

"AS RECEIVED"
ALLOY FOUNDRY CASTING.

-

Figure 4.

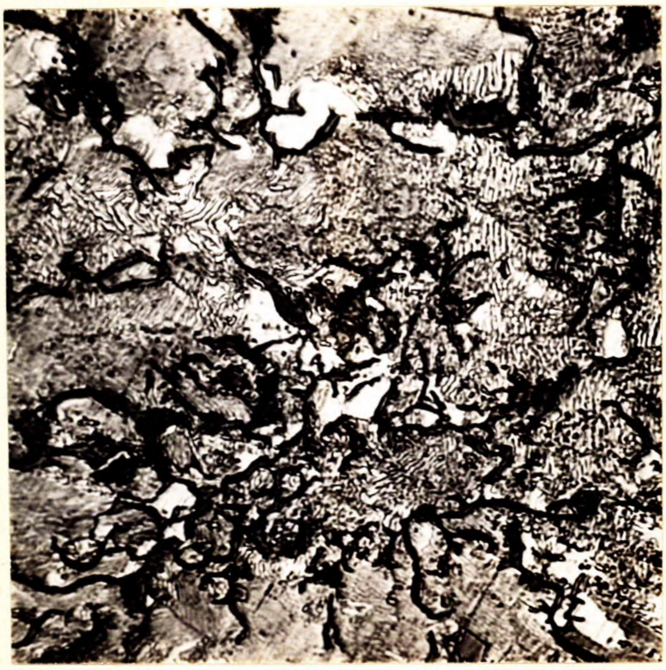
X1000, etched in 2 per cent nital.

J. H. CONNOR CAST IRON.

-

(Microscopic Examination, cont'd) -

Figure 5.



X1000, etched in 2
per cent nital.

ALLOY FOUNDRY CAST IRON.

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The structure of the graphite of the Alloy Foundry cast iron after annealing for one hour at 1400° F. is shown in Figure 6. It will be noted that the graphite is not as finely divided as in "as received" iron (Figure 3). The nital-etched structure of the annealed iron is shown in Figure 7.

Figure 6.

X100, unetched.

ALLOY FOUNDRY CAST IRON
ANNEALED AT 1400° F.

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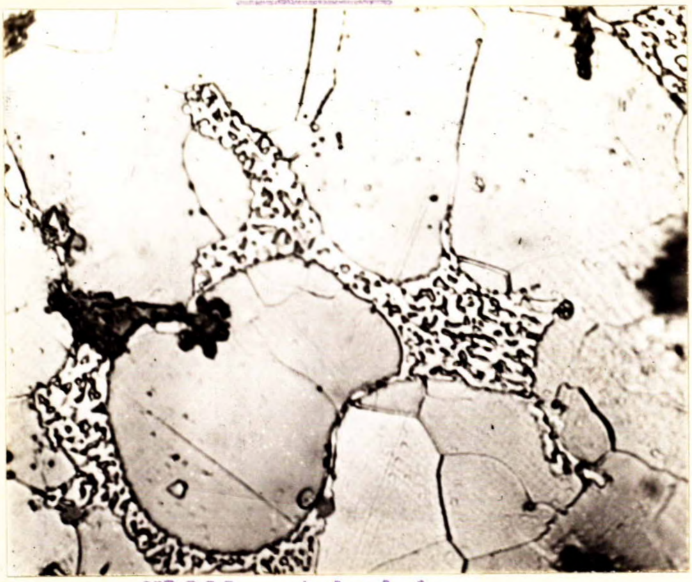
(Microscopic Examination, cont'd) -

Figure 7.



X1000, etched in
2 per cent nital.

ALLOY FOUNDRY IRON ANNEALED AT 1400° F.

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Discussion of Results:

It has recently been shown that the machinability of cast iron can be controlled by controlling the carbon equivalent between certain limits, the carbon equivalent being expressed by the following formula:

C.E. = T.C. + .3(Si + P)
Ideal Limits C.E. = 4.25 to 4.30
C.E. Carbon equivalent
T.C. = % Total carbon
Si = % Silicon
P = % Phosphorus

Applying this formula to the Connor and Alloy Foundry irons, we obtain the following carbon equivalents of these irons:

I. Connor Iron -

C.E. = 3.34 + .3(2.53 + .338)
= 4.20

II. Alloy Foundry Iron -

C.E. = 3.08 + .3(2.29 + .506)
= 3.92

It will be observed that the Connor carbon equivalent is closer to the ideal limits than is the Alloy

(Discussion of Results, cont'd) -

Foundry iron. A change in the chemical composition, if other factors will permit, would give an iron with somewhat lower tensile strength but better machinability.

A possible method which would accomplish the same purpose without lowering the tensile strength of the iron is the addition of silicon in the ladle. The technique of this procedure would have to be worked out in the foundry.

The machinability may be improved by annealing the iron between 1350° and 1500° F. This, of course, lowers the strength of the iron. The temperature chosen for annealing will depend generally upon the composition and the initial hardness of the iron. In the tests carried out in these Laboratories, on six out of eight connecting rods annealed for one hour at 1350° F. the hardness was reduced from Brinell 229-241 to Brinell 156-179.

In order to obtain a Brinell hardness below 200 on some of these castings, it will be necessary to anneal at 1500° F. However, tests have shown that 75 per cent of the castings can be softened below 200 Brinell with an anneal heat treatment at 1350° F. for one hour.

Conclusion:

This investigation shows, on the basis of chemical composition, photomicrographs and mechanical tests, that the Alloy Foundry metal is a better quality iron, showing a higher tensile strength and hardness. From the photomicrographs it can be seen that the graphite in the Alloy Foundry iron is finely distributed whereas in the Connor product the graphite is more coarse and flaky. These characteristics of the Alloy Foundry iron tend to make it more difficult to machine. It will be observed that the Connor iron approxi-

(Conclusion, cont'd) -

mates the Carbon Equivalent formula more closely than does the Alloy Foundry iron. Methods of improving the machinability of the Alloy Foundry product are suggested in the above discussion.

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