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OTTAWA December 1st, 1944.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1751.

Examination of Twenty-four Universal Carrier Pins.

(Copy No. 10.)

Bureau of Mines
Division of Metallic
Minerals

Physical Metallurgy
Research Laboratories

DEPARTMENT
OF
MINES AND RESOURCES

Mines and Geology Branch

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Origin of Material and Object of Investigation:

On November 10th, 1944, Dr. C. W. Drury, Director of Metallurgy, Army Engineering Design Branch, Department of Munitions and Supply, Toronto, Ontario, submitted twenty-four (24) Universal Carrier pins which had not been heat-treated. The accompanying Requisition No. 848, A.E.D.B. Lot 1196, Report No. 9, Section A, Test 30, stated that Canadian Acme felt it was not possible to heat-treat this lot of pins commercially to obtain the required case hardness of 24-32 Rockwell 'C' due to the fact that various heats were represented. It was requested that the pins be cut so that one portion might be heat-treated in the regular way of carburizing and quenching and the core hardness obtained. The other portion was to be used for further experimentation, if necessary.

Heat Treatment:

The 24 sections (one half-cut from each pin) were given 2 hours in approximately 15 per cent cyanide bath at 1625° F. and quenched by hand in a still oil bath. The oil was Houghton's No. 3 grade at 125° F. The properties of this oil are as follows:

Viscosity, seconds Saybolt Universal at 125° F. = 71.
Viscosity index = 72.
A.S.T.M. Colour No. (Union) = 2½.
Specific gravity at 60° F. = 0.886
Degrees A.P.I. = 28.2.
Flash point, ° F. = 350.
Fire point, ° F. (Cleveland open cup) = 385.
Pour point, ° F. = 35.
Carbon residue, per cent by weight (Ramsbottom) = 0.02.
Neutralization No. = 0.03.
Corrosion = Negative.

The ratio of steel to oil, weight to volume, was 5¼ pounds steel to 25 gallons oil.

Core Hardness:

Core hardness readings were taken after the pins were given the above treatment. The results were as follows:

Pin No.		Rockwell 'C' Hardness	Pin No.		Rockwell 'C' Hardness
1	-	20	13	-	17
2	-	8	14	-	24-25
3	-	8	15	-	20
4	-	7	16	-	25
5	-	21-23	17	-	22
6	-	26	18	-	25-26
7	-	23-24	19	-	10-12
8	-	22	20	-	23
9	-	25-26	21	-	29-30
10	-	26-27	22	-	13
11	-	7	23	-	28
12	-	24	24	-	27

Heat Treatment of Low-Core-Hardness Pins:

Pins Nos. 2, 3, 11 and 19 gave low core hardness. The other half of each of these pins was given a different type of treatment. These pieces, along with a number of dummy pieces (to make up the same weight and same arrangement

(Heat Treatment of Low-Core-Hardness Pins, cont'd) -

for quenching as previously used), were subjected to the following heat treatment;

> 2 hours at 1650° F. in 15 per cent (approximately) CN bath. Quenched into Gulf Super-Quench oil at 125° F.

The properties of Gulf Super-Quench are:

Viscosity, seconds Saybolt Universal at 125° F. = 62.
Viscosity index = 110.
A.S.T.M. Colour No. (Union) = Dark green.
Specific gravity at 60° F. = 0.864.
Degrees A.P.I. = 32.3.
Flash point, ° F. = 360.
Fire point, ° F. (Cleveland open cup) = 380.
Pour point, ° F. = 25.
Carbon residue, per cent by weight = 0.50.
Neutralization No. = 0.02.
Corrosion = Negative.

The metal-to-oil ratio by weight on quenching was 5¼ pounds metal to 25 gallons oil.

Core Hardness -

The core hardness of the four pieces after the above treatment is shown below (Table I) in comparison with the hardness obtained on the other half in the previous treatment.

TABLE I.

Pin No.	CORE HARDNESS, ROCKWELL 'C' 1625° F., Houghton No. 3	1650° F., Gulf Super-Quench
2	8	8
3	8	8-9
11	7	8
19	10-12	15

Chemical Analysis:

Drillings were taken from the cores of Pins Nos. 4 and 21, whose core hardnesses after the Houghton oil quench were 7 and 29-30 Rockwell 'C' respectively. These represent the extremes in core hardness. Chemical

(Chemical Analysis, cont'd) -

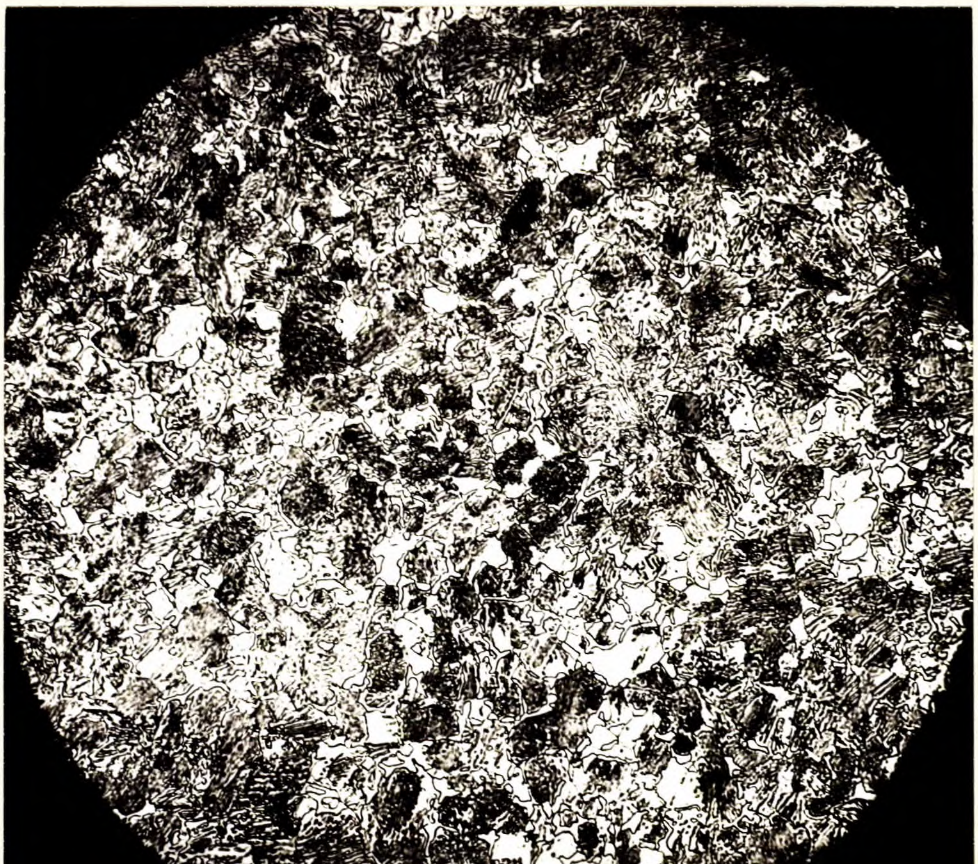
analyses were obtained, as follows:

		PIN NO. 4 (Rockwell 'C' 7)	PIN NO. 21 (Rockwell 'C' 29-30)
		- Per Cent -	
Carbon	-	0.16	0.19
Manganese	-	0.40	0.48
Nickel	-	1.85	1.22
Chromium	-	0.25	0.36
Molybdenum	-	Trace.	0.04

McQuaid-Ehn:

A specimen was taken from Pin No. 4, which gave a core hardness of Rockwell 'C' when given the 1625° F. treatment and quenched into No. 3 Houghton's oil. This was given a McQuaid-Ehn treatment and then examined under the microscope. Figure 1 (X500) illustrates the structure obtained.

Figure 1.



X500, nital etch.

Cementite and ferrite (white constituents) are indicative of an 'abnormal' steel.

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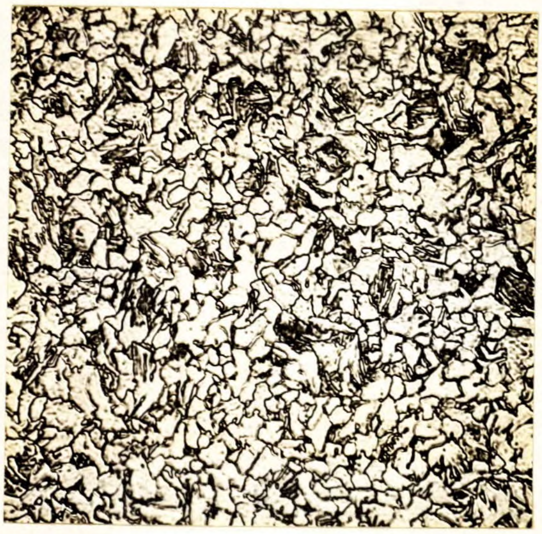
Microscopic Examination:

Transverse specimens were cut from Pins Nos. 4 and 21. These were polished, etched in 2 per cent nital, and examined under the microscope. Figure 2 (X500) illustrates the core structure of the low-hardness Pin No. 4. It consists mainly of ferrite. Figure 3 (X500) shows the structure of the high-hardness Pin No. 21. This structure is mainly low-carbon martensite.

Figure 2.



X500, nital etch.
CORE OF PIN NO. 4; ROCKWELL 'C' 7.
Mainly ferrite (white constituent).

Figure 3.

X500, nital etch.
CORE OF PIN NO. 21; ROCKWELL 'C' 29-30.
Mainly low-carbon martensite.

Discussion:

A great variation in core hardness was obtained in heat treating the twenty-four pieces simultaneously. Analysis of a low-core-hardness and a high-core-hardness pin showed that two different heats of steel were present. A difference in hardenability between the two heats of steel accounts for the wide variation in core hardness obtained after a uniform heat treatment.

Using a higher temperature (1650° F.) and a faster quenching oil did not effect any appreciable increase in the hardness of the low-core-hardness pin. If the temperature were raised any higher, in order to obtain grain coarsening for increased hardenability, the high-hardness pins would present difficulties. The core hardness of this type would probably be over the 32 Rockwell 'C' maximum. Failure to meet the impact requirement might also result.

The McQuaid-Ehn test shows that the low-core-hardness pins are produced from an 'abnormal' heat of steel. An abnormal steel is the result of improper deoxidation practice in the melting operation. It is usually difficult to harden an abnormal steel properly.

In view of the above findings it is felt that it would not be possible to heat-treat commercially a batch of pins similar to those handled in this report so that they would pass all the specification requirements.

Conclusions:

1. The core hardness varied from 7 to 30 Rockwell 'C'.

2. It was established that at least two different heats of steel are represented by this lot of pins.

3. Variation in the hardenability of the two heats of steel examined makes it impractical to heat-treat lots of

(Conclusions, cont'd) -

pins such as these commercially.

4. The low hardenability of the 0.16 carbon steel is due to its being from an 'abnormal' heat of steel.

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