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O T T A W A   May 21st, 1942.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1229.

(M. and S. No. 7/A/2).

Examination of Mark III Track Pins.

(Copy No. 10.)

BUREAU OF MINES
DIVISION OF METALLIC MINERALS

ORE DRESSING AND
METALLURGICAL LABORATORIES

CANADA
DEPARTMENT
OF
MINES AND RESOURCES
MINES AND GEOLOGY BRANCH

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Examination of Mark III Track Pins.

Origin of Material and Object of Investigation:

On Friday, May 15th, 1942, six Mark III track pins were received from the Campbell, Wyant and Cannon Foundry Company, Muskegon, Michigan. The steel used in fabricating these pins was made by the Republic Steel Corporation and was reported to be a modified NE 8817 steel. These pins were treated in a Nicarb furnace and given the same treatment as the regular production Mark III pins made out of modified SAE 3115 steel. Mr. K. J. Ferguson, of the British Purchasing Commission, Washington, D.C., requested that a complete

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

metallurgical examination be carried out, since SAE 3115 steel was being withdrawn from track pin use in the U. S. A. and a suitable substitute has to be found.

Chemical Analysis:

	As Reported by Republic Steel Corp'n.	As Found
	- Per cent -	
Carbon	0.195	0.18
Manganese	0.80	0.80
Phosphorus	0.014	0.008
Sulphur	0.015	0.015
Silicon	0.23	0.27
Nickel	0.43	0.44
Chromium	0.52	0.52
Molybdenum	0.22	0.24

Physical Properties:

A tensile test specimen, of 0.282 in. diameter and 1-inch gauge length, was cut from the core of a pin which had been subjected to a bend test (since no other pin was available). The bend was not very great and the specimen was taken from the end of the pin. Nevertheless it is felt that the following results should be treated with some reservation:

Tensile	-	134,800 p.s.i.
Yield	-	92,000 (dividers method)
Elongation	-	12%
Reduction of area	-	19%

Depth-Hardness:

Hardness readings were taken on the Vickers machine, using a 10-kilogram weight. Table I lists the depth-hardness relationships. The curves are shown in Figures 1 and 2.

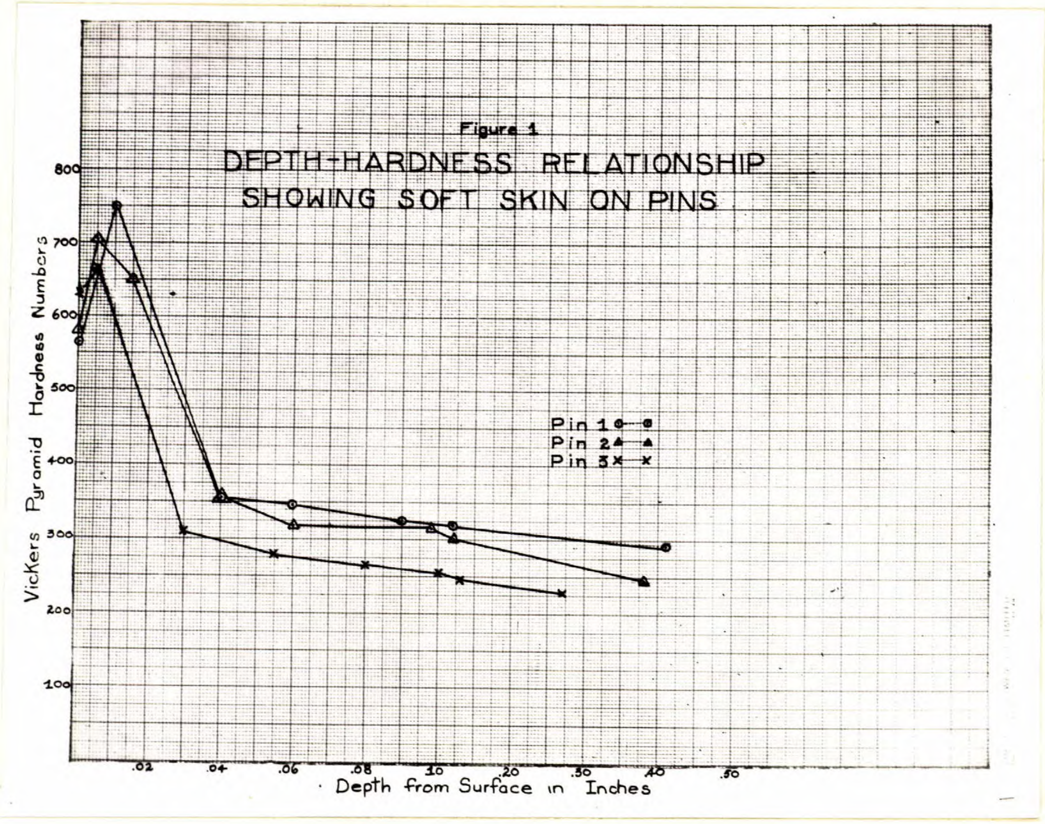
(Continued on next page)

(Depth-Hardness, cont'd) -

TABLE I.

PIN	VICKERS HARDNESS NUMBERS - 10-kilogram weight At depths in inches from the surface									
	At surface	0.005	0.010	0.015	0.020	0.030	0.040	0.050	0.10	0.20
1.	564	645	750	687	620	490	355	350	322	310
2.	578	705	678	650	590	475	355	338	310	285
3.	631	665	595	523	450	310	298	285	255	238
4.	583	715	745	772	668	470	360	352	312	295
5.	579	640	710	640	570	487	415	338	315	278
6.	536	665	618	572	520	420	325	325	308	280

Figure 1.



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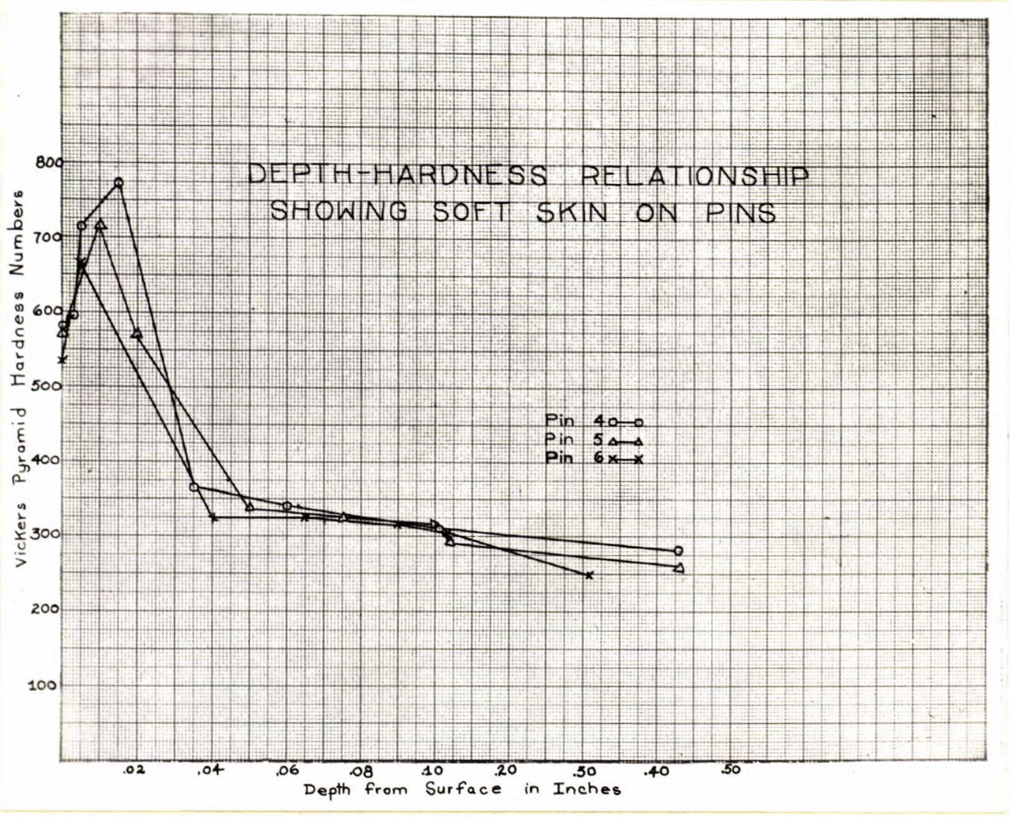
(Depth-Hardness, cont'd) -

Figure 2.



Depth of Case:

Measurements of the depth of case were taken on microspecimens of the pin, etched in nital. The Brinell microscope was used. The average of three readings per pin is shown below:

Pin No.	Inches	
1.	0.029)	
2.	0.028)	
3.	0.023)	Range, 0.023 to 0.029 in.
4.	0.028)	
5.	0.023)	
6.	0.026)	

Bend Tests:

Bend tests were carried out on an Amsler Universal testing machine using a 12-inch radius and 8-inch centres. Charts of increment vs. load were plotted. The elastic limit and the break point were then determined from these

(Bend Tests, cont'd) -

charts. The method used has been illustrated in a previous Investigation No. 1197 (April 2nd, 1942) carried out in these Laboratories. Table II records the results obtained.

TABLE II.

	NE 8817 No. 4		NE 8817 No. 1		SAE 2115*		SAE 3115**	
	Angle	Load (lb.)	Angle	Load (lb.)	Angle	Load (lb.)	Angle	Load (lb.)
Elastic limit -	1°44'	3125	1°	2100	1°	2375	-	-
Break -	3°48'	5250	4°2'	5150	5°24'	5250	5°	6800

* Taken from Investigation No. 1197.

** Taken from Investigation No. 1154.

Drop Impact Tests:

Drop impact tests were carried out to determine the reaction of the pins to sudden shock, both at room temperatures and at -50° F. A 75-pound weight was dropped from successively increasing heights. This was continued until the pin failed. For the low-temperature tests the pins were kept in a bath of acetone and dry ice for ½ hour at -50° F. prior to testing. The results obtained are shown in Table III.

TABLE III.

(75-Pound Weight)

Height of drop, cm.	Sample Identification 2	5	3	6
	- Angle of Bend -			
	Room Temperature		Minus 50° F.	
20	2°	2.5°	1½°	1.3°
40	4.5°	4.5°	Broke	Broke
50	Broke			
60		Broke		
80				
100				
HARDNESS -				
Core	285	278	238	280
Case	715	715	665	665

Microscopic Examination:

Photomicrographs were taken of a typical core and case at X500 magnification and X1000 magnification respectively (see Figures 3 and 4). The core (Figure 3) is pearlitic, the presence of ferrite being indicated. The case shows a retention of austenite in the heat treatment.

(Figures 3, 4 and 5 are at end of report)

Discussion of Results:

The physical test results, although taken from a specimen which might have had some lateral strain, indicate brittleness in the core. A check on these physical tests will be undertaken as soon as more pins are available.

The depth-hardness relationship curves shown in Figures 1 and 2 indicate the existence of a soft outer skin in all of the pins. A photomicrograph (Figure 5) was taken at X500 magnification. Clear white particles can be observed near the surface. These are free carbides, as was shown by etching with a sodium hydroxide, potassium ferricyanide solution. In the presence of free carbides austenitic retention at the surface can be expected to be greater and this would result in a soft skin. A diffusion treatment to eliminate the carbides should be carried out, since the strength of the case is lowered by their presence.

The depth of case obtained for all of the pins conform to the limits set by the specification, namely, 0.020-0.035 in.

The bend tests show that the pins when subjected to a continuous pressure are slightly more brittle than SAE 2115 (water-quenched from 1400° F.) or SAE 3115 (Taylor-Wharton), all pins having approximately the same surface hardness.

The resistance to sudden shock at room temperature

(Discussion of Results, cont'd) -

of these pins is higher than that of the SAE 2115 type. At -50° F. the drop-impact tests show that the NE 8817 pins are the equivalent of SAE 2115 (water-quenched) but not as good as the SAE 2115 (oil-quenched).

The core structure obtained is not uniform. A more uniform structure can be obtained by quenching from a higher temperature. Austenitic retention is considered to be a valuable factor in producing a tougher case. Too much austenite, however, would lower the wear properties of the pin.

CONCLUSIONS:

1. The physical results indicate brittleness in the core. These results, however, should be checked.

2. Free carbides are present. A diffusion treatment should be adopted to eliminate them.

3. The depth of case obtained is satisfactory.

4. Bend tests show that the pins are more brittle than SAE 2115 cyanided and water-quenched from 1400° F. or than SAE 3115 cyanided.

5. The drop-impact tests at room temperatures show that the pins have a greater resistance to shock than SAE 2115. At -50° F. the NE 8817, like most cased pins, are quite brittle.

6. A more uniform core structure is desirable.

Recommendations:

1. The physical tests on a 2-inch gauge length specimen should be carried out.

2. A diffusion treatment to eliminate free carbides should be adopted.

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(Recommendations, cont'd) -

3. In order to obtain a more uniform core structure, quenching should be carried out from a higher temperature.

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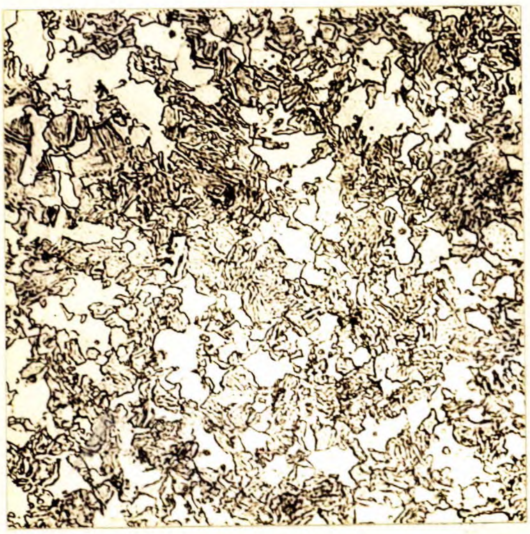
Figure 3.



TYPICAL CORE

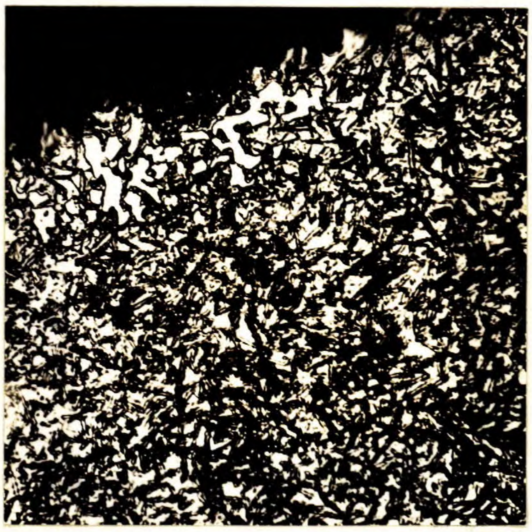
X500, nital etch.

Figure 4.

TYPICAL CASE

X1000, nital etch.

Figure 5.



Photomicrograph showing soft outer skin.

X500, nital etch.

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