OTTAWA April 29th, 1942.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1210.
(M & S. 9/A.)

Investigation of Nitrided 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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Origin of Material and Object of Investigation:

On April 1st, 1942, nine track pins were received for investigation, from the Cam.bell, Wyant and Cannon Foundry Company, Muskegon, Michigan, in accordance with the work program laid out at the Toronto meeting (March 16th) of the Track Pin Committee, Inspection Board of the United Kingdom and Canada. It was reported that three pins received no case-hardening heat treatment but represent the Nitralloy G alloy steel as

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

received from the mill. Three pins were given the regular nitriding treatment, the cycle taking seven days. The final three pins were kept in the nitriding furnace one-half the usual length of time, namely three and one-half days.

General:

The following designations will be adhered to throughout this report to signify the three different types of pins tested:

(a) Pins with no case-hardening heat treatment - SOFT.

(b) Pins given the regular heat treatment (seven-day cycle) - HARD.

(c) Pins given one-half the regular treatment (three and one-half days) - SEMI-HARD.

Chemical Analysis:

Drillings of the cores of the pins were taken for chemical analysis:

Soft -

		Per cent
Aluminium	-	1.20
Chromium	-	1.10

Semi-Hard -

Aluminium	-	1.22
Chromium	-	1.10

Hard -

Carbon	-	0.35
Manganese	-	0.52
Silicon	-	0.28
Phosphorus	-	0.019
Sulphur	-	0.015
Nickel	-	Trace
Chromium	-	1.09
Aluminium	-	1.25
Copper	-	0.10
Molybdenum	-	0.18

Hardness Tests:

Using the Vickers method and a 10-kilogram load, hardnesses were taken on polished samples at various distances from the surface.

	Distance from the Surface		V. P. N.
Soft Pin -			
	0.34 in.	-	258
	0.09 "	-	266
	0.02 "	-	267
	Surface	-	267
Hard Pin -			
	0.35 in.	-	273
	0.07 "	-	274
	0.05 "	-	276
	0.03 "	-	341
	0.02 "	-	576
	0.01 "	-	729
	Surface	-	967
Semi-Hard Pin -			
	0.35 in.	-	282
	0.15 "	-	281
	0.09 "	-	288
	0.025 "	-	291
	0.01 "	-	606
	Surface	-	1044

Bend Tests:

Bend tests were carried out on an Amsler Universal testing machine. A 12-inch radius and eight-inch centres were used. These tests were carried out at room temperature. The soft pin gave a 52° bend without cracking. The hard and semi-hard pins cracked at loads of 3,500 pounds and 3,250 pounds respectively, without showing any appreciable bend (less than 1°).

Drop Impact Tests:

The pins were tested to see the reaction to sudden shock, both at room temperatures and at minus 50° F. The machine that was employed is illustrated in a report from

(Drop Impact Tests, cont'd) -

these Laboratories, Investigation No. 1197, dated April 2nd, 1942. The pins were kept at minus 50° F. in a bath of acetone and dry ice for ½ hour before being subjected to the test. A seventy-five pound weight was dropped on the pin from different heights (20 cm. increments). Table I lists the results obtained both at room temperatures and at minus 50° F.:

Table I.

Drop Impact Tests on Large Track Pin from the Campbell, Wyant and Cannon Foundry Company.

Height of drop, cm. (75-lb. weight)	SAMPLE IDENTIFICATION					
	Soft		Semi-Hard		Hard	
	R.T.	-50° F.	R.T.	-50° F.	R.T.	-50° F.
	- Angle of Bend -					
20	5°	4°	2.5° crack	2.5°	2° cracked	1.5° cracked
40	14°	10°				
60	21°	18°				
80	32°	28°				
100	39°	36°				
120	45°	41°				
140	No sign of failure	No sign of failure				
160						
180						
200						
	- Hardness (Vickers) -					
CORE	258	258	282	282	273	273
CASE	267	267	1044	1044	967	967

Depth of Case:

Depth of case was measured, using the Brinell microscope. Samples of the pins were polished and etched, after which the readings were taken.

Hard pin	-	0.032 inch
Semi-hard pin	-	0.020 inch.

Microscopic Examination:

Polished sections of the pins were examined under the microscope, both in the etched and in the unetched condition. The unetched specimens showed that the steels were quite clean. Photomicrographs were taken at X1000 magnification for the case and X500 for the core.

(See photomicrographs, Figures 1 to 5, at end of this report.)

Discussion of Results:

The chemical analysis shows that satisfactory nitriding metal was used in all cases.

Depth-hardness relationships show that the hard pins which have undergone the complete heat-treating cycle of seven days have a more gradual transition from the case to the core. Also, as would be expected, a deeper core has been formed. The semi-hard pins, having been treated for only three and a half days, have a shallower case with a greater surface hardness.

Bend tests show that the nitralloy bar stock (soft) has good ductility. The nitrided case (both types) cracks at a very low load, as the elastic limit has been reached. In service it can be assumed that once a crack takes place in the case the pin will fail, since the core will have to withstand the whole load.

The drop impact test results show that the cased

(Discussion of Results, cont'd) -

pins will not withstand sudden shock. One blow was sufficient to cause cracking to appear on the case, both at room temperature and at low temperature. The soft uncased pins showed very good resistance to shock.

From the laboratory tests it appears that the nitrided pins would not be sufficiently tough to be used with steel track links. It should, however, be pointed out that field trials should be undertaken to determine whether:

(a) It is necessary to have a tougher pin.

(b) If such a high hardness is required to resist abrasion.

Nitrided pins used with rubber track are cushioned against shock because of the rubber track. If used with steel track the impact would be felt directly by the pin and consequently it is very probable that a pin that has been used successfully with rubber track would not be satisfactory when used with steel track.

It would seem from the laboratory test results that a tougher pin with a softer case would allow a much greater margin of safety than the nitrided pins.

The photomicrographs show that the case of the hard pin shows a greater concentration of nitrides than that of the semi-hard pin. The cores all have an acicular pattern. They all contain ferrite. The individual grain sizes, however, differ slightly. Figure 5, that of the bar stock, indicates that it was drawn at a very low temperature if drawn at all.

CONCLUSIONS:

1. A satisfactory nitriding steel has been employed.

2. The pins which have been heat treated for the complete seven-day cycle have a more gradual transition in hardness from the surface to the core than those treated for only three and a half days.

3. The bar stock gave an excellent bend, whereas the cased pins (both types) cracked without any appreciable bend angle.

4. The bar stock withstood the sudden shock of the drop test being without cracking. The cased pins crack at the first drop of the weight (from 20 cm. height).

5. Field trials are necessary in order to determine the toughness required by the pins and also whether high surface hardness produced by nitriding is important for abrasion resistance.

6. Laboratory tests point to higher toughness and lower surface hardness for good results.

7. A pin previously used with rubber track meets a new set of conditions when employed on steel track. A pin used with rubber track does not require the resistance to impact necessary for one used with steel track.

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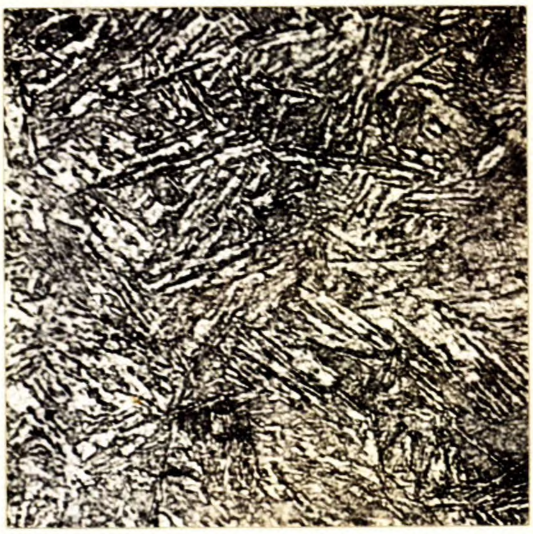
Figure 1.



X500, nital etch.
CORE OF HARD PIN.

Figure 2.

X1000, nital etch.
CASE OF HARD PIN.

Figure 3.

X500, nital etch.
CORE OF SEMI-HARD PIN.

Figure 3.

X1000, nital etch.
CASE OF SEMI-HARD PIN.

Figure 5.

X500, nital etch.
STRUCTURE OF SOFT BAR STOCK.

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