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R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1224.

(M. and S. No. 9/A/3).

Examination of Carbo-Nitrided Universal Carrier Track Pins.

(Copy No. 13.)

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 May 4th, 1942, Dr. C. W. Drury, Director of Metallurgy, of the Department of Munitions and Supply, Ottawa, Ontario, submitted twelve Universal Carrier track pins for investigation. These pins were treated by Campbell, Wyant and Cannon Foundry Company, Muskegon, Michigan, in their Nicarb furnace. They were reported to have been held at a temperature of 1475° F. for a period of five hours and then oil-quenched from that temperature. The furnace atmosphere during the heat treatment was maintained by supplying 150 cubic feet of raw gas and 80 cubic feet of ammonia gas per hour.

Chemical Analysis:

Drillings were taken from the core of a pin for chemical analysis.

		As Found		Specification SAE 3115
		- Per cent -		
Carbon	-	0.21	--	0.10-0.20
Manganese	-	0.57	--	0.30-0.60
Silicon	-	0.24	--	0.15 min.
Phosphorus	-	0.014	--	0.040 max.
Sulphur	-	0.027	--	0.050 max.
Nickel	-	1.27	--	1.00-1.50
Chromium	-	0.62	--	0.45-0.75

Hardness Tests:

Hardness tests were taken on the surface of the pins using the Vickers hardness machine and a 10-kilogram load. The average of three readings is listed below for each pin:

Pin No.		V. P. N.
1	-	557
2	-	599
3	-	669
4	-	830
5	-	847
6	-	796
7	-	796
8	-	592
9	-	561
10	-	564
11	-	574
12	-	669

Depth-hardness relationships for three of the pins were taken, as follows:

Pin No. 2. -

Distance from the surface, in inches		V. P. N.
0.22	-	272
0.15	-	309
0.09	-	319
0.06	-	345
0.04	-	342
0.01	-	450
Surface	-	599

(Continued on next page)

(Hardness Tests, cont'd) -

Pin No. 6. -

Distance from the surface, in inches		V. P. N.
0.22	-	305
0.20	-	304
0.07	-	287
0.04	-	283
0.03	-	299
0.01	-	425
Surface	-	796

Pin No. 7. -

0.22	-	389
0.20	-	401
0.05	-	387
0.04	-	387
0.02	-	399
0.015	-	437
Surface	-	796

Depth of Case:

Microsections were cut from six of the pins and the depth of case was measured using the Brinell microscope. Three depth readings were taken for each sample and the averages are listed below:

Specimen No.		Depth of case, in inches
2	-	0.016
3	-	0.016
4	-	0.018
5	-	0.018
6	-	0.014
7	-	0.016

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, permanent bend, and break point were then determined from these

(Bend Tests, cont'd) -

charts. The method used is illustrated in a previous investigation, No. 1197 (April 2nd, 1942), carried out in these Laboratories. Table I records the results obtained.

Table I.

Physical Property	Pin No. 8		Pin No. 9		Pin No. 10		Pin No. 12	
	Angle	Load, pounds	Angle	Load, pounds	Angle	Load, pounds	Angle	Load, pounds
Elastic limit	36'	250	44'	315	1° 28'	405	1° 44'	435
Permanent bend	2° 25'	625	2° 17'	625	2° 21'	540	4° 51'	875
Break	5° 12'	1000	5° 49'	1100	6° 32'	1000	5° 36'	900
Surface hardness	592 V.P.N.		561 V.P.N.		564 V.P.N.		669 V.P.N.	

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 5-kilogram weight (11.02 pounds approximately) was dropped from successively increasing heights. This was continued until the pin showed the first signs of cracking. 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 II. Figures 1 and 2 are comparisons of drop impact test results, obtained with pins of approximately the same case and core hardnesses, from the three main producers of Universal Carrier pins. Curve A represents a Campbell, Wyant and Cannon carbo-nitrided pin (present investigation). Curve B is a Canadian Acme Screw and Gear carburized pin (results taken from Investigation No. 1197). Curve C is an Allied Products pin (also from Investigation No. 1197).

(Continued on next page)

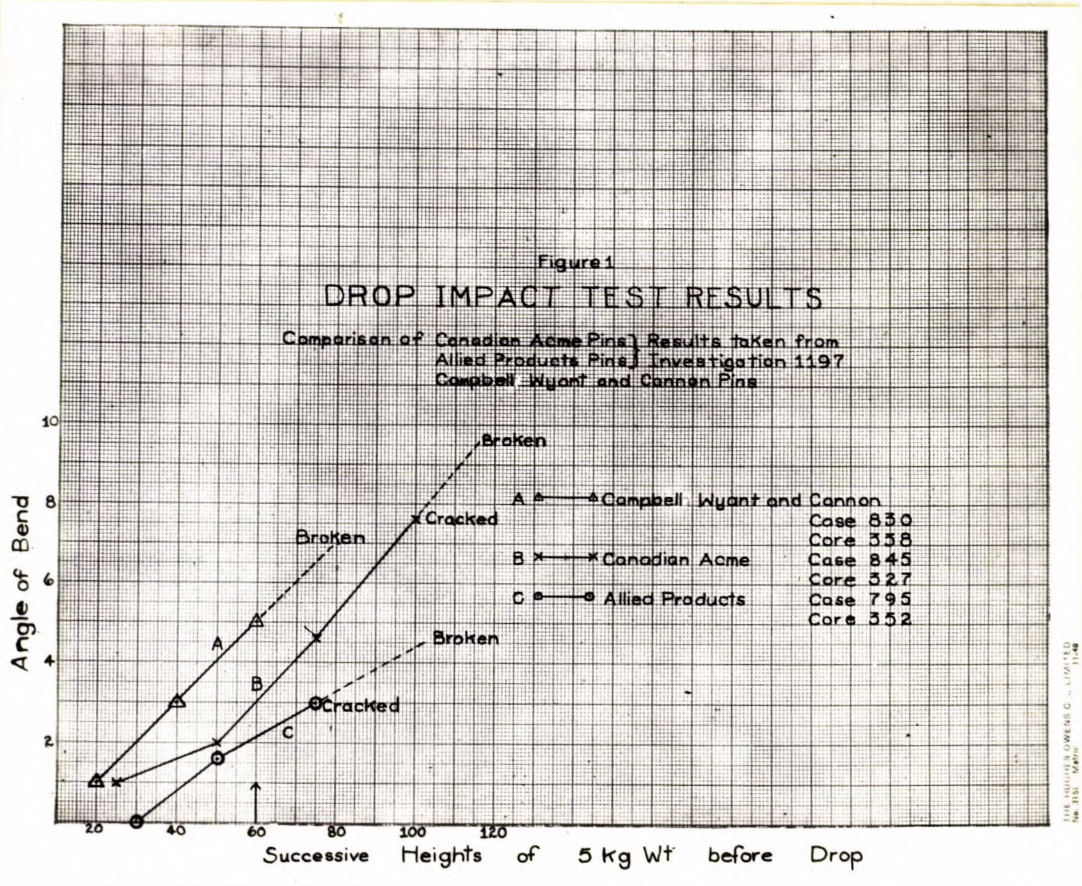
(Drop Impact Tests, cont'd) -

Table II.

Drop Impact Tests on
Universal Carrier Carbo-Nitrided Pins.

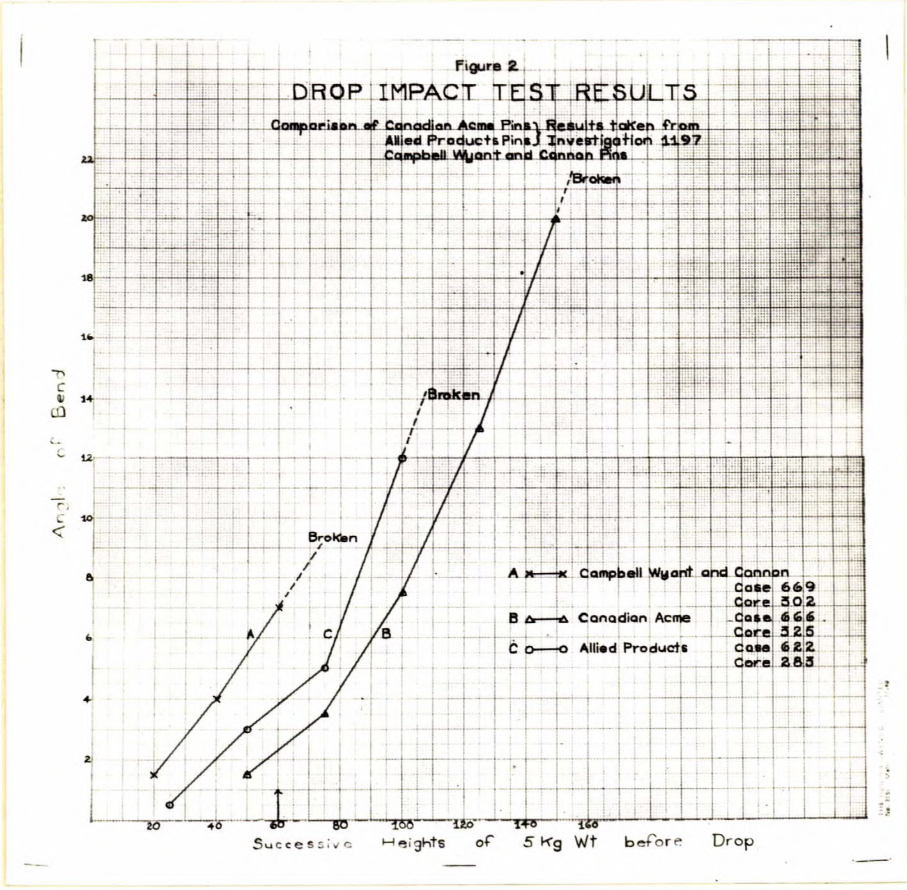
Height of drop, cm. (5-Kg. weight)	SAMPLE IDENTIFICATION					
	Room Temperature			-50° F.		
	- Angle of Bend -					
	Pin No. 2	Pin No. 3	Pin No. 4	Pin No. 5	Pin No. 6	Pin No. 7
20	1°	1.5°	1°	1°	1°	1°
40	3.5°	4.0°	3.0°	3°	3.5°	3°
60	6.0°	7.0°	5.0°	broke	broke	cracked 5°
80	cracked 8.0°	broke	broke			
100						
- Hardness (Vickers) -						
CORE	272	302	338	311	305	389
CASE	599	669	830	847	796	796

Figure 1.



(Drop Impact Tests, cont'd) -

Figure 2.



Microscopic Examination:

Microsections of the pins were polished and examined under the microscope in the unetched and nital-etched conditions. The unetched specimens revealed the steel to be quite clean. Figures 3 and 4, taken at X500 and X1000 magnifications respectively, are photomicrographs of a typical core and the approximate centre of the case. Figure 5, taken at X500, shows the structure of the cases of the pins as the surface is approached.

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

Discussion of Results:

The twelve pins were reported to have undergone the same treatment. A wide variation in the surface hardnesses exists; the pins range from 557 to 847, indicating lack of control in the process. A study of the various factors of the process in their relationship to the final case obtained should be made by the manufacturers so that a controlled product can be turned out.

The depths of case obtained are satisfactory and within the proposed limits of the specification, 0.012 to 0.020 inch.

The bend tests compare favourably with those obtained in a previous investigation of Canadian Acme pins and Allied Products pins. Very little difference is observed between the three types of pins under continuous pressure.

The drop impact results at low temperatures, shown in Table II, indicate that the toughnesses of these pins are about the same at -50° F. as are those of the Allied and Acme pins. Figure 1 shows that at room temperatures, for 800 V.P.N. (approx.) surface hardness pins, those of Canadian Acme are the toughest. The carbo-nitrided pins can absorb 6 Kg./m. of energy before failing, whereas those of Canadian Acme absorb 12.5 Kg./m. The Allied pins take 7.5 Kg./m. before breaking. Figure 2 shows a comparison of results for pins having a surface hardness of approximately 650 V.P.N. Here, again, Canadian Acme pins are the toughest. The Allied Products pins have intermediate properties.

Figure 3 is a photomicrograph of a typical core. The structure indicates the presence of pearlite and ferrite. Figures 4 and 5 illustrate the difference in the amount of retained austenite in the case (white constituent) as the surface is approached. The centre of the case (Figure 4) shows

(Discussion of Results, cont'd) -

the structure to be of a uniform nature. However, in proceeding toward the surface more and more austenite is evident. Although austenite confers toughening characteristics to a case a more uniform structure is desirable. This also appears to be the reason for the great variation in the surface hardness of the pins.

CONCLUSIONS:

1. Lack of control in the process is indicated by the wide variation in the surface hardness of the twelve pins.

2. The depths of case obtained are within the limits set by the specification, 0.012 to 0.020 inches.

3. Under continuous pressure the carbo-nitrided pins compare favourably with the Canadian Acme and Allied Products' pins.

4. At -50° the drop impact test results indicate that the carbo-nitrided pins have a slightly greater ductility than the Canadian Acme or Allied Products' pins and about the same toughness.

5. At room temperatures, for pins of approximately 800 V.P.N., the order of toughness is:

(a) Canadian Acme Screw and Gear - 12.5 Kg./m.
(b) Allied Products Limited - 7.5 Kg./m.
(c) Campbell, Wyant and Cannon - 6 Kg./m.

For pins of approximately 650 V.P.N. surface hardness, the order of toughness is:

(a) Canadian Acme Screw and Gear.
(b) Allied Products, and
(c) Campbell, Wyant and Cannon.

(Continued on next page)

(Conclusions, cont'd) -

6. The case structure is not uniform. This probably accounts for the great variation in surface hardness observed.

7. The carbo-nitrided pins, like all cased pins, do not give as favourable laboratory results as those obtained with the homogeneously hardened type.

Recommendations:

(a) A study of the various factors of the process in their relationship to the final case obtained should be made by the manufacturers so that a controlled product may be turned out.

(b) A diffusion treatment is required in order to produce a more uniform case.

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SLC:GHB.

Figure 3.

X500, nital etch.
TYPICAL CORE.

Figure 4.

X1000, nital etch.
TYPICAL CASE.

Figure 5.

X500, nital etch.

STRUCTURE OF THE CASE OF THE PIN NEAR THE SURFACE.

Note increasing amount of austenite towards the surface.

SLG:GHB.