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January 2, 1945.

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of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1769.

Metallurgical Examination of  
Two SAE 4340 Steel Plates.

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Origin of Material and Object of Investigation:

On December 18, 1944, Dr. C. W. Drury, Director of Metallurgy, Army Engineering Design Branch, Department of Munitions and Supply, Toronto, Ontario, submitted two plates (3" x 5" x 1/8", approximately) for examination. Requisition No. 873 (A.E.D.B. Lot Nos. 1204 and 1205, Report No. R107, Test No. 2) stated that these plates are SAE 4340 steel received by the Skinner Manufacturing Company from Atlas Steels Limited, but manufactured elsewhere. It was requested that the following be determined:

1. Surface hardness on both sides.
2. Depth of decarburization on both sides.
3. Depth of partial decarburization.
4. Grain size and grain characteristics.

Chemical Analysis:

Drillings were taken from each plate for chemical analysis.

|              | As Found        |                 | Specification<br>SAE 4340 |
|--------------|-----------------|-----------------|---------------------------|
|              | Lot No.<br>1204 | Lot No.<br>1205 |                           |
| - Per Cent - |                 |                 |                           |
| Carbon       | 0.40            | 0.42            | 0.38-0.43                 |
| Manganese    | 0.75            | 0.78            | 0.60-0.80                 |
| Chromium     | 0.71            | 0.82            | 0.70-0.90                 |
| Nickel       | 1.66            | 1.74            | 1.65-2.00                 |
| Molybdenum   | 0.22            | 0.22            | 0.20-0.30                 |
| Silicon      | 0.29            | 0.29            | 0.20-0.35                 |

Hardness Tests:

|                          | Lot No. 1204                       | Lot No. 1205   |
|--------------------------|------------------------------------|--|
| <u>Surface</u>           | Rockwell 'B' 89-90,<br>both sides. | Rockwell 'C' 27-28,<br>on one side.<br>Rockwell 'C' 26-27,<br>on the other side. |
| <u>Core</u> <sup>•</sup> | Rockwell 'C' 20.                   | Rockwell 'C' 28.   |

• Core hardness readings were made on the face of a transverse section, using the Vickers machine and a 10-kilogram load. The Scott-Grey conversion chart was used to translate to Rockwell.

Decarburization:

The amount of total and partial decarburization at the surfaces of each plate was determined by measuring the nital-etched microspecimens on the microscope. The results were:

|               | Lot No. 1204 |            | Lot No. 1205 |            |
|---------------|--------------|------------|--------------|------------|
|               | One Side     | Other Side | One Side     | Other Side |
| - In Inches - |              |            |              |            |
| Total         | 0.004        | 0.004      | None.        | None.      |
| Partial       | 0.009        | 0.005      | 0.002        | 0.004      |

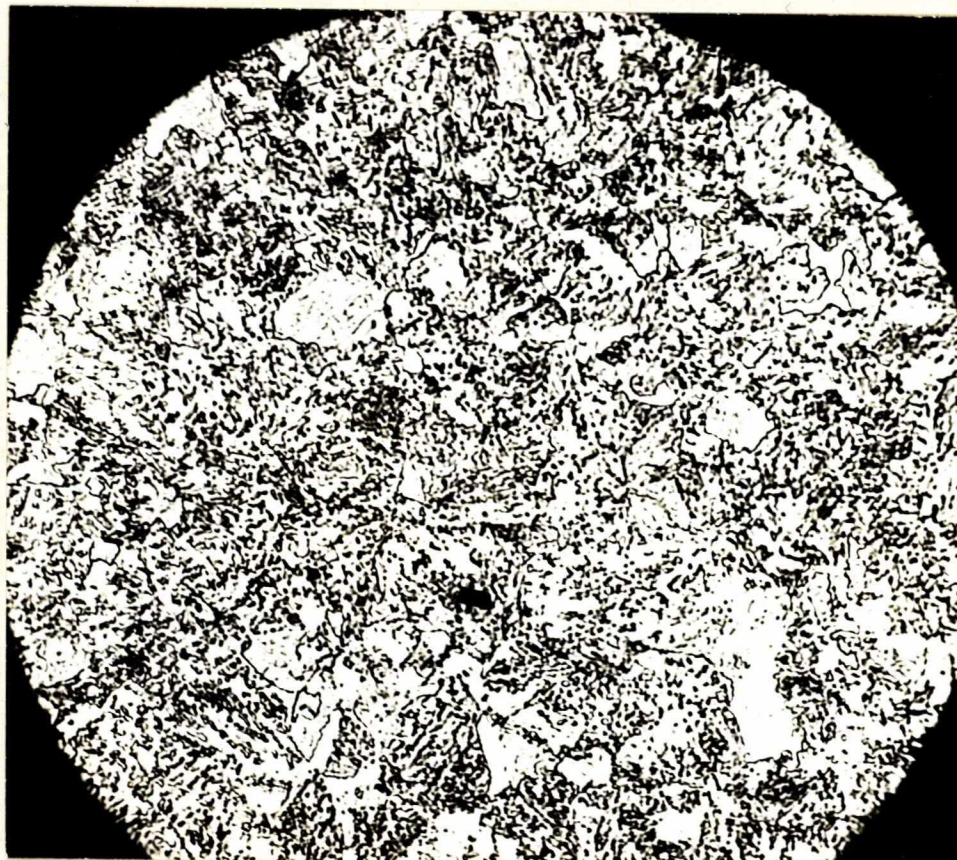
Grain Size:

A standard McQuaid-Ehn grain size test was made on both plates. The results were 4-5 A.S.T.M. for each plate.

Microscopic Examination:

Transverse microspecimens were cut from each plate and then polished. These were etched in 2 per cent nital and examined under the microscope. Figure 1, at X1000 magnification, illustrates the spheroidal structure obtained from Lot No. 1204. Figure 2 (X1000) shows the acicular ferrite, tempered martensite structure of the Lot No. 1205 plate.

Figure 1.



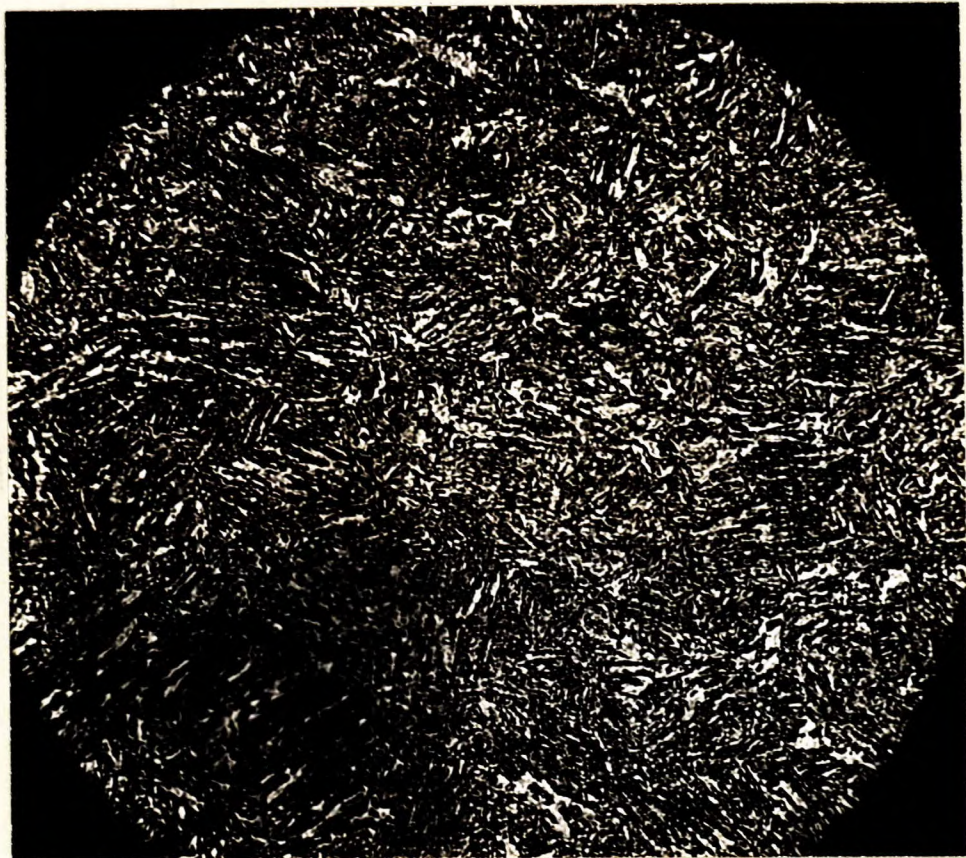
X1000, nital etch.

LOT NO. 1204.

Spheroidized structure.

(Microscopic Examination, cont'd) -

Figure 2.



X1000, nital etch.

LOT NO. 1205.

Tempered structure.

Discussion:

The chemical analysis indicates that two different heats of steel are represented by the two plates. Lot No. 1204 is softer, both at the surface and in the core, and also has more decarburization. This plate is in the spheroidized condition, probably because of a long time draw at a high

(Discussion, cont'd) -

temperature, whereas the Lot No. 1205 plate appears to be tempered martensite and acicular ferrite. The appearance of the latter structure is indicative of a high-temperature draw where the soaking time has not been long enough to cause spheroidization.

Conclusions:

1. Two different heats of steel appear to be represented by the plates submitted.
2. Lot No. 1204 is of lower hardness and has more decarburization than Lot No. 1205.
3. The McQuaid-Ehn grain size of both plates is 4-5.
4. Lot No. 1204 plate has a spheroidized structure whereas the other plate is well tempered martensite and acicular ferrite.

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SLG:GHB.