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DEPARTMENT OF MINES AND RESOURCES

BUREAU OF MINES

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Ottawa, November 13, 1946.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 2139.

Metallurgical Examination of Induction-Heated Rock Drills..

(Copy No. 9.)

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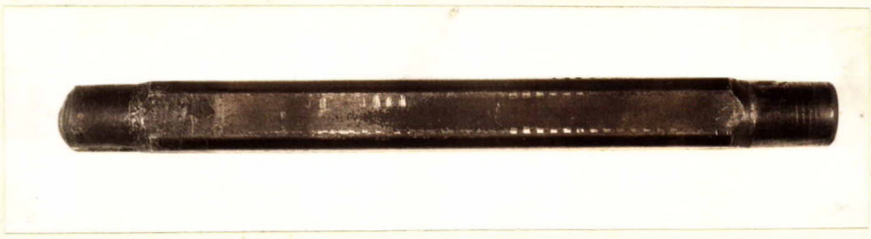
Origin of Material and Object of Investigation:

On November 1, 1946, Dr. G. S. Farnham, metallurgist, Development and Research Division, The International Nickel Company of Canada, Limited, 25 King St. W., Toronto 1, Ontario, submitted personally for examination two specimens of steel rock drill (see Figure 1). It was stated that one piece had been induction heated, forged, and air cooled and that the other had been induction heated, forged, air cooled, reheated by induction, and water quenched. It was requested that a metallurgical examination be carried out to determine the effects of induction heating, since this method was being tried experimentally with a view to using it in production.

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

Figure 1.



ROCK DRILL.
(Approximately 1/2 size.)

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Chemical Analysis:

Drillings were taken from each sample which was submitted, for chemical analysis. The results were as follows:

	Forged Only	Forged and Quenched
	- Per Cent -	
Carbon -	0.82	0.81
Manganese -	0.27	0.24
Silicon -	0.13	0.14
Sulphur -	0.020	0.019
Phosphorus -	0.021	0.022

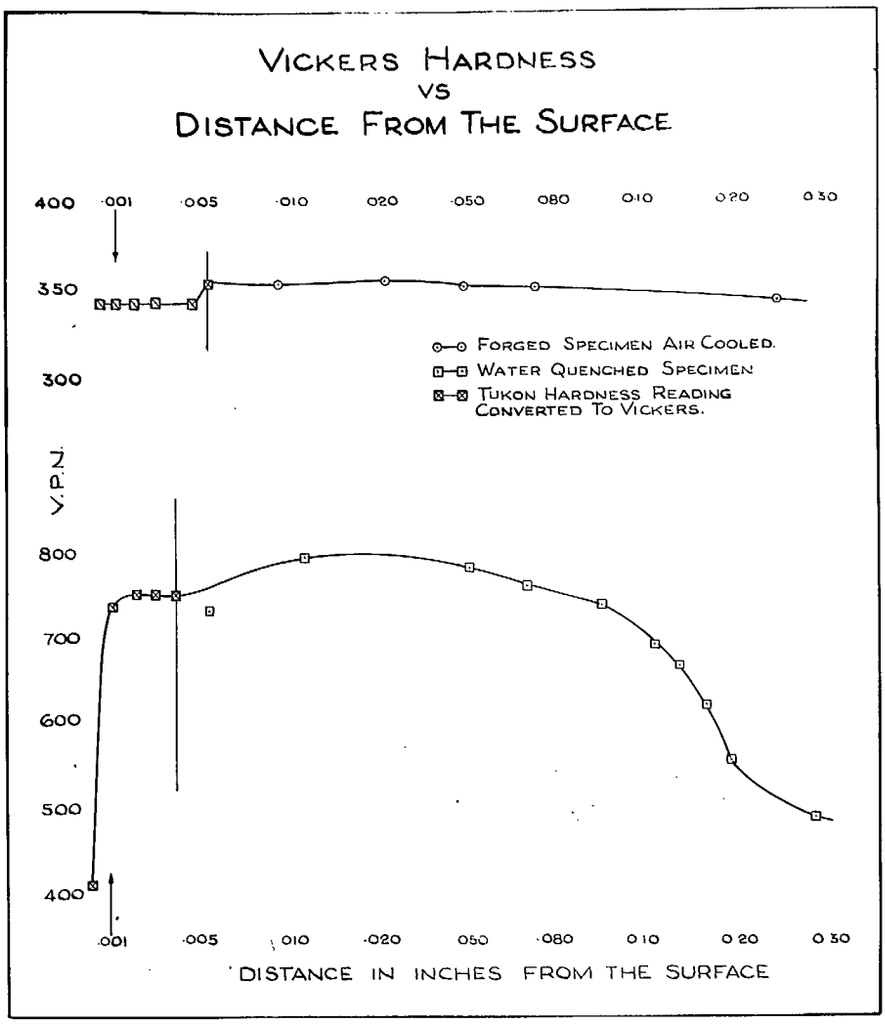
Hardness Tests:

Samples were cut from each rock drill, for hardness tests. A section was cut from the top flat face longitudinally down the shaft of the drill for about one inch in length. Hardness readings were taken on the inner face, from the centre out to the surface. The Vickers machine and a 10-kg. load was used. Readings were taken on this machine to about 0.005 inch from the surface. In order to obtain hardnesses even closer than 0.005 inch, further

(Hardness Tests, cont'd) -

tests were made using the Tukon hardness machine and a $\frac{1}{2}$-kg. load. Figure 2 shows the curves obtained on plotting the results. The vertical line divides the readings taken on the Tukon tester from those taken on the Vickers machine. The Tukon test results have been translated to Vickers hardness numbers for comparison. It should be pointed out that the translated figures are somewhat less accurate than the true readings.

Figure 2.



Grain Size and Microscopic Examination:

The samples used for hardness tests were polished and etched in 2 per cent nital. Figures 3 and 4, taken at X100 magnification, illustrate the fine pearlitic structure at the centre and at the surface of the forged and air-cooled sample. The grains appear to be relatively fine at both points in the specimen. No visible decarburization exists at the surface. Figure 5 (X100) illustrates the fine grain size (7-8) shown by the grain boundary troostite in the centre of the water-quenched rock drill. Figure 6 (X300) shows the fine martensite structure, some nodular carbides, and a small amount of decarburization at the surface of the water-quenched specimen. Vilella's etch on this sample indicated a grain size of 7 to 8 at the surface.

Figure 3.

X100, nital etched.

CENTRE OF FORGED AIR-COOLED SPECIMEN.

Figure 4.

X100, nital etched.

SURFACE OF FORGED AIR-COOLED SPECIMEN.

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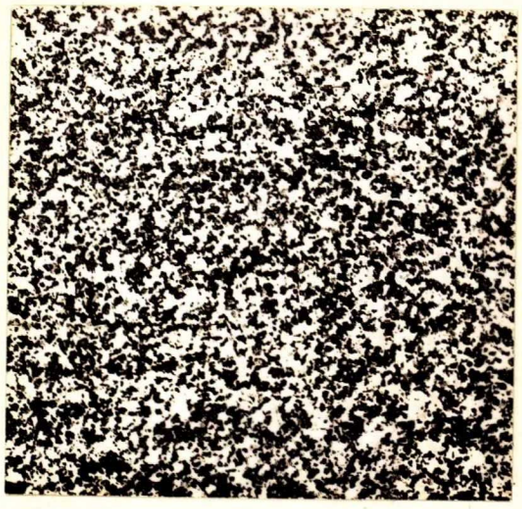
(Grain Size and Microscopic Examination, cont'd) -

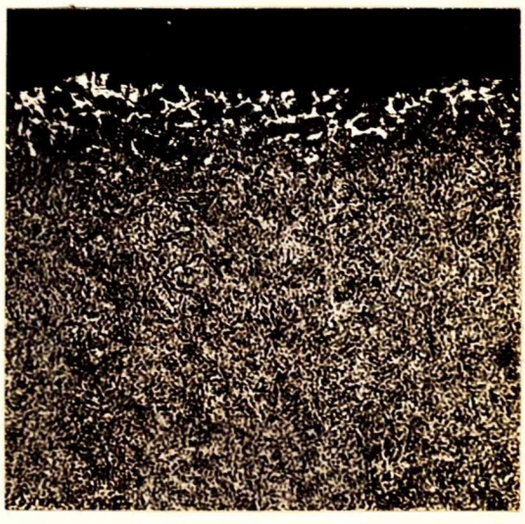
Figure 5.



X100, nital etched.

TROOSTITE STRUCTURE AT CENTRE OF QUENCHED SPECIMEN.

Figure 6.



X300, nital etched.

FINE MARTENSITE.

Note decarburized layer at the surface, also several very small nodules of cementite.

Discussion:

Both rock drill samples appear to be from the same heat of steel. The chemistry of the steel corresponds to that of Atlas X-10 or similar grades of water hardening tool steel.

The hardness tests and the microscopic examination indicate practically no decarburization on the forged, air-cooled drill. From this standpoint, the advantage of induction heating can readily be appreciated. It should also be mentioned that the piece of bar stock used for this drill must have been relatively free from decarburization. The fine grain both at the centre and at the surface indicates that the steel has not been heated to too high a temperature.

The quenched specimen has a very thin, partially decarburized layer, less than 0.001 inch from the surface, as indicated by the curve in Figure 8. It will be noted that at 0.001 inch

(Discussion, cont'd) -

from the surface the hardness is still over 700 V.P.N. In production the decarburization may vary somewhat, if proper precautions have not been taken.

The temperature from which the drill was quenched was over the critical temperature of the steel (1360° F.), since the proper hardness (namely 750 V.P.N.) and structure were obtained on quenching for this type of steel. The temperature was also well under the coarsening temperature of the steel, since a fine grain size was obtained, namely 7 to 8.

The hardness curve of the quenched drill indicates that a satisfactory depth of hardness has been obtained. At 0.10 inch from the surface a hardness of 700 V.P.N. is shown.

The induction heating cycle used for the drills appears to be satisfactory in so far as the grain size and decarburization are concerned.

Conclusions:

1. A eutectic steel has been used for the drills, resembling Atlas X-10 in analysis.

2. Hardness tests and microscopic examination show that there is practically no decarburization on the air-cooled drill.

3. The steel has been heated to a temperature below its coarsening temperature for the forging operation, since a fine grain exists in the air-cooled sample both at the centre and at the surface.

4. The quenched specimen has a slight partially decarburized layer to a depth of approximately 0.001 inch.

(Continued on next page)

(Conclusions, cont'd) -

5. At 0.001 inch from the surface the hardness of the quenched sample is over 600 V.P.N.

6. The temperature from which the drill was quenched was over the critical (1360° F.) and under the coarsening temperature of the steel.

7. The grain size of the quenched sample is 7-8 at the centre and at the surface.

8. A satisfactory depth of hardening has been obtained.

9. The cycle used for the induction heating appears to be satisfactory, since a fine-grained steel has resulted in hardening and very little decarburization has been formed.

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