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O T T A W A November 19th, 1943.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1535.

Examination of Two 6-mm. Armour Plates Which Cracked on Bending.

(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 Request and Object of Investigation:

On October 26th, 1943, two samples of cracked 6-mm. armour plates were submitted to these Laboratories for examination. These plates (AEDB Lots Nos. 817 and 818) were sent under Requisition No. 731, Report No. 13 T.50, Request J-26, by Dr. C. W. Drury, Director of Metallurgy, Army Engineering Design Branch, Department of Munitions and Supply, Toronto, Ontario, who requested that an investigation be made to determine the cause of cracking which was said to have occurred in the cold-forming operation.

Macro-Examination:

A visual examination revealed that the crack on one plate was blued. The macroscopic examination brought out no other point of interest.

Chemical Analysis:

	Lot No. 817	Lot No. 818
	- Per cent -	
Carbon -	0.25	0.25
Manganese -	0.85	0.85
Silicon -	0.44	0.45
Sulphur -	0.037	0.038
Phosphorus -	0.034	0.021
Chromium -	1.10	1.03
Nickel -	0.80	0.81
Molybdenum -	0.23	0.21

Hardness Measurements:

Surface hardness measurements were made on each plate. In both cases, results of 341 Brinell were obtained.

Cross-sectional hardness surveys were made with the Vickers hardness tester, using a 10-kilogram load. The results are shown, in chart form, on Page 6.

Bending Tests:

Both of these plates were bent in the Amsler machine using a $\frac{1}{2}$-inch-radius former. In all cases, the plates cracked when bent to the same angle as the pieces as received.

Microscopic Examination:

Sections of the plates were examined under the microscope and both steels were found to be very dirty. The inclusions were elongated and of a bluish-grey colour, indicating that they are of the sulphide type. Figures 1 and 2 show, for each plate, at X100 magnification, typical examples of these inclusions as revealed after a light picral etch. The microstructures of the

(Microscopic Examination, cont'd) -

plates after a longer picral etching are shown in Figures 3 and 4.

Figure 5 shows an enlargement of a sulphur print, taken on one of the plates, which definitely confirms that the inclusions are of the sulphide type.

Discussion of Results; Conclusions:

The chemical analysis of the plates under examination, in itself, gives no answer to the problem of cracking. However, it must be noted that the sulphur content in each case is toward the maximum usually permitted by the SAE specification.

Although the hardness of the plates definitely contributed to the cracking, the prime cause is believed to be steel dirtiness.

The inclusions were proven to be sulphur-bearing. However, they are not believed to be straight manganese or iron sulphide, because of the lack of correlation between the sulphur content and the number of inclusions found. Most probably the inclusions are sulpnide containing silicates.

The bending tests carried out in these Laboratories indicate that defects in the material, rather than some fault in the mechanical operation of bending, are responsible for the cracking.

The question of whether a clean steel of the same hardness could be cold-formed without cracking could not be answered, because no inclusion-free steel of the same analysis was available for testing.

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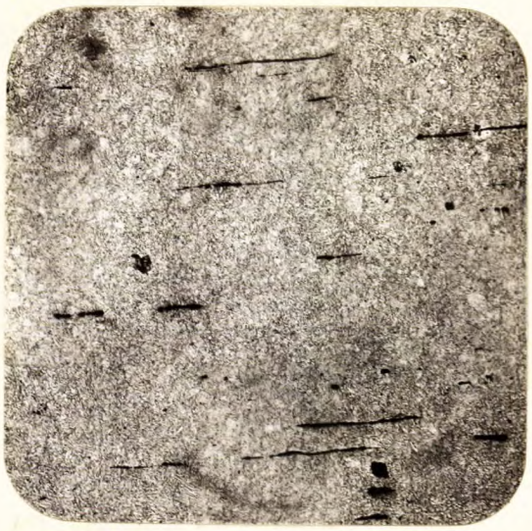
Figure 1.



X100, light picral etch.

SHOWING AN INCLUSION PATTERN
IN AEDB LOT NO. 817 SPECIMEN.

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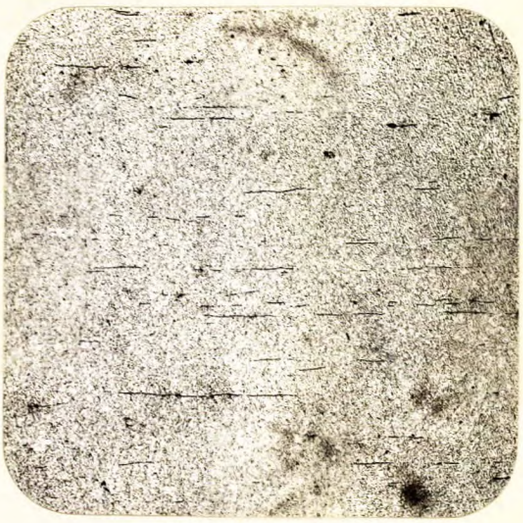
Figure 2.



X100, light picral etch.

SHOWING AN INCLUSION PATTERN
IN AEDB LOT NO. 818 SPECIMEN.

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Figure 3.

X500, picral etch.

SHOWING THE MICROSTRUCTURE
OF AEDB LOT NO. 817.

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Figure 4.

X500, picral etch.

SHOWING THE MICROSTRUCTURE
OF AEDB LOT NO. 818.

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Figure 5.

X9.

A SULPHUR PRINT OF A SECTION
OF AEDB LOT NO. 817.

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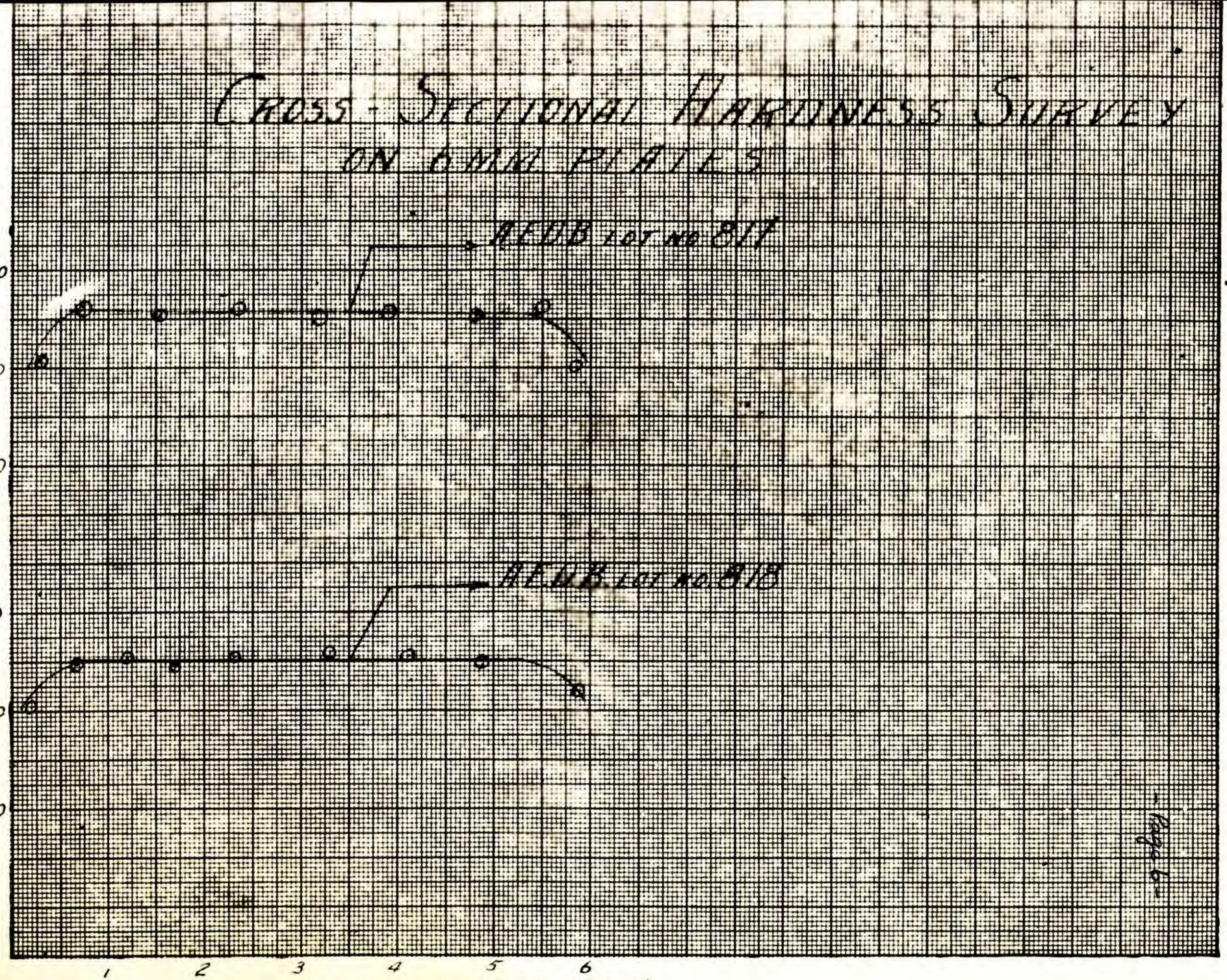
(Note: Page 6 following is
a hardness survey chart.)

Cross-Sectional Hardness Survey on 6 mm Plates



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