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O T T A W A May 14th, 1943.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1406.

Examination of Armour Plate Which Cracked in Straightening.

(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 Sample:

On May 6th, 1943, Dr. C. W. Drury, Director of Metallurgy, Army Engineering Design Branch, Department of Munitions and Supply, Toronto, Ontario, submitted a sample of armour plate which had fractured during the straightening process.

Object of Study:

Request was made (Requisition No. 459, May 10th, 1943, AEDB Lot No. 498, Report No. 12, Test 2) for a metallurgical examination of this plate in order to determine, if possible, the cause of failure.

Chemical Analysis:

After approximately one-tenth of an inch had been removed from the surface, drillings for chemical analysis were taken from the plate. The composition was found to be as follows:

		Per cent
Carbon	=	0.29
Manganese	=	0.86
Silicon	=	0.60
Sulphur	=	0.035
Phosphorus	=	0.042
Nickel	=	0.72
Chromium	=	0.96
Molybdenum	=	0.13

Macro-Examination:

The plate broke with a duplex fracture. This fracture, all across one side of the plate (top, Figure 1), had a slaty, laminated appearance and was partially oxidized while most of the rest of the fracture apparently occurred at a single moment of time. The slaty defect seemingly did not extend more than 1.5 mm. to 2 mm. into the plate.

Physical Examination:

Hardness readings were taken (using the Vickers method with a 10-kilogram load) through the thickness of the plate. Figure 2 depicts graphically the values obtained. These tests indicate that there is approximately 0.9 mm. decarburization on the slaty side of the plate and about 1.2 mm. decarburization on the other (decarburized material being considered as any which has lost a portion of its original carbon).

Hardness tests on the slaty part of the fracture shown at 100 diameters in Figure 3 gave readings of 178 and 222 Vickers.

An izod bar 10 mm. square with notches 2 mm. deep

(Physical Examination, cont'd) -

was machined parallel to the direction of fracture. It gave the following values at test:

Breaking load, foot pounds = 21.5, 14, 20.

Microstructure:

Two specimens for the microscope were cut from the fractured part of the plate and were polished on a face approximately perpendicular to the direction of failure.

The slaty part of the fracture had very large inclusions, with numerous small inclusions acting as connectors between the larger ones. These points are illustrated in Figure 4. Examination of these large inclusions at high magnifications (Figure 5) shows that they are of the duplex type and that they contain little globules of metal. These large inclusions, however, were found only at and in the vicinity of the slaty part of the fracture.

After an etch of 2 per cent nitric acid in alcohol was applied, the slaty part of the fracture was found to be much more severely decarburized than the outside edge of the plate. This is shown in Figure 3.

Discussion of Results:

Chemical analysis results showed that apparently there was nothing in the composition of the part that would account for the breakage.

The oxidation on part of the surface of the slaty section of the fracture indicates that this was never continuous with the plate. Large inclusions present in this region probably hindered its being joined by a process similar to forge welding.

The duplex nature of the large inclusions, the metal

(Discussion of Results, cont'd) -

globules present in them, and possibly also the greater decarburization of the slaty part of the fracture (shown by hardness tests and microstructure) as compared to the surface of the plate, all show that this slaty, laminated discontinuity was caused by a defect in the ingot used in forming the plate and not by lapping over metal in the rolling operation. Since it is difficult to imagine how a central piping defect could occur on the surface of the finished plate, it is probable that the defect encountered here was caused by an undercutting cavity at or near the surface of the ingot or by localized surface roughness and uncleanness.

From all of the foregoing it appears that, in all probability, the failure of this plate during straightening was caused by the notch effect of the slaty, laminated discontinuity.

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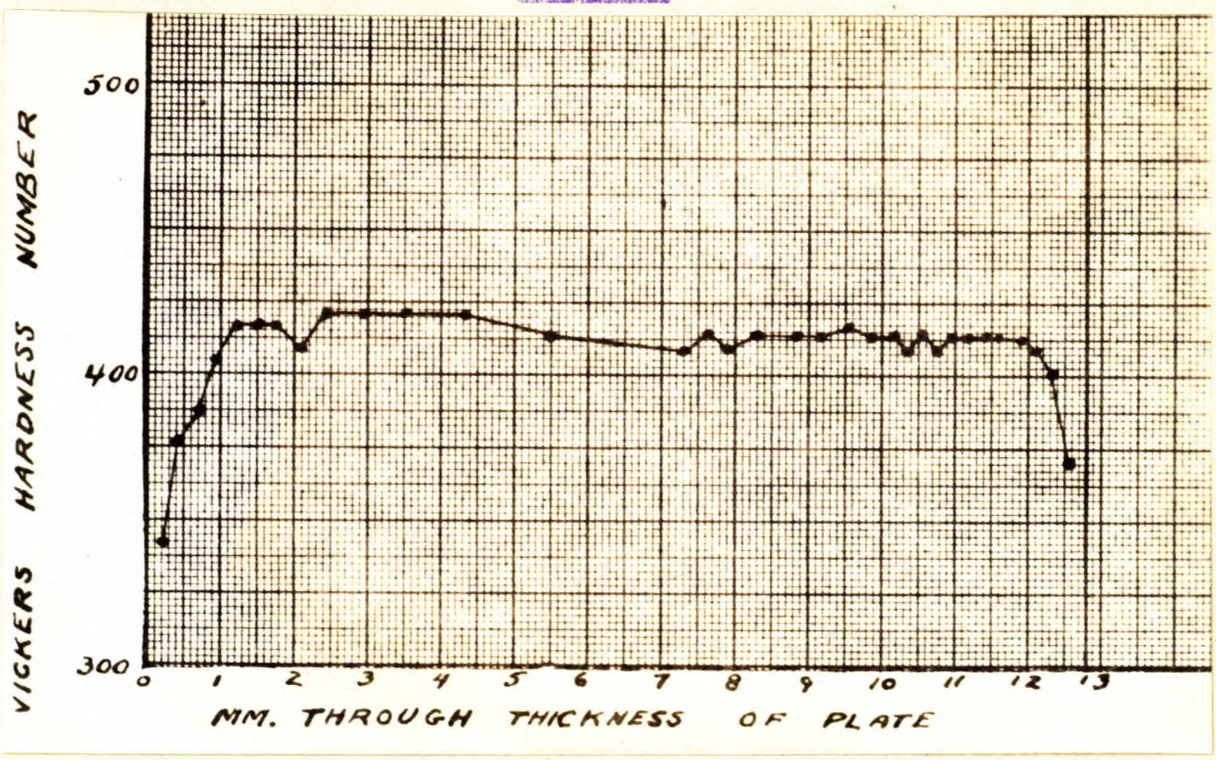
Figure 1.

View of fracture, showing slaty defect at top of picture.

(Approximately to size).

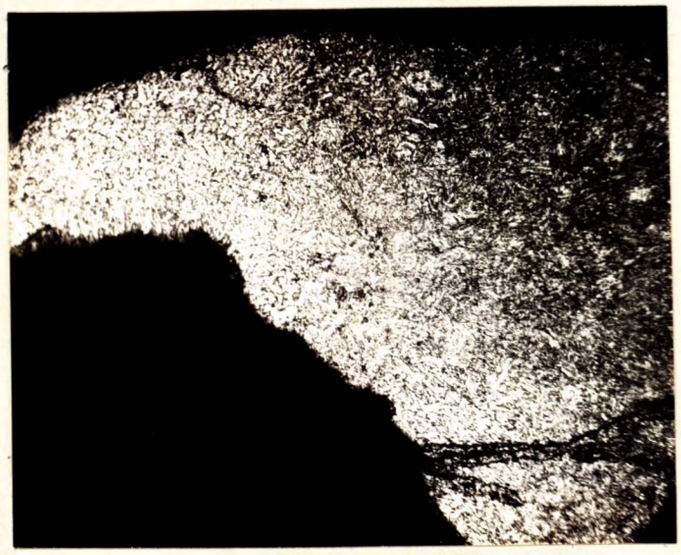
Figure 2.



Side of plate that had slaty defect on it is at right of diagram.

(Approximately to size).

Figure 3.



X100, nital etch.

Surface at top of picture is outside edge of plate. Irregular sloping surface is part of slaty section of fracture.

Figure 4.

X100, unetched.

Figure 5.

X1000, unetched.

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