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REPORT NO. 710/871

EXAMINATION OF A FRAGMENT OF AN  
ARMOR PLATE CASING FROM M. W. KELLOGG CO.

by

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SEPTEMBER 25, 1936

WASHINGTON, D. C.  
ARMY ORDNANCE CORPS

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October 25, 1938

EXAMINATION OF A FRAGMENT OF AN  
ARMOR PLATE CASING FROM M. W. KELLOGG CO.

Reference: O.O. 470.5/2417

Purpose

The purpose of this investigation was to determine the composition and study the microstructure of a fragment of armor plate casing manufactured by the M. W. Kellogg Co.

Conclusions

1. The casing is a carburized high chromium product (9.7% Cr) containing the normal molybdenum and vanadium contents found in the Standard Chrome-Molybdenum-Vanadium plate with an addition of .85% Nickel.
2. The micro structure shows very prominent grains which vary to a considerable extent in size.
3. Pronounced grain boundary carbide was found, suggesting that the casing would be very brittle.

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### Method of Procedure

An examination of the sample included the following:

- (1) Spectrographic analysis
- (2) Chemical analysis
- (3) Hardness survey
- (4) Microscopic examination

### Experimental Results

1. Spectrographic Analysis: The spectrographic analysis is given below.

Iron - base metal	:	Titanium - trace
Chromium	:	Aluminum - "
Nickel	:	Tin - "
Manganese	:	Tungsten - none
Silicon	:	Tantalum - "
Molybdenum	:	Columbium- "
Vanadium	:	Cobalt - "
Copper - small amount	:	Zirconium- "

2. Chemical Analysis: Chemical analysis of the sample is given below.

<u>C</u>	<u>Mn</u>	<u>Si</u>	<u>Cr</u>	<u>Mo</u>	<u>V</u>	<u>Ni</u>	<u>Cu</u>
.765	.82	.370	9.70	.63	.24	.85	.04

3. Hardness Survey: Surface hardness ranged from 341 to 545 Brinell with an average value of 456.

On the cross section, the hardness was 477/555 Brinell.

Due to the small size of sample, Rockwell "C" hardness values were determined and then transposed to Brinell (3000 Kg load).

4. Microscopic Examination: Photomicrographs illustrating the grain boundary conditions and general micro structure are shown in Figures 1 - 7, inclusive.

#### Discussion

Small rounded nonmetallic inclusions were found in a pattern which appears as though segregated in remnants of the primary grain boundaries, see Figures 1 and 2.

A Murakami etch reveals the presence of many carbide chains, see Figure 3. We believe this indicates lack of ductility under impact.

Figures 4, 5 and 6 show polyhedral grains typical of austenitic structure in the cross section; Figure 4 illustrates the average grain size; Figure 5 illustrates the occasional large grain scattered through the specimen; while Figure 6 is a higher pour showing in more detail the carbides. Figure 7 illustrates the very

large grain found on the surface of the specimen.  
This large grain on the surface may be indicative of  
a certain amount of surface decarburization, since  
the hardness survey indicated softer material at the  
immediate surface.

Respectfully submitted,

*E. L. Reed*

E. L. Reed,  
Research Metallurgist.

*S. L. Kruegel*  
S. L. Kruegel,  
Jr. Physical Sci. Aide.

- (1) Small rounded nonmetallics segregated in a pattern resembling grain boundaries.

Unetched, X1000

MA1363

- (2) Same area as (1) at a higher magnification, X250.

MA1362

(2)

X/00

(2)

X250

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- (3) Fairly continuous carbide chains,  
segregated at the grain boundaries.

Murakami etch, X1000

- (4) & (5) Polyhedral grains typical of  
austenitic structure. Note variation  
in size of grains.

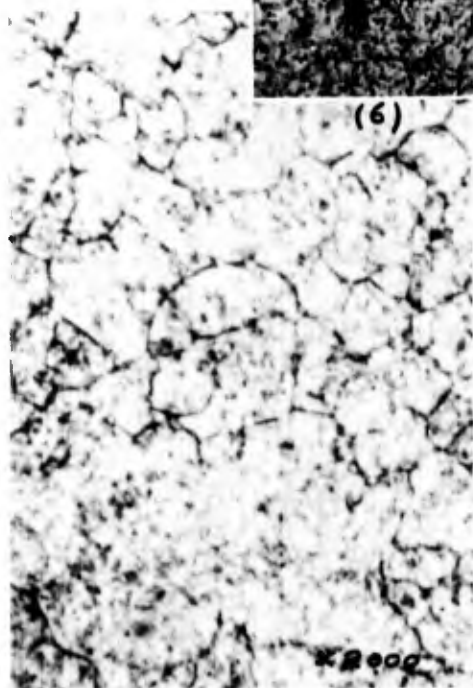
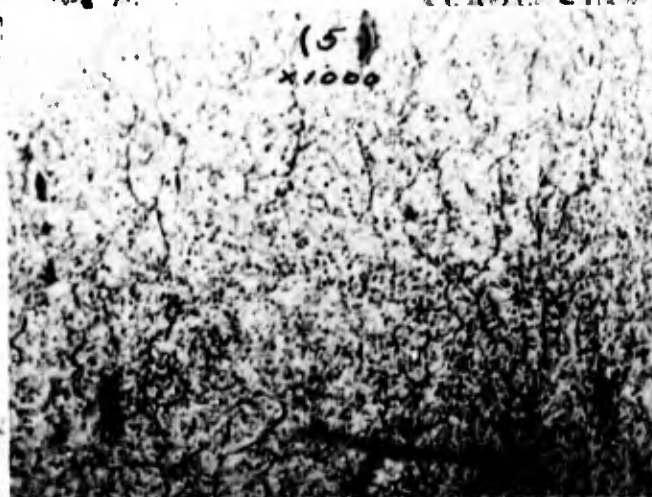
1% Nital etch, X1000      MA1370  
MA1377

- (6) High magnification shows in greater  
detail carbides at grain boundaries.

1% Nital etch, X2000      MA1371

- (7) Extremely large grains predominate on  
the surface.

1% Nital etch, X1000      MA1369



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