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WATERTOWN ARSENAL LABORATORY

MEMORANDUM REPORT

NO. WAL 710/735

Metallurgical Examination of a Cast Turret Manufactured by
the American Steel Foundries

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BY
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WATERTOWN ARSENAL LABORATORY

MEMORANDUM REPORT NO. WAL 71076

Final Report on Problem B-4,73

28 March 1945

UNANNOUNCED



Metallurgical Examination of a Cast Turret Manufactured by
the American Steel Foundries

ABSTRACT

Metallurgical examination of two specimens representing the thinnest and thickest sections (1" to 1-1/4" and 3" to 3-1/2" respectively) of an M4 Cast Turret, No. B171, produced by the American Steel Foundries, indicated that the properties of the two sections were a function of the ease with which they could be hardened by quenching. The thin section has been fully quenched out and has good impact strength at both room temperature and at -40°F. The thick section has not been completely hardened through the section, as evidenced by the decreased impact strength at the center of the section when tested at -40°F. These results were corroborated by fracture tests. The impact properties of the heavy section are, however, deemed adequate to insure ductile behavior upon ballistic impact.

1. As requested by the Ordnance Research Center, Aberdeen¹, a metallurgical examination has been conducted on two samples of the cast turret No. B171 for the Medium Tank M4, manufactured by the American Steel Foundries, which was subjected to ballistic tests at the Ordnance Research Center, Aberdeen, and exhibited high resistance to penetration with the 37mm APM 74 projectiles. The samples were of two thicknesses and were numbered as follows: B171A-1-1/4" thick, and B171B-3-3-1/2" thick. It was requested that a comparison of the two samples be made in order to determine the relation of the quality of the two thicknesses of the cast turret.

1. APO 470.5/1025 - Wtn 470.5/8635(r), dated 14 February 1945.

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2. The metallurgical examination of the cast turret consisted of the following tests:

- a. Chemical analysis.
- b. Brinell hardness survey.
- c. Fracture tests.
- d. V-notch Charpy tests.
- e. Microscopic examination.

3. The results of the metallurgical examination are as follows:

- a. Chemical analysis.

<u>Sample No.</u>	<u>C</u>	<u>Mn</u>	<u>Si</u>	<u>S</u>	<u>P</u>	<u>Ni</u>	<u>Cr</u>	<u>Mo</u>	<u>V</u>	<u>Cu</u>	<u>Al</u>
B171	.29	1.60	.48	.026	.017	.12	.50	.23	Tr	.12	.06

This alloy content is believed too low for the complete hardening of a three inch section, even under the most drastic conditions of quenching.

b. Brinell hardness survey. Slices were cut from the fracture specimens and five Brinell hardness impressions were made on the cross-sections of each slice. The results are given below:

<u>Sample No.</u>	<u>Range</u>	<u>Average</u>
B171A(1" thick)	223-235	231
B171B(3" thick)	212-229	222

c. Fracture test. Both sections were notched and fractured under the forge hammer and were rated with respect to fibre and steel soundness. No. B171A (1" thick section) exhibited a fibrous fracture with some shrinkage throughout. No. B171B (3" thick section) had a predominately fibrous fracture with a crystalline area in the center covering approximately 10% of the total area. The thick section also exhibited some shrinkage areas throughout the fracture.

d. V-notch Charpy impact tests. V-notch impact tests were made on samples machined from the centers of both sections. The results are given below:

Sample No.	Thickness of Section	+70°F.		-40°F.	
		Ft./lbs.	Fracture Rating	Ft./lbs.	Fracture Rating
B171A	1-1/4"	45.8	*F+shrinkage.	42.0	***Cbf-1/4
B171A	1-1/4"	40.3	F+shrinkage.	36.6	Fc-1/3
		Ave. 43.1		Ave. 39.3	
B171B	3-1/2"	58.6	**Fc-1/4+shrinkage.	29.5	Cbf-9/10
B171B	3-1/2"	46.2	Fc-1/4+shrinkage.	27.3	Cbf-9/10
		Ave. 52.4		Ave. 28.4	

*F- Fibrous

**Fc - Fibrous matrix with spots of crystallinity. Fracture refers to amount of crystallinity.

***Cbf - Bright crystalline patch surrounded by fibrous border.

Sample No. B171B shows a decrease in impact energy when tested at -40°F. indicating that this section has not been completely hardened throughout.

e. Microscopic examination. Photomicrographs illustrating the microstructure of both sections of the cast turret are shown in Figure 1. Section No. B171A (1-1/4" thick) had a microstructure similar to tempered bainite associated with fine carbides. Section No. B171B (3" thick) exhibits a considerable amount of ferrite and a structure similar to tempered bainite and fine carbides.

4. The results of this investigation indicate that the American Steel Foundries cast turret No. B171 had good metallurgical properties, the thinner section (No. B171A) being fully quench hardened, whereas the thicker 3" section was not completely hardened throughout.

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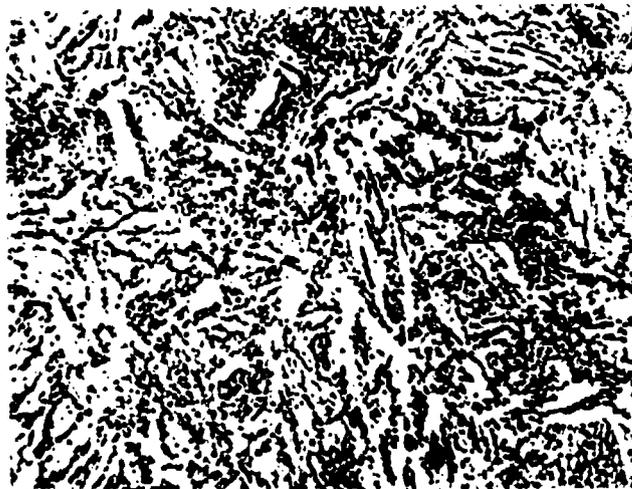
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Microstructure of Cast Turret No. B171 Manufactured by

the American Steel Foundries



No. B171a X1000 Picral
Structure similar to tempered bainite
associated with fine carbides.



No. B171 X1000 Picral
Structure similar to tempered bainite
associated with fine carbides and
ferrite patches.