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WATERTOWN ARSENAL LABORATORY

MEMORANDUM REPORT

NO. WAL 710/563

Metallurgical Examination of Sidewall Section of Cast Turret for T23 Tank Manufactured by General Steel Castings Corporation

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W. C. Woods
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BY

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Asst. Metallurgist

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Watertown Arsenal Laboratory

Memorandum Report WAL 710/563

Final Report on Problem B-4.17

4 December 1943

Metallurgical Examination of Sidewall Section

of Cast Turret for T23 Tank Manufactured

by General Steel Castings Corporation

1. An experimental cast tank turret ~~drawing number D53526~~ for ~~the~~ a medium tank ~~T23, and produced by General Steel Castings Corp~~ was subjected to ballistic test ~~at The Proving Center, Aberdeen (APG Report AD-503). The tests~~ which indicated that the area adjacent to the base ring offered considerably less resistance to penetration than the side of the turret away from the base ring under the impact of 75 mm. M61, ~~APC~~ armor piercing projectiles at an obliquity of 48deg from normal.

2. A sample from the turret sidewall extending up to a distance of 18" from the base ring was submitted to this arsenal for metallurgical examination. The specimens selected for study were obtained from the two areas, one immediately adjacent to the base ring and the other at the uppermost area of the sample submitted. See Figure 1 for locations of test specimens.

3. No differences were observed in the metallurgical properties between the two areas in question, to which the variation in ballistic properties could be attributed. The steel was relatively sound and free from casting defects in the sample examined. The casting would be considered rejectable, however, because of improper heat treatment, since a small amount of crystallinity was observed in the fractures of both areas examined.

4. The metallurgical tests conducted on the sample were as follows:

   a. Hardness surveys.

   b. Macroetching.

   c. Fracture tests.

   d. Microscopic examination.

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5. Results of the metallurgical examination are as follows:

a. Hardness Tests

A Brinell hardness survey was obtained on cross sections of the casting at selected stations covering the area from the base ring to the middle of the sidewall. Except for a slightly increased hardness of 255 Brinell at the botton of the base ring, the section possessed a hardness of 235 to 248 Brinell throughout. The locations of the tests are shown on the macroetched section in Figure 2 and the data are recorded in the accompanying Table I.

b. Macroetched Structure

Macroetching in hot acid revealed a small amount of nonmetallic segregation and porosity which was confined to the central third of the cross section. See Figure 2. Relatively little difference was observed in the two areas under examination.

c. Fracture Tests

A fracture test using a forge hammer for breaking was conducted on specimens from each of the two areas, one adjacent to the base ring, and one in the middle of the sidewall of the turret. Some evidence of a crystalline break was observed in the fractures from both areas. A typical fracture is shown in Figure 3A in which the crystallinity occurs in the form of chevrons at the center of the section.

A small section 2"x3"x6" was reheat treated as follows:

	Temperature	Rise	Soak	Coolant
A	1650°F	1 hr.	3 hrs.	Water
B	1175°F		3 hrs.	Air

The above section was then notched and broken under the forge hammer and the resulting fracture was essentially fibrous. Either increasing the alloy content or improving the quenching practice a small amount should eliminate the formation of high temperature transformation products and thereby improve the toughness of the armor.

d. Microscopic Examination

Microspecimens were obtained from both areas under consideration. There was a small amount of scattered inclusions in both specimens. A small amount of free ferrite was observed in the central area of both specimens, indicating incomplete transformation to martensite on quenching. The structures are shown in Figures 3B and 3C.

e. Discussion of Results

Metallurgical differences between the two areas under discussion (adjacent to the base ring and at the middle of the sidewall) were minor. The hardness, soundness, and microstructure were similar. The material would be expected to exhibit uniform satisfactory properties when tested at room temperature though a small amount of incompletely quenched out structures was present which would probably influence the shock properties of the armor at subzero temperatures.

6. The explanation for the variation in ballistic limits obtained in the two areas cannot be explained from the metallurgical tests. It is suggested that the observed variation was more likely a ballistic phenomenon and that one possible explanation involves the variable resistance to deformation of the wall of the casting in the two areas. It is possible that the upper sidewall area, being unrestrained to deformation as compared to the zone adjacent to the base ring, could yield sufficiently under projectile impact so as to result in a higher ballistic efficiency under the high obliquity conditions. Of course, at high obliquities any incidental yaw would materially effect the depth of penetration of the projectile.

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APPROVED:

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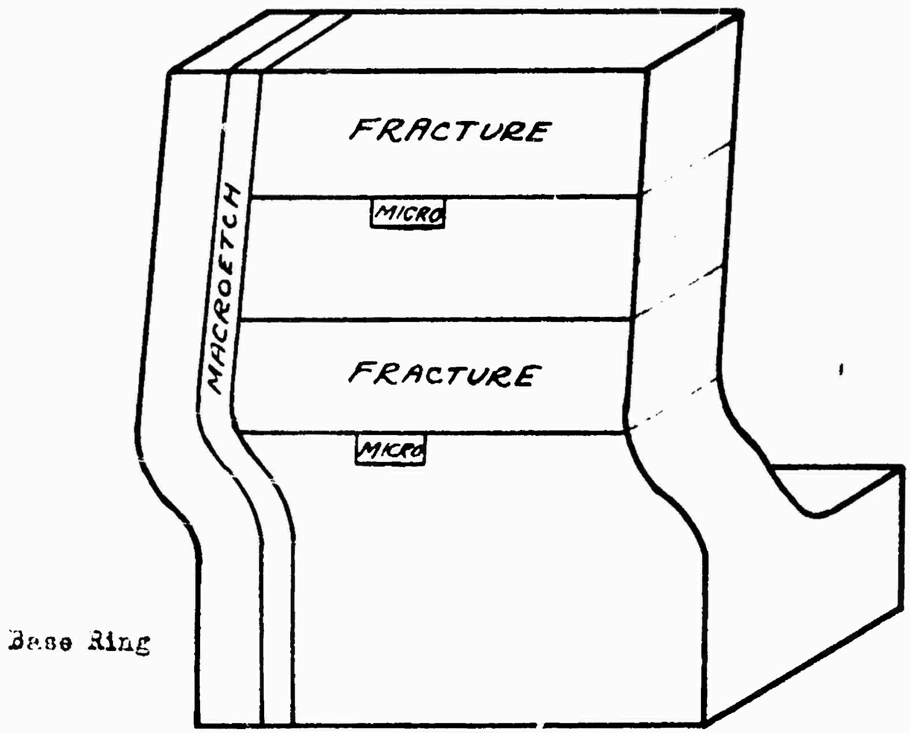

Diagram of Section Submitted from the Cast Turret D53526
Made by General Steel Castings Corporation

Note location of test specimens.

FIGURE 1

TABLE I

Hardness and Thickness Surveys in the
Base Ring and Side of the Cast Turret

Location	Brinell Hardness	Thickness (Inches)
AB	241, 212*, 241, 248, 241	2.68
CD	248, 235, 235, 248, 248	2.58
EF	248, 241, 229, 248, 248	2.60
GH	241, 248, 241, 241, 248	2.62
IJ	- - - - -	2.62
KL	235, 235, 235, 248, 241	
MN	248, 235, 235, 229, 241	
OP	241, 223, 223, 223, 235, 255, 235	
QR	235, 235, 235, 229, 235, 241, 255	
ST	255, 262, 262, 255, 255	

*Low reading due to porosity.

MACROETCHED SECTION OF EXPERIMENTAL CAST TURRET
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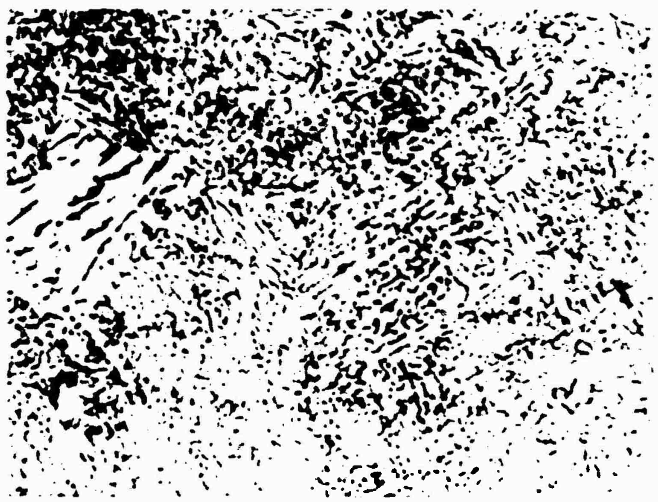
FIGURE 2

Fracture of sample in area adjacent to base ring. Some crystalline streaks are present.

Mag. X1.

Microstructure in the sidewall area of the turret. Some ferrite in the dendritic axes.

Mag. X1000. Picral Etch



Microstructure in area adjacent to base ring. Some ferrite in the dendritic axes.

Mag. X1000. Picral Etch