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IR 65-108
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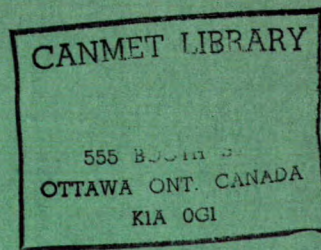
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MINES BRANCH INVESTIGATION REPORT IR 65-108

EXAMINATION OF 155 MM HOWITZER DRIVER CASTING

by

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PHYSICAL METALLURGY DIVISION

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Mines Branch Investigation Report IR 65-108

EXAMINATION OF 155 MM HOWITZER DRIVER CASTING

by

D. E. Parsons* and D. A. Munro**

SUMMARY OF RESULTS

Metallurgical examination of a 155 mm Howitzer driver casting, which contained a 3/8 in. crack adjacent to the boss, showed that the crack coincided with an area of shrinkage.

The chemical composition of the steel conformed to AISI-1020. The casting was used in service in the annealed condition at a hardness of Brinell 150. The casting met the requirements of U.S. Federal Specification QQ-S-681, Class 80-50 (1941), with respect to tensile and yield strength. (Two tensile bars cut from the flat part of the casting gave an average tensile strength of 79 kpsi and an average yield strength of 56 kpsi, with an elongation of 8.8% and a reduction in area of 12.0%.) Possibly higher elongation and reduction in area values were obtained on the separate coupons used for acceptance of the castings.

The subject casting also contained an off-centre hole in the boss and had suffered surface-gouging in two locations apparently due to accidental scarfing by the cutting torch.

It was recommended that the purchase specification, inspection standard and strength level be reconsidered for this casting in view of the stress requirements and service required for this component.

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INTRODUCTION

A 155 mm breech block driver casting was submitted to the Physical Metallurgy Division, Mines Branch, Department of Mines and Technical Surveys by Mr. A. N. Harris, Army Equipment Engineering Division (Armament) with the request that the casting be examined to determine the nature of cracks observed adjacent to the boss.

The covering letter, HQ 6433-155 mm Howitzer (CTS/DEE/AEEE (AD)), dated September 1965, stated that this casting had been subjected to dimensional examination by IS/DND, prior to receipt for sectioning and metallurgical examination.

The covering letter also stated that this "driver" had a service life of only seven proof rounds prior to rejection for inspection and examination.

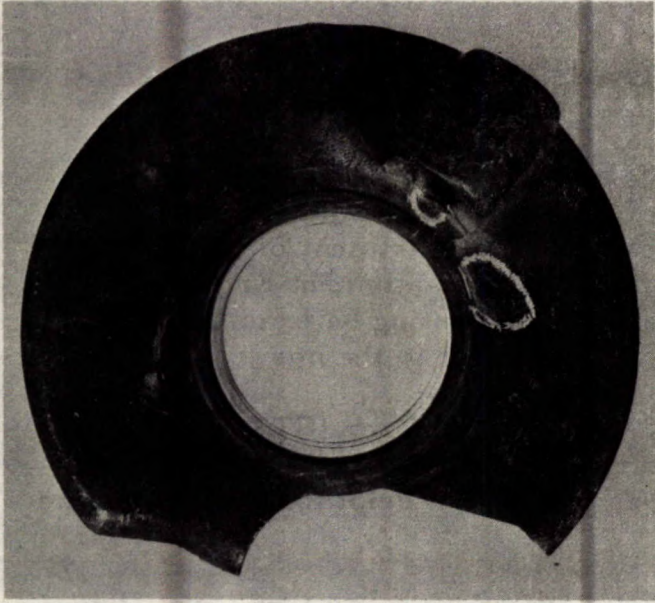
The driver was manufactured to U.S. Ord. Drawing D 5570678 of the Howitzer 155 mm M1A1 Canadian at Sorel Industries Limited.

Figure 1 illustrates three views of the cast steel "driver". Examination of the casting was carried out as follows:-

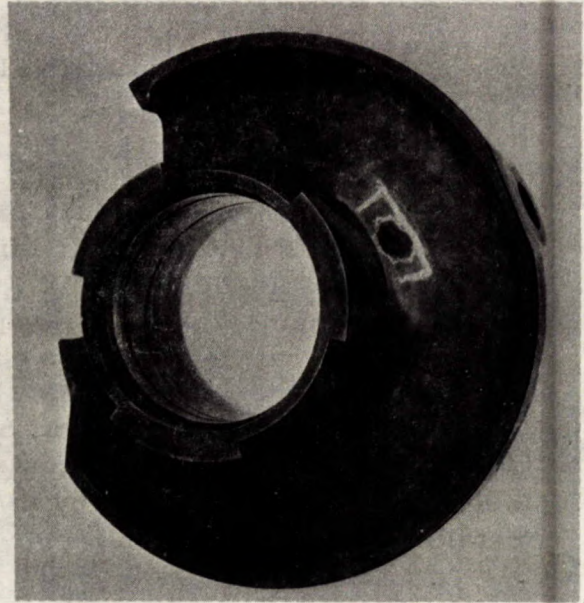
- (1) Visual Inspection
- (2) Radiographic and Magnetic Particle Inspection
- (3) Chemical and Spectrographic Analyses, Tensile Tests
- (4) Metallographic Examination
- (5) Dimensional Check by IS/DND(2).

VISUAL INSPECTION

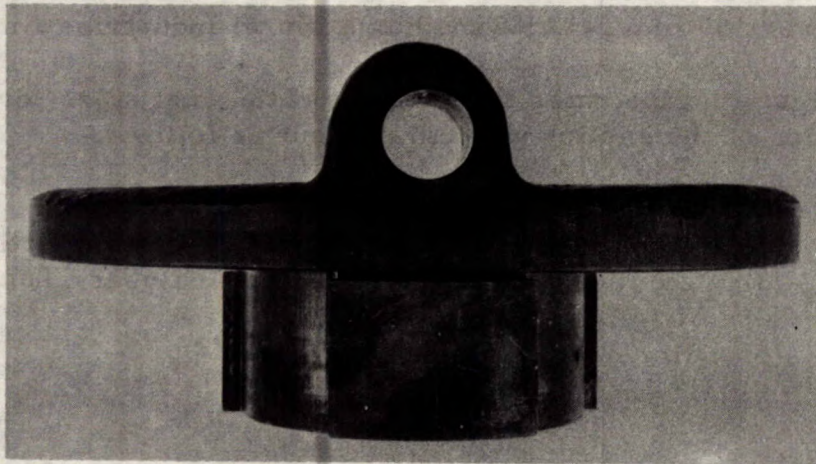
Visual examination showed that the hole present in the boss was off-centre, suggesting an error in boring or misalignment of a core during casting.



(a)



(b)



(c)

X 1/3

Figure 1. Illustrates View of Driver Casting.

(a) Outside Surface

(b) Inside Surface

(c) Elevation Showing Boss

RADIOGRAPHIC AND MAGNAFLUX INSPECTION

Radiograph examination revealed the presence of shrinkage porosity adjacent to the boss. The area of shrinkage is illustrated in a print from the radiograph, Figure 2.

Magnetic particle inspection revealed the presence of a crack approximately 3/8 in. in length adjacent to the boss and associated with the shrinkage area. Two areas were also observed where gouges produced by a cutting torch were visible. Superficial cracks having a length of approximately 1/4 in. were associated with each of the torch marks.

The results of chemical and spectrographic analyses are listed in Table 1.

TABLE 1

Chemical Analyses (Wet Method)

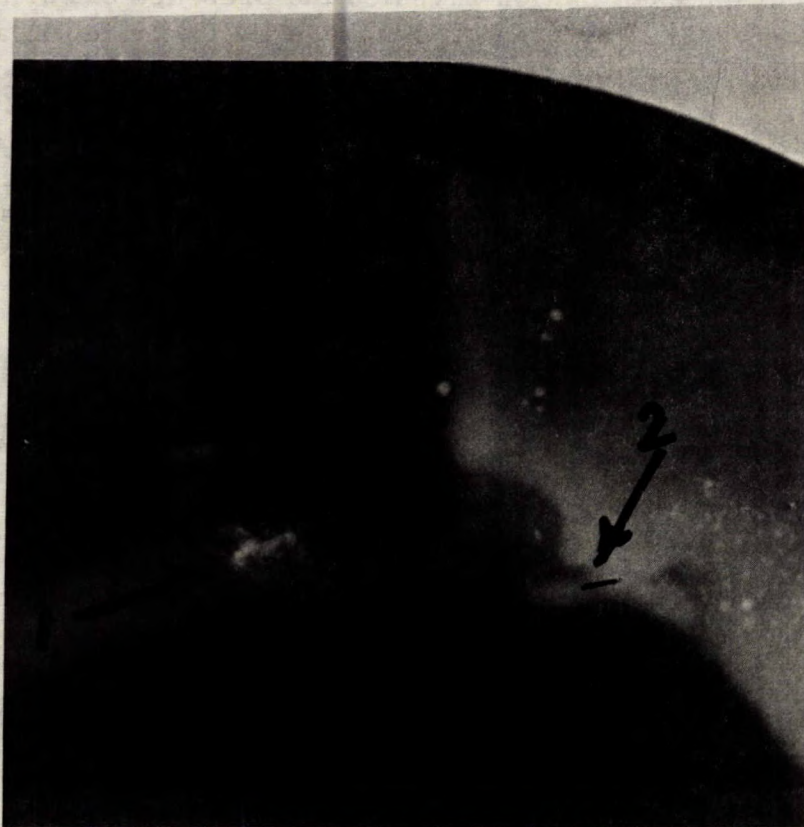
Sample	C	Mn	Si	S	P	Cr	Mo	Ni	Cu
*Driver Casting	0.23	0.61	0.57	0.042	0.044	0.09	0.05	0.11	0.13
AISI-1020	.18/.23	.30/.60		.05 max.	.04 max.				

* The casting was purchased to a strength requirement of 80 kpsi ultimate tensile strength; 50 kpsi yield strength without specification of the steel composition.

Semi-quantitative spectrographic analysis gave a result of 0.02 per cent total aluminum.

The steel composition was a fully-killed grade corresponding to AISI-1020 steel having residual traces of chromium, molybdenum, nickel and copper and would be expected to meet the 80 kpsi ultimate tensile strength and 50 kpsi yield requirement in the annealed condition of heat treatment.

Two tensile bars cut from the casting gave a tensile strength of 79 kpsi (average), 56. kpsi yield strength elongation of 8.8% and a reduction in area of 12% at a hardness of 150 Brinell.

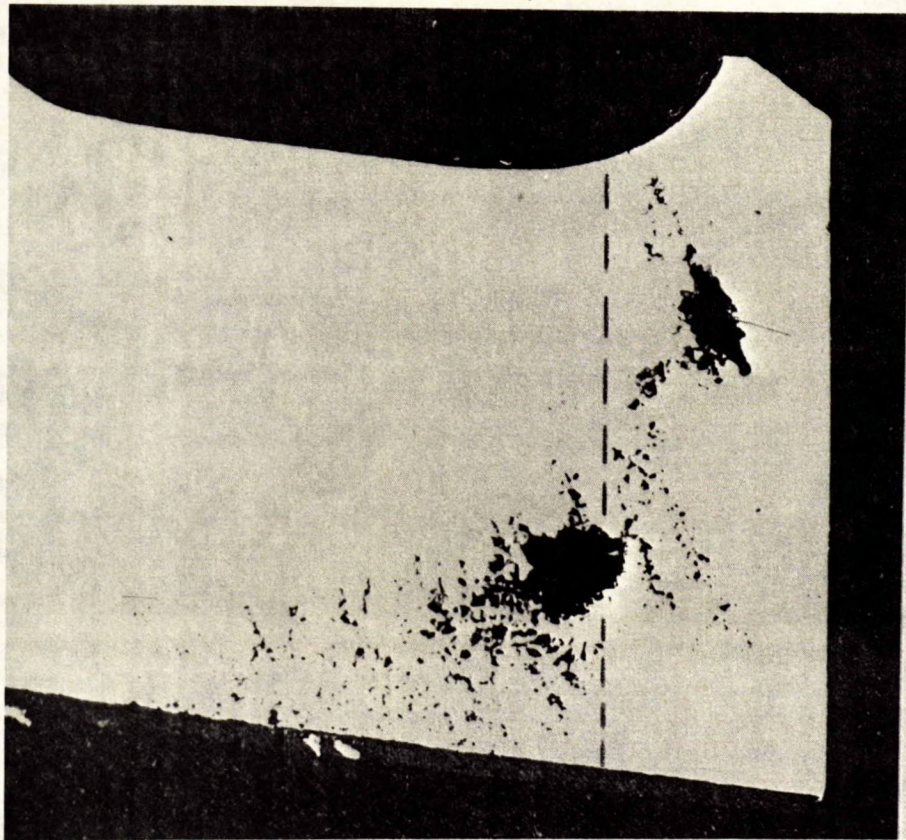


Actual Size

Figure 2. Print taken from Radiograph.
The shrinkage area adjacent to the boss is marked (arrow 1). The location of the groove and superficial crack caused by the cutting torch is marked (arrow 2).

METALLOGRAPHIC EXAMINATION

A radial section was taken through the shrinkage adjacent to the boss corresponding to the location of the crack detected after service. The appearance of this section is illustrated in Figure 3.

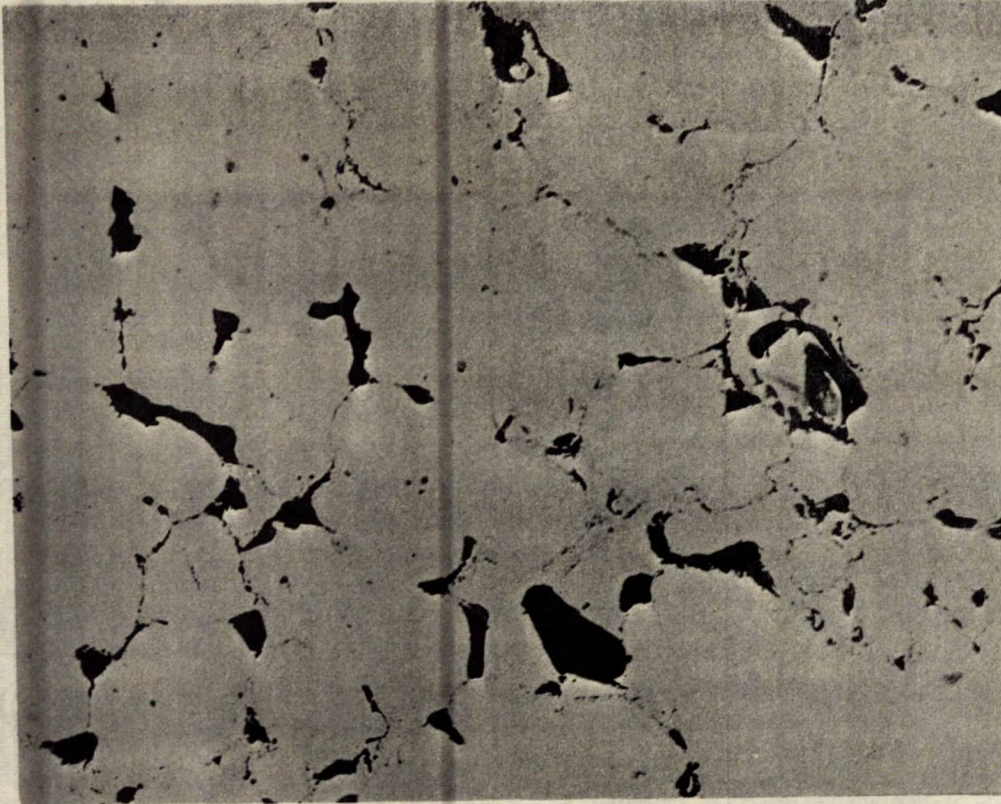


X8

Figure 3. Radial Section Illustrating Shrinkage Area Adjacent to the Boss.

The plane of the circumferential crack having a length of approximately $3/8$ in. is illustrated by the dashed line.

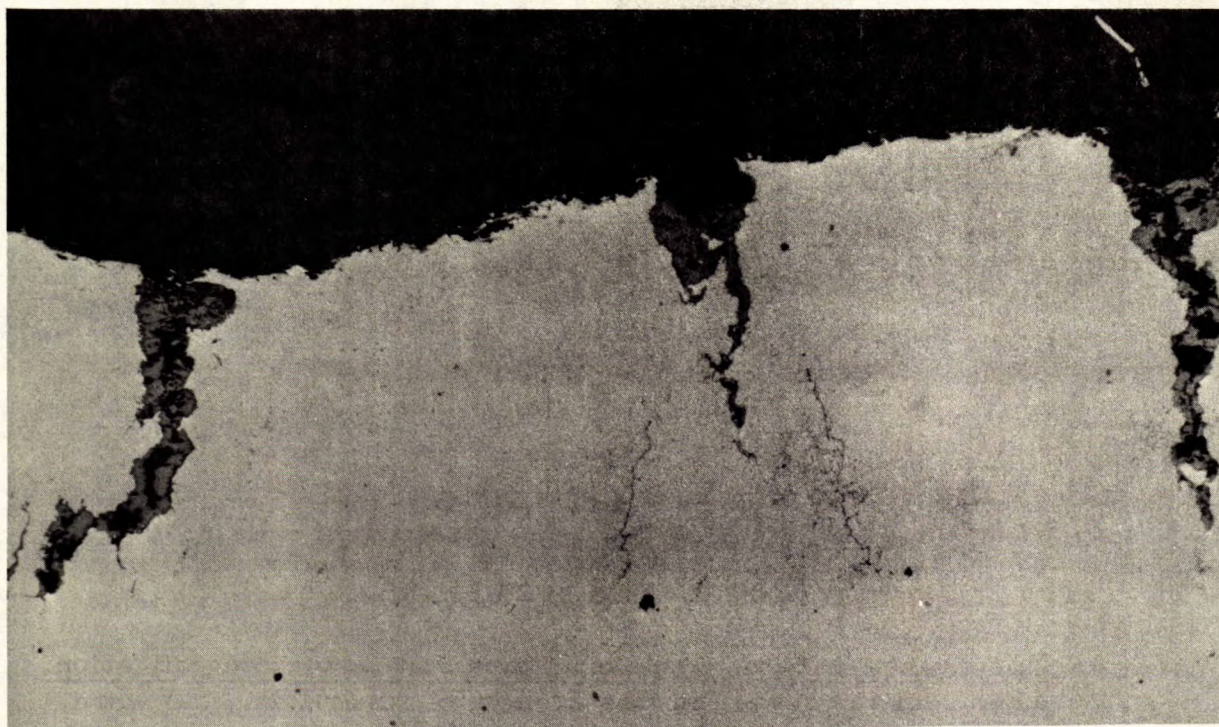
The shrinkage illustrated, while present for a distance of approximately 1/4 in., would offer a plane of weakness and could explain the rapid initiation of the circumferential crack adjacent to the boss.



X100 - as-polished

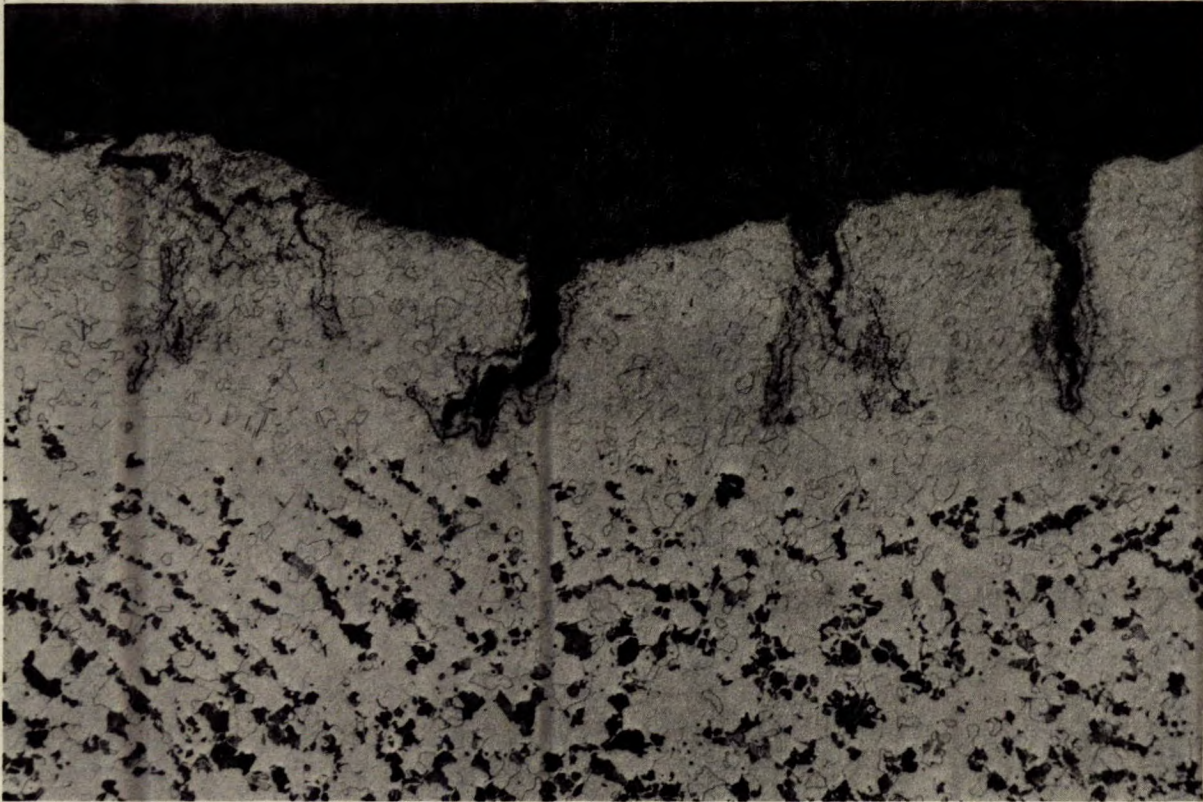
Figure 4. Same Section as Figure 3 at Higher Magnification.

Figure 5 illustrates the appearance of a transverse (radial section) through the groove which appeared to have been produced by an accidental strike from the cutting torch. The surface metal in this zone is decarburized and contains shallow "burn" cracks.



X200 - etched 2% nital

Figure 5. Section Through Groove Observed on Surface of Casting.
The metal is decarburized and appears to have been
burned.



X100 - etched in 2% nital

Figure 6. Appearance of Same Area as Figure 5 at Lower Magnification. The cracks observed in this area were superficial, but were apparently of accidental origin due to gouging by the flame of the cutting torch used to remove the gates and risers. The affected depth is approximately 1/64 in.

DISCUSSION

A previous examination was made of four similar driver castings manufactured to U.S. Federal Specification QQ-S-681, Class 80-50, and reported in Mines Branch Investigation Report IR 65-28, and of two spare castings subsequently returned to stores⁽¹⁾. Radiographic inspection did not reveal microshrinkage in the spare castings.

However, the casting described in this report gave extremely short service and did contain shrinkage associated with a 3/8 in. circumferential crack.

The casting met the requirements of the (1941) specification with respect to tensile and yield strength but had low tensile ductility (12% RA).

The specification QQ-S-681 for Class 80-50 steel does not detail chemical composition or radiographic standards. The required 80 kpsi ultimate tensile strength and 50 kpsi yield strength is usually attained in attached coupons in the annealed condition.

CONCLUSIONS

- (1) Shrinkage was present adjacent to the boss and may have contributed to formation of a circumferential crack in this region.
- (2) The casting was in the annealed condition and met the yield strength requirement of the specification - Class 80-50, but gave a per cent RA value of only 12%.
- (3) The hole was off-centre in the boss.
- (4) Superficial damage had been done to the casting surface by accidental contact with a cutting torch.

RECOMMENDATION

- (1) Consider whether this casting should be purchased in a quenched and tempered condition to a high strength and inspection standard.

REFERENCES

- (1) Examination of Cast Steel Drivers for the 155 mm Howitzer Breech Block, Mines Branch Investigation Report IR 25-28, Department of Mines and Technical Surveys (March 24, 1965).
- (2) Inspection Service Dimensional Inspection, per AEEE/DND.