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O T T A W A July 16th, 1942.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1263.

(M. & S. No. 7/D)

Examination of Zinc Alloy Die Castings for a Tank Periscope.

(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 Problem and Object of Investigation:

In a letter dated June 20th, 1942, Prof. J. U. MacEwan, Consultant to Director of Metallurgy, Army Engineering Design Branch, Department of Munitions and Supply, Ottawa, Ontario, requested the examination of eight different zinc alloy die-cast parts of an Infantry Mark III Tank periscope.

It was requested that these parts be investigated with a view to determining their suitability for withstanding shock such as might be encountered in tank use at low temperatures.

Nature of Samples Received:

It was stated that the submitted samples were made from "Zamak 3" material and conformed to the following chemical and mechanical characteristics:

Chemical Composition -

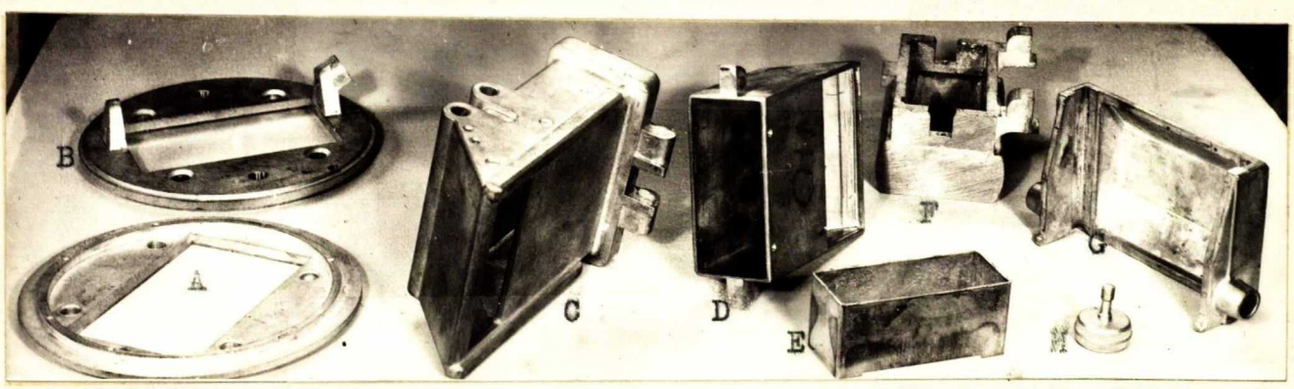
		Per cent
Aluminium	--	4.1-4.3
Magnesium	--	0.04
Zinc	--	Remainder, or
Lead, Iron	--	Possibly present in small quantities.

Mechanical Properties -

Ultimate tensile strength	--	36,000 p.s.i.
Elongation (in 2 inches)	--	4.7 per cent.
Impact strength	--	18.25 foot pounds.

Figure 1 shows the samples as received:

Figure 1.



SAMPLES AS RECEIVED.
(Approximately 1/4 size).

X-Ray Examination:

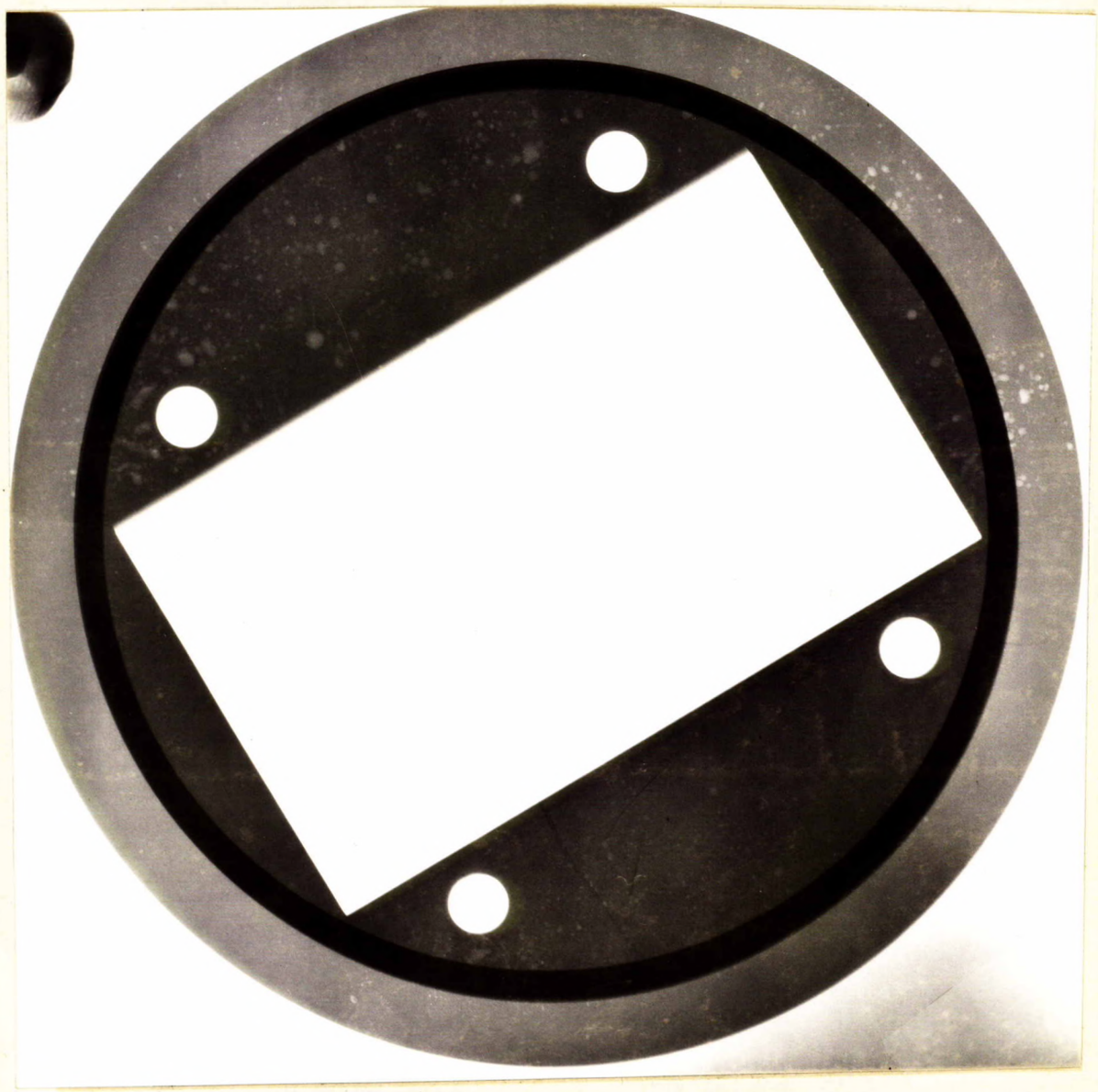
The X-ray examination, carried out by Mr. W. A. Morrison, of the National Research Laboratories, Ottawa, Ontario, showed a large number of cavities and microcavities in all

(X-Ray Examination, cont'd) -

examined castings.

Figures 2 to 4 show contact prints of three radiographs taken from Castings A, B and C. The radiographs of the remaining castings are similar.

Figure 2.

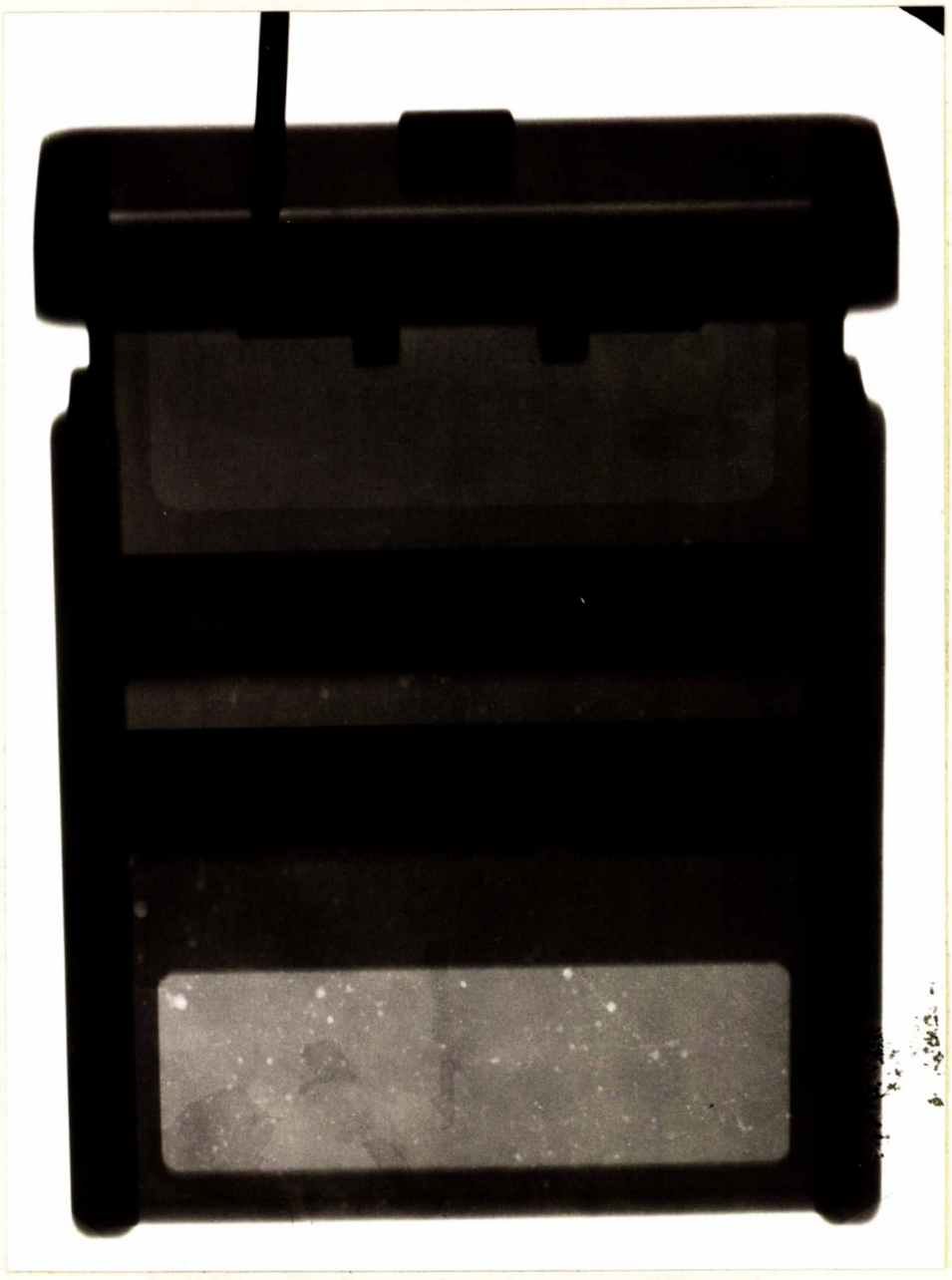


RADIOGRAPH OF CASTING "A"

Figure 3.

RADIOGRAPH OF CASTING "B".

Figure 4.



RADIOGRAPH OF CASTING "C".

Chemical Analysis:

	Castings	B.S. Spec. 1004:1942.	A.S.T.M. Spec. B86-41T, Alloy XXIII
	- Per cent -		
Aluminium --	3.87	3.9-4.3	3.5-4.3
Magnesium --	0.040	0.03-0.06	0.03-0.08
Copper --	0.01	0.10 max.	0.10 max.
Iron --	0.009	0.10 "	0.10 "
Lead --	0.005	0.005 "	0.007 "
Cadmium --	None detected.	0.005 "	0.005 "
Tin --	" "	0.002 "	0.005 "

Mechanical Properties:

a) Tensile Tests -

Two tensile test specimens were cut out of Casting D. The dimensions of these samples were 0.1 in. by 0.372 in., the gauge length being 1 in. The yield strength was determined by the dividers method.

Following are the results obtained:

	Yield strength, p.s.i.	Ultimate Tens. Str., p.s.i.	Elongation in 1 in., per cent
Sample No. 1 --	25,700	39,400	11
Sample No. 2 --	20,900	38,100	5
Required by A.S.T.M. Spec. B86-41T, Alloy XXIII, ----		35,000 minimum.	3 (in 2 in.)

b) Hardness Tests -

Hardness was determined by the Vickers method, using a 5-kilogram load. The following results were obtained:

75-85 V.H.N.

c) Impact Tests -

Twelve impact test specimens were cut out from four of the submitted die castings. The specimens were machined to

(Mechanical Properties, cont'd) -

Impact Tests, cont'd -

dimensions as given in A.S.T.M. Specification E23-41T ($\frac{1}{4}$" x $\frac{1}{4}$").

The tests were carried out on an Amsler Charpy impact tester (capacity, 240 foot pounds; weight of hammer, 44 pounds), using a 50 foot-pound blow and a linear velocity of the hammer of 7.5 feet per second.

The low temperatures used for this testing were obtained by the use of a mixture of dry ice and acetone. The specimens were immersed in the mixture for 30 minutes with the temperature held exactly at the desired point. The bars were handled with tongs at the temperature of the medium, the exact position of the specimens on the machine being predetermined before removing from the low-temperature bath. The time interval between the removal from the bath and the impact was 3 to 4 seconds.

Table I shows the results obtained:

Table I.

Results of Impact Tests at Low Temperatures.

Temperature ° F.	Temperature ° C.	Results obtained, in foot pounds	Average, in foot pounds
+70	+21	11 - 10 - 8	10
+32	0	4	4
0	-18	2.5 - 2.5	2.5
-30	-35	1 - 1 - 1	1
-50	-45	2 - 2 - 1	2

Micro-Examination:

Figure 5 shows the microstructure of the castings, normal for this type of alloy (α-primary crystals in $\alpha + \beta'$ eutectic).

Figure 5.

X200, etched.*

MICROSTRUCTURE OF CASTING "F".

Discussion of Results:

The X-ray examination shows that all examined die castings have many shrinkage holes and microcavities, which possibly might be overcome by improved casting technique.**

The chemical analysis conforms closely to the requirements of the British Standard and A.S.T.M. specifications.

The results of the tensile tests, although measured on specimens cut out from a casting, show that the strength of the material is satisfactory.

The size of the impact tester used for this investigation was not exactly suitable for both the material and the size of the specimens, although the results obtained

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* Etch as given in METALS HANDBOOK, 1939 Edition, pp. 1768-69. (Solutions Nos. 4, 5 and 2).

** Some comments on die casting technique are given in Report of Investigation No. 1061, dated August 14th, 1941.

(Discussion of Results, cont'd) -

are comparable, and also very similar, to results of a previous investigation[@] and to results reported in the literature.[@@]

The results of the impact tests at room temperature are lower than the average value given by the New Jersey Zinc Company (20 ft.lb.) and that cited by the Inspection Board of the U. K. and Canada (18.25 ft.lb.) but are higher than the minimum required in A. S. T. M. Specification B86-41T for Alloy XXIII (8 ft.lb.).

The lower impact results are probably due to shrinkage holes and microcavities, detected in the X-ray examination.

The micro-examination shows uniform structure.

Conclusions:

Impact tests show--in accordance with a previous investigation and with results given in the literature--that the shock resistance of zinc alloy die castings decreases considerably at low temperatures (below freezing point).

Although shock resistance values for zinc-base alloys at low temperature are low, sound castings obtained by improvement of foundry technique should give better service.

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JWM:PES.

[@] Report of Investigation No. 1199, dated April 8th, 1942.

[@@] See "Zamak Alloys for Zinc Alloy Die Castings," pp. 12-13, published by the New Jersey Zinc Company, New York, 1938.