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O T T A W A February 7, 1945.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1787.

Examination of Broken Tail Units of
4.2-inch Trench Mortar Bombs.

(Copy No. 10.)

Bureau of Mines
Division of Metallic
Minerals
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Physical Metallurgy
Research Laboratories

CANADA
DEPARTMENT
OF
MINES AND RESOURCES
Mines and Geology Branch

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REPORT

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Origin of Material and Object of Investigation:

On January 29, 1945, under Analysis Requisition O.T. 4324, Mr. J. M. Gilmartin, for Inspector of Materials, Inspection Board of United Kingdom and Canada, 71 Lyon Street, Ottawa, Ontario, submitted for metallurgical examination the residue of three 4.2-inch trench mortar tail units.

In a letter accompanying the material, it was stated that these units came from lots which had been subjected to proper proof trials and found to be acceptable. It was also stated that it was understood that the test firing took place in cold weather but this should not be a cause of failure. A full metallurgical examination was requested in order to determine, if possible, the cause of failure.

Material Received:

The unit was stated to have been made to Specification IG466. The cartridge container requires a seamless steel tube. Figures 1, 2 and 3 are photographs showing the condition of the three broken tail units. It was noted that rough-machining tool marks were present on the inner surface of some of the tubes. These can be observed in Figure 2.

Figure 1.

(Approximately ½ actual size).

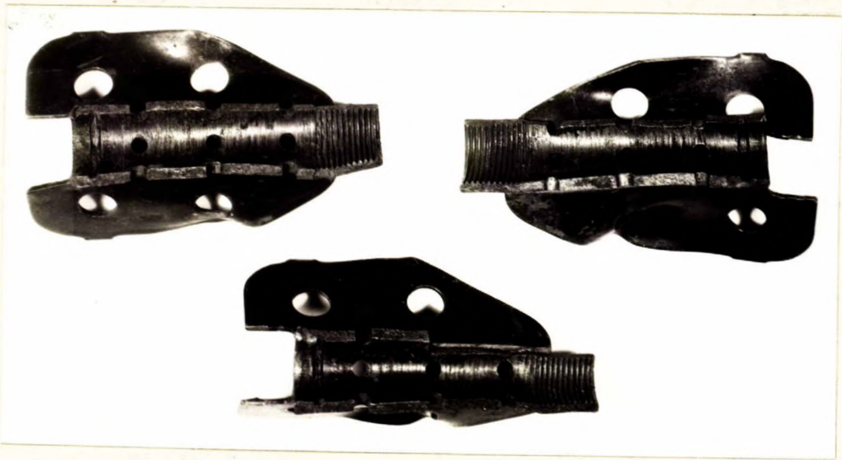

Figure 2.

(Approximately ½ actual size).

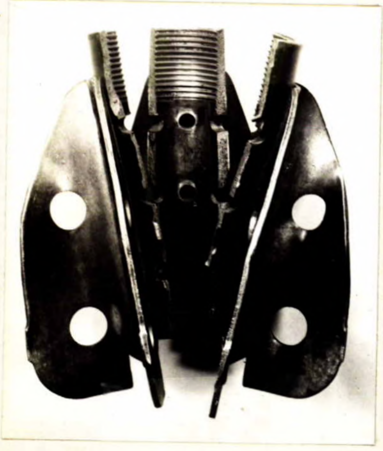

Figure 3.

(Approximately ½ actual size).

Chemical Analysis:

The specified chemical composition and the results of chemical analysis of the tail tube are given respectively in Tables I and II. The composition of the tail pin is given in Table III.

TABLE I. - Chemical Limits Required Under Specification IG466 for Tail Tubes.

		Per Cent
Carbon	-	0.15 to 0.25
Manganese	-	0.40 to 0.80
Silicon	-	0.35 max.
Sulphur	-	0.06 "
Phosphorus	-	0.06 "

TABLE II. - Chemical Composition of Tail Tube.

		Per Cent
Carbon	-	0.23
Manganese	-	0.37
Silicon	-	0.17
Sulphur	-	0.035
Phosphorus	-	0.010
Ni, Cr, V	-	Nil.

TABLE III. - Chemical Composition of Pin.

		Per Cent
Carbon	-	0.04
Manganese	-	0.31
Silicon	-	0.04
Sulphur	-	0.036
Phosphorus	-	0.007
Ni, Cr, V	-	Nil.

Normalizing Treatment:

Samples of the tail tube were given a normalizing heat treatment, the specimen being heated to 1750° F. for 10 minutes in a controlled-atmosphere furnace, followed by cooling in air.

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Mechanical Tests:

The specification requires that the tubing having a minimum tensile strength of 26 long tons per square inch and a minimum elongation of 28 per cent in two inches. Flattening and crushing tests are also specified. Due to lack of material it was not found possible to check these properties.

Hardness Tests:

The hardness of the material was determined by the Vickers method on specimens cut from the three failed tubes and, also, from the normalized sample. The results of these tests are given in Table IV.

TABLE IV. - Vickers Hardness Numbers. (20-Kg. Load)

Failed tail unit tubes	-	170, 160, 177*
Normalized "	-	138*

* Vickers and Brinell hardness numbers in this range are identical.

Steel tubing with a Brinell hardness of 138 should have a tensile strength of 65,000 to 70,000 p.s.i., while with a hardness of 160 to 177 the tensile strength would be approximately 70,000 to 80,000 p.s.i.

Microscopic Examination:

Specimens of the failed and normalized tubing, and also of the fin, were mounted in bakelite, polished, and examined under the microscope in the unetched condition. The steels were found to be fairly clean. After etching in 2 per cent nital, the steels were re-examined.

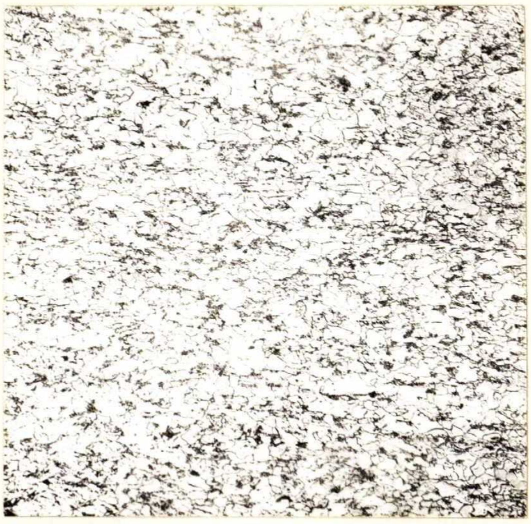
The structure of the failed tubing is shown in Figures 4 and 5. The steel tube is fine-grained, with the iron carbides in the spheroidized condition.

The structure of the fin is typical of low-carbon

(Microscopic Examination, cont'd) -

normalized steel. Figure 7 shows the structure of the steel after normalizing. The structure consists of a dark etching pearlite, the iron-iron carbide constituent, and light etching ferrite, the iron constituent.

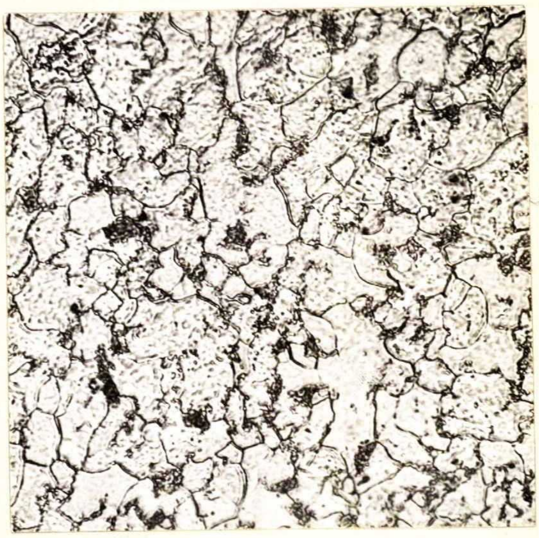
Figure 4.



X100, etched in
2 per cent nital.

TYPICAL STRUCTURE OF
FAILED TUBING.

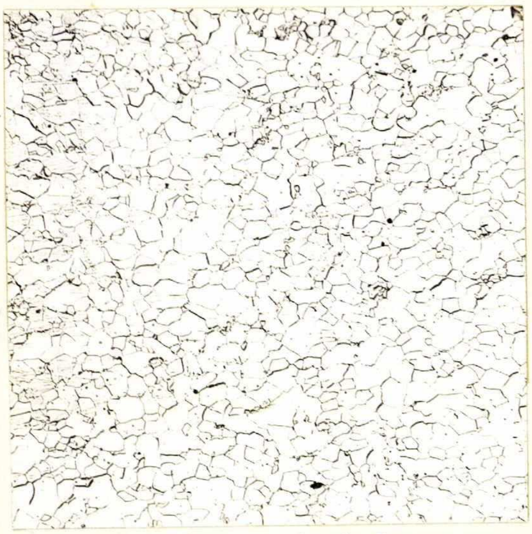
Figure 5.



X500, etched in
2 per cent nital.

STRUCTURE OF FAILED
TUBING.

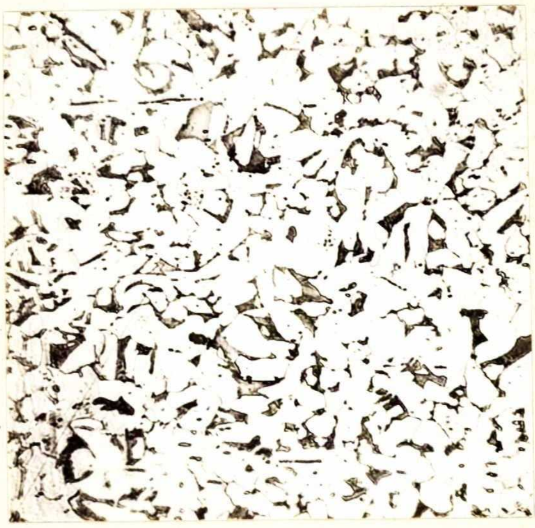
Figure 6.



X100, etched in
2 per cent nital.

STRUCTURE OF FIN.

Figure 7.



X100, etched in
2 per cent nital.

STRUCTURE OF TUBE AFTER
NORMALIZING AT 1750° F.

DISCUSSION OF RESULTS:

The chemical composition of the failed tail tubing is within the limits specified in Specification IG466. Hardness tests on these materials in the "as received" condition gave considerably higher results than those obtained from the tubing after normalizing. It is thought that strain ageing may account for this difference in hardness. The microscopic examination revealed that the tubes were spheroidized rather than simply normalized. This spheroidization may be due to the final heat treatment or may possibly occur because the final heat treatment was of such duration that it did not eliminate a prior spheroidal structure. Mechanical tests carried out on tubing of similar composition and structure showed it to have the specified mechanical properties (see Report of Investigation No. 1722, "Examination of Fractured Composite Tail Tubes of a Piat Bomb," dated October 16, 1944). Incomplete normalizing of the tubing therefore is not considered to be the cause of failure. The results of this investigation, then, indicate that failure in the present instance can be attributed to mechanical rather than metallurgical reasons.

It is recommended that some consideration be given to the surface of the tubes. It is desirable to have as smooth a finish as possible. Defects such as were observed in the broken tube shown in Figure 2 act as stress raisers and may possibly be a cause of trouble.

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