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WATERTOWN ARSENAL

28 OCT 1942

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Report No. 313/26
Watertown Arsenal
(Problem E-28)

October 28, 1942

GUN FORGINGS

Metallurgical examination of section from 37 mm. gun forged by ~~Struthers Wells-Titusville Corporation~~ Watervliet, and machined by ~~National Pneumatic Company~~.

OBJECT

To determine the nature and origin of bore defects in the forging.

REFERENCES

O.O. 472.1/5919 - W.A. 473.1/3883
O.O. 472.1/7419 - W.A. 473.1/3896
O.O. 472.1/7751 - W.A. 473.1/3984

The basic correspondence pertaining to this report is included in the Appendix.

CONCLUSIONS

1. The defects on the lands appear to have been caused by corrosion during the interval between the finish bore and rifling operations.

2. The defects were not caused by heat treatment, poor machining technique, or defective metal.

3. From their appearance the defects were serious enough to warrant rejection. The subsequent investigation indicated that they probably would not have rendered the gun unserviceable.

A. M. White,
Assistant Metallurgist.
NLR

APPROVED:

H. H. Zornig,
Col., Ord. Dept.,
Director of Laboratory.

INTRODUCTION

Boroscopic examination of a 37 mm. gun which was forged by Struthers Wells-Titusville Corporation and machined by the National Pneumatic Company revealed bore defects which appeared serious enough to necessitate rejection. A 4-1/4 inch half round section of this gun was sent to Watervliet Arsenal for the determination of the nature of the defects. That arsenal observed what appeared to be decarburization near the defects and suggested that heat treatment was responsible for the condition. It is known, however, that in usual procedure 37 mm. gun forgings are quenched and drawn before they are rough bored.

The section from the gun, with only a micro specimen removed, was later forwarded to this arsenal and request was made by the Office, Chief of Ordnance for a "more thorough metallographic study--- to determine the nature and seriousness of the defects revealed in the bore of the specimen in question".

Most of the history and data pertaining to the forging, including the forging number, other manufacturing records, inspection reports, and knowledge of the extent of the defects beyond the specimen submitted, were not obtainable. The absence of such information is a distinct disadvantage in an investigation of this type.

In order to determine the nature and origin of the defects, the following tests were performed on the specimen submitted:

(a) Visual examination

(b) Macroexamination

(c) Metallographic investigation

313/26

RESULTS

1. Visual Examination

The defects in question were pitted areas which were scattered on the lands (Figures 1, 2, and 3). By examination of the pits with a binocular microscope, they were seen to contain a greasy, black substance which could be removed with a sharp pointed needle. The greatest depth of pitting was estimated to be about .01 inches. Figure 3 shows pits in a group whose appearance is typical of a corrosion pattern.

2. Macroexamination

Sulphur prints of the transverse and longitudinal specimens, cut as indicated in Figure 1, were made before macroetching. Neither the macroetched specimens nor the sulphur prints gave any indication of defects or irregularities which would tend to cause the pits observed on the land surfaces. (Photomacrographs are reproduced as Figure 4. Sulphur prints are on file at the Watertown Arsenal Laboratory).

3. Metallographic Examination

Transverse and longitudinal micro specimens were cut as indicated in Figures 2 and 3. They were electroplated and mounted in Wood's metal before polishing to insure the retention of any inclusions at the edges. Examination of a polished, unetched specimen showed that the steel contained relatively few nonmetallic inclusions, (Figure 5).

A nital etch did not reveal decarburization near the pits or any nonuniformities other than a slight degree of banding and

micro segregation (Figure 6). Structural distortion which would result from poor machining technique, was not observed.

In an examination of the entire edge of the longitudinal specimen, the severest pit observed was .007 inches deep.

DISCUSSION

Most of the evidence obtained leads to negative conclusions. Macro and micro examinations indicate that the steel is of sufficiently good quality and that nonmetallic inclusions cannot be responsible for the defects. The absence of decarburization eliminates the possibility that the defects might be a result of scaling after heat treatment. The slight degree of microscopic banding is hardly sufficient to affect the machining properties and the apparent absence of deformed metal further diminishes the probability that machining was to blame.

There is no absolute evidence which indicates that the defects are a result of corrosion but that possibility should be considered. Rusting might have occurred at some time between the boring and rifling operations if the forging was stored for a period of months during that interval. If the pits caused by corrosion had been deeper than the height of the lands (.04 inches) they would have been found in the grooves after rifling. The absence of brown rust in the pits might be explained if the cutting oil used for the rifling operation was acidic (as such oils often are). The dark, greasy substance in the pits could have been deposited during the slushing procedure before the bore was inspected.

313/26

FIG. 1

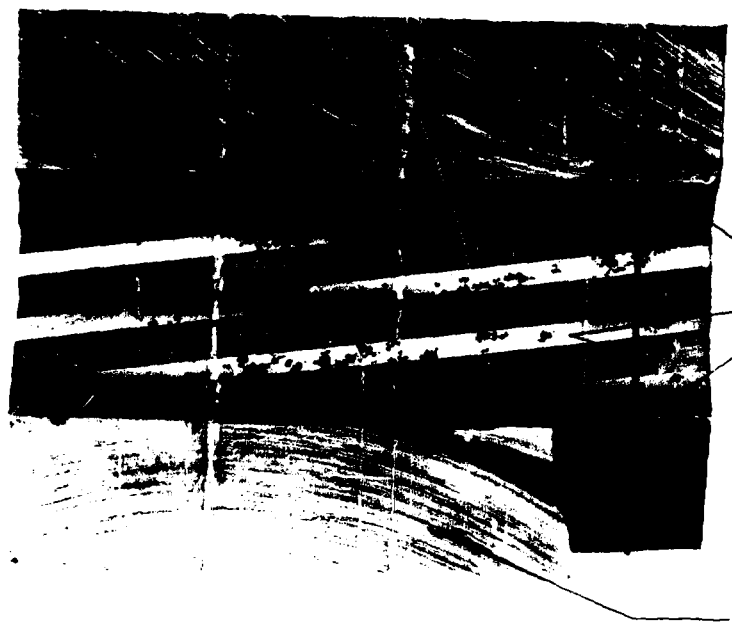
"A" SECTION OF 37MM GUN TUBE FORGING "B"

FORGED BY S[redacted]RP. AND MACHINED BY [redacted]CO.

SHOWING

DEFECTS ON LANDS AND LOCATION OF MACROETCH SPECIMENS

MAGNIFICATION X1



WTN.639-4611

FIG.

DETAIL OF CRACKS IN [illegible] SOLDERING

DEFECTS AND LOCATION OF MICRO SPECIMENS

MAGNIFICATION X2

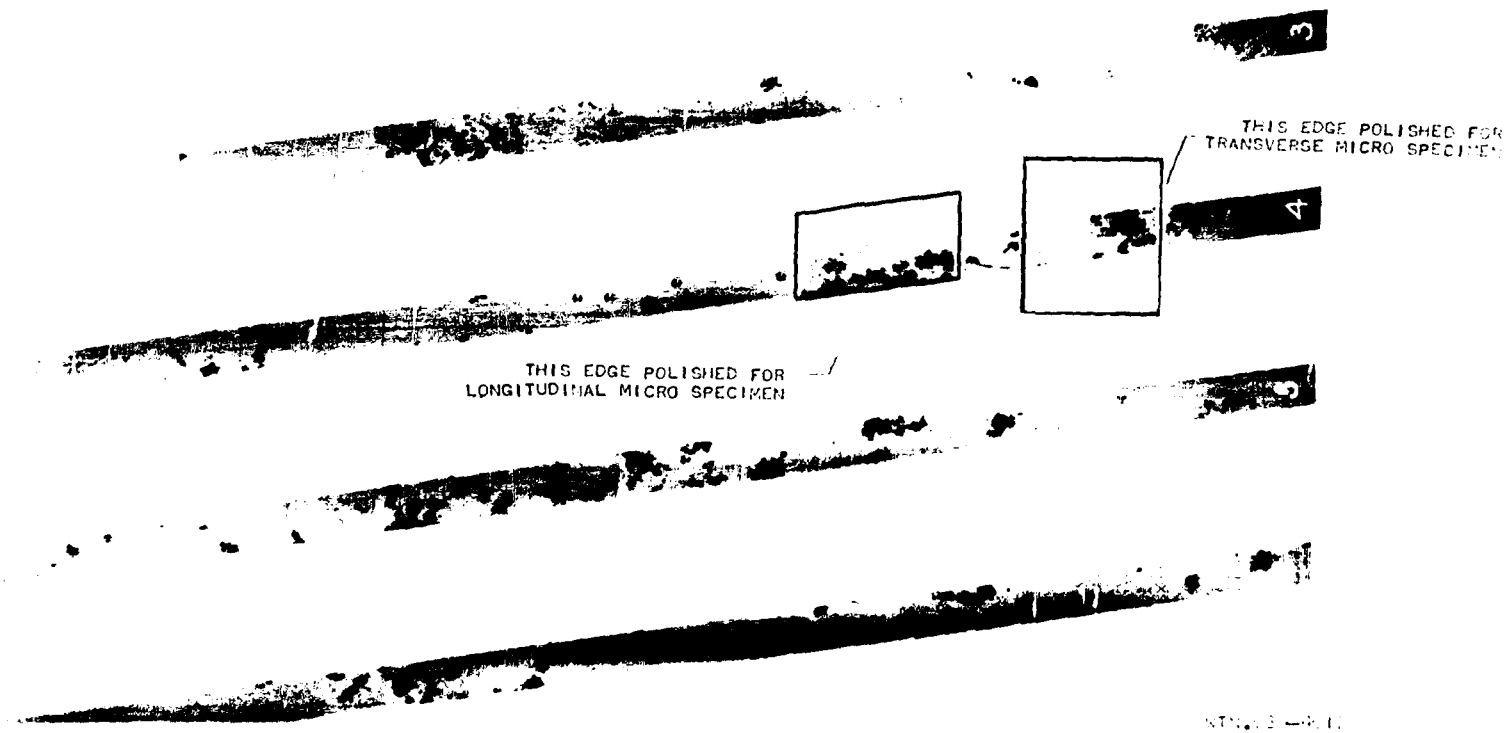


FIG. 3

DETAIL OF TRANSVERSE MICRO SPECIMEN FROM 37MM GUN FORGING

SHOWING
TYPICAL CORROSION PATTERN ON LAND

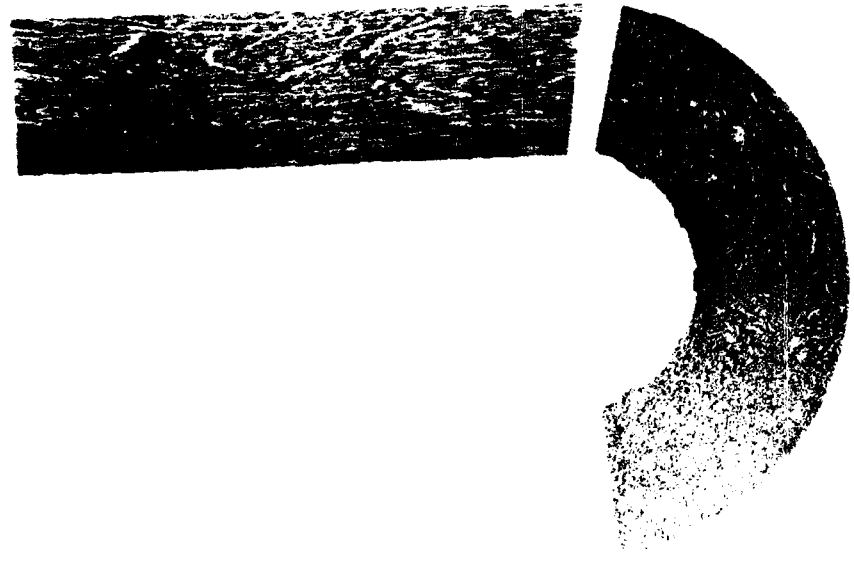
MAGNIFICATION X10

THIS EDGE POLISHED FOR TRANSVERSE MICRO SPECIMEN

PATTERN OF DEFECTS TYPICAL OF CORROSION

"B"

"A"



PHOTOMICROGRAPHS OF [illegible] SOIL FAILURE

TYPICAL PITS ON LAND AND NON-METALLIC INCLUSIONS

UNETCHED X100

LONGITUDINAL

TRANSVERSE

FIG.

PHOTOMICROGRAPHS OF 37MM GUN FORGING

SHOWING

TYPICAL PITS ON LANDS AND MICRO SEGREGATION.

NITAL ETCH X100

LONGITUDINAL

TRANSVERSE

APPENDIX

Yatsevitch/ts

WAR DEPARTMENT

OFFICE OF THE CHIEF OF ORDNANCE

Washington

O.O. 472.1/7419
Attention of
Ind. Serv.-Arty. Div.

March 17, 1942

Subject: 37-mm Tube Forgings from ~~Struthers Wells-Titusville Corporation~~.

To: Commanding General,
Watertown Arsenal
Watertown, Massachusetts.

1. Watervliet Arsenal has been instructed to furnish you with the material described in the attached copy of O.O. 472.1/5919, in order that a more thorough metallographic study may be made. It is requested that this material be subjected to a metallographic examination as soon as it reaches you, and that a report be furnished this office at the earliest possible date. It is desired to determine the nature and seriousness of the defects revealed in the bore of the specimen in question.

By order of the Chief of Ordnance:

(s & t) D. J. Martin,
Lt. Col., Ord. Dept.,
Assistant.

1 Inc.
File O.O. 472.1/5919
(Copy).

313/26

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Yatsevitch /ts

WAR DEPARTMENT

OFFICE OF THE CHIEF OF ORDNANCE

Washington

O.O. 472.1/5919
Attention of
Ind. Serv.-Arty. Div.

January 23, 1942.

A

Subject: 37-mm Tubes from the ~~Struthers-Wells-Titusville~~ Corporation.

To: Commanding General,
Watervliet Arsenal,
Watervliet, New York.

1. Forwarded under separate cover is a piece of a 37-mm tube manufactured by the ~~Struthers-Wells-Titusville~~ Corporation and rejected because of defects revealed by Boroscopic examination. It is requested that this specimen be subjected to a metallagraphic investigation with a view to determine the nature of the defects, and that a report be submitted to this office at the earliest date possible.

By order of the Chief of Ordnance:

D. J. Martin
Lt. Col., Ord. Dept.
Assistant.

1 Incl s/c Sent (6484)
Piece of 37-mm tube.

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O.O. 472.1/5919
Wv.A. 472.56/2967 1st Ind. SLC/WK/js

Watervliet Arsenal, Watervliet, New York, March 7, 1942.
To: Chief of Ordnance, Washington, D. C.
Att: Lt. Col. D. J. Martin, Industrial Service, Artillery Division.

1. The half section, (longitudinal) 4-1/4" long, of a 37 mm. tube which was submitted to this Arsenal for metallographic examination exhibits numerous heterogeneous shaped pits in clusters on the lands of the rifling. In the pits there is present what appears to be dark mill scale. A cluster of these defects is shown in negative PL 233 at 4X magnification. The faces of the grooves are entirely free from any sort of pitting or other defects and show moderately good machined surface.

2. Microscopic examination made at right angle to the face of the land and including an average type of pit is shown in photomicrograph negative PL 232. The photomicrograph shows that there is present a partially decarburized zone at the land face and at the root of the pit. This zone, which also follows the root contour of the pit, is approximately .0025" in depth before it begins to bland into the metal showing normal carbon content for this tube. The microstructure at the face of the groove shows normal carbon content and is represented by the structure in the area 2" from the straight edges which appear to the left and right in the photomicrograph. (Negative PL 232).

3. This Arsenal has no information as to the method of manufacture employed in the manufacture of this tube. It would appear most probable that the tube was subjected to heat treatment after rough boring and that the pits are spots in the gun which would not clean up in finish machining. This condition could be caused by either too large a diameter of rough bored hole, or by excessive crookedness, or by heat treatment of excessive length, resulting in abnormally deep scale, or a combination of these.

For the Commanding General:

S. L. Conner,
Lt. Col., Ord. Dept.,
Assistant.

1 Incl #1
(Photos of defective 37 mm. tube section - in dup.)

cc Major Hammersley

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Yatsevitch /ts

WAR DEPARTMENT

OFFICE OF THE CHIEF OF ORDNANCE

Washington

O.O. 472.1/5919
Attention of
Ind. Serv.-Arty. Div.

January 23, 1942.

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By order of the Chief of Ordnance:

D. J. Martin
Lt. Col., Ord. Dept.
Assistant.

1 Incl s/c Sent (6484)
Piece of 37-mm tube.

313/26