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WATERTOWN ARSENAL LABORATORY

MEMORANDUM REPORT

NO. WAL 316/39

2 3/8" ROUND "RESISTAL" KA2 18-8 STAINLESS STEEL BARS.

P.O. 2975 CRUCIBLE STEEL CO.

BY

H. G. CARTER

DATE 14 December 1932

WATERTOWN ARSENAL
WATERTOWN, MASS.

REPORT NO. 316/39

2 3/8" ROUND "RESISTAL" KA2 18-8 STAINLESS STEEL BARS.

P.O. 2975 CRUCIBLE STEEL CO.

BY

H. G. CARTER

1932

File No. 316/39
Watertown Arsenal

December 14, 1932

2 3/8" Round"Resistal" XA2 18-8 Stainless Steel Bars.

P.O.2975 Crucible Steel Co.

Purpose

The purpose of this investigation was to ascertain the cause of longitudinal hair line "cracks" which appeared on the surface during cold working and machining. For purposes of identification in this report the first bar submitted will be called No. 1 and the second bar submitted No. 2.

Historical

Bar. No. 1. During cold work by longitudinal stretching, fine longitudinal cracks or hair lines (up to 3/4" in length) appeared on the surface, which seemed to open up and become more numerous as the cold working progressed. Cold working was stopped at 16% (before the total desired cold work of 30% was obtained). The bar was then stress relieved by soaking at 300°C for 9 hours and machined hoping to remove the cracks before continuing the cold working. It was found that as each cut was taken these surface cracks were removed but new ones appeared. As this condition continued after several cuts the bar was rejected and specimens were taken for tests and examination to ascertain the cause of these cracks.

Bar. No. 2. As the surface was somewhat rough, it was decided to machine 1/8" off the diameter before cold working. During this machining fine hair line longitudinal "cracks" appeared on one side of the bar at intervals of 3" to 24" apart along the entire length of the bar. These lines or cracks were thought to be similar to those appearing in bar No. 1. These "cracks" were less numerous but in some cases 3" long. Due to the experience with bar No. 1 this bar was also rejected and specimens were cut from one end for examination.

Conclusions

No.1 Bar

1. This bar apparently contained very many minute yellow cubic crystals of Zirconium Nitride which were generally distributed and also segregated in short very closely packed chains.

2. It was segregated throughout and banded for about 1/2" from the outside forming concentric rings.

3. Due to the 16% cold work very many slip planes appeared principally in what probably were at one time the dendrites.

4. These slip planes were not smooth edged but "saw-toothed". This irregularity of the edges was caused by the precipitation of carbides.

5. Whether the carbide precipitation was normally brought about by cold working and soaking at 300°C or whether the steel was unusually sensitive to cold work and 300°C strain relieving is unknown.

6. The surface cracking appearing during cold work and after subsequent machining was undoubtedly due to the chains of cubic crystals of Zirconium Nitride and to the segregated and banded condition of the steel.

No. 2 Bar

1. The specimen from this bar contained no Zirconium Nitrides and only the usual amount of sulphides.

2. The structure had medium sized grains of twinned austenite.

3. There were a few slip planes indicating that the final rolling at the mill was done at a relatively low temperature thereby setting up some strains.

4. The slip planes were generally straight sided showing that carbide precipitation had not been great.

5. No explanation of the cracking was found in this specimen. In as much as the cracks were found intermittently in the bar it is possible that the specimen taken did not contain a cracked zone.

Microscopic Examination

Longitudinal and transverse sections were cut from the specimens Nos. 1 and 2 which had been previously macro-etched. These sections were prepared for microscopic studies.

Fig. 1 shows at X100 a typical segregation of inclusions in the transverse section of No. 1 bar. C68-2

Fig. 2 shows at X100 a bad chain like segregation near the surface in the longitudinal section of No.1 bar. C68-3

Figs. 3 and 4 show at X1000 the cubic crystals before and after 10 minute boiling in 50% Potassium Hydroxide. The cubic crystals are Zirconium Nitride, the gray inclusions are unidentified sulphides in No. 1 bar. C68-C-7

Fig. 5 shows at X100 the segregated condition of the steel of No.1 bar. C68-8

Fig. 6 shows at X1000 the slip planes in No. 1 Bar. Precipitate carbides make the sides of these planes "saw-toothed". C68-9

Fig. 7 shows at X100 a typical short chain of inclusions in No. 2 bar. C68-11

Fig. 8 shows at X100 the medium sized grains of twinned austenite of No. 2 bar. C68-12

Fig. 9 shows at X1000 slip planes in No. 2 bar. The sides of these planes are straight showing that the precipitation of carbides has not been great. C68-13

Note in the etched micrographs there are many round black dots;these are pits resulting from attack on inclusions and surrounding metal caused by several etchings and light repolishing necessary to overcome the amorphous flow of the metal during the original polishing.

Respectfully submitted,

H. C. Carter

Fig. 1.

X100 Unetched No. 1 Bar, Transverse Section. Showing typical segregated areas of inclusions which are mostly Zirconium Nitride. C68-2

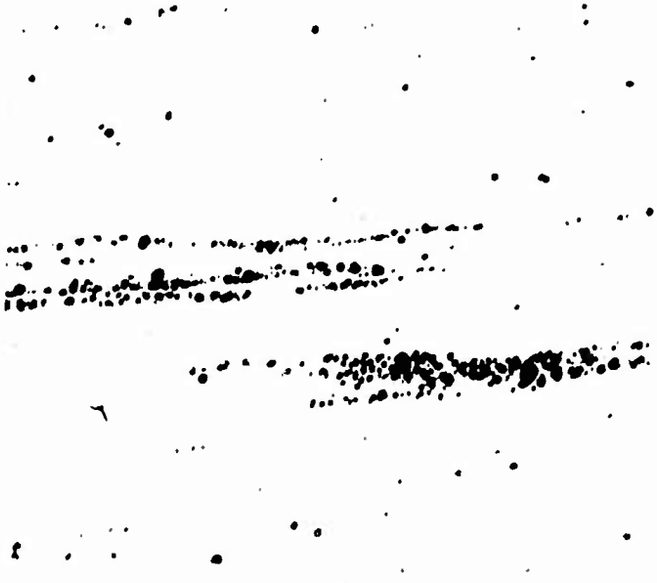

Fig. 2.
X100 Unetched No. 1 Bar, Long Section. Showing a bad chain segregation of inclusions which are mostly Zirconium Nitride. C68-3

Fig. 3.

X1000 Unetched No. 1 Bar, Long Section. Part of Fig.2. Cubic crystals yellow in color are Zirconium Nitrides, gray inclusions are sulphides (unidentified). C68-6

Fig. 4.

X1000 10 Minute boiling 50% KOH etching No. 1 bar, Long Section. Same area as Fig. 3. Cubic crystals are not attacked. Proving them to be Zirconium Nitride. C68-7

Fig. 5.

X100 $FeCl_3$ etched No. 1 Bar, Transverse Section. Showing segregated condition. Note small round black dots are pits resulting from attack on inclusions of several etchings and light polishing necessary to overcome the amorphous flow of the metal during polishing. C68-8

Fig. 6.

X1000 $FeCl_3$ etching No. 1 Bar, Transverse Section. Showing slip planes in which are precipitated carbides. C68-9

Fig. 7.

X100 Unetched No. 2 Bar, Long Section. Typical group of inclusions. C68-11

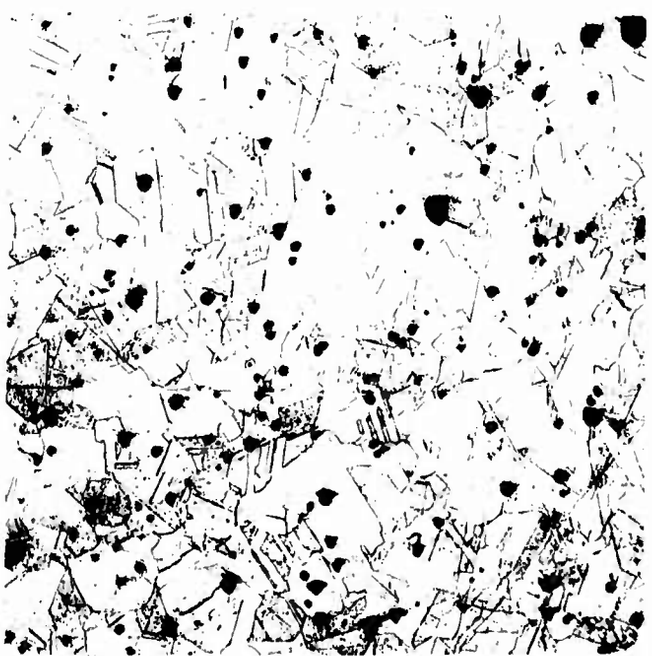

Fig. 8.

X100 FeCl$_3$ etched No. 2 Bar, Transverse Section. Medium sized twinned austenite containing a few slip planes. Note small round black dots are pits resulting from attack on inclusions of several etchings and light polishing necessary to overcome the amorphous flow of the metal during polishing. C68-12

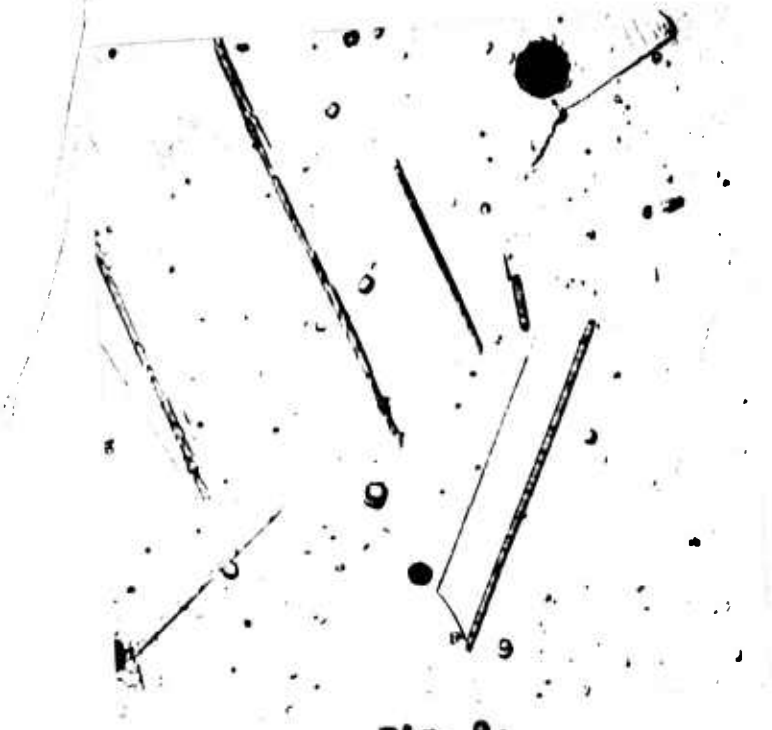

Fig. 9.

X1000 FeCl$_3$ etched No. 2 Bar, Transverse Section showing slip planes in twinned austenite. Only a small amount of precipitated carbides are seen. CCB-13