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SUBJECT: Metallographic Examination of Components
and Coupons from HRP In-Pile Loop L-2-17 - Part I

TO: A. R. Olsen

FROM: A. E. Richt

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Intra-Laboratory Correspondence
OAK RIDGE NATIONAL LABORATORY
Solid State Division

To: A. R. Olsen

Date: February 18, 1958

From: A. E. Richt

Subject: Metallographic Examination of Components and Coupons from
HRP In-Pile Loop L-2-17 - Part I

Introduction

Metallographic examination of representative components and coupons from HRP in-pile loop L-2-17 has been requested. This loop operated for a total of 1136.8 hours at 300°C in beam hole HB-2 of the LITR. A complete report of fabrication, operation, and post-irradiation observations will be issued in the near future.

Specimens from the loop components which were examined included sections from the nose of the core cap, core cap to core body weld, pump outlet piping, pressurizer body, and the pressurizer heater lines. In addition, the following corrosion coupons were also examined: SA-1500, SA-1505, SA-1506, SA-1516, SA-1523, SA-1530, SA-1547, SA-1552, SA-1557, SA-1560 (347 S.S.); SH-1, SH-4 (17-4 PH S.S.); SK-1, SK-5 (431 S.S.); SJ-1, SJ-5 (430 S.S.); SL-2, SL-6 (430L S.S.); ZB-101, ZB-102, ZB-104, ZB-106, ZB-117, ZB-119 (Zircaloy 2); TA-300, TA-307, TA-316, TA-320, TA-337, TA-340 (Ti-55); TJ-1, TJ-5 (Ti-3% Al); TD-25, and TD-29 (Ti-110 AT). An additional series of zirconium-niobium alloys has also been submitted. However, because of some additional post-irradiation examinations requested by M. L. Picklesimer, results on these specimens will be reported at a later date as part II of this report.

Results

Examination of sections from the core cap revealed severe pitting attack to a depth of over $\frac{1}{4}$ mils at the nose of the cap (Fig. 1). Both depth and frequency of attack was significantly less ($1\frac{1}{2}$ mil) near the core-cap to body weld (Fig. 2).

Corrosive attack upon sections from the pressurizer was similar to that noted in previous loops. Slight corrosive penetration was evident on sections exposed to the vapor phase of the fuel solution (Fig. 3) while areas below the fuel solution level showed only slight evidence of surface roughening (Fig. 4).

A section from the loop piping at the pump outlet showed slight corrosive penetration at the grain boundaries (Fig. 5) with some evidence of a $\frac{1}{4}$ mil scale on the base metal surface.

All sections from the pressurizer heater lines revealed evidence of numerous transgranular cracks extending radially from the interior surface to a maximum depth of $3\frac{1}{2}$ mils (Fig. 6). The frequency and uniformity of this cracking was such that it appears to be a fabrication fault rather than stress-corrosion attack. The interior surface of the tubing was covered with a $\frac{1}{4}$ mil scale with occasional globules of oxide increasing the thickness of scale to $3\frac{1}{4}$ mils. No evidence of corrosive attack was noted.

Examination of the Zircaloy-2 coupons revealed that all the submitted specimens exhibited rather badly deformed edges. A typical example is shown in Fig. 7. This deformation might easily be mistaken for a channeling effect during visual examination but coupon thickness measurements in general do not indicate that channeling has occurred. The surfaces of the zircaloy coupons, with the exception of ZB-101, were smooth and even with

no evidence of pitting. Figure 8, of coupon ZB-106, shows a typical appearance of the surfaces of these coupons. Coupon ZB-101, Fig. 9, showed a small area near one end of the coupon where the surface was very irregular, possibly indicating corrosive attack.

Surfaces of the Ti-55 and Ti-110 AT coupons were smooth and even showing no evidence of corrosive attack. Typical areas of the surfaces of these specimens are shown in Figs. 10 and 11. The surfaces of the titanium - 3% aluminum alloy coupons (Fig. 12) were very irregular although relatively smooth. Weight loss data indicates little or no corrosive attack on these specimens, thus the irregularities must be assumed to be a result of fabrication methods.

As would be expected from the weight loss data, considerable variation in corrosive attack was noted in the examination of the 347 S.S. coupons. Coupons SA-1506, SA-1505, SA-1500 (from the core channel holder) showed corrosive attack either in the form of channeling and/or pitting (Fig. 13). The core annulus coupons generally showed evidence of a pitting type of attack (Fig. 14), while the pressurizer coupons showed only slight general surface roughening (Fig. 15).

The surfaces of coupons SJ-1, SJ-5 (430 S.S.); SL-2, and SL-6 (430 L S.S.) were slightly irregular as shown in Figs. 16 and 17, however no evidence of localized corrosive attack was noted. Surfaces of coupons SK-1 and SK-5 (431 S.S.) were smooth and even showing no evidence of corrosive attack (Fig. 18). Similarly, no evidence of corrosive attack was noted in the examination of the 17-4 PH S.S. coupons SH-1 and SH-4 (Fig. 19).

A more detailed description of the surface appearance for each individual coupon is tabulated in Table I. Individual coupon thickness measurements at three locations is also included in this table.

Table I
Summary of Metallographic Examination of Corrosion Coupons

Coupon No.	Material	Calc. Penetr. ¹	End Thick.	Center Thick.	End Thick.	Surface Appearance
ZB-101	Zr-2	1.19 mils	.060 in.	.060 in.	.058 in.	Smooth, irregular surface near one end, ends and other face smooth and even.
ZB-102	Zr-2	0.68	.058	.060	.061	Smooth, even - no evidence of pitting.
ZB-104	Zr-2	0.42	.059	.060	.061	Smooth, even - no evidence of pitting.
ZB-106	Zr-2	0.38	.060	.059	.060	Smooth, even - no evidence of pitting.
ZB-117	Zr-2	1.54	.059	.058	.058	Smooth, even - no evidence of pitting.
ZB-119	Zr-2	1.14	.060	.058	.059	Smooth, even - no evidence of pitting.
TA-300	Ti-55	0.08	.060	.0595	.059	Smooth, even - no evidence of pitting.
TA-307	Ti-55	0.00	.060	.059	.059	Smooth, even - no evidence of pitting.
TA-316	Ti-55	0.03	.060	.060	.060	Smooth, even - no evidence of pitting.
TA-320	Ti-55	0.00	.060	.0595	.059	Smooth, even - no evidence of pitting.
TA-337	Ti-55	Gain	.060	.059	.058	Smooth, even - thin scale on all surfaces.
TA-340	Ti-55	Gain	.060	.059	.059	Smooth, even - thin scale on all surfaces.
TD-25	Ti-110 AT	0.08	.061	.061	.061	Smooth, even - no evidence of attack.
TD-29	Ti-110 AT	0.02	.062	.062	.062	Smooth, even - no evidence of attack.
TJ-1	Ti-3% Al	0.02	.059	.060	.060	Smooth, irregular - all surfaces.
TJ-5	Ti-3% Al	0.00	.061	.061	.061	Smooth, irregular - all surfaces.

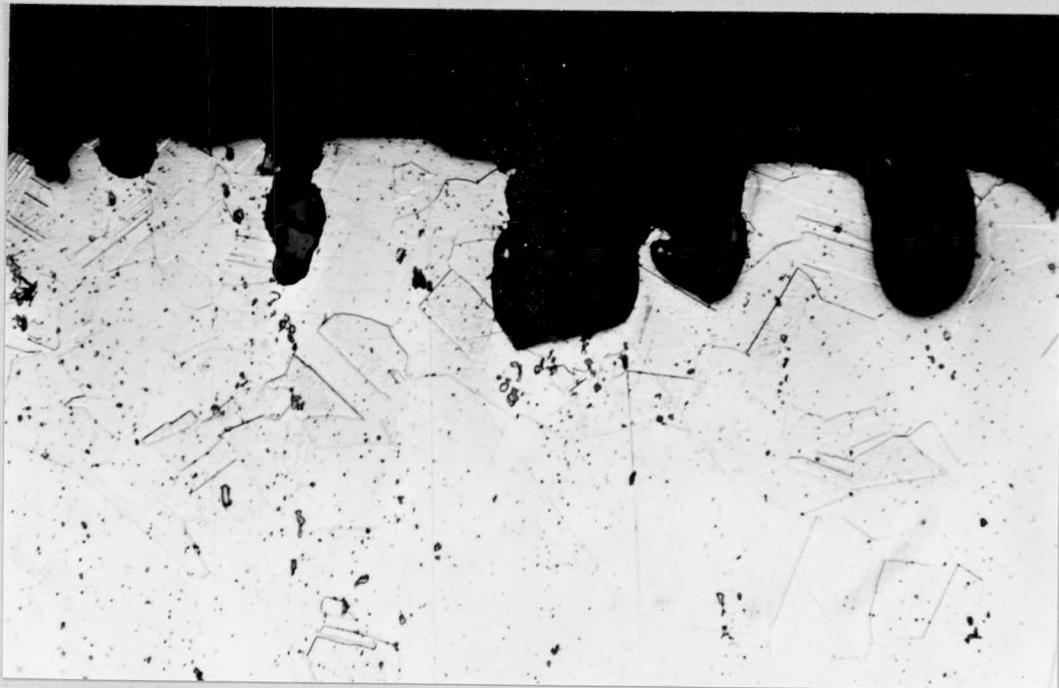
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Table I (Continued)

Summary of Metallographic Examination of Corrosion Coupons

Coupon No.	Material	Calc. Penetr. ¹	End Thick.	Center Thick.	End Thick.	Surface Appearance
SA-1500	347 S.S.	1.14 mils	.058 in.	.057 in.	.056 in.	General surface pitting to $\frac{1}{4}$ mil.
SA-1505	347 S.S.	0.11	.061	.058	.059	Slight pitting on one face only.
SA-1506	347 S.S.	3.35	.064	.052	.061	Heavy channeling, pits on faces and ends.
SA-1516	347 S.S.	0.45	.058	.057	.053	Pitted on both faces and ends.
SA-1523	347 S.S.	0.20	.059	.058	.058	Pitted on faces, no attack at ends.
SA-1530	347 S.S.	0.05	.059	.059	.060	No evidence of corrosive attack.
SA-1547	347 S.S.	0.35	.058	.058	.059	One face pitted, both ends pitted.
SA-1552	347 S.S.	--	.060	.060	.060	Slight general surface roughening.
SA-1557	347 S.S.	0.03	.060	.059	.059	Slight general surface roughening.
SA-1560	347 S.S.	0.08	.060	.060	.061	Poss. slight general surface roughening.
SJ-1	430 S.S.	0.16	.058	.059	.056	Smooth, irregular surface.
SJ-5	430 S.S.	0.02	.058	.059	.060	Smooth, irregular surface.
SL-2	430 L S.S.	0.14	.060	.059	.060	Smooth, irregular surface.
SL-6	430 L S.S.	0.01	.060	.060	.060	Smooth, irregular surface.
SK-1	431 S.S.	0.17	.059	.059	.058	Smooth, even - no evidence of attack.
SK-5	431 S.S.	0.004	.059	.059	.060	Smooth, even - no evidence of attack.
SH-1	17-4 PH S.S.	0.16	.054	.057	.060	Smooth, even - no evidence of attack.
SH-4	17-4 PH S.S.	0.02	.053	.057	.060	Smooth, even - no evidence of attack.

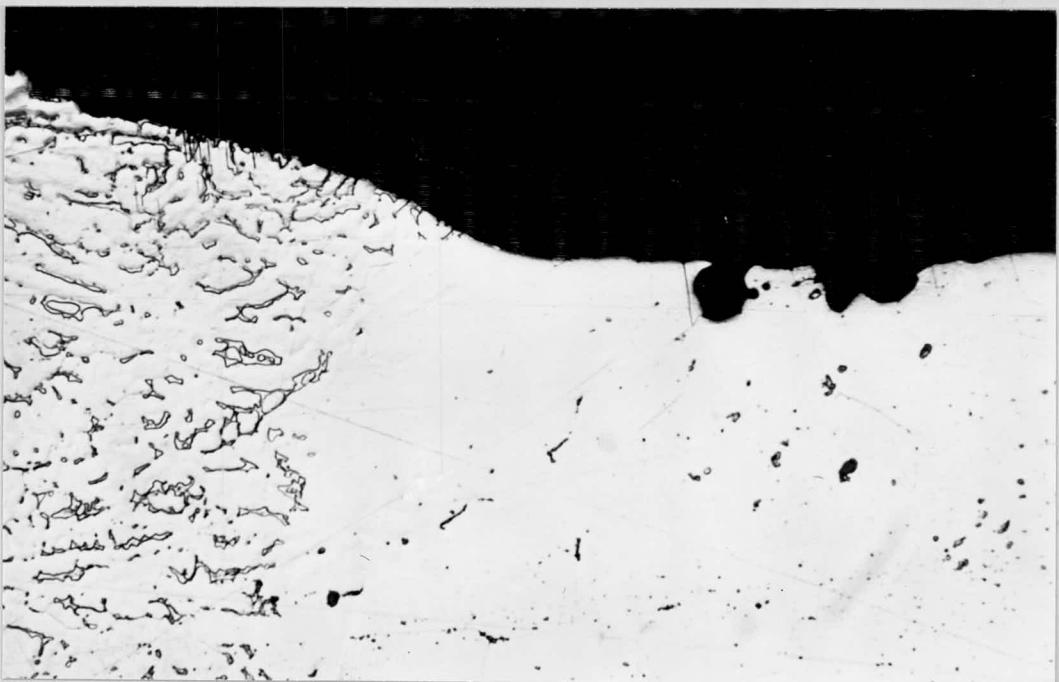
¹ Data obtained from A. R. Olsen



RMG 2108

Fig. 1
Core Cap

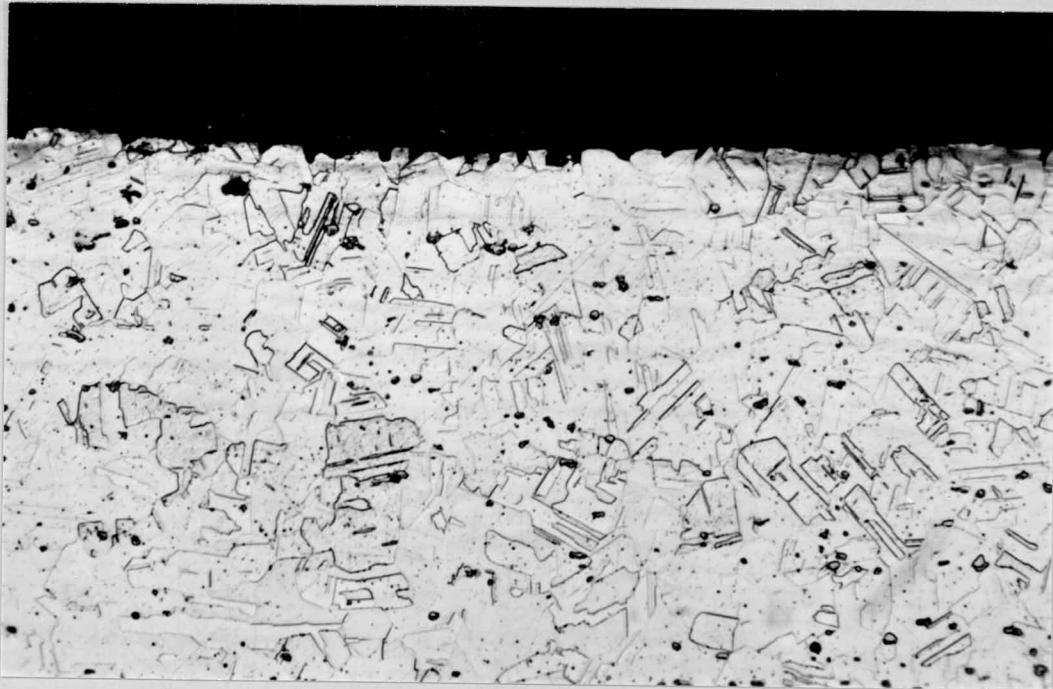
250X



RMG 2109

Fig. 2
Core-Cap to Body Weld

250X



RMG 2110

Fig. 3
Pressurizer-Vapor Phase

250X



RMG 2111

Fig. 4
Pressurizer-Liquid Phase

250X



RMG 2112

Fig. 5
Pump Outlet Piping

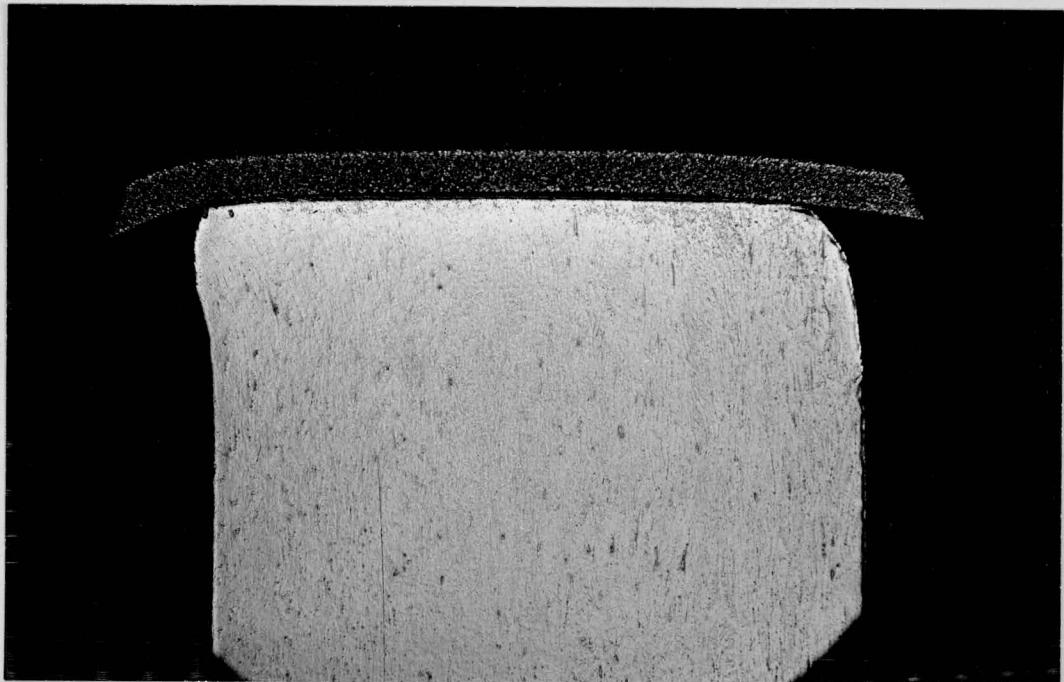
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RMG 2113

Fig. 6
Typical Pressurizer Heater Line

250X



RMG 2114

Fig. 7
Coupon ZB-119

50X



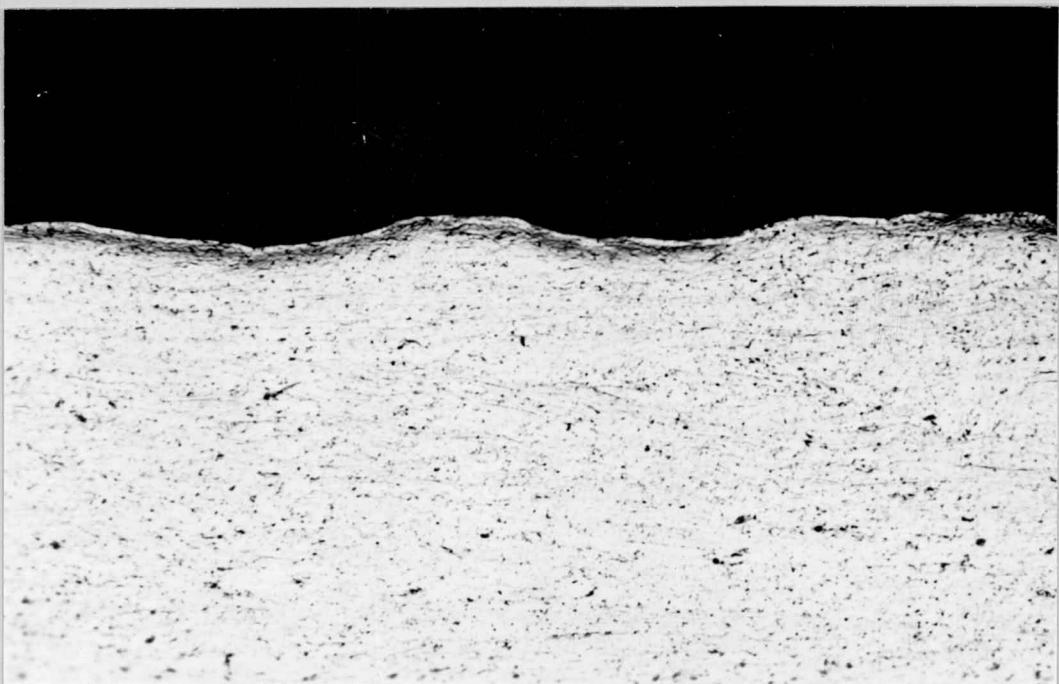
RMG 2115

Fig. 8
Coupon ZB-106

250X

- 10 -

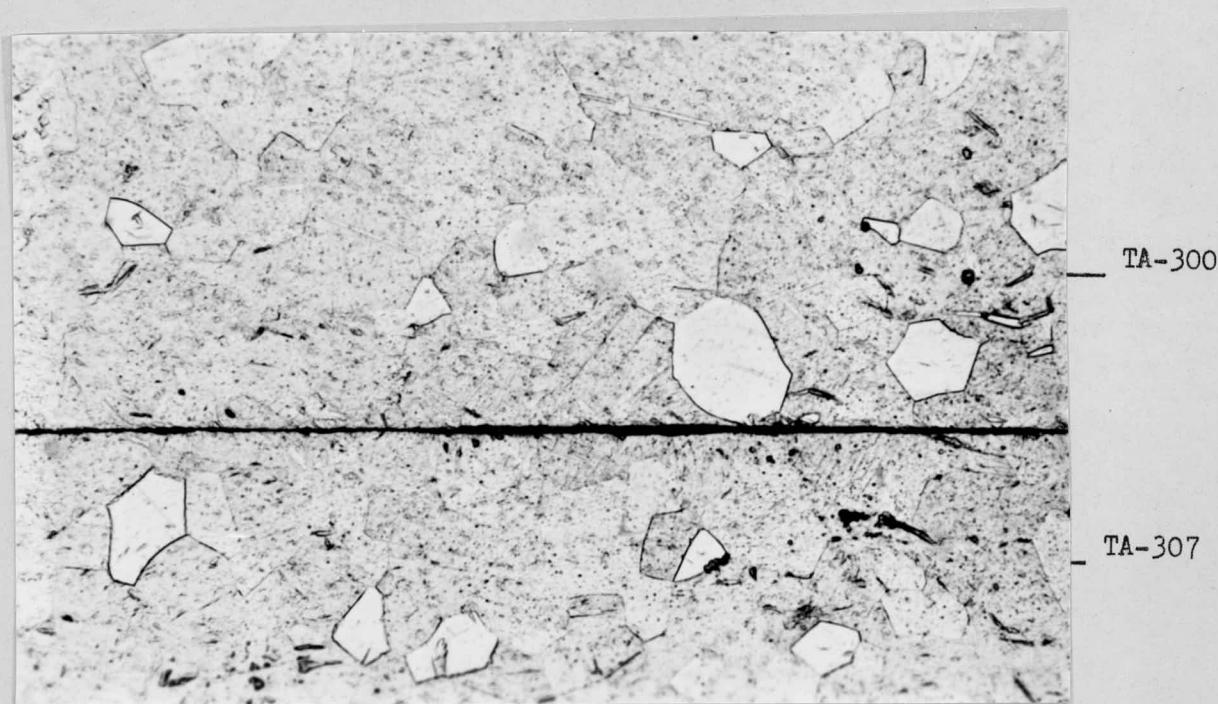
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RMG 2116

Fig. 9
Coupon ZB-101

250X



RMG 2117

Fig. 10
Coupons TA-300 & TA-307

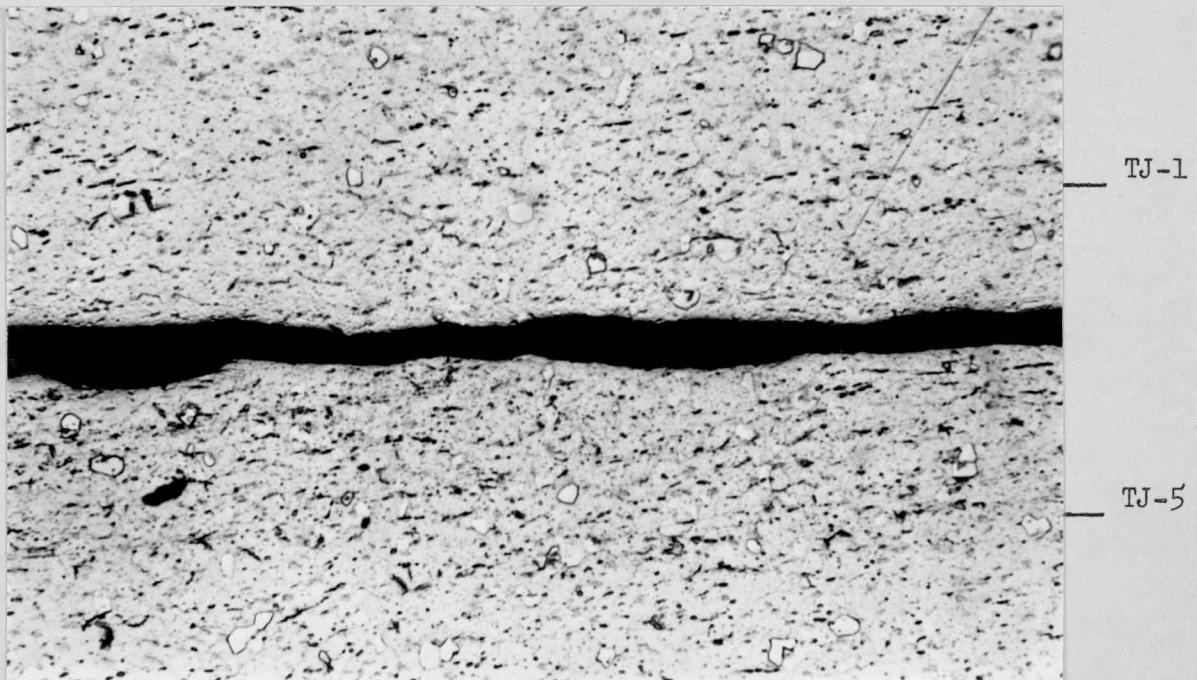
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RMG 2118

Fig. 11
Coupons TD-25 and TD-29

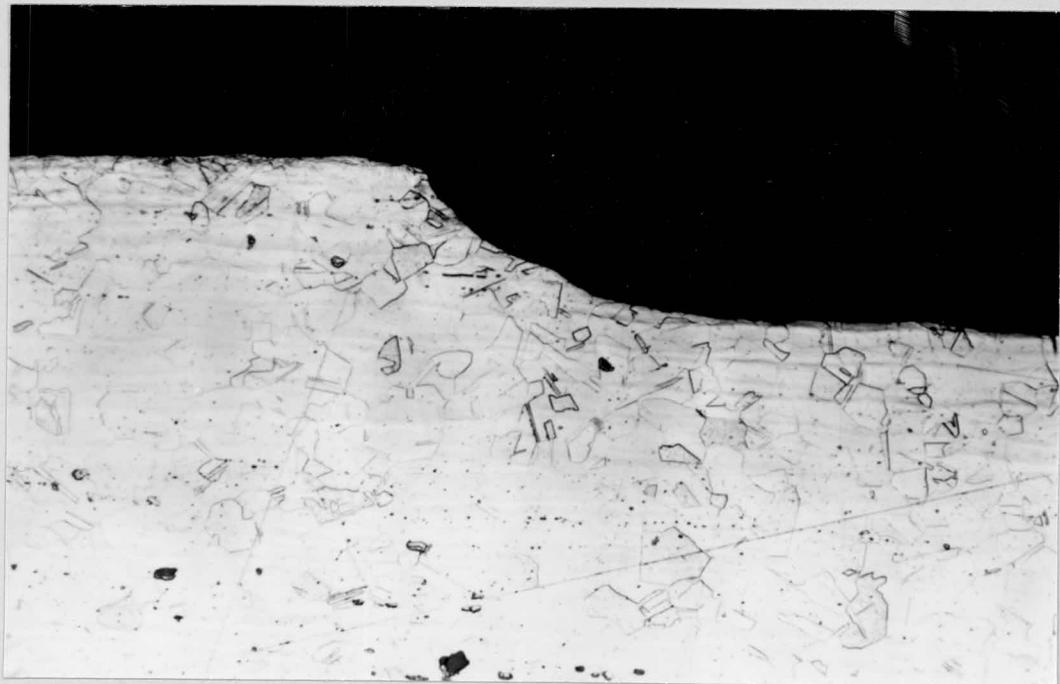
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RMG 2119

Fig. 12
Coupons TJ-1 and TJ-5

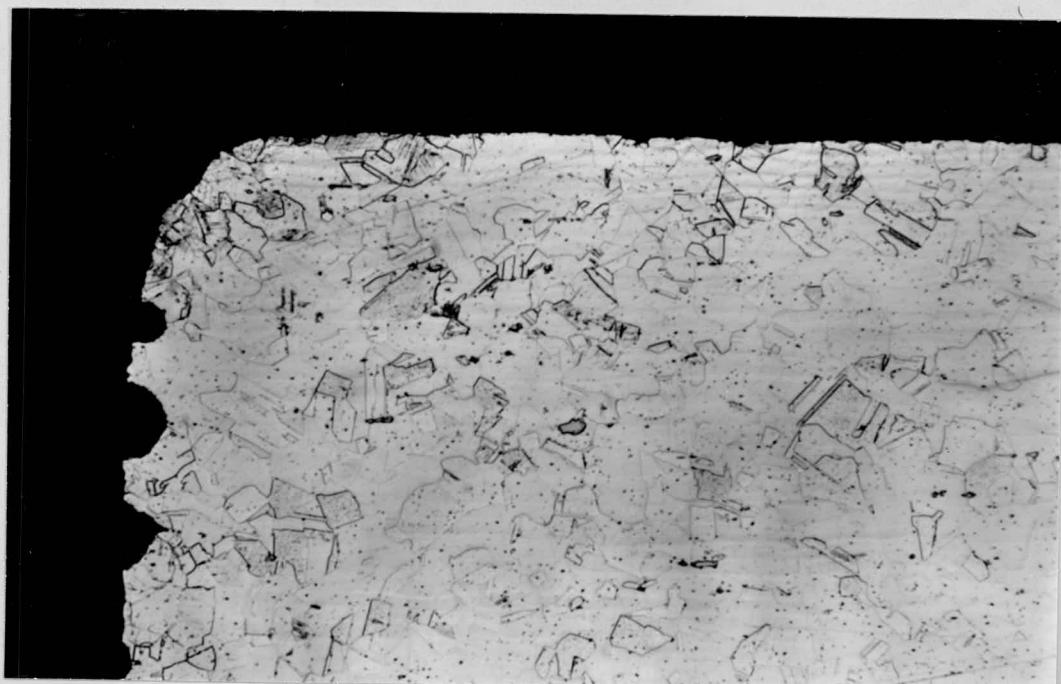
250X



RMG 2120

Fig. 13
Coupon SA-1506

250X



RMG 2121

Fig. 14
Coupon SA-1516

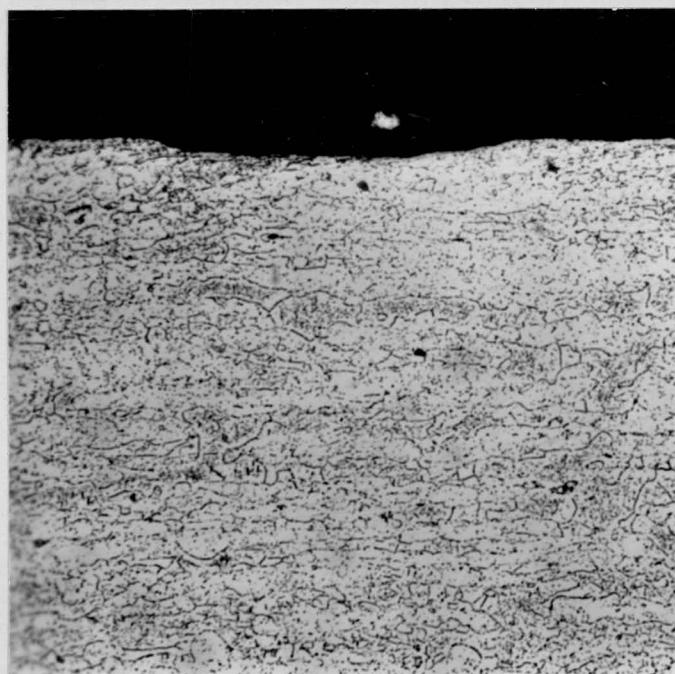
250X



RMG 2122

Fig. 15
Coupons SA-1557 and 1560

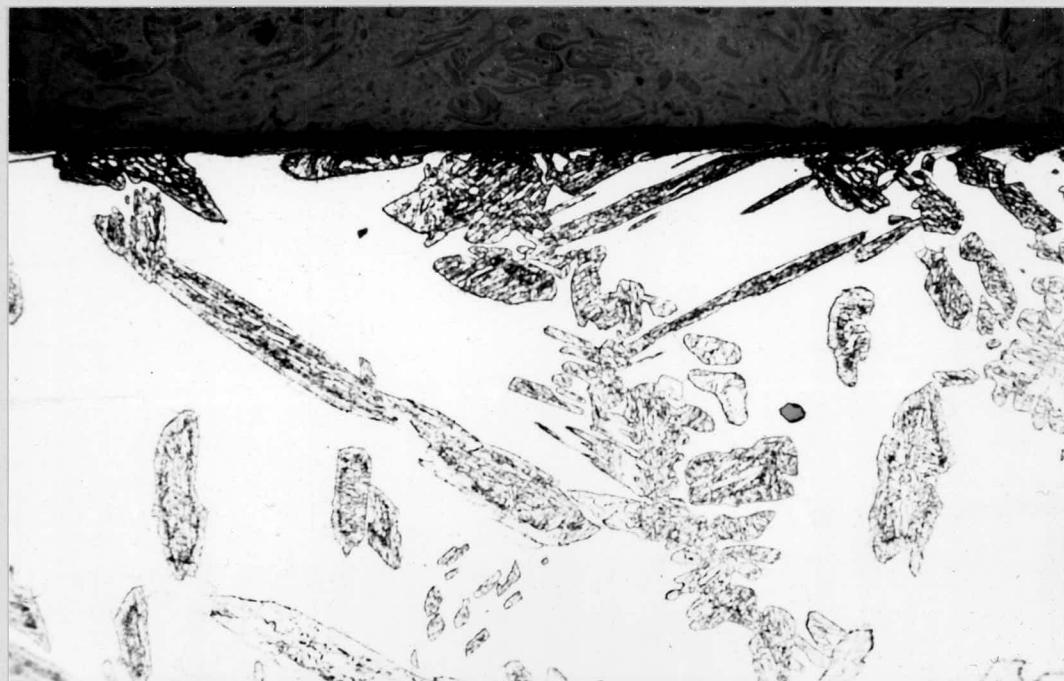
250X



RMG 2123

Fig. 16
Coupon SJ-1

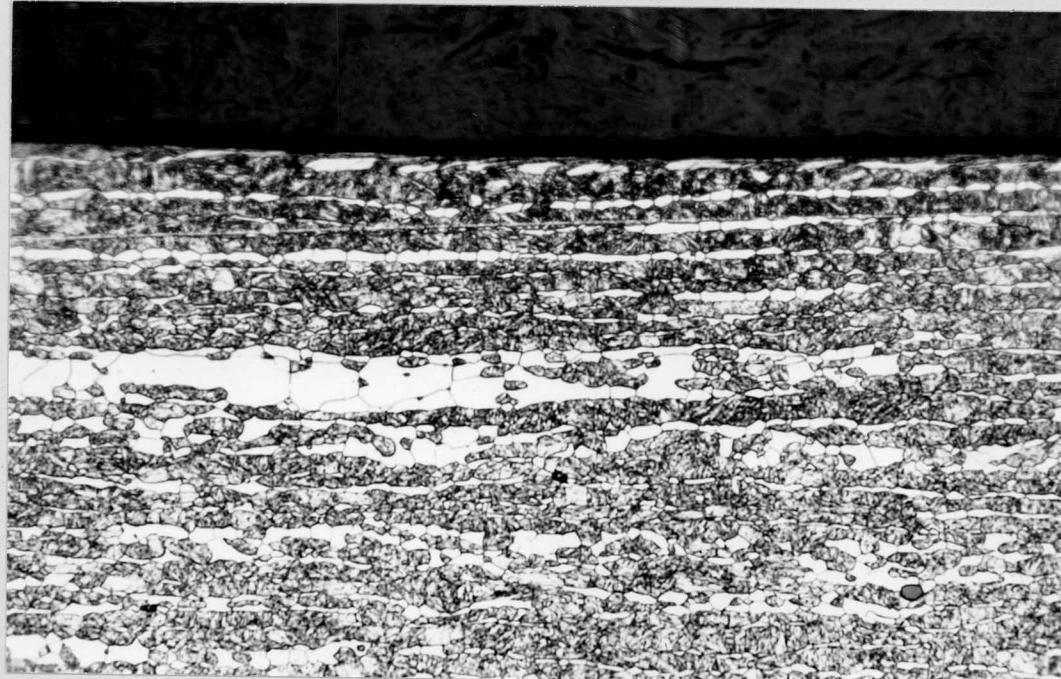
250X



RMG 2124

Fig. 17
Coupon SL-2

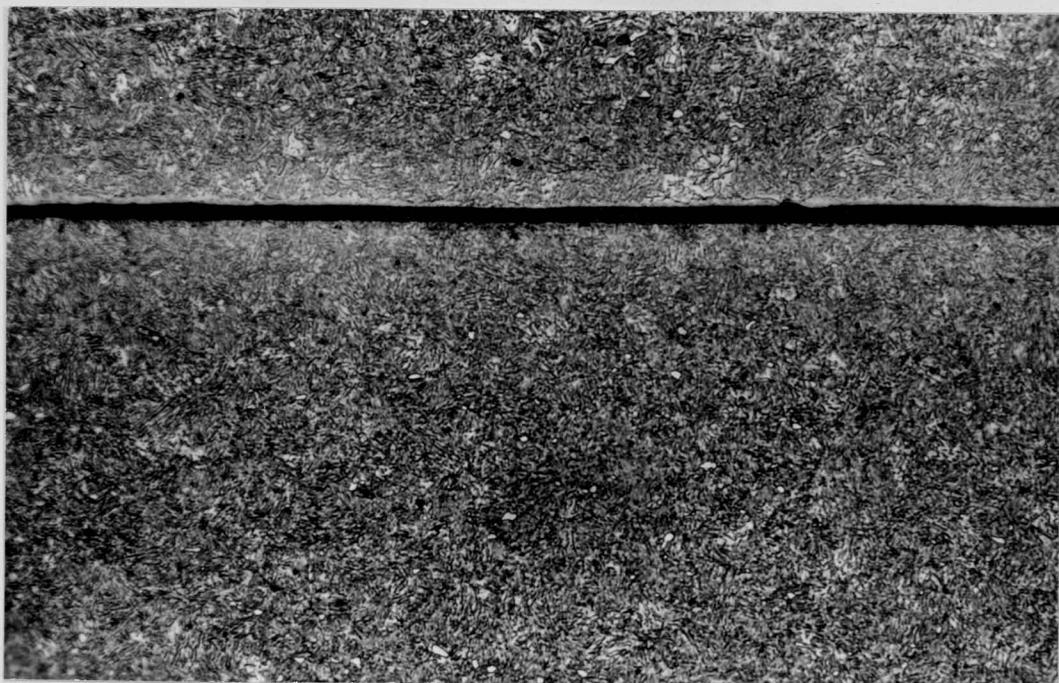
250X



RMG 2125

Fig. 18
Coupon SK-5

250X



RMG 2126

Fig. 19
Coupon SH-1

250X