308 - - - Q200409290003

Scientific Notebook No. 438: Effect of Environment of HE of Ti-7 (01/02/2001 through 09/19/2003)

LABORATORY NOTEBOOK

CNWRA/SwRI

Ti HE
CLST 20.01402.571
BROSSIA, X 5797
Yiming Pan, X6640

NOTEBOOK NO. _____

ISSUED TO _____

ON _____

DEPARTMENT _____

RETURNED _____

Brian K. Derby- BKD
Steve Clay
Jerry Sievert GKS
Roger Dykstra RTD
Sean Brossia CSB
Yiming Pan ZYP

—SCIENTIFIC NOTEBOOK CO.—
2831 LAWRENCE AVE.
P.O. BOX 238
STEVENSVILLE, MI 49127
616-429-8285

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Initial Scientific notebook entry for Titanium Grade 7 Hydrogen Embrittlement Studies.

Title: Effect of Environment HE of Ti-7

Tests Performed by: Sean Brossia, Steve Clay, other personnel will be identified as they begin work on specific tests. Yi-Ming Pan (Div. 20), Jerry Sievert (Div. 18) Brian Derby (Div. 18)

Objectives: Determine the conditions under which HE of Ti grades 2, 5, and 7 take place, including critical hydrogen concentration to induce reduction in mechanical properties, effect of orientation, and crack propagation rates if possible

Equipment: Slow-strain rate machines, Other specific equipment will be identified and calibrated prior to testing.

Materials: Titanium Grades 2,5 and 7 notched slow strain rate specimens procured from Metal Samples

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Equipment sent to cal lab.

S Bruce 3/1/01

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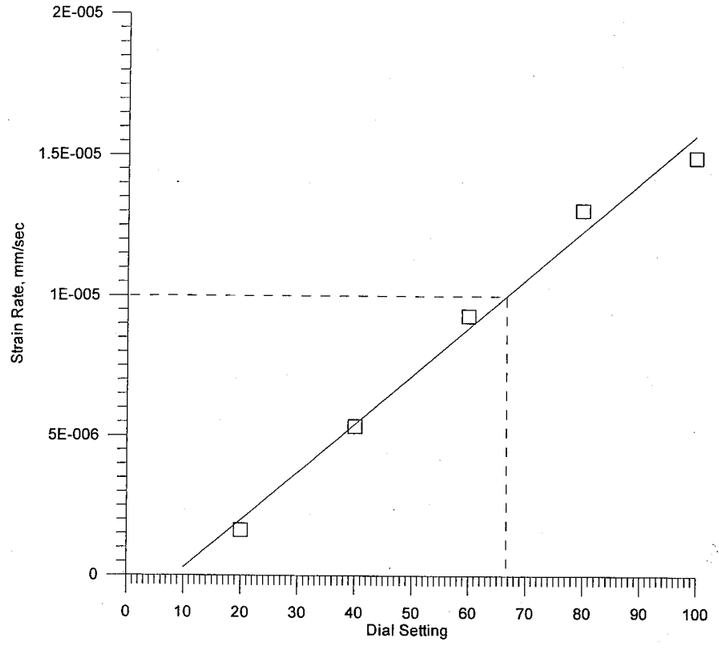
Project No.
Book No.
TITLE Strain Rate Calculation

From Page No.

Checking Gear Motors for Rotation To Calculate Strain Rate

Setting	Time for Large Gear #1	Time for Large Gear #2	Average Time	Strain Rate (in/sec)	Strain Rate (mm/sec)
20	279.60	216.20	247.90	6.39E-08	1.62E-06
40	79.30	71.30	75.30	2.10E-07	5.34E-06
60	44.80	41.90	43.35	3.65E-07	9.28E-06
80	31.80	29.90	30.85	5.13E-07	1.30E-05
100	27.90	26.00	26.95	5.88E-07	1.49E-05

Equation Y = 1.715529159E-007 * X - 1.449603551E-006
Number of data points used = 5
Average X = 60
Average Y = 8.84357E-006
Residual sum of squares = 1.51641E-012
Regression sum of squares = 1.17722E-010
Coef of determination, R-squared = 0.987282
Residual mean square, sigma-hat-sq'd = 5.05471E-013



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Project No.
Book No.
TITLE Ti Slow Strain Rate Specimens

From Page No.

Packing Slip

Alabama Specialty Products, Inc.
152 Metal Samples Road
P. O. Box 8
Munford AL 36268-0055
United States

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Fax: (256)358-4515

Packing Slip: 54598
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Order: 46906

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FOB: COLL /078100014
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1	10.00EA	10.00	0.00	TS1904802	
	Description: TIGR2 NOTCHED SLOW STRAIN RATE SPECIMEN				
2	10.00EA	10.00	0.00	TS1904802	
	Description: TIGR2 NOTCHED SLOW STRAIN RATE SPECIMEN				
3	10.00EA	10.00	0.00	TS1904807	
	Description: TIGR5 NOTCHED SLOW STRAIN RATE SPECIMEN				
4	10.00EA	10.00	0.00	TS1904807	
	Description: TIGR5 NOTCHED SLOW STRAIN RATE SPECIMEN				
5	10.00EA	10.00	0.00	TS1904CSM	
	Description: TIGR7(CSM) NOTCHED SLOW STRAIN RATE SPECIMEN				

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Metal Samples Co.

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United States

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Fax: (256)358-4515

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Sales Person BENJAMIN J. LACKEY

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Ship Via: FEDERAL EXPRESS

Line	Planned Qty	Shipped Qty	Backorder	Part Number	Revision
6	10.00EA	10.00	0.00	TS1904CSM	
	Description: TIGR7(CSM) NOTCHED SLOW STRAIN RATE SPECIMEN				
7	1.00EA	1.00	0.00	CU014829999	
	Description: TIGR2 ARCHIVE SPECIMEN				
8	1.00EA	1.00	0.00	CU014829999	
	Description: TIGR5 ARCHIVE SPECIMEN				
9	1.00EA	1.00	0.00	CU014829999	
	Description: TIGR7(CSM) ARCHIVE SPECIMEN				

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MATERIAL TEST REPORT

DATE : 10/25/00
PAGE : 1
ORDER: 46906

Metal Samples Company
P.O. Box 8
152 Metal Samples Road
Munford, AL 36268
Ph. (256)358-4202 Fx. (256)358-4515

Customer: 01482 SOUTHWEST RESEARCH INSTITUTE
Your PO#: X82483S

Lot No. R951 Mill: Our Order Line No. 1
Description: TIGR2 .375" X 40.5" X 43.25"
Item: 018020375 TIGR2 .375"
Chemical Properties:
C:0.011 Fe:0.111 H:0.001 N:0.016
O:0.141 Ti:BALANCE
Physical Properties:
Tensile-PSI:75,000 Elong-%:29.0
Yield-PSI:50,500 R/A-%:53.3

Lot No. G606 Mill: PRESIDENT TITANIUM Our Order Line No. 3
Description: TIGR5 5/16"THK
Item: 018070312 TIGR5 .312"
Chemical Properties:
Al:6.180 C:0.030 Fe:0.140 H:0.0123
N:0.007 O:0.186 Ti:BALANCE V:4.050
Y:<0.0005
Physical Properties:
Tensile-PSI:146,000 Elong-%:10.9
Yield-PSI:131,000 R/A-%:25.4

Lot No. P586 Mill: TIMET Our Order Line No. 5
Description: TIGR7 1.00" X 24.00" X 48.00"
Chemical Properties:
C:0.009 Fe:0.115 H:50 PPM N:0.007
O:0.140 Pd:0.155 Ti:BALANCE
Physical Properties:
Tensile-PSI:79,000 Elong-%:25.0
Yield-PSI:54,000 R/A-%:45.0
Condition:ANLD

We certify that the Material Test Report is correct to the best of our knowledge and that the material supplied meets your required P.O. specifications.

THANK YOU, Quality Control Dept. KP Karen Braden

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Galvanic Corrosion Scan

objective: To obtain E applied Potential for further Tests

Specimens: Ti 7 Polished To 600 Grit Finish
316 cylinder Polished To 600 Grit Finish

No specimen weights Taken

Solution: 1 m Cl + 0.1 m F^-
58.45 g NaCl Lot # 006924
4.201 g NaF Lot # 991559
+ DI water To 1000 mls

Potentiostat: PC4/750

Reference: Fisher 13-620-52 SN# 0089777

Temperature: 95°C Hg Thermometer SN# C96-649 Cal 6/29/01

Solution Deaerated with 99.999% N_2

Data saved As ti7_fe galv1.DTA

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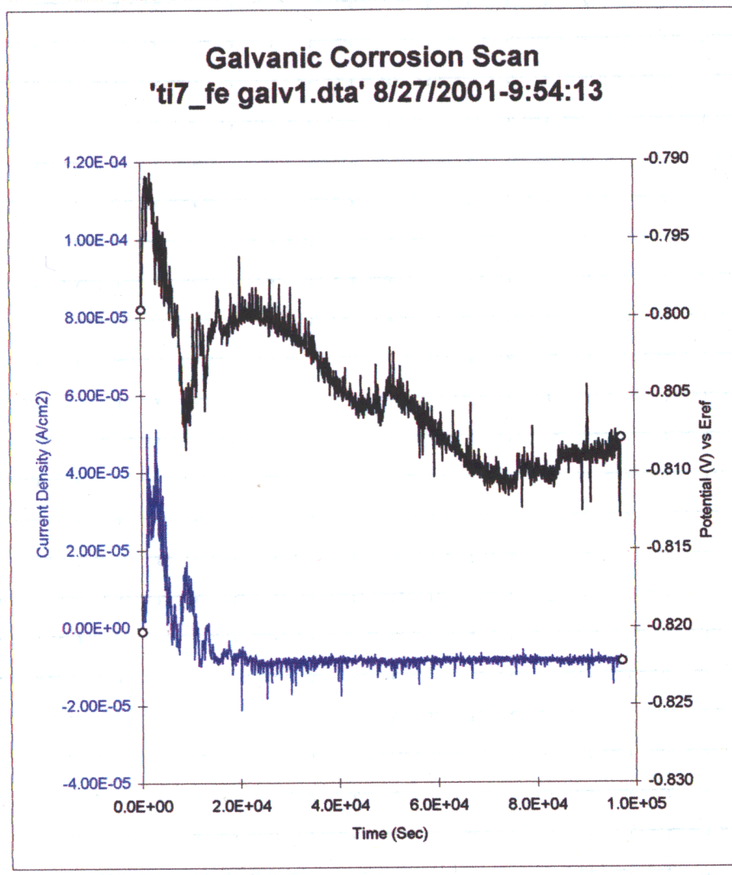

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Book No.
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Testing Plan for the Initial Set of Ti Slow Strain Rate Tests

No. of Tests:	6 (3 materials and 2 orientations)
Materials:	Ti Grades 2, 5, 7
Orientations:	Parallel or perpendicular to rolling direction
Specimen Type:	Notched tensile specimens
Test Conditions:	Deaerated solution — 1M NaCl + 0.1M NaF Temperature — 95 °C Extension rate — $1x10^{-5}$ mm/s (depending on the gear motors) Open circuit
Data Monitoring:	Load Temperature Potential (not available under open-circuit conditions) Current (not available under open-circuit conditions) pH (initial/final)
After Test Analysis:	Elongation Failure time Fractograph XRD

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ZP 4/4/2002

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Witnessed & Understood by me,	Date	Invented by	Date
		Recorded by ZP	3/25/02

Project No._____
Book No._____ TITLE Modified Testing Plan

From Page No.____

Test solutions: 6/27/02

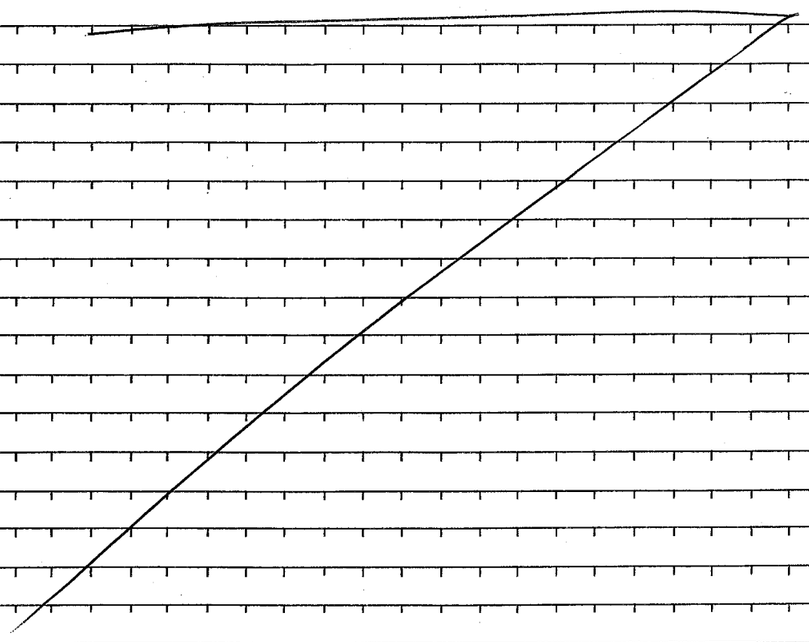
Solution I – 1.0M NaCl + ~~10~~ 0.1 M NaF, deaerated with N_2 (Test Set #1)

Solution II – 1.0M NaCl, deaerated with N_2 (Test set #2)

Data Monitoring:

Load vs. time
Displacement vs. time
Potential vs. time
Current vs. time
} only on one specimen and periodical check on the rest of the specimens*.

* Note: Because all channels in the ESC multichannel potentiostat share the same common ground, potential can not be monitored for all six channels using one reference electrode. Thus, monitoring of potential and current vs. time will be only on Ti Grade 7 specimen.



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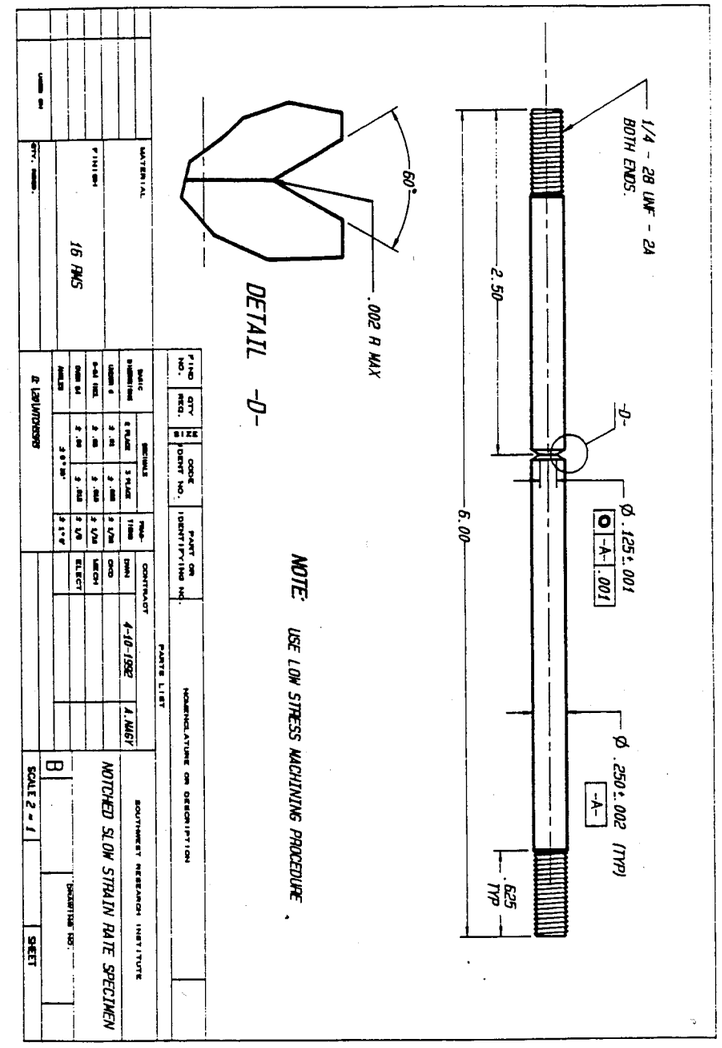
		Recorded by Bijoy Pan	6/27/02

Project No._____
TITLE Notched Slow Strain Rate Specimen Book No._____

From Page No.____ Dimensions



Drawing Number: 20.1402.571.012

Originator: Darrell Dunn Date: 9/8/2000
Darrell Dunn

Reviewed by: N. Sridhar Date: 9/8/2000
Narasi Sridhar

QA Approval: Bruce Mabrito Date: 9/8/2000
Bruce Mabrito

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Witnessed & Understood by me,	Date	Invented by	Date
		Recorded by Bijoy Pan	6/27/02

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Load Cells Channels 1-6

Equipment used:
Morehouse Proving Ring s/n 3668C-709 Due 1/15/04
Keithley 617 Electrometer s/n 537418 Due 3/11/03

Date: 6/25/02 Frame: SS5 Load Cell: 1

Dead Weight	Ring Reading	Output Voltage	Load	Ring Reading	Output Voltage	Load	Average Voltage	Average Load
0	9.8	-.2mV	0	9.7	2.5mV	0	0.0012	0
600	59.9	0.4968	591.07	59.0	0.4996	591.85	0.4982	586.46
1200	109.6	1.0041	1178.36	109.6	1.0056	1179.54	1.0048	1178.95
1800	159.2	1.5109	1766.29	159.4	1.5109	1769.86	1.5109	1768.08
2400	209.3	2.017	2361.08	210.1	2.016	2371.83	2.016	2366.46
3000	259.1	2.521	2954.38	260.9	2.520	2976.83	2.520	2965.60
3600	309.4	3.024	3554.61	309.4	3.025	3559.60	3.024	3555.20
4000	342.2	3.360	3947.02	342.1	3.361	3947.02	3.360	3947.02

SHUNT CAL; 5.552 ✓

Date: 6/25/02 Frame: SS5 Load Cell: #2

Dead Weight	Ring Reading	Output Voltage	Load	Ring Reading	Output Voltage	Load	Average Voltage	Average Load
0	9.9	.4mV	0	9.9	2mV	0	0.0012	0
600	59.0	0.5639	579.48	59.0	.5659	579.48	0.5649	579.48
1200	109.4	1.1385	1174.87	109.3	1.1402	1173.63	1.1394	1174.22
1800	160.6	1.7126	1781.50	160.8	1.7136	1783.858	1.7131	1782.69
2400	210.6	2.285	2375.40	210.4	2.285	2373.02	2.285	2374.21
3000	261.1	2.857	2976.83	260.2	2.856	2966.07	2.856	2971.45
3600	310.2	3.428	3563.04	310.4	3.427	3565.41	3.428	3564.22
4000	344.0	3.809	3967.32	343.5	3.508	3961.36	3.808	3964.34

SHUNT CAL: 6.280 ✓

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Date: 6/25/02 Frame: SS5 Load Cell: #3

Dead Weight	Ring Reading	Output Voltage	Load	Ring Reading	Output Voltage	Load	Average Voltage	Average Load
0	9.9	.9mV	0	9.8	3.9mV	0	0.0042	0
600	59.0	.4894	579.48	59.9	.4933	591.07	0.4914	585.28
1200	109.4	.9863	1174.81	109.4	.9884	1175.99	0.9874	1175.40
1800	160.1	1.4806	1775.56	160.0	1.4822	1775.56	1.4814	1775.56
2400	210.9	1.9746	2378.96	210.8	1.9749	2378.96	1.9748	2378.96
3000	260.6	2.468	2970.85	260.8	2.468	2974.44	2.468	2972.64
3600	310.6	2.960	3567.50	310.1	2.960	3563.02	2.960	3565.41
4000	343.8	3.288	3964.94	343.8	3.288	3966.13	3.288	3965.54

SHUNT CAL; 5,422 ✓

Date: 6/25/02 Frame: SS5 Load Cell: #4

Dead Weight	Ring Reading	Output Voltage	Load	Ring Reading	Output Voltage	Load	Average Voltage	Average Load
0	9.2	.65mV	0	9.2	5.74mV	0	0.0032	0
600	62.0	.5240	623	62.4	.5341	627.72	0.5290	625.36
1200	110.1	1.0035	1191.43	111.1	1.0160	1203.25	1.0098	1197.34
1800	160.6	1.5112	1789.81	161.7	1.5235	1802.89	1.5174	1796.35
2400	210.4	2.020	2381.34	211.4	2.031	2393.23	2.0255	2387.28
3000	260.1	2.528	2973.24	261.3	2.539	2987.57	2.534	2980.40
3600	311.9	3.035	3591.69	311.3	3.045	3584.52	3.040	3588.10
4000	349.0	3.374	3975.69	345.0	3.384	3987.64	3.379	3981.66

SHUNT CAL; 5.342 ✓

Date: 6/26/02 Frame: SS5 Load Cell: #5

Dead Weight	Ring Reading	Output Voltage	Load	Ring Reading	Output Voltage	Load	Average Voltage	Average Load
0	9.4	-.5mV	0	9.7	4.1mV	0	.0016	0
600	61.6	.5155	615.90	62.0	.5243	619.09	0.5199	616.50
1200	109.1	.9962	1177.18	110.2	1.0078	1186.70	1.0020	1181.94
1800	160.5	1.4977	1789.81	161.6	1.5099	1795.76	1.5038	1792.78
2400	210.6	1.999	2381.34	211.6	2.010	2389.66	2.0095	2385.50
3000	260.5	2.499	2975.63	261.5	2.510	2984.00	2.504	2979.82
3600	310.7	2.998	3574.97	311.9	3.009	3585.72	3.004	3580.34
4000	343.6	3.331	3968.52	344.9	3.341	3980.47	3.336	3974.50

SHUNT CAL: 5.411 ✓

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Typical Statistical Plot of Load Cell Information

Nonlinear Regression

[Variables]
x = col(1)
y = col(2)
'Automatic Initial Parameter Estimate Functions
F(q)=ape(x,y,1,0,1)
[Parameters]
y0 = F(0)[1] "Auto {{previous: -2.11528}}
a = F(0)[2] "Auto {{previous: 1175.79}}
[Equation]
f=y0+a*x
fit f to y
[Constraints]
[Options]
tolerance=0.000100
stepsize=100
iterations=100

R = 0.99999717 Rsqr = 0.99999434 Adj Rsqr = 0.99999340

Standard Error of Estimate = 3.6315

	Coefficient	Std. Error	t	P
y0	-2.1153	2.3673	-0.8935	0.4060
a	1175.7858	1.1418	1029.7838	<0.0001

Analysis of Variance:

	DF	SS	MS	F	P
Regression	1	13985229.5582	13985229.5582	1060454.7501	<0.0001
Residual	6	79.1277	13.1880		
Total	7	13985308.6859	1997901.2408		

PRESS = 119.1921

Durbin-Watson Statistic = 1.6695

Normality Test: Passed (P = 0.6084)

Constant Variance Test: Passed (P = 0.7053)

Power of performed test with alpha = 0.0500: 1.0000

Regression Diagnostics:

Row	Predicted	Residual	Std. Res.	Stud. Res.	Stud. Del. Res.
1	-0.7043	0.7043	0.1940	0.2557	0.2347
2	583.6612	2.7988	0.7707	0.9070	0.8913
3	1179.3143	-0.3643	-0.1003	-0.1107	-0.1011
4	1774.3794	-6.2994	-1.7347	-1.8600	-2.6096
5	2368.2688	-1.8088	-0.4981	-0.5348	-0.5002
6	2960.8649	4.7351	1.3039	1.4442	1.6322
7	3553.4609	1.7391	0.4789	0.5673	0.5324
8	3948.5249	-1.5049	-0.4144	-0.5279	-0.4935

Influence Diagnostics:

Row	Cook'sDist	Leverage	DFFITS
1	0.0241	0.4245	0.2016
2	0.1583	0.2779	0.5529
3	0.0013	0.1787	-0.0472
4	0.2591	0.1303	-1.0100
5	0.0218	0.1324	-0.1954
6	0.2365	0.1849	0.7773
7	0.0649	0.2875	0.3382
8	0.0868	0.3838	-0.3895

95% Confidence:

Row	Predicted	Regr. 5%	Regr. 95%	Pop. 5%	Pop. 95%
1	-0.7043	-6.4941	5.0854	-11.3101	9.9014
2	583.6612	578.9768	588.3456	573.6161	593.7063
3	1179.3143	1175.5578	1183.0707	1169.6669	1188.9616
4	1774.3794	1771.1722	1777.5867	1764.9323	1783.8265
5	2368.2688	2365.0352	2371.5025	2358.8127	2377.7249
6	2960.8649	2957.0444	2964.6853	2951.1923	2970.5374
7	3553.4609	3548.6963	3558.2254	3543.3781	3563.5436
8	3948.5249	3943.0197	3954.0301	3938.0717	3958.9781

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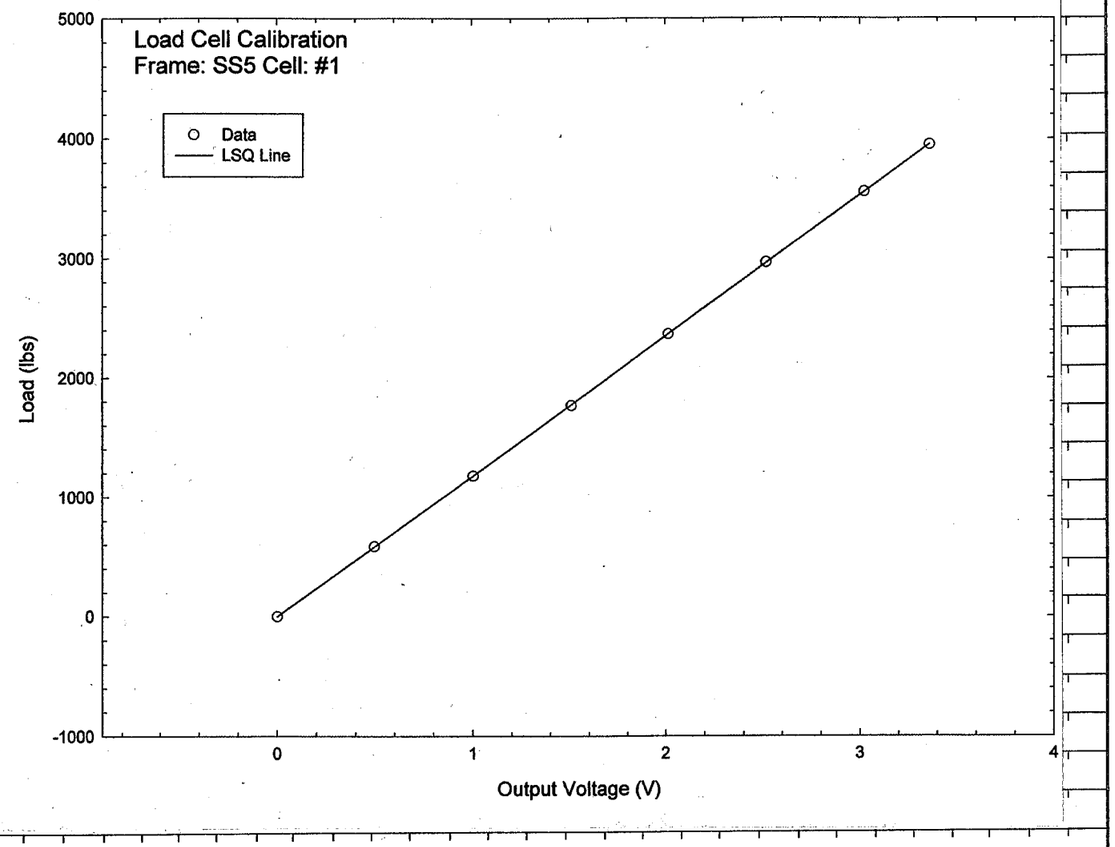

Typical Load Cell Plot

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Witnessed & Understood by me, | Date | Invented by | Date | Recorded by | 7-302

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Date: 6/26/02 Frame: SS5 Load Cell: #6

Dead Weight	Ring Reading	Output Voltage	Load	Ring Reading	Output Voltage	Load	Average Voltage	Average Load
0	9.7	.1 mV	0	9.6	.15mV	0	0.10008	0
600	61.1	.5095	606.44	60.6	.5051	601.71	0.50773	604.08
1200	110.4	1.0019	1189.07	110.4	1.0024	1190.25	1.0022	1189.66
1800	161.7	1.5022	1796.95	161.9	1.5023	1800.52	1.5022	1798.74
2400	211.7	2.002	2390.85	211.8	2.001	2393.23	2.002	2392.04
3000	261.6	2.500	2985.19	261.8	2.500	2988.77	2.500	2986.98
3600	311.8	2.997	3584.52	311.0	2.997	3576.17	2.997	3580.34
4000	344.4	3.329	3974.49	344.8	3328	3980.47	3.328	3977.48

SHUNT CAL: 5.369V

Load Cell Cals: f=yo+A*X

LC	yo	A
1	-2.1153	1175.789
2	-6.4951	1042.225
3	-10.1332	1208.32
4	1.8534	1178.357
5	-5.0143	1192.815
6	-2.5485	1195.831

Cal Factors per volt used in software

To Page No.

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From Page No. 18

LVDT

Equipment used:
Keithley 617 Electrometer s/n 537418 Due 3/11/03
Gauge Blocks (Date Below) Due 1/7/03

Carl Zeiss, Incorporated

7008 Northland Drive
Minneapolis, Mn. 55428
Tel. (612) 533-9990
Fax (612) 533-4903

Progam name: Program Number: 0
Date: 01/07/102 Time: 14:10 Page: 1

Description	Value	Tolerance
DISTANCE Plane (Feature # 1) to Point (Feature # 2) DISTANCE	0.0625	1/16 P4W X379A
DISTANCE Plane (Feature # 3) to Point (Feature # 4) DISTANCE	0.0625	1/16 P4W X369A
DISTANCE Plane (Feature # 5) to Point (Feature # 6) DISTANCE	0.1250	.125 P4W Y242A
DISTANCE Plane (Feature # 7) to Point (Feature # 8) DISTANCE	0.2501	.250 P4W Y455A
DISTANCE Plane (Feature # 9) to Point (Feature # 10) DISTANCE	0.5002	.500 P4W 694A
DISTANCE Plane (Feature # 11) to Point (Feature # 12) DISTANCE	1.0000	1.000 P4W Y189B

Bldg# 162
Temp, 70°
Humidity 30%
Small CMM X529

JAN -7 2002

LVDT Model VL7A Part Number 060-3618-01 7/3/2002
S/N L4904600 S. Clay

Gauge Blk	Travel Inch	Volt Run 1	Volt Run 2	Volt Run 3		Cal Factor
0.0000	1.0000	10.000	10.000	10.000	10.000	0.1
0.0625	0.9375	9.366	9.367	9.367	9.367	0.10008897
0.1250	0.8750	8.739	8.739	8.741	8.740	0.10011823
0.1875	0.8125	8.106	8.107	8.112	8.108	0.10020555
0.2500	0.7500	7.486	7.485	7.486	7.486	0.10019148
0.3750	0.6250	6.240	6.242	6.243	6.242	0.10013351
0.5000	0.5000	5.001	5.001	5.004	5.002	0.09996002
0.6250	0.3750	3.755	3.753	3.757	3.755	0.09986684
0.7500	0.2500	2.506	2.503	2.508	2.506	0.09977385
0.8750	0.1250	1.249	1.247	1.251	1.249	0.10008006
1.0000	0.0000	0.002	0.002	0.002	0.002	0

Cal Factor Avg. = 0.10004185

To Page No.

Witnessed & Understood by me, Date | Invented by | Date

Recorded by 7-3-02

Project No.
Book No.

TITLE Slow Strain Test #1

From Page No.

Solution 1M NaCl → 116.88g Fisher 010488
.1M NaF → 8.398g Fisher 896405
2 liters HPDI pH = 8.398 10/8/02

Two batches required for 2.8 liter volumn

Specimen position in autoclave head

Position #6
Grade 7 Par

Position #1
Grade 2 Per

Position #5
Grade 5 Per

Position #2
Grade 5 Par

Position #4
Grade 2 Par

Position #3
Grade 7 Per

Specmens placed in Autoclave with 2.8 liters Solution
Deaerated w/ N_2 for 24 hours while bringing solution
temperature to 95°C

Extension rate set to 1×10^{-6} in/sec

Open circuit potential of Grade 7 Par recorded
Load + Deflection vs Time recorded all Channels

Reference probe is Silver Silver Chloride w/ .1 M Potassium Chloride

Data Storage filenames Spec1.1, Spec2.2, Spec3.3, Spec4.4, Spec5.5, Spec6.6
New Filenames: Ti2PER, Ti5PER, Ti7PER
Ti2PAR, Ti5PAR, Ti7PAR

To Page No.

Witnessed & Understood by me,

Date

Invented by

Recorded by

Date 7-9-02

Project No.
Book No.

TITLE Slow Strain Test #2

From Page No.

Solution 1M NaCl → 116.88g Fisher 010488
2 liters HPDI pH = 6.165 10/8/02

Two 2 liter batches

Specimen position (see page 20)

Specimens placed in Autoclave with 2.8 liters Solution
Deaerated for 24 hours while bringing temperature to 95°C

Extension rate set to 1×10^{-6} in/sec

Open circuit potential of Grade 7 PAR recorded
Load + Deflection vs Time recorded all channels

Reference probe is Silver Silver Chloride w/ .1 M Potassium Chloride

Data Storage filenames
TI2PER2.1, TI5PAR2.2, TI7PER2.3,
TI2PAR2.4, TI5PER2.5, TI7PAR2.6

To Page No.

Witnessed & Understood by me,

Date

Invented by

Recorded by

Date 7-16-02

From Page No.____

Solution is N/A, test conducted in Air

Specimen position (see pg. 20)

Specimens placed in Auto clave, no solution was added. Test was in Air
Heated up to 95°C

Extension rate was 1×10^{-6} in/sec

Open circuit potential of grad. 7 per recorded
load & Deflation vs time recorded on All channels

Reference probe is Silver Silver chloride w/ .1M Potassium chloride

Data Filenames
T12 per 3.1, T15 per 3.2, T17 per 3.3
T12 per 3.4, T15 per 3.5, T17 per 3.6

To Page No.____

Witnessed & Understood by me, | Date | Invented by | Date
Recorded by Roger J Dykstra | 7/29/02

From Page No.____

The reduction in area of the slow strain rate specimens was calculated by measuring the area of the fracture surface dividing by the initial cross section area of the specimens (0.125 in. in diameter). The data are recorded below.

SSRT Specimens Reduction in Area

File Name	Specimen ID	Test Condition	Area(mm^2)	RA(%)
Ti2PAR1	TiGr2-1(L)	1M NaCl+0.1M NaF	6.21	21.5
Ti2PER1	TiGr2-1(T)	1M NaCl+0.1M NaF	5.03	36.4
Ti5PAR1	TiGr5-1(L)	1M NaCl+0.1M NaF	6.67	15.7
Ti7PAR1	TiGr7-1(L)	1M NaCl+0.1M NaF	5.86	25.9
Ti7PER1	TiGr7-1(T)	1M NaCl+0.1M NaF	5.11	35.4
Ti2PAR2	TiGr2-2(L)	1M NaCl	5.68	28.2
Ti2PER2	TiGr2-2(T)	1M NaCl	5.34	32.6
Ti5PAR2	TiGr5-2(L)	1M NaCl	6.36	19.6
Ti5PER2	TiGr5-2(T)	1M NaCl	6.49	18.0
Ti7PAR2	TiGr7-2(L)	1M NaCl	5.29	33.1
Ti7PER2	TiGr7-2(T)	1M NaCl	5.13	35.2
Ti2PAR3	TiGr2-3(L)	Air	5.82	26.5
Ti2PER3	TiGr2-3(T)	Air	5.66	28.5
Ti5PAR3	TiGr5-3(L)	Air	6.39	19.2
Ti5PER3	TiGr5-3(T)	Air	6.84	13.6
Ti7PAR3	TiGr7-3(L)	Air	5.85	26.1
Ti7PER3	TiGr7-3(T)	Air	6.05	23.5

RA(%) = 100 - (Area/((0.125*25.4)^2*3.14/4))*100

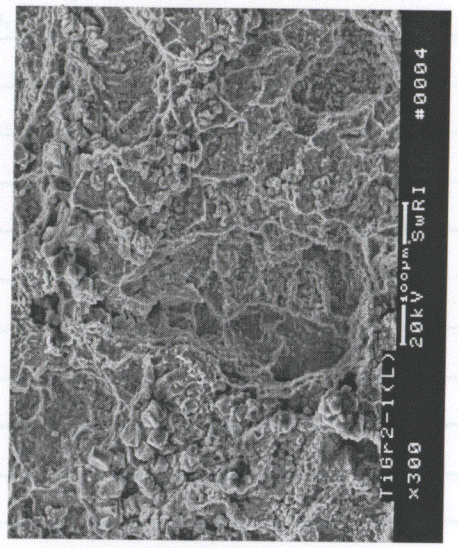
To Page No.____

Witnessed & Understood by me, | Date | Invented by | Date
Recorded by | 7/29/02

Project No.
Book No.

TITLE SEM Micrographs of the Fracture Surfaces (Test Set #1)

From Page No



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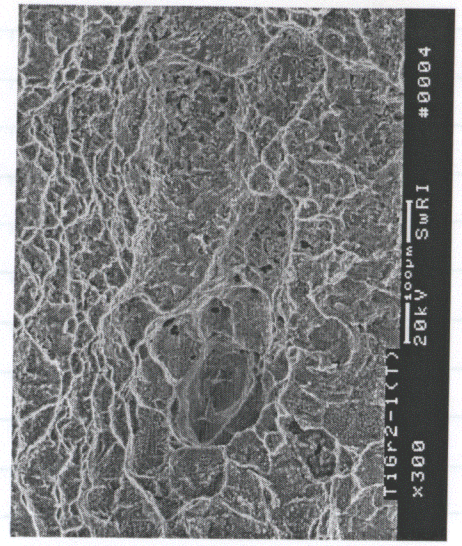

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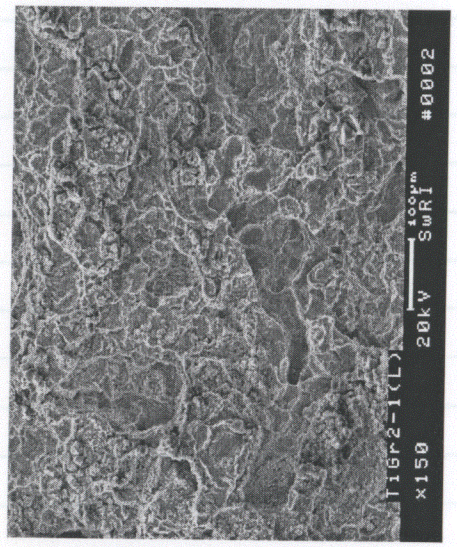

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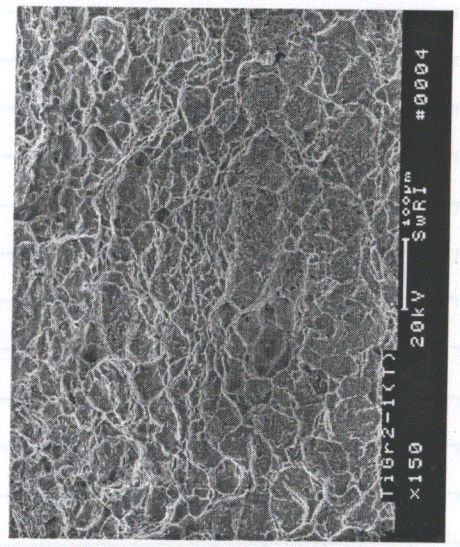

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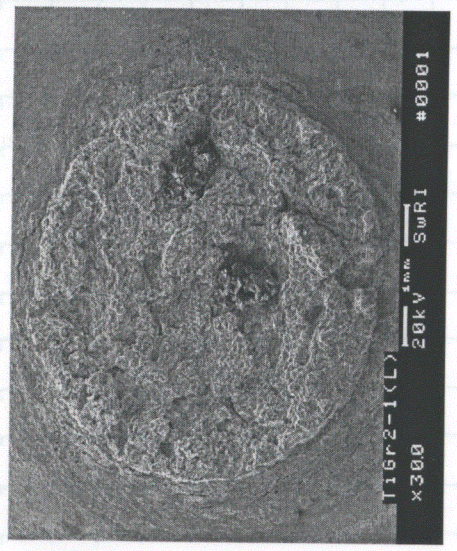

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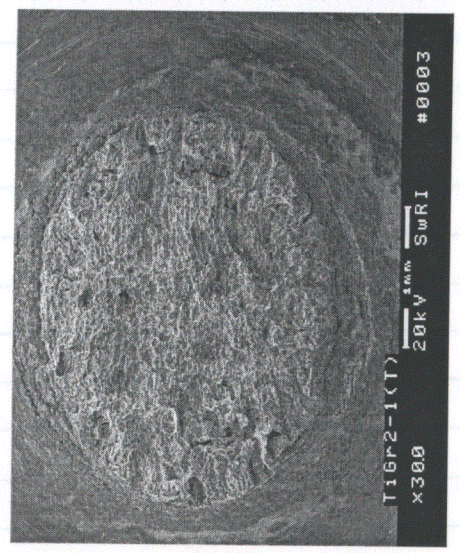
TiGr2-1(L)



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TiGr2-1(T)

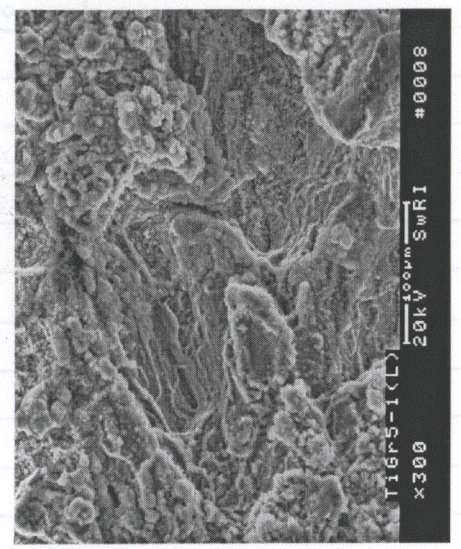
Page No.

Witnessed & Understood by me,	Date	Invented by	Date
		Recorded by	7/30/02

Project No.
Book No.

TITLE

From Page



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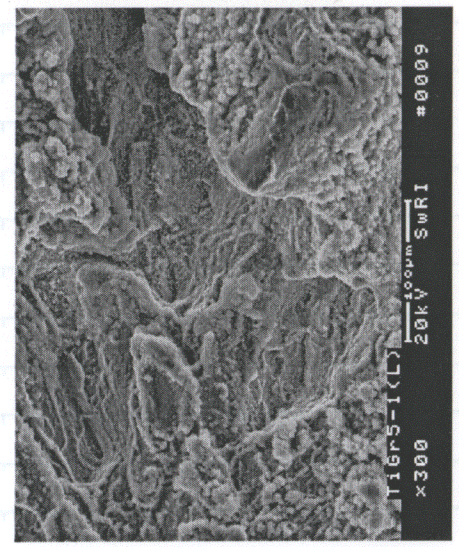

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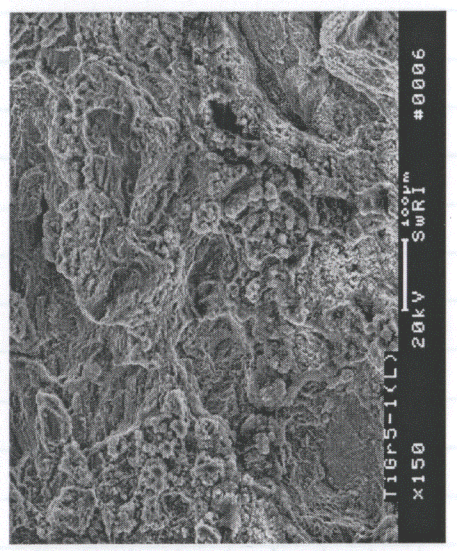

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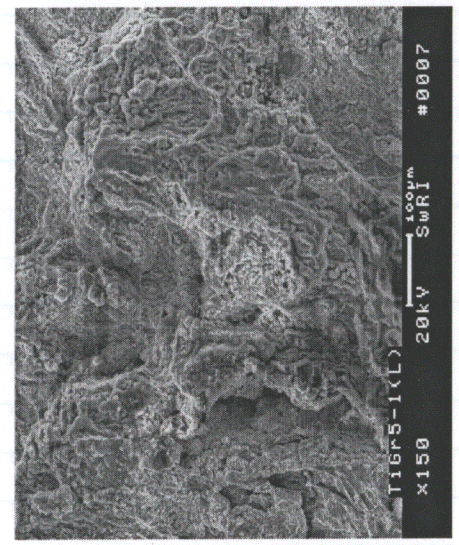

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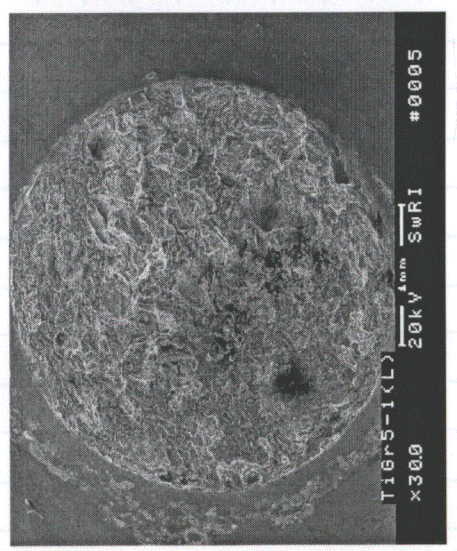

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TiGr5-1(L)

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Witnessed & Understood by me,	Date	Invented by	Date
		Recorded by	7/30/02

Project No.

Book No.

TITLE

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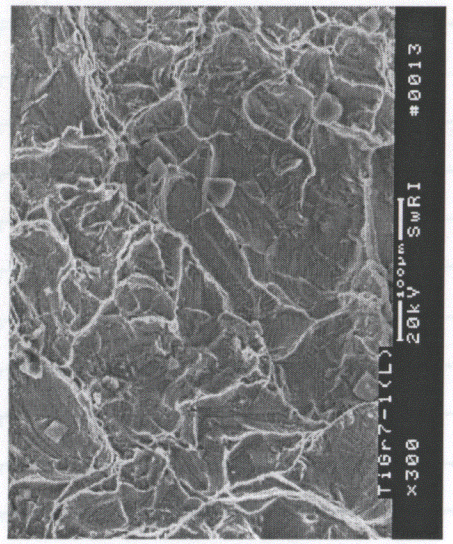

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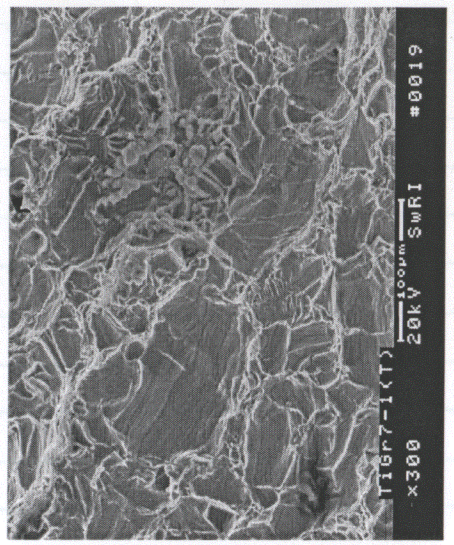

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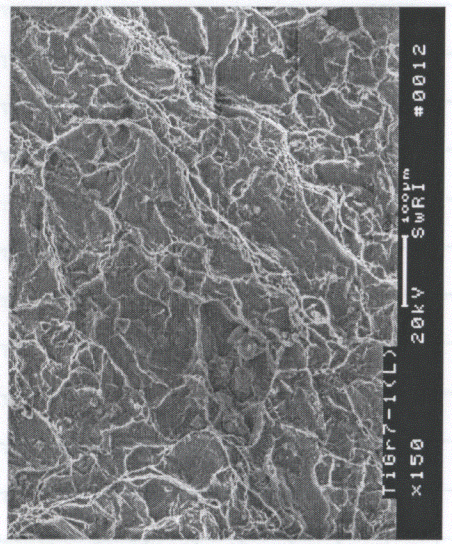

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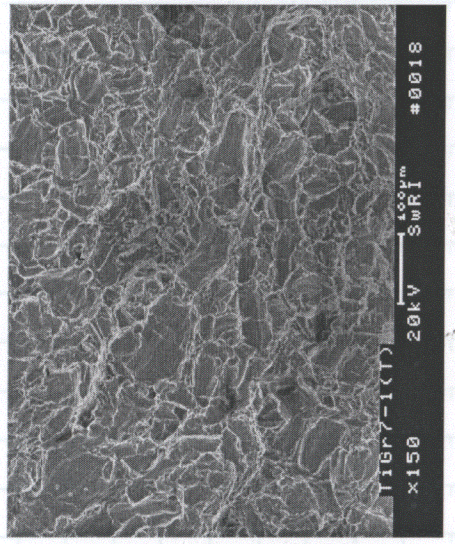

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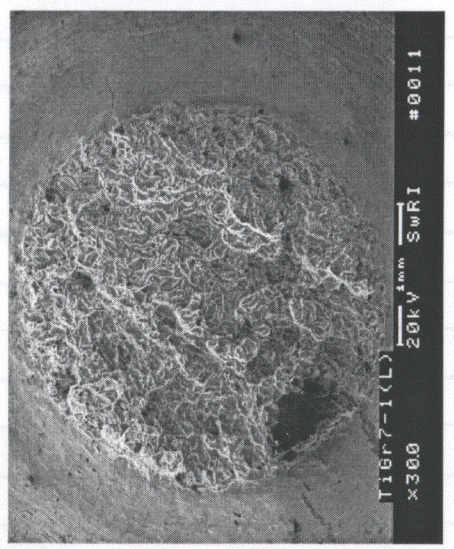

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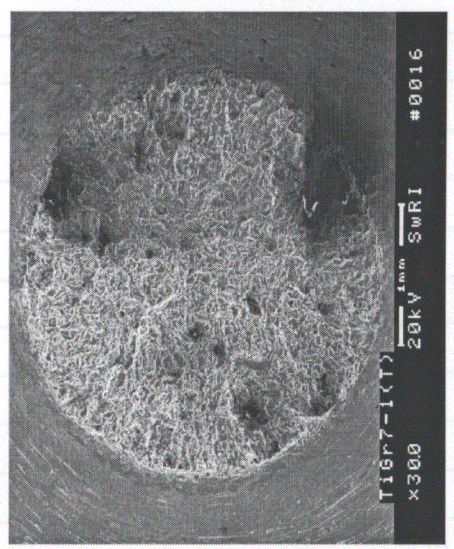

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TiGr7-1(T)

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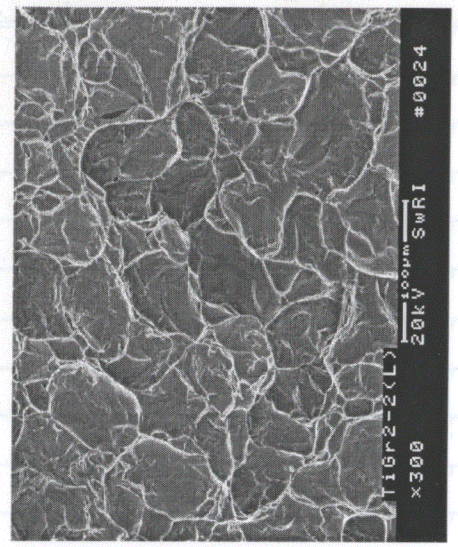
Date 7/30/02

Project No.

Book No.

TITLE SEM Micrographs of Fracture Surfaces (Test Set #2)

From Page N



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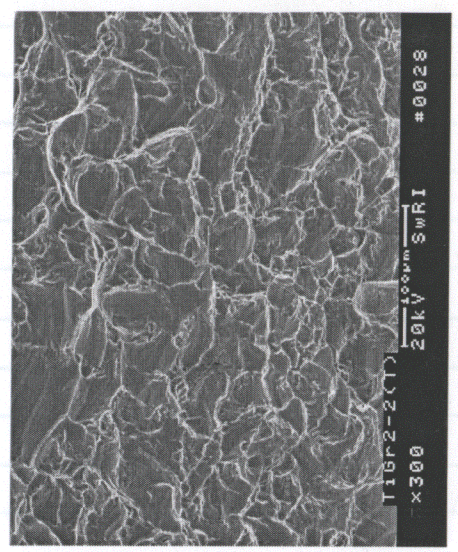

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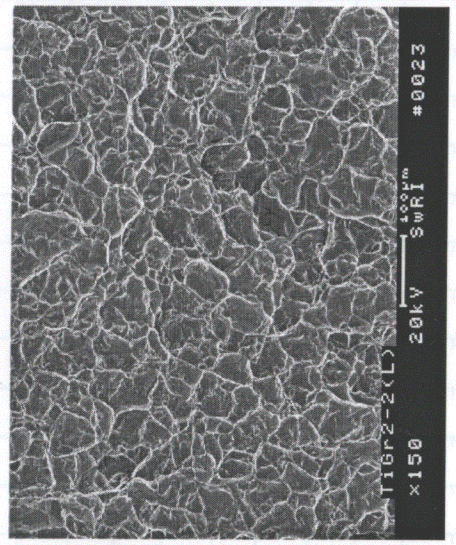

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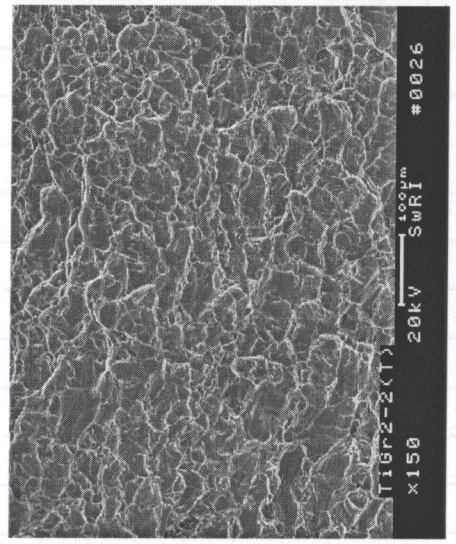

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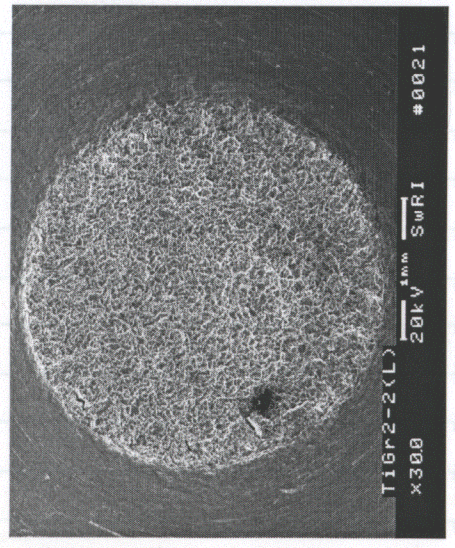

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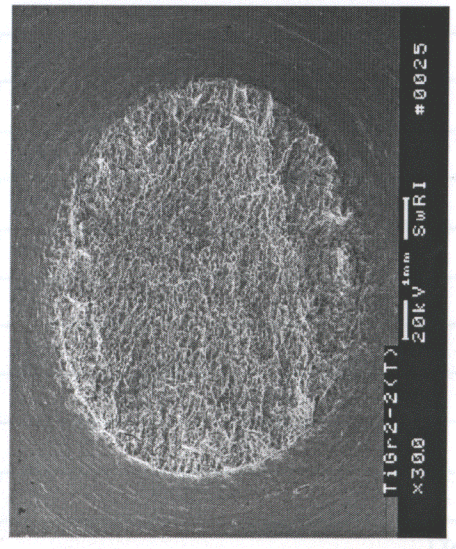

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TiGr2-2(T)

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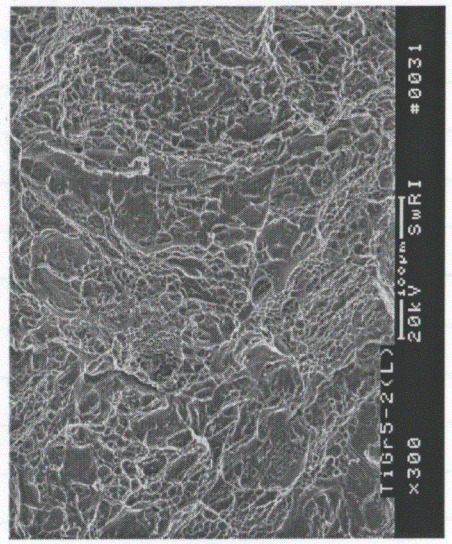
Date 7/30/02

Project No._____
Book No._____ TITLE _____

From Page No



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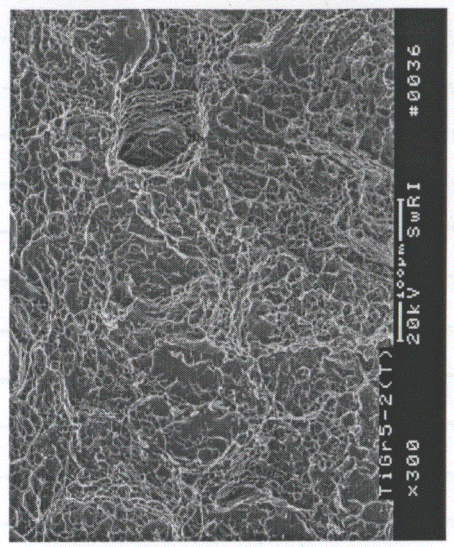

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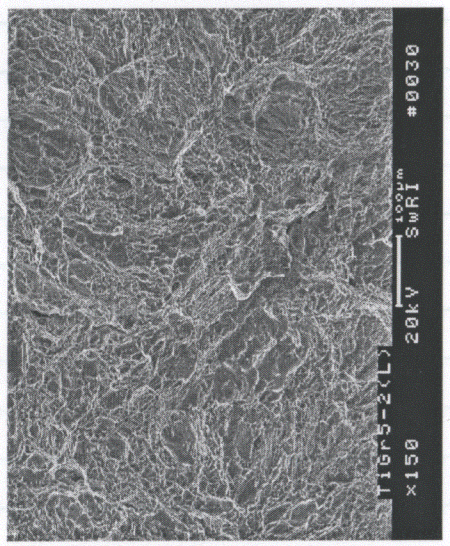

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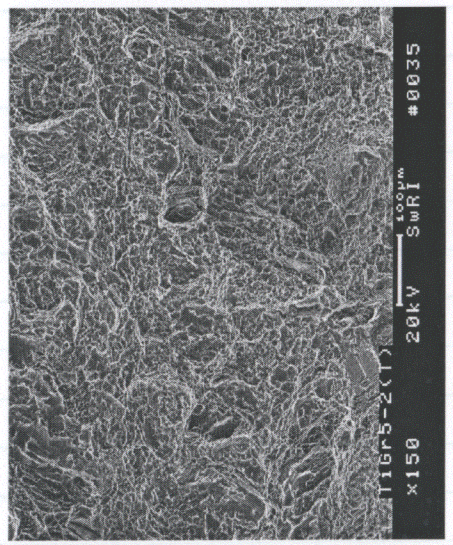

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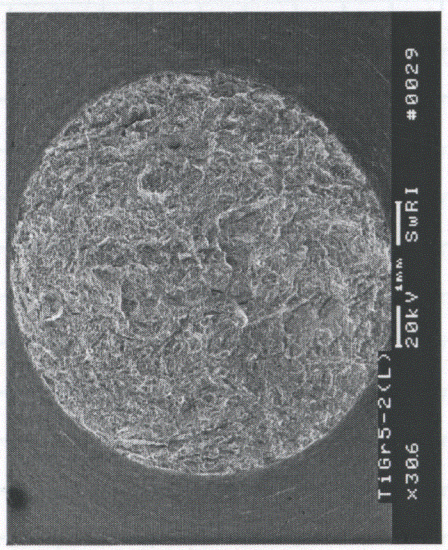

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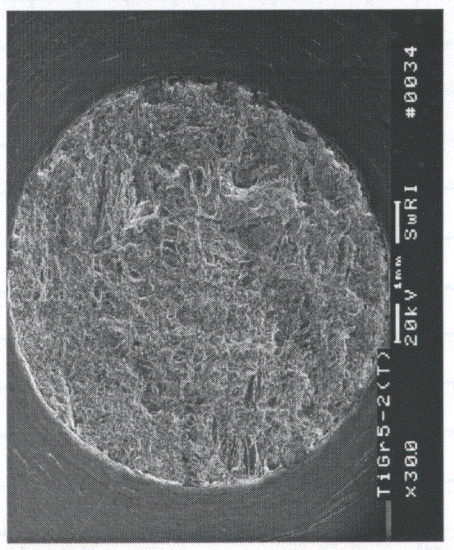

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TiGr5-2(T)

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Invented by

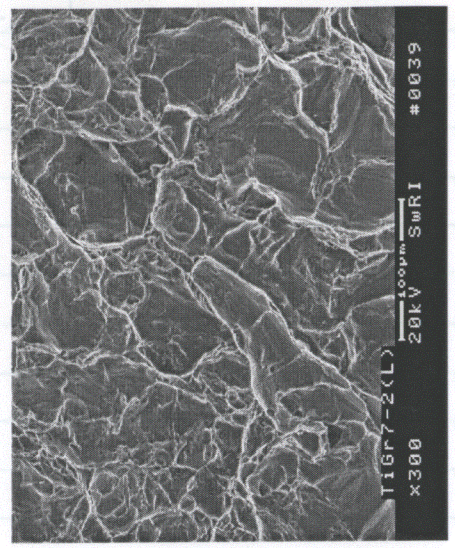
Recorded by

Date 7/30/02

Project No._____
Book No._____

TITLE _____

From Page N



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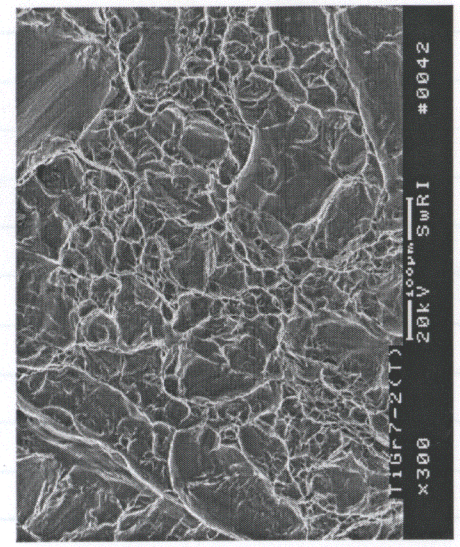

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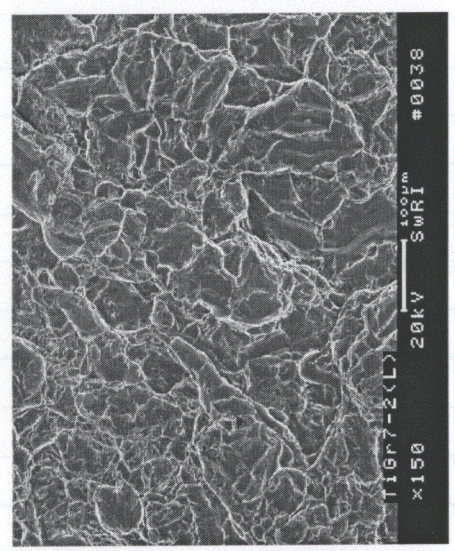

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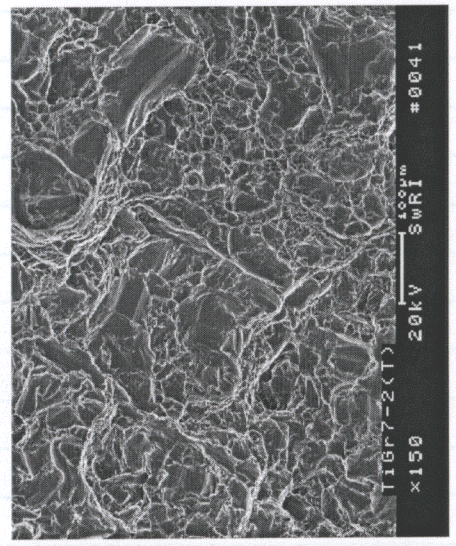

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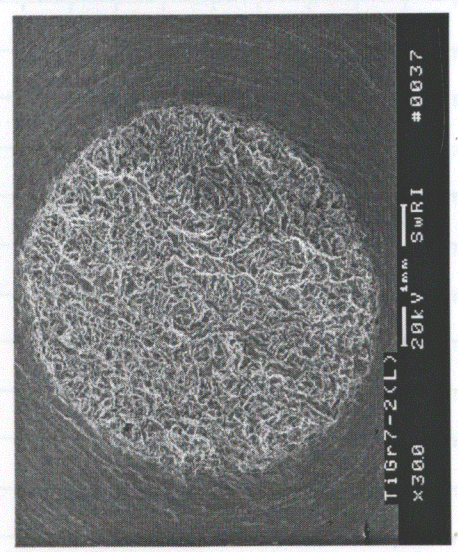

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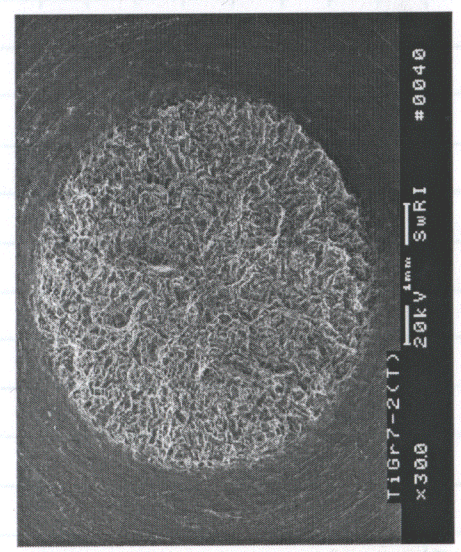

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TiGr7-2(T)

Witnessed & Understood by me,

Date

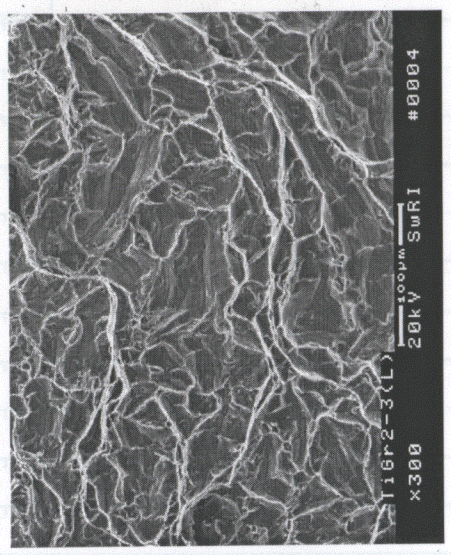
Invented by

Recorded by

Date 7/30/02

Project No.
Book No.
TITLE SEM Micrographs of Fracture Surfaces (Test Set #3)

From Page No



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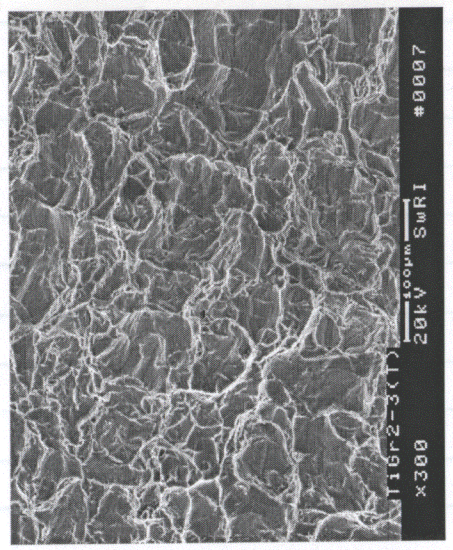

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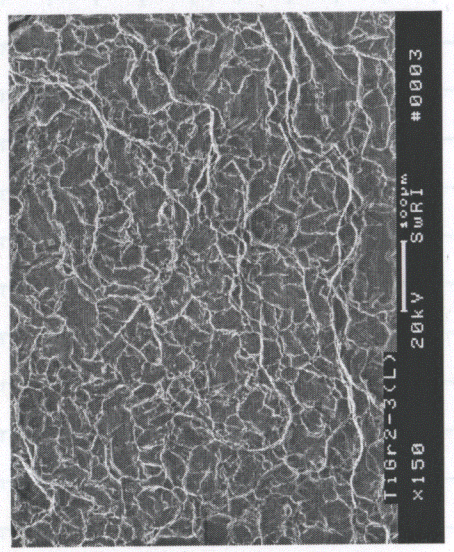

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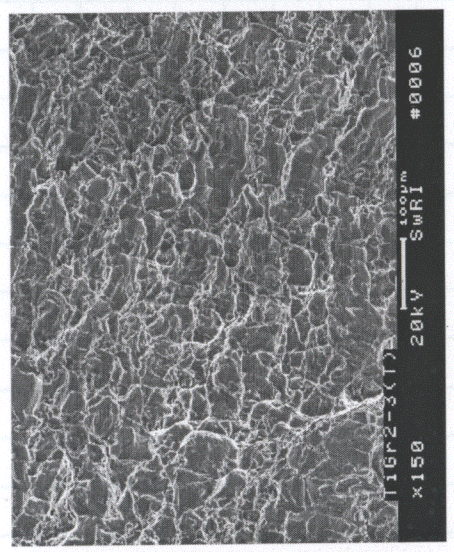

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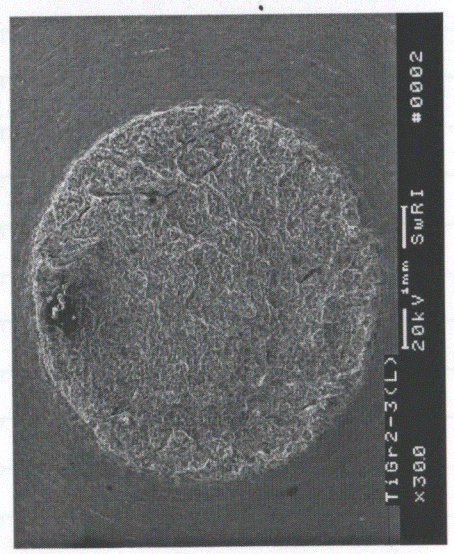

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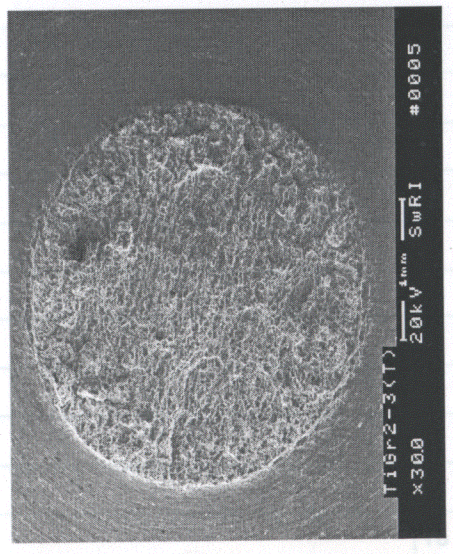

30x TiGr2-3(T)

Witnessed & Understood by me,
Date
Invented by
Recorded by
Date 7/30/02

Project No.
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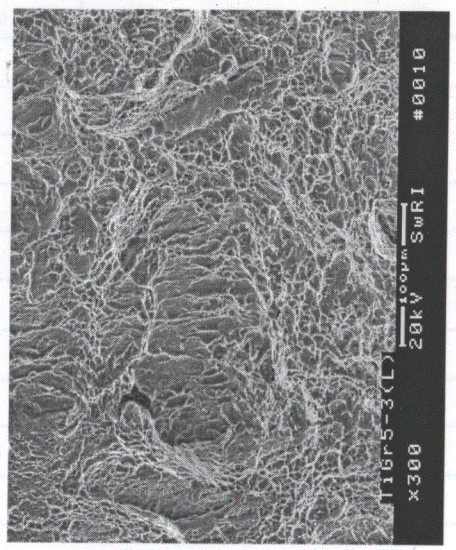
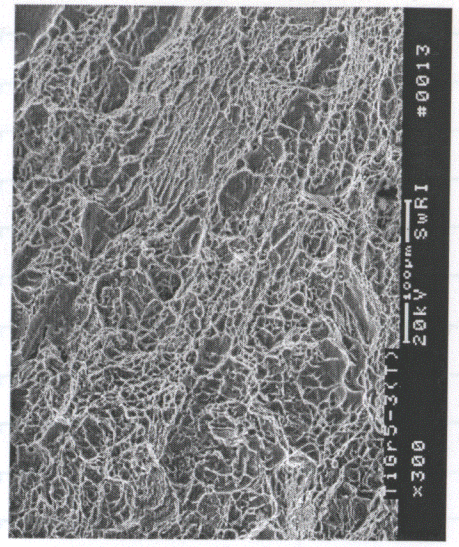
TITLE

From Page



300x



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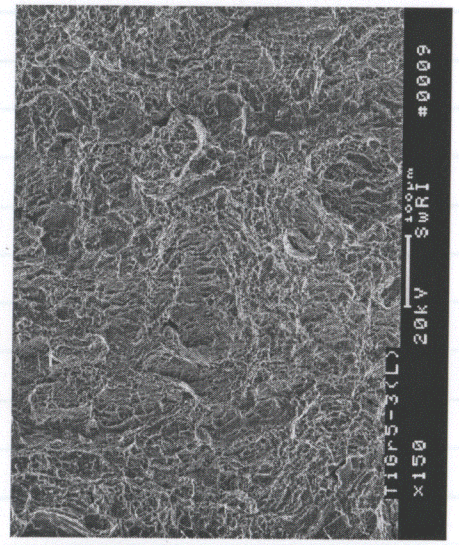

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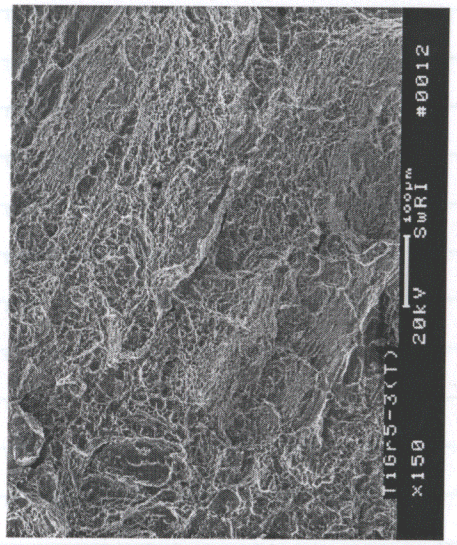

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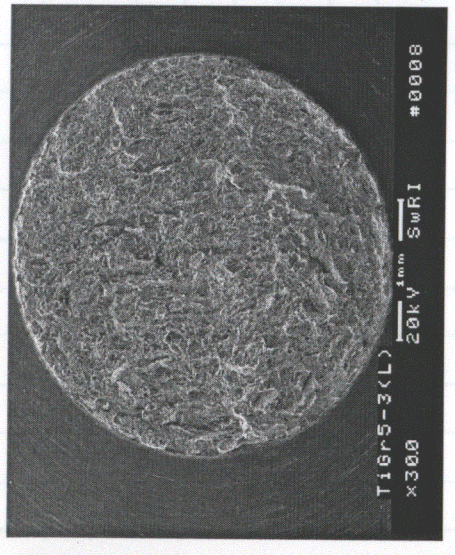
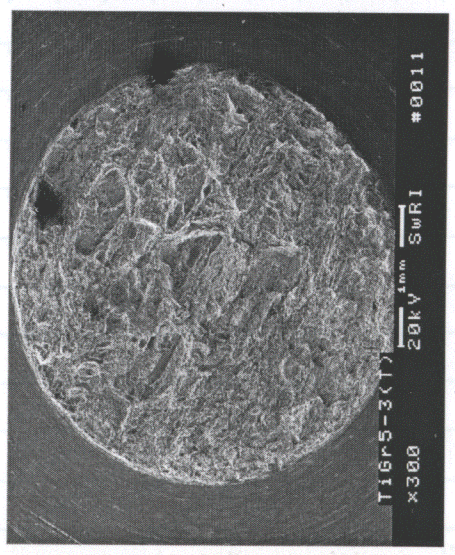
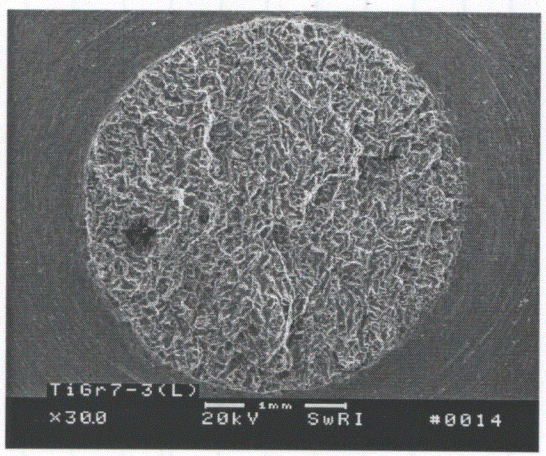


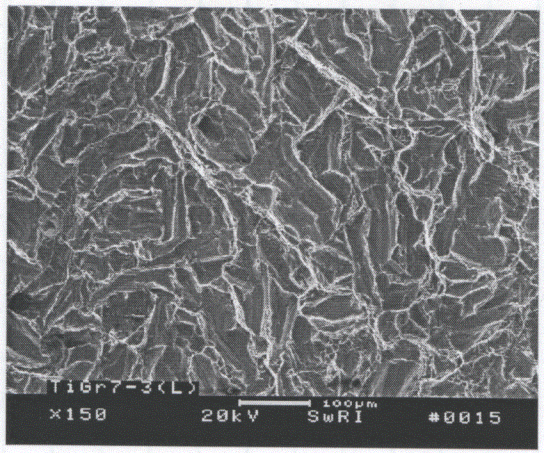
30x TiGr5-3(L)

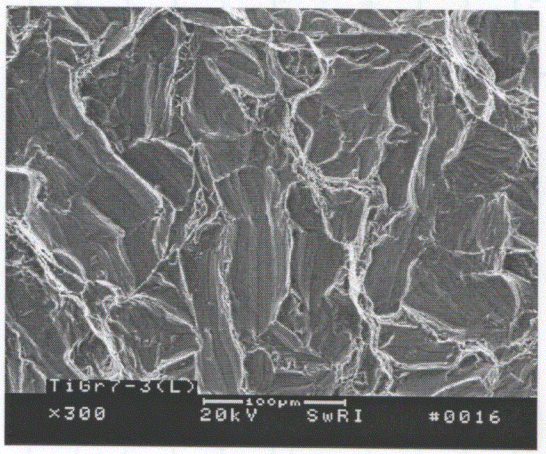


30x TiGr5-3(T)

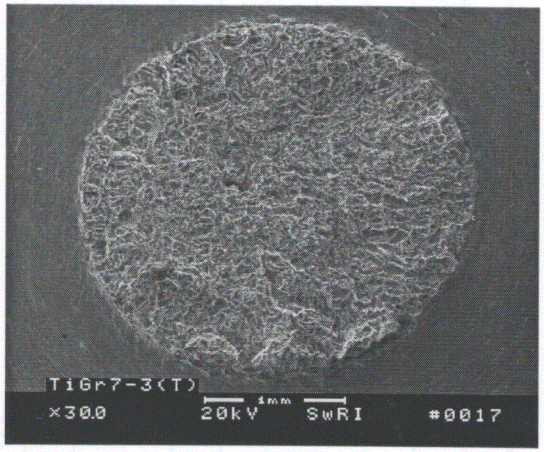
Witnessed & Understood by me,
Date
Invented by
Recorded by
Date 7/30/02

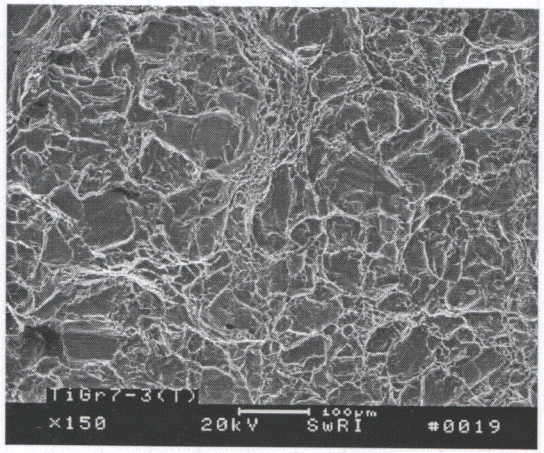


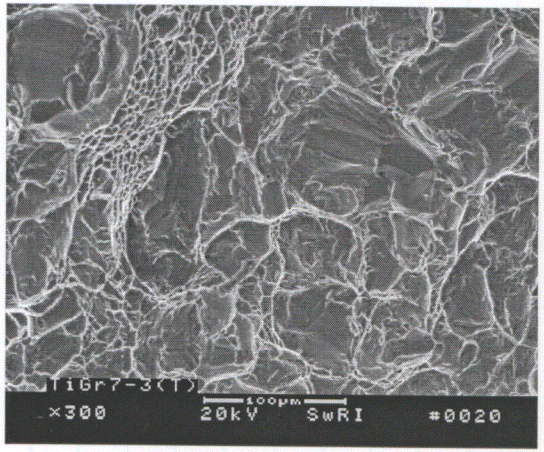




TiGr7-3(L) 30x 150x 300x







TiGr7-3(T) 30x 150x 300x

From Page No.

Solution 1M NaCl → 116.90g Fisher 020814
0.1M NaF → 8.40g Fisher 99155A
2 liters HPDI pH = 8.971 ~~pap~~ 10/8/02

1M NaCl → 58.45g Fisher 020814
0.1M NaF → 4.20g Fisher 99155A
1 liter HPDI pH = 8.863 ~~pap~~ 10/8/02

Specimen position (see pg. 20)

Specimens placed in Autoclave with 2.8 liters of solution. De-aired for 24 hours while bringing temperature to 95°C

Extension rate set to 1×10^{-7} in/sec

Open circuit potential of grade 7 PAR recorded hour & Deflection vs Time recorded all channels

Reference probe is Silver Silver Chloride w/ 1M Potassium Chloride

Data Storage Filenames
T12 par4.1, T15 par4.2, T17 par4.3
T12 par4.4, T15 par4.5, T17 par4.6

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9/11/02

To Page No.

Witnessed & Understood by me, Date

Invented by Date 8.28.02

Recorded by Roger J Rykstra

Project No.____
Book No.____

TITLE ~~Entitled Entry~~ Test Plan for Galvanic Coupling Effect

From Page No.____

FY2003 Augmented Work

Title: Effect of Galvanic Coupling on Hydrogen-Induced Cracking of Titanium Grade 7

Description:

Environmentally assisted cracking arising from hydrogen absorption has been considered a possible failure mode for the titanium drip shield. Hydrogen-induced cracking of Titanium Grade 7 needs to be evaluated by considering the effect of galvanic coupling to carbon and stainless steels on enhancing hydrogen uptake and absorption. This augmented work is aimed at determining the hydrogen-induced cracking susceptibility of Titanium Grade 7, as well as Grades 2 and 5, in fluoride-containing solution as a result of galvanic coupling in comparison to solutions without fluoride. Preliminary scoping experiments are planned with galvanically coupled specimens using a six-specimen slow strain rate test machine. Notched slow strain rate specimens will be galvanically coupled to a cathode made of carbon steel or stainless steel. All slow strain rate tests will be conducted in 1.0 M NaCl solutions with and without the addition of 0.1 M NaF at 95 °C [203 °F]. The fracture surfaces of all specimens will be examined by scanning electron microscopy. Selected specimens will be further analyzed to verify hydride formation and to measure hydrogen concentrations.

Cost Estimate (Outside Div. 20):

Total Cost: $16,000

1. Slow strain rate testing ($13,000)
   - Test machine modification
   - Preparation of galvanically coupled specimens
   - Conducting slow strain rate tests
2. Metallurgical analysis ($1,000)
3. Hydrogen concentration analysis ($2,000)

Test Set #1 for Ti SSRT on the Effect of Galvanic Coupling

No. of Tests:	2 (one each of two materials)
Materials:	Ti Grades 5 and 7
Orientation:	Parallel to rolling direction
Specimen Type:	Notched Ti tensile specimens coupled with cast iron
Test Conditions:	Deaerated solution C 1M NaCl + 0.1M NaF Temperature C 95 EC Extension rate C $1x10^{-7}$ in/s Open circuit
Data Monitoring:	Load vs. Time Deflection vs. Time Potential and Current vs. Time

Measuring both the initial and final pHs

To Page No.____

Witnessed & Understood by me,	Date	Invented by	Date
		Recorded by Jenny Sievert	7/16/03

Project No.____
Book No.____

TITLE SSRT Set #1 on Galvanic Coupling Effect

From Page No.____

TEST SOLUTION: 1M NACL + 0.1 M NAF

NACL 58.45g FISHER LOT 905502
NAF 4.2g FISHER LOT 896405

DI WATER TO MAKE 1 l PH=8.809

NACL 116.9g FISHER LOT 905522
NAF 8.4g ALDRICH LOT 06017KQ

DI WATER TO MAKE 2 l

PH=8.953

NEED 2.8 l SOLUTION PER TEST

AG
9/4/03 FINAL PH = 8.725

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Witnessed & Understood by me,	Date	Invented by	Date
		Recorded by Jenny Sievert	7/28/03

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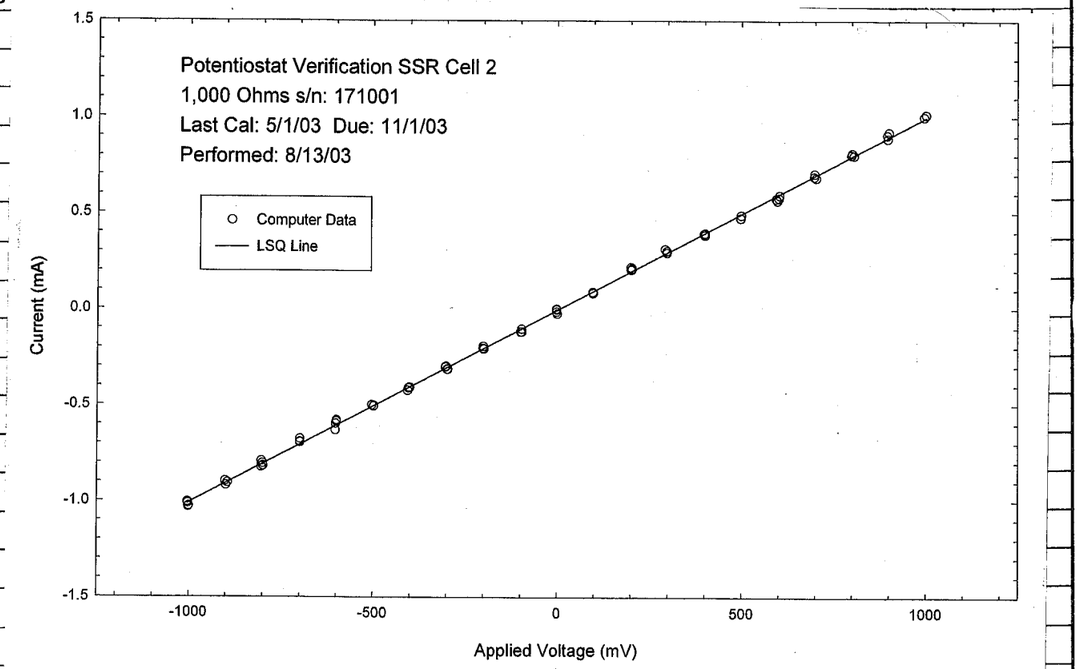
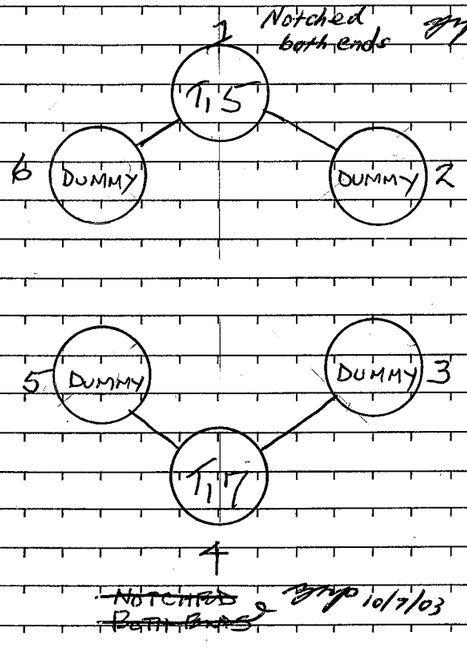


TEST SETUP



BMP 10/7/03

DUMMY IS LOW CARBON STEEL

BMP 10/7/03

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Witnessed & Understood by me,	Date	Invented by	Date
		Recorded by Jerry Sewell	8/15/03

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JACK — GEAR BOX

$\frac{1''}{100\ \text{TURNS}} \cdot \frac{1\ \text{TURN}}{1000\ \text{REV}} \cdot \frac{1\ \text{REV}}{1\ \text{SEC}} = \frac{\text{INCHES}}{\text{SEC}} = 1E-7$

$\frac{1}{T} = 100 \cdot 1000 \cdot 1E-7 = 0.01$

$T = 100$ SECONDS

T1 TEST 1 — BKR 2/1/03

1M NaCl + 0.1M NaF

LOAD CELL 1 GRADE 5
2 7

FILES: T15GT1
T17GT1

			OCV
8/25/03	2:52	START DEAERATING	-575 mV
8/26/03	7:30		-720 mV
	8:31	START HEATING SP 95°C	-725 mV
	9:15	37°C	-727 mV
	10:00	49°C	-730 mV
	10:30	57°C	-735 mV
	12:00	61°C	-740 mV
	1:60	64°C	-744 mV
	2:00	67°C	-760 mV
	2:45	68°C SP A 120°C	-762 mV
	3:45	76°C	-765 mV
8/27/03	7:05	89°C SP A 126°C	-730 mV
	9:05	91°C	-732 mV
	9:05	91°C SP A 130°C	-731 mV

10:07 START LOG
10:10 START LOADING
8/29/03 710 COMPUTER PROBLEMS - STOP LOAD TRAIN -
LAST LOG ENTRY 8/28/03 4:17
NEW FILE NAMES: T15GT1A & T17GT1A
8:18 START LOADING
9/3/03 10:19 T17GT1A FAILED
9/4/03 9:59 T15GT1A HAS FAILED - SHUTDOWN
FINAL PH 8.725

SPECIMEN IN POSITION 1 WAS NOTCHED. S/B POSITION 4
ERROR IN NOTES?

T17GT1 LAST ENTRY 8/28/03 16:17:13 29.8362 HRS
T17GT1A FIRST ENTRY 8/29/03 8:37:01 GAP 16.33 HRS
OFFSET 46.1662 HRS

JKS
9/10/03

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Witnessed & Understood by me,	Date	Invented by	Date
		Recorded by Jerry Sewell	8/15/03

Project No.
Book No.
TITLE SSRT Set #2 on Galvanic Coupling Effect

From Page No.

T1 TEST 2

1M NACL

FILES: T15GT2
T17GT2

LOAD CELL: 1, 2
GRADE: 5, 7 NOTCHED

TEST SOLUTION: 175.33 g NACL - FISHER LOT 905502
DI WATER TO MAKE 3 l
INITIAL PH = 2.538

9/8/03 2:18 START DEAERATING
9/10/03 9:38 83°C OCV = -705 mV / 616 mV
12:35 ZERO TIME - START LOG FILES
12:36 START LOADING

9/18/03 LAST SPECIMEN FAILED

FINAL PH = 6.457

ALL OPEN CIRCUIT VOLTAGE MEASURMENTS WERE MADE USING SCE S/N 0249091. THIS APPLIES TO BOTH TEST 1 & TEST 2.

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[signature] 10/1/03

To Page No.

Witnessed & Understood by me,	Date	Invented by	Date
		Recorded by [signature]	9/19/03

Project No.
Book No.
TITLE

From Page No.

I have reviewed this scientific notebook and find it in compliance with QAP-001. There is sufficient information regarding procedures used for conducting tests, acquiring and analyzing data so that another qualified individual could repeat the activity.

[signature] 9/29/2004

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Witnessed & Understood by me,	Date	Invented by	Date
		Recorded by	