
Performance Test Results Of ETS-VI Ni-Cd Cells

1993 NASA Aerospace Battery Workshop
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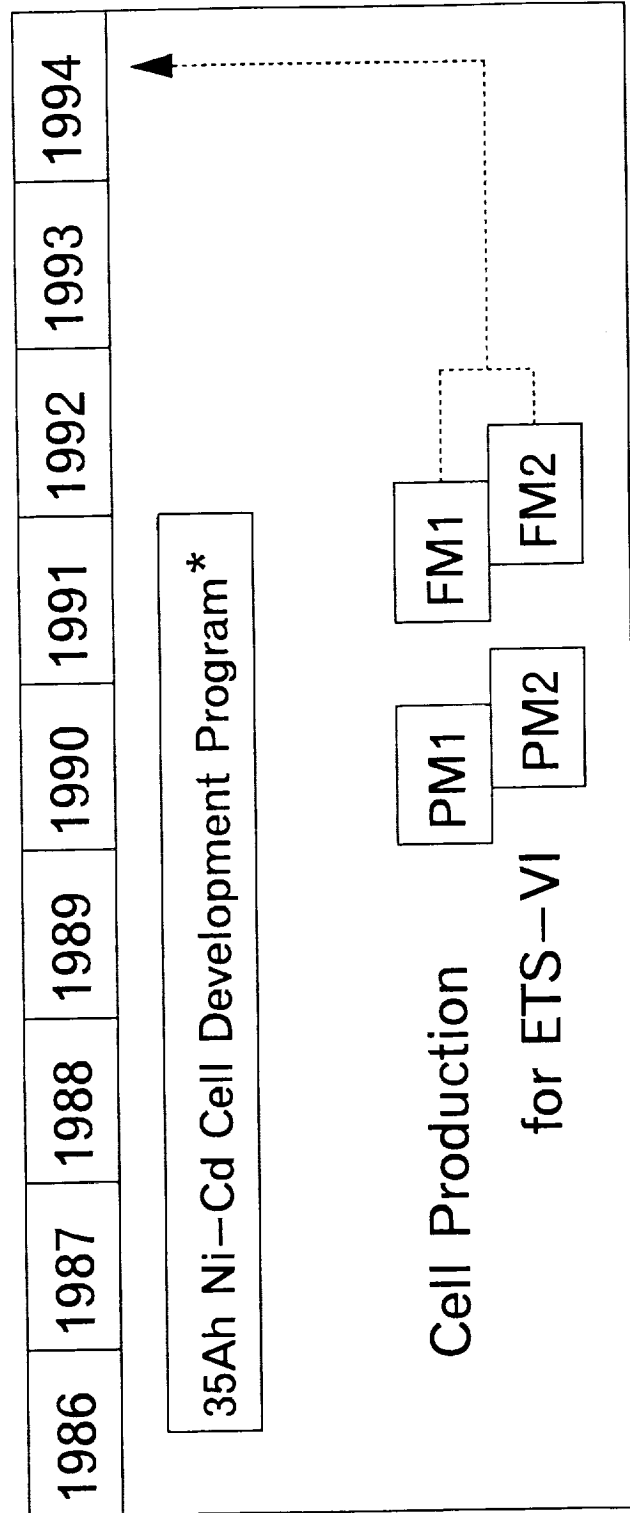
*National Space Development Agency of Japan

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Background

- Development of 35Ah Ni-Cd cell for ETS-VI was initiated in 1986.
- Cell production of ETS-VI/FM : 1991 to 1992
 - 1st lot : delivered 66 cells to battery manufacturer (MELCO)
 - 2nd lot : delivered 83 cells to battery manufacturer
- ETS-VI uses 4 batteries
 - Each battery consists of 2 packs.
 - 16 series cells per pack
- ETS-VI will be scheduled for launch in 1994.
- ETS-VI/FM Batteries are now stored at low temperature.
- Same designed cells were delivered to NASA Lewis Research Center for evaluation in this year.

SANYO Development Schedule



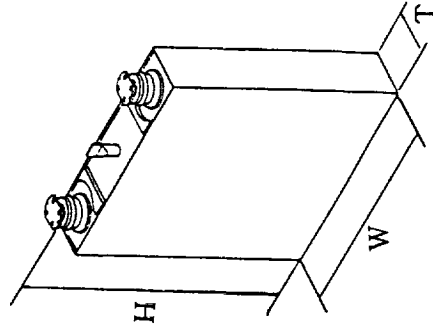
*Life tests are now continued in NASDA.

PM:Prototype Model Cell FM:Flight Model Cell

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Main Specification

- Model Name : N35S
- Dimension : $107^W \times 25^T \times 127^H$ mm
- Weight : max. 1050g
- Nominal Capacity : 35Ah
- Energy Density : 40Wh/kg
- Design Life : 10years in GEO



• Electric Performance

Charge Condition	Charge Volt.	Internal Pressure	Capacity *
0.1C x 24hrs. 20 °C	max. 1.50V	max. 3.5kg/cm ²	min. 35.0Ah
0.1C x 24hrs. 35 °C	max. 1.45V	max. 3.5kg/cm ²	min. 32.0Ah
0.05Cx48hrs. -5 °C	max. 1.55V	max. 3.5kg/cm ²	min. 32.0Ah

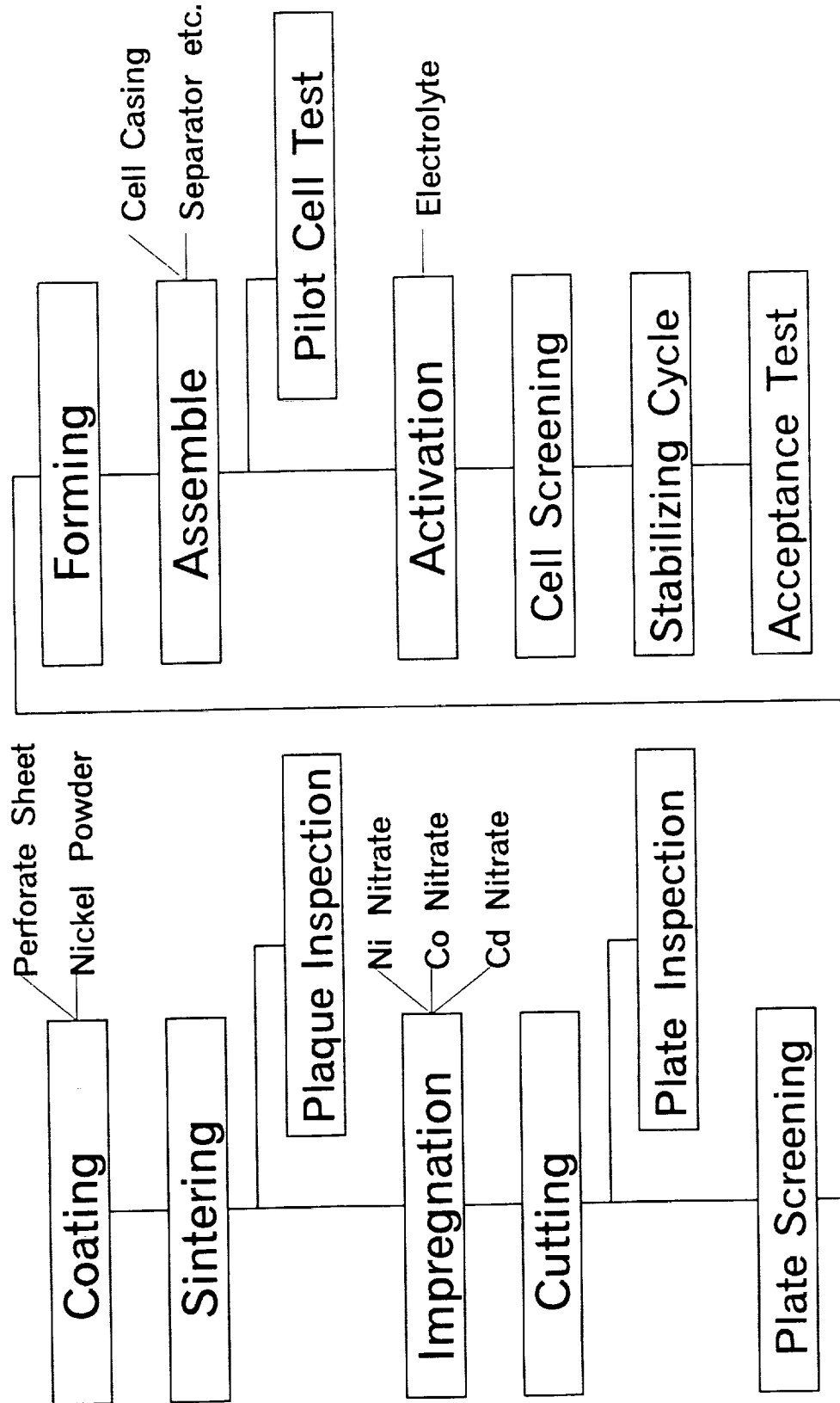
* Discharge 0.5C

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Cell Design

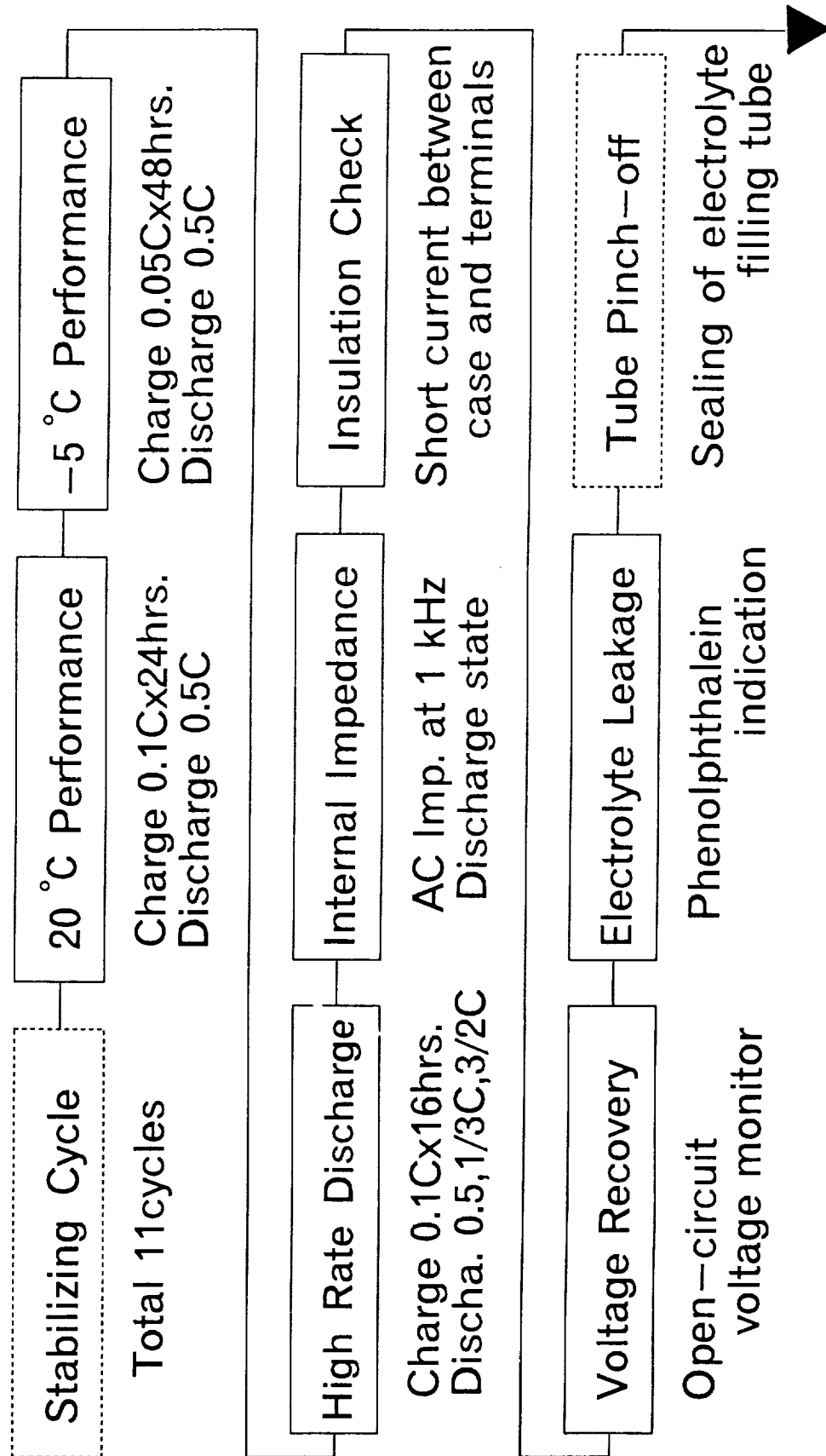
	Positive	Negative
Substrate Porosity	Sinter Ni / 85%	Sinter Ni / 86%
Impregnation	Chemical Impreg.	Chemical Impreg.
Additives	Co and Cd	Non
Number of Plate	13	14
Plate Dimension	104 x 100mm	104 x 100mm
Plate Thickness	0.63mm	0.80mm
Loading Level	2.4g/cc—void	3.0g/cc—void
Plate Capacity	42.6Ah	69.7Ah
Capacity Ratio	1.64	
Separator	Nylon Nonwoven Cloth	
Electrolyte	31%KOH 98g	
Design Weight	1040g	
Design Capacity	38.7Ah	

SANYO Production Flow

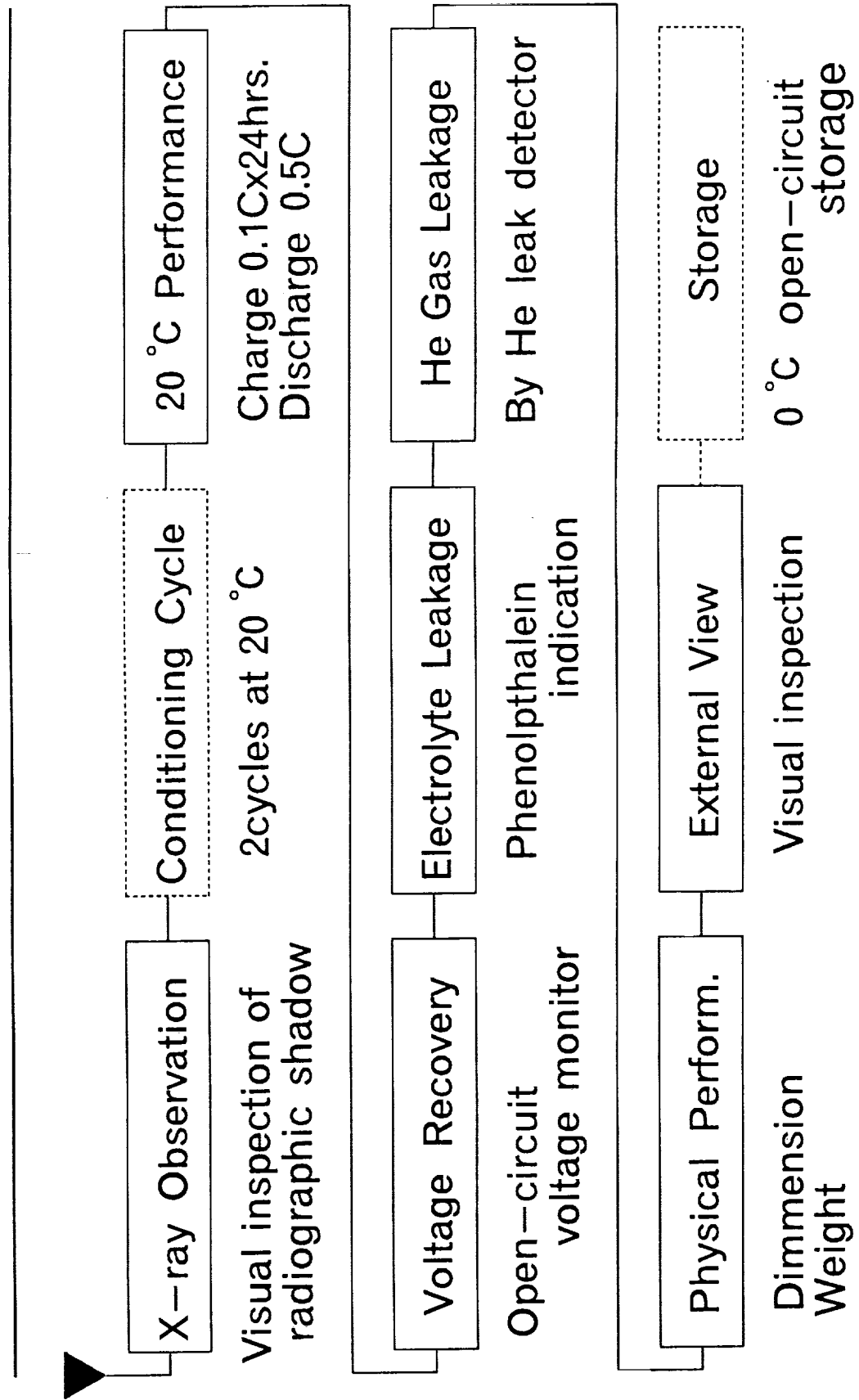


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Acceptance Test (1)

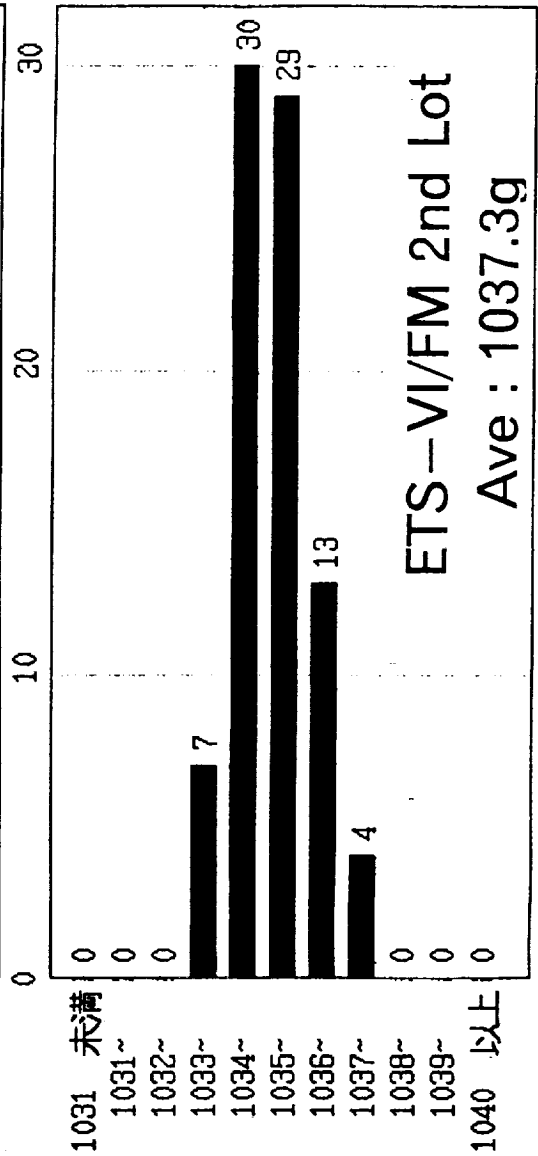
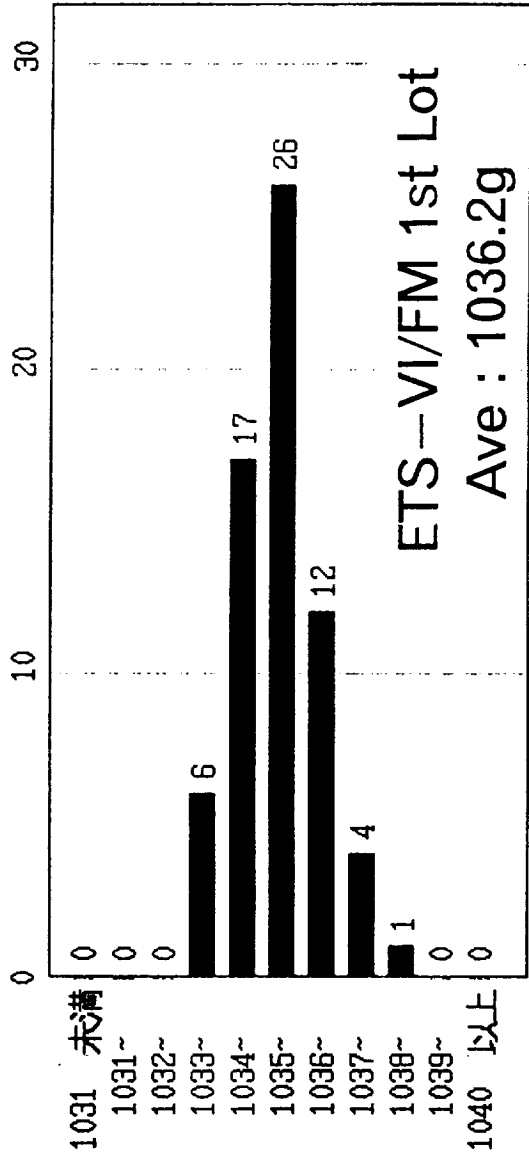


SANYO Acceptance Test (2)

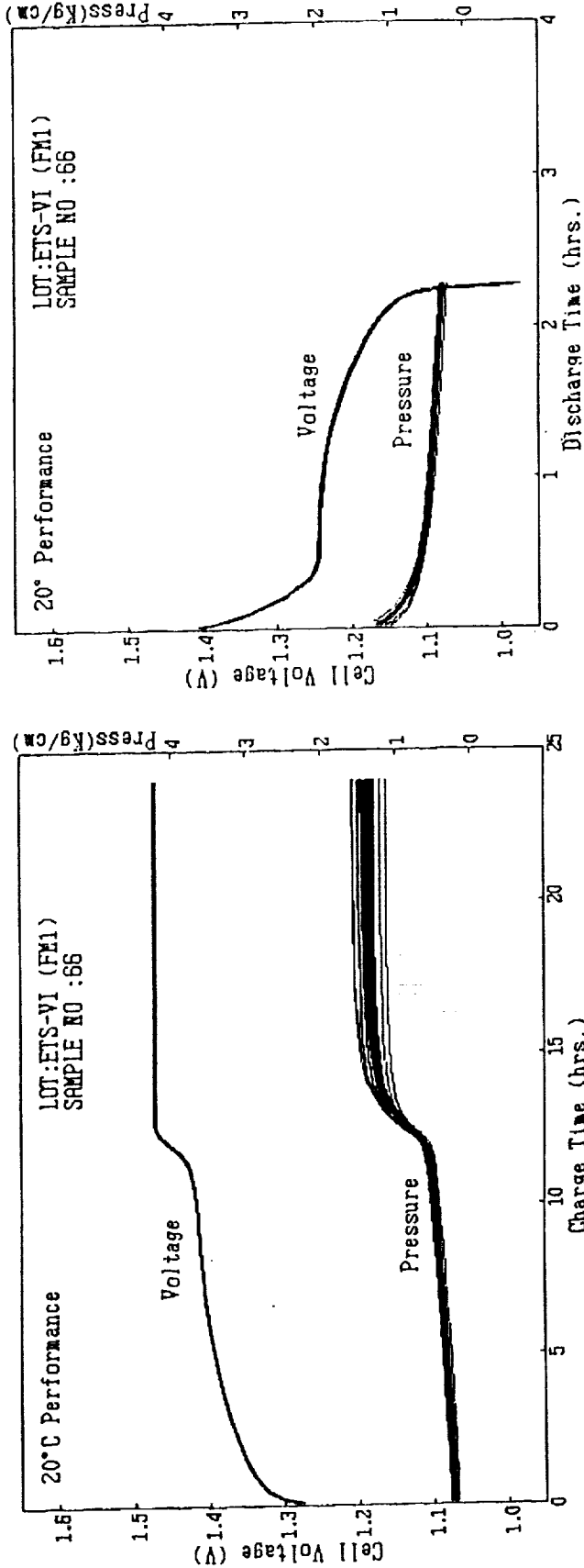


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Cell Weight



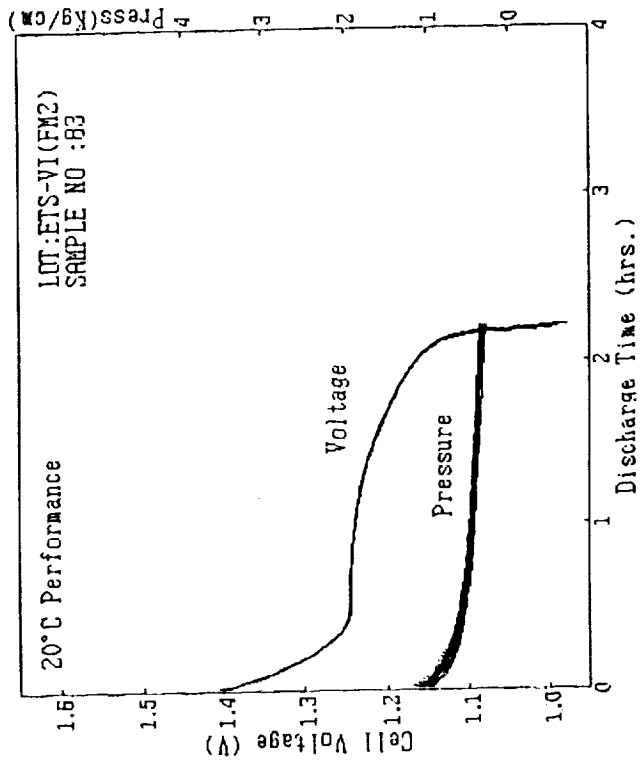
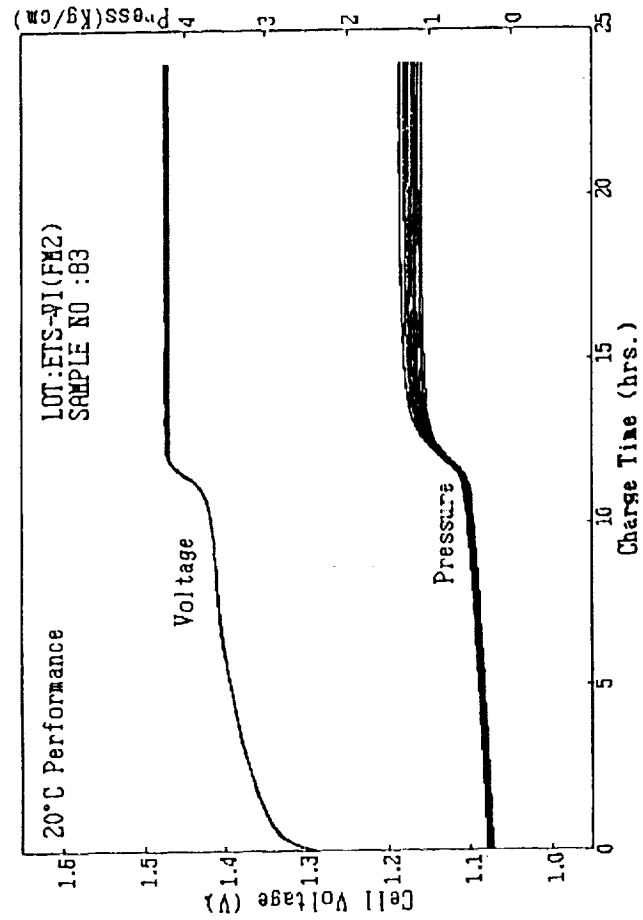
SANYO 20 °C Performance



Charge 3.5A x 24hrs. Discharge 17.5A Temp. 20 °C

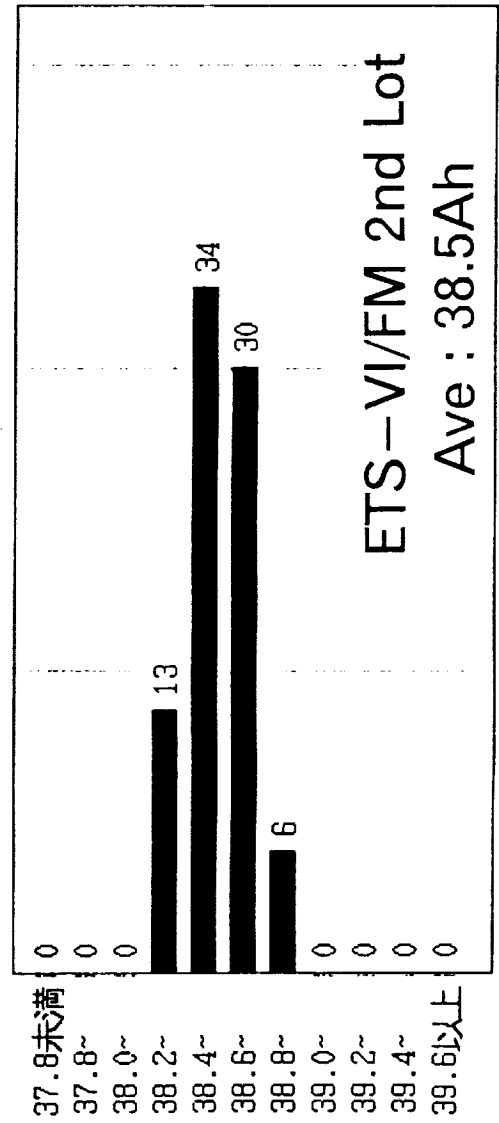
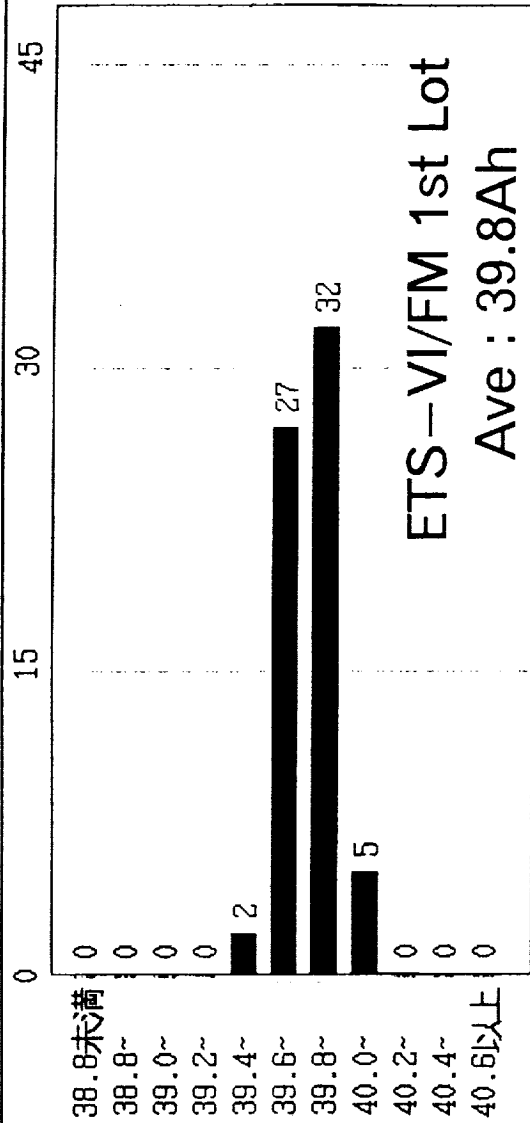
Overplot of 66 Data of ETS-VI/FM 1st Lot

SANYO 20 °C Performance



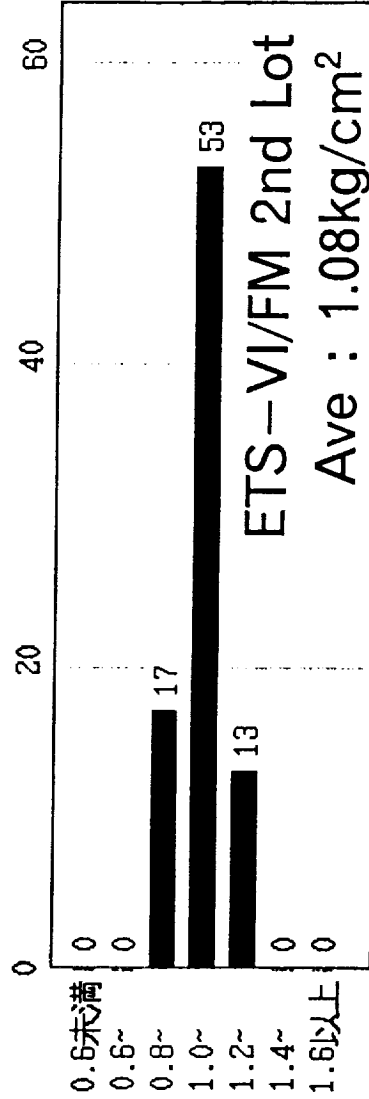
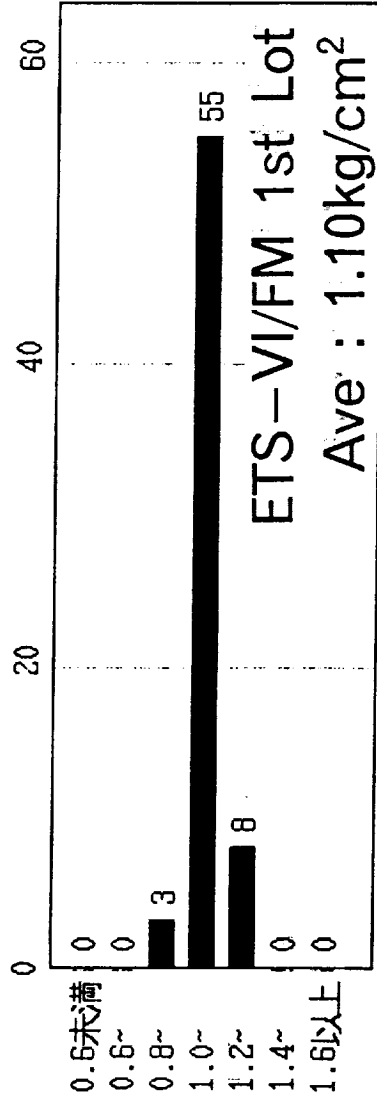
Charge 3.5A x 24hrs. Discharge 17.5A Temp. 20 °C

Overplot of 83 Data of ETS-VI/FM 2nd Lot

Capacity

Charge 3.5A x 24hrs. at 20 °C Discharge 17.5A

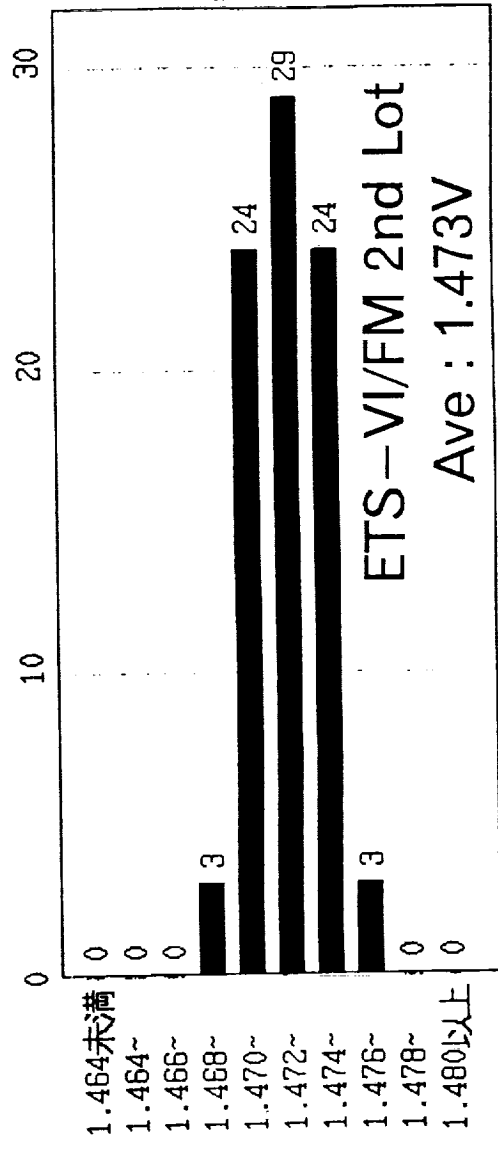
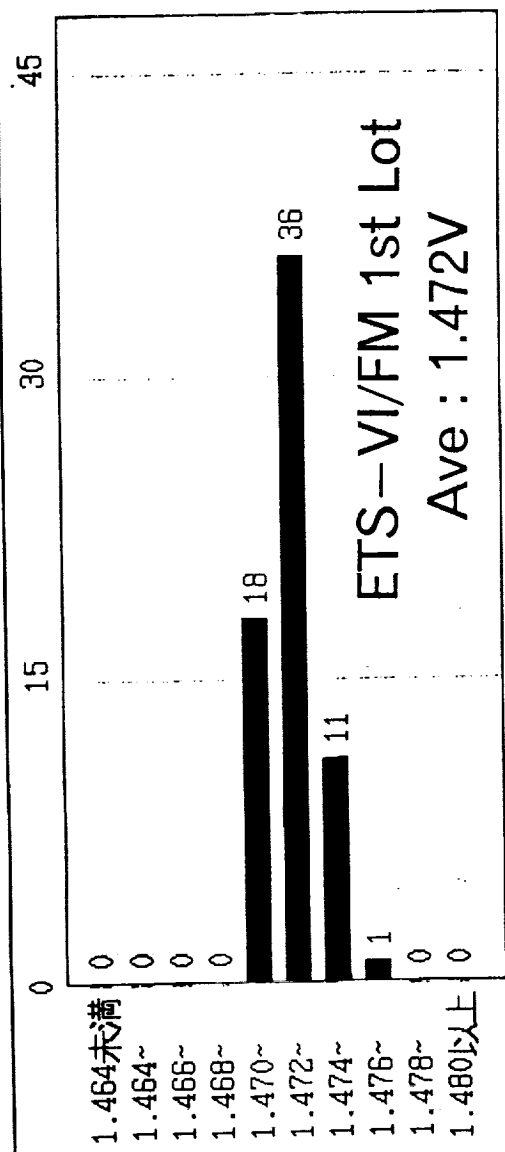
Overcharge Pressure



Charge 3.5A x 24hrs. at 20 °C

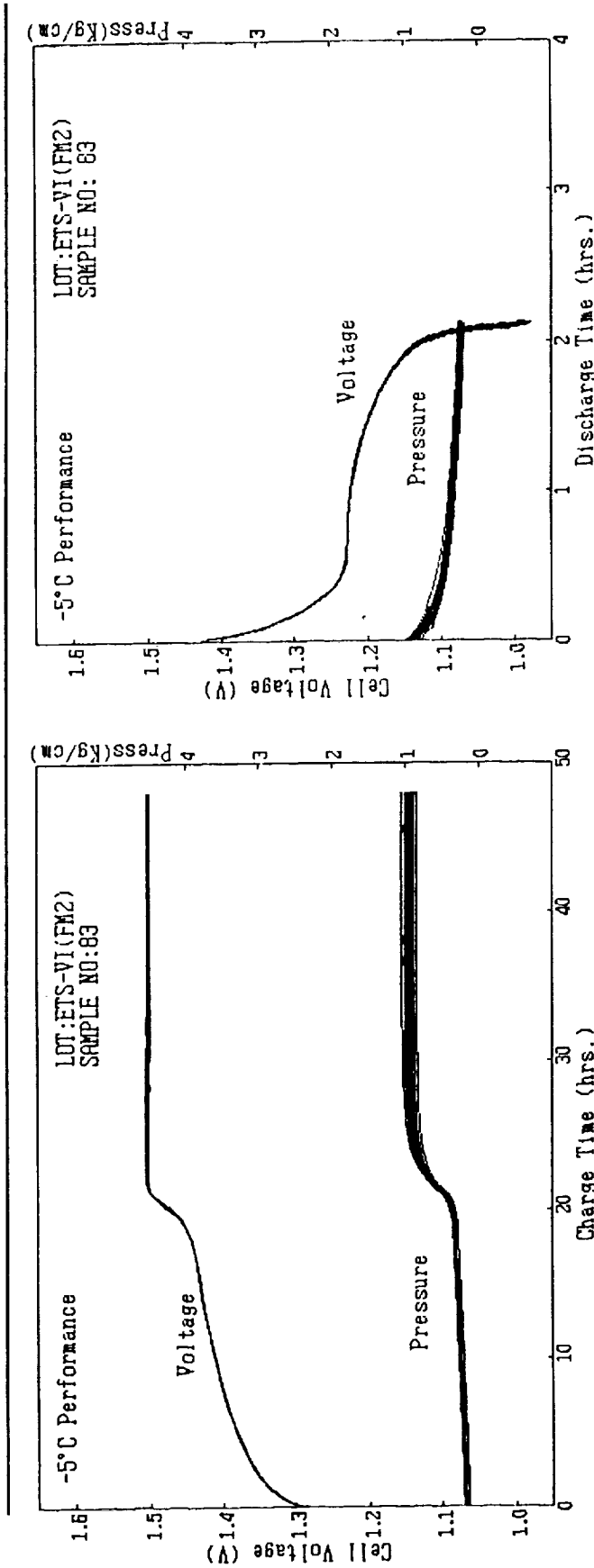
End of Charge Voltage

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Charge 3.5A x 24hrs. at 20 °C

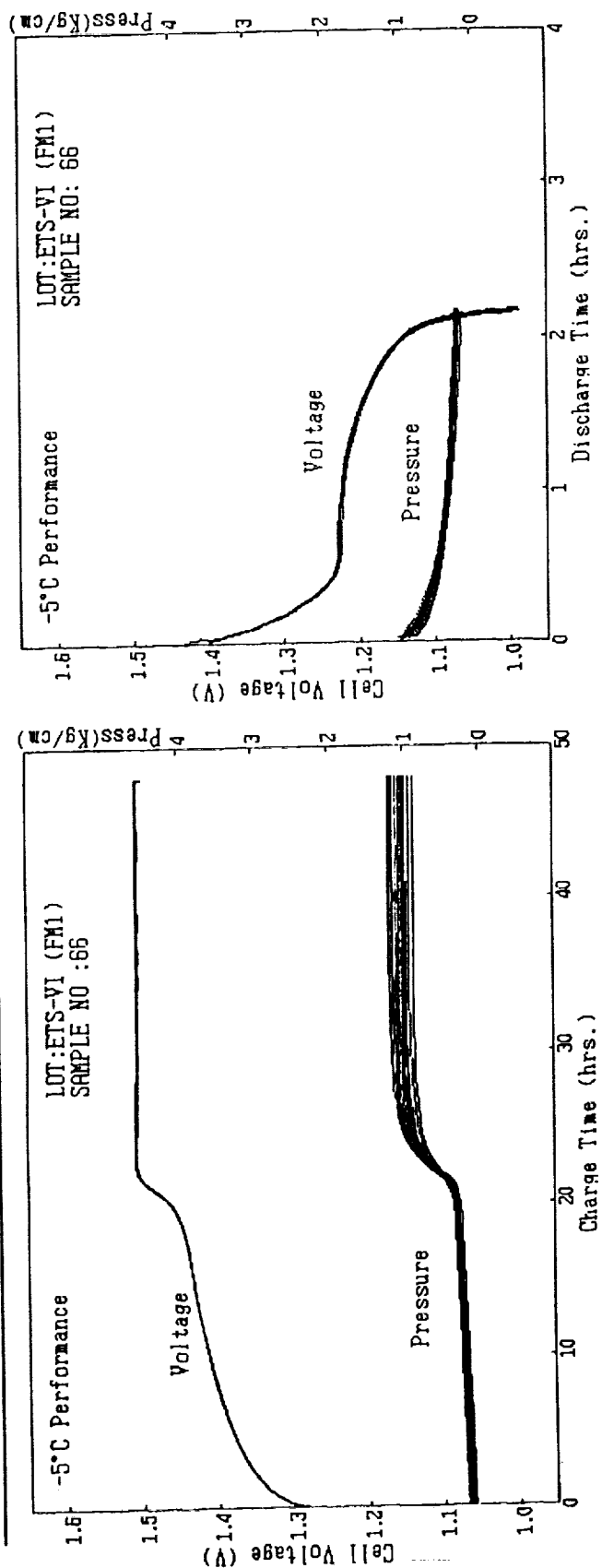
SANYO -5 °C Performance



Charge 1.75A x 48hrs. Discharge 17.5A Temp. -5 °C

Overplot of 83 Data of ETS-VI/FM 2nd Lot

SANYO -5 °C Performance



Charge 1.75A x 48hrs. Discharge 17.5A Temp. -5 °C

Overplot of 66 Data of ETS-VI/FM 1st Lot

SANYO ETS-VI Simulation Cycle Test

Sample :

8cells of PM 2nd lot / electrolyte filling in Nov. 1990

Test facilities :

in NASDA Tsukuba Space Center

Test Status :

Started in Feb. 1991

Continued in 834cycles of 19th season on Nov.1, 1993

Testing Data Summary :

EOCV about 1.45V/cell

8 cells—sample battery has never reached CV mode.

Reconditioning capacities are about 41AH from 5th to 18th season.

SANYO ETS – VI Simulation Cycle Test

Test conditions : from 5th season

Repeat 44cycles

{ Charge : (CC 1.5A + CV 12.5V/8cells) x 14hrs.
Trickle Charge : 0.5A x 8.8hrs.*
Discharge : 14.6A x 1.2hrs. (DOD 50%)
Temperature : 10 °C **

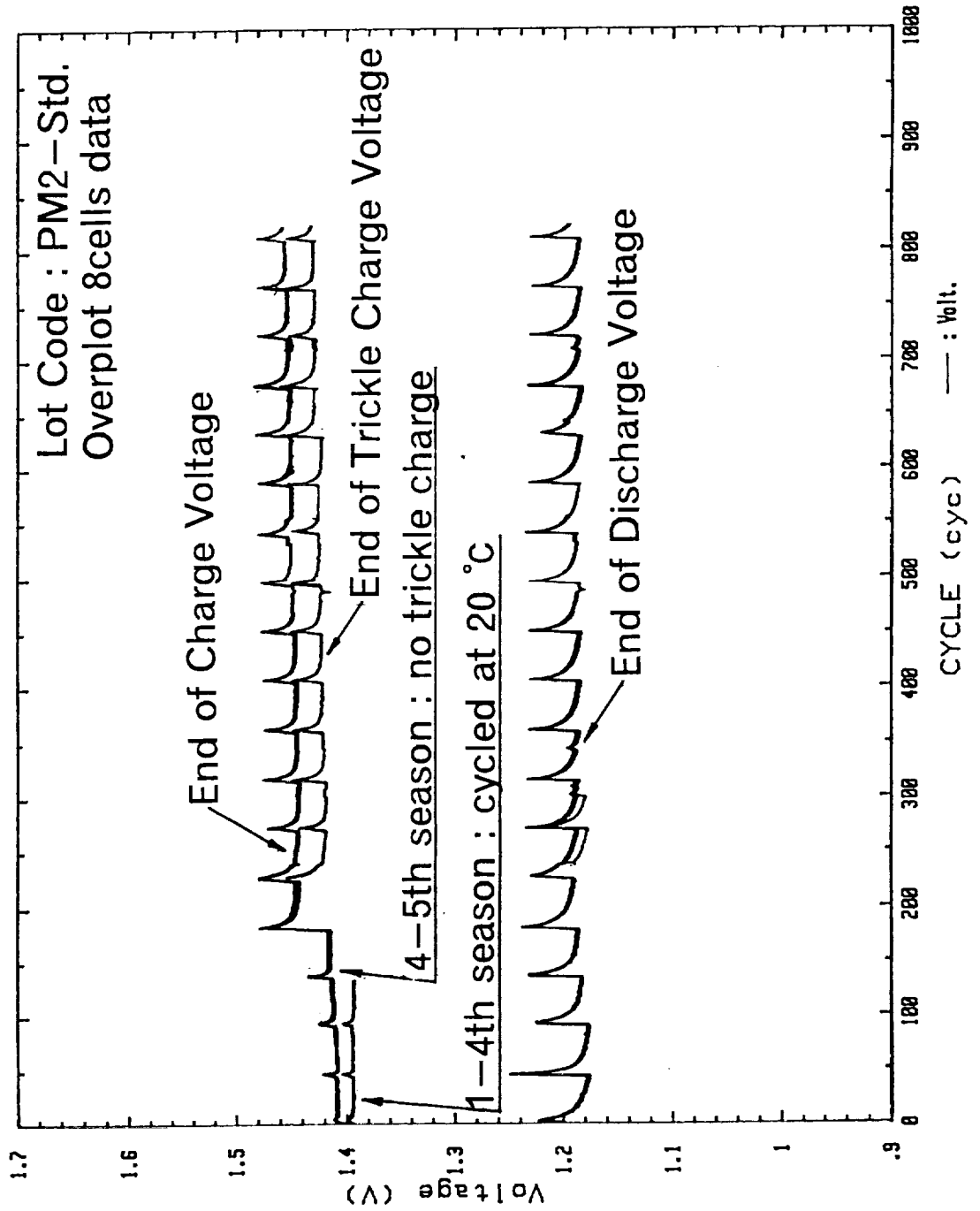
Reconditioning

{ Discharge : 0.66A until any cell falls to 1.0V
Recovery Charge : (CC1.5A+CV12.5V/8cells) x 35hrs.

*Not applied from 4th to 5th season

**Temperature of 20 °C was applied from 1st to 4th season.

SANYO ETS-VI Simulation Cycle Test



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Battery Storage

Storage Condition : Below 0 °C , Open circuit condition
Short circuit storage causes a small fading of capacity.

6months Storage Test of ETS-VI/PM Cells

N=11	Short / 0 °C before → after	Open / 0 °C before → after
End of Charge Volt. [V]	1.471 → 1.471	1.471 → 1.472
Max. Press. [kg/sq.cm]	1.27 → 1.33	1.15 → 1.21
Capacity [Ah]	38.9 → 38.1	38.6 → 38.6

- 35Ah Ni-Cd cells for ETS-VI/FM showed uniform performance in the initial acceptance test.
- Same designed cells are continuously tested in the simulating cycle mode of ETS-VI in NASDA, and these cells operate in a stable state.
- Our aerospace Ni-Cd cells are surely expected to show good performance in space, and selected by the following successive program.
 - ADEOS to launch in 1996 : now manufacturing FM cells to deliver 176cells
 - ETS-VII to be launched in 1998 : will use about 160 cells

The following information is provided for the purpose of the audit:

The company has been operating since the year 2000 and has a long history of successful operations. The company's revenue has increased steadily over the years, and it has a strong market position. The company's assets are well diversified, and it has a strong financial position. The company's management is experienced and has a strong track record of successful operations.

The company's revenue for the year 2023 was \$1,234,567,890. The company's profit for the year 2023 was \$234,567,890. The company's assets for the year 2023 were \$3,456,789,012. The company's liabilities for the year 2023 were \$1,234,567,890.

The company's revenue for the year 2022 was \$1,123,456,789. The company's profit for the year 2022 was \$223,456,789. The company's assets for the year 2022 were \$3,345,678,901. The company's liabilities for the year 2022 were \$1,123,456,789.

The company's revenue for the year 2021 was \$1,012,345,678. The company's profit for the year 2021 was \$212,345,678. The company's assets for the year 2021 were \$3,234,567,890. The company's liabilities for the year 2021 were \$1,012,345,678.

The company's revenue for the year 2020 was \$901,234,567. The company's profit for the year 2020 was \$201,234,567. The company's assets for the year 2020 were \$3,123,456,789. The company's liabilities for the year 2020 were \$901,234,567.

The company's revenue for the year 2019 was \$890,123,456. The company's profit for the year 2019 was \$190,123,456. The company's assets for the year 2019 were \$3,012,345,678. The company's liabilities for the year 2019 were \$890,123,456.

The company's revenue for the year 2018 was \$789,012,345. The company's profit for the year 2018 was \$179,012,345. The company's assets for the year 2018 were \$2,901,234,567. The company's liabilities for the year 2018 were \$789,012,345.

The company's revenue for the year 2017 was \$678,901,234. The company's profit for the year 2017 was \$168,901,234. The company's assets for the year 2017 were \$2,790,123,456. The company's liabilities for the year 2017 were \$678,901,234.

The company's revenue for the year 2016 was \$567,890,123. The company's profit for the year 2016 was \$157,890,123. The company's assets for the year 2016 were \$2,679,012,345. The company's liabilities for the year 2016 were \$567,890,123.

The company's revenue for the year 2015 was \$456,789,012. The company's profit for the year 2015 was \$146,789,012. The company's assets for the year 2015 were \$2,567,901,234. The company's liabilities for the year 2015 were \$456,789,012.

The company's revenue for the year 2014 was \$345,678,901. The company's profit for the year 2014 was \$135,678,901. The company's assets for the year 2014 were \$2,456,790,123. The company's liabilities for the year 2014 were \$345,678,901.

The company's revenue for the year 2013 was \$234,567,890. The company's profit for the year 2013 was \$124,567,890. The company's assets for the year 2013 were \$2,345,679,012. The company's liabilities for the year 2013 were \$234,567,890.

The company's revenue for the year 2012 was \$123,456,789. The company's profit for the year 2012 was \$113,456,789. The company's assets for the year 2012 were \$2,234,567,901. The company's liabilities for the year 2012 were \$123,456,789.

The company's revenue for the year 2011 was \$112,345,678. The company's profit for the year 2011 was \$102,345,678. The company's assets for the year 2011 were \$2,123,456,790. The company's liabilities for the year 2011 were \$112,345,678.

The company's revenue for the year 2010 was \$101,234,567. The company's profit for the year 2010 was \$91,234,567. The company's assets for the year 2010 were \$2,012,345,679. The company's liabilities for the year 2010 were \$101,234,567.

The company's revenue for the year 2009 was \$90,123,456. The company's profit for the year 2009 was \$80,123,456. The company's assets for the year 2009 were \$1,901,234,568. The company's liabilities for the year 2009 were \$90,123,456.

The company's revenue for the year 2008 was \$89,012,345. The company's profit for the year 2008 was \$79,012,345. The company's assets for the year 2008 were \$1,790,123,457. The company's liabilities for the year 2008 were \$89,012,345.

The company's revenue for the year 2007 was \$78,901,234. The company's profit for the year 2007 was \$68,901,234. The company's assets for the year 2007 were \$1,679,012,346. The company's liabilities for the year 2007 were \$78,901,234.

The company's revenue for the year 2006 was \$67,890,123. The company's profit for the year 2006 was \$57,890,123. The company's assets for the year 2006 were \$1,567,901,235. The company's liabilities for the year 2006 were \$67,890,123.

The company's revenue for the year 2005 was \$56,789,012. The company's profit for the year 2005 was \$46,789,012. The company's assets for the year 2005 were \$1,456,790,124. The company's liabilities for the year 2005 were \$56,789,012.

The company's revenue for the year 2004 was \$45,678,901. The company's profit for the year 2004 was \$35,678,901. The company's assets for the year 2004 were \$1,345,679,013. The company's liabilities for the year 2004 were \$45,678,901.

The company's revenue for the year 2003 was \$34,567,890. The company's profit for the year 2003 was \$24,567,890. The company's assets for the year 2003 were \$1,234,567,902. The company's liabilities for the year 2003 were \$34,567,890.

The company's revenue for the year 2002 was \$23,456,789. The company's profit for the year 2002 was \$13,456,789. The company's assets for the year 2002 were \$1,123,456,791. The company's liabilities for the year 2002 were \$23,456,789.

The company's revenue for the year 2001 was \$12,345,678. The company's profit for the year 2001 was \$2,345,678. The company's assets for the year 2001 were \$1,012,345,680. The company's liabilities for the year 2001 were \$12,345,678.

The company's revenue for the year 2000 was \$1,234,567. The company's profit for the year 2000 was \$123,456. The company's assets for the year 2000 were \$101,234,567. The company's liabilities for the year 2000 were \$1,234,567.