# NICKEL-HYDROGEN CELL REVERSAL CHARACTERISTICS

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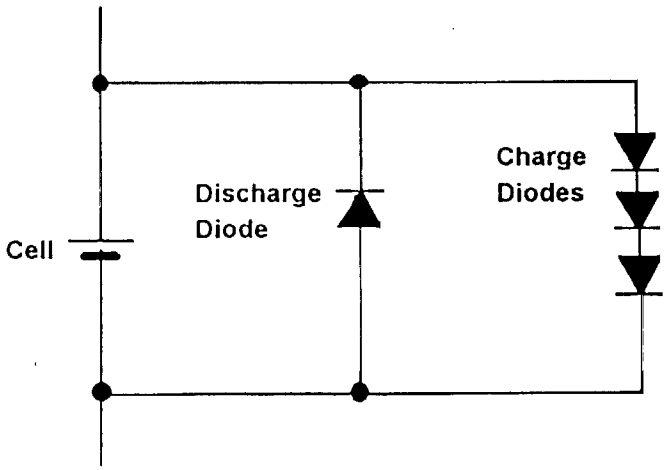
# NICKEL-HYDROGEN CELL REVERSAL CHARACTERISTICS

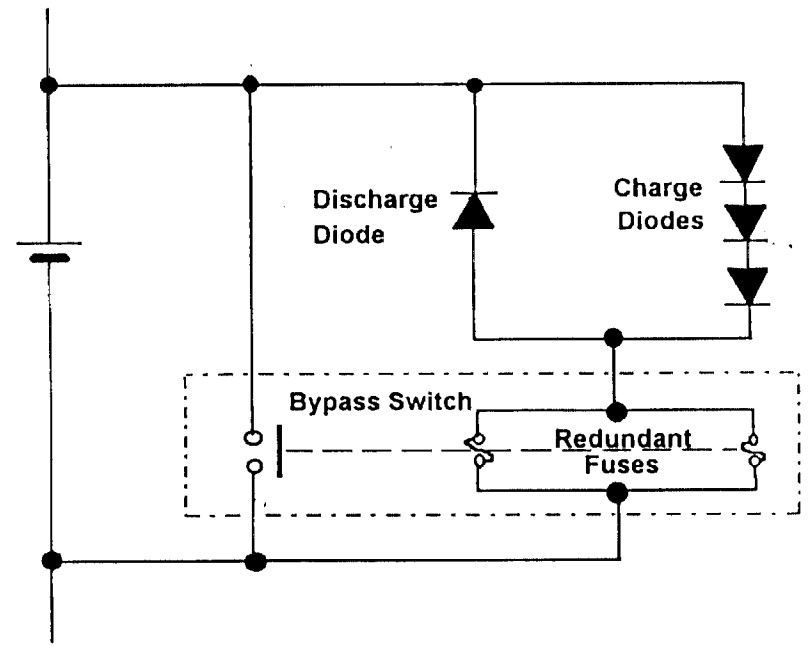
NICKEL-HYDROGEN CELL REVERSAL CHARACTERISTICS ARE BEING STUDIED AS PART OF A TRW PROGRAM DIRECTED TOWARDS DEVELOPMENT OF A HIGH CURRENT BATTERY CELL BYPASS SWITCH.

# CELL BYPASS SWITCH

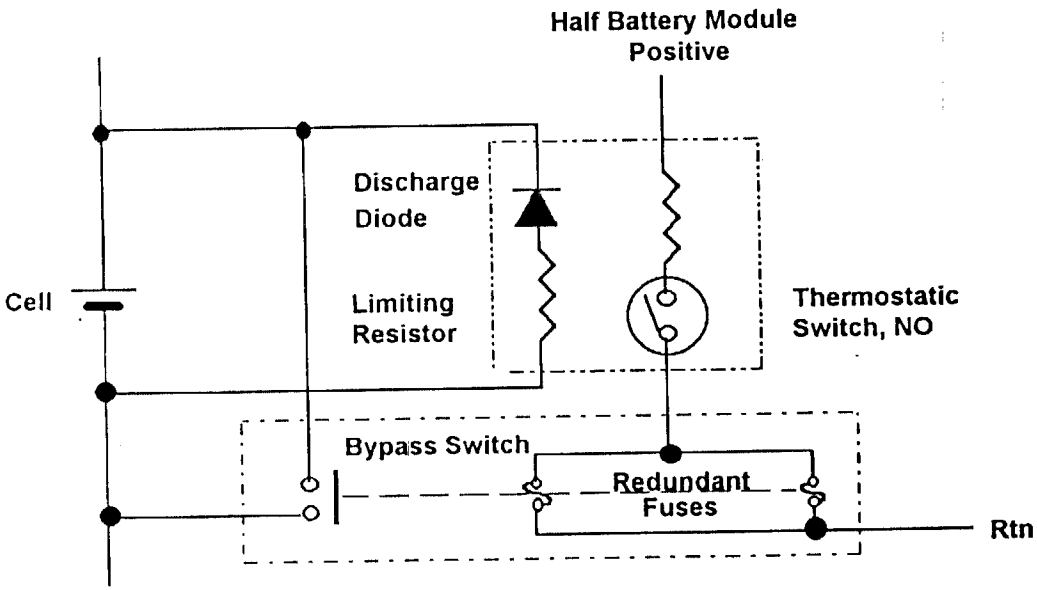
- OPEN CIRCUIT FAILURE MODE CONSIDERED CREDIBLE FOR NICKEL-HYDROGEN CELLS
- BYPASS PROTECTION TRADITIONALLY PROVIDED BY DIODES
- DIODE APPROACH IS POWER LIMITED
  - THERMAL DISSIPATION
  - UNAVAILABILITY OF LARGE FLIGHT QUALIFIED DIODES
- BYPASS WITH A SWITCH IS PREFERRED FOR LARGE CELLS
  - LOWER DISSIPATION
  - LIGHTER



# BYPASS SWITCH APPROACH




Passive fuse wire actuated bypass switch



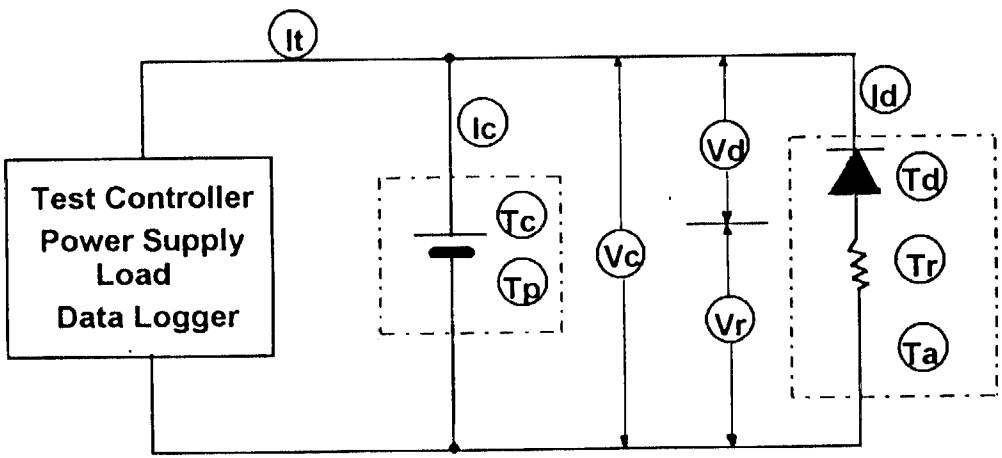

Thermostatically actuated bypass switch

# NICKEL-HYDROGEN CELL REVERSAL CHARACTERISTICS

- CHARACTERIZATION OF THE SWITCH INCLUDES UNDERSTANDING
  - HOW LONG IT WILL TAKE TO ACTUATE
  - AT WHAT VOLTAGE IT WILL ACTUATE
- CHARACTERISTICS OF THE FUSE LINKS, DIODE, RESISTOR, AND THERMOSTAT ARE EASILY DETERMINED
- REVERSAL CHARACTERISTICS OF NICKEL HYDROGEN CELLS MUST ALSO BE KNOWN IF THE SWITCH ACTUATION CHARACTERISTICS ARE TO BE DETERMINED

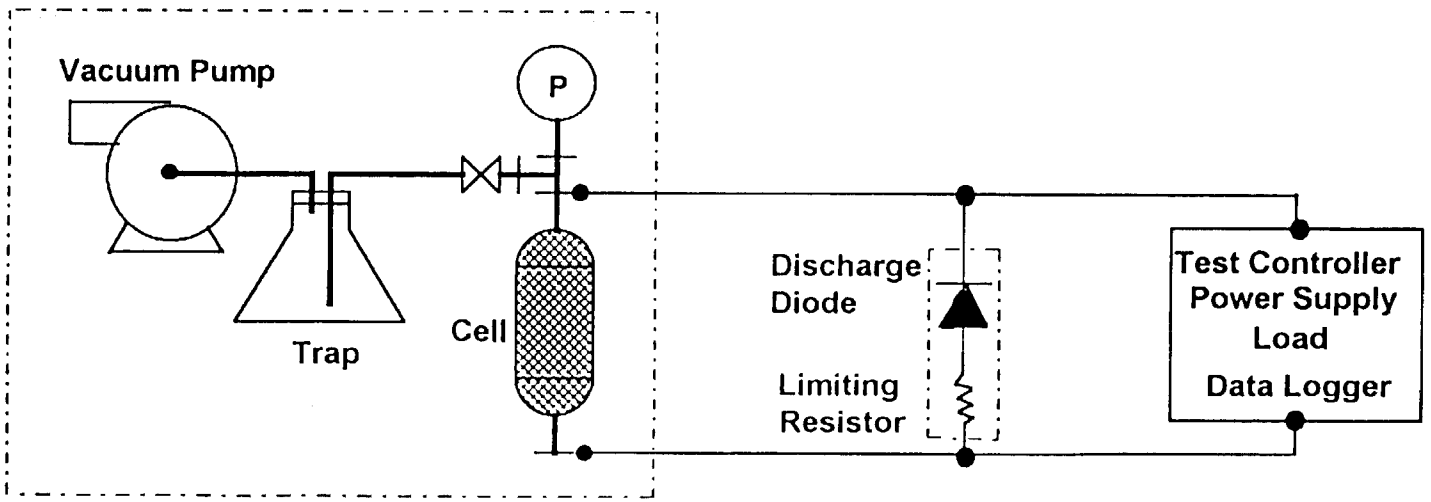
# EXPERIMENTAL

- DETERMINE NICKEL HYDROGEN CELL REVERSAL VOLTAGE TRAJECTORIES
  - HYDROGEN AND NICKEL PRECHARGED CELLS
  - NOMINAL AND MINIMUM RATES
  - CELL LEAKING INTO VACUUM (SPACE)
- TEST INSTRUMENTATION



# EXPERIMENTAL (CONT'D)

- EP RNH 65-17 CELL, IN THERMAL SLEEVE, ON COLD PLATE AT 5 ± 2 DEG C
  - ZIRCAR SEPARATOR, WALL WICK
  - BACK-TO-BACK STACK CONFIGURATION
- LEAK TO SPACE SIMULATED BY VENTING CELL TO VACUUM



# NICKEL-HYDROGEN CELL CHEMISTRY
## DISCHARGE/REVERSAL

### DISCHARGE

| | | | | |
|---|---|---|---|---|
| Nickel | $2\ NiOOH + 2\ HOH + 2\ e$ | $\rightarrow$ | $2\ Ni(OH)_2 + 2\ OH^-$ | $E^\circ = +0.5v$ |
| Hydrogen | $H_2 + 2\ OH^- - 2\ e$ | $\rightarrow$ | $2\ HOH$ | $E^\circ = +0.8v$ |
| Total | $2\ NiOOH + H_2$ | $\rightarrow$ | $Ni(OH)_2$ | $E^\circ = +1.3v$ |

### OVERDISCHARGE (REVERSAL) WITH HYDROGEN PRECHARGE

| | | | | |
|---|---|---|---|---|
| Nickel | $2\ HOH + 2\ e$ | $\rightarrow$ | $H_2 + 2\ OH^-$ | $E^\circ = -0.8v$ |
| Hydrogen | $H_2 + 2\ OH^- - 2\ e$ | $\rightarrow$ | $2\ HOH$ | $E^\circ = +0.8$ |

No net reaction; $H_2$ recombines

# NICKEL-HYDROGEN CELL CHEMISTRY
## OVERDISCHARGE (REVERSAL) WITH NICKEL PRECHARGE

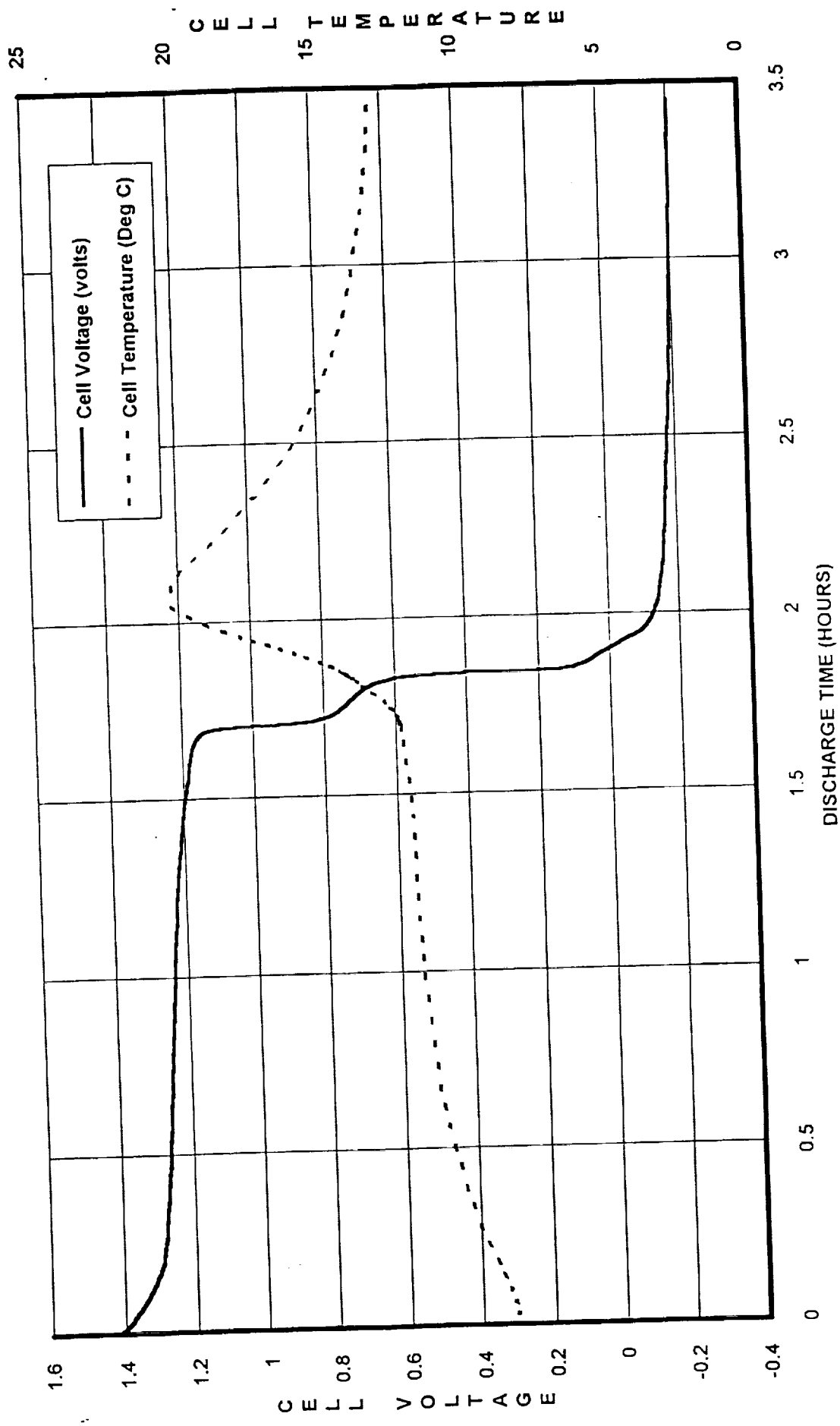
### ACTIVE NICKEL PRECHARGE PRESENT

| | | | | |
|---|---|---|---|---|
| Nickel | $2\ NiOOH + 2\ HOH + 2\ e$ | $\rightarrow$ | $2\ Ni(OH)_2 + 2\ OH^-$ | $E^\circ = +0.5v$ |
| Hydrogen | $2\ OH^- - 2\ e$ | $\rightarrow$ | $1/2\ O_2 + HOH$ | $E^\circ = -0.4v$ |
| Total | $2\ NiOOH + HOH$ | $\rightarrow$ | $2\ Ni(OH)_2 + 1/2\ O_2$ | $E^\circ = +0.1v$ |

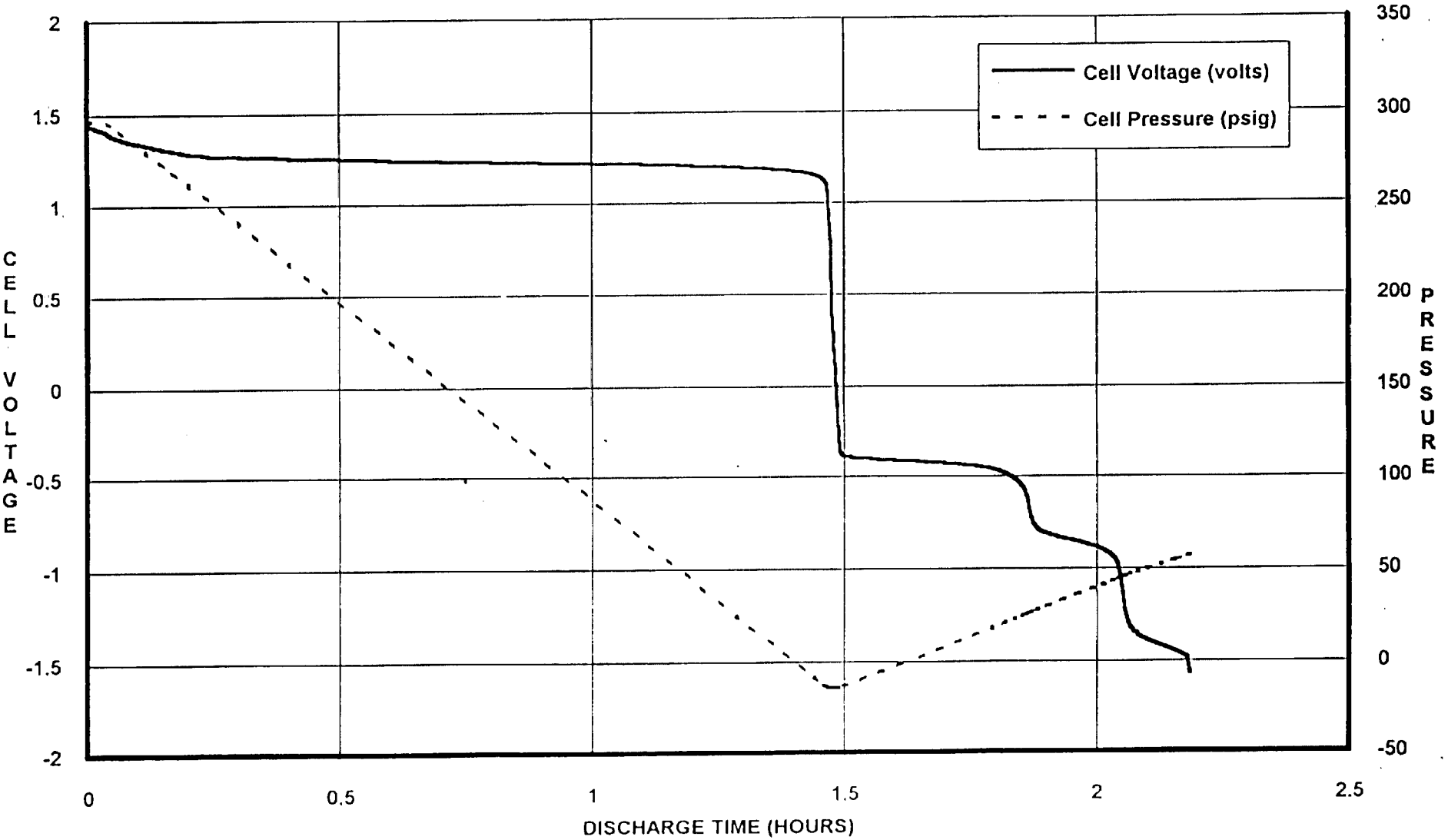
### ACTIVE NICKEL PRECHARGE EXHAUSTED

| | | | | |
|---|---|---|---|---|
| Nickel | $2\ HOH + 2\ e$ | $\rightarrow$ | $2\ OH^- + H_2$ | $E^\circ = -0.8v$ |
| Hydrogen | $2\ OH^- - 2\ e$ | $\rightarrow$ | $1/2\ O_2 + HOH$ | $E^\circ = -0.4v$ |
| Total (electrochemical) | $HOH$ | $\rightarrow$ | $1/2\ O_2 + H_2$ | $E^\circ = -1.2v$ |
| Chemical | $1/2\ O_2 + H_2$ | $\rightarrow$ | $HOH$ | |

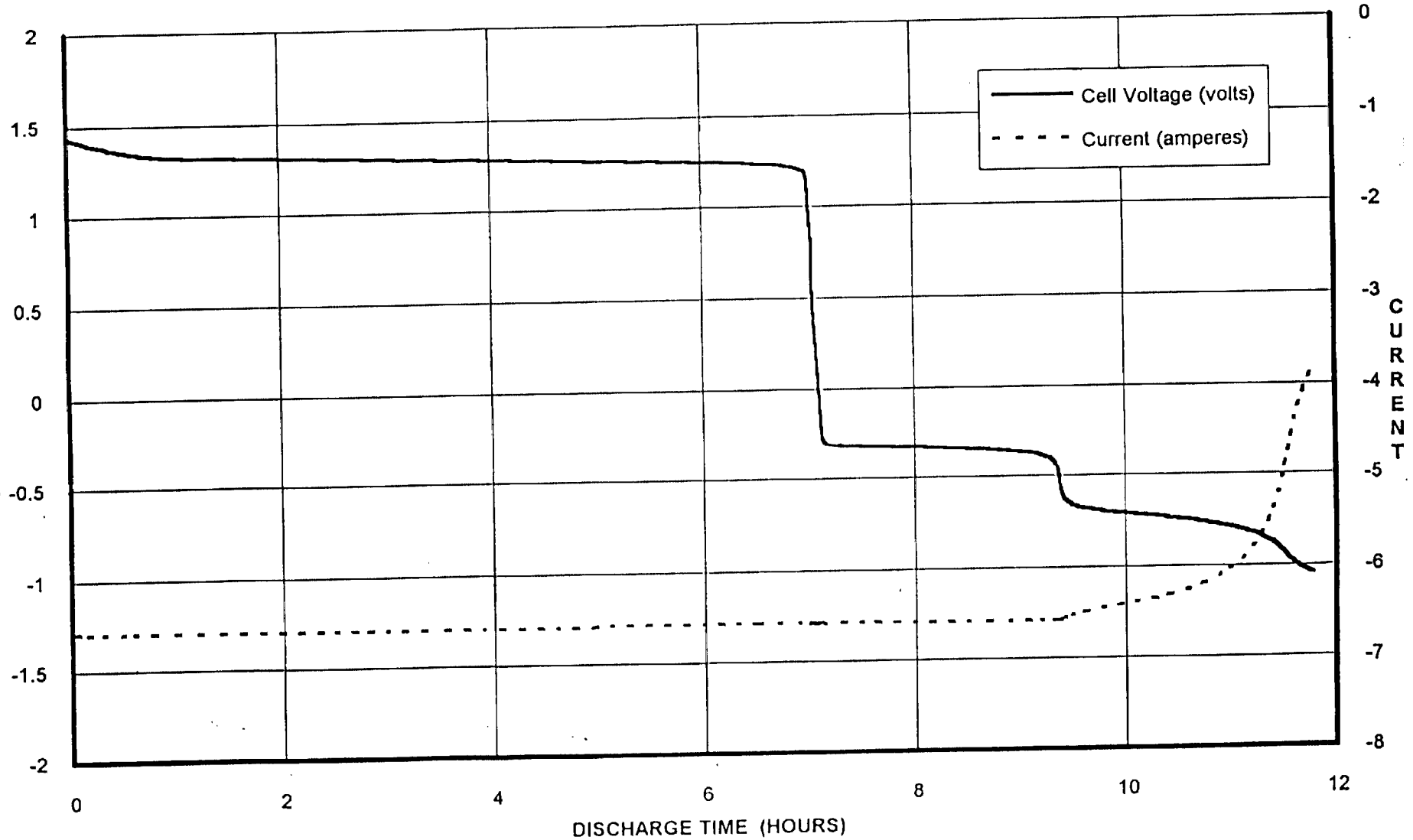
# DISCHARGE INTO REVERSAL WITH HYDROGEN PRECHARGE (C/2)



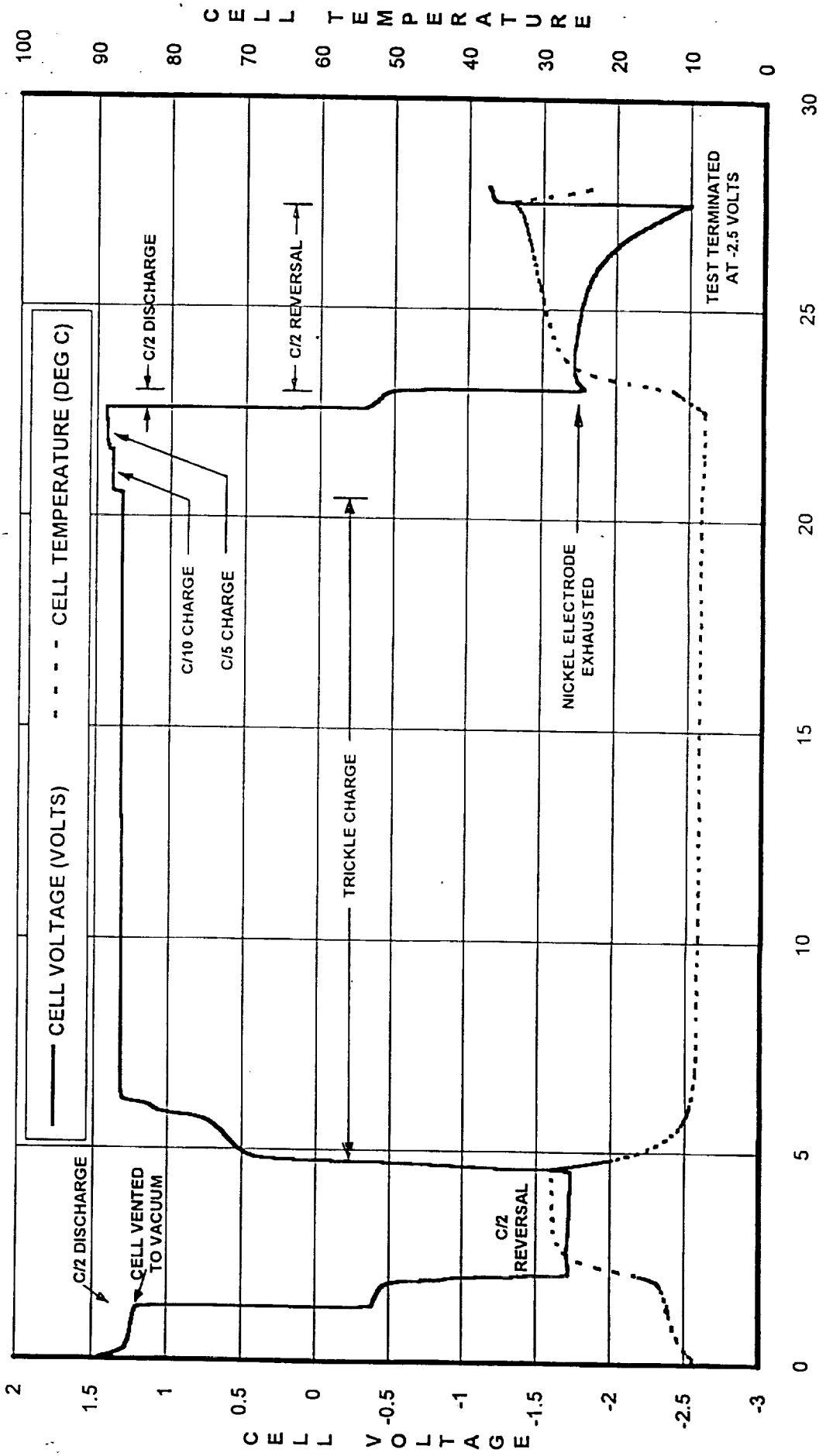
# DISCHARGE INTO REVERSAL WITH NICKEL PRECHARGE (C/2)



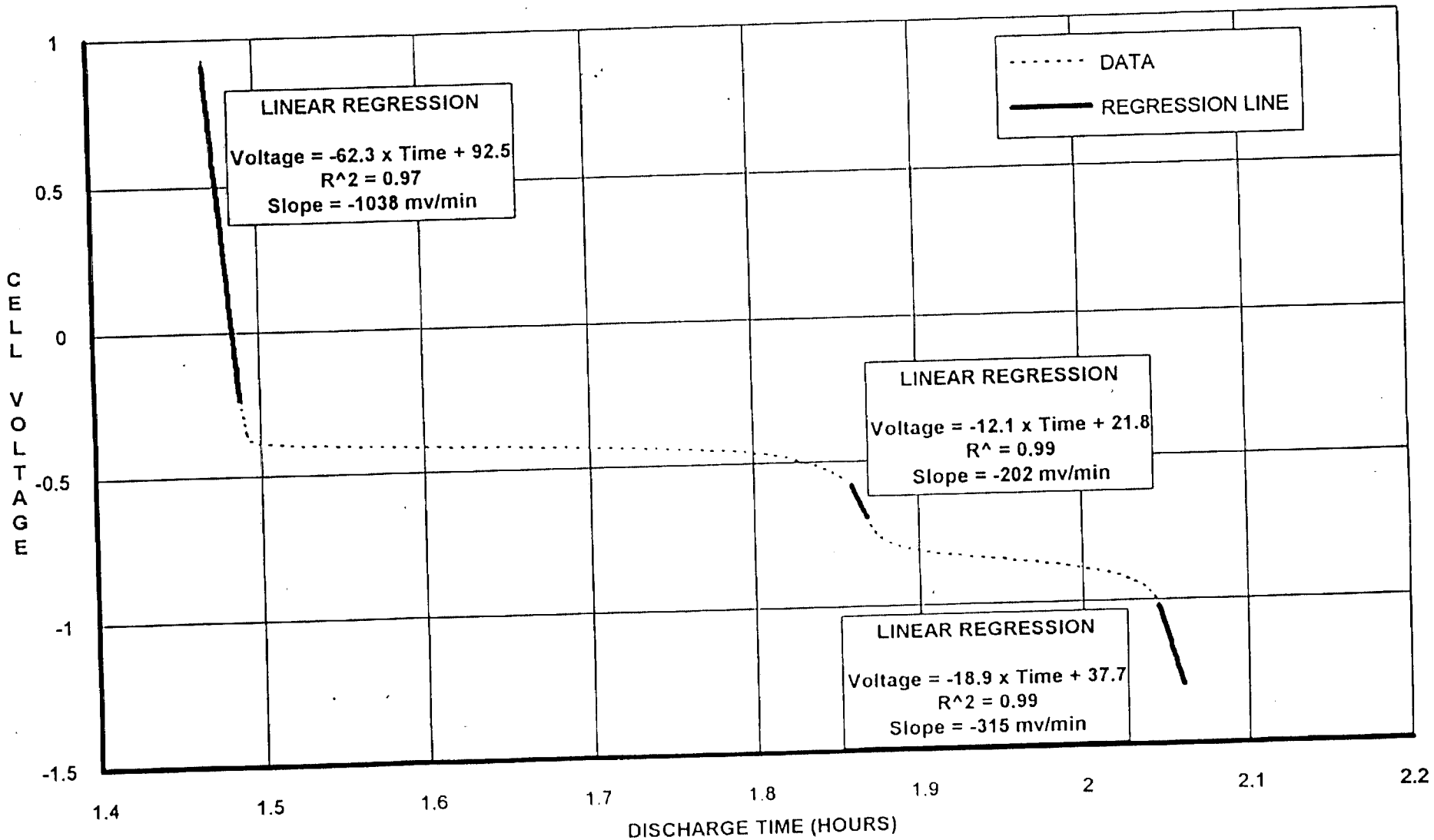
# DISCHARGE INTO REVERSAL WITH NICKEL PRECHARGE (C/10)



# DISCHARGE INTO REVERSAL WITH LEAK-TO-VACUUM



# VOLTAGE TRAJECTORY
# END OF DISCHARGE AND REVERSAL



# COMPOSITE VOLTAGE TRAJECTORY CURVES