PERFORMANCE CHARACTERISTICS OF SINTERED PLATE NICKEL CADMIUM CELLS. IV. CAPACITY TESTS ON BUTTON TYPE CELLS

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Abstract:

Discharge characteristics of completely sealed button type nickel-cadmium cells made in this Institute have been studied both at room temperature as well as at sub-zero temperatures. The temperature was varied between 0°C to —40°C. The results obtained with cells fabricated in this Institute are compared with those of the imported ones.

Introduction:

Sealed cell construction was commercially developed after 1950 to meet a demand for batteries which could be permanently or semi-permanently installed in equipments and operated in all positions with no maintenance beyond recharging. Sealed cells have received and are continuing to receive especially intensive development. The satisfactory performance of a sealed cell depends on the incorporation of features which allow for elimination or recombination within the cell, of gases which might be evolved during charging. The problems of sealing which include heat dissipation on overcharge increase with the size of the cell. Complete hermetic sealing involving the use of metal/metal joints with rubber or plastic washers or ceramic metal seals can be applied with safety to cells which are below certain limits of capacity. A common form for such cells is the button type of cell.

The process for making small size button type cells has now been developed in this Institute and cells of 100 to 150 mA hr capacity have been made on the basis of the same and tested. A selection of cell samples is shown in Plate 1. The cells are made from sintered plates. The assembly consists of positive and negative plates assembled alternatively with a suitable separator in between. The group is enclosed and disposed in nickel plated mild steel containers and sealed in such a way that the same wires insulated from each other will also serve as the terminals of the cells.

Experimental:

The performance characteristics of cells made in this Institute were studied at normal as well as sub-zero temperatures. For this two cells from a group of twenty cells prepared in four batches were taken as the representative samples. Experiments were also carried out with four imported samples of one manufacturer in order to have a comparative data. Charging was carried out C/5 rate where C is the rated capacity for 7 hours at room temperature. Discharge was carried out at five different rates namely C/10, C/5, C, 3C and 5C where C is the rated capacity at 5 hour rate. Discharge was also carried out at C/5 rate at different temperatures namely at 0°C —10°C, —20°C, —30°C and at —40°C. After the high discharge and low temperature tests, the cells were again discharged at C/5 rate at room temperature upto an end voltage of 1.0V per cell to ensure that the cells are in fully discharged state before starting subsequent charging. The conditions of discharge tests and the end of discharge voltage for various tests are summarised in Table I. For tests at sub-zero temperatures the cells were kept inside cold temperature cabinet and the discharge was started after storing the cells for 2 hours in specified temperature. To facilitate easy connections the cells wee mounted in frames as shown in Plate 2. Care was taken to avoid any drop at the contacts during charge-discharge cycles.

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Results and Discussion:

The results are presented in Figs. 1 to 5 and Tables II and III. Fig. 1 represents the charging curves for both cells. The cell voltage is plotted against the period of charging. It can be seen that the charging voltage of the cells made here is lower than that for the imported cells. Further, the cell voltage of the former increases only after 6th hour of charging whereas the voltage of the imported cells rises and reaches 1.50V in 2 hours.

Discharge characteristics are represented in Figures 4 to 6 in the form of cell voltage *vs.* percent capacity output of the rated capacity. Fig. 2 shows the discharge characteristics at room temperature at low rates of discharge. The average voltage for the imported cell is higher than that for the Central Electrochemical Research Institute (CECRI) cells at low rates of discharge. The cell voltage during discharge of the latter at C/5 rate remains steady at 1.25V upto 70% of the rated capacity whereas the imported cells have an average discharge voltage of 1.30V/cell for the same period.

Fig. 3 represents the discharge curves for the two types of cells at high rates namely C, 3C and 5C rates. From the figure it can be seen that there is a marked difference in the performance of the two types of cells. Cell voltage curve for CECRI cells shows a steady value of voltage during discharge and a sudden fall at the end of the discharge. Further, the average discharge voltage of the imported cells at high rates is always lower than of the CECRI cells. The capacity output as percent of the rated capacity at different rates are given in Table III. The capacity at high rates for imported cells is very low when compared with CECRI cells.

Fig. 4 represents the discharge characteristics at sub-zero temperatures. Discharge at room temperature is also plotted for comparison and reference. It can be seen from the figure that the voltage variation of imported cells for discharge at low temperatures below —20°C with percent capacity output is steeper than CECRI cells and at — 40°C, the curve shows a continuous fall in voltage whereas the CECRI cells show more or less a steady voltage for discharge which falls sharply at the end. Further the drops in voltage of cells at different temperatures increases with decrease in temperature as can be seen from Table II. The drop in voltage in the first 30 seconds at after the discharge started, for CECRI cells is lower than that for the imported cells and at —40°C the fall is nearly double. This probably represents larger ohmic drop in the imported cells.

Fig. 5 shows a plot of percent capacity output at different temperatures for both the type of cells. The figure shows a lower capacity output at low temperatures for both the cells but the fall in capacity of imported cell is higher than that of CECRI cells. There is a sharp decrease in capacity output for temperatures lower than —10°C in the case of both the types of cells. But the difference between the two cells at —40°C is marked. CECRI cells giving 46% of their capacity, whereas the imported cells can give only 15% of their capacity.

TABLE I

SUMMARY OF TEST CONDITIONS

PERFORMANCE TESTS AT DIFFERENT RATES			*PERFORMANCE TESTS AT DIFFERENT TEMPERATURES*		
Rate of discharge	*End voltage for discharge (volts/cells)*	*Temperature of discharge (°C)*	*Temperature of discharge (°C)*	*End voltage for discharge (volts/cells)*	*Rate of discharge*
C/10	1.0	30	30	1.0	C/5
C/5	1.0	30	0	0.9	C/5
C	0.9	30	—10	0.9	C/5
3C	0.9	30	—20	0.9	C/5
5C	0.6	30	—30	0.9	C/5
...	...	...	—40	0.9	C/5

TABLE II

DROP IN VOLTAGE PER CELL, DURING DISCHARGE AT DIFFERENT LOW TEMPERATURES

Temperature of discharge (°C)	*DROP IN VOLTAGE IN* 30 *SECS.* (*VOLT/CELL*)	
	CECRI cell	*Imported cell*
Room temperature	0.025	0.025
0	0.035	0.035
—10	0.045	0.050
—20	0.05	0.10
—30	0.08	0.23
—40	0.14	0.31

TABLE III

CAPACITY OUTPUT OF CECRI AND IMPORTED CELLS AT DIFFERENT RATES OF DISCHARGE

Rate of discharge	*End of discharge voltage* (*Volts/cells*)	*CAPACITY OUTPUT AS % OF RATED CAPACITY*	
		CECRI cells	*Imported cell*
C/10	1.0	130	124.2
C/5	1.0	124	108
C	0.9	100	100
3C	0.9	75	30
5C	0.6	68	27

C — Rated capacity

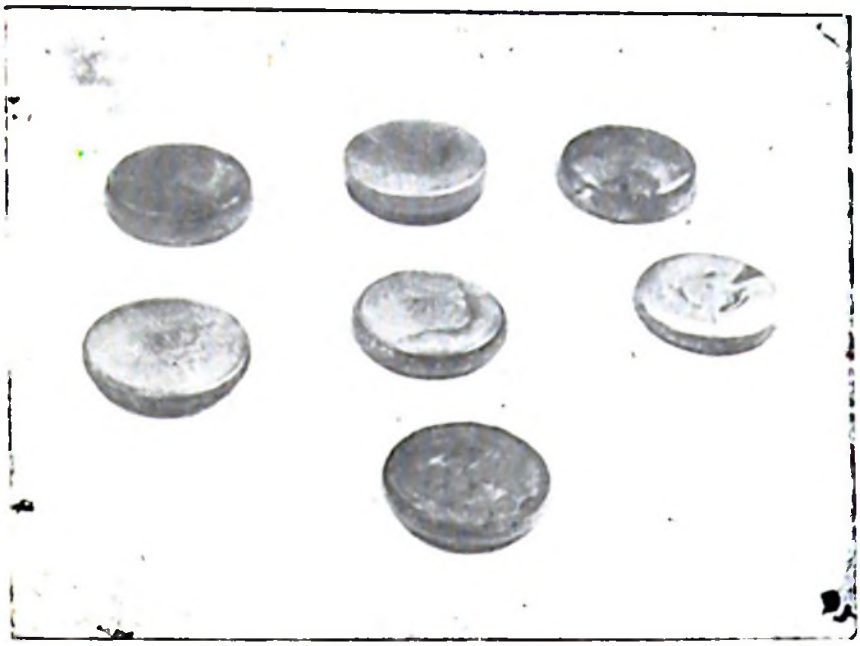


PLATE I

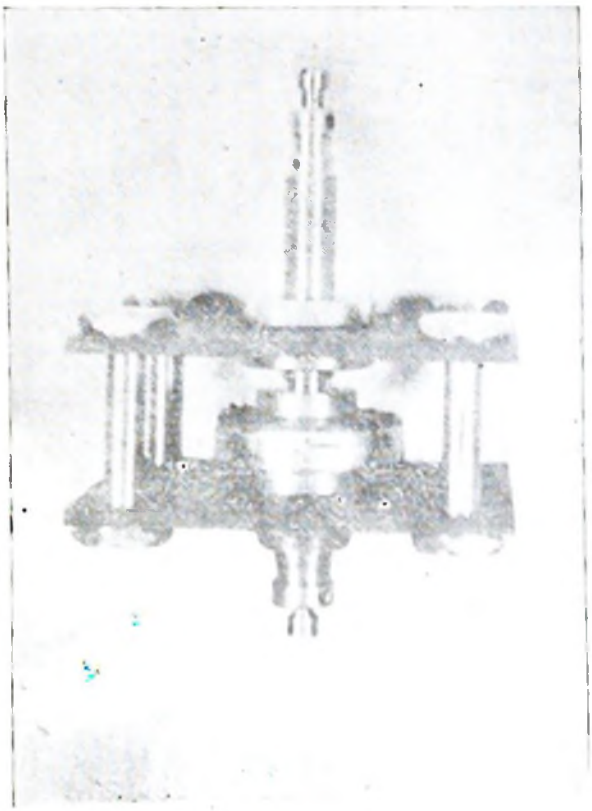


PLATE II

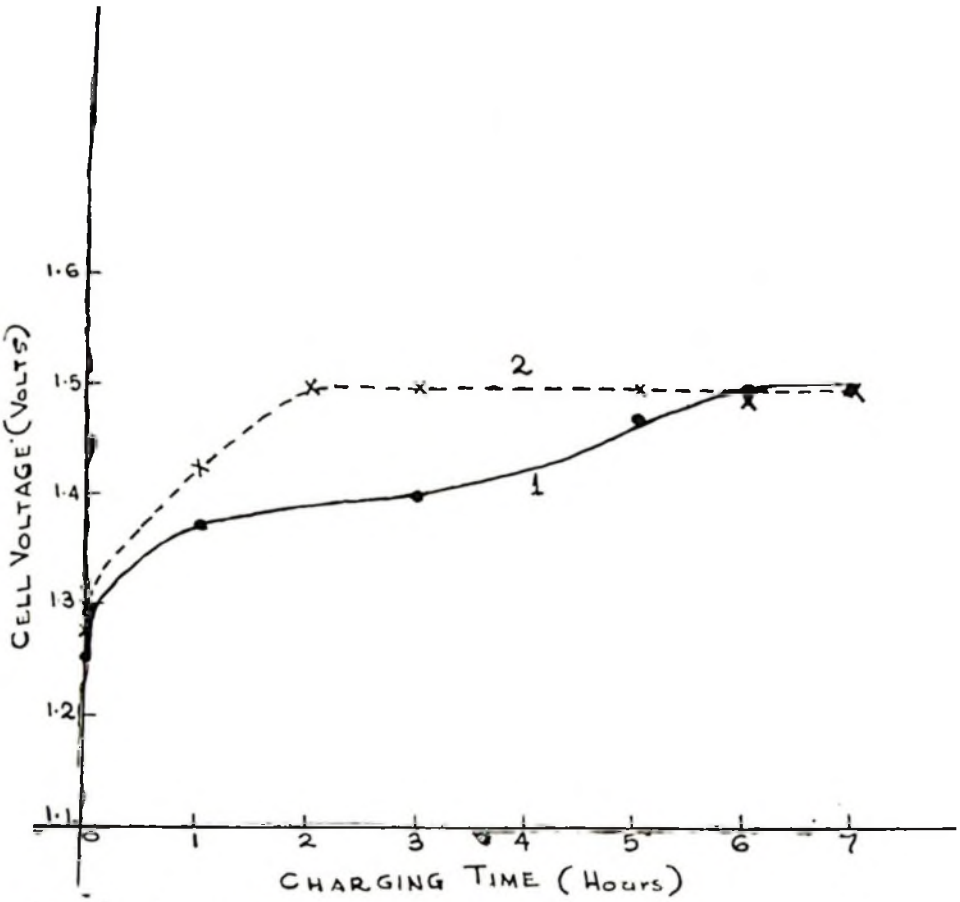


Fig. 1. CHARGING CURVE AT 5 Hr. RATE —
1. C.E.C.R.I. CELL.
2 IMPORTED CELL.

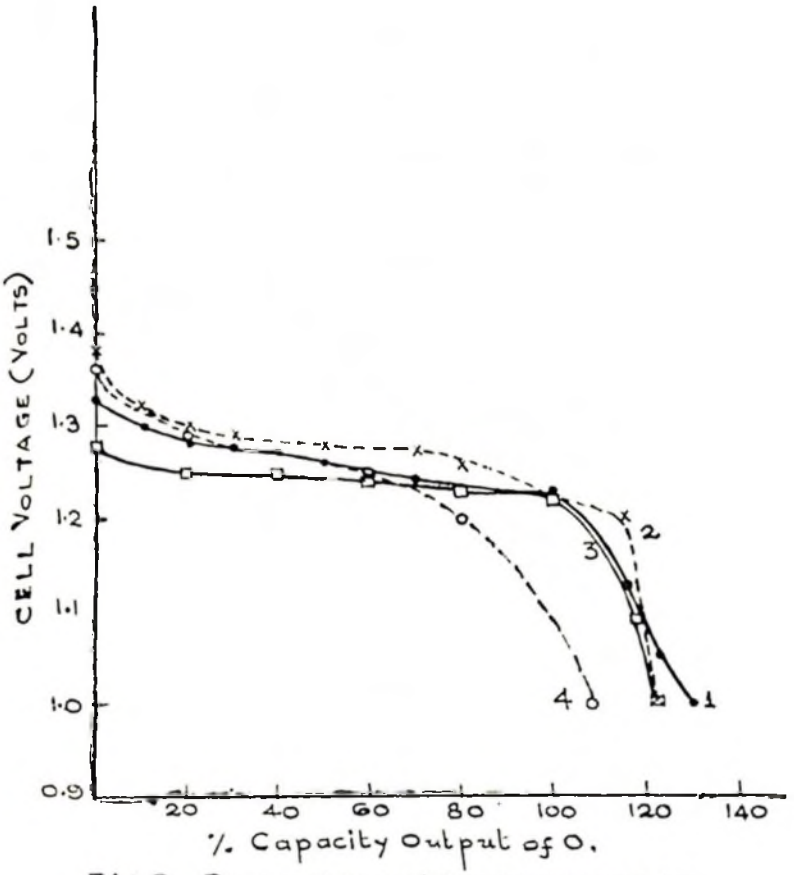


Fig.2. DISCHARGE CHARACTERISTICS AT LOW RATES OF DISCHARGE

Broken Lines refers to Imported Cell.

C = Rated Capacity.

1 & 2 = At 10 Hr. Rate

3 & 4 = At 5 Hr. Rate

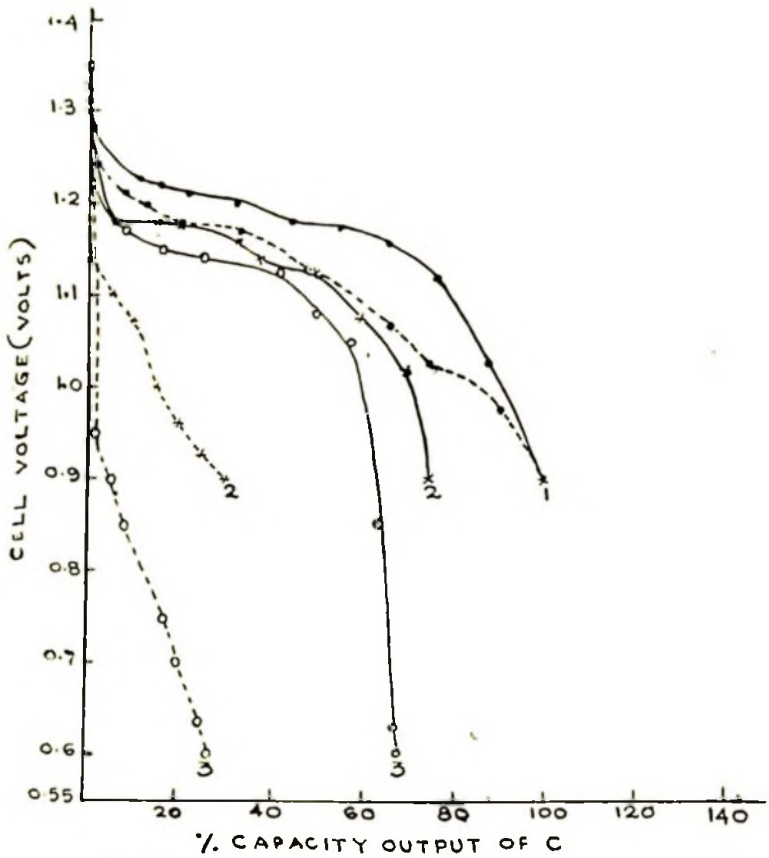


Fig 3. DISCHARGE CHARACTERISTICS AT HIGH RATES OF DISCHARGE

Broken Lines refer to Imported Cell.

C = Rated Capacity.

1 = 1C Rate; 2 = 3C Rate; 3 = 5C Rate.

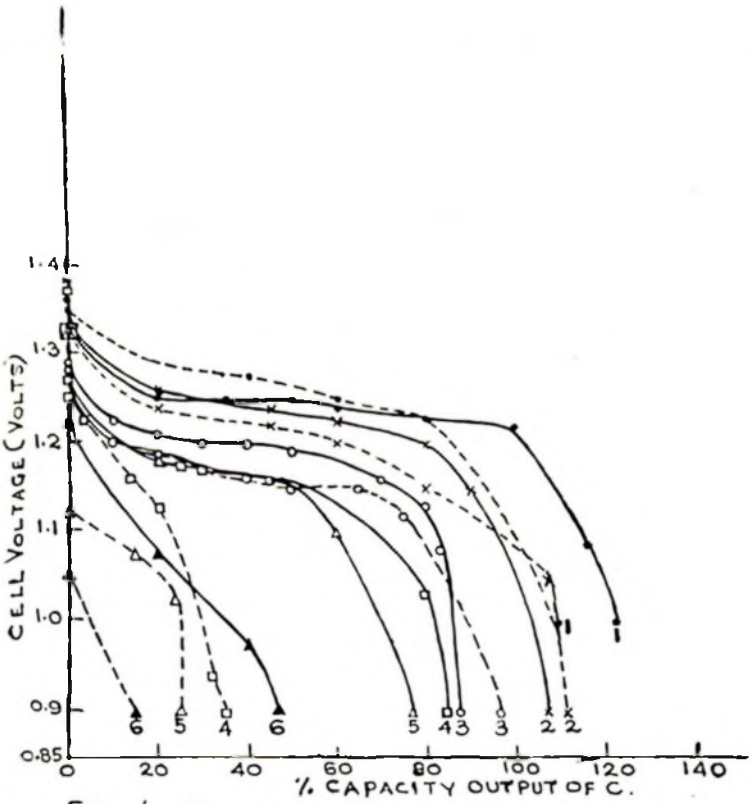


Fig. 4. EFFECT OF LOW TEMPERATURE ON THE DISCHARGE BEHAVIOUR OF SEALED CELLS.
Broken Lines refer to Imported Cell.
C = Rated Capacity.
1 = Room Temperature; 2 = 0°C.; 3 = −10°C.
4 = −20°C; 5 = −30°C; 6 = −40°C

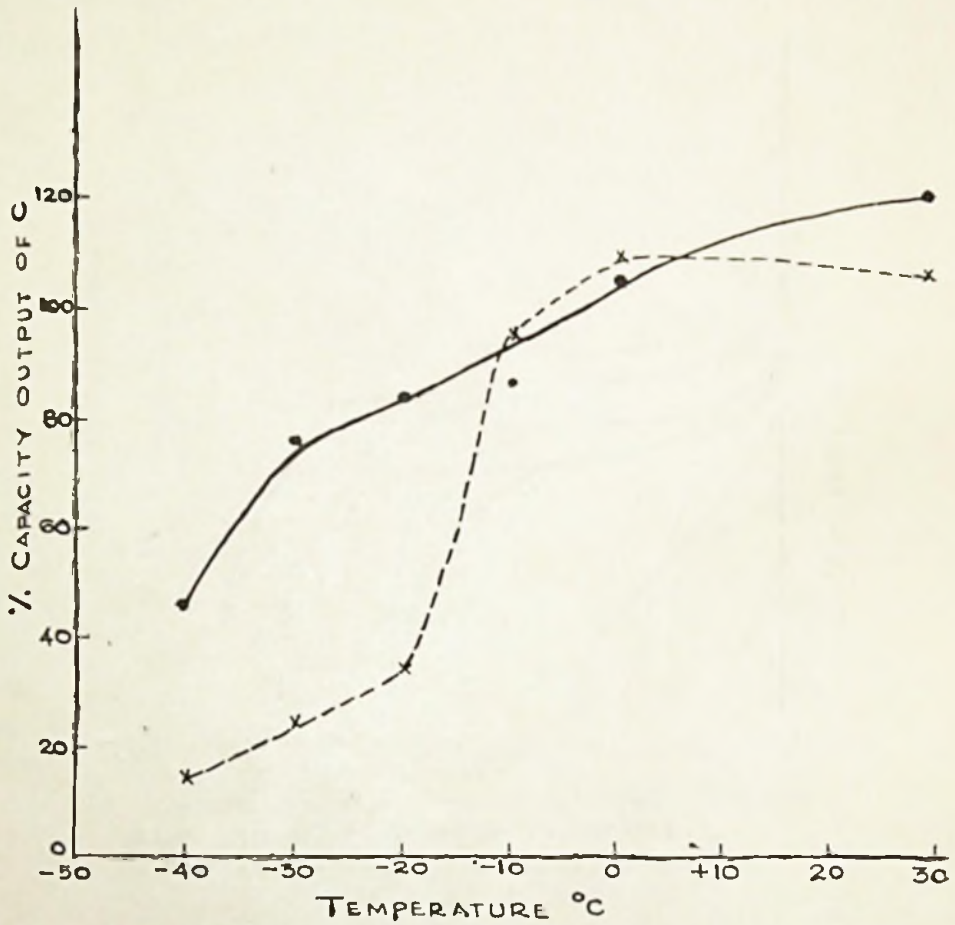


Fig.5. VARIATION OF %. CAPACITY OUTPUT WITH DISCHARGE TEMPERATURE

Broken Lines refer to Imported Cell.