PERFORMANCE CHARACTERISTICS OF SINTERED PLATE NICKEL CADMIUM CELLS. III. CHARGEABILITY AT SUBZERO TEMPERATURES

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Sintered plate nickel cadmium batteries are well known for their performance characteristics at high rates of discharge and ability to deliver high capacity at sub-zero temperatures of the order of —40 *C*. The technical know-how for the production of sintered plate nickel-cadmium cells[1] has been worked out in this Institute and the performance characteristics of the cells produced have now been studied. In earlier communications, 2 — 4 the results of capacity tests both at normal and sub-zero temperatures and environmental tests have been reported. In this communication, the results of tests on chargeability at sub-zero temperatures are presented.

It is very well-known that the performance of nickel-cadmium batteries is better maintained than that of other types of batteries at low temperatures. They will deliver power and accept charge at sub-zero temperatures down to the freezing point of electrolyte. The electrolyte concentration and its freezing point are almost completely unaffected by the state of charge or discharge. The special applications of these batteries include operations covering a very wide range of temperatures down to —40°C. The ability for these batteries to pick up charge at sub-zero temperatures is important when they are used as vehicular batteries which are charged by dynamos incorporated in the vehicles. This study has been made to determine the chargeability as well as the performance of these cells at various sub-zero temperatures.

EXPERIMENTAL

The experiments were carried out with 1.2V, 35 AH starter type cells. Two cells were taken as the representative samples from a batch of twenty cells. Though the cells were rated at 35 AH, their actual capacity output was around 40 AH. The capacity output at different temperatures during this investigation have therefore been calculated based on the original capacity so as to have a more realistic knowledge regarding the performance capabilities. The temperatures for the charge-discharge cycles were varied between room temperature and —40°C and for this purpose a cold temperature cabinet (Standard Cabinet Co.) was used. The cells were kept inside the cabinet and the temperature of the same was measured with Simpson temperature tester. The cells were charged at 5 hour rate of their rated capacity for 7 hours at every temperature and the performance test was carried out only after allowing the cells to attain and remain at the required temperature for at least one hour. After each test the cell was allowed to attain normal temperature before next charge or discharge was carried out. The necessary precautions such as careful maintenance of electrolyte level, concentration as well as clean contacts to avoid any IR drop in the circuit and busbar, were taken. Charging was carried out with a rectifier and discharge was also carried out at the same rate as charging. The individual cell voltages were measured during charging and discharging.

Charging studies were carried out at room temperature (28°C), 0°C, —10°C, —20°C, —30°C and —40°C and discharge at room temperature, 0°C, —20°C and —40°C.

RESULTS AND DISCUSSION

The results are presented in the form of graphs 1 to 8. Fig. 1 represents the charging curve at different temperatures and in this the

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cell voltage has been plotted against time of charging. At every temperature, the cells were charged at least four times for discharging at the four different temperatures mentioned above. It was found that the charging voltage slightly increased at the end of every test and the maximum and minimum are both shown in the figure. With decrease in temperature of charging, the cell voltage increases which may be due to increase in ohmic drop at low temperatures. Apart from this, the discharge at low temperature has also an influence on the charging voltage in the subsequent cycle as can be seen from the figure. In other words, the previous history of cell has not a marked influence on the subsequent charging voltage even though the cells have been brought to room temperature before charging at lower temperatures for the next cycle. This increase in over voltage for charging is perhaps related to the property of the active materials themselves, the passivation and grain size etc. However, this requires further work in this direction. At room temperature the charging curve shows a steady value between 1.38 and 1.42V till current equal to the rated capacity has been passed through the cell whereas at 0° and —10° the voltage rises after current equal to about 80% of rated capacity has been passed. At still lower temperatures —30° and —40° the cell voltage increases even in the initial stages of charging and for charging the current of about 80% of the rated capacity the voltage remains steady till the end of charging which perhaps represents more gas evolution than charging.

Fig. 2 to 7 represent the discharge curves at different temperatures after charging at different temperatures. Not much change could be observed upto —20°C and below this temperature the performance is found to be very much affected. Charging below —20°C was found to yield capacity only to an extent of 80% of the capacity. Further low temperature charging was found to have profound effect on low temperachere capacity of the cells. At —40°C after charging at the same temperature, the discharge voltage was found to fall steeply.

In Fig. 8 the percentage capacity output is plotted against different low temperatures of discharge. Each curve represents one charging temperature. As the temperature of charging decreases the capacity output also decreases. Upto a charging temperature of —20°C there is not much change in the capacity output. Generally it is observed that for charging at lower temperature than —10°C the cell is not capable of receiving the full capacity. But the capacity output curve indicates that by charging at 0°C a slightly higher capacity than at room temperature can be obtained. This may perhaps be due to the heating effect during charging, being very much eliminated at 0°C than at room temperature as it is well known that excessive heating affects the positive plates adversely.

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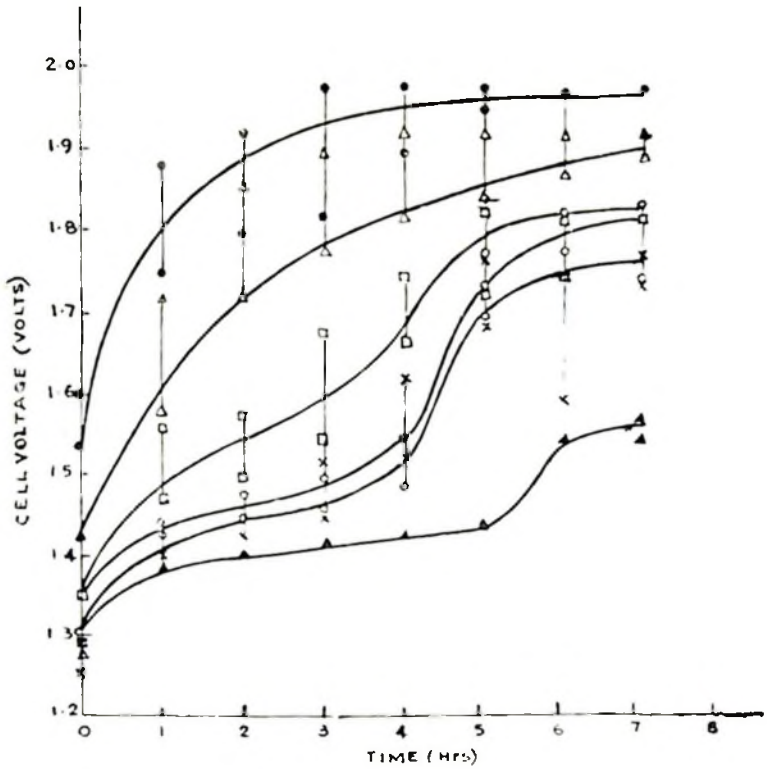


FIG.1.

EFFECT OF CHARGING TEMPERATURE ON VARIATION OF CELL VOLTAGE WITH TIME OF CHARGING

(Room Temperature) 28°C

0°C

−10°C

−20°C

−30°C

−40°C

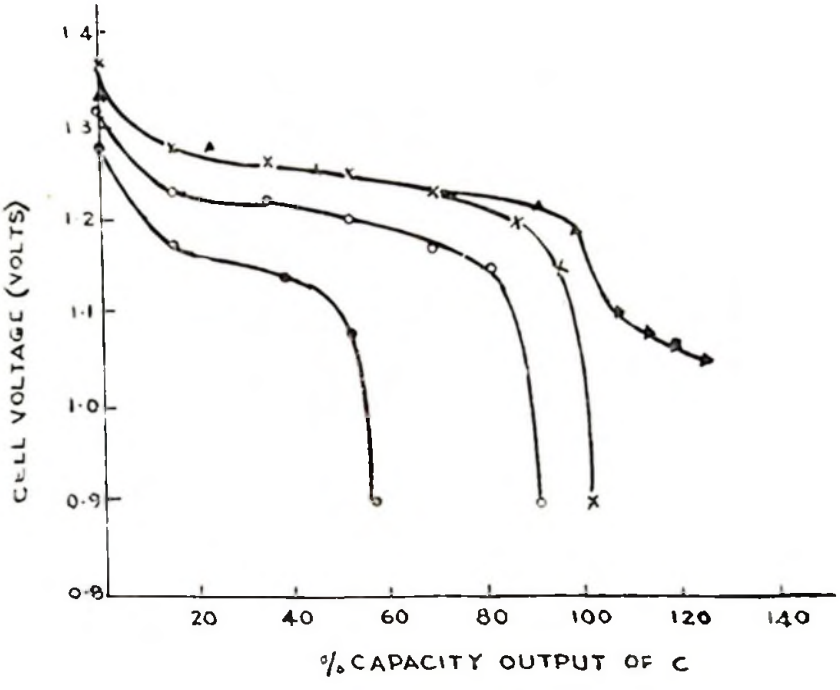


FIG. 2

DISCHARGE CURVES AT VARIOUS TEMPERATURES FOR CELLS CHARGED AT ROOM TEMPERATURE 28°C

C = Original Capacity at Room Temperature.

- Discharge at room temperature
- Discharge at 0°c
- Discharge at - 20°c
- Discharge at - 40°c

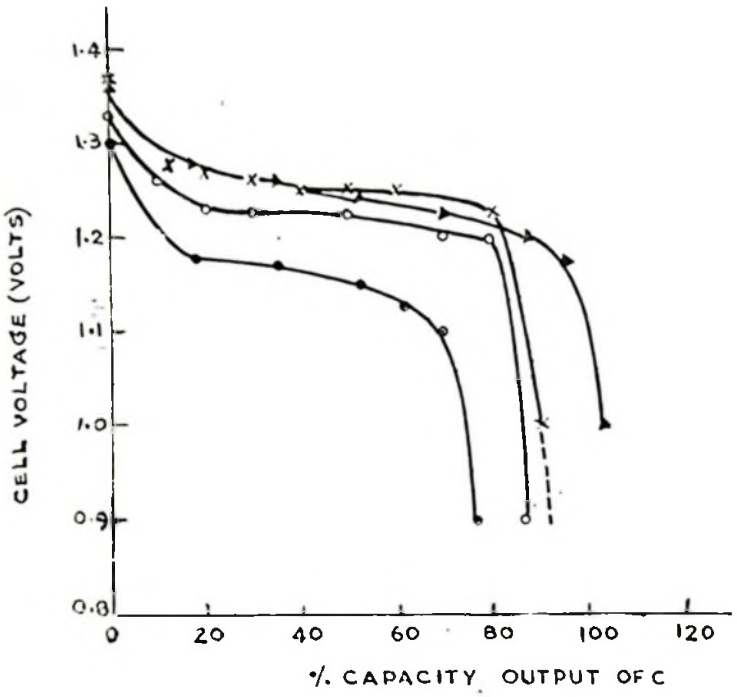


FIG.3

DISCHARGE CURVES AT VARIOUS TEMPERATURES FOR CELLS CHARGED AT 0°C

C = Original Capacity at Room Temperature

Discharge at room temperature

Discharge at 0°C

Discharge at -20°C

Discharge at -40°C

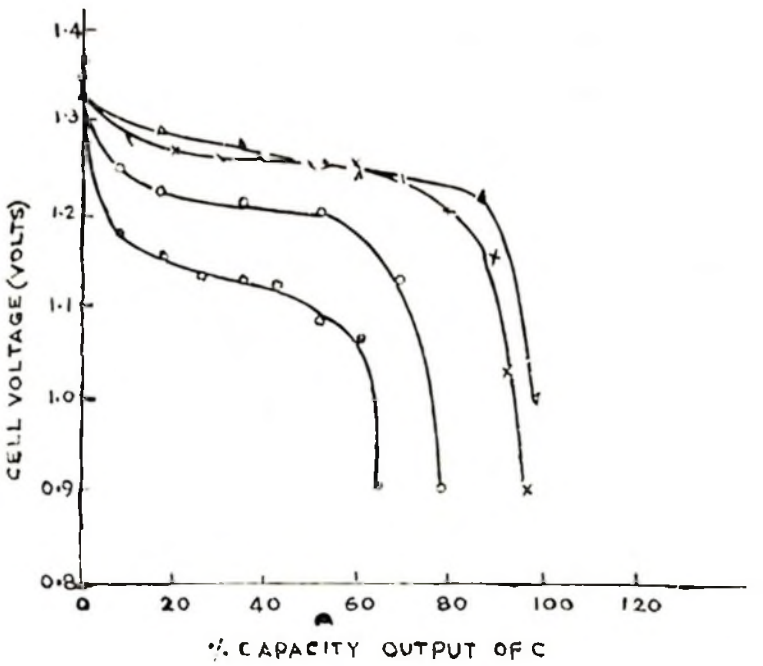


FIG. 4

DISCHARGE CURVES AT VARIOUS TEMPERATURES FOR CELLS CHARGED AT −10°C

C = Original Capacity at Room Temperature

Discharge at room temperature

Discharge at 0°C

Discharge at −20°C

Discharge at −40°C

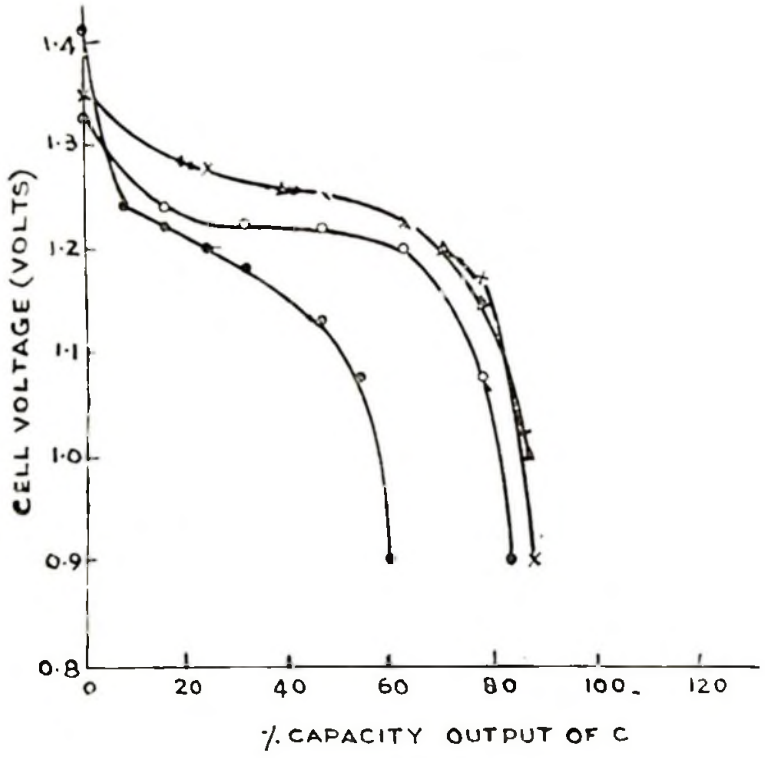


FIG. 5

DISCHARGE CURVES AT VARIOUS TEMPERATURES FOR CELLS CHARGED AT -20°C

C = Original Capacity at Room Temperature

Discharge at room temperature

Discharge at 0°C

Discharge at -20°C

Discharge at -40°C

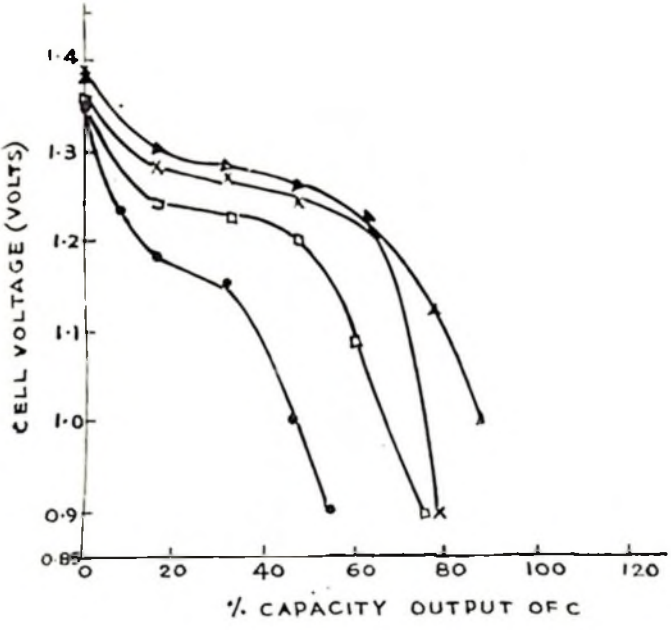


FIG. 6.

DISCHARGE CURVES AT VARIOUS TEMPERATURES FOR CELLS CHARGED AT −30°C

Discharge at room temperature

" " 0°C

" " −20°C

" " −40°C

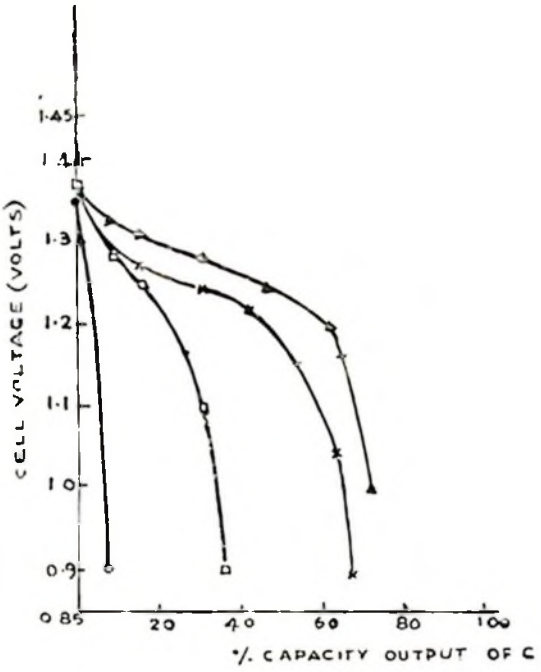


FIG. 7

DISCHARGE CURVES AT VARIOUS TEMPERATURES FOR CELLS CHARGED AT -40°C

C = original capacity at room temperature

Discharge at room temperature

Discharge at 0°C

Discharge at -20°C

Discharge at -40°C

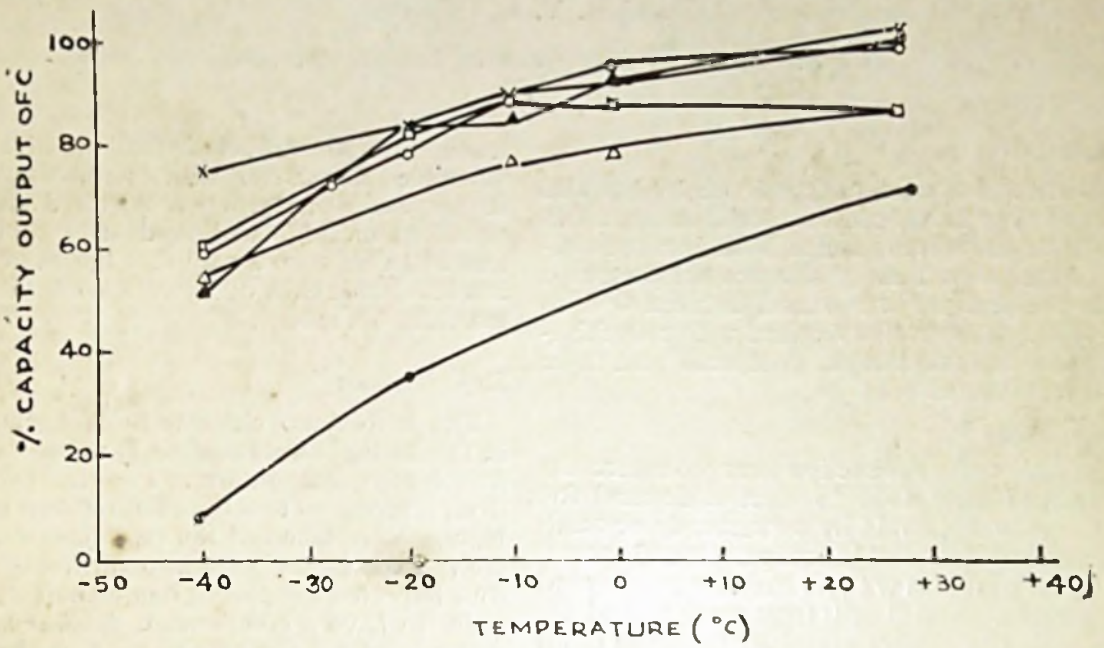


FIG. 8

EFFECT OF CHARGING TEMPERATURE ON THE CAPACITY OUTPUT AT DIFFERENT TEMPERATURES OF DISCHARGE.

▲—▲	28°C	o—o	−20°C
×—×	0°C	△—△	−30°C
□—□	−10°C	•—•	−40°C