Performance Characteristics of Different Types of Nickel-Cadmium Batteries *

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ABSTRACT

The performance characteristics of five types of nickel-cadmium alkaline cells belonging to the categories (1) pocket type, (2) sintered type and (3) button cells have been studied. The discharge characteristics of these cells at different rates, the influence of temperature on the performance at one hour rate of discharge and the charge receiving capacity at different rates were studied.

The results indicate that the sintered plate cells in addition to exhibiting good efficiencies at high rates of discharge, show superior performance at low temperatures. The charge receiving capacity of the sintered type cell is also superior to that of pocket type cell, especially at high rates of charging. Similary, button cells with sintered elements perform better than the ones with pocket type elements.

INTRODUCTION

It is well known that alkaline nickel-cadmium batteries are manufactured with (1) tubular type (2) pocket type and (3) sintered type plates. The cells are available in either semi-sealed or completely sealed (button cells) types. The semi-sealed types have limited vent for the gas escape during charging and the volume of electrolyte is fairly large to cover the plates. In the sealed type cells, the electrolyte is limited to just facilitate ionic conduction. The performance characteristics largely depend upon the type of construction, the sintered type construction being superior to others. The know-how of the fabrication of sintered type cells has been worked out earlier[1] in this Institute and the performance characteristics of a few cells made here are compared with the other types imported from foreign countries. The general characteristics of five type of cells belonging to the above categories have now been studied and the results are presented.

EXPERIMENTAL

Discharges studies—Rates : The types of cell studied, their capacities and dimensions along with the output per unit weight and per unit volume are given in Table 1. The cells were discharged at 10 hr rate, 5 hr rate, 1 hr rate and 0.33 hr rate. The discharge was also studied through a very small resistance of 0.02 ohm corresponding more or less to short circuit conditions. The cells were all charged at 10 hr rate for 14 hours, kept for one or two hours after charging and then discharged at the various rates mentioned above.

Temperature : The influence of temperature on discharge characteristics was studied at 0°, 10°, 30°, 45° and 60°C. The discharge was carried out at one hour rate after charging at 10 hr rate for 14 hours. The charging was carried out at the laboratory temperature. For higher temperature of 45° and 60°C, a thermostatically controlled hot air oven was used and for the temperatures of 0° and 10°C a frigidaire was used as the cold chamber. The temperatures for the above experiments were controlled within ± 1°C of the respective values. The electrolyte of the cell was maintained for at least 1 to 2 hours at the respective temperatures before starting the discharge.

Charging rate : The cells were charged at the following different rates : ½ hour rate, 1 hour rate, 5 hour rate and 10 hour rate and discharged at 1 hour rate in the same way as described above. The cells were charged at the different rates for a length of time equivalent to 140 per cent of its rated capacity.

End voltage : The end voltage for the discharge studies was fixed at 0.9 volts for all the rates of discharge, although for the lower rates, it is usually fixed at 1.0V. The difference in time to attain 1.0V or 0.9V during discharge was not much and to keep a uniform end voltage for

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TABLE I: Details of different types of cells studied

	Type of cells	Dimensions			Volume (cc)	Weight (g)	Capacity (amp-hr)	g/ (amp-hr)	cc/ (amp-hr)
		Length (cm)	Breadth (cm)	Height (cm)					
I.	Pocket type (Semisealed)	5	2.5	10	136	212	2.5	85.8	54.4
II.	Pocket type (Completely sealed) Button cell	4.30 (Diameter)		0.767 (Thickness)	11.15	29	0.450	65	25.0
III.	Sintered type Semisealed (CECRI)	2.3	2.3	14.2	76	426	2.5	170	30.4
IV.	Sintered type (Semisealed)	5.5	2.5	8.2	120.0	360	7.0	51.5	17.0
V.	Sintered type (Completely sealed) Button cell	2.50 (Diameter)		0.90 (Thickness)	8.66	27.5	0.500	55.0	17.3

the purpose of comparison, 0.9V was chosen. In the case of discharge through 0.02 ohm, the end voltage has been taken as 0.7V.

Ammeters and Voltmeters: Sangamo Weston standard ammeters of appropriate range were used for measuring current values and voltmeters with a sensitivity of 0.025V per division and with 1000 ohm/volt were used for measuring cell voltages. In most of the cases the charge and discharge curves were automatically recorded with a suitable voltage recorder.

RESULTS AND DISCUSSION

Discharge rates: The results of the discharge studies are graphically represented (Fig. 1). It can be noted that the performance of sintered plate cell is better than the other types and the sintered plate cell fabricated in this Institute compares fairly well with the same especially at the high discharge rates. It is also evident from the curves in Figs. 1 and 2 that the sintered type construction offers an advantage at high discharge rates of 1 hour, 0.33 hour and short circuited discharges. At other rates of discharge, both pocket type and sintered type give more or less the same type of discharge curves.

Temperature: The results of the effect of temperature on discharge capacity of the different types of cells are shown in Figs. 3 and 4. The pocket type cells show a uniform rise in their performance at higher temperatures whereas sintered plate cells show an initial rise and then a fall at higher temperatures. This might perhaps be due to the absorbed hydrogen and oxygen escaping quickly away at higher temperatures. The cell fabricated by the authors shows characteristics at different temperatures similar to those of an imported sintered plate cell. At low temperatures sintered plate cells show better performance characteristics than pocket type cells and the completely sealed button cells also give performance similar to the semisealed type cells of the respective categories.

Charging rate and charge receiving efficiency: The rate at which a battery can receive charge is an important factor because during emergency a battery should be capable of being charged to a useful capacity in as short a time as possible. The different types of cells were charged at $\frac{1}{2}$ hour rate, 1 hour rate, 5 hour rate and 10 hour rate and discharged at 1 hour rate in the same way as before. The voltage time curves for the different rates of charging and the capacity output at different rates of charging, taking rated capacity as 100 per cent, are shown in Fig. 5. It can be seen that the charging voltage goes up to a very high value at very high rates of charging. It is already known[2] that the voltages for charging pocket type cells are more than for sintered

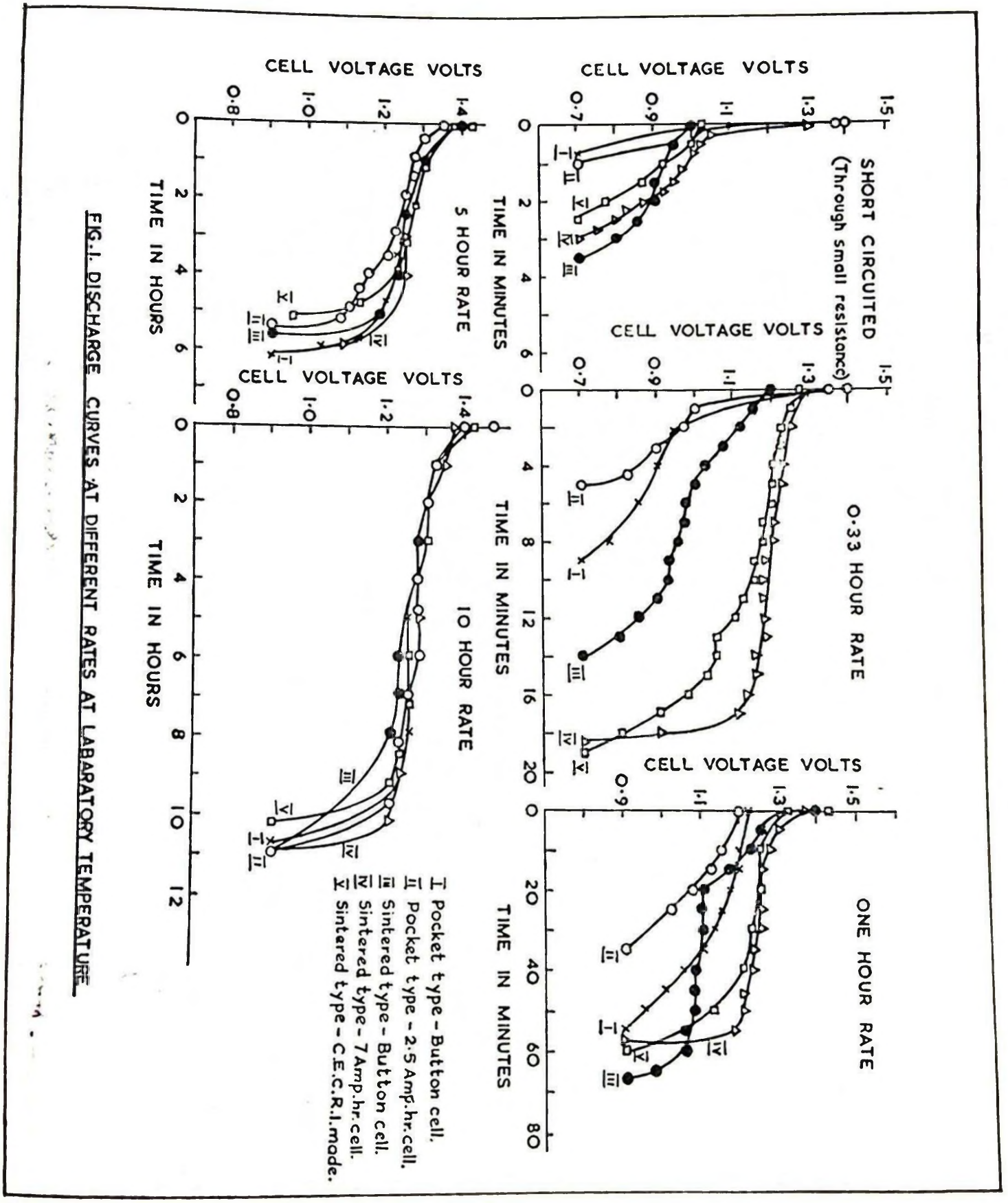


FIG.1. DISCHARGE CURVES AT DIFFERENT RATES AT LABARATORY TEMPERATURE

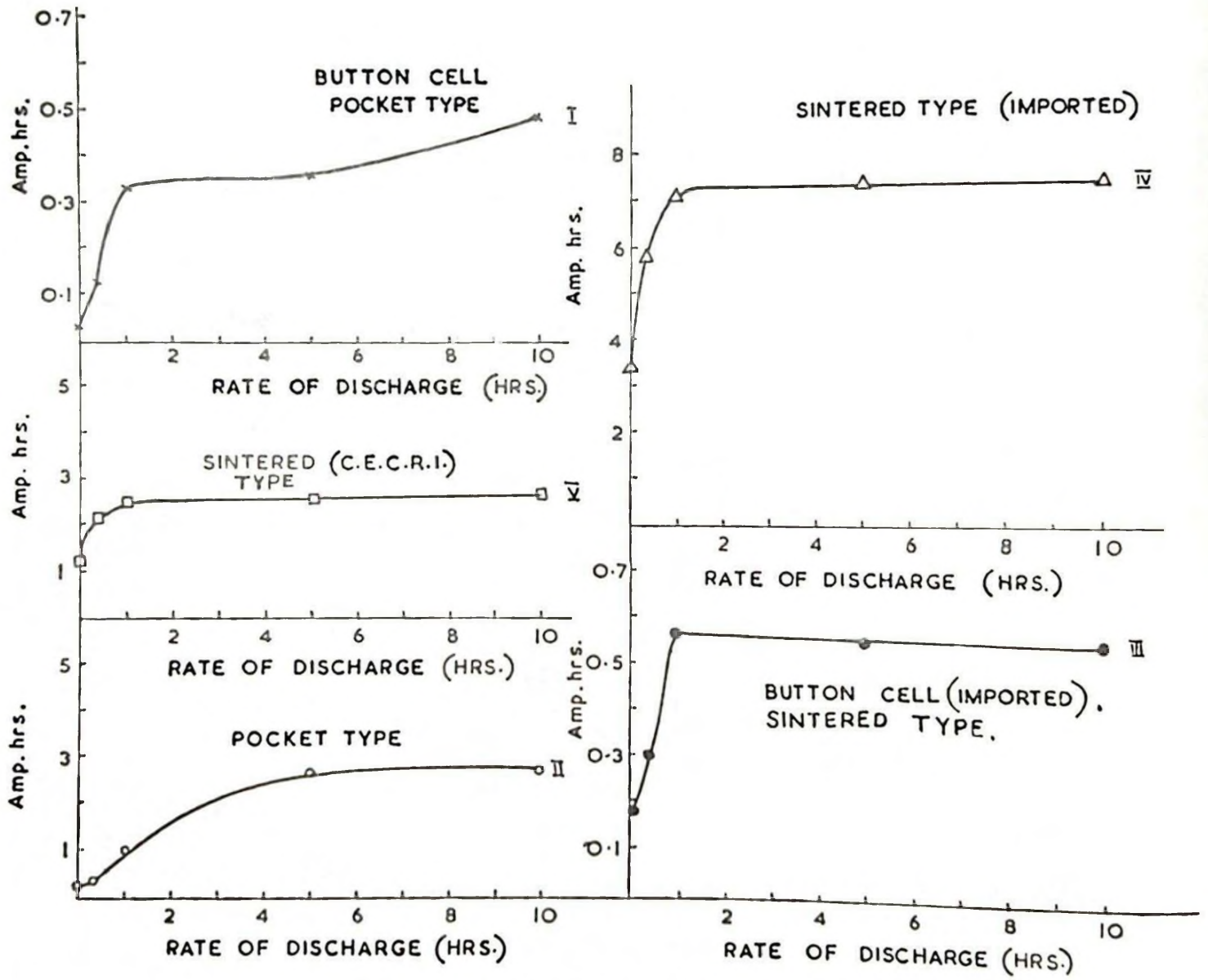


FIG. 2. AMP. HOUR OUTPUT AT VARIOUS RATES OF DISCHARGE

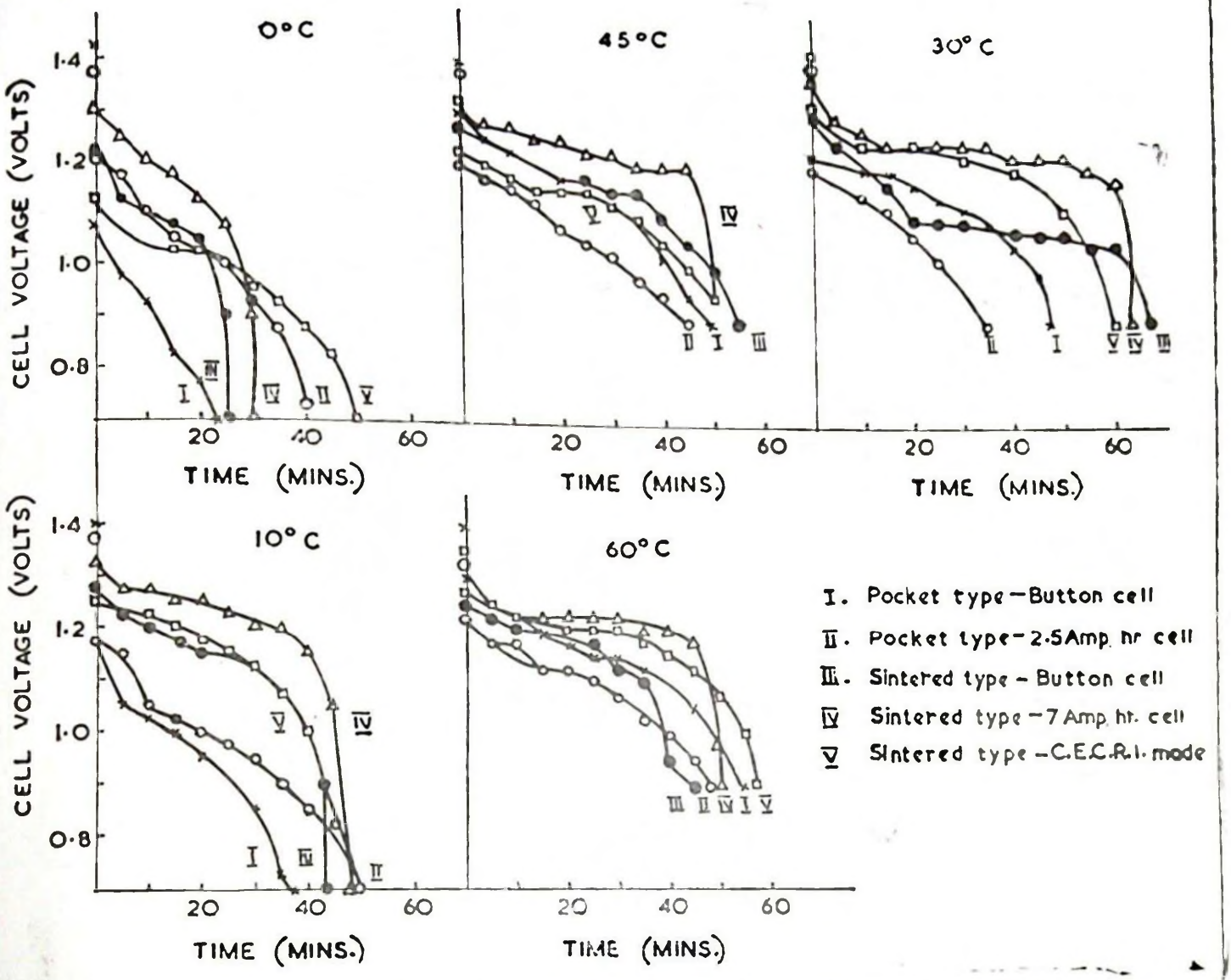


FIG.3. DISCHARGE CURVES AT ONE HOUR RATE AT DIFFERENT TEMPERATURES

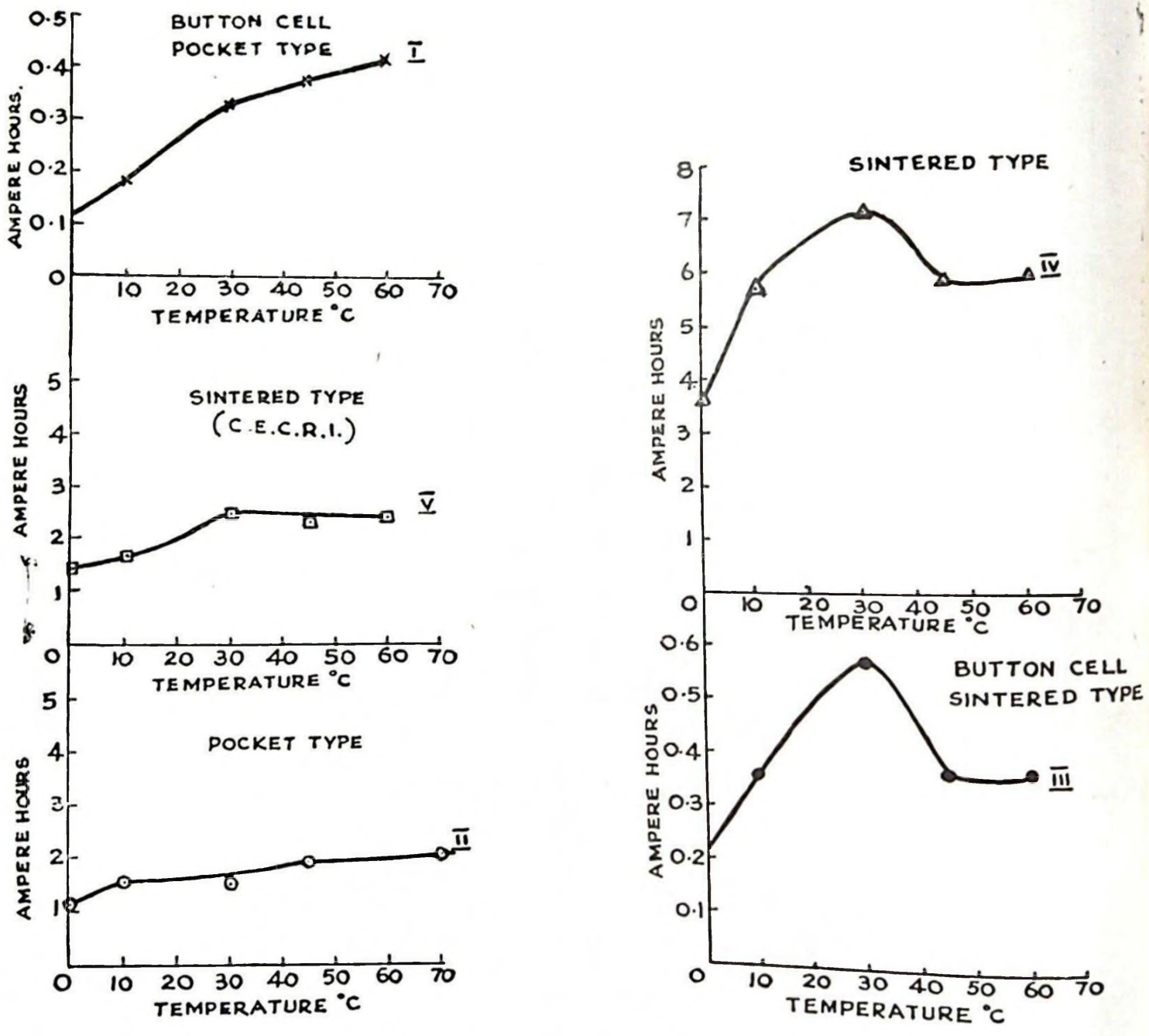


FIG. 4 AMPERE HOUR OUTPUT OF THE CELLS AT VARIOUS TEMPERATURES

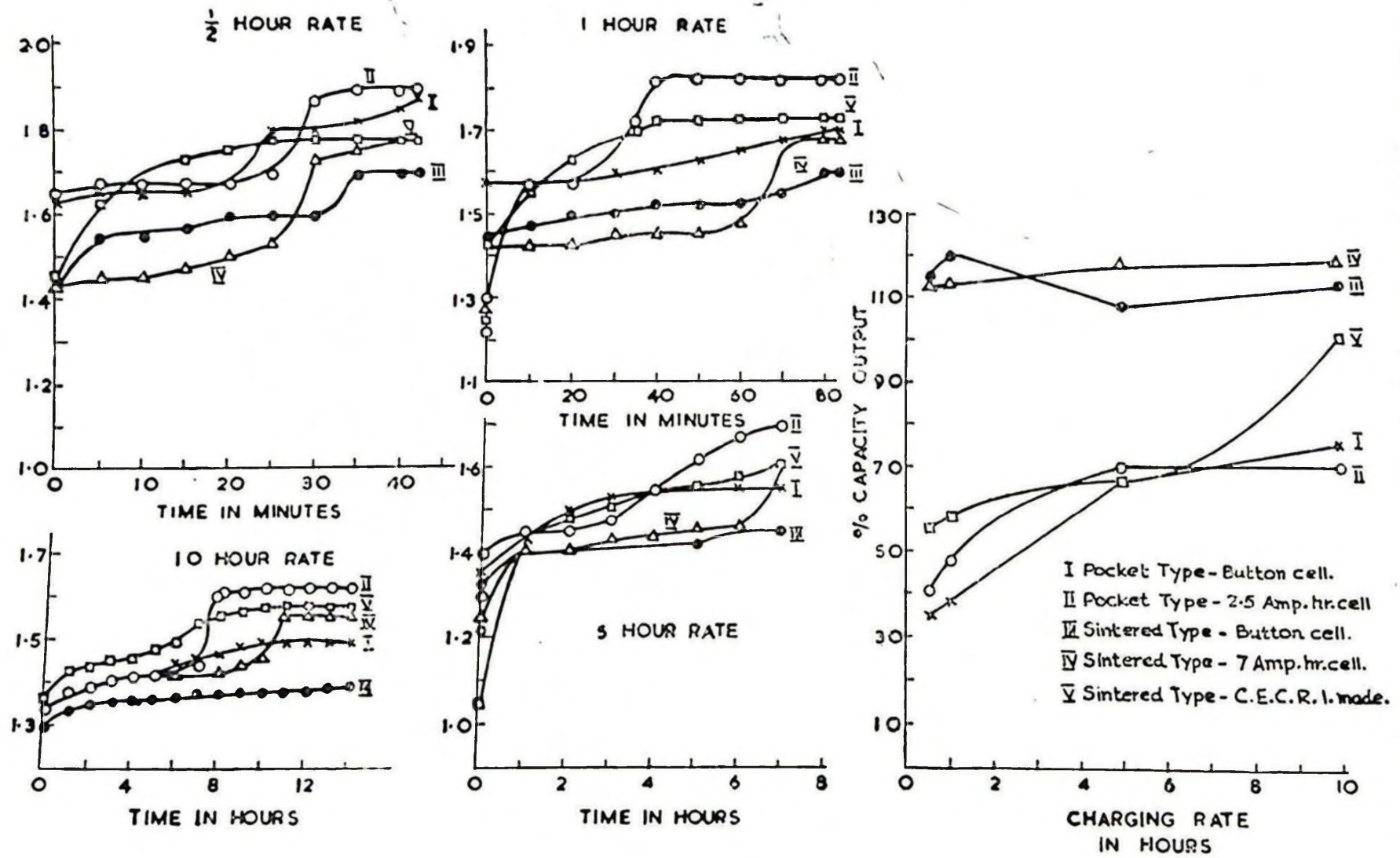


FIG. 5. VOLTAGE - TIME CURVE FOR CHARGING OF THE CELLS AT VARIOUS RATES

plate cells. The charging curves also indicate that there are two steps in the curves showing that after the electrode reaction in the charging direction nears completion, the secondary reaction of water decomposition becomes predominant. This characteristic is not shown by the button cells mainly due to limited availability of electrolyte at the electrodes and partly due to the gas evolution and the charging, proceeding simultaneously. The cell fabricated here however shows characteristics similar to that of button cells. The capacity given by the cells also indicate the extent of charge received by them at different rates. The sintered plate cell (imported) gives a capacity of 100 per cent or more of the rates capacity even at $\frac{1}{2}$ hour rate charging and a look at the charging curve at this rate shows that the secondary reaction begins only after the cell has received its full charge. The other cells show lower capacity due to the current being used up for the secondary reaction and not for charging the cell fully.

When the capacity obtained is more than 100 per cent, it is primarily due to the rated capacity being taken as equivalent to 100 per cent and due to the discharge being carried out after one or two hours of charging. It is well known[3] that an extra capacity is given due to the reaction proceeding as given below (i), if the discharge is carried out immediately on charging.

$$Ni\ O_2 \rightarrow \beta\text{-}Ni\ OOH \quad \ldots\ldots\ldots\ldots \quad (i)$$

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