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van Phuoc et al.

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[54] **BATTERY PACK HAVING A PROCESSOR CONTROLLED BATTERY OPERATING SYSTEM**

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[51] **Int. Cl.**[6] **H01M 10/44**; H02J 7/00

[52] **U.S. Cl.** **320/30**; 320/48

[58] **Field of Search** 320/5, 19, 20, 320/22, 30, 35, 48; 324/426; 361/96, 106; 364/483, 350, 550

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[57] **ABSTRACT**

A smart battery device which provides electrical power and which reports predefined battery parameters to an external device having a power management system, includes: at least one rechargeable cell connected to a pair of terminals to provide electrical power to an external device during a discharge mode and to receive electrical power during a charge mode, as provided or determined by the remote device; a data bus for reporting predefined battery identification and charge parameters to the external device; analog devices for generating analog signals representative of battery voltage and current at said terminals, and an analog signal representative of battery temperature at said cell; a hybrid integrated circuit (IC) having a microprocessor for receiving the analog signals and converting them to digital signals representative of battery voltage, current and temperature, and calculating actual charge parameters over time from the digital signals, the calculations including one calculation according to the following algorithm;

$$CAP_{rem}=CAP_{FC}-\Sigma I_d\Delta t_d-\Sigma I_s\Delta t+\Sigma\epsilon_c I_c\Delta t_c$$

wherein ϵ_c is a function of battery current and temperature; and I_s is a function of battery temperature and CAP_{FC}. Superimposed on this equation is reset logic, that self corrects the value of CAP_{FC} with a capacity calculation at each full charge (EOC) and each end of full discharge.

32 Claims, 31 Drawing Sheets

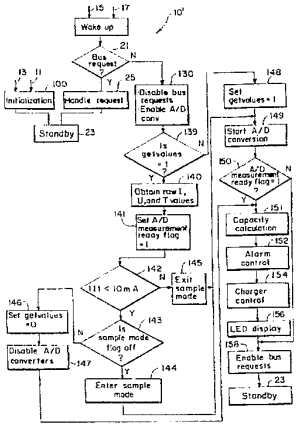

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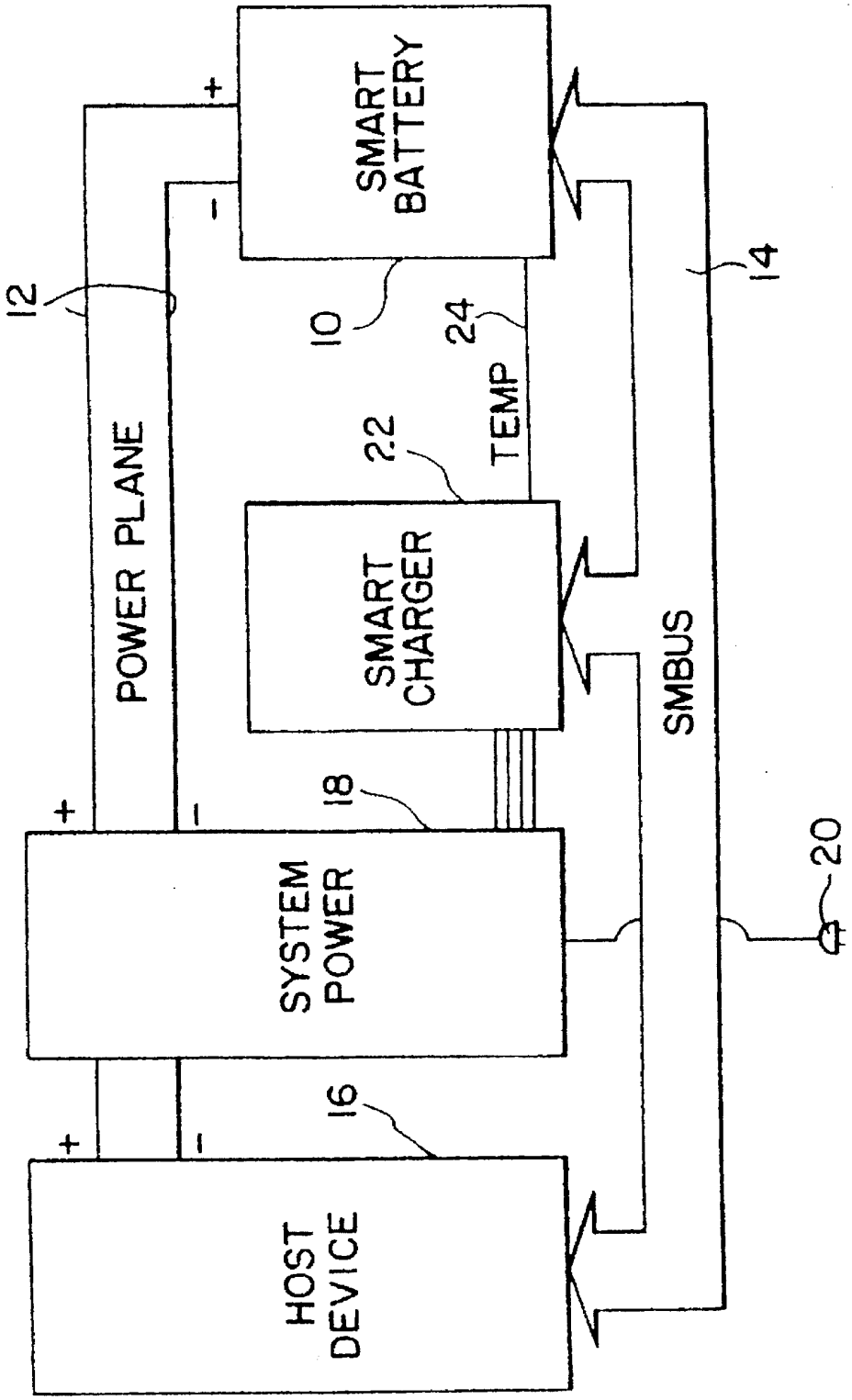
FIG.1



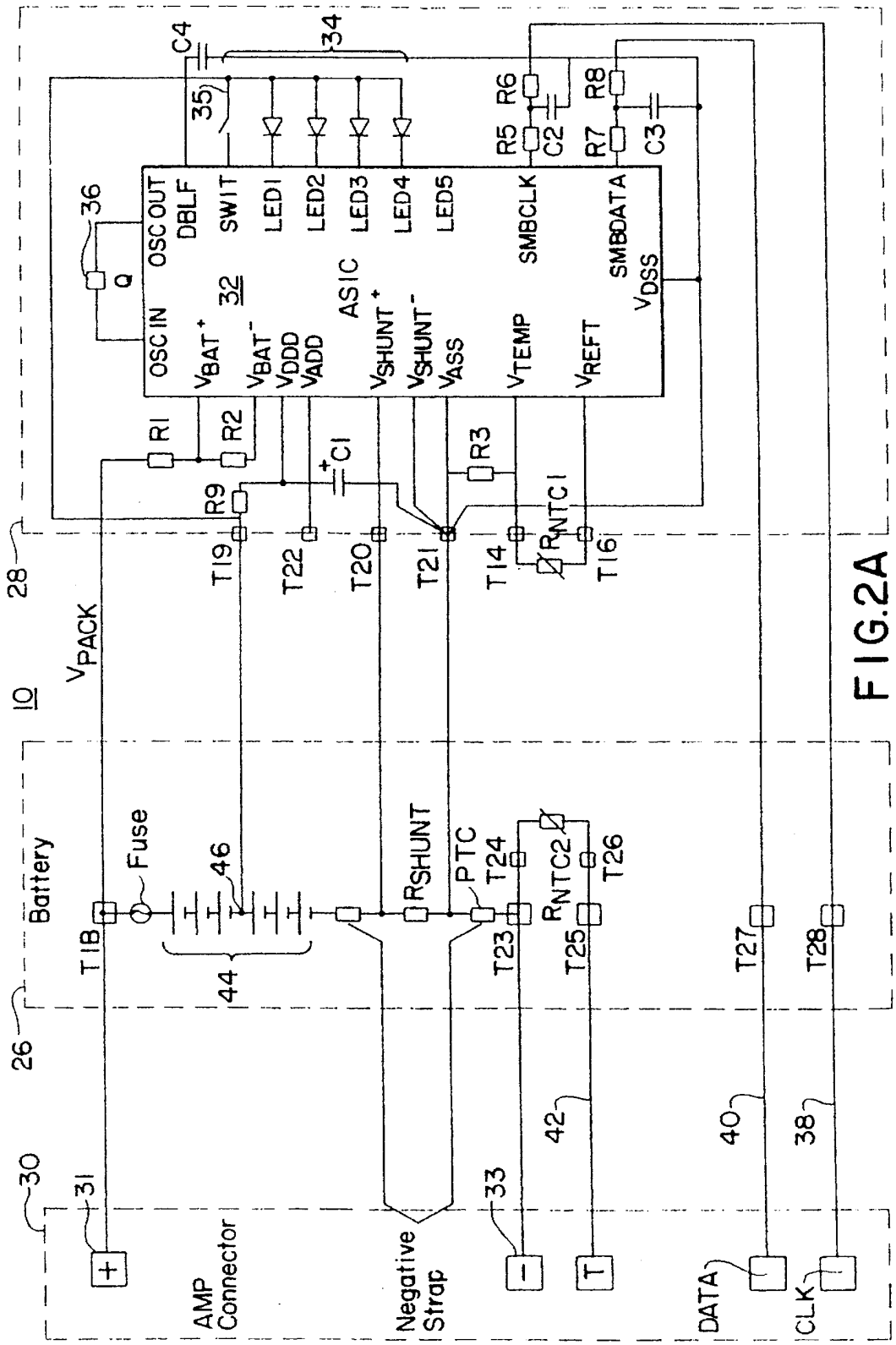
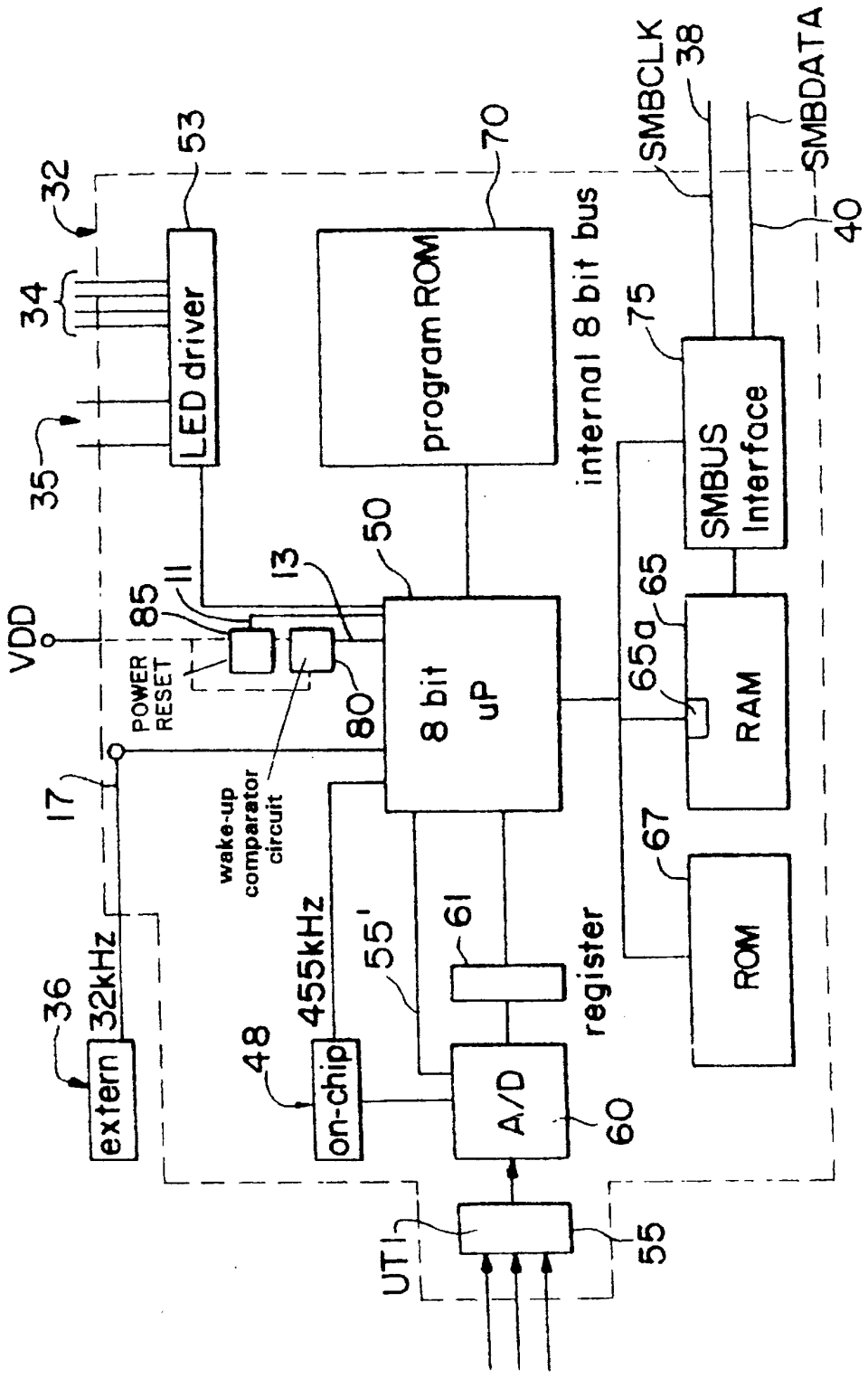


FIG.2A

FIG.2B



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