

[54] SMART BATTERY ALGORITHM FOR REPORTING BATTERY PARAMETERS TO AN EXTERNAL DEVICE

4,949,046 8/1990 Seyfang .
4,961,043 10/1990 Koencck .
4,965,738 10/1990 Bauer et al. .... 364/483

(List continued on next page.)

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OTHER PUBLICATIONS

M. Bullinger, "Quick Charging with Intelligence an IC Controls NiCd and NiHM Battery Chargers", Elektronik, vol. 42, No. 6, pp. 74-77 (1993).
P. Guerle, "Integrated Circuits for Rapid Chargers", Electronique Radio Plans, No. 543, pp. 57-64 (1993).

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[58] Field of Search ..... 320/5, 19, 20, 320/22, 30, 35, 48; 324/426; 365/96, 106

[57] ABSTRACT

A smart battery 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 - \sum I\_d \Delta t - \sum I\_s \Delta t + \sum \epsilon\_c I\_c \Delta t\_c

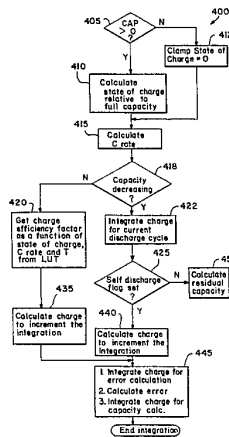
wherein \epsilon\_c is a function of battery current and temperature; and I\_s is a function of battery temperature and CAP\_FC. Superimposed on this equation is reset logic, that self corrects the value of CAP\_FC with a capacity calculation at each full charge (EOC) and each end of full discharge.

[56] References Cited

U.S. PATENT DOCUMENTS

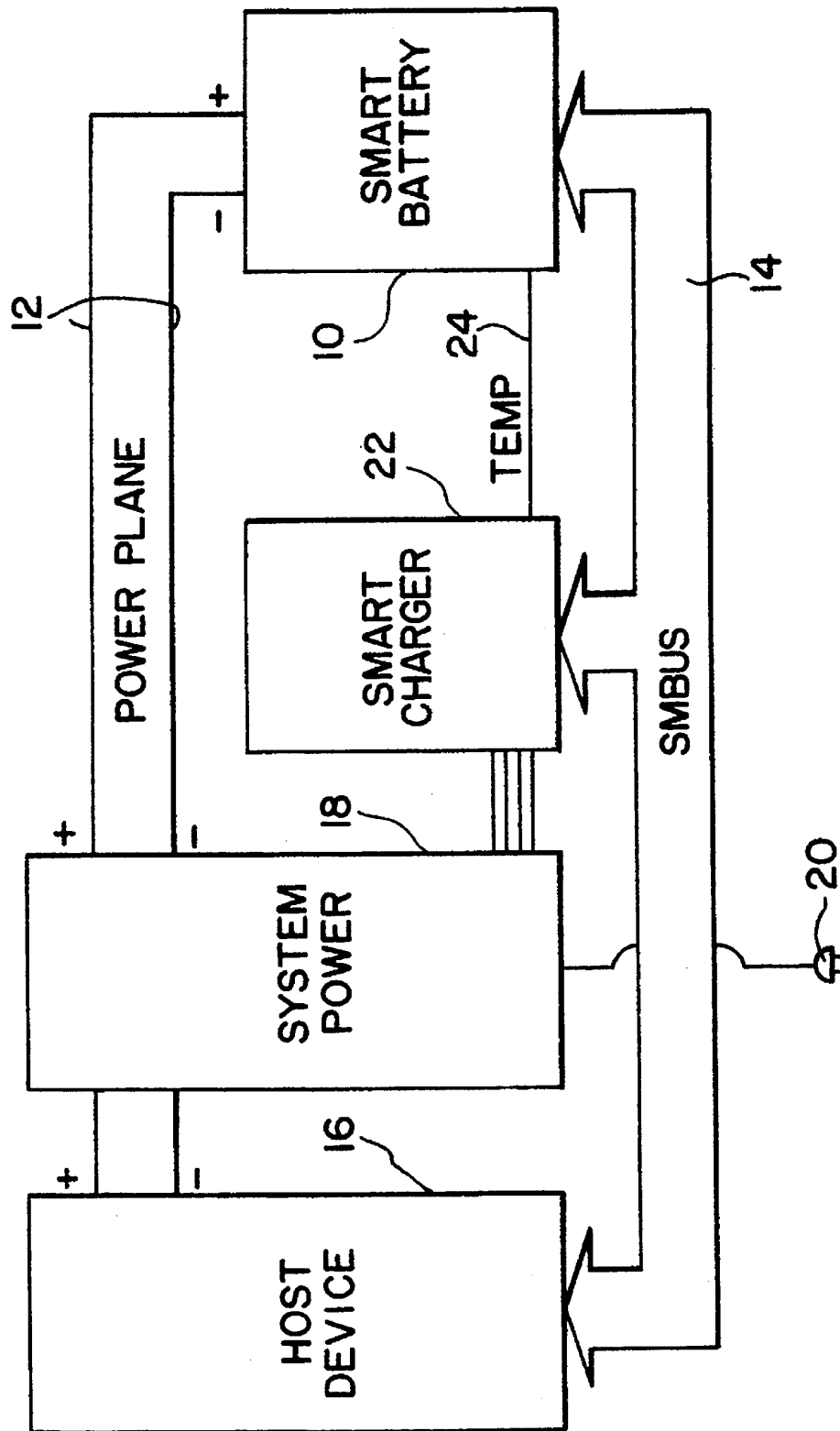
3,971,980 7/1976 Jungfer et al. .
4,238,839 12/1980 Redfern et al. .... 365/96
4,289,836 9/1981 Lemelson .
4,307,330 12/1981 Belot ..... 320/44
4,333,149 6/1982 Taylor et al. .... 364/481
4,377,787 3/1983 Kikuoka et al. .
4,387,334 6/1983 Loper ..... 320/44
4,390,841 6/1983 Martin et al. .
4,392,101 7/1983 Saar et al. .... 320/20
4,455,523 6/1984 Koencck ..... 320/43
4,583,034 4/1986 Martin .
4,595,880 6/1986 Patil .
4,677,363 6/1987 Kopmann .
4,709,202 11/1987 Koencck et al. .... 320/43
4,716,354 12/1987 Hacker ..... 320/39
4,724,528 2/1988 Eaton ..... 364/715
4,725,784 2/1988 Peled et al. .
4,737,702 4/1988 Koencck ..... 320/40
4,743,831 5/1988 Young .
4,746,854 5/1988 Baker et al. .... 320/20
4,803,416 2/1989 Abiven et al. .... 320/44
4,806,840 2/1989 Alexander ..... 320/20
4,885,523 12/1989 Koencck ..... 370/21
4,947,123 8/1990 Minezawa .

31 Claims, 32 Drawing Sheets



U.S. PATENT DOCUMENTS		
5,027,294	6/1991	Fakruddin et al. .
5,043,651	8/1991	Tamura ..... 320/43
5,047,961	9/1991	Simonsen .
5,130,659	7/1992	Sloan ..... 324/435
5,136,246	8/1992	Sakamoto ..... 324/435
5,151,644	9/1992	Pearson et al. .... 320/14
5,180,961	1/1993	Tsujino ..... 320/20
5,196,779	3/1993	Alexandres et al. .
5,200,689	4/1993	Interiano et al. .
5,206,097	4/1993	Burns ..... 429/90
5,216,371	6/1993	Nagai .
5,248,929	9/1993	Burke ..... 320/48
5,254,928	10/1993	Young et al. .
5,278,487	1/1994	Koenck ..... 320/21
5,284,719	2/1994	Landau et al. .
5,287,286	2/1994	Ninomiya et al. .
5,315,228	5/1994	Hess et al. .... 320/31
5,321,627	6/1994	Reher .
5,325,041	6/1994	Briggs .
5,341,084	8/1994	Gotoh et al. .
5,349,282	9/1994	McClure ..... 320/32
5,349,535	9/1994	Gupta ..... 364/483
5,381,350	1/1995	Fiorina et al. .... 364/550
5,459,671	10/1995	Duly ..... 364/483

FIG. 1



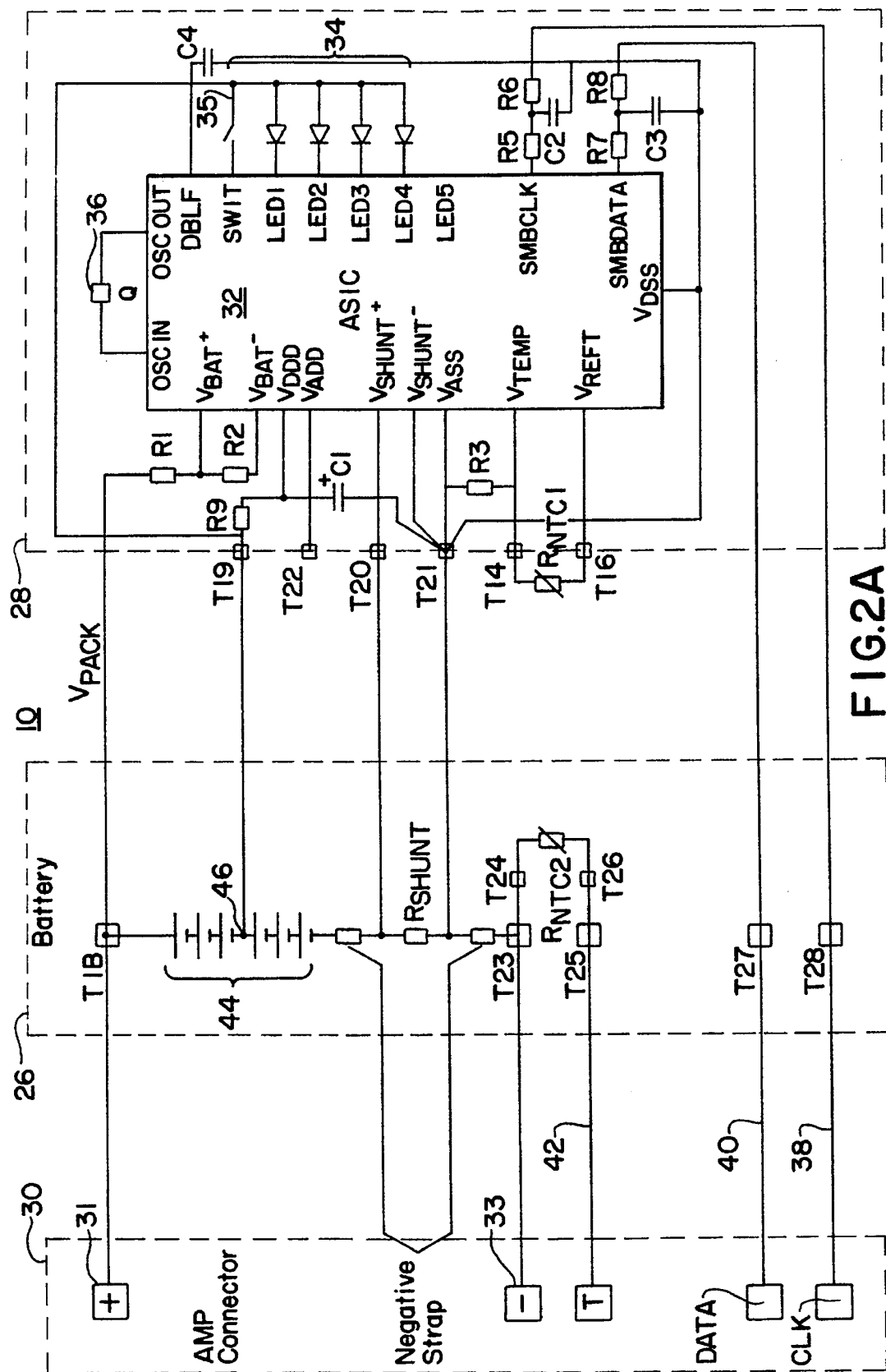
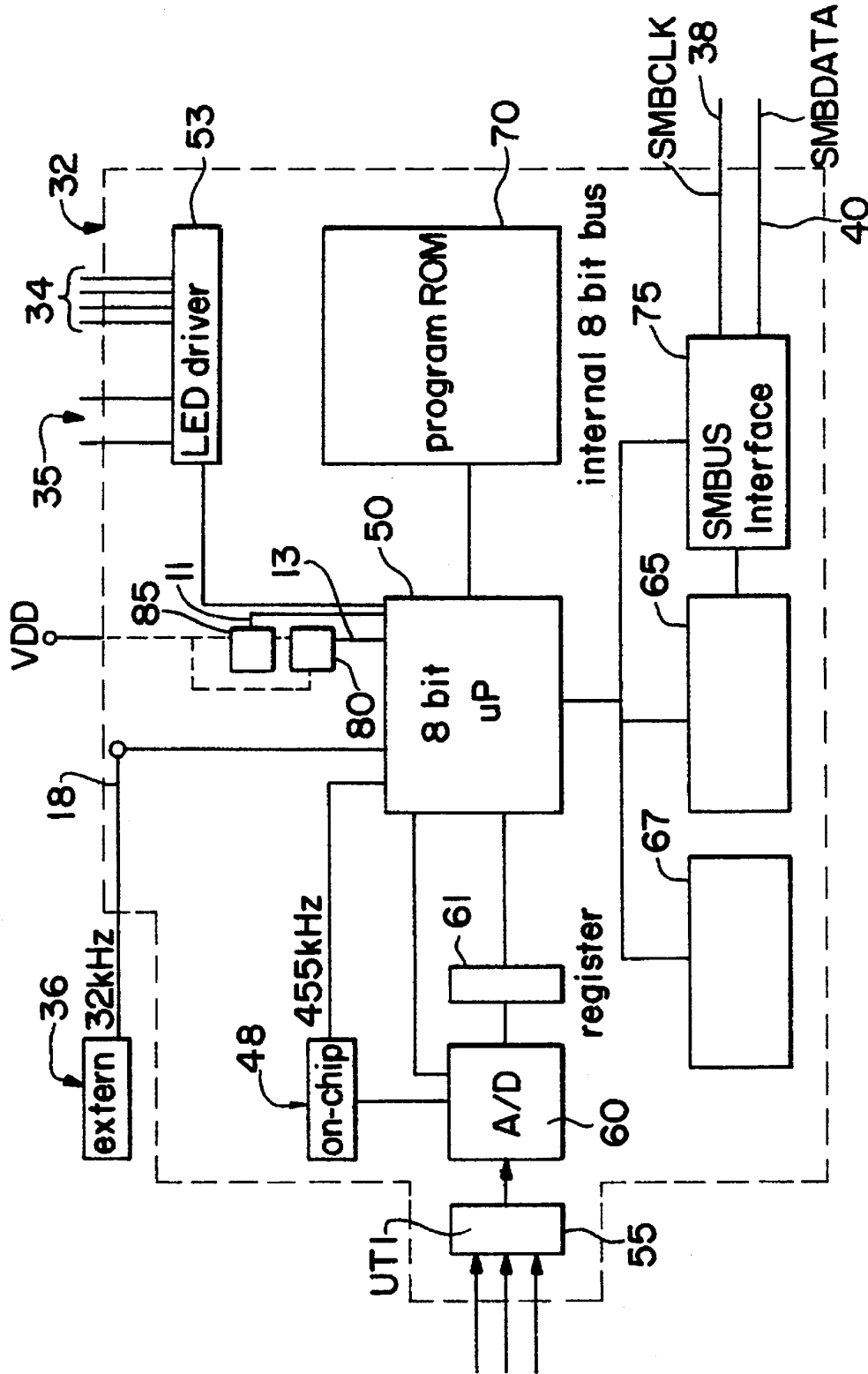


FIG. 2A

FIG. 2B



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