



US006057665A

United States Patent [19]
Herniter et al.

[11] **Patent Number:** **6,057,665**
[45] **Date of Patent:** **May 2, 2000**

- [54] **BATTERY CHARGER WITH MAXIMUM POWER TRACKING**
- [75] Inventors: **Marc E. Herniter; William J. Schlanger**, both of Flagstaff, Ariz.
- [73] Assignee: **Fire Wind & Rain Technologies LLC**, Flagstaff, Ariz.
- [21] Appl. No.: **09/156,228**
- [22] Filed: **Sep. 18, 1998**
- [51] **Int. Cl.⁷** **H01M 10/46**
- [52] **U.S. Cl.** **320/101; 323/906**
- [58] **Field of Search** 320/101, 123, 320/137, 139, 140, 143, 163, DIG. 28, DIG. 29; 136/242, 290, 291, 293; 323/299, 303, 906

5,077,652	12/1991	Faley	363/97
5,105,352	4/1992	Iwasa et al.	363/98
5,120,986	6/1992	Shekhawat	307/261
5,166,870	11/1992	Shimuzu et al.	363/41
5,229,929	7/1993	Shimuzu et al.	363/98
5,270,636	12/1993	Lafferty	320/61
5,309,345	5/1994	Nakamura et al.	363/41
5,327,071	7/1994	Frederick et al.	323/299
5,381,328	1/1995	Umezama et al.	363/41
5,400,237	3/1995	Flanagan et al.	363/41
5,442,538	8/1995	Ikeda et al.	363/95
5,563,776	10/1996	Eck	363/26
5,654,883	8/1997	Takehara et al.	363/79
5,668,713	9/1997	Eguchi et al.	363/95
5,680,302	10/1997	Iwata et al.	363/132

- [56] **References Cited**
- U.S. PATENT DOCUMENTS**
- 3,350,635 10/1967 Mesch 324/29.5
- 3,384,806 5/1968 Hartman 322/2
- 3,696,286 10/1972 Ule 323/15
- 3,825,816 7/1974 Togneri et al. 321/18
- 4,200,833 4/1980 Wilkerson 323/20
- 4,375,662 3/1983 Baker 363/95
- 4,390,940 6/1983 Corbefin et al. 363/132
- 4,404,472 9/1983 Steigerwald 307/46
- 4,604,567 8/1986 Chetty 323/299
- 4,679,130 7/1987 Moscovici 363/17
- 4,692,855 9/1987 Kuroiwa et al. 363/95
- 4,873,480 10/1989 Lafferty 323/229
- 4,924,323 5/1990 Inaba et al. 363/95
- 5,027,051 6/1991 Lafferty 323/222

Primary Examiner—Edward H. Tso
Attorney, Agent, or Firm—Cabill, Sutton & Thomas P.L.C.

[57] **ABSTRACT**

Apparatus and attendant methodology for extracting maximum power from an energy source, such as a photo voltaic panel, an array of photo voltaic panels, or a windmill and delivering that power to a battery or an array of batteries is disclosed. The apparatus determines the maximum operating point of the energy source, and circuits and circuit topologies are presented for extracting the energy. The apparatus eliminates the problem of finding local maximum points, and problems attendant variations of the absolute maximum power point as a function of temperature, insolation, array construction, and photo voltaic panel manufacturing tolerances. The energy source supplies power in the form of a voltage and charges the batteries with a controllable current source.

31 Claims, 17 Drawing Sheets

