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(54) **ELECTRONIC BATTERY TESTER WITH VEHICLE TYPE INPUT**

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G01N 27/416 (2006.01)

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(58) **Field of Classification Search** ..... 320/104, 320/132, 110, DIG. 19, DIG. 21; 324/426, 324/430, 433

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,000,665 A 5/1935 Neal 439/440

(Continued)

FOREIGN PATENT DOCUMENTS

DE 29 26 716 B1 1/1981

(Continued)

OTHER PUBLICATIONS

"Electrochemical Impedance Spectroscopy in Battery Development and Testing", *Batteries International*, Apr. 1997, pp. 59 and 62-63.

(Continued)

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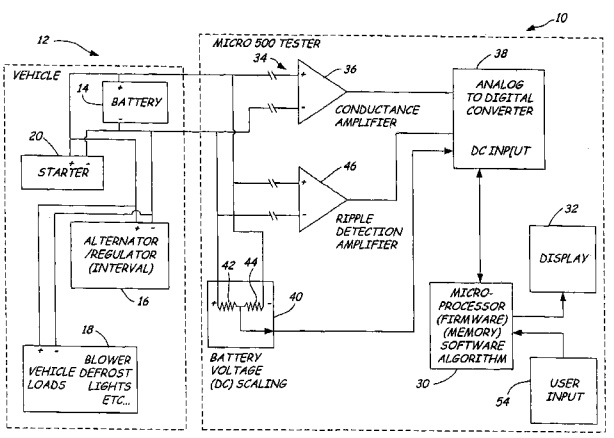
(57) **ABSTRACT**

An electronic battery tester for testing a storage battery includes test circuitry configured to provide an output based upon a selected test criteria. Additionally, circuitry is provided to assist in balancing batteries used in a string of multiple batteries.

99 Claims, 3 Drawing Sheets



U.S. PATENT DOCUMENTS

2,417,940	A	3/1947	Lehman	200/61.25
2,514,745	A	7/1950	Dalzell	324/115
2,727,221	A	12/1955	Springg	340/447
3,178,686	A	4/1965	Mills	340/447
3,223,969	A	12/1965	Alexander	340/447
3,267,452	A	8/1966	Wolf	340/249
3,356,936	A	12/1967	Smith	324/429
3,562,634	A	2/1971	Latner	324/427
3,593,099	A	7/1971	Scholl	320/127
3,607,673	A	9/1971	Seyl	324/425
3,652,341	A	3/1972	Halsall et al.	20/623.2
3,676,770	A	7/1972	Sharaf et al.	324/430
3,729,989	A	5/1973	Little	73/862.192
3,750,011	A	7/1973	Kreps	324/430
3,753,094	A	8/1973	Furuishi et al.	324/430
3,796,124	A	3/1974	Crosa	411/521
3,808,522	A	4/1974	Sharaf	324/430
3,811,089	A	5/1974	Strezelewicz	324/170
3,816,805	A	6/1974	Terry	320/123
3,850,490	A	11/1974	Zehr	439/822
3,873,911	A	3/1975	Champlin	324/430
3,876,931	A	4/1975	Godshalk	324/429
3,886,426	A	5/1975	Daggett	320/117
3,886,443	A	5/1975	Miyakawa et al.	324/426
3,889,248	A	6/1975	Ritter	340/636
3,906,329	A	9/1975	Bader	320/134
3,909,708	A	9/1975	Champlin	324/431
3,936,744	A	2/1976	Perlmutter	324/772
3,946,299	A	3/1976	Christianson et al.	320/430
3,947,757	A	3/1976	Grube et al.	324/416
3,969,667	A	7/1976	McWilliams	324/427
3,979,664	A	9/1976	Harris	324/397
3,984,762	A	10/1976	Dowgiallo, Jr.	324/430
3,984,768	A	10/1976	Staples	324/712
3,989,544	A	11/1976	Santo	429/65
4,008,619	A	2/1977	Alcaide et al.	73/724
4,023,882	A	5/1977	Pettersson	439/426
4,024,953	A	5/1977	Nailor, III	206/344
4,047,091	A	9/1977	Hutchines et al.	363/59
4,053,824	A	10/1977	Dupuis et al.	324/434
4,056,764	A	11/1977	Endo et al.	320/101
4,057,313	A	11/1977	Polizzano	439/219
4,070,624	A	1/1978	Taylor	324/772
4,086,531	A	4/1978	Bernier	324/772
4,106,025	A	8/1978	Katz	343/715
4,112,351	A	9/1978	Back et al.	324/380
4,114,083	A	9/1978	Benham et al.	320/150
4,126,874	A	11/1978	Suzuki et al.	396/301
4,160,916	A	7/1979	Papasideris	307/10.6
4,178,546	A	12/1979	Hulls et al.	324/772
4,193,025	A	3/1980	Frailing et al.	324/427
4,207,611	A	6/1980	Gordon	324/503
4,217,645	A	8/1980	Barry et al.	702/63
4,280,457	A	7/1981	Bloxham	123/198
4,297,639	A	10/1981	Branham	324/429
4,315,204	A	2/1982	Sievers et al.	322/28
4,316,185	A	2/1982	Watrous et al.	320/116
4,322,685	A	3/1982	Frailing et al.	324/429
4,351,405	A	9/1982	Fields et al.	180/65.2
4,352,067	A	9/1982	Ottone	324/434
4,360,780	A	11/1982	Skutch, Jr.	324/437
4,361,809	A	11/1982	Bil et al.	324/426
4,363,407	A	12/1982	Buckler et al.	209/3.3
4,369,407	A	1/1983	Korbell	324/416
4,379,989	A	4/1983	Kurz et al.	320/165
4,379,990	A	4/1983	Sievers et al.	322/99
4,385,269	A	5/1983	Aspinwall et al.	320/129
4,390,828	A	6/1983	Converse et al.	320/153
4,392,101	A	7/1983	Saar et al.	320/156
4,396,880	A	8/1983	Windebank	320/156
4,408,157	A	10/1983	Beaubien	324/712
4,412,169	A	10/1983	Dell 'Orto	320/123
4,423,378	A	12/1983	Marino et al.	324/427
4,423,379	A	12/1983	Jacobs et al.	324/429
4,424,491	A	1/1984	Bobbett et al.	324/433
4,459,548	A	7/1984	Lentz et al.	324/772
4,514,694	A	4/1985	Finger	324/429
4,520,353	A	5/1985	McAuliffe	340/636
4,521,498	A	6/1985	Juergens	429/59
4,564,798	A	1/1986	Young	320/103
4,620,767	A	11/1986	Woolf	439/217
4,633,418	A	12/1986	Bishop	702/63
4,637,359	A	1/1987	Cook	123/179
4,659,977	A	4/1987	Kissel et al.	320/150
4,663,580	A	5/1987	Wortman	320/153
4,665,370	A	5/1987	Holland	324/429
4,667,143	A	5/1987	Cooper et al.	320/153
4,667,279	A	5/1987	Maier	363/46
4,678,998	A	7/1987	Muramatsu	324/427
4,679,000	A	7/1987	Clark	324/428
4,680,528	A	7/1987	Mikami et al.	320/165
4,686,442	A	8/1987	Radomski	320/123
4,697,134	A	9/1987	Burkum et al.	320/134
4,707,795	A	11/1987	Alber et al.	702/63
4,709,202	A	11/1987	Koenck et al.	320/112
4,710,861	A	12/1987	Kanner	363/46
4,719,428	A	1/1988	Liebermann	324/436
4,723,656	A	2/1988	Kiernan et al.	206/705
4,743,855	A	5/1988	Randin et al.	324/430
4,745,349	A	5/1988	Palanisamy et al.	320/125
4,773,011	A	9/1988	VanHoose	701/30
4,781,629	A	11/1988	Mize	439/822
4,816,768	A	3/1989	Champlin	324/428
4,820,966	A	4/1989	Fridman	320/116
4,825,170	A	4/1989	Champlin	324/436
4,847,547	A	7/1989	Eng, Jr. et al.	320/153
4,849,700	A	7/1989	Morioka et al.	324/427
4,874,679	A	10/1989	Miyagawa	429/91
4,876,495	A	10/1989	Palanisamy et al.	320/106
4,881,038	A	11/1989	Champlin	324/426
4,888,716	A	12/1989	Ueno	702/63
4,901,007	A	2/1990	Sworm	324/110
4,907,176	A	3/1990	Bahnick et al.	364/551.01
4,912,416	A	3/1990	Champlin	324/430
4,913,116	A	4/1990	Katogi et al.	123/406.32
4,926,330	A	5/1990	Abe et al.	364/424.03
4,929,931	A	5/1990	McCuen	340/636
4,931,738	A	6/1990	MacIntyre et al.	324/435
4,932,905	A	6/1990	Richards	439/822
4,933,845	A	6/1990	Hayes	710/104
4,934,957	A	6/1990	Bellusci	439/504
4,937,528	A	6/1990	Palanisamy	324/430
4,947,124	A	8/1990	Hauser	324/430
4,949,046	A	8/1990	Seyfang	324/427
4,956,597	A	9/1990	Heavey et al.	320/129
4,968,941	A	11/1990	Rogers	324/428
4,968,942	A	11/1990	Palanisamy	324/430
4,969,834	A	11/1990	Johnson	439/141
4,983,086	A	1/1991	Hatrock	411/259
5,004,979	A	4/1991	Marino et al.	324/160
5,032,825	A	7/1991	Xuznicki	340/636
5,034,893	A	7/1991	Fisher	701/99
5,037,778	A	8/1991	Stark et al.	437/216
5,047,722	A	9/1991	Wurst et al.	324/430
5,081,565	A	1/1992	Nabha et al.	362/465
5,087,881	A	2/1992	Peacock	324/378
5,095,223	A	3/1992	Thomas	307/110
5,108,320	A	4/1992	Kimber	439/883
5,109,213	A	4/1992	Williams	340/447
5,126,675	A	6/1992	Yang	324/435
5,130,658	A	7/1992	Bohmer	324/435
5,140,269	A	8/1992	Champlin	324/433
5,144,218	A	9/1992	Bosscha	320/139
5,144,248	A	9/1992	Alexandres et al.	324/428

5,159,272	A	10/1992	Rao et al.	324/429	5,572,136	A	11/1996	Champlin	324/426
5,160,881	A	11/1992	Schramm et al.	322/7	5,573,611	A	11/1996	Koch et al.	152/152.1
5,168,208	A	12/1992	Schultz et al.	322/25	5,574,355	A	11/1996	McShane et al.	320/161
5,170,124	A	12/1992	Blair et al.	324/434	5,578,915	A	11/1996	Crouch, Jr. et al.	324/428
5,179,335	A	1/1993	Nor	320/159	5,583,416	A	12/1996	Klang	320/160
5,194,799	A	3/1993	Tomantschger	320/103	5,585,416	A	12/1996	Audett et al.	522/35
5,204,611	A	4/1993	Nor et al.	320/145	5,585,728	A	12/1996	Champlin	324/427
5,214,370	A	5/1993	Harm et al.	320/152	5,589,757	A	12/1996	Klang	320/160
5,214,385	A	5/1993	Gabriel et al.	324/434	5,592,093	A	1/1997	Klingbiel	324/426
5,241,275	A	8/1993	Fang	324/430	5,592,094	A	1/1997	Ichikawa	324/427
5,254,952	A	10/1993	Salley et al.	324/429	5,596,260	A	1/1997	Moravec et al.	320/135
5,266,880	A	11/1993	Newland	320/125	5,598,098	A	1/1997	Champlin	324/430
5,281,919	A	1/1994	Palanisamy	324/427	5,602,462	A	2/1997	Stich et al.	323/258
5,281,920	A	1/1994	Wurst	324/430	5,606,242	A	2/1997	Hull et al.	320/106
5,295,078	A	3/1994	Stich et al.	320/136	5,614,788	A	3/1997	Mullins et al.	315/82
5,298,797	A	3/1994	Redl	327/387	5,621,298	A	4/1997	Harvey	320/134
5,300,874	A	4/1994	Shimamoto et al.	320/106	5,633,985	A	5/1997	Severson et al.	704/267
5,302,902	A	4/1994	Groehl	324/434	5,637,978	A	6/1997	Kellett et al.	320/104
5,313,152	A	5/1994	Wozniak et al.	320/118	5,642,031	A	6/1997	Brotto	320/152
5,315,287	A	5/1994	Sol	340/455	5,650,937	A	7/1997	Bounaga	702/6
5,321,626	A	6/1994	Palladino	702/63	5,652,501	A	7/1997	McClure et al.	320/118
5,321,627	A	6/1994	Reher	364/483	5,653,659	A	8/1997	Kunibe et al.	477/111
5,323,337	A	6/1994	Wilson et al.	364/574	5,654,623	A	8/1997	Shiga et al.	320/106
5,325,041	A	6/1994	Briggs	320/149	5,656,920	A	8/1997	Cherng et al.	320/161
5,331,268	A	7/1994	Patino et al.	320/158	5,661,368	A	8/1997	Deol et al.	315/82
5,332,927	A	7/1994	Paul et al.	307/66	5,675,234	A	10/1997	Greene	320/DIG. 18
5,336,993	A	8/1994	Thomas et al.	324/158.1	5,677,077	A	10/1997	Faulk	429/90
5,338,515	A	8/1994	Dalla Betta et al.	422/95	5,684,678	A	11/1997	Barrett	363/17
5,339,018	A	8/1994	Brokaw	320/147	5,699,050	A	12/1997	Kanazawa	340/636
5,343,380	A	8/1994	Champlin	363/46	5,701,089	A	12/1997	Perkins	324/772
5,347,163	A	9/1994	Yoshimura	307/66	5,705,929	A	1/1998	Caravello et al.	324/430
5,352,968	A	10/1994	Reni et al.	320/136	5,707,015	A	1/1998	Guthrie	241/120
5,357,519	A	10/1994	Martin et al.	371/15.1	5,710,503	A	1/1998	Sideris et al.	320/116
5,365,160	A	11/1994	Leppo et al.	320/160	5,711,648	A	1/1998	Hammerslag	414/800
5,365,453	A	11/1994	Startup et al.	320/136	5,717,336	A	2/1998	Basell et al.	324/430
5,369,364	A	11/1994	Renirie et al.	324/430	5,717,937	A	2/1998	Fritz	320/128
5,381,096	A	1/1995	Hirzel	324/427	5,739,667	A	4/1998	Matsuda et al.	320/128
5,387,871	A	2/1995	Tsai	324/429	5,744,962	A	4/1998	Alber et al.	324/426
5,402,007	A	3/1995	Center et al.	290/40 B	5,745,044	A	4/1998	Hyatt, Jr. et al.	340/5.23
5,410,754	A	4/1995	Klotzbach et al.	370/466	5,747,189	A	5/1998	Perkins	429/91
5,412,308	A	5/1995	Brown	323/267	5,747,909	A	5/1998	Syverson et al.	310/156.56
5,412,323	A	5/1995	Kato et al.	324/429	5,747,967	A	5/1998	Muljadi et al.	320/148
5,425,041	A	6/1995	Seko et al.	372/45.01	5,754,417	A	5/1998	Nicollini	363/60
5,426,371	A	6/1995	Salley et al.	324/429	5,757,192	A	5/1998	McShane et al.	324/427
5,426,416	A	6/1995	Jefferies et al.	340/664	5,760,587	A	6/1998	Harvey	324/434
5,430,645	A	7/1995	Keller	364/424.01	5,772,468	A	6/1998	Kowalski et al.	439/506
5,432,025	A	7/1995	Cox	429/65	5,773,978	A	6/1998	Becker	324/430
5,432,426	A	7/1995	Yoshida	320/160	5,778,326	A	7/1998	Moroto et al.	701/22
5,434,495	A	7/1995	Toko	320/135	5,780,974	A	7/1998	Pabla et al.	315/82
5,435,185	A	7/1995	Eagan	73/587	5,780,980	A	7/1998	Naito	318/139
5,442,274	A	8/1995	Tamai	320/146	5,789,899	A	8/1998	van Phuoc et al.	320/112
5,445,026	A	8/1995	Eagan	73/591	5,793,359	A	8/1998	Ushikubo	345/169
5,449,996	A	9/1995	Matsumoto et al.	320/148	5,796,239	A	8/1998	van Phuoc et al.	320/107
5,449,997	A	9/1995	Gilmore et al.	320/148	5,808,469	A	9/1998	Kopera	324/434
5,451,881	A	9/1995	Finger	324/433	5,818,234	A	10/1998	McKinnon	324/433
5,453,027	A	9/1995	Buell et al.	439/433	5,820,407	A	10/1998	Morse et al.	439/504
5,457,377	A	10/1995	Jonsson	320/DIG. 21	5,821,756	A	10/1998	McShane et al.	324/430
5,459,660	A	10/1995	Berra	701/33	5,821,757	A	10/1998	Alvarez et al.	324/434
5,469,043	A	11/1995	Cherng et al.	320/161	5,825,174	A	10/1998	Parker	324/106
5,485,090	A	1/1996	Stephens	324/433	5,831,435	A	11/1998	Troy	324/426
5,488,300	A	1/1996	Jamieson	324/432	5,832,396	A	11/1998	Moroto et al.	701/22
5,504,674	A	4/1996	Chen et al.	705/4	5,850,113	A	12/1998	Weimer et al.	307/125
5,508,599	A	4/1996	Koenck	320/138	5,862,515	A	1/1999	Kobayashi et al.	702/63
5,519,383	A	5/1996	De La Rosa	340/636	5,865,638	A	2/1999	Trafton	439/288
5,528,148	A	6/1996	Rogers	320/137	5,871,858	A	2/1999	Thomsen et al.	429/7
5,537,967	A	7/1996	Tashiro et al.	123/192.1	5,872,443	A	2/1999	Williamson	320/160
5,541,489	A	7/1996	Dunstan	320/134	5,872,453	A	2/1999	Shimoyama et al.	324/431
5,546,317	A	8/1996	Andrieu	702/63	5,883,306	A	3/1999	Hwang	73/146.8
5,548,273	A	8/1996	Nicol et al.	340/439	5,895,440	A	4/1999	Proctor et al.	702/63
5,550,485	A	8/1996	Falk	324/772	5,903,716	A	5/1999	Kimber et al.	395/114
5,561,380	A	10/1996	Sway-Tin et al.	324/509	5,912,534	A	6/1999	Benedict	315/82
5,562,501	A	10/1996	Kinoshita et al.	439/852	5,914,605	A	6/1999	Bertness	324/430
5,563,496	A	10/1996	McClure	320/128	5,927,938	A	7/1999	Hammerslag	414/809

5,929,609	A	7/1999	Joy et al.	322/25	6,294,896	B1	9/2001	Champlin	320/134
5,939,855	A	8/1999	Proctor et al.	320/104	6,294,897	B1	9/2001	Champlin	320/153
5,939,861	A	8/1999	Joko et al.	320/122	6,304,087	B1	10/2001	Bertness	324/426
5,945,829	A	8/1999	Bertness	324/430	6,307,349	B1	10/2001	Koenck et al.	320/112
5,946,605	A	8/1999	Takahisa et al.	455/68	6,310,481	B2	10/2001	Bertness	324/430
5,951,229	A	9/1999	Hammerslag	414/398	6,313,607	B1	11/2001	Champlin	320/132
5,961,561	A	10/1999	Wakefield, II	701/29	6,313,608	B1	11/2001	Varghese et al.	32/132
5,961,604	A	10/1999	Anderson et al.	709/229	6,316,914	B1	11/2001	Bertness	320/134
5,969,625	A	10/1999	Russo	340/636.19	6,320,351	B1	11/2001	Ng et al.	320/104
5,978,805	A	11/1999	Carson	707/10	6,323,650	B1	11/2001	Bertness et al.	324/426
5,982,138	A	11/1999	Krieger	320/105	6,329,793	B1	12/2001	Bertness et al.	320/132
6,002,238	A	12/1999	Champlin	320/134	6,331,762	B1	12/2001	Bertness	320/134
6,005,759	A	12/1999	Hart et al.	361/66	6,332,113	B1	12/2001	Bertness	702/63
6,008,652	A	12/1999	Theofanopoulos et al.	324/434	6,346,795	B2	2/2002	Haraguchi et al.	320/136
6,009,369	A	12/1999	Boisvert et al.	701/99	6,347,958	B1	2/2002	Tsai	439/488
6,016,047	A	1/2000	Notten et al.	320/137	6,351,102	B1	2/2002	Troy	320/139
6,031,354	A	2/2000	Wiley et al.	320/116	6,356,042	B1	3/2002	Kahlon et al.	318/138
6,031,368	A	2/2000	Klippel et al.	324/133	6,359,441	B1	3/2002	Bertness	324/426
6,037,745	A	3/2000	Koike et al.	320/104	6,359,442	B1	3/2002	Henningson et al.	324/426
6,037,749	A	3/2000	Parsonage	320/132	6,363,303	B1	3/2002	Bertness	701/29
6,037,751	A	3/2000	Klang	320/160	RE37,677	E	4/2002	Irie	315/83
6,037,777	A	3/2000	Champlin	324/430	6,377,031	B1	4/2002	Karuppana et al.	323/220
6,037,778	A	3/2000	Makhija	324/433	6,384,608	B1	5/2002	Namaky	324/430
6,046,514	A	4/2000	Rouillard et al.	307/77	6,388,448	B1	5/2002	Cervas	324/426
6,051,976	A	4/2000	Bertness	324/426	6,392,414	B2	5/2002	Bertness	324/429
6,055,468	A	4/2000	Kaman et al.	701/29	6,396,278	B1	5/2002	Makhija	324/402
6,061,638	A	5/2000	Joyce	702/63	6,407,554	B1	6/2002	Godau et al.	324/503
6,064,372	A	5/2000	Kahkoska	345/173	6,411,098	B1	6/2002	Laletin	324/436
6,072,299	A	6/2000	Kurie et al.	320/112	6,417,669	B1	7/2002	Champlin	324/426
6,072,300	A	6/2000	Tsuji	320/116	6,420,852	B1	7/2002	Sato	320/134
6,081,098	A	6/2000	Bertness et al.	320/134	6,424,157	B1	7/2002	Gollomp et al.	324/430
6,081,109	A	6/2000	Seymour et al.	324/127	6,424,158	B2	7/2002	Klang	324/433
6,087,815	A	7/2000	Pfeifer et al.	323/282	6,437,957	B1	8/2002	Karuppana et al.	361/78
6,091,238	A	7/2000	McDermott	324/207.2	6,441,585	B1	8/2002	Bertness	320/132
6,091,245	A	7/2000	Bertness	324/426	6,445,158	B1	9/2002	Bertness et al.	320/104
6,094,033	A	7/2000	Ding et al.	320/132	6,449,726	B1	9/2002	Smith	713/340
6,100,670	A	8/2000	Levesque	320/150	6,456,036	B1	9/2002	Thandiwe	320/106
6,104,167	A	8/2000	Bertness et al.	320/132	6,456,045	B1	9/2002	Troy et al.	320/139
6,113,262	A	9/2000	Purola et al.	374/45	6,465,908	B1	10/2002	Karuppana et al.	307/31
6,114,834	A	9/2000	Parise	320/109	6,466,025	B1	10/2002	Klang	324/429
6,137,269	A	10/2000	Champlin	320/150	6,466,026	B1	10/2002	Champlin	324/430
6,140,797	A	10/2000	Dunn	320/105	6,469,511	B1	10/2002	Vonderhaar et al.	324/425
6,144,185	A	11/2000	Dougherty et al.	320/132	6,477,478	B1	11/2002	Jones et al.	702/102
6,150,793	A	11/2000	Lesesky et al.	320/104	6,495,990	B2	12/2002	Champlin	320/132
6,158,000	A	12/2000	Collins	713/1	6,497,209	B1	12/2002	Karuppana et al.	123/179.3
6,161,640	A	12/2000	Yamaguchi	180/65.8	6,500,025	B1	12/2002	Moenkhaus et al.	439/502
6,163,156	A	12/2000	Bertness	324/426	6,505,507	B1	1/2003	Imao	73/146.5
6,164,063	A	12/2000	Mendler	60/274	6,507,196	B2	1/2003	Thomsen et al.	324/436
6,167,349	A	12/2000	Alvarez	702/63	6,526,361	B1	2/2003	Jones et al.	702/63
6,172,483	B1	1/2001	Champlin	320/134	6,529,723	B1	3/2003	Bentley	455/405
6,172,505	B1	1/2001	Bertness	324/430	6,531,848	B1	3/2003	Chitsazan et al.	320/153
6,177,737	B1	1/2001	Palfey et al.	307/64	6,532,425	B1	3/2003	Boost et al.	702/63
6,181,545	B1	1/2001	Amatucci et al.	361/502	6,534,993	B2	3/2003	Bertness	324/433
6,211,651	B1	4/2001	Nemoto	320/133	6,544,078	B2	4/2003	Palmisano et al.	439/762
6,215,275	B1	4/2001	Bean	320/106	6,545,599	B2	4/2003	Derbyshire et al.	340/442
6,218,936	B1	4/2001	Imao	340/447	6,556,019	B2	4/2003	Bertness	324/426
6,222,342	B1	4/2001	Eggert et al.	320/105	6,566,883	B1	5/2003	Vonderhaar et al.	324/426
6,222,369	B1	4/2001	Champlin	324/430	6,570,385	B1	5/2003	Roberts et al.	324/378
D442,503	S	5/2001	Lundbeck et al.	D10/77	6,586,941	B2	7/2003	Bertness et al.	324/426
6,225,808	B1	5/2001	Varghese et al.	324/426	6,597,150	B1	7/2003	Bertness et al.	320/104
6,236,332	B1	5/2001	Conkright et al.	340/3.1	6,599,243	B2	7/2003	Woltermann et al.	600/300
6,238,253	B1	5/2001	Qualls	439/759	6,600,815	B1	7/2003	Walding	379/93.07
6,242,887	B1	6/2001	Burke	320/104	6,611,740	B2	8/2003	Lowrey et al.	701/29
6,249,124	B1	6/2001	Bertness	324/426	6,618,644	B2	9/2003	Bean	700/231
6,250,973	B1	6/2001	Lowery et al.	439/763	6,621,272	B2	9/2003	Champlin	324/426
6,254,438	B1	7/2001	Gaunt	439/755	6,623,314	B1	9/2003	Cox et al.	439/759
6,259,170	B1	7/2001	Limoge et al.	307/10.8	6,624,635	B1	9/2003	Lui	324/426
6,259,254	B1	7/2001	Klang	324/427	6,628,011	B2	9/2003	Droppo et al.	307/43
6,262,563	B1	7/2001	Champlin	320/134	6,629,054	B2	9/2003	Makhija et al.	702/113
6,263,268	B1	7/2001	Nathanson	701/29	6,633,165	B2	10/2003	Bertness	324/426
6,271,643	B1	8/2001	Becker et al.	320/112	6,635,974	B1	10/2003	Karuppana et al.	307/140
6,271,748	B1	8/2001	Derbyshire et al.	340/442	6,667,624	B1	12/2003	Raichle et al.	324/522
6,275,008	B1	8/2001	Arai et al.	320/132	6,679,212	B2	1/2004	Kelling	123/179.28

6,686,542	B2	2/2004	Zhang	174/74
6,696,819	B2	2/2004	Bertness	320/134
6,707,303	B2	3/2004	Bertness et al.	324/426
6,736,941	B2	5/2004	Oku et al.	203/68
6,737,831	B2	5/2004	Champlin	320/132
6,738,697	B2	5/2004	Breed	701/29
6,740,990	B2	5/2004	Tozuka et al.	307/9.1
6,745,153	B2	6/2004	White et al.	702/184
7,744,149		6/2004	Karuppana et al.	307/31
6,759,849	B2	7/2004	Bertness	324/426
6,777,945	B2	8/2004	Roberts et al.	324/426
6,781,382	B2	8/2004	Johnson	324/426
6,784,635	B2	8/2004	Larson	320/104
6,788,025	B2	9/2004	Bertness et al.	320/104
6,795,782	B2	9/2004	Bertness et al.	702/63
6,796,841	B1	9/2004	Cheng et al.	439/620.3
6,805,090	B2	10/2004	Bertness et al.	123/198
6,806,716	B2	10/2004	Bertness et al.	324/426
6,850,037	B2	2/2005	Bertness	320/132
6,871,151	B2	3/2005	Bertness	702/63
6,885,195	B2	4/2005	Bertness	324/426
6,888,468	B2	5/2005	Bertness	340/636.15
6,891,378	B2	5/2005	Bertness et al.	324/426
6,904,796	B2	6/2005	Pacsai et al.	73/146.8
6,906,522	B2	6/2005	Bertness et al.	324/426
6,906,523	B2	6/2005	Bertness et al.	324/426
6,906,624	B2	6/2005	McClelland et al.	340/442
6,909,287	B2	6/2005	Bertness	324/427
6,913,483	B2	7/2005	Restaino et al.	439/504
6,914,413	B2	7/2005	Bertness et al.	320/104
6,919,725	B2	7/2005	Bertness et al.	324/433
6,930,485	B2	8/2005	Bertness et al.	324/426
6,933,727	B2	8/2005	Bertness et al.	324/426
6,941,234	B2	9/2005	Bertness et al.	702/63
6,967,484	B2	11/2005	Bertness	324/426
6,998,847	B2	2/2006	Bertness et al.	324/426
7,003,410	B2	2/2006	Bertness et al.	702/63
7,003,411	B2	2/2006	Bertness	702/63
7,012,433	B2	3/2006	Smith et al.	324/426
7,058,525	B2	6/2006	Bertness et al.	702/63
7,081,755	B2	7/2006	Klang et al.	324/426
7,106,070	B2	9/2006	Bertness et al.	324/538
7,116,109	B2	10/2006	Klang	324/426
7,119,686	B2	10/2006	Bertness et al.	340/572.1
7,126,341	B2	10/2006	Bertness et al.	324/426
7,129,706	B2	10/2006	Kalley	324/426
7,272,519	B2	9/2007	Lesesky et al.	702/63
2002/0004694	A1	1/2002	McLeod	701/29
2002/0010558	A1	1/2002	Bertness et al.	702/63
2002/0030495	A1	3/2002	Kechmire	324/427
2002/0041175	A1	4/2002	Lauper et al.	320/106
2002/0044050	A1	4/2002	Derbyshire et al.	340/442
2002/0050163	A1	5/2002	Makhija et al.	73/116
2002/0171428	A1	11/2002	Bertness	324/426
2002/0176010	A1	11/2002	Wallach et al.	348/362
2003/0009270	A1	1/2003	Breed	701/29
2003/0025481	A1	2/2003	Bertness	324/427
2003/0036909	A1	2/2003	Kato	704/275
2003/0088375	A1	5/2003	Bertness et al.	702/63
2003/0169018	A1	9/2003	Berels et al.	320/132
2003/0184262	A1	10/2003	Makhija	320/130
2003/0184306	A1	10/2003	Bertness et al.	324/426
2003/0187556	A1	10/2003	Suzuki	701/29
2003/0194672	A1	10/2003	Roberts et al.	431/196
2003/0214395	A1	11/2003	Flowerday et al.	340/445
2004/0000590	A1	1/2004	Raichle et al.	235/462.01
2004/0000891	A1	1/2004	Raichle et al.	320/107
2004/0000893	A1	1/2004	Raichle et al.	320/135
2004/0000913	A1	1/2004	Raichle et al.	324/426
2004/0000915	A1	1/2004	Raichle et al.	324/522
2004/0002824	A1	1/2004	Raichle et al.	702/63
2004/0002825	A1	1/2004	Raichle et al.	702/63
2004/0002836	A1	1/2004	Raichle et al.	702/188
2004/0032264	A1	2/2004	Schoch	324/426
2004/0044452	A1	3/2004	Bauer et al.	703/33
2004/0049361	A1	3/2004	Hamdan et al.	702/115
2004/0051533	A1	3/2004	Namaky	324/426
2004/0054503	A1	3/2004	Namaky	702/183
2004/0113588	A1	6/2004	Mikuriya et al.	320/128
2004/0145342	A1	7/2004	Lyon	320/108
2004/0227523	A1	11/2004	Namaky	324/537
2004/0239332	A1	12/2004	Mackel et al.	324/426
2004/0251907	A1*	12/2004	Kalley	324/426
2005/0017726	A1	1/2005	Koran et al.	324/433
2005/0043868	A1	2/2005	Mitcham	701/29
2005/0102073	A1	5/2005	Ingram	701/29
2005/0182536	A1	8/2005	Doyle et al.	701/29
2005/0254106	A9	11/2005	Silverbrook et al.	358/539
2005/0256617	A1	11/2005	Cawthorne et al.	701/22
2006/0030980	A1	2/2006	St. Denis	701/29
2006/0089767	A1	4/2006	Sowa	701/29
2006/0217914	A1	9/2006	Bertness	702/113

FOREIGN PATENT DOCUMENTS

DE	19638324		9/1996
EP	0 022 450	A1	1/1981
EP	0 637 754	A1	2/1995
EP	0 772 056	A1	5/1997
EP	0 982 159	A2	3/2000
FR	2 749 397		12/1997
GB	2 029 586		3/1980
GB	2 088 159	A	6/1982
GB	2 246 916	A	10/1990
GB	2 275 783	A	7/1994
GB	2 387 235	A	10/2003
JP	59-17892		1/1984
JP	59-17893		1/1984
JP	59-17894		1/1984
JP	59017894		1/1984
JP	59215674		12/1984
JP	60225078		11/1985
JP	62-180284		8/1987
JP	63027776		2/1988
JP	03274479		12/1991
JP	03282276		12/1991
JP	4-8636		1/1992
JP	04095788		3/1992
JP	04131779		5/1992
JP	04372536		12/1992
JP	05211724	A	8/1993
JP	5216550		8/1993
JP	7-128414		5/1995
JP	09061505		3/1997
JP	10056744		2/1998
JP	10232273		9/1998
JP	11103503	A	4/1999
RU	2089015	C1	8/1997
WO	WO 93/22666		11/1993
WO	WO 94/05069		3/1994
WO	WO 96/01456		1/1996
WO	WO 96/06747		3/1996
WO	WO 97/44652		11/1997
WO	WO 98/04910		2/1998
WO	WO 98/58270		12/1998
WO	WO 99/23738		5/1999
WO	WO 00/16083		3/2000
WO	WO 00/16614	A1	3/2000
WO	WO 00/16615	A1	3/2000
WO	WO 00/62049		10/2000
WO	WO 00/67359		11/2000
WO	WO 01/59443		2/2001
WO	WO 01/51947		7/2001
WO	WO 03/047064	A3	6/2003
WO	WO 03/076960	A1	9/2003

WO WO 2004/047215 A1 6/2004

OTHER PUBLICATIONS

"Battery Impedance", by E. Willihnganz et al., *Electrical Engineering*, Sep. 1959, pp. 922-925.
"Determining The End of Battery Life", by S. DeBardelaben, *IEEE*, 1986, pp. 365-368.
"A Look at the Impedance of a Cell", by S. Debardelaben, *IEEE*, 1988, pp. 394-397.
"The Impedance of Electrical Storage Cells", by N.A. Hampson et al., *Journal of Applied Electrochemistry*, 1980, pp. 3-11.
"A Package for Impedance/Admittance Data Analysis", by B. Boukamp, *Solid State Ionics*, 1986, pp. 136-140.
"Precision of Impedance Spectroscopy Estimates of Bulk, Reaction Rate, and Diffusion Parameters", by J. Macdonald et al., *J. Electroanal, Chem*., 1991, pp. 1-11.
Internal Resistance: Harbinger of Capacity Loss in Starved Electrolyte Sealed Lead Acid Batteries, by Vaccaro, F.J. et al., *AT&T Bell Laboratories*, 1987 IEEE, Ch. 2477, pp. 128, 131.
IEEE Recommended Practice For Maintenance, Testings, and Replacement of Large Lead Storage Batteries for Generating Stations and Substations, *The Institute of Electrical and Electronics Engineers, Inc., ANSI/IEEE Std*. 450-1987, Mar. 9, 1987, pp. 7-15.
"Field and Laboratory Studies to Assess the State of Health of Valve-Regulated Lead Acid Batteries: Part I Conductance/Capacity Correlation Studies", by D. Feder et al., *IEEE*, Aug. 1992, pp. 218-233.
"Battery Impedance", by E. Willihnganz et al., *Electrical Engineering*, Sep. 1959, pp. 922-925.
"JIS Japanese Industrial Standard-Lead Acid Batteries for Automobiles", *Japanese Standards Association UDC*, 621.355.2:629.113.006, Nov. 1995.
"Peformance of Dry Cells", by C. Hambuechen, Preprint of *Am. Electrochem. Soc*., Apr. 18-20, 1912, paper No. 19, pp. 1-5.
"A Bridge for Measuring Storage Battery Resistance", by E. Willihncanz, *The Electrochemical Society*, preprint 79-20, Apr. 1941, pp. 253-258.
National Semiconductor Corporation, "High Q Notch Filter", Mar. 1969, Linear Brief 5.
Burr-Brown Corporation, "Design A 60 Hz Notch Filter with the UAF42", Jan. 1994, AB-071.
National Semiconductor Corporation, "LMF90-4th-Order Elliptic Notch Filter", Dec. 1994, RRD-B30M115.
"Alligator Clips with Wire Penetrators"*J.S. Popper, Inc.* product information, downloaded from http://www.jspopper.com/, undated.
"#12: LM78S40 Simple Switcher DC to DC Converter", *ITM e-Catalog*, downloaded from http://www.pcbcafe.com, undated.
"Simple DC-DC Converts Allows Use of Single Battery", *Electronix Express*, downloaded from http://www.elexp.com/t_dc-dc.htm, undated.
"DC-DC Converter Basics", *Power Designers*, downloaded from http://www.powerdesigners.com/InforWeb.design_center/articles/DC-DC/converter.shtm, undated.
"Notification of Transmittal of The International Search Report or the Declaration", PCT/US02/29461.
"Notification of Transmittal of The International Search Report or the Declaration", PCT/US03/07546.
"Notification of Transmittal of The International Search Report or the Declaration", PCT/US03/06577.
"Notification of Transmittal of The International Search Report or the Declaration", PCT/US03/07837.
"Notification of Transmittal of The International Search Report or the Declaration", PCT/US03/41561.
"Notification of Transmittal of The International Search Report or the Declaration", PCT/US03/27696.
"Programming Training Course, 62-000 Series Smart Engine Analyzer", Testproducts Division, Kalamazoo, Michigan, pp. 1-207, (1984).
"Operators Manual, Modular Computer Analyzer Model MCA 3000", Sun Electric Corporation, Crystal Lake, Illinois, pp. 1-1-14-13, (1991).
"Notification of Transmittal of The International Search Report or the Declaration", PCT/US02/29461.
"Dynamic modelling of lead/acid batteries using impedance spectroscopy for parameter identification", Journal of Power Sources, pp. 69-84, (1997).
"A review of impedance measurements for determination of the state-of-charge or state-of-health of secondary batteries", Journal of Power Sources, pp. 59-69, (1998).
"Improved Impedance Spectroscopy Technique For Status Determination of Production Li/SO_2 Batteries" Terrill Atwater et al., pp. 10-113, (1992).
"Search Report Under Section 17" for Great Britain Application No. GB0421447.4. (Jan. 28, 2005).
"Results of Discrete Frequency Immittance Spectroscopy (DFIS) Measurements of Lead Acid Batteries", by K.S. Champlin et al., *Proceedings of 23rd International Teleco Conference* (*INTELEC*), published Oct. 2001, IEE, pp. 433-440.
"Examination Report" from the U.K. Patent Office for U.K. App. No. 0417678.0.
Young Illustrated Encyclopedia Dictionary of Electronics, 1981, Parker Publishing Company, Inc., pp. 318-319.
"Office Action" dated Oct. 29, 2008 from corresponding U.S. Appl. No. 10/441,271, filed May 19, 2003.
Office Action issued Jun. 23, 2008 by the United States Patent and Trademark Office for U.S. Appl. No. 10/791,141, filed Mar. 2, 2004; 17 pages.
Office Action issued Jun. 16, 2008 by the United States Patent and Trademark Office for U.S. Appl. No. 10/441,271, filed May 19, 2003; 6 pages.
Wikipedia Online Encyclopedia, Inductance, 2005, http://en.wikipedia.org/wiki/inductance, pp. 1-5, mutual Inductance, pp. 3,4.
Young Illustrated Encyclopedia Dictionary of Electronics, 1981, Parker Publishing Company, Inc., pp. 318-319.
Notification of Transmittal of the International Search Report for PCT/US03/30707.
"Office Action" from related U.S. Appl. No. 10/791,141, dated Apr. 2, 2009.
"Office Action" from related U.S. Appl. No. 10/791,141, dated Jul. 9, 2009.
"A Microprocessor-Based Control System for a Near-Term Electric Vehicle", Bimal K. Bose; IEEE Transactions on Industry Applications, vol. IA-17, No. 6, Nov./Dec. 198?,; 0093-9994/81/1100-0626$00.75 © 1981 IEEE, 6 pages.
"DSP Applications in Hybrid Electric Vehicle Powertrain", Miller et al., Proceedings of the American Control Conference, Sand Diego, CA, Jun. 1999; 2 ppg.
"Notification of Transmittal of the International Search Report and the Written Opinion of the International Searching Authority, or the Declaration" for PCT/US2008/008702 filed Jul. 1, 2008; 15 pages.

* cited by examiner

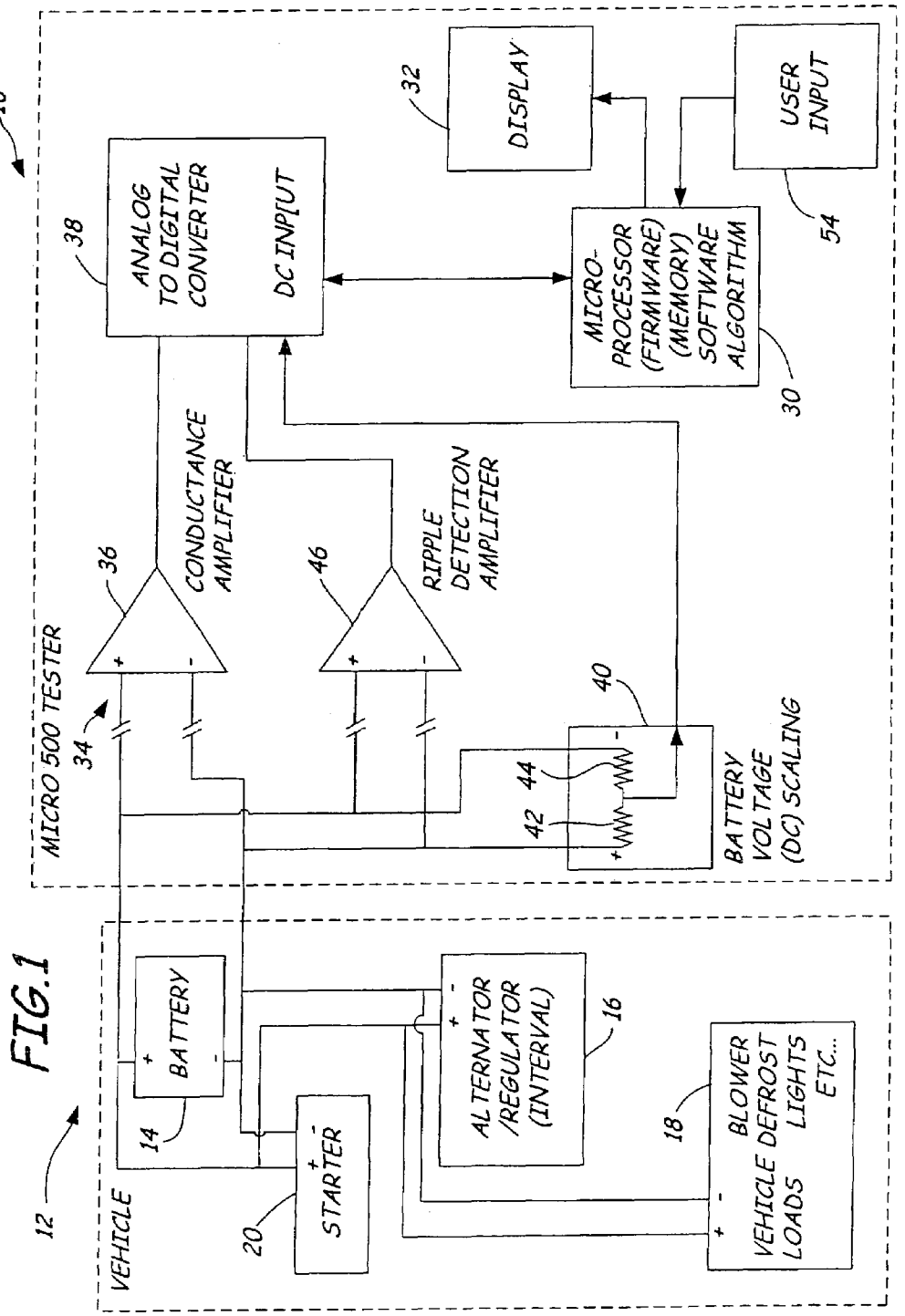

10
MICRO 500 TESTER
ANALOG TO DIGITAL CONVERTER
DC INPUT
38
DISPLAY
32
USER INPUT
54
MICRO-PROCESSOR (FIRMWARE) (MEMORY) SOFTWARE ALGORITHM
30
CONDUCTANCE AMPLIFIER
36
RIPPLE DETECTION AMPLIFIER
46
34
40
44
42
BATTERY VOLTAGE (DC) SCALING
12
VEHICLE
BATTERY
14
STARTER
20
ALTERNATOR /REGULATOR (INTERVAL)
16
BLOWER DEFROST LIGHTS ETC...
VEHICLE LOADS
18

FIG.1

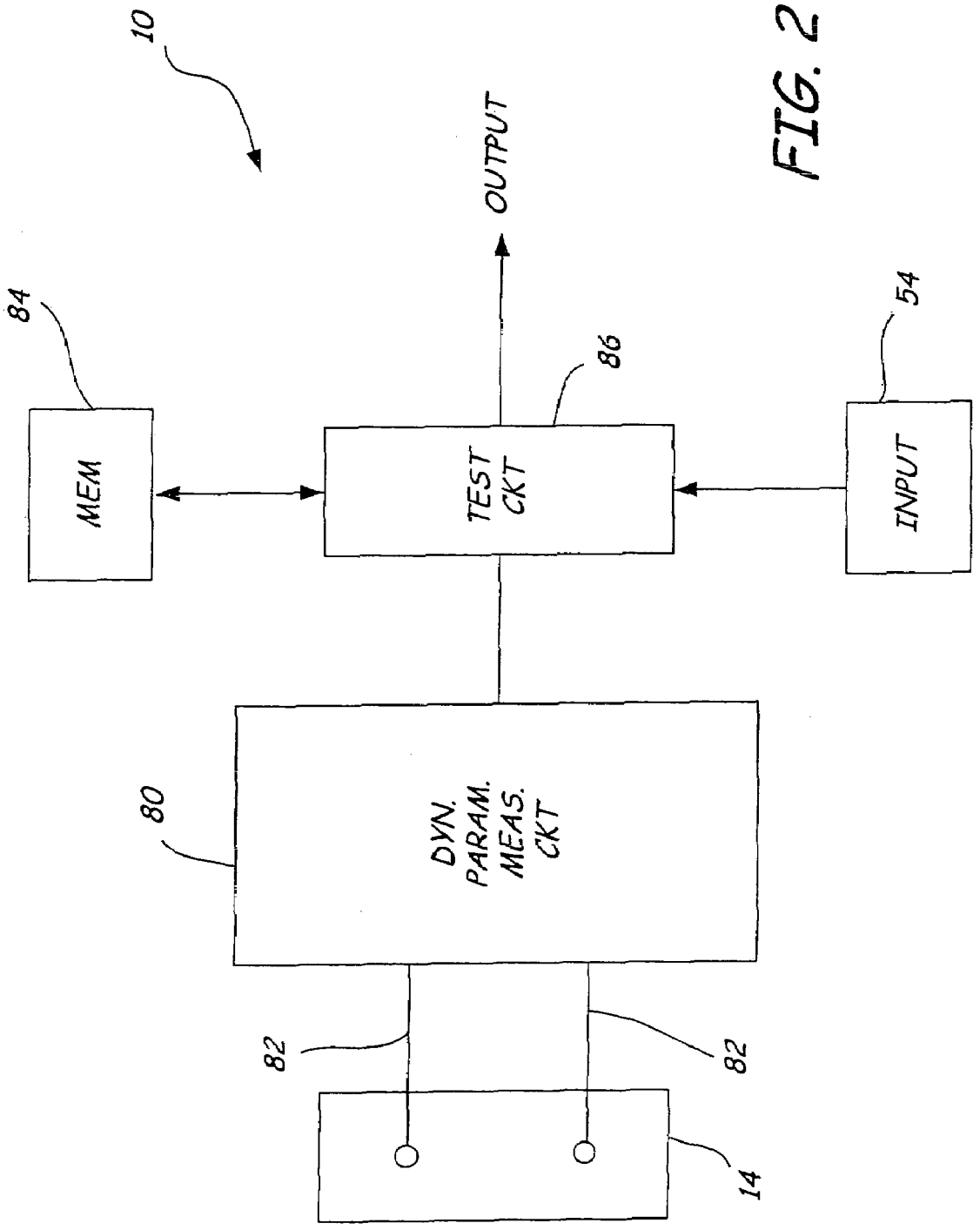

10
OUTPUT
84
MEM
86
TEST CKT
54
INPUT
80
DYN. PARAM. MEAS. CKT
82
82
14

FIG. 2

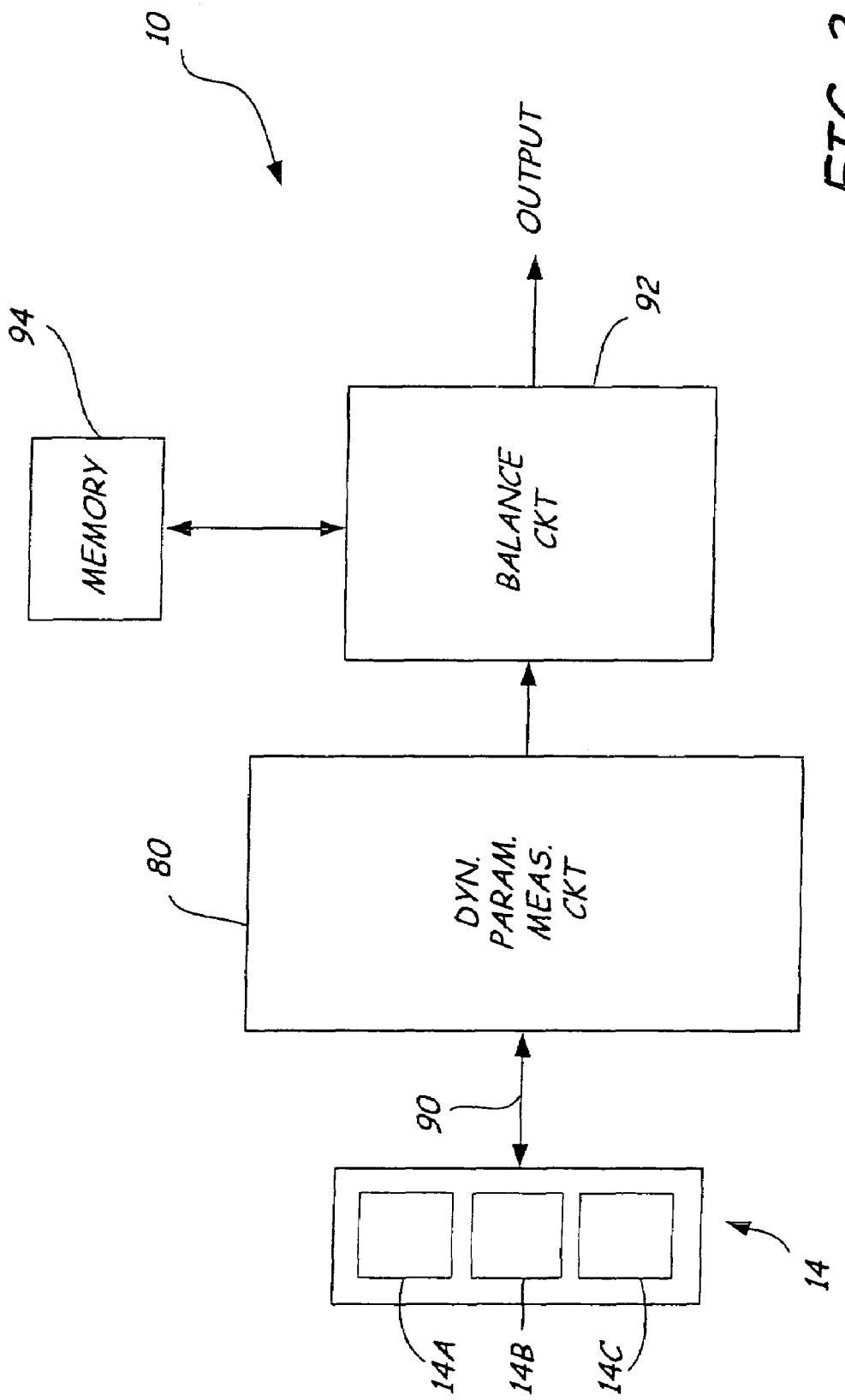

10
OUTPUT
92
94
MEMORY
BALANCE CKT
80
DYN. PARAM. MEAS. CKT
90
14
14A
14B
14C

FIG. 3

ELECTRONIC BATTERY TESTER WITH VEHICLE TYPE INPUT

The present invention is a Continuation of and claims priority of U.S. patent application Ser. No. 10/441,271, filed May 19, 2003, which is a Divisional of U.S. patent application Ser. No. 09/703,270, now U.S. Pat. No. 6,566,883, which claims priority to Provisional Application Ser. No. 60/163,013, filed Nov. 1, 1999 and entitled AUTOMOTIVE BATTERY CHARGING SYSTEM TESTER, the present application is also a Continuation-In-Part of U.S. patent application Ser. No. 10/271,342, filed Oct. 15, 2002, which is a Continuation-In-Part of U.S. patent application Ser. No. 09/960,117, filed Sept. 20, 2001, now U.S. Pat. No. 6,633,165, which is a Continuation-In-Part of U.S. patent application Ser. No. 09/564,740, filed May 4, 2000, now U.S. Pat. No. 6,331,762, which claims the benefit of provisional patent application Ser. No. 60/132,622, filed May 5, 1999, and provisional Ser. No. 60/165,208, filed Nov. 12, 1999, and provisional Ser. No. 60/175,762, filed Jan. 12, 2000, application Ser. No. 09/564,740 is also a Continuation-in-Part of patent application Ser. No. 08/962,754, filed Nov. 3, 1997, now U.S. Pat. No. 6,081,098, application Ser. No. 10/271,342 is also a Continuation-in-Part of patent application Ser. No. 10/046,659, filed Oct. 29, 2001, which is a Divisional of patent application Ser. No. 09/564,740, filed May 4, 2000, now U.S. Pat. No. 6,331,762, which claims the benefit of provisional patent application Ser. No. 60/132,622, filed May 5, 1999, and provisional Ser. No. 60/165,208, filed Nov. 12, 1999, and provisional Ser. No. 60/175,762, filed Jan. 12, 2000, application Ser. No. 10/046,659 is also a Continuation-In-Part of patent application Ser. No. 09/575,627, filed May 22, 2000, now U.S. Pat. No. 6,313,608, which is a Continuation-in-Part of patent application Ser. No. 08/962,754, filed Nov. 3, 1997, now U.S. Pat. No. 6,081,098; the present application is also a Continuation-In-Part of patent application Ser. No. 10/791,141, filed Mar. 2, 2004, which is a Continuation-in-Part of application Ser. No. 10/098,741, filed Mar. 14, 2002 which is a Continuation-in-Part of U.S. patent application Ser. No. 09/575,629, filed May 22, 2000, now U.S. Pat. No. 6,445,158, which is a Continuation-in-Part of Ser. No. 09/293,020, filed Apr. 16, 1999, now U.S. Pat. No. 6,351,102; application Ser. No. 09/575,629 is also a Continuation-in-Part of Ser. No. 09/426,302, filed Oct. 25, 1999, now U.S. Pat. No. 6,091,245; which is a Divisional of Ser. No. 08/681,730, filed Jul. 29, 1996, now U.S. Pat. No. 6,051,976, the contents of which are hereby incorporated by reference in their entirety.

BACKGROUND OF THE INVENTION

The present invention relates to storage batteries. More specifically, the present invention relates to a battery system tester for testing storage batteries.

Many attempts have been made to test storage batteries. One technique which has been pioneered by Dr. Keith S. Champlin and Midtronics, Inc. of Burr Ridge, Ill. relates to measuring the conductance of batteries to determine their condition. This technique is described in a number of United States patents, for example, U.S. Patent Nos. U.S. Pat. No. 3,873,911, issued Mar. 25, 1975, to Champlin, entitled ELECTRONIC BATTERY TESTING DEVICE; U.S. Pat. No. 3,909,708, issued Sep. 30, 1975, to Champlin, entitled ELECTRONIC BATTERY TESTING DEVICE; U.S. Pat. No. 4,816,768, issued Mar. 28, 1989, to Champlin, entitled ELECTRONIC BATTERY TESTING DEVICE; U.S. Pat. No. 4,825,170, issued Apr. 25, 1989, to Champlin, entitled ELECTRONIC BATTERY TESTING DEVICE WITH AUTOMATIC VOLTAGE SCALING; U.S. Pat. No. 4,881,038, issued Nov. 14, 1989, to Champlin, entitled ELECTRONIC BATTERY TESTING DEVICE WITH AUTOMATIC VOLTAGE SCALING TO DETERMINE DYNAMIC CONDUCTANCE; U.S. Pat. No. 4,912,416, issued Mar. 27, 1990, to Champlin, entitled ELECTRONIC BATTERY TESTING DEVICE WITH STATE-OF-CHARGE COMPENSATION; U.S. Pat. No. 5,140,269, issued Aug. 18, 1992, to Champlin, entitled ELECTRONIC TESTER FOR ASSESSING BATTERY/CELL CAPACITY; U.S. Pat. No. 5,343,380, issued Aug. 30, 1994, entitled METHOD AND APPARATUS FOR SUPPRESSING TIME VARYING SIGNALS IN BATTERIES UNDERGOING CHARGING OR DISCHARGING; U.S. Pat. No. 5,572,136, issued Nov. 5, 1996, entitled ELECTRONIC BATTERY TESTER WITH AUTOMATIC COMPENSATION FOR LOW STATE-OF-CHARGE; U.S. Pat. No. 5,574,355, issued Nov. 12, 1996, entitled METHOD AND APPARATUS FOR DETECTION AND CONTROL OF THERMAL RUNAWAY IN A BATTERY UNDER CHARGE; U.S. Pat. No. 5,585,728, issued Dec. 17, 1996, entitled ELECTRONIC BATTERY TESTER WITH AUTOMATIC COMPENSATION FOR LOW STATE-OF-CHARGE; U.S. Pat. No. 5,592,093, issued Jan. 7, 1997, entitled ELECTRONIC BATTERY TESTING DEVICE LOOSE TERMINAL CONNECTION DETECTION VIA A COMPARISON CIRCUIT; U.S. Pat. No. 5,598,098, issued Jan. 28, 1997, entitled ELECTRONIC BATTERY TESTER WITH VERY HIGH NOISE IMMUNITY; U.S. Pat. No. 5,757,192, issued May 26, 1998, entitled METHOD AND APPARATUS FOR DETECTING A BAD CELL IN A STORAGE BATTERY; U.S. Pat. No. 5,821,756, issued Oct. 13, 1998, entitled ELECTRONIC BATTERY TESTER WITH TAILORED COMPENSATION FOR LOW STATE-OF-CHARGE; U.S. Pat. No. 5,831,435, issued Nov. 3, 1998, entitled BATTERY TESTER FOR JIS STANDARD; U.S. Pat. No. 5,914,605, issued Jun. 22, 1999, entitled ELECTRONIC BATTERY TESTER; U.S. Pat. No. 5,945,829, issued Aug. 31, 1999, entitled MIDPOINT BATTERY MONITORING; U.S. Pat. No. 6,002,238, issued Dec. 14, 1999, entitled METHOD AND APPARATUS FOR MEASURING COMPLEX IMPEDANCE OF CELLS AND BATTERIES; U.S. Pat. No. 6,037,777, issued Mar. 14, 2000, entitled METHOD AND APPARATUS FOR DETERMINING BATTERY PROPERTIES FROM COMPLEX IMPEDANCE/ADMITTANCE; U.S. Pat. No. 6,051,976, issued Apr. 18, 2000, entitled METHOD AND APPARATUS FOR AUDITING A BATTERY TEST; U.S. Pat. No. 6,081,098, issued Jun. 27, 2000, entitled METHOD AND APPARATUS FOR CHARGING A BATTERY; U.S. Pat. No. 6,091,245, issued Jul. 18, 2000, entitled METHOD AND APPARATUS FOR AUDITING A BATTERY TEST; U.S. Pat. No. 6,104,167, issued Aug. 15, 2000, entitled METHOD AND APPARATUS FOR CHARGING A BATTERY; and U.S. Pat. No. 6,137,269, issued Oct. 24, 2000, entitled METHOD AND APPARATUS FOR ELECTRONICALLY EVALUATING THE INTERNAL TEMPERATURE OF AN ELECTROCHEMICAL CELL OR BATTERY.

With the advent of accurate battery testing, it has become apparent that in some instances the battery testing technique may not be appropriate for the particular purpose of the battery or configuration of multiple batteries.

SUMMARY OF THE INVENTION

An electronic battery tester for testing a storage battery, includes a dynamic measurement circuit configured to measure at least one dynamic parameter of the battery. A memory

is configured to store a plurality of test criteria and an input is configured to receive input data related to a selected test criteria. A test circuit provides an output related to battery condition as a function of the dynamic parameter an the selected test criteria. In another aspect, a memory is configured to store a first dynamic parameter from the measurement circuitry related to a first battery of a battery pack. Balance circuitry provides an in-balance output if a second battery in the pack has a dynamic parameter which is substantially equal to the first dynamic parameter.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a simplified block diagram of a battery tester in accordance with the present invention.

FIG. **2** is a simplified diagram illustrating a tester in accordance with the present invention.

FIG. **3** is a simplified diagram illustrating a tester in accordance with the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** is a simplified block diagram of a battery tester **10** in accordance with one embodiment of the present invention coupled to a vehicle **12**. Vehicle **12** includes a battery **14** having positive and negative terminals, an alternator with internal regulator **16**, various vehicle loads **18**, and a starter motor **20**. In operation, battery **14** provides power to starter **20** and vehicle loads **18** when the engine in vehicle **12** is not running. When the engine in vehicle **12** is running, alternator **16** is used to power vehicle loads **18** and provide a charging current to battery **14** to maintain the charge of battery **14**.

Charging system tester **10** includes a microprocessor **30** which controls operation of tester **10** and provides instructions and test result information to an operator through, for example, a display **32**. Tester **10** includes a battery testing section **34** which is illustrated generally as conductance amplifier **36**. Section **34** operates in accordance with, for example, the conductance based battery testing techniques described in Champlin patents U.S. Patent Nos. U.S. Pat. No. 3,873,911, issued Mar. 25 1975, to Champlin, entitled ELECTRONIC BATTERY TESTING DEVICE; U.S. Pat. No. 3,909,708, issued Sep. 30, 1975, to Champlin, entitled ELECTRONIC BATTERY TESTING DEVICE; U.S. Pat. No. 4,816,768, issued Mar. 28, 1989, to Champlin, entitled ELECTRONIC BATTERY TESTING DEVICE; U.S. Pat. No. 4,825,170, issued Apr. 25, 1989, to Champlin, entitled ELECTRONIC BATTERY TESTING DEVICE WITH AUTOMATIC VOLTAGE SCALING; U.S. Pat. No. 4,881,038, issued Nov. 14, 1989, to Champlin, entitled ELECTRONIC BATTERY TESTING DEVICE WITH AUTOMATIC VOLTAGE SCALING TO DETERMINE DYNAMIC CONDUCTANCE; U.S. Pat. No. 4,912,416, issued Mar. 27, 1990, to Champlin, entitled ELECTRONIC BATTERY TESTING DEVICE WITH STATE-OF-CHARGE COMPENSATION; U.S. Pat. No. 5,140,269, issued Aug. 18, 1992, to Champlin, entitled ELECTRONIC TESTER FOR ASSESSING BATTERY/CELL CAPACITY; U.S. Pat. No. 5,343,380, issued Aug. 30, 1994, entitled METHOD AND APPARATUS FOR SUPPRESSING TIME VARYING SIGNALS IN BATTERIES UNDERGOING CHARGING OR DISCHARGING; U.S. Pat. No. 5,572,136, issued Nov. 5, 1996, entitled ELECTRONIC BATTERY TESTER WITH AUTOMATIC COMPENSATION FOR LOW STATE-OF-CHARGE; U.S. Pat. No. 5,585,728, issued Dec. 17, 1996, entitled ELECTRONIC BATTERY TESTER WITH AUTOMATIC COMPENSATION FOR LOW STATE-OF-CHARGE; U.S. Pat. No. 5,598,098, issued Jan. 28, 1997, entitled ELECTRONIC BATTERY TESTER WITH VERY HIGH NOISE IMMUNITY; U.S. Pat. No. 5,821,756, issued Oct. 13, 1998, entitled ELECTRONIC BATTERY TESTER WITH TAILORED COMPENSATION FOR LOW STATE-OF-CHARGE. Section **34** is illustrated in very simplified form and conductance amplifier **36** provides an output to an analog to digital converter **38** which is related to the internal conductance of battery **14**.

A DC voltage sensor **40** includes voltage scaling resistors **42** and **44** and is coupled to battery **14** to provide an output to analog to digital converter **38** which is representative of the DC voltage across battery **14**. Further, an AC ripple detector amplifier **46** is coupled to battery **14** through capacitors **48** and **50** and provides an output to analog to digital converter **38** which is representative of the AC ripple voltage across battery **14**.

Microprocessor **30** controls analog to digital converter **38** to select which of the three inputs to digitize. Microprocessor **30** includes firmware, memory, and a software program in accordance with the invention. The user input **54** is coupled to microprocessor **30** to provide the information to microprocessor **30** from an operator.

Preferably, tester **10** is portable such that it may be easily moved between vehicles or otherwise transported. Portability of tester **10** is achieved because tester **10** does not require large internal carbon pile loads to load the battery charging system. Instead, as described herein, tester **10** utilizes loads internal to the vehicle **12** in testing the charging system. Further, the battery tester performed by tester **10** is in accordance with the non-load battery testing technique as described above.

In another aspect of the present invention, microprocessor **30** includes a memory which is capable of storing a number of different decision making algorithms or test criteria. The particular test criteria or algorithm can be selected through user input **54**. For example, in one aspect, the test criteria is selected based upon the particular type of battery or rated reserve capacity of the battery. For example, if a battery is rated as having a particularly robust design with a large reserve capacity, the test criteria can be made more stringent such that an indication that the battery is "good" is only provided if the battery meets the higher test criteria.

FIG. **2** is a simplified block diagram of tester **10** in accordance with such an embodiment. In FIG. **2**, tester **10** includes dynamic parameter measurement circuitry **80** which couples to battery **14** through Kelvin connections **82**. Dynamic parameter measurement circuitry **80** can be any circuit configuration which measures a dynamic parameter of battery **14**. As used herein, a dynamic parameter is one which is related to a signal having an AC component. The signal can be either applied directly or drawn from battery **14**. Example dynamic parameters include dynamic resistance, conductance, impedance, admittance, etc. This list is not exhaustive, for example, a dynamic parameter can include a component value of an equivalent circuit of battery **14**. Memory **84** is configured to store a plurality of different test criteria. For example, the test criteria can be a number of different thresholds or errors which are used to provide an indication as to whether the battery **14** is "good." Input **54**, which can comprise a user input, is coupled to test circuitry **86**. Test circuitry **86** applies a selected test criteria for memory **84** based upon user input **54** to the dynamic parameter measured by dynamic parameter measurement circuitry **80**. Based upon this comparison, an output is provided. FIG. **2** is a very simplified block diagram and in actual practice a number of the individual elements can

be implemented in a single microprocessor and other circuit configurations. Input **64** can be any type of input and is not limited to a user input.

In this aspect of the invention, the criteria used to test battery **14** can be adjusted based upon a particular aspect of battery **14**. For example, if battery **14** is a new battery, a more stringent test can be applied to battery **14**. Additionally, if battery **14** is intended to be used in an industrial vehicle or other situation which is very demanding of a battery, a more "difficult" or stringent test criteria can be provided. The test criteria can be based upon other factors to the dynamic parameter such as temperature or "static" parameters. The input from input **54** can be any type of input data and does not need to be user generated. Example input data includes every make, model, type, construction date, present date, temperature, vehicle type, VIN code, battery service requirements, requirements for a particular application, etc.

Tester **10** can test a battery which is formed by more than one individual battery. This is called a "battery pack". For example, some vehicles such as large industrial vehicles include multiple batteries which are connected in series, parallel or series-parallel. In such an embodiment, element **14** in FIGS. **1** and **2** can represent such a pack such batteries can be particularly difficult to test and, in many prior art battery testers, have required the batteries to be disconnected and individually tested. In accordance with one aspect of the present invention, microprocessor **30** tests the multiple batteries using a variety of appropriate techniques. Microprocessor **30** is capable of determining the configuration of the batteries (parallel, series or series-parallel) by measuring the voltage at the terminals of the "battery pack" and through receiving user input through input **54** indicating the number of batteries in the pack. Additionally, in some instances microprocessor **30** may also need to receive information related to the voltage of the individual batteries in the pack in order to make a determination as to the configuration of the pack. There are some instances where the configuration of the pack cannot be determined by simply knowing the voltage of individual batteries and taking measurements. A series of standard known configurations can be stored in the memory in tester **10** tester, and a user can select one such configuration. Configurations of battery packs include up to 12 batteries in parallel, three batteries in series and 12 batteries in series-parallel configurations. Microprocessor **30** is capable of determining the CCA rating and/or conductance of the entire battery pack using the information it has determined regarding the configuration of the battery pack. For example, in parallel configurations the CCA measurement is additive as is conductance, while in series-parallel or series configurations the voltage can be additive but the CCA/conductance can remain the same.

In one aspect, tester **10** is capable of detecting a good battery, a discharged battery, a bad cell, a bad battery, a marginal and/or defective wiring within a battery pack without disconnecting the pack. In one such embodiment, multiple test connections are used to connect to the battery pack. For example, one pair of connections can be used to connect to either end of the battery pack while another connection can be used to connect to points within the battery pack or to measure current flowing between points within the battery pack. Using this technique, the various currents flowing within the battery pack can be determined and this information can be used to detect a bad connection, such as a bad cable or poor physical connection between two points within the battery pack. Additionally, microprocessor **30** can instruct the user using display **32** to make various measurements at various points along the battery pack to more fully determine the condition of various portions of the battery pack.

In some instances, the microprocessor **30** can instruct the user to disconnect a certain battery within the battery pack in order to perform an isolated test on that battery.

In another aspect, microprocessor **30** uses advanced testing criteria or testing techniques such as fuzzy logic, neural networks or other artificial intelligence techniques to detect and make decisions regarding the health of a battery or a battery pack. Such techniques can also be used in evaluating time varying signals such as signals generated by the operation of alternator **16** or starter **20** in vehicle **12**.

In another aspect, tester **10** includes a load such that a traditional load test can be performed on the battery **14**. Such a load test is known in the art and is performed by applying a load to a battery and observing the effect of the applied load to the voltage or current flowing from the battery. In such an embodiment, such information can be used in conjunction with a resistance, impedance, conductance or admittance test of the battery **14** to identify a defect in the battery or otherwise determine the condition of the battery. This technique can also be used to measure the remaining or reserve capacity of the battery or battery pack. Such a testing technique provides additional information to microprocessor **30** which can then be used to make more advanced decisions regarding battery condition.

Microprocessor **30** can also compute, store, display or print out equivalent rating information regarding equivalent ratings of battery **14**. Such equivalent ratings include CCA, SAE, DIN, IEC, EN, CA, MCA, JIS or others of the battery. In such an embodiment, microprocessor **30** can adjust for variations in the measured conductance of a battery pack due to cables between batteries in the pack or the connectors between the cables and the battery which can insert series resistances into the measurement. The adjustment can be based upon compensation data stored in a memory which is determined empirically by measuring different types of batteries or through other techniques. Particular compensation information can be determined through determining the configuration of batteries within a battery pack as described above. The compensation information can in the form of a multiplier which is used to multiply a conductance measurement.

In another aspect, measurements of battery conductance are used to "balance" the various batteries in a battery pack such that they are selected and arranged for delivering optimized current and/or receiving optimized charge current. This aspect is illustrated in FIG. **3**. For example, if a 600 CCA battery is placed in series with a 500 CCA battery, one of the batteries will tend to become overcharged while the other battery will tend to be undercharged. Tester **10** can alert an operator regarding the unbalanced condition of the batteries within the pack. Tester **10** can prompt a user to disconnect certain batteries within the pack and perform individual tests on the batteries to determine which battery is unbalanced from the others. This will also assist in selecting the batteries used in the battery pack.

FIG. **3** illustrates a simplified diagram of this aspect of tester **10** and includes a dynamic parameter measurement circuit **80** coupled to battery **14** through connection **90**. Battery **14** is illustrated as multiple batteries, in this case three separate batteries **14**A, **14**B and **14**C. These batteries can be connected in series, parallel or series parallel. Connection **90** can be a single pair of Kelvin connectors which are selectively positioned between or on various batteries in pack **14**. There can be more than two Kelvin connections which are coupled to pack **14**. Memory **94** stores a first dynamic parameter from dynamic parameter measurement circuit **80** related to a

dynamic parameter of at least one battery **14**A, **14**B or **14**C within battery pack **14**. Balance circuit **92** provides an in-balance output if a second dynamic parameter of a second battery or batteries within pack **14** is "substantially equal" to the dynamic parameter stored in memory **94**. As used in this context, the term "substantially equal" means that the two dynamic parameters are within a predetermined or adjustable percentage or fixed amount from one another. If the two dynamic parameters are measured simultaneously, memory **94** is not required to store a dynamic parameter. In a further embodiment of this a aspect of the invention, a static parameter such as voltage is used in determining if the batteries are within balance. For example, the two batteries are within 0.1 volts of each other (i.e., 12.5 and 12.6 volts) and the conductance within 10%, an in-balance indication is provided. In another example, less than a 0.05 volt difference is required in addition to the dynamic parameter requirement. Additionally, data from multiple batteries can be stored in memory **94** and a preferred configuration of the batteries can be provided by balance circuitry **92** on its output. Information regarding the configuration of battery pack **14** can be received through the input **54** shown in FIGS. **1** and **2** and the output from balance circuit **92** adjusted accordingly.

The condition of cables or connectors can be determined by applying a large load, such as through an internal load in battery tester **10** or through application of a vehicle load **18**, or through the application of a large resistance, for example more than about 0.1 ohms. An amp clamp measurement can also be used. Further, microprocessor **30** can prompt a user to measure voltage drops across various cables in the pack and make a decision (i.e., good/bad) regarding a cable or connection in the battery pack. Microprocessor **30** can store, display, print and manage multiple test results associated with the multiple test measurements made when measuring a number of batteries which make a battery pack. This can be partial measurement, parameter, or other items related to individual batteries within the pack.

In one aspect, battery tester **10** is configured to determine the CCA rating of a battery or battery pack having a relatively large CCA value, for example, up to 5000 CCA. In such an embodiment, sensitive amplifiers and/or relatively large current values can be used to obtain the CCA or conductance measurement. In another aspect, tester **10** can perform a test on vehicle **12** by instructing an operator to apply a load (i.e., head lights, blower, etc.) or a combination of loads and reserve the response from battery **14**. This information can be used to determine diagnostic information regarding battery **14** out of the operation of components within vehicle **12**.

With one aspect of the invention, the tester can be used to test the "straps" that are used to couple individual batteries together to form a battery pack. For example, a dynamic parameter can be measured with the Kelvin probes applied directly to the battery. A second dynamic parameter can be measured in which one of the straps separates a Kelvin probe from the battery. A microprocessor can then compute the dynamic parameter of the strap alone and provide an output if the strap is poor. For example, if the strap dynamic conductance is too low, a warning can be provided. This technique can be extended to test multiple straps. In addition to testing straps within the pack, this technique can also be used to test cables that connect to the battery. Dynamic parameters can be stored in the memory for use in subsequent computations, or multiple Kelvin probes can be used to simultaneously measure multiple dynamic parameters.

In some aspects, a separate current probe can be used, such as a shunt, amp clamp or Hall effect sensor, to measure the current flowing into or out of a battery or group of batteries under test. This data can be paired with voltage measurements to obtain static or dynamic parameters.

The tester can store measurements in memory such that the battery pack can be ranked in terms of performance.

Although the present invention has been described with reference to preferred embodiments, workers skilled in the art will recognize that changes may be made in form and detail without departing from the spirit and scope of the invention.

What is claimed is:

1. An electronic battery tester for testing a storage battery for use in a vehicle, comprising:

a circuitry configured to measure at least one parameter of the battery;

an input configured to receive input data related to a type of the vehicle; and

test circuit configured to provide an output related to battery condition as a function of the dynamic parameter and the vehicle type.

2. The apparatus of claim **1** wherein the parameter comprises a dynamic parameter.

3. The apparatus of claim **1** wherein the test circuitry includes an electrical load.

4. The apparatus of claim **1** wherein the test circuit includes a microprocessor which operates in accordance with an equivalent rating of the battery.

5. The apparatus of claim **4** wherein the equivalent rating comprises a CCA rating.

6. The apparatus of claim **4** wherein the equivalent rating comprises a SAB rating.

7. The apparatus of claim **4** wherein the equivalent rating comprises a DIN rating.

8. The apparatus of claim **4** wherein the equivalent rating comprises a IEC rating.

9. The apparatus of claim **4** wherein the equivalent rating comprises a EN rating.

10. The apparatus of claim **4** wherein the equivalent rating comprises a CA rating.

11. The apparatus of claim **4** wherein the equivalent rating comprises a MCA rating.

12. The apparatus of claim **4** wherein the equivalent rating comprises a JIS rating.

13. The apparatus of claim **1** wherein the test circuitry is configured to couple to the battery through a Kelvin connection.

14. The apparatus of claim **1** wherein the input comprises a user input.

15. The apparatus of claim **1** including a memory configured to store a plurality of test criteria each associated with a vehicle type.

16. The apparatus of claim **15** wherein the test circuitry is configured to retrieve test criteria from the memory based upon the vehicle type input.

17. The apparatus of claim **1** wherein the test circuitry provides the output related to battery condition based upon a comparison.

18. The apparatus of claim **1** wherein the parameter comprises dynamic conductance.

19. The apparatus of claim **1** wherein the parameter comprises dynamic resistance.

20. An electronic battery tester for testing a storage battery for use in a vehicle, comprising:

a circuitry configured to measure at least one parameter of the battery;

an input configured to receive input data related to a VIN code of the vehicle; and

test circuit configured to provide an output related to battery condition as a function of the dynamic parameter and the VIN code of the vehicle.

21. The apparatus of claim **20** wherein the parameter comprises a dynamic parameter.

22. The apparatus of claim **20** wherein the test circuitry includes an electrical load.

23. The apparatus of claim **20** wherein the test circuit includes a microprocessor which operates in accordance with an equivalent rating of the battery.

24. The apparatus of claim **23** wherein the equivalent rating comprises a CCA rating.

25. The apparatus of claim **23** wherein the equivalent rating comprises a SAB rating.

26. The apparatus of claim **23** wherein the equivalent rating comprises a DIN rating.

27. The apparatus of claim **23** wherein the equivalent rating comprises a IEC rating.

28. The apparatus of claim **23** wherein the equivalent rating comprises a EN rating.

29. The apparatus of claim **23** wherein the equivalent rating comprises a CA rating.

30. The apparatus of claim **23** wherein the equivalent rating comprises a MCA rating.

31. The apparatus of claim **23** wherein the equivalent rating comprises a JIS rating.

32. The apparatus of claim **20** wherein the test circuitry is configured to couple to the battery through a Kelvin connection.

33. The apparatus of claim **20** wherein the input comprises a user input.

34. The apparatus of claim **20** including a memory configured to store a plurality of test criteria each associated with a vehicle type.

35. The apparatus of claim **34** wherein the test circuitry is configured to retrieve test criteria from the memory based upon the VIN code of the vehicle.

36. The apparatus of claim **20** wherein the test circuitry provides the output related to battery condition based upon a comparison.

37. The apparatus of claim **20** wherein the parameter comprises dynamic conductance.

38. The apparatus of claim **20** wherein the parameter comprises dynamic resistance.

39. An electronic battery tester for testing a storage battery for use in a vehicle, comprising:

a circuitry configured to measure at least one parameter of the battery;

an input configured to receive input data related to battery requirements of the vehicle; and

test circuit configured to provide an output related to battery condition as a function of the dynamic parameter and the battery requirements of the vehicle.

40. The apparatus of claim **39** wherein the requirements comprise battery service requirements.

41. The apparatus of claim **39** wherein the requirements comprise requirements for a particular application.

42. The apparatus of claim **39** wherein the parameter comprises a dynamic parameter.

43. The apparatus of claim **39** wherein the test circuitry includes an electrical load.

44. The apparatus of claim **39** wherein the test circuit includes a microprocessor which operates in accordance with an equivalent rating of the battery.

45. The apparatus of claim **44** wherein the equivalent rating comprises a CCA rating.

46. The apparatus of claim **44** wherein the equivalent rating comprises a SAE rating.

47. The apparatus of claim **44** wherein the equivalent rating comprises a DIN rating.

48. The apparatus of claim **44** wherein the equivalent rating comprises a IEC rating.

49. The apparatus of claim **44** wherein the equivalent rating comprises a EN rating.

50. The apparatus of claim **44** wherein the equivalent rating comprises a CA rating.

51. The apparatus of claim **44** wherein the equivalent rating comprises a MCA rating.

52. The apparatus of claim **44** wherein the equivalent rating comprises a JIS rating.

53. The apparatus of claim **39** wherein the test circuitry is configured to couple to the battery through a Kelvin connection.

54. The apparatus of claim **39** wherein the input comprises a user input.

55. The apparatus of claim **39** including a memory configured to store a plurality of test criteria each associated with battery requirements of the vehicle.

56. The apparatus of claim **55** wherein the test circuitry is configured to retrieve test criteria from the memory based upon the VIN code of the vehicle.

57. The apparatus of claim **39** wherein the test circuitry provides the output related to battery condition based upon a comparison.

58. The apparatus of claim **39** wherein the parameter comprises dynamic conductance.

59. The apparatus of claim **39** wherein the parameter comprises dynamic resistance.

60. A method for testing a storage battery for use in a vehicle, comprising:

measuring at least one parameter of the battery;

receiving input data related to a type of the vehicle; and

providing an output related to battery condition as a function of the dynamic parameter and the vehicle type.

61. The method of claim **60** wherein the parameter comprises a dynamic parameter.

62. The method of claim **60** including applying an electrical load.

63. The method of claim **60** wherein providing an output related to battery condition is based upon an equivalent rating of the battery.

64. The method of claim **60** wherein the equivalent rating comprises a CCA rating.

65. The method of claim **63** wherein the equivalent rating comprises a SAB rating.

66. The method of claim **63** wherein the equivalent rating comprises a DIN rating.

67. The method of claim **63** wherein the equivalent rating comprises a IEC rating.

68. The method of claim **63** wherein the equivalent rating comprises a EN rating.

69. The method of claim **63** wherein the equivalent rating comprises a CA rating.

70. The method of claim **63** wherein the equivalent rating comprises a MCA rating.

71. The method of claim **63** wherein the equivalent rating comprises a JIS rating.

72. The method of claim **60** wherein the measuring is through a Kelvin connection.

73. The method of claim **60** wherein the input data comprises user input data.

74. The method of claim 60 wherein providing an output related to battery condition is a function of one of a plurality of test criteria each associated with a VIN code.

75. The method of claim 74 wherein test circuitry is configured to retrieve test criteria from the memory based upon the vehicle type input.

76. The method of claim 60 wherein providing the output related to battery condition is based upon a step of comparing.

77. The method of claim 60 wherein the parameter comprises dynamic conductance.

78. The method of claim 60 wherein the parameter comprises dynamic resistance.

79. A method for testing a storage battery for use in a vehicle, comprising:

measuring at least one parameter of the battery;

receiving input data related to a VIN code of the vehicle; and

providing an output related to battery condition as a function of the dynamic parameter and the VIN code of the vehicle.

80. The method of claim 79 wherein the parameter comprises a dynamic parameter.

81. The method of claim 79 including applying an electrical load.

82. The method of claim 79 wherein providing an output related to battery condition is based upon an equivalent rating of the battery.

83. The method of claim 82 wherein the equivalent rating comprises a CCA rating.

84. The method of claim 82 wherein the equivalent rating comprises a SAB rating.

85. The method of claim 82 wherein the equivalent rating comprises a DIN rating.

86. The method of claim 82 wherein the equivalent rating comprises a IEC rating.

87. The method of claim 82 wherein the equivalent rating comprises a EN rating.

88. The method of claim 82 wherein the equivalent rating comprises a CA rating.

89. The method of claim 82 wherein the equivalent rating comprises a MCA rating.

90. The method of claim 82 wherein the equivalent rating comprises a JIS rating.

91. The method of claim 79 wherein the measuring is through a Kelvin connection.

92. The method of claim 79 wherein the input data comprises user input data.

93. The method of claim 79 wherein providing an output related to battery condition is a function of one of a plurality of test criteria each associated with a VIN code.

94. The method of claim 93 wherein test circuitry is configured to retrieve test criteria from the memory based upon the vehicle type input.

95. The method of claim 79 wherein providing the output related to battery condition is based upon a step of comparing.

96. The method of claim 79 wherein the parameter comprises dynamic conductance.

97. The method of claim 79 wherein the parameter comprises dynamic resistance.

98. An electronic battery tester for testing a storage battery for use in a vehicle, comprising:

means for measuring at least one parameter of the battery;

means for receiving input data related to a type of the vehicle; and

means for providing an output related to battery condition as a function of the dynamic parameter and the vehicle type.

99. An electronic battery tester for testing a storage battery for use in a vehicle, comprising:

means for measuring at least one parameter of the battery;

means for receiving input data related to a VIN code of the vehicle; and

means for providing an output related to battery condition as a function of the dynamic parameter and the VIN code of the vehicle.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 7,656,162 B2
APPLICATION NO. : 10/896834
DATED : February 2, 2010
INVENTOR(S) : Vonderhaar et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

On the Title Page:

The first or sole Notice should read --

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 902 days.

Signed and Sealed this

Thirtieth Day of November, 2010

David J. Kappos

David J. Kappos
Director of the United States Patent and Trademark Office