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Steinberg et al.

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(54) **SYSTEM AND METHOD FOR CALCULATING THE THERMAL MASS OF A BUILDING**

(56) **References Cited**

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U.S. PATENT DOCUMENTS

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4,136,732 A 1/1979 Demaray et al.
4,341,345 A 7/1982 Hammer et al.
(Continued)

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FOREIGN PATENT DOCUMENTS

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EP 0415747 3/1991
JP 05-189659 7/1993
(Continued)

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OTHER PUBLICATIONS

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Related U.S. Application Data

(63) Continuation of application No. 13/409,729, filed on Mar. 1, 2012, which is a continuation of application No. 12/959,225, filed on Dec. 2, 2010, now Pat. No. 8,131,497, which is a continuation of application No. 12/211,733, filed on Sep. 16, 2008, now Pat. No. 7,848,900.

(57) **ABSTRACT**

(60) Provisional application No. 60/994,011, filed on Sep. 17, 2007.

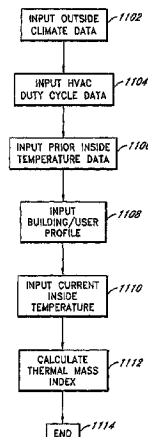
The invention comprises a system for calculating a value for the effective thermal mass of a building. The climate control system obtains temperature measurements from at least a first location conditioned by the climate system. One or more processors receive measurements of outside temperatures from at least one source other than the control system and compare the temperature measurements from the first location with expected temperature measurements. The expected temperature measurements are based at least in part upon past temperature measurements obtained by said HVAC control system and said outside temperature measurements. The processors then calculate one or more rates of change in temperature at said first location.

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G01D 1/00 (2006.01)

(52) **U.S. Cl.**
USPC **702/130; 702/182**

(58) **Field of Classification Search**
USPC 702/130, 182; 700/276, 277, 278;
236/91 D; 165/58, 200, 287
See application file for complete search history.

13 Claims, 13 Drawing Sheets



(56)

References Cited

U.S. PATENT DOCUMENTS

4,403,644	A	9/1983	Hebert	7,232,075	B1	6/2007	Rosen
4,475,685	A	10/1984	Grimado et al.	7,242,988	B1	7/2007	Hoffberg et al.
4,655,279	A	4/1987	Harmon	7,260,823	B2	8/2007	Schlack et al.
4,674,027	A	6/1987	Beckey	7,356,384	B2	4/2008	Gull et al.
5,244,146	A	9/1993	Jefferson et al.	7,483,964	B1	1/2009	Jackson et al.
5,270,952	A	12/1993	Adams et al.	7,644,869	B2	1/2010	Hoglund et al.
5,314,004	A	5/1994	Strand et al.	7,784,704	B2	8/2010	Harter
5,462,225	A	10/1995	Massara et al.	7,848,900	B2	12/2010	Steinberg et al.
5,544,036	A	8/1996	Brown et al.	7,894,943	B2	2/2011	Sloup et al.
5,555,927	A	9/1996	Shah	7,908,116	B2	3/2011	Steinberg et al.
5,572,438	A	11/1996	Ehlers et al.	7,908,117	B2	3/2011	Steinberg et al.
5,682,949	A	11/1997	Ratcliffe et al.	8,010,237	B2	8/2011	Cheung et al.
5,717,609	A	2/1998	Packa et al.	8,019,567	B2	9/2011	Steinberg et al.
5,729,474	A *	3/1998	Hildebrand et al. 700/276	8,090,477	B1	1/2012	Steinberg
5,818,347	A	10/1998	Dolan et al.	8,131,497	B2	3/2012	Steinberg et al.
5,977,964	A	11/1999	Williams et al.	8,131,506	B2	3/2012	Steinberg et al.
6,115,713	A	9/2000	Pascucci et al.	8,180,492	B2	5/2012	Steinberg
6,145,751	A	11/2000	Ahmed	8,340,826	B2	12/2012	Steinberg
6,178,362	B1	1/2001	Woolard et al.	8,412,488	B2	4/2013	Steinberg et al.
6,241,156	B1 *	6/2001	Kline et al. 236/49.3	8,423,322	B2	4/2013	Steinberg et al.
6,260,765	B1	7/2001	Natale et al.	8,457,797	B2	6/2013	Imes et al.
6,351,693	B1	2/2002	Monie	2003/0040934	A1	2/2003	Skidmore et al.
6,400,996	B1	6/2002	Hoffberg et al.	2004/0176880	A1	9/2004	Obradovich et al.
6,437,692	B1	8/2002	Petite et al.	2005/0222889	A1	10/2005	Lai et al.
6,478,233	B1	11/2002	Shah	2005/0288822	A1	12/2005	Rayburn
6,480,803	B1	11/2002	Pierret et al.	2006/0045105	A1	3/2006	Dobosz et al.
6,483,906	B1	11/2002	Iggulden et al.	2006/0214014	A1	9/2006	Bash et al.
6,536,675	B1	3/2003	Pesko et al.	2007/0043477	A1	2/2007	Ehlers et al.
6,542,076	B1	4/2003	Joao	2007/0045431	A1	3/2007	Chapman et al.
6,549,130	B1	4/2003	Joao	2007/0146126	A1	6/2007	Wang
6,574,537	B2	6/2003	Kipersztok et al.	2008/0083234	A1	4/2008	Krebs et al.
6,580,950	B1	6/2003	Johnson	2008/0198549	A1	8/2008	Rasmussen et al.
6,594,825	B1	7/2003	Goldschmidtiki et al.	2008/0281472	A1	11/2008	Podgorny et al.
6,595,430	B1	7/2003	Shah	2009/0052859	A1	2/2009	Greenberger et al.
6,598,056	B1	7/2003	Hull et al.	2009/0099699	A1	4/2009	Steinberg et al.
6,619,555	B2	9/2003	Rosen	2009/0125151	A1	5/2009	Steinberg et al.
6,622,097	B2	9/2003	Hunter	2009/0240381	A1	9/2009	Lane
6,622,115	B1	9/2003	Brown et al.	2009/0281667	A1	11/2009	Masui et al.
6,622,925	B2	9/2003	Carner et al.	2010/0019052	A1	1/2010	Yip
6,622,926	B1	9/2003	Sartain et al.	2010/0070086	A1	3/2010	Harrod et al.
6,628,997	B1	9/2003	Fox et al.	2010/0070089	A1	3/2010	Harrod et al.
6,633,823	B2	10/2003	Bartone et al.	2010/0070093	A1	3/2010	Harrod et al.
6,643,567	B2	11/2003	Kolk et al.	2010/0156608	A1	6/2010	Bae et al.
6,671,586	B2	12/2003	Davis et al.	2010/0162285	A1	6/2010	Cohen et al.
6,695,218	B2	2/2004	Fleckenstein	2010/0211224	A1	8/2010	Keeling et al.
6,726,113	B2	4/2004	Guo	2010/0235004	A1	9/2010	Thind
6,731,992	B1	5/2004	Ziegler	2010/0282857	A1	11/2010	Steinberg
6,734,806	B1	5/2004	Cratsley	2010/0289643	A1	11/2010	Trundle et al.
6,772,052	B1	8/2004	Amundsen	2010/0308119	A1	12/2010	Steinberg et al.
6,785,592	B1	8/2004	Smith	2010/0318227	A1	12/2010	Steinberg et al.
6,785,630	B2	8/2004	Kolk	2011/0031323	A1	2/2011	Nold et al.
6,786,421	B2	9/2004	Rosen	2011/0046792	A1	2/2011	Imes et al.
6,789,739	B2	9/2004	Rosen	2011/0046798	A1	2/2011	Imes et al.
6,853,959	B2	2/2005	Ikeda et al.	2011/0046799	A1	2/2011	Imes et al.
6,868,293	B1	3/2005	Schurr	2011/0046800	A1	2/2011	Imes et al.
6,868,319	B2	3/2005	Kipersztok et al.	2011/0046801	A1	2/2011	Imes et al.
6,882,712	B1	4/2005	Iggulden et al.	2011/0051823	A1	3/2011	Imes et al.
6,889,908	B2	5/2005	Crippen et al.	2011/0054699	A1	3/2011	Imes et al.
6,891,838	B1	5/2005	Petite et al.	2011/0054710	A1	3/2011	Imes et al.
6,912,429	B1	6/2005	Bilger	2011/0224838	A1	9/2011	Imes et al.
6,991,029	B2	1/2006	Orfield et al.	2011/0246898	A1	10/2011	Imes et al.
7,009,493	B2	3/2006	Howard	2011/0290893	A1	12/2011	Steinberg
7,031,880	B1	4/2006	Seem et al.	2011/0307101	A1	12/2011	Imes et al.
7,039,532	B2	5/2006	Hunter	2011/0307103	A1	12/2011	Cheung et al.
7,061,393	B2	6/2006	Buckingham et al.	2012/0023225	A1	1/2012	Imes et al.
7,089,088	B2	8/2006	Terry et al.	2012/0046859	A1	2/2012	Imes et al.
7,130,719	B2	10/2006	Ehlers et al.	2012/0064923	A1	3/2012	Imes et al.
7,130,832	B2	10/2006	Bannai et al.	2012/0065935	A1	3/2012	Steinberg et al.
H2176	H	12/2006	Meyer et al.	2012/0072033	A1	3/2012	Imes et al.
7,167,079	B2	1/2007	Smyth et al.	2012/0086562	A1	4/2012	Steinberg
7,187,986	B2	3/2007	Johnson et al.	2012/0093141	A1	4/2012	Imes et al.
7,205,892	B2	4/2007	Luebke et al.	2012/0101637	A1	4/2012	Imes et al.
7,215,746	B2	5/2007	Iggulden et al.	2012/0135759	A1	5/2012	Imes et al.
				2012/0158350	A1	6/2012	Steinberg et al.
				2012/0215725	A1	8/2012	Imes et al.
				2012/0221151	A1	8/2012	Steinberg
				2012/0221718	A1	8/2012	Imes et al.

(56)

References Cited

U.S. PATENT DOCUMENTS

2013/0053054	A1	2/2013	Lovitt et al.
2013/0054758	A1	2/2013	Imes et al.
2013/0054863	A1	2/2013	Imes et al.
2013/0060387	A1	3/2013	Imes et al.
2013/0144445	A1	6/2013	Steinberg
2013/0144453	A1	6/2013	Subbloie
2013/0167035	A1	6/2013	Imes et al.
2013/0238143	A1	9/2013	Steinberg et al.
2013/0310989	A1	11/2013	Steinberg et al.

FOREIGN PATENT DOCUMENTS

JP	2010-038377	2/2010
JP	2010-286218	12/2010
KR	10-1994-0011902	6/1994
KR	10-1999-0070368	9/1999
KR	10-2000-0059532	10/2000
WO	WO 2011/149600	12/2011
WO	WO 2012/024534	2/2012

OTHER PUBLICATIONS

U.S. Appl. No. 13/725,447, Dec. 21, 2012, Steinberg, John Douglas. Arens, et al., "How Ambient Intelligence Will Improve Habitability and Energy Efficiency in Buildings", 2005, research paper, Center for the Built Environment, Controls and Information Technology.

Bourhan, et al., "Cynamic model of an HVAC system for control analysis", Elsevier 2004.

Comverge SuperStat Flyer, prior to Jun. 28, 2007.

Control4 Wireless Thermostat Brochure, 2006.

Cooper Power Systems Web Page, 2000-2009.

Emerson Climate Technologies, "Network Thermostat for E2 Building Controller Installation and Operation Manual", 2007.

Enernoc Web Page, 2004-2009.

Enerwise Website, 1999-2009.

Honeywell Programmable Thermostat Owner's Guide, www.honeywell.com/yourhome, 2004.

Honeywell, W7600/W7620 Controller Reference Manual, HW0021207, Oct. 1992.

Johnson Controls, "T600HCx-3 Single-Stage Thermostats", 2006.

Johnson Controls, Touch4 building automation system brochure, 2007.

Kilicotte, et al., "Dynamic Controls for Energy Efficiency and Demand Response: Framework Concepts and a New Construction Study Case in New York", Proceedings of the 2006 ACEEE Summer Study of Energy Efficiency in Buildings, Pacific Grove. CA, Aug. 13-18, 2006.

Lin, et al., "Multi-Sensor Single-Actuator Control of HVAC Systems", 2002.

Pier, Southern California Edison, Demand Responsive Control of Air Conditioning via Programmable Communicating Thermostats Draft Report, 2006.

Proliphix Thermostat Brochure, prior to Jun. 2007.

Raji, "Smart Networks for Control", IEEE Spectrum, Jun. 1994.

Wang, et al., "Opportunities to Save Energy and Improve Comfort by Using Wireless Sensor Networks in Buildings," (2003), Center for Environmental Design Research.

Wetter, et al., A comparison of deterministic and probabilistic optimization algorithms for nonsmooth simulation-based optimization., Building and Environment 39, 2004, pp. 989-999.

Written Opinion and Search Report for PCT/US2011/032537, dated Dec. 12, 2011.

U.S. Appl. No. 13/470,074, Aug. 30, 2012, Steinberg.

U.S. Appl. No. 13/852,577, Mar. 28, 2013, Steinberg et al.

U.S. Appl. No. 13/858,710, Sep. 5, 2013, Steinberg et al.

U.S. Appl. No. 13/861,189, Apr. 11, 2013, Steinberg et al.

Brush, et al., Preheat—Controlling Home Heating with Occupancy Prediction, 2013.

Gupta, Adding GPS-Control to Traditional Thermostats: An Exploration of Potential Energy Savings and Design Challenges, MIT, 2009.

Gupta, et al., A Persuasive GPS-Controlled Thermostat System, MIT, 2008.

Krumm, et al., Learning Time-Based Presence Probabilities, Jun. 2011.

Scott, et al., Home Heating Using GPS-Based Arrival Prediction, 2010.

International Search Report and Written Opinion for PCT/US2013/035726, dated Aug. 6, 2013.

* cited by examiner

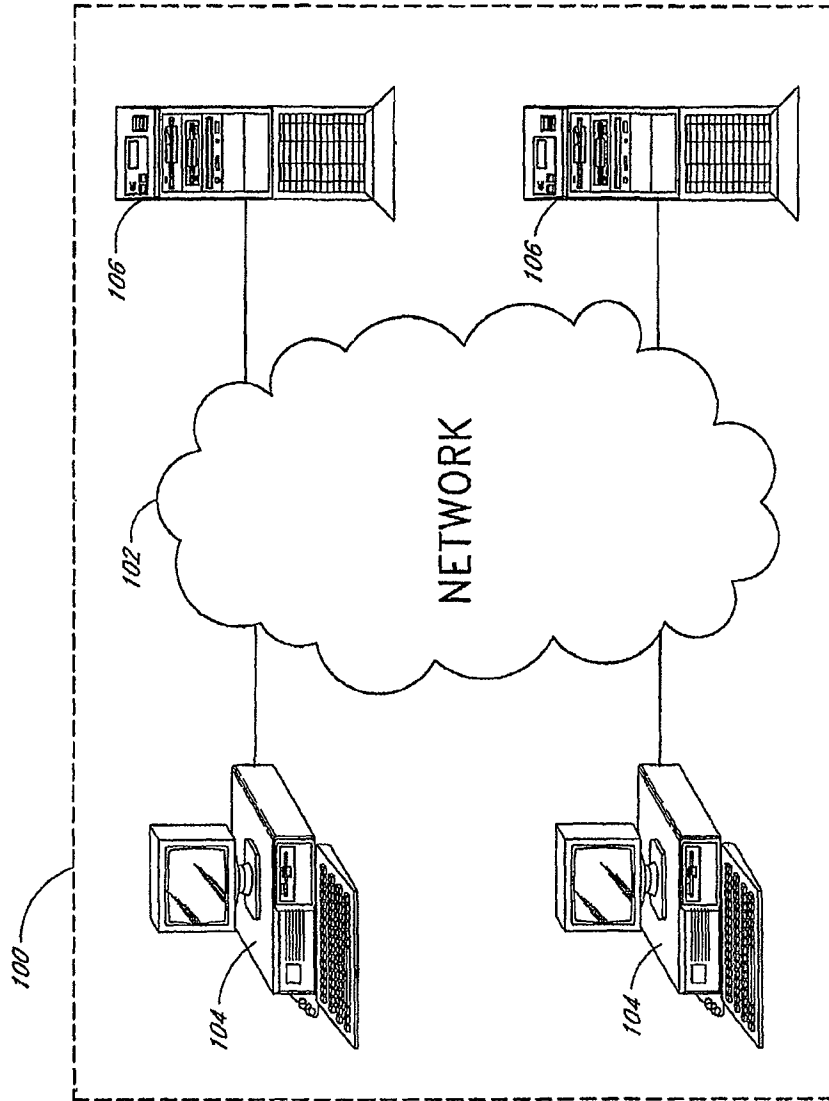


FIG. 1

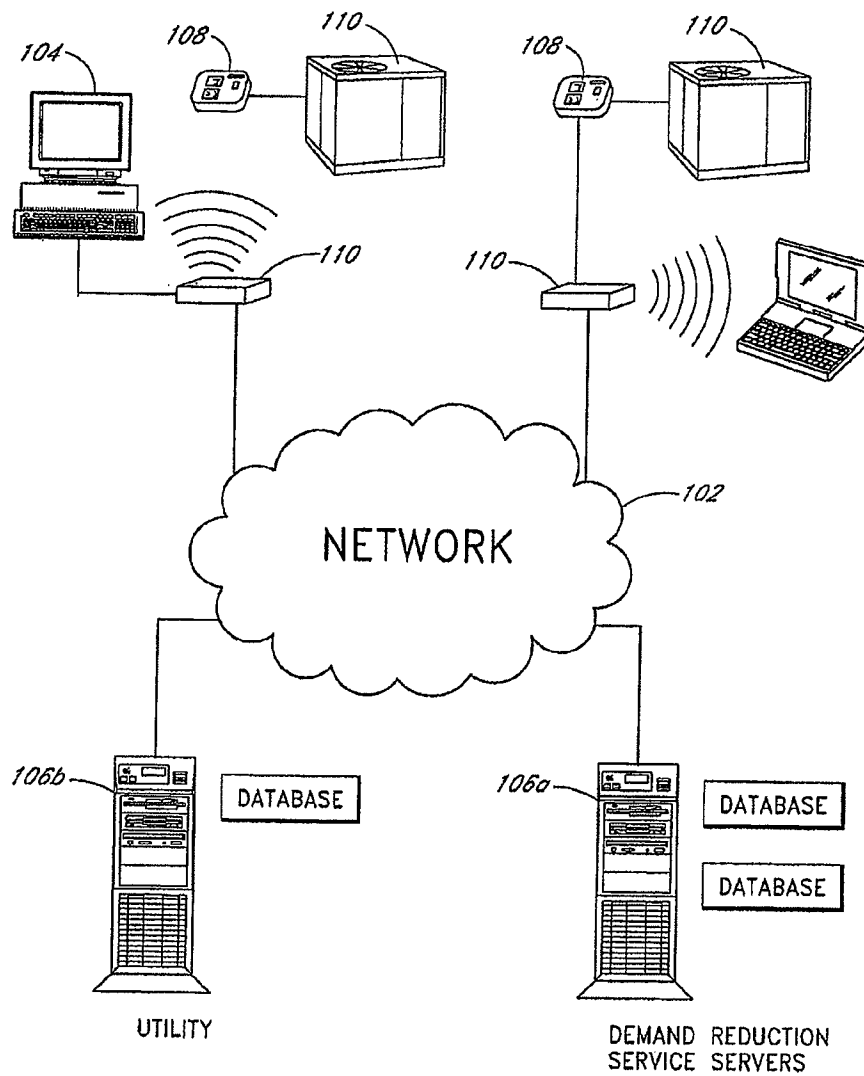


FIG. 2

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