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

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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.

(56) **References Cited**

U.S. PATENT DOCUMENTS

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

(Continued)

FOREIGN PATENT DOCUMENTS

EP 0415747 3/1991  
JP 05-189659 7/1993

(Continued)

OTHER PUBLICATIONS

U.S. Appl. No. 13/523,697, Jun. 14, 2012, Hublou, Scott Douglas et al.

(Continued)

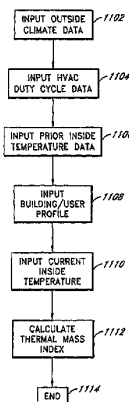
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(57) **ABSTRACT**

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.

**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	Lggulden 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	Ikedo 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.
7,216,015 B2	5/2007	Poth	2012/0158350 A1	6/2012	Steinberg et al.
7,231,424 B2	6/2007	Bodin et al.	2012/0215725 A1	8/2012	Imes et al.
			2012/0221151 A1	8/2012	Steinberg
			2012/0221718 A1	8/2012	Imes et al.
			2012/0252430 A1	10/2012	Imes et al.
			2012/0324119 A1	12/2012	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.  
 Converge 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

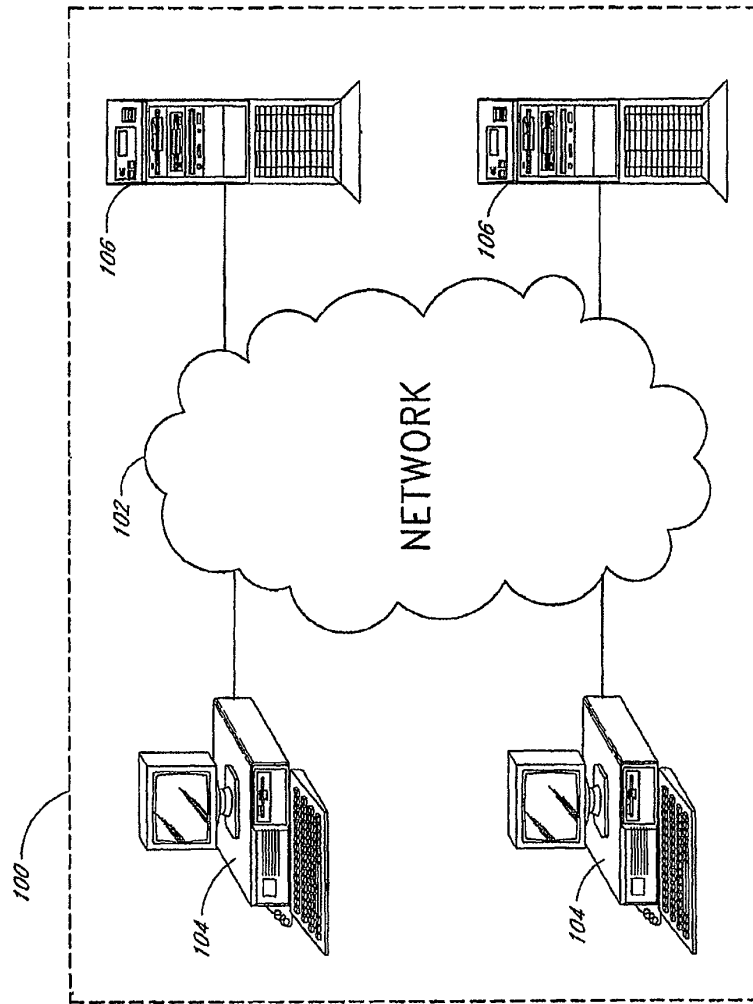


FIG. 1

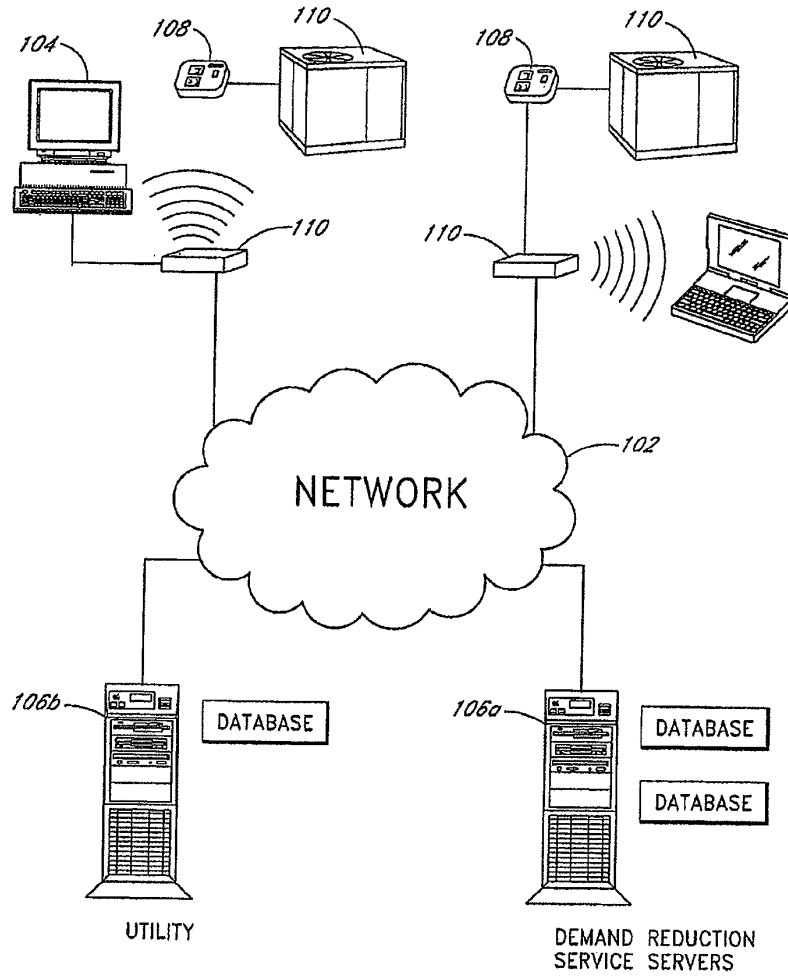


FIG. 2

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