US008305728B2

(12) **United States Patent**
Lee et al.

(10) **Patent No.: US 8,305,728 B2**
(45) **Date of Patent: Nov. 6, 2012**

(54) **METHODS AND APPARATUS FOR COOLING ELECTRONIC DEVICES**

(75) Inventors: **Jean L. Lee**, San Jose, CA (US); **Richard Lidio Blanco, Jr.**, Santa Clara, CA (US)

(73) Assignee: **Apple Inc.**, Cupertino, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 302 days.

(21) Appl. No.: **12/827,421**

(22) Filed: **Jun. 30, 2010**

(65) **Prior Publication Data**

US 2012/0002342 A1 Jan. 5, 2012

(51) **Int. Cl.**
H01T 23/00 (2006.01)

(52) **U.S. Cl.** **361/231**

(58) **Field of Classification Search** ..... None
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,139,879 A * 2/1979 Laws 361/230
4,549,639 A * 10/1985 Hansen 192/48.91
6,522,536 B2 2/2003 Brewer et al.
7,266,964 B2 * 9/2007 Vogel et al. 62/259.2
7,416,902 B2 * 8/2008 Pletcher et al. 436/174
7,839,634 B2 * 11/2010 Ouyang 361/691
2002/0126448 A1 * 9/2002 Brewer et al. 361/687
2006/0169441 A1 8/2006 Schlitz
2006/0176664 A1 * 8/2006 Casebolt 361/687
2007/0157402 A1 7/2007 Caffarella
2008/0060794 A1 * 3/2008 Wei 165/109.1
2009/0001787 A1 1/2009 Lawall et al.
2009/0321044 A1 * 12/2009 Hernon et al. 165/80.2
2009/0321056 A1 12/2009 Ran et al.

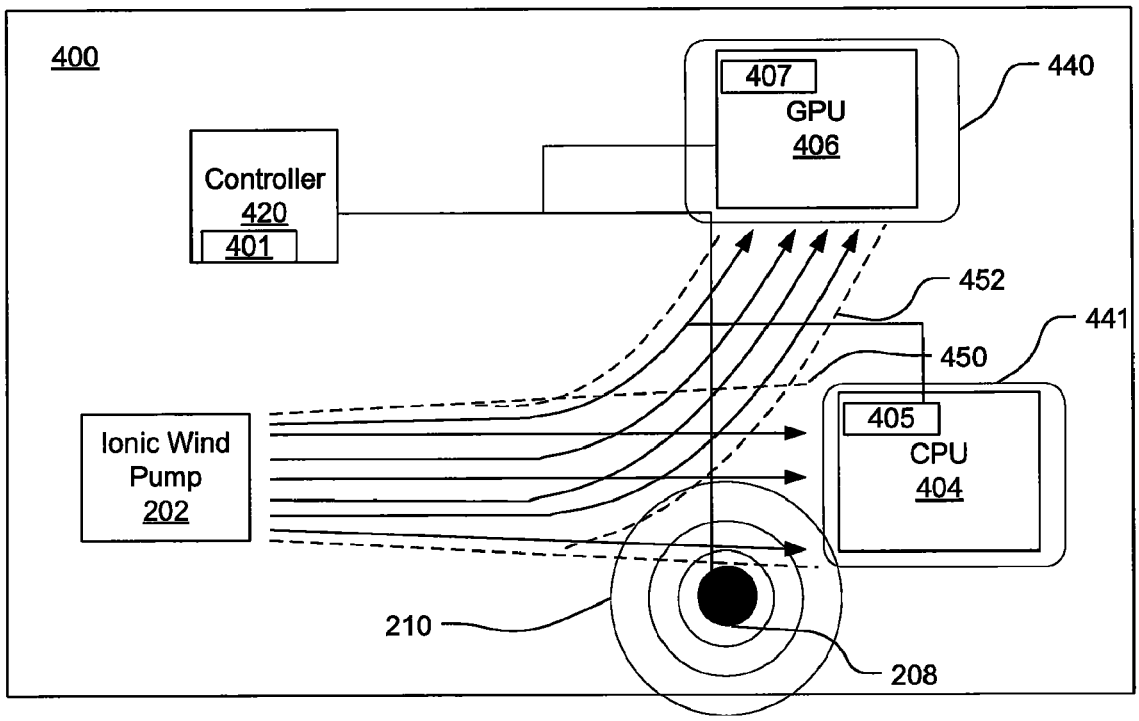
OTHER PUBLICATIONS

Jewell-Larsen, N. E., et al., "Electrohydrodynamic (EHD) Cooled Laptop", *25th IEEE Semi-Therm Symposium*, (2009), 7 pgs.

* cited by examiner

Primary Examiner — Stephen W Jackson
Assistant Examiner — Angela Brooks
(74) *Attorney, Agent, or Firm* — Park, Vaughan, Fleming & Dowler LLP

(57) **ABSTRACT**

Embodiments provide various apparatus and techniques for deflecting or redirecting a flow of ionized air generated from an ionic wind generator. In general, a deflection field generator can be located proximate to the path of the flow of ionized air. The deflection field generator is configured to generate an electromagnetic field, which deflects a least a portion of the flow of ionized air to a different path and may possibly increase local heat transfer.

18 Claims, 7 Drawing Sheets