AO 120 (Rev. 08/10)

TO: Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	**REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK**

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court USDC, Western District of Texas (Waco) on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
6:21-cv-00501	5/14/2021	USDC, Western District of Texas (Waco)

PLAINTIFF	DEFENDANT
ASETEK DANMARK A/S	SHENZHEN APALTEK CO., LTD., A/K/A SHENZHEN ANG PAI TECHNOLOGY CO., LTD. AND GUANGDONG APALTEK LIQUID COOLING TECHNOLOGY CO., LTD., A/K/A GUANGDONG ANG PAI LIQUID COOLING

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 8240362	8/14/2012	ASETEK DANMARK A/S
2 8245764	8/21/2012	ASETEK DANMARK A/S
3 10078355	9/18/2018	ASETEK DANMARK A/S
4 10599196	3/24/2020	ASETEK DANMARK A/S
5		

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	**DATE OF PATENT OR TRADEMARK**	**HOLDER OF PATENT OR TRADEMARK**
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In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT
5/6/2022 Motion to transfer case to the Northern District of California was granted. (document # 72).

CLERK	(BY) DEPUTY CLERK	DATE
Jeannette J. Clack		05/09/2022

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy

AO 120 (Rev. 08/10)

TO: **Mail Stop 8** **Director of the U.S. Patent and Trademark Office** **P.O. Box 1450** **Alexandria, VA 22313-1450**	**REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK**

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court USDC, Western District of Texas (Waco) on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO. 6:21-cv-00501	DATE FILED 5/14/2021	U.S. DISTRICT COURT USDC, Western District of Texas (Waco)
PLAINTIFF ASETEK DANMARK A/S		DEFENDANT SHENZHEN APALTEK CO., LTD., A/K/A SHENZHEN ANG PAI TECHNOLOGY CO., LTD. AND GUANGDONG APALTEK LIQUID COOLING TECHNOLOGY CO., LTD., A/K/A GUANGDONG ANG PAI LIQUID COOLING

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 8240362	8/14/2012	ASETEK DANMARK A/S
2 8245764	8/21/2012	ASETEK DANMARK A/S
3 10078355	9/18/2018	ASETEK DANMARK A/S
4 10599196	3/24/2020	ASETEK DANMARK A/S
5		

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
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In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy

PATENT
Customer No. 22,852
Attorney Docket No. 10494.0003-01000

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re U.S. Patent No.: 8,245,764 B2	)	
	)	
Inventor: Andre Sloth ERIKSEN	)	Group Art Unit: 3784
	)	
Issue Date.: August 21, 2012	)	Examiner: Emmanuel E. Duke
	)	
For: COOLING SYSTEM FOR A COMPUTER SYSTEM	)	Confirmation No.: 1954
	)	
		VIA EFS-WEB

Office of Public Records
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Madam:

COMBINED DESIGNATION OF DOMESTIC REPRESENTATIVE AND STATEMENT UNDER 37 C.F.R. § 3.73(b)

Pursuant to 35 U.S.C. § 293 and in accordance with 37 C.F.R. § 3.61 and M.P.E.P. § 302.04, the assignee of the above-identified patent, who does not reside in the United States, hereby designates:

Bend Law Group, PC
2181 Greenwich Street
San Francisco, CA 94123
Phone: (415) 633-6841

as the domestic representative on whom process or notice of proceedings affecting the patent may be served. The prior designation filed on January 30, 2015 is hereby revoked.

Asetek Danmark A/S, a corporation of Denmark, is the assignee of the entire right, title, and interest in the patent identified above by virtue of an assignment from inventor André Sloth Eriksen to Asetek A/S, recorded in the United States Patent and Trademark Office (USPTO) at Reel 028525, Frame 0059 on July 10, 2012, and a change of name from Asetek A/S to Asetek Danmark A/S, recorded in the USPTO at Reel 033748, Frame 0097 on September 16, 2014. Thus, in accordance with 37 C.F.R. § 3.73(b), the undersigned (whose title is supplied below) is empowered to sign this designation on behalf of the assignee.

I hereby declare that all statements made herein of my own knowledge are true, and that all statements made on information and belief are believed to be true; and further, that these statements are made with the knowledge that willful false statements, and the like so made, are punishable by fine or imprisonment, or both, under Section 1001, Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Respectfully submitted,

Asetek Danmark A/S

Dated: September 30, 2020

By: /André Sloth Eriksen/
André Sloth ERIKSEN
Chief Executive Officer

Dated: September 30, 2020

By: /Peter Dam Madsen/
Peter Dam MADSEN
Chairman of the Board

UNITED STATES
PATENT AND TRADEMARK OFFICE

P.O. Box 1450
Alexandria, VA 22313 - 1450
www.uspto.gov

ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
13/269,234	09/30/2020 07:11:32 PM ET	10494.0003-01000

Title of Invention

COOLING SYSTEM FOR A COMPUTER SYSTEM

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	8245764
CONFIRMATION #	1954	FILED BY	Donna Studley
PATENT CENTER #	60090245	FILING DATE	10/07/2011
CUSTOMER #	22852	FIRST NAMED INVENTOR	André Sloth ERIKSEN
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	Eric Raciti

Documents

TOTAL DOCUMENTS: 1

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
2020_09_30 As-Filed - 0003-01 - Combined Designation of Domestic Representative and Statement Under 37 C.F.R. 3.73b.pdf	2	Miscellaneous Incoming Letter	98 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
2020_09_30 As-Filed - 0003-01 - Combined Designation of Domestic Representative and	8FE153A4A1A45EBCDC5EA7C7C7BB72CB05F909E94C7F8444 7D0B6E6023251C043DA2B8D6BCE3C8D46B4968D93B3120841 3716E814E35A8B7950DC513723161EE

Statement Under 37 C.F.R.
3.73b.pdf

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

TO: **Mail Stop 8** **Director of the U.S. Patent & Trademark Office** **P.O. Box 1450** **Alexandria, VA 22313-1450**	**REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK**

In Compliance with 35 § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Northern District of California on the following:
(X) Patents or ( ) Trademarks

DOCKET NO:	DATE FILED:	UNITED STATES DISCTRICT COURT
16-cv-07068-EDL	December 9, 2016	Phillip Burton Federal Building 450 Golden Gate Avenue San Francisco, CA 94102

PLAINTIFF:
Asetek Danmark A/S

DEFENDANT:
Newegg Inc.

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1. **US 8,240,362 B2**	**Aug. 14, 2012**	**AsetekA/S,** Bronderslev (DK)
2. **US 8,245,764 B2**	**Aug. 21, 2012**	**AsetekA/S,** Bronderslev (DK)
3.		
4.		
5.		

In the above-entitled case, the following patent(s) have been included.

DATE INCLUDED INCLUDED BY:
( ) Amendment ( ) Answer ( ) Cross Bill ( ) Other Pleading

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
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In the above-entitled case, the following decision has been rendered or judgment issued:

DECISION/JUDGEMENT:

Susan Y. Soong

Susan Y. Soong, Clerk

Yumiko Saito

(by) Deputy Clerk, Yumiko Saito

Copy 1 – Upon initiation of action, mail this copy to Commissioner
Copy 2 – Upon filing document adding patent(s) mail this copy to Commissioner
Copy 3 – Upon termination of action, mail this copy to the Commissioner
Copy 4 – Case file copy

AO 120 (Rev. 08/10)

TO: **Mail Stop 8** **Director of the U.S. Patent and Trademark Office** **P.O. Box 1450** **Alexandria, VA 22313-1450**	**REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK**

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Eastern District of Virginia on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
1:14cv1293	9/30/2014	Eastern District of Virginia
PLAINTIFF Asia VItal Components Co., Ltd.		DEFENDANT Asetek Danmark A/S

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 8,240,362	8/14/2012	Asetek Danmark A/S
2 8,245,764	8/21/2012	Asetek Danmark A/S
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In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
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In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT
See Attached Order

CLERK	(BY) DEPUTY CLERK	DATE
Fernando Galindo	/s/ Richard Banke	5/11/2015

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy

AO 120 (Rev. 2/99)

TO: Mail Stop 8 Director of the U.S. Patent & Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	**REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK**

In Compliance with 35 § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Northern District of California on the following X Patents or ☐ Trademarks:

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
CV 12-04498 NC	8/27/12	450 Golden Gate Avenue, 16th Floor San Francisco, CA 94102

PLAINTIFF	DEFENDANT
ASETEK HOLDINGS INC	COOLIT SYSTEMS INC

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 SEE COMPLAINT		
2 8,240,362		
3 8,245,764		
4		
5		

In the above—entitled case, the following patent(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
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In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT
Stipulation and Order of Dismissal filed 2/9/2015

CLERK	(BY) DEPUTY CLERK	DATE
Richard W. Wieking	Alfred Amistoso	August 28, 2012

Copy 1—Upon initiation of action, mail this copy to Commissioner **Copy 3—Upon termination of action, mail this copy to Commissioner**
Copy 2—Upon filing document adding patent(s), mail this copy to Commissioner **Copy 4—Case file copy**

Robert F. McCauley (SBN 162056)
robert.mccauley@finnegan.com
Jeffrey D. Smyth (SBN 280665)
jeffrey.smyth@finnegan.com
FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER, LLP
3300 Hillview Avenue
Palo Alto, California 94304
Tel: (650) 849-6600
Fax: (650) 849-6666

Attorneys for Plaintiffs ASETEK HOLDINGS, INC. and ASETEK A/S

COOLEY LLP
HEIDI L. KEEFE (178960)
(hkeefe@cooley.com)
DANIEL J. KNAUSS (267414)
(dknauss@cooley.com)
Five Palo Alto Square
3000 El Camino Real
Palo Alto, CA 94306-2155
Telephone: (650) 843-5000
Facsimile: (650) 849-7400

DENNIS McCOOE
(mccooe@blankrome.com)
(admitted *Pro Hac Vice*)
BLANK ROME LLP
One Logan Square
130 North 18th Street
Philadelphia. PA 19103
Telephone: (215) 569-5580
Facsimile: (215) 832-5580

Attorneys for Defendant COOLIT SYSTEMS INC.

UNITED STATES DISTRICT COURT

NORTHERN DISTRICT OF CALIFORNIA

SAN FRANCISCO DIVISION

ASETEK HOLDINGS, INC. and ASETEK A/S, Plaintiffs and Counterclaim Defendants, v. COOLIT SYSTEMS INC., Defendant and Counterclaim Plaintiff.	CASE NO. 3:12-CV-04498-EMC **STIPULATED DISMISSAL OF ACTION WITH PREJUDICE;** **[PROPOSED] ORDER** Judge: Hon. Edward M. Chen

Pursuant to Fed. R. Civ. P. 41(a)(1)(A)(ii) and 41(c), Plaintiffs and Counterclaim Defendants Asetek Holdings, Inc. and Asetek A/S ("Asetek") and Defendant and Counterclaim Plaintiff CoolIT Systems Inc., ("CoolIT") stipulate that this action (*i.e.*, all claims and counterclaims) is dismissed with prejudice in its entirety. Magistrate Judge Grewal, or in his absence, the Northern District of California, will retain jurisdiction to enforce the parties' confidential settlement agreement (the terms of which are incorporated herein by reference). Each party shall bear its own attorneys fees and costs.

The parties further note for the record that the named plaintiff "Asetek A/S" is currently known as Asetek Danmark A/S and that references to "Asetek A/S" in this stipulation and proposed order refer to the corporate entity currently known as "Asetek Danmark A/S."

By his signature below, counsel for Asetek attests under penalty of perjury that counsel for CoolIT concurs in the filing of this document.

Dated: February 6, 2015

Respectfully submitted,

FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER, LLP

By: */s/Robert F. McCauley*
Robert F. McCauley

Attorneys for Plaintiff and Counterclaim Defendant Asetek Holdings, Inc. and Asetek A/S

Dated: February 6, 2015

COOLEY LLP

By: */s/Daniel J. Knauss*
Daniel J. Knauss
Attorneys for Defendant and Counterclaim Plaintiff CoolIT Systems Inc.

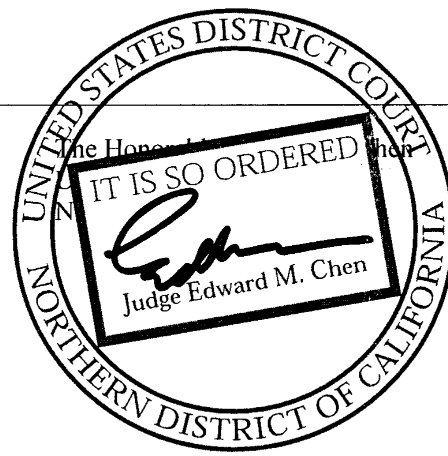
[~~PROPOSED~~] ORDER

PURSUANT TO STIPULATION OF ALL PARTIES, AND FOR GOOD CAUSE SHOWN:

This action (i.e., all claims and counterclaims) is dismissed with prejudice in its entirety, with Magistrate Judge Grewal, or in his absence, the Northern District of California, retaining jurisdiction to enforce the parties' confidential settlement agreement (the terms of which are incorporated herein by reference). Each party shall bear its own attorneys fees and costs.

IT IS SO ORDERED.

Dated: February 9 2015



OPAP
JAN 3 0 2015
PATENT & TRADEMARK OFFICE

2-3-15
13/269234

PATENT
Customer No. 22,852
Attorney Docket No. 10494.0003-01000

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re U.S. Patent No.: 8,245,764 B2	)
Inventor: Andre Sloth ERIKSEN	)
Issue Date.: August 21, 2012	)
For: COOLING SYSTEM FOR A COMPUTER SYSTEM	)

Office of Public Records
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Madam:

COMBINED DESIGNATION OF DOMESTIC REPRESENTATIVE AND STATEMENT UNDER 37 C.F.R. § 3.73(b)

Pursuant to 35 U.S.C. § 293 and in accordance with 37 C.F.R. § 3.61 and M.P.E.P. § 302.04, the assignee of the above-identified patent, who does not reside in the United States, hereby designates:

Corporation Service Company
2720 Gateway Oaks Dr.
Suite 150N
Sacramento, CA 95833
Phone: (916) 641-5100

as the domestic representative on whom process or notice of proceedings affecting the patent may be served.

Asetek Danmark A/S, a corporation of Denmark, is the assignee of the entire right, title and interest in the patent identified above by virtue of an assignment from Asetek A/S from the inventors of the patent, identified above, recorded in the U.S.

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FEB 04 2015

Patent and Trademark Office (USPTO) at Reel 28525, Frame 0059 on July 10, 2012, the name of Asetek A/S changed to Asetek Danmark A/S as recorded in the USPTO at Reel 33748, Reel 0097 on September 16, 2014. Thus, in accordance with 37 C.F.R. § 3.73(b), the undersigned (whose title is supplied below) is empowered to sign this designation on behalf of the assignee.

I hereby declare that all statements made herein of my own knowledge are true, and that all statements made on information and belief are believed to be true; and further, that these statements are made with the knowledge that willful false statements, and the like so made, are punishable by fine or imprisonment, or both, under Section 1001, Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Respectfully submitted,

Asetek Danmark A/S

Dated: January 27, 2015

By: /André Sloth Eriksen/
André Sloth ERIKSEN
Chief Executive Officer

Dated: January 27, 2015

By: /Peter Dam Madsen/
Peter Dam MADSEN
Chairman of the Board

Large Entity Declaration

Schedule A – Patents assigned to *Assignee*

APPLICATION NUMBER	FILING DATE	PATENT NUMBER	ISSUE DATE
		7926553	
		7971632	
		8240362	
13/269,239		8245764	
		8274787	
		8755179	
		8358505	
		8492691	
		8724315	
		8749968	

Large Entity Declaration

PATENT
IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

ASSERTION OF LARGE ENTITY STATUS
PURSUANT TO 37 C.F.R. §1.27 (g)(2)

Commissioner for Patents
Mail Stop M Correspondence
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

This communication hereby asserts that the patents identified in the attached Schedule A are entitled to large entity status.

COMPANY or FIRM NAME AND ADDRESS:

ASETEK

Asetek Danmark A/S
Assensvej 2
DK-9220 Aalborg Øst
Phone +45 9645 0047
Fax +45 9645 0048
CVR nr. 25210980

Respectfully submitted,

Signature

OLE MADSEN

Printed Name

VP ENGINEERING

Title

OR

Reg. # if US Attorney ____________

AO 120 (Rev. 08/10)

TO: **Mail Stop 8** **Director of the U.S. Patent and Trademark Office** **P.O. Box 1450** **Alexandria, VA 22313-1450**	**REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK**

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Eastern District of Virginia, Alexandria Division on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
1:14cv1293	9/30/2014	Eastern District of Virginia, Alexandria Division

PLAINTIFF	DEFENDANT
ASIA VITAL COMPONENTS CO., LTD	ASETEK DANMARK A/S

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 8,240,362	8/14/2012	Asetek Danmark A/S
2 8,245,764	8/21/2012	Asetek Danmark A/S
3		
4		
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In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
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In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	PATENT NUMBER	GROUP ART UNIT	FILE WRAPPER LOCATION
13/269,234	8245764	3784	9200

OC000000062970214

Correspondence Address/Fee Address Change

The following fields have been set to Customer Number 197 on 07/31/2013

- **Maintenance Fee Address**

The address of record for Customer Number 197 is:

197
CPA GLOBL LIMITED
2318 Mill Road 12th Floor
ALEXANDRIA, VA 22314

PART 1 - ATTORNEY/APPLICANT COPY

AO 120 (Rev. 2/99)

TO: Mail Stop 8 Director of the U.S. Patent & Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	**REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK**

In Compliance with 35 § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court ______________________ on the following X Patents or ☐ Trademarks:

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
CV 12-04498 ~~NC~~ EMC	8/27/12	450 Golden Gate Avenue, 16th Floor San Francisco, CA 94102

PLAINTIFF	DEFENDANT
ASETEK HOLDINGS INC	COOLIT SYSTEMS INC

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 SEE COMPLAINT		
2 8,240,362		
3 8,245,764		
4		
5		

In the above—entitled case, the following patent(s) have been included:

DATE INCLUDED	INCLUDED BY
	☑ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
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In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE
Richard W. Wieking	Alfred Amistoso	August 28, 2012

Copy 1—Upon initiation of action, mail this copy to Commissioner Copy 3—Upon termination of action, mail this copy to Commissioner
Copy 2—Upon filing document adding patent(s), mail this copy to Commissioner Copy 4—Case file copy

✎ AO 120 (Rev. 2/99)

TO: **Mail Stop 8** **Director of the U.S. Patent & Trademark Office** **P.O. Box 1450** **Alexandria, VA 22313-1450**	**REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK**

In Compliance with 35 § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Northern District of California on the following X Patents or ☐ Trademarks:

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
CV 13-00457 JSC	1/31/13	United States District Court, Northern District of California

PLAINTIFF	DEFENDANT
ASETEK HOLDINGS INC	COOLER MASTER CO

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 8,246,362		
2 8,245,764		
3		
4		
5		

In the above—entitled case, the following patent(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	**DATE OF PATENT OR TRADEMARK**	**HOLDER OF PATENT OR TRADEMARK**
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In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE
Richard W. Wieking	Gloria Acevedo	February 1, 2013

Copy 1—Upon initiation of action, mail this copy to Commissioner Copy 3—Upon termination of action, mail this copy to Commissioner
Copy 2—Upon filing document adding patent(s), mail this copy to Commissioner Copy 4—Case file copy

AO 120 (Rev. 2/99)

TO: Mail Stop 8 Director of the U.S. Patent & Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	**REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK**

In Compliance with 35 § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court ______________________ on the following X Patents or ☐ Trademarks:

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
CV 12-04498 NC	8/27/12	450 Golden Gate Avenue, 16th Floor San Francisco, CA 94102

PLAINTIFF	DEFENDANT
ASETEK HOLDINGS INC	COOLIT SYSTEMS INC

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 SEE COMPLAINT		
2 8,240,362		
3 8,245,764		
4		
5		

In the above—entitled case, the following patent(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
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In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE
Richard W. Wieking	Alfred Amistoso	August 28, 2012

Copy 1—Upon initiation of action, mail this copy to Commissioner Copy 3—Upon termination of action, mail this copy to Commissioner
Copy 2—Upon filing document adding patent(s), mail this copy to Commissioner Copy 4—Case file copy

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Tel: (650) 849-6600
Fax: (650) 849-6666

Attorneys for Plaintiffs ASETEK HOLDINGS, INC.
and ASETEK A/S

NC

UNITED STATES DISTRICT COURT

NORTHERN DISTRICT OF CALIFORNIA

ASETEK HOLDINGS, INC. and ASETEK A/S,

Plaintiffs,

v.

COOLIT SYSTEMS INC.,

Defendant.

CV 12 4498

CASE NO.

COMPLAINT FOR PATENT INFRINGEMENT

DEMAND FOR JURY TRIAL

COMES NOW Plaintiffs Asetek A/S ("Asetek") and Asetek Holdings, Inc., by and through their attorneys, and for their Complaint against CoolIT Systems Inc. ("CoolIT" or "Defendant"), state as follows:

Nature of the Action

1. This Complaint seeks judgment that CoolIT has infringed and continues to infringe Asetek's U.S. Patent Nos. 8,240,362 ("the '362 patent") and 8,245,764 ("the '764 patent") (collectively, "the Patents-in-Suit"). The Patents-in-Suit relate to a cooling system and cooling method for a computer system. A true and accurate copy of the '362 patent is attached hereto as Exhibit A. A true and accurate copy of the '764 patent is attached hereto as Exhibit B.

The Parties

2. Plaintiff Asetek Holdings, Inc. is organized and exists under the laws of Delaware. Asetek Holdings, Inc.'s principal place of business is 5285 Hellyer Avenue, Suite 110, San Jose, California 95138.

3. Plaintiff Asetek is a corporation organized and existing under the laws of Denmark, and has its principal place of business at Saltumvej 27, DK-9700 Broenderslev, Denmark. Asetek is the owner of the Patents-in-Suit, and is a wholly owned subsidiary of Asetek Holdings, Inc.

4. Upon information and belief, Defendant CoolIT is a corporation operating and existing under the laws of Canada with its principal place of business at 3920 29th Street NE, Calgary, Alberta, Canada T1Y 6B6.

Jurisdiction

5. This Court has subject matter jurisdiction over this complaint pursuant to 28 U.S.C. §§ 1331 and 1338(a), and under the patent laws of the United States, 35 U.S.C. § 1, *et seq.*

6. This Court has personal jurisdiction over CoolIT because CoolIT infringes the Patents-in-Suit in the United States, in California, and in this judicial district. CoolIT maintains a website via which it promotes and offers to sell its infringing products to customers, including customers in the United States, in California, and in this judicial district. Among other things, upon information and belief, CoolIT offers to sell and sells its infringing products to Corsair Components, Inc. and Corsair Memory, Inc. (collectively "Corsair") for importation, promotion, sales, and distribution to end users

throughout the United States, including in California and in this judicial district. Corsair's principal place of business is in Fremont, California, in this judicial district. CoolIT's website identifies Corsair as a "proud retailer of CoolIT's liquid cooling solutions." CoolIT further identifies Corsair as a "retail partner" on its website, and further states that "[d]ue to our partnership with Corsair for the retail market, please visit the Corsair website for any direct retail sales inquiries." Upon information and belief, CoolIt has entered into one or more contracts with Corsair for this "partnership" and the promotion, importation, offers for sale, sale, and distribution of CoolIT products, including products that infringe the Patent-in-Suit, to end users in the United States (including California and this judicial district). Upon information and belief, CoolIT derives substantial revenue from its sales of infringing products to Corsair in California and this judicial district, and CoolIT purposefully avails itself of the privilege of conducting activities in California, thus invoking the benefits and protections of the laws of California.

Facts

7. Asetek is the world leading provider of CPU and GPU liquid cooling systems for thermal and acoustic management. Asetek's solutions are used by leading OEMs servicing the gaming, workstation and performance PC markets. In 2006, the company made a strategic decision to shift its focus to providing water-based cooling solutions for the OEM market and introduced the first fully assembled, factory sealed liquid cooling system. In addition to being designed for manufacturing and providing up to 50,000 hours of maintenance-free operation, Asetek shattered liquid cooling's price barriers. Asetek is now the vendor of choice for CPU cooling in factory overclocked gaming systems, serving Dell Alienware, Acer and multiple leading gaming system providers.

8. Asetek is also active in the workstation market, supplying liquid cooling for HP's Z400 and Z800 workstations and several tier 2 workstation suppliers. "Quiet computing" and reliability are the principle drivers for superior thermal management within the workstation market. Liquid cooling delivers both by moving heat to a location where it can be exhausted directly from the chassis using modest air flow velocities, reducing internal chassis temperatures and lowering system noise.

9. Asetek is addressing the server market with its new low profile integrated pump and cold plate CPU cooler. The low profile pump is sized perfectly to fit in 1U rack servers. The company's heat exchanger technology for servers is derived from solutions the company has developed for all-in-one and notebook PCs. Within the server market the key benefits of water-based cooling are enabling increased thermal density and energy savings.

10. CoolIT identifies itself a "leading supplier of reliable and customizable liquid cooling solutions for computers." CoolIT touts its liquid cooling solutions for computers by stating on its website (www.coolitsystems.com), among other things, that:

> If you are integrating liquid cooling into your systems today or are looking to do so soon, CoolIT offers customizable solutions that fit your specific requirements.
>
> . . .
>
> ***The Future of Enterprise Cooling***
>
> Liquid cooling has recently become a requirement of high-end desktop processors with the launch of the Intel® Core™ i7-3900 series. . . .
>
> CoolIT Systems . . . offers a compelling alternative with the ECO II series self-contained liquid coolers. ECO II was designed from the ground up to be the highest performance liquid solution available with a design featuring thoughtful touches to make integration easier and faster.

11. Upon information and belief, CoolIT is an original equipment manufacturer ("OEM") and manufactures at least the H60, H80, and H100 liquid cooling products that infringe the Patents-in-Suit. Upon information and belief, CoolIT offers to sell and sells at least the H60, H80, and H100 products to, at least, Corsair in the United States, and Corsair then offers to sell and sells them to end users in the United States, in California, and in this judicial district. Upon information and belief, CoolIT's claimed "partner" Corsair has demonstrated these CoolIT products at trade shows within the United States, and has sent out product samples to potential customers within the United States. Upon information and belief, CoolIT is also offering to sell and is selling cooling products that infringe the Patents-in-Suit to additional resellers in the United States, who then offer to sell and sell them to end in the United States.

COUNT I

Infringement of U.S. Patent No. 8,240,362

12. Plaintiffs incorporate by reference each and every allegation set forth in paragraphs 1 through 11 of this Complaint as if fully set forth and restated herein.

13. The '362 patent entitled "Cooling System for a Computer System" was duly and legally issued by the United States Patent and Trademark Office ("PTO") on August 14, 2012. Asetek is the sole and exclusive owner of the '362 patent. CoolIT, without authority or consent of Asetek, has been and continues to offer to sell and sell in the United States products that infringe the '362 patent, including but not limited to the H60, H80, and H100 cooling products. CoolIt has directly infringed and continues to directly infringe the '362 patent.

14. At least as of the date of this complaint, CoolIT has knowledge of the '362 patent and, upon information and belief, has induced and continues to induce direct infringement of the '362 patent by aiding and abetting infringement by customers in the United States, including but not limited to customers of the H60, H80, and H100 cooling products. CoolIT has intentionally taken action that has actually induced and continues to induce direct infringement by customers in the United States, and has known that the acts it has been and is causing infringe the '362 patent. These acts include, but are not limited to, CoolIT's promotion on its website and its partnership with Corsair for the promotion, offers to sell, and sales of H60, H80, and H100 cooling products in the United States.

15. At least as of the date of this complaint, CoolIT has knowledge of the '362 patent and has contributed and continues to contribute to direct infringement of the '362 patent by supplying an important (material) component of the infringing products and method to customers in the United States, including but not limited to the H60, H80, and H100 cooling products, which are not a common components suitable for non-infringing use. CoolIT supplies the components with knowledge of the '362 patent and knowledge that the components were especially made or adapted for use in an infringing manner, and that customers and end users directly infringe the '362 patent in the United States.

16. CoolIT's infringement of the '362 patent has caused and continues to cause damages and irreparable harm to Plaintiffs.

COUNT II

Patent Infringement of U.S. Patent No. 8.245,764

17. Plaintiffs incorporate by reference each and every allegation set forth in paragraphs 1 through 16 of its Complaint as if fully set forth and restated herein.

18. The '764 patent entitled "Cooling System for a Computer System" was duly and legally issued by the United States Patent and Trademark Office ("PTO") on August 21, 2012. Asetek is the sole and exclusive owner of the '764 patent. CoolIT, without authority or consent of Asetek, has been and continues to offer to sell and sell in the United States products that infringe the '764 patent, including but not limited to the H60, H80, and H100 cooling products. CoolIt has directly infringed and continues to directly infringe the '764 patent.

19. At least as of the date of this complaint, CoolIT has knowledge of the '764 patent and, upon information and belief, has induced and continues to induce direct infringement of the '764 patent by aiding and abetting infringement by customers in the United States, including but not limited to customers of the H60, H80, and H100 cooling products. CoolIT has intentionally taken action that has actually induced and continues to induce direct infringement by customers and end users in the United States, and has known that the acts it has been causing would infringe the '764 patent. These acts include, but are not limited to, CoolIT's promotion on its website and its partnership with Corsair for the promotion, offers to sell, and sales of H60, H80, and H100 cooling products to customers and end users in the United States.

20. At least as of the date of this complaint, CoolIT has knowledge of the '764 patent and has contributed and continues to contribute to direct infringement of the '764 patent by supplying an important (material) component of the infringing products and method to customers and end users in the United States, including but not limited to the H60, H80, and H100 cooling products, which are not a common components suitable for non-infringing use. CoolIT supplies the components with knowledge of the '764 patent and knowledge that the components were especially made or adapted for use in an infringing manner, and that customers and end users directly infringe the '764 patent in the United States.

21. CoolIT's infringement of the '764 patent has caused and continues to cause damages and irreparable harm to Plaintiffs.

PRAYER

WHEREFORE, Plaintiffs respectfully pray that the Court enter judgment in their favor and award the following relief against CoolIT:

A. A judgment in favor of Plaintiffs that CoolIT has infringed, directly, contributorily, and by inducement, the Patents-in-Suit;

B. Preliminarily and permanently enjoin CoolIT and its officers, directors, employees, agents, licensees, representatives, affiliates, related companies, servants, successors and assigns, and any and all persons acting in privity or in concert with any of them, from further infringing upon the Patents-in-Suit;

C. Award Plaintiffs actual damages pursuant to 35 U.S.C. § 284, in an amount to be determined at trial, as a result of CoolIT's infringement of the Patents-in-Suit;

D. Find this to be an exceptional case and award Plaintiffs their costs and attorney's fees under 28 U.S.C. § 285; and

E. Award and grant Plaintiffs such other and further relief as the Court deems just and proper under the circumstances.

DEMAND FOR JURY TRIAL

Plaintiffs demand a jury trial on all matters triable to a jury.

Dated: August 27, 2012

FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER, LLP

By: Robert McCauley

Robert F. McCauley
Attorneys for Plaintiffs
Asetek A/S and Asetek Holdings, Inc.

✎ AO 120 (Rev. 2/99)

TO: **Mail Stop 8** **Director of the U.S. Patent & Trademark Office** **P.O. Box 1450** **Alexandria, VA 22313-1450**	**REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK**

In Compliance with 35 § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court ______________________ on the following X Patents or ☐ Trademarks:

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
CV 12-04498 NC	8/27/12	450 Golden Gate Avenue, 16th Floor San Francisco, CA 94102

PLAINTIFF	DEFENDANT
ASETEK HOLDINGS INC	COOLIT SYSTEMS INC

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 SEE COMPLAINT		
2 8,240,362		
3 8,245,764		
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In the above—entitled case, the following patent(s) have been included:

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PATENT OR TRADEMARK NO.	**DATE OF PATENT OR TRADEMARK**	**HOLDER OF PATENT OR TRADEMARK**
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In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE
Richard W. Wieking	Alfred Amistoso	August 28, 2012

Copy 1—Upon initiation of action, mail this copy to Commissioner Copy 3—Upon termination of action, mail this copy to Commissioner
Copy 2—Upon filing document adding patent(s), mail this copy to Commissioner Copy 4—Case file copy

Robert F. McCauley (SBN 162056)
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GARRETT & DUNNER, LLP
3300 Hillview Avenue
Palo Alto, California 94304
Tel: (650) 849-6600
Fax: (650) 849-6666

Attorneys for Plaintiffs ASETEK HOLDINGS, INC. and ASETEK A/S

NC

UNITED STATES DISTRICT COURT

NORTHERN DISTRICT OF CALIFORNIA

ASETEK HOLDINGS, INC. and ASETEK A/S, Plaintiffs, v. COOLIT SYSTEMS INC., Defendant.	CV 12 4498 CASE NO. **COMPLAINT FOR PATENT INFRINGEMENT** **DEMAND FOR JURY TRIAL**

COMES NOW Plaintiffs Asetek A/S ("Asetek") and Asetek Holdings, Inc., by and through their attorneys, and for their Complaint against CoolIT Systems Inc. ("CoolIT" or "Defendant"), state as follows:

Nature of the Action

1. This Complaint seeks judgment that CoolIT has infringed and continues to infringe Asetek's U.S. Patent Nos. 8,240,362 ("the '362 patent") and 8,245,764 ("the '764 patent") (collectively, "the Patents-in-Suit"). The Patents-in-Suit relate to a cooling system and cooling method for a computer system. A true and accurate copy of the '362 patent is attached hereto as Exhibit A. A true and accurate copy of the '764 patent is attached hereto as Exhibit B.

The Parties

2. Plaintiff Asetek Holdings, Inc. is organized and exists under the laws of Delaware. Asetek Holdings, Inc.'s principal place of business is 5285 Hellyer Avenue, Suite 110, San Jose, California 95138.

3. Plaintiff Asetek is a corporation organized and existing under the laws of Denmark, and has its principal place of business at Saltumvej 27, DK-9700 Broenderslev, Denmark. Asetek is the owner of the Patents-in-Suit, and is a wholly owned subsidiary of Asetek Holdings, Inc.

4. Upon information and belief, Defendant CoolIT is a corporation operating and existing under the laws of Canada with its principal place of business at 3920 29th Street NE, Calgary, Alberta, Canada T1Y 6B6.

Jurisdiction

5. This Court has subject matter jurisdiction over this complaint pursuant to 28 U.S.C. §§ 1331 and 1338(a), and under the patent laws of the United States, 35 U.S.C. § 1, *et seq.*

6. This Court has personal jurisdiction over CoolIT because CoolIT infringes the Patents-in-Suit in the United States, in California, and in this judicial district. CoolIT maintains a website via which it promotes and offers to sell its infringing products to customers, including customers in the United States, in California, and in this judicial district. Among other things, upon information and belief, CoolIT offers to sell and sells its infringing products to Corsair Components, Inc. and Corsair Memory, Inc. (collectively "Corsair") for importation, promotion, sales, and distribution to end users

throughout the United States, including in California and in this judicial district. Corsair's principal place of business is in Fremont, California, in this judicial district. CoolIT's website identifies Corsair as a "proud retailer of CoolIT's liquid cooling solutions." CoolIT further identifies Corsair as a "retail partner" on its website, and further states that "[d]ue to our partnership with Corsair for the retail market, please visit the Corsair website for any direct retail sales inquiries." Upon information and belief, CoolIt has entered into one or more contracts with Corsair for this "partnership" and the promotion, importation, offers for sale, sale, and distribution of CoolIT products, including products that infringe the Patent-in-Suit, to end users in the United States (including California and this judicial district). Upon information and belief, CoolIT derives substantial revenue from its sales of infringing products to Corsair in California and this judicial district, and CoolIT purposefully avails itself of the privilege of conducting activities in California, thus invoking the benefits and protections of the laws of California.

Facts

7. Asetek is the world leading provider of CPU and GPU liquid cooling systems for thermal and acoustic management. Asetek's solutions are used by leading OEMs servicing the gaming, workstation and performance PC markets. In 2006, the company made a strategic decision to shift its focus to providing water-based cooling solutions for the OEM market and introduced the first fully assembled, factory sealed liquid cooling system. In addition to being designed for manufacturing and providing up to 50,000 hours of maintenance-free operation, Asetek shattered liquid cooling's price barriers. Asetek is now the vendor of choice for CPU cooling in factory overclocked gaming systems, serving Dell Alienware, Acer and multiple leading gaming system providers.

8. Asetek is also active in the workstation market, supplying liquid cooling for HP's Z400 and Z800 workstations and several tier 2 workstation suppliers. "Quiet computing" and reliability are the principle drivers for superior thermal management within the workstation market. Liquid cooling delivers both by moving heat to a location where it can be exhausted directly from the chassis using modest air flow velocities, reducing internal chassis temperatures and lowering system noise.

9. Asetek is addressing the server market with its new low profile integrated pump and cold plate CPU cooler. The low profile pump is sized perfectly to fit in 1U rack servers. The company's heat exchanger technology for servers is derived from solutions the company has developed for all-in-one and notebook PCs. Within the server market the key benefits of water-based cooling are enabling increased thermal density and energy savings.

10. CoolIT identifies itself a "leading supplier of reliable and customizable liquid cooling solutions for computers." CoolIT touts its liquid cooling solutions for computers by stating on its website (www.coolitsystems.com), among other things, that:

> If you are integrating liquid cooling into your systems today or are looking to do so soon, CoolIT offers customizable solutions that fit your specific requirements.
>
> . . .
>
> ***The Future of Enterprise Cooling***
>
> Liquid cooling has recently become a requirement of high-end desktop processors with the launch of the Intel® Core™ i7-3900 series. . . .
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> CoolIT Systems . . . offers a compelling alternative with the ECO II series self-contained liquid coolers. ECO II was designed from the ground up to be the highest performance liquid solution available with a design featuring thoughtful touches to make integration easier and faster.

11. Upon information and belief, CoolIT is an original equipment manufacturer ("OEM") and manufactures at least the H60, H80, and H100 liquid cooling products that infringe the Patents-in-Suit. Upon information and belief, CoolIT offers to sell and sells at least the H60, H80, and H100 products to, at least, Corsair in the United States, and Corsair then offers to sell and sells them to end users in the United States, in California, and in this judicial district. Upon information and belief, CoolIT's claimed "partner" Corsair has demonstrated these CoolIT products at trade shows within the United States, and has sent out product samples to potential customers within the United States. Upon information and belief, CoolIT is also offering to sell and is selling cooling products that infringe the Patents-in-Suit to additional resellers in the United States, who then offer to sell and sell them to end in the United States.

COUNT I

Infringement of U.S. Patent No. 8,240,362

12. Plaintiffs incorporate by reference each and every allegation set forth in paragraphs 1 through 11 of this Complaint as if fully set forth and restated herein.

13. The '362 patent entitled "Cooling System for a Computer System" was duly and legally issued by the United States Patent and Trademark Office ("PTO") on August 14, 2012. Asetek is the sole and exclusive owner of the '362 patent. CoolIT, without authority or consent of Asetek, has been and continues to offer to sell and sell in the United States products that infringe the '362 patent, including but not limited to the H60, H80, and H100 cooling products. CoolIt has directly infringed and continues to directly infringe the '362 patent.

14. At least as of the date of this complaint, CoolIT has knowledge of the '362 patent and, upon information and belief, has induced and continues to induce direct infringement of the '362 patent by aiding and abetting infringement by customers in the United States, including but not limited to customers of the H60, H80, and H100 cooling products. CoolIT has intentionally taken action that has actually induced and continues to induce direct infringement by customers in the United States, and has known that the acts it has been and is causing infringe the '362 patent. These acts include, but are not limited to, CoolIT's promotion on its website and its partnership with Corsair for the promotion, offers to sell, and sales of H60, H80, and H100 cooling products in the United States.

15. At least as of the date of this complaint, CoolIT has knowledge of the '362 patent and has contributed and continues to contribute to direct infringement of the '362 patent by supplying an important (material) component of the infringing products and method to customers in the United States, including but not limited to the H60, H80, and H100 cooling products, which are not a common components suitable for non-infringing use. CoolIT supplies the components with knowledge of the '362 patent and knowledge that the components were especially made or adapted for use in an infringing manner, and that customers and end users directly infringe the '362 patent in the United States.

16. CoolIT's infringement of the '362 patent has caused and continues to cause damages and irreparable harm to Plaintiffs.

COUNT II

Patent Infringement of U.S. Patent No. 8.245,764

17. Plaintiffs incorporate by reference each and every allegation set forth in paragraphs 1 through 16 of its Complaint as if fully set forth and restated herein.

18. The '764 patent entitled "Cooling System for a Computer System" was duly and legally issued by the United States Patent and Trademark Office ("PTO") on August 21, 2012. Asetek is the sole and exclusive owner of the '764 patent. CoolIT, without authority or consent of Asetek, has been and continues to offer to sell and sell in the United States products that infringe the '764 patent, including but not limited to the H60, H80, and H100 cooling products. CoolIt has directly infringed and continues to directly infringe the '764 patent.

19. At least as of the date of this complaint, CoolIT has knowledge of the '764 patent and, upon information and belief, has induced and continues to induce direct infringement of the '764 patent by aiding and abetting infringement by customers in the United States, including but not limited to customers of the H60, H80, and H100 cooling products. CoolIT has intentionally taken action that has actually induced and continues to induce direct infringement by customers and end users in the United States, and has known that the acts it has been causing would infringe the '764 patent. These acts include, but are not limited to, CoolIT's promotion on its website and its partnership with Corsair for the promotion, offers to sell, and sales of H60, H80, and H100 cooling products to customers and end users in the United States.

20. At least as of the date of this complaint, CoolIT has knowledge of the '764 patent and has contributed and continues to contribute to direct infringement of the '764 patent by supplying an important (material) component of the infringing products and method to customers and end users in the United States, including but not limited to the H60, H80, and H100 cooling products, which are not a common components suitable for non-infringing use. CoolIT supplies the components with knowledge of the '764 patent and knowledge that the components were especially made or adapted for use in an infringing manner, and that customers and end users directly infringe the '764 patent in the United States.

21. CoolIT's infringement of the '764 patent has caused and continues to cause damages and irreparable harm to Plaintiffs.

PRAYER

WHEREFORE, Plaintiffs respectfully pray that the Court enter judgment in their favor and award the following relief against CoolIT:

A. A judgment in favor of Plaintiffs that CoolIT has infringed, directly, contributorily, and by inducement, the Patents-in-Suit;

B. Preliminarily and permanently enjoin CoolIT and its officers, directors, employees, agents, licensees, representatives, affiliates, related companies, servants, successors and assigns, and any and all persons acting in privity or in concert with any of them, from further infringing upon the Patents-in-Suit;

C. Award Plaintiffs actual damages pursuant to 35 U.S.C. § 284, in an amount to be determined at trial, as a result of CoolIT's infringement of the Patents-in-Suit;

D. Find this to be an exceptional case and award Plaintiffs their costs and attorney's fees under 28 U.S.C. § 285; and

E. Award and grant Plaintiffs such other and further relief as the Court deems just and proper under the circumstances.

DEMAND FOR JURY TRIAL

Plaintiffs demand a jury trial on all matters triable to a jury.

Dated: August 27, 2012

FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER, LLP

By: Robert McCauley

Robert F. McCauley
Attorneys for Plaintiffs
Asetek A/S and Asetek Holdings, Inc.

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 8,245,764 B2
APPLICATION NO. : 13/269234
DATED : August 21, 2012
INVENTOR(S) : André Sloth Eriksen

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

Claim 10, col. 28, line 37, "vertically spaced part" should read --vertically spaced apart--.

Signed and Sealed this
Twenty-fifth Day of September, 2012

David J. Kappos

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

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re U.S. Patent No.: 8,245,764 B2	)
Inventors: **André Sloth ERIKSEN**	)
Issue Date: August 21, 2012	) ***VIA EFS-Web***
For: COOLING SYSTEM FOR A COMPUTER SYSTEM	)

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Commissioner:

REQUEST FOR CERTIFICATE OF CORRECTION

Pursuant to 35 U.S.C. § 255, and 37 C.F.R. § 1.323, this is a request for a Certificate of Correction related to the above-identified patent. The mistake identified in the appended Form is of a clerical or typographical nature, or of minor character, and resulted from an error made in good faith by patentee. Since the error is the fault of the patentee, the fee of $100.00 set forth in 37 C.F.R. § 1.20(a) is being paid concurrently herewith.

The complete Certificate of Correction involves one (1) page. Issuance of the Certificate of Correction containing the correction is earnestly requested.

Please charge any required fees not included herewith to Deposit Account No. 06-0916.

Respectfully submitted,

FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER, LLP

Dated: August 23, 2012

By: */Eric P. Raciti/*
Eric P. Raciti
Reg. No. 41,475

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. 8,245,764 B2 Page 1 of 1

APPLICATION NO.: 13/269,234

ISSUE DATE: August 21, 2012

INVENTOR(S): **André Sloth ERIKSEN**

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

Claim 10, col. 28, line 37, “vertically spaced part” should read --vertically spaced apart--.

MAILING ADDRESS OF SENDER

Finnegan, Henderson, Farabow,
Garrett & Dunner, LLP
901 New York Avenue, N.W.
Washington, D.C. 20001-4413

Electronic Patent Application Fee Transmittal

Application Number:	13269234
Filing Date:	07-Oct-2011
Title of Invention:	COOLING SYSTEM FOR A COMPUTER SYSTEM
First Named Inventor/Applicant Name:	André Sloth ERIKSEN
Filer:	Adriana Leigh Burgy/Amy-Marie Gonnella
Attorney Docket Number:	10494.0003-01000

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Certificate of correction	1811	1	100	100
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
		Total in USD ($)		**100**

Electronic Acknowledgement Receipt

EFS ID:	13568737
Application Number:	13269234
International Application Number:	
Confirmation Number:	1954
Title of Invention:	COOLING SYSTEM FOR A COMPUTER SYSTEM
First Named Inventor/Applicant Name:	André Sloth ERIKSEN
Customer Number:	22852
Filer:	Adriana Leigh Burgy/Amy-Marie Gonnella
Filer Authorized By:	Adriana Leigh Burgy
Attorney Docket Number:	10494.0003-01000
Receipt Date:	23-AUG-2012
Filing Date:	07-OCT-2011
Time Stamp:	11:35:29
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$100
RAM confirmation Number	10817
Deposit Account	
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)

1	Request for Certificate of Correction	Certificate_of_Correction.pdf	26063 fdf36eb56e2637c8be7922ef39a1dc42625df141	no	3
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	30084 d21daf921a459869060bde52e1249598b652cb60	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	56147		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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P.O. Box 1450
Alexandria, Virginia 22313-1450
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APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/269,234	08/21/2012	8245764	10494.0003-01000	1954

22852 7590 08/01/2012

FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER LLP
901 NEW YORK AVENUE, NW
WASHINGTON, DC 20001-4413

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

André Sloth ERIKSEN, Aalborg C, DENMARK;

IR103 (Rev. 10/09)

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
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INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

22852 7590 05/23/2012

FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER LLP
901 NEW YORK AVENUE, NW
WASHINGTON, DC 20001-4413

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)

(Signature)

(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/269,234	10/07/2011	André Sloth ERIKSEN	10494.0003-01000	1954

TITLE OF INVENTION: COOLING SYSTEM FOR A COMPUTER SYSTEM

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	$870	$0	$0	$870	08/23/2012

EXAMINER	ART UNIT	CLASS-SUBCLASS
DUKE, EMMANUEL E	3784	165-080400

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,

(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 FINNEGAN, HENDERSON FARABOW, GARRETT &
2 DUNNER, LLP
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: ASETEK A/S

(B) RESIDENCE: (CITY and STATE OR COUNTRY): BRONDERSLEV, DENMARK

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☒ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:

☒ Issue Fee

☐ Publication Fee (No small entity discount permitted)

☐ Advance Order - # of Copies ______

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**

☐ A check is enclosed.

☒ Payment by credit card. Form PTO-2038 is attached.

☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number 06-0916 (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)

☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.

☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature [signature] Date July 23, 2012

Typed or printed name Biju I. Chandran Registration No. 63,684

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

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PATENT
Customer No. 22,852
Attorney Docket No. 10494.0003-01000

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	
André Sloth ERIKSEN	Group Art Unit: 3784
Application No.: 13/269,234	Examiner: DUKE, Emmanuel E.
Filed: October 7, 2011	
For: COOLING SYSTEM FOR A COMPUTER SYSTEM	Confirmation No.: 1954

Mail Stop Issue Fee
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

COMMENTS ON STATEMENT OF REASONS FOR ALLOWANCE

Applicant thanks the Examiner for the Notice of Allowance mailed on May 23, 2012. Without withdrawing the allowed claims from issue, Applicant submits the following comments on the Examiner's Statement of Reasons for Allowance that accompanied the Notice of Allowance.

In the Examiner's Statement, the Examiner made certain characterizations and assertions about the claims and the related prior art. Although Applicant agrees with the Examiner's ultimate conclusion that the claims are patentable over the prior art of record, Applicant does not necessarily agree with the characterizations and assertions contained in the Examiner's statement.

For example, the Examiner stated that the claims are allowable because certain features of the independent claims 1, 12, and 17 are not taught by the cited art. *See* pp. 2-3. Applicant respectfully submits that each of the allowed claims is patentable based on the subject matter defined by the claim language and the combination of recitations within the claims, not solely because of the specific features referenced by the Examiner. The claims recite combinations and features not referenced in the Examiner's Statement that provide further bases for distinguishing the prior art of record.

Should the Examiner disagree with these comments, the Examiner is invited to contact the undersigned, to discuss the same.

If there are any fees due in connection with the filing of this paper, please charge the fees to Deposit Account No. 06-0916.

Respectfully submitted,

FINNEGAN, HENDERSON, FARABOW,
GARRETT & DUNNER, L.L.P.

Dated: July 23, 2012

By: ______________________

Biju I. Chandran
Reg. No. 63,684
202.408.4230 (direct)

Electronic Patent Application Fee Transmittal

Application Number:	13269234
Filing Date:	07-Oct-2011
Title of Invention:	COOLING SYSTEM FOR A COMPUTER SYSTEM
First Named Inventor/Applicant Name:	André Sloth ERIKSEN
Filer:	Biju I. Chandran/Faith Wills
Attorney Docket Number:	10494.0003-01000

Filed as Small Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Utility Appl issue fee	2501	1	870	870
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
		Total in USD ($)		**870**

Electronic Acknowledgement Receipt

EFS ID:	13316475
Application Number:	13269234
International Application Number:	
Confirmation Number:	1954
Title of Invention:	COOLING SYSTEM FOR A COMPUTER SYSTEM
First Named Inventor/Applicant Name:	André Sloth ERIKSEN
Customer Number:	22852
Filer:	Biju I. Chandran/Faith Wills
Filer Authorized By:	Biju I. Chandran
Attorney Docket Number:	10494.0003-01000
Receipt Date:	23-JUL-2012
Filing Date:	07-OCT-2011
Time Stamp:	16:29:44
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$870
RAM confirmation Number	5565
Deposit Account	
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)

1		IssueFee.pdf	184386 ad4043377f279a0d987ffafe66ec196d3d5aeb57	yes	3
	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Issue Fee Payment (PTO-85B)		1	1	
	Miscellaneous Incoming Letter		2	3	
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	30491 22a72c985d2beee44a1f459f999a35a5c8d5acec	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	214877		

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<u>National Stage of an International Application under 35 U.S.C. 371</u>
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<u>New International Application Filed with the USPTO as a Receiving Office</u>
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NOTICE OF ALLOWANCE AND FEE(S) DUE

22852 7590 05/23/2012

FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER LLP
901 NEW YORK AVENUE, NW
WASHINGTON, DC 20001-4413

EXAMINER	
DUKE, EMMANUEL E	
ART UNIT	**PAPER NUMBER**
3784	

DATE MAILED: 05/23/2012

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/269,234	10/07/2011	André Sloth ERIKSEN	10494.0003-01000	1954

TITLE OF INVENTION: COOLING SYSTEM FOR A COMPUTER SYSTEM

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	$870	$0	$0	$870	08/23/2012

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PART B - FEE(S) TRANSMITTAL

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CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

22852 7590 05/23/2012

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Certificate of Mailing or Transmission

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(Depositor's name)

(Signature)

(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/269,234	10/07/2011	André Sloth ERIKSEN	10494.0003-01000	1954

TITLE OF INVENTION: COOLING SYSTEM FOR A COMPUTER SYSTEM

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	$870	$0	$0	$870	08/23/2012

EXAMINER	ART UNIT	CLASS-SUBCLASS
DUKE, EMMANUEL E	3784	165-080400

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
   - ❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
   - ❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
   (1) the names of up to 3 registered patent attorneys or agents OR, alternatively,
   (2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

   1____________________
   2____________________
   3____________________

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:
- ❑ Issue Fee
- ❑ Publication Fee (No small entity discount permitted)
- ❑ Advance Order - # of Copies ________________

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- ❑ A check is enclosed.
- ❑ Payment by credit card. Form PTO-2038 is attached.
- ❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number __________ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ❑ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
- ❑ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature ________________________ Date ____________________

Typed or printed name ________________________ Registration No. ____________________

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/269,234	10/07/2011	André Sloth ERIKSEN	10494.0003-01000	1954

22852 7590 05/23/2012

FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER LLP
901 NEW YORK AVENUE, NW
WASHINGTON, DC 20001-4413

EXAMINER	
DUKE, EMMANUEL E	
ART UNIT	PAPER NUMBER
3784	

DATE MAILED: 05/23/2012

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)

(application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 0 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 0 day(s).

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

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Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No.	Applicant(s)	
	13/269,234	ERIKSEN, ANDR LOTH FINNEGAN, HENDERSON,	
	Examiner	Art Unit	
	EMMANUEL DUKE	3784	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *04/06/2012*.
2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on ______; the restriction requirement and election have been incorporated into this action.
3. ☒ The allowed claim(s) is/are *1-5, 7-8 and 10-20*.
4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☐ All b) ☐ Some* c) ☐ None of the:
   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. ______ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: ______.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.
6. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
   1) ☐ hereto or 2) ☐ to Paper No./Mail Date ______.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date ______.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
7. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date ______
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date ______ .
7. ☐ Examiner's Amendment/Comment
8. ☒ Examiner's Statement of Reasons for Allowance
9. ☒ Other *CLM 04/06/2012*.

/EMMANUEL DUKE/
Examiner, Art Unit 3784

REASON FOR ALLOWANCE

The following is an examiner's statement of reasons for allowable: The prior art of record when consider as a whole, alone or in combination, neither anticipates nor renders obvious: A cooling system for a heat-generating component, comprising: a double-sided chassis adapted to mount a pump configured to circulate a cooling liquid, a reservoir adapted to pass the cooling liquid there through, the reservoir including: a pump chamber including an impeller and formed below the chassis, the pump chamber defined by at least an impeller cover having one or more passage for the cooling liquid to pass through; a thermal exchange chamber formed below the pump chamber and vertically space apart from the pump chamber, the pump chamber and the thermal exchange chamber being separate chambers that are fluidly coupled together by the one or more passages; and a heat exchanging interface, the heat-exchanging interface forming a boundary wall of the thermal exchange chamber, and configured to be placed in thermal contact with a surface of the heat-generating component of instant claims 1, 12 and 17.

Tomioka (US 2005/0069432) teaches a cooling apparatus having pump unit for cooling an electronic device; however, Tomioka '432 does not teach a thermal exchange chamber formed below the pump chamber and vertically space apart from the pump chamber, the pump chamber and the thermal exchange chamber being separate chambers that are fluidly coupled together by the one or more passages of instant claims 1, 12 and 17.

Additional references that also fail to meet the bounds of the present invention's claims are as follows: Lee et al. (US 2005/0061482) teach a liquid cooling system having pump unit for cooling an electronic device; however, Lee et al. '482 does not teach a thermal exchange chamber formed below the pump chamber and vertically space apart from the pump chamber, the pump chamber and the thermal exchange chamber being separate chambers that are fluidly coupled together by the one or more passages of instant claims 1, 12 and 17.

Batchelder (US 6,019,165) teaches a heat exchange apparatus having pump unit for cooling an electronic device; however, Batchelder ‘165 does not teach a thermal exchange chamber formed below the pump chamber and vertically space apart from the pump chamber, the pump chamber and the thermal exchange chamber being separate chambers that are fluidly coupled together by the one or more passages of instant claims 1, 12 and 17.

Therefore, independents claims 1, 12 and 17 with the depending claims therefrom are considered allowable.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled “Comments on Statement of Reasons for Allowance.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to EMMANUEL DUKE whose telephone number is (571)270-5290. The examiner can normally be reached on Monday - Friday; 8:00am - 5:00pm EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner’s supervisor, Cheryl Tyler or Frantz Jules can be reached on 571-272-4834 or 571-272-

6681. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Frantz F. Jules/

Supervisory Patent Examiner, Art Unit 3784

/EMMANUEL DUKE/

Examiner, Art Unit 3784

05/11/2012

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13269234	ERIKSEN, ANDR LOTH FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER
	Examiner	**Art Unit**
	EMMANUEL DUKE	3784

SEARCHED

Class	Subclass	Date	Examiner
165	80.4104.33, 120, 80.3, 80.4	5/11/2012	ED
361	699	5/11/2012	ED

SEARCH NOTES

Search Notes	Date	Examiner
Updated Search	5/11/2012	ED
PLUS Search Requested and Reviewed	12/20/2011	ED
Consulted Allan Flanigan -PE	5/11/2012	ED

INTERFERENCE SEARCH

Class	Subclass	Date	Examiner
62	80.4	5/11/2012	ED

/EMMANUEL DUKE/ Examiner.Art Unit 3784	

OK TO ENTER: /E.D./ (05/11/2012)

AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions and listings of claims in the application:

1. (Currently amended) A cooling system for a heat-generating component, comprising:

a double-sided chassis adapted to mount a pump configured to circulate a cooling liquid, the pump comprising a stator and an impeller, the impeller being positioned ~~in a recess~~ on the underside of the chassis and the stator being positioned on the upper side of the chassis and isolated from the cooling liquid;

a reservoir adapted to pass the cooling liquid therethrough, the reservoir including:

a pump chamber ~~formed by the recess and~~ including the impeller and formed below the chassis, the pump chamber being defined by at least an impeller cover having one or more passages for the cooling liquid to pass through;

a thermal exchange chamber formed below the pump chamber and vertically spaced apart from the pump chamber, the pump chamber and the thermal exchange chamber being separate chambers that are fluidly coupled together by the one or more passages; and

a heat-exchanging interface, the heat-exchanging interface forming a boundary wall of the thermal exchange chamber, and configured to be placed in thermal contact with a surface of the heat-generating component; and

a heat radiator fluidly coupled to the reservoir and configured to dissipate heat from the cooling liquid.

OK TO ENTER: /E.D./ (05/11/2012)

2. (Original) The cooling system of claim 1, wherein the chassis shields the stator from the cooling liquid in the reservoir.

3. (Original) The cooling system of claim 1, wherein the heat-exchanging interface includes a first side and a second side opposite the first side, and wherein the heat-exchanging interface contacts the cooling liquid in the thermal exchange chamber on the first side and the heat-exchanging interface is configured to be in thermal contact with the surface of the heat-generating component on the second side.

4. (Original) The cooling system of claim 3, wherein the first side of the heat-exchanging interface includes features that are adapted to increase heat transfer from the heat-exchanging interface to the cooling liquid in the thermal exchange chamber.

5. (Original) The cooling system of claim 4, wherein the features include at least one of pins or fins.

6. (Cancelled).

7. (Original) The cooling system of claim 1, wherein a passage of the one or more passages that fluidly couple the pump chamber and the thermal exchange chamber is offset from a center of the impeller.

8. (Original) The cooling system of claim 1, wherein the impeller includes a plurality of curved blades.

9. (Cancelled).

10. (Original) The cooling system of claim 1, wherein the heat-exchanging interface includes one of copper and aluminum.

11. (Original) The cooling system of claim 1, wherein the heat radiator is fluidly coupled to the reservoir using flexible conduits, and the heat radiator is configured to be positioned remote from the reservoir.

12. (Original) A cooling system for a computer system, comprising:

a centrifugal pump adapted to circulate a cooling liquid, the pump including:

an impeller exposed to the cooling liquid; and

a stator isolated from the cooling liquid;

a reservoir configured to be thermally coupled to a heat-generating component of the computer system, the reservoir including:

a thermal exchange chamber adapted to be positioned in thermal contact with the heat-generating component;

a separate pump chamber vertically spaced part from the thermal exchange chamber and coupled with the thermal exchange chamber through one or more passages configured for fluid communication between the pump chamber and the thermal exchange chamber, and wherein at least one of the one or more passages is offset from a center of the impeller.

13. (Original) The cooling system of claim 12, wherein a top wall of the reservoir physically separates the impeller from the stator.

14. (Original) The cooling system of claim 12, wherein the thermal exchange chamber includes a heat-exchange interface configured to be placed in thermal contact with the heat-generating component.

15. (Original) The cooling system of claim 12, further including a heat radiator fluidly coupled to the reservoir using flexible conduits, wherein the heat radiator is configured to be positioned remote from the reservoir.

16. (Original) The cooling system of claim 12, wherein the fluid passage that is offset from the center of the impeller is positioned tangentially to the circumference of the impeller.

17. (Original) A cooling system for a heat-generating component, comprising:

a pump adapted to circulate a cooling liquid, the pump including:

an impeller exposed to the cooling liquid; and

a stator isolated from the cooling liquid;

a reservoir including an impeller cover, an intermediate member and a heat exchange interface, wherein a top wall of the reservoir and the impeller cover define a pump chamber for housing the impeller, and the intermediate member and the heat exchange interface define a thermal exchange chamber, the pump chamber and the thermal exchange chamber being spaced apart from each other in a vertical direction and fluidly coupled together; and

wherein a first side of the heat-exchanging interface is in contact with a cooling liquid in the thermal exchange chamber and a second side of the heat-exchanging interface opposite the first side is configured to be placed in thermal contact with a surface of the heat-generating component; and

a liquid-to-air heat exchanger fluidly coupled to the reservoir using flexible conduits, the heat exchanger being configured to be positioned remote from the reservoir.

18. (Original) The cooling system of claim 17, wherein the impeller cover includes a first opening radially offset from a center of the impeller and the intermediate member includes a

second passage that is aligned with the first opening, the first and the second opening being configured to direct the cooling liquid from the pump chamber into the thermal exchange chamber.

19. (Original) The cooling system of claim 17, wherein the first side of the heat-exchanging interface includes at least one of pins or fins.

20. (Original) The cooling system of claim 17, wherein the top wall of the reservoir extends between the stator and the impeller and shields the stator from the cooling liquid in the reservoir.

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S45	1	165/80.4 cooling liquid system centrifugal pump stator impeller reservoir radiator fins	USPAT	AND	OFF	2012/05/11 14:47
S50	5	(165/104.33,120,80.3,80.4 OR 361/699).ccls. cooling liquid system centrifugal pump stator impeller reservoir radiator fins	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2012/05/11 15:09

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S47	1	165/80.4 cooling liquid system centrifugal pump stator impeller reservoir radiator fins	USPAT; UPAD	AND	OFF	2012/05/11 14:46
S48	8	165/80.4 chamber pump thermal reservoir impeller	USPAT; UPAD	AND	OFF	2012/05/11 14:48

5/11/2012 3:11:32 PM
C:\Users\eduke\Documents\EAST\Workspaces\13269234.wsp

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13269234	ERIKSEN, ANDR LOTH FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER
	Examiner	**Art Unit**
	EMMANUEL DUKE	3784

ORIGINAL	
CLASS	SUBCLASS
165	80.4

CROSS REFERENCE(S)

CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)				
361	699				

INTERNATIONAL CLASSIFICATION

CLAIMED					NON-CLAIMED
F	2	8	F	7 / 00 (2006.01.01)	
H	0	5	K	7 / 20 (2006.01.01)	

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
1	1	15	17												
2	2	16	18												
3	3	17	19												
4	4	18	20												
5	5														
	6														
6	7														
7	8														
	9														
8	10														
9	11														
10	12														
11	13														
12	14														
13	15														

/EMMANUEL DUKE/ Examiner.Art Unit 3784 (Assistant Examiner)	05/11/2012 (Date)	**Total Claims Allowed:** 18	
/FRANTZ JULES/ Supervisory Patent Examiner.Art Unit 3784 (Primary Examiner)	05/18/2012 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 20

Issue Classification	**Application/Control No.** 13269234	**Applicant(s)/Patent Under Reexamination** ERIKSEN, ANDR LOTH FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER
	Examiner EMMANUEL DUKE	**Art Unit** 3784

☐ **Claims renumbered in the same order as presented by applicant** ☐ **CPA** ☐ **T.D.** ☐ **R.1.47**

14	16														

/EMMANUEL DUKE/ Examiner.Art Unit 3784 (Assistant Examiner)	05/11/2012 (Date)	**Total Claims Allowed:** 18	
/FRANTZ JULES/ Supervisory Patent Examiner.Art Unit 3784 (Primary Examiner)	05/18/2012 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 20

U.S. Patent and Trademark Office Part of Paper No. 20120511

Index of Claims	**Application/Control No.** 13269234	**Applicant(s)/Patent Under Reexamination** ERIKSEN, ANDR LOTH FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER
	Examiner EMMANUEL DUKE	**Art Unit** 3784

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ **Claims renumbered in the same order as presented by applicant** ☐ **CPA** ☐ **T.D.** ☐ **R.1.47**

CLAIM		DATE								
Final	Original	12/13/2011	03/08/2012	05/11/2012						
1	1	✓	✓	=						
2	2	✓	✓	=						
3	3	✓	✓	=						
4	4	✓	✓	=						
5	5	✓	✓	=						
	6	✓	✓	-						
6	7	✓	✓	=						
7	8	✓	✓	=						
	9	✓	✓	-						
8	10	✓	✓	=						
9	11	✓	✓	=						
10	12	✓	✓	=						
11	13	✓	✓	=						
12	14	✓	✓	=						
13	15	✓	✓	=						
14	16	✓	✓	=						
15	17	✓	✓	=						
16	18	✓	✓	=						
17	19	✓	✓	=						
18	20	✓	✓	=						

PATENT
Customer No. 22,852
Attorney Docket No. 10494.0003-01000

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	)	
	)	
André Sloth ERIKSEN	)	Group Art Unit: 3784
	)	
Application No.: 13/269,234	)	Examiner: DUKE, Emmanuel E.
	)	
Filed: October 7, 2011	)	
	)	
For: COOLING SYSTEM FOR A COMPUTER SYSTEM	)	Confirmation No.: 1954
	)	

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

REPLY TO OFFICE ACTION

In reply to the Office Action mailed March 13, 2012, please amend the above-identified application as follows:

Amendments to the Claims are reflected in the listing of claims in this paper.

Remarks/Arguments follow the amendment sections of this paper.

AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions and listings of claims in the application:

1. (Currently amended) A cooling system for a heat-generating component, comprising:

a double-sided chassis adapted to mount a pump configured to circulate a cooling liquid, the pump comprising a stator and an impeller, the impeller being positioned ~~in a recess~~ on the underside of the chassis and the stator being positioned on the upper side of the chassis and isolated from the cooling liquid;

a reservoir adapted to pass the cooling liquid therethrough, the reservoir including:

a pump chamber ~~formed by the recess and~~ including the impeller and formed below the chassis, the pump chamber being defined by at least an impeller cover having one or more passages for the cooling liquid to pass through;

a thermal exchange chamber formed below the pump chamber and vertically spaced apart from the pump chamber, the pump chamber and the thermal exchange chamber being separate chambers that are fluidly coupled together by the one or more passages; and

a heat-exchanging interface, the heat-exchanging interface forming a boundary wall of the thermal exchange chamber, and configured to be placed in thermal contact with a surface of the heat-generating component; and

a heat radiator fluidly coupled to the reservoir and configured to dissipate heat from the cooling liquid.

2. (Original) The cooling system of claim 1, wherein the chassis shields the stator from the cooling liquid in the reservoir.

3. (Original) The cooling system of claim 1, wherein the heat-exchanging interface includes a first side and a second side opposite the first side, and wherein the heat-exchanging interface contacts the cooling liquid in the thermal exchange chamber on the first side and the heat-exchanging interface is configured to be in thermal contact with the surface of the heat-generating component on the second side.

4. (Original) The cooling system of claim 3, wherein the first side of the heat-exchanging interface includes features that are adapted to increase heat transfer from the heat-exchanging interface to the cooling liquid in the thermal exchange chamber.

5. (Original) The cooling system of claim 4, wherein the features include at least one of pins or fins.

6. (Cancelled).

7. (Original) The cooling system of claim 1, wherein a passage of the one or more passages that fluidly couple the pump chamber and the thermal exchange chamber is offset from a center of the impeller.

8. (Original) The cooling system of claim 1, wherein the impeller includes a plurality of curved blades.

9. (Cancelled).

10. (Original) The cooling system of claim 1, wherein the heat-exchanging interface includes one of copper and aluminum.

11. (Original) The cooling system of claim 1, wherein the heat radiator is fluidly coupled to the reservoir using flexible conduits, and the heat radiator is configured to be positioned remote from the reservoir.

12. (Original) A cooling system for a computer system, comprising:

a centrifugal pump adapted to circulate a cooling liquid, the pump including:

an impeller exposed to the cooling liquid; and

a stator isolated from the cooling liquid;

a reservoir configured to be thermally coupled to a heat-generating component of the computer system, the reservoir including:

a thermal exchange chamber adapted to be positioned in thermal contact with the heat-generating component;

a separate pump chamber vertically spaced part from the thermal exchange chamber and coupled with the thermal exchange chamber through one or more passages configured for fluid communication between the pump chamber and the thermal exchange chamber, and wherein at least one of the one or more passages is offset from a center of the impeller.

13. (Original) The cooling system of claim 12, wherein a top wall of the reservoir physically separates the impeller from the stator.

14. (Original) The cooling system of claim 12, wherein the thermal exchange chamber includes a heat-exchange interface configured to be placed in thermal contact with the heat-generating component.

15. (Original) The cooling system of claim 12, further including a heat radiator fluidly coupled to the reservoir using flexible conduits, wherein the heat radiator is configured to be positioned remote from the reservoir.

16. (Original) The cooling system of claim 12, wherein the fluid passage that is offset from the center of the impeller is positioned tangentially to the circumference of the impeller.

17. (Original) A cooling system for a heat-generating component, comprising:

a pump adapted to circulate a cooling liquid, the pump including:

an impeller exposed to the cooling liquid; and

a stator isolated from the cooling liquid;

a reservoir including an impeller cover, an intermediate member and a heat exchange interface, wherein a top wall of the reservoir and the impeller cover define a pump chamber for housing the impeller, and the intermediate member and the heat exchange interface define a thermal exchange chamber, the pump chamber and the thermal exchange chamber being spaced apart from each other in a vertical direction and fluidly coupled together; and

wherein a first side of the heat-exchanging interface is in contact with a cooling liquid in the thermal exchange chamber and a second side of the heat-exchanging interface opposite the first side is configured to be placed in thermal contact with a surface of the heat-generating component; and

a liquid-to-air heat exchanger fluidly coupled to the reservoir using flexible conduits, the heat exchanger being configured to be positioned remote from the reservoir.

18. (Original) The cooling system of claim 17, wherein the impeller cover includes a first opening radially offset from a center of the impeller and the intermediate member includes a

second passage that is aligned with the first opening, the first and the second opening being configured to direct the cooling liquid from the pump chamber into the thermal exchange chamber.

19. (Original) The cooling system of claim 17, wherein the first side of the heat-exchanging interface includes at least one of pins or fins.

20. (Original) The cooling system of claim 17, wherein the top wall of the reservoir extends between the stator and the impeller and shields the stator from the cooling liquid in the reservoir.

REMARKS

In the Office Action mailed on March 13, 2012("Office Action"), claims 1-4, 6-9, and 11-16 were rejected under 35 U.S.C. 102(b) as being anticipated by U.S. Patent Publication No. 2005/0069432 to Tomioka ("Tomioka"); claim 5 was rejected under 35 U.S.C. 103(a) as being unpatentable over Tomioka in view of U.S. Patent Publication No. 2005/0069432 to Lee et al. ("Lee"); claims 10, 17, 18, and 20 were rejected under 35 U.S.C. 103(a) as being unpatentable over Tomioka, in view of U.S. Patent No. 6,019,165 to Batchelder ("Batchelder"), and claim 19 was rejected under 35 U.S.C. 103(a) as being unpatentable over Tomioka and Batchelder as applied to claims 17, in view of Lee.

Applicant does not necessarily agree with the rejections in the Office Action. Nevertheless, to advance prosecution, Applicant amends claim 1, and cancels claims 6 and 9. These amendments find support in the originally filed specification and claims. Claims 1-5, 7, 8, and 10-20 are pending.

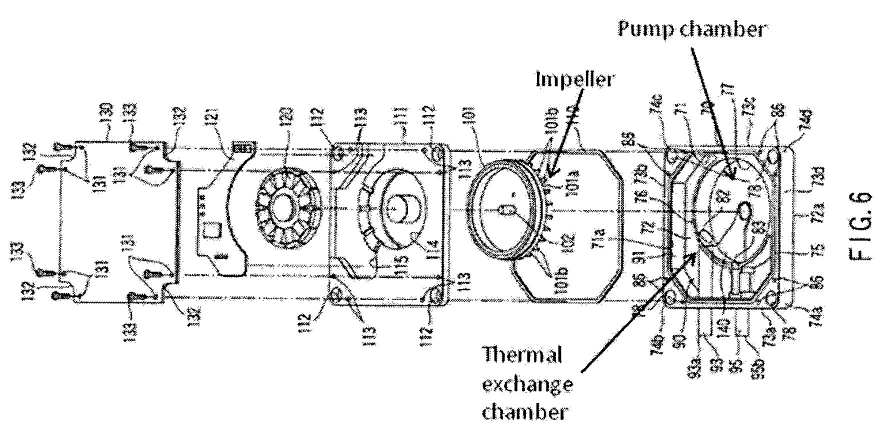
Record of Personal Interview under 37 C.F.R. § 1.133(b).

A telephone interview was conducted on Thursday, March 29, 2012 between a representative of the Applicant, Biju Chandran, Examiner Emmanuel Duke, and SPE Frantz Jules to discuss the Office Action. The Applicant and Applicant's representative thank Examiner Duke and SPE Jules for taking the time to discuss this Office Action. Prior to the interview, in an email to the Examiner, the Applicant's representative explained the differences between the recited reservoir of independent claims 12 and 17, and the reservoir of Tomioka. During the interview, the Examiner acknowledged the differences between independent claims 12 and 17 and Tomioka, but maintained that independent claim 1 does not include these differences. The amendments and remarks in this response substantially conform to the discussions during the interview.

Among the pending claims, claims 1, 12, and 17 are independent.

Independent claim 12

Independent claim 12 recites a cooling system for a computer system including, among other features, a reservoir configured to be thermally coupled to a heat-generating component of the computer system, the reservoir including "a thermal exchange chamber adapted to be positioned in thermal contact with the heat-generating component; [and] a separate pump chamber vertically spaced part from the thermal exchange chamber and coupled with the thermal exchange chamber through one or more passages configured for fluid communication between the pump chamber and the thermal exchange chamber." That is, independent claims 12 recites a reservoir with a "pump chamber vertically spaced part from the thermal exchange chamber." In the Office Action, independent claim 12 was rejected as being anticipated by Tomioka. Office Action, pg. 2.



With reference to FIGS. 4-7 (FIG. 6 reproduced above), Tomioka describes a pump unit 60 of an electronic apparatus. Abstract. The pump unit 60 includes a housing 70. ¶ [0039]. The bottom surface 72 of the housing 70 serves as a heat receiving surface that contacts a top surface of a CPU 33. ¶¶ [0039], [0050]. The housing 70 includes a centrally located pump chamber 77 that houses the impeller 101a of the pump, and a reserve tank 90 located radially outwards of the pump chamber 77. ¶¶[0043], [0044]. The pump chamber 77 and the reserve tank 90 are separated by a partition member 76 having fluid passages (first pipe 93, second pipe 94, and third pipe 95) therethrough. ¶[0043], ll.12-16; ¶[0044]. In the Office Action, as illustrated in annotated FIG. 6 of Tomioka above, the central chamber 77 is interpreted as the "pump chamber," and the reserve tank 90 is interpreted as the vertically spaced apart "thermal exchange chamber." See Office Action, pg. 5, lns. 10-12; pg. 7, lns. 24-26. However, as agreed upon during the interview, these chambers are not vertically spaced apart as required by independent claim 12.

"A claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference." M.P.E.P. 2131 quoting *Verdegaal Bros. v. Union Oil Co. of California*, 814 F. 2d 628, 631, 2 USPQ 2d 1051, 1053 (Fed. Cir. 1987). Tomioka does not expressly or inherently disclose at least this aspect of independent claim 12. Accordingly, independent claim is not anticipated by Tomioka. Claims 13-16 depend from independent claim 12 and include all of its limitations. Therefore, these dependent claims are allowable over Tomioka at least for the same reason independent claim 12 is allowable over Tomioka. These dependent claims are also allowable because Tomioka does not expressly or inherently disclose the combined limitations of these dependent claims with independent claim 12.

Independent claim 17

Independent claim 17 recites a cooling system for a heat-generating component including, among other features, a reservoir including an impeller cover, an intermediate member and a heat exchange interface, wherein "a top wall of the reservoir and the impeller cover define a pump chamber for housing the impeller, and the intermediate member and the heat exchange interface define a thermal exchange chamber, the pump chamber and the thermal exchange chamber being spaced apart from each other in a vertical direction and fluidly coupled together."

In the Office Action, independent claim 17 was rejected as being obvious over Tomioka and Batchelder. Office Action, pg. 7. Among these references, Tomioka was relied upon for the teaching of the vertically spaced apart pump chamber and thermal exchange chamber (Office Action, pg. 7), and Batchelder was relied upon for the teaching of the recited intermediate member. Office Action, pg. 8. However, for similar reasons as discussed with reference to independent claim 12, Tomioka does not disclose that "the pump chamber and the thermal exchange chamber [are] spaced apart from each other in a vertical direction," as recited in independent claim 17. In fact, as explained below, Tomioka teaches away from spacing apart the pump chamber 77 and the reserve tank 90 in a vertical direction.

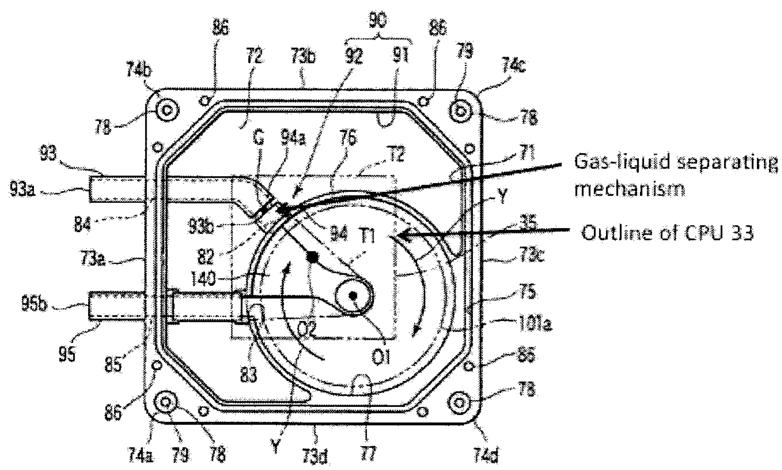


FIG.7

With reference to FIG. 7 annotated and reproduced above, in Tomioka, a first pipe 93 delivers liquid from outside the pump housing 70 to the reserve tank 90, and the second pipe 94 directs the liquid from the reserve tank 90 to the pump chamber 77. ¶[0045]. The outlet 93b of the first pipe 93 and the inlet of the 94a of the second pipe 94 form a gas-liquid separating mechanism 92 (¶[0044). This gas-liquid separating mechanism 92 operates by using the heat of the CPU 33. ¶[0050]. To enable the mechanism 92 to be heated by the heat of CPU 33, the mechanism 92 is positioned proximate the CPU 33. *Id.* Additionally, to ensure that the gas-liquid separating mechanism 92 is always submerged in the liquid in the pump housing 70 even when the housing 70 is tilted (see FIG. 8 and 9) (so that the mechanism works), the mechanism 92 is positioned at the center of mass (barycenter G) and proximate the bottom wall 72. ¶[0046]. Since the gas-liquid separating mechanism 72 is formed at the inlet of the passage which directs fluid from the reserve tank 90 to the pump chamber 77, if these chambers (pump chamber 77 and the reserve tank 90) were "spaced apart from each other in a vertical direction," the gas-liquid separating mechanism 92 will be positioned further away from the bottom wall 72 and the CPU

33. Applicant submits that, positioning the gas-liquid separating mechanism 92 away from the bottom wall 72 and the CPU 33 will decrease the amount of heat transmitted to mechanism 92 from the CPU 33, and also cause the mechanism 92 to be above the fluid surface when the housing 70 is tilted (see FIG. 9). Therefore, the gas-liquid separating mechanism 92 will not function properly if the pump chamber 77 and the reserve tank 90 of Tomioka were "spaced apart from each other in a vertical direction," as recited in independent claim 17[1]. That is, Tomioka teaches away from spacing apart the pump chamber 77 and the reserve tank 90 "in a vertical direction," as recited in independent claim 17. Therefore, Tomioka also does not suggest this aspect of independent claim 17. Batchelder does not rectify the deficiencies of Tomioka. Accordingly, independent claim 17 is allowable over Tomioka and Batchelder. Claims 18 and 20 depend from independent claim 17, and is therefore allowable over these references at least for the same reason independent claim 17 is allowable.

Claim 19 was rejected as being obvious over Tomioka and Batchelder and further in view of Lee. Office Action, pg. 6. Lee does not remedy the deficiencies of Tomioka and Batchelder discussed above. Therefore, claim 19 is allowable over these references at least for the same reason independent claim 17 is allowable over Tomioka and Batchelder.

Independent claim 1

Although different in scope, amended independent claim 1 includes limitations similar to those discussed with reference to independent claims 12 and 17. For instance, amended independent claim 1 recites a cooling system for a heat-generating component having a double-

[1] See Examination Guidelines Update: Developments in the Obviousness Inquiry After KSR v.Teleflex, Federal Register, Vol. 75, No. 169, September 1, 2010, p. 53649, describing *DePuy Spine, Inc. v. Medtronic Sofamor Danek, Inc.*, 567 F.3d 1314 (Fed. Cir. 2009) as supporting the proposition that combinations that render the modified device unsuitable for its intended purposes are grounds for a finding of non-obviousness.

sided chassis with an impeller positioned on the underside of the chassis and a stator positioned on the upper side of the chassis, a reservoir including "a pump chamber including the impeller and formed below the chassis," the pump chamber being defined by at least an impeller cover having one or more passages for the cooling liquid to pass through, "a thermal exchange chamber formed below the pump chamber and vertically spaced apart from the pump chamber," the pump chamber and the thermal exchange chamber being separate chambers that are fluidly coupled together by the one or more passages.

In the Office Action, independent claim 1 was rejected as being anticipated by Tomioka. Office Action, pg. 2. However, for similar reasons as discussed with reference to independent claim 12, Tomioka does not expressly or inherently disclose the above recited aspects of independent claim 1. Accordingly, independent claim 1 is not anticipated by Tomioka. Claims 6 and 9 have been cancelled by this response, thereby mooting the rejection of these claims. Claims 2-4, 8, and 11 depend from amended independent claim 1 and include all of its limitations. Therefore, these dependent claims are allowable over Tomioka at least for the same reason amended independent claim 1 is allowable over Tomioka.

In the Office Action, claim 5 was rejected as being obvious over Tomioka in view of Lee. Claim 5 depends from amended independent claim 1. Lee does not remedy the deficiencies of Tomioka discussed above. Therefore, dependent claim 5 is allowable over Tomioka and Lee at least for the same reason amended independent claim 1 is allowable over these references.

For the reasons discussed above, Applicant submits that the pending claims are allowable over the prior art of record. If the Examiner disagrees, the MPEP states that "a second or any subsequent action on the merits in any application … will not be made final if it includes a rejection, on newly cited art, ... , of any claim not amended by applicant or patent owner in spite of the fact that other claims may have been amended to require newly cited art." M.P.E.P. § 706.07(a). Applicant notes that independent claims 12 and 17, and the claims that depend therefrom, are not amended by this response. Therefore, to the extent that the Examiner rejects these unamended claims using newly cited art, Applicant respectfully requests that the Examiner make the rejection non-final.

CONCLUSIONS

In view of the foregoing remarks, Applicant respectfully requests reconsideration and reexamination of this application and the timely allowance of all pending claims.

The Office Action contains characterizations of the claims with which Applicant does not necessarily agree. Unless expressly noted otherwise, Applicant declines to subscribe to any statement or characterization in the Office Action.

If the Examiner believes a telephone conversation might advance prosecution, the Examiner is invited to call Applicant's undersigned representative at 202.408.4230.

Please grant any extensions of time required to enter this response and charge any additional required fees to our deposit account 06-0916

Respectfully submitted,

FINNEGAN, HENDERSON, FARABOW,
GARRETT & DUNNER, L.L.P.

Dated: April 6, 2012

By: ______________________
Biju I. Chandran
Reg. No. 63,684
(202) 408-4000

Electronic Acknowledgement Receipt

EFS ID:	12486705
Application Number:	13269234
International Application Number:	
Confirmation Number:	1954
Title of Invention:	COOLING SYSTEM FOR A COMPUTER SYSTEM
First Named Inventor/Applicant Name:	André Sloth ERIKSEN
Customer Number:	22852
Filer:	Biju I. Chandran/Faith Wills
Filer Authorized By:	Biju I. Chandran
Attorney Docket Number:	10494.0003-01000
Receipt Date:	06-APR-2012
Filing Date:	07-OCT-2011
Time Stamp:	12:52:31
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Amendment/Req. Reconsideration-After Non-Final Reject	Reply.pdf	657036 102868917bc4d755663d37cb2726e92d904c07c1	no	15

Warnings:

Information:

Total Files Size (in bytes):	657036

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/06 (07-06)
Approved for use through 1/31/2007. OMB 0651-0032
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PATENT APPLICATION FEE DETERMINATION RECORD
Substitute for Form PTO-875

Application or Docket Number	Filing Date	
13/269,234		☐ To be Mailed

APPLICATION AS FILED – PART I

FOR	NUMBER FILED (Column 1)	NUMBER EXTRA (Column 2)	SMALL ENTITY ☒ RATE ($)	FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
			TOTAL			TOTAL	

* If the difference in column 1 is less than zero, enter "0" in column 2.

APPLICATION AS AMENDED – PART II

AMENDMENT	04/06/2012	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 18	Minus	** 20	= 0	X $30 =	0	OR	X $ =	
	Independent (37 CFR 1.16(h))	* 3	Minus	***3	= 0	X $125 =	0	OR	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE	**0**	OR	TOTAL ADD'L FEE	

AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/STELLA LITTLE/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/269,234	10/07/2011	André Sloth ERIKSEN	10494.0003-01000	1954

22852 7590 04/05/2012
FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER
LLP
901 NEW YORK AVENUE, NW
WASHINGTON, DC 20001-4413

EXAMINER	
DUKE, EMMANUEL E	

ART UNIT	PAPER NUMBER
3784	

MAIL DATE	DELIVERY MODE
04/05/2012	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Applicant-Initiated Interview Summary	**Application No.** 13/269,234	**Applicant(s)** ERIKSEN, ANDR LOTH FINNEGAN, HENDERSON,
	Examiner EMMANUEL DUKE	**Art Unit** 3784

All participants (applicant, applicant's representative, PTO personnel):

(1) *EMMANUEL DUKE*.

(2) *FRANTZ JULES (SPE)* .

(3) *BIJU CHANDRAN, Esq., (Reg. No. 63,684)*.

(4) _____.

Date of Interview: *03/29/2012*.

Type: ☒ Telephonic ☐ Video Conference
☐ Personal [copy given to: ☐ applicant ☒ applicant's representative]

Exhibit shown or demonstration conducted: ☐ Yes ☒ No.
If Yes, brief description: _____.

Issues Discussed ☐101 ☐112 ☐102 ☐103 ☒Others
(For each of the checked box(es) above, please describe below the issue and detailed description of the discussion)

Claim(s) discussed: *12 and 17*.

Identification of prior art discussed: *Tomioka*.

Substance of Interview
(For each issue discussed, provide a detailed description and indicate if agreement was reached. Some topics may include: identification or clarification of a reference or a portion thereof, claim interpretation, proposed amendments, arguments of any applied references etc...)

Applicant's arguments that the pump chamber and the thermal chamber being separate chamber; and the pump chamber vertically spaced apart from the thermal chamber was reviewed and found to be persuasive, and considered to be distinguished over the rejection under 35 U.S.C. 102(b) as being anticipated by Tomioka '432. When the Applicant files a proper response to the Office Action mailed 03/13/2012, a decision on patentablility will be consider upon further consideration and search.

Applicant recordation instructions: The formal written reply to the last Office action must include the substance of the interview. (See MPEP section 713.04). If a reply to the last Office action has already been filed, applicant is given a non-extendable period of the longer of one month or thirty days from this interview date, or the mailing date of this interview summary form, whichever is later, to file a statement of the substance of the interview

Examiner recordation instructions: Examiners must summarize the substance of any interview of record. A complete and proper recordation of the substance of an interview should include the items listed in MPEP 713.04 for complete and proper recordation including the identification of the general thrust of each argument or issue discussed, a general indication of any other pertinent matters discussed regarding patentability and the general results or outcome of the interview, to include an indication as to whether or not agreement was reached on the issues raised.

☐ Attachment

/EMMANUEL DUKE/ Examiner, Art Unit 3784	/Frantz F. Jules/ Supervisory Patent Examiner, Art Unit 3784

Summary of Record of Interview Requirements

Manual of Patent Examining Procedure (MPEP), Section 713.04, Substance of Interview Must be Made of Record
A complete written statement as to the substance of any face-to-face, video conference, or telephone interview with regard to an application must be made of record in the application whether or not an agreement with the examiner was reached at the interview.

Title 37 Code of Federal Regulations (CFR) § 1.133 Interviews
Paragraph (b)

In every instance where reconsideration is requested in view of an interview with an examiner, a complete written statement of the reasons presented at the interview as warranting favorable action must be filed by the applicant. An interview does not remove the necessity for reply to Office action as specified in §§ 1.111, 1.135. (35 U.S.C. 132)

37 CFR §1.2 Business to be transacted in writing.
All business with the Patent or Trademark Office should be transacted in writing. The personal attendance of applicants or their attorneys or agents at the Patent and Trademark Office is unnecessary. The action of the Patent and Trademark Office will be based exclusively on the written record in the Office. No attention will be paid to any alleged oral promise, stipulation, or understanding in relation to which there is disagreement or doubt.

The action of the Patent and Trademark Office cannot be based exclusively on the written record in the Office if that record is itself incomplete through the failure to record the substance of interviews.

It is the responsibility of the applicant or the attorney or agent to make the substance of an interview of record in the application file, unless the examiner indicates he or she will do so. It is the examiner's responsibility to see that such a record is made and to correct material inaccuracies which bear directly on the question of patentability.

Examiners must complete an Interview Summary Form for each interview held where a matter of substance has been discussed during the interview by checking the appropriate boxes and filling in the blanks. Discussions regarding only procedural matters, directed solely to restriction requirements for which interview recordation is otherwise provided for in Section 812.01 of the Manual of Patent Examining Procedure, or pointing out typographical errors or unreadable script in Office actions or the like, are excluded from the interview recordation procedures below. Where the substance of an interview is completely recorded in an Examiners Amendment, no separate Interview Summary Record is required.

The Interview Summary Form shall be given an appropriate Paper No., placed in the right hand portion of the file, and listed on the "Contents" section of the file wrapper. In a personal interview, a duplicate of the Form is given to the applicant (or attorney or agent) at the conclusion of the interview. In the case of a telephone or video-conference interview, the copy is mailed to the applicant's correspondence address either with or prior to the next official communication. If additional correspondence from the examiner is not likely before an allowance or if other circumstances dictate, the Form should be mailed promptly after the interview rather than with the next official communication.

The Form provides for recordation of the following information:
– Application Number (Series Code and Serial Number)
– Name of applicant
– Name of examiner
– Date of interview
– Type of interview (telephonic, video-conference, or personal)
– Name of participant(s) (applicant, attorney or agent, examiner, other PTO personnel, etc.)
– An indication whether or not an exhibit was shown or a demonstration conducted
– An identification of the specific prior art discussed
– An indication whether an agreement was reached and if so, a description of the general nature of the agreement (may be by attachment of a copy of amendments or claims agreed as being allowable). Note: Agreement as to allowability is tentative and does not restrict further action by the examiner to the contrary.
– The signature of the examiner who conducted the interview (if Form is not an attachment to a signed Office action)

It is desirable that the examiner orally remind the applicant of his or her obligation to record the substance of the interview of each case. It should be noted, however, that the Interview Summary Form will not normally be considered a complete and proper recordation of the interview unless it includes, or is supplemented by the applicant or the examiner to include, all of the applicable items required below concerning the substance of the interview.

A complete and proper recordation of the substance of any interview should include at least the following applicable items:
1) A brief description of the nature of any exhibit shown or any demonstration conducted,
2) an identification of the claims discussed,
3) an identification of the specific prior art discussed,
4) an identification of the principal proposed amendments of a substantive nature discussed, unless these are already described on the Interview Summary Form completed by the Examiner,
5) a brief identification of the general thrust of the principal arguments presented to the examiner,
   (The identification of arguments need not be lengthy or elaborate. A verbatim or highly detailed description of the arguments is not required. The identification of the arguments is sufficient if the general nature or thrust of the principal arguments made to the examiner can be understood in the context of the application file. Of course, the applicant may desire to emphasize and fully describe those arguments which he or she feels were or might be persuasive to the examiner.)
6) a general indication of any other pertinent matters discussed, and
7) if appropriate, the general results or outcome of the interview unless already described in the Interview Summary Form completed by the examiner.

Examiners are expected to carefully review the applicant's record of the substance of an interview. If the record is not complete and accurate, the examiner will give the applicant an extendable one month time period to correct the record.

Examiner to Check for Accuracy

If the claims are allowable for other reasons of record, the examiner should send a letter setting forth the examiner's version of the statement attributed to him or her. If the record is complete and accurate, the examiner should place the indication, "Interview Record OK" on the paper recording the substance of the interview along with the date and the examiner's initials.

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/269,234	10/07/2011	Andre Sloth ERIKSEN	10494.0003-01000

CONFIRMATION NO. 1954

PUBLICATION NOTICE

OC000000053140137

22852
FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER LLP
901 NEW YORK AVENUE, NW
WASHINGTON, DC 20001-4413

Title:COOLING SYSTEM FOR A COMPUTER SYSTEM

Publication No.US-2012-0061058-A1
Publication Date:03/15/2012

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently http://www.uspto.gov/patft/.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Office of Public Records. The Office of Public Records can be reached by telephone at (703) 308-9726 or (800) 972-6382, by facsimile at (703) 305-8759, by mail addressed to the United States Patent and Trademark Office, Office of Public Records, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently http://pair.uspto.gov/. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

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Office of Data Managment, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/269,234	10/07/2011	André Sloth ERIKSEN	10494.0003-01000	1954

22852 7590 03/13/2012
FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER LLP
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EXAMINER	
DUKE, EMMANUEL E	

ART UNIT	PAPER NUMBER
3784	

MAIL DATE	DELIVERY MODE
03/13/2012	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

PTOL-90A (Rev. 04/07)

Office Action Summary	Application No.	Applicant(s)	
	13/269,234	ERIKSEN, ANDR LOTH FINNEGAN, HENDERSON,	
	Examiner	Art Unit	
	EMMANUEL DUKE	3784	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *01/30/2012*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

5)☒ Claim(s) *1-20* is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6)☐ Claim(s) _____ is/are allowed.

7)☒ Claim(s) *1-20* is/are rejected.

8)☐ Claim(s) _____ is/are objected to.

9)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

12)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)

2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)

3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.

4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

5) ☐ Notice of Informal Patent Application

6) ☐ Other: _____.

DETAILED ACTION

Examiner's Comments

1. For applicant's information, a personal interview under 37 C.F.R. § 1.138(b) was never requested nor such granted. As stated on page 2 of the remarks sheet; on Wednesday, January 25, 2012, the Examiner received a phone call from a representative of Applicant, Mr. Biju Chandran, pointing out that cited Eriksen '310 cited reference does not qualified as a prior art, and in response the Examiner requested that these argument be presented in a written response to Office Action. Therefore, the Applicant's argument that a personal interview under 37 C.F.R. § 1.138(b) was conducted is not correct.

Claim Rejections - 35 USC § 102

2. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

Claims 1- 4, 6-9 and 11-16 *are rejected under 35 U.S.C. 102(**b**) as being anticipated by Tomioka (**U.S. PG Pub No.: 2005/0069432 A1**), hereinafter referred to as Tomioka '432.*

Regarding claim 1, Tomioka ‘432 discloses a cooling system (Fig. 6: [0006-0007]) for a heat-generating component **33** [0031], comprising: a double-sided chassis **111** [0053 - 0054] adapted to mount a pump **60** configured to circulate a cooling liquid **[0036]**, the pump comprising a stator **120** [0039] and an impeller **101a**, the impeller being positioned in a recess **76 (as shown in Fig. 7: [0043])** on the underside of the chassis and the stator being positioned on the upper side of the chassis and isolated from the cooling liquid; a reservoir **90** [0044] adapted to pass the cooling liquid therethrough, the reservoir including: a pump chamber **77** [0043] formed by the recess and at least an impeller cover **70** having one or more passages **82, 83** [0043] for the cooling liquid to pass through; (Fig. 5: [0040-0041], wherein a housing recess portion **71** constitutes a thermal exchange chamber), the pump chamber and the thermal exchange chamber being separate chambers that are fluidly coupled together by the one or more passages (as shown in Fig. 6-7); and a heat-exchanging interface **72** ([0040-0041], wherein a bottom wall constitutes a heat-exchanger interface), the heat-exchanging interface forming a boundary wall [0040] of the thermal exchange chamber (as shown in Fig. 5), and configured to be placed in thermal contact with a surface 35 of the heat-generating component [0041]; and a heat radiator **40** [0065] and fluidly coupled to the reservoir and configured to dissipate heat from the cooling liquid (Fig. 2-3: [0067-0068]).

Regarding claim 2, Tomioka ‘432 discloses the cooling system of claim 1, wherein the chassis shields the stator from the cooling liquid in the reservoir (as shown in Fig. 6: [0054-0055], wherein the stator 120 is shielded from the cooling liquid within the 72 by first cover 111).

Regarding claim 3, Tomioka ‘432 discloses the cooling system of claim 1, wherein the heat-exchanging interface includes a first side ([0040], wherein an inner surface of the bottom wall 72 constitutes a first side) and a second side **72a** [0041] opposite the first side, and wherein the heat- exchanging interface contacts the cooling liquid in the thermal exchange chamber on the first side and the heat-exchanging interface is configured to be in thermal contact with the surface of the heat-generating component on the second side (as shown in Fig. 5).

Regarding claim 4, Tomioka ‘432 discloses the cooling system of claim 3, wherein the first side of the heat-exchanging interface includes features that are adapted to increase heat transfer from the heat-exchanging interface to the cooling liquid in the thermal exchange chamber. Applicant should note it has been held that the recitation that an element is “adapted to” performing a function is not positive limitation but only requires the ability to so perform. It does not constitute a limitation in any patentable sense. In re Hutchison, 69 USPQ 138.

Regarding claim 6, Tomioka ‘432 discloses the cooling system of claim 1, wherein the impeller is positioned in the pump chamber (as shown in Fig. 7).

Regarding claim 7, Tomioka ‘432 discloses the cooling system of claim 1, wherein a passage of the one or more passages that fluidly couple the pump chamber and the thermal exchange chamber is offset from a center (as shown in Fig. 7 [0051]) of the impeller.

Regarding claim 8, Tomioka ‘432 discloses the cooling system of claim 1, wherein the impeller includes a plurality of curved blades **101b** [0052].

Regarding claim 9, Tomioka ‘432 discloses the cooling system of claim 1, wherein the pump chamber and the thermal exchange chamber are spaced apart in a vertical direction (as shown in Fig. 6 and 7)

Regarding claim 11, Tomioka ‘432 discloses the cooling system of claim 1, wherein the heat radiator is fluidly coupled to the reservoir using flexible conduits **51, 52** [0036-0037], and the heat radiator is configured to be positioned remote from the reservoir (as shown in Fig. 2).

Regarding claim 12, Tomioka ‘432 discloses a cooling system (Fig. 6: [0006-0007]) for a computer system (Fig. 1: [0022]), comprising: a centrifugal pump **60** adapted to circulate a cooling liquid **[0036]**, the pump including: an impeller **101a** [0039] exposed to the cooling liquid; and a stator **120** isolated from the cooling liquid (as shown in Fig. 6: [0054-0055], wherein the stator is isolated from the cooling liquid by first cover 111); a reservoir **90** [0044] configured to be thermally coupled to a heat-generating component **33** [0031] of the computer system, the reservoir including: a thermal exchange chamber (Fig. 5: [0040-0041], wherein a housing recess portion **71** constitutes a thermal exchange chamber) adapted to be positioned in thermal contact with the heat-generating component; a separate pump chamber **77** [0043] vertically spaced part from the thermal exchange chamber and coupled with the thermal exchange chamber through one or more passages **82, 83** [0043] configured for fluid communication between the pump chamber and the thermal exchange chamber, and wherein at least one of the one or more passages is offset from a center (as shown in Fig. 7 [0051]) of the impeller.

Regarding claim 13, Tomioka ‘432 discloses the cooling system of claim 12, wherein a top wall 111 (as shown in Fig. 6: [0054-0055) of the reservoir physically separates the impeller from the stator.

Regarding claim 14, Tomioka ‘432 discloses the cooling system of claim 12, wherein the thermal exchange chamber includes a heat-exchange interface **72** ([0040-0041], wherein a bottom wall constitutes a heat-exchanger interface) configured to be placed in thermal contact with the heat-generating component.

Regarding claim 15, Tomioka ‘432 discloses the cooling system of claim 12, further including a heat radiator **40** [0065] fluidly coupled to the reservoir using flexible conduits **51, 52** [0036-0037], wherein the heat radiator is configured to be positioned remote from the reservoir (as shown in Fig. 2).

Regarding claim 16, Tomioka '432 discloses the cooling system of claim 12, wherein the fluid passage that is offset from the center of the impeller is positioned tangentially to the circumference of the impeller (as shown in Fig. 6 and 7).

Claim Rejections - 35 USC § 103

3. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

*__Claim 5__ is rejected under 35 U.S.C. 103(a) as being unpatentable over Tomioka '432, in view of Lee et al. (**U.S. PG Pub No.: 2005/0069432 A1**), hereinafter referred to as Lee et al. '432.*

Regarding claim 5, Tomioka '432 discloses the cooling system of claim 4, except the limitation of wherein the features include at least one of pins or fins.

Lee et al. '432 teach: the heat-exchanging interface **11** (Fig.3: [0015]) features includes at least one of pins or fins **18** (Fig. 2: [0017]). Therefore, it would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the Tomioka '432 heat-exchanging interface to include the use of fins as taught by Lee et al. '432, in order to provide channels and increase flow surface area for the flow of the liquid (Lee et al. '432 - [0017] and [0019]).

__Claims 10, 17, 18 and 20__ *are rejected under 35 U.S.C. 103(a) as being unpatentable over Tomioka '432, in view of Batchelder (**U.S. Patent No.: 6,019,165)**, hereinafter referred to as Batchelder '165.*

Regarding claim 10, Tomioka '432 discloses the cooling system of claim 1, except the limitation of wherein the heat-exchanging interface includes one of copper and aluminum.

Batchelder '165 teaches: that the heat-exchanging interface one of copper and aluminum (Col. 7, lines 4-22). Therefore, it would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the Tomioka '432 heat-exchanging interface to include the use of one of copper and aluminum as taught by Batchelder '165, in order to facilitate increase in thermal conductivity (Batchelder '165 - (Col. 7, lines 4-22).

Regarding claim 17, Tomioka '432 discloses a cooling system (Fig. 6: [0006-0007]) for a heat-generating component **33** [0031], comprising: a pump **60** adapted to circulate a cooling liquid **[0036]**, the pump including: an impeller exposed to the cooling liquid; and a stator isolated from the cooling liquid; a reservoir **90** [0044] including an impeller cover **70**, a heat exchange interface **72** ([0040-0041], wherein a bottom wall constitutes a heat-exchanger interface), wherein a top wall **111** [0053 - 0054] of the reservoir and the impeller cover define a pump chamber **77** [0043] for housing the impeller, and the intermediate member and the heat exchange interface define a thermal exchange chamber (Fig. 5: [0040-0041], wherein a housing recess portion **71** constitutes a thermal exchange chamber), the pump chamber and the thermal exchange chamber being spaced apart from each other in a vertical direction and fluidly coupled together (as shown in Fig. 5); and wherein a first side of the heat-exchanging interface is in contact with a cooling liquid in the thermal exchange chamber and a second side of the heat- exchanging interface opposite the first side is configured to be placed in thermal contact with a surface of the heat-generating component; and a liquid-to-air heat exchanger fluidly coupled to the reservoir using flexible conduits **51, 52** [0036-0037], the heat exchanger being configured to be positioned remote from the reservoir. However, Tomioka '432 does not disclose the limitation of an intermediate member.

Batchelder '165 teaches: that the pump unit includes an intermediate member **206** (Fig. 7: Col 7, lines 36-39). Therefore, it would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the Tomioka '432 pump unit to include the use of an intermediate member as taught by Batchelder '165, in order to facilitate radially flow of the liquid away from the impeller (Batchelder '165 - Col. 7, lines 60-67).

Regarding claim 18, the combination of Tomioka '432 and Batchelder '165 disclose and teach the cooling system of claim 17; Tomioka '432 discloses wherein the impeller cover includes a first opening **82** [0043] radially offset from a center (as shown in Fig. 7 [0051]) of the impeller and the intermediate member includes a second passage **83** [0043] that is aligned with the first opening, the first and the second opening being configured to direct the cooling liquid from the pump chamber into the thermal exchange chamber.

Regarding claim 20, the combination of Tomioka '432 and Batchelder '165 disclose and teach the cooling system of claim 17; Tomioka '432 discloses wherein the top wall of the reservoir extends between the stator and the impeller and shields the stator from the cooling liquid (as shown in Fig. 6: [0054-0055], wherein the stator 120 is shielded from the cooling liquid by top wall 111) in the reservoir.

<u>Claim 19</u> *is rejected under 35 U.S.C. 103(a) as being unpatentable over Tomioka '432 and Batchelder '165 as applied to claim 17, in view of Lee et al. '432.*

<u>Regarding claim 19</u>, the combination of Tomioka '432 and Batchelder '165 discloses the cooling system of claim 17, except the limitation of wherein the features include at least one of pins or fins.

Lee et al. '432 teach: the heat-exchanging interface **11** (Fig.3: [0015]) features includes at least one of pins or fins **18** (Fig. 2: [0017]). Therefore, it would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the Tomioka '432 and Batchelder '165 heat-exchanging interface to include the use of fins as taught by Lee et al. '432, in order to provide channels and increase flow surface area for the flow of the liquid (Lee et al. '432 - [0017] and [0019]).

Response to Arguments

4. Applicant's arguments, see Remarks Sheet, pages 2-3, filed 01/30/2012, with respect to the rejection(s) of claim(s) 1-20 under 35 U.S.C. 102(b) as being anticipated by Eriksen '310 have been fully considered and are persuasive. Therefore, the rejection has been withdrawn. However, upon further consideration, a new ground(s) of rejection is made over Tomioka '432 in view of Batchelder '165 as set forth above.

Conclusion

5. Any inquiry concerning this communication or earlier communications from the examiner should be directed to EMMANUEL DUKE whose telephone number is

(571)270-5290. The examiner can normally be reached on Monday - Friday; 8:00am - 5:00pm EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Cheryl Tyler or Frantz Jules can be reached on 571-272-4834 or 571-272-6681. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Frantz F. Jules/
Supervisory Patent Examiner, Art Unit 3784

/EMMANUEL DUKE/
Examiner, Art Unit 3784
03/07/2012

Notice of References Cited	Application/Control No. 13/269,234	Applicant(s)/Patent Under Reexamination ERIKSEN, ANDR LOTH FINNE	
	Examiner EMMANUEL DUKE	Art Unit 3784	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-6,019,165 A	02-2000	Batchelder, John Samuel	165/80.3
*	B	US-2005/0061482 A1	03-2005	Lee et al.	165/096
*	C	US-2005/0069432 A1	03-2005	Tomioka, Kentaro	417/423.1
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Index of Claims	Application/Control No. 13269234	Applicant(s)/Patent Under Reexamination ERIKSEN, ANDR LOTH FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER
	Examiner EMMANUEL DUKE	Art Unit 3784

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	12/13/2011	03/08/2012							
	1	✓	✓							
	2	✓	✓							
	3	✓	✓							
	4	✓	✓							
	5	✓	✓							
	6	✓	✓							
	7	✓	✓							
	8	✓	✓							
	9	✓	✓							
	10	✓	✓							
	11	✓	✓							
	12	✓	✓							
	13	✓	✓							
	14	✓	✓							
	15	✓	✓							
	16	✓	✓							
	17	✓	✓							
	18	✓	✓							
	19	✓	✓							
	20	✓	✓							

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S22	1397	417/423.1	US-PGPUB; USPAT	OR	OFF	2012/03/07 14:59
S23	2	417/423.1 (reservoir OR tank) (heat near2 exchanger) (condenser OR radiator) fan pump	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2012/03/07 15:00
S24	92	361/699,702,720.ccls. (reservoir OR tank) (heat near2 exchanger) (condenser OR radiator) fan pump	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2012/03/07 15:01
S25	65	361/699,702,720.ccls. (reservoir OR tank) (heat near2 exchanger) (condenser OR radiator) fan pump computer	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2012/03/07 15:01
S28	3451	165/80.4 and @PD>="12111213"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2012/03/08 18:38
S29	5	S28 pump impeller stator rotor (reservoir OR tank) heat exchanger	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2012/03/08 18:39

EAST Search History (Interference)

<This search history is empty>

3/8/2012 6:41:02 PM
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Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13269234	ERIKSEN, ANDR LOTH FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER
	Examiner	**Art Unit**
	EMMANUEL DUKE	3784

SEARCHED

Class	Subclass	Date	Examiner
165	80.4	3/8/2012	ED
361	699, 702,720	3/7/2012	ED
417	423.1	3/7/2012	ED

SEARCH NOTES

Search Notes	Date	Examiner
Updated Search	3/8/2012	ED
PLUS Search Requested and Reviewed	12/20/2011	ED

INTERFERENCE SEARCH

Class	Subclass	Date	Examiner

/EMMANUEL DUKE/ Examiner.Art Unit 3784	

PATENT
Customer No. 22,852
Attorney Docket No. 10494.0003-01000

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	)	
	)	
André Sloth ERIKSEN	)	Group Art Unit: 3784
	)	
Application No.: 13/269,234	)	Examiner: DUKE, Emmanuel E.
	)	
Filed: October 7, 2011	)	
	)	
For: COOLING SYSTEM FOR A COMPUTER SYSTEM	)	Confirmation No.: 1954

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

REPLY TO OFFICE ACTION

In reply to the Office Action mailed December 20, 2011, Applicant requests reconsiderations for the reasons that follow:

Remarks/Arguments begin on page 2 of this Reply.

REMARKS

In the Office Action mailed on December 20, 2011 ("Office Action"), claims 1-20 were rejected under 35 U.S.C. 102(b) as being anticipated by PCT Application No. DK2005-000310 to Eriksen ("the '310 application").

Applicant traverses this rejection for the reasons that follow. No claims have been amended. Claims 1-20 remain pending.

Record of Personal Interview under 37 C.F.R. § 1.133(b).

A personal interview was conducted on Wednesday, January 25, 2012 between a representative of Applicant, Biju Chandran, and Examiner Duke to discuss the Office Action. Applicant and Applicant's representative thank Examiner Duke for taking the time to discuss this Office Action. During the interview, Applicant's representative pointed out the '310 application is not prior art to the current application because the current application is a continuation of U.S. Application No. 11/919,974 ('974 application) and the '310 application is the PCT application of the '974 application. Applicant's representative further pointed out that priority to the filing date of the '310 application was correctly claimed in the current application. The Examiner requested that these arguments be presented in a written response to Office Action. The remarks in this response substantially conform to the discussions during the interview.

35 U.S.C § 120 states that:

> An application for patent for an invention disclosed in the manner provided by the first paragraph of section 112 of this title in an application previously filed in the United States, or as provided by section 363 of this title, which is filed by an inventor or inventors named in the previously filed application shall have the same effect, as to such invention, as though filed on the date of the prior application, if filed before the patenting or abandonment of or termination of proceedings on the first application or on an application similarly entitled to the benefit of the filing date of the

> first application and if it contains or is amended to contain a specific reference to the earlier filed application. ...

The current application was filed on October 7, 2011 as a continuation of U.S. Application No. 11/919,974 ('974 application) during the pendency of '974 application. The '974 application is a national stage application of International Application No. PCT/DK2005/000310 (the '310 application) that correctly entered the U.S. national stage on November 6, 2007 (30 months after the May 6, 2005 filing date of the '310 application). See 35 U.S.C § 371. The specification of the current application was amended to include a specific reference to the '974 and '310 applications. For example, ¶ [001] of the current application states that:

> This application is a continuation of U.S. Application No. 11/919,974, filed January 6, 2009, which is a U.S. National Phase Application of PCT/DK2005/000310, filed May 6, 2005, which is incorporated herein by reference in its entirety.

The filing receipt of the current application mailed by the Office on October 27, 2012 (a portion of which is reproduced below) evidences the claim of priority to the '310 application.

Domestic Priority data as claimed by applicant
This application is a CON of 11/919,974 01/06/2009
which is a 371 of PCT/DK2005/000310 05/06/2005

Accordingly, the current application correctly claims priority to the filing date of the '310 application. Applicant respectfully requests that the Examiner acknowledge the claimed priority to the '974 and the '310 applications and withdraw the applied rejections in the Office Action.

CONCLUSIONS

In view of the foregoing remarks, Applicant respectfully requests reconsideration and reexamination of this application and the timely allowance of all pending claims.

The Office Action contains characterizations of the claims with which Applicant does not necessarily agree. Unless expressly noted otherwise, Applicant declines to subscribe to any statement or characterization in the Office Action.

If the Examiner believes a telephone conversation might advance prosecution, the Examiner is invited to call Applicant's undersigned representative at 202.408.4230.

Please grant any extensions of time required to enter this response and charge any additional required fees to our deposit account 06-0916

Respectfully submitted,

FINNEGAN, HENDERSON, FARABOW,
GARRETT & DUNNER, L.L.P.

Dated: January 30, 2012

By: Biju Chandran

Biju I. Chandran
Reg. No. 63,684
(202) 408-4000

Electronic Acknowledgement Receipt

EFS ID:	11950154
Application Number:	13269234
International Application Number:	
Confirmation Number:	1954
Title of Invention:	COOLING SYSTEM FOR A COMPUTER SYSTEM
First Named Inventor/Applicant Name:	André Sloth ERIKSEN
Customer Number:	22852
Filer:	Biju I. Chandran/Carolyn Perry
Filer Authorized By:	Biju I. Chandran
Attorney Docket Number:	10494.0003-01000
Receipt Date:	30-JAN-2012
Filing Date:	07-OCT-2011
Time Stamp:	13:50:38
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		10494_0003_01_AMENDMENT.pdf	137655 d72dbb2da3908d9bf3e8a472d3818e9f895feeaf	yes	4

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Amendment/Req. Reconsideration-After Non-Final Reject	1	1
	Applicant Arguments/Remarks Made in an Amendment	2	4
Warnings:			
Information:			
	Total Files Size (in bytes):	137655	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/06 (07-06)
Approved for use through 1/31/2007. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 13/269,234	Filing Date	☐ To be Mailed

APPLICATION AS FILED – PART I

SMALL ENTITY ☒ OR OTHER THAN SMALL ENTITY

FOR	NUMBER FILED (Column 1)	NUMBER EXTRA (Column 2)	RATE ($)	FEE ($)		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
			TOTAL			TOTAL	

* If the difference in column 1 is less than zero, enter “0” in column 2.

APPLICATION AS AMENDED – PART II

SMALL ENTITY OR OTHER THAN SMALL ENTITY

AMENDMENT	01/30/2012	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 20	Minus	** 20	= 0	X $30 =	0	OR	X $ =	
	Independent (37 CFR 1.16(h))	* 3	Minus	***3	= 0	X $125 =	0	OR	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE	**0**	OR	TOTAL ADD'L FEE	

AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write “0” in column 3.
** If the “Highest Number Previously Paid For” IN THIS SPACE is less than 20, enter “20”.
*** If the “Highest Number Previously Paid For” IN THIS SPACE is less than 3, enter “3”.
The “Highest Number Previously Paid For” (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/ROSALIND BALL/

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/269,234	10/07/2011	André Sloth ERIKSEN	10494.0003-01000	1954

22852 7590 12/20/2011
FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER
LLP
901 NEW YORK AVENUE, NW
WASHINGTON, DC 20001-4413

EXAMINER	
DUKE, EMMANUEL E	

ART UNIT	PAPER NUMBER
3784	

MAIL DATE	DELIVERY MODE
12/20/2011	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

PTOL-90A (Rev. 04/07)

Office Action Summary	Application No.	Applicant(s)	
	13/269,234	ERIKSEN, ANDR LOTH FINNEGAN, HENDERSON,	
	Examiner	Art Unit	
	EMMANUEL DUKE	3784	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE _3_ MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on _10/07/2011_.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

5)☒ Claim(s) _1-20_ is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6)☐ Claim(s) _____ is/are allowed.

7)☒ Claim(s) _1-20_ is/are rejected.

8)☐ Claim(s) _____ is/are objected to.

9)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☒ The drawing(s) filed on _11/18/2011_ is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

12)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)

2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)

3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _10/07/2011, 12/01/2011_.

4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

5) ☐ Notice of Informal Patent Application

6) ☐ Other: _____.

DETAILED ACTION

Claim Rejections - 35 USC § 102

1. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

Claims 1-20 *are rejected under 35 U.S.C. 102(**b**) as being anticipated by Eriksen (**PCT Publication No.: DK2005-000310)**, hereinafter referred to as Eriksen '310.*

Regarding claim 1, Eriksen '310 discloses a cooling system (Fig. 1-8: page 2, lines 5-6) for a heat-generating **1** (see Fig. 4, page 2, line 7) component, comprising: a double-sided chassis (Fig. 17, depicts a form of a double-sided chassis) adapted to mount a pump (as see page 29, line 19) configured to circulate a cooling liquid (see page 1, lines 21-24), the pump comprising a stator **37** (see page 28, lines 6-21) and an impeller **33** (see page 29, lines 17-28), the impeller being positioned in a recess (see Fig. 17: page 29, line 17, wherein a pump chamber **46** constitutes a recess) on the underside of the chassis and the stator being positioned on the upper side of the chassis and isolated from the cooling liquid (as shown in Fig. 17); a reservoir **14** (page 29, lines 6-25) adapted to pass the cooling liquid therethrough, the reservoir including: a pump chamber formed by the recess (see Fig. 17: page 29, line 17, wherein a pump chamber **46** constitutes the recess) and at least an impeller cover (see annotated Fig. 17: wherein **46A** constitutes an impeller cover) having one or more passages **34** for the cooling liquid to pass through; a thermal exchange chamber (see annotated Fig. 17: page 29, lines 24-28, wherein interior chamber **47A** between an intermediate member **47** and the heat exchange surface **4** constitutes a thermal exchange chamber), the pump chamber and the thermal exchange chamber being separate chambers that are fluidly coupled together by the one or more passages **48, 49**; and a heat-exchanging interface **4** (see Fig. 15 and 17: page 29, lines 30-33), the heat-exchanging interface forming a boundary wall **4A** (see Fig. 15: page 24, lines 15-20) of the thermal exchange chamber, and configured to be placed in thermal contact with a surface (Fig. 10: page 23, lines 30-39: wherein a free surface constitutes a surface) of the heat-generating component; and a heat radiator (see page 28, lines 30-40) fluidly coupled to the reservoir and configured to dissipate heat from the cooling liquid.

Regarding claim 2, Eriksen ‘310 discloses the cooling system of claim 1, wherein the chassis shields the stator (see page 28, lines 6-12, wherein the stator is being shielded within recess 40) from the cooling liquid in the reservoir.

Regarding claim 3, Eriksen ‘310 discloses the cooling system of claim 1, wherein the heat-exchanging interface includes a first side **4A** (see Fig. 15: page 24, lines 15-20) and a second side **4B** opposite the first side, and wherein the heat- exchanging interface contacts the cooling liquid in the thermal exchange chamber on the first side and the heat-exchanging interface is configured to be in thermal contact with the surface of the heat-generating component on the second side,

Regarding claim 4, Eriksen ‘310 discloses the cooling system of claim 3, wherein the first side of the heat- exchanging interface includes features **29** (see Fig. 15: page 24, lines 15-20) that are adapted to increase heat transfer from the heat-exchanging interface to the cooling liquid in the thermal exchange chamber.

Regarding claim 5, Eriksen ‘310 discloses the cooling system of claim 4, wherein the features include at least one of pins or fins (see Fig. 11-13: page 24, lines 15-20).

Regarding claim 6, Eriksen ‘310 discloses the cooling system of claim 1, wherein the impeller is positioned in the pump chamber (see Fig. 17: page 29, line 17).

Regarding claim 7, Eriksen ‘310 discloses the cooling system of claim 1, wherein a passage **34** of the one or more passages that fluidly couple the pump chamber and the thermal exchange chamber is offset from a center of the impeller (see Fig. 17: page 29, lines 17-19).

Regarding claim 8, Eriksen ‘310 discloses the cooling system of claim 1, wherein the impeller includes a plurality of curved blades (as shown in Fig 17).

Regarding claim 9, Eriksen ‘310 discloses the cooling system of claim 1, wherein the pump chamber and the thermal exchange chamber are spaced apart in a vertical direction (as shown in annotated FIG. 17).

Regarding claim 10, Eriksen ‘310 discloses the cooling system of claim 1, wherein the heat-exchanging interface includes one of copper and aluminum (see page 29, lines 6-11).

Regarding claim 11, Eriksen ‘310 discloses the cooling system of claim 1, wherein the heat radiator **11** (see Fig. 8: pages 33-39) is fluidly coupled to the reservoir **14** using flexible conduits **24 and 25**, and the heat radiator is configured to be positioned remote from the reservoir (as shown in Fig. 8).

Regarding claim 12, Eriksen ‘310 discloses a cooling system for a computer system (Fig. 1-8: page 2, lines 5-6), comprising: a centrifugal pump (as see page 29, line 19) adapted to circulate a cooling liquid (see page 1, lines 21-24), the pump including: an impeller **33** (see page 29, lines 17-28) exposed to the cooling liquid; and a stator **37** (see page 28, lines 6-21) isolated from the cooling liquid; a reservoir **14** (page 29, lines 6-25) configured to be thermally coupled to a heat-generating component **1** (see Fig. 4, page 2, line 7) of the computer system, the reservoir including: a thermal exchange chamber (see annotated Fig. 17: page 29, lines 24-28, wherein an interior chamber **47A** between an intermediate member **47** and the heat exchange surface **4** constitutes a thermal exchange chamber) adapted to be positioned in thermal contact with the heat-generating component; a separate pump chamber **46** vertically spaced part (as shown in annotated FIG. 17) from the thermal exchange chamber **47A** and coupled with the thermal exchange chamber through one or more passages **48 and 49** configured for fluid communication between the pump chamber and the thermal exchange chamber, and wherein at least one of the one **34** or more passages is offset from a center of the impeller (see Fig. 17: page 29, lines 17-19).

Regarding claim 13, Eriksen '310 discloses the cooling system of claim 12, wherein a top wall **44** (see page 28, lines 14-21) of the reservoir physically separates the impeller from the stator.

Regarding claim 14, Eriksen '310 discloses the cooling system of claim 12, wherein the thermal exchange chamber includes a heat-exchange interface **4** (see Fig. 15 and 17: page 29, lines 30-33) configured to be placed in thermal contact with the heat-generating component.

Regarding claim 15, Eriksen '310 discloses the cooling system of claim 12, further including a heat radiator **11** (see Fig. 8: pages 33-39) fluidly coupled to the reservoir **14** using flexible conduits **24 and 25**, wherein the heat radiator is configured to be positioned remote from the reservoir (as shown in Fig. 8).

Regarding claim 16, Eriksen '310 discloses the cooling system of claim 12, wherein the fluid passage that is offset from the center of the impeller is positioned tangentially to the circumference of the impeller (see Fig. 17: page 29, lines 17-19).

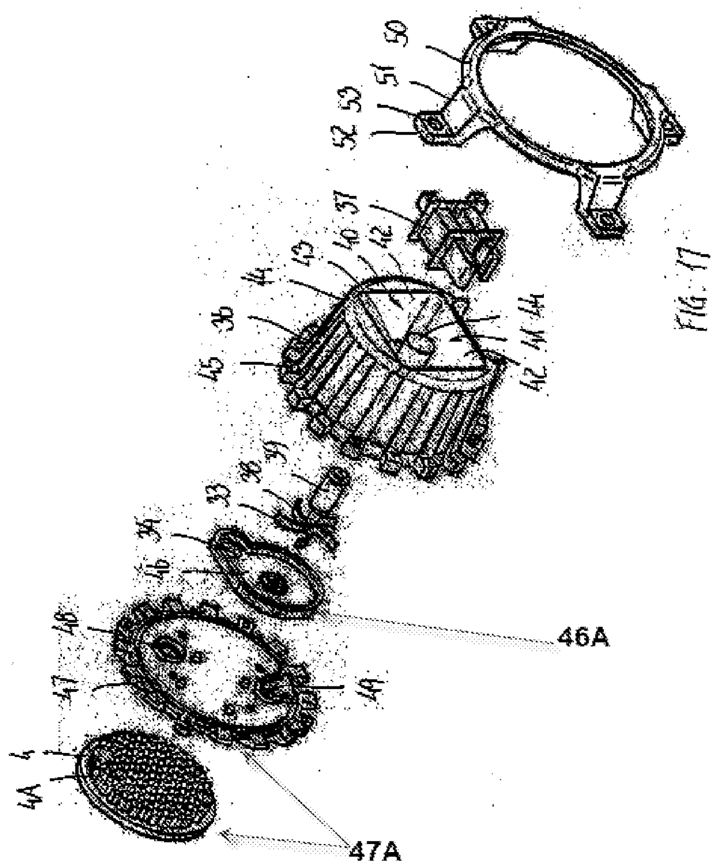
Regarding claim 17, Eriksen '310 discloses a cooling system (Fig. 1-8: page 2, lines 5-6) for a heat-generating **1** (see Fig. 4, page 2, line 7) component, comprising: a pump (as see page 29, line 19) adapted to circulate a cooling liquid (see page 1, lines 21-24), the pump including: an impeller **33** (see page 29, lines 17-28) exposed to the cooling liquid; and a stator **37** (see page 28, lines 6-21) isolated from the cooling liquid; a reservoir including an impeller cover (see annotated Fig. 17: wherein **46A** constitutes an impeller cover), an intermediate member **47** (see page 29, lines 17-28) and a heat exchange interface **4**, wherein a top wall **44** (see page 28, lines 14-21) of the reservoir and the impeller cover define a pump chamber **46** for housing the impeller, and the intermediate member and the heat exchange interface define a thermal exchange chamber (see annotated Fig. 17: page 29, lines 24-28, wherein an interior chamber **47A** between an intermediate member **47** and the heat exchange surface **4** constitutes a thermal exchange chamber), the pump chamber and the thermal exchange chamber being spaced apart from each other in a vertical direction and fluidly coupled together (as shown in annotated FIG. 17); and wherein a first side **4A** (see Fig. 15: page 24, lines 15-20) of the heat-exchanging interface is in contact with a cooling liquid in the thermal exchange chamber and a second side **4B** of the heat- exchanging interface opposite the first side is configured to be placed in thermal contact with a surface (Fig. 10: page 23, lines 30-39: wherein a free surface constitutes a surface) of the heat-generating component; and a liquid-to-air heat exchanger **11** (see Fig. 8: pages 33-39) fluidly coupled to the reservoir using flexible conduits **24 and 25**, the heat exchanger being configured to be positioned remote from the reservoir (as shown in Fig. 8).

Regarding claim 18, Eriksen ‘310 discloses the cooling system of claim 17, wherein the impeller cover includes a first opening **34** radially offset from a center of the impeller (see Fig. 17: page 29, lines 17-19) and the intermediate member includes a second passage **48** that is aligned with the first opening, the first and the second opening **49** being configured to direct the cooling liquid from the pump chamber into the thermal exchange chamber (as shown in Fig. 17).

Regarding claim 19, Eriksen ‘310 discloses the cooling system of claim 17, wherein the first side of the heat- exchanging interface includes at feast one of pins or fins **29** (see Fig. 11-13: page 24, lines 15-20).

Regarding claim 20, Eriksen ‘310 discloses the cooling system of claim 17, wherein the top wall of the reservoir extends between the stator and the impeller and shields the stator from the cooling liquid in the reservoir (as shown in Fig. 17: page 28, lines 14-21).

WO 2006/119761 PCT/DK2005/000310
15/36



Annotated Fig. 17

Conclusion

2. Any inquiry concerning this communication or earlier communications from the examiner should be directed to EMMANUEL DUKE whose telephone number is (571)270-5290. The examiner can normally be reached on Monday - Friday; 8:00am - 5:00pm EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Cheryl Tyler or Frantz Jules can be reached on 571-272-4834 or 571-272-6681. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Frantz F. Jules/
Supervisory Patent Examiner, Art Unit 3784

/EMMANUEL DUKE/
Examiner, Art Unit 3784
12/13/2011

Notice of References Cited	Application/Control No. 13/269,234	Applicant(s)/Patent Under Reexamination ERIKSEN, ANDR LOTH FINNE	
	Examiner EMMANUEL DUKE	Art Unit 3784	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
	A	US-			
	B	US-			
	C	US-			
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N	PCT/DK2005/000310	11-2006	DK	ERIKSEN	G06F 1/20
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13269234	ERIKSEN, ANDR LOTH FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER
	Examiner	**Art Unit**
	EMMANUEL DUKE	3784

SEARCHED

Class	Subclass	Date	Examiner
165	80.2,80.4,104.21,104.31,,104.33	12/13/2011	ED

SEARCH NOTES

Search Notes	Date	Examiner
Inventor TextSearch in East	12/13/2011	ED
PLUS Search Requested and Reviewed	12/20/2011	ED

INTERFERENCE SEARCH

Class	Subclass	Date	Examiner

/EMMANUEL DUKE/ Examiner.Art Unit 3784	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /E.D./ (12/13/2011)

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)	Complete if Known	
	Application Number	13/269,234
	Filing Date	October 7, 2011
	First Named Inventor	Eriksen, Andre Sloth
	Art Unit	~~3744~~ 3784
	Examiner Name	~~Unassigned~~ Emmanuel Duke
Sheet 1 of 1	Attorney Docket Number	10494.0003-01000

U.S. PATENTS AND PUBLISHED U.S. PATENT APPLICATIONS

Examiner Initials*	Cite No.[1]	Document Number: Number-Kind Code[2] (if known)	Issue or Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		US-7,325,591	02-05-2008	Duan et al.	
		US-2004-0052048 A1	03-18-2004	Wu et al.	
		US-			
		US-			
		US-			
		US-			
		US-			
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		US-			
		US-			
		US-			

Note: Submission of copies of U.S. Patents and published U.S. Patent Applications is not required.

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document: Country Code[3] Number[4] Kind Code[5] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	Translation[6]

NONPATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	Translation[6]

Examiner Signature	/Emmanuel Duke/ (12/13/2011)	Date Considered	12/13/2011

EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

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BIB DATA SHEET

CONFIRMATION NO. 1954

SERIAL NUMBER	FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
13/269,234	10/07/2011 **RULE**	165	3784	10494.0003-01000

APPLICANTS
André Sloth ERIKSEN, Aalborg C, DENMARK;

** **CONTINUING DATA** *************************
This application is a CON of 11/919,974 01/06/2009
which is a 371 of PCT/DK2005/000310 05/06/2005

** **FOREIGN APPLICATIONS** *************************

** **IF REQUIRED, FOREIGN FILING LICENSE GRANTED** ** ** SMALL ENTITY **
10/22/2011

		STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
Foreign Priority claimed ☐ Yes ☑ No 35 USC 119(a-d) conditions met ☐ Yes ☑ No Verified and Acknowledged /EMMANUEL E DUKE/ Examiner's Signature	☐ Met after Allowance ED Initials	DENMARK	12	20	3

ADDRESS

FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER LLP
901 NEW YORK AVENUE, NW
WASHINGTON, DC 20001-4413
UNITED STATES

TITLE

COOLING SYSTEM FOR A COMPUTER SYSTEM

FILING FEE RECEIVED		
830	FEES: Authority has been given in Paper No.____________ to charge/credit DEPOSIT ACCOUNT No.____________ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other ________________ ☐ Credit

BIB (Rev. 05/07).

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /E.D./ (12/13/2011)

IDS Form PTO/SB/08: Substitute for form 1449A/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Application Number	13/269,234
				Filing Date	October 7, 2011
				First Named Inventor	Eriksen, André Sloth
				Art Unit	~~To be assigned~~ 3784
(Use as many sheets as necessary)				Examiner Name	~~To be assigned~~ Emmanuel Duke
Sheet	1	of	2	Attorney Docket Number	10494.0003-01000

U.S. PATENTS AND PUBLISHED U.S. PATENT APPLICATIONS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] *(if known)*	Issue or Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		US-2003/151895 A1	08-14-2003	Zuo	
		US-2004/0105232 A1	06-03-2004	Ito et al.	
		US-4,898,579 A	02-06-1990	Groshong et al.	
		US-6,668,911 A	12-30-2003	Bingler	
		US-6,749,012 B2	06-15-2004	Gwin et al.	
		US-6,725,682 B2	04-27-2004	Scott	
		US-3,810,509	05/14/1974	Kun	
		US-5,708,564	01/13/1998	Lin	
		US-5,731,954	03/24/1998	Cheon	
		US-5,784,257	07/21/1998	Tata	
		US-5,825,622	10/20/1998	Rife et al.	
		US-5,890,880	04/06/1999	Lustwerk	
		US-5,901,037	05/04/1999	Hamilton et al.	
		US-6,166,907	12/26/2000	Chien	
		US-6,305,463 B1	10/23/2001	Salmonson	
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		US-2004/0052049 A1	03/18/2004	Wu et al.	
		US-2005/0061482 A1	03/24/2005	Lee et al.	

Note: Submission of copies of U.S. Patents and published U.S. Patent Applications is not required.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /E.D./ (12/13/2011)

IDS Form PTO/SB/08: Substitute for form 1449A/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				*Application Number*	13/269,234
				Filing Date	October 7, 2011
				First Named Inventor	Eriksen, André Sloth
				Art Unit	~~To be assigned~~ 3784
(Use as many sheets as necessary)				*Examiner Name*	~~To be assigned~~ Emmanuel Duke
Sheet	2	of	2	*Attorney Docket Number*	10494.0003-01000

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3] Number[4] Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	Translation[6]
		WO 01/25881 A	04-12-2001	Asetek A/S		
		WO 2005/017468 A2	02-24-2005	Apple Computer Inc.		
		EP 0,574,823 A2	12/22/1993	Askoll S.p.A.		
		EP 0,610,826 A2	08/17/1994	Askoll S.p.A.		
		WO 2005/045654 A2	05/19/2005	Asetek A/S		

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	Translation[6]

Examiner Signature	/Emmanuel Duke/ (12/13/2011)	Date Considered	12/13/2011

EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant

Index of Claims	Application/Control No. 13269234	Applicant(s)/Patent Under Reexamination ERIKSEN, ANDR LOTH FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER
	Examiner EMMANUEL DUKE	Art Unit 3784

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	12/13/2011								
	1	✓								
	2	✓								
	3	✓								
	4	✓								
	5	✓								
	6	✓								
	7	✓								
	8	✓								
	9	✓								
	10	✓								
	11	✓								
	12	✓								
	13	✓								
	14	✓								
	15	✓								
	16	✓								
	17	✓								
	18	✓								
	19	✓								
	20	✓								

PLUS Search Results for S/N 13269234, Searched Tue Dec 13 10:37:24 EST 2011

The Patent Linguistics Utility System (PLUS) is a USPTO automated search system for U.S. Patents from 1971 to the present PLUS is a query-by-example search system which produces a list of patents that are most closely related linguistically to the application searched. This search was prepared by the staff of the Scientific and Technical Information Center, SIRA.

4291756 99
4393922 98
4612782 98
5787720 98
4258676 97
4874390 97
5573184 97
5731954 97
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5891188 96
5921086 96
6116042 96

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/269,234	10/07/2011	André Sloth ERIKSEN	10494.0003-01000	1954

22852 7590 12/06/2011
FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER LLP
901 NEW YORK AVENUE, NW
WASHINGTON, DC 20001-4413

EXAMINER	

ART UNIT	PAPER NUMBER
3785	

MAIL DATE	DELIVERY MODE
12/06/2011	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

PTOL-90A (Rev. 04/07)

Doc Code: TRACK1.GRANT

Decision Granting Request for Prioritized Examination (Track I)	Application No.: 13/269234

1. THE REQUEST FILED October 7, 2011 IS **GRANTED.**

   The above-identified application has met the requirements for prioritized examination (Track I).

2. **The above-identified application will undergo prioritized examination.** The application will be accorded special status throughout its entire course of prosecution until one of the following occurs:

   A. filing a **petition for extension of time** to extend the time period for filing a reply;

   B. filing an **amendment to amend the application to contain more than four independent claims, more than thirty total claims**, or a multiple dependent claim;

   C. filing a **request for continued examination**;

   D. filing a notice of appeal;

   E. filing a request for suspension of action;

   F. mailing of a notice of allowance;

   G. mailing of a final Office action;

   H. completion of examination as defined in 37 CFR 41.102; or

   I. abandonment of the application.

Telephone inquiries with regard to this decision should be directed to Linda Sholl at 571-272-4391. In her absence, calls may be directed to Josie Ballato at 571-272-3567.

/Linda Sholl/
Linda Sholl
Quality Assurance Specialist
Technology Center 3700

U.S. Patent and Trademark Office
PTO-2298 (Rev. 09-2011)

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 13/269,234

APPLICATION AS FILED - PART I

FOR	NUMBER FILED (Column 1)	NUMBER EXTRA (Column 2)	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	95		N/A	
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	310		N/A	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	125		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	20 minus 20 =	*	x 30 =	0.00	OR		
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	*	x 125 =	0.00			
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			0.00			
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				0.00			
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	530		TOTAL	

APPLICATION AS AMENDED - PART II

AMENDMENT A

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

AMENDMENT B

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	RATE($)	ADDITIONAL FEE($)		RATE($)	ADDITIONAL FEE($)
Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

UNITED STATES DEPARTMENT OF COMMERCE
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Alexandria, Virginia 22313-1450
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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
13/269,234	10/07/2011	3744	830	10494.0003-01000	20	3

CONFIRMATION NO. 1954

UPDATED FILING RECEIPT

OC000000051200069

22852
FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER LLP
901 NEW YORK AVENUE, NW
WASHINGTON, DC 20001-4413

Date Mailed: 12/02/2011

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Applicant(s)

André Sloth ERIKSEN, Aalborg C, DENMARK;

Power of Attorney: The patent practitioners associated with Customer Number 22852

Domestic Priority data as claimed by applicant

This application is a CON of 11/919,974 01/06/2009
which is a 371 of PCT/DK2005/000310 05/06/2005

Foreign Applications (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.)

If Required, Foreign Filing License Granted: 10/22/2011

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 13/269,234**

Projected Publication Date: 03/15/2012

Non-Publication Request: No

Early Publication Request: No
**** SMALL ENTITY ****

Title

COOLING SYSTEM FOR A COMPUTER SYSTEM

Preliminary Class

062

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4158).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				*Complete if Known*	
				Application Number	13/269,234
				Filing Date	October 7, 2011
				First Named Inventor	Eriksen, Andre Sloth
				Art Unit	3744
				Examiner Name	Unassigned
Sheet	1	of	1	*Attorney Docket Number*	10494.0003-01000

U.S. PATENTS AND PUBLISHED U.S. PATENT APPLICATIONS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] *(if known)*	Issue or Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		US-7,325,591	02-05-2008	Duan et al.	
		US-2004-0052048 A1	03-18-2004	Wu et al.	
		US-			
		US-			
		US-			
		US-			
		US-			
		US-			
		US-			
		US-			
		US-			

Note: Submission of copies of U.S. Patents and published U.S. Patent Applications is not required.

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3] Number[4] Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	Translation[6]

NONPATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	Translation[6]

Examiner Signature		Date Considered	

EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

Electronic Acknowledgement Receipt	
EFS ID:	11521439
Application Number:	13269234
International Application Number:	
Confirmation Number:	1954
Title of Invention:	COOLING SYSTEM FOR A COMPUTER SYSTEM
First Named Inventor/Applicant Name:	André Sloth ERIKSEN
Customer Number:	22852
Filer:	Biju I. Chandran/Faith Wills
Filer Authorized By:	Biju I. Chandran
Attorney Docket Number:	10494.0003-01000
Receipt Date:	01-DEC-2011
Filing Date:	07-OCT-2011
Time Stamp:	14:14:54
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		0003-IDS.pdf	93260 e7f7bb7349fc9776ca86f86ecb719911f71f45a7	yes	3

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Transmittal Letter	1	2
	Information Disclosure Statement (IDS) Form (SB08)	3	3
Warnings:			
Information:			
	Total Files Size (in bytes):	93260	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	)	
	)	
Inventor: André Sloth ERIKSEN	)	Group Art Unit: 3744
	)	
Application No.: 13/269,234	)	
	)	Examiner: Unassigned
Filed: October 7, 2011	)	
	)	
For: COOLING SYSTEM FOR A COMPUTER SYSTEM	)	Confirmation No.: 1954
	)	
	)	

Sir:

INFORMATION DISCLOSURE STATEMENT UNDER 37 C.F.R. § 1.97(b)

Pursuant to 37 C.F.R. §§ 1.56 and 1.97(b), Applicant brings to the attention of the Examiner the listed documents on the attached PTO SB/08 Form. This Information Disclosure Statement is being filed before the mailing date of a first Office Action on the merits for the above-referenced application.

Copies of the U.S. patent publications are not enclosed.

Applicant respectfully requests that the Examiner consider the listed documents and indicate that it was considered by making appropriate notations on the attached form.

This submission does not represent that a search has been made or that no better art exists and does not constitute an admission that the listed documents are material or constitute "prior art." If the Examiner applies any of the documents as prior art against any claim in the application and Applicant determines that the cited documents do not constitute "prior art" under United States law, Applicant reserves the right to present to the U.S. Patent and Trademark Office the relevant facts and law regarding the appropriate status of such documents.

Applicant further reserves the right to take appropriate action to establish the patentability of the disclosed invention over the listed documents, should one or more of the documents be applied against the claims of the present application.

If there is any fee due in connection with the filing of this Statement, please charge the fee to Deposit Account 06-0916.

Respectfully submitted,

FINNEGAN, HENDERSON, FARABOW,
GARRETT & DUNNER, L.L.P.

Dated: December 1, 2011

By: Biju Chandran

Biju I. Chandran
Reg. No. 63,684

PATENT
Attorney Docket No. 10494.0003-01000

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	)	
	)	
André Sloth ERIKSEN	)	Group Art Unit: Not yet assigned
	)	
Application No.: 13/269,234	)	Examiner: Not yet assigned
	)	
Filed: October 7, 2011	)	
	)	Confirmation No.: 1954
For: COOLING SYSTEM FOR A COMPUTER SYSTEM	)	
	)	

Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

VIA EFS Web

Sir:

RESPONSE TO NOTICE TO FILE
CORRECTED APPLICATION PAPERS

In response to the communication of October 27, 2011, Applicant submits herewith a Replacement Drawings in compliance with 37 CFR 1.84 and 37 CFR 1.121(d). These Replacement Drawings contain no new matter. Applicant submits that these Replacement Drawings are reasonably free from erasures, overwriting, interlineations, folds, and copy marks.

Please replace the drawings in the above-identified application with FIGS. 1-20 in the twelve (12) Replacement Sheets filed herewith. If the replacement drawings for any reason are not in full compliance with the pertinent statutes and regulations, please so advise the undersigned.

Please grant any extensions of time required to enter this response, and charge any required fees to Deposit Account 06-0916.

Respectfully submitted,

FINNEGAN, HENDERSON, FARABOW,
GARRETT & DUNNER, L.L.P.

Dated: November 18, 2011

By: ______________________
Biju I. Chandran
Reg. No. 63,684
(202) 408-4230

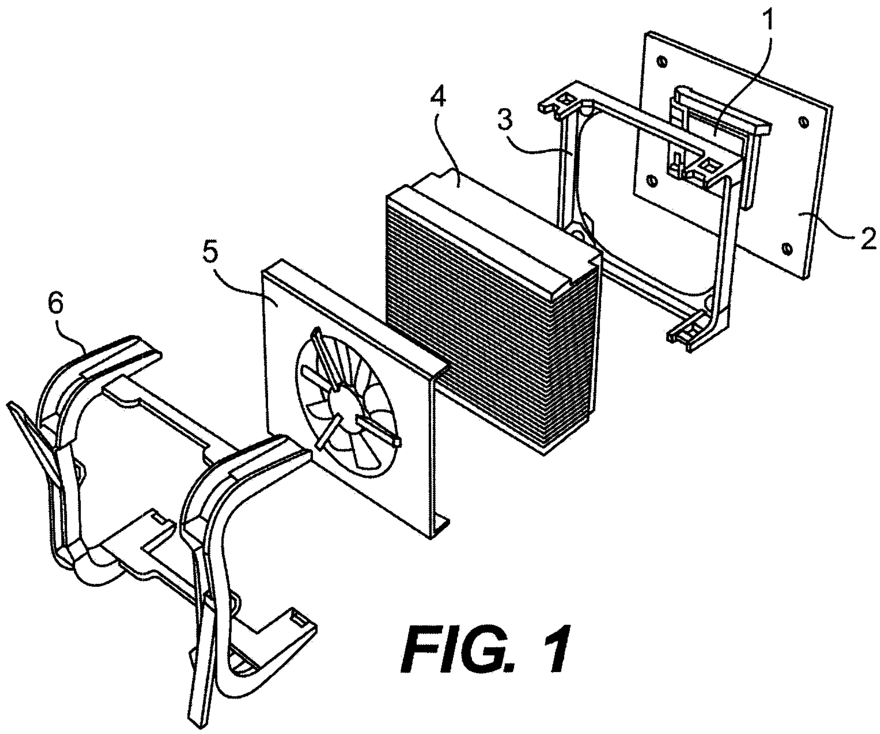

FIG. 1

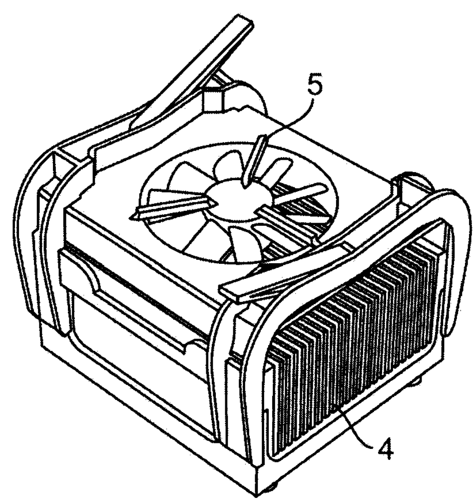

FIG. 2

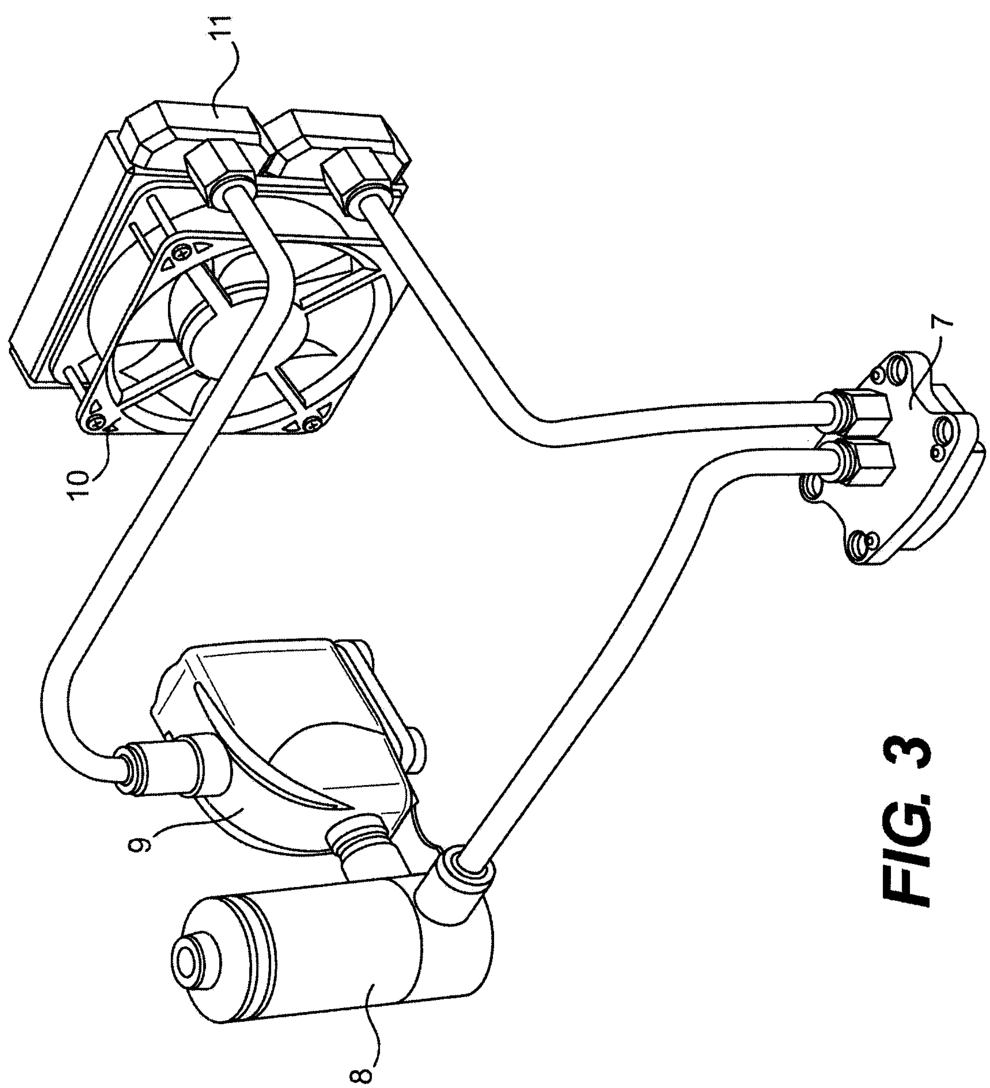

FIG. 3

Replacement Sheet

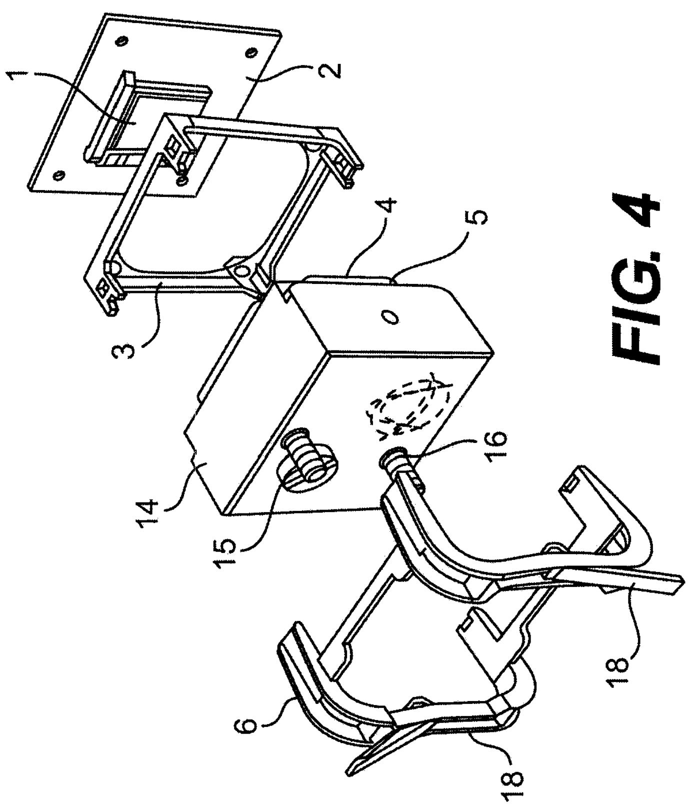

FIG. 4

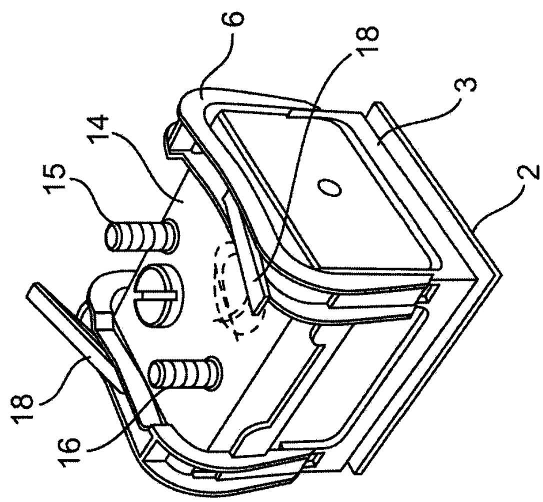

FIG. 5

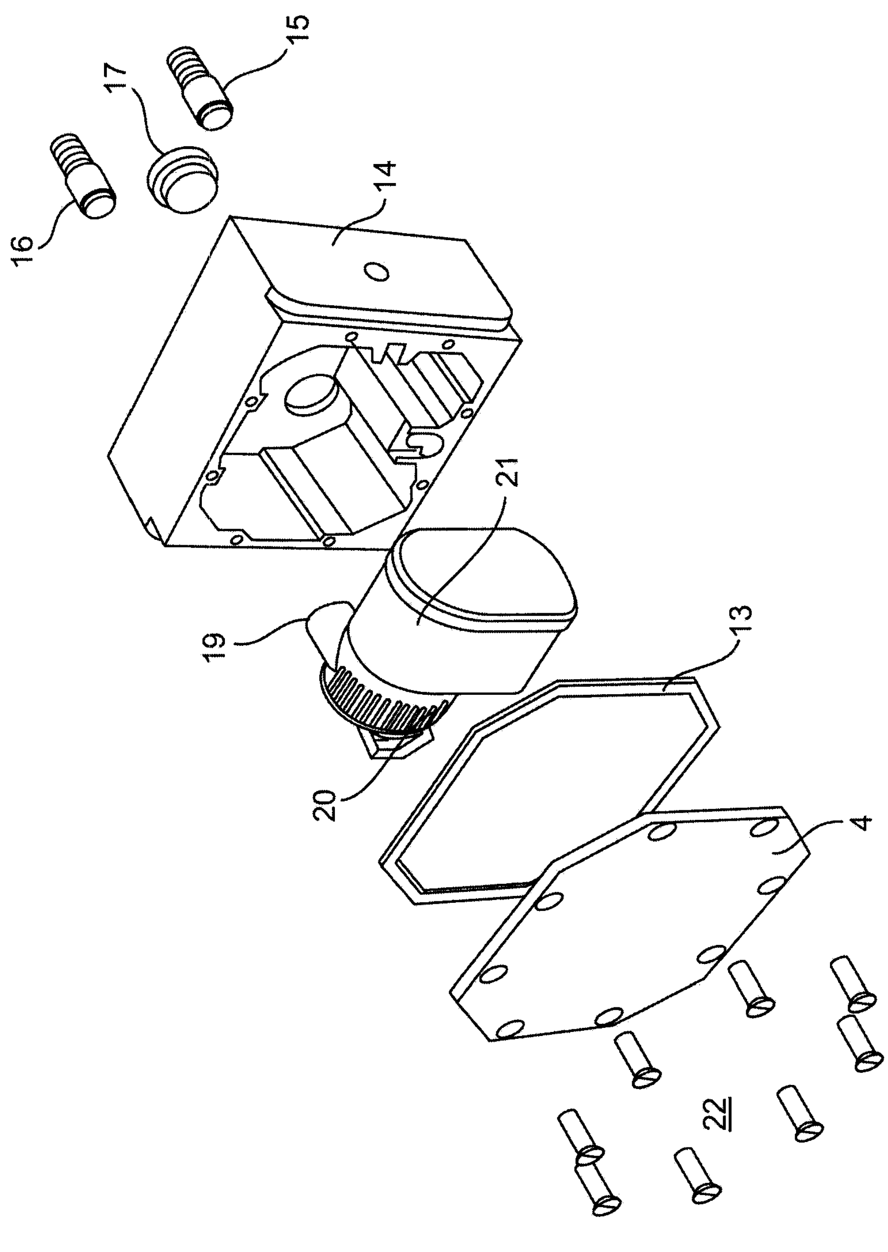

FIG. 6

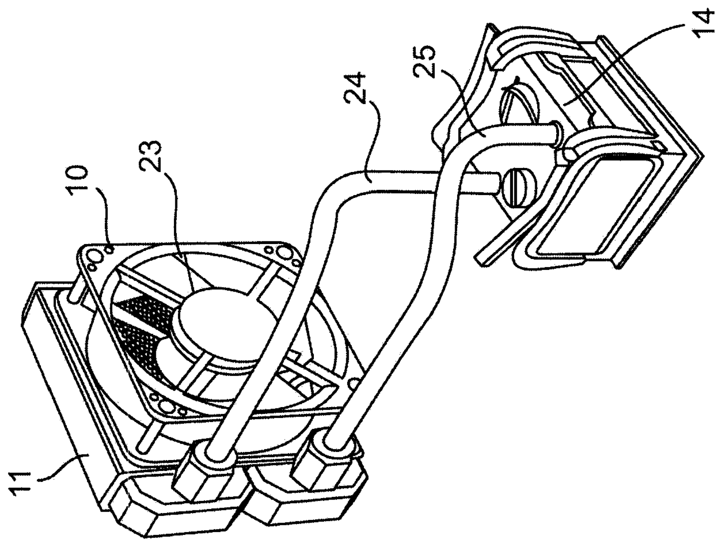

FIG. 7

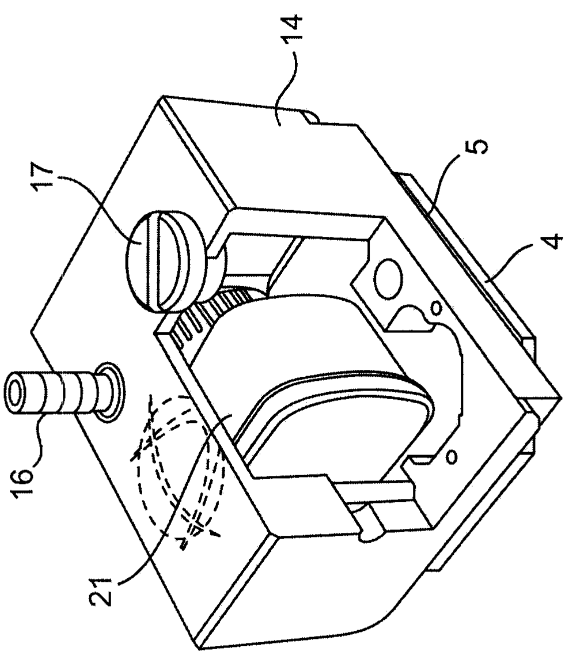

FIG. 8

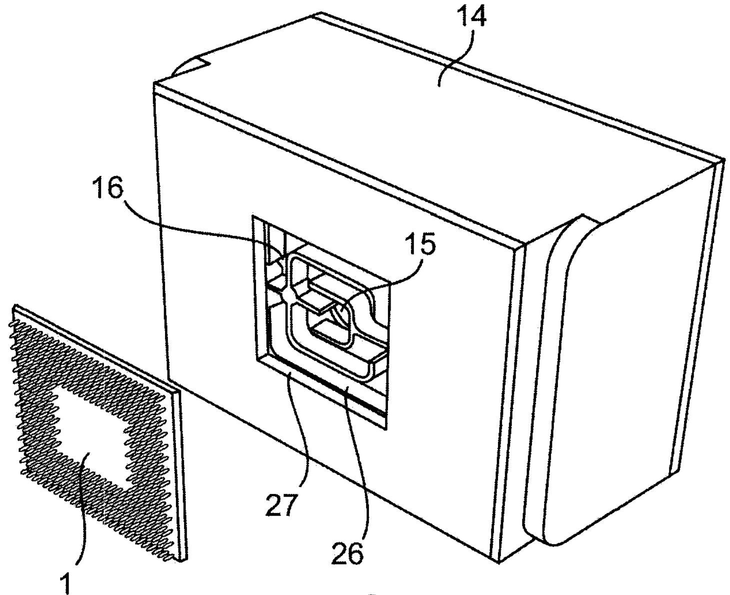

FIG. 9

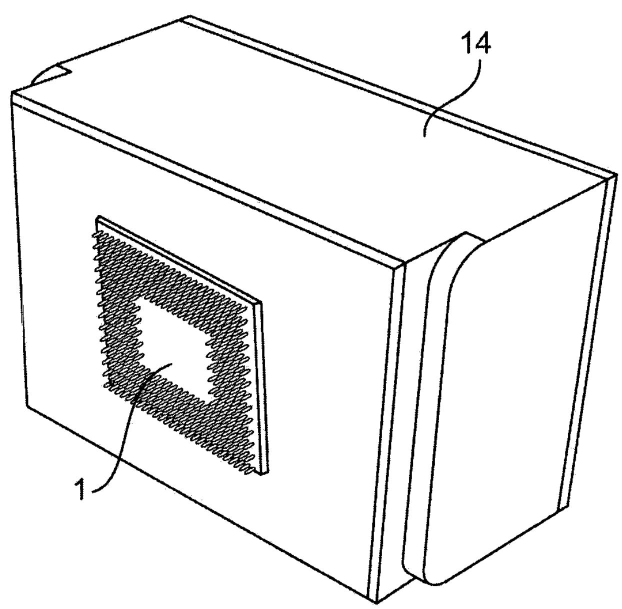

FIG. 10

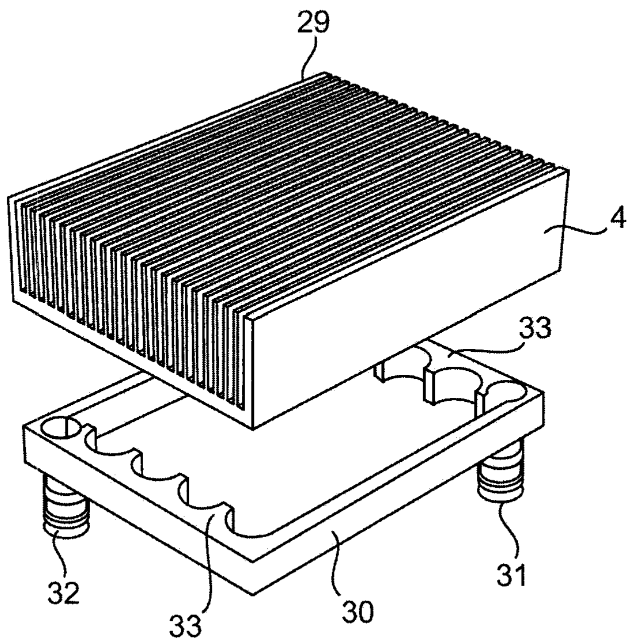

FIG. 11

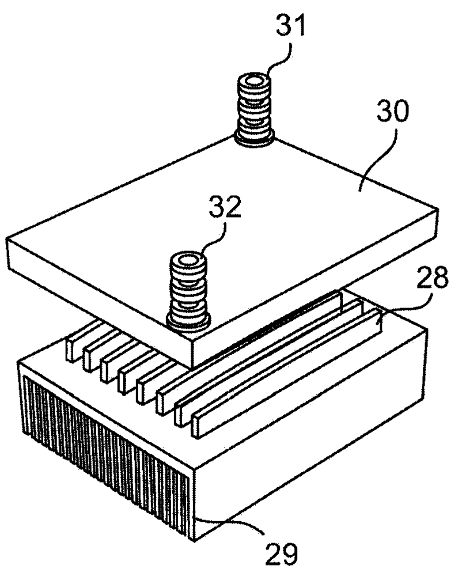

FIG. 12

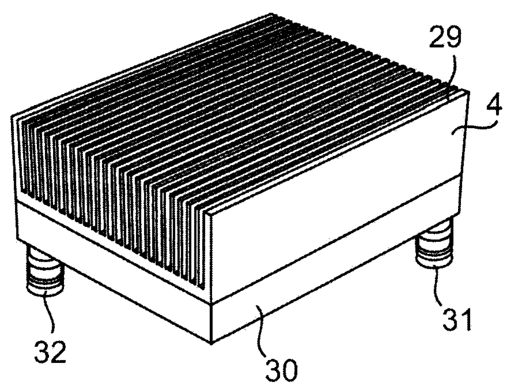

FIG. 13

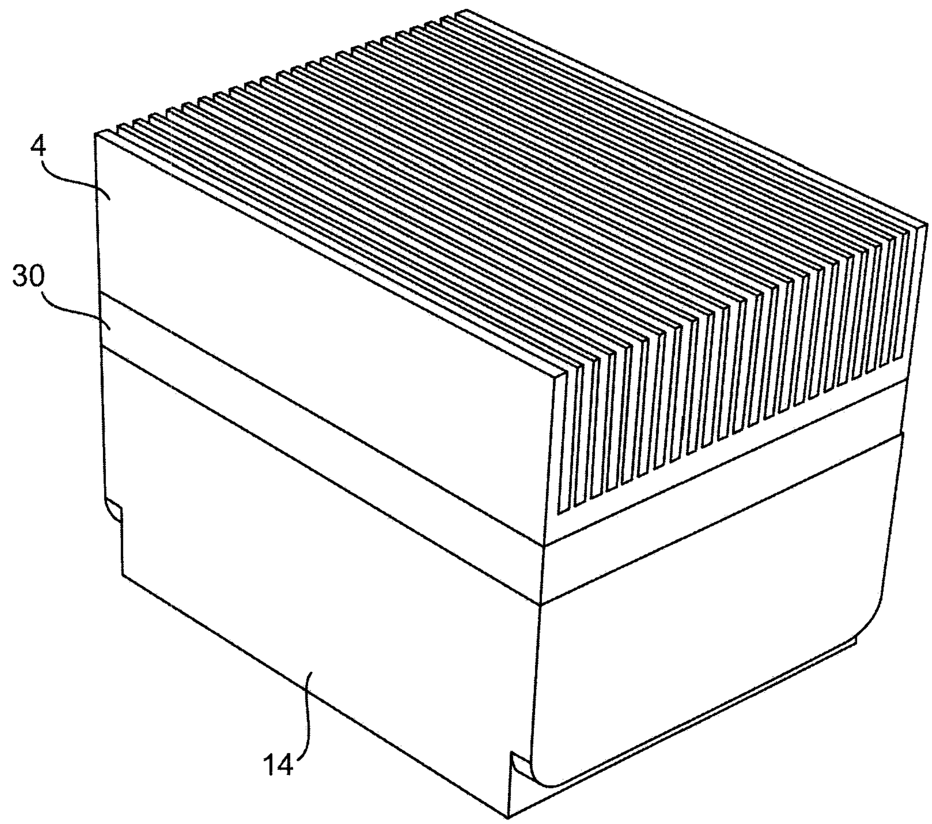

FIG. 14

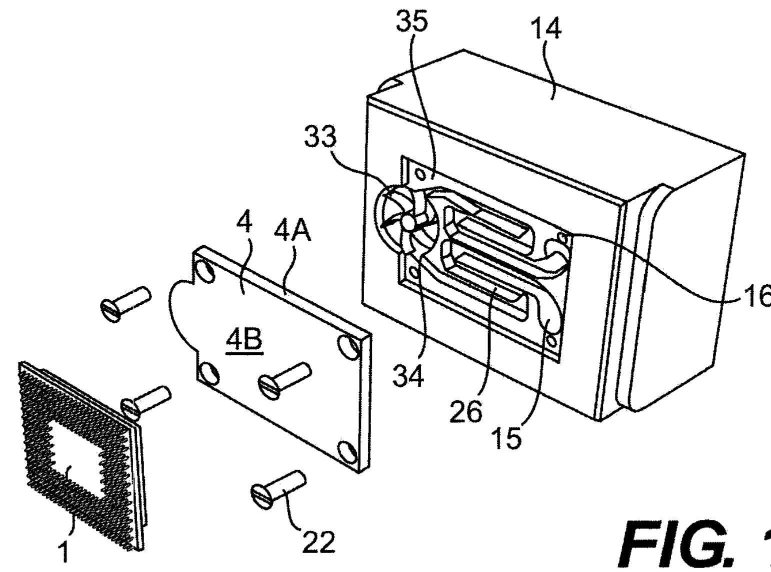

FIG. 15

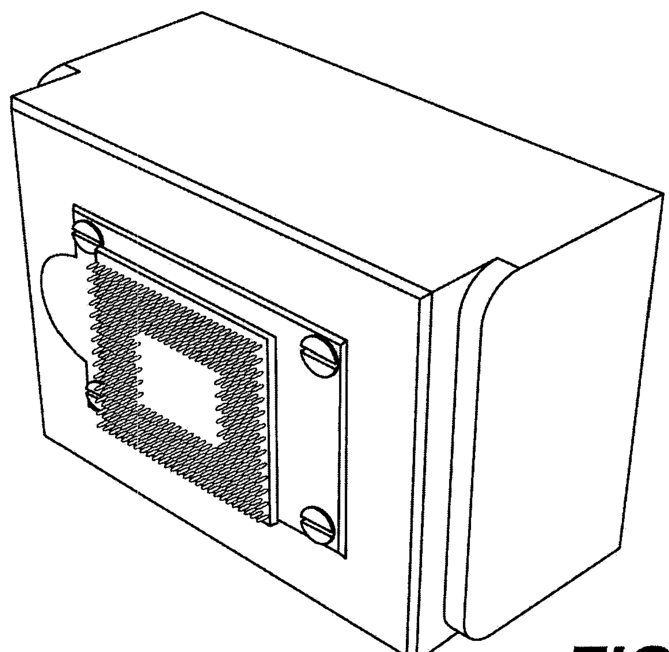

FIG. 16

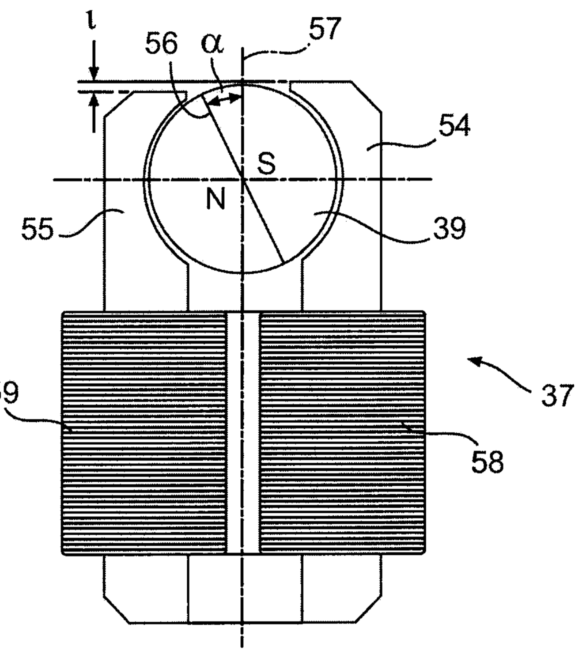

FIG. 18

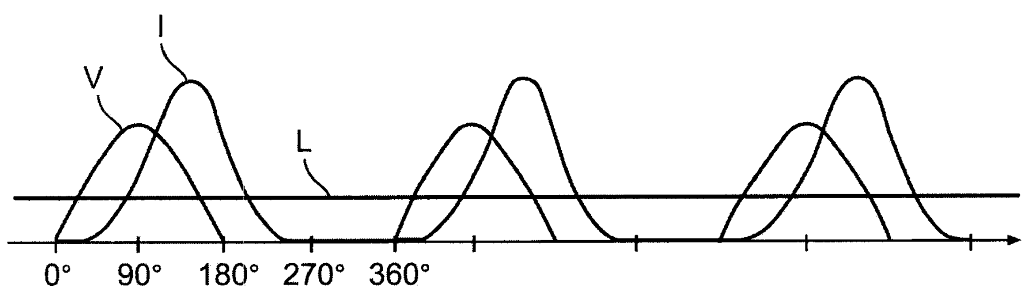

FIG. 19

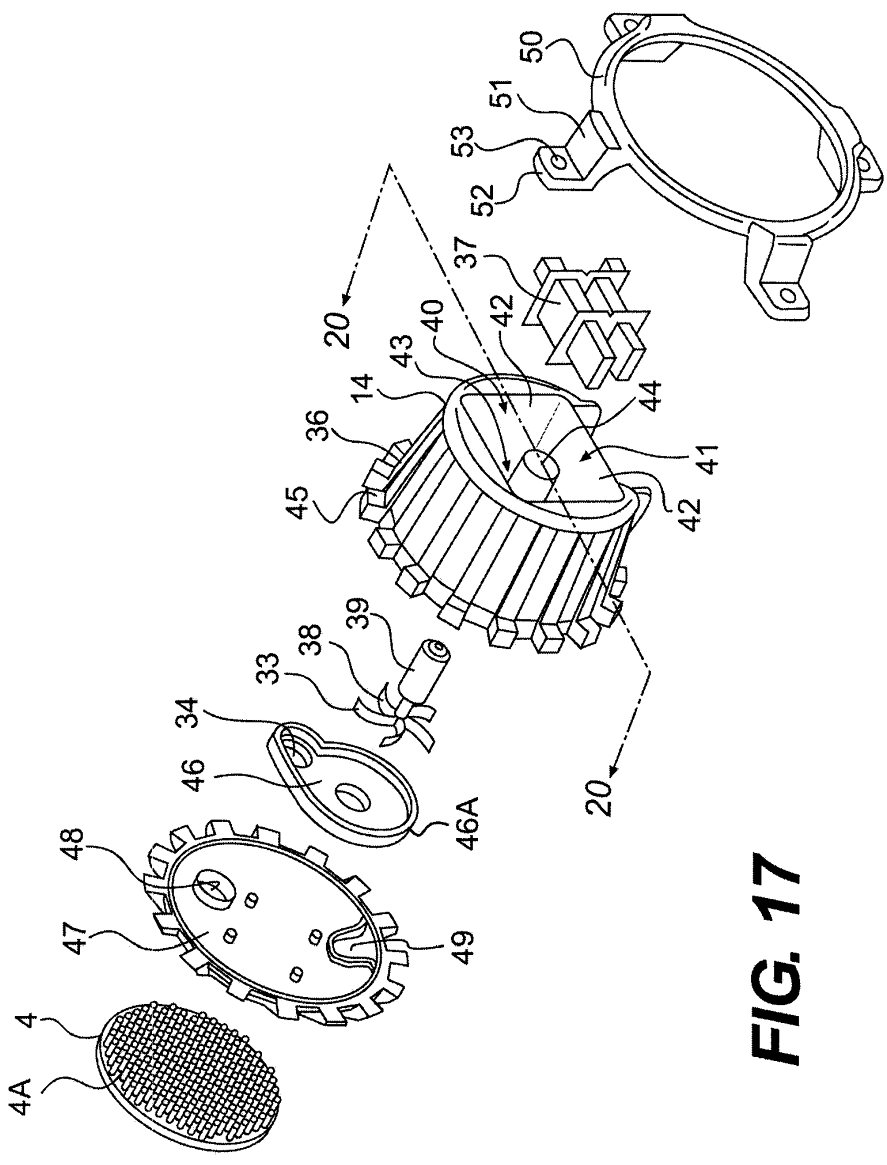
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FIG. 17

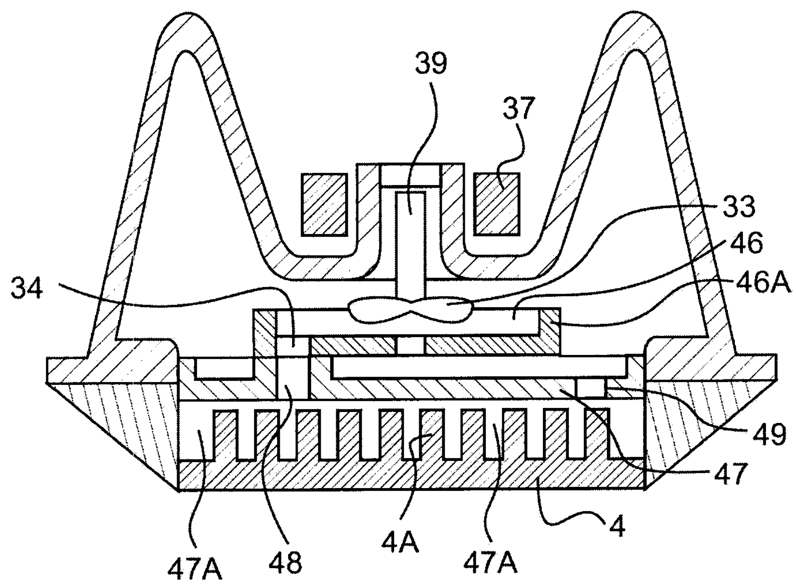

FIG. 20

Electronic Acknowledgement Receipt

EFS ID:	11445707
Application Number:	13269234
International Application Number:	
Confirmation Number:	1954
Title of Invention:	COOLING SYSTEM FOR A COMPUTER SYSTEM
First Named Inventor/Applicant Name:	André Sloth ERIKSEN
Customer Number:	22852
Filer:	Biju I. Chandran/Margie Harris
Filer Authorized By:	Biju I. Chandran
Attorney Docket Number:	10494.0003-01000
Receipt Date:	18-NOV-2011
Filing Date:	07-OCT-2011
Time Stamp:	18:17:49
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Applicant Response to Pre-Exam Formalities Notice	ResponseToNoticeToFileCorrectedApplicationPapers.pdf	39586 9d06450a751dd0be2d231770e6a251453d8ebb02	no	2

Warnings:

Information:

2	Drawings-only black and white line drawings	ReplacementSheets.pdf	363564 e78c0f9ce05fa4beea7de92f9808822bafc53b0a	no	12
Warnings:					
Information:					
			Total Files Size (in bytes):	403150	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/269,234	10/07/2011	André Sloth ERIKSEN	10494.0003-01000

CONFIRMATION NO. 1954

FORMALITIES LETTER

OC000000050565622

22852
FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER LLP
901 NEW YORK AVENUE, NW
WASHINGTON, DC 20001-4413

Date Mailed: 10/27/2011

NOTICE TO FILE CORRECTED APPLICATION PAPERS

Filing Date Granted

An application number and filing date have been accorded to this application. The application is informal since it does not comply with the regulations for the reason(s) indicated below. Applicant is given TWO MONTHS from the date of this Notice within which to correct the informalities indicated below. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

The required item(s) identified below must be timely submitted to avoid abandonment:

- Replacement drawings in compliance with 37 CFR 1.84 and 37 CFR 1.121(d) are required. The drawings submitted are not acceptable because:
  - The drawings must be reasonably free from erasures and must be free from alterations, overwriting, interlineations, folds, and copy marks. See Figure(s) 9-16 & 18-19.

Applicant is cautioned that correction of the above items may cause the specification and drawings page count to exceed 100 pages. If the specification and drawings exceed 100 pages, applicant will need to submit the required application size fee.

Replies should be mailed to:

Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

Registered users of EFS-Web may alternatively submit their reply to this notice via EFS-Web.
https://sportal.uspto.gov/authenticate/AuthenticateUserLocalEPF.html

For more information about EFS-Web please call the USPTO Electronic Business Center at **1-866-217-9197** or visit our website at http://www.uspto.gov/ebc.

If you are not using EFS-Web to submit your reply, you must include a copy of this notice.

/mkibret/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number
13/269,234

APPLICATION AS FILED - PART I

FOR	NUMBER FILED (Column 1)	NUMBER EXTRA (Column 2)	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	95		N/A	
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	310		N/A	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	125		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	20 minus 20 =	*	x 30 =	0.00	OR		
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	*	x 125 =	0.00			
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			0.00			
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				0.00			
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	530		TOTAL	

APPLICATION AS AMENDED - PART II

AMENDMENT A

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE($)	ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	ADDITIONAL FEE($)
Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

AMENDMENT B

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	RATE($)	ADDITIONAL FEE($)		RATE($)	ADDITIONAL FEE($)
Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

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United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
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Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
13/269,234	10/07/2011	3744	830	10494.0003-01000	20	3

CONFIRMATION NO. 1954

FILING RECEIPT

OC000000050565621

22852
FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER LLP
901 NEW YORK AVENUE, NW
WASHINGTON, DC 20001-4413

Date Mailed: 10/27/2011

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Applicant(s)

André Sloth ERIKSEN, Aalborg C, DENMARK;

Power of Attorney: The patent practitioners associated with Customer Number 22852

Domestic Priority data as claimed by applicant

This application is a CON of 11/919,974 01/06/2009
which is a 371 of PCT/DK2005/000310 05/06/2005

Foreign Applications (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.)

If Required, Foreign Filing License Granted: 10/22/2011

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 13/269,234**

Projected Publication Date: To Be Determined - pending completion of Corrected Papers

Non-Publication Request: No

Early Publication Request: No
**** SMALL ENTITY ****

Title

COOLING SYSTEM FOR A COMPUTER SYSTEM

Preliminary Class

062

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4158).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

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The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

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NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

Doc Code: TRACK1.REQ
Document Description: TrackOne Request

PTO/SB/424 (09-11)

CERTIFICATION AND REQUEST FOR PRIORITIZED EXAMINATION (TRACK I) (Page 1 of 1)

First Named Inventor:	André Sloth ERIKSEN	Nonprovisional Application Number (if known):	Not known
Title of Invention:	COOLING SYSTEM FOR A COMPUTER SYSTEM		

APPLICANT HEREBY CERTIFIES THE FOLLOWING AND REQUESTS PRIORITIZED EXAMINATION (TRACK I) FOR THE ABOVE-IDENTIFIED APPLICATION.

1. (a) The application is an original nonprovisional utility application filed under 35 U.S.C. 111(a). This certification and request is being filed with the utility application via EFS-Web.

   OR

   (b) The application is an original nonprovisional plant application filed under 35 U.S.C. 111(a). This certification and request is being filed with the plant application in paper. (Note: Plant applications cannot be filed via EFS-Web.)

   Note: The following are excluded from the Track I program: design applications, provisional applications, national stage applications, PCT international applications, reissue applications, and reexamination proceedings.

2. The following fees (in amounts consistent with the current fee schedule available at http://www.uspto.gov/about/offices/cfo/finance/fees.jsp) are filed with the application: (1) basic filing fee; (2) search fee; (3) examination fee; (4) any required excess claims fees; (5) any required application size fee; (6) publication fee; (7) processing fee (Track I) set forth in 37 CFR 1.17(i); and (8) prioritized examination fee (Track I) set forth in 37 CFR 1.17(c).

3. An executed oath or declaration under 37 CFR 1.63 is filed with the application.

4. The application contains or is amended to contain no more than four independent claims and no more than thirty total claims, and no multiple dependent claims.

Signature	[signature]	Date	October 7, 2011
Name (Print/Typed)	Biju I. Chandran	Practitioner Registration Number	63,684

Note: *Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required in accordance with 37 CFR 1.33 and 11.18. Please see 37 CFR 1.4(d) for the form of the signature. If necessary, submit multiple forms for more than one signature, see below*.*

☑ *Total of One forms are submitted.

Biju I. Chandran
202.408.4230
biju.chandran@finnegan.com

October 7, 2011

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

ATTORNEY DOCKET NO. 10494-0003.01000

New Track 1 U.S. Patent Application
Title: COOLING SYSTEM FOR A COMPUTER SYSTEM
Inventor(s): André Sloth ERIKSEN

Sir:

Enclosed is a new Track 1 Prioritized Examination application, comprising the following:

The application consists of 68 pages, including no more than 4 independent claims, no more than 30 total claims and no presentation of multiple dependent claims, and 12 sheets of drawings (Figures 1-20).

A copy of the declaration of the inventors filed with parent Application No. 11/919,974 is attached.

Filing fees (**for Small Entity**) are being paid electronically as follows:

$ 190.00	Basic Filing Fee
$ 310.00	Search Fee
$ 125.00	Examination Fee
$ 300.00	Publication Fee
$ 130.00	Track 1 Processing Fee
$2,400.00	Track 1 Prioritized Examination Fee

This application is a continuation of prior Application No. 11/919,974, filed January 6, 2009. This application is being filed under the provisions of 37 C.F.R. § 1.53(b).

Please address all correspondence with respect to this application to: **FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER, L.L.P., Customer Number 22,852.**

The Commissioner is hereby authorized to charge any additional filing fees, including any fees necessary to complete the Track 1 requirements, and any other fees due under 37 C.F.R. § 1.16 or §1.17 during the pendency of this application to Deposit Account 06-0916.

Respectfully submitted,

FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER, L.L.P.

By: ______________________

Biju I. Chandran
Reg. No. 63,638
(202) 408-4000

BIC/fw
Enclosures

COOLING SYSTEM FOR A COMPUTER SYSTEM

[001] This application is a continuation of U.S. Application No. 11/919/974, filed January 6, 2009, which is a U.S. National Phase Application of PCT/DK2005/000310, filed May 6, 2005, which is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

[002] The present invention relates to a cooling system for a central processing unit (CPU) or other processing unit of a computer system. More specifically, the invention relates to a liquid-cooling system for a mainstream computer system such as a PC.

[003] During operation of a computer, the heat created inside the CPU or other processing unit must be carried away fast and efficiently, keeping the temperature within the design range specified by the manufacturer. As an example of cooling systems, various CPU cooling methods exist and the most used CPU cooling method to date has been an air-cooling arrangement, wherein a heat sink in thermal contact with the CPU transports the heat away from the CPU and as an option a fan mounted on top of the heat sink functions as an air fan for removing the heat from the heat sink by blowing air through segments of the heat sink. This air-cooling arrangement is sufficient as long as the heat produced by the CPU is kept at today's level, however it becomes less useful in future cooling arrangements when considering the development of CPUs since the speed of a CPU is said to double perhaps every 18 months, thus increasing the heat production accordingly.

[004] Another design used today is a CPU cooling arrangement where cooling liquid is used to cool the CPU by circulating a cooling liquid inside a closed system by means of a pumping unit, and where the closed system also comprises a heat exchanger past which the cooling liquid is circulated.

[005] A liquid-cooling arrangement is more efficient than an air-cooling arrangement and tends to lower the noise level of the cooling arrangement in general. However, the liquid-cooling design consists of many components, which increases the total installation time, thus making it less desirable as a mainstream solution. With a trend of producing smaller and more compact PCs for the end-users, the greater amount of components in a typical liquid-cooling arrangement is also undesirable. Furthermore, the many components having to be coupled together incurs a risk of leakage of cooling liquid from the system.

SUMMARY

[006] It may be one object of the invention to provide a small and compact liquid-cooling solution, which is more efficient than existing air-cooling arrangements and which can be produced at a low cost enabling high production volumes. It may be another object to create a liquid-cooling arrangement, which is easy-to-use and implement, and which requires a low level of maintenance or no maintenance at all. It may be still another object of the present invention to create a liquid-cooling arrangement, which can be used with existing CPU types, and which can be used in existing computer systems.

[007] This object may be obtained by a cooling system for a computer system, said computer system comprising: at least one unit such as a central processing unit (CPU) generating thermal energy and said cooling system intended for cooling the at least one processing unit, a reservoir having an amount of cooling liquid, said cooling liquid intended for accumulating and transferring of thermal energy dissipated from the processing unit to the cooling liquid, a heat exchanging interface for providing thermal contact between the processing unit and the cooling liquid for dissipating heat from the processing unit to the cooling liquid, a pump being provided as part of an integrate element, said integrate element comprising the heat exchanging interface, the reservoir and the pump, said pump intended for pumping the cooling liquid into the reservoir, through the reservoir and from the reservoir to a heat radiating means, said heat radiating means intended for radiating thermal energy from the cooling liquid, dissipated to the cooling liquid, to surroundings of the heat radiating means.

[008] By providing an integrate element, it is possible to limit the number of separate elements of the system. However, there is actually no need for limiting the number of elements, because often there is enough space within a cabinet of a computer system to encompass the different individual elements of the cooling system. Thus, it is surprisingly that, at all, any attempt is conducted of integrating some of the elements.

[009] In possible embodiments according to this aspect of the invention, the entire pump is placed inside the reservoir with at least an inlet or an outlet leading to the liquid in the reservoir. In an alternative embodiment the pump is placed outside the reservoir in the

immediate vicinity of the reservoir and wherein at least an inlet or an outlet is leading directly to the liquid in the reservoir. By placing the pump inside the reservoir or in the immediate vicinity outside the reservoir, the integrity of the combined reservoir, heat exchanger and pump is obtained, so that the element is easy to employ in new and existing computer systems, especially mainstream computer systems.

[010] In a preferred embodiment, the pumping member of the pump and a driven part of the motor of the pump, such as a rotor of en electrical motor, is placed inside the reservoir embedded in the cooling liquid, and wherein a stationary part of the motor of the pump, such as a stator of an electrical motor, is placed outside the reservoir. By having the driven part of the motor placed inside the reservoir submerged in the cooling liquid and the stationary part of the motor outside the reservoir, there is no need for encapsulating the stationary part in a liquid-proof insulation. However, problems may occur having then stationary part driving the driven part. However, the present invention provide means for obtaining such action, although not at all evident how to solve this problem.

[011] The object may also be obtained by a cooling system for a computer system, said computer system comprising: at least one unit such as a central processing unit (CPU) generating thermal energy and said cooling system intended for cooling the at least one processing unit, a reservoir having an amount of cooling liquid, said cooling liquid intended for accumulating and transferring of thermal energy dissipated from the processing unit to the cooling liquid, a heat exchanging interface for providing thermal contact between the processing unit and the cooling liquid for dissipating heat from the processing unit to the

cooling liquid, a pump intended for pumping the cooling liquid into the reservoir, through the reservoir and from the reservoir to a heat radiating means, said cooling system being intended for thermal contact with the processing unit by means of existing fastening means associated with the processing unit, and said heat radiating means intended for radiating from the cooling liquid thermal energy, dissipated to the cooling liquid, to surroundings of the heat radiating means.

[012] The use of existing fastening means has the advantage that fitting of the cooling system is fast and easy. However, once again there is no problem for the person skilled in the art to adopt specially adapted mounting means for any element of the cooling system, because there are numerous possibilities in existing cabinets of computer systems for mounting any kind of any number of elements, also elements of a cooling system.

[013] In preferred embodiments according to this aspect of the invention, the existing fastening means are means intended for attaching a heat sink to the processing unit, or the existing fastening means are means intended for attaching a cooling fan to the processing unit, or the existing fastening means are means intended for attaching a heat sink together with a cooling fan to the processing unit. Existing fastening means of the kind mentioned is commonly used for air cooling of CPUs of computer systems, however, air cooling arrangements being much less complex than liquid cooling systems. Nevertheless, it has ingeniously been possible to develop a complex and effective liquid cooling system capable of utilizing such existing fastening means for simple and less effective air cooling arrangements.

[014] According to an aspect of the invention, the pump is selected from the following types: Bellows pump, centrifugal pump, diaphragm pump, drum pump, flexible liner pump, flexible impeller pump, gear pump, peristaltic tubing pump, piston pump, processing cavity pump, pressure washer pump, rotary lobe pump, rotary vane pump and electro-kinetic pump. By adopting one or more of the solution of the present invention, a wide variety of pumps may be used without departing from the scope of the invention.

[015] According to another aspect of the invention, driving means for driving the pump is selected among the following driving means: electrically operated rotary motor, piezo-electrically operated motor, permanent magnet operated motor, fluid-operated motor, capacitor-operated motor. As is the case when selecting the pump to pump the liquid, by adopting one or more of the solution of the present invention, a wide variety of pumps may be used without departing from the scope of the invention.

[016] The object may also be obtained by a cooling system for a computer system, said computer system comprising: at least one unit such as a central processing unit (CPU) generating thermal energy and said cooling system intended for cooling the at least one processing unit, a reservoir having an amount of cooling liquid, said cooling liquid intended for accumulating and transferring of thermal energy dissipated from the processing unit to the cooling liquid, a heat exchanging interface for providing thermal contact between the processing unit and the cooling liquid for dissipating heat from the processing unit to the cooling liquid, a pump intended for pumping the cooling liquid into the reservoir, through the reservoir and from the reservoir to a heat radiating means, and said cooling system further

comprising a pump wherein the pump is driven by an AC electrical motor by a DC electrical power supply of the computer system, where at least part of the electrical power from said power supply is intended for being converted to AC being supplied to the electrical motor.

[017] It may be advantageous to use an AC motor, such as a 12V AC motor, for driving the pump in order to obtain a stabile unit perhaps having to operate 24 hours a day, 365 days a year. However, the person skilled in the art will find it unnecessary to adopt as example a 12V motor because high voltage such as 220V or 110V is readily accessible as this is the electrical voltage used to power the voltage supply of the computer system itself. Although choosing to use a 12V motor for the pump, it has never been and will never be the choice of the person skilled in the art to use an AC motor. The voltage supplied by the voltage supply of the computer system itself is DC, thus this will be the type of voltage chosen by the skilled person.

[018] In preferred embodiments according to any aspect of the invention, an electrical motor is intended both for driving the pump for pumping the liquid and for driving the a fan for establishing a flow of air in the vicinity of the reservoir, or an electrical motor is intended both for driving the pump for pumping the liquid and for driving the a fan for establishing a flow of air in the vicinity of the heat radiating means, or an electrical motor is intended both for driving the pump for pumping the liquid, and for driving the a fan for establishing a flow of air in the vicinity of the reservoir, and for driving the a fan for establishing a flow of air in the vicinity of the heat radiating means.

[019] By utilizing a single electrical motor for driving more than one element of the cooling system according to any of the aspects of the invention, the lesser complexity and the reliability of the cooling system will be further enhanced.

[020] The heat exchanging interface may be an element being separate from the reservoir, and where the heat exchanging interface is secured to the reservoir in a manner so that the heat exchanging interface constitutes part of the reservoir when being secured to the reservoir. Alternatively, the heat exchanging interface constitutes an integrate surface of the reservoir, and where the heat exchanging surface extends along an area of the surface of the reservoir, said area of surface being intended for facing the processing unit and said area of surface being intended for the close thermal contact with the processing unit. Even alternatively, the heat exchanging interface is constitutes by a free surface of the processing unit, and where the free surface is capable of establishing heat dissipation between the processing unit and the cooling liquid through an aperture provided in the reservoir, and where the aperture extends along an area of the surface of the reservoir, said surface being intended for facing the processing unit.

[021] Possibly, an uneven surface such as pins or fins extending from the copper plate provide a network of channels across the inner surface of the heat exchanging interface. A network of channels ensure the cooling liquid being passed along the inner surface of the interface such as a copper plate in a way that maximizes the retention time of the cooling liquid along the heat exchanging interface and in a way that optimizes the thermal

exchange between the heat exchanging interface and the cooling liquid as long as the cooling liquid is in thermal contact with heat exchanging interface.

[022] Possibly, the cooling system may be provided with a heat exchanging interface for providing thermal contact between the processing unit and the cooling liquid for dissipating heat from the processing unit to the cooling liquid, a pumping means being intended for pumping the cooling liquid into the reservoir, through the reservoir and from the reservoir to a heat radiating means, said heat radiating means intended for radiating thermal energy from the cooling liquid, dissipated to the cooling liquid, to surroundings of the heat radiating means, said heat exchanging interface constituting a heat exchanging surface being manufactured from a material suitable for heat conducting, and with a first side of the heat exchanging surface facing the central processing unit being substantially plane and with a second side of the heat exchanging surface facing the cooling liquid being substantially plane and said reservoir being manufactured from plastic, and channels or segments being provided in the reservoir for establishing a certain flow-path for the cooling liquid through the reservoir.

[023] Providing a plane heat exchanging surface, both the first, inner side being in thermal contact with the cooling liquid and the second, outer side being in thermal contact with the heat generating processing unit, results in the costs for manufacturing the heat exchanging surface is reduced to an absolute minimum.

[024] According to the above possible solution, an inlet of the pumping means is positioned in immediate vicinity of the heat exchanging interface for thereby obtaining a turbulence of flow of the cooling liquid in the immediate vicinity of the heat exchanging interface. The turbulence of flow is advantageous for obtaining a heat dissipation. If the heat exchanging interface is plane, the inlet of the pump being positioned as mentioned above, may result in a turbulence of flow occurring along the heat exchanging interface, at least in the vicinity of the inlet of the pump, but possibly also distant form the inlet.

[025] Alternatively, or additionally, an outlet of said pumping means being positioned in immediate vicinity of the heat exchanging interface for thereby obtaining a turbulence of flow of the cooling liquid in the immediate vicinity of the heat exchange interface. The turbulence of flow is advantageous for obtaining a heat dissipation. If the heat exchanging interface is plane, the inlet of the pump being positioned as mentioned above, may result in a turbulence of flow occurring along the heat exchanging interface, at least in the vicinity of the inlet of the pump, but possibly also distant form the inlet.

[026] However, a plane first, inner surface may also result in the cooling liquid passing the heat exchanging surface too fast. This may be remedied by providing grooves along the inner surface, thereby providing a flow path in the heat exchanging surface. This however results in the costs for manufacturing the heat exchanging surface increasing.

[027] The solution to this problem has been dealt with by providing channels or segments in the reservoir housing instead. The reservoir housing may be manufactured by injection

molding or by casting, depending on the material which the reservoir housing is made from. Proving channels or segments during molding or casting of the reservoir housing is much more cost-effective than milling grooves along the inner surface of the heat exchanging surface.

[028] Possibly, the cooling system may be provided with at least one liquid reservoir mainly for dissipating or radiating heat, said heat being accumulated and transferred by said cooling liquid, said cooling system being adapted such as to provide transfer of said heat from a heat dissipating surface to a heat radiating surface where said at least one liquid reservoir being provided with one aperture intended for being closed by placing said aperture covering part of, alternatively covering the whole of, the at least one processing unit in such a way that a free surface of the processing unit is in direct heat exchanging contact with an interior of the reservoir, and thus in direct heat exchanging contact with the cooling liquid in the reservoir, through the aperture.

[029] Heat dissipation from the processing unit to the cooling liquid must be very efficient to ensure proper cooling of the processing unit, Especially in the case, where the processing unit is a CPU, the surface for heat dissipation is limited by the surface area of the CPU. This may be remedied by utilizing a heat exchanging surface being made of a material having a high thermal conductivity such as copper or aluminum and ensuring a proper thermal bondage between the heat exchanging interface and the CPU.

[030] However, in a possible embodiment according to the features in the above paragraph, the heat dissipation takes place directly between the processing unit and the cooling liquid by providing an aperture in the reservoir housing, said aperture being adapted for taking up a free surface of the processing unit. Thereby, the free surface of the processing unit extends into the reservoir or constitutes a part of the boundaries of the reservoir, and the cooling liquid has direct access to the free surface of the processing unit.

[031] A possible heat exchanging interface may be the direct contact between the heat generating unit such as a CPU and the cooling liquid, where at least one unit such as a central processing unit (CPU) generating thermal energy and said cooling system intended for cooling the at least one processing unit comprising at least one liquid reservoir mainly for dissipating or radiating heat, said heat being accumulated and transferred by said cooling liquid, said cooling system being adapted such as to provide transfer of said heat from a heat dissipating interface to a heat radiating surface where said at least one liquid reservoir being provided with one aperture intended for being closed by placing said aperture covering part of, alternatively covering the whole of, the at least one processing unit in such a way that a free surface of the processing unit is in direct heat exchanging contact with an interior of the reservoir, and thus in direct heat exchanging contact with the cooling liquid in the reservoir, through the aperture.

[032] The aperture of the reservoir may be intended for being closed by attaching boundaries of said aperture to a free surface of a the processing unit, said boundaries being liquid-proof when attached to the free surface of the processing unit so that the liquid

may flow freely across the free surface without the risk of the liquid dissipating through the boundaries. Alternatively, but posing the same technical effect, the aperture of the reservoir is intended for being closed by attaching boundaries of said aperture along boundaries of a free surface of the processing unit.

[033] If a heat sink is provided as an aid in dissipating heat from the heat generating unit such as a CPU, the aperture of the reservoir may be intended for being closed by attaching boundaries of said aperture to a free surface of a heat sink. Alternatively, the aperture of the reservoir may be intended for being closed by attaching boundaries of said aperture along boundaries of a free surface of a heat sink. Alternatively, possibly, the heat exchanging interface may be provided as a first reservoir intended for being closed by attaching boundaries of an aperture in the first reservoir to, alternatively along, a free surface of a said processing unit, and a second reservoir intended for being closed by attaching boundaries of an aperture in the second reservoir to, alternatively along, a free surface of a to a free surface of a heat sink, and liquid conducting means provided between the first reservoir and the second reservoir.

[034] The first reservoir may be closed by attaching said first reservoir to a heat exchanging surface element being in close thermal contact with the processing unit, said heat exchanging surface intended for dissipating heat from the processing unit to cooling liquid in the first reservoir, and wherein a second reservoir is closed by attaching said second reservoir to a surface of a heat sink, said heat sink intended for radiating heat from cooling liquid in the second reservoir to the exterior surroundings.

[035] Also, the first reservoir and said second reservoir may be provided as a monolithic structure comprising both the first reservoir and the second reservoir and where both a heat dissipation from the processing unit to the cooling liquid in the first reservoir and heat radiation from the cooling liquid in the second reservoir to exterior surrounding is provided by the monolithic structure. The said monolithic structure may preferably be manufactured at least partly from plastic, preferably being manufactured fully in plastic, and said monolithic structure thus being manufactured by injection molding.

[036] Transfer of said cooling liquid from an outlet of the first reservoir to an inlet of the second reservoir, and from an outlet of the second reservoir to an inlet of the first reservoir, and circulating the cooling liquid within said liquid conducting means is provided by a pumping means being intended for pumping the cooling liquid. One of said reservoirs of said monolithic structure may comprise said pumping means.

[037] An inlet and/or an outlet and/or a pumping member of said pumping means, may be provided in the vicinity of said substantially plane side in order to provide a turbulence of flow and hereby improve the exchange of heat between said cooling liquid and substantially plane side, and the inlet of the pumping means may be provided within the first reservoir and the outlet may be provided within the second reservoir.

[038] According to one aspect of the invention, a method is envisaged, said method of cooling a computer system comprising at least one unit such as a central processing unit (CPU) generating thermal energy and said method utilizing a cooling system for cooling the

at least one processing unit and, said cooling system comprising a reservoir, at least one heat exchanging interface and a pumping means, said method of cooling comprising the steps of establishing, or defining, or selecting an operative status of the pumping means; controlling the operation of the motor of the pumping means in response to the following parameters; the necessary direction of movement for obtaining a pumping action of a pumping member of the pumping means, the possible direction of movement of a driving part of the motor of the pumping means; and in accordance with the operative status being established, defined or selected, controlling the operation of the computer system in order to achieve the necessary direction of movement of the driving part of the motor for establishing the necessary direction of movement for obtaining he pumping action of the pumping member.

[039] There may be pumping means, where the pumping member is only operable in one direction but where the motor driving the pumping member is operable in two directions. The solution to this problem is to either choose a pumping member operable in both directions or to chose a motor being operable in only one direction. According to the invention, a solution is provided where a one-way directional pumping member may be operated any a two-way directional motor. Despite the contradictory nature of this solution, advantages may however be present.

[040] As example, the method is being applied to a cooling system where the pumping member is a rotary impeller having a one-way direction for obtaining a pumping action, and where the motor of the pumping means is an electrical AC motor having a rotor constituting

the driving part of the motor, and where said method comprises the step of establishing, or defining, or selecting a rotary position of the rotor of the electrical AC motor, and applying at least one half-wave of an AC power signal to the stator of the AC motor before applying a full-wave AC power signal.

[041] As an alternative example, the method is being applied to a cooling system where the pumping member is a rotary impeller having a one-way direction for obtaining a pumping action, and where the motor of the pumping means is an electrical AC motor having a rotor constituting the driving part of the motor, and said method comprises the step of establishing, or defining, or selecting a rotary position of the rotor of the electrical AC motor, and applying at least one half-wave of an AC power signal to the stator of the AC motor after having applied the full-wave AC power signal.

[042] In both the above examples, the advantages of the one-way impeller from a traditional DC pump together with the advantages of a motor from a traditional AC pump is obtained in the solution mentioned. The performance of an impeller of a DC pump is much better than the performance of an impeller from an AC pump. The motor from an AC pump is more reliable than a motor from a DC pump. The advantageous obtained is thus of synergetic nature, seeing that different advantages of the impeller of the DC pump and of the motor of the AC pump are different in nature.

[043] According to another aspect of the invention, a method is envisaged, said method of cooling a computer system comprising at least one unit such as a central processing unit

(CPU) generating thermal energy and said method utilizing a cooling system for cooling the at least one processing unit and, said cooling system comprising a reservoir, at least one heat exchanging interface, an air blowing fan, a pumping means, said method of cooling comprising the steps of applying one of the following possibilities of how to operate the computer system: establishing, or defining, or selecting an operative status of the computer system; controlling the operation of at least one of the following means of the computer system; the pumping means and the air blowing fan in response to at least one of the following parameters; a surface temperature of the heat generating processing unit, an internal temperature of the heat generating processing unit, or a processing load of the CPU; and in accordance with the operative status being established, defined or selected, controlling the operation of the computer system in order to achieve at least one of the following conditions; a certain cooling performance of the cooling system, a certain electrical consumption of the cooling system, a certain noise level of the cooling system.

[044] Applying the above method ensures an operation of the computer system being in accordance with selected properties during the use of the computer system. For some applications, the cooling performance is vital such as may be the case when working with image files or when downloading large files from a network during which the processing units is highly loaded and thus generating much heat. For other applications, the electrical power consumption is more vital such as may be the case when utilizing domestic computer systems or in large office building in environments where the electrical grid may be weak such as in third countries. In still other applications, the noise generated by the

cooling system is to be reduced to a certain level, which may be the case in office buildings with white collar people working alone, or at home, if the domestic computer perhaps is situated in the living room, or at any other location where other exterior considerations have to be dealt with.

[045] According to another aspect of the invention, a method is envisaged, said method being employed with cooling system further comprising a pumping means with an impeller for pumping the cooling liquid through a pumping housing, said pumping means being driven by an AC electrical motor with a stator and a rotor, and said pumping means being provided with a means for sensing a position of the rotor, and wherein the method comprises the following steps: initially establishing a preferred rotational direction of the rotor of the electrical motor; before start of the electrical motor, sensing the angular position of the rotor; during start, applying an electrical AC voltage to the electrical motor and selecting the signal value, positive or negative, of the AC voltage at start of the electrical motor; said selection being made according to the preferred rotational direction; and said application of the AC signal, such as an AC voltage, being performed by the computer system for applying the AC signal, such as an AC voltage, from the electrical power supply of the computer system during conversions of the electrical DC signal, such as a DC voltage, of the power supply to the AC signal, such as an AC voltage, for the electrical motor.

[046] Adopting the above method according to the invention ensures the most efficient circulation of cooling liquid in the cooling system and at the same time ensures the lowest

possible energy consumption of the electrical motor driving the impeller. The efficient circulation of the cooling liquid is obtained by means of an impeller being designed for rotation in one rotational direction only, thus optimizing the impeller design with regard to the only one rotational direction as opposed to both rotational directions. The low energy consumption is achieved because of the impeller design being optimized, thus limiting the necessary rotational speed of the impeller for obtaining e certain amount of flow of the cooling liquid through the cooling system. A bonus effect of the lowest possible energy consumption being obtained is the lowest possible noise level of the pump also being obtained. The noise level of the pump is amongst other parameters also dependent on the design and the rotational speed of the impeller. Thus, an optimized impeller design and impeller speed will reduce the noise level to the lowest possible in consideration of ensuring a certain cooling capacity.

BRIEF DESCRIPTION OF THE FIGURES

[047] The invention will hereafter be described with reference to the drawings, where

[048] FIG. 1 shows an embodiment of the prior art. The figure shows the typical components in an air-cooling type CPU cooling arrangement.

[049] FIG. 2 shows an embodiment of the prior art. The figure shows the parts of the typical air-cooling type CPU cooling arrangement of FIG. 1 when assembled.

[050] FIG. 3 shows an embodiment of the prior art. The figure shows the typical components in a liquid-cooling type CPU cooling arrangement.

[051] FIG. 4 is an exploded view of the invention and the surrounding elements.

[052] FIG. 5 shows the parts shown in the previous figure when assembled and attached to the motherboard of a computer system.

[053] FIG. 6 is an exploded view of the reservoir from the previous FIGS. 4 and 5 seen from the opposite site and also showing the pump.

[054] FIG. 7 is a cut-out view into the reservoir housing the pump and an inlet and an outlet extending out of the reservoir.

[055] FIG. 8 is a view of the cooling system showing the reservoir connected to the heat radiator.

[056] FIG. 9-10 are perspective views of a possible embodiment of reservoir housing providing direct contact between a CPU and a cooling liquid in a reservoir.

[057] FIG. 11-13 are perspective views of a possible embodiment of heat sink and a reservoir housing constituting an integrated unit.

[058] FIG. 14 is a perspective view of the embodiment shown in FIG. 9-10 and the embodiment shown in FIG. 11-13 all together constituting an integrated unit.

[059] FIG. 15-16 are perspective view of a possible embodiment of a reservoir and a pump and a heat exchanging surface constituting an integrated unit

[060] FIG. 17 is a perspective view of a preferred embodiment of a reservoir and a pump and a heat exchanging surface constituting an integrated unit,

[061] FIG. 18 is a plane view of a possible, however preferred embodiment of an AC electrical motor for a pumping means of the cooling system according to the invention, and

[062] FIG. 19 is a graph showing a method for starting a rotor of the electrical AC motor, said AC motor driving an impeller selected from a pump driven by a DC motor.

[063] FIG. 20 is a is a simplified schematic showing a cross-sectional view of the reservoir along plane 20-20 of Fig. 17.

DETAILED DESCRIPTION

[064] FIG. 1 is an exploded view of an embodiment of prior art cooling apparatus for a computer system. The figure shows the typical components in an air-cooling type CPU cooling arrangement. The figure shows a prior art heat sink 4 intended for air cooling and provided with segments intersected by interstices, a prior art air fan 5 which is to be mounted on top of the heat sink by use of fastening means 3 and 6.

[065] The fastening means comprises a frame 3 provided with holes intended for bolts, screws, rivets or other suitable fastening means (not shown) for thereby attaching the frame to a motherboard 2 of a CPU 1 or onto another processing unit of the computer system. The frame 3 is also provided with mortises provided in perpendicular extending studs in each corner of the frame, said mortises intended for taking up tenons of a couple

of braces. The braces 6 are intended for enclosing the heat sink 4 and the air fan 5 so that the air fan and the heat sink thereby is secured to the frame. Using proper retention mechanisms, when the frame is attached to the motherboard of the CPU of other processing unit, and when the tenons of the braces are inserted into the mortises of the frame, the air fan and heat exchanger is pressed towards the CPU by using a force perpendicular to the CPU surface, said force being provided by lever arms.

[066] FIG. 2 shows the parts of the typical air-cooling type CPU cooling arrangement of FIG. 1, when assembled. The parts are attached to each other and will be mounted on top of a CPU on a motherboard (not shown) of a computer system.

[067] FIG. 3 shows another embodiment of a prior art cooling system. The figure shows the typical components in a liquid-cooling type CPU cooling arrangement. The figure shows a prior art heat exchanger 7, which is in connection with a prior art liquid reservoir 8, a prior art liquid pump 9 and a heat radiator 11 and an air fan 10 provided together with the heat radiator. The prior art heat exchanger 7, which can be mounted on a CPU (not shown) is connected to a radiator and reservoir, respectively. The reservoir serves as a storage unit for excess liquid not capable of being contained in the remaining components. The reservoir is also intended as a means for venting the system of any air entrapped in the system and as a means for filling the system with liquid. The heat radiator 11 serves as a means for removing the heat from the liquid by means of the air fan 10 blowing air through the heat radiator. All the components are in connection with each other via tubes for conducting the liquid serving as the cooling medium.

[068] FIG. 4 is an exploded view of a cooling system according to an embodiment of the invention. Also elements not being part of the cooling system as such are shown. The figure shows a central processing unit CPU 1 mounted on a motherboard of a computer system 2. The figure also shows a part of the existing fastening means, i.e. amongst others the frame 3 with mortises provided in the perpendicular extending studs in each corner of the frame. The existing fastening means, i.e. the frame 3 and the braces 6, will during use be attached to the motherboard 2 by means of bolts, screws, rivets or other suitable fastening means extending through the four holes provided in each corner of the frame and extending through corresponding holes in the motherboard of the CPU. The frame 3 will still provide an opening for the CPU to enable the CPU to extend through the frame.

[069] The heat exchanging interface 4 is a separate element and is made of a heat conducting material having a relative high heat thermal conductivity such as copper or aluminum, and which will be in thermal contact with the CPU 1, when the cooling system is fastened to the motherboard 2 of the CPU. The heat exchanging surface constitutes part of a liquid reservoir housing 14, thus the heat exchanger 4 constitutes the part of the liquid reservoir housing facing the CPU. The reservoir may as example be made of plastic or of metal. The reservoir or any other parts of the cooling system, which are possibly manufactured from a plastic material may be "metalized" in order to minimize liquid diffusion or evaporation of the liquid. The metal may be provided as a thin layer of metal coating provided on either or on both of the internal side or the external side of the plastic part.

[070] If the reservoir is made of metal or any other material having a relative high heat conductivity compared to as example plastic, the heat exchanging interface as a separate element may be excluded because the reservoir itself may constitute a heat exchanger over an area, wherein the reservoir is in thermal contact with the processing unit. Alternatively to having the heat exchanging interface constitute part of the liquid reservoir housing, the liquid reservoir housing may be tightly attached to the heat exchanging interface by means of screws, glue, soldering, brazing or the like means for securing the heat exchanging interface to the housing and vice versa, perhaps with a sealant 5 provided between the housing and the heat exchanging interface.

[071] Alternatively to providing a heat exchanging interface integrate with the reservoir containing the cooling liquid, it will be possible to exclude the heat exchanger and providing another means for dissipating heat from the processing unit to the cooling liquid in the reservoir, The other means will be a hole provided in the reservoir, said hole intended for being directed towards the processing unit. Boundaries of the hole will be sealed towards boundaries of the processing unit or will be sealed on top of the processing unit for thereby preventing cooling liquid from the reservoir from leaking. The only prerequisite to the sealing is that a liquid-tight connection is provided between boundaries of the hole and the processing unit or surrounding of the processing unit, such as a carrier card of the processing unit.

[072] By excluding the heat exchanger, a more effective heat dissipation will be provided from the processing unit and to the cooling liquid of the reservoir, because the intermediate

element of a heat exchanger is eliminated. The only obstacle in this sense is the provision of a sealing being fluid-tight in so that the cooling liquid in the reservoir is prevented from leaking.

[073] The heat exchanging surface 4 is normally a copper plate. When excluding the heat exchanging surface 4, which may be a possibility not only for the embodiments shown in FIG. 4, but for all the embodiments of the invention, it may be necessary to provide the CPU with a resistant surface that will prevent evaporation of the cooling liquid and/or any damaging effect that the cooling liquid may pose to the CPU. A resistant surface may be provided the CPU from the CPU producer or it may be applied afterwards. A resistant surface to be applied afterwards may e.g. be a layer, such as an adhesive tape provided on the CPU. The adhesive tape may be made with a thin metal layer e.g. in order to prevent evaporation of the cooling liquid and/or any degeneration of the CPU itself.

[074] Within the liquid reservoir, a liquid pump (not shown) is placed for pumping a cooling liquid from an inlet tube 15 connection being attached to the housing of the reservoir through the reservoir and past the heat exchanger in thermal contact with the CPU to an outlet tube connection 16 also being attached to the reservoir housing. The existing fastening means comprising braces 6 with four tenons and the frame 3 with four corresponding mortises will fasten the reservoir and the heat exchanger to the motherboard of the CPU. When fastening the two parts of the existing fastening means to each other the fastening will by means of the lever arms 18 create a force to assure thermal contact

between the CPU 1 mounted on the motherboard and the heat exchanger 4 being provided facing the CPU.

[075] The cooling liquid of the cooling system may be any type of cooling liquid such as water, water with additives such as anti-fungicide, water with additives for improving heat conducting or other special compositions of cooling liquids such as electrically non-conductive liquids or liquids with lubricant additives or anti-corrosive additives.

[076] FIG. 5 shows the parts shown in FIG. 4 when assembled and attached to the motherboard of a CPU of a computer system 2. The heat exchanger and the CPU is in close thermal contact with each other. The heat exchanger and the remainder of the reservoir housing 14 is fastened to the motherboard 2 by means of the existing fastening means being secured to the motherboard of the CPU and by means of the force established by the lever arms 18 of the existing fastening means. The tube inlet connection 15 and the tube outlet connection 16 are situated so as to enable connection of tubes to the connections.

[077] FIG. 6 is an exploded view of the reservoir shown in previous FIG. 4 and FIG. 5 and seen from the opposite site and also showing the pump 21 being situated inside the reservoir. Eight screws 22 are provided for attaching the heat exchanging surface 4 to the remainder of the reservoir. The heat exchanging surface is preferably made from a copper plate having a plane outer surface as shown in the figure, said outer surface being intended for abutting the free surface of the heat generating component such as the CPU (see FIG.

4). However, also the inner surface (not shown, see FIG. 7) facing the reservoir is plane. Accordingly, the copper plate need no machining other than the shaping of the outer boundaries into the octagonal shape used in the embodiment shown and drilling of holes for insertion of the bolts. No milling of the inner and/or the outer surface need be provided.

[078] A sealant in form of a gasket 13 is used for the connection between the reservoir housing 14 and the heat exchanging surface forming a liquid tight connection. The pump is intended for being placed within the reservoir. The pump has a pump inlet 20 through which the cooling liquid flows from the reservoir and into the pump, and the pump has a pump outlet 19 through which the cooling liquid is pumped from the pump and to the outlet connection. The figure also shows a lid 17 for the reservoir. The non-smooth inner walls of the reservoir and the fact that the pump is situated inside the reservoir will provide a swirling of the cooling liquid inside the reservoir.

[079] However, apart from the non-smooth walls of the reservoir and the pump being situated inside the reservoir, the reservoir may be provided with channels or segments for establishing a certain flow-path for the cooling liquid through the reservoir (see FIG. 9-10 and FIG. 15). Channel or segments are especially needed when the inner surface of the heat exchanging surface is plane and/or when the inner walls of the reservoir are smooth and/or if the pump is not situated inside the reservoir. In either of the circumstances mentioned, the flow of the cooling liquid inside the reservoir may result in the cooling liquid passing the reservoir too quickly and not being resident in the reservoir for a sufficient amount of time to take up a sufficient amount of heat from the heat exchanging surface. By

providing channels or segments inside the reservoir, a flow will be provided forcing the cooling liquid to pass the heat exchanging surface, and the amount of time increased of the cooling liquid being resident inside the reservoir, thus enhancing heat dissipation. If channels or segments are to be provided inside the reservoir, the shape and of the channels and segments may be decisive of whether the reservoir is to be made of plastic, perhaps by injection molding, or is to be made of metal such as aluminum, perhaps by die casting.

[080] The cooling liquid enters the reservoir through the tube inlet connection 15 and enters the pump inlet 20, and is pumped out of the pump outlet 19 connected to the outlet connection 16. The connection between the reservoir and the inlet tube connection and the outlet tube connection, respectively, are made liquid tight. The pump may not only be a self-contained pumping device, but may be made integrated into the reservoir, thus making the reservoir and a pumping device one single integrated component. This single integrated element of the reservoir and the pumping device may also be integrated, thus making the reservoir, the pumping device and the heat exchanging surface one single integrated unit. This may as example be possible if the reservoir is made of a metal such as aluminum. Thus, the choice of material provides the possibility of constituting both the reservoir and a heat exchanging surface having a relatively high heat conductivity, and possibly also renders the possibility of providing bearings and the like constructional elements for a motor and a pumping wheel being part of the pumping device.

[081] In an alternative embodiment, the pump is placed in immediate vicinity of the reservoir, however outside the reservoir. By placing the pump outside, but in immediate vicinity of the reservoir, still an integrate element may be obtained. The pump or the inlet or the outlet is preferably positioned so as to obtain a turbulence of flow in the immediate vicinity of the heat exchanging interface, thereby promoting increased heat dissipation between the heat exchanging interface end the cooling liquid. even in the alternative, a pumping member such as an impeller (see FIG. 15-16) may be provided in the immediate vicinity of the heat exchanging surface. The pumping member itself normally introduces a turbulence of flow, and thereby the increased heat dissipation is promoted irrespective of the position of the pump itself, or the position of the inlet or of the outlet to the reservoir or to the pump.

[082] The pump may be driven by an AC or a DC electrical motor. When driven by an AC electrical motor, although being technically and electrically unnecessary in a computer system, this may be accomplished by converting part of the DC electrical power of the power supply of the computer system to AC electrical power for the pump. The pump may be driven by an electrical motor at any voltage common in public electrical networks such as 110V or 220V. However, in the embodiment shown, the pump is driven by a 12V AC electrical motor.

[083] Control of the pump in case the pump is driven by an AC electrical motor, preferably takes place by means of the operative system or an alike means of the computer system itself, and where the computer system comprises means for measuring the CPU load

and/or the CPU temperature. Using the measurement performed by the operative system or alike system of the computer system eliminates the need for special means for operating the pump. Communication between the operative system or alike system and a processor for operating the pump may take place along already established communication links in the computer system such as a USB-link. Thereby, a real-time communication between the cooling system and the operative system is provided without any special means for establishing the communication.

[084] In the case of the motor driving the pump is an AC electrical motor, the above method of controlling the pump may be combined with a method, where said pumping means is provided with a means for sensing a position of the rotor of the electrical motor, and wherein the following steps are employed: Initially establishing a preferred rotational direction of the rotor of the electrical motor, before start of the electrical motor, sensing the angular position of the rotor, during start, applying an electrical AC voltage to the electrical motor and selecting the signal value, positive or negative, of the AC voltage at start of the electrical motor, said selection being made according to the preferred rotational direction, and said application of the AC voltage being performed by the computer system for applying the AC voltage from the electrical power supply of the computer system during conversion of the electrical DC voltage of the power supply to AC voltage for the electrical motor. By the operative system of the computer system itself generating the AC voltage for the electrical motor, the rotational direction of the pump is exclusively selected by the

computer system, non-depending on the applied voltage of the public grid powering the computer system.

[085] Further control strategies utilizing the operative system or alike system of the computer system may involve balancing the rotational speed of the pump as a function of the cooling capacity needed. If a lower cooling capacity is needed, the rotational speed of the pump, may be limited, thereby limiting the noise generating by the motor driving the pump.

[086] In the case an air fan is provided in combination with a heat sink as shown in FIG. 1, of the air fan is provided in combination with the heat radiator, the operative system or alike system of the computer system may be designed for regulating the rotational speed of the pump, and thus of the motor driving the pump, and the rotational speed of the air fan, and thus the motor driving the air fan. The regulation will take into account the cooling capacity needed, but the regulation will at the same time take into account which of the two cooling means, i.e. the pump and the air fan, is generating the most noise. Thus, it the air fan generally is generating more noise than the pump, then the regulation will reduce the rotational speed of the air fan before reducing the rotational speed of the pump, whenever a lower cooling capacity is needed. Thereby, the noise level of the entire cooling system is lowered as much as possible. If the opposite is the case, i.e. the pump generally generating more noise than the air fan, then the rotational speed of the pump will be reduced before reducing the rotational speed of the air fan.

[087] Even further control strategies involve controlling the cooling capacity in dependence on the type of computer processing taking place. Some kind of computer processing, such as word-processing, applies a smaller load on the processing units such as the CPU than other kinds of computer processing, such as image processing. Therefore, the kind of processing taking place on the computer system may be used as an indicator of the cooling capacity. It may even be possible as part of the operative system or similar system to establish certain cooling scenarios, depending on the kind of processing intended by the user. If the user selects as example word-processing, a certain cooling strategy is applied based on a limited need for cooling. If the user selects as example image-processing, a certain cooling strategy is applied based on an increased need for cooling. Two or more different cooling scenarios may be established depending on the capacity and the control possibilities and capabilities of the cooling system and depending on the intended use of the computer system, either as selected by a user during use of the computer system or as selected when choosing hardware during build-up of the computer system, i.e. before actual use of the computer system.

[088] The pump is not being restricted to a mechanical device, but can be in any form capable of pumping the cooling liquid through the system. However, the pump is preferably one of the following types of mechanical pumps: Bellows pump, centrifugal pump, diaphragm pump, drum pump, flexible liner pump, flexible impeller pump, gear pump, peristaltic tubing pump, piston pump, processing cavity pump, pressure washer pump, rotary lobe pump, rotary vane pump and electro-kinetic pump. Similarly, the motor driving

the pumping member need not be electrical but may also be a piezo-electrically operated motor, a permanent magnet operated motor, a fluid-operated motor or a capacitor-operated motor. The choice of pump and the choice of motor driving the pump id dependent on many different parameters, and it is up to the person skilled in the art to choose the type of pump and the type of motor depending on the specific application. As example, some pumps and some motors are better suited for small computer systems such as lab-tops, some pumps and some motors are better suited for establishing high flow of the cooling liquid and thus a high cooling effect, and even some pumps and motors are better suited for ensuring a low-noise operation of the cooling system.

[089] FIG. 7 is a cut-out view into the reservoir, when the reservoir and the heat exchanging surface 4 is assembled and the pump 21 is situated inside the reservoir. The reservoir is provided with the tube inlet connection (not seen from the figure) through which the cooling liquid enters the reservoir. Subsequently, the cooling liquid flows through the reservoir passing the heat exchanging surface and enters the inlet of the pump. After having been passed through the pump, the cooling liquid is passed out of the outlet of the pump and further out through the tube outlet connection 16. The figure also shows a lid 17 for the reservoir. The flow of the cooling liquid inside the reservoir and trough the pump may be further optimized in order to use as little energy as possible for pumping the cooling liquid, but still having a sufficient amount of heat from the heat exchanging surface being dissipated in the cooling liquid. This further optimization can be established by changing the length and shape of the tube connection inlet within the reservoir, and/or by changing the

position of the pump inlet, and/or for instance by having the pumping device placed in the vicinity and in immediate thermal contact with the heat exchanging surface and/or by providing channels or segments inside the reservoir.

[090] In this case, an increased turbulence created by the pumping device is used to improve the exchange of heat between the heat exchanging surface and the cooling liquid. Another or an additional way of improving the heat exchange is to force the cooling liquid to pass through specially adapted channels or segments being provided inside the reservoir or by making the surface of the heat exchanging surface plate inside the reservoir uneven or by adopting a certain shape of a heat sink with segments. In the figure shown, the inner surface of the heat exchanging surface facing the reservoir is plane.

[091] FIG. 8 is a perspective view of the cooling system showing the reservoir housing 14 with the heat exchanging surface (not shown) and the pump (not shown) inside the reservoir. The tube inlet connection and the tube outlet connection are connected to a heat radiator by means of connecting tubes 24 and 25 through which the cooling liquid flows into and out of the reservoir and the heat radiator, respectively. Within the heat radiator 11, the cooling liquid passes a number of channels for radiating the heat, which has been dissipated into the cooling liquid inside the reservoir, and to the surroundings of the heat exchanger. The air fan 10 blows air past the channels of the heat radiator in order to cool the radiator and thereby cooling the cooling liquid flowing inside the channels through the heat radiator and back into the reservoir.

[092] According to the invention, the heat radiator 11 may be provided alternatively. The alternative heat radiator is constituted by a heat sink, such as a standard heat sink made of extruded aluminum with fins on a first side and a substantially plane second side. An air-fan may be provided in connection with the fins along the first side. Along the second side of the heat sink a reservoir is provided with at least one aperture intended for being closed by placing said aperture covering part of, alternatively covering the whole of, the substantial plane side of the heat sink. When closing the reservoir in such a way a surface of the heat sink is in direct heat exchanging contact with an interior of the reservoir, and thus in direct heat exchanging contact with the cooling liquid in the reservoir, through the at least one aperture. This alternative way of providing the heat radiator may be used in the embodiment shown in FIG. 8 or may be used as a heat radiator for another use and/or for another embodiment of the invention.

[093] A pumping means for pumping the cooling liquid trough the reservoir may or may not be provided inside the reservoir at the heat sink. The reservoir may be provided with channels or segments for establishing a certain flow-path for the cooling liquid through the reservoir. Channels or segments are especially needed when the inner surface of the heat exchanging surface is plane and/or when the inner walls of the reservoir are smooth and/or if the pump is not situated inside the reservoir. In either of the circumstances mentioned, the flow of the cooling liquid inside the reservoir may result in the cooling liquid passing the reservoir too quickly and not being resident in the reservoir for a sufficient amount of time to take up a sufficient amount of heat from the heat exchanging surface. If channels or

segments in the reservoir are to be provided inside the reservoir, the shape and of the channels and segments may be decisive of whether the reservoir is to be made of plastic, perhaps by injection molding, or is to be made of metal such as aluminum, perhaps by die casting.

[094] By means of the alternative heat radiator, the heat radiator 11 is not provided as is shown in the figure with the rather expensive structure of channels leading the cooling liquid along ribs connecting the channels for improved surface of the structure. Instead, the heat radiator is provided as described as a unit constituted by a heat sink with or without a fan and a reservoir, and thereby providing a simpler and thereby cheaper heat radiator than the heat radiator 11 shown in the figure.

[095] The alternative heat radiator provided as an unit constituted by a heat sink and a reservoir, may be used solely, with or without a pump inside the reservoir and with or without the segments or channels, for being placed in direct or indirect thermal contact with a heat generating processing unit such as CPU or with the heat exchanging surface, respectively. These embodiments of the invention may e.g. be used for a reservoir, where the cooling liquid along a first side within the reservoir is in direct heat exchanging contact with the heat generating processing unit such as a CPU and the cooling liquid along a second side within the reservoir is in direct heat exchanging contact with a heat sink. Such a reservoir may be formed such as to provide a larger area of heat exchanging surface towards the heat generating processing unit such as a CPU than the area of the heat exchanging surface facing the heat sink. This may e.g. have the purpose of enlarging the

area of the heat exchanging surface so as to achieve an improved heat dissipation form e.g. the CPU to the heat sink than that of a conventional heat sink without a reservoir attached. Conventional heat sinks normally only exchanges heat with the CPU through the area as given by the area of the top side of the CPU. A system comprising a liquid reservoir and a heat sink with a fan provided has been found to be a simple, cost optimized system with an improved heat dissipation than that of a standard heat sink with a fan, but without the reservoir. In another embodiment of the invention, which may be derived from FIG. 8, the air fan and the heat radiator is placed directly in alignment of the reservoir. Thereby, the reservoir housing 14, the air fan 10 and the radiator 11 constitute an integrate unit. Such an embodiment may provide the possibility of omitting the connection tubes, and passing the cooling liquid directly from the heat radiator to the reservoir via an inlet connection of the reservoir, and directly from the reservoir to the heat radiator via an outlet connection of the reservoir. Such an embodiment may even render the possibility of both the pumping device of the liquid pump inside the reservoir and the electrical motor for the propeller of the air fan 23 of the heat radiator 11 being driven by the same electrical motor, thus making this electrical motor the only motor of the cooling system.

[096] When placing the heat radiator on top of the air fan now placed directly in alignment with the reservoir and connecting the heat radiator directly to the inlet connection and outlet connection of the reservoir, a need for tubes will not be present. However, if the heat radiator and the reservoir is not in direct alignment with each other, but tubes may still be needed, but rather than tubes, pipes made of metal such as copper or aluminum may be

employed, such pipes being impervious to any possible evaporation of cooling liquid. Also, the connections between such pipes and the heat radiator and the reservoir, respectively, may be soldered so that even the connections are made impervious to evaporation of cooling liquid.

[097] In the derived embodiment just described, an integrated unit of the reservoir, the heat exchanging surface and the pumping device will be given a structure establishing improved heat radiating characteristics because the flow of air of the air fan may also be directed along outer surfaces of the reservoir. If the reservoir is made of a metal, the metal will be cooled by the air passing the reservoir after having passed or before passing the heat radiator. If the reservoir is made of metal, and if the reservoir is provided with segments on the outside surface of the reservoir, such cooling of the reservoir by the air will be further improved. Thereby, the integrated unit just described will be applied improved heat radiating characteristics, the heat radiation function normally carried out by the heat radiator thus being supplemented by one or more of the further elements of the cooling system, i.e. the reservoir, the heat exchanging surface, the liquid pump and the air fan.

[098] FIG. 9-10 show an embodiment of a reservoir housing 14, where channels 25 are provided inside the reservoir for establishing a forced flow of the cooling liquid inside the reservoir. The channels 25 in the reservoir housing 14 lead from an inlet 15 to an outlet 16 like a maze between the inlet and the outlet. The reservoir housing 14 is provided with an aperture 27 having outer dimensions corresponding to the dimensions of a free surface of

the processing unit 1 to be cooled. In the embodiment shown, the processing unit to be cooled is a CPU 1.

[099] When channels 26 are provided inside the reservoir, the shape of the channels may be decisive of whether the reservoir is to be made of plastic, perhaps manufactured by injection molding, or is to be made of metal such as aluminum, perhaps manufactured by extrusion or by die casting.

[0100] The reservoir housing 14 or any other parts of the cooling system, which are possibly manufactured from a plastic material may be "metalized" in order to minimize liquid diffusion or evaporation of the liquid. The metal may be provided as a thin layer of metal coating provided on either or on both of the internal side or the external side of the plastic part.

[0101] The CPU 1 is intended for being positioned in the aperture 27, as shown in FIG. 10, so that outer boundaries of the CPU are engaging boundaries of the aperture. Possibly, a sealant (not shown) may be provided along the boundaries of the CPU and the aperture for ensuring a fluid tight engagement between the boundaries of the CPU and the boundaries of the aperture. When the CPU 1 is positioned in the aperture 27, the free surface (not shown) of the CPU is facing the reservoir, i.e. the part of the reservoir having the channels provided. Thus, when positioned in the aperture 27 (see FIG. 10), the free surface of the CPU 1 is having direct contact with cooling liquid flowing through the channels 26 in the reservoir.

[0102] When cooling liquid is forced from the inlet 15 along the channels 26 to the outlet 16, the whole of the free surface of the CPU 1 will be passed over by the cooling liquid, thus ensuring a proper and maximized cooling of the CPU. The configuration of the channels may be designed and selected according to any one or more provisions, i.e. high heat dissipation, certain flow characteristics, ease of manufacturing etc. Accordingly, the channels may have another design depending on any desire or requirement and depending on the type of CPU and the size and shape of the free surface of the CPU. Also. other processing units than a CPU may exhibit different needs for heat dissipation, and may exhibit other sizes and shapes of the free surface, leading to a need for other configurations of the channels. If the processing unit is very elongate, such as a row of microprocessors, one or a plurality of parallel channels may be provided, perhaps just having a common inlet and a common outlet.

[0103] FIG. 11-13 show an embodiment of a heat sink 4, where segments 28 are provided at a first side 4A of the heat sink, and fins 29 for dissipating heat to the surroundings are provided at the other, second side 4B of the heat sink. An intermediate reservoir housing 30 is provided having a recessed reservoir at the one side facing the first side 4A of the heat sink. The recessed reservoir 30 has an inlet 31 and an outlet 32 at the other side opposite the side facing the heat sink 4.

[0104] When segments 28 are provided on the first side 4A of the heat sink, the shape of the segments may be decisive of whether the reservoir, which is made from metal such as aluminum or copper, is to be made by extrusion or is to be made by other manufacturing processes such as die casting. Especially when the segments 28 are linear and are parallel with the fins 29, as shown in the embodiment, extrusion is a possible and cost-effective means of manufacturing the heat sink 4.

[0105] The intermediate reservoir 30 or any other parts of the cooling system, which are possibly manufactured from a plastic material may be "metalized" in order to minimize liquid diffusion or evaporation of the liquid. The metal may be provided as a thin layer of metal coating provided on either or on both of the internal side or the external side of the plastic part.

[0106] The recessed reservoir is provided with a kind of serration 33 along opposite sides of the reservoir, and the inlet 31 and the outlet 32, respectively, are provided at opposite corners of the intermediate reservoir 30. The segments 28 provided at the first side 4A of the heat sink, i.e. the side facing the intermediate reservoir 30, are placed so that when the heat sink is assembled with the intermediate reservoir housing (see FIG. 13) the segments 29 run from one serrated side of the reservoir to the other serrated side of the reservoir.

[0107] When cooling liquid is forced from the inlet 31 through the reservoir, along channels (not shown) formed by the segments 29 of the heat sink 4 and to the outlet 32, the whole of the first side 4A of the heat sink will be passed over by the cooling liquid, thus ensuring a proper and maximized heat dissipation between the cooling liquid and the heat sink. The configuration of the segments on the first side 4A of the heat sink and the configuration of the serrated sides of the intermediate reservoir housing may be designed and selected according to any provisions. Accordingly, the segments may have another design, perhaps being wave-shaped or also a serrated shape, depending on any desired flow characteristics of the cooling liquid and depending on the type of heat sink and the size and shape of the reservoir.

[0108] Also other types of heat sinks, perhaps circular shaped heat sinks may exhibit different needs for heat dissipation, may exhibit other sizes and shapes of the free surface, leading to a need for other configurations of the segments and the intermediate reservoir. If the heat sink and the reservoir are circular or oval, a spiral-shaped segmentation or radially extending segments may be provided, perhaps having the inlet or the outlet in the centre of the reservoir. If an impeller of the pump is provided, as shown in FIG. 15-16, the impeller of the pump may be positioned in the centre of a spiral-shaped segmentation or in the centre of radially extending segments.

[0109] FIG. 14 shows the reservoir housing 14 shown in FIG. 9-10 and the heat sink 4 and the intermediate reservoir 30 shown in FIG. 11-13 being assembled for thereby constituting an integrated monolithic unit. It is not absolutely necessary to assemble the reservoir housing 14 of FIG. 9-10 and the heat sink 4 and the intermediate reservoir 30 of FIG. 11-13 in order to obtain a properly functioning cooling system. The inlet 15 and the outlet 16 of the reservoir housing 14 of FIG. 9-10 may be connected to the outlet 32 and the inlet 31, respectively, of the intermediate reservoir of FIG. 11-13 by means of tubes or pipes.

[0110] The reservoir housing 14 of FIG. 9-10 and the heat sink 4 and the intermediate reservoir 30 of FIG. 11-13 may then be positioned in the computer system at different locations. However, by assembling the reservoir housing 14 of FIG. 9-10 and the heat sink 4 and the intermediate reservoir 30 of FIG. 11-13 a very compact monolithic unit is obtained, also obviating the need for tubes or pipes. Tubes or pipes may involve an increased risk of leakage of cooling liquid or may require soldering or other special working in order to eliminate the risk of leakage of cooling liquid. By eliminating the need for tubes or pipes, any leakage and any additional working is obviated when assembling the cooling system.

[0111] FIG. 15-16 show a possible embodiment of a reservoir according to the invention. The reservoir is basically similar to the reservoir shown in FIG. 9-10. However, an impeller 33 of the pump of the cooling system is provided in direct communication with the channels 26. Also, in the embodiment shown, a heat exchanging interface 4 such as a surface made from a copper plate, alternatively a plate of another material having a high thermal conductivity, is placed between the channels 26 inside the reservoir and the CPU 1 as the processing unit.

[0112] The heat exchanging surface 4 is preferably made from a copper plate having a plane outer surface as shown in the figure, said outer surface being intended for abutting the free surface of the heat generating component such as the CPU 1 (see FIG. 4). However, also the inner surface (not shown, see FIG. 7) facing the reservoir is plane. Accordingly, the copper plate need no machining other than the shaping of the outer boundaries into the specially adapted shape used in the embodiment shown and drilling of holes for insertion of the bolts. No milling of the inner and/or the outer surface need be provided.

[0113] The provision of the heat exchanging surface 4 need not be a preferred embodiment, seeing that the solution incorporating the aperture (see FIG. 9-10) result in a direct heat exchange between the free surface of the CPU or other processing unit and the cooling liquid flowing along the channels in the reservoir. However, the heat exchanging surface enables usage of the cooling system independently on the type and size of the free surface of CPU or other processing unit. Also, the heat exchanging surface enables replacement, repair or other intervention of the cooling system without the risk of cooling liquid entering the computer system as such and possibly without the need for draining the cooling system fully or partly of cooling liquid.

[0114] In the embodiment shown, the heat exchanging surface 4 is secured to the reservoir by means of bolts 22. Other convenient fastening means may be used. The heat exchanging surface 4 and thus the reservoir housing 14 may be fastened to the CPU 1 or other processing unit by any suitable means such as soldering, brazing or by means of thermal paste combined with glue. Alternatively, special means (not shown) may be provided for ensuring a thermal contact between the free surface of the CPU or other processing unit and the heat exchanging surface. One such means may be the fastening means shown in FIG. 4 and FIG. 5 or similar fastening means already provided as part of the computer system.

[0115] When channels 26 are provided inside the reservoir housing 14, the shape of the channels may be decisive of whether the reservoir is to be made of plastic, perhaps by injection molding, or is to be made of metal such as aluminum, perhaps by die casting.

[0116] The reservoir housing 14 or any other parts of the cooling system, which are possibly manufactured from a plastic material may be "metalized" in order to minimize liquid diffusion or evaporation of the liquid. The metal may be provided as a thin layer of metal coating provided on either or on both of the internal side or the external side of the plastic part.

[0117] The impeller 33 (see FIG. 14) of the pump is positioned in a separate recess of the channels 26, said separate recess having a size corresponding to the diameter of the impeller of the pump. The recess is provided with an inlet 34 and an outlet 35 being positioned opposite an inlet 31 and an outlet 32 of cooling liquid to and from, respectively, the channels 26. The impeller 33 of the pump has a shape and a design intended only for one way rotation, in the embodiment shown a clock-wise rotation only. Thereby, the efficiency of the impeller of the pump is highly increased compared to impellers capable of and intended for both clock-wise and counter clock-wise rotation.

[0118] The increased efficiency of the impeller design results in the electric motor (not shown) driving the impeller of the pump possibly being smaller than otherwise needed for establishing a proper and sufficient flow of cooling liquid through the channels. In a preferred embodiment, the electric motor is an AC motor, preferably a 12V AC motor, although the impeller is intended for a DC motor. The contradictory use of an AC motor driving a DC impeller leads to the possibility of an even smaller motor needed for establishing the proper and sufficient flow of cooling liquid through the channels.

[0119] The impeller may be driven by an electrical motor at any voltage common in public electrical networks such as 110V or 220V. The power supply of the computer system converts the high voltage AC power to low voltage DC power. Thus, the impeller of the pump may be driven by an AC or a DC electrical motor. As mentioned, preferably the impeller of the pump is driven by an AC electrical motor. Although being technically unnecessary to use an AC electrical motor and being electrically disadvantageous to use an AC electrical motor in a computer system supplying DC electrical power, this may be accomplished by converting part of the DC electrical power of the power supply of the computer system to AC electrical power for the AC motor of the pump. However, in the embodiment shown, the impeller of the pump is driven by a 12V electrical motor.

[0120] FIG. 17 shows a preferred possible embodiment of a reservoir according to the invention. The reservoir housing 14, as shown in FIGS. 17 and 20, is in the form of a double-sided chassis configured to mount an electrical motor. The reservoir housing 14 has basically the same features as the reservoir housing shown in FIG. 15-16. In the embodiment shown, the reservoir substantially has a conical, circular configuration and is provided with stiffening ribs 36 extending axially along the exterior of the reservoir housing 14.

[0121] Other shapes such as cylindrical, circular, or conical rectangular or cylindrical, rectangular or even oval or triangular shapes may be adopted, when designing and possibly injection molding or casting the reservoir. The dimension of the embodiment shown is approximately 55 mm in diameter and also 55 mm in axial extension.

[0122] The reservoir housing 14 has a recess 40 in the centre on the upper side_of the reservoir. The recess 40 is intended for accommodating a stator 37 of an electrical motor driving an impeller 33 of the pump, said impeller being attached to a shaft 38 of a rotor 39 of the electrical motor. The recess 40 has an orifice 41, four sidewalls 42, a bottom 43 and a circular jacket 44 extending from the bottom 43 of the recess 40 and outwards towards the orifice 41 of the recess 40. The interior (see FIG. 20) of the jacket 44 is intended for encompassing the rotor 39 of the pump. As shown in FIG. 20, the impeller 33 is housed in a recess on the underside of the reservoir housing 14, the recess being an extension of the interior of the jacket 44.

[0123] Thereby, a liquid-proof division is made between the rotor 39 of the motor, said rotor 39 being placed inside the interior of the jacket 44 and being submerged in the cooling liquid, and the stator 37 of the pump, said stator 37 being positioned in the recess 40 and surrounding the exterior of the jacket 44. Accordingly, the stator 37 need not be sealed against the cooling liquid, because the recess 40 together with the jacket 44 ensures the stator staying dry from the cooling liquid, but the stator 37 still being capable of driving the rotor 39, when being supplied with electrical power from a power supply (not shown) of the computer system.

[0124] Along an outer circumferential extension, the reservoir housing 14 is provided with protrusions 45 extending outwardly from the circumferential extension. The protrusions are intended for cooperating with a clip (see description below) for fastening the reservoir housing 14 to the CPU or other processing unit of the computer system. The protrusions 45 are shown as a plurality of singular protrusions. Alternatively, the protrusions may be only one continuous protrusion extending outwardly and around the circumferential extension.

[0125] The reservoir housing 14 may also be provided with an inlet (not shown) and an outlet (not shown) for the cooling liquid. The inlet and the outlet are provided along a surface of the reservoir facing downward and inwards when seen in the perspective view of the drawing. The inlet and the outlet lead to a radiator (not shown) intended for cooling the cooling liquid after having been heated by the processing unit via a heat exchanging surface (see description below).

[0126] The radiator may be placed nearby or distant from the reservoir housing 14, depending on the set-up of the computer system. In one possible embodiment, the radiator is placed in the immediate vicinity of the reservoir, thereby possible excluding any tubing extending between the radiator and the inlet and the outlet, respectively. Such embodiment provides a very compact configuration of the entire cooling system, namely a monolithic configuration where all elements needed for the cooling system are incorporated in one unit.

[0127] In an alternative embodiment, the reservoir housing 14 itself also constitutes the radiator of the cooling system. In such embodiment, an inlet and an outlet are not needed. If the reservoir is made of a metal such as copper or aluminum or other material having a high thermal conductance, the cooling liquid, after having been heated by the processing unit via a heat exchanging surface 8 see description below) may radiate the heat via the exterior surface of the reservoir housing 14 itself. In such embodiment, the ribs 36 along the exterior surface of the reservoir housing 14 may also, or may instead, function as cooling fins. In such embodiment, the fins will have a smaller dimension than the transverse dimension of the ribs 14 shown in FIG. 17, and the number of fins will be greater than the number of fins shown in FIG. 17.

[0128] An impeller 33 of the pump of the cooling system is provided in direct communication with a pump chamber 46 formed by impeller cover 46A having an outlet 34 provided tangentially to the circumference of the impeller 33. Thus, the pump functions as a centrifugal pump. The inlet of the pump chamber 46 is the entire opening into the cavity that the pump chamber configures, said cavity being in direct communication with the interior of the reservoir housing 14 as such. An intermediate member 47 is provided between the pump chamber 46 together with the interior of the reservoir and a heat exchanging interface 4. The intermediate member 47 is provided with a first passage 48 for leading cooling liquid from the pump chamber 46 to a thermal exchange chamber 47A provided at the opposite of the intermediate member 47. The intermediate member 47 is provided also with a second passage 49 for leading cooling liquid from the thermal exchange chamber 47A provided at the opposite of the intermediate member 47 to the interior of the reservoir housing 14. Thus, the area enclosed between the underside of the reservoir housing 14 and the heat exchange surface 4 constitutes an enclosed space for circulating the cooling liquid therethrough. The enclosed spaced is divided into two separate chambers by the impeller cover 46A and the intermediate member 47, as shown in FIG. 20. The impeller cover 46A interfaces with the recess on the underside of the reservoir 14 to define the pump chamber 46 which houses the impeller 33, while the intermediate member 47 and the heat exchange surface 4 together define the thermal exchange chamber 47A.

[0129] In the embodiment shown, a heat exchanging interface 4 such as a surface made from a copper plate, alternatively a plate of another material having a high thermal conductivity, is placed in thermal communication with the thermal exchange chamber (not shown) at the opposite side of the intermediate member 47.

[0130] The heat exchanging interface 4 is preferably made from a copper plate having a plane outer surface (not shown) at the opposite side as the side shown in the figure, said outer surface being intended for abutting the free surface of the heat generating component such as the CPU (see FIG. 4). The inner surface facing the thermal exchange chamber (not shown) at the opposite side of the intermediate member 47 is provided with pins 4A extending from the base of the copper plate and into the thermal exchange chamber (not shown) at the opposite side of intermediate member 47. The pins 4A constitutes an uneven surface and may either be provided during casting of the copper plate or may be provided by means of milling or other machining process of a copper plate. The pins provide a network of channels across the inner surface of the heat exchanging interface, along which network the cooling liquid is intended to flow.

[0131] Alternatively, also the inner surface of the copper plate facing the reservoir is plane. In this alternative embodiment, the copper plate need no machining other than the shaping of the outer boundaries into the specially adapted shape used in the embodiment shown. No milling or other machining process of the inner and/or the outer surface need be provided, when both the outer surface and the inner surface is plane.

[0132] The provision of the heat exchanging interface 4 need not be a preferred embodiment, seeing that the solution incorporating the aperture (see FIG. 9-10) result in a direct heat exchange between the free surface of the CPU or other processing unit and the cooling liquid flowing along the channels in the reservoir. However, the heat exchanging interface enables usage of the cooling system independently on the type and size of the free surface of CPU or other processing unit. Also, the heat exchanging interface enables replacement, repair or other intervention of the cooling system without the risk of cooling liquid entering the computer system as such and possibly without the need for draining the cooling system fully or partly of cooling liquid.

[0133] In the embodiment shown, the heat exchanging interface 4 is secured to the intermediate member 47 by means of gluing or other means ensuring a proper and liquid-tight fastening of the heat exchanging interface with the intermediate member. Any other suitable and convenient means (not shown) for securing the heat exchanging interface to the intermediate member may be envisaged.

[0134] The heat exchanging interface and thus the reservoir is fastened to the top of the CPU by means of a clip 50. The clip 50 has a circular configuration and has four legs 51 extending axially from the circular configuration. The four legs 51 are provided with footing 52 and the footings 52 are provided with holes 53. The clip 50 is intended for being displaced around the exterior of the reservoir housing 14 and further axially to the protrusions 45 of the reservoir housing 14.

[0135] The clip 50, after having been placed around the reservoir housing 14, is fastened to the motherboard of the computer system by means of bolts (not shown) or the like fastening means extending through the holes 53 in the footings 52 and further though corresponding holes in the motherboard. The corresponding holes in the motherboard are preferably holes already available in the motherboard in the vicinity of the CPU and the socket of the CPU, respectively. Accordingly, the legs 51 and the footings 52 of the clip 50 are specially designed in accordance with the already provided holes in the motherboard.

[0136] Alternatively, the heat exchanging interface 4 and thus the reservoir housing 14 may be fastened to the CPU or other processing unit by any other suitable means such as soldering, brazing or by means of thermal paste combined with glue. Alternatively, special means (not shown) may be provided for ensuring a thermal contact between the free surface of the CPU or other processing unit and the heat exchanging interface. One such means may be the fastening means shown in FIG. 4 and FIG. 5 or similar fastening means already provided as part of the computer system.

[0137] When stiffening and/or cooling fins 36 are provided at the exterior of the reservoir housing 14, the shape of and the number of fins may be decisive of whether the reservoir is to be made of plastic, perhaps by injection molding, or is to be made of metal such as aluminum, perhaps by die casting. Also, the purpose of the fins i.e. just for stiffening the reservoir, or also or instead for cooling purposes, may be decisive of whether the reservoir is to be made of plastic, perhaps by injection molding, or is to be made of metal such as aluminum, perhaps by die casting.

[0138] The reservoir housing 14 or any other parts of the cooling system, which are possibly manufactured from a plastic material may be "metalized" in order to minimize liquid diffusion or evaporation of the liquid. The metal may be provided as a thin layer of metal coating provided on either or on both of the internal side or the external side of the plastic part.

[0139] The impeller 33 of the pump has a shape and a design intended only for one way rotation, in the embodiment shown a clock-wise rotation only. Thereby, the efficiency of the impeller of the pump is highly increased compared to impellers capable of and intended for both clock-wise and counter clock-wise rotation.

[0140] The increased efficiency of the impeller design results in the electric motor (not shown) driving the impeller of the pump possibly being smaller than otherwise needed for establishing a proper and sufficient flow of cooling liquid through the channels. In a preferred embodiment, the electric motor is an AC motor, preferably a 12V AC motor, although the impeller is intended for a DC motor. The contradictory use of an AC motor driving a DC impeller leads to the possibility of an even smaller motor needed for establishing the proper and sufficient flow of cooling liquid through the channels.

[0141] The impeller may be driven by an electrical motor at any voltage common in public electrical networks such as 110V AC power or 220V AC power. The power supply of the computer system converts the high voltage AC power to low voltage DC power. Thus, the impeller of the pump may be driven by either an AC or a DC electrical motor. As mentioned, preferably the impeller of the pump is driven by an AC electrical motor. Although being technically unnecessary to use an AC electrical motor and being electrically disadvantageous to use an AC electrical motor in a computer system supplying DC electrical power, this may be nevertheless be accomplished by converting part of the DC electrical power of the power supply of the computer system to AC electrical power for the AC motor of the pump.

[0142] In every aspect of the invention, where an AC motor is used for driving an impeller from a DC motor, although this way of configuring a pump is contradictory, the following preferred mode of operation is established for alleviating the disadvantages:

[0143] In order to be able to control direction of rotation of the impeller attached to the rotor and to optimize the conditions of maximum average torque value during starting, i.e. from zero speed up to the synchronous speed, an electronic control circuit is used. The electronic control circuit comprises a processing unit, which drives a static power switch, constituted for example by a triac arranged in series between the alternating-voltage power, which is obtained from the DC power supply of the computer system, and the AC motor. The same series network also includes a detector for the current I which flows through the triac and then through the AC motor. The output of the current detector is an input signal for the electronic processing unit.

[0144] The electronic control circuit may also comprise a number or sensors suitable for detecting the position and polarity of the permanent magnets comprised in the rotor of the AC motor, both when the rotor is moving and when it is in particular operating conditions, or when it is motionless or stalled at zero speed. The number of position sensors may be Hall sensors, encoders or optical or electromechanical sensors capable of establishing and/or measuring the position of the rotor. The output signal from the number of position sensors is an input signal for the electronic processing unit.

[0145] Alternatively, the output signal from the position sensor may be phase shifted by means of an electronic phase shifting circuit before the output signal is sent to the input of the electronic processing unit.

[0146] A third signal may be input to the processing unit, said third signal enabling the processing unit to detect the polarity of the AC voltage applied to the AC motor. However, the third signal is not compulsory.

[0147] The signals input to the electronic processing unit are converted into digital form and after being processed by the processing unit, an output signal is provided by the processing unit. The output signal is used for closing or opening the static switch constituted by a triac arranged in series with the AC motor.

[0148] In the electronic processing unit, the current signal provided by the current sensor enters a zero-crossing detector which provides in output a logical "1" signal indicating that said current approaches zero with a positive or negative deviation from the zero value of said current. This deviation depends on the type of motor used and on its application, as well as on the type of static power switch being used. The signal arriving from the position sensor enters a phase-shift and processing circuit the output whereof is 1 or 0 according to the position and polarity of the rotor.

[0149] In the electronic processing unit, the phase shifted position signal as well as the signal processed from the AC voltage, enter an electronic logic XOR gate which outputs a "1" signal if the digital value of the AC voltage is equal to "0" and the digital value of the phase shifted position signal is equal to "1" or the digital value of the AC voltage is equal to "1" and the digital value of the phase shifted position signal is equal to "0".

[0150] The output of the zero-crossing detector and the output of the XOR gate, thus in digital form, enter an electronic logic AND gate which provides in output the control signal for closing or opening the static power switch.

[0151] The AND gate with two inputs and the signal processing system allow determining two conditions: 1) the AC voltage signal is positive, the current is proximate to zero, and the rotor rotation angle is between 0 degrees and 180 degrees; 2) the AC voltage signal is negative, the current is proximate to zero, and the rotor rotation angle is between 180 degrees and 360 degrees. These two conditions provide the same rotation direction of the rotor of the AC motor.

[0152] FIG. 18 shows an embodiment of an AC motor in which one stator pole 54 is longer than the other stator pole 55 by an amount indicated by l. With this configuration the permanent-magnet rotor 39 with an ideal line 56 separating the north N and the south S of the rotor, is positioned so that the ideal line 56 do not coincide with the median axis 57 of the stator 37, but so that the ideal line 56 is tilted by a certain angle .alpha. in respect to the median 57 of the stator 37.

[0153] Two energizing windings 58, 59 are provided on the two poles 54,55 of the stator 37, respectively, and the energizing windings are connected in series and are powered, through terminals (not shown), by an AC power source. With this configuration of the AC motor, the motor is able to start more easily in an intended rotational direction of the rotor.

[0154] In a preferred embodiment of the invention, the control electronics supplies the AC motor with only a half-wave voltage signal during start up, thereby providing torque pulses to the rotor. Since only a half-wave voltage signal is supplied to the motor, the torque pulses are always unidirectional and will therefore force the rotor to start rotating in a required direction. The required direction of rotation is determined by the design of the impeller attached to the rotor and by polarity of the half-wave voltage signal.

[0155] After some amount of time, in which a number of half-wave voltage signals has been supplied to the motor, the rotor will stop rotating at a certain position e.g. as shown in the figure. Thus, the rotor is brought into a determined steady state position that is independent of its start position. Subsequent to this process, the AC motor is supplied with a full-wave voltage signal that will accelerate the rotor until the motor enters synchronous operation, that is, when the rotor rotates with the same cyclic frequency as the frequency of the AC voltage source.

[0156] The initial polarity of the AC voltage signal is determinative for the resulting direction of rotation of the rotor, thus if the initial voltage is positive with an increasing amplitude, the rotor will start rotating in one direction, whereas if the voltage is negative with a decreasing amplitude, the rotor will start rotating in an opposite direction.

[0157] The number of half-waves required for bringing the rotor into a determined steady state position, where the rotor stops rotating, depends on the characteristics of the motor such as moment of inertia and the external load applied to the rotor. Thus, the number of half-waves required is based on empirical analysis of a particular motor in particular load conditions.

[0158] The half-wave voltage signal and the corresponding half-wave current signal supplied to the motor will have an appearance as shown in FIG. 19.

[0159] In an alternative embodiment the control electrics used to drive the AC motor shown if FIG. 18 is configured so that that the control electronics dictates the AC motor to stop at a predetermined position by supplying the motor with a number of half-wave voltage signals subsequent to the synchronous operation in which the motor was supplied with a full-wave voltage signal. Thus, at the time the motor needs to be started again, the rotor is already in a position so that only the polarity of the full-wave AC voltage signal supplied to the motor must be chosen so that the resulting direction of rotation of the rotor is in conformity with the terminal position of the rotor at the last operation.

[0160] According to this method, the initial step of bringing the rotor into a determined steady state position by supplying the motor with a number of half-wave voltage signals is not required. Even in the alternative, it will be possible to both terminate the full-wave power supply with a number of half-wave voltage signals as well as commencing the full-wave power supply by initially supplying the motor with a number of half-wave signals. However, this is more cumbersome, but nevertheless more safe.

[0161] FIG. 19 shows a voltage signal V and a current signal I applied to the AC motor as well as the position signal of the rotor. Initially the rotor stands still, which is represented by the straight line L. The electronic control circuit controls the static power switch so that the voltage signal V and the current signal I are present as half-waves. Thus, the rotor receives torque pulses due to the current-voltage combination; these pulses are always one-way directional and tend to start the rotor moving in the required direction. Subsequent to the start-up phase, the rotor enters into its synchronous operation.

[0162] Thus, an AC signal is generated, preferably a 12 V AC signal, possibly by means of digital electric pulses from the 12 V DC power supply of the computer's power supply. Based on a possible sensor output relating to the impeller position, a decision is made of how to initiate the AC power signal, i.e. with a negative or positive half-wave, and by doing making sure the impeller starts in the same rotational direction each time and thus the performance benefits of the AC pump is similar to those of a DC pump.

[0163] Alternatively, the magnetic field sensor is omitted, and instead of reading the impeller position, the impeller is forced to be in the same position every time the impeller starts. To be sure the impeller is in a defined position before start, a signal is supplied to the stator of the AC motor for a defined period of time. The signal is supplied perhaps three times in a row according to the curvature of the electrical power source. The pulses must be within the same half-wave part of a signal period. The frequency of the pulsed signal is arbitrary, but may be 50/60 Hz, although, despite the fact that under normal circumstances an AC pump being driven by the AC signal from the power outlet of the public electrical power network and transformed from 230/115 V to 12V would not function, as there is no chance of changing the sine signal from the public network.

[0164] By this way the impeller will be forced to the right polarity before start, and the pump will start turning the impeller in a defined way of rotation when the power signal full-wave is supplied. The full-wave power signal, which is supplied, must start in the opposite signal half-wave amplitude than that of the initial half-wave pulses, that was supplied before start of the full-wave power signal.

[0165] The invention has been described with reference to specific embodiments and with reference to specific utilization, it is to be noted that the different embodiments of the invention may be manufactured, marketed, sold and used separately or jointly in any combination of the plurality of embodiments. In the above detailed description of the invention, the description of one embodiment, perhaps with reference to one or more figures, may be incorporated into the description of another embodiment, perhaps with reference to another or more other figures, and vice versa. Accordingly, any separate embodiment described in the text and/or in the drawings, or any combination of two or more embodiments is envisaged by the present application.

CLAIMS

What is claimed is:

1. A cooling system for a heat-generating component, comprising:

a double-sided chassis adapted to mount a pump configured to circulate a cooling liquid, the pump comprising a stator and an impeller, the impeller being positioned in a recess on the underside of the chassis and the stator being positioned on the upper side of the chassis and isolated from the cooling liquid;

a reservoir adapted to pass the cooling liquid therethrough, the reservoir including:

a pump chamber formed by the recess and at least an impeller cover having one or more passages for the cooling liquid to pass through;

a thermal exchange chamber, the pump chamber and the thermal exchange chamber being separate chambers that are fluidly coupled together by the one or more passages; and

a heat-exchanging interface, the heat-exchanging interface forming a boundary wall of the thermal exchange chamber, and configured to be placed in thermal contact with a surface of the heat-generating component; and

a heat radiator fluidly coupled to the reservoir and configured to dissipate heat from the cooling liquid.

2. The cooling system of claim 1, wherein the chassis shields the stator from the cooling liquid in the reservoir.

3. The cooling system of claim 1, wherein the heat-exchanging interface includes a first side and a second side opposite the first side, and wherein the heat-exchanging interface contacts the cooling liquid in the thermal exchange chamber on the first side and the heat-exchanging interface is configured to be in thermal contact with the surface of the heat-generating component on the second side.

4. The cooling system of claim 3, wherein the first side of the heat-exchanging interface includes features that are adapted to increase heat transfer from the heat-exchanging interface to the cooling liquid in the thermal exchange chamber.

5. The cooling system of claim 4, wherein the features include at least one of pins or fins.

6. The cooling system of claim 1, wherein the impeller is positioned in the pump chamber.

7. The cooling system of claim 1, wherein a passage of the one or more passages that fluidly couple the pump chamber and the thermal exchange chamber is offset from a center of the impeller.

8. The cooling system of claim 1, wherein the impeller includes a plurality of curved blades.

9. The cooling system of claim 1, wherein the pump chamber and the thermal exchange chamber are spaced apart in a vertical direction.

10. The cooling system of claim 1, wherein the heat-exchanging interface includes one of copper and aluminum.

11. The cooling system of claim 1, wherein the heat radiator is fluidly coupled to the reservoir using flexible conduits, and the heat radiator is configured to be positioned remote from the reservoir.

12. A cooling system for a computer system, comprising:

a centrifugal pump adapted to circulate a cooling liquid, the pump including:

an impeller exposed to the cooling liquid; and

a stator isolated from the cooling liquid;

a reservoir configured to be thermally coupled to a heat-generating component of the computer system, the reservoir including:

a thermal exchange chamber adapted to be positioned in thermal contact with the heat-generating component;

a separate pump chamber vertically spaced part from the thermal exchange chamber and coupled with the thermal exchange chamber through one or more passages configured for fluid communication between the pump chamber and the thermal exchange chamber, and wherein at least one of the one or more passages is offset from a center of the impeller.

13. The cooling system of claim 12, wherein a top wall of the reservoir physically separates the impeller from the stator.

14. The cooling system of claim 12, wherein the thermal exchange chamber includes a heat-exchange interface configured to be placed in thermal contact with the heat-generating component.

15. The cooling system of claim 12, further including a heat radiator fluidly coupled to the reservoir using flexible conduits, wherein the heat radiator is configured to be positioned remote from the reservoir.

16. The cooling system of claim 12, wherein the fluid passage that is offset from the center of the impeller is positioned tangentially to the circumference of the impeller.

17. A cooling system for a heat-generating component, comprising:

a pump adapted to circulate a cooling liquid, the pump including:

an impeller exposed to the cooling liquid; and

a stator isolated from the cooling liquid;

a reservoir including an impeller cover, an intermediate member and a heat exchange interface, wherein a top wall of the reservoir and the impeller cover define a pump chamber for housing the impeller, and the intermediate member and the heat exchange interface define a thermal exchange chamber, the pump chamber and the thermal exchange chamber being spaced apart from each other in a vertical direction and fluidly coupled together; and wherein a first side of the heat-exchanging interface is in contact with a cooling liquid in the thermal exchange chamber and a second side of the heat-exchanging interface opposite the first side is configured to be placed in thermal contact with a surface of the heat-generating component; and

a liquid-to-air heat exchanger fluidly coupled to the reservoir using flexible conduits, the heat exchanger being configured to be positioned remote from the reservoir.

18. The cooling system of claim 17, wherein the impeller cover includes a first opening radially offset from a center of the impeller and the intermediate member includes a second passage that is aligned with the first opening, the first and the second opening being configured to direct the cooling liquid from the pump chamber into the thermal exchange chamber.

19. The cooling system of claim 17, wherein the first side of the heat-exchanging interface includes at least one of pins or fins.

20. The cooling system of claim 17, wherein the top wall of the reservoir extends between the stator and the impeller and shields the stator from the cooling liquid in the reservoir.

ABSTRACT

The invention relates to a cooling system for a computer system, said computer system comprising at least one unit such as a central processing unit (CPU) generating thermal energy and said cooling system intended for cooling the at least one processing unit and comprising a reservoir having an amount of cooling liquid, said cooling liquid intended for accumulating and transferring of thermal energy dissipated from the processing unit to the cooling liquid. The cooling system has a heat exchanging interface for providing thermal contact between the processing unit and the cooling liquid for dissipating heat from the processing unit to the cooling liquid, Different embodiments of the heat exchanging system as well as means for establishing and controlling a flow of cooling liquid and a cooling strategy constitutes the invention of the cooling system.

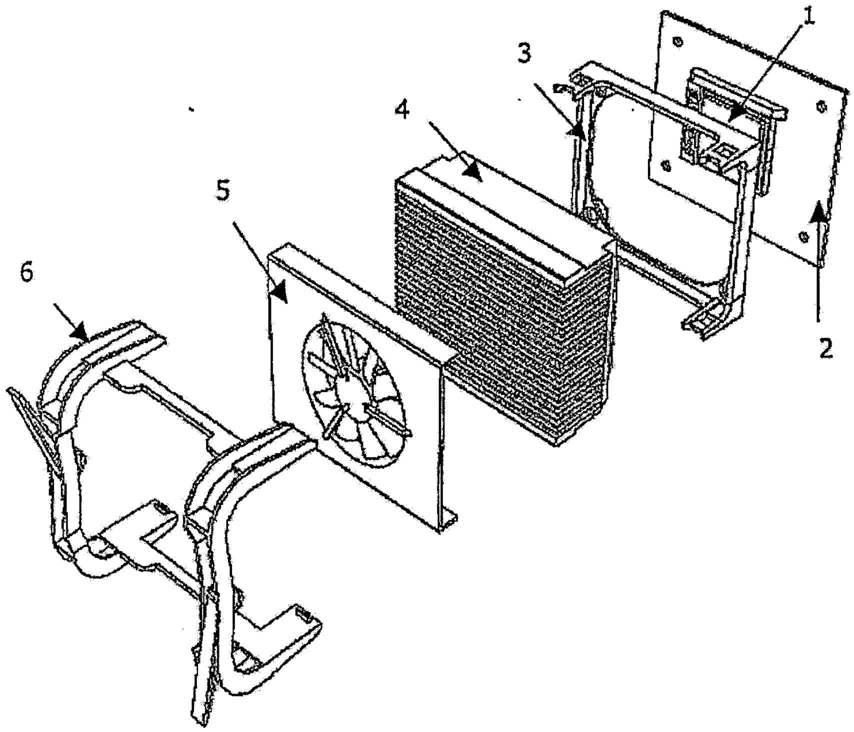

FIG. 1

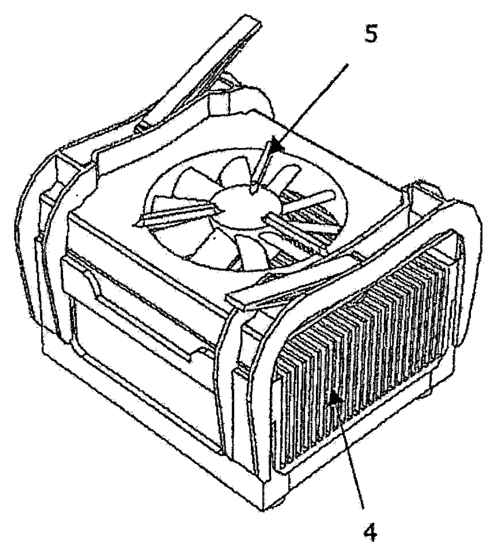

FIG. 2

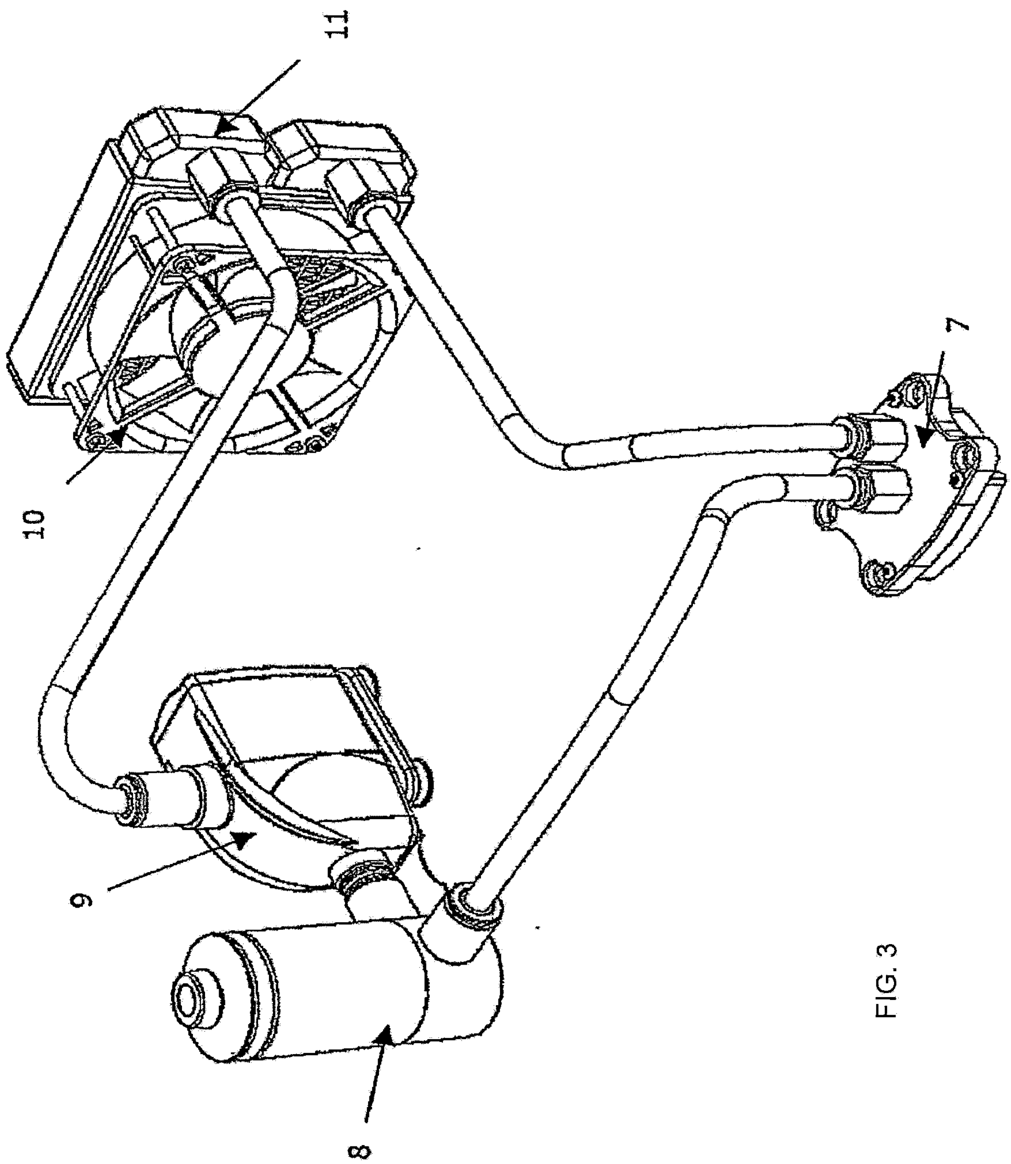

FIG. 3

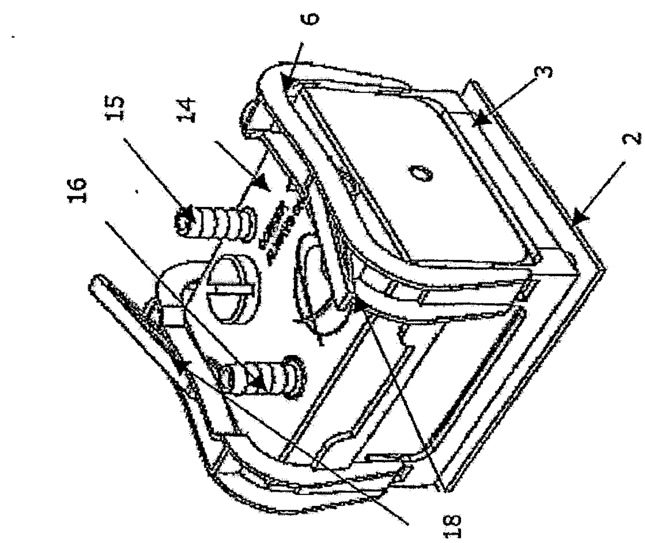

FIG. 5

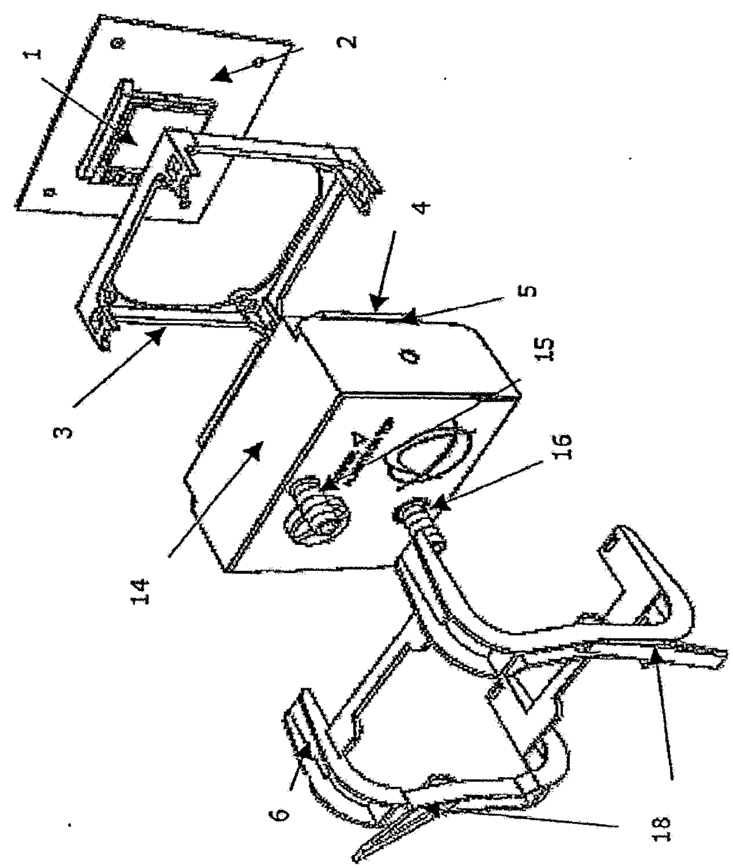

FIG. 4

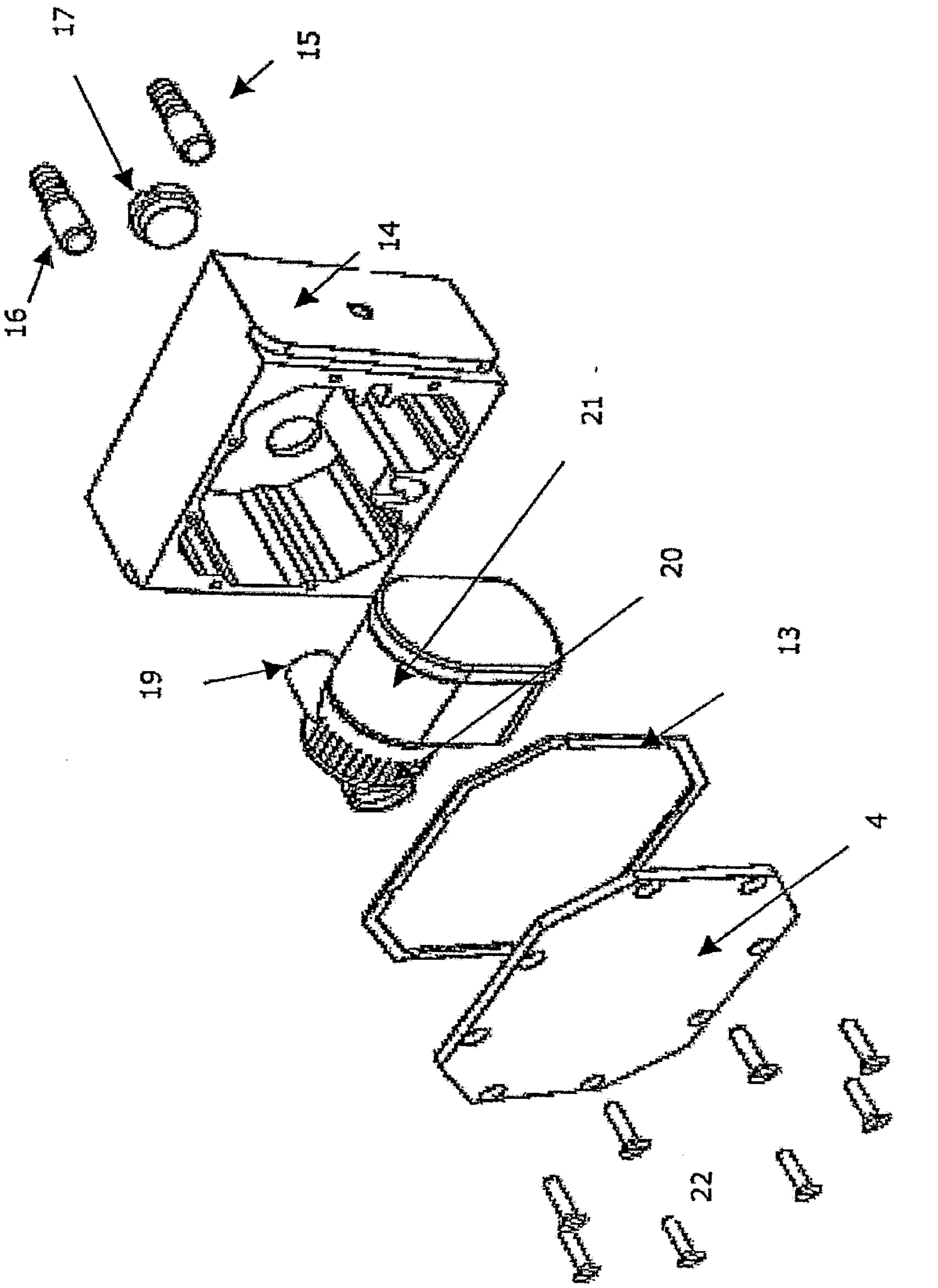

FIG. 6

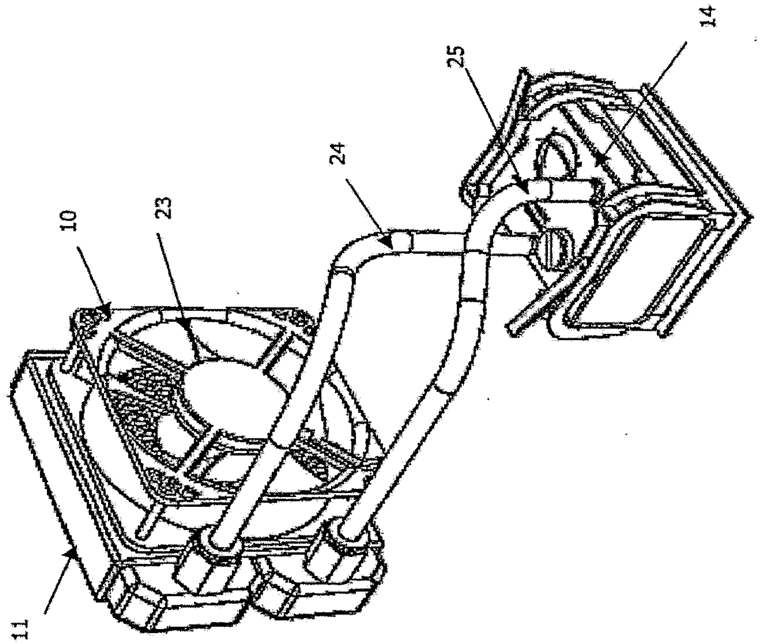

FIG. 7

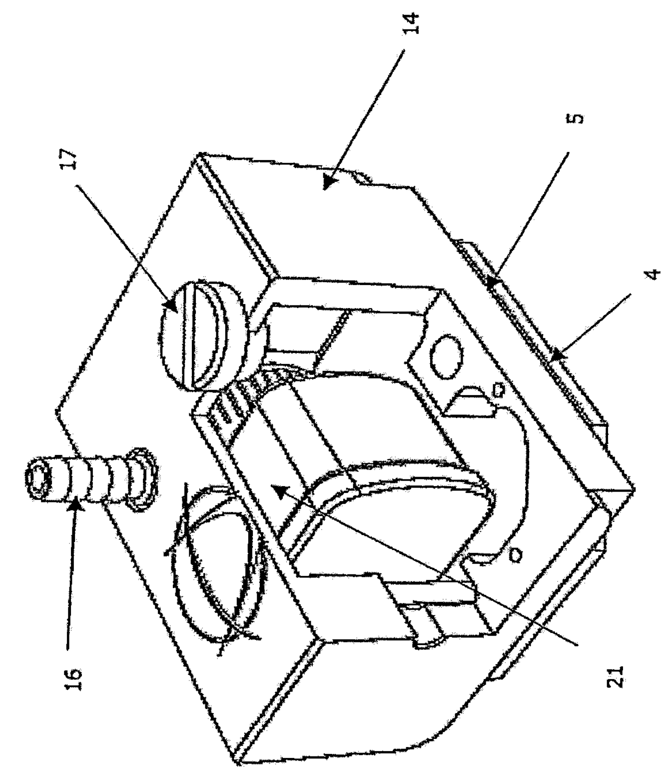

FIG. 8

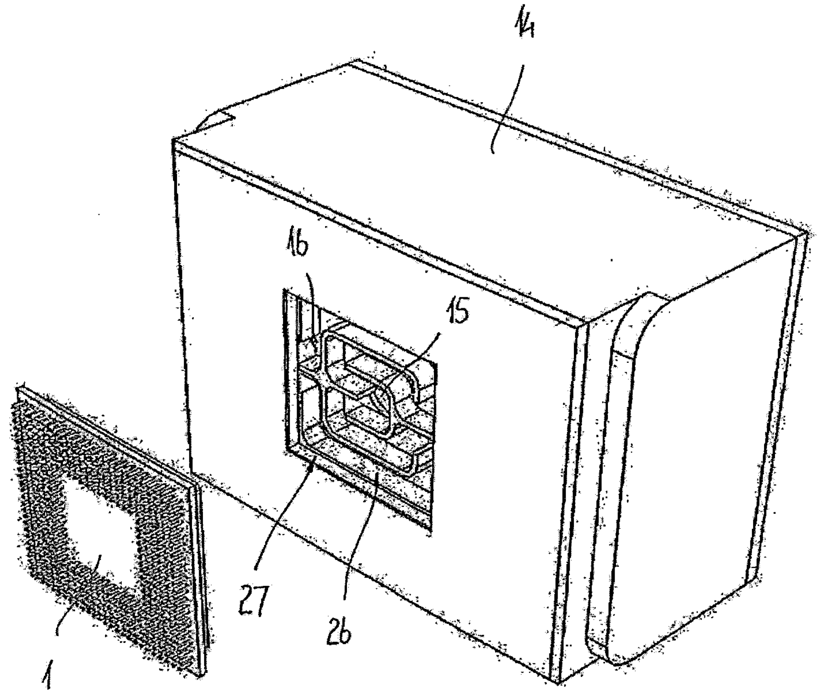

FIG. 9

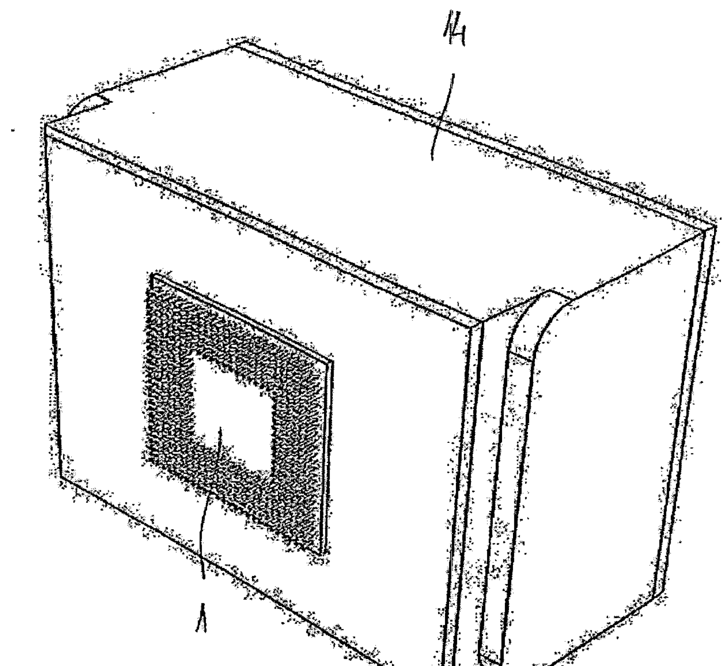

FIG. 10

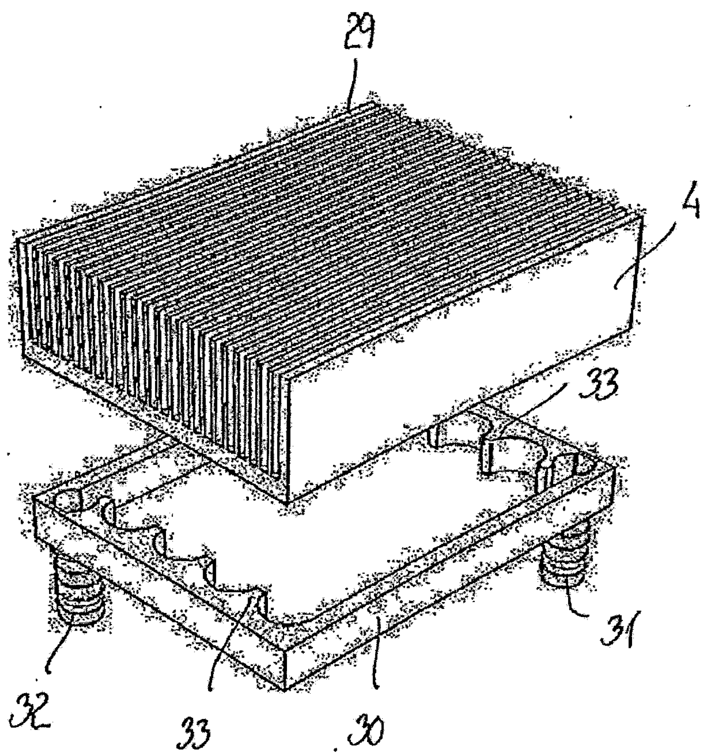

FIG. 11

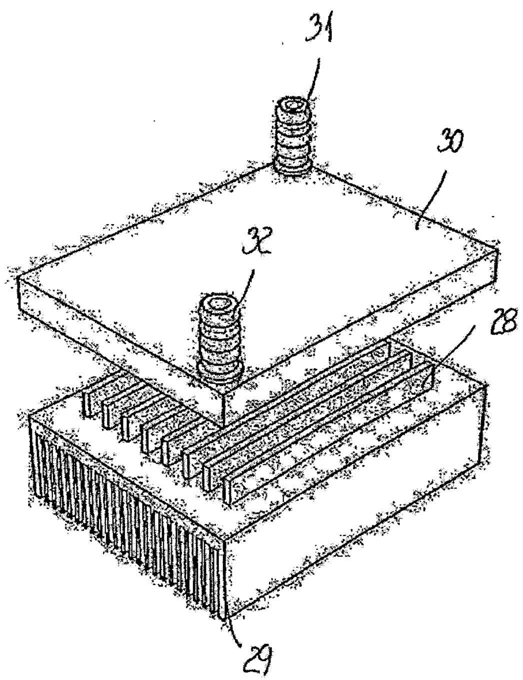

FIG. 12

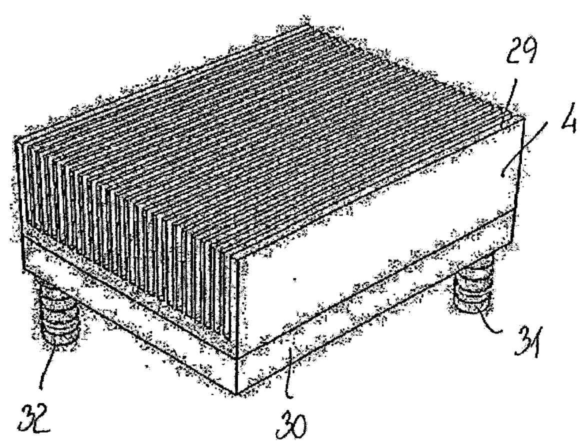

FIG. 13

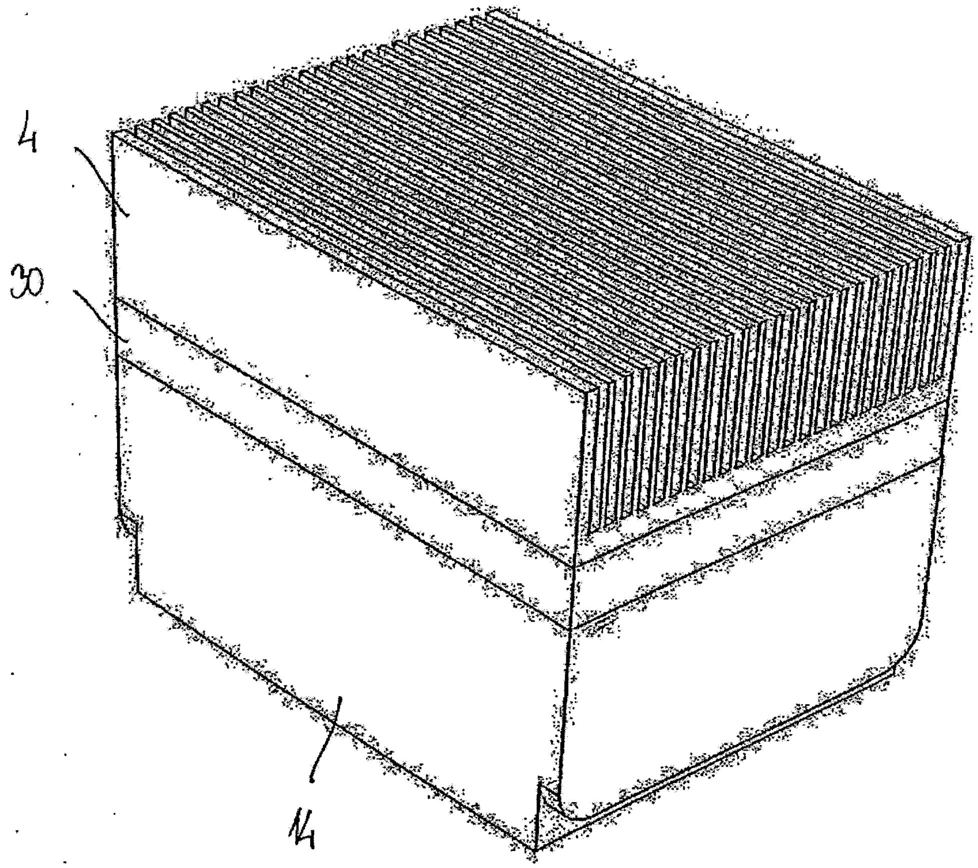

FIG. 14

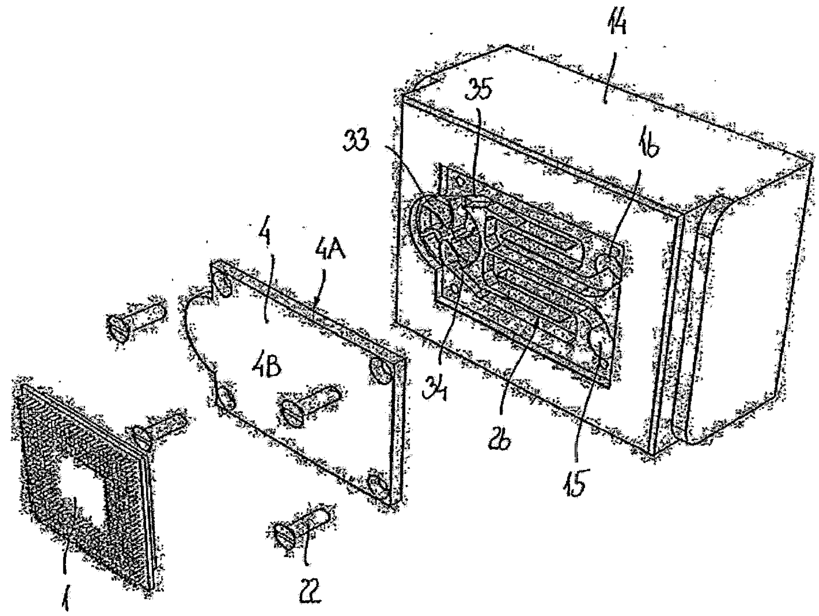

FIG. 15

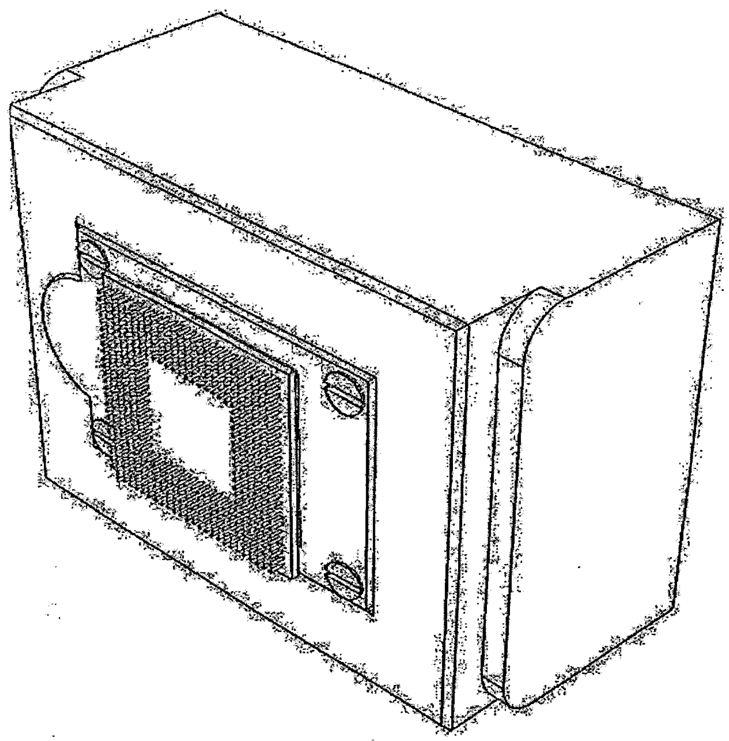

FIG. 16

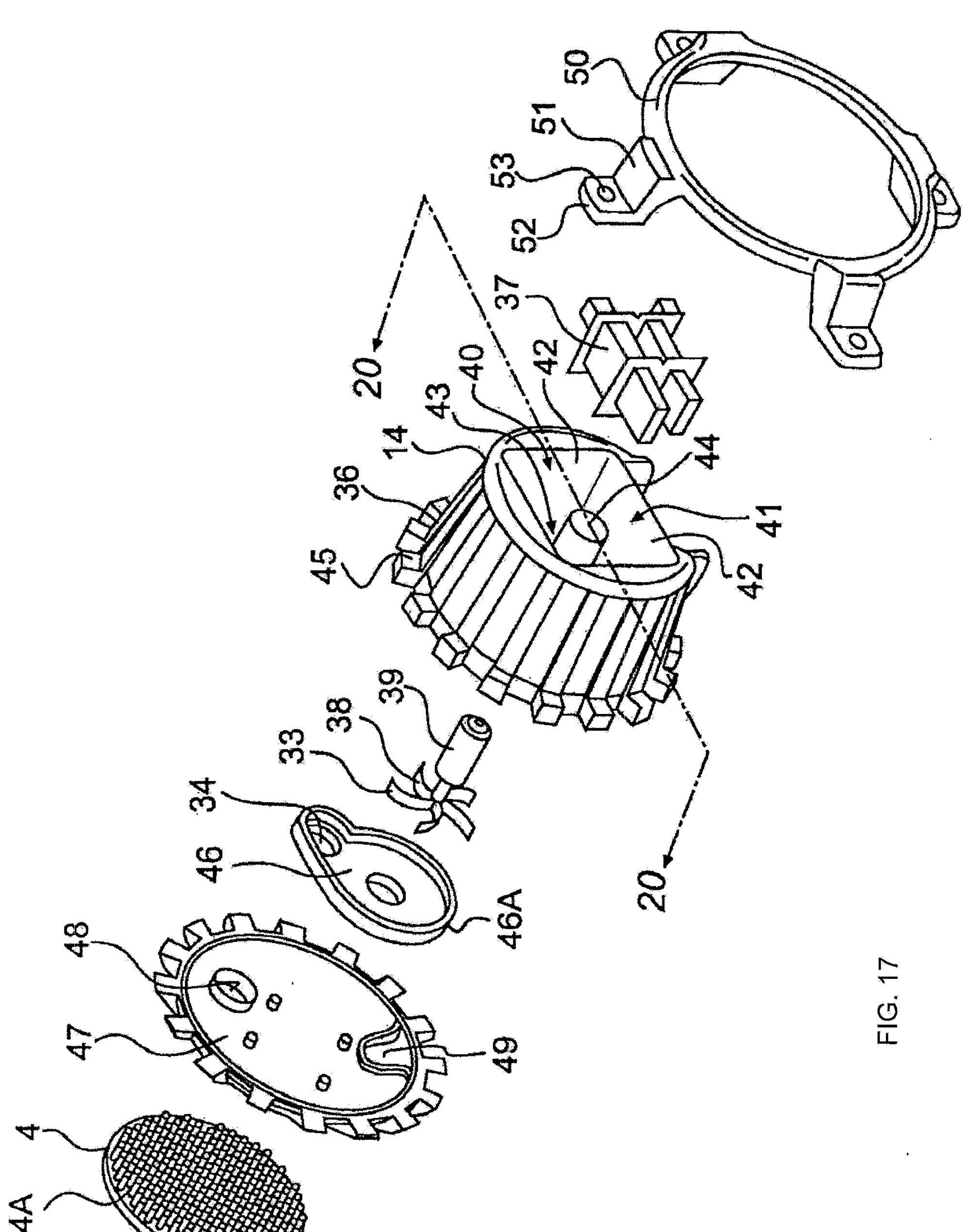
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FIG. 17

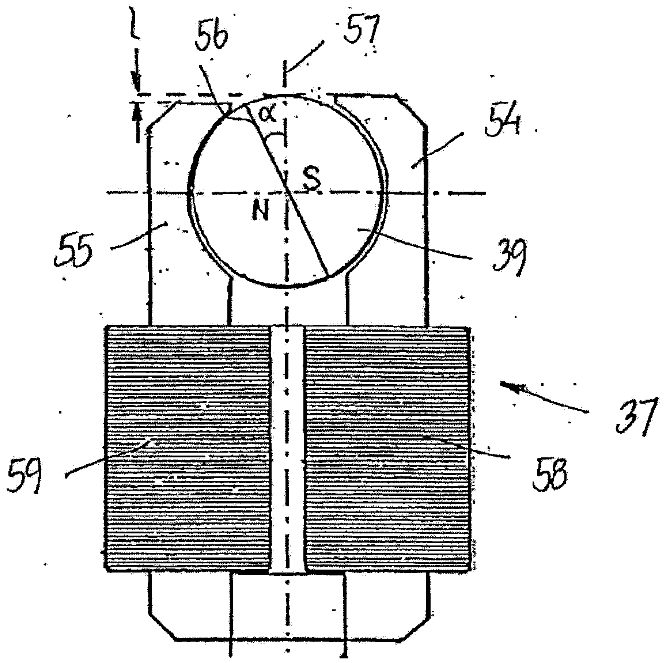

FIG. 18

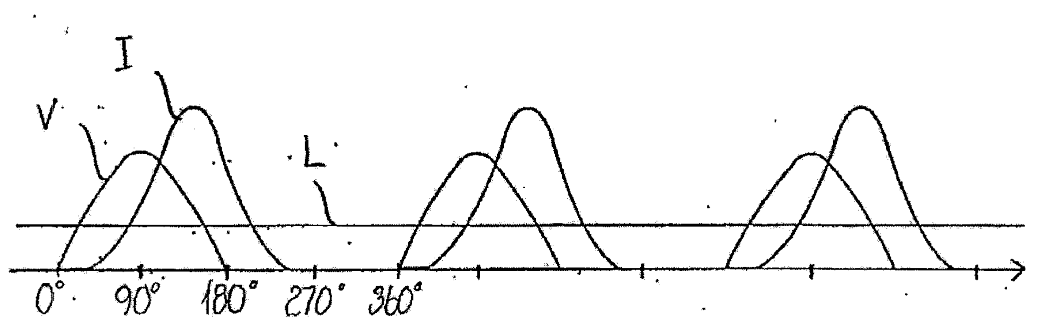

FIG. 19

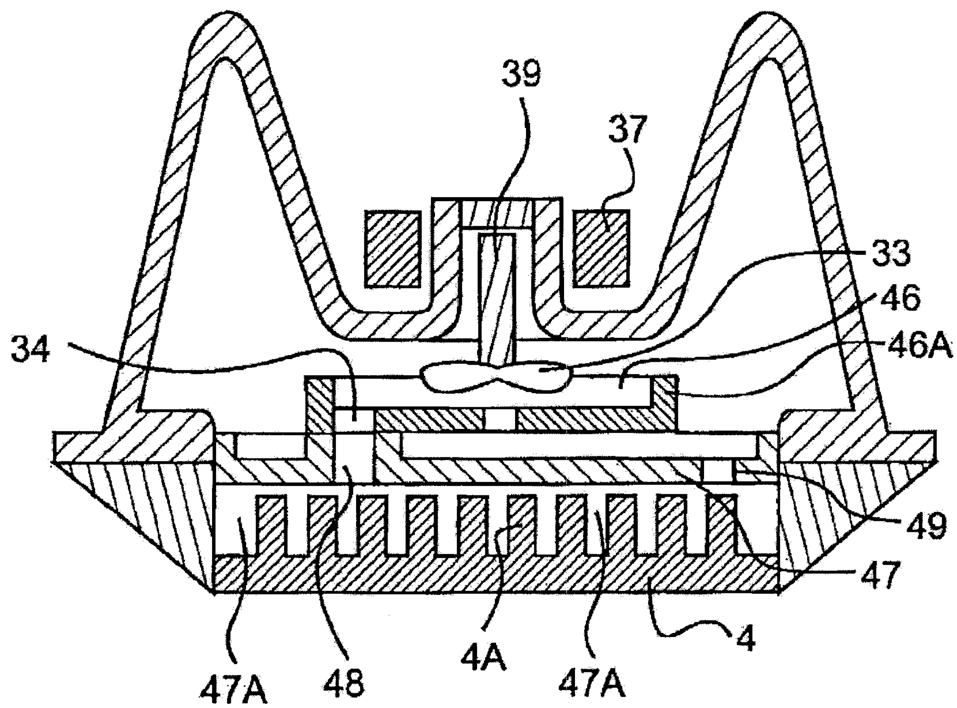

FIG. 20

DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that: my residence, post office address and citizenship are as stated below next to my name; I believe I am the original, first, and sole inventor (if only one name is listed below) or an original, first, and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

COOLING SYSTEM FOR A COMPUTER SYSTEM

the specification of which
☐ is attached and/or
☒ was filed on November 6, 2007 as United States Application Serial No. and
was amended on November 6, 2007
☒ was filed on May 6, 2005 as PCT International Application No. PCT/DK2005/000310 and
was amended on

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above. I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR § 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. § 119(a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate or § 365(a) of any PCT International application(s) designating at least one country other than the United States, listed below and have also identified below, any foreign application(s) for patent or inventor's certificate, or any PCT International application(s) having a filing date before that of the application(s) of which priority is claimed:

Country	Application Number	Date of Filing	Priority Claimed Under 35 U.S.C. 119
			☐ YES ☐ NO
			☐ YES ☐ NO

I hereby claim the benefit under 35 U.S.C. § 119(e) of any United States provisional application(s) listed below:

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

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Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	COOLING SYSTEM FOR A COMPUTER SYSTEM
First Named Inventor/Applicant Name:	Andre Sloth ERIKSEN
Filer:	Biju I. Chandran/Sharon Ambrose
Attorney Docket Number:	10494.0003-01000

Filed as Small Entity

Track I Prioritized Examination - Nonprovisional Application under 35 USC 111(a) Filing Fees

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Basic Filing:				
Utility filing Fee (Electronic filing)	4011	1	95	95
Utility Search Fee	2111	1	310	310
Utility Examination Fee	2311	1	125	125
Request for Prioritized Examination	2817	1	2400	2400
Pages:				
Claims:				
Miscellaneous-Filing:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Publ. Fee- early, voluntary, or normal	1504	1	300	300
Processing Fee, except for Provis. apps	1808	1	130	130
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
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Miscellaneous:				
		Total in USD ($)		**3360**

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First Named Inventor/Applicant Name:	Andre Sloth ERIKSEN
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Filer:	Biju I. Chandran/Sharon Ambrose
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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)

1	TrackOne Request	track1appl.pdf	54945 79fb810b79420afe9675b00d75054f9bb284bdb4	no	1
Warnings:					
Information:					
2	Transmittal of New Application	newtransmt.pdf	48587 eddbdfb9048da09715df53fcf410e2f59ea613a6	no	2
Warnings:					
Information:					
3		newspec.pdf	1724249 308eca57c5046b9aad3b7eb4bc18f1f2b4e87332	yes	68

Multipart Description/PDF files in .zip description

Document Description	Start	End
Specification	1	61
Claims	62	67
Abstract	68	68

Warnings:					
Information:					
4	Drawings-only black and white line drawings	newdrawings.pdf	748434 cca967a4f63e52d9165d77c3926bc732073d9cc0	no	12
Warnings:					
Information:					
5	Oath or Declaration filed	newdec.pdf	95207 9f9009d36d3f53d54861536fc1bb58bea471e59d	no	2
Warnings:					
Information:					
6	Fee Worksheet (SB06)	fee-info.pdf	40133 17be5eba5736737bb3bb35f5a065cc382c058c97	no	2
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New Applications Under 35 U.S.C. 111
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National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IDS Form PTO/SB/08: Substitute for form 1449A/PTO				*Complete if Known*	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				*Application Number*	13/269,234
				Filing Date	October 7, 2011
				First Named Inventor	Eriksen, André Sloth
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(Use as many sheets as necessary)				*Examiner Name*	To be assigned
Sheet	1	of	2	*Attorney Docket Number*	10494.0003-01000

U.S. PATENTS AND PUBLISHED U.S. PATENT APPLICATIONS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] *(if known)*	Issue or Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		US-2003/151895 A1	08-14-2003	Zuo	
		US-2004/0105232 A1	06-03-2004	Ito et al.	
		US-4,898,579 A	02-06-1990	Groshong et al.	
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IDS Form PTO/SB/08: Substitute for form 1449A/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				*Application Number*	13/269,234
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Sheet	2	of	2	*Attorney Docket Number*	10494.0003-01000

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Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3] Number[4] Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	Translation[6]
		WO 01/25881 A	04-12-2001	Asetek A/S		
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NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	Translation[6]

Examiner Signature		Date Considered	

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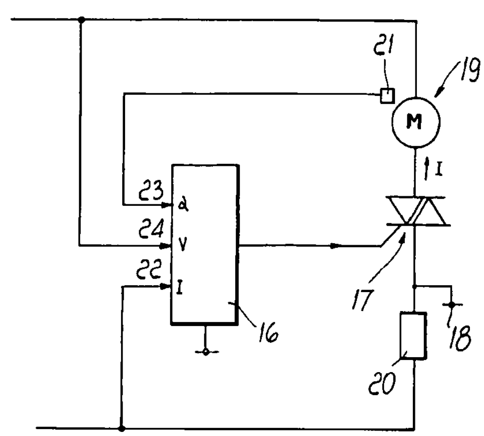
(54) Electronic device for starting a synchronous motor with permanent-magnet rotor.

(57) Device for starting a synchronous motor with a permanent-magnet rotor, particularly with two stator poles and two rotor poles, including a static power switch (17), a triac, arranged in series between the stator winding of the motor (19) and the alternating-voltage source (18) at mains frequency. The triac (17) is controlled by an electronic circuit (16) which processes three factors, namely the current (I) flowing through the coil of the synchronous motor (19), the position and polarity (α) of the permanent magnet of the rotor, and the polarity of the alternating-voltage source (V).



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The present invention relates to an electronic device for starting a synchronous motor with permanent-magnet rotor particularly suitable, in its configuration, for starting a motor with two stator poles and two rotor poles.

As is known, synchronous motors have considerable problems in starting due to the fact that the rotor must pass from a condition in which its speed is zero to a condition in which it is frequency-locked with the power supply source.

If the power supply source is the ordinary power distribution grid, the frequency is 50 or 60 Hz, and in these conditions the rotor would have to attain synchronous speed in a time equal to one half-period.

This is very often troublesome, especially when the rotor has a significant mass and when the starting contrast torque is nonzero.

In practice, one may say that the problem always occurs in all motors of this type.

Many solutions have been sought in order to overcome this problem and to allow use of this type of motor, which is advantageous as regards efficiency and speed stability once the power supply grid frequency is locked onto.

However, known solutions are particularly complicated and consequently expensive, and are therefore such that they cannot be used conveniently in motors which must have a low cost.

These solutions entail, by means of memories residing within the electronic device, the application of a current having an effect equivalent to that of a current having a frequency which varies from zero to the running value in a preset time.

In practice, the rotor, independently of its actual conditions, is accelerated by means of a transient until it can then be locked directly onto the mains power supply.

As mentioned, the componentry of these devices is complicated and expensive.

The aim of the present invention is to provide an electronic device for starting a synchronous motor with permanent-magnet rotor which is particularly simple and thus has an extremely low cost.

A further object is to provide a safe and reliable device for starting a motor, particularly of the type with two stator poles and two rotor poles.

Another object is to adapt the electrical parts of the motor so that they cooperate advantageously with the starting device.

The proposed aim and objects and others which will become apparent hereinafter are achieved by an electronic device for starting a synchronous motor with permanent-magnet rotor, characterized in that it comprises at least one static switch arranged in series between at least one stator winding of the motor and the alternating-voltage source at mains frequency, said switch being controlled by an electronic circuit which processes three factors, namely the current flowing through the coil of the synchronous motor, the position and polarity of the permanent magnet of the rotor, and the polarity of the alternating-voltage source, so that said switch starts to conduct every time the flux generated by the stator winding entails a torque on the rotor which is concordant with the direction of rotation of said rotor.

This torque arises from the correct combination of the polarity of the stator flux and of the intrinsic polarity of the permanent magnet of the rotor.

Further characteristics and advantages will become apparent from the following detailed description of embodiments given only by way of non-limitative example and illustrated in the accompanying drawings, wherein:

figure 1 is a schematic view of a synchronous motor with two stator poles and with a permanent-magnet rotor of the type which can be started with the device according to the present invention;

figure 2 is an enlarged-scale view of the rotor and of the poles of the motor according to figure 1, illustrating the location of the sensor suitable to detect the angular position of the rotor and its polarity;

figure 3 is a general block diagram of the power supply of the permanent-magnet synchronous motor of the rotor according to figure 1;

figure 4 is a block diagram of the triac control device;

figure 5 plots the characteristics of voltage, current and rotor position when synchronization is achieved;

figure 6 plots the same characteristics as figure 5 when the rotor is stalled or motionless;

figures 7 to 12 are diagrams of equivalent devices suitable for motors with particular utilization characteristics.

With reference to the above figures, the synchronous motor on which the starting device according to the present invention is combined is composed of a stator pack 1 provided with two unbalanced poles 2 and 3 and made so that it has two gap regions, respectively 4 and 5, which are wider than two other respectively consecutive regions 6 and 7.

With this configuration, the permanent-magnet rotor 8 arranges the ideal line 9, which separates its north and south, not so that it coincides with the median axis 10 of the stator pack but so that it is tilted by a certain angle.

At startup, with this configuration the rotor 8 can start more easily in an intended direction.

Two energization windings 13 and 14 are provided on the two posts 11 and 12 of the stator pack respectively, are connected in series and are powered, through the terminals 15, by the alternating-voltage source.

The electronic circuit that powers the stator windings is schematically shown in figure 3 and is composed of a processing block 16 which drives a static power switch 17, constituted for example by a triac arranged in series between the alternating-voltage source 18 and the permanent-magnet synchronous motor, now designated by the reference numeral 19 in figure 3.

The same series network also includes a detector 20 for the current I which flows through the triac 17 and then through the motor 19.

Its response in terms of signal is an input signal for the electronic processing block 16, with criteria which are described hereinafter.

There is also a sensor 21 suitable for detecting the position and polarity of the permanent magnet composing the rotor of the synchronous motor 19 both when the rotor is moving and when it is in particular operating conditions or when it is motionless or stalled at zero speed.

The current-related signal detected by means of the device 20 enters the block 16 through the input 22, whereas the signal of the position sensor enters the same block through the input 23; a third signal 24 is input to the block 16 and detects the polarity of the alternating-voltage source 18.

The block 16 is shown schematically more clearly in figure 4.

It is an electronic logic circuit which, by receiving the signals from the inputs 22, 23 and 24 and by converting said signals into digital form, provides the control signal for closing or opening the static switch 17 constituted by the triac arranged in series with the motor.

More particularly, the current signal provided by the block 20 enters a zero-crossing detector 25 which provides in output a logic signal 1 when said current tends to zero.

Said block receives as input the signal provided by the device 20, and detects the zero-crossing of the current I which flows in the motor.

The output is a logical "1" signal indicating that said current I approaches zero with a positive or negative deviation from the zero value of said current.

This deviation depends on the type of motor used and on its application, as well as on the type of static power switch being used.

The signal arriving from the sensor 21, which conveniently can be of the Hall-effect type, enters a phase-shift and processing circuit 26, the output whereof is 1 or 0 according to the position and polarity of the rotor.

The electronic processing of the phase shift and of the position of the rotor of the synchronous motor, which is an enabling component of the AND gate after it has been combined in XOR with the voltage signal V, is used to optimize the conditions of maximum average torque value during starting, i.e. from zero speed up to the synchronous speed, thus optimizing the interaction between the magnetic flux generated by the current I and the field of the permanent magnet in the two half-cycles from 0° to 180° and from 180° to 360°.

This output, as well as the signal processed from the mains voltage, enter an XOR 27 which outputs a "1" signal if the input V 24 is equal to zero and H (which is the output of 26) is equal to 1 or if V 24 is equal to 1 and H (which is the output of 26) is equal to zero.

The output of 25 and the output of 27, thus in digital form, enter the electronic logic circuit 28 in an AND combination which provides in output the control signal for closing or opening the static power switch 17.

Therefore, the AND gate with two inputs and the signal processing system allow to determine two conditions:

1) the alternating voltage V is positive, the current I is proximate to zero, and the rotor rotation angle is between 0° and 180°;

2) the alternating voltage V is negative, the current I is proximate to zero, and the rotor rotation angle is between 180° and 360°.

These two conditions are given by way of example after selecting a rotor rotation direction.

Figure 5 plots the characteristics of the system in synchronous conditions.

In this case, it can be seen that the sinusoid 29, which is the time-based plot of the source of the alternating voltage applied to the synchronous motor, is phase-shifted by an angle φ with respect to the sinusoid 30 representing the current absorbed by the motor.

This phase shift angle is very large, since the motor has a low resistive component in its stator winding and a high inductive component; consequently, the zero-crossing of the current cannot be made to coincide with the zero-crossing of the power supply source voltage.

This electronic phase shift of the position of the permanent magnet thus allows to have the maximum possible instantaneous average torque during the dynamic step to allow the acceleration of the rotating masses and thus overcome the moments of inertia, which have a decisive effect during this step up to the normal operating speed, when the acceleration step ends and the motor locks onto a rotation rate which is proportional to the frequency of the alternating power supply source.

If the motor has a torque sufficient to rotate the rotating masses involved at this synchronous speed, this locking occurs spontaneously, i.e. the motor controls itself by means of the electronic circuit with which it is combined.

The plot of the signal indicating the position of the permanent magnet which composes the rotor, designated by the reference numeral 31, is instead exactly in phase with the current, and the three curves have the same frequency.

Figure 6 instead shows the condition in which the rotor is stalled, as occurs for example at startup.

The voltage sinusoid, now designated by the reference numeral 32, and the current sinusoid, designated by the reference numeral 33, are present only with their half-wave which is concordant with the plot of the position of the rotor which, being stalled, is a straight line which is parallel to the time axis and substantially indicates a zero frequency for the rotor.

In these conditions, the rotor receives torque pulses due to the current-voltage combination; these pulses are always unidirectional and tend to start it moving in the required direction.

For particular applications, it may be convenient to use two energization windings in the motor.

A first winding, termed as the starting winding, is sized so as to develop a greater instantaneous average torque in order to rotate the motor from zero speed to the synchronous speed.

A second winding, termed as the sustaining winding, is sized so as to develop a smaller torque which is in any case sufficient to keep the rotor locked onto the frequency of the supply source according to the load for which it has been sized.

This embodiment is shown schematically in figure 7.

In this case, the motor has been shown schematically with a pair of inductance coils, respectively a starting coil 135 and a sustaining coil 136, arranged so as to form an inductive divider.

Each one of the two inductance coils 135 and 136 is supplied by a triac, respectively a starting triac 137 and a sustaining triac 138.

As an alternative to this arrangement, the two starting and sustaining windings may be arranged as in figure 8, i.e. no longer in series to each other but substantially parallel.

In this case, the starting winding is the one designated by the reference numeral 139, whereas the sustaining winding is the one designated by the reference numeral 140.

In this case, too, there are two triacs, respectively a starting triac 141 and a sustaining triac 142.

The two structures of figures 7 and 8 are substantially equivalent both in principle and in operation.

The two triacs operate in a mutually exclusive manner in both cases.

Initially, the triacs of the startup winding, i.e. the triacs 137 and 141, are made to conduct; then, once the synchronous condition has been reached, these triacs open, whereas those of the sustaining circuits, i.e. those designated by 138 and 142, close.

The electronic circuit allowing to pass from the starting condition to the sustaining or normal condition is shown schematically in figure 9.

In this figure, the portion delimited by the dashed lines is exactly equivalent to the one of the figure 3 explained previously.

In this circuit of figure 9, the block 143 is a timer having the purpose of providing a logic signal T for a precisely defined time, which can in any case be calibrated; by means of the block 144, this signal allows to send the control pulses to the gate of the starting triac, simultaneously disengaging the sustaining triac, which is in the open-switch condition.

After the preset time T, during which the rotor has or should have reached synchronous speed, the pulses are automatically sent, by means of the block 145, to the sustaining triac, simultaneously disabling the starting triac, which passes into the open-switch condition.

In order to reset the entire system, i.e. to return to the initial conditions, re-enabling the starting winding, the motor system and its electronic part must be disconnected for a few moments from the alternating-voltage power supply source.

This dual-winding structure is justified mainly in motors in which the rotating elements, such as for example the permanent-magnet rotor, have heavy masses, thus requiring during pickup or starting a greater torque than that required once synchronization has been reached.

Another advantage is that it is possible to lock the rotor of the motor onto the synchronous speed even with alternating-voltage source values which are relatively very low with respect to nominal normal operating values.

It is also possible to have a motor having a smaller size, and thus less weight, less physical bulk and thus a considerable saving in iron as well as the advantage of an extremely high efficiency, since the intrinsic losses of the motor decrease.

It should furthermore be noted that once the synchronous condition, in which only the sustaining winding is engaged, is reached, there is a weaker current than at startup, with a reduction in the heating of said winding.

Due to various reasons, the motor may not reach synchronous speed in the time T, set by the timer 143, after which the two windings are switched.

In this case, the motor would be subjected to a continuous dynamic step of acceleration of rotating masses, with a consequent high power absorption, but with a condition in which the winding is sized for synchronous-speed working conditions.

These phenomena could entail a considerable heating of the motor with the consequent risk of failure.

In addition to this, since the rotor is of the permanent-magnet type, if this step lasts for a prolonged time the magnet may demagnetize.

The extreme and most dangerous condition occurs when the rotor of the motor is stalled, i.e. when the contrast torque applied to the shaft is greater than the motor torque.

In such conditions, the current absorbed by the motor has an extremely high value, with consequent overheating in a short time.

In order to obviate this drawback, a modified circuit, shown in figure 10, is provided.

In said figure, the input of the block 246 is the digital signal H, which is the response of the position sensor, and its output is a digital signal S which is the input for the block 247.

Said signal S is an enabling signal for processing, or not processing, the control pulses for the sustaining triac and thus for enabling the power supply of the sustaining winding.

In this case, operation occurs according to the following steps:

1) the starting winding is engaged for a fixed time T, set by the timer 248, driving the starting triac by means of the block 249 and simultaneously disabling the sustaining triac by means of the block 247;

2) after the time T, obviously represented by a logic signal provided by the block 248, the starting winding is disabled and the sustaining winding is engaged automatically, as described earlier.

Throughout the starting step, the block 246 with the related output signal S does not affect the behavior of the system constituted by the electronics and the motor;

3) if the motor has reached synchronous speed, the block 246 provides a logic signal S, for example a "1", which allows the block 247 to send the control pulses to the sustaining triac and thus to make the motor run normally at synchronous speed;

4) if the motor has not reached synchronous speed and therefore has a rotation rate smaller than the synchronous rate or has a zero rate (in the case of a stalled rotor), the block 246 provides a logic signal S, for example a "0", which provides a zero logic signal at the output of the block 247 and thus at the gate of the sustaining triac.

The triac is thus open and the motor is no longer connected to the alternating-voltage source, and the current through its winding consequently becomes nil.

It is convenient to allow the possibility of calibrating the rotation rate at which a logic signal S of zero value which opens the circuit can be provided by means of the block 246, so that said rate is lower than the rotation rate of the rotor when it is synchronous.

The concept and the functionality expressed by the block 246 of figure 10 can also be applied to a motor with a single winding, such as the one already shown in figure 1.

In this configuration, the block diagram is shown in figure 11, wherein the functions performed by the block 246 of figure 10 are now performed by the block 350 of figure 11.

The block 351 is the timer, which in this case sets a time T to allow the motor to accelerate up to synchronous speed; if this does not occur, the block 350, by means of the logic signal S, for example zero, prevents the logic unit composing the block 352 from sending the pulses to the gate of the triac (which is a single triac in this case), preventing the conduction of said triac.

If instead the motor, in the set time T, is able to accelerate the rotating masses up to synchronous speed, the block 350 provides a digital signal S, for example 1, to allow the normal driving of the triac and thus the normal operation of the motor at synchronous speed.

Here, too, as in the case of a dual-winding system, the rotation rate at which it is possible to provide, by means of the block 350, a zero-value logic signal S which opens the power circuit can be calibrated electronically to a rotation rate which must be lower than the rotation rate of the rotor when it rotates at synchronous speed.

In the case of a motor with a single coil, a further modification for disengaging the motor supply voltage is shown in the block diagram of figure 12.

The protective function is performed by the block 451.

In this case, too, the block 451 provides a logic signal S which allows the block 452 to send, or not sent, the triggering pulses to the triac (which is single in this case too), in order to allow the normal operation of the motor or its disengagement, disconnecting the power supply voltage from it.

In this case, however, the circuit designated by the block 451 has a certain hysteresis, i.e. it acts with a certain lag (which can be calibrated by an electronic circuit) with respect to the occurrence of the incorrect operation of the motor, for example when the rotor stalls momentarily for accidental reasons due to the load applied to the shaft of the motor itself.

In this case, too, the system can be calibrated by means of an electronic circuit to determine the rotation rate below which this protection must act and disconnect the motor from the alternating-voltage supply source.

The block 451 provides a signal S, for example having a logical value 1, if synchronous speed has been reached, and then enables the block 452 so that it can provide the triggering pulses to the triac for the normal operation of the motor; it provides a logic signal S, for example zero, if this speed has not been reached, disabling the entire system.

In this case, too, if the system has been disabled, in order to reset it it is necessary to remove voltage from the system constituted by the electronics and the motor and return it after some time.

From what has been described and illustrated it can be seen that the intended aim and objects have all been achieved and that in particular a device and some variations thereof have been provided which are suitable to allow the starting of synchronous motors so that with a short transient the speed of the rotor locks onto the frequency of the power supply grid.

In addition to this, the device is particularly simple in its components and can thus be fitted even on small low-cost motors.

The device is furthermore provided, when prescribed by safety requirements or by statutory provisions, with systems suitable to check whether the motor has started incorrectly, disconnecting it completely from the power supply.

Obviously, as already shown, the device can assume different configurations and use different components; all this is within the protective scope of the present application.

Where technical features mentioned in any claim are followed by reference signs, those reference signs have been included for the sole purpose of increasing the intelligibility of the claims and accordingly such reference signs do not have any limiting effect on the scope of each element identified by way of example by such reference signs.

Claims

1. Electronic device for starting a synchronous motor with permanent-magnet rotor, characterized in that it comprises at least one static switch (17) arranged in series between at least one stator winding (19) of the motor and the alternating-voltage source (18) at mains frequency, said switch (17) being controlled by an electronic circuit (16) which processes three factors, namely the current (I) flowing through the coil of the synchronous motor, the position and polarity of the permanent magnet of the rotor (α), and the polarity (V) of the alternating-voltage source (V), so that said switch (17) starts to conduct every time the flux generated by the stator winding entails a torque on the rotor which is concordant with the direction of rotation of said rotor.

2. Electronic device for starting a synchronous motor according to claim 1, characterized in that three signals (α,V,I), converted into logic signals, enter said electronic control circuit (16) for the static switch (17), which is conveniently a triac, said signals being constituted respectively by the current (I) flowing through said triac with particular reference to its zero-crossing, by a logic signal (α) arriving from a rotor position sensor (21) which can be conveniently of the Hall-effect type, and by a logic signal (V) detecting the polarity of the power supply voltage.

3. Electronic device according to the preceding claims, characterized in that said current signal (I) is processed by a zero-crossing detector (25) which provides in output a logic "1" signal when the current approaches zero.

4. Device according to the preceding claims, characterized in that said signal (α) arriving from the position sensor (21), which is conveniently of the Hall-effect type, is processed by a phase shift circuit (26) the delay whereof is linked to the physical location of said sensor (21) with respect to the rotor (19), said circuit providing in output a "zero" value or a "one" value according to the position of said rotor.

5. Device according to the preceding claims, characterized in that said signal (α) related to the position sensor (21) and said signal related to the polarity of the voltage (V) form the imputs of an XOR block (27) whose output, together with the processed current signal, forms the inputs of a logic circuit (28) in an AND combination which controls in output the gate of said static power switch (17).

6. Device according to claim 1, characterized in that the winding of the motor is divided into two parts (136,140; 135,139), each of which is individually powered by means of a static current switch (138,140; 137,139).

7. Device according to the preceding claim, characterized in that said two parts of the winding are mutually different, the first one (135; 139) being able to start the motor and the second one (136,140) being able to sustain the rotor at

synchronous speed.

8. Device according to the preceding claim, characterized in that said two static current switches (136,135; 139,140) meant to supply the stator winding or part of the stator winding operate in a mutually exclusive manner.

9. Device according to one or more of the preceding claims, characterized in that said static power switch (137;141) which supplies the starting winding (135;139) is kept initially in the conducting state for a time (T) which is set on a timer (143; 248; 351), after which said static power switch (138;142) supplying the sustaining circuit starts to conduct.

10. Device according to one or more of the preceding claims, characterized in that it has an electronic device (21,16;144,145) for detecting the speed of the rotor, said device, after the time set by said timer (143) has elapsed, enabling or disabling the entire power supply, depending on whether the rotor has reached synchronous speed or is below it by a preset value.

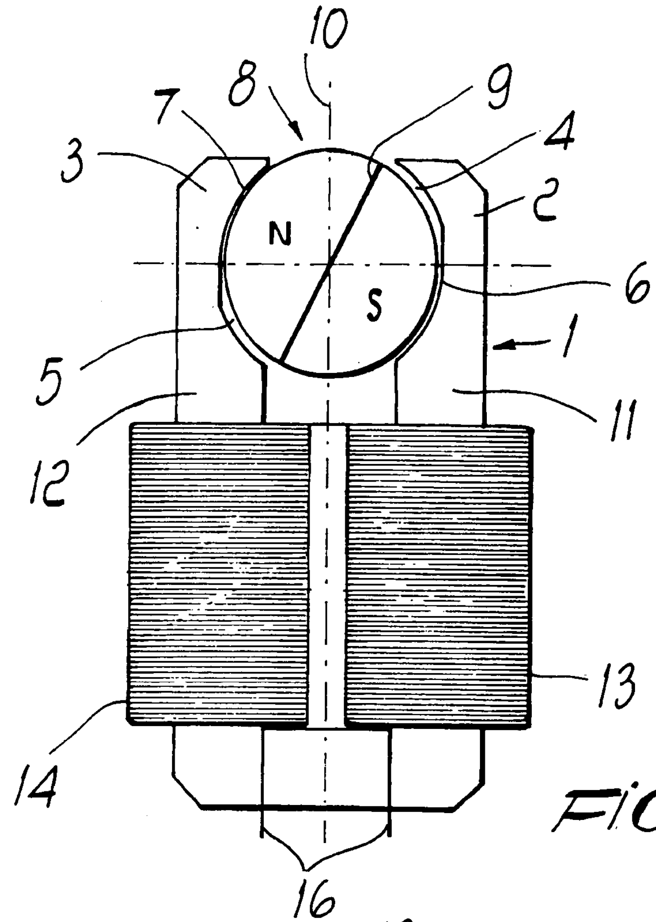

Fig. 1

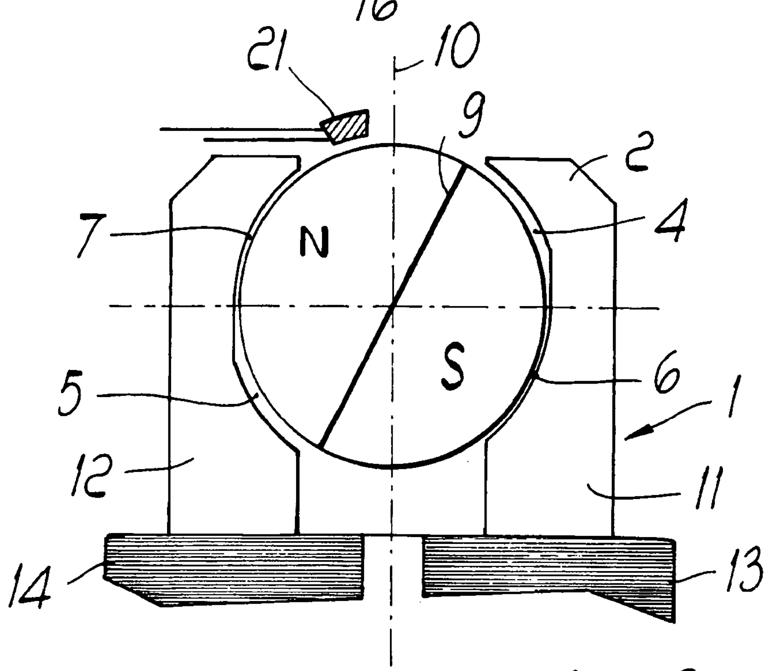

Fig. 2

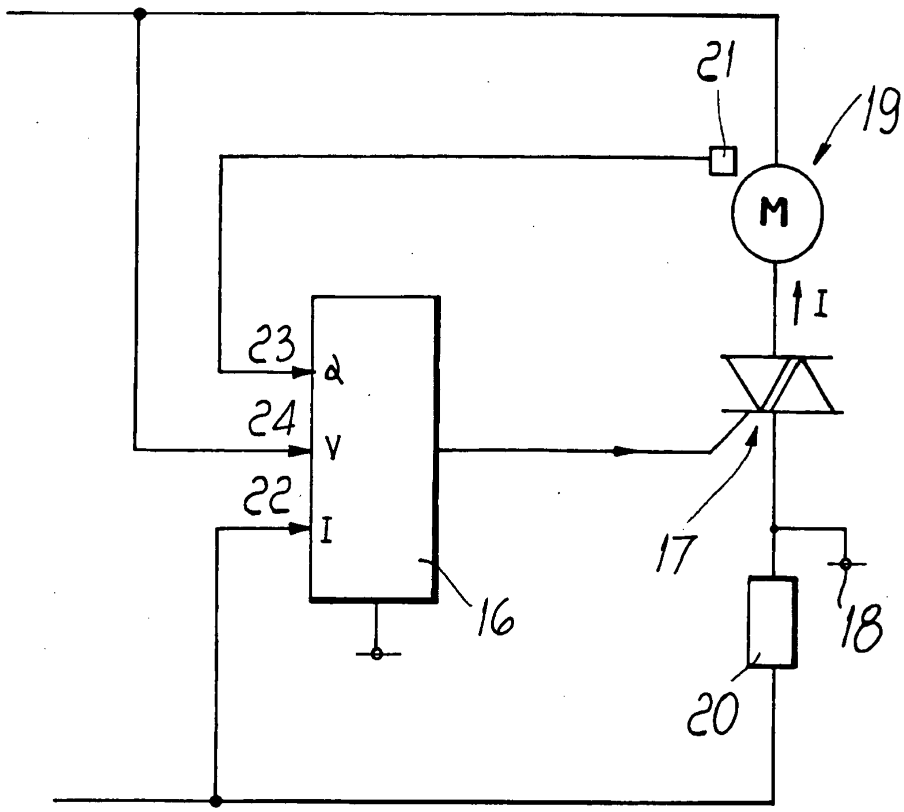

Fig. 3

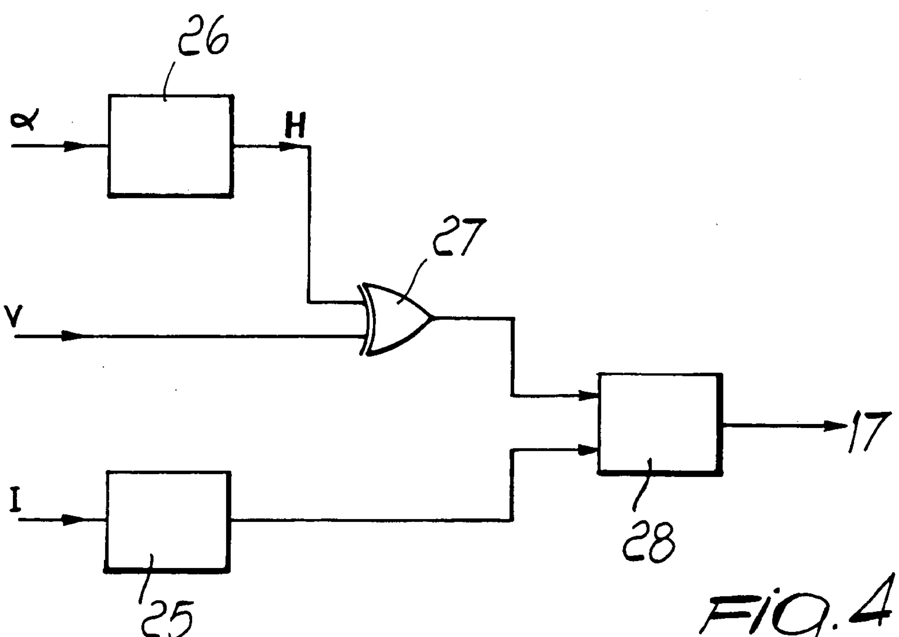

Fig. 4

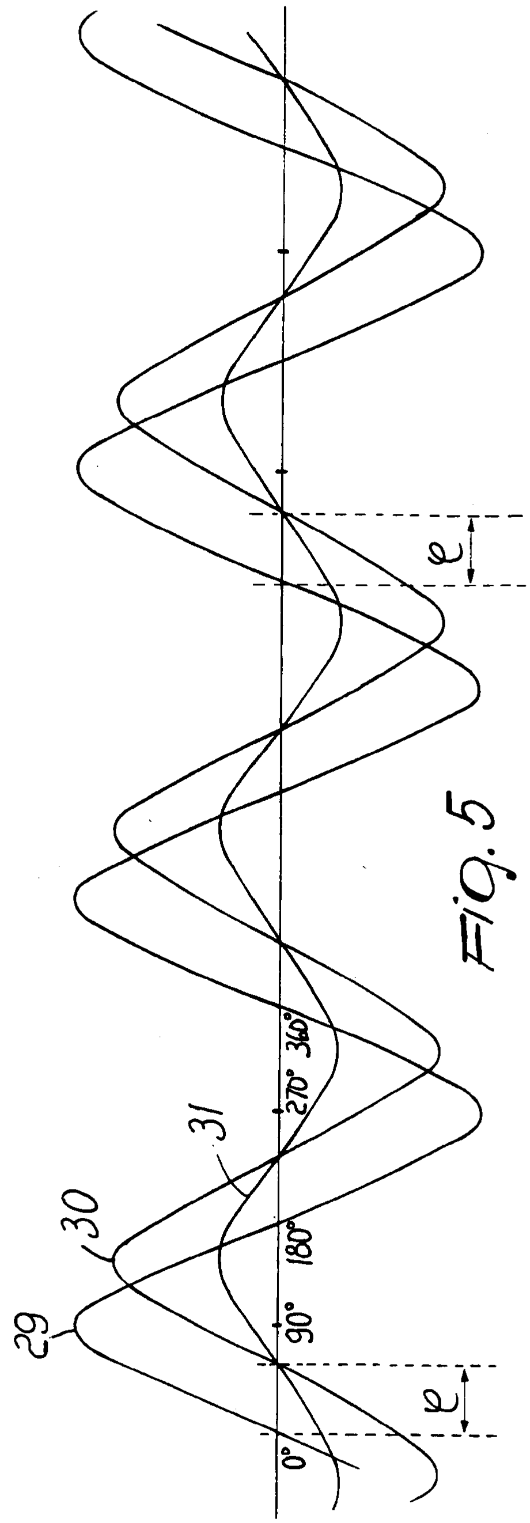

Fig. 5

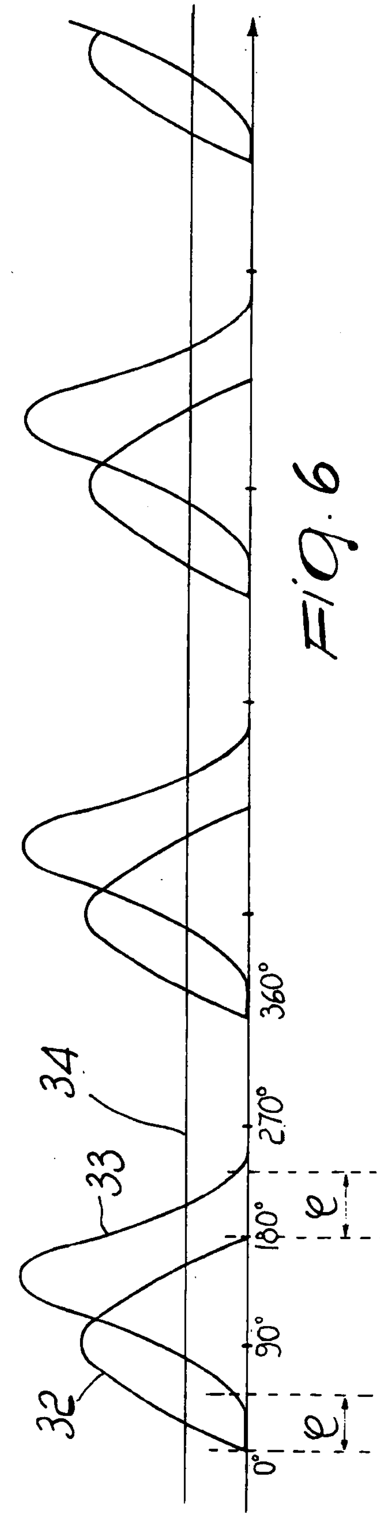

Fig. 6

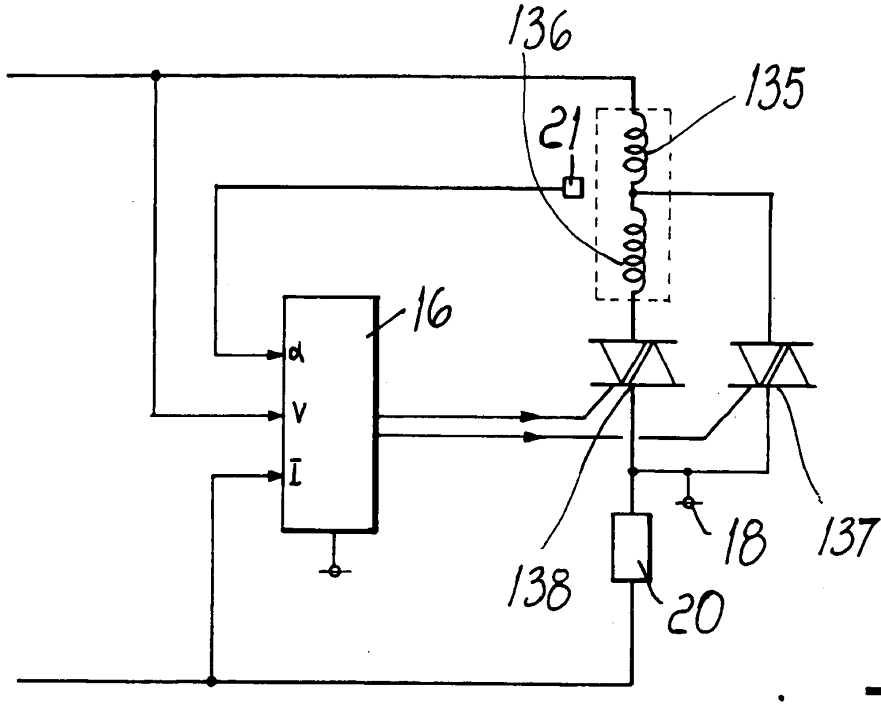

Fig.7

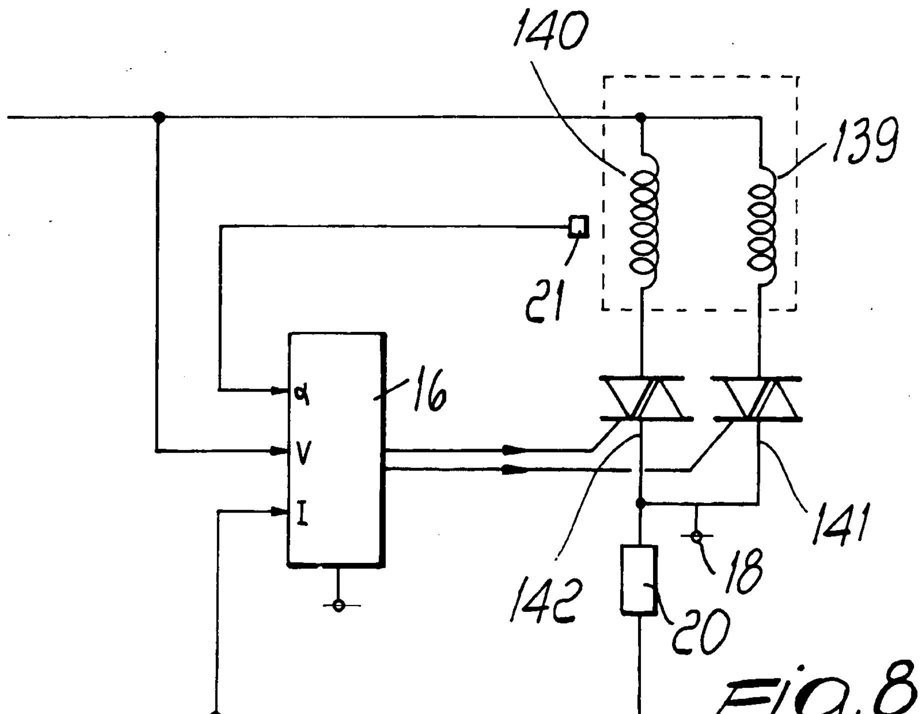

Fig.8

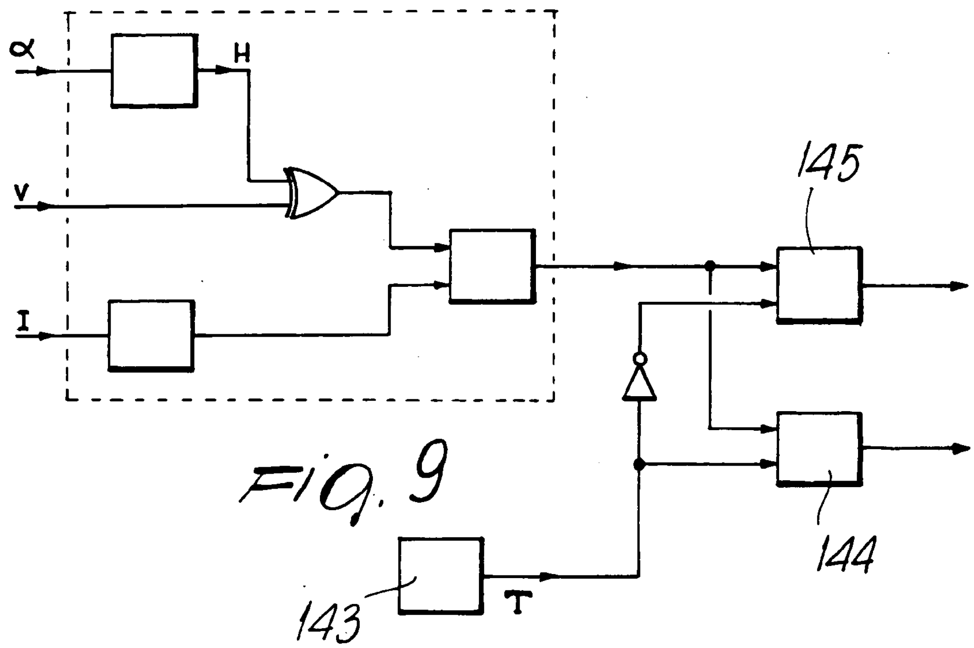

Fig. 9

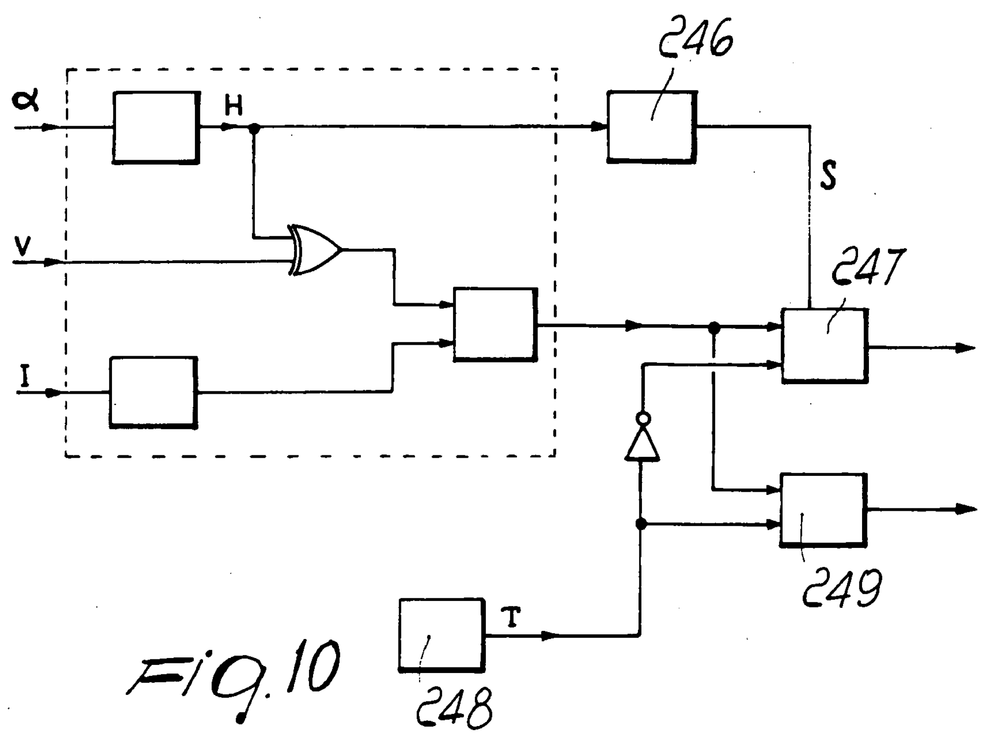

Fig. 10

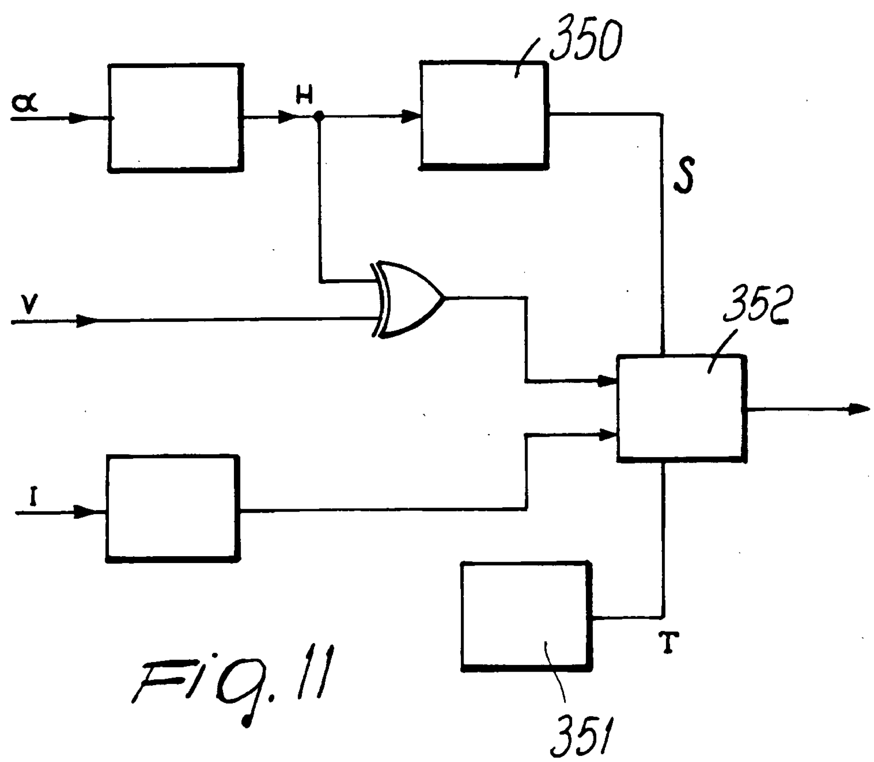

Fig. 11

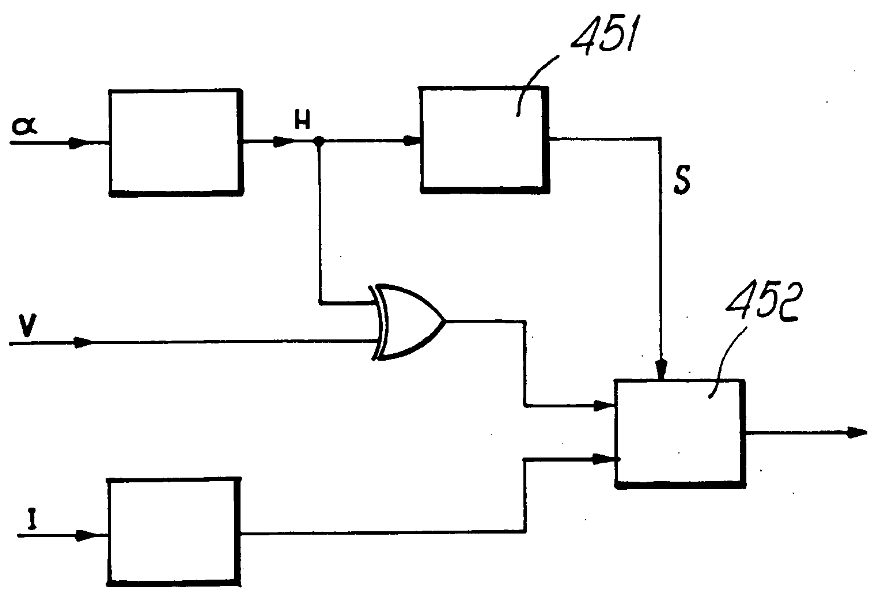

Fig. 12

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(54) **Improved centrifugal pump.**

(57) Improved centrifugal pump of the type comprising a supporting body (10) for a permanent-magnet synchronous motor with an impeller (49) coupled to its rotor (22), and for a volute (48) in which the impeller is accommodated. The body (10) and the volute (48) form a sealed housing which contains the rotor and the impeller in respective chambers, separating them from the stator part of the motor. The rotor (22) is rigidly coupled to a shaft (24) that rotates on sliding bearings (26,29) supported by elastic supports (27) which are locked in the corresponding chamber; one of these supports forms a ring for providing hydraulic sealing between the two chambers of the container.

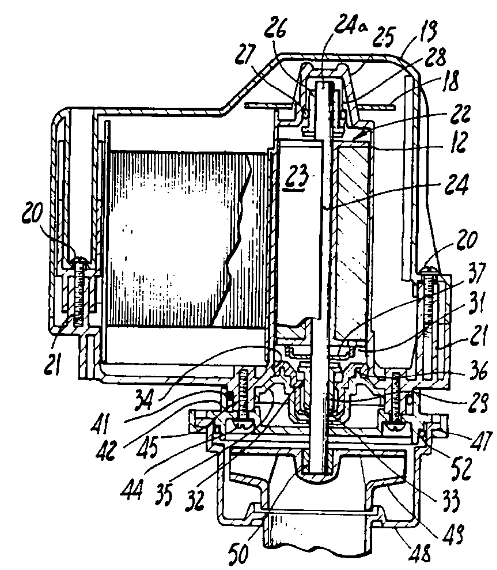

FIG. 2

EP 0 610 826 A2

The present invention relates to an improved centrifugal pump.

The pump can be used, particularly but not exclusively, as a pump for dishwashers, as a pump for other household appliances, as a circulating pump for heating systems, etc.

Known pumps suitable for these uses are coupled to asynchronous electric motors and consequently entail some problems particularly due to the fact that the rotor parts are air-immersed.

This leads to a certain noisiness and to the need to adequately lubricate the supports and the rotation bearings to avoid their early wear.

Centrifugal pumps with an asynchronous permanent-magnet motor, in which the rotor part is contained in a sealed housing separating it from the stator part and containing a lubricating liquid, are also known.

However, these pumps have proved to be unsuitable for the particular use requiring rather large flow-rates and heads which they cannot achieve since the motor, by being able to start indifferently in one rotation direction or the other, entails the use of unsophisticated and low-efficiency hydraulics.

The aim of the present invention is to eliminate the drawbacks mentioned above in pumps with asynchronous motor.

A consequent primary object of the present invention is to prevent the onset of noise, vibrations or early wear due to insufficient lubrication.

Another important object is to prevent the start-up problems occurring in current pumps with air-immersed rotor due to the mutual sticking of the parts when not in use.

With this aim in view, as well as these and other objects which will become apparent hereinafter, there is provided, according to the present invention, an improved centrifugal pump of the type comprising a supporting body for a permanent-magnet synchronous motor with an impeller coupled to its rotor, and for a volute in which said impeller is accommodated, said body and said volute forming a sealed housing which contains the rotor and the impeller in respective chambers, separating them from the stator part of said motor, said pump being characterized in that said rotor is rigidly coupled to a shaft that rotates on sliding bearings supported by elastic supports which are locked in the corresponding chamber, one of said supports defining a ring for providing hydraulic sealing between the two chambers of said housing.

Further characteristics and advantages of the centrifugal pump according to the present invention will become apparent from the following detailed description of a preferred but not exclusive embodiment thereof, illustrated only by way of non-limitative example in the accompanying drawings, wherein:

figures 1 and 2 are sectional views of the centrifugal pump according to the present invention, taken along mutually perpendicular planes passing through the axis of the motor;

figure 3 is an exploded perspective view of the pump;

figure 4 is a partially exploded sectional view of the pump.

With reference to the above figures, a centrifugal pump comprises a supporting body 10 made of plastic material composed of a base 11, from which an element 12, shaped like an inverted cup and open at said base 11, extends at right angles.

The element 12 is externally partially surrounded by the poles formed by a pack of metal laminations 13 which, together with windings 14, forms the stator part of the pump motor.

The lamination pack 13 is fixed laterally by means of brackets 15 to the base 11 of the body 10.

Fixing occurs by means of self-tapping screws 16 that pass in through holes of the brackets 15 and engage tubular tabs 17 of the base 11.

An electronic board 18, of the kind disclosed in EPA N. 93109284.5 filed June 9, 1993 by the same Applicant and suitable to achieve the unidirectional rotation of the rotor of a permanent-magnet synchronous motor, is furthermore located on the top of the cup-like element 12.

A box-like housing 19 made of plastics covers the entire stator part of the motor and is fixed to the base 11 by means of self-tapping screws 20 that pass in through holes of the housing and engage tubular tabs 21 of said base 11.

A permanent-magnet rotor 22 is located inside the element 12 and is thus separated from the stator part; said rotor is embedded in a jacket 23 made of diamagnetic material, for example stainless steel, which accordingly does not affect the operation of the motor.

The rotor 22 is rigidly coupled to a shaft 24 passing axially therethrough and a first end 24a whereof is located inside a tapered top portion 25 of the element 12.

Said end 24a is rotatable on a sliding bearing 26 having a cylindrical bush and an annular flange on the side of the rotor 22; said bearing is supported by an elastic support constituted by an elastomer ring 27, for example of the O-ring type, which is interposed between said bearing and the wall of the tapered portion 25 in which a corresponding seat is formed.

A radial groove 28 is formed on said wall and connects the two internal parts of the tapered portion 25 which are divided by the ring 27.

On the other side there is also a sliding bearing 29 for the second end 24b of the shaft 24; said bearing 29 is identical to the bearing 26, but the elastic support that now supports it is integrated in an elastomer cap 30 that closes the chamber 31 of the rotor 22.

In particular, said cap 30 has an internal annular ridge 32 for supporting the bearing 29, an internal annular end lip 33 for forming a sliding seal on the shaft 24, and an annular outer ridge 34 for providing a seal on the inner wall of the cup-like element 12.

Said cap 30 is supported by a lid 35 made of plastics which is shaped substantially complementarily thereto and rests between the base 11 and the cup-like element 12 at the open end of the latter.

The portion of the cap 30 that comprises the ridge 34 is located between an annular ridge 36 of the lid 35 and the internal wall of the element 12.

It should also be noted that a washer 37, suitable to prevent wear of the bearing 29, is fixed to the end of the rotor 22 on the side of said cap 30.

An annular ridge 38 extends around the lid 35 on said base 11 and forms externally a seat 40 for an elastomer ring 41, for example of the O-ring type, for forming a seal between said ridge 38 and a corresponding ridge 42 of a disk-like intermediate impeller-supporting element 43 which is also made of plastics.

The element 43 is fixed to the base 11 by means of self-tapping screws 44 that pass in through holes thereof and engage tubular tabs 45 of said base 11 located internally with respect to the ring 41.

The intermediate element 43 has an axial hole allowing the shaft 24 to protrude and has radial spokes 46 resting on the lid 35, locking it between said lid and its corresponding seat.

A volute 48 is fixed by means of bayonet couplings 47 on the intermediate element 43 and contains an impeller 49.

Said impeller is rigidly coupled to the end 24a of the shaft 24 and is inserted and locked in a tubular insert 50 which is accommodated in an adapted seat 51.

A hydraulic sealing ring 52, for example of the O-ring type, is provided between the intermediate element 43 and the volute 48 and is appropriately located between corresponding edges thereof.

First of all it should be noted that the permanent-magnet synchronous motor becomes unidirectional due to the presence of the electronic board.

This has allowed to provide the volute 48 with an axial intake and a tangential delivery and an impeller 49 with curved vanes.

As mentioned, the part of the pump that contains the rotor 22 in one chamber and the impeller 49 in another chamber is fully separated and sealed from the rest.

The rotor 22 is immersed in a liquid bath, and this considerably reduces noise and vibrations as well as wear of the sliding bearings.

Lubrication is independent, and this avoids the mutual sticking of the parts during idle periods and consequent start-up problems.

Finally, the presence of the intermediate element 43 allows to interchange the hydraulic part with respect to the electrical part.

In practice it has been observed that the intended aim and objects of the present invention have been achieved.

The invention thus conceived is susceptible to numerous modifications and variations, all of which are within the scope of the inventive concept.

All the details may furthermore be replaced with other technically equivalent elements.

In practice, the materials employed, so long as they are compatible with the contingent use, as well as the dimensions, may be any according to the requirements.

Where technical features mentioned in any claim are followed by reference signs, those reference signs have been included for the sole purpose of increasing the intelligibility of the claims and accordingly such reference signs do not have any limiting effect on the scope of each element identified by way of example by such reference signs.

Claims

1. Improved centrifugal pump of the type comprising a supporting body (10) for a permanent-magnet synchronous motor with an impeller (49) coupled to its rotor (22), and for a volute (48) in which said impeller (49) is accommodated, said body (10) and said volute (48) forming a sealed housing which contains the rotor and the impeller (49) in respective chambers, separating them from the stator part (13,14) of said motor, said pump being characterized in that said rotor (22) is rigidly coupled to a shaft (24) that rotates on sliding bearings (26,29) supported by elastic supports (27,30) which are locked in the corresponding chamber (31), one of said supports forming a ring for providing hydraulic sealing between the two chambers of said housing.

2. Centrifugal pump according to claim 1, characterized in that said permanent-magnet rotor is embedded in a jacket (23) made of diamagnetic material.

3. Centrifugal pump according to one or more of the preceding claims, characterized in that the

stator part (13,14) of said motor comprises, in addition to a pack of laminations (13) that form the poles and electrical windings (14), an electronic board (18) adapted to make said motor unidirectional at start-up.

4. Centrifugal pump according to one or more of the preceding claims, characterized in that an intermediate element (43) is interposed between said supporting body (10) and said volute (48) and is adapted to allow the interchangeability of the hydraulic part with respect to the electric part.

5. Centrifugal pump according to one or more of the preceding claims, characterized in that said rotor (22) is immersed in a liquid bath.

6. Centrifugal pump according to one or more of the preceding claims, characterized in that said supporting body (10) comprises a base (11) from which a cup-shaped element (12) extends at right angles, said cup-shaped element (12) having an opening located at said base (11), said cup-shaped element (12) being externally partially surrounded by the poles formed by said pack of laminations (13).

7. Centrifugal pump according to one or more of the preceding claims, characterized in that said electronic board (18) is located on the outer top of said cup-shaped element (12).

8. Centrifugal pump according to one or more of the preceding claims, characterized in that a first one (26) of said sliding bearings is located at a tapering top portion (25) of said cup-shaped element (12), said bearing (26) being supported by an elastic support constituted by an elastomer ring (27) that is interposed between said bearing (26) and the wall of said tapering portion (25) in which a corresponding seat is formed, a radial groove (28) being formed on said wall and being adapted to connect the two inner parts of said tapering portion, which are divided by said elastomer ring (27).

9. Centrifugal pump according to one or more of the preceding claims, characterized in that a second one (29) of said sliding bearings is supported by an elastic support which is integrated in an elastomer cap (30) closing the chamber (31) of said rotor, said cap (30) having an internal annular ridge (32) for supporting said bearing (29), an internal end lip (33) for forming a sliding seal on said shaft (24), and an annular external ridge (34) for forming a seal on the inner wall of said cup-shaped element (12).

10. Centrifugal pump according to claim 9, characterized in that said cap (30) is supported by a lid (35) which is substantially shaped complementarily thereto and rests between said base (11) of said supporting body (10) and said cup-shaped element (12) at the open end thereof, the portion of said cap (12) that comprises said outer sealing annular ridge (34) being arranged between an annular ridge (32) of said lid (35) and the inner wall of said cup-shaped element (12).

11. Centrifugal pump according to one or more of the preceding claims, characterized in that a washer (37) is fixed to the end of said rotor (22) on the side of said cap and is suitable to avoid wear of the corresponding sliding bearing (29).

12. Centrifugal pump according to one or more of the preceding claims, characterized in that an annular ridge (38) is formed around said lid (35) on said base (11) of said supporting body (10) and forms externally a seat (40) with a ring (41) for forming a seal between said ridge (38) and a corresponding ridge (42) of said intermediate element (43).

13. Centrifugal pump according to one or more of the preceding claims, characterized in that said intermediate element (43) is fixed to said base (11) of said supporting body (10) by means of screws (44) located internally with respect to said sealing ring (41).

14. Centrifugal pump according to one or more of the preceding claims, characterized in that said intermediate element (43) has spokes (46) which are suitable to rest on said lid (35) of said cup-like element (12), locking it between said lid (35) and its corresponding seat.

15. Centrifugal pump according to one or more of the preceding claims, characterized in that said volute (48) is fixed on said intermediate element (43) by means of bayonet couplings (47), a hydraulic sealing ring (52) being provided between said couplings.

16. Centrifugal pump according to one or more of the preceding claims, characterized in that one end of said shaft (24) passes through said cap (30), said lid (35) and said intermediate element (43), ends in said volute (48) and is coupled to an impeller (49), the coupling being

obtained by inserting said end in a tubular insert (50) which is accommodated in an adapted seat of the impeller (51).

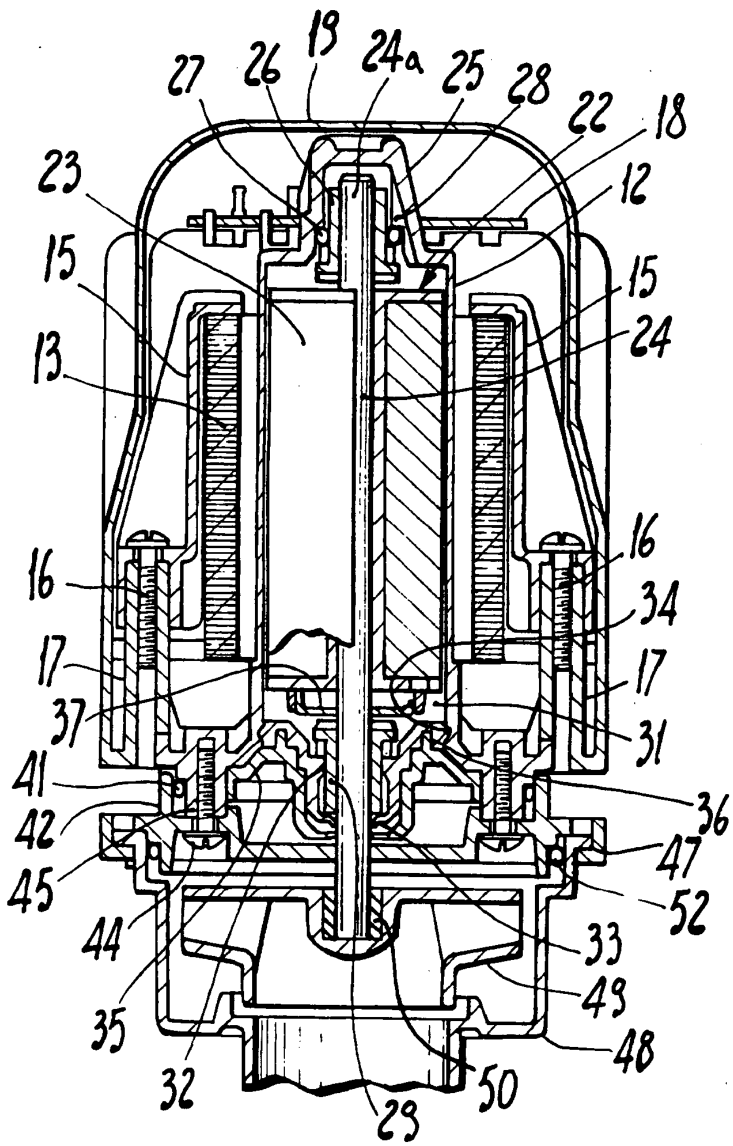
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FIG. 1

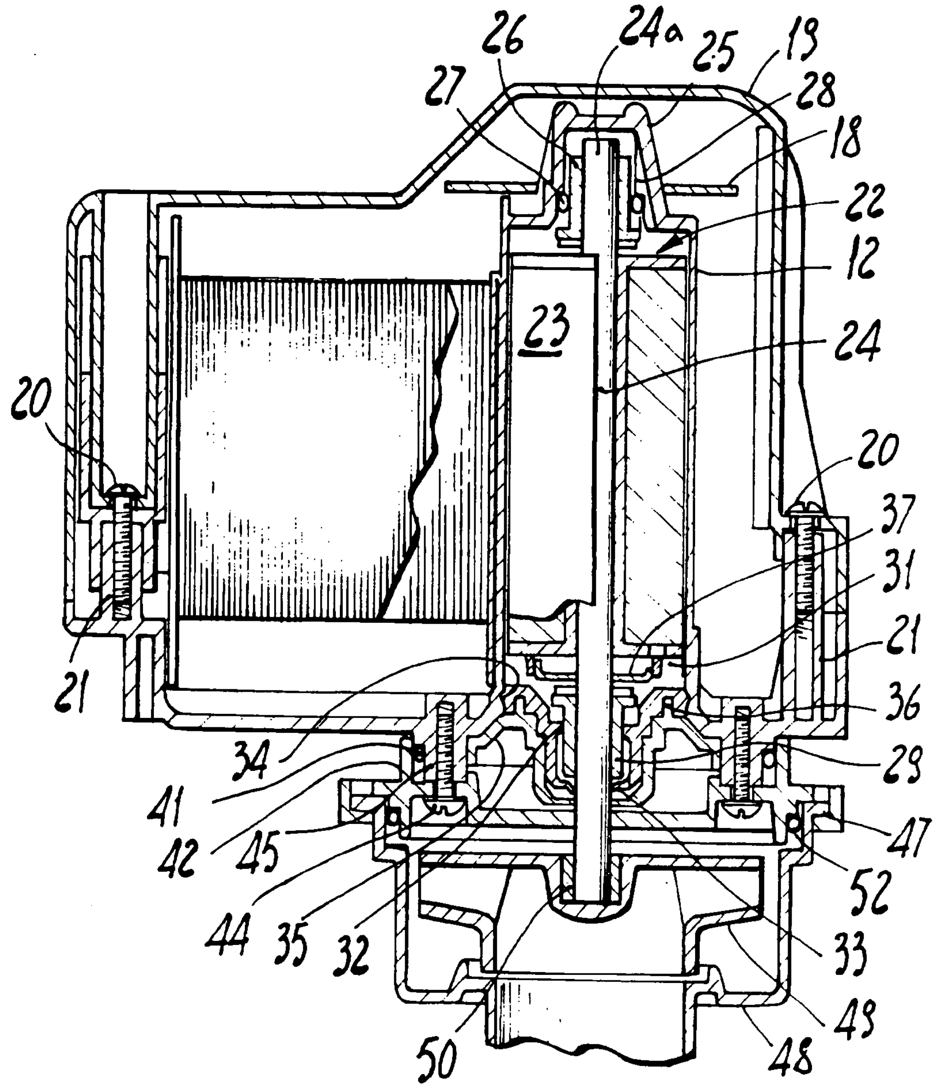
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FIG. 2

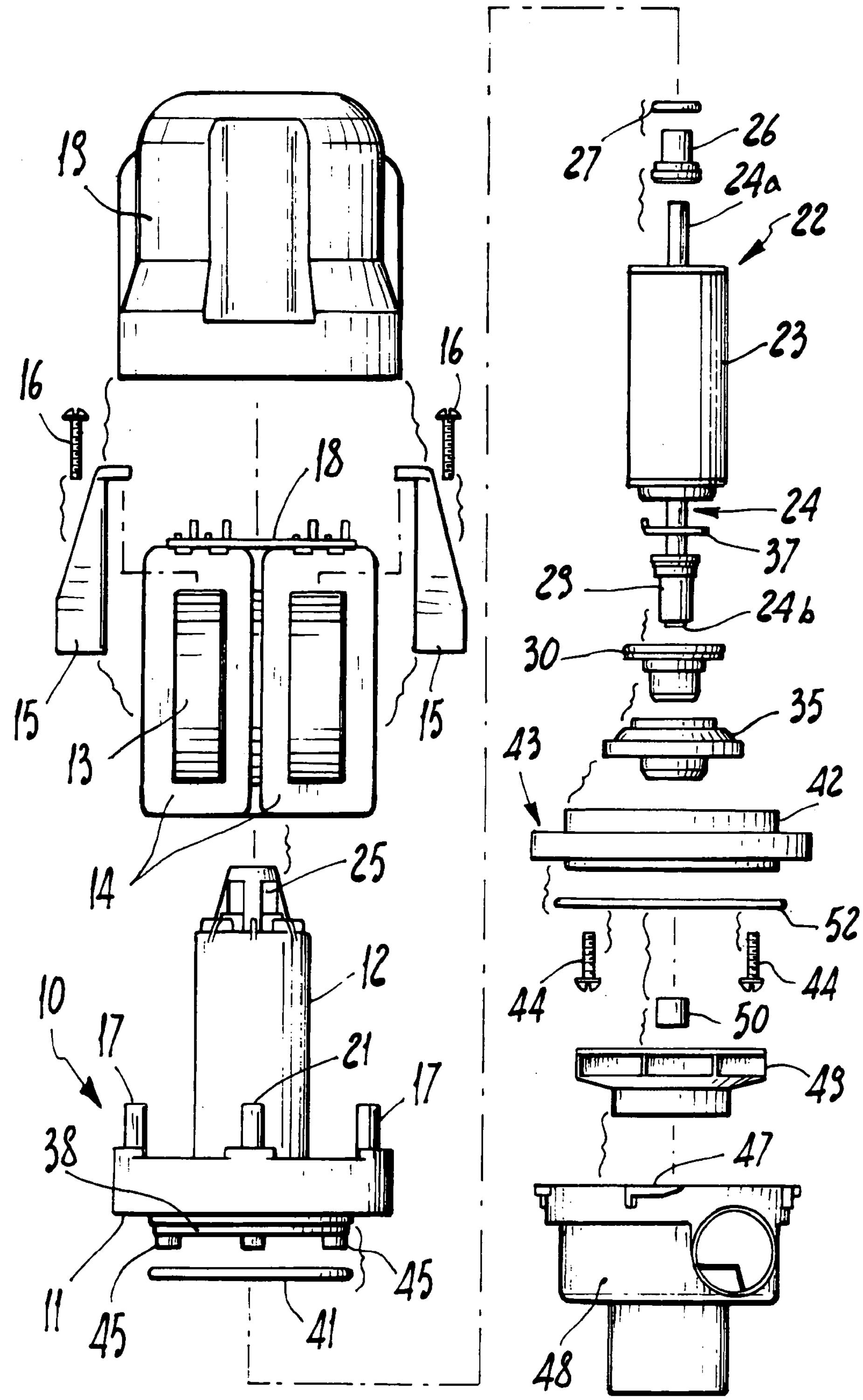
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Fig. 3

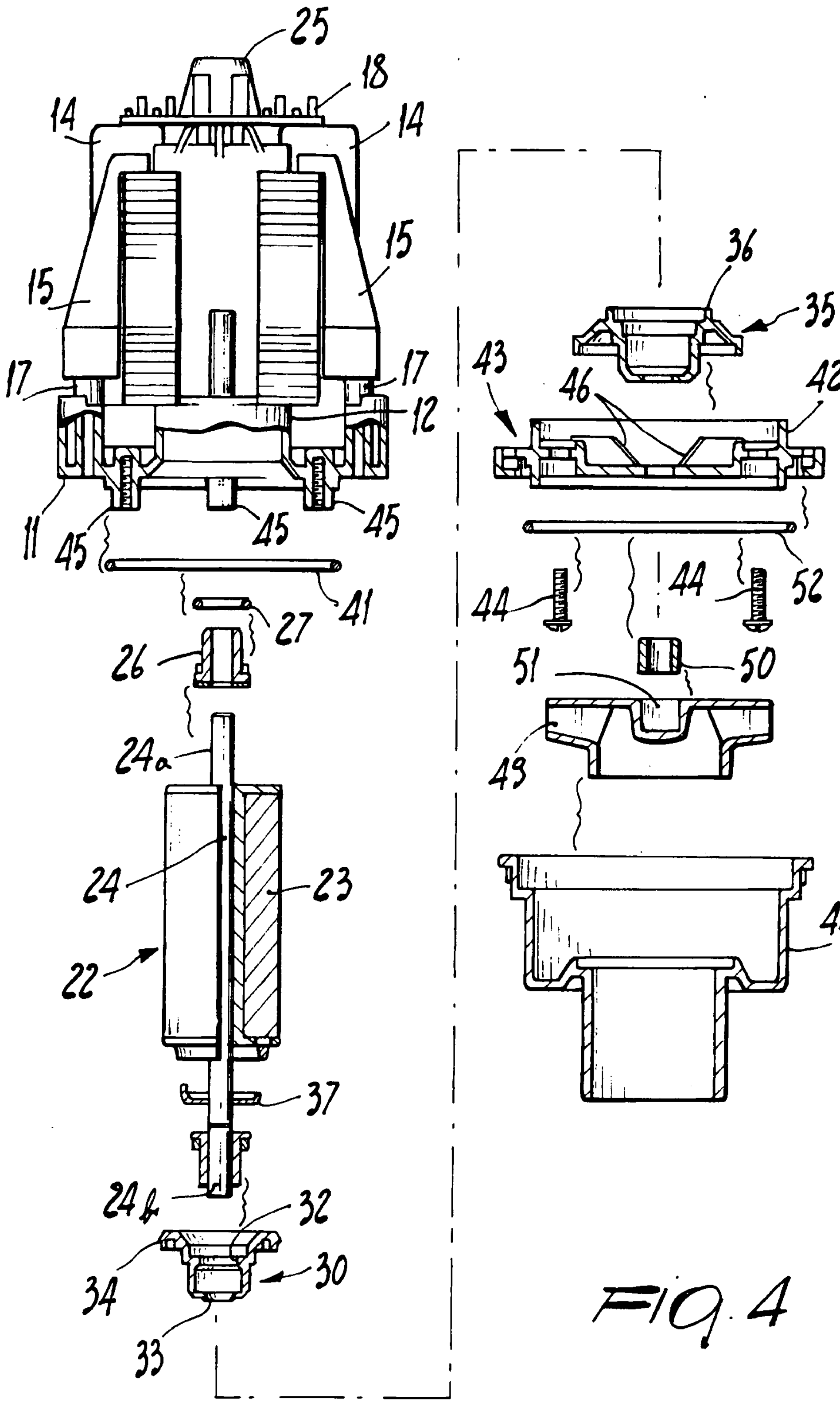
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FIG. 4

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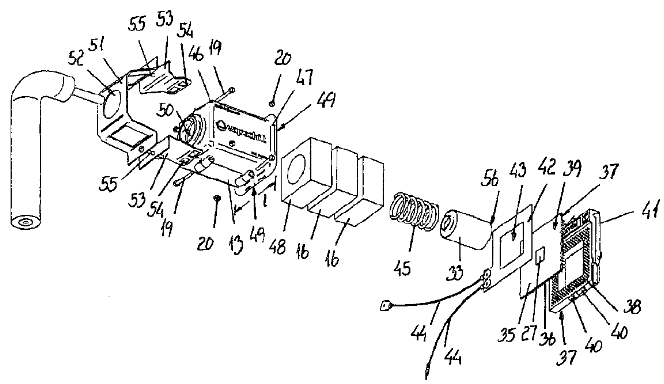
(54) Title: COMPUTER SYSTEM COMPRISING A COOLING SYSTEM AND A COOLING SYSTEM FOR A COMPUTER SYSTEM



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(57) Abstract: The invention relates to a computer system incorporating a cooling unit. The cooling unit uses conventional coolant that is being led from a compressor to a heat exchanger being in thermal contact with a component in the computer system generating heat, as example a central processing unit (CPU). The compressor is a low voltage compressor although the computer system has to have high voltage electrical power from the public electricity distribution net. By using a low voltage compressor the demands for power consumption and space may be limited. Also, it is possible to power the compressor from the built-in power supply of the computer system. In a preferred embodiment the heat exchanger being in thermal contact with the processing unit is enclosed in an insulated box. The box has openings for piping leading the coolant to and from the heat exchanger, and the box preferably also has a slot so that connection pins from the printed circuit board of the processing unit can protrude put through the box. Thereby the box can be attached to the motherboard by means of the connection pins. An alternative box has an orifice intended for abutting a base plate of the processing unit and has biasing means for holding the box onto a socket for the base plate and in abutment with the base plate.

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

COMPUTER SYSTEM COMPRISING A COOLING SYSTEM AND A COOLING SYSTEM FOR A COMPUTER SYSTEM

BACKGROUND OF THE INVENTION

The present invention relates to a computer system comprising at least a processing unit such as a central processing unit (CPU) generating thermal energy when processing and said computer system also comprising a cooling system with a heat exchanger being in thermal contact with the CPU and comprising a compressor for compressing cooling refrigerant from a vaporised state to a liquid state and comprising first pipes transporting the cooling refrigerant from the compressor to the heat exchanger and second pipes leading the cooling refrigerant from the heat exchanger back to the compressor and said computer system further comprising a regulating means for at least starting and stopping the compressor.

It is known to cool the processor of a computer system in order to increase the operating frequency of the processor to a value above the value intended or expected by the producer of the processor. Whenever a processing unit of a computer system is processing, heat is generated. This reduces the working capacity of the unit, and therefore it is desirable to cool the processing unit by means of a cooling system in order to increase the processing frequency of the processor.

DESCRIPTION OF THE PRIOR ART

US 5.574.627 describes such a cooling system. The system comprises a heat exchanger being in contact with a central processing unit. The CPU is attached to a so-called motherboard. A refrigeration compressor unit such as the one used in a conventional refrigerator provides the cooling. Similar cooling unit is further described at homepage www.kryotech.com from the company Kryotech, Inc. Around the CPU and around the heat exchanger, insulation is provided. The insulation ensures that any dew that may be generated on the cool surface of the heat exchanger or on the cooled down surface of the processor is avoided. However, if dew never the less should generate on the insulation, resistive ink is provided at the outer surface of the insulation in order to heat the insulation if necessary.

CONFIRMATION COPY

This cooling system described in this patent and also the system described at the web-site www.kryotech.com have some disadvantages. Firstly, the compressor used is very bulky compared to the rest of the components of the computer system which all should be as small as possible for fulfilling the demands of small sized computers. The compressor is a conventional compressor using high voltage power supply such as 220/230 V or 110/115 V. This creates the need for extra electrical insulation and other measures for maintaining a sufficient electrical security. Also, the heat generated by the compressor will to a certain extend be conducted up through the computer itself and past the components of the computer system thereby increasing the internal temperature of the casing of the compressor.

US 5.488.279 describes using a low-voltage compressor to be used in an electrical refrigerator working at locations away from an access to the public electrical network such as off a battery incorporated in an automobile. Thus, using a low-voltage compressor in a refrigerator in an automobile is due to the necessity of using a compressor, which is capable of running on electrical power having a voltage level corresponding to the voltage level that an automobile can provide. There is no discussion of the possible advantages of using a low voltage compressor in stead of using a high voltage compressor, namely because using a low voltage compressor is a necessity and not an option when using it in an electrical refrigerator in an automobile.

US 6.054.676 describes an apparatus for cooling an integrated circuit. The cooling unit comprises casings enclosing a base plate that the integrated circuit is mounted to. Inside the casing a cold plate is provided. The cold plate is situated, together with the integrated circuit, within the casing, and the casing provides insulation around the cold plate. The apparatus also comprises a heating foil being provided with holes along the periphery of the foil. Leggings extending from the base plate extend through the holes in the heating foil. The cooling of the integrated circuit and the heat exchanger is dependant on the insulating capacity of the casing, and the thermal contact between the cold plate and the integrated circuit is limited because there is no means for establishing a close physical contact between the cold plate and the integrated circuit.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a computer system with a cooling system where the flexibility of using the cooling system is greater than for known systems and where the risk of electrical damage or lack of electrical security is reduced so that the overall functionality of the computer system is increased.

This purpose is obtained by a computer system where the compressor is a low voltage compressor with a voltage usage below the voltage of the public electrical power distribution network.

Using the public net is obvious because the computer system itself always has the need for electrical power from the public net, so there is no reason why the compressor should not also have electrical power from the public net. However, by using a low voltage compressor certain surprising advantages are obtained compared to using conventional high voltage compressors adapted for using the voltage supply of the public electrical distribution net, although special supplementary features are needed in the computer system, which may cause disadvantages which do not occur when using high voltage compressors. However, the advantages obtained when using low voltage compressor may justify the disadvantages involved.

A first advantage of using a low voltage compressor is that it is possible to power the compressor from the electrical power supply of the computer system itself, thereby eliminating the need for a supplementary power supply. It also means that using the computer with different networks as example 220/230 V or 110/115 V is indifferent to the compressor because the power is supplied from the power supply of the computer system. Any switch between as example 220 V and 110 V will just have to be made for the components of the computer, and the compressor neither needs to be suited for the actual voltage of the electrical distribution network nor needs to have a switch of its own for switching between different voltages of networks around the world.

A second advantage of using a low voltage computer is that it is very easy to incorporate means for regulating the capacity of the compressor. This makes it possible to individually graduate the degree of lowering the temperature and also makes it possible to adjust the capacity in response to the need for cooling. As example, when the computer system is in a standby mode or in any other way is not performing greater processing, then the need for cooling is limited as compared to situations when the processor is performing actual processing. The means for regulating the capacity of the compressor may be controlled by additional software incorporated in the computer system. The means for regulation may also be more conventional regulating means or a combination of these and software controlling.

A third advantage is that the size of a low voltage compressor may be smaller than the size of a conventional high voltage compressor. This means that the space needed for the cooling system is limited and advantageously the cooling system may be incorporated into the standard cabinet of the computer system. Also, the power consumption of a low voltage compressor is lower than that of conventional high voltage compressors, as example 50W compared to 120W. Apart from reducing the overall power consumption of the computer system, the reduced power consumption may also limit the size of certain electrical components in the compressor.

Also it is possible to incorporate the compressor into the top of the cabinet because not only the size but also the weight of the low voltage compressor may be smaller than for conventional compressors. Accordingly, there will neither be any space problem nor any stability problem of placing the compressor in the top of the cabinet. Placing the compressor in the top of the cabinet means that the heat generated when the compressor is working is not passed through the computer itself and is not passed through the components of the computer system.

In a preferred embodiment the computer system wherein the CPU and the heat exchanger are enclosed in a box, the insulation material is provided between at least the heat exchanger and the inside of the box, preferably is provided also between the CPU and the inside of the box.

The advantages of enclosing the heat exchanger and the processor in insulation are already known. However, also enclosing the insulation in a box has the advantage that the processor and the insulation are capsuled and constitute a unit of its own. Enclosing the heat exchanger and the processor together with the insulation in a box means that it is actually possible to market and sell these components as an integrated unit.

As example, if a computer already having a cooling system has to be upgraded, then it is necessary to substitute the processor. Substituting the processor may involve also substituting the heat exchanger to one with a larger cooling capacity. This can easily be done if the processor, the heat exchanger and the insulation are enclosed in a box constituting a unit. Thereby it is not necessary to dismantle the insulation and the heat exchanger, substituting the processor and afterwards assemble the heat exchanger and the insulation again.

If the box is black and perhaps is also lustreless, then the outside of the box will have the best opportunity to receive heat from the surroundings, and thereby keeping as high a temperature as possible of the box. This avoids the formation of dew on the box. The box may as a supplement be provided with a heating element in thermal contact with the outer or inner surface of the box for heating the box to further avoid the formation of dew.

However, in other situations it may only be necessary to substitute the processor, but not absolutely necessary to substitute the heat exchanger. Also in this situation it is convenient to have the processor, the heat exchanger and the insulation all enclosed in a box. It will be possible to dismantle the insulation and the heat exchanger outside of the computer system and thereafter substituting the processor and assemble the insulation and the heat exchanger again also outside the computer and finally placing the box in the computer.

Thus the overall flexibility of the computer system according to the invention is highly increased by the combination of the above mentioned features. This is important in especially this field of business, where the technical development is extremely fast and therefore fosters the need of a possibility to substitute one or more components with new components, but also a need for a uniform product that may be used all around the world because most computer systems are universal. Thus using a low voltage compressor makes the computer system according to the invention universal, while using components that are not physically bonded together and which are enclosed in a box constituting a unit at the same time increases the flexibility by facilitating easy substitution of the components.

Another aspect of the present invention is to further increase the cooling of the computer system by means of an exterior cooling system functioning as an air conditioning system for cooling the interior of a computer cabinet. A separate cooling system from which a hose or a pipe leads to the cabinet of a computer system and through which hose or pipe pre-cooled air is let into the computer cabinet has the effect of cooling the entire interior of the cabinet, i.e. the air and thus all components inside the cabinet. The processing units are those that are most relevant to cool and depending on the type of processing unit and the way it is attached to the motherboard the firstly mentioned or the alternative mentioned type of heat exchanger may be employed.

However, a further advantage by cooling can be obtained by also cooling the interior of the computer cabinet. By only cooling the interior of the computer cabinet and not also cooling the exterior surroundings of the cabinet, a much faster and more efficient cooling takes place and it is possible to obtain a certain cooling rate by means of only a smaller cooling system. Lastly, it is possible to take the cooling system along to the computer to be cooled, thus not being restricted to cooling the computers being situated in a certain room being provided with air condition for the entire room, i.e. where also the exterior surroundings of the computer cabinets being cooled in such a room.

BRIEF DESCRIPTION OF THE INVENTION

The invention will now be described in detail with reference to the accompanying drawing, where

fig. 1 shows an embodiment of a computer system with a cooling system according to the invention with a cooling unit enclosed in a box that is mounted in the computer system,
fig. 2 shows a cooling system mounted in the top of a computer cabinet and comprising a compressor and an external heat exchanger,
fig. 3 shows the box with the embodiment of the invention enclosed and provided with a heating element around the exterior of the box,
fig. 4 shows different components of the box enclosing part of the cooling system according to the invention
fig. 5 - fig. 13 show different steps in assembling the components inside the box and in assembling the box itself,
fig. 14 shows an alternative embodiment of the invention enclosed in a box that is alternatively mounted in a computer system,

fig. 14a shows a cross section of an embodiment of a heat exchanger to be used in the alternatively mounted box, and

fig. 15 and fig. 16 shows an embodiment of a separate cooling system for cooling the interior of a computer cabinet.

DETAILED DESCRIPTION OF THE INVENTION

Fig. 1 is a photograph showing a motherboard 1 inside a computer cabinet 2. At the motherboard 1 a black box 3 is shown. The box 3 encloses the central processing unit (CPU) (not shown) of the computer system. Apart from enclosing the CPU, the box also encloses a cooling unit comprising a heat exchanger (not shown) being in thermal contact with the CPU. The box is kept in place by means of the connection pins from the printed circuit board at which the CPU is placed (see fig. 6), said connection pins being inserted in the appropriate slots in the motherboard. A hose 4 extends from the box 3 to a compressor (see fig. 2). The hose 4 contains metal piping for conducting coolant liquid from the compressor to the heat exchanger in the box and for returning the vaporised coolant from the heat exchanger in the box to the compressor.

Fig. 2 is a photograph showing the part of the cooling system being outside the box (see fig. 1), i.e. all of the cooling system, except the parts inside the box including the heat exchanger being in thermal contact with the CPU. The cooling system comprises a compressor 5. The compressor 5 is a special low voltage compressor, preferably a 12V compressor. A metal piping (not shown) is leading through the hose 4 from the compressor 5 to the heat exchanger in the box (see fig. 1), and an other metal piping 6 is leading back to the compressor 5. Before being led to the heat exchanger being in thermal contact with the CPU, the vaporised coolant is led past an exterior condenser 7 for liquefying the coolant.

The cooling system is placed inside the standard cabinet 2 of a computer system, and is placed in the top of the cabinet. This way it is assured that the heat from the compressor 5 when in duty and the heat from the exterior heat exchanger 7 shown is not led past any of the other components in the computer system causing these to be further heated. The duty periods of the compressor are regulated in accordance with the demand for cooling. The regulation may be either an on/off switching of the compressor, or may be a stepwise or may even be an infinitely adjusting of the rotational speed of the compressor. Regulation of the rotational speed may be controlled by software programs installed in the computer system. Alternatively the regulation of the rotational speed may be controlled by hardware.

In the embodiment of the cooling system as shown in fig. 1 and fig. 2, the compressor and the condenser is mounted on a frame. The frame has dimensions being the same as or smaller than inner dimensions of the computer cabinet. Preferably the frame and the compressor and condenser has a width being not larger than 5 1/4" (five and a quarter of an inch) or alternatively a width being not larger than 3 1/2" (three and a half of an inch). Thereby it is possible to use one or more of the external so-called drive bay shafts, which are already fitted at the front side of the computer cabinet and which are externally accessible. Thereby, it is not necessary to dismount the entire cabinet of the computer cabinet in order to install or remove the cooling system from the interior of the computer cabinet. The rails that may be mounted inside the computer cabinet for supporting a disc drive or other hardware facilities of the computer may in stead be used to support the frame of the compressor and the condenser.

Fig. 3 is a photograph showing the box 3 provided with a heating element 8 around the outer surface of the box. The heating element 8 consists of a foil 9 provided with metallic wires 10 attached to the foil. Electric wires 11 lead to the heating element 8 for providing electrical power to the wires 10 on the foil 9 in order to heat the outer surface of the box 3. By heating the outer surface of the box the risk of dew forming on the outer surface is avoided. Dew may occur because of the cold heat exchanger inside the box although insulation is provided between the heat exchanger and the casing of the box.

Apart from being provided with a heating element 8 the box is preferably black and provided with a lustreless surface. Both of these features further minimises the risk of dew occurring because the casing of the box, when being black and lustreless, receives as much heat in the form of radiation heat both from the heating element wrapped around the outer surface of the box but also from the surroundings. Alternatively, the box may have other appearances in relation to colour and surface if the problem of dew occurring is not that great a problem. As example, if it is a greater problem that heat from the surroundings limits the capacity of the heating element inside the box because of heat penetrating through the box and through the insulation, it will be more favourable to have a white box with a shiny surface in order to reject as much of the heating radiating from the surroundings inside the computer system.

Fig. 4 is a photograph showing the different components of a cooling unit in a box shown in fig. 1 and fig. 3. The box 3 consists of a casing consisting of two halves 12,13 (see fig. 5 and fig. 13) and of insulation 14-17 for being placed inside the casing and for surrounding the CPU and the heat exchanger thereby forming a thermal barrier between these components and the casing of the box. Furthermore the box comprises bolts 18,19 and nuts 20 for holding together of the two parts which constitutes the casing (see the subsequent figures). The box also comprises a plate 21 for holding the heat exchanger in a firm physical and thereby firm thermal contact with the CPU. Lastly, as an option, the box comprises the heating element 8 in the form of the foil with wires (see fig. 3) for wrapping around the outer surface of the casing.

Fig. 5 - fig. 13 are photographs showing assembling of the box and of the CPU and the heat exchanger inside the box. Fig. 5 shows a first half part 12 of the casing into which a first layer 14 of insulation is placed. In the right side upper side 22 of the casing an opening 23 is provided for insertion of the tube 4 and the piping into the box 3. The part 12 of the casing and the insulation 14 are provided with holes 24 for accommodating the insertion of the bolts 19 through the insulation 14 and through the box 3. In the bottom 25 of the casing a slot (not shown) is provided through which the connecting pins of the print circuit board can be introduced (see fig. 7).

Fig. 6 shows a print circuit board 26 on which a central processing unit (CPU) 27 is placed. Also other electrical components are placed on the board 26. The board 26 is provided with connection pins 28 along the lower edge of the board. The pins 28 are intended for insertion into corresponding slots in the motherboard (see fig. 1) of the computer system. Bolts 18 are attached to the print circuit board 26. The bolts 18 are for fastening of the plate 21 for keeping the heat exchanger in place in relation to the insulation and the casing of the box (see fig. 11). The board 26 is also provided with holes 29 for accommodating the insertion of the bolts 19 through the board.

Fig. 7 shows the print board circuit 26 as shown in fig. 6 placed in the half part 12 of the casing as shown in fig. 5. The connecting pins 28 on the print circuit board 26 are inserted though the slot (not shown) in lower part 25 of the part 12 of the casing so that the pins 28 extrude outside of the casing. Thereby the box may be fixed to the motherboard of the computer system by just inserting the connecting pins of the print circuit board in the corresponding slots in the motherboard (see fig. 1).

Fig. 8 shows a first intermediate layer 15 of insulation placed on top of the print circuit board 26 (see fig.7). A rectangular opening 30 is made in the first intermediate layer 15 of insulation so that the CPU 28 is still exposed. The first intermediate layer 15 of insulation is provided with four holes (not shown) in the sides of the insulation through which the guiding bolts 18 and the bolts 19 for assembling the casing are extending.

Fig. 9 shows a second intermediate layer 16 of insulation placed above the first intermediate layer 15 shown in fig. 8. The second intermediate layer 16 is provided with a rectangular opening 31 that is bigger than the opening 30 in the first intermediate layer 15 and intended for receiving the heat exchanger (see fig. 10). The second intermediate layer 16 is provided with a groove 32 extending from the opening 31 to the one side of the layer. The groove 32 is intended for receiving piping (see fig. 10) leading to and from the heat exchanger (see fig. 10). Also, the second intermediate layer 16 of insulation is provided with four holes (not shown) in the sides of the insulation through which the fastening bolts 18 and the assembling bolts 19 for assembling the casing are extending.

Fig. 10 shows a heat exchanger 33 placed in the insulation in the casing. The heat exchanger 33 consists of a square block inside which canals (not shown) are made for the coolant to flow through the heat exchanger. The heat exchanger 33 is accommodated in the opening 31 of the second intermediate layer 16 of insulation (see fig. 9). Piping 34 leads the coolant to and from the heat exchanger 33. The piping 34 consists of an outer pipe with a larger diameter and an inner pipe with a smaller diameter. The inner pipe extends co-axially and inside the outer pipe. The tube 4 surrounding the piping 34 is shown outside the casing. The tube 4 is insulated so that the piping 34 leading between the heat exchanger 33 and the compressor 5 (see fig. 2) is thermally insulated from the surroundings.

Fig. 11 shows the plate 21 for keeping the heat exchanger 33 in place. The plate 21 is provided with holes (not shown) through which the fastening bolts 18 and assembling bolts 19 are extending. Nuts 20 are screwed onto the bolts 18,19 so that the plate 21 is kept in place against the heat exchanger 33 thereby assuring sufficient physical and thermal contact between the heat exchanger 33 and the CPU 27. Both the fastening bolts 18 and the assembling bolts 19 and the nuts 20 are made of plastic having a poor thermal conductivity. Thereby the bolts 18,19 and the nuts 20 will not be responsible of thermal transportation of energy either heat from the surroundings to the metal plate 21 and further on to the heat exchanger 33 or cold from the heat exchanger 33 and further on to the metal plate 21 and to the surroundings.

Fig. 12 shows a final layer 17 of insulation placed above the already mounted components in the box. The final layer is provided with two holes (not shown) through which the assembling bolts 19 extend.

Fig. 13 shows a second half part 13 of the casing of the box placed above all of the components inside the box and thereby enclosing these components in the box. The second half 13 of the casing is provided with two holes (not shown) through which the assembling bolts 19 extend. Nuts 20 are screwed onto the bolts 19 for assembling the two halves 12,13 of the box. The box is now closed. The piping (not shown) extend out through the hole 23 (see fig. 5) in the upper right side of the box and is being provided with the tube 4 around it. The connecting pins 28 of the print circuit board 26 (see fig. 6) extend through the slot (not shown) in the bottom of the box.

In the embodiment shown of the computer system according to the invention different alterations may be induced without departing from the scope of protection. As mentioned, it will be possible to exclude using the heating element wrapped around the box as shown in fig. 3. It will also be possible to use low voltage compressors with other voltage needs than 12V, as example 6V, 24V or 48V. Also, in stead of using electrical power from the built in power supply of the computer system it will be possible to provide a separate low voltage power supply for the compressor parallel to the built in power supply. Regulation of the rotational speed of the compressor may be adjusted between a simple on/off switching of the compressor to a constant 24-hour rotation of the compressor and regulating the rotational speed according to the demand for cooling.

Fig. 14 is an exploded view of an alternative embodiment of a cooling unit for a computer system. As is the case with the before-mentioned cooling unit, the alternative embodiment also comprises a box 13, a heat exchanger 33, and insulation 16 provided around the heat exchanger. Also, the box is constituted of two parts being held together by appropriate fastening means such as bolts 19 and nuts 20 as shown and similar to those keeping the two parts of the before-mentioned box together. The advantage of having the box constituted by two halves is that it is easy to join the two halves when the heat exchanger of the cooling unit is already placed in abutment with the processing unit that is to be cooled. Thus, it is not necessary to have the complete casing joined and attached to the processing unit before installing the processing unit onto the motherboard.

The difference between the box of the before-mentioned cooling unit and the box of the alternative embodiment is determined by a difference between the processing unit and the base plate onto which the processing unit is attached. In the before-mentioned computer system, the processing unit is attached to a base plate constituted by a print circuit board and having connecting pins extending outwards form the print circuit board parallel to the print circuit board. However, in the alternative embodiment shown, the processing unit is attached to a base plate 35 having leggings 36 extending perpendicular outwards from a bottom side 37 of the base plate 35 and establishing connection between the processing unit 27, which is placed in the middle of the base plate 35, and a socket 37 on the motherboard (not shown) and thus the rest of the computer system.

The leggings 36 are intended for extending through holes 38 in the socket 37 that is to be mounted on the motherboard of the computer system, however, in such a way that the socket 37 and the base plate 35 lie parallel to the motherboard. Contrary to this, the processing unit that the before-mentioned cooling unit is intended for is being placed on a separate print circuit board mounted perpendicular to the motherboard, and not parallel with the motherboard, in a slot on the motherboard. The difficulty of the processing unit shown here in fig. 14 is that the socket 37 and the base plate 35 are parallel with the motherboard, thereby limiting the access to a top surface 39 of the base plate 35.

The socket is a standard component of the computer system. As mentioned, the socket 37 is provided with holes 38 through which the leggings 36 of the base plate 35 extend. The socket 37 itself is mounted on the motherboard (not shown). Along the circumference, the socket 37 is provided with small protrusions 40 extending outwardly from the circumference of the socket. The socket 37 is also provided with a lever arm 41 intended to be handled for securing the socket to the motherboard by appropriate securing means, after the socket has been placed on the motherboard. The socket 37 is only intended as an intermediate means between the motherboard and the base plate 35 of the processing unit in order to avoid that the base plate, having small and fragile leggings 36, have to placed directly on the motherboard.

A heating foil 42 is introduced above the base plate 35 and is intended for abutting the top surface 39 of the base plate. The heating foil 42 has a rectangular shape with a rectangular hole 43 in the middle of the heating foil. The shape is established so that the foil is abutting the top surface 39 of the base plate 35 corresponding to the position of the leggings 36 extending from the bottom side of the base plate 35. The hole in the middle allows the processing unit 27 to protrude through the heating foil 42 so that the top of the processing unit can have abutting contact established with the heat exchanger 33. Electrical wires 44 lead to the heating foil 42 in order to heat the foil by means of electrical resistive wiring (not shown) on the heating foil. The heating foil 42 is intended for heating of the leggings 36 in order to prevent any moist condensing on the leggings because of any low temperatures originating from the cooled processing unit 27 and dissipating to the leggings. Accordingly, by heating the leggings separately from cooling the processing unit, then any dew on the leggings can be avoided, thus avoiding any unintentional short-cut between the leggings.

The heat exchanger 33 has a circular cylindrical shape. The heat exchanger 33 is surrounded by insulation 16. A spring member 45 being a spiral spring is provided above the heat exchanger 33 and is compressed between a top 46 of the heat exchanger 33 and the interior of an end 47 of the box. The spring member 45 is intended for biasing the heat exchanger 33 towards the processing unit 27. Also the spring member 45 is surrounded by insulation 48.

The box 13 is divided into two halves and the box contains the heat exchanger 33, the spring member 45 and the insulation 16,48. The box 13 is provided with a first opening (not shown) directed towards the heating foil 42, the base plate 35 and the socket 37. An orifice (not shown) of the opening is intended for abutting the heating foil 42 and via the heating foil resting against the base plate 35. The orifice has a circumference with edges 49 having a length l. The length l is approximately the same as an edge length of the heating foil 42 and the base plate 35. Thus, the box 13 does not take up more space than the base plate 35. This ensures that the box can be placed on the base plate 35 irrespective of eventual lack of space beside the base plate when the socket 37 and the base plate 35 are placed on the motherboard of the computer system.

The two halves of the box 13 are mutually joined by means of bolts 19 and nuts 20. At the end 47, the box 13 has a second opening 50 through which the pipes 34 pass to and from the heat exchanger 33. Outside the box 13, the pipes 34 are provided with insulation 4. The end 47 of the housing is provided with a first part 51 of a biasing member. The first part 51 of the biasing member has a hole 52 through which the second opening 50 of the box protrudes and the first part 51 of the biasing member is thereby fixed in relation to the box 13. Second parts 53 of the biasing member have small holes 54 intended for engagement with the small protrusions 40 on the circumference of the socket 37. The first part 51 and the second parts 53 of the biasing member are intended for being mutually joined by means of proper fastening means such as bolts 55 and nuts (not shown) at opposing ends 56,57 of the biasing members.

The biasing member 51,53 shown has the advantage that it is possible to evenly and adjustably bias the box 13 towards the socket 37 and thereby also evenly and adjustably biasing the orifice of the box towards the heating foil 42 and the base plate 35. This ensures that the heating foil 42, the base plate 37 and via the spring member 45 the top of the processing unit 27 are not damaged due to unevenly biasing of the box 13 towards the base plate 35 or due to a to a biasing with to great a force applied to the box. Apart from the spring member 45 biasing the heat exchanger 33 towards the processing unit 27, other spring members (not shown) could be provided in connection with and along the bolts 55 and nuts of the biasing member 51,53 in such a way that the force exerted when tightening the bolts and nuts will pass through the other spring members. Thereby, the force applied when tightening the bolts 55 and nuts would not exceed the spring force of such other spring members, as long as such spring members were not fully compressed.

In a preferred embodiment of the box 13, the box is made of plastic and is provided with a metal foil or is coated with a metallic film either on an interior surface or an exterior surface of the box. Thereby, it is avoided that moisture from the ambient surroundings migrate through the box that may be permeable to moisture and into the insulation 16,48 surrounding the heat exchanger 33 and the spring member 35. Moisture in the insulation 16,48 will decrease the efficiency of the heat exchanger 33 and may damage the insulation itself. Alternatively, the box 13 may be made of a material impermeable to moisture such as metal like cast aluminium.

Fig. 14A shows a cross section of a preferred embodiment of heat exchanger to be used in a cooling unit as shown in fig. 14. The heat exchanger 33 may be made in any suitable manner, however, the preferred way of producing the heat exchanger is to sinter together small metal balls 71 and provide an outer metal shelf 72 around the sintered metal balls. A preferred metal is copper having a good thermal conductance. Spacing 73 between the metal balls 71 provides passages for the liquid refrigerant to pass through the heat exchanger, and the metal shelf 72 provides an enclosure for the liquid refrigerant. The small metal balls 71 provide easy dissipation of the cold temperature of the liquid refrigerant to the outer shelf 72 of the heat exchanger.

A central bore 74 is provided along the centre of the heat exchanger. The bottom part of the sintered metal balls 71 is configured like a cone. Via a first pipe (not shown) leading from the compressor through a condenser to the heat exchanger, the liquid refrigerant is passed through the central bore 74 forward to a bottom 75 of the heat exchanger. The liquid refrigerant is then led from the bottom 75 of the heat exchanger backwards into the passages 73 between the sintered metal balls 71. After having passed through the passages 73, the refrigerant, via the passages, is led back to the bottom 75 and into a second pipe (not shown) configured co-axially with the first pipe and leading from the bottom of the heat exchanger to the compressor. An outer end surface 56 of the bottom 75 of the cylindrical heat exchanger is in thermal abutting contact with the processing unit 27 provided in the middle of the base plate 35 (see fig. 14). By providing a central bore 71, it is assured that the liquid refrigerant initially is passed to the bottom 75 and thus cools down the end surface 56 of the heat exchanger, the part of the heat exchanger being in thermal contact with the processing unit. It is also assured that the refrigerant subsequently is passed through the entire heat exchanger before finally being led out of the heat exchanger. Because of the insulation 16 (see fig. 14) and because of the easy and controlled passage of the liquid refrigerant into, through and out of the heat exchanger, the cooling takes place fast and efficient. Also, the type of heat exchanger is easy and cheap to produce.

Fig. 15 and fig. 16 show a possible embodiment of a separate cooling system functioning as an air conditioning equipment for cooling the interior of computer cabinets. The separate cooling system is constituted by a casing 60 containing a compressor and a heat exchanger and an evaporizer, none of which are shown. A front 61 of the casing 60 comprises an upper grate 62 through which air from the exterior surroundings is being pulled into the casing by means of a fan (not shown) inside the casing. The air pulled through the upper grate 62 is led past an evaporizer (not shown) cooling the air by evaporating a cooling liquid coming from the compressor within the casing. The air passed through the evaporizer is led further through the casing 60 and through a hose 63 being coupled to a back 64 of the casing 60. The hose 63 leads to a computer cabinet (not shown) so that the air that has been cooled by the cooling system is led directly to the interior of the computer cabinet. The front 61 of the casing 60 also comprises a lower grate 65 being used for letting air into the casing, the air being passed through a condenser (not shown), where the liquid refrigerant is condensed. The air passed through the condenser is led further through the casing 60 and through a grate 66 at the back 64 of the casing 60.

The front 61 of the casing 60 furthermore comprises a switch button 67 for switching the power to the cooling system off and on and comprises a display 68 for showing the temperature of the air being led through the hose to the computer cabinet. Lamps 69,70, as example one being green and one being red, indicates whether the temperature is below, indicated by the green lamp, a chosen temperature such as 10° C, or is above the chosen temperature, indicated by the red lamp. Other means may be used for showing the status of the cooling system.

Thus, the casing 60 is provided with all the means of a cooling system and the cooling system may be implemented in any situation where the possibility exists of employing a pipe or a hose to a computer cabinet. When using the separate cooling system, there is no need for integrating the cooling system into the computer cabinet itself, but the cooling of the entire interior of the cabinet may take place by use of the separate cooling system. However, the efficient cooling of the processing unit itself as described in connection with the previous figures is not possible to establish by means of the separate cooling system, thus the cooling system will mostly be employed as a supplement to the direct contact cooling between a heat exchanger and the processing unit. Alternatively, the system casing may be employed in stead of the direct cooling of the processing unit if the cooling by means of the cooling system is satisfactory or if it is other components of the computer system than a processing unit that set the limit for the performance of the computer system.

CLAIMS

1. A computer system comprising a cooling system, said computer system comprising at least a processing unit such as a central processing unit generating thermal energy when processing and said cooling system comprising a heat exchanger intended for being in thermal contact with the processing unit and where the processing unit is of a type comprising a base plate having leggings extending parallel outwards from the base member, said leggings being intended for extending through openings in a slot mounted on a motherboard of the computer system, and where the heat exchanger constitutes an individual unit separate from the processing unit, and said cooling unit comprising a compressor for compressing cooling refrigerant from a vaporised state to a liquid state and comprising first pipes transporting the cooling refrigerant from the compressor to the heat exchanger and second pipes leading the cooling refrigerant from the heat exchanger back to the compressor and said computer system further comprising a regulator for at least starting and stopping the compressor and where the compressor is a low voltage compressor with a voltage usage below the voltage of the public electrical power distribution network.

2. A computer system according to claim 1, wherein the low voltage compressor is intended for voltages in the range from 6V to 48V, preferably is intended for voltages in the range from 6V to 12V, most preferably is intended for voltages of 12 V.

3. A computer system according to claim 1 or claim 2, wherein the regulating means is capable of variable regulating the rotational speed and thereby the capacity of the compressor, preferably by regulating the speed infinitely, alternatively by regulating the speed stepwise.

4. A computer system according to claim 3, wherein the regulating means is regulated by a software means controlled by the computer system, alternatively that the regulating means is regulated by hardware means preferably also controlled by the computer system, alternatively controlled by components other than those of the computer system.

5. A computer system according to any of the preceding claims, wherein the processing unit and the heat exchanger both are enclosed in an insulation material and that the insulation material is provided between at least the heat exchanger and the ambient environment, preferably also between the processing unit and the ambient environment.

6. A computer system according to claim 5 wherein the processing unit and the heat exchanger both are enclosed in a box, that insulation material is provided between at least the heat exchanger and the inside of the box, preferably also between the processing unit and the inside of the box.

7. A computer system according to any of the preceding claims, wherein a heating element is in contact with the outside of the box, alternatively is in contact with the inside of the box, where the heating element consists of resistive wires, that the wires are in contact with the insulation, alternatively are in contact with the box, and that electrical power is supplied to the resistive wires for providing a heating of the wires and to the insulation, alternatively a heating of the inside or the outside of the box.

8. A computer system comprising a cooling system, said computer system comprising at least a processing unit such as a central processing unit (CPU) generating thermal energy when processing and said cooling system comprising a heat exchanger being in thermal contact with the processing unit and where the processing unit is of a type comprising a base plate having leggings extending perpendicular outwards from the base member, said legging being intended for extending through openings in a socket mounted on a motherboard of the computer system, and where the heat exchanger constitutes an individual unit separate from the processing unit, and said cooling system comprising a compressor for compressing cooling refrigerant from a vaporised state to a liquid state and comprising first pipes transporting the cooling refrigerant from the compressor to the heat exchanger and second pipes leading the cooling refrigerant from the heat exchanger back to the compressor, and the heat exchanger being intended for thermal contact with the processing unit by a force directed perpendicular to a top of the processing unit.

9. A computer system according to claim 8, where the force is applied by means of spring members being attached between the heat exchanger and the socket.

10. A computer system according to claim 8 or claim 9, where the heat exchanger is contained in a box and where the force is applied by means of spring members being attached between the box and the socket.

11. A computer system according to claim 10, where the box is provided with a first opening intended for receiving the heat exchanger and a second opening intended for receiving the pipes to and from the heat exchanger, and where the first opening is directed towards the base plate and the socket and has an orifice havingcircumferential measures being approximately the same as, alternatively smaller than, external measures of the base plate and the socket.

12. A computer system according to any of claim 10 or claim 11, where the box is biased towards the base plate by means of biasing members, where the biasing members is attached between the box and the socket onto which the base plate is mounted.

13. A computer system according to claim 12, where the biasing members consist of at least one first part attached to the box and at least one second part attached to the socket, and where opposing ends of the first part and the second part are intended for being biased towards each other by fastening means, preferably adjustable fastening means such as bolts and nuts.

14. A computer system according to claim 13, where other spring members are provided in connection with the fastening means, and where biasing of the first part and the second part of the biasing means takes place via the other spring members so that a biasing force between the box and the base plate, and thereby between the heat exchanger and the processing unit, is limited by a spring force of the spring members.

15. A computer system according to any of claims 8-15, and where the heat exchanger consists of metallic balls being in close proximate contact with each other, preferably being sintered together, and where passages are formed between the balls, and where said passages form passages for the cooling refrigerant to pass trough the heat exchanger.

16. A computer system according to claim 15, and where the heat exchanger has a circular cylindrical shape, and where an end surface of the cylinder is in abutting contact with a top surface of the processing unit.

17 A computer system according to any of claims 8-16, wherein only the heat exchanger is enclosed in an insulation material, and where the insulation material is provided between the heat exchanger and the ambient environment.

18. A computer system according to any of claims 8-17, wherein only the heat exchanger is enclosed in a box, and where insulation material is provided between the heat exchanger and the inside of the box.

19. A computer system according to any of claims 8-18, wherein a heating element is in contact with the leggings extending from a bottom surface of the base plate of the processing unit, alternatively is in contact with a top surface of the base plate, where the heating element consists of resistive wires, and that electrical power is supplied to the resistive wires for providing a heating of the leggings and alternatively also of the base plate.

20. A computer system according to any of the preceding claims, wherein the components of the cooling system is provided with means for placing the components inside a standard cabinet of the computer system, and that said means is shaped so that the means may be placed in slots inside the computer system, alternatively may be attached to boards of the computer

21. A computer system according to any of the preceding claims, wherein the compressor is supplied with electrical power from the built-in power supply of the computer, which power supply also is intended for powering other components of the computer, such as data-processing components.

22. A computer system according to any of the preceding claims, wherein at least the compressor, preferably at least the compressor and the condenser, is/are mounted on a frame, where the compressor and the condenser have dimensions smaller than 5 1/4 inches, where the frame has dimensions of about 5 1/4 inches and that the frame with the

compressor and the condenser mounted is capable of being displaced in and out of built in drive bay shafts on the front side of a computer cabinet.

23. A computer system according to any of claims 1-18, wherein at least the compressor, preferably at least the compressor and the condenser, is/are mounted on a frame, where the compressor and the condenser have dimensions smaller than 3 1/2 inches, where the frame has dimensions of about 3 1/2 inches and that the frame with the compressor and the condenser mounted is capable of being displaced in and out of built in drive bay shafts on the front side of a computer cabinet.

24 A computer system according to any of the preceding claims, wherein the box is a plastic box having a thermal conductivity lower than that of metallic materials and that the box consists of at least two parts that are mutually connected by connection means and that the connection means are made of a material with thermal conductivity that is low compared to metallic materials.

25. A computer system according to any of the preceding claims, wherein the heat exchanger only is in thermal contact with the processing unit, and that the heat exchanger and the processing unit is separable so that the processing unit may be substituted and the heat exchanger may be thermally connected to a substitutive processing unit, alternatively that the heat exchanger may be substituted and the processing unit may be thermally connected to a substitutive heat exchanger.

26. A computer system according to any of the preceding claims, wherein at least an outer surface of the box is black and preferably is also lustreless, so that the box is capable as easy as possible to receive heat from the ambient environment.

27. A computer system according to any of the preceding claims, wherein the box on an inner surface, alternatively on an outside surface, of the box is provided with a moisture impermeable coating, preferably a metallic coating such as a metallic foil or a metallic film, so that insulation inside the box is prevented from absorbing moisture.

28. A computer system according to any of the preceding claims, wherein the first pipe and the second pipe are led from the compressor to the heat exchanger respectively from the heat exchanger to the compressor in parallel, and that the first pipe in immediate vicinity of the heat exchanger has a smaller cross section than the second pipe, and that

the first pipe when entering the heat exchanger is led into the second pipe and is led into the heat exchanger co-axially with the second pipe.

29. A computer system according to any of the preceding claims wherein the heat exchanger is made of copper and that the pipes is made of copper and that the pipes and the heat exchanger are mutually able of being disconnected.

30. A cooling system for a computer system, said computer system comprising a number of electronic components generating thermal energy when being employed and said cooling system constituting a separate cooling system with a fan for sucking air from the surroundings into the cooling system, and a heat exchanger for cooling the air being sucked into the cooling system, and comprising a compressor for compressing cooling refrigerant from a vaporised state to a liquid state and comprising first pipes transporting the cooling refrigerant from the compressor to the heat exchanger and second pipes leading the cooling refrigerant from the heat exchanger back to the compressor and further on to the condenser, and said cooling system further comprising a means for passing air, that has been sucked past the heat exchanger and thereby has been cooled by the cooling system, to the interior of a cabinet of a computer system

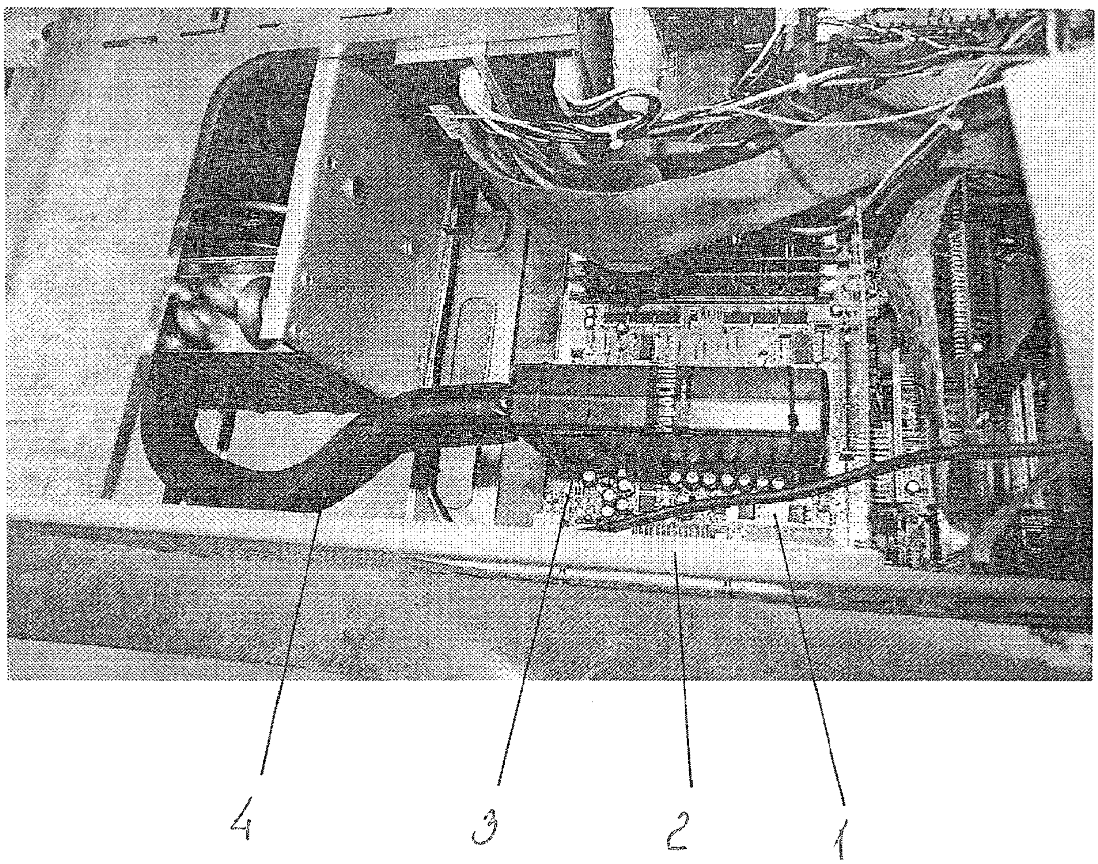

Fig. 1

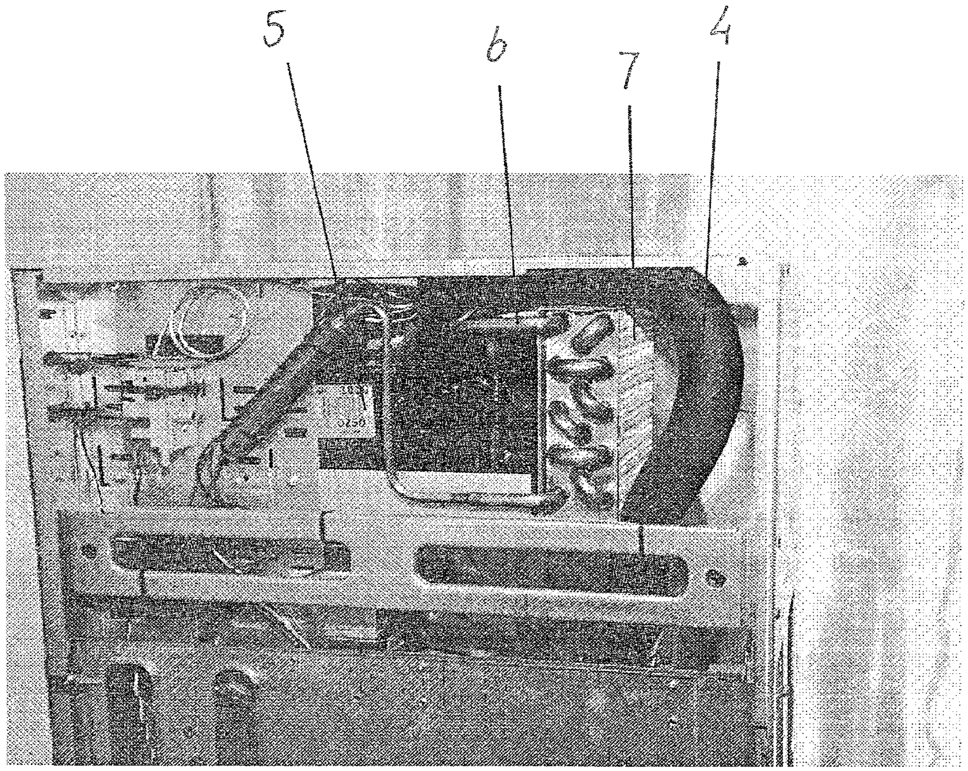

Fig. 2

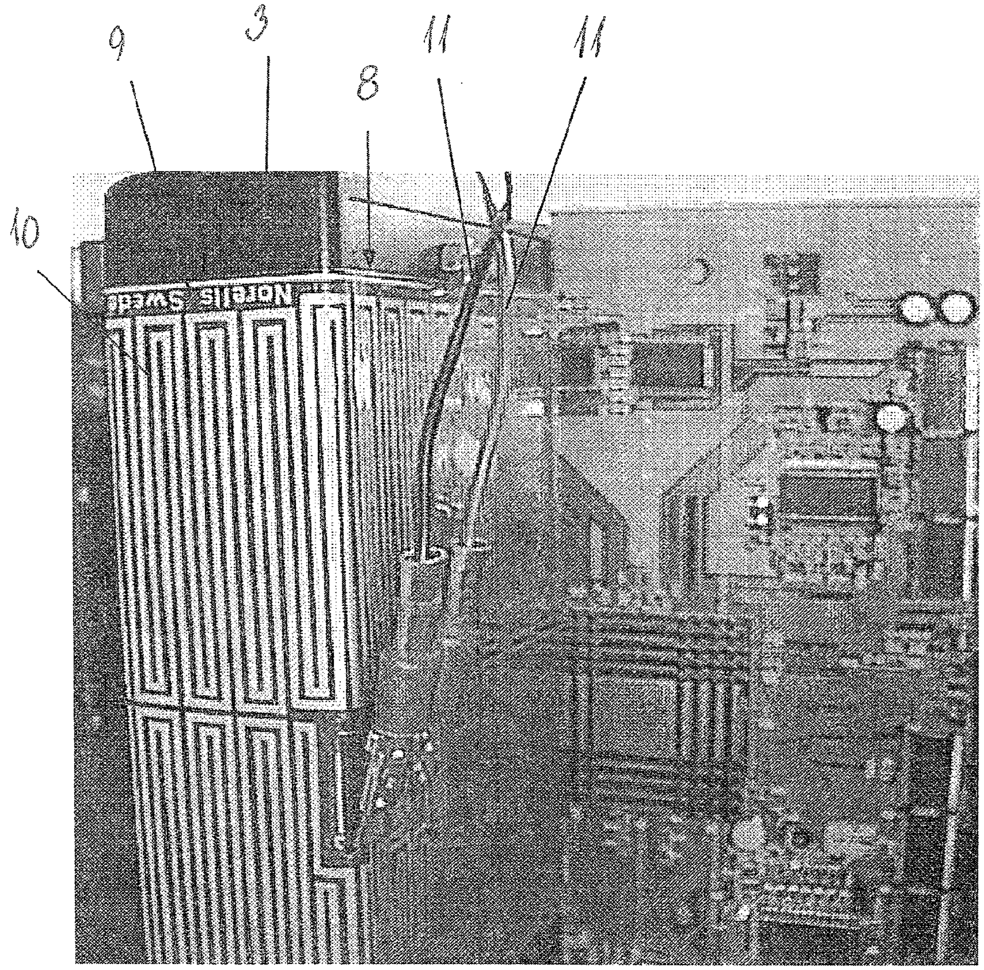

Fig. 3

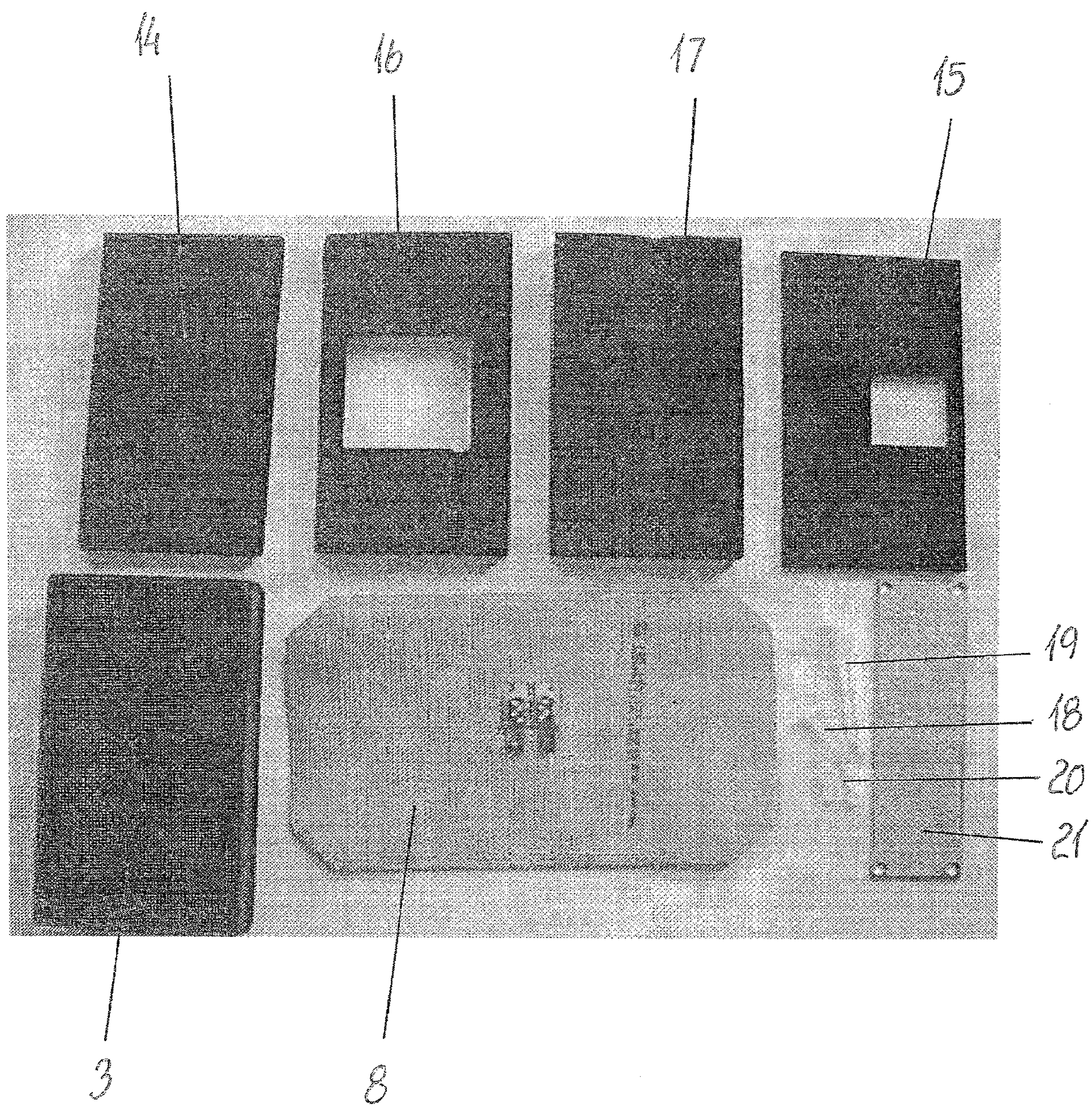

Fig. 4

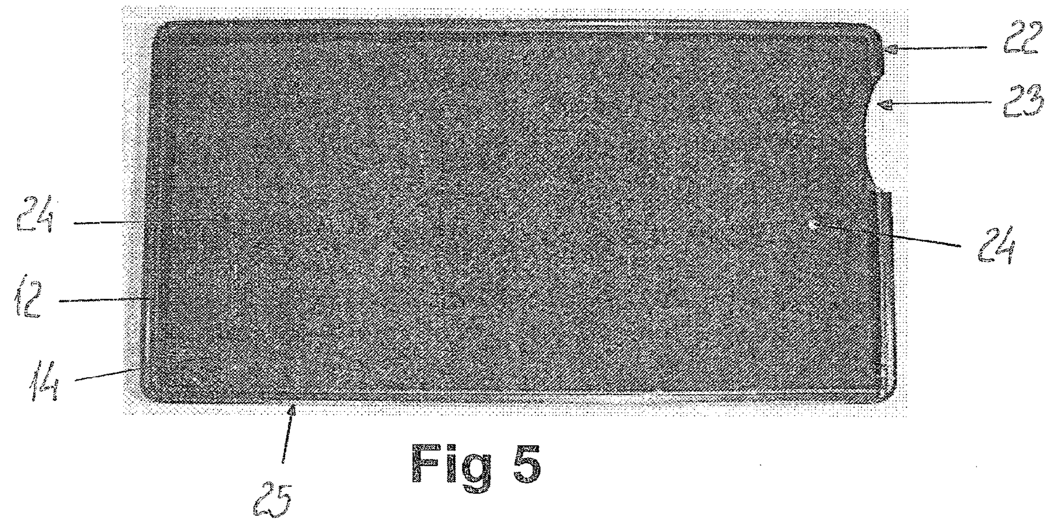

Fig 5

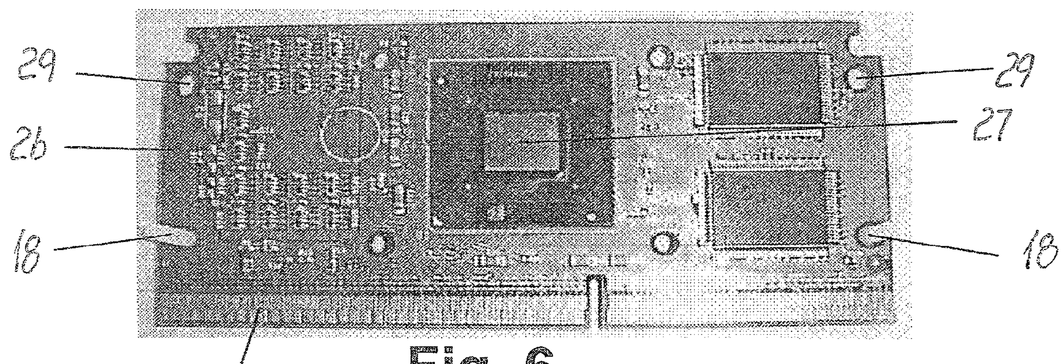

Fig. 6

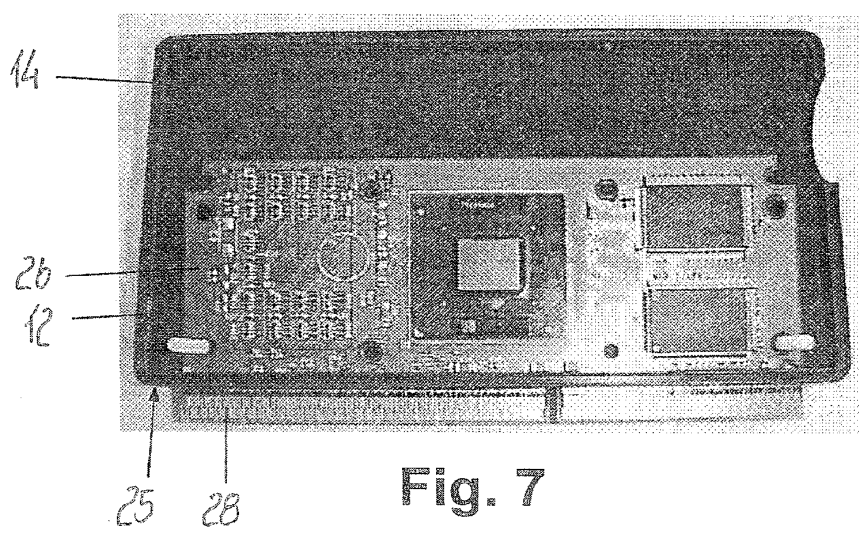

Fig. 7

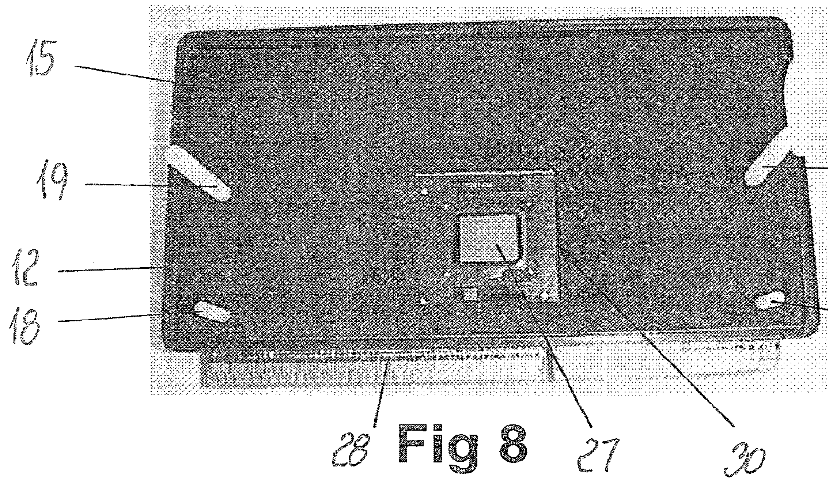

Fig 8

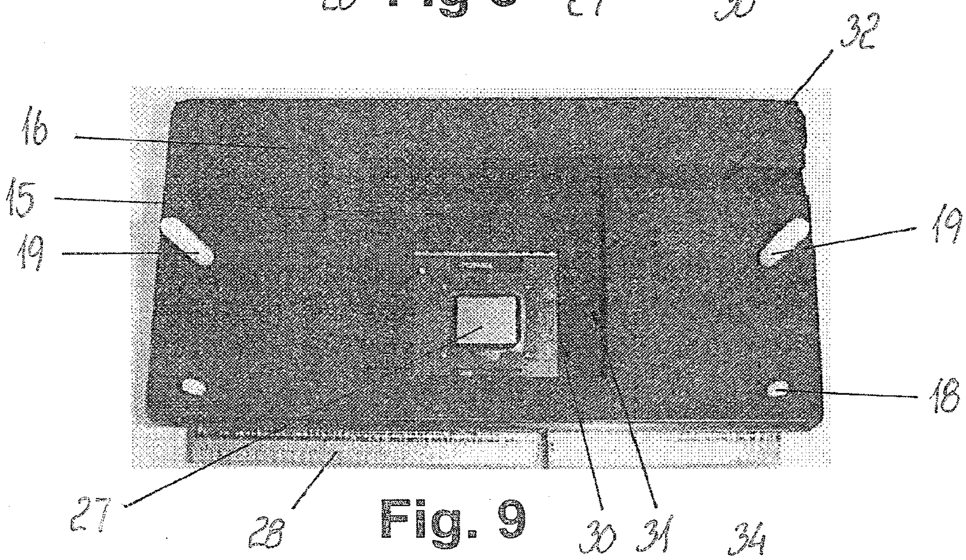

Fig. 9

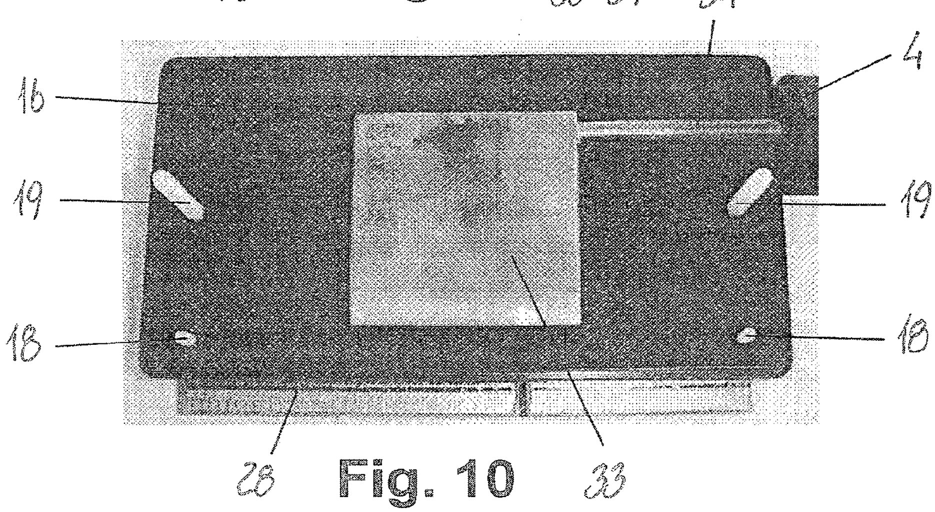

Fig. 10

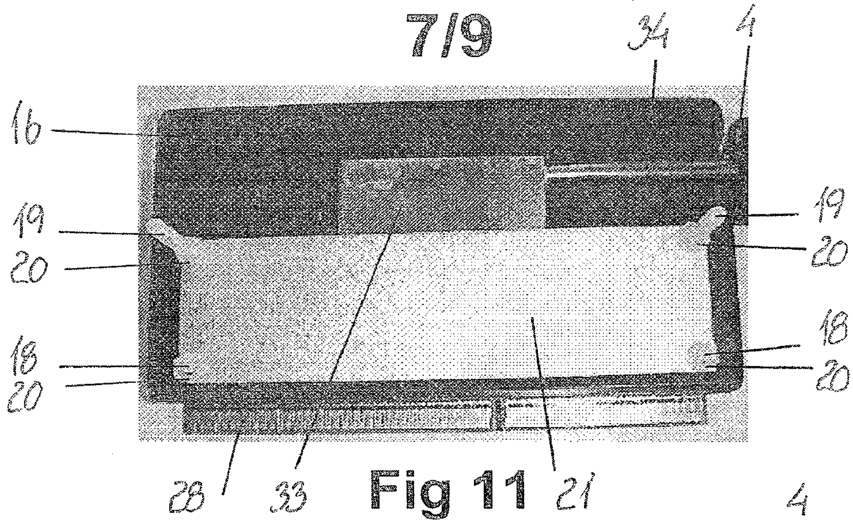

Fig 11

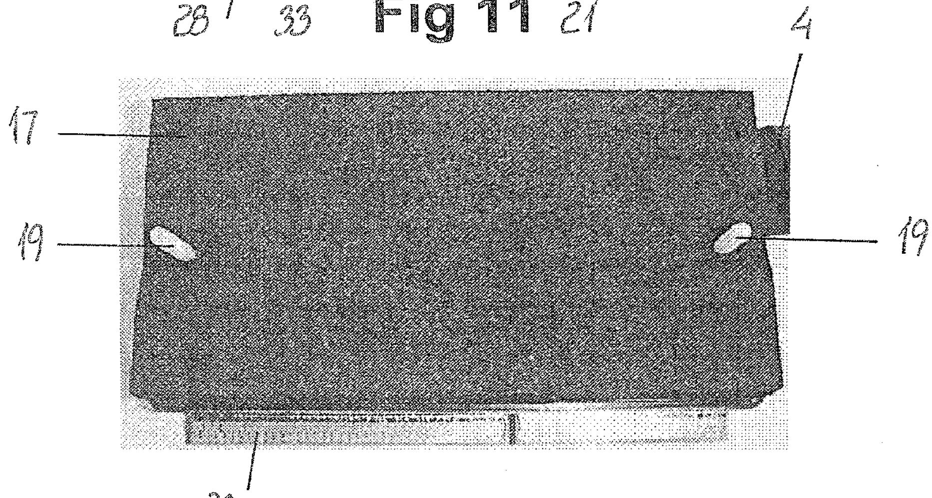

Fig. 12

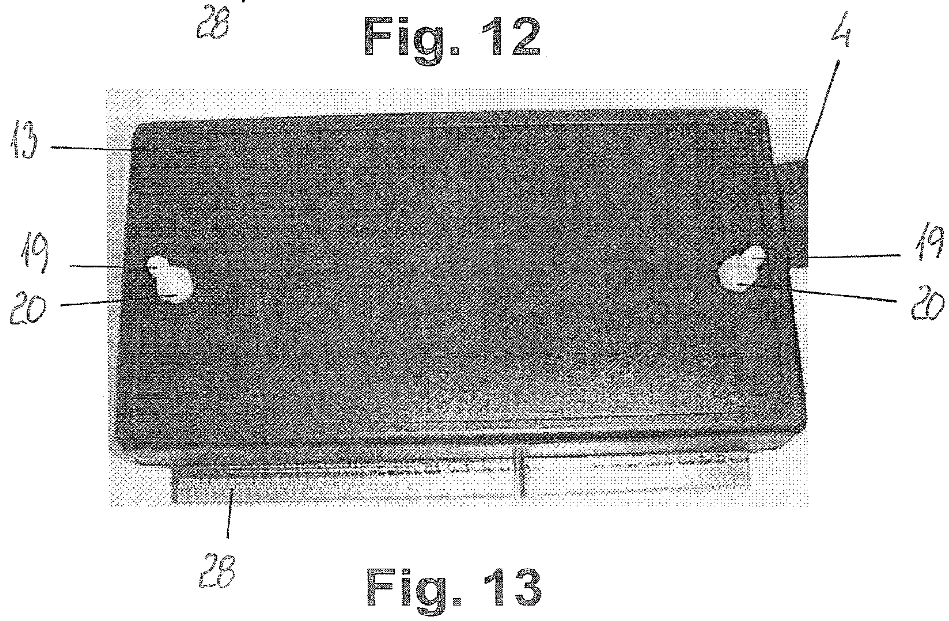

Fig. 13

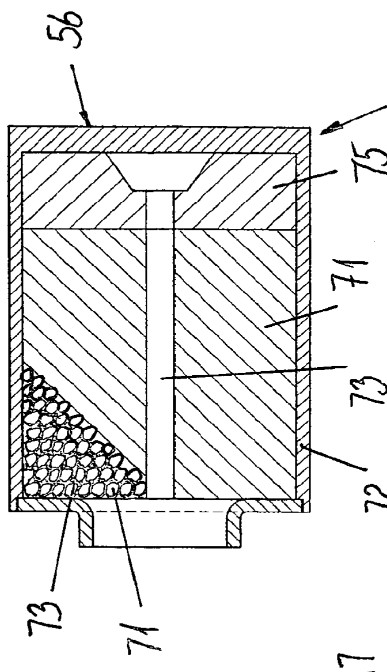

Fig. 14 a

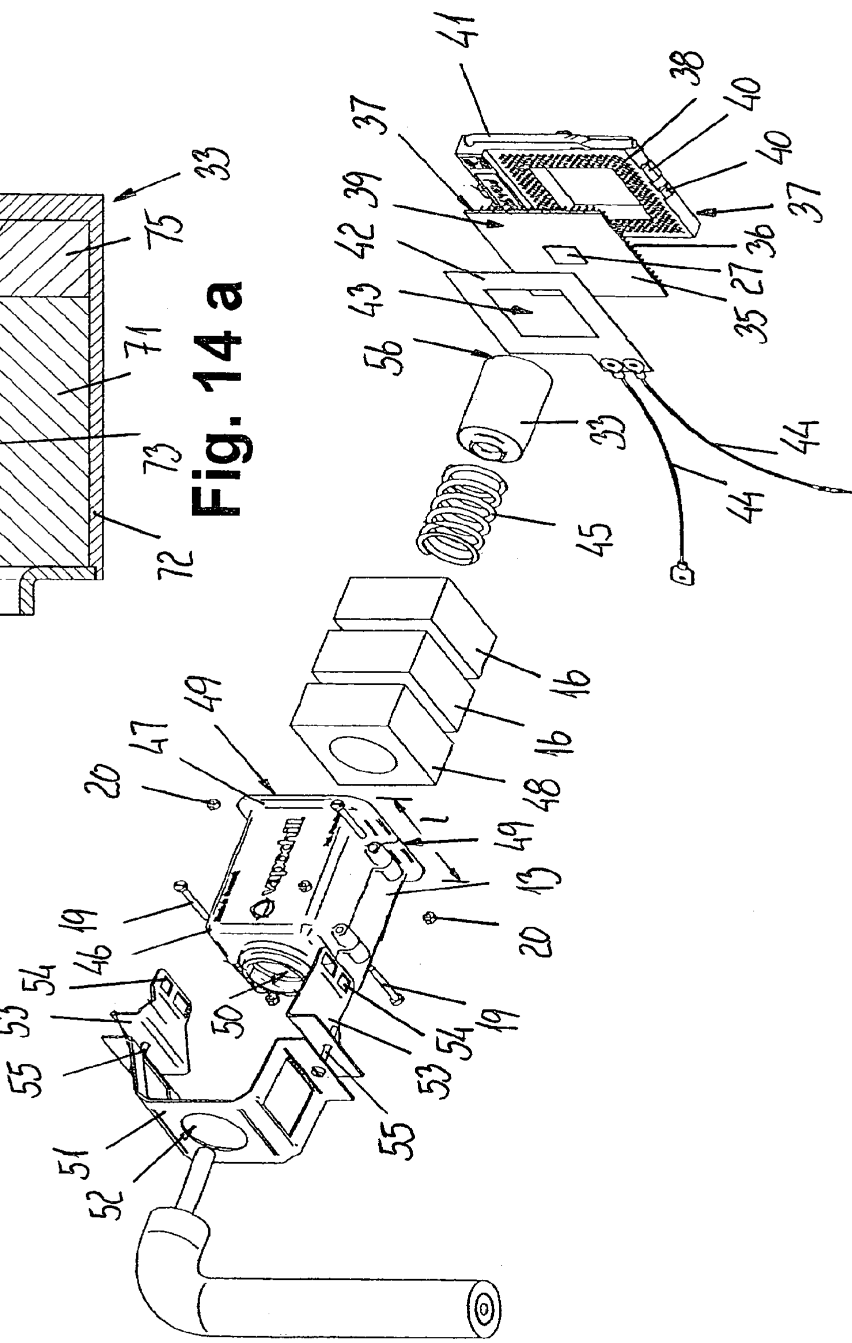

Fig. 14

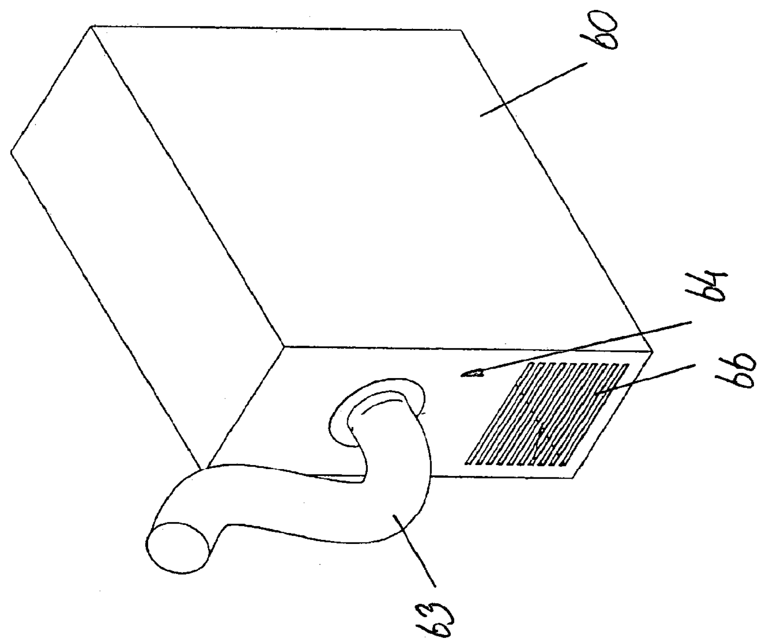

Fig. 16

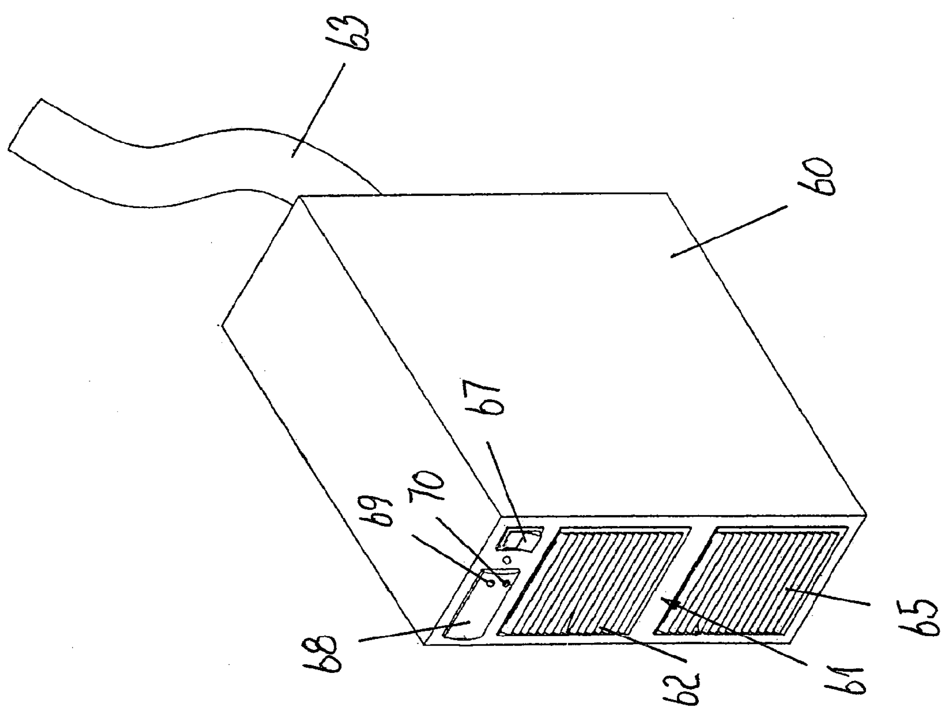

Fig. 15

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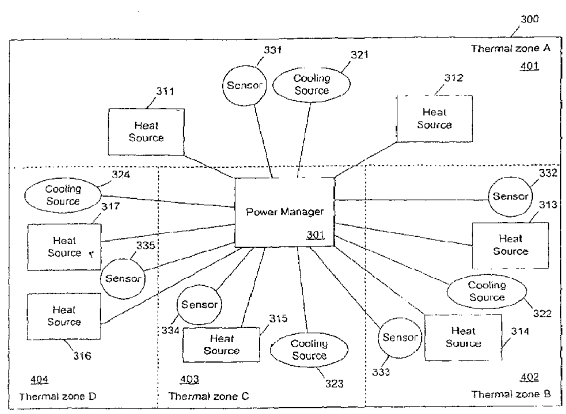
(54) **Title:** METHODS AND APPARATUS FOR OPERATING A DATA PROCESSING SYSTEM



(57) **Abstract:** Methods and apparatuses to manage working states of a data processing system. At least one embodiment of the present invention includes a data processing system with one or more sensors (e.g., physical sensors such as tachometer and thermistors, and logical sensors such as CPU load) for fine grain control of one or more components (e.g., processor, fan, hard drive, optical drive) of the system for working conditions that balance various goals (e.g., user preferences, performance, power consumption, thermal constraints, acoustic noise). In one example, the clock frequency and core voltage for a processor are actively managed to balance performance and power consumption (heat generation) without a significant latency. In one example, the speed of a cooling fan is actively managed to balance cooling effort and noise (and/or power consumption).

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METHODS AND APPARATUSES FOR OPERATING A DATA PROCESSING SYSTEM

[0001] This application is related to and claims the benefit of the filing date of U.S. provisional application serial no. 60/495,447, filed August 15, 2003, and entitled "Methods and Apparatuses for Operating a Data Processing System" by the inventors Michael Culbert, Keith Cox, Brian Howard, Josh De Cesare, Rich Williams, Dave Falkenburg, Daisie Huang, and Dave Radcliffe.

FIELD OF THE TECHNOLOGY

[0002] The field of technology relates generally to data processing systems, and more particularly but not exclusively to the management of power usage and temperature in the data processing systems.

BACKGROUND

[0003] A data processing system (e.g., a desktop computer or a laptop computer) typically contains a number of components that consume power from a power supply (e.g., battery or AC adapter) to perform different tasks. For example, a microprocessor consumes power to perform computation, generating heat in the process; and, a cooling fan consumes power to dissipate heat.

[0004] Typically, a data processing system is designed for operating in a given environment to deliver high computation performance. One or more fans and heat sinks are typically used to cool the system so that the data processing system is not overheated in a condition of normal use.

[0005] To be energy efficient, some computers have power management systems which may temporarily put a hard drive or a display screen in a low power mode after idling for a period of time. When a component is in a low power mode, the component is not functioning at least in part (e.g., the display screen is not displaying images, a hard drive cannot be accessed for read or write operations, and a section of a chip is not energized with power to perform computation). In some systems, a cooling fan is triggered by a temperature sensor such that the cooling fan is turned on when the sensor detects that the temperature is above a threshold.

[0006] To protect from overheating, some microprocessors have built-in hardware to slow a processor when the processor is too hot. However, built-in hardware in a processor that slows down the processor when the processor is too hot is restricted to only changing processor performance to regulate the temperature. Intrinsically, it is not able to regulate other devices in the system or optimize thermal management of the entire system. Similarly, some computers (e.g., iBook laptops from Apple Computer, Inc.) automatically enter into a shut down when it is too hot (e.g., because a fan failed). Automatic shutdown of a notebook computer is an emergency solution for unusual situations, such as when the cooling fan is failing. It does not regulate the temperature during the normal use of the computer.

[0007] Thus, a computing platform (including a processor) is commonly designed for increased performance, which typically requires increased power consumption. However, computing platforms, especially in mobile applications, are also designed to reduce power consumption such that a limited power resource (e.g., a battery) can support the computing platform for an increased period of usage time. These design goals are typically in conflict.

[0008] One conventional solution to the conflicting design goals is to provide a means for a user to switch the configuration of the computing platform between a high performance mode and a power conservation mode, as desired. For example, a computing platform may allow a user to select the desired mode via a hardware switch or via a menu and dialog box displayed by the computing platform. For example, some computers allow a user to manually select a clock frequency for the microprocessor.

SUMMARY OF THE DESCRIPTION

[0009] Methods and apparatuses to manage working states of a data processing system are described here. Some of the embodiments of the present invention are summarized in this section.

[0010] At least one embodiment of the present invention includes a data processing system with one or more sensors (e.g., physical sensors such as tachometer and thermistors, and logical sensors such as CPU load) for fine grain control of one or more components (e.g., processor, fan, hard drive, optical drive) of the system for working conditions that balance various goals (e.g., user preferences, performance, power consumption, thermal constraints, acoustic noise). In one example, the clock frequency and the core voltage for a processor are actively managed to balance performance and power consumption (heat generation) without a significant latency. In one example, the speed of a cooling fan is actively managed to balance cooling effort and noise (and/or power consumption).

[0011] Thermal managers according to embodiments of the present invention monitor the system temperature based on a number of sensors and conditions (e.g., sensed temperatures, lid position, battery charging status, current computation tasks and user preferences) to provide the best of mixture of cooling (e.g., by controlling one or more cooling fans) and reduced heat generation (e.g., by adjusting the working states of the heat generating devices, such as CPU, GPU, hard drives, optical drives, memory chips, core logic chips and others) to provide the best performance for the current task.

[0012] In one aspect of the present invention, a method to operate a data processing system includes: determining a control level for a first component of the data processing system based on information obtained from a plurality of sensors (e.g., a temperature sensor determining a temperature in the data processing system, such as a particular component's local temperature which is one of many components in the system); and, automatically adjusting the control of the first component according to the control level to move the first component from a first working state to a second working state. In one example, the first component includes a cooling fan of the data processing system; and, the cooling fan runs at a first speed in the first working state and a second speed in the second working state; and, in one example, a duty cycle of the cooling fan is adjusted to run the cooling fan from the first speed to the second speed. In one example, the first component includes a processor; the first working state includes a first clock frequency and a first core voltage for the processor; and, the second working state includes a second clock frequency (which may be lower or higher than the first clock frequency) and a second core voltage (which may be lower or higher than the first core voltage) for the processor. In one example, the first component includes a Graphics Processing Unit (GPU); the first working state includes a first swap interval; and, the second working state includes a second swap interval. In one example, the control of a second component is further adjusted automatically based on the information obtained from the plurality of sensors to move the second component from a third working state to a fourth working state. In one example, the first component is a heat source of the data processing system and the second component is a cooling source of the data processing system. In one example, the control level is determined further based on one or more user preferences. In one example, one of the sensors includes a software module (e.g., an operating system's kernel) determining a processor load of the data processing system.

[0013] In one aspect of the present invention, a method to operate a data processing system includes: determining a subset of control settings from a plurality of control settings of a plurality of components of the data processing system based on information obtained from a plurality of sensors (e.g., a temperature sensor, a tachometer, a software module determining a load of a processor), each of which determines an aspect of a working condition of the data processing system; and adjusting the subset of control settings to change working states of corresponding components of the data processing system to balance requirements in performance and in at least one of: thermal constraint and power consumption. In one example, the plurality of components include heat sources (e.g., a Central Processing Unit (CPU), a Graphics Processing Unit (GPU), a hard drive, an optical drive, an Integrated Circuit (IC) bridge chip) of the data processing system and cooling sources of the data processing system. In one example, an amount of cooling change is determined based on the information obtained from the plurality of sensors; and, the subset of control settings are adjusted to effect the amount of cooling change. In one example, the amount of cooling change is determined according to a fuzzy logic; and, determining the subset of control settings includes determining a prioritized list of the plurality of control settings. In one example, the prioritized list is determined at least partially based on one or more user preferences. In one example, the amount of cooling change is parceled out to the subset of control settings. In one example, a first state of the data processing system is determined from the information obtained from the plurality of sensors; and, the subset of control settings is determined from a decision to move the data processing system from the first state to a second state.

[0014] In one aspect of the present invention, a method to operate a cooling fan of a data processing system includes: adjusting the cooling fan from running at a first speed to running at a second speed in response to a temperature sensor measurement and a user preference. In one example, it is further verified that the cooling fan is running at the second speed (e.g., using tachometer information obtained from a fan controller for the cooling fan). In one example, a duty cycle of the cooling fan is adjusted to run the cooling fan from the first speed to the second speed. In one example, one or more temperature measurements are determined; and the second speed for the cooling fan is determined based at least partially on the one or more temperature measurements. In one example, the one or more temperature measurements are obtained from one or more temperature sensors instrumented in the data processing system; and, the one or more temperature measurements indicate temperatures of at least one of: a) a microprocessor of the data processing system; b) a graphics chip of the data processing system; and c) a memory chip of the data processing system. In one example, the microprocessor of the data processing system determines the second speed. In one example, the second speed is determined further based on at least one of: a user preference stored in a machine readable medium of the data processing system; and, a computation load level on the data processing system (e.g., the load level is low because the processor is idling and the temperature level is low and a user preference has been set by a user such that in this state the fan's speed is reduced to reduce noise and power consumption).

[0015] In one aspect of the present invention, a method to operate a processor of a data processing system includes: shifting a power supply of the processor from a first voltage to a second voltage without resetting the processor. In one example, a frequency of a clock of the data processing system is slewed (changed slowly) to transit a clock of the processor from a first frequency to a second frequency (e.g., by instructing a clock chip to use a new frequency multiplier). In one example, the processor continues to execute instructions while the frequency of the clock is slewed and while the power supply is shifted from the first voltage to the second voltage. In one example, the power supply is maintained at one of the first and second voltages while the frequency of the clock is slewed; and, the clock of the processor is maintained at one of the first and second frequencies while the power supply is shifted from the first voltage to the second voltage. In one example, the first frequency is higher than the second frequency; the first voltage is higher than the second voltage; and, the power supply is shifted from the first voltage to the second voltage after the clock of the processor transits from the first frequency to the second frequency. In another example, the first frequency is lower than the second frequency; the first voltage is lower than the second voltage; and, the power supply is shifted from the first voltage to the second voltage before the clock of the processor transits from the first frequency to the second frequency. In one example, a frequency multiplier of the processor is adjusted to switch a clock of the processor from a first frequency to a second frequency. In one example, the processor is not reset during switching from the first frequency to the second frequency.

[0016] The present invention includes apparatuses which perform these methods, including data processing systems which perform these methods, and computer readable media which when executed on data processing systems cause the systems to perform these methods.

[0017] Other features of the present invention will be apparent from the accompanying drawings and from the detailed description which follows.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] The present invention is illustrated by way of example and not limitation in the figures of the accompanying drawings in which like references indicate similar elements.

[0019] **Figure 1** shows a block diagram example of a data processing system which may be used with the present invention.

[0020] **Figure 2** shows a data processing system according to one embodiment of the present invention.

[0021] **Figure 3** is a simplified block diagram illustrating heat sources and cooling sources of an exemplary data processing system having power and temperature management according to one embodiment of the present invention.

[0022] **Figure 4** is a simplified block diagram illustrating a data processing system depicted partitioned into thermal zones for power and temperature management according to one embodiment of the present invention.

[0023] **Figure 5** illustrates operational states for system level power management according to one embodiment of the present invention.

[0024] **Figure 6** illustrates operational states for processor and/or system power management according to one embodiment of the present invention.

[0025] **Figure 7** illustrates transitions from one run state to another run state according to one embodiment of the present invention.

[0026] **Figure 8** illustrates a detailed block diagram representation of a data processing system with active power and temperature management according to one embodiment of the present invention.

[0027] **Figure 9** shows a software module diagram which shows software to manage the operation state of a data processing system according to one embodiment of the present invention.

[0028] **Figure 10** illustrates an example of a method to determine actions to be performed using fuzzy logic in operating a data processing system according to one embodiment of the present invention.

[0029] **Figures 11** and **12** illustrate an example defuzzification method to merge different actions as one quantified action to operate a data processing system according to one embodiment of the present invention.

[0030] **Figure 13** shows a software module diagram which shows software to manage the operation state of a data processing system according to one embodiment of the present invention.

[0031] **Figures 14 – 16** show methods to operate a data processing system according to embodiments of the present invention.

[0032] **Figure 17** illustrates a method to parcel out cooling changes to a number of controls according to one embodiment of the present invention.

[0033] **Figure 18** illustrates an example of a state diagram which shows a way to operate a data processing system according to one embodiment of the present invention.

DETAILED DESCRIPTION

[0034] The following description and drawings are illustrative of the invention and are not to be construed as limiting the invention. Numerous specific details are described to provide a thorough understanding of the present invention. However, in certain instances, well known or conventional details are not described in order to avoid obscuring the description of the present invention. References to one or an embodiment in the present disclosure are not necessarily references to the same embodiment; and, such references mean at least one.

[0035] As the performance of data processing systems continues to increase, so do power and cooling requirements. A fan and heat sink may not be adequate for such high performance data processing systems. To meet the challenge of combined conflicting design goals (e.g., computation performance, power usage, cooling, acoustic noise, and others), at least one embodiment of the present invention seeks to manage the working states of various components of a data processing system according to sensed information (e.g., one or more temperature sensors and performance sensors and fan speed sensors). Since hardware-based solutions have pre-determined flexibility, at least one embodiment of the present invention utilizes the processing power of the data processing system to provide software-based management solutions (e.g., software in a kernel of an operating system).

[0036] In the present document, a working state of a component (e.g., a microprocessor or a fan) is a state in which the component works to provides the functionality of the component at a specific level of cost (e.g., the consumption of power usage, the generation of noise or heat, or other factors). A working state does not normally include the state in which the component does not work to provide its functionality for the system.

[0037] One embodiment of the present invention involves power and thermal management strategies to meet the combined challenge of high performance, low power consumption, low noise and tight thermal constraints. In one embodiment, power and temperature in a computer are actively managed so that the computer can go faster, run quieter with extended battery life, and avoid running too hot, as the computation speeds increase and the enclosures of computers continue to push the limits of engineering.

[0038] In one embodiment of the present invention, a computer system is instrumented with one or more sensors; and, at least one component of the system has a number of different working states. For example, different working states have different power consumption levels and performance levels (e.g., processor speeds measured in megahertz or processing operations per second, etc.), which are actively managed to meet conflicting goals, such as high performance and low power consumption, subject to thermal constraints (e.g., the interior of the computer enclosure should not or cannot exceed a certain temperature which may damage certain components in the enclosure). Managing thermal output and finessing cooling efforts can help some machines avoid the need for fans, while allowing other machines to run fans more quietly. With the help of the information collected from the sensors, the computation performance, user preferences and environmental requirements can be balanced to reach a best mix for a particular usage of the system.

[0039] In one embodiment of the present invention, sensors are instrumented (e.g., in the hot spots for measuring temperature); controls are constructed to gracefully adjust the working states (e.g., through the adjustment of frequencies and voltages) for tradeoff in performance, power consumption, heat generation and heat removal; and, a thermal manager is provided to monitor and control one or more thermal zones, according to the constraints of system and user preferences, which define the priorities of conflicting goals.

[0040] In one embodiment of the present invention, temperature sensors are instrumented so that the temperatures of hot spots can be periodically polled. The temperature sensors can be implemented as thermal diodes on Integrated Circuit (IC) chips (e.g., microprocessors, graphics chips, microcontrollers, and others). Further, tachometers are instrumented to obtain the feedback about the working states of fans.

[0041] In one embodiment of the present invention, fine-grained control of frequencies and voltages for a data processing system is added in an architecture-independent way to manage power consumption and heat generation. For example, Central Processing Unit (CPU) voltage and frequency control are provided to allow multiple CPU frequency and voltage states with fine-grained control beyond just high or low; and cooling fans have speed control beyond just on or off.

[0042] In one embodiment of the present invention, software device drivers dynamically tweak power and performance. For example, a CPU software driver manages CPU working states (e.g., speed, frequency, voltage) based on computation load, sensor measurements (e.g., CPU temperatures and CPU load levels), and various preferences and priorities (e.g., user preferences with respect to fan noise or other noise or battery life). Device drivers for other controls use a similar approach to select the working state based on the required work load and various constraints.

[0043] In one embodiment of the present invention, a thermal manager software module controls the power consumption level of various components through the software device drivers. For example, the software thermal manager may monitor and control physical (e.g. temperature) and logical (e.g. CPU load) sensors, optimize for user-center or design-center priorities, such as performance, heat, battery life, and noise, force drivers into lower power states to minimize power consumption and/or heat production, and remove heat with minimal noise. Further, the thermal manager may monitor and control multiple independent zones.

[0044] It is vastly cheaper to reject a faulty part during a factory burn in process (before a customer receives the part) than to handle a customer return. After a design is instrumented, bad parts can be detected early during the manufacture of or testing of the system, using diagnostics tools. For example, when a computer is instrumented with temperature sensors, misapplied heatsinks may be detected for correction, removing one of the most costly manufacturing defects.

[0045] Many of the methods of the present invention may be performed with a digital processing system, such as a conventional, general-purpose computer system. Special purpose computers, which are designed or programmed to perform only one function, may also be used.

[0046] **Figure 1** shows one example of a typical computer system which may be used with the present invention. Note that while **Figure 1** illustrates various components of a computer system, it is not intended to represent any particular architecture or manner of interconnecting the components as such details are not germane to the present invention. It will also be appreciated that network computers and other data processing systems which have fewer components or perhaps more components may also be used with the present invention. The computer system of **Figure 1** may, for example, be a Macintosh computer from Apple Computer, Inc.

[0047] As shown in **Figure 1**, the computer system 101, which is a form of a data processing system, includes a bus 102 which is coupled to a microprocessor 103 and a ROM 107 and volatile RAM 105 and a non-volatile memory 106. The microprocessor 103, which may be, for example, a G3 or G4 microprocessor from Motorola, Inc. or IBM or a G5 microprocessor from IBM is coupled to cache memory 104 as shown in the example of **Figure 1**. The bus 102 interconnects these various components together and also interconnects these components 103, 107, 105, and 106 to a display controller and display device 108 and to peripheral devices such as input/output (I/O) devices which may be mice, keyboards, modems, network interfaces, printers, scanners, video cameras and other devices which are well known in the art. Typically, the input/output devices 110 are coupled to the system through input/output controllers 109. The volatile RAM 105 is typically implemented as dynamic RAM (DRAM) which requires power continually in order to refresh or maintain the data in the memory. The non-volatile memory 106 is typically a magnetic hard drive or a magnetic optical drive or an optical drive or a DVD RAM or other type of memory systems which maintain data even after power is removed from the system. Typically, the non-volatile memory will also be a random access memory although this is not required. While **Figure 1** shows that the non-volatile memory is a local device coupled directly to the rest of the components in the data processing system, it will be appreciated that the present invention may utilize a non-volatile memory which is remote from the system, such as a network storage device which is coupled to the data processing system through a network interface such as a modem or Ethernet interface. The bus 102 may include one or more buses connected to each other through various bridges, controllers and/or adapters as is well known in the art. In one embodiment the I/O controller 109 includes a USB (Universal Serial Bus) adapter for controlling USB peripherals, and/or an IEEE-1394 bus adapter for controlling IEEE-1394 peripherals.

[0048] Sensors 112 are coupled to controller 109 to provide information about the operating environment condition of the components of the data processing system. For example, sensors 112 may include temperature sensors for determining the temperatures at a plurality of locations in the data processing system, such as the temperatures of microprocessor 103, volatile RAM 104, a hard drive and an optical (e.g., CD/DVD) drive; sensors 112 may further include a fan tachometer for determining the speed of a cooling fan, a light sensor for determining the amount of required backlight; a sensor to determine whether a display of a laptop is opened or closed and others. Although **Figure 1** illustrates a configuration in which sensors 112 are coupled to controller 109, it is understood that sensors may also be integrated into components (e.g., microprocessor 103). Further, software sensors like kernel load factor are also used in at least some embodiments of the present invention.

[0049] It will be apparent from this description that aspects of the present invention may be embodied, at least in part, in software. That is, the techniques may be carried out in a computer system or other data processing system in response to its processor, such as a microprocessor, executing sequences of instructions contained in a memory, such as ROM 107, volatile RAM 105, non-volatile memory 106, cache 104 or a remote storage device or a combination of memory devices. In various embodiments, hardwired circuitry may be used in combination with software instructions to implement the present invention. Thus, the techniques are not limited to any specific combination of hardware circuitry and software nor to any particular source for the instructions executed by the data processing system. In addition, throughout this description, various functions and operations are described as being performed by or caused by software code to simplify description. However, those skilled in the art will recognize what is meant by such expressions is that the functions result from execution of the code by a processor, such as the microprocessor 103.

[0050] A machine readable medium can be used to store software and data which when executed by a data processing system causes the system to perform various methods of the present invention. This executable software and data may be stored in various places including for example ROM 107, volatile RAM 105, non-volatile memory 106 and/or cache 104 as shown in **Figure 1**. Portions of this software and/or data may be stored in any one or more of these storage devices.

[0051] Thus, a machine readable medium includes any mechanism that provides (i.e., stores and/or transmits) information in a form accessible by a machine (e.g., a computer, network device, personal digital assistant, manufacturing tool, any device with a set of one or more processors, etc.). For example, a machine readable medium includes recordable/non-recordable media (e.g., read only memory (ROM); random access memory (RAM); magnetic disk storage media; optical storage media; flash memory devices; etc.), as well as electrical, optical, acoustical or other forms of propagated signals (e.g., carrier waves, infrared signals, digital signals, etc.); etc.

[0052] **Figure 2** shows a data processing system according to one embodiment of the present invention. In **Figure 2**, the data processing system includes one or more processors 201 (e.g., a Graphics Processing Unit (GPU) and one or more Central Processing Units (CPU)), devices 221 – 229 (e.g., cooling fan, battery charging system, AC adapter) and machine readable media 209 (e.g., RAM chips, ROM chips, hard drive, optical drive). The data processing system may include communication links to one or more devices outside housing 200. For example, the data processing system may be connected to a network or peripheral devices (221), such as a monitor, a keyboard, a cursor controlling device (e.g., mouse, a track ball, or a touch screen, or a touch pad), a printer, a storage device, or others. Although **Figure 2** shows that machine readable media 209 are inside housing 200, it is understood that a portion of the machine readable media may be outside housing 200 (e.g., connected through an IEEE 1394 bus or a USB bus, or a network connection). Further, some of the peripheral devices listed above as examples of devices 221 may be integrated inside housing 200. For example, a touch pad, an LCD display panel and a keyboard can be integrated within housing 200 (e.g., on a notebook computer).

[0053] Machine readable media 209 have program instructions and data for operating system 233 (e.g., Mac OS X), application programs 231 (e.g., a word processing program), and operating manager 235 for managing the states of the components of the system. Note that operating manager 235 can be a part of operating system 233. Sensors 211 – 219 are instrumented within housing 200 of the data processing system to obtain information about the environmental conditions of various components of the data processing system, such as the temperature of the processors (201), the fan speed of a cooling fan, the lid position (e.g., open or closed). Some of the sensors can also be software modules that determine the computation loads for the processors. Operating manager 235, when executed on at least one of the processors (201), causes the processing of the information obtained from sensors 211 – 219 and the adjustment of the working states of the processors (201) and the devices (e.g., 221 – 229) to provide trade-off between performance and power usage while maintain proper thermal constraints to avoid damage or loss of data.

[0054] Because software can crash, a safety thermal cutoff remains independent of the operating system and is tied directly to Power Management Unit (PMU 205) which includes a hardware only portion which is not effected by a software crash. When a sensor (e.g., 207) detects a temperature that exceeds a safety threshold, hardware-based safety trigger 203 signals PMU for proper action. PMU 205 may force a shutdown of the data processing system to prevent damage when an extreme thermal condition is detected. PMU 205 notifies processors 201 about the safety threshold; and, a software module may then notify the user that the safety threshold is being approached, if one of processors 201 is responsive to PMU. If none of processors 201 is responding to the safety alert or if its response is inadequate to reduce the temperature, PMU 205 takes actions to power off the data processing system. Note that sensor 207 may be different and separate from sensors 211 – 219; alternatively, sensor 207 may be part of sensors 211 – 219 as shared hardware.

[0055] **Figure 3** is a simplified block diagram illustrating heat sources and cooling sources of an exemplary data processing system having power and temperature management according to one embodiment of the present invention. In **Figure 3**, data processing system 300 has power and temperature management according to one embodiment of the present invention. System 300 includes power manager 301 (e.g., a software program running as a portion of the operating system on data processing system 300), heat sources 311 – 317 (e.g., Central Processing Unit (CPU), Graphics Processing Unit (GPU), memory chips, hard drive, optical drive, backlight, battery charging system, system core logic and others) and cooling sources 321 – 324 (e.g., cooling fans, heat pipes and heat sinks) located within housing 300 of the data processing system. The data processing system is instrumented with sensors 331 – 335 (e.g., temperature sensors, tachometers, light sensors, noise sensor and others) within housing 300.

[0056] In one embodiment of the present invention, power manager 301 is physically and/or logically coupled to heat sources 311 – 317, cooling sources 321 – 324 and sensors 331 – 335. For example, power manager 301 can be partially a software program running on the data processing system, using the processing power and storage capacities provided by the heat sources, and partially hardware providing control signals to the heating sources and cooling sources to balance the performance and power consumption and limit the temperatures monitored by the sensors. Some of sensors 331 – 335 may be disposed proximate to some of heat sources 311 – 317, with some of cooling sources 321 – 324 being disposed so as to operatively coupled to the heat sources to remove heat from the heat sources.

[0057] **Figure 4** is a simplified block diagram illustrating a data processing system depicted partitioned into thermal zones for power and temperature management according to one embodiment of the present invention. In **Figure 4**, the data processing system is thermally divided into a plurality of zones (e.g., zones 401 – 404). The temperature of these thermal zones can be individually controlled via controls (e.g., CPU controller, fan controller, hard drive controller) to the heat sources and cooling sources disposed within each thermal zone using the information from the sensors in the corresponding zone.

[0058] In one embodiment of the present invention, the data processing system is enclosed within multiple isolated thermal zones (MITZ). In the present application, a thermal zone is a volume of space containing components that have strong thermal interaction. For example, in a thermal zone, the heat from one device may raise significantly the temperature of another; the devices may share a common cooling system or a common temperature sensor. One or more temperatures within one zone are sensed for thermal management in that zone.

[0059] It is possible that one zone in a system requires software management, and another does not. For example, a power supply could control a fan in a first zone, with the CPU and another fan in a second zone. In this example, cooling the power supply may very well cool the rest of the zone adequately (perhaps even over-cooling some components). Since power consumption relates to heat in the power supply, it might be possible that meeting the cooling requirements of the power supply is guaranteed to cool all other devices in its thermal zone. In this case, the power supply zone would require no active management. At the same time, the CPU zone would need sensors and active thermal management.

[0060] **Figure 5** illustrates operational states for system level power management according to one embodiment of the present invention. There are four basic states in the system level power state diagram. These states are Off 507, Run 501, Idle 509 and Sleep 503. Run 501 includes a range of working states with different power and performance levels.

[0061] Off 507 represents a state when all power plane for the system is turned off, with the exception of those power planes necessary to run the power system (and one or more peripherals that can be operated in an autonomous mode).

[0062] Idle 509 represents a state when the system is idling. Cache coherency is maintained when in Idle 509. All clocks are running and the system can return to running code within a few nanoseconds. When all CPUs stop computing, the system enters (519) from Run 501 into Idle 509, such as when the last active processor of the system is stopped in the Nap state 603 and is dynamically switched between the Nap state 603 and the Doze state 607 for snoop cycles to complete. The North Bridge can control the switching between the Nap state 603 and the Doze state 607, which will be described below with **Figure 6** in detail. Any processor interrupt returns (519) the system from Idle 509 to Run 501.

[0063] Sleep 503 represents a state when the system is shutdown with various states preserved for instance recovery (513) to Run 501. In one embodiment, the states of the North Bridge, RAM and South Bridge are preserved to provide the appearance of instant-on/always-available. All processors are powered off after their caches are flushed and their states preserved in RAM for the system to enter (513) from Run 501 into Sleep 503. Other devices, such as the devices in PCI slots (or PCMCIA slots) are also powered off after preserving their state in RAM. All clocks in the system in the system are stopped except for the one for real-time clock function.

[0064] Run 501 represents a state when a least one processor of the system is running. If the system has multiple processors, the individual processors may move in and out of their respective processor power states (e.g., Doze 607, Nap 603, Sleep 605, Off 609 in **Figure 6**) in a fully independent manner. While in Run 501 state, the processors can move together between different performance levels. The operating system sets the policies for when to shift performance levels and when to power manage individual CPUs. For example, if there are threads waiting to be scheduled, the system is in Run 501 state and at least one CPU is running and executing the threads. When the scheduler of the operating system runs out of threads, the system transitions from Run 501 to Idle 509.

[0065] There are multiple power and performance levels associated with Run 501, in which the system moves (511) among them as load and other constraints dictate. In one embodiment of the present invention, the processor continues executing instructions while shifting in performance levels, remaining in Run 501 but shifting between different working states with different power consumption levels and performance levels. For example, when more performance is needed, the CPU voltage and frequency may be increased to trade increased power consumption for high performance. When full performance is not needed and/or cooling down is required, the CPU voltage and frequency may be decreased to trade performance for reduction in power consumption, which helps cooling the processor(s) down.

[0066] In one embodiment of the present invention, a device is placed into a working state that uses as only much power as is required to perform a task. The power consumption for a device is scaled to match the work being requested. For example, the speed of a fan is adjusted to keep the temperature within the allowable range while using less power and producing less noise than when the fan is at the full speed. The fan is controlled to run only as fast as it needs to, and no faster. Sensors instrumented in the system are used to gather the information; and, the data processing system processes the information to decide how to control the devices.

[0067] In a given system implementation, there are different devices (e.g., CPU, hard drive, optical drive, graphics chip, power supply, memory chip, core logic) that may reach their thermal maximums (maximum thermal thresholds). If a device may be above its allowable temperature (to become overheated) under certain operating condition, the device may be included in a thermal management algorithm; and, a temperature sensor can be instrumented for detecting the current temperature of the device. If the enclosure and airflow somehow guarantees that a device will stay within its specifications (including noise), temperature sensing of that device is not required; and, that device may be included only for power management.

[0068] There also might be a case where the temperature of one device is sensed indirectly via its effect on another device. For example, a design might have the hard drives preheating the air that flows over the CPU. If the algorithm for protecting the CPU always turns on the fan before the hard drives overheat, it is not necessary to sense hard drive temperature directly.

[0069] In one embodiment of the present invention, device management includes using sensors for the devices and implementing software drivers that controls the operations of the devices according to the work being requested. In one embodiment, sensors include thermistors, hard drive temperatures, kernel loads, and more. Controls are provided to vary fan speeds, backlight brightness, hard drive speeds, to power devices off, to put a CPU in a different working state, and to throttle thread scheduling.

[0070] Many of the devices of a computer (e.g., CPUs, GPU, hard drives, optical drives, backlight, charging system, etc.) have multiple power states, which can be used for active power management, such as varying spindle speed of hard drives.

[0071] **Figure 6** illustrates operational states for processor and/or system power management according to one embodiment of the present invention. In the Run state 601, all processor units are active. Dynamic clock stopping to individual functional units is allowed, but are invisible to software. Clocks are automatically restored to functional units immediately upon detection of any instruction to be dispatched for that functional unit.

[0072] In the Doze state 607, all execution units are stopped. All processor caches and bus interface logic necessary to maintain cache coherency are active.

[0073] In the Nap state 603, all execution units are stopped, along with all caches and bus interface logic. The system can bring (621) the processor back to the Doze state 607 by de-asserting a signal (e.g., QAck). This is done when the system needs the processor to perform cache coherency operations.

[0074] In the Sleep state 605, all execution units are stopped, while the processor state is maintained. Before entering (619) the Sleep state 605, all processor caches are flushed, as a sleeping processor does not perform any cache coherence operation. In systems with multi-drop bus topologies (60x, MaxBus), sleeping processors do not respond to deassertion (e.g., QAck). Systems with point-to-point interconnect topologies (e.g., ApplePI) uses per-processor deassertion signals, but not to a sleeping processor.

[0075] In the Off state 609, core power is removed from the processor. The Off state 609 is typically used in multiprocessor systems. In one embodiment, before a processor enters the Power Off state, it sets its PowerDownEnabled bit inside the core logic. Once the core logic asserts deassertion signal (e.g., QAck) to put a processor into the Sleep state 605, the core logic checks the PowerDownEnabled bit. If the bit is set, the processor interface is then put into an appropriate condition for powering down the processor. An interrupt is generated to signal the system that the processor is ready to have its power removed. A live processor receives the interrupt and performs the appropriate actions to remove power from the sleeping CPU, moving (615) it into the Off state 609.

[0076] When software determines that it again needs the processor that is in the Off state 609, it performs the appropriate actions to reapply power to the CPU and reset it, returning (613) it to the Run state 601.

[0077] In a single processor system, the CPU may avoid the Sleep state 605 and target the Nap state 607 to avoid the penalty associated with cache flushing. In a multi-processor system, every processor except the last active processor uses either the Doze state 607 or the Sleep state 605. These two states impose no penalty for performing snoop operations. The last active processor will use Nap 607 in a manner similar to the single processor. The system enters the Idle state 509 when the last active (or the only) processor enters the Nap state 603.

[0078] One embodiment of the present invention moves the processor from performance level to performance level by changing frequency and power voltage while staying within the Run state 601. Each performance level is a different combination of CPU core frequency, CPU bus frequency, and CPU core voltage that defines both a computing performance level and a power consumption level. Each performance level representing a working state of the CPU.

[0079] The number of performance levels implemented in a system depends upon a variety of factors. For example, some CPUs may only support two operating points, limiting the system implementation to Run 0 and Run 1. A well-managed portable design may implement Run 0 for minimum power, Run 1 for specific functionality level such as DVD playback, and Run 2 for the clock frequency for the portable system. A high performance desktop may implement Run 0 for power and thermal savings, Run 1 at 90% of maximum clock frequency for most operations, and Run 2 at maximum power. One example of different performance levels is illustrated below.

[0080] Run 0: This is the lowest power and performance level supported by the system. The processor's Doze mode entered from Run 0 may be different than that used at the other performance levels. In particular, a large portion of the CPU may be powered at a lower voltage than that required by the snoop logic, saving significant leakage power. Run 0 can be the state at which the system starts executing code after a Power-On or Restart event.

[0081] Run 1 ... n: These states have incremental power and performance levels above the next lower level one. These states differ solely by CPU core voltage and frequency, which sets leakage power, operating power and CPU performance.

[0082] Run n+1: This state is special in requiring no transitions out of this state. Some systems may achieve higher performance if the CPU does not leave the Run state 601. Since the surge currents for transition in and out of Run can be significant, transitions can cause the maximum droop on the power supply rail. By avoiding these droops at the highest performance point, the maximum performance can be achieved. However, by not allowing the CPU to Nap (603) or Sleep (605), significant additional power will be used.

[0083] In one embodiment, with the processor environment set to a specific performance level, the processors can independently transition back and forth between their different power saving states (Run 601, Doze 607, Nap 603, Sleep 605, and Off 609). The system enters automatically from Run 501 into Idle 509 whenever there are no processors in the Run state 601.

[0084] Some operating systems (e.g., Mac OS X) have the capabilities for monitoring the activity level of the CPU(s). In one embodiment, after determining the processing load currently required by the CPU, the CPU can determine if it is above a certain activity level. Based on the processing load level, the management system can initiate a shift upward or downward in performance.

[0085] Likewise, if the CPU determines that it doesn't need all the performance that is currently available, it can shift downward in performance in order to save significant power. Since the CPU continues to operate throughout the process of shifting, no significant latency is incurred as a result of the performance level change.

[0086] In one embodiment, the algorithms used to determine when to shift up and down in performance are contained in system software. The software makes the decisions about when to change the performance level. In one embodiment of the present invention, the software relies not only on CPU load, but also on system thermal conditions, user preferences and others, to decide whether to move to a higher or lower performance level.

[0087] In one embodiment of the present invention, the CPU continues executing instructions throughout the performance transition process without CPU reset.

[0088] **Figure 7** illustrates transitions from one run state to another run state according to one embodiment of the present invention. In one embodiment of the present invention, the transitions between the different CPU run levels are accomplished using a combination of frequency and voltage control. To increase performance (e.g., to move from Run 707 to Run 705), the CPU core voltage is first increased (701) to the level appropriate for Run 705. The CPU power supply moves the voltage between the two voltage points at a rate slow enough such that it does not induce errors in the running CPU. When the voltage transition is complete, the CPU is currently operating at point 709 in **Figure** 7; and, the CPU power supply may signal the system with an interrupt, indicating that it is now safe to increase frequency. At this point, the clock source starts to transition to the new (faster) operating frequency. The clock source slews (slowly changing) the frequency between the two operating points (e.g., 709 and 705) slow enough such that all the Phase Lock Loops (PLL) in the system can track the clock without causing errors in the running system.

[0089] Similarly, to decrease performance (e.g., to move from Run 705 to Run 707), the clock source is first instructed to move to the new (slower) operating frequency. The clock source again slews the frequency between the two operating points slow enough such that all the PLLs in the system can track the clock without causing errors in the running system.

[0090] Since the operation of slewing the frequency from point 705 to 709 takes a deterministic amount of time, it is possible to have the CPU wait the appropriate delay and then infer that it is operating at point 709. Alternatively, the clock chip can generate an interrupt after achieving the new frequency.

[0091] Once point 709 is reached, the CPU core voltage is decreased to the level appropriate for Run 707. The CPU power supply moves the voltage between the two voltage points at a rate slow enough such that it does not induce errors in the running CPU. Since no further action needs to be taken, the voltage transition may be left to complete unmonitored.

[0092] In a typical system, the different PLLs in the system have certain inter-relationships. For example, each PLL associated with the CPU may run at a frequency derived from a single, common reference clock. Each of these PLLs also has its own specified minimum and maximum operating frequencies. The individual PLL operating minimum and maximum frequencies imply that each PLL also has a specific minimum and maximum reference frequency that it will accept. In order for the system to work correctly, the reference clock must obey all the individual reference clock minima and maxima. In some cases, the PLL of a device (e.g., core logic) may be reprogrammed during the frequency transition operation to obey the clock minima and maxima of the device.

[0093] **Figure 8** illustrates a detailed block diagram representation of a data processing system with active power and temperature management according to one embodiment of the present invention. In **Figure 8**, the data processing system contains system core logic 801 (North Bridge), which interconnects CPU 805 and RAM 809. I/O controller 803 (South Bridge) connects core logic 801 with hard drive 811 and optical drive 813 (e.g., CD ROM, DVD ROM, CD R, CD RW, DVD R, or DVD RW) and other I/O devices (e.g., a keyboard, a cursor control device, or others, not shown in **Figure 8**). Some components (e.g., CPU 805, GPU 807 and RAM 809) may have elevated temperature after generating significant amount of heat during operation. Some components (e.g., hard drive 811 and optical drive 813) consume more power at a high speed and less power at a lower speed. Heat pipe 825 moves heat from one location to anther to transfer heat; heat sink 823 absorbs heat to regulate temperature; and, under the control of fan controller 845, variable speed fans 819 and 821 can work at different speeds for tradeoff between the rate of cooling and the associated cost (e.g., noise and power consumption). Sensors 831 and 833 monitor the temperate of GPU 807 and CPU 805 for active management of the system according to embodiments of the present invention.

[0094] **Figure 8** shows a particular configuration for the illustration purpose. It is understood that different configurations can also be used with various methods of the present invention.

[0095] In one embodiment, CPU power 843 is controllable to move the core voltage of CPU 805 from one point to another for the shifting of power consumption level (e.g., along path 701 in **Figure** 7); and, clock source 841 is controllable to slew the core frequency of CPU 805 from one point to another for the shifting of performance level (e.g., along path 703 in **Figure 7**). When the CPU is working at a lower frequency, the CPU voltage is reduced to save power and reduce heat generation.

[0096] In **Figure 8**, sensor 831 measures the temperature of GPU 807; thus, GPU 807 and sensors 831 are in thermal zone 853. CPU 805, fan 819 and sensor 833 are thermally coupled in thermal zone 851. Fan 821 may cools power unit 817 and other components sufficiently such that other components may not need active thermal management.

[0097] Although the software-based thermal and power management can manage the operations of the system according to combined goals to achieve a best mix, software may crash. Thus, a hardware-based failsafe mechanism is used in one embodiment of the present invention as a backup. For example, sensor 835 may trigger a safety alert when a safety threshold for temperature is reached or exceeded. Note that sensor 835 may be replaced by an output from sensor 833 or 831. Alternatively, sensor 835 may be a circuit which combines the output of sensors 831 and 833 for safety trigger. In one embodiment of the present invention, the temperature sensors can trigger operations (e.g., force the fan to run at the full speed or a shutdown of the system) to prevent thermal runaway (overheating to cause damage), when the temperature is above a threshold. In one embodiment, the sensor sends a signal to the power management unit (PMU 815) when this happens; and, PMU 815 controls power unit 817 for emergency powering off to prevent permanent damage.

[0098] In one embodiment of the present invention, software (e.g., a part of the operating system) has the responsibility for keeping all components within their respective thermal specification. The hardware failsafe is intended to prevent a crashed system from destroying itself. As such, the failsafe threshold may be set above a device's maximum operating temperature, as long as it is still below the threshold above which permanent damage may occur.

[0099] In one embodiment, PMU 815 implements a forced system shutdown function. When a hardware failsafe trips (e.g., by sensor 835), PMU 815 tries to determine if the CPU is active. One method of determining if the CPU is dead is to use a watchdog timer (e.g., in KeyLargo/K2) to determine whether the CPU response to a signal within a specified time period set for the timer. If the CPU is dead (e.g., not responding to the signal before the timer expires) after the failsafe has tripped, PMU 815 shuts off power to the system.

[00100] In one embodiment, when the failsafe triggers, the information about the failsafe shutdown is recorded so that a user can find out about the event at the next boot of the system. If a machine refuses to boot because it detects a misapplied heatsink, the LED emits a code to convey the nature of the failure. Further, when the system cannot be sufficiently cooled, and devices are set to slower operating speeds, the user might be informed that the system's performance is suffering because of the heat.

[00101] Heatsinks (e.g., 823) generally provides a valuable time to respond to non-responsive systems. Conversely, misapplied heatsinks can lead to destruction of a CPU in mere seconds. In one embodiment, during boot time, PMU 815 has a thermal trip watchdog timer that shuts off a non-responsive system with a time period before an unsinked device melts down.

[00102] In one embodiment of the present invention, the boot ROM code sets the thermal trip points in the thermal sensors for devices that might sustain permanent damage if over a critical temperature for more than a few seconds (e.g. CPUs).

[00103] In one embodiment of the present invention, software manages a thermal zone (e.g., 851) by controlling one or more fans (e.g., fan 819 or other "cooling" devices, such as CPU 805 for reduced heat generation) in that zone. The fan control is in the form of speed control, and not simple on or off operations. For example, a signal is sent to control the fan speed by varying duty cycle.

[00104] In addition to telling the fan how fast to spin, the software detects whether or not the fan has responded to reliably manage the thermal zone. For example, the software can used the tachometer input from fan controllers to obtain this feedback.

[00105] In one embodiment of the present invention, the tachometer feedback is to ensure that the fan begins spinning when first turned on. Fans may run at speeds slower than those required for spin-up. Some fan controllers start the fan at full speed and then backs off. In one embodiment, a better algorithm for spinning up a fan is to slowly increase the duty cycle until the fan starts up, and then slowly back it down to the actual desired fan speed (if slower than the startup speed). Tachometer feedback can be used to implement this algorithm.

[00106] In one embodiment of the present invention, a fan is controlled by a fan curve, which describes the relationship between the temperature values of one or more temperature sensors and the speed of the fan. For example, one fan curve specifies that for a given temperature the fan is to run a given speed. In one embodiment, there is one fan curve to map each senor to each fan for a given performance level; thus, the total number of fan curves is:

[00107] (number of sensor and performance level combinations) × (number of fans)

[00108] The manager select the maximum speed from the speeds required by all sensors according to the fan curves at the current performance level as the desired fan speed.

[00109] In one embodiment of the present invention, the fan curves are determined based on temperature measurements taken at different fan speeds and at different performance levels.

[00110] In one embodiment of the present invention, software controls fan speed to manage system thermals. The goal of the software is to run the fan, as slowly and quietly as possible while maintaining device specification. Since a single thermal zone may have multiple hot spots, the software runs the fan at the slowest speed required to keep all hot spots in check, even if it means that one device is cooled more than required in order to keep another device within the specification.

[00111] In one embodiment of the present invention, Active Thermal Management software is implemented in the kernel of an operating system. A thermal manager processes input data, including sensed information (e.g., temperature, CPU processing load, GPU processing load), detected conditions (e.g., battery charging, lid closed, sleep mode) and user preferences (e.g., prefer high graphics processing, prefer low noise) to optimize and direct accordingly CPU and/or GPU processing levels, battery charging periods, fan speeds and drive performance. Thus, the management system integrates the inputs from sensors, user preferences, current tasks and other conditions like lid closed operation to determine the optimum way to keep the temperature of the system within a desired range by increasing the cooling or decreasing the heat produced. In at least one embodiment, users of the data processing system can manage their own thermal solutions through the thermal management software modules implemented on the data processing system (e.g., by setting the user preferences).

[00112] **Figure 9** shows a software module diagram which shows software to manage the operation state of a data processing system according to one embodiment of the present invention. In one embodiment of the present invention, a thermal management software system includes several modules, including sensor driver 907, thermal manager 901, and control driver 903. Thermal manager 901 performs the central decision-making. Sensor driver 907 communicates with device driver 909 to obtain sensed information; and, control driver 903 communicates with device driver 905 to adjust working states of one or more components (e.g., CPU, GPU or fan). In one embodiment of the present invention, device information 911 from the device tree 913 and Boot ROM 915 are collected for the instantiation of sensor driver 907 and control driver 903 during the initialization period.

[00113] In one embodiment of the present invention, the thermal manager monitors and controls the internal temperatures of the data processing system, on which the operating system is running, to prevent uncomfortable or unsafe temperatures. Certain parts, like the processor and graphics hardware, are more prone to overheating than others. Other components, like optical and hard drives, may fail due to excessive heat in the system. In order to monitor the temperatures of particularly hot components, the thermal manager (901) obtains temperature information about them from sensor drivers (e.g., 907). Based on the temperature information, the operating system instructs control drivers (e.g., 903) to take action to mitigate temperature increases as necessary in a coherent fashion.

[00114] In one embodiment of the present invention, thermal manager 901 contains a set of global rules that dictate how to manage the system: whether to manage more heavily, stay the same, or manage less heavily. For example, a thermal manager may contain a Cooling Decider to determine the amount of cooling adjustment required based on the information obtained from sensor driver 907, a priority decider to prioritize a list of controls according to user preferences 921, system information 923, and a control decider to adjust the controls according to the prioritized list of controls to achieve the determined amount of cooling adjustment. For example, the Cooling Decider takes sensor value data of the present invention. In one embodiment of the present invention, a thermal management software system includes several modules, including sensor driver 907, thermal manager 901, and control driver 903. Thermal manager 901 performs the central decision-making. Sensor driver 907 communicates with device driver 909 to obtain sensed information; and, control driver 903 communicates with device driver 905 to adjust working states of one or more components (e.g., CPU, GPU or fan). In one embodiment of the present invention, device information 911 from the device tree 913 and Boot ROM 915 are collected for the instantiation of sensor driver 907 and control driver 903 during the initialization period.

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For example, the Cooling Decider takes sensor value data and calculates how much it should turn the system cooling up or down. Specific rules that represent additional criteria, such as user preferences and environmental factors, are used to prioritize the available controls for use in the determination of control indices. The Priority Decider creates a sorted list of controls ranked in the order they should be changed according to these rules. The Cooling Decider passes the desirable cooling change and any relevant information, such as the target thermal zone in which the cooling change is to be implemented, to a Control Decider, which implements the desirable cooling change. The Control Decider takes the amount of cooling determined by the Cooling Decider and parcels out those changes to the controls in the order determined by the Priority Decider. In one implementation, this decision-making happens at polled intervals.

[00115] In one embodiment of the present invention, thermal manager 901 employs Fuzzy Logic and other data-driven algorithms to manage system temperature. For example, the Cooling Decider uses fuzzy logic principles and inference rules to determine the amount of cooling change, instead of modeling the system mathematically, in which the fuzzy logic model is empirically derived and modified through testing or simulation. An example of a rule is:

[00116] IF (temperature is hot) AND (temperature is increasing) THEN (turn cooling up).

[00117] After a number of rules are evaluated, their results are combined to generate a single result. Terms like (temperature is very hot), (temperature is increasing) or (turn cooling up a lot) can be defined for better precision in control.

[00118] For example, a Cooling Decider may use the following rules.

[00119] 1. IF (temperature is cold) THEN (turn cooling down)

[00120] 2. IF (temperature is warm) THEN (do nothing)

[00121] 3. IF (temperature is hot) THEN (turn cooling up)

[00122] **Figure 10** illustrates an example of a method to determine actions to be performed using fuzzy logic in operating a data processing system according to one embodiment of the present invention. A sensed temperature may be classified non-exclusively as cold, warm and hot. For example, if the current temperature is a number of degrees below the desired temperature, it can be classified mostly warm and a little cold. In **Figure 10**, membership functions 1001, 1003 and 1005 define the levels of truth for the classification of different temperatures. For example, curve 1001 represents the level of truth for different temperatures. When the different between the current temperature and the target temperature, $T-T_o$, is between -10^o and 0^o, the truth value increases linearly as the current temperature reduces (and decreases as the current temperature increases). When the current temperature is 10^o below the target temperature, the truth value of being cold is 1.0; and, when the current temperature is above the target temperature, the truth value of being cold is 0.0. Curve 1003 defines non-constant truth values of warm when the difference between the current temperature and the target temperature ($|T-T_0|$) is less than 10^o; and, curve 1005 defines the linear variation of truth values of hot when the current temperature is within 10^o above the target temperature. Thus, if a current temperature is 7.5^o, the truth values for cold, warm and hot are 0, 0.25 and 0.75 (1021, 1023 and 1025) respectively. The above rules for the cooling decider then lead (1011, 1013 and 1015) to the corresponding truth values 0, 0.25 and 0.75 for the actions (turn cooling down), (do nothing) and (turn cooling up) respectively, when the above inference rules are used.

[00123] Membership graphs may be of complex shapes, such as Gaussian curves. Keeping them to triangles and trapezoids makes the calculations much faster.

[00124] **Figures 11** and **12** illustrate an example defuzzification method to merge different actions as one quantified action to operate a data processing system according to one embodiment of the present invention.

[00125] To merge the different results, the Cooling Decider goes through a process called "defuzzification" to get a single, crisp result in the range of ±20 units for the cooling, assuming the change of cooling is always limited within 20 units. Consider an example in which the actions of (turn cooling down), (do nothing) and (turn cooling up) have member functions 1111, 1113 and 1115 respectfully, as shown in **Figure 11**. In **Figure 11**, when cooling is turned down by no more than 10 units, the truth value of (turn cooling down) increases linearly as the unit of cooling decreases; when cooling is turned up by no more than 10 units, the truth value of (turn cooling up) increases linearly as the unit of cooling increases; and, when the change in cooling ($|\Delta C|$) is less than 10 units, (Do nothing) has non-constant truth value.

[00126] Note that the shapes, ranges and slopes of member functions 1111, 113 and 1115 for (turn cooling down), (do nothing) and (turn cooling up) are in general different from those for cold, warm and hot.

[00127] A commonly used method for "defuzzification", called the Centroid algorithm, first clips each consequent (result) by the degree of truth of its antecedent. Since (turn cooling down), (do nothing) and (turn cooling up) have truth values 0, 0.25, 0.75 respectively, member functions 1111, 1113 and 1115 are clipped to generate functions 1101, 1103 and 1105 respectively.

[00128] Next, the clipped member functions are overlaid as in **Figure 12** to calculate an average point where there is an equal area under the graph on each side of the average point. This is analogous to finding the center of mass in physics and is called the Centroid Method. Curve 1203 in **Figure 12** corresponds to the portion of curve 1103 between points 1122 and 1125 in **Figure** 11; and, curve 1205 corresponds to the portion of curve 1105 beyond point 1126. The average point 1211 in **Figure 12** is at 10.2 unit. Thus, the Cooling Decider reaches the conclusion to turn up cooling for 10.2 units.

[00129] The priority decider and the control decider then determine how to turn up cooling for 10.2 units.

[00130] There are at least two kinds of data that are taken into account in deciding the priority ordering of controls: thermal zone and control type. For example, a system might have two fans: a CPU near one fan, and a GPU near the other. In this example, there might be two thermal zones, one specifying the CPU and its associated fan, and the other specifying the GPU and its fan. However, the fans, CPU, and GPU are different types of thermal controls: they create different side effects when in modulating the temperatures. Therefore, they are associated by type of control (e.g., fan, processor, etc). Each type of control has certain known properties, depending on the user's preferences or current environmental factors.

[00131] The Priority Decider prioritizes the controls by type and zone into a single priority queue for the Control Decider to adjust. For example, the list can be determined by user profiles, like "quiet" and "high performance." These profiles sort the controls by type. Within a type, the controls can be ordered by proximity to hot sensors: if a particular control is closer to the hot sensor than another similarly-typed control, it will have a higher priority. However, differently-typed controls are sorted according to profiles, not zones.

[00132] In one embodiment of the present invention, the Priority Decider is based on an expert system, which takes in dynamic system information and applies it to a list of rules to determine the priorities of the controls. The rules for the Priority Decider include system environmental rules and user preference rules. A level of priority indicates that the level of importance of the work of the device. Examples of system environmental rules include:

[00133] If intake temperature is high, decrease the fan's priority

[00134] If battery is charging and is above 90%, increase the battery charger's priority

[00135] If CPU load is low, decrease the CPU's priority

[00136] If zone x is hot, use controls in zone x first

[00137] If graphics pipeline is busy, decrease the GPU's priority

[00138] If DVD is playing, decrease the CPU's priority

[00139] If burning CD/DVD, decrease the CPU's priority

[00140] If filesystem is busy, decrease the hard drive's priority

[00141] If sensors are too hot, don't burn CD/DVD

[00142] If CPU speed is too slow, can't burn CD/DVD

[00143] Examples of user preference rules include:

[00144] If "quiet," decrease the fan's priority

[00145] If "high performance," decrease the CPU's priority

[00146] If "high performance," decrease the GPU's priority

[00147] The Control Decider adjusts the list of controls to achieve the required cooling change determined by the Cooling Decider, according to a list of controls ranked by the Priority Decider in the order they should be changed. In one embodiment, the cooling change that the Cooling Decider provides can be considered as the quantity of total control index change to be made, with 0 being no cooling change, positive representing more aggressive cooling, and negative representing less aggressive cooling.

[00148] For example, if the Cooling Decider determines to increase cooling for a number of units, the control with the lowest priority is adjusted first (e.g., to reach the maximum cooling capacity if necessary) to provide the required cooling. If the required unit of cooling is not satisfied after the total cooling capacity of the control with the lowest priority is exhausted, the control with the next lowest priority is adjusted. Thus, the list of controls is processed in the ascending order of priority for adjustment until the required units of cooling is satisfied.

[00149] Similarly, if the Cooling Decider determines to decrease cooling for a

number of units, the control with the highest priority is adjusted first (e.g., to reach the minimum cooling capacity and maximum performance) to accommodate the decrease of cooling. If an extra number of unit of cooling is available for decreasing after the cooling provided by the control with the highest priority reaches the minimum, the control with the next highest priority is adjusted. Thus, the list of controls is processed in the descending order of priority for adjustment until the given units of cooling is decreased.

[00150] In one embodiment of the present invention, the number of cooling units to be changed can be zero, with the changed priorities of the controls. To reflect the changes in priorities, the cooling units may be traded between controls of different priorities to achieve better performance. For example, if high priority control A is providing more cooling than low priority control B, the high priority control A is adjusted for higher performance but less cooling, while the low priority control B is adjusted to provide more cooling to compensate for the reduced cooling from control A.

[00151] In one embodiment of the present invention, the information about sensors and controls in the system (e.g., type, zone, and others), environmental parameters (e.g., high/low temperature thresholds), membership functions and inference rules required by the Cooling Decider, priority lists of controls needed for various user-affected settings, and others are collected (e.g., from device tree 913, Boot ROM 915) during an initialization period (e.g., at startup) of the management system.

[00152] **Figure 13** shows a software module diagram which shows software to manage the operation state of a data processing system according to one embodiment of the present invention. In one embodiment of the present invention, thermal manager manages system temperature through making simple decisions based on the temperature sensors and adjusting the CPU and GPU performance accordingly. In one embodiment, the thermal manager is a platform dependent driver (e.g., platform monitor 1321) that responds to events generated by sensor drivers (e.g., in response to excessive thermal loading), power management requests (e.g., from power management 1313), or configuration changes from the user to modify the behavior of the system (e.g., by adjusting the working states of the components of the data processing system through controls 1325, 1327 and 1329). The thermal manager monitors the environmental factors (e.g., using sensors 1323) and takes necessary action to prevent damage to machine components or loss of user data.

[00153] In one embodiment of the present invention, state watcher 1311 allows a user to monitor sensors and observe the behavior of the thermal manager. This tool may be used to report all relevant data from the thermal management system, as well as make runtime tweaks to parameters in the system. For example, the user can see what the system would do if it were at a certain temperature or a certain state and set thresholds and polling periods for the individual sensors.

[00154] In one implementation, platform monitor 1321 implements a state machine, which in response to the input, adjusts various system parameters in order to adjust the level of cooling needed for the computer system. The knowledge about the temperature being managed and what constitutes too hot versus too cold are coded in the platform monitor. In one embodiment of the present invention, the platform monitor determines the current state of the system from the information obtained from the sensor drivers and adjusts the thermal controls of the system to move the system from one state to another, if the current state is not a desirable one. For example, the states are determined from the information collected from sensors (e.g., temperatures sensors), system conditions (e.g., lid open or closed), and preferences (e.g., "quiet" or "high performance"). There may also be different profiles for lid-closed, "quiet", or other situations so that the monitor actively manages the system to move between the states in the current profile. The platform monitor is platform specific and has detailed knowledge of the platform on which it is running. Using this knowledge, it collects information from sensors in the system and takes appropriate actions based on the states of these sensors.

[00155] Sensor drivers provide environmental information about the computer. An instance of a sensor driver represents a specific environmental-sensing device, like a thermistor, an ambient light sensor, or a software sensor like kernel load factor. For example, temperature sensors provide temperature information about the data processing system on which the sensor drivers are running. A sensor driver gets information about the sensor (e.g., thermal zone, type (such as temperature, light, battery, kernel load), thresholds, and others). Sensor drivers can be polled to get the current values and may support event notification to signal important threshold conditions.

[00156] A sensor driver (e.g., 907 or 1323) may apply to any sensor that detects one aspect of the state of the system. For example, the user selecting "Reduced performance" in the Energy Saver preference panel is sensor input. Whether the user has open or closed the clamshell is sensed information about the environment of the data processing system. Any input may trigger a response that dictates a state change of the system; and, the platform monitor is the centralized decision maker for taking actions to adjust the state of the system.

[00157] In one embodiment, each sensor registers itself with the manager (e.g., platform monitor 1321 or thermal manager 901). For some sensors, such as temperature sensors, the manager sets a threshold that controls when the sensor driver notifies the manager. For example, a temperature sensor may be given an upper threshold and a lower threshold so that the sensor driver notifies the manager whenever the sensed temperature crosses one of those thresholds. The sensor may be a smart one so that it triggers an interrupt when a threshold is crossed. Alternatively, the sensor driver may simulate this behavior by polling the sensor and only notifying also registers as a client of the sensor driver to establish communication. The sensor driver sends a message to the manager when an interesting event occurs, such as a threshold that has been hit or exceeded, or when the manager polls the sensor for the current value. In one embodiment of the present invention, the generic temperature sensor driver is a generic liaison driver. It obtains the actual value for the sensor by talking to a specific device driver.

[00163] Control drivers are the actual effectors of the state change. Examples of these include drivers that can change CPU multiplier, system bus speed, or GPU performance level. In one implementation, some of these controls are linked into the manager (e.g., platform monitor).

[00164] In one embodiment of the present invention, an instance of a control driver represents a device that is able to adjust its working state for environmental variation, including devices that are designed for removing heat, such as fans, or devices that can adjust their performance to reduce heat generation. Control drivers may be visualized as a dial for the output of the device they're controlling. In one implementation, a control driver accepts a value for the dial (e.g., indicating a working state as a index value within 0-100, with higher values representing most aggressive cooling and lower values representing least aggressive cooling); and, the control driver also supports reporting its current index value and information about whether it is at the maximum or minimum control level.

[00165] The devices that can have a corresponding control driver include: CPU, GPU, fan, backlight, battery charging, hard drive, optical drive, PCI card, and others. CPU and GPU can be of a type of "performance hit" for which different working states correspond to different tradeoff in performance and heat generation (or power consumption); fan can be of a type of "noisy" for which different working states correspond to different tradeoff in heat removal (and noise) and power consumption; backlight and battery charging can be of a type of "user impact" for which different working states correspond to different tradeoff in user experience impact and power consumption.

[00166] The CPU clock is generated for some CPUs via an on-chip PLL that selectively multiplies and divides the processor bus clock. However, the CPU clock PLL configuration of many microprocessors is only programmable during a reset cycle. Thus, these CPU may be rebooted in order to change clock speeds. The special reset cycle for changing clock may be accomplished by programming a register in the memory controller for state initialization and then sending a command to the PMU for a reset.

[00167] The latency for switching the CPU multiplier is very high when a complete reset of the CPU is performed. In such an implementation, interrupts can be deferred for a period of time until the CPU reset is complete. This high interrupt latency can be evident to the end use in the form of audio drop outs and/or pops. Thus, such a method for CPU speed switch is generally not transparent without affecting the user experience. In one embodiment of the present invention, such an approach for CPU multiplier shift is used primarily to cope with excessive thermal stress.

[00168] To achieve a more transparent CPU speed change, the CPU clock is altered through slewing (slowly changing) the bus clock. Some microprocessors derive their clock from the system bus clock using an on-chip PLL. In one embodiment of the present invention, the processor clock is changed, without a reset, through slowly changing the processor bus clock at a rate slow enough to allow the on-chip PLL remain locked. One technical challenge is that changing the bus clock has the side effect of changing the rate at which the decrementer register is modified. In one embodiment of the present invention, several hardware components are used to implement CPU speed adjustment through slewing the bus clock, including a programmable clock source (e.g., Cypress CY28512) to support slewing and a circuitry in the core logic to handle the time base drift problem. Some CPUs have a signal called "TBEN" (Time Base ENable), which can be used to temporarily stop the processor from keeping track of time. Custom logic inside the core logic modulates (changes) the TBEN signal in response to monitoring the master clocks. As a result, the CPU concept of time is updated at a constant rate, even though the bus clock changes with time.

[00169] In one embodiment of the present invention, a chip (e.g., CY28512) is used to take in a clock signal, apply some user-programmable multipliers to it, and output the clock signal at the resulting frequency. The formula that the chip uses to calculate the output frequency is as follows:

[00170] Output Frequency = Input frequency * (N / M)

[00171] The N and M values (along with some other options) are user programmable. For better usability, some chips (e.g., CY28512) accept two separate pairs of N and M values, and provides a way to switch between them. At initialization time, one pair is programmed with a set of "low" multipliers for the generation of a low output frequency, and the other pair with a set of "high" multipliers for the generation of a high output frequency. While the system is running, a control driver can toggle between them dynamically to effectively turn the clock frequency up and down. To slew the frequency slowly enough so that the on-chip PLL of the CPU can follow the frequency change, a number of frequency changes can be performed in small steps.

[00172] One advantage of lowering the clock frequency is that it allows the system to run at a lower voltage than normal to save power and reduce heat. Thus, after turning the clock down, the control driver can also turn the voltage down.

[00173] Some Graphics Processing Units (GPU) (e.g., the nVidia GeForce4Go (NV17M)) have a variety of power saving features designed (e.g., with a mobile application in mind). Some of these features are automatic; and, others are manually settable. For example, NV17M allows the chip to turn off unneeded areas to save power when they are not being used. Unused blocks can power down, as they are not needed. For example, the driver to an unattached display can be powered off if a second display is not attached, or the MPEG decoder cell turned off if there is no need for it. The hardware clock saves power during tiny fractions of a second when the graphics hardware is not being used to its fullest.

[00174] The configurable feature of the NV17M is the ability to modify the swap interval. The swap interval defines the maximum number of frames the GPU renders per second. It also defines the number of screen refreshes between redraws. The overall effect is a change in GPU workload, which may also change the workload of the CPU. For example, the GPU may be configured to work at swap interval of 0 without power saving, at swap interval of 1 to generate frames at no faster than the display refresh rate, or at swap interval of 2 to generate frames at half the display refresh rate. In one embodiment of the present invention, the configurable swap interval is manipulated to limit temperature.

[00175] In one embodiment of the present invention, devices that act as sensors or controls are described in the device tree with a set of properties added to the nodes in the device tree, such as the type of sensor (i.e. temperature), a unique sensor ID, and the thermal zone of the sensor, location, polling period, and others. During the initialization period, control drivers and sensor drivers obtain this information from the device tree. For example, a control driver gets from the device tree information about the control, such as thermal zone, attributes (e.g., performance hit, noisy, cooling device), type of control (e.g., fan, processor, etc). The manager uses this information in determining the instantaneous index value for each control when new sensor values arrive. When an instantaneous index is received from the manager, the control driver communicates with one or more device drivers to adjust the control as necessary.

[00176] A state manager connects the sensor drivers and the control drivers to manage the working states of the components to provide the desirable result. For example, the levels of power and temperature dynamics may be control by the manager to best perform the current task within power and thermal constraints. The manager chooses the most relevant thermal controls to adjust, as well as how much to adjust. When some sensors indicate that they are at a particularly low temperature, the polling of these sensors may be stopped after setting a threshold at which the sensors notify the system to restart polling them.

[00177] While the modules are functionally very independent, they may be in separate drivers or combined drivers. For example, some hardware device, such as fan controllers, may a combined sensor and control driver. If the only temperature of interest is the highest one of a number of thermistors, they may be combined into a single sensor. Further, the Cooling, Priority and Control Deciders may be just sets of routines within a single code module. From this description, a person skilled in the art can envision many different combinations, modifications and variations.

[00178] **Figures 14 – 16** show methods to operate a data processing system according to embodiments of the present invention.

[00179] In **Figure 14**, operation 1401 receives sensed information from a plurality of physical sensors (e.g., thermistor, tachometer) instrumented in a housing of a data processing system. Operation 1403 receives load information on processing loads (e.g., CPU load). Operation 1405 controls working states of a plurality of components of the data processing system in the housing according to the sensed information and the load information. The sensed information and the load information can be used to fine grain control the components to balance different goals, such as high performance, low power consumption, low acoustic noise, thermal constraints, user preferences, system design constraints, and others.

[00180] In **Figure 15**, after operation 1501 collects sensed information (e.g., CPU load and processor temperatures) from a plurality of sensors of a data processing system, operation 1503 determines a current state of the data processing system based on the sensed information and user preferences. Operation 1505 determines a target state according to a predetermined state diagram. Operation 1507 selectively adjusts a set of controls to change working states of components of the data processing system to move the system from the current state to the target state. The state diagram may be pre-designed to specify control adjustments for transition from one state to another to balance different goals.

[00181] **Figure 18** illustrates an example of a state diagram which shows a way to operate a data processing system according to one embodiment of the present invention. In one embodiment of the present invention, the state of the system is determined from the temperature and the position of the lid. When the temperature is in the normal range, the system is either in state 1817 if the lid is in the open position or in state 1827 if the lid is in the closed position. When the system is in state 1817 or 1827, the system is allowed to operate at a maximum performance level. For example, the cooling provided by the CPU is at the lowest level (e.g., 0%), allowing a fast dynamic speed and the maximum computation performance; and, the cooling provided by the GPU is also at the lowest level (e.g., 0%). It is understood that the cooling provided by a processor (e.g., CPU or GPU) can be achieved through adjusting the working state of the processor to reduce the power consumption and the associated heat (e.g., through reducing the clock frequency and the core voltage). However, in one embodiment, when the lid is closed, the PMU is forced to run at a slow speed. As the temperature T increases to pass thresholds $T^{a}_{lid\text{-}open}$, $T^{b}_{lid\text{-}open}$, $T^{c}_{lid\text{-}open}$, and $T^{d}_{lid\text{-}open}$, the state of the system transits from state 1817 (normal) to states 1815 (warm), 1813 (very warm), 1811 (hot), and 1803 (very hot), if the lid is open. Similarly, as the temperature T increases to pass thresholds $T^{a}_{lid\text{-}closed}$, $T^{b}_{lid\text{-}closed}$, $T^{c}_{lid\text{-}closed}$, and $T^{d}_{lid\text{-}closed}$, the state of the system transits from state 1827 (normal, lid closed) to states 1825 (warm, lid closed), 1823 (very warm, lid closed), 1821 (hot, lid closed), and 1803 (very hot, lid closed), if the lid is closed. As the system goes into the states of high temperatures, the working states of the components of the system may be adjusted to cool down the system. For example, when in state 1815 (1825, 1813, 1823, 1811 or 1821), the cooling of the CPU may be adjusted to a higher level (e.g., 50%) to trade performance for cooling. For example, the

CPU may be forced into a slow dynamic speed. Further, when in a very hot state (1803), the working state of the CPU may be adjusted to provide maximum cooling (e.g., 100%). Similarly, when in state 1813 (or 1823), the cooling of the GPU may be adjusted to a higher level (e.g., 50%) to trade performance for cooling; and, when in state 1811 (1821, or 1803), the working state of the GPU may be adjusted to provide maximum cooling (e.g., 100%). To provide cooling from the graphics system, DVD (or other optical drive) speed may be reduced. When the temperature exceeds the safety threshold (e.g., $T > T_{safety}$), the system moves into a too hot state (1801), in which state PMU initiates a request for forced sleep. If the system remains in the too hot state (e.g., for 4 minutes) without going to a sleep mode, PMU triggers a forced shutdown. Without changing the temperature range, the system may transit between a lid closed state (e.g., 1821 – 1827) and a corresponding lid open state (e.g., 1811 – 1817) when the lid is opened or closed. When the system cools down, working states of the components (e.g., CPU, GPU, DVD) can be adjusted for higher performance. In **Figure 18**, different thresholds are used for defining the transition between two states due to the change in temperature. For example, when $T > T^{a}_{lid\text{-}open}$, the system moves from state 1817 (normal) to state 1815 (warm); and, the system moves back to state 1817 (normal) from state 1815 (warm) only when $T < T^{a}_{lid\text{-}open} - T_{hysterisis}$. The difference in the threshold, $T_{hysterisis}$, allows the system to be at one state when the temperature fluctuates only slightly near one threshold, avoiding unnecessary actions in adjusting working states.

[00182] Although one embodiment of the present invention uses the state diagram illustrated in **Figure 18** and operations for cooling adjustment for various states described above with **Figure 18**, it is understood that various different states of a state diagram can be defined and used for the operation of a computer system. Further, different transition paths and different adjustments of working states to more or less components (e.g., fan, memory chips, microprocessors, graphics chips, hard drives, optical drives, bridge chips, and others) for cooling and performances can be defined for different state diagrams for operating a data processing system. For example, in one implementation, when T exceeds T_0, cooling fan is activated (e.g., 33% duty cycle for ADM103x); when $T \leq T_1$, CPU can run at full speed; when T exceeds T_2, cooling fan runs at full speed; when T exceeds T_3, CPU is forced into reduced speed mode; when T exceeds T_4, the system is forced to sleep, or to shutdown if not responding to the request to sleep.

[00183] In **Figure 16**, after operation 1601 collects sensed information (e.g., CPU load and processor temperatures) from a plurality of sensors of a data processing system, operation 1603 determines an amount of cooling change based on the sensed information. For example, fuzzy logic principles and inference rules can be used to determine the amount of cooling changes based on the sensed information. Operation 1605 determines a prioritized list of controls to balance different goals (e.g., performance, power consumption, thermal constraint, acoustic noise, user preference, system constraint). For example, an expert system can be used to prioritize the list according to a number of system rules and user preferences. Operation 1607 selectively adjusts a subset of the prioritized list of controls to effect the amount of cooling change. The amount of cooling change can be parceled out to one or more controls according to the priorities of the controls.

[00184] **Figure 17** illustrates a method to parcel out cooling changes to a number of controls according to one embodiment of the present invention.

[00185] If operation 1701 determines to increase cooling, operation 1711 first increases the speed of the cooling fan (e.g., up to the maximum fan speed when necessary). If operation 1713 determines that more cooling is required, operation 1715 decreases the CPU clock frequency within the allowable frequency range; and, operation 1717 decreases the CPU core voltage within the allowable frequency range. This adjustment to the CPU reduces the heat generation at the expense of computation performance. Thus, the thermal constraint can be maintained while running the system at high computation performance.

[00186] If operation 1703 determines to decrease cooling, operation 1721 increases the CPU core voltage within the allowable voltage range; and, operation 1723 increases the CPU clock frequency within the allowable frequency range. This adjustment to the CPU increases the computation performance of the CPU and heat generation, which corresponds to decrease cooling. If the CPU is at the maximum performance state and operation 1725 determines less cooling is allowable, operation 1727 decreases the speed of the cooling fan to reduce noise and power consumption.

[00187] If operation 1731 determines that the CPU and the fan can trade cooling, operation 1733 increases the CPU core voltage; operation 1735 increases the CPU clock frequency; and, operation 1737 increases the speed of the cooling fan. Thus, the CPU is allowed to run at high performance, generating more heat, which is removed by increased cooling from the fan.

[00188] Thus, in **Figure 17**, cooling efforts are parceled out between the CPU and the cooling fan to have a high performance within a thermal constraint. In general, the cooling efforts can be parceled out (e.g., by a Control Decider) among a list of controls according to priorities (e.g., as determined by a Priority Decider), which reflect the balancing of different goals, such as performance, power consumption, thermal constraint, acoustic noise, user preference, system constraint).

[00189] In the foregoing specification, the invention has been described with reference to specific exemplary embodiments thereof. It will be evident that various modifications may be made thereto without departing from the broader spirit and scope of the invention as set forth in the following claims. The specification and drawings are, accordingly, to be regarded in an illustrative sense rather than a restrictive sense.

CLAIMS

What is claimed is:

1. A method to operate a data processing system, the method comprising:

determining a control level for a first component of the data processing system based on information obtained from a plurality of sensors, at least one of the sensors determining a temperature in the data processing system; and

automatically adjusting control of the first component according to the control level to move the first component from a first working state to a second working state.

2. A method as in claim 1, wherein the first component comprises a cooling fan of the data processing system; and, the cooling fan runs at a first speed in the first working state and a second speed in the second working state.

3. A method as in claim 2, wherein a duty cycle of the cooling fan is adjusted to run the cooling fan from the first speed to the second speed.

4. A method as in claim 1, wherein the first component comprises a processor.

5. A method as in claim 4, wherein the first working state comprises a first clock frequency and a first core voltage for the processor; and, the second working state comprises a second clock frequency and a second core voltage for the processor.

6. A method as in claim 4, wherein the processor comprises a Graphics Processing Unit (GPU); the first working state comprises

a first swap interval; and, the second working state comprises a second swap interval.

7. A method as in claim 1, further comprising:

automatically adjusting control of a second component based on the information obtained from the plurality of sensors to move the second component from a third working state to a fourth working state.

8. A method as in claim 7, wherein the first component is a heat source of the data processing system and the second component is a cooling source of the data processing system.

9. A method as in claim 1, wherein the control level is determined further based on one or more user preferences.

10. A method as in claim 1, wherein one of the sensors comprises a software module determining a processor load of the data processing system.

11. A method to operate a data processing system, the method comprising:

determining a subset of controls from a plurality of controls of a plurality of components of the data processing system based on information obtained from a plurality of sensors, each of the plurality of sensors determining an aspect of a working condition of the data processing system; and

adjusting the subset of controls to change working states of corresponding components of the data processing system to balance requirements in performance and in at least one of: thermal constraint and power consumption.

12. A method as in claim 11, wherein the plurality of sensors comprise at least one of:

a) a temperature sensor;

b) a tachometer; and

c) a software module determining a load of a processor.

13. A method as in claim 11, wherein the plurality of components comprise heat sources of the data processing system and cooling sources of the data processing system.

14. A method as in claim 13, wherein the heat sources comprises at least one of:

a) a Central Processing Unit (CPU);

b) a Graphics Processing Unit (GPU);

c) a hard drive;

d) an optical drive; and

e) an Integrated Circuit (IC) chip.

15. A method as in claim 11, further comprising:

determining an amount of cooling change based on the information obtained from the plurality of sensors;

wherein the subset of controls are adjusted to effect the amount of cooling change.

16. A method as in claim 15, wherein the amount of cooling change is determined according to a fuzzy logic.

17. A method as in claim 16, wherein said determining the subset of controls comprises:

determining a prioritized list of the plurality of controls.

18. A method as in claim 17, wherein the prioritized list is determined at least partially based on one or more user preferences.

19. A method as in claim 17, further comprising:

parceling out the amount of cooling change to the subset of controls.

20. A method as in claim 11, further comprising:

determining a first state of the data processing system from the information obtained from the plurality of sensors;

wherein the subset of controls is determined from a decision to move the data processing system from the first state to a second state.

21. A method to operate a cooling fan of a data processing system, the method comprising:

adjusting the cooling fan from running at a first speed to running at a second speed in response to a temperature sensor measurement and a user preference.

22. A method as in claim 21, further comprising:

verifying that the cooling fan is running at the second speed.

23. A method as in claim 22, wherein tachometer information obtained from a fan controller for the cooling fan is used to verify that the cooling fan is running at the second speed.

24. A method as in claim 23, wherein a duty cycle of the cooling fan is adjusted to run the cooling fan from the first speed to the second speed.

25. A method as in claim 21, further comprising:

determining one or more temperature measurements; and

determining the second speed for the cooling fan based at least partially on the one or more temperature measurements.

26. A method as in claim 25, wherein the one or more temperature measurements are obtained from one or more temperature sensors instrumented in the data processing system.

27. A method as in claim 26, wherein the one or more temperature measurements indicate temperatures of at least one of:

a) a microprocessor of the data processing system;

b) a graphics chip of the data processing system; and

c) a memory chip of the data processing system.

28. A method as in claim 27, wherein the microprocessor of the data processing system determines the second speed.

29. A method as in claim 25, wherein the second speed is determined further based on a user preference stored in a machine readable medium of the data processing system.

30. A method as in claim 25, wherein the second speed is determined further based on a computation load level on the data processing system.

31. A method to operate a processor of a data processing system, the method comprising:

shifting a power supply of the processor from a first voltage to a second voltage without resetting the processor.

32. A method as in claim 31, further comprising:

slewing a frequency of a clock of the data processing system to transit a clock of the processor from a first frequency to a second frequency.

33. A method as in claim 32, wherein the processor continues to execute instructions while the frequency of the clock is slewed.

34. A method as in claim 33, wherein the processor continues to execute instructions while the power supply is shifted from the first voltage to the second voltage.

35. A method as in claim 32, wherein the power supply is maintained at one of the first and second voltages while the frequency of the clock is slewed; and, the clock of the processor is maintained at one of the first and second frequencies while the power supply is shifted from the first voltage to the second voltage.

36. A method as in claim 32, wherein the first frequency is higher than the second frequency; the first voltage is higher than the second voltage; and, the power supply is shifted from the first voltage to

the second voltage after the clock of the processor transits from the first frequency to the second frequency.

37. A method as in claim 32, wherein the first frequency is lower than the second frequency; the first voltage is lower than the second voltage; and, the power supply is shifted from the first voltage to the second voltage before the clock of the processor transits from the first frequency to the second frequency.

38. A method as in claim 32, wherein said slewing a frequency of a clock comprises:

instructing a clock chip to use a new frequency multiplier.

39. A method as in claim 31, further comprising:

adjusting a frequency multiplier of the processor to switch a clock of the processor from a first frequency to a second frequency.

40. A method as in claim 39, wherein the processor is not reset during switching from the first frequency to the second frequency.

41. A data processing system, comprising:

a housing;

a plurality of components mounted within the housing, the plurality of components including:

a memory; and

a processor coupled to the memory; and

a plurality of sensors instrumented within the housing, at least one of the sensors determining a temperature in the data processing system, the processor determining a control level for a first component of the plurality of components based on information obtained from the plurality of sensors, the processor causing the first component be adjusted according to the control level to move the first component from a first working state to a second working state.

42. A data processing system as in claim 41, wherein the first component comprises a cooling fan of the data processing system; and, the cooling fan runs at a first speed in the first working state and a second speed in the second working state.

43. A data processing system as in claim 42, wherein a duty cycle of the cooling fan is adjusted to run the cooling fan from the first speed to the second speed.

44. A data processing system as in claim 41, wherein the first component comprises the processor.

45. A data processing system as in claim 44, wherein the first working state comprises a first clock frequency and a first core voltage for the processor; and, the second working state comprises a second clock frequency and a second core voltage for the processor.

46. A data processing system as in claim 44, wherein the processor comprises a Graphics Processing Unit (GPU); the first working state comprises a first swap interval; and, the second working state comprises a second swap interval.

47. A data processing system as in claim 41, wherein the processor further cause a second component of the plurality of components be adjusted based on the information obtained from the plurality of sensors to move the second component from a third working state to a fourth working state.

48. A data processing system as in claim 47, wherein the first component is a heat source of the data processing system and the second component is a cooling source of the data processing system.

49. A data processing system as in claim 41, further comprising:

one or more input/output (I/O) devices coupled to the processor, the one or more input/output (I/O) devices receive one or more user preferences;

wherein the control level is determined further based on one or more user preferences.

50. A data processing system as in claim 41, wherein the processor determines a processor load of the data processing system; and, the control level is determined further based on the processor load.

51. A data processing system, comprising:

a housing;

a plurality of components mounted within the housing, the plurality of components including:

a memory; and

a processor coupled to the memory; and

a plurality of sensors instrumented within the housing, each of the plurality of sensors determining an aspect of a working condition of the data processing system, the processor determining a subset of controls from a plurality of controls of the plurality of components based on information obtained from the plurality of sensors, the processor adjusting the subset of controls to change working states of corresponding components of the data processing system to balance requirements in performance and in at least one of: thermal constraint and power consumption.

52. A data processing system as in claim 51, wherein the plurality of sensors comprise at least one of:

a) a temperature sensor; and

b) a tachometer.

53. A data processing system as in claim 51, wherein the plurality of components comprise heat sources of the data processing system and cooling sources of the data processing system.

54. A data processing system as in claim 53, wherein the heat sources comprises at least one of:

a) a Graphics Processing Unit (GPU);

b) a hard drive;

c) an optical drive; and

d) an Integrated Circuit (IC) chip.

55. A data processing system as in claim 51, wherein the processor determines an amount of cooling change based on the information obtained from the plurality of sensors; and, the subset of controls are adjusted to effect the amount of cooling change.

56. A data processing system as in claim 55, wherein the amount of cooling change is determined according to a fuzzy logic.

57. A data processing system as in claim 56, wherein the processor determines a prioritized list of the plurality of controls in determining the subset of controls

58. A data processing system as in claim 57, further comprising:

one or more input/output (I/O) devices coupled to the processor, the one or more input/output (I/O) devices receive one or more user preferences;

wherein the prioritized list is determined at least partially based on the one or more user preferences.

59. A data processing system as in claim 57, wherein the processor further parcels out the amount of cooling change to the subset of controls.

60. A data processing system as in claim 51, wherein the processor determines a first state of the data processing system from the

information obtained from the plurality of sensors; and, the subset of controls is determined from a decision to move the data processing system from the first state to a second state.

61. A data processing system, comprising:

a housing;

a cooling fan coupled with the housing;

a processor mounted within the housing, the processor causing the cooling fan from running at a first speed to running at a second speed in response to a temperature sensor measurement and a user preference.

62. A data processing system as in claim 61, further comprising:

a tachometer coupled with the cooling fan and coupled to the processor, the processor communicating with the tachometer to verify that the cooling fan is running at the second speed.

63. A data processing system as in claim 62, further comprising:

a fan controller coupled to the cooling fan and the processor, the the fan controller comprising the tachometer.

64. A data processing system as in claim 63, wherein a duty cycle of the cooling fan is adjusted to run the cooling fan from the first speed to the second speed.

65. A data processing system as in claim 61, further comprising:

one or more temperature sensors instrumented within the house, the one or more temperature sensors determining one or more temperature measurements, the processor determining the second speed for the cooling fan based at least partially on the one or more temperature measurements.

66. A data processing system as in claim 65, further comprising:

a graphics chip coupled to the processor; and

a memory chip coupled to the processor.

67. A data processing system as in claim 66, wherein the one or more temperature measurements indicate temperatures of at least one of:

a) the processor;

b) the graphics chip; and

c) the memory chip.

68. A data processing system as in claim 65, further comprising:

one or more input/output (I/O) devices coupled to the processor;

memory coupled to the processor;

wherein the one or more I/O devices receive a user preference and the processor stores the user preference on the memory.

69. A data processing system as in claim 68, wherein the second speed is determined further based on the user preference.

70. A data processing system as in claim 65, wherein the processor determines a computation load level on the data processing system; and, the second speed is determined further based on the computation load level.

71. A data processing system, comprising:

a processor; and

a power supply coupled to the processor to energize the processor with a first voltage, the processor causing the power supply to adjust the first voltage to a second voltage without resetting the processor.

72. A data processing system as in claim 71, further comprising:

a clock source coupled to the processor, the processor deriving a clock of the processor from the clock source, the processor causing the clock source to slew a frequency of the clock source to transit the clock of the processor from a first frequency to a second frequency.

73. A data processing system as in claim 72, wherein the processor continues to execute instructions while the frequency of the clock source is slewed.

74. A data processing system as in claim 73, wherein the processor continues to execute instructions while the power supply is shifted from the first voltage to the second voltage.

75. A data processing system as in claim 72, wherein the power supply is maintained at one of the first and second voltages while the frequency of the clock source is slewed; and, the clock of the processor is maintained at one of the first and second frequencies while the power supply is shifted from the first voltage to the second voltage.

76. A data processing system as in claim 72, wherein the first frequency is higher than the second frequency; the first voltage is higher than the second voltage; and, the power supply is shifted from the first voltage to the second voltage after the clock of the processor transits from the first frequency to the second frequency.

77. A data processing system as in claim 72, wherein the first frequency is lower than the second frequency; the first voltage is lower than the second voltage; and, the power supply is shifted from the first voltage to the second voltage before the clock of the processor transits from the first frequency to the second frequency.

78. A data processing system as in claim 72, wherein the processor instructs the clock source to use a new frequency multiplier to slew the frequency of the clock source.

79. A data processing system as in claim 71, wherein the processor adjusts a frequency multiplier of the processor to switch a clock of the processor from a first frequency to a second frequency.

80. A data processing system as in claim 79, wherein the processor is not reset during switching from the first frequency to the second frequency.

81. A machine readable medium containing executable computer program instructions which when executed by a data processing system cause said system to perform a method to operate the data processing system, the method comprising:

determining a control level for a first component of the data processing system based on information obtained from a plurality of sensors, at least one of the sensors determining a temperature in the data processing system; and

automatically adjusting control of the first component according to the control level to move the first component from a first working state to a second working state.

82. A medium as in claim 81, wherein the first component comprises a cooling fan of the data processing system; and, the cooling fan runs at a first speed in the first working state and a second speed in the second working state.

83. A medium as in claim 82, wherein a duty cycle of the cooling fan is adjusted to run the cooling fan from the first speed to the second speed.

84. A medium as in claim 81, wherein the first component comprises a processor.

85. A medium as in claim 84, wherein the first working state comprises a first clock frequency and a first core voltage for the processor; and, the second working state comprises a second clock frequency and a second core voltage for the processor.

86. A medium as in claim 84, wherein the processor comprises a Graphics Processing Unit (GPU); the first working state comprises

a first swap interval; and, the second working state comprises a second swap interval.

87. A medium as in claim 81, wherein the method further comprises:

automatically adjusting control of a second component based on the information obtained from the plurality of sensors to move the second component from a third working state to a fourth working state.

88. A medium as in claim 87, wherein the first component is a heat source of the data processing system and the second component is a cooling source of the data processing system.

89. A medium as in claim 81, wherein the control level is determined further based on one or more user preferences.

90. A medium as in claim 81, wherein one of the sensors comprises a software module determining a processor load of the data processing system.

91. A machine readable medium containing executable computer program instructions which when executed by a data processing system cause said system to perform a method to operate the data processing system, the method comprising:

determining a subset of controls from a plurality of controls of a plurality of components of the data processing system based on information obtained from a plurality of sensors, each of the plurality of sensors determining an aspect of a working condition of the data processing system; and

adjusting the subset of controls to change working states of corresponding components of the data processing system to balance requirements in performance and in at least one of: thermal constraint and power consumption.

92. A medium as in claim 91, wherein the plurality of sensors comprise at least one of:

a) a temperature sensor;

b) a tachometer; and

c) a software module determining a load of a processor.

93. A medium as in claim 91, wherein the plurality of components comprise heat sources of the data processing system and cooling sources of the data processing system.

94. A medium as in claim 93, wherein the heat sources comprises at least one of:

a) a Central Processing Unit (CPU);

b) a Graphics Processing Unit (GPU);

c) a hard drive;

d) an optical drive; and

e) an Integrated Circuit (IC) chip.

95. A medium as in claim 91, wherein the method further comprises:

determining an amount of cooling change based on the information obtained from the plurality of sensors;

wherein the subset of controls are adjusted to effect the amount of cooling change.

96. A medium as in claim 95, wherein the amount of cooling change is determined according to a fuzzy logic.

97. A medium as in claim 96, wherein said determining the subset of controls comprises:

determining a prioritized list of the plurality of controls.

98. A medium as in claim 97, wherein the prioritized list is determined at least partially based on one or more user preferences.

99. A medium as in claim 97, wherein the method further comprises:

parceling out the amount of cooling change to the subset of controls.

100. A medium as in claim 91, wherein the method further comprises:
determining a first state of the data processing system from the information obtained from the plurality of sensors;
wherein the subset of controls is determined from a decision to move the data processing system from the first state to a second state.

101. A machine readable medium containing executable computer program instructions which when executed by a data processing system cause said system to perform a method to operate a cooling fan of the data processing system, the method comprising:
adjusting the cooling fan from running at a first speed to running at a second speed in response to a temperature sensor measurement and a user preference.

102. A medium as in claim 101, wherein the method further comprises:
verifying that the cooling fan is running at the second speed.

103. A medium as in claim 102, wherein tachometer information obtained from a fan controller for the cooling fan is used to verify that the cooling fan is running at the second speed.

104. A medium as in claim 103, wherein a duty cycle of the cooling fan is adjusted to run the cooling fan from the first speed to the second speed.

105. A medium as in claim 101, wherein the method further comprises:
determining one or more temperature measurements; and
determining the second speed for the cooling fan based at least partially on the one or more temperature measurements.

106. A medium as in claim 105, wherein the one or more temperature measurements are obtained from one or more temperature sensors instrumented in the data processing system.

107. A medium as in claim 106, wherein the one or more temperature measurements indicate temperatures of at least one of:

a) a microprocessor of the data processing system;

b) a graphics chip of the data processing system; and

c) a memory chip of the data processing system.

108. A medium as in claim 107, wherein the microprocessor of the data processing system determines the second speed.

109. A medium as in claim 105, wherein the second speed is determined further based on a user preference stored in a machine readable medium of the data processing system.

110. A medium as in claim 105, wherein the second speed is determined further based on a computation load level on the data processing system.

111. A machine readable medium containing executable computer program instructions which when executed by a data processing system cause said system to perform a method to operate a processor of the data processing system, the method comprising:

shifting a power supply of the processor from a first voltage to a second voltage without resetting the processor.

112. A medium as in claim 111, wherein the method further comprises:

slewing a frequency of a clock of the data processing system to transit a clock of the processor from a first frequency to a second frequency.

113. A medium as in claim 112, wherein the processor continues to execute instructions while the frequency of the clock is slewed.

114. A medium as in claim 113, wherein the processor continues to execute instructions while the power supply is shifted from the first voltage to the second voltage.

115. A medium as in claim 112, wherein the power supply is maintained at one of the first and second voltages while the frequency of the clock is slewed; and, the clock of the processor is

maintained at one of the first and second frequencies while the power supply is shifted from the first voltage to the second voltage.

116. A medium as in claim 112, wherein the first frequency is higher than the second frequency; the first voltage is higher than the second voltage; and, the power supply is shifted from the first voltage to the second voltage after the clock of the processor transits from the first frequency to the second frequency.

117. A medium as in claim 112, wherein the first frequency is lower than the second frequency; the first voltage is lower than the second voltage; and, the power supply is shifted from the first voltage to the second voltage before the clock of the processor transits from the first frequency to the second frequency.

118. A medium as in claim 112, wherein said slewing a frequency of a clock comprises:

instructing a clock chip to use a new frequency multiplier.

119. A medium as in claim 111, wherein the method further comprises:

adjusting a frequency multiplier of the processor to switch a clock of the processor from a first frequency to a second frequency.

120. A medium as in claim 119, wherein the processor is not reset during switching from the first frequency to the second frequency.

121. A data processing system, comprising:

means for determining a control level for a first component of the data processing system based on information obtained from a plurality of sensors, at least one of the sensors determining a temperature in the data processing system; and

means for automatically adjusting control of the first component according to the control level to move the first component from a first working state to a second working state.

122. A data processing system as in claim 121, wherein the first component comprises a cooling fan of the data processing system; and, the cooling fan runs at a first speed in the first working state and a second speed in the second working state.

123. A data processing system as in claim 122, wherein a duty cycle of the cooling fan is adjusted to run the cooling fan from the first speed to the second speed.

124. A data processing system as in claim 121, wherein the first component comprises a processor.

125. A data processing system as in claim 124, wherein the first working state comprises a first clock frequency and a first core voltage for the processor; and, the second working state comprises a second clock frequency and a second core voltage for the processor.

126. A data processing system as in claim 124, wherein the processor comprises a Graphics Processing Unit (GPU); the first working state comprises a first swap interval; and, the second working state comprises a second swap interval.

127. A data processing system as in claim 121, further comprising:

means for automatically adjusting control of a second component based on the information obtained from the plurality of sensors to move the second component from a third working state to a fourth working state.

128. A data processing system as in claim 127, wherein the first component is a heat source of the data processing system and the second component is a cooling source of the data processing system.

129. A data processing system as in claim 121, wherein the control level is determined further based on one or more user preferences.

130. A data processing system as in claim 121, wherein one of the sensors comprises a software module determining a processor load of the data processing system.

131. A data processing system, comprising:

means for determining a subset of controls from a plurality of controls of a plurality of components of the data processing system based on information obtained from a plurality of sensors, each of the plurality of sensors determining an aspect of a working condition of the data processing system; and

means for adjusting the subset of controls to change working states of corresponding components of the data processing system to balance requirements in performance and in at least one of: thermal constraint and power consumption.

132. A data processing system as in claim 131, wherein the plurality of sensors comprise at least one of:

a) a temperature sensor;

b) a tachometer; and

c) a software module determining a load of a processor.

133. A data processing system as in claim 131, wherein the plurality of components comprise heat sources of the data processing system and cooling sources of the data processing system.

134. A data processing system as in claim 133, wherein the heat sources comprises at least one of:

a) a Central Processing Unit (CPU);

b) a Graphics Processing Unit (GPU);

c) a hard drive;

d) an optical drive; and

e) an Integrated Circuit (IC) chip.

135. A data processing system as in claim 131, further comprising:

means for determining an amount of cooling change based on the information obtained from the plurality of sensors;

wherein the subset of controls are adjusted to effect the amount of cooling change.

136. A data processing system as in claim 135, wherein the amount of cooling change is determined according to a fuzzy logic.

137. A data processing system as in claim 136, wherein said means for determining the subset of controls comprises:

means for determining a prioritized list of the plurality of controls.

138. A data processing system as in claim 137, wherein the prioritized list is determined at least partially based on one or more user preferences.

139. A data processing system as in claim 137, further comprising:

means for parceling out the amount of cooling change to the subset of controls.

140. A data processing system as in claim 131, further comprising:

means for determining a first state of the data processing system from the information obtained from the plurality of sensors;

wherein the subset of controls is determined from a decision to move the data processing system from the first state to a second state.

141. A data processing system, comprising:

a cooling fan; and

means for adjusting the cooling fan from running at a first speed to running at a second speed in response to a temperature sensor measurement and a user preference.

142. A data processing system as in claim 141, further comprising:

means for verifying that the cooling fan is running at the second speed.

143. A data processing system as in claim 142, wherein tachometer information obtained from a fan controller for the cooling fan is used to verify that the cooling fan is running at the second speed.

144. A data processing system as in claim 143, wherein a duty cycle of the cooling fan is adjusted to run the cooling fan from the first speed to the second speed.

145. A data processing system as in claim 141, further comprising:
means for determining one or more temperature measurements; and
means for determining the second speed for the cooling fan based at least partially on the one or more temperature measurements.

146. A data processing system as in claim 145, wherein the one or more temperature measurements are obtained from one or more temperature sensors instrumented in the data processing system.

147. A data processing system as in claim 146, wherein the one or more temperature measurements indicate temperatures of at least one of:
a) a microprocessor of the data processing system;
b) a graphics chip of the data processing system; and
c) a memory chip of the data processing system.

148. A data processing system as in claim 147, wherein the microprocessor of the data processing system determines the second speed.

149. A data processing system as in claim 145, wherein the second speed is determined further based on a user preference stored in a machine readable medium of the data processing system.

150. A data processing system as in claim 145, wherein the second speed is determined further based on a computation load level on the data processing system.

151. A data processing system, comprising:
a processor; and

means for shifting a power supply of the processor from a first voltage to a second voltage without resetting the processor.

152. A data processing system as in claim 151, further comprising:

means for slewing a frequency of a clock of the data processing system to transit a clock of the processor from a first frequency to a second frequency.

153. A data processing system as in claim 152, wherein the processor continues to execute instructions while the frequency of the clock is slewed.

154. A data processing system as in claim 153, wherein the processor continues to execute instructions while the power supply is shifted from the first voltage to the second voltage.

155. A data processing system as in claim 152, wherein the power supply is maintained at one of the first and second voltages while the frequency of the clock is slewed; and, the clock of the processor is maintained at one of the first and second frequencies while the power supply is shifted from the first voltage to the second voltage.

156. A data processing system as in claim 152, wherein the first frequency is higher than the second frequency; the first voltage is higher than the second voltage; and, the power supply is shifted from the first voltage to the second voltage after the clock of the processor transits from the first frequency to the second frequency.

157. A data processing system as in claim 152, wherein the first frequency is lower than the second frequency; the first voltage is lower than the second voltage; and, the power supply is shifted from the first voltage to the second voltage before the clock of the processor transits from the first frequency to the second frequency.

158. A data processing system as in claim 152, wherein said means for slewing a frequency of a clock comprises:

means for instructing a clock chip to use a new frequency multiplier.

159. A data processing system as in claim 151, further comprising:

means for adjusting a frequency multiplier of the processor to switch a clock of the processor from a first frequency to a second frequency.

160. A data processing system as in claim 159, wherein the processor is not reset during switching from the first frequency to the second frequency.

161. A data processing system, comprising:

a housing;

a plurality of components mounted within the housing, the plurality of components including:

a memory;

a processor coupled to the memory; and

a power management unit coupled to the processor; and

a plurality of sensors instrumented within the housing, at least one of the sensors determining a temperature in the data processing system, according to instructions stored in the memory the processor managing working states of at least a portion of the plurality of components based on information obtained from at least a portion of the plurality of sensors, the power management unit causing the system a shutdown when a measurement of one of the plurality of sensors exceeds a threshold.

162. A data processing system as in claim 161, wherein the power management unit sends a signal to the processor when the measurement exceeds the threshold.

163. A data processing system as in claim 162, wherein the processor instructs the system to shutdown in response to the signal from the power management unit.

164. A data processing system as in claim 162, wherein the power management unit determines whether or nor the processor is responsive to the signal.

165. A data processing system as in claim 164, wherein the power management unit shuts off power to at least a portion of the system in response to a determination that the processor is not responsive to the signal.

166. A data processing system as in claim 165, wherein the power management unit comprises a watchdog timer; the processor is not responsive to the signal if the watchdog timer expires after the signal is sent to the processor.

167. A data processing system as in claim 161, wherein information about the shutdown is recorded in the memory.

168. A data processing system as in claim 167, wherein the processor records the information about the shutdown and instructs the system to shutdown in response to a signal from the power management unit.

169. A data processing system as in claim 167, wherein the power management unit records the information about the shutdown.

170. A method performed by a data processing system, the method comprising:

automatically managing, according to instructions stored in a memory of the data processing system, working states of a plurality of components of the data processing system based on information obtained from at least a portion of a plurality of sensors instrumented within a housing of the data processing system, at least one of the sensors determining a temperature in the data processing system; and

initiating a shutdown from a power management unit of the data processing system in response to a measurement of one of the plurality of sensors exceeding a threshold.

171. A method as in claim 170, wherein the power management unit sends a signal to a processor of the data processing system when the measurement exceeds the threshold.

172. A method as in claim 171, wherein the processor instructs the system to shutdown in response to the signal from the power management unit.

173. A method as in claim 171, wherein the power management unit determines whether or nor the processor is responsive to the signal.

174. A method as in claim 173, wherein the power management unit shuts off power to at least a portion of the system in response to a determination that the processor is not responsive to the signal.

175. A method as in claim 174, wherein the power management unit comprises a watchdog timer; the processor is not responsive to the signal if the watchdog timer expires after the signal is sent to the processor.

176. A method as in claim 170, wherein information about the shutdown is recorded in the memory.

177. A method as in claim 176, wherein a processor of the data processing system records the information about the shutdown and instructs the system to shutdown in response to a signal from the power management unit.

178. A method as in claim 176, wherein the power management unit records the information about the shutdown.

179. A machine readable medium containing executable computer program instructions which when executed by a data processing system cause said system to perform a method performed by a data processing system, the method comprising:

automatically managing working states of a plurality of components of the data processing system based on information obtained from at least a portion of a plurality of sensors instrumented within a housing of the data processing system, at least one of the sensors determining a temperature in the data processing system;

wherein a power management unit of the data processing system initiates a shutdown in response to a measurement of one of the plurality of sensors exceeding a threshold.

180. A medium as in claim 179, wherein the power management unit sends a signal to a processor of the data processing system when the measurement exceeds the threshold.

181. A medium as in claim 180, wherein the processor instructs the system to shutdown in response to the signal from the power management unit.

182. A medium as in claim 180, wherein the power management unit determines whether or nor the processor is responsive to the signal.

183. A medium as in claim 182, wherein the power management unit shuts off power to at least a portion of the system in response to a determination that the processor is not responsive to the signal.

184. A medium as in claim 183, wherein the power management unit comprises a watchdog timer; the processor is not responsive to the signal if the watchdog timer expires after the signal is sent to the processor.

185. A medium as in claim 179, wherein information about the shutdown is recorded in a memory of the data processing system.

186. A medium as in claim 185, wherein a processor of the data processing system records the information about the shutdown and instructs the system to shutdown in response to a signal from the power management unit.

187. A medium as in claim 185, wherein the power management unit records the information about the shutdown.

188. A data processing system, comprising:

means for automatically managing working states of a plurality of components of the data processing system based on information obtained from at least a portion of a plurality of sensors instrumented within a housing of the data processing system, at least one of the sensors determining a temperature in the data processing system; and

means for initiating a shutdown from a power management unit of the data processing system in response to a measurement of one of the plurality of sensors exceeding a threshold.

189. A data processing system as in claim 188, wherein the power management unit sends a signal to a processor of the data processing system when the measurement exceeds the threshold.

190. A data processing system as in claim 189, wherein the processor instructs the system to shutdown in response to the signal from the power management unit.

191. A data processing system as in claim 189, wherein the power management unit determines whether or nor the processor is responsive to the signal.

192. A data processing system as in claim 191, wherein the power management unit shuts off power to at least a portion of the

system in response to a determination that the processor is not responsive to the signal.

193. A data processing system as in claim 192, wherein the power management unit comprises a watchdog timer; the processor is not responsive to the signal if the watchdog timer expires after the signal is sent to the processor.

194. A data processing system as in claim 188, wherein information about the shutdown is recorded in the memory of the data processing system.

195. A data processing system as in claim 194, wherein a processor of the data processing system records the information about the shutdown and instructs the system to shutdown in response to a signal from the power management unit.

196. A data processing system as in claim 194, wherein the power management unit records the information about the shutdown.

197. A method to manage a data process system enclosed in an housing of the data processing system, the method comprising:

individually monitoring a plurality of temperatures in a plurality of thermal zones respectively, the plurality of thermal zones being within the housing, the plurality of thermal zones not being isolated from each other, each of the plurality of thermal zones comprising at least one component that generates heat to substantially influence one of the plurality of temperatures when performing operations in a corresponding one of the plurality of thermal zones, each of the plurality of thermal zones comprising at least one component adjustable to reduce heat in a corresponding one of the plurality of thermal zones; and

adjusting working states of components in the plurality of thermal zones separately according to the plurality of temperatures respectively to limit measurements of the plurality of temperatures to allowable levels.

198. The method of claim 197, wherein the at least one component adjustable to reduce heat comprises a cooling fan; and the at least one component that generates heat comprises an Integrated Circuit (IC) chip.

199. The method of claim 198, wherein the measurements of the plurality of temperatures are obtained from one or more thermal diodes integrated on the IC chip; and the IC chip comprises one of:

a microprocessor;

a graphics chip; and

a microcontroller.

200. The method of claim 198, further comprising:

determining a control setting for the cooling fan, the control setting causing the cooling fan to run at a desired speed;

wherein said adjusting comprises:

adjusting control of the cooling fan to the control setting to cause the cooling fan running at a current speed to run at the desired speed.

201. The method of claim 200, further comprising:

verifying that the cooling fan is running at the desired speed.

202. The method of claim 200, wherein said adjusting further comprises:

slowly adjusting a clock source and a voltage source to cause the IC chip running at a current clock frequency and a current core voltage to run at a desired clock frequency and a desired core voltage.

203. A method to operate a data process system enclosed in an housing of the data processing system, the method comprising:

receiving measurements from a plurality of temperature sensors instrumented in the data processing system;

adjusting working states of components of the data processing system to limit the measurements to allowable levels; and

in response to one of the measurements exceeding an allowable level:

storing data indicating a cause of turning off the data processing system; and

automatically turning off the data processing system to prevent damage to the data processing system.

204. The method of claim 203, further comprising:

determining whether or not a heatsink of the data processing system is functioning properly.

205. The method of claim 204, wherein when the heatsink is misapplied, adjusting the working states cannot limit at least one of the measurements to an allowable level in a typical operating environment.

206. The method of claim 204, wherein the data indicates that a software process for adjusting working states of the components failed to respond.

207. The method of claim 203, further comprising:

informing a user of trading performance for reduced heat when one or more components are adjusted to a low performance working state.

208. The method of claim 207, wherein the low performance working state comprises running a processor at a reduced frequency and a reduced core voltage.

209. A data process system enclosed in an housing of the data processing system, the data processing system comprising:

memory to store instructions;

a processor coupled to the memory; and

a plurality of temperature sensors coupled to the processor, the plurality of temperature sensors to individually monitor a plurality of temperatures in a plurality of thermal zones respectively, the plurality of thermal zones being within the housing, the plurality of thermal zones not being isolated from each other, each of the plurality of thermal zones comprising at least one component that generates heat to substantially influence one of the plurality of temperatures when performing operations in a corresponding one of the plurality of thermal zones, each of the plurality of thermal zones comprising at least one component adjustable to reduce heat in a corresponding one of the plurality of thermal zones, the plurality of the temperature sensors to provide measures of the plurality of temperatures to the processor, according to the instructions the processor to adjust working states of components in the plurality of thermal zones separately according to the plurality of temperatures respectively to limit measurements of the plurality of temperatures to allowable levels.

210. The system of claim 209, wherein the at least one component adjustable to reduce heat comprises a cooling fan; and the at least one component that generates heat comprises an Integrated Circuit (IC) chip.

211. The system of claim 210, wherein the measurements of the plurality of temperatures are obtained from one or more thermal diodes integrated on the IC chip; and the IC chip comprises one of:

a microprocessor;

a graphics chip; and

a microcontroller.

212. The system of claim 210, wherein the processor is further configured to determine a control setting for the cooling fan, the

control setting causing the cooling fan to run at a desired speed; and wherein to adjust the working states of the components, the processor is configured to adjust control of the cooling fan to the control setting to cause the cooling fan running at a current speed to run at the desired speed.

213. The system of claim 212, further comprising:

a tachometer coupled to the cooling fan and to the processor, the processor retrieving measurements from the tachometer to verify that the cooling fan is running at the desired speed.

214. The system of claim 212, further comprising:

a adjustable clock source coupled to the IC chip;

a voltage source coupled to the IC chip; and

wherein to adjust the working states of the components, the processor is configured to slowly adjust the clock source and the voltage source to cause the IC chip running at a current clock frequency and a current core voltage to run at a desired clock frequency and a desired core voltage.

215. A data process system enclosed in an housing of the data processing system, the data processing system comprising:

memory to store instructions;

a processor coupled to the memory;

a plurality of temperature sensors instrumented in the data processing system and coupled to the processor, the processor to receive measurements from the plurality of temperature sensors, according to the instructions the processor to adjust working states of components of the data processing system to limit the measurements to allowable levels;

a power management unit coupled to the processor, in response to one of the measurements exceeding an allowable level:

the power management unit and the processor to store data indicating a cause of turning off the data processing system in the memory;

the power management unit to automatically turn off the data processing system to prevent damage to the data processing system.

216. The system of claim 215, wherein the processor is configured according to the instructions to determine whether or not a heatsink of the data processing system is functioning properly.

217. The system of claim 216, wherein when the heatsink is misapplied, adjusting the working states cannot limit at least one of the measurements to an allowable level in a typical operating environment.

218. The system of claim 216, wherein the data indicates that a software process for adjusting working states of the components failed to respond.

219. The system of claim 215, wherein the processor is configured according to the instructions to inform a user of trading performance for reduced heat when one or more components are adjusted to a low performance working state.

220. The system of claim 219, wherein the low performance working state comprises running a processor at a reduced frequency and a reduced core voltage.

221. A machine readable medium containing executable computer program instructions which when executed by a data processing system cause said system to perform a method to manage the data process system enclosed in an

housing of the data processing system, the method comprising:

individually monitoring a plurality of temperatures in a plurality of thermal zones respectively, the plurality of thermal zones being within the housing, the plurality of thermal zones not being isolated from each other, each of the plurality of thermal zones comprising at least one component that generates heat to substantially influence one of the plurality of temperatures when performing operations in a corresponding one of the plurality of thermal zones, each of the plurality of thermal zones comprising at least one component adjustable to reduce heat in a corresponding one of the plurality of thermal zones; and

adjusting working states of components in the plurality of thermal zones separately according to the plurality of temperatures respectively to limit measurements of the plurality of temperatures to allowable levels.

222. The medium of claim 221, wherein the at least one component adjustable to reduce heat comprises a cooling fan; and the at least one component that generates heat comprises an Integrated Circuit (IC) chip.

223. The medium of claim 222, wherein the measurements of the plurality of temperatures are obtained from one or more thermal diodes integrated on the IC chip; and the IC chip comprises one of:

a microprocessor;

a graphics chip; and

a microcontroller.

224. The medium of claim 222, wherein the method further comprises:

determining a control setting for the cooling fan, the control setting causing the cooling fan to run at a desired speed;

wherein said adjusting comprises:

adjusting control of the cooling fan to the control setting to cause the cooling fan running at a current speed to run at the desired speed.

225. The medium of claim 224, wherein the method further comprises:

verifying that the cooling fan is running at the desired speed.

226. The medium of claim 224, wherein said adjusting further comprises:

slowly adjusting a clock source and a voltage source to cause the IC chip running at a current clock frequency and a current core voltage to run at a desired clock frequency and a desired core voltage.

227. A machine readable medium containing executable computer program instructions which when executed by a data processing system cause said system to perform a method to operate the data process system enclosed in an housing of the data processing system, the method comprising:

receiving measurements from a plurality of temperature sensors instrumented in the data processing system;

adjusting working states of components of the data processing system to limit the measurements to allowable levels; and

in response to one of the measurements exceeding an allowable level:

storing data indicating a cause of turning off the data processing system; and

automatically turning off the data processing system to prevent damage to the data processing system.

228. The medium of claim 227, wherein the method further comprises:

determining whether or not a heatsink of the data processing system is functioning properly.

229. The medium of claim 228, wherein when the heatsink is misapplied, adjusting the working states cannot limit at least one of the measurements to an allowable level in a typical operating environment.

230. The medium of claim 228, wherein the data indicates that a software process for adjusting working states of the components failed to respond.

231. The medium of claim 227, wherein the method further comprises:

informing a user of trading performance for reduced heat when one or more components are adjusted to a low performance working state.

232. The medium of claim 231, wherein the low performance working state comprises running a processor at a reduced frequency and a reduced core voltage.

233. A data process system enclosed in an housing of the data processing system, the data processing system comprising:

means for individually monitoring a plurality of temperatures in a plurality of thermal zones respectively, the plurality of thermal zones being within the housing, the plurality of thermal zones not being isolated from each other, each of the plurality of thermal zones comprising at least one component that generates heat to substantially influence one of the plurality of temperatures when performing operations in a corresponding one of the plurality of thermal zones, each of the plurality of thermal zones comprising at least one component adjustable to reduce heat in a corresponding one of the plurality of thermal zones; and

means for adjusting working states of components in the plurality of thermal zones separately according to the plurality of temperatures respectively to limit measurements of the plurality of temperatures to allowable levels.

234. The system of claim 233, wherein the at least one component adjustable to reduce heat comprises a cooling fan; and the at least one component that generates heat comprises an Integrated Circuit (IC) chip.

235. The system of claim 234, wherein the measurements of the plurality of temperatures are obtained from one or more thermal diodes integrated on the IC chip; and the IC chip comprises one of:

a microprocessor;

a graphics chip; and

a microcontroller.

236. The system of claim 234, further comprising:

means for determining a control setting for the cooling fan, the control setting causing the cooling fan to run at a desired speed;

wherein said means for adjusting comprises:

means for adjusting control of the cooling fan to the control setting to cause the cooling fan running at a current speed to run at the desired speed.

237. The system of claim 236, further comprising:

means for verifying that the cooling fan is running at the desired speed.

238. The system of claim 236, wherein said means for adjusting further comprises:

means for slowly adjusting a clock source and a voltage source to cause the IC chip running at a current clock frequency and a current core voltage to run at a desired clock frequency and a desired core voltage.

239. A data process system enclosed in an housing of the data processing system, the data processing system comprising:

means for receiving measurements from a plurality of temperature sensors instrumented in the data processing system;

means for adjusting working states of components of the data processing system to limit the measurements to allowable levels; and

in response to one of the measurements exceeding an allowable level:

means for storing data indicating a cause of turning off the data processing system; and

means for automatically turning off the data processing system to prevent damage to the data processing system.

240. The system of claim 239, further comprising:

means for determining whether or not a heatsink of the data processing system is functioning properly.

241. The system of claim 240, wherein when the heatsink is misapplied, said means for adjusting the working states cannot limit at least one of the measurements to an allowable level in a typical operating environment.

242. The system of claim 240, wherein the data indicates that a software process for adjusting working states of the components failed to respond.

243. The system of claim 239, further comprising:

means for informing a user of trading performance for reduced heat when one or more components are adjusted to a low performance working state.

244. The system of claim 243, wherein the low performance working state comprises running a processor at a reduced frequency and a reduced core voltage.

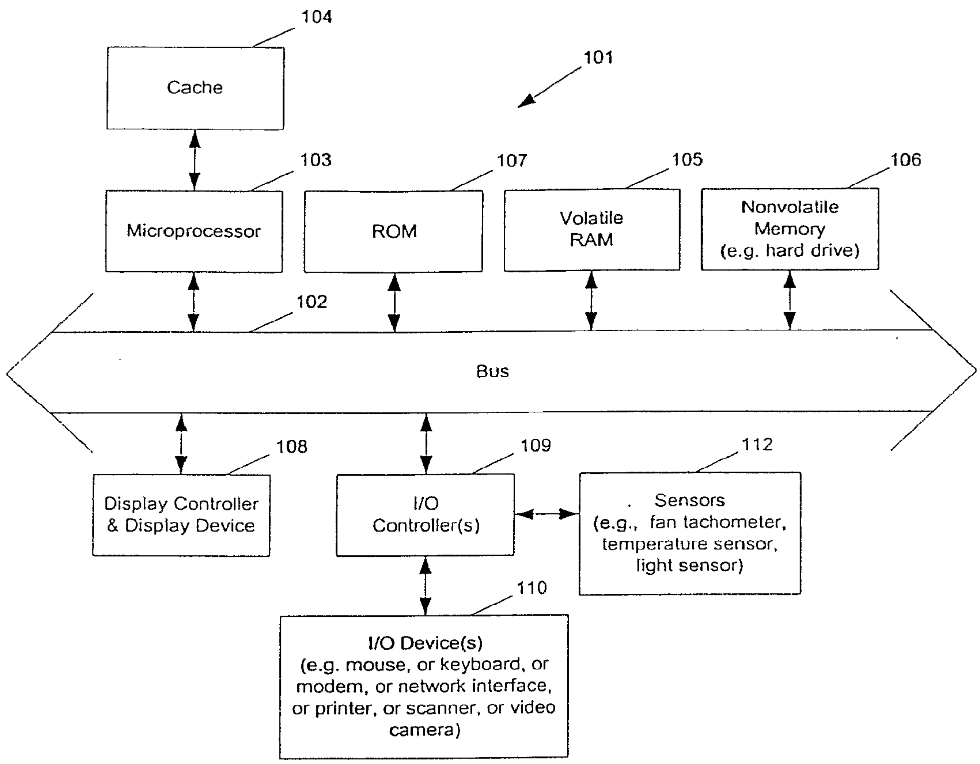
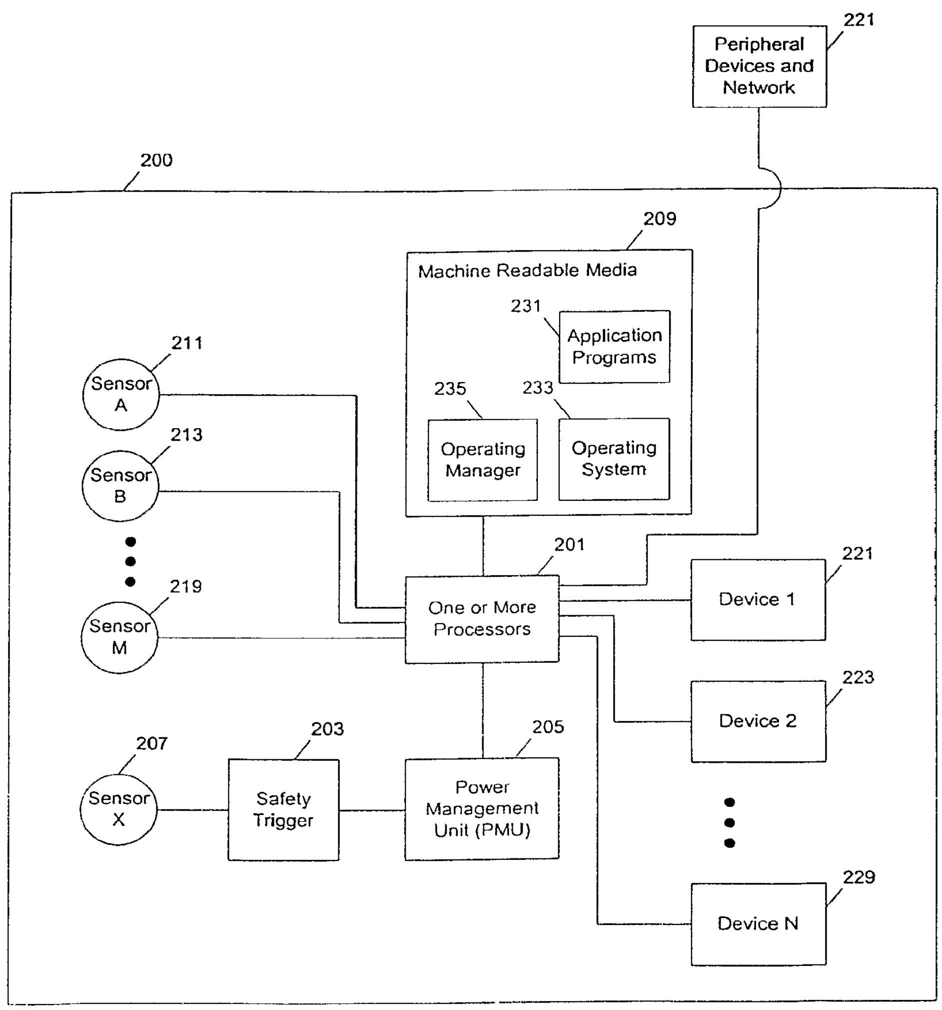

104
Cache
101
103
Microprocessor
107
ROM
105
Volatile RAM
106
Nonvolatile Memory (e.g. hard drive)
102
Bus
108
Display Controller & Display Device
109
I/O Controller(s)
112
Sensors (e.g., fan tachometer, temperature sensor, light sensor)
110
I/O Device(s) (e.g. mouse, or keyboard, or modem, or network interface, or printer, or scanner, or video camera)

Fig. 1



221
Peripheral Devices and Network
200
209
Machine Readable Media
231
Application Programs
235
233
Operating Manager
Operating System
211
Sensor A
213
Sensor B
219
Sensor M
201
One or More Processors
221
Device 1
223
Device 2
229
Device N
207
Sensor X
203
Safety Trigger
205
Power Management Unit (PMU)

Fig. 2

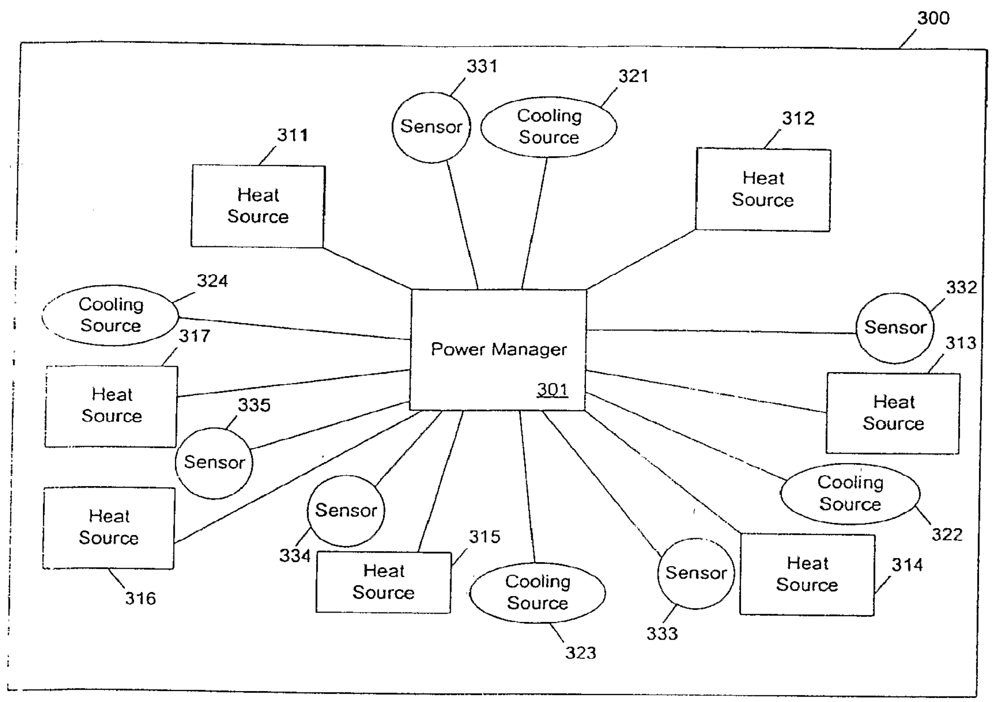

300
331
321
Sensor
Cooling Source
312
311
Heat Source
Heat Source
324
332
Cooling Source
317
Sensor
313
Power Manager
301
Heat Source
Heat Source
335
Sensor
Cooling Source
Heat Source
Sensor
322
315
334
Heat Source
Cooling Source
Sensor
Heat Source
314
316
333
323

Fig. 3

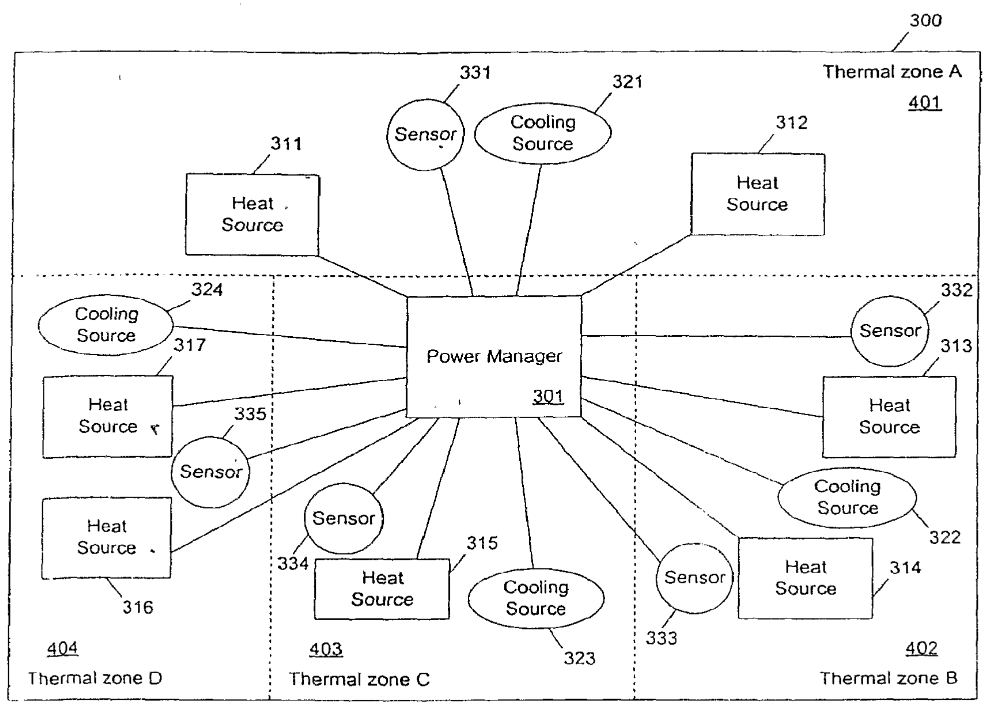

300
Thermal zone A
401
331
Sensor
321
Cooling Source
312
Heat Source
311
Heat Source
324
Cooling Source
332
Sensor
Power Manager
301
317
Heat Source
313
Heat Source
335
Sensor
Cooling Source
322
Heat Source
Sensor
315
334
Heat Source
Cooling Source
Sensor
Heat Source
314
316
333
323
404
Thermal zone D
403
Thermal zone C
402
Thermal zone B

Fig. 4

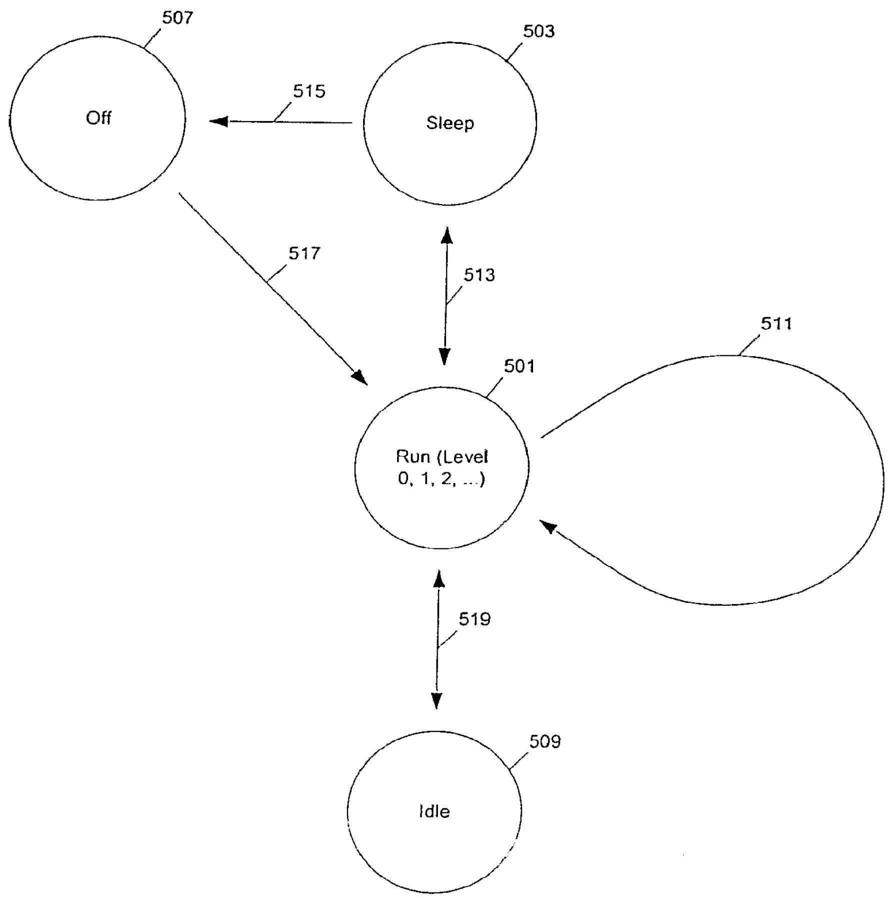

507
Off
515
503
Sleep
517
513
511
501
Run (Level
0, 1, 2, ...)
519
509
Idle

Fig. 5

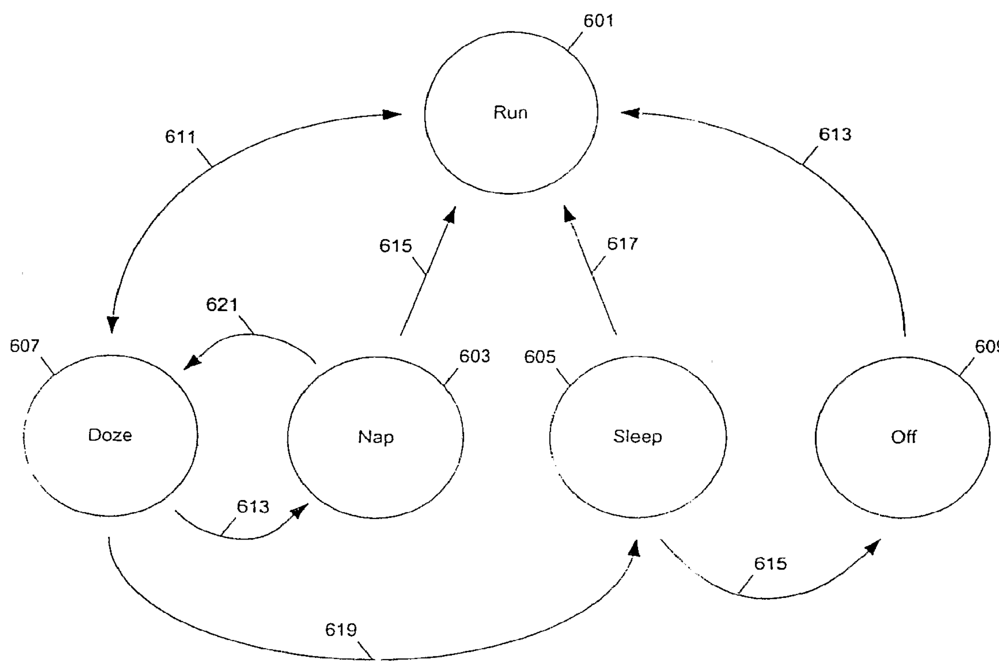

601
Run
611
613
615
617
621
607
Doze
Nap
603
605
Sleep
Off
609
613
615
619

Fig. 6

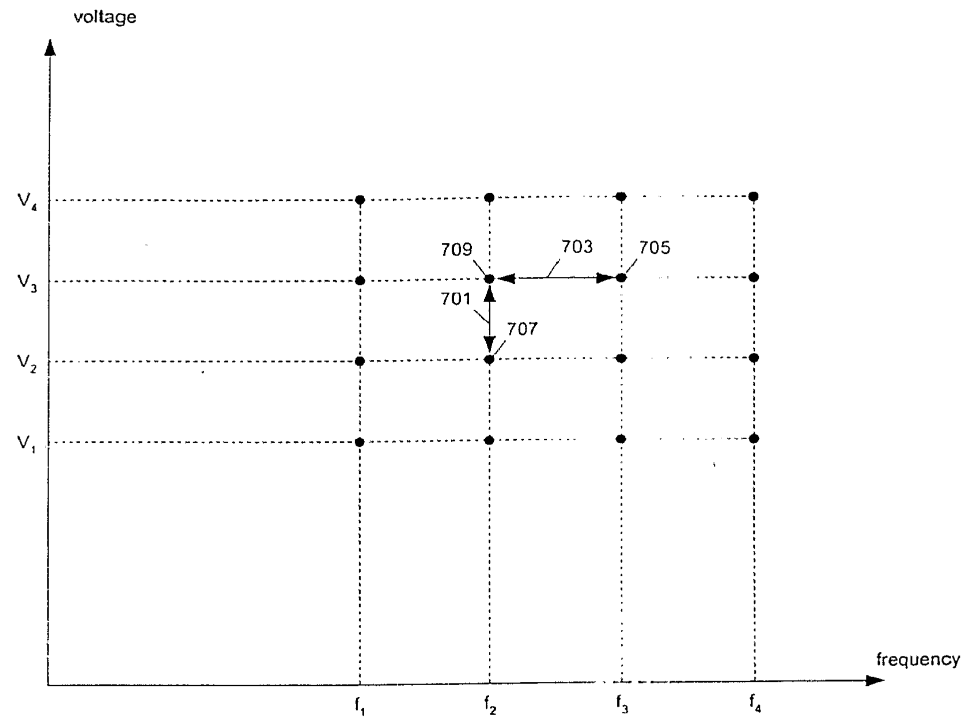


Fig. 7

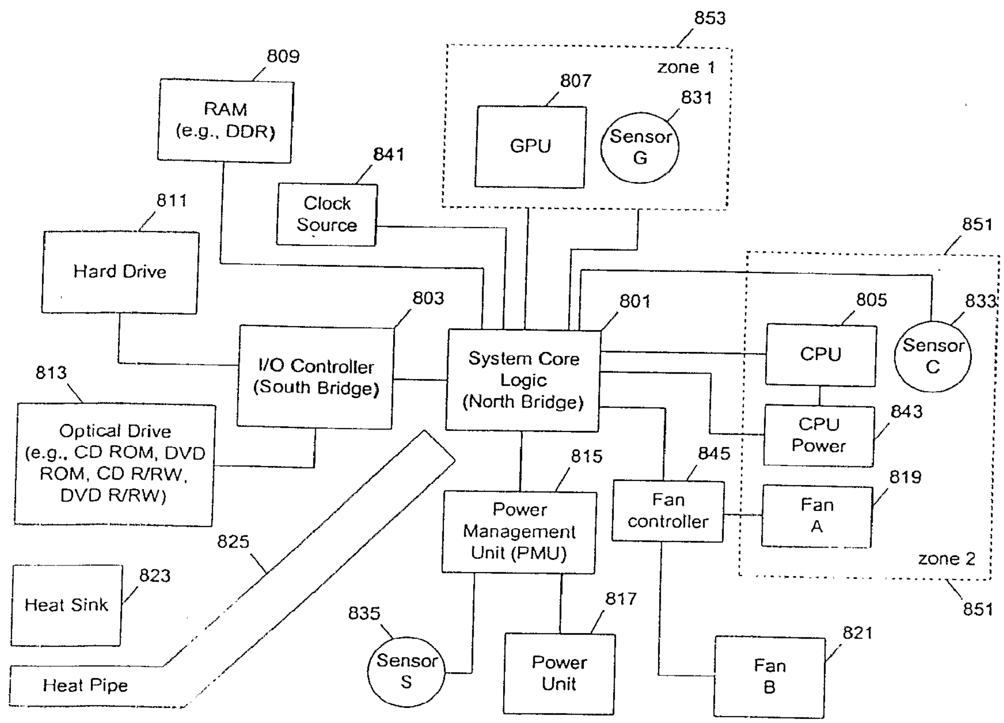
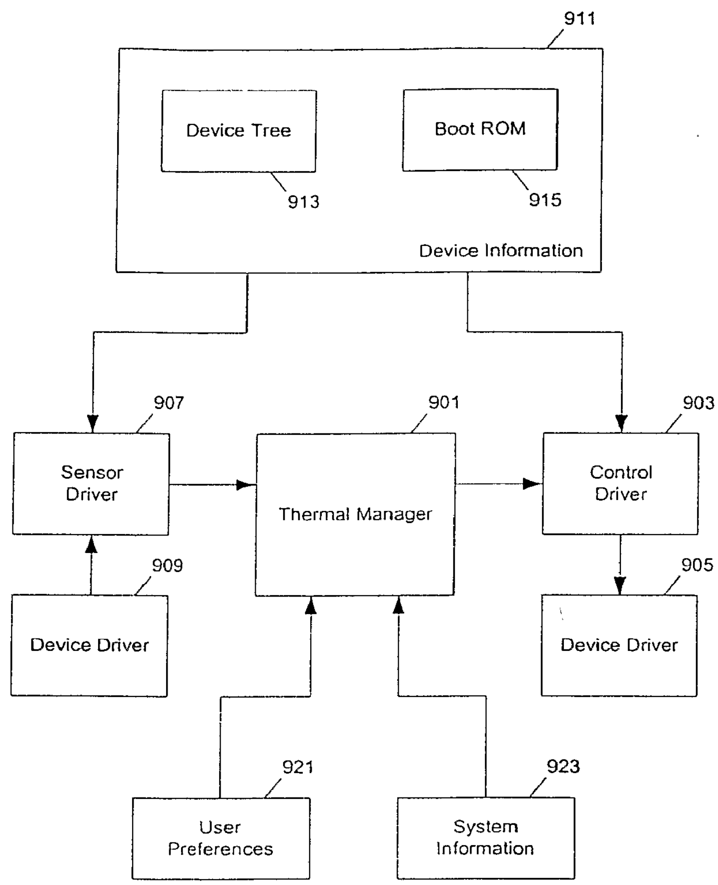

853
zone 1
809
RAM
(e.g., DDR)
807
GPU
831
Sensor
G
841
Clock
Source
811
Hard Drive
851
803
801
805
833
I/O Controller
(South Bridge)
System Core
Logic
(North Bridge)
CPU
Sensor
C
813
CPU
Power
843
Optical Drive
(e.g., CD ROM, DVD
ROM, CD R/RW,
DVD R/RW)
815
845
819
Power
Management
Unit (PMU)
Fan
controller
Fan
A
825
zone 2
823
Heat Sink
851
835
817
821
Sensor
S
Power
Unit
Fan
B
Heat Pipe

Fig. 8



911
Device Tree
913
Boot ROM
915
Device Information
907
Sensor Driver
901
Thermal Manager
903
Control Driver
909
Device Driver
905
Device Driver
921
User Preferences
923
System Information

Fig. 9

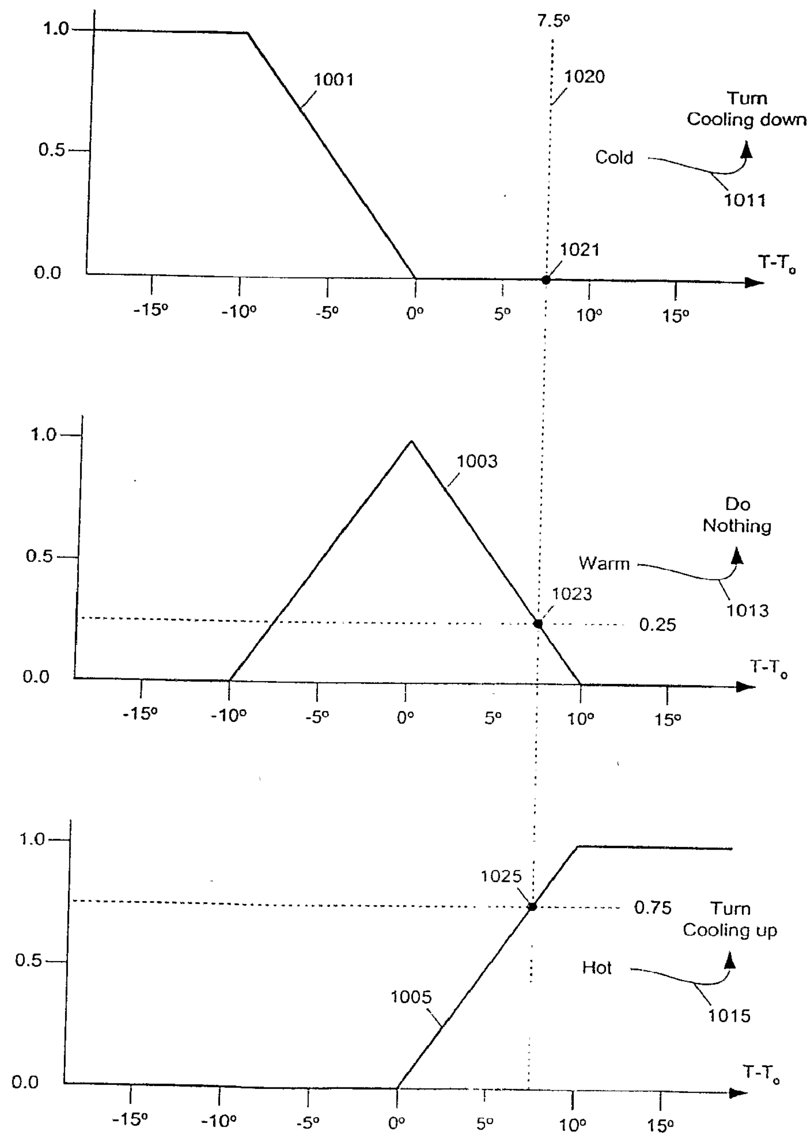

1.0
0.5
0.0
7.5°
1001
1020
Turn
Cooling down
Cold
1011
1021
T-T₀
-15° -10° -5° 0° 5° 10° 15°
1003
Do
Nothing
Warm
1013
1023
0.25
1025
0.75
Turn
Cooling up
Hot
1005
1015

Fig. 10

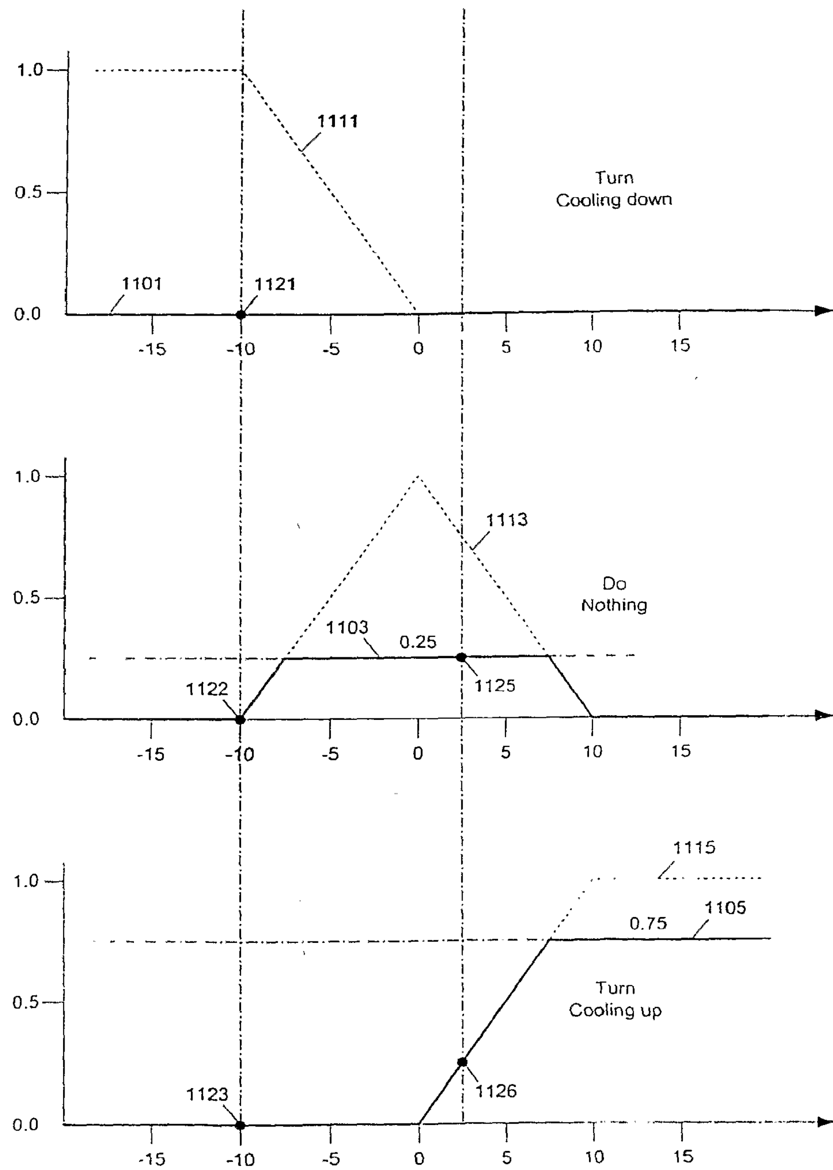

1.0
0.5
0.0
1111
1101
1121
Turn
Cooling down
ΔC
-15
-10
-5
0
5
10
15
1.0
0.5
0.0
1113
Do
Nothing
1103
0.25
1122
1125
ΔC
-15
-10
-5
0
5
10
15
1.0
0.5
0.0
1115
1105
0.75
Turn
Cooling up
1123
1126
ΔC
-15
-10
-5
0
5
10
15

Fig. 11

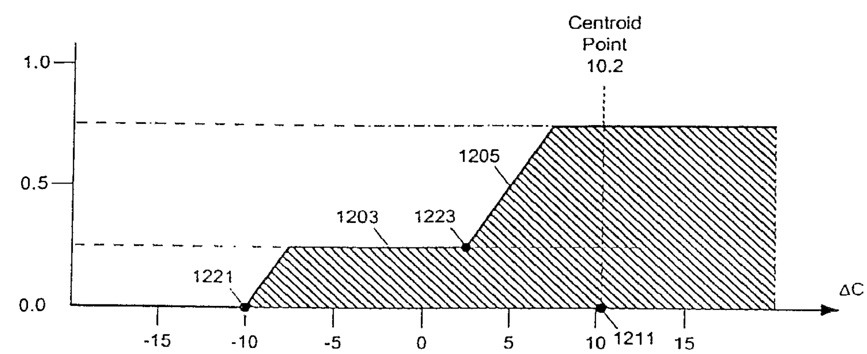

Centroid
Point
10.2
1.0
0.5
0.0
1205
1203
1223
1221
-15
-10
-5
0
5
10
1211
15
ΔC

Fig. 12

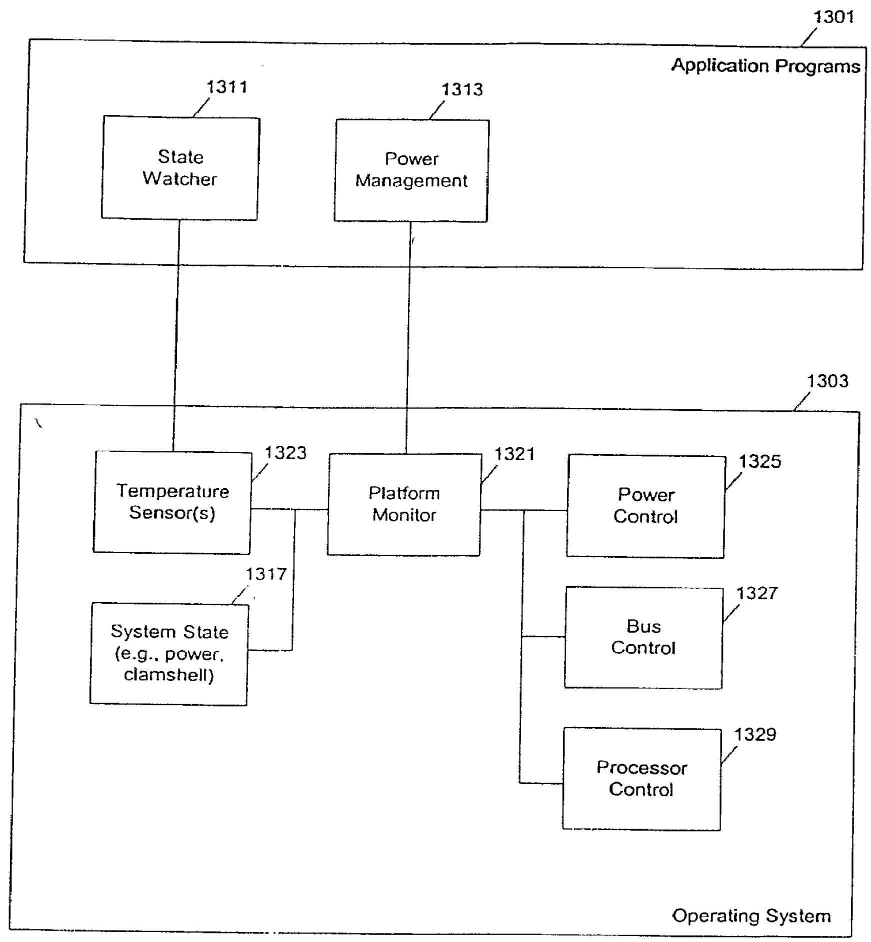

1301
Application Programs
1311
State Watcher
1313
Power Management
1303
1323
Temperature Sensor(s)
1321
Platform Monitor
1325
Power Control
1317
System State (e.g., power, clamshell)
1327
Bus Control
1329
Processor Control
Operating System

Fig. 13

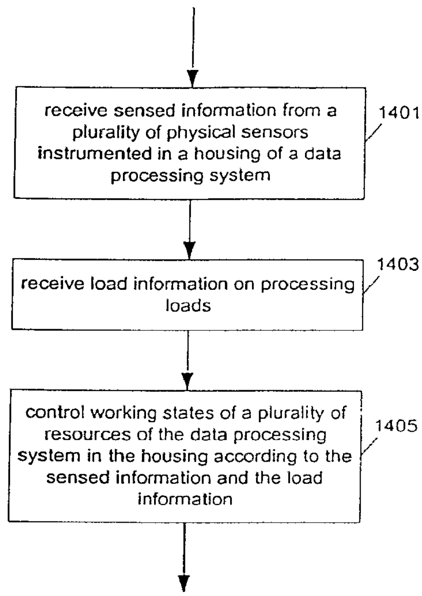

receive sensed information from a plurality of physical sensors instrumented in a housing of a data processing system
1401
receive load information on processing loads
1403
control working states of a plurality of resources of the data processing system in the housing according to the sensed information and the load information
1405

Fig. 14

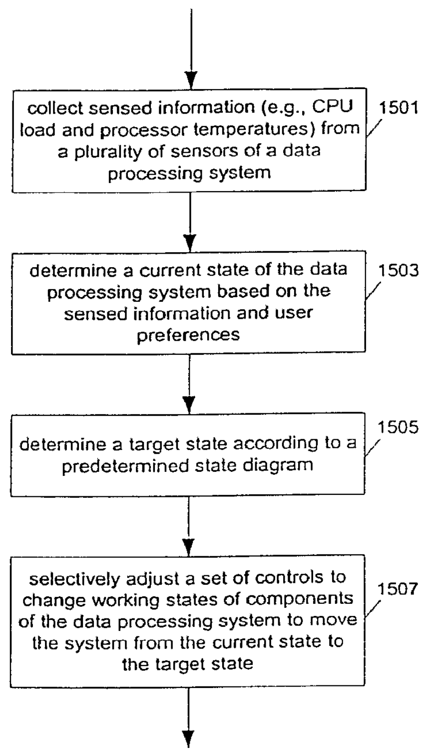

collect sensed information (e.g., CPU load and processor temperatures) from a plurality of sensors of a data processing system
1501
determine a current state of the data processing system based on the sensed information and user preferences
1503
determine a target state according to a predetermined state diagram
1505
selectively adjust a set of controls to change working states of components of the data processing system to move the system from the current state to the target state
1507

Fig. 15

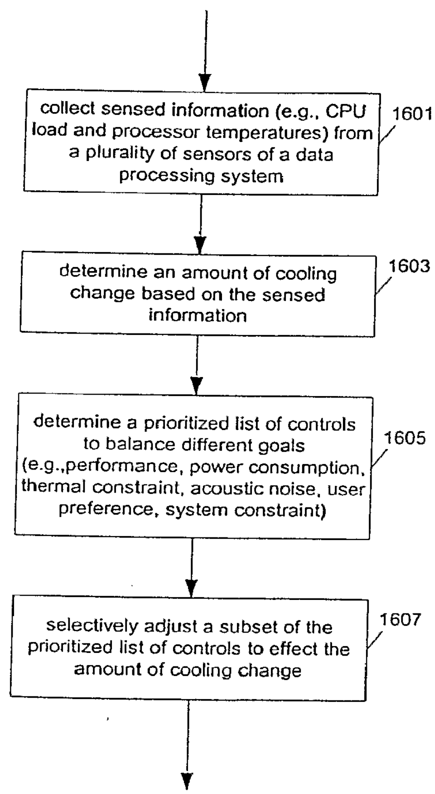
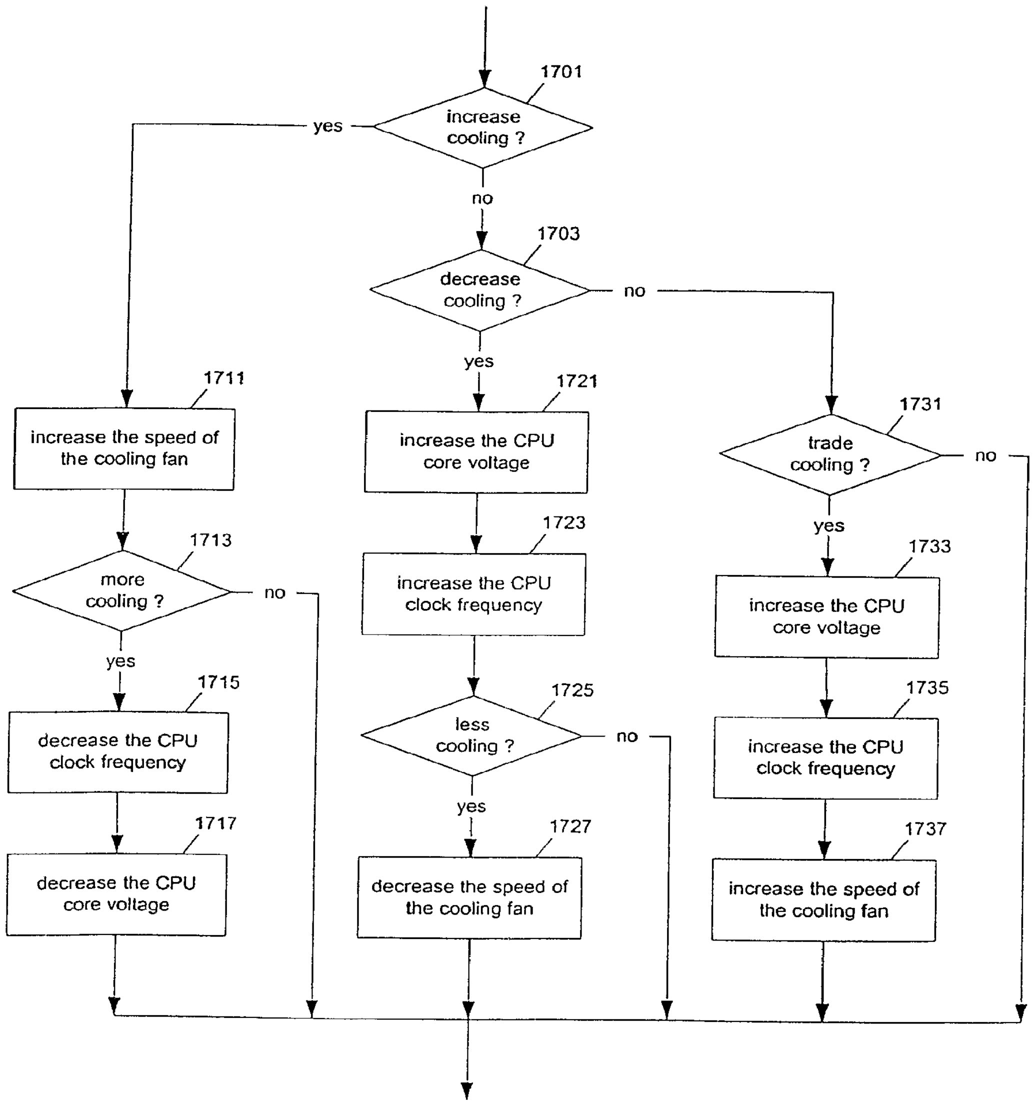

collect sensed information (e.g., CPU load and processor temperatures) from a plurality of sensors of a data processing system
1601
determine an amount of cooling change based on the sensed information
1603
determine a prioritized list of controls to balance different goals (e.g.,performance, power consumption, thermal constraint, acoustic noise, user preference, system constraint)
1605
selectively adjust a subset of the prioritized list of controls to effect the amount of cooling change
1607

Fig. 16



1701
increase cooling ?
yes
no
1703
decrease cooling ?
no
yes
1711
increase the speed of the cooling fan
1713
more cooling ?
no
yes
1715
decrease the CPU clock frequency
1717
decrease the CPU core voltage
1721
increase the CPU core voltage
1723
increase the CPU clock frequency
1725
less cooling ?
no
yes
1727
decrease the speed of the cooling fan
1731
trade cooling ?
no
yes
1733
increase the CPU core voltage
1735
increase the CPU clock frequency
1737
increase the speed of the cooling fan

Fig. 17

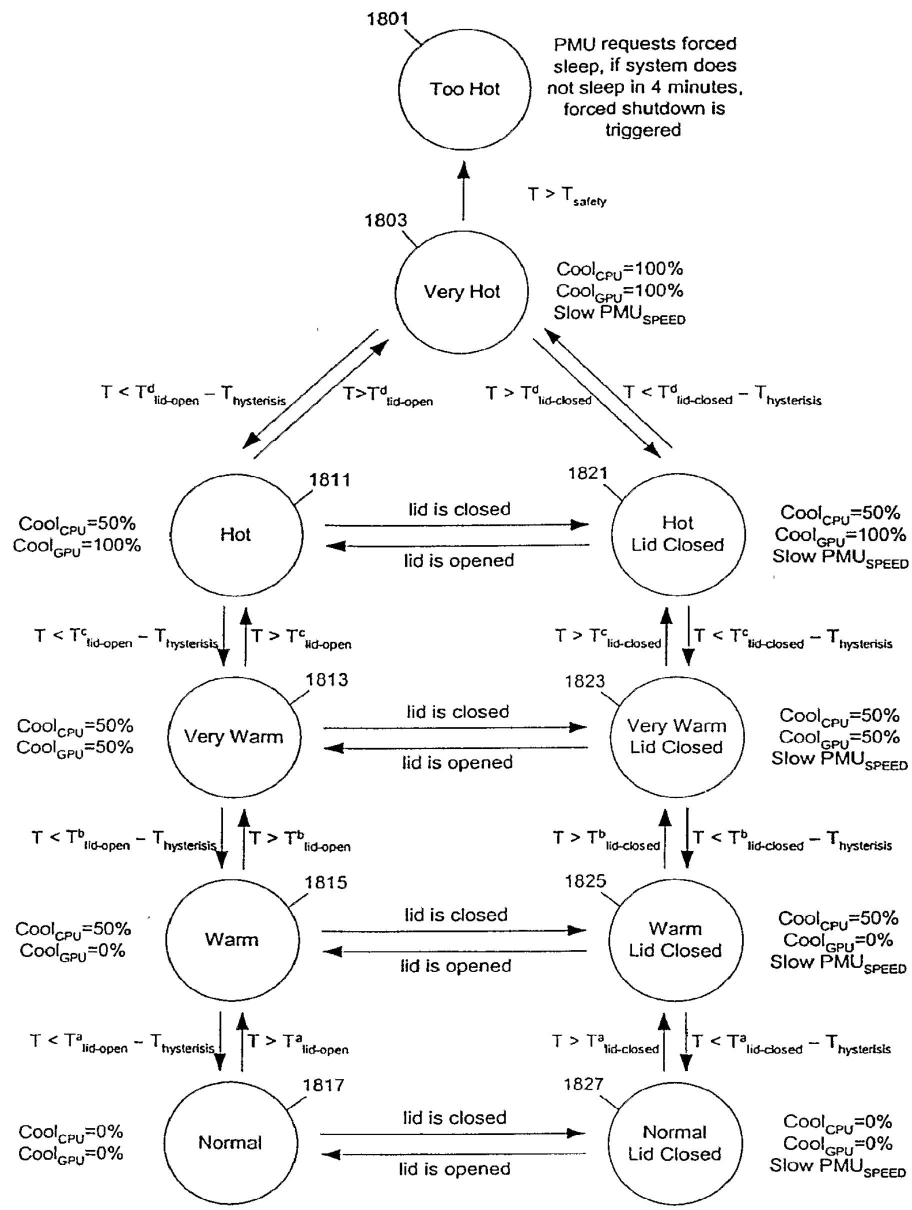

1801
Too Hot
PMU requests forced sleep, if system does not sleep in 4 minutes, forced shutdown is triggered
T > T safety
1803
Very Hot
CoolCPU=100%
CoolGPU=100%
Slow PMUSPEED
T < Td lid-open − T hysterisis
T>Td lid-open
T > Td lid-closed
T < Td lid-closed − T hysterisis
1811
Hot
CoolCPU=50%
CoolGPU=100%
lid is closed
lid is opened
1821
Hot
Lid Closed
CoolCPU=50%
CoolGPU=100%
Slow PMUSPEED
T < Tc lid-open − T hysterisis
T > Tc lid-open
T > Tc lid-closed
T < Tc lid-closed − T hysterisis
1813
Very Warm
CoolCPU=50%
CoolGPU=50%
lid is closed
lid is opened
1823
Very Warm
Lid Closed
CoolCPU=50%
CoolGPU=50%
Slow PMUSPEED
T < Tb lid-open − T hysterisis
T > Tb lid-open
T > Tb lid-closed
T < Tb lid-closed − T hysterisis
1815
Warm
CoolCPU=50%
CoolGPU=0%
lid is closed
lid is opened
1825
Warm
Lid Closed
CoolCPU=50%
CoolGPU=0%
Slow PMUSPEED
T < Ta lid-open − T hysterisis
T > Ta lid-open
T > Ta lid-closed
T < Ta lid-closed − T hysterisis
1817
Normal
CoolCPU=0%
CoolGPU=0%
lid is closed
lid is opened
1827
Normal
Lid Closed
CoolCPU=0%
CoolGPU=0%
Slow PMUSPEED

Fig. 18

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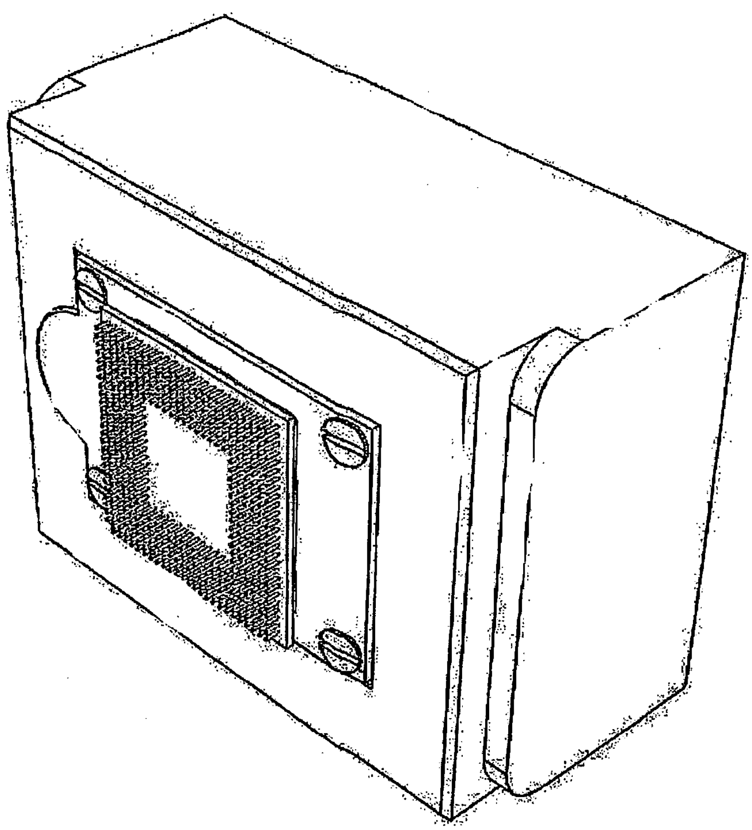
[Continued on next page]

(54) Title: COOLING SYSTEM FOR A COMPUTER SYSTEM



(57) Abstract: The invention relates to a cooling system for a computer system, said computer system comprising at least one unit such as a central processing unit (CPU) generating thermal energy and said cooling system intended for cooling the at least one processing unit and comprising a reservoir having an amount of cooling liquid, said cooling liquid intended for accumulating and transferring of thermal energy dissipated from the processing unit to the cooling liquid. The cooling system has a heat exchanging interface for providing thermal contact between the processing unit and the cooling liquid for dissipating heat from the processing unit to the cooling liquid. Different embodiments of the heat exchanging system as well as means for establishing and controlling a flow of cooling liquid and a cooling strategy constitutes the invention of the cooling system.

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Published:

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

COOLING SYSTEM FOR A COMPUTER SYSTEM

BACKGROUND OF THE INVENTION

The present invention relates to a cooling system for a central processing unit (CPU) or other processing unit of a computer system. More specifically, the invention relates to a liquid-cooling system for a mainstream computer system such as a PC.

During operation of a computer, the heat created inside the CPU or other processing unit must be carried away fast and efficiently, keeping the temperature within the design range specified by the manufacturer. As an example of cooling systems, various CPU cooling methods exist and the most used CPU cooling method to date has been an air-cooling arrangement, wherein a heat sink in thermal contact with the CPU transports the heat away from the CPU and as an option a fan mounted on top of the heat sink functions as an air fan for removing the heat from the heat sink by blowing air through segments of the heat sink. This air-cooling arrangement is sufficient as long as the heat produced by the CPU is kept at today's level, however it becomes less useful in future cooling arrangements when considering the development of CPUs since the speed of a CPU is said to double perhaps every 18 months, thus increasing the heat production accordingly.

Another design used today is a CPU cooling arrangement where cooling liquid is used to cool the CPU by circulating a cooling liquid inside a closed system by means of a pumping unit, and where the closed system also comprises a heat exchanger past which the cooling liquid is circulated.

A liquid-cooling arrangement is more efficient than an air-cooling arrangement and tends to lower the noise level of the cooling arrangement in general. However, the liquid-cooling design consists of many components, which increases the total installation time, thus making it less desirable as a mainstream solution. With a trend of producing smaller and more compact PCs for the end-users, the greater amount of components in a typical liquid-cooling arrangement is also undesirable. Furthermore, the many components having to be coupled together incurs a risk of leakage of cooling liquid from the system.

SUMMARY OF INVENTION

It may be one object of the invention to provide a small and compact liquid-cooling solution, which is more efficient than existing air-cooling arrangements and which can be produced at a low cost enabling high production volumes. It may be another object to create a liquid-cooling arrangement, which is easy-to-use and implement, and which requires a low level of maintenance or no maintenance at all. It may be still another object of the present invention to create a liquid-cooling arrangement, which can be used with existing CPU types, and which can be used in existing computer systems.

This object may be obtained by a cooling system for a computer system, said computer system comprising:
- at least one unit such as a central processing unit (CPU) generating thermal energy and said cooling system intended for cooling the at least one processing unit,
- a reservoir having an amount of cooling liquid, said cooling liquid intended for accumulating and transferring of thermal energy dissipated from the processing unit to the cooling liquid,
- a heat exchanging interface for providing thermal contact between the processing unit and the cooling liquid for dissipating heat from the processing unit to the cooling liquid,
- a pump being provided as part of an integrate element, said integrate element comprising the heat exchanging interface, the reservoir and the pump,
- said pump intended for pumping the cooling liquid into the reservoir, through the reservoir and from the reservoir to a heat radiating means,
- said heat radiating means intended for radiating thermal energy from the cooling liquid, dissipated to the cooling liquid, to surroundings of the heat radiating means.

By providing an integrate element, it is possible to limit the number of separate elements of the system. However, there is actually no need for limiting the number of elements, because often there is enough space within a cabinet of a computer system to encompass the different individual elements of the cooling system. Thus, it is surprisingly that, at all, any attempt is conducted of integrating some of the elements.

In preferred embodiments according to this aspect of the invention, the pump is placed inside the reservoir with at least an inlet or an outlet leading to the liquid in the reservoir. In an alternative embodiment the pump is placed outside the reservoir in the immediate vicinity of the reservoir and wherein at least an inlet or an outlet is leading directly to the liquid in the reservoir. By placing the pump inside the reservoir or in the immediate vicinity outside the reservoir, the integrity of the combined reservoir, heat exchanger and pump is obtained, so that the element is easy to employ in new and existing computer systems, especially mainstream computer systems.

The object may also be obtained by a cooling system for a computer system, said computer system comprising:

- at least one unit such as a central processing unit (CPU) generating thermal energy and said cooling system intended for cooling the at least one processing unit,
- a reservoir having an amount of cooling liquid, said cooling liquid intended for accumulating and transferring of thermal energy dissipated from the processing unit to the cooling liquid,
- a heat exchanging interface for providing thermal contact between the processing unit and the cooling liquid for dissipating heat from the processing unit to the cooling liquid,
- a pump intended for pumping the cooling liquid into the reservoir, through the reservoir and from the reservoir to a heat radiating means,
- said cooling system being intended for thermal contact with the processing unit by means of existing fastening means associated with the processing unit, and
- said heat radiating means intended for radiating from the cooling liquid thermal energy, dissipated to the cooling liquid, to surroundings of the heat radiating means.

The use of existing fastening means has the advantage that fitting of the cooling system is fast and easy. However, once again there is no problem for the person skilled in the art to adopt specially adapted mounting means for any element of the cooling system, because there are numerous possibilities in existing cabinets of computer systems for mounting any kind of any number of elements, also elements of a cooling system.

In preferred embodiments according to this aspect of the invention, the existing fastening means are means intended for attaching a heat sink to the processing unit, or the existing fastening means are means intended for attaching a cooling fan to the processing unit, or the existing fastening means are means intended for attaching a heat sink together with a cooling fan to the processing unit. Existing fastening means of the kind mentioned is commonly used for air cooling of CPUs of computer systems, however, air cooling arrangements being much less complex than liquid cooling systems. Nevertheless, it has ingeniously been possible to develop a complex and effective liquid cooling system capable of utilising such existing fastening means for simple and less effective air cooling arrangements.

According to an aspect of the invention, the pump is selected from the following types: Bellows pump, centrifugal pump, diaphragm pump, drum pump, flexible liner pump, flexible impeller pump, gear pump, peristaltic tubing pump, piston pump, processing cavity pump, pressure washer pump, rotary lobe pump, rotary vane pump and electro-kinetic pump. By adopting one or more of the solution of the present invention, a wide variety of pumps may be used without departing from the scope of the invention.

According to another aspect of the invention, driving means for driving the pump is selected among the following driving means: electrically operated rotary motor, piezo-electrically operated motor, permanent magnet operated motor, fluid-operated motor, capacitor-operated motor. As is the case when selecting the pump to pump the liquid, by adopting one or more of the solution of the present invention, a wide variety of pumps may be used without departing from the scope of the invention.

The object may also be obtained by a cooling system for a computer system, said computer system comprising:
- at least one unit such as a central processing unit (CPU) generating thermal energy and said cooling system intended for cooling the at least one processing unit,
- a reservoir having an amount of cooling liquid, said cooling liquid intended for accumulating and transferring of thermal energy dissipated from the processing unit to the cooling liquid,
- a heat exchanging interface for providing thermal contact between the processing unit and the cooling liquid for dissipating heat from the processing unit to the cooling liquid,
- a pump intended for pumping the cooling liquid into the reservoir, through the reservoir and from the reservoir to a heat radiating means, and
- said cooling system further comprising a pump wherein the pump is driven by an AC electrical motor by a DC electrical power supply of the computer system,
- where at least part of the electrical power from said power supply is intended for being converted to AC being supplied to the electrical motor.

It may be advantageous to use an AC motor, such as a 12V AC motor, for driving the pump in order to obtain a stabile unit perhaps having to operate 24 hours a day, 365 days a year. However, the person skilled in the art will find it unnecessary to adopt as example a 12V motor because high voltage such as 220V or 110V is readily accessible as this is the electrical voltage used to power the voltage supply of the computer system itself. Although choosing to use a 12V motor for the pump, it has never been and will never be the choice of the person skilled in the art to use an AC motor. The voltage supplied by the voltage supply of the computer system itself is DC, thus this will be the type of voltage chosen by the skilled person.

In preferred embodiments according to any aspect of the invention, an electrical motor is intended both for driving the pump for pumping the liquid and for driving the a fan for establishing a flow of air in the vicinity of the reservoir, or an electrical motor is intended both for driving the pump for pumping the liquid and for driving the a fan for establishing a flow of air in the vicinity of the heat radiating means, or an electrical motor is intended both for driving the pump for pumping the liquid, and for driving the a fan for establishing a flow of air in the vicinity of the reservoir, and for driving the a fan for establishing a flow of air in the vicinity of the heat radiating means.

By utilising a single electrical motor for driving more than one element of the cooling system according to any of the aspects of the invention, the lesser complexity and the reliability of the cooling system will be further enhanced.

The heat exchanging interface may be an element being separate from the reservoir, and where the heat exchanging interface is secured to the reservoir in a manner so that the heat exchanging interface constitutes part of the reservoir when being secured to the reservoir. Alternatively, the heat exchanging interface constitutes an integrate surface of the reservoir, and where the heat exchanging surface extends along an area of the surface of the reservoir, said area of surface being intended for facing the processing unit and said area of surface being intended for the close thermal contact with the processing unit. Even alternatively, the heat exchanging interface is constitutes by a free surface of the processing unit, and where the free surface is capable of establishing heat dissipation between the processing unit and the cooling liquid through an aperture provided in the reservoir, and where the aperture extends along an area of the surface of the reservoir, said surface being intended for facing the processing unit.

The object may also be obtained by a cooling system for a computer system, said computer system comprising:
- at least one unit such as a central processing unit (CPU) generating thermal energy and said cooling system intended for cooling the at least one processing unit comprising
- a reservoir having an amount of cooling liquid, said cooling liquid intended for accumulating and transferring of thermal energy dissipated from the processing unit to the cooling liquid,
- a heat exchanging interface for providing thermal contact between the processing unit and the cooling liquid for dissipating heat from the processing unit to the cooling liquid,
- a pumping means being intended for pumping the cooling liquid into the reservoir, through the reservoir and from the reservoir to a heat radiating means,
- said heat radiating means intended for radiating thermal energy from the cooling liquid, dissipated to the cooling liquid, to surroundings of the heat radiating means,
- said heat exchanging interface constituting a heat exchanging surface being manufactured from a material suitable for heat conducting, and

- with a first side of the heat exchanging surface facing the central processing unit being substantially plane and
- with a second side of the heat exchanging surface facing the cooling liquid being substantially plane and
- said reservoir being manufactured from plastic, and channels or segments being provided in the reservoir for establishing a certain flow-path for the cooling liquid through the reservoir.

Providing a plane heat exchanging surface, both the first, inner side and on the second, outer side, results in the costs for manufacturing the heat exchanging surface is reduced to an absolute minimum. However, a plane first, inner surface may also result in the cooling liquid passing the heat exchanging surface too fast. This may be remedied by providing grooves along the inner surface, thereby providing a flow path in the heat exchanging surface. This however results in the costs for manufacturing the heat exchanging surface increasing.

The solution to this problem according to the invention has been dealt with by providing channels or segments in the reservoir housing in stead. The reservoir housing may be manufactured by injection moulding or by casting, depending on the material which the reservoir housing is made from. Proving channels or segments during moulding or casting of the reservoir housing is much more cost-effective than milling grooves along the inner surface of the heat exchanging surface.

The object may also be obtained by a cooling system for a computer system, said computer system comprising:
- at least one unit such as a central processing unit (CPU) generating thermal energy and said cooling system intended for cooling the at least one processing unit comprising
- at least one liquid reservoir mainly for dissipating or radiating heat, said heat being accumulated and transferred by said cooling liquid,
- said cooling system being adapted such as to provide transfer of said heat from a heat dissipating surface to a heat radiating surface where
- said at least one liquid reservoir being provided with one aperture intended for being closed by placing said aperture covering part of, alternatively covering the whole of, the at least one processing unit in such a way that a free surface of the processing unit is in direct heat exchanging contact with an interior of the reservoir, and thus in direct heat exchanging contact with the cooling liquid in the reservoir, through the aperture.

Heat dissipation from the processing unit to the cooling liquid must be very efficient to ensure proper cooling of the processing unit, Especially in the case, where the processing unit is a CPU, the surface for heat dissipation is limited by the surface area of the CPU. This may be remedied by utilising a heat exchanging surface being made of a material having a high thermal conductivity such as copper or aluminium and ensuring a proper thermal bondage between the heat exchanging surface and the CPU.

However, in a possible embodiment according to the features in the above paragraph, the heat dissipation takes place directly between the processing unit and the cooling liquid by providing an aperture in the reservoir housing, said aperture being adapted for taking up a free surface of the processing unit. Thereby, the free surface of the processing unit extends into the reservoir or constitutes a part of the boundaries of the reservoir, and the cooling liquid has direct access to the free surface of the processing unit.

According to one aspect of the invention, a method is envisaged, said method of cooling a computer system comprising at least one unit such as a central processing unit (CPU) generating thermal energy and said method utilising a cooling system for cooling the at least one processing unit and, said cooling system comprising a reservoir, at least one heat exchanging interface, an air blowing fan, a pumping means, said method of cooling comprising the steps of
- applying one of the following possibilities of how to operate the computer system: establishing, or defining, or selecting an operative status of the computer system
- controlling the operation of at least one of the following means of the computer system; the pumping means and the air blowing fan in response to at least one of the following parameters; a surface temperature of the heat generating processing unit, an internal temperature of the heat generating processing unit, or a processing load of the CPU and
- in accordance with the operative status being established, defined or selected, controlling the operation of the computer system in order to achieve at least one of the following conditions; a certain cooling performance of the cooling system, a certain electrical consumption of the cooling system, a certain noise level of the cooling system.

Applying the above method ensures an operation of the computer system being in accordance with selected properties during the use of the computer system. For some applications, the cooling performance is vital such as may be the case when working with image files or when downloading large files from a network during which the processing units is highly loaded and thus generating much heat. For other applications, the electrical power consumption is more vital such as may be the case when utilising domestic computer systems or in large office building in environments where the electrical grid may be weak such as in third countries. In still other applications, the noise generated by the cooling system is to be reduced to a certain level, which may be the case in office buildings with white collar people working alone, or at home, if the domestic computer perhaps is situated in the living room, or at any other location where other exterior considerations have to be dealt with.

According to another aspect of the invention, a method is envisaged, said method being employed with cooling system further comprising a pumping means with an impeller for pumping the cooling liquid through a pumping housing, said pumping means being driven by an AC electrical motor with a stator and a rotor, and said pumping means being provided with a means for sensing a position of the rotor, and wherein the method comprises the following steps:

- initially establishing a preferred rotational direction of the rotor of the electrical motor
- before start of the electrical motor, sensing the angular position of the rotor
- during start, applying an electrical AC voltage to the electrical motor and selecting the signal value, positive or negative, of the AC voltage at start of the electrical motor
- said selection being made according to the preferred rotational direction, and
- said application of the AC voltage being performed by the computer system for applying the AC voltage from the electrical power supply of the computer system during conversions of the electrical DC voltage of the power supply to AC voltage for the electrical motor.

Adopting the above method according to the invention ensures the most efficient circulation of cooling liquid in the cooling system and at the same time ensures the lowest possible energy consumption of the electrical motor driving the impeller. The efficient circulation of the cooling liquid is obtained by means of an impeller being designed for rotation in one rotational direction only, thus optimising the impeller design with regard to the only one rotational direction as opposed to both rotational directions. The low energy consumption is achieved because of the impeller design being optimised, thus limiting the necessary rotational speed of the impeller for obtaining e certain amount of flow of the cooling liquid through the cooling system. A bonus effect of the lowest possible energy consumption being obtained is the lowest possible noise level of the pump also being obtained. The noise level of the pump is amongst other parameters also dependent on the design and the rotational speed of the impeller. Thus, an optimised impeller design and impeller speed will reduce the noise level to the lowest possible in consideration of ensuring a certain cooling capacity.

BRIEF DESCRIPTION OF THE FIGURES

The invention will hereafter be described with reference to the drawings, where

Fig. 1 shows an embodiment of the prior art. The figure shows the typical components in an air-cooling type CPU cooling arrangement.

Fig. 2 shows an embodiment of the prior art. The figure shows the parts of the typical air-cooling type CPU cooling arrangement of figure 1 when assembled.

Fig. 3 shows an embodiment of the prior art. The figure shows the typical components in a liquid-cooling type CPU cooling arrangement.

Fig. 4 is an exploded view of the invention and the surrounding elements.

Fig. 5 shows the parts shown in the previous figure when assembled and attached to the motherboard of a computer system.

Fig. 6 is an exploded view of the reservoir from the previous figures 4 and 5 seen from the opposite site and also showing the pump.

Fig. 7 is a cut-out view into the reservoir housing the pump and an inlet and an outlet extending out of the reservoir.

Fig. 8 is a view of the cooling system showing the reservoir connected to the heat radiator.

Fig. 9-10 are perspective views of a possible embodiment of reservoir housing providing direct contact between a CPU and a cooling liquid in a reservoir.

Fig. 11-13 are perspective views of a possible embodiment of heat sink and a reservoir housing constituting an integrated unit.

Fig. 14 is a perspective view of the embodiment shown in fig. 9-10 and the embodiment shown in fig. 11-13 all together constituting an integrated unit.

Fig. 15-16 are perspective view of a preferred embodiment of a reservoir and a pump and a heat exchanging surface constituting an integrated unit.

DETAILED DESCRIPTION OF THE INVENTION

Fig. 1 is an exploded view of an embodiment of prior art cooling apparatus for a computer system. The figure shows the typical components in an air-cooling type CPU cooling arrangement. The figure shows a prior art heat sink 4 intended for air cooling and provided with segments intersected by interstices, a prior art air fan 5 which is to be mounted on top of the heat sink by use of fastening means 3 and 6.

The fastening means comprises a frame 3 provided with holes intended for bolts, screws, rivets or other suitable fastening means (not shown) for thereby attaching the frame to a motherboard 2 of a CPU 1 or onto another processing unit of the computer system. The frame 3 is also provided with mortises provided in perpendicular extending studs in each corner of the frame, said mortises intended for taking up tenons of a couple of braces. The braces 6 are intended for enclosing the heat sink 4 and the air fan 5 so that the air fan and the heat sink thereby is secured to the frame. Using proper retention mechanisms, when the frame is attached to the motherboard of the CPU of other processing unit, and when the tenons of the braces are inserted into the mortises of the frame, the air fan and heat exchanger is pressed towards the CPU by using a force perpendicular to the CPU surface, said force being provided by lever arms.

Fig. 2 shows the parts of the typical air-cooling type CPU cooling arrangement of figure 1, when assembled. The parts are attached to each other and will be mounted on top of a CPU on a motherboard (not shown) of a computer system.

Fig. 3 shows another embodiment of a prior art cooling system. The figure shows the typical components in a liquid-cooling type CPU cooling arrangement. The figure shows a prior art heat exchanger 7, which is in connection with a prior art liquid reservoir 8, a prior art liquid pump 9 and a heat radiator 11 and an air fan 10 provided together with the heat radiator. The prior art heat exchanger 7, which can be mounted on a CPU (not shown) is connected to a radiator and reservoir, respectively. The reservoir serves as a storage unit for excess liquid not capable of being contained in the remaining components. The reservoir is also intended as a means for venting the system of any air entrapped in the system and as a means for filling the system with liquid. The heat radiator 11 serves as a means for removing the heat from the liquid by means of the air fan 10 blowing air through the heat radiator. All the components are in connection with each other via tubes for conducting the liquid serving as the cooling medium.

Fig. 4 is an exploded view of a cooling system according to an embodiment of the invention. Also elements not being part of the cooling system as such are shown. The figure shows a central processing unit CPU 1 mounted on a motherboard of a computer system 2. The figure also shows a part of the existing fastening means, i.e. amongst others the frame 3 with mortises provided in the perpendicular extending studs in each corner of the frame. The existing fastening means, i.e. the frame 3 and the braces 6, will during use be attached to the motherboard 2 by means of bolts, screws, rivets or other suitable fastening means extending through the four holes provided in each corner of the frame and extending through corresponding holes in the motherboard of the CPU. The frame 3 will still provide an opening for the CPU to enable the CPU to extend through the frame.

The heat exchanging interface 4 is a separate element and is made of a heat conducting material having a relative high heat thermal conductivity such as copper or aluminium, and which will be in thermal contact with the CPU 1, when the cooling system is fastened to the motherboard 2 of the CPU. The heat exchanging surface constitutes part of a liquid reservoir housing 14, thus the heat exchanger 4 constitutes the part of the liquid reservoir housing facing the CPU. The reservoir may as example be made of plastic or of metal. The reservoir or any other parts of the cooling system, which are possibly manufactured from a plastic material may be "metallised" in order to minimise liquid diffusion or evaporation of the liquid. The metal may be provided as a thin layer of metal coating provided on either or on both of the internal side or the external side of the plastic part.

If the reservoir is made of metal or any other material having a relative high heat conductivity compared to as example plastic, the heat exchanging interface as a separate element may be excluded because the reservoir itself may constitute a heat exchanger over an area, wherein the reservoir is in thermal contact with the processing unit. Alternatively to having the heat exchanging interface constitute part of the liquid reservoir housing, the liquid reservoir housing may be tightly attached to the heat exchanging interface by means of screws, glue, soldering, brazing or the like means for securing the heat exchanging interface to the housing and vice versa, perhaps with a sealant 5 provided between the housing and the heat exchanging interface.

Alternatively to providing a heat exchanging interface integrate with the reservoir containing the cooling liquid, it will be possible to exclude the heat exchanger and providing another means for dissipating heat from the processing unit to the cooling liquid in the reservoir, The other means will be a hole provided in the reservoir, said hole intended for being directed towards the processing unit. Boundaries of the hole will be sealed towards boundaries of the processing unit or will be sealed on top of the processing unit for thereby preventing cooling liquid from the reservoir from leaking. The only prerequisite to the sealing is that a liquid-tight connection is provided between boundaries of the hole and the processing unit or surrounding of the processing unit, such as a carrier card of the processing unit.

By excluding the heat exchanger, a more effective heat dissipation will be provided from the processing unit and to the cooling liquid of the reservoir, because the intermediate element of a heat exchanger is eliminated. The only obstacle in this sense is the provision of a sealing being fluid-tight in so that the cooling liquid in the reservoir is prevented from leaking.

The heat exchanging surface 4 is normally a copper plate. When excluding the heat exchanging surface 4, which may be a possibility not only for the embodiments shown in fig. 4, but for all the embodiments of the invention, it may be necessary to provide the CPU with a resistant surface that will prevent evaporation of the cooling liquid and/or any damaging effect that the cooling liquid may pose to the CPU. A resistant surface may be provided the CPU from the CPU producer or it may be applied afterwards. A resistant surface to be applied afterwards may e.g. be a layer, such as an adhesive tape provided on the CPU. The adhesive tape may be made with a thin metal layer e.g. in order to prevent evaporation of the cooling liquid and/or any degeneration of the CPU itself.

Within the liquid reservoir, a liquid pump (not shown) is placed for pumping a cooling liquid from an inlet tube 15 connection being attached to the housing of the reservoir through the reservoir and past the heat exchanger in thermal contact with the CPU to an outlet tube connection 16 also being attached to the reservoir housing. The existing fastening means comprising braces 6 with four tenons and the frame 3 with four corresponding mortises will fasten the reservoir and the heat exchanger to the motherboard of the CPU. When fastening the two parts of the existing fastening means to each other the fastening will by means of the lever arms 18 create a force to assure thermal contact between the CPU 1 mounted on the motherboard and the heat exchanger 4 being provided facing the CPU.

The cooling liquid of the cooling system may be any type of cooling liquid such as water, water with additives such as anti-fungicide, water with additives for improving heat conducting or other special compositions of cooling liquids such as electrically non-conductive liquids or liquids with lubricant additives or anti-corrosive additives.

Fig. 5 shows the parts shown in fig. 4 when assembled and attached to the motherboard of a CPU of a computer system 2. The heat exchanger and the CPU is in close thermal contact with each other. The heat exchanger and the remainder of the reservoir 14 is fastened to the motherboard 2 by means of the existing fastening means being secured to the motherboard of the CPU and by means of the force established by the lever arms 18 of the existing fastening means. The tube inlet connection 15 and the tube outlet connection 16 are situated so as to enable connection of tubes to the connections.

Fig. 6 is an exploded view of the reservoir shown in previous fig. 4 and fig. 5 and seen from the opposite site and also showing the pump 21 being situated inside the reservoir. Eight screws 22 are provided for attaching the heat exchanging surface 4 to the remainder of the reservoir. The heat exchanging surface is preferably made from a copper plate having a plane outer surface as shown in the figure, said outer surface being intended for abutting the free surface of the heat generating component such as the CPU (see fig. 4). However, also the inner surface (not shown, see fig. 7) facing the reservoir is plane. Accordingly, the copper plate need no machining other than the shaping of the outer boundaries into the octagonal shape used in the embodiment shown and drilling of holes for insertion of the bolts. No milling of the inner and/or the outer surface need be provided.

A sealant in form of a gasket 13 is used for the connection between the reservoir 14 and the heat exchanging surface forming a liquid tight connection. The pump is intended for being placed within the reservoir. The pump has a pump inlet 20 through which the cooling liquid flows from the reservoir and into the pump, and the pump has a pump outlet 19 through which the cooling liquid is pumped from the pump and to the outlet connection. The figure also shows a lid 17 for the reservoir. The non-smooth inner walls of the reservoir and the fact that the pump is situated inside the reservoir will provide a swirling of the cooling liquid inside the reservoir.

However, apart from the non-smooth walls of the reservoir and the pump being situated inside the reservoir, the reservoir may be provided with channels or segments for establishing a certain flow-path for the cooling liquid through the reservoir (see fig 9-10 and fig 15). Channel or segments are especially needed when the inner surface of the heat exchanging surface is plane and/or when the inner walls of the reservoir are smooth and/or if the pump is not situated inside the reservoir. In either of the circumstances mentioned, the flow of the cooling liquid inside the reservoir may result in the cooling liquid passing the reservoir too quickly and not being resident in the reservoir for a sufficient amount of time to take up a sufficient amount of heat from the heat exchanging surface. By providing channels or segments inside the reservoir, a flow will be provided forcing the cooling liquid to pass the heat exchanging surface , and the amount of time increased of the cooling liquid being resident inside the reservoir, thus enhancing heat dissipation. If channels or segments are to be provided inside the reservoir, the shape and of the channels and segments may be decisive of whether the reservoir is to be made of plastic, perhaps by injection moulding, or is to be made of metal such as aluminium, perhaps by die casting.

The cooling liquid enters the reservoir through the tube inlet connection 15 and enters the pump inlet 20, and is pumped out of the pump outlet 19 connected to the outlet connection 16. The connection between the reservoir and the inlet tube connection and the outlet tube connection, respectively, are made liquid tight. The pump may not only be a self-contained pumping device, but may be made integrated into the reservoir, thus making the reservoir and a pumping device one single integrated component. This single integrated element of the reservoir and the pumping device may also be integrated, thus making the reservoir, the pumping device and the heat exchanging surface one single integrated unit. This may as example be possible if the reservoir is made of a metal such as aluminium. Thus, the choice of material provides the possibility of constituting both the reservoir and a heat exchanging surface having a relatively high heat conductivity, and possibly also renders the possibility of providing bearings and the like constructional elements for a motor and a pumping wheel being part of the pumping device.

In an alternative embodiment, the pump is placed in immediate vicinity of the reservoir, however outside the reservoir. By placing the pump outside, but in immediate vicinity of the reservoir, still an integrate element may be obtained, The pump or the inlet or the outlet is preferably positioned so as to obtain a turbulence of flow in the immediate vicinity of the heat exchanging interface, thereby promoting increased heat dissipation between the heat exchanging interface end the cooling liquid. even in the alternative, a pumping member such as an impeller (see fig. 15-16) may be provided in the immediate vicinity of the heat exchanging surface. The pumping member itself normally introduces a turbulence of flow, and thereby the increased heat dissipation is promoted irrespective of the position of the pump itself, or the position of the inlet or of the outlet to the reservoir or to the pump.

The pump may be driven by an AC or a DC electrical motor. When driven by an AC electrical motor, although being technically and electrically unnecessary in a computer system, this may be accomplished by converting part of the DC electrical power of the power supply of the computer system to AC electrical power for the pump. The pump may be driven by an electrical motor at any voltage common in public electrical networks such as 110V or 220V. However, in the embodiment shown, the pump is driven by a 12V AC electrical motor.

Control of the pump in case the pump is driven by an AC electrical motor, preferably takes place by means of the operative system or an alike means of the computer system itself, and where the computer system comprises means for measuring the CPU load and/or the CPU temperature. Using the measurement performed by the operative system or alike system of the computer system eliminates the need for special means for operating the pump. Communication between the operative system or alike system and a processor for operating the pump may take place along already established communication links in the computer system such as a USB-link. Thereby, a real-time communication between the cooling system and the operative system is provided without any special means for establishing the communication.

In the case of the motor driving the pump is an AC electrical motor, the above method of controlling the pump may be combined with a method, where said pumping means is provided with a means for sensing a position of the rotor of the electrical motor, and wherein the following steps are employed: Initially establishing a preferred rotational direction of the rotor of the electrical motor, before start of the electrical motor, sensing the angular position of the rotor, during start, applying an electrical AC voltage to the electrical motor and selecting the signal value, positive or negative, of the AC voltage at start of the electrical motor, said selection being made according to the preferred rotational direction, and said application of the AC voltage being performed by the computer system for applying the AC voltage from the electrical power supply of the computer system during conversion of the electrical DC voltage of the power supply to AC voltage for the electrical motor. By the operative system of the computer system itself generating the AC voltage for the electrical motor, the rotational direction of the pump is exclusively selected by the computer system, non-depending on the applied voltage of the public grid powering the computer system.

Further control strategies utilising the operative system or alike system of the computer system may involve balancing the rotational speed of the pump as a function of the cooling capacity needed. If a lower cooling capacity is needed, the rotational speed of the pump, may be limited, thereby limiting the noise generating by the motor driving the pump.

In the case an air fan is provided in combination with a heat sink as shown in fig. 1, of the air fan is provided in combination with the heat radiator, the operative system or alike system of the computer system may be designed for regulating the rotational speed of the pump, and thus of the motor driving the pump, and the rotational speed of the air fan, and thus the motor driving the air fan. The regulation will take into account the cooling capacity needed, but the regulation will at the same time take into account which of the two cooling means, i.e. the pump and the air fan, is generating the most noise. Thus, it the air fan generally is generating more noise than the pump, then the regulation will reduce the rotational speed of the air fan before reducing the rotational speed of the pump, whenever a lower cooling capacity is needed. Thereby, the noise level of the entire cooling system is lowered as much as possible. If the opposite is the case, i.e. the pump generally generating more noise than the air fan, then the rotational speed of the pump will be reduced before reducing the rotational speed of the air fan.

Even further control strategies involve controlling the cooling capacity in dependence on the type of computer processing taking place. Some kind of computer processing, such as word-processing, applies a smaller load on the processing units such as the CPU than other kinds of computer processing, such as image processing. Therefore, the kind of processing taking place on the computer system may be used as an indicator of the cooling capacity. It may even be possible as part of the operative system or similar system to establish certain cooling scenarios, depending on the kind of processing intended by the user. If the user selects as example word-processing, a certain cooling strategy is applied based on a limited need for cooling. If the user selects as example image-processing, a certain cooling strategy is applied based on an increased need for cooling. Two or more different cooling scenarios may be established depending on the capacity and the control possibilities and capabilities of the cooling system and depending on the intended use of the computer system, either as selected by a user during use of the computer system or as selected when choosing hardware during build-up of the computer system, i.e. before actual use of the computer system.

The pump is not being restricted to a mechanical device, but can be in any form capable of pumping the cooling liquid through the system. However, the pump is preferably one of the following types of mechanical pumps: Bellows pump, centrifugal pump, diaphragm pump, drum pump, flexible liner pump, flexible impeller pump, gear pump, peristaltic tubing pump, piston pump, processing cavity pump, pressure washer pump, rotary lobe pump, rotary vane pump and electro-kinetic pump. Similarly, the motor driving the pumping member need not be electrical but may also be a piezo-electrically operated motor, a permanent magnet operated motor, a fluid-operated motor or a capacitor-operated motor. The choice of pump and the choice of motor driving the pump id dependent on many different parameters, and it is up to the person skilled in the art to choose the type of pump and the type of motor depending on the specific application. As example, some pumps and some motors are better suited for small computer systems such as lab-tops, some pumps and some motors are better suited for establishing i high flow of the cooling liquid and thus a high cooling effect, and even some pumps and motors are better suited for ensuring a low-noise operation of the cooling system.

Fig. 7 is a cut-out view into the reservoir, when the reservoir and the heat exchanging surface 4 is assembled and the pump 21 is situated inside the reservoir. The reservoir is provided with the tube inlet connection (not seen from the figure) through which the cooling liquid enters the reservoir. Subsequently, the cooling liquid flows through the reservoir passing the heat exchanging surface and enters the inlet of the pump. After having been passed through the pump, the cooling liquid is passed out of the outlet of the pump and further out through the tube outlet connection 16. The figure also shows a lid 17 for the reservoir. The flow of the cooling liquid inside the reservoir and trough the pump may be further optimised in order to use as little energy as possible for pumping the cooling liquid, but still having a sufficient amount of heat from the heat exchanging surface being dissipated in the cooling liquid. This further optimisation can be established by changing the length and shape of the tube connection inlet within the reservoir, and/or by changing the position of the pump inlet, and/or for instance by having the pumping device placed in the vicinity and in immediate thermal contact with the heat exchanging surface and/or by providing channels or segments inside the reservoir.

In this case, an increased turbulence created by the pumping device is used to improve the exchange of heat between the heat exchanging surface and the cooling liquid. Another or an additional way of improving the heat exchange is to force the cooling liquid to pass through specially adapted channels or segments being provided inside the reservoir or by making the surface of the heat exchanging surface plate inside the reservoir uneven or by adopting a certain shape of a heat sink with segments. In the figure shown, the inner surface of the heat exchanging surface facing the reservoir is plane.

Fig. 8 is a perspective view of the cooling system showing the reservoir 14 with the heat exchanging surface (not shown) and the pump (not shown) inside the reservoir. The tube inlet connection and the tube outlet connection are connected to a heat radiator by means of connecting tubes 24 and 25 through which the cooling liquid flows into and out of the reservoir and the heat radiator, respectively. Within the heat radiator 11, the cooling liquid passes a number of channels for radiating the heat, which has been dissipated into the cooling liquid inside the reservoir, and to the surroundings of the heat exchanger. The air fan 10 blows air past the channels of the heat radiator in order to cool the radiator and thereby cooling the cooling liquid flowing inside the channels through the heat radiator and back into the reservoir.

According to the invention, the heat radiator 11 may be provided alternatively. The alternative heat radiator is constituted by a heat sink, such as a standard heat sink made of extruded aluminium with fins on a first side and a substantially plane second side. An air-fan may be provided in connection with the fins along the first side. Along the second side of the heat sink a reservoir is provided with at least one aperture intended for being closed by placing said aperture covering part of, alternatively covering the whole of, the substantial plane side of the heat sink. When closing the reservoir in such a way a surface of the heat sink is in direct heat exchanging contact with an interior of the reservoir, and thus in direct heat exchanging contact with the cooling liquid in the reservoir, through the at least one aperture. This alternative way of providing the heat radiator may be used in the embodiment shown in fig. 8 or may be used as a heat radiator for another use and/or for another embodiment of the invention.

A pumping means for pumping the cooling liquid trough the reservoir may or may not be provided inside the reservoir at the heat sink. The reservoir may be provided with channels or segments for establishing a certain flow-path for the cooling liquid through the reservoir. Channels or segments are especially needed when the inner surface of the heat exchanging surface is plane and/or when the inner walls of the reservoir are smooth and/or if the pump is not situated inside the reservoir. In either of the circumstances mentioned, the flow of the cooling liquid inside the reservoir may result in the cooling liquid passing the reservoir too quickly and not being resident in the reservoir for a sufficient amount of time to take up a sufficient amount of heat from the heat exchanging surface. If channels or segments in the reservoir are to be provided inside the reservoir, the shape and of the channels and segments may be decisive of whether the reservoir is to be made of plastic, perhaps by injection moulding, or is to be made of metal such as aluminium, perhaps by die casting.

By means of the alternative heat radiator, the heat radiator 11 is not provided as is shown in the figure with the rather expensive structure of channels leading the cooling liquid along ribs connecting the channels for improved surface of the structure. Instead, the heat radiator is provided as described as a unit constituted by a heat sink with or without a fan and a reservoir, and thereby providing a simpler and thereby cheaper heat radiator than the heat radiator 11 shown in the figure.

The alternative heat radiator provided as an unit constituted by a heat sink and a reservoir, may be used solely, with or without a pump inside the reservoir and with or without the segments or channels, for being placed in direct or indirect thermal contact with a heat generating processing unit such as CPU or with the heat exchanging surface, respectively. These embodiments of the invention may e.g. be used for a reservoir, where the cooling liquid along a first side within the reservoir is in direct heat exchanging contact with the heat generating processing unit such as a CPU and the cooling liquid along a second side within the reservoir is in direct heat exchanging contact with a heat sink. Such a reservoir may be formed such as to provide a larger area of heat exchanging surface towards the heat generating processing unit such as a CPU than the area of the heat exchanging surface facing the heat sink. This may e.g. have the purpose of enlarging the area of the heat exchanging surface so as to achieve an improved heat dissipation form e.g. the CPU to the heat sink than that of a conventional heat sink without a reservoir attached. Conventional heat sinks normally only exchanges heat with the CPU through the area as given by the area of the top side of the CPU. A system comprising a liquid reservoir and a heat sink with a fan provided has been found to be a simple, cost optimised system with an improved heat dissipation than that of a standard heat sink with a fan, but without the reservoir. In another embodiment of the invention, which may be derived from fig. 8, the air fan and the heat radiator is placed directly in alignment of the reservoir. Thereby, the reservoir 14, the air fan 10 and the radiator 11 constitute an integrate unit. Such an embodiment may provide the possibility of omitting the connection tubes, and passing the cooling liquid directly from the heat radiator to the reservoir via an inlet connection of the reservoir, and directly from the reservoir to the heat radiator via an outlet connection of the reservoir. Such an embodiment may even render the possibility of both the pumping device of the liquid pump inside the reservoir and the electrical motor for the propeller of the air fan 23 of the heat radiator 11 being driven by the same electrical motor, thus making this electrical motor the only motor of the cooling system.

When placing the heat radiator on top of the air fan now placed directly in alignment with the reservoir and connecting the heat radiator directly to the inlet connection and outlet connection of the reservoir, a need for tubes will not be present. However, if the heat radiator and the reservoir is not in direct alignment with each other, but tubes may still be needed, but rather than tubes, pipes made of metal such as copper or aluminium may be employed, such pipes being impervious to any possible evaporation of cooling liquid. Also, the connections between such pipes and the heat radiator and the reservoir, respectively, may be soldered so that even the connections are made impervious to evaporation of cooling liquid.

In the derived embodiment just described, an integrated unit of the reservoir, the heat exchanging surface and the pumping device will be given a structure establishing improved heat radiating characteristics because the flow of air of the air fan may also be directed along outer surfaces of the reservoir. If the reservoir is made of a metal, the metal will be cooled by the air passing the reservoir after having passed or before passing the heat radiator. If the reservoir is made of metal, and if the reservoir is provided with segments on the outside surface of the reservoir, such cooling of the reservoir by the air will be further improved. Thereby, the integrated unit just described will be applied improved heat radiating characteristics, the heat radiation function normally carried out by the heat radiator thus being supplemented by one or more of the further elements of the cooling system, i.e. the reservoir, the heat exchanging surface, the liquid pump and the air fan.

Fig. 9-10 show an embodiment of a reservoir housing 14, where channels 25 are provided inside the reservoir for establishing a forced flow of the cooling liquid inside the reservoir. The channels 25 in the reservoir 14 lead from an inlet 15 to an outlet 16 like a maze between the inlet and the outlet. The reservoir 14 is provided with an aperture 27 having outer dimensions corresponding to the dimensions of a free surface of the processing unit 1 to be cooled. In the embodiment shown, the processing unit to be cooled is a CPU 1.

When channels 26 are provided inside the reservoir, the shape of the channels may be decisive of whether the reservoir is to be made of plastic, perhaps manufactured by injection moulding, or is to be made of metal such as aluminium, perhaps manufactured by extrusion or by die casting.

The reservoir 14 or any other parts of the cooling system, which are possibly manufactured from a plastic material may be "metallised" in order to minimise liquid diffusion or evaporation of the liquid. The metal may be provided as a thin layer of metal coating provided on either or on both of the internal side or the external side of the plastic part.

The CPU 1 is intended for being positioned in the aperture 27, as shown in fig. 10, so that outer boundaries of the CPU are engaging boundaries of the aperture. Possibly, a sealant (not shown) may be provided along the boundaries of the CPU and the aperture for ensuring a fluid tight engagement between the boundaries of the CPU and the boundaries of the aperture. When the CPU 1 is positioned in the aperture 27, the free surface (not shown) of the CPU is facing the reservoir, i.e. the part of the reservoir having the channels provided. Thus, when positioned in the aperture 27 (see fig. 10), the free surface of the CPU 1 is having direct contact with cooling liquid flowing through the channels 26 in the reservoir.

When cooling liquid is forced from the inlet 15 along the channels 26 to the outlet 16, the whole of the free surface of the CPU 1 will be passed over by the cooling liquid, thus ensuring a proper and maximised cooling of the CPU. The configuration of the channels may be designed and selected according to any one or more provisions, i.e. high heat dissipation, certain flow characteristics, ease of manufacturing etc. Accordingly, the channels may have another design depending on any desire or requirement and depending on the type of CPU and the size and shape of the free surface of the CPU. Also. other processing units than a CPU may exhibit different needs for heat dissipation, and may exhibit other sizes and shapes of the free surface, leading to a need for other configurations of the channels. If the processing unit is very elongate, such as a row of microprocessors, one or a plurality of parallel channels may be provided, perhaps just having a common inlet and a common outlet.

Fig. 11-13 show an embodiment of a heat sink 4, where segments 28 are provided at a first side 4A of the heat sink, and fins 29 for dissipating heat to the surroundings are provided at the other, second side 4B of the heat sink. An intermediate reservoir housing 30 is provided having a recessed reservoir at the one side facing the first side 4A of the heat sink. The recessed reservoir 30 has an inlet 31 and an outlet 32 at the other side opposite the side facing the heat sink 4.

When segments 28 are provided on the first side 4A of the heat sink, the shape of the segments may be decisive of whether the reservoir, which is made from metal such as aluminium or copper, is to be made by extrusion or is to be made by other manufacturing processes such as die casting. Especially when the segments 28 are linear and are parallel with the fins 29, as shown in the embodiment, extrusion is a possible and cost-effective means of manufacturing the heat sink 4.

The intermediate reservoir 30 or any other parts of the cooling system, which are possibly manufactured from a plastic material may be "metallised" in order to minimise liquid diffusion or evaporation of the liquid. The metal may be provided as a thin layer of metal coating provided on either or on both of the internal side or the external side of the plastic part.

The recessed reservoir is provided with a kind of serration 33 along opposite sides of the reservoir, and the inlet 31 and the outlet 32, respectively, are provided at opposite corners of the intermediate reservoir 30. The segments 28 provided at the first side 4A of the heat sink, i.e. the side facing the intermediate reservoir 30, are placed so that when the heat sink is assembled with the intermediate reservoir housing (see fig 13) the segments 29 run from one serrated side of the reservoir to the other serrated side of the reservoir.

When cooling liquid is forced from the inlet 31 through the reservoir, along channels (not shown) formed by the segments 29 of the heat sink 4 and to the outlet 32, the whole of the first side 4A of the heat sink will be passed over by the cooling liquid, thus ensuring a proper and maximised heat dissipation between the cooling liquid and the heat sink. The configuration of the segments on the first side 4A of the heat sink and the configuration of the serrated sides of the intermediate reservoir housing may be designed and selected according to any provisions. Accordingly, the segments may have another design, perhaps being wave-shaped or also a serrated shape, depending on any desired flow characteristics of the cooling liquid and depending on the type of heat sink and the size and shape of the reservoir.

Also other types of heat sinks, perhaps circular shaped heat sinks may exhibit different needs for heat dissipation, may exhibit other sizes and shapes of the free surface, leading to a need for other configurations of the segments and the intermediate reservoir. If the heat sink and the reservoir are circular or oval, a spiral-shaped segmentation or radially extending segments may be provided, perhaps having the inlet or the outlet in the centre of the reservoir. If an impeller of the pump is provided, as shown in fig. 15-16, the impeller of the pump may be positioned in the centre of a spiral-shaped segmentation or in the centre of radially extending segments.

Fig. 14 shows the reservoir 14 shown in fig. 9-10 and the heat sink 4 and the intermediate reservoir 30 shown in fig. 11-13 being assembled for thereby constituting an integrated monolithic unit. It is not absolutely necessary to assemble the reservoir 14 of fig. 9-10 and the heat sink 4 and the intermediate reservoir 30 of fig. 11-13 in order to obtain a properly functioning cooling system. The inlet 15 and the outlet 16 of the reservoir 14 of fig. 9-10 may be connected to the outlet 32 and the inlet 31, respectively, of the intermediate reservoir of fig. 11-13 by means of tubes or pipes.

The reservoir 14 of fig. 9-10 and the heat sink 4 and the intermediate reservoir 30 of fig. 11-13 may then be positioned in the computer system at different locations. However, by assembling the reservoir 14 of fig- 9-10 and the heat sink 4 and the intermediate reservoir 30 of fig. 11-13 a very compact monolithic unit is obtained, also obviating the need for tubes or pipes. Tubes or pipes may involve an increased risk of leakage of cooling liquid or may require soldering or other special working in order to eliminate the risk of leakage of cooling liquid. By eliminating the need for tubes or pipes, any leakage and any additional working is obviated when assembling the cooling system.

Fig. 15-16 show a possible embodiment of a reservoir according to the invention. The reservoir is basically similar to the reservoir shown in fig. 9-10. However, an impeller 33 of the pump of the cooling system is provided in direct communication with the channels 26. Also, in the embodiment shown, a heat exchanging interface 4 such as a surface made from a copper plate, alternatively a plate of another material having a high thermal conductivity, is placed between the channels 26 inside the reservoir and the CPU 1 as the processing unit.

The heat exchanging surface 4 is preferably made from a copper plate having a plane outer surface as shown in the figure, said outer surface being intended for abutting the free surface of the heat generating component such as the CPU 1 (see fig. 4). However, also the inner surface (not shown, see fig. 7) facing the reservoir is plane. Accordingly, the copper plate need no machining other than the shaping of the outer boundaries into the specially adapted shape used in the embodiment shown and drilling of holes for insertion of the bolts. No milling of the inner and/or the outer surface need be provided.

The provision of the heat exchanging surface 4 need not be a preferred embodiment, seeing that the solution incorporating the aperture (see fig. 9-10) result in a direct heat exchange between the free surface of the CPU or other processing unit and the cooling liquid flowing along the channels in the reservoir. However, the heat exchanging surface enables usage of the cooling system independently on the type and size of the free surface of CPU or other processing unit.

In the embodiment shown, the heat exchanging surface 4 is secured to the reservoir by means of bolts 22. Other convenient fastening means may be used. The heat exchanging surface 4 and thus the reservoir 14 may be fastened to the CPU 1 or other processing unit by any suitable means such as soldering, brazing or by means of thermal paste combined with glue. Alternatively, special means (not shown) may be provided for ensuring a thermal contact between the free surface of the CPU or other processing unit and the heat exchanging surface. One such means may be the fastening means shown in fig. 4 and fig. 5 or similar fastening means already provided as part of the computer system.

When channels 26 are provided inside the reservoir 14, the shape of the channels may be decisive of whether the reservoir is to be made of plastic, perhaps by injection moulding, or is to be made of metal such as aluminium, perhaps by die casting.

The reservoir 14 or any other parts of the cooling system, which are possibly manufactured from a plastic material may be "metallised" in order to minimise liquid diffusion or evaporation of the liquid. The metal may be provided as a thin layer of metal coating provided on either or on both of the internal side or the external side of the plastic part.

The impeller 33 (see fig. 14) of the pump is positioned in a separate recess of the channels 26, said separate recess having a size corresponding to the diameter of the impeller of the pump. The recess is provided with an inlet 34 and an outlet 35 being positioned opposite an inlet 31 and an outlet 32 of cooling liquid to and from, respectively, the channels 26. The impeller 33 of the pump has a shape and a design intended only for one way rotation, in the embodiment shown a clock-wise rotation only. Thereby, the efficiency of the impeller of the pump is highly increased compared to impellers capable of and intended for both clock-wise and counter clock-wise rotation.

The increased efficiency of the impeller design results in the electric motor (not shown) driving the impeller of the pump possibly being smaller than otherwise needed for establishing a proper and sufficient flow of cooling liquid through the channels. In a preferred embodiment, the electric motor is an AC motor, preferably a 12V AC motor, leading to the possibility of an even smaller motor needed for establishing the proper and sufficient flow of cooling liquid through the channels.

The impeller of the pump may be driven by an AC or a DC electrical motor. However, as mentioned, preferably the impeller of the pump is driven by an AC electrical motor. Although being technically and electrically unnecessary to use an AC electrical motor in a computer system, this may be accomplished by converting part of the DC electrical power of the power supply of the computer system to AC electrical power for the impeller of the pump. The impeller may be driven by an electrical motor at any voltage common in public electrical networks such as 110V or 220V. However, in the embodiment shown, the impeller of the pump is driven by a 12V electrical motor.

The invention has been described with reference to specific embodiments and with reference to specific utilisation, it is to be noted that the different embodiments of the invention may be manufactured, marketed, sold and used separately or jointly in any combination of the plurality of embodiments. In the above detailed description of the invention, the description of one embodiment, perhaps with reference to one or more figures, may be incorporated into the description of another embodiment, perhaps with reference to another or more other figures, and vice versa. Accordingly, any separate embodiment described in the text and/or in the drawings, or any combination of two or more embodiments is envisaged by the present application.

CLAIMS

1. A cooling system for a computer system, said computer system comprising
- at least one unit such as a central processing unit (CPU) generating thermal energy and said cooling system intended for cooling the at least one processing unit and comprising
- a reservoir having an amount of cooling liquid, said cooling liquid intended for accumulating and transferring of thermal energy dissipated from the processing unit to the cooling liquid,
- a heat exchanging interface for providing thermal contact between the processing unit and the cooling liquid for dissipating heat from the processing unit to the cooling liquid,
- a pumping means being provided as part of an integrate element, said integrate element comprising the heat exchanging interface, the reservoir and the pump,
- said pump intended for pumping the cooling liquid into the reservoir, through the reservoir and from the reservoir to a heat radiating means,
- said heat radiating means intended for radiating thermal energy from the cooling liquid, dissipated to the cooling liquid, to surroundings of the heat radiating means.

2. A cooling system according to claim 1, wherein the pump is placed inside the reservoir with at least an inlet or an outlet leading to the cooling liquid in the reservoir.

3. A cooling system according to claim 1, wherein the pump is placed outside the reservoir in the immediate vicinity of the reservoir and wherein at least an inlet or an outlet is leading directly to the cooling liquid in the reservoir.

4. A cooling system according to any of the preceding claims, wherein an inlet of the pump is positioned in immediate vicinity of the heat exchanging interface for thereby obtaining a turbulence of flow of the cooling liquid in the immediate vicinity of the heat exchanging interface.

5. A cooling system according to any of the preceding claims, wherein an outlet of the pump is positioned in immediate vicinity of the heat exchanging interface for thereby obtaining a turbulence of flow of the cooling liquid in the immediate vicinity of the heat exchanging interface.

6. A cooling system according to any of the preceding claims, wherein a pumping member of the pump is positioned in immediate vicinity of the heat exchanging interface for thereby obtaining a turbulence of flow of the cooling liquid in the immediate vicinity of the heat exchanging interface.

7. A cooling system according to any of the preceding claims, wherein the pump is selected from the following types: Bellows pump, centrifugal pump, diaphragm pump, drum pump, flexible liner pump, flexible impeller pump, gear pump, peristaltic tubing pump, piston pump, processing cavity pump, pressure washer pump, rotary lobe pump, rotary vane pump and electro-kinetic pump.

8. A cooling system according to any of the preceding claims, wherein driving means for driving the pump is selected among the following driving means: electrically operated rotary motor, piezo-electrically operated motor, permanent magnet operated motor, fluid-operated motor, capacitor-operated motor.

9. A cooling system according to any of the preceding claims, wherein one or more of the following means are provided inside the reservoir for increasing the heat absorption by the cooling liquid: channels or segments inside the reservoir, an uneven surface being provided on a physical surface of the heat exchanging interface, a heat sink with segments provided inside the reservoir and being in thermal contact with the cooling liquid.

10. A cooling system according to any of the preceding claims, where the heat exchanging interface is a heat exchanging surface being in close thermal contact with the processing unit for dissipating heat from the processing unit to the cooling liquid via the heat exchanging surface.

11. A cooling system according to any of the preceding claims, where the heat exchanging interface is a free surface of the processing unit, said free surface of the processing unit having direct access to the cooling liquid for dissipating heat from the processing unit directly to the cooling liquid,

12. A cooling system for a computer system, said computer system comprising
- at least one unit such as a central processing unit (CPU) generating thermal energy and said cooling system intended for cooling the at least one processing unit and comprising
- a reservoir having an amount of cooling liquid for accumulating and transferring of thermal energy dissipated from the processing unit to the cooling liquid,
- a heat exchanging interface for providing thermal contact between the processing unit and the cooling liquid for dissipating heat from the processing unit to the cooling liquid,
- a pump intended for pumping the cooling liquid into the reservoir, through the reservoir and from the reservoir to a heat radiating means,
- said cooling system being intended for thermal contact with the processing unit by means of existing fastening means associated with the processing unit, and

- said heat radiating means intended for radiating from the cooling liquid thermal energy, dissipated to the cooling liquid, to surroundings of the heat radiating means.

13. A cooling system according to claim 12, wherein the existing fastening means are means intended for attaching a heat sink to the processing unit.

14. A cooling system according to claim 12, wherein the existing fastening means are means intended for attaching a cooling fan to the processing unit.

15. A cooling system according to claim 12, wherein the existing fastening means are means intended for attaching a heat sink together with a cooling fan to the processing unit.

16. A cooling system according to any of claims 12-15, wherein the pump is selected from the following types: Bellows pump, centrifugal pump, diaphragm pump, drum pump, flexible liner pump, flexible impeller pump, gear pump, peristaltic tubing pump, piston pump, processing cavity pump, pressure washer pump, rotary lobe pump, rotary vane pump and electro-kinetic pump.

17. A cooling system according to any of claims 12-16, wherein driving means for driving the pump is selected among the following driving means: electrically operated rotary motor, piezo-electrically operated motor, permanent magnet operated motor, fluid-operated motor, capacitor-operated motor.

18. A cooling system according to any of claims 12-17, wherein one or more of the following means are provided inside the reservoir for increasing the heat absorption by the cooling liquid: channels or segments inside the reservoir, an uneven surface being provided on a physical surface of the heat exchanging interface, a heat sink with segments provided inside the reservoir and being in thermal contact with the heat exchanging surface.

19. A cooling system according to any of claims 12-18, where the heat exchanging interface is a heat exchanging surface being in close thermal contact with the processing unit for dissipating heat from the processing unit to the cooling liquid via the heat exchanging surface.

20. A cooling system according to any of claims 12-18, where the heat exchanging interface is a free surface of the processing unit, said free surface of the processing unit

having direct access to the cooling liquid for dissipating heat from the processing unit directly to the cooling liquid,

21. A cooling system for a computer system, said computer system comprising
- at least one unit such as a central processing unit (CPU) generating thermal energy and said cooling system intended for cooling the at least one processing unit and comprising
- a reservoir having an amount of cooling liquid for accumulating and transferring of thermal energy dissipated from the processing unit to the cooling liquid,
- a heat exchanging interface for providing thermal contact with the processing unit and the cooling liquid for dissipating heat from the processing unit to the cooling liquid,
- a pump intended for pumping the cooling liquid into the reservoir, through the reservoir and from the reservoir to a heat radiating means, and
- said cooling system further comprising a pump wherein the pump is driven by an AC electrical motor powered by a DC electrical power supply of the computer system,
- where at least part of the electrical power from said power supply is intended for being converted to AC being supplied to the electrical motor.

22. A cooling system according to claim 21, wherein the pump is selected from the following types: Bellows pump, centrifugal pump, diaphragm pump, drum pump, flexible liner pump, flexible impeller pump, gear pump, peristaltic tubing pump, piston pump, processing cavity pump, pressure washer pump, rotary lobe pump, rotary vane pump and electro-kinetic pump.

23. A cooling system according to claim 21 or 22, wherein one or more of the following means are provided inside the reservoir for increasing the heat absorption by the cooling liquid: channels or segments inside the reservoir, an uneven surface being provided on a physical surface of the heat exchanging interface, a heat sink with segments provided inside the reservoir and being in thermal contact with the heat exchanging surface.

24. A cooling system according to any of claims 21-23, where the heat exchanging interface is a heat exchanging surface being in close thermal contact with the processing unit for dissipating heat from the processing unit to the cooling liquid via the heat exchanging surface.

25. A cooling system according to any of the claims 21-23, where the heat exchanging interface is a free surface of the processing unit, said free surface of the processing unit having direct access to the cooling liquid for dissipating heat from the processing unit directly to the cooling liquid,

26. A cooling system according to any of the claims 1-25, wherein a motor is intended both for driving the pump for pumping the cooling liquid and for driving a fan for establishing a flow of air in the vicinity of the reservoir.

27. A cooling system according to any of the claims 1-25, wherein a motor is intended both for driving the pump for pumping the cooling liquid and for driving a fan for establishing a flow of air in the vicinity of the heat radiating means.

28. A cooling system according to any of the claims 1-25, wherein a motor is intended both for driving the pump for pumping the cooling liquid, and for driving the a fan for establishing a flow of air in the vicinity of the reservoir, and for driving a fan for establishing a flow of air in the vicinity of the heat radiating means.

29. A cooling system according to any of the preceding claims, wherein the heat exchanging interface is an element being separate from the reservoir, and where the heat exchanging interface is secured to the reservoir in a manner so that the heat exchanging interface constitutes part of the reservoir when being secured to the reservoir.

30. A cooling system according to any of claims 1-28, wherein the heat exchanging interface constitutes an integrate part of the reservoir, and where the heat exchanging interface extends along an area of a surface of the reservoir, said area of surface being intended for facing the processing unit and said area of surface being intended for close thermal contact with the processing unit.

31. A cooling system according to any of claims 1-28, wherein the heat exchanging interface is constituted between a free surface of the processing unit and the cooling liquid in the reservoir, and where the heat exchanging interface is capable of establishing the close thermal contact with the processing unit through an aperture provided in the reservoir, and where the aperture extends along an area of the surface of the reservoir, said area of surface being intended for facing the processing unit.

32. A cooling system according to any of the preceding claims wherein said heat exchanging interface has an surface facing said reservoir, and said inside surface being substantially plane.

33. A cooling system for a computer system, said computer system comprising
- at least one unit such as a central processing unit (CPU) generating thermal energy and said cooling system intended for cooling the at least one processing unit comprising

- a reservoir having an amount of cooling liquid, said cooling liquid intended for accumulating and transferring of thermal energy dissipated from the processing unit to the cooling liquid,
- a heat exchanging interface for providing thermal contact between the processing unit and the cooling liquid for dissipating heat from the processing unit to the cooling liquid,
- a pumping means being intended for pumping the cooling liquid into the reservoir, through the reservoir and from the reservoir to a heat radiating means,
- said heat radiating means intended for radiating thermal energy from the cooling liquid, dissipated to the cooling liquid, to surroundings of the heat radiating means,- said heat exchanging interface being manufactured from a material suitable for heat conducting, and
- with a first side of the heat exchanging interface facing the central processing unit being substantially plane and
- with a second side of the heat exchanging interface facing the cooling liquid being substantially plane and
- said reservoir being manufactured from plastic, and channels or segments being provided in the reservoir for establishing a certain flow-path for the cooling liquid through the reservoir.

34. A cooling system according to claim 33, wherein said pumping means is provided as part of an integrate element, said integrate element comprising the heat exchanging interface, the reservoir and the pumping means. 35. A cooling system according to claim 33 or 34, wherein an inlet of said pumping means is positioned in immediate vicinity of the heat exchanging interface for thereby obtaining a turbulence of flow of the cooling liquid in the immediate vicinity of the heat exchanging interface.

36. A cooling system according to claim 33 or 34, wherein an outlet of said pumping means is positioned in immediate vicinity of the heat exchanging interface for thereby obtaining a turbulence of flow of the cooling liquid in the immediate vicinity of the heat exchange interface.

37. A cooling system according to claim 33 or 34, wherein a pumping member of said pumping means is positioned in immediate vicinity of the heat exchanging interface for thereby obtaining a turbulence of flow of the cooling liquid in the immediate vicinity of the heat exchanging interface.

38. A cooling system according to any of claims 33-37, wherein the pumping means is selected from the following types: Bellows pump, centrifugal pump, diaphragm pump, drum pump, flexible liner pump, flexible impeller pump, gear pump, peristaltic tubing

pump, piston pump, processing cavity pump, pressure washer pump, rotary lobe pump, rotary vane pump and electro-kinetic pump.

39. A cooling system according to any of claims 33-38, wherein driving means for driving the pump is selected among the following driving means: electrically operated rotary motor, piezo-electrically operated motor, permanent magnet operated motor, fluid-operated motor, capacitor-operated motor.

40. A cooling system according to any of claims 33-39, wherein said pumping means is driven by an AC electrical motor by a DC electrical power supply of the computer system, wherein at least part of the electrical power from said power supply is intended for being converted to AC being supplied to the electrical motor.

41. A cooling system according to any of claims 33-40, where the heat exchanging interface is a heat exchanging surface being in close thermal contact with the processing unit for dissipating heat from the processing unit to the cooling liquid via the heat exchanging surface.

42. A cooling system according to any of claims 33-40, where the heat exchanging interface is a free surface of the processing unit, said free surface of the processing unit having direct access to the cooling liquid for dissipating heat from the processing unit directly to the cooling liquid,

43. A cooling system for a computer system, said computer system comprising
- at least one unit such as a central processing unit (CPU) generating thermal energy and said cooling system intended for cooling the at least one processing unit comprising
- at least one liquid reservoir mainly for dissipating or radiating heat, said heat being accumulated and transferred by said cooling liquid,
- said cooling system being adapted such as to provide transfer of said heat from a heat dissipating interface to a heat radiating surface where
- said at least one liquid reservoir being provided with one aperture intended for being closed by placing said aperture covering part of, alternatively covering the whole of, the at least one processing unit in such a way that a free surface of the processing unit is in direct heat exchanging contact with an interior of the reservoir, and thus in direct heat exchanging contact with the cooling liquid in the reservoir, through the aperture.

44. A cooling system for a computer system according to claim 43, wherein the aperture of the reservoir is intended for being closed by attaching boundaries of said aperture to a free surface of a the processing unit.

45. A cooling system for a computer system according to claim 43, wherein the aperture of the reservoir is intended for being closed by attaching boundaries of said aperture along boundaries of a free surface of the processing unit.

46. A cooling system for a computer system according to claim 43, wherein the aperture of the reservoir is intended for being closed by attaching boundaries of said aperture to a free surface of a heat sink.

47. A cooling system for a computer system according to claim 43, wherein the aperture of the reservoir is intended for being closed by attaching boundaries of said aperture along boundaries of a free surface of a heat sink.

48. A cooling system according to claim 43, wherein
- a first reservoir is intended for being closed by attaching boundaries of an aperture in the first reservoir to, alternatively along, a free surface of a said processing unit and wherein
- a second reservoir is intended for being closed by attaching boundaries of an aperture in the second reservoir to, alternatively along, a free surface of a to a free surface of a heat sink, and where
- liquid conducting means are provided between the first reservoir and the second reservoir.

49. A cooling system according to claim 43, wherein a first reservoir is closed by attaching said first reservoir to a heat exchanging surface element being in close thermal contact with the processing unit, said heat exchanging surface intended for dissipating heat from the processing unit to cooling liquid in the first reservoir, and wherein a second reservoir is closed by attaching said second reservoir to a surface of a heat sink, said heat sink intended for radiating heat from cooling liquid in the second reservoir to the exterior surroundings.

50. A cooling system according to claim 48 or 49, wherein said first reservoir and said second reservoir are provided as a monolithic structure comprising both the first reservoir and the second reservoir and where both a heat dissipation from the processing unit to the cooling liquid in the first reservoir and heat radiation from the cooling liquid in the second reservoir to exterior surrounding is provided by the monolithic structure.

51. A cooling system according to claim 50, wherein said monolithic structure is manufactured at least partly from plastic, preferably is manufactured fully in plastic, and said monolithic structure being manufactured by injection moulding.

52. A cooling system according to any of claims 43-51, wherein transfer of said cooling liquid from an outlet of the first reservoir to an inlet of the second reservoir, and from an outlet of the second reservoir to an inlet of the first reservoir, and circulating the cooling liquid within said liquid conducting means is provided by a pumping means being intended for pumping the cooling liquid.

53. A cooling system according to any of claims 43-52 wherein one of said reservoirs of said monolithic structure comprises said pumping means.

54. A cooling system according to claim 52 or 53, wherein an inlet and/or an outlet and/or a pumping member of said pumping means, is provided in the vicinity of said substantially plane side in order to provide a turbulence of flow and hereby improve the exchange of heat between said cooling liquid and substantially plane side.

55. A cooling system according to claim 54, wherein an inlet of the pumping means is provided within the first reservoir and the outlet is provided within the second reservoir.

56. A cooling system according to any of the claims 43-55, wherein the pump is selected from the following types: Bellows pump, centrifugal pump, diaphragm pump, drum pump, flexible liner pump, flexible impeller pump, gear pump, peristaltic tubing pump, piston pump, processing cavity pump, pressure washer pump, rotary lobe pump, rotary vane pump and electro-kinetic pump.

57. A cooling system according to any of the claims 43-56, wherein driving means for driving the pump is selected among the following driving means: electrically operated rotary motor, piezo-electrically operated motor, permanent magnet operated motor, fluid-operated motor, capacitor-operated motor.

58. A cooling system according to any of claims 43-57, wherein said pumping means is driven by an AC electrical motor by a DC electrical power supply of the computer system, wherein at least part of the electrical power from said power supply is intended for being converted to AC being supplied to the electrical motor.

59. A cooling system according to any of claims 43-58, wherein one or more of the following means are provided inside the reservoir for increasing the heat absorption by the cooling liquid: channels or segments inside the reservoir, an uneven surface being provided on a physical surface of the heat exchanging interface, a heat sink with segments

provided inside the reservoir and being in thermal contact with the heat exchanging interface.

60. A cooling system according to any of claims 43-59, wherein an electrical motor is intended both for driving the pump for pumping the cooling liquid through the reservoir and for driving a fan for establishing a flow of air around the reservoir.

61. A cooling system according to any of claims 43-59, wherein an electrical motor is intended both for driving the pump for pumping the cooling liquid through the reservoir and for driving a fan for establishing a flow of air along heat radiating means.

62. A cooling system according to any of claims 43-59, wherein an electrical motor is intended both for driving the pump for pumping the cooling liquid through the reservoir, and for driving a fan for establishing a flow of air around the reservoir, and for driving a fan for establishing a flow of air along heat radiating means.

63. A method of cooling a computer system comprising at least one unit such as a central processing unit (CPU) generating thermal energy and said method utilising a cooling system for cooling the at least one processing unit and, said cooling system comprising

- a reservoir
- at least one heat exchanging interface
- an air blowing fan
- a pumping means

said method of cooling comprising the steps of

- applying one of the following possibilities of how to operate the computer system: establishing, or defining, or selecting an operative status of the computer system
- controlling the operation of at least one of the following means of the computer system; the pumping means and the air blowing fan in response to at least one of the following parameters; a surface temperature of the heat generating processing unit, an internal temperature of the heat generating processing unit, or a processing load of the CPU and
- in accordance with the operative status being established, defined or selected, controlling the operation of the computer system in order to achieve at least one of the following conditions; a certain cooling performance of the cooling system, a certain electrical consumption of the cooling system, a certain noise level of the cooling system.

64. A method according to claim 63 for cooling a computer system, wherein the operation of the air blowing fan is controlled before any control of the operation of the pumping means in order to achieve the at least one selected condition of the cooling system.

65. A method according to claim 63 or 64 for cooling a computer system, wherein said computer system further comprises an operative system or an alike means comprising a means for measuring the CPU load and/or the CPU temperature, and wherein said method of cooling said CPU further comprises the step of
- using a measurement, performed by said BIOS or alike means, of the CPU load and/or the CPU temperature for controlling said cooling system.

66. A method according to claim 63 for cooling a computer system, wherein said cooling system further comprises a temperature measuring means for measuring a temperature of the CPU, and wherein said method of cooling said CPU further comprises the step of
- using a measurement, performed by said temperature measurement means, of the CPU temperature for controlling said cooling system.

67. A method for cooling a computer system, wherein said cooling system further comprises a pumping means with an impeller for pumping the cooling liquid through a pumping housing, said pumping means being driven by an AC electrical motor with a stator and a rotor, and said pumping means being provided with a means for sensing a position of the rotor, and wherein the method comprises the following steps- initially establishing a preferred rotational direction of the rotor of the electrical motor
- before start of the electrical motor, sensing the angular position of the rotor
- during start, applying an electrical AC voltage to the electrical motor and selecting the signal value, positive or negative, of the AC voltage at start of the electrical motor
- said selection being made according to the preferred rotational direction, and
- said application of the AC voltage being performed by the computer system for applying the AC voltage from the electrical power supply of the computer system during conversions of the electrical DC voltage of the power supply to AC voltage for the electrical motor.

68. A method according to claim 67, where sensing the angular position of the rotor is accomplished by a number Hall-sensors placed at angular intervals for detection of the rotor's magnetic poles, the number of sensors corresponding to the number of magnetic poles establishing the mechanical angle, and corresponding to the electrical angle.

69. A method according to claim 67 or claim 68, where application of the electrical AC voltage to the electrical motor and selection of the signal value, positive or negative, of the

AC voltage at start of the electrical motor is accomplished by the operating system of the computer system and is communicated to an DC/AC converter of the computer system.

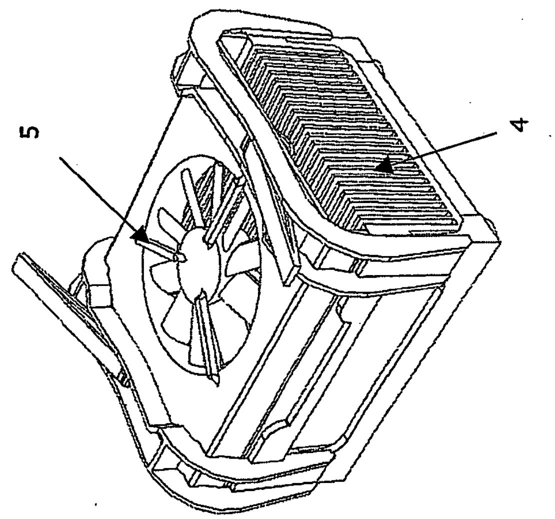

FIG. 2

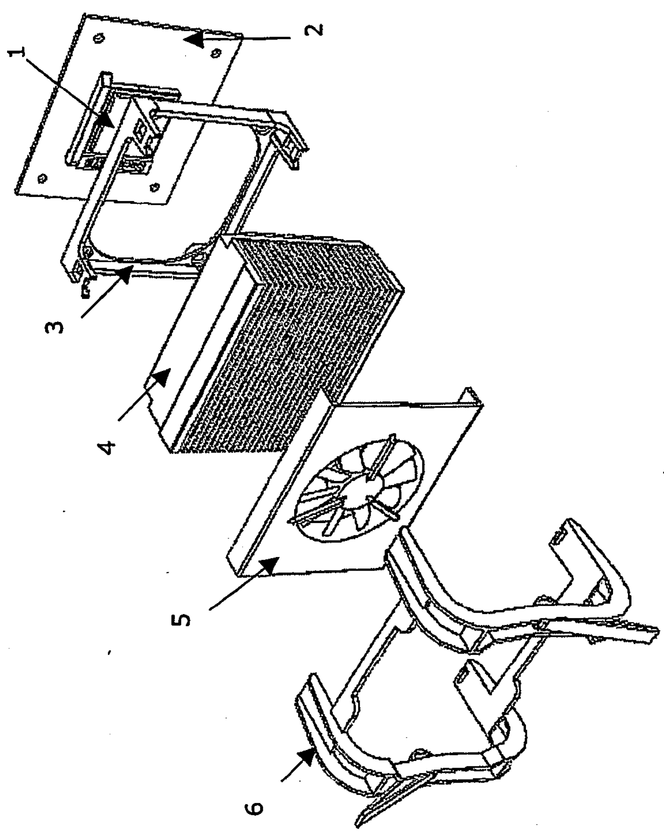

FIG. 1

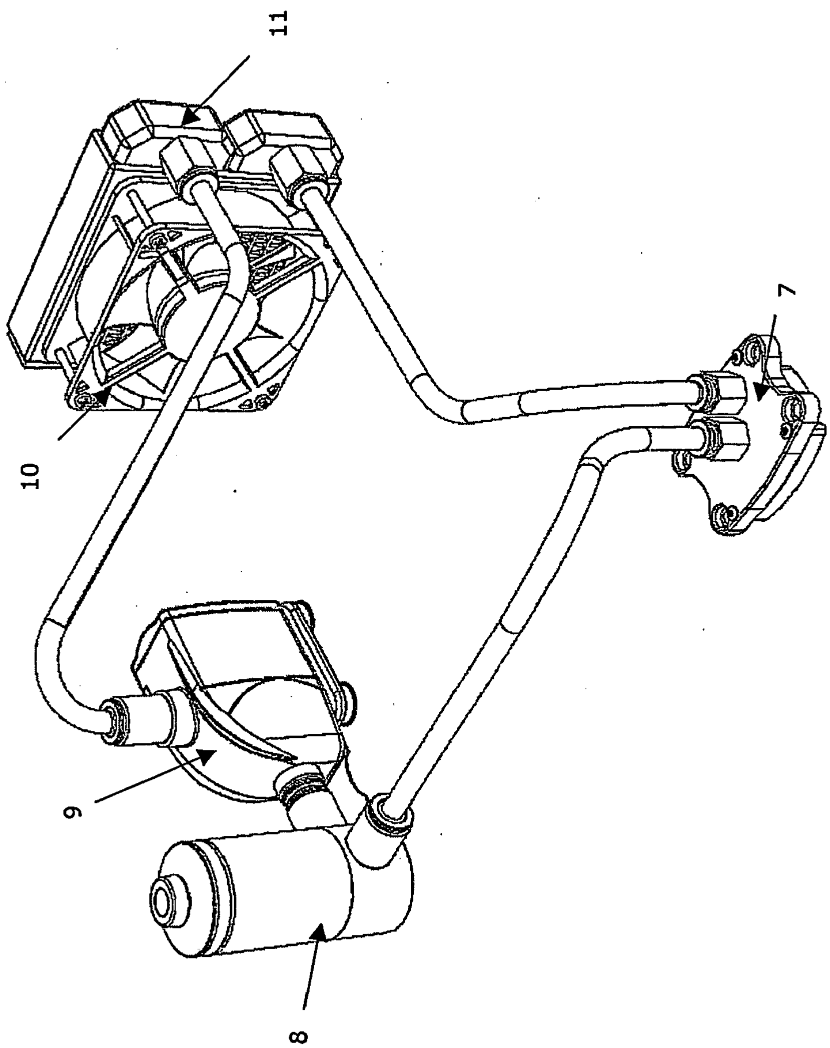

FIG. 3

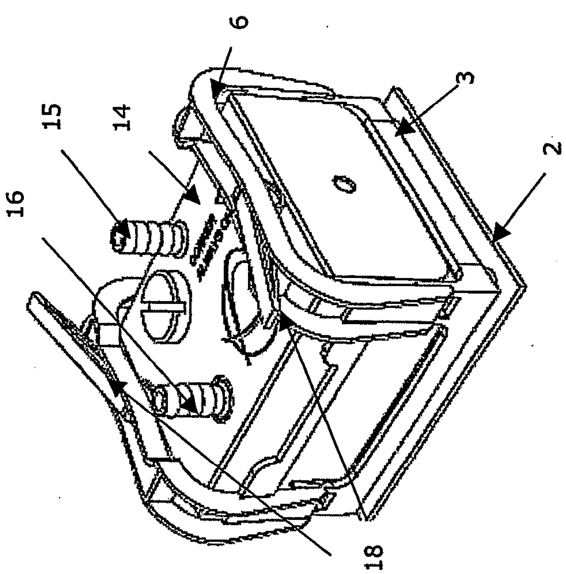

FIG. 5

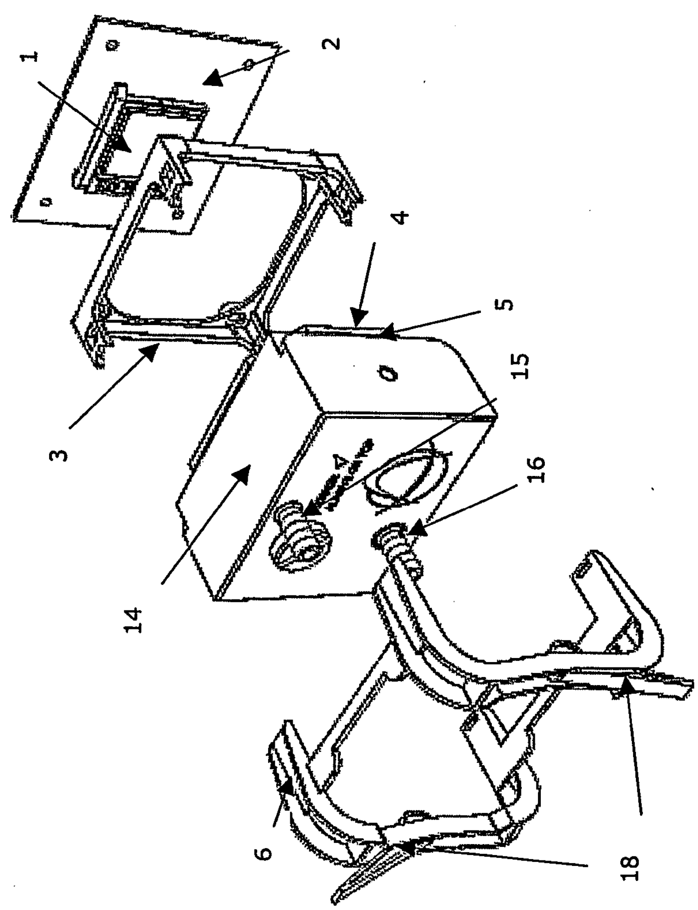

FIG. 4

SUBSTITUTE SHEET (RULE 26)

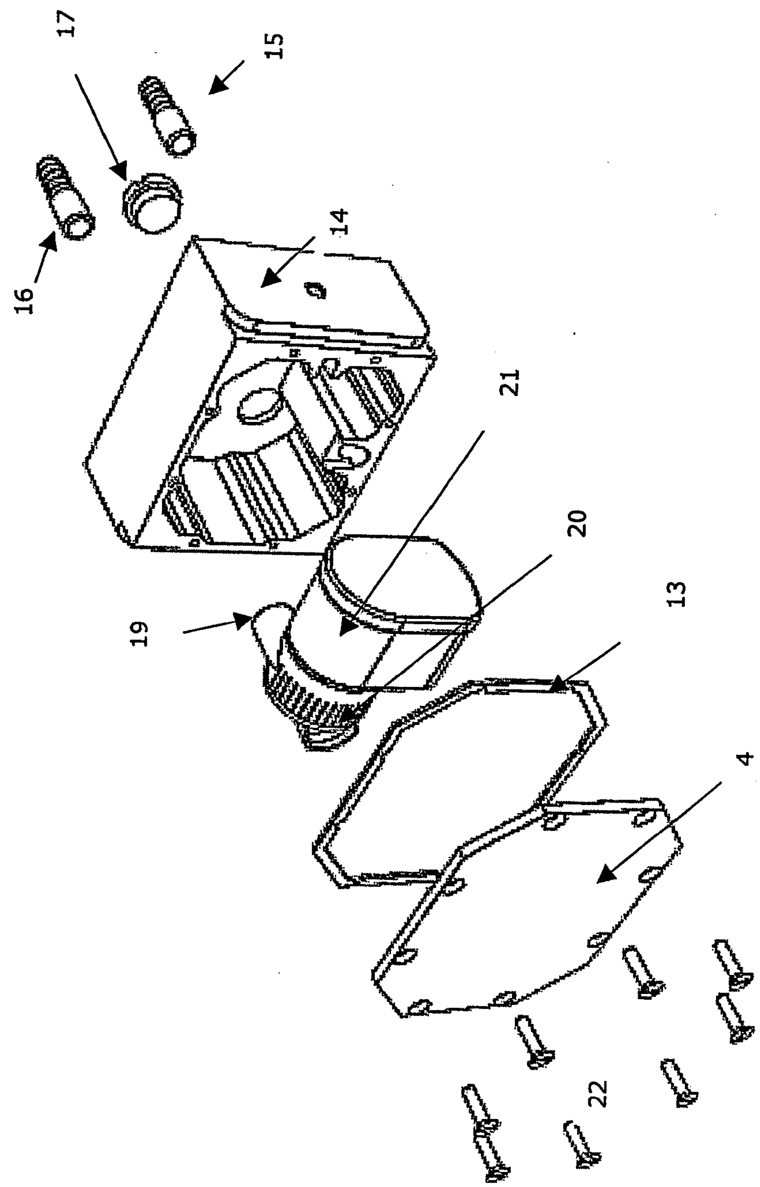

FIG. 6

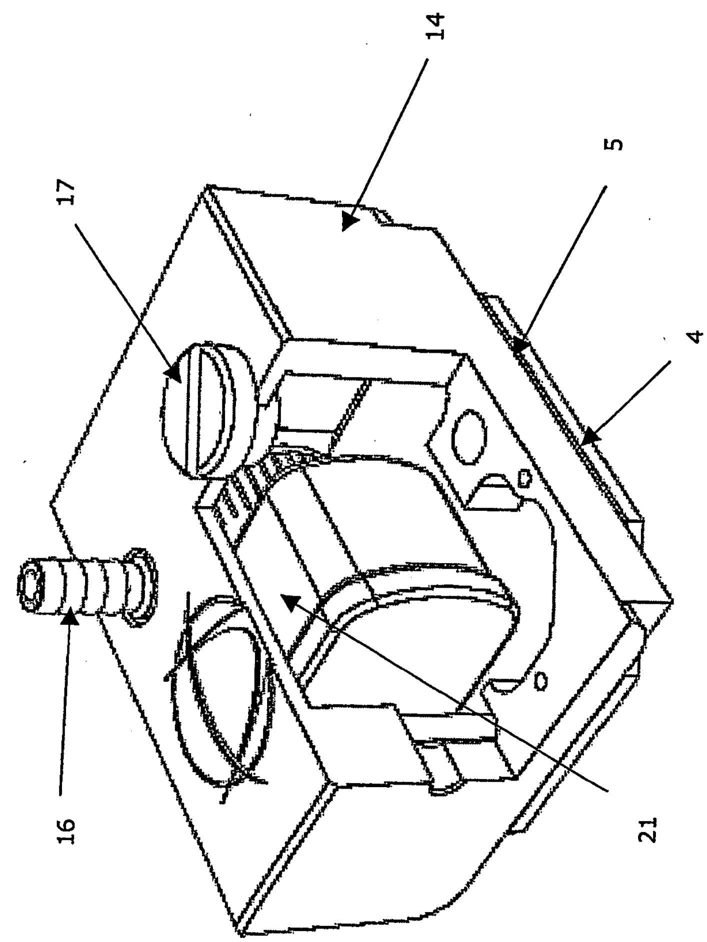

FIG. 7

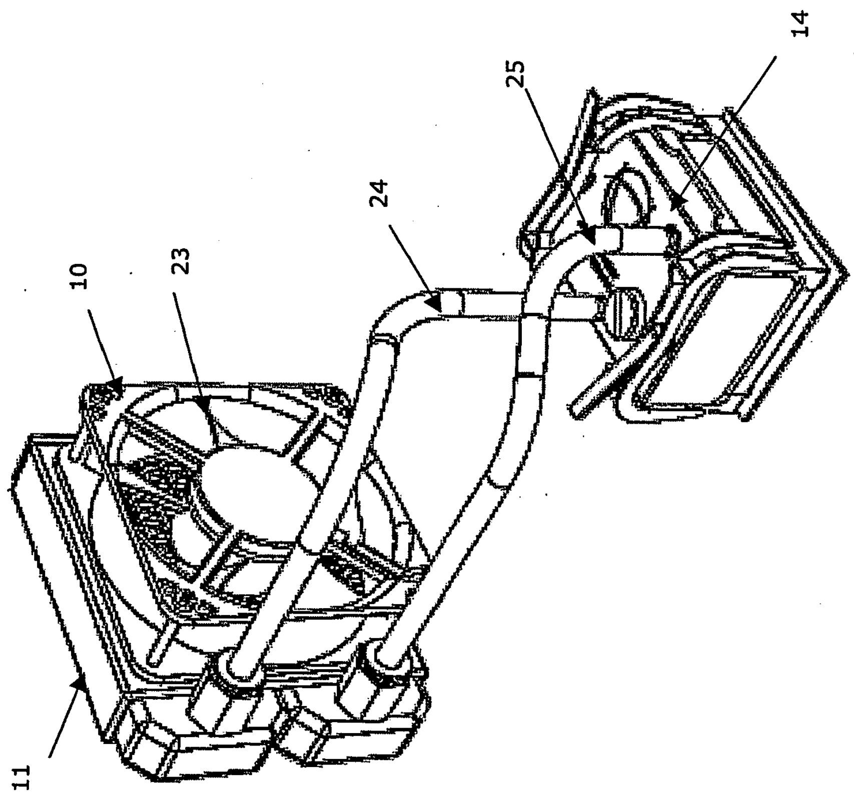

FIG. 8

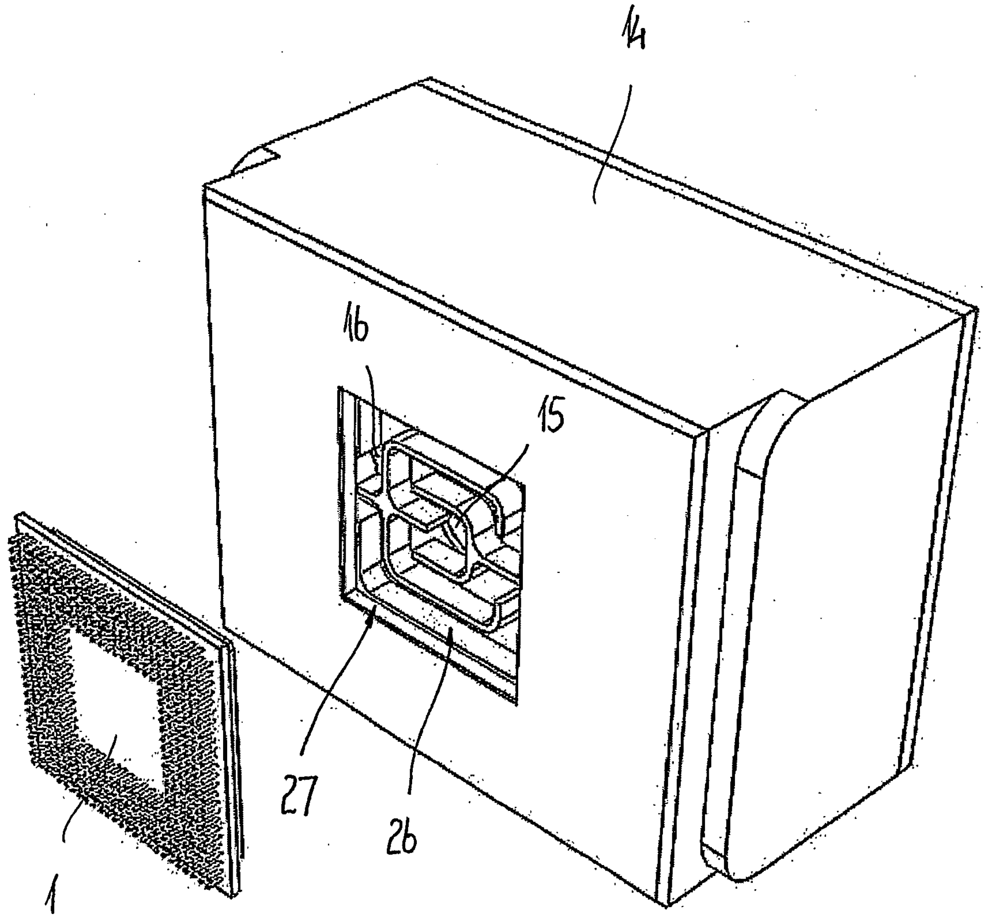

FIG. 9

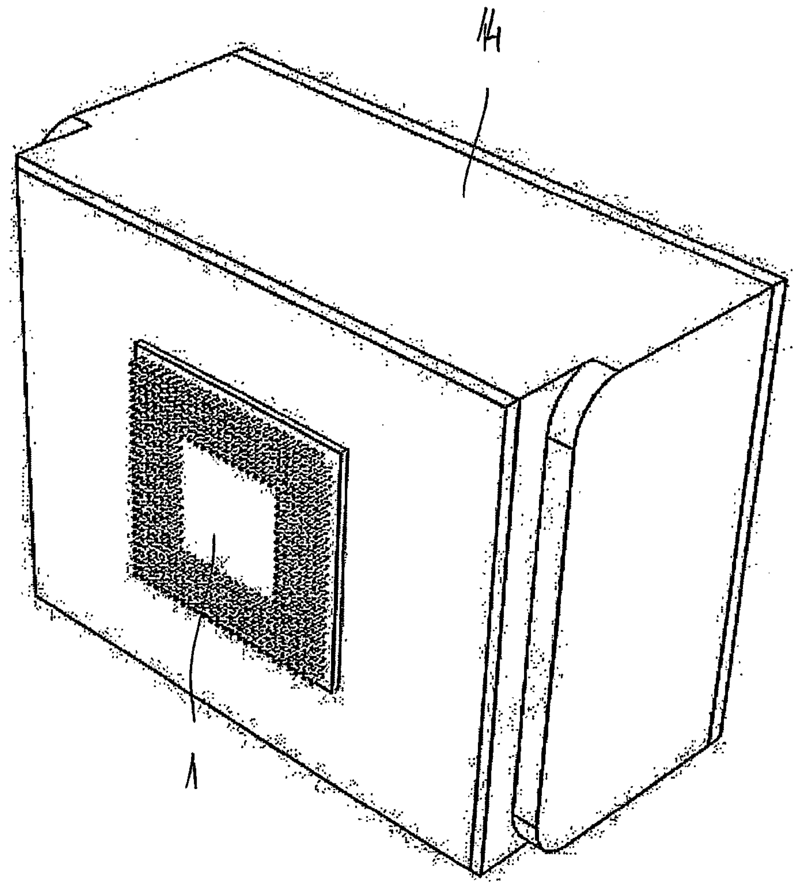

FIG. 10

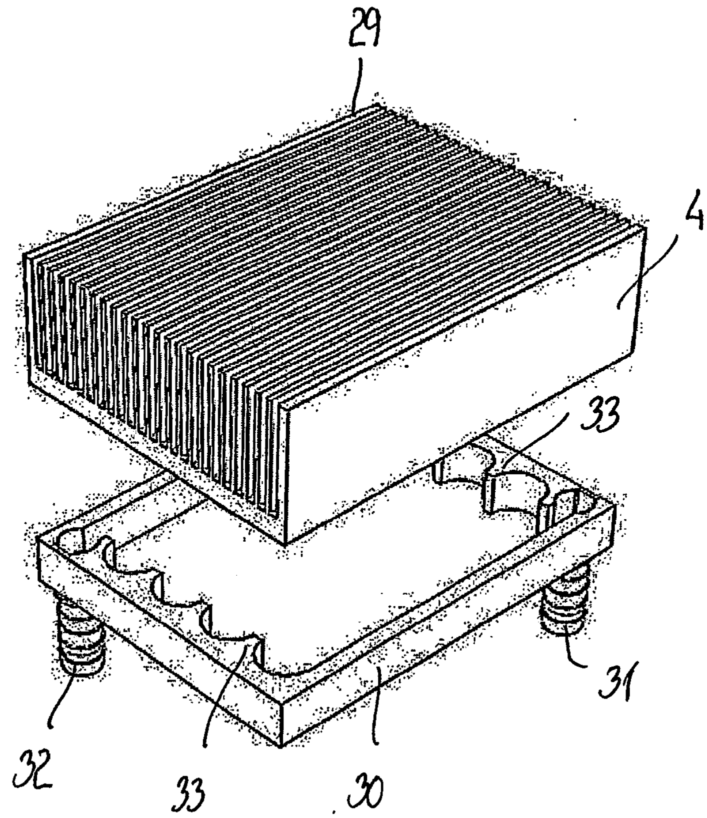

FIG. 11

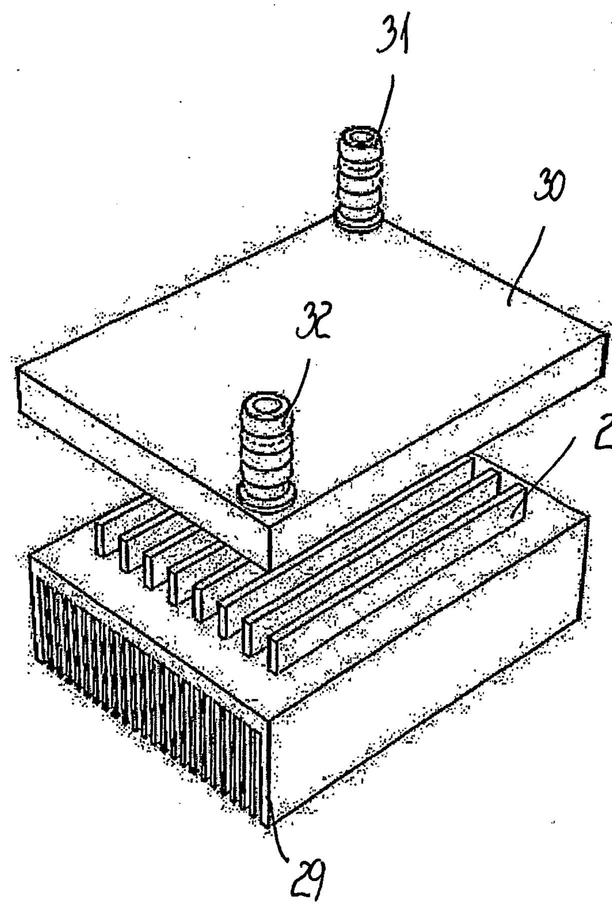

FIG. 12

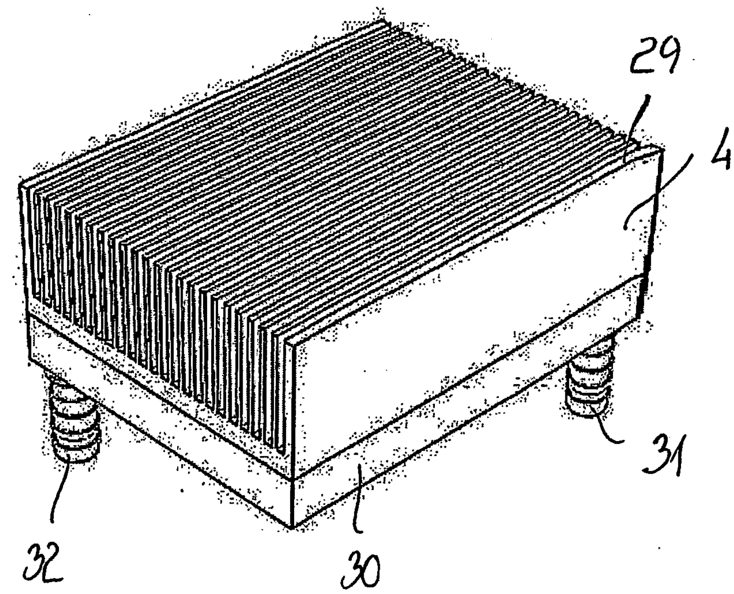

FIG. 13

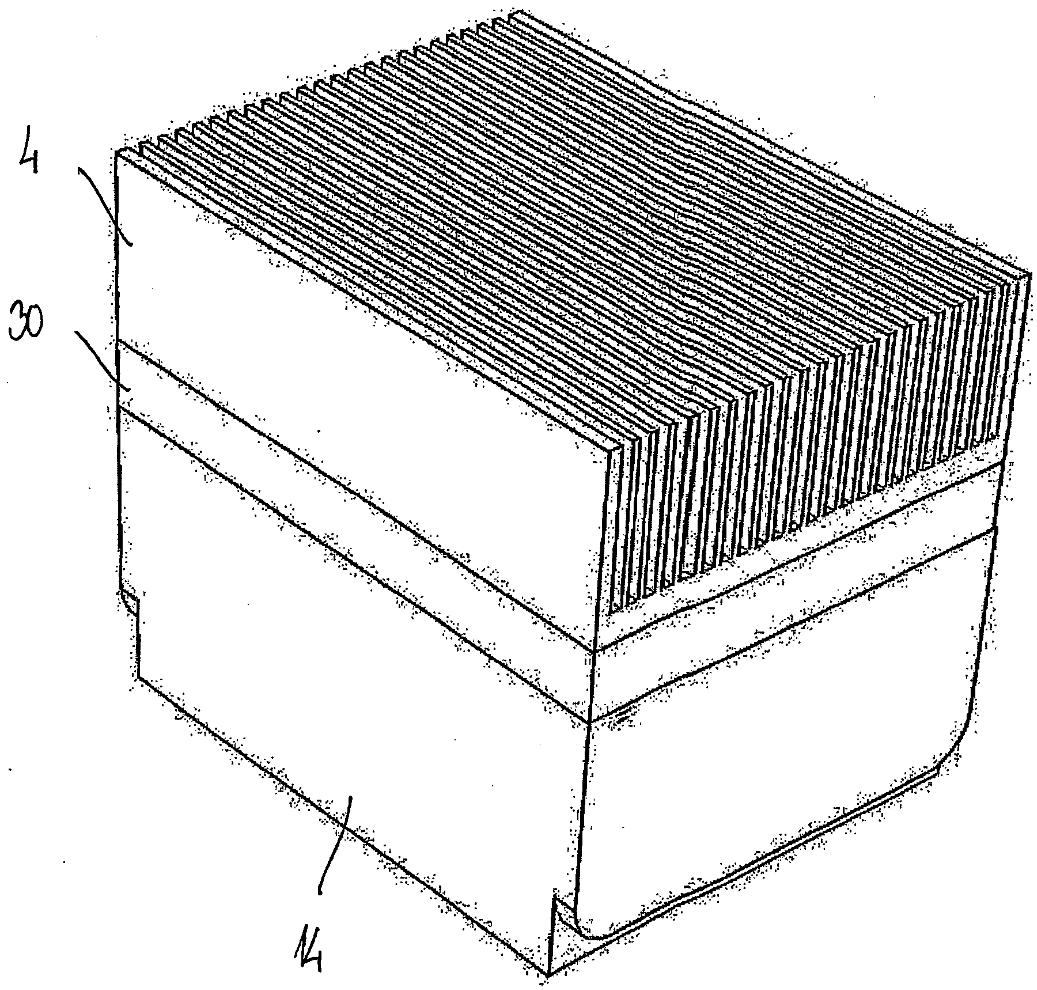

FIG. 14

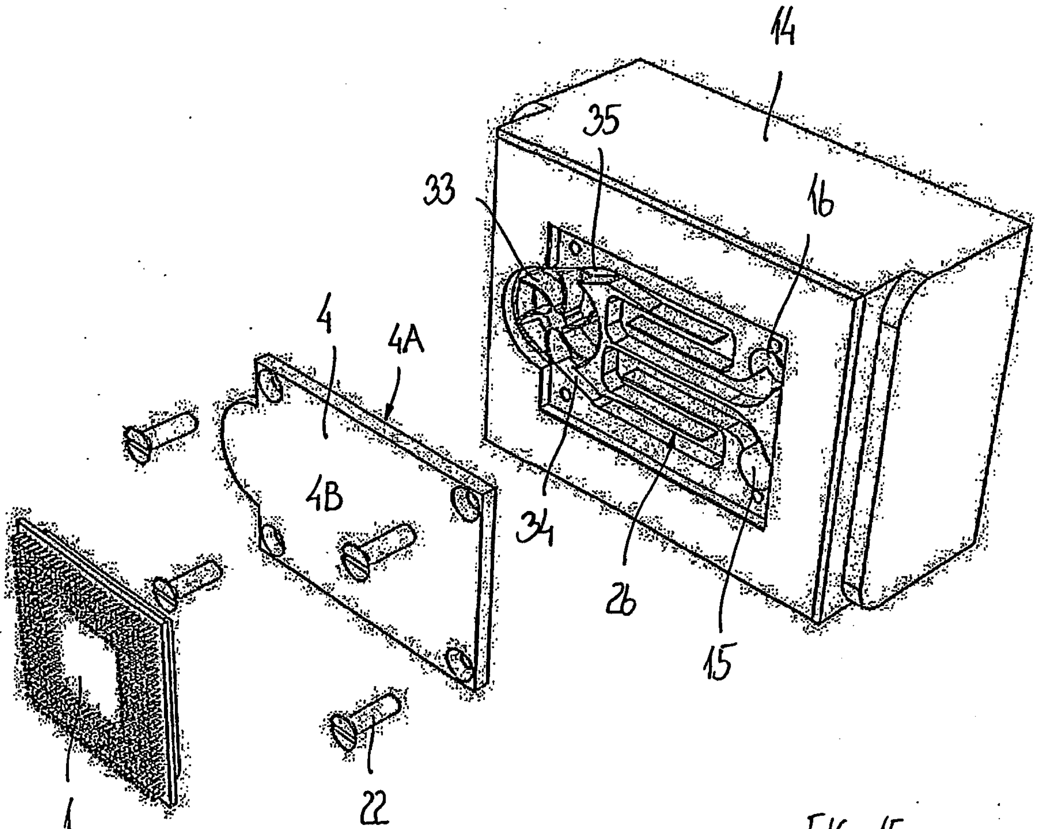

FIG. 15

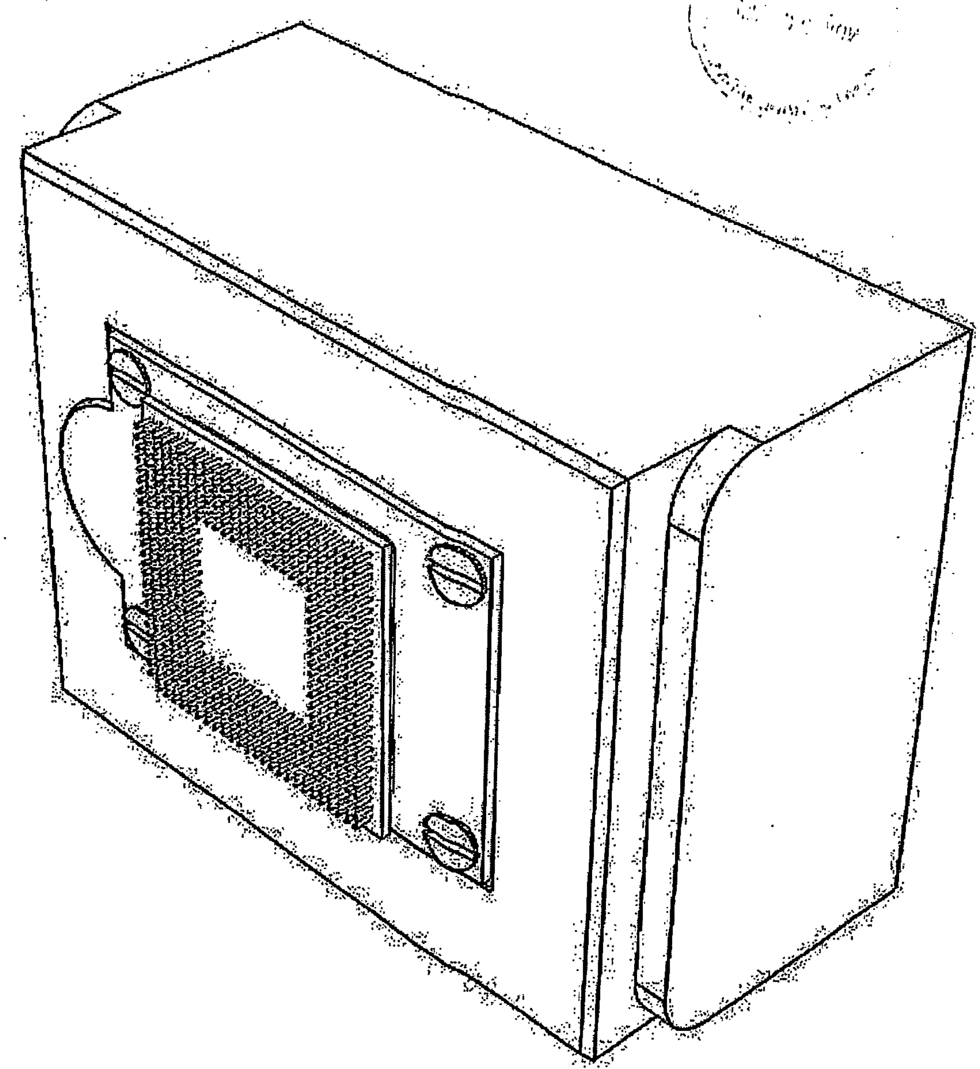

FIG. 1b

Electronic Acknowledgement Receipt

EFS ID:	11145708
Application Number:	13269234
International Application Number:	
Confirmation Number:	1954
Title of Invention:	COOLING SYSTEM FOR A COMPUTER SYSTEM
First Named Inventor/Applicant Name:	Andre Sloth ERIKSEN
Customer Number:	22852
Filer:	Biju I. Chandran/Sharon Ambrose
Filer Authorized By:	Biju I. Chandran
Attorney Docket Number:	10494.0003-01000
Receipt Date:	07-OCT-2011
Filing Date:	
Time Stamp:	17:26:35
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal Letter	10494-0003-01ids.pdf	57077 a2623cb759b7c81a79f2c69a6b25062ddab97aac	no	2

Warnings:

Information:

2	Information Disclosure Statement (IDS) Form (SB08)	10494-0003-01formsb08.pdf	85123 f2e1a3b3aaf55213bddbd4d260cdec54affded6e	no	2
Warnings:					
Information:					
This is not an USPTO supplied IDS fillable form					
3	Foreign Reference	10494-0003-01EP0574823.pdf	558179 82b46617a16bc7b87454514bbfcbd11a23638fd8	no	13
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Warnings:					
Information:					
		Total Files Size (in bytes):	11458163		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

<u>New Applications Under 35 U.S.C. 111</u>
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

<u>National Stage of an International Application under 35 U.S.C. 371</u>
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PATENT
Customer No. 22,852
Attorney Docket No. 10494.0003-01000

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	)	
Inventor: André Sloth ERIKSEN	)	Group Art Unit: Unassigned
Application No.: 13/269,234	)	
Filed: October 7, 2011	)	Examiner: Unassigned
For: COOLING SYSTEM FOR A COMPUTER SYSTEM	)	Confirmation No.: 1954

Sir:

INFORMATION DISCLOSURE STATEMENT UNDER 37 C.F.R. § 1.97(b)

Pursuant to 37 C.F.R. §§ 1.56 and 1.97(b), Applicant brings to the attention of the Examiner the listed documents on the attached PTO SB/08 Form. This Information Disclosure Statement is being filed before the mailing date of a first Office Action on the merits for the above-referenced application.

Copies of the listed foreign patent documents are attached. Copies of the U.S. patent publications are not enclosed.

Applicant respectfully requests that the Examiner consider the listed documents and indicate that it was considered by making appropriate notations on the attached form.

This submission does not represent that a search has been made or that no better art exists and does not constitute an admission that the listed documents are material or constitute "prior art." If the Examiner applies any of the documents as prior art against any claim in the application and Applicant determines that the cited documents do not constitute "prior art" under United States law, Applicant reserves the right to present to the U.S. Patent and Trademark Office the relevant facts and law regarding the appropriate status of such documents.

Applicant further reserves the right to take appropriate action to establish the patentability of the disclosed invention over the listed documents, should one or more of the documents be applied against the claims of the present application.

If there is any fee due in connection with the filing of this Statement, please charge the fee to Deposit Account 06-0916.

Respectfully submitted,

FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER, L.L.P.

Dated: October 7, 2011

By: ______________________
Biju I. Chandran
Reg. No. 63,684