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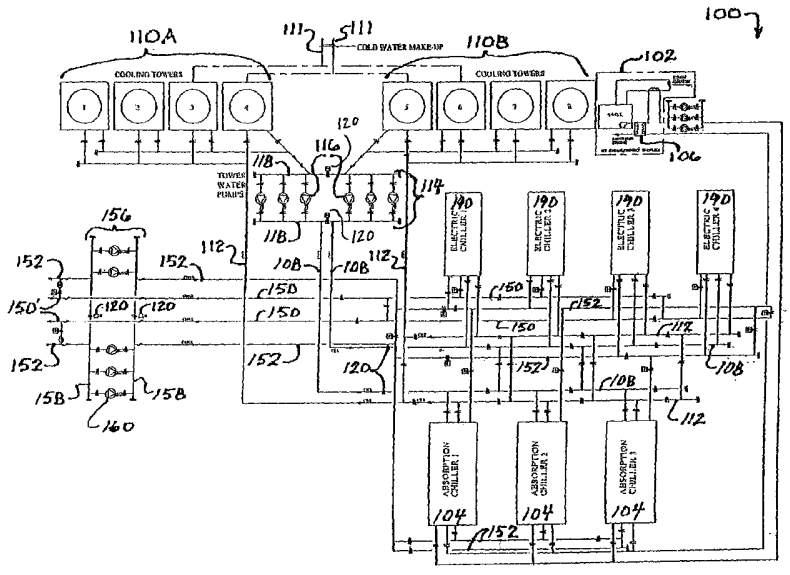
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: HEAT RECOVERY COOLING SYSTEM



(57) Abstract: An exemplary embodiment of the invention is a cooling system (100) including a first absorption chiller (104) and a second absorption chiller (104). A first condenser refrigerant return (112) is coupled to the first absorption chiller (104) and a second condenser refrigerant return (112) is coupled to the second absorption chiller (104). A first condenser refrigerant supply (108) is coupled to the first absorption chiller (104) and a second condenser refrigerant supply (108) is coupled to the second absorption chiller (104). A first cooling assembly (110A) is coupled to the first condenser refrigerant return (112) and a second cooling assembly (110B) is coupled to the second condenser refrigerant return (112).

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HEAT RECOVERY COOLING SYSTEM

BACKGROUND OF THE INVENTION

The invention relates in general to power systems and in particular to a cooling system that recovers heat from power generators and uses the heat to provide cooling.

Power generation systems often produce heat as a by-product. In many applications, such as computer data centers, excess heat is detrimental to the electrical loads and thus, the heat generated is vented to the external environment. This venting of by-product heat represents wasted energy.

SUMMARY OF THE INVENTION

An exemplary embodiment of the invention is a cooling system including a first absorption chiller and a second absorption chiller. A first condenser refrigerant return is coupled to the first absorption chiller and a second condenser refrigerant return is coupled to the second absorption chiller. A first condenser refrigerant supply is coupled to the first absorption chiller and a second condenser refrigerant supply is coupled to the second absorption chiller. A first cooling assembly is coupled to the first condenser refrigerant return a second cooling assembly is coupled to the second condenser refrigerant return.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring now to the drawings wherein like elements are numbered alike in the several FIGURES:

FIG. 1 is a block diagram of a cooling system in an embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 is a block diagram of a cooling system 100 in an embodiment of the invention. The cooling system 100 is designed to utilize heat from a power generator 102 and provide cooling as described in further detail herein. The power generator may be any known type of power generator such as a fuel cell, micro-turbine, turbine, reciprocating engine and other types of power sources, and combinations of different types of power sources. Excess or by-product heat energy from the power generator 102 is transferred to absorption chillers 104 through one or more heat exchangers 106.

As known in the absorption chiller field, the absorption chillers 104 circulate a refrigerant (e.g., water) through a condenser to remove heat from a coolant (e.g., water) in another loop. As shown in FIG. 1, a condenser refrigerant supply 108 provides cooled refrigerant to the absorption chillers 104. Two redundant condenser refrigerant supplies 108 are used to provide the cooled refrigerant to the absorption chillers 104. The refrigerant is cooled by cooling assemblies 110A and 110B. Through the chilling of the coolant, the refrigerant obtains heat and is supplied back to cooling assemblies 110A and 110B over redundant condenser refrigerant returns 112, which feed cooling assembly 110A and cooling assembly 110B. The cooling assemblies 110A and 110B include a number of cooling towers, each receiving refrigerant from the condenser refrigerant returns 112 and supplying cooled refrigerant to the refrigerant pump assembly 114. Each absorption chiller 104 is connected to two condenser refrigerant returns 112, which are connected to each other.

The refrigerant is circulated through the system by refrigerant pump assembly 114 including a plurality of redundant pumps 116 feeding a common condenser refrigerant supply header 118. Multiple condenser refrigerant supplies 108 are coupled to the condenser refrigerant supply header 118. Each absorption chiller 104 is connected to two condenser refrigerant supplies 108, which are connected to each other.

The refrigerant pump assembly 114, the condenser refrigerant supplies 108 and the condenser refrigerant returns 112 all include a number of valves 120 that allow for isolating portions of the condenser refrigerant supply 108 and the condenser refrigerant return 112. This allows refrigerant to be re-routed in the event of a pipe failure or for scheduled maintenance. The condenser refrigerant supply header 118 includes valves to

isolate refrigerant flowing from cooling assemblies 110A and 110B so that refrigerant flowing to and from these cooling assemblies can be isolated from each other in two separate loops. Redundant refrigerant make-up feeds 111 provide additional refrigerant to the cooling assemblies to replace refrigerant lost during a cooling process (e.g., evaporated refrigerant).

The absorption chillers 104 utilize the refrigerant to cool a second loop of coolant (e.g., water). As shown in FIG. 1, each absorption chiller 104 receives coolant from a chilled coolant return 152, chills this coolant and feeds a chilled coolant supply 150. The chilled coolant supply 150 is fed to a building cooling system that utilizes the chilled coolant as known in the art (e.g., air conditioning). The chilled coolant return 152 returns coolant to the absorption chillers 104. There are two chilled coolant returns 152, with each chilled coolant return 152 being connected to each absorption chiller. The chilled coolant returns 152 are connected to each other.

There are two chilled coolant supplies 150 with each with each chilled coolant supply 150 being connected to each absorption chiller 104. The chilled coolant supplies 150 are connected to each other. The chilled coolant supplies 150 are connected to a coolant pump assembly 156 including a header 158 and a number of pumps 160. The coolant pump assembly 156 outputs two chilled coolant supplies 150' to a conventional cooling system (e.g., air conditioning system). The coolant pump assembly 156 includes a number of valves 120 which may be closed to isolate a first chilled coolant supply from a second chilled coolant supply at coolant pump assembly 156.

If the absorption chillers 104 cannot support the cooling load, additional chillers 190 (e.g., electrically powered, high efficiency centrifugal chillers) may be coupled to the condenser refrigerant return 112, condenser refrigerant supply 108, chilled coolant return 152 and chilled coolant supply 150 in a manner similar to the absorption chillers 104.

It is understood that the system of FIG. 1 is exemplary and the number of components exemplary. The number of condenser refrigerant supplies 108, condenser refrigerant returns 112, chilled coolant supplies 150 and chilled coolant returns 152 employed may be increased to provide additional redundancy. Additional absorption chillers may be employed to provide additional redundancy.

Devices such as chillers 104, pumps 116, pumps 160 and cooling towers in the cooling assemblies 110 may employ variable speed drive devices to provide efficient

and reliable partial load operation. The partial load efficiencies allowed by the variable speed drive devices allow the redundant equipment to be operating at all times. This not only provides the added reliability of a 'spinning reserve,' but actually decreases the overall power consumption. For example, variable speed chillers are most efficient at 50% or lower loads, and the cooling towers are configured to run in parallel offering the cube law fan savings. For example, running two cooling towers at 50% fan speed uses about one quarter the power of a single tower at full speed.

As described above, the system 100 includes redundant piping for the condenser refrigerant return, condenser refrigerant supply, chilled coolant return and chilled coolant supply. The redundant piping can be used to bypass the damaged equipment or piping and keep the system operating. Under normal operation, the redundant piping allows the system to operate at lower pressures. This allows the variable speed devices to operate efficiently by automatically taking advantage of the pressure drop and reducing pumping power, and thus operating costs, significantly.

Pumps 116 serve a common header 118 and pumps 160 serve common header 158, so a single pump failure will not cause a system failure. The condenser refrigerant return 112, condenser refrigerant supply 108, chilled coolant return 152 and chilled coolant supply 150 may be collocated in a central spine. The spine provides for modularity allowing staged build-out of the cooling system 100. Further absorption chillers 104 or additional chillers 190 may be coupled to the spine as desired. This allows the cooling system 100 to be expanded to provide additional capacity or functionality (such as free cooling / water side economizer).

While preferred embodiments have been shown and described, various modifications and substitutions may be made thereto without departing from the spirit and scope of the invention. Accordingly, it is to be understood that the present invention has been described by way of illustration and not limitation.

CLAIMS

What is claimed is:

1. A cooling system comprising:

a first absorption chiller and a second absorption chiller;

a first condenser refrigerant return coupled to said first absorption chiller;

a second condenser refrigerant return coupled to said second absorption chiller;

a first condenser refrigerant supply coupled to said first absorption chiller;

a second condenser refrigerant supply coupled to said second absorption chiller;

a first cooling assembly coupled to said first condenser refrigerant return; and

a second cooling assembly coupled to said second condenser refrigerant return.

2. The cooling system of claim 1 wherein:

said first condenser refrigerant return is coupled to said second condenser refrigerant return.

3. The cooling system of claim 1 wherein:

said first condenser refrigerant supply is coupled to said second condenser refrigerant supply.

4. The cooling system of claim 1 wherein:

said first cooling assembly includes a plurality of first cooling towers receiving refrigerant from said first condenser refrigerant return.

5. The cooling system of claim 4 wherein:

said second cooling assembly includes a plurality of second cooling towers receiving refrigerant from said second condenser refrigerant return.

6. The cooling system of claim 1 further comprising:

a pump assembly including a plurality of pumps in fluid communication with said first condenser refrigerant supply and said second condenser refrigerant supply.

7. The cooling system of claim 6 wherein:

said pump assembly includes a condenser refrigerant supply header including at least one valve for isolating said first condenser refrigerant supply from said second condenser refrigerant supply at said pump assembly.

8. The cooling system of claim 1 further comprising:

a first chilled coolant return coupled to said first absorption chiller;

a second chilled coolant return coupled to said second absorption chiller;

a first chilled coolant supply coupled to said first absorption chiller; and

a second chilled coolant supply coupled to said second absorption chiller.

9. The cooling system of claim 8 wherein:

said first chilled coolant return is coupled to said second chilled coolant return.

10. The cooling system of claim 8 wherein:

said first chilled coolant supply is coupled to said second chilled coolant supply.

11. The cooling system of claim 8 further comprising:

a coolant pump assembly including a plurality of pumps in fluid communication with said first chilled coolant supply and said second chilled coolant supply.

12. The cooling system of claim 11 wherein:

said coolant pump assembly includes a chilled coolant supply header including at least one valve for isolating said first chilled coolant supply from said second chilled coolant supply at said coolant pump assembly.

13. The cooling system of claim 1 further comprising:

a first additional chiller and a second additional chiller;

said first condenser refrigerant return coupled to said first additional chiller;

said second condenser refrigerant return coupled to said second additional chiller;

said first condenser refrigerant supply coupled to said first additional chiller; and

said second condenser refrigerant supply coupled to said second additional chiller.

14. A cooling system comprising:

a first absorption chiller and a second absorption chiller;

a first condenser refrigerant return coupled to said first absorption chiller;

a second condenser refrigerant return coupled to said second absorption chiller and to said first condenser refrigerant return;

a first condenser refrigerant supply coupled to said first absorption chiller;

a second condenser refrigerant supply coupled to said second absorption chiller and to said first condenser refrigerant supply;

a first cooling assembly coupled to said first condenser refrigerant return;

a second cooling assembly coupled to said second condenser refrigerant return;

a first chilled coolant return coupled to said first absorption chiller;

a second chilled coolant return coupled to said second absorption chiller and to said first chilled coolant return;

a first chilled coolant supply coupled to said first absorption chiller; and

a second chilled coolant supply coupled to said second absorption chiller and to said first chilled coolant supply.

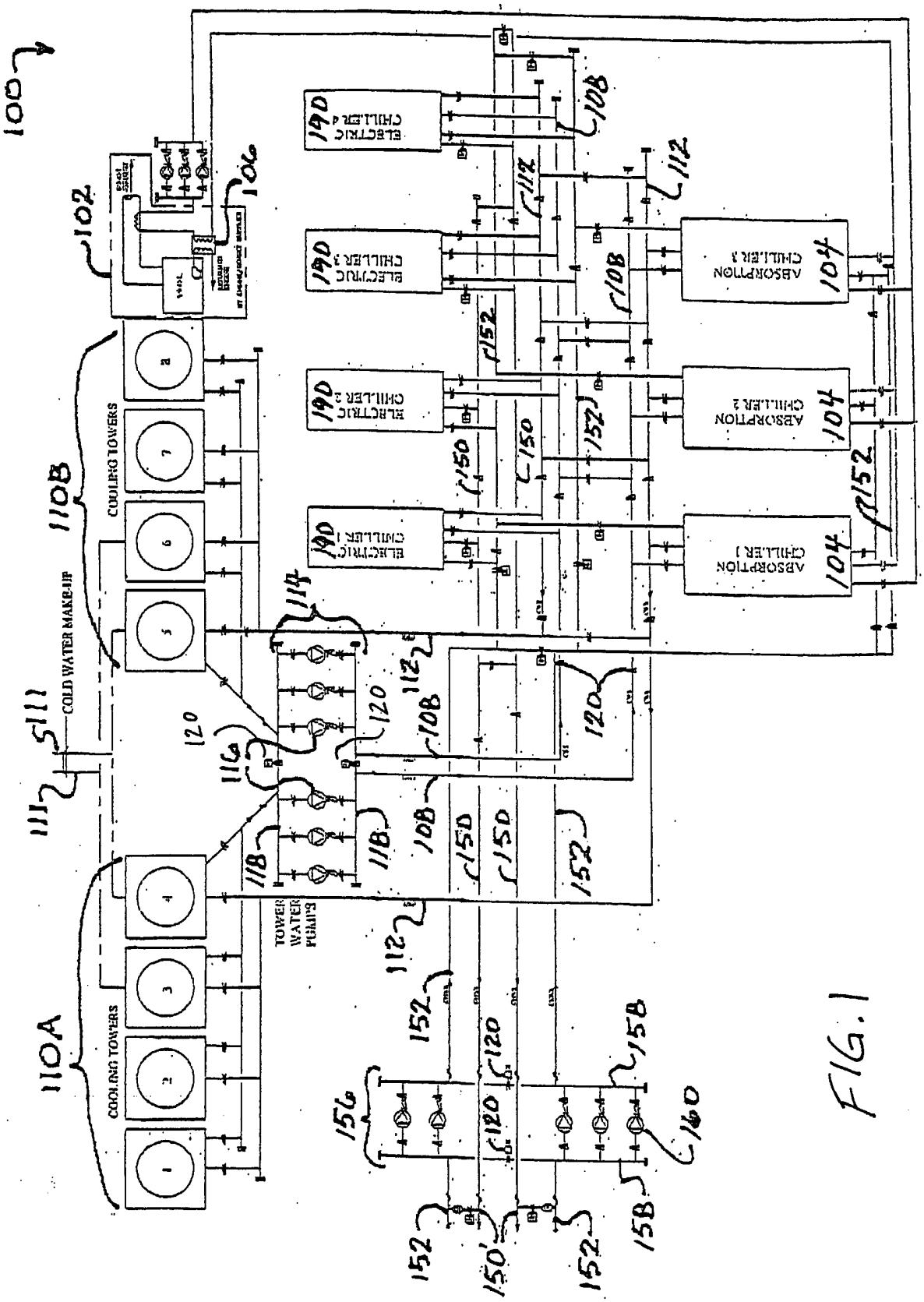
100
102
106
110B
110A
111
COLD WATER MAKE-UP
COOLING TOWERS
COOLING TOWERS
TOWER WATER PUMPS
ELECTRIC CHILLER 4
ELECTRIC CHILLER 3
ELECTRIC CHILLER 2
ELECTRIC CHILLER 1
ABSORPTION CHILLER 3
ABSORPTION CHILLER 2
ABSORPTION CHILLER 1
104
108
112
114
116
118
120
150
150'
152
156
158
160

FIG. 1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US02/27826

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : F25B 27/00
US CL : 62/238.3, 141

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 62/238.3, 141, 94, 96, 97, 104, 271

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,447,042 A (OHUCHI et al) 05 September 1995 (05.09.1995), see entire document.	1,4,5,8,9,10
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Y		6,7,11,12,13
Y	US 5,737,933 A (IDEI et al) 14 April 1998 (14.04.1998), see entire document.	6,7,11,12,13
A	US 3,301,000 A (HOLBAY) 31 January 1967 (31.01.1967), see entire document.	1

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 October 2002 (16.10.2002)	16 DEC 2002
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703)305-3230	Authorized officer Chen-Wen Jiang Telephone No. (703) 306-5648

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