US 20120011865A1

(19) United States

(12) Patent Application Publication

Ivison

(10) Pub. No.: US 2012/0011865 A1

(43) Pub. Date: Jan. 19, 2012

(54) **COMBINED WATER EXTRACTOR AND ELECTRICITY GENERATOR**

(75) Inventor: **Walter Ivison**, New South Wales (AU)

(73) Assignee: **Set IP Holdings, LLC**

(21) Appl. No.: **13/256,929**

(22) PCT Filed: **Mar. 26, 2010**

(86) PCT No.: **PCT/AU2010/000357**

§ 371 (c)(1), (2), (4) Date: **Sep. 15, 2011**

(30) **Foreign Application Priority Data**

Mar. 27, 2009 (AU) 2009901358

Publication Classification

(51) **Int. Cl.**

F25B 27/02 (2006.01)

F25B 49/04 (2006.01)

(52) **U.S. Cl.** **62/79**; 62/238.3; 62/190

(57) **ABSTRACT**

A water extraction system having a cooling system adapted to cool air to below the dew point, the cooling system including an absorption chiller (**1.002**) including a heat source (**1.004**), the system includes an air/heat transfer fluid heat exchanger (**1.016**), and a water collector (**1.022**) arranged to collect water from the air/heat transfer fluid heat exchanger. The air/heat transfer fluid heat exchanger (**1.016**) is adapted to cool the air below the dew point. The chiller can include a heat input in the form of exhaust gasses from a gas turbine. The gas turbine can also drive an electrical generator. The air outlet from the water generator can be used in an air conditioning system. The system can include one or more chillers powered by, for example, turbine exhaust. Additional heat source, such as natural gas can be provided to bring the chillers to the operating temperature. A controller controls the change-over between heat sources.

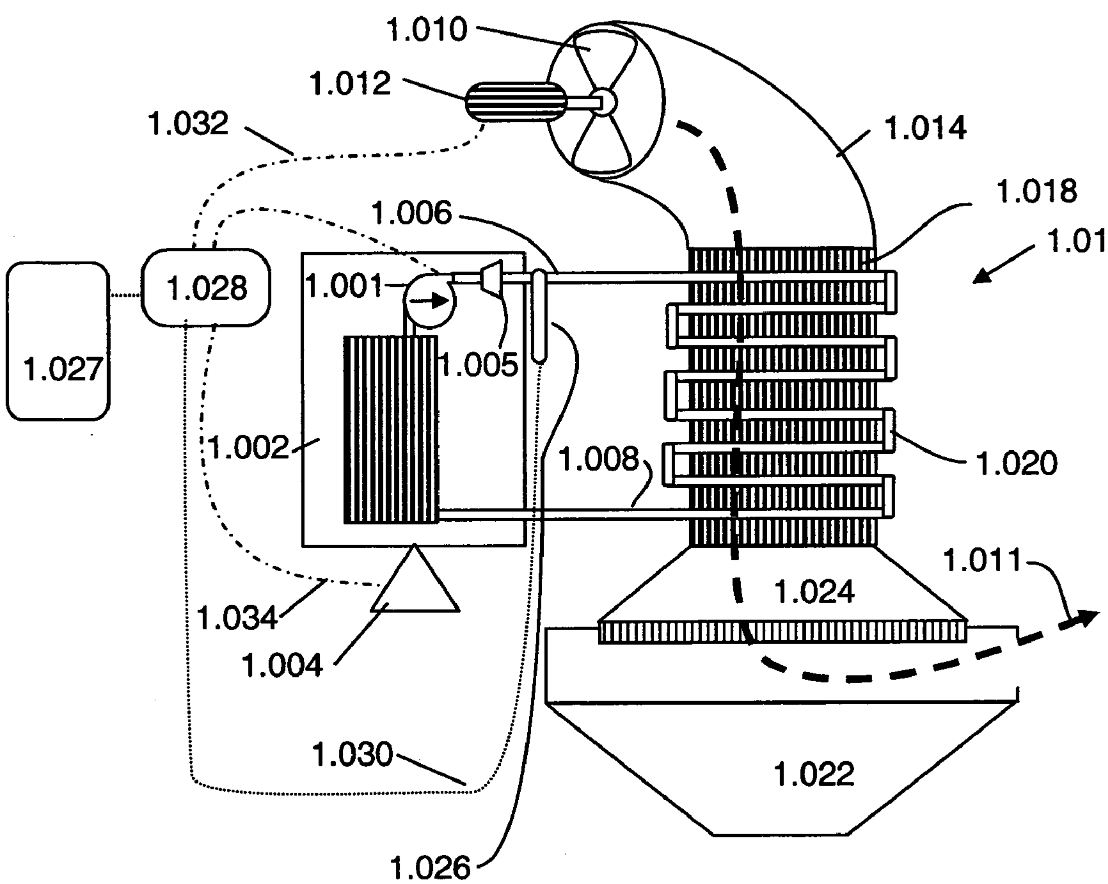


FIGURE 1

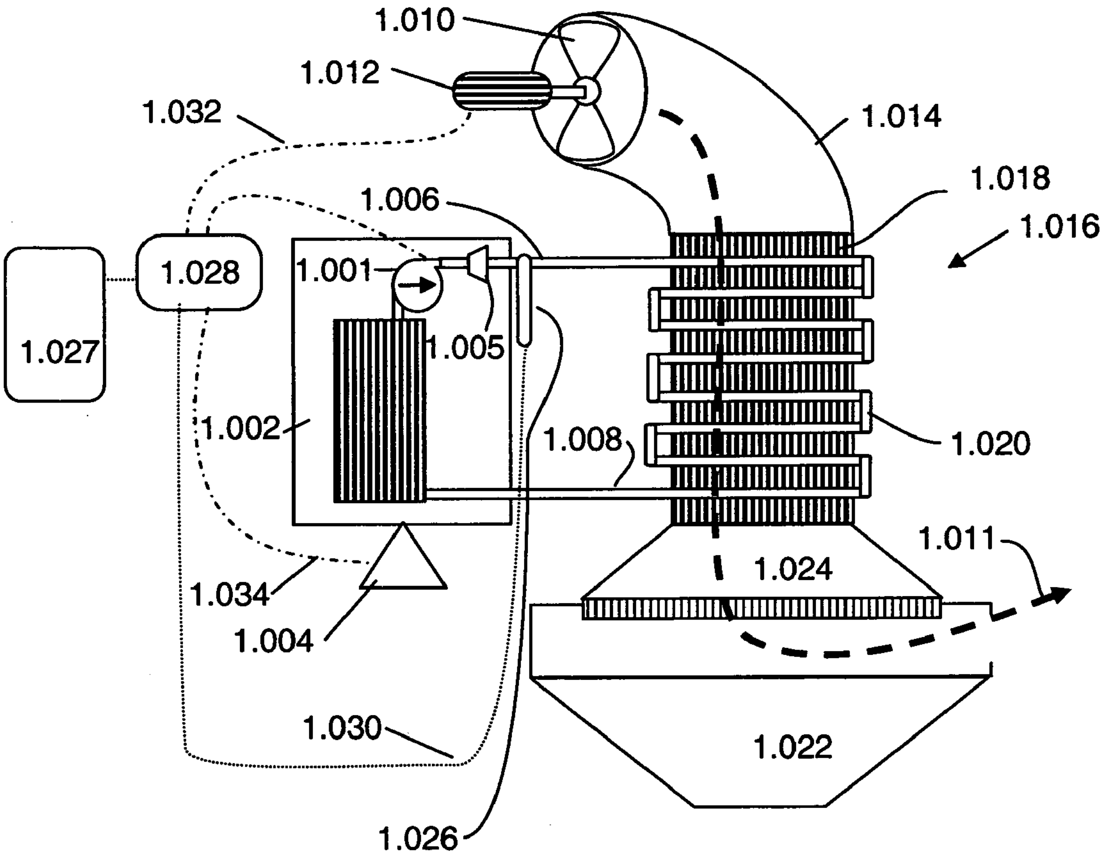

1.010
1.012
1.032
1.014
1.018
1.006
1.016
1.028
1.001
1.027
1.005
1.002
1.008
1.020
1.011
1.024
1.034
1.004
1.030
1.022
1.026

FIGURE 2

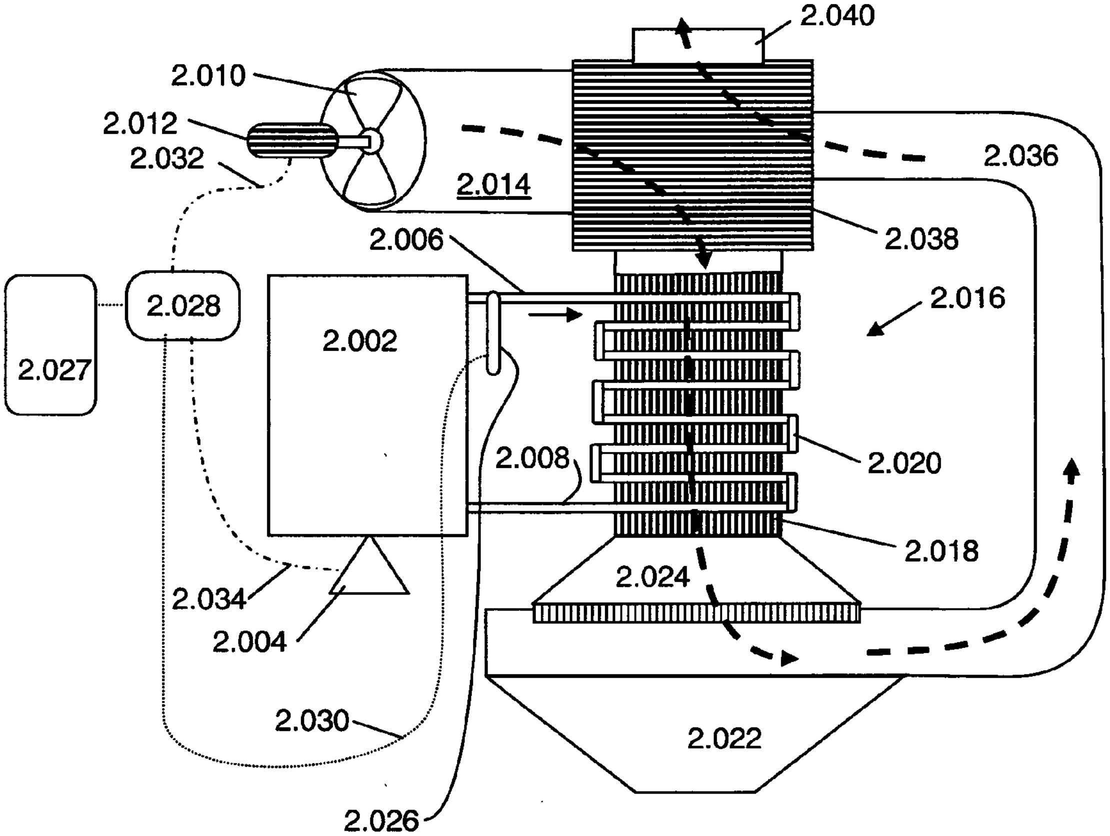

2.040
2.010
2.012
2.032
2.014
2.036
2.038
2.006
2.016
2.028
2.027
2.002
2.008
2.020
2.018
2.024
2.034
2.004
2.030
2.022
2.026

FIGURE 3

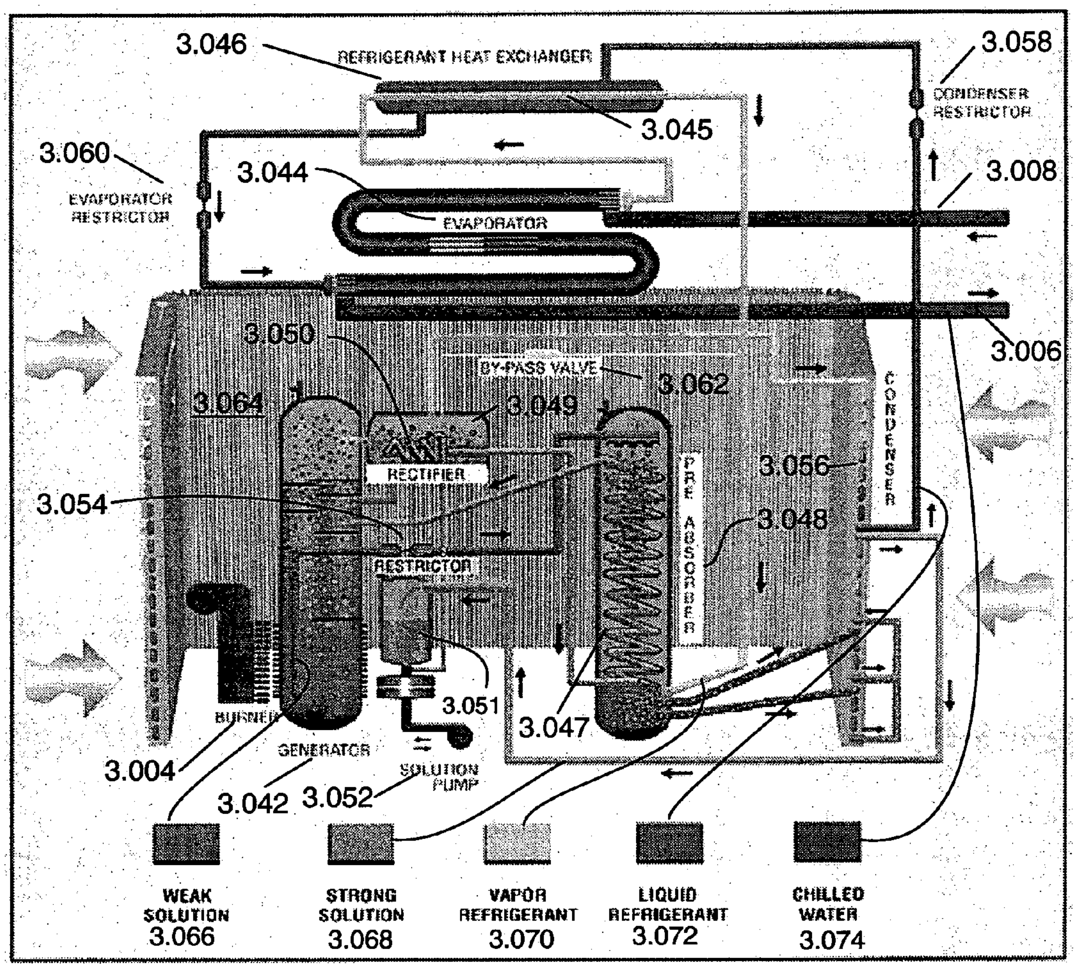
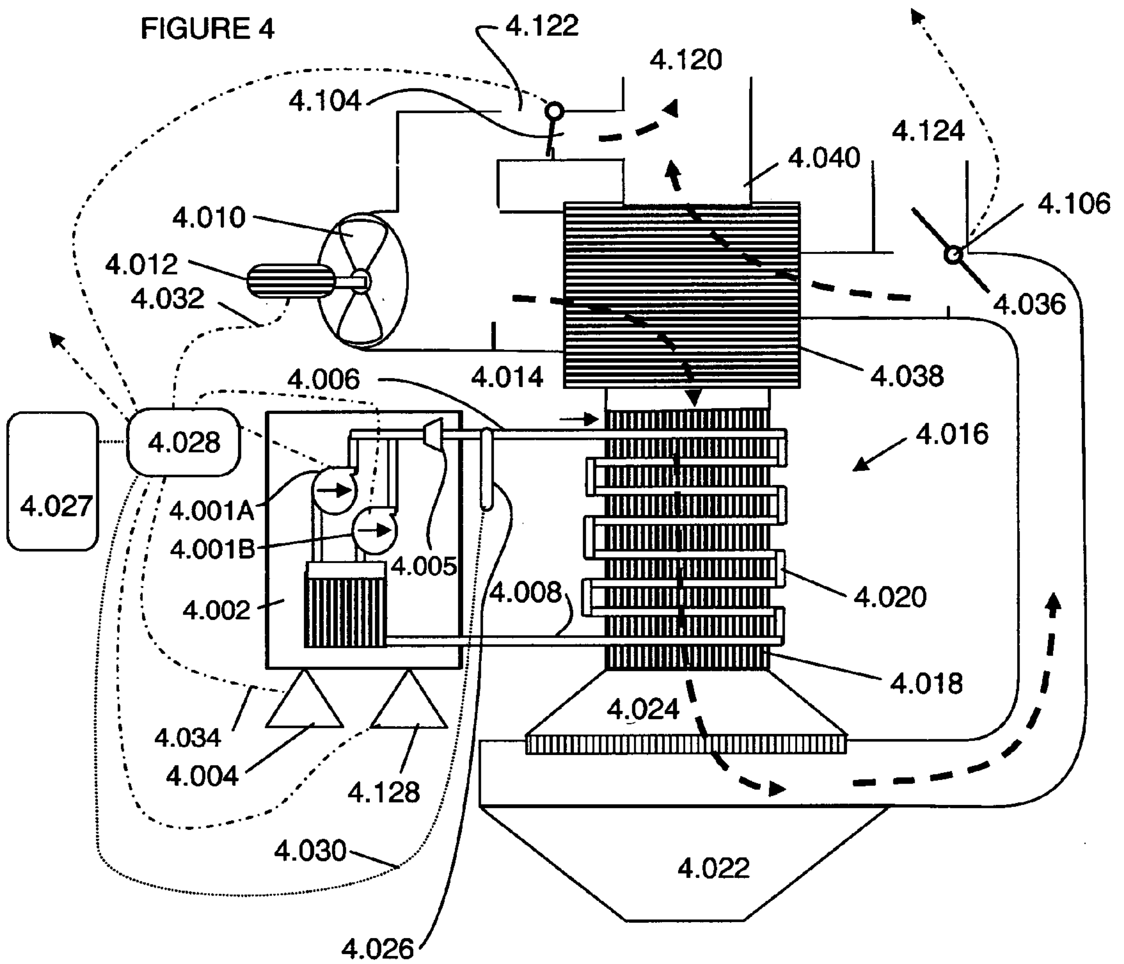

3.046
REFRIGERANT HEAT EXCHANGER
3.045
3.058
CONDENSER RESTRICTOR
3.060
EVAPORATOR RESTRICTOR
3.044
EVAPORATOR
3.008
3.006
3.050
BY-PASS VALVE
3.062
3.064
3.049
RECTIFIER
3.056
CONDENSER
3.054
3.048
PRE ABSORBER
RESTRICTOR
3.051
3.047
BURNER
3.004
GENERATOR
3.042
3.052
SOLUTION PUMP
WEAK SOLUTION 3.066
STRONG SOLUTION 3.068
VAPOR REFRIGERANT 3.070
LIQUID REFRIGERANT 3.072
CHILLED WATER 3.074

FIGURE 4



4.122
4.120
4.104
4.124
4.040
4.106
4.010
4.012
4.032
4.036
4.006
4.014
4.038
4.016
4.028
4.027
4.001A
4.001B
4.005
4.008
4.020
4.002
4.018
4.024
4.034
4.004
4.128
4.030
4.022
4.026

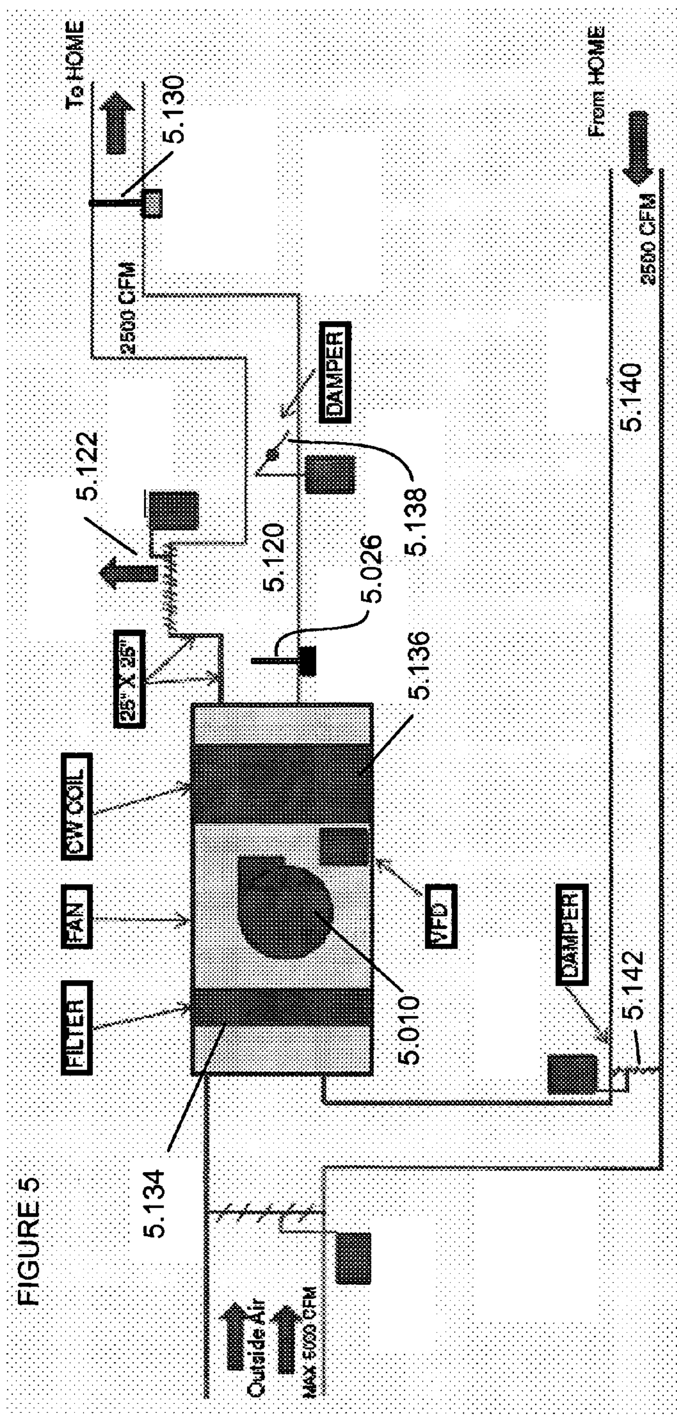


FIGURE 5
Outside Air
MAX 5000 CFM
FILTER
FAN
CW COIL
VFD
25" X 25"
DAMPER
DAMPER
To HOME
From HOME
2500 CFM
2500 CFM
5.134
5.010
5.136
5.026
5.120
5.122
5.138
5.130
5.140
5.142

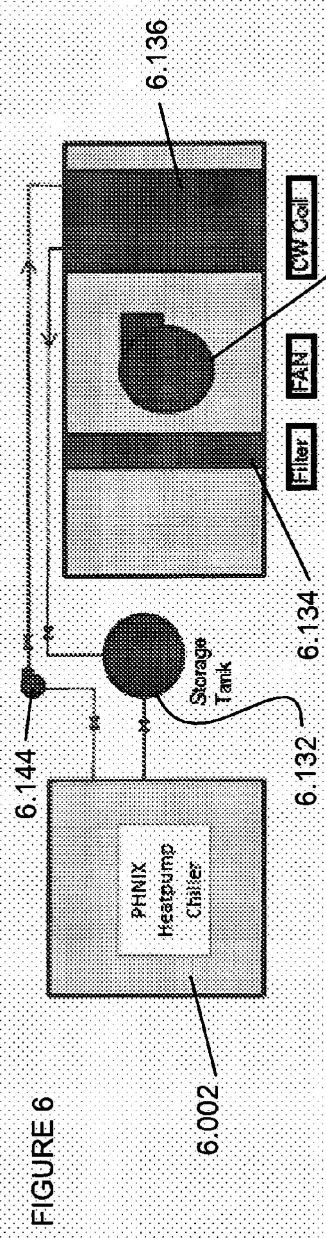


FIGURE 6
PHNIX Heatpump Chiller
Storage Tank
Filter
FAN
CW Coil
6.002
6.144
6.132
6.134
6.010
6.136

FIGURE 7

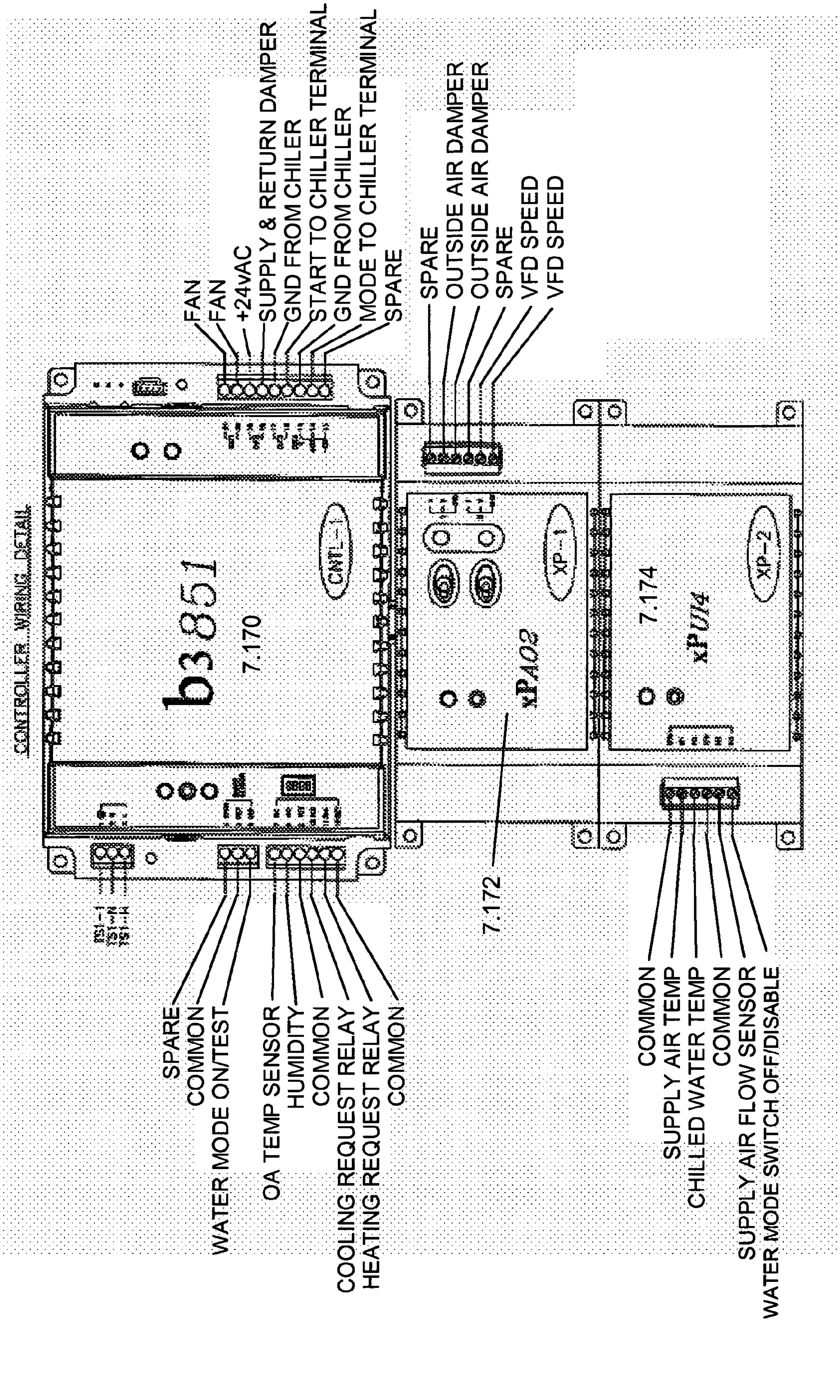

CONTROLLER WIRING DETAIL
FAN
FAN
+24vAC
SUPPLY & RETURN DAMPER
GND FROM CHILLER
START TO CHILLER TERMINAL
GND FROM CHILLER
MODE TO CHILLER TERMINAL
SPARE
SPARE
OUTSIDE AIR DAMPER
OUTSIDE AIR DAMPER
SPARE
VFD SPEED
VFD SPEED
b3851
7.170
CNTL-1
XP-1
xPAO2
XP-2
7.174
xPUI4
7.172
SPARE
COMMON
WATER MODE ON/TEST
OA TEMP SENSOR
HUMIDITY
COMMON
COOLING REQUEST RELAY
HEATING REQUEST RELAY
COMMON
COMMON
SUPPLY AIR TEMP
CHILLED WATER TEMP
COMMON
SUPPLY AIR FLOW SENSOR
WATER MODE SWITCH OFF/DISABLE

FIGURE 8

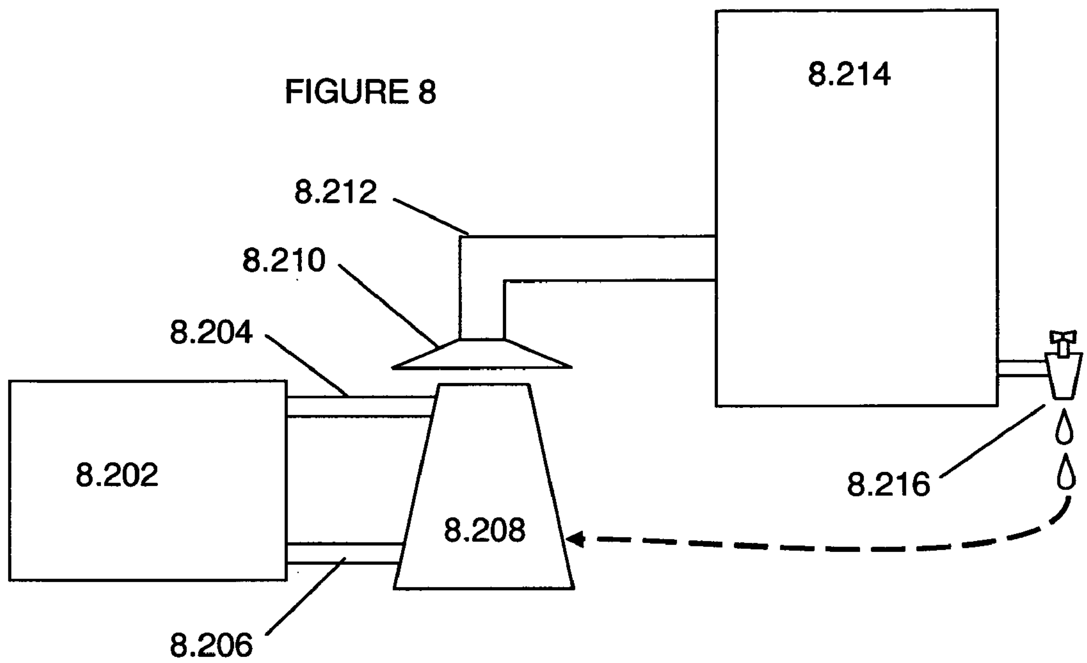


FIGURE 9

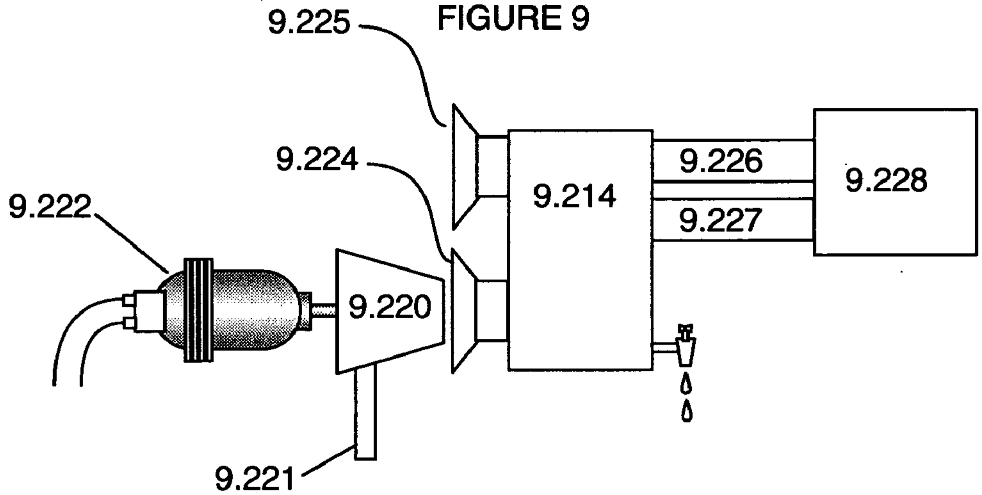


FIGURE 10

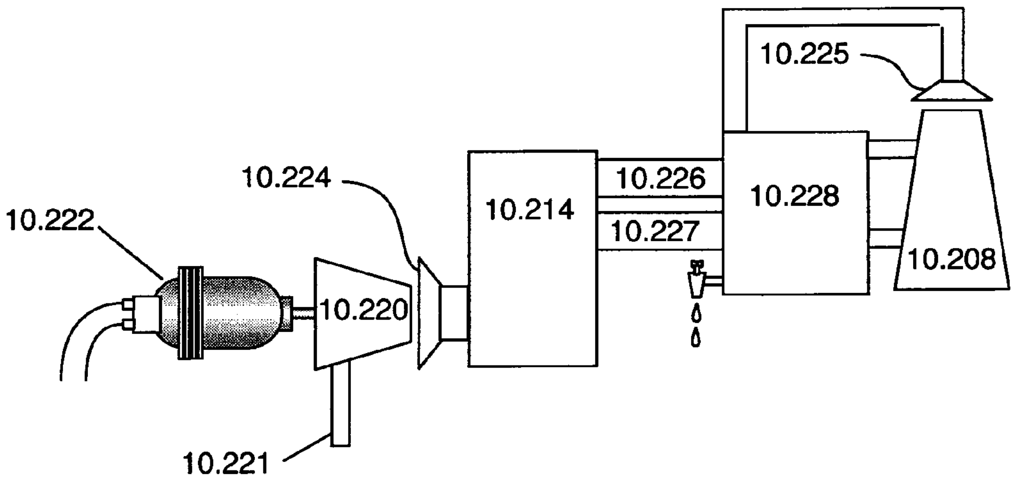
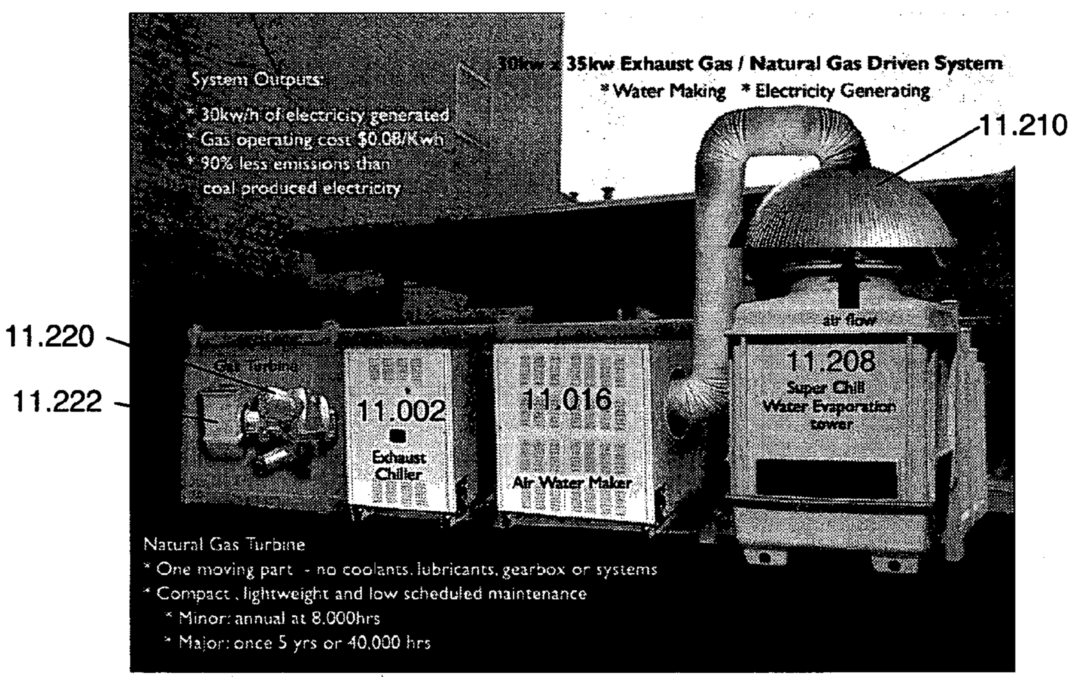


FIGURE 11



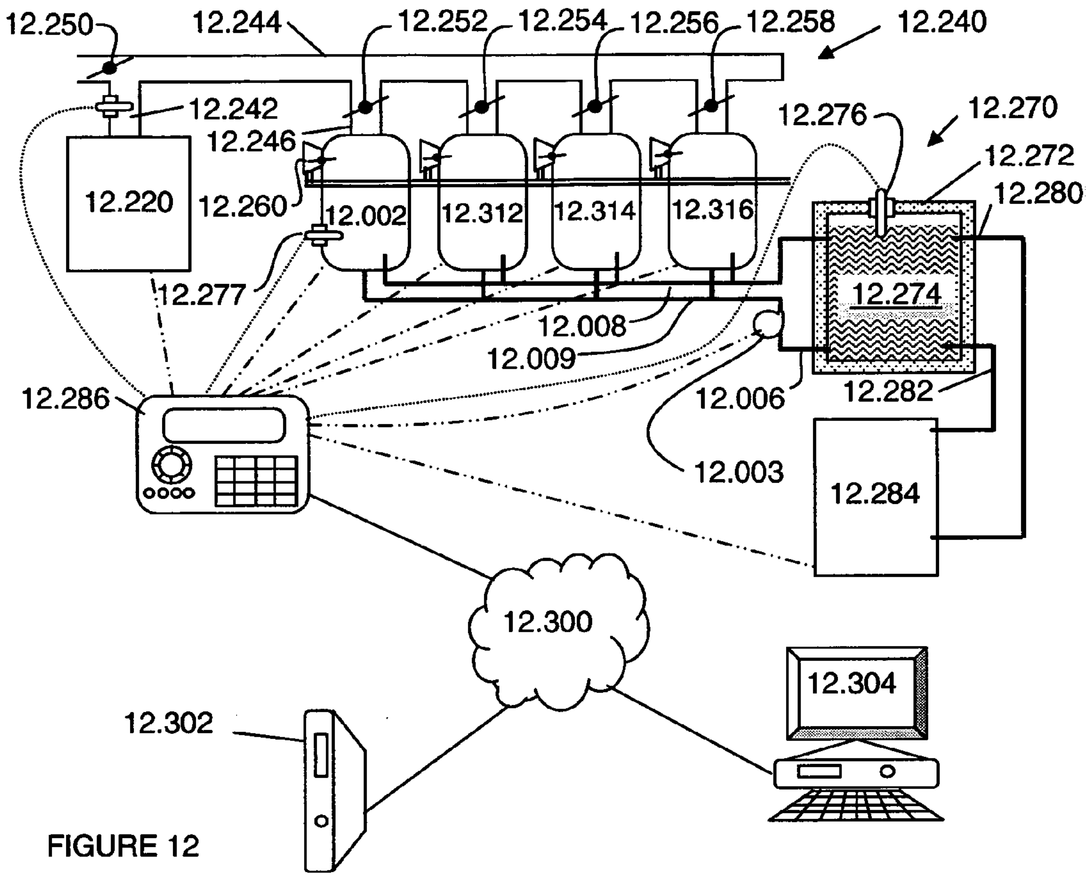

12.250
12.244
12.252
12.254
12.256
12.258
12.240
12.242
12.246
12.276
12.270
12.272
12.280
12.220
12.260
12.002
12.312
12.314
12.316
12.274
12.277
12.008
12.009
12.006
12.282
12.286
12.003
12.284
12.300
12.304
12.302

FIGURE 12

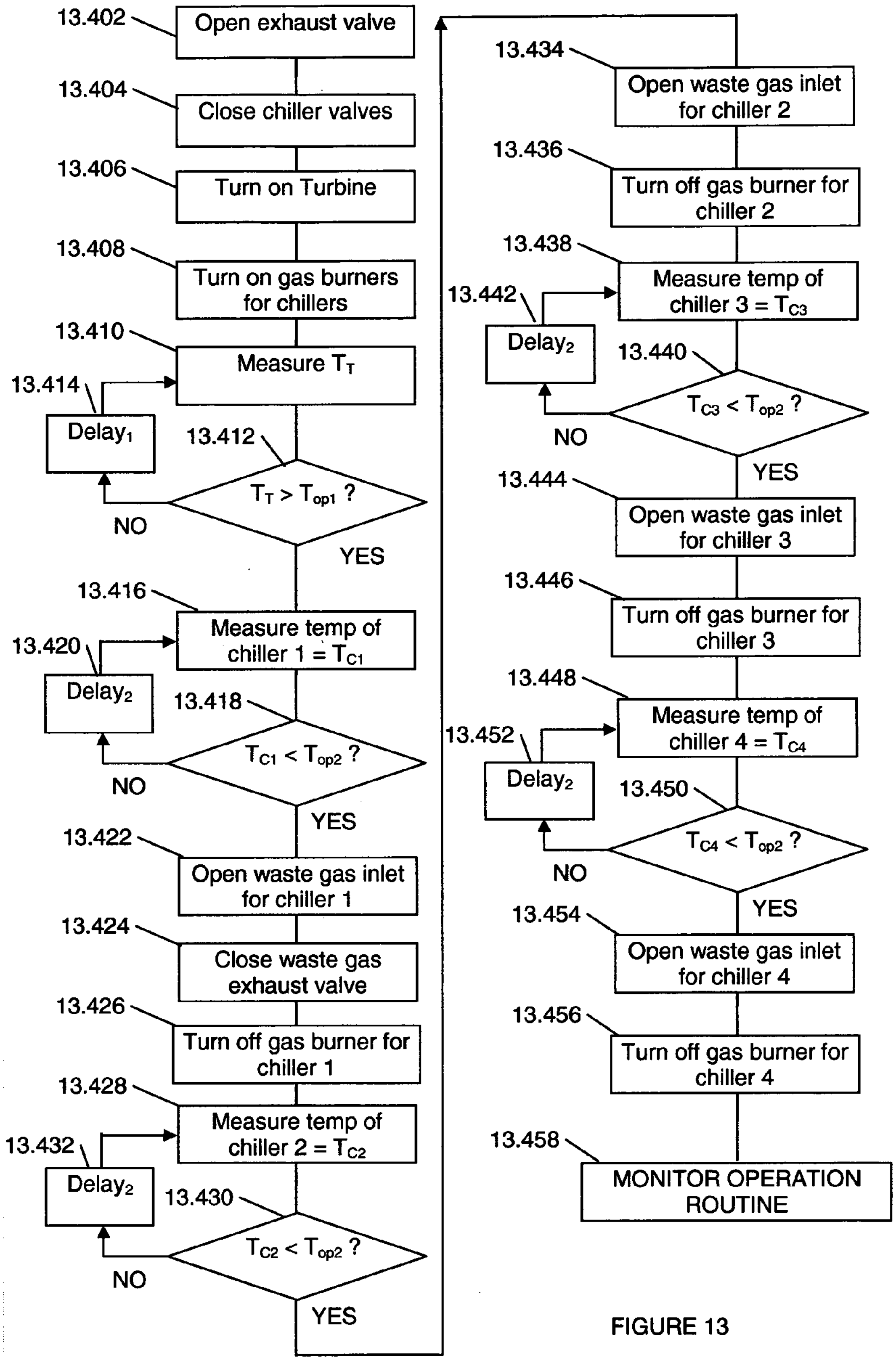

13.402
Open exhaust valve
13.404
Close chiller valves
13.406
Turn on Turbine
13.408
Turn on gas burners for chillers
13.410
Measure T_T
13.414
Delay₁
13.412
$T_T > T_{op1}$?
NO
YES
13.416
Measure temp of chiller 1 = T_{C1}
13.420
Delay₂
13.418
$T_{C1} < T_{op2}$?
NO
YES
13.422
Open waste gas inlet for chiller 1
13.424
Close waste gas exhaust valve
13.426
Turn off gas burner for chiller 1
13.428
Measure temp of chiller 2 = T_{C2}
13.432
Delay₂
13.430
$T_{C2} < T_{op2}$?
NO
YES
13.434
Open waste gas inlet for chiller 2
13.436
Turn off gas burner for chiller 2
13.438
Measure temp of chiller 3 = T_{C3}
13.442
Delay₂
13.440
$T_{C3} < T_{op2}$?
NO
YES
13.444
Open waste gas inlet for chiller 3
13.446
Turn off gas burner for chiller 3
13.448
Measure temp of chiller 4 = T_{C4}
13.452
Delay₂
13.450
$T_{C4} < T_{op2}$?
NO
YES
13.454
Open waste gas inlet for chiller 4
13.456
Turn off gas burner for chiller 4
13.458
MONITOR OPERATION ROUTINE

FIGURE 13

FIGURE 14

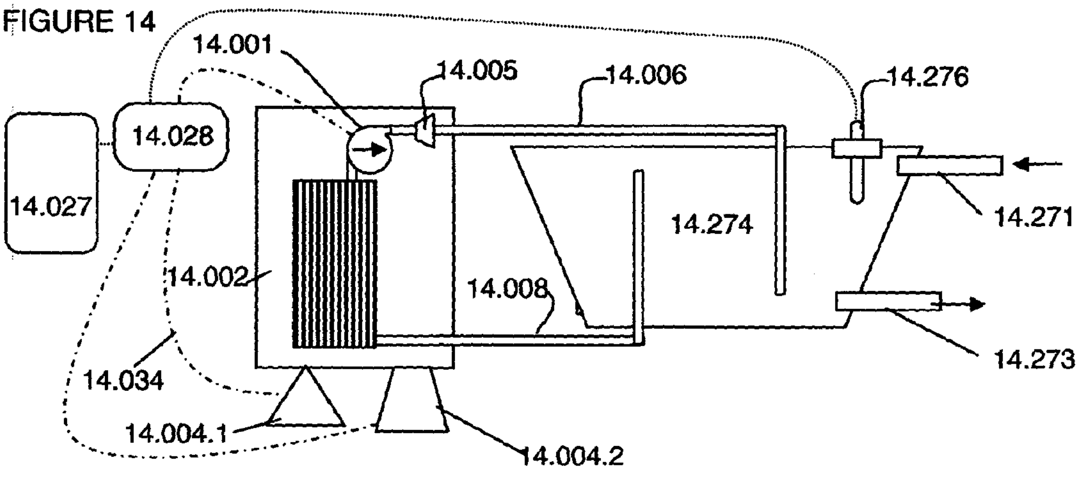
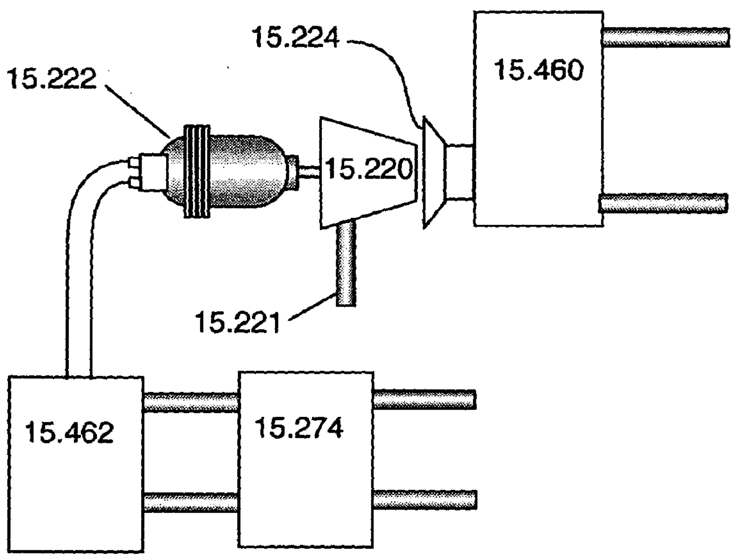


FIGURE 15



COMBINED WATER EXTRACTOR AND ELECTRICITY GENERATOR

FIELD OF THE INVENTION

[0001] This invention relates to improvements in the use of absorption chillers for the production of a cooled air or liquid outlet for use in applications requiring a chilled fluid, such as air conditioning, atmospheric water extraction, and the like.

[0002] Our copending Australian patent application AU2008237617 discloses an absorption chiller water extraction system powered by gas.

[0003] This invention builds on that invention to provide a source of chilled fluid for various applications.

BACKGROUND OF THE INVENTION

[0004] Air conditioning systems sometimes produce water as a waste product in higher humidity conditions, but such equipment is not specifically adapted to the production of water at lower humidity levels because the system does not consistently cool the air below the dew point at lower humidity levels. For example, an air conditioner may typically cool the room temperature to a steady state temperature of about 22° C., while the dew point can be several degrees less, so that, where the dew point is below the operating temperature of the air conditioning system, the system will not produce useful quantities of water.

[0005] Conventional vapour compression air conditioning systems for large buildings use a water evaporative cooling system to cool the hot heat transfer fluid from the air conditioning heat exchanger after the vapour has been compressed. In a city of 4 million people, this can result in the evaporation of the order of 30 mL of water per day.

[0006] Absorption chillers use the strong affinity between water and lithium bromide in the working fluid cycle. An absorption chiller includes a solution pump, a generator, a condenser, an evaporator, and an absorber in a vacuum process.

[0007] A dilute solution of lithium bromide solution is collected in the absorber and pumped to a first heat exchanger where it is pre-heated.

[0008] In a second heat exchanger, the solution is boiled by a heat source, such as steam. The vapour is delivered to the condenser. A concentrated lithium bromide solution is left behind. The concentrated lithium bromide solution is then cooled in the heat exchanger by the weak solution pumped up to the generator.

[0009] The condenser includes an enclosed bundle of tubes. The refrigerant vapour passes through mist eliminators to the condenser tube bundle and condenses on the tubes. The heat is removed by the cooling water which moves through the inside of the tubes. The condensed refrigerant falls into a trough at the bottom of the condenser.

[0010] In the evaporator the hygroscopic interaction of the lithium bromide and water creates an effective vacuum. As the refrigerant liquid cools the evaporator tube bundle, the refrigerant liquid boils at approximately 4° C. The latent heat of vapourization causes a cooling effect.

[0011] In the absorber the concentrated lithium bromide solution from the generator is applied to the absorber tube bundle, and absorbs the refrigerant vapour into solution, creating the vacuum in the evaporator. The cooling water removes the heat generated by the absorption.

[0012] The newly diluted lithium bromide solution returns to the solution pump for recirculation.

[0013] There are various sources of thermal energy. Coal gas and natural gas can be burned to produce heat. Gas turbine electricity generators produce a large amount of waste heat in their exhaust gasses while delivering useful electrical energy.

[0014] Thus both air conditioning systems and gas turbines produce waste heat, and air conditioning systems also consume water by way of evaporative cooling.

[0015] Atmospheric water generators are known which use the vapour compressor driven refrigeration cycle system to cool air below the dew point. U.S. Pat. No. 5,259,203 describes such a system. U.S. Pat. No. 4,255,937 describes an electrically operated dehumidifier using standard refrigeration techniques which serves as a small scale water extractor. U.S. Pat. No. 5,857,344 describes a compressor driven refrigeration system used in a small scale water extractor. U.S. Pat. No. 6,705,104 also describes a compressor operated refrigeration system used to extract water from air. However, such systems use a large amount of electrical energy per litre of water extracted, and are generally not suitable for large scale water production plants.

[0016] It is desirable to provide a cooling source capable of scaling up for industrial applications.

[0017] It is desirable to provide a large scale water extraction system.

[0018] It is also desirable to provide a water extraction system which produces water at an economic cost.

[0019] Absorption chillers can use the properties of fluids, such as the latent heat of vaporization, to provide a cyclical endothermic or heat absorbing process. Energy can be input to the system using an energy source, such as electricity. One such system uses ammonia, hydrogen and water as the working fluids. A description of such a system can be found at http://www.gasrefrigerators.com/howitworks.htm

[0020] The mixed hydrogen vapour is then separated by using water to absorb the ammonia. The heat input is then used to separate the water and ammonia by evaporating the ammonia.

[0021] An alternative absorption chiller system uses a Li/Br salt solution to absorb water from the air.

[0022] Any reference herein to known prior art does not, unless the contrary indication appears, constitute an admission that such prior art is commonly known by those skilled in the art to which the invention relates, at the priority date of this application.

SUMMARY OF THE INVENTION

[0023] This invention utilizes latent synergies between exothermal energy sources, such as gas turbine generators, internal combustion engines, or combustible gas supplies, and absorption chillers, condensation water generators, and air conditioning systems to produce a tri-generation system with good energy efficiency.

[0024] The invention provides a water extraction system having a cooling system adapted to cool air to below the dew point, the cooling system including a refrigeration system and a heat exchanger, a collector to collect water, and a gas turbine, wherein the cooling system is an absorption chiller, and wherein the exhaust gasses from the turbine are used to supply heat energy to the chiller.

[0025] The chiller can additionally or alternatively be powered by electricity or solar energy from a solar collector.

[0026] The system can include air flow generator adapted to cause air to flow through the heat exchanger.

[0027] The air flow generator can be controllable to control the air flow through the heat exchanger.

[0028] The heat exchanger can include a coolant pipe and cooling fins thermally connected to the coolant pipe, wherein the surface area of the fins is enlarged to increase the contact between the air flow and the fins.

[0029] The system can include a dew point sensor to determine the dew point of the air.

[0030] The system can include a controller controlling the air flow generator to maintain the temperature of the air from the heat exchanger below the dew point.

[0031] The invention also provides a combined electricity generation system, air-conditioning system, and water generator, including a turbine driven electricity generator, a chiller supplied with heat from the exhaust of the turbine, the chiller being connected to an air heat exchanger and cooling the air below the dew point to produce water from condensation, and an air conditioning system receiving cooled air from the outlet of the air heat exchanger.

[0032] The invention also provides a water extraction system as described in Australian patent application AU2008237617, including an air intake arrangement adapted to draw air from a source of enhanced humidity air.

[0033] The source of enhanced humidity can be the outlet of an evaporating cooling system.

[0034] The invention also provides an absorption chiller system including one or more absorption chillers, each chiller having at least a first and a second heat input, the system including a controller, wherein, on start-up of the chiller, the controller is adapted to turn the first heat source on to bring the chiller to a first predetermined temperature, and wherein controller is adapted to turn the second heat source on and to turn the first heat source off when the corresponding chiller reaches the predetermined temperature.

[0035] The controller can be adapted to bring each chiller to the predetermined temperature in sequence.

[0036] The invention also provides a method of extraction water from air, the method including using an absorption chiller to cool an air/heat transfer fluid heat exchanger to a temperature below the dew point, and collecting water from the air/heat transfer fluid heat exchanger.

[0037] The method can include the step of using gas as a source of heat energy to operate the chiller.

[0038] The method can use the step of using solar energy as a source of heat to operate the chiller.

[0039] The system can be used to produce potable water by the addition of suitable filtration and other water treatment processes as required by the nature of the water generated from the water extraction system.

BRIEF DESCRIPTION OF THE DRAWINGS

[0040] An embodiment or embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

[0041] FIG. **1** is a schematic illustration of a water extraction system according to a first embodiment of the invention.

[0042] FIG. **2** is a schematic illustration of a water extraction system according to a second embodiment of the invention.

[0043] FIG. **3** schematically illustrates an absorption chiller suitable for use in relation to the present invention.

[0044] FIG. **4** schematically illustrates a further arrangement embodying the invention.

[0045] FIG. **5** is a schematic functional block diagram of a system embodying the invention.

[0046] FIG. **6** is a functional block diagram of the water extraction system which forms part of the system of FIG. **5**.

[0047] FIG. **7** illustrates a controller adapted for use in an embodiment of the invention.

[0048] FIG. **8** schematically illustrates an embodiment of the invention in which the air intake of the water generator system is drawn from the outlet of an evaporating cooler apparatus.

[0049] FIG. **9** is a schematic illustration of a multi-function electricity generator, air-conditioner, and condensing water generator.

[0050] FIG. **10** schematically illustrates a system combining the features of the embodiments of FIGS. **8** & **9**.

[0051] FIG. **11** is a photo-superposition of a system according to an embodiment of the invention.

[0052] FIG. **12** illustrates a multi-turbine version of a system according to an embodiment of the invention.

[0053] FIG. **13** is a flow diagram illustrating a start-up process according to an embodiment of the invention.

[0054] FIG. **14** illustrates a general purpose chiller arrangement according to an embodiment of the invention.

[0055] FIG. **15** illustrates a system according to a further embodiment of the invention which uses a gas turbine electric generator to power an electric chiller.

[0056] The numbering convention used in the drawings is nn.nnn, or n.nnn, where the digits before the stop indicate the drawing number, and the digits after the stop indicate the item number. Where possible, the same item number is used in different figures to indicate the corresponding item.

[0057] It is understood that, unless indicated otherwise, the drawings are intended to be illustrative rather than exact representations, and are not necessarily drawn to scale. The orientation of the drawings is chosen to illustrate the features of the objects shown, and does not necessarily represent the orientation of the objects in use.

DETAILED DESCRIPTION OF THE EMBODIMENT OR EMBODIMENTS

[0058] FIG. **1** shows a water extraction system according to a first embodiment of the invention.

[0059] An absorption chiller **1.002**, a heat energy input **1.004**, a heat transfer outlet pipe **1.006**, a heat transfer fluid return pipe **1.008**, a heat transfer fluid compressor **1.003**, a fan **1.010**, fan motor **1.012**, air duct **1.014**, a restrictor valve **1.015**, an evaporator/heat exchanger **1.016** having fins **1.018** and heat transfer fluid pipe **1.020**. The air path through the heat exchanger **1.016** emerges in cowling **1.024** located over water trough **1.022**. A temperature sensor **1.026** senses the temperature at the outlet of the chiller. The sensor **1.026** is connected to a controller **1.028**. The controller is connected to control the speed of the air flow by controlling the speed of the fan. The controller can also control the heat input **1.004**.

[0060] The fans and pumps can be powered by electricity from the mains or from a solar generator or other source of electrical power. In one embodiment, electrical power can be used as an alternative power source to operate the chiller.

[0061] Further, a system can be provided having two or more power sources. For example, the system can include both gas power and electrical power for the chiller, with a programmable changeover based on the comparative tariffs or energy costs. The energy costs take account of the relative efficiencies of the gas and electrical systems. Thus the switchover can be based on the energy cost of electricity divided by the efficiency of the electrical chiller compared with the energy cost of gas divided by the gas efficiency. Thus, if the electrical cost is less than gas during an off-peak electrical supply period, the system can switch to electricity. To implement this facility, the system is provided with continually updated information on electricity tariffs, as well as with the cost of fuel for the turbine. The electricity tariff can be provided by an internet link or other communication link. The system can include a processor which receives information on the amount of power generated and the amount of fuel consumed, and can thus calculate the break-even point between the cost of fuel and the cost of electricity.

[0062] Alternative energy sources can also be incorporated to advantage. For example, solar energy can be used during periods of adequate sunlight, and gas can be used when insufficient sunlight is available. Thus energy sources can include on or more of the following: waste heat, combustion gasses from burning natural gas or coal gas, electrical energy, solar energy.

[0063] Optionally, a dew point monitor **1.027** can be connected to the controller. This enables the controller to determine the required chiller temperature or air cooling rate and the air flow rate from the fan. The dew point can be calculated by the controller from measurements of relative humidity and temperature.

[0064] In use, the fan delivers air to the heat exchanger **1.016** at a first flow rate. The dotted line arrow **1.011** indicates the air flow through the system. Because this exhaust air is chilled, it can be used to deliver cool, de-humidified air to a building. The absorption chiller operates to cool the heat transfer fluid (HTF) which is delivered to the heat exchanger so that the output air from the heat exchanger is below the dew point. Where the humidity is low, the air flow rate from the fan can be decreased. When the dew point falls below a selected threshold, the water generating function can be discontinued by the controller. We have found that, for a gas fired chiller, the cut-off threshold dew point temperature can be as low as about 0.5° C. (33° F.), while, for electrical chillers, a cut-off dew point temperature of about 7° C. (45° F.) an be used to keep down the cost of electricity consumed.

[0065] Preferably, the cooling fins **1.018** have an upright orientation to assist the flow of water into the collector **1.022**. The fins need not be vertical, but are preferably at an angle of less than 45° to the vertical. However, they can be horizontal. The cooling fins have an enlarged area, such as extended length. Inn one embodiment, the area can be increased by from about 10% to 100% compared with a standard refrigeration condenser. However, larger increases are within the scope of the invention. These fins are designed to allow the air to contact the fins for extended time frame to allow greater extraction of vapour combined with lower coolant temps and slower fan speeds if applicable to reach dew point.

[0066] The heat transfer fluid compressor **1.003** can be controlled on an ON/OFF mode.

[0067] The controller can be programmed to control the outlet temperature from the air/heat transfer fluid heat exchanger to a few degrees below the dew point to increase the rate of condensation. This temperature is referred to as the set point.

[0068] Set point=dew point−ΔT, where ΔT is a predetermined temperature below the dew point.

[0069] Thus, by controlling the air flow, the temperature, the rate of condensation can be controlled. Optionally, the operation of the compressor **1.003** can also be controlled to optimize the operation of the system. However, as compressors are designed to operate at a particular speed, alternative methods of providing compressed HTF can be used, for example by using two or more compressors as described below with reference to FIG. **4**. The individual compressors can be switched on or off as required to achieve the required cooling rate.

[0070] The controller can be programmed to prevent the condensate on the fins of the air/heat transfer fluid heat exchanger from freezing. However, because the air is travelling at a significant flow rate, the temperature of the heat transfer fluid can be of the order of +5° C. to −10° C. The upper temperature can be set to below the dew point, which, in some cases can be +10° C. or higher. In one embodiment, the controller can be set to maintain the temperature between −5° C. and +6° C. This temperature range provides a thermal hysteresis which means that the gas burner can be operated intermittently rather than continuously if the temperature were set closer to the dew point. Thus the gas burner can have a variable duty cycle determined by the dew point.

[0071] Preferably, the air flow in the air/heat transfer fluid heat exchanger is in a top-to-bottom direction, or at least inclined to assist the downward flow of the water condensed from the atmosphere.

[0072] FIG. **2** illustrates a modified version of the system of FIG. **1**, in which corresponding elements have the same item numbers as in FIG. **1**.

[0073] The system of FIG. **2** includes an air/air heat exchanger **2.038** connected by ducting **2.036** to the outlet **2.024** of the air/heat transfer fluid heat exchanger **2.016**. The air flow output from the fan **2.010** is directed into the air/air heat exchanger **2.038** and gives up heat to the cool air flow delivered from the air/heat transfer fluid heat exchanger **2.016**. The pre-cooled air flow from the fan then enters the air/heat transfer fluid heat exchanger, and the "dehydrated" exhaust air exits via vent **2.040**. This reduces the cooling work required from the chiller **2.002**. This exhaust air is still below the ambient air temperature and can be used to cool a building.

[0074] FIG. **3** illustrates an absorption chiller producing chilled water at **3.006**, returning via **3.008**. The water can include an anti-freeze solution to enable it to operate at subzero temperatures. The working fluid can be ammonia.

[0075] Working solution path is as follows: solution pump **3.052**, rectifier **3.050**, pre-absorber coil **3.047**, generator **3.042**, at which point the light and heavy constituents split.

[0076] The heavy constituents take a path through restrictor **3.054**, pre-absorber **3.048**, condenser **3.056**, solution chamber **3.051**.

[0077] The lighter constituents take a path through generator **3.042**; rectifier tank **3.049**, pre absorber **3.048**, condenser **3.056** and thence to the solution tank **3.051**.

[0078] Vapour refrigerant exits the rectifier tank **3.050**, to condenser **3.056**, condenser restrictor **3.058**, jacket of refrigerant hex **3.046**, evaporator restrictor **3.060**, evaporator **3.044** internal refrigerant heat exchanger **3.045**, and to the pre-absorber **3.048**, where it merges with the heavier constituents from the generator **3.042**.

[0079] FIG. **4** illustrates an atmospheric water extraction system according to a further embodiment of the invention. Specific changes in this system compared with the arrangement of FIG. **2** include two or more compressors **4.001**A and **4.001**B, an additional chiller power source **4.128**, together with ducting **4.120**, **4.124** and dampers **4.104**, **4.016** adapted to use part or all of the air intake and part or all of the air outlet for air conditioning a building.

[0080] In one embodiment, the compressors can have individual air/htf heat exchangers.

[0081] The compressors are controllable so the amount of power used by the chiller operation can be varied. This is particularly useful when using electrical power. The system operates under the control of the controller **4.028**. For example, in the case of a system having three compressors, on startup of the electrical system, all the compressors are used to bring the chiller to the set point. Then number 3 compressor can be switched off, and if the temperature falls below the set point, number 2 compressor is switched off, leaving number 1 compressor to maintain the temperature within a specified temperature range around the set point. The number 2 and 3 compressors can then be used as required depending on atmospheric conditions to maintain the system within the operating range. Thus the higher the dew point, the less cooling energy is required.

[0082] In one embodiment, the set point can be determined in the factory, and may be determined by the use of information relating to the locality into which the system is to be installed. Optionally a number of set points can be programmed into the controller to take account of seasonal variations.

[0083] In one embodiment, in an electrically operated mode, the set point can be of the order of 5° C., while in the gas operated mode, the set point can be of the order of 0.5° C.

[0084] In a further embodiment, the controller can actively calculate the set point based on the prevailing atmospheric conditions, such as temperature, humidity, dew point.

[0085] When the system is powered by gas, full power is used to bring the system to a temperature below the set point, and the gas can then be turned off so the system uses its thermal hysteresis to continue operating until the temperature rises to the set point, and the gas is again applied.

[0086] The fan speed is controllable by the controller in response to the performance of the system in the prevailing atmospheric conditions. For example, the fan speed can be varied in response to changes in the atmospheric dew point. Thus the optimum air flow across the air/htf heat exchanger to be maintained. If the dew point falls below a predetermined threshold temperature, water making is discontinued.

[0087] The controller looks at the Dew Point temp/Enthalpy/Dry Bulb temperatures (Entering air & Leaving air) to make calculations and adjustment in fan speed. Fan speed control is based on an algorithm to maximize dehumidification based on entering dry bulb and dew point temperatures. This fan speed calculates approximate tonnage to maximize efficiency and maximize water extraction based on standard energy equation $Qt=4.5\ CFM\ (H1-H2)$ where H is enthalpy of entering and leaving air. The CFM is increased to keep Qt as close to maximum tonnage as chiller/absorber is capable of producing. The controller then sends an appropriate signal to Variable Frequency Drive to modify fan RPM an in turn CFM produced.

[0088] The controller can be selectively controlled by a keyboard or other input to operate the system in a number of different operational modes, such as water extraction only, air conditioning only, or water extraction and air conditioning combined.

[0089] Ducting and dampers as shown in FIG. **4** can be added to control the flow of air from the system into a building. Damper **4.104** is adapted to divert air from the fan **4.010** to vent **4.122** or to an air conditioning duct **4.120**. Damper **4.106** can block flow through the chiller, or divert flow from the chiller either through air/air heat exchanger **4.038** or to duct **4.124**. The dampers can be controlled by the controller **4.028**.

[0090] The additional power source can be, for example, electrical mains power. The controller can select the power source.

[0091] FIG. **5** is a functional block diagram of the air conditioning system of a system according to an embodiment of the invention. The fan **5.010** draws air through filter **5.134** and directs it to CW coil **5.136** whence it enters duct **5.120** for delivery to the air conditioned building. Exhaust vent **5.122** is controllable to divert air from the building duct when damper **5.138** is closed. An air flow sensor **5.130** reports the air flow rate to the controller. A return duct **5.140** returns air to the inlet, controllable by damper **5.142**.

[0092] FIG. **6** is a functional block diagram of the water extraction system which forms part of the system of FIG. **5**. The fan **6.010** filter **6.134** and CW coil **6.136** correspond to the same elements in FIG. **5**. The heat pump chiller **6.002** delivers cool water to the CW coil via pump **6.144** and the water is then delivered to the storage tank **6.132**.

[0093] FIG. **7** illustrates a controller adapted for use in an embodiment of the invention. The controller **7.170** can be, for example, an Andover B3 851 with an analog output module **7.172** and a universal input module **7.174**.

[0094] A commercially available absorption chiller, such as the Robur 5 Ton Absorption Chiller, can be used to implement an embodiment of the invention. The specification for a chiller and air handler used in an embodiment of the invention are set out below.

Specifications of the 5 Ton Gas Fired Chiller HP5T	
Voltage	240 V
Cooling capacity	16 kW
Gas consumption @26%	67 cubic meter/hour.
Total electric load (constant running)	540 watts.
Weight	276 KG
Dimensions	850 w × 655d × 1310 h.
Noise level	49 db

Specifications of the Air Handler HP16 Kw	
Voltage	240 V
Cooling capacity	17 Kw
Electrical fans (2)	240 watts and 120 watts
Weight	160 KGs
Dimensions (horizontal)	1300 w × 600 d × 710 w
Coil coated with anti corrosive coatings	
Filter from water collection tank to storage tank if required.	
Circulation pump (s)	
‘Manufactured water’ Transfer pump	
Water manufacturing ability at 50% humidity and 26° C.	17 Litres/hour

[0095] The gas turbine can operate on natural gas, biogas, propane and other gas sources.

[0096] The system can be scaled up to provide large scale water extraction capabilities. An air handler system capable of providing efficient cooling includes a sufficiently large fin area to ensure efficient cooling of the air below the dew point.

[0097] FIG. **8** illustrates a conventional air conditioning system **8.202** with an evaporating cooling system **8.208** to which the heat transfer fluid of the air conditioning system is connected by a hot outlet pipe **8.204** via which the hot fluid from the air conditioning system is delivered to the cooling tower, and a cool fluid pipe **8.206** via which the cooled fluid is returned to the air conditioning system. The cooling system generates an outlet of humid air due to evaporative cooling. The heat transfer fluid can be water.

[0098] In this embodiment of the invention, the humid air discharged from the cooling tower **8.208** is harvested by a cowling **8.210** similar to a range hood with an intake fan to draw the humid air into the cowling from whence it is ducted to the air intake of the condensing water generator such as that described in AU2008237617. This means that the humidity of the air from the evaporative cooling tower **8.208** is usually higher than ambient humidity, thus the condensing water generator assists in capturing the water from the cooling tower which would otherwise be lost through evaporation. The water generated by the water generator can be used for a number of purposes. In one implementation, the water is fed back to replenish evaporation from the cooling tower. In an alternative system, the water can be used for flushing toilets.

[0099] FIG. **9** schematically illustrates an embodiment of the invention in which a gas turbine **9.220** drives an electrical generator **9.222**. Gas is delivered to the turbine via gas supply line **9.221**. The gas can be natural gas. The exhaust gasses from the turbine **9.220** are harvested by cowling **9.224** and delivered to the combined absorption chiller and condensing water generator **9.214** as a source of heat for the absorption chiller. Ambient air is drawn in through air inlet **9.225**, using a fan as described in relation to FIG. **1**. The cooled air from the condensing water generator **9.214** is delivered to an air conditioning system **9.228** via duct **9.226** and hot air from the condensing water generator system is likewise delivered to the air conditioning system via duct **9.227** for use in producing conditioned (cooled/heated/dehumidified) air in the building system. Manifolds, ducts and vanes can be used to control the mixture of hot and cooled de-humidified air in response to an air-conditioning controller receiving information such as the temperature of the heated and cooled air and the humidity of the cooled air and ambient humidity.

[0100] FIG. **10** schematically illustrates a system in which the capture of humid air of the arrangement of FIG. **8** is combined with the gas exhaust capture of the arrangement of FIG. **9**. This arrangement can be useful in the case where the chiller does not produce sufficient cool air for the purposes of the air conditioning system, so the air conditioning system has a second cooling source. The gas turbine **10.220** receives gas via pipe **10.221** and drives an electrical generator **10.222**. The exhaust from the turbine is directed to the chiller **10.214**, eg, via cowling and ducting. The generator can be used to provide power for the fans and pumps of the system and for other on-site purposes or, where a favourable tariff arrangement is provided by the local electricity utility, to deliver power to the mains grid.

[0101] In order to reduce operating costs, the system of FIG. **10** can optionally include means for incorporating one or more additional energy sources which have time varying tariffs of time varying availability. Thus, advantage can be taken of, for example, low electricity tariff periods, or of availability of solar energy.

[0102] In FIG. **10**, an optional mains electricity input is provided. The system can include a processor to select the electricity input in stead of the gas input when the cost of electricity is sufficiently low to make this an economic choice, such as in periods of low electricity demand. The arrangement of FIG. **10** thus includes gas meter **10.242**, electricity meter **10.240**, mains switch **10.246**, processor **10.244**. The processor receives updated information on the electricity tariff via the internet **10.250** and also receives information on the consumption of gas from gas meter **10.242**. The cost of gas is also accessible to the processor. The processor also receives information on the amount of electricity generated via electricity meter **10.240**. When the break-even point between gas and electricity is crossed in favour of electricity, the processor **10.244** can turn the gas turbine off and switch the cooler **10.214** to electric power.

[0103] Cool air can be diverted from duct **10.226** via duct **10.260** to cool the turbine.

[0104] Alternative sources of exhaust heat, such as reciprocating diesel or petrol engines can be used in place of or in addition to, the turbine.

[0105] FIG. **11** is a photo-superposition illustrating the physical arrangement of a system according to an embodiment of the invention. The gas turbine **11.220** drives a generator **11.222**, and its exhaust gasses are directed to supply heat to the absorption chiller **11.002** which in turn cools the water generation heat exchanger in **11.016**. Moist air from the separate air conditioning cooling tower **11.208** is harvested by the cowling **11.210** and delivered to the air intake of the water generator **11.016**.

[0106] The system can be modularly expandable as shown the arrangement of FIG. **12**, which shows an arrangement with one turbine **12.220** and **4** chillers **12.002**. The chillers each have a heat input connected to a hot gas manifold **12.244** supplied via duct **12.242** from the turbine exhaust. A number of control vanes or valves **12.250**, **12.0252**, **12.254**, **12.0256**, **12.258** control the flow of the turbine exhaust gasses inn the manifold **12.244**. The valve **12.250** can be used to either vent the gasses to the exterior of the manifold, or to direct the gases down the manifold towards the chiller inlets. The valves **12.252**, **12.254**, **12.256**, and **12.258** can be used to provide a path through the corresponding chiller via manifold outlet ducts such as **12.246**.

[0107] Optionally, the chillers **12.002** can have a second heat input, such as the gas burner input **12.260** which can be used when the turbine is not operating. Additionally, the gas burner inputs **12.260** can be used on start-up of the chillers, as this can require more heat than is required to maintain the chillers in the operational state.

[0108] Optionally, the cooled working fluid from the chillers can be can be delivered via a working fluid circulating path including pipes **12.008**, **12.006** and pump **12.001** to a thermal store **12.274** which stores a large volume of working fluid. The storage tank can be thermally insulated. The storage tank can deliver the chilled working fluid to a downstream heat exchanger, such as **12.284**, which can be part of, for example, a water maker or refrigeration system.

[0109] A controller **12.286** can be used to control the operation of the system. The controller can receive inputs from sensors such as temperature sensor **12.276** indicating the temperature of the working fluid in the tank **12.274**. The controller can then control various system parameters to ensure that the temperature of the working fluid is within a predetermined range.

[0110] Additional sensors can measure, for example, ambient temperature, relative humidity.

[0111] For example, the controller can control one or more of the following:

[0112] the operation of the chillers **12.002**;

[0113] the turbine **12.220**; the gas burners **12.246**;

[0114] the system pumps;

[0115] the system fans.

[0116] The controller can also be responsive to information received, for example via a communication network, such as the internet **12.300** from one or more data sources such as server **12.032** which may contain relevant operating information, such as the relative prices of alternative fuel sources. The information can be supplied on a push basis or on a pull basis.

[0117] In addition, instructions can be sent to the controller via the communication network from a signal originating device, shown illustratively as a computer **12.304**.

[0118] The system of FIG. **12** is illustrated in the flow diagram of FIG. **13**. This can be implemented using the controller **12.286**. In the description of the start-up routine, the chillers **12.002**, **12.312**, **12.314**, & **12.361** will be referred to as Chiller **1**, Chiller **2**, Chiller **3**, and Chiller **4**.

[0119] At step **13.402**, the exhaust valve **12.250** is opened and the waste gas inlets **12.252**, **12.254**, **12.256**, & **12.258** are closed at step **13.404**.

[0120] The turbine **12.220** is then started at **13.406** and the gas burners **12.260** for the Chillers **1** to **4** are turned on at step **13.408**.

[0121] The temperature T_T of the turbine gas can then be checked at **13.410** and measured against a first threshold temperature T_{op1} at **13.412** to ensure the exhaust gas is at a sufficient temperature to heat the absorption chillers. This step can generally be omitted as the exhaust gas will be above T_{op1} while the turbine is operating. If the exhaust gas is not at the operating temperature, a first delay **14.414** is initiated during which a restart of the turbine can be attempted. If the turbine does not start after a predetermined number of attempts or a predetermined time period, an alarm can be initiated using a "watchdog timer" or sanity check which measures the elapsed time or number of repeat operations of the delay loop.

[0122] A temperature measuring loop, including temperature sensing **13.416**, temperature comparison **13.418**, and delay **13.420**, is implemented to determine when Chiller **1** has been cooled to the chiller operating temperature threshold T_{op2} by the gas burner. The delay can again include a sanity check (time limit or repetition counter) to ensure the system does not become locked in a continuous loop.

[0123] When Chiller **1** has reached the operating temperature threshold T_{op2}, the waste gas inlet **12.252** of Chiller **1** is opened at **13.422**, the waste gas exhaust **12.250** is closed at step **13.424**, and the gas burner for Chiller **1** is turned off at **13.426**.

[0124] Chiller **2** is next tested to determine if it has reached the operating temperature threshold T_{op2}, again using the loop including temperature measurement **13.428**, temperature comparison **13.430**, and delay **13.432**. When Chiller **2** reaches the operating temperature threshold T_{op2}, the waste heat inlet **12.254** is opened at **13.434**, and the gas burner for Chiller **2** is turned off at **13.436**.

[0125] The process for Chillers **3** & **4** is the same as for Chiller **2** with the corresponding waste gas inlets and burners being substituted.

[0126] Once the system has all chillers running on the waste gas from the turbine **12,220**, the system then switches to monitor mode, in which it responds to the inputs from sensors such as temperature sensor **12.276** in the chilled working fluid reservoir **12.274**.

[0127] In addition, in the monitor mode, the controller can monitor the operation of the turbine, and, when the turbine ceases to operate, the controller can reignite the gas burners to run the chillers.

[0128] The arrangement of FIG. **12** can be used to bring the system rapidly to the operating state because the gas burner can deliver greater heat than the exhaust gas.

[0129] FIG. **14** illustrates a general purpose chiller arrangement according to an embodiment of the invention. The absorption chiller **14.002** has a pair of heat inputs. The heat inputs can be, for example, a gas input **14.004.1** and a waste heat input **14.004.2**. The compressor **14.001** circulates the chillers cooled working fluid from choke **14.005** between the chiller and an insulated working fluid reservoir **14.274** via pipes **14.006**, **14.008**. A temperature sensor **14.276** measures the temperature of the working fluid in the reservoir, and feeds this information to the controller **14.028**. An external thermal load is supplied from the reservoir via outlet pipe **14.273** and inlet pipe **14.271**. Thus, the reservoir can absorb a certain amount of heat from the external thermal load without the need for the chiller to operate continuously.

[0130] Various forms of load can be connected to the reservoir **14.274**. The load can be an air conditioning system, a containerized data centre cooling system, an atmospheric water maker.

[0131] The dehumidified cooled air from the system can also be used for air conditioning purposes.

[0132] FIG. **15** illustrates a system according to a further embodiment of the invention which uses a gas turbine electric generator to power an electric chiller **15.462**. The turbine **15.220** powers en electric generator **15.222**. The electricity from the generator is used to power the electric chiller **15.462** to provide chilled working fluid for the reservoir **15.274**.

[0133] The exhaust gasses from the turbine are used in a heat exchanger in water heater **15.450** to heat water to provide a source of hot water.

[0134] The system can also deliver hot water using a hot water take-off point before the cooling tower.

[0135] Where ever it is used, the word "comprising" is to be understood in its "open" sense, that is, in the sense of "including", and thus not limited to its "closed" sense, that is the sense of "consisting only of". A corresponding meaning is to be attributed to the corresponding words "comprise", "comprised" and "comprises" where they appear.

[0136] It will be understood that the invention disclosed and defined herein extends to all alternative combinations of two or more of the individual features mentioned or evident from the text. All of these different combinations constitute various alternative aspects of the invention.

[0137] While particular embodiments of this invention have been described, it will be evident to those skilled in the art that the present invention may be embodied in other specific forms without departing from the essential characteristics thereof. The present embodiments and examples are therefore to be considered in all respects as illustrative and not restrictive, and all modifications which would be obvious to those skilled in the art are therefore intended to be embraced therein.

What is claimed is:

1. A water extraction system having a cooling system adapted to cool air to below the dew point, the cooling system including an absorption chiller system including a heat source, the system including an air/heat transfer fluid heat exchanger, a water collector arranged to collect water from the air/heat transfer fluid heat exchanger, and an exothermal energy source, wherein the cooling system is an absorption chiller, and wherein waste heat from the energy source are used as the heat source to supply heat energy to the chiller.

2. A water extraction system as claimed in claim **1**, including an air conditioning system using discharge air from the water generator to control the temperature and/or humidity of the air in an air conditioned space.

3. A water extraction system as claimed in claim **1**, including an electrical generator driven by the gas turbine.

4. A water extraction system as claimed in claim **1**, including an air intake located to draw air from a source of humid air.

5. A water extraction system as claimed in claim **4**, wherein the source of humid air is a cooling tower.

6. A system as claimed in claim **5**, wherein water from the water extractor is fed back to the source of humid air.

7. A water extraction system as claimed in claim **1**, including an air flow generator adapted to cause air to flow through the air/heat transfer fluid heat exchanger.

8. A water extraction system as claimed in claim **7**, wherein the air flow generator is controllable to control the air flow through the heat exchanger.

9. A water extraction system as claimed in claim **1**, wherein the heat exchanger includes a coolant pipe and cooling fins thermally connected the coolant pipe, wherein the surface area of the fins is enlarged to increase the time the contact surface between the air flow and the fins.

10. A water extraction system as claimed in claim **1**, including a dew point sensor to determine the dew point of the air.

11. A water extraction system as claimed in claim **1**, including a controller controlling the air flow generator to maintain the temperature of the air from the heat exchanger below the dew point.

12. A water extraction system as claimed in claim **8**, wherein, in use, the controller is adapted to control the heat source to maintain the outlet temperature of the heat exchanger below the dew point.

13. A water extraction system as claimed in claim **1**, including an additional chipper power supply.

14. A water extraction system as claimed in claim **12**, wherein the additional power source is an electrical power supply.

15. A water extraction system as claimed in claim **1**, wherein the chiller system includes two or more selectively switchable compressors.

16. (canceled)

17. An absorption chiller system including two or more absorption chillers, each chiller having at least a first and a second heat input, the system including a controller, wherein, on start-up of the chiller, the controller is adapted to turn the first heat source on to bring the chiller to a first predetermined temperature, and wherein controller is adapted to turn the second heat source on and to turn the first heat source off when the corresponding chiller reaches the predetermined temperature.

18. A system as claimed in claim **17**, wherein the controller is adapted to bring each chiller to the predetermined temperature in sequence.

19. A system as claimed in claim **17**, including a working fluid reservoir connected to store cooled working fluid from the chillers and to provide a thermal buffer between the chillers and a thermal load.

20. A method of extraction water from air, the method including delivering hot exhaust gasses from a gas turbine to an absorption chiller to cool an air/heat transfer fluid heat exchanger to a temperature below the dew point, and collecting water from the air/heat transfer fluid heat exchanger.

21. A method as claimed in claim **20**, including the steps of:

using the gas turbine to drive an electrical generator; and

using the outlet air from the water generator to air condition a space.

22. (canceled)

* * * * *