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(54) SELF SUSTAINING ENERGY SYSTEM FOR A BUILDING

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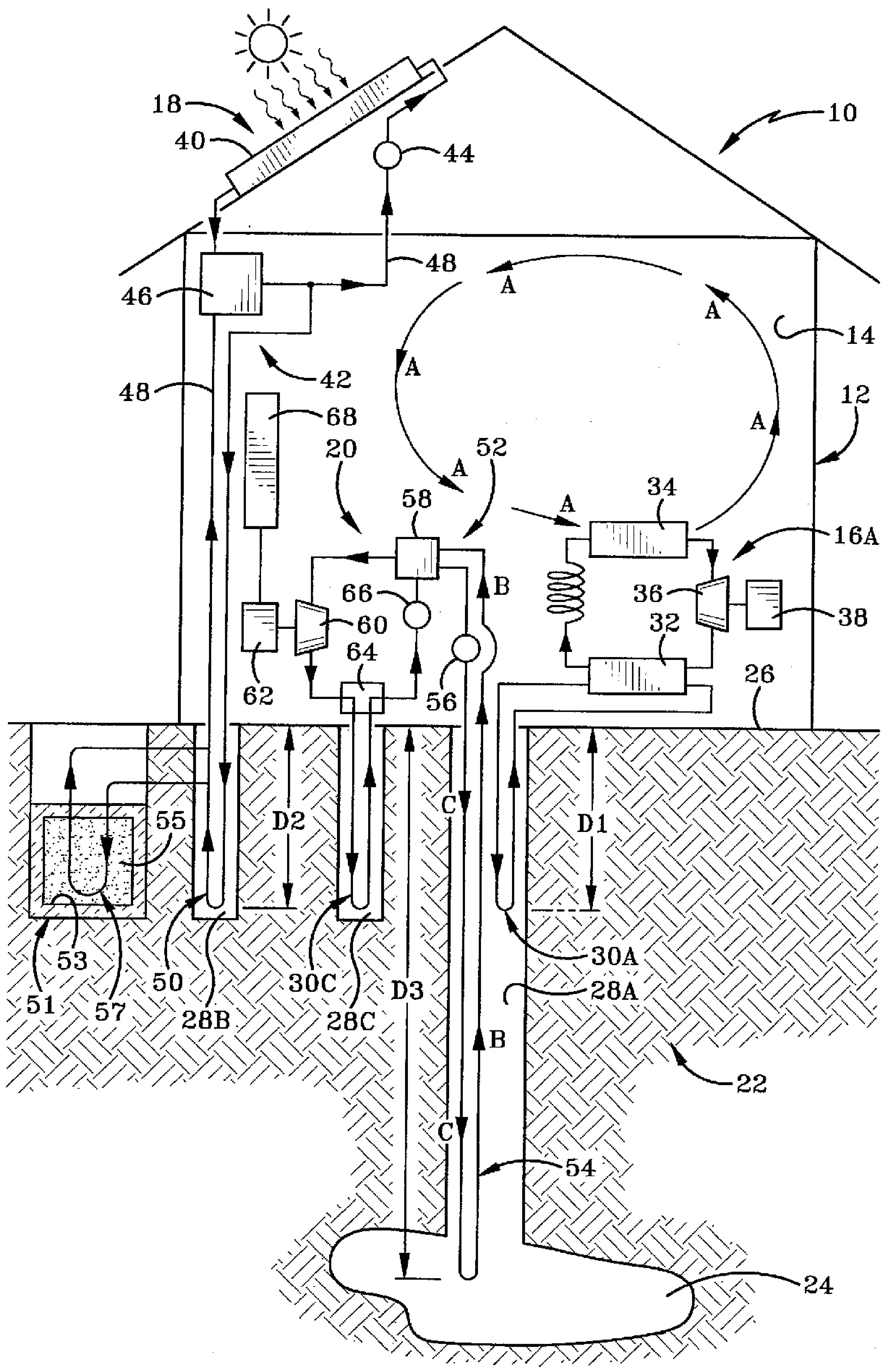
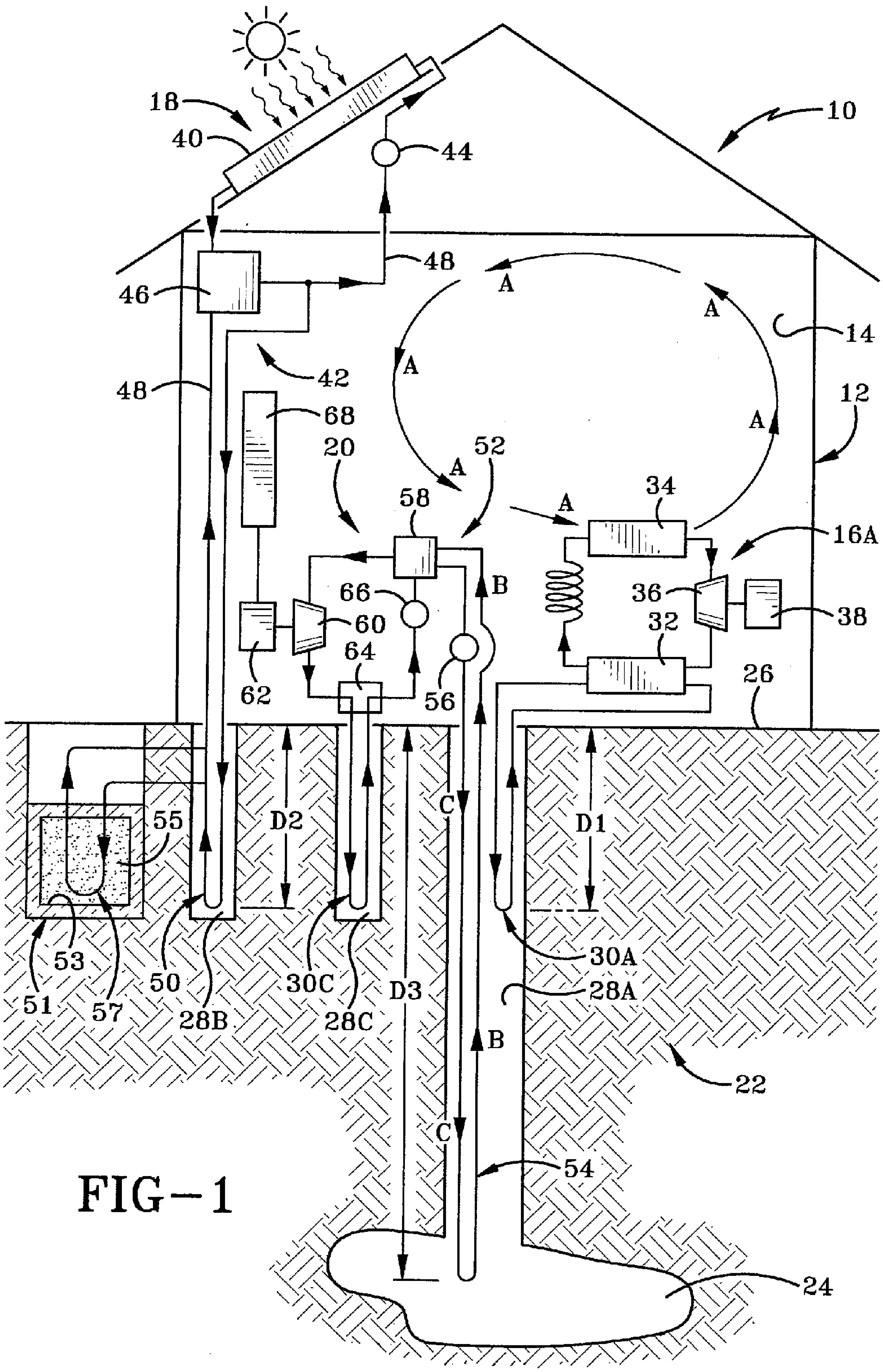
(57) **ABSTRACT**

A self sustaining energy system for a building is provided part of which is typically driven by geothermal energy. The energy system typically uses a ground source heat pump for heating and cooling the building airspace and an organic Rankine cycle drive for producing electricity. A solar powered heating system may also serve as a heat source for providing domestic hot water and supplemental airspace heating.





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62
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D2
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28B
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28C
D3
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22
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54
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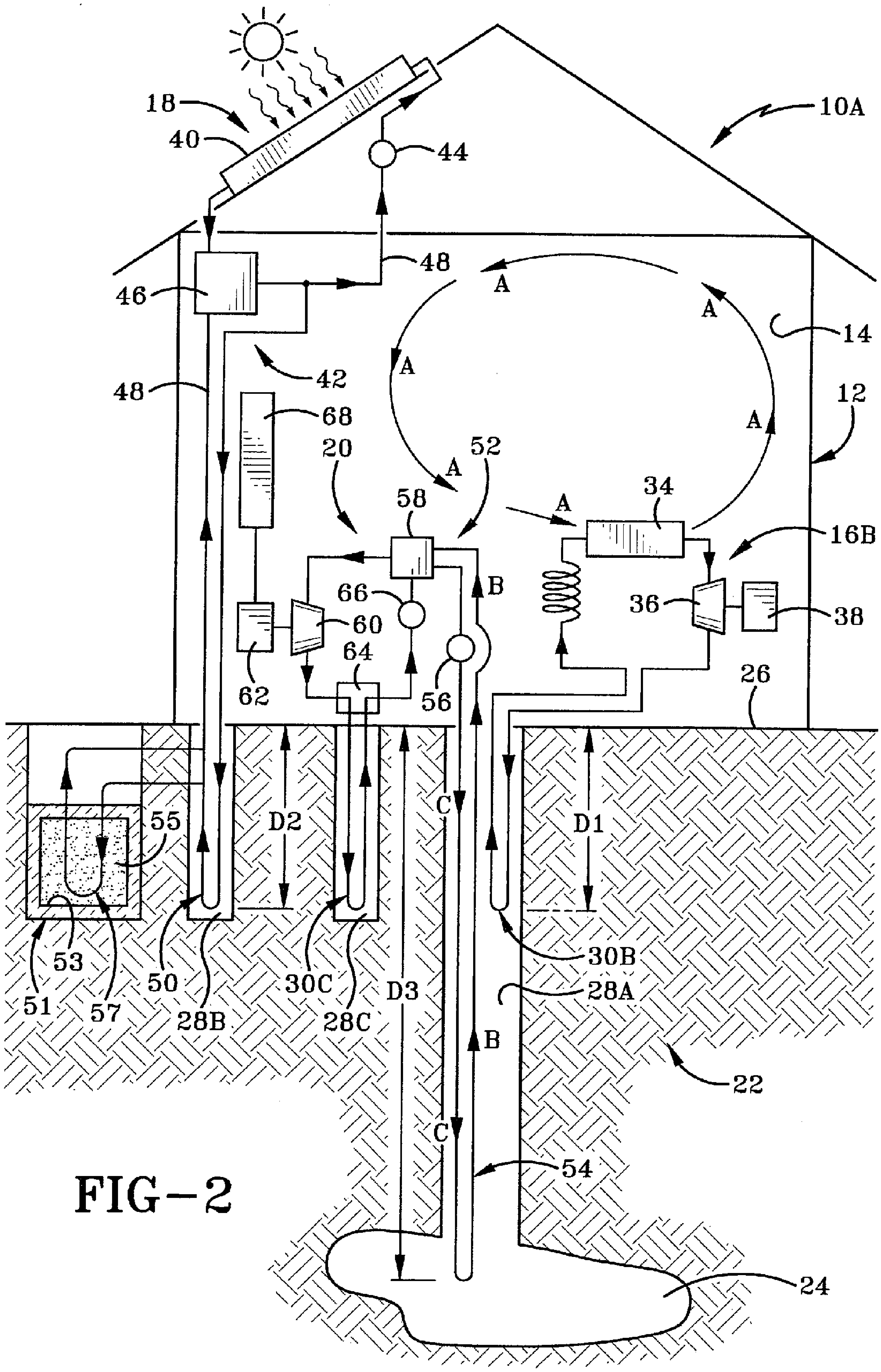
FIG—1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D1
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30C
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28A
51
57
28B
28C
D3
22
54
24

FIG-2

SELF SUSTAINING ENERGY SYSTEM FOR A BUILDING

CROSS REFERENCE TO RELATED APPLICATION

[0001] This applications claims priority from U.S. Provisional Patent Application Ser. No. 61/416,603, filed Nov. 23, 2010; the disclosure of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Technical Field

[0003] The present invention relates generally to a total self sufficient energy system typically including a heating and cooling system. More particularly, the present invention relates to a self sustaining system for heating and cooling a building, providing hot water for the building and generating electricity for the building electrical system. Specifically, the invention relates to such a system which utilizes solar energy, an organic Rankine cycle which is driven by geothermal energy, and a ground source heat pump.

[0004] 2. Background Information

[0005] The heating and cooling of buildings in a manner which provides a desirable work environment increases productivity and job satisfaction while reducing absenteeism. However, the heating and cooling of buildings represents a substantial consumption of energy, with some estimates indicating about 40% of global energy consumption. Thus, there is always a need for improving the energy efficiency of such heating and cooling systems. Furthermore, there are various energy regulations and standards in various countries mandating specific goals. For example, the European Union Building Performance Directive requires net-zero energy by 2019 for all new buildings, and carbon neutrality by 2019 for all new commercial buildings. By way of further example, new and renovated buildings in the United States must achieve 55% fossil fuel reduction targets in 2010 and be carbon neutral by 2030. Future federal legislation may apply additional requirements in the United States. Meanwhile, various state and local governments have already passed pertinent regulations, such as in New York and California. Thus, there is a need in the art to improve the efficiency of heating and cooling systems for buildings both in order to minimize electric energy costs and to meet various regulations. The present invention addresses this need.

BRIEF SUMMARY OF THE INVENTION

[0006] The present invention provides an energy system comprising a heat pump comprising a first earth-coupled heat exchanger; an electric motor operatively connected to the heat pump; an organic Rankine cycle drive; a second earth-coupled heat exchanger which provides a geothermal heat source for the organic Rankine cycle drive; and an electric generator driven by the organic Rankine cycle drive and in electrical communication with the motor.

[0007] The present invention also provides a method comprising the steps of operating an electric motor to circulate a working fluid in a heat pump which comprises a first earth-coupled heat exchanger; providing a geothermal heat source for an organic Rankine cycle drive with a second earth-coupled heat exchanger; driving an electric generator with the organic Rankine cycle drive to produce electricity; and using the electricity to power operation of the electric motor.

[0008] The present invention further provides an energy system comprising a first earth-coupled heat exchanger configured to absorb heat energy from soil; and a second earth-coupled heat exchanger configured to release heat energy to the soil to prevent the soil from freezing as a result of the heat energy absorbed by the first heat exchanger.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0009] A preferred embodiment of the invention, illustrated of the best mode in which Applicant contemplates applying the principles, is set forth in the following description and is shown in the drawings and is particularly and distinctly pointed out and set forth in the appended claims.

[0010] FIG. **1** is a diagrammatic view of the energy system of the present invention.

[0011] FIG. **2** is a diagrammatic view similar to FIG. **1** in which the energy system of the present invention uses an alternate heat pump configuration.

[0012] Similar numbers refer to similar parts throughout the drawings.

DETAILED DESCRIPTION OF THE INVENTION

[0013] The self sustaining energy system of the present invention is shown generally at **10** in FIG. **1** with an alternate embodiment shown generally at **10**A in FIG. **2**. System **10** is configured to provide energy to a building **12** which defines an enclosed building airspace **14**. Airspace **14** may be divided into multiple compartments such as rooms or units which are part of a recirculation loop of air provided by ducts in between these respective rooms. System **10** includes an airspace heating and cooling system in the form of a ground source heat pump (GHP) **16**A configured for heating and cooling airspace **14**. System **10** further includes a solar-powered heating system **18** which is in part configured to provide domestic hot water (DHW) to building **12**. System **10** further includes an electricity generation system **20** configured to provide electrical energy needed to building **12**. Each of systems **16**, **18** and **20** utilizes an earth-coupled heat exchanger as described further below. Building **12** is built on top of the ground, earth or soil **22** and may be positioned above an aquifer **24** typically far below an upper surface **26** of the ground or soil **22**. Various components of systems **10**, **10**A may be above ground or underground and may include above-ground portions and underground portions, respectively above and below surface **26**. Although these portions may not be specified herein elsewhere, such terminology is applicable to these various components or portions, as will be evident from the Figures. To take advantage of ground source heat or geothermal heat, one or more boreholes such as boreholes **28**A and **28**B are typically bored into the earth extending downwardly from upper surface **26** either directly beneath building **12** or adjacent building **12**. It will also be appreciated that the portion of upper surface **26** which is directly below building **12** may be substantially lower than that portion which extends outwardly from building **12**, such as when building **12** includes a basement and/or underground parking deck.

[0014] The airspace heating and cooling system or GHP **16**A includes an earth-coupled heat exchanger **30**A which extends downwardly within borehole **28**A below surface **26** and is in the exemplary embodiment directly below building **12**. Heat exchanger **30** is part of a tubular closed recirculation loop through which is circulated a working fluid for moving heat energy to and from soil **22** and a water cooled condenser **32** of GHP **16**A. The working fluid may be a water-antifreeze solution (such as a water-glycol solution), brine or other water based solution or any other suitable working fluid. GHP **16**A further includes a separate closed recirculation loop which includes condenser **32**, an air cooled condenser **34**, and in which a turbo compressor **36** may be disposed such that turbo compressor **36** is operatively connected to and driven by an electric motor **38**. Condenser **34** includes an air intake and air exhaust each in fluid communication with airspace **14** to allow for air to flow through condenser **14** and for air recirculation within airspace **14** as indicated at arrows A.

[0015] Solar-powered heating system **18** includes thermal solar collectors **40** which are exposed to sunlight during the day and are typically located on the roof of the building. System **18** further includes or is interconnected with a domestic hot water (DHW) system **42** which includes a pump **44**, a hot water tank **46** and appropriate piping or water pipes **48** which provide recirculation loops in combination with pump **44** and tank **46** and also lead to the various water taps (which may include or feed showers, hot tubs, whirlpool baths or Jacuzzis, swimming pools, etc.) within or otherwise adjacent building **12**. Water pipes **48** also include an underground pipe or earth-coupled heat exchanger **50** which extends below surface **26** within soil **22** and borehole **28**B. A thermal storage tank **51** is also provided and typically has thermally insulated walls defining an interior chamber **53** with a phase change material (PCM) **55** therein. Tank **51** is shown as an underground tank although tank **51** may also be above ground. Water pipes **48** extend into tank **51** and thus include a loop or heat exchanger **57** which is within interior chamber **53** and is in direct contact with and surrounded by PCM **55**. PCM **55** changes phase by melting or solidifying typically at a melting or freezing phase change temperature in the range of about 80° F. to 300° F. While material **55** may be a good heat absorbing material able to absorb or release a substantial amount of heat energy even without changing phase, it is preferably a phase change material so that the latent heat of fusion provides substantial thermal storage during the phase change. In one embodiment, PCM **55** may be a paraffin, paraffin wax or black wax paraffin although other suitable materials may be used.

[0016] Electricity generation system **20** includes an organic Rankine cycle (ORC) drive **52** configured to drive the generation of electricity. ORC drive **52** includes a ground-coupled heat exchanger **54** which is part of a tubular closed recirculation loop which circulates an appropriate working fluid and which serves as a heat sink. A portion of the recirculation loop which serves as heat exchanger **54** is, like the other earth-coupled heat exchangers, underground and is shown here in borehole **28**A, although it may be in a separate borehole. Heat exchanger loop **54** may extend into aquifer **24** whereby aquifer **24** and/or soil **22** serves as the heat source for ORC drive **52**. Pump **56** is also provided to pump the working fluid through the recirculation loop including the heat exchanger **54**. This recirculation loop also passes through a heat exchanger **58**, which is part of ORC drive **52**. ORC drive **52** may be a relatively simple organic Rankine cycle drive or may be a more complex one. FIG. **1** illustrates ORC drive **52** as a relatively simple organic Rankine cycle which includes the closed recirculation loop for recycling the refrigerant or refrigerant mixture to pass through heat exchanger **58**, to drive rotation of a turbine **60**, which is within the closed loop and drivingly coupled to generator **62**, and through a condenser **64** and a pump **66**. In the exemplary embodiment, this recirculation loop includes a ground loop **30**C which extends downwardly within another borehole **28**C and which is another earth-coupled heat exchanger which serves as heat exchanger **64**. Various refrigerants or refrigerant mixtures known in the art may be used within this recirculation loop. In the exemplary embodiment, the preferred refrigerant mixtures are those described in U.S. patent application Ser. No. 12/406,187 of the present inventor entitled Power Generator Using an Organic Rankine Cycle Drive With Refrigerant Mixtures and Low Waste Heat Exhaust As a Heat Source, which has also published as U.S. Patent Application Publication No. 2010/0126172, which is incorporated herein by reference for all purposes. Simple and more complex organic Rankine cycle drives are described in greater detail in the above noted Patent Application Publication (2010/0126172), and may be used in the present invention. Generator **62** is in electrical communication with the building electrical system **68**, which is represented diagrammatically and which typically includes electrical outlets throughout the building which are available to electrically power various electrical appliances and other electrical machinery within or adjacent building **12**.

[0017] FIG. **1** further illustrates that heat exchangers **30**A and **30**C extend downwardly below upper surface **26** by a depth D**1** which is typically in the range of about 5 to 10 feet. At a depth of about 6 feet, the ground temperature is usually on the order of about 45° F. to 48° F. although this may vary somewhat. FIG. **1** also illustrates that heat exchanger **50** extends downwardly into soil **22** a depth D**2** which is typically roughly the same as depth D**1** although this may vary somewhat. Heat exchanger **54** extends much deeper into the ground as indicated by depth D**3**, which is typically on the order of 1500 to 2000 feet and is usually at least 500 or 1000 feet.

[0018] Referring now to FIG. **2**, system **10**A is fairly similar to system **10** except that system **10**A uses a modified ground source heat pump **16**B instead of heat pump **16**A. Heat pump **16**B utilizes a direct exchange (DX) ground loop or earth-coupled heat exchanger **30**B which is part of the heat pump's refrigerant loop buried underground. Thus, the working fluid within the loop (which is the same as described above for heat pump **16**A) flows through a single recirculation loop including heat exchanger **30**B and air cooled condenser **34**. As with heat pump **16**A, electric motor **38** is drivingly connected or coupled to compressor **36** to power or drive rotation of compressor **36**, which pumps the working fluid through the recirculation loop in which compressor **36** is disposed.

[0019] The operation of systems **10** and **10**A is now described starting with reference to FIG. **1**. Generally, working fluid is circulated by a suitable pump through the recirculation loop which includes heat exchanger **30**A and condenser or heat exchanger **32**. Meanwhile, working fluid is also circulated through the recirculation loop which includes condenser or heat exchanger **32** and condenser or heat exchanger **34**. At the same time, air is blown with appropriate fans or blowers through heat exchanger **34** via its intake and exhaust to circulate through the recirculation loop or loops within airspace **14** as shown at arrows A. In the heating mode of heat pump **16**A, working fluid passing through heat exchanger **30**A absorbs heat from soil **22** and any water within soil **22** and carries it to heat exchanger **32** whereby the heat energy is released via heat exchanger **32** to the working fluid within the other recirculation loop, which circulates to condenser or heat exchanger **34** to likewise release heat energy to the air circulating at arrows A in order to heat the air within airspace **14**. As previously noted, rotation of turbo compressor **36**, which pumps the working fluid for circulation within the latter recirculation loop, is driven by the rotational drive of motor **38**, which is powered by electricity which may be supplied or fed from electrical system **68**. Motor **38** is typically in electrical communication with generator **62** via electrical system **62**. Thus, heat pump **16** may be powered by electricity produced by the ORC drive via turbine **60** and generator **62**, which is operatively connected to and driven by the ORC drive. In the air cooling mode, heat pump **16**A is operated so that the working fluid within exchanger **30**A rejects heat into the ground which is delivered there via the working fluid from exchanger **32**. Thus, the working fluid within this recirculation loop absorbs heat within heat exchanger **32** from the working fluid circulating in the other recirculation loop which includes the exchanger **34**. Recirculation of air (arrows A) through heat exchanger **34** thus involves a transfer or rejection of heat from the air to the working fluid within condenser **34** so that the air is cooled. Heat from air within the building is ultimately transferred and rejected to the soil **22** via the heat exchanger **30**A. This process thus cools the air being exhausted from heat exchanger **34** in order to cool the air within building **12** while also rejecting heat to soil **22** and water therein to prevent freezing of this soil and water, such as may result from transfer of heat energy from soil **22** to the working fluid in heat exchangers **30**C and **54** and thus to ORC drive **52**.

[0020] Turning to FIG. **2**, heat pump **16**B provides the similar overall result of heating or cooling air within airspace **14** and either rejecting heat to or releasing heat from soil **22** via heat exchanger **30**B. The direct exchange arrangement of heat pump **16**B utilizes a single closed loop instead of the two separate closed loops of heat exchanger **16**A. Thus, in the air heating mode, the working fluid within heat exchanger **30**B absorbs heat from soil **22** and releases heat to the circulating air at exchanger **34** to heat the air within building **12**. In the cooling mode, the working fluid within this recirculation loop rejects heat to the ground or soil **22** via exchanger **30**B and absorbs heat from the circulating air in airspace **14** at exchanger **34** in order to cool the air circulating through exchanger **34** and into airspace **14**. Rejection of heat to the ground via exchanger **30**B may also prevent freezing of soil **22** as noted above.

[0021] It is further noted that outside air may be mixed with the inside air within airspace **14**. More particularly, heat pumps **16**A, **16**B may include a desuperheater which may be used to heat outside air which is mixed with the inside air typically for the purpose of dehumidification. The desuperheater may also be used to heat water and thus produce hot water, which would typically be the case if hot water otherwise runs out.

[0022] The operation of solar-powered heating system **18** is now described with reference to either FIG. **1** or FIG. **2**. The solar collectors **40** absorb heat energy from sunlight (represented by the arrows adjacent collectors **40**) and reject the heat therefrom to potable water flowing through pipes **48** in order to heat the water so that hot water subsequently flows through pipes **48** into hot water tank **46**. The heated water within system **42** remains at a temperature below the boiling point of water and thus remains in a liquid state. In the embodiment shown, pump **44** pumps water from tank **46** and/or various portions of pipes **48** into the heat exchanger of solar collectors **40**. It is noted that a thermosyphon arrangement may also be provided in which the water storage tank **46** is higher than thermal collector **40** whereby the need for pump **44** is eliminated. In addition to providing potable water to the various taps of building **12**, hot water is also circulated through the heat exchanger **50** whereby heat is rejected from the water within exchanger **50** to soil **22** adjacent exchanger **50**. It is noted that boreholes **28**A and **28**B may be backfilled with soil or other material so that the pipes or tubes are in direct contact with the soil and water within the soil. The purpose for providing heat exchanger **50** is to prevent the ground or soil from freezing as a result of heat which is rejected from the soil primarily via heat exchanger **30**A or **30**B during operation of the respective heat pump **16** in the air heating mode and also via heat exchanger **54**.

[0023] Hot water also flows through pipes **48** into thermal storage tank **51** where heat is rejected from the solar heated water to PCM **55** via the heat exchanger **57** loop of pipes **48**. Generally, thermal storage tank **51** is used for heat storage during the day and heat discharge during the night to ensure full 24/7 supply of domestic hot water to building **12**. More particularly, heat energy rejected from the hot water to PCM **55** is stored in PCM **55**, which is insulated against heat loss by the thermal insulation in the walls of tank **51**. Subsequently, when there is a need to heat water within system **42** which has dropped below a predetermined threshold temperature and when solar heating of the water directly via the heat exchanger of thermal solar collectors **40** is no longer possible or is not sufficient (such as at night time or during certain weather conditions), the heat energy stored in PCM **55** is rejected to water in heat exchanger **57** to heat the undesirably cooled water to a chosen desired temperature sufficiently above the threshold temperature to be suitable for use as domestic hot water.

[0024] Typically, the heat rejected from hot water to PCM **55** via heat exchanger **57** will cause all or part of PCM **55** to change phase by melting, thereby storing a relatively large amount of heat energy as latent heat of fusion, although as previously noted, material **55** may nonetheless store a substantial amount of heat energy even without melting. Later, when the water below the threshold temperature absorbs heat from PCM **55** when circulated through heat exchanger **57**, all or part of PCM **55** typically changes phase from liquid to solid, thus again providing a substantial amount of heat energy via latent heat of fusion although heat energy may likewise be transferred from PCM **55** at temperatures both above and below its melting or freezing temperature.

[0025] Although the Figures show that water in pipes **48** is circulated through heat exchanger **57**, other fluids or liquids may be used to circulate in a similar or separate recirculation loop passing through the heat exchanger of thermal solar collectors **40** to absorb heat therefrom and through a heat exchanger analogous to heat exchanger **57** within thermal storage tank **51** to likewise release heat to PCM **55** for storage thereof. Then, relatively cooler water may be circulated through heat exchanger **57** to absorb heat from PCM **55** to heat the water to a temperature suitable for use as domestic hot water in building **12**. The use of certain fluids or coolants other than water in such a separate recirculation loop may be useful at various temperatures, and certainly would be appropriate at relatively higher temperatures which would cause water to boil. Such other liquids or coolants may thus also be used to transfer heat from the solar powered heating system to the ground via heat exchanger **50**.

[0026] Although solar powered heating system **18** is described here primarily as being used to supply heat for the domestic hot water system, it may also be used as a supplemental heat source for heating airspace **14**. Thus, system **18** may include a solar-heated heat exchanger with suitable ducting and a fan to blow air across the heat exchanger whereby system **18** rejects heat via the heat exchanger to the air so that the heated air may be circulated within airspace **14**.

[0027] The operation of electricity generation system **20** is now described. Pump **56** is operated to circulate the working fluid within the closed loop which includes earth-coupled heat exchanger **54** in order to absorb heat from soil **22** and/or aquifer **24** typically at the depths noted with respect to depth D**3** as well as all along the borehole to provide a geothermal heat source for the ORC drive **52**. The working fluid flows within heat exchanger **58** and rejects heat to the refrigerant within the other closed recirculation loop, which is circulated therethrough via pump **66**. As described in greater detail in the above noted patent application publication, the working fluid within this closed loop drives the rotation of turbine **60**, which in turn drives the rotation of generator **62** to produce electrical energy or electricity, whereby an electric current runs from generator **62** to the building electrical system **68** such that the electrical current is available to power electrically powered devices within or adjacent building **12**. Heat energy in the working fluid in the loop of ORC drive **52** which includes turbine **60** is rejected to the ground via heat exchanger **30**C, thereby cooling the working fluid and also preventing or helping prevent freezing of a portion of the ground which may otherwise occur as a result of heat energy being rejected from this portion of the ground via heat exchangers **54** and/or **30**A or **30**B.

[0028] It is further noted that energy systems **10** and **10**A may include a branching recirculation loop configured to transfer heat energy from aquifer **24** and/or the soil along borehole **28**A via heat exchanger **54** to PCM **55** within thermal storage tank **51**. More particularly, such a branching recirculation would be connected to and branch off from the loop which includes heat exchanger **54** and extend into interior chamber **53** to serve as a heat exchanger similar to heat exchanger **57** except that the working fluid used in this branching recirculation loop would be the same as that circulating through heat exchangers **54** and **58**. This option may, for instance, be useful when there is no demand or a decreased demand on ORC drive **52** to produce electricity.

[0029] Thus, systems **10** and **10**A provide a self sustaining configuration for providing various energy to building **12**. More particularly, each of these systems provide the air heating and cooling system or heat pump, a solar-powered domestic hot water system, and an ORC-driven electrical generation system, each of which is coupled to the earth or soil to either reject heat energy to the earth or soil or absorb heat energy therefrom. Energy systems **10** and **10**A are highly efficient and thus substantially reduce operating costs.

[0030] In the foregoing description, certain terms have been used for brevity, clearness, and understanding. No unnecessary limitations are to be implied therefrom beyond the requirement of the prior art because such terms are used for descriptive purposes and are intended to be broadly construed.

[0031] Moreover, the description and illustration of the invention is an example and the invention is not limited to the exact details shown or described.

1. An energy system comprising:
a heat pump comprising a first earth-coupled heat exchanger;
an electric motor operatively connected to the heat pump;
an organic Rankine cycle drive;
a second earth-coupled heat exchanger which provides a geothermal heat source for the organic Rankine cycle drive; and
an electric generator driven by the organic Rankine cycle drive and in electrical communication with the motor.

2. The energy system of claim **1** further comprising a building defining an airspace; an air intake of the heat pump in fluid communication with the airspace; and an air exhaust of the heat pump in fluid communication with the airspace.

3. The energy system of claim **1** further comprising a compressor of the heat pump; wherein the electric motor is operatively connected to the compressor.

4. The energy system of claim **1** wherein the organic Rankine cycle drive comprises a third earth-coupled heat exchanger configured to reject heat to the ground.

5. The energy system of claim **1** further comprising a third earth-coupled heat exchanger configured to release heat energy to the ground to prevent the ground from freezing as a result of the heat energy absorbed from the ground by at least one of the first and second earth-coupled heat exchangers.

6. The energy system of claim **5** further comprising a solar powered heating system coupled to the third earth-coupled heat exchanger whereby the solar powered heating system is configured to reject heat to the third earth-coupled heat exchanger.

7. The energy system of claim **6** further comprising a domestic hot water system coupled to the solar powered heating system whereby the solar powered heating system is configured to reject heat to water in the domestic hot water system.

8. The energy system of claim **7** further comprising a thermal storage tank; a phase change material within the tank; and a portion of the domestic hot water system which extends adjacent the tank whereby the water within the domestic hot water system is configured to reject heat to and melt the phase change material.

9. The energy system of claim **5** further comprising a thermal storage tank; a phase change material within the tank; a recirculation loop in fluid communication with the third earth-coupled heat exchanger; a fluid within the recirculation loop; and a portion of the recirculation loop which extends adjacent the tank whereby the fluid within the recirculation loop is configured to reject heat to and melt the phase change material.

10. The energy system of claim **5** wherein the organic Rankine cycle drive comprises a fourth earth-coupled heat exchanger configured to release heat energy to the ground.

11. The energy system of claim **1** further comprising a domestic hot water system comprising an underground pipe configured to release heat energy to the ground to prevent the ground from freezing as a result of the heat energy absorbed from the ground by at least one of the first and second earth-coupled heat exchangers.

12. The energy system of claim **11** further comprising a solar powered heating system coupled to the domestic hot water system whereby the solar powered heating system is configured to reject heat to the domestic hot water system.

13. The energy system of claim **1** wherein the second earth-coupled heat exchanger extends into an aquifer.

14. The energy system of claim **1** wherein the second earth-coupled heat exchanger extends into the ground to a depth of at least 500 feet.

15. The energy system of claim **1** further comprising a first borehole formed in earth beneath a building; wherein one of the first and second earth-coupled heat exchangers is within the first borehole.

16. The energy system of claim **1** wherein the organic Rankine cycle drive comprises a third earth-coupled heat exchanger configured to release heat energy to the ground.

17. A method comprising the steps of:

operating an electric motor to circulate a working fluid in a heat pump which comprises a first earth-coupled heat exchanger;

providing a geothermal heat source for an organic Rankine cycle drive with a second earth-coupled heat exchanger;

driving an electric generator with the organic Rankine cycle drive to produce electricity; and

using the electricity to power operation of the electric motor.

18. The method of claim **17** further comprising cooling a portion of the ground by releasing heat from the portion of the ground to at least one of the first and second earth-coupled heat exchangers; heating a third earth-coupled heat exchanger with a solar powered heating system; and rejecting heat from the third earth-coupled heat exchanger to the cooled portion of the ground.

19. The method of claim **17** further comprising rejecting heat from the organic Rankine cycle drive to the ground with a third earth-coupled heat exchanger.

20. An energy system comprising:

a first earth-coupled heat exchanger configured to absorb heat energy from soil; and

a second earth-coupled heat exchanger configured to release heat energy to the soil to prevent the soil from freezing as a result of the heat energy absorbed by the first heat exchanger.

* * * * *