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(54) METHOD AND APPARATUS FOR SOLAR HEATING AIR IN A FORCED DRAFT HEATING SYSTEM

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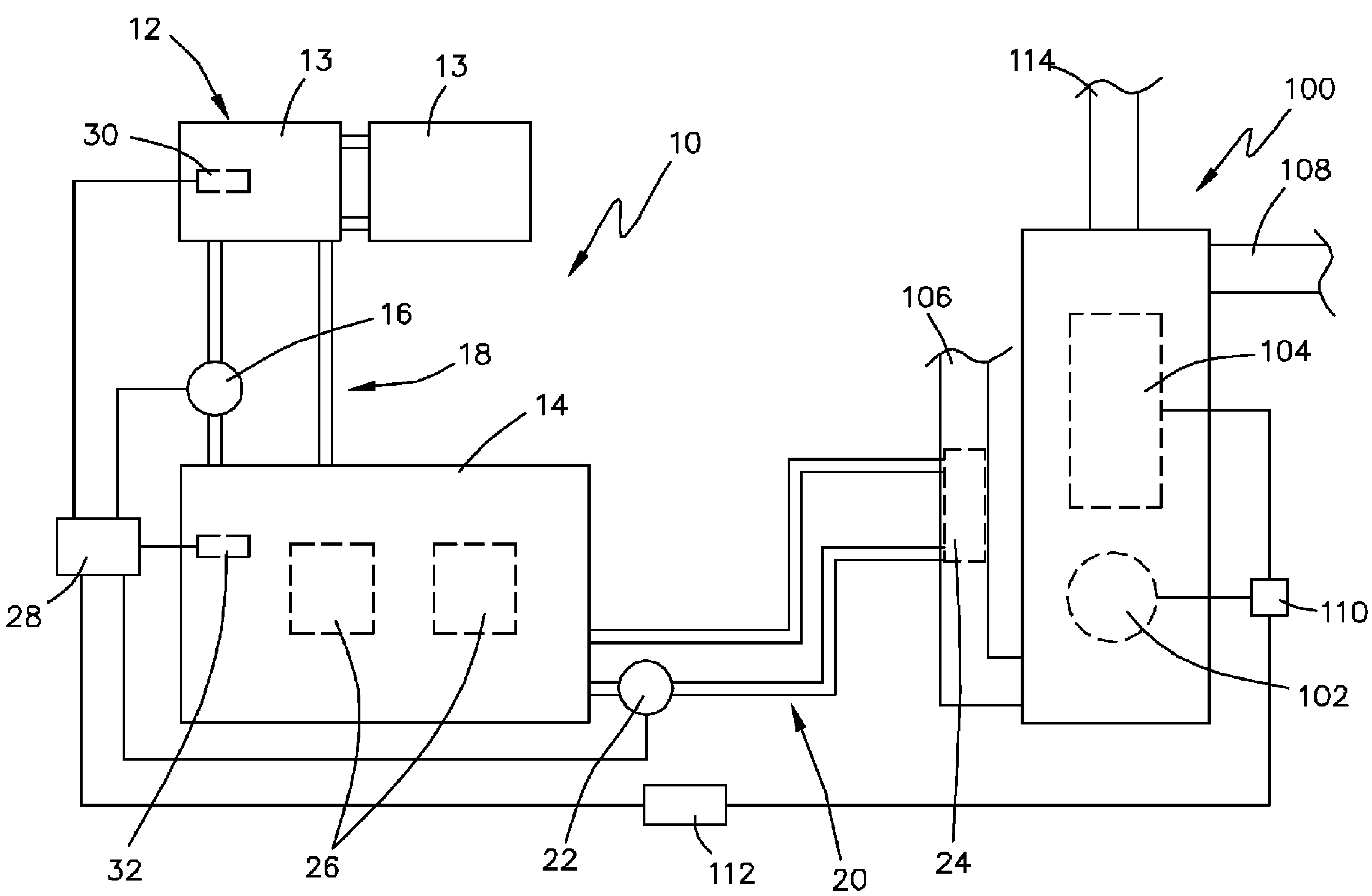
(57) **ABSTRACT**

A solar heating system for use in combination with a forced draft heating system for heating ventilation air of a building. The solar heating system includes a solar collector assembly for heating a liquid circulated through the assembly. The heated liquid is stored in an insulated storage tank where it can be circulated through a heat exchanger positioned in an air duct of the forced draft heating system as need to heat air flow through the duct. The use of a liquid as the heat transfer fluid and providing a storage facility for heated liquid permits the heating system to operate for a period of time after the sun sets or becomes ineffective in providing solar radiation until the heat stored in the liquid becomes exhausted. To increase the heat storage capacity of the liquid, one or more heat sinks can be utilized to absorb excess heat from the liquid and then transfer the absorbed heat back to the liquid when an opposite thermal gradient exists. Additionally, the heating system can recover waste heat from hot combustion gases exhausted from a fuel-fired forced draft heating system.



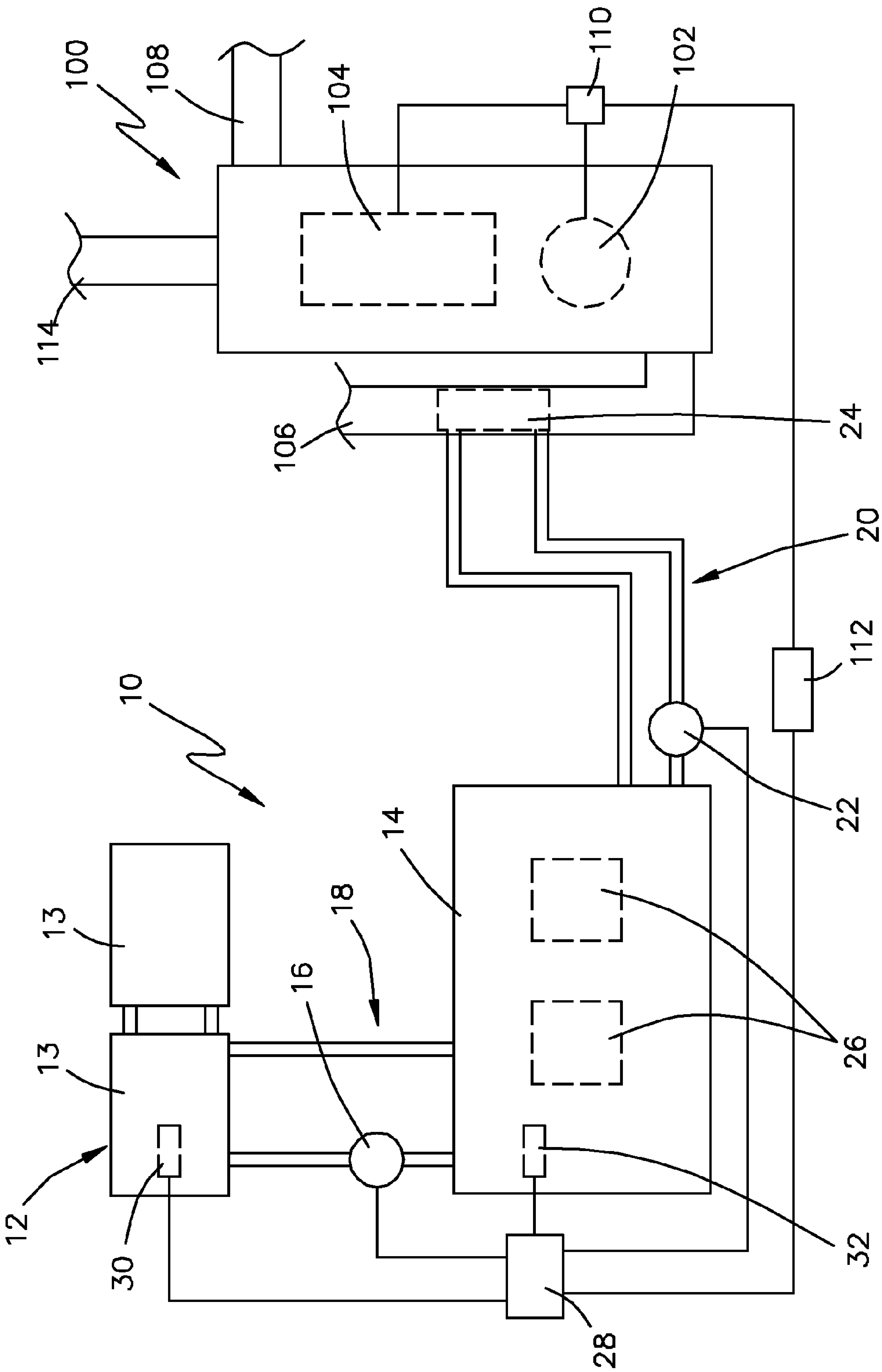

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FIG. 1

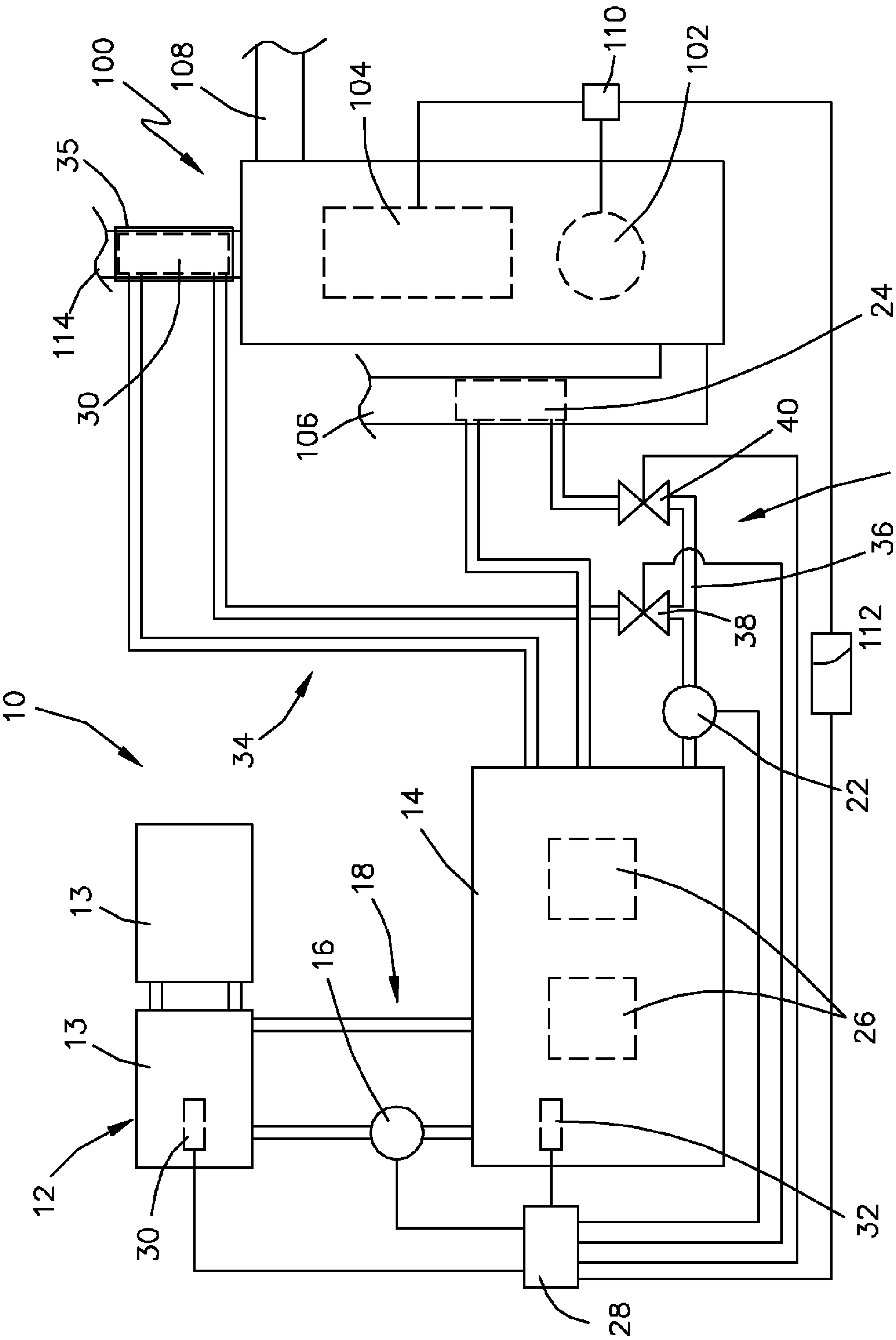
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FIG. 2

METHOD AND APPARATUS FOR SOLAR HEATING AIR IN A FORCED DRAFT HEATING SYSTEM

FIELD OF THE INVENTION

[0001] The present invention relates generally to heating of ventilation air of a building, and more particularly, to solar heating of ventilation air in an existing forced draft heating system.

BACKGROUND OF THE INVENTION

[0002] In recent years, the cost of energy has increased substantially resulting in higher operation costs associated with heating a building including residential and commercial buildings a like. In the most sever situations, the increased costs have forced limited or no operation of the building heating systems. It is known that solar radiation can be used for heating such buildings and an example of such devices are described in the following U.S. Pat. No. 6,880,553; 4,934,338; 4,509,503; and 4,343,296.

[0003] While the devices heretofore fulfill their respective, particular objectives and requirements, they do not provide a solar heating system that is used in combination with an existing forced draft heating system, that can be easily installed in an existing forced draft heating system without substantial modification of the forced draft heating system, can be used alone or concurrently with the forced draft heating system, which can recovery waste heat from a fuel-fired forced draft heating system and which remains to be effective for a period of time after the sun has set or the sun becomes ineffective in providing solar radiation, as such there exists and need for an improved solar heating apparatus and method of using the same in a forced draft heating system, which substantially departs from the prior art.

SUMMARY OF THE INVENTION

[0004] The present invention, which will be described subsequently in greater detail, includes a heating system for installation in a forced draft heating system to heating air flow through the ducting of the forced draft heating system. The heating system includes a solar collector assembly for heating a liquid circulated through the assembly. The heated liquid is stored in an insulated storage tank where it can be circulated through a heat exchanger positioned in an air duct of the forced draft heating system as need to heat air flow through the duct. The use of a liquid as the heat transfer fluid and providing a storage facility for heated liquid permits the heating system to operate for a period of time after the sun sets or becomes ineffective in providing solar radiation until the heat stored in the liquid becomes exhausted. To increase the heat storage capacity of the liquid, one or more heat sinks can be utilized to absorb excess heat from the liquid and then transfer the absorbed heat back to the liquid when an opposite thermal gradient exists. Additionally, the heating system can recover waste heat from hot combustion gases exhausted from a fuel-fired forced draft heating system.

[0005] In general, in one aspect, a solar heating system for use with a forced draft heating system for heating ventilation air of a building, where the forced draft heating system includes an air handler, a heat source, a return air duct, an air discharge duct and a thermostat that controls the operation or the forced heating system is provided. The solar heating system includes a solar collector assembly which heats a liquid as it is circulated therethrough by solar radiation; a fluid storage tank for containing a quantity of heat transfer fluid;

[0006] a first heat exchanger positionable in an air duct of the forced draft heating system such that air flowing through the duct is caused to flow across the first heat exchanger. The solar collector assembly is in fluidic communication with the fluid storage tank such that heat transfer fluid contained therewithin can be circulated through the solar collector assembly and returned to the storage tank. The first heat exchanger is in fluidic communication with the fluid storage tank such that heat transfer fluid contained therewithin can be circulated through the first heat exchanger and returned to the storage tank. A controller is operative to effect the circulation of the heat transfer fluid through the solar collector assembly as a function of a temperature differential between the heat transfer liquid in the solar collector assembly and the heat transfer liquid in the fluid storage tank. The controller is operative to effect the circulation of the heat transfer fluid through the first heat exchanger as a function of the temperature of the heat transfer fluid in the fluid storage tank, the temperature of the air to be heated, and the desired temperature of the air to be heated.

[0007] In general, in another aspect, the solar heating system includes a second heat exchanger positionable in the flow of hot combustion gases exhausted by the heat source of the forced draft heating system, wherein said second heat exchanger is in fluidic communication with said fluid storage tank such that the heat transfer fluid contained within said fluid storage tank can be caused to circulate through said second heat exchanger and returned to said fluid storage tank. The controller is operative to effect the circulation of the heat transfer fluid through said second heat exchanger as a function of the temperature of the heat transfer fluid in said fluid storage tank.

[0008] There has thus been outlined, rather broadly, the more important features of the invention in order that the detailed description thereof that follows may be better understood and in order that the present contribution to the art may be better appreciated.

[0009] Numerous objects, features and advantages of the present invention will be readily apparent to those of ordinary skill in the art upon a reading of the following detailed description of presently preferred, but nonetheless illustrative, embodiments of the present invention when taken in conjunction with the accompanying drawings. The invention is capable of other embodiments and of being practiced and carried out in various ways. Also, it is to be understood that the phraseology and terminology employed herein are for the purpose of descriptions and should not be regarded as limiting.

[0010] As such, those skilled in the art will appreciate that the conception, upon which this disclosure is based, may readily be utilized as a basis for the designing of other structures, methods and systems for carrying out the several purposes of the present invention. It is important, therefore, that the claims be regarded as including such equivalent constructions insofar as they do not depart from the spirit and scope of the present invention.

[0011] For a better understanding of the invention, its operating advantages and the specific objects attained by its uses, reference should be had to the accompanying drawings and descriptive matter in which there is illustrated preferred embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The invention will be better understood and objects other than those set forth above will become apparent when consideration is given to the following detailed description thereof. Such description makes reference to the annexed drawings wherein:

[0013] FIG. **1** is a schematic diagram of a system and apparatus for pre-heating air in a forced draft heating system constructed in accordance with the principles of the present invention; and

[0014] FIG. **2** is a schematic diagram of the system and apparatus shown in FIG. **1** with the inclusion of a heat recovery feature.

DETAILED DESCRIPTION OF THE PREFERED EMBODIMENTS

[0015] Reference will now be made in detail to the drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like elements.

[0016] With reference to FIG. **1** there is schematically shown a solar heating system, generally designated by numeral **10**, for use in combination with a forced draft heating system **100**. The forced draft heating system **100** can be any forced air heating system that is used to heat ventilation air. In general, the solar heating system **10** utilizes solar energy to heat or pre-heat ventilation air flowing through an air duct of the forced draft heating system **100** to reduce energy costs associated with operating the forced draft heating system.

[0017] The forced draft heating system **100** is a typical heating system installed in residential and commercial buildings to heat the interior space of the building by heating the ventilation air. For the purpose herein, the forced draft heating system **100** will be described generally and generically as these systems are well known in the art. Further, the particular construction or type of the forced draft heating system **100** should not be construed as limiting as the solar heating system **10** of the present invention is operable with a wide range of different types of forced draft heating systems, such as for example, heat pump systems, electric resistance heater systems and fuel-fired systems.

[0018] For the purpose of discussion, the forced draft heating system **100** includes a housing containing an air handler **102** and a heat source **104**. The air handler **102** operates to draw ventilation air from the building into a return air duct **106** to be feed to the heat source **104** for heating and to return the air to the building through an air discharge duct **108**. The return air duct **106** and the air discharge duct **108** typically form part of a more complex air distribution network of ducting, as such only a portion of each ducting is shown for clarity. The forced draft heating system further includes a controller **110** that function to control the operation of the air handler **102** and the heat source **104**. A thermostat **112** is operably connected to the controller **110** and issues command signals to the controller to effect the operation of the air handler **102** and the heat source **104**. In one example, the heat source **104** is a fuel-fired heat source. In this example, a flue **114** for carrying hot combustion gases from the heat source extends upwardly from the housing of the forced draft heating system **100**. Generally, in operation, the air handling means **102** draws ventilation air to be heated from the space through the air return duct **106** and into the housing where it is directed through the heat source **104** and then discharged as heated air through the discharge duct **108** for delivery back to the space to be heated. The thermostat **112** monitors the space air temperature and issues a command signal to the controller **110** to effect the operation of the heating system **1 00**.

[0019] The solar heating system **10** of the present invention is designed to be integrated with the forced draft heating system **100**. The solar heating system **10** is capable of providing an additional heat source to pre-heat ventilation air flowing through the ducting of forced draft heating system **100** and is also capable of being the primary heat source to heat the ventilation air during low load conditions.

[0020] In doing so, the solar heating system **10** of the present invention, includes a solar energy collector assembly **12** that is positioned to capture solar energy. Generally, the collector assembly **12** will be positioned exteriorly to a building, such as for example on a roof surface thereof. The collector assembly **12** includes one or more liquid type solar energy collectors **13** which heat a liquid as it flows through the collector. The collector assembly **12** is positioned in a closed-loop flow path along with an insulated liquid storage tank **14** that contains a quantity of heat transfer fluid. A pump **16** is operated to circulate the heat transfer fluid from the storage tank **14** through the collector **12**, where it is heated, and then returned back to the storage tank in a closed-loop path **18**. A second closed loop path **20** includes a second pump **22** that is operated to circulate heated fluid from the storage tank **14** through a heat exchanger **24** that is positioned within an air duct of the forced draft heating system **100** to heat ventilation air flowing through the duct. The air duct is preferably the return air duct **102** that supplies ventilation air to the forced heating system **100** to be heated. However, it is possible to position the heat exchanger **24** in any air duct forming part of the forced heating system **100**.

[0021] The storage tank **14** can be provided with one or more heat sinks **26**, such as ceramic blocks or the like. The heat sinks **26** increase the heat storage capacity of the solar heating system **10** by absorbing excess heat from the heat transfer fluid and then transferring the excess heat back to the heat transfer fluid when an opposite thermal gradient exists.

[0022] A controller **28** measures the temperature differential between the fluid in the collector assembly **12** by a first temperature sensor **30** and the fluid in the storage tank **14** by a second temperature sensor **32**. When the temperature of the fluid in the collector assembly **12** is higher than the temperature of the fluid in the storage tank **14** by a first temperature differential set-point, the controller **28** operates the pump **16** to circulate the fluid from the storage tank through the collector assembly to be heated. As the temperature of the fluid in the storage tank **14** is raised, the temperature differential is reduced. Once a second temperature differential set-point is reached, the controller **28** deactivates the pump **16** and the fluid is no longer circulated through the collector assembly **12**. This operation ensures the highest efficiency by circulating the fluid only during times where a beneficial temperature differential exists. The first and second temperature differential set points can be set during the initial install or during manufacture and may be made adjustable by an end user.

[0023] When the solar heating system **10** is integrated with a forced draft heating system **100** having a fuel-fired heat source **104**, the solar heating system can include a heat recovery feature to recover waste heat from hot combustion gases, as shown in FIG. **2**. The heat recover feature includes a heat exchanger **30** positioned in or about the flow of hot combustion gases exhausted from the heat source **104**. The heat exchanger **30** can be positioned about the flue **114** exhausting the combustion gases or can be positioned within the flue to directly contact the combustion gases. For exemplary purposes only, the heat exchanger **30** can include a serpentine shaped tube wrapped around a length of the flue **114**. Further, a heat insulating blanket **35** can be wrapped around the heat exchanger **30** and the flue **114** to increase thermal efficiency.

[0024] The heat exchanger **30** is positioned in a third closed loop path **34** with the fluid storage tank **14**, thereby permitting circulation of the heat transfer fluid through the heat exchanger **30** where it is heated by hot combustion gases exhausted from the heat source **104**. The third closed loop path **34** may include it own separate pump (not shown) or can be connected to the second pump **22** through a valve manifold **36**. The manifold **36** includes a first valve **38** for controlling the flow of fluid through the third closed loop path **34** and a second valve **40** for controlling the flow of fluid through the second closed loop path **20**. The first and second valves **38**, **40** could be replaced by a single proportion valve (not shown) to proportion the flow fluid discharged by pump **22** between the second and third paths **20** and **34**. The first and second valves **38**, **40** are operably connected to the controller **28**. Valve **40** is a normally closed valve and valve **38** is a normal open valve. Generally, when the heat recovery feature is operational, the heat transfer fluid is prevented from flowing through the second closed path **20**, thereby preventing fluid from flowing through heat exchanger **24** that may have a lower temperature than the ventilation air that other would result in cooling the ventilation air.

[0025] The thermostat **112** of the forced draft heating system **100** is connected to the controller **28** in a bidirectional communication path and is capable of sending and receiving information to and from the controller **28**. The thermostat **112** monitors the air temperature of the space to be heated and when the temperature drops below a set-point, the thermostat **112** communicates with the controller **28** to determine the temperature of the heat transfer fluid in the fluid storage tank **14**. Based upon the temperature of the heat transfer fluid in the storage tank **14**, the current temperature of the air to be heated and the desired air temperature, the thermostat **112** will issue command signals to the controller **28** and the controller **110** to operate in one of several different modes of operation. The thermostat **112** can be set to manually operate in either of these modes or can be set to automatically operate in the mode which is most efficient for the current conditions.

[0026] In a first mode, ventilation air is heated by the circulation of heated fluid through heat exchanger **24**. In a second mode, ventilation air is heated by the circulation of heated fluid through the heat exchanger **24** in tandem with the forced draft heating system **100**. In a third mode, ventilation air is heated solely by the forced draft heating system **100** and the heat recovery feature of the system **10** of the present invention is operated to recover waste heat from hot combustion gases by circulating the heat transfer fluid through heat exchanger **30**. In a fourth mode, ventilation air is heated solely by the forced heating system **100**.

[0027] In the first mode, where ventilation air is heated by the circulation of heated fluid from the storage tank **14** through heat exchanger **24**. To operate in this mode, the temperature of the heat transfer fluid in the storage tank **14** must be above a first threshold and the temperature differential between the actual temperature of the air in the spaced to be heated and the desired temperature must be within a second threshold. If both of these conditions are met, the thermostat **112** will issue a command signal to controller **110** to operate the air handling means **102** to draw ventilation air into duct **106** and discharge the air through duct **108**. The thermostat **112** also issues a command signal to controller **28** to operate pump **22** to circulate the heat transfer fluid through the heat exchanger **24**. As the air is drawn through duct **106** it is passed across the heat exchanger **24** where it is heated by the heat transfer fluid. The air handling means **102** continues to draw the air into the housing of the forced draft heating system **100** and then discharges it through duct **108**. The first mode will continue to operate until either the desired temperature of the air is reached or the temperature of the heat transfer fluid drops below the first threshold or the temperature differential between the actual air temperature and the desired air temperature exceeds the second threshold. In the later, operation will automatically switch to another mode that is best suited to reduce the temperature differential between the actual air temperature and the desired temperature.

[0028] In the second mode, where ventilation air is heated by the circulation of heated fluid from the storage tank **14** through heat exchanger **24** in tandem with the forced draft heating system **100**. To operate in this mode, the temperature of heat transfer fluid in the storage tank **14** must above the first threshold and the temperature differential between the actual temperature of the air and the desired temperature of the air is outside of the second threshold. If both of these conditions are met, the thermostat **112** will issue a command signal to controller **110** to operate the heat source **104** and the air handling means **102**. The air handling means **102** draws air into duct **106** and across the heat source **104** where it is then discharged through duct **108**. The thermostat will also issue a command signal to controller **28** to operate pump **22** to circulate the heat transfer fluid through the heat exchanger **24**. As the air flows through duct **106** it is passed across the heat exchanger **24** where it is heated to a first temperature. The air then continues to flow across the heat source **104** where is it heated to a second temperature and then discharged through duct **108**. This mode of operation will continue to operate until either the desired temperature of the air is reached or the temperature of the heat transfer fluid drops below the first threshold. In the later, the thermostat **112** will issue a command signal to controller **28** to stop operation of pump **22** while the forced draft heating system **100** continues to operate until the desired ventilation air temperature is met, which is the third mode of operation.

[0029] In the third mode of operation, where the heat recovery feature of system **10** is active to recovery waste heat from hot combustion gases exhausted by the operation of a fuel-fired heat source **104**. To operate in this mode, the temperature of heat transfer fluid in the storage tank **14** is below the first threshold and the force draft heating system **100** must be a fuel-fired system. In this mode, thermostat **112** communicated to controller **28** that the forced draft heating system **100** is operational. Controller **28** then operates to open valve **34** and close valve **36** and pump **22** to circulate heat transfer fluid from the storage tank **14** through heat exchanger **30** where it is heated by the hot combustion gases exhausted from the heat source **104**.

[0030] In the forth mode, where the forced draft heating system **100** is operated alone to heat ventilation air. In other words, heat transfer fluid is not circulated from the storage tank **14** through heat exchanger **24**. The ventilation air is heated solely by the heat source **104** of the forced draft heating system.

[0031] A number of embodiments of the present invention have been described. Nevertheless, it will be understood that various modifications may be made without departing from the spirit and scope of the invention. Accordingly, other embodiments are within the scope of the following claims.

I claim:

1. A solar heating system for use with a forced draft heating system for heating ventilation air of a building, where the forced draft heating system includes an air handler, a heat source, a return air duct, an air discharge duct and a thermostat that controls the operation or the forced heating system, the solar heating system comprising:

a solar collector assembly which heats a liquid as it is circulated therethrough by solar radiation;

a fluid storage tank for containing a quantity of heat transfer fluid;

a first heat exchanger positionable in an air duct of the forced draft heating system such that air flowing through the duct is caused to flow across said first heat exchanger;

said solar collector assembly is in fluidic communication with said fluid storage tank such that heat transfer fluid contained therewithin can be circulated through said solar collector assembly and returned to said storage tank;

said first heat exchanger is in fluidic communication with said fluid storage tank such that heat transfer fluid contained therewithin can be circulated through said first heat exchanger and returned to said storage tank;

a controller;

said controller operative to effect the circulation of the heat transfer fluid through said solar collector assembly as a function of a temperature differential between the heat transfer liquid in said solar collector assembly and the heat transfer liquid in said fluid storage tank; and

said controller operative to effect the circulation of the heat transfer fluid through said first heat exchanger as a function of the temperature of the heat transfer fluid in said fluid storage tank, the temperature of the air to be heated, and the desired temperature of the air to be heated.

2. The solar heating system of claim **1**, wherein the duct of the forced draft heating system is the return air duct.

3. The solar heating system of claim **1**, further comprising:

one or more heat sinks positioned to be in heat transfer communication with the heat transfer liquid contained within said fluid storage tank.

4. The solar heating system of claim **3**, wherein said one or more heat sinks is positioned within said fluid storage tank.

5. The solar heating system of claim **1**, further comprising:

a second heat exchanger positionable in the flow of hot combustion gases exhausted by the heat source of the forced draft heating system, wherein said second heat exchanger is in fluidic communication with said fluid storage tank such that the heat transfer fluid contained within said fluid storage tank can be caused to circulate through said second heat exchanger and returned to said fluid storage tank; and

said controller operative to effect the circulation of the heat transfer fluid through said second heat exchanger as a function of the temperature of the heat transfer fluid in said fluid storage tank.

6. The solar heating system of claim **1**, wherein

said solar collector assembly is in fluidic communication with said fluid storage tank in a first closed loop flow path; and wherein

said first heat exchanger is in fluidic communication with said fluid storage tank in a second closed loop flow path.

7. The solar heating system of claim **6**, wherein said first and second closed loop flow paths are separate from each other.

8. The solar heating system of claim **7**, further comprising:

a first pump in said first closed loop flow path for circulating the heat transfer liquid through said solar collector assembly;

a second pump in said second closed loop flow path for circulating the heat transfer liquid through said first heat exchanger; and

said controller operatively connected to said first pump to effect the circulation of the heat transfer fluid through said collector assembly and operatively connected to said second pump to effect the circulation of the heat transfer fluid through said first heat exchanger.

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