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(54) **PACKAGED HVAC SYSTEM FOR INDOOR INSTALLATION**

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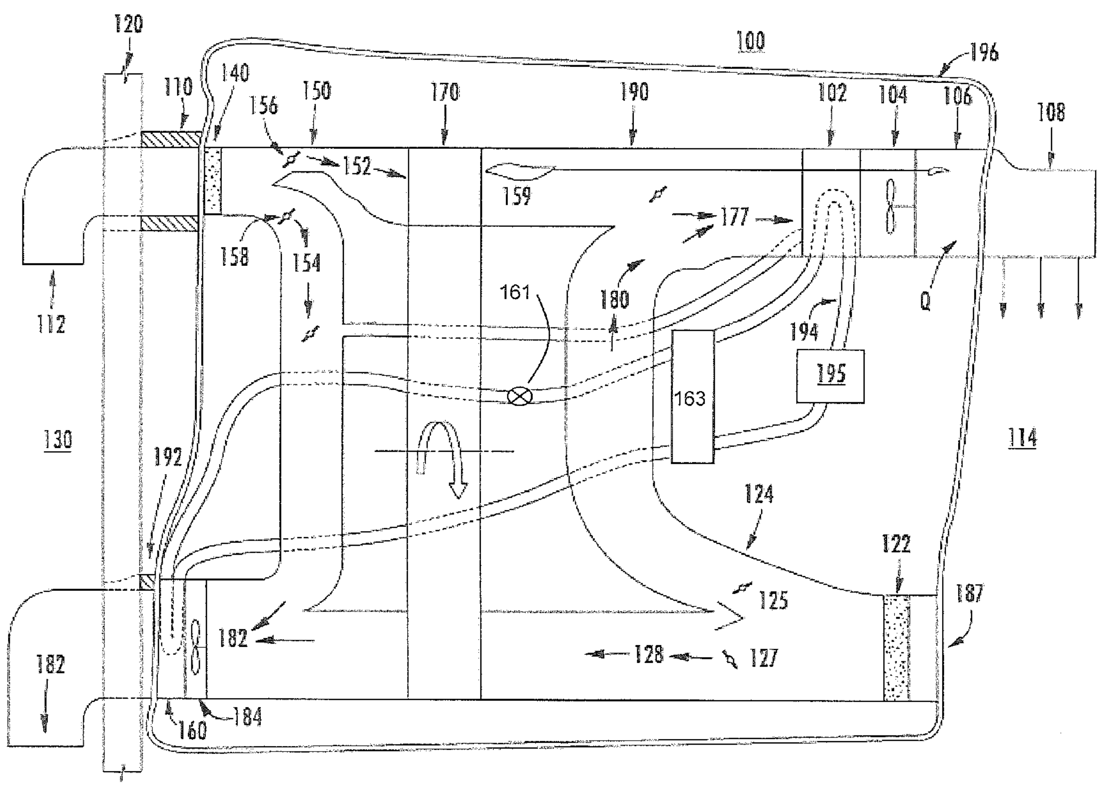
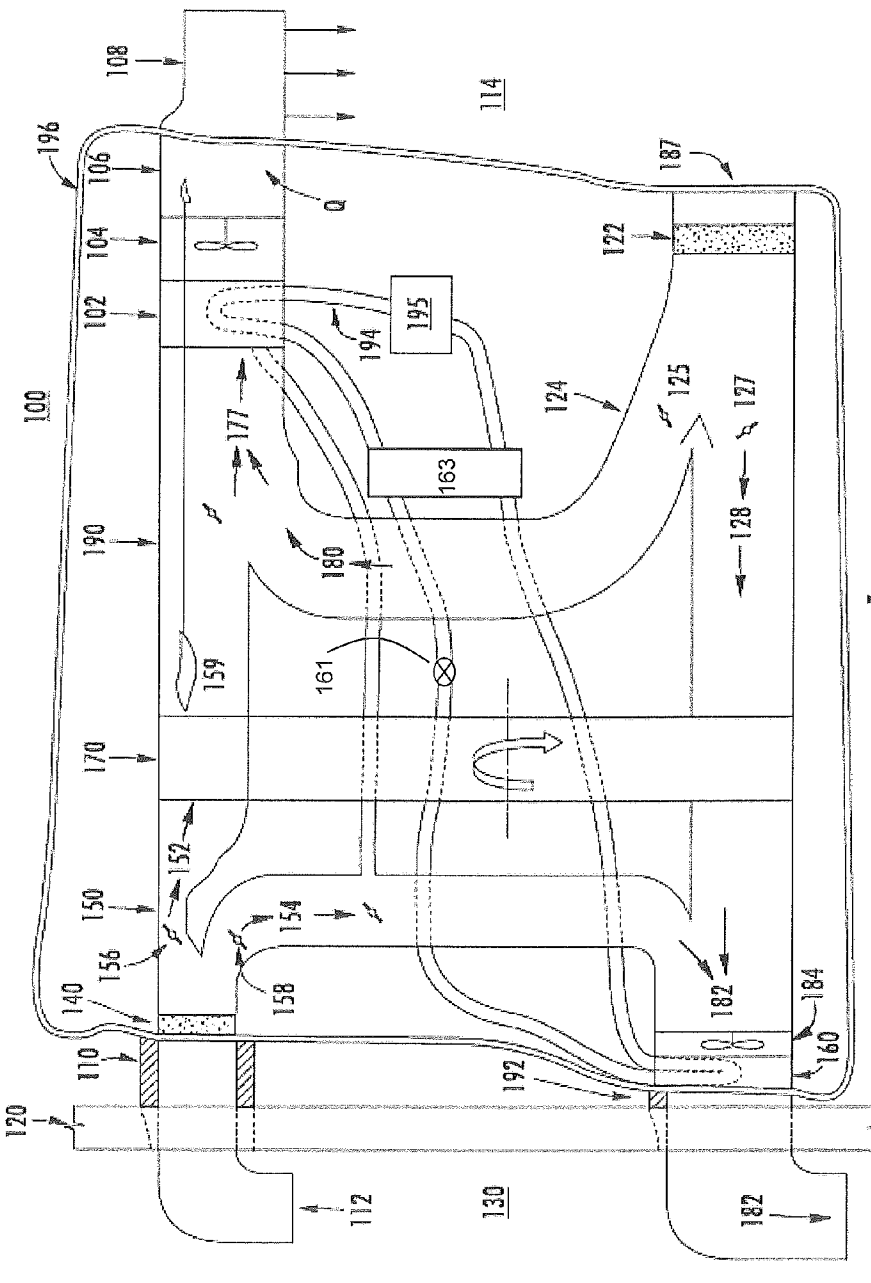
(57) **ABSTRACT**

A pre-packaged air conditioning system for providing heating, cooling, ventilation and energy recovery, the system comprising: an energy recovery ventilator, condenser, condenser fan, compressor, expansion device, flow reversing valve, evaporator and evaporator fan; an inlet for providing outside air to the evaporator, the inlet for extending beyond a wall of a host structure; and an exhaust duct for exhausting air outside of the host structure, the exhaust duct for extending beyond a wall to the host structure; wherein the energy recovery ventilator, condenser, condenser fan, compressor, evaporator and evaporator fan are housed within a single envelope configured for installation inside the host structure.

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102
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FIG. 1

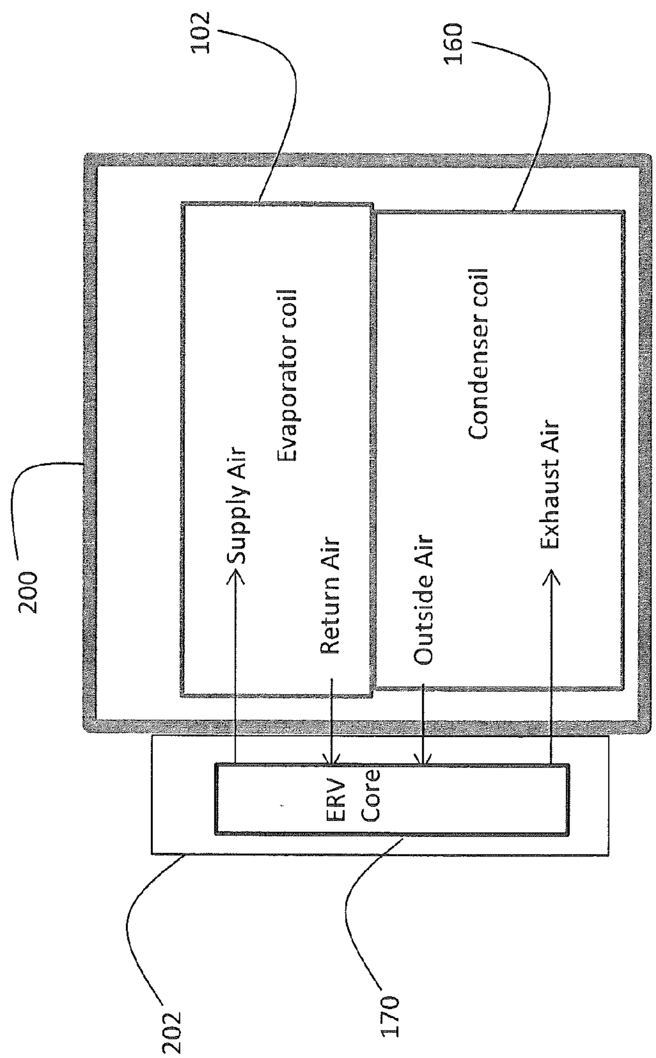
102
160
200
Evaporator coil
Supply Air
Return Air
Condenser coil
Outside Air
Exhaust Air
ERV
Core
202
170

FIG. 2

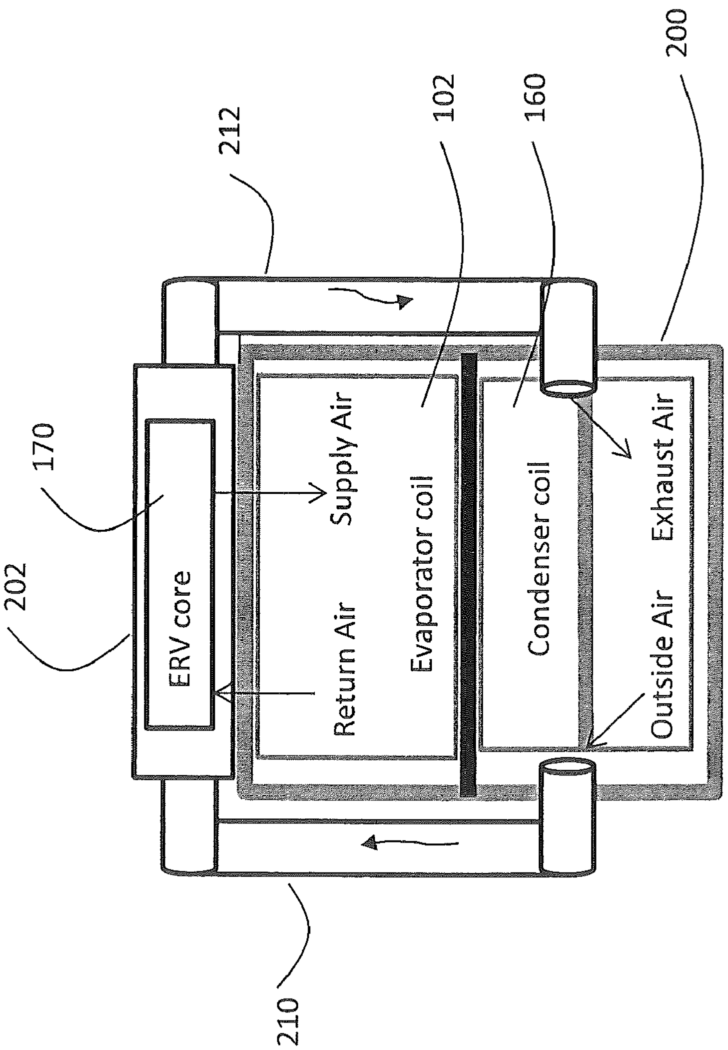
212
102
160
200
170
202
ERV core
Supply Air
Return Air
Evaporator coil
Condenser coil
Exhaust Air
Outside Air
210

FIG. 3

PACKAGED HVAC SYSTEM FOR INDOOR INSTALLATION

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. provisional patent application Ser. No. 61/447361 filed Feb. 28, 2011, the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] This application relates generally to heating, ventilation, and cooling (HVAC) systems and particularly to a packaged HVAC system configured for indoor installation. An HVAC system typically comprises several components installed in distributed locations both inside and outside a home. For example, HVAC systems often include an air handler positioned inside a structure, the air handler having one or more fans or blowers to move an airstream through various system components and to distribute the conditioned airstream via a system of ducts. In such systems, an evaporator may be positioned within the airstream in a first location inside the home and may be configured to remove heat from the airstream and transfer that heat to a working fluid (e.g., R-410A refrigerant). The working fluid may be carried through a fluid line (e.g., copper pipe) through an exterior wall of the home to a compressor and a condenser where heat can be effectively released directly to the atmosphere. Such compressor/condenser units are often positioned outside the structure on a concrete slab, and electric service to the compressor is provided through an electric line passing through the exterior wall of the structure. Finally, the cooled, compressed working fluid is returned to the evaporator via another fluid line passing through the exterior wall to the inside of the structure.

[0003] To provide heating of the airstream, an electric heating element or a gas heat exchanger may also be positioned in the conditioned airstream, often near the evaporator. For gas-burning applications, combustion air is typically carried from outside the home to a burner, and, following a transfer of heat to the conditioned airstream, the products of combustion are exhausted outside the home. The gas heat exchanger is coupled to a set of ducts that carry the combustion air and the products of combustion through an exterior wall to and from a location outside the home.

[0004] Thus, conventional HVAC systems often comprise a number of interconnected subsystem components positioned remotely from one another, both inside and outside the host structure. The subsystem components are coupled to one another via ducts and fluid lines and lines carrying electricity and gas. A common example of a conventional HVAC system is known as a split-system, which comprises an indoor unit that includes an air handler with an integrated heater and evaporator and an outdoor unit that integrates the compressor and condenser into a single packaged unit.

[0005] Due to the variety of available components making up a conventional HVAC system and the wide degree of variation in the structures into which conventional HVAC systems are installed, HVAC systems tend to be unique and widely varied. This necessitates a relatively high degree of skill for HVAC technicians to be able to properly specify, adapt, install, evaluate, and repair HVAC systems in individual homes. Moreover, due to the distributed nature of conventional HVAC systems, and the requirements that fluid lines, electrical lines, gas lines, and system ducts (i.e., mechanical interconnections) connect with the subsystem components and properly integrate with the structural and mechanical elements of the home, cooperation between many construction trades (e.g., framers/carpenters, electricians, plumbers, drywall contractors, etc., is necessitated. It has also been recognized that each of the lines and ducts passing through the exterior walls of a structure introduce the potential for air leaks and energy inefficiencies.

[0006] Thus, a need exists for a pre-packaged HVAC system that can reduce or eliminate the need for external (i.e., positioned completely or partially outside the HVAC packaging) mechanical interconnections that may be exposed to the host structure or that interact with and/or interfere with and/or penetrate the host structure.

[0007] There is also a need for increased energy efficiency in home HVAC systems, and home designers are increasingly seeking to incorporate mechanical ventilation systems, often incorporating energy recovery features, into new homes. Such systems carry ventilation air from outside the host structure to the inside. A corresponding volume of air is returned from inside the structure to the outside. Such ventilation systems typically require openings in one or more exterior walls of the structure, through which the ventilation and exhaust air is passed. The incorporation of these additional ventilation systems exacerbates the need for simplification and integration of HVAC system components and for reduction of external mechanical interconnections.

BRIEF DESCRIPTION OF THE INVENTION

[0008] An embodiment is a pre-packaged air conditioning system for providing heating, cooling, ventilation and energy recovery, the system comprising: an energy recovery ventilator (ERV), condenser, condenser fan, compressor, expansion device, flow reversing valve, evaporator and evaporator fan; an inlet for providing outside air to the evaporator, the inlet for extending beyond a wall of a host structure; and an exhaust duct for exhausting air outside of the host structure, the exhaust duct for extending beyond a wall to the host structure; wherein the energy recovery ventilator, condenser, condenser fan, compressor, evaporator and evaporator fan are housed within a single envelope configured for installation inside the host structure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The subject matter which is regarded as the invention is particularly pointed out and distinctly claimed in the claims at the conclusion of the specification. The foregoing and other features, and advantages of the invention are apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

[0010] FIG. **1** is a schematic drawing of an exemplary pre-packaged HVAC system in one embodiment;

[0011] FIG. **2** is a front view of an exemplary pre-packaged HVAC system in another embodiment; and

[0012] FIG. **3** is a front view of an exemplary pre-packaged HVAC system in another embodiment.

DETAILED DESCRIPTION OF THE INVENTION

[0013] Embodiments provide a pre-packaged HVAC system that greatly reduces the need for external mechanical interconnections that may be exposed within the host structure and that otherwise interact with and/or interfere with or require separate penetrations to the host structure. Embodiments also provide for integration with a mechanical ventilation system and for incorporation of energy recovery features, all while reducing the need for openings in the exterior walls of the host structure. Embodiments may also provide for simplified installation and reduced floor space.

[0014] In an exemplary embodiment, a fully integrated HVAC system includes an energy recovery ventilator, condenser, condenser fan, and compressor, together with an evaporator and evaporator fan, all integrated into a single, prepackaged unit that is configured for installation inside the host structure. In accordance with this embodiment, the airflow over the condenser and its fan is acquired through the same external wall opening that service the air for the energy recovery ventilator. Incoming outside air may be preheated or pre-cooled, and energy may also be recovered from the stream of return air. As one skilled in the art will appreciate, the energy recovery ventilator may be configured to transfer not only thermal energy (heat or cool), but also moisture. To transfer moisture, the system may incorporate a membrane to recapture water from return air and transfer that moisture to the incoming stream of outside air.

[0015] Energy recovery may be accomplished through a variety of devices including a rotating wheel, and internal dampers may be included so as to effectuate control of indoor return air and outside ventilation air. The energy recovery system may recover energy from the return air. The volume of an exemplary pre-packaged HVAC system may be in the range of six to fifteen cubic feet. The capacity of an exemplary pre-packaged HVAC system may be in the range of five to twenty four thousand BTUs. Accordingly, as one skilled in the art will appreciate, a pre-packaged HVAC system tends to reduce the risk of exposure to foreign objects or other environmental contaminants inherent in split system refrigerant piping installation, particularly as the HVAC package is configured to provided a substantially sealed environment for the compressor.

[0016] An exemplary HVAC system may also include devices for providing one or more economizer modes by manipulating or even disabling the rotational speed of the energy recovery wheel and/or by adjusting or closing bypass dampers.

[0017] In operation, the system transfers the stream of air used by the condenser to and from the outside of the host structure, and heat is transferred between the air and the condenser in a location inside the host structure, i.e., within the pre-packaged, integrated HVAC system. Moreover, the system of the employs a single system of ducts to carry both ventilation air and condenser airflow.

[0018] In accordance with an exemplary embodiment, and as shown in FIG. **1**, an integrated, pre-packaged HVAC system **100** includes insulated inlet **110** (i.e., duct), through which outside air stream **112** is received from the atmosphere **130** outside the host structure. Insulated inlet **110** passes through exterior wall **120** of a host structure such as a home, accepts air from the atmosphere **130**, and provides outside air stream **112** to inlet filter **140**, which filters outside air stream **112** before it is separated by inlet splitter **150** into outside air stream **152** and condenser stream **154**. In accordance with this embodiment, inlet splitter **150** may be equipped with inlet core damper **156** and a bypass dampers **158** configured so as to control the flow rates of outside air stream **152** and condenser stream **154**.

[0019] As one skilled in the art will appreciate, the flow rate of outside air stream **152** should be adjusted to provide the amount of air needed for proper ventilation, and the flow rate of condenser stream **154** should be adjusted to provide the amount of air for appropriate heat transfer (with acceptable pressure loss) in condenser **160**. For example, inlet splitter **150** may be configured (and/or inlet core and bypass dampers **156** and **158** may be positioned) such that the flow rate of outside air stream **152** is approximately 100 cubic feet per minute (cfm) and the flow rate of condenser stream **154** is approximately 800 cfm.

[0020] After being split from condenser stream **154**, outside air stream **152** flows through heat recovery wheel **170**, and is mixed with recirculation stream **180** in mixer **190** to form supply stream **177** before passing through evaporator **102**, intake blower **104**, and heater **106** and subsequently being provided to distribution system **108** for distribution to conditioned space **114** within the home or other host structure. It should be noted that the order and positioning of evaporator **102**, heater **106**, and inlet blower **104** may be adjusted to suit system design requirements in individual systems. As one skilled in the art will appreciate, heater **106** may be electric, gas or any other known form of heater. Energy recovery wheel **170** is one form of energy recovery ventilator that may be used in the packaged system, and it is understood that other types of energy recovery ventilators may be used.

[0021] In accordance with this embodiment, a return stream **187** is extracted from conditioned space **114** and passes through return filter **122** before being separated by return splitter **124** into recirculation stream **180** and exhaust stream **128**. In accordance with this embodiment, return splitter **124** may be equipped with exhaust damper **127** and recirculation damper **125** configured so as to control the flow rates of recirculation stream **180** and exhaust stream **128**. For example, splitter **124** may be configured, or dampers **125** and **127** may be positioned, such that the flow rate of recirculation stream **180** is approximately 300 cfm and the flow rate of exhaust stream **128** is approximately 100 cfm. As described above, recirculation stream **180** is mixed with outside air stream **152** to form supply stream **177** prior to passage through evaporator **102** and heater **106**.

[0022] After being split from recirculation stream **180**, exhaust stream **128** is passed through heat recovery wheel **170** and is mixed with condenser stream **154** to form combined exhaust stream **182**, which flows through exhaust blower **184** and condenser **160** before passing through insulated exhaust duct **192**, which passes through an exterior wall **120** of the host structure, and being released to the atmosphere **130**.

[0023] As outside air stream **152** flows through heat recovery wheel **170**, thermal energy is transferred between wheel **170** and outside air stream **152**. Similarly, as return stream **128** passes through heat recovery wheel **170**, thermal energy is transferred between wheel **170** and exhaust stream **128**. In this way, thermal energy (heating or cooling) is effectively transferred between outside air stream **152** and exhaust stream **128**. As one skilled in the art will appreciate, a number of mechanisms (e.g., a cross-flow core heat exchanger) could be employed—with or without a bypass damper to facilitate an economizer mode—so as to transfer heat between outside air stream **152** and exhaust stream **128**. It should also be noted that the use of a rotating wheel or cross-flow core heat exchanger and internal dampers allows for control of internal recirculation air, outside ventilation air, and allows for an economizer mode wherein the rotating energy recovery wheel is disabled and bypass dampers are closed.

[0024] As supply stream **177** passes through evaporator **102**, heat is transferred between supply stream **177** and a working fluid flowing inside fluid lines **194**. As one skilled in the art will appreciate, compressor **195** moves the working fluid (e.g., refrigerant) through fluid lines **194** from compressor **195**, to condenser **160**, expansion device **161** and evaporator **102**. As combined exhaust stream **182** passes through condenser **160**, heat is transferred between combined exhaust stream **182** and the working fluid. It is understood that the refrigerant system may be run in reverse (e.g., as a heat pump) such that evaporator **102** serves as a condenser and condenser **160** serves as an evaporator. A flow reversing valve **163** is included to enable operation as a heat pump.

[0025] Condenser **160**, compressor **195**, and fluid lines **194** are all contained within HVAC package **196**, which may be hermetically sealed. In effect, insulated inlet **110** and insulated exhaust **192** carry not only air for ventilation of the host structure, but also air for exchanging heat with condenser **160** and evaporator **102**.

[0026] In accordance with an exemplary embodiment, pre-packaged HVAC system **100** may be located indoors (i.e., within the host structure such as a home or office), and such a placement is facilitated by incorporation of insulated inlet **110**, which passes through exterior wall **120** of the host structure and accepts air from atmosphere **130**, and insulated exhaust **192**, which also passes through an exterior wall of the host structure and releases combined exhaust stream **182** to atmosphere **130**.

[0027] In an alternative embodiment, inlet splitter **150** of integrated, pre-packaged HVAC system **100** also splits from outside air **152** stream a combustion air stream **159**. As one skilled in the art will appreciate, combustion air stream **159** is adjusted to facilitate combustion in heater **106**, which would incorporate a gas heat exchanger, burner, and combustion blower. In accordance with this embodiment, combustible fuel is added to combustion air stream **159** and heat is extracted from the products of combustion. That heat is then transferred to supply airstream **177** in the gas heat exchanger contained within that embodiment of heater **106**. Products of combustion may be mixed with flow **154** prior to, or downstream of, the exhaust fan, preferably downstream of the ERV to avoid migration of combustion gas to indoor air.

[0028] FIG. **2** is a front view of an exemplary pre-packaged HVAC system in another embodiment. In this embodiment, the ERV **170** is in a housing **202** mounted on the side of a cabinet **200** containing the evaporator **102** and condenser **160**. ERV **170** may be any type of ERV, including wheel or plate type, and include internal fans for moving air through the ERV core as known in the art. Housing **202** and cabinet **200** include openings to allow return air and outside to enter the ERV **170**. Similarly, openings in the housing **202** and cabinet **200** allow for supply air and exhaust air to exit the ERV **170** and pass over the evaporator **102** and condenser **160**, respectively. The housing **202** of ERV **170** is sealed to cabinet **200** to provide a packaged unit in a sealed envelope. The packaged HVAC system of FIG. **2** interfaces with inlet **110** and exhaust duct **192** as described above.

[0029] FIG. **3** is a front view of an exemplary pre-packaged HVAC system in another embodiment. In this embodiment, the ERV **170** is in a housing **202** mounted on top of a cabinet **200** housing the evaporator **102** and condenser **160**. ERV **170** may be any type of ERV, including wheel or plate type, and include internal fans for moving air through the ERV core as known in the art. Housing **202** and cabinet **200** include openings to allow return air to enter the ERV **170** and supply air to exit the ERV **170**. A first duct **210** couples the outside air from cabinet **200** to housing **202**, to provide outside air to the ERV **170**. A second duct **212** couples the exhaust air from housing **202** to cabinet **200**. Ducts **210** and **212** may be located within cabinet **200**, rather than outside cabinet **200** as shown in FIG. **3**. The housing **202** of ERV **170** is sealed to cabinet **200** to provide a packaged unit in a sealed envelope. The packaged HVAC system of FIG. **2** interfaces with an inlet **110** and exhaust duct **192** as described above.

[0030] As a result, embodiments provide a fully-integrated HVAC system that combines the functionality of a high-efficiency heat pump with that of an energy-recovery ventilator, together with the condenser and condenser fan also integrated into a single packaged unit suitable for installation inside a host structure such as a home or apartment. Accordingly, embodiments provide a relatively high-efficiency, integrated, heat-pump system that can meet emerging needs for relatively low capacity installations. Embodiments overcome the need for split heat-pump systems and the issues inherent with distribution throughout the inside and outside of a host structure. Embodiments eliminate the need to place a condenser, condenser fan, and compressor outside the host structure. Embodiments include the compressor, condenser, and condenser fan in an integrated indoor unit and utilizes an integrated ventilation system to provide necessary condenser airflow.

[0031] While the invention has been described in detail in connection with only a limited number of embodiments, it should be readily understood that the invention is not limited to such disclosed embodiments. Rather, the invention can be modified to incorporate any number of variations, alterations, substitutions or equivalent arrangements not heretofore described, but which are commensurate with the spirit and scope of the invention. Additionally, while various embodiments of the invention have been described, it is to be understood that aspects of the invention may include only some of the described embodiments. Accordingly, the invention is not to be seen as limited by the foregoing description, but is only limited by the scope of the appended claims.

1. A pre-packaged air conditioning system for providing heating, cooling, ventilation and energy recovery, the system comprising:

an energy recovery ventilator, condenser, condenser fan, compressor, expansion device, flow reversing valve, evaporator and evaporator fan;

an inlet for providing outside air to the evaporator, the inlet for extending beyond a wall of a host structure; and

an exhaust duct for exhausting air outside of the host structure, the exhaust duct for extending beyond a wall to the host structure;

wherein the energy recovery ventilator, condenser, condenser fan, compressor, expansion device, flow reversing valve, evaporator and evaporator fan are housed within a single envelope configured for installation inside the host structure.

2. The pre-packaged air conditioning system of claim **1**, wherein outside air supplied to the energy recovery ventilator is acquired through the inlet, and wherein airflow over the condenser exits through the exhaust duct.

3. The pre-packaged air conditioning system of claim **1**, wherein the energy recovery ventilator recovers thermal energy from a stream of exhaust air.

4. The pre-packaged air conditioning system of claim **1**, wherein the energy recovery ventilator transfers thermal energy and moisture to an outside air stream.

5. The pre-packaged air conditioning system of claim **1**, wherein the energy recovery ventilator comprises a membrane to recapture water from exhaust air and transfer moisture to an outside air stream.

6. The pre-packaged air conditioning system of claim **1**, wherein the energy recovery ventilator comprises a rotating wheel or cross-flow core heat exchanger to recover energy.

7. The pre-packaged air conditioning system of claim **1**, wherein the system has a volume of between six and fifteen cubic feet.

8. The pre-packaged air conditioning system of claim **1**, wherein the system has a capacity of between of five and twenty four thousand BTUs.

9. The pre-packaged air conditioning system of claim **1**, wherein the pre-packaged HVAC system comprises a sealed container enveloping the condenser, condenser fan, compressor, expansion device, flow reversing valve, evaporator and evaporator fan, with a single inlet and a single outlet.

10. The pre-packaged air conditioning system of claim **1**, further comprising:

a splitter receiving outside air and dividing the outside air into an outside air stream directed to the evaporator and a condenser stream directed to the condenser.

11. The pre-packaged air conditioning system of claim **1**, wherein:

the splitter includes an inlet core damper controlling the outside air stream to the evaporator and a bypass damper controlling the condenser stream to the condenser.

12. The pre-packaged air conditioning system of claim **1**, wherein:

the energy recovery ventilator is positioned in a housing;

the evaporator and condenser are positioned in a cabinet;

the housing being mounted to the cabinet to define the single envelope.

13. The pre-packaged air conditioning system of claim **12**, wherein:

the housing and cabinet include openings to allow outside air and return air to flow from the cabinet to the housing.

the housing and cabinet include openings to allow supply air and exhaust air to flow from the housing to the cabinet.

14. The pre-packaged air conditioning system of claim **13**, wherein:

the openings are joined by ducts.

15. The pre-packaged air conditioning system of claim **12**, wherein:

the ducts are positioned internal to the cabinet.

16. The pre-packaged air conditioning system of claim **12**, wherein:

the ducts are positioned external to the cabinet.

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