

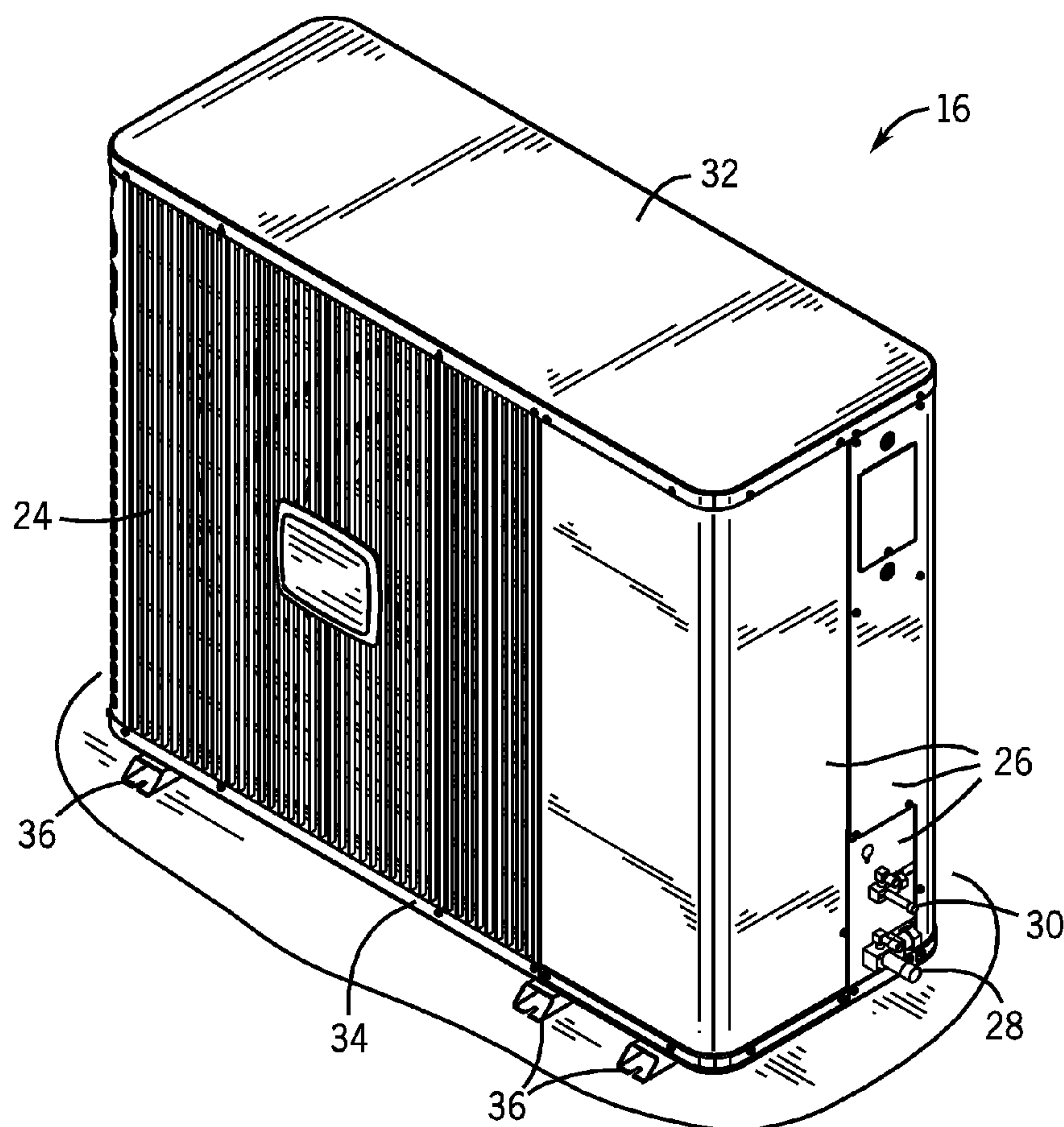
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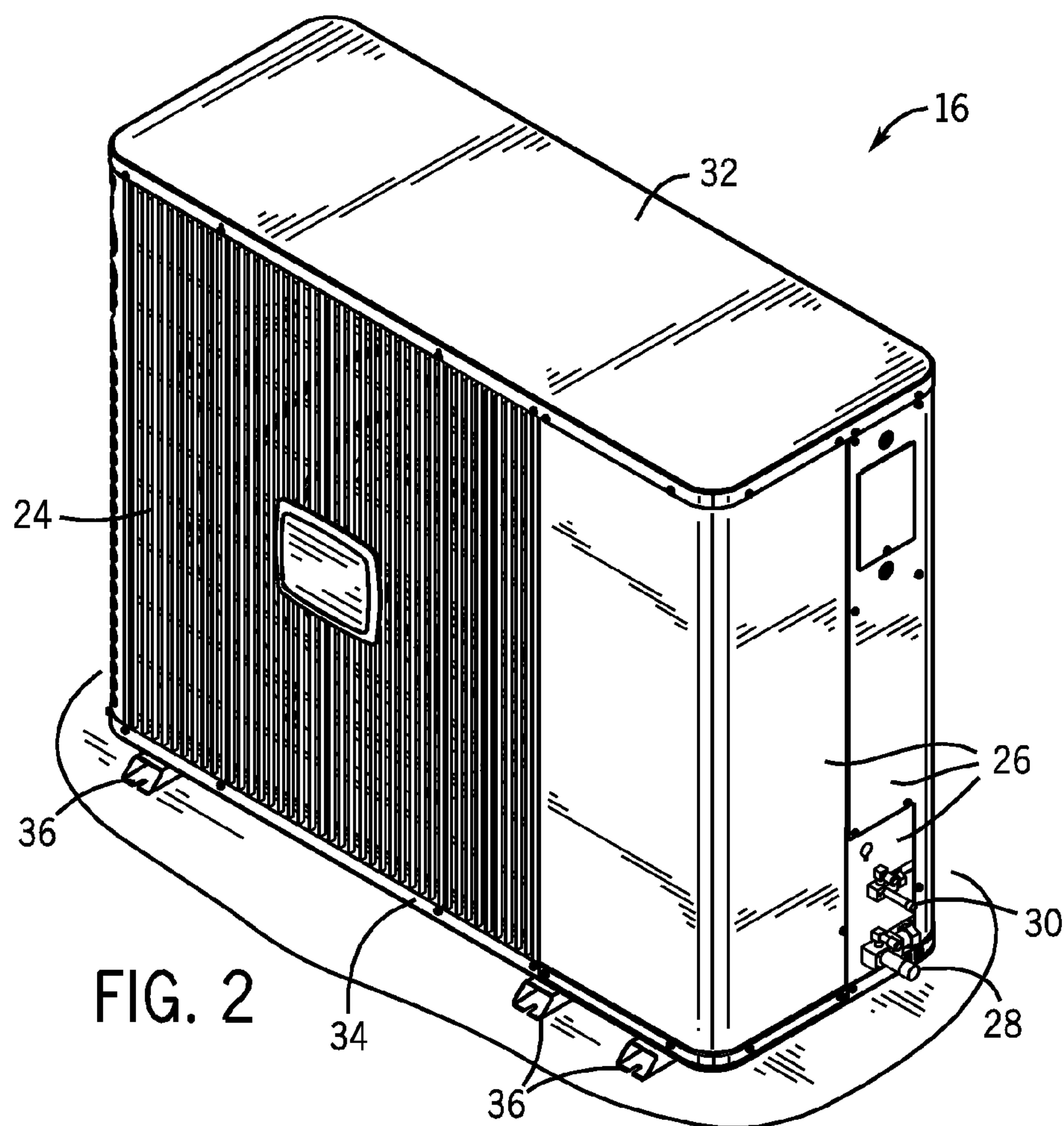
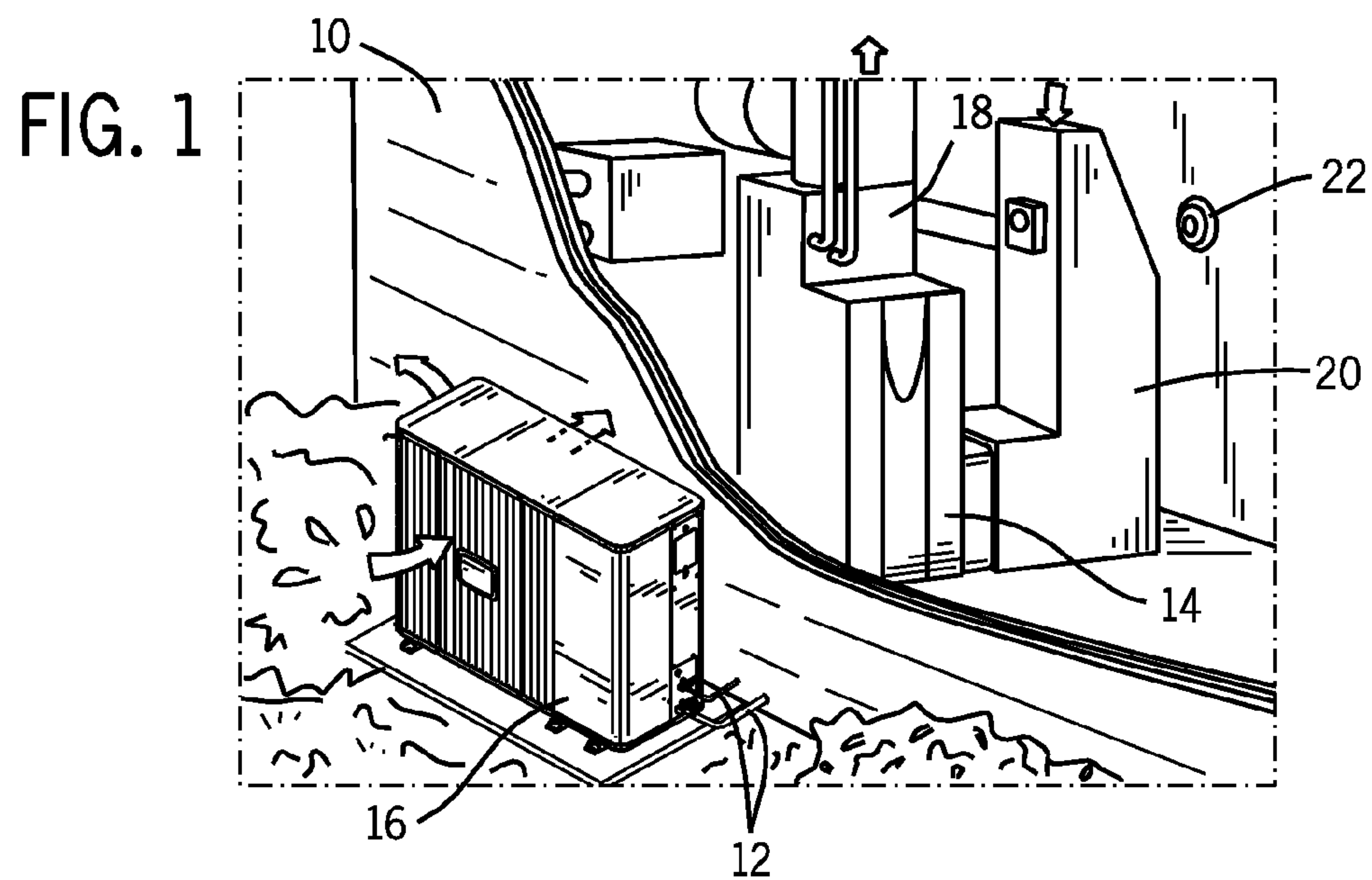
(19) **United States**(12) **Patent Application Publication**
Warnecker et al.(10) **Pub. No.: US 2010/0011803 A1**(43) **Pub. Date: Jan. 21, 2010**(54) **HORIZONTAL DISCHARGE AIR
CONDITIONING UNIT***F28D 15/00* (2006.01)*F25D 3/00* (2006.01)*F25B 39/02* (2006.01)(75) Inventors: **Christopher Darren Warnecker**,
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Clearwater, KS (US)(52) **U.S. Cl. 62/498; 165/81; 165/104.34; 62/56;
62/515**

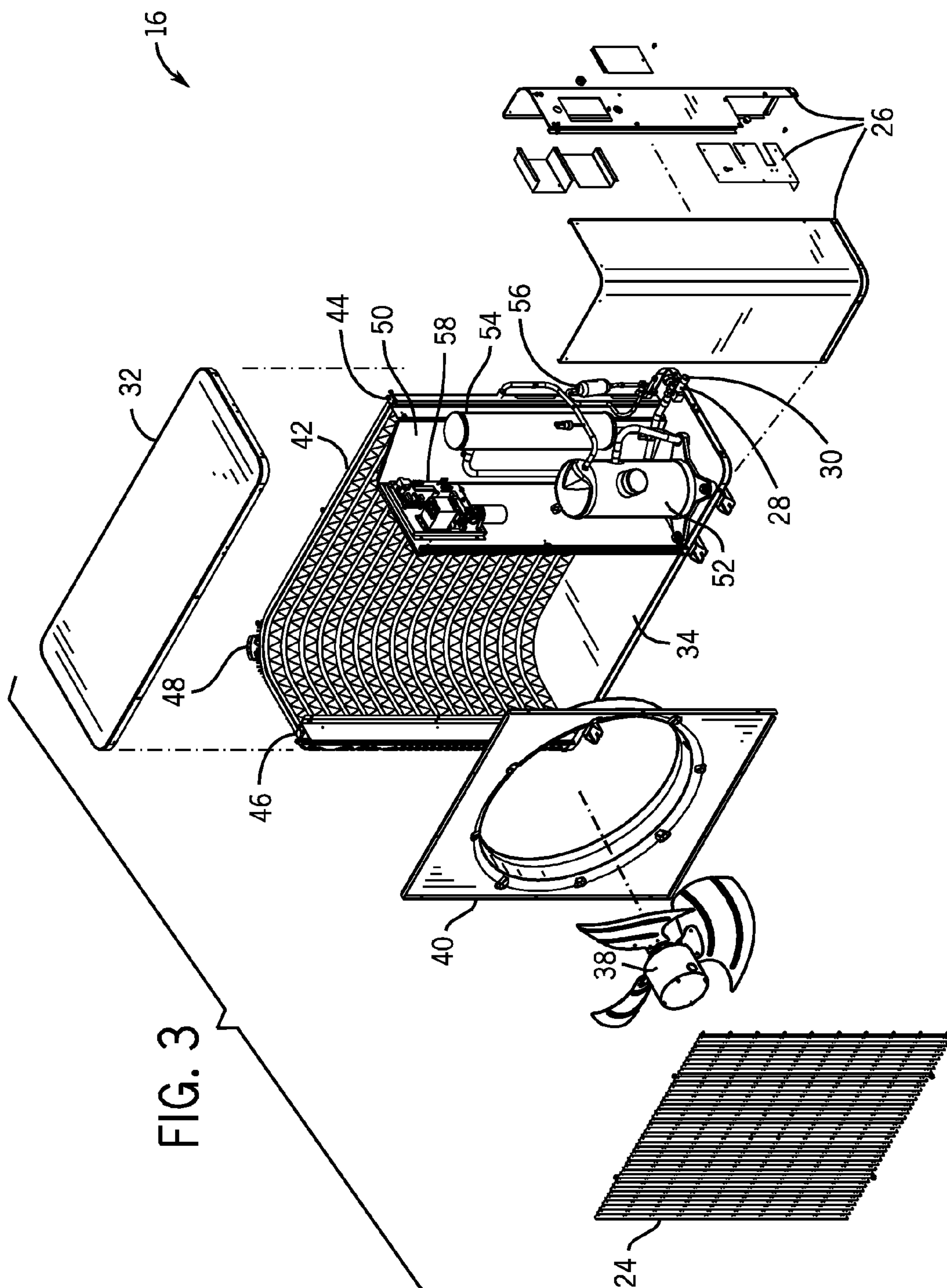
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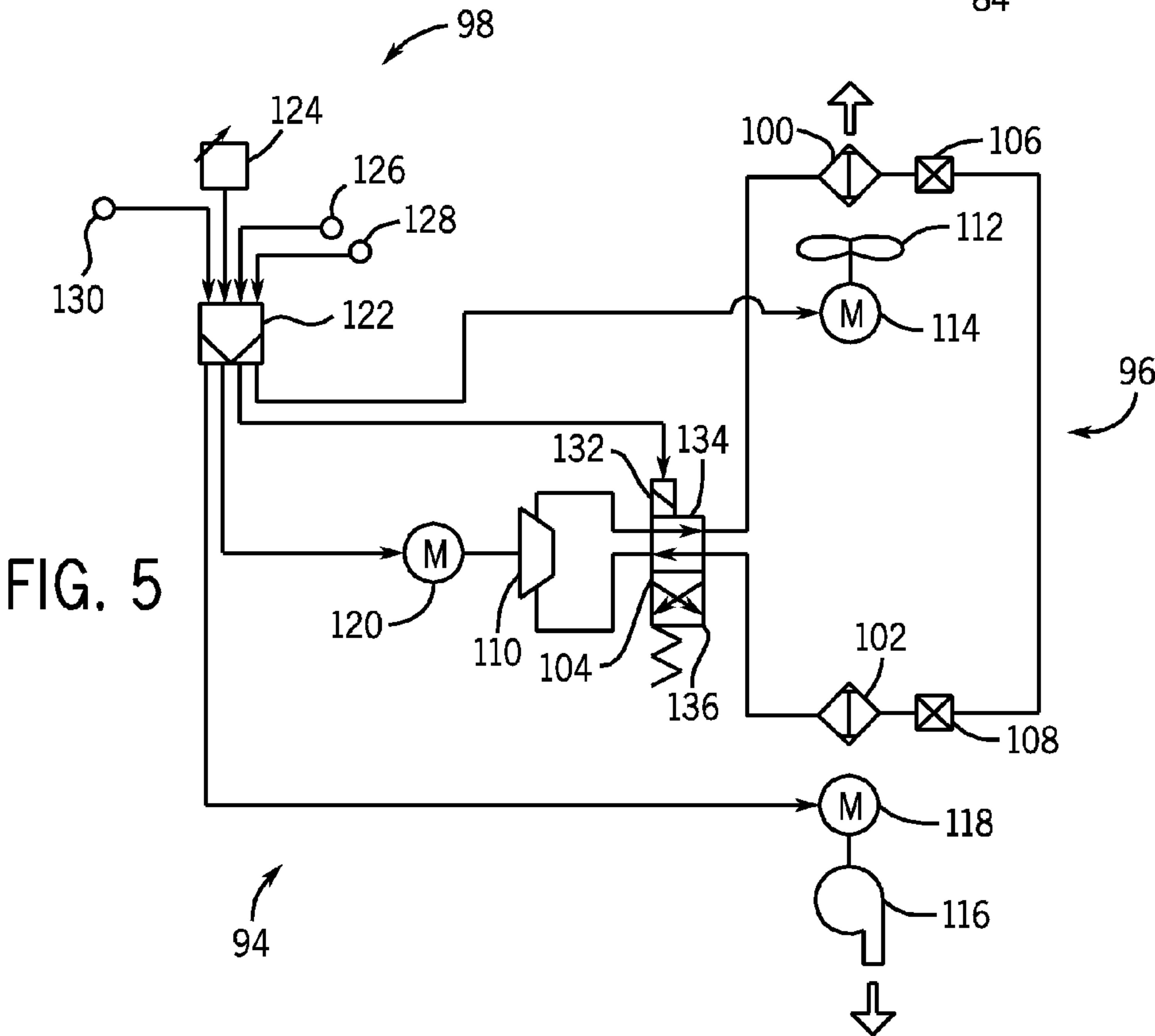
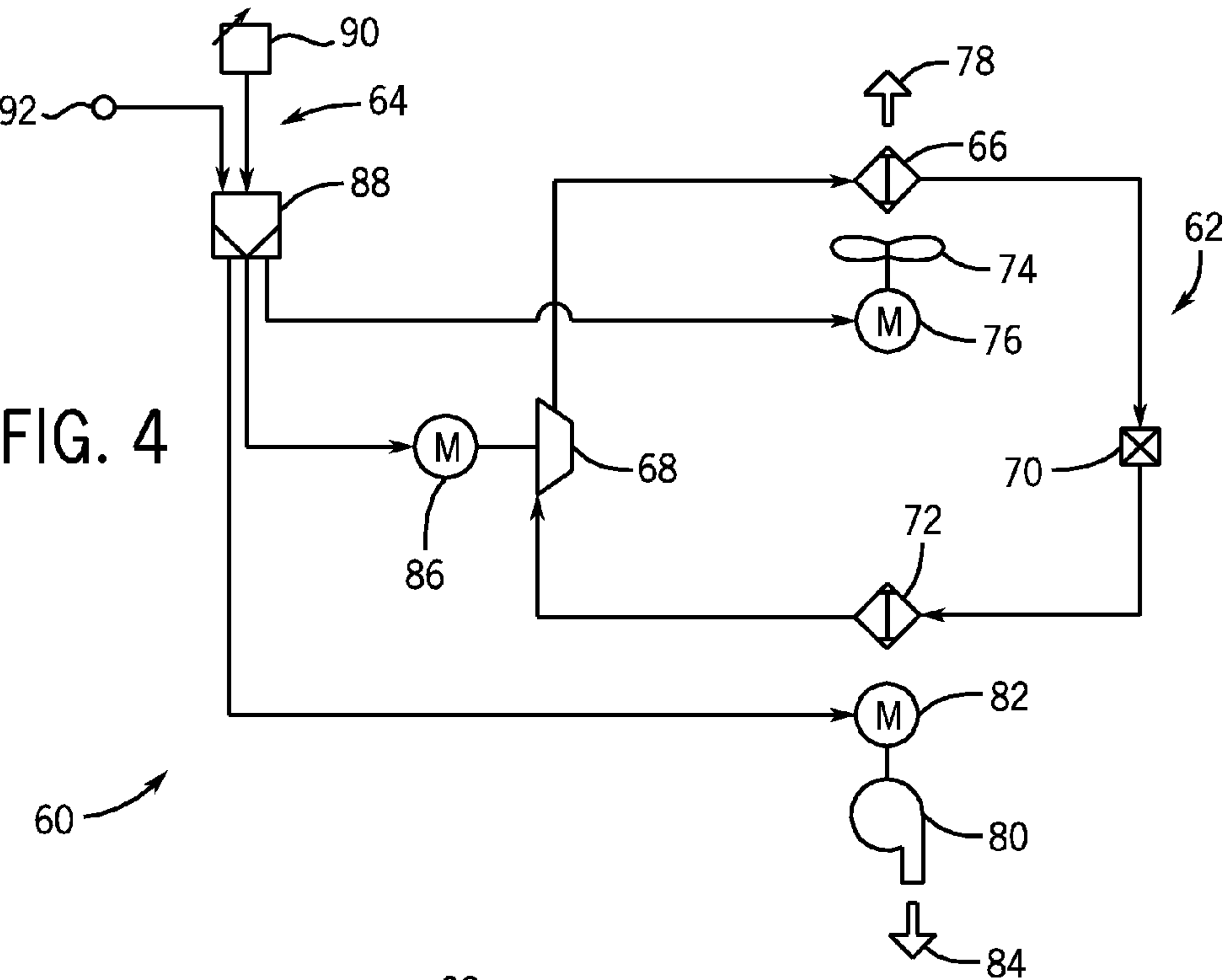
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F25B 1/00 (2006.01)
F28F 7/00 (2006.01)(57) **ABSTRACT**

Heating, ventilating, air conditioning or refrigeration (HVAC&R) systems and associated outdoor horizontal discharge units are provided. The units include a heat exchanger. The heat exchanger includes a plurality of manifolds. The heat exchanger also includes a plurality of multichannel tubes in fluid communication with the manifolds. Each multichannel tube includes a plurality of parallel flow paths through which an internal fluid flows. Each flow path extends lengthwise through its respective multichannel tube. The heat exchanger further includes a plurality of fins disposed between the multichannel tubes for transferring heat between the external air and the internal fluid flowing through the flow paths. The units also include a fan configured to blow air horizontally through the heat exchanger such that the air discharges the unit horizontally through at least one side of the unit.









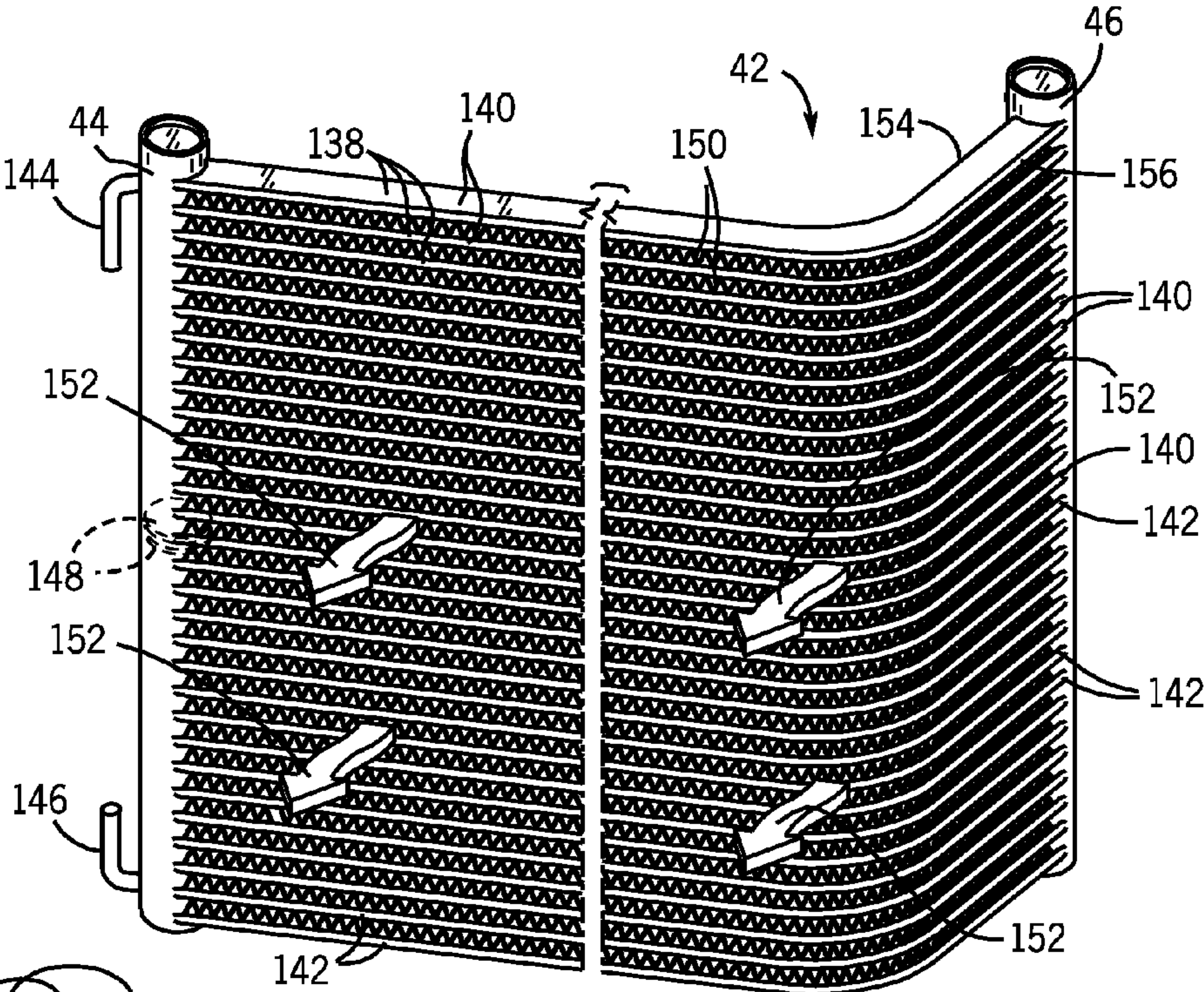


FIG. 6

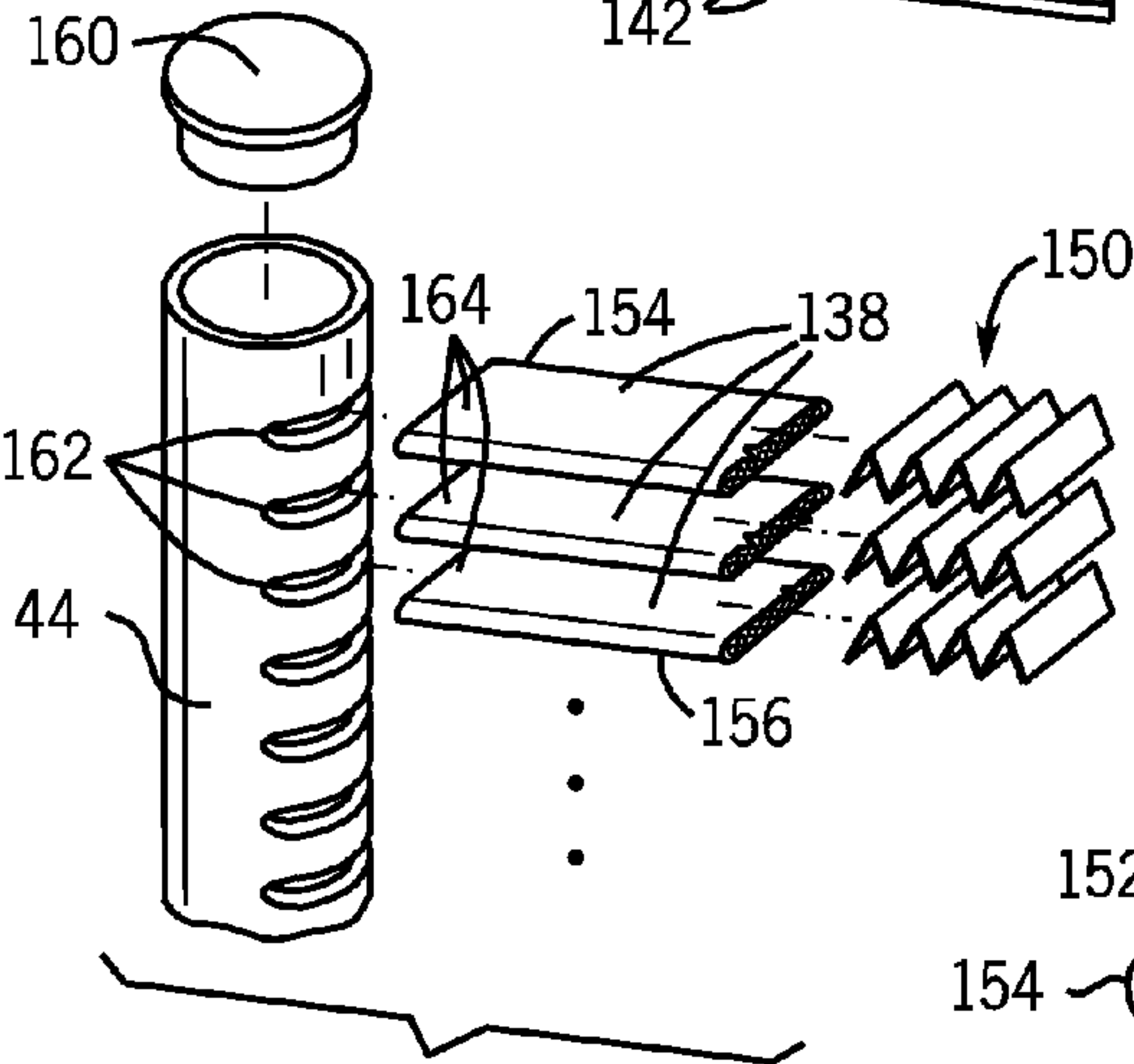


FIG. 8

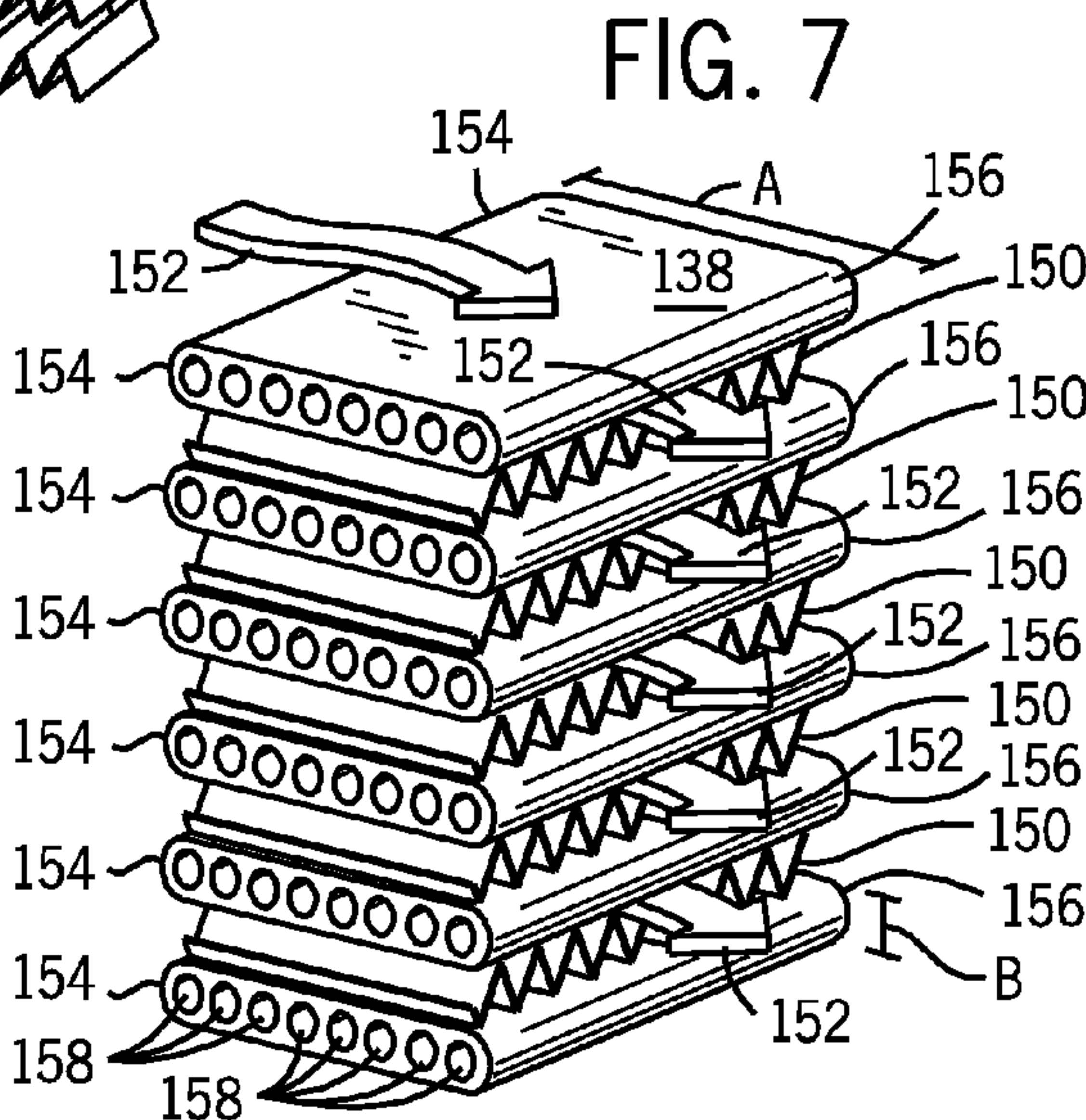


FIG. 7

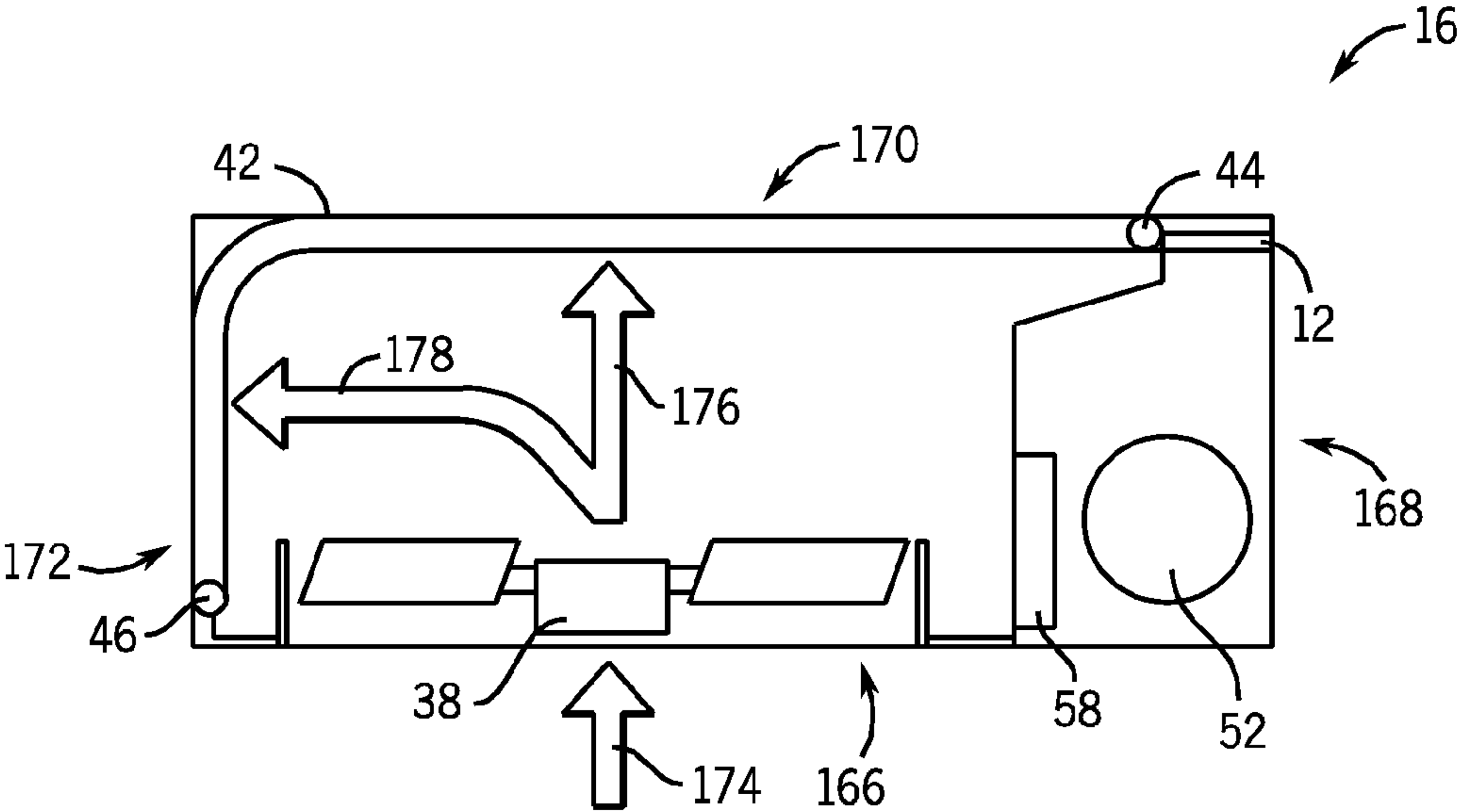


FIG. 9A

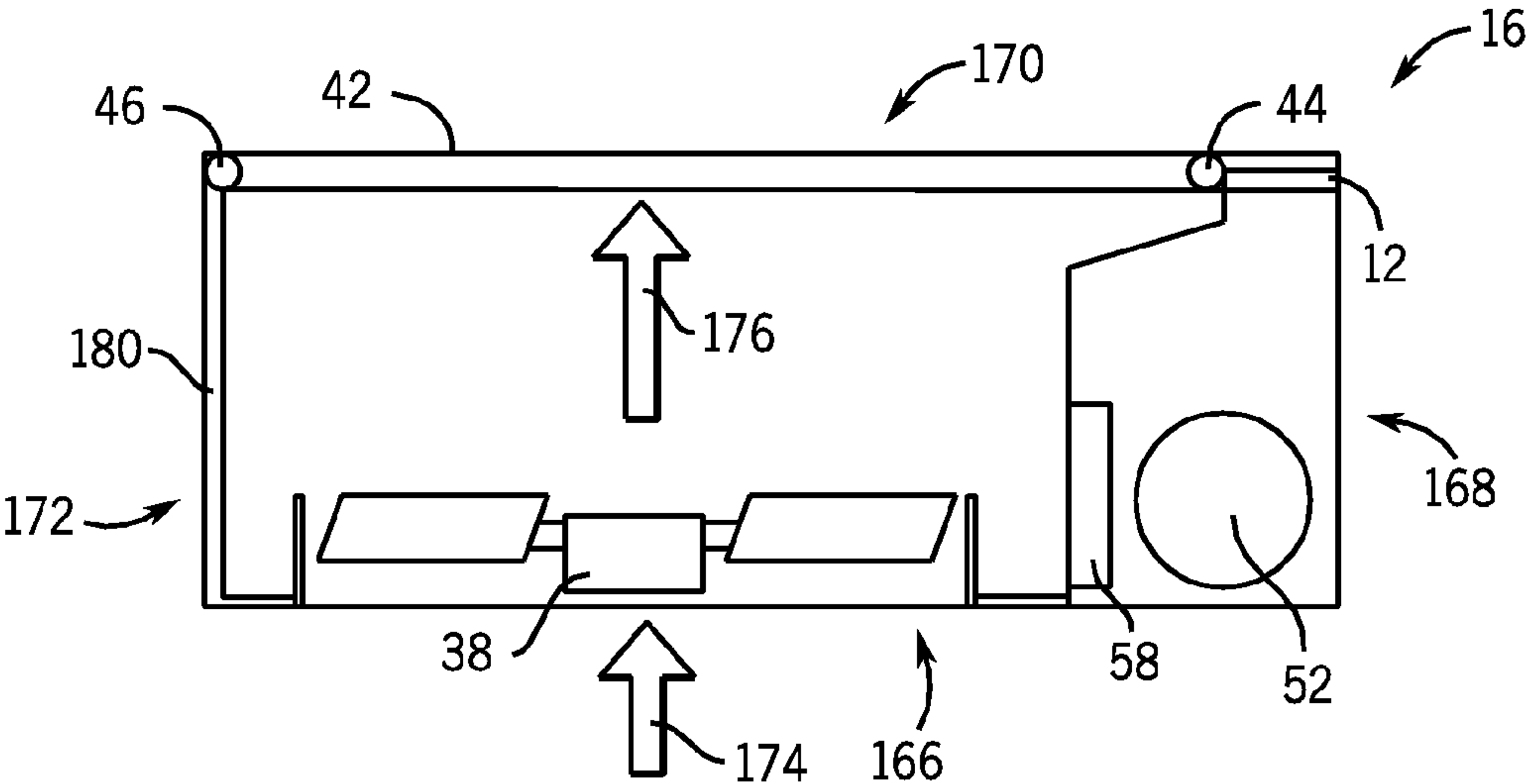


FIG. 9B

HORIZONTAL DISCHARGE AIR CONDITIONING UNIT

BACKGROUND

[0001] The invention relates generally to heating, ventilation, air conditioning, and refrigeration (HVAC&R) units which discharge air horizontally. In particular, the invention relates to outdoor horizontal discharge air conditioning units.

[0002] HVAC&R systems for use in residential, commercial, and light industrial applications often require indoor units and outdoor units. Generally, the indoor units condition indoor environments by, for instance, cooling or heating the air in the indoor environment. In contrast, the outdoor units typically either discharge unwanted heat from the HVAC&R system or transfer external heat into the HVAC&R system, depending on whether the indoor environment is being cooled or heated. In either mode of operation, outdoor units usually draw external air into the unit across heat exchangers, which may be either condensers or evaporators, depending on whether the unit is in a cooling or heating mode. In particular, outdoor units typically draw air in through a side of the unit horizontally across fin/tube heat exchangers extending along the sides of the unit. The fans used in these outdoor units are usually located near the top of the unit such that the air is drawn over the heat exchangers and discharged vertically through the top of the unit.

[0003] These outdoor units may work adequately for transferring heat to/from the indoor environment, depending on the mode of operation. However, the units tend to have footprints that are not conducive to the narrow spaces occasionally found between residential homes. In particular, the units typically draw air in through all four sides since increased heat transfer area is often required with the standard fin/tube heat exchangers typically used in these units. Therefore, because the units utilize less efficient fin/tube designs, more heat transfer area may be required, thereby necessitating somewhat larger footprints. In addition, noise levels during operation of these outdoor units is always a concern since the outdoor units are frequently used in residential, commercial, and other areas where high noise levels may cause a nuisance.

SUMMARY

[0004] The present invention relates to an outdoor HVAC&R unit. The unit includes a heat exchanger. The heat exchanger includes a plurality of manifolds. The heat exchanger also includes a plurality of multichannel tubes in fluid communication with the manifolds. Each multichannel tube includes a plurality of parallel flow paths through which an internal fluid flows. Each flow path extends lengthwise through its respective multichannel tube. The heat exchanger further includes a plurality of fins disposed between the multichannel tubes for transferring heat between the external air and the internal fluid flowing through the flow paths. The unit also includes a fan configured to blow air horizontally through the heat exchanger such that the air exits the unit horizontally through at least one side of the unit.

[0005] The present invention also relates to a method of operating an outdoor HVAC&R unit. The method includes drawing air into the unit via a fan. The method also includes blowing the air from the fan through a heat exchanger. The method further includes discharging the air from the unit horizontally through at least one side of the unit.

[0006] The present invention further relates to an HVAC&R system. The system includes an outdoor unit. The unit includes a compressor configured to compress a gaseous refrigerant. The unit also includes a heat exchanger configured to receive and to condense the compressed refrigerant. The heat exchanger includes a plurality of manifolds. The heat exchanger also includes a plurality of multichannel tubes in fluid communication with the manifolds. Each multichannel tube includes a plurality of parallel flow paths through which the compressed refrigerant flows. Each flow path extends lengthwise through its respective multichannel tube. The heat exchanger further includes a plurality of fins disposed between the multichannel tubes for transferring heat between the external air and the compressed refrigerant flowing through the flow paths. The unit also includes a fan configured to blow air horizontally through the heat exchanger such that the air exits the outdoor unit horizontally through at least one side of the unit. The system also includes an expansion device configured to reduce pressure of the refrigerant. The system further includes an evaporator configured to evaporate the refrigerant prior to returning the refrigerant to the compressor.

DRAWINGS

[0007] FIG. 1 is a perspective view of an exemplary residential air conditioning or heat pump system that may employ outdoor horizontal discharge units.

[0008] FIG. 2 is a perspective view of an exemplary outdoor horizontal discharge unit.

[0009] FIG. 3 is an exploded detailed perspective view of an exemplary outdoor horizontal discharge unit.

[0010] FIG. 4 is a diagrammatical overview of an exemplary air conditioning system that may employ outdoor horizontal discharge units.

[0011] FIG. 5 is a diagrammatical overview of an exemplary heat pump system that may employ outdoor horizontal discharge units.

[0012] FIG. 6 is a perspective view of an exemplary heat exchanger containing multichannel tubes for use in outdoor horizontal discharge units.

[0013] FIG. 7 is a detailed perspective view of a section of multichannel tubes and fins employed in the heat exchanger of FIG. 6.

[0014] FIG. 8 is a partially exploded detailed perspective view of a portion of the heat exchanger of FIG. 6.

[0015] FIGS. 9A and 9B are diagrammatical overviews of an exemplary outdoor horizontal discharge unit.

DETAILED DESCRIPTION

[0016] FIG. 1 shows an exemplary application for outdoor horizontal discharge air conditioning and heat pump units. Such units, in general, may be applied in a range of settings. In presently contemplated applications, however, outdoor horizontal discharge air conditioning and heat pump units may be used in residential, commercial, light industrial, industrial, and any other applications for heating or cooling a volume or enclosure, such as a residence, building, structure, and so forth. FIG. 1 illustrates a residential heating and cooling system. In general, a residence 10, will include refrigerant conduits 12 that operatively couple an indoor unit 14 to an outdoor unit 16. Indoor unit 14 may be positioned in a utility room, an attic, a basement, and so forth. Outdoor unit 16 may typically be situated adjacent to a side of residence 10 and

may be covered by a shroud to protect the system components and to prevent leaves and other contaminants from entering the unit. Refrigerant conduits **12** transfer refrigerant between indoor unit **14** and outdoor unit **16**, typically transferring primarily liquid refrigerant in one direction and primarily vaporized refrigerant in an opposite direction.

[0017] When the system shown in FIG. **1** is operating as an air conditioner, a coil in outdoor unit **16** serves as a condenser for condensing vaporized refrigerant. In these applications, a coil of the indoor unit, designated by the reference numeral **18**, serves as an evaporator coil. Evaporator coil **18** receives liquid refrigerant (which may be expanded by an expansion device, not shown) and evaporates the refrigerant before returning it to outdoor unit **16**.

[0018] Outdoor unit **16** may draw environmental air in through a first side as indicated by the arrows into the front of the unit shown, force the air through the outdoor unit coil by a means of a fan (not shown), and expel the air through one or more of the remaining sides as indicated by the arrows out of the back and side of the unit shown. When outdoor unit **16** operates as an air conditioner, outdoor air condenses the refrigerant by absorbing its heat from the condenser coil within outdoor unit **16** and exits one or more of the sides of the unit at a temperature higher than it entered the first side. Indoor air is blown over evaporator coil **18** and circulated through residence **10** by means of ductwork **20**, as indicated by the arrows entering and exiting ductwork **20**. The indoor air evaporates the refrigerant by transferring its heat to evaporator coil **18** within indoor unit **14** and exits the indoor unit **14** at a temperature lower than when it entered. The overall system operates to maintain a desired temperature as set by a thermostat **22**, or other control device. When the temperature sensed inside the residence is higher than the set point on thermostat **22** (plus a small amount), the air conditioner may become operative to refrigerate additional air for circulation through the residence. When the temperature reaches the set point (minus a small amount), the unit may stop the refrigeration cycle temporarily. Other control devices may include application specific or general purpose computers or processors, networked computers or building controllers, and so forth.

[0019] When outdoor unit **16** operates as a heat pump, the roles of the coils are simply reversed. That is, the coil of outdoor unit **16** will serve as an evaporator to evaporate refrigerant, thereby cooling the air entering outdoor unit **16** as the air passes over the outdoor unit coil. Indoor coil **18** will receive a stream of air blown over it and will heat the air by condensing a refrigerant.

[0020] FIG. **2** is a perspective view of an exemplary outdoor unit **16**. In the illustrated embodiment, outdoor unit **16** may include a fan guard **24** through which air is drawn into outdoor unit **16** by a fan (not shown). Fan guard **24** may prevent foreign objects from being drawn into outdoor unit **16**. In addition, fan guard **24** may be designed to reduce the air resistance of the air drawn into outdoor unit **16**. Reducing the air resistance may, in turn, lead to reduced noise during operation of outdoor unit **16**.

[0021] Outdoor unit **16** may also include cabinet paneling **26** which may protect the internal cabinet (not shown) of outdoor unit **16**. Cabinet paneling **26** may be designed to include as few removable pieces as possible to facilitate access to the internal cabinet. The internal cabinet may contain many of the major operating components of outdoor unit **16**, such as compressors, accumulators, filter/dryers, conduit

pipings, control circuitry, and so forth. Cabinet paneling **26** may be fabricated from pre-painted or post-painted galvanized steel to resist rust and corrosion. Vapor valve **28** and liquid valve **30** may constitute the refrigerant conduit **12** connections (shown in FIG. **1**) and may enter and exit outdoor unit **16** through cabinet paneling **26**. Vapor valve **28** and liquid valve **30** may be fully exposed to facilitate servicing of outdoor unit **16**. When outdoor unit **16** operates as an air conditioning unit, refrigerant vapor may flow into outdoor unit **16** through vapor valve **28** and refrigerant liquid may flow out of outdoor unit **16** through liquid valve **30**. Conversely, when outdoor unit **16** operates as a heat pump unit, the refrigerant flows may be reversed.

[0022] Outdoor unit **16** may also include a top panel **32** and a base pan **34** to further enclose outdoor unit **16**. These may be designed to reduce the noise generated by outdoor unit **16** during operation. Outdoor unit **16** may also include footing braces **36** which may ensure that outdoor unit **16** remains firmly positioned during operation. In addition, footing braces **36** may also facilitate installation and removal of outdoor unit **16** by leaving space between outdoor unit **16** and the surface upon which outdoor unit **16** is placed.

[0023] All of the outer components of outdoor unit **16** (e.g., cabinet paneling **26**, top panel **32**, and so forth) may be provided with an automotive quality finish such that damage from harmful ultraviolet rays and rust may be minimized. This finish may not only lead to a higher quality external appearance but also lead to a more durable outdoor unit **16**. Increased durability may prove important not only to ensure that outdoor unit **16** experiences a long service life but also to help minimize the potential for increasing noise levels over time due to deterioration of the exterior.

[0024] FIG. **3** is an exploded detailed perspective view of an exemplary outdoor unit **16**. In the illustrated embodiment, outdoor unit **16** is an air conditioning unit. However, other types of outdoor units may be used. In particular, outdoor unit **16** may also be a heat pump unit, albeit with additional components specific to a heat pump unit such as a reversing valve, defrost board, and so forth. As described in greater detail with reference to FIGS. **9A** and **9B**, fan **38** may be used to draw air into outdoor unit **16**. Fan **38** may be positioned within venturi **40** so as to decrease the potential for air recirculation around fan **38**. For instance, the clearance between the fan blades and venturi **40** may be in the order of **3 mm** to **20 mm**. This may help decrease noise levels as well as allowing for more laminar and uniform distribution of the airflow. Any suitable fan blade geometry may be used. However, the use of swept-wing fan blades may lead to reduced noise levels during operation. Furthermore, fan **38** may be driven by a low-RPM, electronically controlled motor, which may further help reduce the airflow noise. For instance, fan **38** may be driven by a permanent split capacitor (PSC) motor, an electrically commutated motor (ECM), or other suitable motor.

[0025] The air drawn into outdoor unit **16** may be blown by fan **38** over heat exchanger **42** and discharged horizontally through at least one side of outdoor unit **16**. As described with respect to FIG. **1**, when outdoor unit **16** operates as an air conditioning unit, heat exchanger **42** may function as a condenser coil, whereby heat is transferred from the refrigerant running through heat exchanger **42** to the air. Conversely, when outdoor unit **16** operates as a heat pump unit, heat exchanger **42** may function as an evaporator coil, whereby heat from the air is transferred to the refrigerant running through heat exchanger **42**. As discussed with respect to

FIGS. 6 through 8, heat exchanger 42 may utilize multichannel tubes and associated fins which help increase heat transfer efficiencies of heat exchanger 42 as well as help reduce noise levels. Heat exchanger 42 may include first and second manifolds 44 and 46 through which the refrigerant flows. In general, the refrigerant may flow from manifold 44 to manifold 46 through a first plurality of multichannel tubes and then return from manifold 46 to manifold 44 through a second plurality of multichannel tubes. As such, manifold 44 may function as both an inlet and outlet for the refrigerant into and out of heat exchanger 42.

[0026] Although often presented throughout this disclosure as first and second manifolds 44 and 46, in certain embodiments, more than two manifolds may be used in multiple rows. In other words, a plurality of manifolds may be used in heat exchanger 42. Therefore, the refrigerant may flow through multiple manifolds in varying configurations. For instance, the refrigerant may flow from a first manifold of a first row to a second manifold of the first row and then through subsequent manifolds of a second row.

[0027] As shown in FIG. 3, heat exchanger 42 may be curved such that it extends along two or more sides of outdoor unit 16. This configuration may allow for increased heat transfer into or out of heat exchanger 42 by increasing the available heat transfer area. Heat exchanger 42 may be protected from damage by a protective mesh applied between heat exchanger 42 and a coil guard (not shown) which may be positioned on an externally-facing side of heat exchanger 42. Corner support members 48 may also be used to protect heat exchanger 42 from damage at a corner of outdoor unit 16. In addition, corner support members 48 may lend more strength and stability to outdoor unit 16 by supporting top panel 32 from base pan 34. The base pan 34 may be made of strong and durable materials in order to prevent rust and corrosion and help reduce vibration and noise. In addition, base pan 34 may be used to collect condensation generated by heat exchanger 42. The condensation collected in base pan 34 may subsequently be removed before it re-freezes. The main interior portion of outdoor unit 16 may be separated from a cabinet portion of outdoor unit 16 by cabinet wall 50. As described with respect to FIG. 2, the cabinet portion may contain several of the major components of outdoor unit 16.

[0028] For instance, compressor 52 serves to compress a refrigerant vapor received through vapor valve 28. The compressed refrigerant may then flow through heat exchanger 42. Compressor 52 may be any suitable compressor such as a screw compressor, reciprocating compressor, rotary compressor, centrifugal compressor, swing link compressor, scroll compressor, or turbine compressor. In addition, compressor 52 may be a single-stage or multiple-stage compressor, e.g., a two-stage compressor. A single-stage compressor is generally one that includes a single output capacity. Conversely, a multiple-stage compressor is a compressor that has multiple output capacities. Compressor 52 may be protected against excessive pressures and temperatures by means of high-pressure relief valves, high and low pressure controls, temperature sensors, and so forth. In addition, in certain embodiments, a molded composite bulkhead may be used to isolate compressor 52 from the rest of the unit to reduce noise and vibration. Furthermore, cushioned compressor mounts may further mitigate noise and vibration generated by compressor 52.

[0029] In addition to compressor 52, other suitable components may be used for processing the refrigerant. For instance,

accumulator 54 may be used to prevent liquid refrigerant from entering the suction side of compressor 52. This may prove beneficial since, if refrigerant did enter the suction side of compressor 52, the oil that lubricates the bearings might be washed out of compressor 52 or the refrigerant liquid might damage the compression mechanism, since liquid is incompressible. In addition, filter/dryer 56 may be used to remove impurities in the refrigerant (e.g. flash or carbon material from brazing) and also any moisture in the refrigerant.

[0030] Control circuitry 58 may be used to control the operation of outdoor unit 16. Control circuitry 58 may include any suitable processors, memory, computers, relays, and so forth. One exemplary function of control circuitry 58 may be to control refrigerant flow through heat exchanger 42 using relays, solenoids, and/or temperature and pressure sensors. The number of relays, solenoids, and/or sensors used may be varied in specific embodiments based upon the degree of control desired for the flow of refrigerant. The sensors may be coupled to control circuitry 58 for directing signals representative of the sensed parameters to control circuitry 58. In operation, the control circuitry may regulate the compressor's pumping rate in order to control the rate of refrigerant circulation through heat exchanger 42.

[0031] Specifically, refrigerant may be received in manifold 44 and circulated through the multichannel flow paths of heat exchanger 42 to manifold 46. Manifolds 44 and 46 and the flow paths may be configured to provide multiple passes through heat exchanger 42 (e.g., from manifold 44 to manifold 46 and returning back to manifold 44). Control circuitry 58 may receive signals from the sensors and regulate the compressor's pumping rate in order to control flow through heat exchanger 42 based upon the sensed signals. Control circuitry 58 may also provide power and control signals to the compressor.

[0032] FIG. 4 shows an air conditioning system 60, which may employ outdoor horizontal discharge units. Refrigerant flows through air conditioning system 60 within a closed refrigeration loop 62. The refrigerant may be any fluid that absorbs and extracts heat. For example, the refrigerant may be hydrofluorocarbon based R-410A, R-407, or R-134a, or it may be carbon dioxide (R-744a) or ammonia (R-717). Air conditioning system 60 includes control devices 64 that enable the system to cool an environment to a prescribed temperature.

[0033] Air conditioning system 60 cools an environment by cycling refrigerant within closed refrigeration loop 62 through a condenser 66, a compressor 68, an expansion device 70, and an evaporator 72. The refrigerant enters condenser 66 as a high pressure and temperature vapor and flows through the multichannel tubes of the condenser. A fan 74, which may be driven by a motor 76, blows air across the multichannel tubes and fins. As the air flows across the tubes and fins, heat transfers from the refrigerant vapor to the air, producing heated air 78 and causing the refrigerant vapor to condense into a liquid. The liquid refrigerant then flows into expansion device 70 where the refrigerant expands to become a low pressure and temperature liquid or vapor/liquid mixture. Typically, expansion device 70 will be a thermal expansion valve. However, according to other exemplary embodiments, expansion device 70 may be an orifice or a capillary tube. After the refrigerant exits expansion device 70, some vapor refrigerant may be present in addition to the liquid refrigerant.

[0034] From expansion device 70, the refrigerant enters evaporator 72 and flows through the evaporator multichannel tubes. A blower 80, which is driven by a motor 82, draws or blows air across the multichannel tubes. As the air flows across the tubes, heat transfers from the air to the refrigerant liquid, producing cooled air 84 and causing the refrigerant liquid to boil into a vapor.

[0035] The refrigerant then flows to compressor 68 as a low pressure and temperature vapor. Compressor 68 reduces the volume available for the refrigerant vapor, consequently increasing the pressure and temperature of the vapor refrigerant. Compressor 68 may be any suitable compressor such as a screw compressor, reciprocating compressor, rotary compressor, centrifugal compressor, swing link compressor, scroll compressor, or turbine compressor. Compressor 68 may be driven by a motor 86 that receives power from a variable speed drive or a direct AC or DC power source. According to an exemplary embodiment, motor 86 may receive fixed line voltage and frequency from an AC power source although in certain applications motor 86 may be driven by a variable voltage or frequency drive. Motor 86 may be a switched reluctance motor, an induction motor, an electronically commutated permanent magnet motor, or any other suitable motor type. The refrigerant exits compressor 68 as a high temperature and pressure vapor that is ready to enter condenser 66 and begin the refrigeration cycle again.

[0036] Control devices 64, which include control circuitry 88, an input device 90, and a temperature sensor 92, may govern the operation of the refrigeration cycle. Control circuitry 88 may be coupled to motors 76, 82, and 86 that drive condenser fan 74, evaporator blower 80, and compressor 68, respectively. Control circuitry 88 may use information received from input device 90 and temperature sensor 92 to determine when to operate motors 76, 82, and 86 that drive air conditioning system 60. In certain applications, input device 90 may be a conventional thermostat. However, input device 90 is not limited to thermostats and, more generally, any source of a fixed or changing set point may be employed. These may include local or remote command devices, computer systems and processors, and mechanical, electrical and electromechanical devices that manually or automatically set a temperature-related signal that the system receives. For example, in a residential air conditioning system, input device 90 may be a programmable thermostat that provides a temperature set point to control circuitry 88. Temperature sensor 92 may determine the ambient air temperature and provide the temperature to control circuitry 88. Control circuitry 88 may then compare the temperature received from temperature sensor 92 to the temperature set point received from input device 90. If the temperature is higher than the set point, control circuitry 88 may turn on motors 76, 82, and 86 to run air conditioning system 60. Control circuitry 88 may execute hardware or software control algorithms to regulate air conditioning system 60. According to exemplary embodiments, control circuitry 88 may include an analog-to-digital converter, a microprocessor, a non-volatile memory, and an interface board. Other devices may be included in the system, such as additional pressure and/or temperature transducers or switches that sense temperatures and pressures of the refrigerant, the heat exchangers, the inlet and outlet air, and so forth.

[0037] FIG. 5 shows a heat pump system 94 that may employ outdoor horizontal discharge units. Because heat pump system 94 may be used for both cooling and heating,

refrigerant may flow through a reversible cooling/heating loop 96. The refrigerant may be any fluid that absorbs and extracts heat. The heating and cooling operations are regulated by control devices 98.

[0038] Heat pump system 94 may include an outside coil 100 and an inside coil 102 that both operate as heat exchangers. Coils 100 and 102 may function either as an evaporator or a condenser depending on the operation mode of heat pump system 94. For example, when heat pump system 94 is operating in cooling mode, outside coil 100 functions as a condenser, releasing heat to the outside air, while inside coil 102 functions as an evaporator, absorbing heat from the inside air. When heat pump system 94 is operating in heating mode, outside coil 100 functions as an evaporator, absorbing heat from the outside air, while inside coil 102 functions as a condenser, releasing heat to the inside air. A reversing valve 104 may be positioned on reversible refrigeration/heating loop 96 between coils 100 and 102 to control the direction of refrigerant flow and thereby to switch heat pump system 94 between heating mode and cooling mode.

[0039] Heat pump system 94 may also include two metering devices 106 and 108 for decreasing the pressure and temperature of the refrigerant before it enters the evaporator. The metering device used may depend on the operation mode of heat pump system 94. According to other exemplary embodiments, a single metering device may be used for both heating mode and cooling mode. Metering devices 106 and 108 are typically thermal expansion valves, but also may be orifices or capillary tubes.

[0040] The refrigerant enters the evaporator, which is outside coil 100 in heating mode and inside coil 102 in cooling mode, as a low temperature and pressure liquid or vapor/liquid mixture. Some vapor refrigerant also may be present as a result of the expansion process that occurs in metering device 106 or 108. The refrigerant flows through multichannel tubes in the evaporator and absorbs heat from the air changing the refrigerant into a vapor. In cooling mode, the indoor air flowing across the multichannel tubes also may be dehumidified. The moisture from the air may condense on the outer surface of the multichannel tubes and consequently be removed from the air.

[0041] After exiting the evaporator, the refrigerant passes through reversing valve 104 and into a compressor 110. Compressor 110 decreases the volume of the refrigerant vapor, thereby increasing the temperature and pressure of the vapor. Compressor 110 may be any suitable compressor such as a screw compressor, reciprocating compressor, rotary compressor, centrifugal compressor, swing link compressor, scroll compressor, or turbine compressor.

[0042] From compressor 110, the increased temperature and pressure vapor refrigerant flows into a condenser, the location of which is determined by the heat pump mode. In cooling mode, the refrigerant flows into outside coil 100 (acting as a condenser). A fan 112, which is powered by a motor 114, blows air across the multichannel tubes containing refrigerant vapor. The heat from the refrigerant is transferred to the outside air causing the refrigerant to condense into a liquid. In heating mode, the refrigerant flows into inside coil 102 (acting as a condenser). A blower 116, which is powered by a motor 118, draws air across the multichannel tubes containing refrigerant vapor. The heat from the refrigerant is transferred to the inside air causing the refrigerant to condense into a liquid. After exiting the condenser, the refrigerant flows through the metering device (106 in heating mode

and 108 in cooling mode) and returns to the evaporator (outside coil 100 in heating mode and inside coil 102 in cooling mode) where the process begins again.

[0043] In both heating and cooling modes, a motor 120 drives compressor 110 and circulates refrigerant through reversible refrigeration/heating loop 96. Motor 120 may receive power either directly from an AC or DC power source or from a variable speed drive. Motor 120 may be a switched reluctance motor, an induction motor, an electronically commutated permanent magnet motor, or any other suitable motor type.

[0044] The operation of motor 120 may be controlled by control circuitry 122. Control circuitry 122 may be coupled to motors 114, 118, and 120 that drive outdoor fan 112, indoor blower 116, and compressor 110, respectively. Control circuitry 122 may receive information from an input device 124 and sensors 126, 128, and 130 and use the information to control the operation of heat pump system 94 in both cooling mode and heating mode. For example, in cooling mode, input device 124 may provide a temperature set point to control circuitry 122. Sensor 130 may measure the ambient indoor air temperature and provide it to control circuitry 122. Control circuitry 122 then may compare the air temperature to the temperature set point and engage motors 114, 118, and 120 to run the cooling system if the air temperature is above the temperature set point. In heating mode, control circuitry 122 may compare the air temperature from sensor 130 to the temperature set point from input device 124 and engage motors 114, 118, and 120 to run the heating system if the air temperature is below the temperature set point.

[0045] Control circuitry 122 may also use information received from input device 124 to switch heat pump system 94 between heating mode and cooling mode. For example, if input device 124 is set to cooling mode, control circuitry 122 may send a signal to a solenoid 132 to place reversing valve 104 in an air conditioning position 134. Consequently, the refrigerant may flow through reversible refrigeration/heating loop 96 as follows: the refrigerant exits compressor 110, is condensed in outside coil 100, is expanded by metering device 108, and is evaporated by inside coil 102. If the input device is set to heating mode, control circuitry 122 may send a signal to solenoid 132 to place reversing valve 104 in a heat pump position 136. Consequently, the refrigerant may flow through the reversible loop 96 as follows: the refrigerant exits compressor 110, is condensed in inside coil 102, is expanded by metering device 106, and is evaporated by outside coil 100.

[0046] Control circuitry 122 also may initiate a defrost cycle when heat pump system 94 is operating in heating mode. When the outdoor temperature approaches freezing, moisture in the outside air that is directed over outside coil 100 may condense and freeze on the coil. Sensor 126 may measure the outside air temperature and sensor 128 may measure the temperature of outside coil 100. These sensors 126 and 128 may provide the temperature information to control circuitry 122 which may determine when to initiate a defrost cycle. For example, if either sensor 126 or 128 provides a temperature below freezing to the control circuitry, heat pump system 94 may be placed in defrost mode. In defrost mode, solenoid 132 may be actuated to place reversing valve 104 in air conditioning position 134, and motor 114 may be shut off to discontinue air flow over the multichannel tubes. Heat pump system 94 may then operate in cooling mode until the increased temperature and pressure refrigerant flowing through outside coil 100 defrosts the coil. Once sen-

sor 128 detects that coil 100 is defrosted, control circuitry 122 may return the reversing valve 104 to heat pump position 136. As will be appreciated by those skilled in the art, the defrost cycle can be set to occur at many different time and temperature combinations.

[0047] Control circuitry 122 may execute hardware or software control algorithms to regulate heat pump system 94. According to exemplary embodiments, control circuitry 122 may include an analog-to-digital converter, a microprocessor, a non-volatile memory, and an interface board.

[0048] FIG. 6 is a perspective view of an exemplary heat exchanger 42 that may be used in air conditioning system 60, shown in FIG. 4, or heat pump system 94, shown in FIG. 5. Heat exchanger 42 may be a condenser 66 or an evaporator 72, as shown in FIGS. 4 and 5. Heat exchanger 42 may include manifolds 44 and 46 that are connected by multichannel tubes 138. Although thirty tubes are shown in FIG. 6, the number of tubes may vary. Manifolds 44 and 46 and tubes 138 may be constructed of aluminum or any other material that promotes heat transfer. Refrigerant may flow from manifold 44 through a first plurality of tubes 140 to manifold 46. The refrigerant then may return to manifold 44 in an opposite direction through a second plurality of tubes 142. First tubes 140 may have the same configuration as second tubes 142 or first tubes 140 may have a different configuration from second tubes 142. Although multichannel tubes 138 are depicted as having an oblong shape, tubes 138 may be any shape, such as tubes with a cross-section in the form of a rectangle, square, circle, oval, ellipse, triangle, trapezoid, or parallelogram. It should also be noted that heat exchanger 42 may be provided in a single slab or in multiple slabs and may include bends, corners, contours, and so forth.

[0049] According to certain exemplary embodiments, the construction of first tubes 140 may differ from the construction of second tubes 142. For example, the tubes of heat exchanger 42 may have different cross-sections, such as where the tubes in a first portion of heat exchanger 42 may be rectangular while the tubes in a second portion of heat exchanger 42 may be oval. The internal construction of the tubes may also vary such that the internal flow paths are of different configurations.

[0050] Refrigerant may enter heat exchanger 42 through an inlet 144 and exit heat exchanger 42 through an outlet 146. Although FIG. 6 shows inlet 144 at the top of manifold 44 and outlet 146 at the bottom of manifold 44, inlet 144 and outlet 146 positions may be interchanged so that the fluid enters at the bottom and exits at the top. The refrigerant also may enter and exit manifold 44 from multiple inlets and outlets positioned on bottom, side, or top surfaces of the manifold. Baffles 148 may separate the inlet and outlet portions of manifold 44. Any number of one or more baffles 148 may be employed to create separation of the inlet and outlet portions. It should also be noted that according to other exemplary embodiments, inlet 144 and outlet 146 may be contained on separate manifolds, eliminating the need for baffle 148.

[0051] Fins 150 are located between multichannel tubes 138 to promote the transfer of heat between tubes 138 and fins 150 and the environment. According to an exemplary embodiment, fins 150 are constructed of aluminum, brazed or otherwise contacting tubes 138, and disposed generally perpendicular to the flow of refrigerant. However, according to other exemplary embodiments, fins 150 may be made of other materials that facilitate heat transfer and may extend parallel

or at varying angles with respect to the flow of the refrigerant. Fins 150 may be louvered fins, corrugated fins, or any other suitable type of fin.

[0052] When air flows across multichannel tubes 138 and fins 150, as generally indicated by arrows 152, heat transfer occurs between the refrigerant flowing within tubes 138 and the air. Typically, air flows through fins 150 contacting the upper and lower sides of multichannel tubes 138. The air first contacts multichannel tubes 138 and fins 150 at a leading edge 154, then flows across the width of the tubes and fins, and lastly contacts a trailing edge 156 of the tubes and fins. As the air flows across the tubes and fins, heat is transferred to the tubes and fins from the refrigerant and from the tubes and fins to the air. For example, in a condenser, the air is generally cooler than the refrigerant flowing within the multichannel tubes 138. As the air contacts the leading edge of a multichannel tubes 138 and fins 150, heat is transferred from the refrigerant within the multichannel tube 138 to the air. Consequently, the air is heated as it passes over the multichannel tubes 138 and fins 150 and the refrigerant flowing within the multichannel tubes 138 is cooled. In an evaporator, the air generally has a temperature higher than the refrigerant flowing within the multichannel tubes 138. Consequently, as the air contacts the leading edge of the multichannel tubes 138 and fins 150, heat is transferred from the air to the refrigerant flowing in the multichannel tubes 138, thereby heating the refrigerant. The air leaving the multichannel tubes 138 and fins 150 is then cooled because the heat has been transferred to the refrigerant.

[0053] FIG. 7 is a detailed perspective view of tubes 138 and fins 150 illustrated in FIG. 6, sectioned through tubes 138 and fins 150. Air, indicated generally by arrows 152, flows through fins 150 and across a width A of tubes 138, contacting the upper and lower surfaces of tubes 138 and fins 150. Fins 150 promote heat transfer between the refrigerant flowing within tubes 138 and the air flowing across the tubes 138 and fins 150. The air first contacts a leading edge 154, flows across width A of a tube 138 and fins 150, and lastly contacts a trailing edge 156. Refrigerant flows within multichannel tubes 138 through flow paths 158 in a direction generally perpendicular to the direction of air flow 152. Each tube 138 has a width A across which the external fluid 152 passes. Each tube 138 also has a height B, which may be larger or smaller than width A. As the air flows across width A of the multichannel tubes 138 and fins 150, heat is transferred between the refrigerant and the air. The temperature difference between the refrigerant and the air is typically the greatest at leading edge 154 because no, or minimal, heat transfer has occurred between the air and the refrigerant. Specifically, as the air flows across tube width A, the air absorbs or transfers heat from or to the refrigerant within the tubes. Because of the heat transfer, the temperature of the air approaches the temperature of the refrigerant as the air travels across the width. Therefore, more heat transfer may occur at leading edge 154 of the tubes and fins (where the temperature difference is generally greatest) than at trailing edge 156 (where the temperature difference is generally smallest).

[0054] FIG. 8 shows certain components of heat exchanger 42 of FIG. 6 in a somewhat more detailed exploded view. Each manifold (manifold 44 being shown in FIG. 8) may be a tubular structure with open ends that are closed by a cap 160. Openings, or apertures, 162 may be formed in the manifolds, such as by conventional piercing operations. Multichannel tubes 138 may then be inserted into openings 162 in a gener-

ally parallel fashion. Ends 164 of the tubes are inserted into openings 162 so that refrigerant may flow from the manifold into flow paths within the tubes. During insertion of the tubes within the manifold, leading edge 154 and trailing edge 156 may be determined by the orientation of the tubes. In certain manufacturing processes, leading edge 154 and trailing edge 156 may be marked on the tube 138 using a process such as stamping, allowing leading edge 154 and trailing edge 156 of each tube 138 to be lined up in parallel during insertion. Fins 150 may then be inserted between the tubes 138 to promote heat transfer between air and the refrigerant flowing within the tubes.

[0055] It should be noted that while the tubes of heat exchanger 42 have been presented herein as multichannel tubes 138, the outdoor unit may also utilize other heat exchanger tubes such as, but not limited to, fin/tube designs. In addition, while the manifolds and multichannel tubes have been illustrated herein as aligned vertically and horizontally, respectively, the outdoor unit may also utilize other configurations. For example, the manifolds may be aligned horizontally with the multichannel tubes aligned vertically.

[0056] FIGS. 9A and 9B are sectional views of exemplary outdoor units 16. Outdoor unit 16 may consist of four sides—an air intake side 166, a cabinet side 168, a primary air discharge side 170, and a secondary air discharge side 172. An internal cabinet may be located along cabinet side 168 and may contain major components for operating outdoor unit 16, such as refrigerant conduit 12 connections, compressor 52, accumulator 54 (not shown), filter/dryer 56 (not shown), control circuitry 58, and so forth. In the embodiment shown in FIG. 9A, heat exchanger 42 may be curved such that heat exchanger 42 extends along the perimeter of both primary and secondary air discharge sides 170 and 172. Specifically, manifold 44 may be located on primary air discharge side 170 near refrigerant conduit 12 connections and manifold 46 may be located on secondary air discharge side 172 near air intake side 166. Air may be drawn into outdoor unit 16 horizontally through air intake side 166 by fan 38, indicated generally by arrow 174, and blown through heat exchanger 42 horizontally, indicated generally by arrows 176 and 178. In a separate embodiment shown in FIG. 9B, heat exchanger 42 may only extend along primary air discharge side 170 with manifold 46 being located near the corner of primary and secondary air discharge sides 170 and 172. In this embodiment, secondary air discharge side 172 may include a panel 180 which precludes air from being discharged through secondary air discharge side 172.

[0057] In either embodiment, air may be drawn into outdoor unit 16 horizontally and blown through heat exchanger 42 horizontally by fan 38. This is in stark contrast to typical outdoor units which draw air into the unit through heat exchangers and subsequently blow the air out of the unit. In particular, these other outdoor units typically draw air into the unit horizontally through heat exchangers and discharge the air vertically through the top of the unit. Conversely, using the present techniques, outdoor unit 16 utilizes “blow-through” techniques as opposed to the typical “draw-through” techniques. The terms “blow-through” and “draw-through” pertain to how air is passed over the heat exchanger. Hence, using the present “blow-through” techniques, air may be blown through, as opposed to be drawn through, heat exchanger 42. The general industry consensus seems to be that draw-through techniques may achieve better air flow distribution across the coils of the heat exchanger. However, multichannel

tubes **138** of the present techniques may improve heat transfer such that air flow distribution is not as significant a design criteria as with typical fin/tube designs. In addition, the present techniques may lead to improved sound management since blow-through techniques in general may lead to less noise.

[0058] Using the present techniques, outdoor unit **16** may also allow for more efficient use of space. First, since air may be drawn into outdoor unit **16** horizontally by fan **38** and then blown over heat exchanger **42** horizontally, the air may follow a more direct path through outdoor unit **16**. As such, narrower footprints may be achieved by outdoor unit **16**. In addition, using the multichannel design of the present techniques may reduce the amount of heat transfer area required from heat exchanger **42**. This reduced area requirement may also allow for narrow footprints being used by outdoor unit **16**.

[0059] Moreover, the use of multichannel tubes for the heat exchanger, in conjunction with the use of a horizontal discharge of air enables a very efficient outdoor unit. That is, the added efficiency of the multichannel tubes, as compared to conventional tube and fin heat exchangers allows a single slab heat exchanger to be used. That is, in presently contemplated embodiments, the heat exchanger is generally planar, and includes a single planar set of tubes. Conventional horizontal discharge units using tube and fin heat exchangers have used multiple sets or planes of single-opening tubes, leading to additional cost, weight and size. The added efficiency also allows for blow-through of the circulated air, while maintaining excellent heat transfer ratings and low noise. It is believed that the arrangement of the multichannel tubes of the heat exchanger, which are typically parallel and have their cross sectional width generally along the path of air flow, may assist in reducing the noise emitted by the unit in operation.

[0060] While only certain features and embodiments of the invention have been illustrated and described, many modifications and changes may occur to those skilled in the art (e.g., variations in sizes, dimensions, structures, shapes and proportions of the various elements, values of parameters (e.g., temperatures, pressures, etc.), mounting arrangements, use of materials, colors, orientations, etc.) without materially departing from the novel teachings and advantages of the subject matter recited in the claims. The order or sequence of any process or method steps may be varied or re-sequenced according to alternative embodiments. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes as fall within the true spirit of the invention. Furthermore, in an effort to provide a concise description of the exemplary embodiments, all features of an actual implementation may not have been described (i.e., those unrelated to the presently contemplated best mode of carrying out the invention, or those unrelated to enabling the claimed invention). It should be appreciated that in the development of any such actual implementation, as in any engineering or design project, numerous implementation specific decisions may be made. Such a development effort might be complex and time consuming, but would nevertheless be a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit of this disclosure, without undue experimentation.

1. An outdoor heating, ventilating, air conditioning or refrigeration unit, comprising:
 - a heat exchanger, comprising:
 - a plurality of manifolds;
 - a plurality of multichannel tubes in fluid communication with the manifolds, each multichannel tube comprising

- ing a plurality of parallel flow paths through which an internal fluid flows, each flow path extending lengthwise through its respective multichannel tube; and
 - a plurality of fins disposed between the multichannel tubes for transferring heat between the external air and the internal fluid flowing through the flow paths; and
- a fan configured to blow air horizontally through the heat exchanger such that the air exits the unit horizontally through at least one side of the unit.
- 2. The unit of claim 1, wherein the unit comprises an air conditioning unit.
- 3. The unit of claim 1, wherein the unit comprises a heat pump unit.
- 4. The unit of claim 1, wherein the unit comprises an accumulator for storing internal fluid.
- 5. The unit of claim 1, wherein the fan comprises swept wing fan blades.
- 6. The unit of claim 1, wherein the fan is configured to draw air into the unit horizontally.
- 7. The unit of claim 1, wherein the heat exchanger is a single slab heat exchanger.
- 8. The unit of claim 1, wherein the heat exchanger is configured such that air blowing through the heat exchanger discharges horizontally through two sides of the unit.
- 9. The unit of claim 1, wherein the manifolds are aligned vertically and the multichannel tubes are aligned horizontally.
- 10. The unit of claim 1, wherein the manifolds are aligned horizontally and the multichannel tubes are aligned vertically.
- 11. The unit of claim 1, wherein a first manifold is separated into an inlet portion and an outlet portion by a baffle, wherein the internal fluid enters the heat exchanger through the inlet portion and exits the heat exchanger through the outlet portion.
- 12. The unit of claim 11, wherein the internal fluid flows from the inlet portion of the first manifold to a second manifold and from the second manifold to the outlet portion of the first manifold.
- 13. A method of operating an outdoor heating, ventilating, air conditioning or refrigeration unit, comprising:
 - drawing air into the unit via a fan;
 - blowing the air from the fan through a heat exchanger; and
 - discharging the air from the unit horizontally through at least one side of the unit.
- 14. The method of claim 13, wherein the heat exchanger comprises
 - a plurality of manifolds;
 - a plurality of multichannel tubes in fluid communication with the manifolds, each multichannel tube comprising
 - a plurality of parallel flow paths through which an internal fluid flows, each flow path extending lengthwise through its respective multichannel tube; and
 - a plurality of fins disposed between the multichannel tubes for transferring heat to or from the internal fluid flowing through the flow paths.
- 15. The method of claim 13, wherein the heat exchanger is a single slab heat exchanger.
- 16. The method of claim 13, wherein the air is drawn into the unit horizontally through one side of the unit.
- 17. The method of claim 13, wherein the unit comprises an air conditioning unit and the heat exchanger comprises a condenser.

18. The method of claim **13**, wherein the unit comprises a heat pump unit and the heat exchanger comprises an evaporator.

19. The method of claim **13**, wherein the heat exchanger extends along at least one side of the unit.

20. A heating, ventilating, air conditioning or refrigeration system comprising: an outdoor unit, comprising:

a compressor configured to compress a gaseous refrigerant;

a heat exchanger configured to receive and to condense the compressed refrigerant, comprising:

a plurality of manifolds;

a plurality of multichannel tubes in fluid communication with the manifolds, each multichannel tube comprising a plurality of parallel flow paths through which the

compressed refrigerant flows, each flow path extending lengthwise through its respective multichannel tube; and

a plurality of fins disposed between the multichannel tubes for transferring heat between the external air and the compressed refrigerant flowing through the flow paths; and

a fan configured to blow air horizontally through the heat exchanger such that the air exits the outdoor unit horizontally through at least one side of the unit; and

an expansion device configured to reduce pressure of the refrigerant; and

an evaporator configured to evaporate the refrigerant prior to returning the refrigerant to the compressor.

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