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(54) HORIZONTAL DISCHARGE AIR CONDITIONING UNIT

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(52) **U.S. Cl.** **62/498**; 165/81; 165/104.34; 62/56; 62/515

(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.

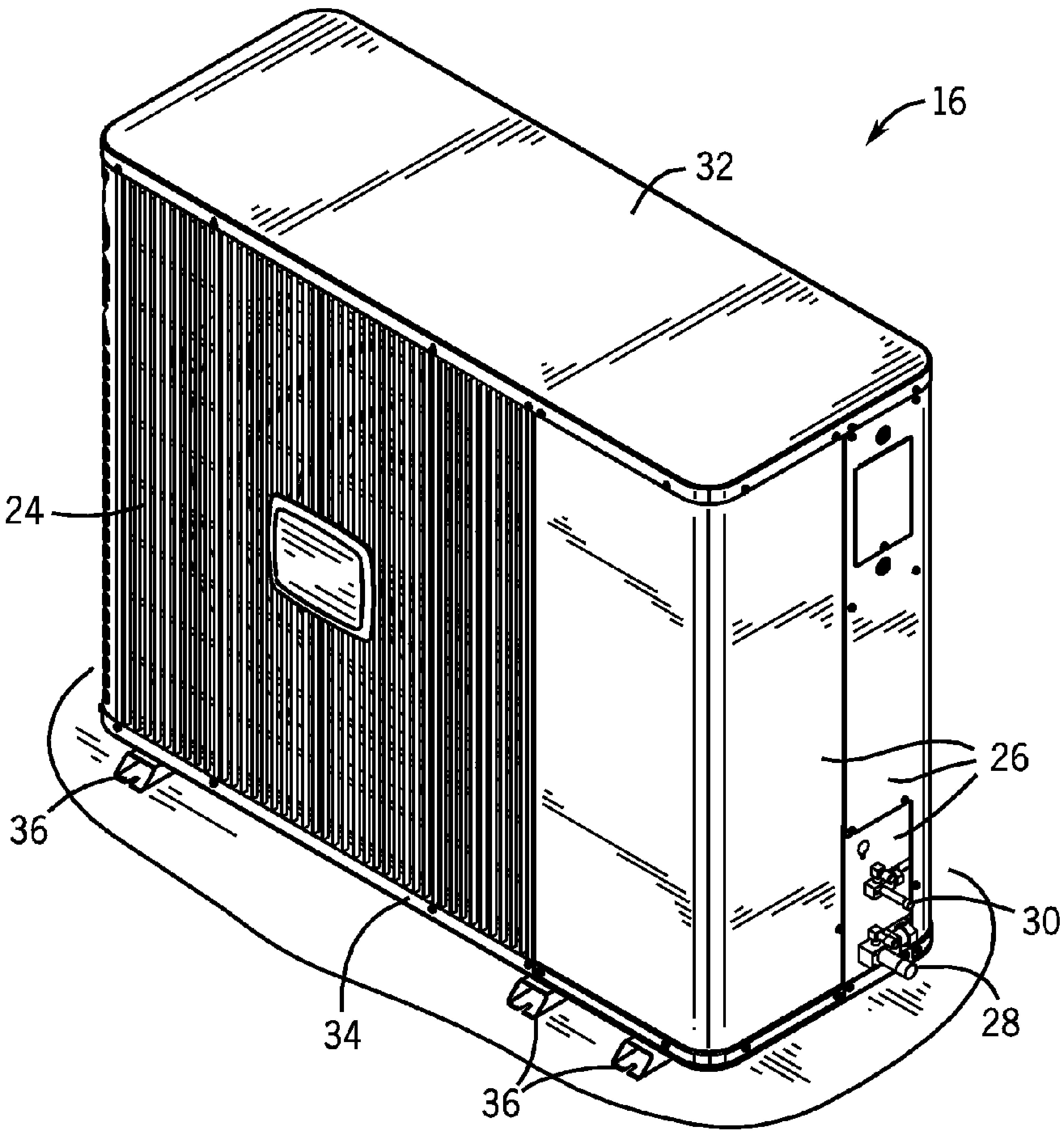
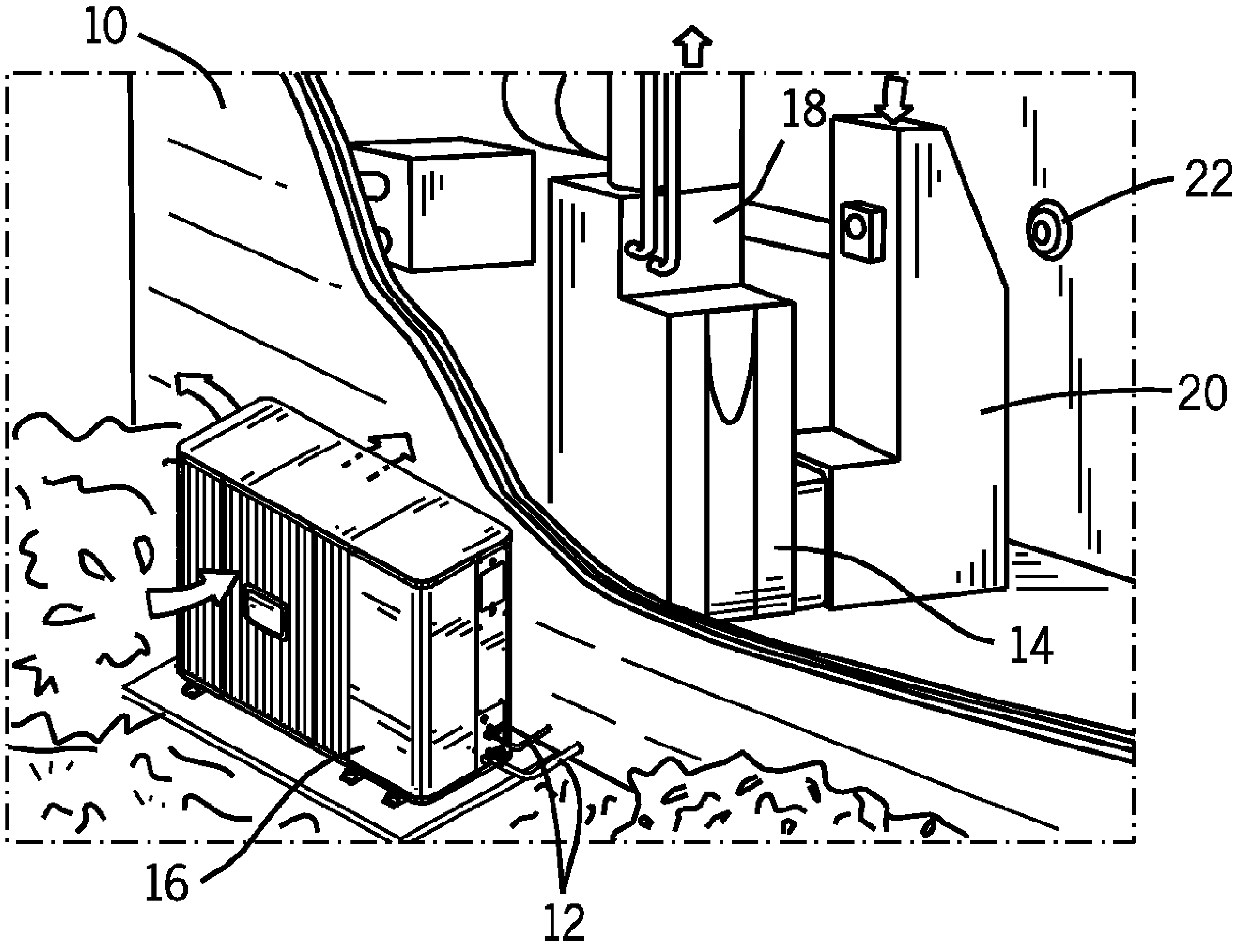


FIG. 1



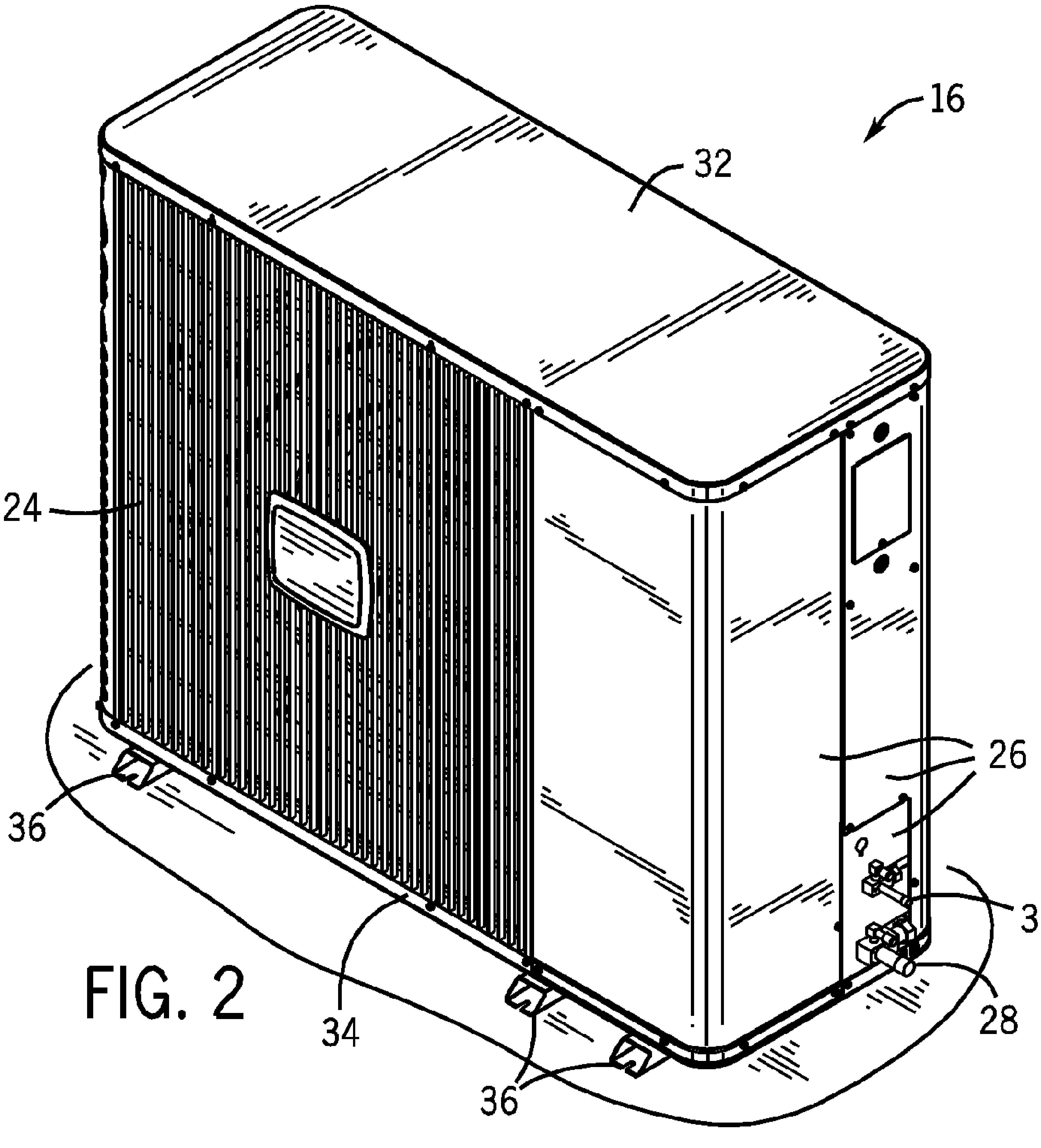


FIG. 2

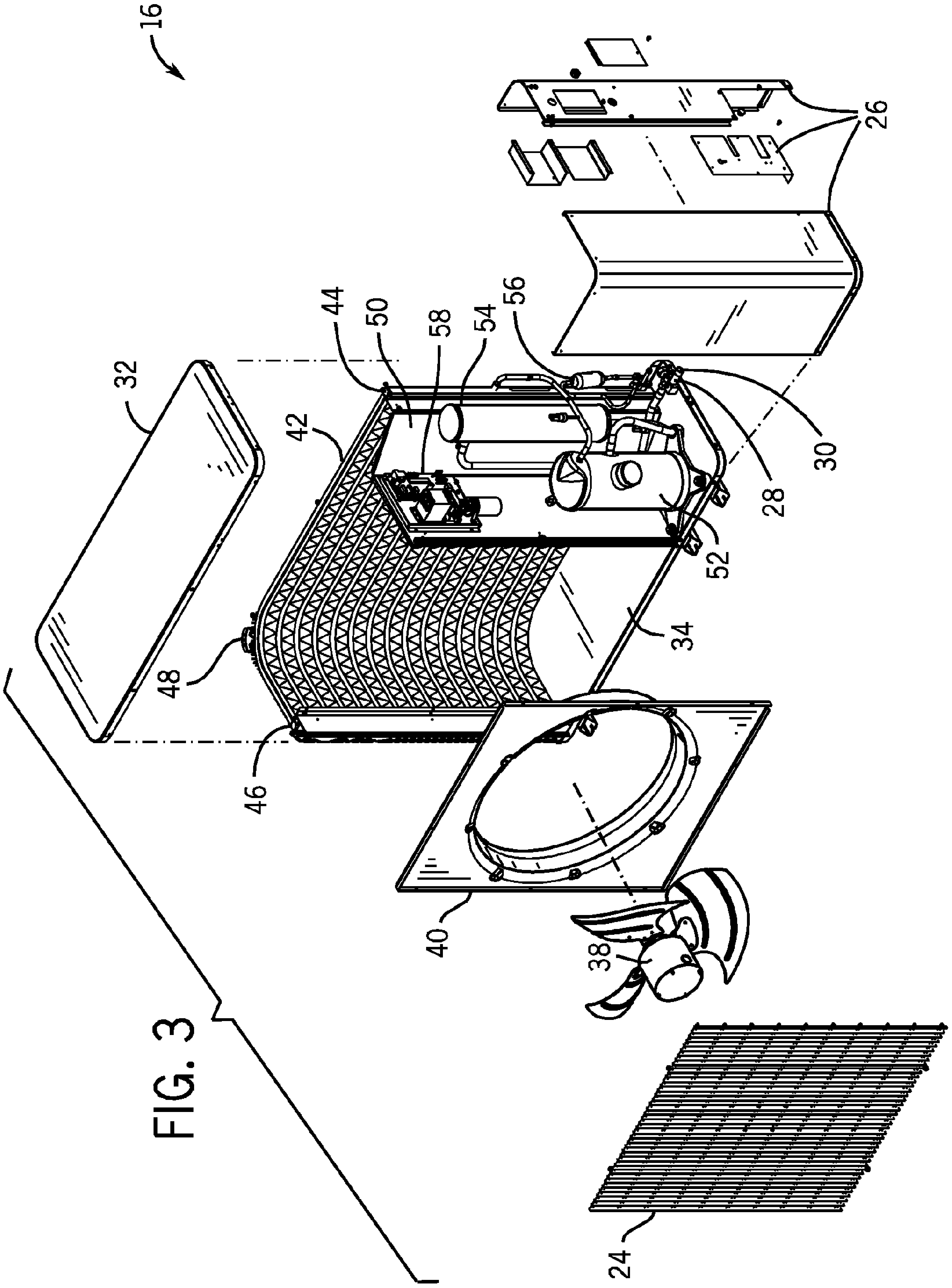


FIG. 3

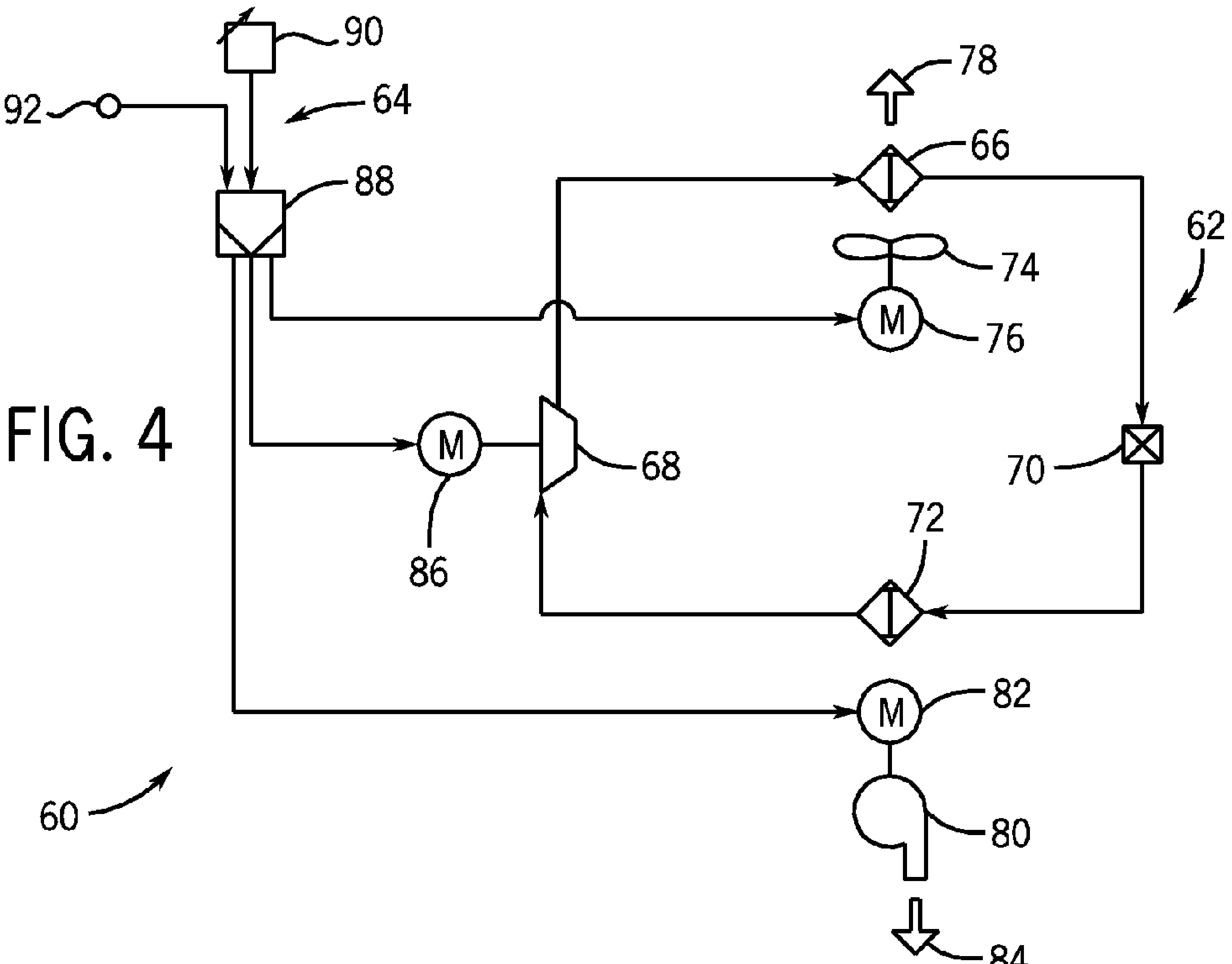

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FIG. 4

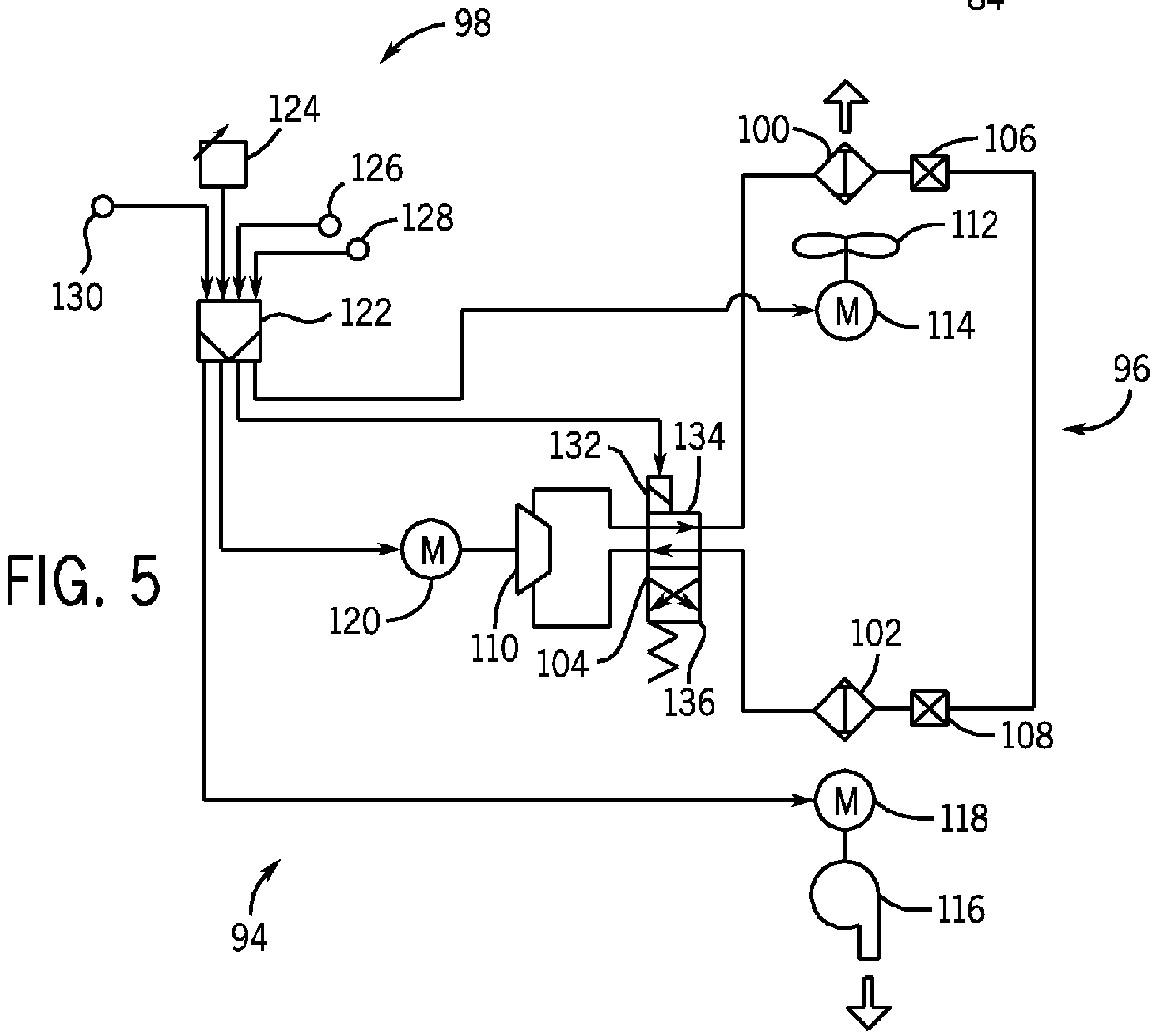
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FIG. 5

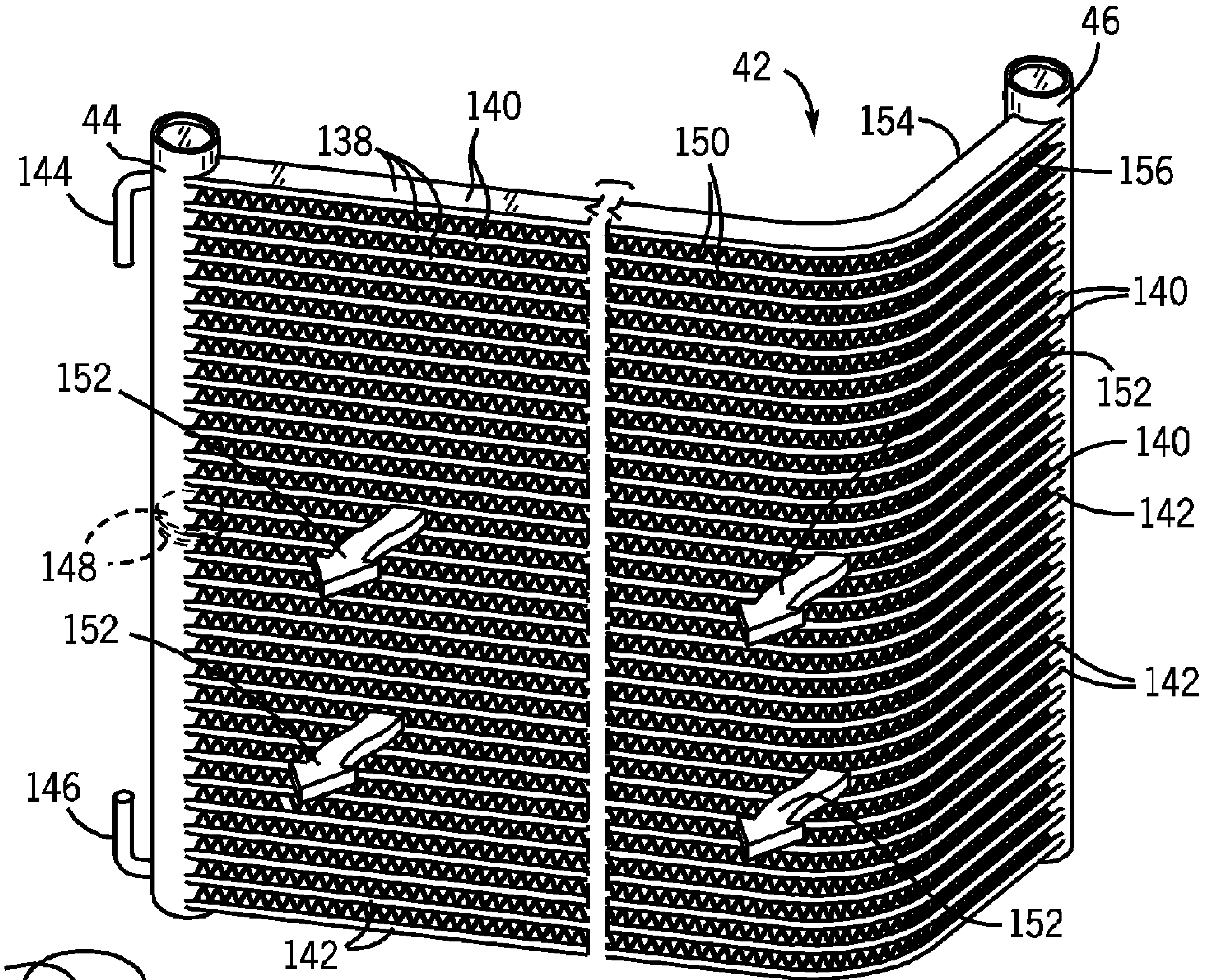


FIG. 6

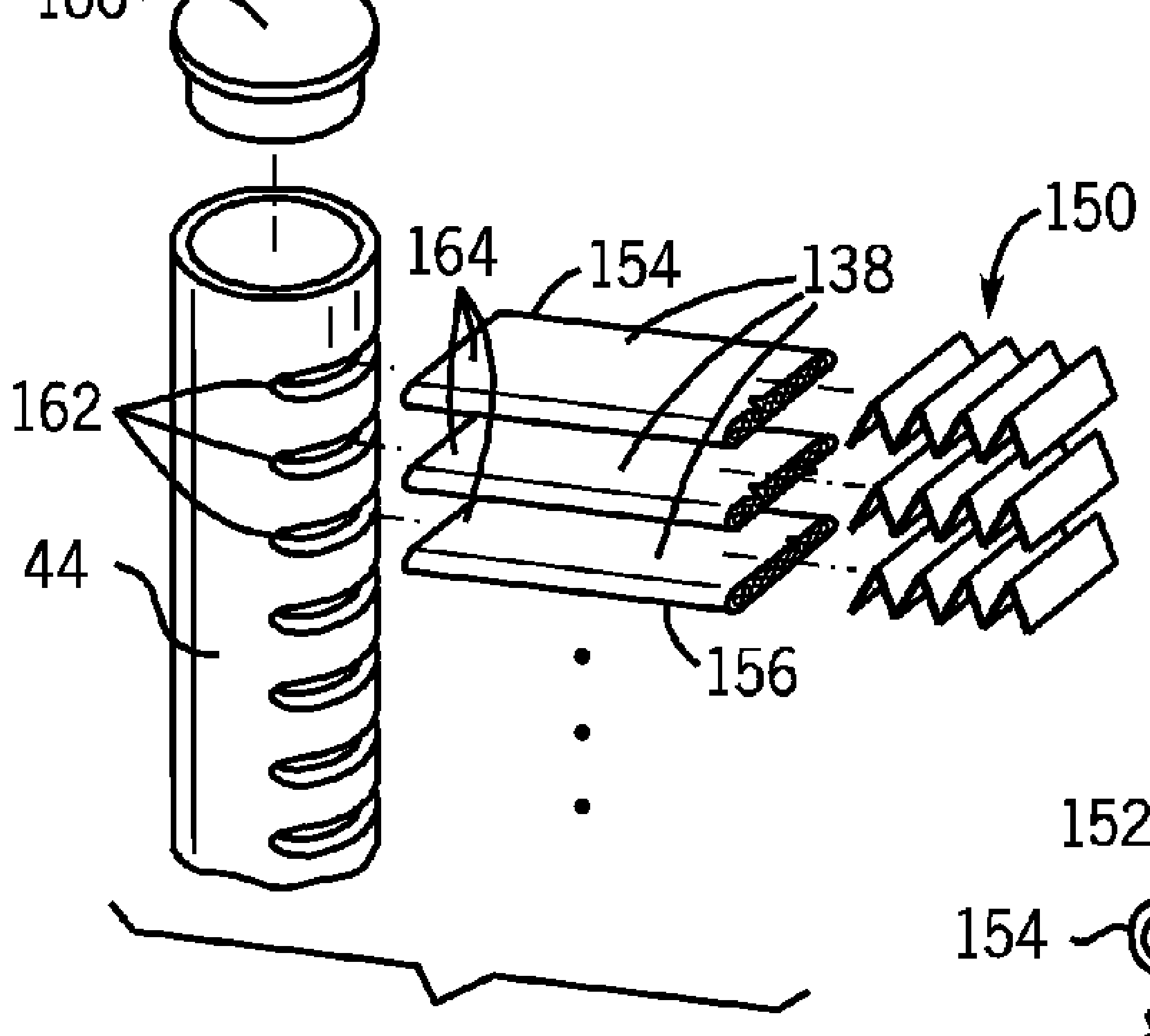
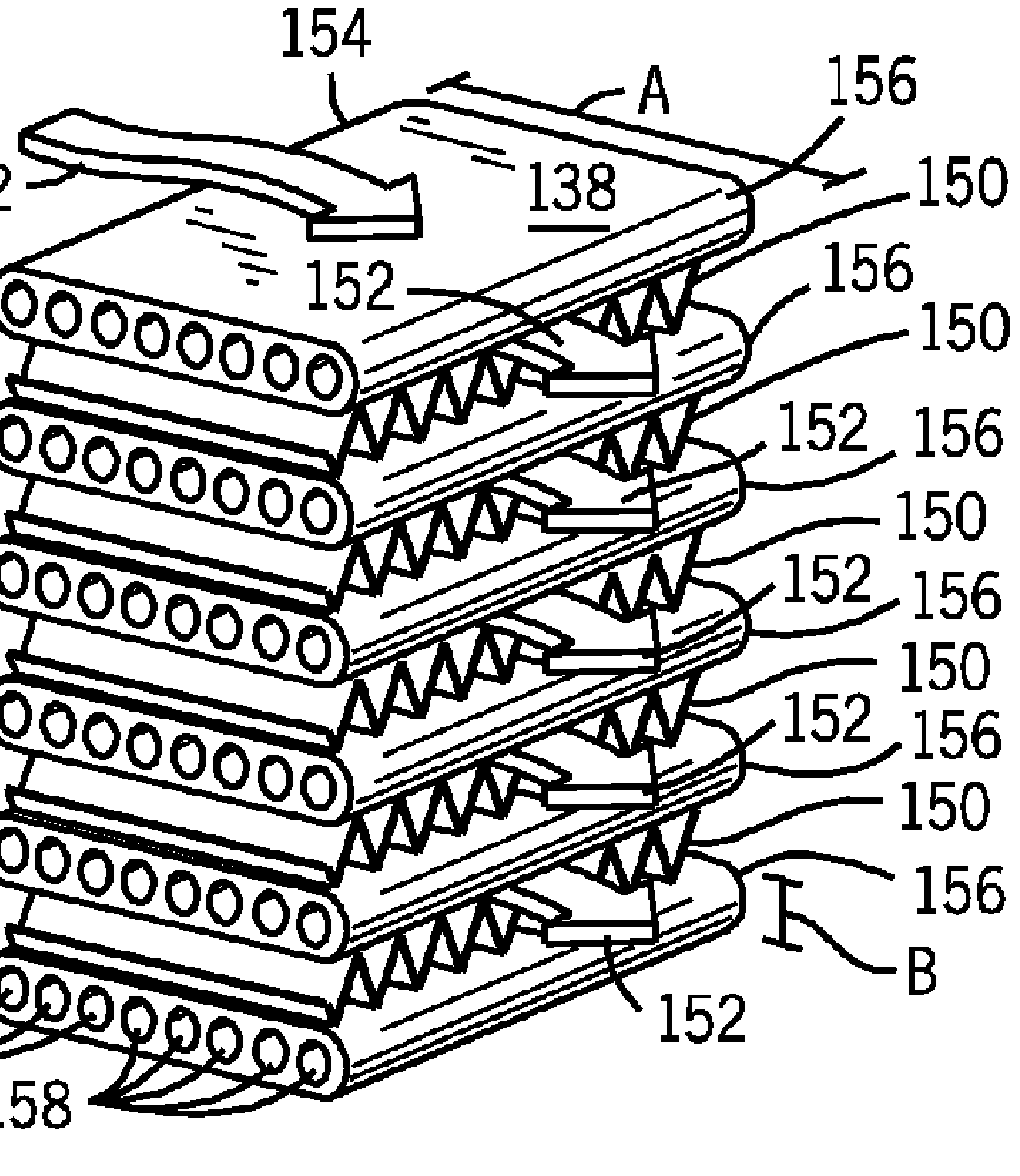


FIG. 8

FIG. 7



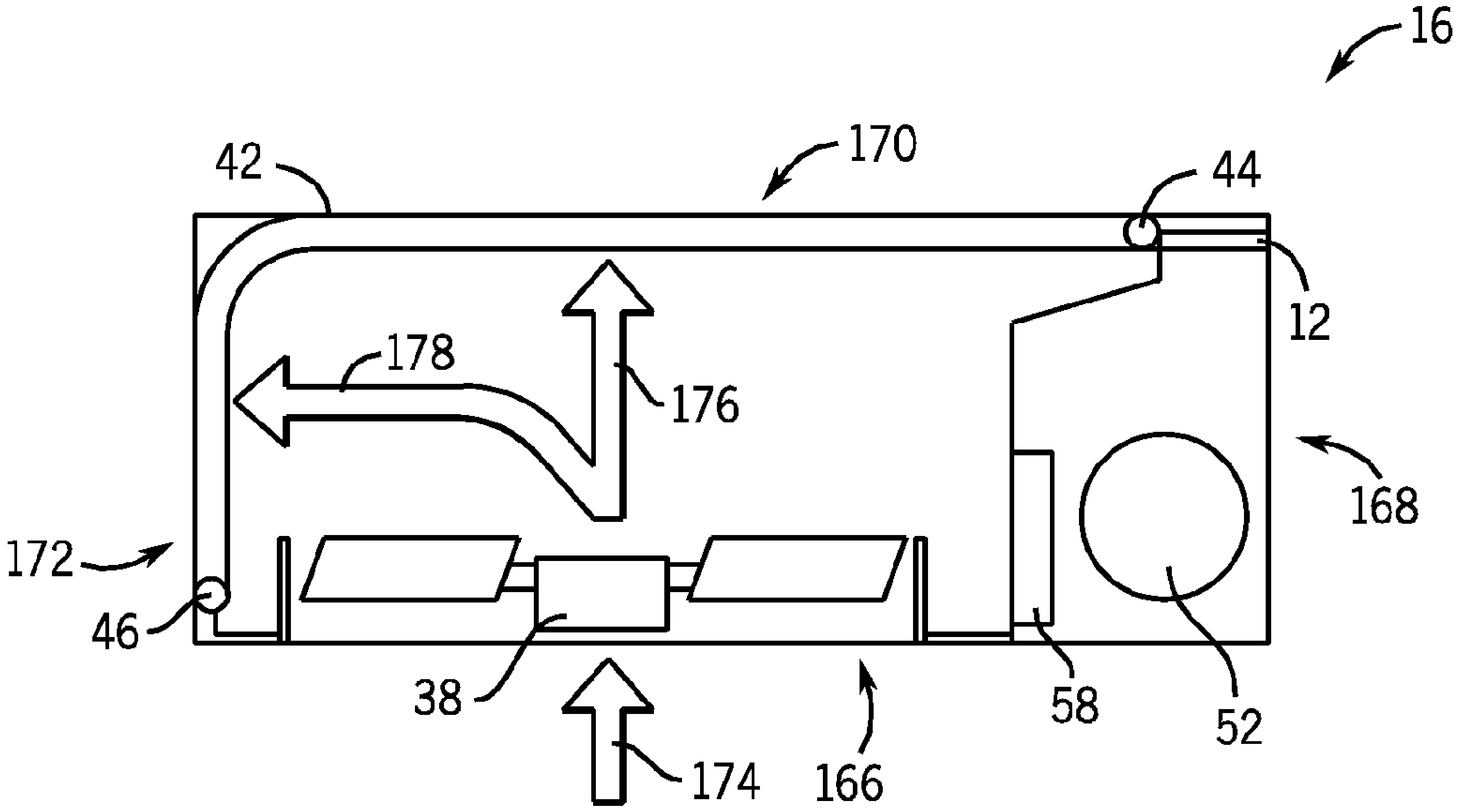

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FIG. 9A

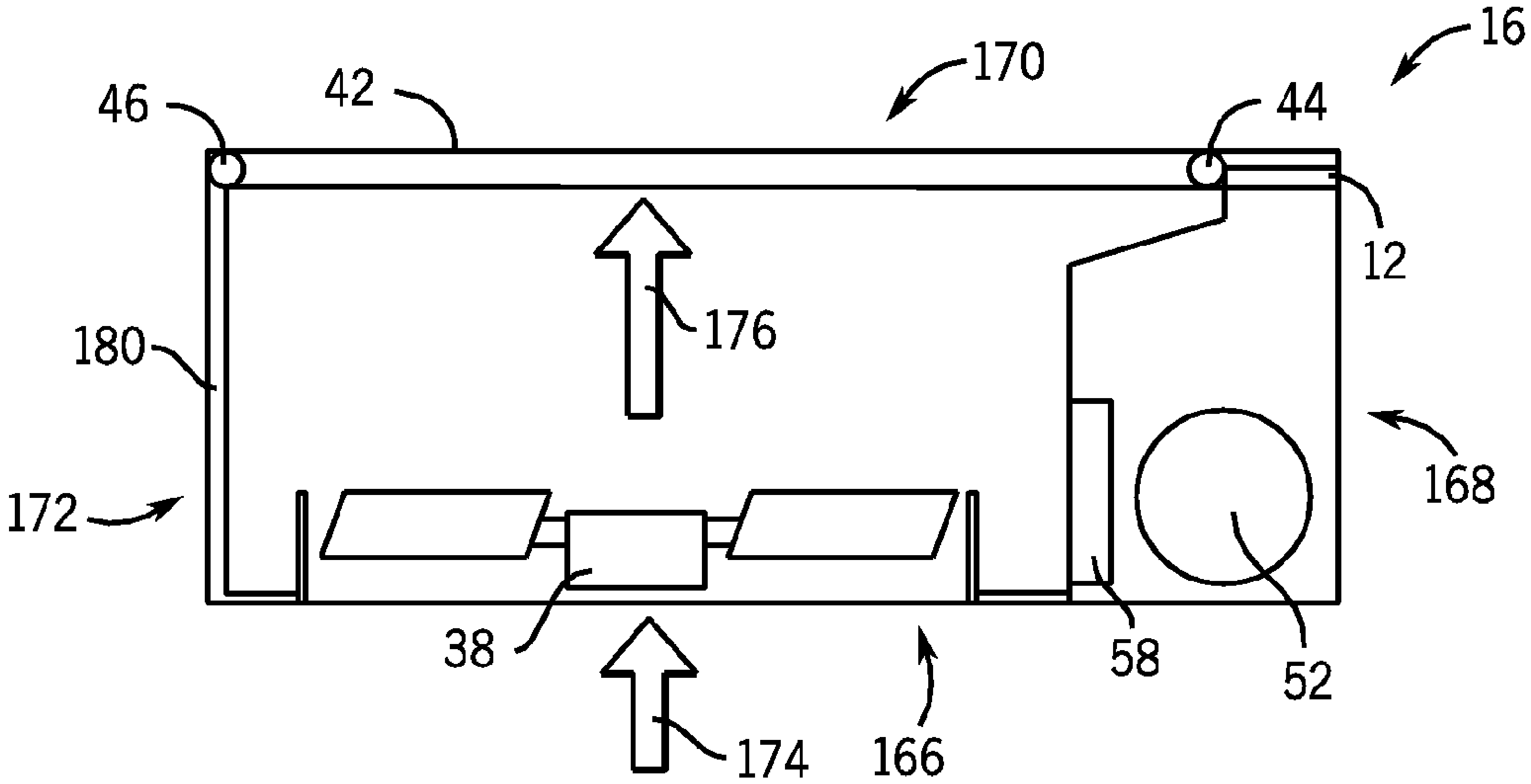
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FIG. 9B

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. **9**A and **9**B 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 piping, 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. **9**A and **9**B, fan **38** may be used to draw air into outdoor unit **16**. Fan **38** may 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 sensor **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 generally 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. **9**A and **9**B 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. **9**A, 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. **9**B, 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 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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