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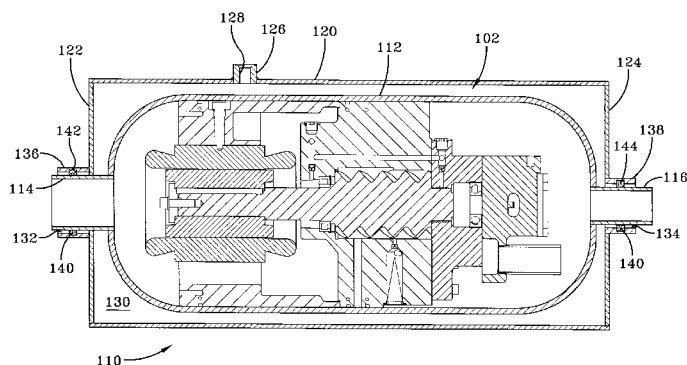


FIG-11

(57) Abstract: An attenuation system includes a device having a first housing from which audible noise generated during operation of the device emanates outwardly from the first housing. A second housing substantially surrounds the first housing. A conduit extends from the first housing and exterior of the second housing, the conduit substantially vibrationally isolated from the second housing. A vacuum is formed between the first housing and the second housing.

NOISE ATTENUATION SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority from and the benefit of U.S. Provisional Application No. 61/474,107, entitled NOISE ATTENUATION SYSTEM, filed April 11, 2011, which is hereby incorporated by reference.

BACKGROUND

[0002] The application generally relates to noise attenuation systems. The application relates more specifically to a noise attenuation system for a device with components contained in a single housing.

[0003] Many devices produce sounds during operation that are considered irritating or damaging to the auditory system. For example, such devices may be associated with heating, ventilation and air conditioning systems that maintain temperature control in a structure. A primary component in such a heating, ventilation and air conditioning system is a positive displacement compressor which receives a cool, low pressure gas and by virtue of a compression device, exhausts a hot, high pressure gas. One type of positive displacement compressor is a screw compressor, which generally includes two cylindrical rotors mounted on separate shafts inside a hollow, double-barreled shell or casing. The side-walls of the compressor shell or casing typically form two parallel, overlapping cylinders which house the rotors side-by-side, with their shafts parallel to the ground. Screw compressor rotors typically have helically extending lobes and grooves on their outer surfaces forming a large thread on the circumference of the rotor. During operation, the threads of the rotors mesh together, with the lobes on one rotor meshing with the corresponding grooves on the other rotor to form a series of gaps between the rotors. These gaps form a continuous compression chamber that communicates with the compressor inlet opening, or "port," at one end of the shell or casing and continuously reduces in volume as the rotors turn and compress the gas toward a discharge port at the opposite end of the shell or casing for use in the system. These rotors rotate at high rates of speed and are a source of operational noise.

[0004] Another source of operational noise emanates from the shell or casing wall. The shell or casing of the compressor becomes a sound radiating surface that transmits noise associated with the oil separator, bearing impacts, rotor meshing and other noise sources to the surroundings. Typically, this source of sound is addressed by adding a sound blanket over the compressor shell or casing. However, sound blankets are expensive and are marginally effective in reducing the noise from the shell or casing wall.

[0005] What is needed is a cost-effective, efficient and easily implemented apparatus for compressor noise attenuation that may be used with variable speed compressors with components contained in a single housing.

[0006] Therefore, what is needed is a noise attenuation system that can be easily assembled and does not require precision manufacturing of housing components.

SUMMARY

[0007] The present invention is directed to an attenuation system including a device having a first housing from which audible noise generated during operation of the device emanates outwardly from the first housing. A second housing substantially surrounds the first housing. A conduit extends from the first housing and exterior of the second housing, the conduit being substantially vibrationally isolated from the second housing. A vacuum is formed between the first housing and the second housing.

[0008] The present invention is further directed to a compressor including a first housing and containing the compressor. A second housing substantially surrounds the first housing. A conduit extends from the first housing and exterior of the second housing, the conduit being substantially vibrationally isolated from the second housing. A vacuum is formed between the first housing and the second housing.

[0009] One advantage of the application is an apparatus for compressor noise attenuation that may be used with variable speed compressors.

DETAILED DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1 shows an exemplary embodiment for a heating, ventilation and air conditioning system.

[0011] FIG. 2 shows an isometric view of an exemplary vapor compression system.

[0012] FIGS. 3 and 4 schematically show exemplary embodiments of vapor compression systems.

[0013] FIG. 5 and 6 show perspective views of an exemplary embodiment of a noise attenuator.

[0014] FIG. 7 shows a side partial cutaway view of the noise attenuator of FIGS. 5 and 6.

[0015] FIG. 8 shows an enlarged, partial view taken along region 8 of the noise attenuator of FIG. 7.

[0016] FIG. 9 shows a cross-sectional view taken along line 9-9 of the attenuator of FIG. 7.

[0017] FIG. 10 shows an enlarged, partial view taken along region 10 of the attenuator of FIG. 9.

[0018] FIG. 11 shows a cross-sectional view taken along line 11-11 along a longitudinal axis of the compressor of FIG. 6.

DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

[0019] FIG. 1 shows an exemplary environment for a heating, ventilation and air conditioning (HVAC) system 10 in a building 12 for a typical commercial setting. System 10 can include a vapor compression system 14 that can supply a chilled liquid which may be used to cool building 12. System 10 can include a boiler 16 to supply a heated liquid that may be used to heat building 12, and an air distribution system which circulates air through building 12. The air distribution system can also include an air

return duct 18, an air supply duct 20 and an air handler 22. Air handler 22 can include a heat exchanger that is connected to boiler 16 and vapor compression system 14 by conduits 24. The heat exchanger in air handler 22 may receive either heated liquid from boiler 16 or chilled liquid from vapor compression system 14, depending on the mode of operation of system 10. System 10 is shown with a separate air handler on each floor of building 12, but it is appreciated that the components may be shared between or among floors.

[0020] FIGS. 2 and 3 show an exemplary vapor compression system 14 that can be used in HVAC system 10. Vapor compression system 14 can circulate a refrigerant through a circuit starting with compressor 32 and including a condenser 34, expansion device(s) 36, and a liquid chiller or evaporator 38. Vapor compression system 14 can also include a control panel 40 that can include an analog to digital (A/D) converter 42, a microprocessor 44, a non-volatile memory 46, and an interface board 48. Some examples of fluids that may be used as refrigerants in vapor compression system 14 are hydrofluorocarbon (HFC) based refrigerants, for example, R-410A, R-407, R-134a, hydrofluoro olefin (HFO), “natural” refrigerants like ammonia (NH₃), R-717, carbon dioxide (CO₂), R-744, or hydrocarbon based refrigerants, water vapor or any other suitable type of refrigerant. In an exemplary embodiment, vapor compression system 14 may use one or more of each of variable speed drives (VSDs) 52, motors 50, compressors 32, condensers 34, expansion devices 36 and/or evaporators 38.

[0021] Motor 50 used with compressor 32 can be powered by a variable speed drive (VSD) 52 or can be powered directly from an alternating current (AC) or direct current (DC) power source. VSD 52, if used, receives AC power having a particular fixed line voltage and fixed line frequency from the AC power source and provides power having a variable voltage and frequency to motor 50. Motor 50 can include any type of electric motor that can be powered by a VSD or directly from an AC or DC power source. Motor 50 can be any other suitable motor type, for example, a switched reluctance motor, an induction motor, or an electronically commutated permanent magnet motor.

[0022] Compressor 32 compresses a refrigerant vapor and delivers the vapor to condenser 34 through a discharge passage. Compressor 32 can be a screw compressor in one exemplary embodiment. The refrigerant vapor delivered by compressor 32 to condenser 34 transfers heat to a fluid, for example, water or air. The refrigerant vapor condenses to a refrigerant liquid in condenser 34 as a result of the heat transfer with the fluid. The liquid refrigerant from condenser 34 flows through expansion device 36 to evaporator 38. In the exemplary embodiment shown in FIG. 3, condenser 34 is water cooled and includes a tube bundle 54 connected to a cooling tower 56.

[0023] The liquid refrigerant delivered to evaporator 38 absorbs heat from another fluid, which may or may not be the same type of fluid used for condenser 34, and undergoes a phase change to a refrigerant vapor. In the exemplary embodiment shown in FIG. 3, evaporator 38 includes a tube bundle having a supply line 60S and a return line 60R connected to a cooling load 62. A process fluid, for example, water, ethylene glycol, calcium chloride brine, sodium chloride brine, or any other suitable liquid, enters evaporator 38 via return line 60R and exits evaporator 38 via supply line 60S. Evaporator 38 chills the temperature of the process fluid in the tubes. The tube bundle in evaporator 38 can include a plurality of tubes and a plurality of tube bundles. The vapor refrigerant exits evaporator 38 and returns to compressor 32 by a suction line to complete the cycle.

[0024] FIG. 4, which is similar to FIG. 3, shows the vapor compression system 14 with an intermediate circuit 64 incorporated between condenser 34 and expansion device 36. Intermediate circuit 64 has an inlet line 68 that can be either connected directly to or can be in fluid communication with condenser 34. As shown, inlet line 68 includes an expansion device 66 positioned upstream of an intermediate vessel 70. Intermediate vessel 70 can be a flash tank, also referred to as a flash intercooler, in an exemplary embodiment. In an alternate exemplary embodiment, intermediate vessel 70 can be configured as a heat exchanger or a "surface economizer." In the configuration shown in FIG. 4, i.e., the intermediate vessel 70 is used as a flash tank, a first expansion device 66 operates to lower the pressure of the liquid received from condenser 34. During the expansion process, a portion of the liquid vaporizes. Intermediate vessel 70 may be used to separate the vapor from the liquid received from first expansion device 66 and may

also permit further expansion of the liquid. The vapor may be drawn by compressor 32 from intermediate vessel 70 through a line 74 to the suction inlet, a port at a pressure intermediate between suction and discharge or an intermediate stage of compression. The liquid that collects in the intermediate vessel 70 is at a lower enthalpy from the expansion process. The liquid from intermediate vessel 70 flows in line 72 through a second expansion device 36 to evaporator 38.

[0025] FIGS. 5-11 show an exemplary embodiment of a noise attenuation system or attenuation system 110 for use with a device, such as compressor 102. In an exemplary embodiment, compressor 102 is a screw compressor, although in another embodiment, other types of compressors may be used. Compressor 102 includes a first housing 112 that contains the working parts of the compressor such as disclosed in Application No. 12/748,285 which is assigned to Applicant and entitled "Compressor", which is hereby incorporated by reference in its entirety. As further shown in the figures, a conduit or inlet 114 extends from one end of first housing 112 and another conduit or outlet 116 extends from another end of the first housing. Conduit or inlet 114 provides refrigerant vapor to compressor 102, while conduit or outlet 116 discharges refrigerant vapor from the compressor. As shown, first housing 112 is substantially cylindrically shaped, and conduit or inlet 114 is substantially axially aligned with conduit or outlet 116 along axis 118, although the conduits may be positioned in a non-axial arrangement. As further shown in the figures, each of conduit or inlet 114 and conduit or outlet 116 further extend exterior of a second housing 120 substantially surrounding first housing 112.

[0026] Second housing 120 includes opposed ends 122, 124 through which a respective conduit or inlet 114 and conduit or outlet 116 extends. That is, each of conduit or inlet 114 and conduit or outlet 116 extends exterior of second housing 120. End 122 includes a sleeve 136 having an opening through which conduit or inlet 114 extends, which sleeve 136 including a circumferential recess 142 that is configured to receive an isolator 140 which provides a separation or spacing 132 between sleeve 136 and conduit or inlet 114. End 124 includes a sleeve 138 having an opening through which conduit or outlet 116 extends, which sleeve 138 including a circumferential recess 144 that is configured to receive an isolator 140 which provides a separation or spacing 134 between

sleeve 138 and conduit or outlet 116. A separation or spacing 130 is maintained between first housing 112 and second housing 120. In a further embodiment, conduits corresponding to inlet 114 and outlet 116 may be arranged to extend exterior of a second housing 120 from a single opening formed in the second housing. In yet a further embodiment, conduits corresponding to inlet 114 and outlet 116 may be arranged to extend exterior of a second housing 120 from more than two openings formed in the second housing.

[0027] As further shown FIG. 11, isolators 140 maintain spacing 132 between sleeve 136 of second housing 120 and conduit or inlet 114 and spacing 134 between sleeve 138 of second housing 120 and conduit or outlet 116, (as well as spacing 130 between first housing 112 and second housing 120). That is, in an exemplary embodiment, isolators 140 structurally support and maintain a predetermined relative positioning between first housing 112 and second housing 120. Isolators 140 are composed of a resilient material having sufficient structural rigidity that prevents a metal-to-metal connection between first housing 112 and second housing 120, and further provides a substantially fluid tight seal to prevent the flow of fluid, such as air, from either of spacing 132 or spacing 134. The fluid tight seal between first housing 112 and second housing 120, as well as between spacings 132 and 134 formed between conduits or inlet/outlet 114, 116 and respective sleeves 136, 138 is to be maintained even when a vacuum is formed between the first housing in the second housing. For example, second housing 120 includes a fitting 126 having an opening 128 is configured for connection with a pressure removal device (not shown) usable to form the vacuum between first housing 112 and second housing 120. For purposes herein, the term vacuum is defined as a space at least partially exhausted by an artificial means. The extent of the vacuum can depend upon application, size, and structural strength limitations of components, such as the first and second housings and the amount of noise reduction desired.

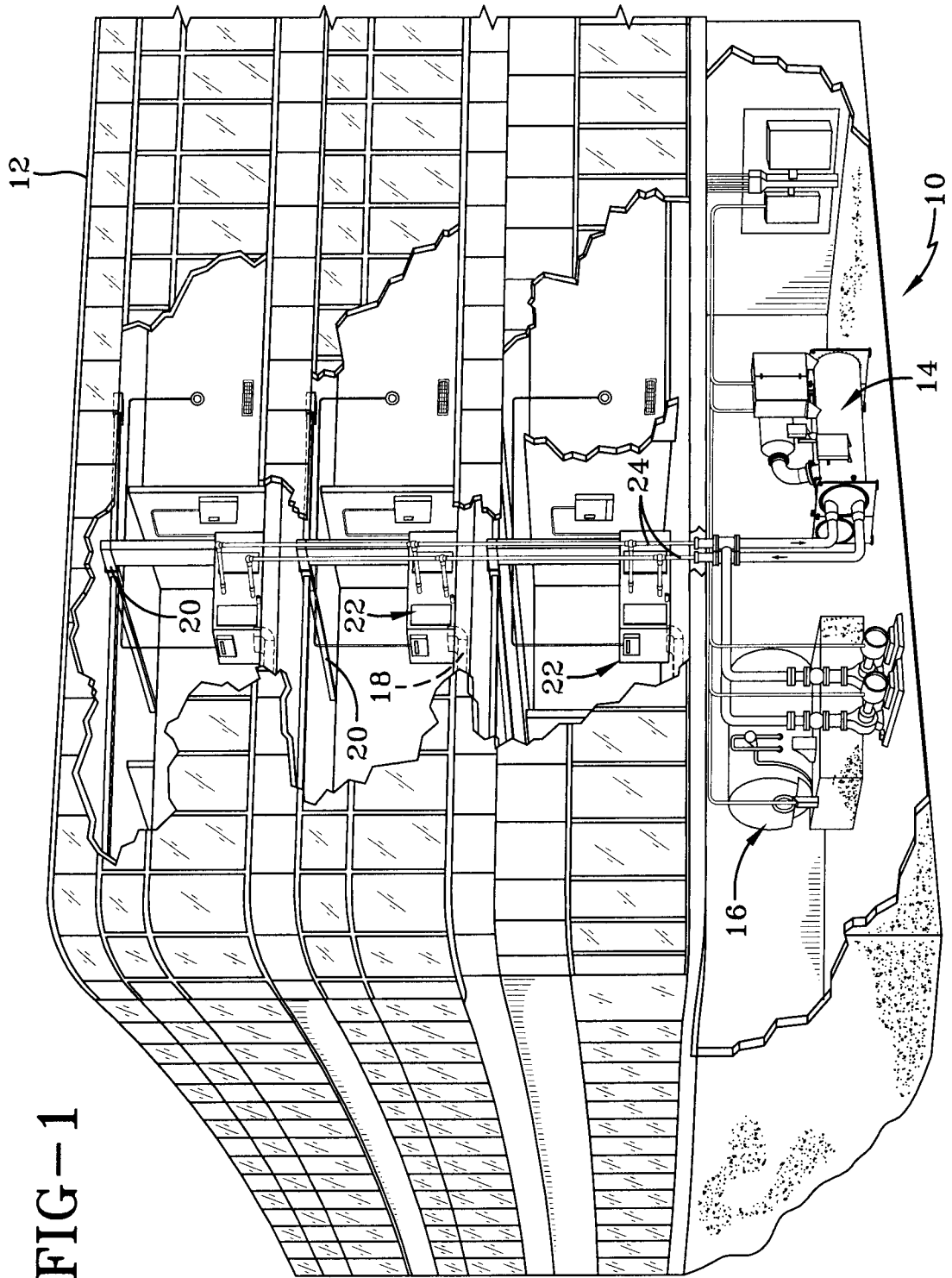
[0028] By virtue of the absence of a metal-to-metal connection between first housing 112 and second housing 120, noise generated during operation of compressor 102 that is propagated through first housing 112 is at least significantly reduced by the addition of the vacuum formed between the first housing and the second housing. The sounds

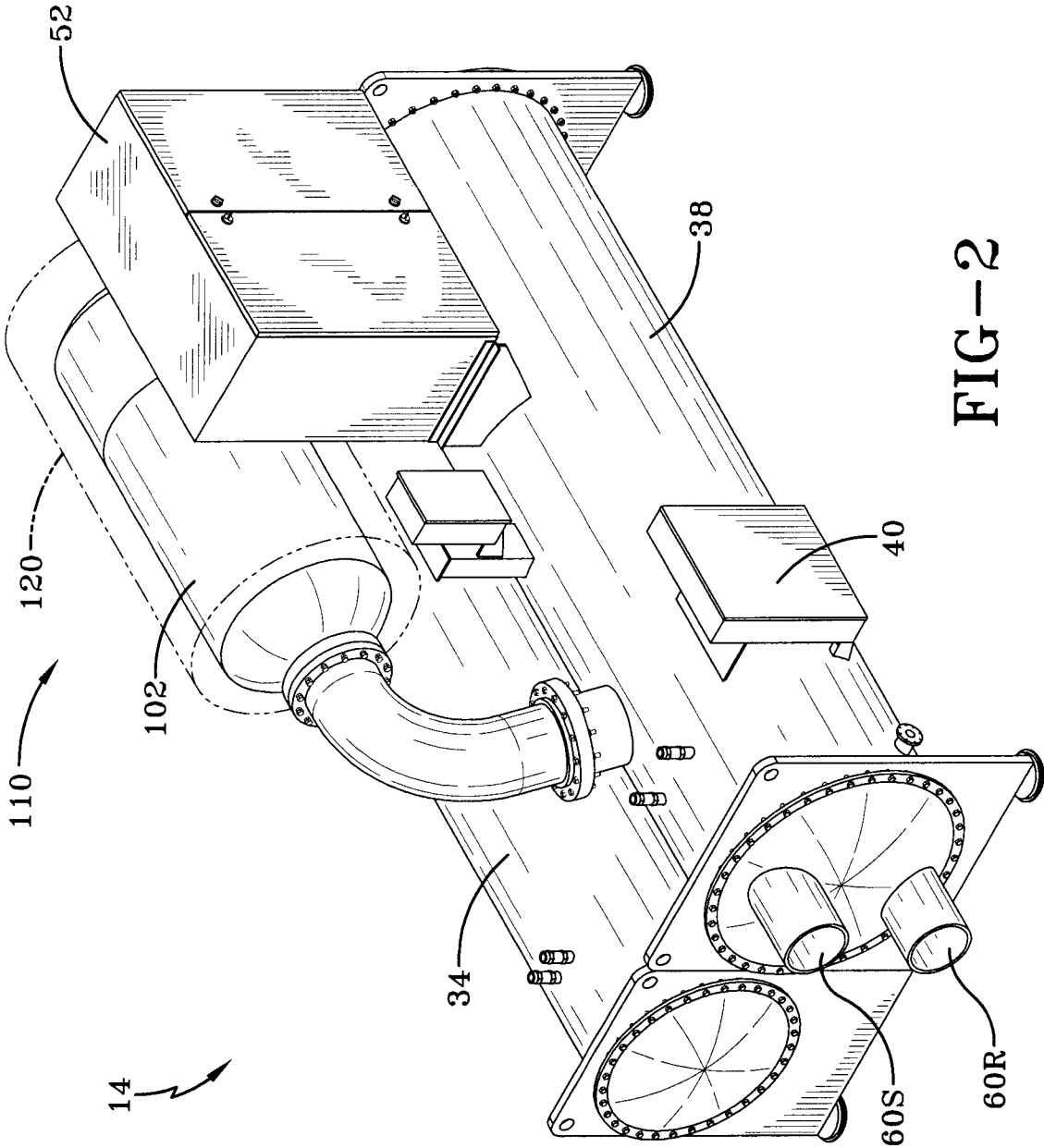
attenuated include, but are not limited to noise associated with operation of the oil separator, rotor bearings, and rotor meshing. It is to be understood that the attenuation system of the present disclosure may also be utilized for devices other than compressors.

[0029] While only certain features and embodiments of the invention have been shown 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.

WHAT IS CLAIMED IS:

1. An attenuation system comprising:
 - a device having a first housing from which audible noise generated during operation of the device emanates outwardly from the first housing;
 - a second housing substantially surrounding the first housing;
 - a conduit extending from the first housing and exterior of the second housing, the conduit substantially vibrationally isolated from the second housing; and
 - wherein a vacuum is formed between the first housing and the second housing.
2. The system of claim 1, wherein a layer of resilient material is positioned on the conduit between the first housing and the second housing.
3. A compressor comprising:
 - a first housing and containing the compressor;
 - a second housing substantially surrounding the first housing;
 - a conduit extending from the first housing and exterior of the second housing, the conduit substantially vibrationally isolated from the second housing; and
 - wherein a vacuum is formed between the first housing and the second housing.
4. The compressor of claim 3, wherein the compressor is a screw compressor.
5. The compressor of claim 3, wherein the compressor includes a VSD.





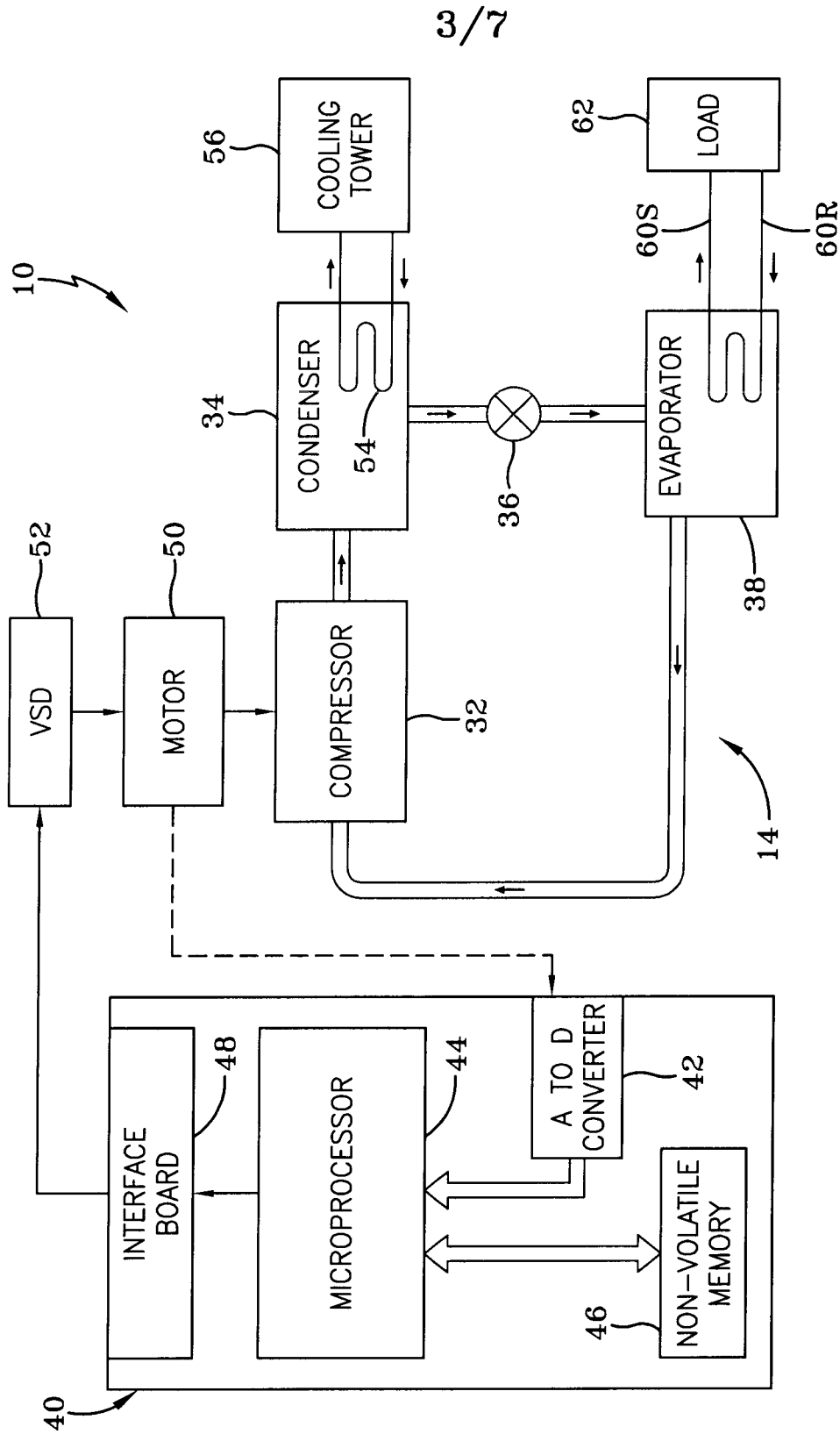


FIG-3

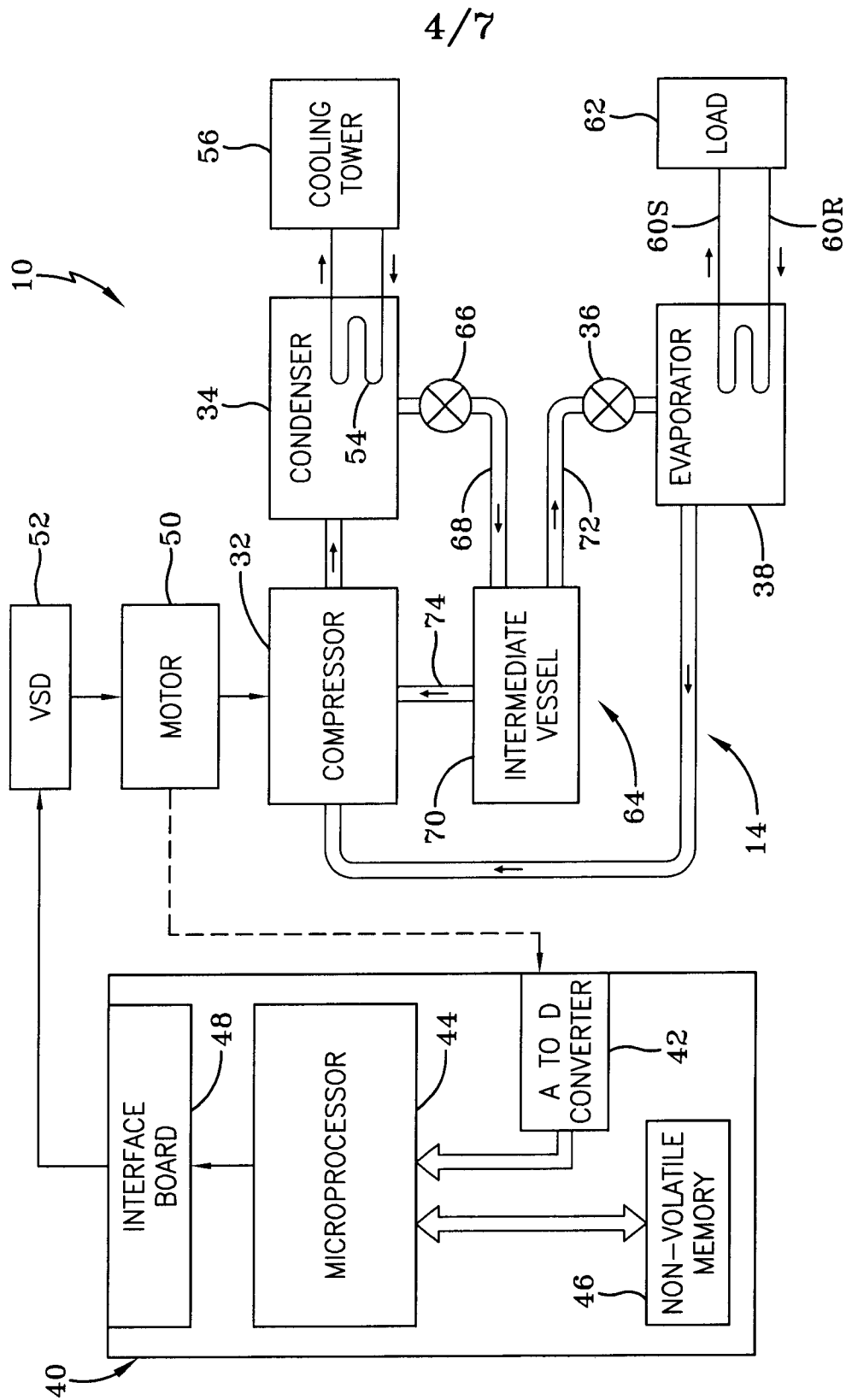


FIG-4

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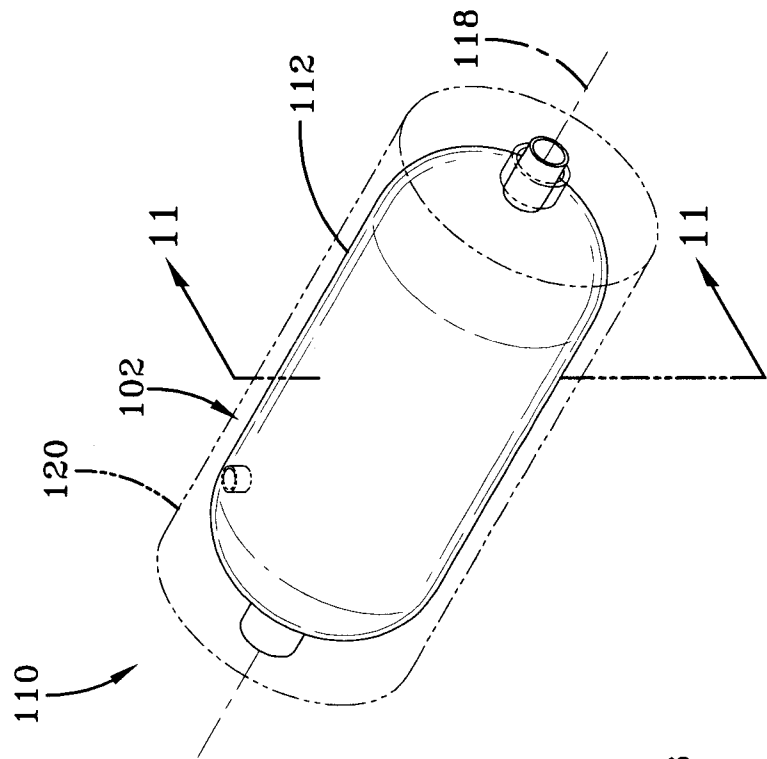


FIG-6

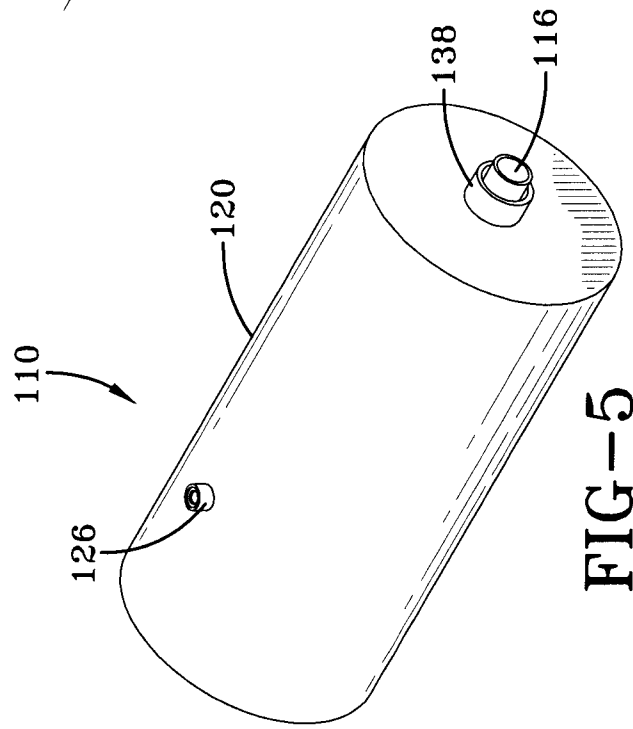


FIG-5

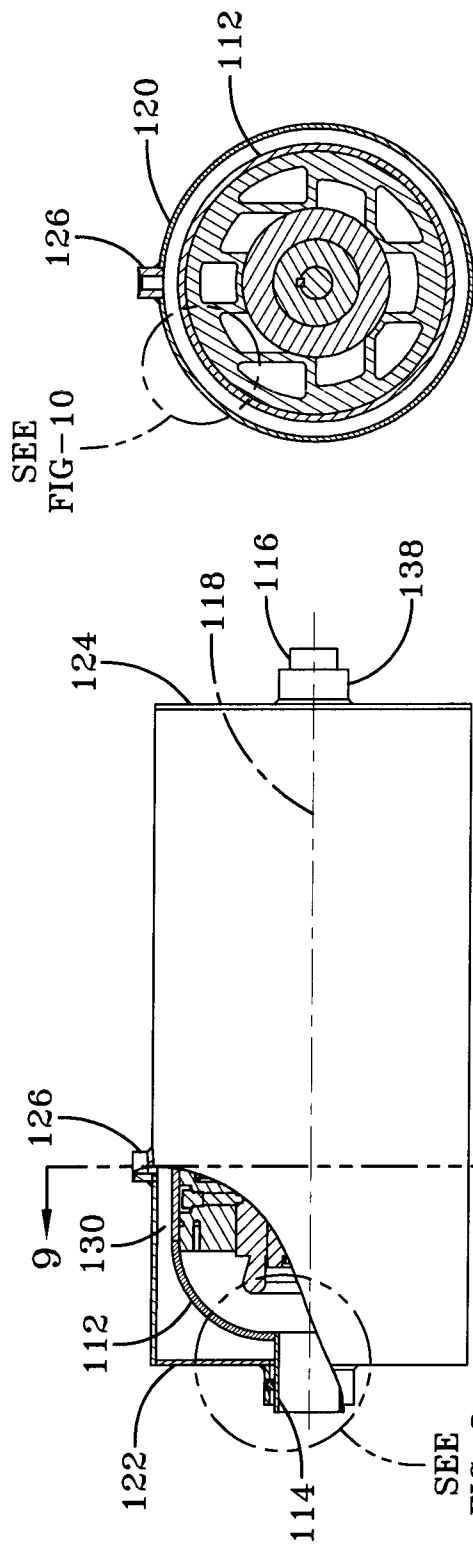


FIG-9

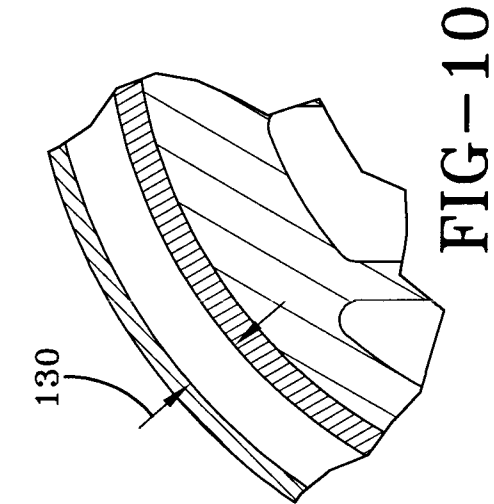
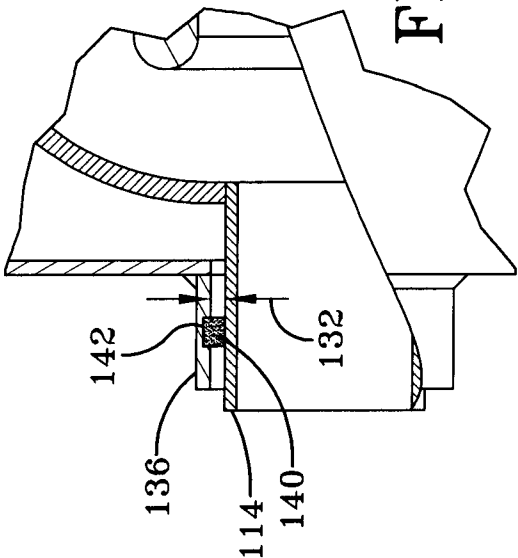


FIG-8



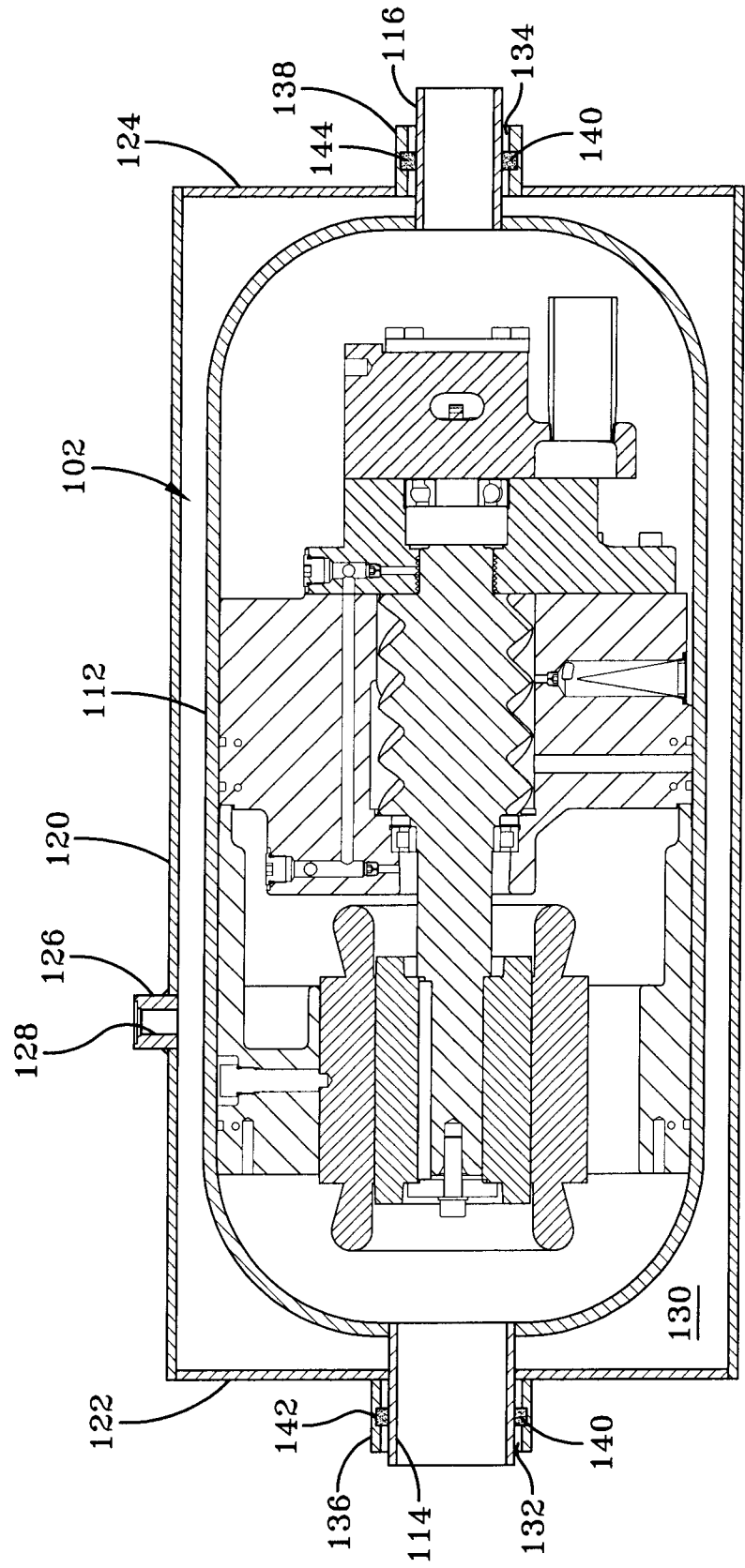


FIG-11