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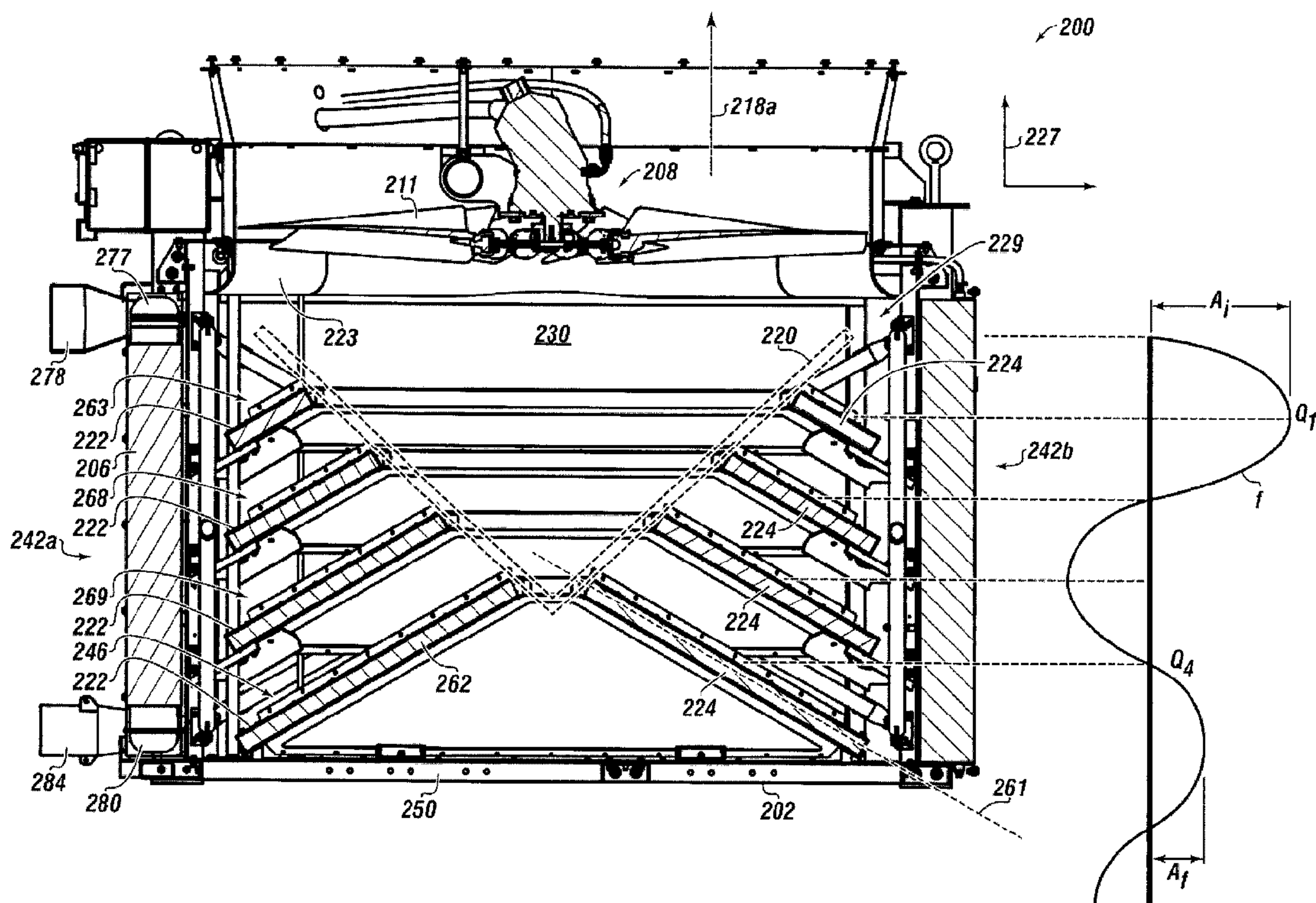
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(54) **Title: IMPROVED HEAT EXCHANGER UNIT**



(57) **Abrégé/Abstract:**

Embodiments of the disclosure pertain to an improved heat exchanger unit that includes a frame having a top region, a bottom region, and a plurality of side regions. The unit has a first cooler coupled with the frame proximate to a respective side region and generally parallel to a vertical axis. The unit has a second cooler coupled with the frame proximate to the top region and generally perpendicular to the vertical axis. The unit includes an inner airflow region within the heat exchanger unit, and a first baffle disposed within the inner airflow region.

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## **ABSTRACT**

Embodiments of the disclosure pertain to an improved heat exchanger unit that includes a frame having a top region, a bottom region, and a plurality of side regions. The unit has a first cooler coupled with the frame proximate to a respective side region and generally parallel to a vertical axis. The unit has a second cooler coupled with the frame proximate to the top region and generally perpendicular to the vertical axis. The unit includes an inner airflow region within the heat exchanger unit, and a first baffle disposed within the inner airflow region.

## **IMPROVED HEAT EXCHANGER UNIT**

### **BACKGROUND**

#### Field of the Disclosure

[0001] This disclosure generally relates to a heat exchanger unit with characteristics of improved: airflow, monitoring, noise reduction, cooling efficiency, and/or structural integrity. In embodiments, the disclosure relates to a heat exchanger unit used in connection with equipment found in an industrial setting. In particular embodiments, the heat exchanger unit may be used for cooling various utility fluids used with a heat generating device, such as an engine, a pump, or a genset.

#### Background of the Disclosure

[0002] Whether its refrigeration, hot showers, air conditioning, and so on, the function of heating and cooling is prevalent in today's residential and industrial settings. One area of relevance is the oil and gas industry, including exploration, upstream, and downstream operations where the ability to heat and/or cool is critical. Upstream operations can include drilling, completion, and production, whereas downstream operations can include refining and other related hydrocarbon processing, all of which utilize a vast amount of process equipment including that which provide heat transfer. To be sure, the background of the disclosure is relevant elsewhere, but for brevity discussion is focused on O&G.

[0003] As the modern world continues to experience growth in population, it similarly continues to experience an increase in energy demand and consumption, and the oil and gas industry needs to respond accordingly. Although 'green' energy has experienced a gain in popularity, the dominant source of energy remains fossil fuels. Driven by demand and high prices for fossil fuels, the U.S. energy sector experienced a boom in the late 2000's and into the early 2010's, contributing to expansion in exploration and production across the country.

[0004] Quite unexpectedly various global economic factors resulted in a rapid turnaround in demand and a decrease in profit margin that left many industry related companies vying to remain in business. This has resulted in consolidation and innovation, as the reality of likely never again seeing the record highs associated with the price of oil sets in. To remain

competitive, companies have begun looking at how they can be successful and profitable with a margin based on an oil price in a range of about \$30-\$50 per barrel.

[0005] A particular segment in the upstream area of oil and gas production pertains to fracing. Now common, fracing includes the use of a plug set in a wellbore below or beyond a respective target zone, followed by pumping or injecting high pressure frac fluid into the zone. The frac operation results in fractures or “cracks” in the formation that allow valuable hydrocarbons to be more readily extracted and produced by an operator, and may be repeated as desired or necessary until all target zones are fractured.

[0006] The injection fluid, which may be mixed with chemicals, sand, acid, etc., may be pressurized and transported at high rate via one or more high pressure frac pumps, typically driven by diesel combustion engines.

[0007] Figures 1A and 1B together illustrate a conventional land-based fracturing operation and frac pump trailer unit. The operation 101 may include multiple frac pump units 105. Each unit 105 is typically operable with a pump 113 and engine 103 mounted or otherwise disposed thereon, and is capable of producing upwards of 15,000 psi. Suitable units 105 include those manufactured or provided by NOV, Haliburton, Magnum, Weatherford, and the like.

[0008] The necessity of fracturing has progressively increased as production rates on new wells continue to decline. It is believed by some that at least 90 percent of all future wells in North America will require some degree of fracturing to increase production results, with a majority of these operations occurring in shale gas formations.

[0009] As demand continues to rise, producers have moved to unconventional sources such as the Barnett Shale, which for the first time resulted in wide reliance on horizontal drilling, leading to an increase on pumping pressures and operating times. Horizontal drilling and its associated multistage fracturing techniques are now the norm as shale formations have become the leading source of natural gas in North America. This harsher pumping environment demands stronger pumps capable of operating at extreme pressures and extended pumping intervals.

[0010] The frac pump is now part of a pumping system (or skid unit, etc.) that is typically self-contained on a transportable system, such as a trailer unit 105. The system components include the engine 103 and the frac pump 113, as well as a radiator (or cooler, heat exchanger, etc.) 100.

Today's pumps are capable of producing 2500 BHP @ 1900 rpm while operating in standard pressure pumping well service operations in ambient conditions of about 0°F to 125 °F, and can provide upwards of 15,000 psi injection pressure at a working rate of 17 bpm. The frac pump 113 provides pressurized fluid into well(s) 191 via transfer (injection) lines 190.

[0011] But there are several drawbacks to this modern equipment. First, the operational requirements have driven the associated equipment to become massive in weight, and single trailer units sometimes exceed 80,000 lbs. Unfortunately the trailer unit 105 must comply with federal, state, and local regulation, where a number of regulators are starting to draw a line on weight limitations. Permits for a job site will only be issued when requirements are met.

[0012] Similarly, the operational requirements have driven the associated equipment, such as the diesel engine or radiator fan, to become huge point sources of noise pollution. And again, regulators are starting to draw a line on noise. This is even more problematic as job sites start to encroach closer and closer to residential areas.

[0013] Next, operational requirements have driven the associated equipment, for example the diesel engine, to become extreme generators of heat, thus requiring a larger cooling system. The typical radiator further adds significant weight to the trailer unit. And as a result of spatial constraints, the radiator 100 often lies horizontal on the bed of the trailer unit 105, as shown in Figure 1B. The problem with this arrangement is that as the radiator fan 108 blows in ambient air to cool various service fluids ( $F_1$ ,  $F_2$ ,  $F_3$ , etc.), the air becomes progressively hot (*e.g.*, cooling in series, where  $T_{out} > T_2 > T_1 > T_{amb}$ ). *See* Figure 1C. This temperature gradient results in ineffective cooling as the air is moved through the radiator 100.

[0014] The heat exchanger is typically used to cool by passing a hot service fluid through the heat exchanger along one path (or side), and passing a cooling medium through the heat exchanger along a second path (or side). In an air-cooled radiator, a fluid may circulate through the equipment and pass through the first side, and air may be drawn through the second side to cool the fluid before it returns to the equipment.

[0015] Operational requirements have further attributed to extreme conditions (*e.g.*, temperature, pressure, vibration, etc.) that subject equipment to additional failure modes, for example, it has been found that leaks may occur at the joints of the equipment.

[0016] One type of heat exchanger is one that may be formed from a series of header bars and face bars, with plates connected between the bars to form flow paths. One or more tanks may be

connected in fluid communication with either or both of a first and a second path to direct fluid flow through the respective path. In one example, in which plates are brazed to the header and face bars, and tanks welded to the ends of the heat exchangers, it was found that leaks were occurring adjacent to the header and face bars.

[0017] It was found that when the header bars and face bars were small, the heat affected zone related to a weld between the core and the tank extended past the header bars and face bars and into the brazed joint between the plates and the respective bar(s). When the weld temperature (*i.e.*, melting point of weld material) was greater than the brazing temperature, the brazing material would melt and flow away, such that the connection at these points was either opened, or weakened, and resulted in greater likelihood of failure during operation.

[0018] Figure 1E shows a close-up side view of part of a radiator core. A tank 177 is welded to the core 106 at the core end 106a (*i.e.*, the weld point). The tank 177 has a tank end, which has an effective tank end mass. The mass of the tank (and its end) 177 is extensive (including as depending on tank wall thickness  $W_t$ ), and a significant amount of heat must be applied in order to reach the weld temperature  $T_w$  at the weld point. The temperature of the melting point of the weld material  $T_w$  (typically about 1200 F) is greater than the melting point  $T_b$  (typically about 960 F) of the brazing material between the parting sheets 172 and respective bars 175 (*e.g.*, header and face). As the tank end mass of the tank end ( $M_{te}$ ) is larger than a core end mass of the core end ( $M_{ce}$ ), the presence of weld temperature at the weld point results in a heat profile  $P$  into the core 106 (which the profile  $P$  may be parabolic).

[0019] Heat at the weld point radiates along the easiest path. As the heat profile of temperature greater than  $T_b$  extends length  $l$ , and is beyond the effective bar brazing length (or area  $A$ ) 185 of the bar 175, the brazing material  $B$  (by having a melting temperature  $T_b$  less than weld temperature  $T_w$ ) is heated and can freely flow or leach away from the area  $A$  between the bar 175 and the parting sheet 172. This results in the core 106 being susceptible to failure because upon cooling the brazing is now incomplete.

[0020] Another issue that reduces the structural integrity of the heat exchanger unit is the thermal expansion of a radiator core, particularly those made of aluminum. Typically a core is rigidly mounted without regard for how it might expand in application. However, as the core experiences expansion, it becomes prone to leaking. It was determined that a cause of the leaks was the impact of thermal expansion, with some large heat exchangers expanding by almost  $\frac{1}{2}$ ".

As the cores are solidly brazed together and then hard mounted (welded or nut/bolt) to a frame, the stress from expansion caused cracking in some welds due to excessive load being applied to it.

[0021] Thermal expansion occurs, for example, when the radiator core is manufactured at ambient temperature, but is generally exposed to temperatures well above ambient during use. As a result, the material of the core will expand. As the core is normally rigidly mounted to a support structure, which resisted thermal expansion, it is believed that stresses are induced in the heat exchanger, and that failures can occur in the welds as a result.

[0022] A related area of relevance pertains to a blender unit that creates the frac slurry, and transfers to unit 105. Figure 1F illustrates a blender unit 160 that may be mobile, such as via skid (or chassis, trailer, etc.) 161, and is known by one of skill in the art for making a slurry of particulate material, such as sand blended with fracturing fluid, proppant, and so forth. The blender unit 160 usually has one or more blending tubs 162, from which the slurry is discharged and transferred via a booster pump 164 to a frac pump (113, Figure 1B), which then injects the slurry into a well and into the producing zones.

[0023] Material (*e.g.*, sand) may be provided to the tubs 162 through one or more screw augers 163. The augers 163 may be may be powered simultaneously or separately, depending on the required amount of particulate matter. The screw augers 163 and the booster pump 164 may be powered by a heat generating device 103b, either of which may be a diesel engine or other comparable driver.

[0024] The blender unit 160 may have a main control system, which may be located in a cab 166 of the trailer 161. The control system may, among other things, control the auger speeds, booster pump speed, engines, and other related equipment. A suitable computer may be used to control the operation of the system so that a desired slurry is achieved. As one of skill would appreciate, the heat generating device(s) 103b may be coupled with a respective radiator(s) 100b so that necessary cooling of service fluids is possible. Radiator 100b alas has the inherent problems described herein related to noise, orientation, size, integrity, fouling, and so forth.

[0025] One or more of these concerns is just as valid to non-oilfield related heat exchangers. Figure 1D illustrates a simple schematic overview of a heat generation device (HGD) 103a used in a general industrial operation or setting 101a. The operation or setting 101a may be a construction site, a building, a water treatment plant, a manufacturing facility, or any other

setting whereby a heat exchanger 100a is used for heat transfer, such as to cool (or heat) a utility fluid F that is used with the HGD 103a. The operation of a fan 108 results in an undesirable noise characterized by an acoustic frequency  $f$  with amplitude  $A1$ , which is readily discernable to an operator.

[0026] In an analogous manner HGD's associated with a residential setting may also have similar concerns. In other aspects, it is becoming more and more common that an industrial setting or operation is adjacent or proximate to a residential setting.

[0027] Common settings are nothing short of challenging in the sense that in many instances operations and processes (and related equipment) are exposed to environmental conditions, such as extreme heat, cold, wind, and dust (including natural amounts of particulate, as well as that caused by the operation of equipment and vehicles).

[0028] It is routine to have (indeed, *need*) some type of heat exchange ability in such settings. As set forth in US S/N 15/477,097, an example operation in an industrial setting may include one or more frac pump units. Each unit is typically operable with a pump and engine mounted or otherwise disposed thereon, as well as a radiator (or analogously referred to as cooler, heat exchanger, etc.). As mentioned before, equipment like this must be rugged and durable in order to have long-term operational capacity and effectiveness.

[0029] The radiator is configured for cooling one or more hot service fluids associated with the equipment of the frac pump unit, such as lube oil or jacket water. The radiator typically includes a 'core' of stacked fins, with one part of the core providing a flow area for the service fluid(s), while another part of the core provides a proximate, albeit separate, flow area for ambient air. A fan is used to blow or pull air through the stacked fins, the air being a low or moderate enough temperature to cool the service fluid, which is then recirculated in a loop.

[0030] The stacked fins often have a configuration that is tantamount to an extensive amount of small air passageways proximate to (albeit separate from) service fluid passageways, whereby the air and the service fluid can 'exchange heat' via the surface material of the stacked fins between the passageways (*e.g.*, aluminum).

[0031] Over time airborne dirt in and other particulate in the air will begin to deposit on the air intake side (and elsewhere), resulting in a fouled radiator. Fouling can seriously deteriorate the capacity of the surface of the fins to transfer heat under the conditions for which they were designed. Among other problems, the fouling layer has a low thermal conductivity which

increases the resistance to heat transfer and reduces the effectiveness of heat exchangers. In addition, fouling reduces the cross-sectional area in the passageways, which causes an increase in pressure drop across a heat exchanger.

[0033] Radiator fouling affects both capital and operating costs of heat exchangers (and overall processes). Higher capital expenditures include that for excess surface area (for heat transfer), extra space, and transport and installation costs. Operating expenditures include that for energy losses due to the decrease in thermal efficiency, increases in the pressure drop through process equipment, and production losses during planned and unplanned plant shutdowns for fouling cleaning.

[0034] Moreover, government emissions regulations are forcing engine manufacturers and their customers to reduce emissions from reciprocating engines. Current solutions involve returning the exhaust through heat exchange, which elevates combustion temperature and puts significantly more heat into the cooling system. Tier 4 Final (US and CA) Emission regulations come into effect in 2017 & 2020 will force end users into significant equipment redesign industry wide.

[0035] In summary, fouling of heat transfer surfaces is one of the most important problems in heat transfer equipment. Some have described fouling as the major unresolved problem in heat transfer. Equipment operators world-wide are also trying to reduce maintenance costs. One of the highest maintenance costs any piece of equipment has is cooling system maintenance.

[0036] And yet despite these detriments, consideration of improved remediation or management techniques have been largely ignored and unchanged. Conventional techniques include mitigation (such as upstream filtering) and chemical treatment.

[0037] Mechanical cleaning is also used, but only during predetermined periodic intervals, namely during a planned shutdown or when an exchanger reaches a point of failure and is no longer operable. This approach relies on extensive cost and resource being allocated toward the antiquated philosophy of operational redundancy.

[0038] There is a need in the art to overcome deficiencies and defects identified herein. There is a need in the art to reliably monitor fouling of a radiator. There is a need in the art to provide a real-time warning indication about fouling conditions of a radiator.

[0038] There is a need in the art for a monitoring system that is durable for use in outdoor and other difficult environmental conditions. There is a need in the art for a monitoring system capable of high degree of sensing accuracy, yet impervious to or otherwise able to withstand external conditions.

[0039] There is a need in the art for a method of doing business that includes monitoring and servicing of radiators, especially when the radiator reaches various stages of fouling or provides other indication requiring attention. There is a need in the art to clean a fouled radiator with little or no downtime.

[0040] There is a need in the art for a monitoring module that can be retrofitted to any existing heat exchanger, including of great importance to a heat exchanger that has one or more sides (or surfaces) exposed to ambient air.

[0041] There is a particular need in the art for a monitoring system that is readily adaptable and compatible to radiators associated with different pieces of heat generating equipment, such as an engine, a motor, a pump, or a genset useable in a wide range of settings.

[0042] There is a need in the art to overcome deficiencies and defects identified herein. There is a particular need in the art for a heat exchanger that is readily adaptable and compatible to different pieces of heat generating equipment, such as an engine, a motor, a pump, or a genset, and is useable in a wide range of settings.

[0043] There is a need in the art to be able to reduce pressure drop, whereby airflow through a heat exchanger can be streamlined and increased. There is a need to reduce sound emission from a heat exchanger so that it may satisfy regulatory limitations or be suitable for use in or proximate to a residential setting.

[0044] There is a need in the art for a heat exchanger that can accommodate spatial constraints, and is lighter in weight. There is a need in the art for a heat exchanger that has improved or reduced sound emissions. There is a need in the art for a heat exchanger that improves cooling efficiency. There is a need in the art for a heat exchanger with improved structural integrity, including the ability to withstand or tolerate thermal expansion and hot welding temperatures.

## SUMMARY

[0045] Embodiments of the disclosure pertain to a heat exchanger unit that may include a frame comprising a top region, a bottom region, and a plurality of side regions. There may be a first cooler coupled with the frame proximate to a respective side region and with its long axis generally parallel to an axis. There may be a second cooler coupled with the frame proximate to the top region, which may have its long axis generally perpendicular to the axis. In aspects, there may be an inner airflow region within the heat exchanger unit. There may be a first baffle disposed within the inner airflow region. The first baffle may be positioned or otherwise oriented as having a first angle to the axis.

[0046] Embodiments of the disclosure pertain to a blender skid for creating a frac fluid mixture that may include one or more of a blender; a first diesel engine; and a heat exchanger unit configured to cool at least one service fluid transferable between the heat exchanger unit and the first diesel engine.

[0047] The heat exchanger unit may include a frame comprising a top region, a bottom region, and a plurality of side regions. There may be a first cooler coupled with the frame proximate to a respective side region. The first cooler may have its body or long axis generally parallel to the axis.

[0048] The heat exchanger unit may include a second cooler coupled with the frame. The second cooler may have its body or long axis generally perpendicular to the orientation of the first cooler.

[0049] In aspects, there may be an inner airflow region within the heat exchanger unit. There may be a first baffle disposed within the inner airflow region. The first baffle may have a planar reference at a first angle to the axis.

[0050] Embodiments for the disclosure pertain to a method for monitoring a heat exchanger unit that may include the steps of operatively coupling the heat exchanger unit with at least one diesel engine. The heat exchanger unit may include a frame comprising a top region, a bottom region, and a plurality of side regions. There may be a first cooler coupled with the frame proximate to a respective side region and generally parallel to an axis. There may be a second cooler coupled with the frame proximate to the top region. The second cooler may be oriented or otherwise positioned with its body generally perpendicular to the axis. There may be an inner airflow

region within the heat exchanger unit. There may be a first baffle disposed within the inner airflow region. The baffle (or a reference plane thereof) may be at a first angle to the axis.

[0051] The method may include associating a monitoring module with an airflow side of at least one of the first cooler and the second cooler

[0052] The monitoring module may include one or more of a cover panel configured for direct or indirect coupling to the heat exchanger unit; an at least one sensor coupled with the cover panel, the at least one sensor having a respective rotating member with a plurality of blades extending therefrom; a logic circuit in operable communication with the at least one sensor, and further comprising: a microcontroller configured with computer instructions for performing a plurality of tasks.

[0053] The tasks may include one or more of: acquiring a set of data from the at least one sensor; sampling the set of data over a predetermined period of time, and computing an average and a standard deviation; comparing the standard deviation with predetermined data stored on a data storage; determining whether the set of data is acceptable within a defined parameter; determining whether a first lookup table comprising a set of lookup data has been completed, and creating the first lookup table using an averaging method if it has not; comparing the set of data to the set of lookup data; and providing an indication based on a result of the comparing the set of data to the set of lookup data step.

[0054] The method may include performing an action based on an indication from the monitoring module.

[0055] Embodiments of the disclosure pertain to a heat exchanger unit that may include a frame comprising a top region, a bottom region, and a plurality of side regions. There may be a first cooler coupled with the frame proximate to a respective side region, with its body or long axis generally parallel to a reference axis. There may be a second cooler coupled with the frame proximate to the top region, with its long axis generally perpendicular to the reference axis.

[0056] The heat exchanger unit may include a first fan mounted to the frame external to a first side of the first cooler. There may be an inner airflow region within the heat exchanger unit. There may be a first baffle disposed within the inner airflow region. The first baffle may have an associated reference plane intersecting the reference axis at a first angle.

[0057] Embodiments herein pertain to a monitored heat exchanger unit of the present disclosure.

[0058] These and other embodiments, features and advantages will be apparent in the following detailed description and drawings.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

[0059] A full understanding of embodiments disclosed herein is obtained from the detailed description of the disclosure presented herein below, and the accompanying drawings, which are given by way of illustration only and are not intended to be limitative of the present embodiments, and wherein:

[0060] **Figure 1A** shows an overview process diagram of a conventional land-based fracturing operation;

[0061] **Figure 1B** shows a side view of a frac pump truck;

[0062] **Figure 1C** shows a close-up profile view of a horizontal heat exchanger useable with the frac pump truck of Figure 1B;

[0063] **Figure 1D** shows a simple schematic view of a heat exchanger used with a heat generation device in a general industrial setting;

[0064] **Figure 1E** shows a close-up side view of a typical temperature profile when a tank is welded to a radiator core;

[0065] **Figure 1F** shows an isometric view of a mobile blender unit;

[0066] **Figure 2A** shows a side view of a heat exchanger unit coupled with a heat generation device according to embodiments of the disclosure;

[0067] **Figure 2B** shows an isometric view of a frame of the heat exchanger unit according to embodiments of the disclosure;

[0068] **Figure 2C** shows a side cross-sectional view of an HX unit configured with a plurality of baffles according to embodiments of the disclosure;

[0069] **Figure 2D** shows an isometric view of a set of a plurality of baffles according to embodiments of the disclosure;

[0070] **Figure 2E** shows a close-up partial side view of a baffle coupled to a vertical member according to embodiments of the disclosure;

[0071] **Figure 3A** shows an isometric view of a baffle according to embodiments of the disclosure;

[0072] **Figure 3B** shows a lateral cross-sectional view of a baffle according to embodiments of the disclosure;

[0073] **Figure 4A** shows an isometric partial view of a radiator core according to embodiments of the disclosure;

[0074] **Figure 4B** shows a partial close-up downward view of an end of a radiator cooler having a tank and a core according to embodiments of the disclosure;

[0075] **Figure 4C** shows a view of a tank welded to a core according to embodiments of the disclosure;

[0076] **Figure 5A** shows a close-up view of a radiator core mounted to a frame of a heat exchanger unit according to embodiments of the disclosure;

[0077] **Figure 5B** shows a component breakout view of a flexible mount assembly according to embodiments of the disclosure;

[0078] **Figure 5C** shows a partial side cross-sectional view of a flexible mount assembly used with a bracket and a frame of a heat exchanger unit assembly according to embodiments of the disclosure;

[0079] **Figure 5D** shows a component breakout view of another flexible mount assembly according to embodiments of the disclosure;

[0080] **Figure 5E** shows a partial side cross-sectional view of the flexible mount assembly of Figure 5D used with a core a heat exchanger unit according to embodiments of the disclosure;

[0081] **Figure 5F** shows a close-up view of a flex mount assembly used for coupling various components of a heat exchanger unit according to embodiments of the disclosure;

[0082] **Figure 6A** shows a downward looking isometric view of a top region of a heat exchanger unit according to embodiments of the disclosure; and

[0083] **Figure 6B** shows an isometric view of a fan mount according to embodiments of the disclosure;

[0084] **Figure 6A** shows a downward looking isometric view of a top region of a heat exchanger unit according to embodiments of the disclosure;

[0085] **Figure 6B** shows an isometric view of a fan mount according to embodiments of the disclosure;

[0086] **Figure 7A** shows an isometric view of a monitored heat exchanger system that includes a monitoring module, a heat exchanger unit, and a heat generation device operably coupled together according to embodiments of the disclosure;

[0087] **Figure 7B** shows an isometric view of a frame of the heat exchanger unit according to embodiments of the disclosure;

[0088] **Figure 7C** shows a component breakout view of a controller housing usable with a monitoring module, and having various internal components according to embodiments of the disclosure;

[0089] **Figure 8A** shows a logic circuit process flow diagram according to embodiments of the disclosure;

[0090] **Figure 8B** shows a logic circuit decision tree operable as part of a monitoring module according to embodiments of the disclosure;

[0091] **Figure 9** shows a side view of a monitored heat exchanger system that includes a monitoring module, a four-sided heat exchanger, and a heat generating device coupled together according to embodiments of the disclosure;

[0092] **Figure 9A** shows a side view of a monitored heat exchanger system that includes a monitoring module, a heat exchanger unit with at least one topside mounted cooler, and a heat generating device coupled together according to embodiments of the disclosure;

[0093] **Figure 10A** shows an isometric view of a heat exchanger unit with a top mounted cooler coupled in fluid communication with a heat generation device according to embodiments of the disclosure;

[0094] **Figure 10B** shows a lateral cutaway view of the heat exchanger unit of Figure 10A according to embodiments of the disclosure;

[0095] **Figure 10C** shows a breakout view of a sidewall according to embodiments of the disclosure;

[0096] **Figure 11A** shows a front isometric view of a heat exchanger unit with two top mounted coolers according to embodiments of the disclosure;

[0097] **Figure 11B** shows a back isometric view of the heat exchanger unit of Figure 11B according to embodiments of the disclosure; and

[0098] **Figure 11C** shows a blender skid having the heat exchanger unit of Figures 11A-11B according to embodiments of the disclosure.

## DETAILED DESCRIPTION

[0099] Herein disclosed are novel apparatuses, systems, and methods that pertain to an improved heat exchanger, details of which are described herein.

[00100] Embodiments of the present disclosure are described in detail with reference to the accompanying Figures. In the following discussion and in the claims, the terms “including” and “comprising” are used in an open-ended fashion, such as to mean, for example, “including, but not limited to...”. While the disclosure may be described with reference to relevant apparatuses, systems, and methods, it should be understood that the disclosure is not limited to the specific embodiments shown or described. Rather, one skilled in the art will appreciate that a variety of configurations may be implemented in accordance with embodiments herein.

[00101] Although not necessary, like elements in the various figures may be denoted by like reference numerals for consistency and ease of understanding. Numerous specific details are set forth in order to provide a more thorough understanding of the disclosure; however, it will be apparent to one of ordinary skill in the art that the embodiments disclosed herein may be practiced without these specific details. In other instances, well-known features have not been described in detail to avoid unnecessarily complicating the description. Directional terms, such as “above,” “below,” “upper,” “lower,” “front,” “back,” “right,” “left,” “down,” etc., are used for convenience and to refer to general direction and/or orientation, and are only intended for illustrative purposes only, and not to limit the disclosure.

[00102] Connection(s), couplings, or other forms of contact between parts, components, and so forth may include conventional items, such as lubricant, additional sealing materials, such as a gasket between flanges, PTFE between threads, and the like. The make and manufacture of any particular component, subcomponent, etc., may be as would be apparent to one of skill in the art, such as molding, forming, press extrusion, machining, or additive manufacturing. Embodiments of the disclosure provide for one or more components to be new, used, and/or retrofitted to existing machines and systems.

### Terms

[00103] The term “noise” as used herein can refer to a sound, including an undesirous sound.

[00104] The term “sound” as used herein can refer to a vibration(s) that travels through the air or another medium, and can be detectable or discernable to the human ear or an instrument. Sound

can be referred to as a pressure wave resulting in pressure variations. A loud noise usually has a larger pressure variation and a weak one has smaller pressure variation. The more readily referred to measurement of loudness of sound is a logarithmic scale of Pascals, the decibel (dB). Sound and noise can be interchangeable, or have comparable meaning.

[00105] The term “noise absorbing material” as used herein can refer to a material having a physical characteristic of being able to reduce amplitude of a noise or sound. That is, reduce a pressure variation. ‘Noise absorbing’ can be interchangeable to noise reduction, noise absorbent, abatement by absorbing, and so forth. The material can be a fibrous material, such as mineral wool.

[00106] The term “noise barrier” can refer to a material or component capable of stopping noise from passing therethrough. In aspects, a noise barrier material can be adhered (such as glued) to a component. The noise barrier material can be vinyl.

[00107] The term “frequency” as used herein can refer to the rate at which a vibration (of a respective sound) occurs over a period of time. The number of pressure variations per second is called the frequency of sound, and is measured in Hertz (Hz) which is defined as cycles per second. The higher the frequency, the more high-pitched a sound is perceived.

[00108] The term “dominant acoustic frequency” can refer to a respective sound that is most discernable or noticeable to a human ear or instrument.

[00109] The term “engine” as used herein can refer to a machine with moving parts that converts power into motion, such as rotary motion. The engine can be powered by a source, such as internal combustion.

[00110] The term “motor” as used herein can be analogous to engine. The motor can be powered by a source, such as electricity, pneumatic, or hydraulic.

[00111] The term “drive” (or drive shaft) as used herein can refer to a mechanism that controls or imparts rotation of a motor(s) or engine(s).

[00112] The term “pump” as used herein can refer to a mechanical device suitable to use an action such as suction or pressure to raise or move liquids, compress gases, and so forth. ‘Pump’ can further refer to or include all necessary subcomponents operable together, such as impeller (or vanes, etc.), housing, drive shaft, bearings, etc. Although not always the case, ‘pump’ can further include reference to a driver, such as an engine and drive shaft. Types of pumps include gas powered, hydraulic, pneumatic, and electrical.

[00113] The term “frac pump” as used herein can refer to a pump that is usable with a frac operation, including being able to provide high pressure injection of a slurry into a wellbore. The frac pump can be operable in connection with a motor or engine. In some instances, and for brevity, ‘frac pump’ can refer to the combination of a pump and a driver together.

[00114] The term “frac truck” as used herein can refer to a truck (or truck and trailer) useable to transport various equipment related to a frac operation, such as a frac pump and engine, and a radiator.

[00115] The term “frac operation” as used herein can refer to fractionation of a downhole well that has already been drilled. ‘Frac operation’ can also be referred to and interchangeable with the terms fractionation, hydrofracturing, hydrofracking, fracking, fraccing, and frac. A frac operation can be land or water based.

[00116] The term “radiator” can also be referred to or interchangeable with the term ‘heat exchanger’ or ‘heat exchanger panel’. The radiator can be a heat exchanger used to transfer thermal energy from one medium to another for the purpose of cooling and/or heating.

[00117] The term “cooler” as used herein can refer to a radiator made up of tubes or other structure surrounded by fins (or ‘core’) that can be configured to extract heat from a fluid moved through the cooler. The term can be interchangeable with ‘heat exchanger panel’ or comparable. Heat can also be exchanged to another fluid, such as air.

[00118] The term “cooling circuit” as used herein can refer to a cooler and respective components.

[00119] The term “core” as used herein can refer to part of a cooler, and can include multiple layers of fins or fin elements.

[00120] The term “heat exchanger unit” as used herein can refer to a device or configuration that uses multiple coolers along with other components, such as a fan, mounts, tubing, frame, and so on. The heat exchanger unit can be independent and standalone or can be directly mounted to a heat generating device. The heat exchanger unit can be operable to pull (draw) ambient air in through the coolers in order to cool one or more service fluids. The heated air is moved or blown out as a waste exhaust stream.

[00121] The term “heat generating device” (or sometimes ‘HGD’) as used herein can refer to an operable device, machine, etc. that emits or otherwise generates heat during its operation, such as

an engine, motor, a genset, or a pump (including the pump and/or respective engine). The HGD can be for an industrial or a residential setting.

[00122] The term “genset” (or generator set) as used herein can refer to a ‘diesel generator’ or the combination of a diesel engine (or comparable) and an electric generator. The genset can convert the mechanical energy to electrical energy.

[00123] The term “baffle” as used herein can refer to a component used within a heat exchanger unit to help regulate or otherwise improve airflow therethrough. The baffle can be one-piece in nature or configured from a number of subcomponents connected together. There can be a plurality of baffles, including various ‘sets’ of baffles. The baffle(s) can include noise absorbing material.

[00124] The term “utility fluid” as used herein can refer to a fluid used in connection with the operation of a heat generating device, such as a lubricant or water. The utility fluid can be for heating, cooling, lubricating, or other type of utility. ‘Utility fluid’ can also be referred to and interchangeable with ‘service fluid’ or comparable.

[00125] The term “mesh” as used herein can refer to a material made of a network of wire or thread, or an interlaced/interconnected structure.

[00126] The term “brazed” as used herein can refer to the process of joining two metals by heating and melting a filler (alloy) that bonds the two pieces of metal and joins them. The filler may have a melting temperature below that of the two metal pieces.

[00127] The term “welded” as used herein can refer to a process that uses high temperatures to melt and join two metal parts, which are typically the same. Such a process can refer to different types of welding, including TIG weld, metal inert gas (MIG), arc, electron beam, laser, and stir friction.

[00128] The term “deformable” as used herein can refer to an ability for a material to experience a change in shape from an original shape, such as from a force, and then substantially return to the original shape.

[00129] The term “machining” (“machine”, “machined”, etc.) as used herein can refer to re-machining, cutting, drilling, abrading, cutting, drilling, forming, grinding, shaping, etc. of a target piece.

[00130] The term “effective mass” as used herein can refer to the mass of part of a component, or partial mass of the component. For example, a core may have a core end, and the core end may

have an effective mass, or a core end mass. The mass of the core end is less than the mass of the whole core.

[00131] The term “mounted” can refer to a connection between a respective component (or subcomponent) and another component (or another subcomponent), which can be fixed, movable, direct, indirect, and analogous to engaged, coupled, disposed, etc., and can be by screw, nut/bolt, weld, and so forth.

[00132] The term “sensor” as used herein can refer to a device that detects or measures a physical property and records, indicates, or otherwise responds to it. The output of a sensor can be an analog or digital signal.

[00133] The term “airflow sensor” as used herein can refer to a sensor used to detect or otherwise be able to measure (directly or indirectly) airflow.

[00134] The term “microprocessor” as used herein can refer to a logic chip or a computer processor on a microchip. The microprocessor may have most or all central processing unit (CPU) functions.

[00135] The term “microcontroller” as used herein can refer to a CPU with additional function or structure, such as RAM, ROM, and or peripherals like I/O all embedded on a single chip.

[00136] The term “voltage regulator” as used herein can refer to a device or logic circuit that maintains a constant voltage level.

[00137] The term “computer readable medium” (CRM) as used herein can refer to any type of medium that can store programming for use by or in connection with an instruction execution system, apparatus, or device. The CRM may be, for example, a device, apparatus, or system based on electronic, magnetic, optical, electromagnetic, or semiconductor function. By way of further example, the CRM may include an electrical connection (electronic) having one or more wires, a portable computer diskette (magnetic or optical), a random access memory (RAM) (electronic), a read-only memory (ROM) (electronic), an erasable programmable read-only memory (EPROM, EEPROM, or Flash memory) (electronic), an optical fiber (optical), and a portable compact disc memory (CDROM, CD R/W) (optical).

[00138] The term “solid data storage” as used herein can refer to a CRM having an array of data, including one or more lookup tables (LUT).

[00139] The term “lookup table” (or LUT) as used herein can refer to a data array that may include predetermined or reference data useable for comparison. A LUT(s) can be stored in static program storage, including solid data storage.

[00140] The term “Wi-Fi module” as used herein can refer to a device or logic circuit that provides ability for a microcontroller to communicate data to a network, as well as update firmware and code inside the microcontroller.

[00141] The term “GSM module” as used herein can refer to a device or logic circuit that provides ability for a microcontroller to communicate data or signal to a Global System for Mobile communication (GSM). The microcontroller can thus initiate, for example, the sending of information in a SMS message.

[00142] The term “CAN-Bus module” as used herein can refer to a message-based protocol that allows a microcontroller to communicate with other devices, which can include industrial or large pieces of equipment associated with a respective microcontroller.

[00143] The term “blender unit” as used herein can refer to one or more pieces of equipment arranged together for the purpose of forming a frac slurry. The blender unit can have one or more engines associated and operably engaged with a respective cooler. The blender unit can, but need not have to be, mobile.

[00144] Embodiments herein pertain to a heat exchanger unit that may include a vertical axis; and a frame. The frame may include a top region, a bottom region, and a plurality of side regions. A first cooler may be coupled with the frame proximate to a respective side region. The first cooler may be mounted with its long axis generally may be parallel to the vertical axis.

[00145] The heat exchanger unit may include a second cooler coupled with the frame. The second cooler may be coupled proximate to the top region. The second cooler may be coupled and oriented in a manner whereby its long axis may be generally perpendicular to the vertical axis.

[00146] The heat exchanger unit may include an inner airflow region therein. There may be a first baffle disposed within the inner airflow region, and at a first angle to the vertical axis.

[00147] The heat exchanger unit may include a third cooler. The third cooler may be coupled with the frame proximate to a respective side region. The third cooler may be coupled adjacent the first cooler. The third cooler may be coupled and oriented with its long axis generally parallel to the vertical axis. The heat exchanger unit may include a fourth cooler.

[00148] The fourth cooler may be coupled proximate to the top region, and may be adjacent the second cooler. The fourth cooler may be coupled and oriented in a manner whereby its long axis may be generally perpendicular to the vertical axis.

[00149] The heat exchanger unit may include a second airflow region partitioned from the inner airflow region. The second airflow region may be associated with the third cooler and the fourth cooler. There may be a second baffle disposed within the second airflow region. The second baffle may be coupled and oriented at a second angle to the vertical axis. The first angle and/or the second angle may be in the range of about 30 degrees to about 60 degrees. The first angle and the second angle may be at least substantially the same.

[00150] Either of the first baffle and the second baffle may include a sound absorbing material. In aspects, the sound absorbing material may be mineral wool or other comparable material.

[00151] The heat exchanger unit may include at least one fan configured to operate and produce a point source dominant acoustic frequency. Sound absorbing material may be capable to reduce the point source dominant acoustic frequency by at least 10 dB.

[00152] The heat exchanger unit may include a first fan mounted to the frame external to a first side of the first cooler. There may also be a second fan mounted to the frame external to a first side of the third cooler. Each of the first fan and the second fan may have an axis of rotation substantially perpendicular to the vertical axis.

[00153] One or more coolers of the exchanger unit may be configured to permit airflow to pass therethrough. In aspects, operation of the first fan and/or the second fan may result in airflow through one or more respective coolers and airflow regions, and out of an outlet of the HX unit.

[00154] The HX unit may include a first sidewall; a second sidewall; a back wall; and a bottom. At least one of the first sidewall, the second sidewall, the back wall, and the bottom may have a sound absorbing material. At least one of the first sidewall, the second sidewall, the back wall, and the bottom may have a vinyl-based material. In aspects, At least one of the first sidewall, the second sidewall, the back wall, and the bottom may have an inner layer of sound absorbing material; and an exterior layer of a vinyl-based material.

[00155] The heat exchanger unit may include a monitoring module proximately coupled to at least one of the first cooler, the second cooler, the third cooler, and the fourth cooler. The monitoring module may include: a cover panel; at least one sensor coupled with the cover panel; at least one controller housing coupled with the cover panel; and a microcontroller

disposed within the controller housing and in operable communication with the at least one sensor.

[00156] At least one sensor of the module may include a rotating member configured to generate a system signal proportional to an amount of rotation of the rotating member. The microcontroller may be provided and programmed with computer instructions for processing the system signal. In aspects, the system signal may pertain to an amount of fouling.

[00157] The monitoring module may include a plurality of sensors. One or more of the plurality of sensors may be in operable communication with the microcontroller. At least one of the plurality of sensors may include a plurality of blades radially extending from the respective rotating member.

[00158] The monitoring module may include one or more of: a solid data storage, a Wi-Fi module, a GSM module, and a CAN-Bus module being disposed within the controller housing and in operable communication with the microcontroller. The microcontroller may be provided with computer instructions for communicating with one or more of the solid data storage, the Wi-Fi module, the GSM module, and the CAN-Bus module.

[00159] Embodiments of the disclosure pertain to a blender skid for creating a frac fluid mixture that may include a blender (or tub); a heat generating device; and a heat exchanger unit configured to cool at least one service fluid transferable between the heat exchanger unit and the heat generating device.

[00160] The heat exchanger unit may include a vertical axis; and a frame having a top region, a bottom region, and a plurality of side regions. The unit may include a first cooler coupled with the frame proximate to a respective side region. The first cooler may be mounted in a manner to have its long axis generally parallel to the vertical axis. The unit may include a second cooler coupled with the frame.

[00161] In aspects, the second cooler may have its long axis generally perpendicular to the long axis of the first cooler. Accordingly, the second cooler may be coupled proximate to the top region. In other aspects, the second cooler may have its long axis generally parallel to the long axis of the first cooler. Accordingly, the second cooler may be coupled proximate to one of the plurality of side regions.

[00162] The heat exchanger unit may include an inner airflow region within the heat exchanger unit. There may be a first baffle disposed within the inner airflow region, and at a first angle to

the vertical axis. The heat exchanger unit may include a second baffle disposed therein. The second baffle may be disposed and oriented at a second angle to the vertical axis. The first angle and the second angle may be in the range of 30 degrees to 60 degrees. In aspects, either of the first baffle and the second baffle may include or otherwise have a sound absorbing material.

[00163] The heat exchanger unit of the skid may include a first sidewall; a second sidewall; a back wall; and a bottom.

[00164] At least one of the first sidewall, the second sidewall, the back wall, and the bottom further may include: an inner layer of sound absorbing material; and an exterior layer of a vinyl-based material.

[00165] Embodiments of the disclosure pertain to a method for monitoring a heat exchanger unit that may include one or more of coupling the heat exchanger unit with at least heat generating device; associating a monitoring module with an airflow side of at least one cooler; performing an action based on an indication of the monitoring module.

[00166] The heat exchanger unit of the method may include a vertical axis; a frame comprising a top region, a bottom region, and a plurality of side regions; a first cooler coupled with the frame proximate to a respective side region and generally parallel to the vertical axis; a second cooler coupled with the frame proximate to the top frame and generally perpendicular to the vertical axis; and an inner airflow region within the heat exchanger unit. There may be a first baffle disposed within the inner airflow region, and at a first angle to the vertical axis.

[00167] The monitoring module may include a cover panel configured for direct or indirect coupling to the heat exchanger unit; an at least one sensor coupled with the cover panel, the at least one sensor having a respective rotating member with a plurality of blades extending therefrom; a logic circuit in operable communication with the at least one sensor; and a microcontroller. The microcontroller may have computer instructions for performing one or more of a plurality of tasks that includes: acquiring a set of data from the at least one sensor; sampling the set of data over a predetermined period of time, and computing an average and a standard deviation; comparing the standard deviation with predetermined data stored on a data storage; determining whether the set of data is acceptable within a defined parameter; determining whether a first lookup table comprising a set of lookup data has been completed, and creating the first lookup table using an averaging method if it has not; comparing the set of data

to the set of lookup data; and providing the indication based on a result of the comparing the set of data to the set of lookup data step.

[00168] The indication from the monitoring module may be communicated to an end user by way of at least one of: a text message, an email, an audio signal, display, a visual indicator, and combinations thereof.

[00169] The monitoring module may further include one or all of: a solid data storage, a Wi-Fi module, a GSM module, and a CAN-Bus module being disposed within the controller housing and in operable communication with the microcontroller. The microcontroller may thus have computer instructions for communicating with one or more of the solid data storage, the Wi-Fi module, the GSM module, and the CAN-Bus module.

[00170] The heat exchanger unit of the method may include a third cooler; and a fourth cooler.

[00171] Any coolers of the heat exchanger unit may have a respective core and a respective tank. The respective core(s) may have a core end having a core end mass. The respective tank(s) may have a tank end having a tank end mass. In aspects, any respective core end mass may be greater than any respective tank end mass.

[00172] The heat exchanger unit of the method may include a mount assembly for coupling any cooler to the frame. The mount assembly may include an elongated fastening member; a rigid outer ring; a rigid inner ring; and a deformable ring disposed between the rigid outer ring and the inner outer ring. Any of the coolers of the heat exchanger unit may have a mounting slot, whereby the respective elongated fastening member may extend therethrough and at least partially into the frame.

[00173] The heat exchanger unit may have a second airflow region partitioned from the inner airflow region. The second airflow region may be associated with the third cooler and the fourth cooler. There may be a second baffle disposed within the second airflow region, and at a second angle to the vertical axis.

[00174] Other embodiments of the disclosure pertain to a heat exchanger unit that may have a vertical axis; a frame comprising a top region, a bottom region, and a plurality of side regions; a first cooler coupled with the frame proximate to a respective side region and generally parallel to the vertical axis; a second cooler coupled with the frame proximate to the top region and generally perpendicular to the vertical axis; a first fan mounted to the frame external to a first

side of the first cooler; an inner airflow region within the heat exchanger unit; and a first baffle disposed within the inner airflow region, and at a first angle to the vertical axis.

[00175] The heat exchanger unit may include a third cooler coupled with the frame proximate to the respective side region, and adjacent the first cooler. The heat exchanger unit may include a fourth cooler coupled with the frame proximate to the top frame, and adjacent the second cooler.

[00176] The heat exchanger unit may include a second airflow region partitioned from the inner airflow region. The second airflow region may be associated with the third cooler and the fourth cooler.

[00177] The heat exchanger unit may have a second baffle disposed therein.

[00178] Any baffle of the heat exchanger unit may have or otherwise include a sound absorbing material. The sound absorbing material may be that for which is capable of reducing noise associated with a point source, such as noise from a fan. The sound absorbing material may be mineral wool.

[00179] The heat exchanger unit may include a second fan mounted to the frame external to a first side of the second cooler. Any fan of the heat exchanger unit may have an axis of rotation substantially perpendicular to the vertical axis.

[00180] The heat exchanger unit may include a monitoring module operably associated therewith. In aspects, the monitoring module may be proximately coupled to one of the first cooler, the second cooler, the third cooler, and the fourth cooler. The monitoring module may include: a cover panel; an at least one sensor coupled with the cover panel; at least one controller housing coupled with the cover panel; and a microcontroller disposed within the controller housing and in operable communication with the at least one sensor.

[00181] The sensor of the module may include a rotating member configured to generate a system signal proportional to an amount of rotation of the rotating member. The microcontroller may have computer instructions for processing the system signal.

[00182] The monitoring module may include a plurality of sensors, with each of the plurality of sensors in operable communication with the microcontroller. At least one of the plurality of sensors comprises may include a plurality of blades radially extending from the respective rotating member

[00183] The monitoring module may include any or all of: a solid data storage, a Wi-Fi module, a GSM module, and a CAN-Bus module being disposed within the controller housing and in

operable communication with the microcontroller. The microcontroller may be provided with computer instructions for communicating with one or more of the solid data storage, the Wi-Fi module, the GSM module, and the CAN-Bus module.

[00184] In aspects, the system signal may pertain to an amount of fouling.

[00185] In aspects, the heat exchanger unit may have a plurality of monitoring modules operably associated therewith.

[00186] Any cooler of the heat exchanger unit may have a respective core and a respective tank, which may further have a respective core end having a core end mass, and a respective tank end having a tank end mass. Although not necessary, the respective core end mass may be greater than the respective tank end mass.

[00187] Yet other embodiments pertain to a monitored heat exchanger system that may include a heat exchanger unit in operable engagement with a heat generating device, with an at least one service fluid being transferable therebetween. The HX unit may include a frame; and at least one cooler coupled with the frame, the at least one cooler having an airflow-in side and a service fluid-in side.

[00188] The system may include a monitoring module coupled to the heat exchanger unit. The monitoring module may include a panel (or cover panel); an at least one sensor coupled with the cover panel; an at least one controller housing coupled with the cover panel; and a microcontroller disposed within the controller housing and in operable communication with the at least one sensor.

[00189] The at least one sensor may include a rotating member configured to generate a system signal proportional to an amount of rotation of the rotating member. In aspects, the microcontroller may be provided with computer instructions, and may be otherwise operable, for processing the system signal.

[00190] The monitoring module may include a plurality of sensors. One or more of the plurality of sensors may be in operable communication with the microcontroller. In aspects, at least one of the plurality of sensors or the microcontroller may be powered at least partially, directly or indirectly, by rotation of the rotating member.

[00191] The at least one sensor may include a plurality of blades extending (such as generally radially) from the rotating member. The system signal may pertain to or be based on an amount of fouling associated with the airflow side of the at least one cooler.

[00192] The monitoring module may include one or more of a solid data storage, a Wi-Fi module, a GSM module, and a CAN-Bus module. Each may be disposed within the controller housing and may be in operable communication with the microcontroller. Accordingly, the the microcontroller may be provided with computer instructions for communicating with one or more of the solid data storage, the Wi-Fi module, the GSM module, and the CAN-Bus module.

[00193] The at least one service fluid comprises one of lube oil, hydraulic fluid, fuel, charge air, transmission fluid, jacket water, and engine cooler. The heat generation device may be a diesel engine. In aspects, the heat exchanger unit may have four respective sides (and thus cubical or rectangular prism shaped). Each side may have a respective cooler mounted to the frame.

[00194] The heat exchanger unit may have a plurality of coolers configured to permit airflow to pass therethrough. In aspects, operation of a fan may result in airflow through each of the plurality of coolers, into the airflow region, and out of the outlet. The frame of the heat exchanger unit may include a plurality of horizontal members and vertical member configured together in a manner that results in a generally cube-shaped frame.

[00195] The heat exchanger unit of the system may include other configurations, such as a frame comprising a top region, a bottom region, and plurality of side regions; a plurality of coolers, each of the plurality of coolers coupled with the frame proximate to a respective side region, and each of the plurality of coolers comprising a core welded with a tank. Each core further may include a core end having a core end mass. Each tank further may include a tank end having a tank end mass. In aspects, each core end mass may be greater than each respective tank end mass.

[00196] The system may include the use of a mount assembly for coupling a cooler to the frame of the HX unit. The mount assembly may include an elongated fastening member; a rigid outer ring; a rigid inner ring; and a deformable ring disposed between the rigid outer ring and the inner outer ring.

[00197] Other embodiments of the disclosure pertain to a system that may include a heat exchanger unit in operable engagement (including fluid communication) with a heat generating device. There may be an at least one service fluid transferable therebetween. The heat exchanger unit may include a frame; and at least one cooler coupled with the frame, the at least one cooler having an airflow side and a service fluid side fluidly separated from each other.

[00198] The at least one service fluid may be one of lube oil, hydraulic fluid, fuel, charge air, transmission fluid, jacket water, and engine cooler. The heat generation device may be a diesel engine. The heat exchanger unit may have a plurality of sides, such as about three sides to about five sides. In aspects, there may be four sides. Any of the sides may have a respective cooler mounted to the frame proximate thereto. Any of the sides may have a respective monitoring module operably associated therewith.

[00199] In aspects, one or more cores may have a core end having a core end mass. In aspects, one or more tanks may have a tank end having a tank end mass. In aspects, the core end mass may be greater than the tank end mass of a respective core.

[00200] The heat exchanger unit may include a mount assembly associated therewith. The mount assembly may be configured for coupling a respective cooler to the frame. The mount assembly may include an elongated fastening member; a rigid outer ring; a rigid inner ring; and a deformable ring disposed between the rigid outer ring and the inner outer ring. The respective cooler may include at least one mounting slot, whereby the elongated fastening member may extend through the rigid inner ring and at least partially into the frame.

[00201] The heat exchanger unit may include a vertical axis; an airflow region within the heat exchanger unit; and a first set of baffles, each of the first set of baffles configured at an angle to the vertical axis.

[00202] Any of the baffles may have a sound absorbing material, such as mineral well, disposed therein (or therewith). An orientation angle of the baffle within the heat exchanger unit may be in the range of about 30 to about 60 degrees.

[00203] Any respective cooler may include a weld between the tank end and the core end that may be a v-groove weld.

[00204] The heat exchanger unit may include between about one set of baffles to about four sets of baffles, any of which may include the sound absorbing material, which may include mineral wool. Baffles of the sets may have various orientation angles, including in the range of about 30 degrees to about 60 degrees. Baffles of the sets may have various shapes, any of which may be generally isosceles trapezoidal in shape.

[00205] Embodiments of the disclosure pertain to a monitoring module for monitoring operation of a heat exchanger unit that may include a cover panel configured for direct or indirect coupling to the heat exchanger unit; one or more sensors coupled with the cover panel. Any of the one or

more sensors may have a respective rotating member with a plurality of blades extending therefrom.

[00206] The module may include a logic circuit in operable communication with the plurality of sensors, and further comprising: a microcontroller and a data storage. The microcontroller may be configured with computer instructions for performing one or more of the tasks of: acquiring a set of data from at least one of the plurality of sensors; sampling the set of data over a predetermined period of time; computing an average and a standard deviation of the set of data; comparing the standard deviation with predetermined data; determining whether the set of data is acceptable within a defined parameter; determining whether a first lookup table comprising a set of lookup data has been completed, and creating the first lookup table using an averaging method if it has not; comparing the set of data to the set of lookup data; and providing an indication based on a result of the comparing the set of data to the set of lookup data step.

[00207] The microcontroller may be powered at least partially, directly or indirectly, by at least one of the plurality of sensors.

[00208] The indication may be communicated to an end user by way of at least one of: a text message, an email, an audio signal, a visual indicator, and combinations thereof.

[00209] The logic circuit may include the microcontroller in operable communication with one or more of: a Wi-Fi module, a GSM module, and a CAN-Bus module. Accordingly, the microcontroller may be provided with computer instructions for communicating with one or more of: the Wi-Fi module, the GSM module, and the CAN-Bus module.

[00210] Other embodiments of the disclosure pertain to a monitoring module that may include a cover panel mountingly associated with an airflow side of the heat exchanger unit; a plurality of sensors coupled with the cover panel, each of the sensors having a respective rotating member with a plurality of blades extending therefrom; a logic circuit in operable communication with the plurality of sensors. The logic circuit may include a microcontroller configured with computer instructions for performing one or more of the tasks of: acquiring a set of data from at least one of the plurality of sensors; sampling the set of data over a predetermined period of time of less than 120 seconds; computing an average and a standard deviation of the set of data; comparing the standard deviation with predetermined data stored in a data storage; determining whether the set of data is acceptable within a defined parameter; determining whether a first lookup table comprising a set of lookup data has been completed, and creating the first lookup

table using an averaging method if it has not; comparing the set of data to the set of lookup data; and providing an indication based on a result of the comparing the set of data to the set of lookup data step.

[00211] The logic circuit may include the microcontroller in operable communication with one or more of a Wi-Fi module, a GSM module, and a CAN-Bus module. Thus the microcontroller may have computer instructions programmed therein for communicating with one or more of the Wi-Fi module, the GSM module, and the CAN-Bus module.

[00212] The monitoring module may be operable to provide the indication as it pertains to an amount of fouling on the airflow side.

[00213] The microcontroller may be powered at least partially by at least one of the plurality of sensors.

[00214] The heat exchanger unit may include a fan. The fan may be operable in a manner whereby the fan produces a point source dominant acoustic frequency. Which is to say during operation the fan may generate the point source dominant acoustic frequency. The sound absorbing material within respective baffles of the heat exchanger unit may be suitable to reduce the point source dominant acoustic frequency by at least 10 dB.

[00215] One or more baffles of the heat exchanger unit may be generally isosceles trapezoidal in shape. In aspects, each of the first set of baffles are generally isosceles trapezoidal in shape.

[00216] The sound absorbing material may be mineral wool.

[00217] One or more coolers of the heat exchanger unit may be configured to permit airflow to pass therethrough. Operation of the fan may result in airflow through at least one of the plurality of coolers, into the airflow region, and out of the outlet.

[00218] The frame may include a plurality of horizontal members and vertical member configured together in a manner that results in a generally 'cube-shaped' frame.

[00219] Other embodiments of the disclosure pertain to a heat exchanger unit that may include a vertical axis and a frame. The frame may include one or more regions, such as a top region, a bottom region, and a plurality of side regions.

[00220] The unit may further include a plurality of coolers. At least one of the plurality of coolers may be coupled with the frame proximate to a respective side region. At least one of the plurality of coolers may have an outer surface and an inner surface.

[00221] The heat exchanger unit may have an airflow region therein.

[00222] The fan may be operable with an axis of rotation. The axis of rotation may be substantially parallel to the vertical axis. Operation of fan may result in airflow through one or more of the plurality of coolers, into the airflow region, and out of the top region.

[00223] The exchanger unit may include other components or features, such as a tubular fan mount bar; a shroud coupled to a top surface; and an aeroring. There may be a fan mount coupled to the tubular fan mount bar. There may be a fan coupled to the fan mount. The fan may be a hydraulic motor.

[00224] Yet other embodiments of the disclosure pertain to a heat exchanger unit that may include a frame having one or more associated regions, such as a top region, a bottom region, and a plurality of side regions. The heat exchanger unit may have a plurality of coolers coupled with the frame. Various coolers of the plurality of coolers may be coupled with the frame proximate to a respective side region. The coolers may have an outer surface and an inner surface.

[00225] The heat exchanger unit may include one or more mount assemblies. A respective mount assembly (or sometimes 'flexible mount assembly') may be configured for the coupling of a corresponding cooler of the plurality of coolers to the frame.

[00226] The amount assembly may include an elongated fastening member; a rigid outer ring; a rigid inner ring; and a deformable ring disposed between the rigid outer ring and the inner outer ring.

[00227] In aspects, the mount assembly may include a top plate, a bottom plate, and a washer.

[00228] Any of the plurality of coolers may include a mounting slot. The elongated fastening member may extends through the rigid inner ring. The elongated fastening member may extend at least partially into and/or engage the frame.

[00229] The heat exchanger unit may include an axis, such as a vertical axis.

[00230] The heat exchanger unit may include an airflow region therein.

[00231] The heat exchanger unit may include a first set of baffles. One or more baffles of the first set of baffles may be configured (positioned, oriented, etc.) at a respective angle to the vertical axis.

[00232] The heat exchanger unit may include other sets of baffles, such as a second set of baffles, third set of baffles, fourth set of baffles, fifth set of baffles, etc. One or more baffles of the second set of baffles may be configured at a respective second angle to the vertical axis. One or more baffles of the third set of baffles may be configured at a respective third angle to the

vertical axis. Other baffles of other sets may likewise be configured with a respective angle to an applicable axis.

[00233] Any of the sets of baffles may have between about one to about ten baffles. In aspects, the first set of baffles, the second set of baffles, and the third set of baffles may each have about three to about five baffles.

[00234] Any of the baffles of the heat exchanger unit may have therewith or otherwise be configured with a sound absorbing material. In aspects, any of the baffles of either of the first set of baffles, the second set of baffles, and the third set of baffles may include the sound absorbing material. The sound absorbing material may be mineral wool.

[00235] Any of the baffles of the heat exchanger unit may be formed with a desired shape. For example, one or more of the baffles of the first set of baffles may have a generally isosceles trapezoidal shape.

[00236] Any of the baffles of the heat exchanger unit may be configured with a respective angle to an axis. The angle may be in the range of about 30 degrees to about 60 degrees.

[00237]

[00238] Any of the plurality of coolers may be configured to permit airflow to pass therethrough. In aspects, operation of a fan of the heat exchanger unit may result in airflow through any of the respective plurality of coolers, into the airflow region, and out of an exhaust outlet.

[00239] The heat exchanger unit may include one or more mount assemblies. A respective mount assembly may be configured for the coupling of, at least partially, a corresponding cooler of the plurality of coolers to the frame. Any respective mount assembly may include various components, such as an elongated fastening member; a rigid outer ring; a rigid inner ring; a deformable ring disposed between the rigid outer ring and the inner outer ring.

[00240] Any cooler may include or be associated with one or more mounting slots. The elongated fastening member of a respective mount assembly may be configured to extend into and through the rigid inner ring, through the respective mounting slot, and/or at least partially into the frame.

[00241] Any mount assembly may include a top plate, a bottom plate, and/or a washer.

[00242] The frame of the heat exchanger unit may include one or more frame members, such as horizontal members and vertical members. In aspects, a plurality of horizontal members and vertical member coupled together in a manner that results in a desired frame shape. The desired frame shape may be a cube-shape.

[00243] Other embodiments of the disclosure pertain to a method of operating or otherwise using a heat exchanger unit of the present disclosure. The method may include the steps of assembling a heat exchanger unit that includes a plurality of horizontal members and vertical member coupled together in a manner that results in a desired frame shape. The heat exchanger unit may include one or more coolers. One or more coolers may be associated with one or more respective mount assemblies. The mount assemblies may be configured or otherwise suitable for the coupling, at least partially, of the respective cooler to the frame.

[00244] The method may include the step of associating a fan (or fan system) with the frame. The fan may be driving by a motor, which may be a hydraulic motor.

[00245] The method may include the step of operating the fan motor with a pressurized hydraulic fluid.

[00246] The method may include using one or more coolers having a respective core end welded with a first tank end. The core end may have a core end mass. The first tank end may have a tank end mass. The core end mass may be greater than the tank end mass.

[00247] The heat exchanger unit may include various sets of baffles, such as a first set, second set, third set, fourth set, etc.

[00248] Any baffle of any respective set of baffles may be coupled to the frame. Any baffle of any respective set of baffles may have a material capable of effecting sound associated therewith.

[00249] In aspects, any baffle of the first set of baffles may be coupled to the frame at an orientation of a respective first angle to the axis. Any baffle of the first set of baffles may include a sound absorbing material.

[00250] In aspects, any baffle of the second set of baffles may be coupled to the frame at an orientation of a respective second angle to the axis. Any baffle of the second set of baffles may include a sound absorbing material.

[00251] In aspects, any baffle of the third set of baffles may be coupled to the frame at an orientation of a respective third angle to the axis. Any baffle of the third set of baffles may include a sound absorbing material.

[00252] In aspects, any baffle of the fourth set of baffles may be coupled to the frame at an orientation of a respective fourth angle to the axis. Any baffle of the fourth set of baffles may include a sound absorbing material.

[00253] Any of the respective first angle, the second angle, the third angle, and the fourth angle may be in the range of about 30 to about 60 degrees.

[00254] Any respective set of baffles may be positioned a quarter wavelength below the fan, the quarter wavelength being calculated based on a dominant acoustic frequency generated by the fan during its operation.

[00255] The method may include the step of using at least one baffle within the heat exchanger unit that has a sound absorbing material therein.

[00256] The method may include the step of coupling the heat exchanger unit with a heat generating device. The heat exchanger unit and the heat generating device may be in fluid communication.

[00257] Other embodiments of the disclosure pertain to a system for cooling a fluid that may include a heat exchanger unit of the present disclosure coupled in fluid communication with at least one heat generating device. The heat exchanger unit may include a plurality of horizontal members and vertical member coupled together in a manner that results in a desired frame shape. The heat exchanger unit may include one or more coolers. One or more coolers may be associated with one or more respective mount assemblies. The mount assemblies may be configured or otherwise suitable for the coupling, at least partially, of the respective cooler to the frame.

[00258] The heat exchanger unit of the system may include a fan coupled with the frame. The fan may be operably associated with a motor, which may be a hydraulic motor. The motor may be operable via the use of a pressurized hydraulic fluid.

[00259] The heat exchanger unit of the system may include one or more coolers having a respective core end welded with a first tank end. The core end may have a core end mass. The first tank end may have a tank end mass. The core end mass may be greater than the tank end mass.

[00260] The heat exchanger unit of the system may include various sets of baffles, such as a first set, second set, third set, fourth set, etc.

[00261] Any baffle of any respective set of baffles may be coupled to the frame. Any baffle of any respective set of baffles may have a material capable of effecting sound associated therewith.

[00262] The heat exchanger unit and the heat generating device may be in fluid communication.

[00263] There may be a plurality of heat exchanger units coupled with a respective plurality of heat generating devices.

[00264] In aspects, the heat generating device may be an engine of a frac pump. The frac pump may be associated with a mobile frac pump skid or trailer. In aspects, the heat generating device may be an engine of a blender unit. The engine may be associated with a screw auger or blender unit booster pump.

[00265] The system may include the frac pump in fluid communication with a wellbore. The system may include the booster pump in fluid communication with the frac pump. The system may include the blender unit in fluid communication with the frac pump skid.

[00266] Referring now to Figures 2A and 2B together, a side view of a heat exchanger unit coupled with a heat generation device, and an isometric view of a frame of the heat exchanger unit, respectively, in accordance with embodiments disclosed herein, are shown. Embodiments herein apply to a heat exchanger unit that may be an inclusive assembly of a number of components and subcomponents. The heat exchanger unit 200 may include a solid integral frame (or skeletal frame) or may be a frame 202 that includes a number of elements arranged and coupled together, such as a plurality of horizontal elements 250 and a plurality of vertical elements 251.

[00267] Although the shape of the frame 202 need not be limited, Figure 2B illustrates a generally cubical shape (*i.e.*, four side regions, a top region, and a bottom region) that results from the horizontal elements 250 and the vertical elements 251 being connected at various corners and generally perpendicular to one another. Other shapes of the frame 202 could include cylindrical, hexagonal, pyramidal, and so forth. As the shape of the frame 202 may vary, so may the shape of frame elements 250, 251. It is within the scope of the disclosure that heat exchanger unit 200 may have a single side (or region), and thus a single frame side.

[00268] The frame 202 may include additional frame support plates, which may be suitable for further coupling elements 250 and 251 together, as well as providing additional surface area or contact points for which other components may be coupled therewith. One or more frame support plates 252a may have a generally vertical orientation, whereas one or more frame support plates 252b may have a generally horizontal orientation. One or more frame support plates 252 (or 252a, b etc.) may include a support plate slot or groove 253.

[00269] The horizontal or vertical members 250, 251 may include one or more core support mount slots 282, whereby a radiator core (or 'core') 206 may be coupled to the frame 202 via

therewith. There may be a plurality of such slots 282 configured and arranged in a manner (of respective members 250 or 251) whereby a plurality of cores 206 may be coupled therewith. One or more coolers (comprising a respective core 206) may be coupled to the frame with respective mount assemblies (*e.g.*, 1000, 1000a Figures 5A-5E). One or more cores 206 may be associated with and proximate to a respective protective grate 248, which may be useful for protecting fins of the core 206.

[00270] The frame 202 may include yet other additional support or structural elements, such as one or more frame support bars 254. The support bar(s) 254 may be coupled between various elements 250, 251, such as in a horizontal, vertical, or diagonal manner. The support bars 254 may be arranged in a 'turnbuckle' configuration. The support bar(s) 254 may be coupled to elements in a known manner, such as rivet, weld, nut-and-bolt, etc. The bars 254 may be tubular in shape, which may help improve airflow and reduce pressure drop thereacross.

[00271] The frame 202 may also include a top plate 255, which may have a top plate opening 256. The top plate opening 256 may be of a shape and size suitable for accommodating airflow therethrough. The HX unit 200 may include a fan system 257. The fan system 257 may include related subcomponents, such as a fan 208 that may be understood to include a rotating member with a plurality of fan blades 211 extending therefrom. The fan 208 may be a Multi-Wing fan from Multi-Wing International or a Horton® fan.

[00272] There may be in the range of about 4 to about 16 blades 210 attached in a generally symmetrical manner. The blades 211 may be oriented at a blade angle to the horizontal axis 226 in the range of about 10 degrees to about 50 degrees. The angle of blades 211 may be adjusted to promote optimal and efficient cooling of the HX unit 200.

[00273] The blades 211 may have an effective blade diameter in the range of about 10 inches to about 100 inches. The fan 208 may be operable by way of a suitable driver, such as a fan motor 212, which may be hydraulic, electrical, gas-powered, etc. The fan motor 212 may receive power through various power cords, conduits (*e.g.*, conduit and cabling 258), etc., as would be apparent to one of skill in the art. The conduits 258 may be configured for the transfer of pressurized hydraulic fluid to and from the motor 212. As such, pressurized hydraulic fluid may be used to power the motor 212. The pressure of the hydraulic fluid may be in the range of about 2,000 psi to about 6,000 psi. Hydraulic fluid may exit the motor 212, and be cooled via the HX unit 200, repressurized, and recirculated back to the motor 212.

[00274] The fan 208 may operate in the range of about 200 rpm to about 1200 rpm. The fan 208 may operate in a manner to provide airflow in the range of about 10,000 cfm to about 200,000 cfm. The originating noise of the fan 208 may be the range of about 70 dB's to about 120 dB's. The frequency of noise from the fan 208 may be in the range of about 20 hz to about 20,000 hz.

[00275] The frame 202 may include a fan rock guard mount 210, which may be used for the coupling of a fan rock guard 247 thereto. The frame 202 may include a fan mount plate 249. The fan mount plate 249 may include a generally planar surface for coupling with respective fan mounts of the fan 208. The fan mount plate 249 may be connected to a fan mount bar 209. The mount bar 209 may be a rigid bar or beam that extends from one side 259a of the HX unit 200 to another side 259b. The mount bar 209 may be generally cylindrical or tubular shaped, and may be integral to the frame 202 or coupled therewith. In aspects, the bar 209 may be welded to the frame 202 (such as to horizontal members 250 a,b – *see* Figure 6A).

[00276] The fan mount bar 209 may be suitable to provide a synergistic effect of sufficient strength for supporting the fan 208, as well as have smooth surfaces that reduce noise as a result of a decrease in a pressure variation from air flowing over surface area of the bar 209. The fan 208 may have a drive that extends downwardly through fan motor slot 249a.

[00277] The fan system 257 may include a fan shroud 213, which may be generally annular. The fan shroud 213 may be coupled to the frame 202 via connection with the top plate 255. The rock guard 247 may be coupled to the shroud 213. The shroud 213 may include one or more lateral openings 260 to accommodate the passing of the mount bar 209 therethrough. The fan 208 may have a central rotational axis around the vertical axis 227. The shroud 213 may be positioned with respect to the central rotational axis such that fan blades 211 may be extended within desired manufacturing tolerances whereby a clearance exists between the fan blades 211 and a shroud inner surface 213a. The shroud 213 may be a unitary piece or the combination of multiple pieces. The size of the shroud 213, including its height and diameter may be as desired to accommodate airflow through and out of the HX unit 200.

[00278] The shroud 213 may be proximate to an aeroring (223, Figure 2C). The aeroring (223) may be annular in nature, and have a ring cross-section that may have a radius of curvature. Thus, the aeroring (223) may have a rounded surface that may aid in improving airflow and reducing pressure in and around the fan system 257. Without the aeroring (223), eddies and other undesired airflow may occur in corners of the top of the frame 202.

[00279] The configuration of the shroud and aeroring may provide added ability for further streamlining airflow, which may beneficially reduce overall power requirements.

[00280] The fan system 257 can be operable to draw in and direct the flow of air 216. The air 216 may be drawn through the sides of the HX unit 200 (and respective cores, which may then be used to cool one or more utility fluids F) and out as heated exhaust 218. The benefit of such a configuration is the ability to provide cooling in parallel, versus series. In a series configuration (*i.e.*, a typical horizontal orientation – see Figure 1C), the airflow becomes progressively hotter as it passes through each cooling circuit, resulting in a loss in cooling efficiency. This can be especially problematic where ambient air temperature is usually hotter, like Texas and Oklahoma.

[00281] Utility fluid F (or multiple F's) may include by way of example, lube oil, jacket water, turbo (such as for an engine), transmission fluid (such as for a pump), and hydraulic fluid (such as for fan drive 212).

[00282] One of skill in the art would appreciate that airflow through the core 206 may be generally in a path parallel to horizontal axis 226. In an analogous manner, the fan 208 may have an axis of rotation generally parallel to vertical axis 227. In aspects, airflow through the core 206 may be generally perpendicular to the fan 208 axis of rotation. Accordingly, airflow through the HX unit 200 may be transitioned from (approximately) horizontal to vertical as the airflow moves through the core 206 and out the fan exhaust 218.

[00283] As such, by way of example, utility fluid F<sub>1</sub> may be transferred from a heat generating device 203 at a hot temperature into an HX unit inlet 278, cooled with airflow via core 206, and transferred out of an HX unit outlet 284 back to the HGD 203 at a cooler temperature. While not meant to be limited, HGD 203 may be an engine, a genset, a motor, a pump, or other comparable equipment that operates in a manner whereby a utility fluid is heated.

[00284] There may be one or more cores 206. A 'cooler' or 'cooling circuit' may include one or more cores 206. The HX unit 200 may have between about 1 to about 8 cooling circuits, which each may be configured for cooling in parallel to each other.

[00285] Referring now to Figures 5A, 5B, and 5C together, a close-up view of a radiator core mounted to a frame of a heat exchanger unit, a component breakout view of a flexible mount assembly, and a partial side cross-sectional view of a flexible mount assembly used with a

bracket and a frame of a heat exchanger unit, respectively, in accordance with embodiments disclosed herein, are shown.

[00286] Any cooler 204 (or core 206) of the disclosure may be mounted to a frame 202 with a flexible mount assembly 1000. The flexible mount 1000 provides for the ability to have one or more degrees of movement between the core(s) 206 and the frame 202, such as movement that may be caused by thermal expansion of the core 206. As shown, the mount assembly 1000 includes various components, including a bolt 1002 with elongated member or shaft 1001, a first washer 1004, a top plate 1006, an outer rigid ring 1008, an inner rigid (spacer) ring 1012, and a deformable ring 1010, and a bottom (or back) plate 1014 (with plate slot 1014a). Although not shown here, the flexible mount assembly 1000 may be coupled to the frame 202 (or also vertical member 251 and/or horizontal member 250) via a nut plate or threaded receptacle.

[00287] The core 206 may have various structure configured for coupling to the frame 202. For example, there may be one or more core mounts or core mount brackets 287, which may each have one or more core mount slots 288. The bracket 287 may be an integral piece of the core 206 formed at the time of manufacture, or may be connected therewith, such as via a welding process. In addition or alternative, there may be a bracket 287 coupled with a tank 277 of a cooler (204).

[00288] The OD of the outer rigid ring 1008, and ID's of bottom plate slot 1014a and core mount slot 288 may be substantially equivalent, or to the point where ring 1008 may fit (including with tight tolerance fit) within one or both of the bottom plate slot 1014a and core mount slot 288.

[00289] Outer ring 1008 may have an ID configured or otherwise sized in a manner whereby the deformable ring 1010 may fit therein. Similarly the deformable ring 1010 may have an ID (defined by the presence of ring slot 1010a) configured or otherwise sized in a manner whereby the inner rigid ring 1012 may fit therein. And each of the inner rigid ring 1012, the top plate 1006, the washer 1004, and a core mount slot 282 may have a respective slot or orifice size configured to receive a bolt shaft 1002a, including with tight tolerance fit. The mount assembly 1000 may be matable with a mount slot 282a of a respective member 250 and/or 251.

[00290] The deformable ring 1010 may have a generally cylindrical shape, with the ring slot 1010a. The ring slot 1010a may be concentric with respect to the ring 1010 (*e.g.*, see Figure 5E), or may be eccentric. The clearance between the top plate 1006 and the bottom plate 1014 may

accommodate movement of the mount 287, which may result from thermal expansion or contraction of the core 206.

[00291] The deformable ring 1010 may be of such a material that the movement in one or more vectors may be accommodated (such as laterally and axially, and so forth). As shown in Figure 5C, the mount 287 may move back and forth along a path of the directional arrow. In aspects the deformable ring 1010 may be a rubbery material, such as neoprene. The deformable ring 1010 may have the characteristic of having an original shape, being deformed as a result of a force, and then returning (substantially or even exactly) to the original shape. The deformable ring 1010 may have excellent chemical stability and maintain flexibility over a wide temperature range. The force may be that which is incurred as a result of thermal expansion of the core 206, and thus movement of mount 287.

[00292] Referring now to Figures 5D, 5E, and 5F together, a component breakout view of a mount assembly, a side cross-sectional view of a mount assembly used with a bracket and a frame of a heat exchanger unit, and a close-up view of a radiator core mounted to a frame of a heat exchanger unit, respectively, in accordance with embodiments disclosed herein, are shown.

[00293] Any core 206 (or cooler) may be mounted to a frame 202 (or member(s) 250/251) with a flex mount 1000a. The flex mount 1000a provides for the ability to have one or more degrees of movement between the core(s) (206) and the frame 202, such as movement that may be caused by thermal expansion of the core. As shown, the flex mount 1000a may include various components including a bolt 1002a, a first washer 1004a, a top plate 1006a, an outer rigid ring 1008a, an inner rigid (spacer) ring 1012a, and a deformable ring 1010b, and a bottom (or back) plate 1014b (with plate slot 1014c). Although not shown here, the flex mount 1000a may be coupled to the frame 202 (or members 250 and/or 251) via a nut plate or threaded receptacle. Alternatively, the flex mount 1000a may be bolted or coupled with the respective cooler 204.

[00294] The cooler (or core 206) may have one or more core mounts or core mount brackets 287, which may each have one or more core mount slots 288.

[00295] As the flexible mount 1000a may be comparable to flexible mount 1000, flexible mount 1000a is only discussed in brevity. Of note, is the presence of one or more clearance regions 1018, which may promote or otherwise accommodate movement of the core 206 in one more vectors, such as illustrated by way of example via the directional arrows.

[00296] Referring now to Figures 2C, 2D, and 2E together, a side cross-sectional view of an HX unit configured with a plurality of baffles, an isometric view of a set of a plurality of baffles, and a close-up partial side view of a baffle coupled to a vertical member, respectively, in accordance with embodiments disclosed herein, are shown.

[00297] Airflow through an HX unit 200 may be turbulent and otherwise chaotic. In addition, a fan 208 may be so loud in noise emission that it may be impossible to have a conversation between operators in an area of proximity near the fan 208 (or HX unit 200). In addition or the alternative, the noise from the fan 208 may exceed a regulation, which is of even greater significance in the event the HX unit 200 is used in or proximate to a residential setting.

[00298] As illustrated by way of example in Figure 2C, the HX unit 200 may be configured with one or more baffles 222, which may be arranged or otherwise installed on a pseudo-interior side 229 of the unit 200 (the “exterior” 229a and “interior” 229 of the HX unit 200 may be thought of as positionally relative to where ambient air and heated air are).

[00299] Although numerous components around or proximate to an HGD (203, Figure 2A) may be a source of noise, a fan 208 may produce a noise having dominant acoustic frequency ‘f’ with initial amplitude  $A_i$ . To reduce noise emitted from the fan 208, the HX unit 200 may be configured with one or more baffles 222 coupled to a frame 202. It was initially contemplated that the use of baffles 222 could be problematic (restrictive) to airflow; however, in field testing it was unexpectedly discovered that airflow through HX unit 200 had actually increased as a result of the presence of baffles 222. This synergistic effect is believed attributable to the baffles 222 (and position of the baffles) helping to streamline the airflow, rather than acting as a restriction.

[00300] Thus, instead of chaotic turbulence within the interior of the HX unit 200, a baffle shape and an angled orientation of the baffles 222 may result in smoothing out the transition of the airflow from generally horizontal to generally vertical, reducing the airflow recirculation within the interior of HX unit 200, and thus reducing restriction and increasing airflow. The angled orientation may allow for a wider baffle width, which when paired with the proper baffle spacing and absorption material, may work to reduce undesirous fan noise. Spacing may be done in a manner to account for a quarter wave length ( $Q_1 - Q_4$ ) of the fan noise.

[00301] While the baffles 222 may be shown herein as having a generally planar face 261, it will be understood that baffles 222 may have other shapes, such as curved (thus a non-planar face). The positioning of any baffle 222 herein may depend on an angle at which the respective baffle

222 is mounted, and will generally be at an angle  $\alpha$  between 0 degrees to 90 degrees relative to the vertical axis (*i.e.*, an angle defined by where a plane of face 261 intersects a vertical axis 227), as illustrated by way of example in Figure 2E. In aspects, the angle  $\alpha$  may be in the range of about 30 degrees to about 60 degrees. Dimensions of baffles 222 herein may be dependent upon variables, such as the size of the HX unit 200, proximity of other baffles 222, and the angle  $\alpha$  of the baffle orientation, and may change from those depicted. The angle  $\alpha$  of baffle orientation may help direct airflow into and toward the exhaust outlet 218a, such that air may be more easily drawn through the HX unit 200.

[00302] The dominant acoustic frequency  $f$  of the fan 208 may depend on the intended operating speed of the fan 208 and/or number of fan blades 211. The baffle(s) 222 may be designed, configured, and oriented (positioned) to optimize a reduction in amplitude of fan noise. One or more baffles 222 may be made to include or be fitted with a sound absorbing material 262. The material 262 may be mineral wool or another suitable material. The sound absorbing material 262 may be capable of reducing the level of at least the dominant acoustic frequency by 10 dB or more. In an analogous manner, the sound absorbing material may reduce the amplitude of the original fan noise.

[00303] One or more baffles 222 may be positioned approximately a quarter wavelength  $Q_1$  below where the fan 208 is mounted. The quarter wavelength  $Q_1$  may be calculated based on the dominant acoustic frequency  $f$  generated by the fan 208. By referring to a quarter wavelength distance, it will be understood that it may be a multiple of the quarter wavelength, *i.e.*, at or close to the position at which the acoustic wavelength is at its maximum.

[00304] In the instance of using a plurality of sets of baffles 222, it may be desirable to arrange baffles 222 in sets positionable at the quarter wavelength (*e.g.*,  $Q_1$  to  $Q_4$ ) of a different acoustic frequency in order to target different frequencies for acoustic damping. In this respect, baffles 222 of respective sets may be oriented at various angles  $\alpha_x$ . As the baffles 222 may be at varied angles  $\alpha_x$ , the entire face of the respective baffle 222 may not be at the same quarter wavelength position, which allows for some variation in the position of the baffles. Generally speaking, a baffle midpoint 224 of the baffle 222 may be positioned at the respective quarter wavelength position, but this may depend on the acoustic profile of the fan 208.

[00305] In aspects, there may be a first (or ‘upper’) set of baffles 263. One or more of the first set of baffles 263 may be configured in a manner whereby a first baffle plane 261 (relative to a first

baffle planar surface) intersects the vertical axis 227 of the frame at an angle  $\alpha$ . The angle  $\alpha$  may be in the range of about 30 degrees to about 60 degrees. In embodiments, each baffle 222 of the first set of baffles 263 may be coupled to the frame 202 in a manner whereby the respective angle  $\alpha$  of each of the first set of the baffles 263 is in the range of about 30 degrees to about 60 degrees. It is within the scope of the disclosure that the angle  $\alpha$  of each respective baffle 222 of the first set of baffles 263 may be substantially similar; however, the angle  $\alpha$  of each baffle 222 may also be varied with respect to the angles of the other baffles.

[00306] The sets of baffles may each have a respective angle  $\alpha$ , such as  $\alpha_1$  for the first set,  $\alpha_2$  for the second set, etc. In aspects, the angle of each may be substantially the same, such as within about 1 to about 5 degrees.

[00307] The baffles 222 may be pivotably connected directly to the frame 202. Alternatively, the baffles 222 may be fixedly connected to the frame 202, such as with a nut-bolt connection or weld. In this respect, one or more baffle mount couplers 221 may be connected to the frame 202 via coupling to multiple points of either or both of horizontal and vertical members 250, 251. In general, the vertical member 251 may have a plurality of baffle mount couplers 221 thereon. In aspects, each vertical member 251 may have in the range of about three to about five baffle mount couplers 221. The baffle mount coupler 221 may have a hole or slot configured to align with a corresponding frame hole or slot, whereby a bolt or pin from the baffle 222 may be inserted therethrough.

[00308] The HX unit 200 may be optimized for the greatest amount of sound absorption by taking into account variables such as the number of baffles 222, distance between baffles 222 (or sets of baffles), baffle length, and density of sound absorbing material.

[00309] As shown in Figure 2D, a lower part (or bottom region) of the frame 202 may be defined by a plurality of horizontal members 250 and/or horizontal support plates 252b. Various support plates 252b may have one or more baffle mount couplers 221b installed or mounted thereon. The lower part of the frame 202 may be configured in a manner to accommodate various equipment, piping, ducts, or other structure within the HX unit 200, such as housing 245. Accordingly, baffles 222, such as baffles that are part of a lower set of baffles 246, one or more of which may be non-isosceles trapezoidal in shape, may also be configured in a manner to accommodate various equipment piping, ducts, etc.

[00310] The lower set of baffles 246 may include one or more asymmetrical baffles 222, with one or more of which that may be polygonal. The housing 245 may have one or more baffle mount couplers 221b installed or mounted thereon. Equipment and components in the lower part of the frame 202 may have a noise blocking material associated therewith. In aspects, the noise blocking material may be vinyl. The noise blocking material may be adhered to a respective surface. Other parts or components of HX unit 200 may include noise blocking material adhered thereto.

[00311] The baffle mount coupler(s) 221 may be integral to respective vertical member 251 (or other mountable structure, such as horizontal support plate 252b), or may be coupled therewith via rigid and sturdy connection, such as a weld, rivet, or other suitable manner. The baffle mount coupler 221 (or 221b) may include an extended baffle mount element 233 (or 233b) oriented to or at a predetermined angle  $\beta$ . In this respect, when the respective baffle 222 is coupled therewith, the baffle angle  $\alpha$  may be substantially equal to the predetermined angle  $\beta$ , as shown by way of example in Figure 2E.

[00312] The first set of baffles 263 may include in the range of about three to about five baffles 222. The first set of baffles 263 may be arranged in a generally symmetrical manner to each other, such that a first baffle 222 is associated with a first side region 242a, a second baffle 222 is associated with the second side region 242b, and so on. The configuration of the set of baffles may result in a first airflow region 230. As would be apparent to one of skill in the art, the volume of airflow in the first region 230 may be greater than at other regions, and thus a larger region 230 (relatively) may be desirable. Figure 2C illustrates the sets of baffles may be configured in a manner whereby the positioning of baffles form a pseudo 'chevron' shape 220 (in cross-sectional) within the interior 229.

[00313] While baffle shape is not meant to be limited, and may vary amongst respective baffles of the first set of baffles 263, the baffle shape may be generally isosceles trapezoidal in nature. In this respect the baffles 222 of the first set 263 may have at least some minimal clearance with respect to each other upon installation and orientation within the HX unit 200.

[00314] There may be additional baffles 222, such as a second set of baffles 268, a third set of baffles 269, and so forth. The configuration of the second set of baffles 268 may result in a second airflow region proximate thereto, and similarly, the configuration of the third set of baffles 269 may result in a third airflow region proximate thereto.

[00315] While the number of baffles 222 (including sets of baffles) is not meant to be limited, there may be spatial and operational constraints and considerations. For example, too many baffles may result in inability for adequate airflow, and too few baffles may have no effect on negating unwanted noise.

[00316] At the same time, a sound absorbing material 262 (see also Figure 3B) within the baffle(s) may provide the synergistic effect of reducing decibels of the noise attributable to operation of the fan 208. A person standing next to a fan and radiator may not be able to have an audible conversation with another person standing relatively adjacent thereto, as the loudness may be in excess of 70 dBs. In contrast, beneficially the operation of the HX unit 200 configured with the baffles 222 in accordance with embodiments of the disclosure results in significantly reduced noise whereby person-to-person conversation in the proximate vicinity of the HX unit 200 is possible. The reduced loudness may be in the range of about 20 dB's to about 65 dB's.

[00317] Accordingly, the HX unit 200 may include the second set of baffles 268, each of the second set of baffles configured at an angle  $\alpha$  to the vertical axis 227. While not meant to be limited, the angle  $\alpha$  of any of the baffles 222 may be in the range of about 0 degrees to about 90 degrees. In aspects, the angle  $\alpha$  of any of the baffles 222 of the second set of baffles 268 may be in the range of about 30 degrees to about 60 degrees. Each of the second set of baffles 268 may be connected to the frame 202 in a manner comparable to that of the first set 263. As such, the second set of baffles 268 may be connected to respective baffle mount couplers 221.

[00318] The HX unit 200 may include additional sets of baffles, such as a third set of baffles, fourth (or 'lower') set of baffles, and so forth. Each and every baffle of any respective set of baffles may be coupled to the frame 222 via the respective and corresponding baffle mount couplers. Each of the third set of baffles 269 may be configured with an orientation at an angle  $\alpha$  to the vertical axis 237. That is, each respective baffle 222 of the third set 269 may have a plane 261 that intersects the vertical axis 237 at the angle  $\alpha$ . The angle  $\alpha$  may be in the range of about 30 to about 60 degrees.

[00319] It is within the scope of the disclosure that respective baffles of any particular set of baffles may be asymmetrical. Thus, as an example, one or more of the baffles of the first set of baffles may be generally isosceles trapezoidal in shape, while the remaining baffles of the first set are not (*i.e.*, the remaining baffles are other quadrilateral in shape, polygonal, hemispherical, and so on). The shape of the baffle may need to be made to account other internals of the HX unit 200, such as piping, ducts, other subcomponents, etc. (*e.g.*, housing 245, Figure 2D).

[00320] In aspects, the HX unit 200 may include four sets of baffles. One or more, including all, baffles 222 may have a respective plane 261 (associated to an effective planar baffle face surface). The respective plane 261 may intersect the vertical axis 227 at an angle  $\alpha$  in the range of about 0 to about 90 degrees. In aspects, the respective angle  $\alpha$  may be in the range of about 30 to about 60 degrees.

[00321] The core(s) 206 may be coupled to the frame 202 in accordance with embodiments disclosed herein, including directly, or indirectly via mounting a cooler 204 to the frame 202. The cooler 204 may include the core 206 and a tank. The core(s) 206 may include one or more tanks (such as inlet tank 277 and outlet tank 280) welded thereto. The inlet tank 277 may be associated with a tank inlet 278. Similarly, the outlet tank 280 may be associated with a tank outlet 284.

[00322] As shown in the drawings and as would be understood by one of skill in the art, each set of baffles may have a respective first baffle associated with a first side region of the HX unit 200. As it follows, each set of baffles may have a respective second baffle associated with a second side region of the HX unit 200, a respective third baffle associated with a third side region, respective fourth baffle associated with a fourth side region, and so on.

[00323] Referring now to Figures 3A and 3B together, an isometric view of a baffle, and a lateral cross-sectional view of a baffle, respectively, in accordance with embodiments disclosed herein, are shown. As illustrated by way of example, the baffle (including any baffle of the disclosure) 222 may include one or more rigid members 237. The rigid member 237 may be a mesh. The mesh 237 may include various cross-linking or interconnected structure that may result in a plurality of orifices or openings 238. The orifices 238 may be in the range of about 0.1 inches to about 2 inches in mesh size.

[00324] The baffle 222 may include a baffle frame 264. The baffle frame 264 may be a unitary piece, or the combination of multiple subpieces. As shown, the baffle frame 264 may have a generally elongated linear member 239, as well as a non-linear member 240 (as a result of a curve, plurality of linear segments, bend, etc.). While other shapes are within the scope of the disclosure, one or both of the elongated member 239 and the non-linear member 240 may have a generally u-shape cross-sectional 241, as shown in Figure 3B.

[00325] As such, each of the elongated member 239 and the non-linear member 240 may have a first side 265 a,b, a middle 266 a,b, and a second side 267 a,b, respectively. There may be a first mesh 237a connected to the first side 265a of the elongated member 239 and the corresponding first side

265b of the non-linear member 240. In a similar manner, there may be a second mesh 237b connected to the second side 267a of the elongated member 239 and corresponding second side 267b of the non-linear member 240.

[00326] The mesh 237 a,b may be connected to the members 239, 240 in a secured or other fixed manner, such as weld or other suitable form of attachment. As shown in Figure 3B, the baffle 222 may form an effective enclosure or have a resultant baffle chamber 236. The baffle chamber 236 may be filled with a material 262, which may be sound absorbing. The material 262 may be mineral wool, such as a mineral wool product provided by Roxul, Inc. (subsidiary of Rockwool International). The material 262 may have other characteristics, such as non-combustible, high melting point, fire retardant, hypoallergenic, and chemically inert, any of which may be useful for the environment associated with a HGD (*e.g.*, 203, Figure 2A). The material 262 may be a ‘green’ material made from recycled materials.

[00327] While the baffle 222 may be constructed and otherwise completed prior to insertion of the material 262, ease of insertion of the material 262 may be achieved prior to final construction. For example, the first mesh 237a may be welded to the first side 265a of the non-linear member 239, then the second mesh 237b may be welded to the second side 267a of the linear member 239, and then the material 262 may be inserted into chamber 236. Once the material 262 is inserted, each side 265b and 267b the non-linear member 240 may be correspondingly welded with the first and second mesh.

[00328] One or more, including all, baffles 222 may include the material 262. The presence of the sound absorbing material may contribute to a reduction of the loudness of the dominant acoustic frequency of the fan by at least 10 dB. At least one of the sets of baffles may be positioned approximately a quarter wavelength below the fan mounted to the outlet. The quarter wavelength may be calculated based on the dominant acoustic frequency ( $f$ ) generated by the fan (208).

[00329] One of ordinary skill in the art would appreciate that embodiments herein provide for an improved heat exchanger unit of the present disclosure that need not have one or more baffles therein.

[00330] Referring now to Figures 4A, 4B, and 4C together, an isometric partial view of a radiator core, a close-up downward view of a tank welded to a core, and an isometric view of a core end welded to a tank end, respectively, in accordance with embodiments disclosed herein, are shown.

A radiator core 206 for an HX Unit (*e.g.*, 200) may include a structure formed from stacked layers 270 a, b, etc. of corrugated fin elements. Each layer 270 may be mounted or otherwise arranged in manner so that channels 271a formed by the fins in one layer 270a lie in transverse (or albeit sometimes parallel) relation to the channels 271b formed by the fins in adjacent layers 270b, whereby fluid flow passing through the channels may be in cross-flow or counterflow relation in alternate layers.

[00331] While only some layers of the core 206 are shown, various numbers of finned layers may be similarly stacked for completing the core 206, the number of layers depending on the particular application.

[00332] A parting sheet 272 may be placed between adjacent layers to maintain separation between alternate fluid flow paths, and an outer cover bracket(s) 281 may also be used, including for structural support. The cover bracket 281 may be similar to the parting sheets 272, but of thicker stock for added strength. The cover brackets 281 may be brazed to the core 206 (or parts of core 206, such as sheets 272) on each respective side.

[00333] In aspects, the core 206 may be a structure in which a first fluid passes through alternate layers of the core in one direction and a second fluid passes through the remaining layers in a direction perpendicular to the first fluid.

[00334] The core 206 may include external fins 273, which may be associated with each layer where airflow passes therethrough. The core 206 may include internal fins 274, which may be associated with each layer where a HGD utility fluid F passes therethrough.

[00335] The fin elements of layers 270 a,b may be made of aluminum, or other material suitable for heat transfer, including copper, brass, steel, and composite. In aspects, the fins may be made of 3003 aluminum. Each layer 270 may have a fin density of about 4 to about 30 fins per inch. In aspects, layers 270 of the external and internal fins 273, 274 may have in the range of about 10 to about 15 fins per inch.

[00336] In manufacture, the layers 270 of fins may be laid alternately transverse to each other between parting sheets 272, and fitted with respective header bars 275 and face bars 276. A brazing material may be placed between respective sheets 272 and bars 275, 276. The brazing material may be 4004 aluminum, or other comparable material.

[00337] The layers are pressed and held together, and then placed into a brazing oven (or heating furnace, etc.). The brazing operation is finished by taking out the core from the oven, and then

cooled. The brazing may be controlled with time and temperature. The assembled unit may be a 'core' 206.

[00338] The core 206 may be part of a cooler 204 (or cooling circuit). There may be an inlet tank 277 and an outlet tank (not shown here), which may be welded to a core end 206a of the core 206. The tank 277 may be welded in a manner whereby a HGD utility fluid F may flow therein, and into respective layers 270b of internal fins 274. Although not shown here, the inside of inlet tank 277 may be divided by one or more partition walls or plates, for which fluid may flow therein. The inlet tank may have one or more tank inlets 278. The tank inlets 278 may be configured in a manner whereby a fluid may be transferred into the tank 277 via the inlets 278. Various piping, tubing, etc. may be connected to the tank inlets 278, as may be desired for a particular application, and as would be apparent to one of skill in the art. Fluid may be generally evenly distributed through the respective channels 271 as a result of inherent resistance from the fin stack configuration.

[00339] With brief additional reference to Figure 2A, in operation, a utility fluid F from HGD 203 may be transferred into the HX unit 200. The transfer may be direct or indirect (such as from a holding tank). Within the unit 200, the fluid may flow into a tank chamber (not shown) via inlet 278 of inlet tank 277. The fluid then distributes into the various alternating layers 270 b, etc. and respective channels 271b.

[00340] Similarly airflow 216 may be drawn into HX unit 200, and into the various perpendicular and alternating layers 270 a, etc. and respective channels 271a. The HX unit 200 may be configured for passing atmospheric air through or in contact with the core 206, so as to reduce the temperature of the service fluid circulated through the core 206. In this respect, a fan (or fan system) 208 may be rotatable about a fan axis so as to draw in (or suction, etc.) atmospheric air inwardly through channels 271a, resulting in airflow through the core 206. The fan 208 may operate in a manner whereby airflow may move in a generally horizontal direction from external of the core 206, through the core 206, and into the interior of the HX unit 200, whereby the heated air then may transition to a generally vertical direction and out as exhaust 218.

[00341] The service fluid  $F_{1-hot}$ , having a temperature hotter than the airflow, may be cooled (and conversely, the airflow warms). Cooled service fluid  $F_{1-cold}$  leaves the cooling circuit via a fluid outlet 284. Various piping, tubing, etc. may be connected to the tank outlet 284, as may be desired for a particular application, and as would be apparent to one of skill in the art. In some

aspects, the tank outlet 284 may be in fluid communication with an inlet of a subsequent cooling circuit also connected with the frame 202.

[00342] Cooled utility fluid may be returned from the HX unit 200 to a source tank, or directly to the HGD 203. Thus, service fluid from the heat generation unit 203 may be circulated in a cooling circuit in a systematic and continuous manner. As will be appreciated, a suitable circulating pump (not shown) may be provided to circulate the service fluid through the core cooler 204.

[00343] Header bars 275 and face bars 276 may be mounted adjacent to the sides of fins 274 and 273, respectively, the bars being brazed between the extending ends of the parting sheets 272. The face bars 276 may be coupled parallel to the channels 271b and serve to block the sides of the channels to prevent fluid leakage, add structural stability and strength to the core 206, and provide a structure to which the tanks may be welded.

[00344] To direct the fluid flow into the channels, tanks may be welded to the core 206 at the fluid inlet side 206a, or the fluid outlet side, or commonly both sides. Since the core 206 (including the fins), parting sheets, and bars are normally joined by brazing, welding the tanks directly to the core 206 may be of concern as the welding temperature may be about or in excess of 1200° F. These temps may leave the core 206 distorted, and promote flow and leaching of the braze alloy.

[00345] The bars 275, 276 may have a respective bar length 286, which may include pointed extension 283. Thus the bar 275 or 276 may have an effective brazing length 285. Accordingly, at least some or all of the brazing material between the bar and respective parting sheet may heat, and even partially melt during a weld process; however, the brazing length 285 is sufficient enough to prohibit or deter flow of the brazing material, and after weld heat is removed, the braze resolidifies in place.

[00346] In essence, the bars 275 and 276 are part of a core end 206a, which has an effective core end mass  $M_{ce}$  approximately defined by the mass within region  $M_{ce}$ .  $M_{ce}$  may be determined by mass within a volume (*e.g.*, brazing length 285 x fin stack height x core width). In a similar respect the tank (277, 280) has a tank end 277a, which has an effective tank end mass  $M_{te}$  within region  $M_{te}$ .  $M_{te}$  may be defined by a volume of material at the tank end (*e.g.*, tank wall thickness x tank length x tank width). The effective core end mass  $M_{ce}$  may be greater than the effective tank end mass  $M_{te}$ . This may provide the ability so that whereby when the tank is welded to the core there is a natural barrier within the core (as a result of its increased mass) that

prevents leaching or flowing of the brazing material. And where maybe some of the brazing material becomes molten or gooey, this portion of material may be held in situ by the part of the brazing material that remains solid.

[00347] The tank end 277a may be welded to the core end 206a. The weld 293 may be any desired weld suitable and known to one of skill in the art for welding a tank to a core. In embodiments, the weld 293 may be a v-groove weld. Weld material 294 may be used to accomplish the weld.

[00348] Other coolers 204 (*e.g.*, 204 b, c, d, etc.) may be generally similar in nature, and suitably configured for the cooling of various service fluids from the heat generation device 203.

[00349]

[00350] Referring now to Figures 10A and 10B together, an isometric view of a heat exchanger unit with a top mounted cooler, and coupled in fluid communication with a heat generation device, and a lateral cutaway view of the heat exchanger unit, respectively, in accordance with embodiments disclosed herein, are shown.

[00351] Embodiments herein apply to a heat exchanger unit that may be an inclusive assembly of a number of components and subcomponents. The heat exchanger unit 400 may be like that in many respects to heat exchanger unit 200, but as would be readily apparent need not be the same, and indeed as shown here may have a number of discernable differences. The heat exchanger unit 400 may include a solid integral frame (or skeletal frame) or may be a frame 402 that includes a number of elements arranged and coupled together, such as a plurality of horizontal elements 450 and a plurality of vertical elements 451.

[00352] Although the shape of the frame 402 need not be limited, Figures 10A and 10B together illustrates a generally rectangular prism shape (*i.e.*, four side regions, a top region, and a bottom region) that results from the horizontal elements 450 and the vertical elements 451 being connected at various corners and/or generally perpendicular to one another, and joined together with various sheeting (or sidewall) 452. Other shapes of the frame 402 could include cylindrical, hexagonal, pyramidal, and so forth. As the shape of the frame 402 may vary, so may the shape of frame elements 450, 451.

[00353] The frame 402 may include additional frame support plates (including interior and exterior), sidewalls, sheeting, etc., which may be suitable for further coupling frame elements together, as well as providing additional surface area or contact points for which other

components may be coupled therewith. In aspects, one or more frame support plates 454a may have an angled inclination orientation (such as greater than 0 degrees to less than 90 degrees from either axis 426, 427), whereas one or more frame support plates 454b may have a generally horizontal orientation. One or more frame support plates (*e.g.*, 454a) may include a support plate slot or groove, which may be useable for mounting the plate to the frame 402.

[00354] Members (or frame 402) 450, 451 include one or more core support mount slots, whereby a radiator core (or 'core') 406 may be coupled therewith. There may be a plurality of such slots configured and arranged in a manner whereby a plurality of cores 406 may be coupled therewith. One or more coolers (comprising a respective core 406) may be coupled to the frame with respective mount assemblies (*e.g.*, 1000, 1000a Figures 5A-5E). There may be a first cooler 404a and a second cooler 404b.

[00355] One or more cores 406 may be associated with and proximate to a respective protective grate (not shown here), which may be useful for protecting fins 473 of the core 406.

[00356] The frame 402 may include yet other additional support or structural elements, such as one or more frame support bars, which may be coupled between various elements 450, 451, such as in a horizontal, vertical, or diagonal manner. The support bar(s) may be coupled to elements in a known manner, such as rivet, weld, nut-and-bolt, etc.

[00357] The frame 402 may also include a plate 455, which may have a plate opening. The plate opening may be of a shape and size suitable for accommodating airflow therethrough. The HX unit 400 may include a fan system 457. The fan system 457 may include related subcomponents, such as a fan 408 that may be understood to include a rotating member with a plurality of fan blades 411 extending therefrom. The fan system 457 may be operable by way of a suitable driver, such as a fan motor, which may be hydraulic, electrical, gas-powered, etc. The fan motor may receive power through various power cords, conduits, etc., as would be apparent to one of skill in the art. The fan 400 may operate in the range of about 200 rpm to about 1200 rpm, and may further operate in a manner to provide airflow in the range of about 10,000 cfm to about 200,000 cfm. The originating noise of the fan 408 may be the range of about 70 dB's to about 120 dB's. The frequency of noise from the fan 408 may be in the range of about 20 hz to about 20,000 hz.

[00358] The frame 402 may include a fan rock guard mount, which may be used for the coupling of a fan rock guard 447 thereto. The frame 402 may include a fan mount plate 449. The fan

system 447 can be operable to draw (or blow) in and direct the flow of air 416. The air 416 may be drawn (or blown) through the sides of the HX unit 400 (and respective cores, which may then be used to cool one or more utility fluids F) and out as heated exhaust 418. The benefit of such a configuration is the ability to provide cooling while saving space and/or reducing noise. Utility fluid F (or multiple F's) may include by way of example, lube oil, jacket water, turbo (such as for an engine), transmission fluid (such as for a pump), and hydraulic fluid.

[00359] One of skill in the art would appreciate that airflow through the cooler 404a may be generally in a path parallel to horizontal axis 426. In an analogous manner, the fan 408 may have an axis of rotation generally parallel to horizontal axis 426. In aspects, airflow through the first cooler 404a may be generally parallel to the fan 408 axis of rotation. In aspects, airflow through the second cooler 404b may be generally perpendicular to the fan 408 axis of rotation. Accordingly, airflow through the HX unit 400 may be transitioned from (approximately) horizontal to vertical as the airflow moves through the unit 400 and out as heated exhaust 418.

[00360] As such, by way of example, utility fluid  $F_1$  may be transferred from a heat generating device 403 at a hot temperature into an HX unit inlet 478, cooled with airflow cooler 404a, and transferred out of an HX unit outlet 484 back to the HGD 403 at a cooler temperature. While not meant to be limited, HGD 403 may be an engine (including diesel engine), a genset, a motor, a pump, or other comparable equipment that operates in a manner whereby a utility fluid is heated.

[00361] There may be one or more cores 406. A respective 'cooler' or 'cooling circuit' may include one or more cores 406. The HX unit 400 may have between about 1 to about 8 cooling circuits, which each may be configured for cooling in parallel to each other.

[00362] Any cooler 404 a,b (or respective core) of the disclosure may be mounted to the frame 402 with a flexible mount assembly 1000 as described herein (*see, e.g.*, Figures 5A-5F and supporting text). Although not shown here, the flexible mount assembly 1000 may be coupled to the frame 402 (or also vertical member 451 and/or horizontal member 450) via a nut plate or threaded receptacle.

[00363] Airflow through an HX unit 400 may be turbulent and otherwise chaotic. In addition, a fan 408 may be so loud in noise emission that it may be impossible to have a conversation between operators in an area of proximity near the fan 408 (or HX unit 400). In addition or the alternative, the noise from the fan 408 may exceed a regulation, which is of even greater significance in the event the HX unit 400 is used in or proximate to a residential setting.

[00364] As shown, the HX unit 400 may be configured with one or more baffles 422, which may be arranged or otherwise installed on a pseudo-interior side 429 of the unit 400 (the “exterior” 429a and “interior” 429 of the HX unit 400 may be thought of as positionally relative to where ambient air and heated air are). Ingress and egress may be provided via access way 492. The access way may be closed via door 493, which may be, for example, hingedly mounted to the frame. The door 493 may be shut and held shut via one or more securing members (not viewable here).

[00365] Although numerous components around or proximate to the HGD 403 may be a source of noise, the fan 408 may produce a noise having dominant acoustic frequency ‘f’ with initial amplitude. To reduce noise emitted from the fan 408, the HX unit 400 may be configured with one or more baffles 422 coupled to the frame 402 (such via frame member 454a). In aspects, airflow through HX unit 400 may actually increase as a result of the presence of baffle 422. This synergistic effect is believed attributable to the baffle 422 (and position of the baffles) helping to streamline the airflow, rather than acting as a restriction. The baffle 422 may be like that described herein (*see, e.g.*, Figures 3A-3B and related text).

[00366] Thus, instead of chaotic turbulence within the interior of the HX unit 400, a baffle shape and an angled orientation of the baffles 422 may result in smoothing out the transition of the airflow from generally horizontal to generally vertical, reducing the airflow recirculation within the interior of HX unit 400, and thus reducing restriction and increasing airflow. The angled orientation may allow for a wider baffle width, which when paired with the proper baffle spacing and absorption material, may work to reduce undesirous fan noise.

[00367] While the baffle 422 may be shown herein as having a generally planar face, it will be understood that baffle 422 may have other shapes, such as curved (thus a non-planar face). The positioning of any baffle 422 herein may depend on an angle at which the respective baffle 422 is mounted, and will generally be at an angle  $\alpha$  between 0 degrees to 90 degrees relative to the vertical axis (*i.e.*, an angle defined by where a plane of the baffle face intersects an axis). In aspects, the angle  $\alpha$  may be in the range of about 30 degrees to about 60 degrees. Dimensions of the baffle 422 herein may be dependent upon variables, such as the size of the HX unit 400, proximity of other baffles, and the angle  $\alpha$  of the baffle orientation, and may change from those depicted. The angle  $\alpha$  of baffle orientation may help direct airflow into and toward an exhaust outlet, such that air may be more easily drawn through the HX unit 400.

[00368] The baffle(s) 422 may be designed, configured, and oriented (positioned) to optimize a reduction in amplitude of fan noise. One or more baffles 422 may be made to include or be fitted with a sound absorbing material (262, Figure 3B). The material may be mineral wool or another suitable material as described herein.

[00369] The baffle 422 may be non-isosceles trapezoidal in shape, may also be configured in a manner to accommodate various equipment piping, ducts, etc. While baffle shape is not meant to be limited, the baffle shape may be generally rectangular in nature.

[00370] There may be additional baffles 422, such as a second baffle, a third baffle, and so forth. The use of the second baffle may result in a second airflow region proximate thereto.

[00371] While the number of baffles 422 (including sets of baffles) is not meant to be limited, there may be spatial and operational constraints and considerations. For example, too many baffles may result in inability for adequate airflow, and too few baffles may have no effect on negating unwanted noise.

[00372] At the same time, the sound absorbing material (see also Figure 3B) within the baffle(s) may provide the synergistic effect of reducing decibels of the noise attributable to operation of the fan 408. A person standing next to a fan and radiator may not be able to have an audible conversation with another person standing relatively adjacent thereto, as the loudness may be in excess of 70 dBs. In contrast, beneficially the operation of the HX unit 400 configured with the baffle 422 in accordance with embodiments of the disclosure results in significantly reduced noise whereby person-to-person conversation in the proximate vicinity of the HX unit 400 may be possible. The reduced loudness may be in the range of about 20 dB's to about 65 dB's.

[00373] Referring briefly to Figure 10C, a breakout cross-sectional view of a sidewall of a heat exchanger unit, in accordance with embodiments disclosed herein, is shown. The HX unit 400 may include one or more sidewalls 452 configured with various layers. For example, the outer exterior side may be a sheeting layer 490, which may be sheet metal. The interior side of the sidewall 452 (*i.e.*, the side exposed inward in interior 429, Figure 10B) may have a mesh 437. Between the mesh 437 and sheeting layer 490 may be one or more layers of additional material.

[00374] As shown, there may be a layer of sound absorbing material 462. The sound absorbing material may be mineral wool or other comparable material. There may be a layer of material 491. In aspects, the sound absorbing material 462 may be positioned between the sheeting layer 490 and the layer of material 491. The layer of material may be a vinyl-based material. In aspects, the layer

of material 491 has physical properties and characteristics of being able to reduce or otherwise mitigate the passing of sound thereby.

[00375] Referring again to Figures 10A-10B, the coolers 404 a,b may be coupled to the frame 404 in accordance with embodiments disclosed herein, including directly, or indirectly via mounting to the frame 402. The coolers 404 a,b may include at least one core and a tank. The core(s) 406 may include one or more tanks (such as inlet tank 477 and outlet tank 480) welded thereto. The inlet tank 477 may be associated with the tank inlet 478. Similarly, the outlet tank 480 may be associated with a tank outlet 484.

[00376] One of ordinary skill in the art would appreciate that embodiments herein provide for an improved heat exchanger unit of the present disclosure that need not have one or more baffles therein.

[00377] Referring now to Figures 11A, 11B, and 11C together, a frontal isometric view and a backside isometric view of a heat exchanger unit with two top side mounted coolers, and a blender skid having the heat exchanger unit of Figures 11A-11B coupled with two heat generating devices, respectively, according to embodiments of the disclosure, are shown.

[00378] The HX unit 500 may be like that in many respects to heat exchanger units 200, 400 described herein, but as would be readily apparent need not be the same, and indeed may have a number of discernable differences. The heat exchanger unit 500 may include a solid integral frame (or skeletal frame) or may be a frame 502 that includes a number of elements arranged and coupled together, such as a plurality of horizontal elements 550 and a plurality of vertical elements 551.

[00379] The frame may include a top region 543a, a bottom region 543b, and a plurality of side regions 542 a-d. There may be a first cooler (not viewable here) coupled with the frame 502 proximate to a respective siderregion 542d. The first cooler may have a respective long (or longitudinal axis) that may be generally parallel to a vertical axis 527.

[00380] The HX unit 500 may include a second cooler 504b coupled with the frame 502 proximate to the top region 543a. The second cooler 504b may have its long axis generally perpendicular to the vertical axis 527. Although not viewable here, there may be an inner airflow region within the heat exchanger unit 500. In this respect, there may be a first baffle (*e.g.*, 422, Figure 10B) disposed within the inner airflow region, and at a first angle  $\alpha$  to the vertical axis 527.

[00381] The HX unit 500 may include a third cooler (not viewable here) coupled with the frame 502 proximate to the respective side region 542d, and adjacent the first cooler. And the HX unit 500 may have a fourth cooler 504d coupled with the frame 502 proximate to the top region 543a, and adjacent the second cooler 504b.

[00382] The HX unit may include an inner partition 552a that separates the first airflow region from a second airflow region associated with the third cooler and the fourth cooler. The partition 552a may be formed by connecting two sidewalls together.

[00383] The second airflow region may include a second baffle (*e.g.*, 422, Figure 10B), which may be configured or otherwise oriented at a second angle  $\alpha$  to the vertical axis 527. In aspects, either or both of the first angle and the second angle may be in the range of about 0 degrees to 90 degrees. In aspects, either or both of the first angle and the second angle may be in the range of about 30 to about 60 degrees. Although they need not be, the first angle and the second angle may be substantially the same (*i.e.*, equal or nearly equal to each other).

[00384] The first baffle 522 and/or the second baffle may include a sound absorbing material disposed therein (*see, e.g.*, Figures 3B). The HX unit 500 may include a first fan 508a and a second fan 508b. Either of the fans 508 a,b may be configured to operate and produce a point source dominant acoustic frequency. The sound absorbing material may be capable to reduce the point source dominant acoustic frequency by at least 10 dB.

[00385] The first fan 508a may be mounted to the frame 502 external to a first side of the first cooler. In a similar manner, the second fan 508b may be mounted to the frame external to a first side of the second cooler. The first fan 508a and the second fan 508b may each have an axis of rotation substantially perpendicular to the vertical axis 527.

[00386] In operation, the first cooler and/or the second cooler may be configured to permit airflow to pass therethrough. Related thereto, operation of the first fan 508a and/or the second fan 508b may result in airflow through each of the respective coolers and airflow regions, and out of the outlet.

[00387] The HX unit may include a first sidewall; a second sidewall; a back wall; and a bottom. In aspects, at least one of the first sidewall, the second sidewall, the back wall, and the bottom further may include: an inner layer of sound absorbing material; and an exterior layer of a vinyl-based material. Any of the sidewall(s) may be like that as shown and described for Figure 10C.

[00388] The HX unit 500 may be configured and operable with a monitoring module 1000 as described herein. Ingress and egress may be provided via access way 592. The access way 592 may be closed via door 593, which may be, for example, hingedly mounted to the frame 502. The door 593 may be shut and held shut via one or more securing members 594. In aspects, turning handle 595 may move the securing member 594 to a position, whereby the door 593 may be opened, and the inside of the HX unit 500 may be accessed.

[00389] Figure 11C illustrates the HX unit 500 may be used and operable with a blender unit 560 for creating a frac fluid mixture. One of skill in the art would appreciate the blender unit 560 may be a stationary process, or provided with mobility via a trailer 561. The blender unit 560 may include one or more blender tubs 562; one or more auger screws 563; and at least one HGD 503a. The HGD 503a may be a diesel engine.

[00390] The HX unit 500 may be configured to cool at least one service fluid transferable between the HX unit 500 and the first HGD 503a.

[00391] The second cooler 504b may be coupled with the frame 502 generally perpendicular to the orientation of the first cooler. In this respect, the second cooler 504b may be coupled with the frame 502 proximate to the top region 543a. In other aspects, the second cooler 504b may be coupled with the frame 502 generally parallel to the orientation of the first cooler. In this respect, the second cooler 504b may be coupled with the frame 502 proximate to another side region. The first cooler and/or the second cooler may be thought of as having a long (longitudinal) axis through itself, which may be used as a reference point with respect to other axis. The orientation reference is generally understood as being with respect to a long axis through the core.

[00392] The HX unit 500 may have a third cooler 504c coupled with the frame 502 proximate to the respective side region, and adjacent the first cooler 504a. The HX unit 500 may include a fourth cooler 504d coupled with the frame 502 proximate to the top region 543a, and adjacent the second cooler 504b.

[00393] The HX unit 500 may include a second airflow region partitioned from the inner airflow region. The second airflow region may be associated with the third cooler and the fourth cooler. There may be a second baffle disposed within the second airflow region, and at a second angle to the vertical axis. The second baffle may include a sound absorbing material. In aspects, the sound absorbing material may be mineral wool.

[00394] The angle of orientation of any baffle 522 of the HX unit 500 may be in the range of about 30 to about 60 degrees. In embodiments, the first angle and the second angle may be at least substantially the same.

[00395] The HX unit 500 may include a second fan 508b mounted to the frame 502 external to a first side of the third cooler. The first fan 508a and the second fan 508b each may each have an axis of rotation substantially perpendicular to the vertical axis 527.

[00396] Any of the coolers of the HX unit 500 may be configured to permit airflow to pass therethrough. Operation of the first fan 508a and the second fan 508b may result in airflow (drawn or blown) through each of the respective coolers and airflow regions, and out of the outlet.

[00397] The HX unit 500 may have at least one monitoring module 1000 of the present disclosure operably associated therewith.

[00398] Any of the first cooler, the second cooler, the third cooler, and the fourth cooler may have a respective core and a respective tank. The at least one of the respective cores may have a core end having a core end mass. The at least one of the respective tanks may have a tank end having a tank end mass. In aspects, the core end mass may be greater than the respective tank end mass, as provided for in embodiments herein. *See, e.g.*, Figures 4A-4C.

[00399] The HX unit may include a mount assembly for couple any of the coolers to the frame. The mount assembly may be as described herein, and may thus include an elongated fastening member; a rigid outer ring; a rigid inner ring; and a deformable ring disposed between the rigid outer ring and the inner outer ring. At least one of the plurality of coolers may include a mounting slot, whereby the elongated fastening member may extend through the rigid inner ring and at least partially into the frame. *See, e.g.*, Figures 5A-5E.

[00400] One of skill in the art would appreciate the blender unit 560 may be operable with other HX unit embodiments of the disclosure.

[00401] Referring now to Figures 7A and 7B together, an isometric view of a monitored heat exchanger system that includes a monitoring module, a heat exchanger unit, and a heat generation device operably coupled together, and an isometric component breakout of a monitoring module associated with a heat exchanger unit, respectively, in accordance with embodiments disclosed herein, are shown. Embodiments herein apply to a heat exchanger unit that may be an inclusive assembly of a number of components, subcomponents, which may be further associated with

operable systems, subsystems, assemblies, modules, and so forth that may overall be referred to as a system, such as heat exchanger monitoring system 701 (or monitored heat exchanger system).

[00402] The heat exchanger unit 700 may be part of an overall system 701 that may be monitored. Monitored system 701 includes at least one monitoring module 1000, as described herein. While it need not be exactly the same, system 701 may include various features and components like that of other systems or units described herein, and thus components thereof may be duplicate or analogous. To be sure, the monitoring module may be used with other heat exchanger units, including such as unit 200, 400, 500, etc. of the present disclosure.

[00403] The heat exchanger unit (or HX unit) 700 may include a solid integral frame (or skeletal frame) or may be a frame 702 that includes a number of elements arranged and coupled together. The simplified diagram of Figure 7B illustrates the HX unit 700 coupled with a heat generation device 703. As can be seen a hot service fluid  $F_{hot}$  may circulate from the HGD 703 to the HX unit, be cooled via core 706 (also sometimes recognizes as a cooler or radiator, or part thereof), and recirculate as a cooled service fluid  $F_{cool}$  back to the HGD 703. Other equipment including other piping, valves, nozzles, pumps, tanks, etc. need not be shown, as one of skill in the art would have an understanding of coupling the HX unit 700 with the HGD 703 for operable transfer of one or more service fluids therefrom.

[00404] As shown system 701 may include the use of a monitoring module 1000. The monitoring module 1000 may be usable for monitoring one or more conditions, properties, characteristics, etc. associated with the operation of the HX unit 700. As an example, the monitoring module 1000 may be configured and used for measuring fouling associated with the core 706.

[00405] The module 1000 may be a modular assembly having various components and subcomponents associated and operable together, and like that described herein. The module 1000 may be sized and optimized accordingly for operable coupling with any type of radiator, including that associated with the HX unit 700. One of skill in the art would appreciate the monitoring module 1000 could be retrofitted to equipment already used in the field. Just the same the monitoring module 1000 could come associated and operably engaged with newly fabricated equipment. In aspects, a single HX unit 700 may have multiple monitoring modules 1000 associated therewith.

[00406] The module 1000 may be coupled to the frame 702 on a respective side of the HX unit 700 (including in place of a rock grate [not shown]). As shown, the module 1000 may include a mounting frame 1001. The mounting frame 1001 may be an integral piece having a first mounting frame side 1002, a second mounting frame side 1003, a mounting frame top 1004, and a mounting frame bottom (not shown here). The mounting frame may have a cover panel or guard 1007, which may be integral or coupled therewith. Analogous to the mounting frame 1001, the cover panel 1007 may have a first cover panel side 1008, a second cover panel side 1009, a cover panel top 1010a, and a cover panel bottom 1010b. Although quadrilateral in the general sense, it is within the scope of the disclosure that the mounting frame 1001 and/or the cover panel 1007 may have different shapes, including as might be necessary to be mounted with a different shape HX unit or radiator core.

[00407] As shown in Figure 7A, the cover panel 1007 may have a plurality of cover panel apertures 1012 configured to coincide with a respective plurality of mounting frame apertures 1014a. Likewise the mounting frame 1001 may have a plurality of other mounting frame apertures 1014b configured to coincide with a respective plurality of apertures 782 of the frame 702.

[00408] One of skill would appreciate the mounting frame 1001 may be connected to the frame 702 via insertion of a plurality of connectors (fasteners, etc.) 1013 through apertures 1014b and 782, which may be screws, nut/bolt, quick disconnect, etc. Similarly, the cover panel may be connected to the mounting frame 1001 via insertion of a plurality of cover connectors 1011 through apertures 1012 and 1014a. The use of a separable mounting frame 1001 and cover panel 1007 allows for simple connect and disconnect from each other, which may make it easier for tasks such as maintenance or cleaning. In this respect the panel 1007 may be easily attachable and removable from the HX unit 700.

[00409] There may be a dampener(s) 1018 disposed between various components. For example, there may be one or more dampeners 1018 disposed between the frame 702 and the mounting frame 1001. Analogously, there may be one or more dampeners 1018 disposed between the cover panel 1007 and the mounting frame 1001. The dampener(s) 1018 may be suitable for reducing vibration stemming from operation of the heat exchanger unit 700 that may otherwise be induced into or received by the monitoring module 1000. The dampener 1018 may be one or more layers of a rubbery material, which may have one or more sides with an adhesive thereon.

[00410] The cover panel 1007 may have a front side 1019 and a back side 1020. From a reference standpoint the front side 1019 may be that which tends to face outward or away from the HX unit 700. Or where the cover panel 1007 may be considered exposed or external to the surrounding environment. The back side 1020 of the cover panel 1007 may be associated with one or more sensors 1021. The monitoring module 1000 may have a number of different types of sensors associated therewith, including pressure, temperature, noise, etc. Sensor 1021 may be referred to as an airflow sensor, in that the operation of sensor 1021 may help measure, determine, or otherwise sense airflow 716 moving into (or out of) the HX unit 700. In aspects, there may be about 1 to about 26 sensors 1021 associated with module 1000. However, the number of sensors 1021 is not meant to be limited, and may change depending on desired monitoring requirements for a given type of heat exchanger.

[00411] The sensor 1021 may be mounted to the cover panel 1007, and operated in a manner to sense airflow into the HX unit 700 as a result of suction. However, the sensor 1021 may just as well be mounted and operated in a manner to sense airflow out of the HX unit 700 (as a result of blowing). The sensor 1021 may be operated and setup to detect airflow through the core 706 during a clean, unfouled state, which may then be used as a baseline. As the HX unit 700 fouls, airflow through the core 700 may be effected, and the electrical signal generated by the sensor 1021 will have a measurable, detectable change in signal strength.

[00412] In some embodiments, the configuration (including its size, type placement, etc.) and operation of the sensor 1021 is believed of significance. For example, the sensor 1021 may need to be robust and durable, yet not of any (or as minimal as possible) effect on the operation of the HX unit 700. For example, a sensor that has an orifice may be just as prone to fouling and plugging, and ultimately failure and inability to measure airflow. Other sensors that are large or bulky may be cost prohibitive and/or attribute to unacceptable pressure drop attributable to the monitoring module.

[00413] As shown the sensor 1021 may have a rotating member 1024 (rotatable around an axis) with a plurality of blade members 1023 extending radially therefrom. The blade members 1023 may be configured to induce movement of the rotating member 1024 (rotatable about an axis) much in the same way the blades of a windmill function. That is, upon movement of air thereby, at least a minor amount of force (the amount of force being dependent upon the amount of movement of air) will be

felt by the blade members 1023, and as a result of being connected to the rotating member 1024, induce rotation of the member 1024.

[00414] The rotating member 1024 may be associated with one or more bearings, whereby the rotating member 1024 may be freely movable with respect to a sensor housing or chassis 1025. In aspects, the rotating member 1022 may have a shaft or rotor, and the housing 1025 may be configurable as a (pseudo) stator. The sensor 1021 may have various circuitry and hardware associated therewith, whereby rotation of the shaft may induce or generate an electric current (*e.g.*, via inductive properties attributable to a rotor/stator configuration).

[00415] The sensor 1021 may thus be configured to generate an electric current (or in the analogous sense, a voltage) proportional to an amount of rotation. The current, or really, a signal, may then be communicated to a microcontroller (1006, Figure 1C), which may be part of a logic circuit of the monitoring module 1000.

[00416] Referring briefly to Figure 7C, a component breakout view of a controller housing usable with a monitoring module, and having various internal components, according to embodiments of the disclosure, is shown. Equipment, such as hardware and software, pertaining to the logic circuit may be operably arranged within a controller housing 1016 (which may have a controller housing top 1016a).

[00417] The controller housing 1016 may be weatherproof and dustproof, and this may have an ability to protect internals from undesired environmental and harsh weather conditions. The housing 1016 may be mountable to housing mount 1015. The housing 1016 and housing mount 1015 may have corresponding openings 1017a, 1017b, respectively, for accommodating the passing of wires and other circuitry therethrough. The openings 1017 a,b may be sealed, such as with silicone.

[00418] The controller housing 1016 may be configured with suitable components and hardware for that accommodate or provide functionality of the monitoring system 201. Such components may include, for example, the microcontroller 1006 (in operable communication and connected with sensors 1021 via wiring, circuitry, and so forth), a regulator (such as a voltage regulator) (not shown here), a power supply or battery (or battery cell) 1027a, a charger (*e.g.*, battery charger) (not shown here), solid data storage 1028, a Wi-Fi module 1029, a GSM module 1030, a CAN-Bus module 1031, and various indicators, such as audio or visual (*e.g.*, RGB LEDs) 1032.

[00419] Referring now to Figures 7A, 7B, and 7C, together, the microcontroller 1006 may be readily useable and compatible with various hardware, including switches, LED's, and sensors. The microcontroller 1006 may include HDMI output to a screen such as a TV or a monitor, as well as wirelessly communicating to smart phones or computers via Wifi or Bluetooth.

[00420] A signal from the microcontroller 1006 may generate a signal communicable as a message or other form of warning, including by way of one or more of audio, video/visual (*e.g.*, Green, Yellow, Red LEDs), email, SMS/text, CAN Bus, such as J1939. Thus, the module 1000 may include a LED response interface. In embodiments, LED lights may be configured to provide varied warnings based on monitoring and detection. For example, and with respect to certain percentage of fouling, the LED lights may flash green (0-25% fouled), yellow (25-75% fouled), or red (75-100% fouled). In a similar manner, a warning may be transmitted (*e.g.*, text/SMS, push notification, email, J1939, etc.) based on a percentage of fouling.

[00421] Software herein may be able to read values from the SD card and create a look-up table.

[00422] Referring now to Figures 8A and 8B together, a logic circuit process flow diagram and a logic circuit decision tree operable as part of a monitoring module, respectively, according to the embodiments of the disclosure, are shown. As illustrated and previously touched on, the monitoring module 1000 may include various hardware and software operable together as an overall 'logic circuit' in which logic of the present disclosure may be implemented.

[00423] The logic circuit may be programmable and compatible to various computer devices that include, for example, PCs, workstations, laptops, mobile devices, cell phones, tablets, PDAs, palm devices, servers, storages, and the like. Generally, in terms of hardware and related architecture, the logic circuit may include one or more microcontrollers 1006, memory or data storage 1028, and one or more I/O devices (not shown), which may all be operatively communicatively coupled together, including such as circuitry, pins, and via a local interface (not shown).

[00424] As would be apparent to one of skill in the art the local interface may be understood to include, for example, one or more buses or other wired or wireless connections. The local interface may have additional elements, such as controllers, buffers (caches), drivers, repeaters, and receivers, to enable communications. Further, the local interface may include address, control, and/or data connections to enable appropriate communications among the aforementioned components.

[00425] The logic circuit may receive power from a source, such as (upwards of) a 5V supplier. The power, which may be in the form of a voltage, may be regulated by regulator 1026. An example voltage regulator includes AC DC Converters\_ Recom Power RAC03-05SE/277 (85 ~ 305 VAC TO V). Power from the regulator 1026 may be fed to a power supply or battery 1027a. The battery 1027a may be a LiPo battery cell (1200mAh, 3.7V). The battery 1027a may be charged by a battery charger 1027b. An example battery charger includes LiPo Energy Shield.

[00426] The microcontroller (or sometimes just 'controller') 1006 may be a hardware device configured for execution of software (programming, computer readable instructions, etc.), which may be stored (programed thereinto) in a controller memory. The controller 1006 may be any custom made or commercially available processor, a central processing unit (CPU), a digital signal processor (DSP), or an auxiliary processor among several processors associated therewith. As an example, the controller 1006 may be an Arduino MEGA 2560 microcontroller.

[00427] Microcontroller 1006 may be powered via the battery1027a. In an embodiment, the microcontroller 1006 may be powered, directly or indirectly, via operation of the sensor(s) 1021. With power initiation, such as at startup of the monitoring module (1000), the controller 1006 may be in communicative operability with the SD storage 1028. An example SD storage includes Yun Shield.

[00428] The microcontroller 1006 may be in communicative operability with Wi-Fi module 1029. An example Wi-Fi module includes ESP8266 or particle photon.

[00429] The microcontroller 1006 may be in communicative operability with GSM module 1030. An example GSM module includes Arduino GSM Shield V2 or Particle Elctron.

[00430] The microcontroller 1006 may be in communicative operability with CAN-Bus module 1031. An example CAN-Bus module includes CAN-BUS shield with MCP2515 CAN bus controller.

[00431] The microcontroller 1006 may be in communicative operability with LEDs 1032

[00432] The controller memory may include any one or combination of random access memory (RAM), dynamic random access memory (DRAM), static random access memory (SRAM), ROM, erasable programmable read only memory (EPROM), electronically erasable programmable read only memory (EEPROM), programmable read only memory (PROM), tape, compact disc read only memory (CD-ROM), disk, diskette, cartridge, cassette or the like, and so

forth. Moreover, the controller memory may incorporate electronic, magnetic, optical, and/or other types of storage media.

[00433] Software in the controller memory may include one or more separate programs, each of which may include an ordered listing of executable instructions for implementing logical functions. Software in the controller memory may include a suitable operating system (OS), compiler, source code, and/or one or more applications in accordance with embodiments herein. Software may be an application (“app”) that may include numerous functional components for implementing the features and operations of embodiments of the disclosure.

[00434] The OS may be configured for execution control of other computer programs, and provides scheduling, input-output, file and data management, memory management, and communication control and related services. In aspects, the app may be suitable for implementation of embodiments herein to all commercially available operating systems.

[00435] Software may include an executable program, script, object code, source program, or any other comparable set of instructions to be performed.

[00436] Software may be written as object oriented programming language, which may have classes of data and methods, or a procedure programming language, which has routines, subroutines, and/or functions. The programming language may include for example Python, HTML, XHTML, Java, ADA, XML, C, C++, C#, Pascal, BASIC, API calls, ASP scripts, FORTRAN, COBOL, Perl, .NET, Ruby, and the like.

[00437] The input/output (I/O) device(s) may include an input device such as, for example, a mobile device, a keyboard, a mouse, a touchscreen, a microphone, a camera, a scanner, and so forth. The I/O device(s) may include an output device such as, for example, a display, a printer, an email, a text message, and so forth. The I/O device may include devices configurable to communicate both inputs and outputs, such as a router, a telephonic interface, a modulator/demodulator or NIC (that may be suitable to access remote devices, other files, devices, systems, or a network), a radio frequency (RF) or other transceiver, a bridge, and so forth. The I/O devices may include one or more components for communicating over various networks, such as the Internet or intranet.

[00438] In aspects, external computers (and respective programming) may be communicably operable with the logic circuit (and thus monitoring module 1000).

[00439] In operation of the logic circuit, the microcontroller may: execute software stored within the memory; communicate data to and from the memory; and/or generally control operations of the logic circuit pursuant to the software.

#### In Operation (with logic)

[00440] The operation of the logic circuit may be further understood with an explanation of the tree diagram of Figure 8B. The tasks are numbered in above the task name. Task 1 is to acquire data from the sensors 1021. This may include sampling the data from the sensors 1021 over a short time (*e.g.*, 60 seconds) and taking an average and standard deviation. Task 2 compares the standard deviation of the new data with a predetermined acceptable limit saved on a memory of the system. This allows sporadic or outlier data to be excluded. This consequently ensures that, for example, windy conditions will not be interpreted as fouling, and thus preventing false alarms.

[00441] If the sampled data is sporadic and not acceptable, a delay (task 5) will be implemented to retry (or loop) for data acquisition. Either the data will be acceptable or will remain sporadic. If the sporadic data is very consistent and the number of sporadic data occurrence exceeds a predefined value (task 3), the user is notified of an error (task 4) (typically an installation error).

[00442] Once the sampled data of task 1 has been accepted, it is checked with a lookup-table (LUT) flag (task 6), which is essentially a binary that allows for the completion of the fouling lookup-table. This flag indicates if the fouling lookup-table is already generated and exists or not (Initially and during installation, this flag is false, meaning that the table is not yet generated). If the LUT flag from task 6 is false, the programming uses an averaging method to create a fouling lookup-table containing the data output of the sensors 1021 in a clean condition (tasks 7 and 8). After generating the LUT table through multiple iterations (averaging), the system turns the LUT flag true.

[00443] If the LUT flag is true, the overall fouling is then calculated in task 9. This consists of referencing acquired data from the sensors 1021 against the fouling lookup-table which represents a clean condition. If fouling is evident, a foul state is recorded (task 10). In task 11, the fouled state is evaluated. If consecutive data has determined that the radiator is in a severe (as defined by the user) fouling condition, then the user will be notified using one or more of the defined warning methods (task 10), *e.g.*, LED, email, J1939 message, etc. If the foul count is not

too high. a delay will occur (task 12), and the system will continue to collect data to proactively warn the user in case of any fouling.

[00444] Referring now to Figure 9, a side view of a monitored heat exchanger system that includes a monitoring module, a heat exchanger unit, and a heat generation device, operably coupled together, in accordance with embodiments disclosed herein, are shown. Embodiments herein apply to a heat exchanger unit that may be an inclusive assembly of a number of components and subcomponents. The heat exchanger unit 900 may be part of an overall system 901 that may be monitored. Monitored system 901 may include at least one monitoring module 1000, as described herein.

[00445] While it need not be exactly the same, system 901 may be like that of system 701 of Figures 7A-7C (or other systems herein), and components thereof may be duplicate or analogous. Thus, only a brief discussion of system 701 is provided, recognizing that differences, if any, should be discernable by one of skill in the art. Accordingly it would be further understood that aspects of system 901 may include various additional improvements related to airflow, noise reduction, cooling efficiency, structural integrity, and combinations thereof.

[00446] The HX unit 900 may include one or more cores 906 being associated with respective monitoring module(s) 1000. It should be apparent that while HX unit 900 may have a plurality of sides (or side regions), each of the plurality of sides having respective coolers, not every side need have a monitoring module 1000. Still, it may every well be that every cooler is monitored via one or more modules 1000. Moreover, while the module 1000 may be particularly useful for monitoring fouling, other conditions of the HX unit 900 (or system 901) may be monitored.

[00447] One or more cores 906 may be associated with and proximate to a respective protective grate (not viewable), which may be useful for protecting fins of the core 906. The monitoring module 1000 may be installed in place of the grate.

[00448] Although not shown in entire detail here, the HX unit 900 may include a fan system. Briefly, the fan system may include related subcomponents, such as a fan that may be understood to include a rotating member with a plurality of fan blades extending therefrom. The fan may be operable by way of a suitable driver, such as a fan motor, which may be hydraulic, electrical, gas-powered, etc. Conduits may be configured for the transfer of pressurized hydraulic fluid to and from the motor. As such, pressurized hydraulic fluid may be used to power the motor.

[00449] The fan system may include a fan shroud, which may be generally annular. The fan shroud may be coupled to the frame via connection with the top plate. The shroud may include one or more lateral openings 960 to accommodate the passing of the mount bar 909 therethrough. The mount bar 909 may be a rigid bar or beam that extends from one side 959a of the HX unit 900 to another side 959b.

[00450] A fan rock guard 947 may be coupled to a shroud 913. The shroud 913 may be proximate to an aeroring (not shown). The aeroring may be annular in nature, and have a ring cross-section that may have a radius of curvature. Thus, the aeroring may have a rounded surface that may aid in improving airflow and reducing pressure in and around the fan system. Without the aeroring, eddies and other undesired airflow may occur in corners of the top of the frame.

[00451] The configuration of the shroud and aeroring may provide added ability for further streamlining airflow, which may beneficially reduce overall power requirements.

[00452] The fan system can be operable to draw in and direct the flow of air 916. The air 916 may be drawn through the sides of the HX unit 900 (and respective cores, which may then be used to cool one or more utility fluids F) and out as heated exhaust 918. The benefit of such a configuration is the ability to provide cooling in parallel, versus series. In a series configuration, the airflow becomes progressively hotter as it passes through each cooling circuit, resulting in a loss in cooling efficiency. This can be especially problematic where ambient air temperature is usually hotter, like Texas and Oklahoma.

[00453] Utility fluid F (or multiple F's) may include by way of example, lube oil, jacket water, turbo (such as for an engine), transmission fluid (such as for a pump), and hydraulic fluid (such as for the fan drive).

[00454] One of skill in the art would appreciate that airflow through the core 906 may be generally in a path parallel to a horizontal axis. In an analogous manner, the fan 908 may have an axis of rotation generally parallel to a vertical axis. Accordingly, airflow through the HX unit 900 may be transitioned from (approximately) horizontal to vertical as the airflow moves through the core 906 and out the fan exhaust 918.

[00455] As such, by way of example, utility fluid  $F_1$  may be transferred from a heat generating device 903 at a hot temperature into an HX unit inlet 978, cooled with airflow via core 906, and transferred out of an HX unit outlet 984 back to the HGD 903 at a cooler temperature. While not

meant to be limited, HGD 903 may be an engine, a genset, a motor, a pump, or other comparable equipment that operates in a manner whereby a utility fluid is heated.

[00456] There may be one or more cores 906. A 'cooler' or 'cooling circuit' may include one or more cores 906. The HX unit 900 may have between about 1 to about 8 cooling circuits, which each may be configured for cooling in parallel to each other.

[00457] The HX unit 900 may include various sound reduction or integrity features like that as described herein, such as various sound baffle configurations and/or flexible mount assemblies.

[00458] In operation, a utility fluid F from HGD 903 may be transferred into the HX unit 900. The transfer may be direct or indirect (such as from a holding tank). Within the unit 900, the fluid may flow into a tank chamber (not shown) via inlet 978 of inlet tank. The fluid then distributes into the various alternating layers and respective channels of the core 906.

[00459] Similarly airflow 916 may be drawn into HX unit 900, and into the various perpendicular and alternating layers and respective channels of the core 906. The HX unit 900 may be configured for passing atmospheric air through or in contact with the core 906, so as to reduce the temperature of the service fluid circulated through the core 906. In this respect, a fan (or fan system) may be rotatable about a fan axis so as to draw in (or suction, etc.) atmospheric air inwardly through channels (or fins 973), resulting in airflow through the core 906.

[00460] The service fluid  $F_{1-hot}$ , having a temperature hotter than the airflow, may be cooled (and conversely, the airflow warms). Cooled service fluid  $F_{1-cold}$  leaves the cooling circuit via a fluid outlet 984. Various piping, tubing, etc. may be connected to the tank outlet 984, as may be desired for a particular application, and as would be apparent to one of skill in the art. In some aspects, the tank outlet 984 may be in fluid communication with an inlet of a subsequent cooling circuit also connected with the frame 902.

[00461] Cooled utility fluid may be returned from the HX unit 900 to a source tank, or directly to the HGD 903. Thus, service fluid from the HGD 903 may be circulated in a cooling circuit in a systematic and continuous manner. As will be appreciated, a suitable circulating pump (not shown) may be provided to circulate the service fluid through the core cooler 306.

[00462] Other coolers of the HX unit 900 may be generally similar in nature, and suitably configured for the cooling of various service fluids from the HGD 903.

[00463]

[00464] Referring now to Figure 9A, a side view of a monitored heat exchanger system that includes a monitoring module, a heat exchanger unit, and a heat generation device, operably coupled together, in accordance with embodiments disclosed herein, are shown. Embodiments herein apply to a heat exchanger unit that may be an inclusive assembly of a number of components and subcomponents. The heat exchanger unit 900a may be part of an overall system 901a that may be monitored. Monitored system 901a may include at least one monitoring module 1000, as described herein.

[00465] While it need not be exactly the same, system 901a may be like that of system 701 of Figures 7A-7C, system 901, or other systems herein, and components thereof may be duplicate or analogous. Thus, only a brief discussion of system 901a is provided, recognizing that differences, if any, should be discernable by one of skill in the art. Accordingly it would be further understood that aspects of system 901a may include various additional improvements related to airflow, noise reduction, cooling efficiency, structural integrity, and combinations thereof.

[00466] The HX unit 900a may include one or more coolers being associated with respective monitoring module(s) 1000. It should be apparent that while HX unit 900a may have a plurality of sides (or side regions), and one or more sides may have respective coolers, not every side (nor cooler) need have a monitoring module 1000. Still, it may very well be that every cooler is monitored via one or more modules 1000. Moreover, while the module 1000 may be particularly useful for monitoring fouling, other conditions of the HX unit 900a (or system 901a) may be monitored.

[00467] The fan system (*e.g.*, 457, Figure 10A) can be operable to draw (or blow) in and direct the flow of air. The air may be drawn through the sides of the HX unit 900a (and respective cores, which may then be used to cool one or more utility fluids F) and out as heated exhaust. Utility fluid F (or multiple F's) may include by way of example, lube oil, jacket water, turbo (such as for an engine), transmission fluid (such as for a pump), and hydraulic fluid (such as for the fan drive).

[00468] One of skill in the art would appreciate that airflow through the cooler(s) may be generally in a path parallel to a horizontal axis. In an analogous manner, the fan (*e.g.*, 508, Figure 11A) may have an axis of rotation generally perpendicular to a vertical axis.

Accordingly, airflow through the HX unit 900a may be transitioned from (approximately) horizontal to vertical as the airflow moves through the coolers and out the fan exhaust.

[00469] While not meant to be limited, HGD 903a may be an engine, a genset, a motor, a pump, or other comparable equipment that operates in a manner whereby a utility fluid is heated.

[00470] There may be one or more cores. A ‘cooler’ or ‘cooling circuit’ may include one or more cores. The HX unit 900a may have between about 1 to about 8 cooling circuits, which each may be configured for cooling in parallel to each other.

[00471] The HX unit 900a may include various sound reduction or integrity features like that as described herein, such as various sound baffle configurations and/or flexible mount assemblies.

[00472] Embodiments herein provide for a system (and related method of operating or using the system) using one or more components described herein. For example, such a system may include a wellbore and other wellbore and production equipment, as well as a frac trailer and/or a blender skid. The frac trailer may include a frac pump, a HGD, and a HX unit as pertaining to the disclosure. The blender skid may include a booster pump, at least one HGD, and a HX unit as pertaining to the disclosure.

[00473] Other embodiments herein provide for a method of doing business related to a monitored heat exchanger system. The method may include the steps of having a customer relationship between a provider and recipient (*i.e.*, customer, client, etc.). The method may include charging a one-time or ongoing fee related to the monitored system. The provider may install the monitored heat exchanger system as a new standalone skid. Alternatively, the provider may retrofit existing equipment for operable communication with a monitoring module as described herein. Thus, in embodiments there may be a first transaction related to equipment purchase or use, followed by a second transaction related to installation.

[00474] Another part of transaction, or alternatively, a separate transaction, may pertain to a license for the use software (or programming) related to a logic circuit of the monitoring module, as the provider may own copyright in the respective software (or be an exclusive licensee).

[00475] The provider may provide services and equipment directly, or may use a subcontractor.

[00476] Once a recipient has completed its applicable transaction, and the system has been associated with at least one monitoring module, the recipient may be provided with the capability to track and monitor one or more characteristics or properties respective to an individual heat exchanger unit performance. Reported information (or parameters) may include percentage of

fouling, time between warnings, cleaning frequency, etc). This information may be groupable by location or region to see if one is performing better than another. The system may also indicate them how many units are in green, yellow or red, which may further help identify problem regions, operators etc.

[00477] The method may further include a field service component. That is, the provider, or affiliated field service business, may be able to offer (give, etc.) a solution, whereby the monitored system sends out an alarm of some variation, such as SMS/text, email, etc. In this respect the recipient has the option to address the alarm, or have the provider tend to. In other words, in the event the monitored system provides a warning about, for example, a dirty radiator, the recipient is prompted to find a remedy that can alleviate or mitigate process downtime.

[00478] The business method may thus include steps pertaining to receiving a warning via the monitoring module, and selecting a remediation option, such as cleaning with dry ice or a pressure washer or in their yard when the pump comes back in from the field. In aspects, these steps may be handled remotely and/or off the jobsite. Accordingly, the recipient need not even have to take any action, as the provider may handle all steps.

[00479] The business method may include providing an incentivized transaction if the monitoring module is used with a HX unit that is sold by the provider. The monitoring module may have components as described herein, and the HX unit may likewise have components of any HX unit described herein.

### **Advantages.**

[00480] Embodiments of the disclosure advantageously provide for an improved heat exchanger unit useable with a wide array of heat generating devices.

[00481] Embodiments of the disclosure advantageously provide for new and innovative systems, hardware, software, and related methods, for monitoring a heat exchanger unit. An associated monitoring module may beneficially be retrofitted to existing equipment. Sensors of the module are configured for precision, and in conjunction with a microcontroller, are able together to accurately measure characteristics of a heat exchanger in real-time. In particular, the characteristic may be fouling. The ability to accurately warn of fouling alleviates the need for conventional and cumbersome remediation methods.

[00482] The heat exchanger unit of the disclosure may provide for the ability to reduce sound attributable to a point source, such as a fan. The fan may have a dominant acoustic frequency that may be reduced by at least 10 decibels. The heat exchanger unit may be configured with a particular baffle configuration that helps reduce sound. The baffles may be configured to have or contain a sound absorbing material. At the same time the baffle configuration may help drastically improve streamlined airflow, which further helps reduce sound emission and improves overall efficiency of the heat exchanger unit because of lowered power requirements.

[00483] The heat exchanger unit may advantageously provide for the ability to simultaneously cool multiple utility fluids in parallel.

[00484] Advantages of the disclosure provide for a compact design with more heat transfer area in limited space, more heat transfer capability, reduced overall height by arranging heat exchanger cores at all four sides in general cube shape.

[00485] Embodiments of the disclosure advantageously provide for the ability to improve structural integrity of a heat exchanger unit. A radiator core of the unit may have an increased mass on a core end that may substantially prohibit or eliminate runoff of brazing material during a welding process.

[00486] The heat exchanger unit may provide for the ability to provide an ‘absorber’ effect with any thermal expansion. That is, one or more components may be coupled together via the use of a flex amount assembly, the assembly having a deformable member associated therewith. As thermal expansion occurs, the deformable member may deform resulting to absorb the expansion motion or stress.

[00487] Advantages herein may provide for a more convenient and realizable welding practice for core and tank, and a more convenient and flexible mount assembly.

[00488] While embodiments of the disclosure have been shown and described, modifications thereof can be made by one skilled in the art without departing from the spirit and teachings of the disclosure. The embodiments described herein are exemplary only, and are not intended to be limiting. Many variations and modifications of the disclosure presented herein are possible and are within the scope of the disclosure. Where numerical ranges or limitations are expressly stated, such express ranges or limitations should be understood to include iterative ranges or limitations of like magnitude falling within the expressly stated ranges or limitations. The use of the term “optionally” with respect to any element of a claim is intended to mean that the subject element is required, or alternatively, is not required. Both alternatives are intended to be within

the scope of any claim. Use of broader terms such as comprises, includes, having, etc. should be understood to provide support for narrower terms such as consisting of, consisting essentially of, comprised substantially of, and the like.

[00490] Accordingly, the scope of protection is not limited by the description set out above but is only limited by the claims which follow, that scope including all equivalents of the subject matter of the claims. Each and every claim is incorporated into the specification as an embodiment of the present disclosure. Thus, the claims are a further description and are an addition to the preferred embodiments of the disclosure. The inclusion or discussion of a reference is not an admission that it is prior art to the present disclosure, especially any reference that may have a publication date after the priority date of this application.

## CLAIMS

### What is claimed is:

1. A heat exchanger unit, comprising:
  - a vertical axis;
  - a frame comprising a top region, a bottom region, and a plurality of side regions;
  - a first cooler coupled with the frame proximate to a respective side region and generally parallel to the vertical axis;
  - a second cooler coupled with the frame proximate to the top region and generally perpendicular to the vertical axis;
  - an inner airflow region within the heat exchanger unit; and
  - a first baffle disposed within the inner airflow region, and at a first angle to the vertical axis.
2. The heat exchanger unit of claim 1, the unit further comprising:
  - a third cooler coupled with the frame proximate to the respective side region, and adjacent the first cooler; and
  - a fourth cooler coupled with the frame proximate to the top region, and adjacent the second cooler.
3. The heat exchanger unit of claim 2, the unit further comprising a second airflow region partitioned from the inner airflow region, wherein the second airflow region is associated with the third cooler and the fourth cooler, and wherein a second baffle is disposed within the second airflow region, and at a second angle to the vertical axis.
4. The heat exchanger unit of claim 3, wherein the first baffle and the second baffle comprise a sound absorbing material.
5. The heat exchanger unit of claim 4, the heat exchanger unit further comprising a fan configured to operate and produce a point source dominant acoustic frequency, and

wherein the sound absorbing material is capable to reduce the point source dominant acoustic frequency by at least 10 dB.

6. The heat exchanger unit of claim 5, wherein the sound absorbing material comprises mineral wool, and wherein each of the first angle and the second angle is in the range of about 30 to about 60 degrees.
7. The heat exchanger unit of claim 5, wherein the first angle and the second angle are substantially the same.
8. The heat exchanger unit of claim 3, the heat exchanger unit further comprising:  
a first fan mounted to the frame external to a first side of the first cooler; and  
a second fan mounted to the frame external to a first side of the second cooler,  
the first fan and the second fan each comprising an axis of rotation substantially perpendicular to the vertical axis.
9. The heat exchanger unit of claim 8, wherein each of the coolers are configured to permit airflow to pass therethrough, and wherein operation of the first fan and the second fan results in airflow through each of the respective coolers and airflow regions, and out of the outlet.
10. The heat exchanger unit of claim 2, wherein the first angle, the second angle, and the third angle are substantially the same.
11. The heat exchanger unit of claim 1, wherein the frame further comprises:  
a first sidewall;  
a second sidewall;  
a back wall; and  
a bottom.

12. The heat exchanger unit of claim 1, wherein at least one of the first sidewall, the second sidewall, the back wall, and the bottom further comprises: an inner layer of sound absorbing material; and an exterior layer of a vinyl-based material.
13. The heat exchanger unit of claim 2, the heat exchanger unit further comprising:  
a monitoring module proximately coupled to at least one of the first cooler, the second cooler, the third cooler, and the fourth cooler, the monitoring module further comprising:  
a cover panel; an at least one sensor coupled with the cover panel; at least one controller housing coupled with the cover panel; and a microcontroller disposed within the controller housing and in operable communication with the at least one sensor,  
wherein the at least one sensor comprises a rotating member configured to generate a system signal proportional to an amount of rotation of the rotating member, and wherein the microcontroller is provided with computer instructions for processing the system signal.
14. The heat exchanger unit of claim 13, wherein the monitoring module comprises a plurality of sensors, with each of the plurality of sensors in operable communication with the microcontroller, wherein an at least one of the plurality of sensors comprises a plurality of blades radially extending from the respective rotating member, and wherein the system signal pertains to an amount of fouling.
15. The heat exchanger unit of claim 14, wherein the monitoring module further comprises each of a solid data storage, a Wi-Fi module, a GSM module, and a CAN-Bus module being disposed within the controller housing and in operable communication with the microcontroller, and wherein the microcontroller is provided with computer instructions for communicating with one or more of the solid data storage, the Wi-Fi module, the GSM module, and the CAN-Bus module.

16. A blender skid for creating a frac fluid mixture, the blender skid comprising:  
a blender;  
a first diesel engine;  
a heat exchanger unit configured to cool at least one service fluid transferable between the heat exchanger unit and the first diesel engine, the heat exchanger unit further comprising:  
a vertical axis;  
a frame comprising a top region, a bottom region, and a plurality of side regions;  
a first cooler coupled with the frame proximate to a respective side region and generally parallel to the vertical axis;  
a second cooler coupled with the frame generally perpendicular to the orientation of the first cooler;  
an inner airflow region within the heat exchanger unit; and  
a first baffle disposed within the inner airflow region, and at a first angle to the vertical axis.
17. The blender skid of claim 16, wherein the second cooler is coupled proximate to the top region.
18. The blender skid of claim 16, wherein the second cooler is coupled proximate to one of the plurality of side regions.
19. The blender skid of claim 16, wherein the heat exchanger unit further comprises a second baffle disposed therein at a second angle to the vertical axis, wherein the first angle and the second angle are in the range of 30 degrees to 60 degrees, and wherein the first baffle and the second baffle comprise a sound absorbing material.
20. The blender skid of claim 16, wherein the frame further comprises:  
a first sidewall;  
a second sidewall;  
a back wall; and

a bottom,

wherein at least one of the first sidewall, the second sidewall, the back wall, and the bottom further comprises: an inner layer of sound absorbing material; and an exterior layer of a vinyl-based material.

21. A method for monitoring a heat exchanger unit, the method comprising:  
operatively coupling the heat exchanger unit with at least one diesel engine, the heat exchanger unit comprising:
  - a vertical axis;
  - a frame comprising a top region, a bottom region, and a plurality of side regions;
  - a first cooler coupled with the frame proximate to a respective side region and generally parallel to the vertical axis;
  - a second cooler coupled with the frame proximate to the top region and generally perpendicular to the vertical axis;
  - an inner airflow region within the heat exchanger unit; and
  - a first baffle disposed within the inner airflow region, and at a first angle to the vertical axis;associating a monitoring module with an airflow side of at least one of the first cooler and the second cooler, the monitoring module comprising:
  - a cover panel configured for direct or indirect coupling to the heat exchanger unit;
  - an at least one sensor coupled with the cover panel, the at least one sensor having a respective rotating member with a plurality of blades extending therefrom;
  - a logic circuit in operable communication with the at least one sensor, and further comprising: a microcontroller configured with computer instructions for performing a plurality of tasks comprising:
    - acquiring a set of data from the at least one sensor;
    - sampling the set of data over a predetermined period of time, and
    - computing an average and a standard deviation;
    - comparing the standard deviation with predetermined data stored on a data storage;

determining whether the set of data is acceptable within a defined parameter;  
determining whether a first lookup table comprising a set of lookup data has been completed, and creating the first lookup table using an averaging method if it has not;  
comparing the set of data to the set of lookup data; and  
providing an indication based on a result of the comparing the set of data to the set of lookup data step; and  
performing an action based on the indication.

22. The method for monitoring the heat exchanger unit of claim 21, wherein the indication is communicated to an end user by way of at least one of: a text message, an email, an audio signal, display, a visual indicator, and combinations thereof.
23. The method for monitoring the heat exchanger unit of claim 22, wherein the indication is related to an amount of fouling present within the airflow side.
24. The method for monitoring the heat exchanger unit of claim 22, wherein the monitoring module comprises a plurality of sensors, with each of the plurality of sensors in operable communication with the microcontroller, and wherein the indication pertains to an amount of fouling associated with the airflow side of the heat exchanger unit.
25. The method for monitoring the heat exchanger unit of claim 24, wherein the monitoring module further comprises each of a solid data storage, a Wi-Fi module, a GSM module, and a CAN-Bus module being disposed within the controller housing and in operable communication with the microcontroller, and wherein the microcontroller is provided with computer instructions for communicating with one or more of the solid data storage, the Wi-Fi module, the GSM module, and the CAN-Bus module.
26. The method for monitoring a heat exchanger unit of claim 25, wherein an a least one service fluid transferable between the heat exchanger unit and the diesel engine

comprises one of lube oil, hydraulic fluid, fuel, charge air, transmission fluid, jacket water, and engine cooler.

27. The method for monitoring the heat exchanger unit of claim 21, the heat exchanger unit further comprising a first baffle configured at a first angle to the vertical axis, and having mineral wool disposed therein.
28. The method for monitoring the heat exchanger unit of claim 21, the heat exchanger unit further comprising: a third cooler; and a fourth cooler, wherein each of the coolers comprise a respective core and a respective tank, wherein at least one of the respective cores comprises a core end having a core end mass, wherein at least one of the respective tanks comprises a tank end having a tank end mass, and wherein the core end mass is greater than the respective tank end mass.
29. The method for monitoring the heat exchanger unit of claim 21, wherein the heat exchanger unit further comprises a mount assembly for coupling at least one of the first cooler and the second cooler to the frame, the mount assembly further comprising:
  - an elongated fastening member;
  - a rigid outer ring;
  - a rigid inner ring;
  - a deformable ring disposed between the rigid outer ring and the inner outer ring,wherein the at least one of the plurality of coolers comprises a mounting slot, and wherein the elongated fastening member extends through the rigid inner ring and at least partially into the frame.
30. The method for monitoring the heat exchanger unit of claim 21, wherein the heat exchanger unit further comprises:
  - a third cooler coupled with the frame proximate to the respective side region, and adjacent the first cooler; and
  - a fourth cooler coupled with the frame proximate to the top frame, and adjacent the second cooler.

31. The method for monitoring the heat exchanger unit of claim 30, the unit further comprising a second airflow region partitioned from the inner airflow region, wherein the second airflow region is associated with the third cooler and the fourth cooler, and wherein a second baffle is disposed within the second airflow region, and at a second angle to the vertical axis.
32. The method for monitoring the heat exchanger unit of claim 31, wherein the first baffle and the second baffle comprise a sound absorbing material.
33. A heat exchanger unit, comprising:  
a vertical axis;  
a frame comprising a top region, a bottom region, and a plurality of side regions;  
a first cooler coupled with the frame proximate to a respective side region and generally parallel to the vertical axis;  
a second cooler coupled with the frame proximate to the top region and generally perpendicular to the vertical axis;  
a first fan mounted to the frame external to a first side of the first cooler;  
an inner airflow region within the heat exchanger unit; and  
a first baffle disposed within the inner airflow region, and at a first angle to the vertical axis.
34. The heat exchanger unit of claim 33, the unit further comprising:  
a third cooler coupled with the frame proximate to the respective side region, and adjacent the first cooler; and  
a fourth cooler coupled with the frame proximate to the top frame, and adjacent the second cooler.
35. The heat exchanger unit of claim 34, the unit further comprising a second airflow region partitioned from the inner airflow region, wherein the second airflow region is associated

with the third cooler and the fourth cooler, and wherein a second baffle is disposed within the second airflow region, and at a second angle to the vertical axis.

36. The heat exchanger unit of claim 35, wherein the first baffle and the second baffle comprise a sound absorbing material.
37. The heat exchanger unit of claim 36, wherein the sound absorbing material comprises mineral wool, and wherein each of the first angle and the second angle is in the range of about 30 to about 60 degrees.
38. The heat exchanger unit of claim 35, wherein the first angle and the second angle are substantially the same.
39. The heat exchanger unit of claim 35, the heat exchanger unit further comprising:  
a second fan mounted to the frame external to a first side of the second cooler,  
the first fan and the second fan each comprising an axis of rotation substantially perpendicular to the vertical axis.
40. The heat exchanger unit of claim 39, wherein each of the coolers are configured to permit airflow to pass therethrough, and wherein operation of the first fan and the second fan results in airflow through each of the respective coolers and airflow regions, and out of the outlet.
41. The heat exchanger unit of claim 33, wherein the frame further comprises:  
a first sidewall;  
a second sidewall;  
a back wall; and  
a bottom.

42. The heat exchanger unit of claim 41, wherein at least one of the first sidewall, the second sidewall, the back wall, and the bottom further comprises: an inner layer of sound absorbing material; and an exterior layer of a vinyl-based material.
43. The heat exchanger unit of claim 33, the heat exchanger unit further comprising: a monitoring module proximately coupled to at least one of the first cooler, the second cooler, the third cooler, and the fourth cooler, the monitoring module further comprising: a cover panel; an at least one sensor coupled with the cover panel; at least one controller housing coupled with the cover panel; and a microcontroller disposed within the controller housing and in operable communication with the at least one sensor, wherein the at least one sensor comprises a rotating member configured to generate a system signal proportional to an amount of rotation of the rotating member, and wherein the microcontroller is provided with computer instructions for processing the system signal.
44. The heat exchanger unit of claim 43, wherein the monitoring module comprises a plurality of sensors, with each of the plurality of sensors in operable communication with the microcontroller, wherein an at least one of the plurality of sensors comprises a plurality of blades radially extending from the respective rotating member, and wherein the system signal pertains to an amount of fouling.
45. The heat exchanger unit of claim 43, wherein the monitoring module further comprises each of a solid data storage, a Wi-Fi module, a GSM module, and a CAN-Bus module being disposed within the controller housing and in operable communication with the microcontroller, and wherein the microcontroller is provided with computer instructions for communicating with one or more of the solid data storage, the Wi-Fi module, the GSM module, and the CAN-Bus module.
46. The heat exchanger unit of claim 33, the heat exchanger unit further comprising: a third cooler; and a fourth cooler,

wherein each of the coolers comprise a respective core and a respective tank, wherein at least one of the respective cores comprises a core end having a core end mass, wherein at least one of the respective tanks comprises a tank end having a tank end mass, and wherein the core end mass is greater than the respective tank end mass.

47. The heat exchanger unit of claim 33, wherein the heat exchanger unit further comprises a mount assembly for coupling at least one of the first cooler and the second cooler to the frame, the mount assembly further comprising:
- an elongated fastening member;
  - a rigid outer ring;
  - a rigid inner ring;
  - a deformable ring disposed between the rigid outer ring and the inner outer ring,
- wherein the at least one of the plurality of coolers comprises a mounting slot, and wherein the elongated fastening member extends through the rigid inner ring and at least partially into the frame.
48. The heat exchanger unit of claim 33, wherein the heat exchanger unit further comprises:
- a third cooler coupled with the frame proximate to the respective side region, and adjacent the first cooler; and
  - a fourth cooler coupled with the frame proximate to the top region, and adjacent the second cooler.
49. The heat exchanger unit of claim 48, the unit further comprising a second airflow region partitioned from the inner airflow region, wherein the second airflow region is associated with the third cooler and the fourth cooler, and wherein a second baffle is disposed within the second airflow region, and at a second angle to the vertical axis.
50. The heat exchanger unit of claim 33, wherein the first baffle comprises mineral wool.

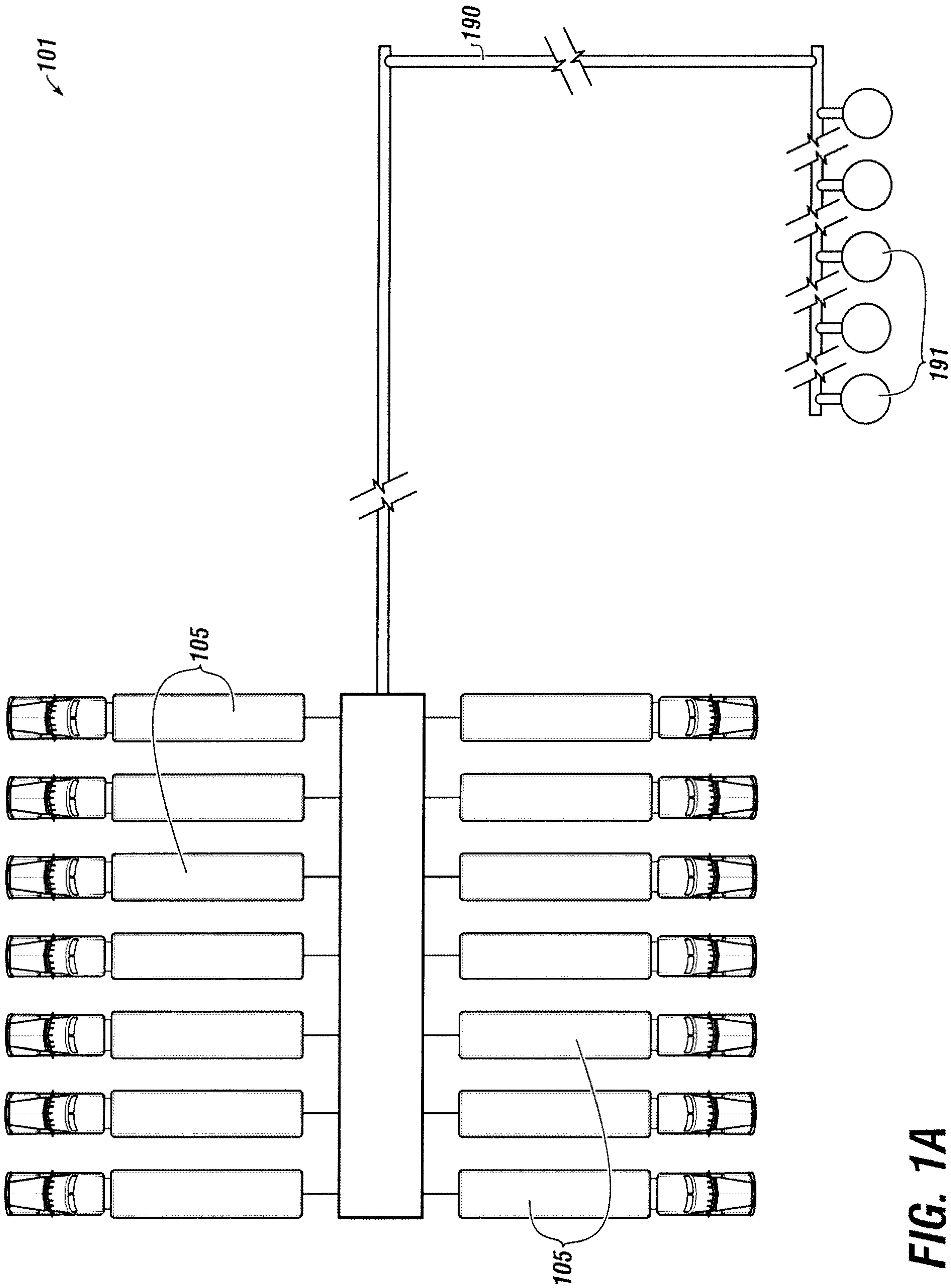


**FIG. 1A**  
(PRIOR ART)

**FIG. 1B**  
(PRIOR ART)

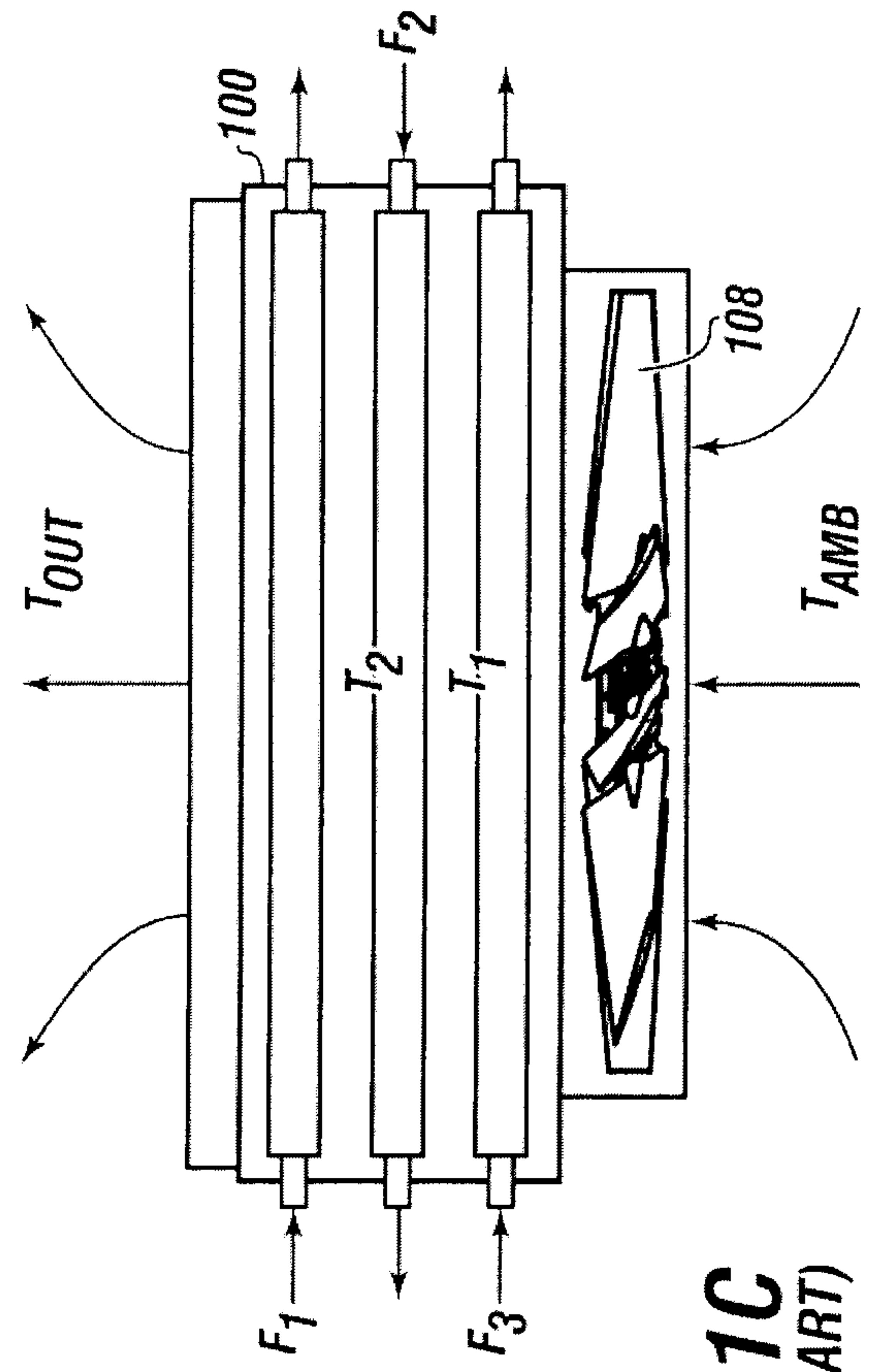
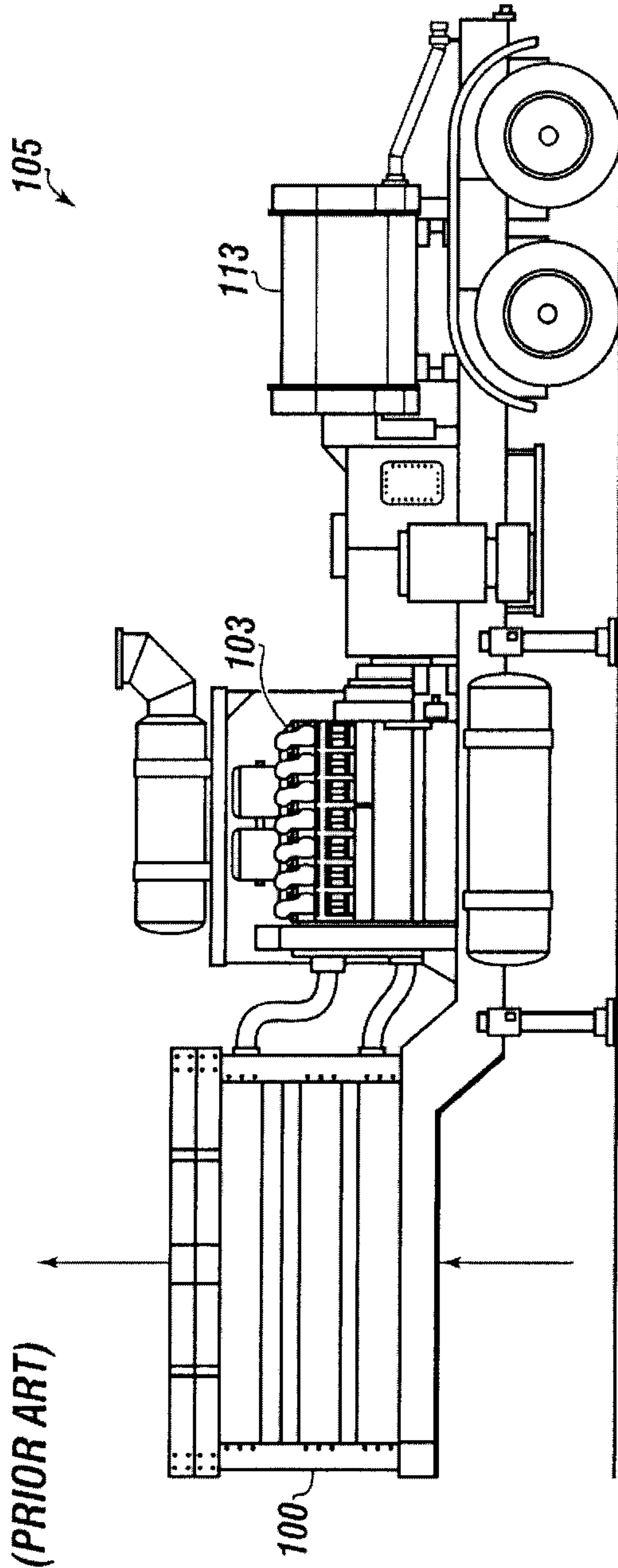


**FIG. 1C**  
(PRIOR ART)

101a

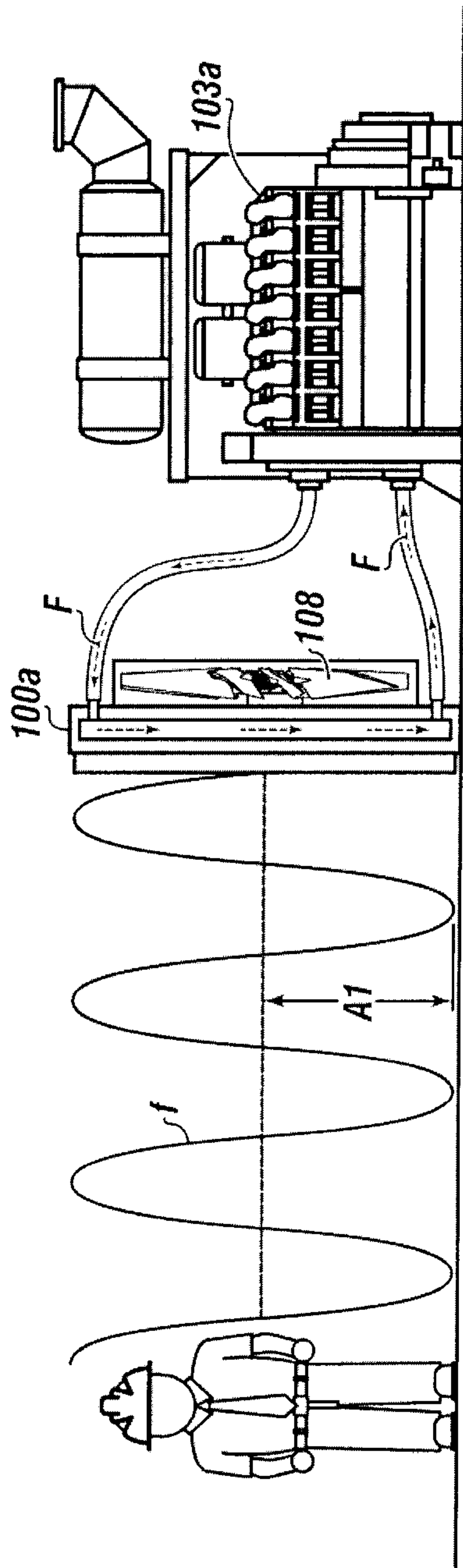
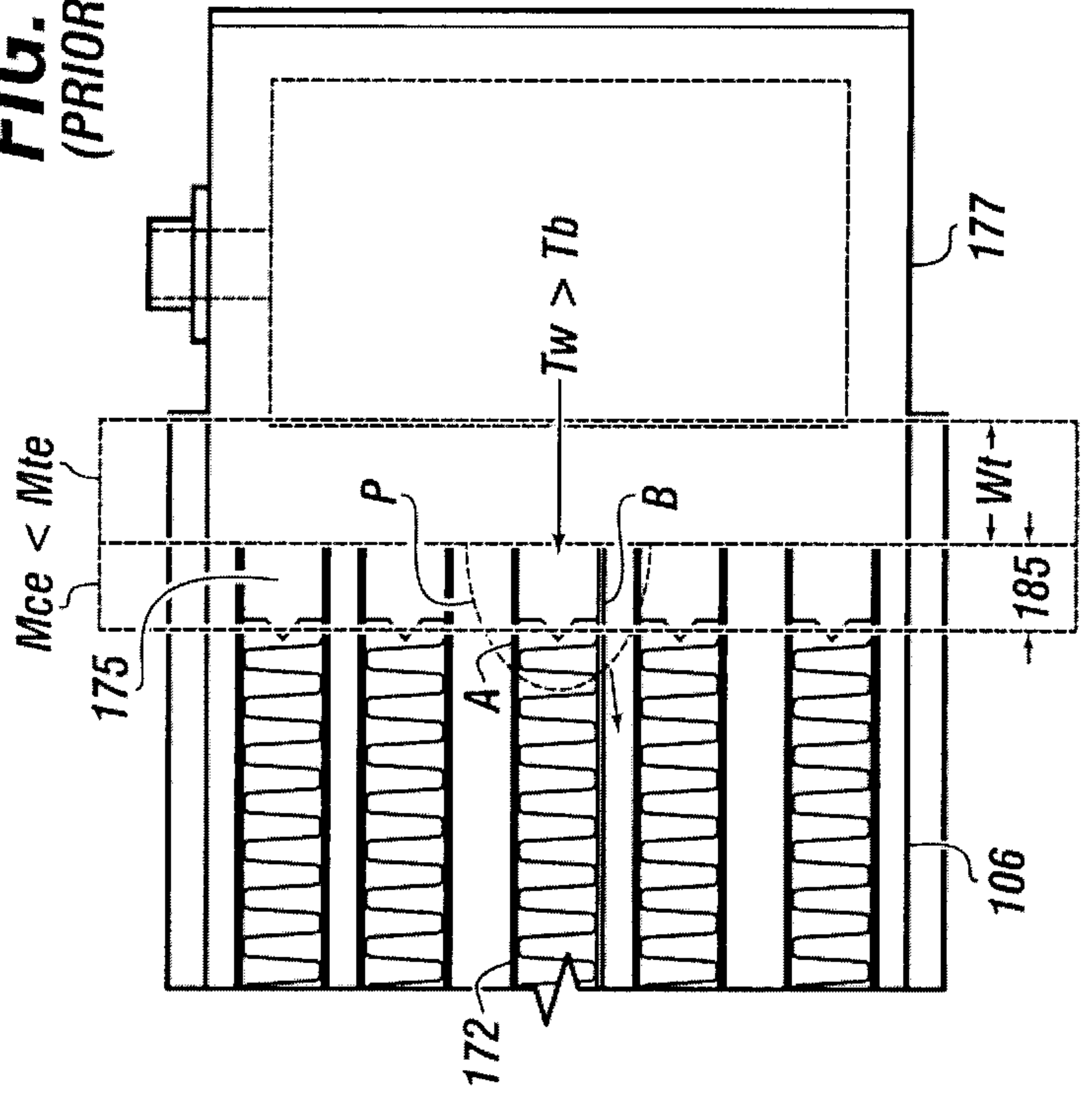


FIG. 1D  
(PRIOR ART)

FIG. 1E  
(PRIOR ART)



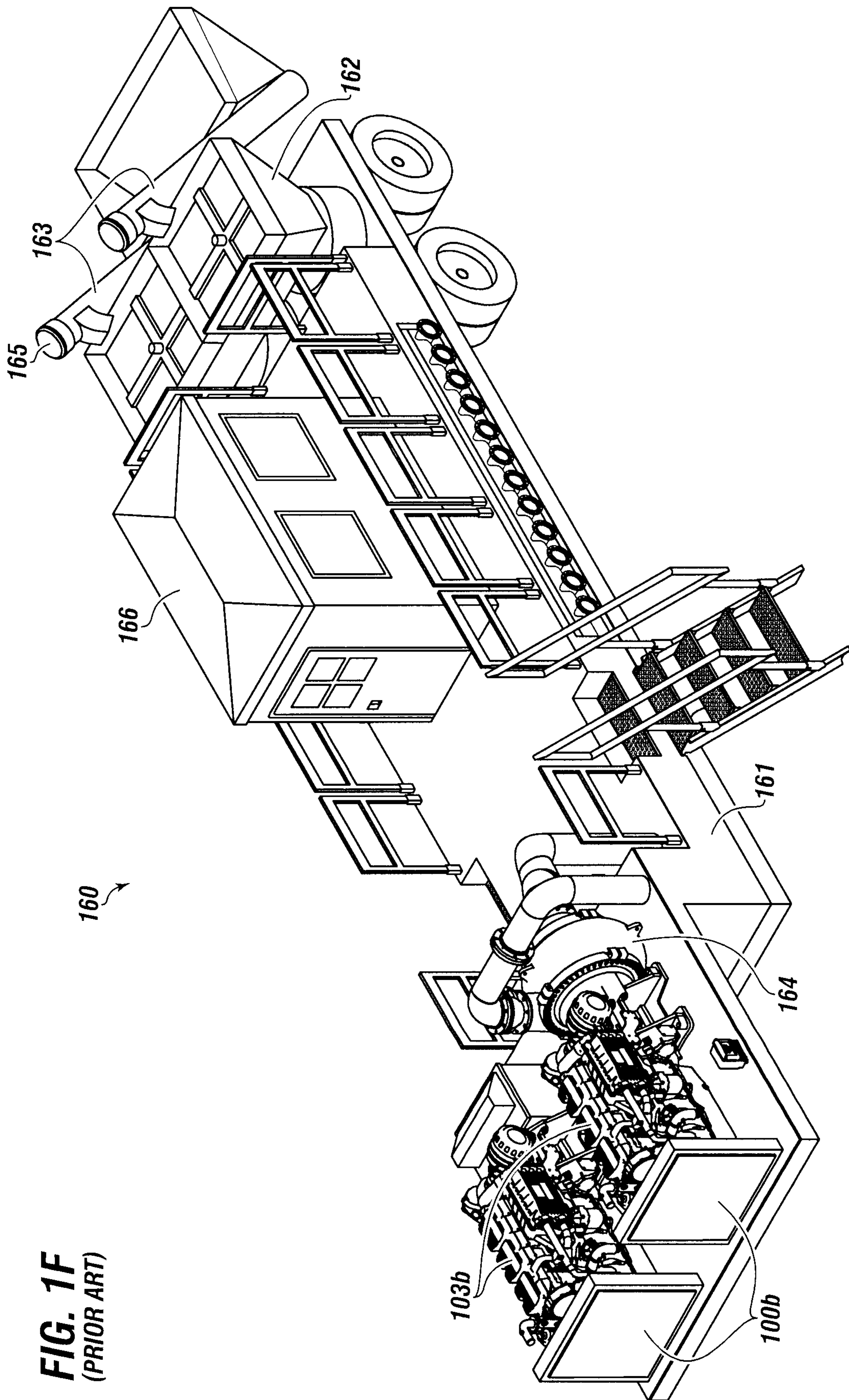


FIG. 2A

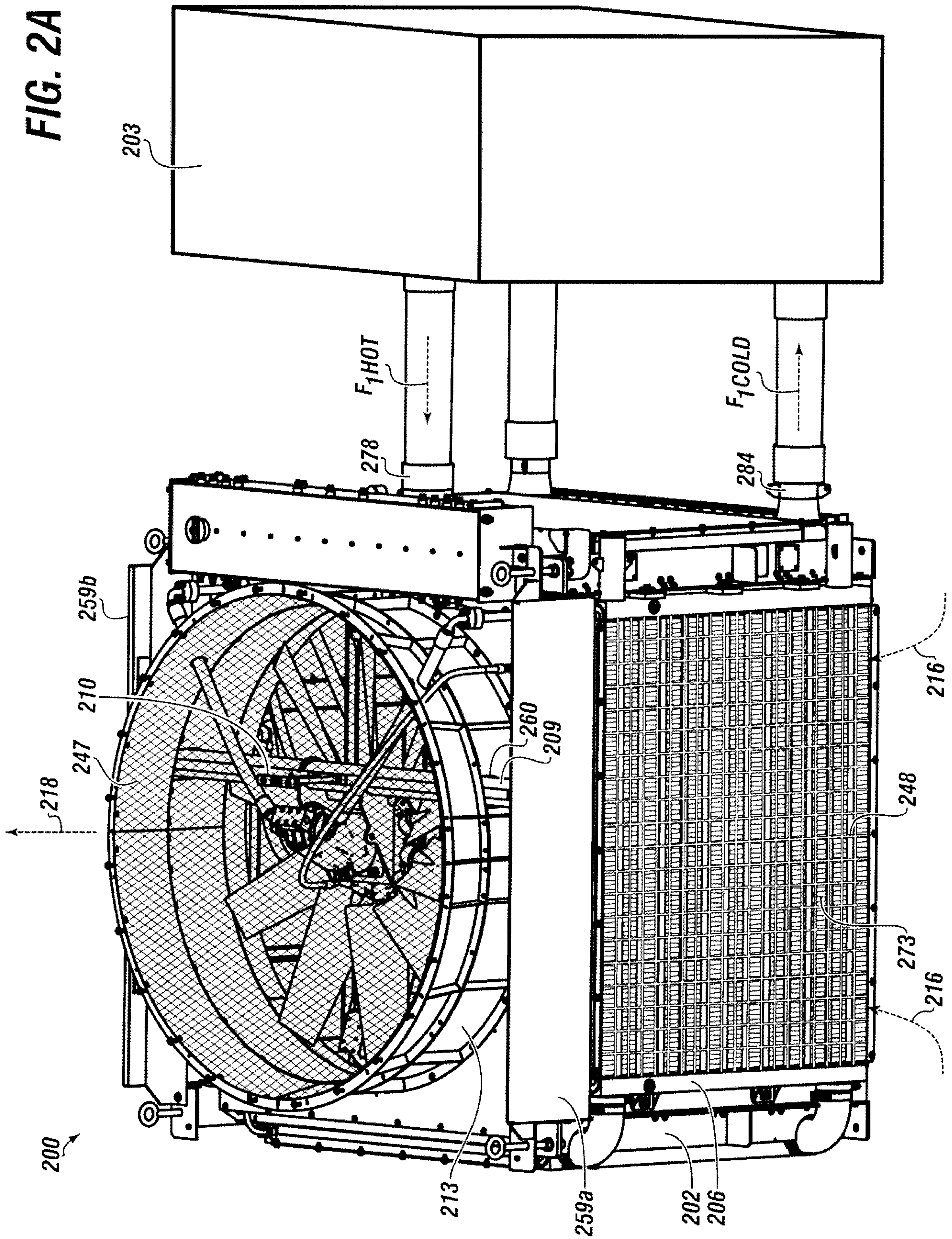


FIG. 2B

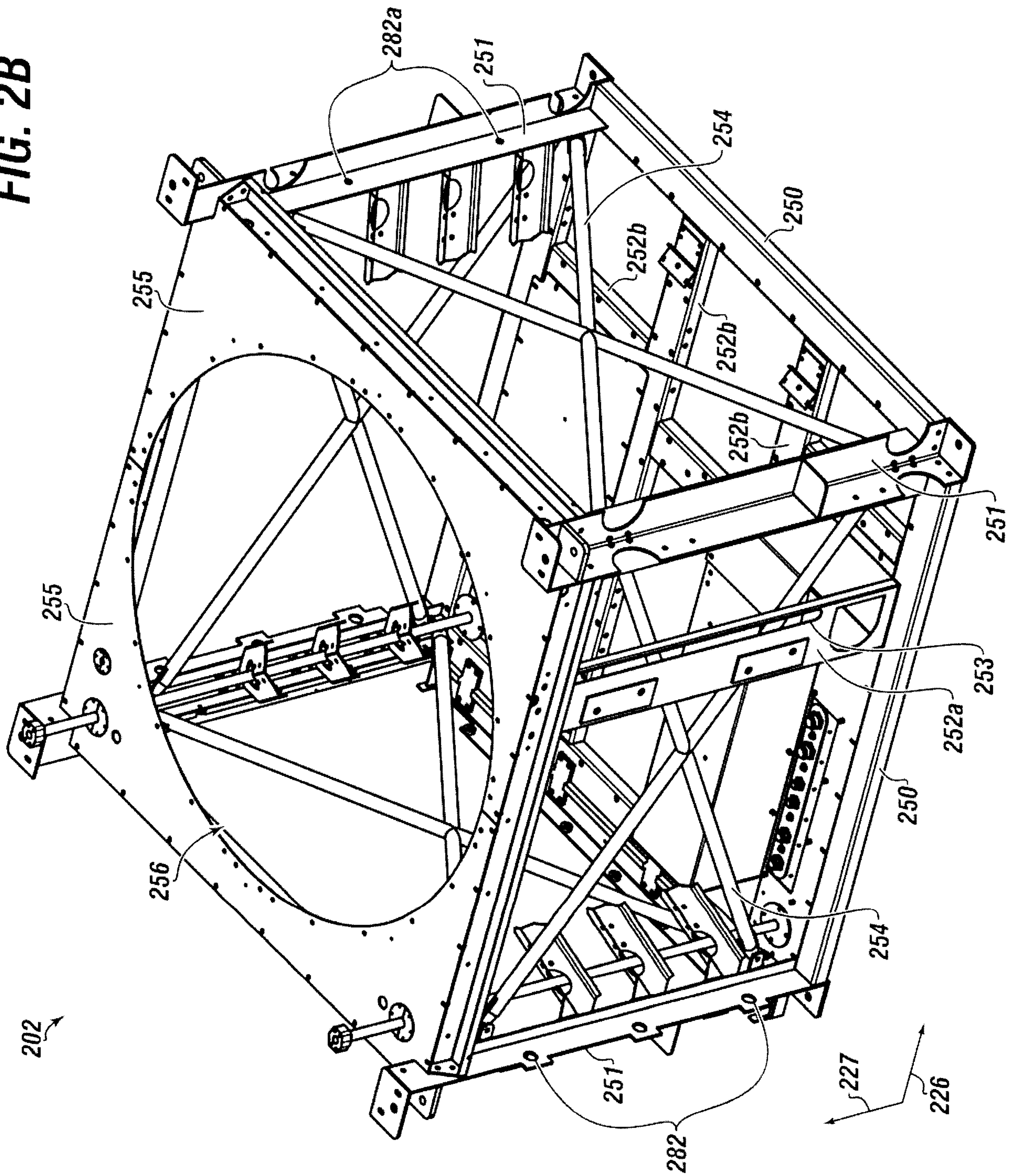


**FIG. 2C**

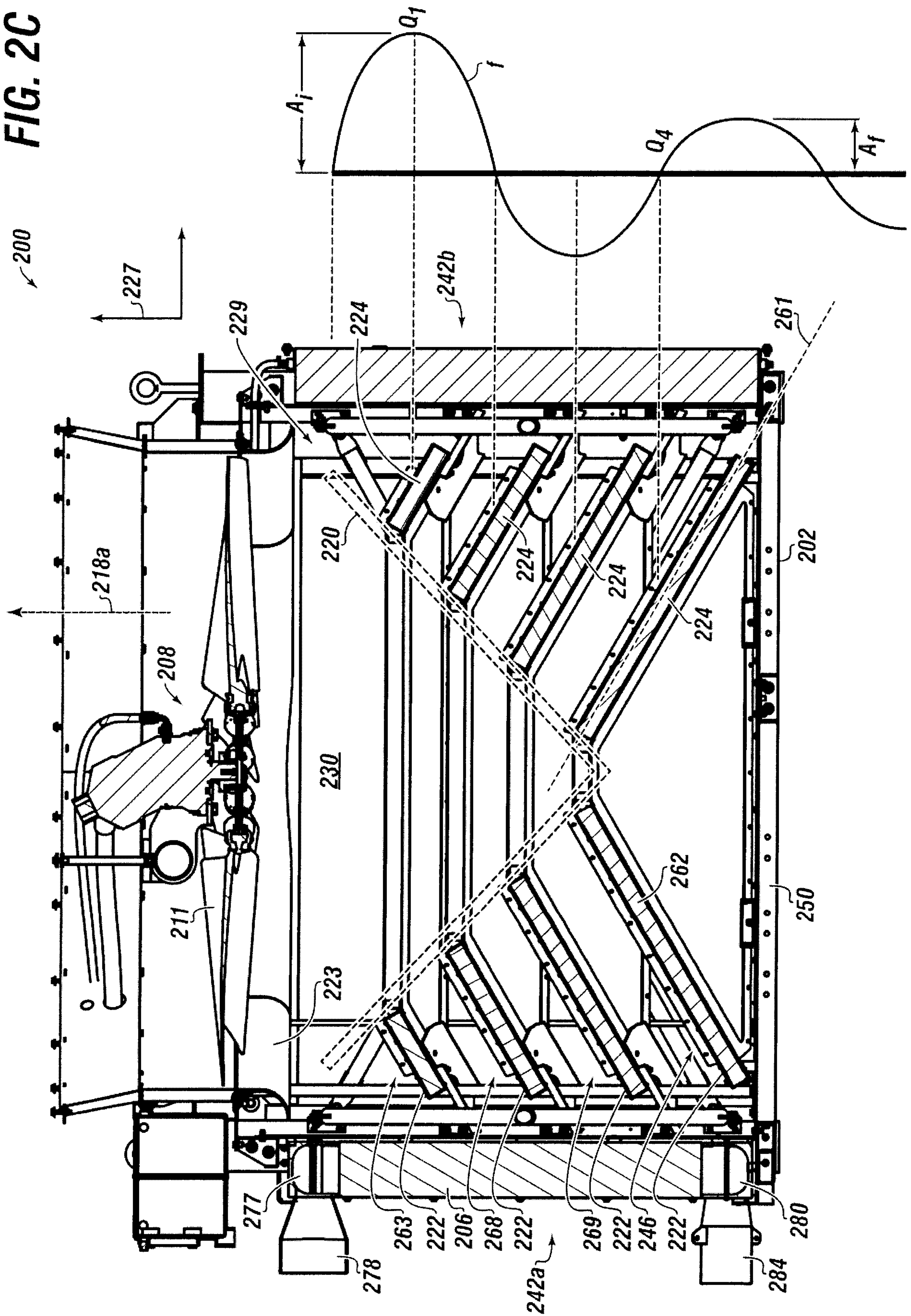
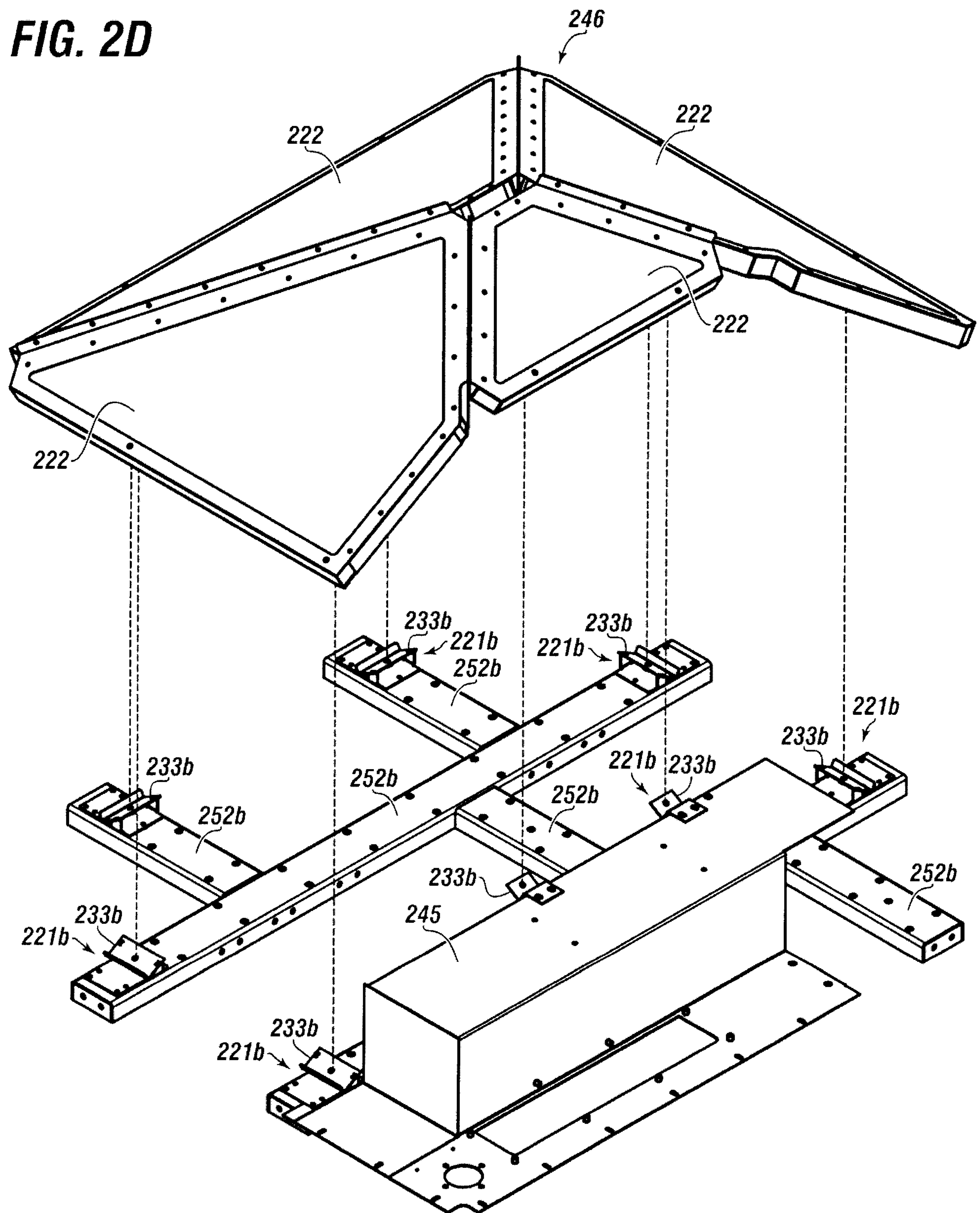


**FIG. 2D**

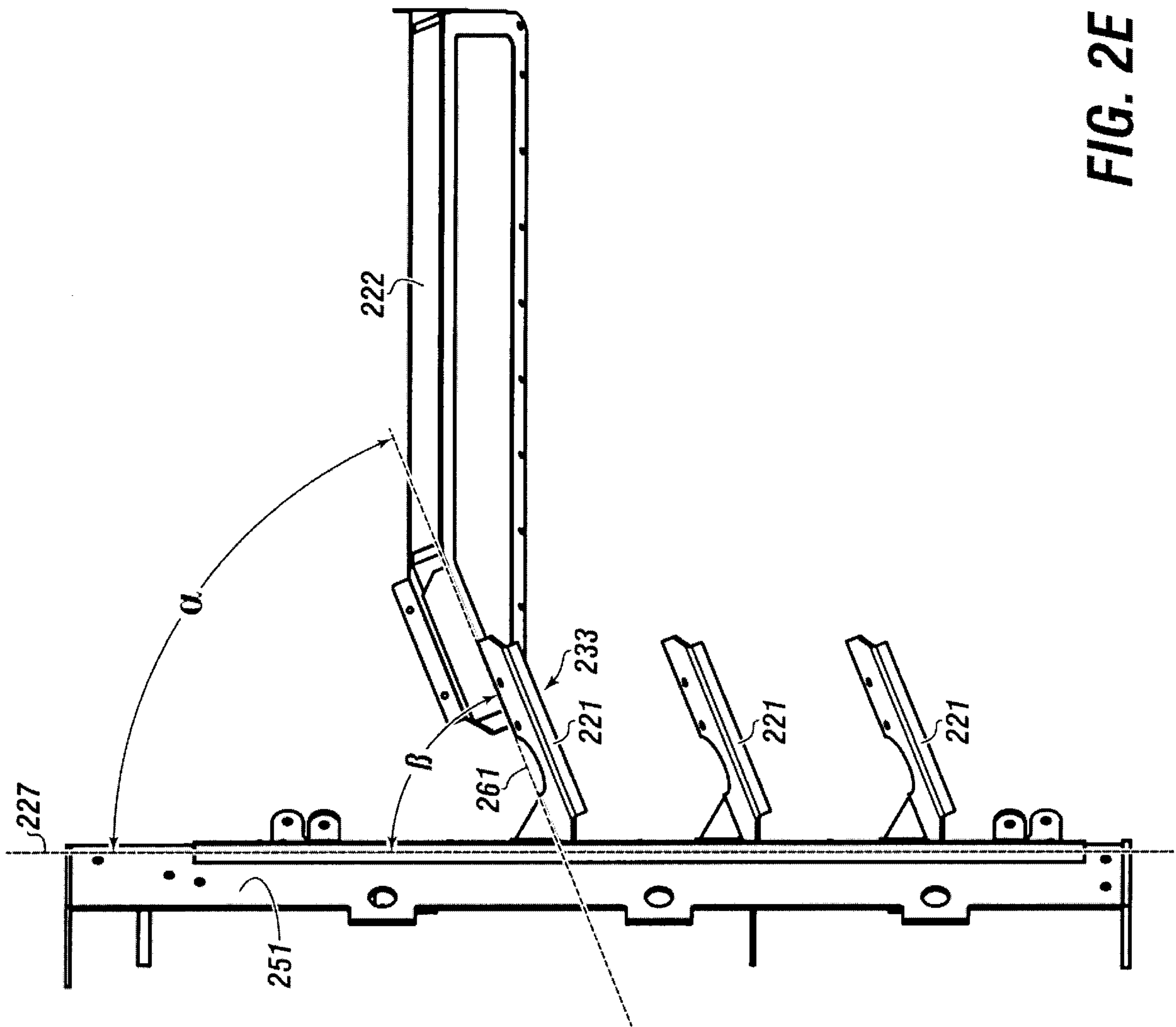


FIG. 3A

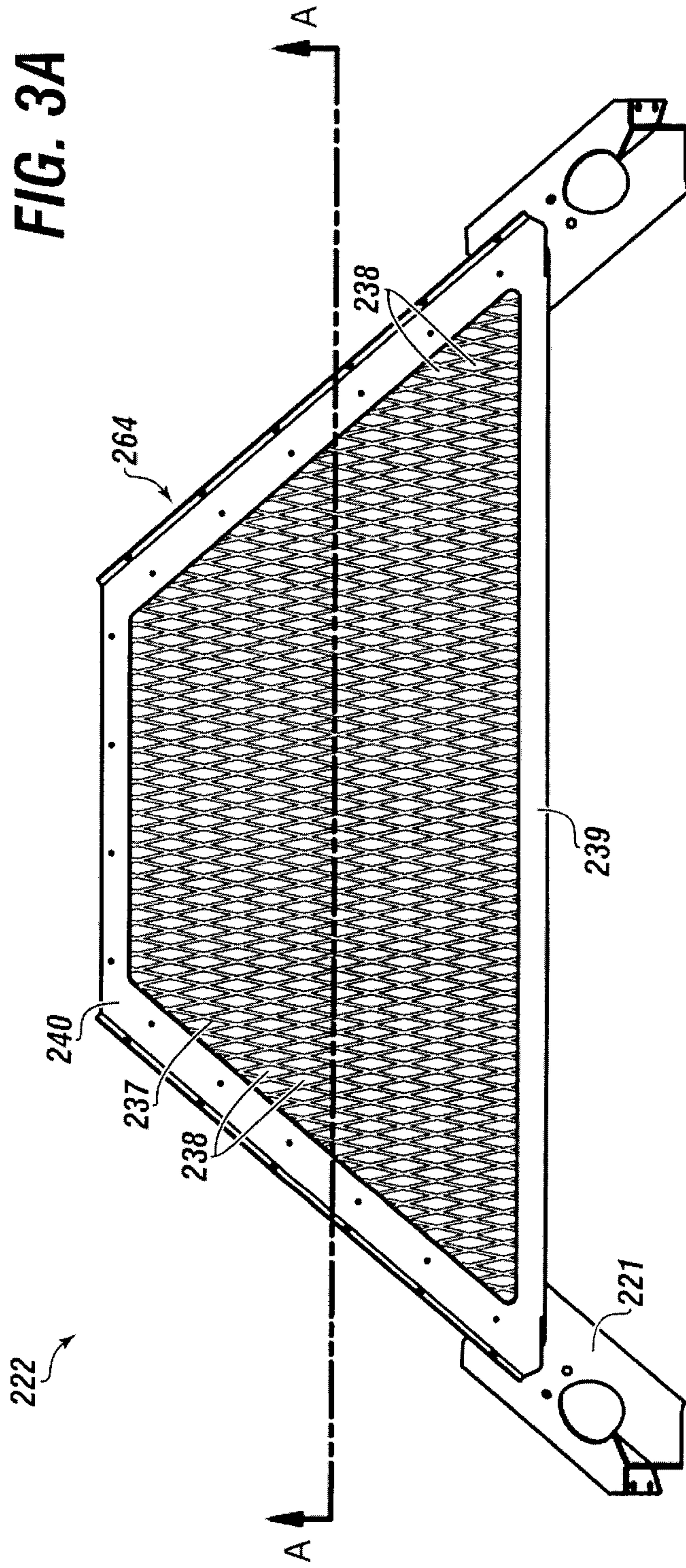
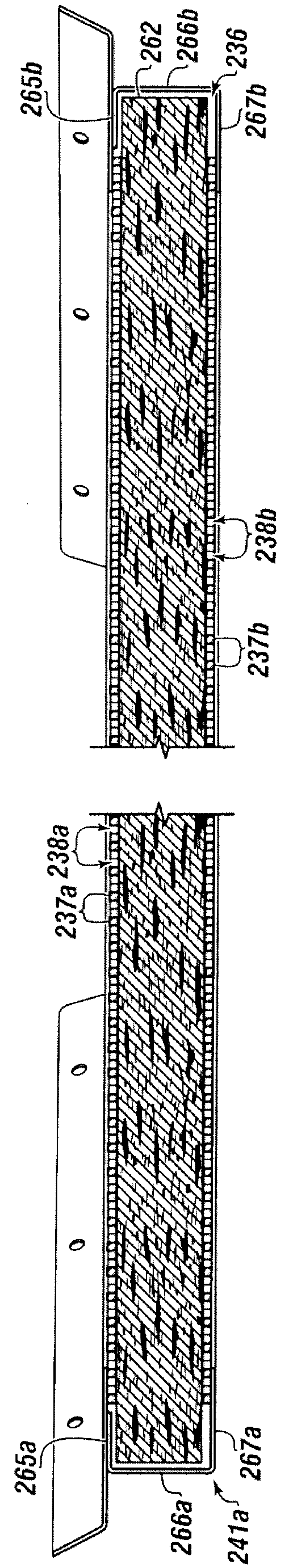


FIG. 3B





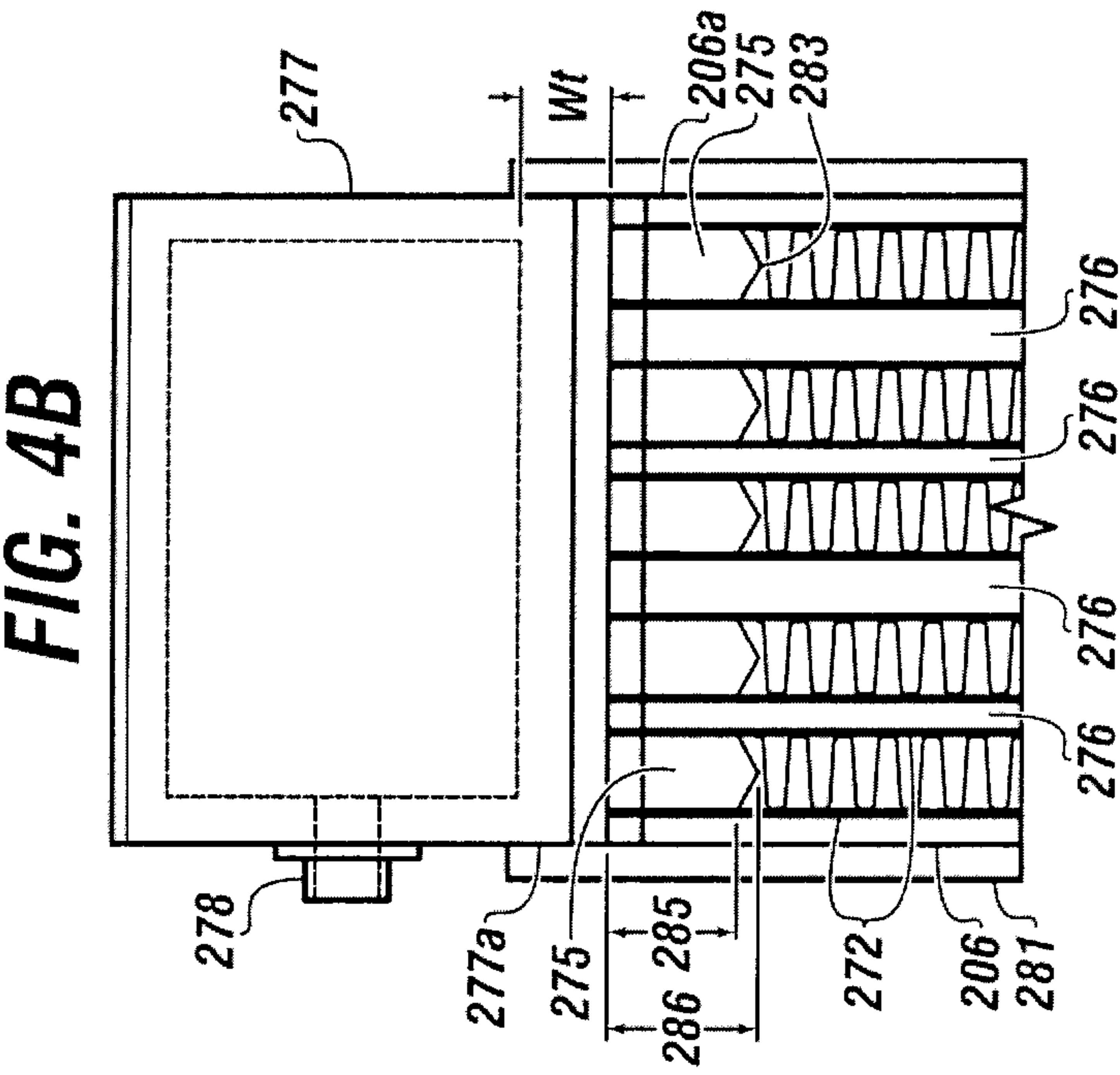
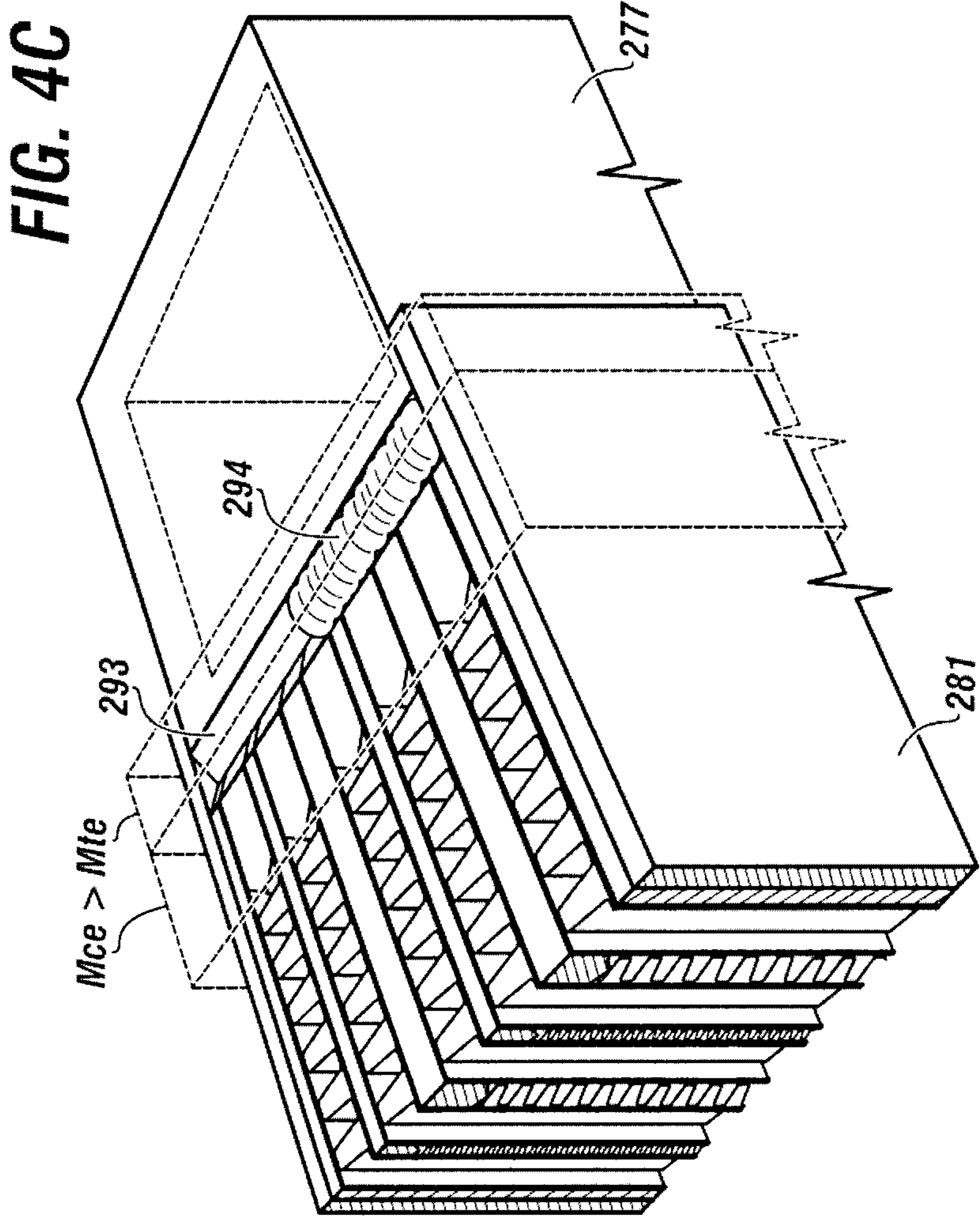




FIG. 5B

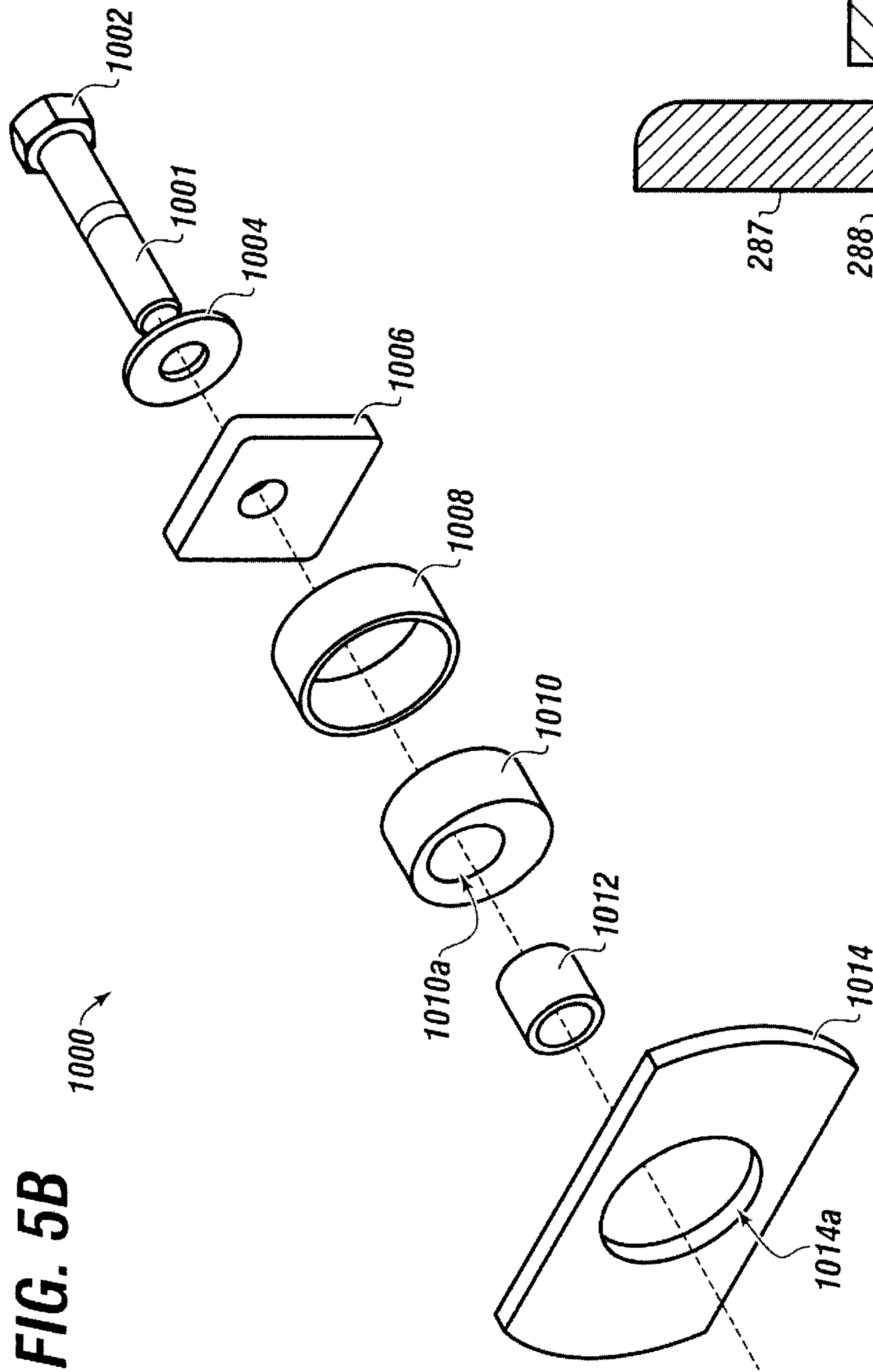
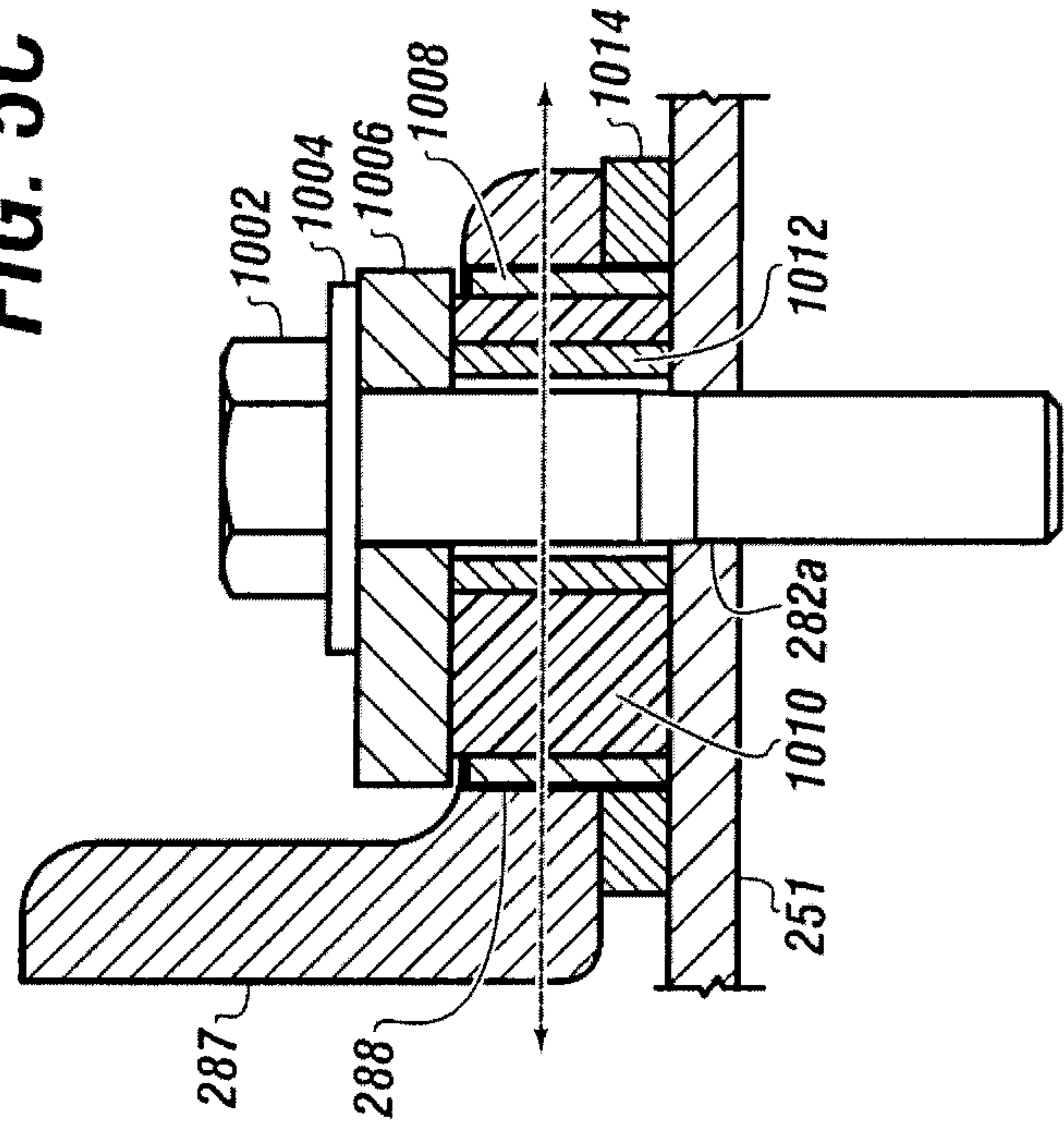


FIG. 5C



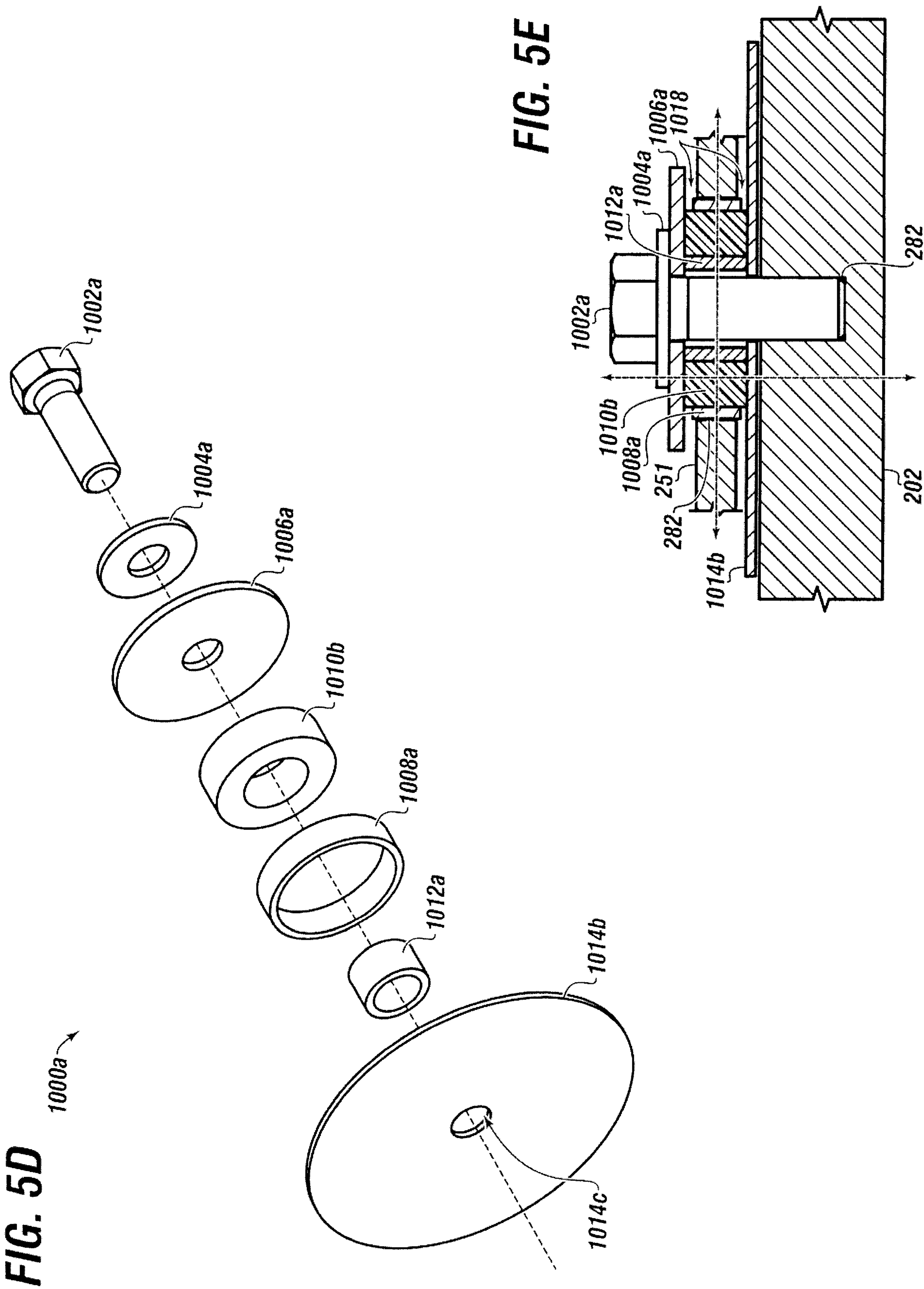
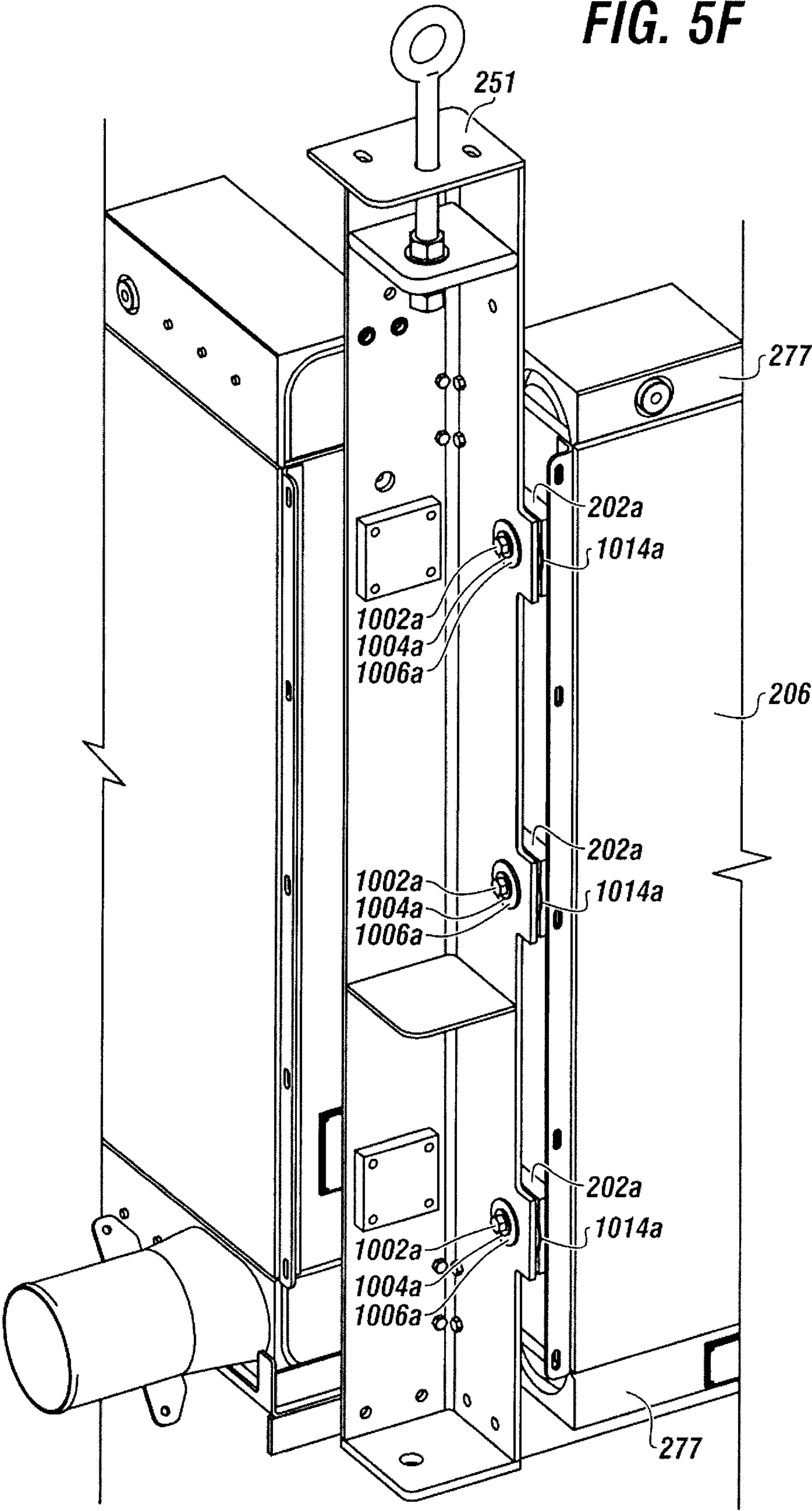


**FIG. 5F**



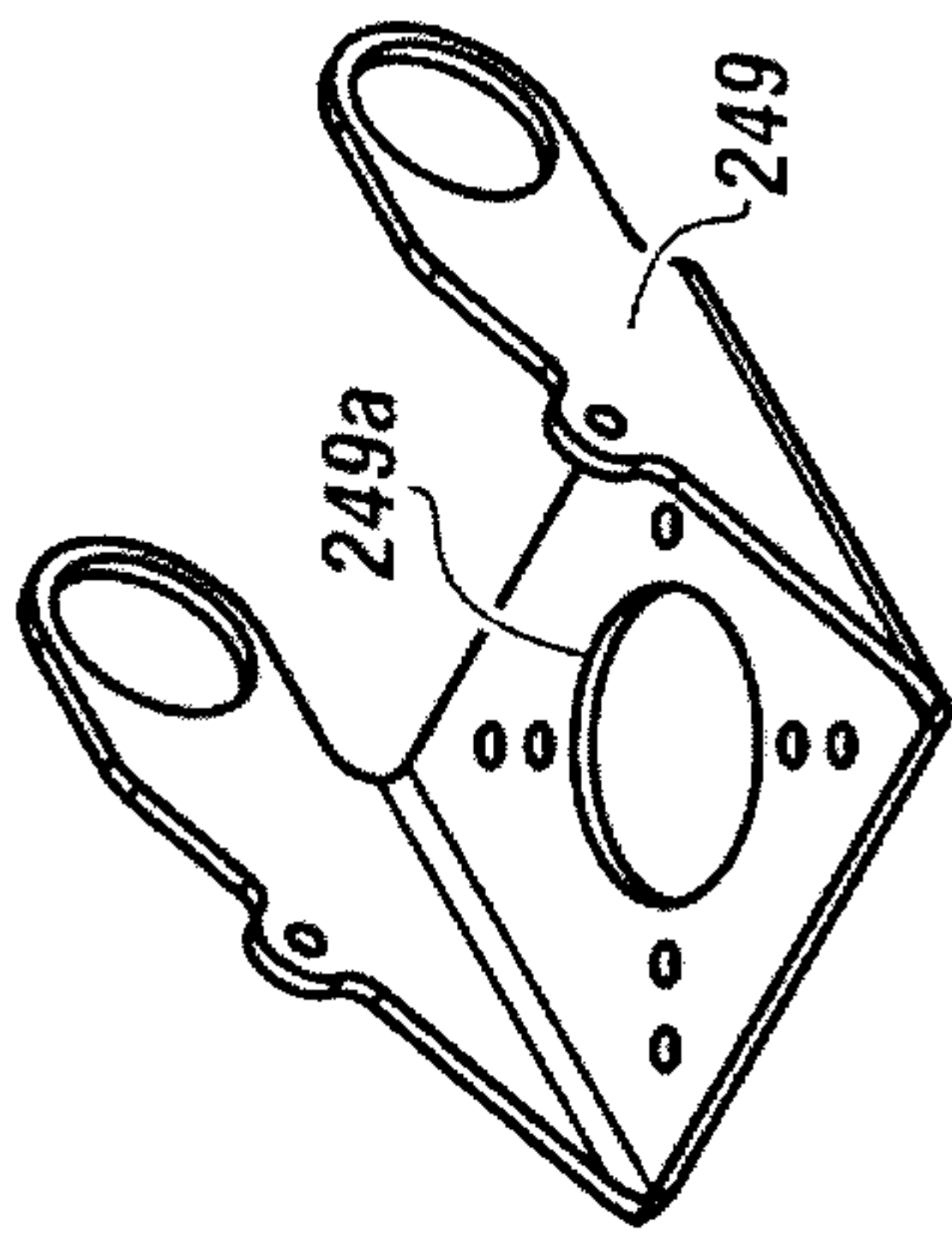


FIG. 6B

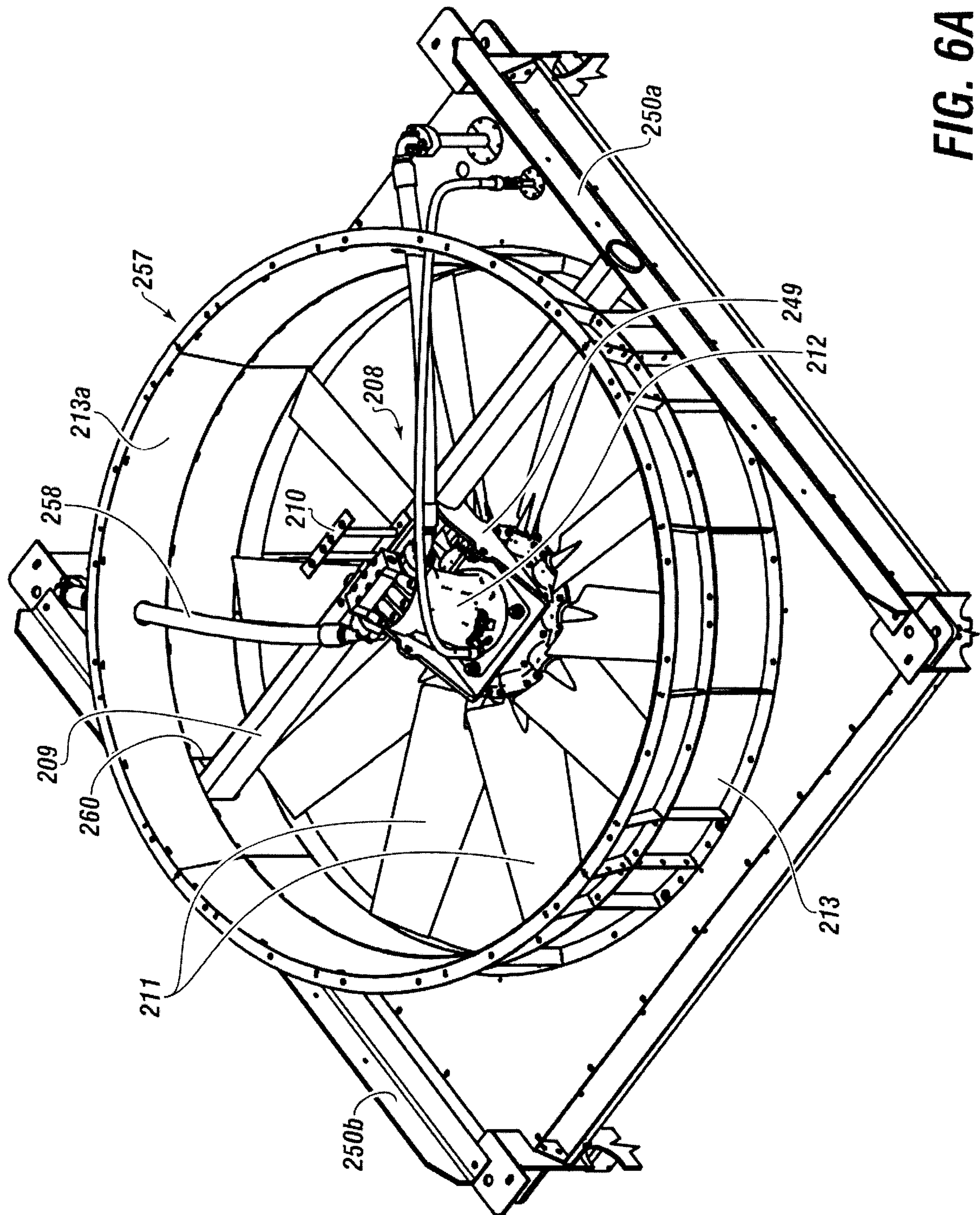


FIG. 6A

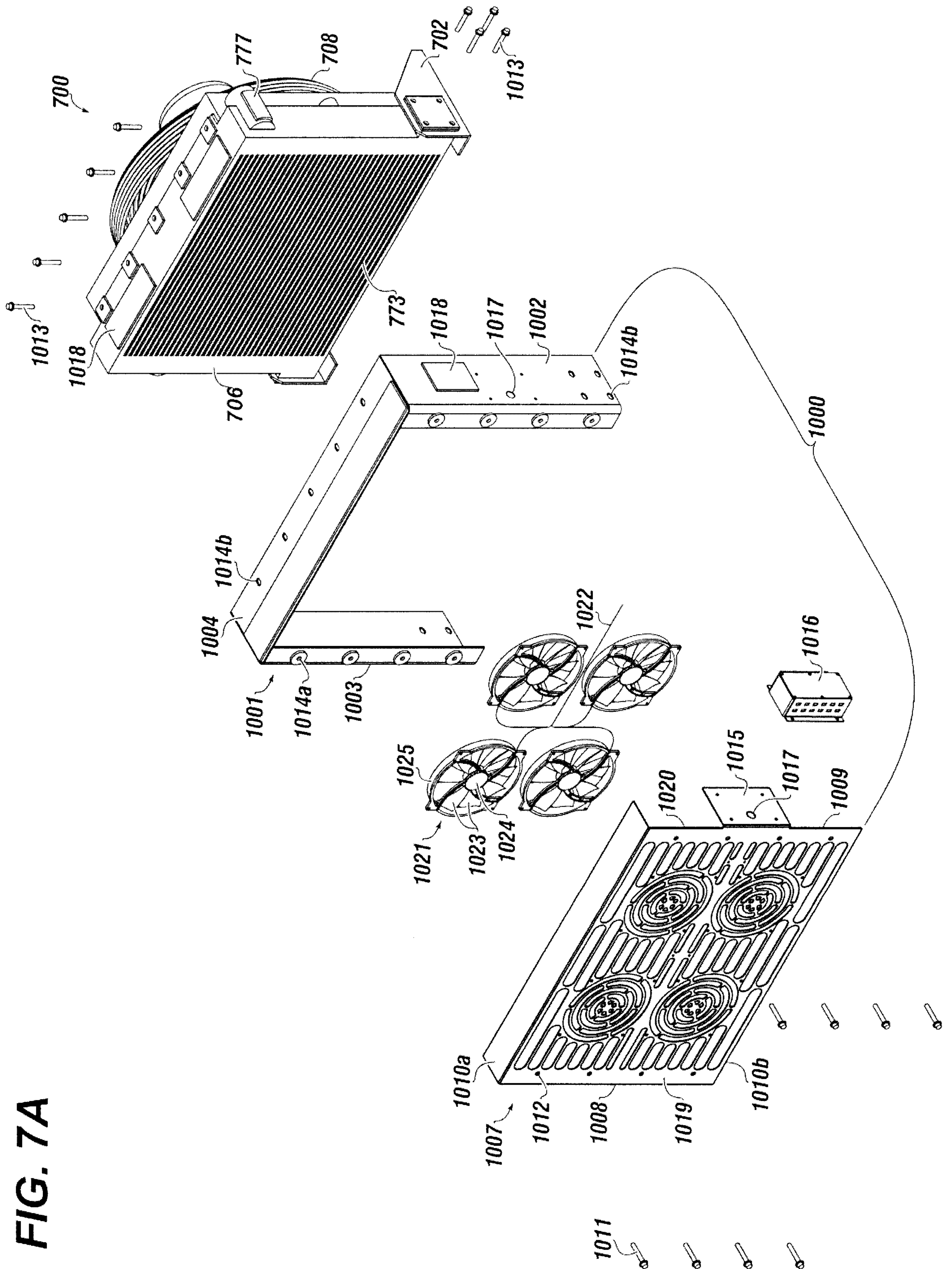


**FIG. 7A**

FIG. 7B

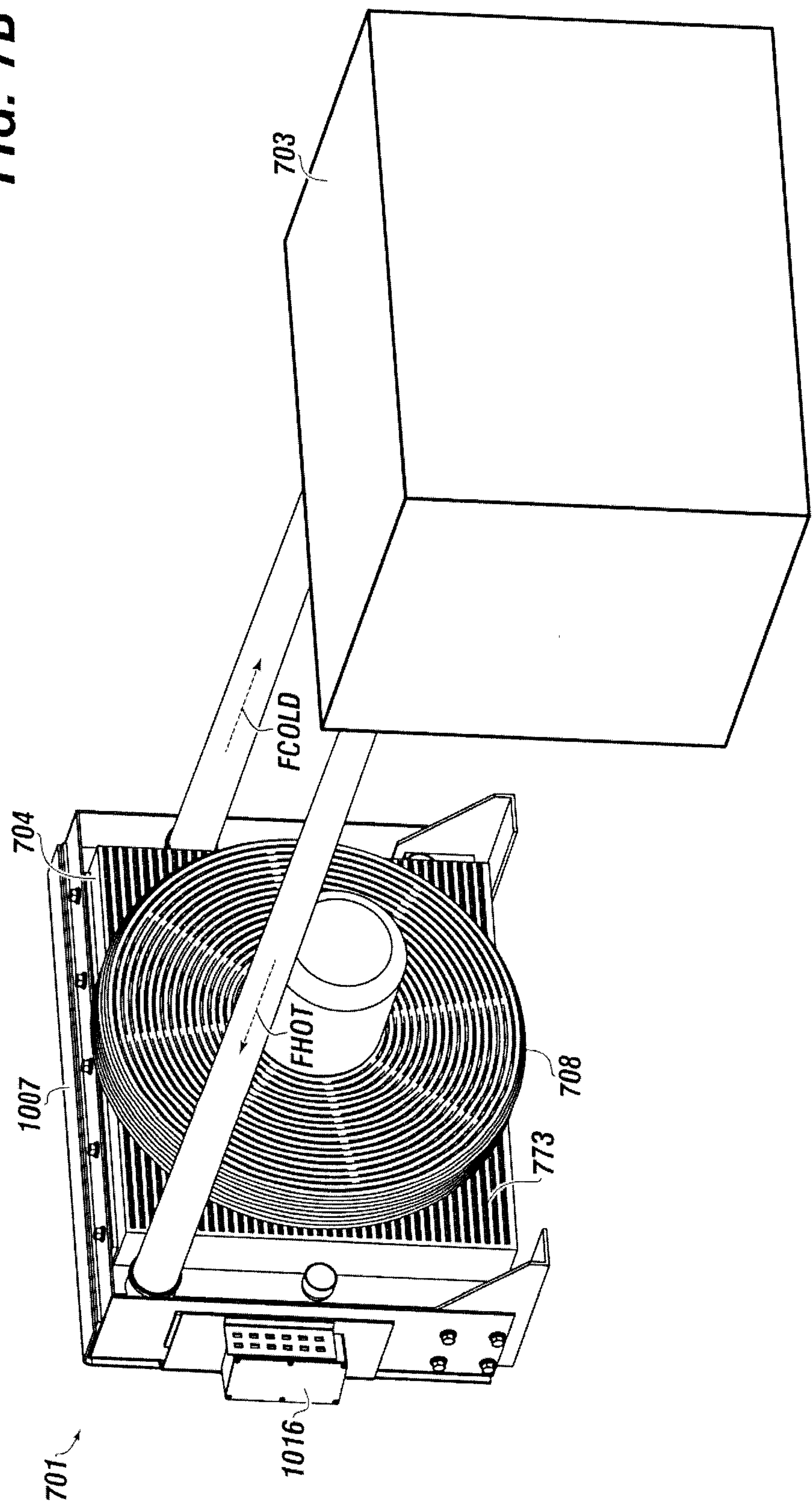
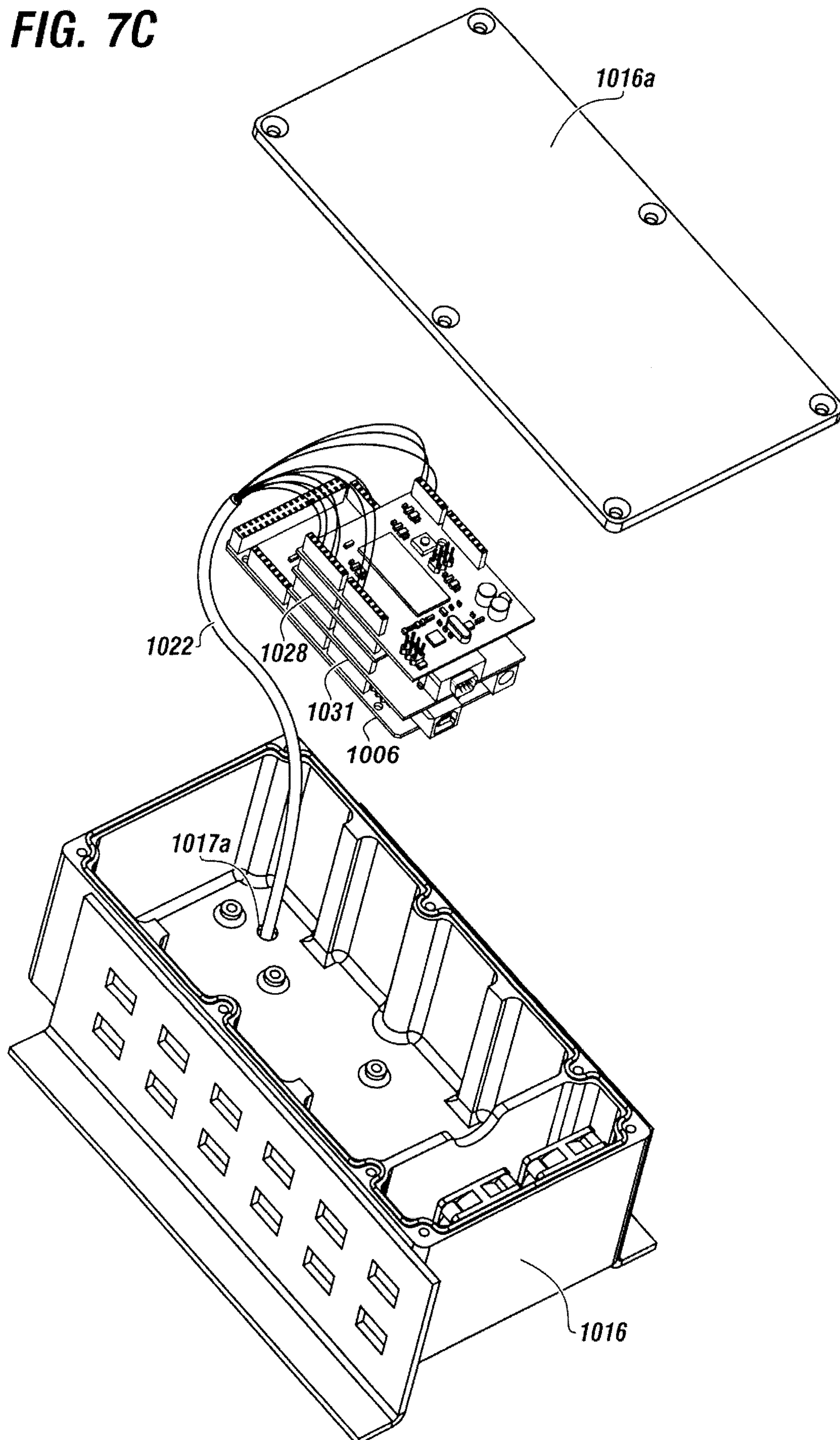


**FIG. 7C**

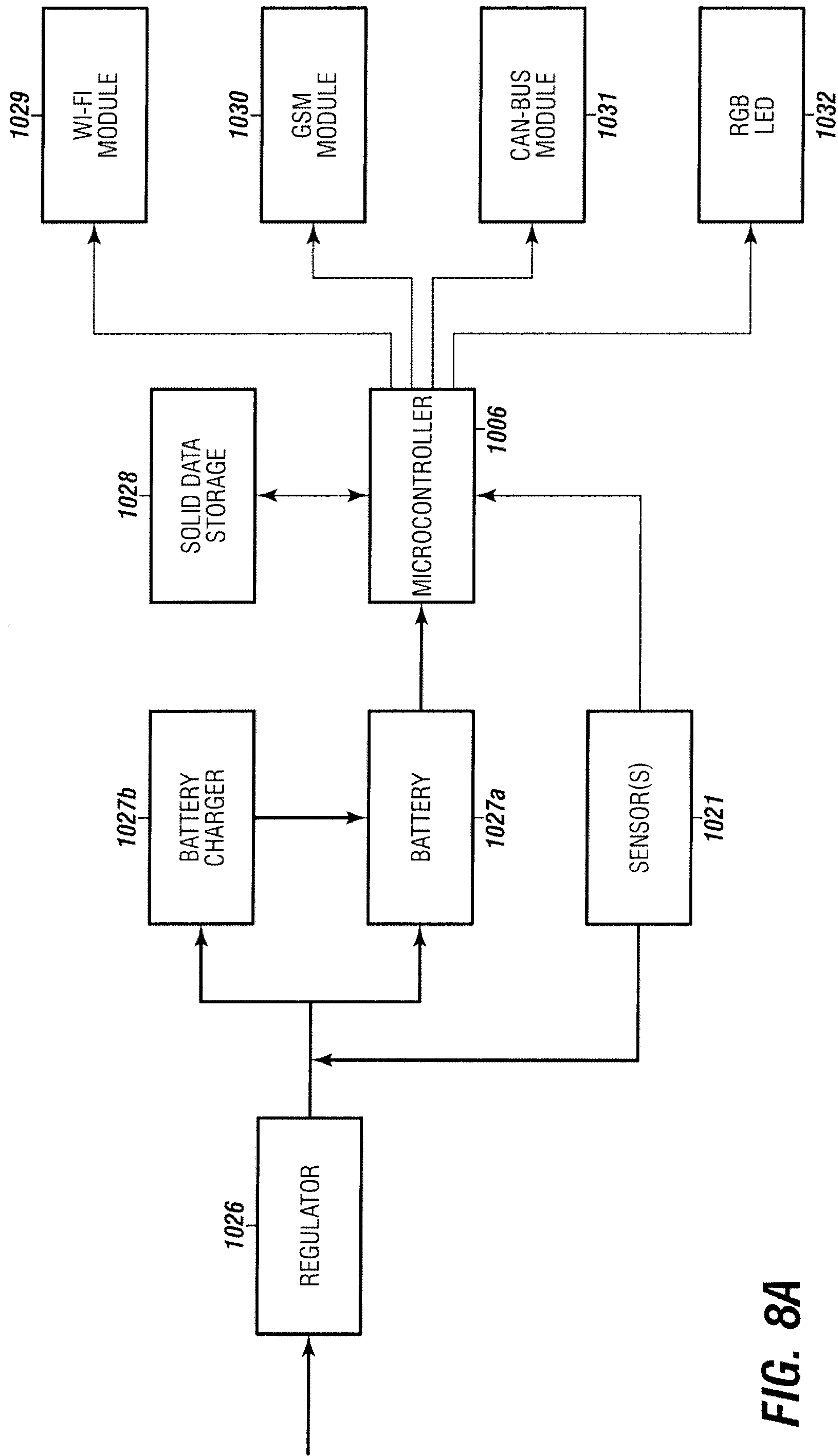


FIG. 8A

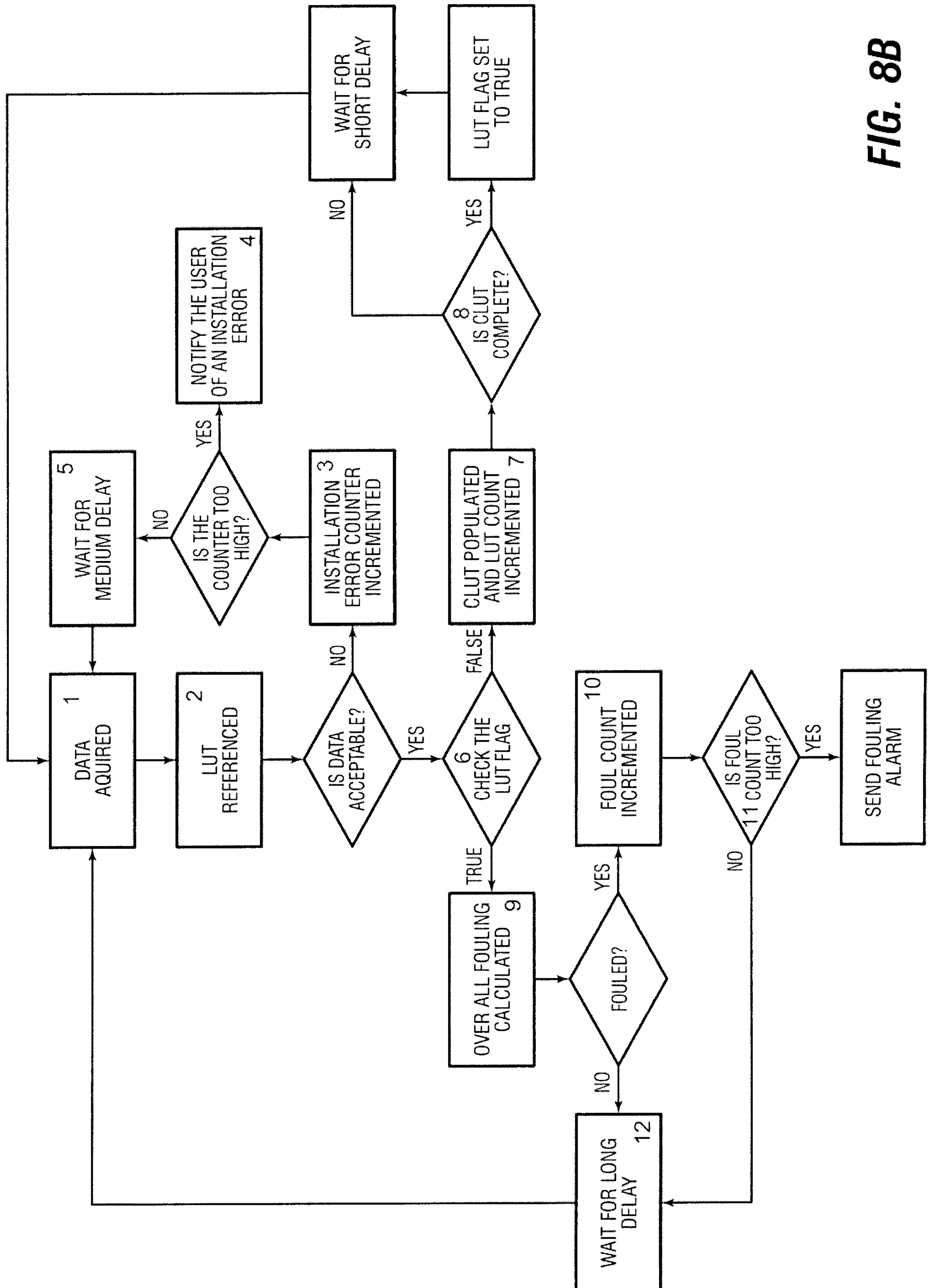


FIG. 8B



FIG. 9A

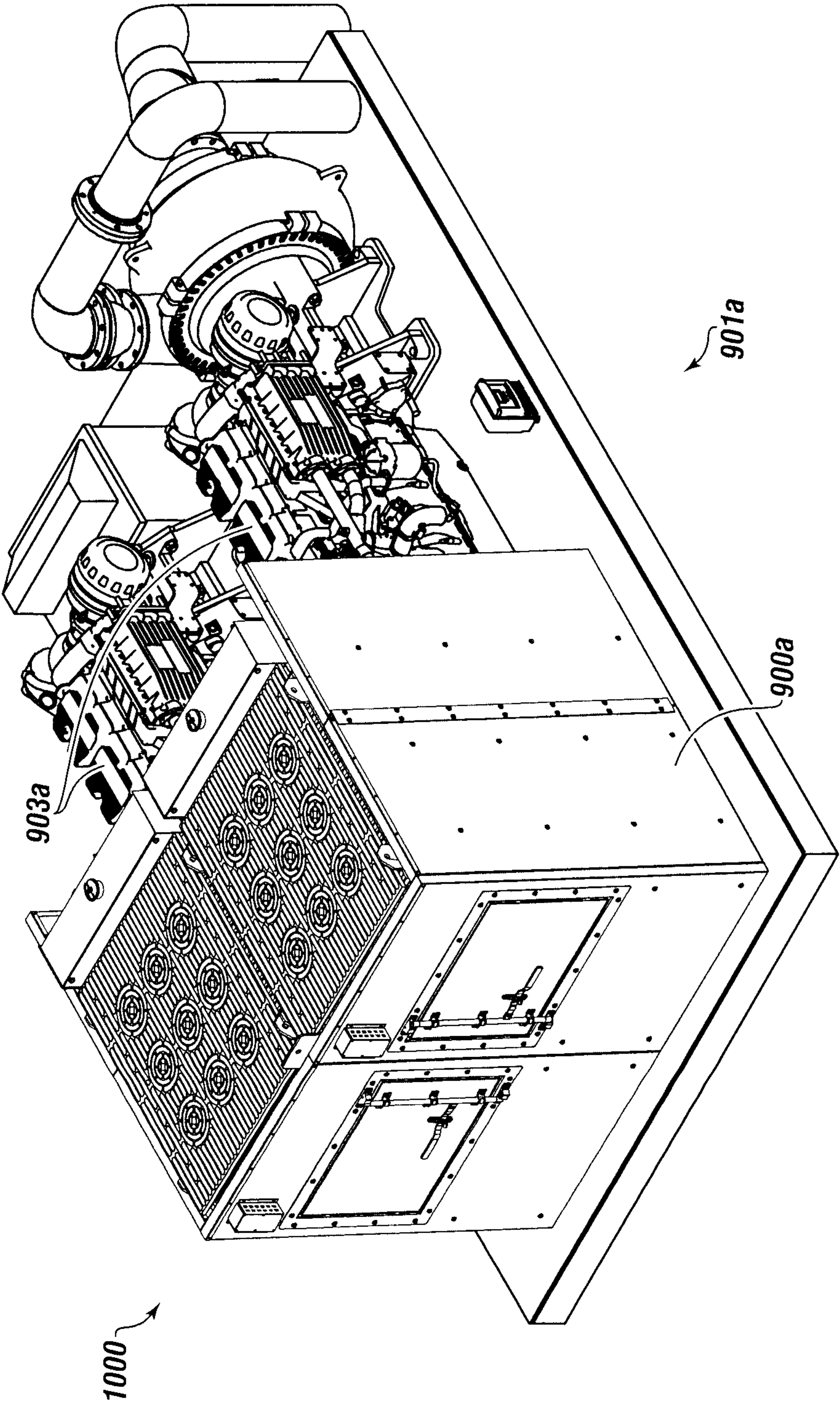


FIG. 10A

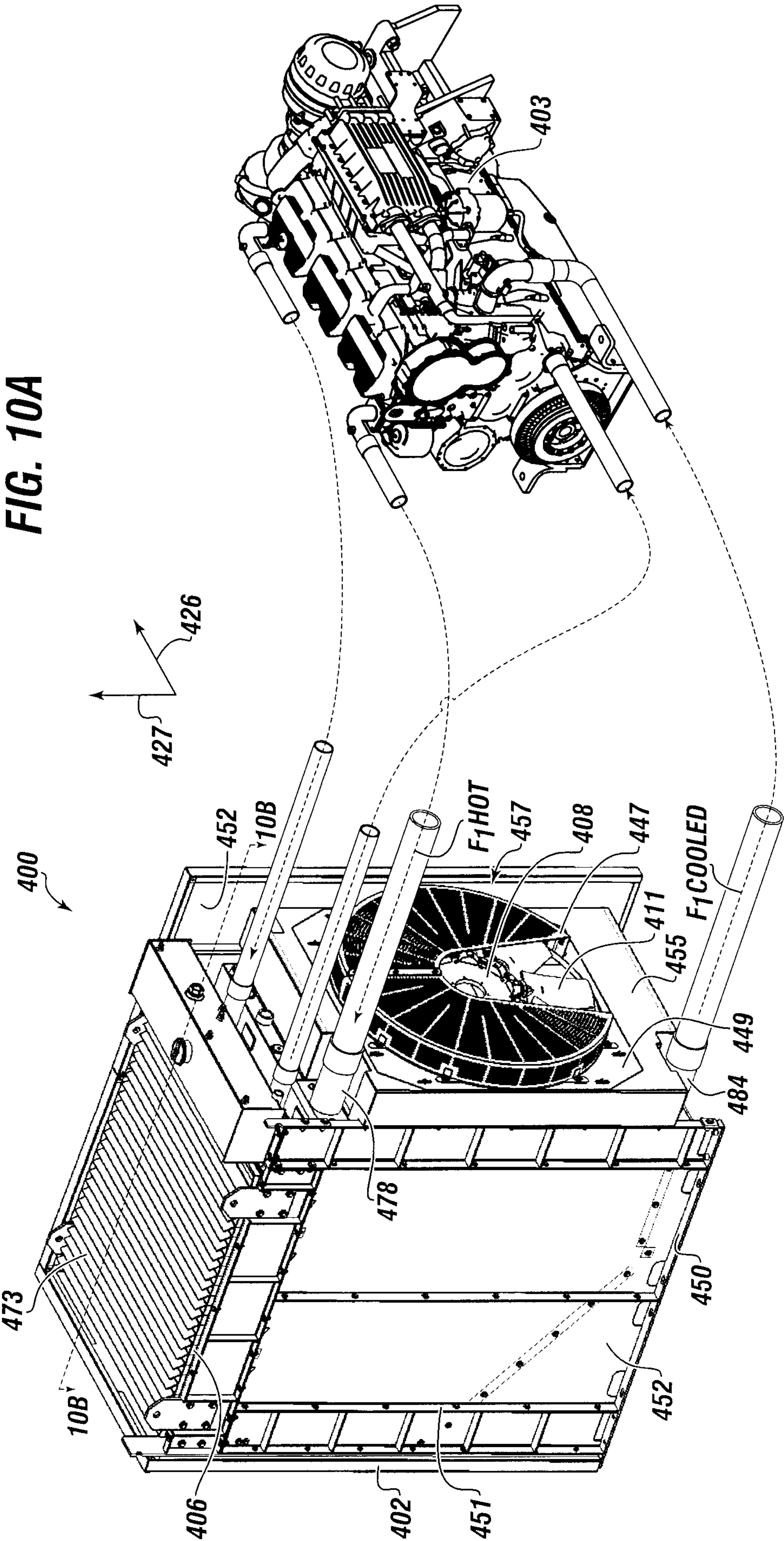
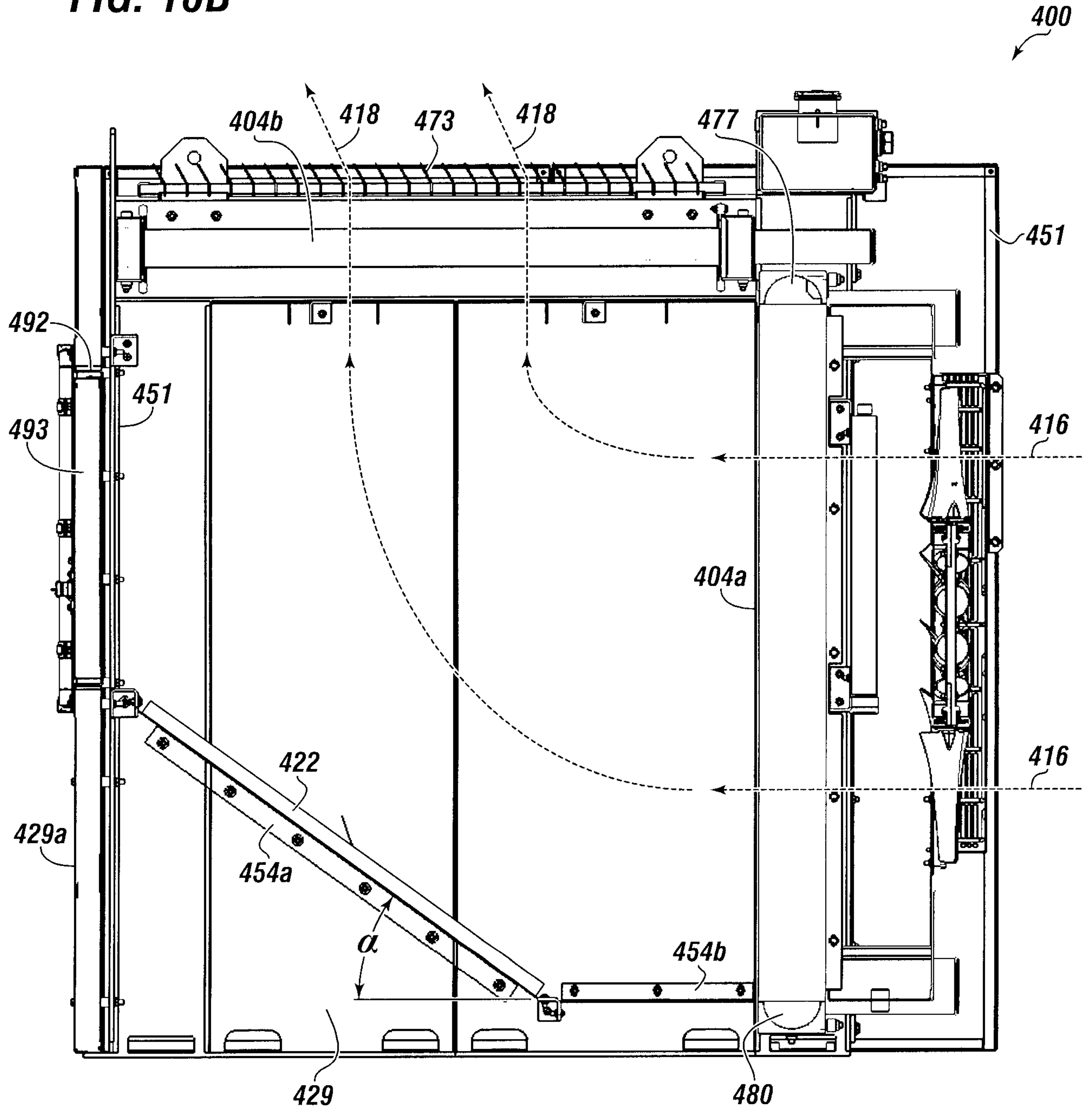


**FIG. 10B**

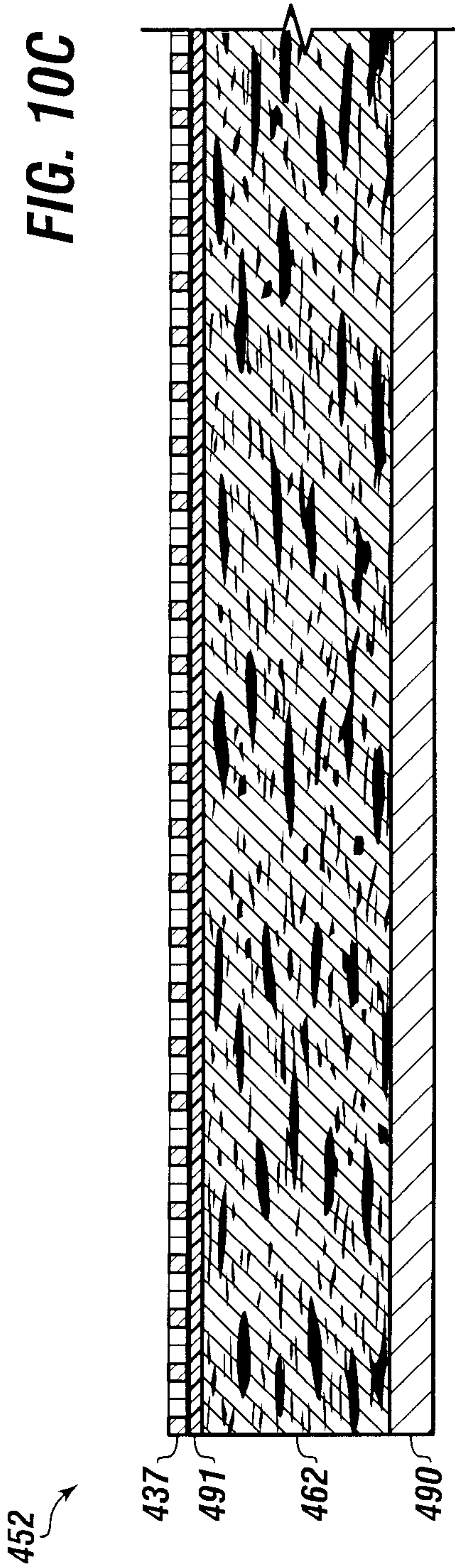
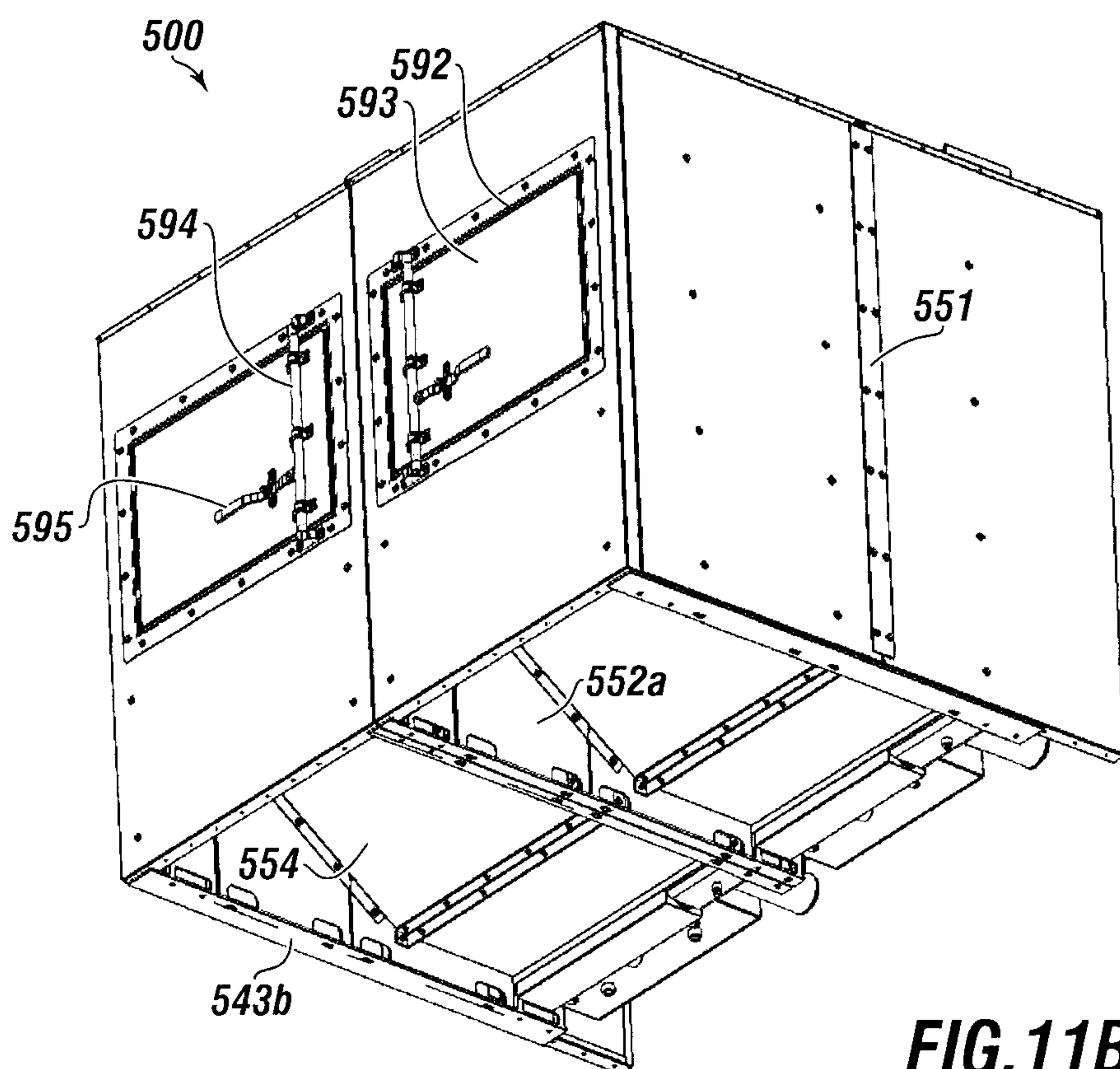
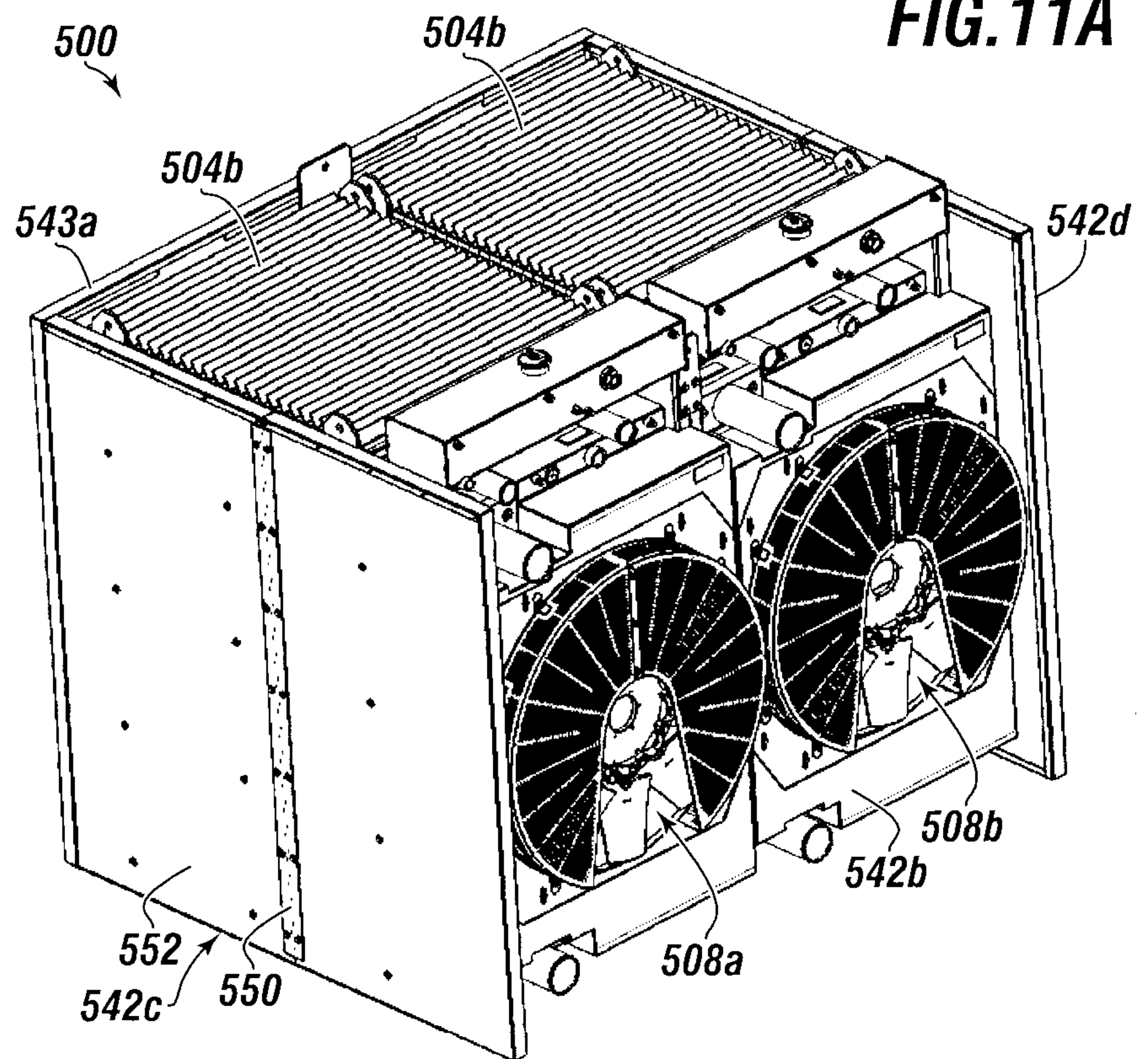


**FIG. 11A****FIG. 11B**

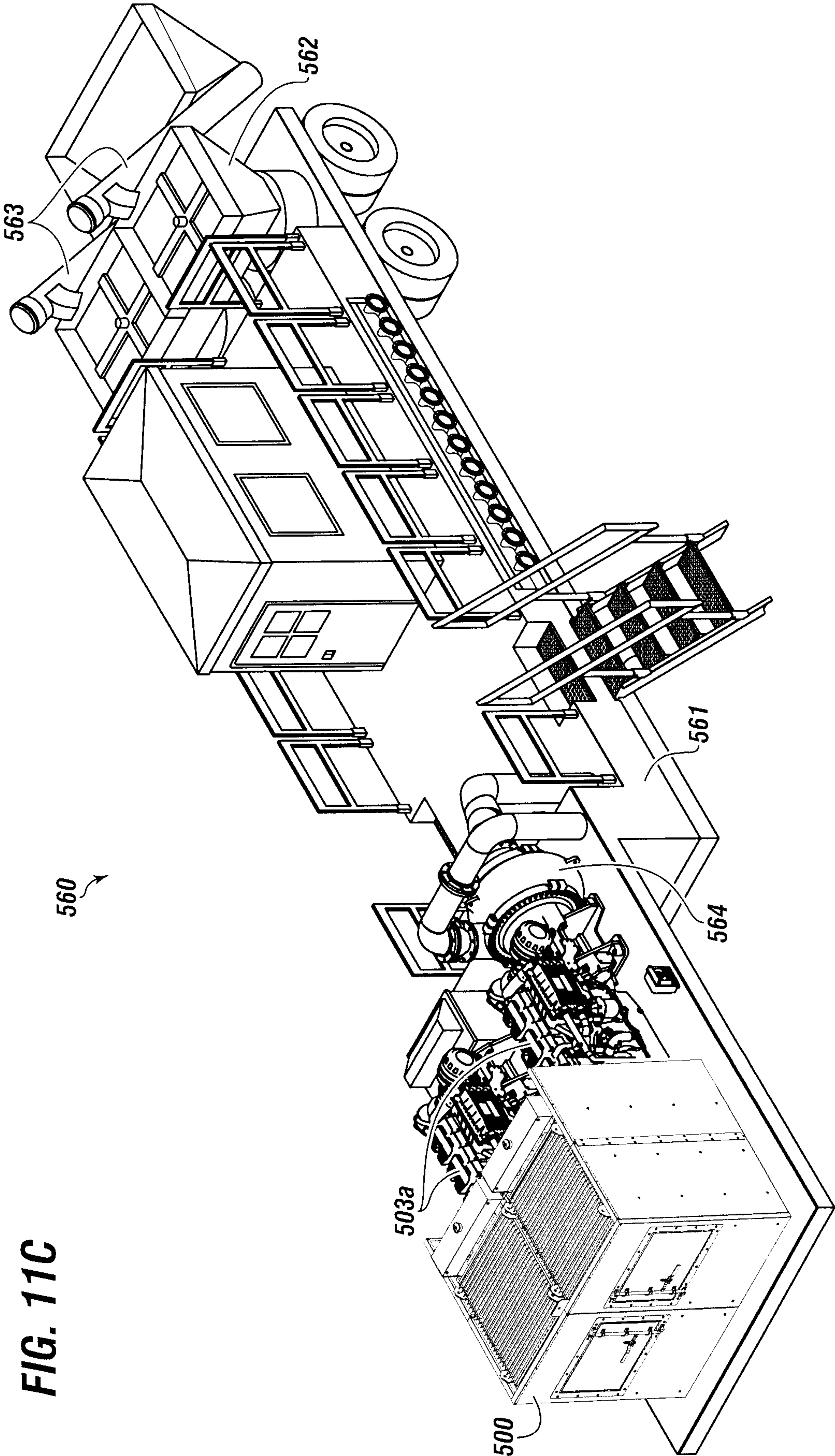


FIG. 11C

