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(54) MULTIPLE MOTOR DRIVERS FOR A HERMETICALLY-SEALED MOTOR-COMPRESSOR SYSTEM

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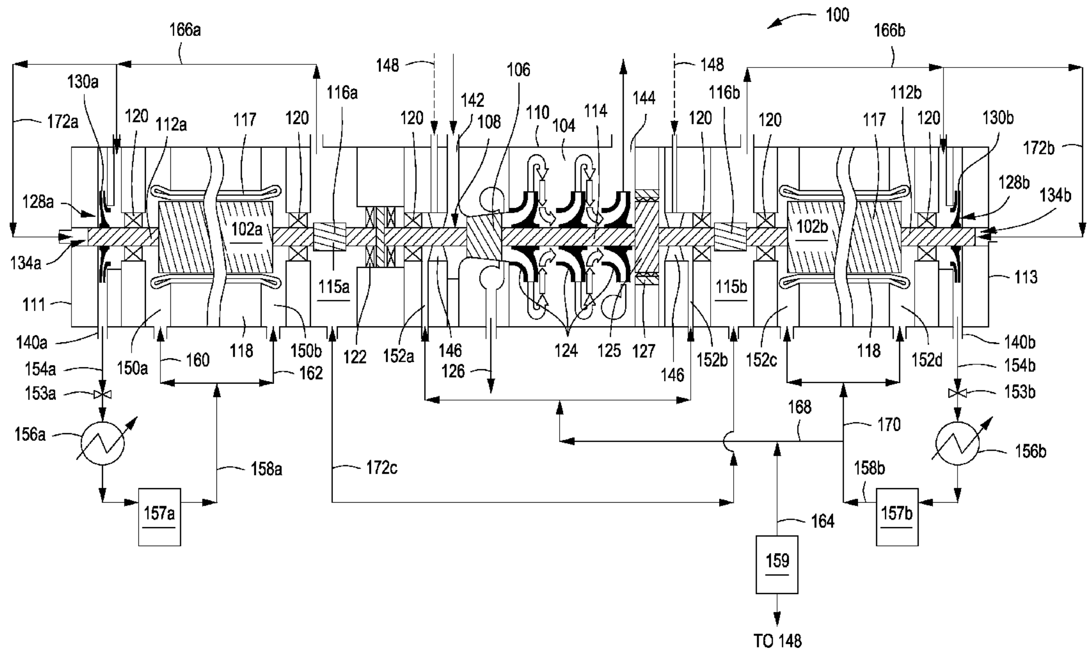
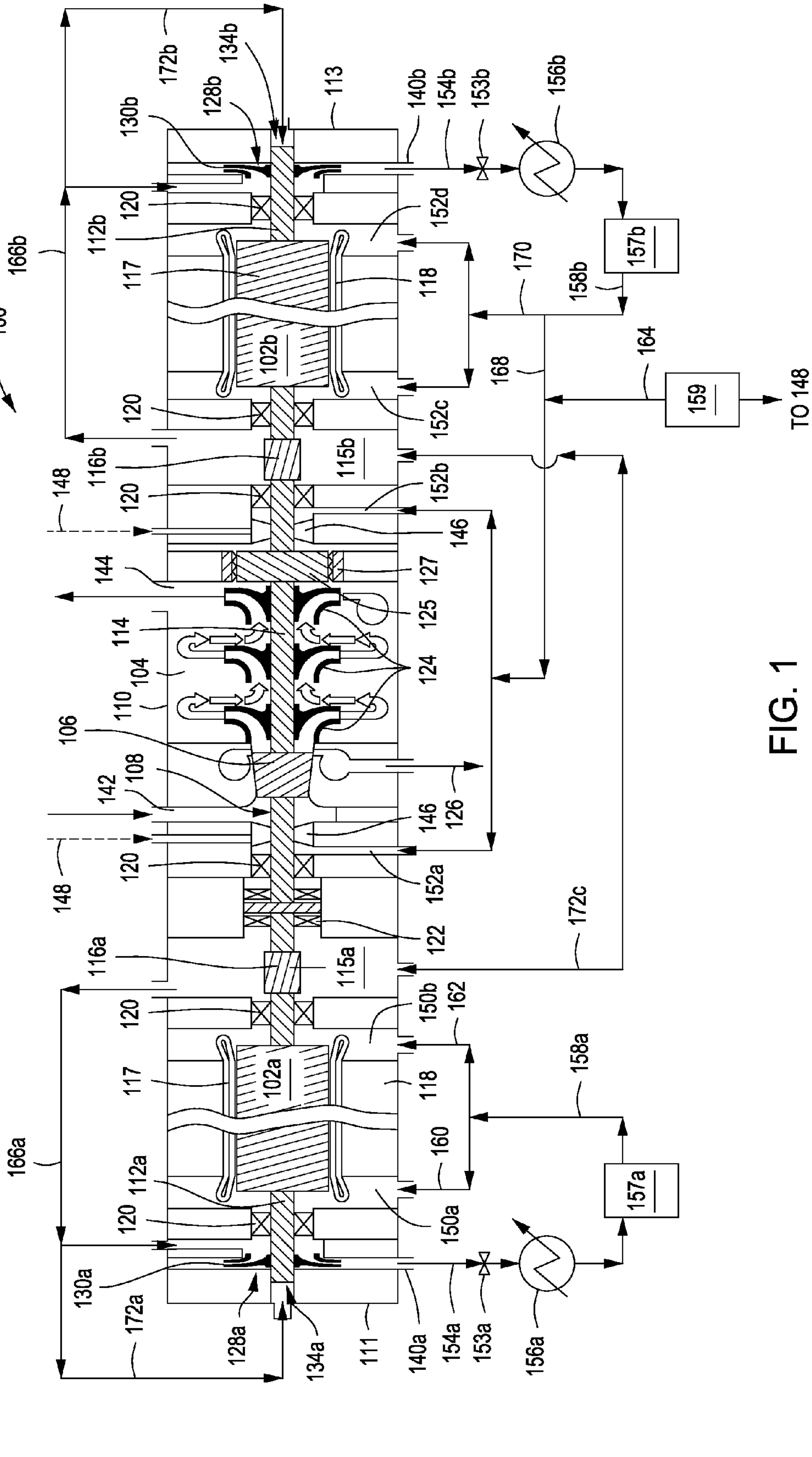
(57) **ABSTRACT**

A fluid compression system is disclosed having a hermetically-sealed housing with at least two motors and a compressor arranged therein. The motors may be arranged either on both sides of the compressor or in a tandem configuration on one side of the compressor. The motors may be adapted to drive both the compressor and at least one blower device coupled to a free end of shaft that extends through the housing, the blower device being configured to circulate a cooling fluid throughout the housing and thereby cool the motors and any accompanying radial/axial bearings.

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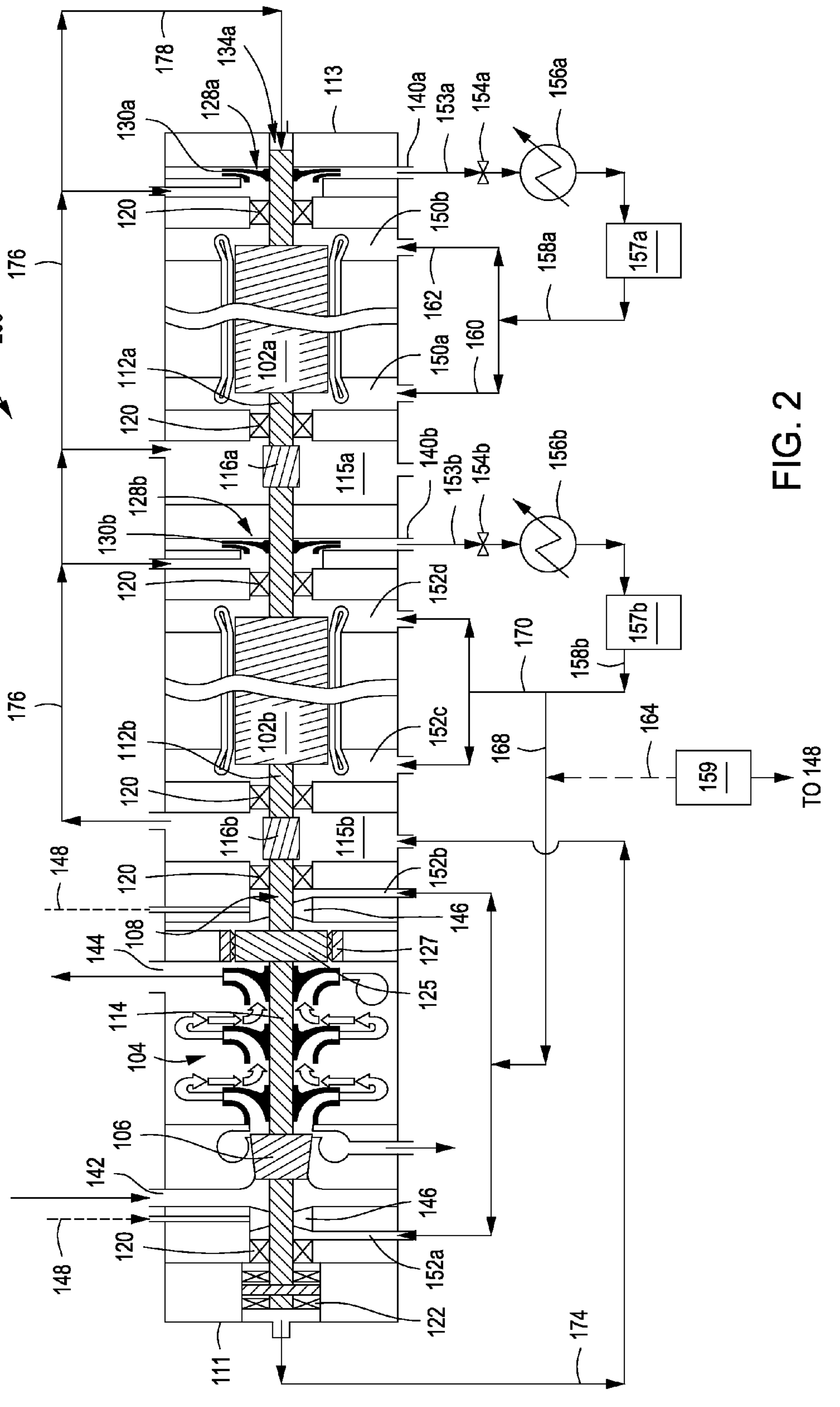
172b
134b
130b
128b
113
140b
154b
153b
156b
166b
120
112b
117
118
152d
157b
170
158b
102b
168
164
159
TO 148
152c
116b
115b
148
152b
146
144
127
125
114
104
124
110
106
108
142
126
152a
122
116a
115a
172c
150b
162
102a
158a
166a
160
112a
150a
157a
130a
172a
128a
134a
111
140a
154a
153a
156a

FIG. 1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178
134a
113
130a
128a
140a
153a
154a
156a
120
150b
157a
158a
176
162
160
112a
102a
150a
140b
116a
115a
128b
130b
153b
154b
156b
152d
157b
170
158b
102b
112b
152c
168
164
159
TO 148
116b
115b
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152b
146
108
144
127
125
114
104
106
142
122
152a
111
174

FIG. 2

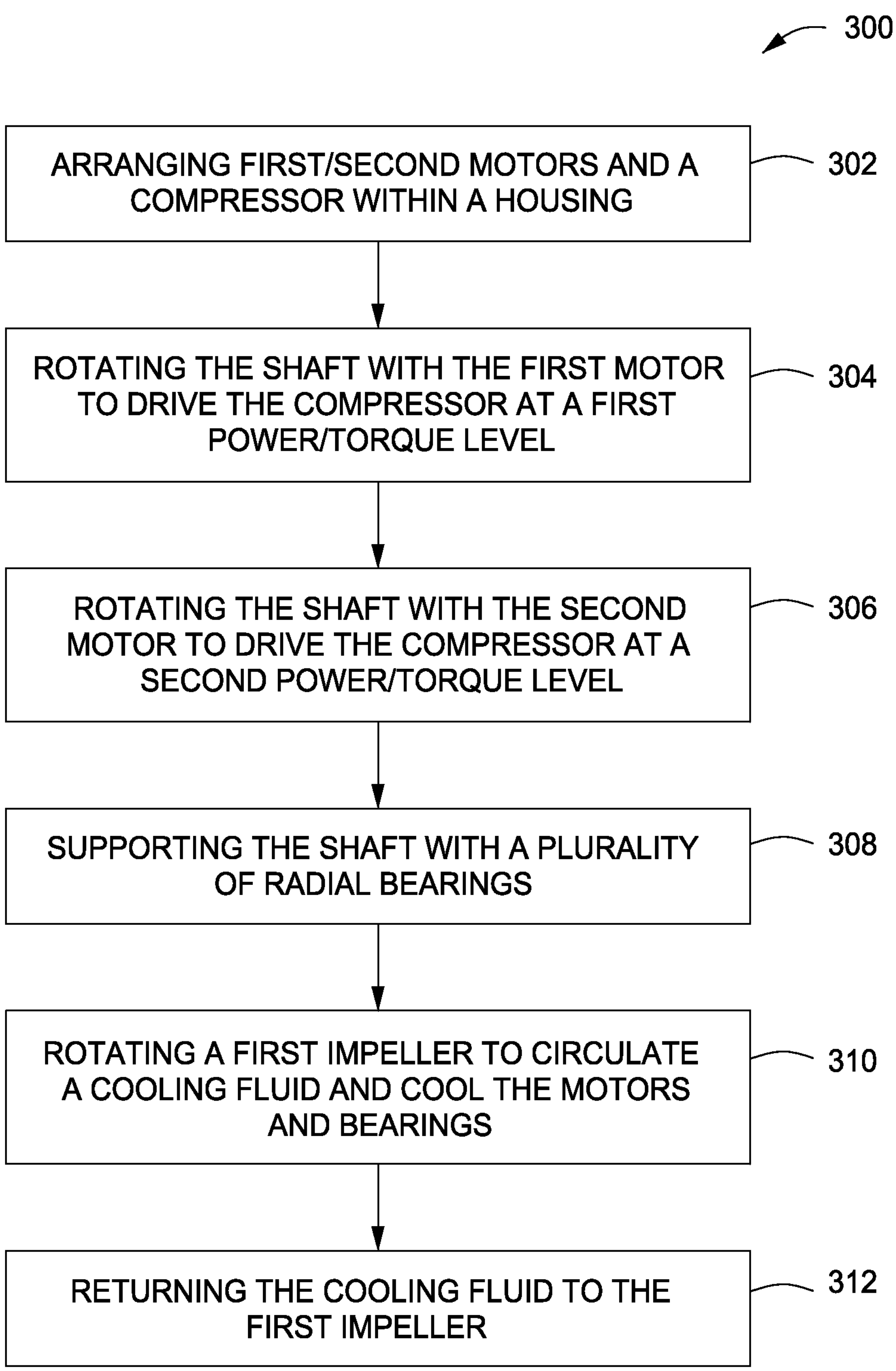
300
ARRANGING FIRST/SECOND MOTORS AND A COMPRESSOR WITHIN A HOUSING
302
ROTATING THE SHAFT WITH THE FIRST MOTOR TO DRIVE THE COMPRESSOR AT A FIRST POWER/TORQUE LEVEL
304
ROTATING THE SHAFT WITH THE SECOND MOTOR TO DRIVE THE COMPRESSOR AT A SECOND POWER/TORQUE LEVEL
306
SUPPORTING THE SHAFT WITH A PLURALITY OF RADIAL BEARINGS
308
ROTATING A FIRST IMPELLER TO CIRCULATE A COOLING FLUID AND COOL THE MOTORS AND BEARINGS
310
RETURNING THE COOLING FLUID TO THE FIRST IMPELLER
312

FIG. 3

MULTIPLE MOTOR DRIVERS FOR A HERMETICALLY-SEALED MOTOR-COMPRESSOR SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Patent Application Ser. No. 61/407,148, entitled "Multiple Motor Drivers for a Hermetically-Sealed Motor-Compressor System," and filed on Oct. 27, 2010. The contents of the priority application are hereby incorporated by reference in their entirety.

BACKGROUND

[0002] A motor is often combined with a compressor in a single housing to provide what is known as a motor-compressor device. Via a shared rotating shaft supported on each end by a rotor-bearing system, the motor drives the compressor in order to generate a flow of compressed process gas. When used to drive a compressor, such as a centrifugal compressor, the motor is required to rotate at sufficiently high speeds to facilitate efficient compression of the process gas.

[0003] The compression range of the motor-compressor, however, may be limited by the power capacity of the motor driver, which is typically a constant-torque machine. In fact, there are many industrial applications in the field where the compressor power requirements exceed the power capacity of the motor driver. In such instances, the process requirements are often served by multiple motor-compressor arrangements, which can significantly increase the cost, weight, and footprint of the application.

[0004] Accordingly, there is a need for an improved motor-compressor arrangement that can supplement the power deficiencies of a single motor driver with a reduced cost when compared to the multiple unit approach.

SUMMARY

[0005] Embodiments of the disclosure may include a fluid compression system. The fluid compression system may include a hermetically-sealed housing having a multi-section shaft extending from a first end of the housing to a second end of the housing, a compressor arranged within the housing and including a driven section of the shaft, and a first motor being disposed within the housing axially-adjacent the compressor at the first end, the first motor including a first motor rotor section of the shaft. The fluid compression system may also include a second motor disposed within the housing axially-adjacent the compressor at the second end, the second motor including a second motor rotor section of the shaft, wherein the first and second motor rotor sections are coupled to the driven section at opposing ends such that the motors are configured to simultaneously drive the driven section of the shaft and thereby rotate the compressor.

[0006] Embodiments of the disclosure may further provide a method of compressing a fluid. The method may include disposing a first motor, a second motor, and a compressor within a hermetically-sealed housing, the housing having a shaft that extends from a first end of the housing to a second end of the housing, and wherein the first and second motors and the compressor are each coupled to the shaft. The method may further include rotating the shaft with the first motor to provide torque to the shaft and drive the compressor at a first power/torque level, and rotating the shaft with the second motor concurrently with the first motor to provide additional torque to the shaft and drive the compressor at a second power/torque level, wherein the second power/torque level is greater than the first power/torque level.

[0007] Embodiments of the disclosure may further provide a fluid compression system. The fluid compression system may include a hermetically-sealed housing having a shaft extending from a first end of the housing to a second end of the housing, a compressor arranged within the housing at the first end and including a driven section of the shaft, and a first motor disposed within the housing at the second end and axially-offset from the compressor, the first motor including a first motor rotor section of the shaft and being in fluid communication with at least one internal cooling passage. The fluid compression system may also include a second motor disposed within the housing interposing the compressor and the first motor, the second motor including a second motor rotor section of the shaft and in fluid communication with at least one internal cooling passage, wherein the first and second motors are configured to drive the driven section of the shaft in tandem and thereby rotate the compressor.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The present disclosure is best understood from the following detailed description when read with the accompanying Figures. It is emphasized that, in accordance with the standard practice in the industry, various features are not drawn to scale. In fact, the dimensions of the various features may be arbitrarily increased or reduced for clarity of discussion.

[0009] FIG. **1** illustrates an exemplary fluid compression system, according to one or more embodiments disclosed.

[0010] FIG. **2** illustrates another exemplary fluid compression system, according to one or more embodiments disclosed.

[0011] FIG. **3** illustrates a schematic flow chart of a method for compressing a working fluid, according to one or more embodiments disclosed.

DETAILED DESCRIPTION

[0012] It is to be understood that the following disclosure describes several exemplary embodiments for implementing different features, structures, or functions of the invention. Exemplary embodiments of components, arrangements, and configurations are described below to simplify the present disclosure; however, these exemplary embodiments are provided merely as examples and are not intended to limit the scope of the invention. Additionally, the present disclosure may repeat reference numerals and/or letters in the various exemplary embodiments and across the Figures provided herein. This repetition is for the purpose of simplicity and clarity and does not in itself dictate a relationship between the various exemplary embodiments and/or configurations discussed in the various Figures. Moreover, the formation of a first feature over or on a second feature in the description that follows may include embodiments in which the first and second features are formed in direct contact, and may also include embodiments in which additional features may be formed interposing the first and second features, such that the first and second features may not be in direct contact. Finally, the exemplary embodiments presented below may be combined in any combination of ways, i.e., any element from one exemplary embodiment may be used in any other exemplary embodiment, without departing from the scope of the disclosure.

[0013] Additionally, certain terms are used throughout the following description and claims to refer to particular components. As one skilled in the art will appreciate, various entities may refer to the same component by different names, and as such, the naming convention for the elements described herein is not intended to limit the scope of the invention, unless otherwise specifically defined herein. Further, the naming convention used herein is not intended to distinguish between components that differ in name but not function. Additionally, in the following discussion and in the claims, the terms "including" and "comprising" are used in an open-ended fashion, and thus should be interpreted to mean "including, but not limited to." All numerical values in this disclosure may be exact or approximate values unless otherwise specifically stated. Accordingly, various embodiments of the disclosure may deviate from the numbers, values, and ranges disclosed herein without departing from the intended scope. Furthermore, as it is used in the claims or specification, the term "or" is intended to encompass both exclusive and inclusive cases, i.e., "A or B" is intended to be synonymous with "at least one of A and B," unless otherwise expressly specified herein.

[0014] FIG. **1** illustrates an exemplary fluid compression system **100** according to embodiments described herein. The system **100** includes at least two drivers, such as motors **102***a* and **102***b*, coupled to a compressor **104** and an integrated separator **106** via a rotatable shaft **108**. In the illustrated embodiment, the motors **102***a,b* are arranged on opposing axial sides of the compressor **104** and configured to drive the compressor **104** and separator **106** combination. In other embodiments, the separator **106** may be omitted from the system **100** so that motors **102***a,b* only drive the compressor **104**.

[0015] The motors **102***a,b*, the compressor **104**, and the separator **106** are each positioned within a hermetically-sealed housing **110** having a first end **111** and a second end **113**. The housing **110** provides both support and protection for the motors **102***a,b*, the compressor **104**, and the separator **106** components, such that each component shares the same pressure-containing casing.

[0016] The shaft **108** extends substantially the whole length of the housing **110**, from the first end **111** to the second end **113**, and includes a first motor rotor section **112***a*, a second motor rotor section **112***b*, and a driven section **114** arranged between the first and second motor rotor sections **112***a,b*. As illustrated, the first motor rotor section **112***a* of the shaft **108** corresponds to the rotor of the first motor **102***a*, and the second motor rotor section **112***b* corresponds to the rotor of the second motor **102***b*. The driven section **114** of the shaft **108** includes both the compressor **104** and the integrated separator **106**. Moreover, the driven section **114** may be connected to the first motor rotor section **112***a* via a first coupling **116***a* and the second motor rotor section **112***b* via a second coupling **116***b*, such that when the first and second rotor sections **112***a,b* rotate, they drive the driven section **114**. The first and second couplings **116***a,b* may be any type of shaft **108** coupling known to those skilled in the art, and may include a flexible or a rigid coupling. The first and second couplings **116***a,b* may be disposed within corresponding first and second cavities **115***a* and **115***b*, respectively, defined within the housing **110**.

[0017] In operation, the motors **102***a,b* work together to rotate the compressor **104** (and the separator **106**, if used) providing more power and torque than could be achieved with the use of a single motor. Because the amount of power delivered by each motor **102***a,b* is inherently limited, the use of two motors in series allows an increase in the power capability and capacity of the overall fluid compression system **100** or motor/compressor arrangement, which allows an extension of the process capabilities that can be met by the compressor **114**.

[0018] Each motor **102***a,b* may be a permanent magnet-type electric motor, having permanent magnets **117** on the rotor and having a stator **118**, or an induction-type machine with a squirrel cage mounted on the rotor (**117**) and having a stator **118**. As will be appreciated, other types of motors **102** may be used, such as, but not limited to, synchronous, brushed DC motors, etc.

[0019] The motor rotor sections **112***a,b* and driven section **114** of the shaft **108** are supported at or near each end, respectively, by one or more radial bearings **120**. Each radial bearing **120** are directly or indirectly supported by the housing **110**, and in turn provide rotational support to the motor rotor sections **112***a,b* and driven section **114**. In one embodiment, the bearings **120** may be magnetic bearings, such as active or passive magnetic bearings. In other embodiments, however, other types of bearings **120** may be used. In addition, at least one axial thrust bearing **122** may be arranged on the shaft **108** between the compressor **104** and the first motor **102***a*. In other embodiments, the axial thrust bearing **122** may be arranged outboard from the first motor **102***a*, at or near the end of the shaft **108** adjacent the first end **111** of the housing **110**. The axial thrust bearing **122** may be a magnetic bearing and be configured to at least partially bear axial thrusts generated by the compressor **104**.

[0020] The compressor **104** may be a multi-stage centrifugal compressor with one or more, in this case three, compressor stages or impellers **124**. As can be appreciated, however, any number of impellers **124** may be implemented or used without departing from the scope of the disclosure. The separator **106** separates and removes higher-density components from lower-density components contained within a process gas introduced into the system **100**. Any higher-density components removed from the process gas are discharged from the separator **106** via a discharge line **126**, thereby providing a relatively dry process gas to the succeeding compressor **104**. Especially in subsea applications where the process gas is commonly multiphase, any separated liquids discharged via line **126** may accumulate in a collection vessel (not shown) and be subsequently pumped back into the process gas at a downstream pipeline location (not shown). Otherwise, separated liquids may be drained into said collection vessel and disposed of properly, as known in the art.

[0021] A balance piston **125**, including an accompanying balance piston seal **127**, may be arranged on the shaft **108** between the compressor and the second motor **102***b*. Due to the pressure rise developed through the compressor **104**, a pressure difference is created such that the compressor **104** has a net axial thrust in the direction of its inlet. The balance piston **125** serves to counteract that force, and any compressor **104** thrust not absorbed by the balance piston **125** may be otherwise absorbed by the thrust bearing(s) **122**.

[0022] Still referring to FIG. **1**, the system **100** further includes a closed-loop cooling system configured to regulate the temperature of the motors **102***a,b* and bearings **120**, **122**

during operation of the system **100**. In one embodiment, the closed-loop cooling system includes a first blower device **128***a* disposed at or near a free end **134***a* of the first motor rotor section **112***a*, located outboard from the first motor **102***a*, and a second blower device **128***b* disposed at or near a free end **134***b* of the second motor rotor section **112***b*, located outboard from the second motor **102***b*. Each blower device **128***a,b* includes an impeller, such as a first impeller **130***a* and a second impeller **130***b*, respectively, disposed within the housing **110** and configured to generate head pressure required to circulate cooling fluid through the closed-loop cooling circuit described below. In at least one embodiment, each impeller **130***a,b* may be a centrifugal compression impeller and may be mounted on or otherwise attached to the respective free ends **134***a,b* of the motor rotor sections **112***a,b* of the shaft **108**. Consequently, rotation of the shaft **108** will also drive each impeller **130***a,b* and thereby draw cooling fluid into each blower device **128***a,b* to be compressed and circulated throughout the closed-loop cooling circuit.

[0023] In one or more embodiments, the closed-loop cooling system may include only the first blower device **128***a* or otherwise include only the second blower device **128***b*, without departing from the scope of the disclosure. In other embodiments, the closed-loop cooling system may include a single blower device (not shown) coupled to the exterior of either the first end **111** or the second end **113** of the housing **110**. In said embodiment, the impeller of the single blower device may be mounted on or otherwise attached to the free end **134***a* or **134***b* of the shaft **108** as it extends through the first end **111** or second end **113**, respectively. Such an embodiment is discussed in detail in co-pending U.S. Pat. App. No. 61/407,059 (Atty. Dock. # 42495.600) entitled "Method and System for Cooling a Motor-Compressor with a Closed-Loop Cooling Circuit," and filed on Oct. 27, 2010, the contents of which are hereby incorporated by reference to the extent consistent with the present disclosure.

[0024] In operation, a process gas to be compressed or otherwise treated is introduced into the system **100** via an inlet **142**. The process gas may include, but is not limited to, a hydrocarbon gas, such as a mixture of natural gas or methane derived from a production field or via a pressurized pipeline. In other embodiments, the process gas may include air, CO_2, N_2, ethane, propane, i-C_4, n-C_4, i-C_5, n-C_5, and/or combinations thereof.

[0025] In at least one embodiment, especially in subsea oil and gas applications, the process gas may be a "wet" process gas having both liquid and gaseous components, or otherwise including a mixture of higher-density and lower-density components. Accordingly, the separator **106** receives the process gas via the inlet **142** and removes portions of high-density components therefrom, thereby generating a substantially dry process gas. The liquid and/or higher-density components extracted from the process gas by the separator **106** are removed via the discharge line **126**, as described above. The compressor **104** receives the substantially dry process gas from the separator **106** and compresses the dry gas through the successive stages of impellers **124** to thereby produce a compressed process gas that is ejected from the compressor **104** via a process discharge **144**.

[0026] To contain the process gas within the housing **110** and prevent "dirty" process gas from leaking into the adjacent bearing assemblies **120**, **122**, the closed-loop cooling circuit, and motors **102***a,b*, the system **100** includes one or more buffer seals **146**. The buffer seals **146** may be radial seals arranged at or near each end of the driven section **114** of the shaft **108** and inboard of the bearings **120**.

[0027] In one or more embodiments, the buffer seals **146** may be brush seals or labyrinth seals. In other embodiments, the buffer seals **146** may be dry gas seals or carbon ring seals configured to receive a feed of pressurized seal gas via lines **148**. When compared to conventional labyrinth or brush seals, the use of carbon rings buffer seals **146** may significantly reduce the amount of seal gas that is consumed, thereby increasing compressor performance efficiency. Moreover, carbon ring seals are less expensive and less susceptible to damage than conventional dry gas seal assemblies, especially when processing wet process gases. Appropriate implementation of carbon ring seals as buffer seals **146** in the system **100** is also described in co-pending U.S. Pat. App. No. 61/407,059 (42495.600), indicated above as being incorporated by reference.

[0028] The seal gas in lines **148** is a pressurized process gas that may be derived from the discharge **144** of the compressor **104** and filtered for injection into the buffer seals **146**. In other embodiments, however, especially in applications having dry gas seals as buffer seals **146**, the seal gas in lines **148** may be a source of clean hydrocarbon gas, hydrogen, or inert gases such as helium, nitrogen, or CO_2. During operation of the system **100**, the seal gas creates a pressure differential designed to prevent process gas leakage across the buffer seals **146** and into locations of the housing **110** where the bearings **120**, **122** and the motors **102***a,b* are located.

[0029] In order to cool or otherwise regulate the temperature of the motors **102***a,b* and the bearings **120**, **122** during operation, cooling fluid is circulated throughout the housing **110** in a cooling loop, or closed-loop cooling circuit, powered by at least one of the blower devices **128***a,b*. The blower devices **128***a,b* immerse the motors **102***a,b* and accompanying bearings **120**,**122** in an atmosphere of pressurized cooling fluid. In one or more embodiments, the cooling fluid may be the same as the seal gas in lines **148**. In other embodiments, the cooling fluid, seal gas, and process gas may all be the same fluid, which may prove advantageous in maintaining and designing any auxiliary systems.

[0030] Since each impeller **130***a,b* may be directly coupled to a corresponding rotor section **112***a,b*, each impeller **130***a,b* operates as long as at least one motor **102***a,b* is in operation and driving the shaft **108**. As each impeller **130***a,b* rotates, it draws in cooling fluid, compresses it, and ultimately ejects the cooling fluid via respective outlets **140***a* or **140***b* and into lines **154***a* or **154***b*, respectively. Valves **153***a* and **153***b* may be communicably coupled to lines **154***a,b*, respectively, to regulate or otherwise control the head pressure of the cooling fluid as the system **100** reaches its normal operating speed. In other embodiments, one or both of the valves **153***a,b* may be entirely omitted from the system **100** and the cooling fluid may instead be circulated at a pressure proportional to the rotational speed of the shaft **108** and the existing flow resistance within the cooling loop.

[0031] In at least one embodiment, the cooling fluid in lines **154***a,b* may be directed through respective heat exchangers **156***a* and **156***b* adapted to reduce the temperature of the cooling fluid, and also directed to respective gas conditioning skids **157***a* and **157***b* configured to filter the cooling fluid. In one embodiment, the heat exchangers **156***a,b* are a single heat exchanger fluidly coupled to both lines **154***a,b*, and the gas conditioning skids **157***a,b* are a single gas conditioning skid also fluidly coupled to both lines **154***a,b*. In one embodiment, the gas conditioning skids **157***a,b* and/or the heat exchangers **156***a,b* may include a density-based separator (not shown), or the like, configured to remove any condensation generated by reducing the temperature of the cooling fluid.

[0032] Other embodiments contemplated herein include placing the heat exchangers **156***a,b* and accompanying gas conditioning skids **157***a,b* prior to the blower devices **128***a,b*. As can be appreciated, cooling and conditioning the cooling fluid prior to entering the blower devices **128***a,b* may prove advantageous, since a lower-temperature working fluid will demand less power from the motors **102***a,b* to compress and circulate the cooling fluid.

[0033] At least one external gas conditioning skid **159** may also be included in the system **100** and configured to provide the seal gas for the buffer seals **146** via lines **148** during system **100** start-up and during normal operation. During start-up there may exist a pressure differential between the area surrounding the compressor **104** and the area surrounding each motor **102***a,b*. The seal gas entering the buffer seals **146** may leak into the area surrounding the motors **102***a,b* until reaching the desired suction pressure of the compressor **104**. The external conditioning skid **159** may also provide initial fill gas via line **164** to provide pressurized cooling fluid for the system **100** until an adequately pressurized source of process gas/cooling fluid may be obtained from the discharge **144** of the compressor **104**. Accordingly, the initial fill gas may be cooling fluid or process gas added to the system **100**. During normal operation, fill gas from line **164** may also be used in the event there is a sudden change in pressure in the system **100** and pressure equilibrium between the compressor **104** and the motor **102** must be located in order to stabilize the cooling loop.

[0034] The cooled and filtered cooling fluid is discharged from the first gas conditioning skid **157***a* and into line **158***a*. Line **158***a* is subsequently separated into lines **160** and **162** before injecting the cooling fluid into internal cooling passages **150***a* and **150***b*, respectively, defined within the housing **110** and configured to cool the first motor **102***a* and bearings **120** that support the first motor rotor section **112***a*. As the cooling fluid circulates around the first motor **102***a* and passes through the adjacent bearings **120** (i.e., through a gap formed between each bearing **120** and the shaft **108**), heat is drawn away from the first motor **102***a* and each adjacent bearing **120**. The cooling fluid returns or otherwise loops back to the first impeller **130***a* either by passing through the bearings **120** outboard from the first motor **102***a*, or by passing through the bearings **120** inboard of the first motor **102***a* and into the first cavity **115***a* where it circulates through a first return line **166***a* fluidly coupled to the first impeller **130***a*.

[0035] On the other side of the system **100**, cooled and filtered cooling fluid is discharged from the second gas conditioning skid **157***b* and into line **158***b*. Line **158***b* is subsequently separated into lines **168** and **170**, where line **168** is split and introduced into internal cooling passages **152***a* and **152***b* defined within the housing **110** to cool the bearings **120**, **122** that support the driven section **114** of the shaft **108**. As the cooling fluid nears the bearings **120**, the buffer seals **146** generally prevent the cooling fluid from passing into the separator **106** and/or compressor **104**. Instead, the cooling fluid freely passes through the bearings **120** toward the ends of the driven section **114**, simultaneously drawing heat away from the bearings **120**. As can be appreciated, there may be embodiments where at least a small portion of the seal gas in lines **148** provided to the buffer seals **146** may be combined with the cooling fluid at each end of the driven section **114** of the shaft **108**.

[0036] The cooling fluid coursing through the internal cooling passage **152***a* may also be configured to cool the axial thrust bearing **122** as it channels toward the first coupling **116***a* and is ultimately discharged into the first cavity **115***a*. The cooling fluid coursing through internal cooling passage **152***b* may cool the bearings **120** adjacent the second coupling **116***b* and in due course escape into the second cavity **115***b*.

[0037] The cooling fluid in line **170** may be split or otherwise introduced into internal cooling passages **152***c* and **152***d* defined within the housing **110** to cool the second motor **102***b* and adjacent bearings **120** that provide support to the second motor rotor section **112***b*. As the cooling fluid circulates around the second motor **102***b* and passes through the adjacent bearings **120** on each side, heat is drawn away to cool the first motor **102***b* and each adjacent bearings **120**. The cooling fluid returns or otherwise loops back to the second impeller **130***b* either by passing through the bearings **120** outboard from the second motor **102***b*, or by passing through the bearings **120** inboard of the second motor **102***b* and into the second cavity **115***b* where it circulates through a second return line **166***b* fluidly coupled to the second impeller **130***b*.

[0038] The system **100** may further include a first pressure balance line **172***a* fluidly coupled to both the first return line **166***a* and the first end **111** of the housing **110**, and a second pressure balance line **172***b* fluidly coupled to both the second return line **166***b* and the second end **113** of the housing **110**. The pressure balance lines **172***a,b* counteract or otherwise equalize axial forces generated by the respective impellers **130***a,b*. A third pressure balance line **172***c* may fluidly connect the first and second cavities **115***a,b* so as to maintain a substantially constant cooling fluid pressure between the first impeller **130***a* and the second impeller **130***b*. It should be noted here again that, although not shown, the cooling loops for both motors **102***a,b* may be combined into a single cooling loop system that uses only one cooler and one gas conditioning skid or system.

[0039] The embodiments described herein are advantageous for a variety of reasons. For example, since the system **100** employs two motors **102***a,b* within the same hermetically-sealed housing **100**, the power and torque capability of the system **100** is dramatically increased. Furthermore, the system **100** may prove advantageous in motor-compressor applications having a laminated shaft **108**, as opposed to a solid shaft **108** design. Laminated shafts for high-speed motors are generally not designed to work in a drive-through configuration which would require one motor to deliver increased amounts of torque to a single end of the compressor **104**, and would probably otherwise fail under such an increase in power. Instead, the system **100** as described delivers torque to the compressor **104** from both ends of the compressor **104** via the first and second motors **102***a,b*, thereby dividing the torque input to separated portions of the shaft **108**.

[0040] Referring now to FIG. **2**, depicted is another exemplary fluid compression system **200**, similar in some respects to the fluid compression system **100** described above in FIG. **1**. Accordingly, the system **200** may be best understood with reference to FIG. **1**, where like numerals correspond to like components that will not be described again in detail. Similar to the system **100** of FIG. **1**, the system **200** may include at least two prime movers, such as motors **102***a* and **102***b*, coupled to the compressor **104** and the separator **106** via the rotatable shaft **108**. The motors **102***a,b*, the compressor **104**, and the separator **106** are each positioned within the hermetically-sealed housing **110** having a first end **111** and a second end **113**.

[0041] The motors **102***a,b* in system **200** are arranged in tandem and power the compressor **104** and separator **106** from a single side of the compressor **104**. The first motor **102***a* and its accompanying bearings **120** and blower device **128***a* are arranged on the outboard side of the second motor **102***b*. The shaft **108** may again include first and second motor rotor sections **112***a,b* and a driven section **114**. However, it is only the second motor rotor section **112***b* that is coupled to the driven section **114** of the shaft **108** via the second coupling **116***b*, whereas the first motor rotor section **112***a* is coupled to the opposing end of the second motor rotor section **112***b* via the first coupling **116***a*. As will be appreciated, the tandem arrangement of the motors **102***a,b* may be disposed on either side of the compressor **104** without departing from the scope of the disclosure.

[0042] The closed-loop cooling system of FIG. **2** may be substantially similar to the closed-loop cooling system of FIG. **1**. For example, cooling fluid in lines **160** and **162** is injected into internal cooling passages **150***a* and **150***b*, respectively to cool the first motor **102***a* and the bearings **120** that support the first motor rotor section **112***a* of the shaft **108**. Moreover, the cooling fluid in line **170** is split and injected into internal cooling passages **152***c,d* to cool the second motor **102***b* and the bearings **120** that support the second motor rotor section **112***b* of the shaft **108**. It will be further appreciated that the closed-loop cooling system of FIG. **2** may omit either the first or the second blower device **128***a,b* without departing from the scope of the disclosure. In other embodiments, the closed-loop cooling system may include a single blower device (not shown) coupled to the exterior of the second end **113** of the housing **110**, such as is disclosed in co-pending U.S. Pat. App. No. 61/407,059 (Atty. Dock # 42495.600), indicated above as being incorporated by reference.

[0043] The cooling fluid in line **168** is split and introduced into the internal cooling passages **152***a,b* to cool the bearings **120** that support the driven section **114** of the shaft **108**. The cooling fluid in the internal cooling passage **152***a* may also cool the axial thrust bearing **122** as it channels toward the compressor end **111** of the housing **110** and is ultimately discharged via line **174**. The cooling fluid in the internal cooling passage **152***b* may escape into the second cavity **115***b*. In one embodiment, the second cavity **115***b* may also receive cooling fluid via line **174**. Accordingly, the cooling fluid channeled through the internal cooling passages **152***a,b* is combined or otherwise mixed within the second cavity **115***b*.

[0044] Cooling fluid collected in the first and second cavities **115***a,b* is discharged into a return line **176** fluidly coupled to each cavity **115***a,b*. The return line **176** recycles a portion of the cooling fluid back to each impeller **130***a,b* to thereby start the closed-loop cooling circuit over again. A balance line **178** may be fluidly coupled to the return line **176** and the motor end **113** of the housing **110** and to counteract or otherwise equalize axial forces generated by the impellers **130***a, b*.

[0045] Several variations of the system **200** may be undertaken without departing from the scope of the disclosure. For example, as described above, the first and second heat exchangers **156***a,b* may be a single heat exchanger, and the first and second gas conditioning skids **157***a,b* may be a single gas conditioning skid. Also, the first or the second heat exchanger **156***a,b* may be disposed before the blower devices **128***a,b* so as to decrease the temperature of the recycled cooling fluid before recompression in each impeller **130***a,b*. Furthermore, the separator **106** may be omitted from the system **200** so that the motors **102***a,b* only drive the compressor **104**.

[0046] Referring now to FIG. **3**, illustrated is a flowchart depicting an exemplary method **300** of compressing a fluid. The method **300** may include arranging first and second motors and a compressor within a hermetically-sealed housing or casing, as at **302**. The housing may have a shaft that extends from a first end to a second end of the housing. Each of the first and second motors and the compressor may be coupled to the shaft such that rotation of at least one of the motors necessarily drives the compressor and compresses the fluid. In one embodiment, the first and second motors are arranged within the housing on opposing sides of the compressor. In another embodiment, the first and second motors are arranged in tandem and axially-spaced from the compressor along the shaft. In at least one embodiment, a separator is also disposed within the housing, axially-spaced from the compressor.

[0047] The method **300** may also include rotating the shaft with the first motor to drive the compressor at a first power/torque level, as at **304**. In an embodiment, the first power/torque level is proportional to the power capability and/or maximum torque that can be provided by the first motor when taking into account the mass of the compressor (and potentially the separator if employed), the work of compression, and any other frictional drag forces that must be overcome to rotate the shaft. The method **300** may further include rotating the shaft with the second motor to drive the compressor at a second or higher power/torque level, as at **306**, wherein the second power/torque level is greater than the first power/torque level and greater than a power/torque level that could be achieved by a single motor. As can be appreciated, the addition of the second motor may provide supplementary torque to the shaft to complement the power capability of the first motor. Consequently, the compressor can handle more demanding power conditions than what the first motor alone could supply, thereby increasing the overall compression power of the motor-compressor system.

[0048] The method **300** may further include supporting the shaft within the housing with a plurality of radial bearings, as at **308**. As the shaft rotates, a first impeller coupled to a first free end of the shaft rotates and circulates a cooling fluid throughout the housing to cool the first and second motors and the bearings, as at **310**. In one or more embodiments, the housing may define a plurality of internal cooling passages that are in fluid communication with the plurality of radial bearings and the first and second motors. As the cooling fluid circulates through the internal cooling passages, heat is drawn away from the motors and bearings, thereby cooling or otherwise regulating the temperature of said components. The cooling fluid is then returned to the first impeller, as at **312**, thereby completing a closed-loop cooling circuit. Accordingly, after cooling the internal components, the cooling fluid is recycled back to the impeller to be recompressed and recirculated back through the housing. In embodiments including an axial thrust bearing also disposed about the shaft, the cooling fluid may be configured to remove heat therefrom also.

[0049] The foregoing has outlined features of several embodiments so that those skilled in the art may better understand the present disclosure. Those skilled in the art should appreciate that they may readily use the present disclosure as a basis for designing or modifying other processes and structures for carrying out the same purposes and/or achieving the same advantages of the embodiments introduced herein. Those skilled in the art should also realize that such equivalent constructions do not depart from the spirit and scope of the present disclosure, and that they may make various changes, substitutions and alterations herein without departing from the spirit and scope of the present disclosure.

1. A fluid compression system, comprising:

a hermetically-sealed housing having a multi-section shaft extending from a first end of the housing to a second end of the housing;

a compressor arranged within the housing and including a driven section of the shaft;

a first motor being disposed within the housing axially-adjacent the compressor at the first end, the first motor including a first motor rotor section of the shaft;

a second motor disposed within the housing axially-adjacent the compressor at the second end, the second motor including a second motor rotor section of the shaft, wherein the first and second motor rotor sections are coupled to the driven section at opposing ends such that the motors are configured to simultaneously drive the driven section of the shaft and thereby rotate the compressor;

radial bearings disposed proximal each end of the first and second motor rotor sections and each end of the driven section, the radial bearings being in fluid communication with at least one internal cooling passage defined within the housing; and

a first impeller coupled to a free end of the second motor rotor section of the shaft, whereby rotation of the second motor rotor section drives the first impeller and circulates a cooling fluid in a closed cooling loop through internal cooling passages defined within the housing.

2. (canceled)

3. The fluid compression system of claim **1**, further comprising a second impeller coupled to a free end of the first motor rotor section of the shaft, whereby rotation of the first motor rotor section drives the second impeller and circulates the cooling fluid in the closed cooling loop through the internal cooling passages.

4. The fluid compression system of claim **1**, wherein the radial bearings are magnetic bearings.

5. The fluid compression system of claim **1**, further comprising a separator axially-spaced from the compressor and disposed within the housing, the separator being coupled to the driven section of the shaft.

6. The fluid compression system of claim **1**, wherein the first motor rotor section and the driven section are connected via a first coupling.

7. The fluid compression system of claim **6**, wherein the second motor rotor section and the driven section are connected via a second coupling.

8. The fluid compression system of claim **1**, wherein the compressor is a multi-stage centrifugal compressor.

9. A method of compressing a fluid, comprising:

disposing a first motor, a second motor, and a compressor within a hermetically-sealed housing, the housing having a shaft that extends from a first end of the housing to a second end of the housing, and wherein the first and second motors and the compressor are each coupled to the shaft;

rotating the shaft with the first motor to provide torque to the shaft and drive the compressor at a first power/torque level; and

rotating the shaft with the second motor concurrently with the first motor to provide additional torque to the shaft and drive the compressor at a second power/torque level, wherein the second power/torque level is greater than the first power/torque level.

10. The method of claim **9**, further comprising:

supporting the shaft within the housing with a plurality of radial bearings, the housing defining a plurality of internal cooling passages in fluid communication with the plurality of radial bearings and the first and second motors;

driving a first impeller coupled to a first free end of the shaft;

circulating a cooling fluid through at least one of the internal cooling passages of the housing with the first impeller;

cooling the first and second motors and the plurality radial bearings with the cooling fluid; and

returning the cooling fluid to the impeller in a closed-loop circuit.

11. The method of claim **10**, further comprising:

driving a second impeller coupled to a second free end of the shaft;

circulating the cooling fluid through at least one of the internal cooling passages of the housing with the second impeller;

cooling the first and second motors and the plurality radial bearings with the cooling fluid; and

returning the cooling fluid to the second impeller in the closed-loop circuit.

12. The method of claim **11**, further comprising directing the cooling fluid through a heat exchanger to reduce the temperature of the cooling fluid.

13. The method of claim **12**, further comprising filtering the cooling fluid with a gas conditioning skid.

14. The method of claim **10**, further comprising cooling an axial thrust bearing with the cooling fluid, the axial thrust bearing being disposed on the shaft between the compressor and the first motor.

15. The method of claim **10**, further comprising separating high-density components from low-density components in the fluid with an integrated separator arranged within the housing and axially-spaced from the compressor, the integrated separator being coupled to the shaft such that rotation of the shaft drives the integrated separator.

16. A fluid compression system, comprising:

a hermetically-sealed housing having a shaft extending from a first end of the housing to a second end of the housing;

a compressor arranged within the housing at the first end and including a driven section of the shaft;

a first motor disposed within the housing at the second end and axially-offset from the compressor, the first motor including a first motor rotor section of the shaft and being in fluid communication with at least one internal cooling passage;

a second motor disposed within the housing interposing the compressor and the first motor, the second motor including a second motor rotor section of the shaft and being in fluid communication with at least one internal cooling passage, wherein the first and second motors are configured to drive the driven section of the shaft in tandem and thereby rotate the compressor;

radial bearings disposed proximal each end of the first and second motor rotor sections and each end of the driven section, the radial bearings being in fluid communication with at least one internal cooling passage; and

a first impeller coupled to a free end of the first motor rotor section of the shaft, whereby rotation of the first motor rotor section drives the first impeller and circulates a cooling fluid in a closed cooling loop through the internal cooling passages.

17. The fluid compression system of claim **16**, further comprising:

a first coupling connecting the first motor rotor section to the second motor rotor section; and

a second coupling connecting the second motor rotor section to the driven section.

18. (canceled)

19. The fluid compression system of claim **16**, further comprising a second impeller coupled to the second motor rotor section of the shaft and disposed between the first and second motors, whereby rotation of the second motor rotor section drives the second impeller and circulates the cooling fluid in the closed cooling loop through the internal cooling passages.

20. The fluid compression system of claim **16**, further comprising a separator axially-spaced from the compressor and disposed within the housing, the separator being coupled to the driven section of the shaft.

21-30. (canceled)

31. The method of claim **12**, further comprising filtering the cooling fluid with a gas conditioning skid.

32-37. (canceled)

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