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(54) LIGHT WEIGHT CRANKCASE CASTING FOR COMPRESSOR

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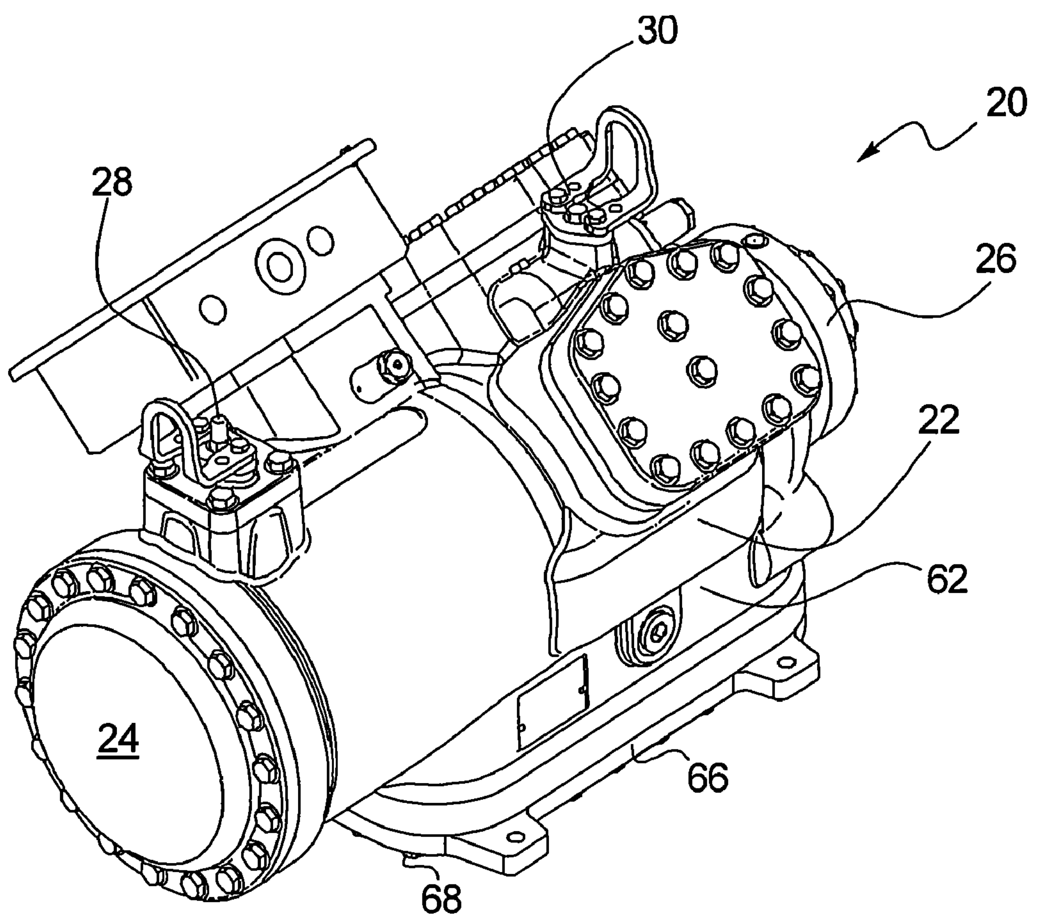
(57) **ABSTRACT**

A compressor, as well as a lightweight and strong casting for a compressor, are disclosed. The compressor, which may be a reciprocating compressor for use in compressing high-pressure refrigerants such as CO_2, includes substantially reduced wall thicknesses (t) compared to prior art castings. The side walls of the compressor can be manufactured to such reduced thicknesses (t) through the use of a bridge spanning across the crankcase. This not only allows the opposing side walls to be manufactured of a thinner material, but the bottom cover removably mounted to the crankcase can be manufactured from a thinner and lighter material as well. Through the use of such a bridge, the resulting compressor is not only able to satisfy current strength requirements, but at significant weight, size and cost savings as well.



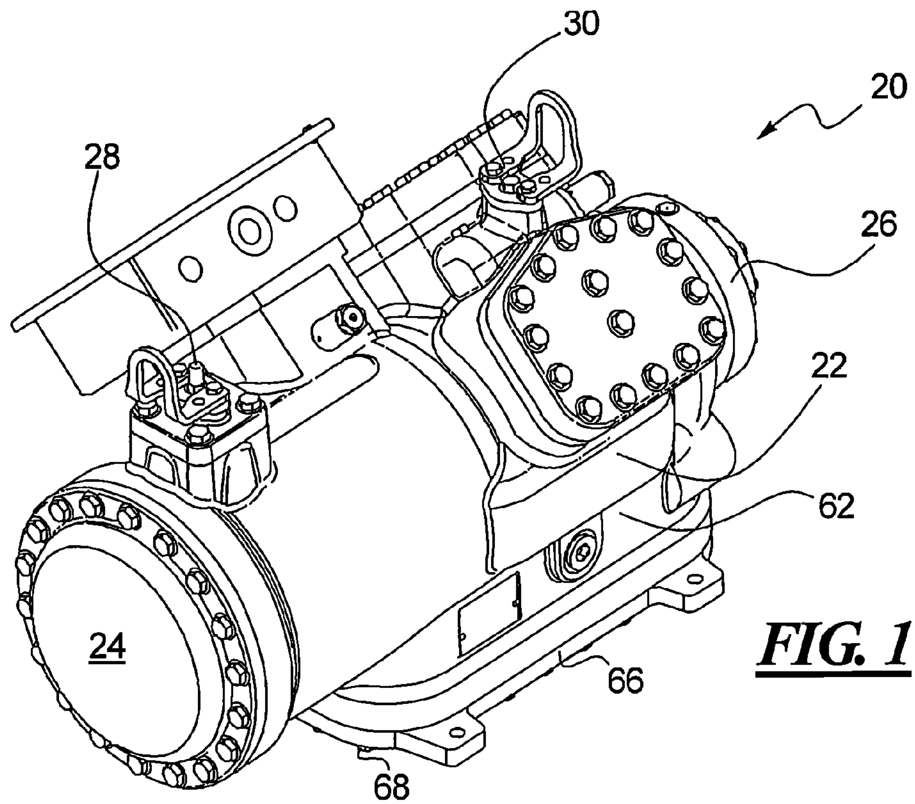


FIG. 1

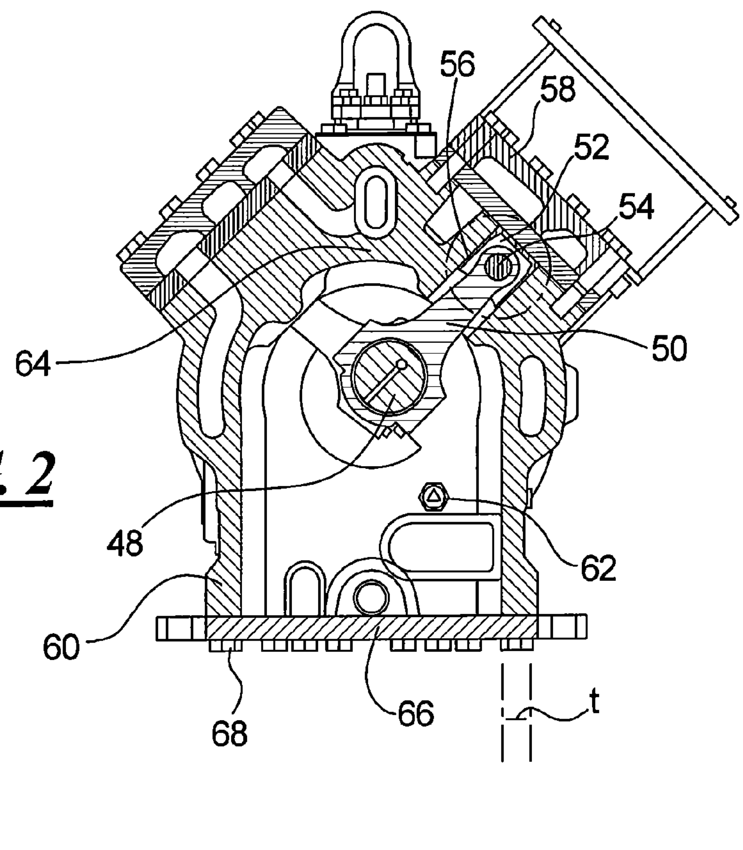


FIG. 2

FIG. 3

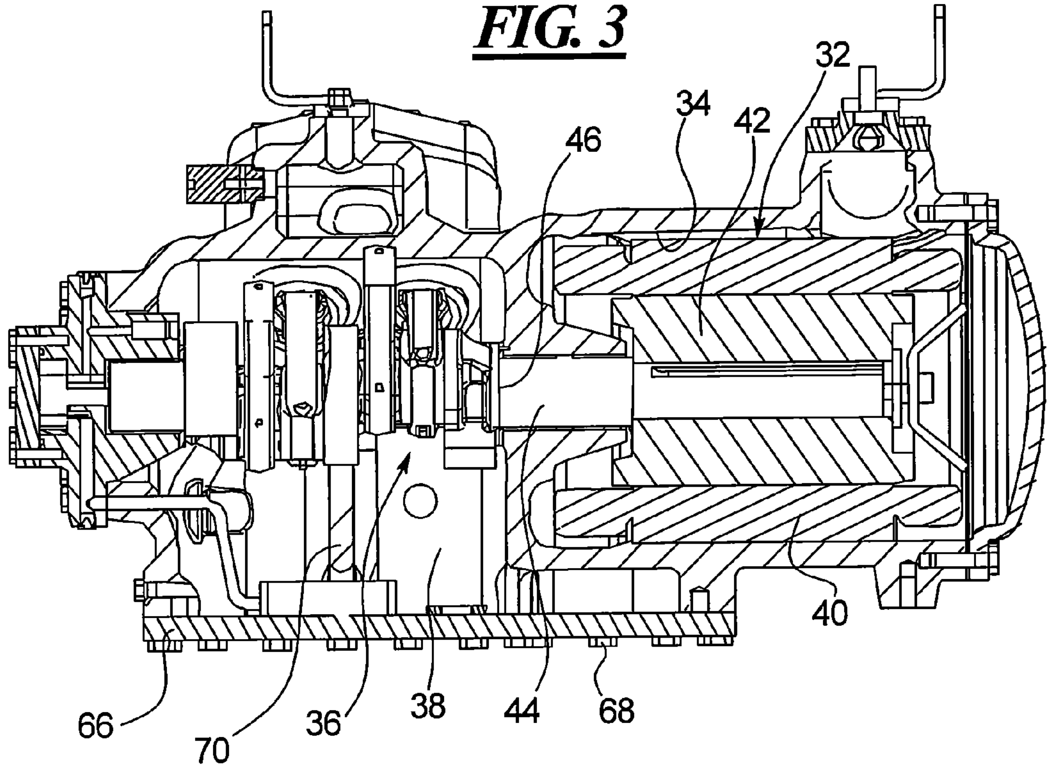
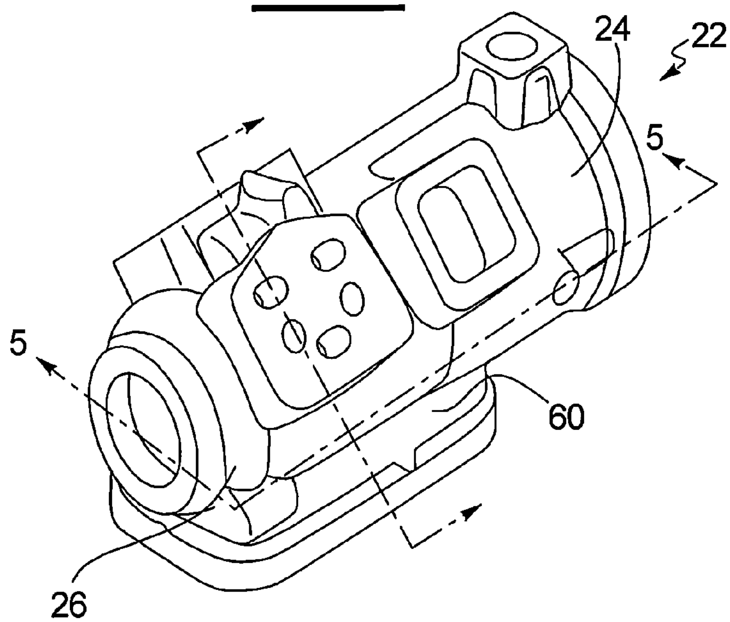


FIG. 4



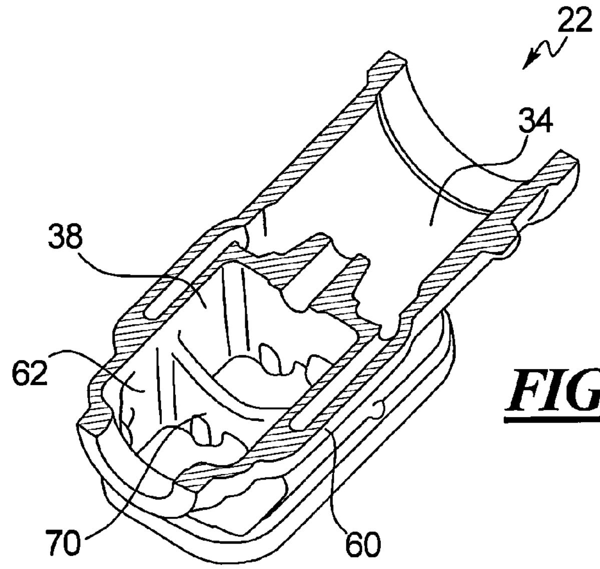


FIG. 5

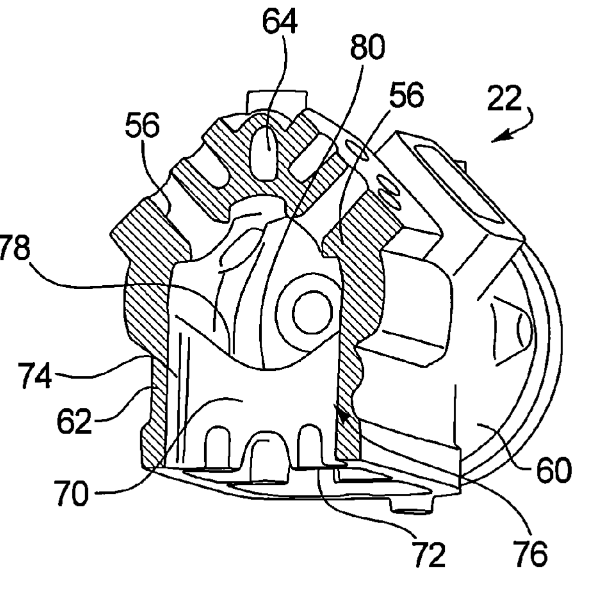


FIG. 6

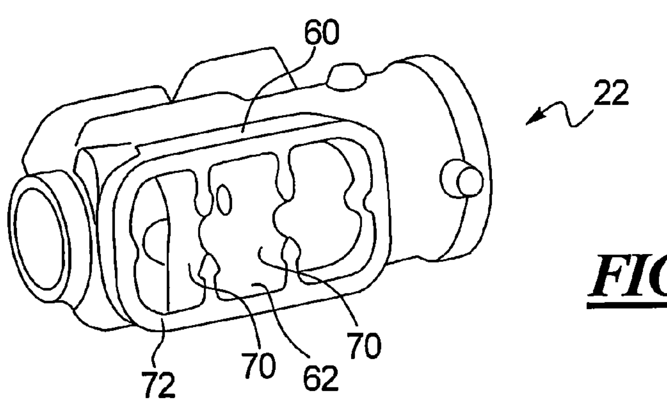


FIG. 7

LIGHT WEIGHT CRANKCASE CASTING FOR COMPRESSOR

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is a non-provisional patent application claiming priority under 35 USC §119(e) to U.S. Provisional Patent Application Ser. No. 61/181,922 filed on May 28, 2009.

BACKGROUND

[0002] 1. Technical Field

[0003] The present disclosure generally relates to compressors and, more particularly, relates to crankcase castings used in compressors for high-pressure fluids.

[0004] 2. Description of the Related Art

[0005] Compressors are common devices for compressing various fluids into higher densities. Compressors come in a variety of forms including, but not limited to, reciprocating, scroll and screw compressors. With reciprocating compressors, a piston moves back and forth within a compression cylinder to compress the working fluid within the cylinder, while with scroll compressors, interleaved scrolls rotate relative to one another to pressurize the fluid between the scrolls. Typically, one of the scrolls is fixed with the other scroll eccentrically rotating about that fixed scroll, but both scrolls can also rotate simultaneously as long as their axes of rotation are offset. Similarly, screw compressors use multiple meshed positive-displacement helical screws to force fluid into a smaller space.

[0006] In connection with air conditioning equipment, reciprocating compressors are often used. The compressor is used to compress the refrigerant such as, but not limited to, carbon dioxide (CO_2). Typically, the refrigerant is compressed to a very high pressure. This increases the temperature of the refrigerant so that when it then passes on to a condenser and then on to an evaporator, heat from the area to be cooled can be extracted and dissipated to the outside ambient air.

[0007] In conventional CO_2 reciprocating compressors, the refrigerant is compressed to a very high pressure of, for example, 500-2000 psi. This compression occurs within the crankcase of the compressor. Not only must be the crankcase therefore be manufactured from a material able to withstand that high pressure fluid, but current safety regulations in the United States, the European Union and other countries require that the crankcase be able to withstand at least five times the operating pressure of the refrigerant. This is known as the burst pressure, and is dictated by, among other things, European Union Safety Standard EN60335-2-34. Another applicable standard is European Union Safety Standard EN378 which requires that the crankcase be able to withstand two to five times the low side pressure relief valve setting of the compressor.

[0008] Prior art systems have achieved this by manufacturing the crankcase through a casting process wherein iron is cast into the desired shape for the crankcase and housing for the overall compressor. In order to satisfy the burst strength and pressure requirements, such castings are manufactured with relatively thick walls. This results in a relatively heavy compressor and adds to the overall cost of the unit. In addition, ductile cast iron is typically required to satisfy the strength requirements, but as this is one of the more expensive cast materials available, this necessarily adds to the expense of the compressor.

[0009] Accordingly, it can be seen that a need exists for a high pressure compressor crankcase casting which is lighter than those currently available, and yet is able to provide the necessary burst strength.

SUMMARY OF THE DISCLOSURE

[0010] In accordance with one aspect of the disclosure, a compressor is disclosed which comprises a motor, a compression element operatively associated with the motor, and a housing surrounding the motor and compression element, the housing including at least one bridge extending between opposing sides of the housing and being integrally cast with the housing.

[0011] In accordance with another aspect of this disclosure, a casting for use with a refrigerant compressor is disclosed which comprises a motor compartment adapted to house a motor, a crankcase compartment integral with the motor compartment and adapted to house at least one moving compression element, and a bridge spanning across the crankcase compartment, wherein the motor compartment, crankcase compartment, and bridge are cast as one integral piece.

[0012] These are other aspects and features of the disclosure will become more apparent upon reading the following detailed description when taken in conjunction with the accompanied drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIG. **1** is an isometric view of a compressor constructed in accordance with the teachings of the disclosure;

[0014] FIG. **2** is a lateral cross-sectional view of the compressor of FIG. **1**;

[0015] FIG. **3** is a longitudinal cross-sectional view of the compressor of FIG. **1**;

[0016] FIG. **4** is an isometric view of a casting constructed in accordance with the teachings of the disclosure;

[0017] FIG. **5** is a longitudinal cross-sectional view of the casting of FIG. **4** taken along line **5**-**5** of FIG. **4**;

[0018] FIG. **6** is a lateral cross-sectional view of the casting of FIG. **4**; and

[0019] FIG. **7** is a bottom view of the casting of FIG. **4**.

[0020] While the present disclosure is susceptible of various modifications and alternative constructions, certain illustrative embodiments thereof will be shown and described below in detail. It should be understood, however, that there is no intention to be limited to the specific embodiments disclosed, but on the contrary, the intention is to cover all modifications, alternative constructions, and equivalents falling within the spirit and scope of the present disclosure.

DETAILED DESCRIPTION OF THE DRAWINGS

[0021] Referring now to the drawings, and with particular reference to FIG. **1**, a compressor constructed in accordance with the teachings of the disclosure is generally referred to by reference numeral **20**. While the following detailed description and drawings are made in reference to a reciprocating type of compressor, it to be understood that the teachings of the disclosure can be used to manufacture a casting for use with many types of compressors including, but not limited to, reciprocating, scroll and screw compressors. In addition, while reference is made to compression of refrigerants, of course a compressor constructed in accordance with the teaching of the disclosure can be used to compress any type of fluid as well.

[0022] Referring again to FIG. **1**, the compressor **20** is shown to include a housing or casting **22** having a power end **24** and a working end **26**. As will be described in further detail therein, the power and working ends are constructed so as to draw uncompressed fluid into an intake **28** and produce compressed fluid at a discharge **30**. With reference now to FIGS. **2** and **3**, the compressor **20** is shown in lateral and longitudinal cross-section. Starting first with the longitudinal sectional view of FIG. **3**, a motor **32** is shown mounted within a motor compartment **34** of the housing **22**, while a plurality of compression elements **36** are mounted within a crankcase compartment **38**. As will be noted, the motor compartment **34** and crankcase compartment **38** are integrally formed together as by a metal casting process.

[0023] The motor **32** may include a stator **40** within which a rotor **42** rotates when electrically induced. A driveshaft **44** extends from the rotor **42** and into the crankcase compartment **38**. As shown in both FIGS. **2** and **3**, the driveshaft **44** terminates at a distal end **46** with one or more eccentrics **48**. As one of ordinary skill in the art will understand, the eccentrics **48** are provided so as to rotate in offset fashion relative to the driveshaft.

[0024] Accordingly, when each eccentric **48** is mounted to a connecting rod **50**, which in turn is connected a piston **52** by way of a wrist pin **54** or the like, the piston **52** is caused to reciprocate back and forth as the driveshaft **44** rotates. Cast into the crankcase compartment **38** are a plurality of compression cylinders **56** which are sized so as to closely receive a piston **52** therein and allow for such reciprocating motion of the piston **52** to compress a working fluid (not showing) such as a refrigerant like CO_2 or the like. Enclosing each cylinder **56** may be a cylinder head **58**.

[0025] As best seen in FIG. **2**, the crankcase compartment **38** may include first and second generally opposed side walls **60**, **62** connected by an upper or top wall **64**. In order to allow for periodic access into the crankcase compartment **38**, a removable bottom cover **66** may be connected to the crankcase compartment **38** by way of a series of fasteners **68**, such as bolts or the like. In so doing, the crankcase compartment **38** is substantially sealed. This is of importance in that the CO_2 refrigerant compressed by the compressor **20** is typically compressed to a pressure of 500-1000 psi (~3.5-7 MPa) or more. This is known as the operating pressure of the working fluid. In addition, current safety regulations require that the housing **22**, specifically the crankcase compartment **38**, be manufactured so as to have a burst pressure which is at least five times that of the operating pressure of the working fluid. This equates to a burst pressure of 5000 psi (~34 MPA).

[0026] Conventionally, this has been accomplished by manufacturing the opposing walls **60**, **62**, top wall **64**, and bottom cover **66** from a very thick, cast iron material. This in turn greatly adds to the overall size, weight and cost of the compressor, especially considering that expensive ductile cast iron is typically required. However, this disclosure sets forth a compressor which can be manufactured from substantially less material and with substantially thinner walls. By way of example, while the actual wall thickness (t) will depend on the pressure to be contained, the present disclosure allows for walls **60** and **62** to have a maximum wall thickness of 25 millimeters for the pressure ranges set forth herein. Depending on the pressure to be contained, a suitable range of wall thicknesses (t) is between 16 millimeters and 25 millimeters, all representing substantial size, weight and cost reductions compared to prior art designs.

[0027] One way the inventors are able to accomplish this is by providing a bridge **70** as shown best in FIGS. **3**, **5**, **6** and **7**. The bridge **70** may be integrally cast with the walls **60** and **62** and extend therebetween. More specifically, as opposed to prior art devices which provide a crankcase compartment **38** which would be completely open between the housing walls **60**, **62**, the present disclosure provides the bridge **70** spanning between the walls **60** and **62**. This in turn enables the walls **60** and **62**, as well as top wall **64** and bottom cover **66** to be manufactured from relatively thin materials.

[0028] For example, the inventors have found, through finite element analysis and other inventive experimentation, that the thickness (t) of walls **60** and **62** can be reduced by up to twenty-nine (29) percent or more by employing the bridge **70**. More specifically, by employing the bridge **70**, one tested wall had a maximum first principal stress at a certain wall location of 219 MPa, whereas the same thickness wall but without a bridge had a maximum first principal stress at the same wall location of 283 MPa. Comparing these two values, this showed a stress ratio of 283/219 or 1.29, thus illustrating the at least twenty-nine percent savings in wall thickness afforded by the present disclosure.

[0029] Another way to measure this improvement is in terms of wall deformation. Not only is the burst pressure an important safety requirement to avoid structural failure of the crankcase, but by limiting wall deformation, compressor efficiency improves in that gasket leaks between the cover **66** and casting **22** can be abated or avoided. Here, the inventors achieved even more compelling results. Again employing finite element analysis, the inventors found that a wall subjected to the same internal pressure without a bridge deformed roughly 0.6 mm, whereas a wall of the same thickness but with a bridge defaulted only 0.17 mm Comparing the two values, this means that for a compressor without a bridge to have the same resistance to deformation, the walls of the compressor would have to be 0.6/0.17 or 3.52 times as thick.

[0030] Referring now to FIG. **6**, the shape of the bridge **70** is shown to include a substantially linear bottom edge **72**. Accordingly, as shown in FIG. **2**, when the bottom cover **66** is bolted onto the housing **22**, the bottom edge **72** is in constant engagement with the bottom cover **66**. The bridge **70** therefore not only provides additional strength against buckling between the generally opposed side walls **60** and **62**, but also provides mid-span support for the bottom cover **60** to reduce stress and allow for a thinner bottom cover plate **66** to be used as well. The bridge **70** further includes first and second side edges **74** and **76** which are integrally cast with the outer walls **60** and **62**, as well as a curvilinear top edge **78**. A valley **80** of the curvilinear top edge **78** may be provided within the center of the top edge **78**, with lateral ends of the top edge **78** being higher than the valley **80**. This is exemplary only as the bridge can of course take other forms and shapes as well.

[0031] In further embodiments, such as that shown in FIG. **7**, more than one bridge can be provided. In the embodiment of FIG. **7**, two bridges **70** are provided but of course it can be understood that more than two bridges can be provided as well, depending on the overall size of the compressor **10** and the number of compression elements **36** therein.

INDUSTRIAL APPLICABILITY

[0032] Based on the foregoing, it can be seen that the present disclosure sets forth a compressor (**20**) and a casting

(**22**) for a compressor (**2**) which is substantially lighter in weight than prior art castings, but which still provides the necessary strength and protection to satisfy the burst requirements of the compressor (**20**). Accordingly, in applications where US, European and other nationalities dictate the compressor (**20**) to have a certain burst strength, the present disclosure sets forth a way to meet such requirements but at less cost to the manufacturer and consumer. In fact, finite element analysis by the inventors have shown that not only is the resulting compressor (**20**) able to provide such burst strength, but it also results in an at least twenty-nine percent wall thickness (t) and thus weight savings compared to comparably sized compressors constructed in accordance with the prior art. In addition, through the novel inclusion of the aforementioned bridge (**70**), the casting (**22**) can be made from less expensive and lighter weight materials. For example, whereas prior art compressors (**20**) would have to be manufactured from ductile cast iron to provide the strength required, the present disclosure allows the use of other materials, such as but not limited to gray cast iron.

[0033] While only certain embodiments have been set forth, alternatives and modifications will be apparent from the above description to those skilled in the art. These and other alternatives are considered equivalents and within the spirit and scope of this disclosure and the appended claims.

1. A compressor, comprising:
- a motor;
- a compression element operatively associated with the motor; and
- a housing surrounding the motor and compression element, at least one bridge extending between opposing side walls of the housing proximate the compression element, the bridge being integrally cast with the housing.

2. The compressor of claim **1**, wherein the housing includes side walls having a maximum wall thickness (t) of twenty-five millimeters.

3. The compressor of claim **1**, wherein the compressor further includes a working fluid to be compressed, the working fluid being a refrigerant.

4. The compressor of claim **3**, wherein the refrigerant is carbon dioxide.

5. The compressor of claim **3**, wherein the refrigerant is compressed to an operating pressure of at least 500 psi.

6. The compressor of claim **5**, wherein the housing has a burst pressure at least five times the operating pressure.

7. The compressor of claim **1**, wherein the housing (**22**) includes a crankcase, connecting rods and a drive shaft moving within the crankcase, the bridge extending across the crankcase.

8. The compressor of claim **1**, further including a bottom cover (**66**) removable from the crankcase, the bridge extending across and in contact with the bottom cover.

9. The compressor of claim **1**, wherein the compressor is a reciprocating compressor.

10. The compressor of claim **8**, wherein the compression element is a piston.

11. The compressor of claim **1**, wherein the housing is made of gray cast iron.

12. The compressor of claim **2**, wherein the side walls have a wall thickness (t) of between sixteen and twenty-five millimeters.

13. A casting for use with a refrigerant compressor, comprising:
- a motor compartment adapted to house a motor;
- a crankcase compartment integral with the motor compartment and adapted to house at least one moving compression element; and
- a bridge spanning across the crankcase compartment, the motor compartment, crankcase compartment and bridge being cast as one integral piece.

14. The casting of claim **13**, where the crankcase compartment is closed by a removable cover, the bridge extending across and in contact with the removable cover when the removable cover is attached to the casting.

15. The casting of claim **13**, wherein the casting is made of gray cast iron.

16. The casting of claim **13**, wherein the refrigerant compressor compresses refrigerant to an operating pressure, the casting having a burst pressure of at least five times the operating pressure.

17. The casting of claim **13**, wherein the crankcase compartment includes side walls with a maximum wall thickness (t) of twenty-five millimeters.

18. The casting of claim **17**, wherein the side walls have a thickness (t) between sixteen and twenty-five millimeters.

* * * * *