

(19)



(11)

EP 2 435 702 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:
02.01.2019 Bulletin 2019/01

(51) Int Cl.:
F04B 39/12 ^(2006.01) **F04B 1/04** ^(2006.01)
F04B 17/03 ^(2006.01) **F04B 53/16** ^(2006.01)

(21) Application number: **10781089.7**

(86) International application number:
PCT/US2010/036073

(22) Date of filing: **25.05.2010**

(87) International publication number:
WO 2010/138510 (02.12.2010 Gazette 2010/48)

(54) LIGHT WEIGHT CRANKCASE CASTING FOR COMPRESSOR

GIESSUNG EINES LEICHTGEWICHTIGEN KURBELGEHÄUSES FÜR EINEN KOMPRESSOR
MOULAGE DE CARTER LÉGER POUR COMPRESSEUR

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO SE SI SK SM TR**

(30) Priority: **28.05.2009 US 181922 P**

(43) Date of publication of application:
04.04.2012 Bulletin 2012/14

(73) Proprietor: **Carrier Corporation**
Farmington, CT 06489 (US)

(72) Inventors:
• **FLANIGAN, Paul, J.**
Cicero
NY 13039 (US)

• **PILESKI, Peter, J.**
Manlius
NY 13104 (US)
• **VAIDYA, Amit**
Jamesville
NY 13078 (US)

(74) Representative: **Dehns**
St. Brides House
10 Salisbury Square
London EC4Y 8JD (GB)

(56) References cited:
EP-A1- 1 584 819 EP-A2- 1 469 200
GB-A- 2 091 354 JP-A- 2 055 880
JP-A- 2007 085 298 KR-B1- 910 004 983
US-A- 2 098 451 US-A- 2 955 750
US-A- 3 189 255 US-A1- 2003 140 780

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Description

[0001] The present disclosure generally relates to compressors and, more particularly, relates to crankcase castings used in compressors for high-pressure fluids.

[0002] 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.

[0003] 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 (CO₂). 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.

[0004] In conventional CO₂ 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.

[0005] 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.

[0006] 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.

[0007] US 3189255 and EP 1469200 disclose compressors of the type defined in the pre-characterising part of claim 1.

[0008] In accordance with one aspect the invention provides a compressor, comprising: a motor; a compression element operatively associated with the motor; a housing surrounding the motor and the compression element, wherein the housing includes a crankcase with connecting rods and a drive shaft within the crankcase; and characterised by at least one bridge extending across the crankcase and spanning between opposing side walls of the housing proximate to the compression element, the at least one bridge being integrally cast with the housing.

[0009] This and 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.

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

FIG. 2 is a lateral cross-sectional view of the compressor of FIG. 1;

FIG. 3 is a longitudinal cross-sectional view of the compressor of FIG. 1

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

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

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

FIG 7 is a bottom view of the casting of FIG. 4.

[0010] 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 scope of the invention as defined by the claims.

[0011] 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.

[0012] 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.

[0013] 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.

[0014] 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 CO₂ or the like. Enclosing each cylinder 56 may be a cylinder head 58.

[0015] 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 CO₂ 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 pres-

sure of the working fluid. This equates to a burst pressure of 5000 psi (~ 34MPa).

[0016] 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.

[0017] 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.

[0018] 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.

[0019] 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 deformed 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.

[0020] 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.

[0021] 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

[0022] 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 afore-mentioned 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.

[0023] 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 scope of the appended claims.

Claims

1. A compressor (20), comprising:

5 a motor (32);
a compression element (36) operatively associated with the motor (32);
a housing (22) surrounding the motor (32) and the compression element (36),
10 wherein the housing (22) includes a crankcase (38) with connecting rods (50) and a drive shaft (44) within the crankcase (38); and
characterised by at least one bridge (70) extending across the crankcase (38) and spanning between opposing side walls (60, 62) of the housing (22) proximate to the compression element (36), the at least one bridge (70) being integrally cast with the housing (22).

20 2. The compressor (20) of claim 1, wherein the housing (22) includes side walls (60, 62) having a maximum wall thickness (l) of twenty-five millimeters, preferably a wall thickness of between sixteen and twenty-five millimeters.

25 3. The compressor (20) of claim 1, wherein the compressor (20) further includes a working fluid to be compressed, the working fluid being a refrigerant, preferably carbon dioxide.

30 4. The compressor (20) of claim 3, wherein the refrigerant is compressed to an operating pressure of at least 500 psi.

35 5. The compressor (20) of claim 4, wherein the housing (22) has a burst pressure at least five times the operating pressure.

40 6. The compressor (20) of claim 1, further including a bottom cover (66) removable from the crankcase (38), the bridge (70) extending across and in contact with the bottom cover (66).

45 7. The compressor (20) of claim 1, wherein the compressor (20) is a reciprocating compressor (20).

8. The compressor (20) of claim 7, wherein the compression element (36) is a piston (52).

50 9. The compressor (20) of claim 1, wherein the housing (22) is made of gray cast iron.

Patentansprüche

55 1. Kompressor (20), umfassend:

einen Motor (32);

- ein Kompressionselement (36), das mit dem Motor (32) wirkverbunden ist;
 ein Gehäuse (22), das den Motor (32) und das Kompressionselement (36) umgibt,
 wobei das Gehäuse (22) ein Kurbelgehäuse (38) mit Pleuelstangen (50) und einer Antriebswelle (44) innerhalb des Kurbelgehäuses (38) beinhaltet; und
gekennzeichnet durch zumindest eine Brücke (70), die sich quer durch das Kurbelgehäuse (38) erstreckt und zwischen gegenüberliegenden Seitenwänden (60, 62) des Gehäuses (22) nahe dem Kompressionselement (36) aufgespannt ist, wobei die zumindest eine Brücke (70) einstückig mit dem Gehäuse (22) gegossen ist.
2. Kompressor (20) nach Anspruch 1, wobei das Gehäuse (22) Seitenwände (60, 62) beinhaltet, die eine maximale Wanddicke (l) von fünfundzwanzig Millimetern, vorzugsweise eine Wanddicke zwischen sechzehn und fünfundzwanzig Millimetern aufweisen.
 3. Kompressor (20) nach Anspruch 1, wobei der Kompressor (20) ferner ein zu komprimierendes Arbeitsfluid umfasst, wobei das Arbeitsfluid ein Kältemittel ist, vorzugsweise Kohlendioxid.
 4. Kompressor (20) nach Anspruch 3, wobei das Kältemittel zu einem Betriebsdruck von zumindest 500 psi komprimiert ist.
 5. Kompressor (20) nach Anspruch 4, wobei das Gehäuse (22) einen Berstdruck aufweist, der zumindest das Fünffache des Betriebsdrucks beträgt.
 6. Kompressor (20) nach Anspruch 1, ferner beinhaltend eine Bodenabdeckung (66), die von dem Kurbelgehäuse (38) entfernbar ist, wobei sich die Brücke (70) quer über die Bodenabdeckung (66) erstreckt und in Kontakt damit ist.
 7. Kompressor (20) nach Anspruch 1, wobei der Kompressor (20) ein sich hin- und herbewegender Kompressor (20) ist.
 8. Kompressor (20) nach Anspruch 7, wobei das Kompressionselement (36) ein Kolben (52) ist.
 9. Kompressor (20) nach Anspruch 1, wobei das Gehäuse (22) aus Grauguss gefertigt ist.
- un élément de compression (36) associé de manière fonctionnelle au moteur (32) ;
 un boîtier (22) entourant le moteur (32) et l'élément de compression (36),
 dans lequel le boîtier (22) inclut un carter (38) avec des bielles (50) et un arbre de transmission (44) à l'intérieur du carter (38) ; et
caractérisé par au moins un organe de liaison (70) s'étendant à travers le carter (38) et se situant entre des parois latérales opposées (60, 62) du boîtier (22) à proximité de l'élément de compression (36), l'au moins un organe de liaison (70) étant moulé d'une seule pièce avec le boîtier (22).
2. Compresseur (20) selon la revendication 1, dans lequel le boîtier (22) inclut des parois latérales (60, 62) ayant une épaisseur de paroi (l) maximale de vingt-cinq millimètres, de préférence une épaisseur de paroi entre seize et vingt-cinq millimètres.
 3. Compresseur (20) selon la revendication 1, dans lequel le compresseur (20) inclut en outre un fluide de travail à comprimer, le fluide de travail étant un fluide frigorigène, de préférence du dioxyde de carbone.
 4. Compresseur (20) selon la revendication 3, dans lequel le fluide frigorigène est comprimé jusqu'à une pression de fonctionnement d'au moins 500 psi.
 5. Compresseur (20) selon la revendication 4, dans lequel le boîtier (22) a une pression de rupture égale à au moins cinq fois la pression de fonctionnement.
 6. Compresseur (20) selon la revendication 1, incluant en outre un couvercle inférieur (66) amovible par rapport au carter (38), l'organe de liaison (70) s'étendant à travers et en contact avec le couvercle inférieur (66).
 7. Compresseur (20) selon la revendication 1, dans lequel le compresseur (20) est un compresseur alternatif (20).
 8. Compresseur (20) selon la revendication 7, dans lequel l'élément de compression (36) est un piston (52).
 9. Compresseur (20) selon la revendication 1, dans lequel le boîtier (22) est fabriqué en fonte grise.

Revendications

1. Compresseur (20), comprenant :

un moteur (32),

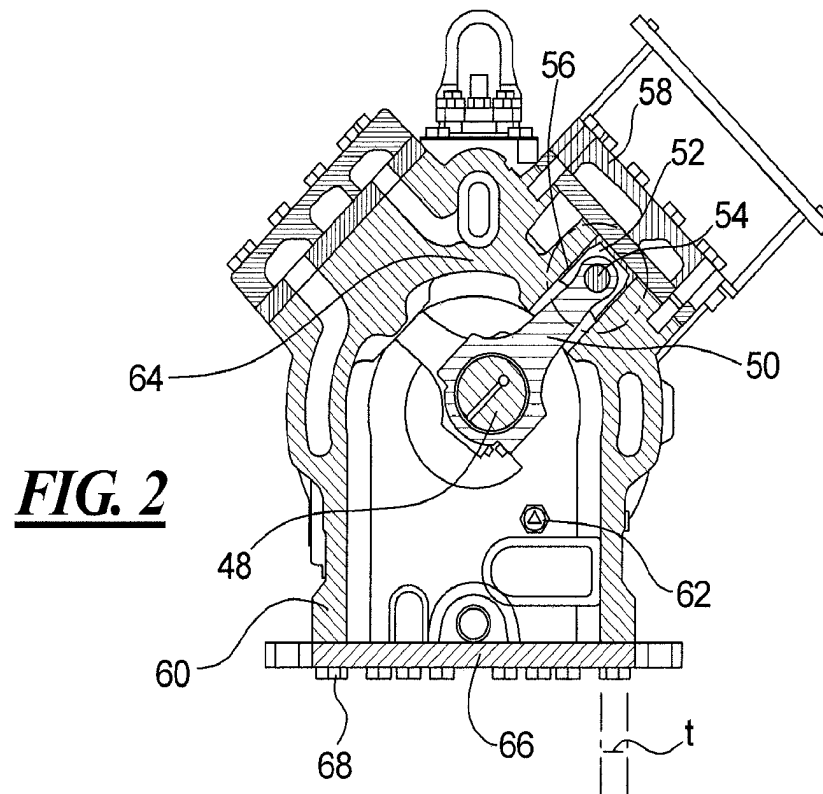
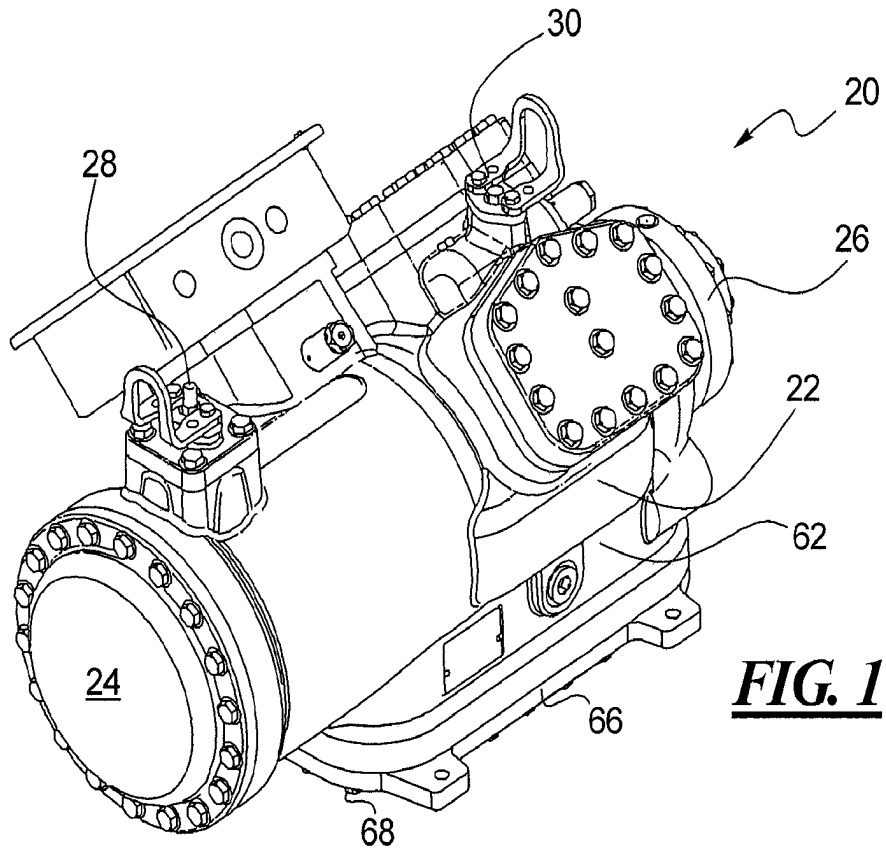


FIG. 3

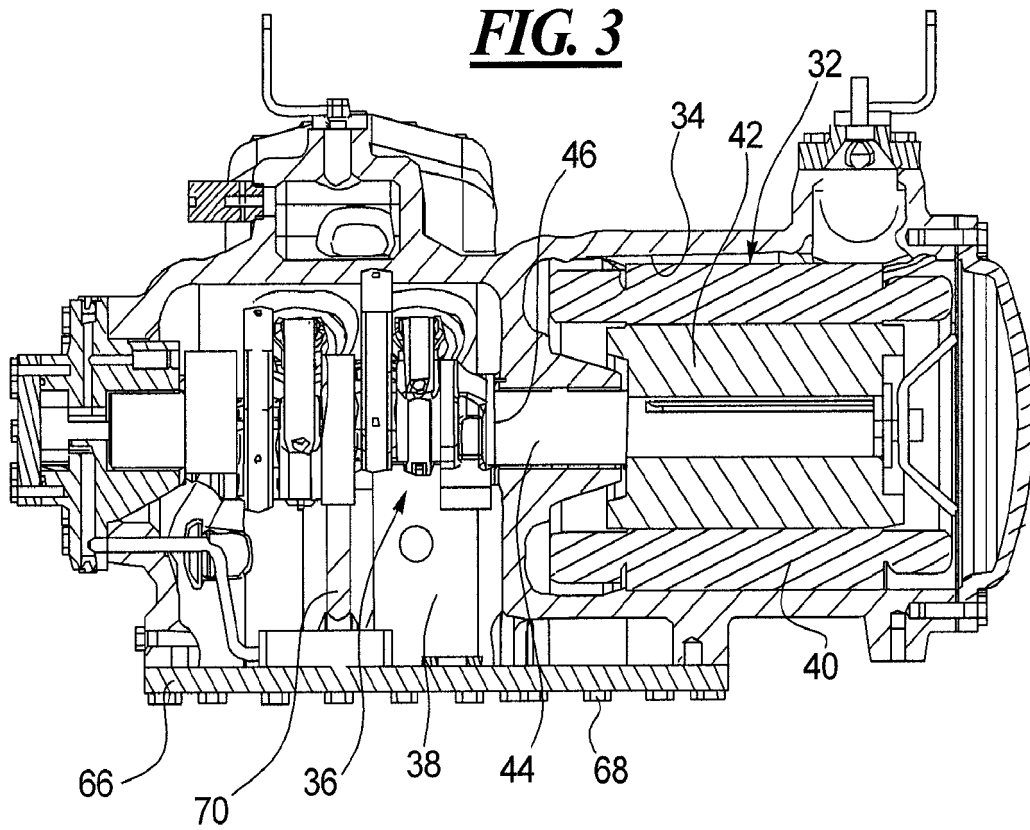
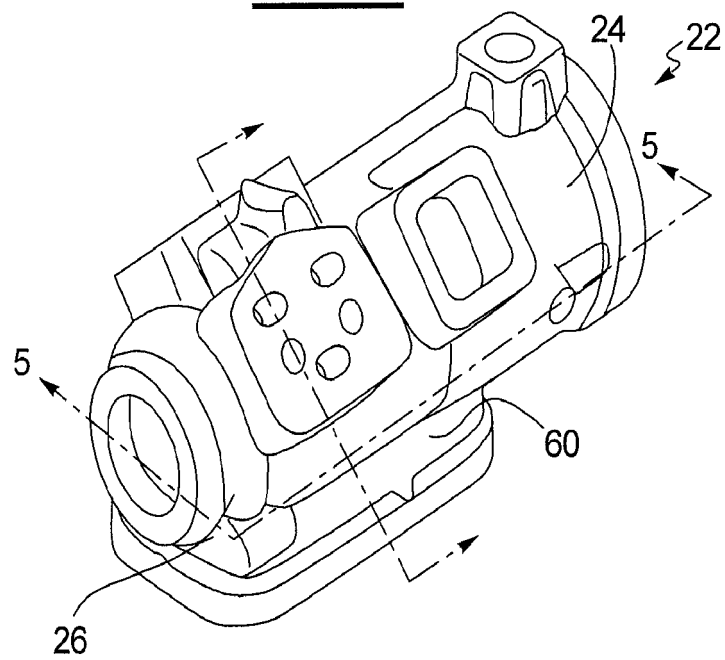
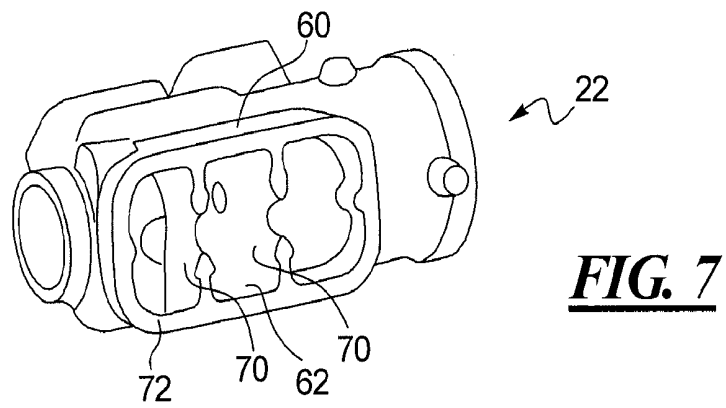
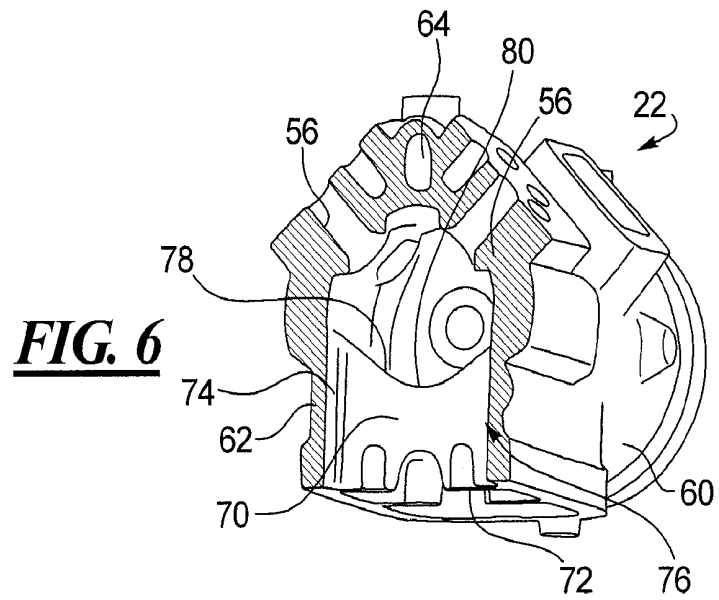
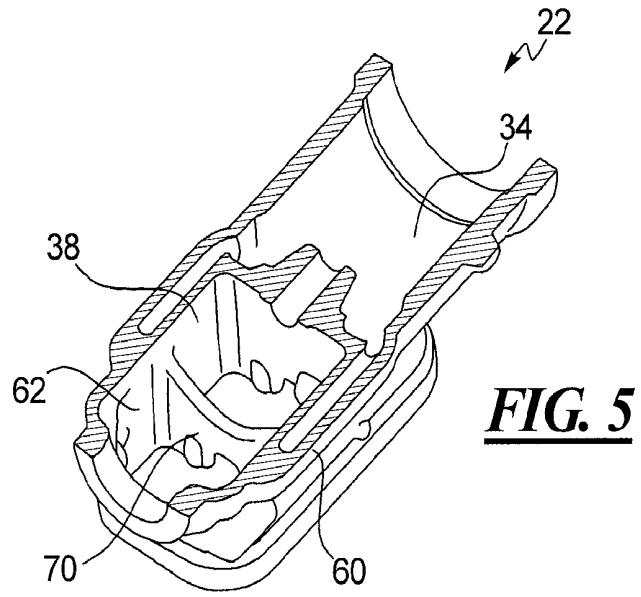


FIG. 4





REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 3189255 A [0007]
- EP 1469200 A [0007]