

Description

[0001] The present invention relates to a hermetically sealed motor driven reciprocating compressor, and more particularly to a reciprocating compressor having an improved construction.

[0002] Generally, a hermetic reciprocating compressor includes a sealed casing including upper and lower shells, a drive motor arranged in the sealed casing for driving a piston disposed within a compression cylinder also arranged in the sealed casing. The electric motor typically includes a stator, a rotor, and a crankshaft with an eccentric portion formed on one end thereof for driving the piston. Typically, the compression cylinder includes a cylinder block defining a compression chamber in which a piston is reciprocally movable in a linear direction by a connecting rod disposed between the piston and the eccentric portion of the crankshaft. Typically, a head portion is mounted to the cylinder block and includes valving therein for providing controlled discharge of compressed gases from the compression chamber. With the high speed operation of the compressor system, a lot of noise and vibration is generated. Accordingly, it is desirable in the art of reciprocating compressors to reduce the amount of noise and vibration caused during operation of the compressor.

[0003] With conventional reciprocating compressors, there are a number of machined surfaces that are required as well as seals or gaskets and fasteners for mounting the head portion to the cylinder block. Accordingly, it is also desirable in the art of reciprocating compressors to provide for simplified manufacture and assembly of a reciprocating compressor to reduce the number of machined surfaces and eliminate additional parts.

[0004] Further areas of applicability of the present invention will become apparent from the detailed description provided hereinafter. It should be understood that the detailed description and specific examples, while indicating the preferred embodiment of the invention, are intended for purposes of illustration only and are not intended to limit the scope of the invention.

[0005] The present invention will become more fully understood from the detailed description and the accompanying drawings, wherein:

[0006] Figure 1 is a partial cross-sectional perspective view of a reciprocating compressor according to the principles of the present invention;

[0007] Figure 2 is a detailed partial cross-sectional exploded perspective view illustrating the piston and discharge valve assembly according to the principles of the present invention;

[0008] Figure 3 is a detailed partial cross-sectional perspective view illustrating the assembly technique for mounting the valve plate assembly according to the principles of the present invention;

[0009] Figure 4A is a partial cross-sectional perspective view illustrating the compressor in a vertical ar-

angement with the motor housing submerged in oil according to the principles of the present invention;

[0010] Figure 4B is a partial cross-sectional perspective view of the compressor being mounted within the hermetic shell in an upside down configuration with the head of the compressor disposed in the oil sump;

[0011] Figure 5 is a detailed cross-sectional view illustrating the connection of the compressor body and motor cover to the motor stator according to the principles of the present invention;

[0012] Figure 6 is a cross-sectional view illustrating the connection between the motor stator and motor cover and lower bearing housing according to the principles of the present invention;

[0013] Figure 7 is an exploded perspective view of a snap-fit discharge tube fitting;

[0014] Figure 8A is a cross-sectional view of a thrust bearing utilized in the compressor of Figure 4A;

[0015] Figure 8B is a cross-sectional view of an oil plug provided in the upper end of the crankshaft utilized in the compressor of Figure 4A;

[0016] Figure 9A is a cross-sectional view of a thrust bearing utilized in the compressor of Figure 4B;

[0017] Figure 9B is a cross-sectional view of an oil plug provided in the upper end of the crankshaft utilized in the compressor of Figure 4B;

[0018] Figure 10 is a detailed cross-sectional view illustrating the connection of the compressor body and motor cover to the motor stator according to alternative embodiments of the present invention; and

[0019] Figure 11 is a detailed cross-sectional view illustrating the connection of the compressor body and motor cover to the motor stator according to further alternative embodiments of the present invention.

[0020] The following description of the preferred embodiment(s) is merely exemplary in nature and is in no way intended to limit the invention, its application, or uses.

[0021] With reference to Figure 1, the hermetically sealed reciprocating compressor 10, according to the principles of the present invention, will now be described. The reciprocating compressor 10 includes a sealed casing 12 including a lower shell 14 and an upper shell 16 sealingly connected to one another. A suction inlet passage 17 is provided in the sealed casing 12. A motor 18 is disposed within the casing 12 and includes a rotor (not shown), a stator 20, and a crankshaft 22 which is connected to the rotor, as known in the art. The crankshaft 22 includes an eccentric portion 24.

[0022] The motor 18 includes a motor cover 25. A uni-body member 26 is mounted to the motor 18. The uni-body member 26 includes a body portion 28 defining a cylinder 30 and a bell-shaped housing portion 32. A head portion 34 is formed as a unitary piece with the body 28 and includes a first discharge cavity 36A in communication with the cylinder 30, and a second discharge cavity 36B is in communication with the first discharge cavity 36A via a restriction 36C. The size of the first and

second discharge chambers 36A, 36B are preferably sized to optimize discharge pulse or efficiency. Further, the restriction 36C can be sized or provided with an insert to further optimize the discharge pulse. A discharge tube 100 is connected to the outlet port 102 of the second discharge chamber 36B. Preferably, the discharge tube 100 has a snap-fit engagement with the outlet port 102. Specifically, as illustrated in Figure 7, the discharge tube 100 can be provided with a tube fitting 104 with a radially expanding retainer ring 106 which upon being pushed through the outlet port 102 expands outward, preventing the tube fitting 104 from being removed or blown out. A compliant seal member 105 forms a generally gas-tight seal between outlet port 102 and tube fitting 104. A muffler 108 can optionally be provided in the discharge tube passage 100. The discharge tube 100 is connected to a discharge port 110 provided in the sealed casing 12.

[0023] A piston 38 is disposed within the cylinder 30 and is connected to a connecting rod 40 which is connected to the eccentric portion 24 of the crankshaft 22. A suction passage 42 is provided in the uni-body member 26 and communicates with the cylinder 30 and a hollow section 44 defined by the bell-shaped portion 32 of the body 28. As best shown in Figures 2 and 3, the piston 38 is generally cylindrical in shape and includes a recessed groove 46 that communicates with an inlet passage 48 that allows suction gas to pass through the suction passage 42, through the groove 46, and inlet passage 48 into the cylinder 30 at the top of the piston 38 through passages 47 which are covered by a suction reed valve 49 (secured to the top of the piston) during a suction phase of the compressor operation.

[0024] A discharge valve assembly 50 is provided in the open end of the cylinder 30. The discharge valve assembly 50 includes a valve plate 52, a discharge valve member 54, and a valve retainer 56. The valve plate 52 is generally disk-shaped and includes a pair of discharge ports 58 disposed therein. The valve plate 52 further includes a plurality of holes 60 for receiving fasteners therein for mounting the discharge valve 54 and retainer 56 to the valve plate 52. The discharge valve 54, as shown in Figure 2, is a reed-type valve which is made from a flexible material. The discharge valve 54 is disposed against a valve retainer 56 which is provided with an arcuate face 62, and also includes mounting holes 64 (only one of which is shown in Figure 1) for receiving fasteners that extend through the mounting holes 60 provided in the valve plate 52, and the holes 66 provided in the discharge valve 54. The discharge valve 54 is provided with arcuate cutouts 68 which are disposed radially inward from the discharge ports 58 provided in the valve plate 52 and help to control the flexibility of the discharge valve 54 to cover the discharge ports 58 during a suction phase of compressor operation and to flex away from the discharge ports 58 during a compression stage of compressor operation. The arcuate face 62 of the valve retainer 56 has a profile

configured to limit the opening of the reed valve 54 for stress and performance optimization.

[0025] The discharge valve assembly 50 can be assembled in the head portion 34 of the uni-body member 26 by forming the valve plate 52 and retainer 56 to have a diameter appropriately machined and toleranced to allow an interference fit between the outside diameter of the valve plate 52 and retainer 56 and the inside diameter of the cylinder 30. The interference fit at the diameter provide sealing and retention of the valve plate 52 and retainer 56. During assembly, the piston 38 is held at a predetermined position such as, for example, top dead center and the discharge valve assembly 50 is chilled to a temperature low enough to thermally shrink the diameter of the assembly 50 so that it will freely drop into the cylinder 30. The discharge valve assembly 50 rests on the piston 38 until it warms and grows into a press-fit in cylinder 30. The press-fit retains the assembly 50 and provides a sealing between the cylinder 30 and the discharge valve assembly 50 diameter. As illustrated in Figure 3, one method of positioning the piston 38 within the cylinder 30 during assembly of the discharge valve assembly 50 is to reverse-load the bearings (by application of force F) between the connecting rod 40 and crankshaft 22, relying on the bearing clearances to position the piston 38 slightly above the normal top dead center position. Gas forces (when the compressor is running) push down on the piston 38, reversing the loading on the bearing and creating a cold piston-to-valve plate clearance approximately equal to the sum of the bearing clearances in the running gear assembly.

[0026] It also should be noted that the interference fit at assembly can be obtained by heating the cylinder in order to cause the cylinder inner diameter to expand prior to inserting the discharge valve assembly into the cylinder, as opposed to cooling the valve assembly, and leaving the cylinder at room temperature. In addition, a combination of the two (heating the cylinder and cooling the discharge valve assembly) is also possible. Furthermore, the sealing and retention between the valve plate 52 and cylinder 30 can also be enhanced by use of a sealing agent, such as, for example, LOCTITE.

[0027] An alternative embodiment would be for the valve plate to set in a counterbore of different diameter than that of the cylinder. However, this option would require that a secondary machine operation be provided in order to generate the counterbore.

[0028] As best illustrated in Figure 2, the top of the piston 38 is provided with contoured posts 70 which are designed to partially fill the discharge ports 58 in the valve plate 52 when the piston 38 is nearing top dead center. The contoured posts 70 further reduce the amount of clearance between the piston 38 at top dead center and the valve plate 52 to further increase the efficiency of the compressor.

[0029] The uni-body member 26 includes a bearing portion 72 that receives an end of the crankshaft 22 therein. The uni-body member 26 further includes an

opening 74 provided in the bell-shaped portion 32 that is spaced from the bearing portion 72 and receives the crankshaft 22 therein. A crank case isolation seal 76 is disposed between the opening 74 and the crankshaft 22 in order to provide for a large suction volume within the hollow section 44 to attenuate suction pulse. The suction gas that enters through the suction inlet passage 17 is drawn into the motor cover 25 over top of an upper edge thereof and between the interior of the motor cover 25 and the outer surface of the stator 20. The suction gas then passes upward between the rotor and stator 20 and into the space between the hollow section 44 of the bell-shaped portion 32 of the body 28 and the stator 20. The free volume between the motor 18 and bell-shaped portion 32 is available to serve as a suction muffler. Additionally, the seal prevents oil from the upper main and connecting rod bearings from flowing down past the crankshaft and becoming entrained in the suction gas. In addition, the above-described suction gas flow passage also prevents oil from becoming entrained in the suction gas. With the uni-body member 26 constructed as a single casting forming the body 28 containing the cylinder 30 and the discharge cavity 36 within the head portion 34. A significant reduction in the number of machined surfaces and elimination of seals or gaskets and fasteners to attach the head to the body are achieved.

[0030] As illustrated with reference to Figures 4A and 4B, the sealed casing 12 is sized and configured to be capable of supporting the motor 18 and uni-body member 26 for two different types of applications. Oil temperature control is important in most hermetic compressors. If the oil is too hot, lubricating properties diminish and oil breakdown may occur. If the oil is too cool, refrigerant dilution may significantly impact lubricating properties of the oil, and otherwise negatively impact the reliability of the compressor. The oil sump temperature is highly dependent on how the compressor is being applied. In those applications with high super heat and high pressure ratios, rejecting a minimal amount of heat to the oil can help keep it in a safe temperature zone. This can be accomplished by keeping the head of the compressor out of the oil. Applications with low super heat and low pressure ratios can benefit from heat rejection to the oil. This heat rejection to the oil can be enhanced by submerging the head and running gear in the oil.

[0031] Accordingly, the present invention provides that the sealed casing 12 be sized and configured to receive the motor 18 and uni-body member 26 with either the motor being disposed in the compressor sump, as illustrated in Figure 4A, or the uni-body member 26 being disposed in the compressor sump, as illustrated in Figure 4B. The modifications required to do this consist in utilizing a crankshaft thrust bearing with an oil pump inlet at the end of the crankshaft that is submerged within the oil sump. With reference to Figure 8A, a cross-sectional view of the crankshaft thrust bearing 120 is shown for the compressor shown in Figure 4A. In par-

ticular, the thrust bearing 120 includes a thrust washer 122 disposed between the end of the crankshaft 22 and a lower bearing housing 92. A bearing 123 is provided between the crankshaft 22 and the lower bearing housing 92.

[0032] Figure 8B illustrates an oil plug 124 provided in the upper end of the crankshaft 22 of the embodiment of Figure 4A. The plug 124 has a vent passage 126 to allow gases to vent while preventing oil from spewing out the upper end of the crankshaft 22 to control the oil circulation rate.

[0033] Figure 9A illustrates a cross-sectional view of a crankshaft thrust bearing 130 for the compressor shown in Figure 4B. In particular, the thrust bearing 130 includes a thrust washer 132 disposed between the lower end of the crankshaft and a retainer ring 134 attached to the body 28. Figure 9B illustrates an oil plug 136 provided in the upper end of crankshaft 22 of the embodiment of Figure 4B. The plug 136 has a vent passage 138 to allow gases to vent while preventing oil from spewing out of the upper end of the crankshaft 22 to control the oil circulation rate. With the current design, many of the same components of the compressor design including the housing, motor, and uni-body member can be utilized in a compressor that is being utilized for either high or low super heat and pressure ratios.

[0034] With reference to Figure 1, the outside diameter of the stator 20 is press-fit in a counterbore inside diameter of the bell-shaped section 32 of the uni-body member 26. The stator 20 is a structural member carrying bearing loads and suspension system loads. As illustrated in Figure 5, an alternative embodiment relies on an epoxy filled gap in the counterbore of the bell-shaped section 32 to allow positioning of the stator 20. The stator may be held in place with tack welds while the epoxy cures. Another alternative embodiment, as illustrated in Figure 10, utilizes bolts 150 that extend through the housing 25, stator 20, and threadedly engage the bell-shaped section 32, stator 20 to position the stator, clamping it against the face of the bell-shaped section 32. Alternatively, as illustrated in Figure 11, the bell-shaped section 32 can be connected by welds 151 to the stator 20.

[0035] Motor 18 includes a motor cover 25 which can be press-fit over the stator 20, as shown in Figure 1. The motor cover can be provided with indents 25A (such as illustrated in Figure 6) that engage the stator and define air gaps between the motor cover 25 and the stator 20 to allow the flow of suction gas therebetween. An alternative embodiment is to plug-weld the motor housing cover 25 to the stator 20. Plug welding may be used in conjunction with press-fitting or to position a housing with an epoxy filled gap 86, as best shown in Figure 5. Air gap shims are utilized during curing, and later removed to define air gaps for the suction gas. Alternatively, motor cover 25 can be fastened to the stator by bolts 150, as illustrated in Figure 10, or connected by welds 152 as illustrated in Figure 11.

[0036] A further alternative embodiment is to use a two-part motor cover housing, including a motor cover 90 and lower bearing housing 92, as illustrated in Figure 6. The motor cover 90 is press-fit, adhered, bolted, and/or welded to the stator 20, as discussed above. The lower bearing housing 92 is moved laterally to position the lower bearing relative to the lower end of the crankshaft 22 and the lower bearing housing 92 is then plug welded to the motor cover housing 90. The separate connection of the lower bearing housing 92 allows for proper location of the crankshaft 22 and rotor relative to the stator 20 to provide a proper air gap between the rotor and stator 20 for efficient motor operation.

[0037] During operation, oil is drawn through the thrust bearing and up through the crankshaft 22 which is provided with an internal lubricant passage 140, as is known in the art. The crankshaft 22 is provided with radial passages 142, 144 for providing lubrication to an internal passage in connecting rod 40 and to the upper crankshaft bearing. The cylinder 30 is splash lubricated with lubrication from the connecting rod 40.

[0038] The description of the invention is merely exemplary in nature and, thus, variations that do not depart from the scope of the claims are intended to be within the scope of the invention.

Claims

1. A compressor comprising:
 - a motor including a crankshaft;
 - a piston drivingly connected to said crankshaft;
 - and
 - a uni-body member including a body portion defining a cylinder for receiving said piston for reciprocating movement therein and a head portion defining a discharge passage in communication with said cylinder, said body portion and said head portion being formed as a unitary member.
2. The compressor according to claim 1, wherein said uni-body member includes a suction passage therein.
3. The compressor according to claim 1 or 2, wherein said uni-body member includes a discharge chamber in communication with said discharge passage.
4. The compressor according to any one of the preceding claims, wherein said uni-body member includes a journal portion for receiving an end portion of said crankshaft.
5. The compressor according to any one of the preceding claims, further comprising a discharge valve assembly disposed in said head portion of said uni-body member.
6. The compressor according to claim 5, wherein said discharge valve assembly is interference fit within said head portion.
7. The compressor according to any one of the preceding claims, wherein said crankshaft extends through an opening in said uni-body member and includes an isolation seal disposed between said crankshaft and said opening.
8. The compressor according to claim 7, wherein said body portion of said uni-body member includes a hollow section that receives a portion of said motor therein, said uni-body member defining a suction passage therein that communicates with a space between said hollow section and said motor.
9. The compressor according to any one of the preceding claims, further comprising a compressor shell having a first end portion and a second end portion each connected by a middle portion, said compressor shell being configured to receive said motor and said uni-body member arranged with said uni-body member being disposed at either one of said first end portion or said second end portion of said compressor shell.
10. The compressor according to any one of the preceding claims, wherein said body portion of said uni-body member includes a hollow section that receives a stator of said motor.
11. The compressor according to claim 10, wherein said body portion of said uni-body member is press-fit on said stator of said motor.
12. The compressor according to claim 10, wherein said body portion of said uni-body member is secured on said stator of said motor by an adhesive.
13. The compressor according to claim 10, wherein said body portion of said uni-body member is bolted on said stator of said motor.
14. The compressor according to any one of the preceding claims, wherein said motor includes a motor cover connected to a stator of said motor.
15. The compressor according to claim 14, wherein said motor cover is press-fit on said stator.
16. The compressor according to claim 14, wherein said motor cover is secured to said stator by an adhesive.
17. The compressor according to claim 14, wherein

said motor cover includes a cover body connected to said stator and a lower bearing housing for supporting a lower motor bearing and being mounted to said cover body.

18. The compressor according to any one of the preceding claims, wherein said piston includes at least one post on a top surface thereof, said post being received in a discharge port in communication with said discharge passage.

19. A compressor, comprising:

a motor including a crankshaft;
a piston drivingly connected to said crankshaft;
a cylinder for receiving said piston for reciprocating movement therein and a head portion defining a discharge passage in communication with said cylinder; and

further comprising a discharge valve assembly interference fit in said cylinder.

20. The compressor according to claim 5, 6 or 19, wherein said discharge valve assembly includes a valve plate disposed at a top portion of said cylinder, a valve member disposed against said valve plate and a retainer disposed on said valve member.

21. The compressor according to claim 20, wherein said valve member is a flexible reed valve.

22. A method of assembling a valve plate in an open end of a cylinder, the cylinder including a piston disposed therein, said method comprising the steps of:

holding the piston at a predetermined position within said cylinder;
thermally shrinking the valve plate and inserting the valve plate in the open end of the cylinder so as to rest on said piston, and
allowing the valve plate to warm so as to expand into a press fit engagement with said cylinder.

23. The method according to claim 22, further comprising the step of fastening a valve retainer to said valve plate and providing a discharge valve between said valve plate and said valve retainer.

24. The method according to claim 22 or 23, further comprising the step of thermally shrinking a valve retainer mounted to said valve plate and inserting said valve retainer with said valve plate into said cylinder and allowing said valve retainer to warm so as to expand into a press fit engagement with said cylinder.

25. The method according to any one of claims 22 to 24, wherein said step of holding the piston at a predetermined position within said cylinder includes reverse loading bearings of a connecting rod connected to the piston.

26. The method according to any one of claims 22 to 25, wherein said piston includes at least one post on a top surface thereof, said post being received in a discharge port in said valve plate.

27. A method of assembling a valve plate in an open end of a cylinder, the cylinder including a piston disposed therein, said method comprising the steps of:

holding the piston at a predetermined position within said cylinder;
thermally expanding the cylinder and inserting the valve plate in the open end of the cylinder so as to rest on said piston, and
allowing the cylinder to cool so as to contract into a press fit engagement with said valve plate.

28. The compressor according to any one of claims 1 to 21, further comprising:

an opening in said body member, said crankshaft extending through said opening; and
an isolation seal disposed between said crankshaft and said opening.

29. The compressor according to claim 28, wherein said body portion of said body member includes a hollow section that receives a portion of said motor therein, said body member defining a suction passage therein that communicates with a space between said hollow section and said motor.

30. A compressor as claimed in any one of claims 1 to 21, further comprising:

a stator on said motor; and
a motor cover connected to said stator, said motor cover and stator defining a suction gas passage therebetween.

31. The compressor according to claim 30, wherein said motor cover is press-fit on said stator.

32. The compressor according to claim 30, wherein said motor cover is secured to said stator by an adhesive.

33. The compressor according to claim 30, wherein said motor cover includes a cover body connected to a stator of said motor and a lower bearing housing for supporting a lower motor bearing and being

mounted to said cover body.

- 34.** A compressor as claimed in any one of claims 1 to 21, further comprising:

5
a motor including a crankshaft;
a piston drivingly connected to said crankshaft;
a body member defining a cylinder for receiving
said piston for reciprocating movement therein
10 and a head portion defining a discharge pas-
sage in communication with said cylinder; and
a discharge valve assembly disposed in said
cylinder and including at least one discharge
port therein, and at least one post on a top sur-
15 face of said piston, said post being received in
said discharge port.

20

25

30

35

40

45

50

55

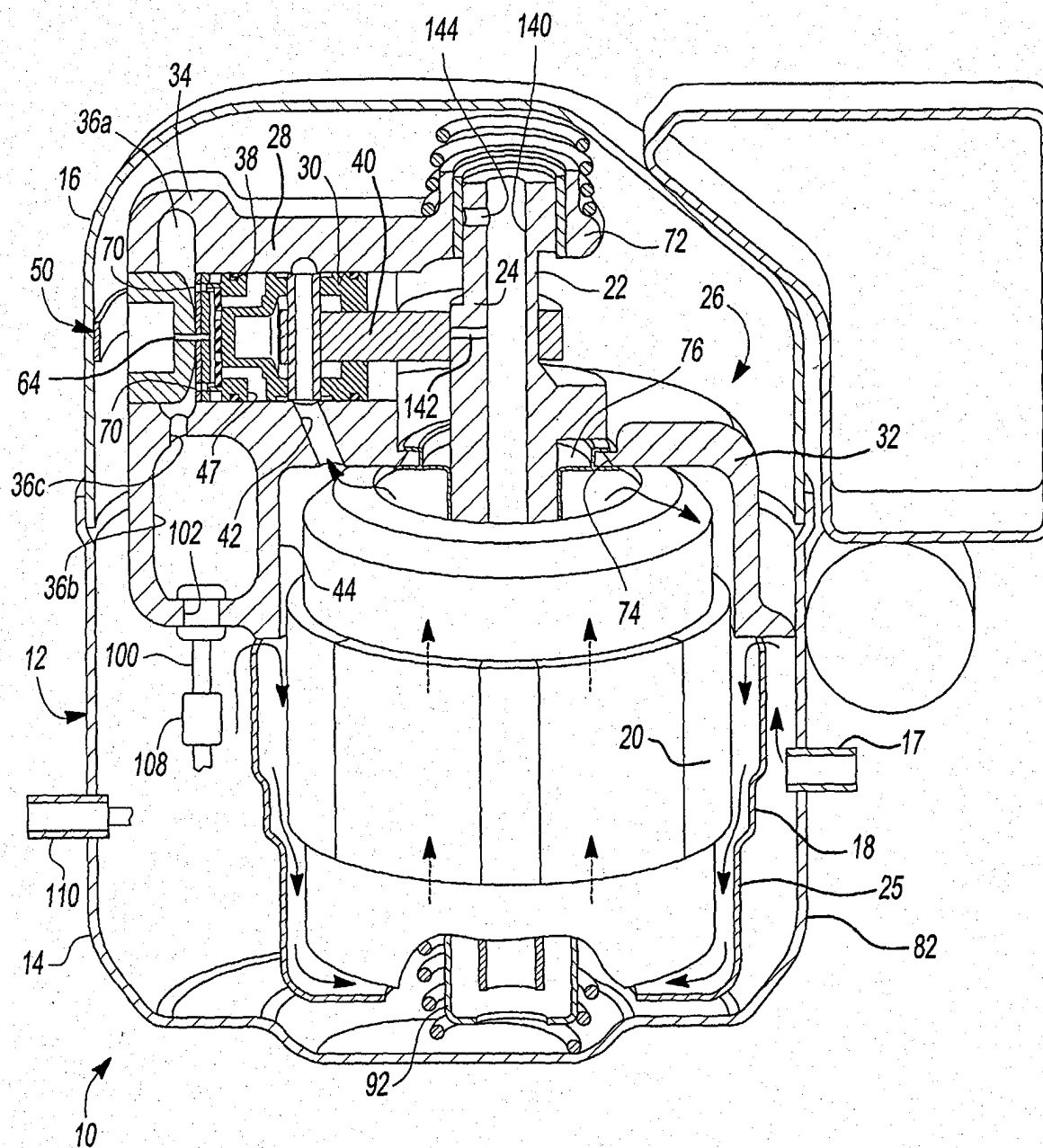
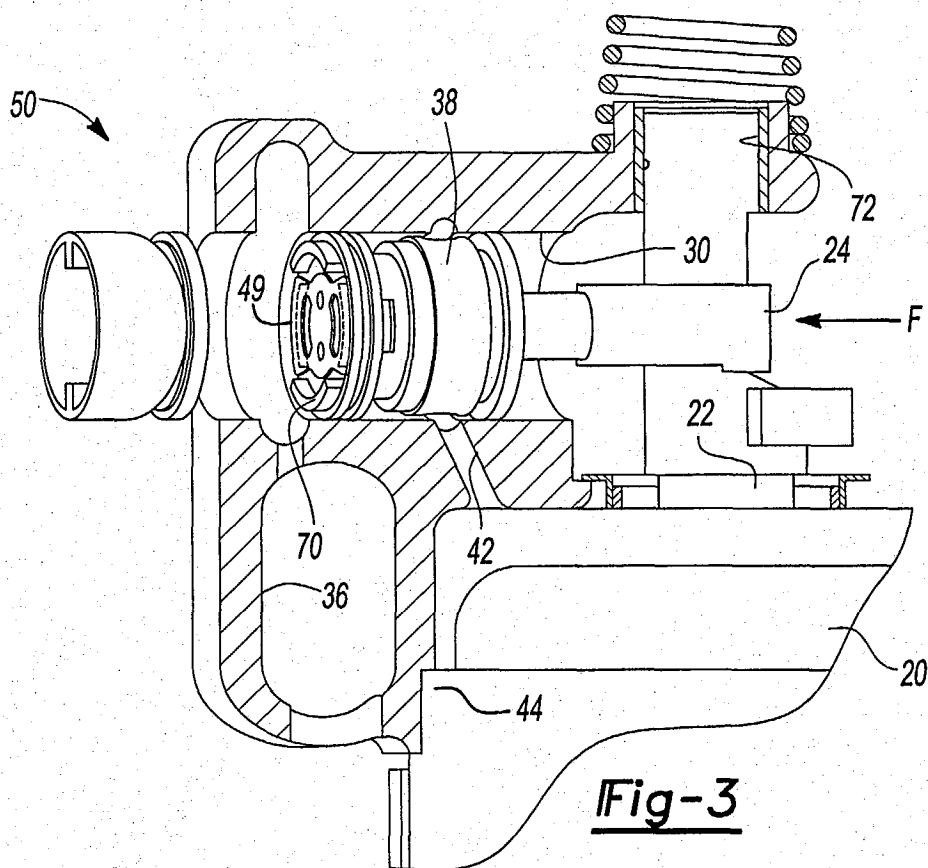
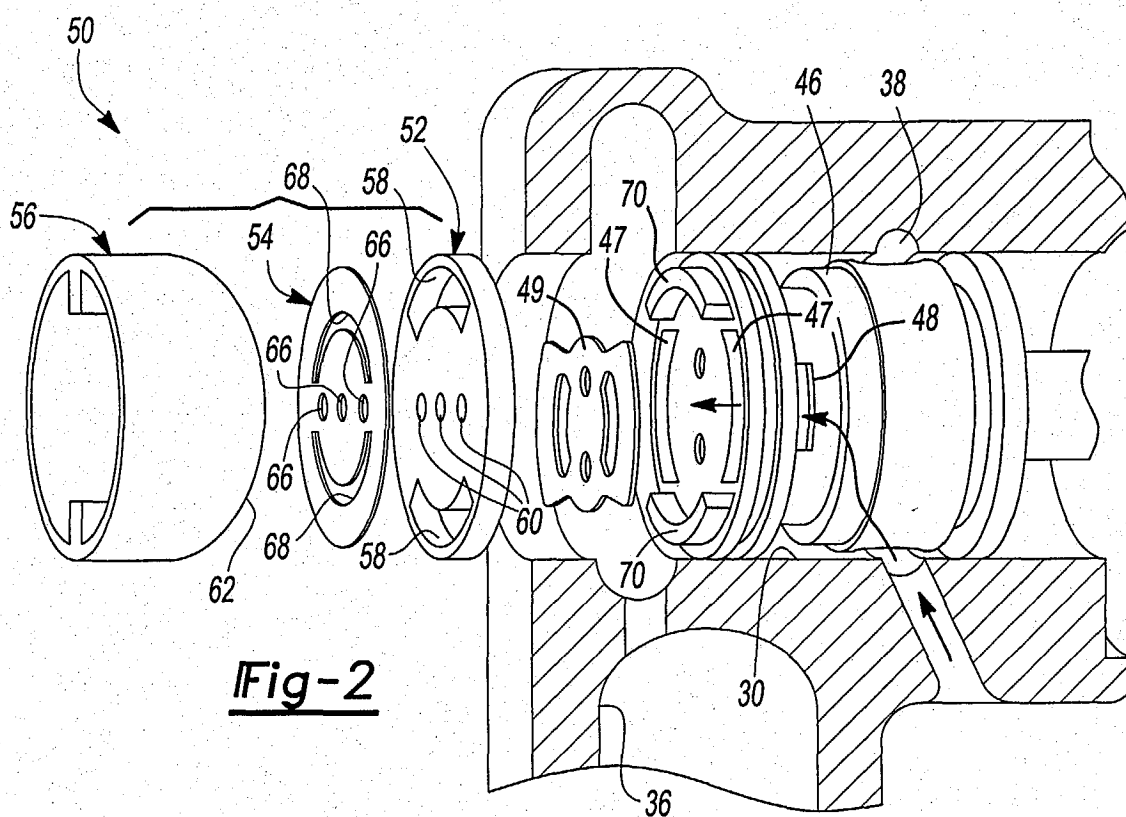
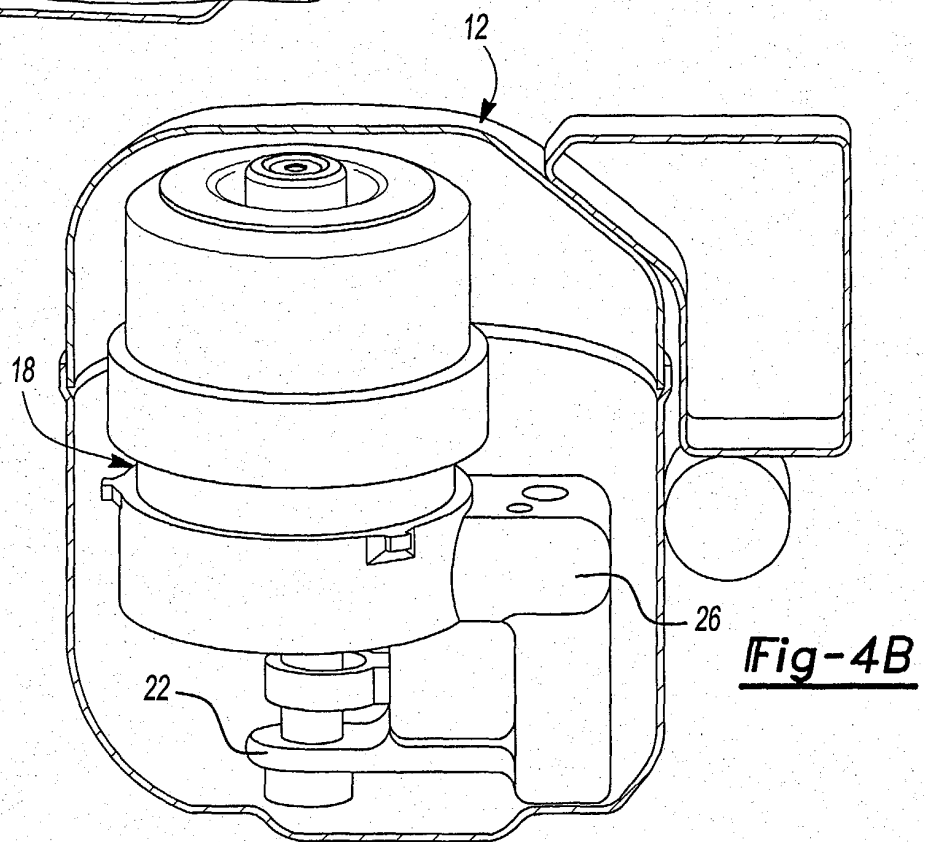
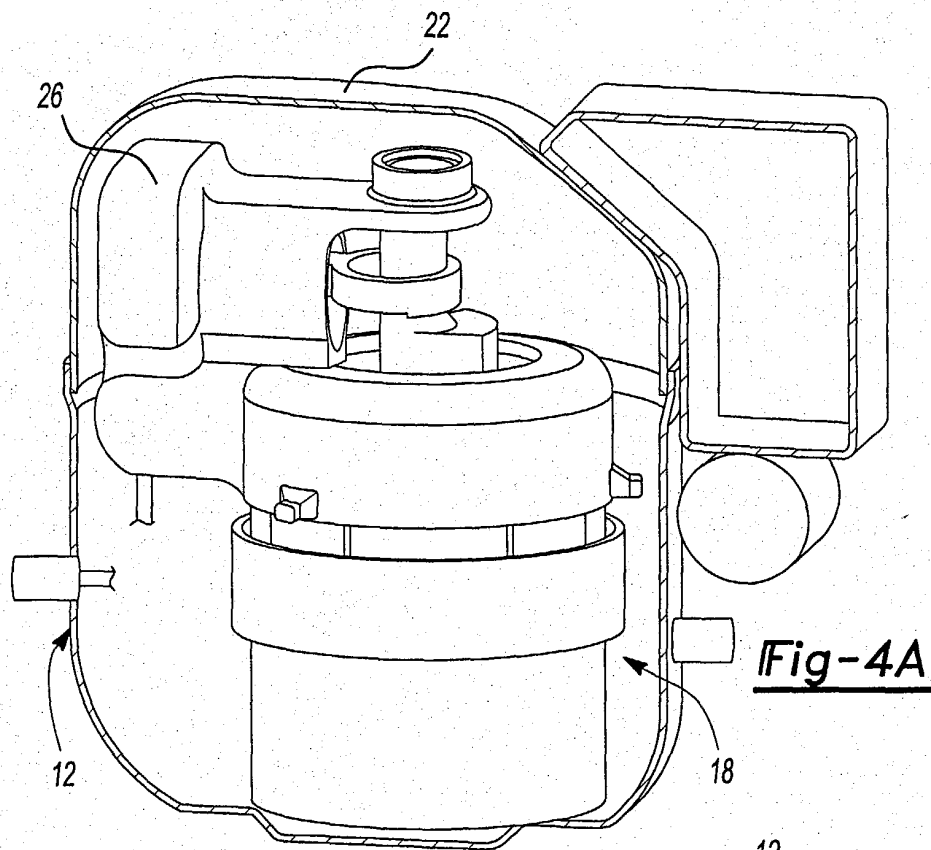


Fig-1





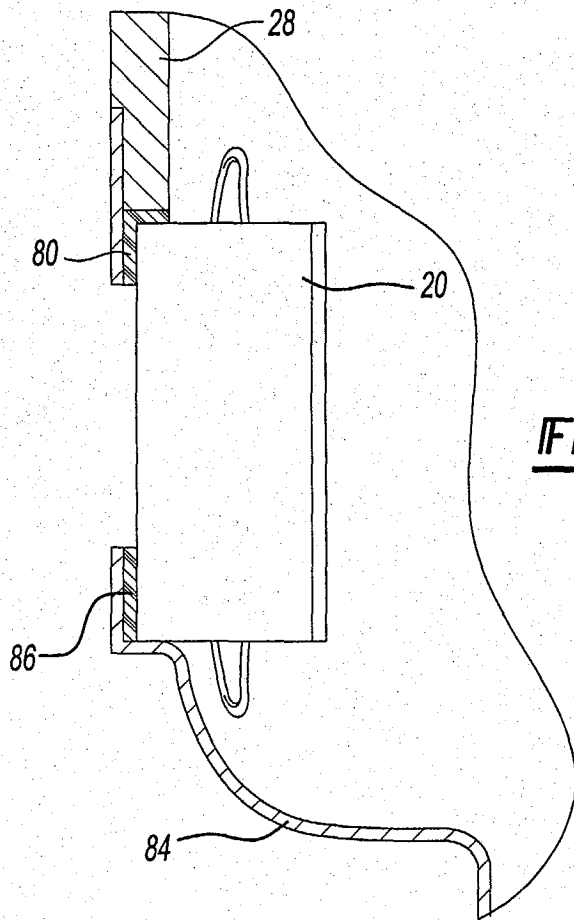


Fig-5

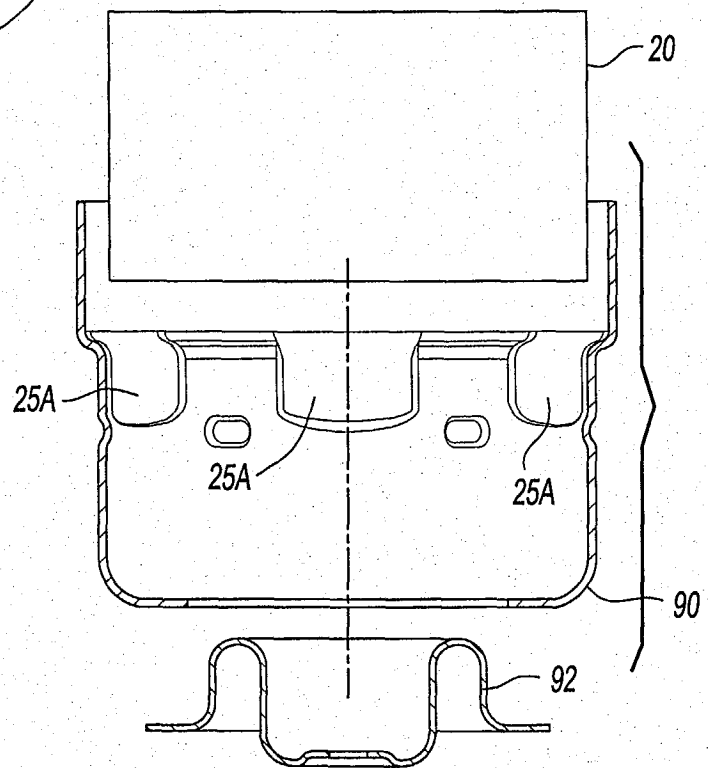


Fig-6

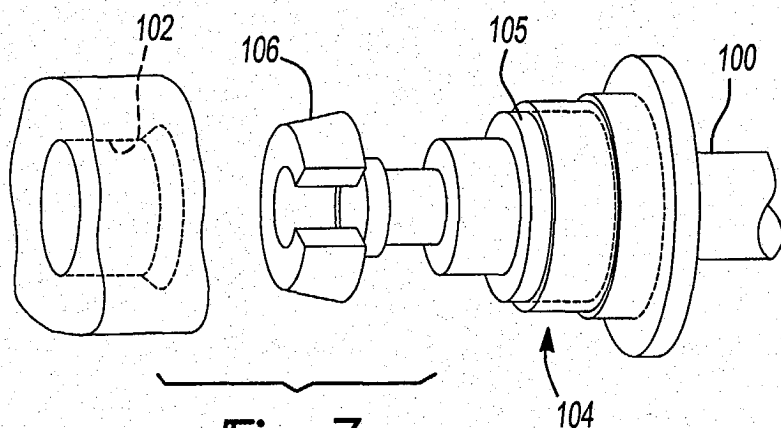


Fig-7

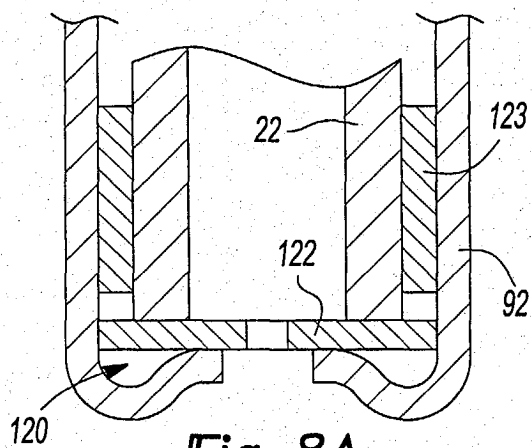


Fig-8A

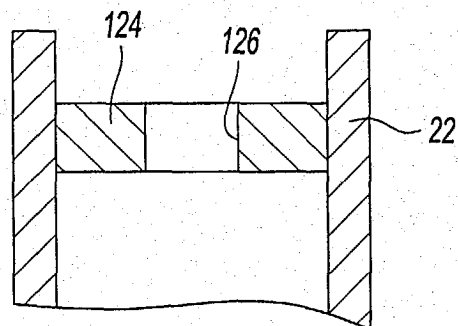


Fig-8B

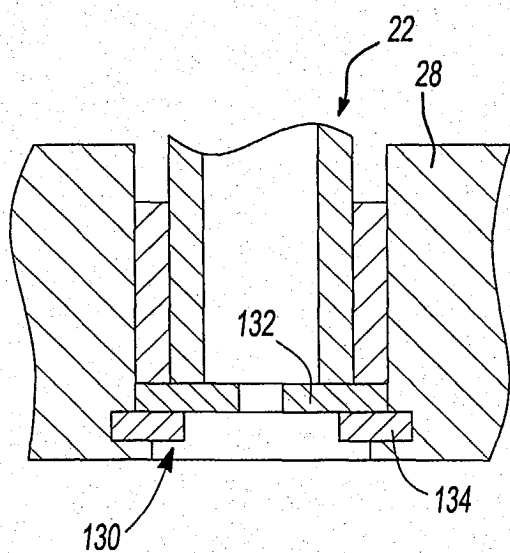


Fig-9A

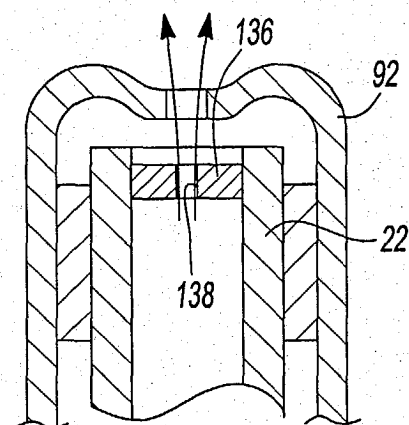


Fig-9B

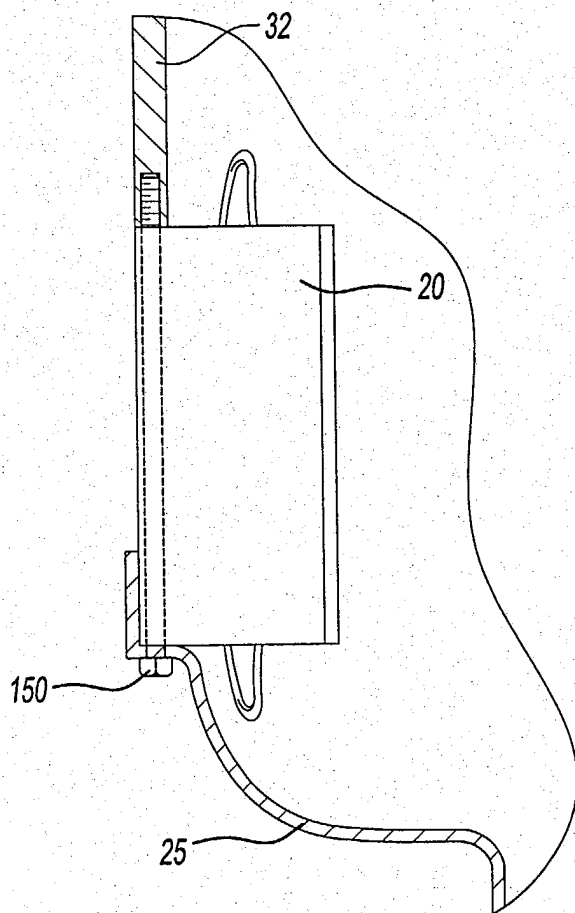


Fig-10

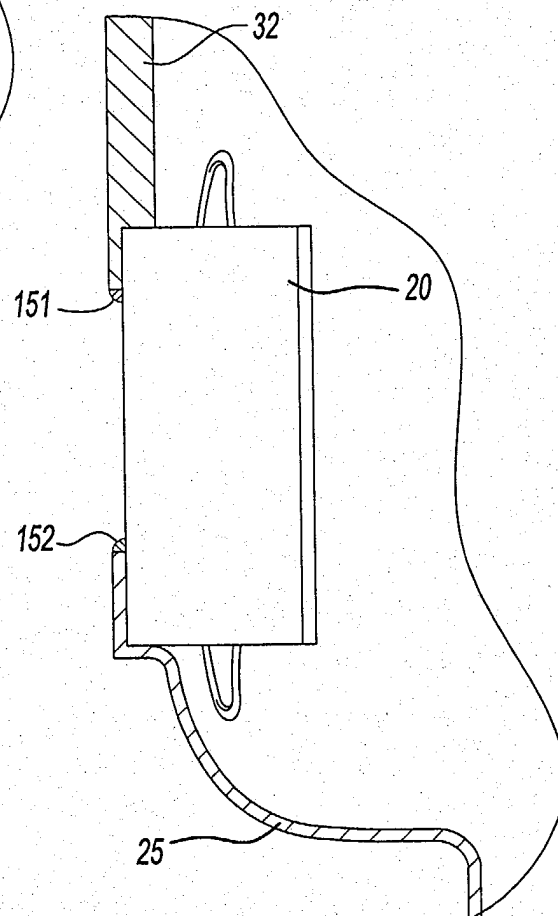


Fig-11