(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
31 March 2011 (31.03.2011)

PCT

(10) International Publication Number
WO 2011/038174 A2

(51) International Patent Classification:
F04C 29/00 (2006.01) *F04C 29/02* (2006.01)
F04C 18/356 (2006.01)

(21) International Application Number:
PCT/US2010/050102

(22) International Filing Date:
24 September 2010 (24.09.2010)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/246,319 28 September 2009 (28.09.2009) US

(71) Applicant (*for all designated States except US*): **TECUMSEH PRODUCTS COMPANY** [US/US]; 1136 Oak Valley Drive, Ann Arbor, MI 48108 (US).

(72) Inventors; and
(75) Inventors/Applicants (*for US only*): **COFFEY, Donald, L.** [US/US]; 11518 Lakeview Drive, Brooklyn, MI 49230 (US). **LENZ, James, R.** [US/US]; 313 Kingsway, Canton, MI 49188 (US).

(74) Agent: **HOFFMAN, John, F.**; BAKER & DANIELS LLP, 111 East Wayne Street, Suite 800, Fort Wayne, IN 46802 (US).

(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

WO 2011/038174 A2

(54) Title: ROTARY COMPRESSOR

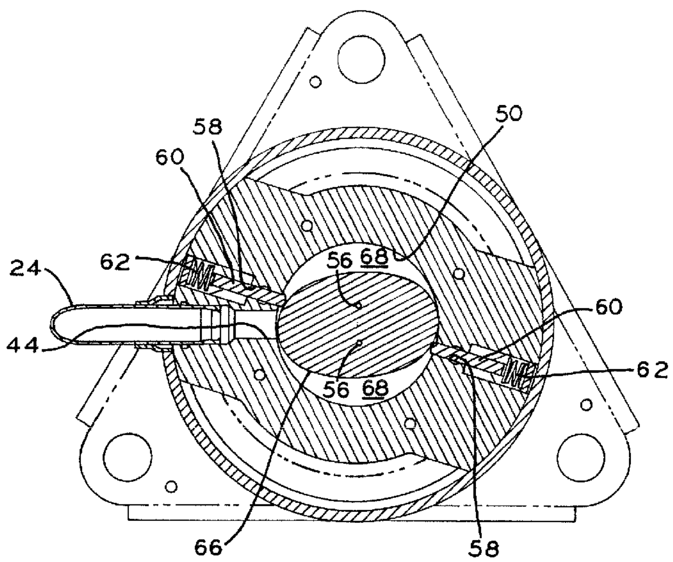

FIG_6

(57) **Abstract**: The eccentric on the crankshaft of a rotary compressor, as well as the roller that surrounds the crankshaft, is replaced by an elliptical cam that acts as a double eccentric. In this manner, the elliptical cam provides for proper balancing of the crankshaft and other components of the compressor, while eliminating the need to use counterweights. Specifically, the elliptical cam is symmetrical, resulting in equal forces acting on opposing sides of the elliptical cam. This allows the elliptical cam to maintain its balance throughout its rotation, even when operating at a high rate of revolution.

ROTARY COMPRESSOR

BACKGROUND

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit under Title 35, U.S.C. § 119(e) of U.S. Provisional Patent Application Serial No. 61/246,319, filed September 28, 2009, titled ROTARY COMPRESSOR, the disclosure of which is expressly incorporated herein by reference.

1. Field of the Invention

[0002] The present invention relates to compressors and, particularly, to rotary compressors.

2. Description of the Related Art.

[0003] In a rotary compressor, the compression mechanism includes an eccentric positioned within a cylindrical compression chamber. A vane extending from the cylindrical wall of the compression chamber contacts a roller positioned around the eccentric and divides the compression chamber into compression and suction pockets. As the eccentric and, correspondingly, the roller move through the compression chamber, the compression pocket decreases in volume to compress a working fluid contained therein. At the same time, the suction pocket is increasing in volume and drawing working fluid into the suction pocket. As the eccentric and roller continue to rotate, the portion of the roller contacting the wall of the compression chamber passes by the vane. When this occurs, the suction pocket becomes the compression pocket.

[0004] Due to the rotation of the eccentric through the compression mechanism, a counterweight must be used to keep the crankshaft and other components of the compressor in balance. However, as the size of the rotary compressor increases, the size of the eccentric and its corresponding counterweight also increase. Additionally, in order to obtain proper balance, two counterweights may be used. For example, in some rotary compressors, a first counterweight is positioned at the end of the crankshaft opposite the eccentric and on the same side as the eccentric, while a second counterweight is position between the eccentric and the first counterweight on the opposite side of the crankshaft as the eccentric and the first counterweight. In order for the second counterweight to effectively balance the system, the mass-eccentricity of the second counterweight must be equal to the sum of the mass-eccentricities of the first counterweight and the eccentric and the roller. Thus, as rotary compressors increase in volume, i.e., provide compression in the range of 5 to 10 tons, the eccentrics and corresponding counterweights also increase in size. As a result, the size of the counterweights make both the design and assembly of such a compressor increasingly difficult. For example, the height of the compressor must be increased to provide room for the counterweights and the counterweight attachments must be made stronger to accommodate increased centrifugal forces.

SUMMARY

[0005] The present invention relates to compressors and, particularly, to rotary compressors. In one exemplary embodiment, the eccentric on the crankshaft of a rotary compressor, as well as the roller that surrounds the eccentric, is replaced by an elongated, preferably elliptical, cam that acts as a double eccentric. In this manner, the elliptical cam provides for inherent balancing of the crankshaft and other components of the compressor, eliminating the need to use counterweights. Specifically, the elliptical cam is symmetrical, resulting in equal inertial forces acting on opposing sides of the elliptical cam. This allows the elliptical cam to maintain its balance throughout its rotation, even when operating at a high rate of revolution. Additionally, because pressure forces from the compression pockets are equal and opposite in direction, bearing loads are reduced which allows for the use of a smaller bearing. This, in turn, reduces the viscous frictional losses associated with shearing of oil in the bearings, which increases mechanical efficiency.

[0006] Advantageously, eliminating the use of counterweights in the rotary compressor of the present invention decreases the overall height and size of the compressor. Additionally, it allows for the rotary compressor to be utilized to compress larger volumes of working fluid and also eliminates the need to provide a roller surrounding an eccentric on the crankshaft.

[0007] In another exemplary embodiment, the present invention includes an open suction pressure channel that extends along an inner surface of the compression mechanism of the compressor to draw suction pressure working fluid into the opposing working pockets defined by the elliptical cam. In another exemplary embodiment, a cross passage is formed through the elliptical cam to draw suction pressure working fluid into the opposing working pockets defined by the elliptical cam. By utilizing the open suction pressure channel and/or the cross passage of

the present invention, a single suction port may be provided in the compression mechanism to draw suction pressure working fluid into both working pockets of the compression mechanism.

[0008] Additionally, in one exemplary embodiment, the outboard journal bearing is eliminated and the crankshaft of the compressor includes only a single journal bearing, i.e., the main bearing, which is positioned between the cylinder and the motor. Elimination of the outboard journal reduces the viscous friction losses of the compressor and increases mechanical efficiency. Also, because the outboard journal consists of precisely machined surfaces, its elimination reduces the cost of manufacturing the compressor.

[0009] In one form thereof, the present invention provides a rotary compressor having an outer hermetic housing, a motor and a cylinder having an inner cylindrical surface including a plurality of slots formed therein, the inner cylindrical surface defining a substantially cylindrical bore. A crankshaft includes an elongate cam, either integral therewith or attached thereto, which is rotatably disposed within the cylinder block such that the outer surface of the elongate cam contacts the inner cylindrical surface of the cylinder block at two circumferentially spaced positions to form a pair of working pockets. First and second vanes are positioned at least partially within the slots in the cylinder block and biased inwardly to contact the outer surface of the elongate cam. An outboard thrust bearing is positioned adjacent the cylinder block and a main bearing positioned adjacent the cylinder block at an axial end thereof and at least partially defining a discharge port in fluid communication with the working pockets at certain rotation angles of the elongate cam. A suction pressure inlet is in communication with the working pockets at certain angles of rotation of the cam to supply suction pressure working fluid into the working pockets.

[0010] In another form thereof, the present invention provides a rotary compressor having an outer hermetic housing, a motor and a cylinder having an inner cylindrical surface including a plurality of slots, the inner cylindrical surface defining a substantially cylindrical bore. A crankshaft having an elongate cam thereon is rotatably disposed within the cylinder block such that the outer surface of the cam contacts the inner surface of the cylinder block at two circumferentially spaced positions to form a pair of working pockets. First and second vanes at least partially positioned within the slots are biased inwardly to contact the outer surface of the elongate cam. An outboard thrust bearing is positioned adjacent the cylinder block and defines a suction pressure passage therein, the suction pressure passage in simultaneous fluid communication with each of the working pockets at certain rotation angles of the cam to draw suction pressure working fluid from a suction pressure inlet to both of the working pockets. A main bearing is provided adjacent the cylinder and at least partially defines a discharge port in fluid communication with the working pockets at certain rotation angles of the elongate cam.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The above-mentioned and other features and advantages of this invention, and the manner of attaining them, will become more apparent and the invention itself will be better understood by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawings, wherein:

[0012] Fig 1 is a perspective view of a rotary compressor in accordance with an embodiment of the present invention;

[0013] Fig. 2 is a plan view thereof;

[0014] Fig. 3 is a sectional view thereof taken along one A-A of Fig. 2 and viewed in the direction of the arrows, wherein the section is taken through the suction port;

[0015] Fig. 4 is a sectional view thereof taken through the vanes;

[0016] Fig. 5 is a sectional view thereof taken through the discharge ports;

[0017] Fig. 6 is a transverse sectional view of the compressor taken through the cylinder;

[0018] Fig. 7 is a perspective view of the outboard thrust bearing showing the suction panel

[0019] Fig. 8 is a perspective view of the main bearing;

[0020] Fig. 9 is a perspective view of an alternative crankshaft and cam design; and

[0021] Fig. 10 is a sectional view of the alternate embodiment.

DETAILED DESCRIPTION

[0022] Fig. 1 illustrates the rotary compressor 10 forming one embodiment of the present invention. Compressor 10 includes an outer hermetic housing 12 including center portion 14 to which upper and lower caps 16 and 18 are connected, such as by welding. A conventional suction accumulator 20 having inlet 22 and outlet suction line 24 is connected to the center portion 14 of compressor 10 by means of mounting strap 26. Compressed refrigerant is discharged from high pressure housing 12 through discharge line 28. Compressor 10 may be a component of a heating and/or cooling circuit and functions to compress the working fluid, such as a refrigerant, which may be a hydrofluorocarbon, chlorofluorocarbon, hydrochlorofluorocarbon, or carbon dioxide refrigerant, for example.

[0023] Turning now to Figs. 3-5, motor 30 and compression mechanism 32 are mounted within hermetic housing 12. Oil sump 41 (Fig. 3) is formed in the lower portion of hermetic housing 12. The motor includes stator 34 and rotor 36. Compression mechanism 32 comprises a cylinder 34 that is rigidly connected to the inner surface 35 of housing center section 14, a main bearing 36 fastened to cylinder 34 by means of a plurality of screws 38 and an outboard thrust bearing 40 connected to cylinder 34 by means of a plurality of screws 42. Suction line 24 extends through the center section 14 of housing 12 and is sealably joined to cylinder block 34 in communication with suction port 44 which opens into the wall of cylinder bore 50.

[0024] An elongate cam 46, which is preferably elliptical, is preferably integrally connected with crankshaft 14, although alternatively it may be a separate element connected by any suitable means. Shaft 64 is rotationally secured to rotor 28 and, as shown in Fig. 6, cam 46 is in sealing engagement with the bore 50 of cylinder 34.

[0025] Extending through elliptical cam 46 and up through shaft 48 is oil passage 52. Oil paddle 54 extends from oil passage 52 of elliptical cam 46 and is configured to draw oil upward and into passageway 52 that is in combination with passages 56 in elliptical cam 46. Passages 56 extend through elliptical cam 46 and direct oil into main bearing 36 between elliptical cam 46 and rotor 28 of motor 30. In order to advance the oil further along the journal surface of crankshaft 48 and substantially entirely along main bearing 36, the journal surface of crankshaft 48 may include a spiral groove (not shown). Alternatively, passages 56 may extend into crankshaft 48 and exit crankshaft 48 at a point above main bearing 36 allowing oil exiting passages 56 to pass along the journal surface and through main bearing 36. For example, passages 56 may be in fluid communication with radial discharge passages (not shown) that are positioned above or within main bearing 36. Alternatively, oil passage 52 may extend through the entire length of crankshaft 48 as shown. Oil passage 92 extends from the oil passage 52 of crankshaft 48 to the outboard thrust bearing surface of thrust bearing 40.

[0026] Referring to Fig. 6, slots 58 are formed in cylinder block 34 and have vanes 60 positioned therein. Springs 62 bias vanes 60 radially inwardly toward the center of cylinder 34 during start-up of the compressor. After start-up, discharge pressure working fluid is used to bias vanes 60 radially inwardly. Cylinder 34 includes an inner cylindrical surface defining cylinder bore 50 for rotation of elliptical cam 46 therein.

[0027] By utilizing elliptical cam 46, the need for a roller is eliminated. As a result, any potential wear that may occur between the contact surfaces of the roller and an eccentric is also eliminated. Additionally, elliptical cam 46 is symmetrical and provides for proper balancing of crankshaft 48 and the other rotating components of the compressor while eliminating the need to use counterweights. As a result, the overall height of the compressor utilizing elliptical cam 46 may be reduced.

[0028] As indicated above, vanes 60 are biased toward the center of cylinder bore 50 where they contact exterior surface 66 of elliptical cam 46. Vanes 60 may be coated with a ceramic or other material to lessen the friction generated between vanes 60 and the exterior surface 66 of cam 46. The contact of the outer surface 66 of elliptical cam 46 with the inner cylindrical surface of bore 50 at two circumferentially spaced positions and the biasing of vanes 60 against surface 66 forms two working pockets 68 that are defined by vanes 60, elliptical cam 46 and cylinder 34.

[0029] Referring to Figs. 3-5, working pockets 68 are sealed on opposite axial sides thereof by outboard bearing 40 and main bearing 36. Outboard bearing 40 includes thrust surfaces 70, 71 upon which elliptical cam 46 is supported. During rotation of crankshaft 48, elliptical cam 46 bears against and rotates on thrust surfaces 70, 71. The surface of elliptical cam 46 that contacts surfaces 70, 71 as well as surfaces 70, 71 and thrust surface 72 (Fig. 8) of main bearing 36 are finely machined surfaces that cooperate to seal working pockets 68.

[0030] As shown in Figs. 3 and 7, outboard bearing 40 includes suction pressure channel 74 formed therein. Channel 74 extends around oil passage 76 formed by boss 73 in outboard bearing 40 and is formed as an open channel that is in fluid communication with bore 50 in cylinder 34.

[0031] Referring to Fig. 6, as elliptical cam 46 moves in a clockwise direction, the volume of working pockets 68 is increased and suction pressure working fluid is drawn into working pockets 68. Specifically, suction pressure working fluid passes through suction port 44 in block 34 to enter the proximal working pocket 68 and suction pressure channel 74. In order to equalize the pressure in working pockets 68, suction pressure working fluid is drawn through suction pressure channel 74, passing under elliptical cam 46, around aerodynamically shaped diverters 78, to enter distal working pocket 68. By utilizing a single suction port 44 to draw suction pressure working fluid into compression mechanism 32, the cost of machining and assembling compression mechanism 32 is reduced. The tapered portions 78 forming the diverters are aligned with the longitudinal axis of slot 74 to thereby smooth the flow of suction fluid around boss 73.

[0032] As elliptical cam 46 continues to rotate, the portions of cam 46 contacting cylindrical surface 50 pass vanes 60. At this point, the volume of working pockets 68 begins to decrease, increasing the pressure of the working fluid contained within pockets 68. As the volume of working pockets 68 continues to decrease with the rotation of elliptical cam 46, working fluid within working pockets 68 reaches a pressure substantially equal to discharge pressure. Once that pressure has been reached, flapper valves 82 open and the working fluid is discharged through discharge ports 80 (Fig. 5) in cylinder 34 and main bearing 36. Flapper valves 82, which are positioned above ports 80, allow for discharge pressure working fluid to flow into the interior of housing 12 but operate in a known manner to prevent discharge pressure working fluid from reentering ports 80 once discharged. Also shown are valve retainers 84 and muffler 86. Discharge pressure working fluid flows past motor 30 and out discharge line 28.

[0033] In addition to, or alternatively to, suction pressure channel 74 in outboard bearing 40, main bearing 36 may be provided with a suction pressure channel 88 that extends between working pockets 68 and around boss 90 (Fig. 8).

[0034] With reference to Figs. 9 and 10, an alternative embodiment is disclosed. In this embodiment, cross passages 94 extending through elliptical cam 96 of crankshaft 98 allow for suction pressure working fluid received through suction port 44 to pass between working pockets 68. Specifically, such pressure working fluid as received through suction port 44 enters the proximal working pocket 68 and then passes through cross passages 94 into the distal working pocket 68. As shown in Fig. 10, cross passages 94 are oriented at a slight angle relative to the major chord of the ellipse defined by elliptical cam 96 so that cross passages 94 are never in fluid communication with the discharge side of the contact points between cam 96 and bore 50. Passages 94 and suction pressure channel 70 may possibly be used in conjunction with one another or, alternatively, employed separately. For example, in one embodiment, suction pressure channel 74 is present and passages 94 are absent. In another alternative embodiment, passages 94 are present and suction pressure channel 74 is absent.

[0035] In addition to the benefits described above, the use of elongate cam 46 also eliminates the need for an outboard journal bearing. In a typical rotary compressor, the outboard journal extends around the oil paddle and through an opening in the outboard bearing. The interaction of the journal with the portion of the outboard bearing that defines the opening prevents off-centered movement of the crankshaft and eccentric during rotation of the crankshaft. By utilizing the elliptical cam of the embodiment of the present invention, the interaction of opposing pressure forces on exterior surface 66 of cam 46 substantially eliminates the need for an outboard journal on crankshaft 48. By eliminating the need for this journal, which must be formed as a highly machined surface, the need to create a correspondingly highly machined journal and outboard bearing 40 is also eliminated. As a result, the cost of manufacturing a rotary compressor in accordance with this embodiment of the invention is substantially reduced.

[0036] While this invention has been described as having a preferred design, the present invention can be further modified within the spirit and scope of this disclosure. This application is therefore intended to cover any variations, uses, or adaptations of the invention using its general principles. Further, this application is intended to cover such departures from the present disclosure as come within known or customary practice in the art to which this invention pertains and which fall within the limits of the appended claims.

WHAT IS CLAIMED IS:

1. A rotary compressor, comprising:

an outer hermetic housing;

a motor having a stator and a rotor;

a cylinder having an inner cylindrical surface including a plurality of slots formed therein, said inner cylindrical surface defining a substantially cylindrical bore;

a crankshaft having an elongate cam, said elongate cam having an outer surface, said elongate cam of said crankshaft being rotatably disposed within said cylinder block, wherein the outer surface of the cam contacts the inner cylindrical surface of the cylinder block at two circumferentially spaced positions to form a pair of working pockets;

a first vane positioned at least partially within one of said plurality of slots of said cylinder, said first vane biased inwardly to contact the outer surface of said elongate cam;

a second vane positioned at least partially within another of said plurality of slots of said cylinder, said second vane biased inwardly to contact the outer surface of said elongate cam;

an outboard bearing positioned adjacent said cylinder block;

a suction pressure inlet in fluid communication with said working pockets to supply suction pressure working fluid to said working pockets; and

a main bearing at least partially defining a discharge port in fluid communication with said working pockets at certain rotation angles of said elongate cam.

2. The compressor of claim 1, wherein:

said main bearing is disposed between said motor and a first axially end of said cylinder, said crankshaft extending through said main bearing and being rotatably supported therein; and

said outboard bearing is an outboard thrust bearing disposed adjacent a second axial end of said cylinder block to support said elongate cam substantially only against axial movement of said cam.

3. The compressor of claim 2, wherein said outboard bearing includes a suction passage therein in fluid communication with said suction inlet and extending across said outboard bearing to a position that is on an opposite side of said elongate cam from said suction inlet, said suction passage being in fluid communication with said working pockets.

4. The compressor of claim 3, wherein said suction passage is formed as a slot in a thrust surface of said outboard thrust bearing facing said cylinder bore.

5. The compressor of claim 4, wherein said suction inlet is on the cylindrical wall of said cylinder bore.

6. The compressor of claim 3, wherein said suction inlet is on the cylindrical wall of said cylinder bore.

7. The compressor of claim 4, wherein said outboard thrust bearing includes an oil passage in communication with an oil sump in said outer housing and a boss surrounding said oil passage, said boss having a side wall including tapered portions aligned with a longitudinal axis of said slot to smooth the flow of suction fluid around said boss.

8. The compressor of claim 3, and including a further suction passage in said main bearing in fluid communication with said working pockets.

9. The compressor of claim 2, and including a suction passage in said main bearing in fluid communication with said working pockets.

10. The compressor of claim 1, wherein said crankshaft is devoid of a counterweight.

11. The compressor of claim 1, including at least one suction fluid cross passage extending through said elongate cam to convey suction pressure fluid between said working pockets.

12. The compressor of claim 11, wherein said elongate cam is elliptical and said cam suction fluid passage is disposed at an angle to a major chord of said elliptical cam.

13. The compressor of claim 1, wherein said elongate cam is elliptical.

14. The compressor of claim 10, wherein said elongate cam is elliptical.

15. A rotary compressor, comprising:

an outer hermetic housing;

a motor having a stator and a rotor;

a cylinder having an inner cylindrical surface including a plurality of slots formed therein, said inner cylindrical surface defining a substantially cylindrical bore;

a crankshaft having an elongate cam, said elongate cam having an outer surface and being rotatably disposed within said cylinder block, the outer surface of said elongate cam contacting the inner cylindrical surface of the cylinder bore at two circumferentially spaced positions to form a pair of working pockets;

first and second vanes positioned at least partially within respective ones of said cylinder slots, said vanes biased inwardly to contact the outer surface of said elongate cam;

an outboard thrust bearing positioned adjacent said cylinder block and defining a suction pressure passage therein, said suction pressure passage in simultaneous fluid communication with each of said working pockets to draw suction pressure working fluid from a suction pressure inlet to both of said working pockets; and

a main bearing at least partially defining a discharge port in fluid communication with said working pockets.

16. The compressor of claim 15, wherein:

said main bearing is disposed between said motor and a first axially end of said cylinder, said crankshaft extending through said main bearing and being rotatably supported therein; and

said outboard thrust bearing is disposed adjacent a second axial end of said cylinder block to support said elongate cam substantially only against axial movement of said cam.

17. The compressor of claim 16, wherein said suction passage is formed as a slot in a thrust surface of said outboard bearing facing said cylinder bore.

18. The compressor of claim 17, wherein said outboard thrust bearing includes an oil passage in communication with an oil sump in said outer housing and a boss surrounding said oil passage, said boss having a side wall including tapered portions aligned with a longitudinal axis of said slot to smooth the flow of suction fluid around said boss.

19. The compressor of claim 15, and including a further suction passage in said main bearing in fluid communication with said working pockets.

20. The compressor of claim 15, wherein said crankshaft is devoid of a counterweight.

21. The compressor of claim 15, wherein said cam is elliptical.

22. The compressor of claim 21, wherein said crankshaft is devoid of a counterweight.

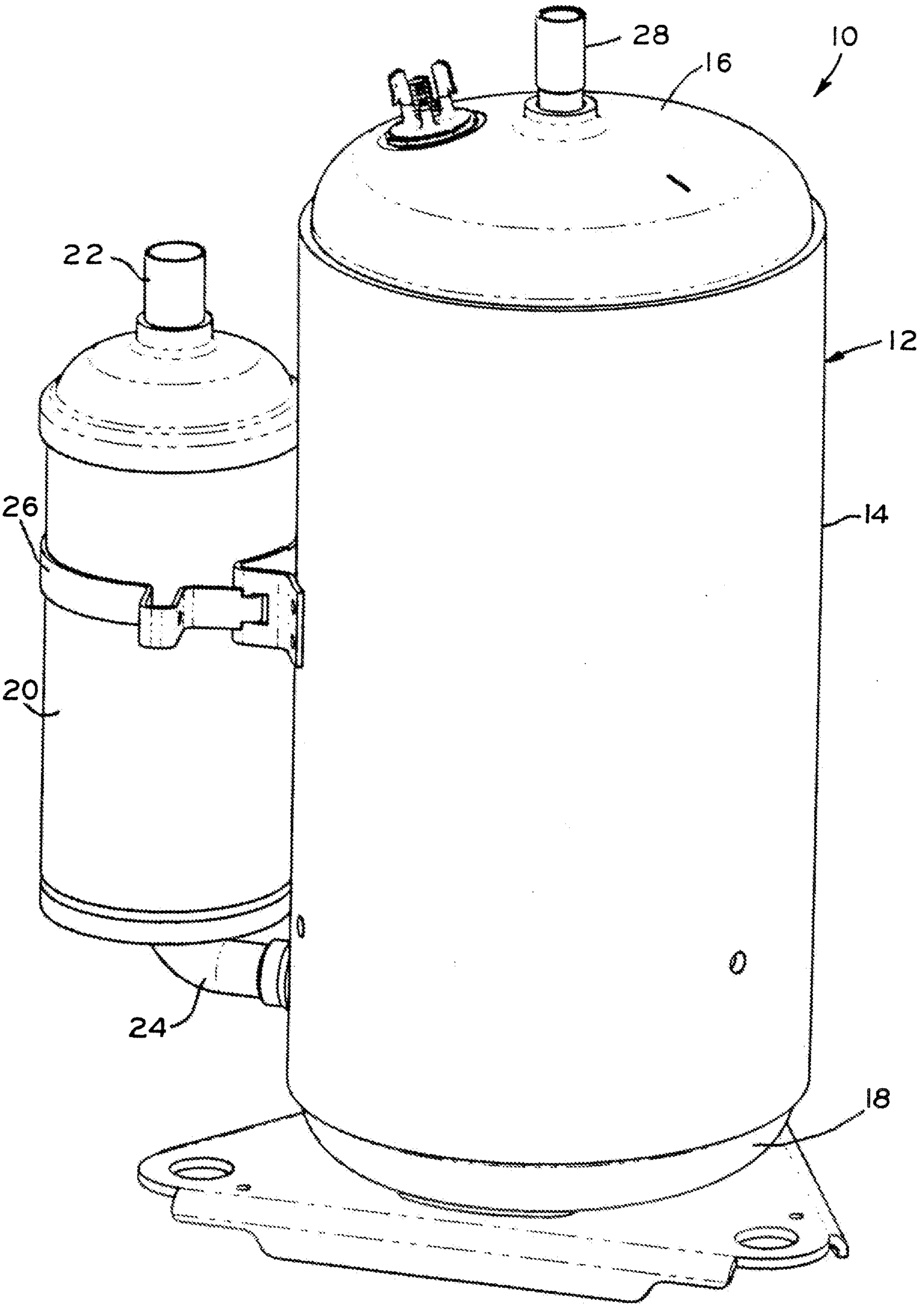

FIG. 1

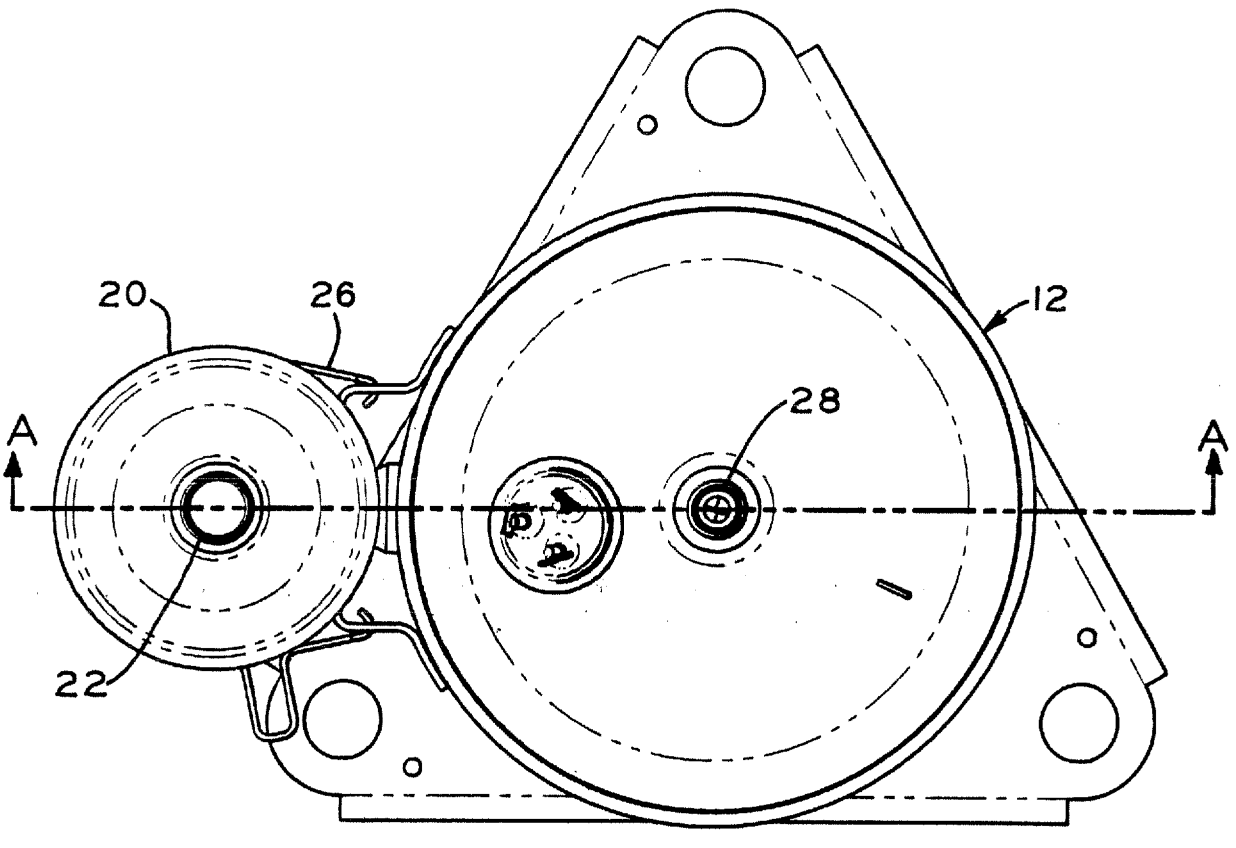

FIG. 2

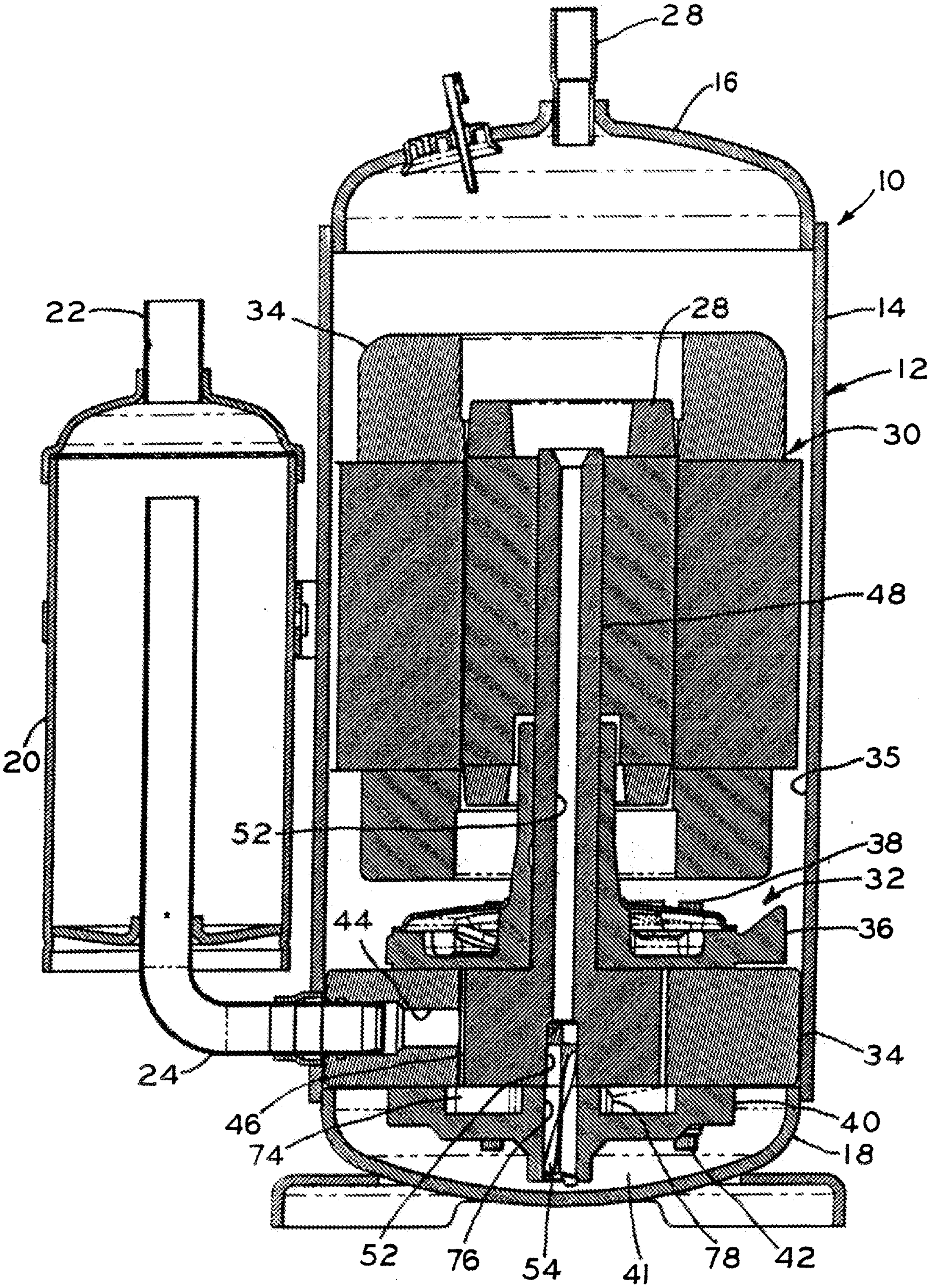
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FIG. 3

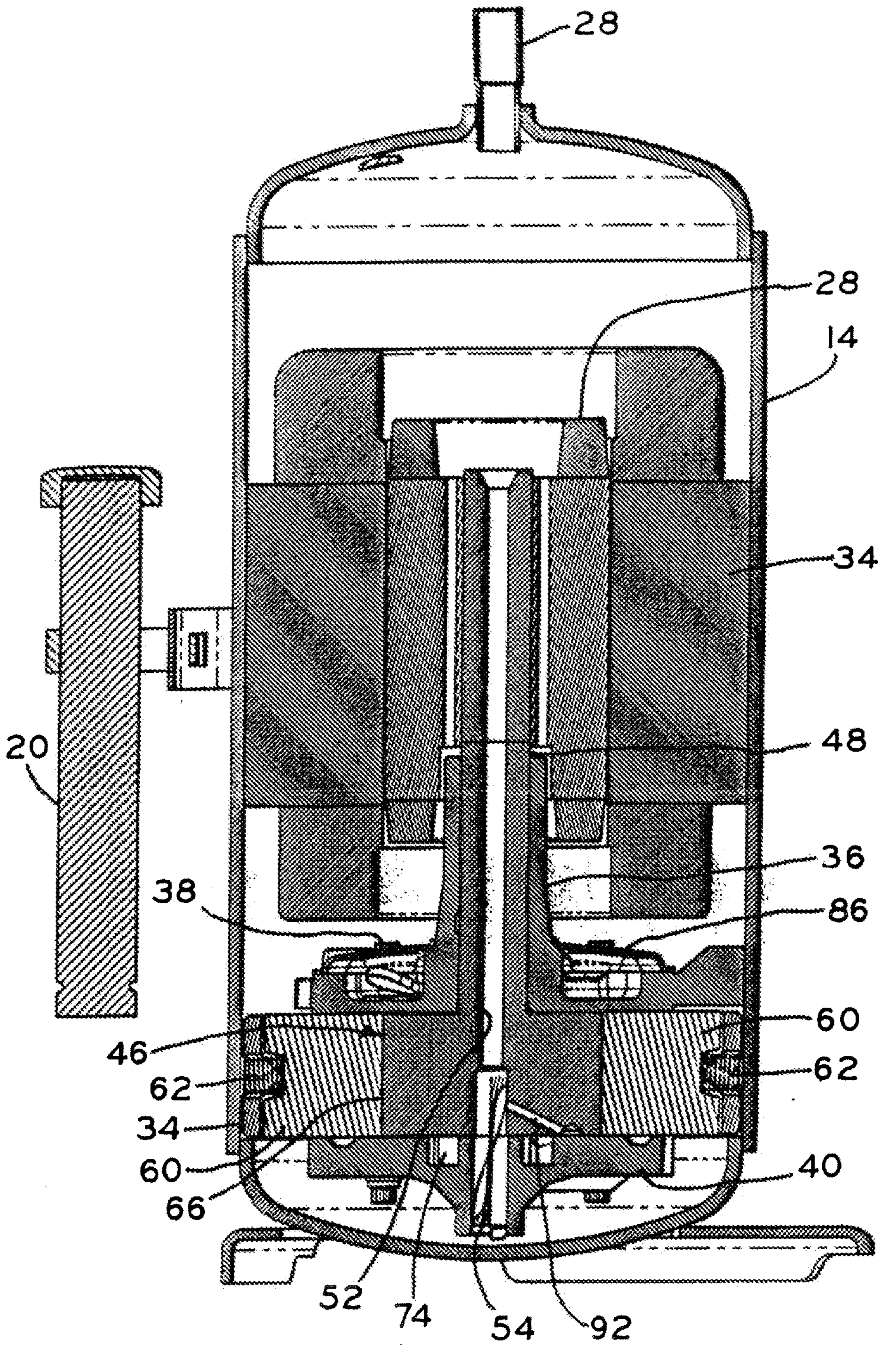

FIG. 4

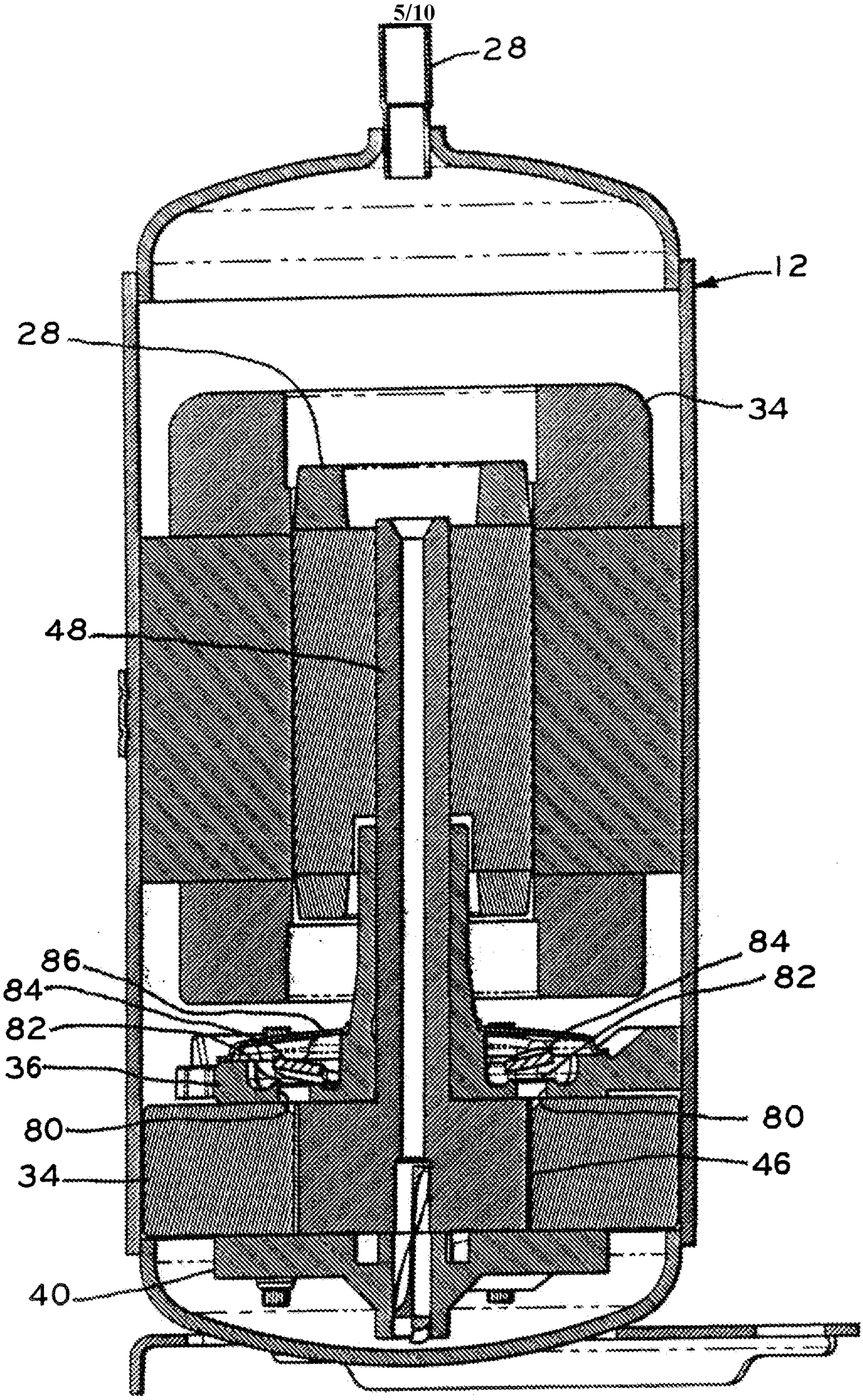

FIG. 5

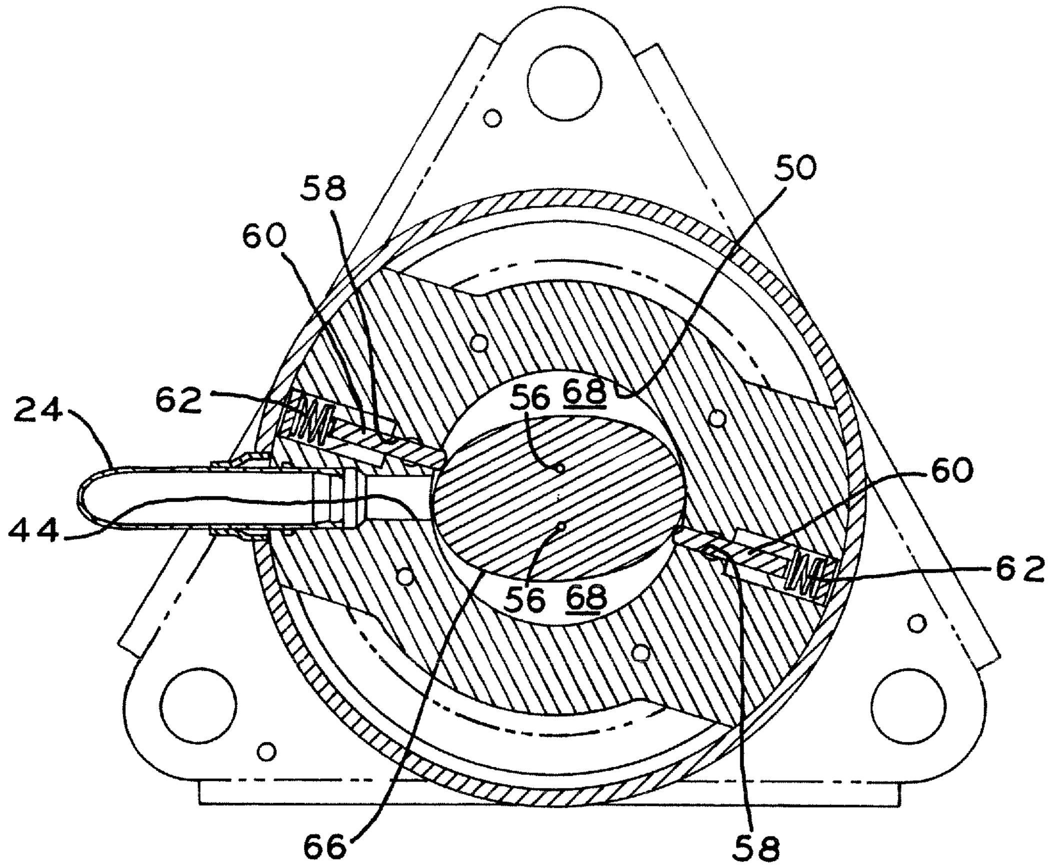

FIG_6

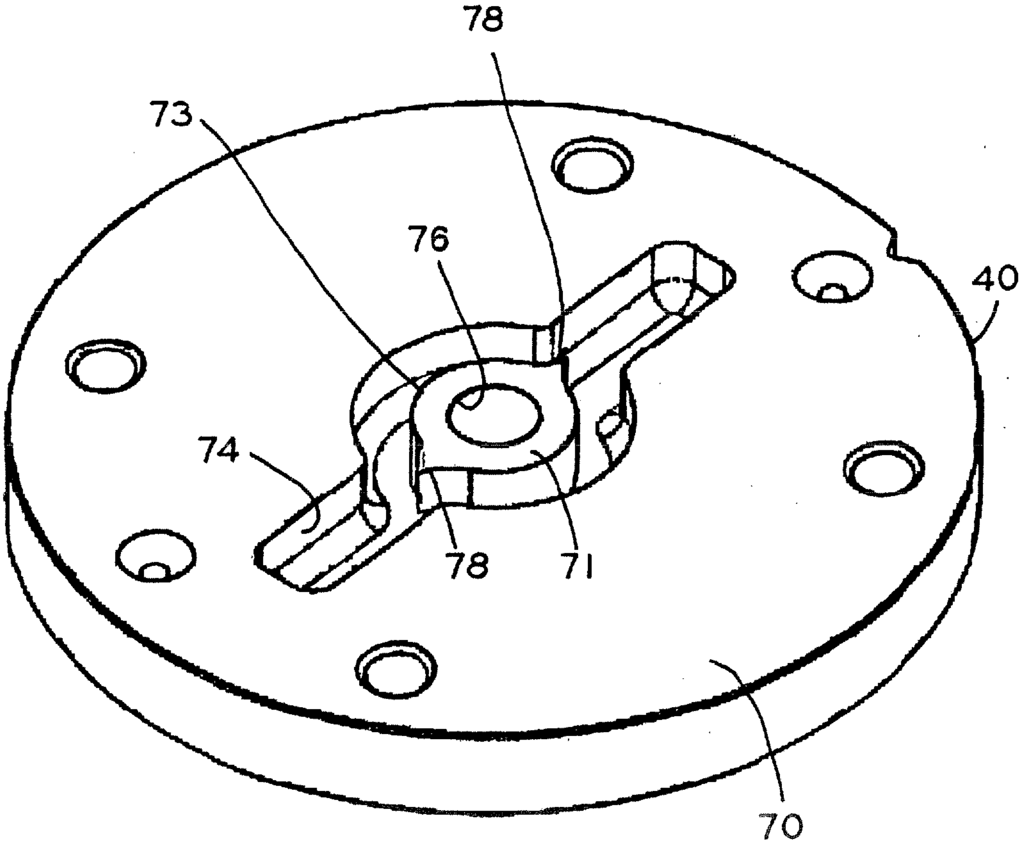

FIG. 7

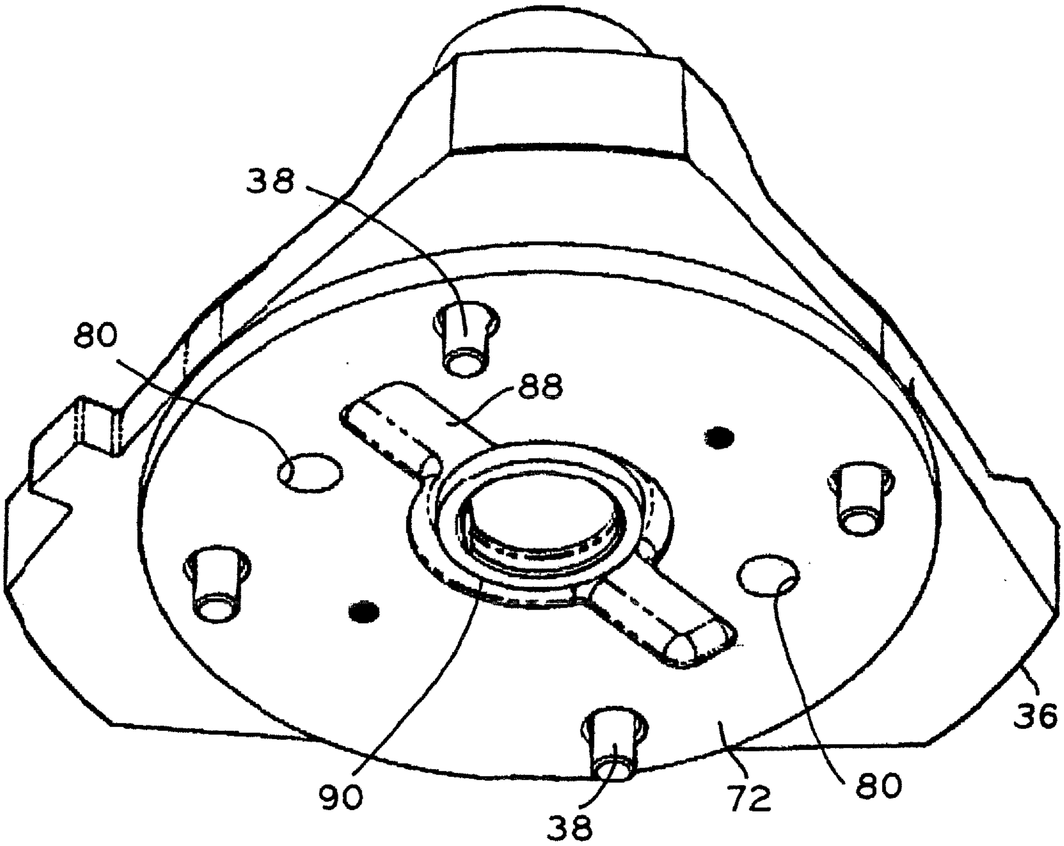

FIG. 8

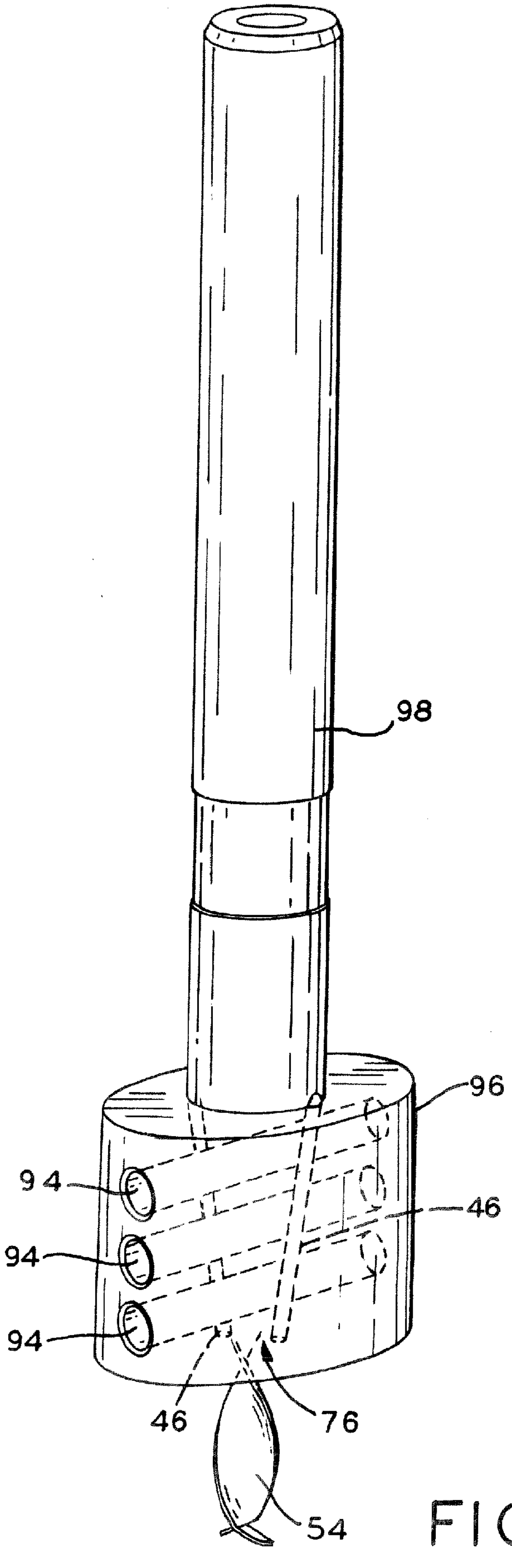

FIG_9

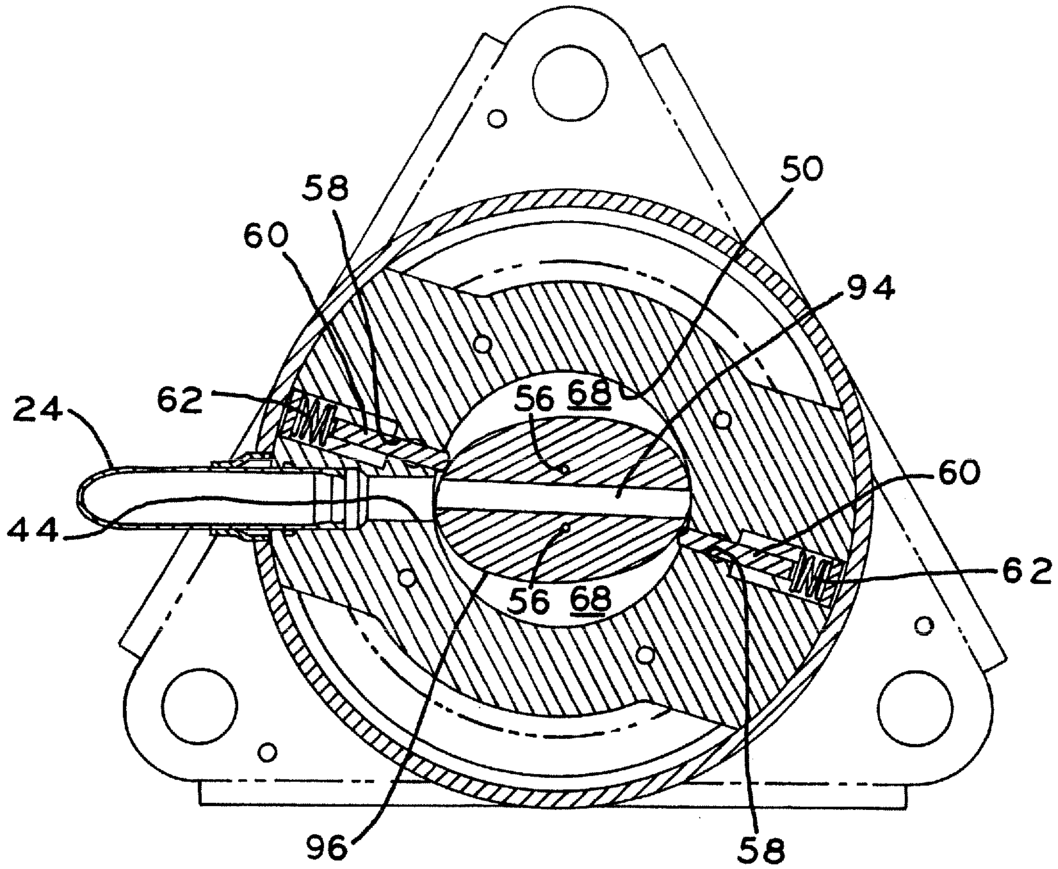

FIG_10