US 20110038740A1

(19) United States
(12) Patent Application Publication
Goertzen et al.
(10) Pub. No.: US 2011/0038740 A1
(43) Pub. Date: Feb. 17, 2011

(54) **COMPRESSOR**

(75) Inventors: **Gerold Goertzen**, Homerville, OH (US); **Michael R. Nemcek**, Avon, OH (US); **Bradley A. Kushner**, Elyria, OH (US); **William A. Null, JR.**, Sullivan, OH (US)

Correspondence Address:
CALFEE HALTER & GRISWOLD, LLP
800 SUPERIOR AVENUE, SUITE 1400
CLEVELAND, OH 44114 (US)

(73) Assignee: **Invacare Corporation**, Elyria, OH (US)

(21) Appl. No.: **12/857,844**

(22) Filed: **Aug. 17, 2010**

Related U.S. Application Data

(60) Provisional application No. 61/234,330, filed on Aug. 17, 2009.

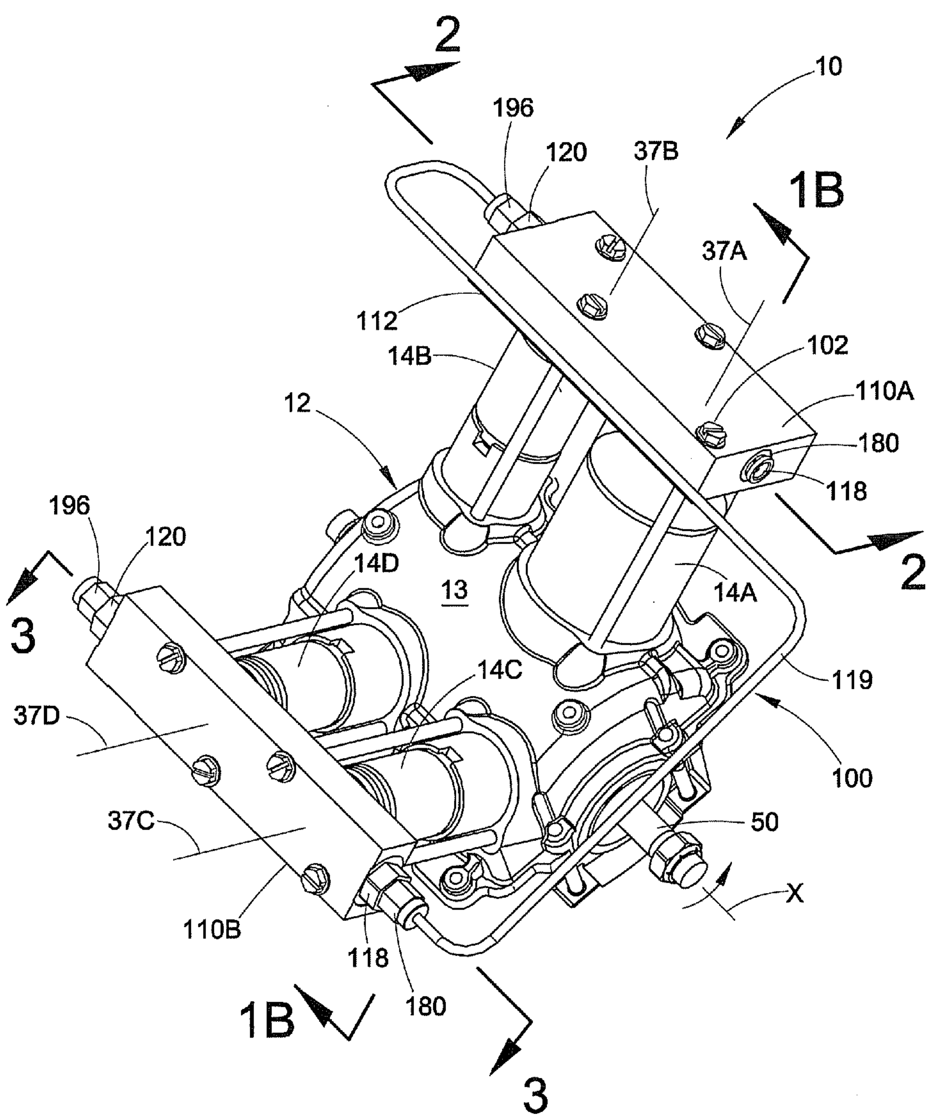
Publication Classification

(51) **Int. Cl.**
F04B 1/04 (2006.01)

(52) **U.S. Cl.** **417/273**

(57) **ABSTRACT**

A compressor includes a cylinder assembly in a V4 configuration. A crankshaft of the compressor has a main shaft and first and second eccentric bodies. The two eccentric bodies drive four pistons.



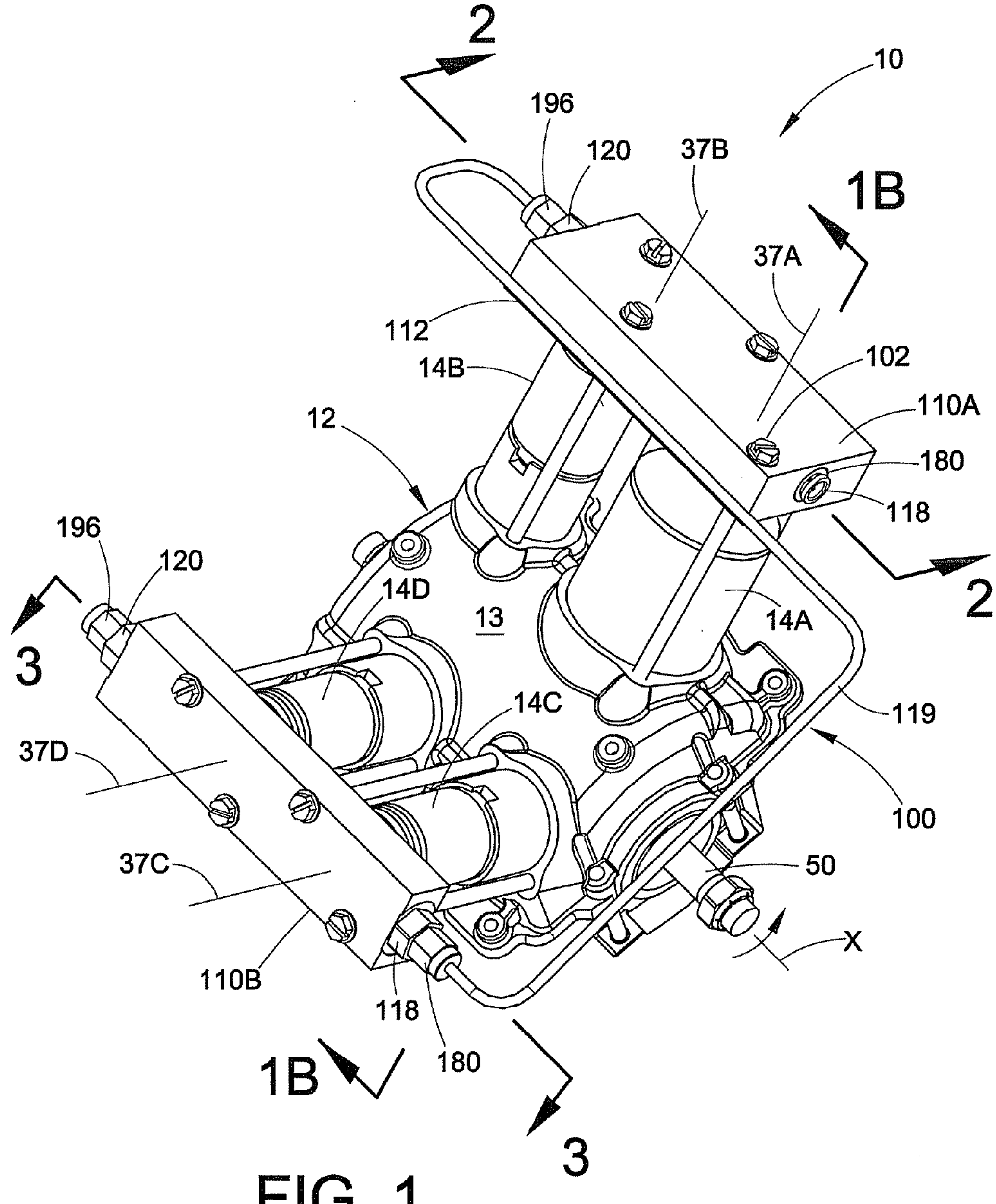

2
10
196
120
37B
1B
37A
112
102
14B
110A
12
180
118
196
120
14D
13
14A
2
3
14C
119
37D
100
37C
50
X
110B
118
180
1B
3

FIG. 1

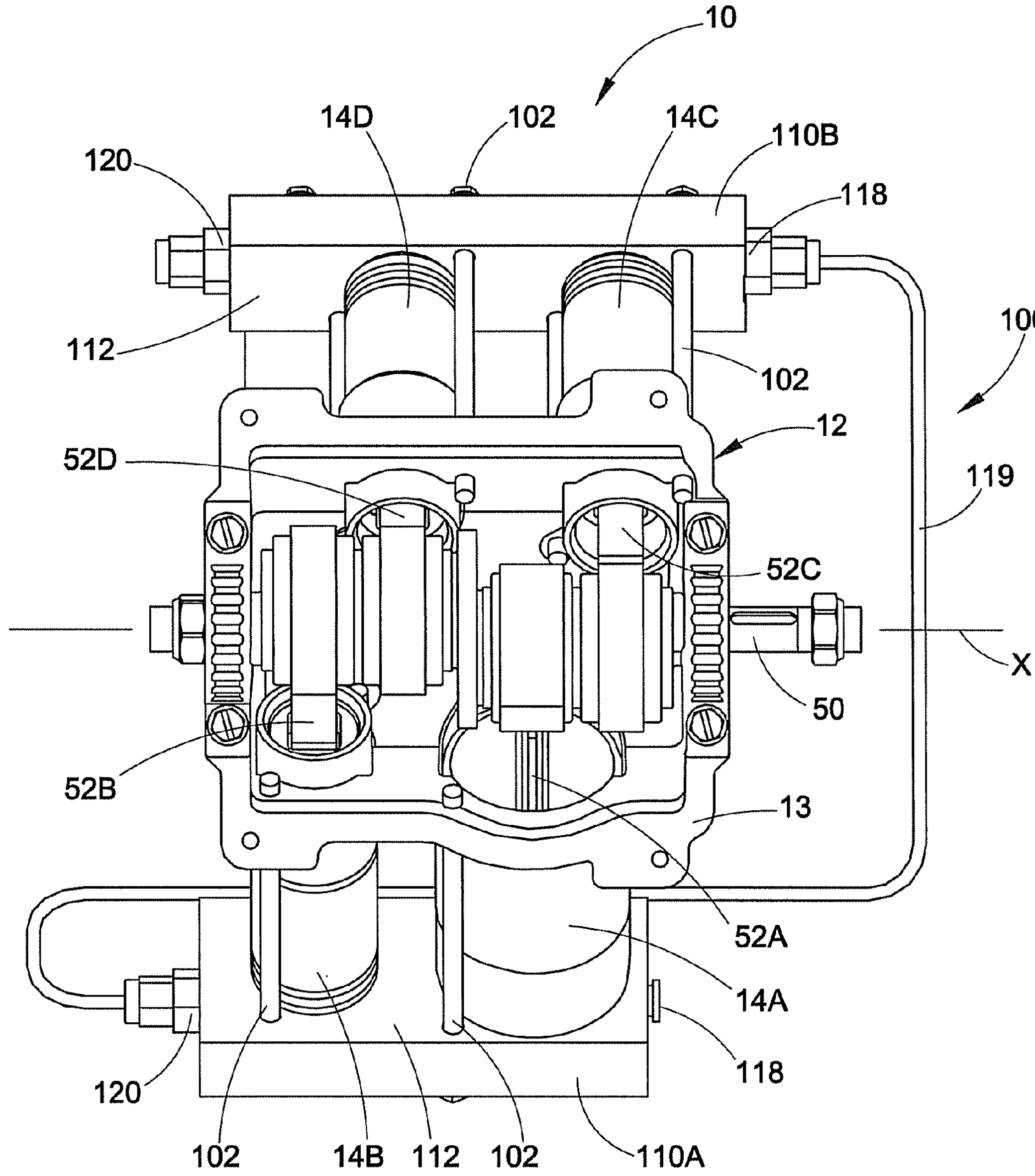

10
14D
102
14C
110B
120
118
100
112
102
12
52D
119
52C
X
50
52B
13
52A
14A
118
120
102
14B
112
102
110A

FIG. 1A

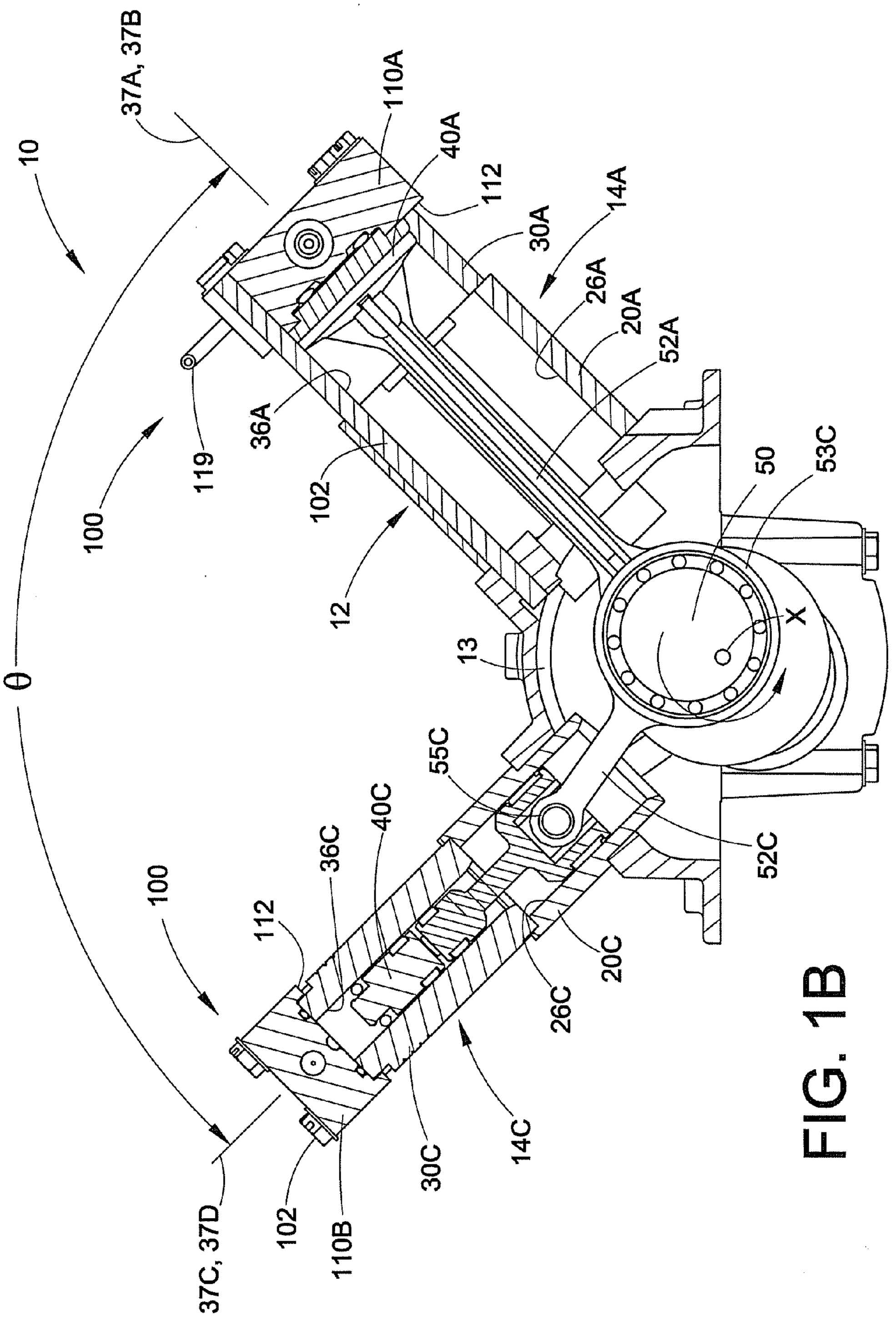

10
37A, 37B
110A
40A
112
30A
14A
26A
20A
52A
36A
119
100
102
12
50
53C
X
13
θ
55C
40C
36C
112
100
52C
20C
26C
14C
30C
102
110B
37C, 37D

FIG. 1B

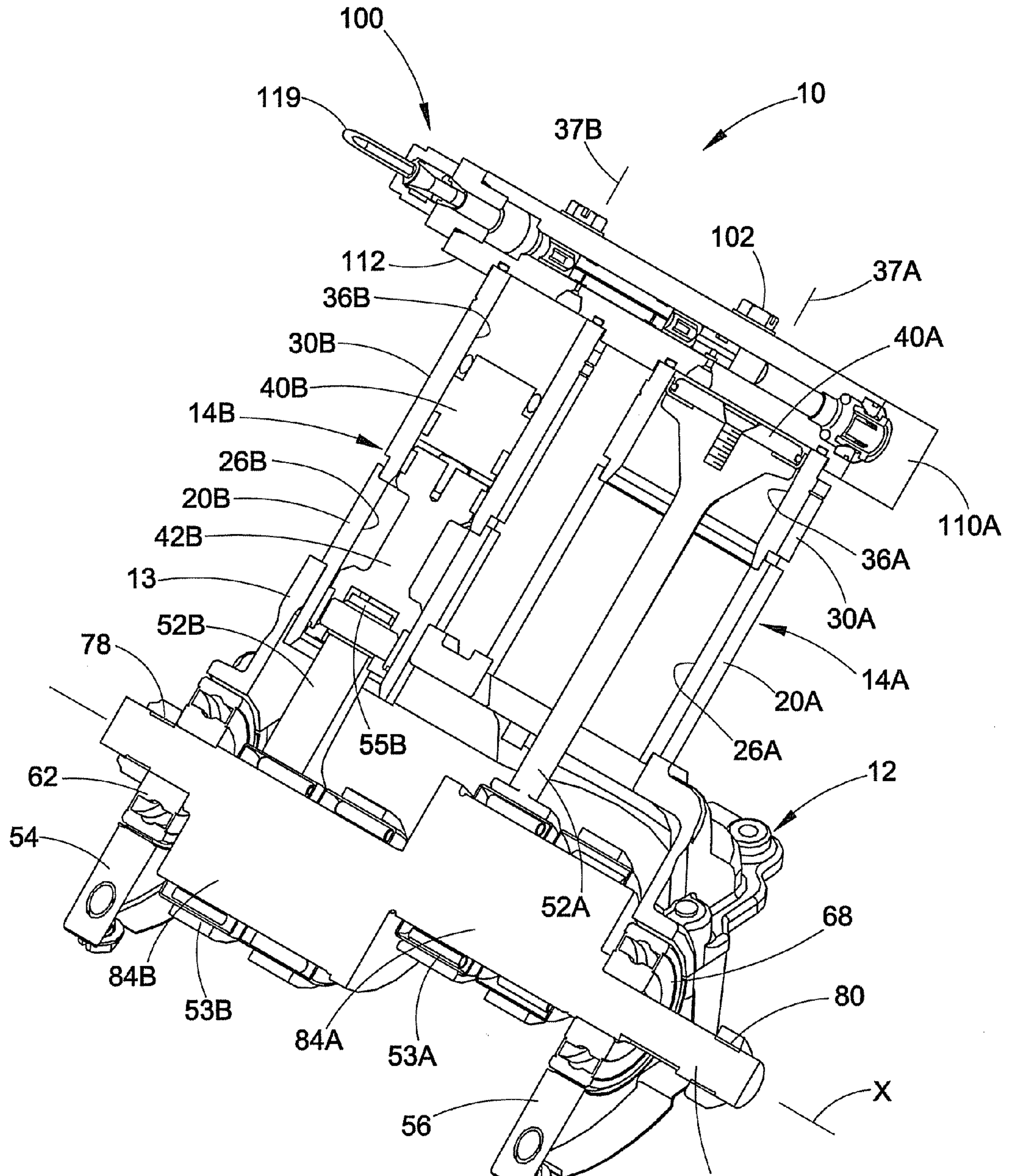

100
10
119
37B
102
37A
112
36B
40A
30B
40B
14B
26B
110A
20B
36A
42B
13
30A
52B
78
14A
20A
55B
26A
62
12
54
52A
68
84B
80
53B
84A
53A
X
56
50

FIG. 2

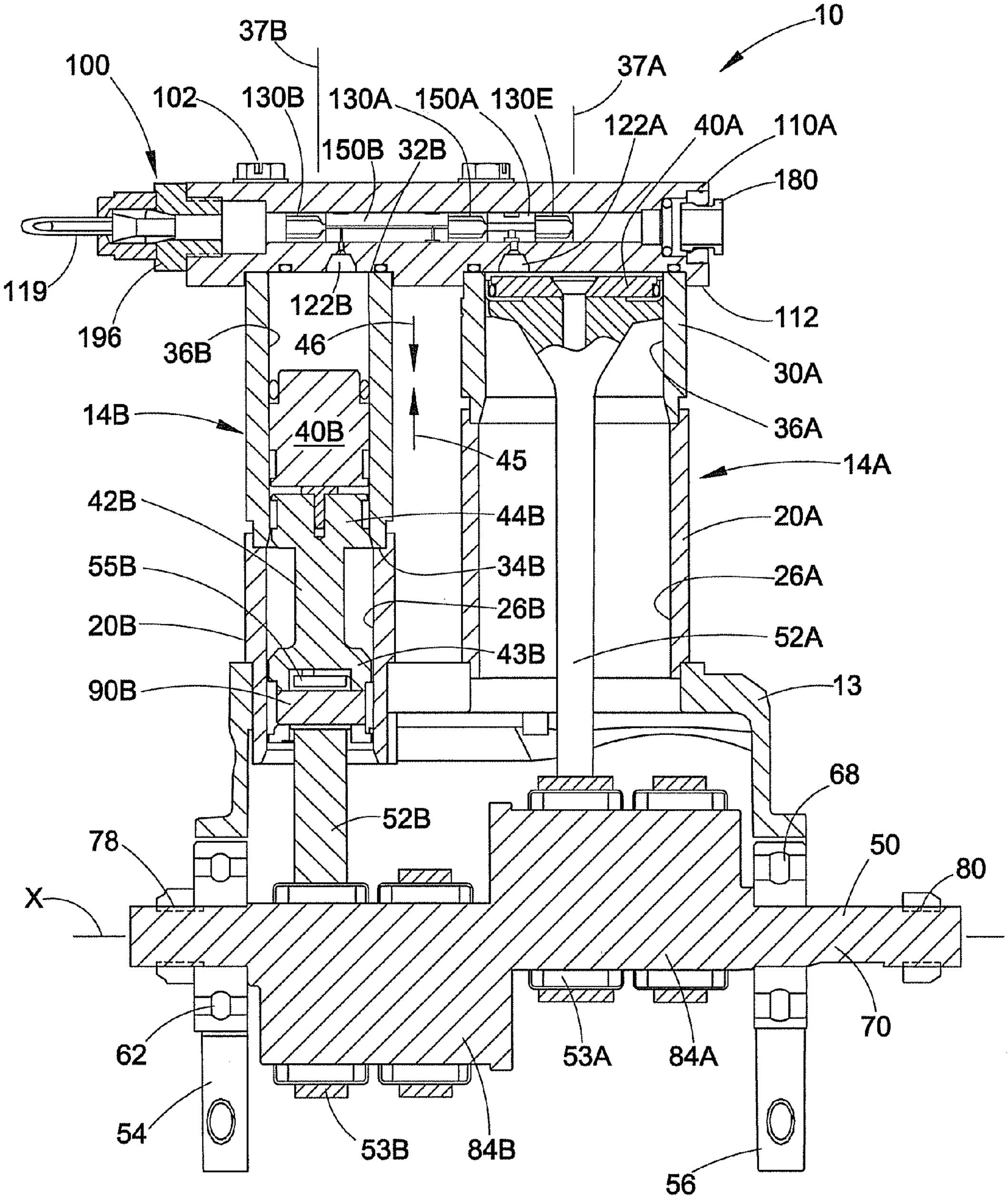

10
37B
37A
100
102
130B
130A
150A
130E
150B
32B
122A
40A
110A
180
119
196
122B
112
36B
46
30A
36A
14B
40B
45
14A
20A
42B
44B
55B
34B
26A
26B
20B
52A
43B
90B
13
68
52B
78
50
80
X
70
62
53A
84A
54
53B
84B
56

FIG. 2A

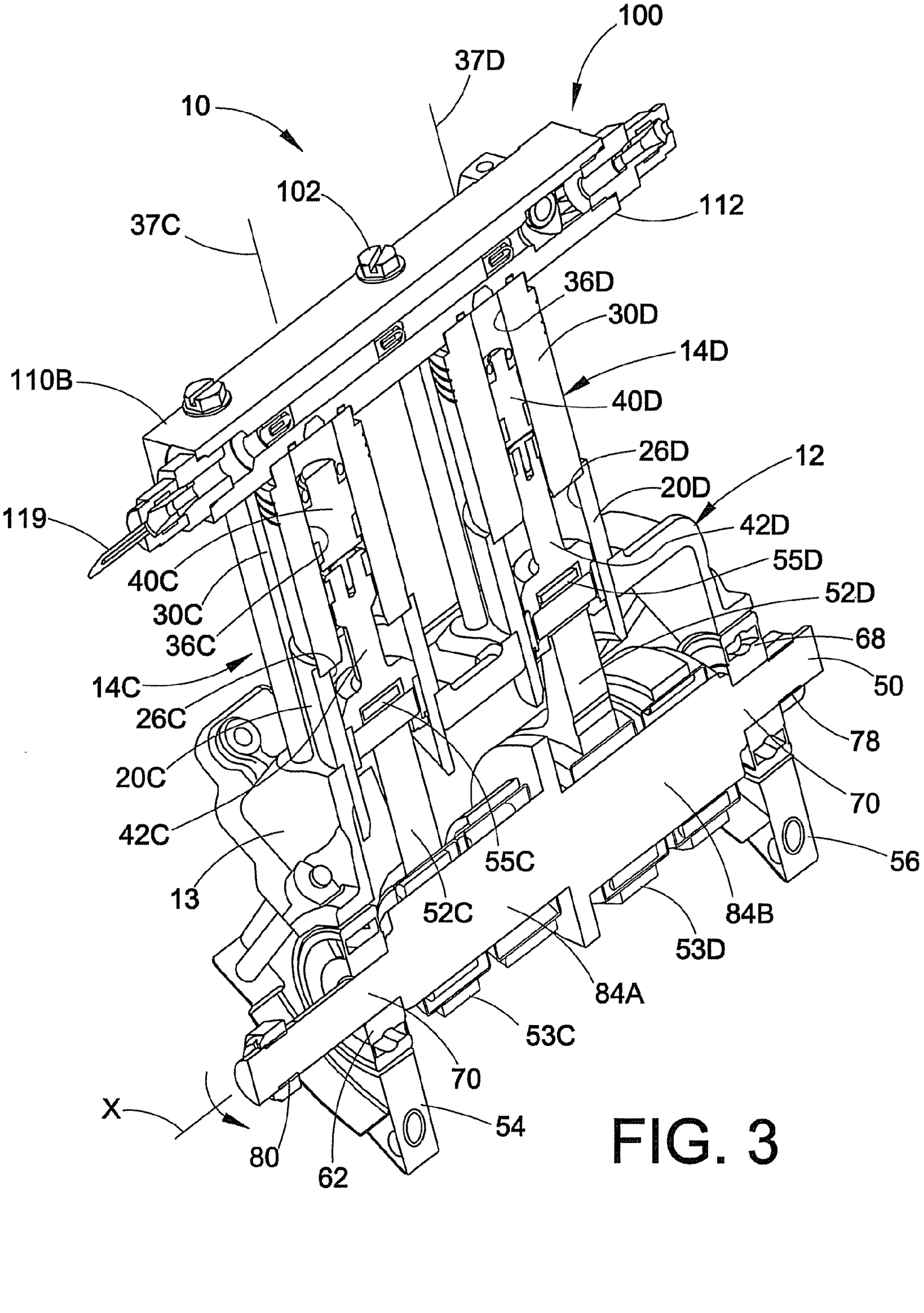

100
37D
10
102
112
37C
36D
30D
14D
110B
40D
26D
12
20D
119
42D
55D
40C
52D
30C
36C
68
50
14C
26C
78
20C
70
42C
56
55C
13
52C
84B
53D
84A
53C
70
X
54
80
62

FIG. 3

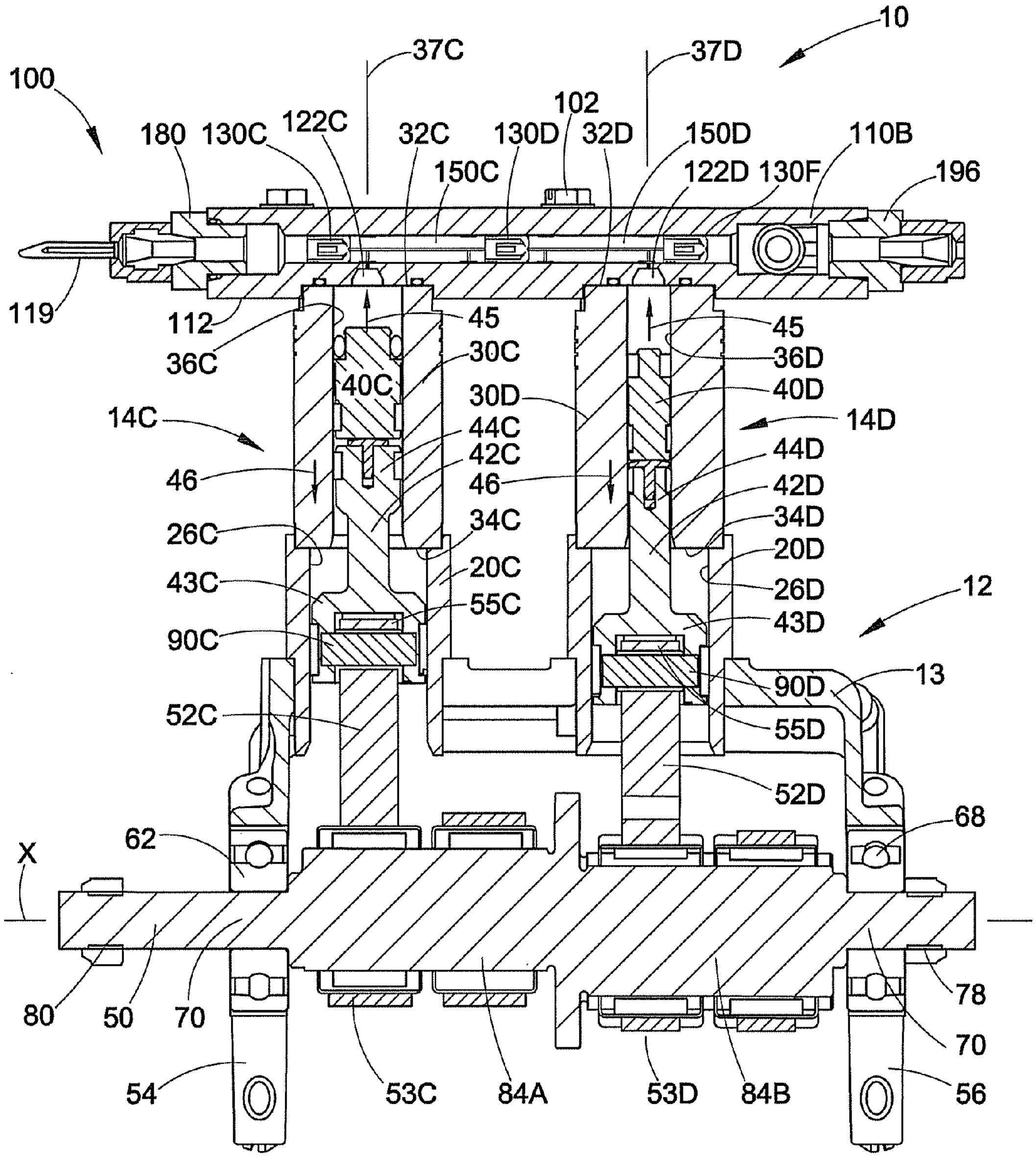

10
100
37C
37D
102
180
130C
122C
32C
150C
130D
32D
150D
122D
130F
110B
196
119
112
45
36C
30C
40C
36D
40D
30D
14C
44C
42C
14D
44D
46
42D
26C
34C
34D
20C
20D
43C
55C
26D
12
43D
90C
13
90D
52C
55D
52D
62
68
X
80
50
70
78
54
53C
84A
53D
84B
56

FIG. 3A

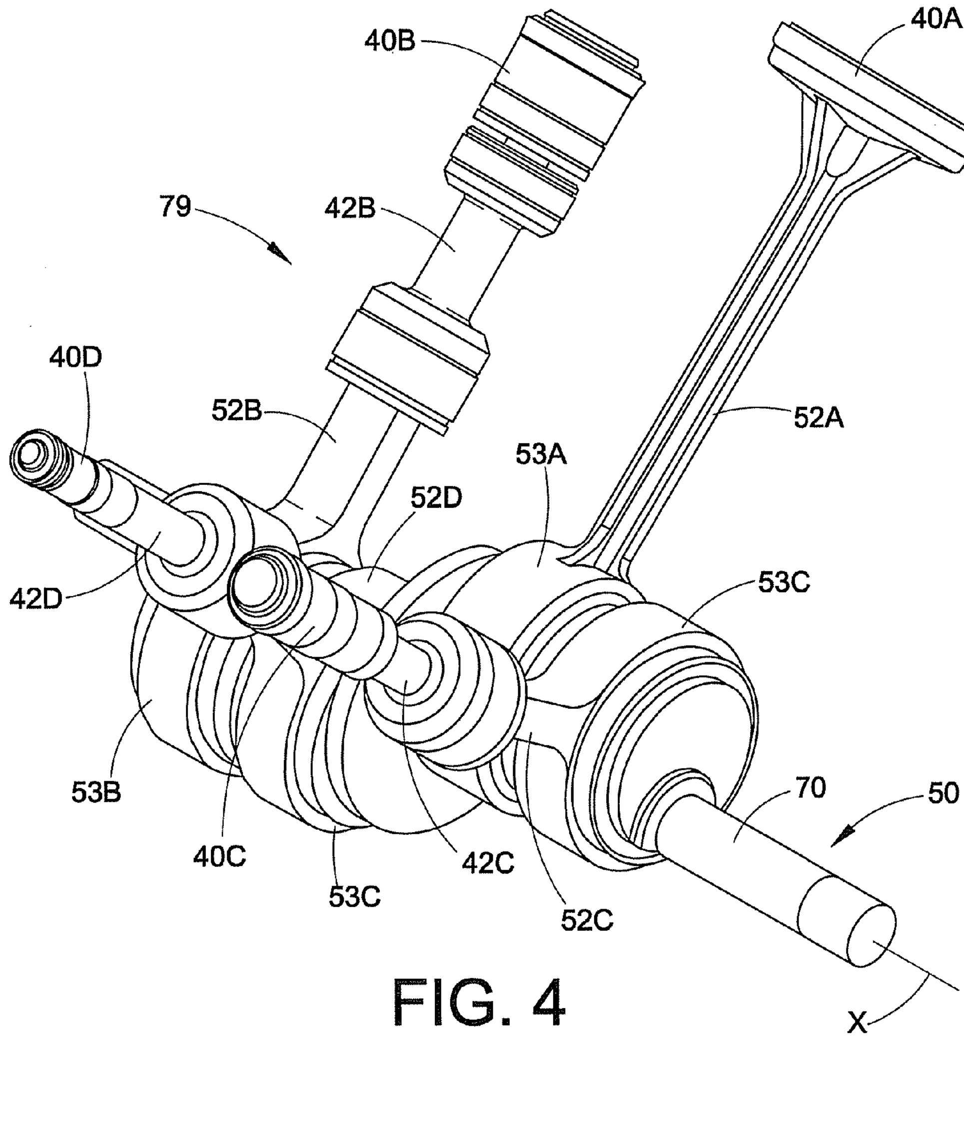

40B
40A
79
42B
40D
52B
52A
53A
52D
42D
53C
53B
40C
53C
42C
70
50
52C
X

FIG. 4

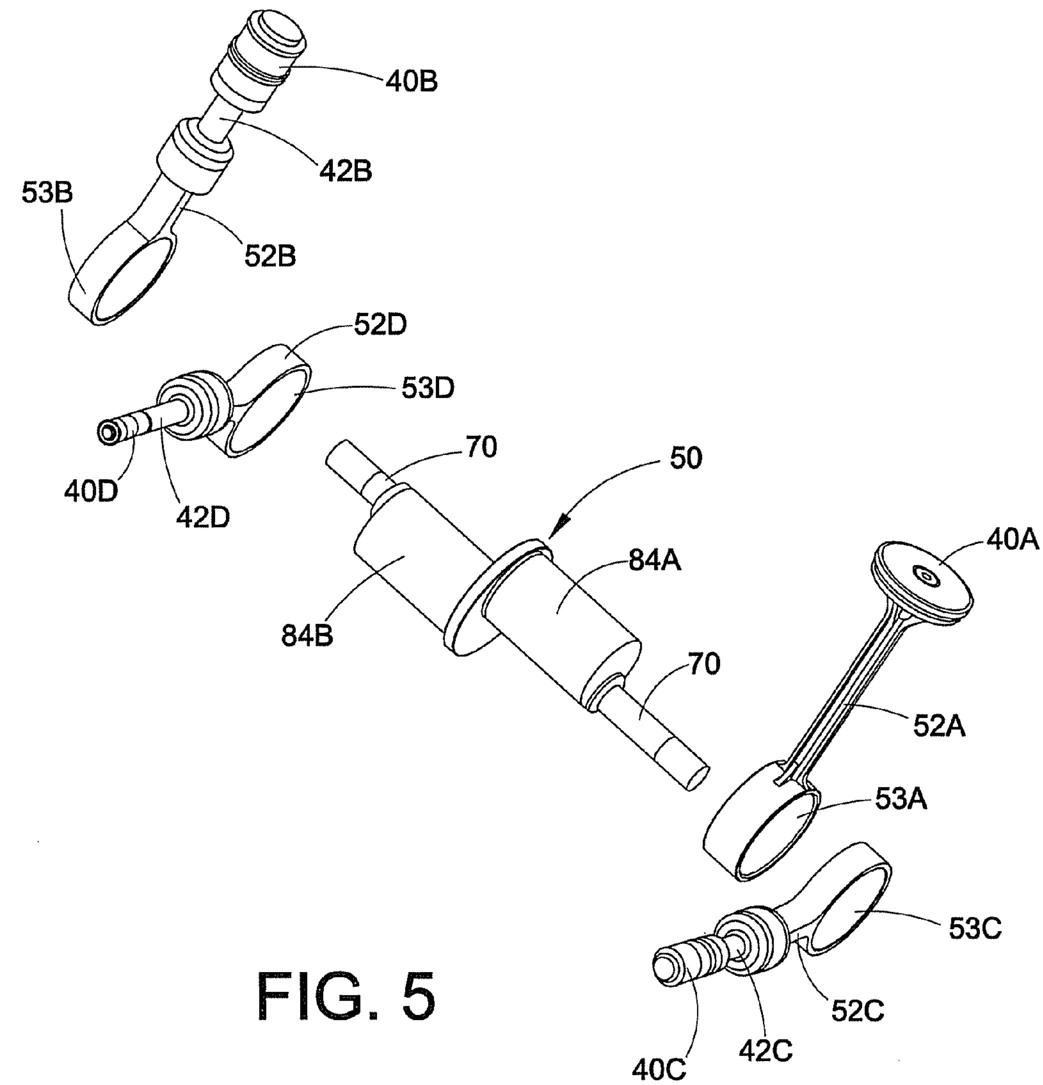

40B
42B
53B
52B
52D
53D
70
50
40D
42D
84A
40A
84B
70
52A
53A
53C
52C
40C
42C

FIG. 5

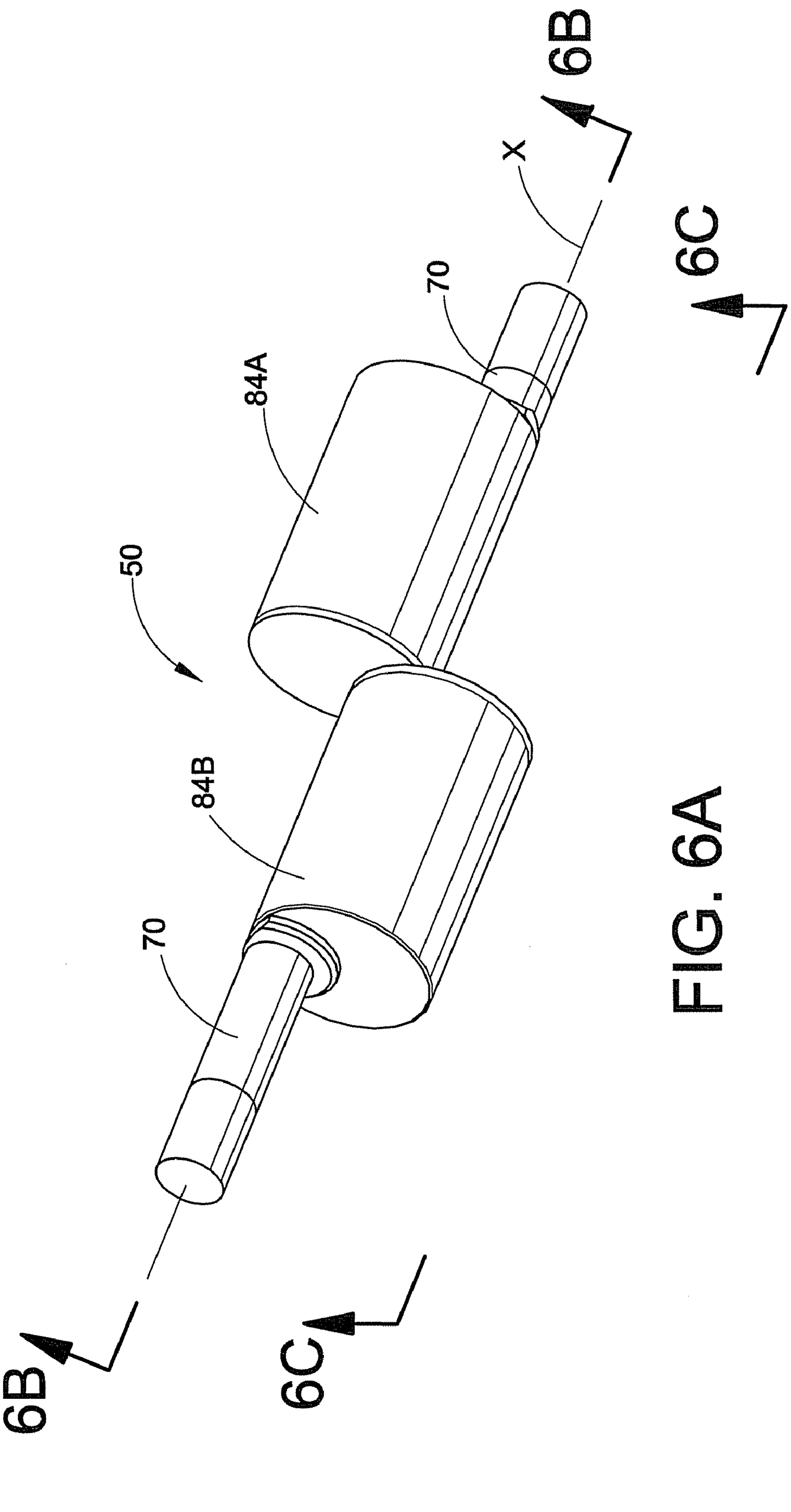


FIG. 6A

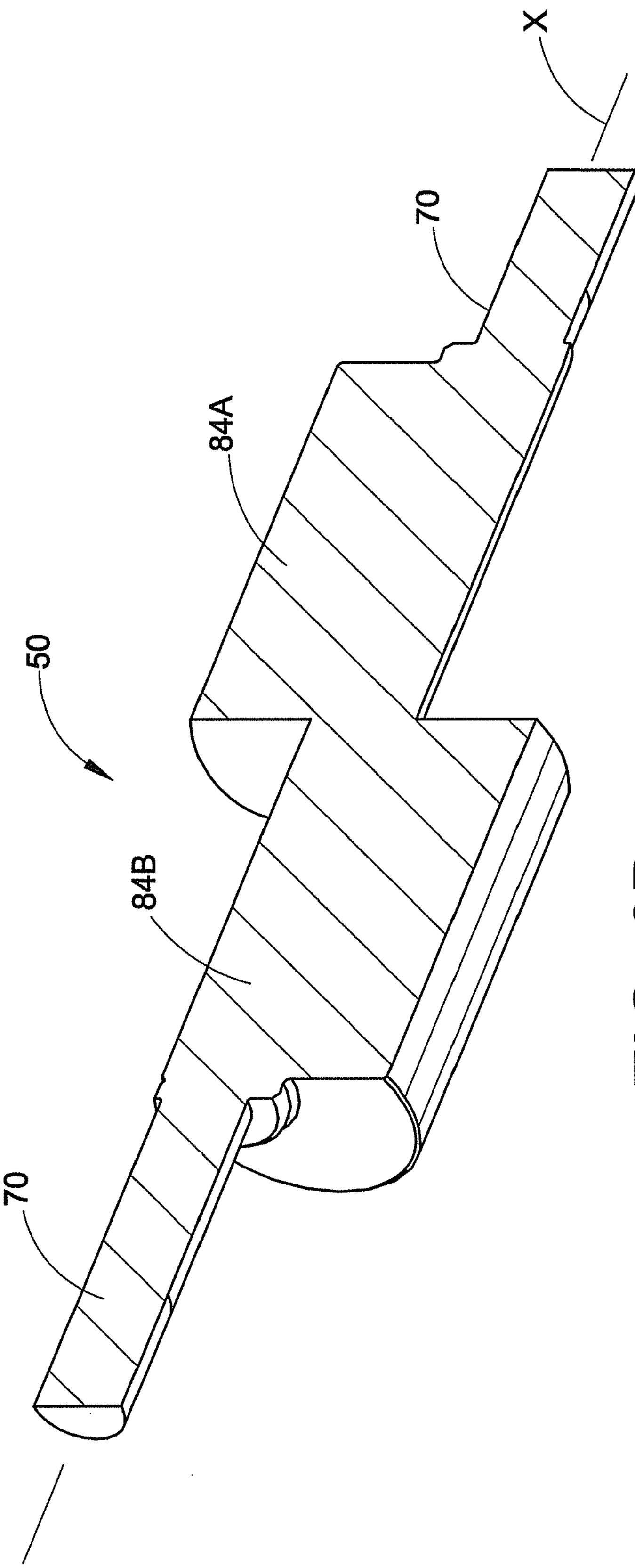


FIG. 6B

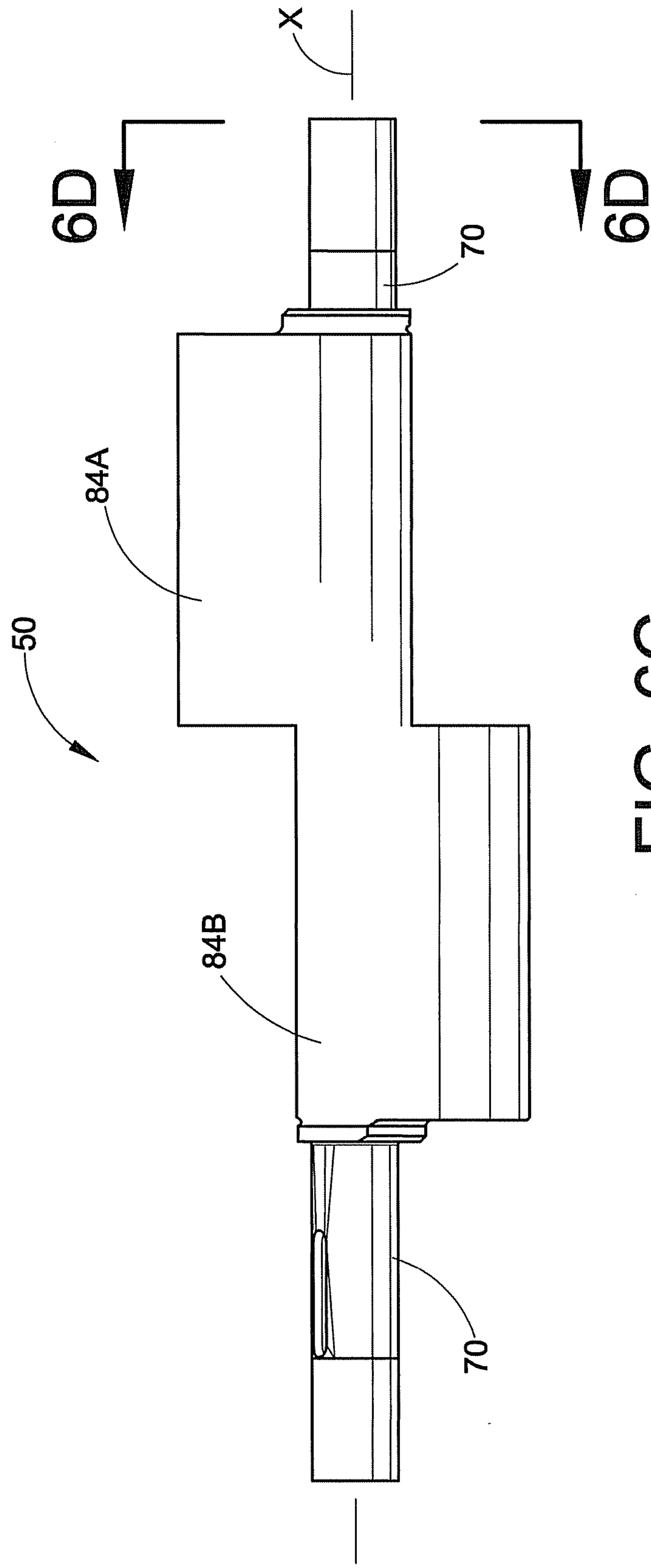


FIG. 6C

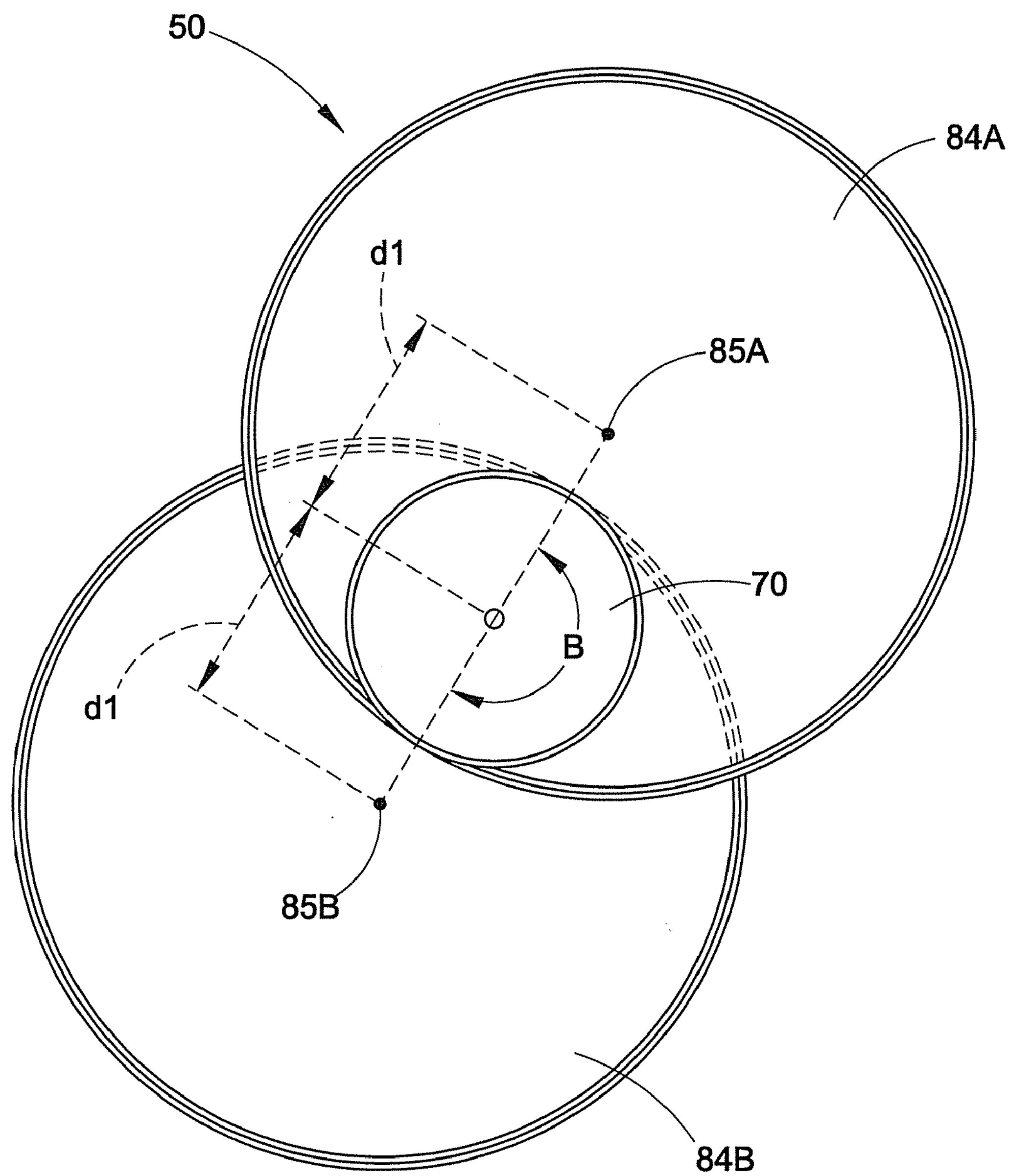


FIG. 6D

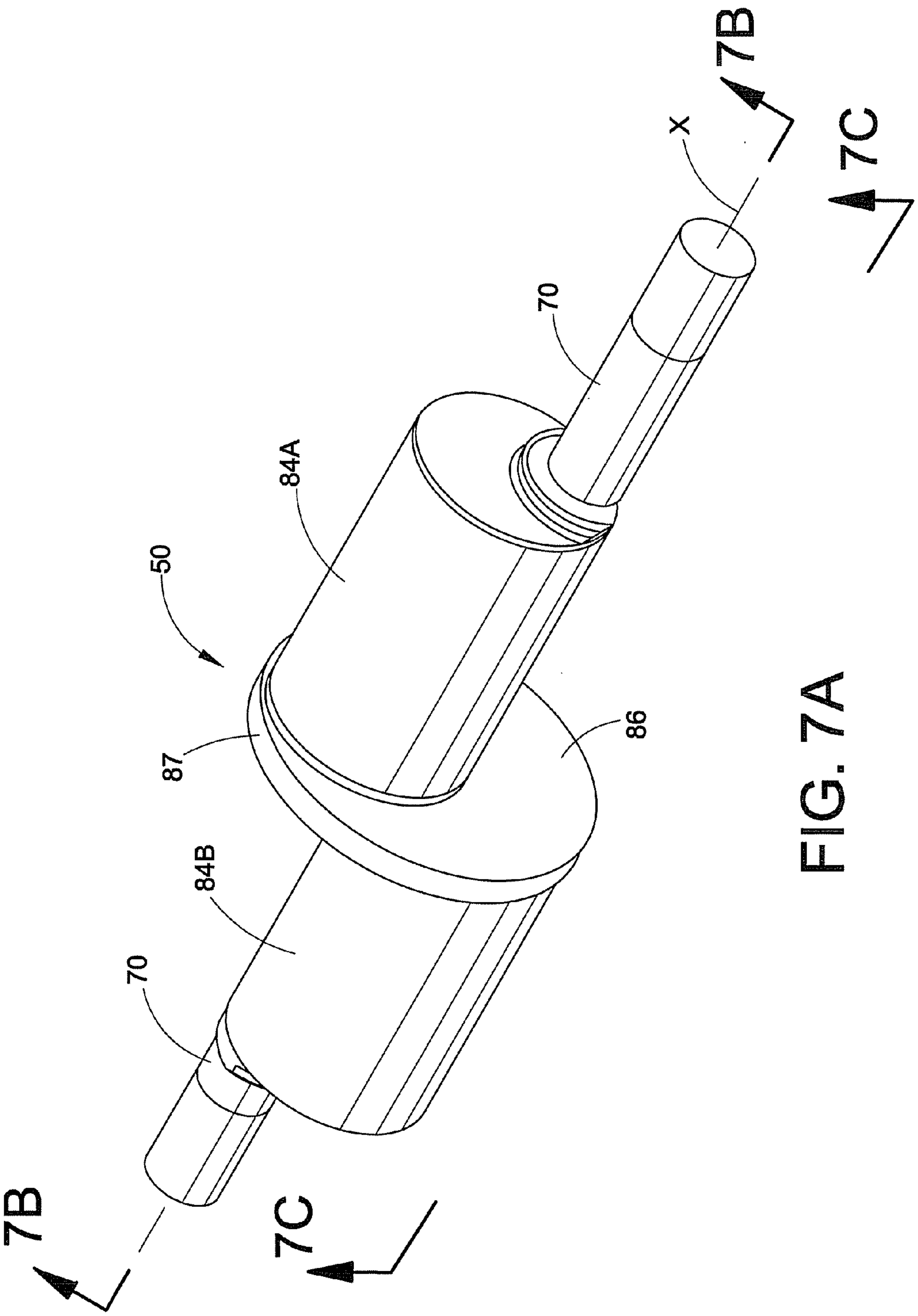


FIG. 7A

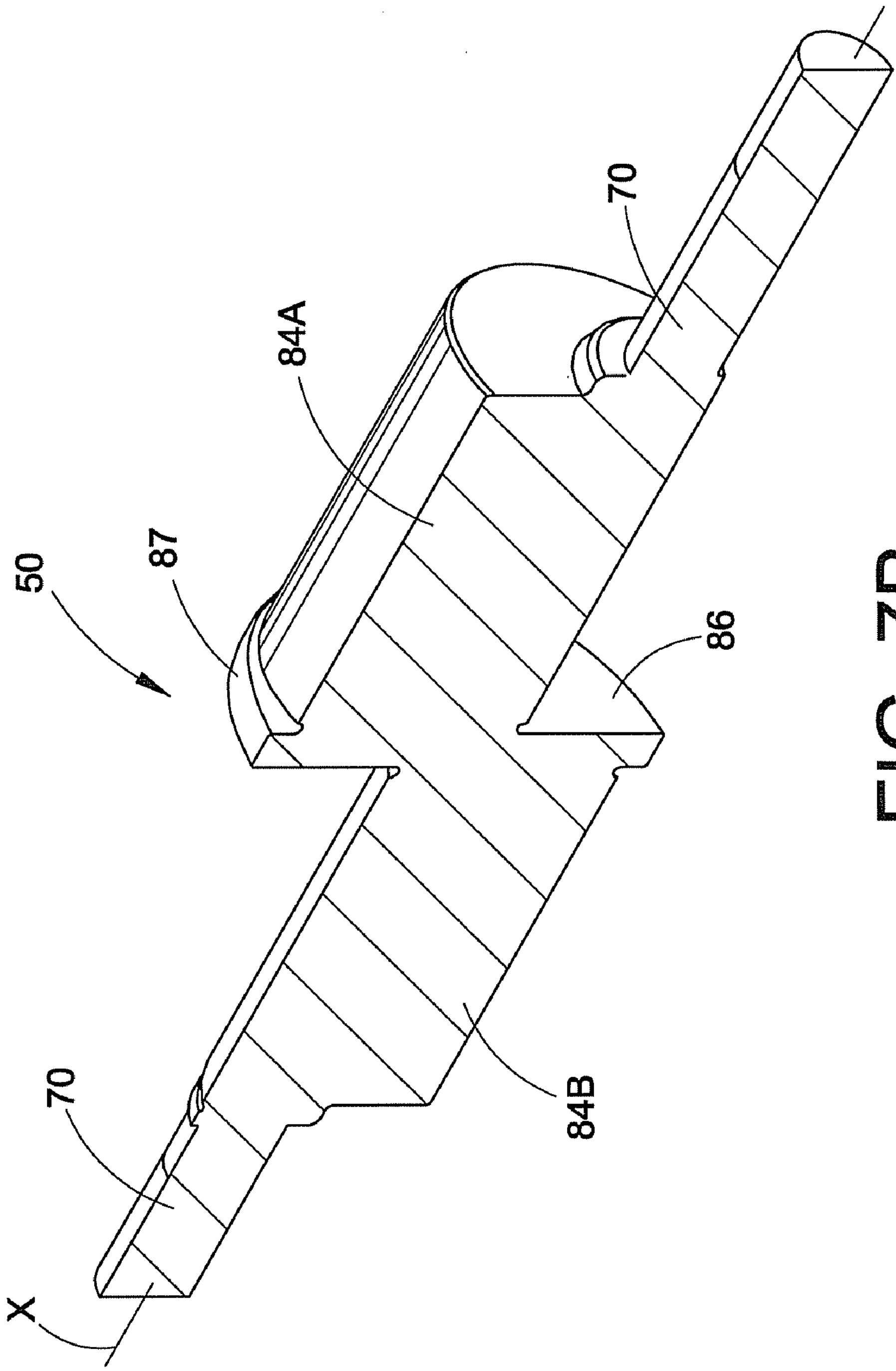


FIG. 7B

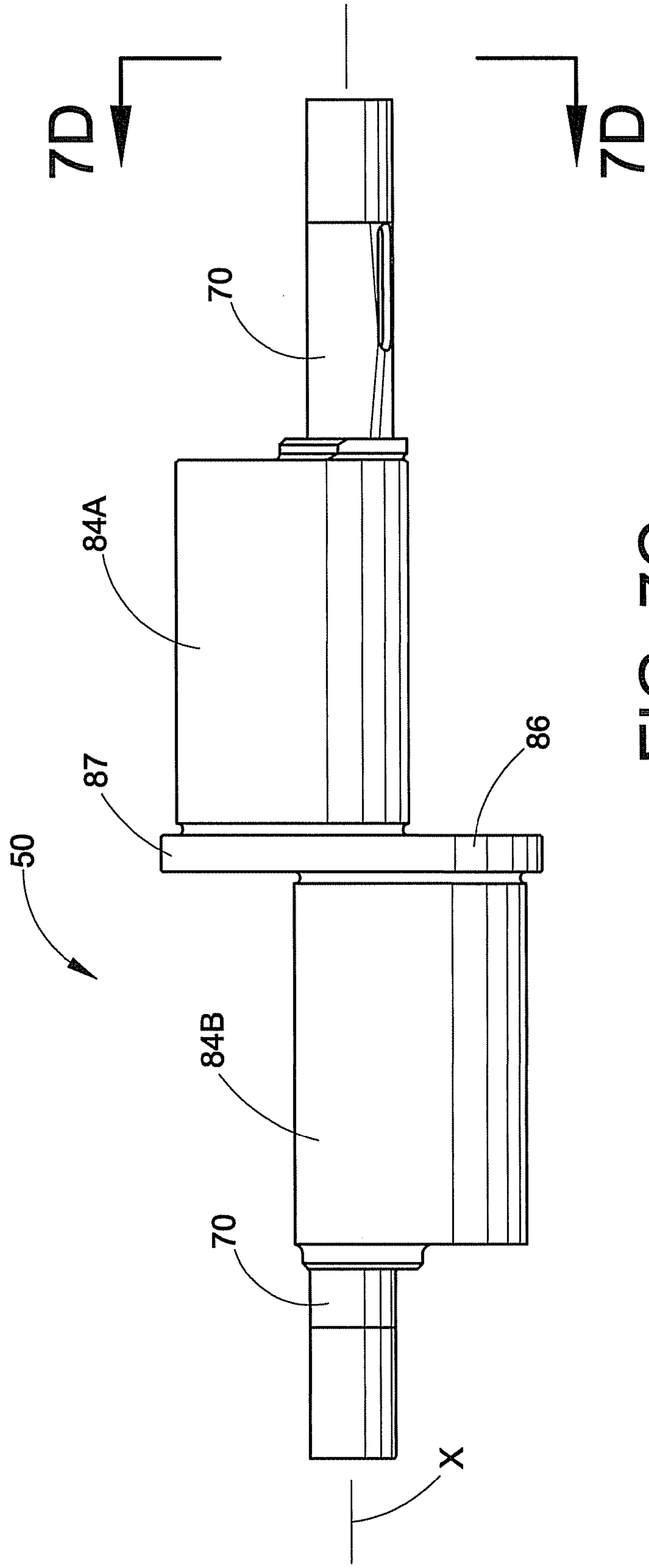


FIG. 7C

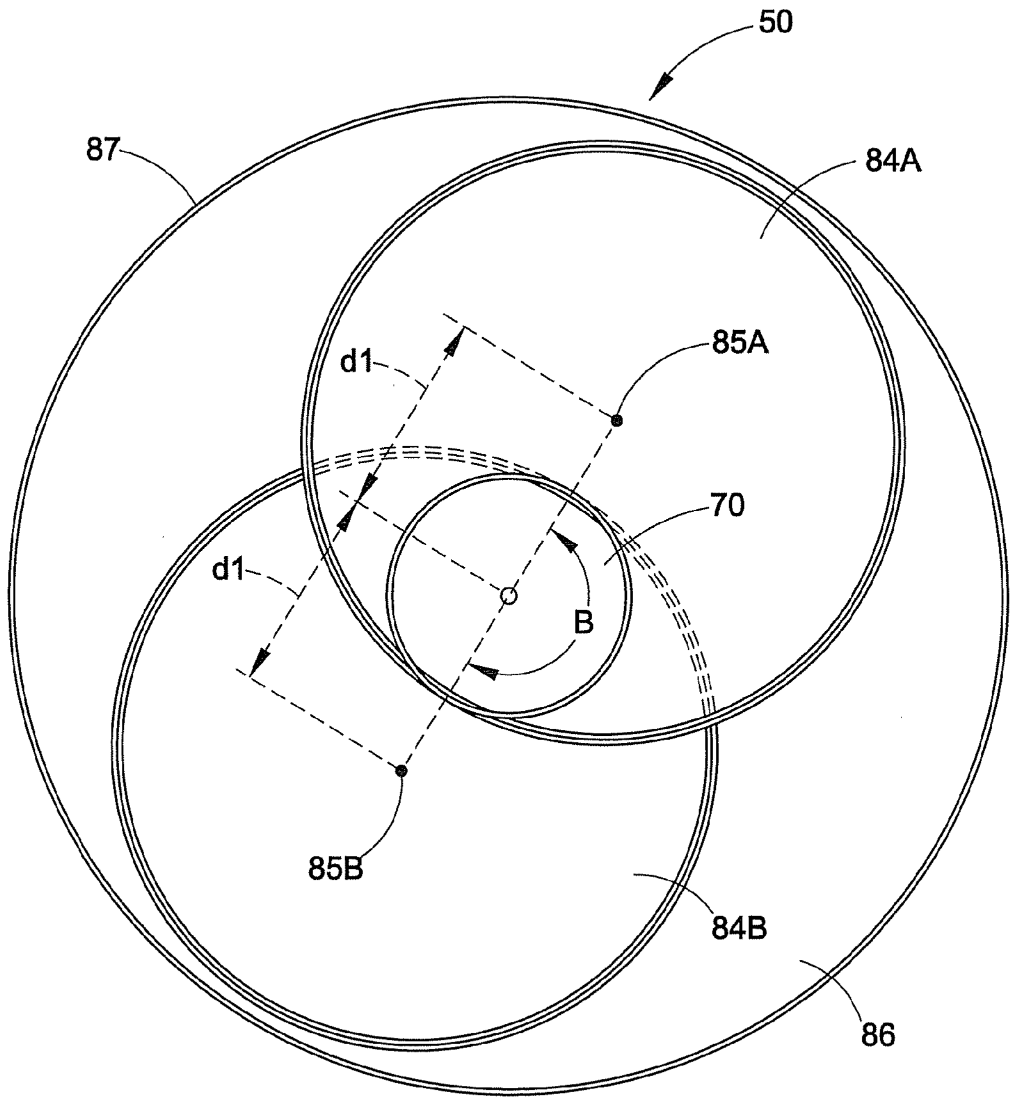


FIG. 7D

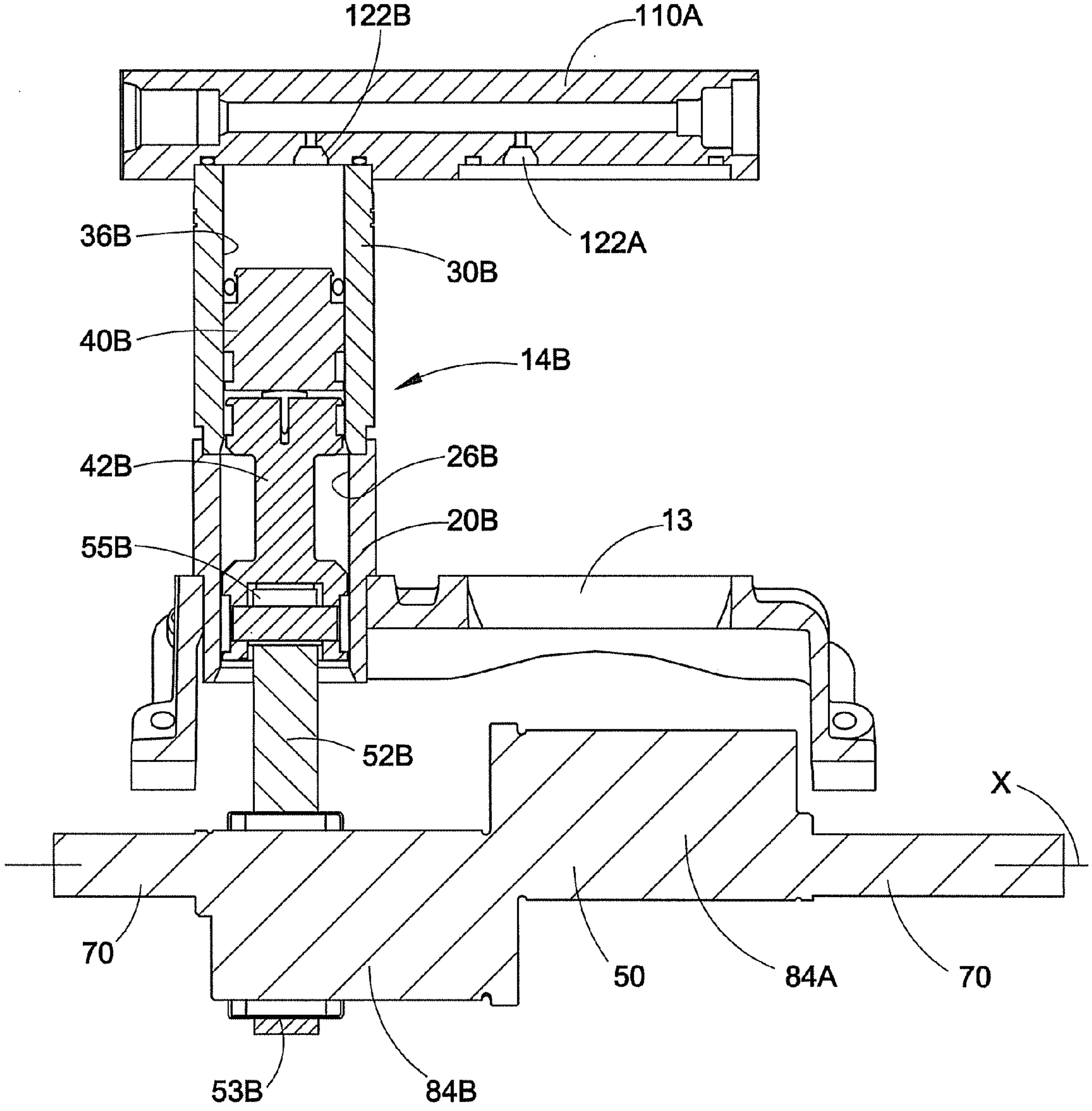

122B
110A
122A
36B
30B
40B
14B
42B
26B
20B
13
55B
52B
X
70
50
84A
70
53B
84B

FIG. 8A

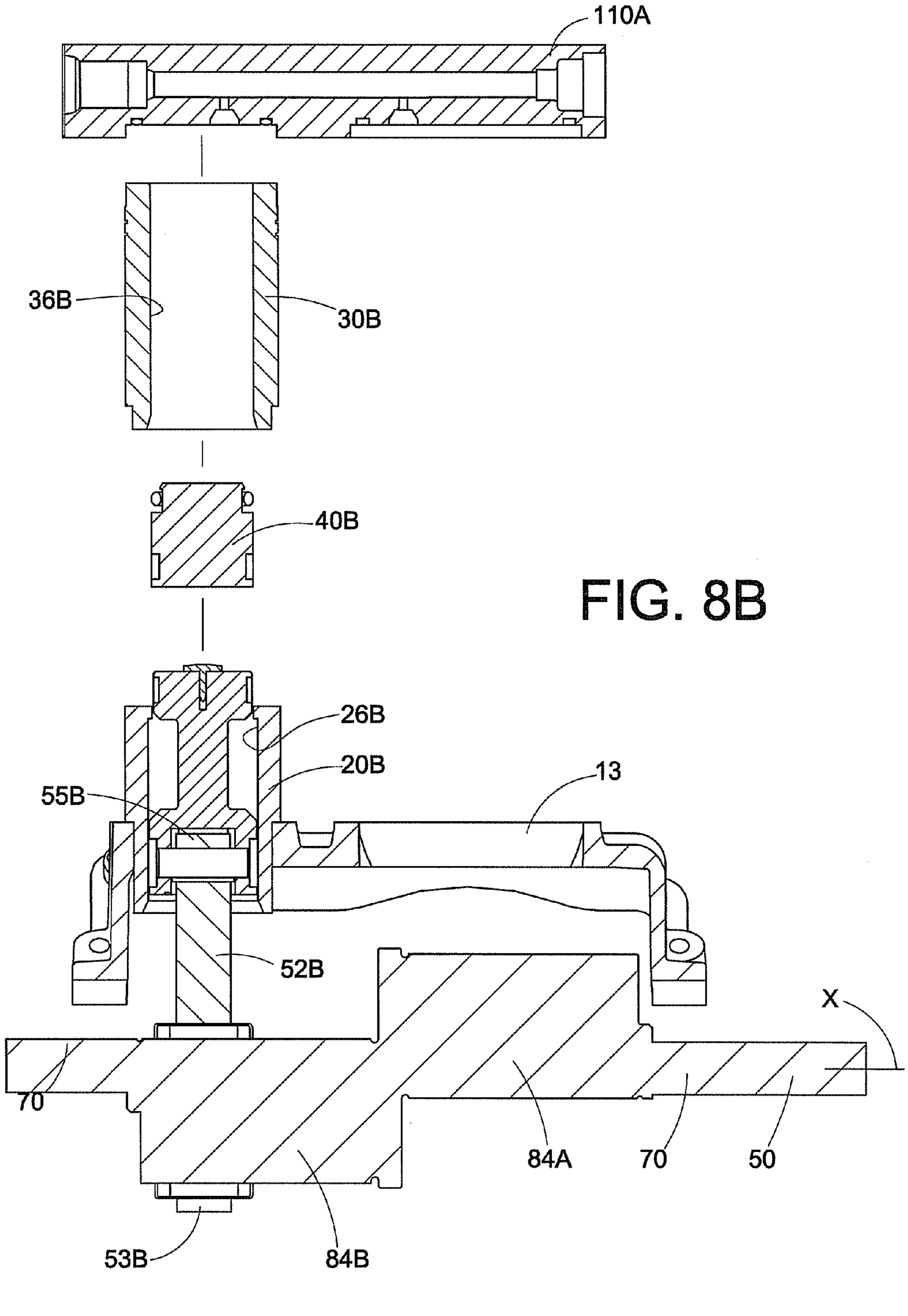


FIG. 8B

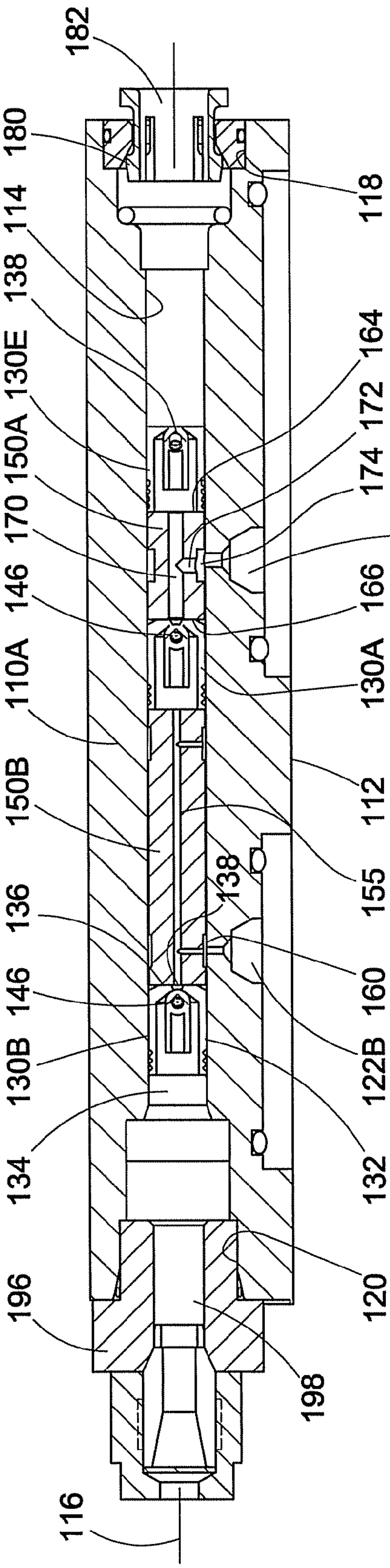

182
180
114
138
130E
150A
170
146
110A
150B
136
146
130B
134
196
116
118
164
172
174
122A
166
130A
112
155
138
160
122B
132
120
198

FIG. 9

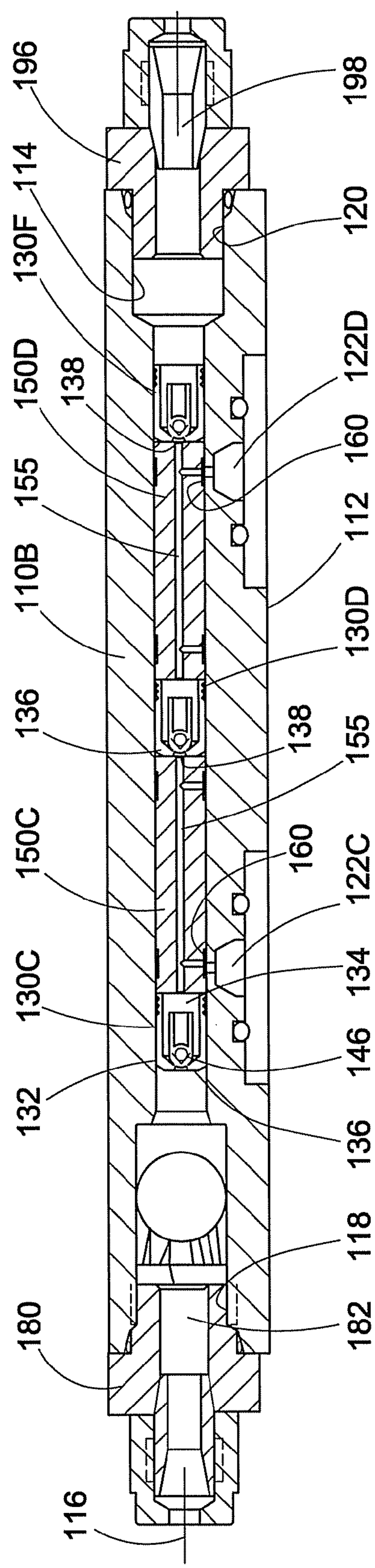

196
198
114
120
130F
122D
150D
138
160
155
112
110B
130D
136
138
155
150C
160
122C
130C
134
146
132
136
118
180
182
116

FIG. 10

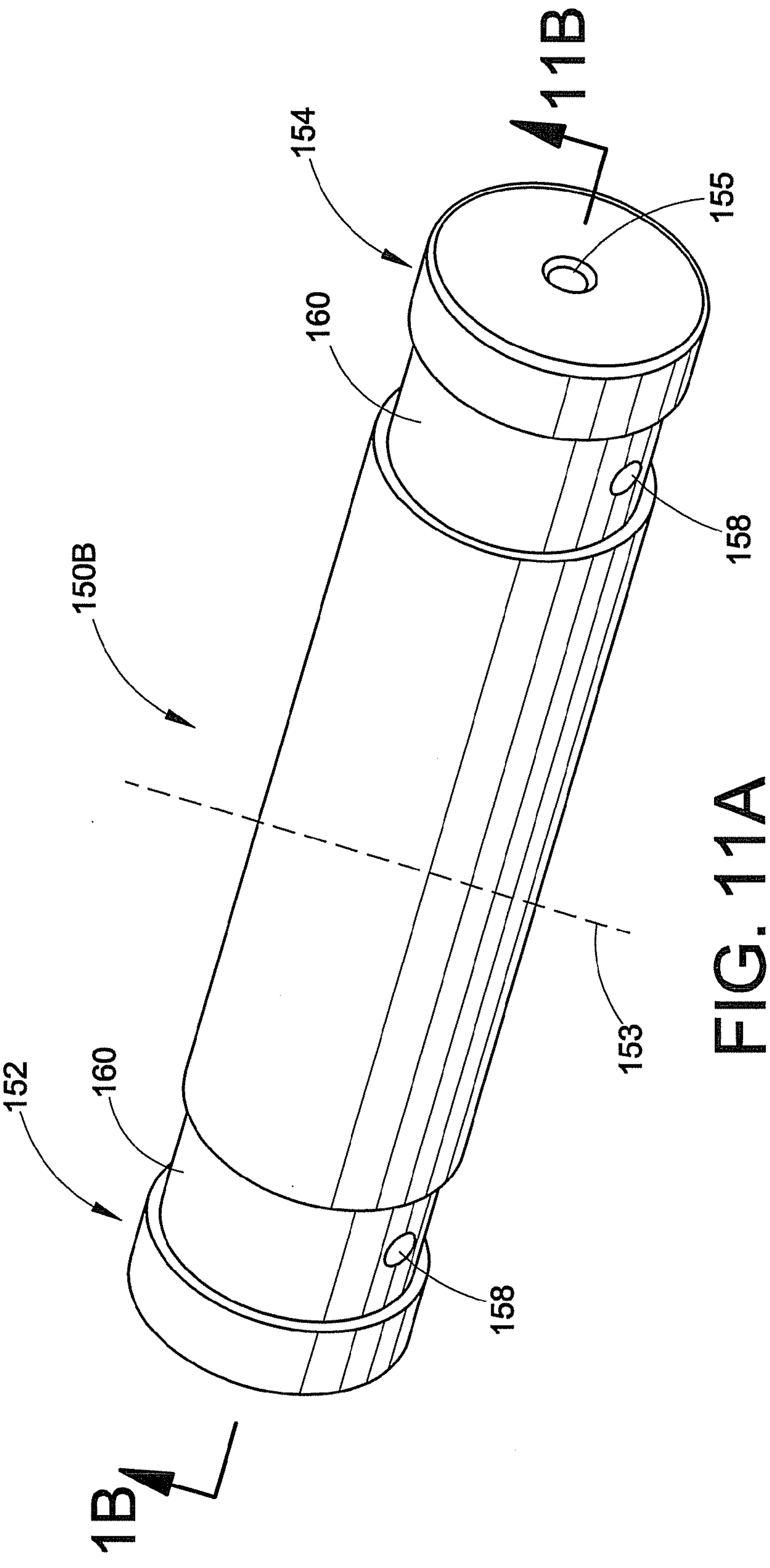


FIG. 11A

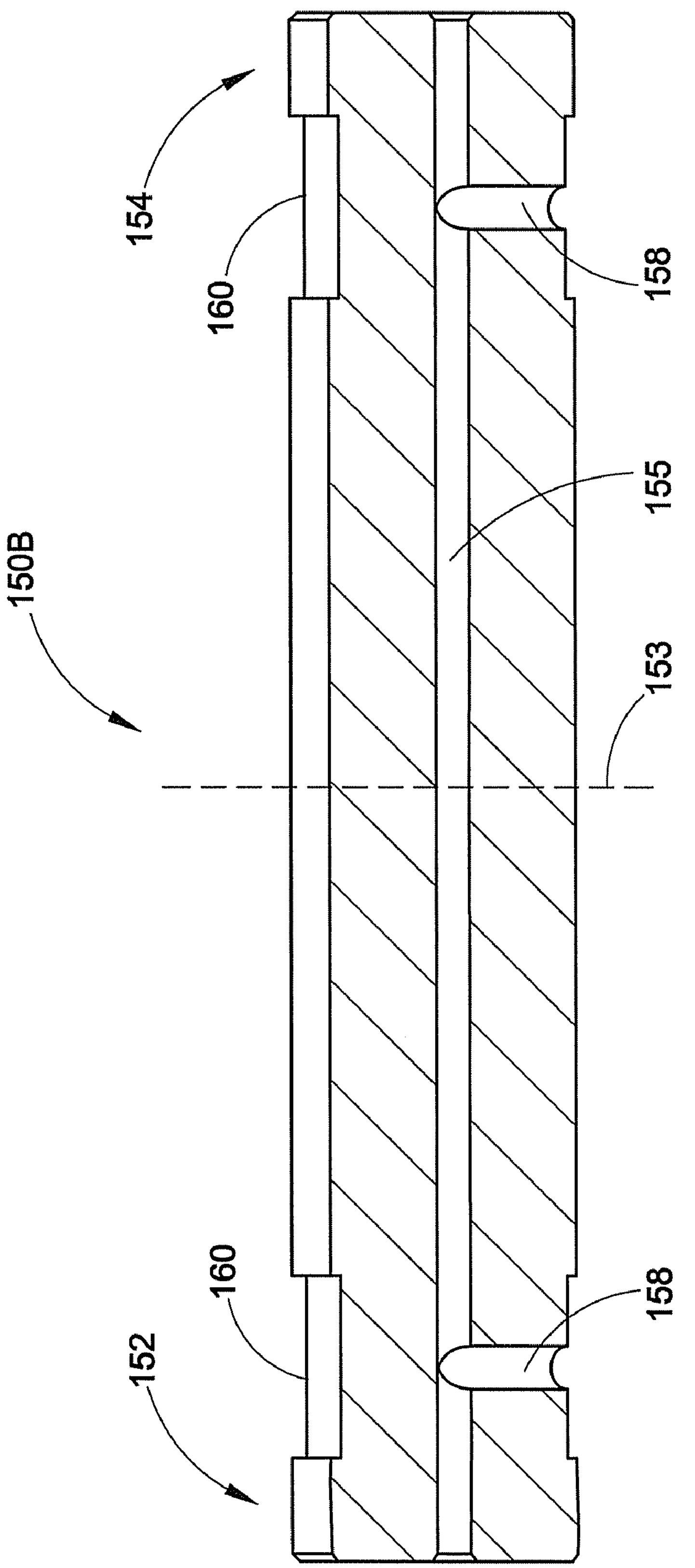


FIG. 11B

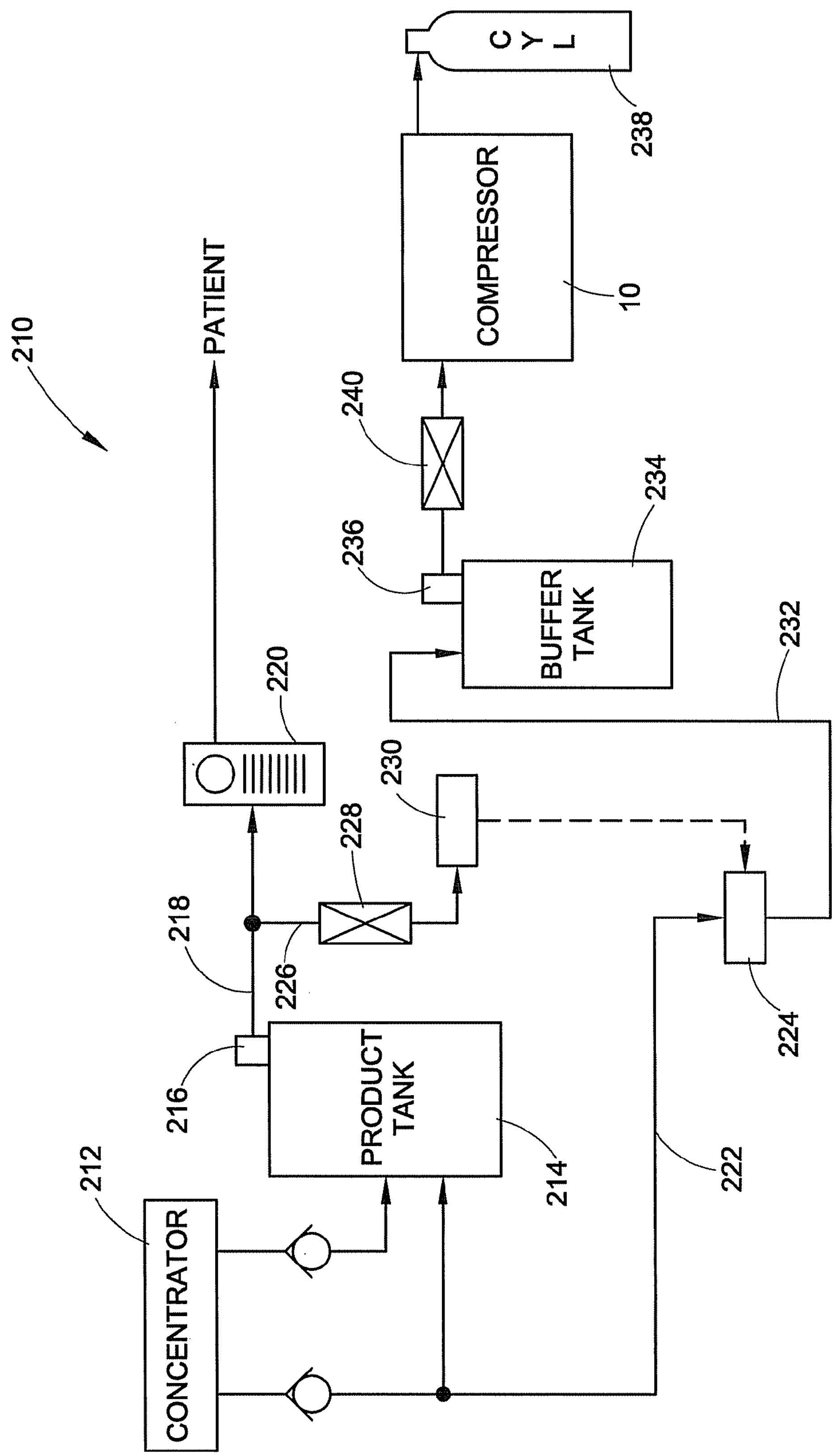

210
CONCENTRATOR
212
PRODUCT TANK
214
216
218
226
228
230
220
PATIENT
222
224
232
BUFFER TANK
234
236
240
COMPRESSOR
10
CYL
238

FIG. 12

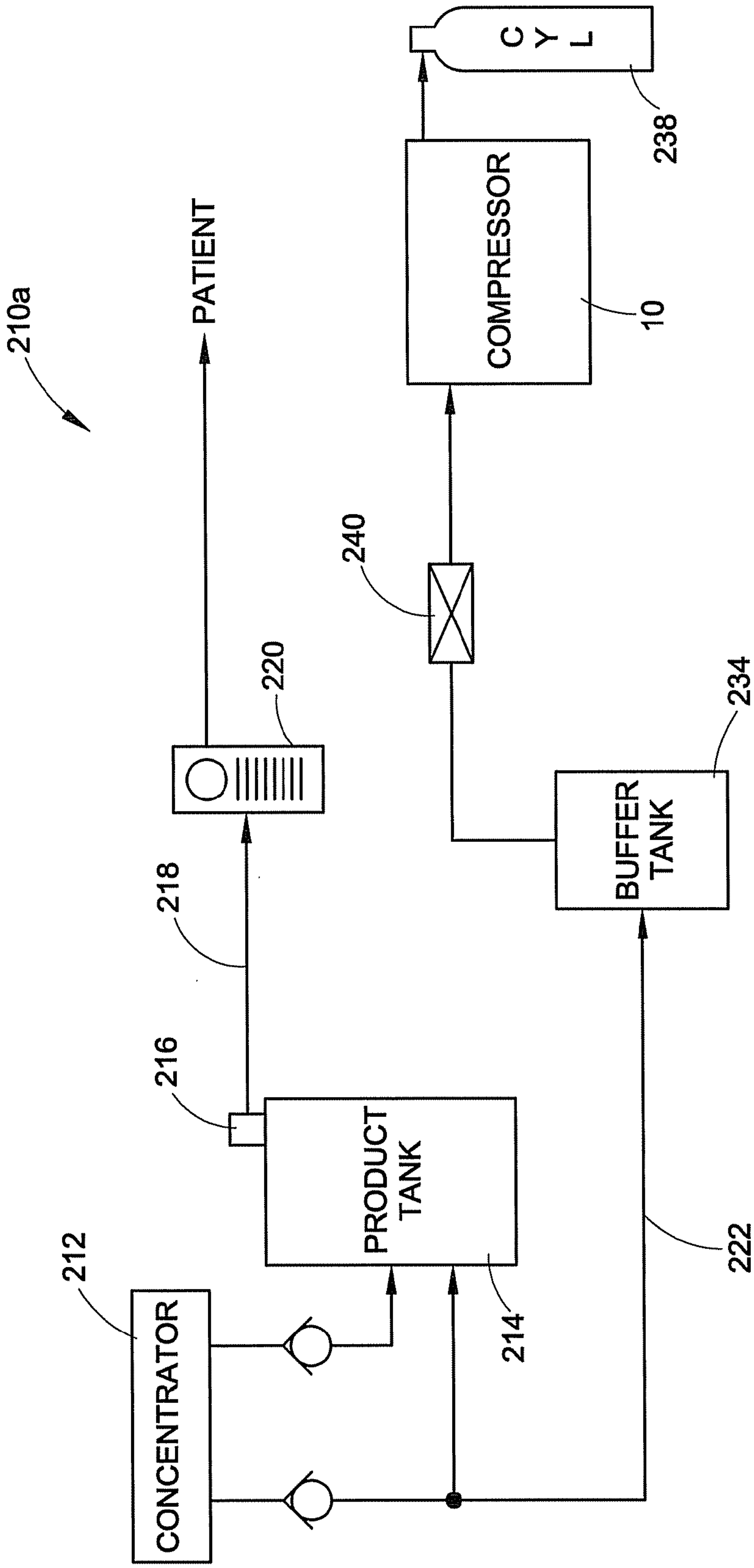

210a
PATIENT
COMPRESSOR
10
C
Y
L
238
240
220
218
216
PRODUCT
TANK
214
BUFFER
TANK
234
212
CONCENTRATOR
222

FIG. 13

COMPRESSOR

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The present application is based on and claims priority to Application Ser. No. 61/234,330 filed Aug. 17, 2010, the disclosure of which is incorporated herein by reference.

FIELD OF THE INVENTION

[0002] The present application relates to the field of gas compressors.

BACKGROUND

[0003] Oxygen has many important medical uses including, for example, assisting patients that have congestive heart failure or other diseases. Supplemental oxygen allows patients to receive more oxygen than is present in the ambient atmosphere. Systems and methods for delivering such oxygen typically include a compressor as a component. U.S. Pat. No. 5,988,165, for example, discloses the use of an inline compressor for this purpose, U.S. Pat. No. 6,923,180 discloses the use of a radial compressor for this purpose, and U.S. Patent Application Publication Pub. No. 2007/0065301 discloses an in-line compressor for this purpose. U.S. Pat. Nos. 5,988,165 and 6,923,180 and U.S. Patent Application Pub. No. 2007/0065301 are incorporated herein by reference in their entirety.

SUMMARY OF THE INVENTION

[0004] The present application discloses embodiments of a gas compressor. For example, compressors that are suitable for compressing oxygen. In one exemplary embodiment, a compressor for compressing gas comprises first, second, third and fourth cylinders. The central axis of the first cylinder is generally parallel with a central axis of the second cylinder and a central axis of the third cylinder is generally parallel with the central axis of the fourth cylinder. The axes of the first and second cylinders are oriented at an angle with respect to the axes of the third and fourth cylinders to form a V4 cylinder configuration. First, second third and fourth pistons are disposed in the first, second, third and fourth cylinders. A crankshaft has a main shaft and only two eccentric driving bodies that drive the first, second, third, and fourth pistons.

[0005] In one exemplary embodiment, a compressor includes a crankshaft having a main shaft that includes a crank axis about which the crankshaft rotates. The crankshaft includes first and second circular driving bodies that extend radially outward from and are eccentric to the crank axis. The first circular connecting rod driving body abuts the second circular connecting rod driving body. Two drive or connecting rods are rotatably connected to each of the first and second circular connecting rod driving bodies, such that rotation of the first and second circular connecting rod bodies about the crank axis reciprocates the four drive or connecting rods.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] Further features and advantages of the present invention will become apparent to those of ordinary skill in the art to which the invention pertains from a reading of the following description together with the accompanying drawings, in which:

[0007] FIG. **1** is a perspective view of a compressor in accordance with an exemplary embodiment;

[0008] FIG. **1**A is a second perspective view of the compressor shown in FIG. **1**, showing a crankshaft and drive rods of the compressor;

[0009] FIG. **1**B is a sectional view taken approximately along the plane indicated by lines **1**B-**1**B in FIG. **1**;

[0010] FIG. **2** is a sectioned perspective view taken along the plane indicated by lines **2**-**2** in FIG. **1**;

[0011] FIG. **2**A is a sectional view taken along the plane indicated by lines **2**-**2** in FIG. **1**,

[0012] FIG. **3** is a sectioned perspective view taken along the plane indicated by lines **3**-**3** in FIG. **1**;

[0013] FIG. **3**A is a sectional view taken along the plane indicated by lines **3**-**3** in FIG. **1**;

[0014] FIG. **4** is a perspective view of an assembly of a crankshaft, drive rods, and pistons;

[0015] FIG. **5** is an exploded perspective view of the assembly shown in FIG. **4**;

[0016] FIG. **6**A is a perspective view of a first embodiment of a crankshaft;

[0017] FIG. **6**B is a sectioned perspective view taken along the plane indicated by lines **6**B-**6**B in FIG. **6**A;

[0018] FIG. **6**C is a view taken along lines **6**C-**6**C in FIG. **6**A;

[0019] FIG. **6**D is a view taken along lines **6**D-**6**D in FIG. **6**C;

[0020] FIG. **7**A is a perspective view of a second embodiment of a crankshaft;

[0021] FIG. **7**B is a sectioned perspective view taken along the plane indicated by lines **7**B-**7**B in FIG. **7**A;

[0022] FIG. **7**C is a view taken along lines **7**C-**7**C in FIG. **7**A;

[0023] FIG. **7**D is a view taken along lines **7**D-**7**D in FIG. **7**C;

[0024] FIG. **8**A is a sectioned perspective view taken along lines **2**-**2** with parts removed to illustrate a cylinder and piston assembly;

[0025] FIG. **8**B is the sectioned perspective view of FIG. **8**A with components exploded to illustrate assembly of the piston in the cylinder;

[0026] FIG. **9** is a sectional view of a first cylinder head assembly that forms part of the compressor of FIG. **1**;

[0027] FIG. **10** is a sectional view of a second cylinder head assembly that forms part of the compressor of FIG. **1**;

[0028] FIG. **11**A is a perspective view of a flow path defining spacer;

[0029] FIG. **11**B is a sectioned perspective view taken along lines **11**B-**11**B in FIG. **11**A;

[0030] FIG. **12** is a schematic illustration of a first exemplary system of the present invention, including a compressor, for providing oxygen-enriched gas for use by a patient; and

[0031] FIG. **13** is a schematic illustration of a second exemplary system of the present invention, including a compressor, for providing oxygen-enriched gas for use by a patient.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0032] As described herein, when one or more components are described as being connected, joined, affixed, coupled, attached, or otherwise interconnected, such interconnection may be direct as between the components or may be in direct such as through the use of one or more intermediary components. Also as described herein, reference to a "member," "component," or "portion" shall not be limited to a single structural member, component, or element but can include an assembly of components, members or elements.

[0033] FIG. **1** illustrates an exemplary embodiment of a compressor **10**. The compressor **10** includes a cylinder assembly **12** and first and second cylinder heads, **110**A, **110**B. The cylinder assembly **12** can take a wide variety of different forms. In the example illustrated by FIG. **1**, the cylinder assembly includes a base **13**, a first sleeve **14**A, a second sleeve **14**B, a third sleeve **14**C, and a fourth sleeve **14**D. Referring to FIGS. **2** and **3**, in an exemplary embodiment, the first sleeve **14**A includes a lower component **20**A and an upper component **30**A (FIG. **2**), the second sleeve **14**B includes a lower component **20**B and an upper component **30**B (FIG. **2**), the third sleeve **14**C includes a lower component **20**C and an upper component **30**C (FIG. **3**), and the fourth sleeve **14**D includes a lower component **20**D and an upper component **30**D (FIG. **3**). The sleeves may take a wide variety of different forms. Any configuration that provides the cylinders can be used. For example, one or more of the cylinders may be formed in only a single component. The first and/or second sleeves and/or the third and fourth sleeves, may be a formed from a single piece or block.

[0034] Referring to FIGS. **2** and **3**, the lower sleeve components **20**A, **20**B, **20**C, **20**D each have an opening **26**A-**26**D. The openings **26**A-**26**D may take a variety of different forms. One or more of the openings **26**A-**26**D may be configured to act as a guide. Further, one or more of the openings **26**A-**26**D may have the same size as one or more of the other openings **26**A-**26**D. The opening **26**A is adjacent and inline with the opening **26**B and the guide opening **26**C is adjacent and inline with the opening **26**D in the illustrated embodiment. Referring to **1**B, an angle θ between the guide openings **26**A, **26**B and the guide openings **26**C, **26**D is approximately 90 degrees in the exemplary embodiment. For example, the angle θ may be and angle in the range between 80 and 100 degrees in one exemplary embodiment, such as an angle between 85 and 95 degrees.

[0035] Referring to FIGS. **2** and **3**, the upper sleeve components **30**A-**30**D include openings or cylinders **36**A-**36**D. The cylinders **36**A-**36**D may take a variety of different forms. The cylinders **36**A-**36**D are inline with the openings **26**A-**26**D. As such, the angle θ is defined between the cylinders **36**A, **36**B and the cylinders **36**C, **36**D. As such, the cylinders **36**A-**36**D are in a substantially "V4" configuration. That is, the central axes **37**A, **37**B of the cylinders **36**A, **36**B from a "V" shape with respect to the central axes **37**C, **37**D of the cylinders **36**C, **36**D (see FIG. **1**B). As can be seen in FIGS. **1**, **2**, and **3**, the central axes **37**A-**37**D are each axially offset from one another in the illustrated embodiment.

[0036] Referring to FIGS. **2** and **3**, the compressor includes a plurality of pistons **40**A-**40**D that are associated in a one to one relationship with the cylinders **36**A-**36**D. A first piston **40**A is located in the first cylinder **36**A and is supported for sliding (reciprocating) movement in the first cylinder (FIG. **2**). A second piston **40**B is located in the second cylinder **36**B and is supported for sliding (reciprocating) movement in the second cylinder (FIG. **2**). A third piston **40**C is located in the third cylinder **36**C and is supported for sliding (reciprocating) movement in the third cylinder (FIG. **3**). A fourth piston **40**D is located in the fourth cylinder **36**D and is supported for sliding (reciprocating) movement in the fourth cylinder (FIG. **3**).

[0037] The cylinders **36**A-**36**D and corresponding pistons **40**A-**40**D are of varying diameters and as a result, the stroke of each piston **40**A-**40**D in its respective cylinder results in a different displacement of gas during the stroke of each piston. The concept of pistons **40**A-**40**D having different strokes from one another may optionally be implemented in the compressor **10**. If the strokes of the pistons are different from one another, one or more of the pistons may have the same diameter as one or more other pistons. In the illustrated embodiment, the first cylinder **36**A is the largest in diameter, the second cylinder **36**B is smaller than the first cylinder, the third cylinder **36**C is smaller yet, and the fourth cylinder **36**D is the smallest. In other embodiments, the compressor may have more than four cylinders or fewer than four cylinders.

[0038] As indicated above, the upper sleeves **30**A-**30**D are in engagement with lower sleeves **20**A-**20**D. The openings **26**A-**26**D in the lower guide sleeves align with the cylinders **36**A-**36**D in the upper cylinder sleeves. The compressor **10** may include one or more guides that are slideably disposed in the openings **26**A-**26**D. Referring to FIGS. **2**-**4**, the compressor includes guides **42**B-**42**D slideably disposed in the openings **26**B-**26**D and a guide is not included in the first opening **26**A in the illustrated embodiment. However, guides may be included in all of the openings **26**A-**26**D or any number of guides may be included. The illustrated guides **42**B-D are driven by a crankshaft **50** and connecting rods **52**B-**52**D, as described below. The illustrated connecting rods **52**B-**52**D each include a first ring portion **53**B-**53**D and a second ring portion **55**B-**55**D for pivotal connection to the crankshaft **50** and the guides **42**B-**42**D respectively (See FIGS. **2** and **3**).

[0039] In the illustrated embodiment, no guide is disposed in the opening **26**A. The first piston **40**A is fixed for movement with the drive or connecting rod **52**A. This arrangement is referred to as a "wobble piston," because fixing the piston **40**A to the connecting rod **52**A causes some amount of canting or wobbling as the piston **40**A moves in the cylinder **36**A. Alternatively, the first piston **40**A could be pivotally connected to the connecting rod **52**A in a conventional manner. In this embodiment, the first piston **40**A will slide in the cylinder **36**A without significant canting or wobbling. The illustrated connecting or drive rod **52**A includes a ring portion **53**A for rotatable connection to a crankshaft **50**.

[0040] Referring to FIG. **2**A, the illustrated guide **42**B includes a first portion **43**B and a second portion **44**B. The first portion **43**B of the guide **42**B is located in the opening **26**B and is supported for sliding (reciprocating) movement in the opening. The second portion **44**B of the guide **42**B is located in the cylinder **36**B and is supported for sliding (reciprocating) movement in the cylinder **36**B. In the embodiment illustrated by FIGS. **2** and **2**A, the second piston **40**B is separate from the guide **42**B and is not attached to the guide. In this embodiment, during a compression stroke (illustrated by arrow **45** in FIG. **2**A), the guide **42**B forces the second piston **40**B toward the end surface **32**B or head end of the cylinder **36**B. During a charging stroke (illustrated by arrow **46** in FIG. **2**A), gas pressure applied to the cylinder **36**B by the first piston **40**A forces the second piston **40**B toward the end surface **34**B or crankshaft end of the cylinder. In an exemplary embodiment, the second piston **40**B remains in contact with the second portion **44**B of the guide **42**B during both the entire compression stroke and the entire charging stroke. In another embodiment, the second piston **40**B is fixed or connected for movement with the guide **42**B.

[0041] Referring to FIG. 3A, the illustrated guide 42C includes a first portion 43C and a second portion 44C. The first portion 43C of the guide 42C is located in the opening 26C and is supported for sliding (reciprocating) movement in the opening. The second portion 44C of the guide 42C is located in the cylinder 36C and is supported for sliding (reciprocating) movement in the cylinder 36C. In the embodiment illustrated by FIG. 3, the third piston 40C is separate from the guide 42C and is not attached to the guide. In this embodiment, during a compression stroke (illustrated by arrow 45 in FIG. 3A), the guide 42C forces the third piston 40C toward the end surface 32C or head end of the cylinder 36C. During a charging stroke (illustrated by arrow 46 in FIG. 3A), gas pressure applied to the cylinder 36C by the second piston 40B forces the third piston 40C toward the end surface 34C or crankshaft end of the cylinder. In an exemplary embodiment, the third piston 40C remains in contact with the second portion 44C of the guide 42C during both the entire compression stroke and the entire charging stroke. In another embodiment, the third piston 40C is fixed or connected for movement with the guide 42C.

[0042] Referring to FIG. 3A, the illustrated guide 42D includes a first portion 43D and a second portion 44D. The first portion 43D of the guide 42D is located in the opening 26D and is supported for sliding (reciprocating) movement in the opening. The second portion 44D of the guide 42D is located in the cylinder 36D and is supported for sliding (reciprocating) movement in the cylinder 36D. In the embodiment illustrated by FIG. 3A, the fourth piston 40D is separate from the guide 42D and is not attached to the guide. In this embodiment, during a compression stroke (illustrated by arrow 45 in FIG. 3A), the guide 42D forces the fourth piston 40D toward the end surface 32D or head end of the cylinder 36C. During a charging stroke (illustrated by arrow 46 in FIG. 3A), gas pressure applied to the cylinder 36D by the third piston 40C forces the fourth piston 40D toward the end surface 34D or crankshaft end of the cylinder. In an exemplary embodiment, the fourth piston 40D remains in contact with the second portion 44D of the guide 42D during both the entire compression stroke and the entire charging stroke. In another embodiment, the fourth piston 40D is fixed or connected for movement with the guide 42D.

[0043] Referring to FIGS. 2 and 3, crankshaft 50 (described below in detail) is supported for rotation about a crank axis X in first and second bearings 62, 68. The first and second bearings 62, 68 are mounted to the base 13 by first and second and second bearing supports 54 and 56 that are located at either end of the compressor base 13.

[0044] Referring to FIG. 4, the crankshaft 50 fauns part of a drive mechanism 79 of the compressor 10 for driving the pistons 40A-40D for movement in the cylinders 36A-36D. The drive mechanism 79 includes the crankshaft 50, the drive or connecting rods 52A-52D, and the guides 42B-42D. However, a wide variety of different drive mechanisms may be used. In other embodiments the crankshaft could be connected to the pistons or coupled to the pistons 40A-40D in other manners, for example with connecting or drive rods but not guides.

[0045] FIGS. 6A-6D and 7A-7D illustrate two embodiments of crankshafts 50. In the embodiments illustrated by FIGS. 6A-6D and 7A-7D the crankshaft 50 is made from a single piece (or welded together to form a single piece). However, the crankshaft 50 may be made from multiple pieces that are assembled together and can be disassembled.

[0046] The crankshaft 50 includes a main shaft 70 having a generally cylindrical configuration defined by a cylindrical outer surface centered on a crank axis X of the compressor 10. The crankshaft 50 rotates about the crank axis X during operation of the compressor 10. In the illustrated embodiments, the main shaft 70 has externally threaded opposite end portions 78 and 80. Referring to FIGS. 1-3, the main shaft 70 is received and supported in the first and second bearings 62 and 68.

[0047] Referring to FIGS. 6A-6D and 7A-7D, in the illustrated embodiments, the crankshaft 50 also includes first and second circular connecting rod driving bodies 84A, 84B that extend radially outward from and are eccentric to the crank axis X. In the illustrated embodiments, the bodies 84A, 84B are identical to each other, for ease of manufacturing. However, the bodies 84A. 84B may have different sizes, for example such that the body 84A provides a different stroke than body 84B. Referring to FIGS. 6D and 7D, each of the eccentric bodies 84A, 84B has a cylindrical configuration with each cylinder having a central axis 85A, 85B that is parallel to, but spaced apart from the crank axis X. In the illustrated embodiments, the central axis 85A and the central axis 85B are positioned away from the crank axis X by the same distance dl and an angle β of approximately 180 degrees (See FIG. 6D) is formed between the central axis 85A, the crank axis X, and the central axis 85B. However, the bodies 84A, 84B can be positioned with respect to the crank axis in any manner to achieve desired motions of crank or drive rods 54A-54D that are coupled to the bodies. In the illustrated embodiment, the main shaft portion 70 that is mounted in the bearings 62, 68 has a diameter that is less than a diameter of the circular connecting rod driving bodies 84A, 84B.

[0048] Referring to FIG. 4, in an exemplary embodiment the first and second circular connecting rod driving bodies 84A, 84B are the only connecting rod driving bodies of the crankshaft. In this embodiment, each of the connecting rod driving bodies drives two connecting or drive rods 54A-54D as will be described in more detail below. However, any number of connecting rod driving bodies can be included. For example, one connecting rod driving body may be included for each connecting or drive rod. Further, one or more connecting rod driving bodies may drive one connecting or drive rod and one or more connecting rod driving bodies may drive two or more connecting or drive rods.

[0049] The connecting rod drive bodies 84A, 84B may take a wide variety of different forms. In the embodiments illustrated by FIGS. 6A-6D and 7A-7D, the connecting rod driving bodies 84A, 84B are each formed as a single continuous cylinder. The illustrated continuous cylinders are integrally formed with the main shaft 70. In another embodiment, the connecting rod driving bodies are two separately formed continuous cylindrical members that are assembled with the main shaft 70. The two separately formed continuous cylindrical members may be identical or may have different sizes to provide different strokes.

[0050] In the embodiment illustrated by FIGS. 6A-6D, the first connecting rod driving body 84A abuts the second connecting rod driving body 84B. The first connecting rod driving body 84A may be integrally formed with the second connecting rod driving body 84B, or the connecting rod driving bodies 84A, 84B may be separate pieces that are fixed together. In the example illustrated by FIGS. 6A-6D, the first connecting rod driving body 84A is connected to the second connecting rod driving body **84**B only at an area of overlap between the first connecting rod driving body and the second connecting rod driving body.

[0051] In the embodiment illustrated by FIGS. **7**A-**7**D, the first connecting rod driving body **84**A is connected to the second connecting rod driving body **84**D by a circular disk **86** disposed between the first connecting rod driving body **84**A and the second connecting rod driving body **84**B. The connecting rod driving bodies **84**A, **84**B may be separate from one another and then fixed to the circular disk **86** or the connecting rod driving body **84**A, the circular disk **86**, and the connecting rod driving body **84**A may be integrally formed. In the embodiment illustrated by FIGS. **7**A-**7**D, the circular disk **86** is centered on the crank axis X. Referring to FIG. **7**D, the illustrated circular disk has an outer circumference **87** that is radially outward of the outer circumferences of both of the first and second connecting rod driving bodies **84**A, **84**B.

[0052] As shown in FIGS. **2** and **2**A a connecting rod **52**A is connected between the first piston **40**A and the first eccentric connecting rod driving body **84**A and a connecting rod **52**B is connected between the guide **42**B (which drives the second piston **40**B) and the second eccentric connecting rod driving body **84**B. In the illustrated embodiment, the ring **53**A is disposed around the body **84**A to rotatably connect the rod **52**A to the body **84**A. A bearing may be disposed between the ring **53**A and the body **84**A. The ring **53**B is disposed around the body **84**B to rotatably connect the rod **52**B to the body **84**B. A bearing may be disposed between the ring **53**B and the body **84**B. A pin **90**B extends through the ring portion **55**B to pivotally connect the guide **42**B the rod **52**B.

[0053] Referring to FIGS. **3** and **3**A, a connecting rod **52**C is connected between the guide **42**C (which drives the third piston **40**C) and the first eccentric connecting rod driving body **84**A and a connecting rod **52**D is connected between the guide **42**D (which drives the fourth piston **40**D) and the second eccentric connecting rod driving body **84**B. In the illustrated embodiment, the ring **53**C is disposed around the body **84**A to rotatably connect the rod **52**C to the body **84**A. A bearing may be disposed between the ring **53**C and the body **84**A. A pin **90**C extends through the ring portion **55**C to pivotally connect the guide **42**C to the rod **52**C. The ring **53**D is disposed around the body **84**B to rotatably connect the rod **52**D to the body **84**B. A bearing may be disposed between the ring **53**D and the body **84**B. A pin **90**D extends through the ring **55**D to pivotally connect the guide **42**D to the rod **52**D.

[0054] The first eccentric connecting rod driving body **84**A drives both the first and third pistons **40**A, **40**C. Referring to FIG. **1**B, due to the "V" configuration of the pistons, the motion of the third piston **40**C follows or lags the motion of the first piston **40**A by rotation of the crankshaft by the angle of the "V" θ (approximately 90 degrees in the illustrated embodiment). The second eccentric connecting rod driving body **84**B drives both the second and fourth pistons **40**B, **40**D. Due to the angular spacing **0** of the first and second connecting rod driving bodies **84**A, **84**B about the crank axis X, the motion of the second piston **40**B follows or lags the motion of the first piston **40**A by rotation of the crankshaft by the angle of the angular spacing β (approximately 180 degrees in the illustrated embodiment). Due to the "V" configuration of the pistons, the motion of the fourth piston **40**D follows or lags the motion of the second piston **40**B by rotation of the crankshaft by the angle of the "V" θ (approximately 90 degrees in the illustrated embodiment).

[0055] Rotation of the main shaft **70** about the crank axis X results in reciprocating movement of pistons **40**A-**40**D in the cylinders **36**A-**36**D. A drive pulley (not shown) may be located on one of the end portions **78** of the main shaft **70** to facilitate the application of a drive torque to the main shaft **70**, to reciprocate the pistons **40**A-**40**D.

[0056] As shown in FIG. **1**, the compressor **10** includes a cylinder head assembly **100**. The cylinder head assembly **100** includes a first cylinder head **110**A and a second cylinder head **110**B that is fastened to the cylinder assembly **12** with a plurality of fasteners. In the illustrated embodiment, the compressor **10** includes fasteners, such as bolts **102** that extend through holes in the cylinder heads **110**A, **110**B and are threaded into the base **13**. When the bolts **102** are tightened down, the cylinder head **110**A is clamped to the first and second sleeves **14**A, **14**B and the cylinder head **110**B is clamped to the third and fourth sleeves **14**C, **14**D.

[0057] Referring to FIGS. **8**A and **8**B, for repair or servicing, each of the separate pistons **40**B-**40**D can be removed from the cylinders **36**B-**36**D by removing the fasteners **102** (See FIG. **1**) that hold the head **110**A and/or **110**B down. The second cylinder **36**B and piston **40**B is illustrated in FIGS. **8**A and **8**B, but the other pistons and cylinders can be repaired or serviced in the same manner. Once the fasteners **102** are removed, the head **110**A, the cylinder **36**B, and the piston **40**B can be removed and separated as illustrated by FIG. **8**B. This arrangement allows the piston **40**B and/or cylinder **36**B to be replaced or serviced without requiring the drive or connecting rod **52**B to be removed from the crankshaft **50**.

[0058] As shown in FIGS. **1**, **9** and **10**, each cylinder head **110**A, **110**E is formed as one piece from metal. In the illustrated embodiment, each cylinder head **110**A, **110**B has a rectangular configuration including a lower side surface **112**. Referring to FIGS. **9** and **10**, a component chamber **114** extends the length of each cylinder head **110**A, **110**B. In the illustrated embodiment, the component chambers **114** each have a cylindrical configuration centered on an axis **116**. Each component chamber **114** has an inlet end portion **118** and an outlet end portion **120**. The inlet end portion **118** of the first cylinder head **110**A forms an inlet of the compressor **10**. The outlet end portion **120** forms an outlet of the first cylinder head **110**A. The inlet end portion **118** of the second cylinder head **110**B fowls an inlet to the second head **110**B. Referring to FIG. **1**, a conduit **119** connects the outlet of the first head **110**A to the inlet of the second head **110**B. The threaded outlet end portion **120** of the second head **110***b* forms an outlet of the compressor **10**.

[0059] Referring to FIGS. **9** and **10**, the cylinder heads **110***a*, **110***b* have a plurality of charging ports **122**A-**122**D that extend between the component chamber **114** and the lower side surface **112**. The number of charging ports **122**A-**122**D is equal to the number of cylinders **36**A-**36**D in the compressor **10** in the illustrated embodiment. Referring to FIGS. **2**A and **3**A, the charging ports **122**A-**122**D establish fluid communication between the cylinders **36**A-**36**D and the component chamber **114**. In the illustrated embodiment, a single charging port **122** is associated with each one of the cylinders **36**. Thus, the first cylinder **36**A has a first charging port **122**A, the second cylinder **36**B has a second charging port **122**B, the third cylinder **36**C has a third charging port **122**C, and the fourth cylinder **36**D has a fourth charging port **122**D.

[0060] A plurality of components are located in the component chamber **114** of the cylinder heads **110**A, **110**B. The components direct fluid flow between the inlet **118** of the first head **110**A, the cylinders **36**A-**36**D and the outlet **120** of the second head **110**B. The components include a plurality of check valves **130**A-**130**F for controlling flow of air into and out of the various cylinders **36**A-**36**D, and a plurality of components or structures for positioning the check valves in the chamber **114** and inhibiting gas flow around the check valves (i.e. leakage around the check valves). In one exemplary embodiment, the components for positioning the check valves are spacers and are configured to direct air to flow between the check valves. The check valves may also be spaced apart in a variety of ways, other than using spacers. For example, one or more of the check valves may thread into the component chamber **114**, the component chamber may include a stop surface, etc. Any manner of positioning the check valves may be used. In the drawings, arrangements for setting the position of the check valves with respect to the inlets **118** and outlets **120** of the cylinder heads **110**A, **110**B are not shown. However, it is understood that spacers or another positioning arrangement would be used to position the illustrated check valves and spacers as shown. For example, U.S. Patent Application Publication, Pub. No. 2007/0065301 shows that inlet and outlet connectors **180**, **196** may engage spacers that fix the position of the valves. The components located in the component chamber may also include a plurality of seals that prevent leakage around the check valves.

[0061] As shown in FIGS. **9** and **10**, the check valves **130**A-**130**F that are in the cylinder heads **110**A, **110**B are preferably identical to each other. Other types of check valves than that shown can be used. Referring to FIGS. **9** and **10**, each illustrated check valve **130**A-**130**F includes a valve body **132** having a generally cylindrical configuration with a central chamber **134**. An end wall **136** is located at the upstream end of the valve body **132**. The end wall **136** has a central opening **138**. The downstream end of the valve body **132** is open. The check valve **130**A-**130**F each include a movable valve element in the form of a ball **146**. The dimensions of the ball **146** are selected so that when the ball is in engagement with the end wall **136** of the valve body **132**, the ball closes the opening **138**. When the ball **146** is away from the end wall **136**, fluid flow is enabled through the check valve. A spring biases the ball into engagement with the end wall **136** to close the valve. Further details of acceptable check valves are described in U.S. Patent Application Publication No. 2007/0065301.

[0062] Spacers **150**A-**150**D are positioned in the chamber **114** and space the check valves **130**A-**130**F apart. FIGS. **11**A and **11**B illustrate the spacers **150**B-**150**D. The spacers **150**B-**150**D are preferably identical to each other. Each spacer **150**B-**150**D is a cylindrical block of metal that has an outside diameter substantially equal in size to the inside diameter of the component chamber **114** in the cylinder heads **110**A, **110**B. The spacers **150**B-**150**D has an upstream end portion **152** and a downstream end portion **154**. However, in the illustrated embodiment, the end portions **152**, **154** are identical, since the spacer is symmetrical about a midplane **153**.

[0063] In the embodiment illustrated in FIGS. **11**A and **11**B, the spacer **150** has a small diameter central opening **155** that extends for the length of the spacer between the upstream end portion **152** and the downstream end portion **154**. The symmetric end portions **152**, **154** both include passages **158** that extend radially outward from the central opening **155** and an external groove **160** in fluid communication with the passage **158**. As a result, fluid communication is established between the central opening **155** of the spacer **150**, and the external groove **160**.

[0064] Referring to FIG. **9**, the spacer **150**A is shorter than the spacers **150**B-**150**D. The spacer **150**A is a cylindrical block of metal that has an outside diameter substantially equal in size to the inside diameter of the component chamber **114** in the cylinder head **110**. The spacer **150**A has symmetrical upstream and downstream end portions **164**, **166**.

[0065] A small diameter central opening **170** extends for the length of the short spacer between the upstream end portion **164** and the downstream end portion **166**. The spacer **150**A also has an internal passage **172** that extends radially outward from the central passage **170** and terminates in a groove **174** on the outer surface of the spacer **150**A. As a result, fluid communication is established between the upstream and downstream end portions **164** and **166** of the spacer **150**A, and the external groove **174**.

[0066] As shown in FIGS. **9** and **10**, an inlet connector **180** is secured in the upstream end of each of the cylinder heads **110**A, **110**B. The inlet connector has a fluid inlet passage **182** that communicates with the component chamber. An outlet connector **196** is secured in the downstream end of each of the cylinder heads **110**A, **110**B. The outlet connector **196** has a fluid outlet passage **198** that communicates with the component chamber **114**. The components are positioned in the component chamber **114** in the cylinder heads **110**A, **110**B.

[0067] An inlet check valve **130**E is positioned in the component chamber **114** in the first cylinder head **110**A. The inlet opening **138** of the inlet check valve **130**E is in communication with the inlet **118** of compressor **10**. In an exemplary embodiment, a seal may be provided between the check valve and the component chamber **114**.

[0068] The spacer **150**A is positioned in the component chamber **114** in the cylinder head **110** such that an upstream end of the spacer **154**A engages the downstream end of the inlet check valve **130**E. The external groove **174** on the spacer **162** aligns with the first charging port **122**A in the cylinder head **110**A. As a result, fluid communication can be established between the component chamber **114** and the first cylinder **36**A. (See FIG. **2**A).

[0069] Referring to FIG. **9**, a second check valve, or first cylinder check valve, **130**A is positioned in the component chamber **114** in the cylinder head **110**A. The upstream end of the second check valve **130**A engages the downstream end of the spacer **150**A. The inlet opening **138** of the second check valve **130**A aligns with the central passage **170** in the spacer **150**B. An optional seal is provided between the spacer **150**A and the second check valve **130**A.

[0070] Referring to FIG. **9**, a spacer **150**B is positioned in the component chamber **114** in the cylinder head **110**A. The upstream end of the spacer **150**B engages the downstream end of the check valve **130**A. The central opening **155** of the spacer **150**B aligns with the outlet of the check valve **130**A. The external groove **160** at the downstream end of the second spacer **150**B aligns with the second charging port **122**B in the cylinder head **110**A. As a result, fluid communication is established between the component chamber **114** and the second cylinder **36**B (See FIG. **2**A).

[0071] Referring to FIG. **9**, a third check valve, or second cylinder check valve, **130**B is positioned in the component chamber **114** in the cylinder head **110**A. The upstream end of the check valve **130**B engages the downstream end of the spacer **150**B. The opening **138** of the check valve **130**B aligns with the central passage **155** in the spacer **150**B. An optional seal is formed between the spacer **150**B and the check valve **130**B.

[0072] Referring to FIG. **10**, an optional fourth check valve, or second head inlet check valve **130**C is positioned in the component chamber **114** in the second cylinder head **110**B.

The inlet opening **138** of the inlet check valve **130**C is in communication with the inlet **118** of second head **110**B. In an exemplary embodiment, a seal may be provided between the check valve and the component chamber **114**.

[0073] A spacer **150**C is positioned in the component chamber **114** in the cylinder head **110**B. The upstream end of the spacer **150**C engages the downstream end of the check valve **130**C. The central opening **155** of the spacer **150**C aligns with the central opening of the check valve **130**C. The external groove **160** of the spacer **150**C aligns with the charging port **122**C in the cylinder head **110**B. As a result, fluid communication can be established between the component chamber **114** and the third cylinder **36**C (See FIG. **3**A).

[0074] A fifth check valve, or third cylinder check valve, **130**D is positioned in the component chamber **114** in the cylinder head **110**B. The upstream end of the check valve **130**D engages the downstream end of the spacer **150**C. The opening **138** of the check valve **130**D aligns with the passage **155** in the spacer **150**C. A seal may be provided between spacer **150**C and the check valve **130**D.

[0075] A spacer **150**D is positioned in the component chamber **114** in the cylinder head **110**B. The upstream end of the spacer **150**D engages the downstream end of the third cylinder check valve **130**D. The central opening **156** of the spacer **150**D aligns with the central chamber of the check valve **130**D. The external groove **160** at the downstream end of the fourth spacer **150**D aligns with the fourth charging port **122**D in the cylinder head **110**. As a result, fluid communication can be established between the component chamber **114** and the fourth cylinder **36**D.

[0076] A sixth check valve, or fourth cylinder check valve **130**F is positioned in the component chamber **114** in the cylinder head **110**B. The upstream end of the fourth cylinder check valve **130**F engages the downstream end of the spacer **150**D. The opening **138** of the check valve aligns with the central passage **155** in the spacer **150**D. An optional seal is provided between the spacer **150**D and the check valve **130**D.

[0077] An outlet connector **196** is fixed to the downstream end of the cylinder head **110**B. The outlet connector **196** has a fluid outlet passage **198** that is in fluid communication with the component chamber **114** of the cylinder head **110**B. In the illustrated embodiments, all the check valves **130**A-F of the compressor **10** are located in the cylinder heads **110**A, **110**B.

[0078] Referring once again to FIGS. **2**A and **3**A, when the compressor **10** is operating, air is admitted to the compressor through the inlet connector **180** of the first head **110**A. The air flows through the inlet connector **180** of the first head **110**A and to the inlet check valve **130**E.

[0079] When the compressor **10** is at the portion of its cycle in which the first cylinder **36**A is on the intake phase, the pressure in the first cylinder is lower than the intake pressure. As a result, intake gas flows through the inlet check valve **130**E and into the spacer **150**A.

[0080] The gas flows from the central passage **170** (See FIG. **9**) of the spacer **150**A, radially outward through the passage **172**, into the external groove **174** on the spacer. The air then flows through the first charging port **122**A and into the first cylinder **36**A (See FIG. **2**A).

[0081] Referring to FIGS. **2**A and **9**, during this time, the gas flowing through the inlet check valve **130**E does not flow through the second check valve **130**A, even though the spacer **150**A is open for free flow to the second check valve. This is because the pressure downstream of the second check valve **130**A, i.e., the pressure in the second cylinder **36**B, is higher than the intake pressure. Therefore, the second check valve **130**A stays closed and the intake air flows into the first cylinder **36**A.

[0082] When the first piston **40**A thereafter is compressing the air in the first cylinder **36**A, the pressure in the first cylinder becomes higher than the intake pressure. As a result, intake air can not flow upstream through the inlet check valve **130**E into the spacer **150**A. Therefore, all the air flowing out of the first cylinder is directed through the first charging port **122**A, the spacer **150**A, and through the second check valve **130**A.

[0083] Referring to FIGS. **2**A and **9**, the second check valve **130**A is forced open to allow air to flow out of the first cylinder **36**A into the second spacer **150**B. The air flows through the second spacer **150**B to the radially extending passages **158** (See FIGS. **11**A and **11**B) and the external groove **160** in the downstream end **154** of the second spacer **150**B. The air then flows from the groove **160** into the second charging port **122**B.

[0084] The timing of the first and second cylinders **36**A and **36**B is selected so that when the first cylinder **36**A is on its exhaust phase, the second cylinder **36**B is on its intake phase. This is achieved by the 180 degree offset β between the first and second eccentric bodies **84**A, **84**B. The air that is compressed in the first cylinder **36**A and forced into the second spacer **150**B is able to flow into the second cylinder **36**B, to be further compressed, because the second cylinder is smaller in diameter than the first cylinder but has the same stroke in the illustrated exemplary embodiment.

[0085] During the time the second cylinder **36**A is being charged by the first cylinder **36**B, the air flowing through the second spacer **150**B does not flow through the third check valve **130**B, even through the second spacer is open to the third check valve. This is because the pressure downstream of the third check valve **130**B, (i.e., the pressure in the third cylinder **36**C), is higher than the pressure at the third check valve. Therefore, the third check valve **130**B stays closed and the air flows into the second cylinder **36**B.

[0086] Referring to FIGS. **3**A and **10**, in a similar manner, the air that is compressed in the second cylinder **36**B flows through the conduit **119** into the third cylinder **36**C, there to be further compressed. The air that is compressed in the third cylinder **36**C flows into the fourth cylinder **36**D, there to be further compressed. The air that is compressed in the fourth cylinder **36**D flows out of the compressor **10** through the outlet connector **194**.

[0087] Referring to FIG. **12**, a system **210** includes a concentrator **212** that is operable to provide oxygen-enriched gas, for example, from an ambient air input. The oxygen-enriched gas is fed to a product tank **214**. A regulator **216** emits oxygen-enriched gas from the product tank **214** into a flow line **218** and feeds the same to a flow meter **220** which subsequently emits the oxygen-enriched gas to the patient at a predetermined flow rate, for example a flow rate of from 0.1 to 6 liters per minute. Optionally, the flow meter **220** can be closed so that all the oxygen-enriched gas is directed to the compressor **10**. The compressor may take a wide variety of fauns and may include any combination or subcombination of the features of the compressors described with respect to FIGS. **1**-**11**. Further, any combination or subcombination of the features of the compressors described with respect to FIGS. **1**-**11** can be used in a wide variety of different applications, including but not limited to the systems illustrated by FIGS. **12** and **13**.

[0088] Gas not directed to the patient is carried via line **222** to two-way valve **224**. A very small portion of the gas in the flow line **220** is directed through line **226** and restrictor **228** into an oxygen sensor **230** which detects whether or not the concentration of the oxygen is of a predetermined value, for example, at least **84** percent as directed to the patient and at least 93±3% as directed to the compressor.

[0089] When the oxygen sensor **230** detects a concentration at or above the predetermined level, the two-way valve **224** is kept open to permit the oxygen-enriched gas to flow through the valve **224** and line **232** into a buffer tank **234** wherein the pressure is essentially the same as the pressure in the product tank **214**. However, should the oxygen sensor **230** not detect a suitable oxygen concentration, two-way valve **224** is closed so that the oxygen concentrator **212** can build up a sufficient oxygen concentration. This arrangement prioritizes the flow of oxygen-enriched gas so that the patient is assured of receiving a gas having a sufficient oxygen concentration therein.

[0090] Buffer tank **234** can have a regulator **236** thereon generally set at 12 psi to admit the oxygen-enriched gas to the compressor **10** when needed. The output of the compressor **10** is used to fill a cylinder or portable tank **238** for ambulatory use by the patient. Alternatively, the pressure regulator **236** can be set at anywhere from about 13 to about 21 psi. A restrictor **240** controls the flow rate of gas from the buffer tank **234** to the compressor **10**. Should the operation of the compressor **10** cause the pressure in the buffer tank **234** to drop below a predetermined value, a pressure sensor (not shown) automatically cuts off the flow of gas at a pressure above the pressure of the gas being fed to the patient. This prioritization assures that the patient receives priority with regard to oxygen-enriched gas.

[0091] FIG. **13** shows a system **210***a* that is somewhat different from the system **210** of FIG. **12**. In the system **210***a*, the compressor **10** includes its own oxygen sensor and control circuitry, so that the elements **224-232** are not present as they are in the system shown in FIG. **12**. In addition, the regulator **236** is not present on the buffer tank. A flow restrictor may be provided between the concentrator and the buffer tank. (It should be noted that the buffer tank **234** is optional in all systems, and that the compressor could be fed directly from the product tank).

[0092] The foregoing description relates to a four-cylinder compressor. However, the features described in this application are applicable to compressors that have different numbers of cylinders. In addition, disclosed features may be used in compressors having cylinder heads with different check valve and spacer designs.

[0093] While the present invention has been illustrated by the description of embodiments thereof, and while the embodiments have been described in considerable detail, it is not the intention of the applicant to restrict or in any way limit the scope of the appended claims to such detail. Additional advantages and modifications will readily appear to those skilled in the art. Still further, while cylindrical components have been shown and described herein, other geometries can be used including elliptical, polygonal (e.g., square, rectangular, triangular, hexagonal, etc.) and other shapes can also be used. Therefore, the invention, in its broader aspects, is not limited to the specific details, the representative apparatus, and illustrative examples shown and described. Accordingly, departures can be made from such details without departing from the spirit or scope of the applicant's general inventive concept.

Having described the invention, we claim:

1. A compressor for compressing gas, comprising:

first, second, third and fourth cylinders, wherein a central axis of the first cylinder is parallel with a central axis of the second cylinder and a central axis of the third cylinder is parallel with the central axis of the fourth cylinder, wherein axes of the first and second cylinders are oriented at an angle with respect to the axes of the third and fourth cylinders to form a V4 cylinder configuration;

first, second, third and fourth pistons disposed in the first, second, third and fourth cylinders;

a crankshaft having a main shaft and only two eccentric driving bodies that drive the first, second, third, and fourth pistons.

2. The compressor of claim **1** wherein an angle formed between the axes of the first and second cylinders and the axes of the third and fourth cylinders is ninety degrees.

3. The compressor of claim **1** further comprising a head assembly that routes gas compressed in the first cylinder to the second cylinder, gas compressed in the second cylinder to the third cylinder, and gas compressed in the third cylinder to the fourth cylinder.

4. The compressor of claim **1** wherein the first cylinder has a first diameter, the second cylinder has a second diameter, the third cylinder has a third diameter, and the fourth cylinder has a fourth diameter, wherein the first diameter is larger than the second diameter, the second diameter is larger than the third diameter, and the third diameter is larger than the fourth diameter.

5. A compressor for compressing a gas, comprising:

a cylinder assembly having a first cylinder having a first diameter, a second cylinder having a second diameter, a third cylinder having a third diameter, and a fourth cylinder having a fourth diameter, wherein the first diameter is larger than the second diameter, the second diameter is larger than the third diameter, and the third diameter is larger than the fourth diameter, wherein the first cylinder is in-line with the second cylinder, wherein third cylinder is in-line with the fourth cylinder, wherein the first and second cylinders form and angle of approximately ninety degrees with respect to the third and fourth cylinders such that the cylinder assembly is a V4 configuration;

first, second, third and fourth pistons received in the first, second, third, and fourth cylinders respectively;

first, second, third, and fourth drive rods arranged to move the first, second, third, and fourth pistons in the first, second, third, and fourth cylinders;

a crankshaft having a main shaft that includes a crank axis about which the crankshaft rotates, wherein the crankshaft includes first and second circular connecting rod driving bodies that extend radially outward from and are eccentric to the crank axis, wherein the first and third drive rods are rotatably connected to the first circular connecting rod driving body such that rotation of the first circular connecting rod body about the crank axis reciprocates the first and third drive rods and wherein the second and fourth drive rods are rotatably connected to the second circular connecting rod driving body such that rotation of the second circular connecting rod body about the crank axis reciprocates the second and fourth drive rods;

a gas inlet for providing a source of gas to the first cylinder, a first gas flow passage for providing the gas from the first cylinder to the second cylinder, a second gas flow passage for providing the gas from the second cylinder to the third cylinder, a third gas flow passage for providing the gas from the third cylinder to the fourth cylinder, and a gas outlet for providing the gas out of the compressor in a compressed state.

6. The compressor of claim **5** wherein the first and second circular connecting rod driving bodies are the only connecting rod driving bodies of the crankshaft.

7. The compressor of claim **5** wherein the connecting rod driving bodies each consist of a single continuous cylinder.

8. The compressor of claim **5** wherein the connecting rod driving bodies each consist of a single continuous cylinder integrally formed with the main shaft.

9. The compressor of claim **5** wherein the first connecting rod driving body abuts the second connecting rod driving body.

10. The compressor of claim **7** wherein the first connecting rod driving body abuts the second connecting rod driving body.

11. The compressor of claim **8** wherein the first connecting rod driving body abuts the second connecting rod driving body.

12. The compressor of claim **5** wherein the first connecting rod driving body is connected to the second connecting rod driving body only at an area of overlap between the first connecting rod driving body and the second connecting rod driving body.

13. The compressor of claim **5** wherein the first connecting rod driving body is connected to the second connecting rod driving body by a circular disk disposed between the first connecting rod driving body and the second connecting rod driving body.

14. The compressor of claim **13** wherein the circular disk is centered on the crank axis.

15. The compressor of claim **14** wherein an outer circumference of the circular disk extends outward of the outer circumference of both of the first and second connecting rod driving bodies.

16. The compressor of claim **8** wherein the first connecting rod driving body is connected to the second connecting rod driving body by a circular disk that is integrally formed with and disposed between the first connecting rod driving body and the second connecting rod driving body.

17. The compressor of claim **5** wherein the first piston comprises a wobble piston.

18. The compressor of claim **5** wherein the second piston comprises a guide member pivotably connected to the second drive rod and a compression member that is separate from the guide member disposed in the second cylinder.

19. The compressor of claim **5** wherein the guide member engages the compression member to force the compression member toward a head end of the second cylinder during a compression stroke of the second drive rod.

20. The compressor of claim **19** wherein pressurized gas forced into the second cylinder by the first piston forces the compression member toward a crank end of the second cylinder during a charging stroke of the second drive rod.

21. The compressor of claim **5** wherein a first bearing support portion of the crankshaft has a diameter that is less than a diameter of the first circular connecting rod driving body.

22. A compressor for compressing a gas, comprising:

a cylinder assembly having a first cylinder having a first diameter, a second cylinder having a second diameter, a third cylinder having a third diameter, and a fourth cylinder having a fourth diameter, wherein the first diameter is larger than the second diameter, the second diameter is larger than the third diameter, and the third diameter is larger than the fourth diameter, wherein the first cylinder is in-line with the second cylinder, wherein third cylinder is in-line with the fourth cylinder;

first, second, third and fourth pistons received in the first, second, third, and fourth cylinders respectively;

first, second, third, and fourth drive rods arranged to move the first, second, third, and fourth pistons in the first, second, third, and fourth cylinders;

a crankshaft having a main shaft that includes a crank axis about which the crankshaft rotates, wherein the crankshaft includes first and second circular connecting rod driving bodies that extend radially outward from and are eccentric to the crank axis, wherein the first circular connecting rod driving body abuts the second circular connecting rod driving body, wherein the first and third drive rods are rotatably connected to the first circular connecting rod driving body such that rotation of the first circular connecting rod body about the crank axis reciprocates the first and third drive rods and wherein the second and fourth drive rods are rotatably connected to the second circular connecting rod driving body such that rotation of the second circular connecting rod body about the crank axis reciprocates the second and fourth drive rods;

a gas inlet for providing a source of gas to the first cylinder, a first gas flow passage for providing the gas from the first cylinder to the second cylinder, a second gas flow passage for providing the gas from the second cylinder to the third cylinder, a third gas flow passage for providing the gas from the third cylinder to the fourth cylinder, and a gas outlet for providing the gas out of the compressor in a compressed state.

23. The compressor of claim **22** wherein the first and second circular connecting rod driving bodies are the only connecting rod driving bodies of the crankshaft.

24. The compressor of claim **22** wherein the connecting rod driving bodies each consist of a single continuous cylinder.

25. The compressor of claim **22** wherein the connecting rod driving bodies each consist of a single continuous cylinder integrally formed with the main shaft.

26. The compressor of claim **22** wherein the first connecting rod driving body is connected to the second connecting rod driving body only at an area of overlap between the first connecting rod driving body and the second connecting rod driving body.

27. The compressor of claim **22** wherein the first piston comprises a wobble piston.

28. The compressor of claim **22** wherein the second piston comprises a guide member pivotably connected to the second drive rod and a compression member that is separate from the guide member disposed in the second cylinder.

29. The compressor of claim **22** wherein the guide member engages the compression member to force the compression member toward a head end of the second cylinder during a compression stroke of the second drive rod.

30. The compressor of claim **29** wherein pressurized gas forced into the second cylinder by the first piston forces the compression member toward a crank end of the second cylinder during a charging stroke of the second drive rod.

* * * * *