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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
21 March 2024 (21.03.2024)

WIPO | PCT

(10) International Publication Number
WO 2024/059604 A1

(51) International Patent Classification:
F04C 18/02 (2006.01) *F04C 29/12* (2006.01)
F04C 18/00 (2006.01) *F04C 29/02* (2006.01)

(21) International Application Number: PCT/US2023/074026

(22) International Filing Date: 13 September 2023 (13.09.2023)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
17/944,004 13 September 2022 (13.09.2022) US

(71) Applicant: MAHLE INTERNATIONAL GMBH [DE/DE]; Pragstrasse 26-46, 70376 Stuttgart (DE).

(72) Inventor; and
(71) Applicant: **BOWMAN, Brett** [US/US]; 4793 Townline Road, Lockport, NY 14094 (US).

(74) Agent: **YEE, James, R.**; Endurance Law Group, PLC, 156 W. Michgan Ave, #55, Jackson, MI 49201 (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, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, 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,

(54) Title: ELECTRIC COMPRESSOR WITH DOMED INVERTER COVER

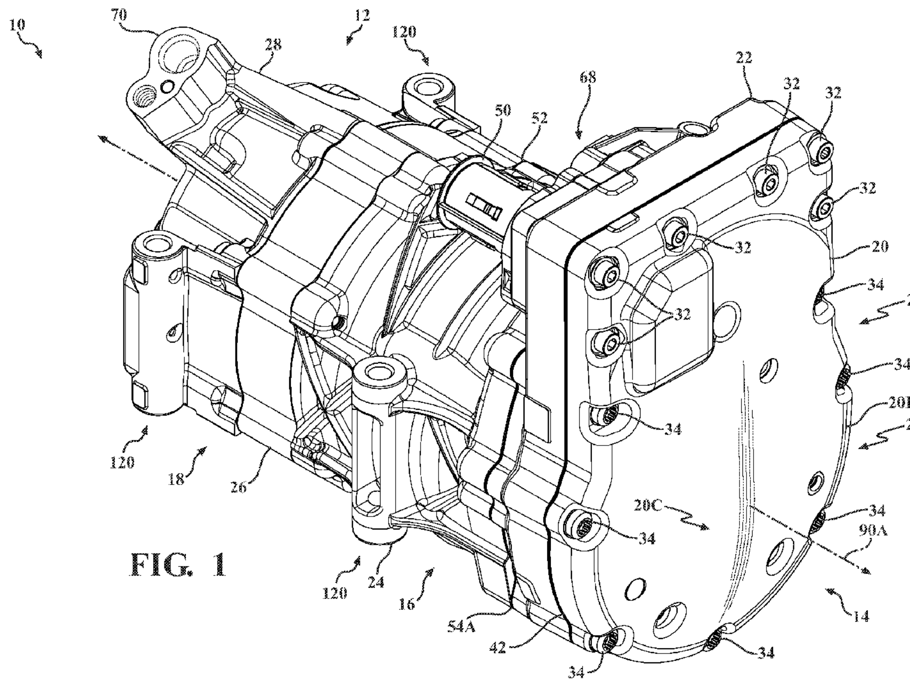


FIG. 1

(57) Abstract: An electric compressor includes a housing, refrigerant inlet port, a refrigerant outlet port, an inverter section, a motor section, a compression device and a front cover. The housing defines an intake volume and a discharge volume. The refrigerant inlet port is coupled to the housing and is configured to introduce the refrigerant to the intake volume. The compression device is a scroll-type compression device configured to compress the refrigerant. The refrigerant outlet port is coupled to the housing and is configured to allow compressed refrigerant to exit the scroll-type electric compressor from the discharge volume.

WO 2024/059604 A1

[Continued on next page]

LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

ELECTRIC COMPRESSOR WITH DOMED INVERTER COVER

Field of the Invention

[0001] The invention relates generally to electric compressor, and more particularly to an electric compressor that compresses a refrigerant using a scroll compression device.

Background of the Invention

[0002] Compressors have long been used in cooling systems. In particular, scroll-type compressors, in which an orbiting scroll is rotated in a circular motion relative to a fixed scroll to compress a refrigerant, have been used in systems designed to provide cooling in specific areas. For example, such scroll-type compressors have long been used in the HVAC systems of motor vehicles, such as automobiles, to providing air-conditioning. Such compressors may also be used, in reverse, in applications requiring a heat pump. Generally, these compressors are driven using rotary motion derived from the automobile's engine.

[0003] With the advent of battery-powered or electric vehicles and/or hybrid vehicles, in which the vehicle may be solely powered by a battery at times, such compressors must be driven or powered by the battery rather than an engine. Such compressors may be referred to as electric compressors.

[0004] In addition to cooling a passenger compart of the motor vehicle, electric compressors may be used to provide heating or cooling to other areas or components of the motor vehicle. For instance, it may be desired to heat or cool the electronic systems and the battery or battery compartment, when the battery is being charged, especially during fast charging modes, as such generate heat which may damage or degrade. the battery and/or other system. It may also be used to cooling the battery during times when the battery is not being charged or used, as heat may damage or degrade the battery. Since the electric compressor may be run at various times, even when the motor vehicle is not in operation, such use, obviously, requires electrical energy from the battery, thus reducing the operating time of the battery.

[0005] Additionally, electric compressors may run at a very high speed, e.g., 2,000 RPM (or higher). Such high speed may generate unwanted levels of noise.

[0006] It is thus desirable, to provide an electric compressor having high efficiency, low-noise and maximum operating life. The present invention is aimed at one or more of the problems or advantages identified above.

BRIEF SUMMARY OF THE INVENTION

[0007] In a first embodiment of the present invention, a scroll-type electric compressor configured to compress a refrigerant, is provided. The scroll-type electric compressor includes a housing, a refrigerant inlet port, a refrigerant outlet port, an inverter module, a motor, a drive shaft, a compression device and an inverter cover. The housing defines an intake volume and a discharge volume. The housing has a generally cylindrical shape and a central axis. The refrigerant inlet port is coupled to the housing and is configured to introduce the refrigerant to the intake volume. The refrigerant outlet port is coupled to the housing and is configured to allow compressed refrigerant to exit the scroll-type electric compressor from the discharge volume. The inverter module is mounted inside the housing and adapted to convert direct current electrical power to alternating current electrical power. The motor is mounted inside the housing. The drive shaft is coupled to the motor. The compression device is coupled to the drive shaft and is configured to receive the refrigerant from the intake volume and to compress the refrigerant as the drive shaft is rotated by the motor. The inverter cover is located at one end of the scroll-type electric compressor and includes a first portion and a second portion. The first portion is generally perpendicular to the central axis and has an apex and an outer perimeter. The first portion has a relatively domed-shaped such that the inverter cover has a curved profile from the apex towards the outer perimeter.

[0008] In a second embodiment of the present invention, a scroll-type electric compressor having a central axis and configured to compress a refrigerant, is provided. The scroll-type electric compressor includes a housing, a refrigerant inlet port, a refrigerant outlet port, an inverter section, a motor section, a compression device and a swing-link mechanism. The housing defines an intake volume and a discharge volume. The refrigerant inlet port is coupled to the housing and is configured to introduce the refrigerant to the intake volume. The refrigerant outlet port is coupled to the housing and is configured to allow compressed refrigerant to exit the scroll-type electric compressor from the discharge volume.

[0009] The inverter section includes an inverter housing, an inverter back cover, an inverter module. The inverter back cover is connected to the inverter housing and forms an inverter cavity. The inverter back cover has a first portion and a second portion. The first portion is generally perpendicular to the central axis and has an apex and an outer perimeter. The first portion has a relatively domed-shaped such that the inverter cover has a curved profile from the apex towards the outer perimeter. The inverter module is mounted inside the inverter cavity and is adapted to convert direct current electrical power to alternating current electrical power.

[0010] The motor section includes a motor housing, a drive shaft and a motor. The motor housing forms a motor cavity and is mounted to the inverter housing. The drive shaft is located within the motor housing, has first and second ends and defines a center axis. The motor is located within the motor housing to controllably rotate the drive shaft about the center axis.

[0011] The compression device includes a fixed scroll, an orbiting scroll, a swing-link mechanism, and a ball bearing. The fixed scroll is located within, and is fixed relative to, the housing. The orbiting scroll is coupled to the drive shaft, the orbiting scroll and the fixed scroll forming compression chambers for receiving the refrigerant from the intake volume and compressing the refrigerant as the drive shaft is rotated about the center axis. The swing-link mechanism is coupled to the drive shaft. The ball bearing is positioned between, and adjacent to each of the orbiting scroll and the swing-link mechanism. The drive shaft, drive pin, orbiting scroll and swing-link mechanism are arranged to cause the orbiting scroll to orbit the central axis in an eccentric orbit. The housing is formed by the inverter back cover, the inverter housing, the motor housing, the fixed scroll and the front cover.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0012] These and other features and advantages of the present invention will become more readily appreciated when considered in connection with the following detailed description and appended drawings.

[0013] FIG. 1 is first perspective view an electric compressor, according to an embodiment of the present invention.

[0014] FIG. 2 is a second perspective view of the electric compressor of FIG. 1.

[0015] FIG. 3A is a first side view of the electric compressor of FIG. 1 illustrating an inverter back cover of an inverter section.

[0016] FIG. 3B is a perspective view of the inverter back cover of FIG. 3A.

[0017] FIG. 3C is a first perspective view of an inverter back cover, according to an alternative embodiment of the present invention.

[0018] FIG. 3D is a second perspective view of the inverter back cover of FIG. 3C.

[0019] FIG. 4 is a second side view of the electric compressor of FIG. 1.

[0020] FIG. 5 is a front view of the electric compressor of FIG. 1.

[0021] FIG. 6 is a rear view of the electric compressor of FIG. 1.

[0022] FIG. 7 is a top view of the electric compressor of FIG. 1.

[0023] FIG. 8 is a bottom view of the electric compressor of FIG. 1.

[0024] FIG. 9 is a first cross-sectional view of the electric compressor of FIG. 1.

[0025] FIG. 10 is a second cross-sectional view of the electric compressor of FIG. 1.

[0026] FIG. 11 is an exploded view of an inverter of the electric compressor of FIG. 1.

[0027] FIG. 12 is an exploded view of a portion of the electric compressor of FIG. 1, including a motor and drive shaft.

[0028] FIG. 13 is an exploded view of a compression device of the electric compressor of FIG. 1.

[0029] FIG. 14A is a first perspective view of a drive shaft of FIG. 12.

[0030] FIG. 14B is a second perspective view of the drive shaft of FIG. 14A.

[0031] FIG. 15A is a first perspective view of a rotor and counterweights of the motor of FIG. 12.

[0032] FIG. 15B is a second perspective view of the rotor and counterweights of FIG. 15A.

[0033] FIG. 16A is a first perspective view of a portion of the electric compressor of FIG. 1, including an orbiting scroll, drive pin and swing-link mechanism.

[0034] FIG. 16B is a second perspective view of the portion of the electric compressor of FIG. 16A.

[0035] FIG. 16C is a perspective view of a plug of the compression device of FIG. 13.

[0036] FIG. 16D is a second perspective view of the plug of FIG. 16C.

[0037] FIG. 16E is a cross-sectional view of the plug of FIG. 16C.

[0038] FIG. 16F is a perspective view of an inverter housing of the inverter of FIG. 11.

[0039] FIG. 16G is a partial expanded view of the compression device of FIG. 13.

[0040] FIGS. 17A-17J are graphic representations of a fixed scroll and an orbiting scroll of a compression device of the electric compressor of FIG. 1, according to an embodiment of the present invention.

[0041] FIG. 18A is a first perspective view of a portion of the compression device of FIG. 13, including a fixed scroll and an orbiting scroll.

[0042] FIG. 18B is a second perspective view of the portion of the compression device of FIG. 18A.

[0043] FIG. 18C is a first perspective view of the fixed scroll of the compression device of FIG. 13.

[0044] FIG. 18D is a second perspective view of the fixed scroll of the compression device of FIG. 13.

[0045] FIG. 18E is a third perspective view of the fixed scroll of the compression device of FIG. 13.

[0046] FIG. 18F is a perspective view of a reed mechanism associated with the compression device of FIG. 13.

[0047] FIG. 19A is a first perspective view of a front cover of an electric compressor forming an oil separator, according to an embodiment of the present invention.

[0048] FIG. 19B is a second perspective view of the front cover of FIG. 19A.

[0049] FIG. 20 is a first perspective view of a front cover of an electric compressor forming an oil separator, according to a second embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0050] Referring to the figures, wherein like numerals indicate like or corresponding parts throughout the several views, an electric compressor **10** having an outer housing **12** is provided. The electric compressor **10** is particularly suitable in a motor vehicle, such as an automotive vehicle (not shown). The electric compressor **10** may be used as a cooling device or as a heating pump (in reverse) to heat and/or cool different aspects of the vehicle. For instance, the electric compressor **10** may be used as part of the heating, ventilation and air conditioning (HVAC) system in electric vehicles (not shown) to cool or heat a passenger compartment. In addition, the electric compressor **10** may be used to heat or cool the passenger compartment, on-board electronics and/or a battery used for powering the vehicle while the vehicle is not being operated, for instance, during a charging cycle. The electric compressor **10** may further be used while the vehicle is not being operated and while the battery is not being charged to maintain, or minimize the degradation, of the life of the battery. In the illustrated embodiment, the electric compressor **10** has a displacement of 57 cubic centimeters (cc). The displacement refers to the initial volume captured within the compression device as the scrolls of the compression device initially close or make contact (see below). It should be noted that the electric compressor **10** disclosed herein is not limited to any such volume and may be sized or scaled to meet particular required specifications.

[0051] In the illustrated embodiment, the electric compressor **10** is a scroll-type compressor acts to compress a refrigerant rapidly and efficiently for use in different systems of a motor vehicle, for example, an electric or a hybrid vehicle. The electric compressor 10 may use a mixture of refrigerant and oil, throughout its operation, which may be referred to simply as "refrigerant".

[0052] The electric compressor includes 10 an inverter section 14, a motor section 16, and a compression device (or compression assembly) 18 contained within the outer housing 12. The outer housing 12 includes an inverter back cover 20, an inverter housing 22¸ a motor housing 24, a fixed scroll 26, and a front cover 28 (which may be referred to as the discharge head).

[0053] In a first aspect of the electric compressor 10 of the disclosure, an electric compressor 10 having a swing-link mechanism and drive shaft with an integrated limit pin is provided. In a second aspect of the electric compressor **10** of the disclosure, an electric compressor **10** with an oil separator is provided. In a third aspect of the electric compressor **10** of the disclosure, an electric compressor **10** having a scroll bearing oil injection, is provided. In a fourth aspect of the electric disclosure of the disclosure, an electric compressor **10** having a bearing oil communication hole is provided. In a fifth aspect of the present invention, an electric compressor **10** having a domed inverter cover is provided.

[0054] In one embodiment, the inverter back cover **20**, the inverter housing **22**¸ the motor housing **24,** a fixed scroll **26**, and the front cover **28** are composed from machined aluminum. The inverter **10** may be mounted, for example, within the body of a motor vehicle, via a plurality of mount points **120**.

*General Arrangement, and Operation, of the Electric Compressor **10***

[0055] The inverter back cover **20** and the inverter housing **22** form an inverter cavity **30**. The inverter back cover **20** is mounted to the inverter housing **22** by a plurality of bolts **32**. The inverter back cover **20** and the inverter housing **22** are mounted to the motor housing **24** by a plurality of bolts **34** which extend through apertures **36** in the inverter back cover **20** and apertures **38** in the inverter housing 22 and are threaded into threaded apertures **40** in the motor housing **24**. An inverter gasket **42**, positioned between the inverter back cover **20** and the inverter housing **22** keeps moisture, dust, and other contaminants from the internal cavity **30**. A motor gasket **54A** is positioned between the inverter housing **22** and the motor housing **24** to provide maintain a refrigerant seal to the environment.

[0056] With reference to FIG. 11, an inverter module **44** mounted within the inverter cavity **30** formed by the inverter back cover **20** and the inverter housing **22**. The inverter module **44** includes an inverter circuit **46** mounted on a printed circuit board **48**, which is mounted to the inverter housing **22**. The inverter circuit **46** converts direct current (DC) electrical power received from outside of the electric compressor **10** into three-phase alternating current (AC) power to supply/power the motor **54** (see below). The inverter circuit **46** also controls the rotational speed of the electric compressor **10**. High voltage DC current is supplied to the inverter circuit **46** via a high voltage connector **50**. Low voltage DC current to drive the inverter circuit **46**, as well as control signals to control operation of the inverter circuit **46**, and the motor section **16**, is supplied via a low voltage connecter **52**.

[0057] The motor section **16** includes a motor **54** located within a motor cavity **56**. The motor cavity **56** is formed by a motor side **22A** of the inverter housing **22** and an inside surface **24A** of the motor housing **22**. With specific reference to FIG. 12, the motor **54** is a three-phase AC motor having a stator **56**. The stator **56** has a generally hollow cylindrical shape with six individual coils (two for each phase). The stator **56** is contained within, and mounted to, the motor housing **22** and remains stationery relative to the motor housing **22**.

[0058] The motor **54** includes a rotor **60** located within, and centered relative to, the stator **58**. The rotor **60** has a generally hollow cylindrical shape and is located within the stator **56**. The rotor **60** has a number of balancing counterweights **60A**, **60B**, affixed thereto. The balancing counterweights balance the motor **54** as the motor **54** drives the compression device **18** and may be machined from brass.

[0059] Power is supplied to the motor **54** via a set of terminals **54A** which are sealed from the motor cavity **56** by an O-ring **54B**.

[0060] A drive shaft **90** is coupled to the rotor **60** and rotates therewith. In the illustrated embodiment, the draft shaft **90** is press-fit within a center aperture **60C** of the rotor **60.** The drive shaft **90** has a first end **90A** and a second end **90B**. The inverter housing **22** includes a first drive shaft supporting member **22B** located on the motor side of the inverter housing **22**. A first ball bearing **62** located within an aperture formed by the first drive shaft supporting member **22** supports and allows the first end of the drive shaft **90** to rotate. The motor housing **24** includes a second drive shaft supporting member **24A**. A second ball bearing **64** located within an aperture formed by the second drive shaft supporting member **24A** allows the second end **90B** of the drive shaft **90** to rotate. In the illustrated embodiment, the first and second ball bearing **62**, **64** are press-fit with the apertures formed by the first drive shaft supporting member **22** of the inverter housing **22** and the second drive shaft supporting member **24A** of the motor housing **24**, respectively.

[0061] As stated above, the electric compressor **10** is a scroll-type compressor. The compression device **18** includes the fixed scroll **26** and an orbiting scroll **66**. The orbiting scroll **66** is fixed to the second end of the rotor **60B**. The rotor **60** with the drive shaft **90** rotate to drive the orbiting scroll **64** motion under control of the inverter module **44** rotate.

[0062] With reference to FIGS. 14A, 14B, 16A and 16B, the drive shaft **90** has a central axis **90C** around which the rotor **60** and the drive shaft **90** are rotated. The orbiting scroll **66** moves about the central axis **90C** in an eccentric orbit, i.e., in a circular motion while the orientation of the orbiting scroll **66** remains constant with respect to the fixed scroll **26**. The center of the orbiting scroll **66** is located along an offset axis **90D** of the drive shaft **90** defined by an orbiting scroll aperture (or drive pin location **90E** (see FIG. 14A) located at the second end **90D** of the drive shaft **90**. As the drive shaft **90** is rotated by the motor **54**, the orbiting scroll **66** follows the motion of the orbiting scroll aperture **90E** through the drive pin **162** and drive hub on the swinglink mechanism **124** and bearing **108** as the drive shaft **90** is rotated about the central axis **60C**.

[0063] With specific reference to FIGS. 1, 2 and 9, intermixed refrigerant and oil (at low pressure) enters the electric compressor **10** via a refrigerant inlet port **68** and exits the electric compressor **10** (at high pressure) via refrigerant outlet port **70** after being compressed by the compression device **18**. As shown in the cross-sectional view of FIG. 9, the refrigerant follows the refrigerant path **72** through the electric compressor **10**. As shown, refrigerant enters the refrigerant inlet port **68** and enters an intake volume **74** formed between the motor side **22A** of the inverter housing **22** and motor housing **24** adjacent the refrigerant inlet port **68**. Refrigerant is then drawn through the motor section **16** and enters a compression intake volume **76** formed between an internal wall of the fixed scroll **26** and the orbiting scroll **66** (demonstrated by arrow **92** in FIG. 14A).

[0064] As shown in FIGS. 9 and 13, the fixed scroll **26** has a fixed scroll base **26A** and a fixed scroll lap **26B** extending away from the fixed scroll base **26A** towards the orbiting scroll **66**. As shown in FIGS. 16A-16B, the orbiting scroll **66** has an orbiting scroll base **66A** and a orbiting scroll lap **66B** extending from the orbiting scroll base **66A** towards the fixed scroll **26**. The laps **26A**, **66A** have a tail end **26C, 66C** adjacent an outer edge of the respective scroll **26A**, **66B** and scroll inward towards a respective center end **26D**, **66D**.

[0065] Respective tip seals **94** are located within a slot **26E**, **66E** located at a top surface of the fixed scroll **26** and the orbiting scroll **66**, respectively. The tip seals **94** are comprised of a flexible material, such as a Polyphenylene Sulfide (PPS) plastic. When assembled, the tip seals **94** are pressed against the opposite base **26A 66A** to provide a seal therebetween. In one embodiment, the slots **26E 66E,** are longer than the length of the tip seals **94** to provide room for adjustment/movement along the length of the tip seals **94**.

[0066] With reference to FIGS. 17A-17I, intermixed refrigerant enters the compression device **12** from the compression intake volume **76**. In FIGS. 17A-17I, a cross-section view of the fixed scroll **16** shown and the top of the orbiting scroll **66** are shown.

[0067] As discussed in detail below, the fixed scroll lap **16A** and the orbiting scroll lap **66A** form compression chambers **80** in which low or unpressurized (saturation pressure) refrigerant enters from the compression device **12**. As the orbiting scroll **66** moves to enable the compression chambers **80** to be closed off and the volume of the compression chambers **80** is reduced to pressurize the refrigerant. At any one time during the cycle, one or more compression chambers **80** are at different stages in the compression cycle. The below description relates just to one set of compression chambers **80** during a complete cycle of the electric compressor **10**.

[0068] The refrigerant enters the compression chambers **80** formed between the orbiting scroll lap **66A** and the fixed scroll lap **26A**. During a cycle of the compressor **10**, the refrigerant is transported towards the center of these chambers. The orbiting scroll **66** orbits in a circular motion indicated by arrow **78** formed by the relative position of the orbiting scroll **66** relative to the fixed scroll **26** is shown during one cycle of the electric compressor **10**.

[0069] In FIG. 17A, the position of the orbiting scroll **66** at the beginning of a cycle is shown. As shown, in this initial position, the tail ends **16B**, **66B** are spaced apart from the other scroll lap **66BA 16**. At this point, the compression chambers **80** are open to the compression intake volume **76** allowing refrigerant under low pressure to fill the compression chambers **80** from the compression intake volume **76.** As the orbiting scroll **66** moves along path **78,** the space between the tail ends **16A**, **66A** and the other scroll **66**, **16** decreases until the compression chambers **80** are closed off from the compression intake volume **76** (FIGS. 17B-17E)**.** As the orbiting scroll **66** continues to move along **78**, the volume of the compression chambers **80** is further reduced, thus pressurizing the refrigerant in both compression chambers **80** (FIGS. 17F-H). As shown in FIGS. 17I-18J, as the orbiting scroll 66 continues to orbit, the two compression chambers **80** are combined into a single volume. This volume is further reduced until the pressurized refrigerant is expelled from the compression device **18** (see below)

[0070] As discussed below, the refrigerant enters chambers formed between the walls of the orbiting scroll **66** and the fixed scroll **26**. During the cycle of the compressor **10**, the refrigerant is transported towards the center of these chambers. The orbiting scroll **66** orbits or moves in a circular motion indicated by arrow 78 formed by the relative position of the orbiting scroll **66** relative to the fixed scroll **26** is shown during one cycle of the electric compressor **10.**

[0071] Returning to FIG. 1, the front cover **28** forms a discharge volume **82**. The discharge volume **82** is in communication with the refrigerant output port **70**. As discussed in more detail below, pressurized refrigerant leaves the compression device **18** through an orifice **84** in the fixed scroll **26** (see FIGS. 18C and 18E) The release of pressurized refrigerant is controlled by a reed mechanism **86**. In the illustrated embodiment, a single reed mechanism **86** is used. However, it should be noted that more than one reed mechanisms may be used.

[0072] As shown in FIGS. 18D and 18E, in the illustrated embodiment, the reed mechanism **86** includes a discharge reed **86**A and a reed retainer **86B**. The discharge reed **86A** is made from a flexible material, such as steel. The characteristics, such as material and strength, are selected to control the pressure at which the pressurized refrigerant is released from the compression device **18**. The reed retainer **86B** is made from a rigid, inflexible material, such as stamped steel. The reed retainer **866** controls or limits the maximum displacement of the discharge reed **86A** relative to the fixed scroll **26**.

[0073] In the illustrated embodiment, the read mechanism **86** is held or fixed in place without a separate fastener. As shown in FIGS. 18E and 18F, the reed mechanism **86** incudes a pair of apertures **86C** which are configured to receive associated posts **84A** on the fixed scroll **26**. When the electric compressor **10** is assembled, the reed mechanism **86** is adjacent, and held in place by, the front cover **28**. As shown in FIG. 18E, the back surface of the fixed scroll **26** includes a bezel **84B** surrounding the orifice **84** which assists in tuning the pressure at which refrigerant exits the compression device **18**. Additionally, a debris collection slot **84B** collects debris near the orifice **84** to prevent from interference with the reed mechanism **86**.

[0074] As shown in FIG. 9, the path of refrigerant through the electric compressor is indicated by dashed arrow **72**.

[0075] The electric compressor **10** utilizes oil (not shown) to provide lubrication to the between the components of the compression device **18** and the motor **54**, for example, between the orbiting scroll **66** and the fixed scroll **26** and within the ball bearings **62**, **64**. The oil intermixes with the refrigerant within the compression device **18** and the motor **54** and exits the compression device **18** via the orifice **84**. As discussed in more detail below, the oil is separated from the compressed refrigerant within the front cover **28** and is returned to the compression device **18**.

[0076] An oil separator **96** facilitates the separation of the intermixed oil and refrigerant. Generally, the oil separator 96 only removes some of the oil within the intermixed oil and refrigerant. The separator oil is stored in an oil reservoir and cycled back through the compression device **18**, where the oil is mixed back in with the refrigerant.

[0077] In the illustrated embodiment, the oil separator **96** is integrated within the front cover **28.** The front cover **28** further defines an oil reservoir **98** which collects oil from the oil separator **96** before the oil is recirculated through the motor **54** and motor cavity **56** and the compression device **18**. In use, the electric compressor **10** is generally orientated as shown in FIGS. 3-5, such that gravity acts as indicated by arrow **106** and oil collects within the oil reservoir **98**. With reference to FIG. 9, the general path oil travels from the bottom of the electric compressor **10** through the compression device **18**, out the orifice **84** to the discharge volume **82** of the front cover **28** and back to the compression device **18** is shown by arrow **88**. As shown, the oil is drawn back up into the compression device **18** where the oil is mixed back into or with the refrigerant.

[0078] As stated above, refrigerant, which is actually a mixture of refrigerant and oil enters the electric compressor **10** via the refrigerant inlet port **70**. The intermix of oil and refrigerant is drawn into the motor section **16**, thereby providing lubrication and cooling to the rotating components of the electric compressor **10**, such as the rotor **60**, the drive shaft **90**. Oil and refrigerant enters the interior of the motor **54** to lubricate the second ball bearing **64** and the oil by the rotational forces within the motor section **16. Oil** may impact against the motor side **22A** of the inverter housing **22**. The refrigerant and oil is further directed by the motor side **22A** into the ball bearing **62**, further discussed below.

[0079] In the illustrated embodiment, the front cover **28** and the fixed scroll **26** are mounted to the motor housing **24** by a plurality of bolts **122** inserted through respective apertures therein and threaded into apertures in the motor housing **24**. A fixed head gasket **110** and a rear heard gasket **112**, are located between the motor housing **24** and the fixed scroll **26** to provide sealing.

Swing-Link Mechanism and Concentric Protrusion of the Drive Shaft

[0080] With specific reference to FIGS. 13-18B, in a first aspect of the electric compressor **10** of the disclosure, an electric compressor **10** includes a swing link mechanism **124** and the drive shaft **90** has a concentric protrusion **126**. In one embodiment, the concentric protrusion **126** is integrally formed with the drive shaft **90**. As discussed below, the swing-link mechanism **124** is used to rotate the orbiting scroll **66** in an eccentric orbit about the drive shaft **90**.

[0081] In the prior art, the drive shaft is coupled to a swing-link mechanism by a drive pin and a separate eccentric pin, both of which are pressing into the drive shaft. The drive pin is used to rotate the swing link mechanism **124** which moves the orbiting scroll **66** along its eccentric orbit. The drive pin and the eccentric pin are inserted into respective apertures in the end of the drive shaft. The eccentric pin is used to limit articulation of the orbiting scroll **66** is the orbiting scroll 66 travels along the eccentric orbit. Neither the drive pin, nor the eccentric pin, are located along the central axis of the drive shaft. As the drive shaft is rotated, the drive pin and the eccentric pin are placed under considerable stress. Thus, both pins are composed from a hardened material, such as, SAE 52100 bearing steel. In addition, the eccentric pin may require an aluminum bushing or other slide bearing to prevent damage to the eccentric pin, as the eccentric pin is used to limit the radial movement of the eccentric orbit of the orbiting scroll 66. Also, the prior art eccentric pin requires additional machining on the face of the drive shaft 90, including precise apertures for the drive pin, and eccentric pin.

[0082] As discussed in more detail below, the eccentric pin of the prior art is replaced with a concentric protrusion **90F**.

[0083] In the illustrated embodiment, the scroll-type electric compressor **10** includes the housing **12**, the refrigerant inlet port **68**, the refrigerant outlet port **70**, the drive shaft **90**, the concentric protrusion **90F**, the motor **54**, the compression device **18**, the swing link mechanism **124**, a drive pin **126** and a ball bearing **108**. The housing **12** defines the intake volume **74** and the discharge volume **82**. The refrigerant inlet port **68** is coupled to the housing **12** and is configured to introduce the refrigerant to the intake volume **74**. The refrigerant outlet port **70** is coupled to the housing **12** and is configured to allow compressed refrigerant to exit the scroll-type electric compressor **10** from the discharge volume **82**. The drive shaft **90** is located within the housing **12** and has first and second ends **90A, 90B**. The drive shaft **90** defines, and is centered upon, a center axis **90C**.

[0084] The concentric protrusion **90F** is located at the second end **90B** of the drive shaft **90** and is centered on the center axis **90C**. The concentric protrusion **90F** and extends away from the drive shaft **90** along the central axis **90C**. The concentric protrusion **90F** includes a drive pin aperture **90E**. The motor **54** is located within the housing **12** and is coupled to the drive shaft **90** to controllably rotate the drive shaft **90** about the center axis **90C**. The drive pin **126** is located within the drive pin aperture **90E** and extends away from the drive shaft **90**. The drive pin **126** is parallel to the concentric protrusion **90F**.

[0085] The concentric pin **90F** may further include an undercut **90G**, and the outer surface may be surface hardened or after treated with a coating or bearing surface. The concentric pin **90F** may be further machined simultaneously with the drive shaft **90**.

[0086] As explained above, the compression device **18** includes the fixed scroll **26** and the orbiting scroll 66. The fixed scroll **26** is located within, and being fixed relative to, the housing **12**. The orbiting scroll **66** is coupled to the drive shaft **90**. The orbiting scroll **66** and the fixed scroll **26** form compression chambers **80** (see above) for receiving the refrigerant from the intake volume

74 and for compressing the refrigerant as the drive shaft **90** is rotated about the center axis **90C**. The orbiting scroll **66** has an inner circumferential surface **66E**.

[0087] The swing-link mechanism **124** is coupled to the drive shaft **90** and has first and second apertures **124A**, **124B** for receiving the concentric protrusion **90F** and the drive pin **126**. The swing-link mechanism **124** further includes an outer circumferential surface **124C**.

[0088] The ball bearing **108** is positioned between, and adjacent to each of, the inner circumferential surface **66E** of the orbiting scroll **66** and the outer circumferential surface **124C** of the swing-link mechanism **124**. The drive shaft **90**, drive pin **126**, orbiting scroll **66** and swing-link mechanism **124** are arranged to cause the orbiting scroll **66** to rotate about the central axis **90C** in an eccentric orbit.

[0089] In one embodiment, the concentric protrusion **90F** is integrally formed with the drive shaft **90**. The drive shaft **90**, concentric protrusion **90F**, and swing-link mechanism **124** may be machined from steel. The concentric protrusion **90F** being formed simultaneously and within the same machining operation with the drive shaft **90** further increases manufacturing efficiencies.

[0090] The expanded view of a portion of the compression device **18** illustrated in FIG. 16G, further illustrates the concentric protrusion **90F**. The concentric protrusion **90F** interacts and guides the swink-link mechanism 124. The concentric protrusion 90F is sized and machined with a controlled tolerance with the first aperture 124A to create a controlled gap that limits the radial movement of the eccentric orbit of the orbiting scroll 66. Unlike the prior art, the concentric protrusion 90F does not require a second pin, or any additional machining operations. The concentric protrusion 90F further co-operates with the guidance pins 128 and the slots 66G on a lower surface 66F of the orbiting scroll 66, further discussed below.

[0091] The scroll-type electric compressor 10 includes an inverter section 14, a motor section 16, and the compression device 18. The motor section 16 includes a motor housing 54 that defines a motor cavity 56. The compression section 18 includes the fixed scroll 26. The housing 12 is formed, at least in part, the fixed scroll 26 and the motor housing 24.

[0092] With specific reference to 13, 16B, and 18A-18F in the illustrated embodiment, the orbiting scroll **66** has a lower surface **66F**. The lower surface **66F** has a plurality of ring-shaped slots **66G**. The motor housing **24** includes a plurality of articulating guidance pin apertures **128**. The guidance pins **128** are located within the guidance pin apertures **66G** and extend towards the compression device **18** and into the ring-shaped slots **66G**. The guidance pins **128** are configured to limit articulation of the orbiting scroll **66** as the orbiting scroll **66** orbits about the central axis **90C**. In one embodiment, each of the ring-shaped slots **66G** includes a ring sleeve **118**. A thrust plate **130** is located between motor housing **24** and the fixed scroll **26** and provides a wear surface therebetween.

Discharge Head Design having an Oil Separator

[0093] In a second aspect of the electric compressor **10** of the disclosure, an electric compressor **10** includes an oil separator **96** located in the discharge volume **82**. which may be located in the discharge volume **82** and integrally formed with the discharge head or front cover **28**. As discussed above, oil is used to provide lubrication between the moving components of the electric compressor **10**. During operation, the oil and the refrigerant become mixed. The oil separator **96** is necessary to separate some of the oil from the mixture of the oil and refrigerant before the refrigerant leaves the electric compressor **10**.

[0094] Generally, refrigerant is released from the compression device **18** once per revolution (or orbit) of the orbiting scroll **66**. This creates a first order pulsation within the compressed refrigerant released by the electric compressor **10**. The relative strong amplitude and low frequency of the pulsation creating in the refrigerant may excite other components (internal or external to the electric compressor **10**) which may create undesirable noise, vibration and harshness (NVH) and low durability conditions. The oil separator 96 of the second aspect (described below), connects the discharge chambers (see below) by relatively small channels to create pressure drops between the chambers. This acts to smooth out the flow of compressed refrigerant out of the electric compressor 10. Additionally, the oil separator 96 utilizes two parallel paths between the compression device 18 and the refrigerant outlet port 70 to reduce the net pressure drop while maintaining the reduction in this pulsation.

[0095] The oil separator 96 may include a series of partitions 98A extending from an inner surface of the front cover 28. As shown, the walls **98A** separate the discharge volume **82** into a central discharge chamber **82A**, two side discharge chambers **82B**, am upper discharge chamber **82C** and the oil reservoir **98**. The central discharge chamber **82A** is adjacent the reed mechanism **86** and receives intermixed pressurized refrigerant and oil from the compression device **18** through the slot **84** via the reed mechanism **86**. The central discharge chamber **82** is in fluid communication with the two side discharge chambers **82B** via respective side channels **100** which are in fluid communication with the upper discharge chamber **82C** and the oil reservoir **98** via upper discharge channels **102** and lower discharge channels **104**, respectively.

[0096] In the illustrated embodiment, the oil separator **96** is formed within the discharge chamber **82** of the housing **12** between the compression device **18** and the refrigerant outlet port **70**. As shown, the oil separator **96** includes a central discharge chamber **82A**, a pair of side discharge chambers **82B**, an oil reservoir **98** and an upper discharge chamber **82C**. The central discharge chamber 82A is formed adjacent the compression device outlet port or slot **84** for receiving the intermixed oil and compressed refrigerant. The pair of side discharge chambers **82B** are located on opposite sides of the central discharge chamber **82A** and are connected to the central discharge chamber **82A** via respective side discharge channels **100**.

[0097] The side chambers **82B** are configured to separate the intermixed oil and compressed refrigerant. Generally, the intermixed oil and compressed refrigerant exit the central discharge chamber **82** through the side channels **100** at a high velocity. Separation of the oil and compressed refrigerant occurs as the intermixed oil and compressed refrigerant hits the interior outer wall of the respective side chambers **82B**.

[0098] The oil reservoir **98** is located below the pair of side chambers and is connected thereto via the respective lower discharge channels **104**. The oil reservoir is configured to receive oil separated from the compressed refrigerant in the side chambers. Gravity acting on the oil assists in the separation and the oil falls through the lower discharge channels **104** located in the side discharge chambers **82B** into the oil reservoir **98**.

[0099] The upper discharge chamber **82C** is formed above the pair of side chambers **82B** and is connected thereto via the respective upper discharge channels **102**. Refrigerant, after being separated from the oil, rises through the upper discharge channels **102**, located at the top of the side discharge chambers **82** and enters the uppers discharge chamber **82** before passing through the refrigerant outlet port **70**,

[0100] As shown, each side discharge channel **100** is configured to direct the intermixed oil and compressed refrigerant towards an opposite interior wall of the respective side channel **82B**. For instance, the side discharge channel is generally at a 90-degree angle from the opposite wall of the side discharge chamber **82B**.

[0101] In an alternative embodiment, as shown in FIG. 20, each side discharge chamber **82B** may include a side baffle **132** located within an interior portion of the respective side chamber **82B**. The side discharge channels **100** are configured to direct the intermixed oil and compressed refrigerant towards a respective side baffle. The side baffle **132** creates, on the back side opposite the discharge channels 100, a low-pressure area within the side discharge chambers **82B** which assists in the separation of the oil and refrigerant. The low-pressure area may further assist gravity and reduce the oil from being carried upwards toward the upper discharge channels **102**. The side discharge channels **100** may incorporate a downward angle that may further assist the gravity forces on the oil and by directing the discharge of the mixture toward a lower area of the side discharge chamber 82B, adjacent to the lower discharge channel 104, to further increase the distance for the oil to fall out of the compressed mixture, and by creating a longer tortuous path to separate the oil downward and away from the high velocity compressed refrigerant entering into the upper discharge channels 102. Also, the side baffles 132 may be arranged to create an impact surface perpendicular to the angled discharge flow path of the oil and refrigerant exiting from the side discharge channel 100. The perpendicular impact surface on the side baffles 132 creates additional turbulence to the discharging mixture and with the lower pressure area behind the side baffles 132 may further increase the gravitational effect on the heavier oil to separate within and direct the oil into the lower discharge channel 104.

[0102] Additionally, as shown in FIG. 20, the oil reservoir **98** may include an oil reservoir baffle **134** located beneath each lower discharge channel **104**. The oil reserve baffle **134** assists in preventing oil within the oil reservoir **98** from being drawn out of the oil reservoir back into the side discharge chambers **82B**. The side baffle **132** and the oil reserve baffle **134** may be used in combination or separately to reduce the oil from traveling upwards along the walls of the side discharge chamber **82B**, and by creating the low-pressure side further reducing the draw or venturi effect that may be created due to the high velocity flow of the refrigerant exiting through the upper discharge channel 102.

Scroll Bearing Oil Orifice

[0103] In a third aspect of the electric compressor **10** of the disclosure, an electric compressor **10** having a scroll bearing oil injection orifice is provided. As discussed above, the compression device **18** of the present disclosure includes a ball bearing **108.** In the illustrated embodiments, the ball bearing **108** is located between the swing-link mechanism **124** and the orbiting scroll **66**. However, as a result of the location of the ball bearing **108** within the compression device **18**, there may be limited oil delivery to the ball bearing **108** resulting in reduced durability.

[0104] The scroll-type electric compressor **10** may include a housing **12**, a refrigerant inlet port **68**, a refrigerant outlet port **70**, an inverter module **144**, a motor **54**, a drive shaft **90** and a compression device **18**. The housing **12** defines an intake volume **74** and a discharge volume **82**. The refrigerant inlet port **68** is coupled to the housing **12** and is configured to introduce the refrigerant to the intake volume **74**. The refrigerant outlet port **70** is coupled to the housing **12** and is configured to allow compressed refrigerant to exit the scroll-type electric compressor **10** from the discharge volume **82**. The inverter module **144** is mounted inside the housing **12** and adapted to convert direct current electrical power to alternating current electrical power. The motor **54** is mounted inside the housing **12**. The drive shaft **90** is coupled to the motor **54**. The compression device **18** receives the refrigerant from the intake volume **74** and compresses the refrigerant as the drive shaft **90** is rotated by the motor **54**. The compression device **18** includes a fixed scroll **26**, an orbiting scroll **66**, a swing-link mechanism **124**, a ball bearing **108** and a pin **136**.

[0105] The fixed scroll **26** is located within, and is fixed relative to, the housing **12**. The orbiting scroll **66** is coupled to the drive shaft **90**. The orbiting scroll **66** and the fixed scroll **26** form compression chambers **80** for receiving the refrigerant from the intake volume **72** and compressing the refrigerant as the drive shaft **90** is rotated about the center axis **90C**. The orbiting scroll **66** has a first side (or the lower surface) **66F** and a second side (or upper surface) **66G**. The orbiting scroll **66** has an oil aperture **140** through the orbiting scroll **66** from the first side **66F** to the second side **66G**.

[0106] The swing-link mechanism **124** is coupled to the drive shaft **90**. The ball bearing **108** is positioned between and adjacent to each of the orbiting scroll **66** and the swing-link mechanism **124**. The drive shaft **90**, orbiting scroll **66** and swing-link mechanism **124** are arranged to cause the orbiting scroll **66** to orbit the central axis **90C** in an eccentric orbit.

[0107] As shown in FIG. 16C, the tip of the orbiting scroll 66 includes a plug **136** and has an oil orifice **138**. The plug **136** may be press fit within the oil aperture **140** of the orbiting scroll **66**. The oil orifice **138** is configured to allow oil with a controlled flow rate or compressed refrigerant to pass through the orbiting scroll **66** to the ball bearing **108**.

[0108] The size of the oil orifice **138** may be tuned to the specifications of the electric compressor **10**. For example, given the specifications of the electric compressor **10**, the diameter of the oil orifice 138 may be chosen such that only oil is allowed to pass through and to limit the equalization of pressure between the first and second sides of the orbiting scroll 66. By using a separate plug 136, rather than machining the oil orifice 138 directly in the orbiting scroll 66, manufacturing efficiencies may be achieved. And the plug 136 may have an oil orifice 138 that is specifically designed and tuned to allow for oil flow and refrigerant flow to increase or decrease depending on the diameter and geometry of the oil orifice 138.

[0109] As shown in FIGS. 16D-16E, in one embodiment, the oil orifice 138 may have a first bore 138A and a second bore 138B, wherein a diameter of the first bore 138A is less than a diameter of the second bore 138B. For example, in one application of this embodiment the first bore 138A has an approximate diameter of 0.3 mm. The second bore 138B has a diameter greater than the diameter of the first bore **138A** and is only used to shorten the length of the first bore **138A.** The flow of the oil and coolant is designed to provide thermal and lubricant to the ball bearing 108 supporting the radial forces created by the eccentric orbit of the orbiting scroll 66.

[0110] Further, as discussed above, the orbiting scroll **66** has an orbiting scroll base **66A** and an orbiting scroll lap **66B**. The orbiting scroll lap **66B** may have an orbiting scroll tail end **66C** and an orbiting scroll center end **66D**. As shown, the oil aperture **140** is located within the orbiting scroll center end **66D**. The plug **136** may be secured into the oil aperture **140**, by press fit or any other method that will secure the plug **136**.

[0111] As shown in FIG. 9, the oil orifice **138** allows oil (and refrigerant) to travel from the discharge chamber **82** to the ball bearing **108** along the bath **73** (which may be referred to as the "nose bleed" path).

Bearing Oil Communication Hole

[0112] In a fourth aspect of the electric disclosure of the disclosure, an electric compressor **10** having a bearing oil communication hole is provided. As discussed above, in the illustrated embodiment, a drive shaft **90** is rotated by the motor **54** to controllably actuate the compression device **18**. The drive shaft **90** has a first end **90A** and a second and **90B**. The housing **10** of the electric compressor **10** forms a first drive shaft supporting member **22B** and a second drive shaft support member **24A**. In the illustrated embodiment, the first drive shaft supporting member **22B**

is formed in a motor side **22** of the inverter housing **22A** and the second drive shaft supporting member **24A** is formed within the motor housing **24**. First and second ball bearings **62**, **64** are located within the first and second drive shaft support members **22B**, **24A**.

[0113] The location of the first drive shaft supporting members 22B is not a flow-through area for refrigerant (and oil). This may result in a low lubricating condition and affect the durability of the electric compressor 10.

[0114] As shown in FIG. 16F, the first drive supporting member 22B may include one or more holes 22C to allow oil and refrigerant to enter the first drive support member 22B and lubricate the first ball bearing 62.

[0115] In the illustrated embodiment, the scroll-type electric compressor 10 includes a housing 12, a first ball bearing 62, a second ball bearing 64, a refrigerant inlet port 68, a refrigerant outlet port 70, an inverter module 44, a motor 54, a drive shaft 90, and a compression device 18.

[0116] The housing 12 defines an intake volume 74 and a discharge volume 82 and includes first and second drive shaft supporting members **22B**, **24A**. The first ball bearing **62** is located within the first drive shaft supporting member **22B**. The first drive shaft support member **22B** of the housing **12** includes an oil communication hole **22C** for allowing oil to enter the first ball bearing **62**.

[0117] The second ball bearing **64** is located within the second drive shaft supporting member **24A**. The refrigerant inlet port 68 is coupled to the housing 12 and is configured to introduce the refrigerant to the intake volume 74. The refrigerant outlet port 70 is coupled to the housing 12 and is configured to allow compressed refrigerant to exit the scroll-type electric compressor **10** from the discharge volume **82**. The inverter module **144** is mounted inside the housing **12** and is adapted to convert direct current electrical power to alternating current electrical power. The motor **54** is mounted inside the housing **12**. The drive shaft **90** is coupled to the motor **54**. The drive shaft **90** has a first end **90A** and a second end **90B**. The first end **90A** of the drive shaft **90** is positioned within the first bearing **62** and the second end **90B** of the drive shaft **90** is positioned within the second bearing **64**. The compression device **18** receives the refrigerant from the intake volume **74** and compresses the refrigerant as the drive shaft **90** is rotated by the motor **54**. As discussed above, in the illustrated embodiment, the first drive shaft support member **22** may be formed on the motor side **22A** of the inverter housing **22**. The rotational movement within the motor section **16** of the compression device **18** creates a flow path and movement to the oil from the oil reservoir **98**, as shown by arrows **88** in FIG. 9. As shown the oil flows from the oil reservoir **98** toward the motor section 16 and continues toward the stator **58** and rotor **60**. The rotational motion of the orbiting scroll, rotor and drive shaft pulls the oil upward to mix with the inlet flow of the refrigerant path **72**. The rotational movement of the rotor **60** and drive shaft **90** will further propel the oil against the motor side **22A** of the inverter housing **22**. The motor side **22A** further includes a series of ribs **22D**, shown in FIG 16F. The ribs **22D** provide the needed rigidity for supporting the first drive shaft support member **22** and allow for a ridged backing and pocket to secure the first bearing **62**. The inverter housing **22** further defines an oil cavity 22E where oil collected between the ribs **22D** is directed by gravity downward and into the oil cavity **22E**. The ribs **22D** and the sloped surface of the motor side **22A** cooperate to capture and direct the oil splashed or propelled against the motor side **22A** by the rotor **60** or drive shaft **90**, to assist in increasing the oil flow into the oil cavity **22E** and first bearing **62**. FIG 16F illustrates only one oil communication hole **22C**, but it is appreciated additional oil communication holes **22C** may be included above and between the ribs **22D** on the motor side **22A** of the inverter housing **22**. For example, in the illustrated embodiment the communication hole **22C** is 3.5 mm in diameter and the motor side **22A** includes a sloping wall between the ribs **22D**. In addition, the motor side **22A** may include an outer oil collection area or depression **22F** surrounding the communication holes **22C.**

Domed Inverter Cover

[0118] In the fifth aspect of the electric compressor **10** of the present disclosure, a scroll-type electric compressor **10** is configured to compress a refrigerant. The scroll-type electric compressor **10** includes the housing **12**, the refrigerant inlet port **68**, the refrigerant outlet port **70**, the inverter module **44**, the motor **54**, the drive shaft **90**, the compression device **18** and the inverter cover **20**. The housing **12** defines the intake volume **70** and the discharge volume **82**. The housing **12** has a generally cylindrical shape and the central axis **90C**. The refrigerant inlet port **68** is coupled to the housing **12** and is configured to introduce the refrigerant to the intake volume **70**. The refrigerant outlet port **82** is coupled to the housing **12** and is configured to allow compressed refrigerant to exit the scroll-type electric compressor **10** from the discharge volume **82**.

[0119] The inverter module **44** is mounted inside the housing **12** and adapted to convert direct current electrical power to alternating current electrical power. The motor **54** is mounted inside the housing **12**. The drive shaft **90** is coupled to the motor **54**. The compression device **18** is coupled to the drive shaft **90** and is configured to receive the refrigerant from the intake volume and to compress the refrigerant as the drive shaft **90** is rotated by the motor **54**.

[0120] As discussed above, the compression device **18** may rotate at a high speed (> 2,000 RPM) which may create undesirable noise, vibration, and harshness (NVH) and low durability conditions. In the prior art, the inverter cover 20 is generally flat and tends to amplify and/or focus, the vibrations from the compression device 18.

[0121] As shown in FIGS. 3A-3D, to disperse vibrations rather than focus, the vibrations from the compression device 18, the inverter back cover 20 of the electric scroll-like compressor 10 of the fifth aspect of the disclosure is provided with a generally curved or domed profile.

[0122] As shown in the FIGS., specifically FIGS. 1, 3A-3B and 6, the inverter cover 20 is located at one end of the scroll-type electric compressor 10 and includes a first portion 20A and a second portion 20B. The first portion **20A** includes an apex or apex portion **20C** and is generally perpendicular to the central axis **90C** and has an apex **20C** and an outer perimeter **20D**. The first portion 20A has a relatively domed-shaped such that the inverter cover **20** has a curved profile from the apex **20C** towards the outer perimeter **20D**. The amount and location of the curvature may be dictated or limited by other considerations, such as packaging constraints, i.e., the space in which the electric scroll-type compressor **10** must fit, and constraints placed by internal components, i.e., location and size). The first portion **20A** may also have to incorporate other features, e.g., apertures to receive fastening bolts. The second portion **20B** may include a portion of the inverter cover **20** that is not domed, i.e., is relatively flat that is located about the perimeter of the inverter cover.

[0123] In FIG. 3B, the rear side of the inverter cover **20** may include a plurality radial ribs **20E** extending outwardly from a center circular rib **20F** to provide rigidity and support for the curved first portion 20A of the inverter back cover 20. As shown, the radial ribs 20E are not equally spaced about the center circular rib 20F. The inverter back cover 20 may also include additional ribs 20G to add additional strength.

[0124] With reference to FIGS. 3C and 3C, an alternative embodiment if the inverter cover **20** is shown. In some applications, the inverter cover **20**, in particular, the first portion **20A** may have to be modified to take into account external constraints, such as packaging or size restraints. In the illustrated embodiments, the illustrated embodiment includes a channel **20H** that runs through the first portion **20A** that is necessary to accommodate an external support structure.

[0125] The foregoing invention has been described in accordance with the relevant legal standards, thus the description is exemplary rather than limiting in nature. Variations and modifications to the disclosed embodiment may become apparent to those skilled in the art and fall within the scope of the invention.

What is claimed is:

1. A scroll-type electric compressor configured to compress a refrigerant, comprising:

a housing defining an intake volume and a discharge volume, the housing having a generally cylindrical shape and having a central axis;

a refrigerant inlet port coupled to the housing and configured to introduce the refrigerant to the intake volume;

a refrigerant outlet port coupled to the housing and configured to allow compressed refrigerant to exit the scroll-type electric compressor from the discharge volume;

an inverter module mounted inside the housing and adapted to convert direct current electrical power to alternating current electrical power;

a motor mounted inside the housing;

a drive shaft coupled to the motor;

a compression device coupled to the drive shaft, for receiving the refrigerant from the intake volume and compressing the refrigerant as the drive shaft is rotated by the motor; and,

an inverter cover located at one end of the scroll-type electric compressor, the inverter cover having a first portion and a second portion, the first portion being generally perpendicular to the central axis and having an apex and an outer perimeter, wherein the first portion has a relatively domed-shaped such that the inverter cover has a curved profile from the apex towards the outer perimeter.

2. The scroll-type electric compressor, as set forth in claim 1, wherein the compression device includes:

a fixed scroll located within, and being fixed relative to, the housing;

an orbiting scroll coupled to the drive shaft, the orbiting scroll and the fixed scroll forming compression chambers for receiving the refrigerant from the intake volume and compressing the refrigerant as the drive shaft is rotated about the center axis;

a swing-link mechanism coupled to the drive shaft; and,

a ball bearing positioned between, and adjacent to each of the orbiting scroll and the swing-link mechanism, the drive shaft, orbiting scroll and swing-link mechanism being arranged to cause the orbiting scroll to orbit the central axis in an eccentric orbit.

3. The scroll-type electric compressor, as set forth in claim 1, wherein the housing includes a motor section and a compression section, the motor section having a motor housing defining a motor cavity for housing the motor, the compression section includes the fixed scroll, the fixed scroll forming part of the housing.

4. The scroll-type electric compressor, as set forth in claim 3, wherein the fixed scroll is mounted to the motor housing, wherein the orbiting scroll has a lower surface, the lower surface having a plurality of ring-shaped slots, wherein the motor housing includes a plurality of articulating guidance pin apertures, further including a plurality of guidance pins located within the articulating guidance pin apertures and extending towards the compression section and into the ring-shaped slots, the plurality guidance pins being configured to limit articulation of the orbiting scroll as the orbiting scroll orbits about the central axis.

5. The scroll-type electric compressor, as set forth in claim 4, including a plurality of ring inserts located within the ring slots.

6. The scroll-type electric compressor, as set forth in claim 1, wherein the housing includes first drive shaft supporting member and a second drive shaft supporting member and further including:

a first ball bearing located within the first drive shaft supporting member and configured to receive the first end of the drive shaft; and,

a second ball bearing located within the second drive shaft supporting member and configured to receive the send end of the drive shaft.

7. The scroll-type electric compressor, as set forth in claim 1, wherein the housing includes a front cover defining the discharge volume, wherein the scroll-type electric compressor utilizes oil to lubricate components of the motor, drive shaft and compression device, the scroll-type electric compressor further includes an oil separator for separating intermixed oil and refrigerants as the intermixed oil and refrigerant exit the compression device and enters the discharge volume.

8. A scroll-type electric compressor having a central axis and being configured to compress a refrigerant, comprising:

a housing defining an intake volume and a discharge volume;

a refrigerant inlet port coupled to the housing and configured to introduce the refrigerant to the intake volume;

a refrigerant outlet port coupled to the housing and configured to allow compressed refrigerant to exit the scroll-type electric compressor from the discharge volume;

an inverter section including:

an inverter housing,

an inverter back cover connected to the inverter housing and forming an inverter cavity, the inverter back cover having a first portion and a second portion, the first portion being generally perpendicular to the central axis and having an apex and an outer perimeter, wherein the first portion has a relatively domed-shaped such that the inverter cover has a curved profile from the apex towards the outer perimeter,

an inverter module mounted inside the inverter cavity and adapted to convert direct current electrical power to alternating current electrical power;

a motor section including:

a motor housing forming a motor cavity and being mounted to the inverter housing,

a drive shaft located within the motor housing, having first and second ends and defining a center axis, and

a motor located within the motor housing to controllably rotate the drive shaft about the center axis, and,

a compression device including

a fixed scroll located within, and being fixed relative to, the housing, and

an orbiting scroll coupled to the drive shaft, the orbiting scroll and the fixed scroll forming compression chambers for receiving the refrigerant from the intake volume and compressing the refrigerant as the drive shaft is rotated about the center axis,

a swing-link mechanism coupled to the drive shaft, and,

a ball bearing positioned between, and adjacent to each of the orbiting scroll and the swing-link mechanism, the drive shaft, orbiting scroll and swing-link mechanism being arranged to cause the orbiting scroll to orbit the central axis in an eccentric orbit; and a front cover, wherein the housing is formed by the inverter back cover, the inverter housing, the motor housing, the fixed scroll and the front cover.

9. The scroll-type electric compressor, as set forth in claim 8, wherein the fixed scroll is mounted to the motor housing, wherein the orbiting scroll has a lower surface, the lower surface having a plurality of ring-shaped slots, wherein the motor housing includes a plurality of articulating guidance pin apertures, further including a plurality of guidance pins located within the articulating guidance pin apertures and extending towards the compression section and into the ring-shaped slots, the plurality guidance pins being configured to limit articulation of the orbiting scroll as the orbiting scroll orbits about the central axis.

10. The scroll-type electric compressor, as set forth in claim 9, including a plurality of ring inserts located within the ring slots.

11. The scroll-type electric compressor, as set forth in claim 10, wherein the housing includes first drive shaft supporting member and a second drive shaft supporting member and further including:

a first ball bearing located within the first drive shaft supporting member and configured to receive the first end of the drive shaft; and,

a second ball bearing located within the second drive shaft supporting member and configured to receive the send end of the drive shaft.

12. The scroll-type electric compressor, as set forth in claim 8, wherein the front cover defines the discharge volume, wherein the scroll-type electric compressor utilizes oil to lubricate components of the motor, drive shaft and compression device, the scroll-type electric compressor further includes an oil separator for separating intermixed oil and refrigerants as the intermixed oil and refrigerant exit the compression device and enters the discharge volume.

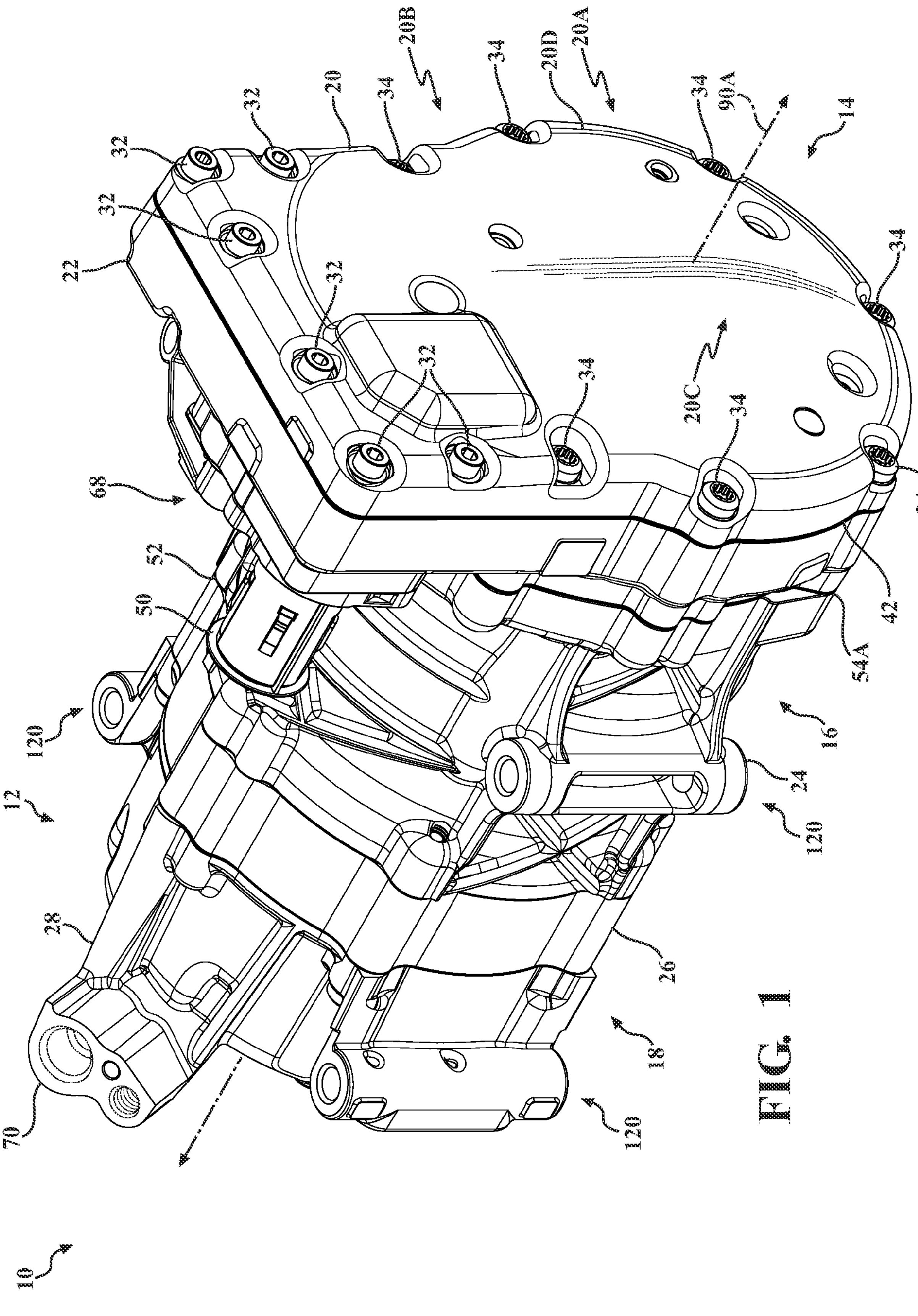

10
12
14
16
18
20
20A
20B
20C
20D
22
24
26
28
32
34
42
50
52
54A
68
70
90A
120

FIG. 1

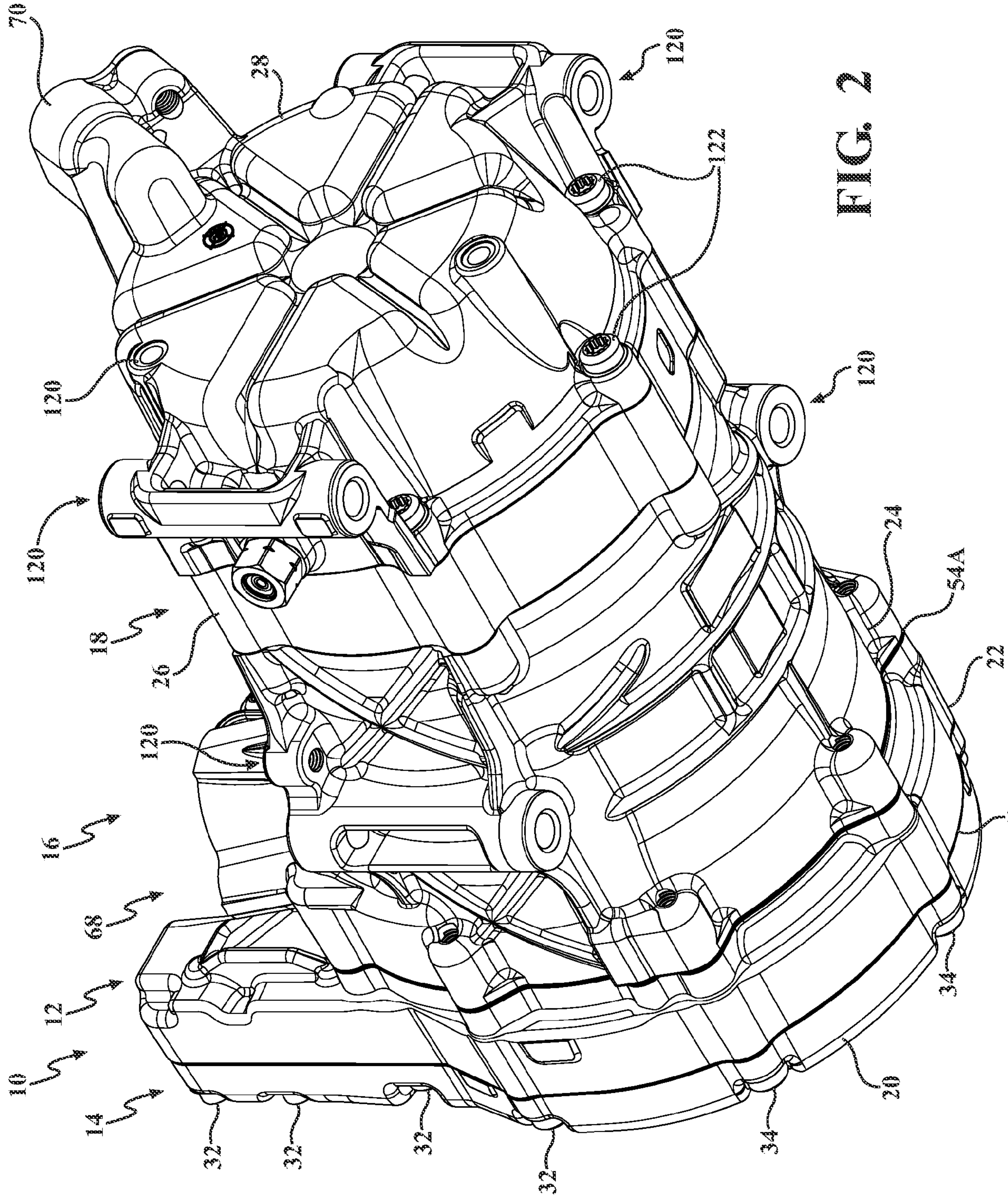

70
28
120
122
120
120
120
18
26
120
16
68
12
10
14
24
54A
22
42
34
20
34
32
32
32
32

FIG. 2

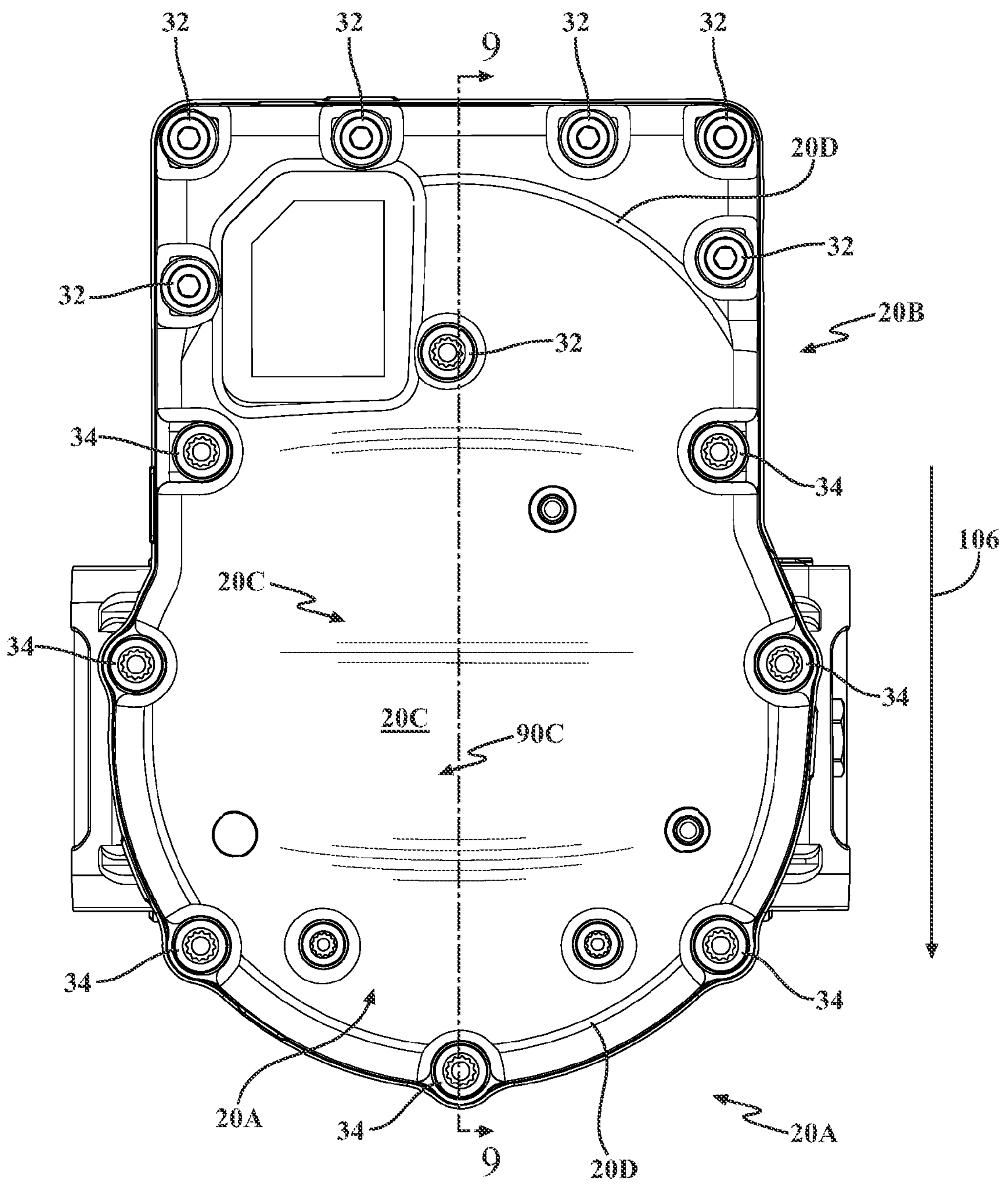

32
32
32
32
9
20D
32
32
20B
32
34
34
106
20C
34
34
20C
90C
34
34
20A
34
9
20D
20A

FIG. 3A

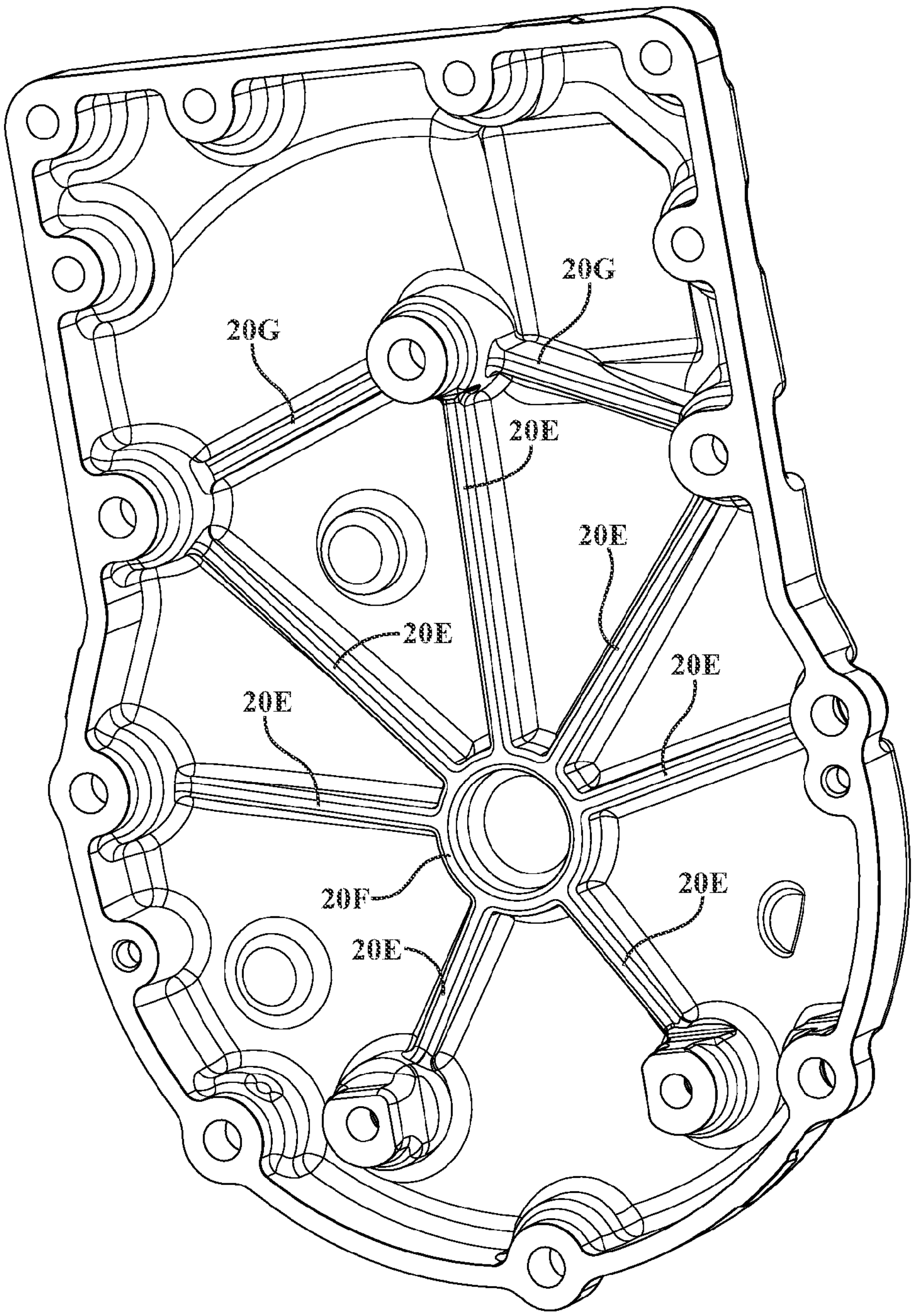


FIG. 3B

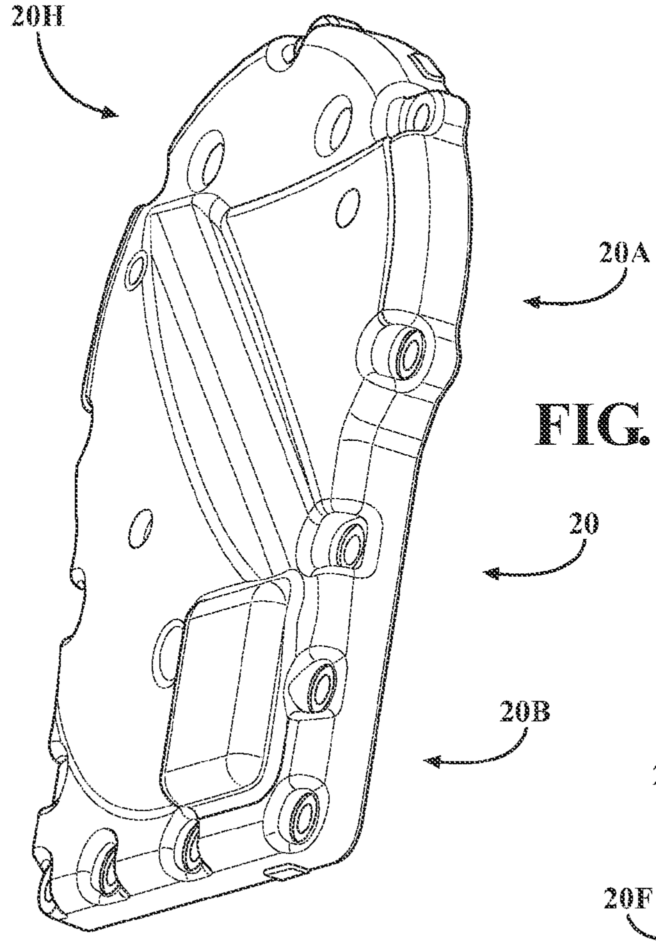


FIG. 3C

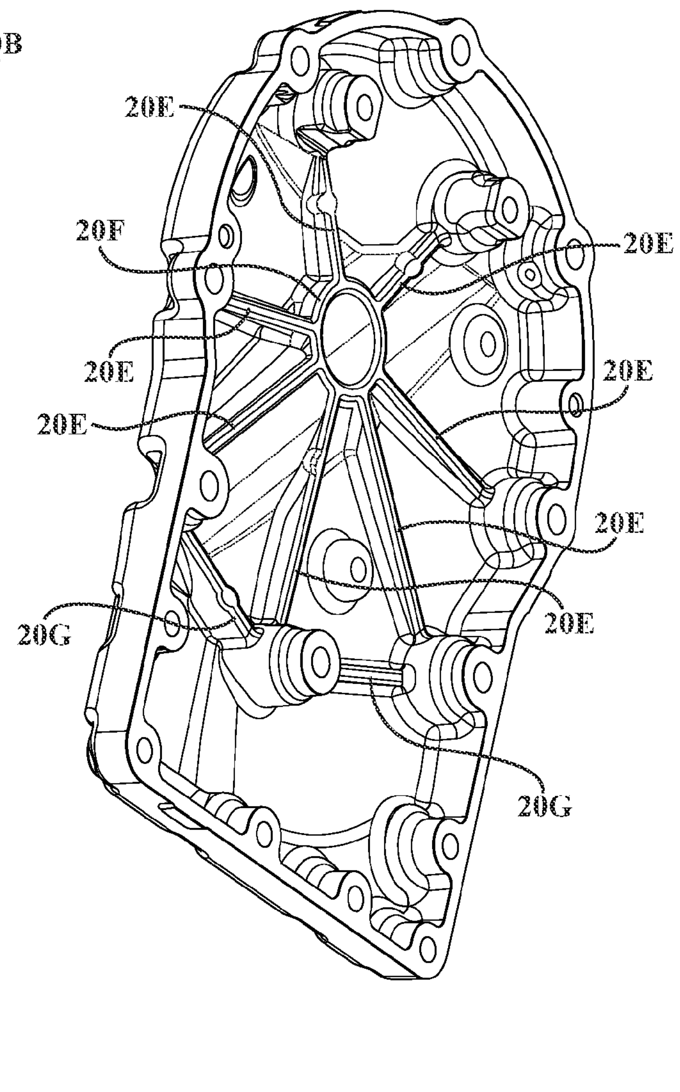


FIG. 3D

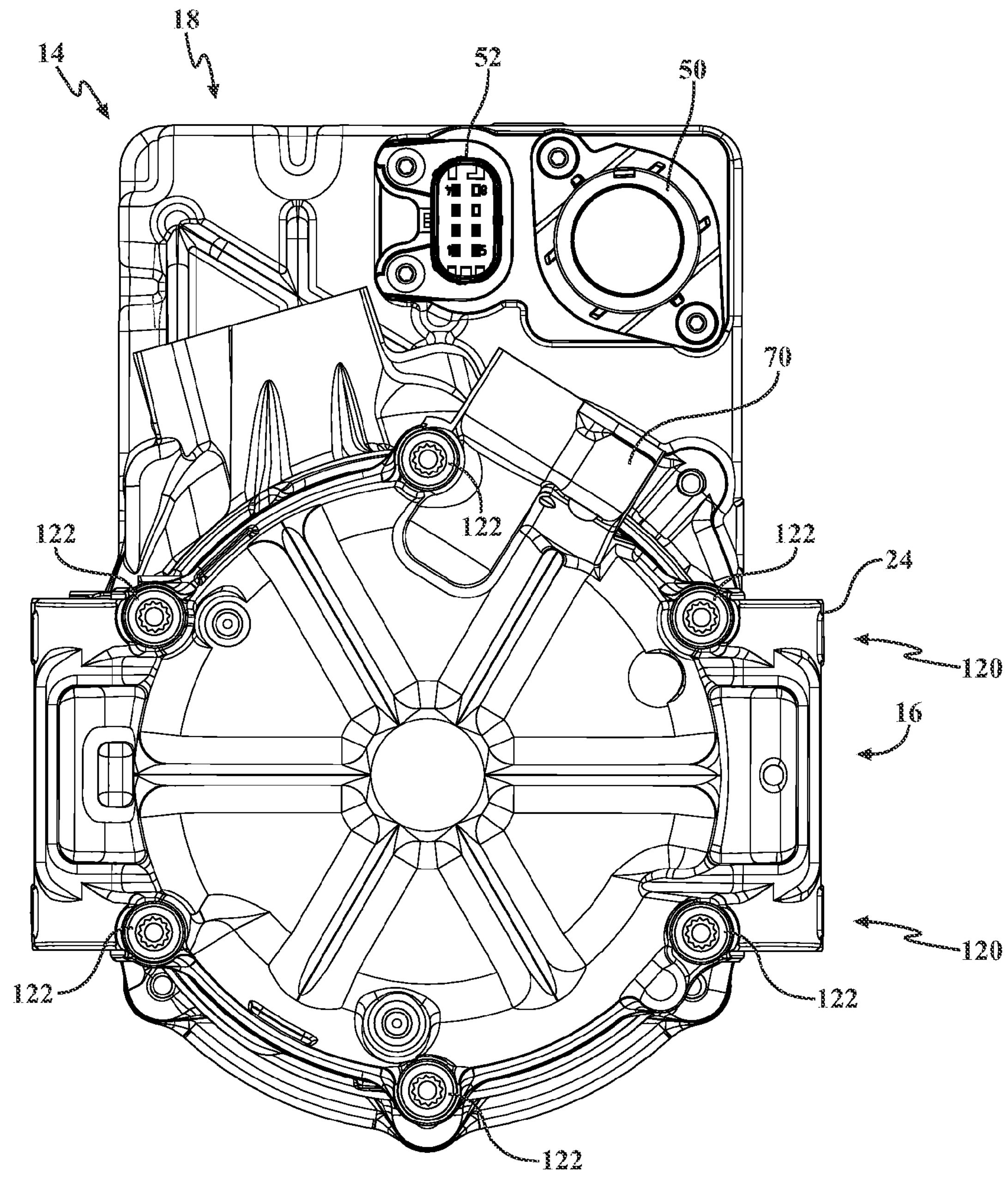


FIG. 4

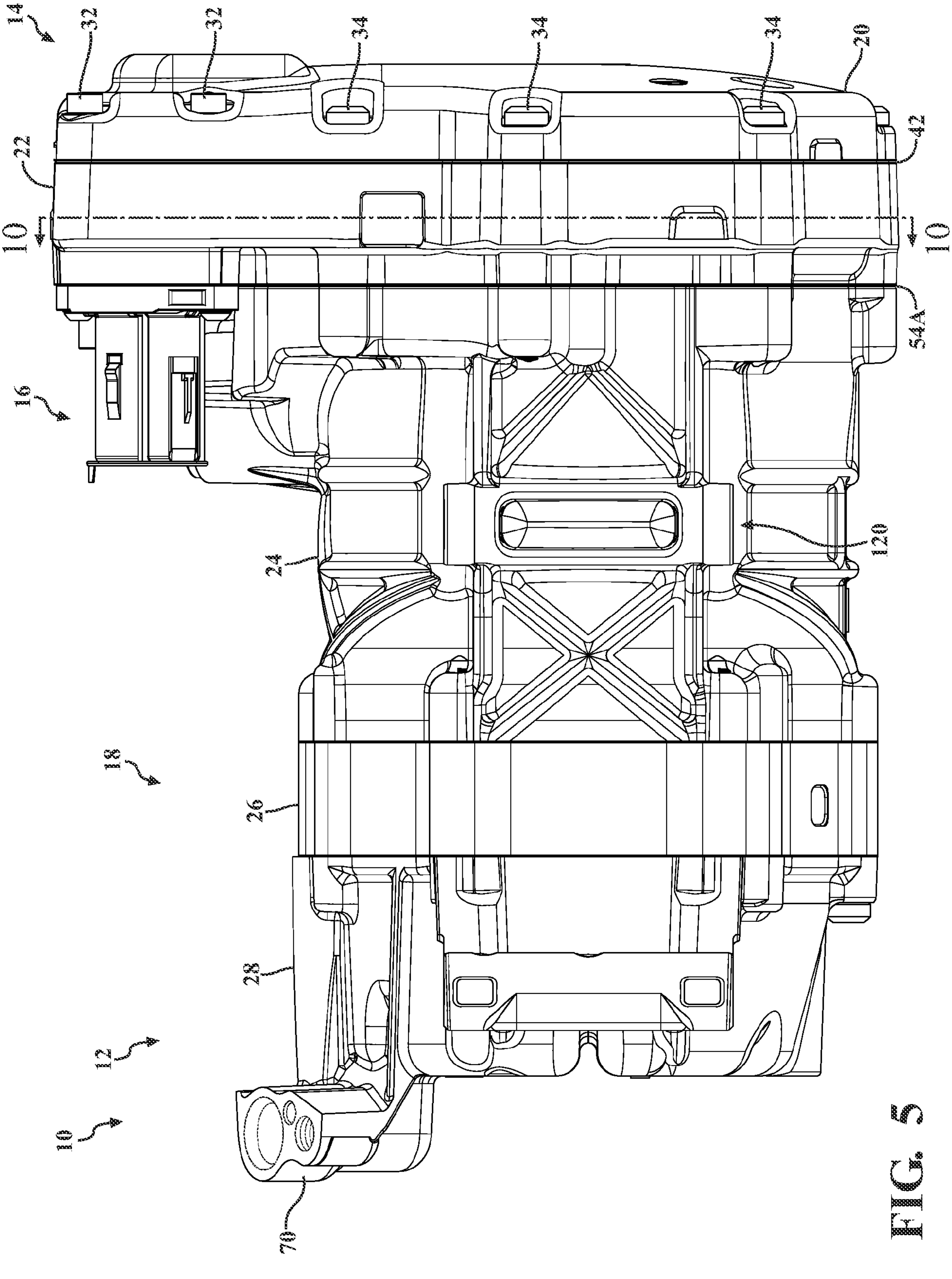


FIG. 5

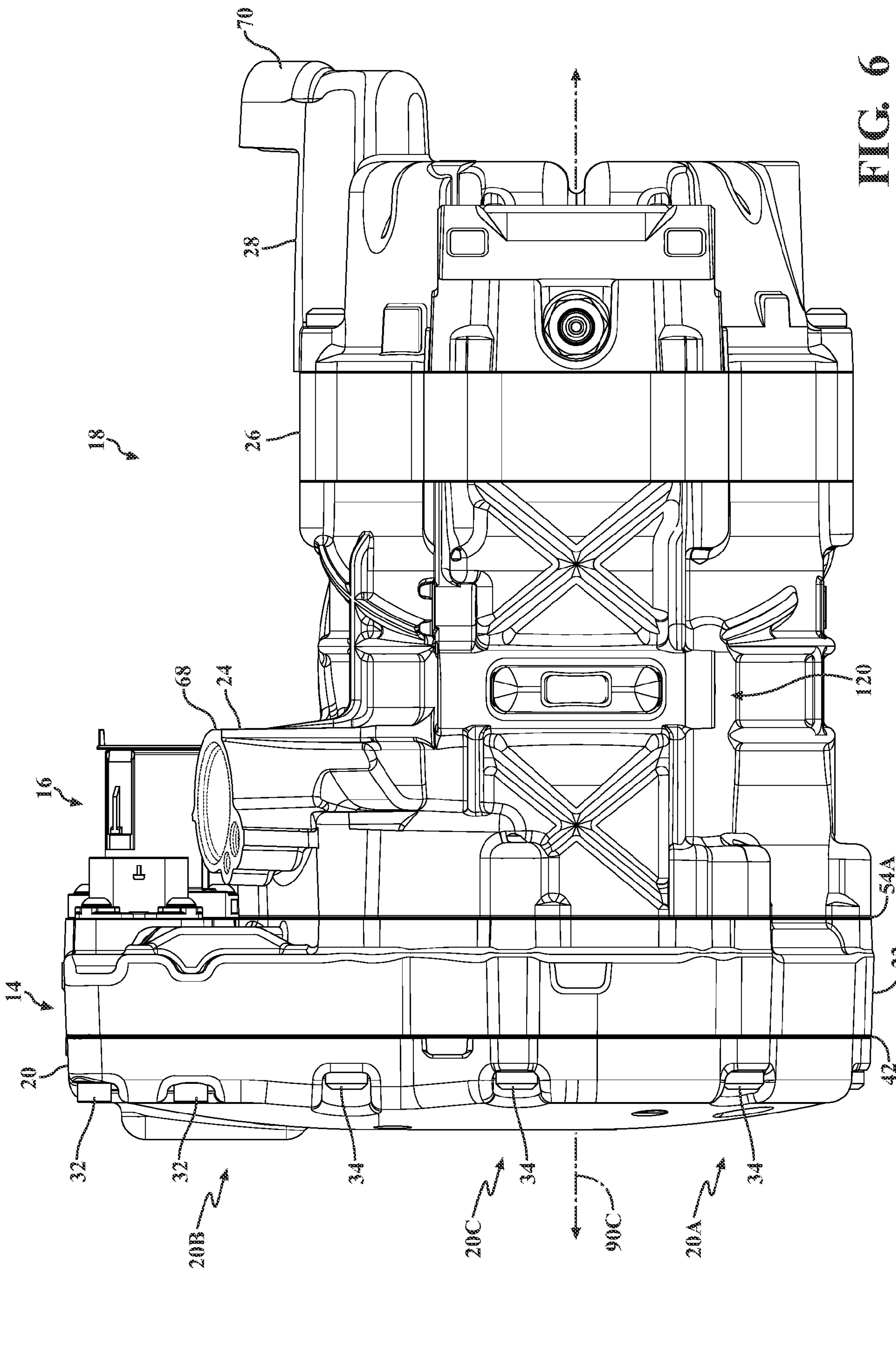

70
28
18
26
68
24
120
16
54A
14
22
20
42
32
32
34
34
34
20B
20C
90C
20A

FIG. 6

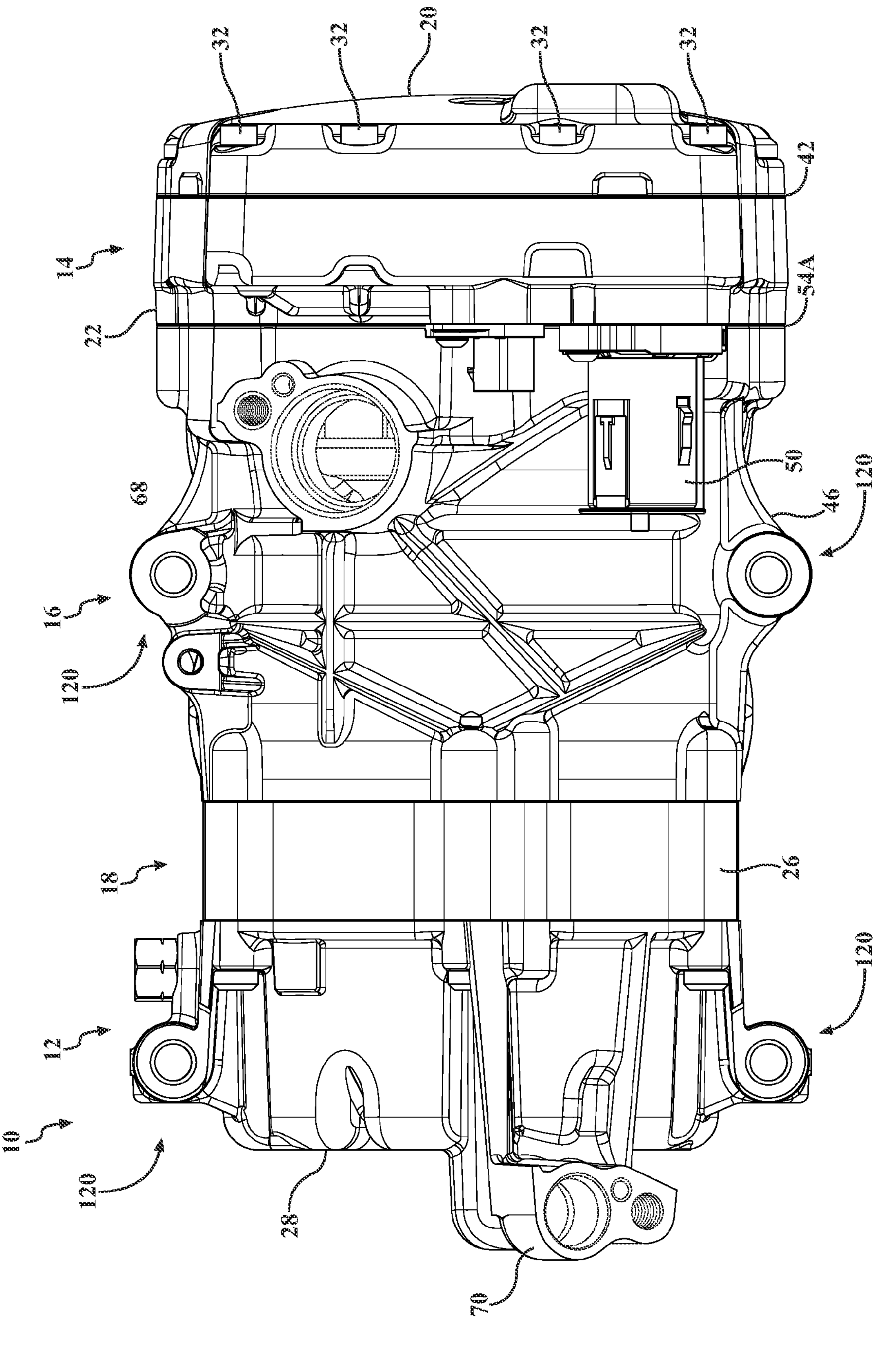

32
32
20
32
32
42
14
54A
22
50
68
46
120
16
120
18
26
120
12
10
120
28
70

FIG. 7

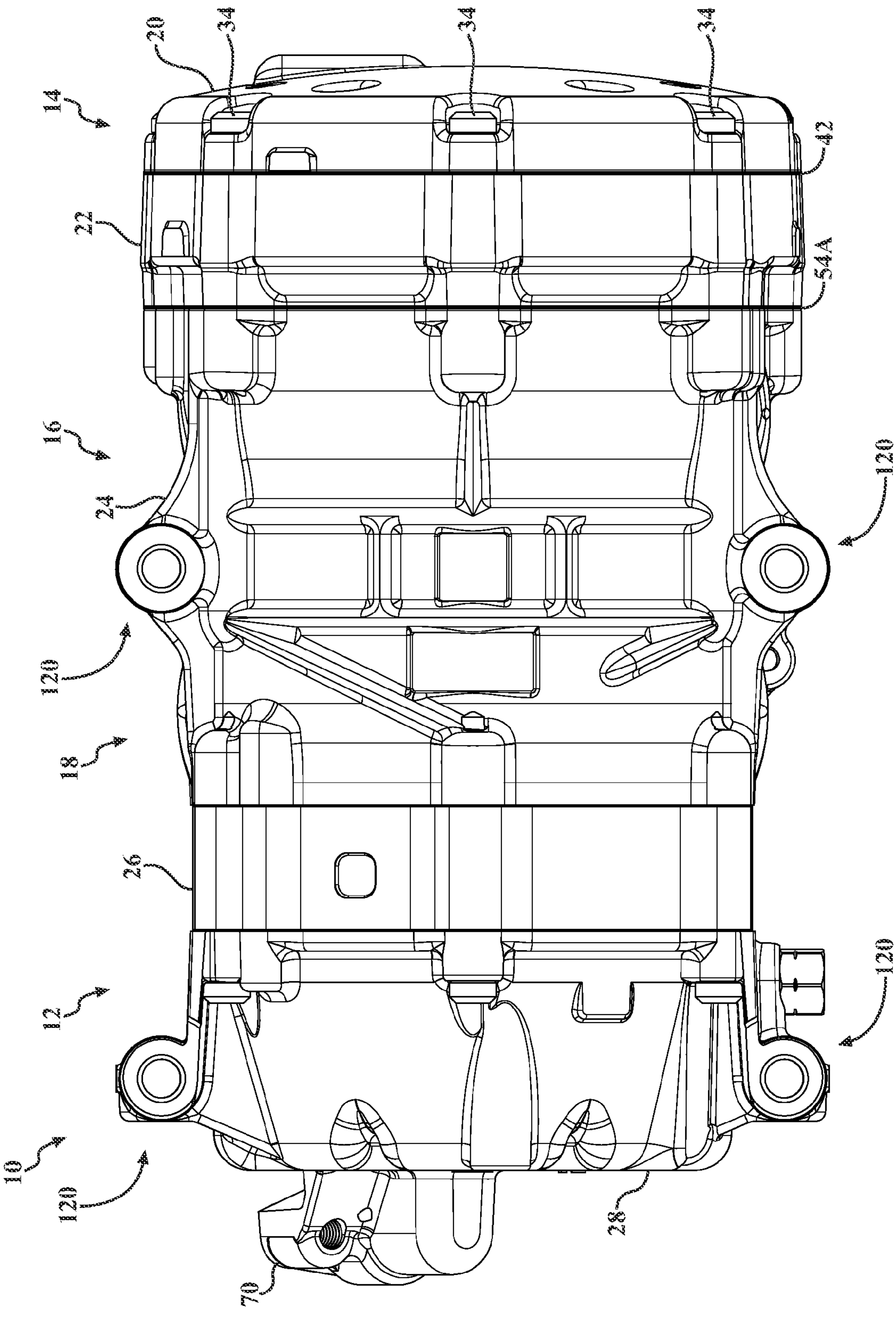
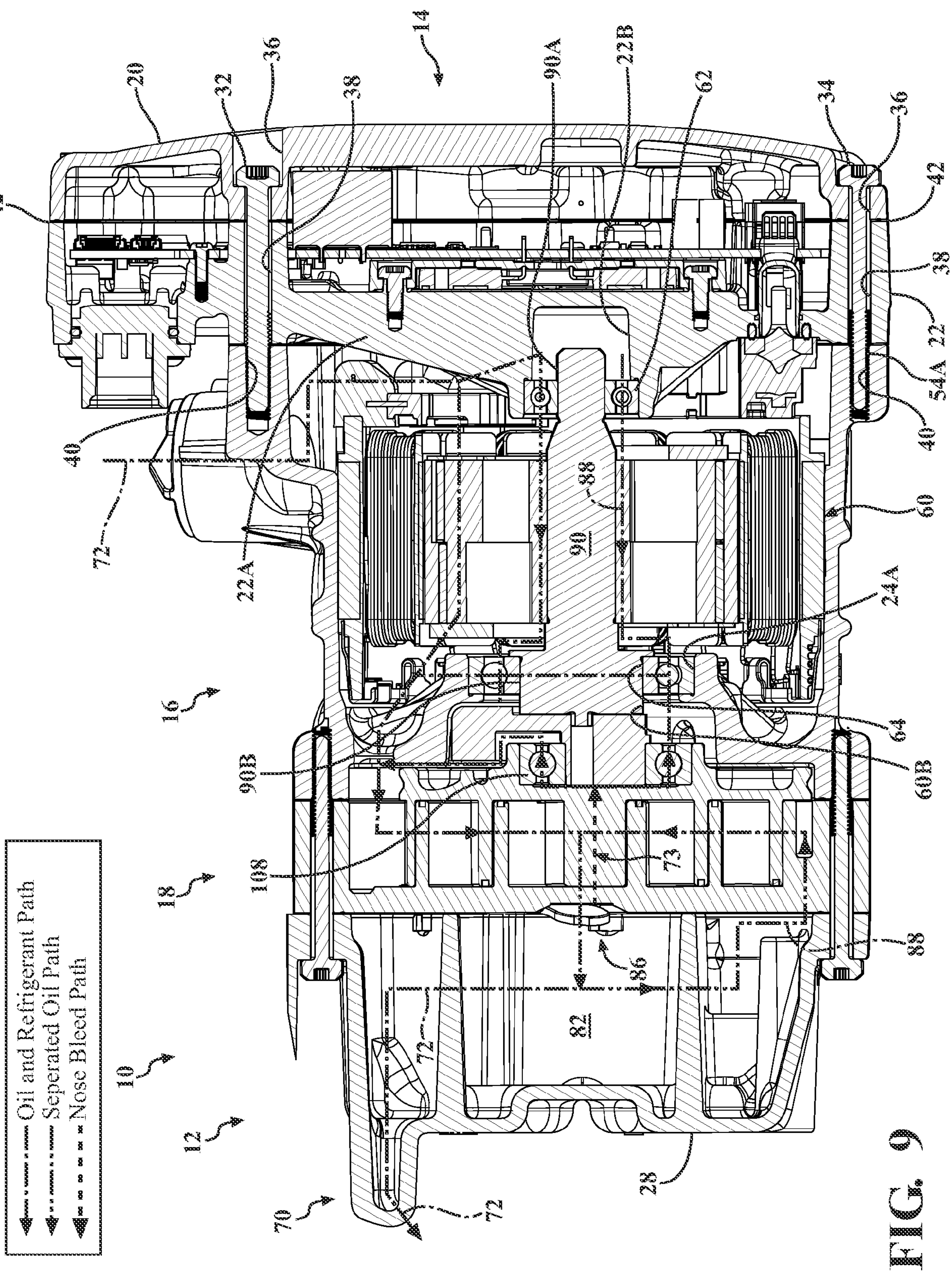


FIG. 8



Oil and Refrigerant Path
Seperated Oil Path
Nose Bleed Path
10
12
14
16
18
20
22
22A
22B
24A
28
32
34
36
38
40
42
54A
60
60B
62
64
70
72
73
82
86
88
90
90A
90B
108

FIG. 9

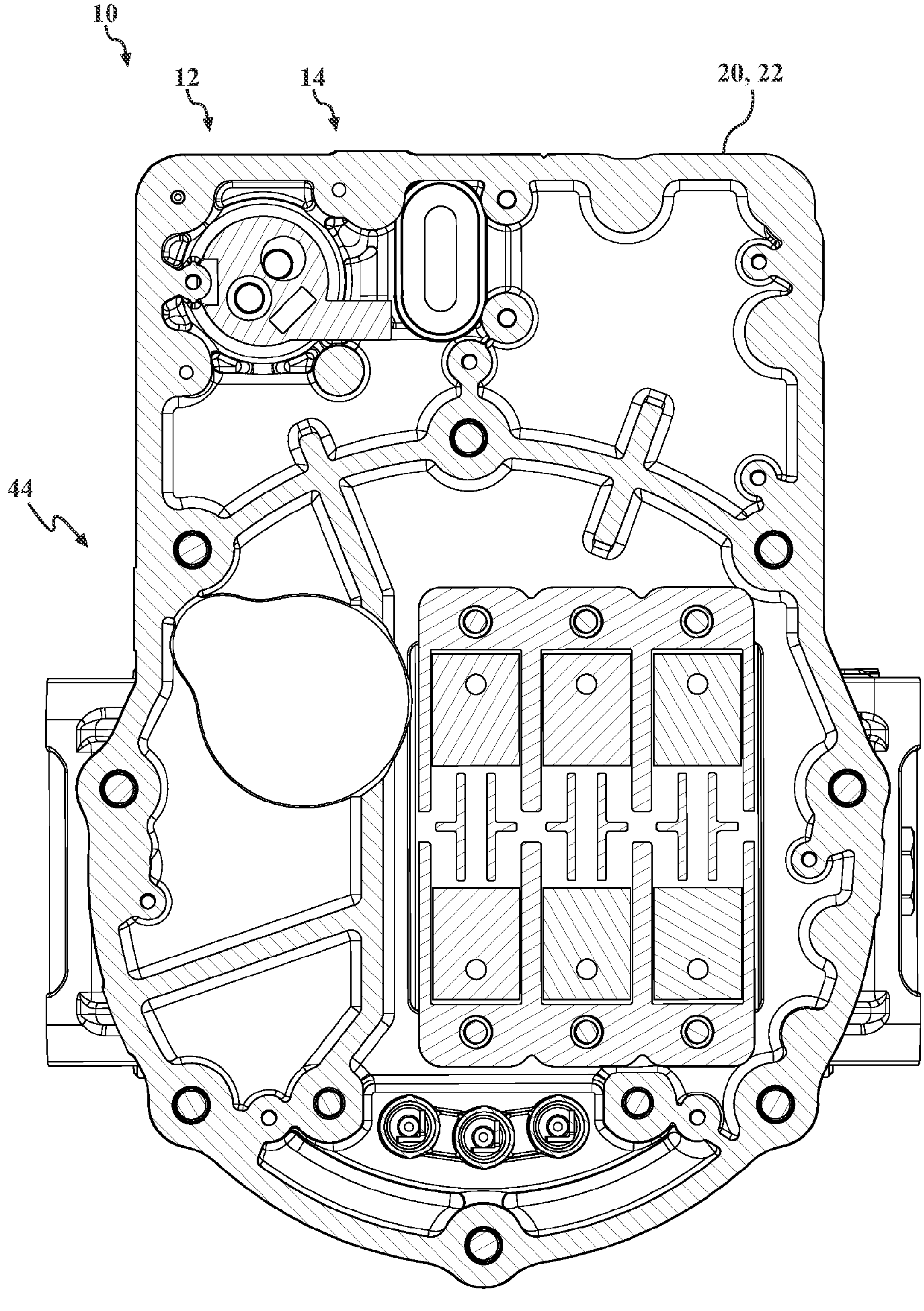


FIG. 10

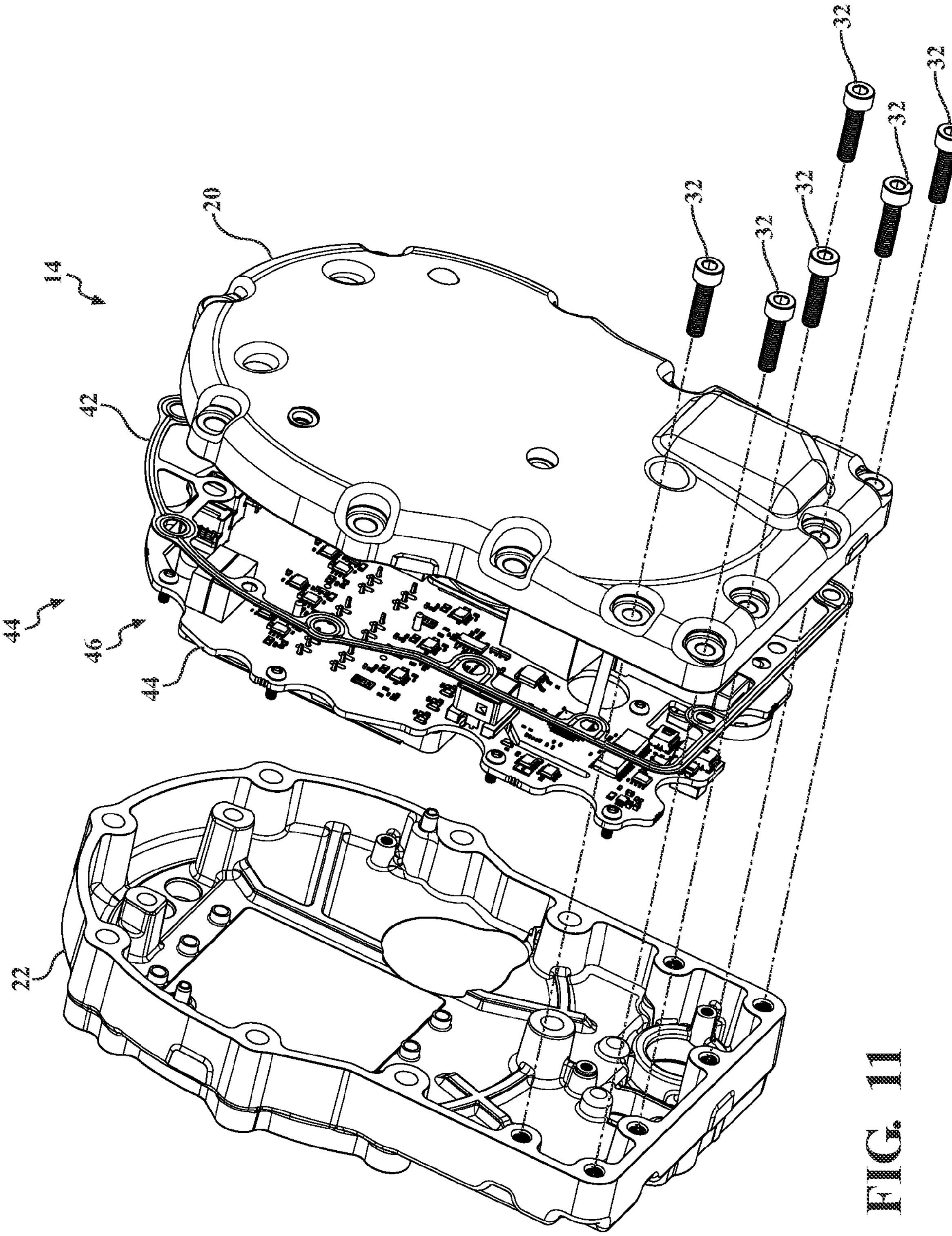


FIG. 11

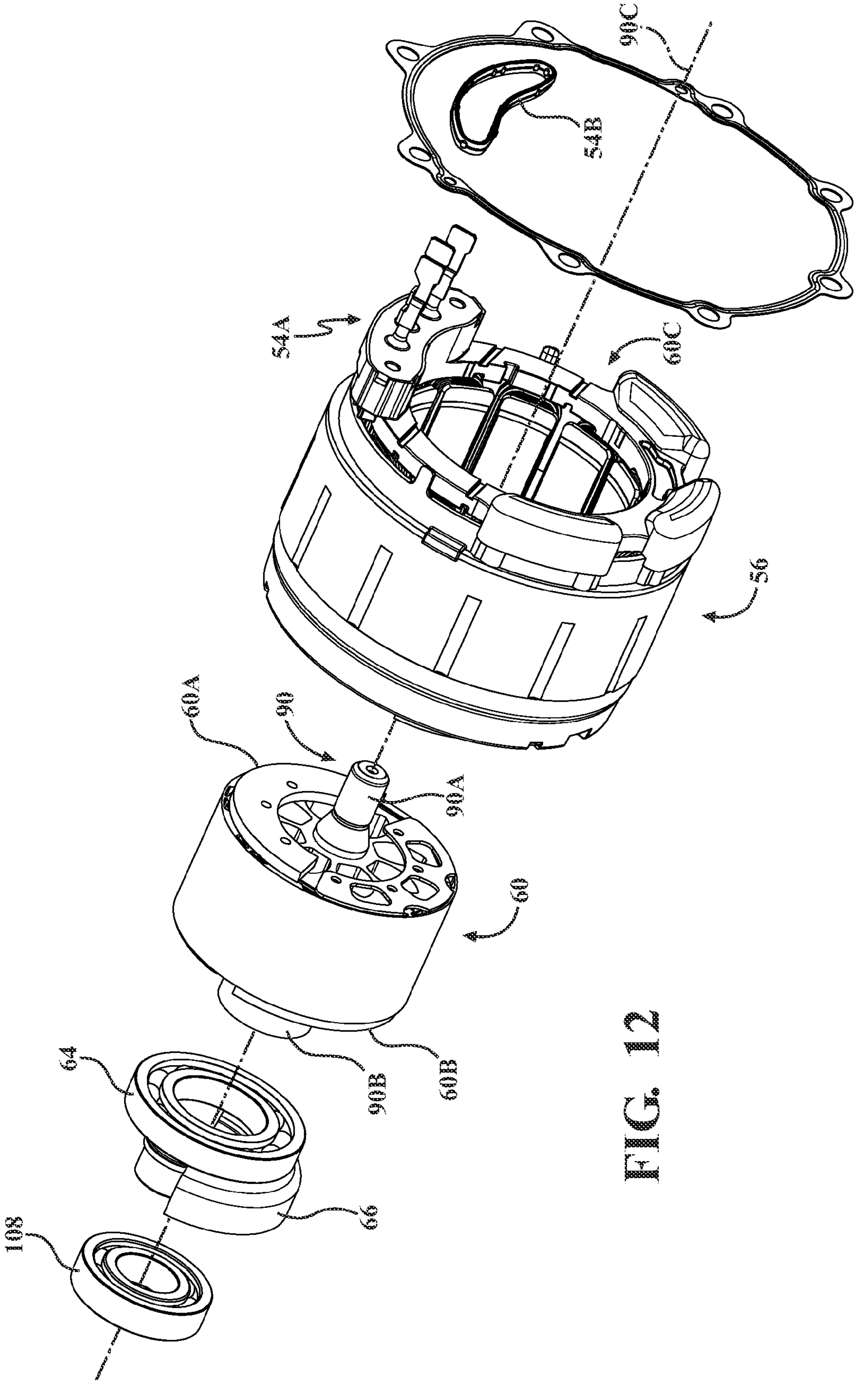


FIG. 12

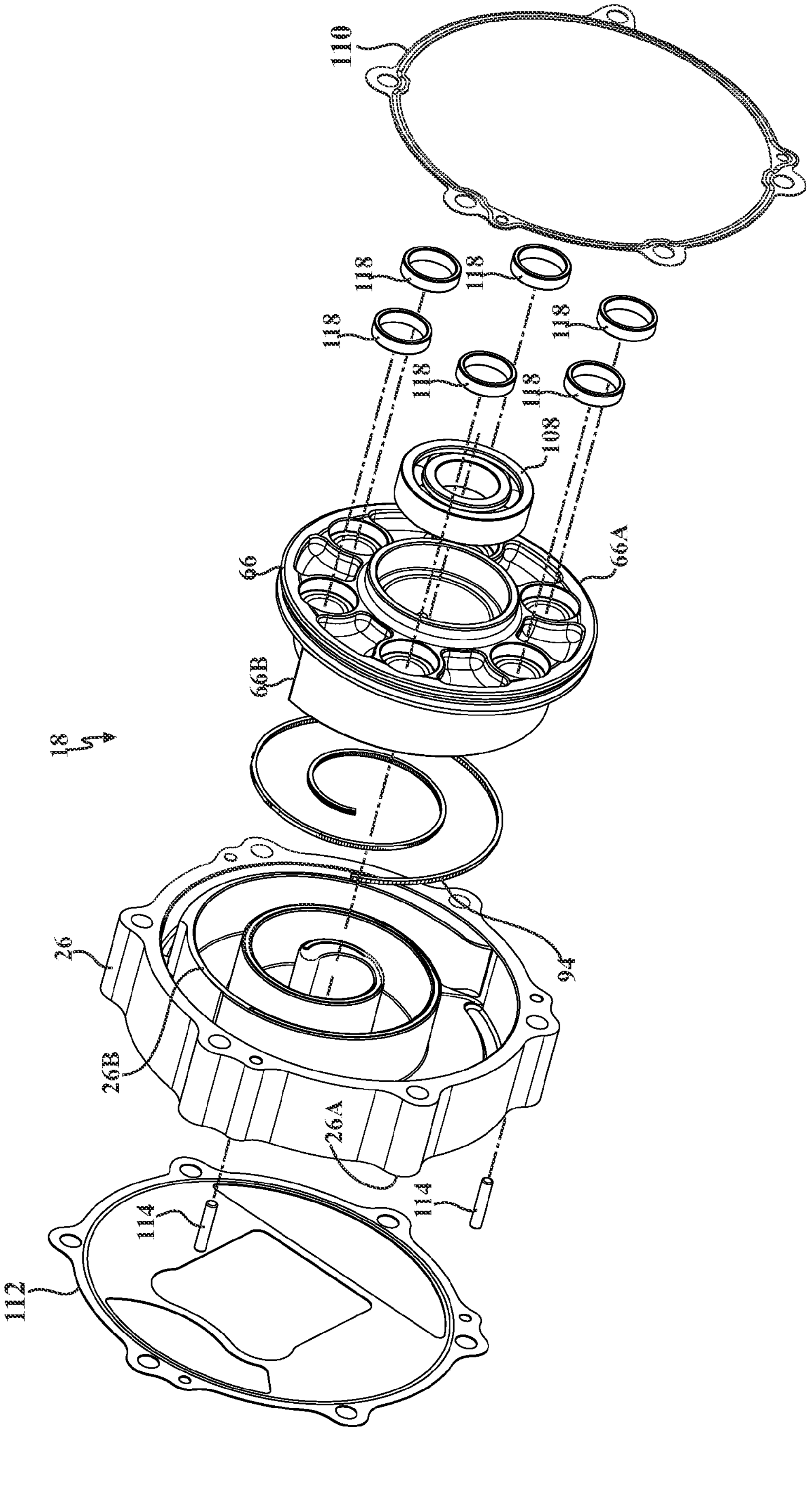

110
118
118
118
118
118
118
108
66
66A
66B
18
26
26B
26A
94
114
114
112

FIG. 13

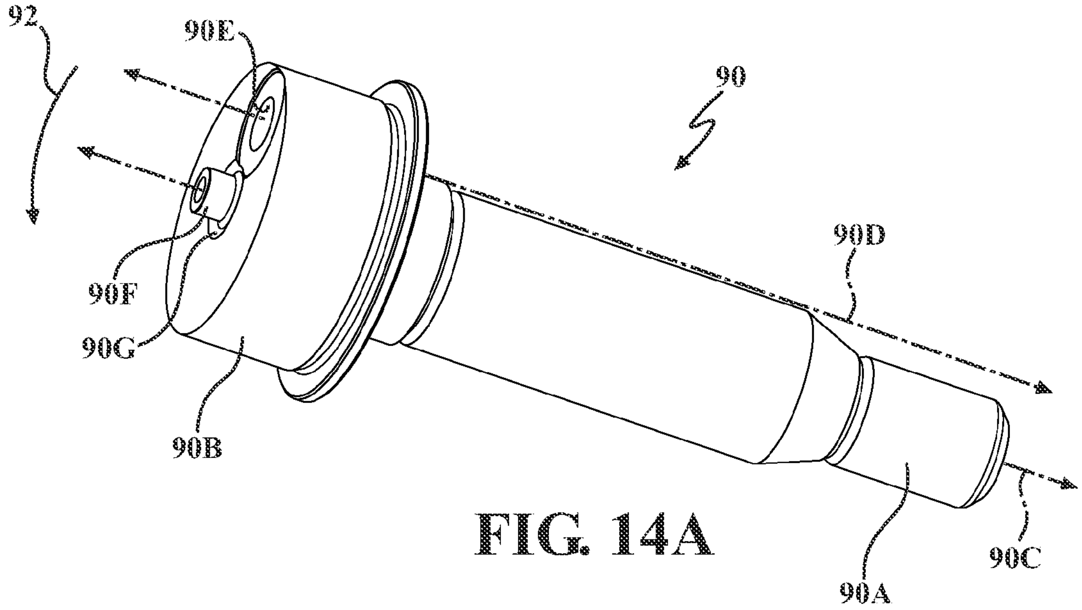


FIG. 14A

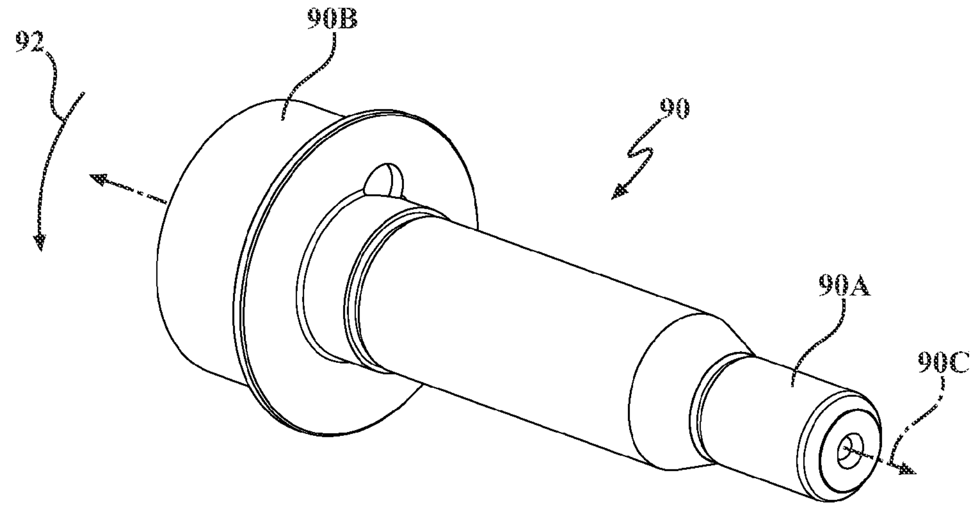


FIG. 14B

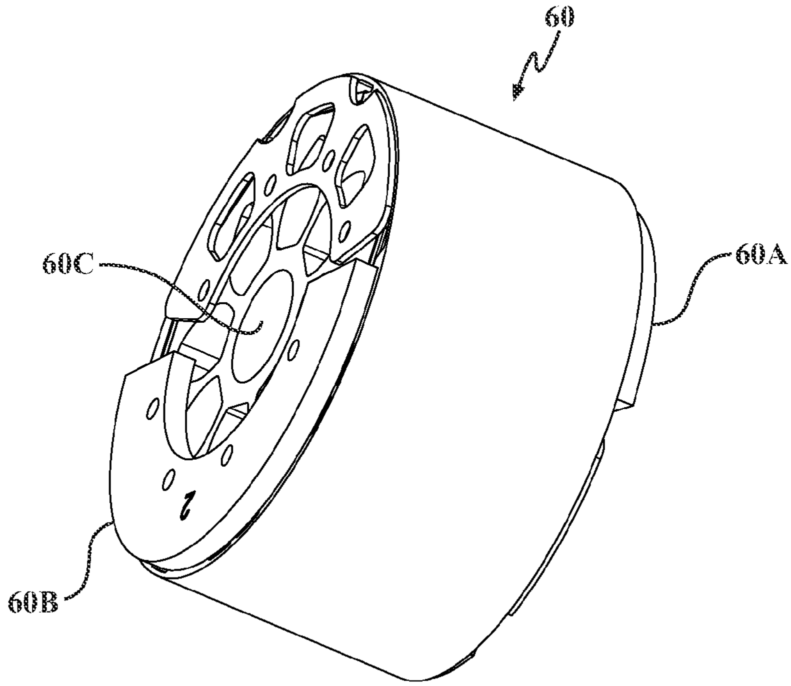


FIG. 15A

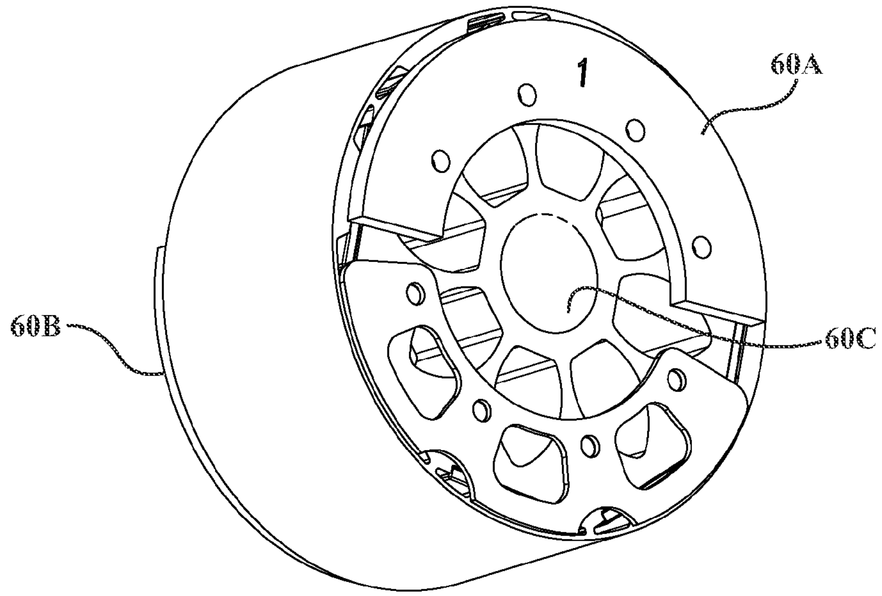


FIG. 15B

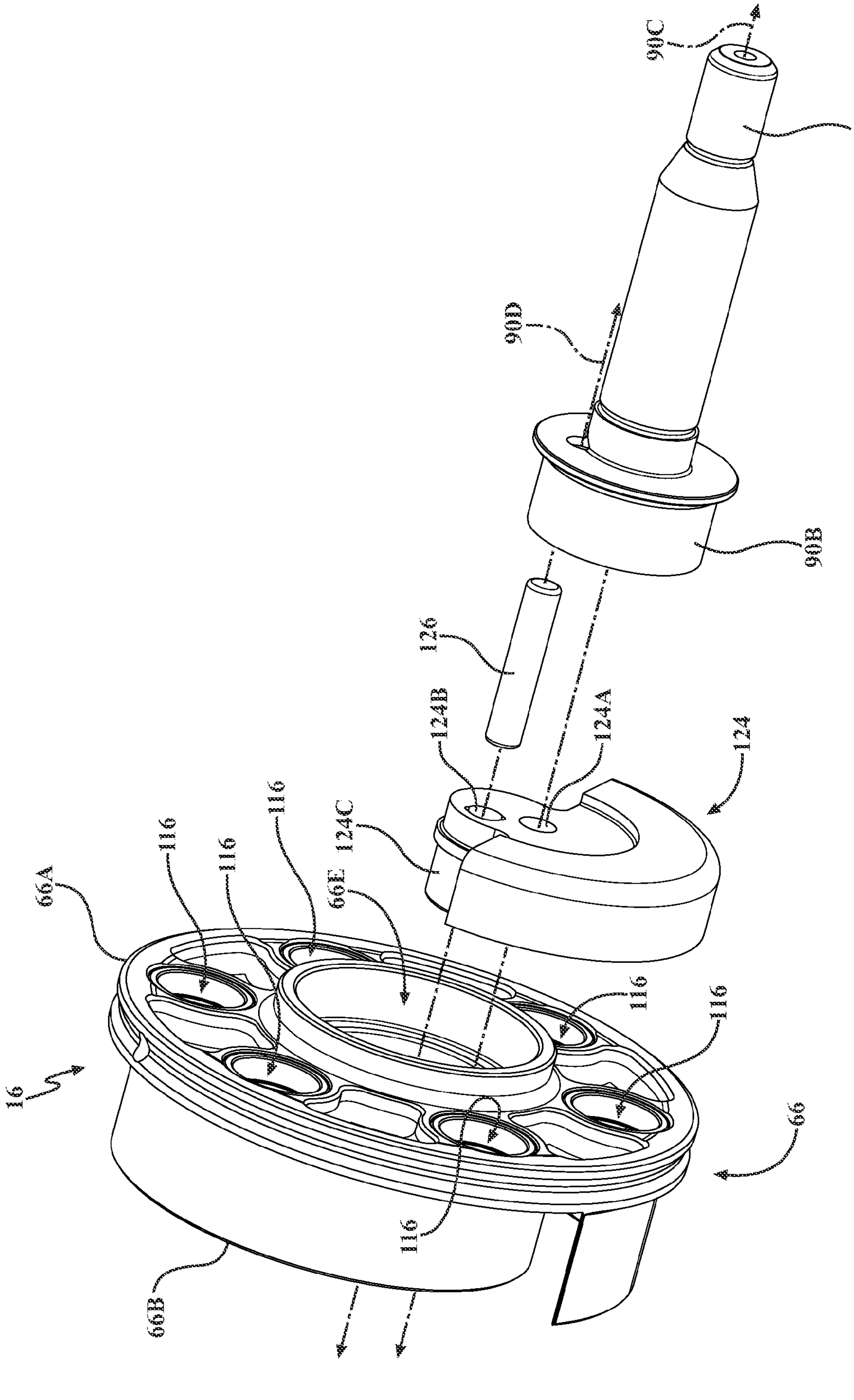

90C
90A
90D
90B
126
124B
124A
124
124C
116
116
116
116
116
116
66A
66E
16
66
66B

FIG. 16A

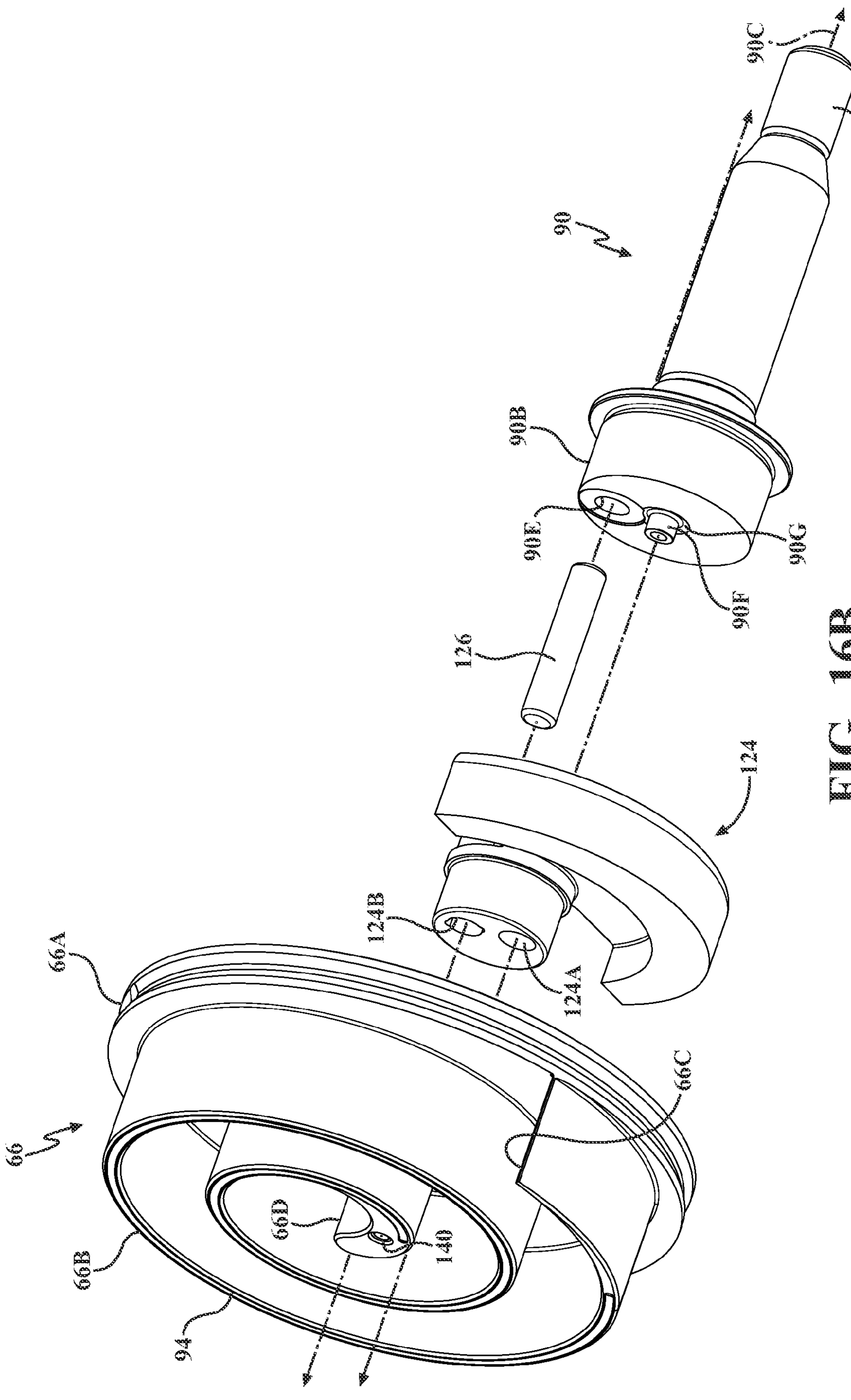

90C
90A
90
90B
90E
90G
90F
126
124
124B
124A
66A
66
66C
66D
140
66B
94

FIG. 16B

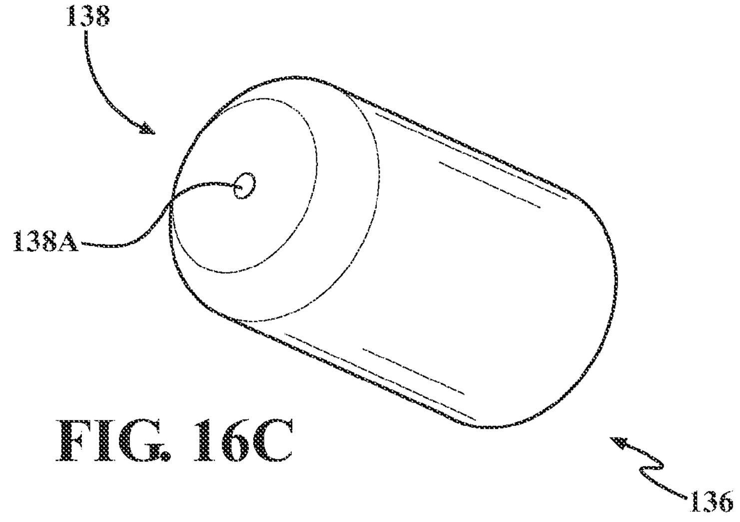


FIG. 16C

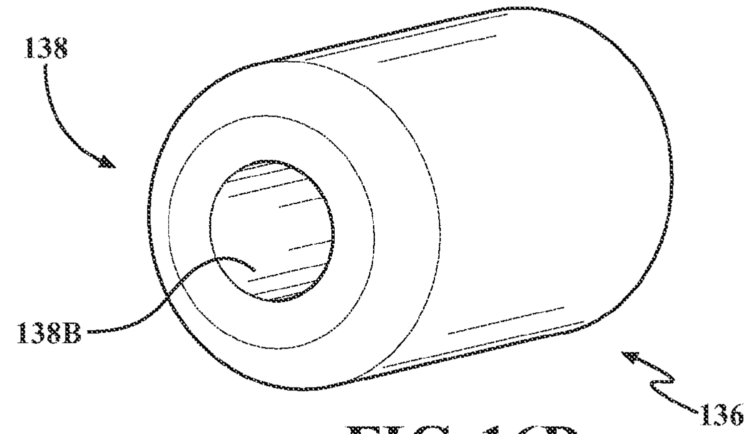


FIG. 16D

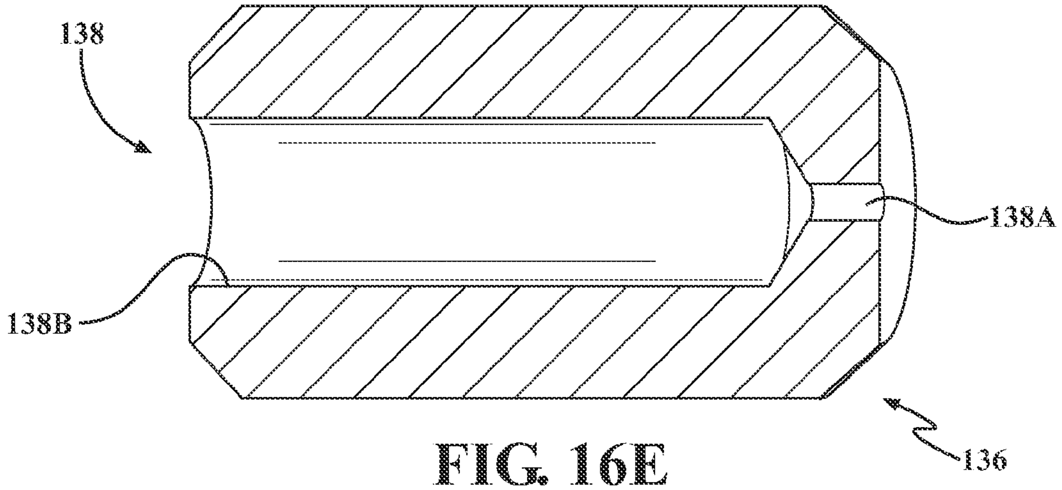


FIG. 16E

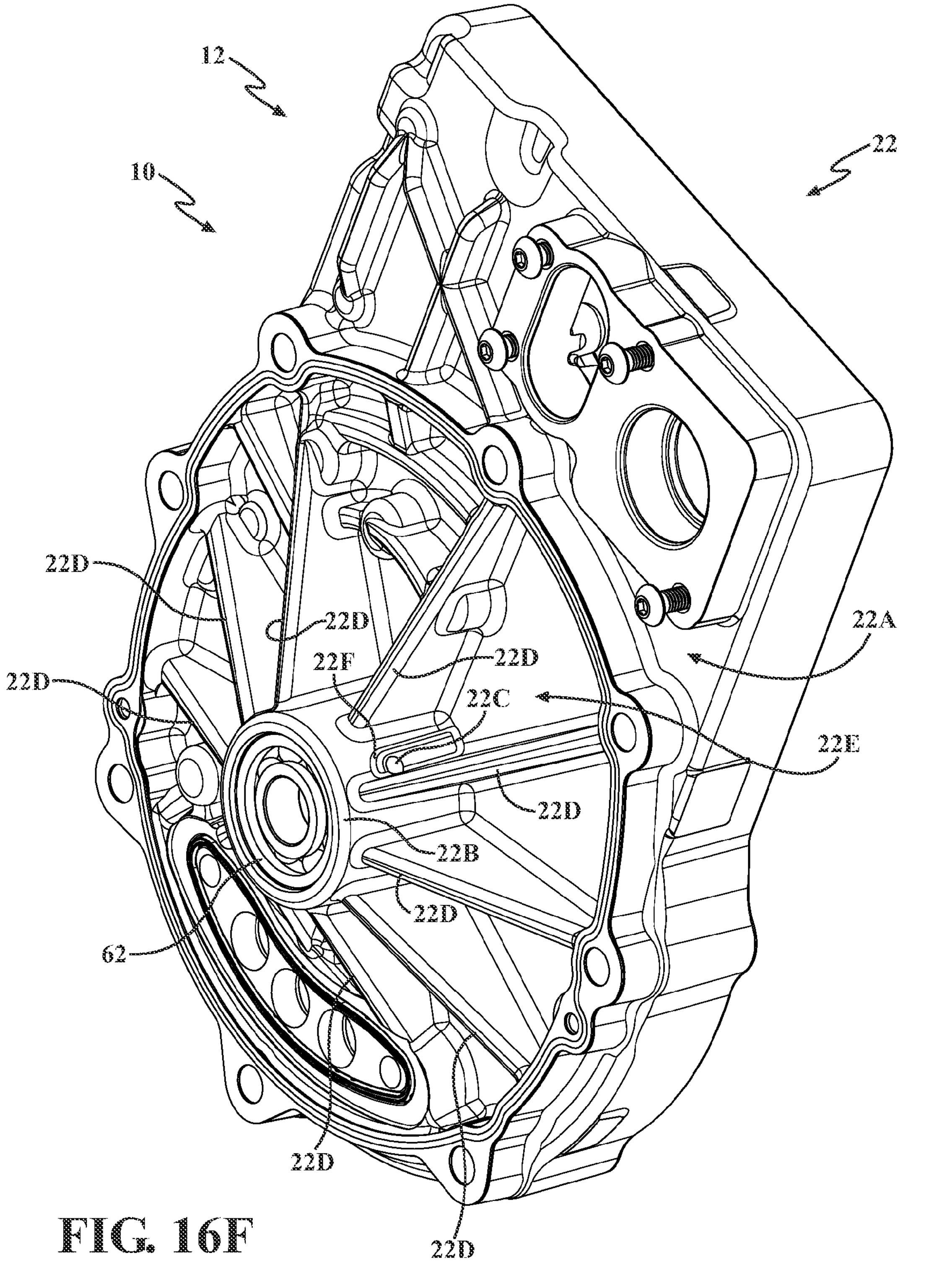


FIG. 16F

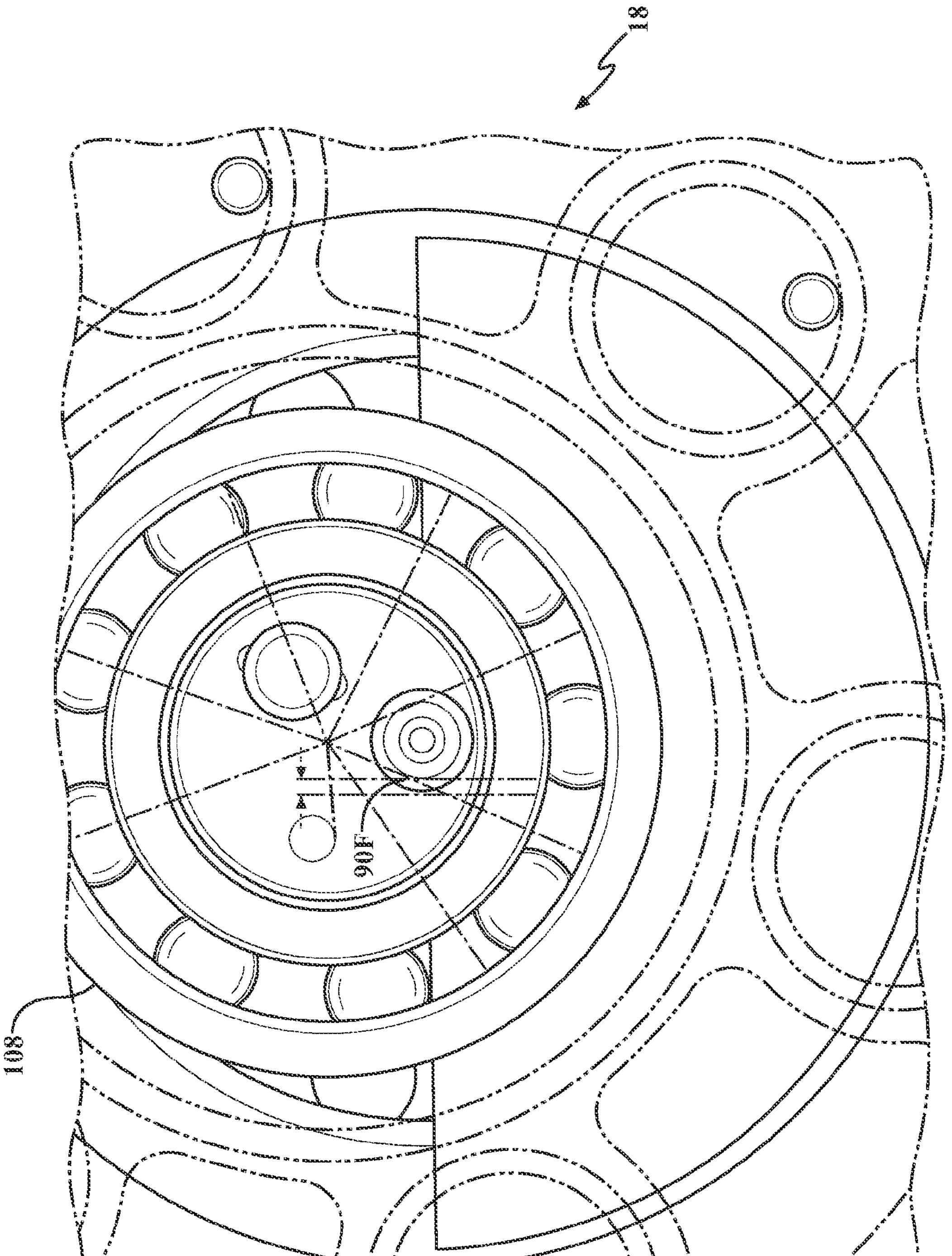


FIG. 16G

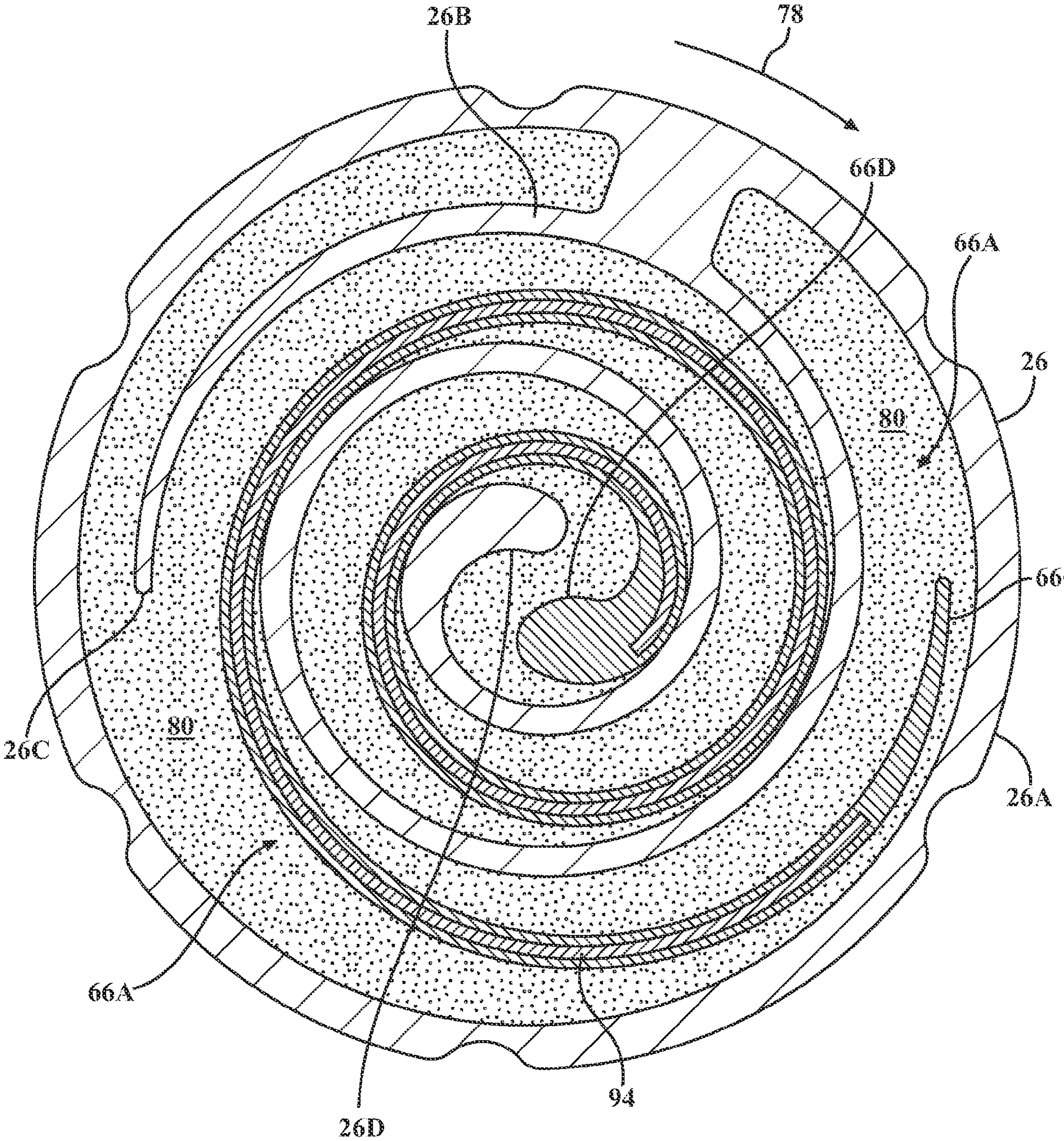


FIG. 17A

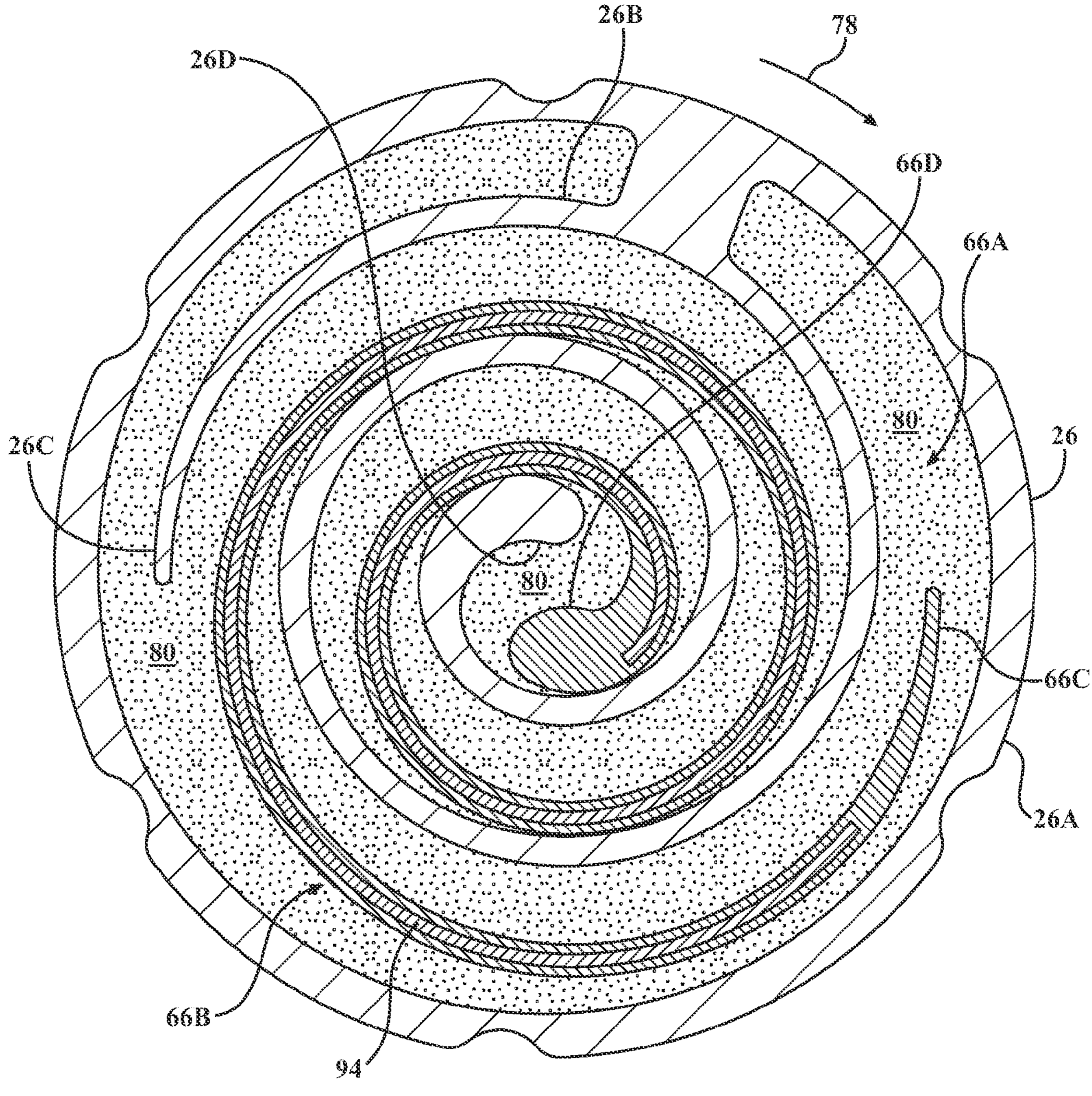


FIG. 17B

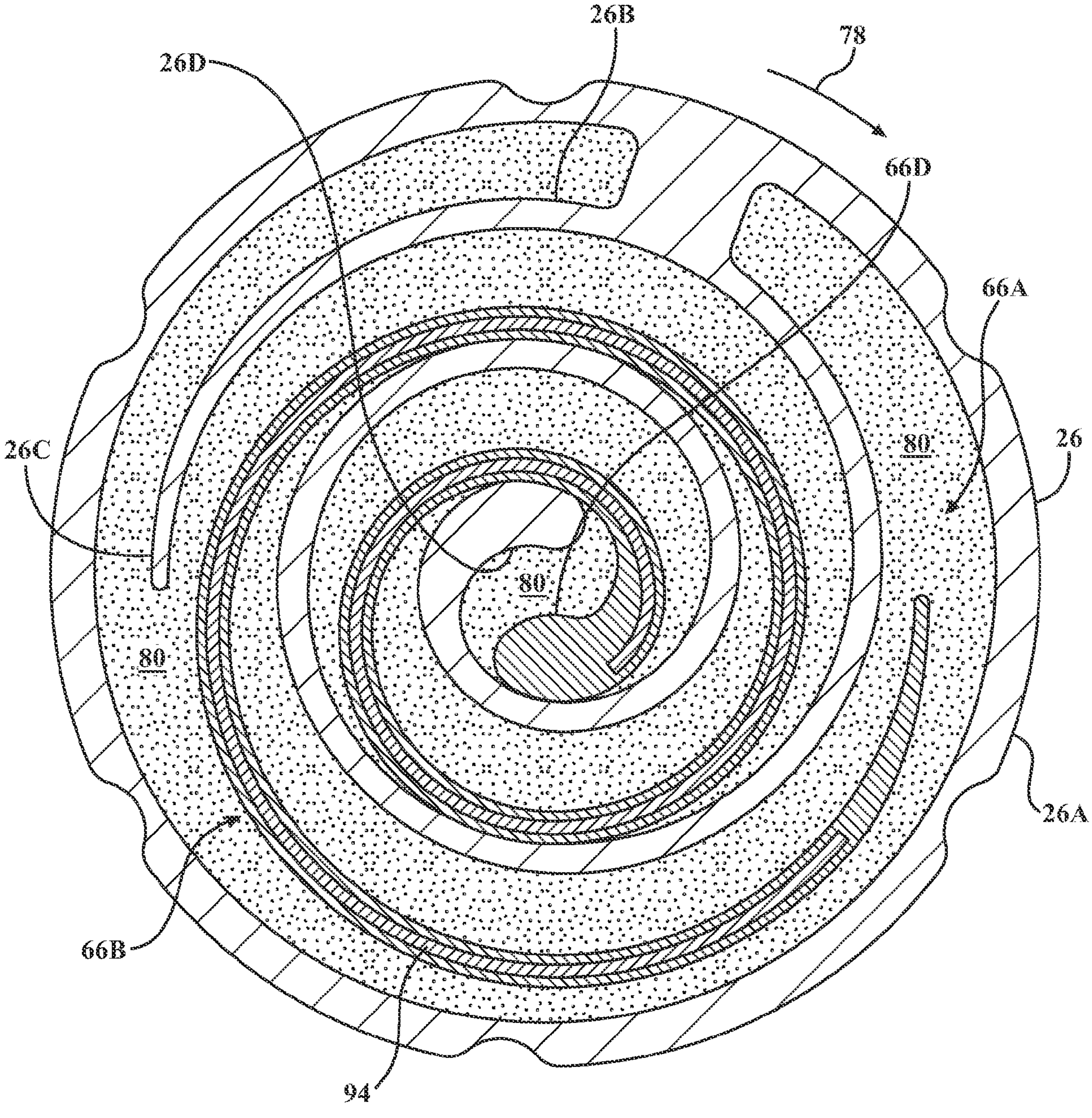


FIG. 17C

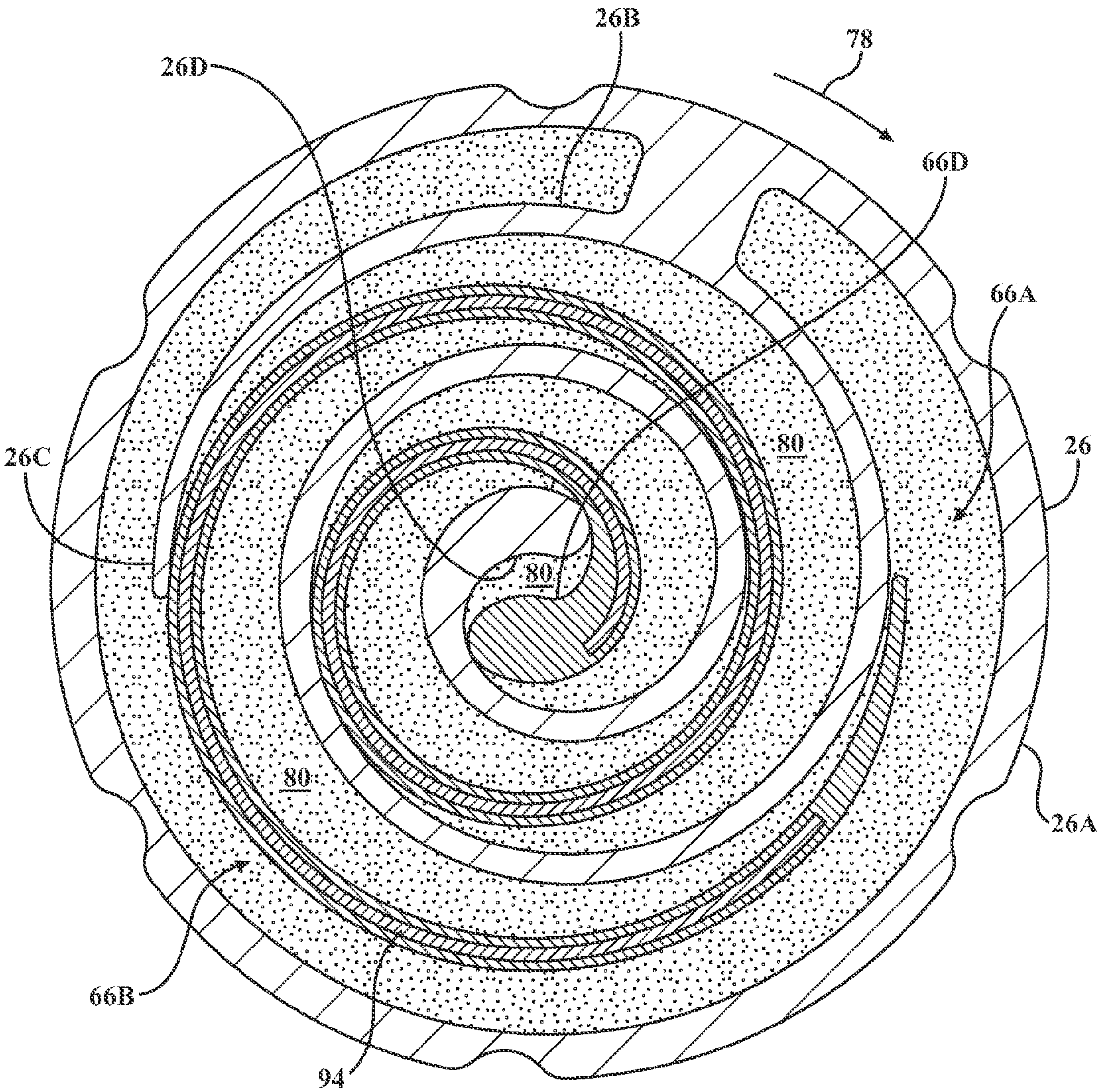


FIG. 17D

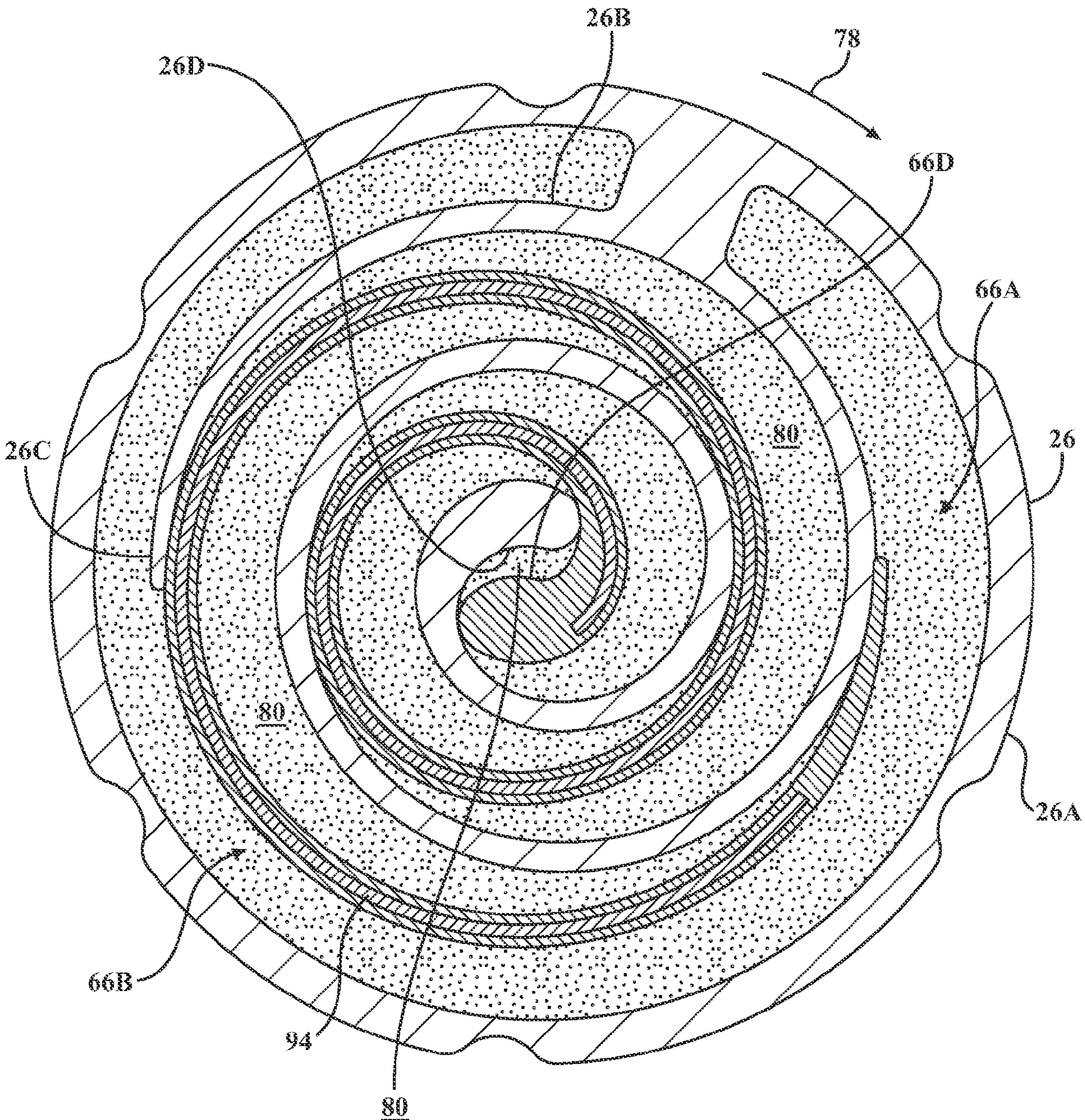


FIG. 17E

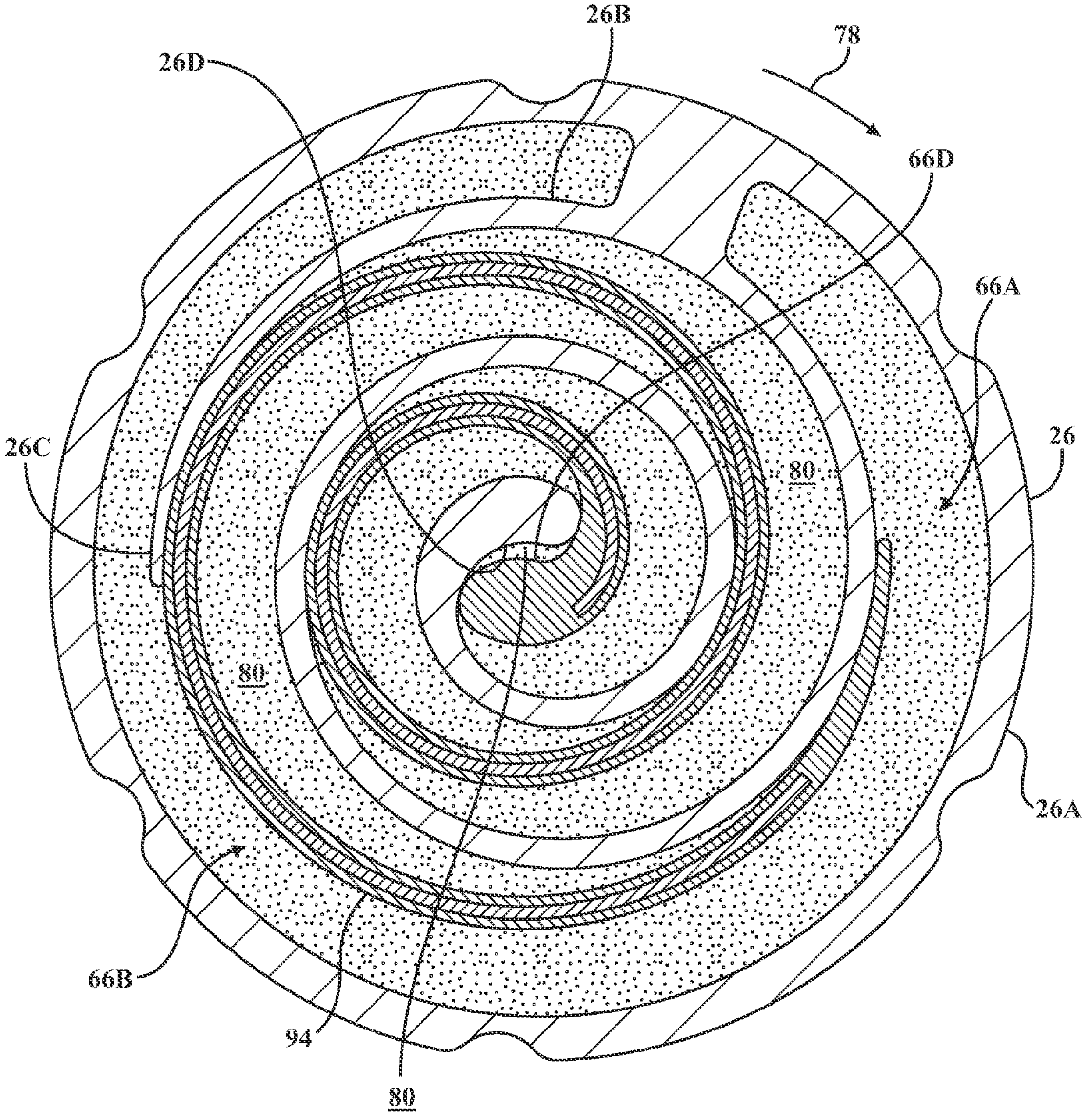


FIG. 17F

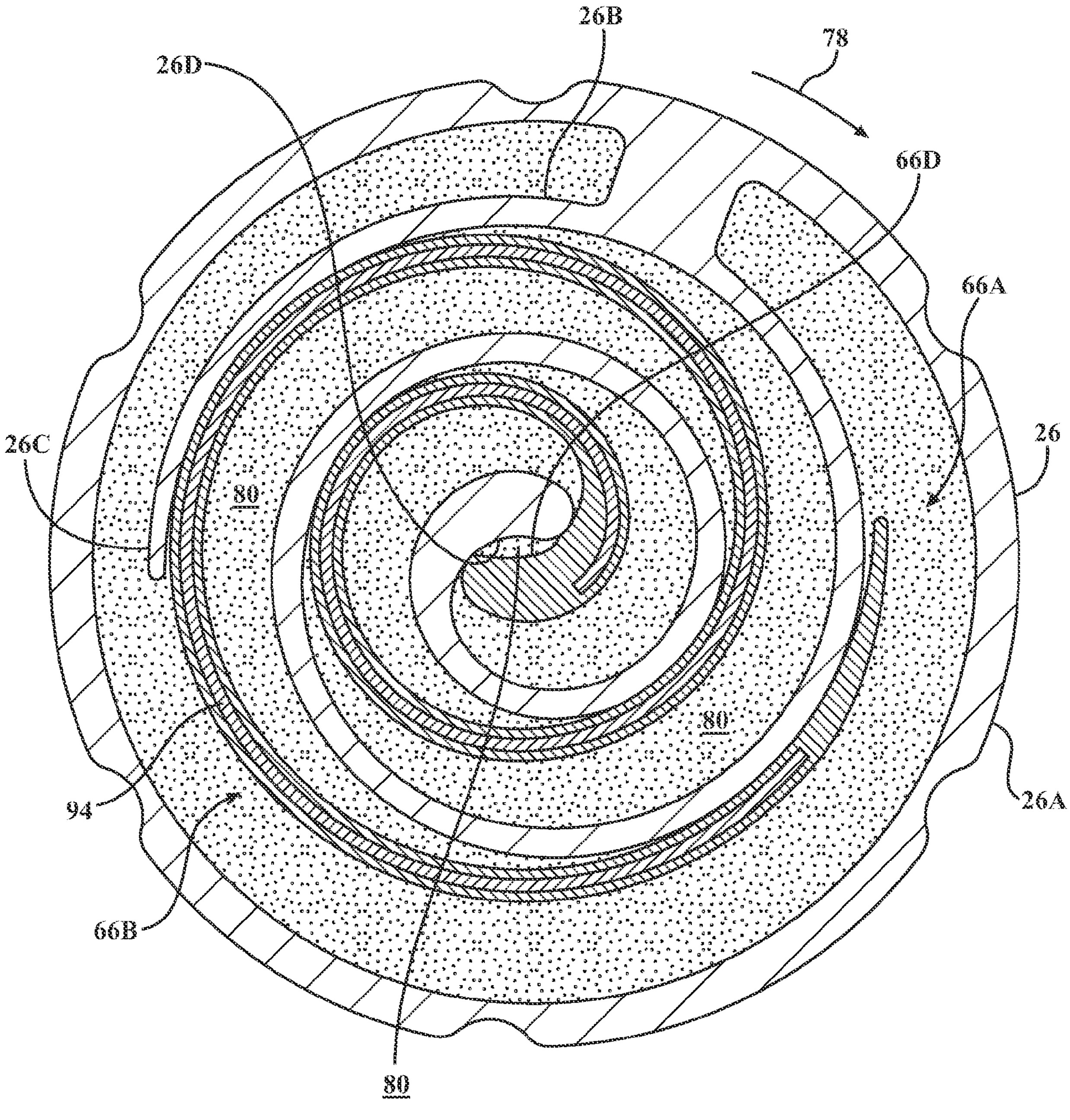


FIG. 17G

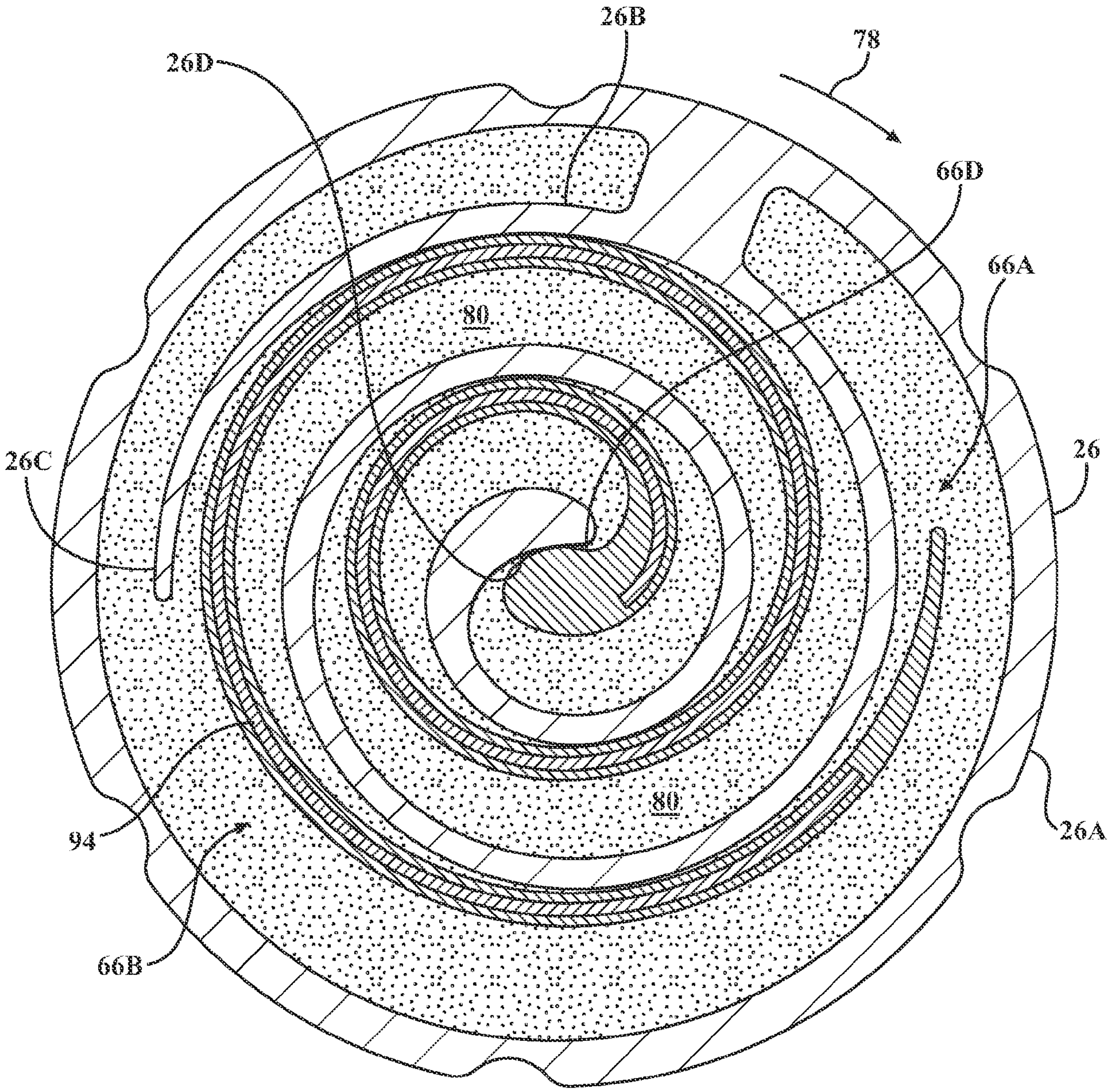


FIG. 17H

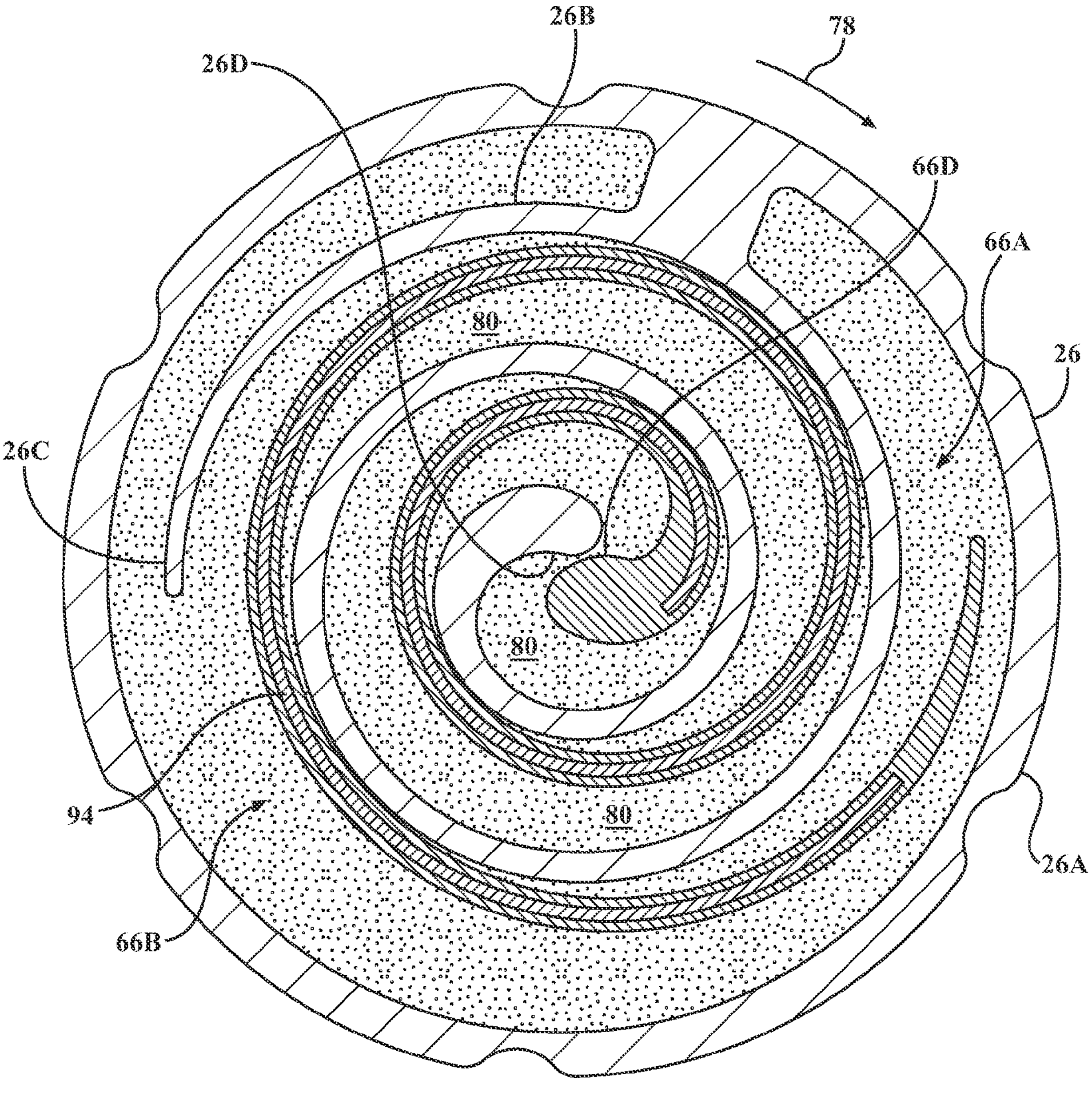


FIG. 17I

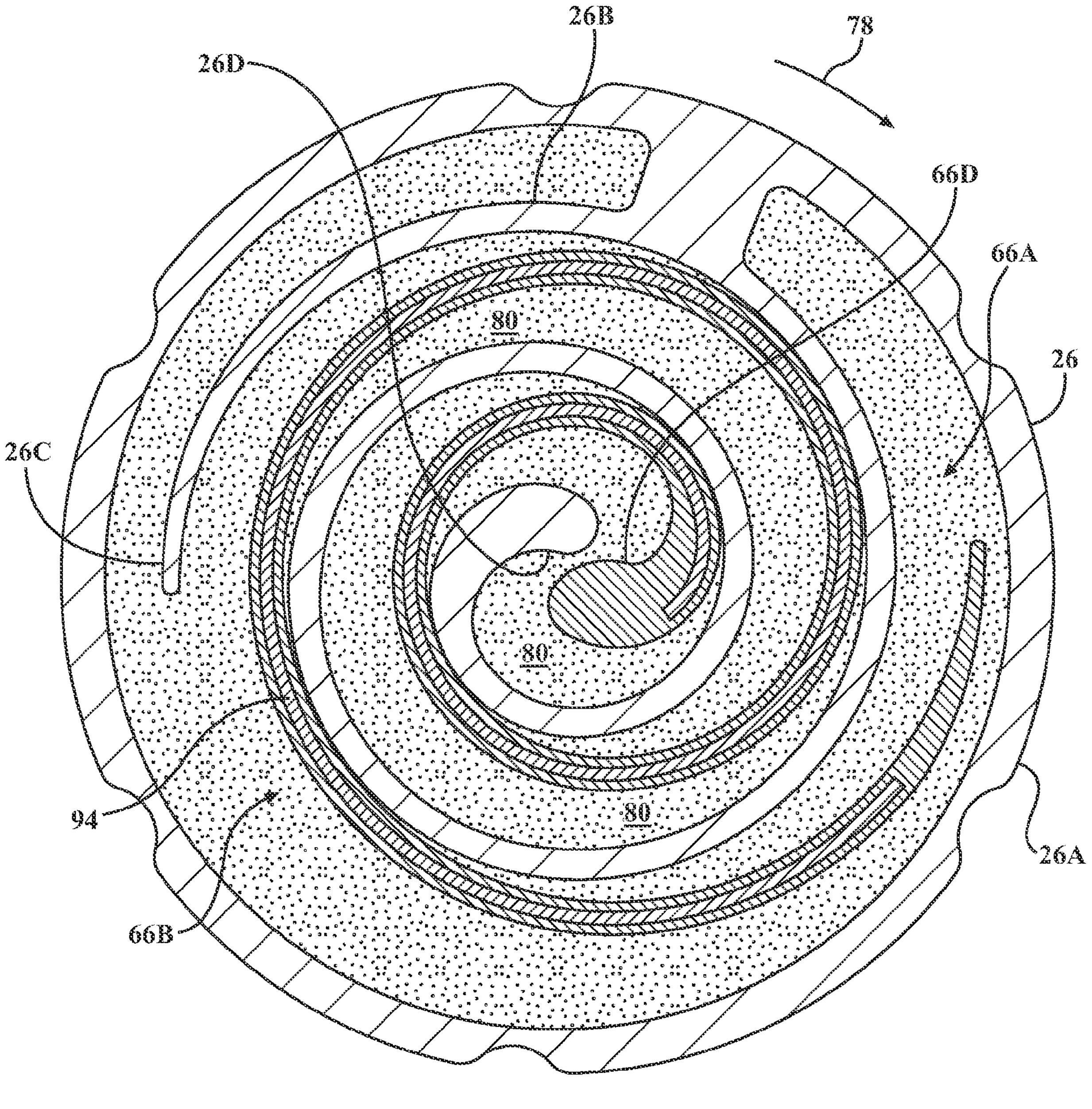


FIG. 17J

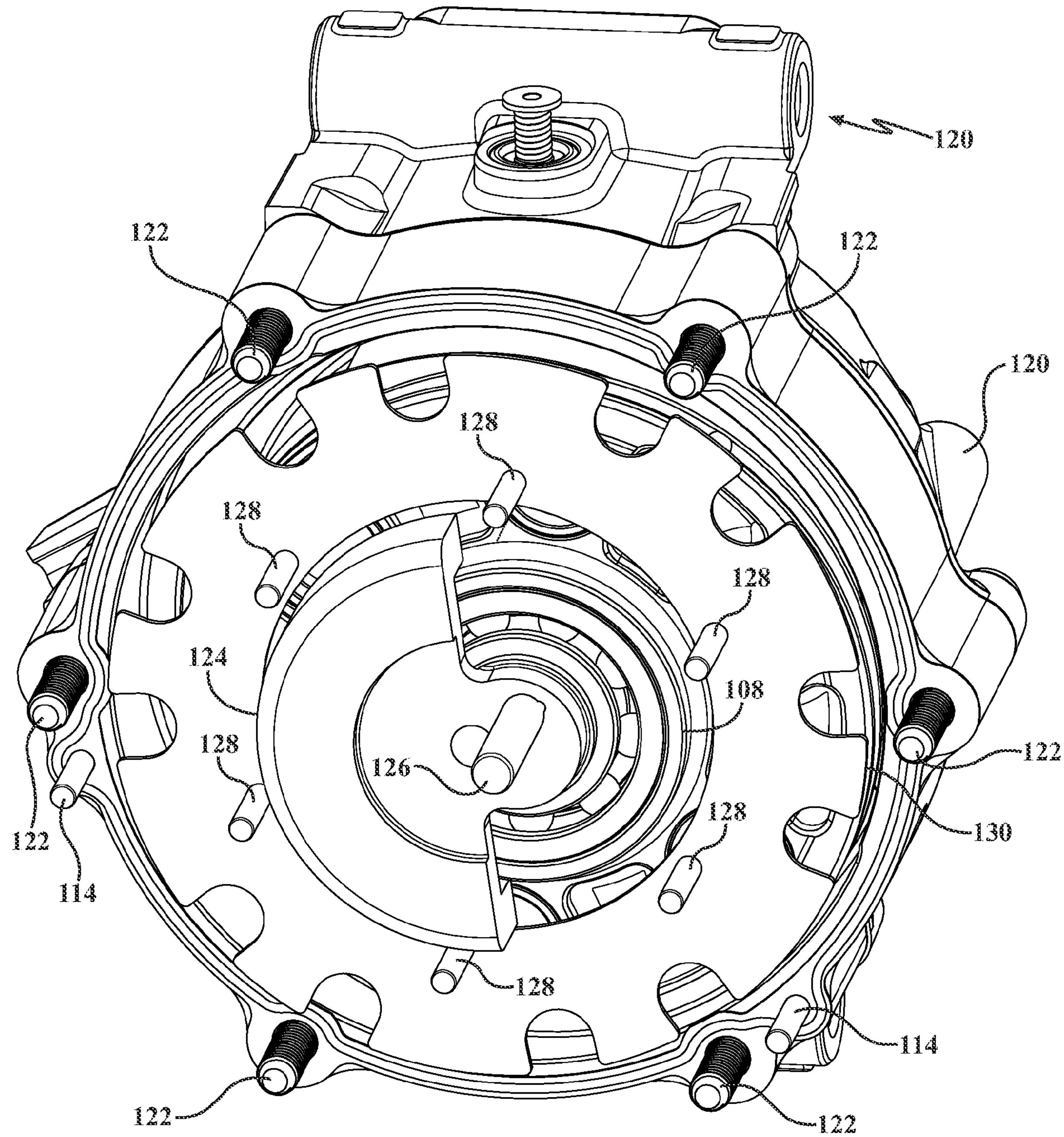

120
122
122
120
128
128
128
124
108
126
122
122
128
128
130
122
114
128
114
122
122

FIG. 18A

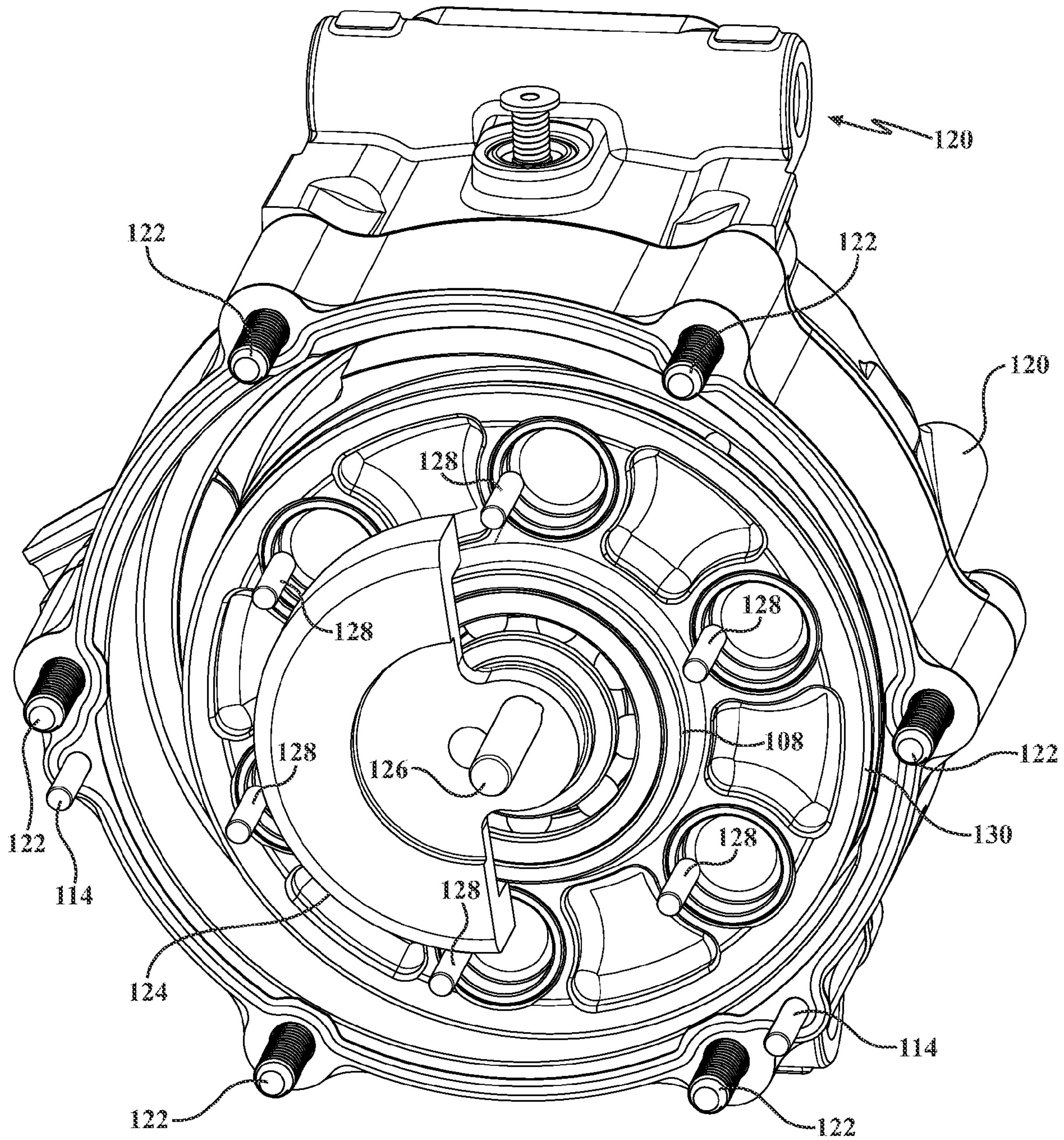

120
122
122
120
128
128
128
108
122
126
128
130
122
114
128
128
124
114
122
122

FIG. 18B

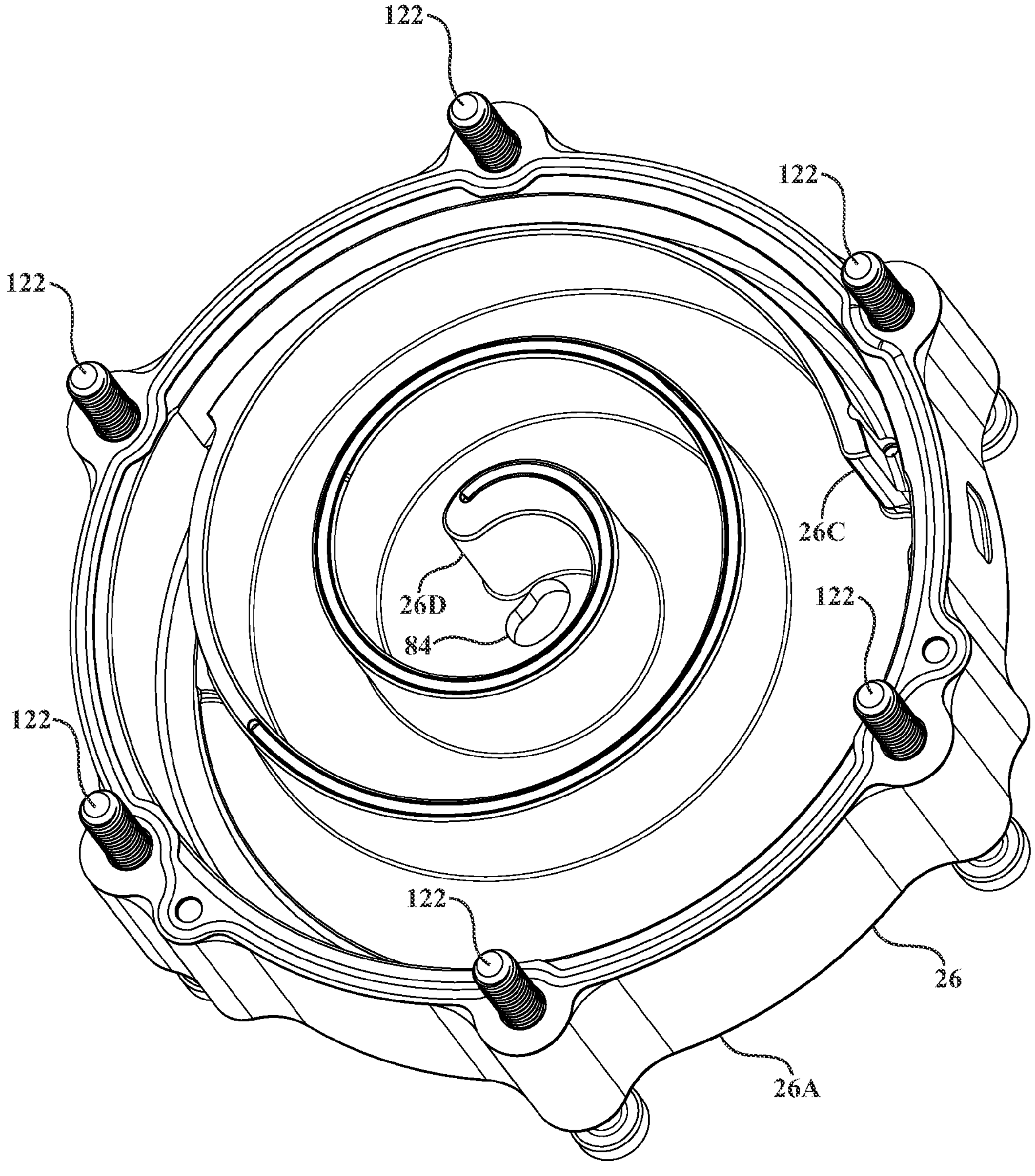


FIG. 18C

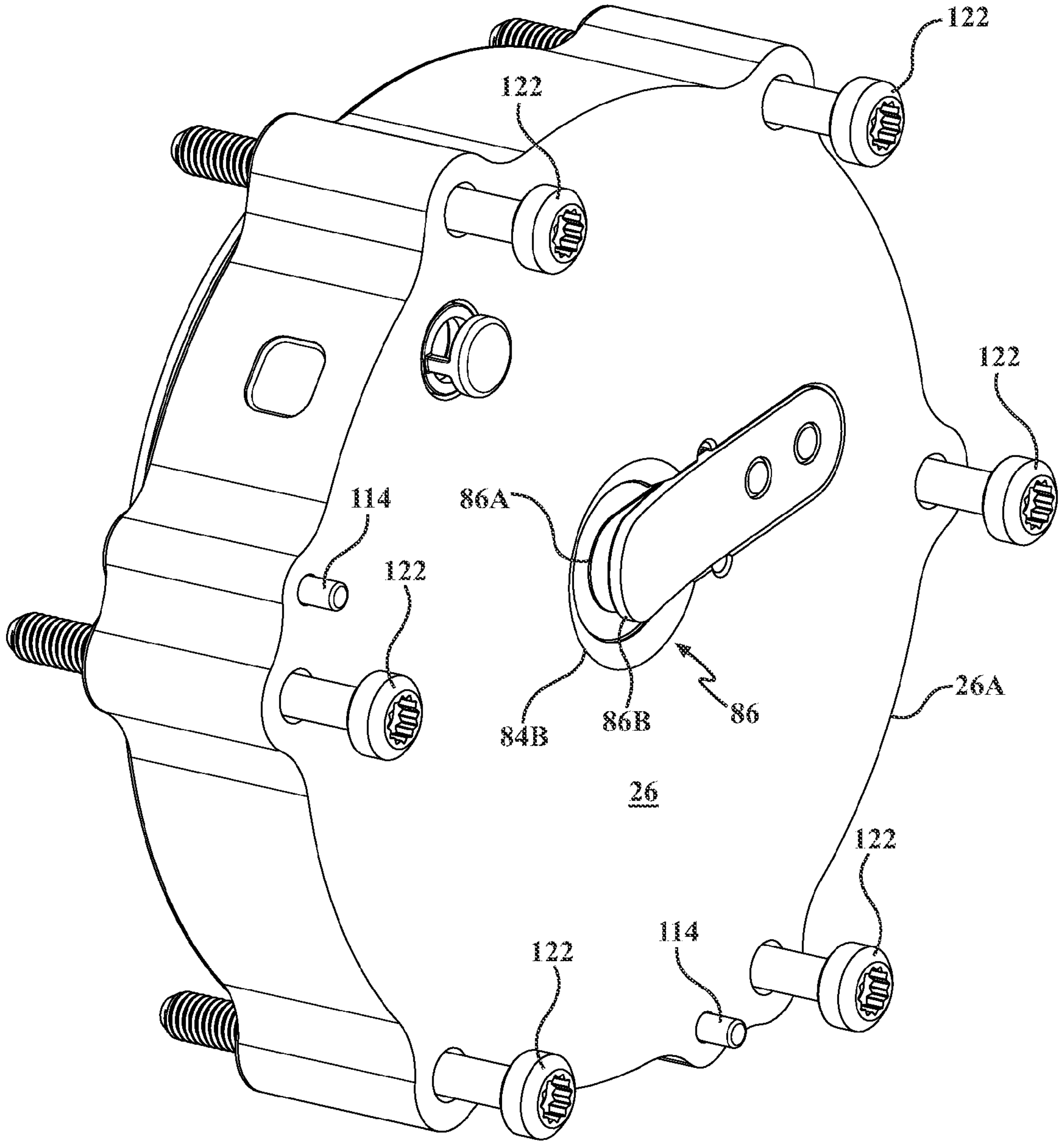


FIG. 18D

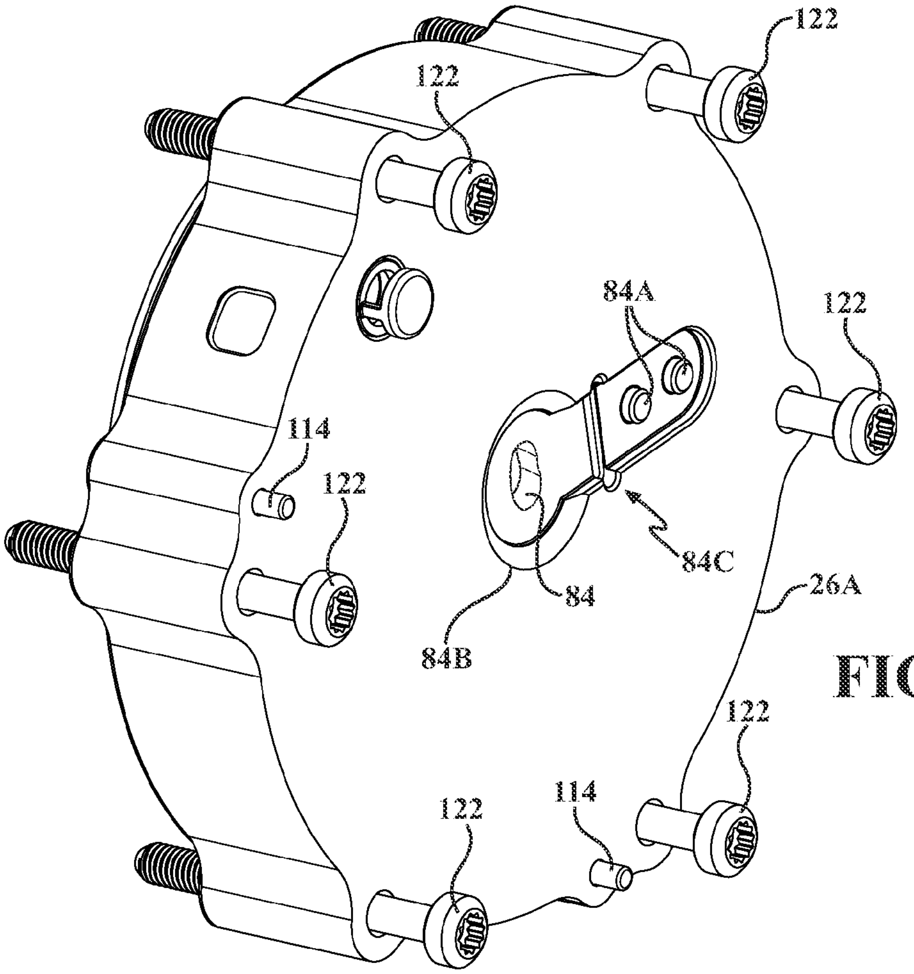


FIG. 18E

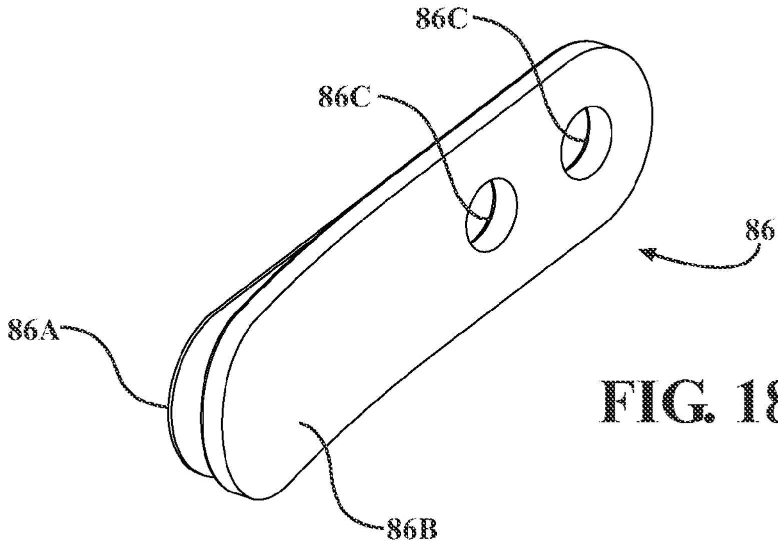


FIG. 18F

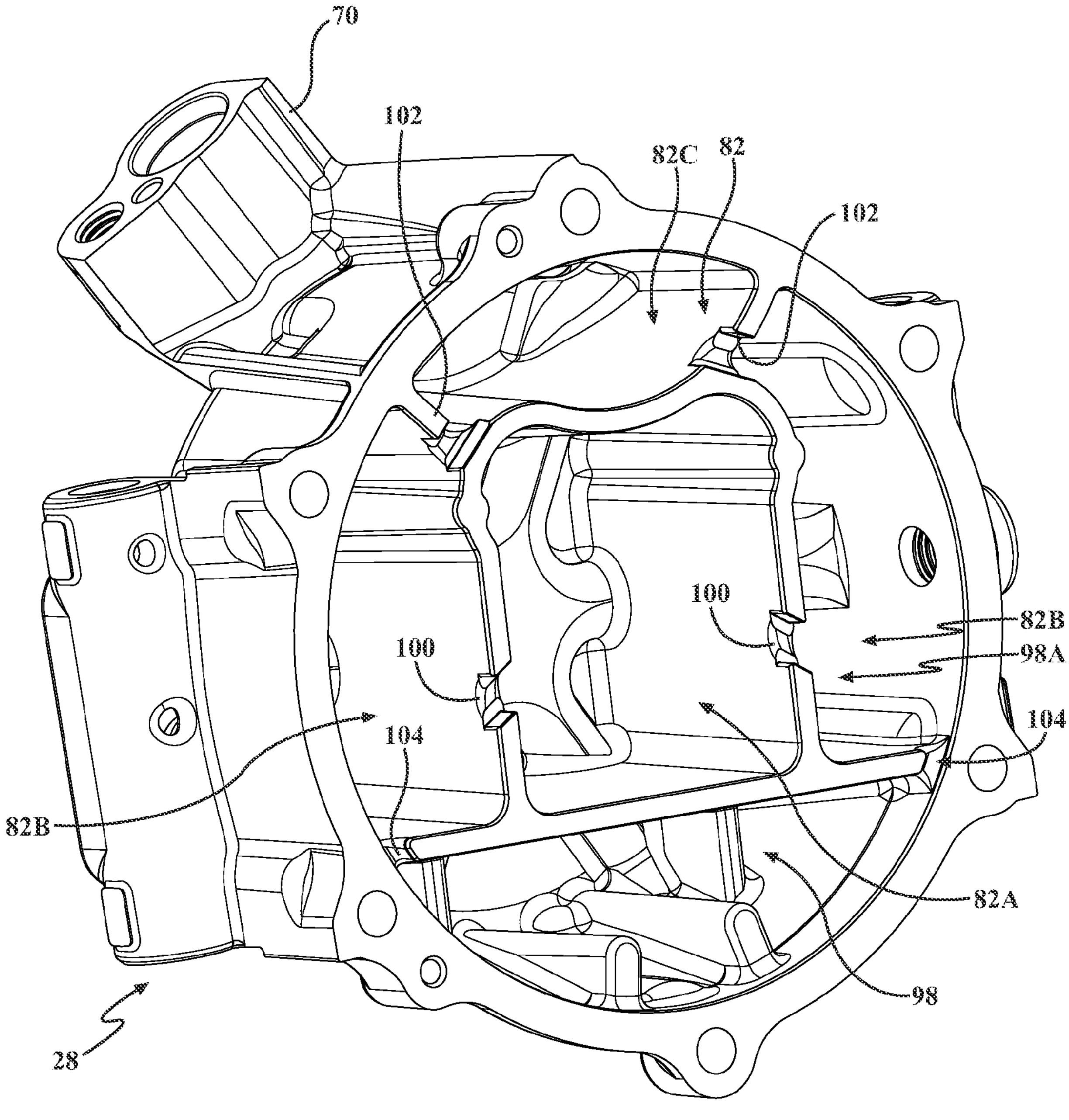


FIG. 19A

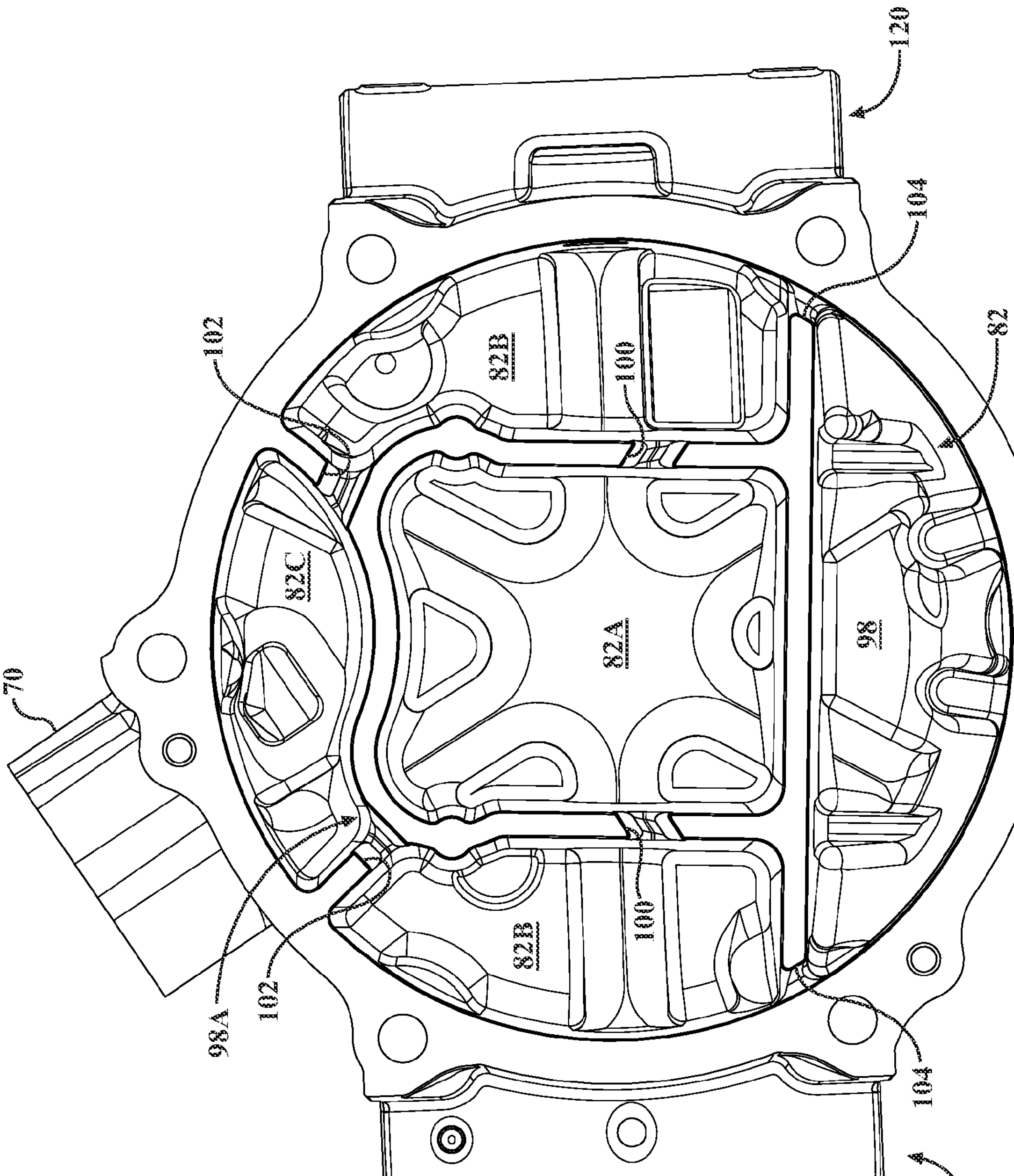


FIG. 19B

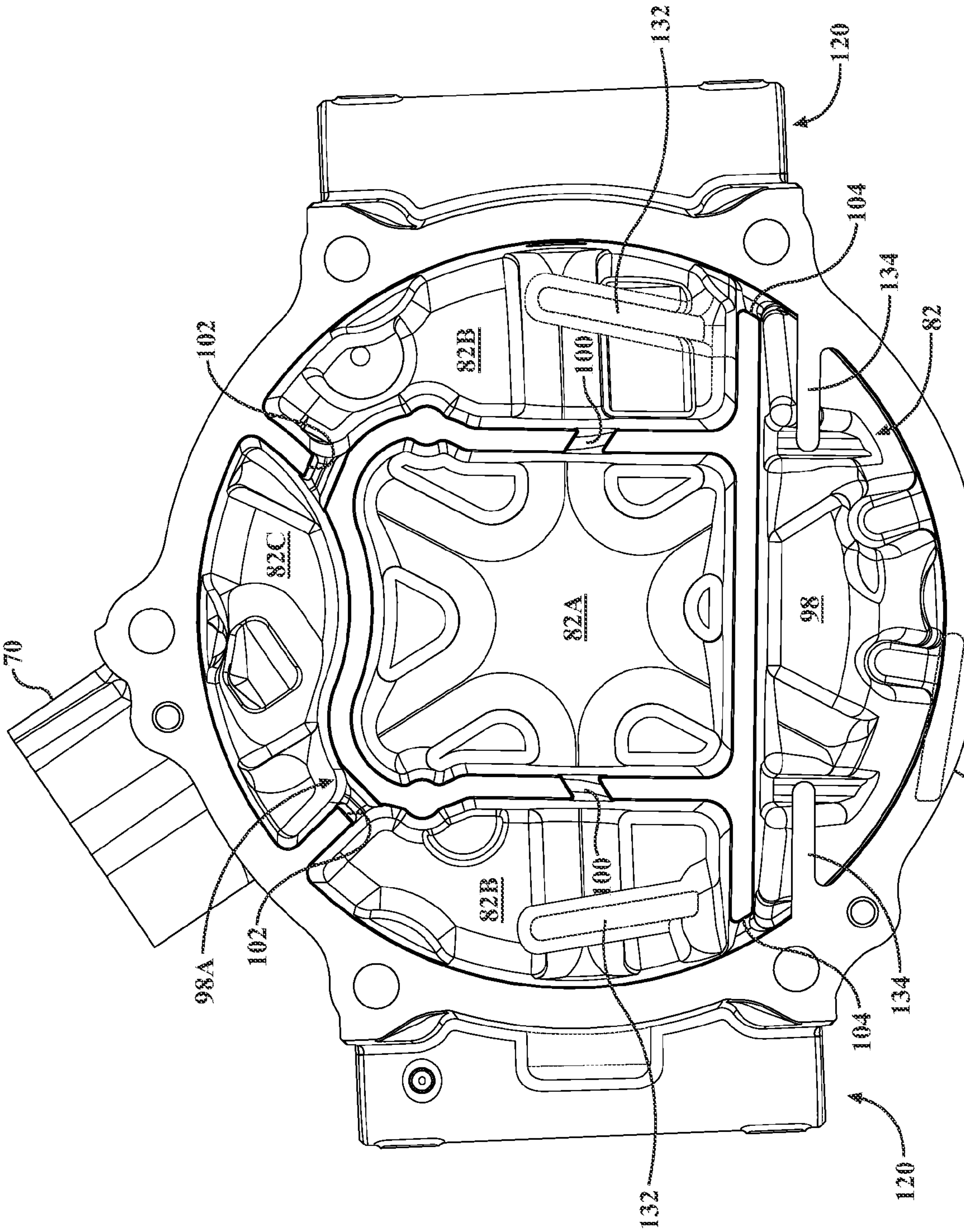

132
120
104
102
134
82
82B
100
82C
82A
98
70
98A
102
100
82B
26
134
104
132
120

FIG. 20

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 23/74026

A. CLASSIFICATION OF SUBJECT MATTER
IPC - INV. F04C 18/02, F04C 18/00 (2023.01)
ADD. F04C 29/12, F04C 29/02 (2023.01)

CPC - INV. F04C 18/0215, F04C 18/0207, F04C 18/0276, F04C 18/02, F04C 18/0253, F04C 18/0246

ADD. F04C 18/0269, F04C 18/0276, F04C 29/12, F04C 29/026, F04C 29/02, F04C 18/0223

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
See Search History document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	WO 2020090701 A1 (VALEO JAPAN CO., LTD.), 07 May 2020 (07.05.2020), entire document, especially Figs 1-7	1-2, 6-8, 12 --- 1-5, 8-11
Y	US 2020/0080547 A1 (SAMSUNG ELECTRONICS CO., LTD.), 12 March 2020 (12.03.2020), entire document, especially Figs 1-14	1-5, 8-11
A	US 2021/0071663 A1 (LG ELECTRONICS INC.), 11 March 2011 (11.03.2021), entire document	1-12
A	US 2020/0072203 A1 (LG ELECTRONICS INC), 05 March 2020 (05.03.2020), entire document	1-12
A	US 11,629,713 B1 (Mahle International GmbH), 18 April 2023 (18.04.2023), entire document	1-12
A, P	US 2020/0173436 A1 (Hyunda Mobis Co., Ltd.), 04 June 2020 (04.06.2020), entire document	1-12

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 November 2023 (17.11.2023)	DEC 12 2023

Name and mailing address of the ISA/US	Authorized officer
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Kari Rodriquez Telephone No. PCT Helpdesk: 571-272-4300