



(51) International Patent Classification:

F04C 23/00 (2006.01) *F01C 21/08* (2006.01)
F04C 29/00 (2006.01) *F01C 21/10* (2006.01)
F04C 18/344 (2006.01)

(21) International Application Number:

PCT/US2016/026411

(22) International Filing Date:

7 April 2016 (07.04.2016)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

62/146,582 13 April 2015 (13.04.2015) US

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(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, CZ, DE, DK, DM,
 DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
 HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR,
 KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG,
 MK, MN, 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, SM, ST, SV, SY, TH, TJ, TM, TN,
 TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every
 kind of regional protection available*): ARIPO (BW, GH,
 GM, KE, LR, LS, MW, MZ, NA, RW, 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, LU,
 LV, MC, 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).

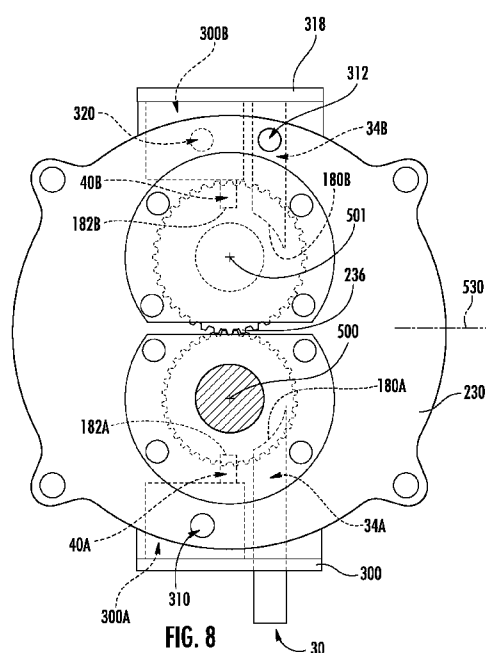
Declarations under Rule 4.17:

— of inventorship (Rule 4.17(iv))

Published:

— with international search report (Art. 21(3))

(54) Title: TWO-STAGE SPOOL COMPRESSOR



(57) Abstract: A spool compressor (220) comprises a housing (228, 244, 248) having: at least a first inlet port (30); and at least a first outlet port (32). A first spool is mounted for rotation of about a first spool axis (500). A second spool is mounted for rotation about a second spool axis (501). A first endplate (234A) of the first spool has a first plurality of teeth (236) and a first endplate (234B) of the second spool has a second plurality of teeth (236) enmeshed with the first plurality of teeth.

TWO-STAGE SPOOL COMPRESSOR

CROSS-REFERENCE TO RELATED APPLICATION

[0001] Benefit is claimed of U.S. Patent Application No. 62/146,582, filed April 13,
5 2015, and entitled " Two-Stage Spool Compressor ", the disclosure of which is incorporated
by reference herein in its entirety as if set forth at length.

BACKGROUND

[0002] The disclosure relates to spool compressors. More particularly, the disclosure
10 relates to economized spool compressors.

[0003] Spool compressors are a form of rotary positive displacement compressor disclosed
in United States Patent 8,113,805, of Kemp, issued February 14, 2012, and International
Application Publication WO 2014/116978 A1, of Torad Engineering, LLC, published July 31,
15 2014.

[0004] FIG. 1 shows an exemplary spool compressor 20 having a motor 22. The exemplary
compressor is a hermetic or semi-hermetic compressor wherein the motor falls within a case
of the compressor. In this example, the motor falls within an outer case or housing 24 and the
20 compressor further comprises an inner case or housing 26 within the outer case discussed
below. The outer case has a suction port or inlet port (inlet) 30 and a discharge port or outlet
port (outlet) 32. The exemplary inner case 26 further includes a suction port or inlet port
(inlet) 34 which may be connected to the outer case suction port 30 via an inlet conduit 36.
The inner case 26 further includes an outlet port. The inner case outlet port 40 (FIG. 3) is
25 closed by a reed valve 42 (FIG. 1). In the exemplary embodiment, the inner case discharge
port comprises two side-by-side ports. Although, in various embodiments, the discharge port
may be connected to the outer case discharge port via conduit, in the exemplary embodiment,
the discharge port 42 is open to the interior of the outer case.

[0005] Viewed alternatively, the inner case 26 may be treated as the case of a core
compressor 50 including the motor but not including the outer case and inlet conduit. In this
example, the ports 34 and 40 would be regarded as inlet and outlet ports of the core
compressor 50.

[0006] FIG. 1 further shows a shaft 100 of the compressor extending into and mating with a shaft (not shown) of the motor to allow the motor to drive the compressor. In an exemplary configuration shown in FIG. 1, a central longitudinal axis 500 is shared by the motor, core compressor, and outer case. In the exemplary illustrated embodiment, in the orientation of FIG. 1, the central longitudinal axis 500 is oriented vertically with the outlet port being in a top of the compressor. Other orientations of the compressor are possible.

[0007] FIG. 2 is an exploded view of the core compressor. The inner housing 26 is shown comprising a main case (or housing) 54 and a bearing case (or housing) 56. The bearing case carries a race of bearings (not shown) to rotationally support the shaft 100 for rotation about the axis 500. In the assembled condition and FIG. 1 orientation, the bearing housing 56 is atop the main housing 54 and secured thereto such as via threaded fasteners (e.g., screws, bolts, studs).

[0008] A spool 78 of the core compressor comprises the combination of a rotor hub member 80 and a pair of endplates 82 and 84. The exemplary hub member 80 comprises a central hub portion 86 having respective first and second ends 88 and 90, an outer surface or periphery 92, and a diametric through-slot 94 (having an opposed pair of openings to the periphery 92). Protruding from the end faces 88 and 90 are respective shaft portions 100 and 102. In the exemplary FIG. 1 orientation, the face 88 is an upper face and face 90 is a lower face.

[0009] The exemplary main housing 54 comprises a first end face 60 and a second end face 62. In the exemplary FIG. 1 orientation, the first end face is an upper end face and the second end face is a lower end face. A compartment or chamber (cylinder) 64 is formed by a surface 66 extending axially through to the surfaces 60 and 62. This chamber 64 forms a cylinder of the compressor. The suction port(s) and discharge port(s) are open to the surface 66 at locations discussed further below. In the assembled condition, the length between the rotor hub faces 88 and 90 is essentially the same as between the main housing faces 60 and 62 and accommodated within the main housing. The endplates 82 and 84 are secured against the faces 88 and 90 (e.g., via press fitting or fasteners) so that respective inboard faces 120 and 122 of these two plates are in sealing engagement with the faces 60 and 62 along outboard portions of the plates. The exemplary sealing engagement may be provided by seal material

(seals; not shown) carried by the main housing 54 or the plates. Thus, the plates 82 and 84 form the flanges of the spool.

[0010] FIG. 2 further shows a vane assembly 140 carried in the slot 94. An exemplary vane assembly comprises a structural vane 142 having respective first and second longitudinal edges 144A and 144B. The longitudinal edges may bear features (e.g., slots) for carrying a respective tip seal 146A, 146B. The structural vane extends from a first end 148 to a second end 150. Extending inward from the second end 150 is a stepped slot or compartment 152. A distal end portion 154 of the slot 152 receives a roller 160 to help guide movement of the vane as is discussed below. The exemplary roller 160 is supported for rotation about an axis 510 by a pin 162 received in a central bore of the roller. The pin 162 is held by a shaft 164 of a support 166. The support 166 is mounted to the second face 62 of the main housing (e.g., via fasteners). The exemplary shaft 164 shares the axis 500 and is received in a central bore of the shaft portion 102. This may be in a journal bearing relation. The axis 510 is parallel to and offset from the axis 500 as is discussed further below. At the upper end of the core compressor, the shaft portion 100 extends through the plate 82 and through the bearing with an intermediate portion engaging the bearing inner race and a distal portion engaging the motor shaft.

[0011] The roller 160 rotating about the axis 510 offset from the axis 500 serves the function of the eccentric cam of other exemplary spool compressors to which the teachings below may also be applied.

[0012] FIG. 3 shows the roller 160 in rolling/sliding engagement with opposite walls 155A and 155B of the slot distal end portion 154. FIGS. 4, 5, and 6 show sequence of operational conditions of the baseline compressor. The illustrations are notational views corresponding approximately to a downward sectional view through the main housing of the FIG. 1 compressor but with FIGS. 4-6 showing the upper endplate superimposed. FIGS. 4-6 show an outer periphery 170 of the endplate superimposed so as to extend beyond the inner surface 66 of the cylinder. FIG. 3 also shows the openings 180 and 182 of the respective suction port and discharge port to the surface 66. In this condition, three pockets (volumes or chambers) are formed in the cylinder. The pockets are separated by the two edges of the vane assembly (e.g., provided by the seals) and by close fitting cooperation of the hub periphery 92 and the surface 66 at one location (for reference defined as the twelve o'clock location at the top of

the view). There is increasing clearance between the hub periphery and surface 66 progressively further away from the twelve o'clock position. Thus, a first volume or pocket 200 is seen between the twelve o'clock position and the next adjacent edge of the vane in the direction of rotation 520 of the hub about its axis 500. A second pocket 202 is to the opposite side of the vane from the first volume and from a third pocket 204 between the nearest vane edge approaching the twelve o'clock position.

[0013] In the exemplary FIG. 4 condition, the first volume 200 is fully exposed to the opening 180 (e.g., as viewed in FIG. 4 a seal has just passed the clockwise-most extreme of the opening 180). With further rotation (e.g., see transition to FIG. 5) the volume of this pocket increases to draw in fluid from the suction port. Accordingly, during this stage this pocket may be referred to as a suction volume or suction port. In the FIGS. 4 and 5 example, the second pocket 202 has already received its charge of fluid and it may be compressing that charge. The third pocket 204 may be discharging through the discharge port. Initially, when a pocket is exposed to the discharge port, back pressure from discharge conditions and from any bias on the discharge valve may prevent discharge until sufficient compression has occurred to overcome these forces.

[0014] FIG. 6 shows a condition wherein the vane has just begun to occlude the opening 182 of the discharge port. Once the seal fully equips as the discharge port, there may be some small volume between the seal and the twelve o'clock position wherein fluid will be compressed. This fluid may end up blowing by the seal back to discharge or blowing between the hub and chamber surface to suction conditions. It is thus seen that a given pocket or volume will sequentially transition between being a suction pocket, a compression pocket, and a discharge pocket. However, depending upon context, the term "compression pocket" may be used to indicate any pocket in any of these conditions.

SUMMARY

[0015] One aspect of the disclosure involves a spool compressor comprising a housing having: at least a first inlet port; and at least a first outlet port. A first spool is mounted for rotation of about a first spool axis. A second spool is mounted for rotation about a second spool axis. A first endplate of the first spool has a first plurality of teeth and a first endplate of the second spool has a second plurality of teeth enmeshed with the first plurality of teeth.

[0016] In one or more embodiments of any of the other embodiments, the housing further comprises a first cylinder having a first end and a second end and a second cylinder having a first end and a second end. The first spool has a first hub having an outer surface accommodated within the first cylinder and a slot having a first opening to the first hub outer surface and a second opening to the first hub outer surface. A first vane is accommodated in the slot of the first hub for reciprocal movement relative to the first hub and has a first edge and a second edge both in contact with an inner diameter wall of the first cylinder. Said first endplate of the first spool is at the first cylinder first end and configured to rotate with the first hub as a unit about the first spool axis. A second endplate is at the first cylinder second end and configured to rotate with the first hub as a unit about the first spool axis. The second spool has a second hub having: an outer surface accommodated within the second cylinder and a slot having a first opening to the second rotor hub outer surface and a second opening to the second rotor hub outer surface. A second vane is accommodated in the slot of the second hub for reciprocal movement relative to the second hub and has a first edge and a second edge both in contact with an inner diameter wall of the second cylinder. Said first endplate of the second spool is at the second cylinder first end and configured to rotate with the second hub as a unit about the second spool axis. A second endplate is at the second cylinder second end and configured to rotate with the second hub as a unit about the second spool axis.

[0017] In one or more embodiments of any of the other embodiments, the first vane comprises: a vane body; a first tip seal forming the first edge of the first vane; and a second tip seal forming the second edge of the first vane. The second vane comprises: a vane body; a first tip seal forming the first edge of the second vane; and a second tip seal forming the second edge of the second vane.

[0018] In one or more embodiments of any of the other embodiments, the inner diameter wall of the first cylinder and the inner diameter wall of the second cylinder are differently sized from each other.

[0019] In one or more embodiments of any of the other embodiments, a motor drives the first spool.

[0020] In one or more embodiments of any of the other embodiments, the first cylinder and the second cylinder share a cylinder block.

[0021] In one or more embodiments of any of the other embodiments, the first end of the first cylinder and the first end of the second cylinder are along a common planar first surface and the second end of the first cylinder and the second end of the second cylinder are along a common planar second surface.

[0022] In one or more embodiments of any of the other embodiments, the housing is an inner housing and an outer housing encloses the inner housing and has an inlet port and an outlet port.

[0023] In one or more embodiments of any of the other embodiments, an electric motor is coupled to the first spool by a shaft penetrating the outer housing.

[0024] In one or more embodiments of any of the other embodiments, the outer housing includes an additional port to an interstage chamber.

[0025] In one or more embodiments of any of the other embodiments, the first spool is supported by a bearing of a first end bearing housing and a bearing of a second end bearing housing; and the second spool is supported by a bearing of a first end bearing housing and a bearing of a second end bearing housing.

[0026] In one or more embodiments of any of the other embodiments, the first end bearing housing for the first spool and the second end bearing housing for the first spool are mounted to a cylinder block with common bolts and the first end bearing housing for the second spool and the second end bearing housing for the second spool are mounted to the cylinder block with common bolts.

[0027] In one or more embodiments of any of the other embodiments, a vapor compression system comprises the spool compressor and further comprises: a heat rejection heat exchanger coupled to the outlet port along a flowpath extending from the outlet port and returning to the inlet port; and a heat absorption heat exchanger coupled to the inlet port along the flowpath.

[0028] In one or more embodiments of any of the other embodiments, the flowpath proceeds sequentially through a first stage having the first spool and a second stage having the second spool.

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[0029] In one or more embodiments of any of the other embodiments, the vapor compression system further comprises a branch flowpath between two locations along the flowpath, one of the two locations being an interstage between the first stage and the second stage.

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[0030] In one or more embodiments of any of the other embodiments, the branch flowpath is an economizer flowpath.

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[0031] In one or more embodiments of any of the other embodiments, a method for using the spool compressor comprises driving rotation of the first spool via a motor and driving rotation of the second spool via the first spool.

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[0032] In one or more embodiments of any of the other embodiments, the first spool and the second spool rotate at different speeds from each other.

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[0033] Another aspect of the disclosure involves a method for operating a spool compressor having a first spool and a second spool. The method comprises: driving rotation of the first spool about a first spool axis; and driving rotation of the second spool about a second spool axis via engaged teeth of an endplate of the first spool and an endplate of the second spool.

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[0034] In one or more embodiments of any of the other embodiments, the first spool and the second spool rotate at different speeds from each other.

[0035] The details of one or more embodiments are set forth in the accompanying drawings and the description below. Other features, objects, and advantages will be apparent from the description and drawings, and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0036] FIG. 1 is a view of a prior art baseline spool compressor with outer case shown in broken lines.

5 [0037] FIG. 2 is a partial exploded view of a core compressor of the compressor of FIG. 1.

[0038] FIG. 3 is a partially schematic transverse sectional view of a spool compressor in an instance during a cycle.

10 [0039] FIG. 4 is a partially schematic transverse sectional view of a spool compressor in another instance during the cycle.

[0040] FIG. 5 is a view of the compressor of FIG. 4 in an instance subsequent to FIG. 4.

15 [0041] FIG. 6 is a view of the compressor of FIG. 4 in an instance subsequent to FIG. 5.

[0042] FIG. 7 is a partially schematic/simplified vertical sectional view of a two-stage compressor.

20 [0043] FIG. 8 is a first end view of a core of a two-stage compressor.

[0044] FIG. 9 is a second end view of the core of FIG. 8.

[0045] FIG. 10 is a partial, partially exploded, view of the core of FIG. 8.

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[0046] FIG. 11 is a schematic view of a vapor compression system.

[0047] Like reference numbers and designations in the various drawings indicate like elements.

30

DETAILED DESCRIPTION

[0048] FIG. 7 shows a two-stage spool compressor 220 with respective first 222 and second 224 stages formed as respective core compressors. For ease of illustration, certain features such as screws and ports are shifted relative to corresponding views of FIGS. 8-10.

5 The exemplary two core compressors share a core housing in the form of a single cylinder block 228 having two of the compartments or chambers 64A, 64B (FIG. 10) for forming the cylinders of the respective stages. The exemplary cylinder block has a first face 230 that may be analogized to the FIG. 2 face 60 and a second face 232 which may be analogized to the face 62. On one side of the cylinder block (e.g., along the face 230) the endplates 234A, 234B
10 each have a peripheral array of teeth 236 engaged (enmeshed) with each other. This engagement allows one rotor/spool to be driven by rotation of the other rotor/spool. In the illustrated example, the first stage rotor/spool is driven about axis 500 by a motor 240 to, in turn, drive the second stage rotor/spool about axis 501.

15 **[0049]** In this example, the compressor is an "open" compressor wherein the motor is not exposed to the refrigerant flow. The first stage spool shaft 242 (e.g., the motor shaft or coupled to a motor shaft) penetrates an outer case member 244 of an outer case and is sealed thereto via a shaft seal 246. The exemplary case member 244 is secured at a first side of the cylinder block 228 and a second outer case member 248 is mounted to the second side of the
20 cylinder block. Thus, the cylinder block effectively forms portions of both the inner/core housing or case and the outer housing or case. Thus, in this example, the second stage does not have a shaft penetrating the outer case or otherwise coupled to a rotor.

[0050] FIG. 7 shows the shaft first portion 250 of the second stage supported by bearings 252 of a second stage first end bearing housing 254B. The exemplary first stage includes similar bearings 252 and first end bearing housing 254A. Respective second end bearing housings 256A and 256B are shown with bearings 258. In the illustrated example, second end endplates 260A and 260B are shown unitarily formed with the hubs 262A and 262B. However, they may be separately formed in other implementations. For purposes of
30 illustration, although the eccentric rollers 160 are illustrated, the vanes and slots are not. Nevertheless, such vanes and slots may be as described for the prior art.

[0051] The first end bearing housing 254A and the second end bearing housing 256A of the first stage may be assembled to the cylinder block 228 with common (in-common or shared)

through-screws or bolts that penetrate both the housings 254A and 256A and the cylinder block 228. With this assembly method, the alignment of the spool hub 262A against the chamber 64A is maintained more easily than if the housings 254A and 256A were attached to the cylinder block with separate bolts. Similarly, the housings 254B and 256B may be secured with screws or bolts. In order to perform accurate alignment, the assembly may be performed separately between the first and second stage spools. To accomplish this separate assembly between the first and second stage spools, the bearing housings 254A and 254B may be separate pieces. Also, the bearing housings 256A and 256B may be separate pieces.

[0052] FIG. 7 further shows the housing members 244 and 248 respectively cooperating with the cylinder block to define internal compressor volumes or chambers 270 and 272. In the exemplary implementation, the volume 270 defines an interstage in communication with a port 274. As is discussed further below, this port may be used for functions such as an economizer port.

[0053] The chamber 272 forms a combined discharge chamber and sump with an oil accumulation 276 in a lower portion and a headspace open to the port 32.

[0054] FIG. 8 is a first end view of the core compressor with first stage input shaft cut away. The exemplary working features of the two stages may essentially be structurally mirror images across a plane 530. The term "structural mirror image" contemplates that the two may not be instantaneous mirror images. Rather, the moving parts of the two may be in phase such that they are instantaneous mirror images or they may be out of phase such that the movable parts of one stage at one point in the cycle are a mirror image of the moving parts of the second stage at another point in the cycle.

[0055] The exemplary compressor hubs and the associated ports may be substantially exact mirror images. Nevertheless, other variations may introduce asymmetries associated with differences in expected flow conditions. One asymmetry may involve different port configurations tailored to the anticipated fluid flow. For example, the flow through the discharge or suction port of one stage may be expected to be different from the corresponding flow through the other stage and the configurations of such ports may be correspondingly tailored. In yet a more significant variation, the rotor hubs and/or cylinders may be differently sized for different flows. Thus, the two stages may be scaled mirror images (axially and/or

transversely). In the exemplary embodiment, in order to have a single width between the faces 230 and 232 for both stages, size asymmetry is also associated with a change in aspect ratio. The hub of the smaller stage is thus more elongate than that of the larger stage. Other variations are possible.

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[0056] Similarly, the geared endplates may be differently sized to provide differing speed between the two stages. In the exemplary implementation, the larger stage has a smaller gear so that the larger stage spins faster. Relative speed as well as relative size may be something optimized for a particular use. Although an open compressor is shown, compressors with
10 hermetic or semi-hermetic configurations may be used. Although an outer housing is shown, alternative configurations may, at one or both sides, replace the outer housing with direct or other connections to associated refrigerant flows.

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[0057] FIG. 8 shows the overall compressor suction port or inlet 30 upstream of the first stage suction port 34A and its cylinder opening 180A. The port 30 may be on a fitting or other conduit mounted to a plate 300. FIG. 8 also shows the first stage discharge opening 182A of the port 40A in communication with a discharge chamber 300A in the cylinder block 228 closed by the plate 300. The discharge chamber 300A has a port 310 to the interstage 270 (e.g., open to the face 230). Thus, the first stage discharges to the interstage. Flow discharged
20 from the first stage may merge with any flow introduced through the port 274 and pass through a port 312 to the second stage (e.g., also in the face 230). In alternative embodiments, flows and dimensions may be such that the second stage inlet flow is smaller than the first stage outlet flow so that there is an outflow from the interstage via the port 274.

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[0058] The port 312 is in communication with the second stage suction port 34B and thus the second stage suction opening 180B. The second stage discharge opening 182B of the second stage discharge port 40B then communicates with a second stage discharge chamber 300B. The second stage discharge chamber may be closed by a plate 318 which also closes a second stage suction chamber. The second stage discharge chamber communicates with the
30 overall discharge chamber 272 via a port 320 (e.g., in the face 232).

[0059] FIG. 10 shows discharge valve assemblies 42A and 42B exploded away. For ease of illustration, the rotors/spools, bearings, and their associated mounting features are not shown.

Similarly, mounting features (e.g., screws and holes for the plates 300 and 318) are not shown).

[0060] The compressor may be made with conventional materials and via conventional techniques. Sizing may correspond to existing sizing for multi-stage compressors or for use of two compressors to provide economized operation. Control may similarly be as in existing economized compressors.

[0061] A further variation may involve an intercooled system. In such a situation, flow between the stages exits the compressor and passes through a heat exchanger to be cooled by some external flow of refrigerant or heat transfer fluid. An exemplary implementation of this otherwise similar to the FIG. 7 configuration involves eliminating the port 310 from discharging to the interstage within the housing member 244. Instead, a corresponding port passes externally (e.g., through the plate 300) to pass to the external heat exchanger (intercooler). This refrigerant flow exiting the intercooler passes back to the second stage such as via the ports 274 and 312. Flow then exits the port 320 to the discharge chamber 272 and out the discharge port 32. Such intercooling may be combined with economizing merely via connecting an economizer line/flowpath somewhere between the first stage discharge and second stage suction ports. Such connection might be external (such as a tee fitting in a line upstream or downstream of the intercooler) or internal (such as 274).

[0062] FIG. 11 shows a vapor compression system 900 containing the compressor 220. A main refrigerant flowpath 902 includes a leg formed by a discharge line 904 extending from the compressor outlet or discharge port 32 to the inlet of a heat rejection heat exchanger (e.g., condenser) 906. The exemplary main flowpath 902 proceeds downstream from the outlet of the heat rejection heat exchanger 906 with an economizer branch 908 branching off at a junction 910 to return to the economizer port 274. The main refrigerant flowpath 902 proceeds downstream from the junction 910 to the compressor suction port 30. The main flowpath passes from the junction 910 through an expansion device (e.g., expansion valve) 912 and a heat absorption heat exchanger 914 to a suction line 916. The exemplary heat exchangers 906 and 914 are refrigerant-air heat exchangers with fan-forced airflows. Alternative heat exchangers include refrigerant-water heat exchangers (e.g., in chiller use).

[0063] An exemplary economizer 920 includes an economizer heat exchanger 922 having a first leg 924 along the main flowpath 902 upstream of the expansion device 912 and a second leg 926 in heat exchange with the first leg. The second leg is along the economizer flowpath 908 downstream of an economizer expansion device (e.g., expansion valve) 928. Alternative economizers include flash tank economizers. In economizer operation, refrigerant is bypassed through the economizer line (e.g., via control of valve 928 or an unillustrated on-off valve) 930 passing along the economizer flowpath. The refrigerant flowing along the economizer flowpath is expanded by the expansion device 928 reducing its temperature. The reduced temperature refrigerant in the economizer leg 926 cools refrigerant in the main flowpath leg 924 prior to the expansion of that main flowpath leg refrigerant in the expansion device 912.

[0064] FIG. 11 further shows a controller 950. The controller may receive user inputs from an input device (e.g., switches, keyboard, or the like) and sensors (not shown, e.g., pressure sensors and temperature sensors at various system locations). The controller may be coupled to the sensors and controllable system components (e.g., valves, the bearings, the compressor motor, vane actuators, and the like) via control lines (e.g., hardwired or wireless communication paths). The controller may include one or more: processors; memory (e.g., for storing program information for execution by the processor to perform the operational methods and for storing data used or generated by the program(s)); and hardware interface devices (e.g., ports) for interfacing with input/output devices and controllable system components.

[0065] The use of “first”, “second”, and the like in the description and following claims is for differentiation within the claim only and does not necessarily indicate relative or absolute importance or temporal order. Similarly, the identification in a claim of one element as “first” (or the like) does not preclude such “first” element from identifying an element that is referred to as “second” (or the like) in another claim or in the description.

[0066] Where a measure is given in English units followed by a parenthetical containing SI or other units, the parenthetical’s units are a conversion and should not imply a degree of precision not found in the English units.

[0067] One or more embodiments have been described. Nevertheless, it will be understood that various modifications may be made. For example, when applied to an existing basic

system, details of such configuration or its associated use may influence details of particular implementations. Accordingly, other embodiments are within the scope of the following claims.

CLAIMS

What is claimed is:

1. A spool compressor (220) comprising:
 - 5 a housing (228, 244, 248) comprising:
 - at least a first inlet port (30); and
 - at least a first outlet port (32);
 - a first spool mounted for rotation of about a first spool axis (500); and
 - a second spool mounted for rotation about a second spool axis (501),
- 10 wherein:
 - a first endplate (234A) of the first spool has a first plurality of teeth (236); and
 - a first endplate (234B) of the second spool has a second plurality of teeth (236) enmeshed with the first plurality of teeth.
- 15 2. The spool compressor of claim 1 wherein:
 - the housing further comprises:
 - a first cylinder having a first end and a second end; and
 - a second cylinder having a first end and a second end;
 - the first spool has:
 - 20 a first hub (262A) having:
 - an outer surface accommodated within the first cylinder; and
 - a slot having a first opening to the first hub outer surface and a second opening to the first hub outer surface;
 - a first vane accommodated in the slot of the first hub for reciprocal movement
 - 25 relative to the first hub and having:
 - a first edge and a second edge both in contact with an inner diameter wall of the first cylinder;
 - said first endplate at the first cylinder first end and configured to rotate with the first hub as a unit about the first spool axis; and
 - 30 a second endplate at the first cylinder second end and configured to rotate with the first hub as a unit about the first spool axis; and
 - the second spool has:
 - a second hub (262B) having:
 - an outer surface accommodated within the second cylinder; and

a slot having a first opening to the second rotor hub outer surface and a second opening to the second rotor hub outer surface;
a second vane accommodated in the slot of the second hub for reciprocal movement relative to the second hub and having:

5 a first edge and a second edge both in contact with an inner diameter wall of the second cylinder;
said first endplate at the second cylinder first end and configured to rotate with the second hub as a unit about the second spool axis; and
a second endplate at the second cylinder second end and configured to rotate with
10 the second hub as a unit about the second spool axis.

3. The spool compressor of claim 2 wherein:

the first vane comprises:

a vane body;
15 a first tip seal forming the first edge of the first vane; and
a second tip seal forming the second edge of the first vane; and

the second vane comprises:

a vane body;
a first tip seal forming the first edge of the second vane; and
20 a second tip seal forming the second edge of the second vane.

4. The spool compressor of claim 2 wherein:

the inner diameter wall of the first cylinder and the inner diameter wall of the second cylinder are differently sized from each other.

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5. The spool compressor of claim 2 further comprising:

a motor (240) driving the first spool.

6. The spool compressor of claim 2 wherein:

30 the first cylinder and the second cylinder share a cylinder block (228).

7. The spool compressor of claim 6 wherein:

the first end of the first cylinder and the first end of the second cylinder are along a common planar first surface (230); and

the second end of the first cylinder and the second end of the second cylinder are along a common planar second surface (232).

- 5 8. The spool compressor of claim 1 wherein:
the housing is an inner housing; and
an outer housing encloses the inner housing and has an inlet port and an outlet port.
9. The spool compressor of claim 8 wherein:
10 an electric motor (240) is coupled to the first spool by a shaft (242) penetrating the outer housing.
10. The spool compressor of claim 8 wherein:
the outer housing includes an additional port (274) to an interstage chamber (270).
- 15 11. The spool compressor of claim 1 wherein:
the first spool is supported by a bearing of a first end bearing housing (254A) and a
bearing of a second end bearing housing (256A); and
the second spool is supported by a bearing of a first end bearing housing (254B) and a
20 bearing of a second end bearing housing (256B).
12. The spool compressor of claim 11 wherein:
the first end bearing housing (254A) for the first spool and the second end bearing
housing (256A) for the first spool are mounted to a cylinder block with common
25 bolts; and
the first end bearing housing (254B) for the second spool and the second end bearing
housing (256B) for the second spool are mounted to the cylinder block with common
bolts.
- 30 13. A vapor compression system (900) comprising the spool compressor of claim 1 and
further comprising:
a heat rejection heat exchanger (906) coupled to the outlet port along a flowpath (902)
extending from the outlet port and returning to the inlet port; and
a heat absorption heat exchanger (914) coupled to the inlet port along the flowpath.

14. The vapor compression system of claim 13 wherein:
the flowpath proceeds sequentially through a first stage (222) having the first spool and a
second stage (224) having the second spool.

5

15. The vapor compression system of claim 14 further comprising:
a branch flowpath (908) between two locations along the flowpath, one of the two
locations being an interstage (270) between the first stage and the second stage.

- 10 16. The vapor compression system of claim 15 wherein:
the branch flowpath is an economizer flowpath.

17. A method for using the spool compressor of claim 1, the method comprising:
driving rotation of the first spool via a motor (240); and
15 driving rotation of the second spool via the first spool.

18. The method of claim 17 wherein:
the first spool and the second spool rotate at different speeds from each other.

- 20 19. A method for operating a spool compressor (220) having a first spool and a second
spool, the method comprising:
driving rotation of the first spool about a first spool axis (500); and
driving rotation of the second spool about a second spool axis (501) via engaged teeth
(236) of an endplate (234A) of the first spool and an endplate (234B) of the second
25 spool.

20. The method of claim 19 wherein:
the first spool and the second spool rotate at different speeds from each other.

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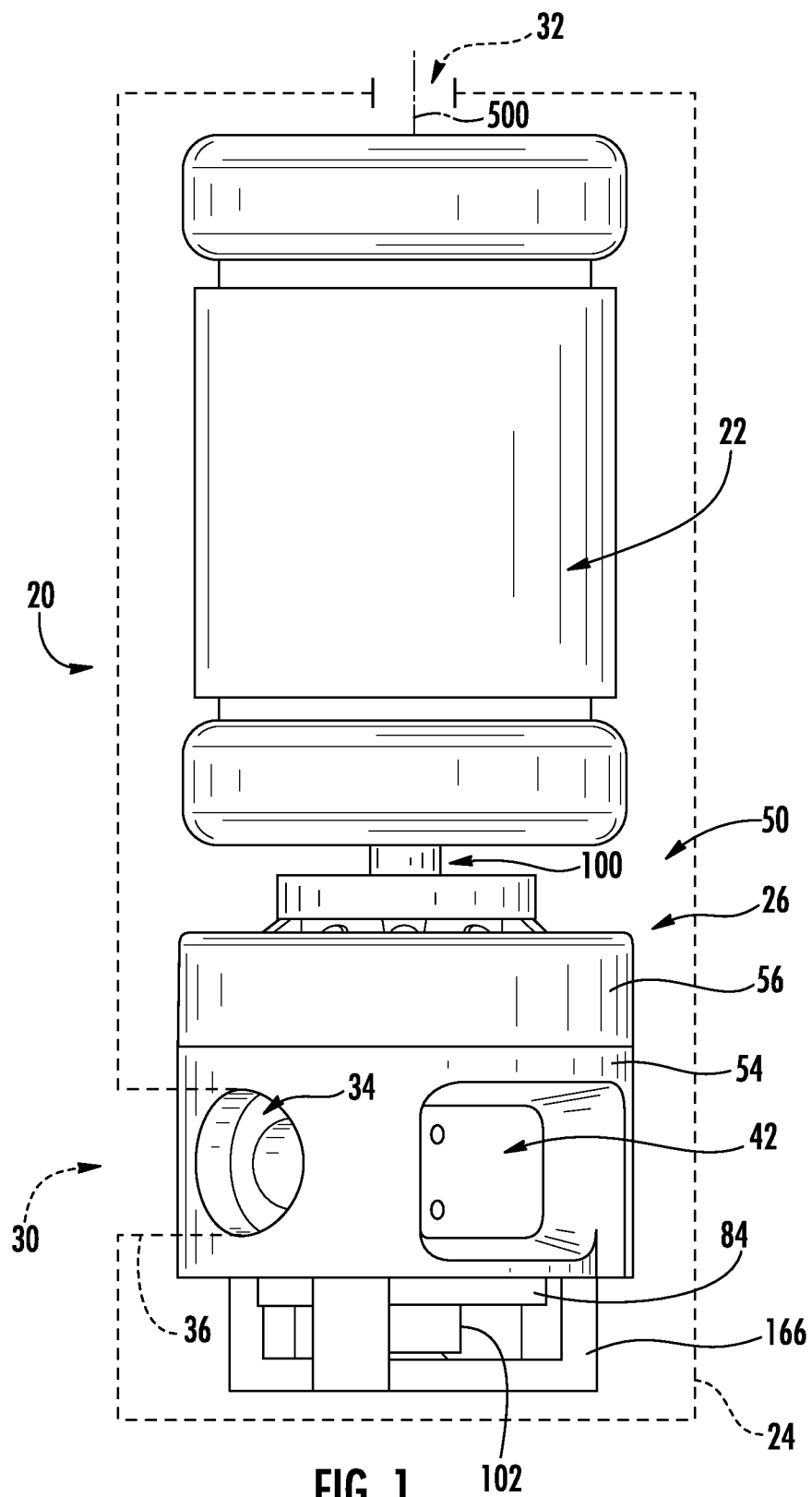
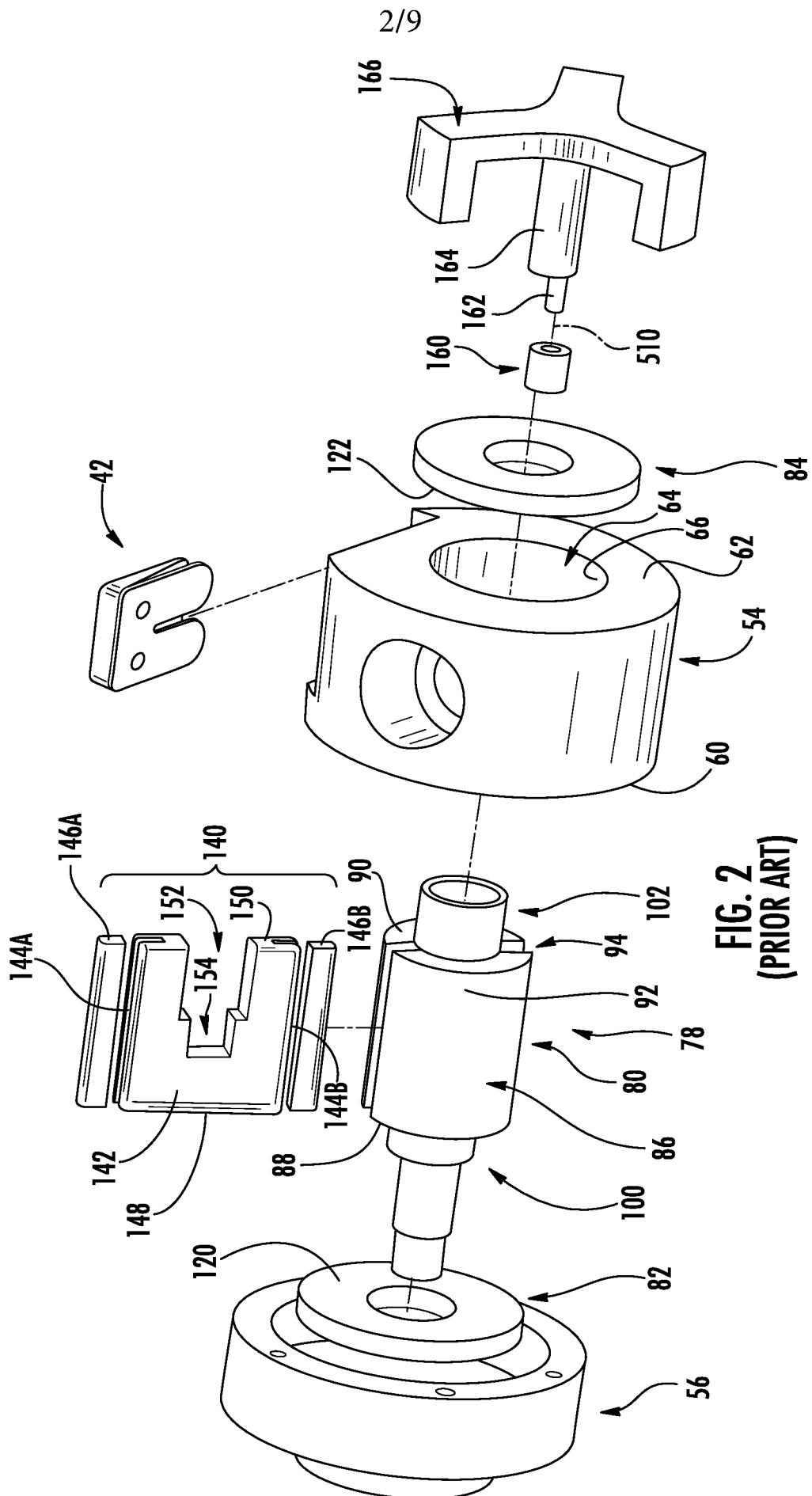


FIG. 1
(PRIOR ART)



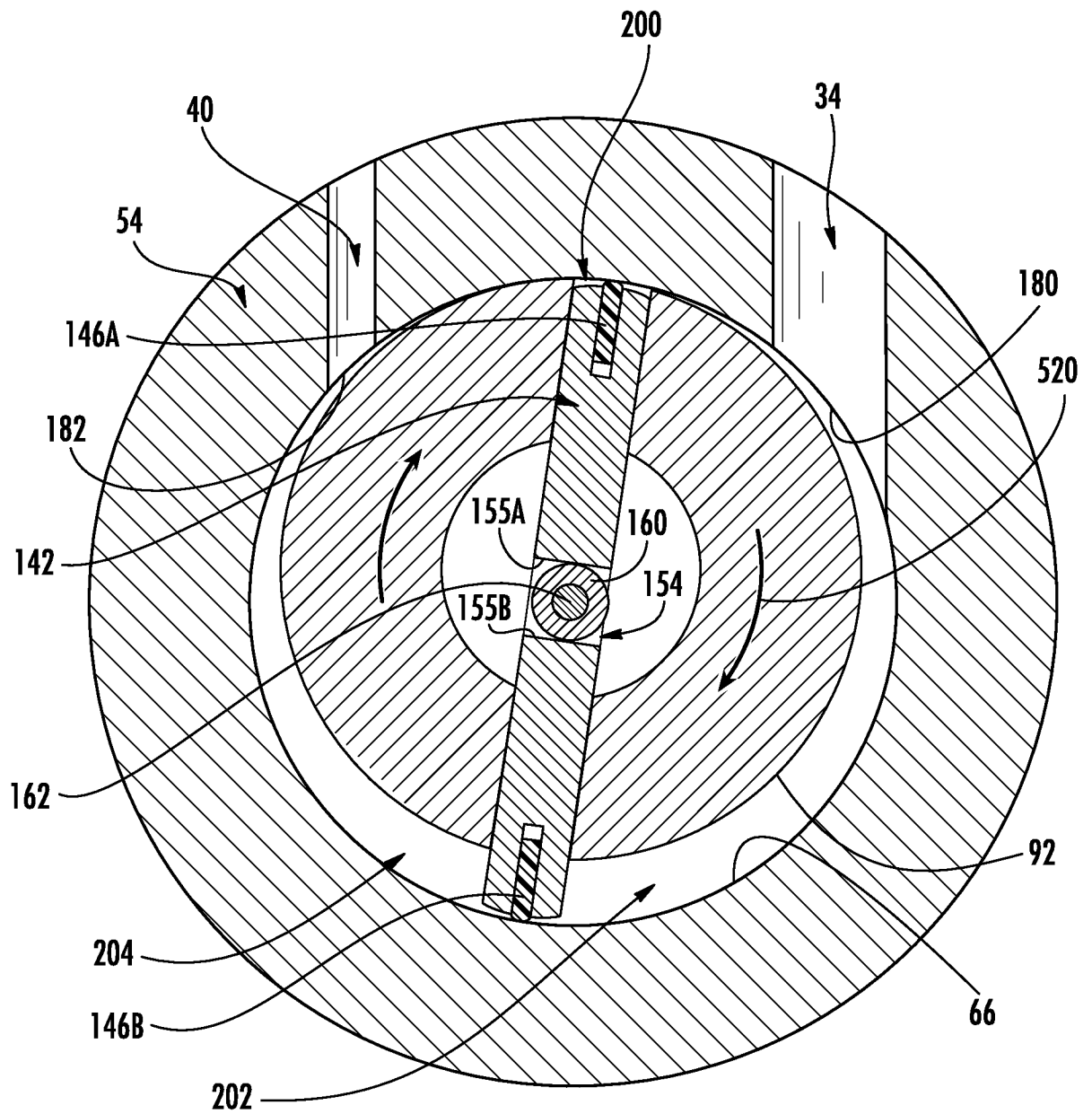


FIG. 3
(PRIOR ART)

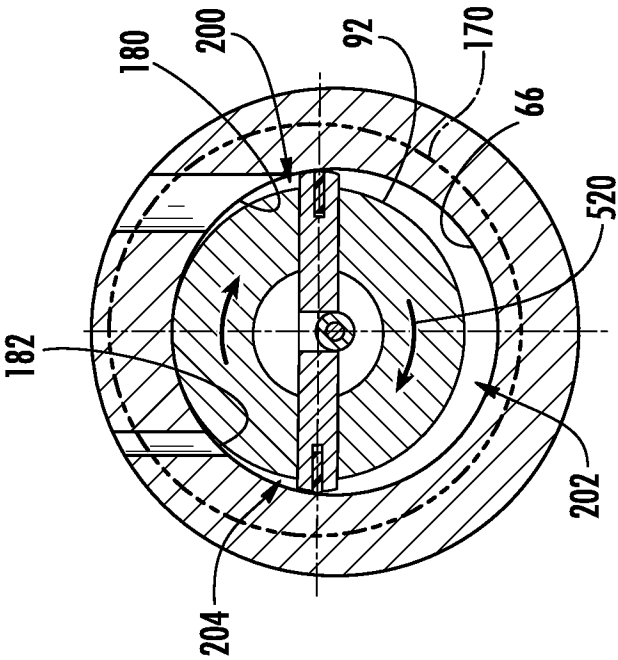


FIG. 4
(PRIOR ART)

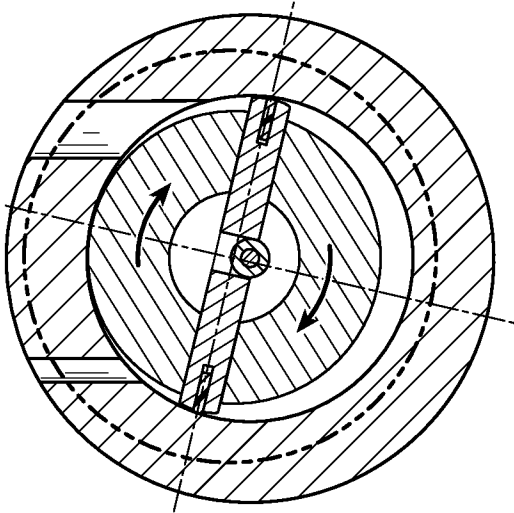


FIG. 5
(PRIOR ART)

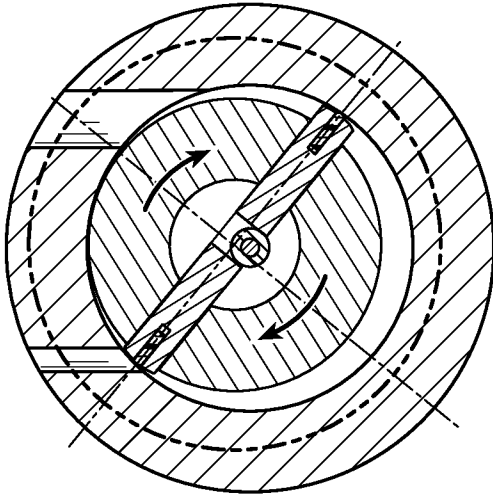
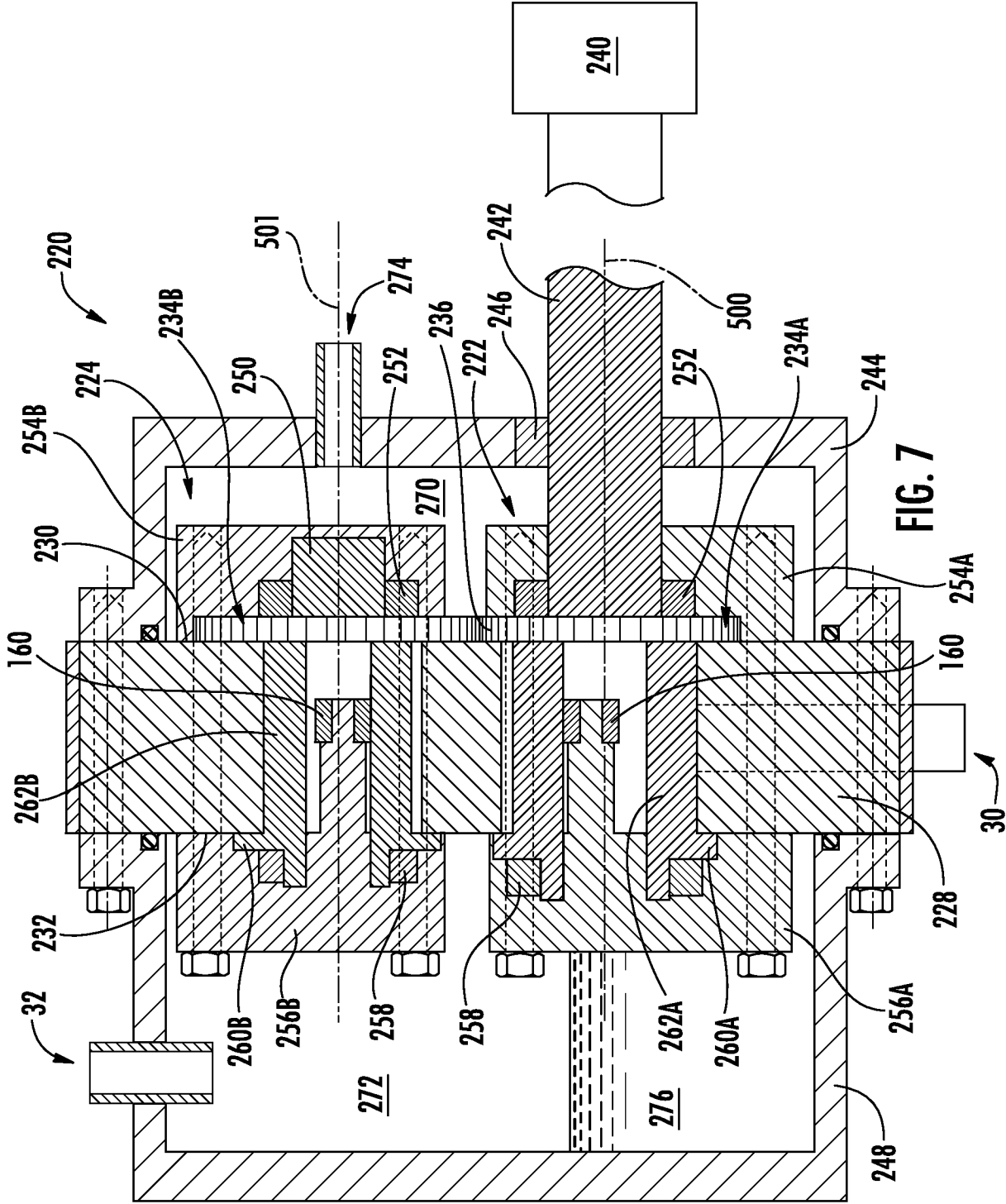
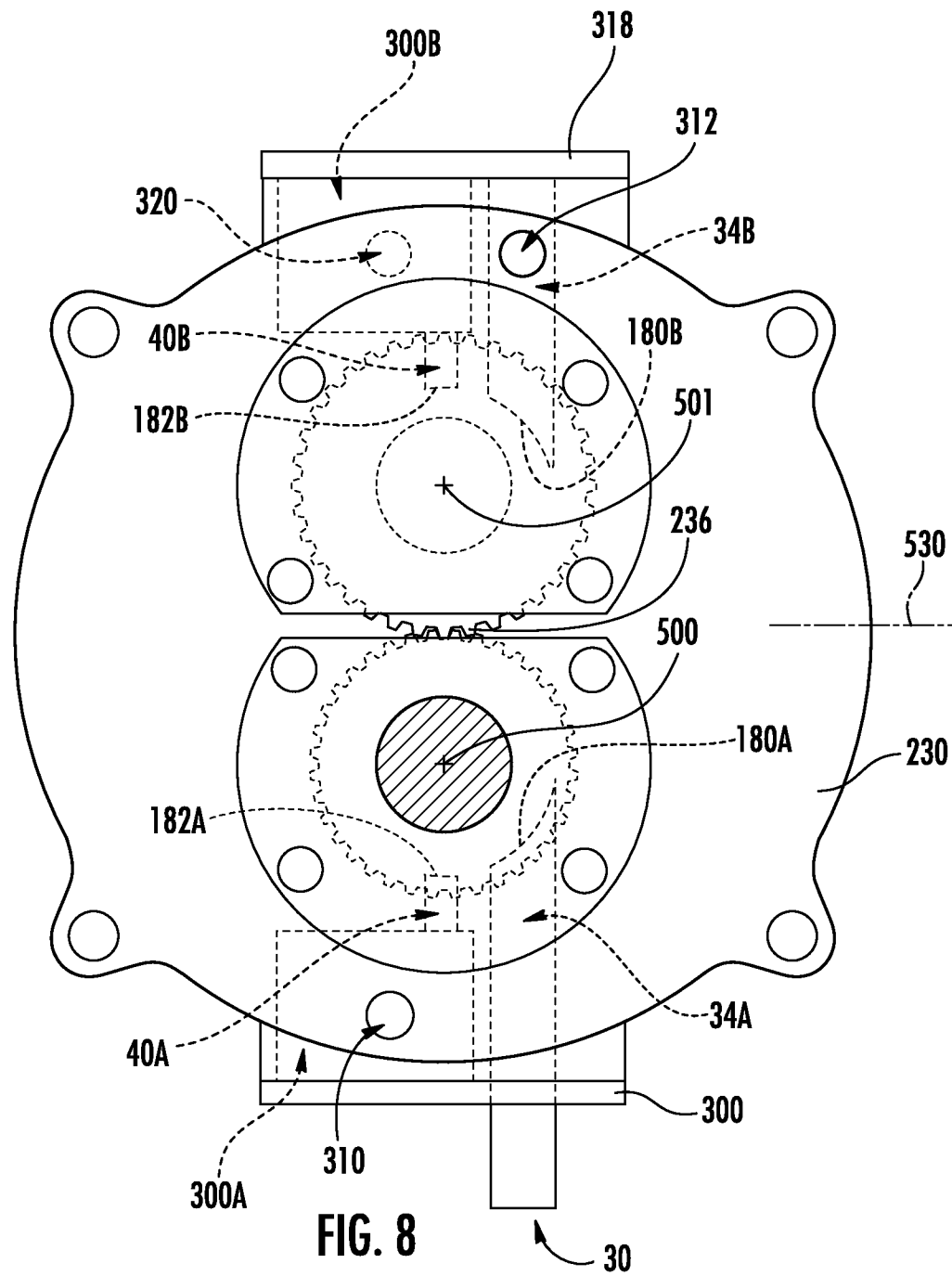
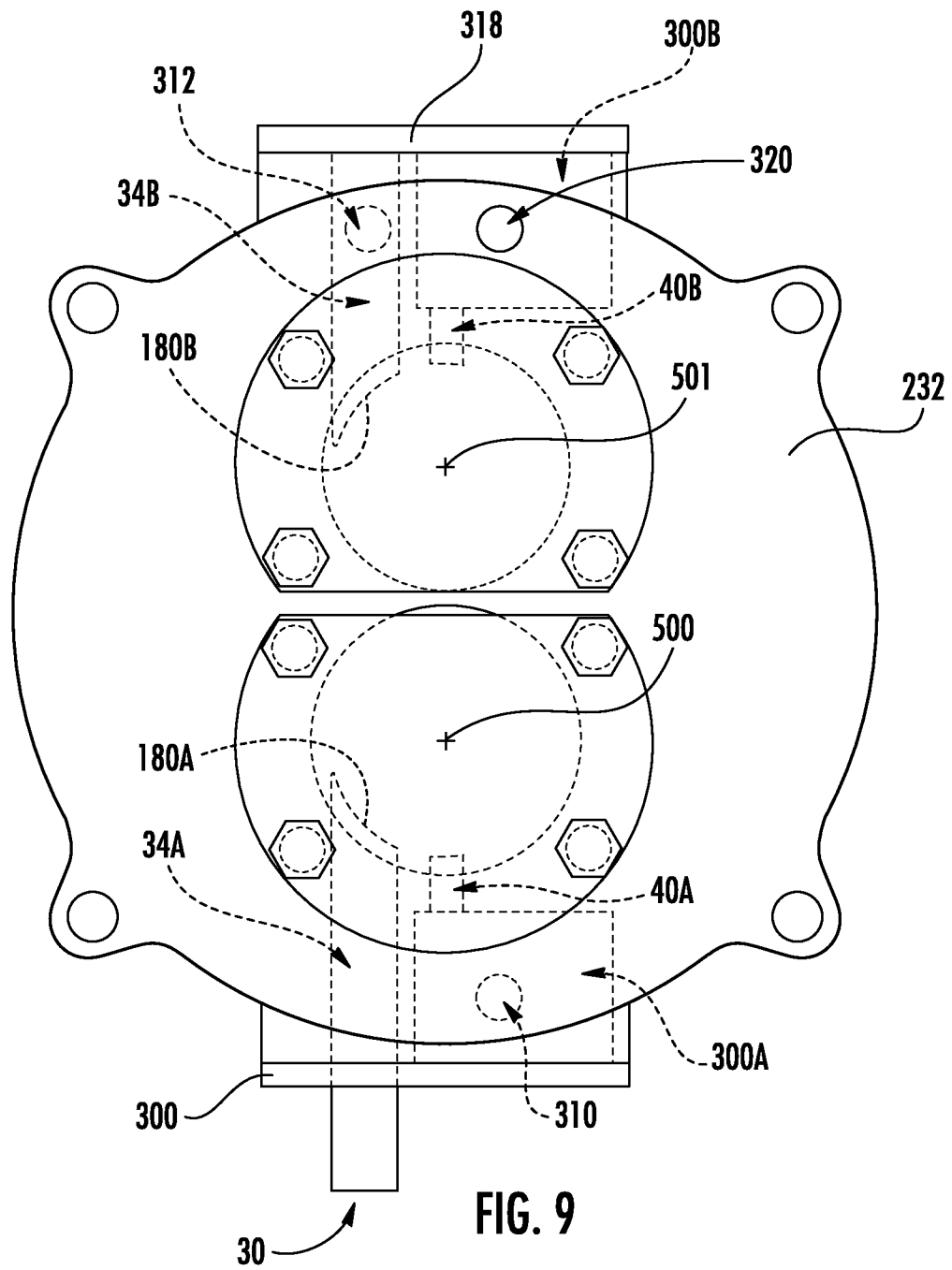


FIG. 6
(PRIOR ART)





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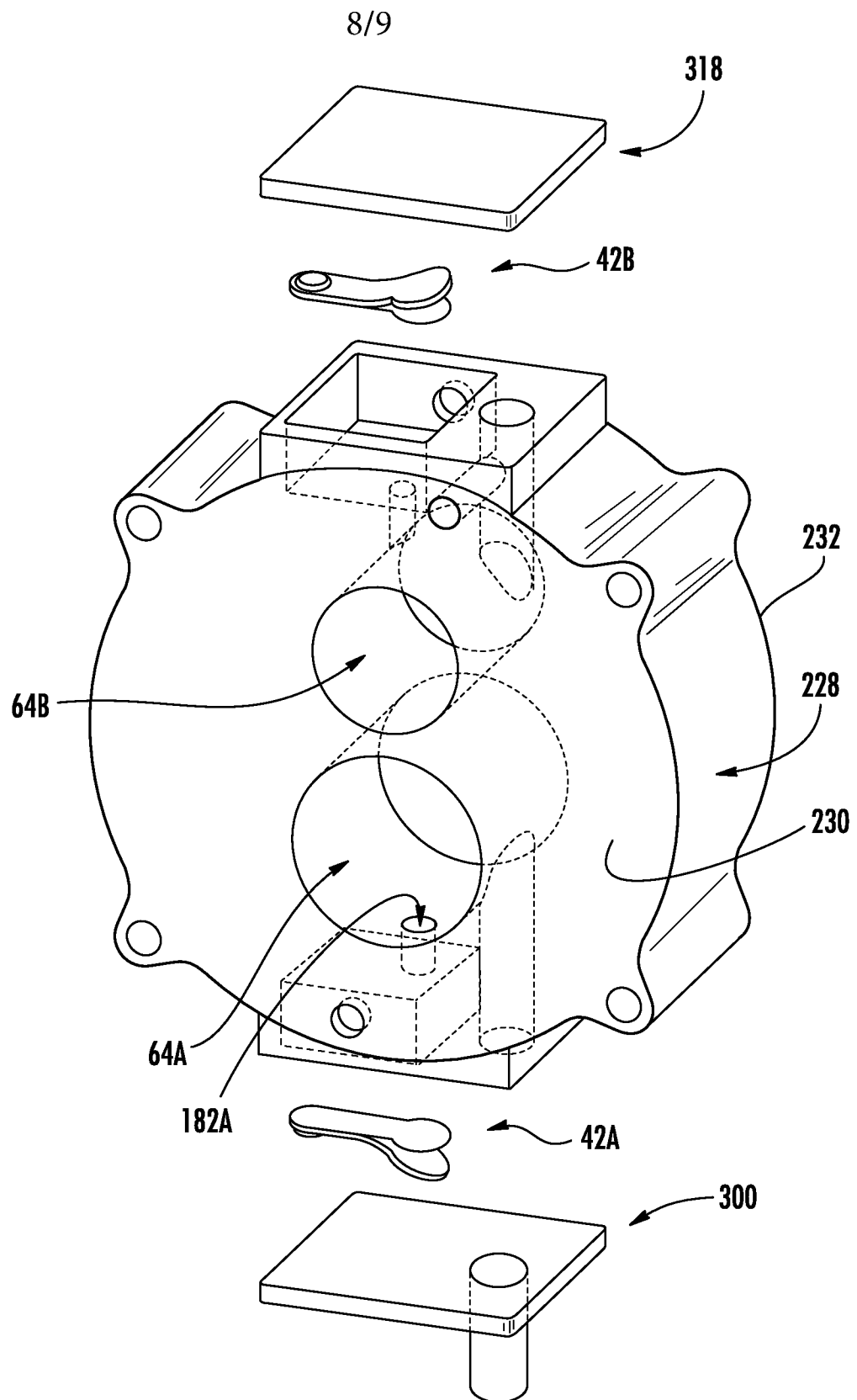


FIG. 10

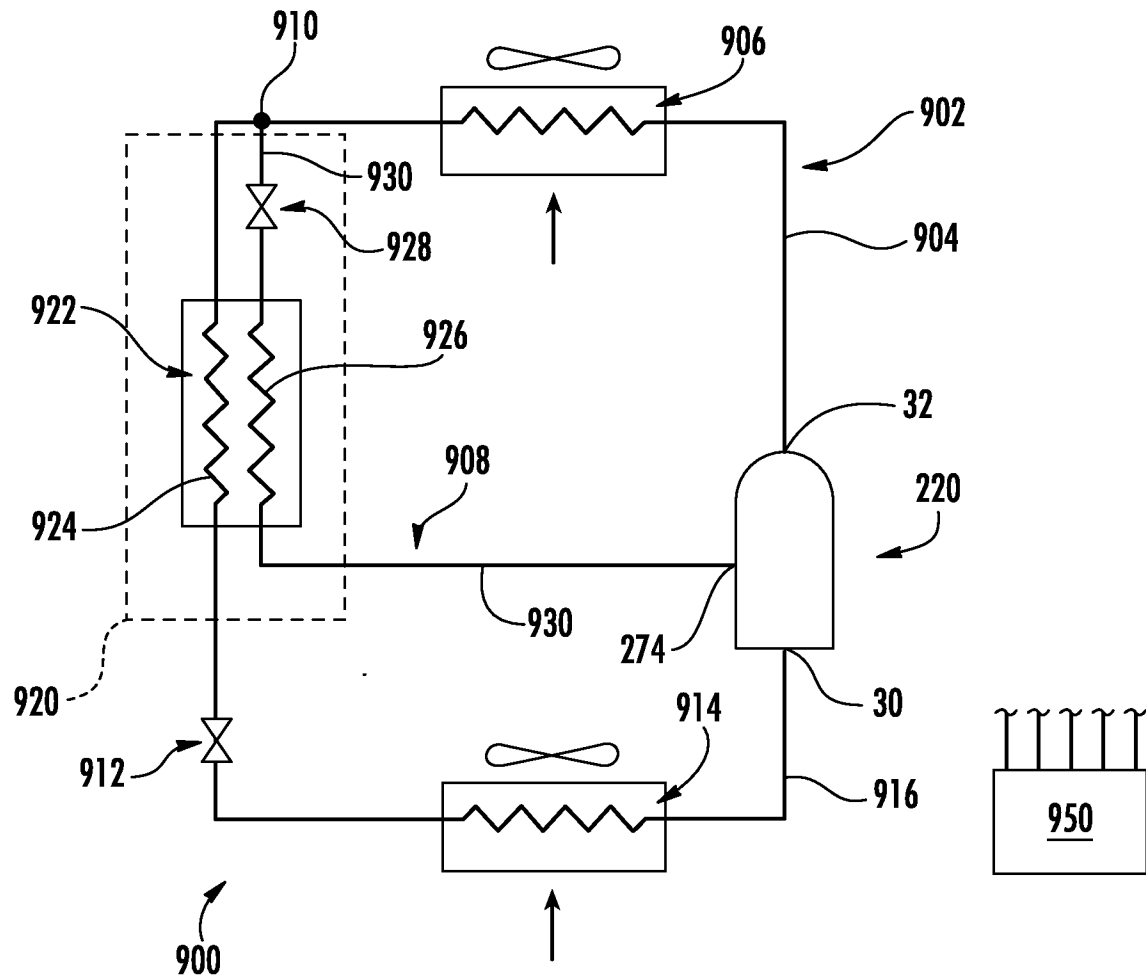


FIG. 11

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/026411

A. CLASSIFICATION OF SUBJECT MATTER

INV. F04C23/00 F04C29/00 F04C18/344 F01C21/08
ADD. F01C21/10

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)
F04C F01C

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FR 1 305 485 A (ALSACIENNE D ELECTRONIQUE ET D) 5 October 1962 (1962-10-05) page 2, left-hand column, line 5 - line 23 page 2, left-hand column, line 40 - right-hand column, line 20 figures 1,2 -----	1-20
A	WO 2013/131004 A1 (TORAD ENGINEERING LLC [US]) 6 September 2013 (2013-09-06) paragraph [0095] - paragraph [0106] figures 1-12 -----	1-20
A	CN 203 432 134 U (GUANGDONG CHANGLING AIR CONDITIONER AIR CONDITIONER MFG CO LTD) 12 February 2014 (2014-02-12) abstract; figure ----- -/-	13-16



Further documents are listed in the continuation of Box C.



See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search

10 June 2016

Date of mailing of the international search report

21/06/2016

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Bocage, Stéphane

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2016/026411

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Information on patent family members

International application No

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