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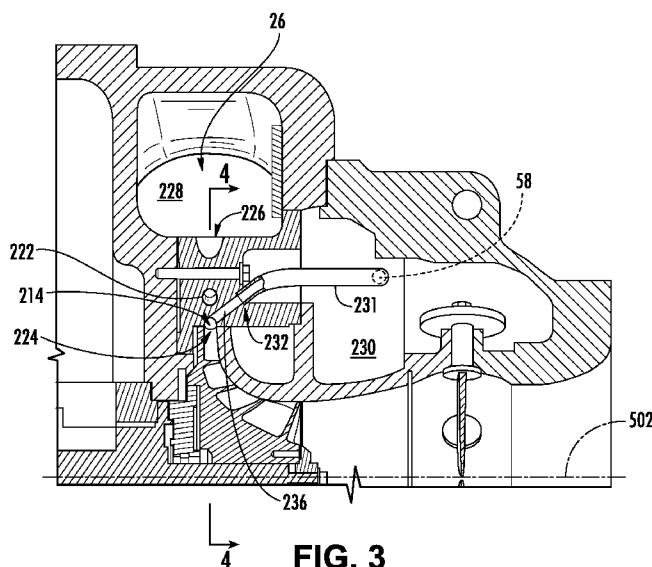
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(54) Title: ECONOMIZED CENTRIFUGAL COMPRESSOR



(57) Abstract: A compressor (22; 260; 300; 400) has a housing assembly (140) with a suction port (24), a discharge port (26), and an economizer port (58). An impeller (154) is mounted to be driven in at least a first condition so as to draw a main flow of fluid through the suction port and discharge the fluid from the discharge port. A diffuser (220; 302; 402) has a plurality of diffuser passages (222; 310, 308; 403). Each diffuser passage has an inlet (224) positioned to receive fluid from the impeller and an outlet (220) downstream of the inlet in the first condition. One or more passages (230, 231, 232, 234, 236, 268; 320, 330, 332; 412) are positioned to draw an economizer flow of fluid from the economizer port and deliver the economizer flow downstream of the impeller inlet (212) but upstream of the diffuser passage outlets (226).

ECONOMIZED CENTRIFUGAL COMPRESSOR

CROSS-REFERENCE TO RELATED APPLICATION

[0001] Benefit is claimed of US Patent Application Ser. No. 61/492,109, filed June 1, 2011,
5 and entitled "Economized Centrifugal 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 compressors. More particularly, the disclosure relates to
10 electric motor-driven hermetic or semi-hermetic compressors.

[0003] One particular use of electric motor-driven compressors is liquid chillers. An
exemplary liquid chiller uses a hermetic centrifugal compressor. The exemplary unit comprises a
standalone combination of the compressor, the cooler unit, the chiller unit, the expansion device,
and various additional components. The exemplary compressor includes a transmission
15 intervening between the motor rotor and the impeller to drive the impeller at a faster speed than
the motor.

[0004] Chiller centrifugal compressors include both two-stage models and single-stage
models. US5145317, US5445496, US6547520, and US6814540, disclose single stage models.
The interstage of a two-stage model may be communicated with an economizer port. An
20 economized single stage compressor has been proposed wherein refrigerant is injected along the
impeller.

SUMMARY

[0005] One aspect of the disclosure involves a compressor having a housing assembly with a
25 suction port, a discharge port, and an economizer port. An impeller is mounted to be driven in at
least a first condition so as to draw a main flow of fluid through the suction port and discharge
the fluid from the discharge port. A diffuser has a plurality of diffuser passages. Each diffuser
passage has an inlet positioned to receive fluid from the impeller and an outlet downstream of the
inlet in the first condition. One or more passages are positioned to draw an economizer flow of
30 fluid from the economizer port and deliver the economizer flow downstream of the impeller inlet
but upstream of the diffuser passage outlets.

[0006] 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.

5

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. 1 is a partially schematic view of a chiller system.

[0008] FIG. 2 is a longitudinal sectional view of a compressor of the chiller system.

[0009] FIG. 3 is an enlarged view of an upstream region of the compressor of FIG. 2.

10 [0010] FIG. 4 is a partial transverse cutaway view of a diffuser of the compressor of FIG. 3, taken along line 4-4.

[0011] FIG. 5 is an enlarged longitudinal sectional view of an upstream region of an alternate compressor.

[0012] FIG. 6 is a longitudinal sectional view of an alternative compressor of the chiller system.

15 [0013] FIG. 7 is a partial enlarged view of an upstream region of the compressor of FIG. 6.

[0014] FIG. 8 is a pressure-enthalpy diagram for the compressor of FIG. 2.

[0015] FIG. 9 is an enlarged longitudinal sectional view of an upstream region of an alternate compressor.

20 [0016] Like reference numbers and designations in the various drawings indicate like elements.

DETAILED DESCRIPTION

[0017] FIG. 1 shows a vapor compression system 20. The exemplary vapor compression system 20 is a chiller system. The system 20 includes a compressor 22 having a suction port (inlet) 24 and a discharge port (outlet) 26. The system further includes a first heat exchanger 28 in a normal operating mode being a heat rejection heat exchanger (e.g., a gas cooler or condenser). In an exemplary system based upon an existing chiller, the heat exchanger 28 is a refrigerant-water heat exchanger in a condenser unit 29 where the refrigerant is cooled by a water (or other heat transfer fluid) flow from an external source (not shown).

[0018] The system further includes a second heat exchanger 30 (in the normal mode a heat absorption heat exchanger or evaporator). In the exemplary system, the heat exchanger 30 is a refrigerant-water heat exchanger for chilling a chilled water flow within a chiller (or cooler) unit 31. An expansion device 32 is downstream of the heat rejection heat exchanger and upstream of the heat absorption heat exchanger along the normal mode refrigerant flowpath 34 (the flowpath being partially surrounded by associated piping, etc.). The exemplary expansion device 32 is formed by a distributor of the cooler unit 31.

[0019] A flash tank economizer 40 is located along the flowpath 34 between a refrigerant outlet 42 of the condenser and a refrigerant inlet 44 of the cooler. The economizer has a primary refrigerant inlet 46, a primary refrigerant outlet 48, and a secondary refrigerant outlet 50. In normal operation, a liquid refrigerant accumulation is maintained in the tank 52 via a float valve 54 controlling flow through the outlet 48. An economizer flowpath branch 56 extends from the secondary outlet 50 to an economizer port 58 of the compressor.

[0020] FIG. 1 further shows a refrigerant inlet 60 of the condenser, a refrigerant outlet 62 of the cooler, and a float valve 64 of the condenser controlling flow through the outlet 42. FIG. 1 further shows conduits/flowpaths for various equipment cooling functions. For example, an equipment cooling flowpath/branch 80 branches off from the main flowpath 34 at the float valve sump, upstream of the float valve. The flowpath 80 further branches into three branches or sub-branches 82, 84, and 86. The exemplary branch 82 passes through an oil cooler 90 to cool compressor oil from a reservoir (not shown) located in compressor 22. The branch 84 passes through a cold plate 92 of a variable frequency drive (VFD; not shown) of the compressor motor. The branches 84 and 82 merge into a branch 83 which enters a secondary inlet 94 of the economizer. The branch 86 passes to a motor compartment inlet 100 of the compressor housing

and cools the motor, thereafter exiting a motor compartment outlet 102 and entering a secondary inlet 104 of the cooler downstream of the distributor.

[0021] FIG. 1 further shows various isolation and/or control valves. These include: a compressor discharge isolation valve 120 in the compressor discharge line along the flowpath 34 between the discharge port/outlet 26 and the condenser inlet 60; a condenser isolation valve 122 along the flowpath 34 downstream of the condenser outlet 42 and upstream of the economizer inlet 46; a cooler isolation valve 124 along the flowpath 34 downstream of the economizer outlet 48 and upstream of the cooler inlet 44; an economizer isolation valve 126 along the branch 56 between the economizer secondary outlet 50 and the compressor economizer port 58; a valve in the branch 86; a cooling isolation valve 128 in the branch 80 (capable of interrupting flow through all three branches 82, 84, and 86); and an oil/VFD cooler isolation valve 130 in the branch 83 and a valve 131 in the branch 86 for isolating the oil cooler 90 and cold plate 92.

[0022] FIG. 1 further shows a controller 132 (e.g., a microprocessor-based controller or other such controller) coupled to the various sensors, user input devices, and controllable system components to control operation in accordance with pre-programmed methods.

[0023] FIG. 1 further shows a main tube bundle 140 and sub-cooler tube bundle 142 of the heat rejection heat exchanger which carry heat transfer fluid (e.g., environmental water or water to be heated for use). FIG. 1 further shows a tube bundle 144 of the heat absorption heat exchanger (e.g., carrying water, brine, or other heat transfer fluid to be chilled).

[0024] An exemplary compressor (FIG. 2) is a centrifugal compressor having a housing assembly (housing) 150. The housing assembly contains an electric motor 152 and an impeller 144 drivable by the electric motor in the first mode to draw fluid (refrigerant) in through the suction port 24, compress the fluid, and discharge the fluid from the discharge port. The exemplary impeller is driven indirectly by the motor via a transmission 156.

[0025] The housing defines a motor compartment 160 containing a stator 162 of the motor within the compartment. A rotor 164 of the motor is partially within the stator and is mounted for rotation about a rotor axis 500. The exemplary mounting is via one or more bearing systems 166, mounting a shaft 170 of the rotor to the housing assembly. The exemplary impeller 154 is mounted to its own shaft 172 to rotate about an axis 502. An exemplary bearing system 174 mounts an intermediate portion of the shaft 172 to an intermediate wall 178 of the housing assembly.

[0026] FIG. 2 further shows the compressor inlet 24 and outlet 26. The inlet 24 is at the upstream end of a suction housing member 200 of the housing assembly. The suction housing member carries a circumferential array of inlet guide vanes 202 which may be articulated (e.g., rotated about respective axes via an actuator not shown) to control the inlet (suction) flow. The flowpath extends downstream to the upstream end or tip 204 of the impeller 154. The impeller has a generally downstream outwardly flaring body 206 bearing blades 208. The blade tips fall along a shroud 210 of the housing assembly extending downstream from the suction housing 200. The impeller and shroud thus define a generally axial inlet 212 and a radial outlet 214.

[0027] The outlet 214 of the impeller is surrounded by a diffuser 220. The diffuser has a circumferential array of passageways 222 extending from inlets 224 to outlets 226. Each passageway is a partial tangential orientation and has a cross-sectional area increasing from upstream/inboard to downstream/outboard. The outlets are along a discharge plenum 228.

[0028] FIG. 3 further shows the economizer port 58. The exemplary port 58 is along a suction housing chamber 230 radially outboard of an upstream portion of the shroud. The economizer flowpath thus passes through a conduit (e.g., tube) 231 within this chamber and through a port 232 in the diffuser. The economizer flowpath then passes through one or more bores 236 to intersect with the diffuser passageways 222. An exemplary intersection is just downstream of the inlets 224. FIG. 4 further shows the intersection 240 of the bores 236 and the passageways. There may be plural such ports and/or conduits (e.g., a circumferential array fed by branches of the conduit 231) sufficient to provide a desired flow rate and distribution. For example, a sufficient number of bores 236 of sufficient diameter may be provided to accommodate a target range of economizer flow. This may involve bores 236 intersecting anywhere between one and all of the diffuser passageways. The port 58, chamber conduit 231, and bores 236 thus define the one or more passages positioned to draw the economizer flow from the economizer port and deliver the economizer flow downstream of the impeller inlet but upstream of the diffuser passage outlets. In this example, the economizer flow is delivered downstream of the impeller outlets, more particularly, at or slightly downstream of the diffuser passageway inlets.

[0029] FIG. 5 shows an alternate compressor 260 wherein, rather than penetrating the diffuser, the economizer flowpath extends to a gap 262 between the diffuser and the impeller. The flowpath may further pass through a gap 264 between the impeller shroud and the diffuser. To do this, the exemplary economizer flowpath passes through a mounting flange 266 of the

shroud extending radially outward and mating with the diffuser. The exemplary economizer flowpath is defined by one or more conduits 268 or branches thereof extending from the economizer port 58 to one or more associated apertures 270 in the flange. The economizer flowpath and main/primary flowpath may thus merge at the intersection/gap 262.

5 **[0030]** FIG. 6 shows an alternate compressor 300 having a variable diffuser 302. The diffuser 302 comprises a fixed outer member (outer diffuser ring) 304 and a movable inner member (inner diffuser ring) 306 (e.g., rotatable about the axis 502). The inner diffuser ring may be rotated relative to the outer diffuser ring so as to bring inboard/upstream portions 308 (FIG. 7) of the passageways (in the inner diffuser ring) into and out of registration with
10 outboard/downstream portions 310 (in the outer diffuser ring) to effectively throttle and unthrottle the passageways. The exemplary economizer passage and flowpath pass from the economizer port 58 through a conduit 320 (the conduit 320 passing through the suction housing chamber 230). A downstream end of the conduit 320 is mounted in a bore 321 in an outboard flange 322 of the shroud. As the embodiment above, there may be multiple such conduits 320 or
15 branches thereof and multiple such bores to provide a desired economizer flow. After exiting the bores 320, the economizer flowpath passes into a shroud chamber 330 along an outboard surface of a downstream portion of the shroud and inboard of an inner/ID surface of the inner diffuser ring. There may be a small radial clearance 332 between the shroud and the diffuser ring through which the economizer flowpath may pass to merge with the main flowpath at the interface of the
20 impeller and diffuser ring.

[0031] FIG. 8 is a pressure-enthalpy diagram for the system of FIG. 1.

[0032] The exact location of the intersection of the economizer flowpath and the main flowpath may be chosen based upon anticipated system conditions. As noted above, a convenient location is exactly between the impeller outlet and diffuser inlet. However, locations more
25 downstream within the diffuser are possible (e.g., between 0% and 70% of a length from the diffuser inlet to the diffuser outlet, more narrowly, 0-50% or 10-50%).

[0033] Although shown implemented in the context of pipe diffusers, such economizer flow introduction may be similarly implemented to vaned diffusers. Additionally, such economizer introduction may be applied to vaneless diffusers. FIG. 9 shows a compressor 400 having a
30 vaneless diffuser 402 having an annular passageway 403. The passageway 403 has an inboard inlet 404 and an outboard outlet 406 to a discharge plenum 408. The economizer conduit has an

outlet 410 of the economizer conduit 412 along the diffuser intermediate the inlet 404 and outlet 406 (but, in the exemplary embodiment, much closer to the inlet 404).

[0034] Although an embodiment is described above in detail, such description is not intended for limiting the scope of the present disclosure. It will be understood that various
5 modifications may be made without departing from the spirit and scope of the disclosure. For example, when applied to the reengineering of an existing compressor or a compressor in an existing application, details of the existing compressor or application may influence details of any particular implementation. Accordingly, other embodiments are within the scope of the following claims.

CLAIMS

What is claimed is:

1. A centrifugal compressor (22; 260; 300; 400) comprising:
a housing assembly (140) having a suction port (24), a discharge port (26), and an
5 economizer port (58);
an impeller (154) mounted to be driven in at least a first condition so as to draw a main
flow of fluid in through the suction port and discharge said fluid out from the discharge port;
a diffuser (220; 302; 402) having one or more diffuser passages (222; 310, 308; 403),
each having an inlet (224) positioned to receive fluid from the impeller and an outlet (220)
10 downstream of the inlet in the first condition; and
one or more passages (230, 231, 232, 234, 236; 268, 320, 330, 332; 412) positioned to
draw an economizer flow of fluid from the economizer port and deliver the economizer flow
downstream of the impeller inlet (212) but upstream of the diffuser passage outlets (226).
- 15 2. The compressor of claim 1 further comprising:
an electric motor (152) having:
a stator (162) within a motor compartment of the case; and
a rotor (164) within the stator, the rotor being mounted for rotation about a rotor
axis (500).
- 20 3. The compressor of claim 1 wherein:
the one or more passages are positioned to deliver said economizer flow of fluid
downstream of the impeller outlet but upstream of the diffuser passage outlets.
- 25 4. The compressor of claim 1 wherein:
the one or more passages are positioned to deliver said economizer flow of fluid between
the impeller and the diffuser passage inlets.
5. The compressor of claim 1 wherein:
30 the compressor is a single-stage compressor.
6. The compressor of claim 1 wherein:

the one or more passages are further positioned to pass said economizer flow of fluid through a chamber along an outboard portion of an impeller shroud.

7. A vapor compression system comprising:

the compressor of claim 1;

a first heat exchanger (28) coupled to the discharge port to receive refrigerant driven in a downstream direction in the first operational condition of the compressor;

an expansion device (32) downstream of the first heat exchanger;

a second heat exchanger (30) downstream of the expansion device and coupled to the suction port to return refrigerant in the first operating condition; and

wherein an economizer flowpath branches off between the first heat exchanger and the expansion device and passes through the economizer port.

8. The system of claim 7 wherein the economizer flowpath passes:

through an economizer expansion device; and then through a leg of an economizer heat exchanger, the leg in heat transfer relation with another leg upstream of the expansion device along the main flowpath.

9. The system of claim 8 wherein:

the first heat exchanger is a heat rejection heat exchanger; and

the second heat exchanger is a heat absorption heat exchanger.

10. A method for operating the compressor of claim 1 comprising:

driving the motor to draw the main flow of fluid in through the suction port and discharge the fluid from the discharge port;

drawing the economizer flow of fluid through the one or more passages; and

passing the economizer flow of fluid through the diffuser to merge with the main flow of fluid.

11. The method of claim 10 wherein:

the compressor is used in a vapor compression system having a heat rejection heat exchanger, an expansion device, and a heat absorption heat exchanger,

wherein:

the main flow of fluid is drawn through the suction port from the heat absorption heat exchanger;

5 the discharge flow of fluid is discharged from the discharge port to the heat rejection heat exchanger;

fluid from the heat rejection heat exchanger is expanded in the expansion device;

fluid expanded in the expansion device is delivered to the heat absorption heat exchanger;

and

10 a portion of the fluid delivered to the heat rejection heat exchanger bypasses the heat absorption heat exchanger and passes as said economizer flow of fluid.

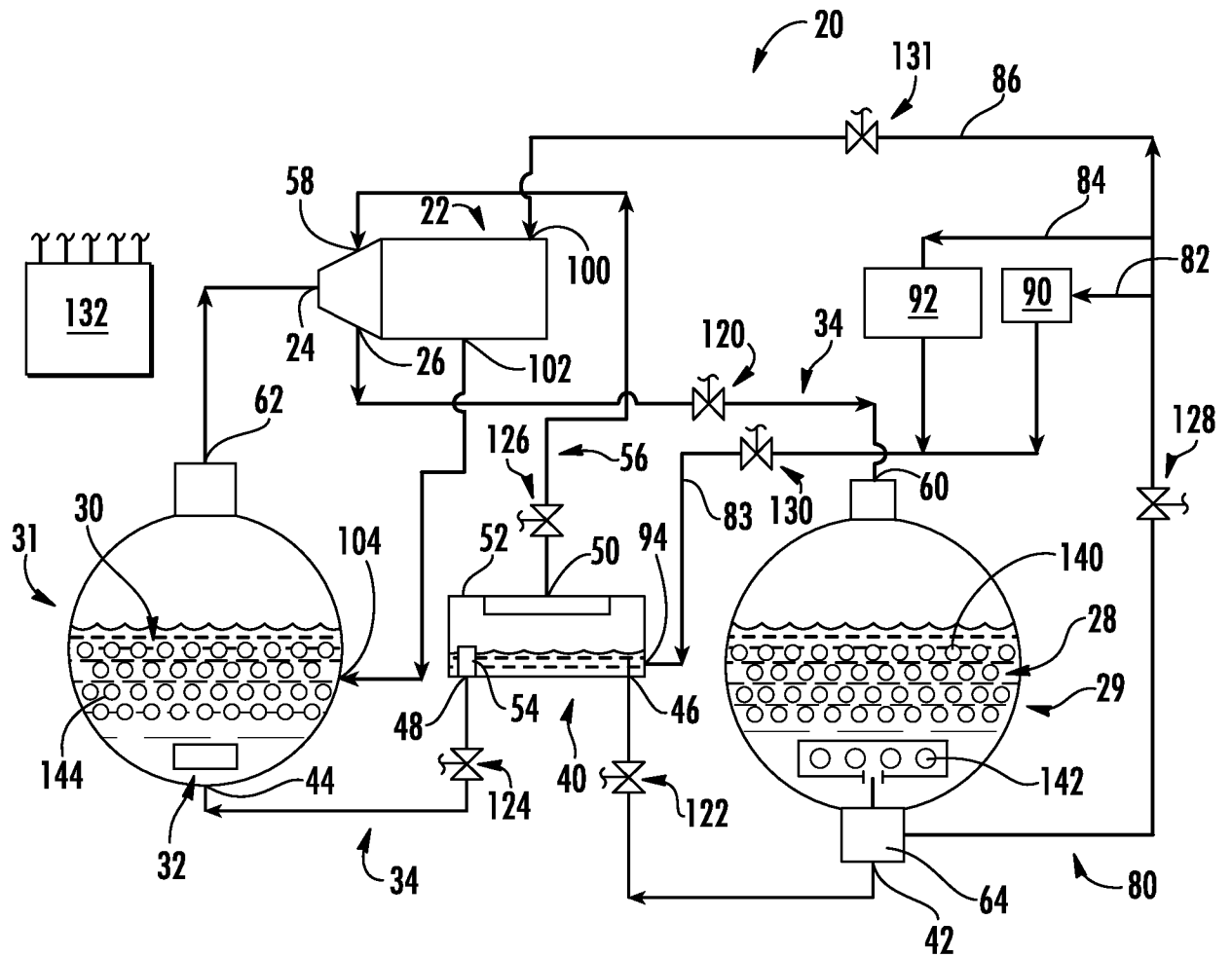
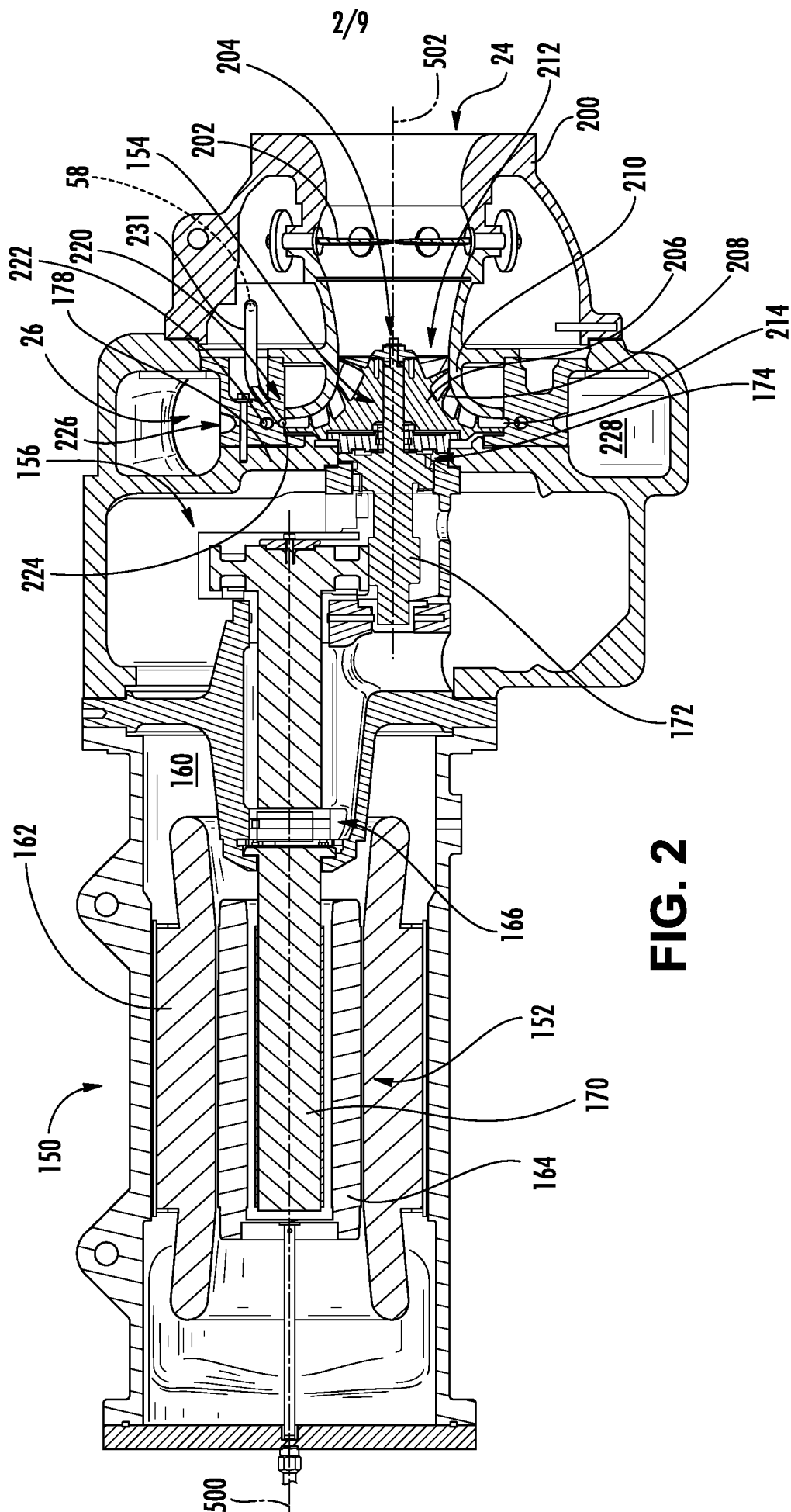
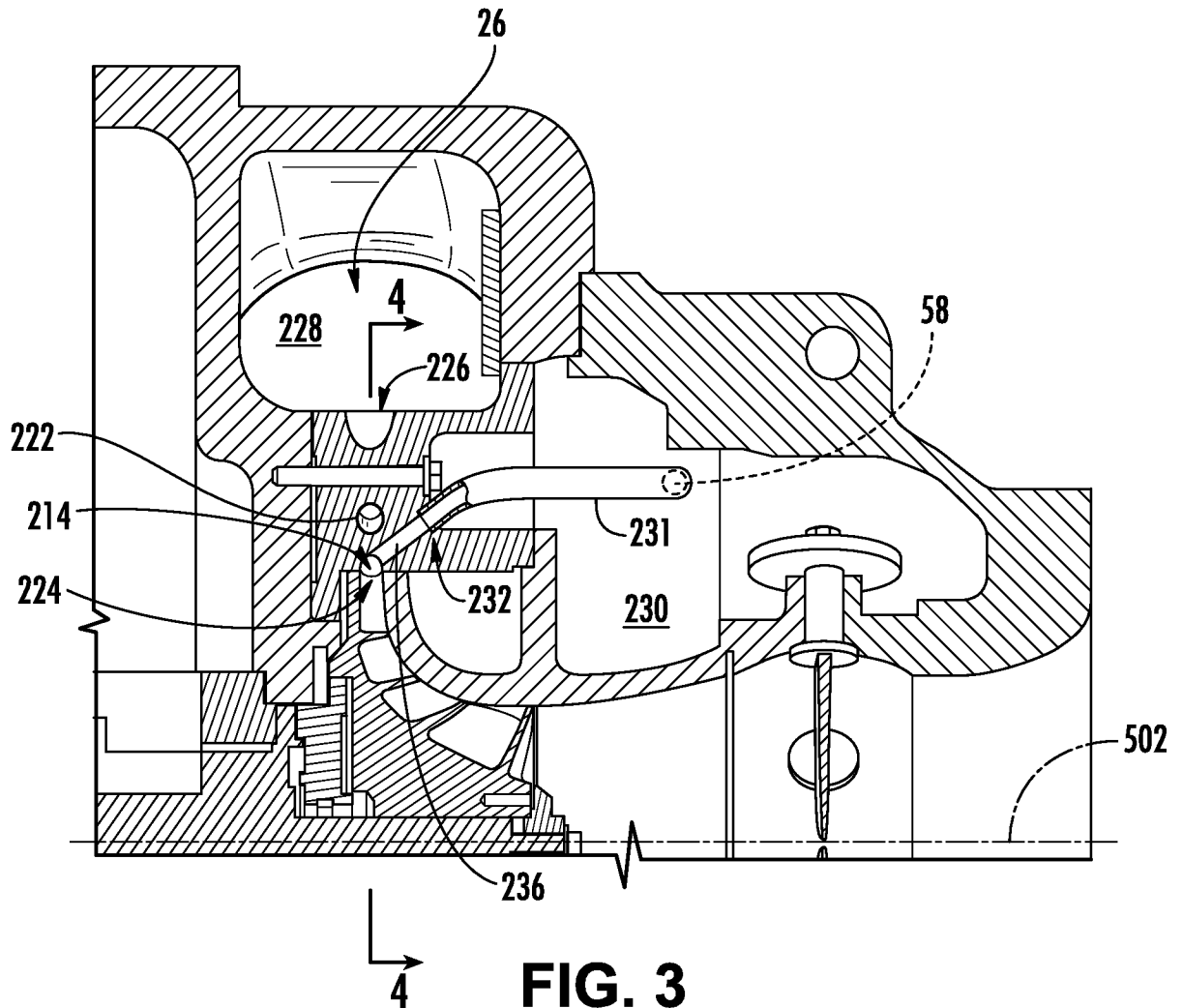


FIG. 1





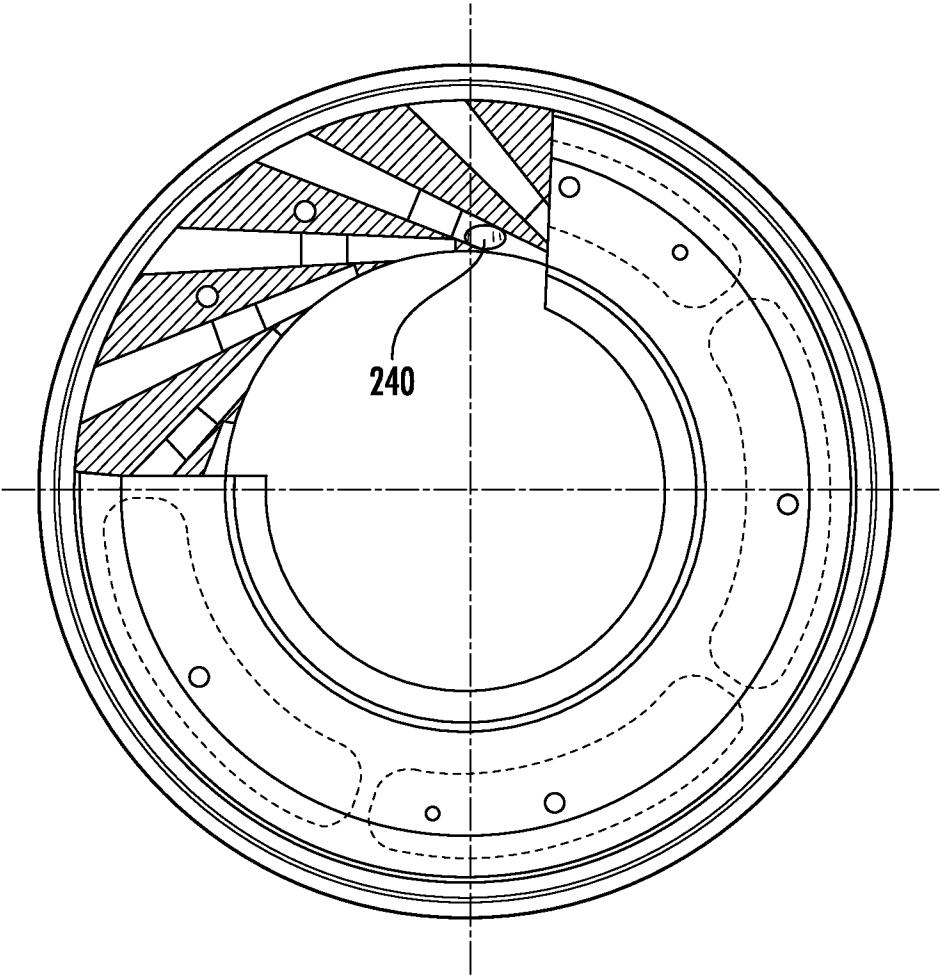


FIG. 4

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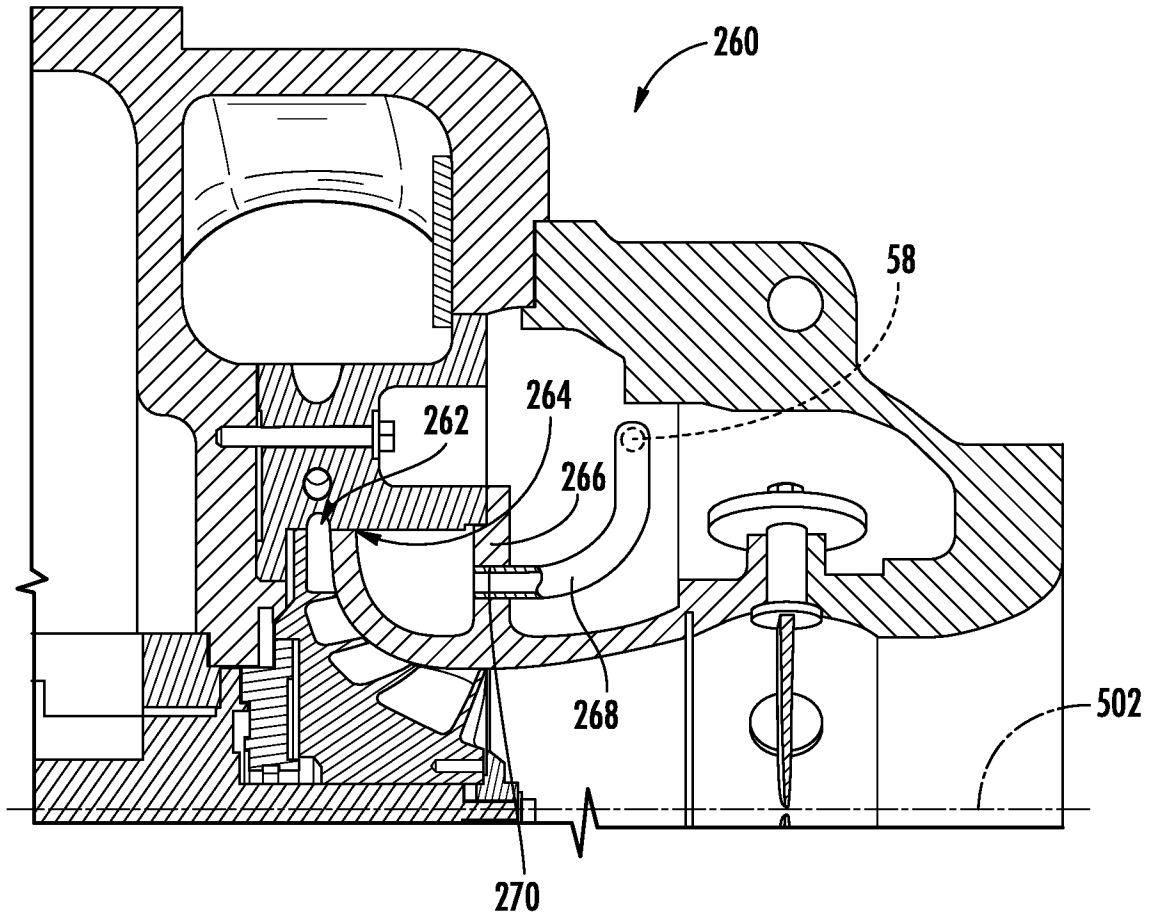


FIG. 5

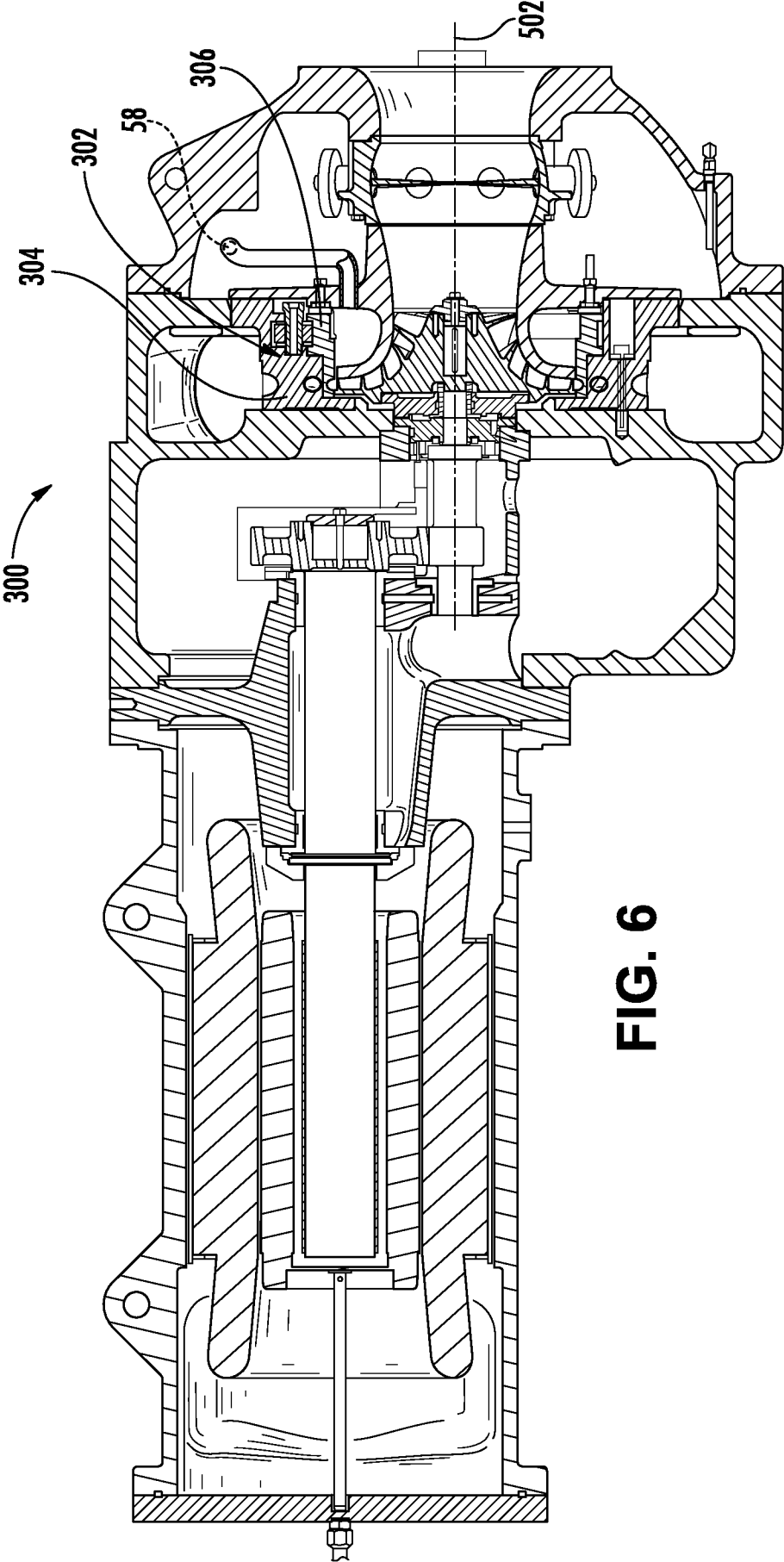


FIG. 6

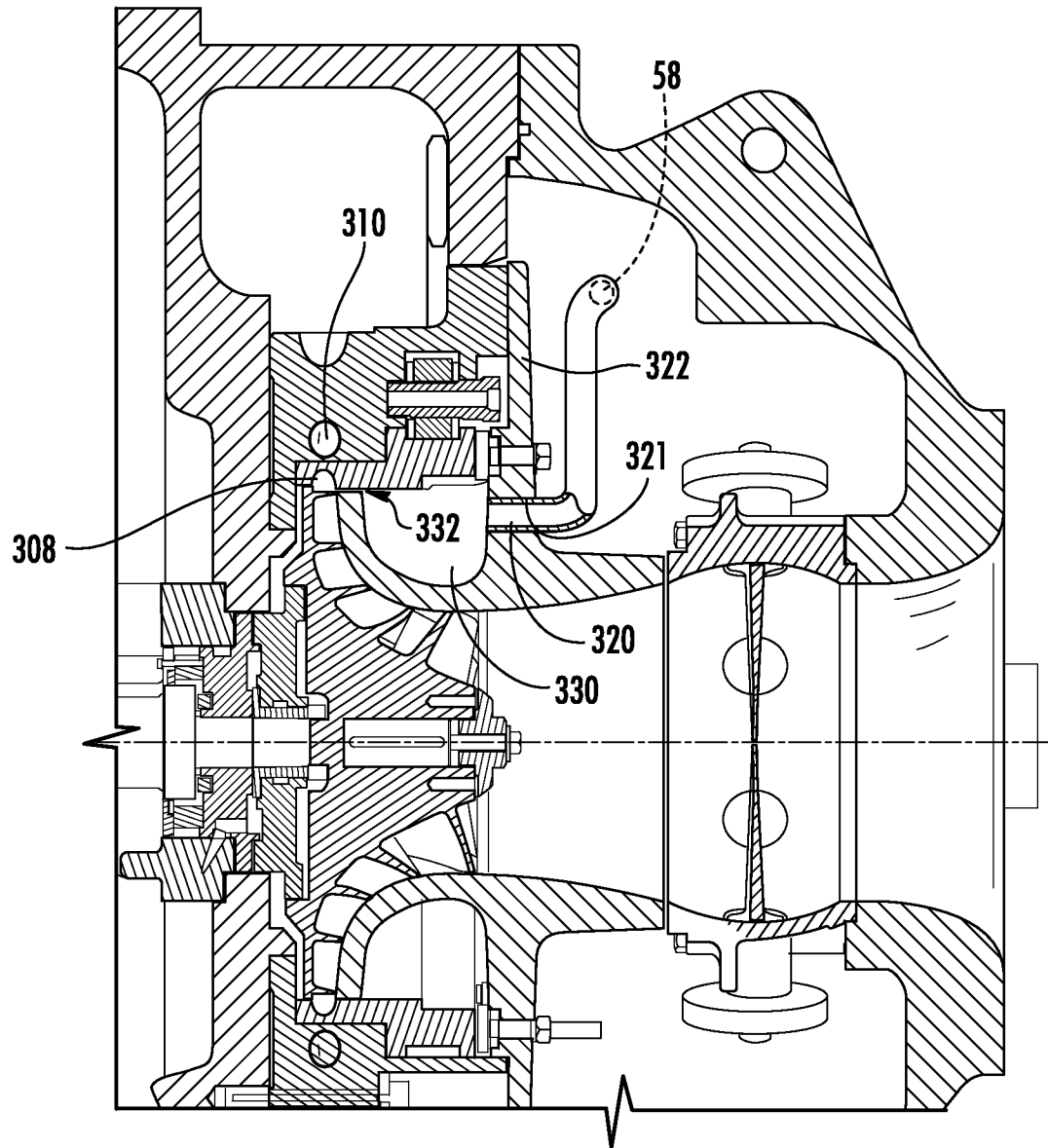


FIG. 7

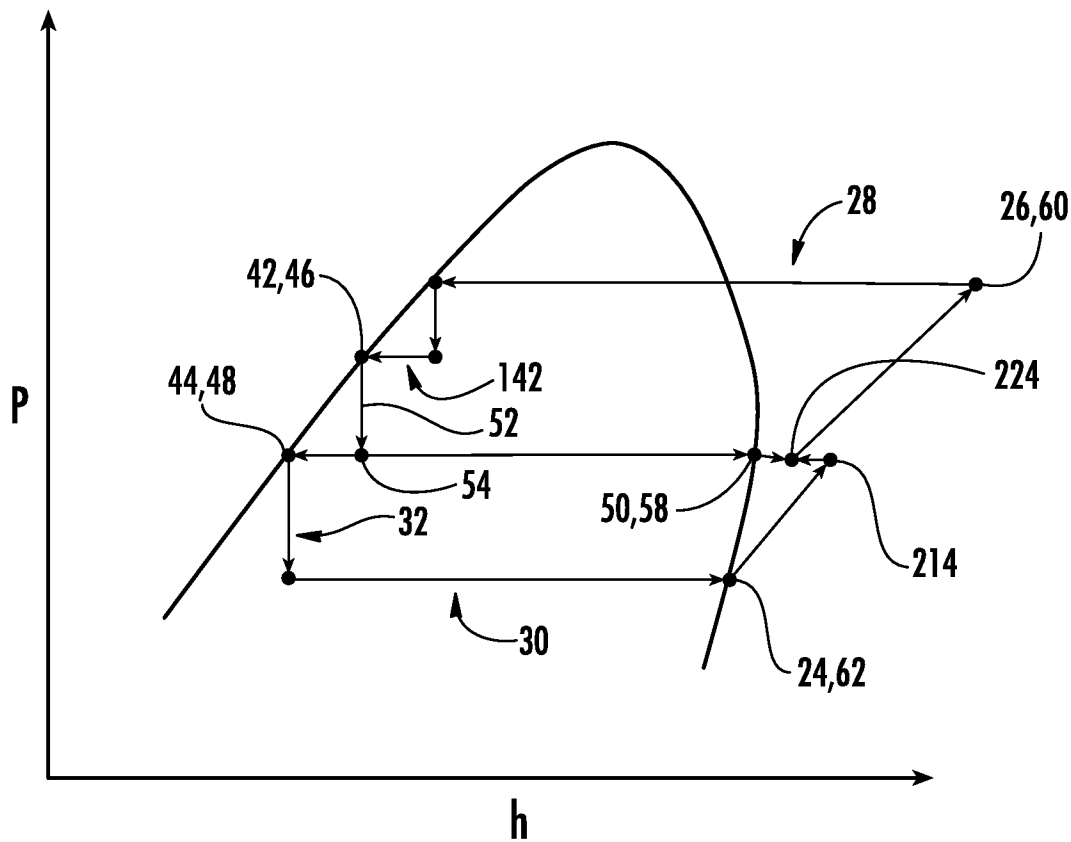


FIG. 8

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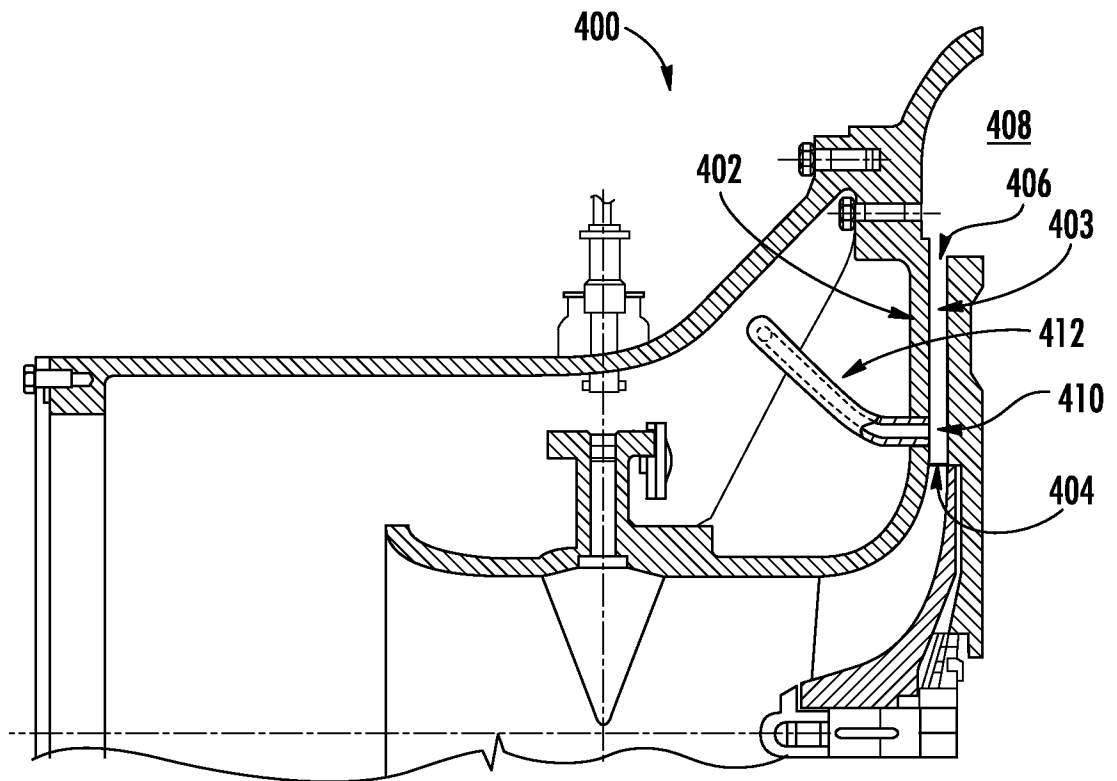


FIG. 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2012/040114

A. CLASSIFICATION OF SUBJECT MATTER
INV. F04D29/44 F25B1/053
ADD.

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)
F04D F25B

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)

EP0-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.
X	US 3 226 940 A (JEKAT WALTER K ET AL) 4 January 1966 (1966-01-04) the whole document figures 1,2,5 -----	1-11
X	DE 10 35 669 B (FRANTISEK WERGNER) 7 August 1958 (1958-08-07) the whole document figures 1,3 -----	1-11
X	US 4 691 533 A (ZIMMERN BERNARD [US]) 8 September 1987 (1987-09-08) the whole document figures 1,2 -----	1-11

☐

Further documents are listed in the continuation of Box C.

☒

See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search

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Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2012/040114

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 3226940	A	04-01-1966	GB 1037006 A	20-07-1966
			US 3226940 A	04-01-1966

DE 1035669	B	07-08-1958	NONE	

US 4691533	A	08-09-1987	DE 3631624 A1	02-04-1987
			FR 2588066 A1	03-04-1987
			GB 2180922 A	08-04-1987
			IT 1196643 B	16-11-1988
			JP 62080451 A	13-04-1987
			US 4691533 A	08-09-1987
