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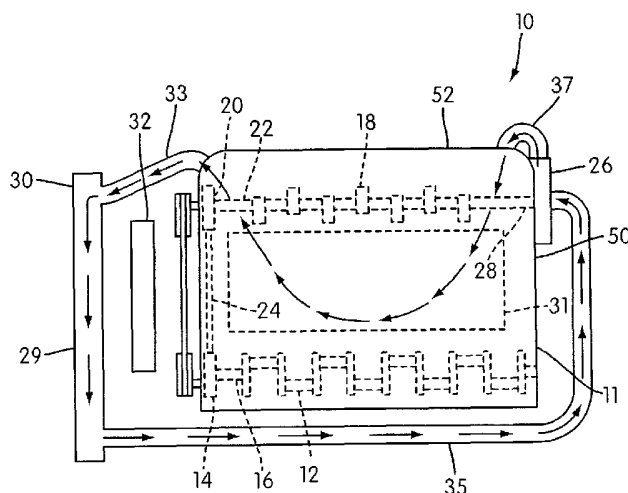
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(54) Title: INTERNAL COMBUSTION ENGINE COMBINATION WITH DIRECT CAMSHAFT DRIVE COOLANT PUMP



(57) Abstract: A coolant pump for use with an internal combustion engine having a crankshaft and a camshaft driven by the crankshaft includes a pump housing fixedly mountable to the engine. The pump housing includes an inlet opening to receive coolant and an outlet opening to discharge coolant. An impeller shaft is operatively coupled to the camshaft so as to be rotatably driven thereby. A pump impeller is operatively mounted to the impeller shaft within the pump housing, the pump impeller rotatable to draw the coolant into the pump housing through the inlet opening and discharge the coolant at a higher pressure through the outlet opening. The pump impeller includes first and second shrouds separated by a plurality of vanes. The first and second shrouds and plurality of vanes are configured and positioned such that a resultant thrust load acting on the pump impeller and hence the impeller shaft is approximately zero. A seal assembly has a surface engaged with the plurality of axial extending projections of the pump impeller so as to maintain perpendicular alignment of the seal assembly with respect to the impeller shaft.

**INTERNAL COMBUSTION ENGINE COMBINATION WITH DIRECT CAMSHAFT DRIVEN
COOLANT PUMP**

FIELD OF THE INVENTION

5 The present invention relates to a coolant pump for use with an internal combustion engine. More particularly, the present invention relates to a coolant pump that is mounted directly to the camshaft of the internal combustion engine.

BACKGROUND OF THE INVENTION

10 Conventional coolant pumps, also referred to as water pumps, are typically mounted on the front of the engine frame so that the pump can be operated by a belt drive system.

 It is also known to mount the water pump on the back of the engine and operatively connect the pump shaft to the back end of the camshaft in order to drive the pump shaft. An example of this type of water pump is disclosed in U.S. Patent No.
15 4,917,052 to Eguchi et al.

 However, the camshaft is subjected to torsional vibrations due to, for example, the natural operating frequency of the engine, cyclic resistance to camshaft rotation, and vibrations occurring in the camshaft drive chain/belt. Such torsional vibrations can cause excessive wear in the chain/belt and at the cam surfaces. As a result, it is known to
20 provide vibration damping means for the camshaft so torsional vibrations may be damped. An example of a camshaft damper is disclosed in U.S. Patent No. 4,848,183 to Ferguson.

 Thus, there is a need for a water pump that can be operated by the camshaft of the internal combustion engine and can also act as a torsional vibration damper for the
25 camshaft. Additionally, there is always a need in the automotive art to provide more cost-effective components. The present invention addresses these needs in the art as well as other needs, which will become apparent to those skilled in the art once given this disclosure.

 GP Patent No. 1,567,303 discloses a water pump impeller connected to the end of
30 a camshaft. Camshaft driven water pumps, such as those disclosed in the '052 U.S. Patent and the '303 GB Patent, have not been commercially viable. The applicant has determined that part of the problem associated with camshaft driven water pumps is that

they place heavy loads on the camshaft as a result of the pumping action. Unlike water pumps that have bearings that are adapted to accommodate both radial and axial loads, camshafts have bearings that primarily accommodate radial loads. While camshaft bearings may accommodate minute axial loads that occur during normal operating conditions, the camshaft is not configured to accommodate substantial axial loads as would be generated by a water pump impeller.

Thus, another aspect of the present invention relates to a water pump that is operated by the camshaft of the internal combustion engine and that is structured to substantially reduce or eliminate the transfer of axial loads from the water pump impeller to the camshaft.

SUMMARY OF THE INVENTION

It is an object of the present invention to meet the above-described need.

It is desirable to provide a coolant pump that can be mounted on the engine and operatively coupled to the camshaft to eliminate the use of bearings in the pump.

It is further desirable to provide a coolant pump that has a damper assembly that dampens torsional vibrations of the camshaft.

In accordance with the principles of the present invention, this objective is achieved by providing a coolant pump comprising a pump housing fixedly mountable to an engine and including an inlet opening to receive coolant and an outlet opening to discharge coolant. An impeller shaft is mounted directly to the camshaft so as to be concentrically rotatably driven thereby. The impeller shaft extends into the housing in a sealing engagement and in an unsupported relation. A pump impeller is operatively mounted to the impeller shaft within the pump housing. The pump impeller is rotatable to draw the coolant into the pump housing through the inlet opening and discharge the coolant at a higher pressure through the outlet opening.

The pump impeller includes first and second shrouds separated by a plurality of vanes. The first and second shrouds and plurality of vanes are configured and positioned such that a resultant thrust load acting on the pump impeller and hence the impeller shaft is approximately zero.

A seal assembly has a surface engaged with the plurality of axial extending projections of the pump impeller so as to maintain perpendicular alignment of the seal assembly with respect to the impeller shaft.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings facilitate an understanding of the various embodiments of this invention. In such drawings:

FIG. 1 is a schematic representation of an automobile internal combustion engine and a coolant system, the coolant system having a coolant pump embodying the principles of the present invention;

FIG. 2 is a perspective view of an embodiment of the coolant pump in accordance with the principles of the present invention;

FIG. 3 is a back view of FIG. 2;

FIG. 4 is a cross-sectional view of an embodiment of the coolant pump of FIG. 1;

FIG. 5 is a top perspective view of the impeller of the coolant pump shown in Fig. 4;

FIG. 6 is a bottom perspective view of the impeller of the coolant pump shown in Fig. 4;

FIG. 7 is a top perspective view of the impeller of the coolant pump shown in Fig. 4 with a graphical representation of the flow of fluid through the impeller;

FIG. 8 is a bottom perspective view of the impeller of the coolant pump shown in Fig. 4 with a graphical representation of the flow of fluid through the impeller;

FIG. 9 is graphical representation of the relation between thrust force and coolant pump RPM for known impellers and the impeller illustrated in the Figs. 5 to 8;

FIG. 10 is a cross-sectional view of another embodiment of the coolant pump of the present invention;

FIG. 11 is an exploded view of the seal assembly of the coolant pump of FIG. 10;

FIG. 12 is an exploded view of another embodiment of the coolant pump; and

FIG. 13 is an enlarged perspective view of the unitizer of the seal assembly of the coolant pump shown in FIG. 10.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Fig. 1 is a schematic view illustrating a valve controlled piston and cylinder internal combustion engine 10 for an automobile. As is conventional, the engine 10 includes a piston driven output shaft 12, or crankshaft, having a driving sprocket or pulley 14 fixedly mounted thereto at one end 16 thereof. A valve actuating camshaft 18, which operates the valve mechanisms of the engine 10, has a driven sprocket or pulley

20 mounted thereto at one end 22 thereof. An endless chain or belt 24 is trained about the driving sprocket/pulley 14 of the crankshaft 12 and the driven sprocket/pulley 20 of the camshaft 18. The driven sprocket/pulley 20 receives driving force from the driving sprocket/pulley 14 via the chain/belt 24, which transmits such force to the camshaft 18.

5 Thus, the camshaft 18 is coupled to the crankshaft 12 of the engine 10 so as to be driven by the crankshaft 12 and rotate under power from the engine 10. It should be understood that the internal combustion engine 10 may be of any known construction. It should also be understood the camshaft 18 may be driven by the crankshaft 12 with a compound drive, wherein more than one endless chain or belt is utilized to transmit driving force
10 from the crankshaft 12 to the camshaft 18.

The present invention is more particularly concerned with a coolant pump 26, which is operatively connected to an opposite end 28 of the camshaft 18 of the engine 10 so as to be rotatably driven thereby. As is conventional, the coolant pump 26, also referred to as a water pump, forms a part of a closed-loop coolant system 29 of the
15 automobile. The coolant system 29 of the automobile requires a steady flow of a coolant in order to remove excess heat from the engine 10. The coolant pump 26 circulates the coolant (preferably a mixture of glycol and water, or any other suitable liquid coolant) through a cooling jacket surrounding piston cylinders 31 of the engine 10 and a radiator 30. Coolant exiting the coolant jacket is directed via flexible hoses or rigid piping 33 to
20 the radiator 30 where the heat is dissipated to the flow of passing air. A fan 32, operatively driven by the output shaft 12 or a motor, is positioned and configured to facilitate the movement of air through the radiator 30 and carry away heat. The coolant cooled by the radiator 30 is then returned to the coolant pump 26 via flexible hoses or rigid piping 35 and circulated back through the coolant jacket to repeat the cycle.

25 As illustrated in Figs. 2-4, the coolant pump 26 includes a pump housing 34 enclosing an interior space 36. The housing 34, positioned within the coolant flow path, includes a generally cylindrical inlet opening 38 configured and positioned to receive coolant from the flow path and a generally cylindrical outlet opening 40 configured and positioned to discharge coolant into the flow path. The inlet opening 38 is communicated
30 to the radiator 30 via flexible hoses or rigid piping 35 to enable coolant from the radiator 30 to enter the housing 34. The outlet opening 40 is communicated to the engine 10 via flexible hoses or rigid piping 37 so as to circulate the coolant from the radiator 30

through the coolant jacket to dissipate engine heat. The inlet and outlet openings 38, 40 have annular flanges 42, 44, respectively, which are positioned and configured to mount the flexible hoses or rigid piping 35, 37 necessary for communicating the coolant.

5 The housing 34 is preferably molded from plastic and comprises first and second sections 46, 48, with the annular flanges 42, 44 of the inlet and outlet openings 38, 40 being integrally formed with the second section 48. The first and second sections 46, 48 are secured together to define the interior space 36.

Referring to Fig. 4, the impeller 766 is structured to substantially reduce or eliminate the transfer of axial thrust loads from the impeller 766 to the pump shaft 762, and hence from the pump shaft 762 to the camshaft 18 of the engine.

10 The impeller 766 includes a hub 701 that is secured directly to the shaft 767 of the pump shaft 762. Moreover, the impeller 766 includes first and second shrouds 702, 703 that are structured so that the axial thrust load on the first shroud 702 is opposite in direction and substantially equal in magnitude to the axial thrust load on the second shroud 703, as will be further discussed. As a result, the resultant axial thrust load applied to the camshaft 18 is substantially reduced or eliminated.

As shown in Figs. 5 and 6, the first shroud 702 has the form of a generally annular disk and includes an opening 704 for receiving the hub 701. The first shroud 702 includes a front face surface 705 and a rear face surface 706. The front face surface 705 is tapered from the edges of the opening 704 to an outer peripheral portion 707 of the first shroud 702. Further, the first shroud 702 may include a plurality of openings 708 therethrough. In the illustrated embodiment, the first shroud 702 includes three openings 708 therethrough.

20 The second shroud 703 is ring-shaped and has a greater outer diameter than the first shroud 702. The second shroud 703 includes an inner peripheral edge 709 and an outer peripheral edge 710. In the illustrated embodiment, the diameter of the inner peripheral edge 709 is substantially equal to the diameter of the outer peripheral edge 711 of the first shroud 702. The second shroud 703 also includes a front face surface 712 and a rear face surface 713.

30 The first and second shrouds 702, 703 are axially spaced apart from one another by a plurality of vanes 714. The vanes 714 have a slight curvature to them and are circumferentially spaced from one another. Each vane 714 extends outwardly from an

intermediate portion on the front face surface 705 of the first shroud 702 to the inner peripheral edge 709 of the second shroud 703. Each vane 714 continues to extend across the rear face surface 713 of the second shroud 703 and protrudes past the outer peripheral edge 710 of the second shroud 703. As a result, the vanes 714 form channels 715 that extend from the front face surface 705 of the first shroud 702 and across the rear face surface 713 of the second shroud 703. The vanes 714 are angled with respect to imaginary radial lines extending outwardly from the axis of the impeller 766. The vane angle and vane thickness may be adjusted to alter the flow of coolant and hence the coolant pressure on the first and second shrouds 702, 703.

In the illustrated embodiment, the vanes 714 and first and second shrouds 702, 703 are integrally molded as a single structure. However, the vanes 714 and first and second shrouds 702, 703 may be formed separately and secured to one another in any suitable manner.

The impeller 766 is mounted to the pump shaft 762 such that the second shroud 703 is positioned closer to the inlet opening 738 in the housing 734 than the first shroud 702.

As shown in Fig. 4, the second shroud 703 has a slight conical shape to conform to the contoured shape of housing 734. However, the housing 734 may be structured to accommodate a substantially flat or planar second shroud 703. In both instances, the rear face surface 713 is considered to face the opposite axial direction as compared to front face surface 712 for the purpose of this disclosure.

Coolant is drawn into the center of the impeller 766 via the inlet opening 738. The coolant flows into the channels 715 defined by the vanes 714 provided on the front face surface 705 of the first shroud 702 and across the rear face surface 713 of the second shroud 703. The vanes 714 on the rear face surface 713 of the second shroud 703 send the coolant radially outwardly into the volute 797 defined by the housing 734.

The impeller 766 is structured so that the axial thrust loads acting on the impeller 766 are balanced. Specifically, the first and second shrouds 702, 703 are structured so that the axial thrust loads thereof are substantially equal in magnitude and are applied in opposite directions such that the sum of the axial thrust loads acting upon the impeller 766 is approximately zero. That is, the force applied by the coolant on the front face surface 705 of the shroud 702 and tending to force the impeller 766 axially toward the

camshaft 18 is balanced by the force applied by the coolant on the rear face surface 713 of the shroud 703 and tending to force the impeller 766 axially away from the camshaft 18.

More specifically, the thrust load acting on a respective one of the shrouds 702, 703 is equal to the pressure applied to the respective shroud 702, 703 by the coolant multiplied by the surface area of the respective face surface 705, 713 of the shroud 702, 703. As shown in Figs. 7 and 8, the impeller 766 is structured such that the first shroud 702 is substantially under suction pressure (i.e., thrust load acting in direction towards the camshaft 18) and the second shroud 703 is substantially under discharge pressure (i.e., thrust load acting in direction away from the camshaft 18). By adjusting the surface area of the respective face surface 705, 713 of the shroud 702, 703, the resultant thrust load acting on the impeller 766 can be substantially reduced or eliminated. In other words, the shrouds 702, 703 are producing opposing thrust loads so the resultant thrust load acting on the impeller 766 can be substantially reduced or eliminated by adjusting the surface areas of the shrouds 702, 703. The size of the openings 708 through the first shroud 702 may be altered to adjust the surface area of the face surface 705 of the first shroud 702.

It should be appreciated that the conical shape of shroud 703 provides an angled rear face surface 713. The angling of this rear face surface 713 is such that radially directed fluid (perpendicular to the axis of rotation) will impact the rear face surface 713 and apply an axial force that balances the force on face surface 705. The angles, shape, and surface area of surfaces 705, 713 can be adjusted to achieve the desired balance.

As shown in Fig. 9, known impellers (e.g., semi-open impeller) produce predictable and significant thrust loads that act on the pump shaft. Moreover, the thrust loads of known impellers acting on the pump shaft increase with increasing diameters and increasing engine speeds. It has been found in prior art applications that relatively large diameter impellers are required to obtain effective pumping action. Such large diameter impellers would ordinarily generate axial loads that would have a detrimental effect on camshaft and associated component operation.

In the coolant pump 726, the impeller 766 is structured such that the magnitude of the thrust load acting on the pump shaft 762, and hence the camshaft 18, is significantly decreased throughout the entire range of engine speeds. In the illustrated

graph, the thrust load on the impeller 766 from 0 to approximately 2500 RPMs is approximately zero. At approximately 2500 RPM, the thrust load on the impeller 766 is a negative thrust load which acts in a direction away from the pump shaft 762, and hence the camshaft 18. Thus, by utilizing the impeller 766, the thrust loads acting on the camshaft 18 can be substantially reduced, eliminated, or reversed. Without significant thrust loads acting on the camshaft 18, the expected lifetime of the camshaft 18 and associated components can be increased.

Figs. 10-12 illustrate another aspect of the coolant pump, indicated as 826. In this embodiment, the impeller 866 and seal assembly 892 of the coolant pump 826 are structured to enable accurate alignment of the seal assembly 892 with respect to the impeller 866, and hence accurate alignment of the seal assembly 892 with respect to the pump shaft 862. Because of the accurate alignment between the seal assembly 892 and the pump shaft 862, the sealing efficiency and effectiveness of the seal assembly 892 is increased.

The seal assembly 892 is positioned between the shaft 867 and the opening 855 of the housing 834 to prevent coolant within the housing 834 from escaping from the housing 834.

Specifically, the seal assembly 892 includes a retaining member 801 (also referred to as a unitizing sleeve or unitizer), a mating ring 802, and a seal unit 803.

The unitizer 801 is mounted on the shaft 867 of pump shaft 862 for rotation therewith about the shaft axis 870. Specifically, the unitizer 801 includes a cylindrical hub portion 804 that defines an opening for receiving the shaft 867. In the illustrated embodiment, the hub portion 804 engages the shaft 867 with a friction fit to secure the unitizer 801 to the shaft 867. As best shown in Fig. 13, the hub portion 804 leads to a radially outwardly extending portion 805 which leads to a generally axially inwardly extending portion 806. The outwardly extending portion 805 includes a plurality of elongated openings 807 therethrough. In the illustrated embodiment, the outwardly extending portion 805 includes three elongated openings 807.

The mating ring 802 is ring-shaped and includes an inner peripheral surface 808 and an outer peripheral surface 809. The mating ring 802 is engaged with the unitizer 801 such that the inner peripheral surface 808 of the mating ring 802 engages the outer peripheral surface of the hub portion 804 and the outer peripheral surface 809 of

the mating ring 802 engages the inner surface of the inwardly extending portion 806. The outer peripheral surface 809 of the mating ring 802 includes a plurality of indentations 810 and the inwardly extending portion 806 of the unitizer 801 has inwardly extending protrusions 811 structured to engage within the plurality of indentations 810 so as to retain the mating ring 802 on the unitizer 801. Further, when the mating ring 802 is mounted to the unitizer 801, the elongated openings 807 in the outwardly extending portion 805 of the unitizer 801 expose portions of the face surface 897 of the mating ring 802 therethrough. In the illustrated embodiment, the outwardly extending portion 805 of the unitizer 801 includes three elongated openings 807 that expose three portions of the face surface 897 of the mating ring 802. However, the outwardly extending portion 805 of the unitizer 801 may include two openings or more than three openings.

The seal unit 803 includes a cup-shaped portion 812 and an elongated seal 813 having one end secured to the cup-shaped portion 812. The hub portion 804 of the unitizer 801 is inserted through the opening in the cup-shaped portion 812 and the edges 817 of the hub portion 804 are crimped radially outwardly to couple the unitizer 801 to the seal unit 803. A rigid ring member 814 is positioned on an opposite end of the seal 813 and includes a face surface 815 that engages the face surface 899 of the mating ring 802 when the unitizer 801 is coupled with the seal unit 803. As a result, the ring member 814 maintains alignment of the seal unit 803 with respect to the mating ring 802. A spring 816 is positioned between the end wall of the cup-shaped portion 812 and the opposite end of the seal 813 to bias the seal 813 and ring member 814, and hence the mating ring 802 and unitizer 801, away from the cup-shaped portion 812.

The impeller 866 includes a hub 818 that is secured directly to the shaft 867 of the pump shaft 862. Moreover, a ring-shaped member 819 is mounted to the rear face of the impeller 866 with the axis of the ring-shaped member 819 aligned with the axis of the impeller 866. The ring-shaped member 819 includes a plurality of axially extending projections 1820 that extend axially outwardly therefrom. In the illustrated embodiment, the number of projections 1820 is equal to the number of elongated openings 807 provided in the outwardly extending portion 805 of the unitizer 801 (i.e., three projections).

The seal assembly 892 is engaged with the ring-shaped member 819 on the impeller 866 such that the projections 1820 of the ring-shaped member 819 extend through the elongated openings 807 in the outwardly extending portion 805 of the unitizer 801 and engage the corresponding exposed portions of the face surface 897 of the mating ring 802. As a result, the mating ring 802 is aligned perpendicularly to the axis 870 of the pump shaft 862, which aligns the ring member 814 engaged with the mating ring 802 to the pump shaft 862, which in turn aligns the seal unit 803 to the pump shaft 862. With the components of the seal assembly 892 accurately aligned with respect to the pump shaft 862, the effectiveness of the seal assembly 892 is maintained during operation of the coolant pump 826.

Specifically, the mating ring 802 is fabricated from a rigid material (e.g., sintered metal, ceramic) to a very high precision. The unitizer 801 is typically manufactured from sheet metal and does not have the rigidity or precision of the mating ring 802.

In known seal assemblies, the seal assembly is spaced from the impeller and the unitizer is relied on to align the seal assembly with respect to the pump shaft. Because of the low rigidity and precision of the unitizer, the seal assembly becomes misaligned with respect to the pump shaft during operation of the coolant pump which affects the integrity of the seal. More specifically, the unitizer in known seal assemblies is not structured to maintain the alignment of the mating ring with respect to the pump shaft such that the mating ring becomes misaligned with respect to the pump shaft which misaligns the seal unit with respect to the pump shaft. The misaligned mating ring is subject to axial run-out or wear which adversely affects the seal.

In the coolant pump 826, the mating ring 802 is engaged with projections 1820 provided on the impeller 866 so as to maintain alignment of mating ring 802, and hence the seal unit 803, with respect to the pump shaft 862. Because the mating ring 802 is properly aligned with respect to the pump shaft 862, axial run-out or wear of the mating ring 802 is reduced (e.g., the axial run-out is reduced from 0.17mm in known coolant pumps to 0.02mm in coolant pump 826). By reducing the axial run-out of the mating ring 802, any movement or wobbling of the mating ring 802 with respect to the pump shaft 862 is reduced so that the mating ring 802 maintains alignment with respect to the pump shaft 862 which increases the effectiveness and efficiency of the seal assembly 892.

Fig. 12 illustrates the impeller 866. The rear face of the impeller 866 is integrally molded with the plurality of axially extending projections 1820. As a result, the separate ring-shaped member 819 of the embodiment of impeller 866 is not necessary. The seal assembly 892 would be engaged with the projections 1820 on the impeller 866 such that
5 the projections 1820 extend through the elongated openings 807 in the outwardly extending portion 805 of the unitizer 801 and engage the corresponding exposed portions of the face surface 897 of the mating ring 802.

Further, the elongated openings 807 in the outwardly extending portion 805 of the unitizer 801 allow coolant to cool the exposed portions of the mating ring 802, which
10 increases the expected lifetime of the mating ring 802.

It can thus be appreciated that the objectives of the present invention have been fully and effectively accomplished. The foregoing specific embodiments have been provided to illustrate the structural and functional principles of the present invention and are not intended to be limiting. To the contrary, the present invention is intended to
15 encompass all modifications, alterations, and substitutions within the spirit and scope of the appended claims.

WHAT IS CLAIMED IS:

1. A coolant pump for use with an internal combustion engine having a crankshaft and a camshaft driven by the crankshaft, said coolant pump comprising:

a pump housing fixedly mountable to the engine and including an inlet opening to receive coolant and an outlet opening to discharge coolant;

an impeller shaft operatively coupled to the camshaft so as to be rotatably driven thereby; and

a pump impeller operatively mounted to the impeller shaft within the pump housing, the pump impeller rotatable to draw the coolant into the pump housing through the inlet opening and discharge the coolant at a higher pressure through the outlet opening, the pump impeller including first and second shrouds separated by a plurality of vanes, the first and second shrouds and plurality of vanes being configured and positioned such that a resultant thrust load acting on the pump impeller and hence the impeller shaft is substantially balanced.

2. The coolant pump according to claim 1, wherein the first and second shrouds are structured such that a thrust load applied to the first shroud is opposite in direction and substantially equal in magnitude to a thrust load applied to the second shroud.

3. The coolant pump according to claim 1, wherein the vanes and first and second shrouds are integrally molded as a single structure.

4. The coolant pump according to claim 1, wherein the first shroud is generally cylindrical and the second shroud is generally ring-shaped, the second shroud having an inner peripheral edge that is substantially equal in diameter to an outer peripheral edge of the first shroud, and wherein each of the plurality of vanes extends from a front face surface of the first shroud to the inner peripheral edge of the second shroud and across a rear face surface of the second shroud.

5. A coolant pump for use with an internal combustion engine having a crankshaft and a camshaft driven by the crankshaft, said coolant pump comprising:

a pump housing fixedly mountable to the engine and including an inlet opening to receive coolant and an outlet opening to discharge coolant;

an impeller shaft mounted directly to the camshaft so as to be concentrically rotatably driven thereby;

a pump impeller operatively mounted to the impeller shaft within the pump housing and including a plurality of axial extending projections, the pump impeller rotatable to draw the coolant into the pump housing through the inlet opening and discharge the coolant at a higher pressure through the outlet opening; and

a seal assembly extending between said pump impeller and said housing substantially preventing coolant from escaping from said housing, said seal assembly having a surface engaged with the plurality of axial extending projections of the pump impeller so as to maintain perpendicular alignment of the seal assembly with respect to the impeller shaft.

6. The coolant pump according to claim 5, wherein the seal assembly includes:

a unitizer mounted on the impeller shaft for rotation therewith, the unitizer including a radially outwardly extending portion having a plurality of openings therethrough;

a mating ring providing a front face surface, the mating ring being mounted to the unitizer such that the plurality of openings in the unitizer expose portions of the front face surface therethrough; and

a seal unit providing a seal and an aligning member, the seal unit being coupled with the unitizer such that the aligning member is engaged with a rear face surface of the mating ring,

wherein the plurality of axial extending projections of the pump impeller extend through the openings in the radially outwardly extending portion of the unitizer and engage the portions of the face surface of the mating ring so as to align the mating ring to the impeller shaft, which aligns the aligning member engaged with the mating ring to the impeller shaft, which in turn aligns the seal unit to the impeller shaft.

7. The coolant pump according to claim 6, wherein the number of axial extending projections of the pump impeller is equal to the number of openings provided in the outwardly extending portion of the unitizer.

8. The coolant pump according to claim 6, wherein the plurality of axial extending projections are integrally molded with the pump impeller.

9. The coolant pump according to claim 6, wherein the plurality of axial extending projections are provided on a ring-shaped member, the ring-shaped member being mounted to the pump impeller.

10. The coolant pump according to claim 6, wherein the pump impeller includes three axial extending projections and the outwardly extending portion of the unitizer includes three openings.
11. The coolant pump according to claim 6, wherein the openings provided in the outwardly extending portion of the unitizer allow coolant to cool the portions of the face surface of the mating ring.
12. The coolant pump according to claim 5, wherein the pump impeller including first and second shrouds separated by a plurality of vanes, the first and second shrouds and plurality of vanes being configured and positioned such that a resultant thrust load acting on the pump impeller and hence the impeller shaft is substantially balanced.
13. The coolant pump according to claim 12, wherein the first and second shrouds are structured such that a thrust load applied to the first shroud is opposite in direction and substantially equal in magnitude to a thrust load applied to the second shroud.
14. The coolant pump according to claim 13, wherein the vanes and first and second shrouds are integrally molded as a single structure.
15. The coolant pump according to claim 13, wherein the first shroud is generally cylindrical and the second shroud is generally ring-shaped, the second shroud having an inner peripheral edge that is substantially equal in diameter to an outer peripheral edge of the first shroud, and wherein each of the plurality of vanes extends from a front face surface of the first shroud to the inner peripheral edge of the second shroud and across a rear face surface of the second shroud.
16. A pump impeller for connection with an impeller shaft of a coolant pump, said pump impeller comprising:
 - a first shroud; and
 - a second shroud separated from the first shroud by a plurality of vanes, wherein the first and second shrouds and plurality of vanes being configured and positioned such that a resultant thrust load acting on the pump impeller and hence the impeller shaft is approximately zero.
17. The pump impeller according to claim 16, wherein the first and second shrouds are structured such that a thrust load applied to the first shroud is opposite in direction and substantially equal in magnitude to a thrust load applied to the second shroud.

18. The pump impeller according to claim 16, wherein the vanes and first and second shrouds are integrally molded as a single structure.

19. The pump impeller according to claim 16, wherein the first shroud is generally cylindrical and the second shroud is generally ring-shaped, the second shroud having an inner peripheral edge that is substantially equal in diameter to an outer peripheral edge of the first shroud, and wherein each of the plurality of vanes extends from a front face surface of the first shroud to the inner peripheral edge of the second shroud and across a rear face surface of the second shroud.

20. A seal assembly for an impeller shaft of a coolant pump, said seal assembly comprising:

- a unitizer mounted on the impeller shaft for rotation therewith, the unitizer including a radially outwardly extending portion having a plurality of openings therethrough;

- a mating ring providing a front face surface, the mating ring being mounted to the unitizer such that the plurality of openings in the unitizer expose portions of the front face surface therethrough; and

- a seal unit providing a seal and an aligning member, the seal unit being coupled with the unitizer such that the aligning member is engaged with a rear face surface of the mating ring,

- wherein the openings in the radially outwardly extending portion of the unitizer is capable of receiving a plurality of axial extending projections of a pump impeller to engage the portions of the face surface of the mating ring so as to align the mating ring to the impeller shaft, which aligns the aligning member engaged with the mating ring to the impeller shaft, which in turn aligns the seal unit to the impeller shaft.

21. A seal assembly as claimed in claim 20, wherein the openings provided in the outwardly extending portion of the unitizer allow coolant flow therethrough to cool the portions of the face surface of the mating ring.

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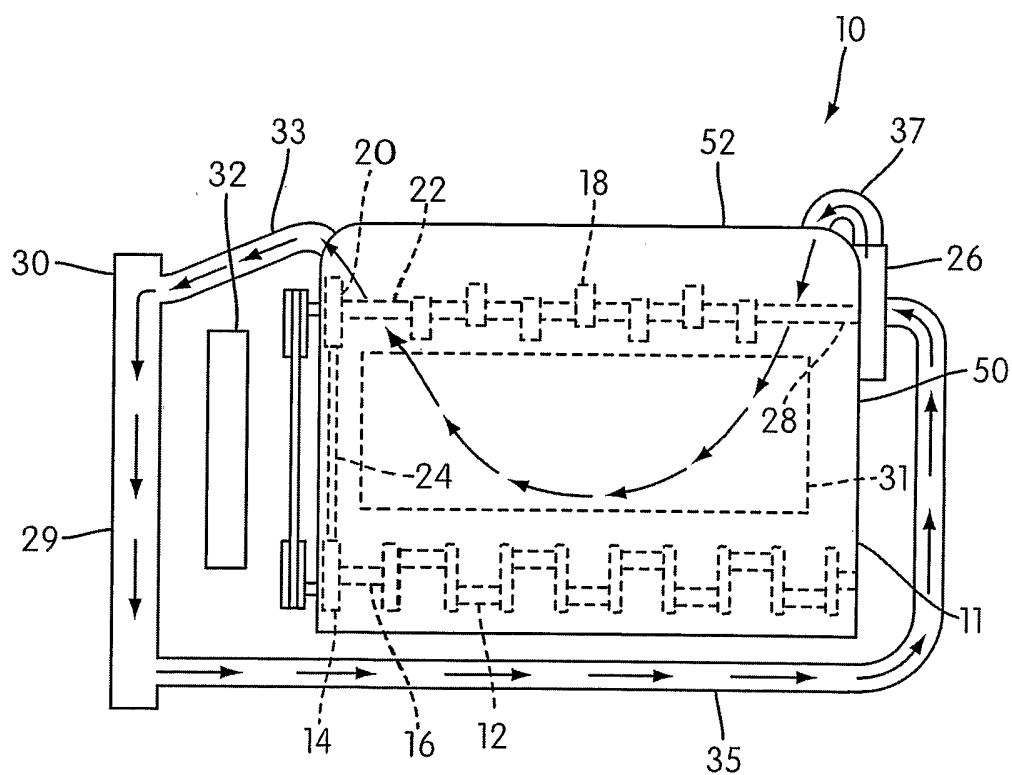


FIG. 1

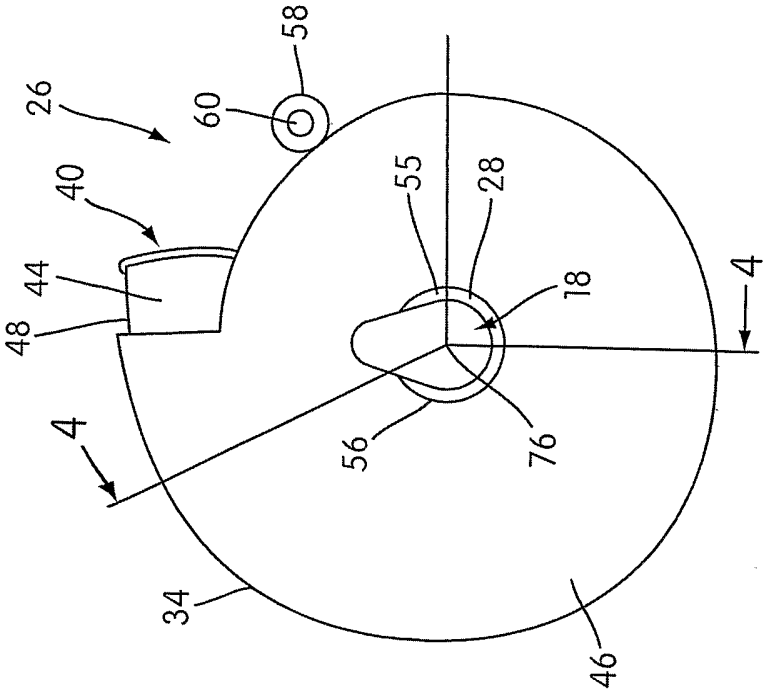


FIG. 3

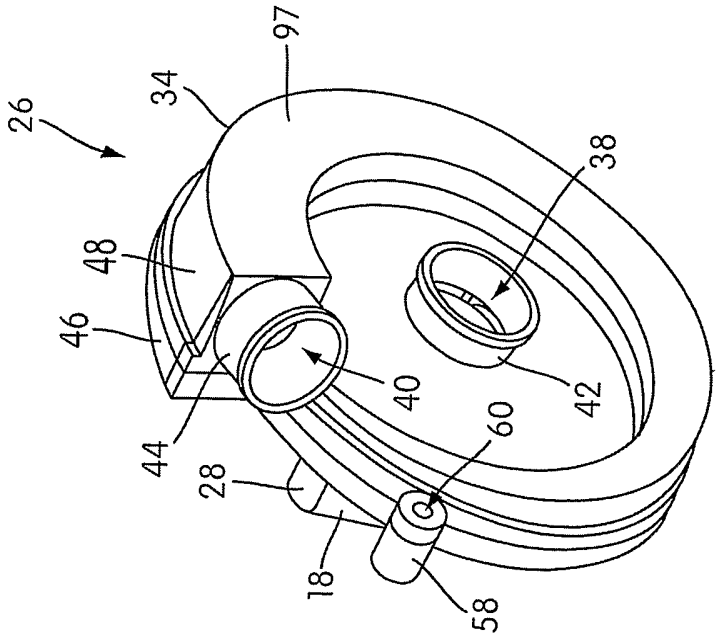


FIG. 2

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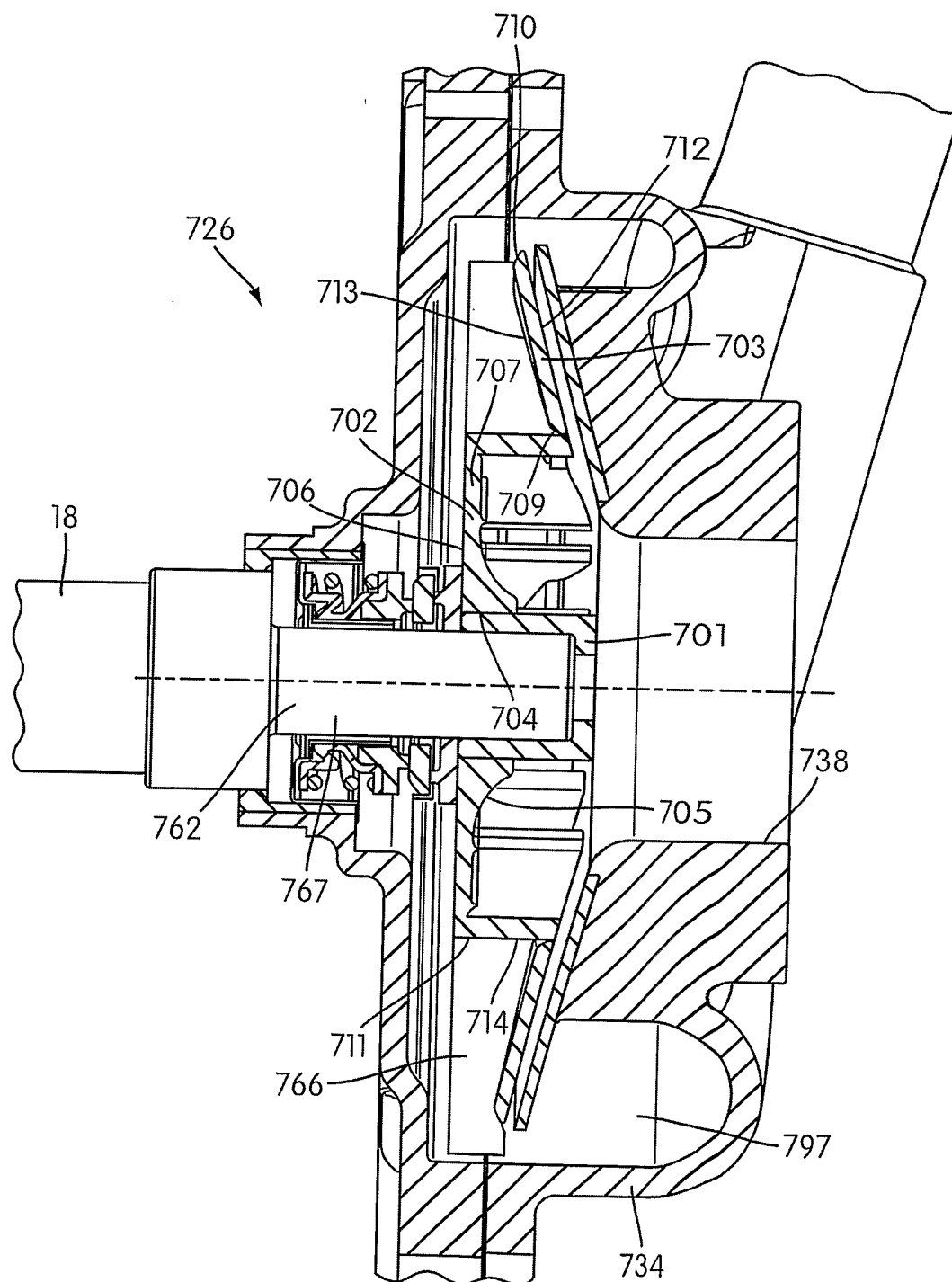


FIG. 4

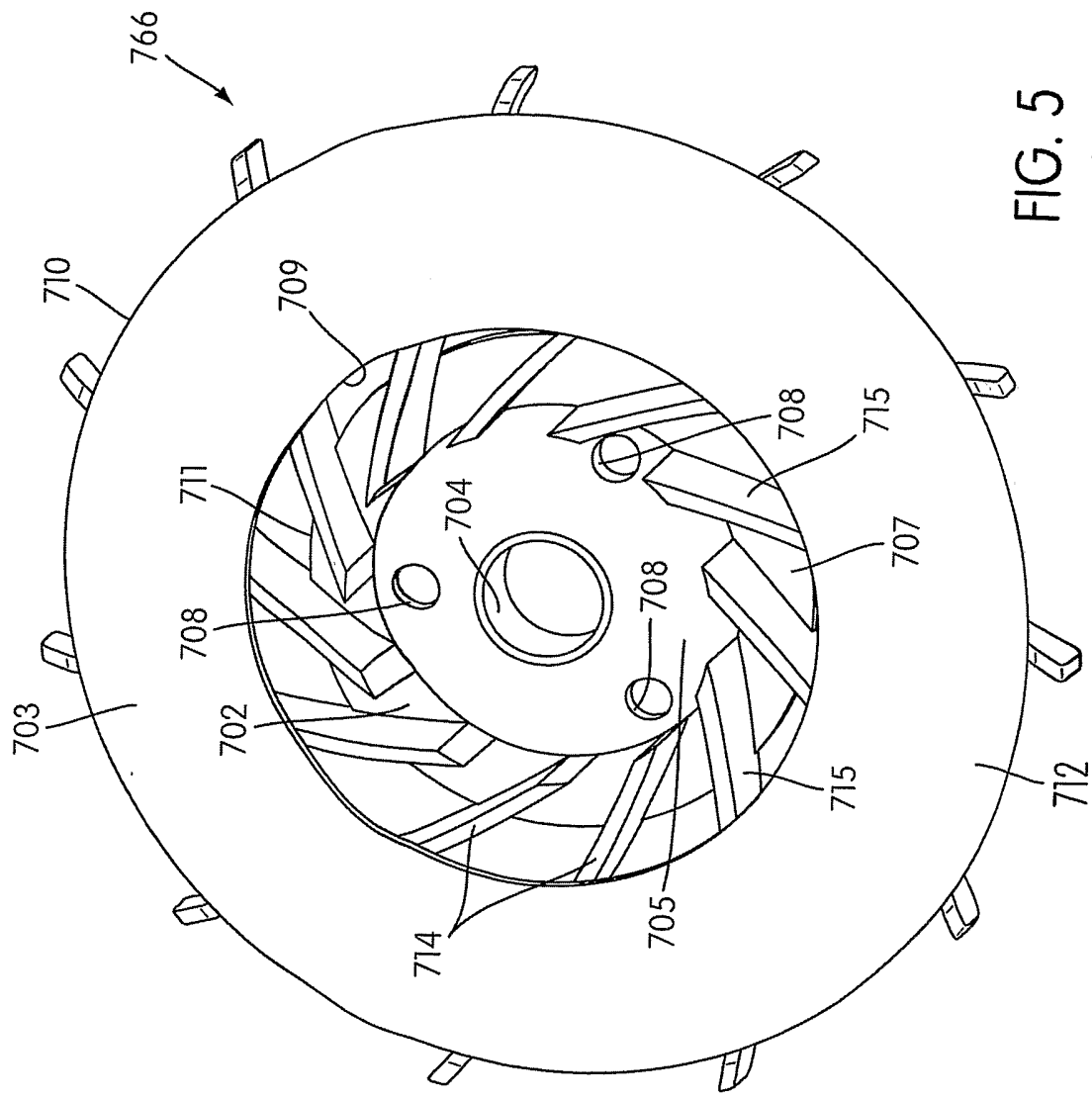
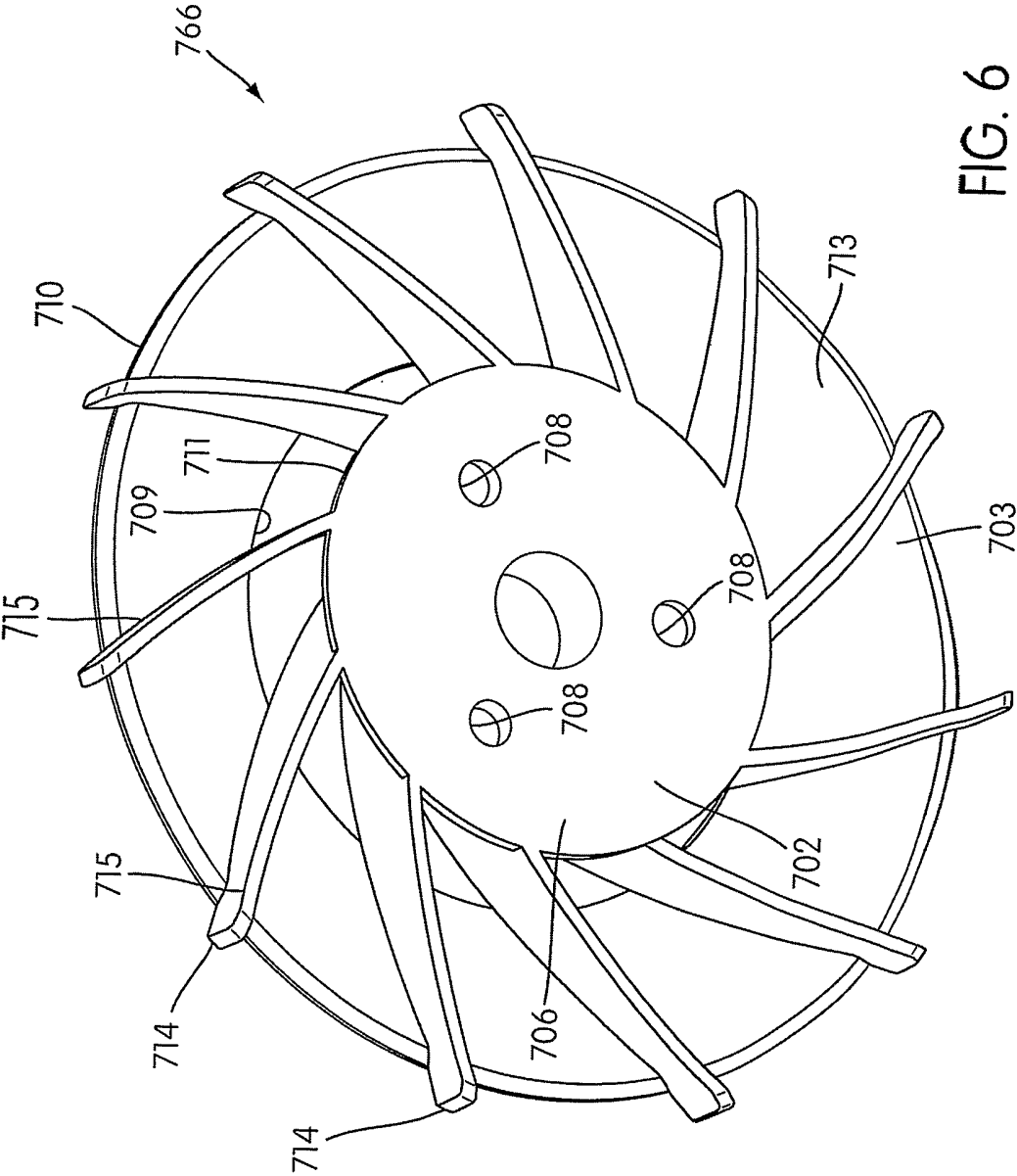
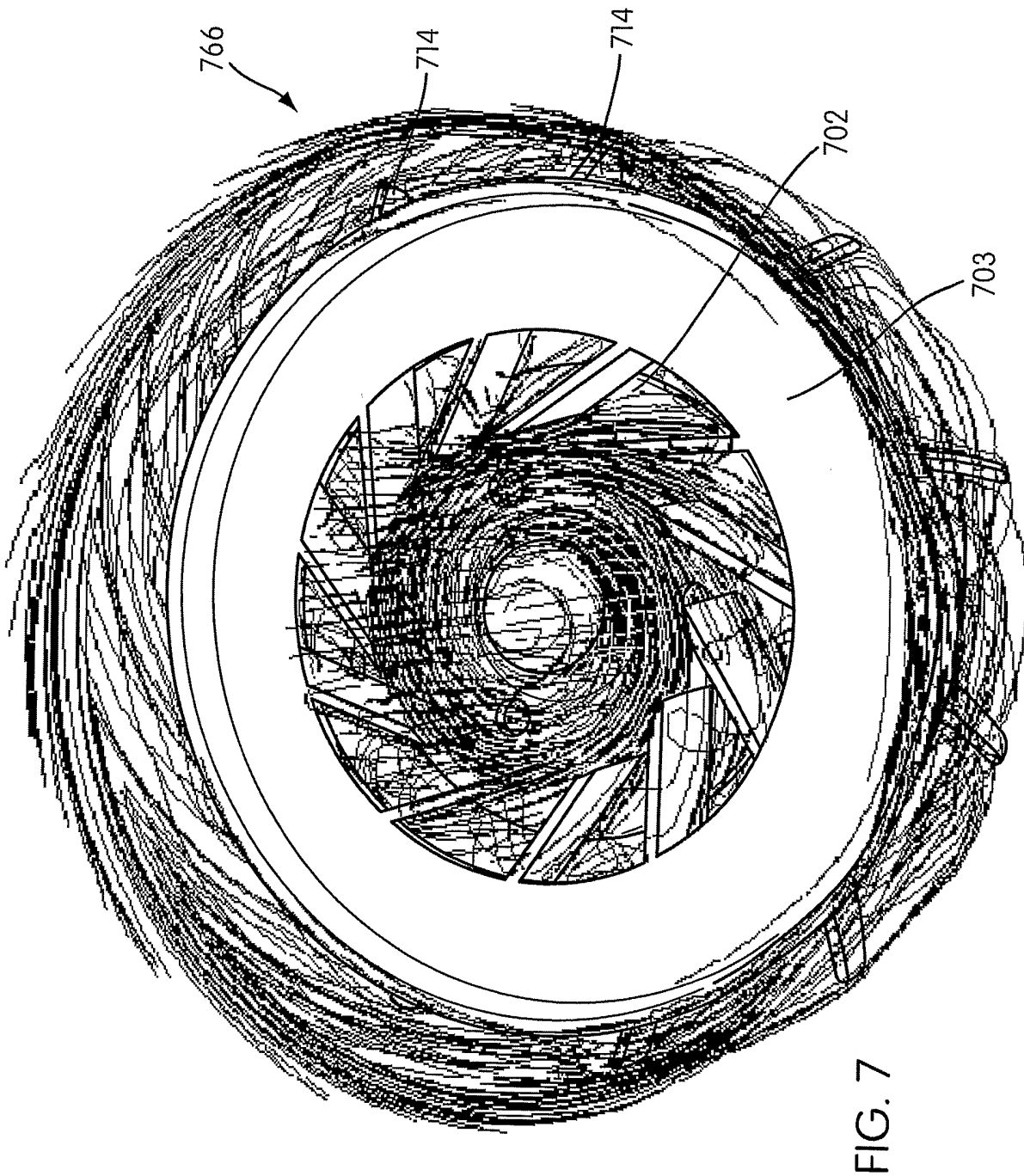


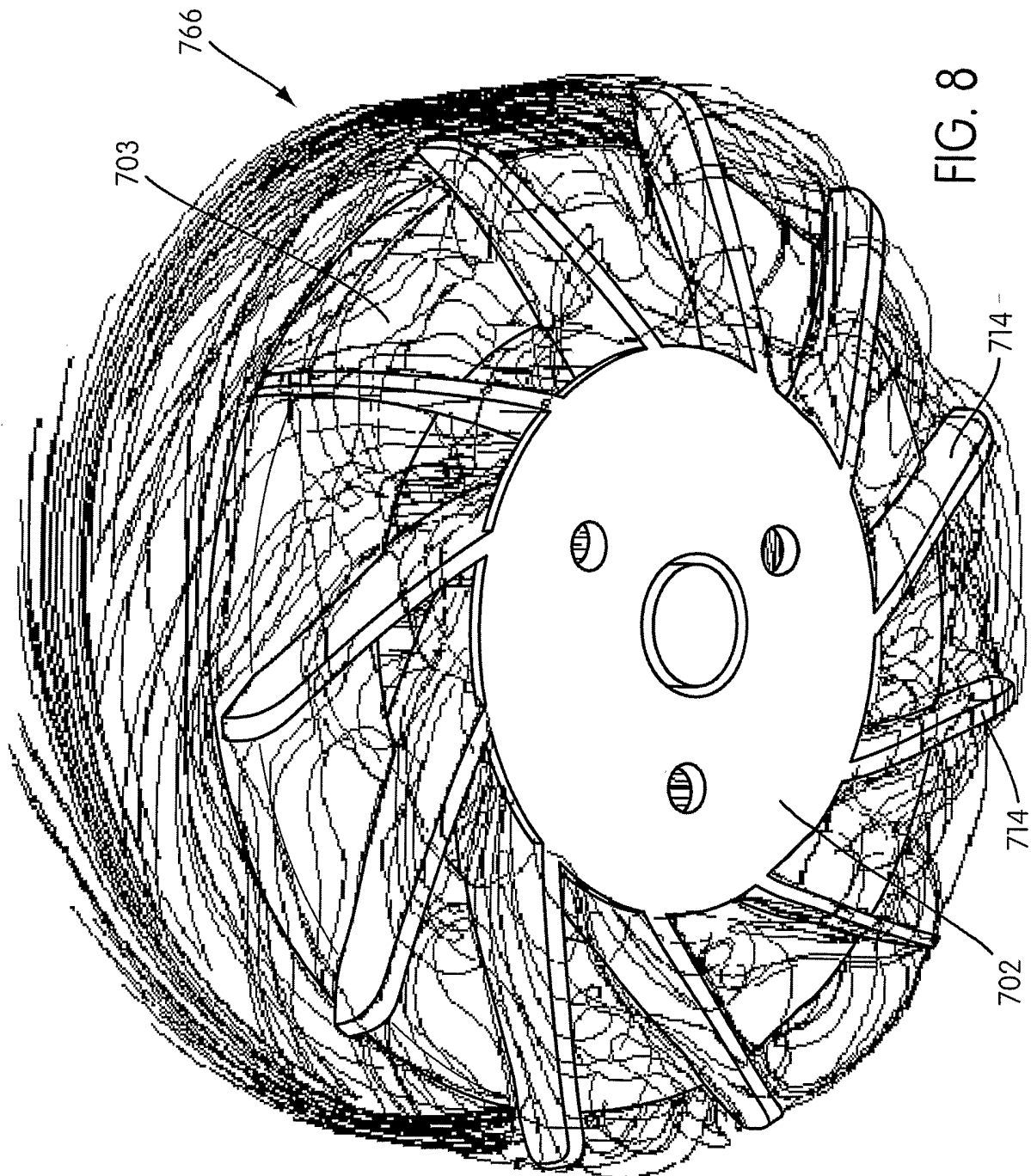
FIG. 5



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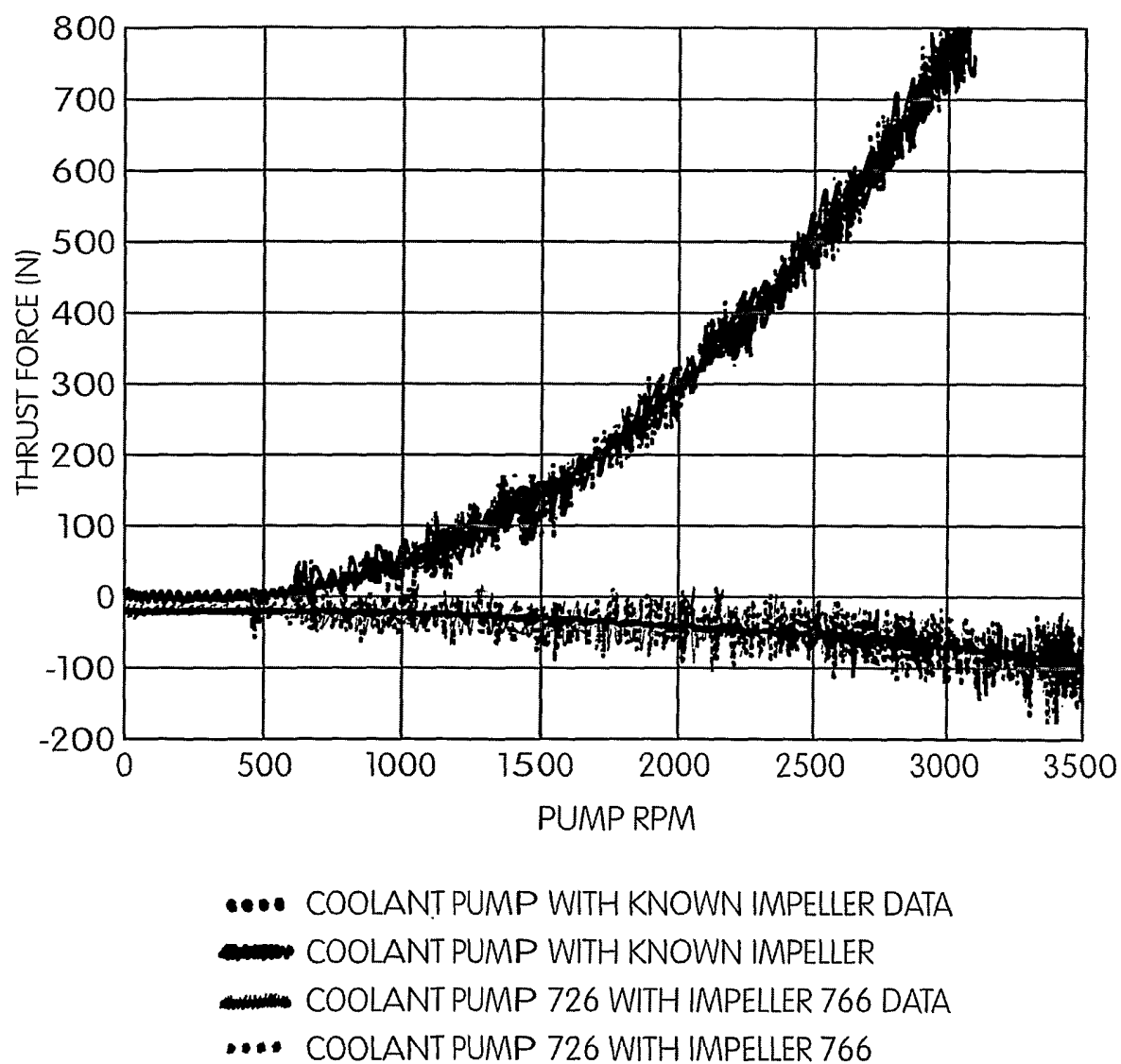


FIG. 9

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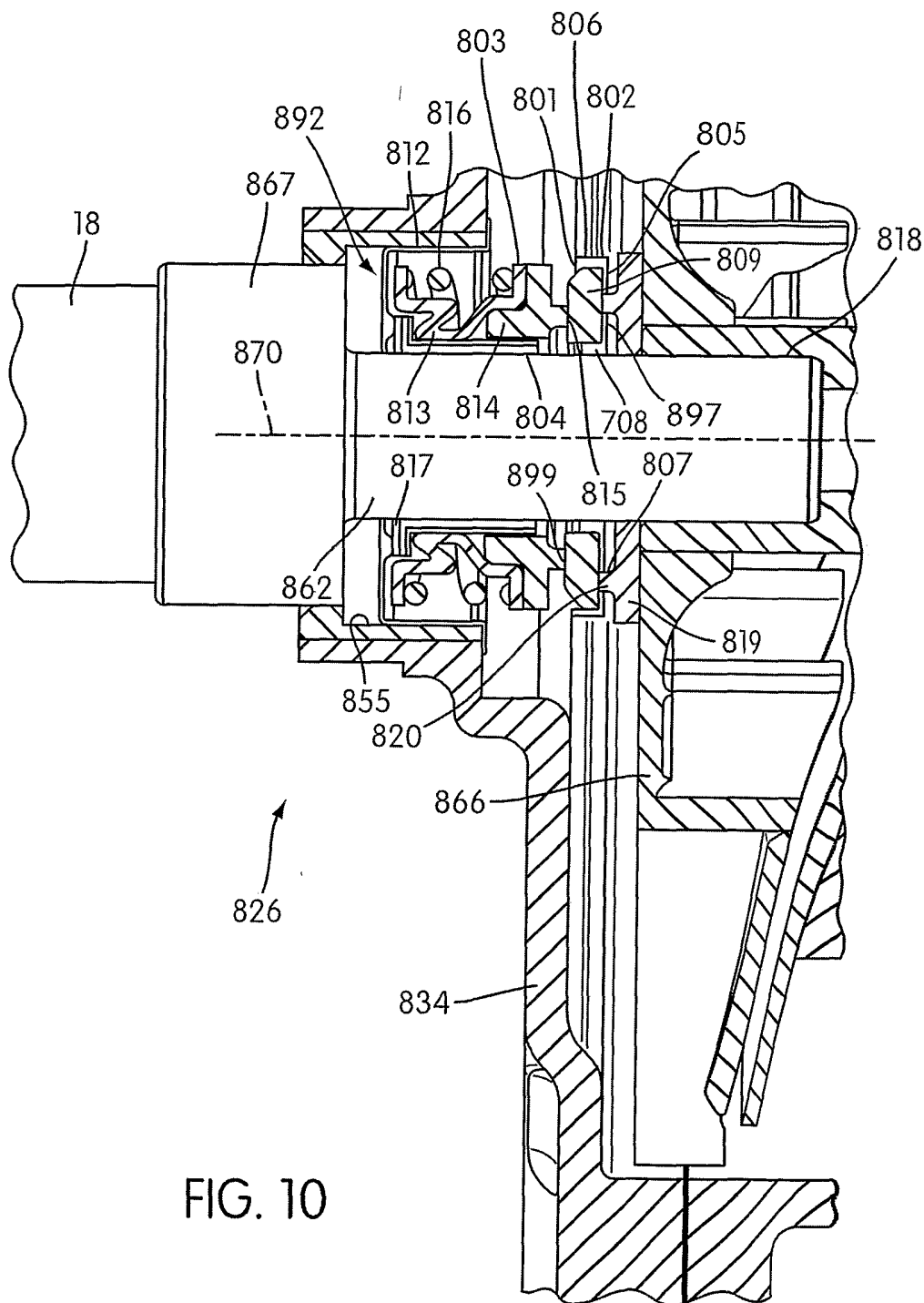


FIG. 10

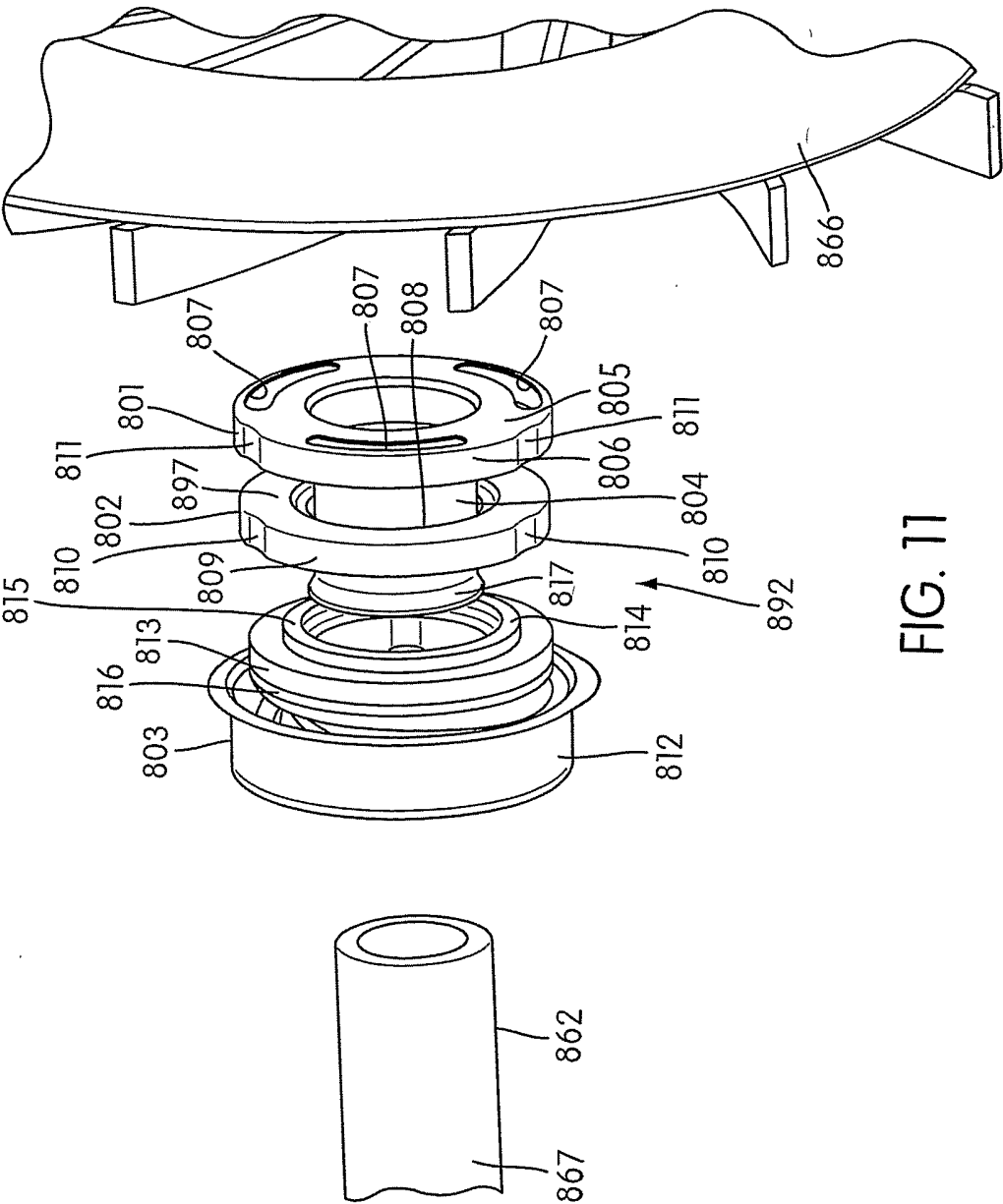


FIG. 11

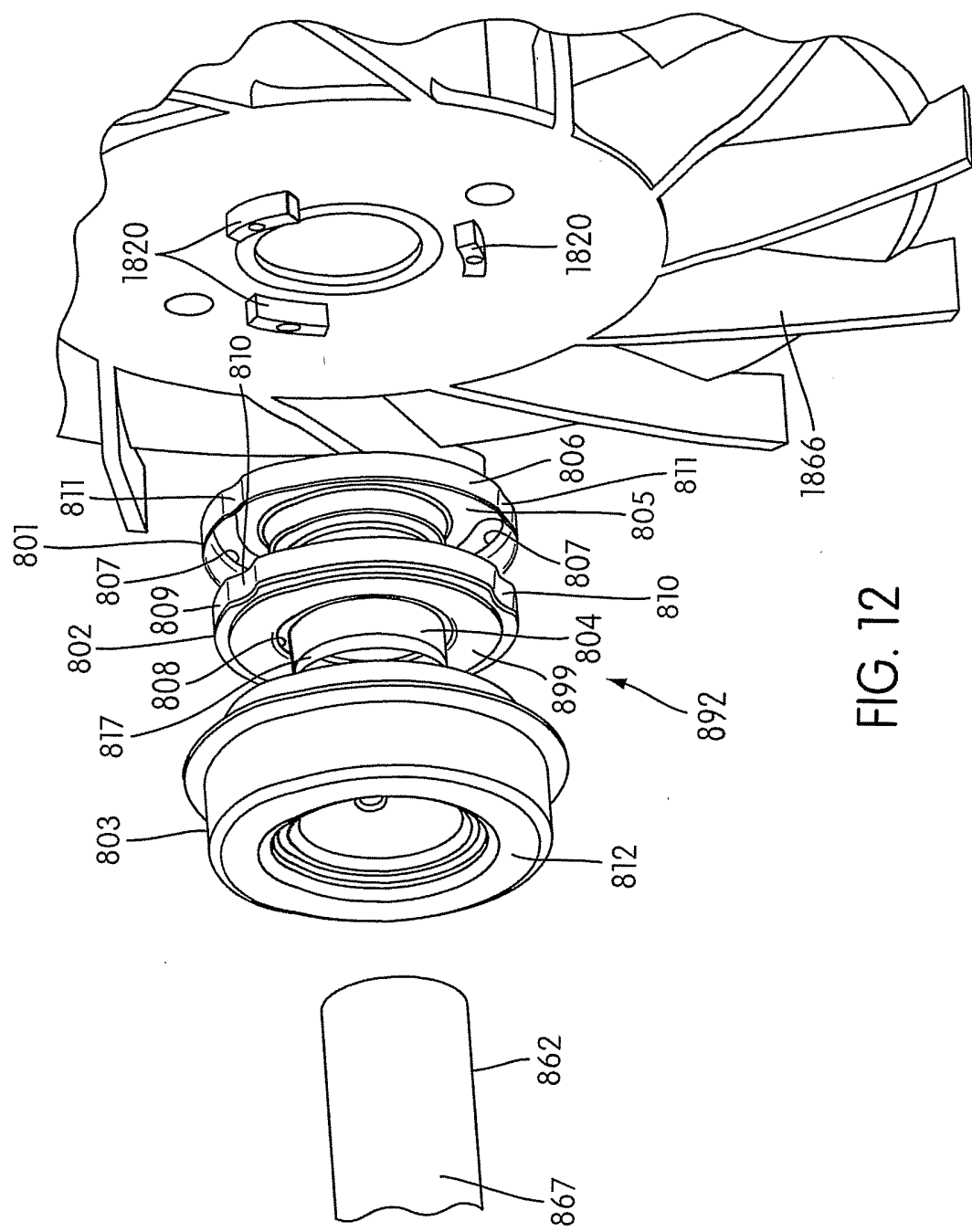


FIG. 12

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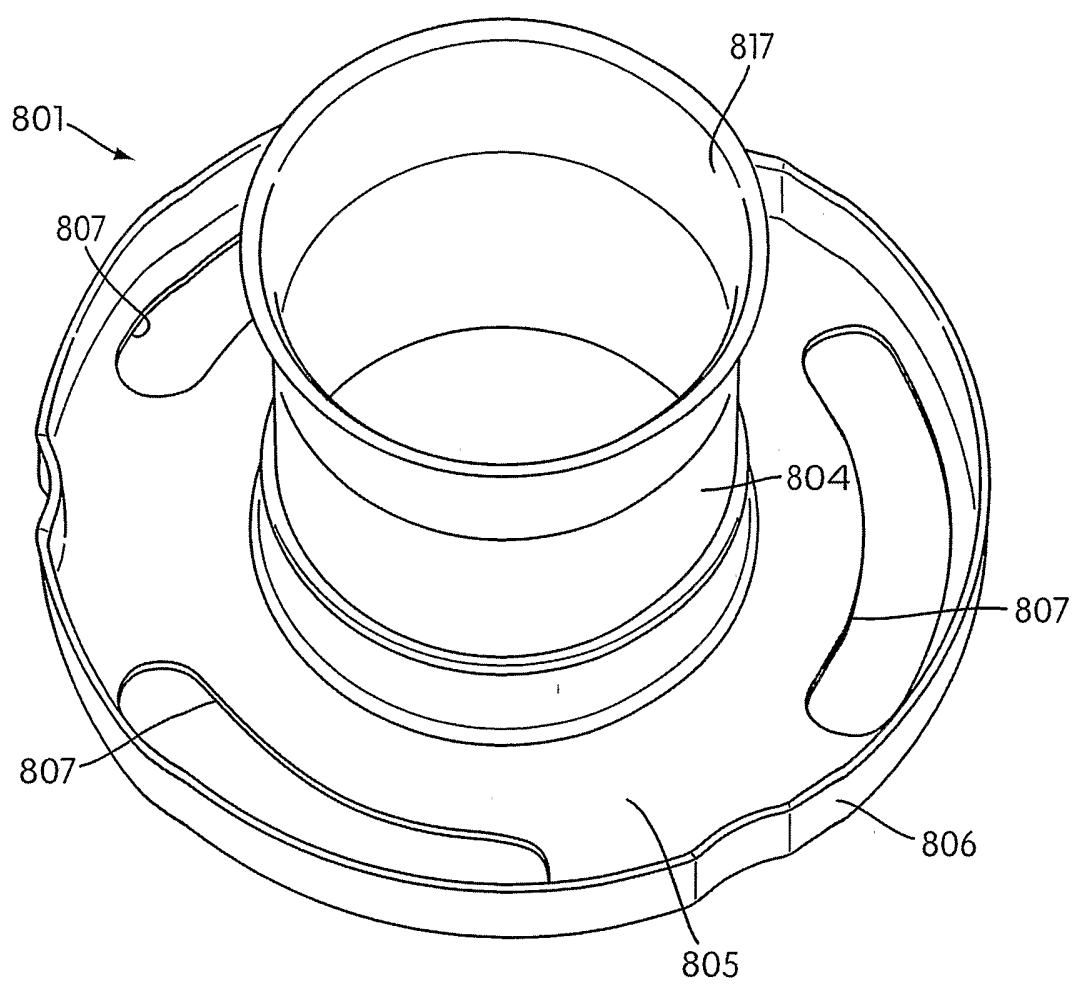


FIG. 13